

TOTAL MAXIMUM DAILY  
LOAD (TMDL) DEVELOPMENT

- CHLORIDES -

for

UNNAMED TRIBUTARY TO  
SOUTH FORK RUSSELL CREEK  
AT RIVER MILE 4.85  
(GREEN COUNTY, KENTUCKY)



Natural Resources and  
Environmental Protection Cabinet

Kentucky Division of Water

TOTAL MAXIMUM DAILY  
LOAD (TMDL) DEVELOPMENT

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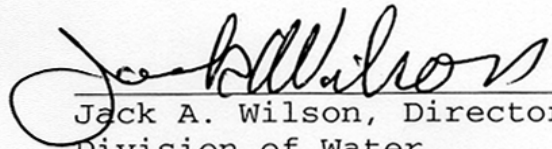
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AT RIVER MILE 4.85  
(GREEN COUNTY, KENTUCKY)

KENTUCKY DEPARTMENT FOR ENVIRONMENTAL PROTECTION  
DIVISION OF WATER

Frankfort, Kentucky

This report has been approved for release:

  
\_\_\_\_\_  
Jack A. Wilson, Director  
Division of Water

Dec 15, 2000  
Date

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List of Contributors

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**TMDL FACT SHEET**

**UNNAMED TRIBUTARY (UT) TO SOUTH FORK RUSSELL CREEK  
AT RIVER MILE (RM) 4.85**

Project  
Name: UT to South Fork Russell Creek at RM 4.85:  
Chlorides/TDS/Salinity

Location: Green County, Kentucky

Scope/Size: UT at RM 4.85: RM 0.0 to 0.6

TMDL Issues: Point and Nonpoint Sources

Data Sources: Kentucky Dept. for Environmental Protection  
Division of Water (KDEP-DOW), SMC Martin  
Inc.

Control  
Measures: KPDES Regulations, Kentucky Nonpoint Source  
TMDL Implementation Plan, Kentucky Watershed  
Framework

Summary: In 1993, the UT at RM 4.85, a tributary to  
South Fork Russell Creek, was determined not  
to be supporting the designated use of  
aquatic life. Therefore, the stream was  
listed on the 303(d) list for Total Maximum  
Daily Load (TMDL) development. The stream  
segment was impacted by chlorides (in  
conjunction with total dissolved solids  
[TDS], and salinity), the result of brine

discharges to surface streams from oil production activities (stripper wells). The period of greatest impact was during low base-flow conditions. Currently, no oil production activity is occurring; however, the potential exists for this to reoccur, thus the need for this TMDL.

#### TMDL

Development: Total maximum daily loads in pounds per day (lbs/day) were computed based on the allowable maximum concentration for chloride (the standard for chronic exposure is 600 milligrams per liter [mg/l] for warm water aquatic habitat) and the estimated 7-day, 10-year low-flow value (0.00 ft<sup>3</sup>/sec). The TMDL was done for chloride because numerical criteria are available for chloride but not for TDS or salinity. Because these parameters are so closely related to chloride, the TMDL for chloride will also account for impairments resulting from TDS and salinity.

The total allowable chloride load is 0.00 lbs/day for the UT at RM 4.85 of South Fork Russell Creek. There are currently no permitted dischargers of chloride (WLAs) and the 7-day 10-year low-flow value is 0.00 ft<sup>3</sup>/sec (which is the critical flow condition). Therefore, the current load from WLAs is 0.00 lbs/day. The allowable

load for contributions from nonpoint sources and from natural background (LAs) is also 0.00 lbs/day because the 7-day 10-year low-flow value is 0.00 ft<sup>3</sup>/sec (which is the critical flow condition). Chloride concentrations at the control site (indicative of background conditions) were about 4 mg/l during the December 1993 synoptic survey, when the stream was flowing. However, because the 7-day 10-year low-flow value is 0.00 ft<sup>3</sup>/sec, the background load is therefore 0.00 lbs/day. Also, allowable nonpoint source contributions (which would most likely come from failing separator tanks or holding ponds, or seepage from holding ponds) is 0.00 lbs/day.

However, for permit requests that may be received in the future by the KDEP-DOW, the allowable loads provided in this TMDL will be modified to account for the permitted flow. The permittee will be allowed 50 percent of the requested load (in effect, meeting a chloride concentration of 300 mg/l). The remaining 50 percent of the load will be allocated to nonpoint sources of chloride as a margin of safety (implicit) to account for uncontrollable or unknown nonpoint sources (failing separator tanks or holding ponds, abandoned wells, seepage from holding ponds, or other sources).



Permit applications requesting to exceed the 50 percent allowable load allocation would be approved by the KDEP-DOW, provided that the applicant remove an equivalent amount from nonpoint sources in the watershed (referred to as an offset), such as separator tanks or abandoned holding ponds. At no time would permits be approved beyond 80 percent of the requested load (in effect, meeting a chloride concentration of 480 mg/l). This would provide at least a 20 percent margin of safety (explicit) to account for uncontrollable or unidentified nonpoint sources. The allocations were made in this manner because of the uncertainty of the impact of abandoned ponds and failing separator tanks.

#### Implementation

Controls: Discharge permits were required from oil producers starting in 1987. Throughout the state, many of these permits were not renewed by the producers because production has ceased or has significantly decreased. Production in Kentucky dropped from 17,700 barrels in 1986 to 9,400 barrels in 1996. Correspondingly, production has decreased in the South Fork Russell Creek basin. The drop in production was likely the result of a drop in crude oil prices worldwide in the 1990's, making production less economical,

particularly for smaller producers. Chloride levels from nonpoint sources should decrease over time as dilution lowers concentration levels in existing ponds. In this respect, this TMDL is a Phased TMDL. Follow-up monitoring will need to be conducted to assess the water quality of the stream. The chloride level for the UT at RM 4.85 on December 21, 1993 was 201 mg/l, which is lower than Kentucky's water quality standard for chloride. However, the biological assessment showed that the UT at RM 4.85 was not meeting the designated use of aquatic life, indicating that the stream had not yet recovered (in 1993) from past practices related to the disposal of brine.

Kentucky is currently conducting stream monitoring on a watershed basis. Sampling to determine levels of chloride, TDS, and salinity will be conducted during the period April 2001 to March 2002 in this watershed. If chloride concentrations are determined to be below 600 mg/l and the biological community is no longer impaired, then a request will be made to remove the stream from the list of impaired waters.

If oil production in the basin appreciably increases (which would most likely result from increasing oil prices or an oil supply shortage), permit compliance will be

pursued, and periodic monitoring of stream water quality (including chloride, TDS, and salinity levels) will be conducted as deemed appropriate.

## CHLORIDES TMDL DEVELOPMENT

### Unnamed Tributary to South Fork Russell Creek at River Mile 4.85 Green County, Kentucky

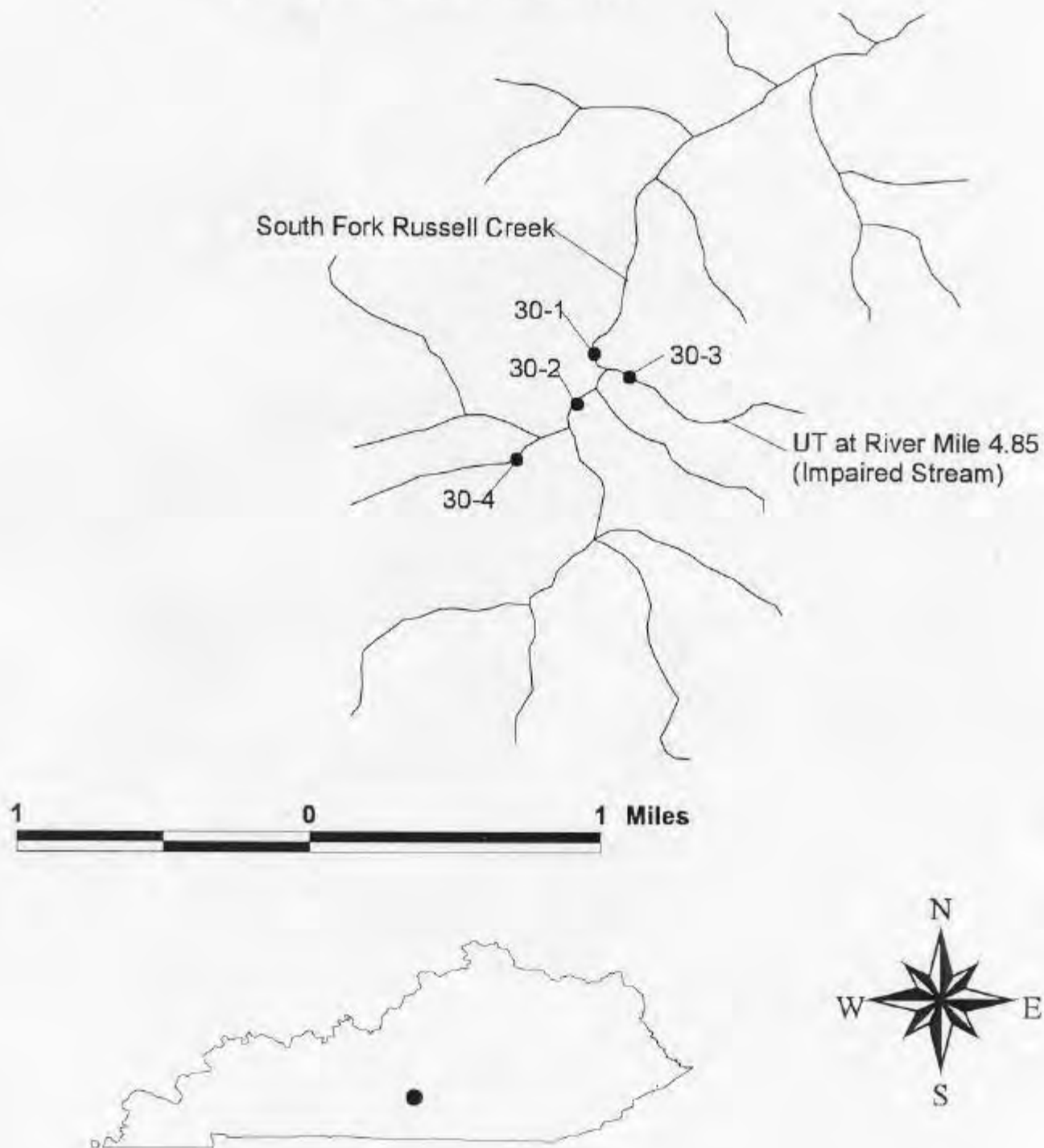
#### **Introduction**

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls for pollution. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relation between pollution sources and in-stream water quality conditions. States can then establish water-quality-based controls to reduce pollution from both point and nonpoint sources and restore the quality of their water resources.

#### **Problem Definition**

The Unnamed Tributary (UT) to South Fork Russell Creek at River Mile (RM) 4.85 (Figure 1) was determined as not supporting the designated use of aquatic life based on information collected during a 1993 intensive survey (Kentucky Department for Environmental Protection - Division of Water [KDEP-DOW], 1995). However, South Fork Russell Creek was listed in the 1996 and subsequent 305(b) Reports (Kentucky Report to Congress on Water Quality) as being in nonsupport (KDEP-DOW, 1996; 1998). Therefore, South Fork Russell Creek was placed on the 1996 and subsequent 303(d) lists (lists of impaired waters in Kentucky) for Total Maximum Daily Load (TMDL) development. However, the listing was made incorrectly in those reports. The listing should

**Figure 1. South Fork Russell Creek Basin, Green County, and  
Sampling Locations for the December 21, 1993  
Intensive Survey (DOW, 1995)  
[UT, Unnamed Tributary]**



have been the UT at RM 4.85 of South Fork Russell Creek and not South Fork Russell Creek. The impaired section on the UT is from RM 0.0 to 0.6, which is the entire length of the UT. The 1995 KDEP-DOW report on the biology and water quality of the South Fork of Russell Creek (KDEP-DOW, 1995) stated that the stream reach on the South Fork of Russell Creek immediately below the UT at RM 4.85 had good/excellent water quality, but that unabated brine discharges in the UT at RM 4.85 may result in deteriorated water quality on South Fork Russell Creek. Therefore, the listing in the 305(b) reports and on the 303(d) lists should have been for the UT at RM 4.85 from RM 0.0 to 0.6 only. The stream segment is impacted by chlorides (in conjunction with total dissolved solids [TDS] and salinity) as a result of brine discharges to surface streams from oil production activities (stripper wells). The period of greatest impact is during low flow (SCM Martin, Inc., 1983; Evaldi and Kipp, 1991).

In the early 1800s, oil was discovered at sites in Kentucky during salt well drilling (SMC Martin Inc., 1983). At that time, oil was considered an unwanted by-product of the process, but in the 1850s, the oil became a desired commodity. Production was high throughout the early 1900s, but yields, and subsequently production, have declined over time. For the past several decades, most wells in Eastern Kentucky yield less than about 10 gallons of oil per day. These are termed 'stripper wells.' Almost half of the producers own only one well, and eight out of ten producers own six wells or fewer. Brine is also extracted during the process, and for each barrel of oil, approximately ten barrels of brine are produced (SMC Martin Inc., 1983). The oil and brine are separated, and the brine is stored in a large tank or discharged to a holding pond. Brine is sometimes disposed of by injection into wells and is also

used to force oil in the well to the surface. Before 1987, brine was also discharged directly to the surface stream. The discharge of brine to the receiving stream adversely affects aquatic life in the stream.

During runoff events, contaminants such as chloride will typically move rapidly through the stream system and become diluted. However, during low-flow conditions there may be only a minor contribution to streamflow from groundwater discharge for many streams (SCM Martin, Inc., 1983). Therefore, only limited dilution of the chloride that is present in the stream or that is discharged to the stream occurs. In addition, some of the flow that may exist in the stream may be from discharges of the brine solution from the separator tanks (discharges or failing separator tanks) or discharges and possibly seepage from holding ponds. Low flow therefore represents the critical condition when adverse stream impacts due to chloride exist in the stream.

#### **Target Identification**

The endpoint or goal of the TMDL is to achieve a chloride concentration (and associated load in lbs/day) that allows for the sustainability of aquatic life in the stream. The chronic chloride criterion to protect Warm Water Aquatic Habitat Use in Kentucky is 600 mg/l (Title 401, Kentucky Administrative Regulations, Chapter 5:031). This criterion was developed from a study conducted in 1985 by the University of Kentucky (Birge et al, 1985) through the KDEP-DOW. Because the critical period of the effect of chloride on water quality occurs during low-flow conditions (as previously discussed), the 7-day, 10-year low-flow value ( $7Q_{10}$ ) was selected as the design flow.

The 7Q<sub>10</sub> flow at the mouth of the UT at RM 4.85 was estimated to be 0.00 cubic feet per second (ft<sup>3</sup>/s). The estimate was based on a combination of: (1) techniques described by Ruhl and Martin (1991); and (2) comparison of drainage area to flow at sites in the Russell Creek and Little Pitman Creek watersheds during low-flow conditions (USGS, 1994). There are some karst features (sinkholes) present along the boundary of the watershed, but probably not enough to cause flow in the UT at RM 4.85 when 7Q<sub>10</sub> conditions exist. There are currently no active permits for the discharge of chloride in the UT at RM 4.85 watershed.

Because the 7Q<sub>10</sub> flow is 0.00 ft<sup>3</sup>/s (and even though the allowable chloride concentration is 600 mg/l), the permissible load of chloride (in lbs/day) at the mouth of the UT at RM 4.85 is 0.00 lbs/day. The UT at RM 4.85 flows into South Fork Russell Creek, and there are no water supply withdrawal locations on South Fork Russell Creek. Therefore, the use of a chloride concentration value of 250 mg/l, which is the state's criterion for drinking water sources, is not necessary.

### **Source Assessment**

Brine was previously discharged directly to streams during oil production activities, but permit limits based on the criterion developed in 1985 were required after 1987. A criminal case was being developed against the only operator in the watershed for directly discharging brine into the stream. That operator subsequently ceased operations and abandoned the site in 1994 or 1995. There have been no other operations in the watershed since that time (personal commun., Reese, KDEP-DOW, 2000). There are currently no active permits for the discharge of chloride in the watershed of the UT at RM 4.85 of South Fork Russell Creek. However,



there are some abandoned wells, separator tanks, and holding ponds that exist in the (UT at RM 4.85) watershed. The separator tanks and holding ponds deteriorate over time and are potential contributors of chloride to the streams. The abandoned wells and holding ponds are also potential sources of chloride during even small runoff events.

#### **Linkage Between Numeric Targets and Sources - Model Development**

Data on chloride were collected at several locations in the South Fork Russell Creek watershed (Figure 1). The data are included in a report by the KDEP-DOW (1995) for the December 21, 1993 intensive survey. On December 21, 1993, the UT at RM 4.85 site and the main stem South Fork Russell Creek site had a chloride concentration of 201 and 27.5 mg/l, respectively. The main stem site upstream of the UT at RM 4.85 and a site on a UT not impacted by brine had a chloride concentration of 4.4 and 5.7 mg/l, respectively. For the 1993 survey, streamflow values from nearby sites (USGS, 1994) indicate that the intensive survey was conducted during a period of high-base flow, and that values were well above the 7Q<sub>10</sub> levels. If streamflow would have been lower, closer to 7Q<sub>10</sub> levels, chloride levels would probably have been higher (because of limited dilution potential), but the extent of this potential increase is unknown.

For the December 21, 1993 intensive survey, the flow at the mouth of the UT at RM 4.85 was estimated as 0.2 ft<sup>3</sup>/s. Using this flow value and the concentration value of 201 mg/l, the load at the mouth of the UT at RM 4.85 on December 21, 1993 was 217 lbs/day. The chloride concentration value is less than the water quality standard of 600 mg/l for Warm Water Aquatic Habitat. However, the stream did not support the

designated use of aquatic life as described by the KDEP-DOW biologists (KDEP-DOW, 1995). This seems to indicate that remediation may occur over time as the chloride concentration continues to decrease. The watershed is scheduled to be sampled again between April 2001 and March 2002. If chloride concentrations are still below 600 mg/l and the biological community is no longer impaired, then a request will be made to remove the stream from the list of impaired waters.

### **TMDL Development**

Total maximum daily loads (TMDLs) are comprised of the sum of individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources (which include natural background levels for a given watershed), and a margin of safety. The sum of these components must not result in the exceedance of water quality standards for that watershed. The TMDL is the total amount of pollutant that can be assimilated by the receiving stream without violating water quality standards. The TMDL document establishes the allowable stream loadings that are less than or equal to the TMDL and thereby provide the basis to establish water-quality based controls.

The total allowable chloride load is 0.00 lbs/day for the UT at RM 4.85 of South Fork Russell Creek. There are currently no permitted dischargers of chloride (WLAs) and the 7-day, 10-year low-flow value is 0.00 ft<sup>3</sup>/sec (which is the critical flow condition). Therefore, the current load from WLAs is 0.00 lbs/day. The allowable load for contributions from nonpoint sources and from natural background (LAs) is also 0.00 lbs/day because the 7-day, 10-year low-flow value is 0.00 ft<sup>3</sup>/sec (which is the critical flow condition). Chloride concentrations at the control site (indicative of background

conditions) were about 4 mg/l during the December 1993 synoptic survey, when the stream was flowing. However, because the 7-day, 10-year low-flow value is 0.00 ft<sup>3</sup>/sec, the background load is therefore 0.00 lbs/day. Also, allowable nonpoint source contributions (which would most likely come from failing separator tanks or holding ponds, or seepage from holding ponds) is 0.00 lbs/day.

However, for permit requests that may be received in the future by the KDEP-DOW, the allowable loads provided in this TMDL will be modified to account for the permitted flow. The permittee will be allowed 50 percent of the requested load (in effect, meeting a chloride concentration of 300 mg/l). The remaining 50 percent of the load will be allocated to nonpoint sources of chloride as a margin of safety (implicit) to account for uncontrollable or unknown nonpoint sources (failing separator tanks or holding ponds, abandoned wells, seepage from holding ponds, or other sources).

Permit applications requesting to exceed the 50 percent allowable load allocation would be approved by the KDEP-DOW, provided that the applicant removed an equivalent amount from nonpoint sources in the watershed, such as separator tanks or abandoned holding ponds. At no time would permits be approved beyond 80 percent of the requested load (in effect, meeting a chloride concentration of 480 mg/l). This would provide at least a 20 percent margin of safety (explicit) to account for uncontrollable or unidentified nonpoint sources. The allocations were made in this manner because of the uncertainty of the impact of abandoned ponds and failing separator tanks. An example of the summary of total maximum daily load allocations for chloride for the UT is provided in Table 1, where a permit application requests a discharge of

6,500 gallons per day (0.01 ft<sup>3</sup>/sec) into the UT at RM 4.85 of South Fork Russell Creek.

**Table 1. An Example of the Summary of Total Maximum Daily Load Allocations for Chloride (in pounds per day) for the Unnamed Tributary at River Mile 4.85 of South Fork Russell Creek for a Hypothetical Permit Application for a Discharge of 6,500 Gallons per Day (0.01 ft<sup>3</sup>/sec)**

**NOTE: 7Q10 = 0.00 ft<sup>3</sup>/sec**

<u>Source:</u>	<u>Chloride Load</u> <u>At Mouth</u>
All Sources	31
Background (use 1.0 if computation <1.0)	1
Waste Load Allocations (WLAs)	
Existing permits	0
New permits (no offset)	15
Maximum of (with offset)	25
Load Allocation (LAs)	
If no offset for WLAs	15
Minimum of (with offset)	5

### **Implementation Controls**

Discharge permits were required from oil producers starting in 1987. Throughout the state, many of these permits were not renewed by the producers because production has ceased or has significantly decreased. Production in Kentucky dropped from 17,700 barrels in 1986 to 9,400 barrels in 1996. Correspondingly, production decreased in the South Fork Russell Creek basin. The drop in production may have been the result of a drop in crude oil prices worldwide in the 1990's, making production less economical, particularly for smaller producers. Chloride levels from nonpoint sources should decrease over time as dilution lowers concentration levels in existing ponds. In this respect, this TMDL is a Phased TMDL. Follow-up monitoring will be needed to assess the water quality of the stream. The chloride level for the UT at RM 4.85 on December 21, 1993 was 201 mg/l, which is lower than Kentucky's water quality standard for chloride.

However, the biological assessment on that day showed that the UT at RM 4.85 was not meeting the designated use of aquatic life, indicating that the stream had not recovered from past practices related to the disposal of brine.

If oil production in watersheds in Kentucky appreciably increases (which would most likely result from increasing oil prices or an oil supply shortage), permit compliance would be pursued, and periodic monitoring of stream water quality, including chloride, TDS, and salinity levels, will be conducted as deemed appropriate.

### **References**

Birge, W. J., J. A. Black, A. G. Westerman, T. M. Short, S. B. Taylor, and D. M. Bruser. 1985. Recommendations on numerical values for regulating iron and chloride concentrations for the purpose of protecting warmwater species of aquatic life in the Commonwealth of Kentucky. University of Kentucky. Lexington, KY.

Evaldi, R. D. and J. A. Kipp. 1991. Effects of oil production on water resources in the Kentucky River basin, Kentucky. U.S. Dept. of Interior, Geological Survey, Water-Resources Investigations Report 90-4191.

(KDEP-DOW) Kentucky Department for Environmental Protection - Division of Water. 1995. South Fork Russell Creek (Green River Drainage) biological and water quality investigation. Technical Report No. 50. Department for Environmental Protection. Ky. Natural Resources and Environmental Protection Cabinet, Frankfort, KY.

(KDEP-DOW) Kentucky Department for Environmental Protection - Division of Water. 1996. 1996 Kentucky Report to Congress on Water Quality. Department for Environmental

Protection. Ky. Natural Resources and Environmental Protection Cabinet, Frankfort, KY.

(KDEP-DOW) Kentucky Department for Environmental Protection - Division of Water. 1999. 1998 Kentucky Report to Congress on Water Quality. Department for Environmental Protection. Ky. Natural Resources and Environmental Protection Cabinet, Frankfort, KY.

Ruhl, K. J. and G. R. Martin. 1991. Low-flow characteristics of Kentucky stream. U.S. Dept. of Interior, Geological Survey, Water-Resources Investigations Report 91-4097.

S. M. C. Martin, Incorporated. 1983. The stripper wells of east-central Kentucky: an environmental assessment. S. M. C. Martin Inc. Valley Forge, PA. Ref. #8412-040-94005.

(USGS) United States Geological Survey. 1994. Water resources data for Kentucky, water year 1994. U.S. Dept. of Interior, Geological Survey, Water Data Report KY-94-1.