UPPER REPUBLICAN BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody/Assessment Unit: Arikaree River
Water Quality Impairment: pH

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

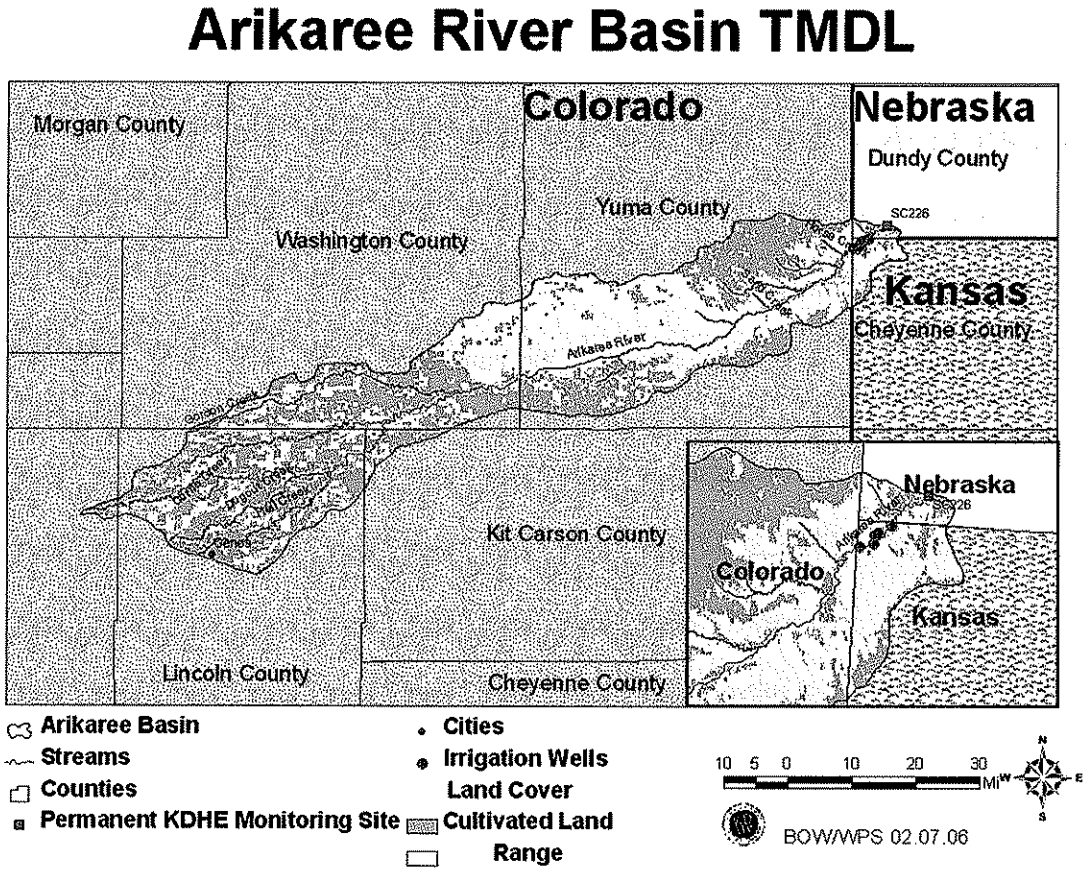
Main Stem Segment: WQLS: 1 (Arikaree River) starting at the Kansas-Nebraska state line and traveling upstream through northwest Cheyenne County to the Kansas-Colorado state line (**Figure 1**).

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: Special Aquatic Life Support

Water Quality Standard: pH: not to exceed 8.5 for Special Aquatic Life Support (KAR 28-16-28e(c) (3) (A))



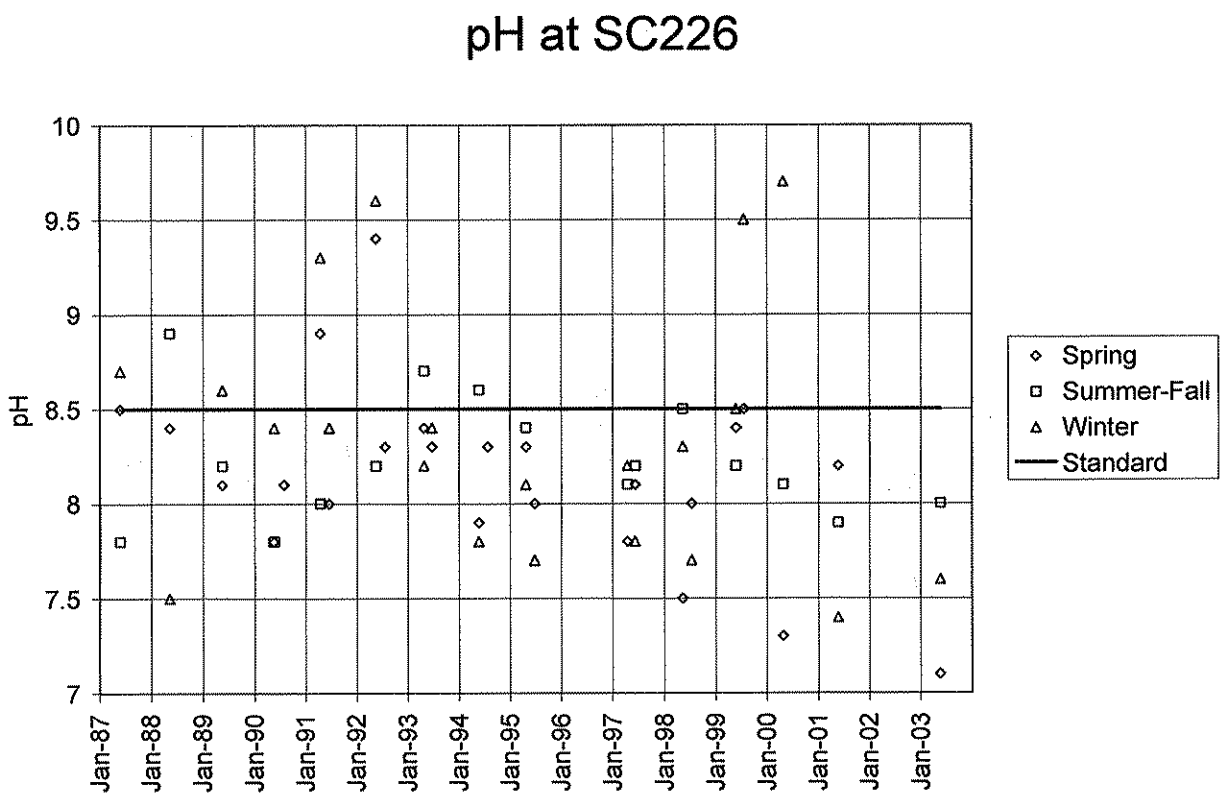
(Figure 1- Land use patterns in the Arikaree basin, and irrigation wells occurring in the Kansas portion of the basin.**)**

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Use under 2004 303(d): Not Supporting Special Aquatic Life Support

Monitoring Sites: Station 226 at Haigler, NE.

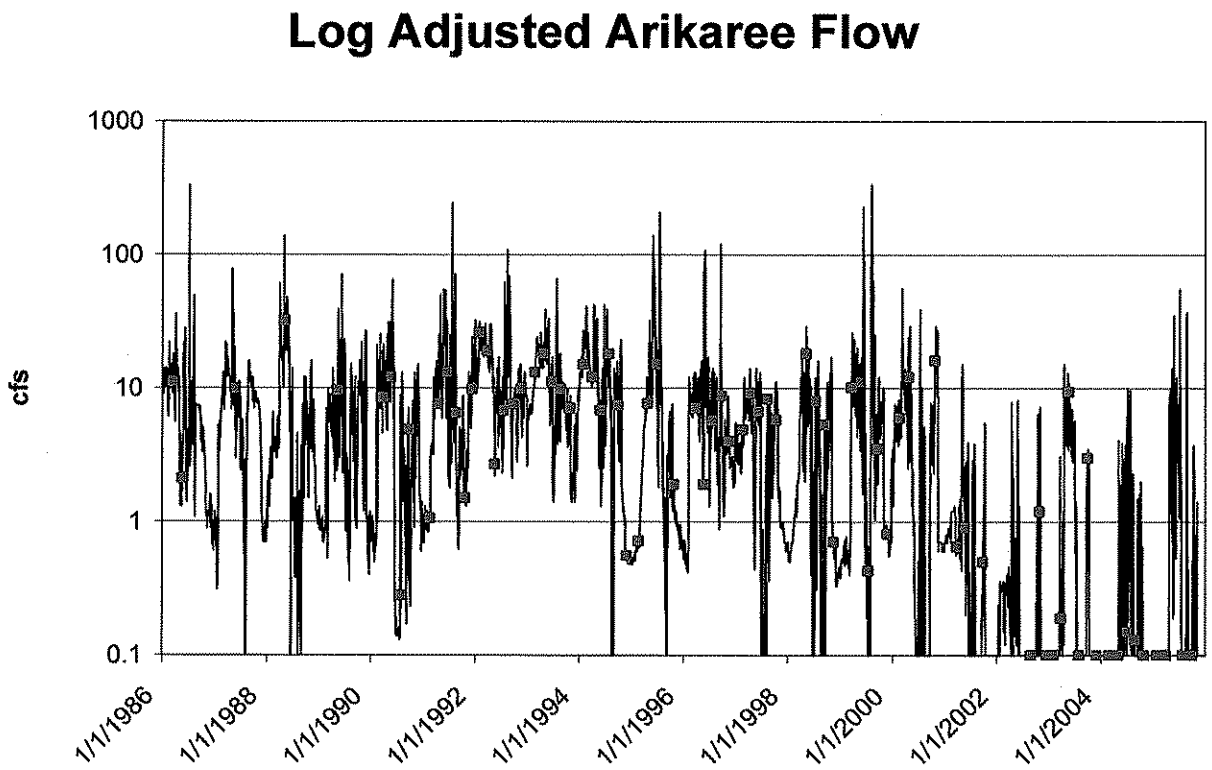
Period of Record Used: 1986-2005 for Station 226 (**Figure 2**)



(Figure 2- pH at SC226 Red line indicates aquatic life 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. No samples were collected at or below the lower bound of the pH water quality standard, 6.5.**)**

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



(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.)

Current Conditions: pH is a function of the negative logarithm of hydrogen ion concentration, but does not load into surface waters as hydrogen ions. Because pH is a function of complex interactions between organic and inorganic acids, bases, buffers, and living organisms, pH may vary substantially throughout the day in aquatic systems. Therefore, a load curve of pH is not an appropriate response to excessively basic conditions, and an alternate control method should be established. Nutrient enrichment has been associated with elevated pH levels in aquatic systems, as photosynthesis generates hydroxyls resulting from cleaved water molecules and concurrent use of the hydrogen ions by the photosynthetic community. Additionally, photosynthesis results in the uptake of CO_2, which reduces the concentration of its chemical equilibrium partner, carbonic acid (H_2CO_3), a potential buffer against excessively basic conditions. When CO_2 supply is limiting some algae use bicarbonate as a source of carbon for photosynthesis. The uptake of bicarbonate generates additional hydroxyl ions, which generates higher pH within the stream. In already basic locations, where hardwater predominates due to the presence of $CaCO_3$ the conditions may be conducive to pH elevated beyond the aquatic life criteria, if there is a relatively large and active photosynthetic community relative to the volume of water. No load curves are proposed for this TMDL for those reasons.

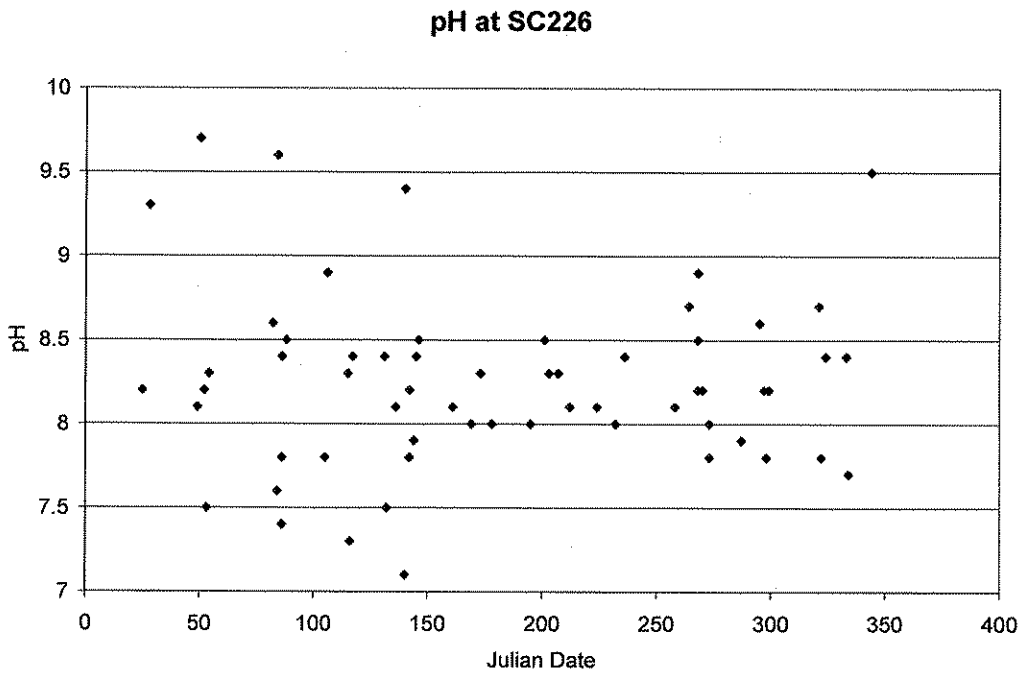
Desired Endpoints of Water Quality (Implied Load Capacity) at Sites 226 over 2008 – 2012

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Aquatic Life criteria. The current standard of pH not greater than 8.5 will be maintained for the monitoring site. The lack of clear causal relationships between elevated pH levels and other potentially influencing factors requires this TMDL to be updated when more information becomes available. In the interim, increases in riparian cover to reduce incident solar radiation will be implemented to reduce photosynthetic activity in the river.

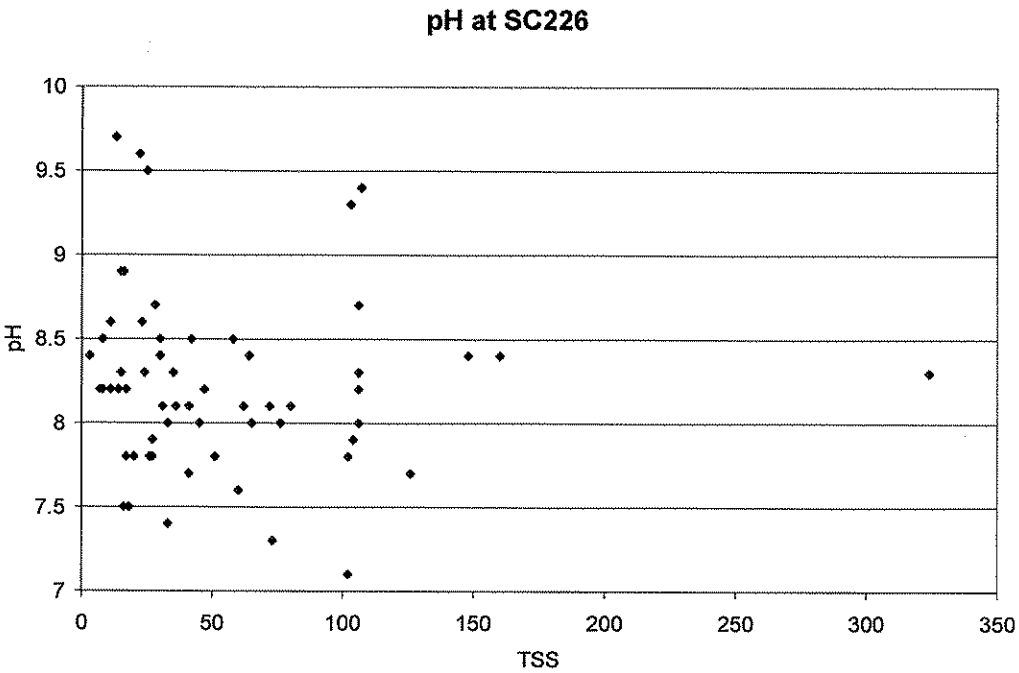
Seasonal variation has been incorporated in this TMDL through the documentation of seasonally elevated pH during winter and spring months. Achievement of the aquatic life criteria will serve as documentation that water quality standards are attained and full support of the designated uses of the stream has been restored.

3. SOURCE INVENTORY AND ASSESSMENT

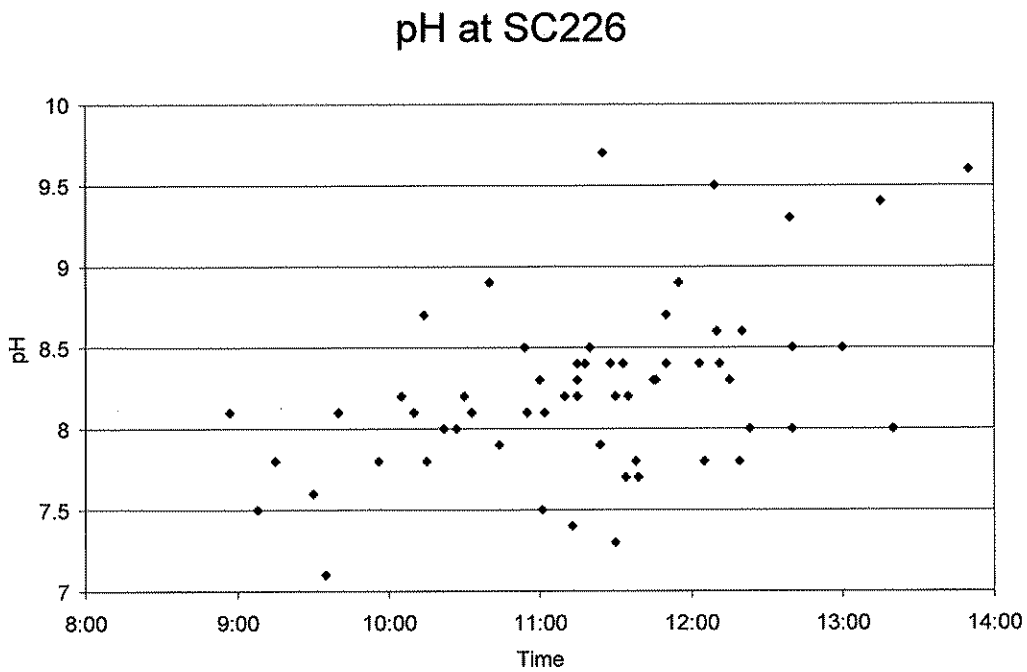
Background Levels: pH levels at SC226 have averaged 8.2 over the period of record. Generally alkaline conditions predominate (alkalinity average: 256), with elevated levels of total hardness, measured as the adjusted calcium and magnesium concentration (average: 385), and associated carbonate and bicarbonate concentrations. Violations of the aquatic life criteria have occurred during the winter and spring months (**Figure 4**), during generally clear conditions (**Figure 5**), and more frequently when samples were taken later in the day (**Figure 6**). Nutrient concentrations, inorganic nitrogen (average: 0.6 mg/L) and phosphorus (average: 0.14 mg/L), are generally low in this river, as is average flow (**Figure 7**). Average daily flow on sampling dates (**Figure 8**) does not appear to be related to pH violations. Antecedent flow conditions for the 30 days prior to pH violations were compared with antecedent flow conditions for the 30 days prior to the lowest recorded pH samples, and were indistinguishable as a group. No strong relationships exist between any measured criteria and the violations. Few exceedences of the aquatic life criteria have occurred since 1992, and those violations (11/17/1998, 3/23/1999, and 9/21/1999) have been minor (8.7, 8.6, and 8.7 respectively).



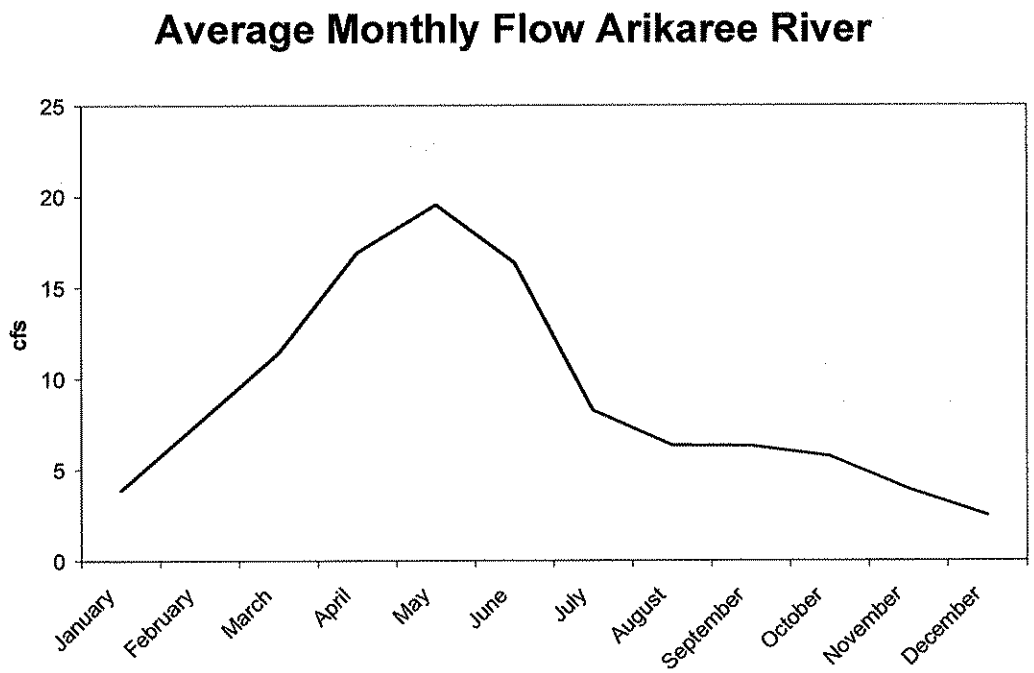
(Figure 4- pH concentrations at SC 226 by sampling date. KDHE seasons are defined as Winter: November – March [305-365, 1-90], Spring: April – July [91-212], and Summer/Fall: August – October [213-304].)



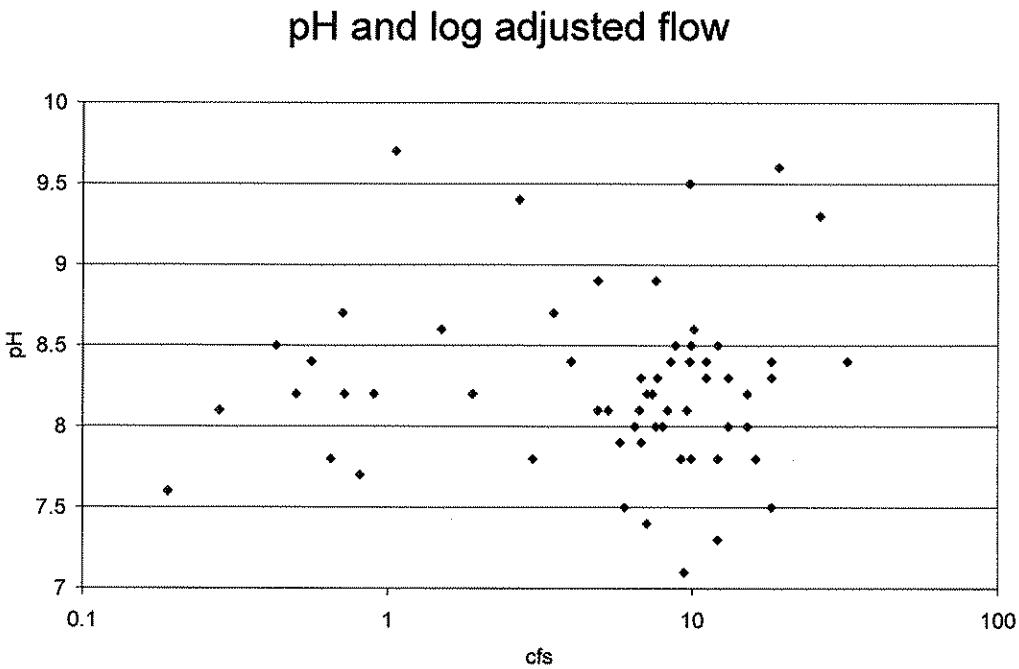
(Figure 5 – pH at SC226 and associated suspended solids concentrations.)



(Figure 6- pH at SC226 as a function of time of day sample was collected.**)**

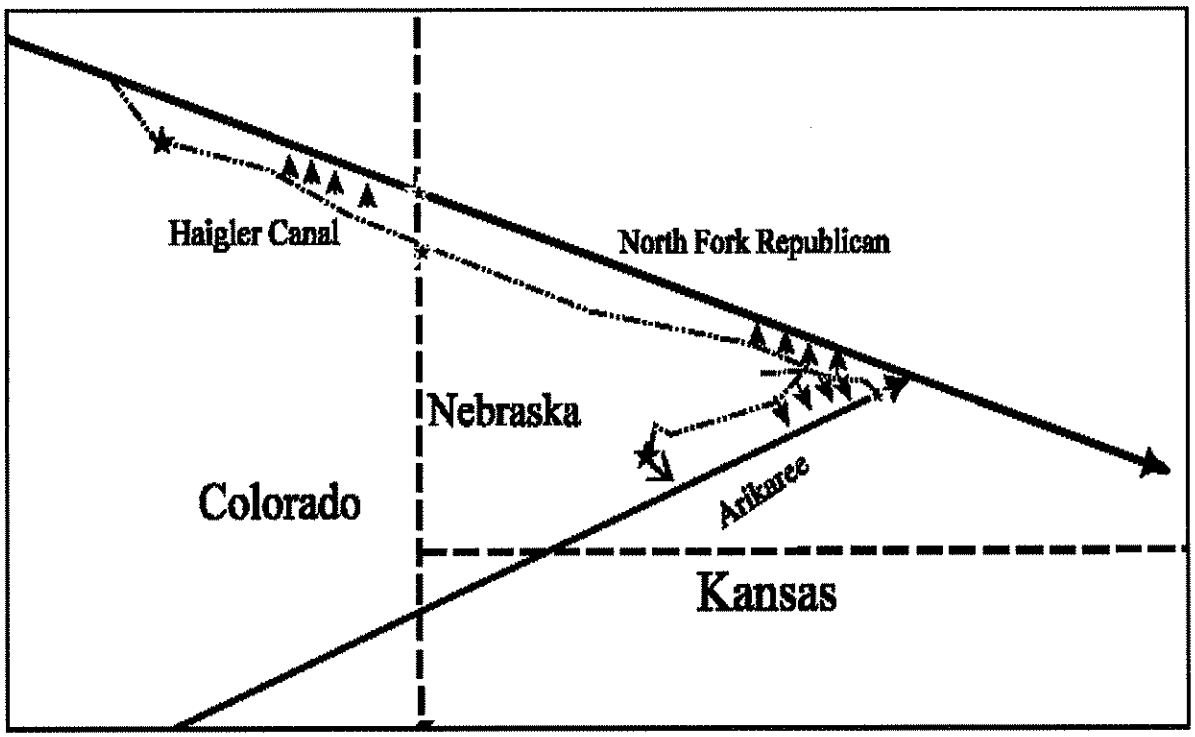


(Figure 7- Monthly average flow from 1970-2005 at USGS gage 06821500.**)**



(Figure 8- pH at SC226 as related to average daily flow conditions measured on the sampling date at USGS gage 06821500.**)**

Documentation provided by the Kansas Division of Water Resources (DWR) suggests that samples taken by KDHE, especially at lower flows, may not reflect conditions in the Arikaree River in Kansas. Pursuant to the Republican River Compact, DWR obtained maps of the Haigler Irrigation Ditch servicing an irrigation district in eastern Colorado and western Nebraska near the Kansas-Nebraska border (**Figure 9**). As marked in the map, this irrigation ditch diverts water from the North Fork of the Republican River to provide irrigation water to fields in Colorado and Nebraska. The ditch carries waste way water or return flows from the irrigated lands into the channel of the Arikaree River, which then joins the North Fork to form the Republican River below Haigler. These flows return to the Arikaree River upstream of the KDHE sampling point, which is located at Haigler, the first readily accessible location in the vicinity of the Kansas-Nebraska border.



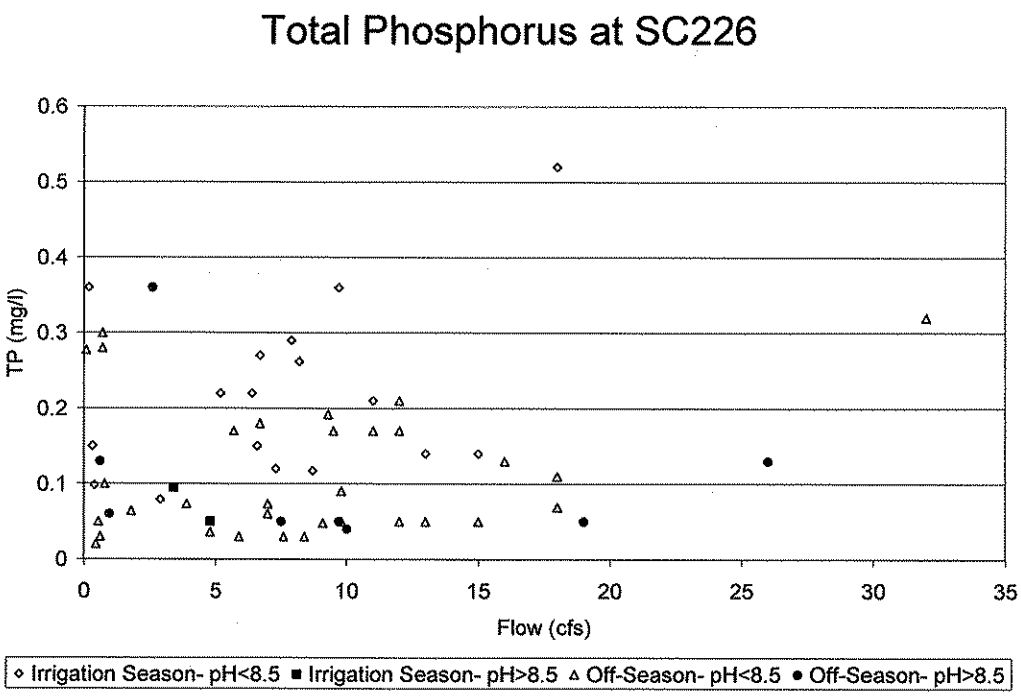
(Figure 9- A general schematic of the location of withdrawals and returns associated with the Haigler irrigation ditch. Provided by the Kansas Division of Water Resources as part of supporting documentation related to the Republican River Compact.)

Field investigation by KDHE personnel during the winter of 2006 revealed that flows originating in the Haigler Ditch system contributed all flows at the KDHE monitoring site. The Arikaree River contained no flow in the Kansas segment, but had flow downstream of the Haigler Ditch return, located in Nebraska. While it is possible that the Arikaree River is impaired in Kansas, sampling at Haigler does not necessarily provide direct evidence of that impairment, given the multiple sources of water seen at Haigler that are not related to Kansas. The field investigation indicated that the channel of the Arikaree River in Kansas had not had flow for some time, based on the state of vegetation encroachment in the flow way. Therefore, to the extent that the impairment originates in Colorado and flows directly to Nebraska, the impairment is a concern for those states, and does not suggest action by Kansas.

Further evidence of the influence of surface water irrigation in Colorado and Nebraska is provided by the tracking the phosphorus levels during the irrigation season and the remainder of the year (**Figure 10**). The concentration of phosphorus should be higher during high flow events when compared to low flow, or base flow conditions. In the case of data collected by KDHE at SC226, phosphorus was elevated during the low flow events, perhaps from mounded ground water from previous irrigation returns flow to the Arikaree through the fertilized soil column into the alluvial aquifer and then to the river. Mounding of groundwater as the result of irrigation activities can provide a source of extended residence groundwater experiencing the conditions described elsewhere in this TMDL. As that water leaves the alluvial aquifer and enters the return ditch, and ultimately the Arikaree River, it will carry with it the ions of concern that have

accumulated in the soils of the irrigated fields and obtained from near surface geologic formations.

The irrigation season has higher phosphorus concentrations, a typical pattern in agriculturally impacted waters. The influence of the irrigation return flows on water quality at SC226 is not presently known, however some information is available for the ditch company irrigation source water. Nebraska samples on the Arikaree River in April and May of 2002 averaged 0.38 ppm, while average phosphorus in the North Fork was 0.08 ppm. The hydraulic function of irrigation ditches requires some wasteway water to exit the ditch into the Arikaree River to facilitate the gravity flow of North Fork Republican water through the irrigation system. Hence the water seen at Haigler during irrigation season is influenced by the quality of water native to the North Fork Republican.



(Figure 10- Total phosphorus concentrations at SC226 as a function of flow by season. Samples were assigned Julian dates, and sorted. The irrigation season was defined as starting on Julian date 151 (the beginning of June) and ending on Julian date 280 (the end of September).)

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: Most of the watershed's population density is low throughout 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 loading from wastewater.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

Additional assessment will be necessary to ascertain the anthropogenic contributions to elevated pH conditions. Until that time the following will be maintained:

Point Sources:
Site 226: A current Wasteload Allocation of zero for inorganic nitrogen and phosphorus is established by this TMDL because of the lack of point sources located within the state upstream of the sampling site, and reflecting the documented relationship between elevated nutrients in other waters. 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: Current conditions will be maintained, reflective of the lack of major violations since 1992. Given the only consistent relationship between physical and chemical characteristics in the Arikaree and its pH level is the observed time of day samples are collected and the likelihood of pH exceedance, Kansas will reduce incident solar radiation on the Arikaree River by increasing riparian canopy along the three miles of the Arikaree River in Kansas.

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty of loading and the pH 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 water in the Arikaree River is from out of state sources, upstream sources are likely contributors to the pH problems seen at the monitoring stations. Additional source assessment is necessary to examine contributing activities 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 lack of clearly identifiable linkages to pH violations, no priority subwatersheds or stream segments will be identified.

5. IMPLEMENTATION

Desired Implementation Activities

1. Evaluate ongoing data collection activities to determine if violations seen at the monitoring station reflect conditions in Kansas.
2. Increase riparian shade cover over the river corridor to reduce limit in-stream primary productivity.

Implementation Programs Guidance

Water Quality Assessment - KDHE

a. Continue monitoring pH levels bimonthly at SC226.
b. Record pH levels in Kansas during flow.

Riparian Protection Program - SCC

a. Increase riparian tree planting along the river.

Timeframe for Implementation: Development of an implementation plan will come forth in the second round of TMDLs for the Upper Republican River Basin in 2008-2009 with additional information on cause and effect related to the pH violations.

Targeted Participants: Primary participants for implementation will be the KDHE Bureau of Environmental Field Services.

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 any causal factors.

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. 65-164 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 until causal factors can be identified.

6. MONITORING

KDHE will continue to collect bimonthly samples at Station 226, including pH samples, in each of the three defined seasons. Based on that sampling, the TMDL will be evaluated in 2009. Should conditions over 8.5 pH arise over 2006-2008, this TMDL will be refined to investigate causal factors.

7. FEEDBACK

Public Meeting: A Public Meeting 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: A Public Hearing on the TMDLs of the Upper Republican Basin were held in Atwood on March 2, 2006. The public comment period remained open until April 1, 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 2011, evaluation will be made to confirm the degree of impairment that has occurred within the watershed of the Arikaree River. Subsequent decisions will be made regarding the need for an implementation approach.

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