LOWER ARKANSAS BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: Quivira Little Salt Marsh and Quivira Big Salt Marsh
Water Quality Impairment: Chloride

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Rattlesnake

Counties: Clark, Ford, Kiowa, Edwards, Pratt, Stafford, Pawnee, Reno and Rice

HUC 8: 11030009
HUC 10 (12): 01 (01, 02, 03, 04, 05, 06, 07)
02 (01, 02, 03, 04, 05, 06, 07)
03 (01, 02, 03, 04, 05, 06, 07, 08)
04 (01, 02, 03, 04, 05)

Ecoregion: Central Great Plains, Great Bend Sand Prairie (27c)
Central Great Plains, Rolling Plains and Breaks (27b)

Drainage Area: Quivira Little: 1,084 square miles
Quivira Big: 103 square miles

Conservation Pool: **Quivira Little:**
Surface Area = 704 acres
Watershed/Lake Ratio: 985:1
Maximum Depth = 1.0 meters
Mean Depth = 0.1 meters
Annual Mean Precipitation = 24.1 inches
Annual Mean Evaporation = 62.4 inches
Storage Volume = 747 acre-feet
Estimated Retention Time = 0.02 years
Mean Annual Discharge = 42,076 acre-feet/year
Quivira Big:
Surface Area = 388 acres
Watershed/Lake Ratio: 170:1
Maximum Depth = 1.0 meters
Mean Depth = 0.1 meters
Annual Mean Precipitation = 24.1 inches
Annual Mean Evaporation = 62.4 inches
Storage Volume = 1,319 acre-feet
Estimated Retention Time = N/A
Mean Annual Discharge = N/A

Designated Uses: Primary Contact Recreation Class B; Special Aquatic Life Support;

Food Procurement; Ground Water Recharge; Industrial Water Supply; Irrigation Use; Livestock Watering Use.

303(d) Listings: Quivira Little Salt Marsh and Quivira Big Salt Marsh, Lower Arkansas River Basin Lakes:
Chloride: 2002, 2004, 2008, 2010, 2012

Impaired Use: Special Aquatic Life Support; and Ground Water Recharge.

Water Quality Criteria: Aquatic Life Support [Acute criterion]: 860 mg/L for Chloride (K.A.R. 28-16-28e(c)(2)(D)(ii)).

In surface waters designated for the groundwater recharge use, water quality shall be such that, at a minimum, degradation of groundwater quality does not occur. Degradation shall include any statistically significant increase in the concentration of any chemical or radiological contaminant or infectious microorganism in groundwater resulting from surface water infiltration or injection. (K.A.R. 28-16-28e(c)(5)).

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Lake Monitoring Sites: KDHE Station LM050201 at Quivira Little Salt Marsh (Figure 1).
KDHE Station LM050601 at Quivira Big Salt Marsh (Figure 1).
Periods of Record: Ten surveys conducted by KDHE in the summers of calendar years 1988, 1991, 1994, 1997, 1998, 1999, 2000, 2003, 2006 and 2009.

Stream Chemistry Sites: KDHE Rotational Station SC660, Rattlesnake Creek near Hudson located above Quivira Little Salt Marsh.
Period of Record: Bi-monthly sampling during calendar years 1992, 1996, 2000, 2004 and 2008.

KDHE Permanent Station SC030, Rattlesnake Creek near Raymond located below Quivira Big Salt Marsh.
Period of Record: Monthly sampling during calendar years 1975-1989, bi-monthly sampling during calendar years 1990 through 2009, quarterly sampling during calendar years 2010-2011.

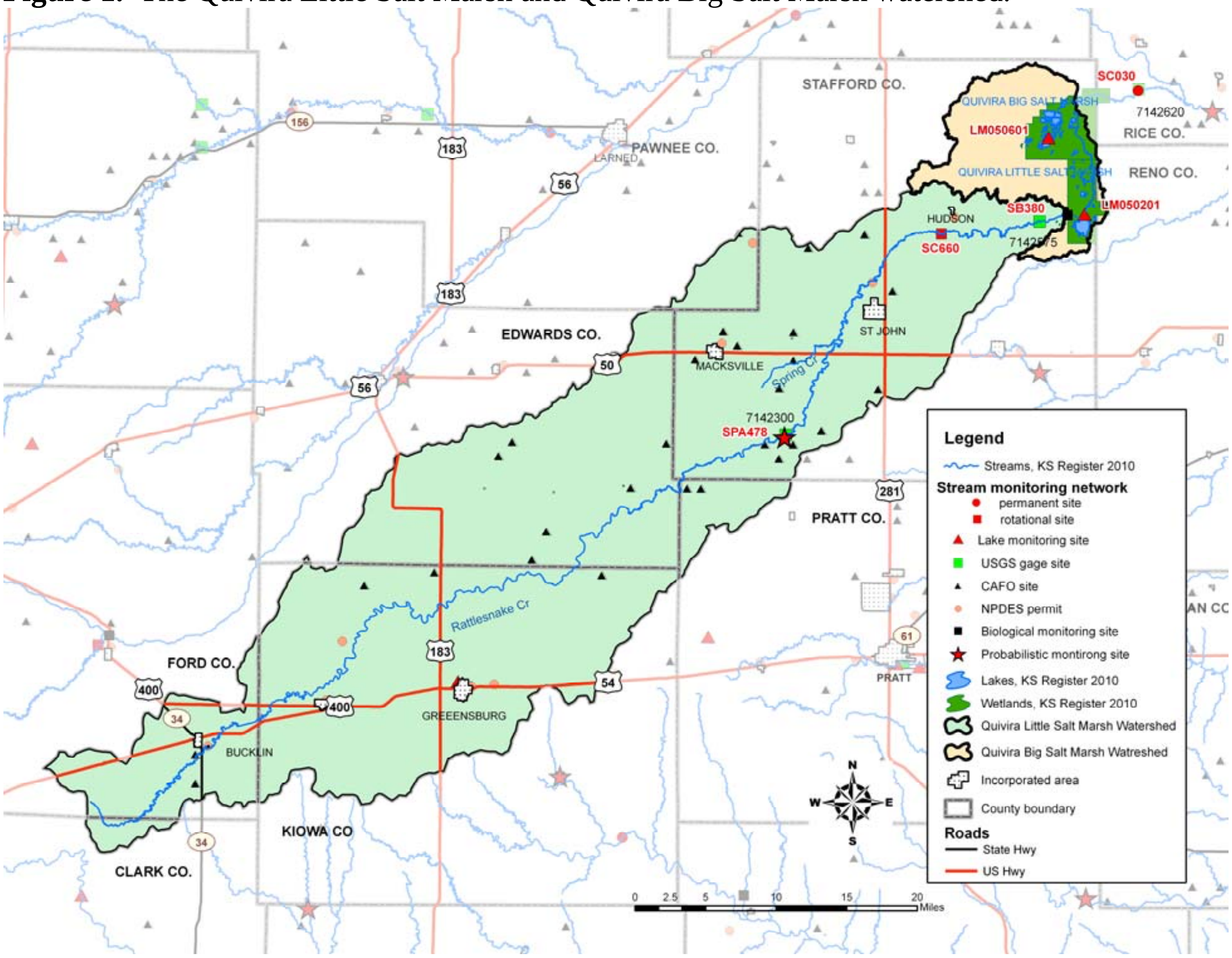
Flow Record: USGS Gage 07142300: Rattlesnake Creek near Macksville, KS, above USGS Gage 07142575.
Period of Record: January 1, 1970 through December 31, 2010.

USGS Gage 07142575: Rattlesnake Creek near Zenith, KS, above Quivira Little Salt Marsh.

Period of Record (Flow): January 1, 1975 through December 31, 2010.
Period of Record (Conductivity): November 16, 1998 through November 30, 2003

USGS Gage 07142620: Rattlesnake Creek near Raymond, KS, below Quivira Big Salt Marsh.
Period of Record: January 1, 1975 through September 30, 1998. Regression analysis with USGS Gage 07142575 was used to estimate flows at Raymond from October 1, 1998 through December 31, 2010 (Appendix A).

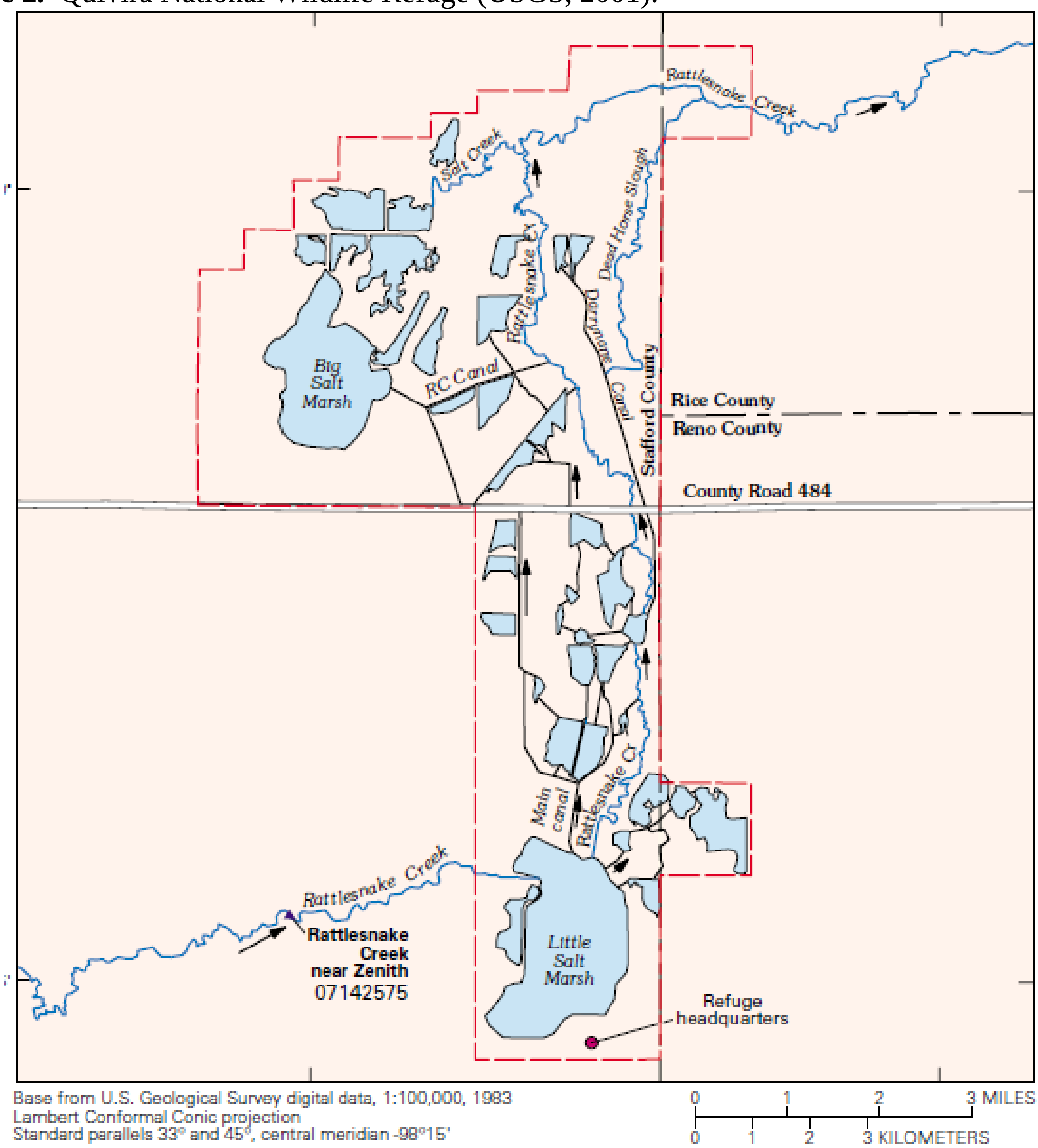
Figure 1. The Quivira Little Salt Marsh and Quivira Big Salt Marsh watershed.



Hydrologic Conditions: The Quivira National Wildlife Refuge (QNWR) is near the downstream end of Rattlesnake Creek which drains about 1,084 mi^2 before it enters the refuge and flows directly into the Little Salt Marsh located in the southern part of QNWR. Rattlesnake Creek continues to flow through the marsh where canals and ponds have been constructed to provide the entire marsh with dependable surface-water supply (Figure 2). North of Big Salt Marsh, Rattlesnake Creek joins with Salt Creek before flowing out of the northeastern corner of

QWNR and on to its confluence with the Arkansas River about 10 miles downstream in Rice County. Additionally, substantial quantities of water are supplied by natural ground-water seepage in the northern part of the refuge near Big Salt marsh (USGS, 2001). In 1996 the U.S. Geological Survey developed a computer-based water-budget and flow-routing model to assist the U.S. Fish and Wildlife Service in managing flow conditions in QNWR. Using the model to simulate the 1996 operating conditions in QNWR results in an average estimated inflow of 7.25 cfs to Quivira Big Salt Marsh (USGS, 1998).

Figure 2. Quivira National Wildlife Refuge (USGS, 2001).



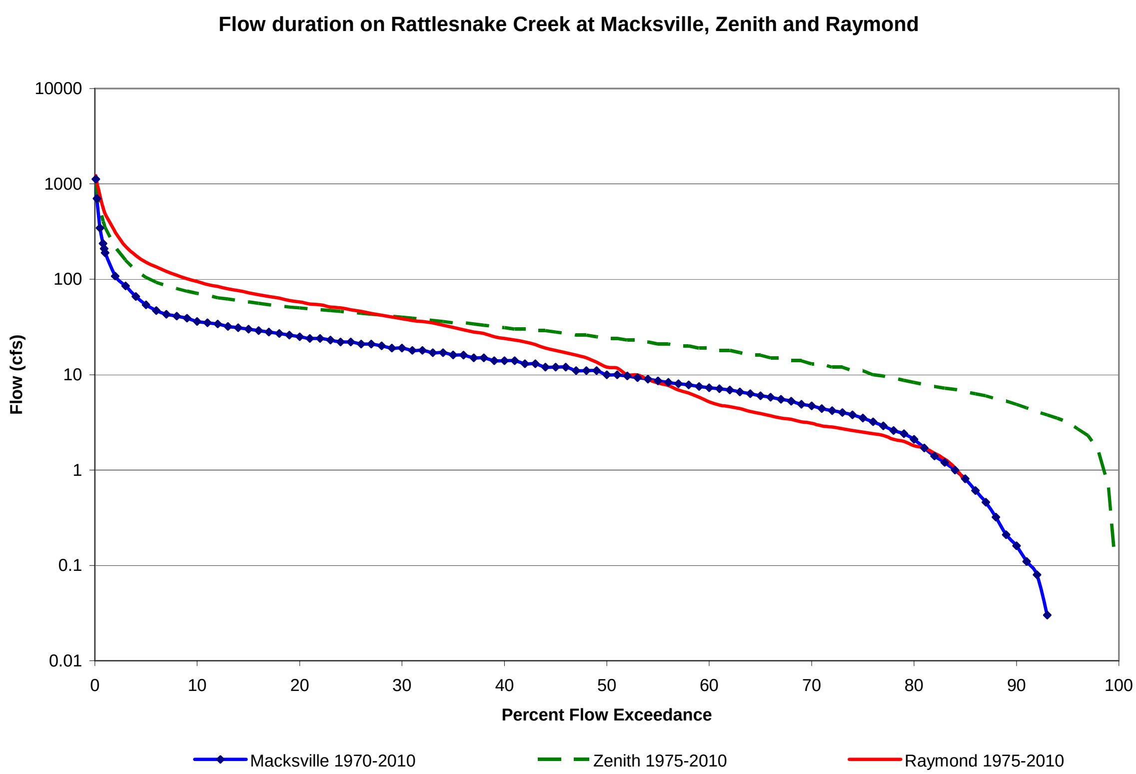
Rattlesnake Creek is a gaining stream with groundwater inflow to the creek below the City of St. John relatively low in chloride concentration making it important for its capacity to dilute the upstream chloride load. Average flow in Rattlesnake Creek near Macksville, below St. John, is 21.6 cfs and, just prior to entering QNWR, the creek has an average flow of 42.9 cfs near Zenith

(Table 1). Flow duration curves for Rattlesnake Creek at Macksville, Zenith and Raymond are displayed in Figures 3 for the gages' period of record and reveal a decline in the flow of Rattlesnake Creek below QNWR at Raymond when the creek is at base and low flow and the marsh is functioning effectively. This dampening of flow in Rattlesnake Creek as it travels through the marsh is likely due to its altered course, evapotranspiration and ground water infiltration. Under high flow conditions, however, flow out of QNWR outpaces that of flow into the marsh indicating the marsh may undergo flushing during high flow events (Figure 3 & Table 1).

Table 1. Flow conditions (cfs) for Rattlesnake Creek at Macksville (07142300, 1970-2010), Zenith (07142575, 1975-2010) and Raymond (07142620, 1975-2010).

Location	Mean Flow	90%	75%	50%	25%	10%
Rattlesnake Creek near Macksville USGS 07142300 (Above USGS 07142575)	21.6	0.16	3.50	10.0	22.0	36.0
Rattlesnake Creek near Zenith USGS 07142575 (Above Quivira Little Salt Marsh)	42.9	4.9	11.0	24.0	45.0	71.0
Rattlesnake Creek near Raymond USGS 07142620 (Below Quivira Big Salt Marsh)	41.8	1.6	3.5	16.9	48.0	91.0

Figure 3. Flow duration curves for Rattlesnake Creek at Macksville (07142300, 1970-2010), Zenith (07142575, 1975-2010) and Raymond (07142620, 1975-2010).



A comparison of flows for the time periods 1970 to 1987 and 1988 to 2010 at Macksville shows a significant decrease in flow for the 1998 to 2010 time period across the range of flow conditions (Figure 4). Decreases in flow for the 1998 to 2010 period are also seen at Zenith, but to a much lesser extent, indicating inflow of saline groundwater to the creek below Macksville (Figure 5). Flows below QNWR at Raymond are reduced for the 1988-2010 time period as well with the creek flowing only 91% of the time and a fall in median flow from 21.5 cfs to 15.0 cfs between the two time periods (Figure 6 & Table 2).

Figure 4. Flow duration curve for Rattlesnake Creek at USGS 07142300 (Macksville).

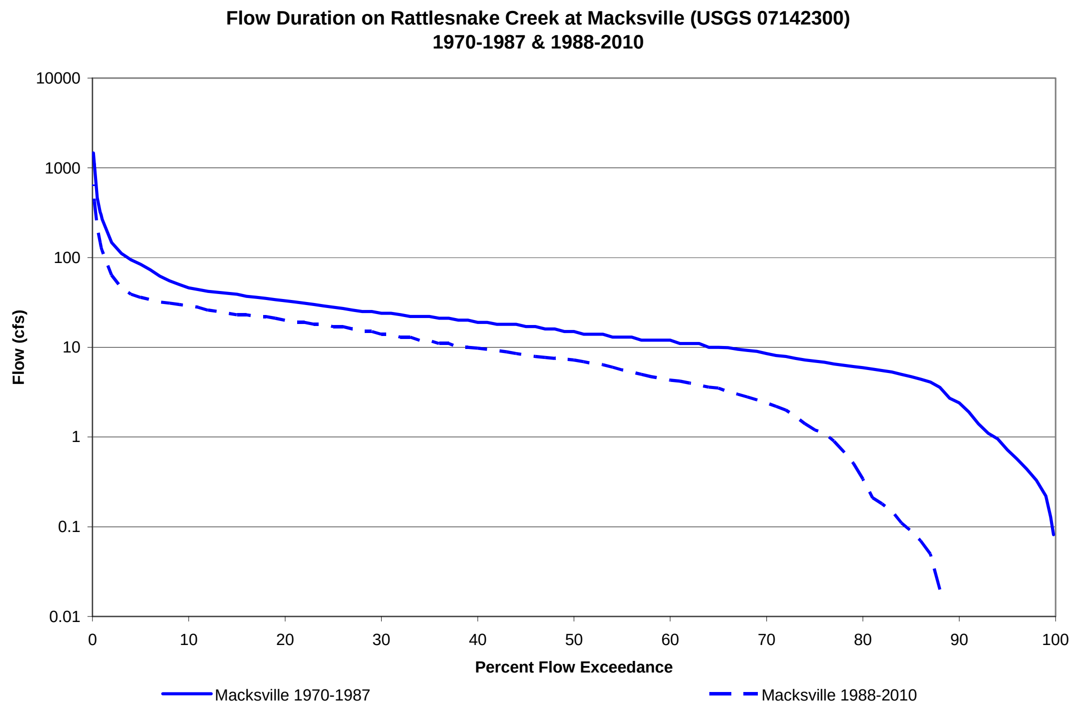


Figure 5. Flow duration curve for Rattlesnake Creek at USGS 07142575 (Zenith) above QNWR.

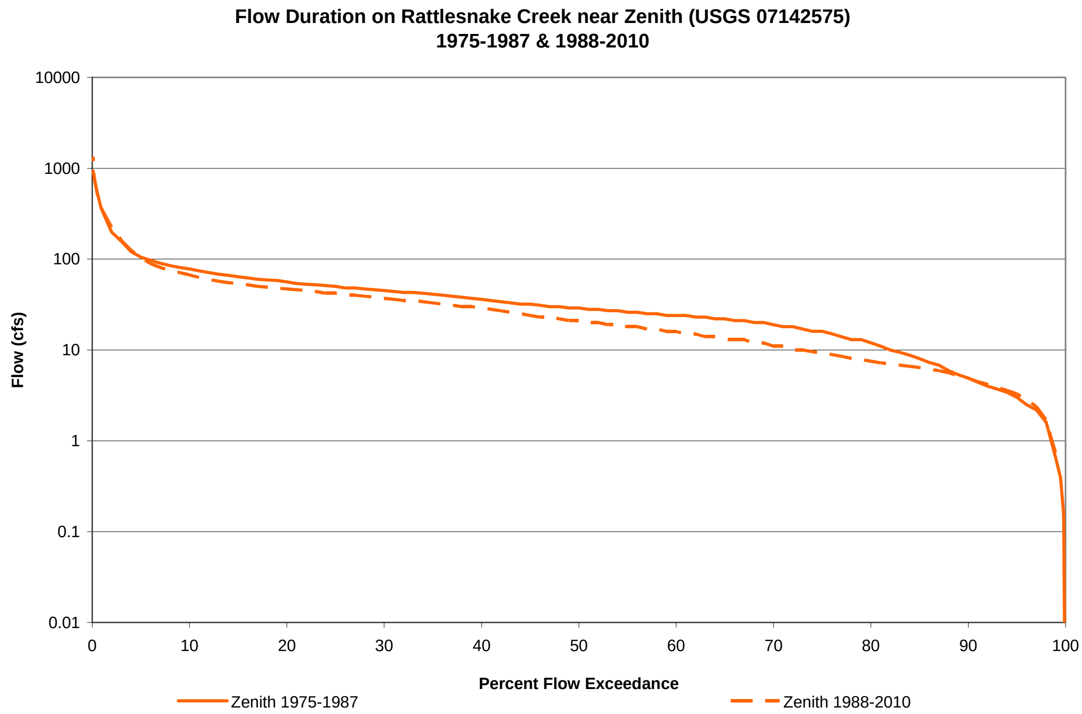


Figure 6. Flow duration curves for Rattlesnake Creek at USGS gage 07142620 (Raymond) below QNWR.

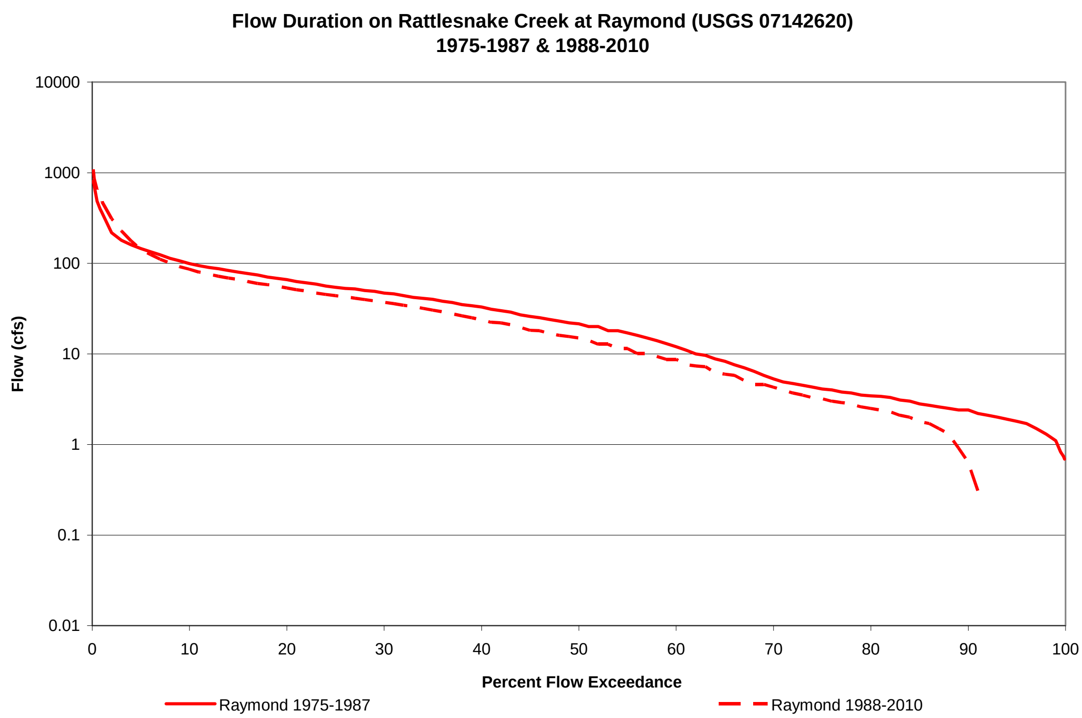
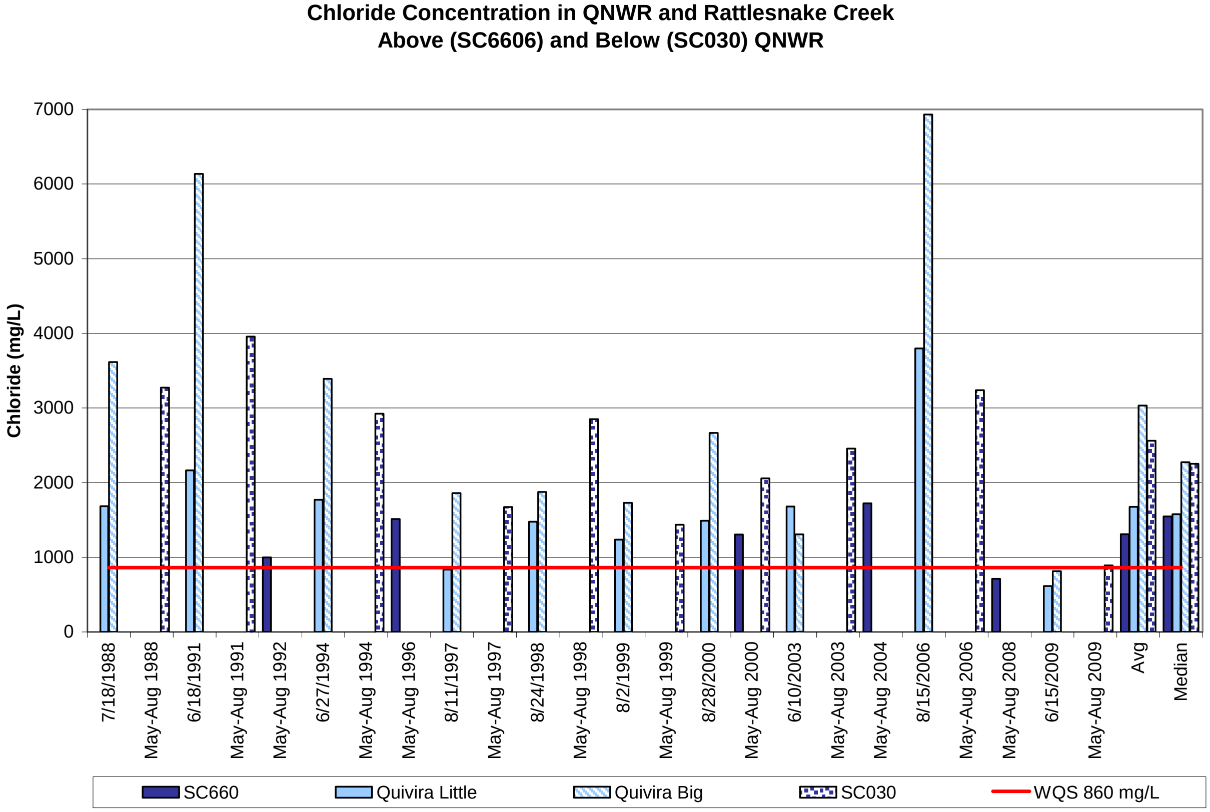


Table 2. Flow (cfs) conditions for Rattlesnake Creek for time periods displayed in Figures 4, 5 & 6.

Location	Time Period	Mean Flow	90%	75%	50%	25%	10%
Rattlesnake Creek near Macksville USGS 07142300 (Above USGS 07142575)	1970-1987	31.0	2.4	7.0	15.0	28.0	46.0
	1988-2010	14.2	0	1.2	7.2	17.0	29.0
Rattlesnake Creek near Zenith USGS 07142575 (Above Quivira Little Salt Marsh)	1975-1987	44.0	4.90	16.0	29.0	50.0	78.0
	1988-2010	42.2	4.90	9.20	21.0	42.0	67.0
Rattlesnake Creek near Raymond USGS 07142620 (Below Quivira Big Salt Marsh)	1975-1987	43.0	2.40	4.10	21.5	54.3	99.0
	1988-2010	41.1	0.64	3.20	15.0	43.9	86.0

Current Conditions: Over the period of record, the chloride concentration in Quivira Little Salt Marsh has exceeded the chloride water quality standard for aquatic life (860 mg/L) 8 of 10 times resulting in an average concentration of 1,675 mg/L while concentrations in the Quivira Big Salt Marsh have exceeded 9 of 10 times with an average of 3,033 mg/L (Figure 7). In 1997, the chloride concentration in Quivira Little Salt Marsh fell below the water quality standard at 836 mg/L and in 2009 both Little and Quivira Big Salt Marsh chloride concentrations were below the water quality standard at 616 mg/L and 814 mg/L, respectively. Higher flows on sampling days in Rattlesnake Creek above QNWR at 38 cfs in 1997 and 135 cfs in 2009 are primarily responsible for lower chloride concentrations due to dilution of the natural contributions of salt from Rattlesnake Creek below St. John. Chloride concentrations are consistently higher in Quivira Big Salt Marsh than in Quivira Little Salt Marsh due to Quivira Little receiving flow directly from Rattlesnake Creek. Quivira Big receives flow via a canal system where flow is subject to evapotranspiration and from the seepage of saline groundwater into the marsh. The increase in chloride concentration is reflected in the higher chloride values consistently seen in Rattlesnake Creek below QNWR versus those seen above the refuge (Figure 7).

Figure 7. Chloride concentrations in Rattlesnake Creek at SC660 & SC030 and Quivira Little and Quivira Big Salt Marshes, for the period of record. Rattlesnake Creek at SC660 values are the average of the May-August samples taken during years the station was sampled while SC030 values are May-August averages for the years Quivira Little & Big were sampled.



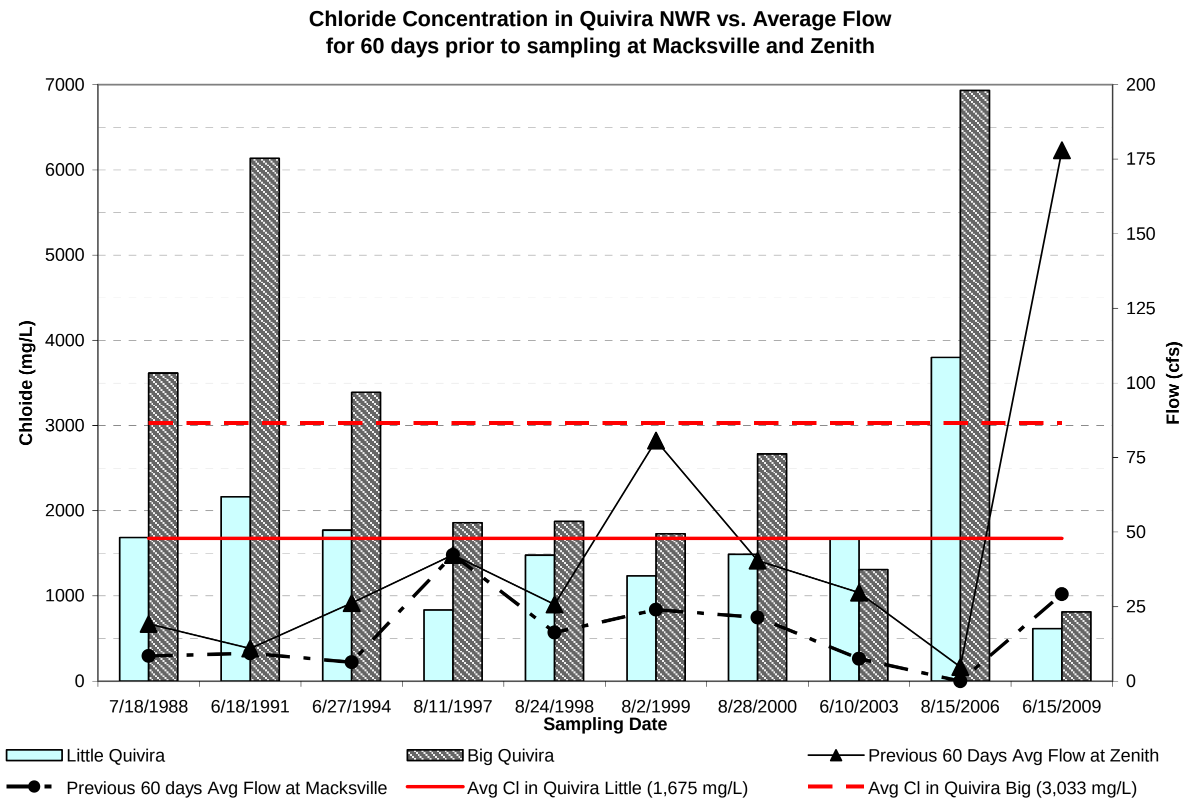
Annual average inflow for QNWR varies and is reflective of rainfall totals in the respective years (Table 3). The flow seen in Rattlesnake Creek at Macksville is indicative of the quantity of fresh water inflow QNWR received for years the marshes were sampled. Annual average discharge from the refuge is generally lower than the average inflow and is characteristic of the level of evapotranspiration and ground water intrusion occurring in the marsh. Years where the average discharge is higher than average inflow possibly reflects periods where seepage into the marsh increased due to higher than normal ground water levels or where the water level in the marsh was manually lowered by pumping.

Table 3. Annual acre-feet in Rattlesnake Creek at Macksville (USGS gage 07142300) and annual inflow and discharge to QNWR based on streamflow measurements at USGS gage 07142575, Rattlesnake Creek near Zenith above QNWR and USGS gage 07142620, Rattlesnake Creek near Raymond below QNWR. Flow measurements at USGS gage 07142620 ceased in October, 1998 thus average discharge for 1998-2009 were estimated by regression analysis with USGS gage 07142575 flow.

Year	Average Annual Freshwater Inflow Acre-Feet (Macksville)	Average Annual Inflow Acre-Feet (Zenith)	Average Annual Discharge Acre-Feet (Raymond)
1988	7,543	16,796	13,027
1991	1,025	4,220	1,798
1994	5,837	14,749	17,660
1997	21,903	36,444	37,013
1998	20,623	41,878	54,663
1999	14,884	36,589	43,358
2000	14,154	34,989	42,243
2003	2,013	11,359	6,369
2006	852	7,073	805
2009	10,278	50,910	68,146
Average	**9,911**	**25,498**	**28,526**

The effect of the flow in Rattlesnake Creek at Macksville and Zenith on chloride concentrations in QNWR can be seen in Figure 8. 1991 and 2006 had the highest chloride concentrations for the period of record while the 60 days prior to the samplings had the lowest average flow at Zenith at 11.0 cfs and 3.5 cfs, respectively; the 2009 sampling with the lowest chloride concentrations had an average flow at Zenith of 178 cfs.

Figure 8. Chloride concentration vs. the average flow at USGS 07142300 (Macksville) and USGS 07142575 during the 60 days preceding the sampling date. Average chloride values for Quivira Little and Quivira Big are for the period of record.



Relationships: Specific conductance values and total dissolved solids values in both Quivira Little and Quivira Big Salt Marshes reflect their respective chloride concentrations. In 2009 both marshes recorded their lowest chloride concentrations, for the period of record, with total dissolved solids (TDS) and specific conductivity following suit. High chloride concentrations were reported in 2006 when specific conductivity and TDS measurements were the highest on record for Quivira Little and Quivira Big Salt Marshes (Table 4).

Table 4. Water quality data for Quivira Little and Quivira Big Salt Marshes at LM050201 and LM050601, respectively. Flow values are daily averages at USGS gage 07142575, Rattlesnake Creek near Zenith, above QNWR.

Sampling Date	Chloride (mg/L)		Specific Conductance (µS/cm)		Total Dissolved Solids (mg/L)		Flow (cfs)
	Little	Big	Little	Big	Little	Big	
7/18/1988	1,685	3,615	5,175	10,915	3,044	6,477	7.8
6/18/1991	2,165	6,135	7,315	18,860	3,931	10,608	5.8
6/27/1994	1,770	3,390	6,595	11,100	3,282	6,294	6.2
8/11/1997	836	1,860	3,010	6,035	1,514	5,748	38
8/24/1998	1,478	1,875	4,975	6,195	2,790	3,506	7.1
8/02/1999	1,236	1,730	4,175	5,830	2,290	3,357	22

8/28/2000	1,488	2,667	5,220	8,590	2,626	4,833	8.5
6/10/2003	1,678	1,308	5,608	4,345	3,123	2,418	15
8/15/2006	3,798	6,933	11,500	20,030	6,616	12,016	6.1
6/15/2009	616	814	2,470	3,196	1,359	1,807	135
Median	*1,576*	*2,273*	*5,175*	*7,310*	*2,910*	*4,833*	N/A
Average	*1,675*	*3,033*	*5,604*	*9,510*	*3,057*	*5,706*	N/A

The nearly perfect relationship between chloride and specific conductance in Quivira Little Salt Marsh can be seen in Figure 9. Conductivity measurements respond to higher chloride concentrations with higher conductivity values due to the charged nature of the anionic chloride ion and its cationic partner in solution. Dissolved solids in Kansas surface water samples include soluble salts that yield ions such as sodium, calcium, magnesium, bicarbonate, sulfate or chloride. The strong correlation between chloride and total dissolved solids (TDS) indicates most of the dissolved solids in QNWR are due to the dissolution of chloride salts in the watershed. The relationship of chloride to flow percentile in Little Quivira is an inverse one with jumps in chloride concentrations accompanied by low flow conditions (Figure 9).

Relationships between chloride concentration, specific conductance and TDS in Quivira Big Salt Marsh are nearly perfect as well (Figure 10). However, there is a decline in the strength of the relationship between flow and chloride from Quivira Little to Quivira Big demonstrating the effect of evapotranspiration and saline groundwater seepage into the Quivira Big Salt Marsh on chloride concentration.

Figure 9. Relationships in Quivira Little Salt Marsh. Flow exceedance percentile is based on flow at USGS gage 07142575, above Quivira at Zenith.

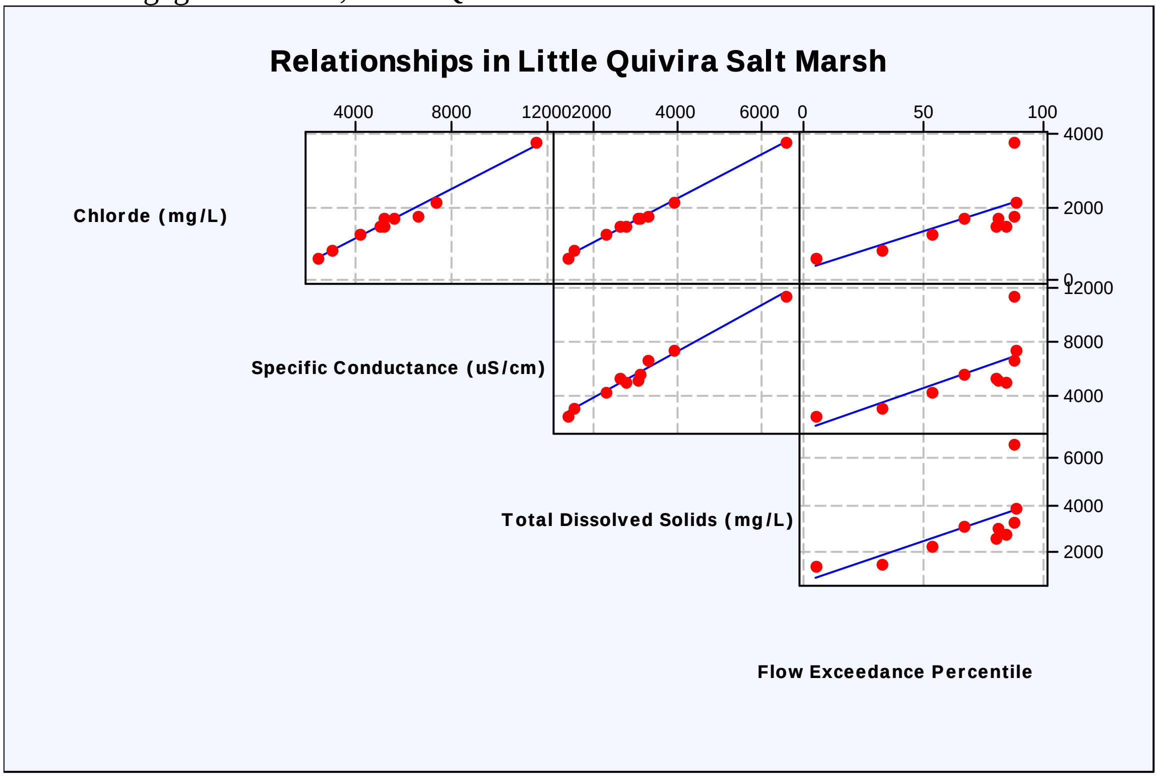
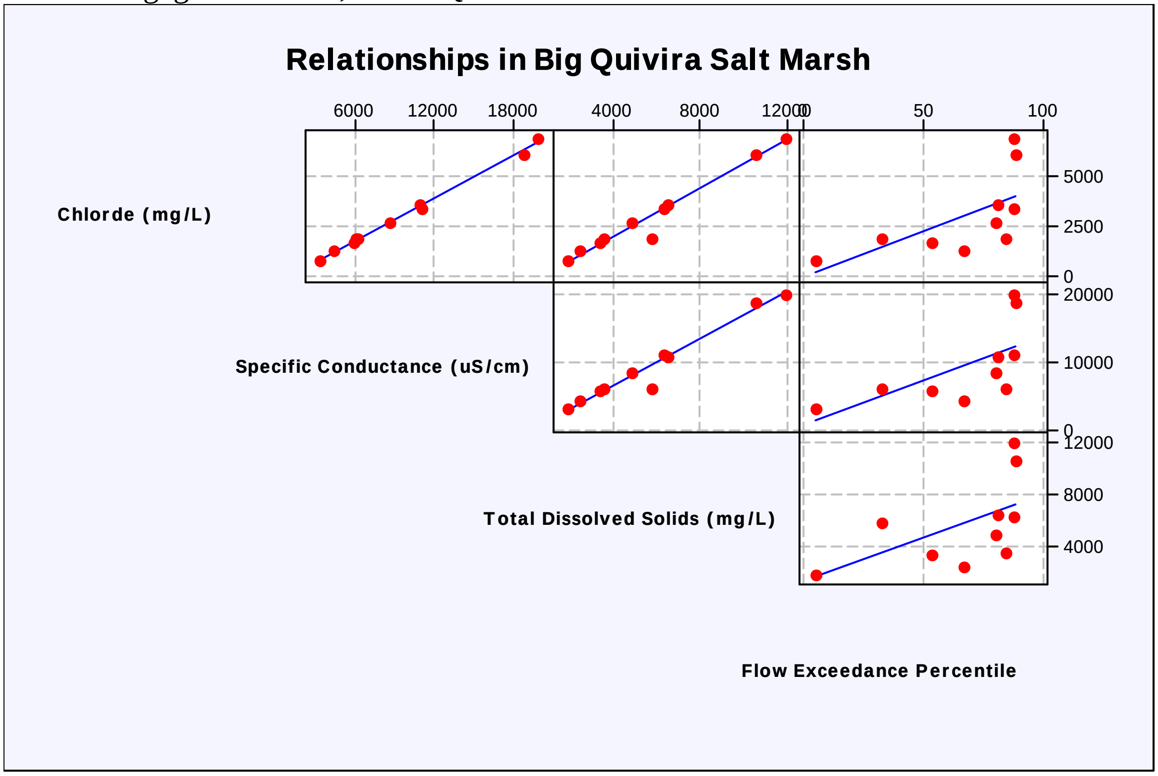


Figure 10. Relationships in Quivira Big Salt Marsh. Flow exceedance percentile is based on flow at USGS gage 07142575, above Quivira at Zenith.



Stream Data: Continuous monitoring for specific conductance was performed by USGS in Rattlesnake Creek near Zenith (USGS 07142575) from late 1998 to late 2003. As discussed earlier, conductivity measurements respond to higher chloride concentrations with higher conductivity values due to the charged nature of the chloride ion and its cationic partner in solution. A comparison of the daily average conductivity values at Zenith to the daily average flows at Zenith and Macksville reveal a moderate relationship between conductivity and flow at both gages; however, the relationship is marginally better at Macksville (Figure 11). Figure 12 presents significant correlations between the annual average flow at Macksville and the average annual chloride concentration in Quivira Little and Quivira Big for sampling years highlighting the importance of the freshwater flow coming from Rattlesnake Creek above St. John to abating the chloride concentration in QNWR.

Figure 11. Flow in Rattlesnake Creek at Macksville vs. continuous monitoring conductivity values in Rattlesnake Creek at Zenith, 11/18/98-11/30/2003.

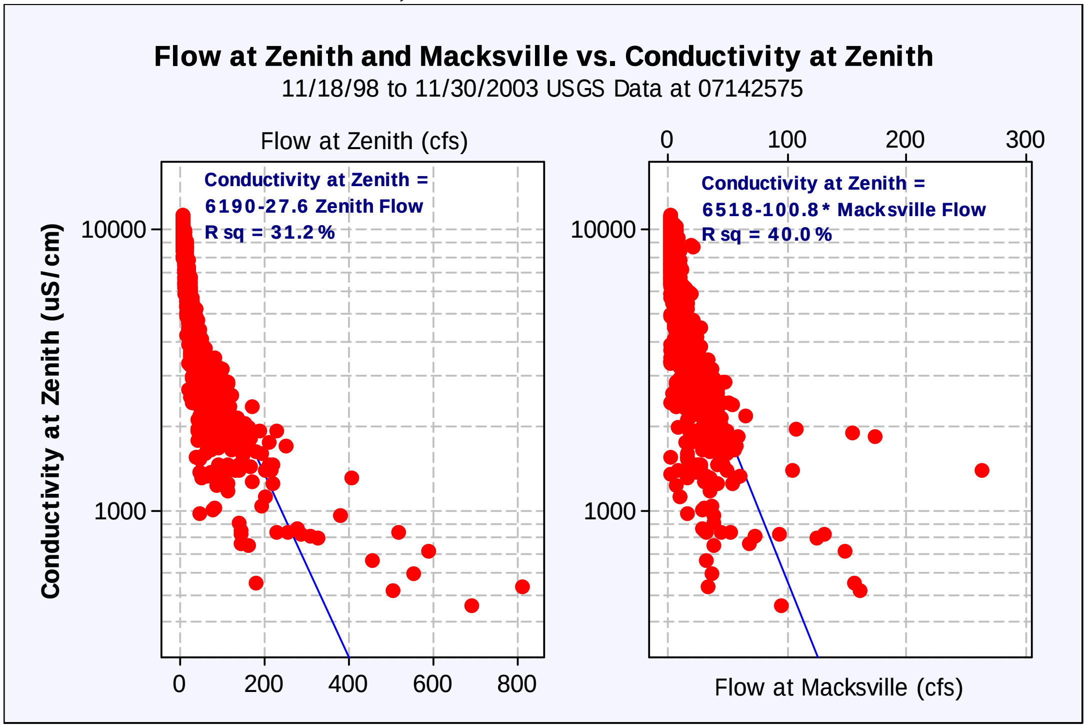
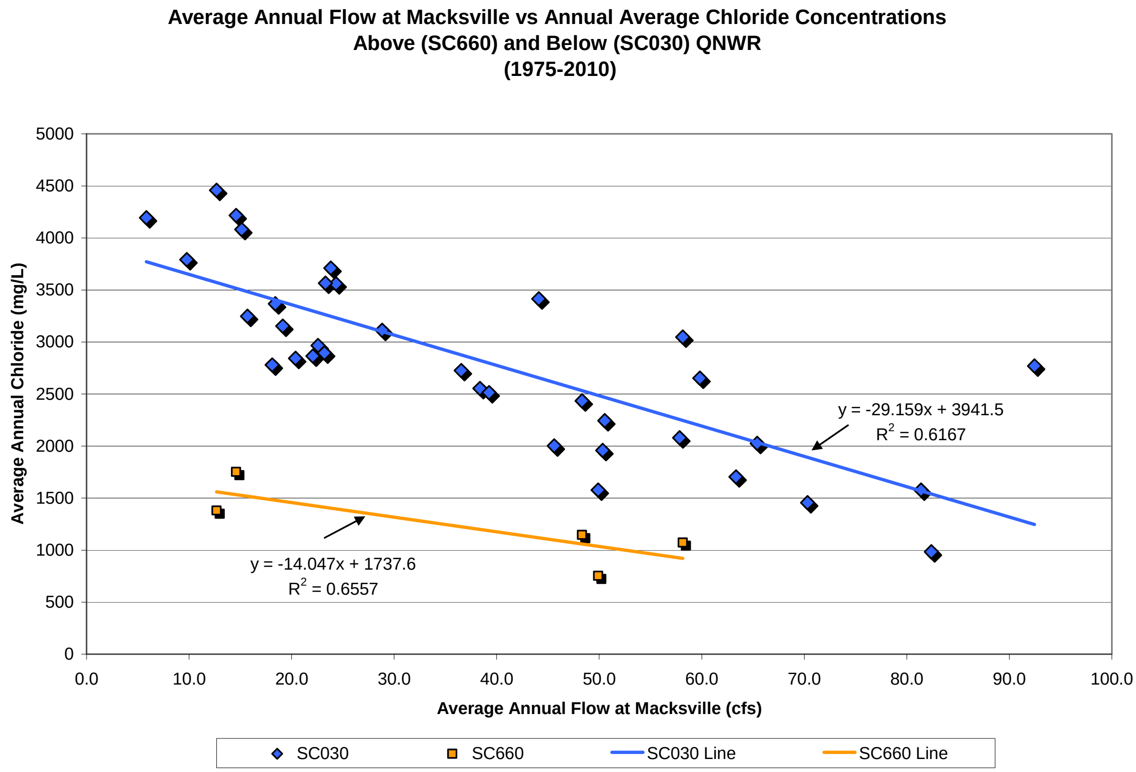
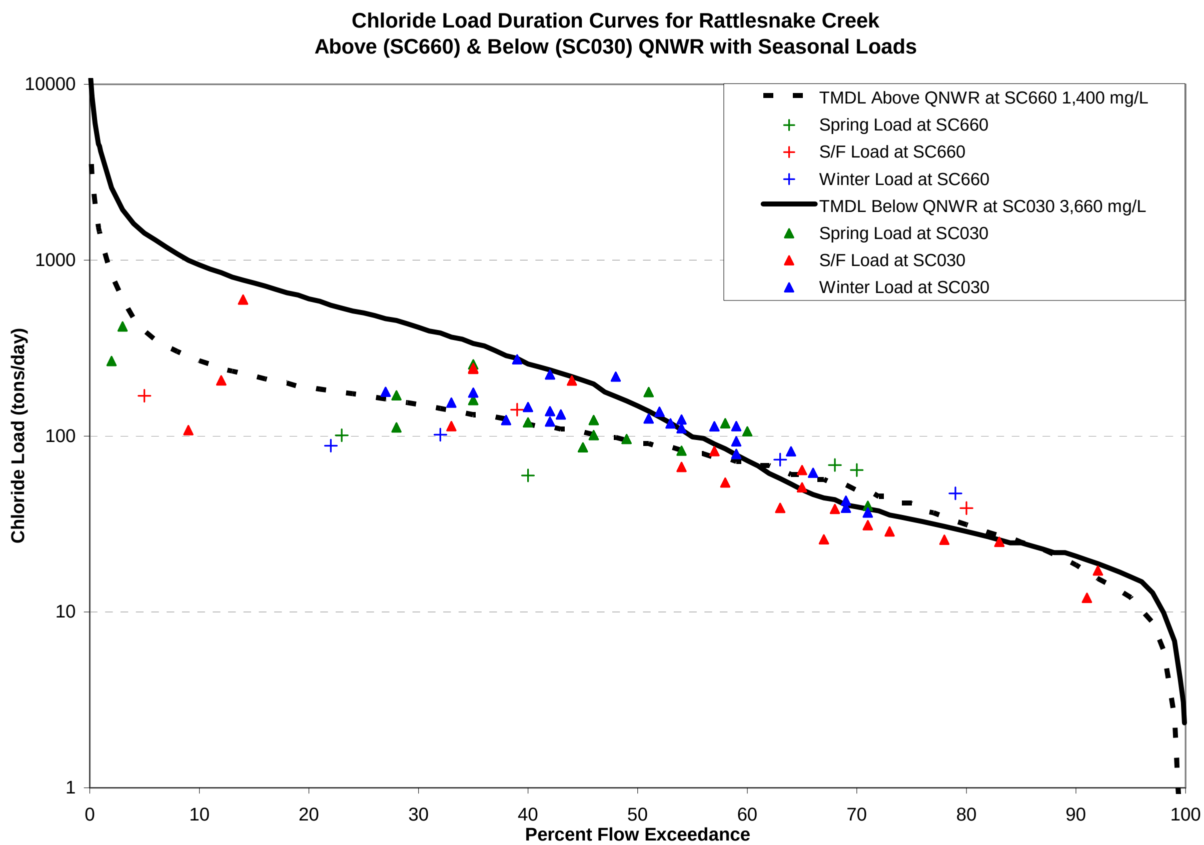


Figure 12. Average annual chloride concentration at Raymond (SC030) below QNWR vs. average annual flow in Rattlesnake Creek at Macksville.



Background chloride concentrations for Rattlesnake Creek segments beginning at the confluence with Wildhorse Creek in Stafford County and ending at the confluence with the Arakansas River in Rice County were developed in 2001. A background concentration for chloride of 1,400 mg/L was established for Segment 1 of Rattlesnake Creek above QNWR (SC660) and at 3,660 mg/L for Segment 1 of Rattlesnake Creek below QNWR (SC030). These background concentrations were incorporated into the Kansas Surface Water Quality Standards in 2004 and Rattlesnake Creek was delisted according to 2010 303(d) listing methodology when median concentrations were found to be below the established background concentrations. As Figure 13 reveals, load exceedances at SC660 and SC030 generally do not occur when Rattlesnake Creek is flowing at or above median flow.

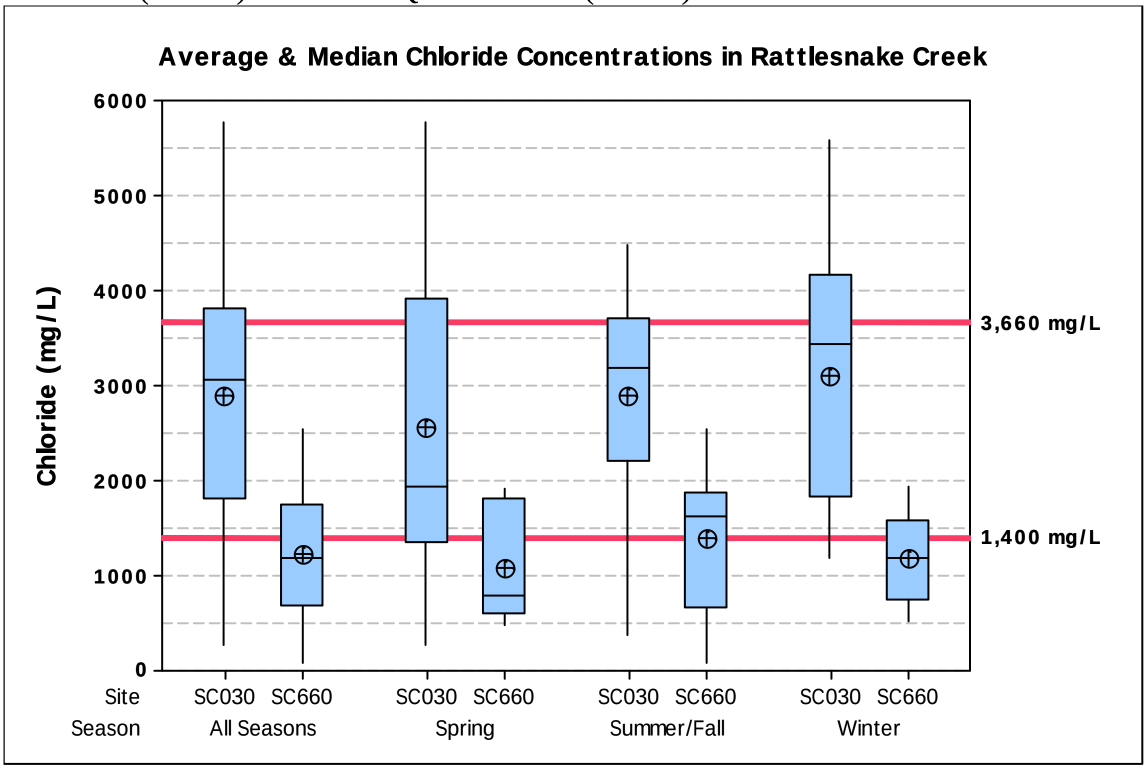
Figure 13. Load duration curves for KDHE sampling sites SC660 & SC030 on Rattlesnake Creek above and below QNWR, respectively, for 2004-2011. Loads are daily loads in terms of tons/day and were calculated from chloride concentrations at SC660 and SC030 and daily average flow in Rattlesnake Creek at Zenith and Raymond, respectively. Flow data from USGS gages 07142575 (Zenith) and 07142620 (Raymond) was used to establish curves.



Chloride concentrations at SC660 above QNWR are consistently lower than concentrations seen downstream at SC030 below QNWR due to evapotranspiration and the seepage of saline water in the marsh. In order to compare data across seasons, sampling data was categorized into three defined seasons: Spring (April-June), Summer-Fall (July-October) and Winter (November-

March). The effect of higher seasonal flows on chloride concentration is highlighted in the low Spring averages at both SC660 and SC030 (Figure 14).

Figure 14. Average and median chloride concentration by season for Rattlesnake Creek above Quivira NWR (SC660) and below Quivira NWR (SC030).



Chloride concentrations decrease at both SC660 and SC030 as flow in Rattlesnake Creek swells while low flow conditions, across the seasons, result in average chloride concentrations of 1,647 mg/L at SC660 and 3,590 mg/L at SC030 (Table 5).

Table 5. Chloride concentrations in Rattlesnake Creek at SC660 & SC030 for the period of record.

Chloride Levels by Season in Rattlesnake Creek (mg/L)										
Stream Flow (% Exceedance)	**Spring Averages**		**Summer-Fall Averages**		**Winter Averages**		**All Season Median**		**All Season Average**	
	SC660	SC030	SC660	SC030	SC660	SC030	SC660	SC030	SC660	SC030
High (0-10%)	No Data	794	593	754	No Data	1424	593	917	593	1000
Normal (11-50%)	655	2406	1635	2229	724	2858	803	1830	712	2632
Low (51-100%)	1827	4537	1695	3245	1495	3883	1553	3710	1647	3590
All Flow Median	797	1937	1635	3107	1195	3445	1195	3182	N/A	N/A
All Flow Avg.	1088	2563	1399	2888	1188	3100	N/A	N/A	1224	2925

Desired Endpoints of Water Quality (Implied Load Capacity) in the Quivira Little Salt Marsh (LM050201) and the Quivira Big Salt Marsh (LM05061):

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Special Aquatic Life Use which will ensure all other designated uses are protected. This TMDL will, however, be phased. Phase one will establish a chloride TMDL at LM050201, Quivira Little Salt Marsh, and at LM050601, Quivira Big Salt Marsh, using the current acute aquatic life criterion of 860 mg/L chloride. However, the discharge of saline ground water along the Rattlesnake Creek corridor, seepage of saline ground water into the Quivira Wildlife Refuge and the decline in fresh water flows above St. John make achievement of the water quality standard (WQS) of 860 mg/L unlikely. Because the standard is not achievable due to natural contributions to the chloride load an alternative endpoint to Quivira Little and Quivira Big Salt Marshes is needed.

Chloride excursions above the acute aquatic life criterion of 860 mg/L chloride in the Quivira Little and Quivira Big Salt Marshes appear to be related to diminished stream flow in Rattlesnake Creek rather than seasonality. However, seasonal variation is accounted for in this TMDL as the endpoint applies to all flow conditions throughout the year.

Kansas Implementation Procedures for Surface Water allow for a numerical criterion based on natural background to be established for lakes and wetlands using the mean of at least five concentration observations for samples collected outside of the regulatory mixing zone. The specific wetland criteria to supplant the general standard will be developed following the appropriate administrative and technical Water Quality Standards processes and will be part of phase two of this TMDL. Meanwhile the current acute aquatic life criterion of 860 mg/L chloride will apply to both the Quivira Little and the Quivira Big Salt Marsh. The proposed alternate endpoints for both marshes have been developed based on currently available information, while taking into consideration established background concentrations for Rattlesnake Creek, resulting proposed background concentrations of 1,675 mg/L chloride in Quivira Little Salt Marsh (LM050201) and 3,033 mg/L chloride in Quivira Big Salt Marsh (LM050601) (Table 6).

Table 6. Chloride Endpoints for the Quivira Little and Quivira Big Salt Marshes.

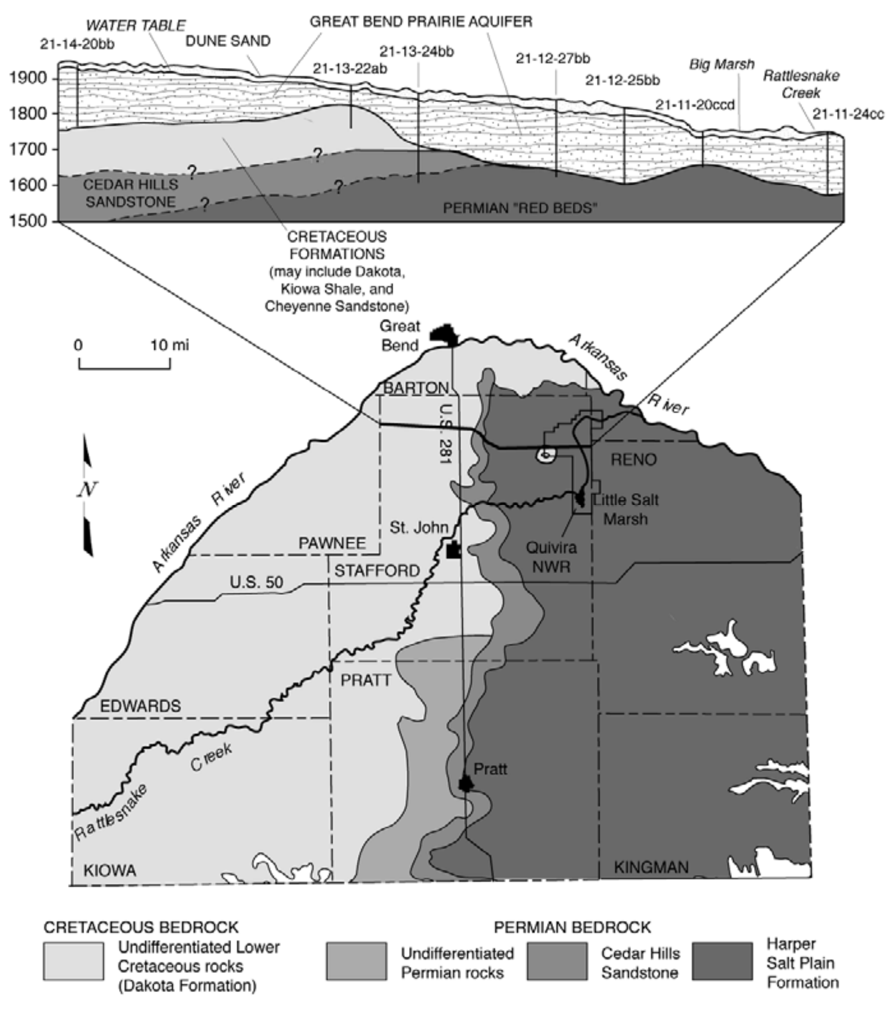
Station	**Waterbody**	**TMDL Endpoint Acute WQS for AL**	**Proposed Chloride Background Concentration to Supplant Acute WQS for AL**
LM050201	Quivira Little Salt Marsh	860 mg/L	1,675 mg/L
LM050601	Quivira Big Salt Marsh	860 mg/L	3,033 mg/L

3. SOURCE INVENTORY AND ASSESSMENT

Background: The Rattlesnake Creek corridor is characterized by several features that lead to comparatively high saltwater discharges penetrating the land surface: 1) there is limited cover of subsurface clay lenses, so Permian zone saltwater is not prevented from penetrating into the entire vertical extent of the Great Bend Prairie aquifer, 2) a paleochannel, located at a course closely matched with that of the Rattlesnake Creek, represents a specific avenue for Permian water transfer into the aquifer and 3) groundwater horizontal gradients are almost parallel to the course of the Rattlesnake Creek and the paleochannel, so the paleochannel system is able to convey groundwater of comparatively high salinity large distances down stream. East of Highway 281 in Stafford County (above St. John), the Rattlesnake Creek corridor is a pathway for natural discharge of both fresh and saline groundwater as there is a direct hydraulic connection between the Permian and alluvial aquifers permitting the natural brine of the Permian bedrock to move upward and contaminate the freshwater of the overlying aquifer (Figure 15). The Cedar Hills Sandstone aquifer also discharges near the surface into the overlying freshwater aquifer west of the Quivira marshes with a north-south trending ridge of Permian bedrock below the marshes restricting the easterly movement of ground water toward the Arkansas River forcing saltwater to discharge into the low-lying streams and marshes. Salt concentrations are further increased in the marshes by evapotranspiration.

The Rattlesnake Creek corridor system, including Quivira National Wildlife Refuge, effectively drains large quantities of salt from the region through coupled surface and groundwater flow. The salt that is not discharged through surface flow remains in the groundwater and is a major source of salinity on the south side of the Arkansas River between Nickerson and Hutchinson making the saline water flow from the Rattlesnake Creek into the Quivira National Wildlife Refuge and then to the Arkansas River crucial to the preservation of the quality of groundwater resources of south-central Kansas (Rubin, 2001).

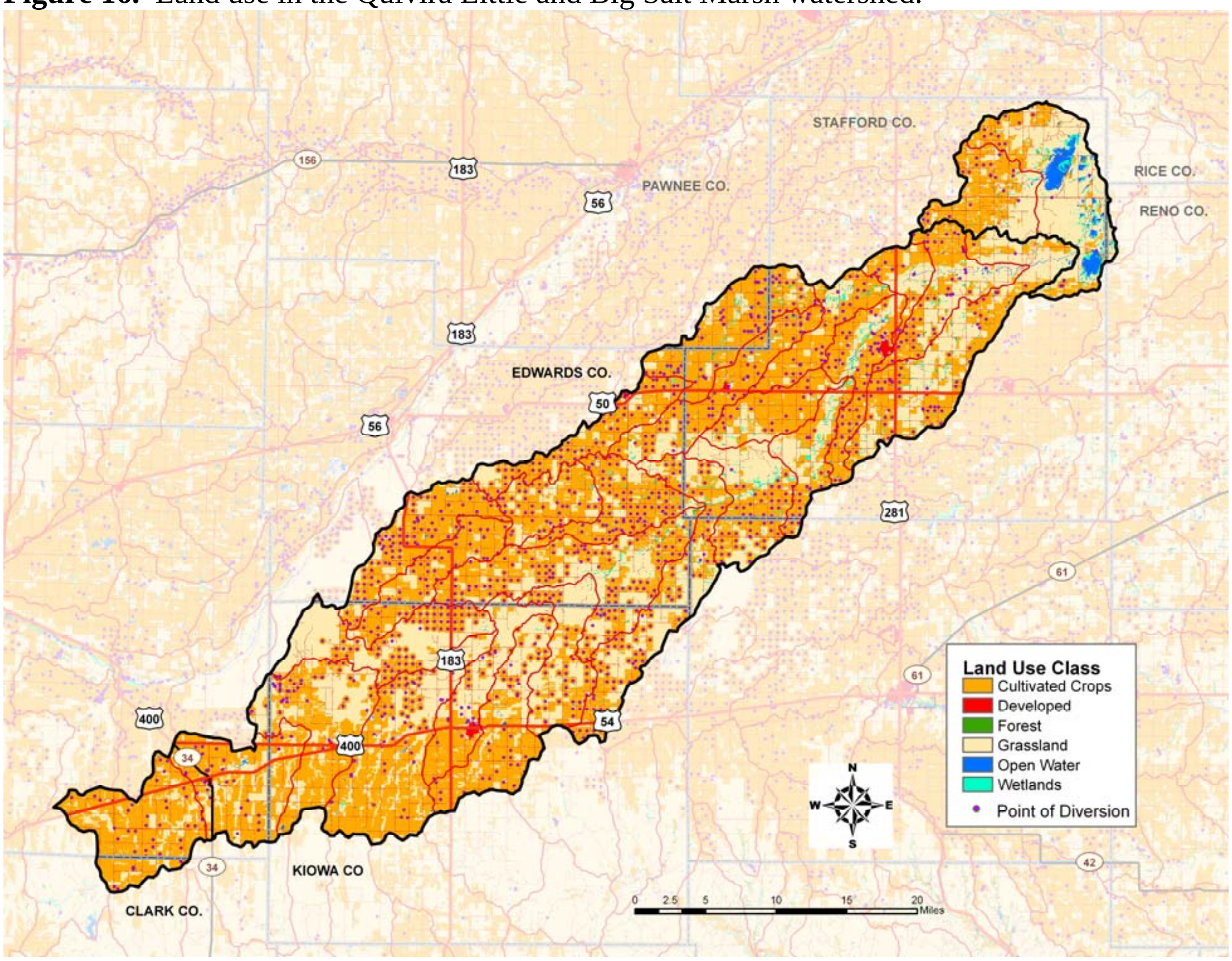
Figure 15. Subsurface geology of the Rattlesnake Creek and Quivira Little/Big Salt Marsh watershed (Rubin, 2001).



Land Use: The predominant land uses in the Quivira Little Salt Marsh watershed are cultivated cropland (60%) and grassland (34%), according to the 2001 National Land Cover Data. Together they account for 94% of the total land area in the watershed with the remaining land area composed of developed land (4.2%), wetlands (0.92%), open water (0.24%), and forest (0.16%) (Figure 11). Grassland and cultivated cropland are also the primary land uses in the Quivira Big Salt Marsh watershed at 54% and 31%, respectively, accounting for 85% of the total land area in the watershed. The remaining land use in the Quivira Big watershed are made up of open water (6.8%), developed (3.9%), wetlands (3.7%) and forest (0.6%).

During precipitation runoff events, the cultivated cropland in the watershed may contribute to the chloride load in the marshes. Precipitation events can render chlorides from soils' surface or wash salt laden soil into the streams in the watershed. Grasslands could also contribute to the chloride load during high flow events, however, to a much lesser extent than cultivated cropland due to the no-till nature of pastureland.

Figure 16. Land use in the Quivira Little and Big Salt Marsh watershed.



Points of Diversion and Irrigation: The Quivira Little Salt Marsh watershed has 1,536 active points of diversion with over 90% of the points identified as for use in irrigation (WIMAS, 2011). There is some concern about the effect of pumping on the balance between the salt fluxes into Rattlesnake Creek and quantities of salt that penetrate and disperse in the groundwater since lowering the water table may both enhance local saltwater penetration from the bedrock due to upconing, and at the same time, reduce natural discharge to the streamflow.

Moving northeastward through the watershed there is a decline in the number of points of diversion largely due to the increase in salinity resulting in water that is unsuitable for most uses Figure 16). The Quivira Big Salt Marsh watershed however does have 37 active points of diversion, including three surface water rights to the flow in Rattlesnake Creek owned by the U.S. Department of Interior and managed by the U.S. Fish & Wildlife Service (WIMAS, 2011). These rights are used to maintain water levels in Quivira National Wildlife Refuge and, although they authorize nearly 44,000 acre-feet per year for diversion, the average diversion for years in which KDHE sampled QWNR was about 4,070 acre-feet per year.

The Stafford County irrigation record in Figure 17 displays the number of acres irrigated and the acre-feet reported as groundwater pumped for the purpose of irrigation from 1960-2010. The number of acres irrigated in the county began to stabilize at about 82,000 in 1998 while the acre-feet pumped is reflective of annual rainfall totals in the area. Comparing irrigation pumping in Stafford County to flow in Rattlesnake Creek at Macksville reveals a moderate correlation indicating increases in groundwater irrigation diversions may decrease the availability of groundwater contributions to the fresh water flow at Macksville (Figure 18).
Although groundwater irrigation occurs in the watershed, the irrigation return flow is not expected to significantly contribute to the chloride load in the Quivira Little and Big Salt Marshes.

Figure 17. Irrigation and precipitation in Stafford County, Kansas, 1960-2010.

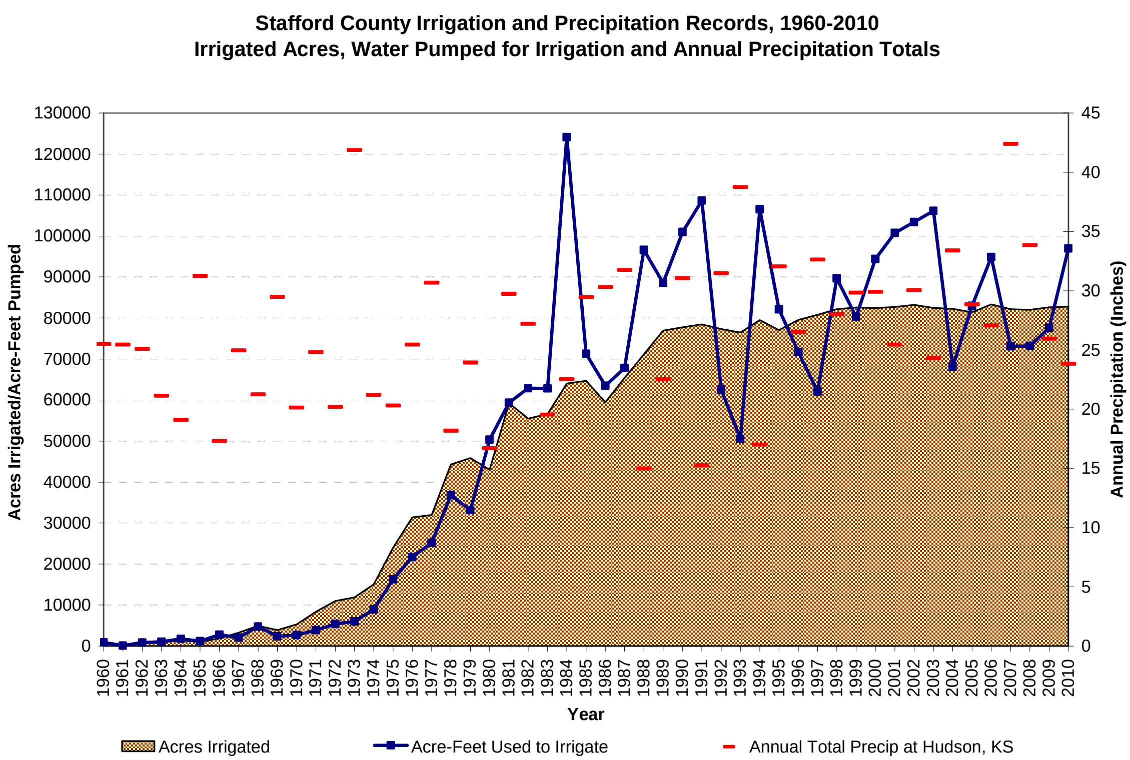
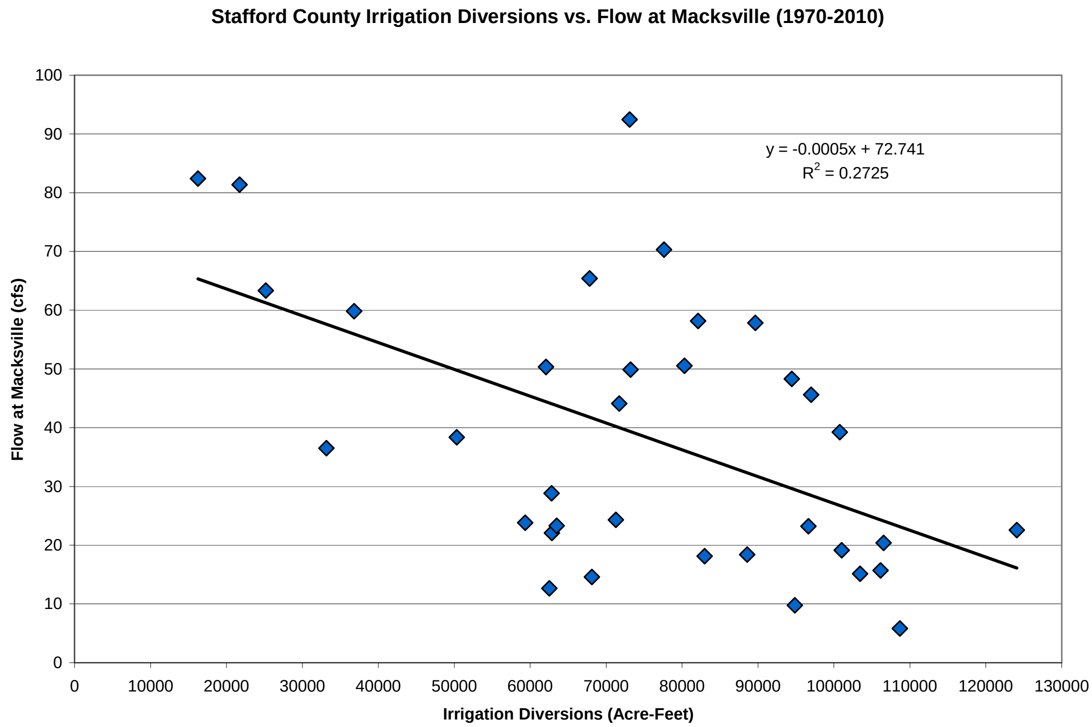


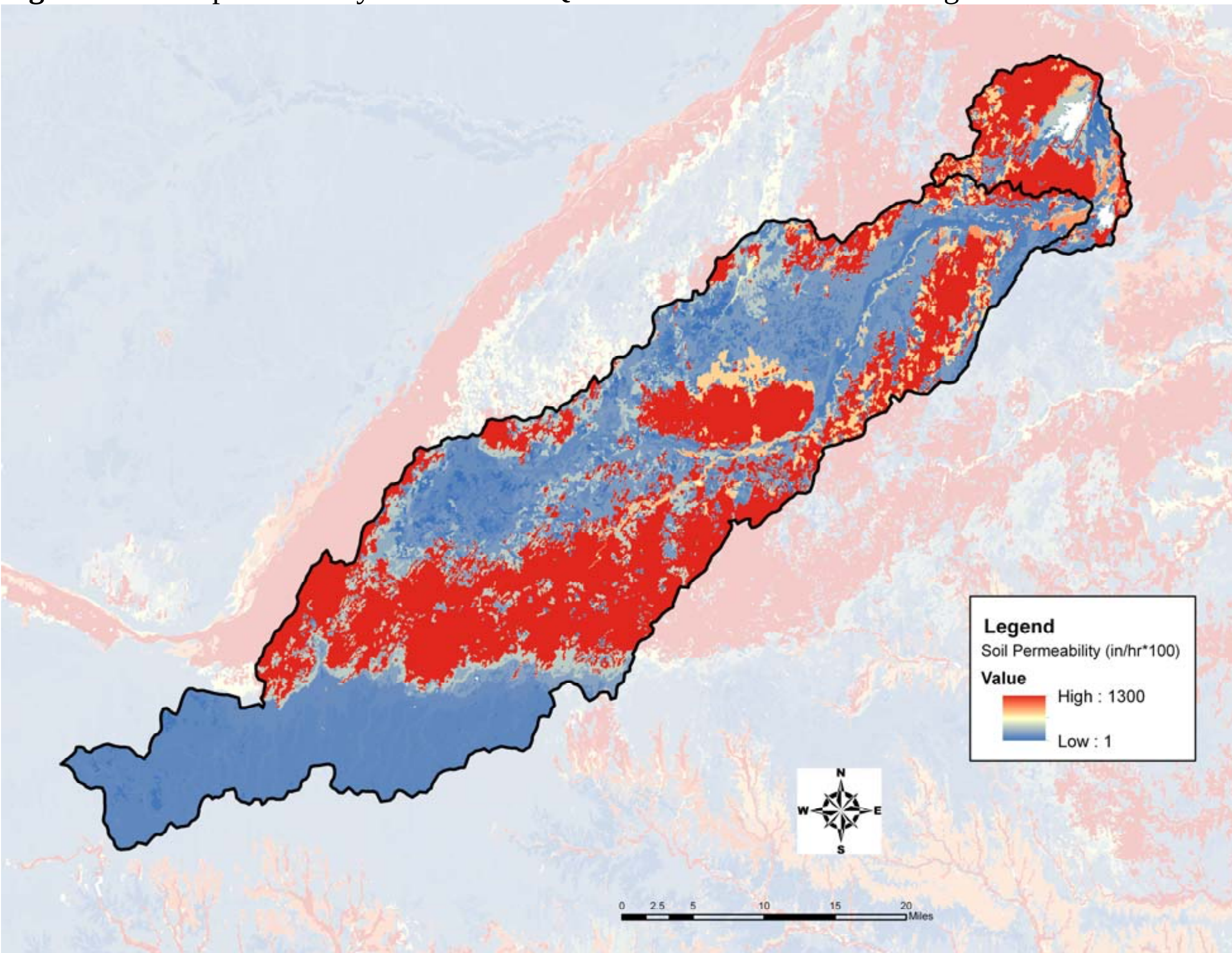
Figure 18. Annual irrigation diversions in Stafford County vs. flow in Rattlesnake Creek at Macksville, 1970-2010.



Oil Field Brine: There are oil fields scattered throughout the watershed, however, their effects to the watershed are likely localized to the production areas and not contributing to the chloride impairments in the Quivira Little and Quivira Big Salt Marshes. Additionally, in 2012, the Kansas Geological Survey (KGS) investigated salinity in an irrigation well located in north-central Stafford County and found the source of the saline groundwater to be from the natural intrusion of saltwater from Permian strata (Whittemore, 2012).

Contributing Runoff: The Quivira Little Salt Marsh and Quivira Big Salt Marsh watersheds have mean soil permeability values of 5.80 and 8.84 inches/hour, respectively (Figure 19). The permeability values range from 0.01 to 13.00 inches/hour according to NRCS STATSGO database, however, about 11% of the Quivira Little Salt Marsh watershed has a permeability value less than 2.29 inches/hour while over 70% of the watershed has a very high permeability value of 13.0 inches/hour or greater. Almost 74% of the Quivira Big Salt Marsh watershed has a permeability value of 13.0 inches/ hour and 8% of the watershed has a permeability value of 8.10 inches/hour or less. According to a USGS open-file report (Juracek, 2000), the threshold soil-permeability values are set at 3.43 inches/hour for very high, 2.86 inches/hour for high, 2.29 inches/hour for moderate, 1.71 inches/hour for low, 1.14 inches/hour for very low, and 0.57 inches/hour for extremely low soil-permeability. Runoff is primarily generated as infiltration excess when soil profiles become saturated and produce excess overland flow due to rainfall intensities that are greater than soil permeability.

Figure 19. Soil permeability values in the Quivira National Wildlife Refuge watershed.



Livestock Waste Management Systems: There are twenty-eight certified or permitted confined animal feeding operations (CAFOs) within the Quivira Little Salt Marsh watershed. Ten of the twenty-eight are large enough to require an NPDES permit and animals in the watershed total 49,377 (Appendix B). These permitted or certified livestock facilities have waste management systems designed to minimize runoff entering their operation or detaining runoff emanating from their facilities. In addition, they are designed to retain a 25-year, 24-hr rainfall/runoff event as well as an anticipated two weeks of normal wastewater from their operations. Typically, this rainfall event coincides with stream flow occurring less than 1-5% of the time. There are no CAFOs located in the Quivira Big watershed and it is unlikely that the CAFOs in the watershed are contributing to the chloride impairment in the Quivira Little or Quivira Big Salt Marsh.

On-Site Waste Systems: The Quivira National Wildlife Refuge watershed is a rural agricultural area that lies primarily across Ford, Kiowa, Edwards and Stafford Counties. It can be assumed that all of the rural residences in the watershed are not connected to public sewer systems and, according to the 1990 U.S. Census, there are 1,722, 344, 603 and 848 septic systems in Ford, Kiowa, Edwards and Stafford Counties, respectively. Failing on-site septic systems are not likely contributors to the chloride load in the watershed.

Point Sources: There are eight NPDES permitted facilities in the Quivira Little Salt Marsh watershed and one NPDES permitted facility in the Quivira Big Salt Marsh watershed (Table 7). Heft & Sons, LLC is a ready-mix concrete plant utilizing an earthen pit for wastewater control and would only contribute a chloride load under extreme precipitation or flooding events. The Cheyenne Plains Gas Pipeline uses an amine/water solution to strip natural gas of carbon dioxide and hydrogen disulfide; however, pipeline liquids generated in the process are treated in scrubbers and then collected in a double synthetic lined storage tank before they are shipped offsite for proper disposal, hence, there is no contribution to the chloride load from this facility. The Northern Natural Gas Company operates a natural gas compressor station that discharges wastewater to a one-cell double lined lagoon that is prohibited from discharging and would only contribute a chloride load under extreme precipitation or flooding events. Four facilities, including the City of Hudson, the lone permittee in the Quivira Big watershed, are municipal non-overflowing lagoon systems that are prohibited from discharging and would only contribute a chloride load under extreme precipitation or flooding events. The City of Bucklin and the City of St. John are permitted to discharge to the Rattlesnake Creek watershed and a wasteload allocation has been calculated that will apply at KDHE sampling stations SC660, LM050201 and LM050601. There is no chloride limit established in the St. John permit; however, as of July 1, 2007, quarterly monitoring of chloride became required when the facility discharges. The wasteload allocation for this facility is based on the average chloride concentration reported in the discharge monitoring reports (four reported concentrations for 7/1/07 – 6/30/11) and the design flow of the facility. Currently, the City of Bucklin is not required to monitor for chloride and there is no discharge data available. Hence, a wasteload allocation for the City of Bucklin was calculated using the facility’s design flow and a chloride concentration of 250 mg/L.

Table 7. NPDES permitted facilities in the Quivira Little and Quivira Big Salt Marsh watershed.

Name	NPDES Permit #	State Permit #	Type	Receiving Stream	Expiration Date	Design Capacity (MGD)	Avg Chloride (mg/L)	Chloride WLA (lbs/day)
Quivira Little NPDES Permitted Facilities								
City of Bucklin	KS0026166	M-AR13-OO01	3 Cell Lagoon	Rattlesnake Cr via W Fork Rattlesnake Cr	6/30/17	0.115	No Data	155
City of Mullinville	KSJ000446	M-AR63-NO01	Non-Overflowing	N/A	1/31/13	N/A	N/A	0
Heft & Sons, LLC	KSG110115	I-AR38-PR01	Earthen Settling Basin	N/A	9/30/17	N/A	N/A	0
City of Greensburg	KSJ000460	M-AR38-NO01	Non-Overflowing	N/A	12/31/13	N/A	N/A	0
Cheyenne Plains	KSJ000625	I-AR63-NP01	Non-Overflowing Lined Pond	N/A	12/31/13	N/A	N/A	0
City of Macksville	KSJ000443	M-AR57-NO01	Non-Overflowing	N/A	7/31/13	N/A	N/A	0
Northern Natural Gas Co.	KSJ000518	I-AR57-NO01	Non-Overflowing	N/A	1/31/13	N/A	N/A	0
City of St. John	KS0027791	M-AR77-OO01	3 Cell Lagoon	Rattlesnake Cr	6/30/12	0.204	152	259
Quivira Big NPDES Permitted Facility								
City of Hudson	KSJ000451	M-AR47-NO01	Non-Overflowing	N/A	10/31/13	N/A	N/A	0

4. ALLOCATION OF POULLUTANT REDUCTION RESPONSIBILITY

This TMDL for chloride at both Quivira Little and Quivira Big Salt Marsh is established using the water quality standard for acute exposure of aquatic life to chloride at 860 mg/L. However, natural chloride loading within the watershed is responsible for the excursions seen at both LM050201 (Quivira Little) and LM050601 (Quivira Big). Therefore, this TMDL will be staged in anticipation of alternative background concentrations for LM050201 and LM050601 that will replace the existing criterion for those stations once approval from the EPA is garnered. The proposed alternative background concentrations were developed based on the average chloride concentration for the period of record, resulting in a proposed chloride background criterion of 1,675 mg/L in Quivira Little Salt Marsh (LM050201) and a proposed chloride background criterion of 3,033 mg/L in Quivira Big Salt Marsh (LM050601).

Average flow, for the period of record, in Rattlesnake Creek at USGS gage 07142575, Rattlesnake Creek near Zenith, was used to estimate the inflow to Quivira Little Salt Marsh and to develop the loads for LM050201. Because of the complicated nature of chloride loading in Quivira Big Salt Marsh due to the canal system and groundwater intrusion, the best estimation of the loads entering the marsh are derived from the 1998 USGS study that determined an average inflow to Quivira Big at 7.25 cfs (Table 8).

Loading scenarios for Quivira Little Salt Marsh detailed in Table 8 were derived using the average flow at USGS gage 07142575 and the acute exposure of aquatic life to the chloride criterion of 860 mg/L as well as using the established background chloride concentration at the Rattlesnake Creek segment above Quivira Little Salt Marsh of 1,400 mg/L. Table 8 also displays loading scenarios for Quivira Big Salt Marsh based on the acute exposure criterion of aquatic life to chloride of 860 mg/L and a chloride concentration of 2,415 mg/L. The chloride concentration of 2,415 mg/L was derived using information from the 1998 USGS study that estimated about 45% of the inflow to Quivira Big came via the canal system and about 55% of its flow came from its watershed. The canal system flow was assigned a concentration of 1,400 mg/L chloride (established background concentration above QNWR) while the watershed was given an estimated concentration of 3,660 mg/L (established background concentration below QNWR) resulting in an estimated inflow concentration of chloride to Quivira Big at 2,415 mg/L.

Table 8. Chloride TMDL based on the Kansas Surface Water Quality Standard's criterion for acute exposure to chloride by aquatic life of 860 mg/L and the site specific chloride criterion of 1,400 mg/L at Rattlesnake Creek above Quivira Little for Quivira Little Salt Marsh (LM050201) and an estimated chloride concentration of 2,415 mg/L for the inflow to Quivira Big for Quivira Big Salt Marsh (LM050601).

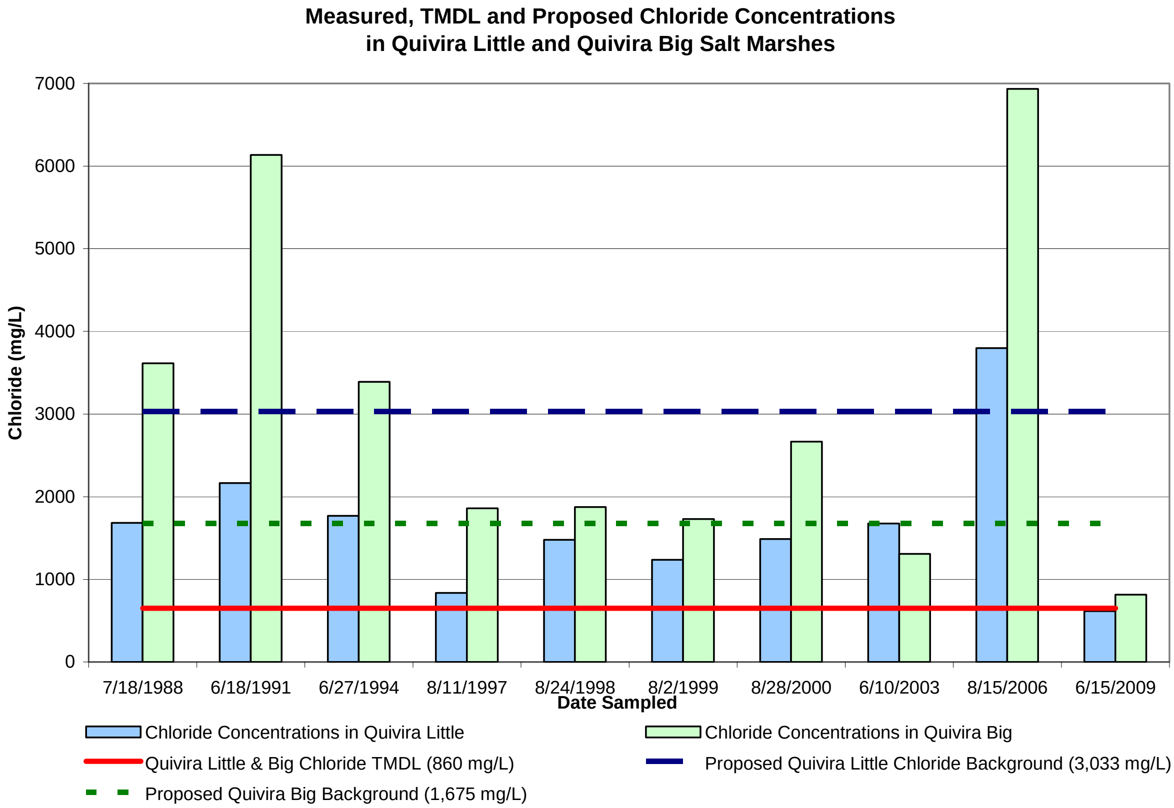
Station	Chloride Concentration (mg/L)	Average Flow (cfs)	Load Allocation (tons/day)	Wasteload Allocation (tons/day)	Margin of Safety (tons/day)	TMDL (tons/day)
LM050201 Quivira Little Salt Marsh	860	42.9	89.4	0.207	9.96	99.6
LM050601 Quivira Big Salt Marsh	860	7.25	14.9	0.207	1.68	16.8
Station	**Chloride Concentration (mg/L)**	**Average Flow (cfs)**	**Load Allocation (tons/day)**	**Wasteload Allocation (tons/day)**	**Margin of Safety (tons/day)**	**TMDL (tons/day)**
LM050201 Quivira Little Salt Marsh	1,400	42.9	145	0.207	16.2	162
LM050601 Quivira Big Salt Marsh	2,415	7.25	42.3	0.207	4.73	47.3

Point Sources: Unless point sources act to concentrate salts through reuse and evaporation or using processes such as reverse osmosis, they will tend to discharge water that is similar in chloride content to their source water. The two existing point source dischargers will be expected to put out an effluent that is less than or equal to the chloride criterion for drinking water use. The wasteload allocation for the City of Bucklin was calculated based on a design flow of 0.115 cfs and a chloride concentration of 250 mg/L resulting in a chloride wasteload allocation of 155 lbs/day. The allocation for the City of St. John was calculated based on a design flow of 0.316 cfs and an average discharge monitoring report chloride concentration of 152 mg/L resulting in a daily chloride wasteload allocation of 259 lbs/day for a total wasteload allocation of 414 pounds, or 0.207 tons, per day in the QNWR watershed. Because of the dominant flow volume and elevated levels of chloride in Rattlesnake Creek, relative to point source contributions, wasteload allocations will not bring attainment of water quality standards for chloride.

Nonpoint Sources: This impairment is primarily associated with background chloride concentrations stemming from the discharge of saline groundwater along the Rattlesnake Creek corridor below St. John and the seepage of saline groundwater into QWNR. The chloride TMDL at Quivira Little Salt Marsh at LM050201 and Quivira Big Salt Marsh at LM050601 is established at the current aquatic life water quality standard for acute exposure to chloride of 860 mg/L under all flow conditions and across all seasons with load allocations displayed in Table 8. Table 8 displays the TMDL at each marsh sampling station using the site specific chloride water quality criteria for Rattlesnake Creek at SC660 and SC030. The proposed background concentrations of 1,675 mg/L and 3,033 mg/L for Quivira Little and Quivira Big, respectively, were derived from chloride concentrations taken under all flow conditions and across all seasons (Figure 20).

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty of variable chloride loads and the endpoints of the TMDL. The margin of safety is explicitly set at 10% of the calculated chloride load which compensates for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality (Table 8). Additionally, an implicit margin of safety is tied to the conservative assumption that discharging NPDES permittees continuously discharge and the entire wasteload allocation will be seen in the marshes.

Figure 20. Historical chloride concentrations, TMDL concentrations and proposed background concentrations for Quivira Little and Quivira Big Salt Marshes.



State Water Plan Implementation Priority: Because this watershed's chloride load is predominately natural in source, this TMDL will be a Low Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Rattlesnake Creek Basin (HUC 8: 11030009) with a priority ranking of 15 (High Priority for restoration work).

Priority HUC 12: Because of the natural geologic contribution of this impairment, no priority subwatersheds will be identified.

5. IMPLEMENTATION

Desired Implementation Activities:

1. Monitor any anthropogenic contributions of chloride loading to Quivira Little and Big Salt Marshes.
2. Establish alternative background concentrations for to Quivira Little and Big Salt Marshes according to Kansas Implementation Procedures: Surface Water Quality Standards.

Implementation Programs Guidance:

NPDES and State Permits – KDHE

a. NPDES and state permits for facilities in the watershed will be renewed in 2012 and 2013 with continued chloride monitoring and any appropriate permit conditions that work to reduce chloride loading to Quivira Little and Big Salt Marshes.

Ground Water Remediation – BER – KDHE

a. Coordinate with Bureau of Water on any existing or new remediation projects to plan for alternative disposal of remediation water to reduce or eliminate chloride loadings to the watershed.

Water Quality Standards and Assessment – KDHE

a. Establish background levels of chloride for Quivira Little and Big Salt Marshes.

Time Frame for Implementation: Development of a background level based water quality standard should be accomplished with the water quality standards revision after 2016.

Targeted Participants: Primary participant for implementation will be KDHE.

Milestone for 2016: In accordance with the TMDL development schedule for the State of Kansas, the year 2016 marks the next cycle of 303(d) activities in the Lower Arkansas Basin. At that point in time, monitoring data from Quivira Little Salt Marsh and Quivira Big Salt Marsh will be reexamined to confirm the impaired status of the lake and the suggested background concentration. Should the cause of impairment remain, source assessment, allocation and implementation activities may begin.

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 pollutants and to assure allocations of pollutant to point and nonpoint sources can be attained.

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.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. 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.

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. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the Kansas Water Plan, including selected Watershed Restoration and Protection Strategies.

7. 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.

8. K.S.A. 32-807 authorizes the Kansas Department of Wildlife and Parks to manage lake resources.

Funding: The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant 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. Additionally, $2 million has been allocated between the State Water Plan Fund and EPA 319 funds to support implementation of Watershed Restoration and Protection Strategies. 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 its 3-year rotational summer sampling schedule in order to assess the chloride impairment in Quivira Little Salt Marsh and Quivira Big Salt Marsh. Providing there is water in the marshes, this schedule allows for duplicate samples to be taken at LM050201 & LM050601 once per summer every three years. Based on these sampling results, the status of the 303(d) listing will be evaluated in 2022.

7. FEEDBACK

Public Notice: An active Internet Web site was established at www.kdheks.gov/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Lower Arkansas Basin.

Public Hearing: A Public Hearing was held on September 21, 2012 in Wellington to receive comments on this TMDL. There were no comments received on this TMDL.

Basin Advisory Committee: The Lower Arkansas River Basin Advisory Committee met to discuss these TMDLs on May 31, 2012 in Hutchinson and September 12, 2012 in Halstead. There were no comments received on this TMDL.

Milestone Evaluation: In 2022, evaluation of sample data from Quivira Little Salt Marsh and Quivira Big Salt Marsh will be reexamined to assess conditions in the marshes. Should the impairment remain procedures to implement the proposed background concentrations for the marshes may begin or adjustments to source assessment, allocation, and implementation activities may occur.

Consideration for 303d Delisting: Quivira Little Salt Marsh and Quivira Big Salt Marsh will be evaluated for delisting under Section 303d, based on the monitoring data over 2012-2021. Therefore, the decision for delisting will come about in the preparation of the 2022-303d list. Should modifications be made to the applicable water quality criteria during the 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 would come in 2012. Recommendations of this TMDL will be considered in the Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2012-2021.

Rev 6/4/13

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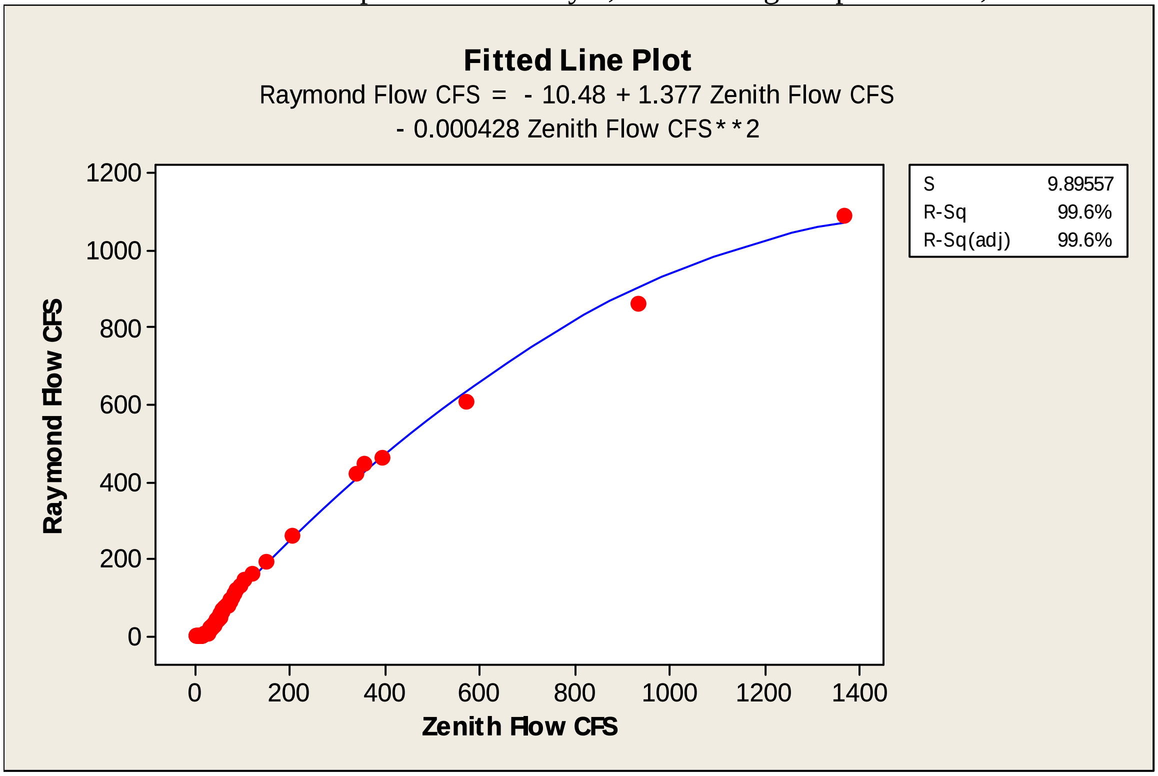
Appendix A. A quadratic regression model was used to estimate flows at USGS Gage 07142620 for the time period October 1, 1998 through December 31, 2010. The model was developed using flow values at USGS 07142620 and USGS 07142575 for the common period of January 1, 1975 through September 30, 1998.



Appendix B. Registered, certified or permitted confined animal feeding operations (CAFOs) in the Quivira Little and Quivira Big Salt Marsh watersheds. Facilities with animal totals ≥ 1,000 are assigned a federal NPDES Permit. Facilities with animal totals < 1,000 are either registered or certified with KDHE. Three digit Kansas permit numbers are place holders and indicate an application in process.

Kansas Permit Number	Federal NPDES Permit Number	Animal Type	County	Animal Total
A-ARED-B001	N/A	Beef	Edwards	700
A-ARED-C003	KS0094919	Beef	Edwards	2000
A-ARED-C004	KS0097403	Beef	Edwards	3000
A-ARED-C006	KS0097543	Beef	Edwards	1500
A-ARED-C002	KS0088251	Beef	Edwards	2500
A-ARED-C005	KS0098868	Beef	Edwards	3500
A-ARFO-B002	N/A	Beef	Ford	540
A-ARFO-BA01	N/A	Beef	Ford	570
A-ARKW-BA01	N/A	Beef	Kiowa	996
A-ARKW-BA03	N/A	Beef	Kiowa	450
A-ARKW-C002	KS0098876	Beef	Kiowa	9500
A-ARPR-BA01	N/A	Beef	Pratt	600
A-ARPR-B005	N/A	Beef	Pratt	999
874	N/A	Beef	Pratt	900
A-ARSF-BA05	N/A	Beef	Stafford	450
A-ARSF-BA03	N/A	Beef	Stafford	600
A-ARSF-BA02	N/A	Beef	Stafford	750
A-ARSF-BA09	N/A	Beef	Stafford	500
A-ARSF-BA06	N/A	Beef	Stafford	500
A-ARSF-C003	KS0115681	Beef	Stafford	4000
A-ARSF-B004	N/A	Beef	Stafford	999
A-ARSF-B007	N/A	Beef	Stafford	999
A-ARSF-B003	N/A	Beef	Stafford	800
A-ARSF-B002	N/A	Beef	Stafford	994
A-ARSF-H001	KS0089958	Swine	Stafford	4530
A-ARSF-T001	N/A	Truck Wash	Stafford	0
A-ARSF-C002	KS0085839	Beef	Stafford	5000
A-ARSF-C004	KS00089117	Beef	Stafford	1500