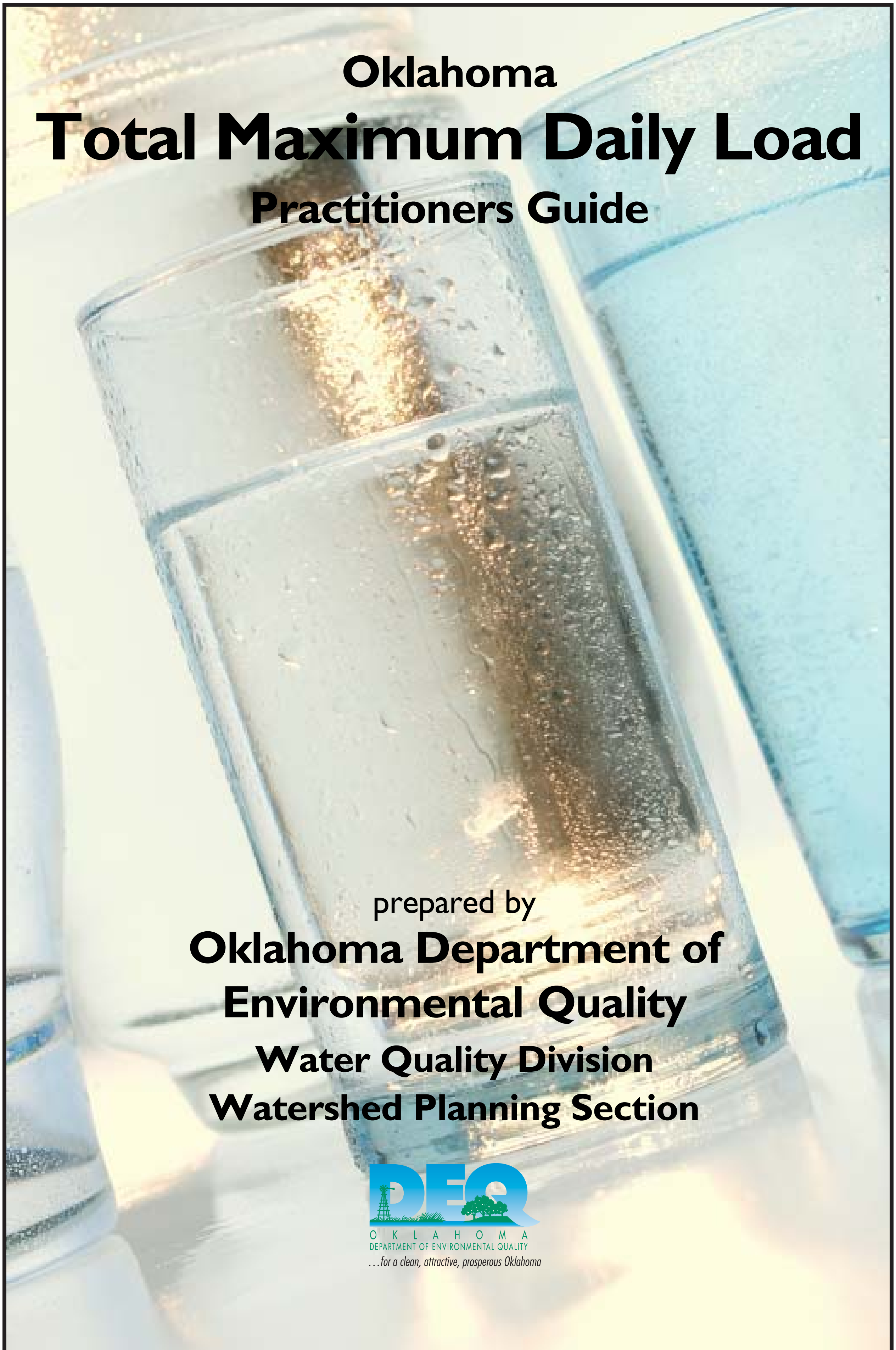

Oklahoma

Total Maximum Daily Load

Practitioners Guide

prepared by

Oklahoma Department of Environmental Quality

Water Quality Division

Watershed Planning Section

OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY
...for a clean, attractive, prosperous Oklahoma

I. Who Should Read This Document?

The Oklahoma TMDL Guide is aimed at professionals in the environmental protection industry. Private consultants and contractors, universities, governmental agencies, stakeholder groups, industries, tribes, and others who want to conduct TMDL projects will benefit from this document.

In addition, this document is valuable to individuals who want to know more about the processes within State government that serve to improve and maintain the quality of Oklahoma's lakes, rivers, and streams. Though not aimed at the general public, the intent of this document is to provide a clear, concise description of the TMDL development, review and approval processes.

A companion pamphlet is available for distribution to a wider audience. The pamphlet provides a brief description of the TMDL process in easy-to-understand language and is suitable for outreach and education efforts to the general public.

II. How Do I Use This Document?

This document lays out the framework for how TMDL projects are planned, developed, reviewed, approved, and implemented. This document is not intended to be a technical manual or a reference document of state and federal regulations. Its primary use is as a roadmap or practical guidebook for those who are interested in developing TMDLs in partnership with the State of Oklahoma.

The standards comprise three components: beneficial uses, criteria, and antidegradation policy.

There are many guidance documents, publications, and rules that impact the development of TMDLs. This guide covers some of the same information as other documents, but should in no way be construed as being an overriding authority.

Though this document attempts to describe the TMDL process thoroughly, each TMDL project is unique. So, naturally, there will be many details throughout the course of a given project that cannot be addressed in this document.

III. When Are TMDLs Necessary?

The TMDL program is targeted at impaired waterbodies. Before we discuss how to conduct a TMDL project, we need to ask an important question: "What constitutes impairment?" There are three documents that help us determine impairment:

- Water Quality Standards
- Use Support Assessment Protocols (USAP)
- Integrated Water Quality Assessment Report

A. Water Quality Standards

The foundation of Oklahoma's water quality protection efforts is standards. Oklahoma's Water Quality Standards (OWQS) are a set of rules (Oklahoma Administrative Code, Title 785, Chapter 45) that provide the baseline against which the quality of waters of the state are measured. The Oklahoma Water Resources Board holds the statutory authority to develop the OWQS. Following is a brief description of the scope of the OWQS.

The standards comprise three components: beneficial uses, criteria, and antidegradation policy.

1. Beneficial Uses

Every waterbody has multiple designated beneficial uses, such as fish & wildlife propagation, drinking water, or recreation. Beneficial uses are assigned by the Oklahoma Water Resources Board. Sometimes a waterbody's beneficial uses are determined statistically, but more often an exercise called a Use Attainability Analysis (UAA) is used to determine the appropriate uses. A UAA begins by obtaining physical, chemical, and biological field measurements. These measurements are compared to a set of conditions that describe a waterbody's ability to support different beneficial uses. If a waterbody currently supports or has the potential to support a particular beneficial use, that use is designated to the waterbody in the OWQS.

Following is the current list of beneficial uses:

- Fish & Wildlife Propagation (four subcategories below)
    - Habitat Limited Aquatic Community
    - Warm Water Aquatic Community
    - Cool Water Aquatic Community
    - Trout Fishery
- Public & Private Water Supply (drinking water) or Emergency Water Supply
- Primary Body Contact Recreation or Secondary Body Contact Recreation
- Fish Consumption
- Agriculture
- Hydroelectric power generation
- Industrial and municipal process and cooling water
- Navigation
- Aesthetics

Once the beneficial uses for a waterbody are determined, we can determine the specific water quality criteria that apply to the waterbody.

2. Water Quality Criteria

Each beneficial use may have one or more water quality criteria associated with it. For example, the Fish & Wildlife Propagation beneficial use has many criteria associated with it. Water quality criteria come in two forms: numerical and narrative.

a) Numerical Criteria

Numerical criteria, as the name indicates, are associated with specific numeric values, usually in the form of concentration of a particular water quality characteristic. Numerical criteria are usually measured in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Example: "For the use of fish & wildlife propagation, the dissolved oxygen concentration in Bee Creek may not drop below 5 mg/L" or "For the use of public drinking water, the concentration of zinc in Buffalo Creek may not exceed 5 mg/L."

Some numerical criteria are dependent on other factors, such as season, temperature, pH, or hardness.

b) Narrative Criteria

Narrative criteria are only defined by a description of the desired condition. Example: "To be aesthetically enjoyable, Honey Creek must be free from floating materials and suspended substances that produce objectionable color and turbidity."

c) Applicability of Criteria

The OWQS document contains descriptions of water quality criteria. They are arranged according to the beneficial use to which they correspond. Only those criteria associated with the beneficial uses assigned to a waterbody apply to that waterbody. For example, if Bee Creek does not carry the Primary Recreation Body Contact (PBCR) beneficial use, then the numerical pathogen criteria associated with PBCR do not apply to Bee Creek.

There are also cases where a single constituent is associated with more than one beneficial use or has more than one criterion. For example, lead has two criteria associated with the Fish & Wildlife Propagation beneficial use: one for long-term exposure and one for short-term exposure. There are also criteria for lead associated with the Public and Private Water Supply and Fish Consumption beneficial uses. Typically, the most stringent of the applicable criteria is what drives a TMDL.

3. Antidegradation Policy

The antidegradation policy of the OWQS describes the conditions under which a waterbody's quality may or may not be decreased. With regard to the TMDL program, the antidegradation policy may have an effect on the water quality target that is chosen as the endpoint of the TMDL exercise. Special designations in the OWQS are used to define how the antidegradation policy is applied. These designations include Outstanding Resource Waters (ORW), High Quality Waters (HQW), and Sensitive Water Supplies (SWS). The OWQS document describes the limitations associated with each special designation.

B. USAP

We still have not answered our initial question, "What constitutes impairment?" One might assume that waterbodies that violate water quality criteria are impaired. But, what about those cases were there are only temporary violations or violations that are only slightly out of compliance with applicable criteria? Instead of using individual criteria violations to determine impairment, a better approach is to look at beneficial uses. The Use Support Assessment Protocols (USAP) are a set of rules (Oklahoma Administrative Code, Title 785, Chapter 45, Subchapter 15) that define how beneficial uses are assessed. These rules apply decision logic to specific water quality constituents in order to determine if each beneficial use for a particular waterbody is fully supported, partially supported or not supported for that constituent. The procedures in USAP take into account the age and amount of available data as well as the magnitude and temporal variation of violations in order to assess the support of beneficial uses. Determining beneficial use support using USAP gets us a long way toward determining impairment, but it's not the whole story. For TMDL purposes, we need to translate the support decisions provided by the USAP into impairment decisions.

C. Integrated Water Quality Assessment Report

The Integrated Water Quality Assessment Report – also known as the Integrated Report – contains a section called the Assessment Methodology that describes the conditions under which a waterbody may be considered impaired. Wherever possible, the Assessment Methodology very closely follows the decision logic described in the USAP. However, the end result of applying the Assessment Methodology is the designation of a waterbody into one of five categories that are described later in this section. Category 5 is the State's 303(d) List of Impaired Waters. Let's take a closer look at the Assessment Methodology.

1. Data Requirements

The Integrated Report establishes spatial, temporal, and quantitative guidelines for making assessments. For example, many types of water quality datasets are required to consist of ten samples, be seasonally representative, and be no older than five years. However, the methodology establishes other limitations depending on the type of data (chemical, biological, etc.) and beneficial use being assessed. In order for an assessment to be valid, the appropriate data requirements must be met.

2. Assessment of Data Types

Much like the USAP, the Assessment Methodology protocols are organized by beneficial use. Within each use, there may be more than one type of data that must be assessed before that particular beneficial use may be completely assessed. For example, the Fish and Wildlife Propagation beneficial use is associated with eight different types of data. Each data type has a set of rules for determining impairment for that data type. Two of these data types are dissolved oxygen and turbidity. The rules for determining whether a waterbody is impaired due to low dissolved oxygen are different from the rules determining impairment caused by turbidity. Each one must be assessed separately. The possible results of applying the Assessment Methodology to a data type are:

To fully assess a waterbody, each one of its designated beneficial uses must be assessed

- Attaining
- Not attaining
- Insufficient information to make an assessment
- Not assessed

In the case of Fish & Wildlife Propagation, an assessment of "not attaining" for any of the eight data types results in an assessment of "not attaining" for the FWP beneficial use. The Assessment Methodology describes the specific attainment conditions for each data type and beneficial use.

1. Assessment of Beneficial Uses

To fully assess a waterbody, each one of its designated beneficial uses must be assessed using the Integrated Report Assessment Methodology. The methodology describes how to assess beneficial uses that have more than one data type. Once each of the beneficial uses has been assessed, an overall category can be assigned.

2. Integrated Report Categories

Using the assessed beneficial uses, an assessed waterbody is placed into one of five categories. A well-defined decision tree for categorizing waterbodies is in the Integrated Water Quality Assessment Report. A brief description of each category is listed below:

- Category 1 – all beneficial uses assessed and attained
- Category 2 – some beneficial uses assessed, no impaired uses
- Category 3 – not enough information to assess beneficial uses
- Category 4 – one or more uses impaired, but no TMDL required
- Category 5 – one or more uses impaired, TMDL required

The Integrated Report contains a more complete description of each of these categories. Category 5 waterbodies make up the State's 303(d) List of Impaired Waters. The waters on the 303(d) list are prioritized and given dates by which TMDLs should be developed to address causes of impairment.

A Total Maximum Daily Load is the total amount of pollutant that a given waterbody can assimilate and still meet state water quality standards.

IV. What is a TMDL?

A. TMDLs: A Working Definition

A Total Maximum Daily Load is the total amount of pollutant that a given waterbody can assimilate and still meet state water quality standards. The term also describes the process of calculating such a load and allocating portions of the load to various sources of pollution in the study area.

It is important to note that the context of the TMDL program includes the review and approval process conducted by the United States Environmental Protection Agency (EPA). The Oklahoma Department of Environmental Quality (DEQ) has the statutory authority to lead the development of TMDLs. However, EPA's stringent review and approval procedures must be met before any TMDL can be implemented. This comprehensive review process only applies to TMDLs conducted for waterbodies that appear on the State's 303(d) list.

The term TMDL contains the words "daily" and "load," which are traditionally interpreted as "pounds per day." However, EPA guidance indicates that TMDLs may be expressed using any units that represent pollutant load. For example, time may expressed as hourly, daily, monthly or even yearly. Mass may be expressed as pounds, tons or some other representation of the amount of pollutant in a given source.

TMDLs are required to account for point sources, such as wastewater discharges; non-point sources, such as polluted runoff from fields, pastures, and construction sites; and natural background sources. TMDLs must also include components that address future growth of these sources, variations in flow and seasons, and a margin of safety. The sum of all non-point source loads, point source loads, background load, and margin of safety for a single pollutant is the TMDL for that pollutant (Fig. 1).

The end result of a TMDL exercise is to identify pollutant sources and to recommend the reductions necessary to meet applicable water quality standards.

Figure 1. TMDL Components

$$TMDL = LA + WLA + MOS$$

A TMDL may be calculated for a single waterbody, multiple waterbodies or even an entire watershed. A TMDL may also be calculated for multiple pollutants. The combination of a single pollutant addressed on a single waterbody constitutes a single TMDL. A single TMDL report may contain several TMDLs. For example, a TMDL report that addresses Lead and Phosphorus for River A and Turbidity for River B contains three individual TMDLs.

The end result of a TMDL exercise is to identify pollutant sources and to recommend the reductions necessary to meet applicable water quality standards. These reductions may be given in absolute terms or may be specified as a percentage of some historical value. Current regulations do not require implementation as part of the TMDL exercise itself. This document does, however, briefly describe the process used by the State of Oklahoma to implement TMDLs.

B. Required Elements

TMDL reports submitted for review in Oklahoma are required to have the following six elements. A typical TMDL report will have each of these elements clearly labeled or separated by tabs in the final document.

1. Problem Definition

This should provide a description of the TMDL study area, including the spatial boundaries. The pollutant(s) being addressed on each waterbody should be included. The waterbodies under study, the applicable water quality standards for each waterbody, existing permit limits for point sources within the study area, and other general descriptive or background information should also be included. The Oklahoma Waterbody Identification System should be used to identify specific waterbodies and watersheds. GIS data should be used to provide a clear visual depiction of the study area.

Oklahoma uses the Albers Equal Area Conic projection with specific parameters for its geospatial data:

Units:	meters	Reference Latitude:	23° 00' 00"
Datum:	NAD83	False Easting:	0
Spheroid:	GRS1980	False Northing:	0
Central Meridian:	-96° 00' 00"		
1st Parallel:	29° 00' 00"		
2nd Parallel:	45° 30' 00"		

2. Endpoint Identification

The endpoint, or water quality target, is a description of the desired condition in the watershed or waterbody. Typically, targets are tied to specific water quality standards that provide measurable goals for the TMDL. After all, if you don't know where you're going, you won't know when you've arrived.

3. Source Analysis

This is a description of the type, magnitude and location of sources of pollutant loading and loading conditions for point sources, nonpoint sources, background contributions, tributaries, and any upstream flows. The simplest of TMDLs may use aggregate, average, literature or historical values for some of these. More complex TMDLs will use reconnaissance surveys, observed water quality data, GIS data and queries into state and federal databases to describe the pollutant sources in the study area as accurately as possible.

The Source Analysis should also estimate future growth in pollutant sources, where applicable. For example, municipal point sources may be characterized by their existing average flows. Future growth in these sources should be characterized by obtaining the twenty-year design flow for each source. Predicted changes in land use, particularly changes that may affect stormwater runoff quantity and quality, should be considered when cataloging non-point sources of pollution in a system.

4. Linkage Between Sources and Receiving Water

This link is provided by monitoring and software-based water quality modeling. Oklahoma DEQ staff use a range of water quality modeling software in addition to statistically based methods, such as load-duration curves. A rationale for selecting a specific water quality model should be provided.

A linkage should provide a determination of the maximum assimilative capacity of the waterbody for a specific pollutant under a range of seasonal conditions. In most cases, this is represented by the pollutant load necessary to stress a system just to the point of meeting the water quality target without exceeding it. For impaired systems, the maximum assimilative capacity will be lower than observed conditions.

One of the key purposes of the linkage is to demonstrate the cause and effect relationship between desired conditions and pollutant load

One of the key purposes of the linkage is to demonstrate the cause and effect relationship between desired conditions and pollutant load in order to make predictive decisions about the system. A thorough description of modeling parameters, procedures, and results should be included in the TMDL report.

5. Margin of Safety

The margin of safety accounts for uncertainty and varying levels of complexity in the TMDL exercise. A calibrated and verified water quality model requires a much smaller margin of safety than a "desktop model." Study areas with a large number of sources or particularly complex sources require a higher margin of safety. The Oklahoma Continuing Planning Process document provides guidance on the margin of safety that should be incorporated into the TMDL.

6. Loading Allocation

Once the linkage (model) has been used to determine the maximum assimilative capacity and the margin of safety has been reserved, the next step is to distribute the remaining load to the various point and nonpoint sources in the system. The maximum assimilative capacity of a system can be represented by a pie. The pieces of the pie represent allocations. The slices of pie that are given to existing and future point sources are called *wasteload allocations.* Existing and future non-point sources are given *load allocations*. There are also allocations for background load and margin of safety.

The manner of distributing allocations can sometimes be complex. Point sources are typically more easily regulated than non-point sources. So, the allocation process for a system that is impacted only by point sources is much more straightforward than that of a system with both point and non-point sources.

Still, a system with multiple stakeholders and multiple types of sources can be difficult to allocate. The methods for making these allocations are not regulated by the Clean Water Act or by Federal regulations. In Oklahoma, implementation of point source allocations is done through permits issued under the Oklahoma Pollution Discharge Elimination System (OPDES) program. EPA delegated permitting authority for the OPDES program to DEQ in 1996. Non-point source pollution, however, is regulated by the Oklahoma Conservation Commission. Non-point sources are regulated through voluntary controls called Best Management Practices (BMPs) and are more difficult to apply with certainty. Where multiple sources exist, fair and equitable methods of allocating loads must be used and should involve as many of the affected stakeholders as possible.

V. TMDL Practitioners

Who can perform TMDLs? Almost anyone, as long as the required elements are met and the methods of conducting the study meet EPA standards.

Although anyone can conduct a TMDL, the DEQ is the "lead" agency for the TMDL program in Oklahoma and conducts the initial review and approval process for TMDLs before sending them to EPA. DEQ is also responsible for producing the Integrated Water Quality Assessment Report, which contains the 303(d) List.

Many other organizations are involved with TMDLs in Oklahoma. Two State agencies are heavily involved, particularly with collecting water quality data: Oklahoma Water Resources Board (OWRB) and Oklahoma Conservation Commission (OCC). OWRB is responsible for developing the State's water quality standards but is also responsible for a large-scale monitoring effort known as the Beneficial Use Monitoring Program (BUMP). OCC conducts its own extensive water quality monitoring program, primarily in support of the non-point source program. The Oklahoma Corporation Commission is also involved in monitoring water quality, particularly near oil and gas fields.

the key to conducting successful TMDL work in Oklahoma is communication.

Two coalitions of local governments are also involved in conducting TMDLs. The Indian Nations Council of Governments (INCOG) operates in northeast Oklahoma while the Association of Central Oklahoma Governments (ACOG) operates primarily in the Oklahoma City metropolitan area. Both coalitions propose and conduct several water quality related projects yearly, including TMDLs.

Oklahoma State University plays a significant role in the area of TMDL modeling by providing technical expertise and contractual work on many projects for various state agencies. To a lesser degree, the University of Oklahoma also provides TMDL services.

Private contractors ranging from large, nation-wide firms to the smallest local firms have also conducted TMDL work in Oklahoma.

In every case, the key to conducting successful TMDL work in Oklahoma is communication. DEQ encourages regular communication and documentation between itself and contractors and between contractors and stakeholders.

VI. Developing TMDL Projects

If you look at the Oklahoma's 303(d) List, it is plain to see that there is a lot of work to be done. So how are projects initiated, developed, and approved?

A. Contracting with DEQ

Aside from other state agencies and universities, DEQ can establish direct contracts with professional engineers registered with any state. Other contracts can be established, but require a lengthy bid process.

Almost all TMDL projects are funded by federal grants. However, federal regulations prohibit these grants from being awarded to private companies or individuals. Federal dollars are appropriated to the EPA which, in turn, makes funding opportunities available to its Regional offices. These opportunities are published in the Federal Register and on the web at <http://www.grants.gov>. Information about funding opportunities in Oklahoma are available from the Office the Secretary of Environment <http://www.ose.state.ok.us>.

In most cases, funding opportunities are closely tied to the goal of addressing TMDLs with priority given to projects that provide reasonable assurances of effective and efficient results.

TMDL practitioners should consult the current 303(d) List to see where their expertise coincides with TMDL work that needs to be done. Practitioners should contact the Watershed Planning Section of DEQ's Water Quality Division directly to discuss potential projects.

B. Developing a TMDL Proposal and Workplan

DEQ generates TMDL project proposals based on a number of factors. Cost, number of TMDLs produced, and the time required to finish the project are important. The TMDL workload in Oklahoma greatly exceeds what can be done by DEQ staff alone. Having a potential contractor who understands the TMDL process is important to getting a proposal and subsequent workplan developed quickly.

TMDL proposals are brief, but must address the goals of the funding opportunity as stated in the letter or public notice announcing the grant opportunity. Proposals should describe the methods for developing the TMDL project in enough detail to provide reasonable assurance that the goals of the project can be completed within the time and financial constraints of the grant. A proposal should include descriptions of:

- the goals of the project
- the geographic scope of the project
- the pollutants to be addressed in the project
- the data required to complete the project
- the methods used to develop the TMDLs
- the cost and milestone estimates

Workplans are based on project proposals, but contain more details. A breakdown of costs including personnel, travel, contractual costs, supplies, and fringe costs should be included. Specific dates for completing each project milestone and/or deliverable should be included.

C. TMDL Quality Assurance Project Plans

Federally funded projects that collect or manipulate data require an EPA-approved Quality Assurance Project Plan (QAPP). Development of a QAPP goes beyond the scope of this document, but we have included a brief description of what a QAPP contains.

QAPPs contain project-specific information that describes all aspects of the project. Required topics range from who will manage the project to what sampling methods will be used to what measures of success will be used for the whole project. Detailed information about what, when, where, and how data will be collected, analyzed, manipulated, assessed and distributed are also part of QAPPs.

A QAPP provides stakeholders and policy makers alike with a single document that supports and documents the legitimacy and defensibility of a project's conclusions and recommendations.

Development of a QAPP is usually included as a deliverable in the project workplan. Depending on the contractor's expertise and working relationship with DEQ, QAPP development may be included as part of a project contract. Regardless of who actually writes the QAPP document, the key to developing an approvable QAPP is frequent, open communication between DEQ and the contractor.

QAPPs contain four key components:

- project management
- data generation and acquisition
- assessment and oversight
- data validation and usability

One key process in developing a QAPP is the Data Quality Objectives Process. The DQO Process is part of the project management component. It is a seven-step planning approach to develop sampling designs for data collection activities that support decision making.

More specific information about QAPP requirements can be found in the document *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) on the web at <http://www.epa.gov/quality/qs-docs/r5-final.pdf>.

The DQO Process is described in the document *Guidance for the Data Quality Objectives Process* (EPA QA/G-4) on the web at <http://www.epa.gov/quality/qs-docs/g4-final.pdf>

D. TMDL Project Management

the Integrated Report includes a comprehensive assessment list.

Each TMDL project has a project manager who is a full-time staff member at DEQ. This person is the primary contact for third-party practitioners and contractors and should be notified of any updates that could affect any project milestones or deliverables. Frequent communication with the project manager helps ensure that the project proceeds smoothly and that the negative impact of changes or problems along the way can be minimized.

EPA requires quarterly or semi-annual progress reports on most grant projects. Therefore, contracts with third-party practitioners also include quarterly or semi-annual progress reports as deliverables. Coordinating with the project manager on a consistent basis helps make progress reports accurate and easy to produce.

VII. When/Where

Although most TMDL projects are initially developed by DEQ, it is helpful to know some of the factors involved in selecting when and where TMDLs need to be done.

A. Integrated Report

In addition to the Assessment Methodology discussed earlier in this document, the Integrated Report includes a comprehensive assessment list. This list shows how each beneficial use was assessed and the year the waterbody is expected to be monitored and, where applicable, the year a TMDL is expected to be developed. Waterbodies having an earlier TMDL date have a higher priority than those with later dates.

The Integrated Report also includes a section that describes additional factors that may affect the priority of a given waterbody such as antidegradation, endangered or threatened species, public health issues, and others.

B. Waterbody Identification System

Identifying the location and extent of impaired waterbodies and their associated watersheds is important to the development of a TMDL. EPA has an existing waterbody system that it uses on a national scale. However, this national system lacks the flexibility required by the State to manage its environmental programs. Therefore, the Oklahoma Waterbody Identification System was developed. This is a system of assigning each assessed waterbody within the state a single, unambiguous identifier called a waterbody identification number (WBID). The Oklahoma WBID System was designed so that waterbodies in the same watershed have similar WBIDs.

A complete description of the Oklahoma WBID System is included in Appendix A of the Integrated Report.

An interactive, GIS-based website is also available to view waterbodies and their water quality assessments. The main DEQ website <http://www.deq.state.ok.us> contains a link to the GIS Data Viewer.

VIII. Modeling

Water quality modeling forms the foundation of the requirement to link water quality targets with sources of impairment. Modeling uses computer algorithms to calculate the response of a system based on changes in inputs to the system. For example, a computer model could be used to predict the dissolved-oxygen deficit in a stream based on the quantity and quality of the discharge from a municipal wastewater treatment plant.

Although models often use sophisticated mathematical equations, water quality modeling is as much "art" as it is science. Before a model can be used to accurately simulate a system, certain assumptions must be made. Even something as simple as the definition of where a system begins and ends can affect the usefulness of the model.

A. Scope

Water quality models are often grouped into two categories. Sometimes the problem to be addressed is limited to one or two reaches of a stream. Models that address these kinds of problems are said to be "near field" models. Other times the problem in question encompasses an entire watershed or even multiple watersheds and requires a "watershed scale" model.

1. Near Field Models

Near field models, such as QUAL2E, take a single stream reach and "cut" it into very small sections called elements. The quality and quantity of the water flowing into the first element is called a boundary condition and is used to begin the modeling process. Boundary conditions inputs may come from observed data or literature values. Within the first element, various processes affect the pollutants. Processes such as interaction with the atmosphere or sediment affect the concentration of pollutants within the first element. Each of these processes take place at different rates. These rates may be calibrated using observed data or use literature values. Mathematical equations are used to calculate the effect of these processes on the final output from the first element. This output is then used as the input for the second element. These calculations continue in chain fashion until the last element is calculated. Water quality models usually include tools to view the calculated results graphically or in a tabular form.

Near field models are often used when the water quality problem includes "nonconservative" pollutants, or pollutants whose chemical makeup degrades over time. A common application of near field modeling is the calculation of organic material that can be discharged from an industrial or municipal wastewater treatment plant that maintains adequate dissolved oxygen levels in the receiving stream.

There are many other water quality models besides QUAL2E, but each one addresses near field problems in a similar fashion. The primary differences between these are ease of use, data requirements, and "bells and whistles" such as reporting tools.

2. Watershed Scale Models

Problems involving conservative substances – such as nutrients, siltation, or metals – often require the use of a model that addresses the long-term impacts on a larger scale. Watershed modeling is commonly used to address problems involving non-point source pollution.

Watershed models typically require a wider variety of data sources than near field models because they cover a broader geographic area and account for more transport mechanisms such as stormwater runoff and atmospheric deposition. Data sources such as accurate land use, daily or even hourly meteorological data, and long-term water quality data are needed to accurately calibrate many watershed models.

Watershed models typically use time-based data, usually daily or hourly. Long periods of contiguous records increase the ability of watershed models to accurately predict responses to future changes in the system. The mathematical algorithms used by watershed models are similar to near field models in the fact that they attempt to calculate the effect of multiple processes on different components of the system.

Watershed models are often used when the impact on a critical downstream resource must be predicted, such as a lake or other a waterbody with a special designation.

3. Other Modeling Approaches

Understanding the data quality objectives of the project is important to selecting the right mode

Other modeling approaches use statistical methods to predict violations of water quality targets. The load-duration curve approach uses existing water quality and quantity data at a single point – typically at the bottom of the watershed under study – to predict the probability of water quality target violations on a long-term basis. Reductions are calculated at the critical point and load allocations are distributed according to land use in the watershed.

This approach, though relatively simple, yields results quickly with little or no supplemental data collection required. A higher margin of safety is used, but this method helps develop large numbers of valid TMDLs in a relatively short period of time. In more complex or more critical watersheds, additional data collection and modeling can be performed to focus on specific problem areas within a watershed.

B. Complexity

When choosing a model, one must first have an idea of how accurate the model must be in order to make defensible decisions. Sometimes having a highly accurate model requires so much resource-intensive work that the accuracy gained is not worth the price. Understanding the data quality objectives of the project is important to selecting the right model and deciding how the model should be applied to the problem.

The use of simple, uncalibrated models requires a much higher margin of safety than calibrated or verified models in order to account for uncertainty in the model and the lack of observed data. The *Oklahoma Continuing Planning Process* <http://www.deq.state.ok.us/WQDnew/pubs/2002_cpp_final.pdf> contains more information about the required margin of safety for different modeling levels.

1. Screening Level Model

Sometimes a problem is simple enough or the decisions to be made are such that spending a lot of time, effort, or money just won't yield better results than a simple approach. Screening level modeling typically involves simple models that require little or no field data. Screening level models never require full calibration and are usually used to rule out various alternatives rather than defend solutions. For example, a screening level model, using reasonable assumptions, could be used to determine that a simple flow-through lagoon is inadequate to treat domestic wastewater and still meet water quality standards in the receiving stream. However, a screening level model would not be used to calculate permit limits for a major industrial discharge that shares a receiving stream with several other permittees.

2. Calibrated Model

A calibrated model requires observed data. Inputs to the model are adjusted so that predicted outputs match the actual observations. This sounds simple enough, but can often prove to be a difficult or, worse, produce misleading results. Each input in a model is an attempt to produce the same results that happen in nature. Complex models have multiple inputs that can be changed. We call this "knob turning." It is possible that multiple combinations of knob turning can result in similar outputs. However, if the values of the inputs are not reasonably accurate, the ability of the model to predict future conditions is undermined. Having a good understanding of the natural system is important in deciding which knobs to turn, how far to turn them, and in which direction.

3. Verified Model

A verified model requires a second set of observed data, preferably from a different season or flow regime. Conditions should be sufficiently different from the data used to calibrate the model so that a better range of accuracy can be established for the model.

Verification usually involves the collection of the same type and quantity of data from the same sampling locations at the same frequency, but during a different time of year or during significantly different flow conditions.

Verified models yield the most accurate results and require a lower margin of safety, but at a much higher cost for data collection, analysis, and modeling.

IX. TMDL implementation

Though not a required element of a TMDL report, implementation deserves to be mentioned because it is the logical next step of a TMDL project. The results of a TMDL are recommendations on the reductions in pollutant load and allocations of these loads among the different sources. In Oklahoma, the recommendations for point sources and non-point sources are applied in different ways.

implementation is the next logical step after development of a TMDL.

Point sources are regulated through the State's OPDES program, as mentioned earlier in this document. But first, the results of the TMDL must be incorporated in the State's Water Quality Management Plan, also called the 208 Plan after the Clean Water Act section that requires it. Among other things, the 208 Plan contains information about all of the regulated point sources in the state. Wasteload allocations for each point source are made part of the 208 Plan and permittees must have a wasteload allocation before a discharge permit is issued.

Non-point source implementation is managed by the Oklahoma Conservation Commission (OCC) through Watershed Base Plans (WBP). Non-point source pollution controls are implemented on a voluntary basis. The primary mechanisms used by OCC are incentive programs for the installation of Best Management Practices and public education and outreach programs.

Other TMDL implementation programs include permits for Concentrated Animal Feeding Operations (CAFOs). The Oklahoma Department of Agriculture, Food & Forestry issues licenses to CAFOs under State rules.

X. Public Participation

Certain public participation activities are required by federal regulations. A public notice of draft TMDL recommendations is required as is a public meeting, preferably located in the project watershed.

However, there is a tremendous resource of knowledge in local stakeholders that should be used *throughout* the TMDL process in order to ensure the success of a TMDL project.

Stakeholders provide resources such as water quality data, access to monitoring sites, and information regarding local land management practices. These resources and many others dramatically improve the quality of TMDL recommendations.

Involving stakeholders in the planning stages of a TMDL project helps avoid costly mistakes later

Involving stakeholders in the planning stages of a TMDL project helps avoid costly mistakes later on. Involving stakeholders during the data collection and draft recommendation phases gives them a sense of ownership of the project which can lead to better reception of final recommendations. Ultimately, having stakeholders involved in the process will result in much better success where it counts: implementing changes that improve water quality for the people most directly affected.

In implementing wasteload allocations for point sources, several public notices are required. Updates to the 208 Plan require a 45-day notice. A notice is required by a permittee that announces when an application for a discharge permit is filed with DEQ. Finally, a public notice and 30-day public comment period is required for draft permits. Other opportunities to hold public meetings and hearings are also available as part of the permitting process. Public participation during implementation of load allocations for non-point sources is conducted as part of the Watershed Base Plan development process. Stakeholder groups are typically involved in the beginning stages of plan development and public meetings are held following completion of the plan.

Appendix A. Contacts

Below are a few useful contacts for practitioners, grouped by organization:

Oklahoma Department of Environmental Quality

TMDL Program Management

Mark Derichsweiler, P.E., Manager
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Water Quality Division
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Water Quality Modeling/Project Management

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Paul Yue, P.E.
Watershed Planning Section
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Integrated Water Quality Assessment Report

David Gann, Environmental Specialist
Water Quality Division
phone: 405.702.8197
email: david.gann@deq.state.ok.us

Grants Management

Ilda Hershey
Water Quality Division
phone: 405.702.8218
email: ilda.hershey@deq.state.ok.us

Office of the Secretary of Environment

Grants Management

Jennifer Wasinger
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email: jlwasinger@owrb.state.ok.us

Oklahoma Conservation Commission

Water Quality Program Management

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email: larrye@okcc.state.ok.us

WBP Development

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Water Quality Division
phone: 405.522.4739
email: shanonp@okcc.state.ok.us

Water Quality Monitoring

Dan Butler, Monitoring Director
Water Quality Division
phone: 405.522.4730
email: danb@okcc.state.ok.us

Oklahoma Water Resources Board

Water Quality Program Management

Derek Smithee, Director
Water Quality Division
phone: 405.530.8800
email: drsmithee@owrb.state.ok.us

Project Management

Bill Cauthron
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email: wlcauthron@owrb.state.ok.us

Water Quality Monitoring

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Water Quality Division
phone: 405.530.8933
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Oklahoma State University

Water Quality Modeling

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Biosystems and Agricultural Engineering Department
phone: 405.744.8422
email: dstorm@okstate.edu

Corporation Commission

Water Quality Monitoring

Patricia Billingsley

Oil & Gas Division

Pollution Abatement Department

phone: 405.522.2758

email: p.billingsley@occmail.occ.state.ok.us

Appendix B. References

Oklahoma Water Quality Standards

OAC Title 785, Chapter 45

http://www.owrb.state.ok.us/util/rules/pdf_rul/Chap45.pdf

Implementation of Oklahoma's Water Quality Standards (includes USAP)

OAC Title 785, Chapter 46

http://www.owrb.state.ok.us/util/rules/pdf_rul/Chap46.pdf

Continuing Planning Process

http://www.deq.state.ok.us/WQDnew/pubs/2002_cpp_final.pdf

Integrated Water Quality Assessment Report

http://www.deq.state.ok.us/WQDnew/305b_303d/index.html

Oklahoma Waterbody Identification System Fact Sheet

http://www.deq.state.ok.us/WQDnew/305b_303d/2002_ir_app_a_okwbid_system.pdf

Appendix C.

Example TMDL - See next page

Draft TMDL

Lytle Creek (OKWBID # 121600040100) and Tar Creek (OKWBID # 121600040060)

Contents

Problem Definition

This TMDL addresses the threat of instream organic enrichment and low dissolved oxygen (DO) due to the discharge of treated municipal wastewater from the City of Picher (under critical conditions by allocating DO-demanding substances (CBOD and Ammonia). It also accounts for non-point source impacts through the use of conservative kinetic inputs and assumptions.

The Oklahoma Water Resources Board (OWRB) performed a Use Attainability Assessment (UAA) on Tar Creek but not on Lytle Creek. OWRB assigned Tar Creek a Habitat Limited Aquatic Community (HLAC) beneficial use but since Lytle Creek is unlisted unless a UAA is performed the higher beneficial use of Warm Water Aquatic Community must be assumed. Lytle Creek's beneficial use designations are:

- Warm Water Aquatic Community (WWAC)
- Primary Body Contact Recreation
- Agriculture
- Aesthetics

Tar Creek currently has the following designated beneficial uses:

- Habitat Limited Aquatic Community (HLAC)
- Secondary Body Contact Recreation

This TMDL has been developed in order to ensure that the limits assigned to the discharge are stringent enough to maintain DO standards under critical conditions in Lytle Creek or Tar Creek. This TMDL is part of the FY1998 104(b)(3) EPA Grant commitment.

Lytle Creek (OK121600040100) is listed on the 1998 Oklahoma 303(d) List for Cause Code 1200 (Organic Enrichment/DO). Tar Creek (OK121600040060) is listed for Cause Code 1200 (Metals). This TMDL will address the Organic Enrichment/DO listings and enable Lytle Creek to be removed from the 303(d) List.

Endpoint Identification

The Oklahoma Water Quality Standards define DO criteria for both HLAC and WWAC. These criteria apply at all flows above the critical low flow of 1cfs or the 7-day 2-year low flow. Nuisance conditions are to be avoided at all other flows. A DO of less than 2.0 mg/l is considered to be nuisance conditions.

The following numerical dissolved oxygen criteria apply to Lytle Creek Warm Water Aquatic Community (WWAC):

Critical Low-Flow Condition ($_7Q_2$)	
Summer (Jun–Oct):	5.0 mg/L
Spring (Apr–May):	6.0 mg/L
Winter (Nov–Mar):	5.0 mg/L

The following numerical dissolved oxygen criteria apply to the un-named tributary to Tar Creek Habitat Limited Aquatic Community (HLAC):

Critical Low-Flow Condition ($_7Q_2$)	
Summer (Jun–Oct):	3.0 mg/L
Spring (Apr–May):	4.0 mg/L
Winter (Nov–Mar):	3.0 mg/L

Source Analysis

Point Sources

Picher Wastewater Treatment Facility (WWTF)

Facility Legal Description: SE¼ of the SW¼of the SE¼ of Section 21, Township 29 North, Range 23 East of I.M., in Ottawa County, Oklahoma

Point of Discharge (POD):
Latitude: 36° 58’ 44” N
Longitude: 94° 49’ 14” W

Current Wasteload Allocation (WLA):
Design Flow: 0.018 MGD
Limits: Lagoon Secondary (year-round)

Non-Point Sources

The allocations in this waterbody assessment are driven by critical instream dissolved oxygen conditions (low-flow, high temperature) as defined in the Oklahoma Water Quality Standards. Low-flow conditions, by definition, assume little or no runoff. The evaluation of pollution from non-point sources (NPS) was accomplished using field observations made on July 21, 1998. Trees and bushes were abundant in the riparian zone of the stream. Surrounding land use of the stream consisted of abandoned mine tailings, agriculture, residential, and pasture. The stream channel varied considerably but on Lytle creek was primarily shallow to deep pools. On Tar Creek the channel varied from wide to narrow riffles and pools. The banks were irregular but generally accessible. Banks in many areas were lined with mine tailings but erosion did not appear to be prominent and there does not appear to be any significant residual impact on the organic enrichment of the stream from non-point sources. Therefore, during low and normal flow conditions the impact of NPS pollution to the stream should be negligible.

Background

The following background conditions for Lytle Creek were used:

Flow:	1.0 cfs
$CBOD_5$:	2.0 mg/L
Ammonia:	0.15 mg/L
DO:	85% saturation at the regulatory seasonal temperature

The background flow in Buzzard Creek was assumed to be zero.

The following background conditions for Tar Creek were used:

Flow:	1.0 cfs
$CBOD_5$:	2.0 mg/L
Ammonia:	0.15 mg/L
DO:	85% saturation at the regulatory seasonal temperature

The background flow in Tar Creek was assumed to be zero.

Linkage between Sources and Receiving Water

Model Inputs – Lytle Creek

The water quality model used to determine the impact of DO-demanding substances on the instream DO concentration is based on a Texas equation. The primary kinetic inputs were derived from literature values and are as follows:

<u>Reach 1</u>

CBOD decay rate (**K_1**):	0.30/day
Reaeration Rate & Formula (**K_2**):	1.91-2.88/day (Texas)
NBOD decay rate (**K_n**):	0.20/day
CBOD setting rate (**K_s**):	0.03/day
Sediment Oxygen Demand (**SOD**):	0.06-0.12 g/ft^2/day

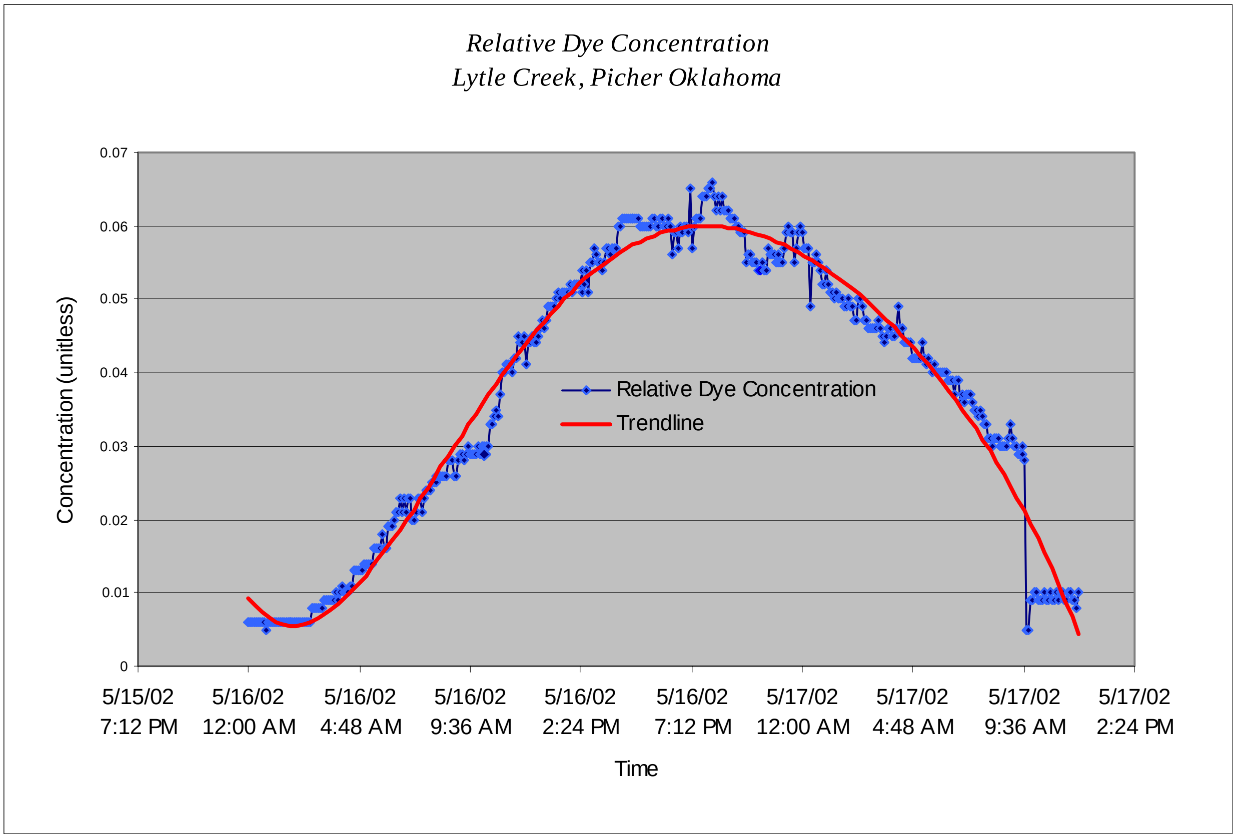
The hydraulic inputs for Lytle Creek were calculated based on data obtained during a May 15, 2002 field survey. A dye study was conducted to measure average stream velocity. Rhodamine WT was released near the POD at 9:00 AM, May 15, 2002. The relative dye concentration was logged continuously beginning at 12:00 AM, May 16, 2002 at a point approximately 0.65 miles downstream from the POD. The peak relative dye concentration occurred at approximately 8:00 P.M., May 16, 2002 (Figure 1).

Hydraulic parameters were estimated based on field observations for side slope and using topographic maps in the stream slope calculations. Manning's 'n' was calculated using the time of travel measurements along with the other estimated hydraulic data listed below. The flow in Lytle Creek used to calculate Manning's 'n' was assumed to be the design flow of 0.18 MGD. This assumption produced a lower value of Manning's 'n' than when the measured discharge flow of 1.8 MGD was used. This was done since the measured flow was probably only at 1.8 MGD for a limited period during the 35 hour travel time.

<u>Reach 1</u>

Stream Slope:	7.6 ft/mile
Side Slope:	0.25 ft/ft
Manning's 'n':	1.0

Figure 1. Time of Travel Plot – Lytle Creek



Model Inputs – Tar Creek

The water quality model used to determine the impact of DO-demanding substances on the instream DO concentration for Tar Creek is based on a Texas equation. The primary kinetic inputs were derived from literature values and are as follows:

Reach 1

CBOD decay rate (**K_1**): 0.30/day
Reaeration Rate & Formula (**K_2**): 2.54-3.82/day (Texas)
NBOD decay rate (**K_n**): 0.20/day
CBOD setting rate (**K_s**): 0.03/day
Sediment Oxygen Demand (**SOD**):0.070 – 0.10 g/ft^2/day

The hydraulic inputs for Tar Creek were calculated based on data obtained during a April 25, 2002 field survey. A dye study was conducted to measure average stream velocity. Rhodamine WT was released near a bridge crossing at 10:00 AM, April 25, 2002. The relative dye concentration was logged continuously beginning at 12:00 PM, April 25, 2002 at a point approximately 1.2 miles downstream from point of the dye was released. The peak relative dye concentration occurred at approximately 2:30 AM, April 26, 2002 (Figure 2).

Hydraulic parameters were estimated based on field observations for side slope and using topographic maps in the stream slope calculations. Manning's 'n' was calculated using the time of travel measurements along with the other estimated hydraulic data listed below.

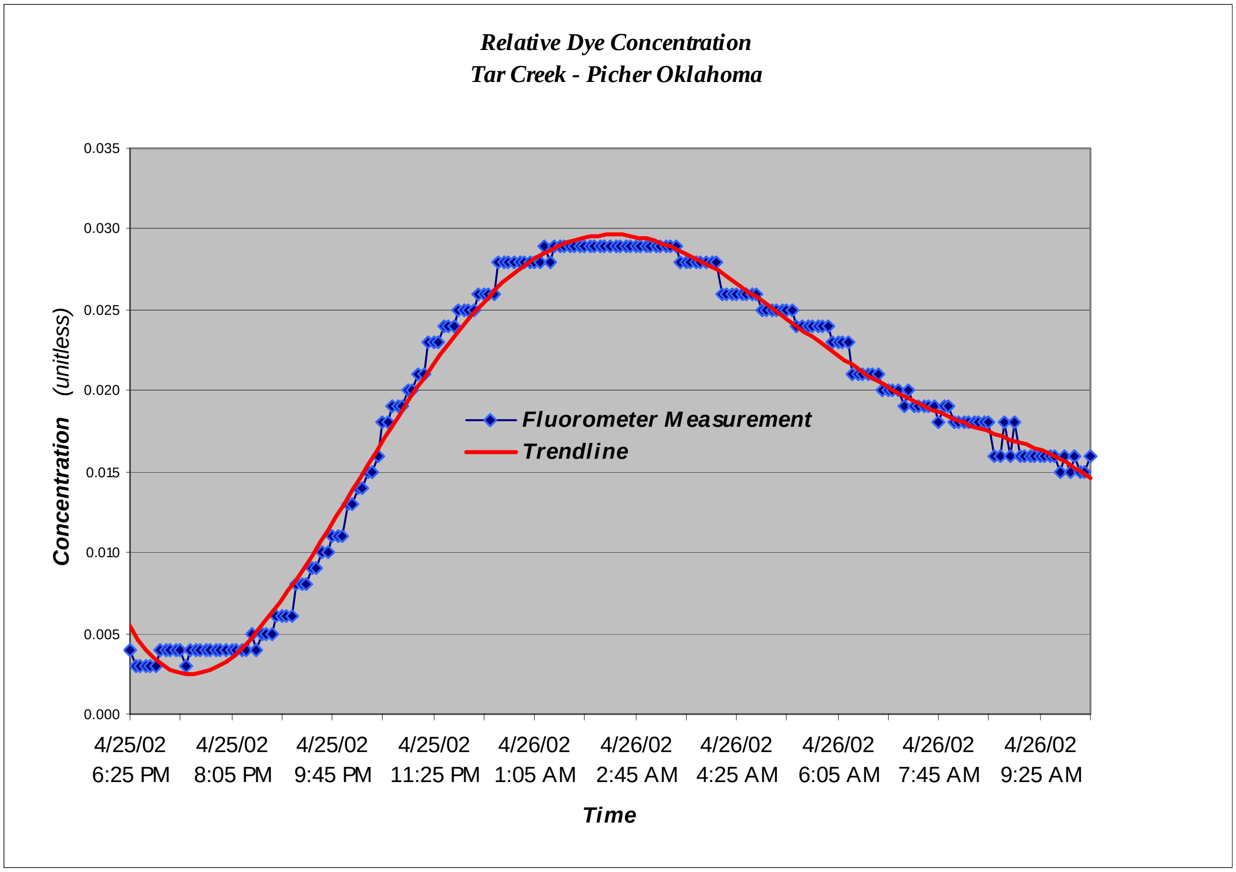
Reach 1

Stream Slope: 6.15 ft/mile

Side Slope:0.10 ft/ft

Manning's 'n': 0.65

Figure 2. Time of Travel Plot – Tar Creek



Maximum Assimilative Capacity

There were no discharge scenarios that would meet the Water Quality Standards for dissolved oxygen in Lytle Creek except NO DISCHARGE. The following discussions are for the modeling of a discharge to Tar Creek. The desktop model was used to determine the stream's maximum assimilative capacity during various seasons. To do this, the concentration of $CBOD_5$ and NH_3-N of the point source are increased at the same rate until the predicted instream DO reaches the DO criteria. The resultant mass loading represents the maximum assimilative capacity of the stream for DO-demanding substances. A summary of the results is shown in Table 1.

Table 1. – Maximum Assimilative Capacity

Season	Maximum Assimilative Capacity (lbs/day)	
	$CBOD_5$	NH_3-N
Summer (Jun–Oct)	**16.7**	**4.2**
Spring (Apr–May)	**26.2**	**8.7**
Winter (Nov–Mar)	**47.3**	**31.6**

The complete model results are attached.

Margin of Safety

The Oklahoma Continuing Planning Process (CPP), 2000 ed., specifies a 20% margin of safety (MOS) for uncalibrated, simple source models. This is implemented by increasing the inputs of DO-demanding substances ($CBOD_5$ and NH_3-N) proportionally just until the DO criteria are met. The quantified MOS is given along with the load allocations and wasteload allocations in the next element.

Allocations

The table below shows the allocation of loads. NPS is not given an explicit allocation due to the nature of critical-condition modeling and the conservative assumptions in the model.

Table 2. – Margin of Safety

Season	Max. Assim. Capacity(lb/day)		MOS		Wasteload Allocation(lb/day)	Margin of Safety (lb/day)	
	$CBOD_5$	NH_3 - N	$CBOD_5$	NH_3 - N	$CBOD_5$	NH_3-N	%
SUMMER	16.7	4.2	12.0	3.0	4.7	1.2	28.1%
SPRING	26.2	8.7	18.0	6.0	8.2	2.7	31.2%
WINTER	47.3	31.6	27.0	18.0	20.3	13.5	42.9%

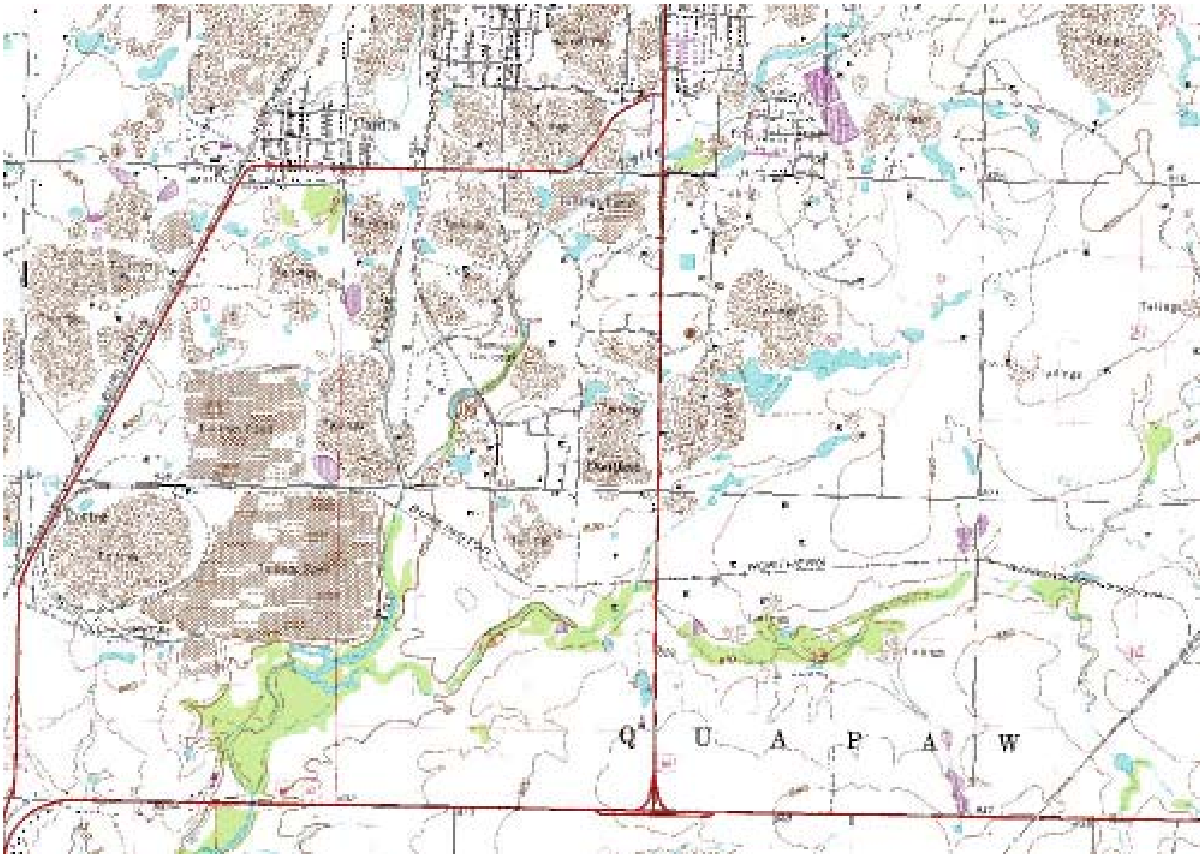
Final Recommendations

The following changes are recommended for inclusion in the Oklahoma Water Quality Management Plan (208 Plan).

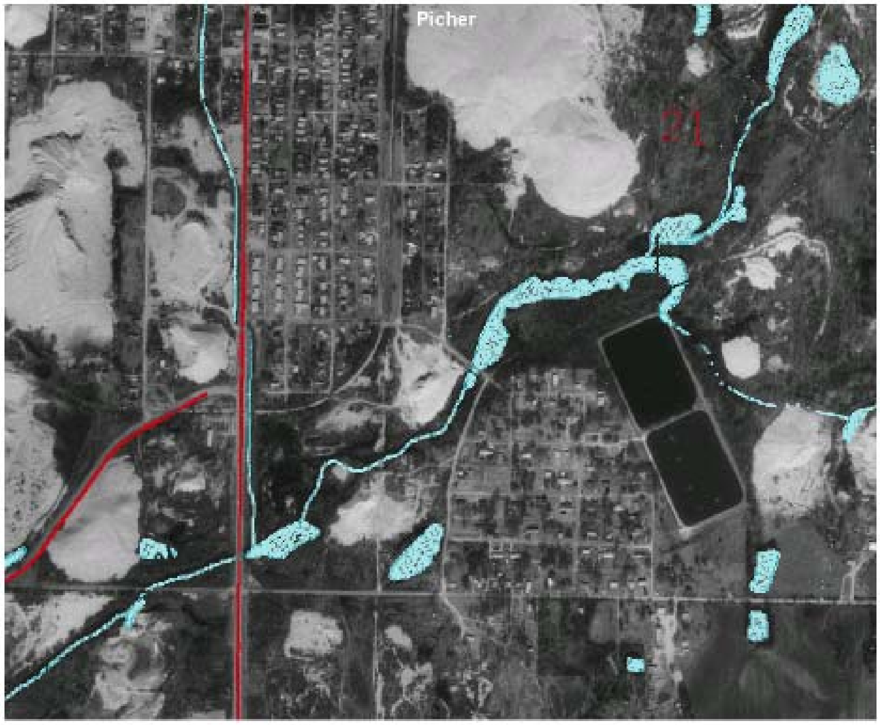
WLA, Picher WWTF Discharge to Tar Creek

Design Flow:	0.18 MGD
Summer Limits (Jun–Oct):	8 mg/l $CBOD_5$, 2 mg/l NH_3-N & 5 mg/l D.O.
Spring Limits (Apr–May):	12 mg/l $CBOD_5$, 4 mg/l NH_3-N & 5 mg/l D.O.
Winter Limits (Nov–Mar):	Mechanical Secondary & 5 mg/l D.O. (20 BOD_5 & 30 TSS)

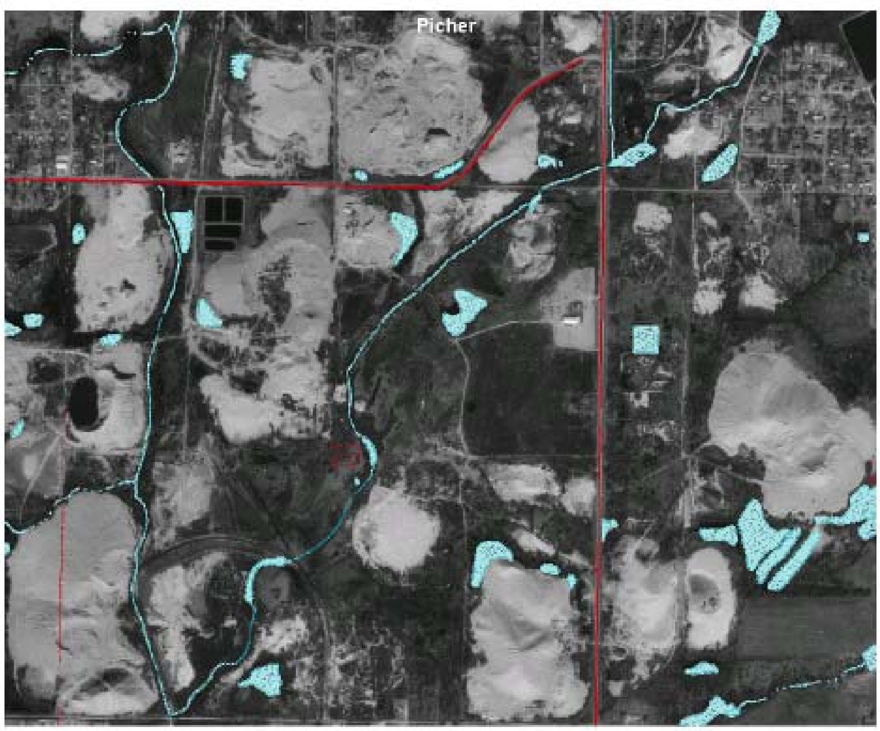
Map of Study Area **– Lytle and Tar Creeks**



Aerial Photographs



Upper Lytle Creek



Lower Lytle Creek and Tar Creek