



NEBRASKA'S WATER MANAGEMENT RESOURCE

Providing the sound science and support for managing  
Nebraska's most precious resource.

## **BASIN WATER SUPPLY**

JAMES C. SCHNEIDER, PH.D., ACTING DIRECTOR

Republican River Basin-Wide Plan Stakeholder Advisory Meeting  
June 16, 2015

# Overview

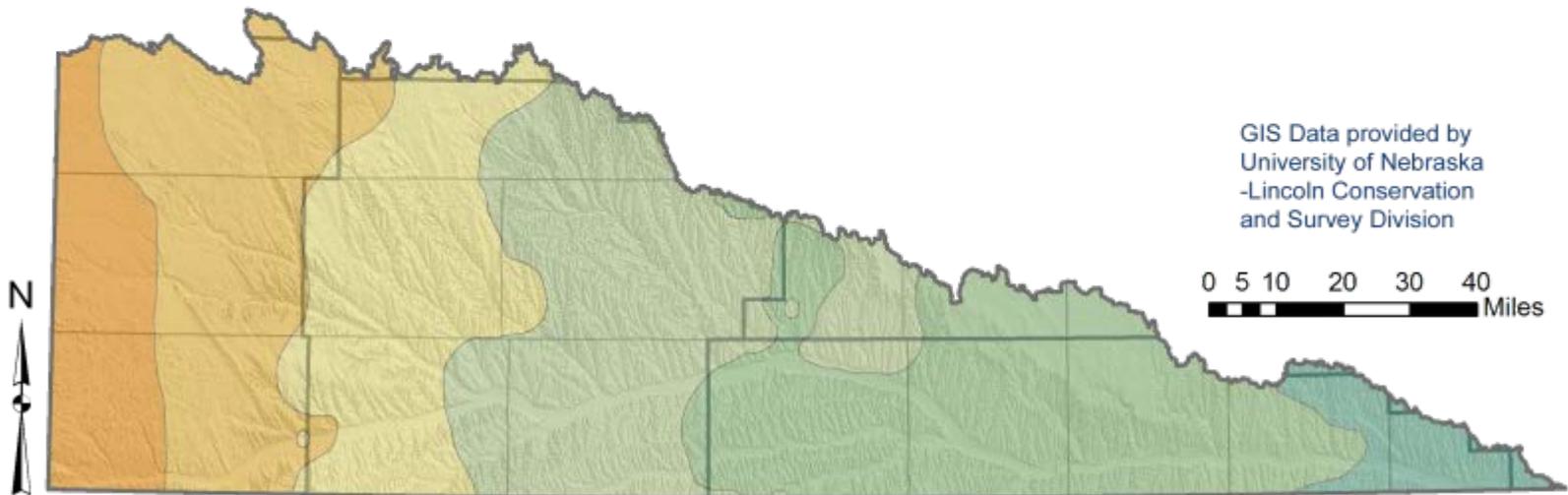
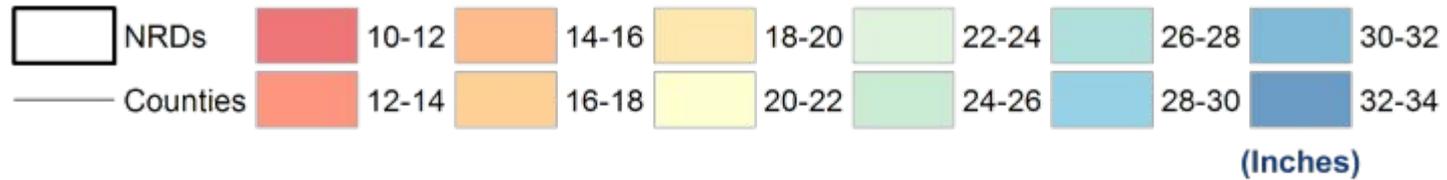
- Update on Three-States discussions
- Hydrologic overview of Basin
- Past impacts to Basin's surface water supply: trends, correlations, and causes
- Potential applicability to basin-wide plan

# UPDATE ON THREE-STATES DISCUSSIONS

# HYDROLOGIC OVERVIEW OF THE REPUBLICAN BASIN IN NEBRASKA

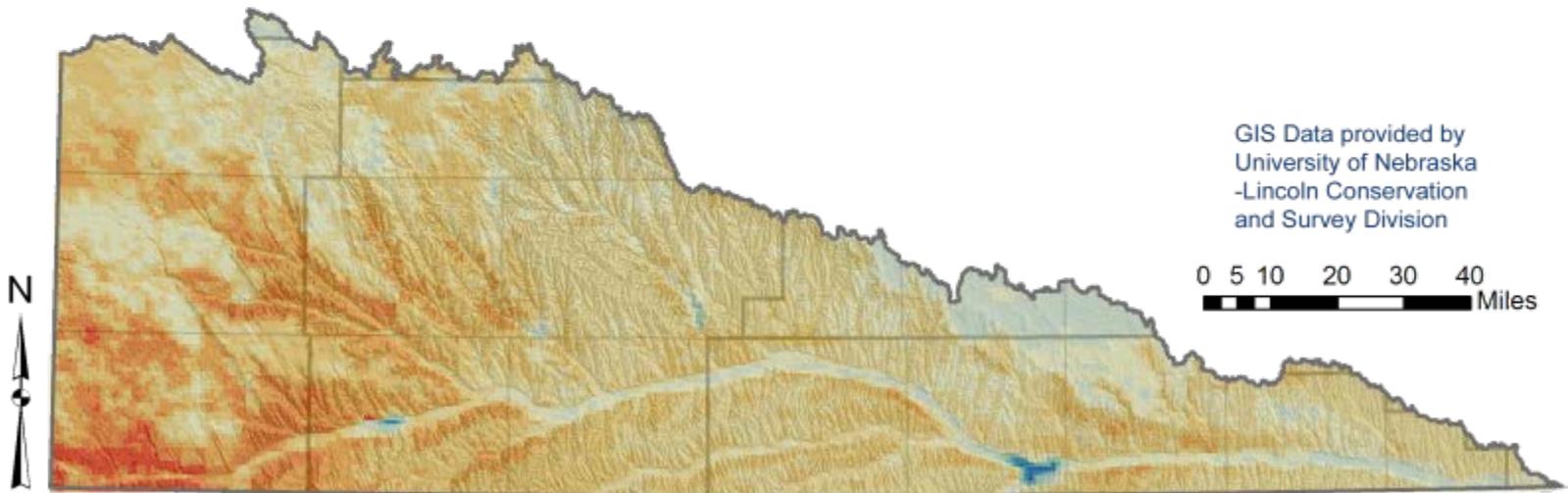
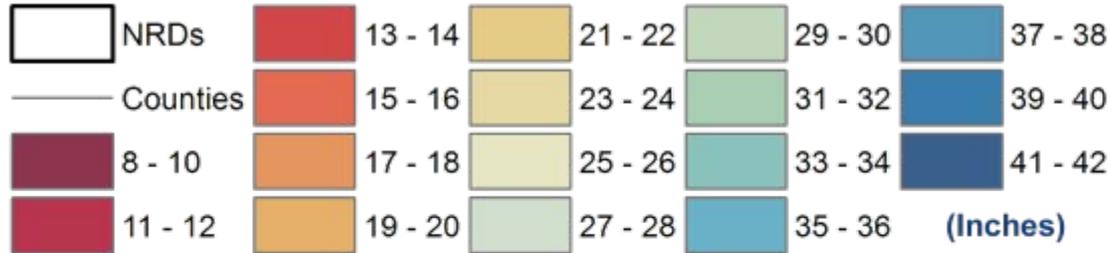
Precipitation, Evapotranspiration, Transmissivity, Well  
Density, Stream Gages, Drought Conditions, Well Depletion  
Zones

# Precipitation



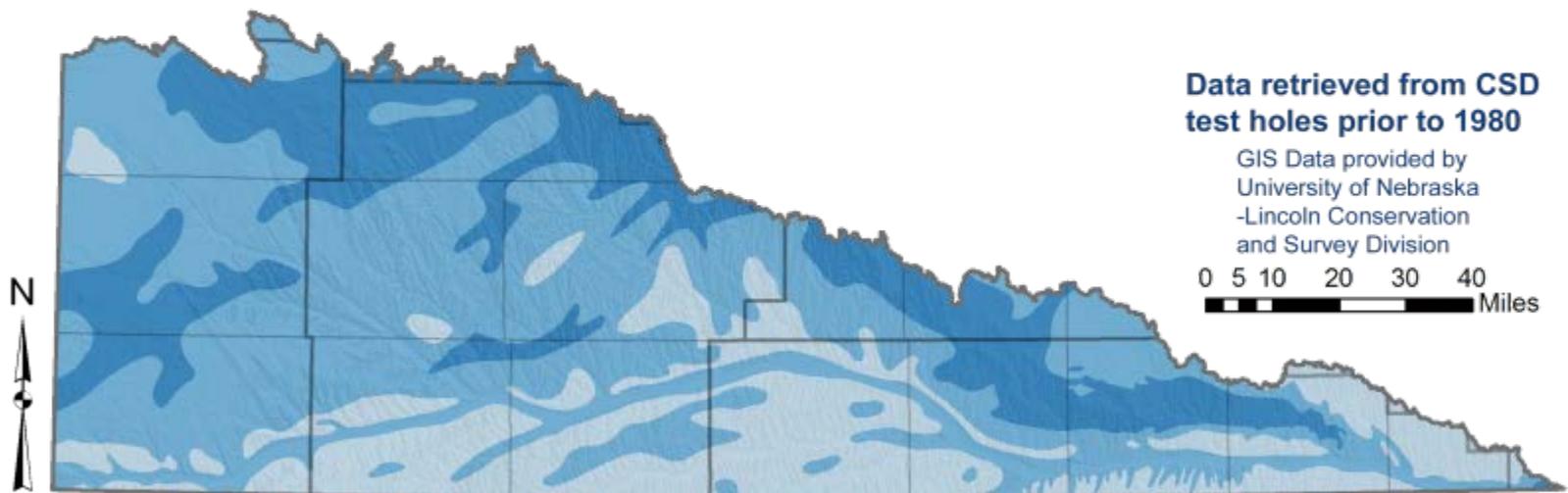
Annual precipitation based on data from 2000 to 2009 (modified from Szilagyi and Jozsa 2012)

# Evapotranspiration



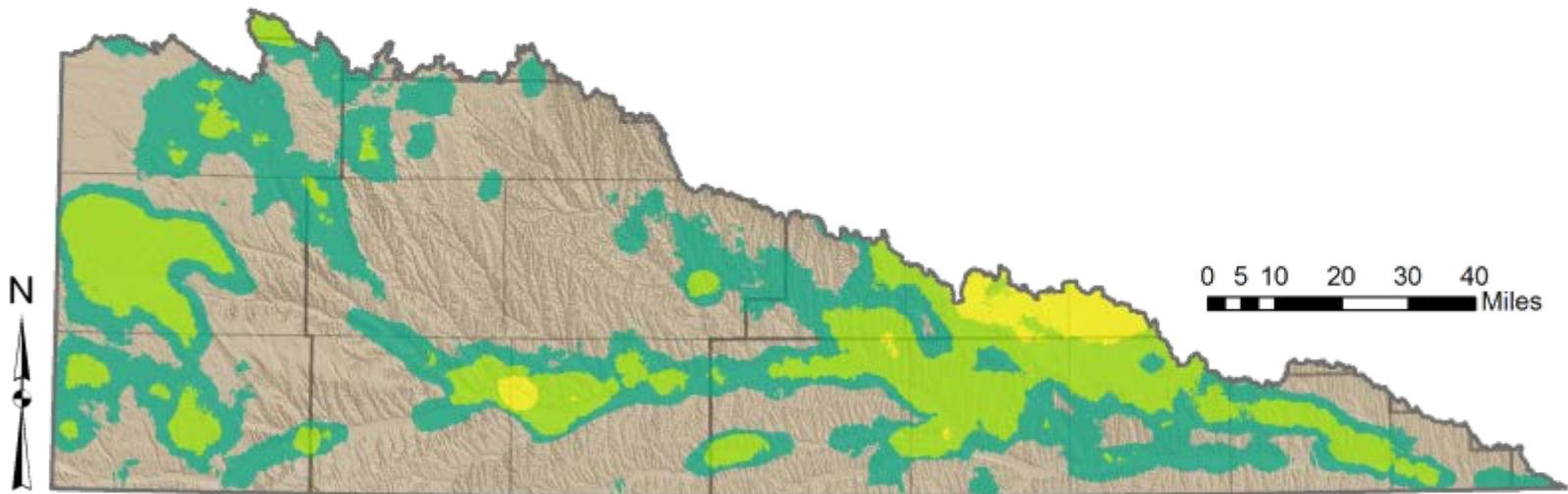
ET rates based on data from 2000 to 2009 (modified from Szilagyi and Jozsa 2012)

# Transmissivity

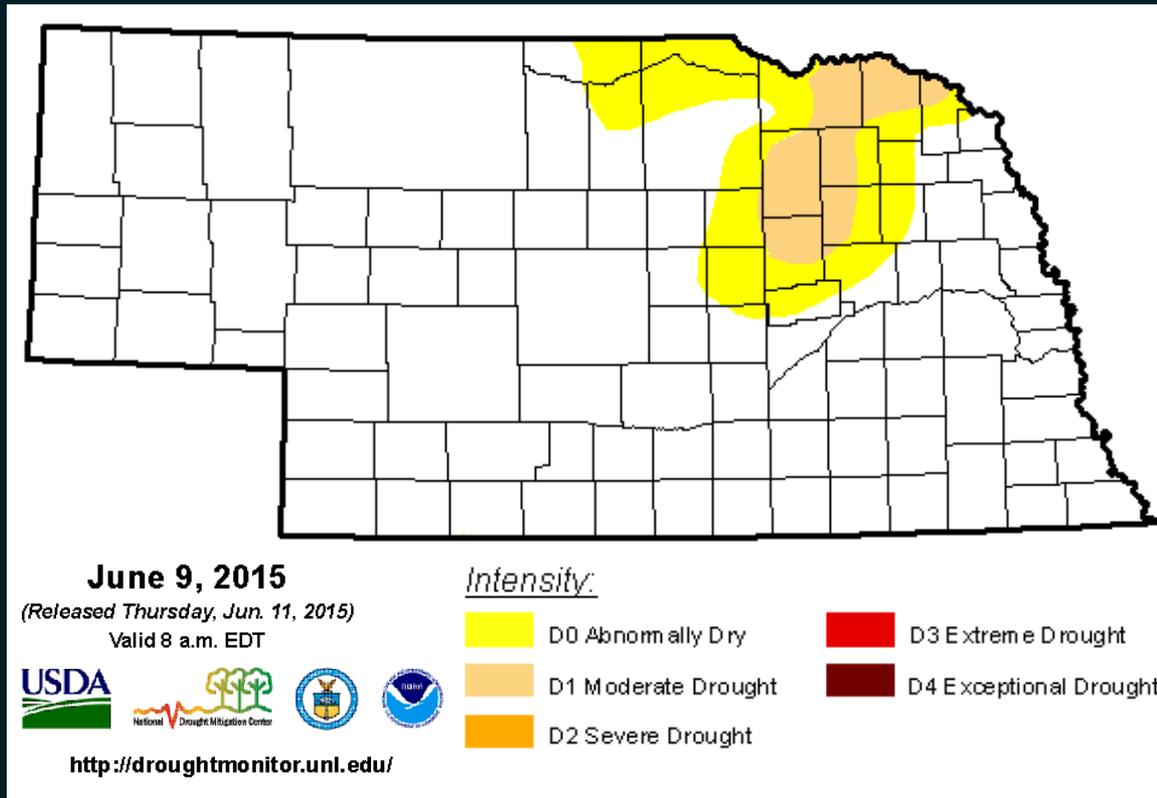


Transmissivity of the primary aquifers in the Republican Basin modified from 1) an unpublished CSD Map; 2) Summerside et al., 2005 and 3) Summerside et al., 2005 in which test hole data were supplemented by data from the logs of registered wells

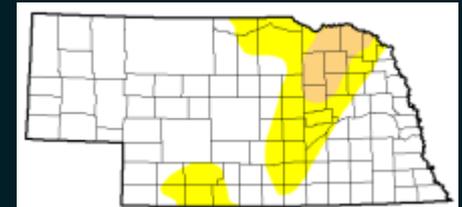
# Well Density



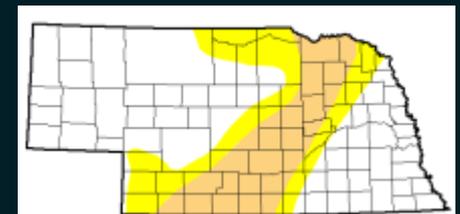
# Most Recent *US Drought Monitor* for Nebraska



Compare with:



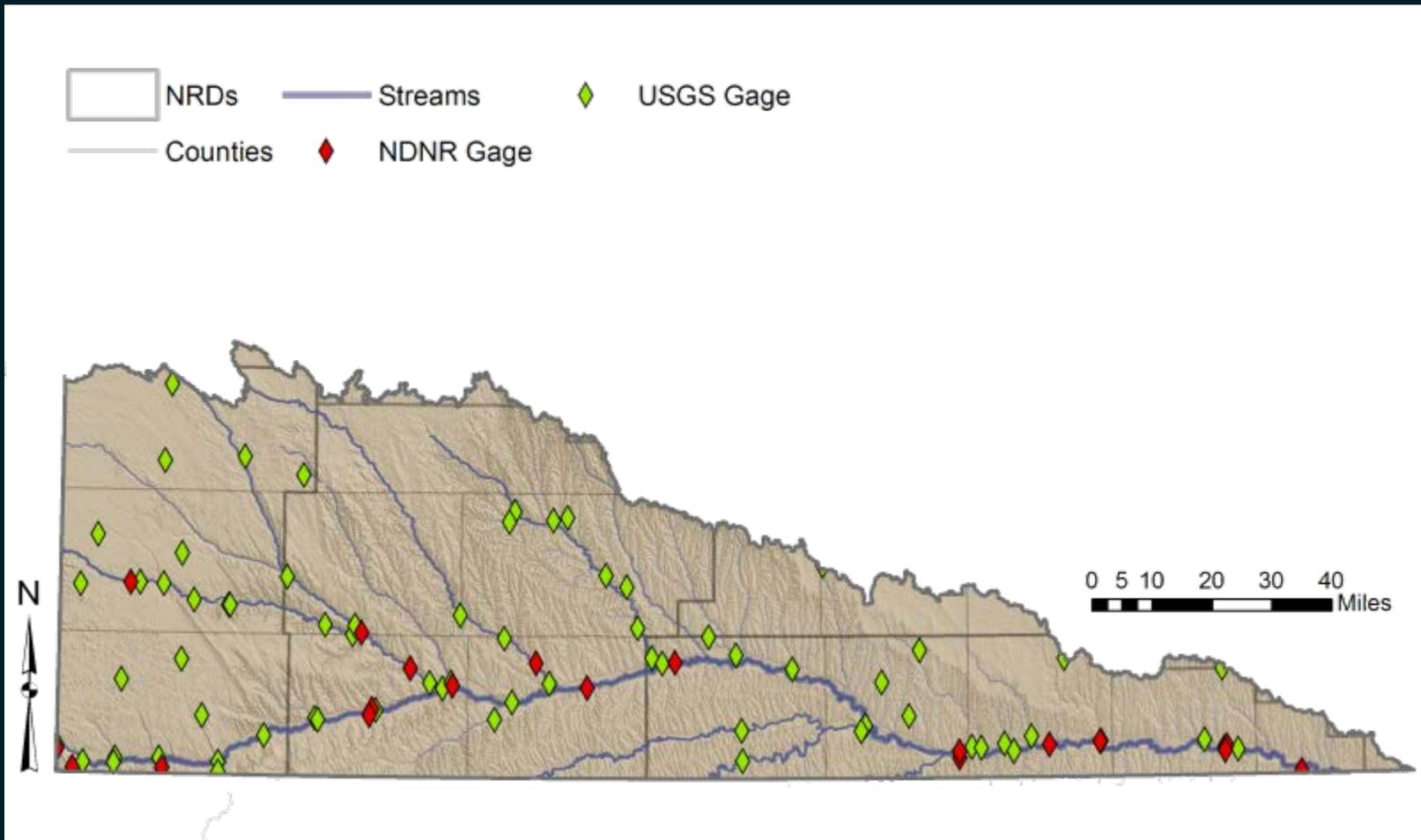
One week earlier  
(June 2, 2015)



One month earlier  
(May 12, 2015)



# Stream Gages



# DNR Real-Time Stream Gage Data (WISKI)

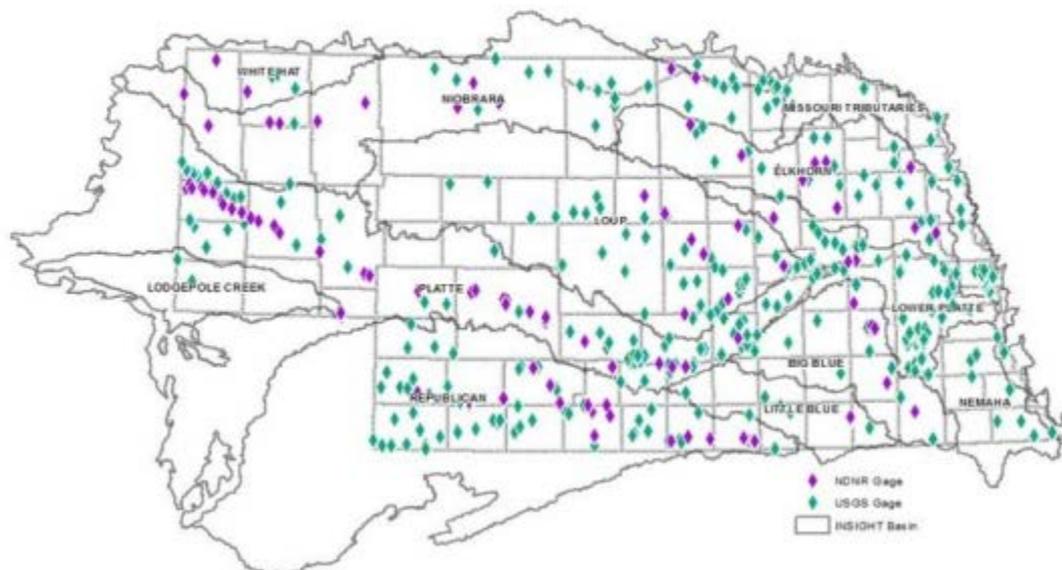
<http://data.dnr.nebraska.gov/RealTime>

Official Nebraska Government Website



Current Streamflow Conditions

This site will be continually revised over the next 6-9 months. Please come back to see what's new.



## Streamgaging

The Department of Natural Resources is authorized to measure and monitor the water flowing in Nebraska's streams, rivers, and canals. For this purpose, the Department has established a Streamgaging Program. Through this program, the Department operates and maintains a streamgaging network comprised of more than 250 gaging sites. The network includes continuous stream and reservoir gages, partial year gages, canal gages, canal return flow gages, and miscellaneous spot measurements. The core network consists of approximately 110 continuous streamgages and 120 canal gages.

Current Streamflow Conditions

*\*Unless otherwise marked, all data is provisional and subject to revision*

# DNR Real-Time Stream Gage Data (WISKI)

<http://data.dnr.nebraska.gov/RealTime>

Official Nebraska Government Website



Current Streamflow Conditions

This site will be continually revised over the next 6-9 months. Please come back to see what's new.

## Active NDNR and USGS Stream Gages/Links to Gage Data

The list below provides data and graphics for Active NDNR and US Geological Survey gages. For inactive NDNR gage records, please contact Susan France at (402) 471-1684 or [susan.france@nebraska.gov](mailto:susan.france@nebraska.gov). For inactive USGS gage records, please refer to the USGS website <http://waterdata.usgs.gov/ne/nwis/rt>.

Unless otherwise marked, all data is provisional and subject to revision.

NDNR Disclaimer | USGS Disclaimer

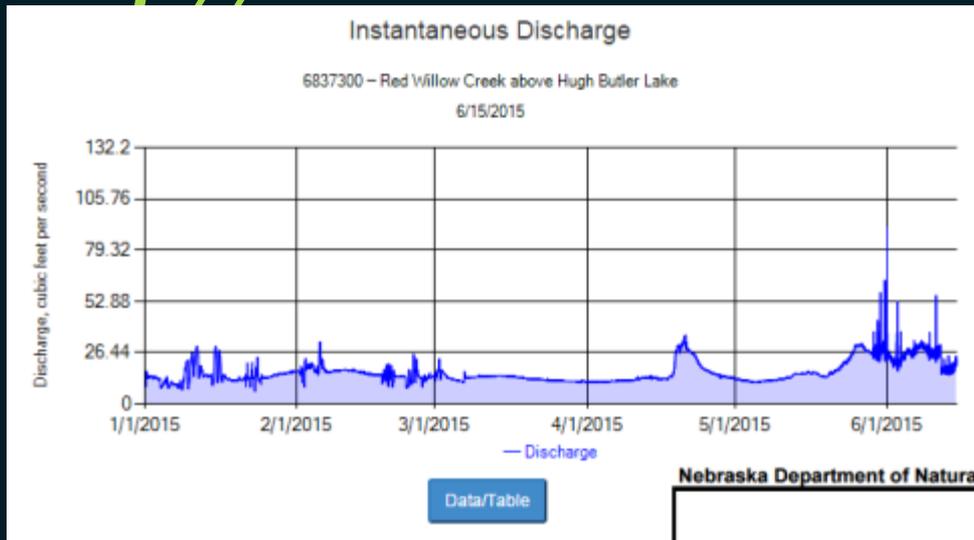
Source:  Type:  River Basin:

Please be aware: Some of the stations listed below are affected by ice conditions during the winter months. Some stations are updated weekly.

Station Name	Station Number	Date Time (UTC)	Stage	Discharge	River Basin	Type	Graph
<a href="#">Arikaree River at Haigler - USGS</a>	500				Republican	Stream	
<a href="#">Beaver Creek near Beaver City - USGS</a>	000				Republican	Stream	
<a href="#">Buffalo Creek near Haigler - USGS</a>	500				Republican	Stream	
<a href="#">Center Creek at Franklin - NDNR</a>	6851000	06/15/2015 14:00	1.69	4.25	Republican	Stream	
<a href="#">Driftwood Creek near McCook - USGS</a>	06836500				Republican	Stream	
<a href="#">Elm Creek at Amboy - NDNR</a>	6852000	06/15/2015 14:00	8.81	43.28	Republican	Stream	

# DNR Real-Time Stream Gage Data (WISKI)

<http://data.dnr.nebraska.gov/RealTime>



## Nebraska Department of Natural Resources

6837300 Red Willow Creek above Hugh Butler Lake  
Q, WATER YEAR OCT 2012 TO SEP 2013  
Daily Mean Values

Day	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13
1	2.8	8.3	9.7	e7.7	e16	16	14	13	16	5.7	5.6	4.0
2	2.7	8.3	9.8	e7.5	e17	16	14	13	14	5.7	5.3	4.6
3	3.0	8.2	10	e7.3	e17	17	14	14	13	5.5	5.1	5.1
4	3.2	8.2	10	e7.1	e17	17	14	17	12	5.5	5.3	4.7
5	3.5	8.5	10	e7.5	e18	18	14	16	11	5.5	5.2	4.4
6	3.8	8.7	10	e8.4	e19	17	14	15	11	5.4	5.4	4.1
7	3.9	8.6	10	e9.4	20	16	13	15	10	5.3	6.3	3.9
8	4.0	8.8	11	e9.7	21	16	14	15	9.8	5.7	7.5	3.9
9	4.1	9.3	e11	e10	20	16	22	15	9.5	5.7	6.8	3.8
10	4.9	9.4	e11	e11	20	16	18	15	9.3	6.1	6.5	3.8
11	5.2	9.4	e11	e11	20	16	18	14	9.0	6.0	6.0	5.7
12	5.4	9.7	e11	e9.6	20	15	17	14	8.7	5.7	5.7	4.5
13	5.6	9.9	e11	e8.5	19	16	16	13	8.8	5.4	5.5	4.7
14	5.6	9.3	e11	e7.9	19	15	16	13	8.7	5.7	5.5	5.0
15	5.7	9.3	e11	e7.9	19	15	16	12	8.1	6.7	5.6	5.6
16	5.9	9.5	e12	e8.9	19	15	15	13	7.8	5.8	5.5	5.7
17	5.9	9.5	e12	e10	18	16	15	13	7.8	5.5	5.9	5.9
18	5.9	9.6	e12	e12	18	16	15	13	8.0	5.3	5.7	6.0
19	6.0	9.6	e12	e13	e18	15	15	13	7.5	5.2	5.6	6.0
20	6.4	9.8	e12	e13	e17	15	15	13	7.5	5.0	5.4	5.9
21	6.4	9.7	e11	e13	e17	15	15	13	7.1	4.9	5.0	6.0
22	6.5	9.7	e11	e12	e17	14	15	13	6.8	4.8	4.8	5.9
23	6.9	9.7	e10	e13	e17	15	15	14	7.4	4.6	4.6	6.2
24	7.3	9.8	e11	e13	e17	15	15	13	7.6	4.6	4.3	6.2
25	7.4	9.6	e9.4	e13	e17	14	14	13	7.9	5.5	3.9	5.9
26	7.6	9.6	e8.4	e13	e17	14	14	13	7.4	5.1	3.8	5.8
27	7.8	e9.7	e7.7	e15	17	14	14	12	6.9	5.0	3.9	6.0
28	7.9	e9.6	e7.0	e15	18	14	14	12	6.3	5.3	4.0	6.7

# Questions?

# TRENDS IN STREAMFLOW AND BASEFLOW

Data developed and summarized by the  
RRCA modeling committee

# Components of Streamflow

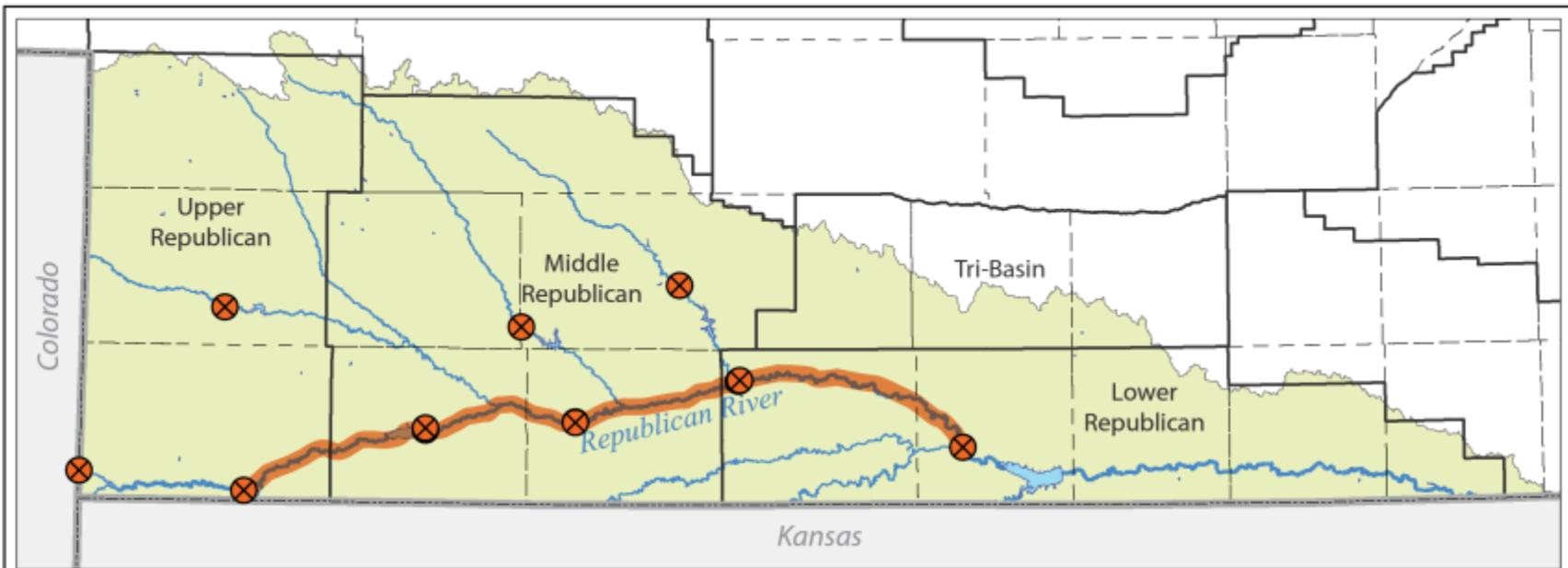
$$\text{Streamflow} = \text{runoff} + \text{baseflow}$$

## ○ Runoff

- Streamflow that results from water that flows over the land after it rains
- Supplies water to a stream only for a short period after recent rain

## ○ Baseflow

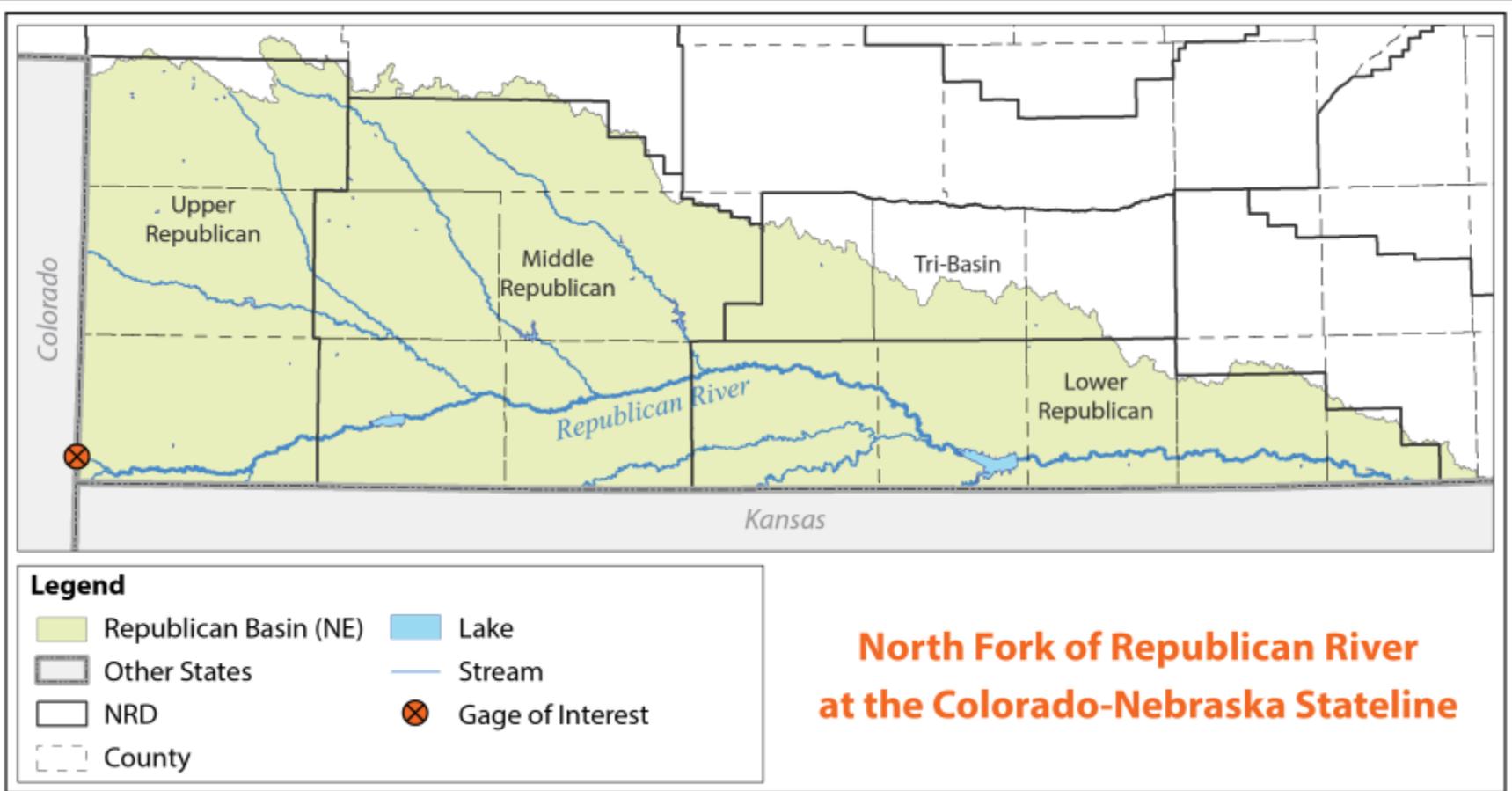
- Streamflow that results from the seepage of groundwater
- Relatively steady source of water; supplies water to a stream regardless of whether it has recently rained



**Legend**

- Republican Basin (NE)
- Other States
- NRD
- County
- Lake
- Stream
- X Gage of Interest
- Stream Reach of Interest

**Gage and Stream Reach Locations  
for Example Flow Data**



**North Fork of Republican River  
at the Colorado-Nebraska Stateline**

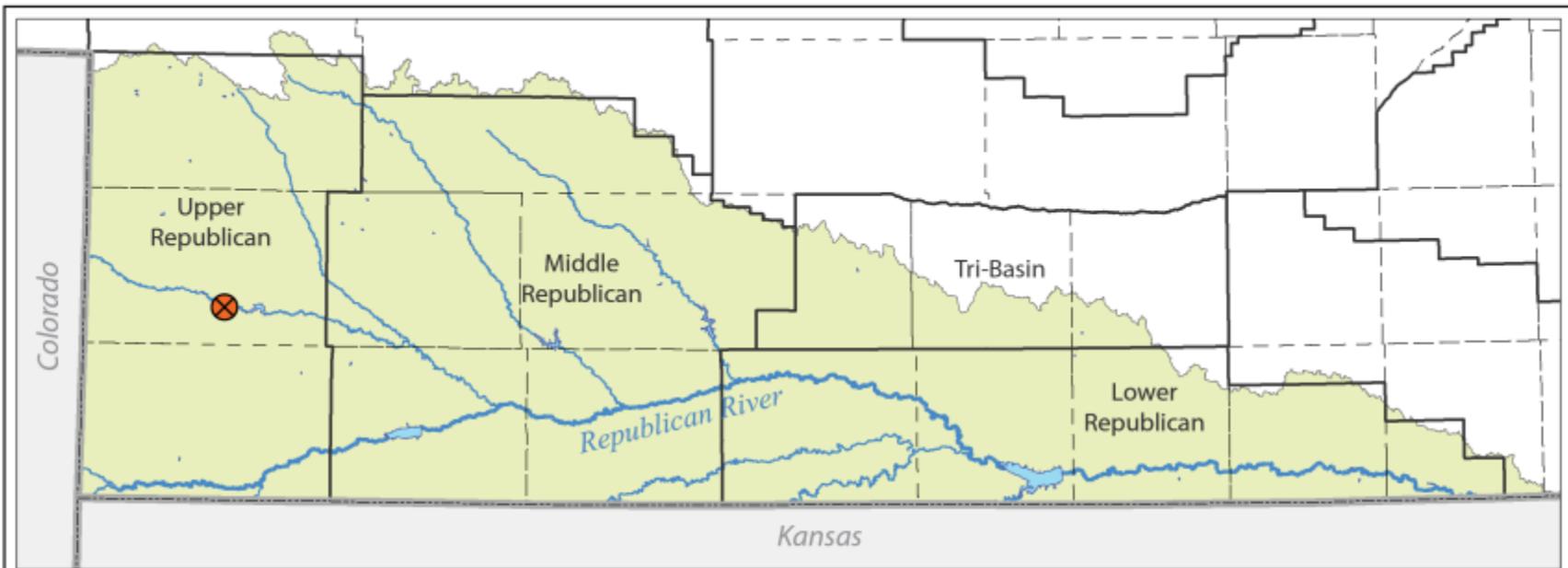
# Estimated Streamflow

## North Fork Republican River at CO-NE Stateline



(values in AF)    Avg. 1950-1964    Avg. 1986-2000    Difference

— Total	53,287	34,730	-18,558
— Baseflow	46,139	31,616	-14,523



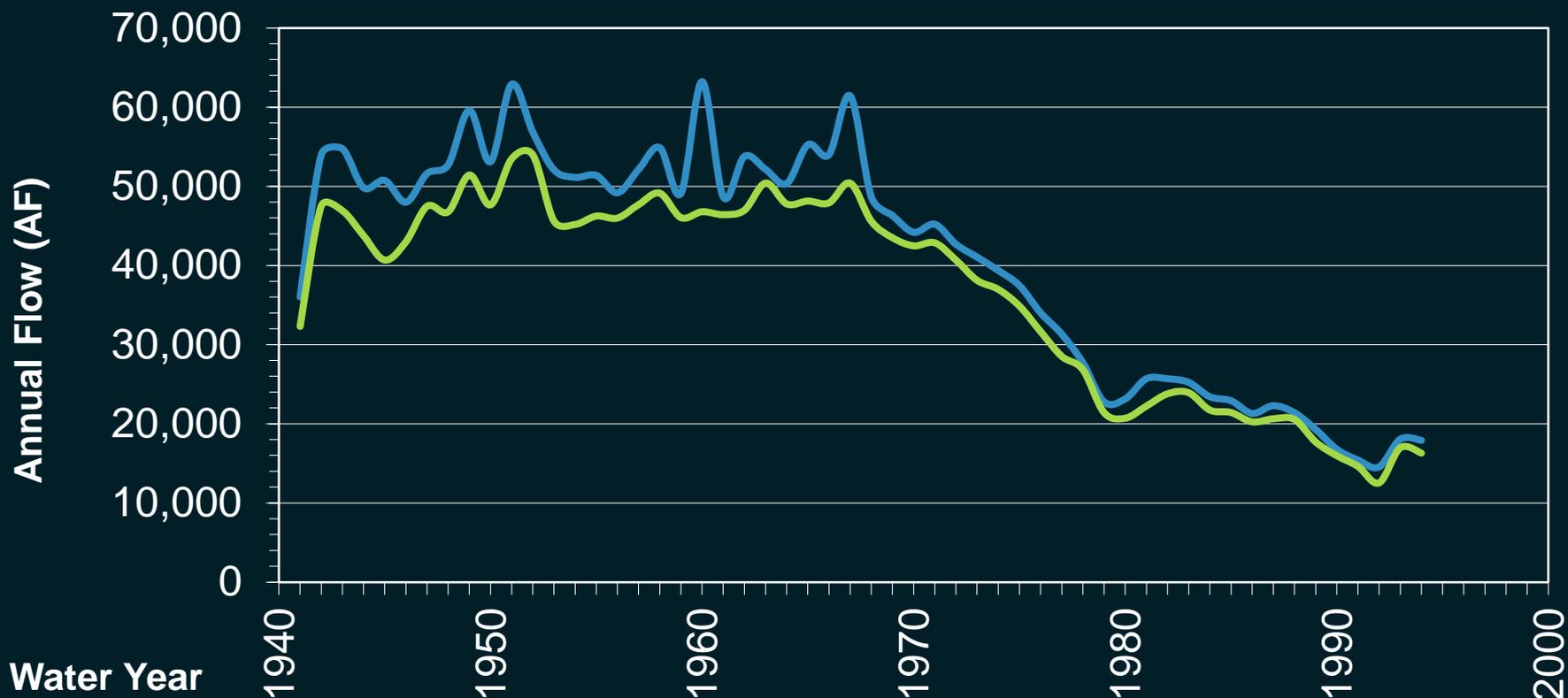
**Legend**

- Republican Basin (NE)
- Other States
- NRD
- County
- Lake
- Stream
- X Gage of Interest

**Frenchman Creek  
near Imperial**

# Estimated Flow

## Frenchman Creek Near Imperial

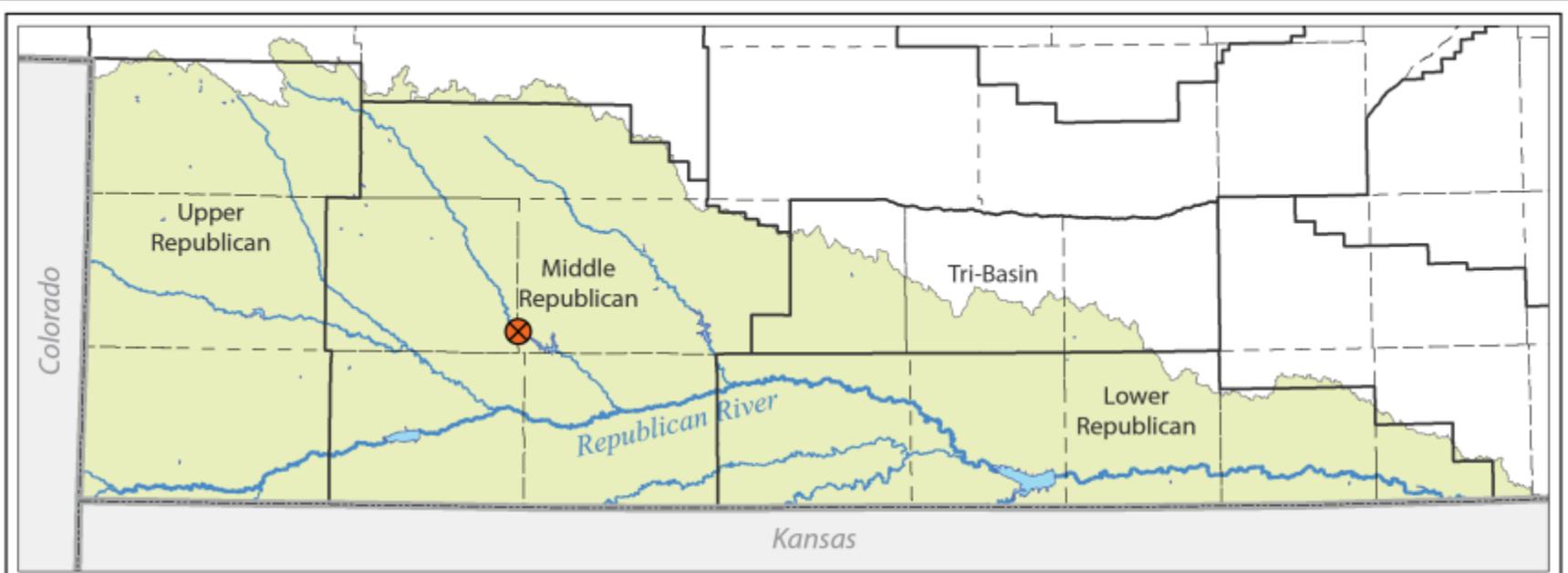


(values in AF) Avg. 1950-1964 Avg. 1986-2000 Difference

— Total
— Baseflow

53,390 18,552 -34,838

47,952 17,278 -30,674



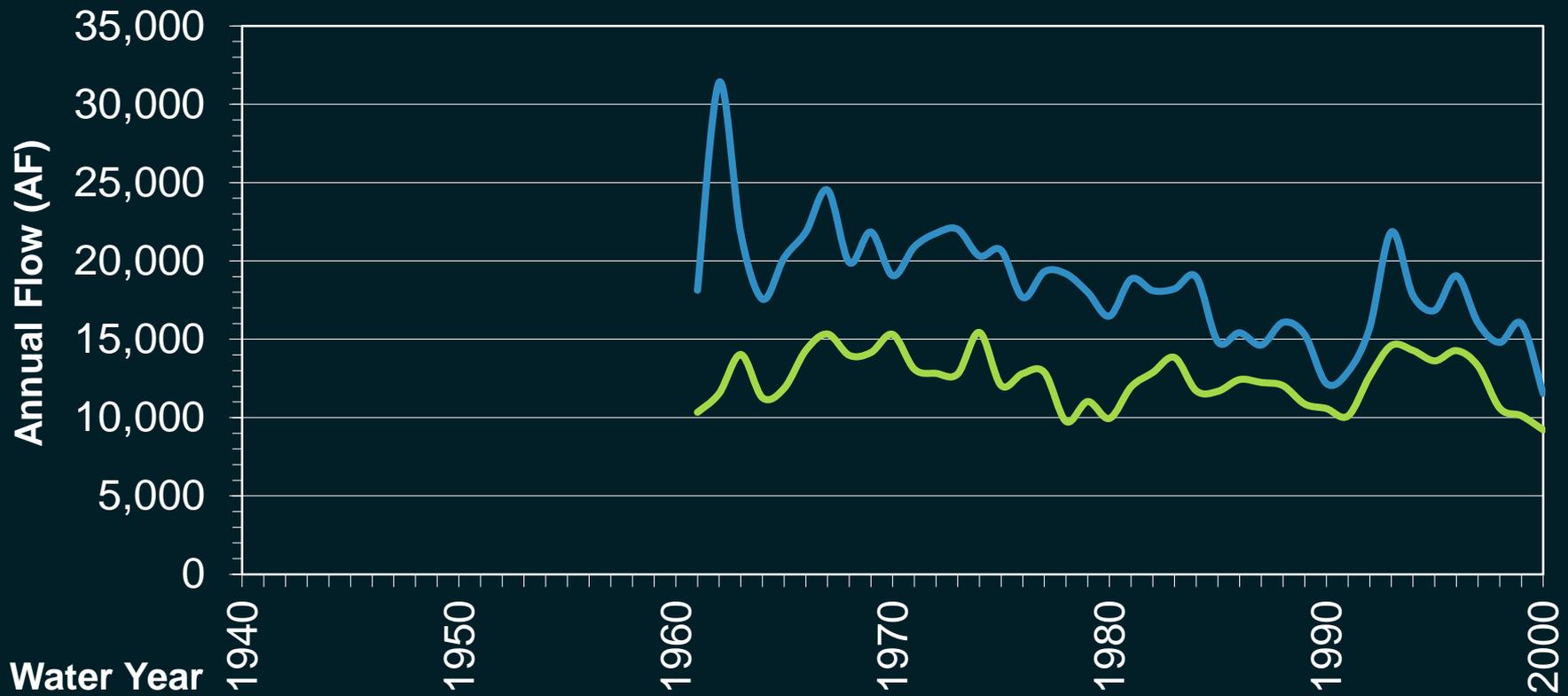
**Legend**

- Republican Basin (NE)
- Other States
- NRD
- County
- Lake
- Stream
- X Gage of Interest

**Red Willow Creek  
at Hugh Butler Lake**

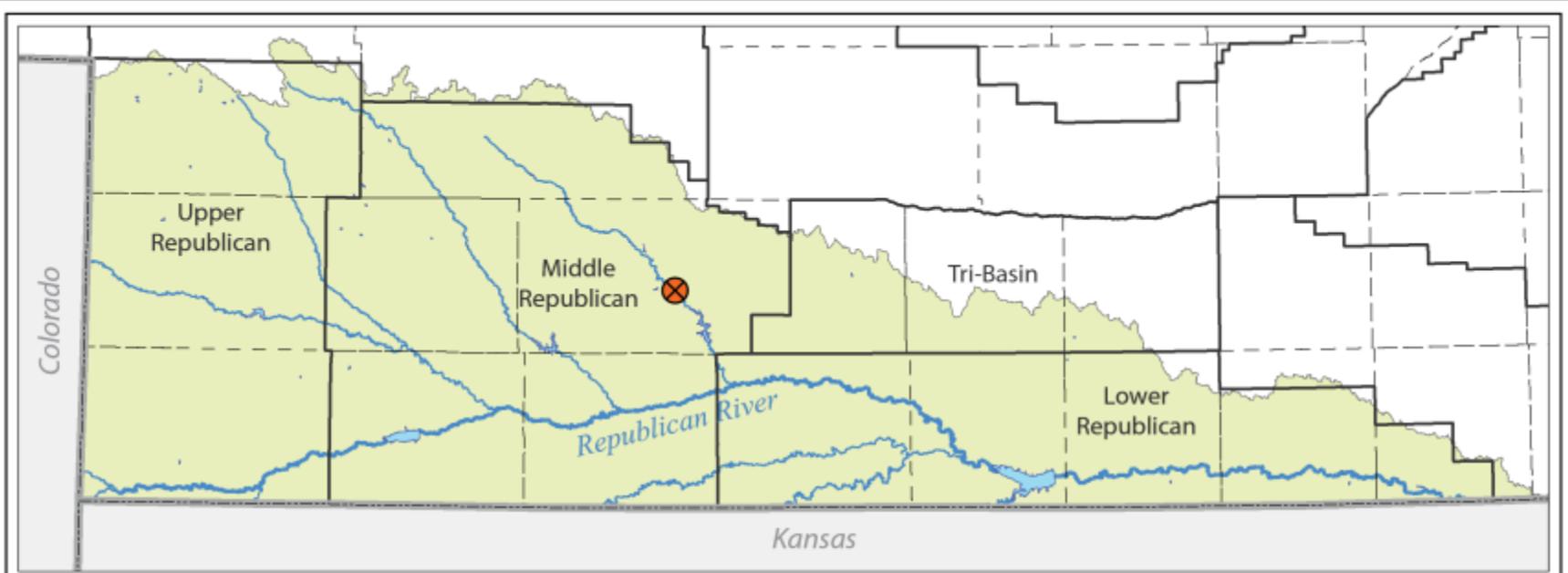
# Estimated Streamflow

## Red Willow Creek at Hugh Butler Lake



(values in AF) Avg. 1950-1964 Avg. 1986-2000 Difference

Total	22,203	15,743	-6,460
Baseflow	11,793	12,060	268



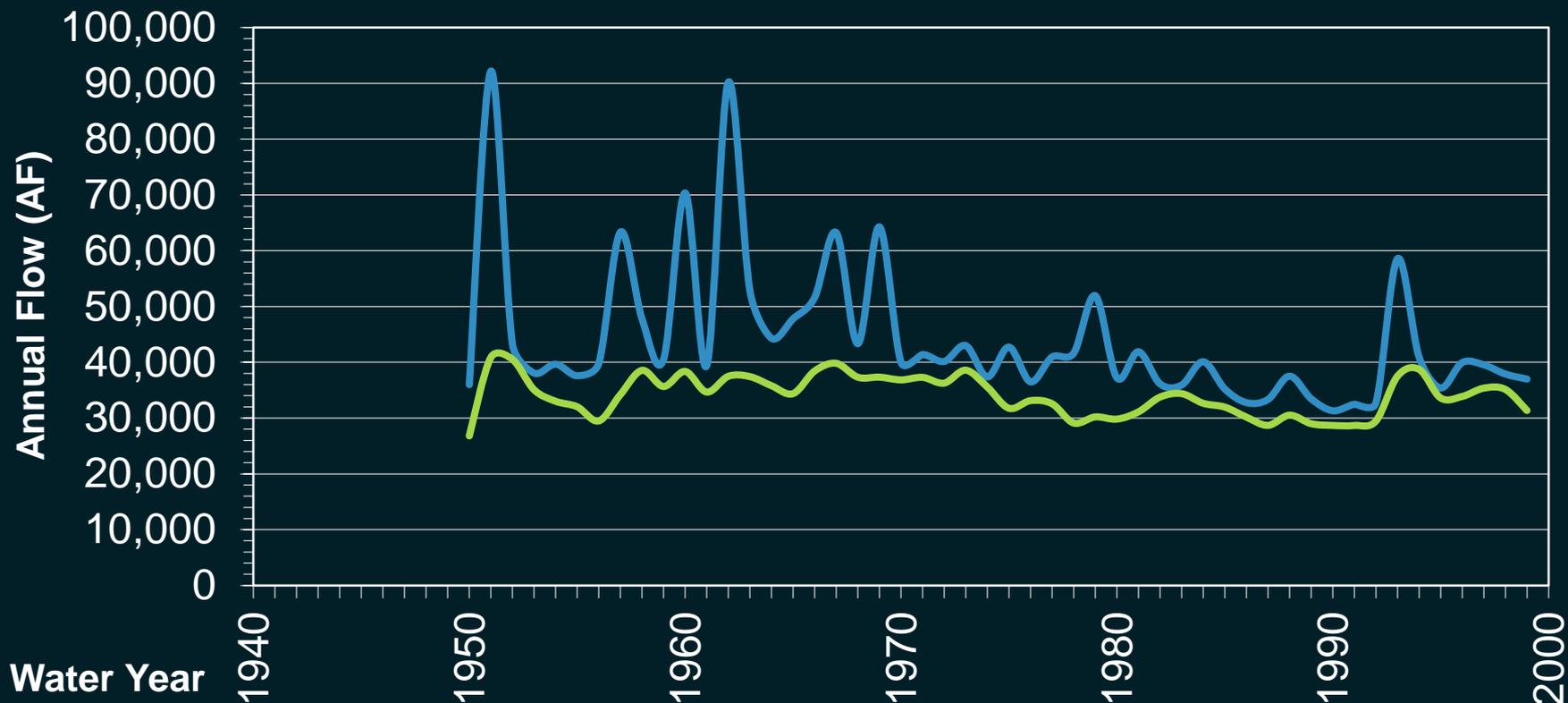
**Legend**

- Republican Basin (NE)
- Lake
- Other States
- Stream
- NRD
- County
- X Gage of Interest

**Medicine Creek  
above Harry Strunk Lake**

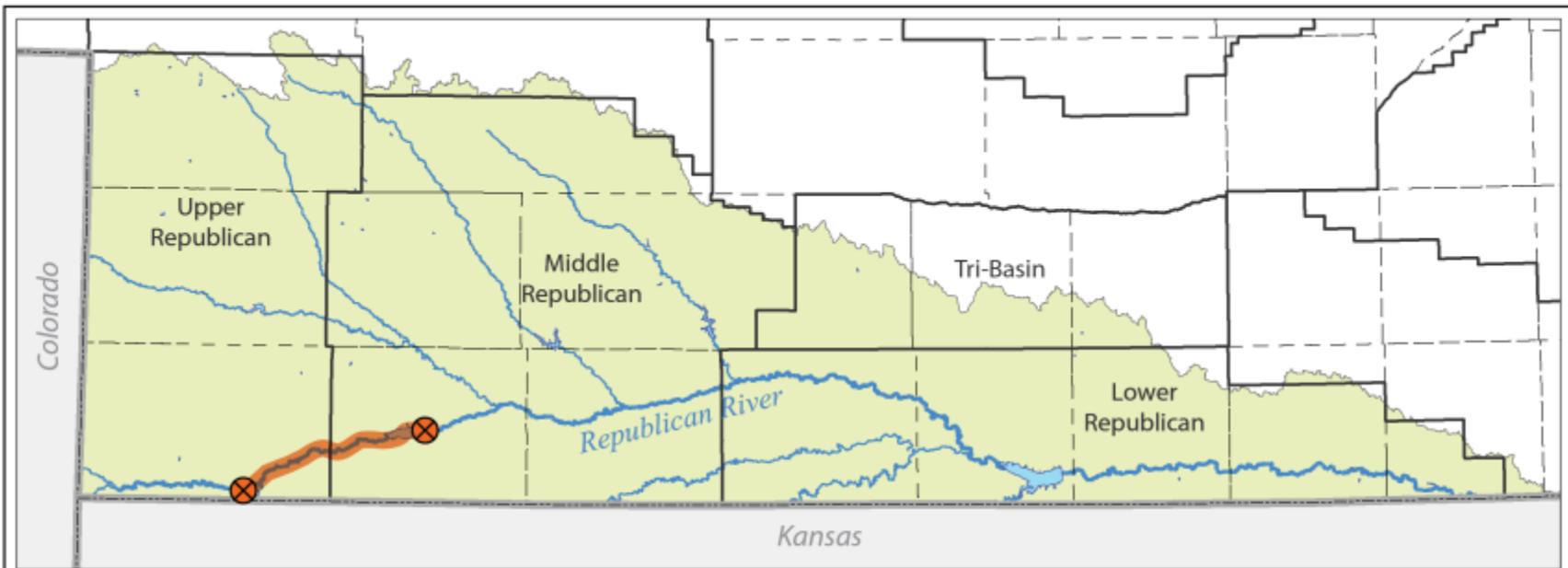
# Estimated Streamflow

## Medicine Creek above Harry Strunk Lake



(values in AF)    Avg. 1950-1964    Avg. 1986-2000    Difference

— Total	51,686	37,350	-14,336
— Baseflow	35,332	32,198	-3,134

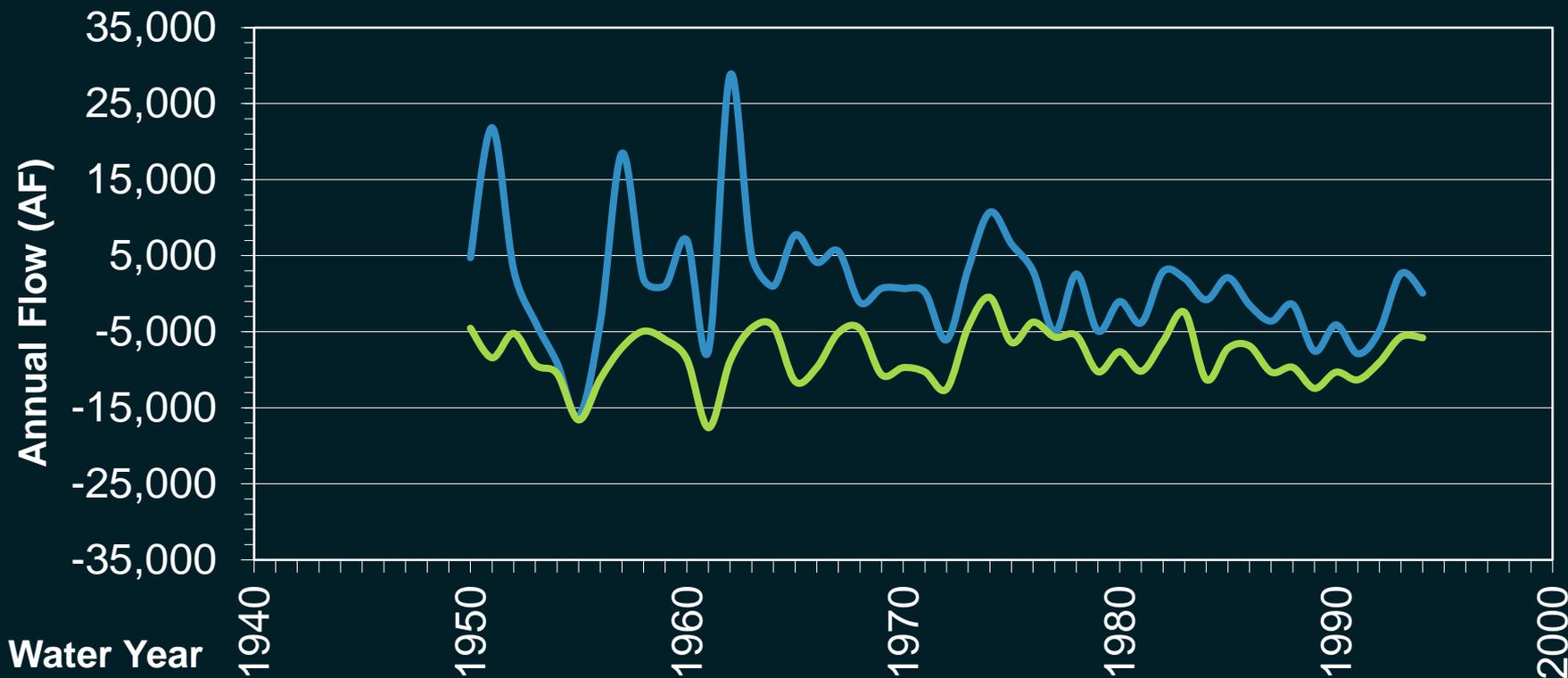


**Legend**

- Republican Basin (NE)
- Other States
- NRD
- County
- Lake
- Stream
- X Gage of Interest
- Stream Reach of Interest

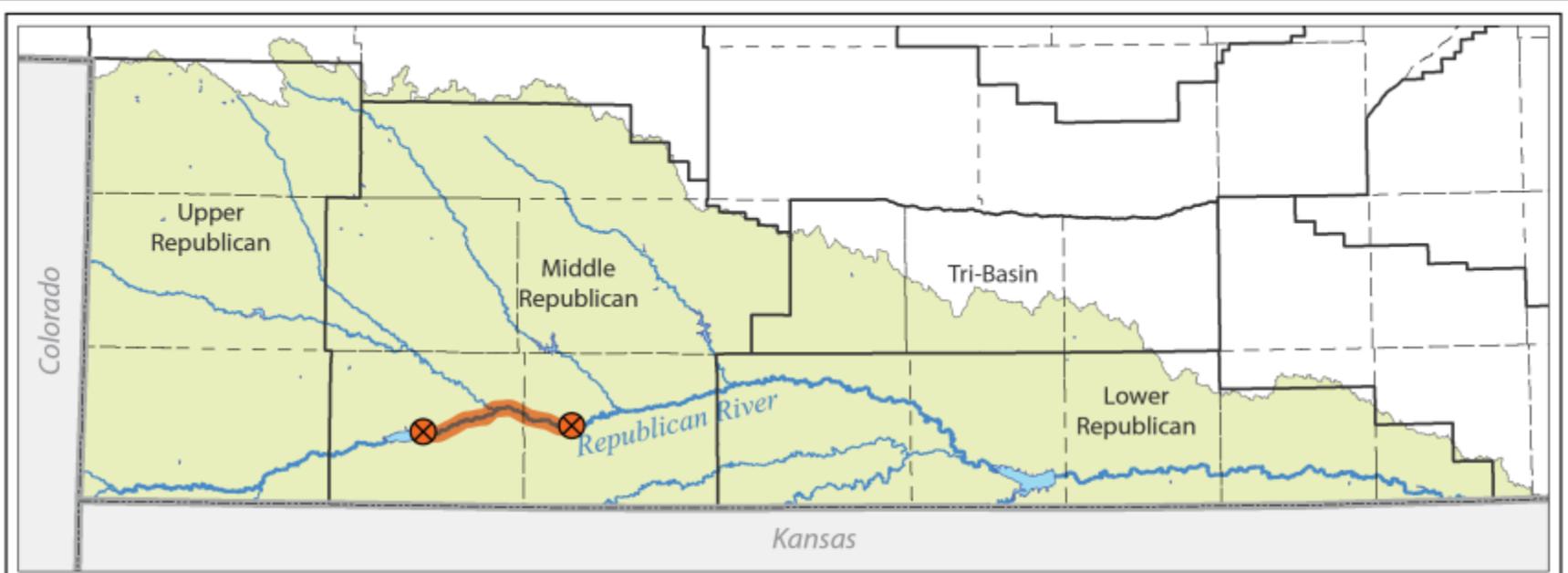
**Republican River,  
Benkleman to Swanson Reach**

# Estimated Streamflow (Reach Gain-Loss) Republican River, Benkleman to Swanson



(values in AF)    Avg. 1950-1964    Avg. 1986-2000    Difference

— Total	3,517	-3,135	-6,652
— Baseflow	-8,516	-9,047	-531

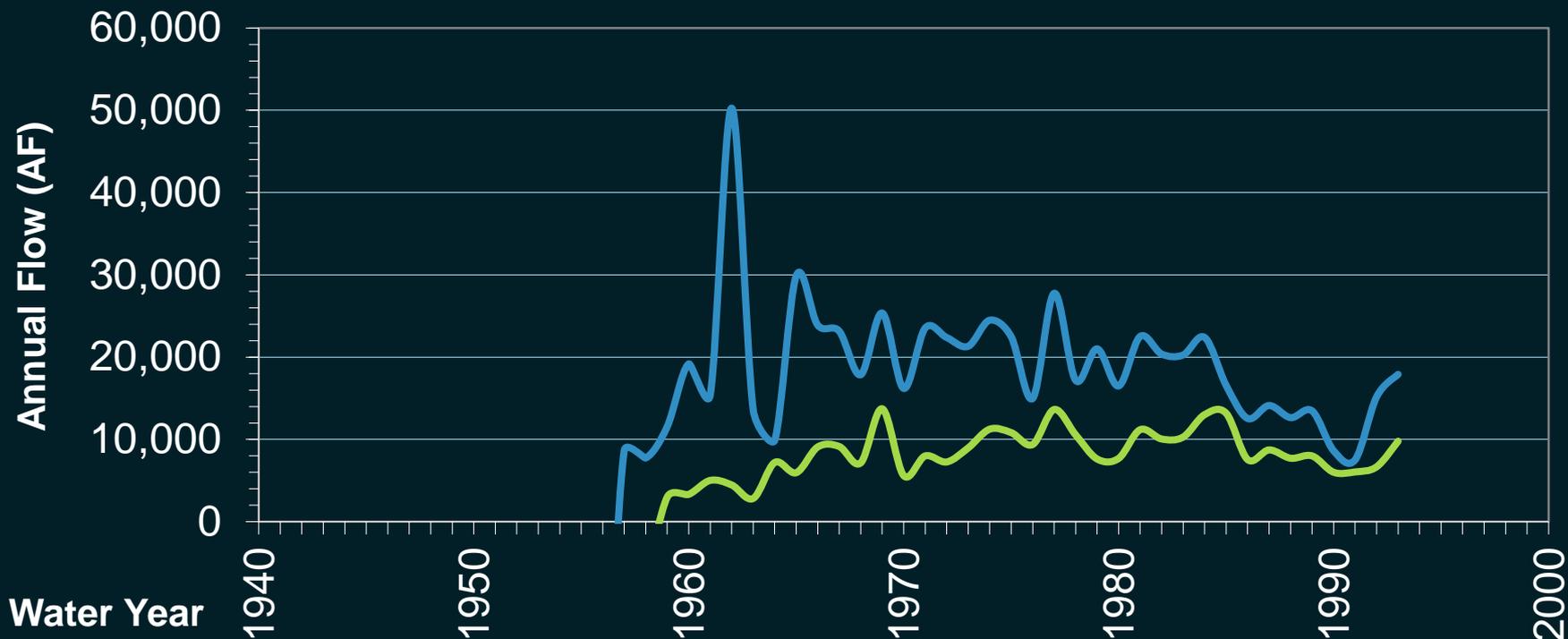


**Legend**

Republican Basin (NE)	Lake
Other States	Stream
NRD	Gage of Interest
County	Stream Reach of Interest

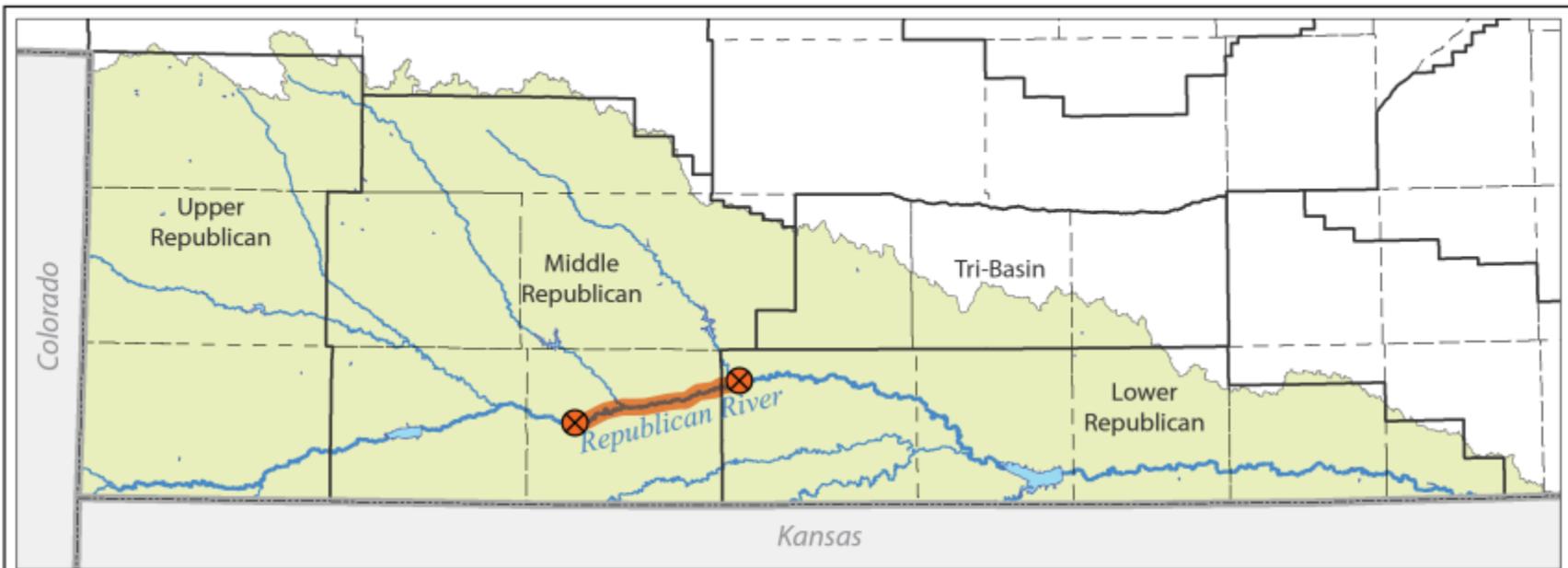
**Republican River,  
Swanson Reservoir to McCook Reach**

# Estimated Streamflow (Reach Gain-Loss) Republican River, Swanson to McCook



(values in AF)    Avg. 1950-1964    Avg. 1986-2000    Difference

— Total	18,172	7,019	-11,153
— Baseflow	1,963	4,678	2,715

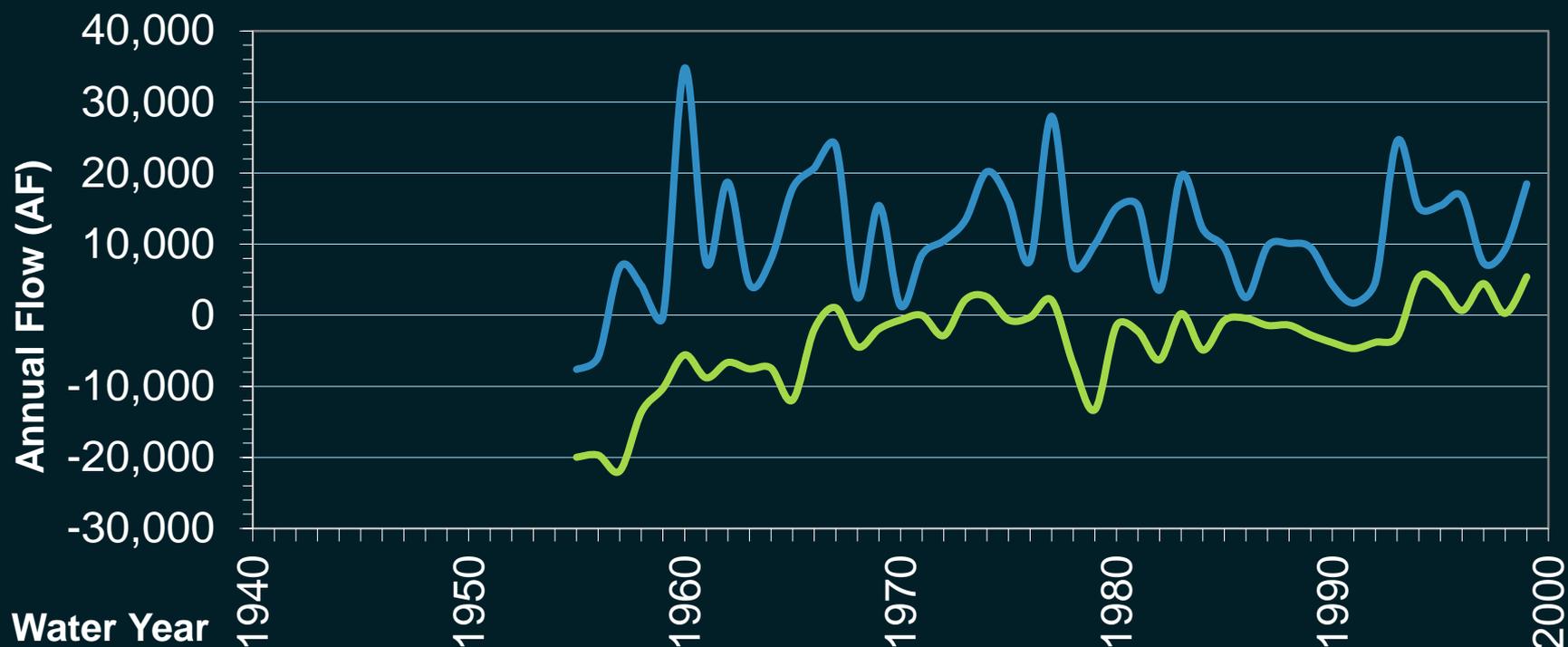


**Legend**

- Republican Basin (NE)
- Other States
- NRD
- County
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- Stream Reach of Interest

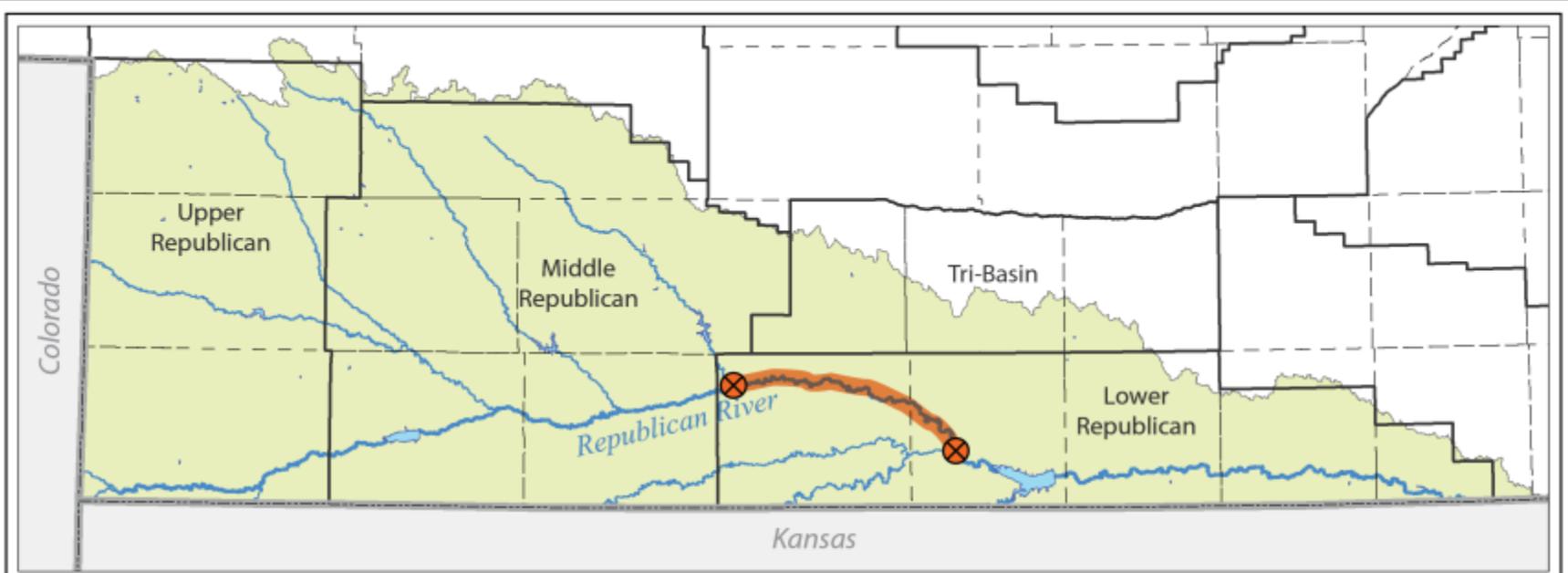
**Republican River,  
McCook to Cambridge Reach**

# Estimated Streamflow (Reach Gain-Loss) Republican River, McCook to Cambridge



(values in AF) Avg. 1950-1964 Avg. 1986-2000 Difference

— Total	7,032	10,680	3,648
— Baseflow	-12,149	-72	12,077



**Legend**

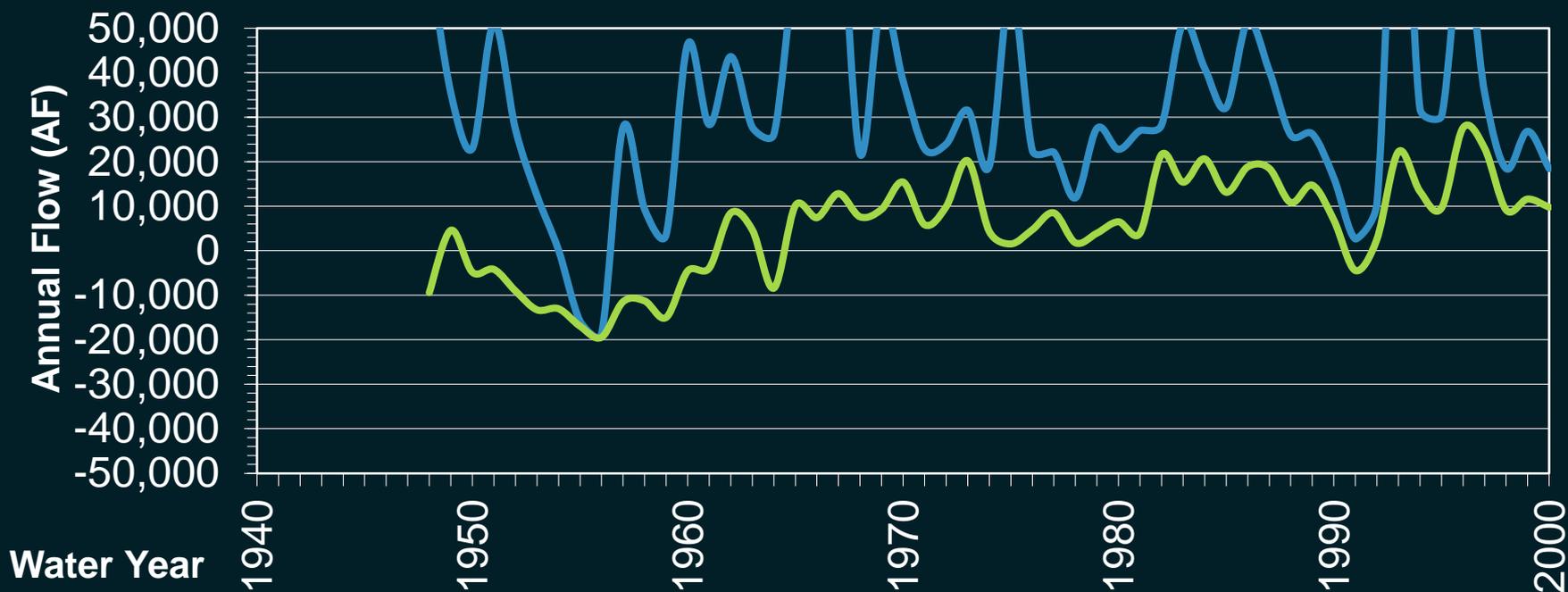
Republican Basin (NE)	Lake
Other States	Stream
NRD	Gage of Interest
County	Stream Reach of Interest

**Republican River,  
Cambridge to Orleans Reach**

# Estimated Streamflow (Reach Gain-Loss\*)

## Republican River, Cambridge to Orleans

\*Gain includes inflow from several tributaries



(values in AF)    Avg. 1950-1964    Avg. 1986-2000    Difference

— Total	18,172	7,019	-11,153
— Baseflow	1,963	4,678	2,715

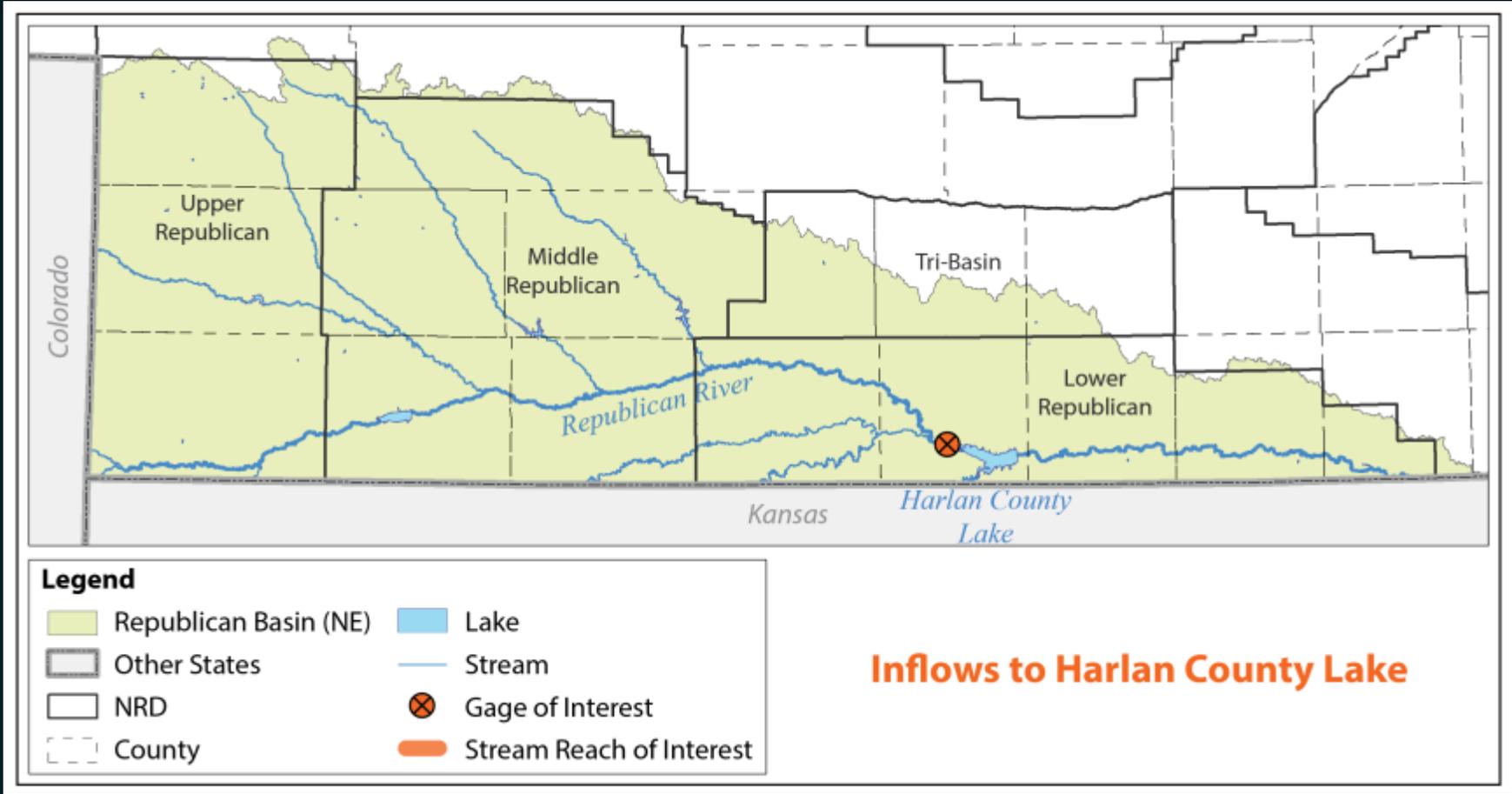
# Observations Based on Trends

- Streamflows in the Basin
  - Have generally declined over time
  - Especially in western and central portions
- Noticeable declines in both **baseflow** and **runoff**

# Questions?

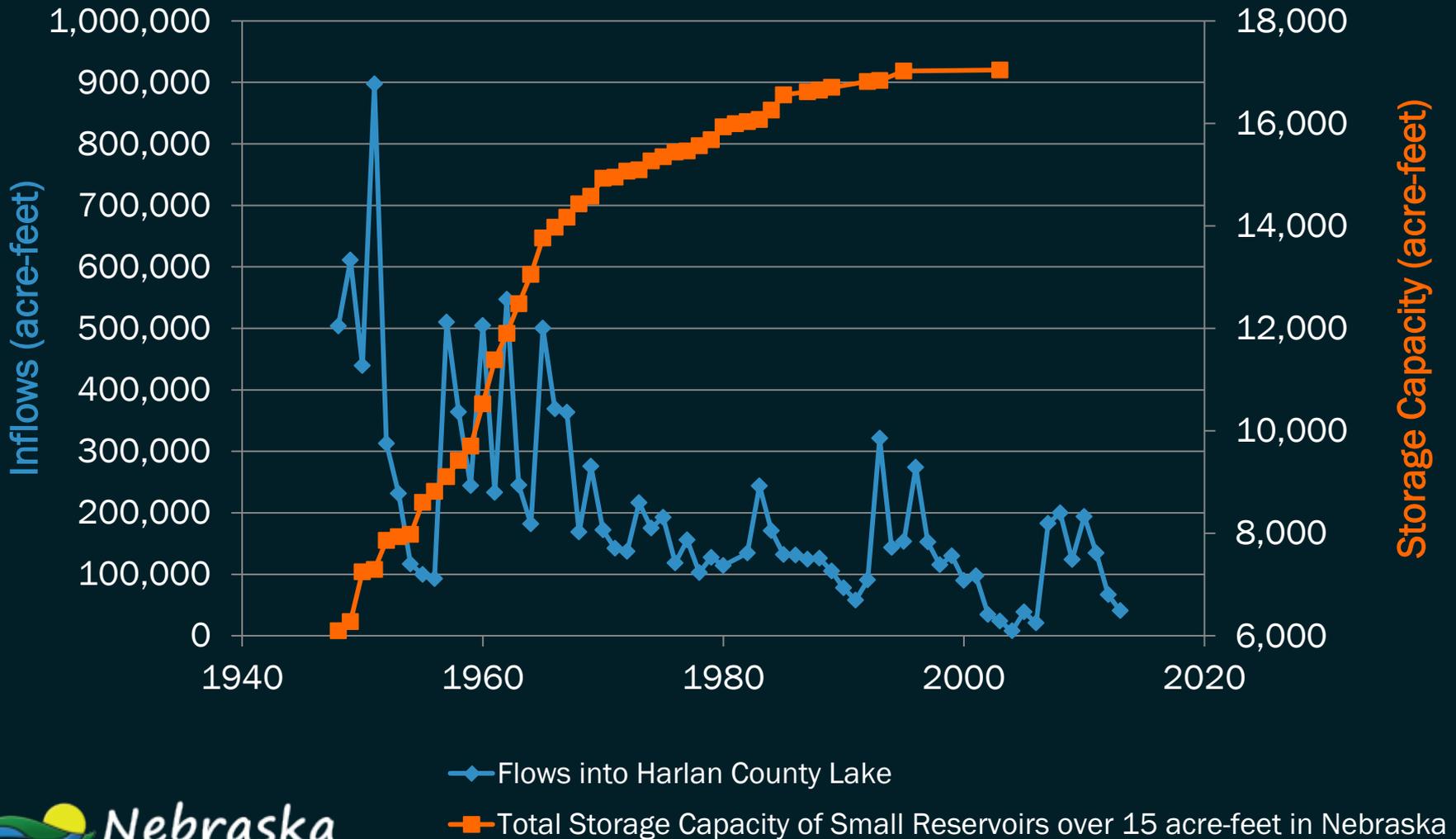
# CORRELATIONS

Comparison between inflows to Harlan County Lake and other changes in the Republican River Basin

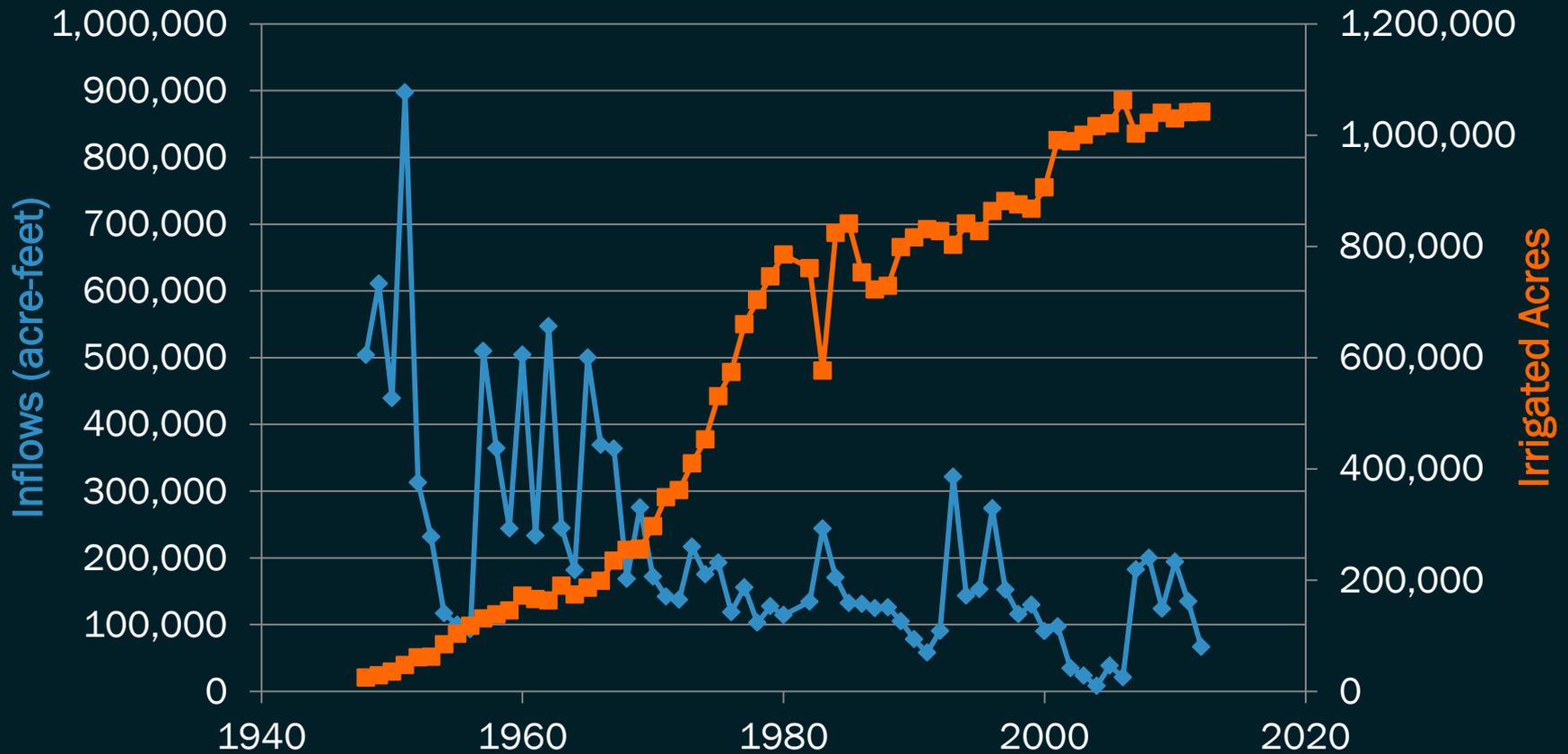


**Inflows to Harlan County Lake**

# Inflows vs. Small Reservoirs



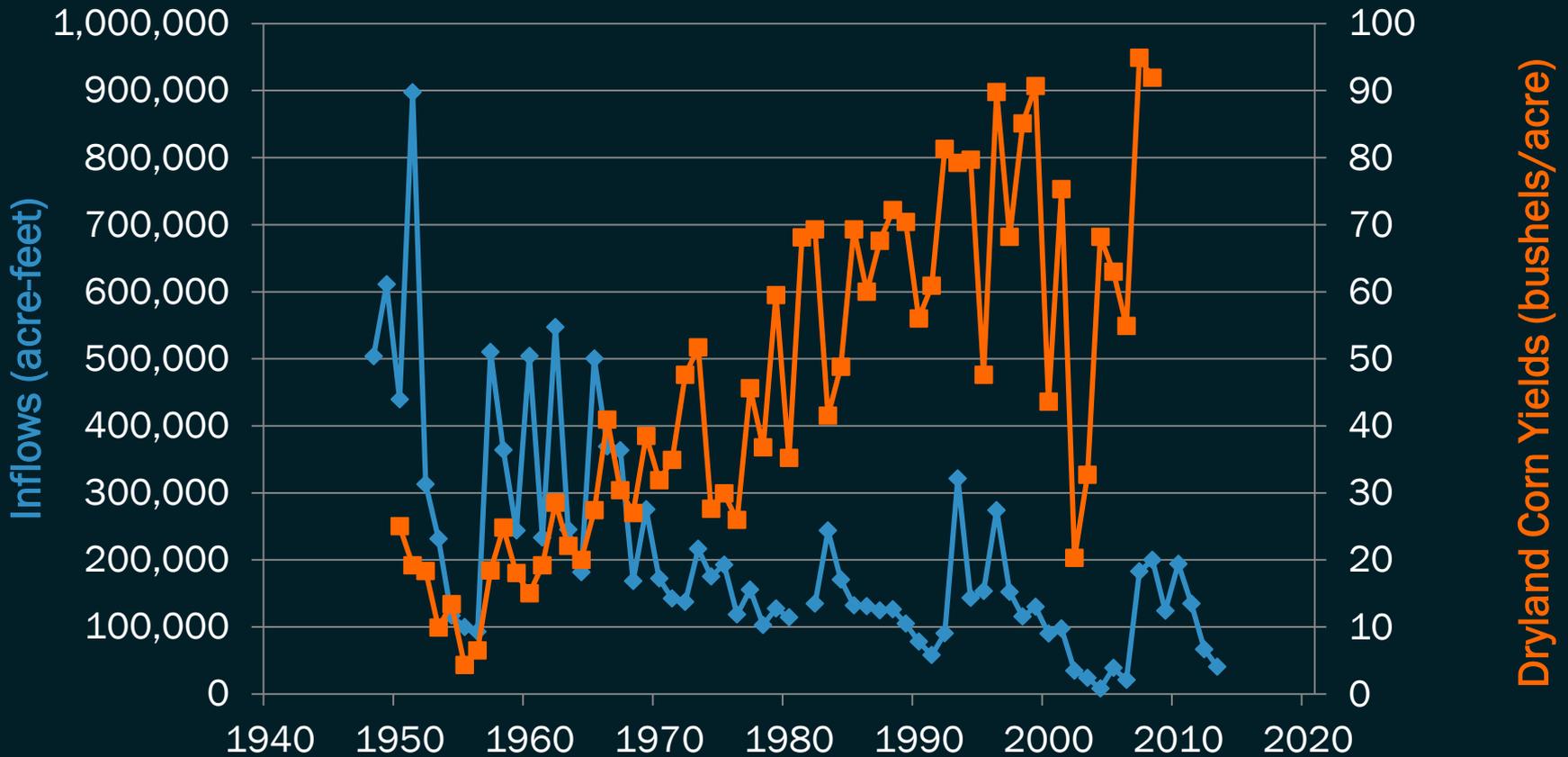
# Inflows vs. Irrigated Acres



—◆— Flows into Harlan County Lake

—■— Irrigated acres in the LRNRD, MRNRD, URNRD

# Inflows vs. Dryland Corn Yields



# Observations Based on Correlations

- Inflows into Harlan County Lake are inversely correlated with:
  - Development of groundwater irrigation
  - Development of conservation practices such as farm ponds
  - Increase in dryland crop yields
- The most significant declines in runoff appear to have occurred:
  - Prior to 1970
  - i.e., during the time that the development of conservation practices increased the most
- Baseflow has declined more steadily, in a manner more similar to:
  - The increase in groundwater irrigation
  - The increase in dryland yields

## Inflows

vs. Small Reservoirs



vs. Irrigated Acres



vs. Dryland Yields



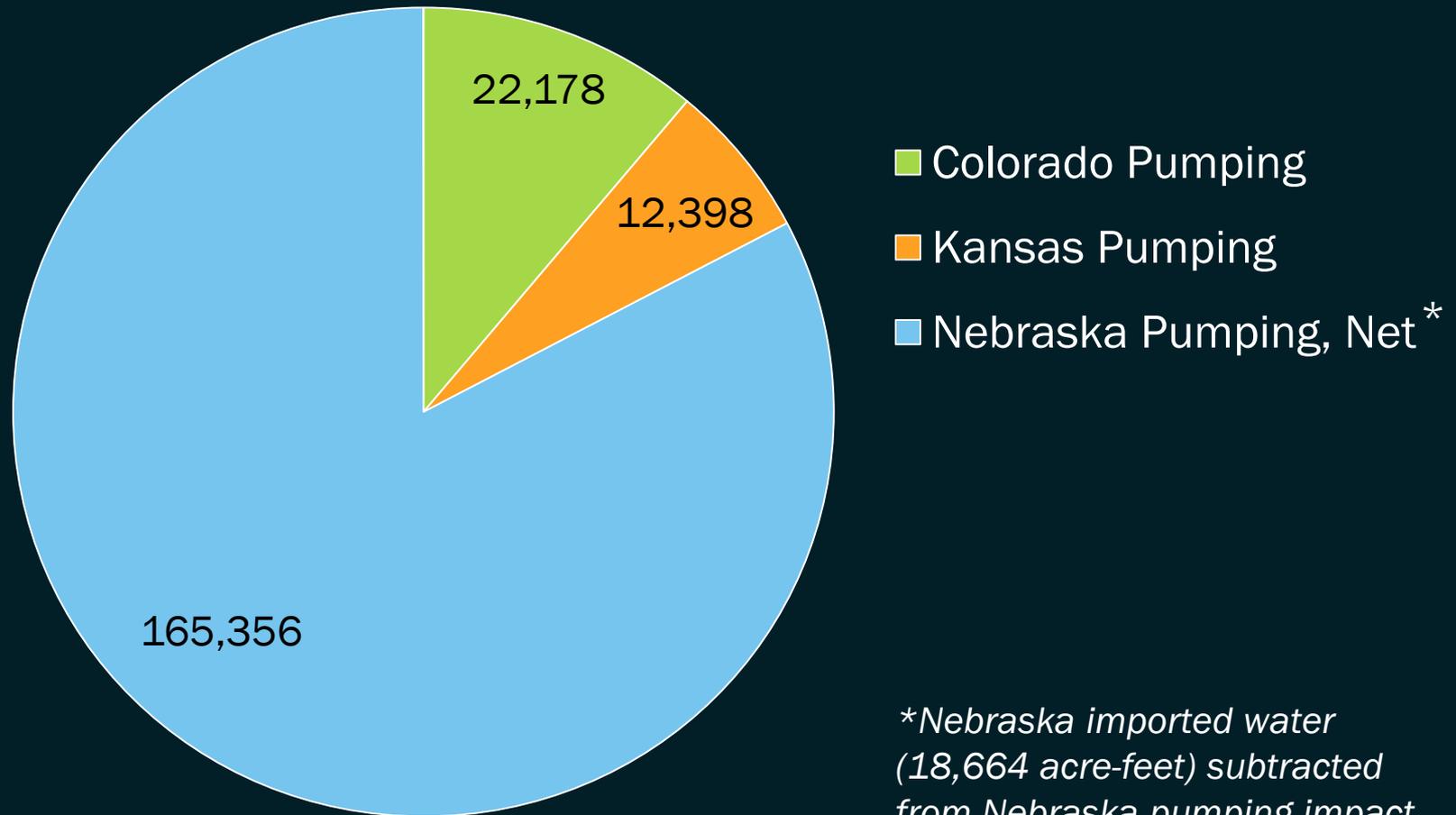
# Questions?

# CAUSES OF REDUCED STREAMFLOW SUPPLY

# Causes of Reduced Streamflow Supply

Causes	Quantifying these impacts
Groundwater pumping by the three states	→ Estimates of streamflow depletions due to groundwater pumping from the RRCA groundwater model
Reductions in runoff	→ RRCA Conservation Study, analysis of historic streamflow and baseflow information to estimate reductions in runoff
Drought	→ Comparison of 2013-2014 with longer-term averages to assess the impact of drought

# Total Depletions Due to Groundwater Pumping Basin-Wide Impacts, 2000 (acre-feet)

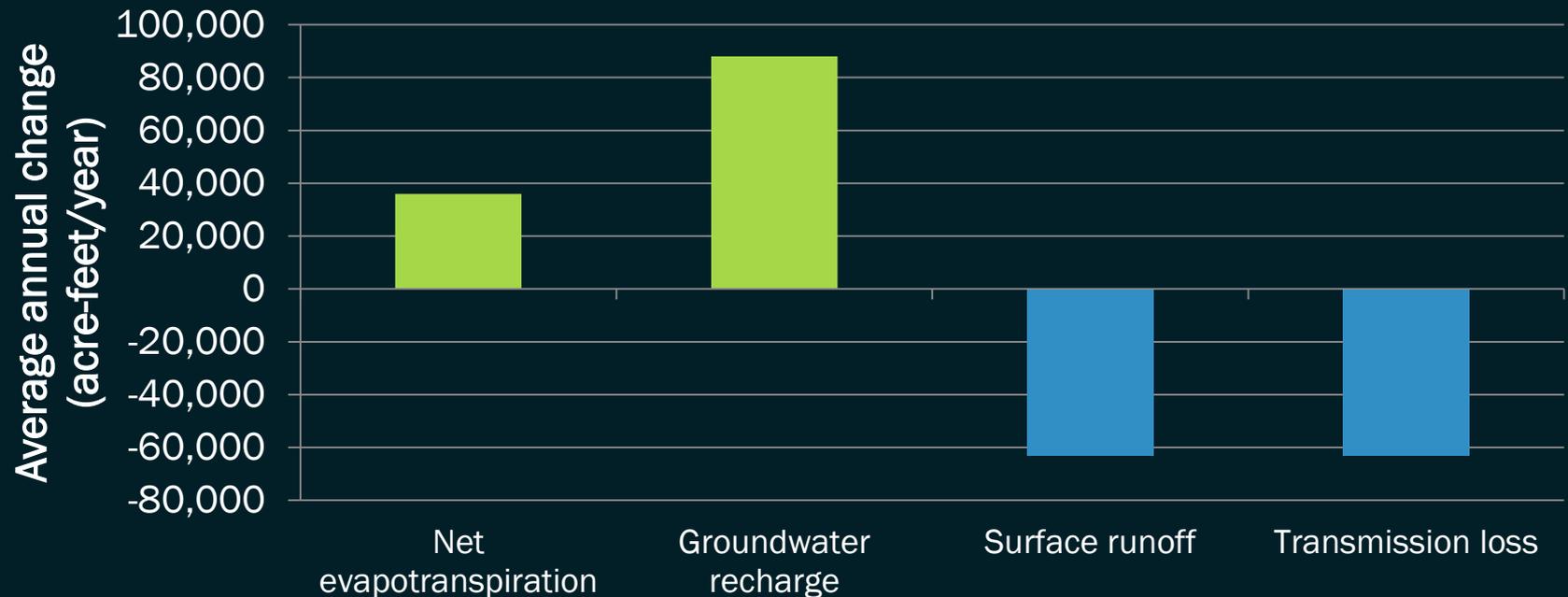


*\*Nebraska imported water (18,664 acre-feet) subtracted from Nebraska pumping impact (184,020 acre-feet)*

# RRCA Conservation Study

## Impacts of Land Terracing and Non-Federal Reservoirs

- *“Land terracing and Non-Federal Reservoirs are having a substantial effect on the water resources of the Republican River Basin above Hardy, Nebraska.”*
- With land terracing and Non-Federal Reservoirs:



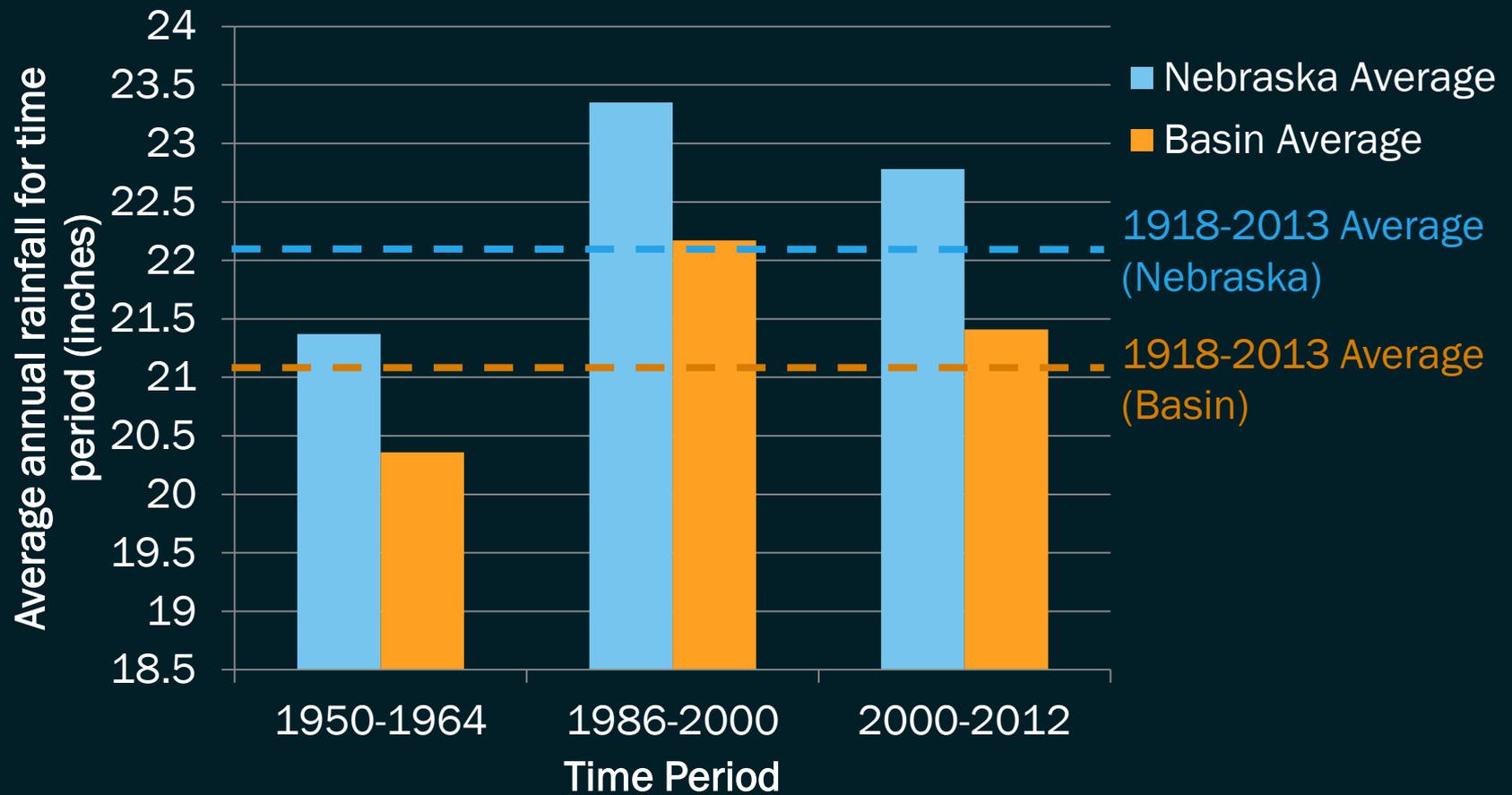
# RRCA Conservation Study

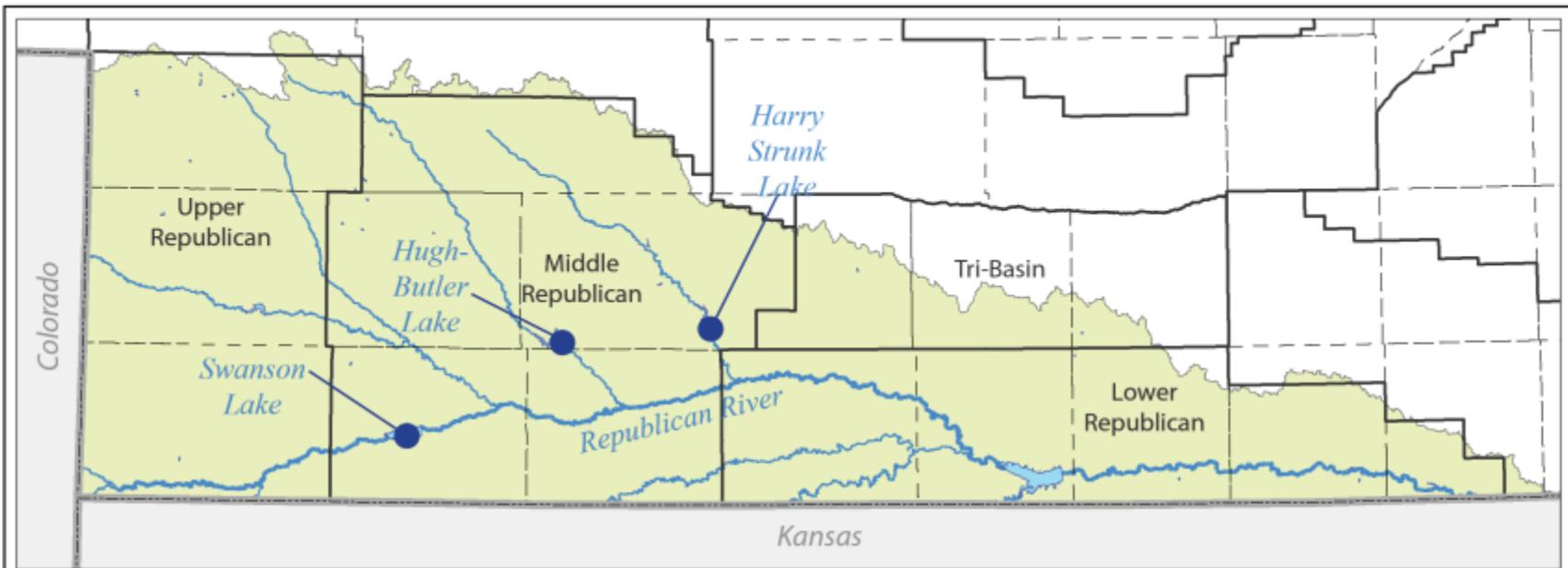
- *“The reduction in runoff and stream transmission losses from both Non-Federal Reservoirs and land terraces operating totals about **125,000 acre-feet** per year. To put the magnitude of the impact in perspective, **this is comparable to estimated average annual inflow to Harlan County Reservoir.**”*

# IMPACTS OVER TIME, USING STREAMFLOW AND BASEFLOW DATA

1950-1964, 1986-2000, and 2000-2012 time periods

# Rainfall Comparison



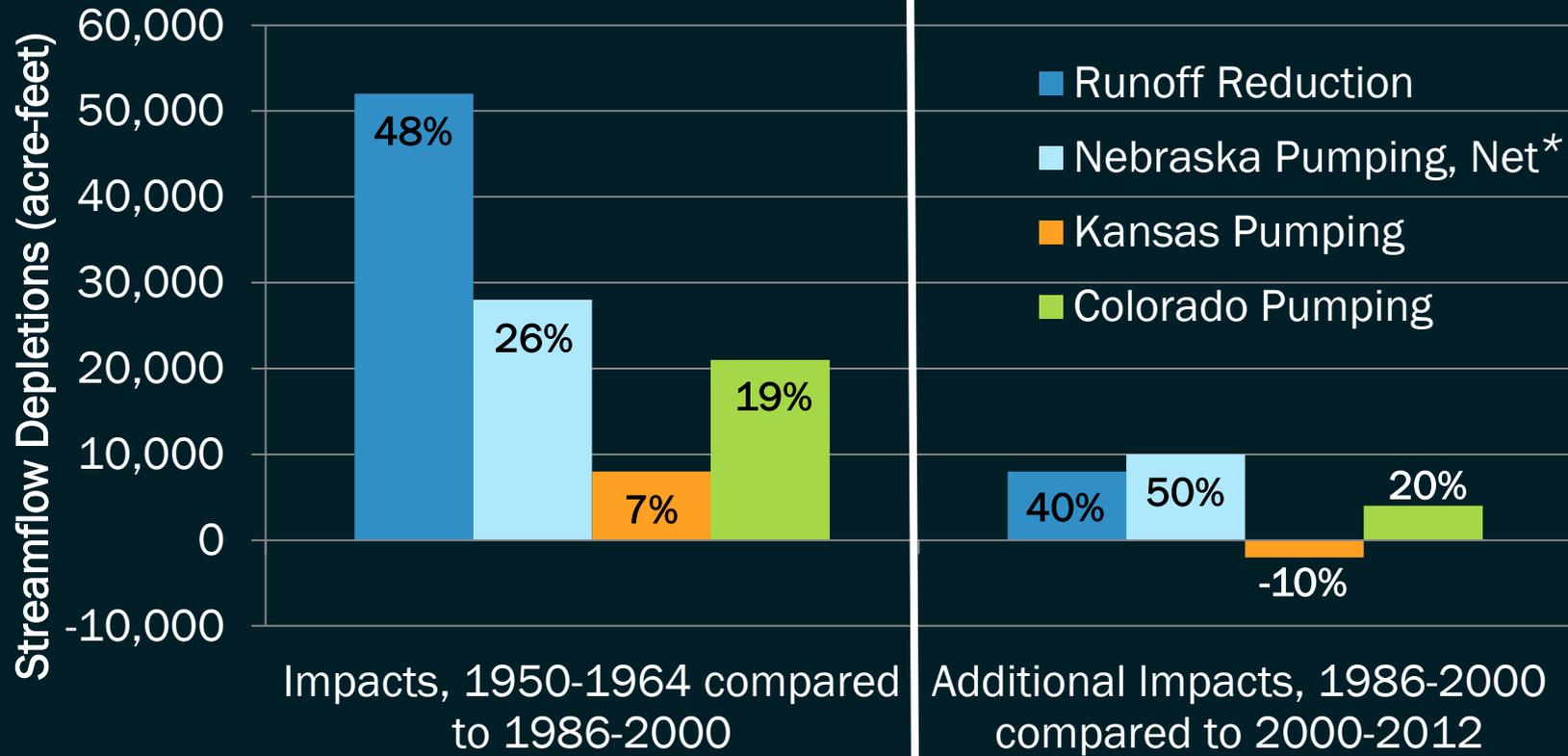


**Legend**

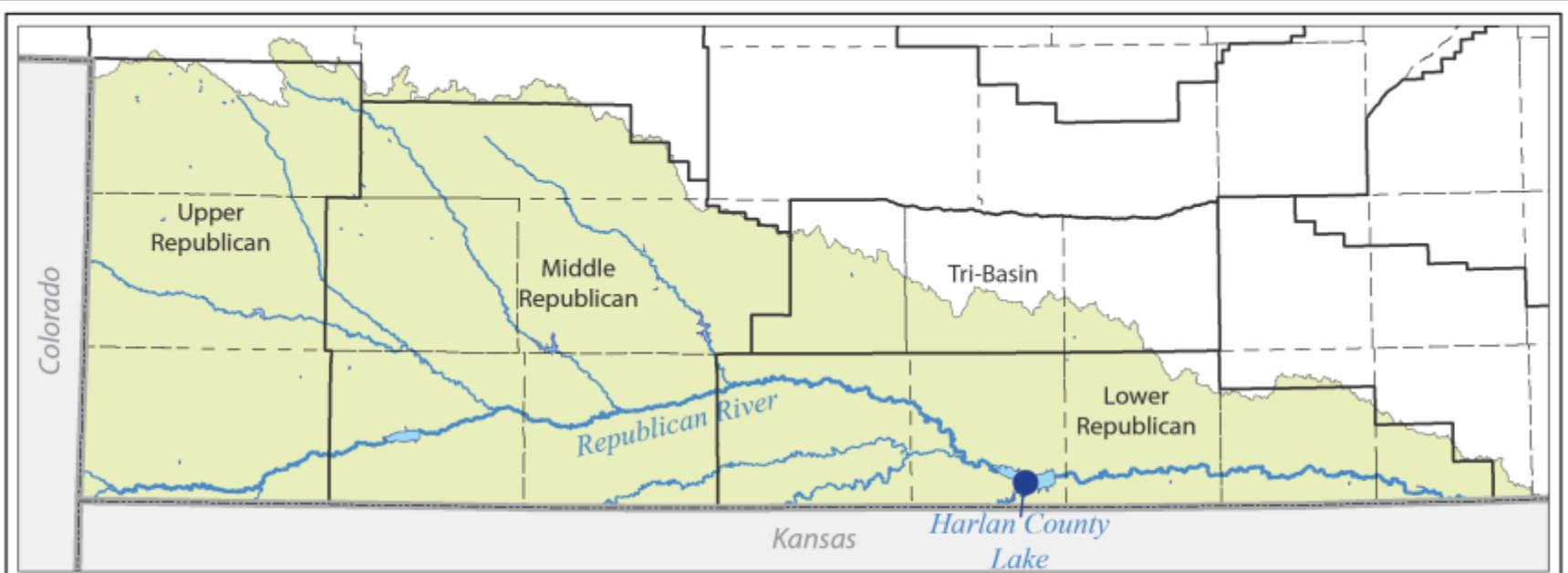
- Republican Basin (NE)
- Other States
- NRD
- County
- Lake
- Stream
- Reservoir of Interest

**Reservoirs Serving  
Frenchman-Cambridge  
Irrigation District**

# Impacts to Reservoirs Serving Frenchman Cambridge Irrigation District



\*Nebraska imported water subtracted from Nebraska pumping impact



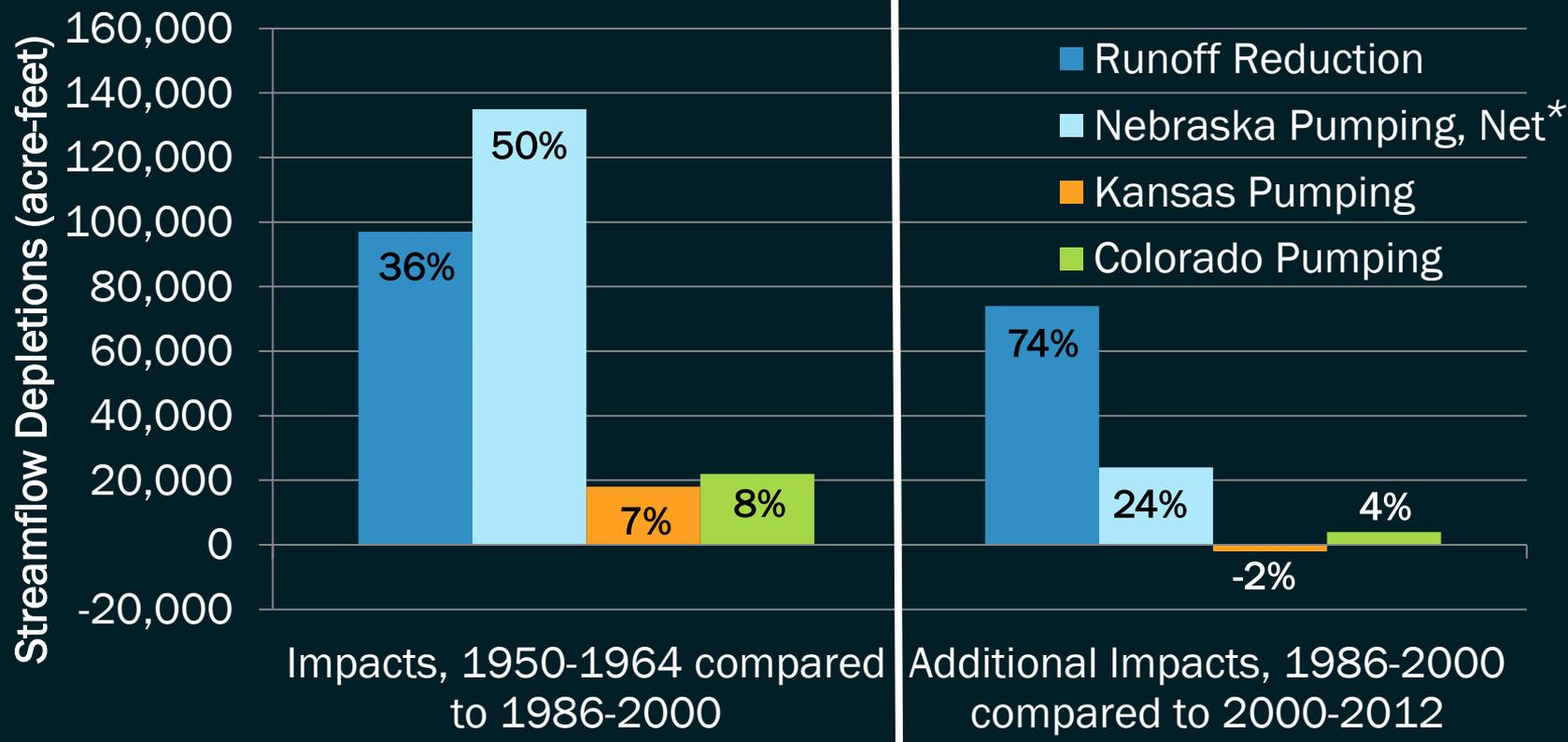
**Legend**

 Republican Basin (NE)	 Lake
 Other States	 Stream
 NRD	 Reservoir of Interest
 County	

**Harlan County Lake**

# Impacts

## Above Harlan County Lake

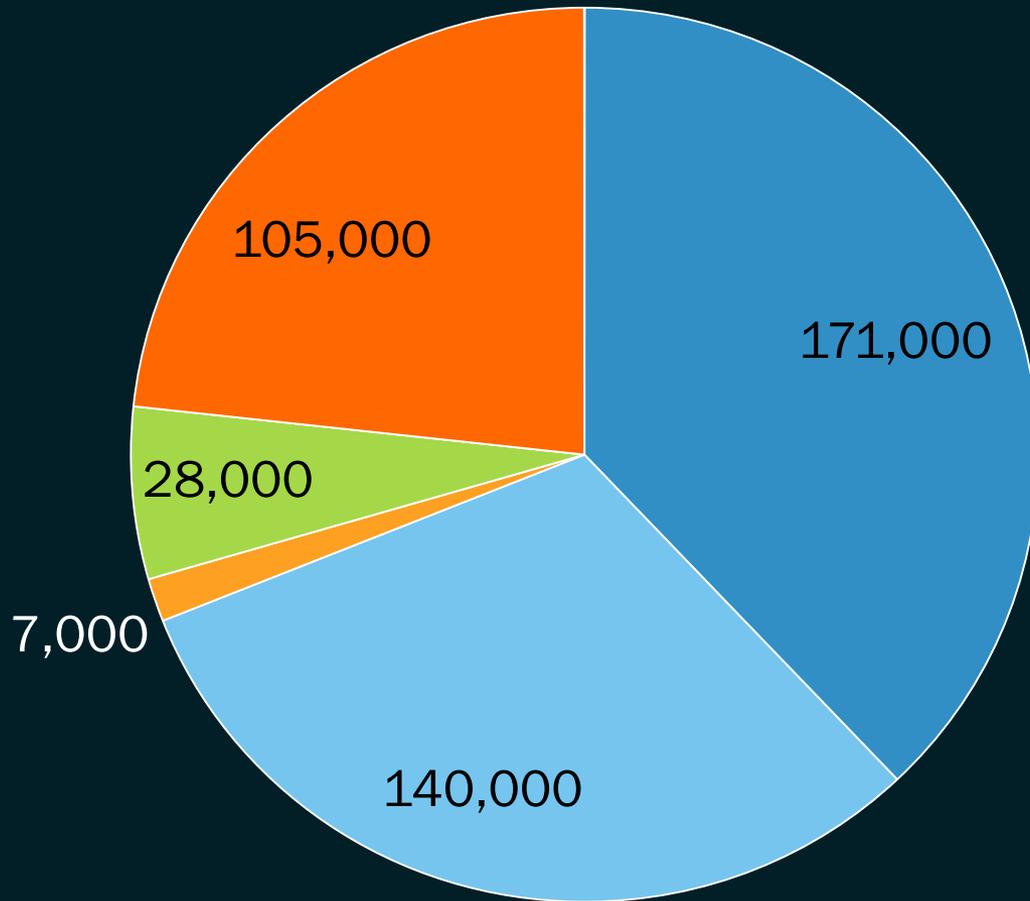


\*Nebraska imported water subtracted from Nebraska pumping impact

# 2013 Impacts, Including Drought Above Harlan County Lake (acre-feet)



2013 rainfall in the Nebraska portion of the Basin was **24% less** than the 1918-2013 average. \*



- Runoff Reduction
- Nebraska Pumping, Net
- Kansas Pumping
- Colorado Pumping
- Drought

\*Nebraska imported water (12,000 acre-feet) subtracted from Nebraska pumping impact (152,000 acre-feet)

# Causes of Reduced Streamflow Supply

Causes	Quantifying these impacts
Groundwater pumping by the three states	→ Estimates of streamflow depletions due to groundwater pumping from the RRCA groundwater model
Reductions in runoff	→ RRCA Conservation Study, analysis of historic streamflow and baseflow information to estimate reductions in runoff
Drought	→ Comparison of 2013-2014 with longer-term averages to assess the impact of drought

# Questions?

# POTENTIAL APPLICABILITY TO BASIN-WIDE PLANNING PROCESS

# CONCLUSIONS

# Key Points

- Current average streamflow supplies have been significantly reduced from historic levels
  - Causes:
    - Groundwater pumping
    - Reduced runoff
  - These causes are exacerbated by drought
- Understanding how water supply has changed since we started using water in the Basin is important for effective water planning



# Nebraska

## Department of Natural Resources

NEBRASKA'S WATER MANAGEMENT RESOURCE

Providing the sound science and support for managing  
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