Wasteload Allocation Report for
Newcastle Public Works Authority

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1. Introduction

This report provides documentation of water quality modeling that evaluates the effect of the Newcastle Public Works Authority’s (NPWA) proposed revised discharge on dissolved oxygen (DO) in the Canadian River.

In the Canadian River Wasteload Allocation (WLA) project (Guernsey/FTN 2014), DO modeling of the Canadian River between Union City and Buckhead, OK was developed under a contract with the Association of Central Oklahoma Governments (ACOG). Several projection scenarios were simulated and the dischargers collectively selected Scenario D. In Scenario D, the discharge from the NPWA Wastewater Treatment Facility (WWTF) was located in the Canadian River just south of the confluence with Pond Creek, and the discharge from the Oklahoma City South Canadian WWTF was the same as their current discharge location, which is in an unnamed tributary (referred to as “UTOC” in the 2014 WLA report). These two discharge locations are shown on Figure 1.

In 2018, ACOG developed a revision to Scenario D with the discharge from the Oklahoma City South Canadian WWTF moved to the Canadian River (“OK City proposed discharge location” on Figure 1). This modeling by ACOG has been approved by the Oklahoma Department of Environmental Quality (ODEQ). On October 4, 2018, ODEQ initiated a public comment period for incorporating the results of this modeling into the Water Quality Management Plan (WQMP).

From 2010 through 2018, the number of sewer connections grew by an average of 6.1% per year. In the last two (2) years, the number of sewer connections has grown by 17% and there are currently 1,390 sewered lots platted but unbuilt at this time. Newcastle expects to average 7.6% growth in sewer connections per year over the next 20 years. This results in 5,448 sewer connections in the year 2039 and a design flow of 1.50 mgd.

The NPWA has decided to construct a new WWTF at a new location due to capacity issues at the existing plant and odor complaints from nearby residential developments. The new WWTF would be located approximately 2,500 feet northeast of the existing WWTF. The new site is south of NE 16th street and west of Portland Avenue. The NPWA proposes to move the discharge point to the east end of NE 16th Street where it ends at the Canadian River (OK520610010010_10), much closer to the WWTF than the location listed in the WLA and discharge permit.
2. Physical Characteristics of the Study Area

A. Physiography/Ecoregions

The Canadian River is located in the Interior Plains Physiographic Division, Rolling Plains, and is generally characterized by slightly to moderately tilted, older sedimentary rocks. In central Oklahoma, the river flows through two ecoregions including Cross Timbers and the Central Great Plains. Most of the WLA study area is located in the Central Great Plains. These two ecoregions are characterized as follows:

- **Cross Timbers**: transition between the once prairie and the forested low mountains of eastern Oklahoma; transitional cross timbers type vegetation includes little bluestem grassland, with scattered blackjack and post oak trees; predominant land cover is rangeland and pastureland; oil extraction is a major activity.

- **Central Great Plains**: once grassland, with scattered low trees and shrubs, much of this region is now cropland; the eastern boundary of this region marks the major winter wheat growing area of the United States.

The remainder of the river to the east of the study area is in the Arkansas Valley Ecoregion, consisting mostly of forested valleys and ridges.

B. Climate

In general, the climate of the study area is classified as sub-humid. Annual precipitation ranges from about 33 inches per year in Canadian County (western side of the study area) to about 39 inches in Garvin County (eastern side of the study area). Temperatures range from an average daytime high of about 94º F in July to an average low of about 27º F in January. The average annual temperature is approximately 61º F. Thunderstorms are common in the spring and summer.

C. Hydrology

The USGS has published stream flow data for the Canadian River at several gauging stations that are located in or near the area of interest for this project. The flow gages with real time data were used to help determine when flows in the river were low enough to conduct the field studies in the 2014 project.

D. Land Use

The study area contains the following communities and their representative Populations (2010):

- Union City (Canadian County) 1,404
- Minco (Grady County) 1,781
- Tuttle (Grady County) 5,842
- Mustang (Canadian County) 17,190
- Newcastle (McClain County) 7,010
• Oklahoma City (Cleveland County portion) 54,748
• Oklahoma City (Oklahoma County portion) 457,589
• Moore (Cleveland County) 51,106
• Norman (Cleveland County) 106,707
• Noble (Cleveland County) 5,707
• Purcell (McClain County) 6,072
• Lexington (Cleveland County) 2,100

Land use within the WLA study area is characterized by a broad spectrum of uses. The western section of the study area, defined as Union City to Newcastle, can generally be characterized as rural, with sporadic urbanization that is not necessarily adjacent to the river, but is somewhat distant based on communities being located along tributaries of the Canadian River. Union City, Minco, Tuttle, Mustang, and Newcastle are all regional communities that are generally associated with the Oklahoma City metropolitan area. The predominant land use along the river, west of Newcastle, is characterized as cropland and pasture, and herbaceous rangeland. Braum’s Dairy Farm is a major commercial operation located west of Tuttle on the south side of the river.

Urbanization along the river significantly increases in the Newcastle area and becomes the predominant land use feature as the river turns to the south/southeast and flows adjacent to or through Oklahoma City, Moore, Norman, and Noble (central section). There are portions of the river in this section that represent transitional mixed rural and urban uses, but in general, urbanization is the dominant feature.

E. Point Sources

Point sources are typically associated with a single discharge location (pipe, defined channel, etc.) of some type of waste effluent from municipal or industrial wastewater treatment facilities. The point source can include either treated or untreated waste. Within the study area, there are 13 existing facilities with Oklahoma Pollutant Discharge Elimination System (OPDES) permits that discharge oxygen-demanding wastewater either directly into the Canadian River or into a tributary of the Canadian River, within several miles of the river. There is also one proposed facility (Tuttle’s Worley Creek facility) that would discharge oxygen-demanding wastewater into the Canadian River.

Figure 2 identifies their current discharge locations. Information for the map was derived from OPDES permits and fact sheets, the ODEQ Water Quality Management Plan (WQMP), and questionnaires that were completed by permit holders.

F. Non-Point Sources

Nonpoint source (NPS) pollution comes from diffuse sources and is typically not defined by a single, isolated discharge location. NPS pollution is caused by rainfall or snowmelt moving over or through the ground. Natural and manmade pollutants are accumulated by the runoff and carried/deposited in lakes, rivers, and wetlands. Contaminants can include:

• Fertilizers, herbicides, and insecticides from agricultural practices
• Oil, grease, and toxic chemicals from urban sources
- Sediment from construction sites, crop and forest lands, and eroding stream banks
- Salt from irrigation activities
- Bacteria and nutrients from livestock and faulty septic systems

NPSs make large contributions to degraded water quality throughout the United States. EPA reports that NPS pollution is the Nation’s largest source of water quality problems. In the Canadian River basin, and specifically within the study area, nonpoint sources are prevalent due to the varied land use activities. NPS pollution aligns very closely with land use and the types of land use in an area. Land uses in the study area include both rural and urban uses and the NPS pollution in the Canadian River Basin is consistent with the various types identified above.

Within Oklahoma, the Oklahoma Conservation Commission (OCC) is the lead technical agency with jurisdiction over NPS pollution in Oklahoma. The OCC works with 88 conservation districts within Oklahoma to address NPS pollution through various programs.

G. Water Quality Standards

Water quality standards, including designated uses, for water bodies in Oklahoma are established by the OWRB and published as Oklahoma Administrative Code (OAC) Title 785, Chapter 45 (OWRB 2017). The designated uses for the Canadian River and other streams in the project area are listed in Table 1. The designated uses for specific streams in Table 1 are from Appendix A.5 of OAC 785:45 and the designated uses for “other streams” (the last row in the table) are the default designated uses that are specified in OAC 785:45-5-3. These default designated uses apply to the unnamed tributaries that receive discharges from the Oklahoma City (South Canadian) and Moore WWTPs. The last column in Table 1 lists WWTP discharges that flow into each stream.
### TABLE 1

**DESIGNATED STREAM USES**

<table>
<thead>
<tr>
<th>Stream</th>
<th>ID Number(s)</th>
<th>Designated Uses*</th>
<th>WWTP Discharges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian River from the US Hwy. 81 bridge to its confluence with Buckhead Creek</td>
<td>520610010010, 520610020010, and 520610020150_00</td>
<td>AES, AG, WWAC, PBCR</td>
<td>Tuttle (proposed facility), Mustang, Norman, Noble, Lexington, Purcell</td>
</tr>
<tr>
<td>Tributary of Canadian River at SW 1/4, Sec. 3, T10N, R7W, IM</td>
<td>520610</td>
<td>AES, AG, HLAC, SBCR</td>
<td>Union City</td>
</tr>
<tr>
<td>Buggy Creek</td>
<td>520610020120</td>
<td>AES, AG, WWAC, PBCR, EWS</td>
<td>Minco</td>
</tr>
<tr>
<td>West Creek</td>
<td>520610020090</td>
<td>AES, AG, HLAC, SBCR</td>
<td>Tuttle (existing facility)</td>
</tr>
<tr>
<td>Store Creek</td>
<td>520610020080</td>
<td>AES, AG, WWAC, PBCR, PPWS</td>
<td></td>
</tr>
<tr>
<td>Tributary of Pond Creek at NE 1/4, Sec. 14, T9N, R4W, IM (Tim's Creek)</td>
<td>520610010215</td>
<td>AES, AG, HLAC, SBCR</td>
<td>Newcastle</td>
</tr>
<tr>
<td>Pond Creek</td>
<td>520610010210</td>
<td>AES, AG, WWAC, PBCR, PPWS</td>
<td></td>
</tr>
<tr>
<td>Other streams within the project area that are not listed above</td>
<td>--</td>
<td>AES, AG, WWAC, PBCR</td>
<td>Oklahoma City, Moore</td>
</tr>
</tbody>
</table>

**NOTES:** Abbreviations for designated uses are:

- AES = aesthetics
- AG = agriculture
- WWAC = warm water aquatic community
- HLAC = habitat limited aquatic community
- PBCR = primary body contact recreation
- SBCR = secondary body contact recreation
- PPWS = public and private water supply
- EWS = emergency water supply

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The water quality standards also specify numeric criteria for protecting designated uses. The designated uses that are of primary interest for this project are warm water aquatic community and habitat limited aquatic community. The water quality standards specify criteria for various parameters for protecting aquatic life, but the parameters of interest for this project are DO, ammonia nitrogen, and nutrients. The criteria for DO are presented in Table 2. The DO criteria must be maintained at the seasonal temperatures in Table 2 as required in OAC 785:45-5-12(f)(1).

**TABLE 2**

### NUMERIC CRITERIA FOR DO AND SEASONAL TEMPERATURES

<table>
<thead>
<tr>
<th>Season</th>
<th>Criteria for Minimum DO (mg/L)</th>
<th>Seasonal Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Habitat Limited Aquatic Community</td>
<td>Warm Water Aquatic Community</td>
</tr>
<tr>
<td>Early Life Stages (4/01 – 6/15)</td>
<td>4.0</td>
<td>6.0 *</td>
</tr>
<tr>
<td>Summer Conditions (6/16 – 10/15)</td>
<td>3.0</td>
<td>5.0 *</td>
</tr>
<tr>
<td>Winter Conditions (10/16 – 3/31)</td>
<td>3.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

**NOTE:** *The following applies to the values marked with an asterisk: “Because of natural diurnal fluctuation, a 1.0 mg/L concentration deficit shall be allowed for not more than eight hours during any 24-hour period”*

The water quality standards do not include numeric criteria for ammonia nitrogen, but OAC 785:45-5-12(f)(6) requires that permit limits for discharges of ammonia be set to prevent the discharge from causing acute toxicity at any location or chronic toxicity outside the mixing zone. The regulations for implementation of the water quality standards (OAC Title 785, Chapter 46) (OWRB 2017) specify a maximum allowable ammonia nitrogen concentration of 6 mg/L outside the mixing zone (OAC 785:46-5-3(b)).

The water quality standards do not specify numeric criteria for nutrients that are applicable within the study area for this WLA, but the following narrative criterion applies to protection of aquatic life throughout Oklahoma and is specified in OAC 785:45-5-9(d):

> “Nutrients from point source discharges or other sources shall not cause excessive growth of periphyton, phytoplankton, or aquatic macrophyte communities which impairs any existing or designated beneficial use.”

As specified in EPA’s regulations at 40 Code of Federal Regulations (CFR) 130.7(b)(2), applicable water quality standards include anti-degradation requirements. Oklahoma’s anti-degradation requirements are presented in both the water quality standards (OAC Title 785, Chapter 45) and the implementation regulations (OAC Title 785, Chapter 46). None of the streams in Table 1 is specified as Outstanding Resource Waters, High Quality Waters, or Sensitive Water Supplies; therefore, the primary anti-degradation requirements for this project are:

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• **Application to beneficial uses**: No water quality degradation which will interfere with the attainment or maintenance of an existing or designated beneficial use shall be allowed. (OAC 785:45-3-2(d))

• **Application to improved waters**: As the quality of any waters of the state improves, no degradation of such improved waters shall be allowed. (OAC 785:45-3-2(e))
3. **Modeling**

**A. Previous Modeling**

The original Guernsey report from 2014 includes detailed information concerning the field studies, WASP model setup, calibration, and validation related to the setup and execution of the model if additional model development information is needed. In the 2014 report, several projection scenarios were simulated and the dischargers collectively selected Scenario D. In Scenario D, the discharge from the City of Newcastle’s wastewater treatment facility (WWTF) was relocated to the Canadian River near the mouth of Pond Creek (OK520610010010_10).

In 2018, ACOG developed a revision to Scenario D with the discharge from the Oklahoma City South Canadian WWTF moved to the Canadian River (“OK City proposed discharge location” on Figure 1). This modeling by ACOG has been approved by the Oklahoma Department of Environmental Quality (ODEQ). On October 4, 2018, ODEQ initiated a public comment period for incorporating the results of this modeling into the Water Quality Management Plan (WQMP).

An explicit margin of safety (MOS) of 5% was incorporated into the model as required by ODEQ for models that are both calibrated and verified. The MOS was applied to both the point source and nonpoint source oxygen demand by entering a value of 1.05263 (1.0 divided by 0.95) in the model as a “scale factor” for the sediment oxygen demand (SOD) and for all the inflow concentrations of ammonia nitrogen, point source CBOD, and ambient CBOD. The model internally multiplies the user-specified SOD values and inflow concentrations with these scale factors.

**B. New Modeling**

The simulations presented in this report are the same as ACOG’s simulations except that the Newcastle PWA’s proposed discharge location has been moved to the Canadian River near the end of Northeast 16th Street, which is approximately 2 miles upstream of the mouth of Pond Creek.

Moving Newcastle’s discharge location in the model required the following changes to the model input files:

- The flow continuity array (routing information) was modified so that the Newcastle discharge will enter the river at segment 169 (near the end of Northeast 16th Street) instead of segment 185 (near the mouth of Pond Creek).

- The boundary concentrations (i.e., effluent concentrations) for the Newcastle discharge were transferred from segment 169 to segment 185.
The effluent concentrations used in the model for Newcastle’s discharge remained the same as in Scenario D in the Canadian River WLA project; these concentrations included the following recommended discharge limits for all three seasons (spring, summer, and winter):

\[
\begin{align*}
\text{CBOD5} &= 18 \text{ mg/L} \\
\text{Ammonia nitrogen} &= 12 \text{ mg/L} \\
\text{Dissolved oxygen} &= 2 \text{ mg/L}
\end{align*}
\]

In addition to moving Newcastle’s discharge location, the effluent flow rate for Newcastle was also varied. For each season, the model was run with Newcastle flow rates of 0.852 MGD (the same as in Scenario D and in ACOG’s modeling), 0.99 MGD, and 1.50 MGD (potential future flow rates).

The results of these simulations showed that the DO standards will be maintained in the Canadian River with Newcastle discharging near the end of Northeast 16th Street at any of the three effluent flow rates that were simulated. Model output for daily minimum DO and number of hours per day that the predicted DO was below the criterion during spring and summer are summarized in Table 3.
### TABLE 3

**SUMMARY OF MODEL OUTPUT FOR DO IN MAIN STEM OF CANADIAN RIVER**

<table>
<thead>
<tr>
<th>Description of simulations (^A)</th>
<th>Newcastle discharge location</th>
<th>Newcastle effluent flow rate</th>
<th>Lowest value of daily minimum DO (mg/L)</th>
<th>Largest number of hours/day that DO is below criterion (^B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.852 MGD</td>
<td>Spring</td>
<td>Summer</td>
</tr>
<tr>
<td>ACOG simulations</td>
<td>Near the mouth of Pond Creek</td>
<td></td>
<td>5.9</td>
<td>4.0</td>
</tr>
<tr>
<td>New discharge location for Newcastle with same flow</td>
<td>Near the end of Northeast 16th Street</td>
<td>0.852 MGD</td>
<td>5.9</td>
<td>4.0</td>
</tr>
<tr>
<td>New discharge location for Newcastle with 0.99 MGD flow</td>
<td>Near the end of Northeast 16th Street</td>
<td>0.99 MGD</td>
<td>5.9</td>
<td>4.0</td>
</tr>
<tr>
<td>New discharge location for Newcastle with 1.50 MGD flow</td>
<td>Near the end of Northeast 16th Street</td>
<td>1.50 MGD</td>
<td>5.9</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Notes:

A. For all of the simulations in this table, the Oklahoma City South Canadian WWTP was modeled as a direct discharge to the Canadian River.

B. During spring and summer, the DO is allowed to drop no more than 1.0 mg/L below the criterion (6.0 mg/L for spring, 5.0 mg/L for summer) up to 8 hours per day.

**C. Results and Conclusions**

Plots of predicted daily minimum DO along the length of the river are shown in Figures 3 through 11. For all of the simulations, the lowest values of the daily minimum DO occurred on the order of 40 to 50 kilometers (25 to 31 miles) downstream of Newcastle’s proposed discharge location.

Changing Newcastle’s discharge location and effluent flow rate to 1.50 mgd affected the predictions for daily minimum DO by no more than 0.2 mg/L at any location along the main stem of the river.
4. References


Figure 1  Map of Current and Proposed Discharge Locations for OKC and Newcastle
Figure 3. Predicted Daily Minimum DO for Canadian River for Spring (Newcastle Flow = 0.852 MGD)

River kilometer (zero is downstream end of model)

- Tuttle
- Mustang
- OG&E
- OK City Direct
- Newcastle (NE 16th)
- Newcastle (Pond Crk)
- Norman
- Noble
- Lexington
- Purcell

Minimum daily DO (mg/L)

- OK City moved to River; Newcastle at mouth of Pond Crk. (ACOG run)
- OK City moved to River; Newcastle at NE 16th St. and 0.852 MGD
Figure 4. Predicted Daily Minimum DO for Canadian River for Summer (Newcastle Flow = 0.852 MGD)

Minimum daily DO (mg/L) vs. River kilometer (zero is downstream end of model)

- Turtle
- Mustang
- OG&E
- OK City Direct
- OK City moved to River; Newcastle at mouth of Pond Crk. (ACOG run)
- Newcastle (NE 16th)
- Newcastle (Pond Cr)
- Norman
- Noble
- Norman
- Purcell
- OK City moved to River; Newcastle at NE 16th St. and 0.852 MGD
- OK City moved to River; Newcastle at mouth of Pond Crk. (ACOG run)
Figure 5. Predicted Daily Minimum DO for Canadian River for Winter (Newcastle Flow = 0.852 MGD)

OK City moved to River; Newcastle at mouth of Pond Crk. (ACOG run)
OK City moved to River; Newcastle at NE 16th St. and 0.852 MGD
Figure 6. Predicted Daily Min. DO for Canadian River for Spring (Newcastle Flow Rates = 0.852 and 1.50)

OK City moved to River; Newcastle at NE 16th St. (0.852 MGD)

OK City moved to River; Newcastle at NE 16th St. (1.50 MGD)
Figure 7. Predicted Daily Min. DO for Canadian River for Summer (Newcastle Flow Rates = 0.852 and 1.50)

- OK City moved to River; Newcastle at NE 16th St. (0.852 MGD)
- OK City moved to River; Newcastle at NE 16th St. (1.50 MGD)

River kilometer (zero is downstream end of model)
Figure 8. Predicted Daily Min. DO for Canadian River for Winter (Newcastle Flow Rates = 0.852 and 1.50)

OK City moved to River; Newcastle at NE 16th St. (0.852 MGD)

OK City moved to River; Newcastle at NE 16th St. (1.50 MGD)