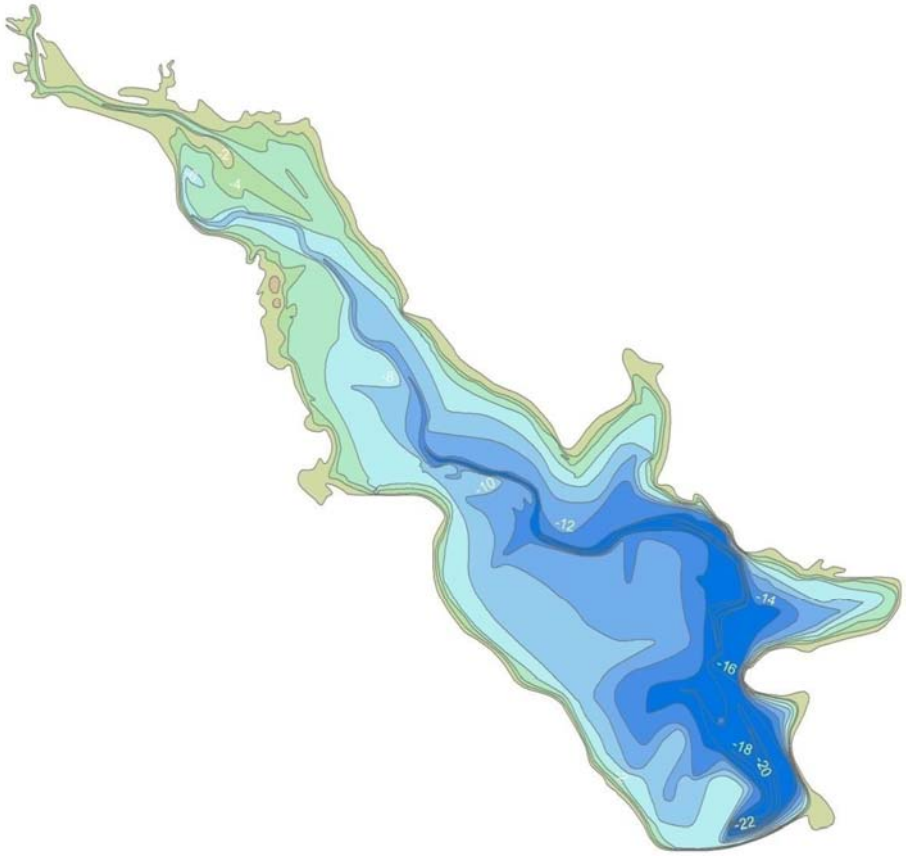
WATERSHED BASED PLAN

FOR

NEW SPIRO LAKE



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OKLAHOMA
CONSERVATION
COMMISSION

INTRODUCTION

The New Spiro Lake watershed is located in the eastern part of the state in LeFlore County. The lake is designated as a water supply and recreation waterbody. New Spiro Lake has been classified as hypereutrophic since 2002, and in 2012, a nutrient limited watershed (NLW) designation was added, which denotes watersheds with waterbodies that are threatened by excess nutrients. According to the State's 2012 Integrated Report, the aesthetic, fish and wildlife propagation, and public and private water supply designated uses of New Spiro Lake are not being supported due to dissolved oxygen, color, and chlorophyll-*a* impairments, and the original volume of the lake has been decreased by 24% due to sedimentation.

In addition, there are extensive summer algae blooms, which increase turbidity and decrease oxygen in summer months. Water treatment to address this has resulted in exceedances of total organic carbon (TOC) and disinfection by-product limits since 2008, with summer spikes indicating that algae growth is at the root of the problem. The City of Spiro has violated the maximum allowable amount of trihalomethanes (THM) at some point annually from 2004 through 2009, with consistent violations of haloacetic acids (HAA5) as well. The City of Spiro has initiated partnerships with a number of agencies and other groups in order to find a solution to these issues, and residents of the watershed have shown a great deal of interest in implementing practices that will improve the water quality.

The Nonpoint Source Program and Grants Guidelines for States and Territories for FY 2004 and Beyond requires a *Watershed Based Plan* (WBP) to be completed prior to implementation using Section 319 incremental funds. The guidance defines the 9 key components to be addressed in a watershed-based plan: 1) identification of causes and sources that will need to be controlled to achieve load reductions, 2) estimate of load reductions expected from the management measures described, 3) a description of the management measures that will need to be implemented to achieve load reductions, 4) an estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources or authorities who will bear responsibility, 5) an information/education component that will be used to enhance public understanding of the project and encourage early participation in the overall program, 6) a schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious, 7) a description of interim, measurable milestones for determining whether control actions are being implemented, 8) a set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made or whether the Watershed Plan or Total Maximum Daily Load (TMDL) needs to be revised, and 9) a monitoring component to evaluate the effectiveness of the implementation efforts over time.

Currently, no Clean Water Act Section 319 funds are being used to fund implementation in this watershed. The New Spiro Lake WBP has been developed as a dynamic document that will be revised to incorporate the latest information, address new strategies, and define new partnerships between watershed shareholders. In particular, this WBP will be a collaborative effort with the local community of Spiro (principal stakeholder) and will continue to evolve as the partnership develops. It is anticipated that at least biannual revisions may be necessary and that the responsibility for such revisions will rest with the Oklahoma Conservation Commission (OCC), with support from the Oklahoma Office of the Secretary of Energy and Environment (OSEE). It is understood that the water quality goals

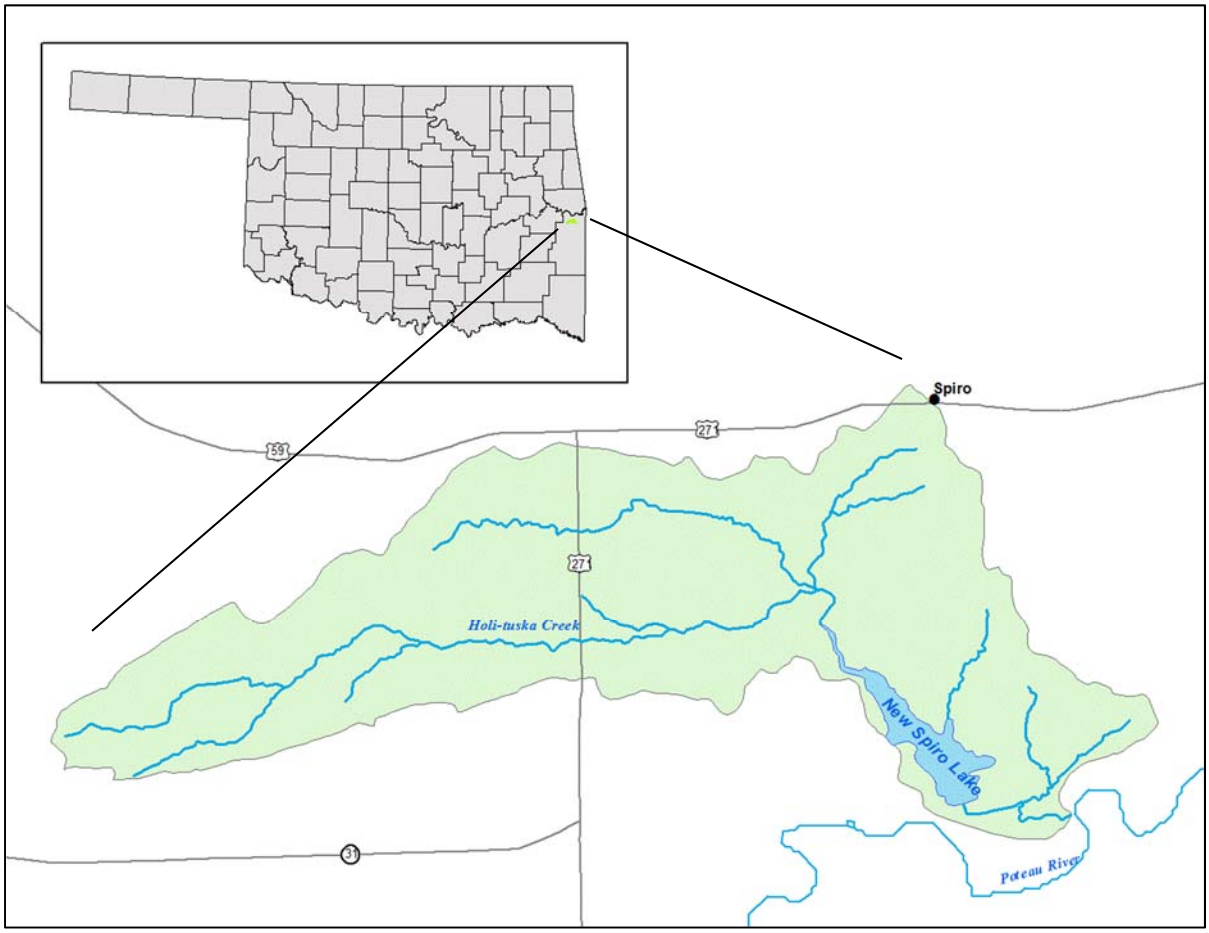
set forth in this WBP, as well as the technical approach to address the goals, may not be comprehensive, so they most certainly will expanded in the future. Federal and state funding allocations for future water quality projects designed to address the New Spiro Lake Watershed problems should not be based solely upon their inclusion in this WBP; rather, the WBP should be considered a focal point for initial planning and strategy development.

CAUSES AND SOURCES *(element a)*

Watershed Characterization

The New Spiro Lake watershed is located in LeFlore County in eastern Oklahoma (Figure 1). The watershed drains approximately 9,746 acres (15 sq. mi.) and occurs in the Poteau River basin (HUC8: 11110105). Holi-Tuska Creek (OK220100010040_00) was impounded in 1963 to form the lake (OK220100010050_00). New Spiro Lake is the drinking water source for Spiro, OK, with a population of approximately 2,200, and is also used for recreation. The lake covers 254 acres, with six miles of shoreline and a capacity of 2,160 acre-feet. The lake releases into the Poteau River below the dam (Figure 1).

Figure 1. New Spiro Lake Watershed.



Physical / natural features: The New Spiro Lake watershed lies within the Omernik's Level III Arkansas Valley ecoregion and the Arkansas Valley Plains level IV ecoregion (Woods et al. 2005). This ecoregion is characterized by forested valleys and ridges. "The **Arkansas Valley Plains** ecoregion is underlain by Pennsylvanian-age shale, sandstone, and coal… its undulating plains are mostly pastureland or hayland, whereas its scattered hills and ridges remain wooded; cropland is much less extensive…Flow in the Poteau River system varies widely; during droughts, tributaries stop or nearly stop flowing, but after heavy precipitation, both flow and turbidity increase, and flooding commonly occurs" (Woods et al. 2005). The elevation of the New Spiro Lake watershed is about 492 ft. Soils in the watershed are primarily silt loams, with some fine sandy loam.

Average annual precipitation in Le Flore County is about 49 inches. May and October are the wettest months, on average, but much of the spring through fall receives sufficient rainfall. Nearly every winter has at least one inch of snow, with one year in eight having ten or more inches. Temperatures average near 61 degrees and range from an average daytime high of 93 degrees in July to an average low of 27 degrees in January. Winds from the south to southeast are quite dominant, averaging nearly five miles-per-hour (OU Climatological Survey website, 2014).

Land Use: The majority of the landuse in the watershed is pasture/hay (70%), and deciduous forest comprises 12% of the watershed. Other landuses are summarized in Figure 2. According to the 2012 USDA Census of Agriculture, farmland accounts for nearly 400,000 acres in Le Flore County (USDA 2014). Grazing land is the primary landuse, with over 67,000 acres used for forage, and cattle are common in the county (Tables 1 and 2). Poultry production is also thriving, with an inventory of over 60 million animals (Table 1).

Table 1. Le Flore County Livestock Production Statistics (USDA 2014).

Type	# Animals	# Farms
Cattle and calves	69,924	1,269
Hogs and pigs	23,610	53
Layers	72,646	179
Broilers / meat-type chickens	60,162,275	145

Table 2. Le Flore County Crop Production Statistics (USDA 2014).

Crop	# Farms	Area (acres)
Soybeans	15	8,639
Vegetables harvested for sale	10	3.985
Forage for hay, silage, and greenchop	994	67,054
Wheat for grain	12	4,156
Corn for grain	8	1,520

Figure 2. Landuse summary of the New Spiro Lake Watershed based on NLCD 2006 data.

Land Cover	Area (Acres)	%
Open Water	251.6	3%
Developed Open Space	354.8	4%
Developed Low Intensity	133.7	1%
Developed Medium Intensity	34.6	<1%
Developed High Intensity	4.0	<1%
Barren Land	4.6	<1%
Deciduous Forest	991.2	12%
Evergreen Forest	38.0	<1%
Mixed Forest	170.9	2%
Shrub/Scrub	112.3	1%
Grassland/Herbaceous	175.1	2%
Pasture/Hay	5599.7	70%
Woody Wetlands	69.4	<1%
Emergent Herbaceous Wetlands	1.5	<1%

Causes

New Spiro Lake is designated as a public and private water supply (PPWS) and primary body contact recreation (PBCR) waterbody. In addition, the lake has use designations for aesthetics, agriculture, fish and wildlife propagation--warm water aquatic community (FWP-WWAC), and fish consumption. The lake is also designated as a sensitive water supply (SWS) and a nutrient limited watershed (NLW), indicating that it is threatened by excess nutrients. New point source discharges or increased loading from existing point sources are prohibited on SWS waterbodies without approval from the OWRB. Holi-Tuska Creek is designated for PBCR, WWAC, aesthetics, agriculture, and fish consumption.

In the 2003 Beneficial Use Monitoring Program (BUMP) report, New Spiro Lake was classified as hypereutrophic due to a trophic state index (TSI) of 61 (OWRB 2003). In the 2012 BUMP report, the TSI was 68, still indicating a hypereutrophic condition and indicating that the aesthetics use is threatened by nutrients. In addition, up to 33% of the water column at the lower monitoring site had dissolved oxygen less than 2 mg/L during August, leading to impairment of the FWP designated use. The chlorophyll-*a* values exceed 10 µg/L, the standard for SWS lakes (OWRB 2012). According to the State's 2012 Integrated Report, the aesthetic, FWP, and PPWS designated uses of New Spiro Lake are not being

supported, and the SWS criteria are not being met. **Impairments currently include dissolved oxygen, color, and chlorophyll-*a*** (ODEQ 2012b). Preliminary data has been collected on Holi-Tuska Creek, and the data collected to date will be used to assess attainment of designated uses for the 2016 Integrated Report.

The original volume of 2,000 acre-feet at normal elevation has been decreased by 24% due to sedimentation. In addition, there are extensive summer algae blooms, which increase turbidity and decrease oxygen in summer months. The City of Spiro has consistently exceeded total organic carbon (TOC) reduction rules and disinfection by-product limits since 2008, with summer spikes indicating that algae growth is at the root of the problem. According to the Safe Drinking Water Information System (SDWIS) operated by the ODEQ, the City of Spiro has violated the maximum allowable amount of trihalomethanes (THM) at some point annually from 2004 through 2009, with consistent violations of haloacetic acids (HAA5) as well.

Sources

Since there are no point sources in the New Spiro Lake watershed, all of the sources contributing to the water quality impairments are nonpoint. Nonpoint sources are those which deliver pollutants to surface waters diffusely, rather than as a definite, measurable quantity from a single location. These sources typically result from land activities that contribute pollutants such as sediment, nutrients, and/or bacteria to surface water as a result of runoff during and following rainfall. Potential sources of concern in this watershed include grazing in riparian or shoreline zones, on-site treatment systems (septic systems and similar decentralized systems), rangeland grazing, and land application of poultry litter. According to an OWRB study in 2011, 84% of nutrients are entering the lake from the watershed and only 16% are from resuspension of lake bottom sediments.

Pasture land comprises approximately 70% of the landuse in the watershed. Livestock grazing in pastures deposit manure containing fecal bacteria onto land surfaces, making it possible for both bacteria and nutrients to enter surface water with runoff. In addition, livestock often have direct access to waterbodies, providing a concentrated source of fecal loading directly into streams. In addition, approximately 31,000 kg of poultry litter is applied to the watershed basin each year, according to 2010 Oklahoma Department of Agriculture, Food, and Forestry poultry litter land application information.

Direct access by livestock also promotes bank trampling/destabilization and trail formation which serve as direct conduits of pollutants through the little riparian area that might be present. In areas of depauperate riparian area, streambank erosion is a likely contributor of sediment and associated nutrient loads.

Roads in the watershed are largely dirt and/or gravel, maintained by the city and county. Some road cuts have significant downcuts, washouts, and other signs of historical and ongoing erosion. Local experts most familiar with the watershed believe that sediment erosion from watershed roads also contributes to the water quality problems.

CRITERIA *(element h)*

Designated beneficial uses for New Spiro Lake and its mainstem tributary Holi-Tuska Creek include primary body contact recreation (PBCR), fish and wildlife propagation--warm water aquatic community (WWAC), aesthetics, agriculture, fish consumption, and public and private water supply (PPWS). The watershed is also designated a "nutrient limited watershed" (NLW) and a sensitive water supply (SWS), denoting a particular sensitivity to and impact by nutrients. According to the State's 2012 Integrated Report, New Spiro Lake exceeds dissolved oxygen, chlorophyll-*a*, and color criteria and is thus not supporting its WWAC, Aesthetic, and PPWS designated uses. Restoration goals of this project will be set in accordance with criteria necessary to achieve a fully attaining status for these waterbody impairments. The criteria and procedures used to assess the associated uses are presented below (adapted from both the *2012 Oklahoma Continuing Planning Process* (ODEQ 2012a) and the *2013 Implementation of Oklahoma's Water Quality Standards* (OWRB 2013)):

To attain **Fish and Wildlife Propagation--Warm Water Aquatic Community** use for lakes (based upon a minimum of 20 samples for a lake greater than 250 acres):

- Dissolved oxygen (DO)
  a) 10% or less of the samples from the epilimnion during periods of thermal stratification, or the entire water column when no stratification is present, are less than 6.0 mg/L from April 1 through June 15 and less than 5.0 mg/L during the remainder of the year
  AND
  b) Less than 50% of the volume or 50% or less of the water column of all sample sites in the lake are less than 2.0 mg/L during periods of thermal stratification

To attain the **Aesthetics** use (based upon a minimum of 20 samples for a lake greater than 250 acres):

- Chlorophyll-*a*
  Planktonic chlorophyll-*a* values in the water column indicate a Carlson's Trophic State Index of less than 62
- Color
  If persistent coloring materials that produce an aesthetically unpleasant appearance are not observed and no public complaints regarding such are registered for a waterbody, the waterbody shall be considered fully supporting of the aesthetics beneficial use with regard to color. If coloring materials that produce an aesthetically unpleasant appearance are observed, and they are determined to be from natural sources, the waterbody shall be considered fully supporting of the aesthetics beneficial use with regard to color. Natural sources may be determined by the process of elimination. If no point or substantial nonpoint sources discharges known to affect waterbody color are present in the watershed then the remaining sources are considered natural.

To attain the **Public and Private Water Supply** use (based upon a minimum of 20 samples for a lake greater than 250 acres):

- Chlorophyll-*a*
  The long term average concentration of chlorophyll-*a* at a depth of 0.5 meters below the surface shall not exceed 0.010 mg/L in any waterbody designated SWS

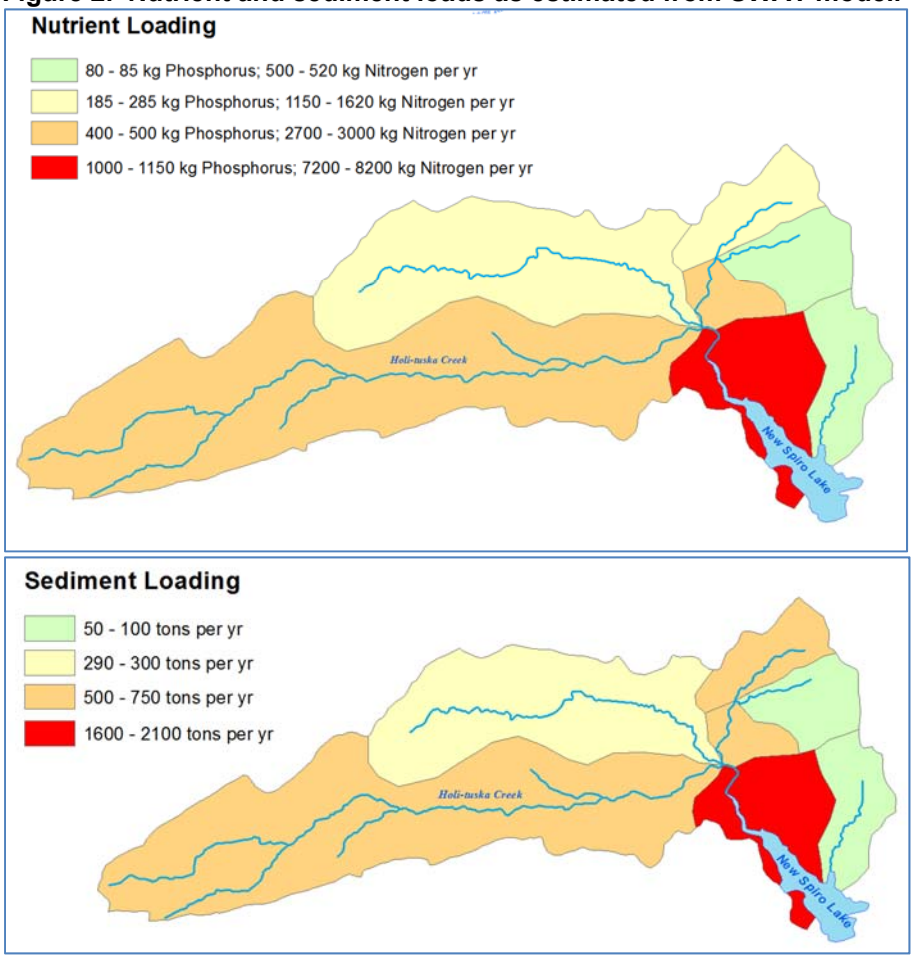
All data collected from Holi-Tuska Creek and the lake will be assessed to determine attainment of designated uses. At least biannual assessment will occur as part of the Integrated Reporting process, and the published criteria in the State's Standards (OWRB 2013) will be the values to determine progress toward improved water quality. The ultimate goal of implementation of any project in this watershed is to attain all designated uses, so these criteria are the target values to attain.

LOAD REDUCTIONS *(element b)*

A BATHTUB model was used to establish the relationship between algae growth and nutrient input for the purpose of planning appropriate measures to manage the Lake New Spiro. All details of the modeling efforts in this watershed can be found in a final report produced by the Oklahoma Water Resources Board (OWRB 2011). Bathymetric data was integrated with dissolved oxygen profile data, water quality data, and sediment phosphorus (P) data in order to model the amount of anaerobic mediated sediment P release (the internal P load of the lake). For the model, the lake was segmented into a mixing zone and a lacustrine zone based on water quality data. The calculated sediment P release was removed in portions from the BATHTUB model to determine its impact on chlorophyll-*a* (chl-*a*) values and total P. Certain Best Management Practice (BMP) options were also evaluated for reduction of internal P loading and the resulting drop in chl-*a*.

A SWAT model was also produced in order to estimate the average yearly external nutrient load for the BATHTUB model. This watershed model incorporated the landuse in the watershed, weather, hydrology, soil information, and land use data such as amount of poultry waste litter applied. Outputs calculated included flow, organic and mineral P, organic nitrogen, ammonia, nitrate and nitrite, sediment, and soil nutrients. The figures below show estimates of nutrient and sediment loads from subwatersheds.

Figure 2. Nutrient and sediment loads as estimated from SWAT model.



For Lake New Spiro, the combination of the SWAT and BATHTUB models indicated that the eutrophic situation stems from high nutrient input from its small watershed. Lake New Spiro's chlorophyll-*a* impairment is compounded by the addition of anaerobic mediated phosphorus release from the lake sediment in the late summer timeframe. According to the models, internal loading represents only 16% of the entire phosphorus load of the lake, therefore, reducing the internal load resulted in much smaller changes in total phosphorus concentrations than reducing the external load. When the internal load was completely removed, only a 9% reduction in total phosphorus was realized (Table 4). This translated into a 6% reduction in mean chl-*a* for the year.

Table 4. New Spiro BATHTUB area weighted mean Total P and chl-a for changes in internal phosphorus load concentrations (OWRB 2011).

Change in Internal Phosphorus Load (%)	Total Phosphorus Conc. (mg/L)	Chlorophyll-*a* (mg/m^3)
+100%	0.121	34.0
+75%	0.119	33.5
+50%	0.116	33.2
+25%	0.114	32.8
0%	0.111	32.3
-25%	0.109	31.9
-50%	0.106	31.4
-75%	0.103	30.9
-100%	0.100	30.4

Modeling the effects of the chosen in-lake BMP indicated that the total sediment P load could be reduced by between 8% (60 kg) and 39% (275 kg) per year, depending on the precipitation in a given year (Table 5).

Table 5. Average, minimum, and maximum estimated reduction of internal P load during evaluation period (OWRB 2011).

	Average from 2000-2008	2006	2007
Maximum number of days pipe could be operated	88.6	28.3	125
Average epilimnetic total P	0.1 mg/L	0.1 mg/L	0.1 mg/L
Average hypolimnetic total P	0.2 mg/L	0.2 mg/L	0.2 mg/L
Total P lost by pipe flow per day	5.4 kg	5.4 kg	5.4 kg
Total P lost by pipe flow per year	478 kg	152 kg	675 kg
Total P lost by overflow per day	3.2 kg	3.2 kg	3.2 kg
Total P lost by overflow per year	283.5 kg	91.8 kg	400 kg
Calculated Total P reduction	**195 kg**	**60.9 kg**	**275 kg**
BATHTUB predicted Sediment P Load	**706.8 kg**	**706.8 kg**	**706.8 kg**
Sediment P Load reduction	**27.6%**	**8.6%**	**38.9%**

NPS MANAGEMENT MEASURES *(element c)*

A small amount of BMP implementation in the watershed has already occurred through a partnership between the City of Spiro and the Oklahoma Rural Water Association (ORWA 2014). New fencing has been installed around the lake to restrict off-road vehicle access, thus reducing soil erosion and sediment runoff into the lake. The Oklahoma Department of Fish and Wildlife (ODFW) has installed fish habitat in three locations within New Spiro Lake in order to enhance fishing and fish propagation. Signage will be installed around the lake identifying it as a public water source for Spiro.

The first priority to address water quality impairments in New Spiro Lake will be through BMP implementation throughout the watershed. At least initially, this effort will primarily be funded by the NRCS through the National Water Quality Initiative (NWQI). Since 70% of the landuse in the watershed is pastureland, potential BMPs to address NPS pollution include:

- Grazing management—rotational grazing plans with cross-fencing and alternative water supplies, supplemental grass planting, soil testing to ensure proper nutrient application
- Riparian buffers—fencing to keep livestock out of streams, alternative water sources, supplemental vegetation planting in riparian areas

A more detailed list of BMPs and cost-share rates will be available through the NRCS local office and will be included in this WBP as an appendix when it is finalized. Once water quality data from tributaries in the watershed has been collected, watershed level BMPs can be promoted in targeted areas. Section 319 funds may be utilized to promote crucial BMPs through additional incentives if signup for NWQI is low.

According to the 2011 OWRB modeling report, only 16% of the total phosphorus load to New Spiro Lake comes from the in-lake sediment via anaerobic mediated release. While the majority of the nutrients come from the watershed, reducing phosphorus through in-lake best management practices could provide some relief to the intense algal growth witnessed in the reservoir throughout the growing season. The City of Spiro considered three in-lake methods for managing the anoxic hypolimnion of Lake New Spiro. The “depth-selective flow routing” option was the most efficient and has been implemented at no cost to the city. This is expected to result in an average 28% reduction of anaerobic mediated sediment phosphorus load, which equates to 195 kg of total phosphorus each summer. On any given year, actual reduction of sediment phosphorus load could be more or less, depending on the hydraulic conditions, ranging from a reduction of internal P load of 60 kg, or 8%, of the total sediment phosphorus load to 39% of the total sediment phosphorus load. This reduced sediment P load should result in reductions in the water column phosphorus and algal biomass and should also reduce chl-*a* and raw water treatment costs as well.

In 2013, with the assistance of the Oklahoma Wetland Work Group, the OCC finalized the State’s Wetland Program Plan (WPP). The purpose of the WPP is to guide and focus wetland related activities within the state. In order to meet this objective, two action items were identified:

- Integrate federal, state, and non-governmental organization (NGO) wetland

restoration, enhancement, creation, and protection (RECP) programs, promote wetland RECP, and develop informational tools for land-users.
- Integrate wetland RECP with watershed based approaches (OCC 2013).

To achieve these goals, the OCC has undertaken a pilot project that will result in development of an assessment methodology to identify, catalogue, and rank wetland resources based on the potential to alleviate NPS impacts to receiving waters. Currently, the assessment tool has been completed and applied in three priority watersheds, and field-validation of the results of the assessment tool is ongoing. This effort will provide targeting for protection and restoration of wetland resources and an avenue through the NPS program or other voluntary program to implement those efforts to protect/restore wetlands and water quality. The OCC is committed to applying this assessment protocol through all watersheds in Oklahoma, as funding becomes available, to incorporate this process into each WBP. Wetland development and restoration to mitigate the impacts of nutrients and sediment in the New Spiro Lake Watershed will be evaluated as funding becomes available.

The effects of BMPs may be modeled using a program such as StepL to predict load reductions. These estimates will be included in the WBP once further information is collected.

PUBLIC OUTREACH *(element e)*

At the request of the Oklahoma Rural Water Association, the Mayor (and water system manager) of Spiro formed a Watershed Advisory Committee to make recommendations and support the Town of Spiro in efforts to protect and restore water quality within New Spiro Lake. Committee participants include six residents, business owners, industry professionals, and educators from the local area of Spiro and professionals from the following agencies: Oklahoma Rural Water Association, Oklahoma Water Resources Board (OWRB), LeFlore County Conservation District, Poteau Valley Improvement Authority (PVIA), Oklahoma Department of Wildlife Conservation (ODWC), and the Oklahoma Conservation Commission (OCC). Landowner education and support will be essential to successful implementation of BMPs in the watershed.

Workshops with County Commissioners and others have been provided by the Choctaw Nation, to better educate on sedimentation and erosion concerns from unpaved roads directly affecting surface waters. The goal is to pave, gravel, and grade the roads in a manner which prevents large amounts of sediment from entering the lake.

Supplemental water monitoring is being done through a Blue Thumb Volunteer Monitoring group, which has been trained and established through Source Water Protection Planning efforts. Volunteers include students and teachers from Spiro Schools.

Oklahoma Rural Water Association is working to get watershed education more embedded within the curriculum in the local schools. The Association will meet with school teachers to provide curriculum materials and training within the classroom as needed. Project Wet and

Future Farmers of America (FFA) source water lessons will be introduced to teachers and students as well.

TECHNICAL and FINANCIAL ASSISTANCE NEEDED *(element d)*

Implementation of BMPs necessary to improve water quality in the lake and watershed may be funded through several different programs. NRCS funding is available through the local conservation district, and state funding is also available to landowners through the locally-led cost-share program, administered through the conservation district and the OCC. One hundred and fifty thousand dollars per year in additional NRCS funding will be available from 2015 through 2020 through the National Water Quality Initiative (NWQI). These funds will be used as cost-share for BMP implementation, so the landowners will be providing a portion of all implementation monies. OCC Section 319 funds may be used to help further incentivize BMPs during this time. Once further monitoring has been accomplished in the watershed, more detailed BMP planning can occur which will provide a better idea of assistance needed.

The estimated cost to implement water quality monitoring as described in the monitoring section of this WBP is approximately $35,000 per year. The Choctaw Nation has provided this amount for the first year of monitoring, and the OCC has committed the same amount for the second year of monitoring. The OCC is providing technical guidance and equipment for stream monitoring, as well as training and support for the Blue Thumb educational program in the watershed.

IMPLEMENTATION SCHEDULE and INTERIM MILESTONES *(elements f and g)*

From the summer of 2009 to spring of 2011, the OWRB investigated in-lake BMPs at Lake New Spiro. This study provided the City of Spiro with recommendations to implement the most cost-effective in-lake BMP options, mitigating excessive algae growth currently witnessed within these lakes achieved by reduction of phosphorus cycling. For Lake New Spiro, a modified management scheme was recommended to reduce the effects of sediment phosphorus release by releasing hypolimnetic waters during flood pool conditions utilizing the emergency draw-down pipe that currently exists in the dam structure. Reducing sediment phosphorus load through the recommended in-lake BMPs should provide immediate relief to the high levels of algae growth observed and is predicted to make reductions in total organic carbon levels, thereby reducing drinking water treatment costs and disinfectant by-product formation.

Minimal watershed BMPs have been installed to date. More intensive BMP implementation will be accomplished through the NRCS NWQI from 2015 through 2020. The OCC may provide additional cost-share incentives if critical BMPs are not being embraced. Details will be added to the WBP if that occurs. The primary role of the OCC currently is to provide technical assistance for the monitoring that is occurring in the watershed, to advise the local group as asked, and to aid in educational activities.

Table 6. Schedule for activities in New Spiro Lake watershed.

Year Started	Project Actions	Agency Responsible	Status	Interim Actions?
2009	QAPP written	OWRB	Complete	Complete
	City of Spiro communication			
2010	Collect and analyze environmental and bathymetric data			
	Create preliminary watershed models			
	Collect additional water quality data and sediment samples			
2011	Analysis of in-lake BMP options			
	Cost analysis of water quality/drinking water treatment			
	Report on findings			
2013	Initiate monthly lake sampling	Bio X Design and partners	Ongoing	
	Initiate storm event stream sampling		Ongoing	
	Initiate volunteer stream monitoring	OCC	Ongoing	Hold quarterly QA sessions and assist as needed
2014	Develop WBP		Ongoing	Update as details change, at least biannually
2014	Blue Thumb training and education in community		Ongoing	Follow up with attendees to maximize impact
2015	TMDL for New Spiro Lake	ODEQ	Due 2015	
2015	Analyze water quality data	Bio X Design	Ongoing	Annually share results with partners
2015	Implement BMPs in watershed	NRCS	Ongoing through 2020	Explore option of partnering with OCC to increase incentives if low interest/participation

MONITORING PLAN *(element i)*

Baseline data

Data used in the BATHTUB and SWAT models was limited to that collected on a quarterly basis on a 5-year rotation by the Beneficial Use Monitoring Program (BUMP). In

January 2010, a bathymetric survey was done at the lake, and an Ekman dredge sediment sample was collected to estimate the phosphorus release rate, for input into the BATHTUB model.

Tables 7 and 8 show the summary of water quality data used in the OWRB 2011 modeling effort. Lake New Spiro was subdivided into two segments, segment 1 being the mixing zone and segment 2 the lacustrine zone.

Table 7: Water quality of segment 1. Mean depth was 1.19 meters, surface area of 0.21 km^2.

Parameter	Mean	Coefficient of Variation
Non-algal Turbidity (1/m)	2.35	0.48
Total P (µg/L)	118.2	0.14
Total N (µg/L)	1296	0.15
Chlorophyll-a (µg/L)	37.4	0.23
Secchi Depth (m)	0.40	0.16
Organic Nitrogen (µg/L)	1103	0.08
Total P- Ortho P (µg/L)	90.12	0.174

Table 8: Water quality of segment 2. Mean depth was 2.85 meters, surface area of 0.78 km^2.

Parameter	Mean	Coefficient of Variation
Non-algal Turbidity (1/m)	1.76	0.42
Total P (µg/L)	110.3	0.36
Total N (µg/L)	1202	0.12
Chlorophyll-a (µg/L)	36.7	0.32
Secchi Depth (m)	0.51	0.12
Organic Nitrogen (µg/L)	1116	0.10
Total P- Ortho P (µg/L)	82.79	0.11

Table 9, below, gives summary data from OWRB BUMP sampling which occurred at three locations in the lake. Each site was visited four times from October 2005-July 2006 (OWRB 2012).

Table 9. Average water quality data from BUMP sampling in Lake New Spiro.

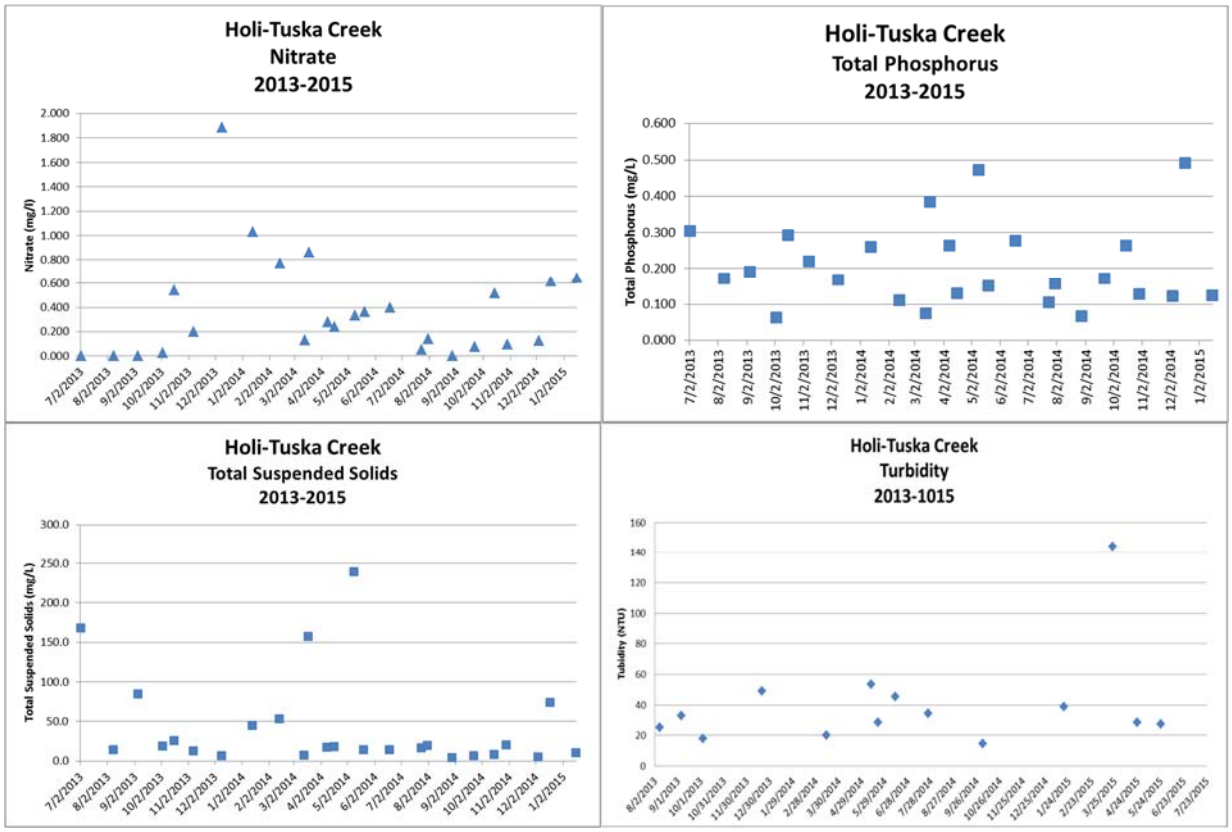
Parameter	Result
Average Turbidity	18 NTU
Average True Color	26 units
Average Secchi Disk Depth	47 cm
Water Clarity Rating	good
Trophic State Index	68
Trophic Class	hypereutrophic
Salinity	0.04 – 0.09 ppt
Specific Conductivity	106.8 – 155.4 µS/cm
pH	7.09 – 9.24 pH units

Oxidation-Reduction Potential	121 – 483 mV
Dissolved Oxygen	Up to 33% of water column < 2 mg/L in August
Surface Total Nitrogen	0.98 – 1.68 mg/L
Surface Total Phosphorus	0.076 –0.170 mg/L
Nitrogen to Phosphorus Ratio	11:01

Watershed data

In July of 2013, data collection was initiated for Holi-Tuska Creek, the source for Lake New Spiro, through a collaborative effort with the Choctaw Nation and the OCC. The goal is to monitor the streams leading into New Spiro Lake as well as collect more current samples within the lake. The first eighteen months of this monitoring effort has been funded by the Choctaw Nation. Water sampling equipment is being loaned for use by the OCC, and Bio x Design is conducting the sampling.

An ISCO automated water sampler has been installed on Holi-Tuska Creek above the inflow to the lake. The sampler will be used to collect water during at least one rainfall event per month. **Samples will be analyzed for nutrients (total nitrogen, nitrate-nitrite, ammonia, total phosphorus, and soluble reactive phosphorus) and total suspended solids**. An additional grab sample will be analyzed monthly for these parameters, as well as for turbidity, resulting in a total of two sampling episodes a month. *E. coli* levels will also be analyzed from a grab sample during the summer recreation season (May through September). This data will provide information to characterize loads of nutrients, bacteria, and sediments entering the lake. Data from July 2013 through January 2015 is shown below:



The BATHTUB model (OWRB 2011) produced the following values for Holi-Tuska Creek, which were used as inflow values for the lake model, and actual data will be compared against these once it has been collected:

Parameter	Mean	Coefficient of Variation
Flow (hm^3/yr)	12.2	0.54
Total P (mg/L)	0.240	0.28
Ortho P (mg/L)	0.108	0.53
Total N (mg/L)	2.698	0.52
Inorganic N (mg/L)	1.965	0.75

In addition to the automated sampler data, the OCC Blue Thumb program, the statewide nonpoint source education program, will work with Spiro teachers and students to develop a volunteer-based monitoring program for Holi-Tuska Creek and / or its tributaries that will complement the monitoring described above. Once established, the Blue Thumb monitoring program will assess these water chemistry parameters monthly: water clarity (Secchi depth), temperature, dissolved oxygen, pH, orthophosphorus, nitrate, nitrite, ammonia, and chloride. In addition, *E. coli* bacteria counts will be processed once a month during the summer months, May through September. Winter and summer macroinvertebrate collections will be made, as well as a summer fish collection and extensive habitat assessment every other year. Living organisms are good indicators of the water quality of the streams in which they live and can provide insights into water quality and ecological integrity of a stream, as well as baseline data against which to measure future improvements.

Lake data

Lake monitoring will be conducted monthly by Bio x Design as described in a monitoring proposal submitted to the watershed group (Bio x Design 2012). Lake monitoring will follow the same basic protocols and sample for the same suite of parameters as OWRB does through their BUMP program, but the sampling will be conducted at a single site in the middle of the lake.

Sampling parameters:

- **Secchi depth** will be measured.
- **Turbidity** will measured approximately 6” below the surface.
- Vertical water quality profiles will be recorded at one-half meter intervals from the lake surface to the lake bottom. Profile data will be recorded for:
    - **temperature**
    - **dissolved oxygen (concentration & % saturation)**
    - **depth**
    - **pH**
    - **oxidation-reduction potential (redox)**

  - **conductivity**
- Based on these measurements, concentrations will be calculated for:
  - **salinity**
  - **specific conductivity**
  - **total dissolved solids (TDS)**

Surface water quality samples will be collected at the lake station by grab sampling. An additional set of water quality samples will be collected one-half meter from the lake bottom. Each water chemistry sample will be analyzed for:

- **nitrate nitrogen**
- **ammonia nitrogen**
- **total nitrogen**
- **total phosphorus**
- **ortho-phosphorus (SRP)**
- **total alkalinity**
- **chloride**
- **sulfate**
- **total suspended solids (TSS)**
- **chlorophyll-a**
- **total organic carbon (TOC)**

Lake profile analyses will be conducted using a YSI 6820-V2 Multiparameter Water Quality Sonde, used in conjunction with a YSI 650 Multiparameter Display System data logger, or similar. A Hach 2100N Portable Turbidity Meter, or similar, will be used for turbidity measurements. Grab samples will be taken from approximately 6" below the surface into pre-labeled 1 liter sample bottles. A Van Dorn sampler will be used to collect the near-bottom sample.

In addition, a lake level gauge will be installed at the Town of Spiro water intake on the lake. Town of Spiro Water Plant staff will read the gauge once daily and record the lake elevation. An ongoing record of lake elevation data will assist lake modeling and lake data analysis by providing more accurate hydrological data than currently exists. A survey will be conducted to accurately associate the lake gauge readings to the lake outlet elevation and the local topographic baseline. Surveyors will also survey the elevation and dimensions of the lake outlet to facilitate more accurate assessment of lake hydrology.

Sample Analysis and Reporting

Water samples collected for the New Spiro Lake and watershed monitoring program will be stored on ice and delivered to the Arkansas Water Resources Center Water Quality Laboratory (AWRCWQL) at the University of Arkansas in Fayetteville, Arkansas for analysis within 6 hours of collection (http://www.uark.edu/depts/awrc/waterqualitylab.htm). AWRCWQL is certified by the Arkansas Department of Environmental Quality and the US EPA. Data will be analyzed in accord with State standards, and assessment results will be included in the Integrated Report every two years.

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