Nebraska
Department of Natural Resources

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

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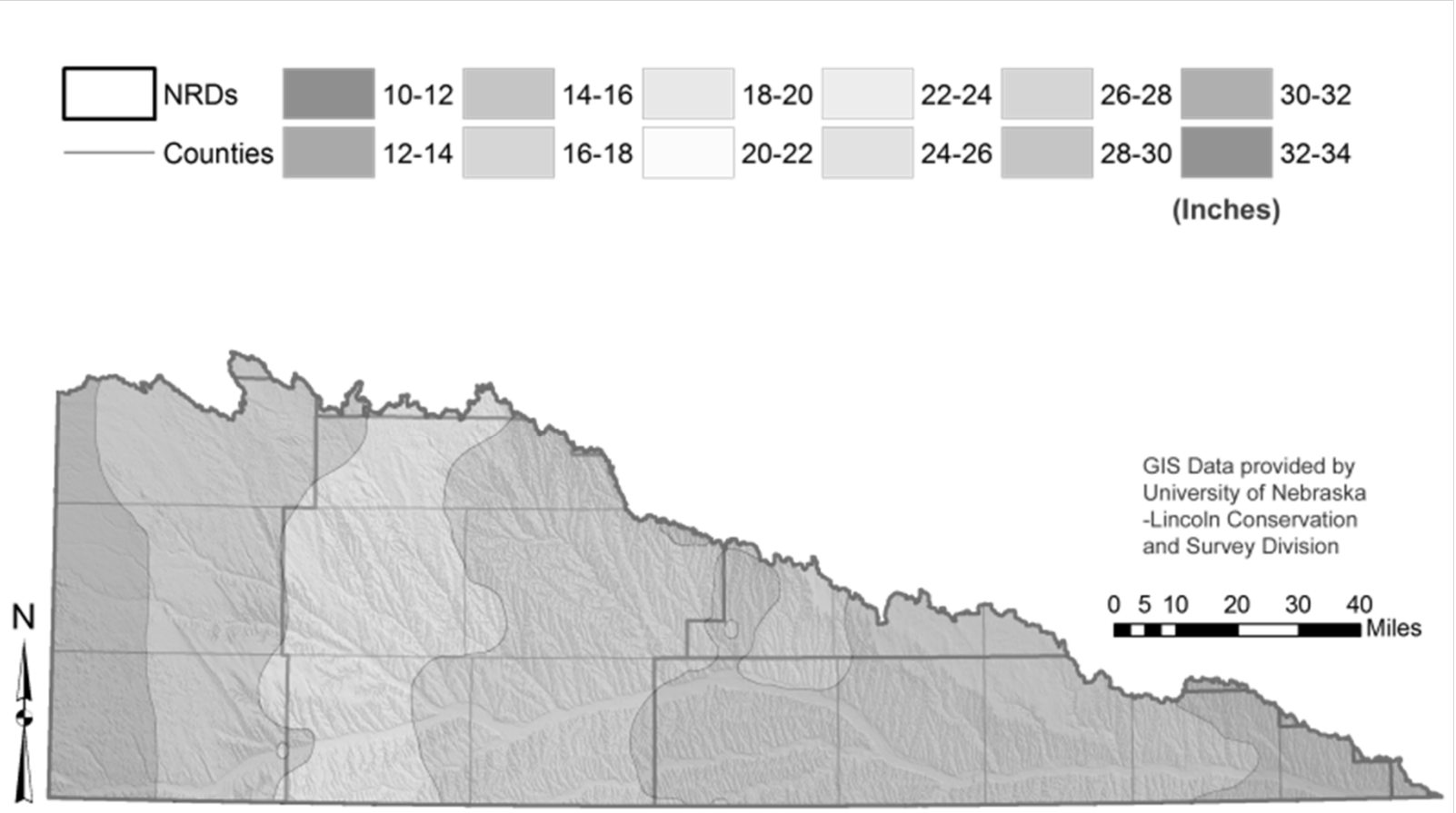
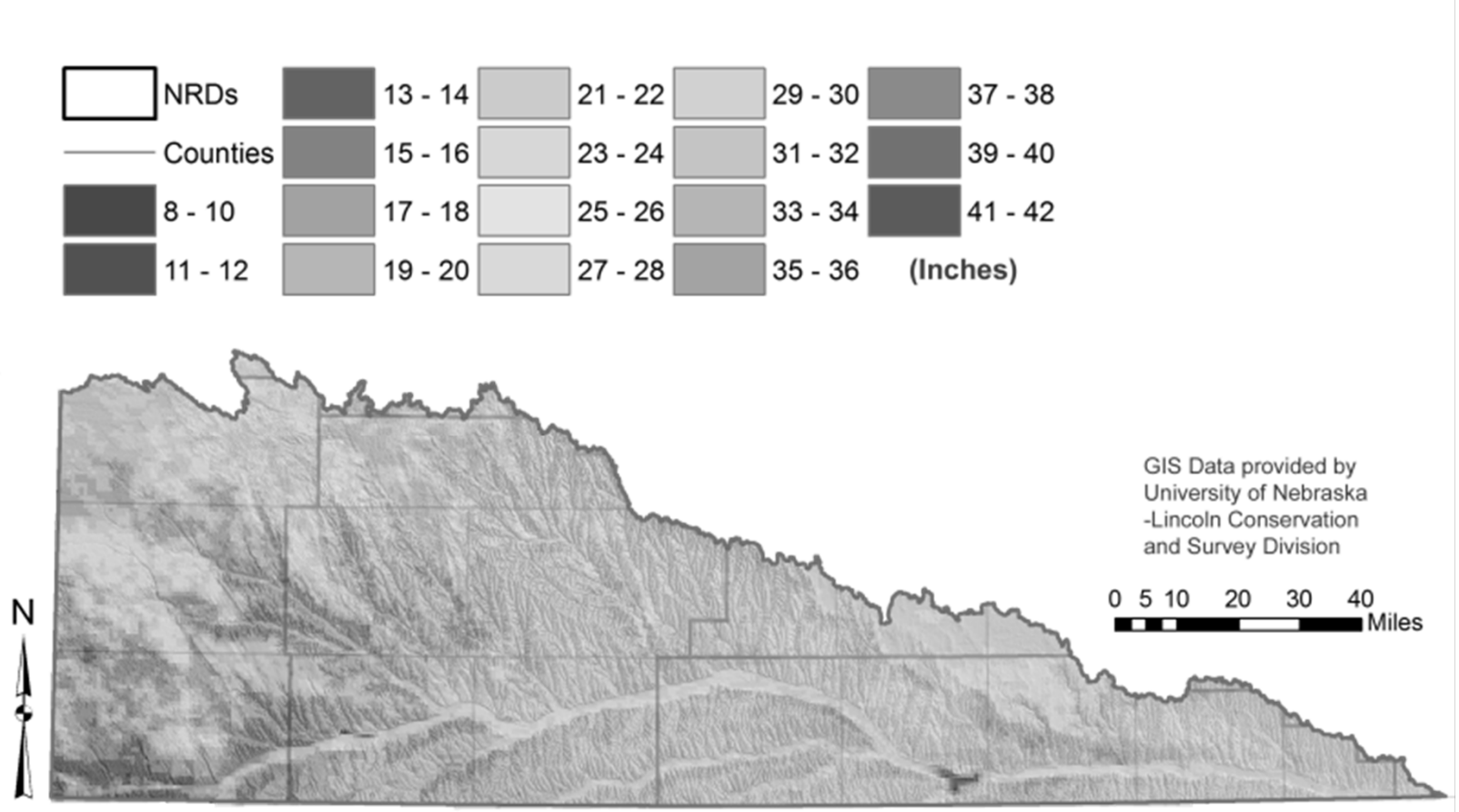
Precipitation



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)

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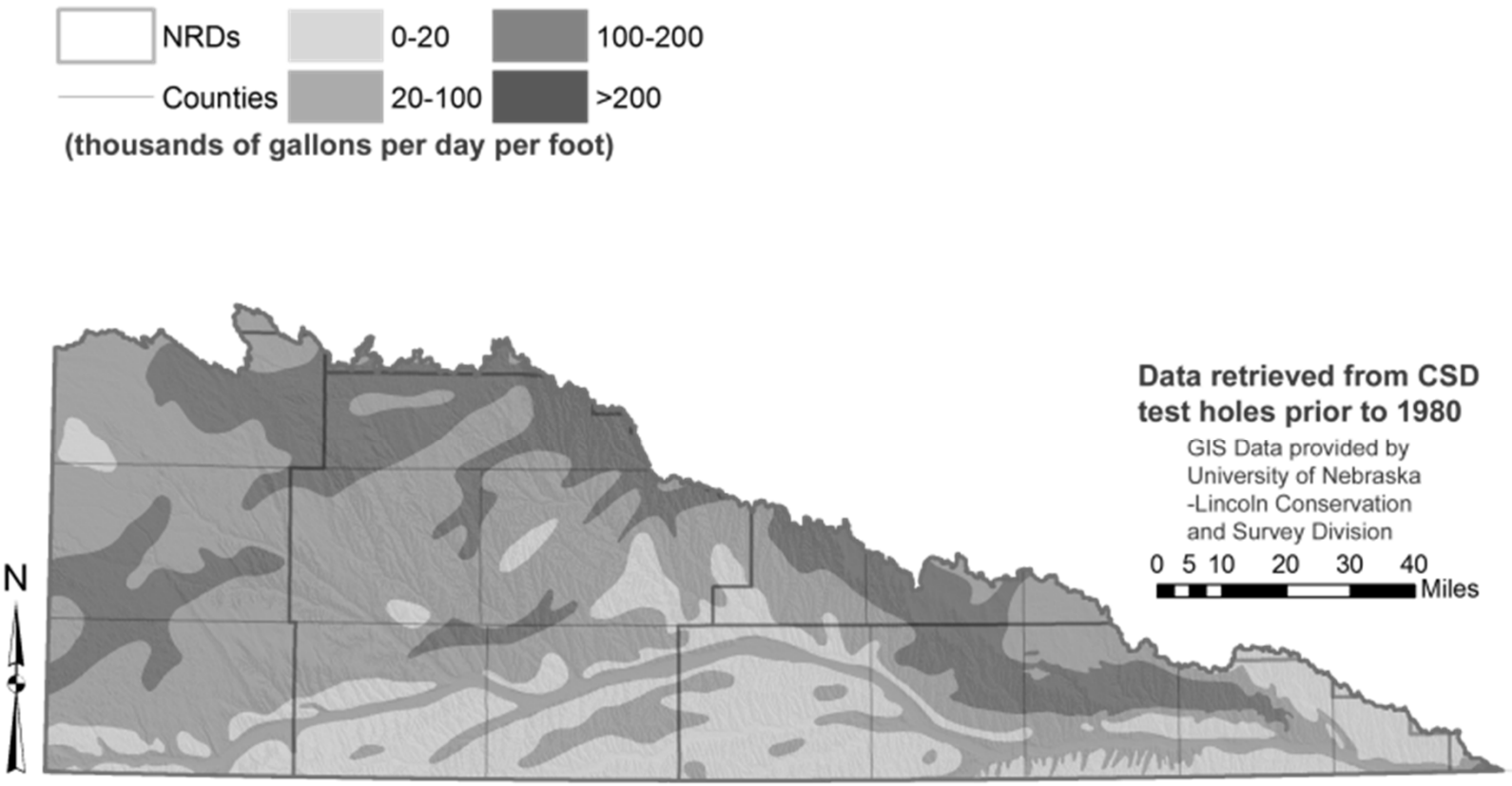
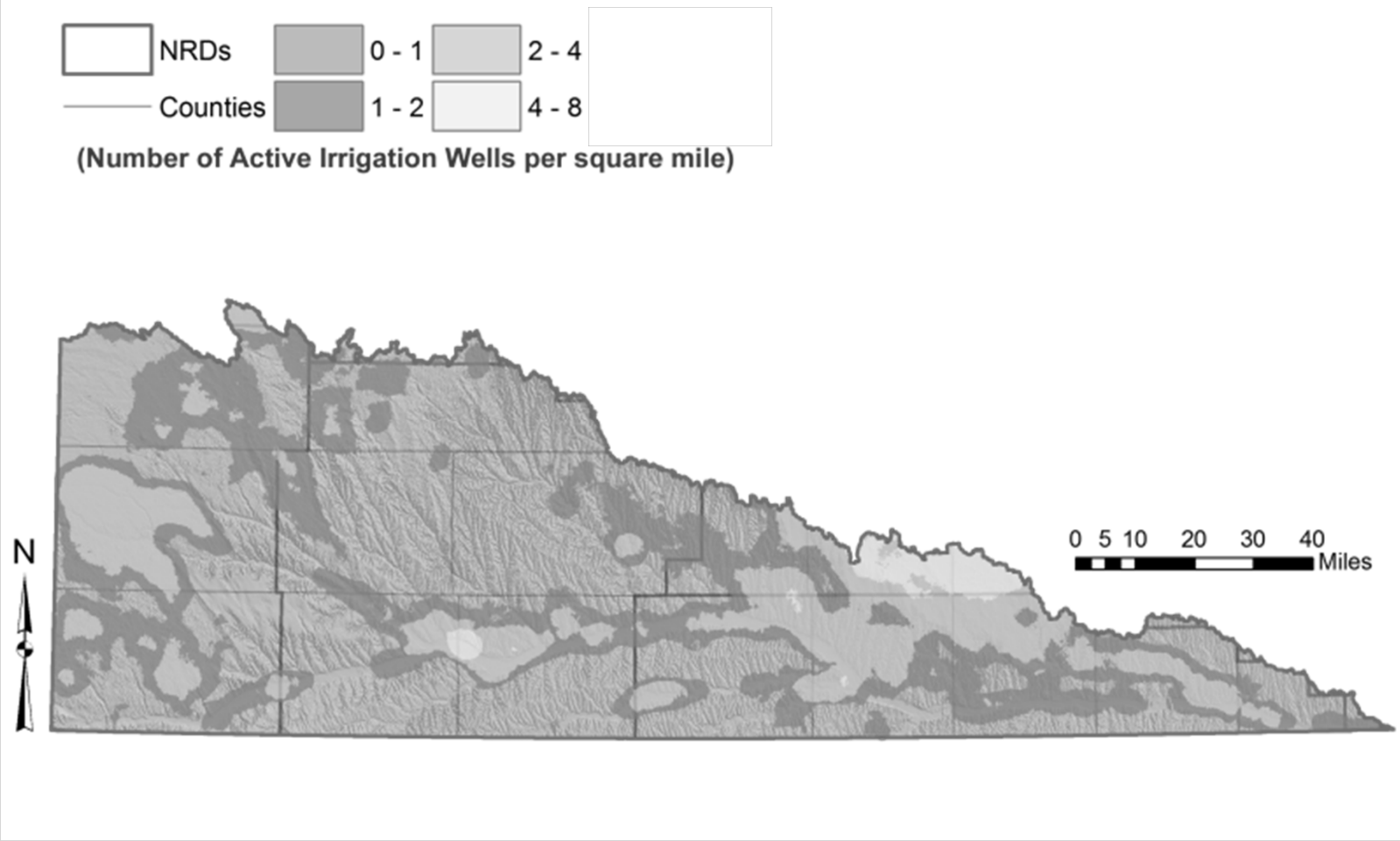
Transmissivity



Transmissivity of the primary aquifers in the Republican Basin modified from 1) an unpublished CSD Map; 2) Summerside et al., 2005 and 3) Summerside et al., 2005 in which test hole data were supplemented by data from the logs of registered wells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



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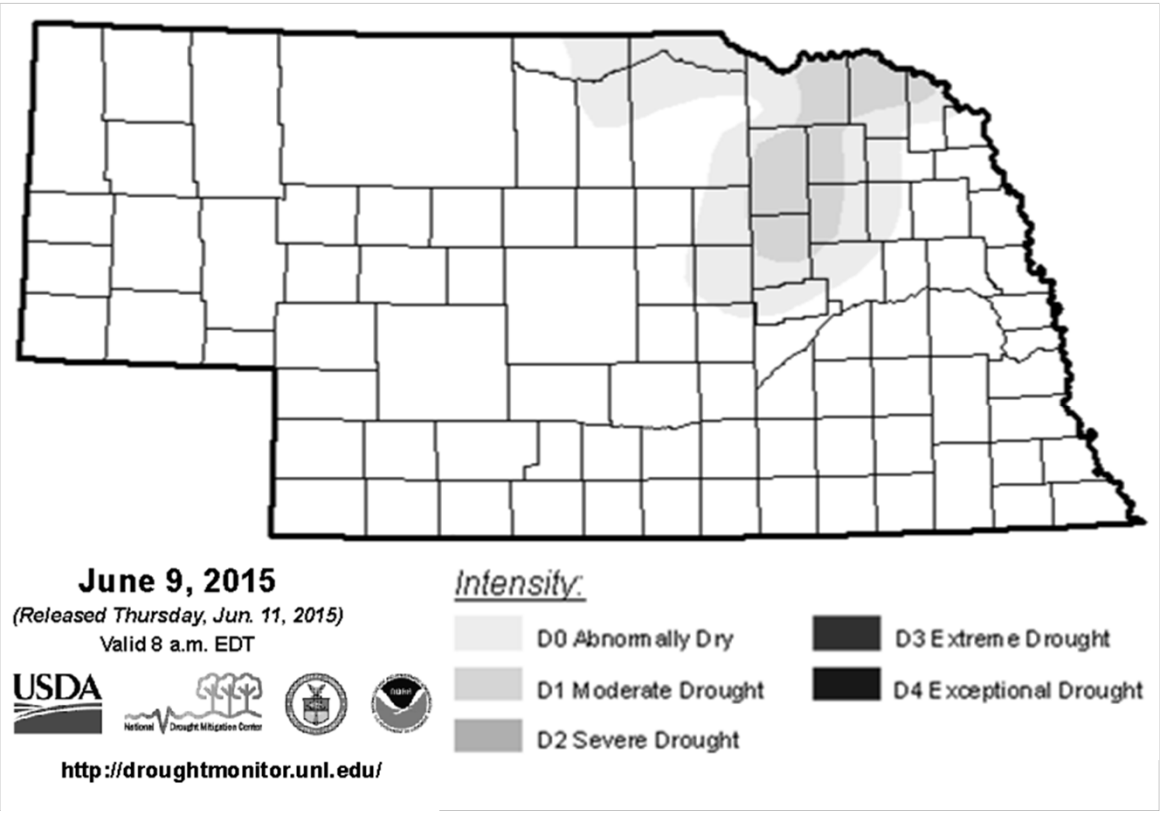
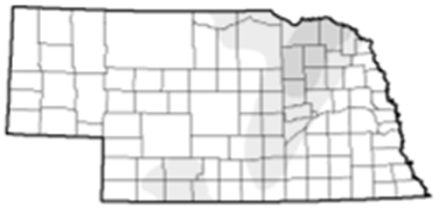
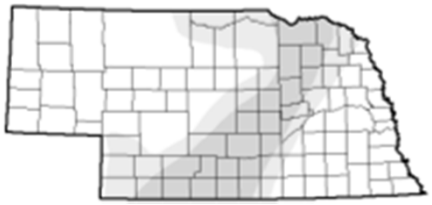
Most Recent *US Drought Monitor* for Nebraska



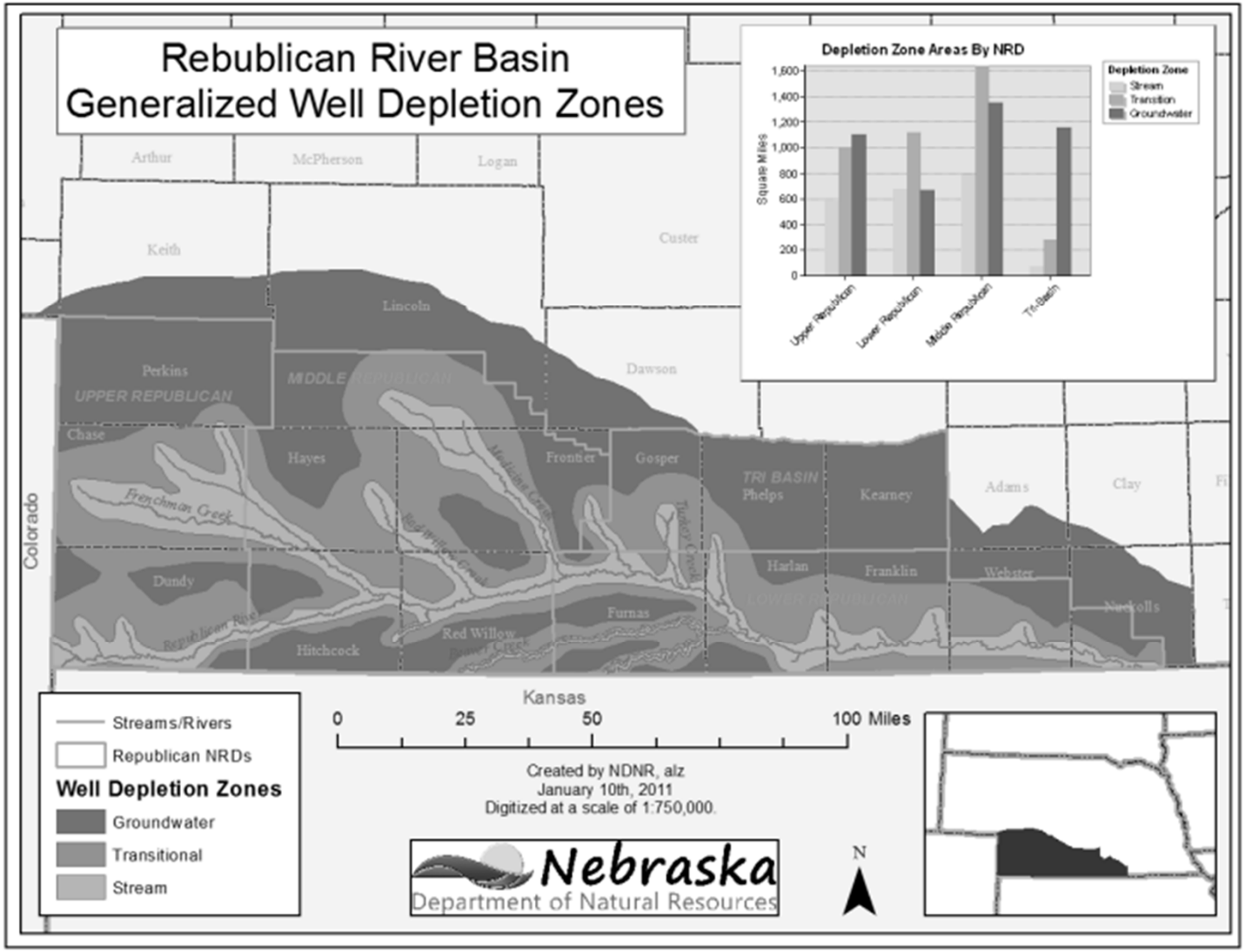
Compare with:



One week earlier
(June 2, 2015)



One month earlier
(May 12, 2015)


Rebublican River Basin
Generalized Well Depletion Zones
Depletion Zone Areas By NRD
Square Miles
1,600
1,400
1,200
1,000
800
600
400
200
0
Upper Republican
Lower Republican
Middle Republican
Tri-Basin
Depletion Zone
Stream
Transition
Groundwater
Arthur
McPherson
Logan
Keith
Custer
Lincoln
Perkins
UPPER REPUBLICAN
MIDDLE REPUBLICAN
Dawson
Chase
Hayes
Frontier
Gosper
TRI BASIN
Phelps
Kearney
Adams
Clay
Frenchman Creek
Red Willow Creek
Medicine Creek
Turkey Creek
Colorado
Dundy
Harlan
Franklin
Webster
Nuckolls
LOWER REPUBLICAN
Furnas
Republican River
Hitchcock
Red Willow
Kansas
Streams/Rivers
Republican NRDs
Well Depletion Zones
Groundwater
Transitional
Stream
0
25
50
100 Miles
Created by NDNR, alz
January 10th, 2011
Digitized at a scale of 1:750,000.
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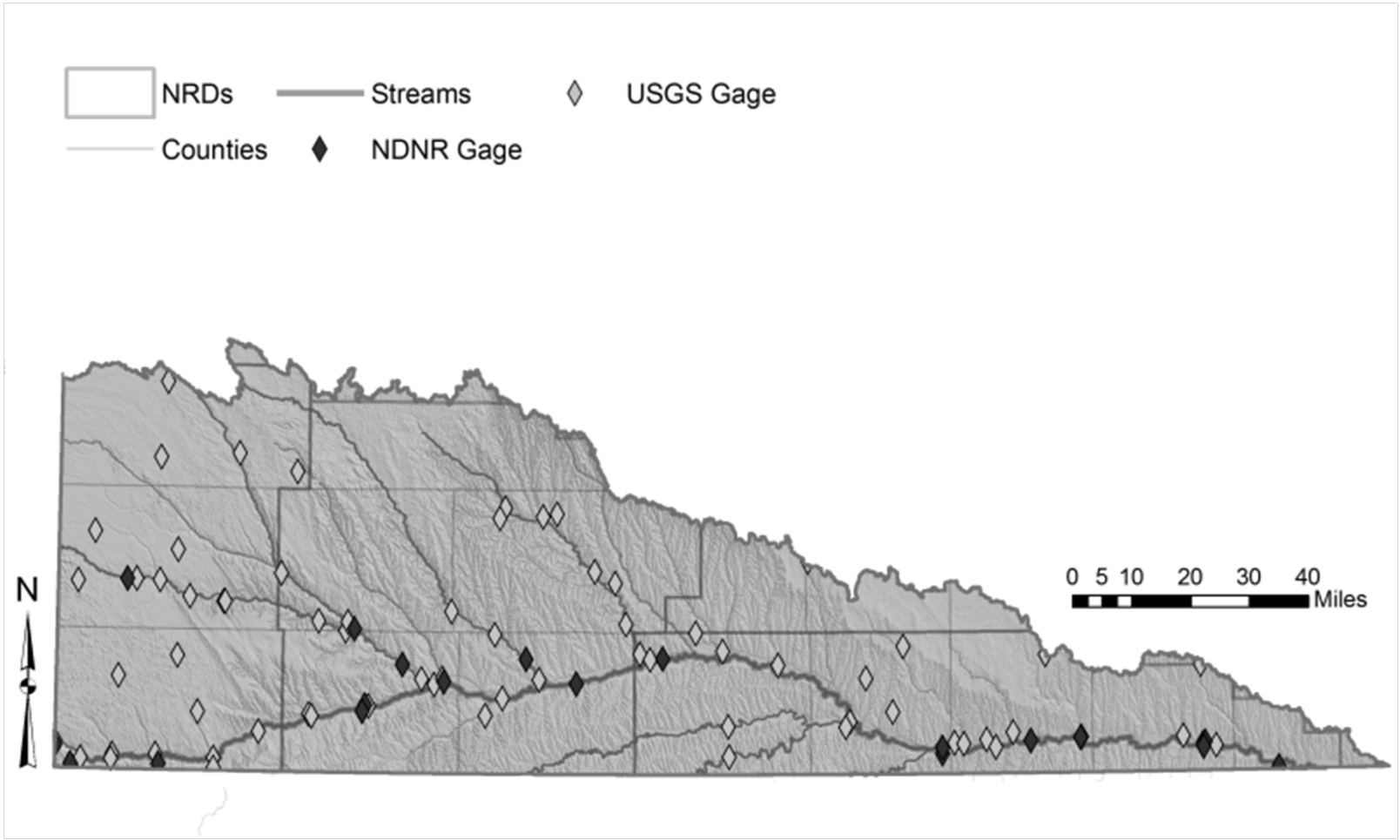
N

Stream Gages



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DNR Real-Time Stream Gage Data (WISKI)

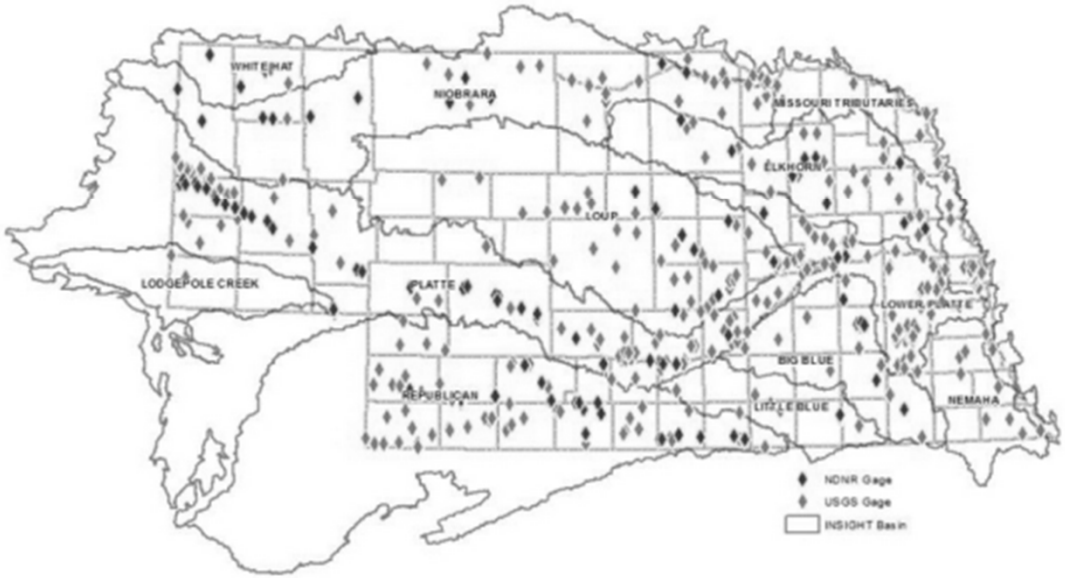
http://data.dnr.nebraska.gov/RealTime

Official Nebraska Government Website

Nebraska
Department of Natural Resources

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

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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. 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* USGS

Source: All ▾ Type: Stream ▾ River Basin: Republican ▾ Submit

All
Big Blue
Elkhorn
Little Blue
Lodgepole Creek
Loup
Lower Platte
Missouri Tributaries
Nemaha
Niobrara
Platte
Republican
White Hat

Please be aware: Some of the stations listed below ...sonally and the remainder of the stations that are operated throughout the year can be **affected by ice conditions during the winter month** ...ns are updated weekly.

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

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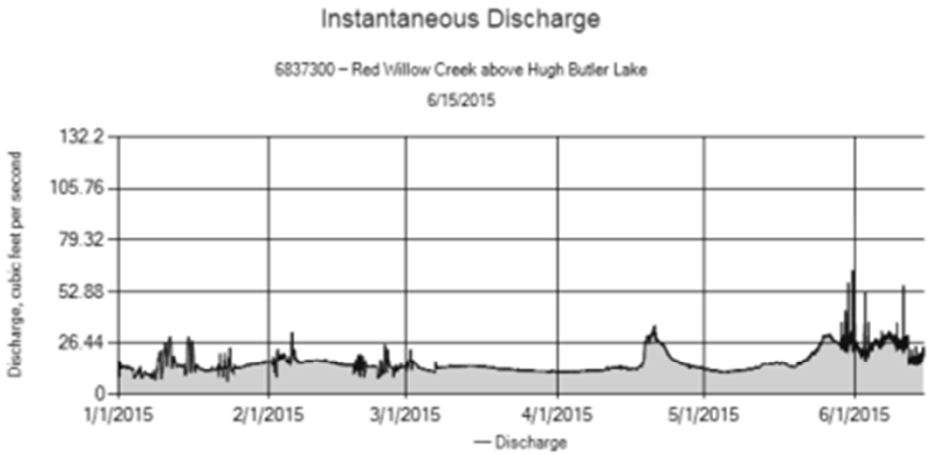
DNR Real-Time Stream Gage Data (WISKI)

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



Data/Table

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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

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Questions?

TRENDS IN STREAMFLOW AND BASEFLOW

Data developed and summarized by the RRCA modeling committee

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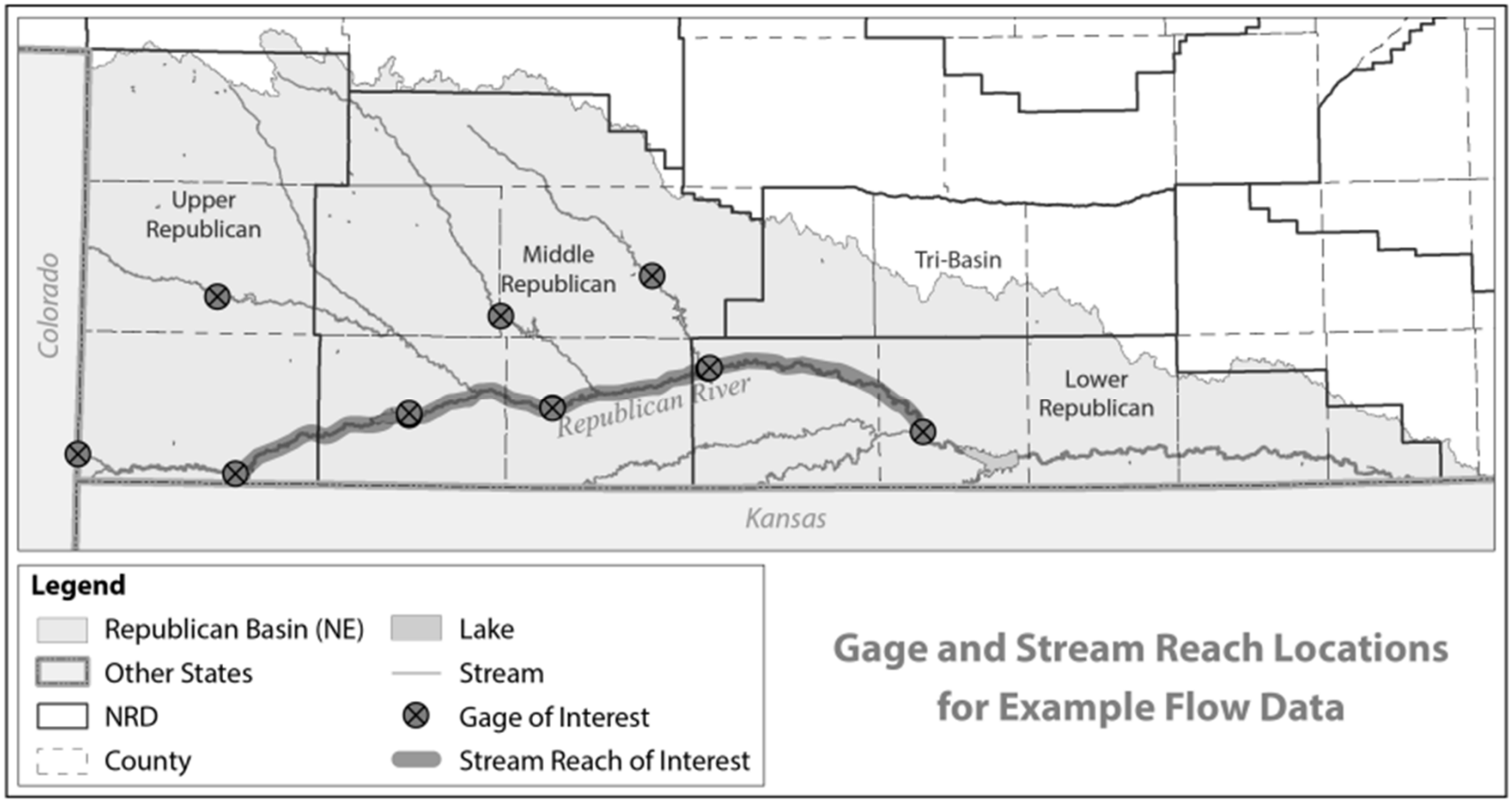
Components of Streamflow

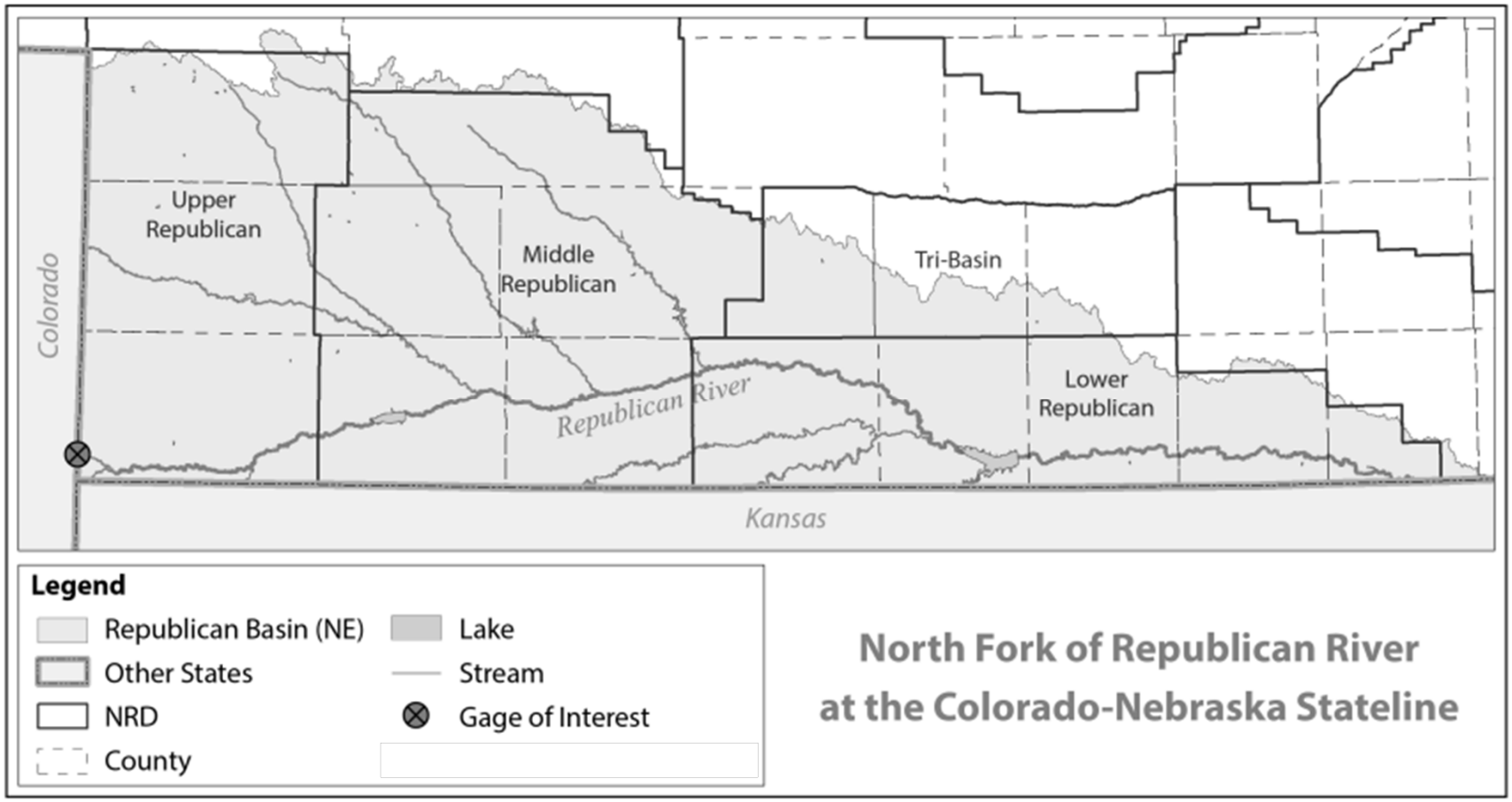
Streamflow = runoff + baseflow

- 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



Gage and Stream Reach Locations for Example Flow Data



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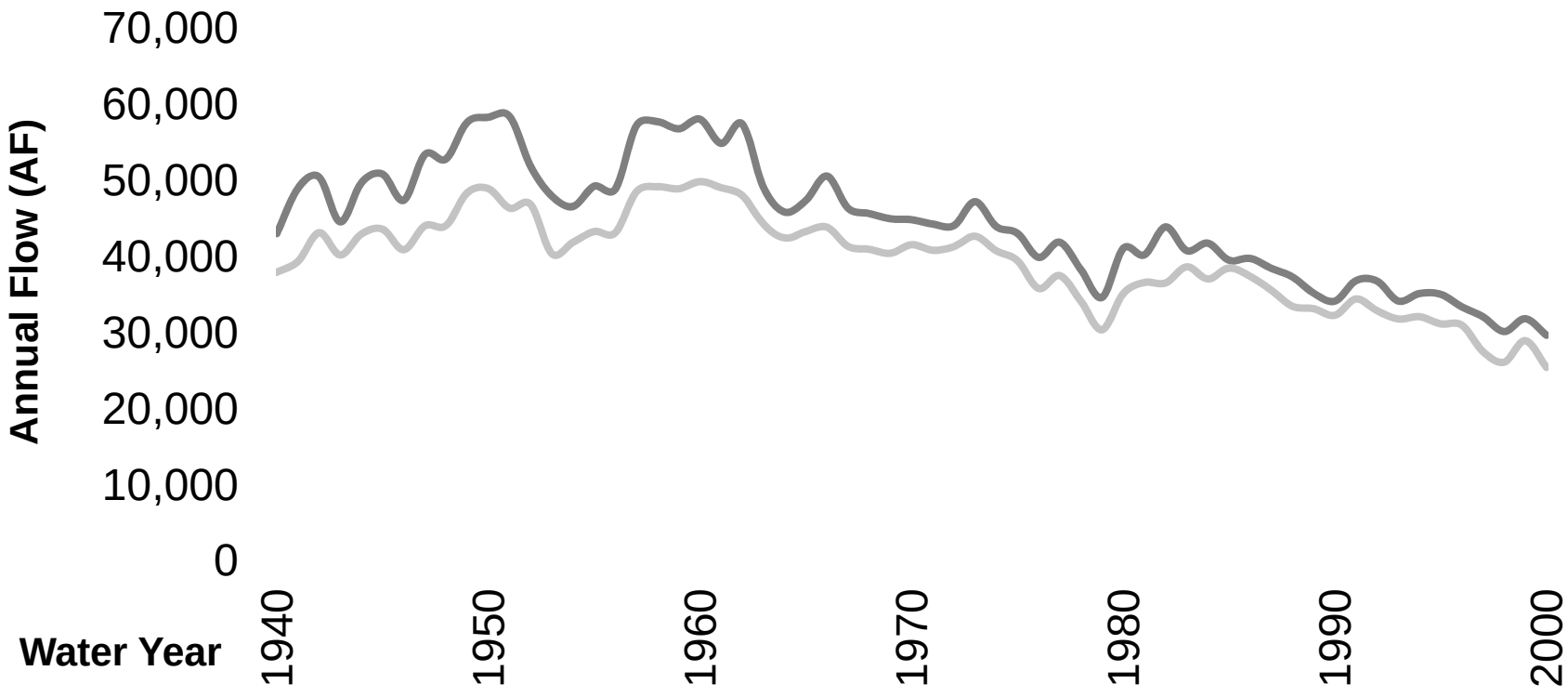
Estimated Streamflow
North Fork Republican River at CO-NE Stateline



(values in AF)	Avg. 1950-1964	Avg. 1986-2000	Difference
Total	53,287	34,730	-18,558
Baseflow	46,139	31,616	-14,523

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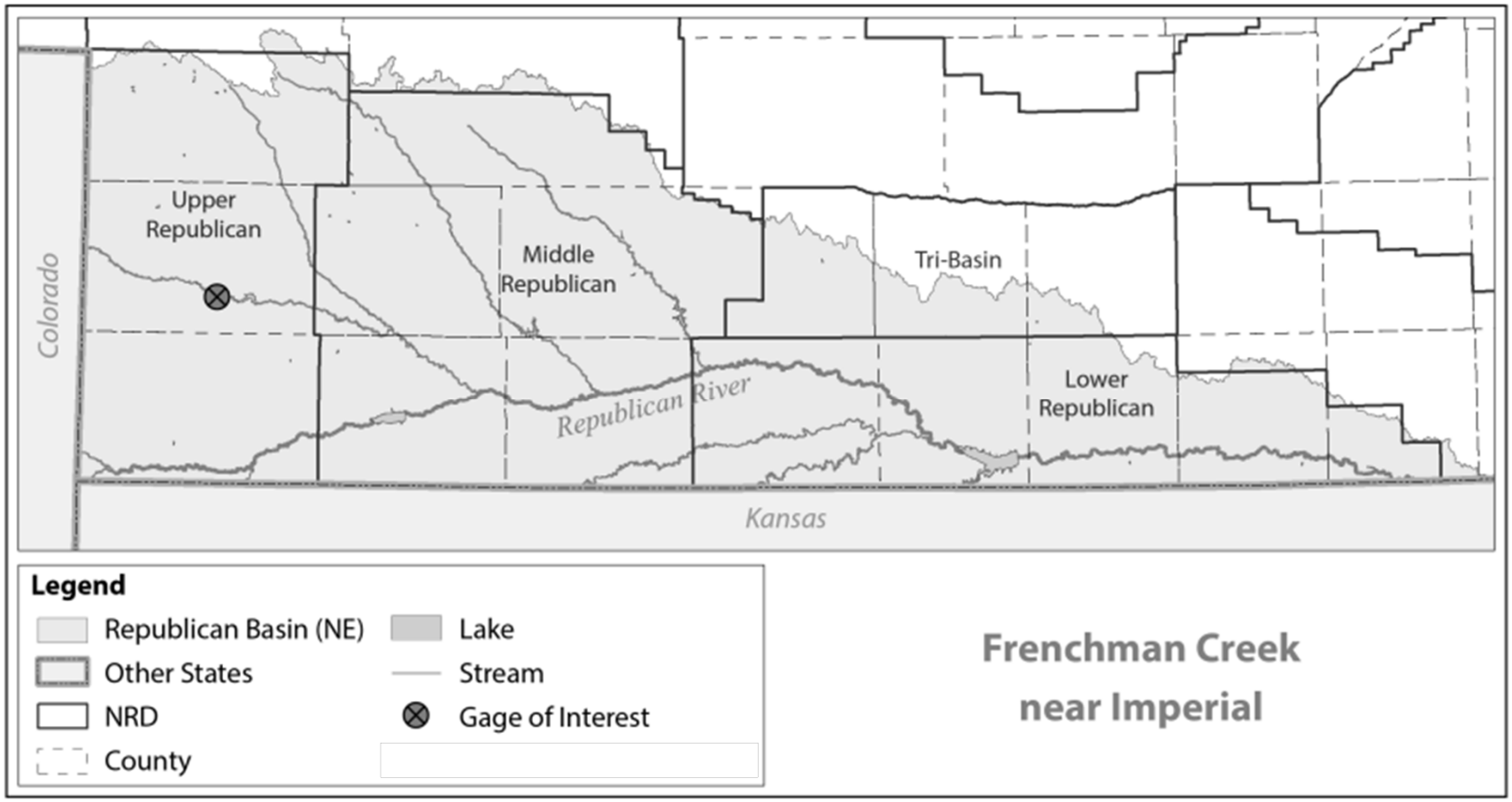
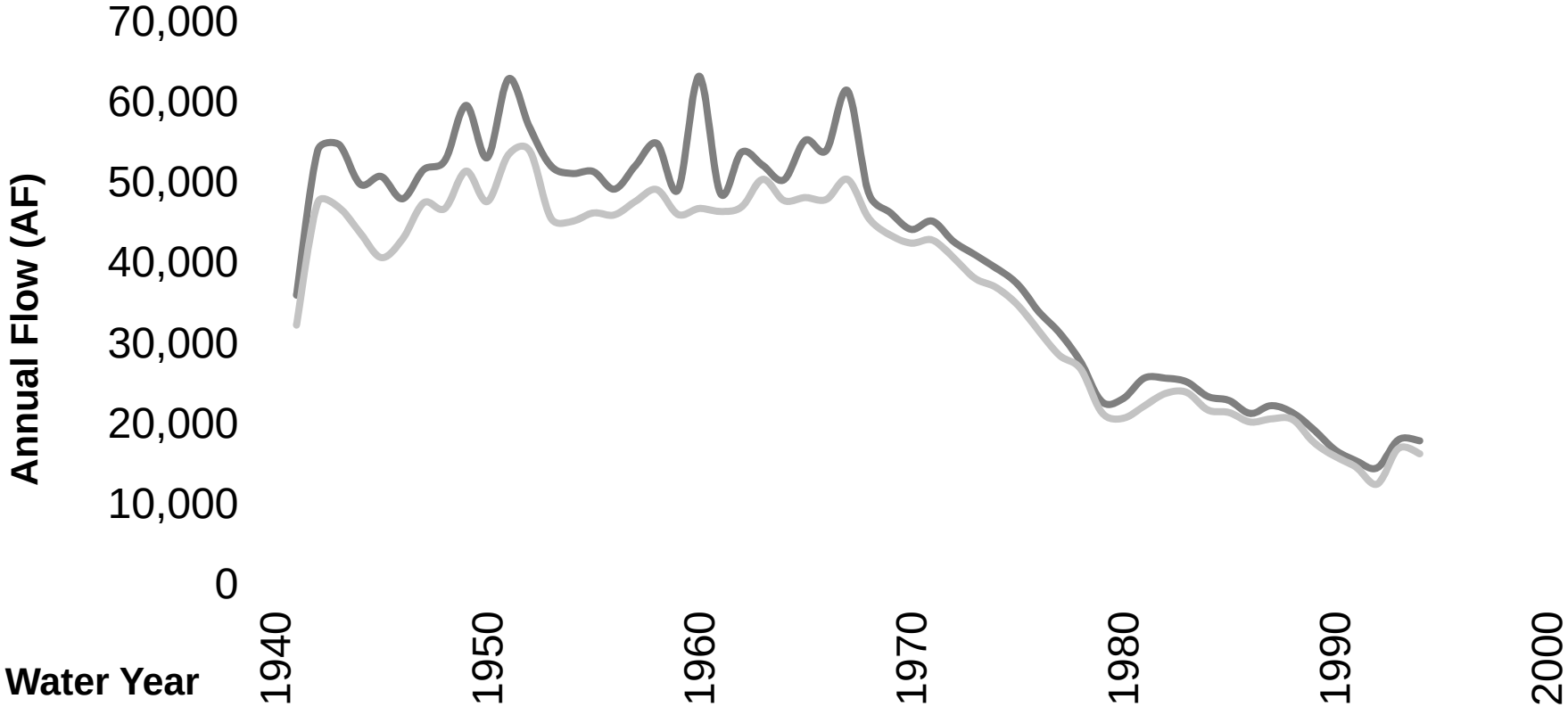

Upper Republican
Middle Republican
Tri-Basin
Lower Republican
Colorado
Kansas
Republican River
Legend
Republican Basin (NE)
Other States
NRD
County
Lake
Stream
Gage of Interest
Frenchman Creek near Imperial

Estimated Flow

Frenchman Creek Near Imperial



(values in AF)	Avg. 1950-1964	Avg. 1986-2000	Difference
Total	53,390	18,552	-34,838
Baseflow	47,952	17,278	-30,674

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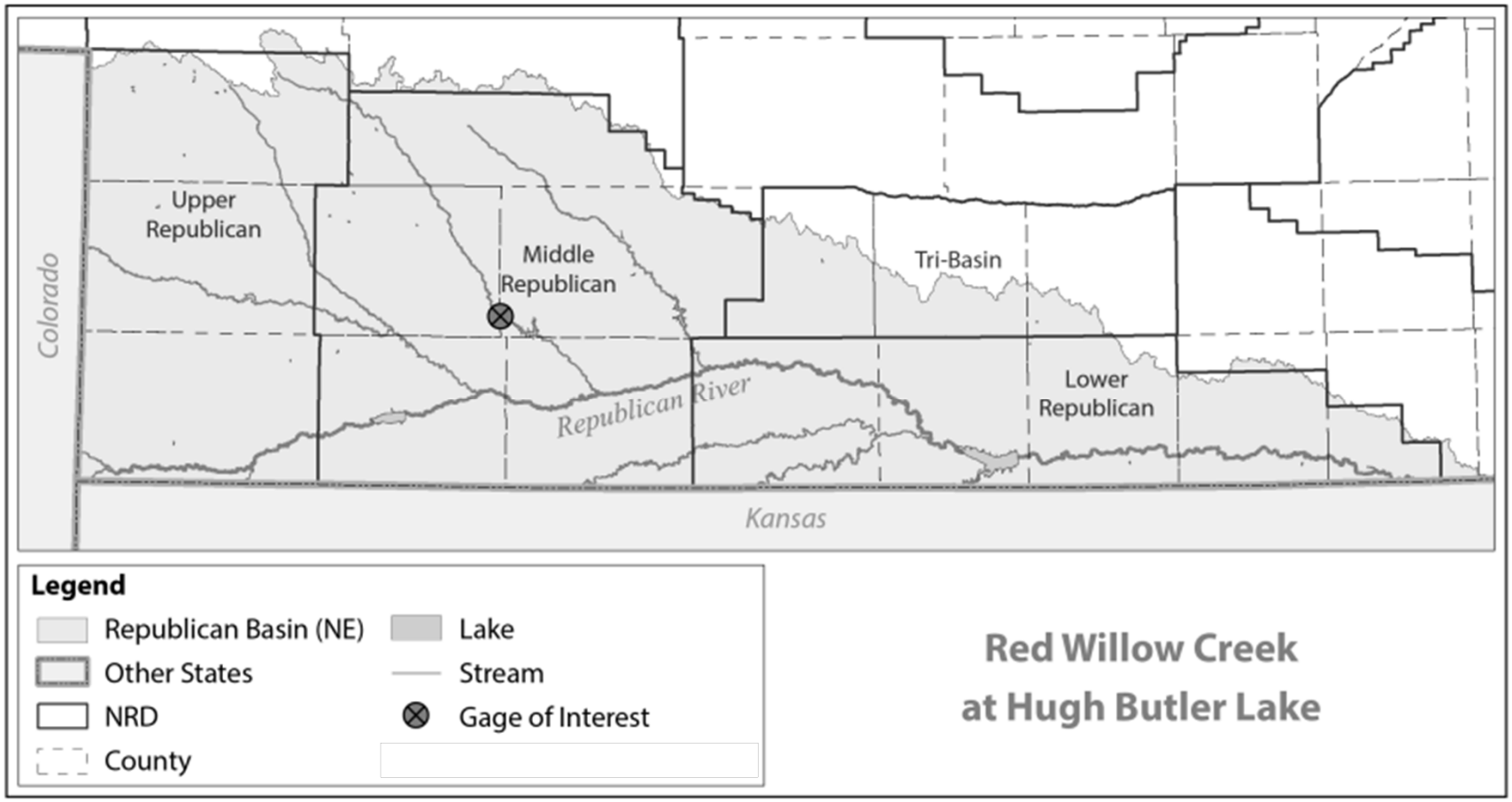
Upper Republican
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Republican Basin (NE)
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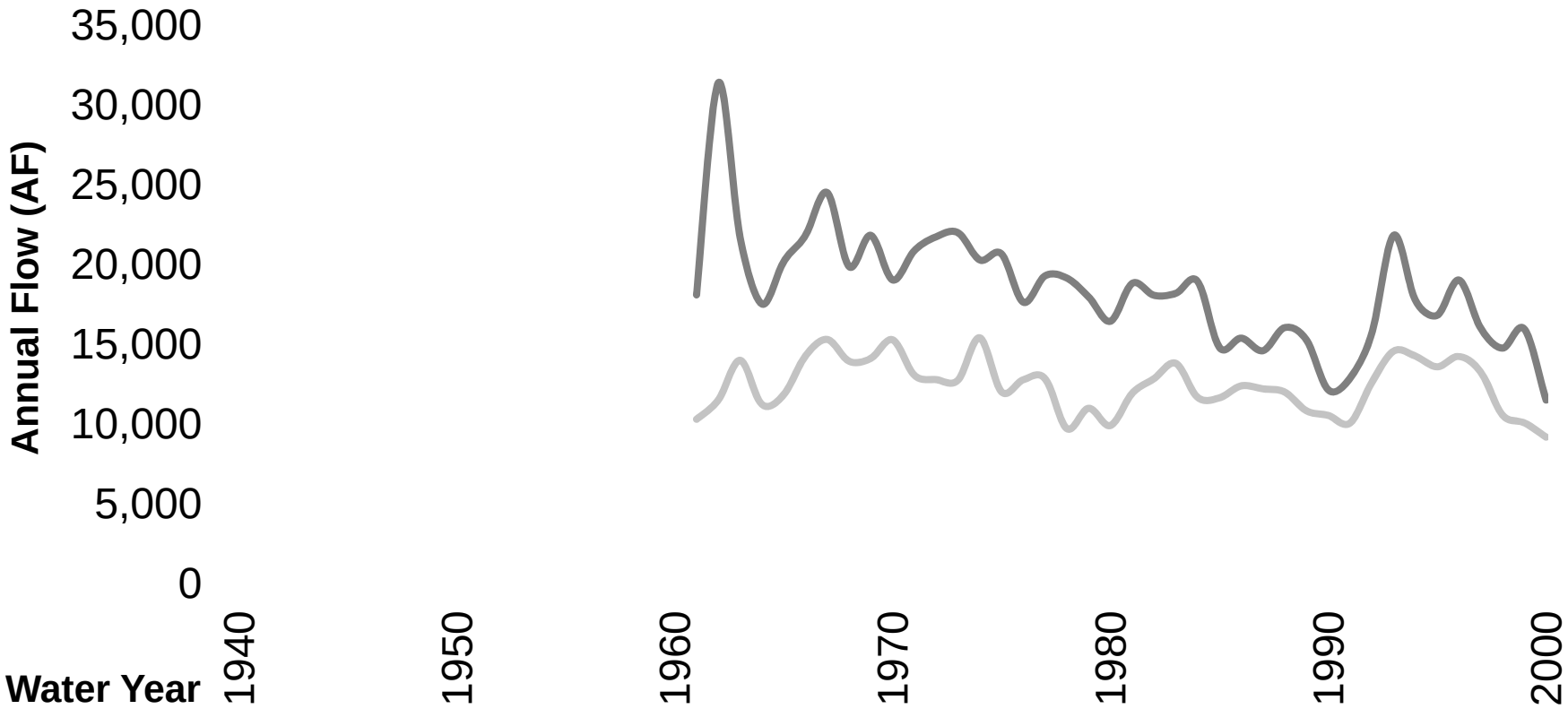
Lake
Stream
Gage of Interest
Red Willow Creek
at Hugh Butler Lake

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

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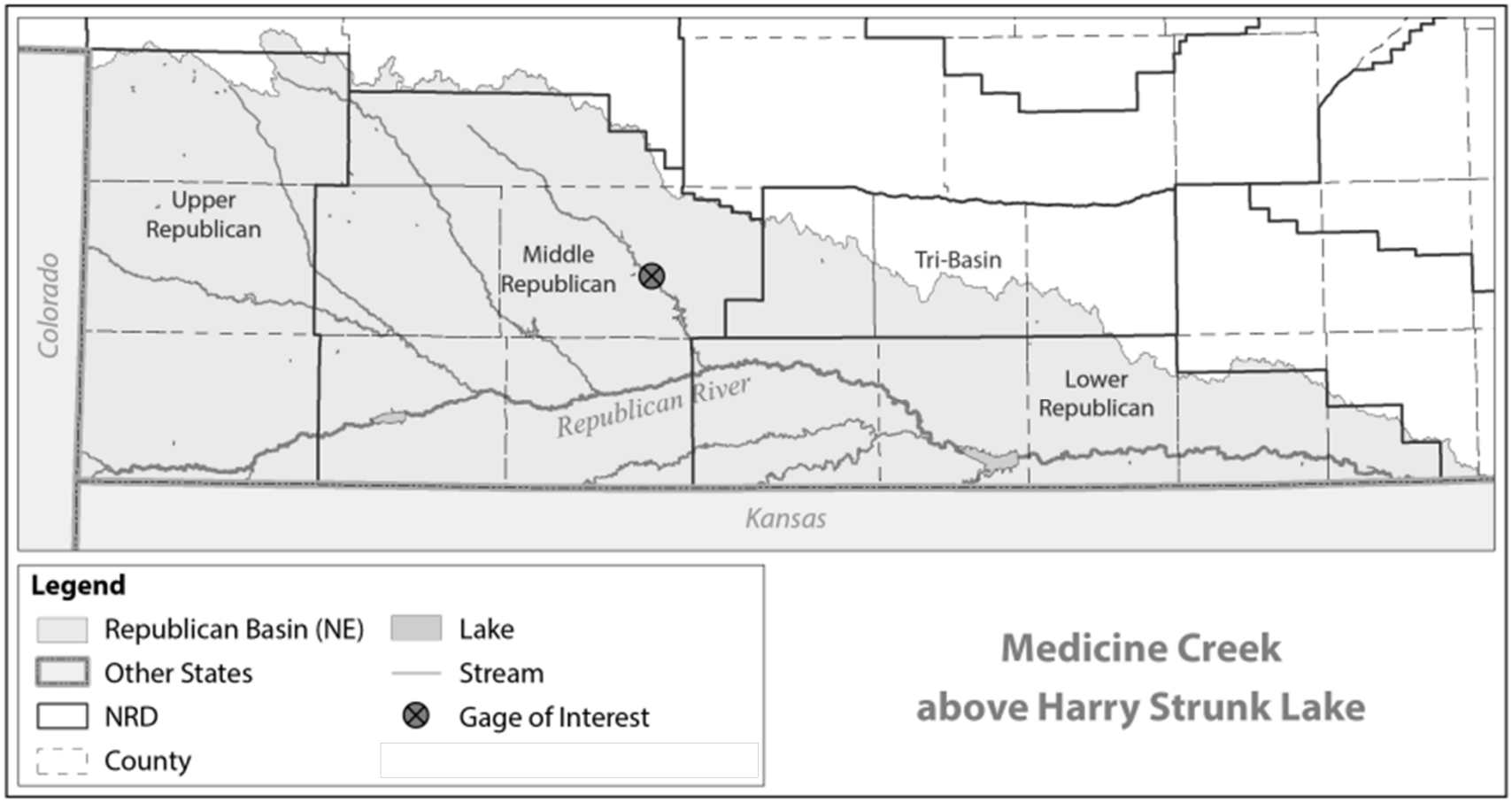

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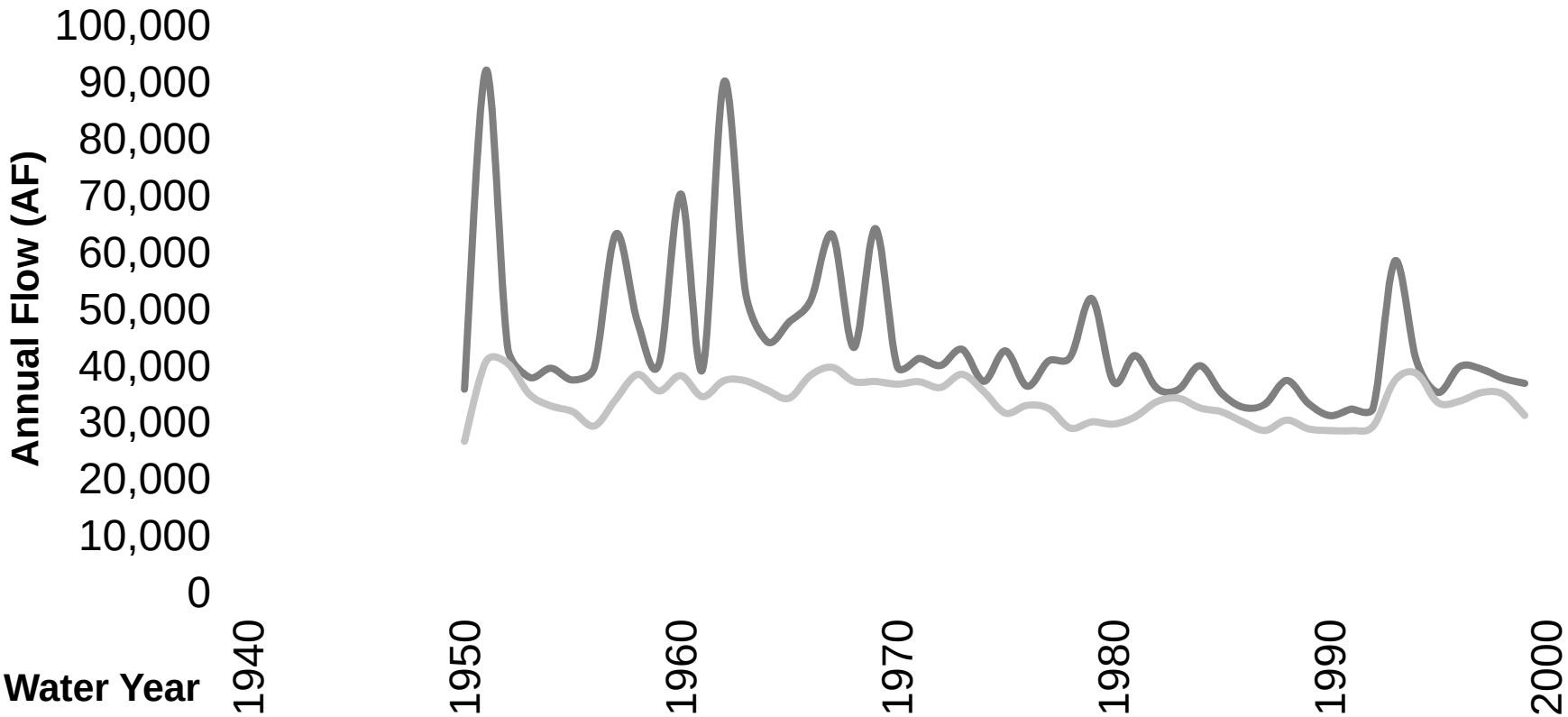
Estimated Streamflow

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

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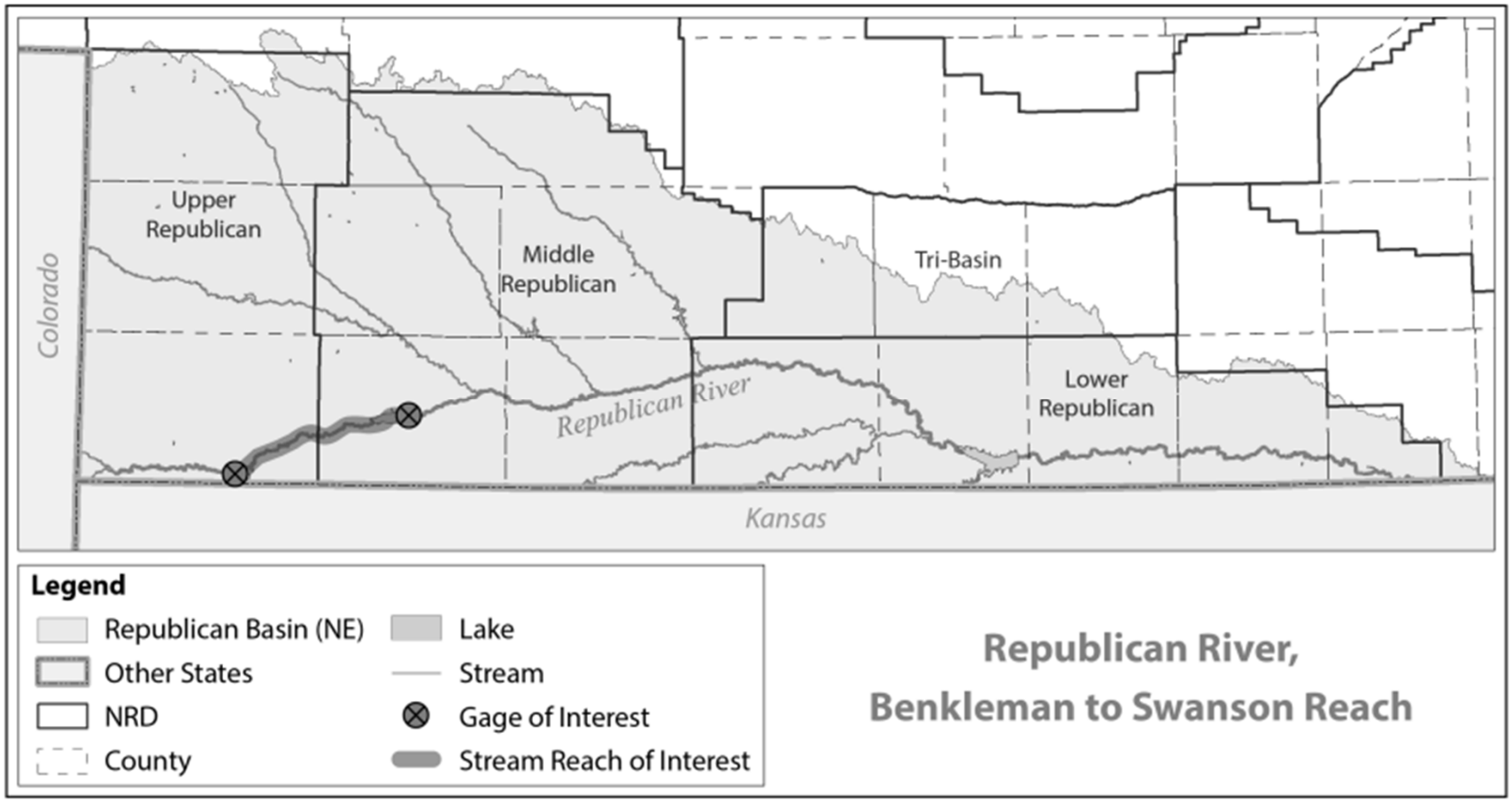

Republican River, Benkleman to Swanson Reach

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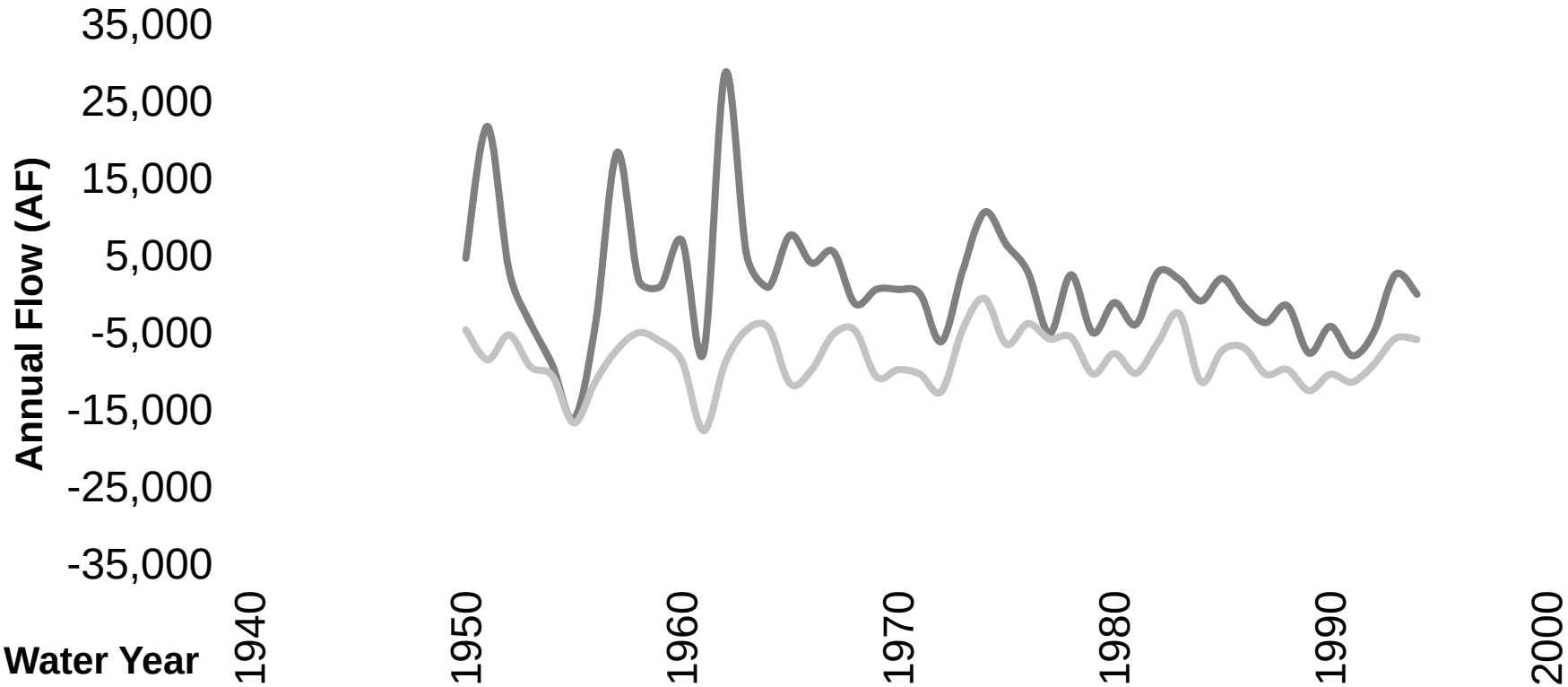
Estimated Streamflow (Reach Gain-Loss)
Republican River, Benkleman to Swanson



(values in AF)	Avg. 1950-1964	Avg. 1986-2000	Difference
Total	3,517	-3,135	-6,652
Baseflow	-8,516	-9,047	-531

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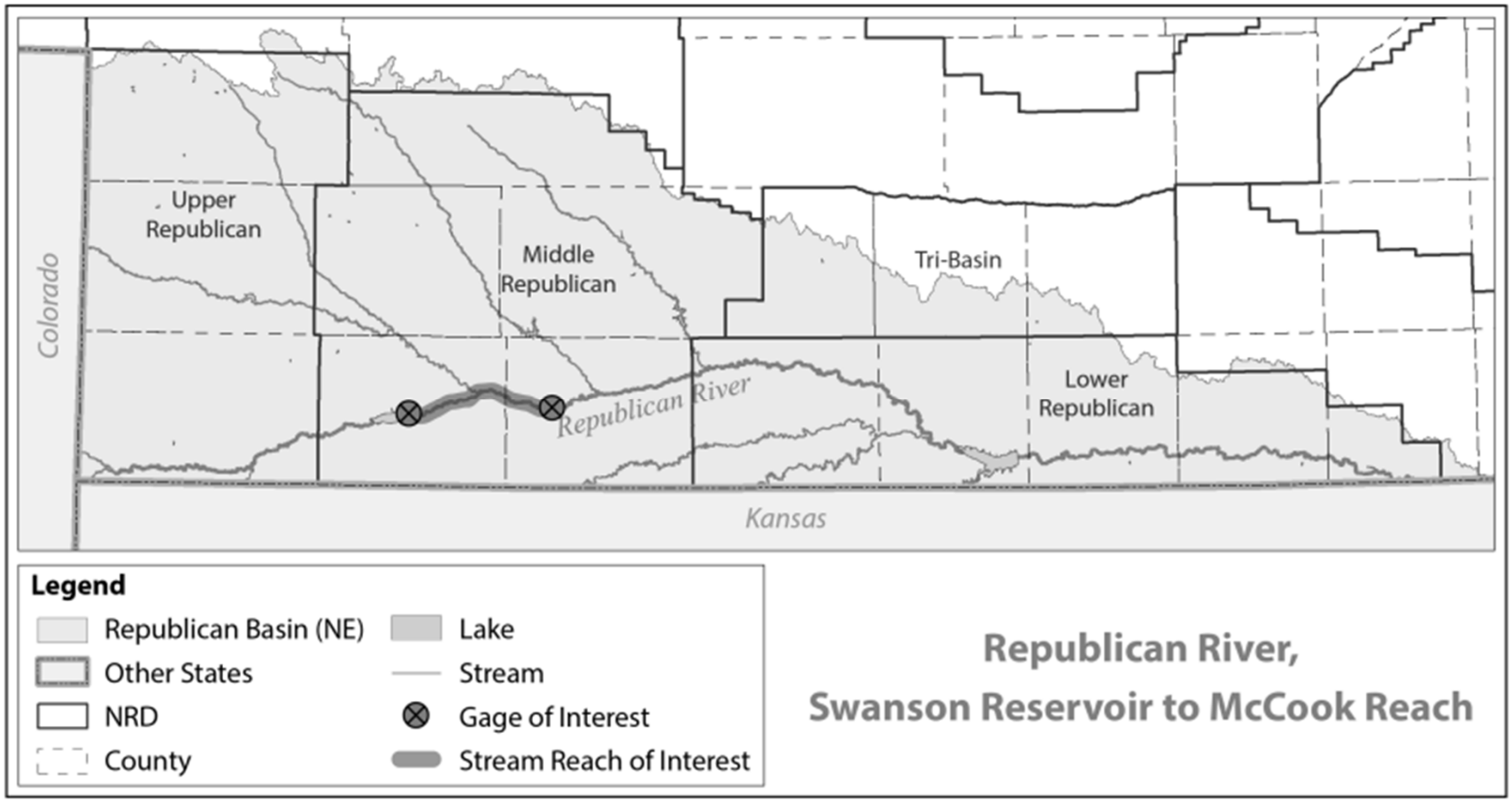

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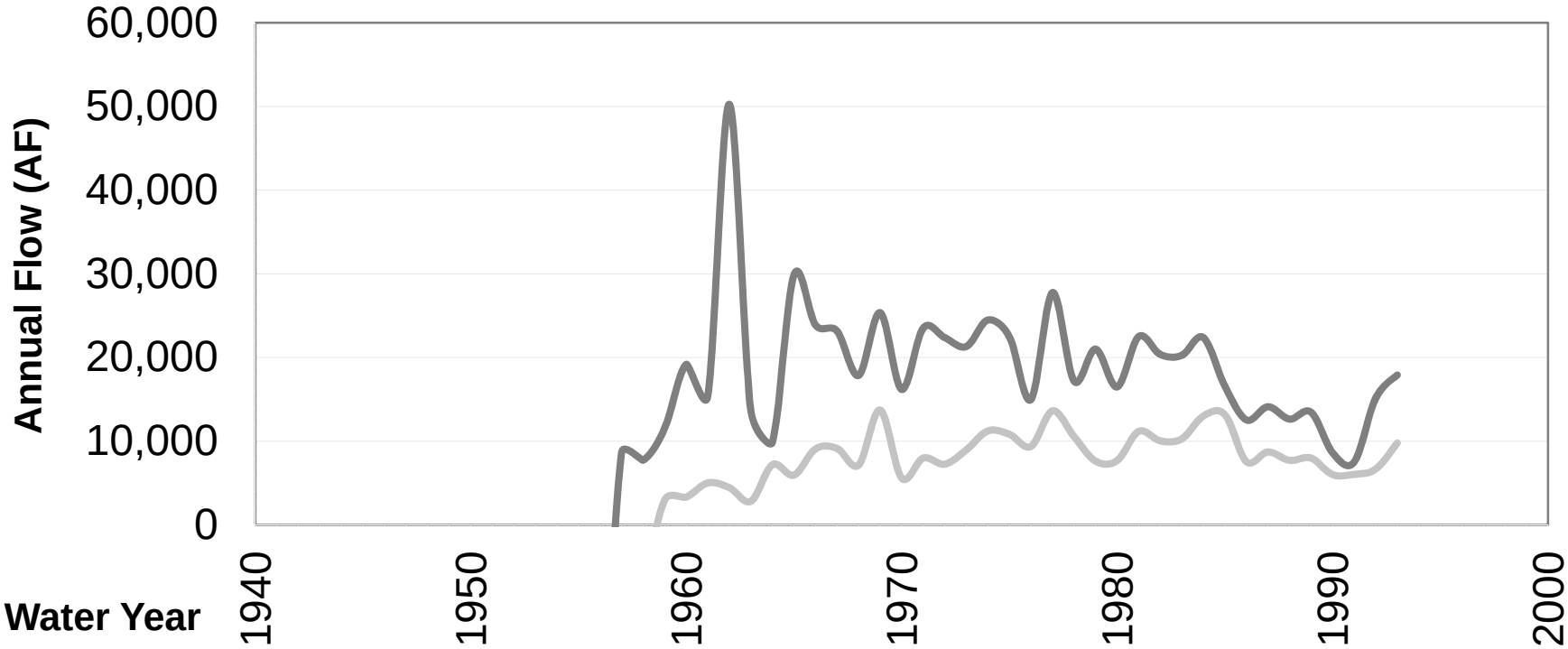
Estimated Streamflow (Reach Gain-Loss)

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

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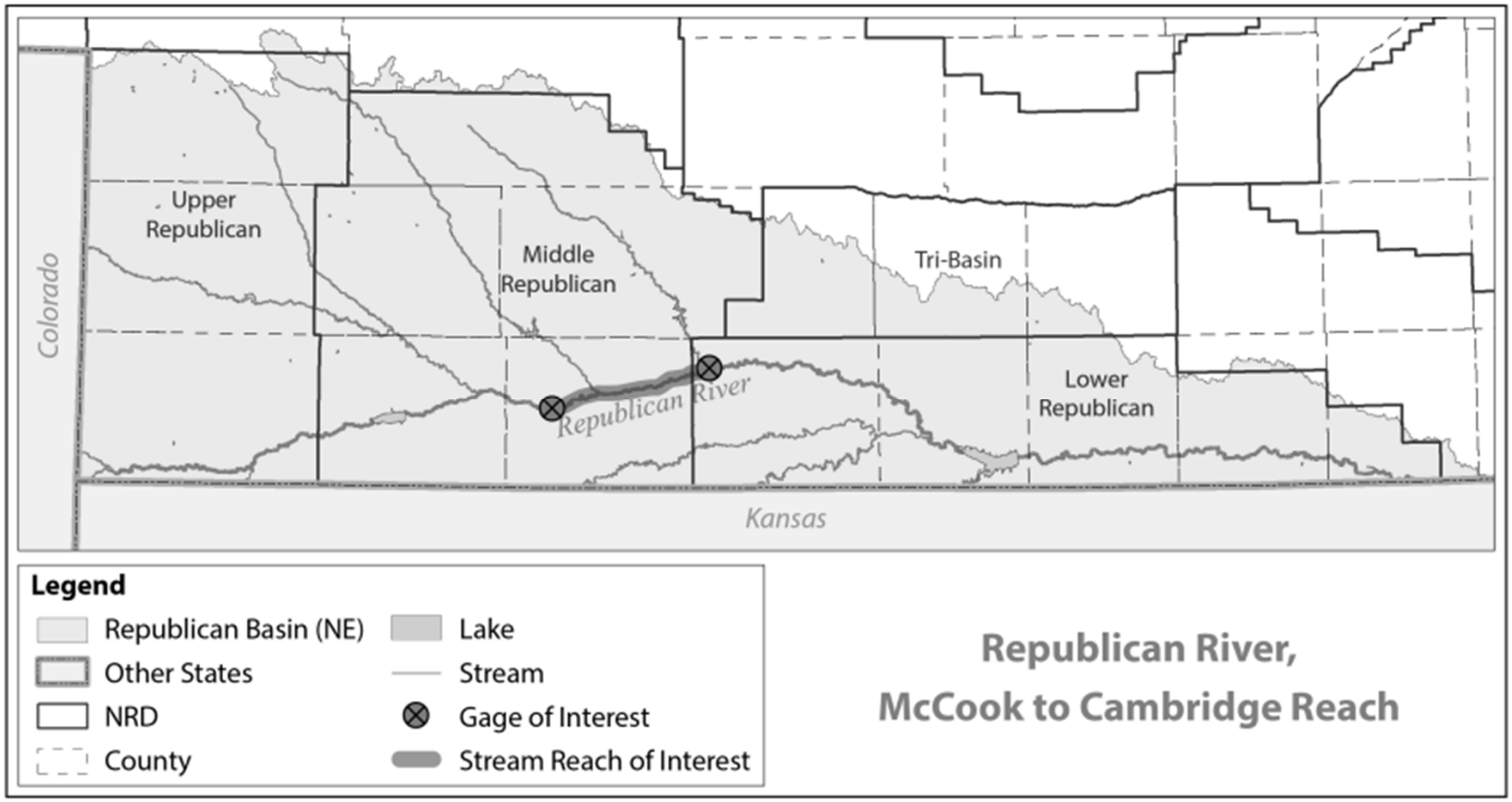

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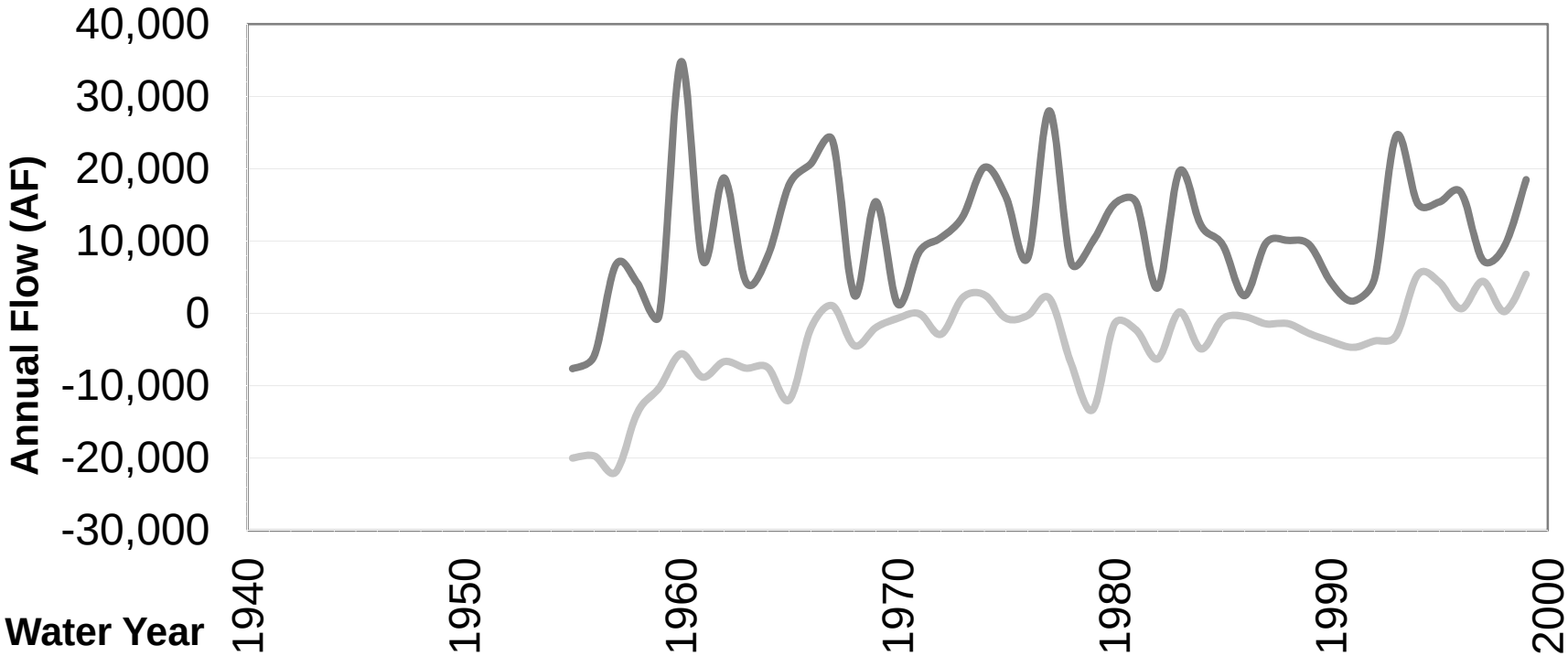
Estimated Streamflow (Reach Gain-Loss)

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

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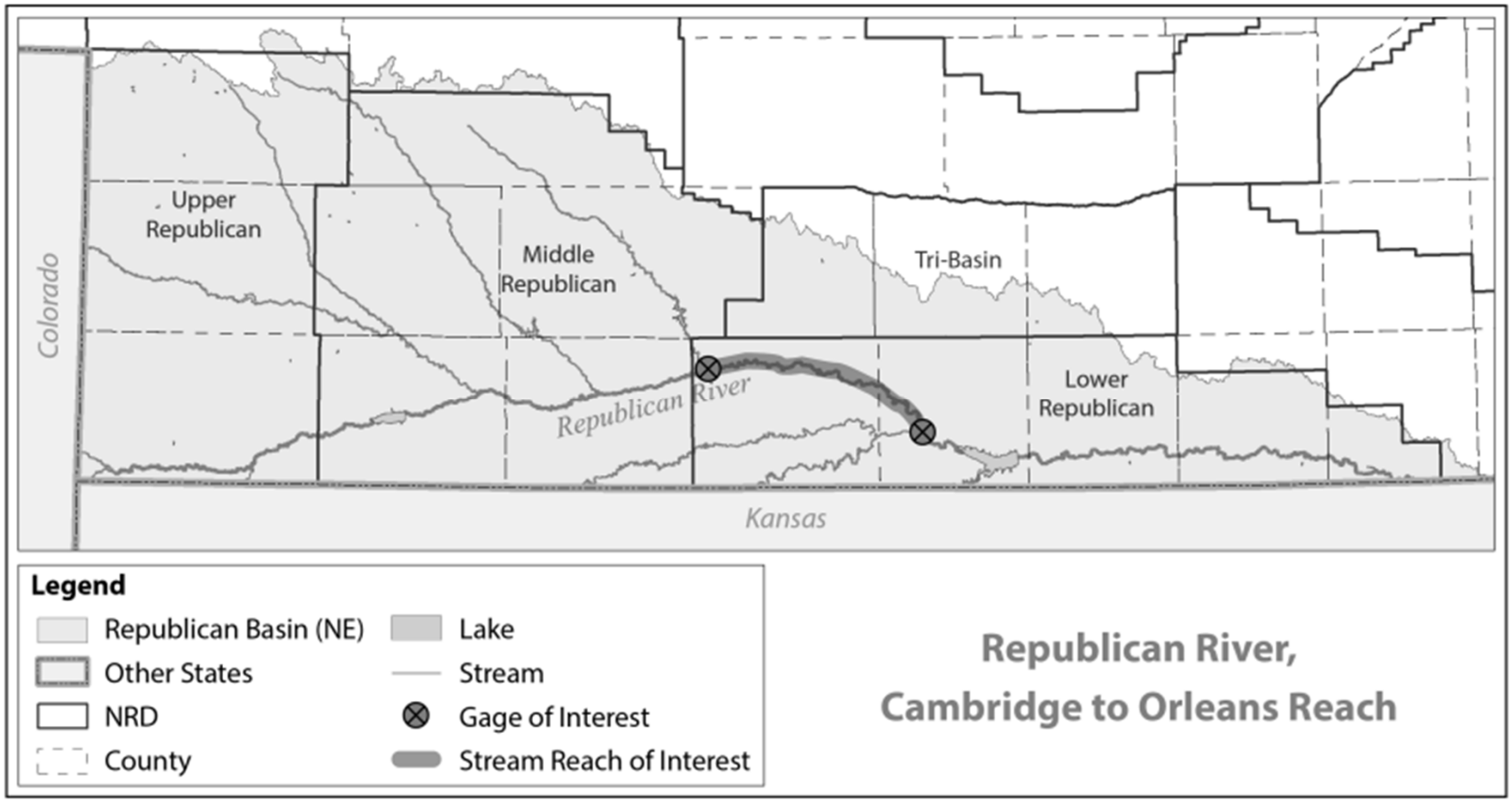

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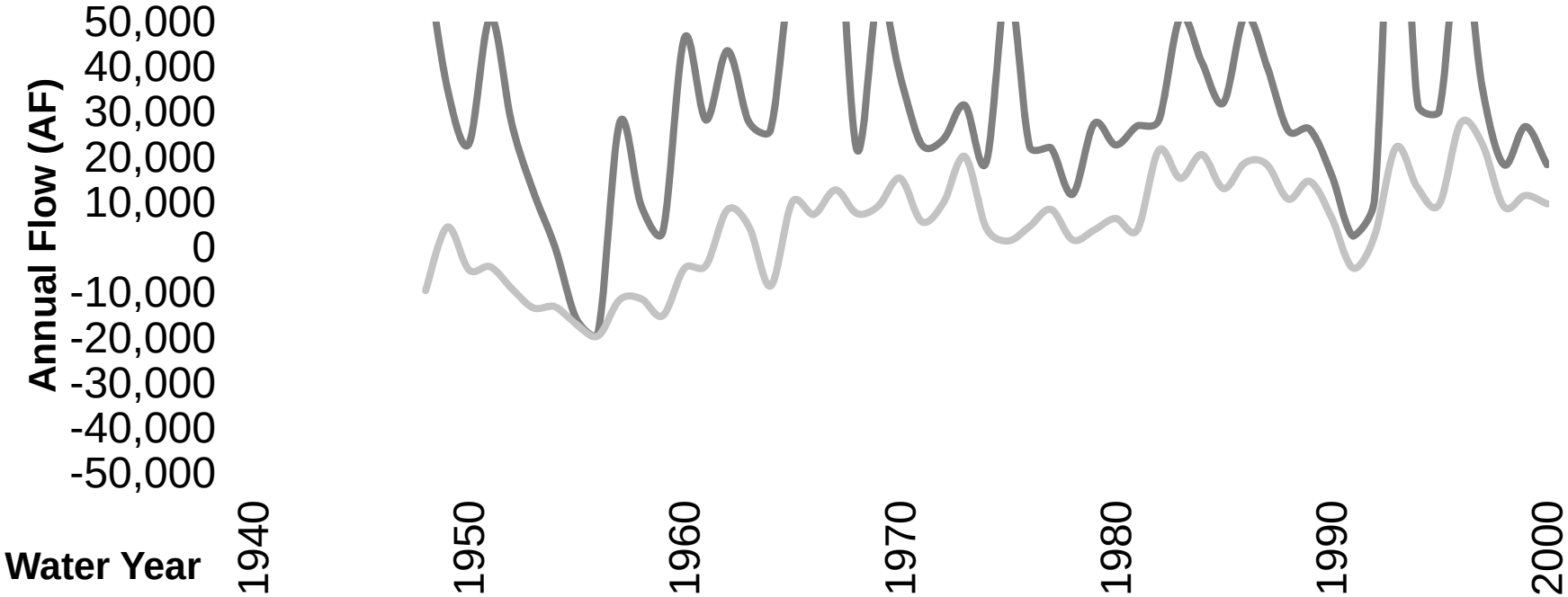
Estimated Streamflow (Reach Gain-Loss*)

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

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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

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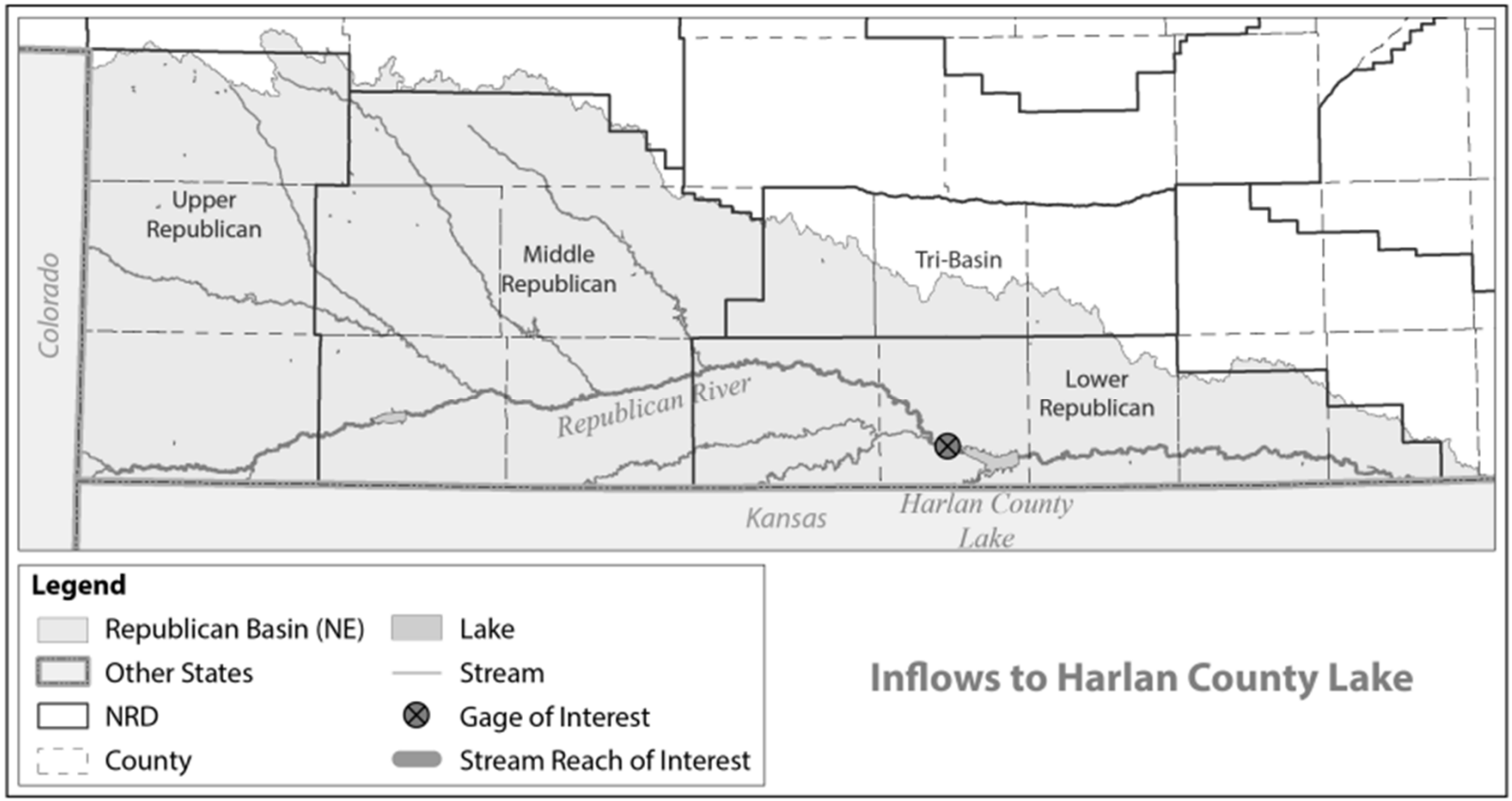

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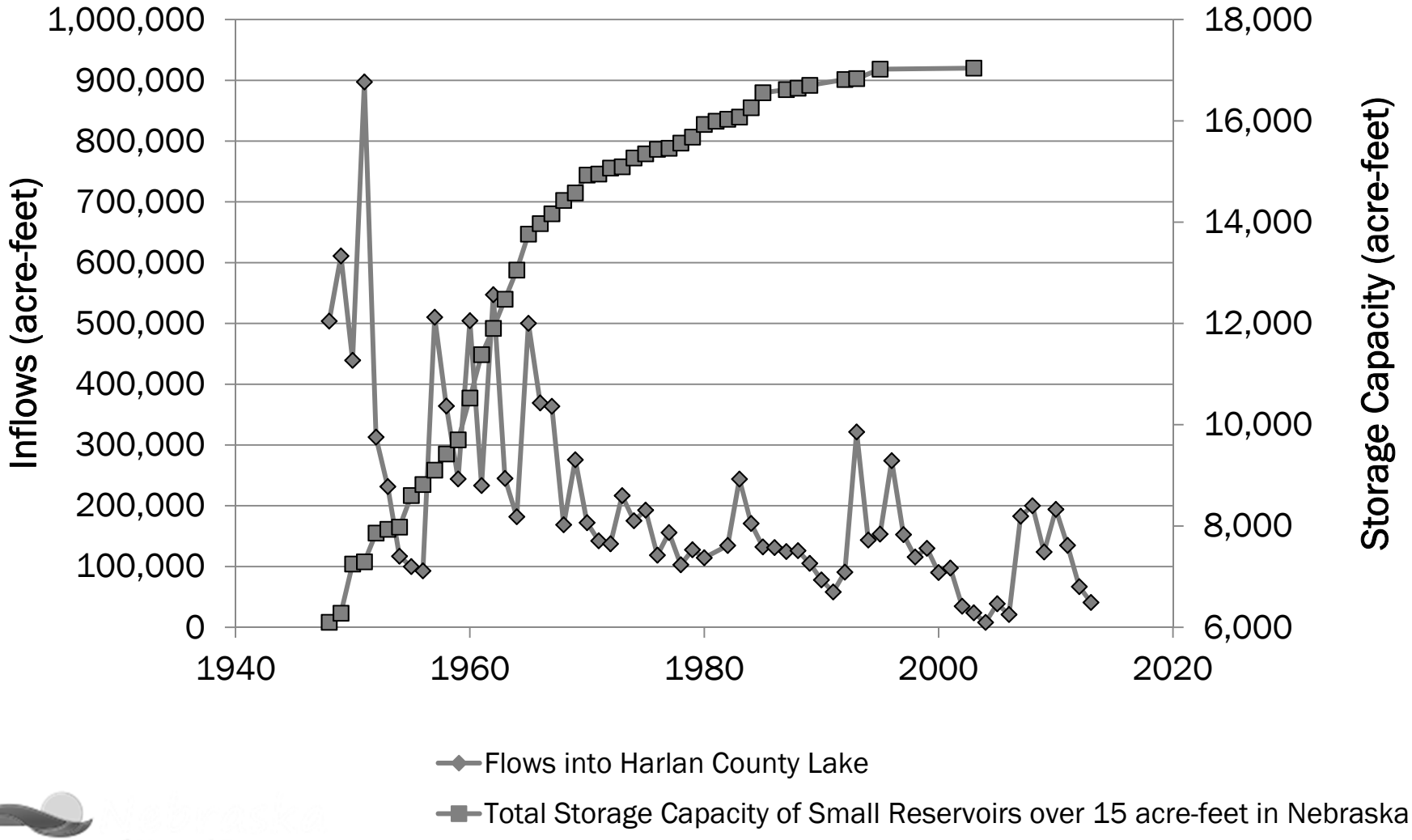
Inflows vs. Small Reservoirs



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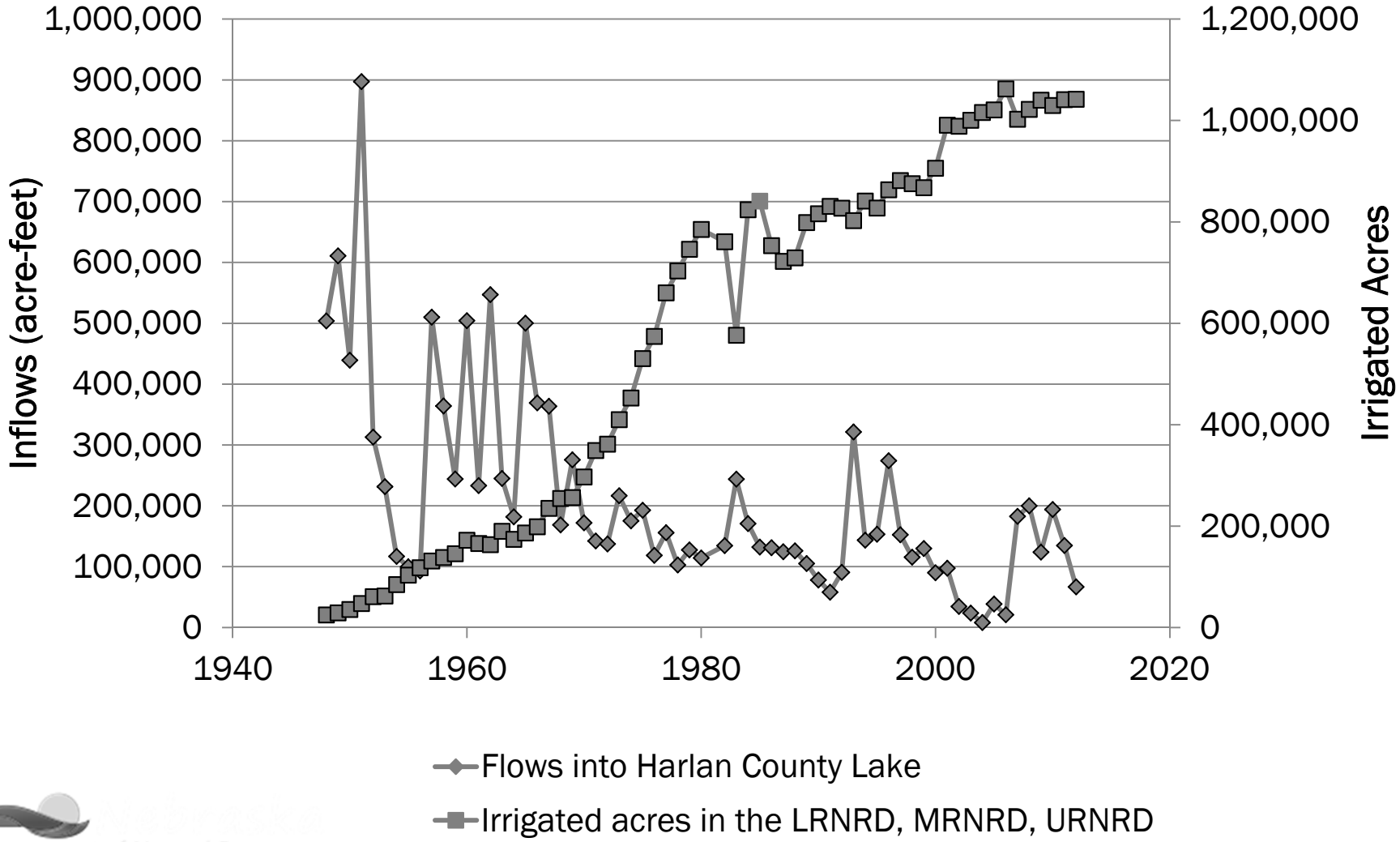
Inflows vs. Irrigated Acres



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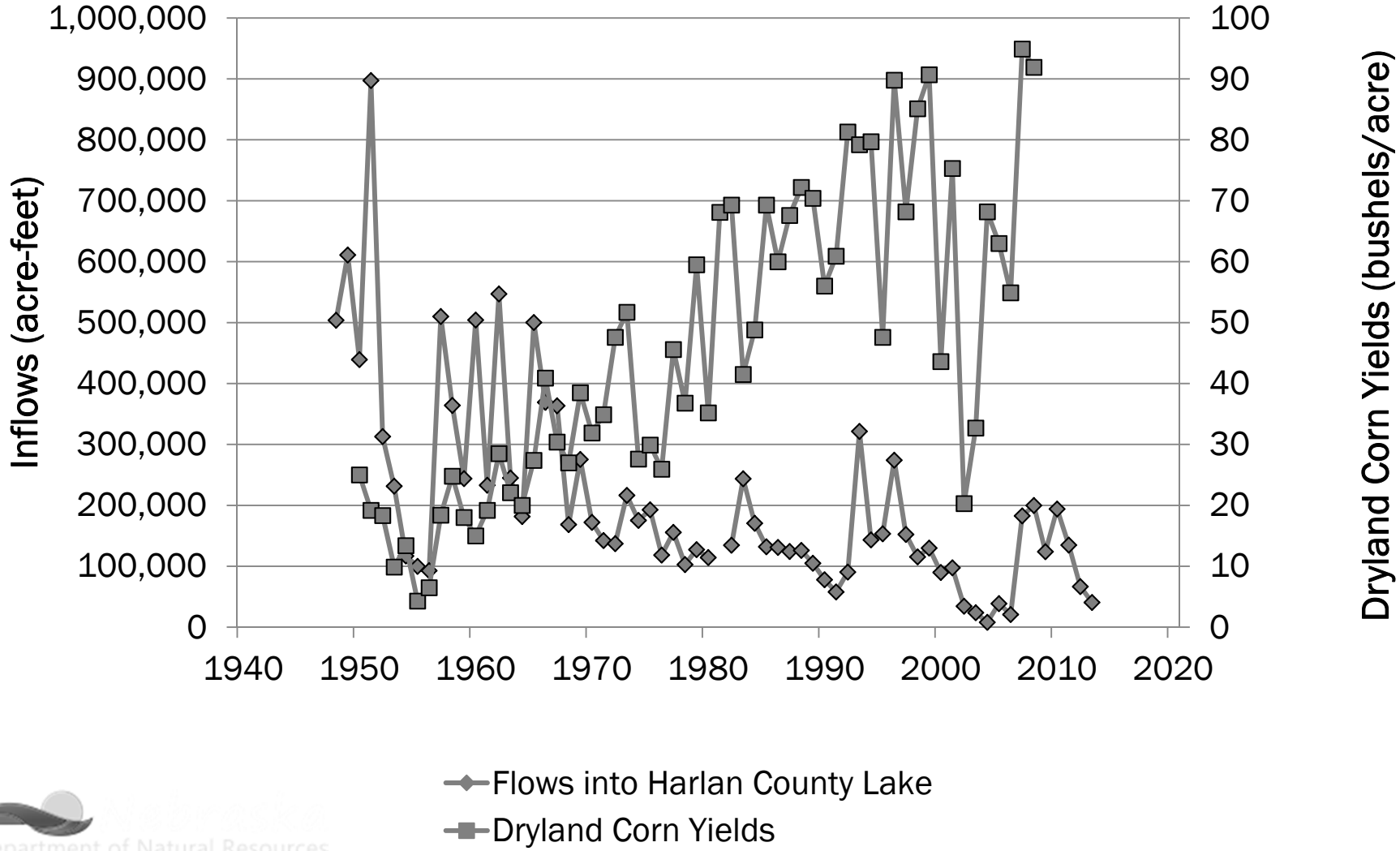
Inflows vs. Dryland Corn Yields



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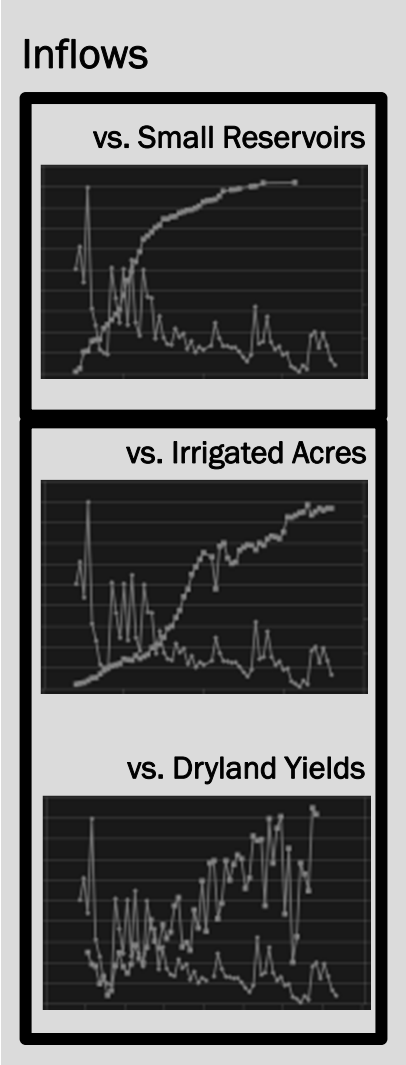
Observations Based on Correlations

- 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



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Questions?

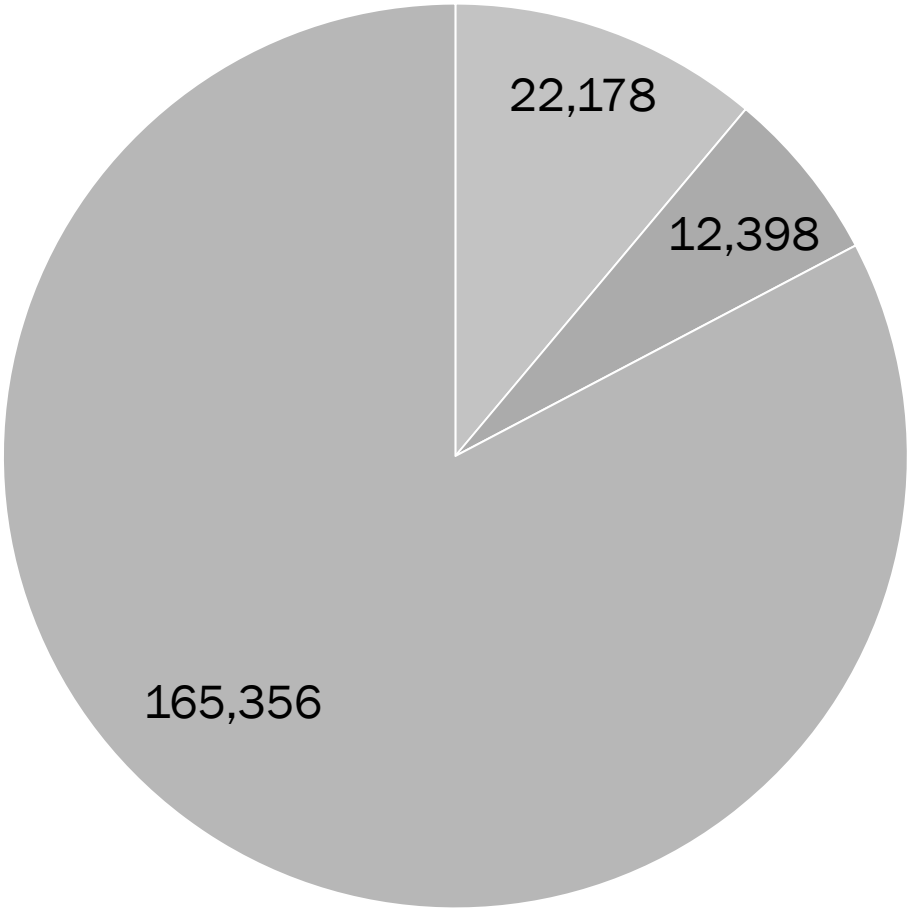
CAUSES OF REDUCED STREAMFLOW SUPPLY

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)



- Colorado Pumping
- Kansas Pumping
- Nebraska Pumping, Net *

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

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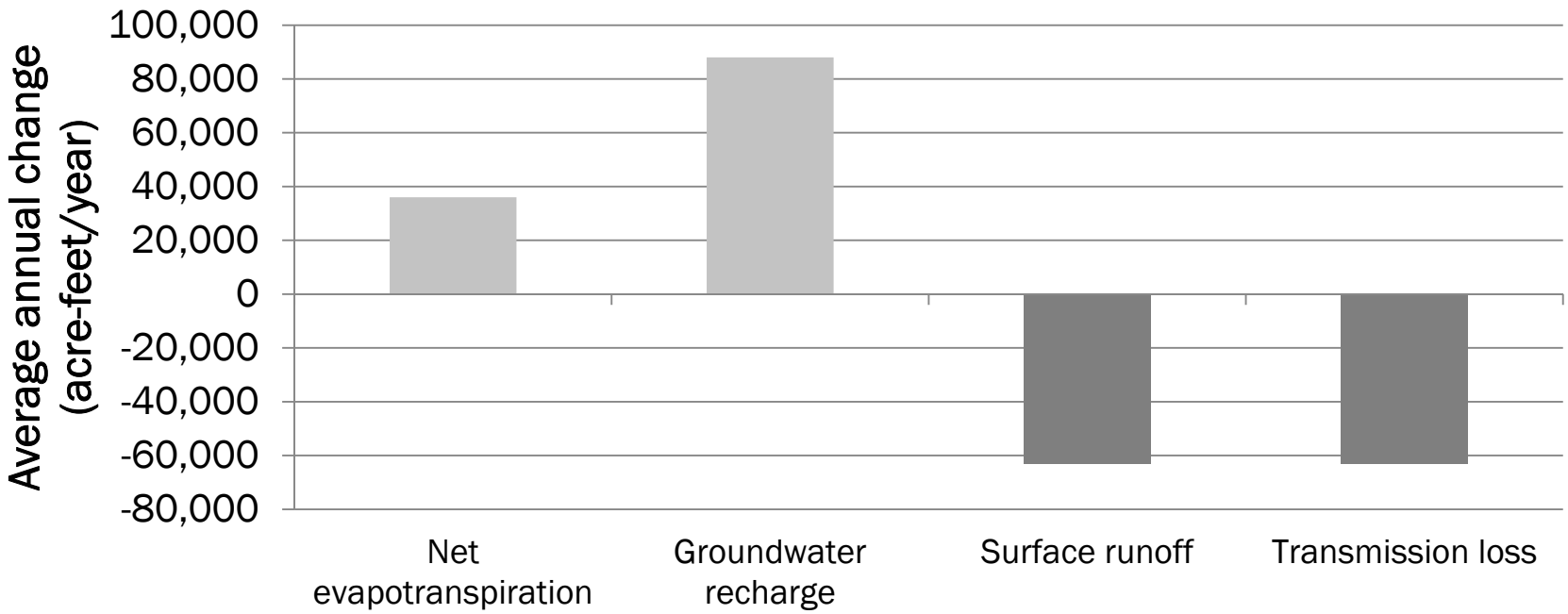
RRCA Conservation Study

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:



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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

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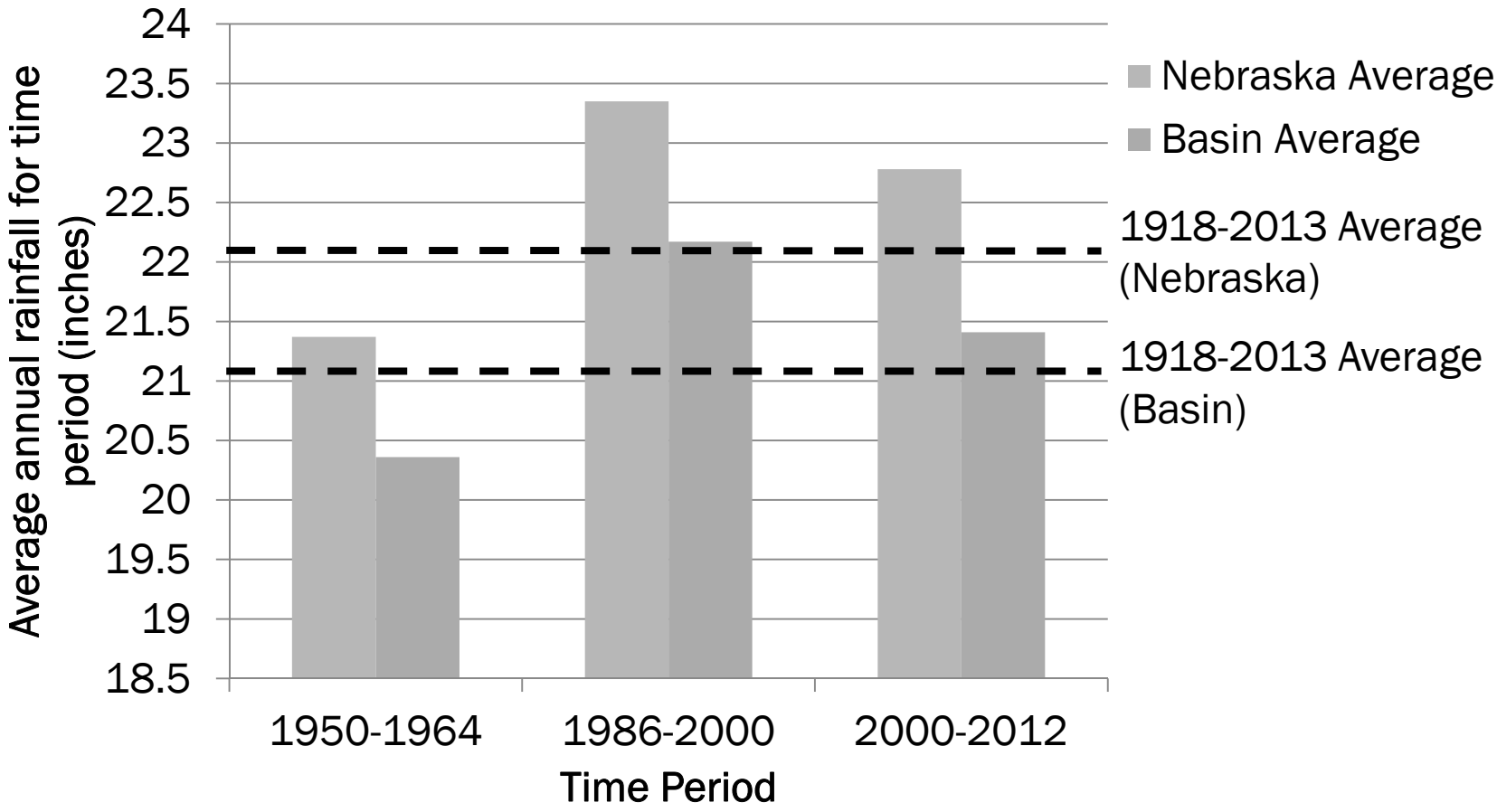
Rainfall Comparison



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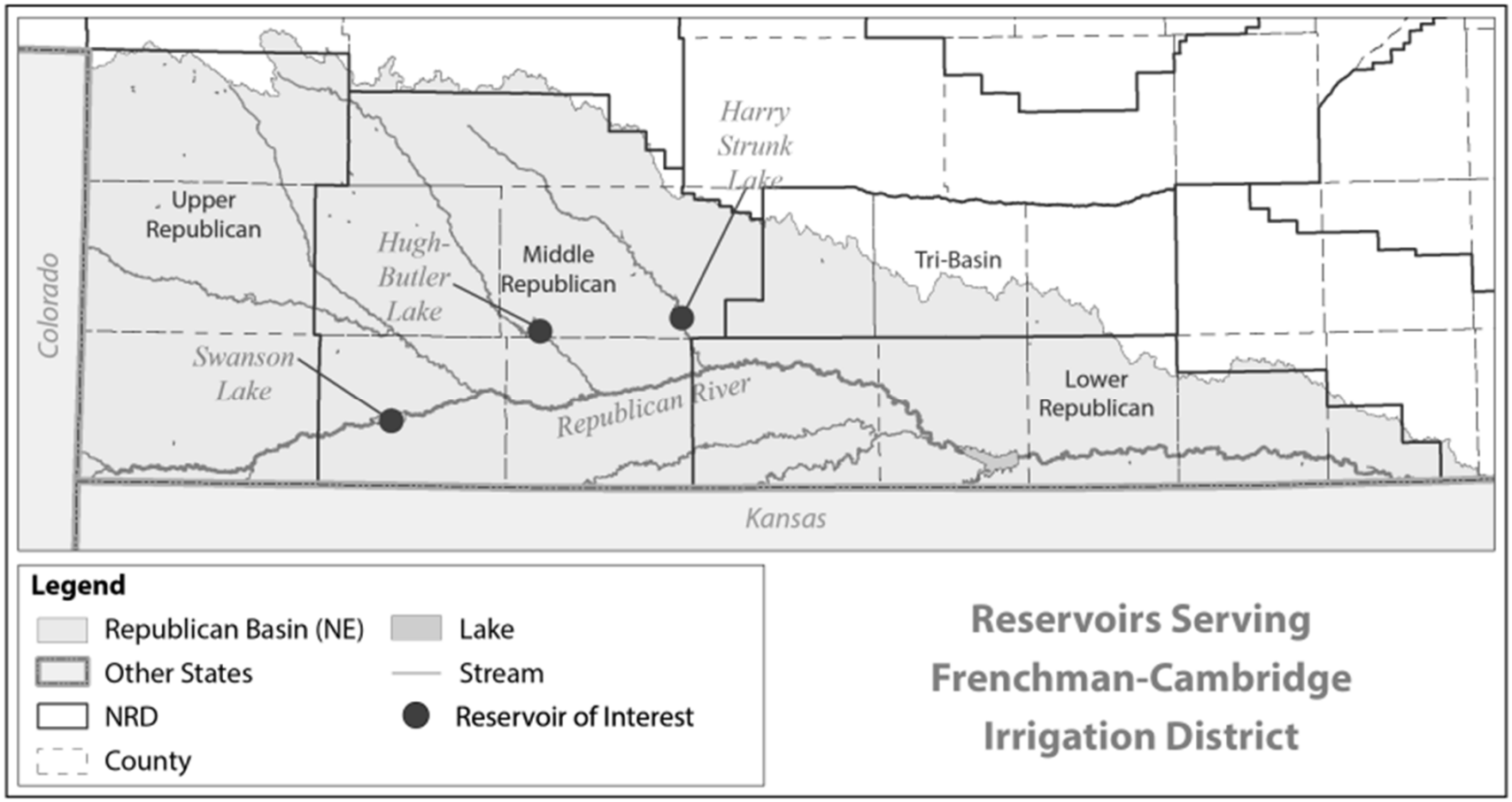

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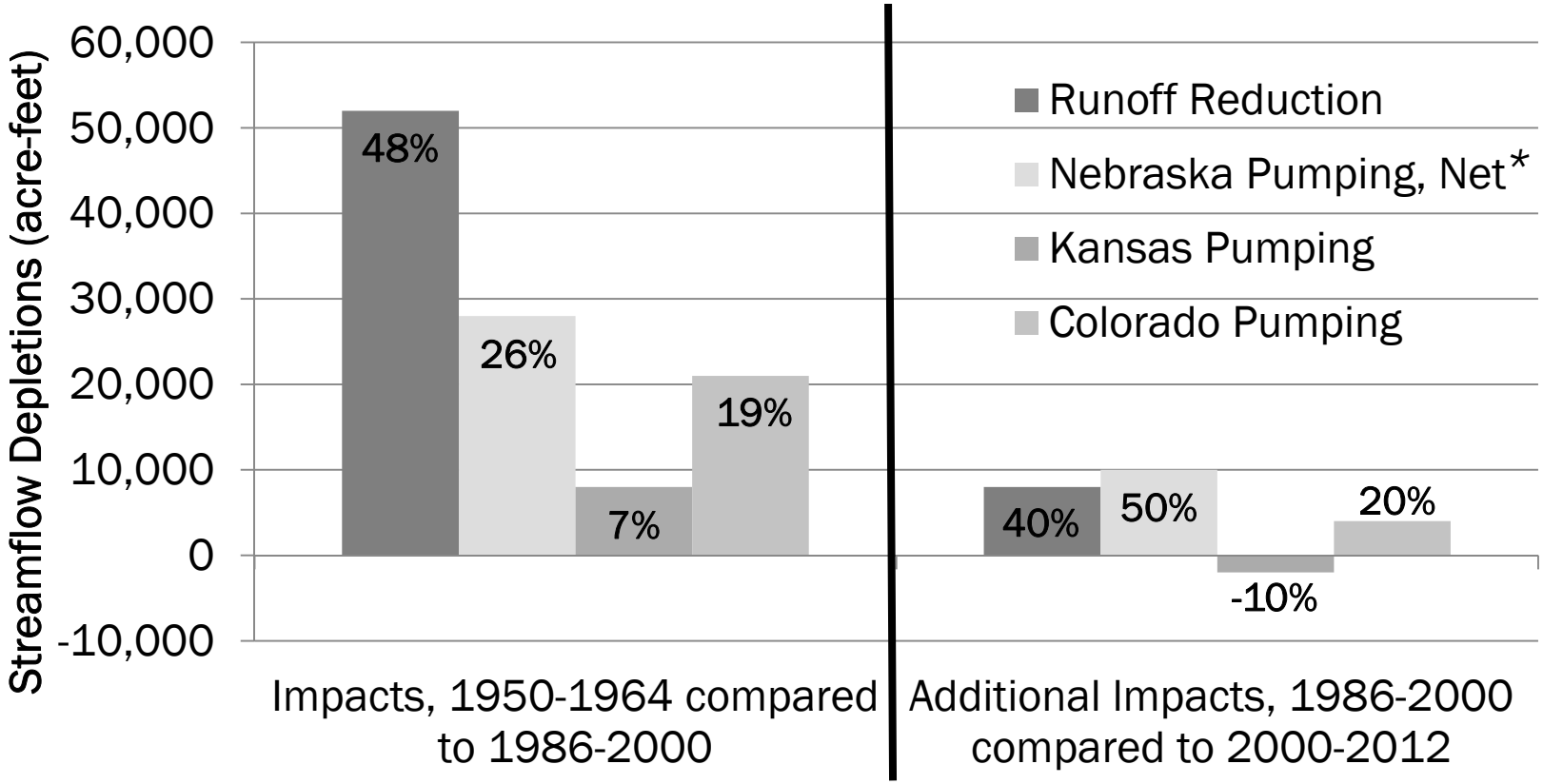
Impacts to Reservoirs Serving Frenchman Cambridge Irrigation District



**Nebraska imported water subtracted from Nebraska pumping impact*

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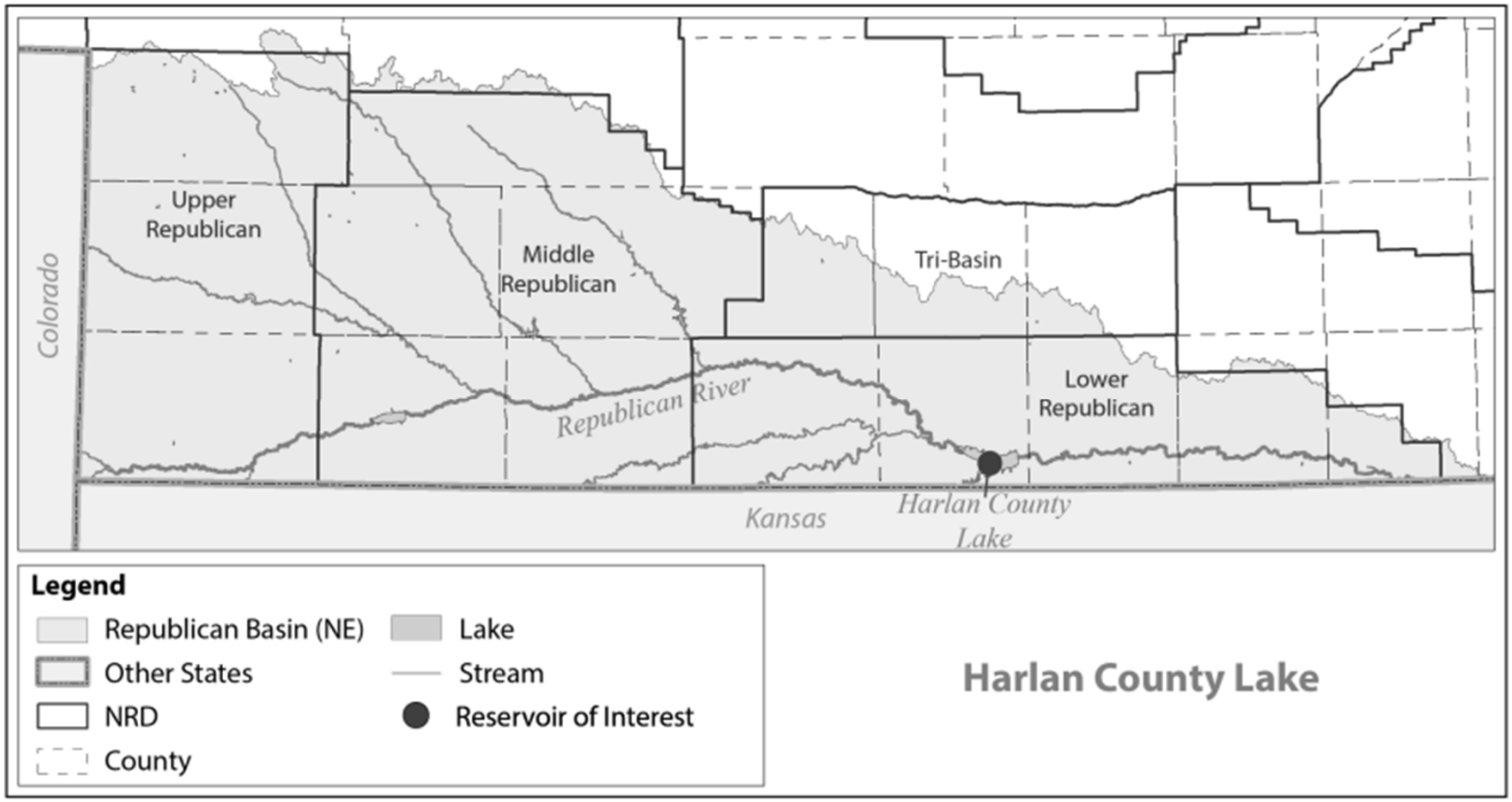
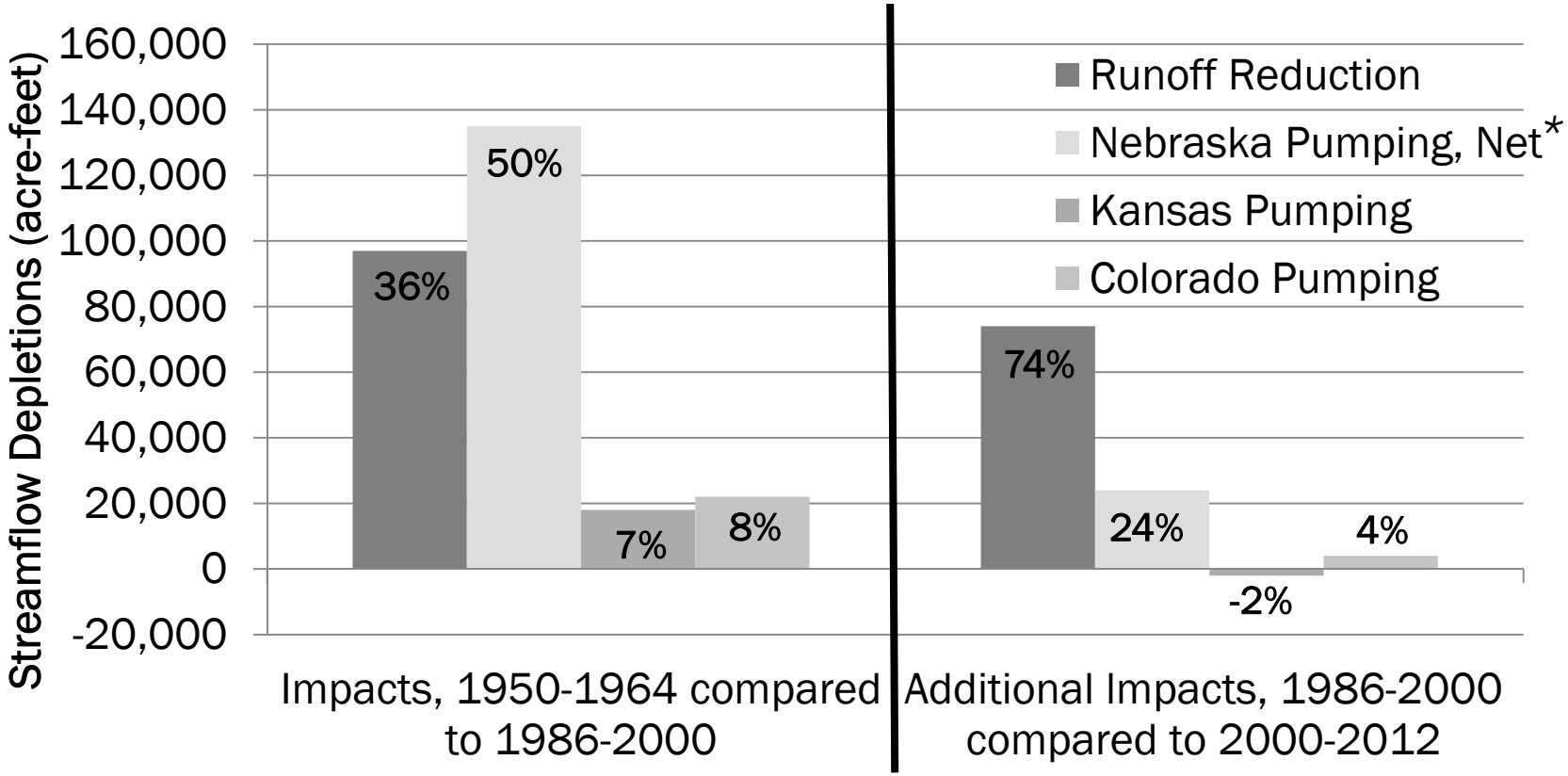

Upper Republican
Middle Republican
Tri-Basin
Lower Republican
Colorado
Republican River
Kansas
Harlan County Lake
Legend
Republican Basin (NE)
Other States
NRD
County
Lake
Stream
Reservoir of Interest
Harlan County Lake

Impacts
Above Harlan County Lake



**Nebraska imported water subtracted from Nebraska pumping impact*

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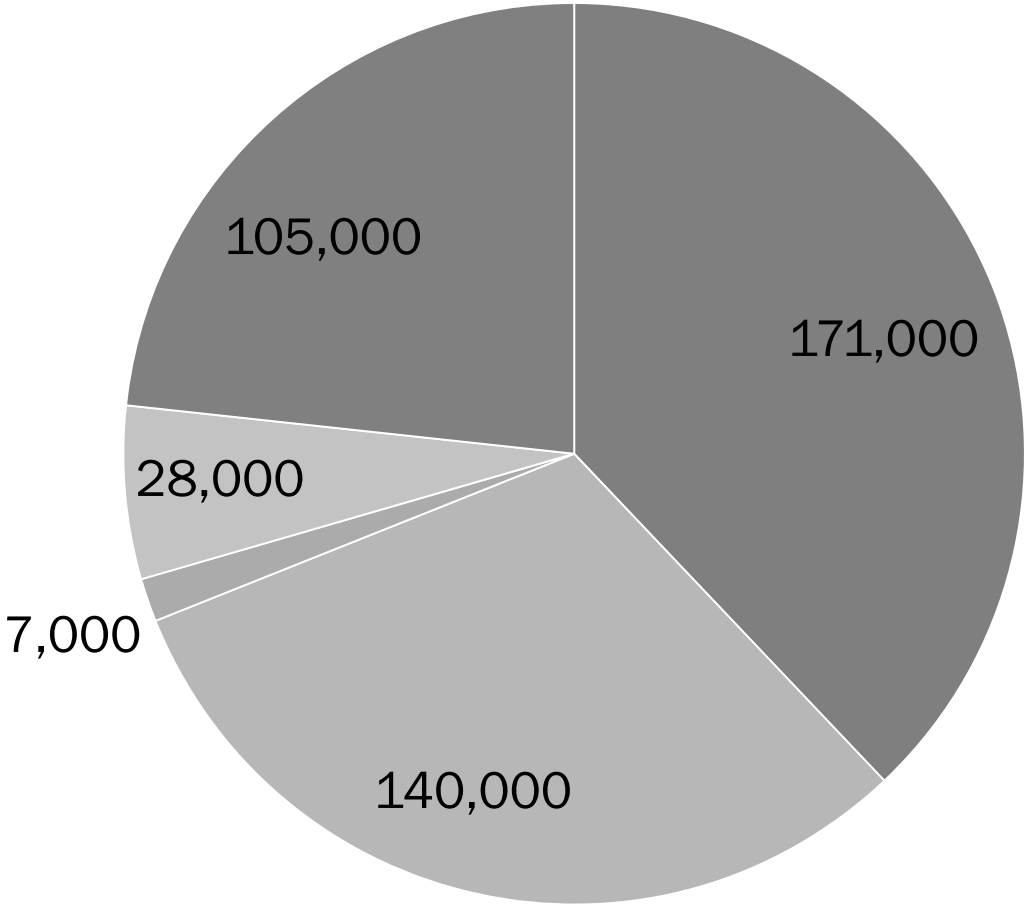
2013 Impacts, Including Drought

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)*

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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

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NEBRASKA'S WATER MANAGEMENT RESOURCE

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

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

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