

## UPPER REPUBLICAN BASIN TOTAL MAXIMUM DAILY LOAD

**Waterbody/Assessment Unit: Arikaree River**  
**Water Quality Impairment: Fluoride**

### 1. INTRODUCTION AND PROBLEM IDENTIFICATION

**Subbasin:** Arikaree River

**County:** Cheyenne

**HUC 8:** (*In Kansas*) 10250001

**HUC 11 (HUC 14s):** (*In Kansas*) **080** (030, 040 and 050)

**Drainage Area:** 37 square miles in Kansas  
1725 square miles total above sampling station

**Main Stem Segment:** WQLS: 1 (Arikaree River) starting at the Kansas-Nebraska state line and traveling upstream through northwest Cheyenne County to the Kansas-Colorado state line (**Figure 1**).

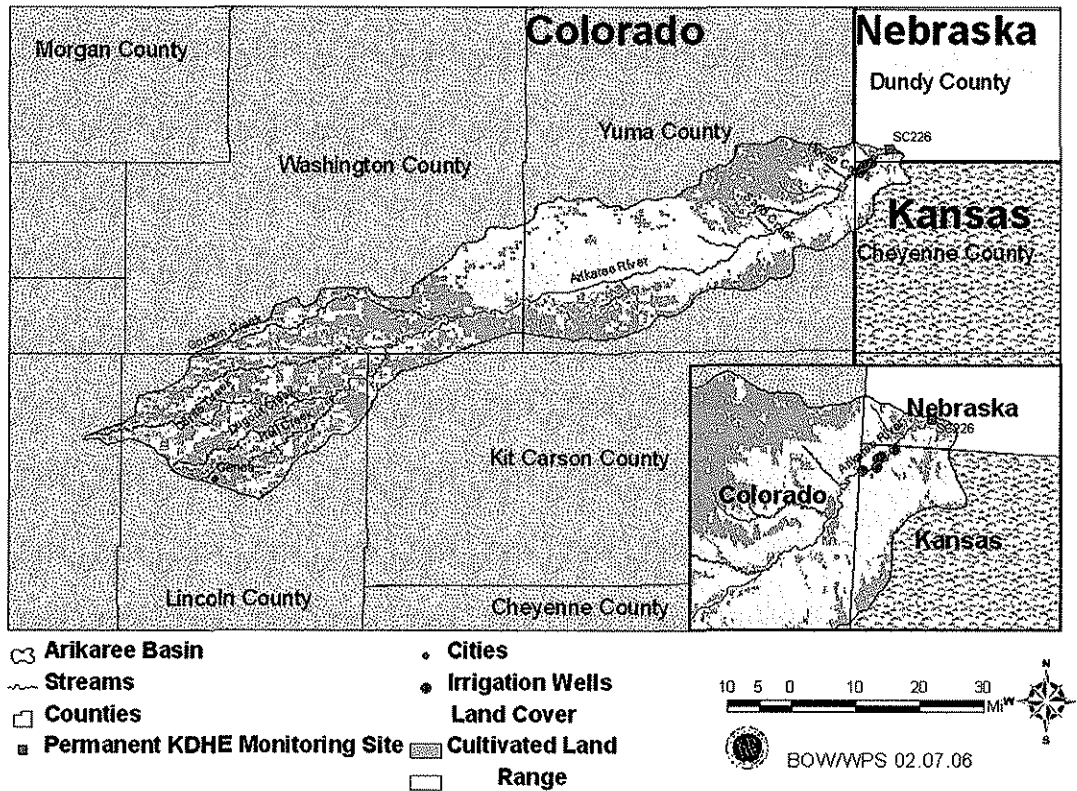
**Tributaries:** **All tributaries located in Colorado, segment numbers unknown**  
Horse Creek  
Sand Creek  
Gordon Creek  
Currie Creek  
Dugout Creek  
Hell Creek  
North Fork Arikaree River

**Designated Uses:** Special Aquatic Life Support, Primary Contact Recreation (C), Domestic Water Supply; Food Procurement; Ground Water Recharge; Industrial Water Supply Use; Irrigation Use; Livestock Watering Use for Kansas Segment.

**Impaired Use:** Irrigation Use

**Water Quality Standard:** Fluoride: 1 mg/L for Agricultural Water Supply (Irrigation) Use, 2 mg/L for Livestock and Domestic Water Supply (KAR 28-16-28e(c)(1)).

# Arikaree River Basin TMDL



(Figure 1- Land use in the Arikaree River Basin. Kansas irrigation wells are visible in the inset. The KDHE monitoring station is located in Nebraska, the nearest readily accessible sampling point after the Colorado border.)

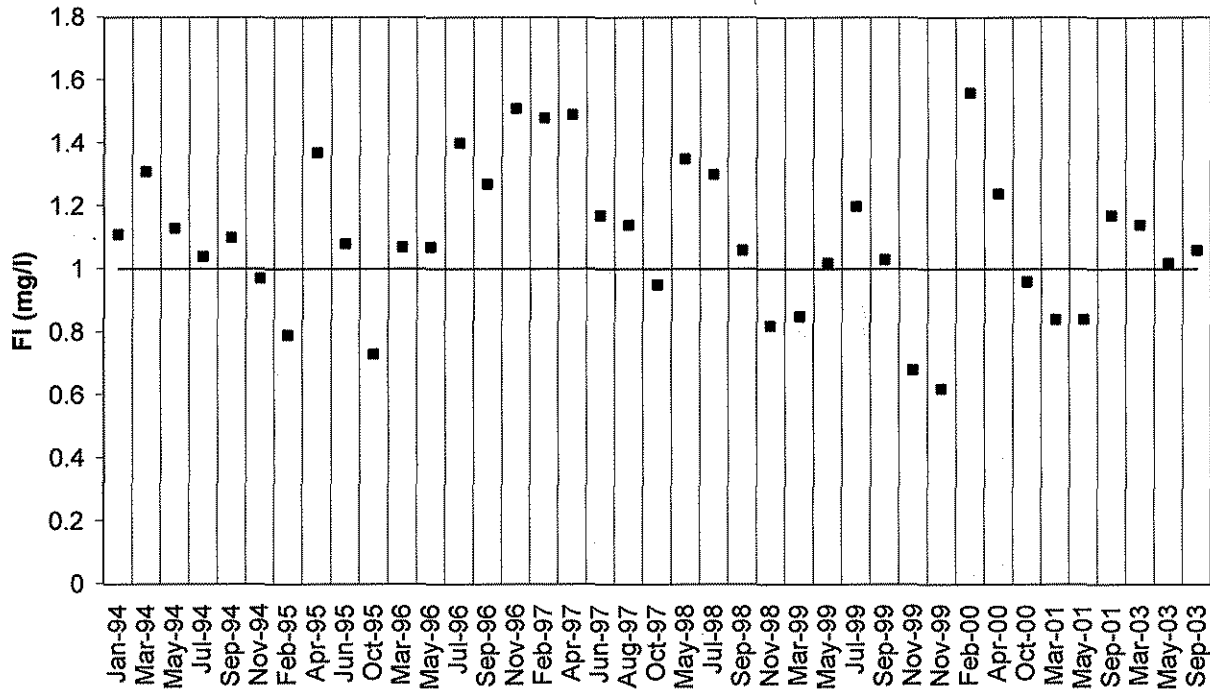
## 2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

**Level of Support for Designated Use under 2004 303(d):** Not Supporting Irrigation

**Monitoring Site:** Station 226 at Haigler, NE.

**Period of Record Used:** 1986-2005 for Station 226 (Figure 2)

## Fluoride Concentration at SC226

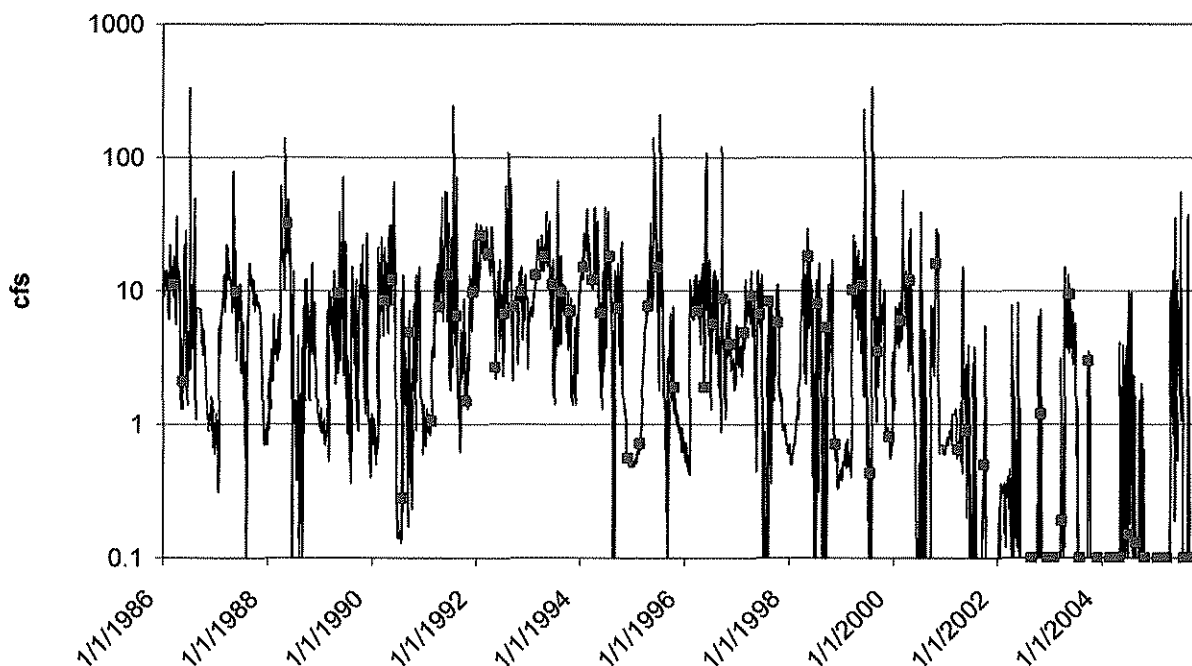


(Figure 2- Blue line indicates irrigation water quality criteria. The lack of recent data reflects no-flow events when KDHE personnel visited the site for a regularly scheduled sampling; those dates are shown in Figure 3.)

**Flow Record:** Arikaree River at Haigler, NE (USGS Station 06821500); 1970-2005 (Figure 3).

**Long Term Flow Conditions:** 90% Exceedance = 0 cfs, 75% Exceedance = 0.86 cfs, 50% Exceedance = 3.7 cfs, 25% Exceedance = 11 cfs, 10% Exceedance Flows = 21 cfs

## Log Adjusted Arikaree Flow



(Figure 3- 20-year flow record. Red squares indicated sampling dates. Flow adjusted by adding 0.1 cfs to all flow values for log transformation. Dates with 0.1 cfs were no flow events, and red squares during no flow events indicate that KDHE personnel visited the site and found insufficient water to conduct routine sampling. Since 2002 15 of 18 site visits corresponded to no-flow events.)

**Current Conditions:** Since loading capacity varies as a function of the flow present in the stream, this TMDL represents a continuum of desired loads over all flow conditions, rather than fixed at a single value. High flows and runoff equate to lower flow durations; baseflow and point source influences generally occur in the 75-99% range. Load Curves were established for the Irrigation Use criterion by multiplying the flow values along the curve by the applicable water quality criterion and converting the units to derive a load duration curve of pounds of fluoride per day. These load curves represent the TMDL since any point along the curve denotes water quality for the standard at that flow. Historic excursions from the water quality standard are seen as plotted points above the load curve. Water quality standards are met for those points plotting below or on the load duration curve (Figure 4). Violations of the criteria occur more frequently during greater than average flow events during all three defined seasons, Winter: November-March, Spring: April-July, Summer-Fall: August-October (Table 1). Nebraska currently does not assess this river for fluoride. Colorado has indicated that their portion of the Arikaree River is fully supporting its designated uses, aquatic life, recreation, and agriculture. Colorado has not, however, monitored fluoride.

Average	Overall	Winter	Spring	Summer-Fall
>3.7 cfs	1.19	1.27	1.26	1.08
<3.7cfs	0.92	0.83	1.03	0.99

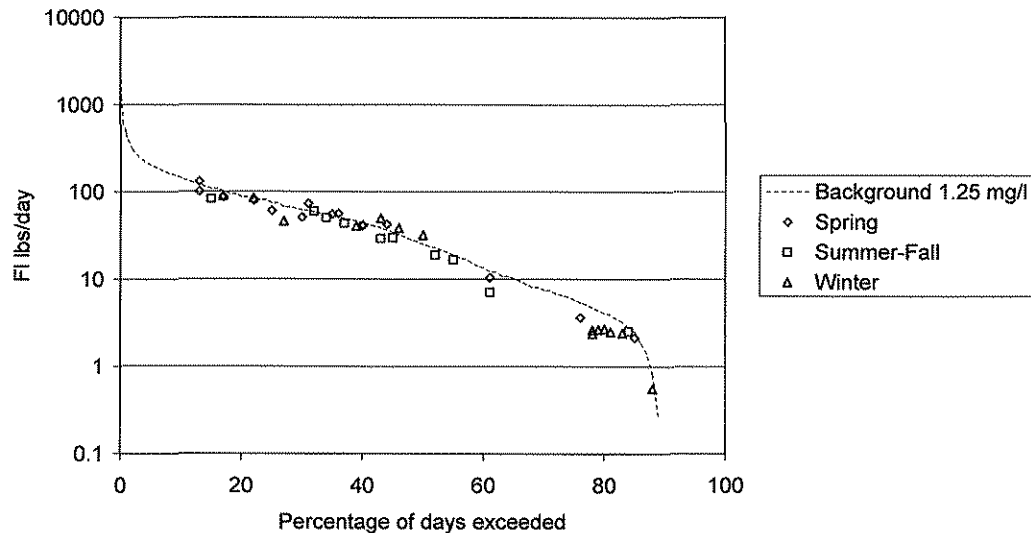
(Table 1- Average fluoride concentrations in the Arikaree River at SC226.)

### Arikaree Fluoride TMDL



(Figure 4 – Fluoride loads in pounds per day based on flow duration curve. No values are projected for 90-100% because long-term gaging data indicate that ten percent of the time the Arikaree River has no flow.)

## Arikaree Fluoride TMDL- Proposed Background



(Figure 5 – Proposed fluoride background loads in pounds per day based on flow duration curve. No values are projected for 90-100% because long-term gaging data indicate that ten percent of the time the Arikaree River has no flow.)

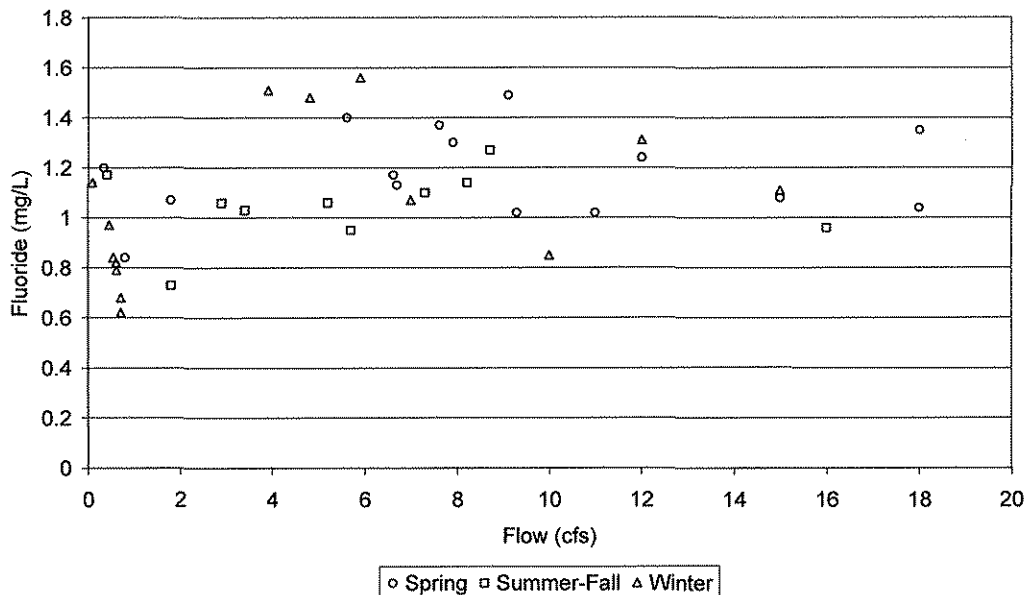
### Desired Endpoints of Water Quality (Implied Load Capacity) at Site 226 over 2008 – 2012

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Irrigation Water Use. The presence of natural sources elevating concentrations above the criteria over most flows requires this TMDL, however, to be staged. The current criterion of 1 mg/L of fluoride was used to establish a load duration curve (Figure 4) for the monitoring site.

Kansas Implementation Procedures for Surface Water allow for a background to be established when the monitoring record indicates that the existing criteria is unachievable due to naturally occurring conditions. The specific stream criteria to supplant the existing criteria will be developed concurrent with Stage One of this TMDL following the appropriate administrative and technical Water Quality Standards processes for Site 226 based on currently available information and will be 1.25 mg/L (reflecting the averages during the winter greater than median flow) from data collected over 1986-2005 (Figure 5). Future TMDL assessment will be based on this proposed background criteria.

Seasonal variation has been incorporated in this TMDL through the documentation of the seasonal consistency of elevated fluoride levels across all flows (Figure 6). Achievement of the endpoints indicate 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.

## Fluoride at SC226 by season



(Figure 6- Seasonal fluoride concentration as a function of flow. Generally, concentrations are greatest at moderate flows during the winter and spring. The highest flows show a possible dilution effect. Spring and winter flows, the non-irrigation season, show similar patterns, with lower concentrations at the lowest flows, peaking at 4-6 cfs, and then declining with increasing flow.)

### 3. SOURCE INVENTORY AND ASSESSMENT

#### Background Levels:

Significant irrigation activity associated with corn production occurs in the Arikaree basin in Colorado. Irrigation water is drawn from deepwater wells that tap the High Plains Aquifer and withdraw water that is higher in fluoride and silica concentrations. KDHE monitoring data were analyzed to determine if elevated silica concentrations were present at SC226, and other sampling stations throughout the region. Sampling stations farther east tended to have lower overall fluoride and silica levels, which broadly correlate to climatic influences on irrigation choices. Worldwide silica concentrations average 13 mg/l, less than half of the lowest values found at SC226 (Figure 7).

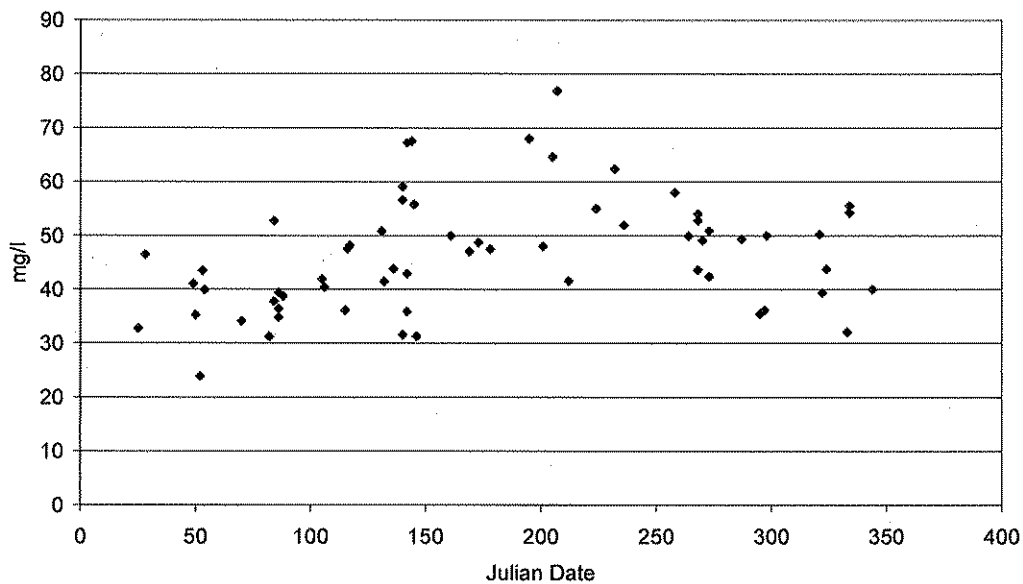
Based upon observations provided by the Kansas Geological Survey, the source of the dissolved fluoride in the river water is likely water from the Ogallala-High Plains aquifer discharged to the river either from elevated groundwater levels, baseflow contributions after runoff events, or return flows from irrigated lands. Colorado pumping in Yuma, Washington and Lincoln counties over 1981-2000 depleted the Arikaree River streamflows by an average of 1289 acre-feet per year. Over the same period pumping in Cheyenne County, KS, was responsible for an average depletion of 175 acre-feet per year. Very little surface water irrigation occurs in the watershed, confined to Yuma County. There is no surface water irrigation in the Kansas portion of the

drainage and the five active ground water rights used an average of 153 acre-feet over 2000-2004 along the Arikaree.

The Ogallala portion of the High Plains aquifer typically has higher fluoride concentrations than in the Quaternary portion of the aquifer in south-central Kansas and the alluvial aquifers in eastern Kansas. The higher fluoride concentration in the High Plains aquifer of Kansas is generally associated with higher silica content in the ground water. The higher silica concentrations are generally derived from dissolution of the ash deposits in the Tertiary Ogallala deposits. The amorphous glass in the ash has a higher solubility than silica in the form of quartz that composes most of the silt, sand, and gravel in the aquifer sediments. Fluoride is commonly associated with volcanic gases; therefore, fluoride could be expected to be associated with volcanic ash.

Average fluoride concentration on neighboring streams tend to be greater than the existing criterion of 1 mg/L. Samples collected by the USGS averaged 1.4 mg/L on the North Fork of the Republican River in 1947 and 1.2 mg/L on the Republican River below the confluence of the Arikaree River from 1980-1984. Samples collected by Colorado on the North Fork from 1968-1977 average 1.1 mg/L. Kansas has already established elevated background fluoride criteria on the South Fork of the Republican.

### Silica at 226



(Figure 7- Silica levels at SC226. Of particular note for tracing irrigation activity is the increase in concentrations during the irrigation season, although all measured concentrations substantially exceed worldwide average values.)

**NPDES:** There are no NPDES permitted dischargers within the Kansas portion of the watershed. There is one city within the watershed; Genoa, CO. US Census figures list 211 people in Genoa in 2000.

**Livestock Waste Management Systems:** There are no confined animal feeding operations within the Kansas portion of the watershed.

**Land Use:** National Land Cover Database GIS layers were used to assess land use in the basin. Most of the watershed is grassland (59% of the area) or cropland (41%). Major crops were estimated by county level National Agricultural Statistics records. The majority of crop production is dryland wheat and irrigated corn. Irrigation water likely draws on deepwater wells drawing from the high plains aquifer.

**Population Density:** Population density is low throughout most of the basin. Colorado county level populations statistics for 2000 are, Yuma- 4 person/ sq. mile, Washington- 2 persons/ sq. mile, and Lincoln- 2 person/ sq. mile. The rural population projection for Cheyenne County through 2020 shows slight declines (7% decrease). The small population is not likely to contribute significant fluoride loading from wastewater.

#### **4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY**

Additional assessment will be necessary to ascertain the natural fluoride loading within the watershed and balance due to anthropogenic contributions. The following can be anticipated:

**Point Sources:**

Site 226: A current Wasteload Allocation of zero is established by this TMDL because of the lack of point sources located within the state upstream of the sampling site. Should future point sources be proposed in the watershed and discharge into the impaired segments, the current wasteload allocation will be revised by adjusting current load allocations to account for the presence and impact of these new point source dischargers.

There will be a wasteload allocation of zero for state and NPDES permitted CAFO's within the drainage because no such facilities exist in Kansas in this drainage basin.

**Non-Point Sources:** The majority of the fluoride load in the Arikaree River appears to be background in nature. At site 226 the Load Allocation based on the existing fluoride criteria of 1.0 mg/L across all flow conditions is shown in **Figure 4**, and is 20 pounds per day of fluoride at the median flow of 3.7 cfs. The LA at station 226 will increase if the elevated background concentration (1.25 mg/L) becomes the applicable criteria (25 lbs/day at median flow of 3.7 cfs) (**Figure 5**). Exceedances were noted at flows in excess of the median flow.

**Defined Margin of Safety:** The Margin of Safety provides some hedge against the uncertainty of loading and the fluoride endpoints for the Arikaree River system, specifically, lack of knowledge between effluent limitations and the river's water quality. Since there are no point sources discharging to the Arikaree River, there are no effluent limitations, there is complete certainty over the impact of this lack of point source loading, and, hence, the Margin of Safety for this TMDL will be set at zero.

**State Water Plan Implementation Priority:** Because the dominant source for fluoride in the stream is from natural sources, groundwater sources are likely contributors to the fluoride concentrations seen at the monitoring stations and elevated fluoride occurs during higher flows along the main stem. This TMDL will be a **Low Priority** for implementation.

**Unified Watershed Assessment Priority Ranking:** This watershed lies within the Arikaree River Basin (HUC 8: 10250001) and is classified as a Category I, priority 55 watershed under the Unified Watershed Assessment, a low priority for restoration.

**Priority HUC 11s and Stream Segments:** Because of the natural geologic contribution of this impairment, no priority subwatersheds or stream segments will be identified.

## **5. IMPLEMENTATION**

### **Desired Implementation Activities**

1. Establish alternative background criterion.

### **Implementation Programs Guidance**

#### **Water Quality Standards and Assessment - KDHE**

- a. Establish background levels of 1.25 mg/L for fluoride for the river and tributaries.

**Timeframe for Implementation:** Development of a background level-based water quality standard should be accomplished with the 2008 water quality standards revision.

**Targeted Participants:** Primary participants for implementation will be the Technical Services Section of KDHE.

**Milestone for 2011:** The year 2011 marks the mid-point of the ten-year implementation window for the watershed. At that point in time, additional monitoring data from Arikaree River will be reexamined to confirm the impaired status of the river and the suggested background concentration.

**Delivery Agents:** The primary delivery agents for program participation will be the Kansas Division of Water Resources.

#### **Reasonable Assurances:**

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

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

5. The *Kansas Water Plan* and the Upper Republican 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 and should not receive funding.

**Effectiveness:** Minimal control can be exerted on natural contributions to loading.

## 6. MONITORING

KDHE will continue to collect bimonthly samples at Station 226, including fluoride samples, in each of the three defined seasons. Based on that sampling, the stream will be evaluated in 2011 with application of numeric criterion based on background concentrations.

## 7. FEEDBACK

**Public Meetings:** Public meetings to discuss TMDLs in the Upper Republican Basin were held March 2, 2006 in Atwood. An active Internet Web site was established at <http://www.kdheks.gov/tmdl/index.htm> to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Upper Republican Basin.

**Public Hearing:** Public Hearings on the TMDLs of the Upper Republican Basin were held in Atwood on March 2, 2006.

**Basin Advisory Committee:** The Upper Republican Basin Advisory Committee met to discuss the TMDLs in the basin on March 2, 2006.

**Milestone Evaluation:** In 2008, evaluation will be made to confirm the stability of average fluoride concentrations along the Arikaree River. Subsequent decisions will be made regarding the need for an implementation approach, if fluoride levels are elevated above the background concentration.

**Consideration for 303(d) Delisting:** The stream will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2006-2011. 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 intervening implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities might be adjusted accordingly.

**6/26/06**