NEOSHO BASIN TOTAL MAXIMUM DAILY LOAD

Water Body/Assessment Unit: South Cottonwood River
Water Quality Impairment: Mercury

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Upper Cottonwood

County: Marion

HUC 8: 11070202

HUC 11 (HUC 14s)**:** 010 (060, 070, 080)

Drainage Area: 118.1 square miles

Main Stem Segments: WQLS: 17 and 18 beginning at confluence with the Cottonwood River and continuing upstream to headwaters in western Marion County (**Figure 1**).

Tributary Segments: Antelope Creek (19)
Stony Brook (25)
Unnamed Stream (456)

Designated Uses: Expected Aquatic Life Support, Secondary Contact Recreation, Domestic Water Supply, Food Procurement, Groundwater Recharge, Industrial Water Supply, Irrigation Use, Livestock Watering use for Main Stem Segments 17 and 18.

Impaired Use: Expected Aquatic Life Support

Water Quality Standard: Aquatic Life Use Chronic Water Quality Standard (WQS) = 0.012 µg/L (KAR 28-16-28e(c)(2)(F)(ii))

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

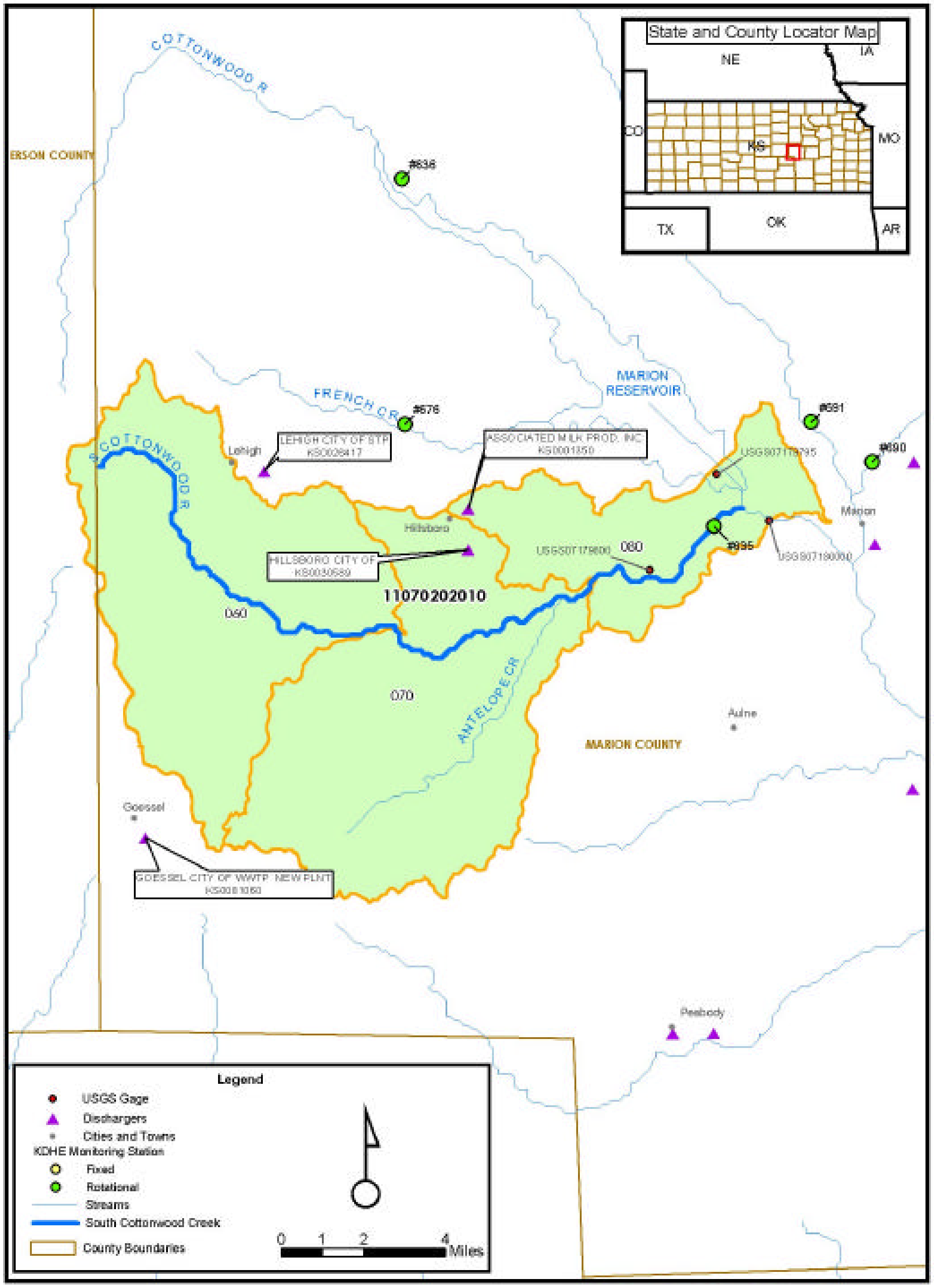
Level of Support for Designated Use under 2002 303(d): Not Supporting Aquatic Life

Monitoring Site: Station 635 near Canada

Period of Record Used for Monitoring and Modeling: 1993, 1997, and 2001 for Station 635. Generalized Watershed Loading Function (GWLF) modeling period for soils data is 1999 – 2003.

Flow Record: Cedar Creek near Cedar Point flow record from 1938 to 2002 (USGS 07180500) matched to South Cottonwood River near Marion (USGS 07179850). A summary of the flow data used to generate the load duration curves are included in **Table B-1** of the TMDL report.

Figure 1 South Cottonwood River Location Map



Long Term Flow Conditions: 10% Exceedance Flows = 79 cfs, 95% = 1.1 cfs

Critical Condition: All seasons; median flows

TMDL Development Tools: Load Duration Curves, Generalized Watershed Loading Function Model (GWLF), and outputs from the Regional Modeling System for Aerosols and Deposition (REMSAD)

Summary of Current Conditions:

Estimated Average Non-point Load of Mercury: **0.031 lb/day** (11.3 lb/yr)
(derived from GWLF annual estimate)

Estimated Point Source Load: **0.0000038 lb/day**
(assumed mercury concentration multiplied by Hillsboro MWTP design flow)

Summary of TMDL Results:

Average TMDL: **0.000596 lb/day**

Waste Load Allocation (WLA): **0.0000038 lb/day** (Hillsboro MWTP)

Average Load Allocation (LA): **0.00053 lb/day**
(Average LA = average TMDL –average WLA – average MOS; see **Figure 7** for LA at specific flow exceedance ranges)

Average Margin of Safety (MOS): **0.000059 lb/day**

TMDL Source Reduction:

WLA Sources (MWTP): No reduction necessary

Non-Point Sources **0.030 lb/day (98.3%)**
(equal to TMDL reduction)

GWLF Modeling for Generating Load Estimates:

Existing non-point source loads of mercury to South Cottonwood Creek were estimated using the Generalized Watershed Loading Function (GWLF) (Haith et al. 1996) model. The model, in conjunction with some external spreadsheet calculations, estimates dissolved and total mercury loads in surface runoff from complex watersheds such as South Cottonwood Creek. Both surface runoff and groundwater sources are included in the simulations. The GWLF model requires daily precipitation and temperature data, runoff sources and transport, and chemical parameters. Transport parameters include areas, runoff curve numbers for antecedent moisture condition II, and the erosion product KLSCP (Universal Soil Loss Equation parameters) for each runoff source. Required watershed transport parameters are groundwater recession and seepage coefficients, available water capacity of the unsaturated zone, sediment delivery ratio, monthly values for evapotranspiration cover factors, average daylight hours, growing season indicators, and rainfall erosivity coefficients. Initial values must also be specified for unsaturated and shallow saturated zones, snow cover, and five-day antecedent rainfall plus snowmelt. The GWLF model itself estimates both surface runoff and sediment yield from the modeled watershed. The external spreadsheet calculations require data for mercury in soils as well as information pertaining to water column mercury concentrations.

Input data for mercury in soils were obtained from SCS and USGS (e.g. Juracek, K. E. and D. P. Mau. 2002 and 2003). For modeling purposes, South Cottonwood Creek was divided into several subwatersheds. The model was run for each subwatershed separately using a five-year period, January 1998 - December 2002, and first year results were ignored to eliminate effects of arbitrary initial conditions. Daily precipitation and temperature records for the period were obtained from the Western Regional Climate Center (Haith et al. 1996). All transport and chemical parameters were obtained by general procedures described in the GWLF manual (Haith 1996), and values used in the model are in Appendix. Parameters needed for land use were obtained from the State Soil Geographic (STATSGO) Database compiled by Natural Resources Conservation Service (NRCS) (Schwarz and Alexander 1995).

For each land use area shown on **Figure 4**, NRCS Curve Number (CN), length (L), and gradient of the slope (S) were estimated from intersected electronic geographic information systems (GIS) land use and soil type layers. Soil erodibility factors (Kk) were obtained from the STATSGO database (Schwarz and Alexander 1995). Cover factors (C) were selected from tables provided in the GWLF manual (Appendix C). Supporting practice factors of P = 1 were used for all source areas for lack of detailed data. Area-weighted CN and Kk, (LS)k, Ck, and Pk values were calculated for each land use area. Coefficients for daily rainfall erosivity were selected from tables provided in the GWLF manual. Model input variables and model outputs are shown in Appendix C.

To calculate the watershed yield for mercury, the GWLF model was run to generate the average annual runoff and average annual sediment load generated from each subwatershed. This modeling was conducted based on average sediment mercury concentrations derived from several USGS studies of lake and river bottom sediments in Kansas (Juracek and Mau 2002, 2003). The average sediment mercury concentration for this area is approximately 0.2 µg/g (ppm). This is generally consistent with the range of mercury concentrations summarized in Section 2. This mass concentration of mercury in sediments was used in conjunction with the TSS concentrations in the ambient sampling to determine the particulate portion of the ambient total mercury results that are attributable to mercury in suspended sediments. The remainder of the ambient total mercury sampling results are, therefore, dissolved mercury concentrations.

Table 1 Estimated Annual Average Mercury Loading from Watershed

Source	(lb/yr)
Soil Erosion Load	0.13
Runoff Load	11.19
Total	11.32

This ambient dissolved mercury concentration was conservatively assumed to be the same concentration as in the runoff generated from the watershed. This fraction was estimated using partitioning assumptions implicit in the model. In addition, the average sediment concentration of 0.2 µg/g of mercury in soil was used with the GWLF generated average annual sediment yield to calculate the average annual mercury yield associated with sediment.

Regional Modeling System for Aerosols and Deposition: Atmospheric deposition is a contributing source of mercury load in the South Cottonwood River watershed. Both the wet and dry mercury deposition rates were derived from REMSAD model simulations provided by ICF Consulting (ICF, 2004). In work for EPA Office of Water (OW), ICF Consulting has developed REMSAD model input files for the simulation of mercury for the 1998 calendar year. ICF has also developed a method called tagging that allows the estimation of the contribution of emissions from specific areas or specific emissions categories to deposition of mercury. These 1998 modeling files, comprising meteorological inputs, criteria pollutant emissions, and mercury emissions, were used as the basis for these simulations

The REMSAD model outputs for wet and/or dry deposition were converted to GIS files, allowing the correlation of the model results with information stored in GIS systems. These GIS files were intersected with coverages of the South Cottonwood Creek watershed to provide spatially weighted averages of both wet and dry mercury deposition in the watershed.

Load Duration Curves: Because loading capacity is believed to vary as a function of the flow present in the stream, **Table 2** was prepared to show the number of water quality samples exceeding the chronic water quality standard (WQS) for mercury as a function of flow during different seasons of the year. This table displays a continuum of desired loads over all flow exceedance ranges, rather than fixed at a single value. Ambient water quality data from the KDHE rotational sampling site 635 were categorized for each of the three defined seasons: spring (Apr-Jul), summer-fall (Aug-Oct) and winter (Nov-Mar). Flow data and ambient water quality data for mercury, collected during 1993, 1997, and 2001, from station 635 are provided in Appendix B, **Table B-2**. High flows and runoff generally equate to median flows (e.g. about 50% flow exceedance); baseflow and point source influences generally occur in the 75-99% (lower) flow exceedance range.

From **Table 2** a total of two excursions of the chronic WQS for total mercury were observed (out of a total of 12 samples collected) during rotational monitoring, consisting of one during January and one during September 2001. Both exceedances occurred during moderate flows. These two exceedances account for the impaired water body designation and inclusion on the 2002 Kansas §303(d) list.

Table 2 Number of Samples Exceeding Mercury Public Health Criteria by Flow during Spring, Summer/Fall, and Winter

Station	Season	Percent Flow Exceedance						Cumulative Frequency
		0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	
South Cottonwood River (635)	Spring	0	0	0	0	0	0	0/4 (0%)
	Summer-Fall	0	0	1	0	0	0	1/2 (50%)
	Winter	0	0	0	1	0	0	1/6 (16.7%)

Figure 2 compares KDHE measured mercury concentrations with the chronic WQS for total mercury. As can be seen on the diagram, a total of two exceedances have been measured during that time out of the 12 samples taken, although the analytical detection limit (0.5 µg/L) is well above the chronic water quality criterion (0.012 µg/L).

Figure 2 Comparison of Total Mercury Concentrations with Aquatic Life Use Chronic Criterion for Monitoring Station #635

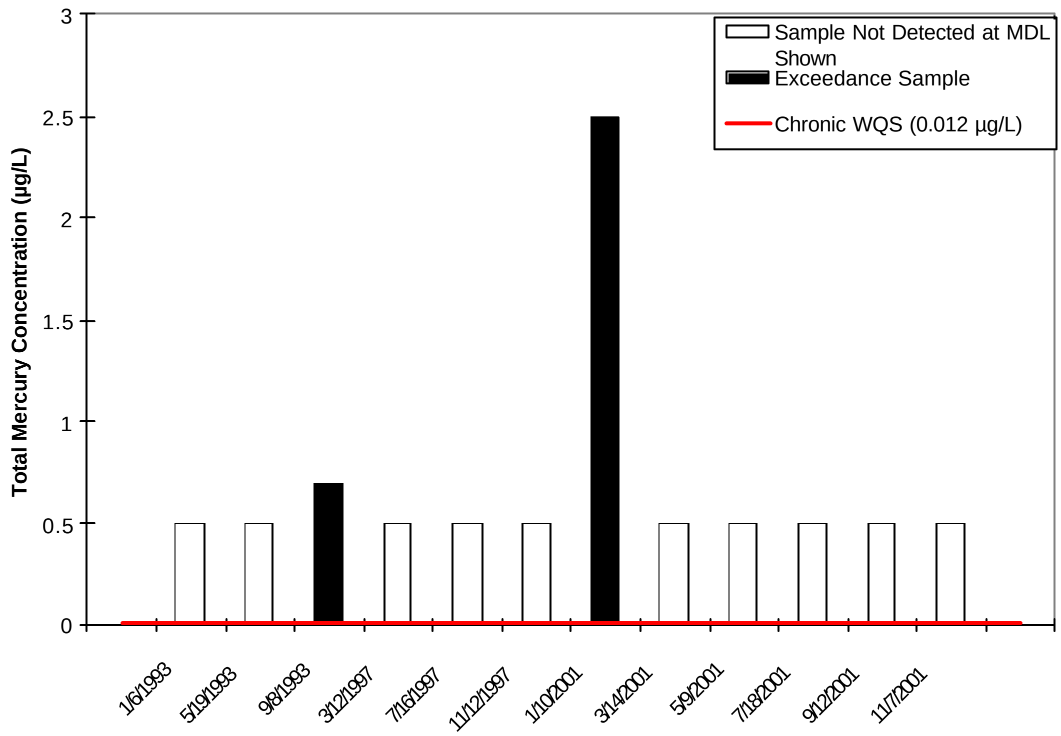
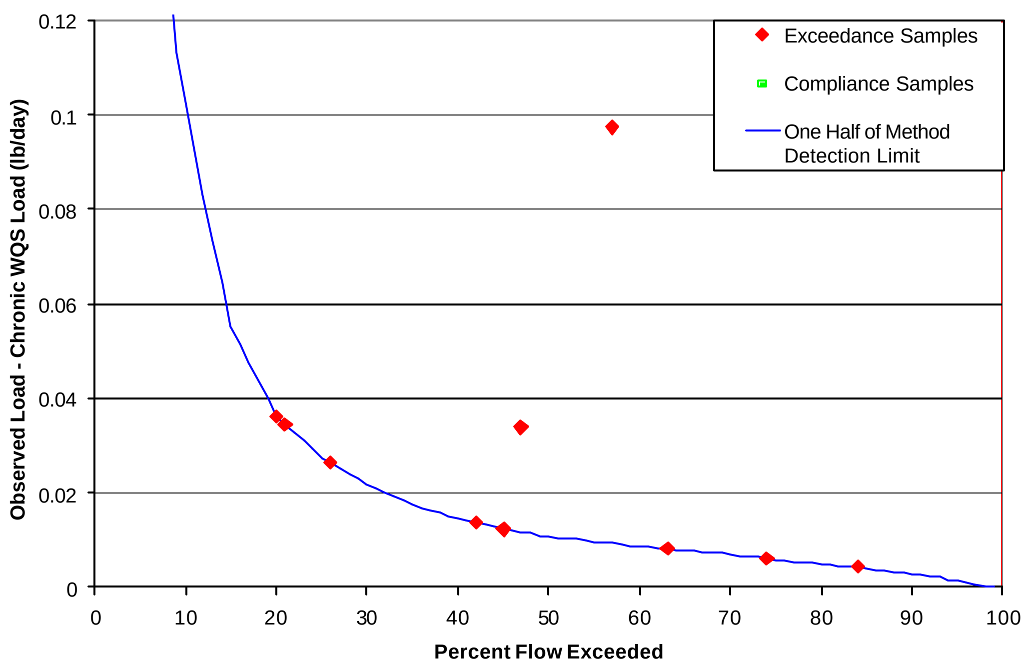


Figure 3 Exceedances of Mercury Chronic Criterion Load as a Function of Percent Flow Exceedance



Estimated South Cottonwood River flow data for the associated sample date was used to estimate both the observed load and the chronic WQS load (**Figure 3**). Measured mercury concentration and the chronic criterion load were used to calculate the observed load and the assimilative capacity based on the chronic WQS, respectively. Differences in the observed load from the chronic WQS load were calculated by subtracting the chronic WQS load from the observed load and positive (i.e. above zero) differences indicate load exceedances. From **Figure 3** it is clear that both exceedances occurred at median range flows (47% and 57%). This observation clearly suggests that mercury loading occurs from nonpoint sources, as the design flow for the MWTP is well below this flow exceedance range.

Desired Endpoints of Water Quality (Implied Load Capacity) at Site 635 over 2007 – 2011

South Cottonwood River was assigned for TMDL development on the KDHE 2002 303(d) list. 40 CFR§130.7(c)(1) states that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standard." The desired endpoint of the South Cottonwood River watershed will be such that total mercury concentrations attributed to identified potential sources of mercury in the watershed remain below the chronic WQS in the stream. This desired endpoint should improve water quality in the stream at both low and high flows. Seasonal variation is accounted for by this TMDL, since the TMDL endpoint accounts for both low and high flows occurring throughout the year.

This endpoint will be reached as a result of expected, though unspecified, reductions in non-point source loading from the watershed resulting from implementation of corrective actions and Best Management Practices, as directed by this TMDL. Achievement of this endpoint is expected to provide full support of aquatic life use chronic criterion for mercury.

3. SOURCE INVENTORY AND ASSESSMENT

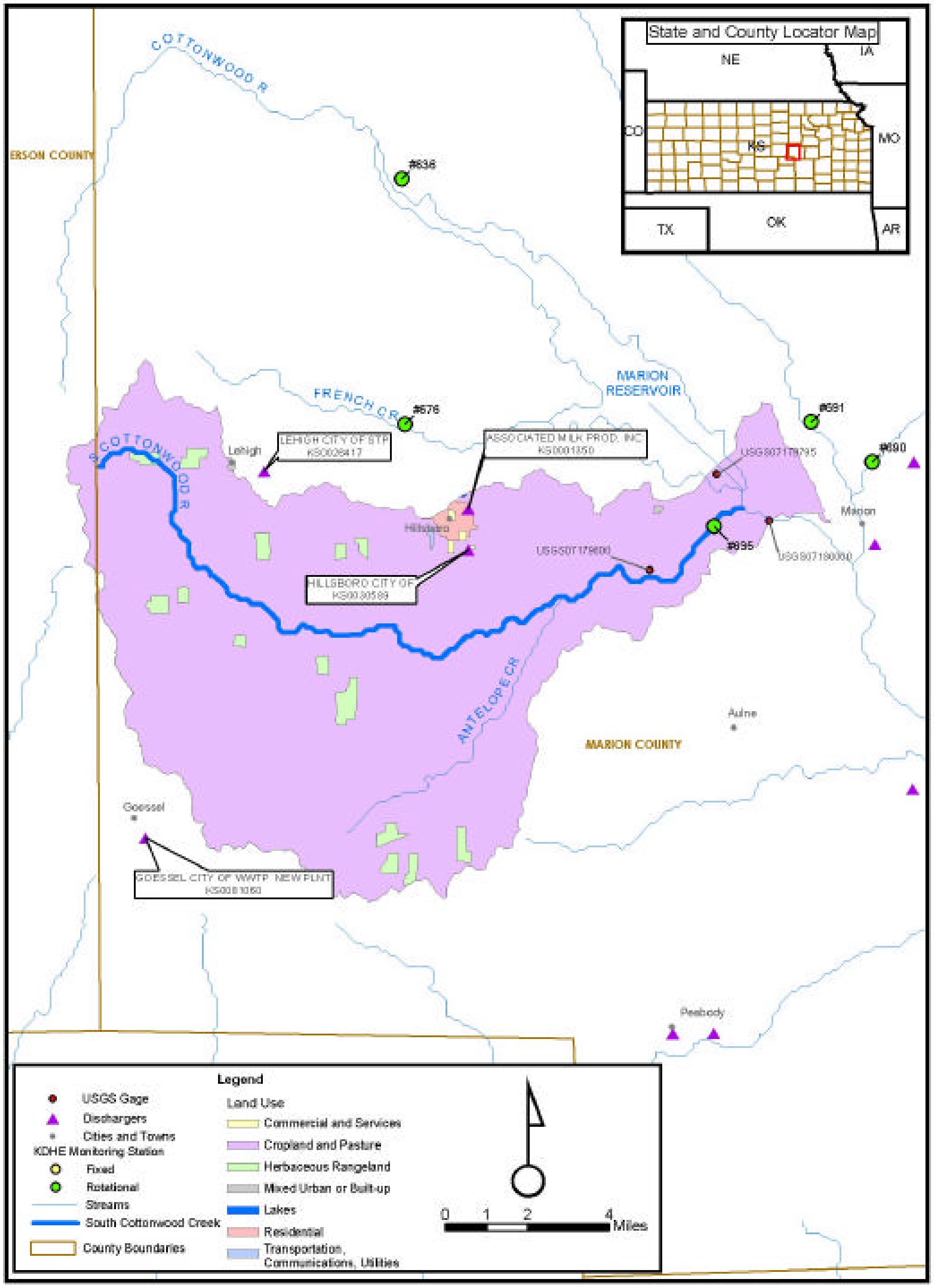
General Watershed Description: The South Cottonwood River watershed lies entirely within Marion County (**Figure 1**), with a drainage area of approximately 118.1 square miles. The watershed's population density is low when compared to densities across the Neosho Basin (6-9 person/mi^2). The rural population projection for Marion County, for example, through 2020 shows modest growth. Population statistics for this part of Kansas show generally light to moderate densities (for example, Marion County's population in 2000 was 13,400). The annual average rainfall in the South Cottonwood River watershed is approximately 32.4 inches (based on data from Topeka, Kansas). Approximately 70 percent of this precipitation falls between April and September. Ten to 18 inches of snow falls in an average winter. Average temperatures vary from 35 degrees in the winter to 78 degrees in the summer.

Land Use: Table 3 shows the general land use categories within the South Cottonwood River watershed derived from USEPA BASINS Version 3.0 land use/land cover data (USGS 1994). Cropland and pasture cover approximately 97% of the total acreage in the South Cottonwood River watershed, with herbaceous rangeland covering 2% and all other uses combined covering less than 1%. Most of the riparian corridor traverses through cropland and pasture and there is an insignificant amount (less than 1% of the total) of commercial or developed land in the watershed. **Figure 4** depicts the spatial distribution of the general land use categories found within the South Cottonwood River watershed.

Table 3 Land Use Categories for South Cottonwood River

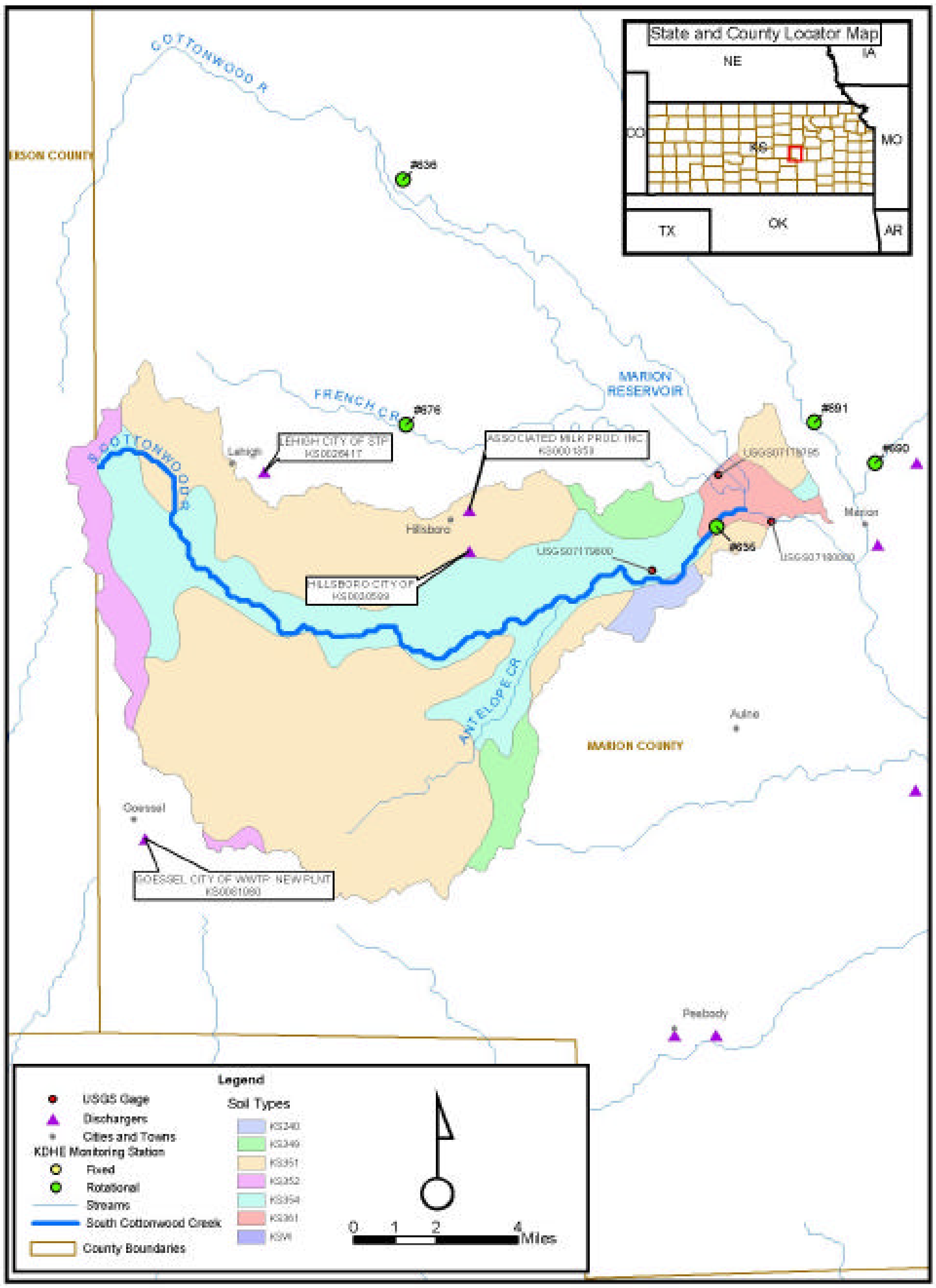
LANDUSE	Total Acres/	%of Total
COMMERCIAL AND SERVICES	93.86	0.12
CROPLAND AND PASTURE	74097.47	97.02
HERBACEOUS RANGELAND	1670.14	2.19
MXD URBAN OR BUILT-UP	52.91	0.07
RESERVOIRS	3.89	0.01
RESIDENTIAL	424.28	0.56
TRANS, COMM, UTIL	27.10	0.04
Totals	**76,370**	**100**

Figure 4 South Cottonwood River Watershed Land Use Map



Soils. **Figure 5**, derived from STATSGO data, generally represents soils types prevalent throughout the South Cottonwood River watershed. Major soil types throughout the region of the South Cottonwood River Watershed consist of silty clay loam, loam, and silt loam (Schwarz and Alexander 1995). Various USGS studies were evaluated that indicate background concentrations of mercury in the surrounding geology of the watershed (Juracek 2003; Mau 2004).

Figure 5 South Cottonwood River Watershed Soils Map



Overview of Mercury Cycle and Sources

The purpose of this TMDL is to establish the acceptable loading of mercury from all sources so that mercury levels in water and, possibly, fish tissue will decline to levels necessary to maintain water quality standards. Mercury is a highly volatile element emitted and cycled in the environment through both natural and anthropogenic processes. The following excerpt from the Louisiana Department of Environmental Quality Mercury 2000 Report, provides a helpful synopsis of the many and varied sources of mercury around the nation (Summary of Issues Related to Mercury Contamination of Fish, LDEQ, March 2000, http://www.deq.state.la.us/surveillance/mercury/mercsumm.htm).

"Ambient concentrations of mercury throughout the United States have increased significantly since the beginning of the industrial revolution. Much of this is due to the fact that mercury is present in coal used at electrical power plants and is used in many products such as thermometers, fluorescent and mercury vapor lights, and electrical switches which may eventually be incinerated or placed in landfills. Mercury in these materials is released to the atmosphere as a gas by coal burning, trash incineration or direct volatilization. In a process similar to acid rain, the mercury is later deposited on the earth's surface through atmospheric deposition. Other sources of mercury emissions to the atmosphere include chloralkali plants, which use mercury cathodes to generate chlorine and alkali from brine using electricity, hazardous waste incinerators, and pulp and paper mills."

Although there are many potential sources, the largest anthropogenic source of mercury in water appears to be emissions from coal fired electric plants. Mercury released into the air can travel long distances and then be deposited into streams and lakes through atmospheric deposition (fall-out), making it very difficult to identify specific contaminant sources. Mercury is also released into water and air by some industrial processes, waste incineration, and improper disposal of mercury-containing products.

Mercury exists in the environment in different forms: Hg(0) (elemental), Hg(II) (inorganic), and CH3Hg (organic). In the atmosphere, mercury exists almost entirely in the relatively insoluble gaseous Hg(0) state which can be transported over long distances from the source. Elemental Hg(0) can be converted in the atmosphere to the more soluble inorganic form that can be readily deposited to land or water. Wet and dry deposition is the mechanism by which mercury emitted into the atmosphere is transported to land and surface water. In surface waters, methylation of mercury can occur where inorganic Hg (II) binds to sediment or suspended solids and is transformed into methylmercury, which is created when bacteria convert inorganic mercury into an organic compound (CH3Hg). Methylmercury is the only form of mercury that can be readily bioaccumulated by fish, humans, and other organisms.

Point Source Discharges

KDHE (2002) reported one NPDES permitted wastewater discharger within the South Cottonwood River watershed, which is the Hillsboro MWTP (**Table 4**).

Table 4 NPDES Permitted Discharger to South Cottonwood River

Discharging Facility	Stream Reach	Segment	Design Flow	Type

Hillsboro MWTP	S. Cottonwood River	18	0.065 cfs	mechanical

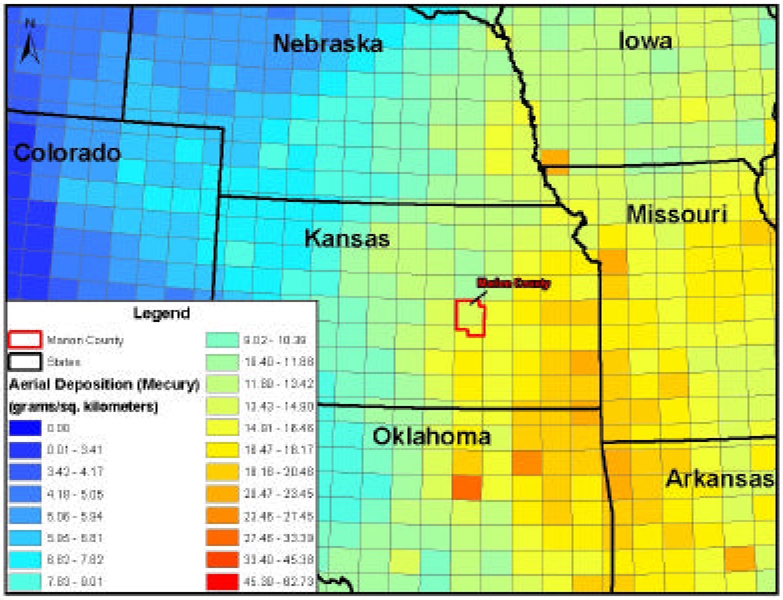
The city of Hillsboro relies on an activated sludge mechanical system for treatment of their wastewater. The permit for the City of Hillsboro has recently been renewed. Examination of the effluent monitoring requirements for the city of Canton indicates that no permit limits have been set for mercury, and thus no monitoring data were available from this MWTP. The population projection for Hillsboro to the year 2020 indicates significant growth (47% increase). Populations of future water use and resulting wastewater still appear to be within the design flow of the current system's treatment capacity. At site 635, excursions from the mercury chronic WQS appear to occur primarily under runoff conditions or higher flows. Of significance to point sources are the lack of excursions under low flow in all seasons, especially during winter; therefore point sources are an insignificant source of mercury loading in the watershed.

Non-point Sources

Regional Geology: Various regional studies of sediment and lake bottom sediment cores indicate that background traces of mercury are present throughout eastern Kansas (Christensen 1999; Juracek 2003). Based on a cursory literature review of the geologic and soil properties of the region the average sediment mercury concentrations for this area are approximately 0.2 µg/g (Christensen 1999). Therefore background sources of mercury are present in the South Cottonwood River watershed. The background sources of mercury are most probably associated with historical loadings from atmospheric deposition.

Atmospheric Deposition: Specific data summarizing mercury loading to the South Cottonwood River watershed from atmospheric deposition was provided by the EPA contractor ICF Consulting. The data acquired that clearly indicates atmospheric deposition as a pathway for mercury loading to the South Cottonwood watershed was derived from the modeling outputs of the Regional Modeling System for Aerosols and Deposition (REMSAD) (Meyers, Wei 2004). **Figure 6** displays the average loading of total mercury in Marion County, Kansas in 1998 at approximately 13.43 g/sq.km.

Figure 6 1998 Estimated Mercury Deposition in Marion County, Kansas (g/sq.km)



Source: USEPA, ICF Consulting

Utilizing the national air emission databases [Toxic Release Inventory (TRI), Toxic Emissions Data Inventory (TEDI)], which are supported by the monitoring stations of the Mercury Deposition Network (MDN) the REMSAD model outputs, provide the most detailed data available to quantify wet and dry deposition of mercury to the South Cottonwood River watershed. The Kansas Environmental Air Release Profile for 2000 (KDHE 2000) reports approximately 1,405 lb/yr of mercury released from eight coal-fired plants located in Southeastern Kansas. KDHE Environmental Remediation has an ongoing mercury hazard and cleanup awareness campaign described at http://www.kdhe.state.ks.us/mercury/index.html.

Based on the REMSAD data, **Table 5** shows that the total estimated mercury loading from air sources to the watershed from both wet and dry deposition is 11.97 lb/yr. Therefore, it would appear that non-point source pollutants from atmospheric deposition represent over 99 percent of the total loading to the watershed. Total wet deposition of mercury estimated by REMSAD for the South Cottonwood River watershed is 8.37 lb/yr and the total estimated dry deposition is 3.6 lb/yr. The values demonstrate that atmospheric deposition is a significant pathway of mercury loading to the South Cottonwood River.

Table 5 Estimated Annual Average Mercury Loading from Air Sources

Source	(lb/yr)
Dry Deposition	3.6
Wet Deposition	8.37
Total	11.97

Anthropogenic non-point sources: KDHE (pers. comm. 2004) identified an historic source of mercury in the South Cottonwood River watershed. A battery recycling facility (without secondary smelting) was located in the town of Hillsboro from about 1991 through 1993. Lead-acid batteries were reportedly dismantled and the sulfuric acid was converted to fertilizer which was later sold to area farmers for land application. No NPDES permit was ever filed for this facility and therefore there is limited site specific mercury data from this site. It is highly possible that this former battery recycling plant is a significant legacy source of mercury in the watershed.

Other non-point sources of mercury within the watershed may include roads and highways (e.g. from automobile batteries), urban areas and agriculture lands. A common source of mercury includes light ballast, thermostats, and automobile batteries (Kansas Environment 2000 report). However, since no waterbodies in adjacent watersheds are listed on the State 303(d) list and include similar demographic distributions and land use patterns, these disparate anthropogenic non-point sources of mercury would not appear to be the cause of the mercury impairment.

Non-point Source Assessment Conclusion

The above discussion concerning nonpoint sources of mercury is a qualitative assessment of the potential anthropogenic sources of mercury in the South Cottonwood River watershed. The three main sources of mercury identified are: background sources, atmospheric deposition, and other anthropogenic non-point sources. It is uncertain what percentage of the total estimated current mercury loading is associated with these three source categories. However a number of assumptions can be made that support the premise that the majority of the non-point source loading from mercury is emanating from the derelict battery site and atmospheric deposition. First, due to the relatively low density of human population in the South Cottonwood River watershed, it is not likely that diffuse sources such as agriculture, automobiles, and landfills would contribute to the mercury impairment in the watershed. Second, background sources of mercury in soils constitute a very minor portion of the available mercury existing in the watershed. The average sediment mercury concentration for this area is approximately 0.2 µg/g (ppm).

Therefore it is likely that atmospheric deposition and the individual legacy non-point source of mercury from the battery recycling plant are the two primary origins of the mercury loading contributing to the water quality impairment in the South Cottonwood River watershed.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

Following is a discussion of the results of the TMDL process for total mercury at South Cottonwood River, and an evaluation of potential sources and responsibility.

TMDL Calculations

Figure 7 shows the load duration curve for mercury which also defines the South Cottonwood River TMDL, WLA, LA, and MOS. The Information Sheet at the beginning of the document summarizes all the numbers and calculations. **Figure 7** also depicts measured loadings of mercury in relation to the TMDL.

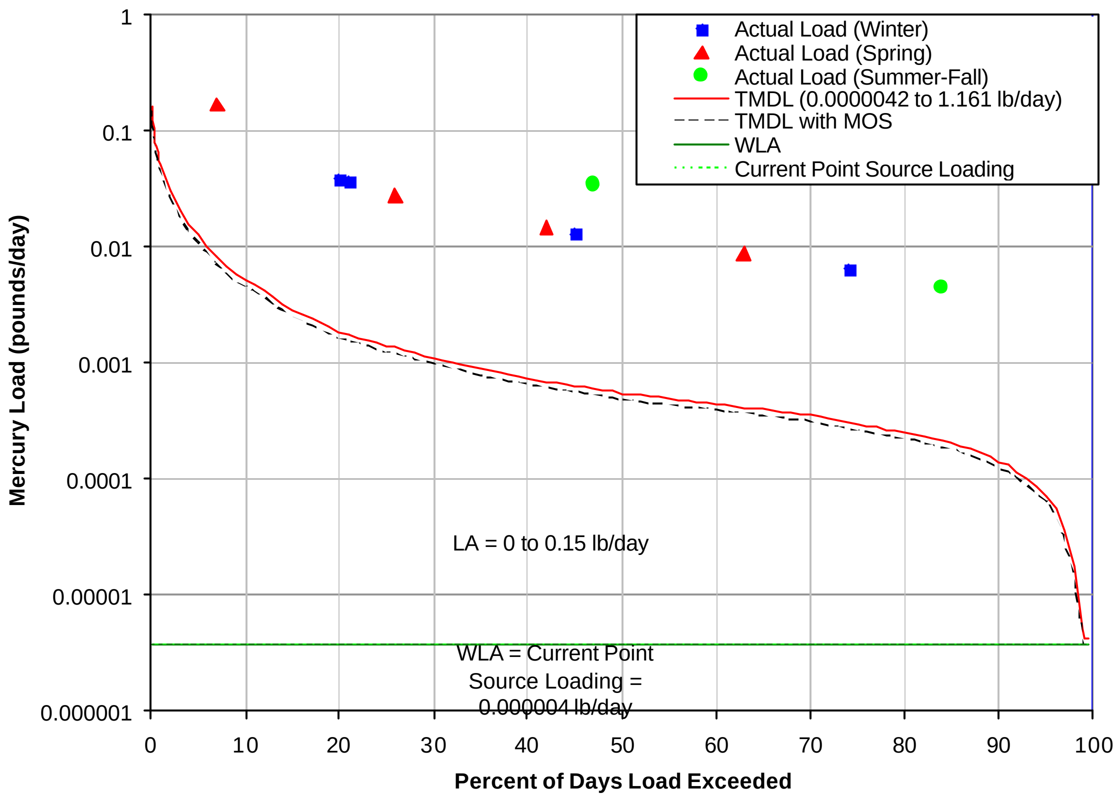
The area below the TMDL with MOS and above the WLA represents the LA in **Figure 7. Figure 7** shows the LA range based on flow exceedance. Current point source loading is shown on **Figure 7** as a line below the WLA estimate, indicating that no point source load reduction would be necessary. The current non-point loading estimate is not shown in **Figure 7** because the GWLF estimate is based on average loadings rather than flow exceedance ranges. Therefore the current non-point loading estimate was only compared to the average TMDL value. Based on these calculations, the calculated average TMDL for mercury in South Cottonwood River is 0.0072 lb/day (2.63 lb/yr).

The calculated average TMDL from the load duration curve for total mercury in South Cottonwood River was computed:

Average TMDL (0.000596 lb/day) = LA (0.00053 lb/day) + WLA (0.0000038 lb/day) + MOS (0.000059 lb/day)

These values, along with other key loading and allocation estimates, are shown in the Current Condition (**Section 2**).

Figure 7 Load Duration Curve Used to Derive TMDL



Results of normality testing. For the data sets used to support all averaged load estimates such as TMDL, LA/WLA, MOS, and load reduction, results of normality testing indicated that these data were not normally distributed, and it was necessary to log-transform the data before the calculations could be completed.

TMDL Pollutant Allocation and Reductions

Any allocation of wasteloads and loads will be made in terms of total mercury reductions. Yet, because mercury loadings are a manifestation of multiple factors, the initial pollution load reduction responsibility will be to decrease the total mercury inputs over the critical range of flows encountered on the South Cottonwood River system. Allocations relate to the average mercury levels seen in the South Cottonwood River system at site 635 for the critical higher flow conditions. Additional monitoring over time will be needed to further ascertain the relationship between mercury reductions of non-point sources, flow conditions, and concentrations within the stream.

In calculating the TMDL the average condition is considered across the seasons to establish goals of the endpoint and desired reductions. Therefore, the target chronic WQS mercury level was multiplied by the average daily flow for South Cottonwood River across all hydrologic conditions. This is represented graphically by the integrated area under the mercury load duration curve (**Figure 7**). The area is segregated into allocated areas assigned to point sources (WLA) and non-point sources (LA). Future increases in wasteloads should be offset by reductions in the loads contributed by non-point sources. This offset, along with appropriate limitations, is expected to eventually eliminate the impairment.

WLA for South Cottonwood River

The WLA for the South Cottonwood River TMDL used the design flow for the permitted point source discharge, and the mercury chronic WQS. The total estimated WLA for this NPDES discharge is 0.000046 lb/day. **Figure 7** clearly shows that based on the estimated WLA, there appear to be no historical excursions for mercury from point sources.

WLA (0.0000038 lb/day) = design flow (0.065 cfs) * chronic WQS (0.000012 mg/L) * 5.394

The WLA for the South Cottonwood River TMDL used the design flow for the permitted point source discharge, and assumed a generalized mercury concentration of 2.5 µg/L based on one-half the detection limit for mercury discharges in treated wastewater.

LA for South Cottonwood River

The LA was estimated by filling in the following formula:

LA (0.00053 lb/day) = TMDL (0.000596 lb/day) – MOS (0.000059 lb/day) – WLA (0.0000038 lb/day)

This calculation strongly suggests that the majority of mercury loading occurs from non-permitted nonpoint discharges, and that the contribution from NPDES point source discharges is by comparison virtually negligible. The load from all non-point sources is contributed from various land uses or atmospheric deposition, although the majority of the LA appears to come from soil loading, which may be partially representative of natural background.

The LA assigns responsibility for maintaining the historical average in-stream mercury levels at site 635 to below chronic WQS values for specific flow exceedance levels. As seen on **Figure 7**, the assimilative capacity for LA equals zero for flows from 0 - 0.065 cfs (99.2 - 100% exceedance), since the flow at this condition may be entirely effluent created, and then increases to the TMDL curve with increasing flow beyond 0.065 cfs.

Point Source Load Reduction

Point sources are responsible for maintaining their systems in proper working condition and appropriate capacity to handle anticipated wasteloads of their respective populations. The State and NPDES permits will continue to be issued on five year intervals, with inspection and monitoring requirements and conditional limits on the quality of effluent released from these facilities. Ongoing inspections and monitoring of the systems will be made to ensure that minimal contributions have been made by this source.

Based upon the preceding assessment, the sole permitted point source discharge is the MWTP from the city of Canton, which may have contributed a load of total mercury into the South Cottonwood River watershed upstream of site 635. This discharge was considered in the WLA estimate. The design flow of the discharging point source equals the lowest flows seen at station 635 (95-99% flow exceedance), and the WLA equals the TMDL curve across this flow exceedance range (**Figure 7**). The anticipated WLA source reduction is expected to be zero.

Non-Point Source Load Reduction

Based on the prior assessment of sources, the distribution of excursions from water quality standards at site 635 and the relationship of those excursions to runoff conditions and seasons, non-point sources are regarded as the primary contributing factor to the occasional total mercury excursions in the watershed.

The LA equals zero for flows at 0.065 cfs (99.2 - 100% exceedances), as seen on **Figure 7**), since the flow at this condition may be entirely effluent created, and then increases to the TMDL curve with increasing flow beyond 0.065 cfs (**Figure 7**). Sediment control practices such as buffer strips and grassed waterways should help reduce any anthropogenic non-point mercury loadings under higher flows as well as reduce the sediment transported to the stream that may occur during the critical flow period.

The anticipated average LA source reduction was calculated by subtracting the LA from the GWLF non-point loading estimate. This estimate is 0.024 lb/day, which represents a 79.1% reduction from current non-point loading estimates.

Margin of Safety

Federal regulations [40 CFR §130.7(c)(1)] require that TMDLs take into consideration a margin of safety (MOS). The MOS is a conservative measure incorporated into the TMDL equation that accounts for the uncertainty associated with calculating the allowable mercury pollutant loading to ensure water quality standards are attained. USEPA guidance allows for use of implicit or explicit expressions of the MOS, or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a specific percentage of the TMDL is set aside to account for uncertainty, then the MOS is considered explicit. This mercury TMDL relies on both an implicit and explicit MOS derived from a variety of calculations and assumptions made which are summarized below. The net effect of the TMDL with MOS is that the assimilative capacity of the watershed is slightly reduced to ensure protection of the designated use. This TMDL incorporates an explicit MOS by using a curve representing 90% of the TMDL as the average MOS.

The following conservative assumptions were made providing an implicit MOS. The estimated mercury concentration in runoff is equivalent to the concentration of mercury in the originating rainfall, which assumes no loss of mercury from adsorption or any other mechanism during overland flow. Calculations for mercury concentrations associated with TSS loading from soil erosion to the water column assume no loss of mercury from any mechanism during transport. NPDES permitting procedures used by KDHE are conservative and provide an implicit MOS built into the calculations (e.g., whether or not to allow a mixing zone). As an example, the calculation to determine the permit limit is based on the long term average treatment efficiency based on a 90 percent probability that the discharge will meet the WLA. It is common knowledge that a mechanical MWTP's efficiency is greater during prolonged dry weather than under wet weather conditions. The log-normal probability distribution curves for treatment plant performance used by USEPA to determine the long-term average takes into account wet weather reduction in efficiency for calculating the 90th percentile discharge concentration of mercury (USEPA 1996). During wet weather periods there would be water flowing in South Cottonwood River, further diluting the MWTP discharge. Another conservative assumption that is the WLA calculation uses the design flow rather than actual effluent flows, which are lower. This maximizes the predicted impact of discharges, and provides an allocation that is more protective.

Uncertainty Discussion

Key assumptions used. Following is a list of operating assumptions needed, due in part to the limited data set used to support the calculations.

- The lowest stream flow was adjusted to assure that it would not drop below the design flow of the Hillsboro MWTP
- Assumed that discharged concentration occurred at one-half the analytical detection limit for mercury, 2.5 µg/L is the assumed value.
- Matched flow data for USGS station for Cedar Creek near Cedar Point was used rather than actual flow for South Cottonwood River.
- Total loading data was not normally distributed, and required log-transformation to support the calculations.

The LDC method is used to calculate TMDLs in general because it relies on measured water quality data and paired water hardness data, and a wide range of "flow exceedance" data representing a complete range of flows anticipated at South Cottonwood River. Given the lack of water quality data and sediment data, GWLF and the supporting REMSAD model outputs provide the most reliable method for deriving current non-point source loading and non-point load reduction estimates.

Using measured WQS excursions (Figure 3) to estimate load reduction. Load reduction is defined as the positive difference between the WQS and the measured load (exceedance), and may be estimated from the load exceedances shown on **Figure 2**. However, due to the small number of exceedances from the overall water quality monitoring data, the uncertainty was too large and therefore the GWLF model load estimate was used instead.

Comparing GWLF output with LDC TMDL. It is possible to compare the non-point loads for mercury using the GWLF and LDC methods. The three basic differences between the GWLF and LDC approaches to making these estimates are: (1) GWLF output is based on watershed precipitation data rather than measured flow data and therefore results would not be expected to be comparable between the two methods; (2) the GWLF algorithms more completely account for mercury loadings (including natural background concentrations of mercury in soil) because GWLF estimates the total amount of sediment loading from the watershed to the receiving water. Finally, (3) the ambient water quality data used to develop the LDC only accounts for the portion of mercury detected in the water column and does not take into account the mercury loading from the watershed that resides in the bed load. This fact also partially explains the higher mercury loading estimates provided by the GWLF output.

Seasonal Variability

Federal regulations [40 CFR §130.7(c)(1)] require that TMDLs take into consideration seasonal variability in applicable standards. Chronic WQS exceedances occurred during spring and high flow seasons only, suggesting that seasonal variability is a controlling factor in this watershed.

State Water Plan Implementation Priority: Because the mercury impairment is due to atmospheric deposition and an individual legacy non-point source, this TMDL will be a Low Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Upper Neosho Basin (HUC 8: 11070202) with a priority ranking of 20 (High Priority for restoration).

Priority HUC 11s and Stream Segments: Because atmospheric deposition affects the entire watershed, no priority subwatersheds or stream segments will be identified.

5. IMPLEMENTATION

Desired Implementation Activities

1. Monitor any anthropogenic contributions of mercury loading to river.

Implementation Programs Guidance

Until the 2007 assessment of the continuation of monitoring is made, no direction can be made to those implementation programs.

Timeframe for Implementation: Continued monitoring over the years from 2002 to 2007.

Targeted Participants: Primary participants for implementation will be KDHE.

Milestone for 2007: The year 2007 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from the South Cottonwood River watershed should indicate no evidence of increasing mercury levels relative to the conditions seen in 1993-2001. Should the case of impairment remain, source assessment, allocation and implementation activities will ensue.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Department of Health and Environment.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollution.

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.

4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan.*

6. The *Kansas Water Plan* and the Neosho Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund, annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollution reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a Low Priority consideration.

Effectiveness: Appendix A provides a variety of strategies and actions that demonstrate reasonable assurance that non-point source mercury loadings can be reduced to the level necessary to achieve water quality standards in South Cottonwood River. The future renewed and revised NPDES permits for the two permitted discharges, the city of Canton, will provide reasonable assurances by limiting total mercury (concentration and load) to the effluent of both facilities. A reopener clause in the NPDES permit may be necessary should future ambient water monitoring show no progress or an increase in the ambient mercury concentration associated with point source discharges.

6. MONITORING

KDHE will continue to collect bimonthly samples at rotational Station 635 in 2004 and 2008 including total mercury samples in order to assess progress and success in implementing this TMDL. Should impaired status remain, the desired endpoints under this TMDL may be refined and more intensive sampling may need to be conducted under higher flow conditions over the period 2007-2011. Use of the real time flow data available at the South Cottonwood River stream gauging station, or other appropriate station, can help direct these sampling efforts. Also, use of USEPA Method 1669 - Sampling Ambient Water for Trace Metals at USEPA Water Quality Criteria Levels for ultra-clean mercury sampling and analysis could help to further define potentially bioavailable and toxic forms of mercury occurring in the subwatershed.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Neosho Basin were held January 9, 2002 in Burlington, March 4, 2002 in Council Grove, and July 30, 2004 in Marion. An active Internet Web site was established at http://www.kdhe.state.ks.us/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Neosho Basin.

Public Hearing: Public Hearings on the TMDLs of the Neosho Basin were held in Burlington and Parsons on June 3, 2002.

Basin Advisory Committee: The Neosho Basin Advisory Committee met to discuss the TMDLs in the basin on October 2, 2001, January 9, March 4, and June 3, 2002.

Discussion with Interest Groups: Meetings to discuss TMDLs with interest groups include:
Kansas Farm Bureau: February 26 in Parsons and February 27 in Council Grove

Milestone Evaluation: In 2007, evaluation will be made as to the degree of implementation that has occurred within the watershed and current condition of the South Cottonwood River watershed. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

Consideration for 303(d) Delisting: The wetland will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2007-2011. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision will come in 2003 that will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2003-2007.

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APPENDIX A
WATER QUALITY DATA

Table A-1: Data Used to Generate the South Cottonwood River Flow Duration Curve

	Flow (cfs)	
P	07180500	S. Cottonwood River
99.5	0	0.064985301
99.4	0.02	0.064985301
99.3	0.05	0.064985301
99.2	0.1	0.064985301
99.1	0.16	0.064985301
99	0.2	0.0791
98	1	0.2712
97	1.5	0.565
96	1.8	0.8475
95	2.1	1.1187
94	2.4	1.3334
93	2.7	1.5594
92	3	1.7741
91	3.3	2.0227
90	3.5	2.147
89	3.72	2.3504
88	3.94	2.5538
87	4.16	2.7572
86	4.38	2.9606
85	4.6	3.164
84	4.86	3.2996
83	5.12	3.4352
82	5.38	3.5708
81	5.64	3.7064
80	5.9	3.842
79	6.14	3.9776
78	6.38	4.1132
77	6.62	4.2488
76	6.86	4.3844
75	7.1	4.52
74	7.48	4.7008
73	7.86	4.8816
72	8.24	5.0624
71	8.62	5.2432
70	9	5.424
69	9.44	5.5596
68	9.88	5.6952
67	10.32	5.8308
66	10.76	5.9664
65	11.2	6.102
64	11.68	6.2376
63	12.16	6.3732
62	12.64	6.5088
61	13.12	6.6444
60	13.6	6.78

	Flow (cfs)	
P	07180500	S. Cottonwood River
59	14.08	6.9382
58	14.56	7.0964
57	15.04	7.2546
56	15.52	7.4128
55	16	7.571
54	16.58	7.7292
53	17.16	7.8874
52	17.74	8.0456
51	18.32	8.2038
50	18.9	8.362
49	19.56	8.6106
48	20.22	8.8592
47	20.88	9.1078
46	21.54	9.3564
45	22.2	9.605
44	22.86	9.944
43	23.52	10.283
42	24.18	10.622
41	24.84	10.961
40	25.5	11.3
39	26.52	11.752
38	27.54	12.204
37	28.56	12.656
36	29.58	13.108
35	30.6	13.56
34	31.68	14.238
33	32.76	14.916
32	33.84	15.594
31	34.92	16.272
30	36	16.95
29	37.4	17.854
28	38.8	18.758
27	40.2	19.662
26	41.6	20.566
25	43	21.47
24	44.86	22.826
23	46.72	24.182
22	48.58	25.538
21	50.44	26.894
21	50.44	26.894
20	52.3	28.25
19	54.86	31.188
18	57.42	34.126
17	59.98	37.064
16	62.54	40.002
15	65.1	42.94
14	69.5	50.172

P	Flow (cfs) 07180500	S. Cottonwood River
13	73.9	57.404
12	78.3	64.636
11	82.7	71.868
10	87.1	79.1
9	96.3	88.14
8	109.3	103.96
7	122.3	124.3
6	137.4	155.94
5	171.1	192.1
4	207.7	237.3
3	293.3	316.4
2	460.3	463.3
1	961.7	800.04
0.9	1145.28	861.06
0.8	1270	932.25
0.7	1377.1	1000.05
0.6	1548.6	1096.1
0.5	1548.6	1243
0.4	1850	1412.5
0.3	2057.28	1627.2
0.2	2504.68	1921
0.1	3401.6	2486

Table A-2: Water Quality Data for Station 635 and Matched Flow Data Used to Support the Load Duration Curve

Collection Date	Flow (cfs)	Mercury Concentration (µg/L)	Hg Chronic Criteria (µg/L)
1/6/1993	51	0.5*	0.012
5/19/1993	116	0.5*	0.012
9/8/1993	21	0.7	0.012
3/12/1997	52	0.5*	0.012
7/16/1997	24	0.5*	0.012
11/12/1997	22	0.5*	0.012
1/10/2001	15	2.5	0.012
3/14/2001	50	0.5*	0.012
5/9/2001	42	0.5*	0.012
7/18/2001	12	0.5*	0.012
9/12/2001	4.9	0.5*	0.012
11/7/2001	7.5	0.5*	0.012

Note: * indicates not detected at the method detection limit shown

APPENDIX B
INPUT AND OUTPUT DATA FOR REMSAD/GWLF MODELS

South Cottonwood Input

LAND USE	AREA(ha)	CURVE NO	KLSCP
CROPLAND AND PASTURE	29986.	86.0	0.00140
HERBACEOUS RANGELAND	676.	88.0	0.00130
RESERVOIRS	2.	0.0	0.00000
COMMERCIAL AND SERVICES	38.	98.0	0.00140
MXD URBAN OR BUILT-UP	204.	98.0	0.00140

MONTH	ET CV()	DAY HRS	GROW. SEASON	EROS. COEF
JAN	6.000	9.7	0	.2
FEB	6.000	10.6	0	.2
MAR	6.000	11.8	0	.2
APR	6.000	13	0	.2
MAY	6.000	14	1	.3
JUNE	6.000	14.5	1	.3
JULY	6.000	14.3	1	.3
AUG	6.000	13.4	1	.3
SEPT	6.000	12.2	1	.3
OCT	6.000	11	1	.3
NOV	6.000	10	0	.2
DEC	6.000	9.4	0	.2

ANTECEDENT RAIN+MELT FOR DAY -1 TO DAY -5

0 0 0 0 0

INITIAL UNSATURATED STORAGE (cm) = 10

INITIAL SATURATED STORAGE (cm) = 0

RECESSION COEFFICIENT (1/day) = .01

SEEPAGE COEFFICIENT (1/day) = 0

INITIAL SNOW (cm water) = 0

SEDIMENT DELIVERY RATIO = 0.065

UNSAT AVAIL WATER CAPACITY (cm) = 10

South Cottonwood Output

S_Cottonwood YEAR SIMULATION

YEAR	PRECIP	EVAPOTRANS	GR.WAT.FLOW	RUNOFF	STREAMFLOW
			(cm)		
1	88.2	85.9	0.1	12.2	12.3
2	69.6	61.6	0.0	7.1	7.1
3	108.5	85.0	0.0	24.5	24.5
4	70.8	63.6	0.0	7.1	7.1
5	74.8	59.3	0.0	15.5	15.5

YEAR	EROSION	SEDIMENT	DIS.NITR	TOT.NITR	DIS.PHOS	TOT.PHOS
			(1000 Mg)			
1	16.0	1.0	0.0	0.0	0.0	0.0
2	14.5	0.9	0.0	0.0	0.0	0.0
3	26.0	1.7	0.0	0.0	0.0	0.0
4	13.6	0.9	0.0	0.0	0.0	0.0
5	18.0	1.2	0.0	0.0	0.0	0.0