

208 TMDL FACTSHEET FOR NUTRIENTS, TURBIDITY, AND DISSOLVED OXYGEN IN THE LAKE THUNDERBIRD WATERSHED

Background: The [Federal Clean Water Act](#) requires states to develop [Water Quality Standards](#) (WQS) which provide goals and pollution control targets for improving water quality where minimum standards are not met. The waterbodies where these minimum standards are not met are considered to be “[impaired](#).” Impaired waterbodies are listed on what is known as the [303\(d\) list](#), which refers to section 303(d) of the [Clean Water Act](#). The plan to improve water quality for impaired waterbodies is accomplished by establishing limits known as [Total Maximum Daily Loads \(TMDLs\)](#)¹ for each pollutant exceeding the standards. TMDLs set levels for pollutants that allow waterbodies to achieve their WQS for [beneficial uses](#). Beneficial uses include water for [drinking](#), recreation, aesthetics, irrigation, fishing, and swimming. All waterbodies and their designated uses can be found in [Oklahoma’s Integrated Report](#).

Watershed: [Lake Thunderbird](#) (OK52081000020_00) is a 6,070-acre reservoir impounded by the U.S. Bureau of Reclamation in 1965 for the purposes of flood control, water supply, recreation, and fish & wildlife. It is located in central Oklahoma about 13 miles east of downtown Norman in [Cleveland County](#). Lake Thunderbird is in the upper [Little River watershed](#) (USGS [HUC](#) 11090203).

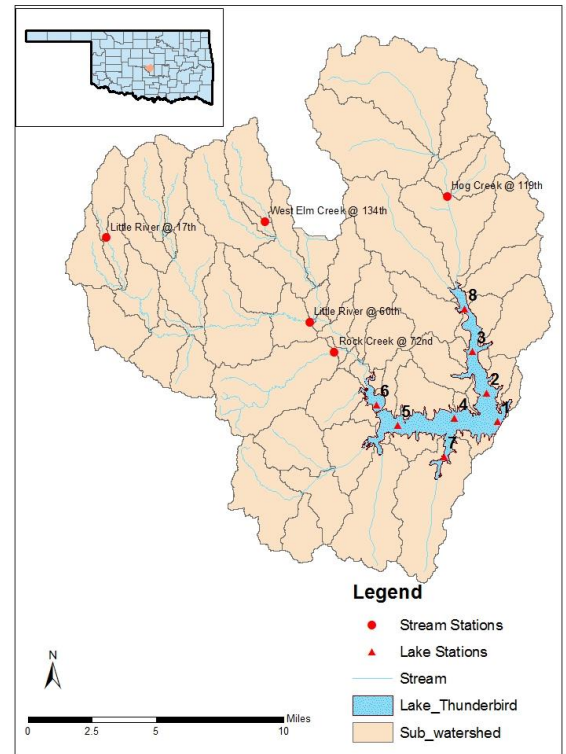
Beneficial Uses and Impairments: According to Oklahoma’s [2010 Integrated Report](#), the impairments [[303\(d\) list in Appendix C](#)] and beneficial uses ([Appendix B](#)) addressed in the Lake Thunderbird study were [turbidity](#) [Fish & Wildlife Propagation-Warm Water Aquatic Community (WWAC) Subcategory], [dissolved oxygen](#) (DO) [Fish & Wildlife Propagation-Warm Water Aquatic Community (WWAC) Subcategory], and [chlorophyll-*a*](#) [Public & Private Water Supply]. According to Oklahoma’s [Water Quality Standards](#) (WQS) [Appendix A.5 of Title 785, Chapter 45 of the Oklahoma Administrative Code], Lake Thunderbird is also considered to be a Sensitive Water Supply (SWS) [785:45-5-25(c)(4)] and nutrient limited watershed (NLW) [785:45-5-29(b)(20)] lake. The SWS designation means that conditions are present that make these public and private water supply lakes more susceptible to pollution. As a result, the WQS require that the water quality of SWS lakes must be maintained and [protected](#) [785:45-3-2(c)]. The NLW designation means that a designated beneficial use is adversely affected by excess [nutrients](#) (785:45-1-2).

The Public and Private Water Supply designated use, as outlined in the Oklahoma WQS, limits the amount of chlorophyll-*a* allowed in SWS lakes to 10.0 µg/L [785:45-5-10(7)]. Since there are no specific WQS for [nitrogen](#) and [phosphorus](#) (also referred to as [nutrients](#)) for Lake Thunderbird, this TMDL provides a numeric limit on



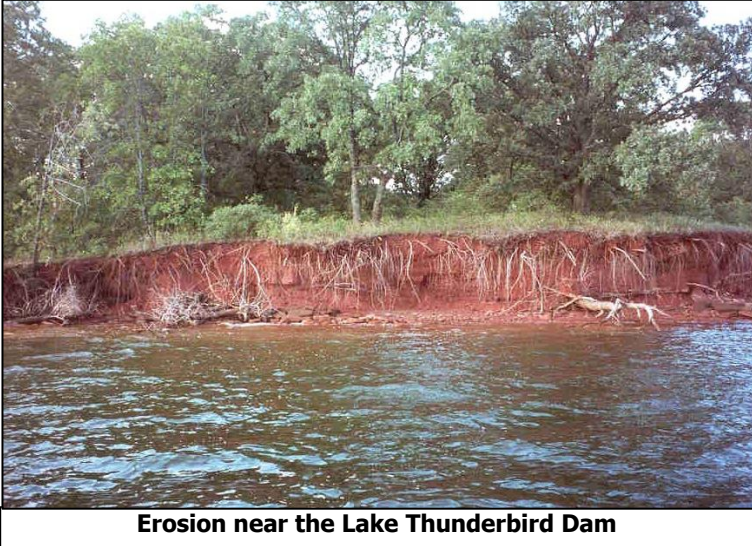
Photo courtesy of [USGS](#)

nutrients needed to reach the chlorophyll-*a* standard. Elevated levels of chlorophyll-*a* mean that too much [algae](#) is growing in the lake. Too much algae ([eutrophication](#)) means there is a high concentration of nutrients, especially nitrogen and phosphorus, in the lake. [Eutrophication](#) can cause surface scum, poor water clarity, and noxious odors. It can affect the taste of drinking water as well as increase the costs of [treating the water](#). Algae in drinking water can also interact with disinfectants ([chloramines](#)) to produce unwanted byproducts ([trihalomethanes](#)), some of which can be carcinogenic.



1 Disregard that this link is under “Emerging Issues” under “Dredged Material Management” under “Ocean Dumping”. The explanation of TMDLs on this EPA webpage is much better than anything found at EPA’s TMDL webpage.

The WWAC subcategory evaluates whether the water quality and habitat are adequate to support a [climax](#) (fully-developed) fish community. One of the impairments in Lake Thunderbird that threatens WWAC is low dissolved oxygen. As algae die, decomposition of the organisms use up the oxygen in the water ([hypoxia](#)). Low levels of oxygen in the water can result in the death of aquatic organisms, such as fish and zooplankton, since they need dissolved oxygen to live. To prevent hypoxia and meet the beneficial use for the Fish and Wildlife subcategory of WWAC with respect to DO, Lake Thunderbird must meet the criterion described in the WQS [785:45-5-12(f)(1)(D)(v)].



The other impairment in Lake Thunderbird that affects the WWAC beneficial use (and is a threat to the fish community) is [turbidity](#). Turbidity is mostly caused by soil erosion and sediment runoff. It is a measure of the cloudiness of water from suspended particles such as [sediment](#), clay, silt, plankton, or microscopic organisms. Other factors such as true color, dissolved solids etc. may also affect turbidity. The suspended particles are generally referred to as [Total Suspended Solids \(TSS\)](#). Because turbidity cannot be expressed as a mass load, TSS is used as a surrogate for turbidity in this TMDL. Higher turbidity/TSS increases water temperatures because these suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because

warm water holds less DO than cold water. Turbidity also reduces sunlight penetration to aquatic plants. Aquatic plants produce DO through [photosynthesis](#). If aquatic plants don't get enough sunlight, then photosynthesis won't occur which reduces the level of DO in the lake.

Turbidity/TSS can affect fish by clogging the gills they need to breathe, rotting their fins, and reducing their resistance to diseases. Turbidity/TSS can also impact aquatic biota by reducing habitat through the blanketing of fish spawning and feeding areas and eliminating sensitive food organisms. Turbidity/TSS may add to the mechanical wear of water supply pumps and distribution systems, thus increasing water treatment costs. In addition, turbidity/TSS can cause lakes to fill in faster and provide a mechanism for the transport of other pollutants (metals, bacteria, pesticides, and/or other toxic compounds). To prevent some of these problems and assist the waterbody in meeting the beneficial use for the Fish and Wildlife subcategory of WWAC in respect to turbidity, the WQS says that turbidity from other than natural sources shall not exceed 25 NTUs (nephelometric turbidity units). [785:45-5-12(f)(7)].

[TMDLs](#)

A TMDL is a plan of action to reduce pollutant loads so that impaired waterbodies will be able to meet their beneficial uses. TMDLs calculate the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will be able to meet water quality standards for that particular pollutant. The TMDL report uses scientific data collection, analysis, and [water quality modeling](#) to determine the sources and amounts of the pollutants entering the lake and allocates pollutant loads to those sources at levels that would ultimately restore water quality to meet clean water standards. The TMDL allocates loads to point sources (these are known as waste load allocation or WLA) and [nonpoint sources](#) (load allocation or LA). The [National Pollutant Discharge Elimination System \(NPDES\) program](#) regulates point source discharges. A point source is described as a "discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters." These are usually, but not always, discharges from a pipe. Nonpoint sources (NPS) are ones, like agricultural runoff, that cannot be identified as entering a waterbody at a single location.

In a TMDL, all contributing sources of the pollutants (point and nonpoint sources) are identified, and they are allocated a portion of the allowable load that usually requires a reduction in their pollution discharge in order to help the waterbody no longer be impaired. Natural background sources, seasonal variations, and a margin of safety (usually at least 10%) are all taken into account in the allocations. The TMDL equation is as follows:

TMDL = WLA (waste load allocations from point sources) + **LA** (from nonpoint sources) + **MOS** (Margin of safety)

Point Source Discharges in the Lake Thunderbird Watershed

Point source discharges are single, identifiable, and localized, like discharges from a pipe. TMDLs must provide WLAs for all NPDES regulated point sources.

- **NPDES regulated [municipal](#) and [industrial](#) wastewater treatment facilities:** There are no municipal or industrial wastewater facilities discharging into the Lake Thunderbird watershed.
- **No-Discharge Facilities:** For the purposes of these TMDLs, it is assumed that no-discharge facilities (such as towns with [total retention lagoons](#)) do not contribute sediment, organic matter, or nutrients into watershed streams and Lake Thunderbird. However, it is possible that the wastewater collection systems associated with these no-discharge facilities could be a pollutant source or that discharges from the wastewater plant may occur during large rainfall events that exceed the systems' storage capacities. In the Lake Thunderbird watershed, there are currently 14 no-discharge (aka total retention) facilities. A list of these facilities is in Table 3-1 of the [Lake Thunderbird Nutrients, Turbidity, and DO TMDL Report](#).
- **NPDES regulated [Concentrated Animal Feeding Operations \(CAFOs\)](#):** A CAFO is an animal feeding operation that confines and feeds 1,000 or more animal units for 45 days or more in a 12-month period. The [CAFO Act](#) is designed to protect water quality by using [Best Management Practices](#) (BMPs) (such as dikes, berms, terraces, ditches or other similar structures) to prevent [animal waste](#) from reaching the water. CAFOs are considered "no discharge" facilities. However, there are no CAFOs in the Lake Thunderbird Watershed.
- **NPDES regulated stormwater discharges:** DEQ regulates stormwater discharges from [Municipal Separate Storm Sewer Systems \(MS4s\)](#), industrial sites, and construction sites. But DEQ's stormwater program does not include the discharges from Indian Country lands, discharges related to oil & gas extraction, or discharges associated with agricultural purposes. For details about DEQ's Stormwater Program, go to <http://www.deq.state.ok.us/WQDnew/stormwater/>.
 - **MS4s (OKR04):** Polluted stormwater runoff is commonly transported through MS4s from which it is often discharged untreated into local creeks or rivers. To prevent harmful pollutants from being washed or dumped into an MS4, operators must obtain a NPDES permit and develop a [stormwater management program](#). Under Oklahoma's Stormwater Program, there are two MS4 Phase I cities ([Oklahoma City](#) and [Tulsa](#)) which EPA defines as cities or certain counties with populations of 100,000 or more. There are also currently 48 MS4 Phase II small municipalities in Oklahoma. These are defined by EPA as small communities in [urbanized areas](#), as well as small MS4s outside the urbanized areas that are designated by the permitting authority. Their stormwater discharges are permitted under [OKR04](#).

In the Lake Thunderbird Watershed, a major source of pollutants is stormwater [runoff](#) from Moore, Norman, and Oklahoma City. Because there are no numeric load limits for MS4 permits, Moore, Norman, and Oklahoma City will each receive a separate WLA. This WLA is based on the proportional contribution of pollutant loading from each of these three cities relative to the total watershed load determined with the watershed model developed for this TMDL study. The MS4 permits for these three cities will have additional requirements as a result of this TMDL. (See Appendix E of the report) Midwest City and Noble have a very small contribution to the total watershed area so they were not

included as part of the WLA determined for the MS4 permits for the three larger cities in the watershed. These two smaller MS4 areas will, however, be accounted for by the Load Allocation (LA) for the portion of the watershed that is not included in the three MS4 urban areas.

- **Industrial Sites (OKR05):** Stormwater run-off from [industrial sites](#) is regulated because stormwater from industrial facilities may come into contact with many different types of pollutants including process wastewater, equipment wash run-off, leaks from storage tanks, oil & gas from vehicles, pesticides & [fertilizers](#), and sediment. DEQ's [Multi-Sector General Permit \(MSGP\)](#) authorizes the discharge of stormwater from industrial facilities. The determination of whether or not an industrial facility must obtain stormwater discharge permit coverage is based both on the facility's Standard Industrial Classification (SIC) code and whether or not the facility has the potential to contaminate stormwater. To find out if an industry is covered, refer to Table 1-2 beginning on Page 3 of the MSGP. To get an industrial stormwater permit, file a [Notice of Intent \(NOI\)](#) with DEQ and pay the applicable application fee and annual permit fee. Also, a [stormwater pollution prevention plan \(SWP3\)](#) **must** be developed and implemented according to the requirements of this permit. There are 14 industrial facilities in the Lake Thunderbird Watershed with a MSGP. These facilities are listed in Table 3-5 of the Lake Thunderbird TMDL report. Industrial stormwater discharges from facilities with certain SIC codes will have additional permit requirements as a result of this TMDL. (See Appendix E of the report)

- **Construction Sites (OKR10):** A [Construction General Permit](#) is required for any stormwater discharges associated with [construction activities](#) that result in land disturbance of equal to or greater than one (1) acre, or less than one (1) acre if they are part of a larger common plan of development or sale that totals at least one (1) acre. The permit also authorizes any stormwater discharges from support activities (e.g. concrete or asphalt batch plants, equipment staging yards, material storage areas, excavated material disposal areas, and borrow areas) that are directly related to a construction site that is required to have permit coverage, and is not a commercial operation serving unrelated different sites.



Photo courtesy of the City of Oklahoma City Stormwater Program

An authorization to discharge from DEQ is required prior to beginning any construction activities with stormwater discharges. In order to receive this authorization, a [Notice of Intent \(NOI\)](#) must be filed with DEQ and the applicable application fee and annual permit fee must be paid. Also, a [stormwater pollution prevention plan \(SWP3\)](#) **must** be developed and implemented according to the requirements of the OKR10 permit. From 2007 – 2012, 243 OKR10 construction permits were issued for projects in the Lake Thunderbird Watershed. Stormwater discharges from construction sites will have additional permit requirements as a result of this TMDL. (See Appendix E of the report)

- **Sanitary sewer overflows (SSO):** The sanitary sewer system is the network of underground pipes that carry wastewater from sinks, toilets, showers, bathtubs, and interior floor drains to the wastewater treatment plant where it is cleaned and treated before being discharged into local waterbodies. [Sanitary sewer overflows](#) from wastewater collection systems can be a major source of harmful bacteria and other pollutants into streams. Most overflows are caused by blockage of sewer pipes by grease, tree roots, trash, and other debris that clog sewer lines; by sewer line breaks and leaks; by cross connections with storm sewers; excessive rain; and by inflow and infiltration of groundwater into sanitary sewers. SSOs are a common result of



Photo courtesy of the City of Raleigh, NC

the aging wastewater infrastructure around Oklahoma. Oklahoma has been ahead of other states and, in some cases EPA itself, in its handling of SSOs. Due to the widespread nature of the SSO problem, DEQ has focused its limited resources to first target SSOs that result in definitive environmental harm (such as fish kills) or lead to citizen complaints. All SSOs falling into these two categories are addressed through DEQ's formal enforcement process. While not all sewer overflows are reported, DEQ has some data. For example in the Lake Thunderbird Watershed between 2000 and 2012, there were 126 SSO occurrences greater than 1000 gallons. A summary of these can be found in Table 3-2 with details in Appendix F of the TMDL report.

- **Section 404 Permits:** Because discharge of dredged or fill material in waters can be a significant source of turbidity/TSS, [Section 404 of the Clean Water Act \(CWA\)](#) requires a permit from the [U.S. Army Corps of Engineers \(USACE\)](#) before discharging those materials into waters of the United States, including [wetlands](#). [BMPs](#) should be used in projects affecting rivers, streams, and tributaries. Activities regulated under this program include - but are not limited to - fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. However, certain farming and forestry activities are exempt. Both USACE and EPA can take enforcement actions for violations of Section 404. Under Section 401 of the CWA, [DEQ](#) reviews and certifies that Oklahoma Water Quality Standards are protected. Additional certification conditions will be required for 404 Permits as a result of this TMDL (see Section 5.6.3 of the Thunderbird TMDL Report).

Nonpoint Sources

Nonpoint sources include those sources that cannot be identified as entering the waterbody at a specific location. Non-point sources of pollutants are typically separated into [urban](#) and [rural](#) categories. Surface storm runoff is an important source of loading in urban or residential settings with [high amounts of paved, impervious areas](#). Many nutrients and sediment from nonpoint sources get into waterbodies through [stormwater runoff](#).²

Nonpoint sources of [sediment](#) and [nutrients](#) may include:

- [Soil erosion](#)
- Agriculture (e.g., fertilized soils, [manure](#) application)
- [Urban runoff](#) (e.g., [lawns](#), [roads & highways](#))
- [Grazing livestock](#)
- [Failing Septic Systems](#) (source of nutrients)
- [Domestic pets](#)



Green driveways and rain gardens are attractive ways of reducing stormwater runoff.

2 For information on how to reduce runoff after rainstorms, request the free DVD, "Reduce Runoff: Slow it Down, Spread it Out, Soak it in!" (EPA Publication #84211001) from the National Service Center for Environmental Publications at their webpage (<http://www.epa.gov/nscep/>) or call them at 800-490-9198. The DVD includes the video, "After the Storm" which was co-produced by EPA and The Weather Channel. The "After the Storm" brochure (PDF) can be downloaded at <http://water.epa.gov/action/weatherchannel/index.cfm>.

Sample Results and TMDL Calculations

The purpose of a TMDL is to estimate allowable pollutant loads and to allocate these loads to the known pollutant sources in the watershed. Streamflow, runoff, and pollutant loading of nutrients, organic matter, and sediments from the Little River drainage basin into Lake Thunderbird was simulated for a one year period from April 2008 to April 2009 using [HSPF](#) (Hydrological Simulation Program – Fortran) which is a watershed loading model.

A model framework was developed to establish the cause-effect linkage between pollutant loading from the watershed (the HSPF model) and water quality conditions in the lake. The water quality linkage analysis was performed using the [EFDC](#) (Environmental Fluid Dynamics Code) reservoir water quality model. The EFDC model was developed to simulate water quality conditions in Lake Thunderbird for sediments, nutrients, organic matter, dissolved oxygen and chlorophyll-*a*. The EFDC lake model was developed with water quality data collected at eight locations in the Lake during the one year period from April 2008 through April 2009. Model results were calibrated to observations for water level, water temperature, TSS, nitrogen, phosphorus, dissolved oxygen, organic carbon and algae biomass (chlorophyll-*a*).

The calibrated lake model was used to evaluate the water quality response to reductions in watershed loading of sediment and nutrients. The linked watershed (HSPF) and lake (EFDC) model framework was used to calculate average annual loads that, if achieved, should meet water quality standards within a reasonable time. The calibrated model results supported the development of TMDLs for TSS, CBOD (carbonaceous biochemical oxygen demand), TN (total nitrogen) and TP (total phosphorus) to achieve compliance with water quality standards for turbidity, chlorophyll-*a*, and dissolved oxygen.

Recommendations

The TMDL values derived from the linked watershed and lake model framework are shown in the following table. These maximum daily loads include a margin of safety (MOS). The TMDL reflects a 35% reduction in the load of TN, TP and TSS from that existing during the 2008 – 2009 period. The CBOD load is equal to that during 2008 – 2009.

| Water Quality Constituent | TMDL | LA (for nonpoint sources) | Total | WLA (for point sources) | | |
|-------------------------------------|------------------------|------------------------------|-----------------|----------------------------|------------------------|------------------------|
| | | | | Moore | Norman | OKC |
| Total Nitrogen (TN) | 807.7 kg/day | 21.3 kg/day | 786.4 kg/day | 205.1 kg/day | 319.4 kg/day | 261.8 kg/day |
| Total Phosphorus (TP) | 158.4 kg/day | 4.4 kg/day | 154.0 kg/day | 44.5 kg/day | 60.1 kg/day | 49.4 kg/day |
| CBOD | 2,480.8 kg/day | 57.4 kg/day | 2,423.4 kg/day | 781.3 kg/day | 955.6 kg/day | 686.5 kg/day |
| Total suspended solids (TSS) | 76,950.8 kg/day | 2,068.7 kg/day | 74,882.1 kg/day | 16,236.0 kg/day | 31,596.1 kg/day | 27,049.9 kg/day |

EPA Approval Date: 11/13/2013

Record Last Updated: 11/20/2013