LOWER ARKANSAS RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Water Body: **Arkansas River between Hutchinson and Maize**
Water Quality Impairment: Sulfate

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Gar-Peace **Counties:** Reno and Sedgwick

HUC 8: 11030010

HUC 11 (HUC 14s)**:** **010** (010,050); **020** (010,020,030,040,050 and 070)

Drainage Area: 3095 square miles between Maize and Nickerson

Main Stem Segments: WQLS: 1, 4 and 5; starting at the confluence with Rattlesnake Creek and ending at the confluence with the Little Arkansas River.
Non-WQLS: 3, between Salt Creek and Cow Creek

Designated Uses: Special Aquatic Life Support; Primary & Secondary Contact Recreation; Domestic Water Supply; Food Procurement; Ground Water Recharge; Industrial Water Supply Use; Irrigation Use; Livestock Watering Use for Main Stem Segments

1998 303d Listing: Table 1 - Predominant Point Source and Nonpoint Source Impacts and Table 3 - Predominant Natural Conditions Impact

Impaired Use: Domestic Water Supply

Water Quality Standards: Domestic Water Supply: 250 mg/l at any point of domestic water supply diversion (K.A.R.28-16-28e(c) (3) (A); Livestock Watering: 1000 mg/l (Table 1a of K.A.R. 28-16-28e(d));

In stream segments where background concentrations of naturally occurring substances, including chlorides, sulfates and selenium, exceed the water quality criteria listed in Table 1a of KAR 28-16-28e(d), at ambient flow, the existing water quality shall be maintained, and the newly established numeric criteria shall be the background concentration, as defined in KAR 28-16-28b(e). (KAR 28-16-28e(b)(9)).

In surface waters designated for the groundwater recharge use, water quality shall be such that, at a minimum, degradation of ground water

quality does not occur. Degradation shall include any statistically significant increase in the concentration of any chemical contaminant in ground water resulting from surface water infiltration or injection. (K.A.R. 28-16-28e(c) (5)).

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Use under 1998 303d: Non-Support of Domestic Water Supply

Monitoring Sites: Station 523 above Hutchinson, Station 524 at Yoder, and Station 536 at Maize

Period of Record Used: 1990 to 2000

Flow Record: Arkansas River nr Hutchinson (USGS Station 07143330); 1970 to 2000; Arkansas River nr Nickerson (USGS Station 07142680); 1997-2000; Arkansas River nr Maize (07143375); 1987-2000

Long Term Flow Conditions: At Hutchinson, median flow = 265 cfs; 7Q10 = 46 cfs; Estimated 7Q10 at Nickerson = 20 cfs; Estimated 7Q10 at Maize = 19 cfs

Current Conditions: Sulfate concentrations averaged 328 mg/l above Hutchinson, 294 mg/l at Yoder and 280 mg/l at Maize over 1990-2000. There is a high degree of correlation (r= 0.98) in sulfate concentrations at the three stations. When sulfate levels above Hutchinson are low (164 mg/l on average), sulfate levels at Maize average 160 mg/l. However, when sulfates are elevated above Hutchinson (averaging 611 mg/l), the average at Maize rises to 499 mg/l.

All sites are influenced by immigration of sulfate-laden water from the Garden City area moving past Dodge City and arriving at Hutchinson. Sulfate levels over 250 mg/l between Hutchison and Maize over 1996-1999 coincide with movement of flow down the Arkansas River past Dodge City. Arkansas River water entering Kansas from Colorado has extreme concentrations of sulfate (>2000 mg/l). The river undergoes dilution as it flows downstream. Frequently, regional conditions in the river and surrounding aquifers causes flow to cease between Dodge City and Garden City, as was the case between 1990 and mid-1996. Under those conditions, sulfate levels seen between Hutchinson and Maize remain below the water quality standard.

Monitoring Site	Average Sulfate Concentration and Range, 1990 - 1996	Average Sulfate Concentration and Range, 1996 - 1999
Above Hutchinson	168 mg/L (40-602 mg/l)	611 mg/L (35-1210 mg/l)
Yoder	158 mg/l (21-529 mg/l)	537 mg/l (40-952 mg/l)
Maize	159 mg/l (26-427 mg/l)	499 mg/l (42-861 mg/l)

There is no statistically significant difference in sulfate levels seen at the three sites, indicating the average decrease in sulfate in a downstream direction is not distinguishable from the inherent variability in sulfate at each of the three sites.

Plotting sulfate loads exceeding the standard over the cumulative frequencies of flows seen at the three stations reveals the excursions occur at flows near median flow or higher. No violations occur at the extreme low flow condition, where point sources impact dominate. Concentrations at higher flows sporadically exceed the standard. Therefore, sulfate concentrations seen between Hutchinson and Maize reflect movement of high sulfate water from western Kansas past Great Bend and dilution of that water by the low sulfate water of the surrounding aquifer and alluvium of the Arkansas River.

Of the 61 - 62 samples taken at the three stations over 1990-2000, 19 or 31% of the samples exceeded 250 mg/l. One of those occurred in 1995 and the other 18 since September 1996. In all cases, flows in the Arkansas River's western reaches were moving eastward past the historic no flow zone near Dodge City.

NUMBER OF SAMPLES OVER SULFATE STANDARD OF 250 MG/L BY FLOW AND SEASON

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%.	Cum Freq.
Hutchinson	Spring	1	3	3	1	0	0	8/22= 31%
	Summer	0	2	2	0	0	0	4/14= 29%
	Winter	1	4	2	0	0	0	7/19= 37%

Similar distribution of violations occurred at Yoder and Maize, although the violations at Maize tended to occur under less frequent flow durations because of gains in flow below Hutchinson. However, under low flow conditions, there is a marked loss of flow between Hutchinson and Maize. A 60% loss in streamflow is estimated under 7Q10 flow conditions during the 1990-1992 drought. Since there is no corresponding significant change in sulfate concentrations between Hutchinson and Maize, the loss of flow translates into a loss of load mass into the surrounding aquifer.

Desired Endpoint Condition of Water Quality at Stations 524 and 536 over 2005 -2010

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Drinking Water Use. The current standard of 250 mg/L of sulfate was used to establish a load duration TMDL curve and represents this endpoint. At 7Q10 flow conditions, the resulting total load would be 37.5 tons per day. The corresponding total load seen downstream at Maize would be 15 tons per day, reflecting the loss of flow along the river.

The load will increase during periods when the Arkansas River is flowing from the Colorado stateline to the Oklahoma stateline with continued excursions of the sulfate criterion at flows greater than median flow. Establishing a second endpoint reflecting these elevated background conditions would use a suggested value of 610 mg/l, which is the average concentration of

sulfate during recent high flows. At the median flow, the resulting load would be 436 tons per day.

Seasonal variation has been incorporated in this TMDL through the documentation of the seasonal consistency of elevated sulfate levels. Achievement of the endpoints indicates loads are within the loading capacity of the stream, water quality standards are attained, and full support of the designated uses of the stream has been restored.

3. SOURCE INVENTORY AND ASSESSMENT

NPDES: There are multiple NPDES permitted facilities discharging to the river, but most lack information on the sulfate content of their wastewater. Two facilities have monitored sulfate; Morton Salt averaged 425 mg/l at 5.4 MGD over 1999-2000, while Cargill Salt averaged 167 mg/l at 4.2 MGD over the same time period. Given the lack of elevated sulfate noted in the river during low flow conditions, the remaining discharges are assumed to have sulfate levels below 250 mg/l. There are several ground water remediation projects in the region, which utilze air stripper technology to remove organics. The effluent discharged from these projects contains varying concentrations of sulfate.

Irrigation Return Flow: Surface water irrigation is nonexistent along the Arkansas River (segments 1, 3, 4 & 5). Ground water irrigation is extensive throughout the regional area, but probably minimal immediately adjacent on the south side of the river, because of salt intrusion. Irrigation Return Flows do not appear to significantly increase the sulfate load to the Arkansas River in the Gar-Peace Subbasin.

Background: The primary geologic material at the flood plain of the Arkansas River is unconsolidated Quaternary sediment comprising the broad alluvial aquifer of the Arkansas River valley. The alluvial aquifer interacts well with the river where it underlies and is adjacent to the river. Permian bedrock underlies the Arkansas River alluvium. Most of this bedrock is the Wellington Formation that includes limestone beds, gypsum ($CaSO_4 \cdot H_2O$), anhydrite ($CaSO_4$), and rock salt (halite, NaCl). The evaporite deposits (halite, gypsum, and anhydrite) are important to the water quality in the subbasin because they contribute large amounts of chloride and sulfate to groundwater discharging from the Permian rocks to the streams and alluvial aquifers in the subbasin.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

The nature of sulfate loading along the Arkansas River reflects decades of natural contributions aggravated by patterns of irrigation water use and reuse along the upstream reaches near the state line. Resumption of flow around Dodge City has brought about a significant increase in sulfate seen at Hutchinson and Maize. Therefore, reduction in sulfate concentrations in this reach of the river at higher flows will be a function of dilution by tributary waters and load reduction will be negligible. Improvement in sulfate levels above Garden City should result in gradual lowering of

ambient concentrations of sulfate seen throughout these stream reaches. However, at lower flows, particularly when the Arkansas River does not flow past Dodge City, sulfate levels in the river remain below the 250 mg/l criterion. Therefore, point sources would be expected to not cause violations in the sulfate standard by discharging their wastewater.

Point Sources: Multiple point sources discharge into Segments 1 and 3, although few facilities likely contribute significant amounts of sulfate to the river. Based on an estimated discharge volume from all point sources of 27 MGD (42 cfs) a Wasteload Allocation of 25.5 tons per day at 7Q10 flow conditions will be established by this TMDL, after accounting for the Margin of Safety. Calculations used to estimate wasteload allocations are given in the attached appendix. Since most sources have modest (<200 mg/l sulfate) levels, this allocation may be used to manage major industrial discharger loads as well as the ground water remediation projects along the river.

Non-Point Sources: For the purposes of deriving a TMDL for these river segments, a background flow and sulfate level were estimated for Segments 1 and 3, where the majority of point sources discharge. The assumptions and calculations for the Load Allocation are given in the attached appendix. An assumed 7Q10 flow entering the segment was estimated to be 20 cfs based on the Nickerson and Hutchinson gage stations. The estimated sulfate concentration attributed to background was determined to be 170 mg/l based on average concentrations and low flows seen above Hutchinson. Given these assumed background conditions, the Load Allocation is 9.2 tons per day.

Under conditions when Arkansas River water from western Kansas arrives at Hutchinson, thereby elevating sulfate levels there and at Maize, the Load Allocation increases in response to greater flows and sulfate concentrations. At median flow conditions (265 cfs), the Load Allocation is calculated to be 408 tons per day, reflecting an average sulfate concentration of 610 mg/l, consistent with levels seen from 1996-1999. Average concentrations at Maize fall to 500 mg/l, reflecting an 18% dilution under higher flow conditions. Calculations are provided in the Appendix

Defined Margin of Safety:. The Margin of Safety will be used to protect the low flow regime of these segments against future loadings of sulfate causing violation of the 250 mg/l water quality standard and to not unduly raise downstream ambient concentrations nor overload the surrounding aquifer where the river loses flow. Therefore, the Margin of Safety will withhold 10% of the available wasteload allocation from future point sources (2.8 tons per day), until further source assessment and monitoring confirms the lack of significant impact to the river from existing permitted discharges. Furthermore, the Margin of Safety is conservative because of the presumption of existing facilities discharging 250 mg/l sulfate at their design flows, exceeding estimated actual loads assumed from ambient data.

At higher flows which coincide with the incidence of elevated sulfate, any point source impacts will be masked by upstream nonpoint and natural contributions. Nonetheless, the Margin of

Safety of 10% of future Wasteload Allocation will be maintained. Additionally, given the dilution impact of the drainage between Maize and Hutchinson, the objective of the Margin of Safety would be to attempt to maintain an average 20% reduction in sulfate concentration between Hutchinson and Maize.

State Water Plan Implementation Priority: This TMDL will be a Low Priority for implementation because of the influence of upstream sulfate loading entering these stream reaches, the time needed to establish any sulfate improvements in the upstream reaches, and the need to monitor the impact of any sources along these reaches and within the immediate watershed which might contribute sulfate under conditions seen on the river prior to 1996.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Gar- Peace Subbasin (HUC 8: 11030010) with a priority ranking of 19 (High Priority for restoration work).

Priority HUC 11s and Stream Segments: Because the sulfate impairment is confined to the mainstem of the Arkansas River, priority will be given to Segment 1 which will reflect all potential contributions arriving from upstream.

5. IMPLEMENTATION

Desired Implementation Activities

1. Evaluate any potential sources between Hutchinson and Maize which possibly raise sulfate levels in the river above pre-1996 levels
2. Establish alternative background criterion
3. Assess likelihood of river being used for domestic uses.

Implementation Programs Guidance

NPDES and State Permits - KDHE

a. Evaluate any point sources releasing wastewater in and around these impacted reaches as to potential to contribute sulfate and degrading water quality below Hutchinson.

Non-Point Source Pollution Technical Assistance - KDHE

a. Evaluate any potential anthropogenic activities which might contribute sulfate to the river as part of an overall Watershed Restoration and Protection Strategy.

Water Quality Standards and Assessment - KDHE

a. Establish background levels of sulfate for the river and recommend an alternative water quality criterion for high flows.

Use Attainability Analysis - KDHE

a. Consult with Division of Water Resources on locating existing or future domestic points of diversion on the Arkansas River for drinking water purposes.

Subbasin Water Management - Division of Water Resources

a. Evaluate stream-aquifer interactions and the fate of water at low flow conditions at Maize.

Time Frame for Implementation: Work on the upstream management of sulfate levels, including that crossing the state line will commence over 2001-2005. Evaluation of impact of any sulfate control on downstream reaches should occur after 2005. Development of a background level-based water quality standard should be accomplished with the 2002 water quality standards revision.

Targeted Participants: Primary participants for implementation will be KDHE. Otherwise, activity is deferred to that which has to occur along the river above Garden City.

Milestone for 2006: The year 2006 marks the midpoint of the ten-year implementation window for the stream segments. At that point in time, some consideration of upstream water quality improvement on downstream reaches should be evaluated. Additionally, sampled data from Stations 523, 524 and 536 should indicate evidence of reduced sulfate levels at flow conditions relative to the conditions seen over 1990-2000.

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 along the river to reduce pollution.

1. K.S.A. 65-164 and 165 empowers the Secretary of KDHE to regulate the discharge of sewage into the waters of the state.

2. 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.

3. K.A.R. 28-16-69 to -71 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.

4. The Federal Safe Drinking Water Act empowers KDHE to develop Source Water Protection Assessments and Plans.

5. 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.

6. The *Kansas Water Plan* and the Lower Arkansas 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.

7. K.S.A. 82a-701, et seq. authorizes the Chief Engineer and the Division of Water Resources to administer water appropriations in the state, including prevention of waste and planning and practicing water conservation.

Funding: Other protection or planning activities are incorporated within the Lower Arkansas Basin Plan of 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 a portion of the $16-18 million available annually from the State Water Plan Fund to water quality and water conservation projects and programs. This watershed and its TMDL are a Low Priority consideration and should not receive funding.

Effectiveness: Irrigation return flow controls are difficult to implement, although tailwater management has been practiced in Kansas for decades. The influence of upstream sulfate levels complicates the ability of the state to implement this TMDL. As such, the priority for this TMDL will remain Low, as the state evaluates downstream benefits from irrigation return flow management in western Kansas and Colorado.

6. MONITORING

KDHE should collect bimonthly samples at Stations 523, 524 and 536 over 2001-2010 in order to assess progress in implementing this TMDL over each of the three defined seasons during the initial implementation period. Based on that sampling, the status of 303(d) listing will be evaluated in 2010 including application of numeric criterion based on background concentrations at high flows. Should impaired status remain, the desired endpoints under this TMDL will be refined. Use of the real time flow data available at the Hutchinson and Maize stream gaging stations can direct sampling efforts.

Monitoring of sulfate levels in effluent may be a condition of NPDES and state permits for facilities significantly discharging (Q>0.33 MGD) to the Arkansas River or tributaries leading to the mainstem of the river.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Lower Arkansas River Basin were held March 9, 2000 and April 26-27, in Hutchinson, Wichita, Arkansas City and Medicine Lodge. 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 Lower Arkansas River Basin. A draft of this TMDL has been maintained on the website since June 1, 2000 and modifications to the original draft have been available to the public for viewing and review up to the date of submitting this TMDL to EPA.

Public Hearing: A Public Hearing on the original draft of these TMDLs of the Lower Arkansas River Basin was held in Wichita on June 1, 2000.

Basin Advisory Committee: The Lower Arkansas River Basin Advisory Committee met to discuss the TMDLs in the basin on September 27, and November 8, 1999; January 13 and March 9, 2000. The Committee recommended approval of the Basin Plan which set high priority TMDLs in the basin, thereby, delegating medium and low priority status to this and subsequent TMDLs for the basin. The Kansas Water Authority approved the Basin Plan on July 11, 2000.

Discussion with Interest Groups: Meetings to discuss TMDLs with interest groups include:

Agriculture: January 12, February 2 and 29, 2000
Environmental: March 9, 2000
Conservation Districts: November 22, 1999
Industry: December 15, 1999, January 13, February 9 and 22, 2000
Local Environmental Protection Groups: September 30, November 2, December 16, 1999

Milestone Evaluation: In 2006, evaluation will be made as to the degree of improvement in water quality in downstream reaches from activities occurring above Garden City. Subsequent decisions will be made on further implementation after 2006.

Consideration for 303d Delisting: The river will be evaluated for delisting under Section 303d, based on the monitoring data over the period 2005-2009. Therefore, the decision for delisting will come about in the preparation of the 2010 303d 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 2002 which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations under this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process after Fiscal Year 2005.

APPENDIX -- COMPUTATION OF LOADS AND ALLOCATIONS

1. Average Ambient Concentrations of Sulfate and Estimated Low Flows

Site	Sulfate	Sulfate	Est.
Arkansas River	1990-Sept 96	Nov 1996-2000	7Q10
Above Hutchinson	170 mg/l	610 mg/l	20 cfs
At Yoder	160 mg/l	540 mg/l	46 cfs
At Maize	160 mg/l	500 mg/l	19 cfs
Tributaries			
Cow Creek			
Willowbrook	91 mg/l	84 mg/l	0.6 cfs
Hutchinson	138 mg/l	142 mg/l	1.0 cfs
Peace Creek	152 mg/l	199 mg/l	0.1 cfs
Salt Creek	160 mg/l	156 mg/l	0.1 cfs

2. Significant Discharges to Segments 1 and 3 (Q> 0.33 MGD (0.5 cfs))

Facility	Design Flow	Sulfate Level
Morton Salt	5.52 MGD	425 mg/l
S. Hutchinson	0.97 MGD	N/A
Hutchinson	9.27 MGD	N/A
Cessna-Eaton	2.88 MGD	N/A
Cargill Salt	5.66 MGD	167 mg/l
IMC Salt	3.40 MGD	N/A
Brooks Landfill	0.43 MGD	N/A

Total Design Flow = 42 cfs, Estimated current discharge = 26 cfs (from Hutch/Nick gage data)

3. Allocations of Loads

a. Load Allocation - 7Q10 at Hutch (1970-2000) = 46 cfs
Contemporary WW discharge = 26 cfs
Estimated 7Q10 at Nickerson = 20 cfs
Average sulfate concentration above Hutchinson = 170 mg/l
Load Allocation = 20 cfs * 170 mg/l * 5.4/2000 **= 9.2 Tons per Day**

b. Wasteload Allocation - Total Design Flow = 42 cfs
Sulfate Standard = 250 mg/l
Wasteload Allocation = 42 cfs * 250 mg/l *5.4/2000 = 28.3 Tons per Day

c. Total Maximum Daily Load = 37.5 Tons per Day

d. Resulting Downstream Ambient Concentration = 224 mg/l Sulfate
(20 cfs*170 mg/l + 42 cfs*250 mg/l) / 62 cfs

e. Resulting TMDL at Maize - 60% Loss of Flow
62 cfs * 0.6 = 24.8 cfs
24.8 cfs * 224 mg/l * 5.4 / 2000 = 15 Tons per Day

f. Potential Loss of Sulfate to Aquifer = 22.5 Tons per Day

4. Impact of **Margin of Safety (10% = 2.8 T/D)**

Apply 10% Reduction to **Wasteload Allocation**	**= 25.5 Tons per Day**
Resulting Load below Hutchinson	= 34.7 Tons per Day
Resulting Load at Maize	= 13.9 Tons per Day
Resulting Potential Loss to Aquifer	= 20.8 Tons per Day
Resulting Downstream Ambient Concentration	= 207 mg/l Sulfate

5. Aquifer Loading if Point Sources discharged at ambient SO4 concentrations
Ambient Sulfate = 170 cfs, 62 cfs downstream flow

Hutchinson Total Load	= 28.5 Tons per Day
Maize Total Load (40% of Hutch Load)	= 11.4 Tons per Day
Potential Loss of Sulfate to Aquifer	= 17.1 Tons per Day

6. Increase in Concentration and Loading Resulting from TMDL
Downstream Ambient Concentrations increases by 22% (207mg/l / 170 mg/l)
Potential Loading to Aquifer increases by 8.1 Tons per Day (20.8 T/D - 12.7 T/D)
over current loading; 3.7 Tons per Day over future ambient loading (20.8 T/D - 17.1 T/D)

7. High Flow TMDL

Load at Median Flow = 265 cfs * 610 mg/l *5.4 / 2000	***= 436 Tons per Day***
Wasteload Allocation = same as at low flow	***= 25.5 Tons per Day***
Margin of Safety = same as at low flow	***= 2.8 Tons per Day***
Resulting Load Allocation	***= 408 Tons per Day***

Approved July 27, 2001.