Republican River Basin Study

Summary of Nebraska Results

December 1, 2015

Republican River Restoration Partners

Three States Working Together to Achieve Future Benefits

THE FLATWATER GROUP INC.

Prepared for Republican River Restoration Partners meeting in Oberlin, Kansas

Outline

- Background on RRBS Study
- Summary of Nebraska methodology
- Overview of Nebraska alternatives
- Summary of Nebraska results

Study Background

- Republican River Conjunctive Management Project (initial development late 2010)
  - Began STELLA surface water model construction
  - Started looking at alternatives for management strategies
  - Received input from stakeholders

Study Background

WaterSMART grant in 2012 for Republican River Basin Study

Bureau of Reclamation (Dept. of Interior)

State of Nebraska

State of Colorado

State of Kansas

Study Background

Republican River Basin Study (RRBS) Goals (from MOA):

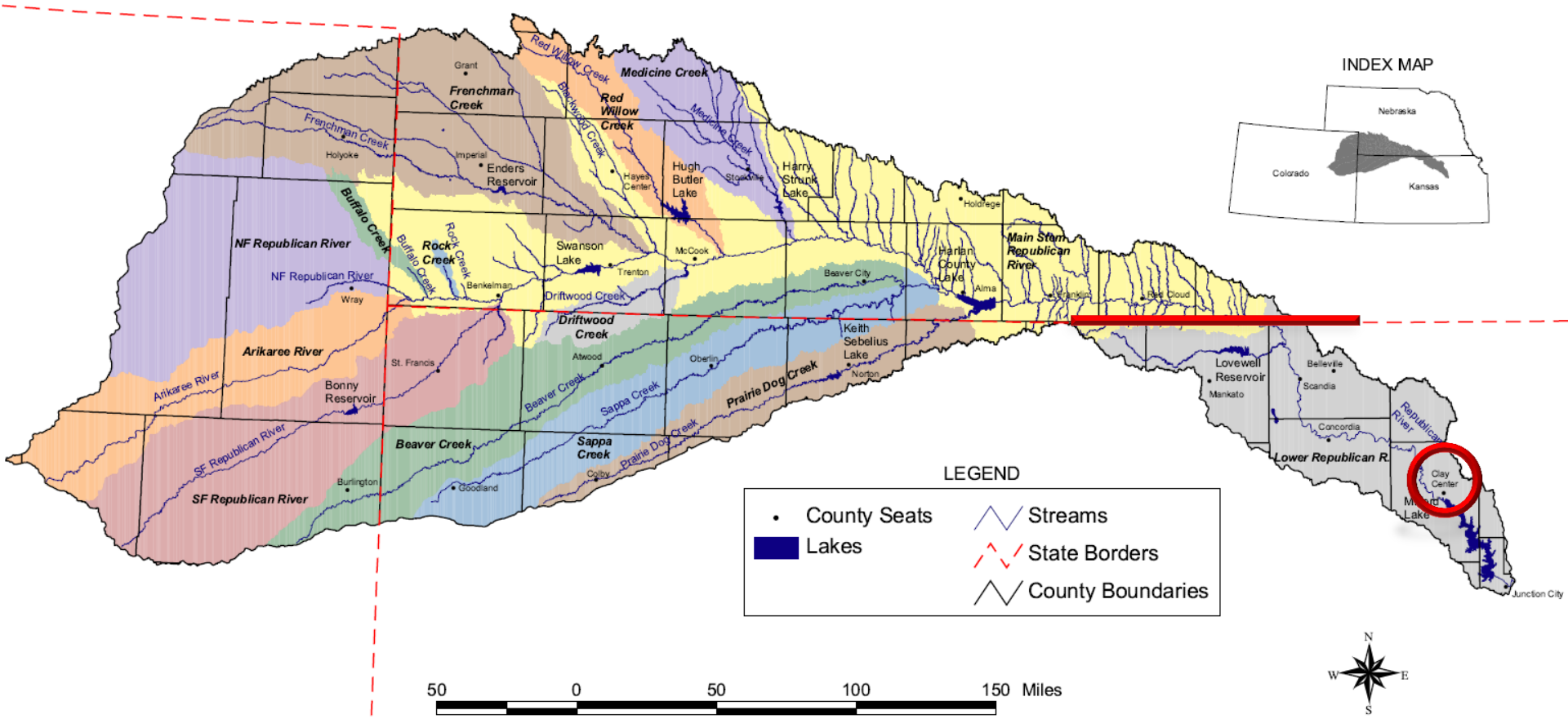
- **Protect future supply and demand in the Republican River Basin.**
- **Analyze how existing water operations and infrastructure will perform in the face of uncertain or variable water supply and/or demands.**
- **Identify and evaluate options to improve operations and infrastructure to address future water supply needs.**
- **Recommend options (operations and infrastructure) to supply adequate water in the future.**

Study Background

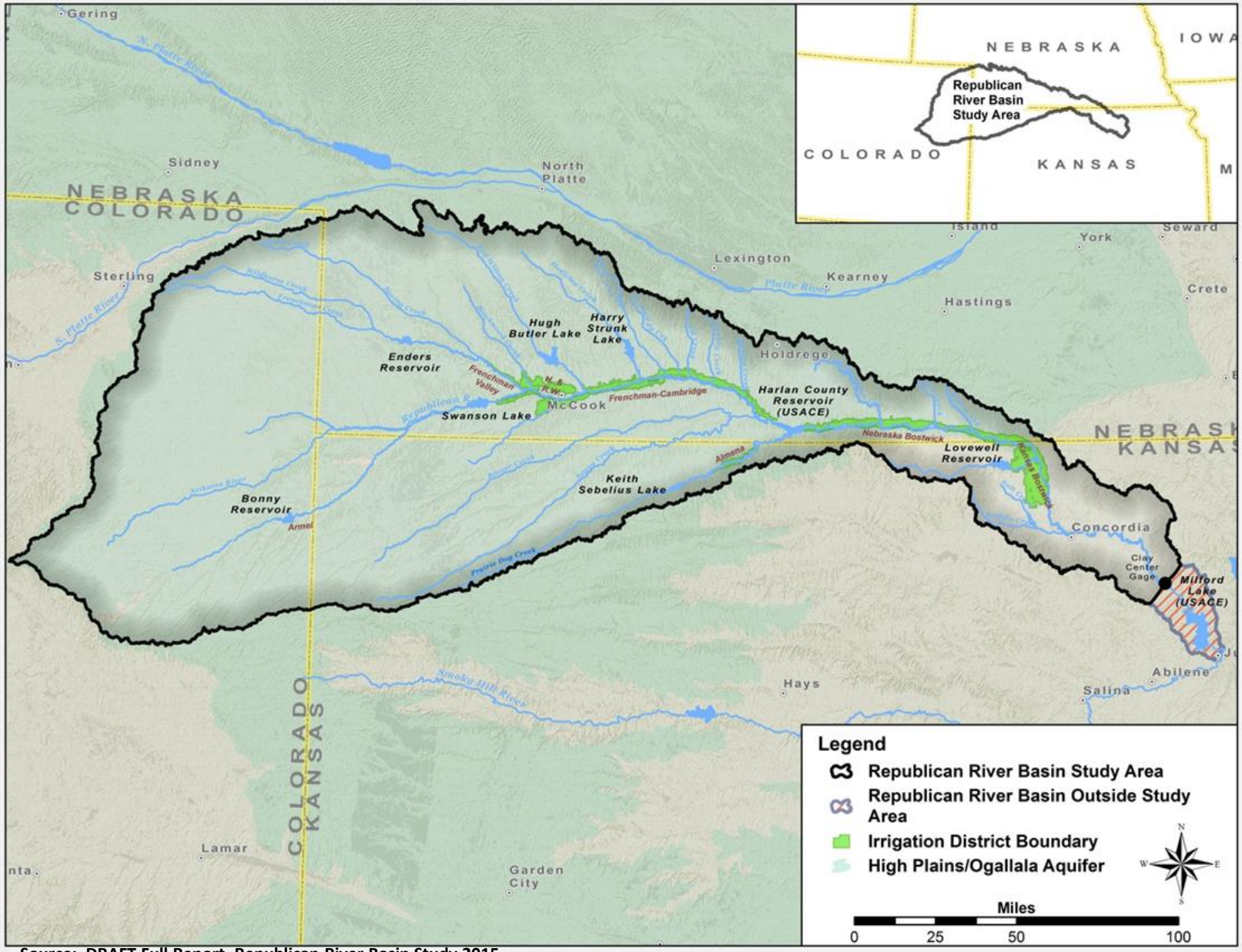
Nebraska Study Objectives:

- **Maintain Compact Compliance**
  - **Include simplified representation of IMP management actions**
  - **Include simplified measurement of Compact Accounting**
- **Maximize Beneficial Water Use**
  - **Include both ground water and surface water**
  - **Consider both quantity and timing**

Study Background

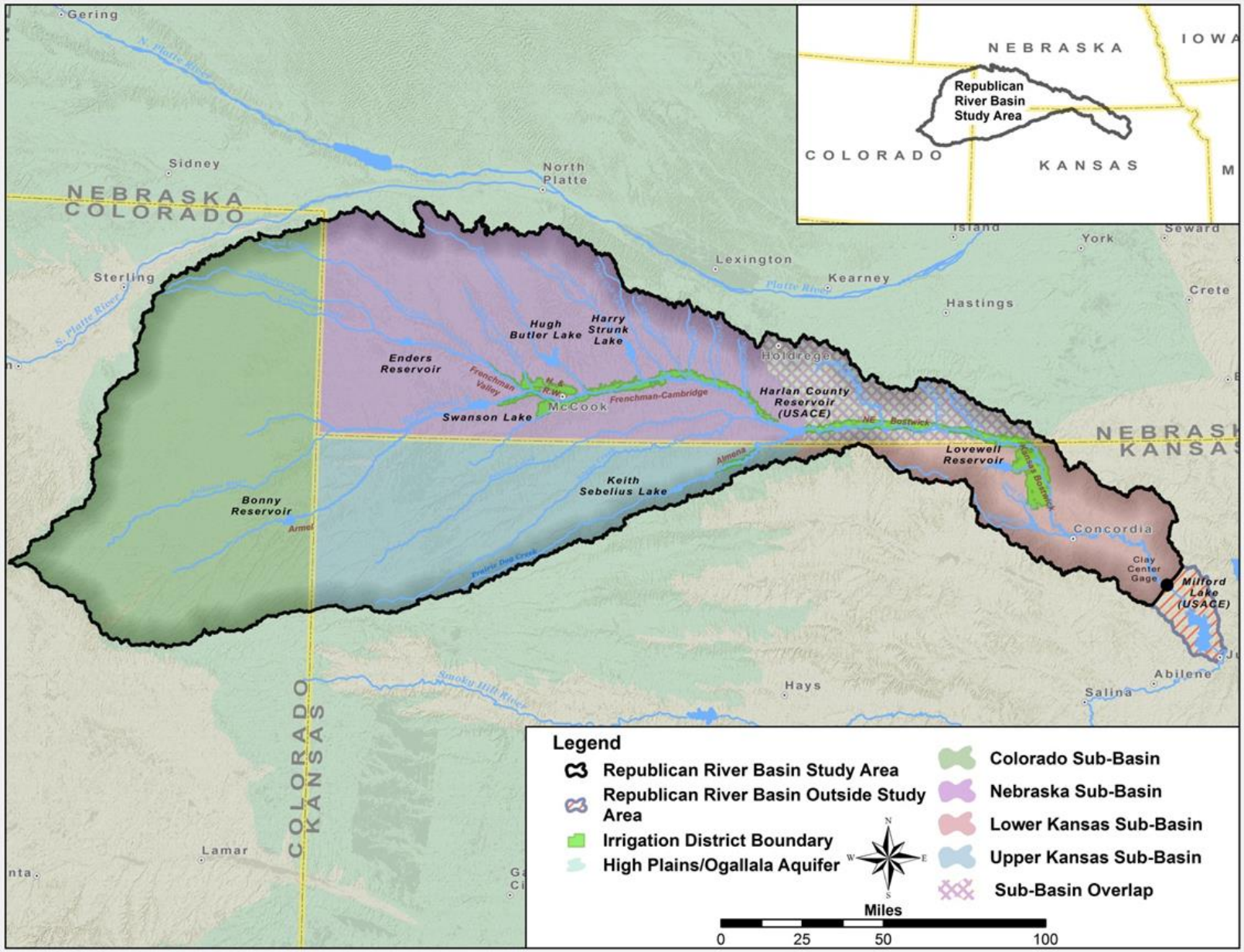


Study Background



Source: DRAFT Full Report, Republican River Basin Study 2015

Study Background

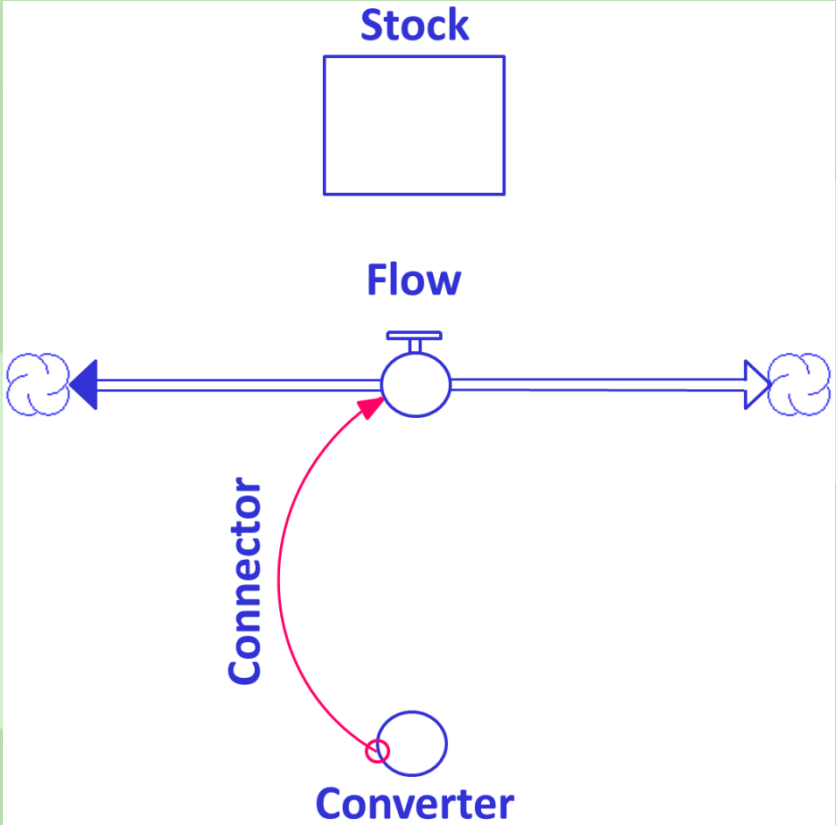


Source: DRAFT Full Report, Republican River Basin Study 2015

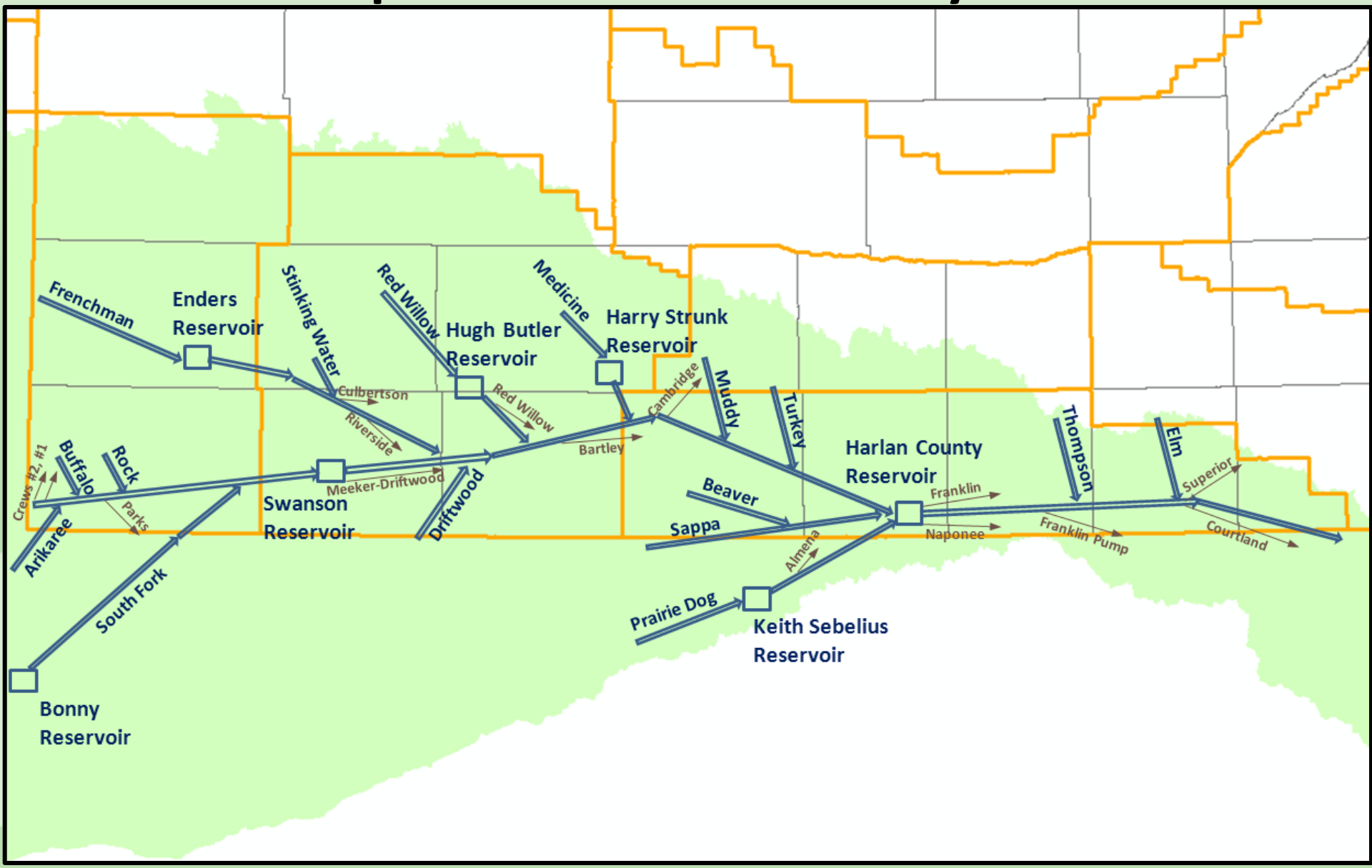
Study Background

- Construction of reservoirs, under Pick-Sloan program, for flood control, irrigation, and other purposes.
- Compact between Nebraska, Kansas, and Colorado in 1943.
- Final Settlement Stipulation in 2002 – included groundwater model, but not surface water model.

Nebraska Methodology



Nebraska Methodology
Simplified Surface Water System



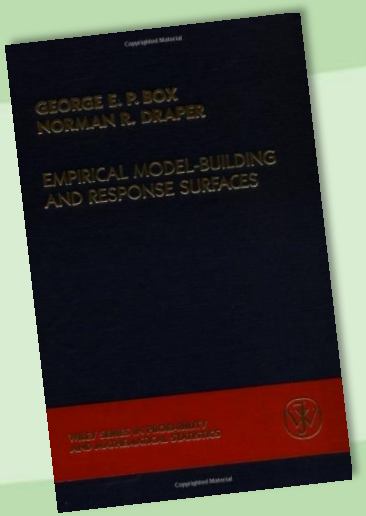
Nebraska Methodology

STELLA Model
"Tale of the Tape"

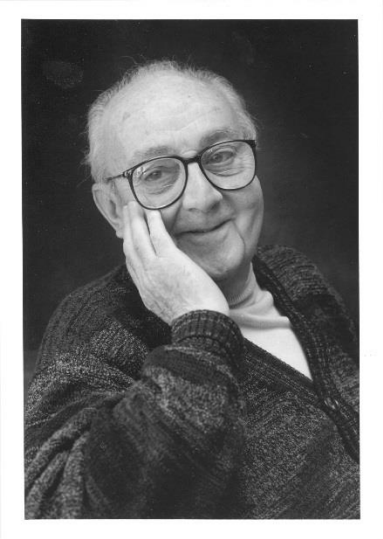
- **STELLA model approximately 40MB in size, over 3,000 elements***
- **Time increments (dt) of 45 minutes, 584,384 time steps over 50 years**
- **About 3 hours to run model and export results**

Nebraska Methodology
STELLA Model

"…all models are wrong, but some are useful."



Empirical Model-Building and Response Surfaces (1987)

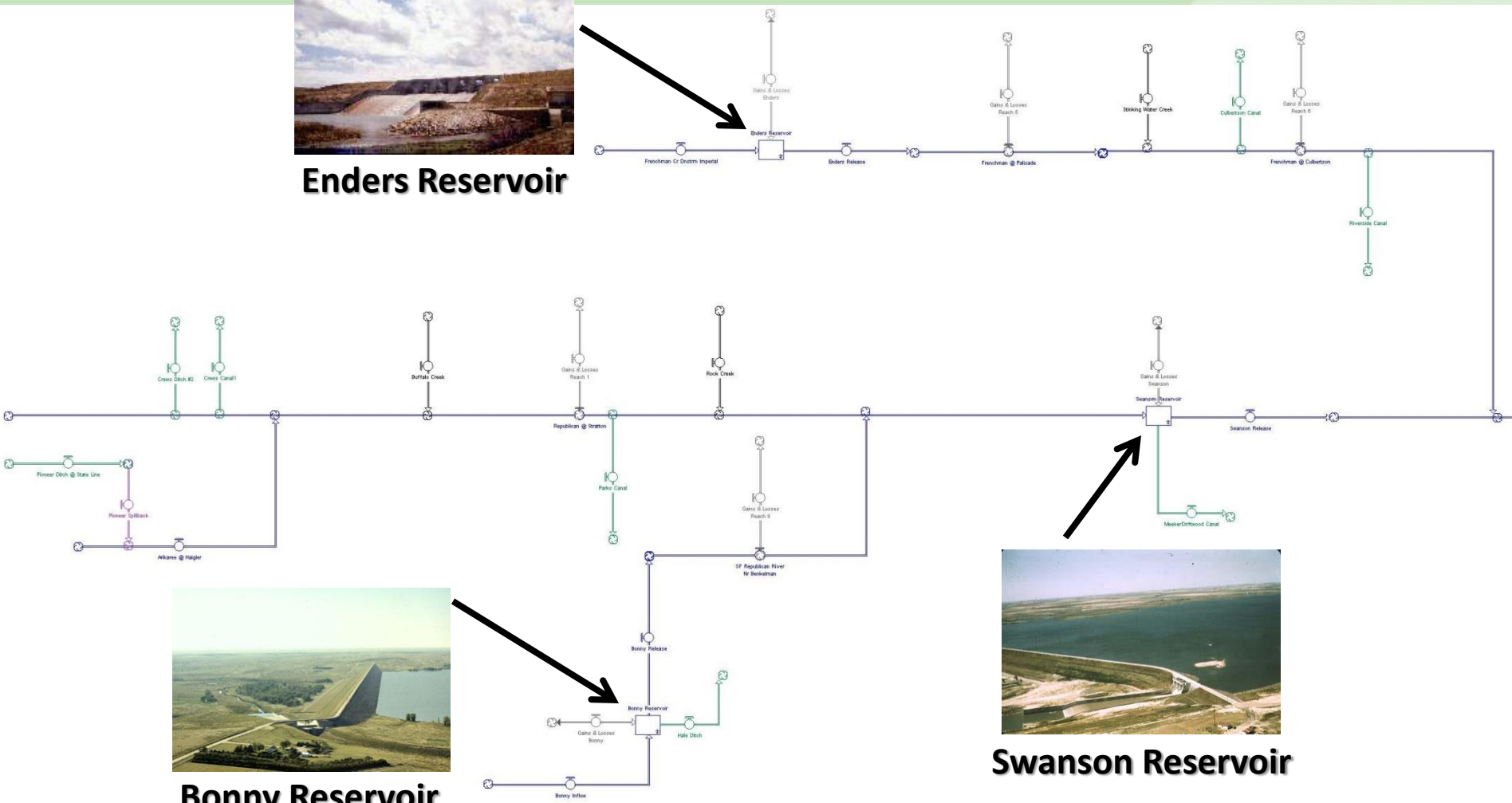


George E. P. Box

Jim Goeke

Nebraska Methodology
STELLA – Western Section

Enders Reservoir



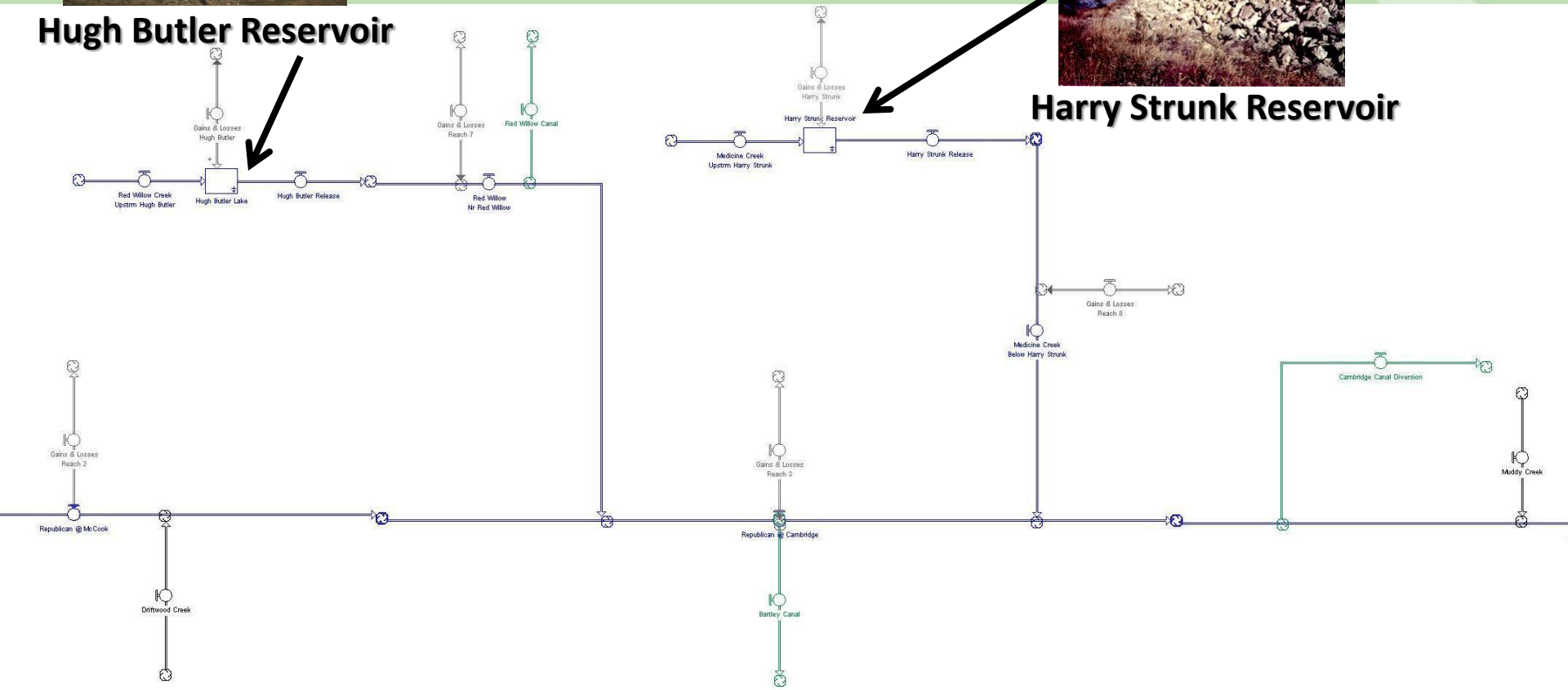
Bonny Reservoir

Swanson Reservoir

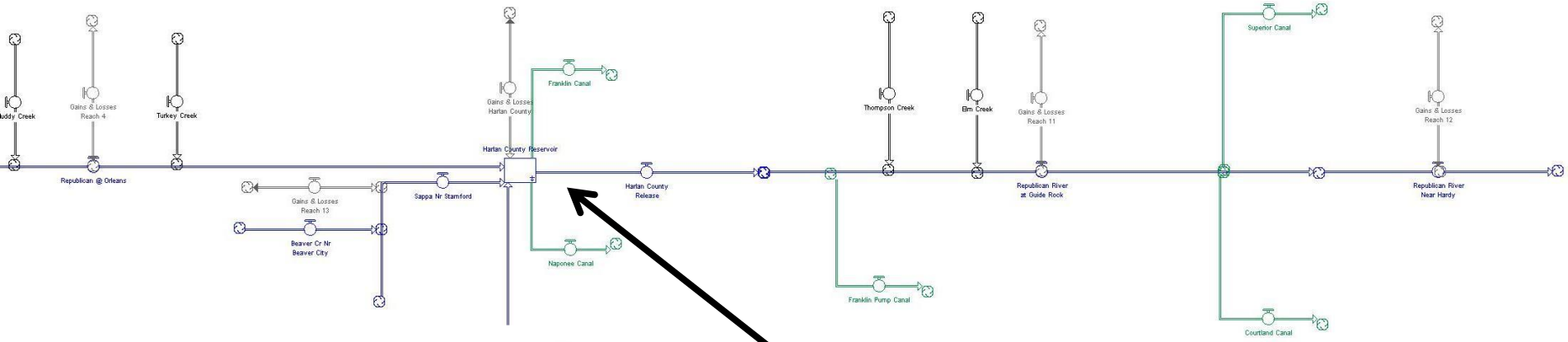
Nebraska Methodology
STELLA – Central Section

Hugh Butler Reservoir

Harry Strunk Reservoir



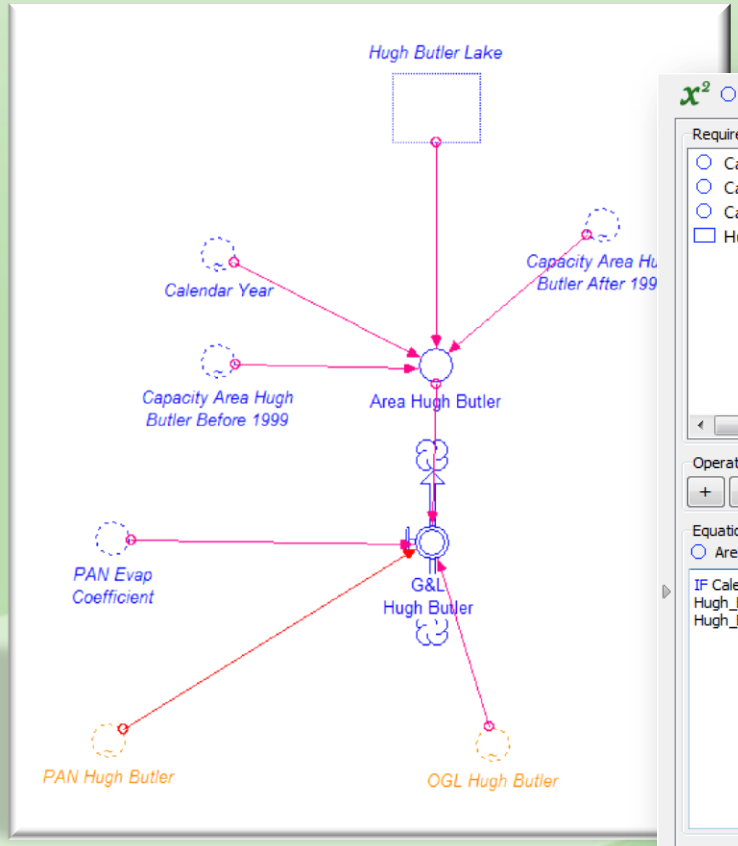
Nebraska Methodology
STELLA – Eastern Section

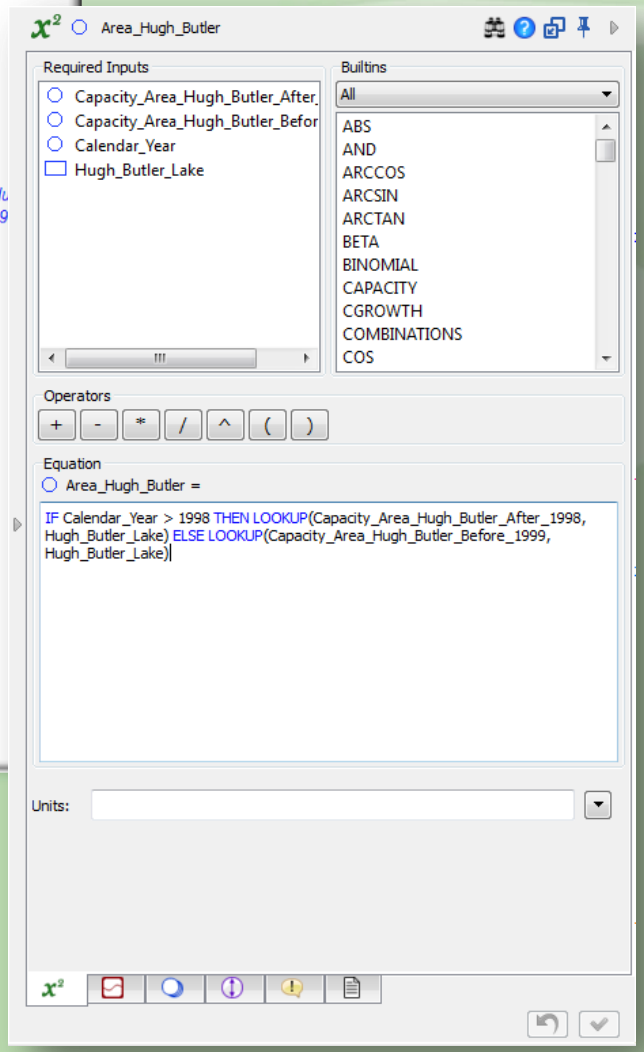


Harlan County Reservoir

Nebraska Methodology

Reservoir Parameters and Storage – Evaporation Connection





Hugh Butler Reservoir

Nebraska Methodology

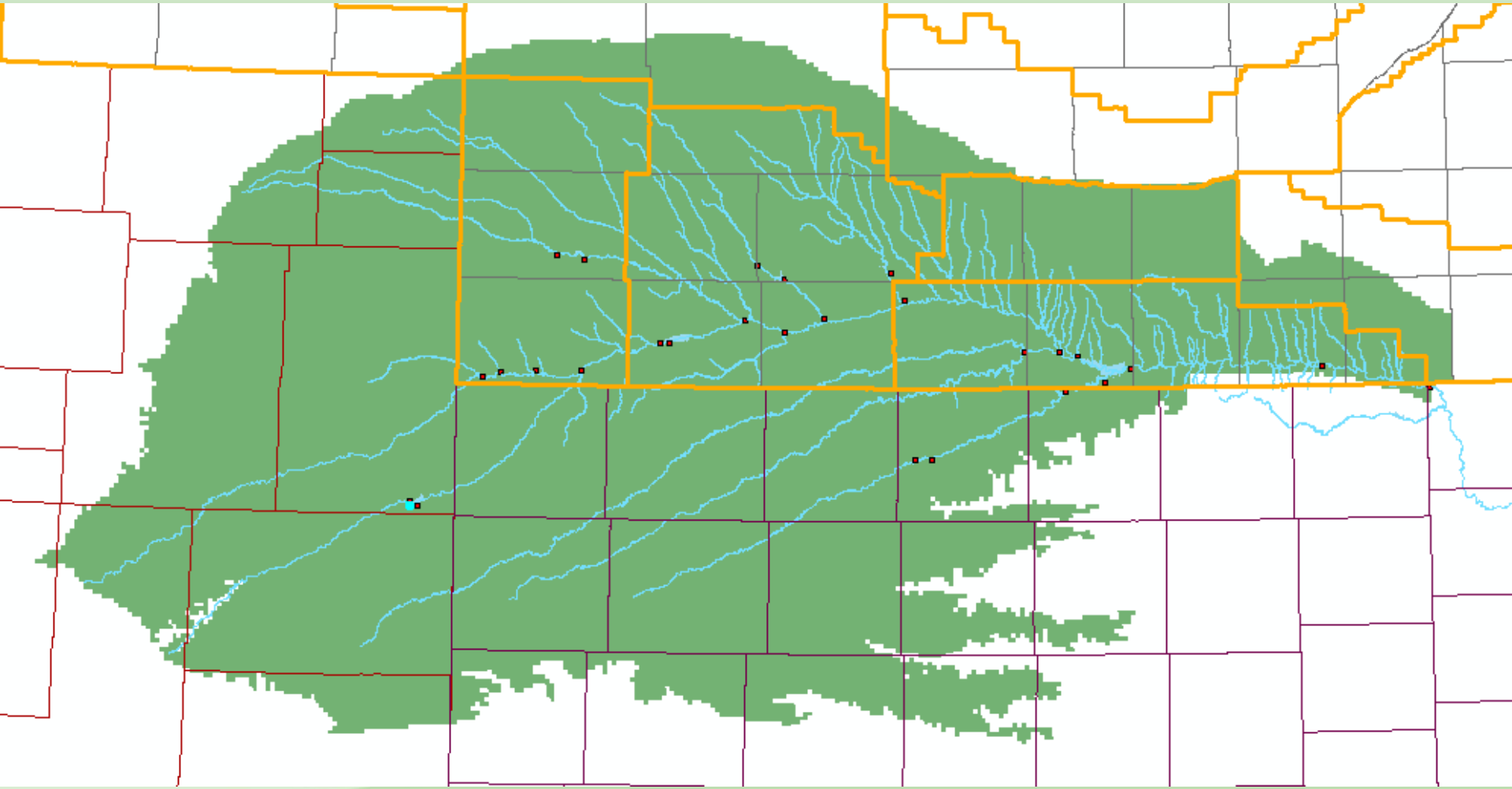
Water Rights (Appropriation System)

Discussing Water Rights the Old Fashioned Way!

- Simplified appropriation system, including 20 of the major canals and reservoirs
- Possibly first use of STELLA for modeling appropriation water rights structure

Nebraska Methodology

Connections with Ground Water Model



Nebraska Methodology

Time

- Calibrated to historical 1995 to 2010 conditions
- Future model runs for 2011 to 2060
- Base conditions using 1961 to 2010 inflows, 1995 to 2010 gains and losses

Nebraska Methodology
Climate Scenarios

- Baseline Climate = 1961 to 2010
- Climate Scenarios
  - Scenario 1 (Dry)
  - Scenario 2 (Median)
  - Scenario 3 (Wet)

Nebraska Methodology

Compact Call Years

- Simplified from actual procedures
- Uses reservoir storage and accounting balances to determine if Compact Call required

Nebraska Methodology

Compact Call Years - Simplified

- All USBR reservoirs must pass through inflows during Compact Call Year
- Harlan County Lake allowed to store prior to irrigation season, but stored water tracked as Compact water
- HCL Compact water released to Kansas to meet KBID demands or to fill Lovewell Reservoir – remaining Compact water released at end of year
- Nebraska canals allowed to divert starting July 1
- 15,000 af and 60,000 af pumped from Rock Creek and N-CORPE aug projects, respectively

Nebraska Methodology
Evaluation Metrics

- Number of Compact Call Years
- Reservoir Storage Levels
- Irrigation Diversions
- Diversions for project-specific purposes
- Cost*

Overview of Nebraska Alternatives

No Action Alternative

"Stay the Course"

- A baseline against which other alternatives can be evaluated
- Existing infrastructure (dams, canals, etc.)
- Current IMPs with Compact Call Year process
- Current management policies with canal and reservoir operations

Overview of Nebraska Alternatives

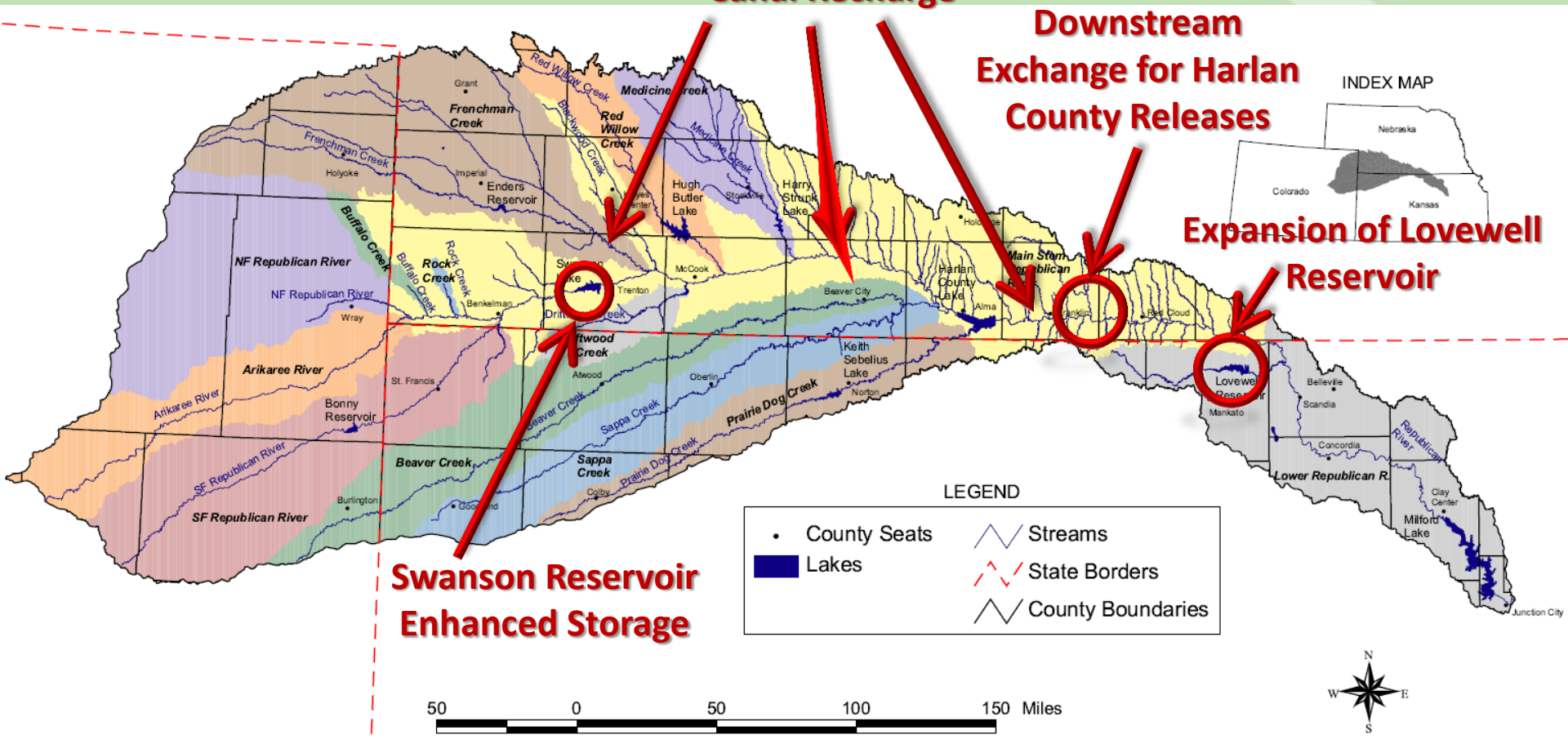
Nebraska Alternatives

- Swanson Reservoir Enhanced Storage (Pump-Back)
- Downstream Exchange for Harlan County Lake Releases (Thompson Creek Dam)
- Non-Irrigation Season Canal Recharge

Kansas Alternatives

- Expansion of Lovewell Reservoir

Overview of Nebraska Alternatives Location

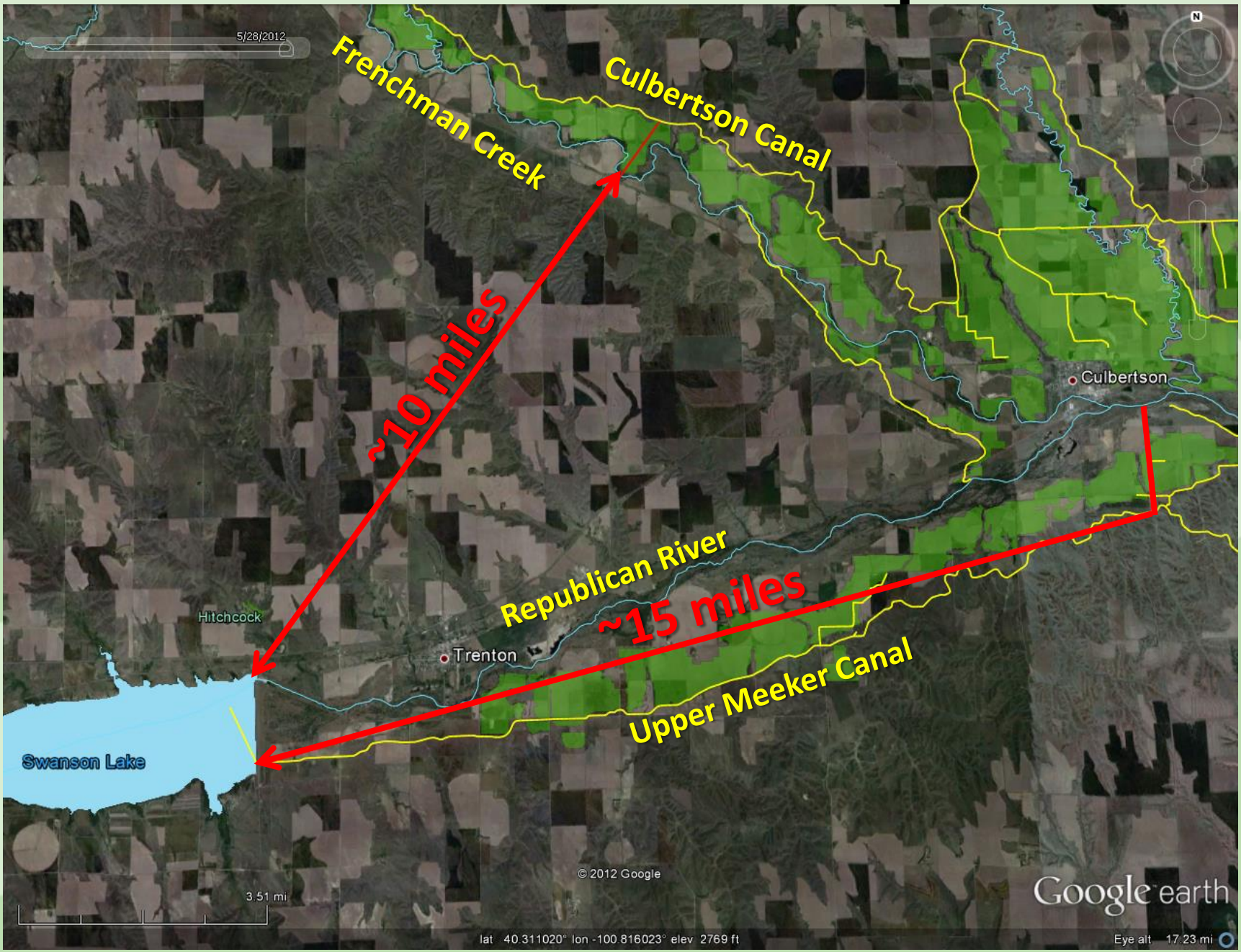


Summary of Nebraska Results

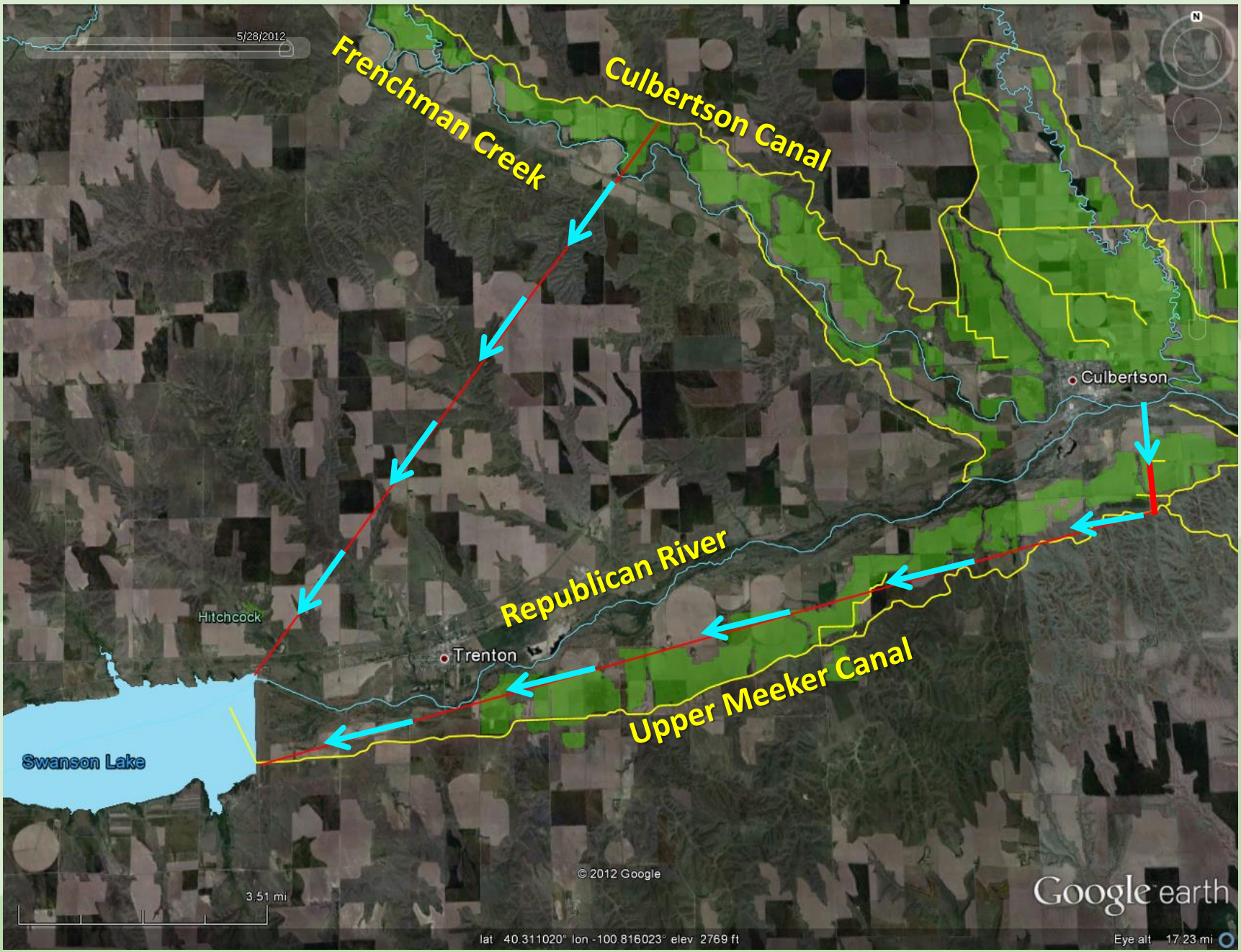
Swanson Reservoir Pump-Back

- New pipeline constructed to pump back water to Swanson Reservoir from downstream:
  - Frenchman River
  - Republican River
- Take advantage of available storage space upstream
- Improve water supply reliability for Frenchman Cambridge Irrigation District
- Use existing reservoir operations

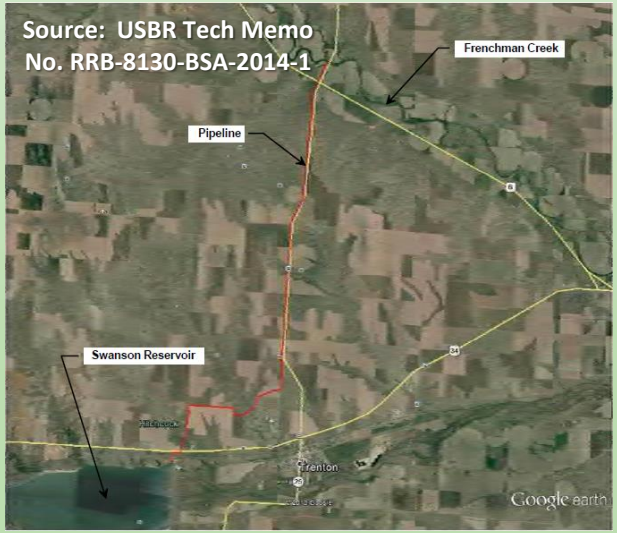
Swanson Reservoir Pump-Back



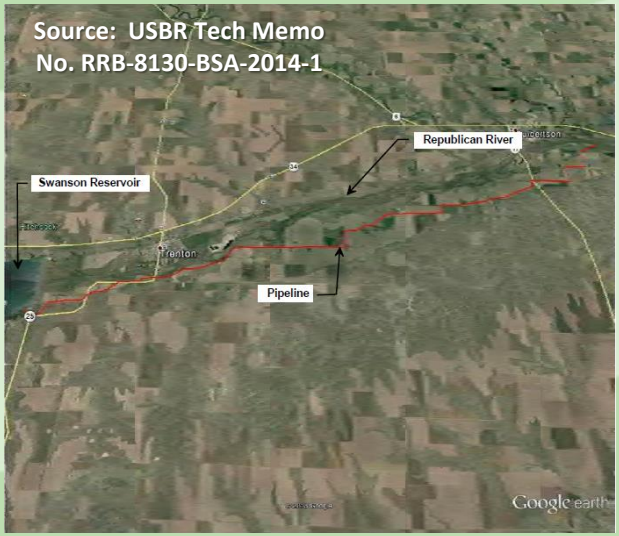
Swanson Reservoir Pump-Back



Swanson Reservoir Pump-Back

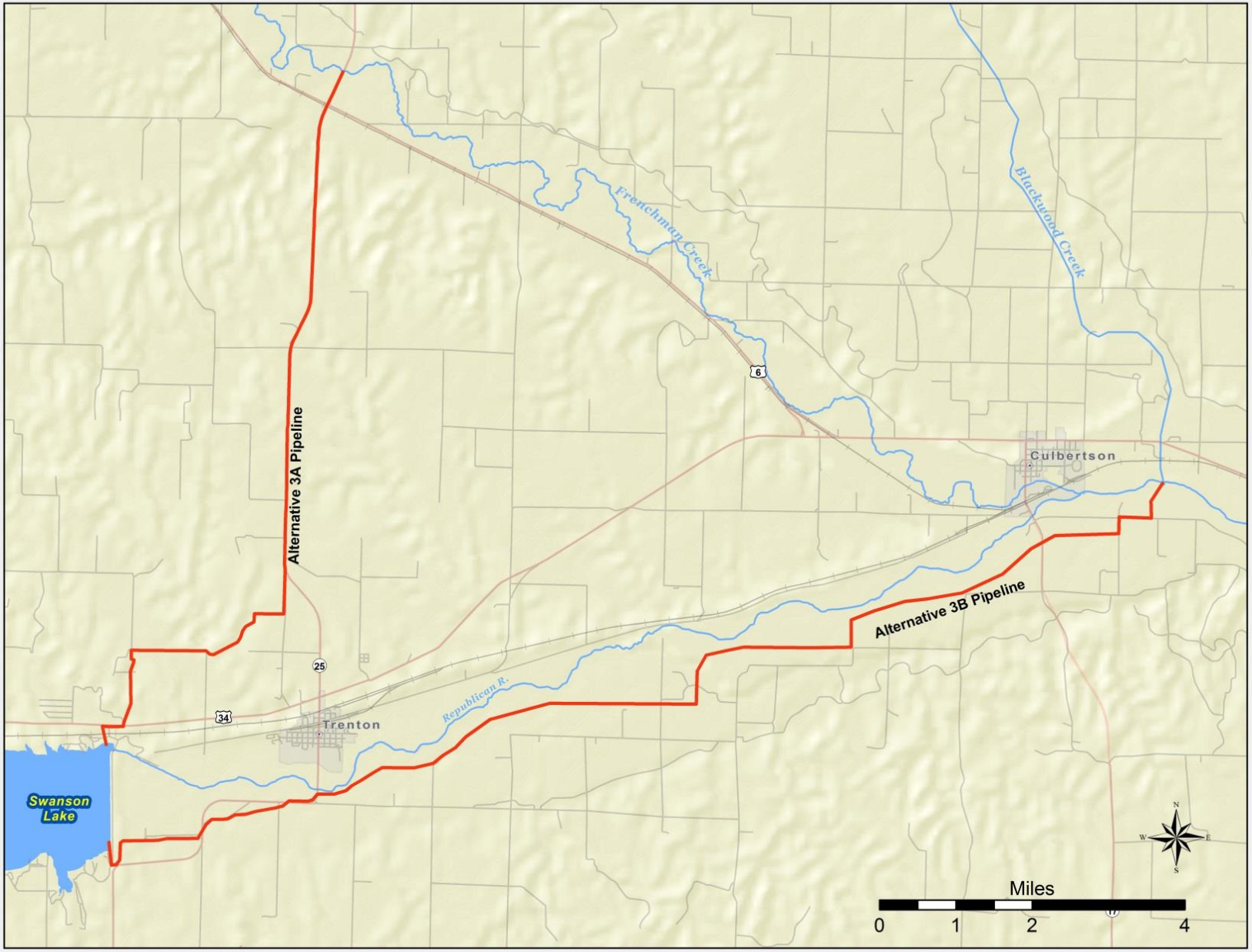


- Alternative 3A (Frenchman Cr)
  - 11.3 mile long pipeline
  - 3,000 gpm design flow (6.7 cfs)



- Alternative 3B (Republican R)
  - 17.4 mile long pipeline
  - 5,000 gpm design flow (11.1 cfs)

Swanson Reservoir Pump-Back



Swanson Reservoir Pump-Back

Evaluation Metrics

- Number of Compact Call Years
- Pump-back Diversions
- Swanson Lake Storage Levels
- Harlan County Lake Storage Levels
- FCID Irrigation Diversions
- NBID Irrigation Diversions (w/o Courtland Canal)
- Cost*

Swanson Reservoir Pump-Back

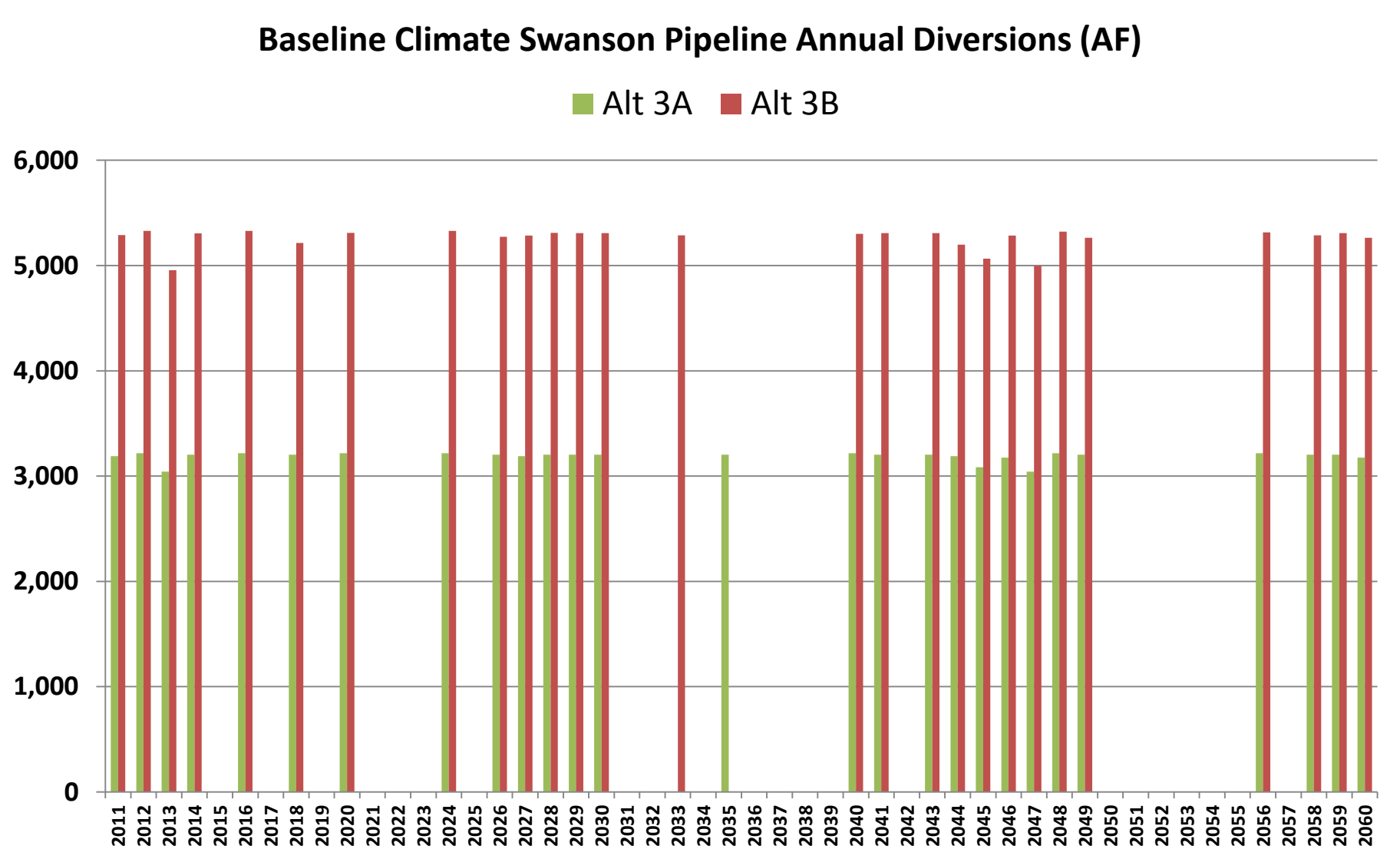
Compact Call Years

- 23 Compact Call Years for No Action
- 23 Compact Call Years for Frenchman Creek Swanson Pump-Back
- 23 Compact Call Years for Republican River Swanson Pump-Back

Compact Call Years may switch, but total number unchanged

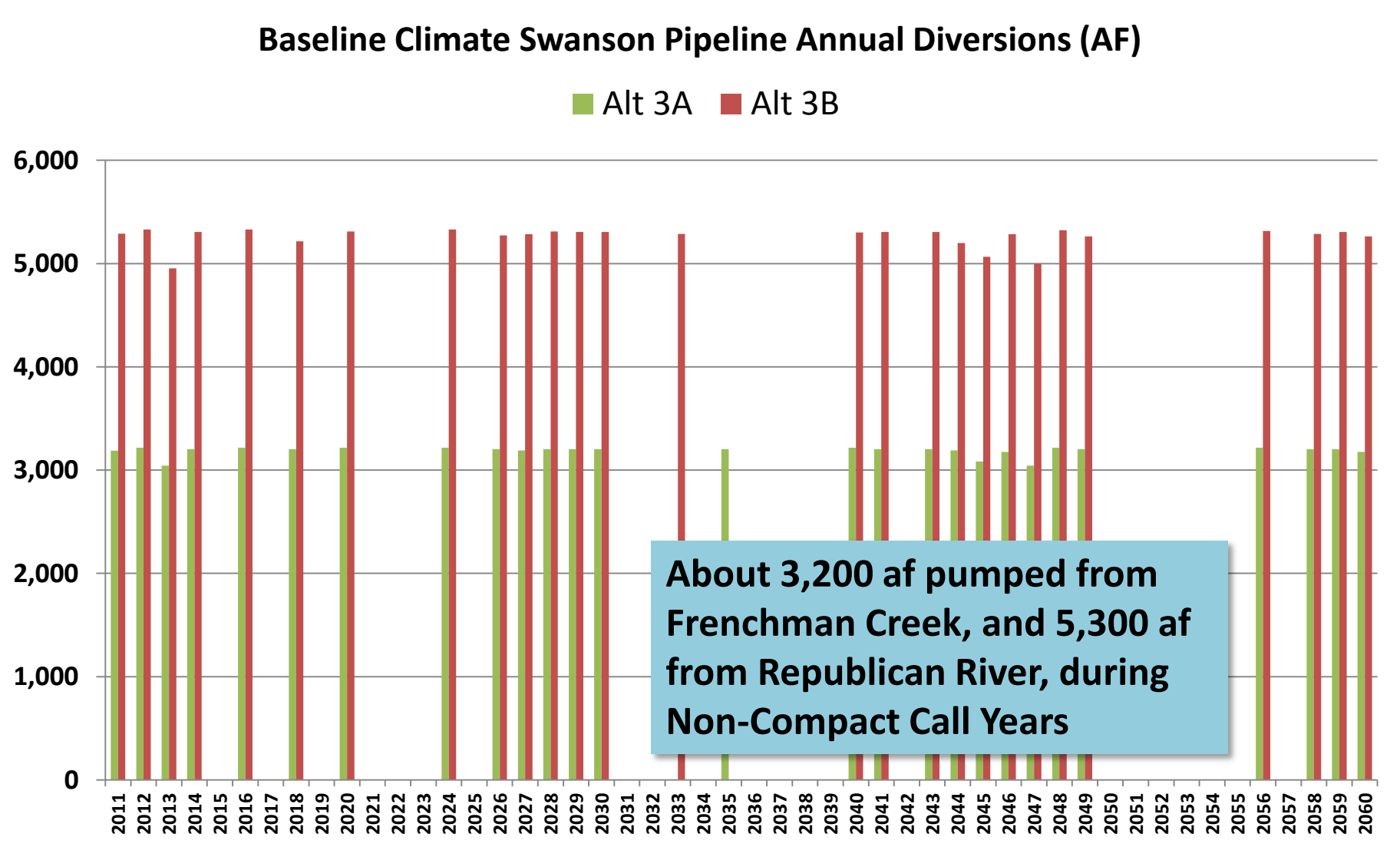
Swanson Reservoir Pump-Back

Pipeline Diversions



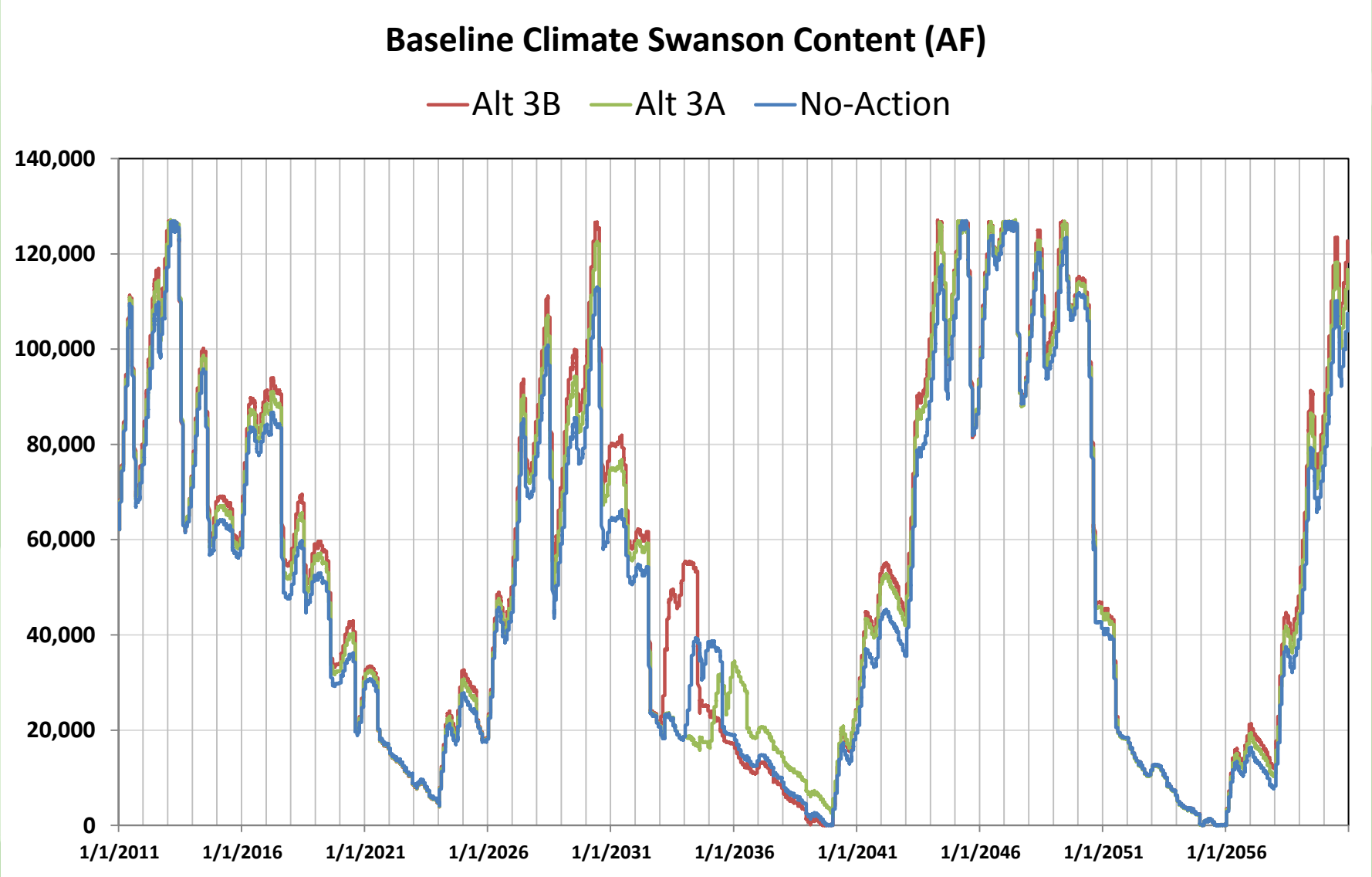
Swanson Reservoir Pump-Back

Pipeline Diversions



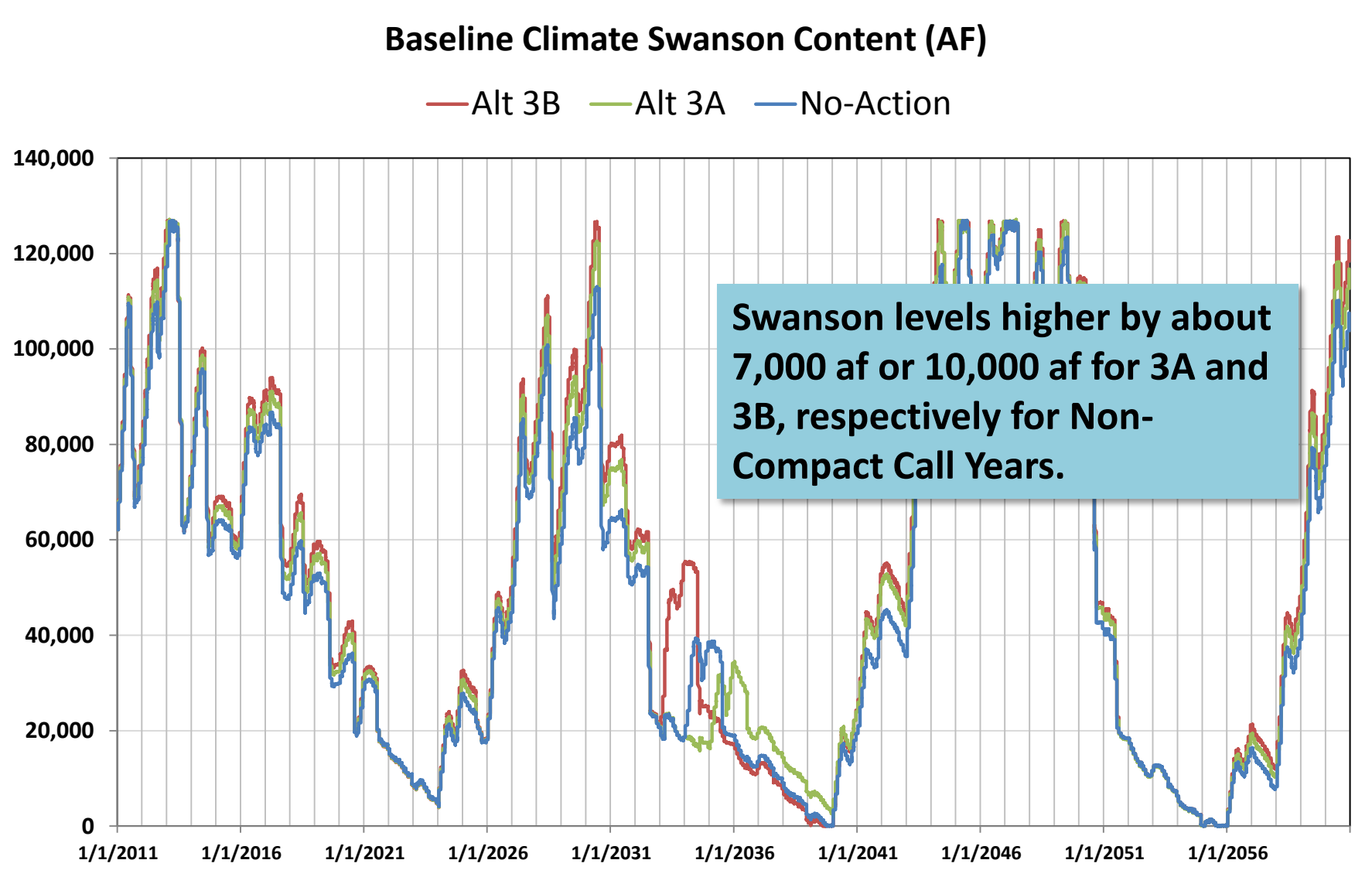
Swanson Reservoir Pump-Back

Swanson Lake Levels



Swanson Reservoir Pump-Back

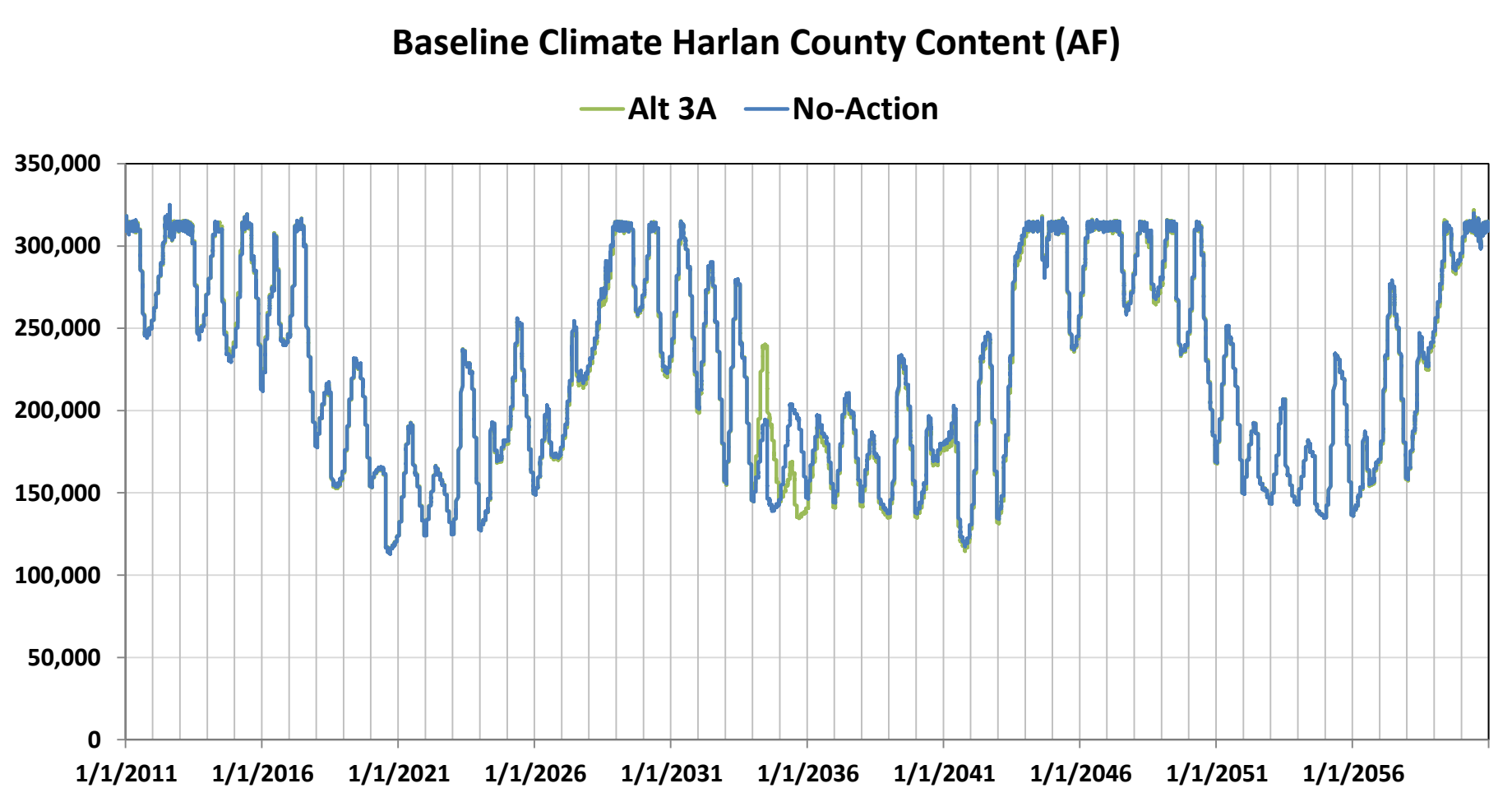
Swanson Lake Levels



Swanson Reservoir Pump-Back

Harlan County Lake Levels

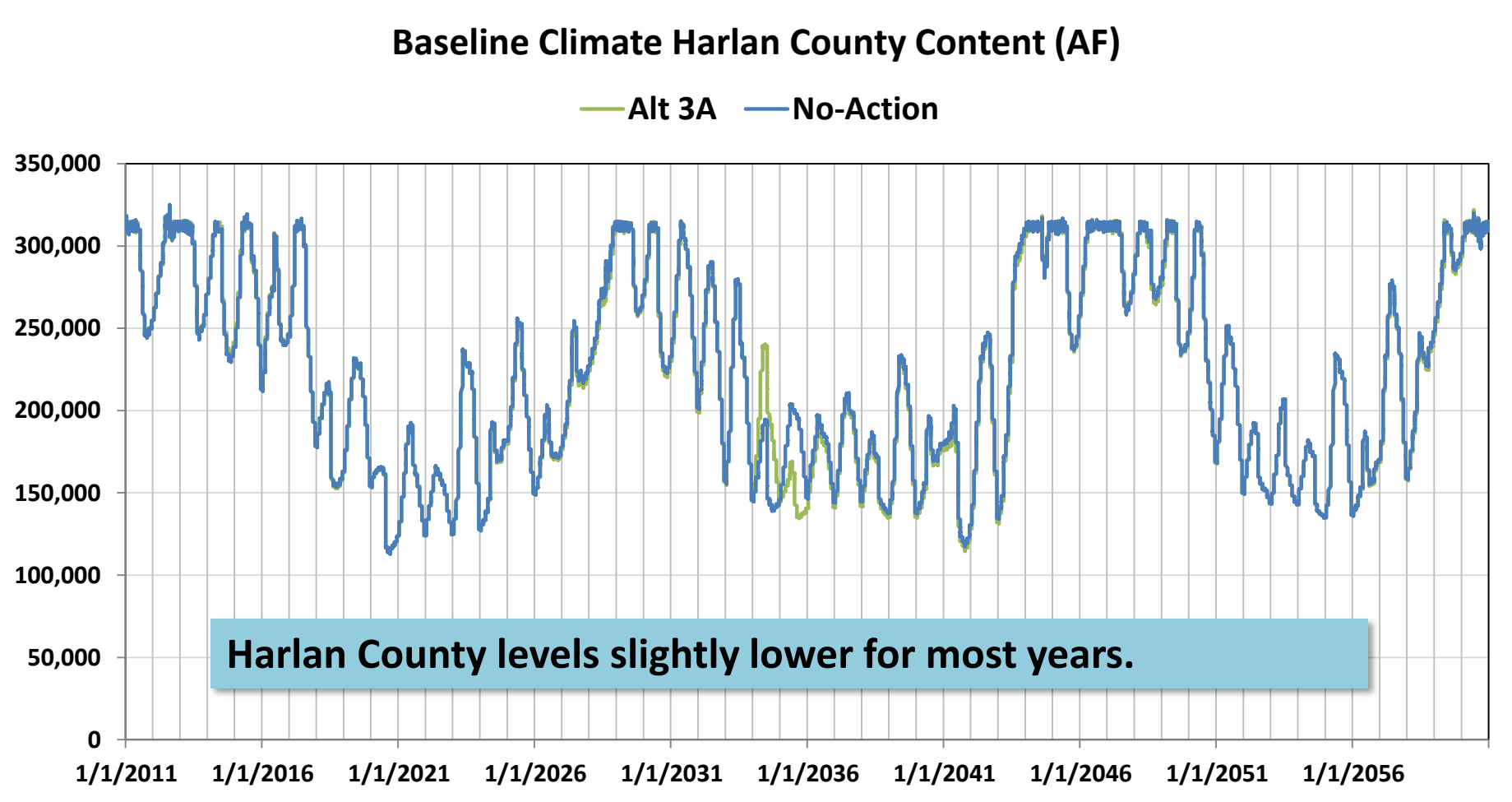
(Frenchman Creek Source Option 3A)



Swanson Reservoir Pump-Back

Harlan County Lake Levels

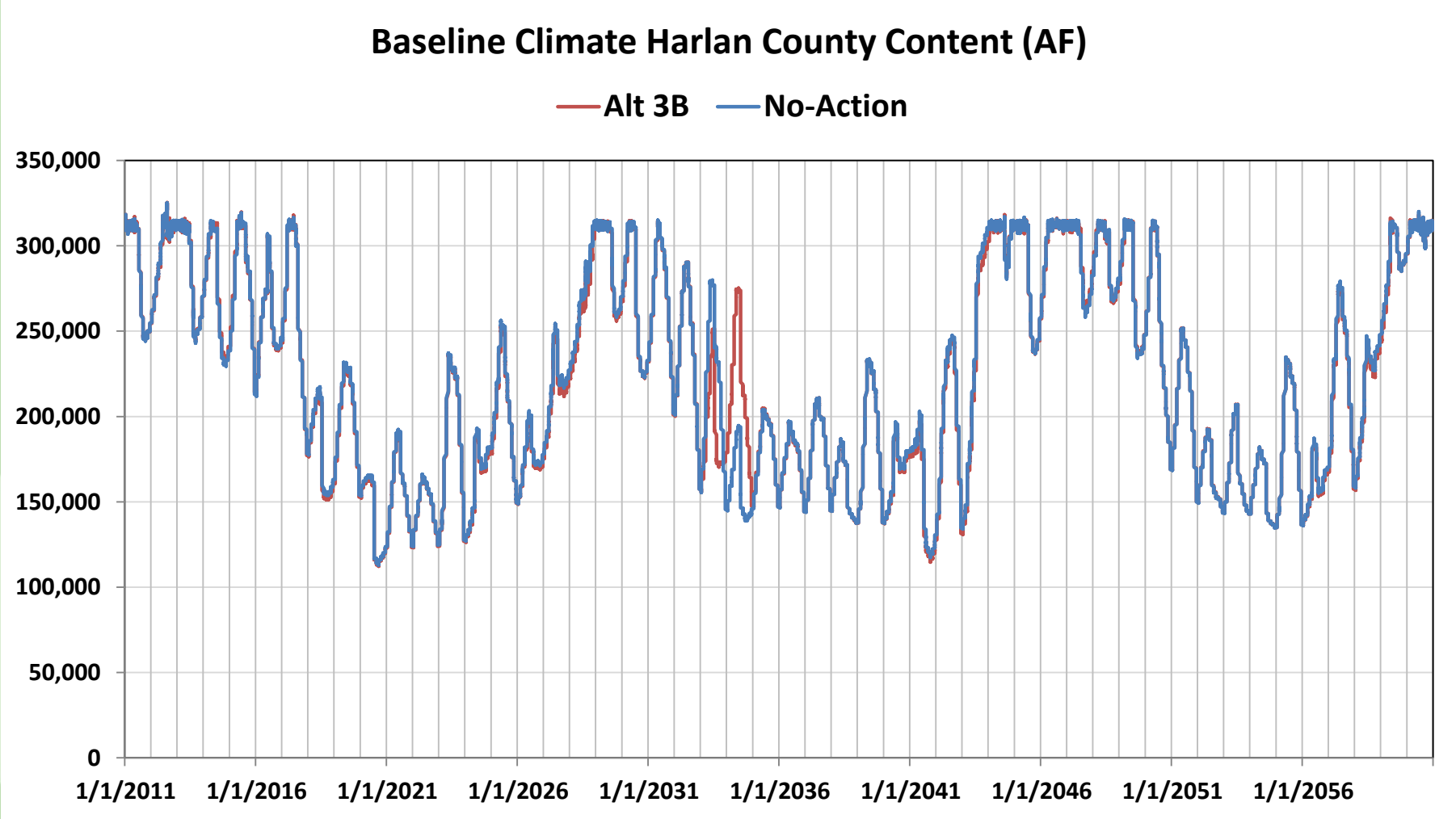
(Frenchman Creek Source Option 3A)



Swanson Reservoir Pump-Back

Harlan County Lake Levels

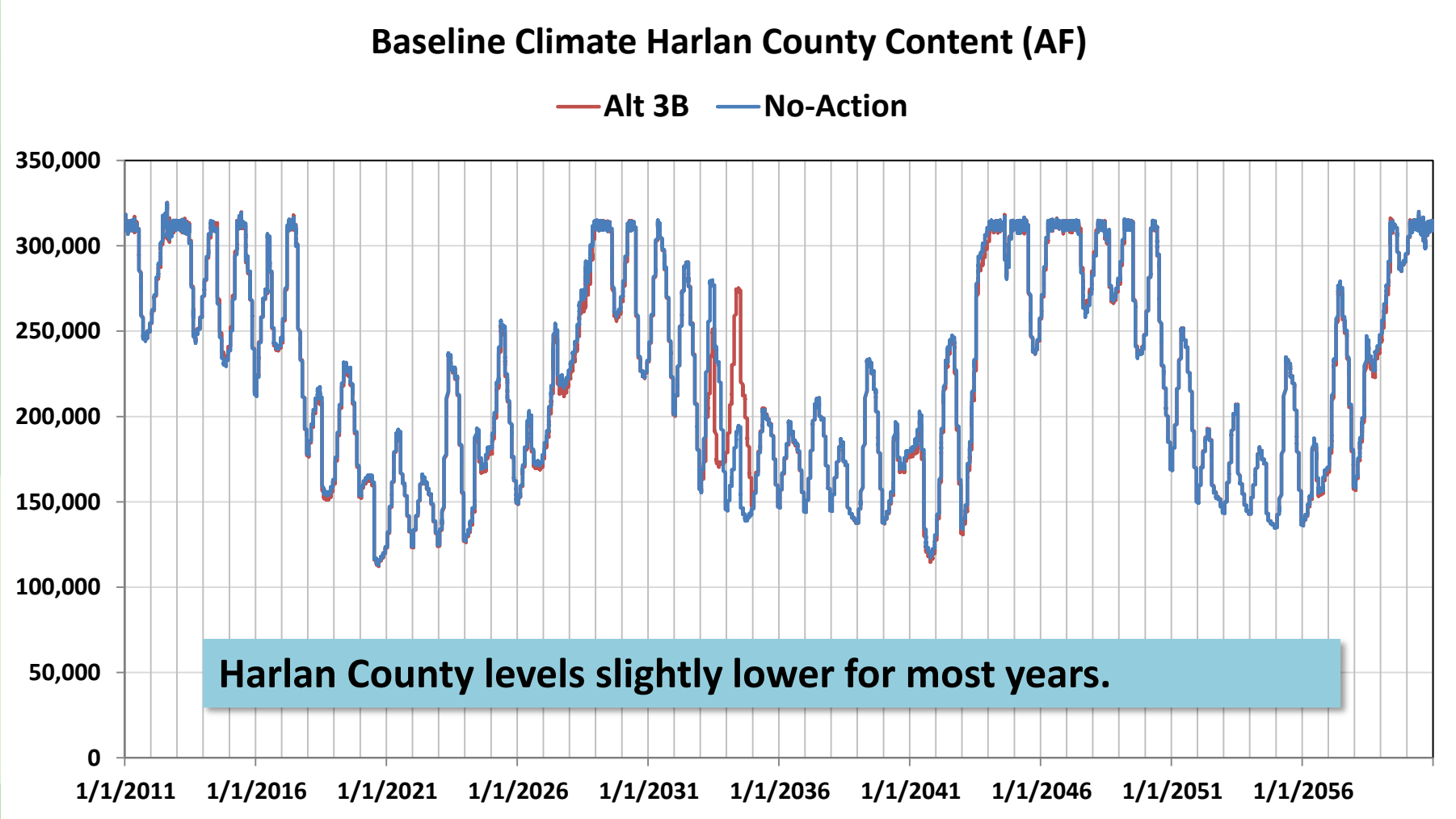
(Republican River Source Option 3B)



Swanson Reservoir Pump-Back

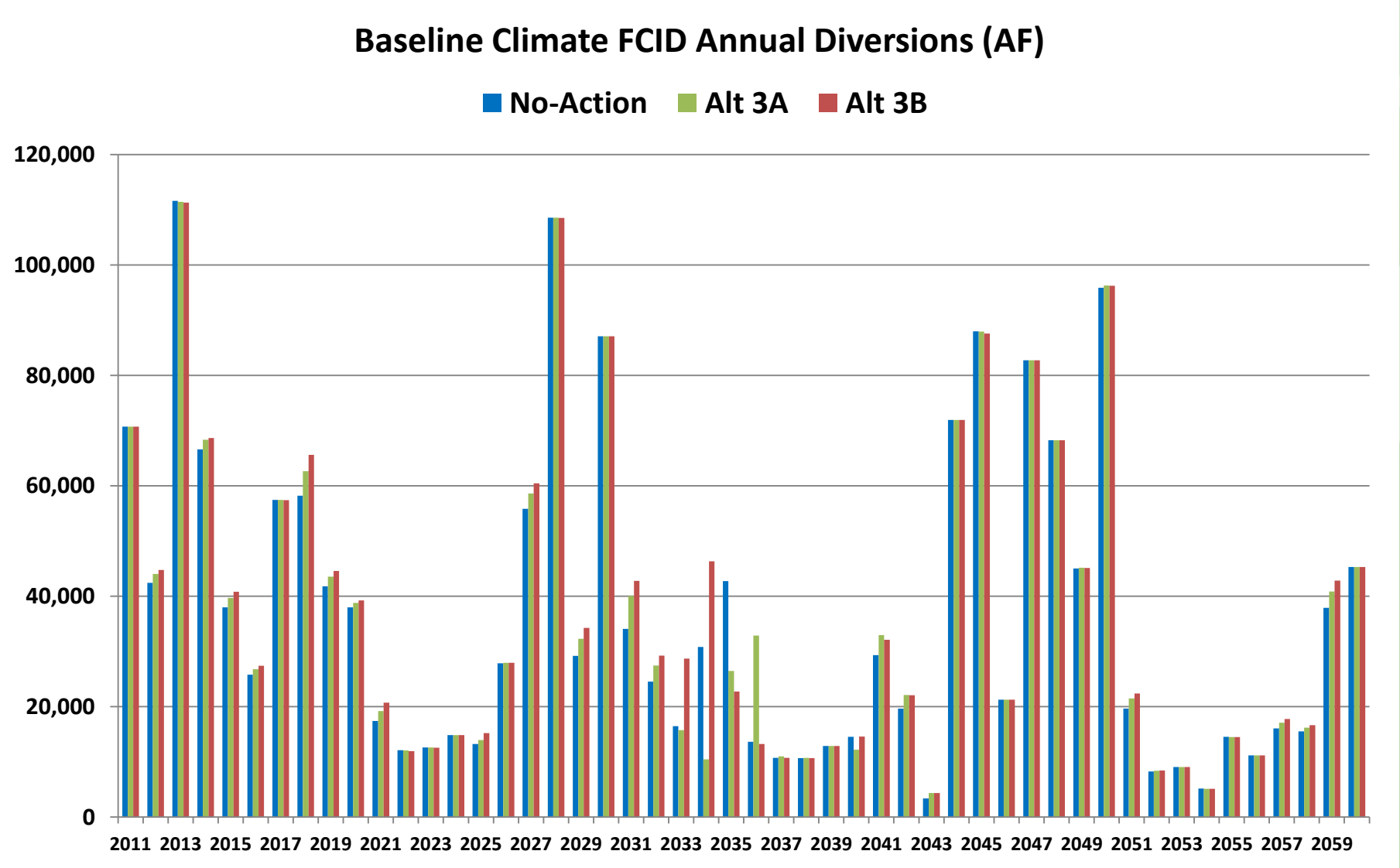
Harlan County Lake Levels

(Republican River Source Option 3B)



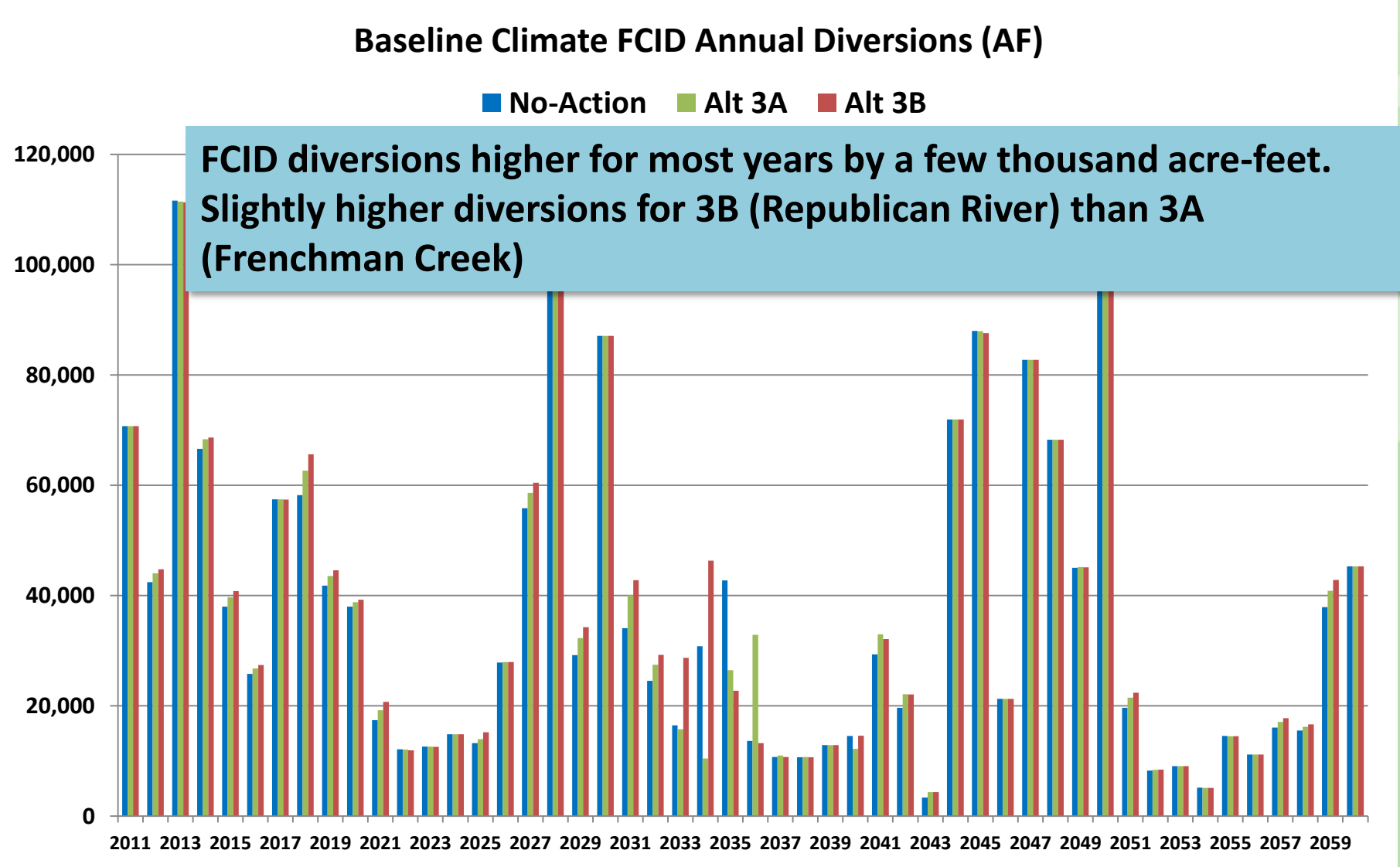
Swanson Reservoir Pump-Back

FCID Diversions



Swanson Reservoir Pump-Back

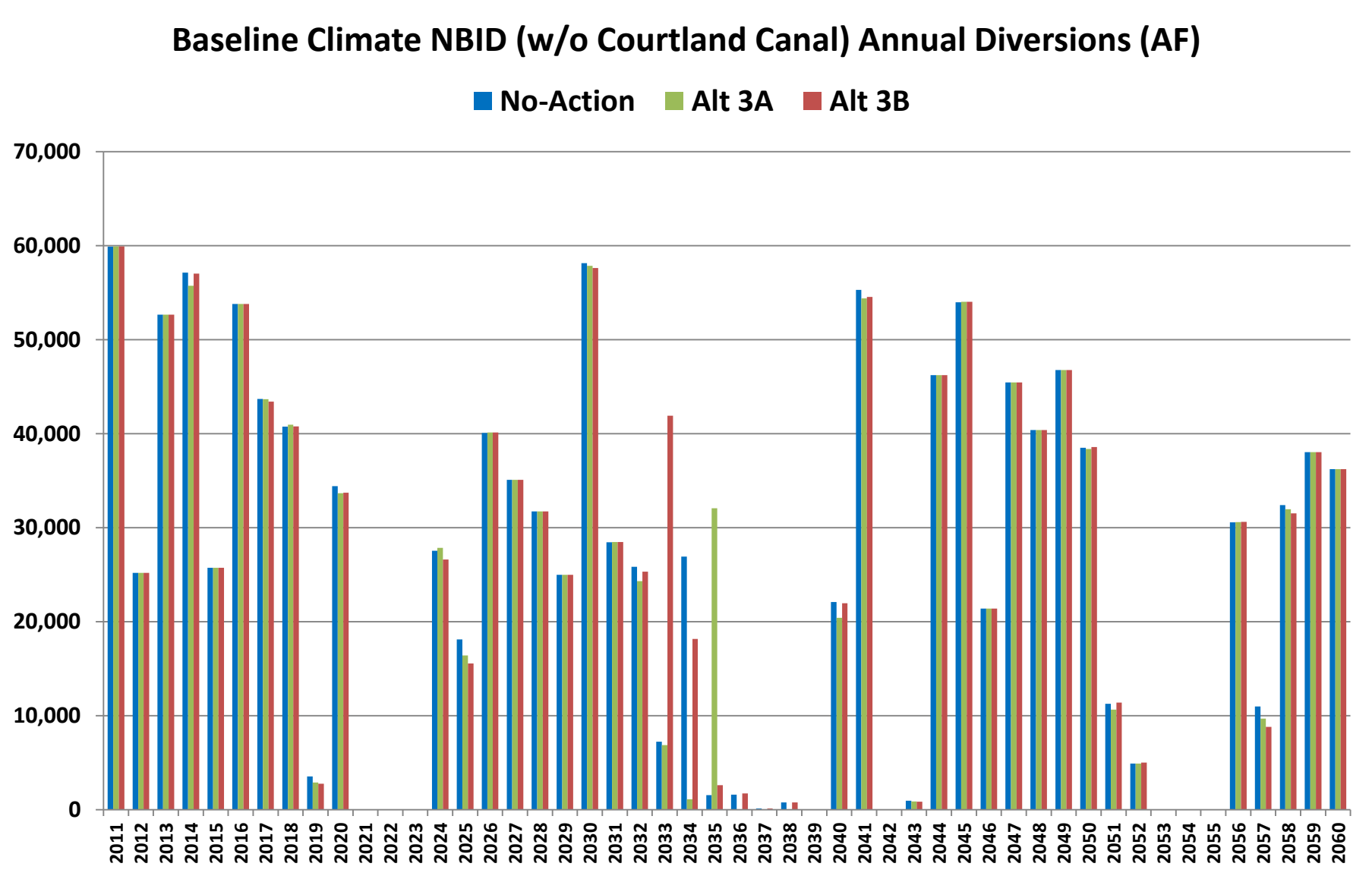
FCID Diversions



FCID diversions higher for most years by a few thousand acre-feet. Slightly higher diversions for 3B (Republican River) than 3A (Frenchman Creek)

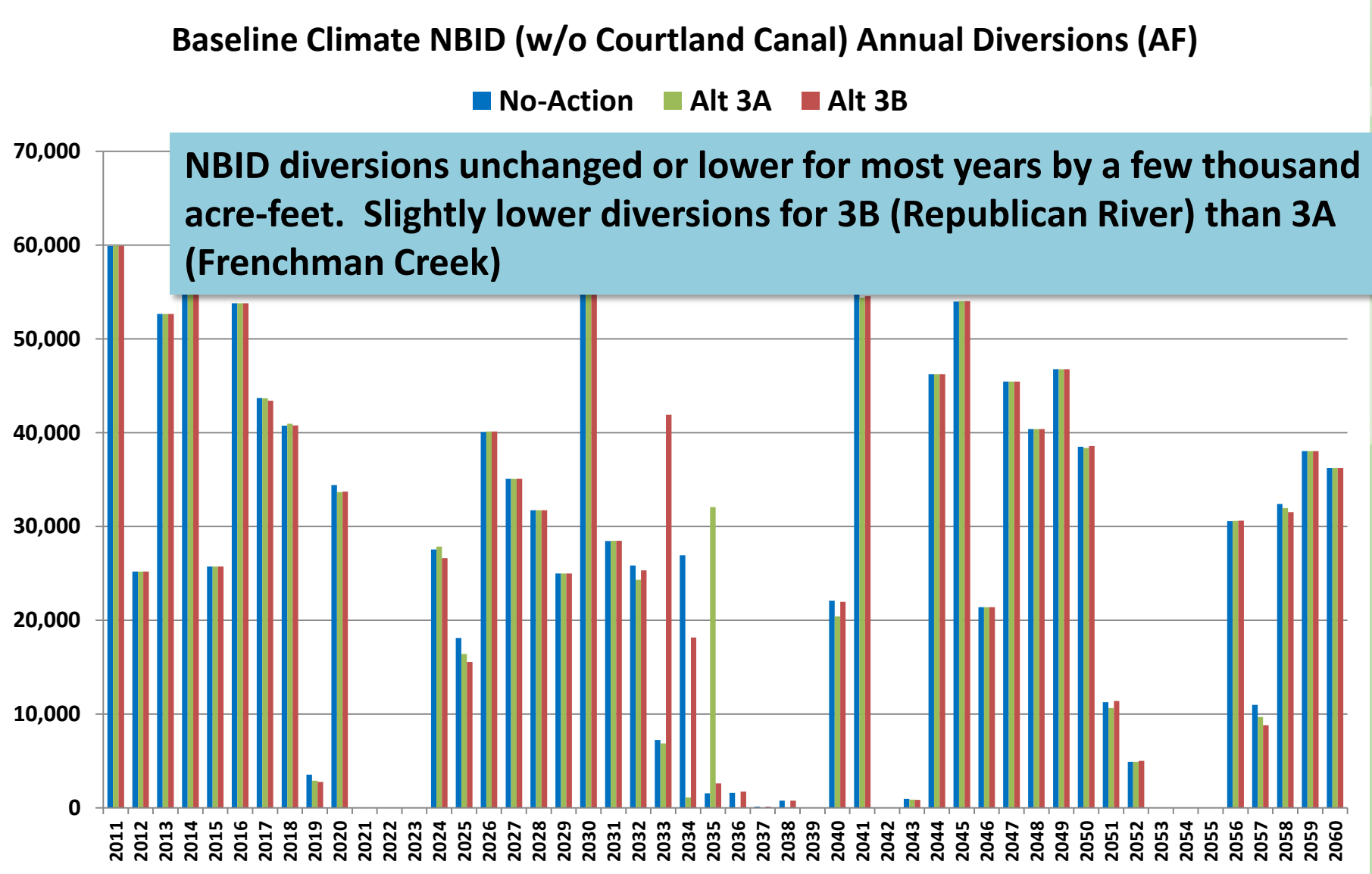
Swanson Reservoir Pump-Back

NBID Diversions



Swanson Reservoir Pump-Back

NBID Diversions



NBID diversions unchanged or lower for most years by a few thousand acre-feet. Slightly lower diversions for 3B (Republican River) than 3A (Frenchman Creek)

Swanson Reservoir Pump-Back

Evaluation Metrics

	No Action	3A – Frenchman Pumpback	3B – Republican River Pumpback
Compact Call Years	23	23	23
Pump-back diversions	NA	~3,200 af for Non-Compact Call Years	~5,300 af for Non-Compact Call Years
Swanson Lake Levels	No Action Baseline	~7,000 af Higher	~10,000 af Higher
Harlan Lake Levels	No Action Baseline	Slightly Lower	Slightly Lower
FCID Diversions	No Action Baseline	A few thousand af higher	A few thousand af higher
NBID Diversions*	No Action Baseline	A few thousand af lower	A few thousand af lower
Cost	NA	$72 Million	$164 Million

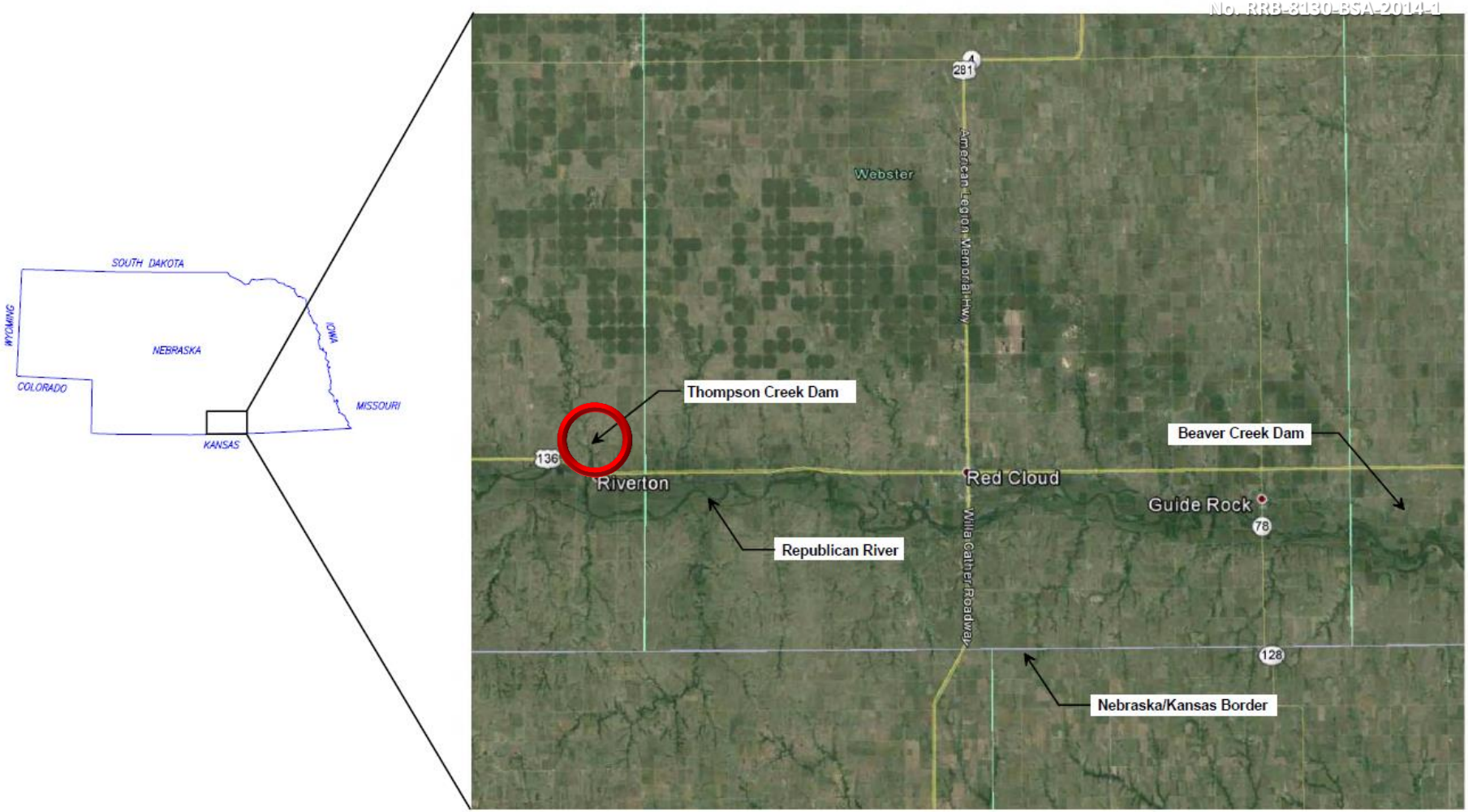
* Not including Nebraska Courtland Canal

Downstream Exchange for Harlan County Lake

- New reservoirs located below Harlan County Lake
- Provide an alternative supply source for NBID, allowing Harlan County Lake to stay more full
- Could reduce occurrence of Water Short Years
- Potential tool for Compact Compliance
- Potential recreation benefits for both new reservoir and Harlan County Lake
- Locations above and below Guide Rock Diversion Dam considered

Downstream Exchange for Harlan County Lake

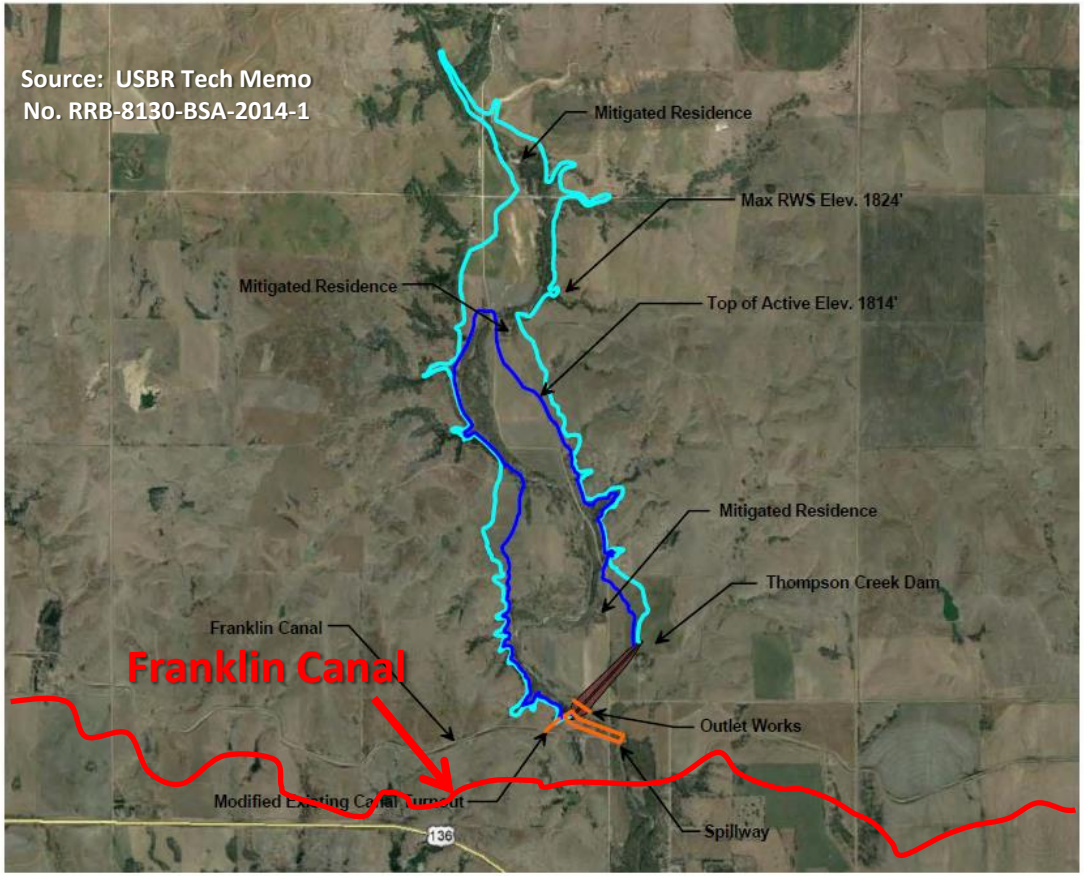
Source: USBR Tech Memo No. RRB-8130-BSA-2014-1



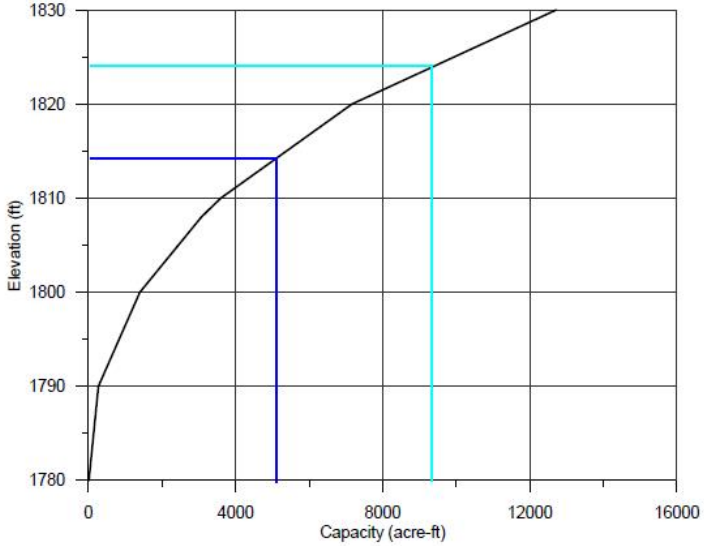
Dam Site Location Map

Notes: 1) Aireal image from Google Earth

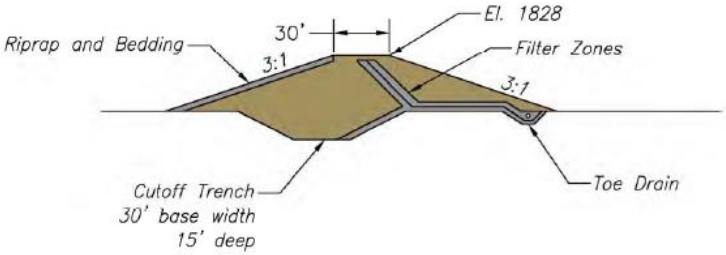
Thompson Creek Dam



Thompson Creek Dam Plan



Reservoir Capacity



Preliminary Dam Cross Section

Thompson Creek Dam

- New storage of 5,000 af
- Allowed to store water during non-irrigation season for Non-Compact Call Years
- Pumping plant required to allow for Franklin Canal connection (up to 11.1 cfs)
- Outlet to Creek would have capacity over 400 cfs

Thompson Creek Dam

Evaluation Metrics

- Number of Compact Call Years
- Franklin Canal Diversions/Releases from Thompson Creek Reservoir
- Thompson Creek Reservoir Levels
- Harlan County Lake Storage Levels
- NBID Irrigation Diversions (w/o Courtland Canal)
- FCID Irrigation Diversions
- Courtland Canal Flows (River Diversion and State Line)
- Guide Rock Flows
- Cost*

Thompson Creek Dam

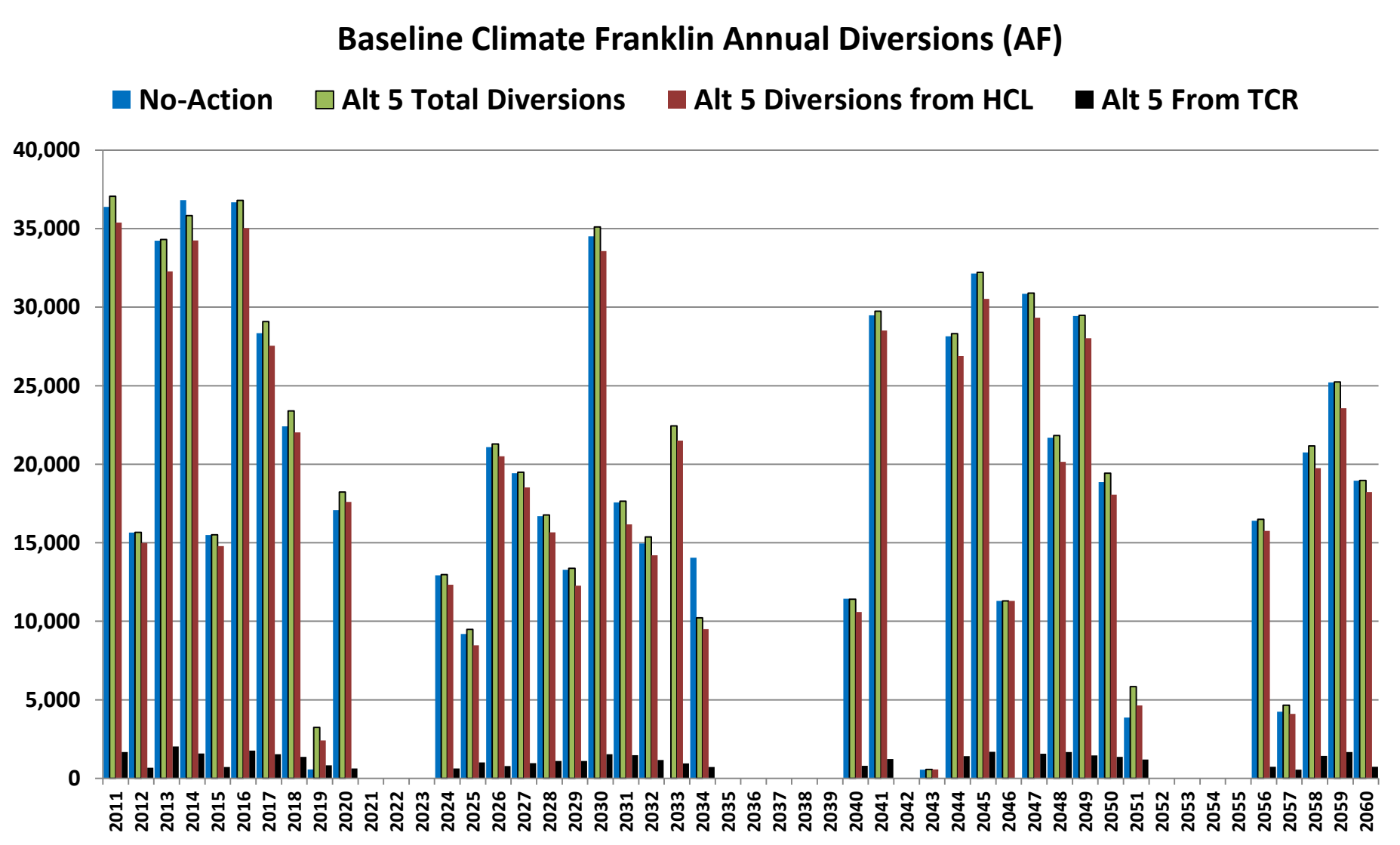
Compact Call Years

- 23 Compact Call Years for No Action
- 23 Compact Call Years for Thompson Creek Dam Alternative

Compact Call Years may switch, but total number unchanged

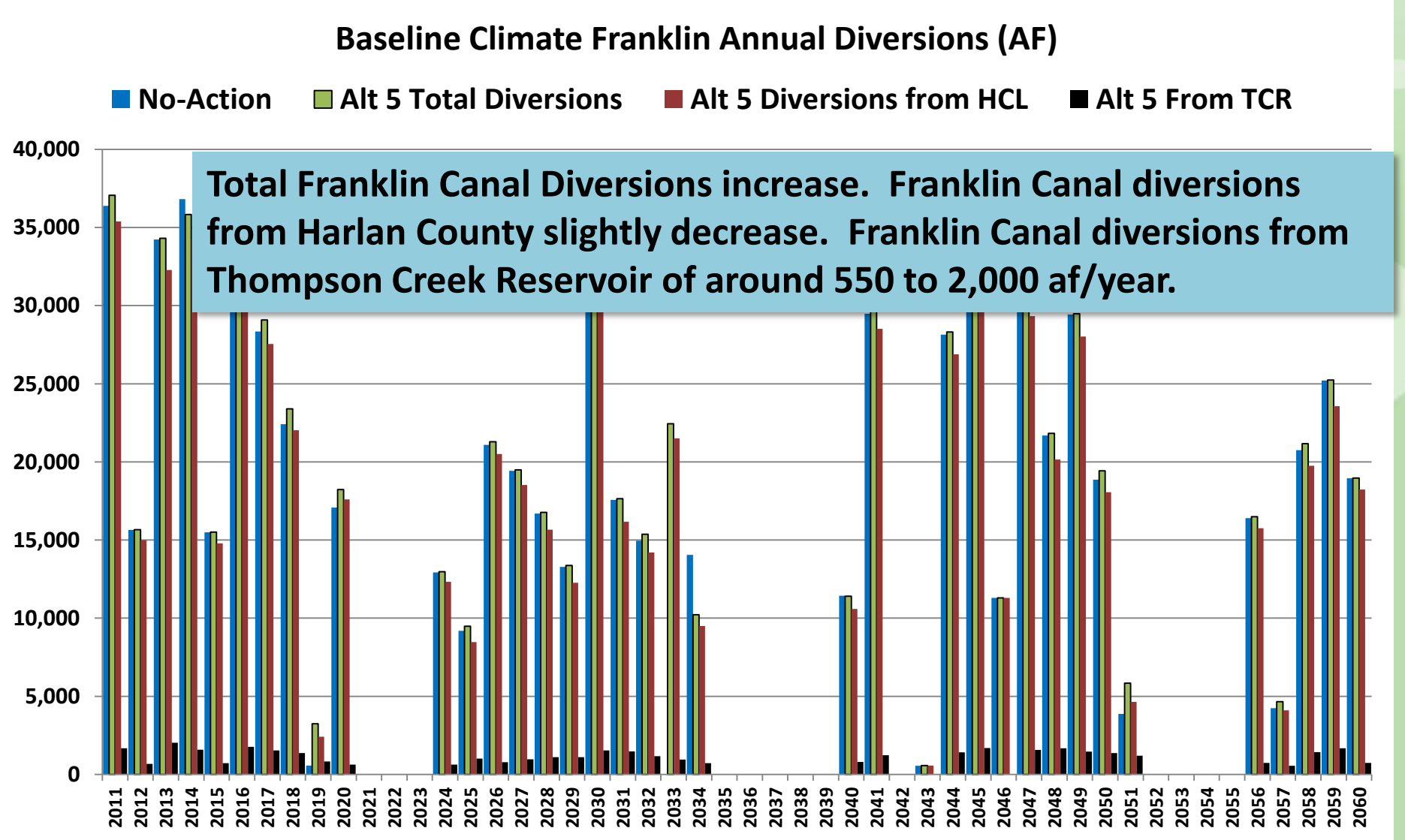
Thompson Creek Dam

Franklin Canal Diversions



Thompson Creek Dam

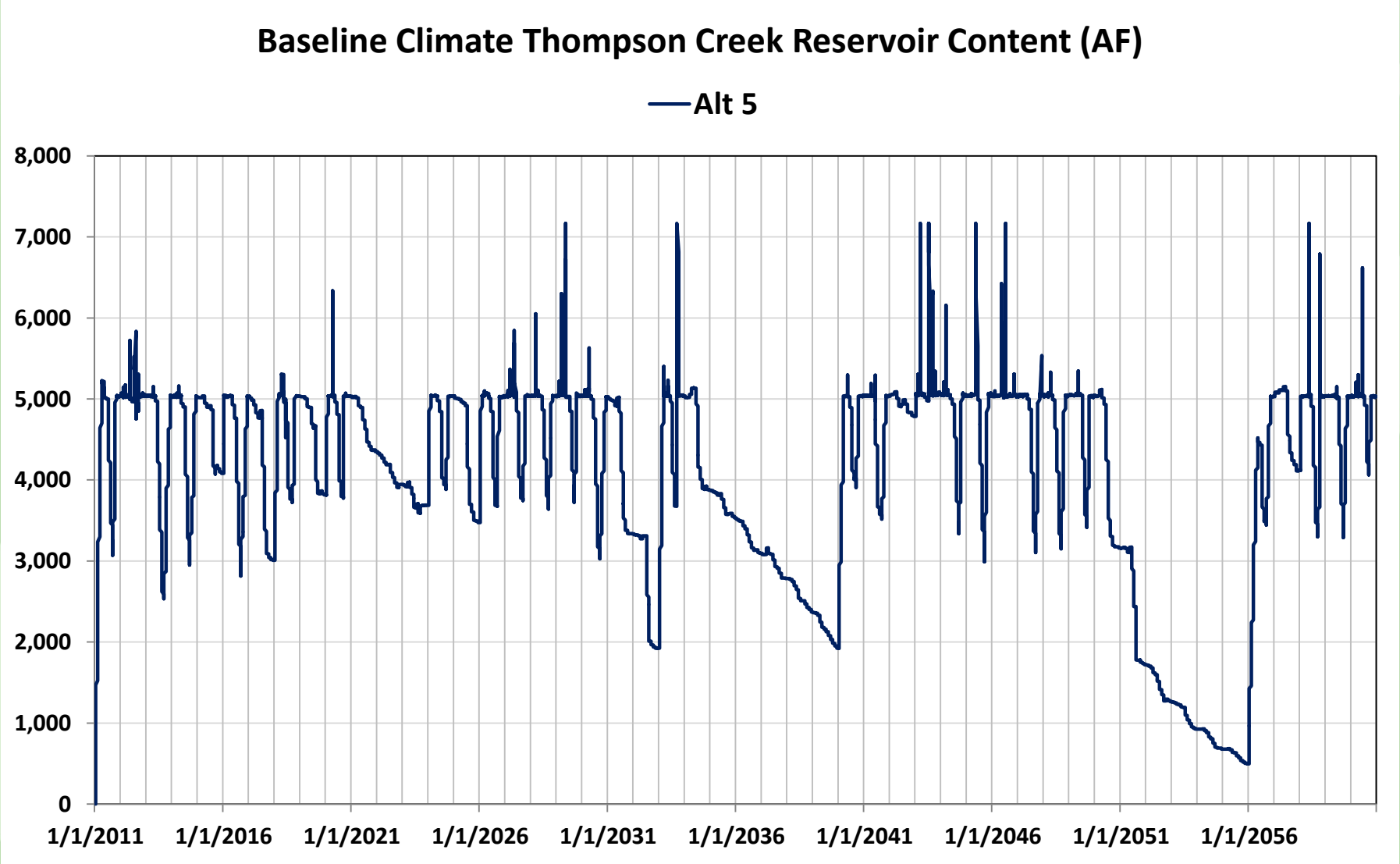
Franklin Canal Diversions



Total Franklin Canal Diversions increase. Franklin Canal diversions from Harlan County slightly decrease. Franklin Canal diversions from Thompson Creek Reservoir of around 550 to 2,000 af/year.

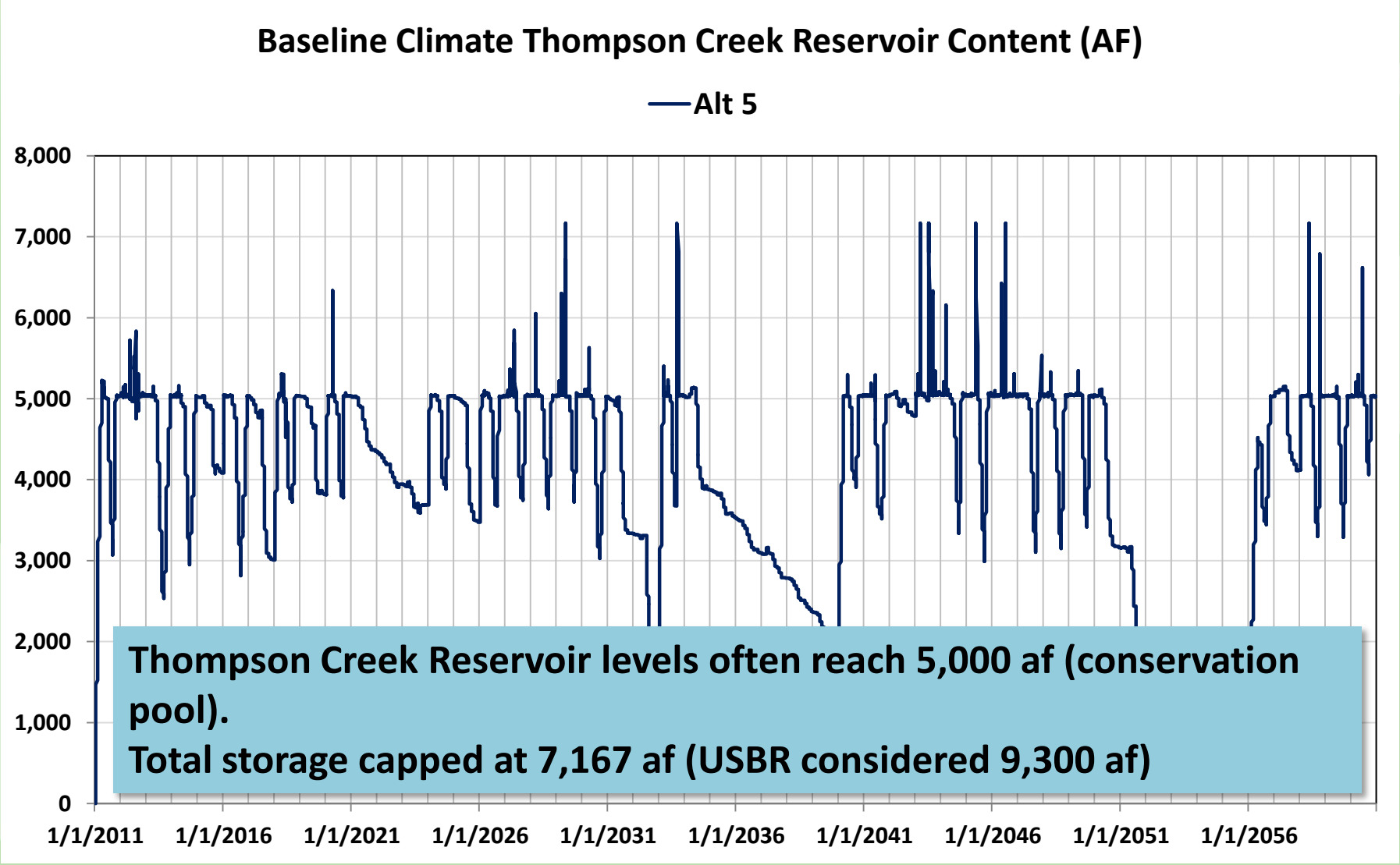
Thompson Creek Dam

Thompson Creek Reservoir Levels



Thompson Creek Dam

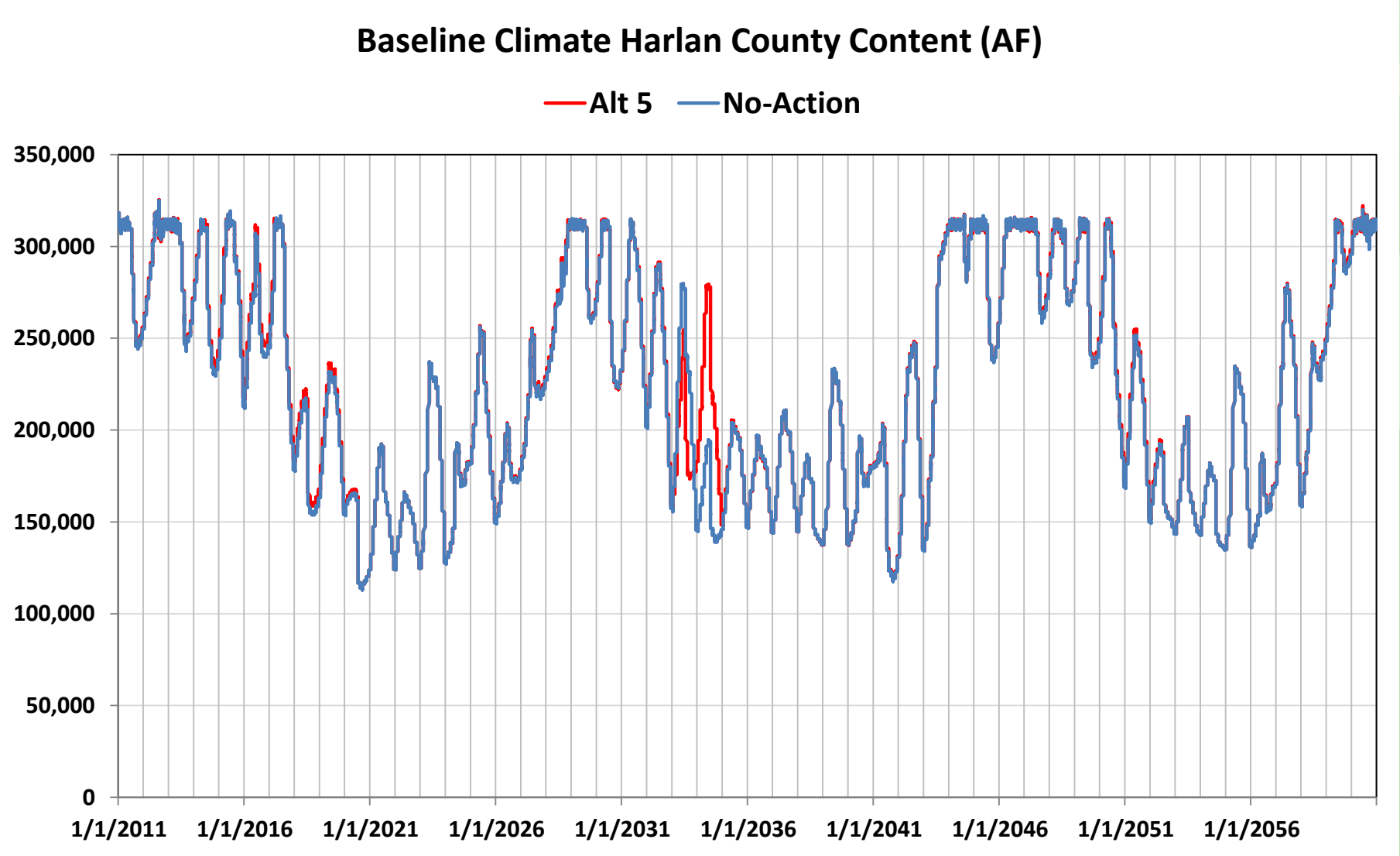
Thompson Creek Reservoir Levels



Thompson Creek Reservoir levels often reach 5,000 af (conservation pool).
Total storage capped at 7,167 af (USBR considered 9,300 af)

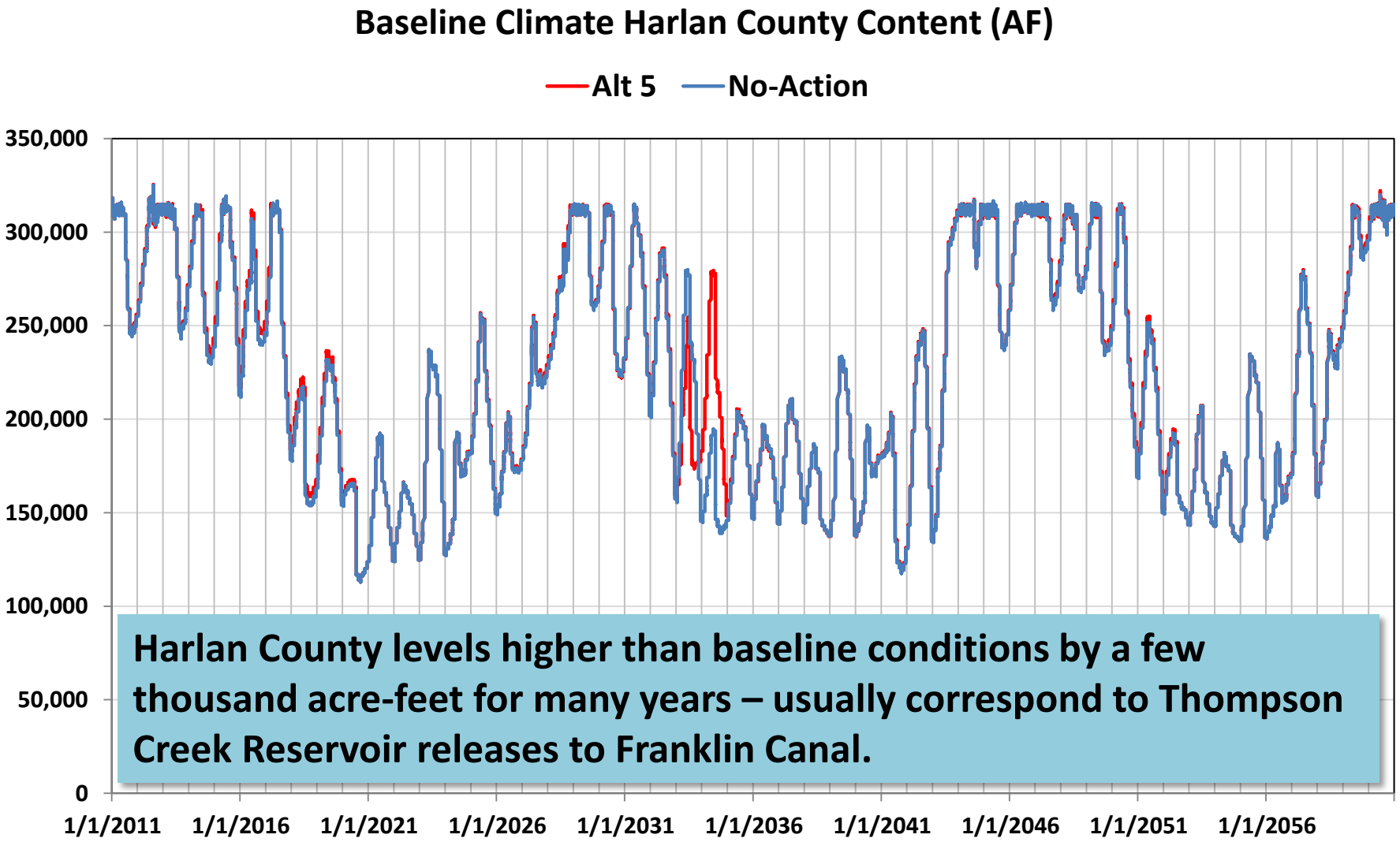
Thompson Creek Dam

Harlan County Lake Levels



Thompson Creek Dam

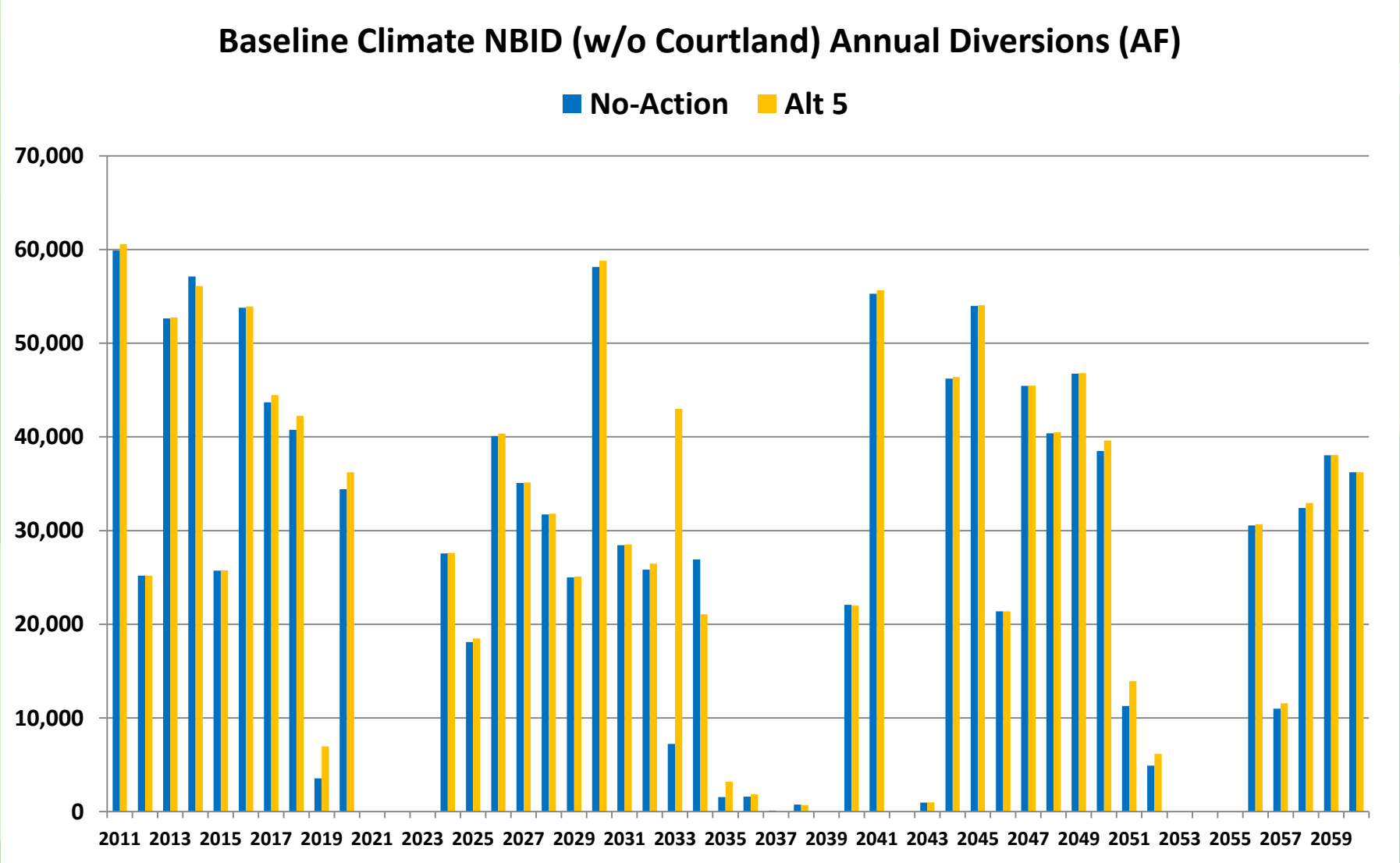
Harlan County Lake Levels



Harlan County levels higher than baseline conditions by a few thousand acre-feet for many years – usually correspond to Thompson Creek Reservoir releases to Franklin Canal.

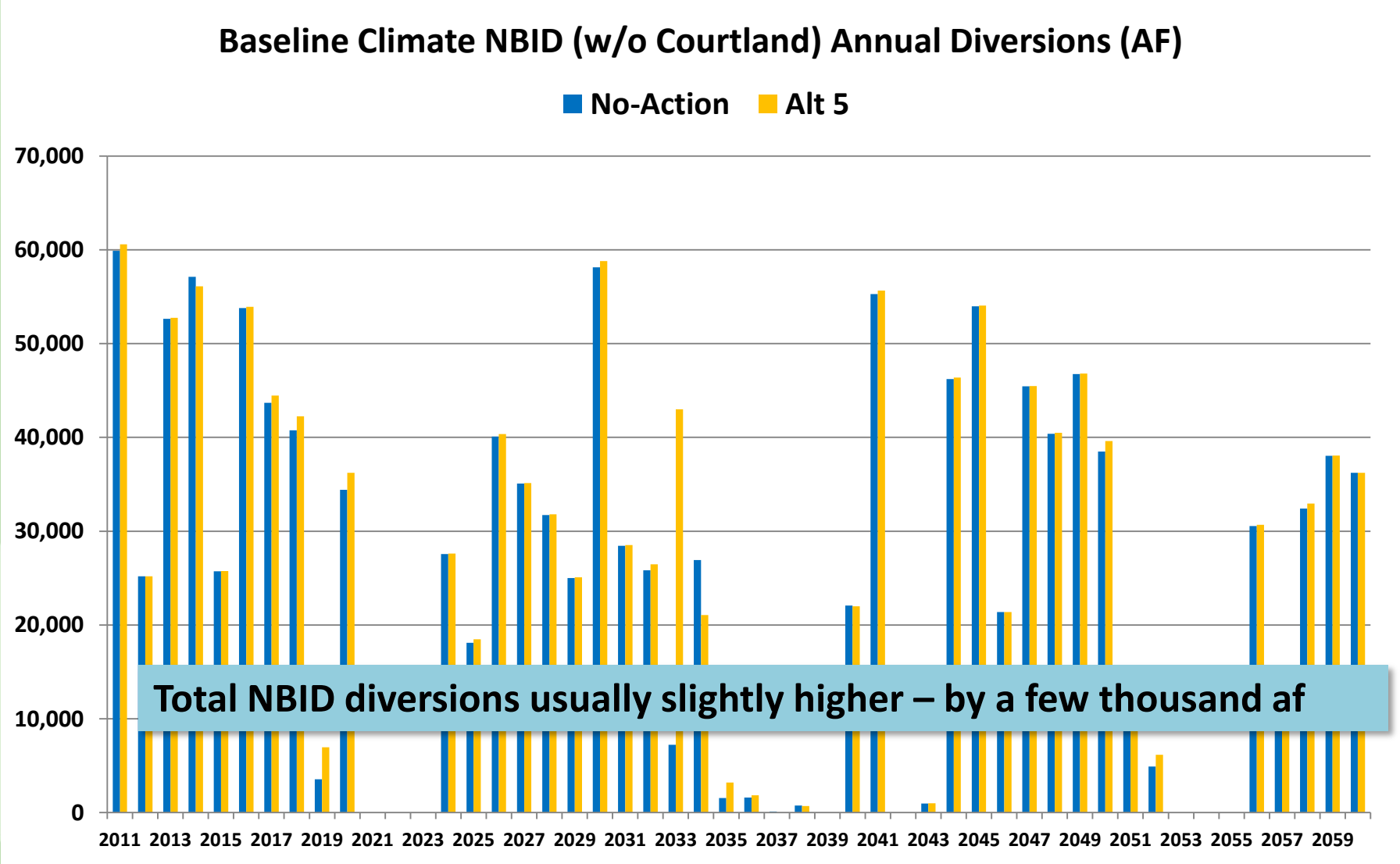
Thompson Creek Dam

Total NBID Diversions (w/o Courtland Canal)



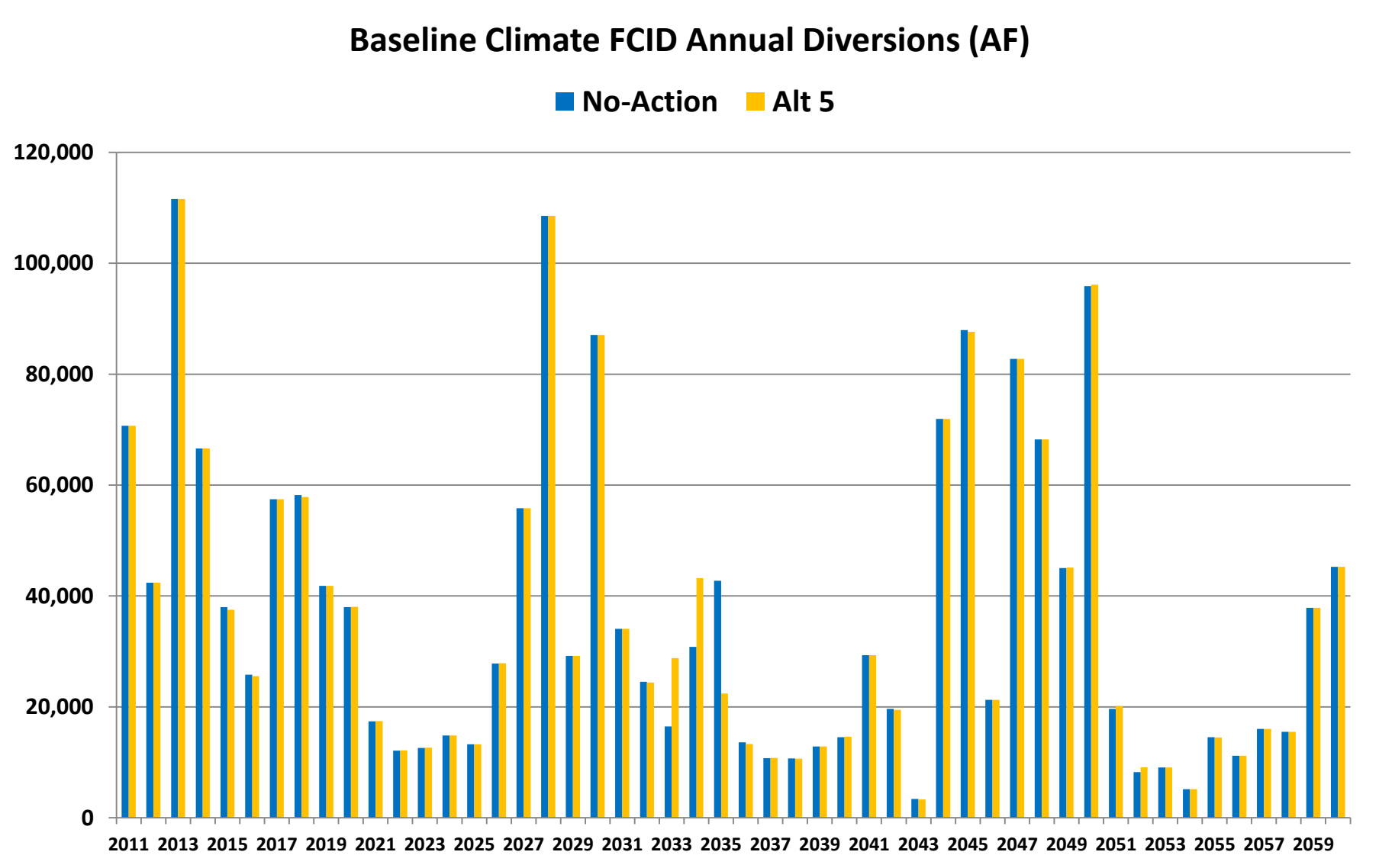
Thompson Creek Dam

Total NBID Diversions (w/o Courtland Canal)



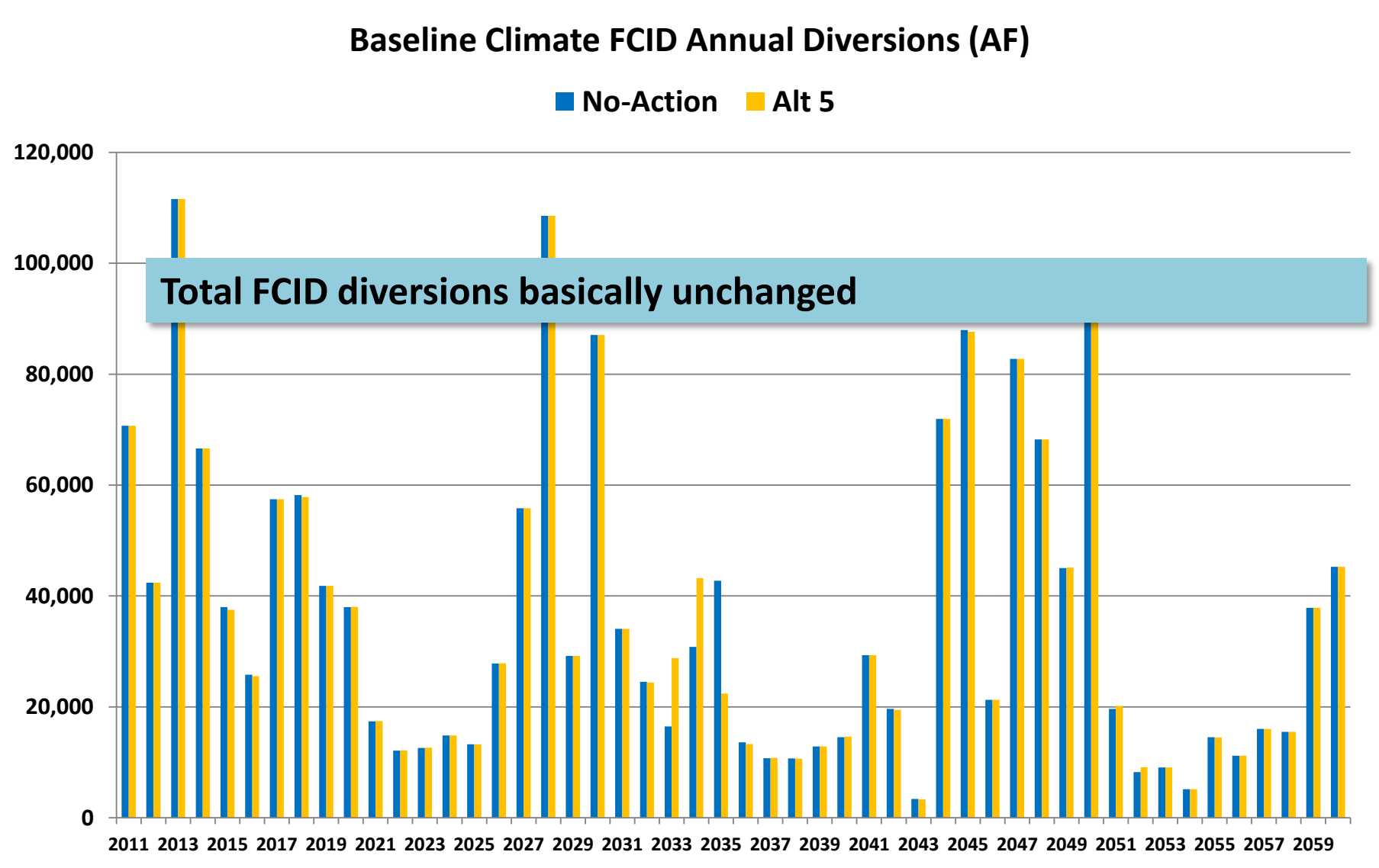
Thompson Creek Dam

Total FCID Diversions



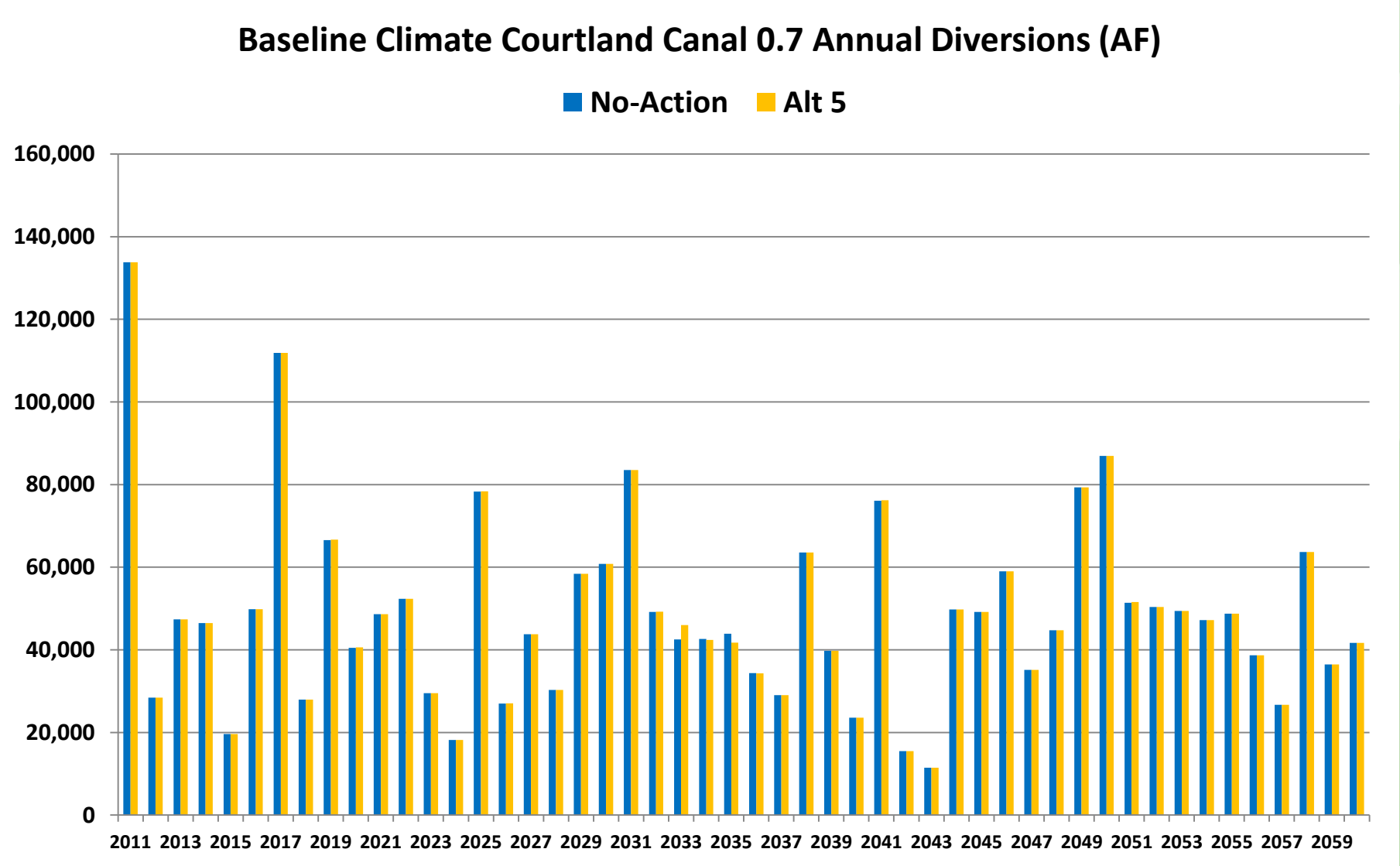
Thompson Creek Dam

Total FCID Diversions



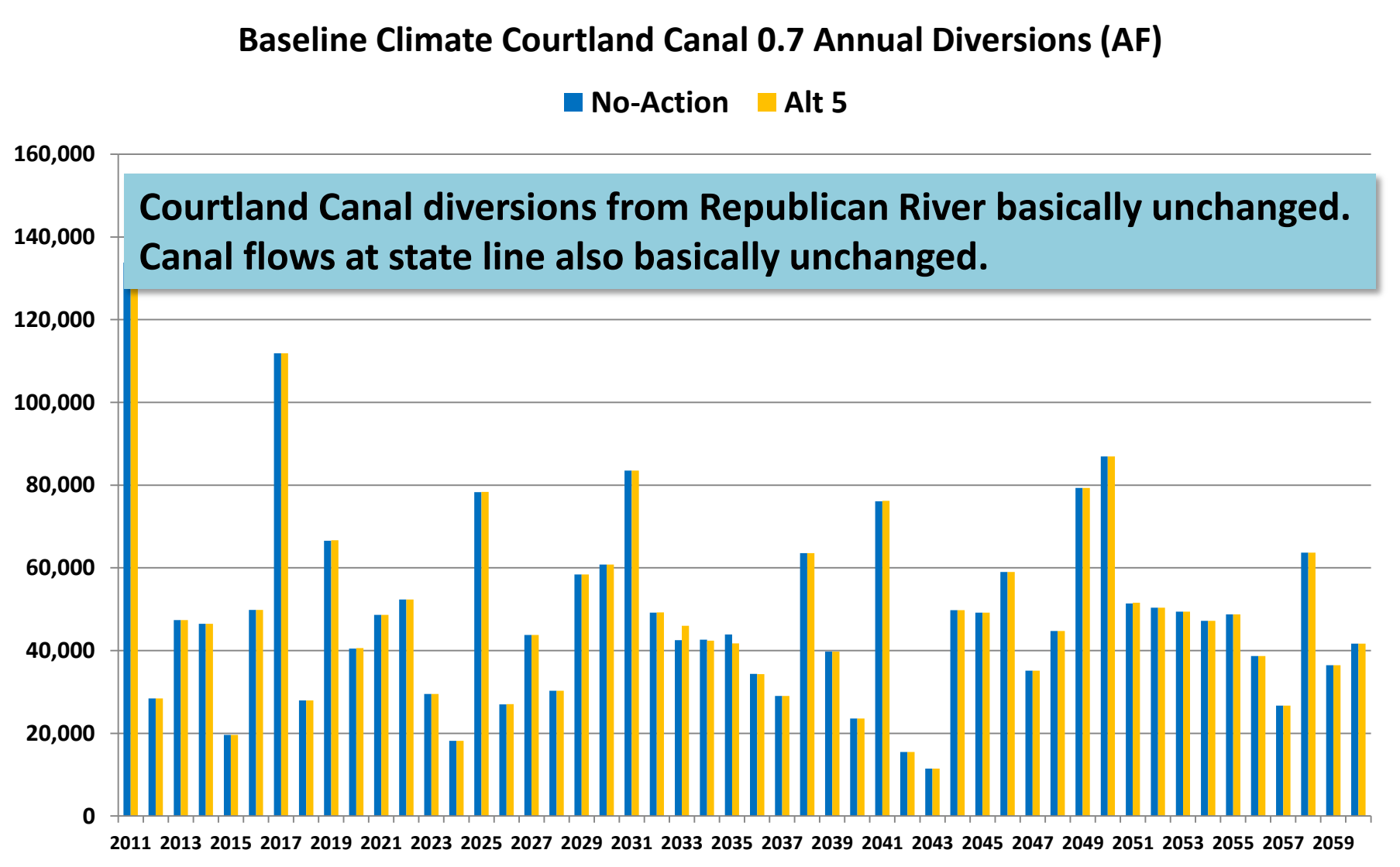
Thompson Creek Dam

Courtland Canal River Diversions



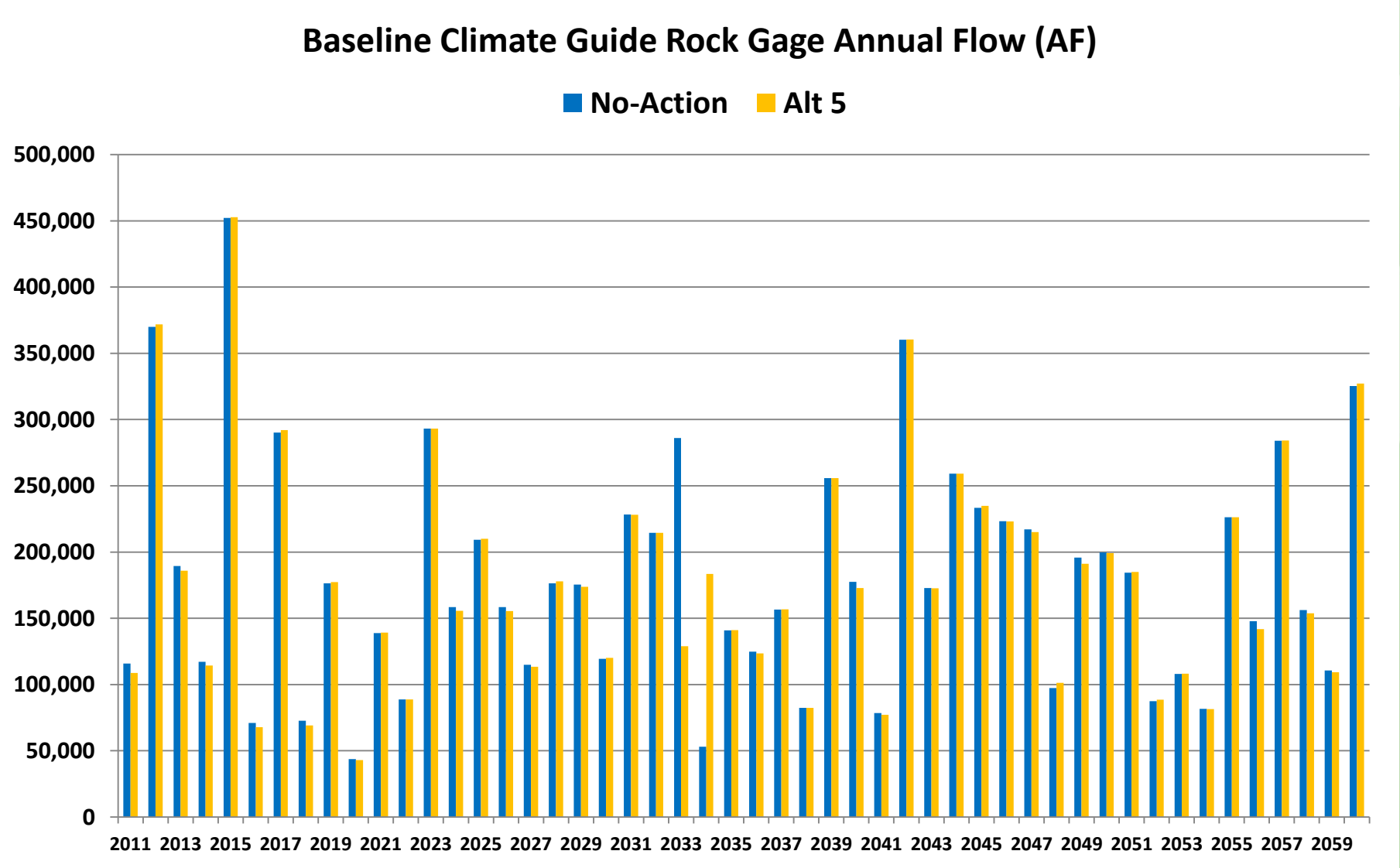
Thompson Creek Dam

Courtland Canal River Diversions



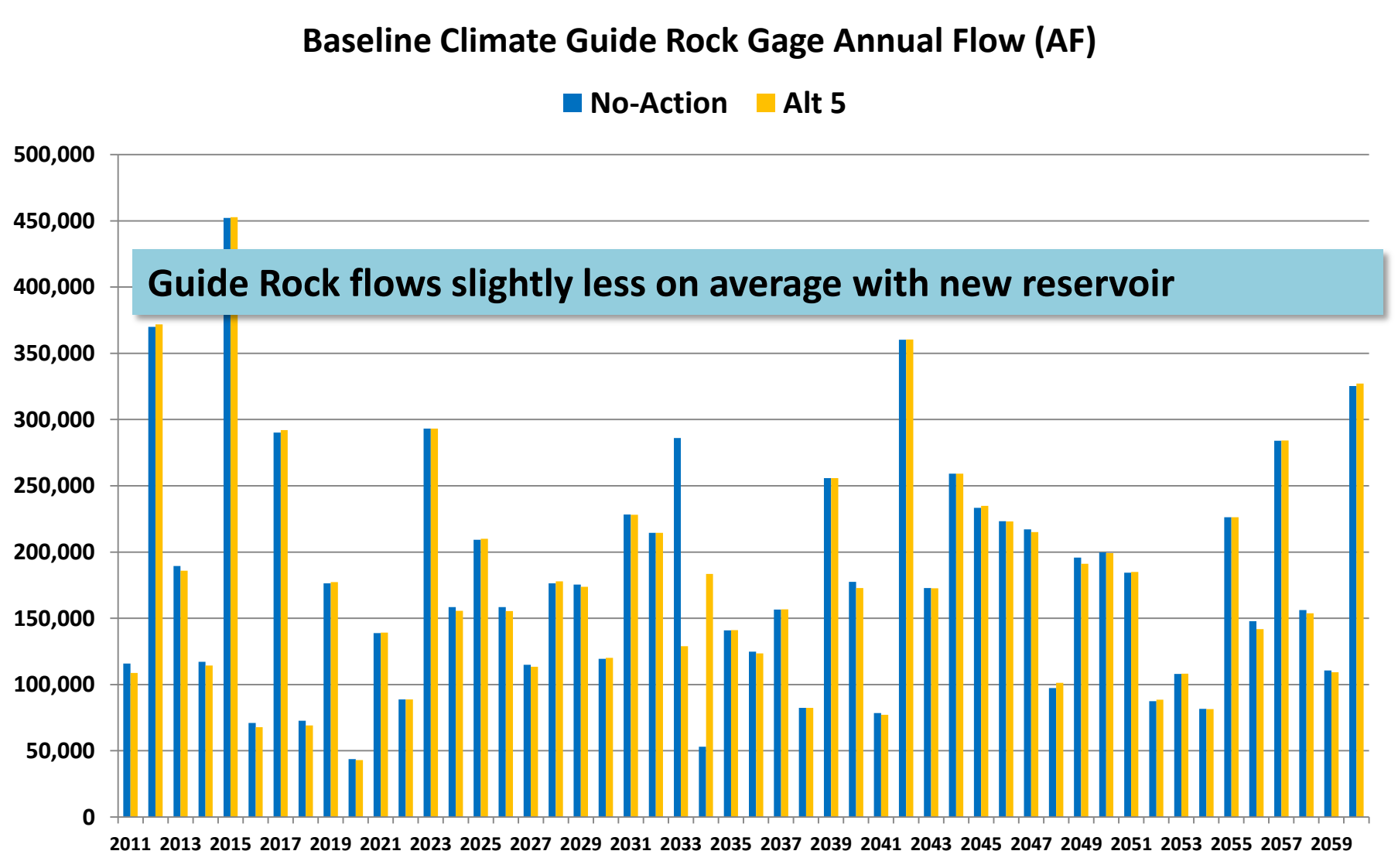
Thompson Creek Dam

Guide Rock Flows



Thompson Creek Dam

Guide Rock Flows



Guide Rock flows slightly less on average with new reservoir

Thompson Creek Dam

Evaluation Metrics

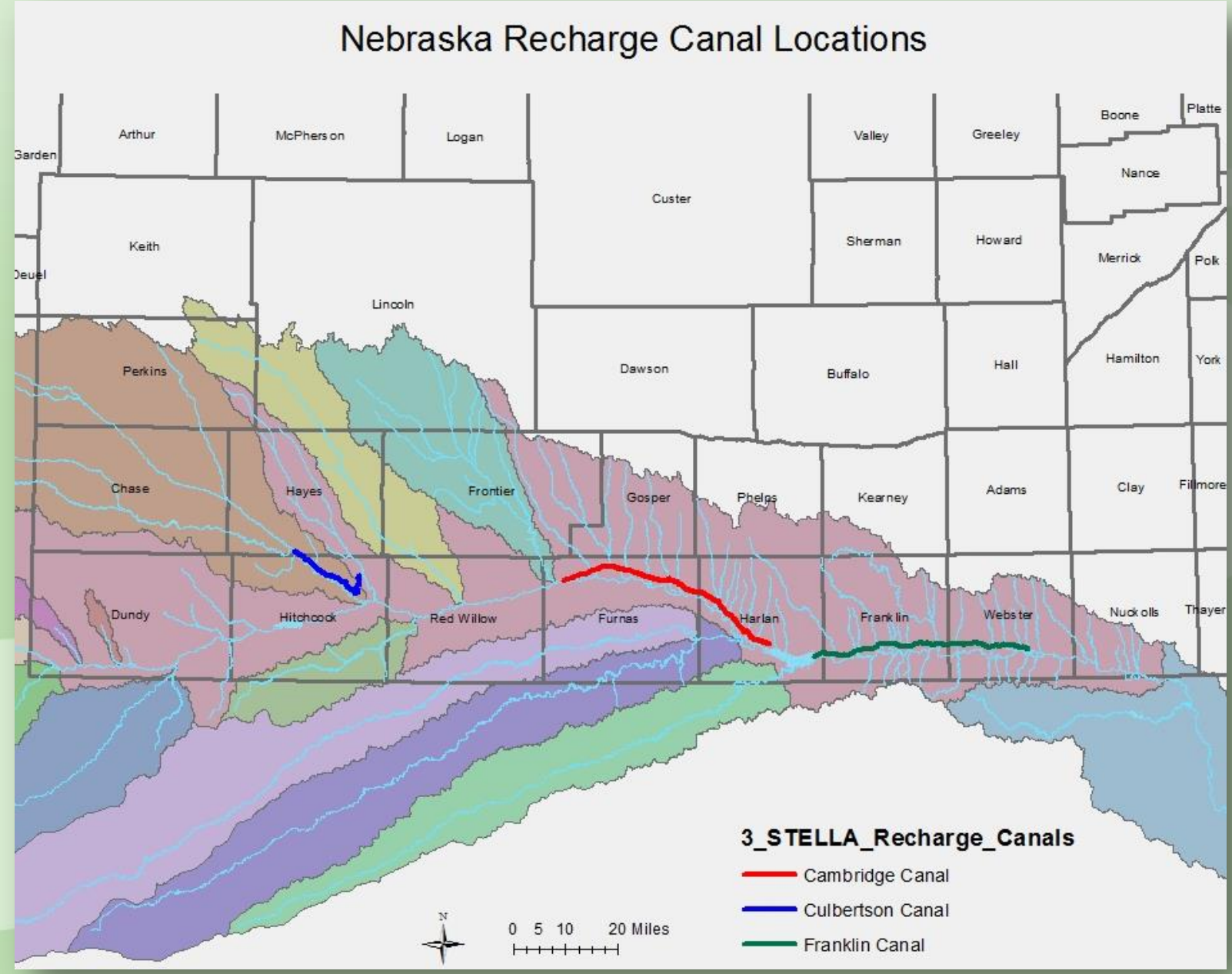
	No Action	Alt 5 – Thompson Cr Dam
Compact Call Years	23	23
Total Franklin Canal Diversions	Baseline	Slight Increase
Thompson Creek Dam Releases to Franklin Canal	NA	550 af to about 2,000 af per year
Thompson Creek Reservoir Levels	NA	Varies – often 5,000 af
Harlan Lake Levels	Baseline	A few thousand af higher at times
NBID Diversions*	Baseline	Usually a few thousand af greater
FCID Diversions	Baseline	Basically unchanged
Courtland Canal Flows	Baseline	Basically unchanged
Guide Rock Flows	Baseline	Slight decrease
Cost	NA	$184 Milion

* Not including Nebraska Courtland Canal

Non-Irrigation Season Canal Recharge

- Four configurations considered, with 10,000 af total diversions:
  - Culbertson Canal
  - Cambridge Canal
  - Franklin Canal
  - All three canals
- Divert flows during non-irrigation season (Sep. 16 – May 14), for Non-Compact Call Years
- Retiming of supplies – returns back to the river delayed, mitigate damages from high flows

Non-Irrigation Season Canal Recharge

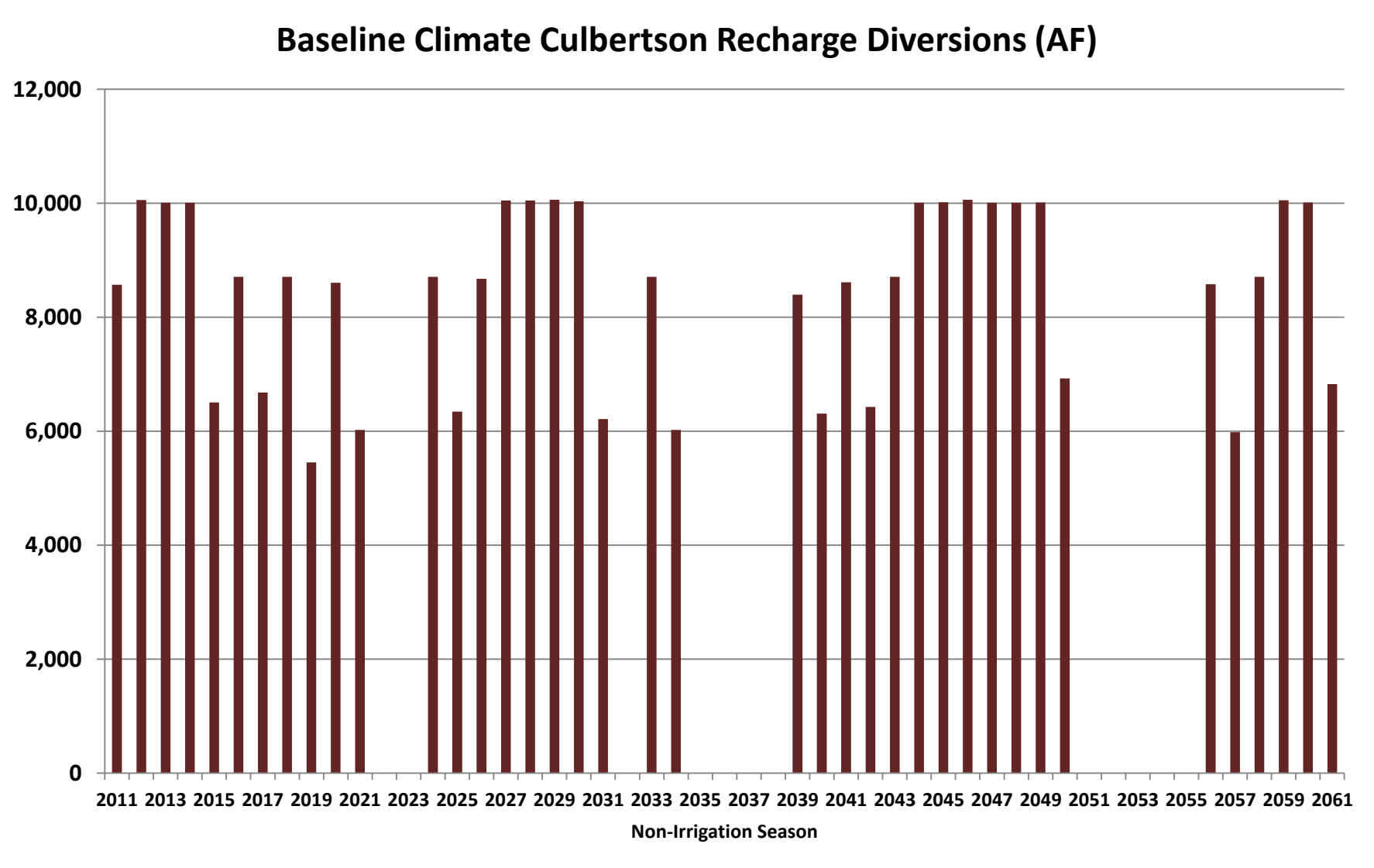


Non-Irrigation Season Canal Recharge

- Full analysis of recharge alternative not completed due to modeling and time limitations – linkage with ground water model
- Preliminary results were, however, obtained for potential recharge diversions from the river system

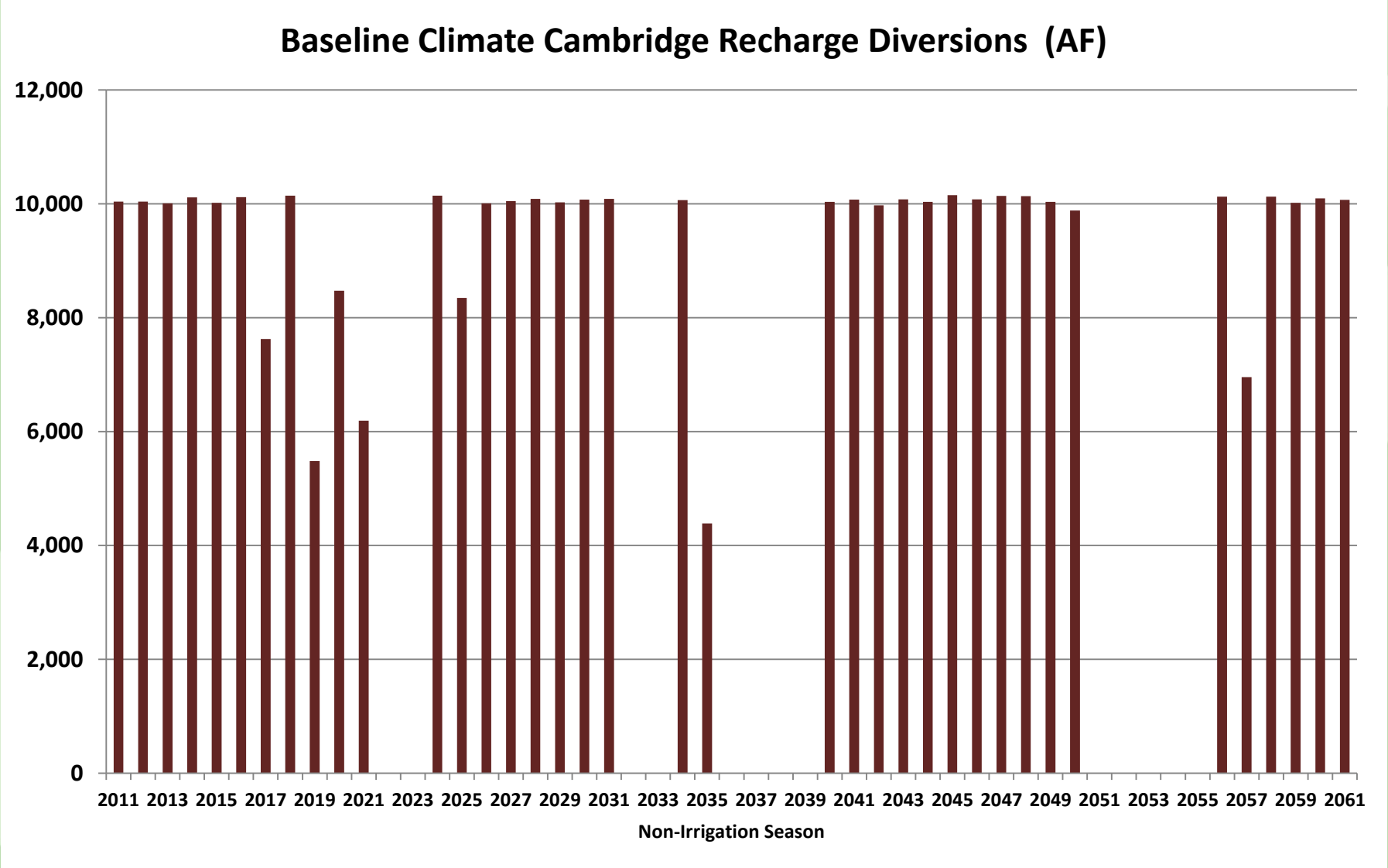
Non-Irrigation Season Canal Recharge

Culbertson Canal Recharge Diversions



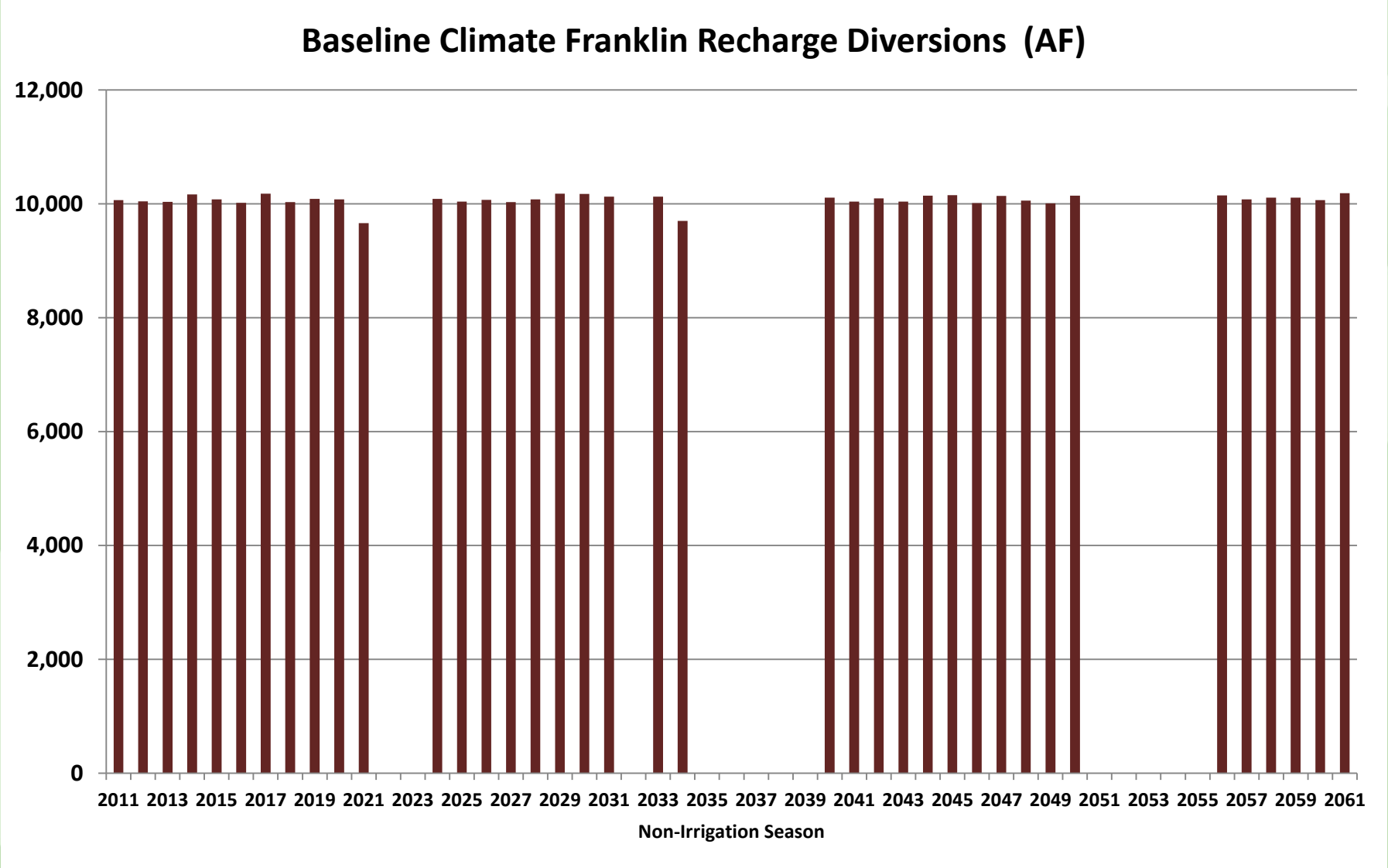
Non-Irrigation Season Canal Recharge

Cambridge Canal Recharge Diversions



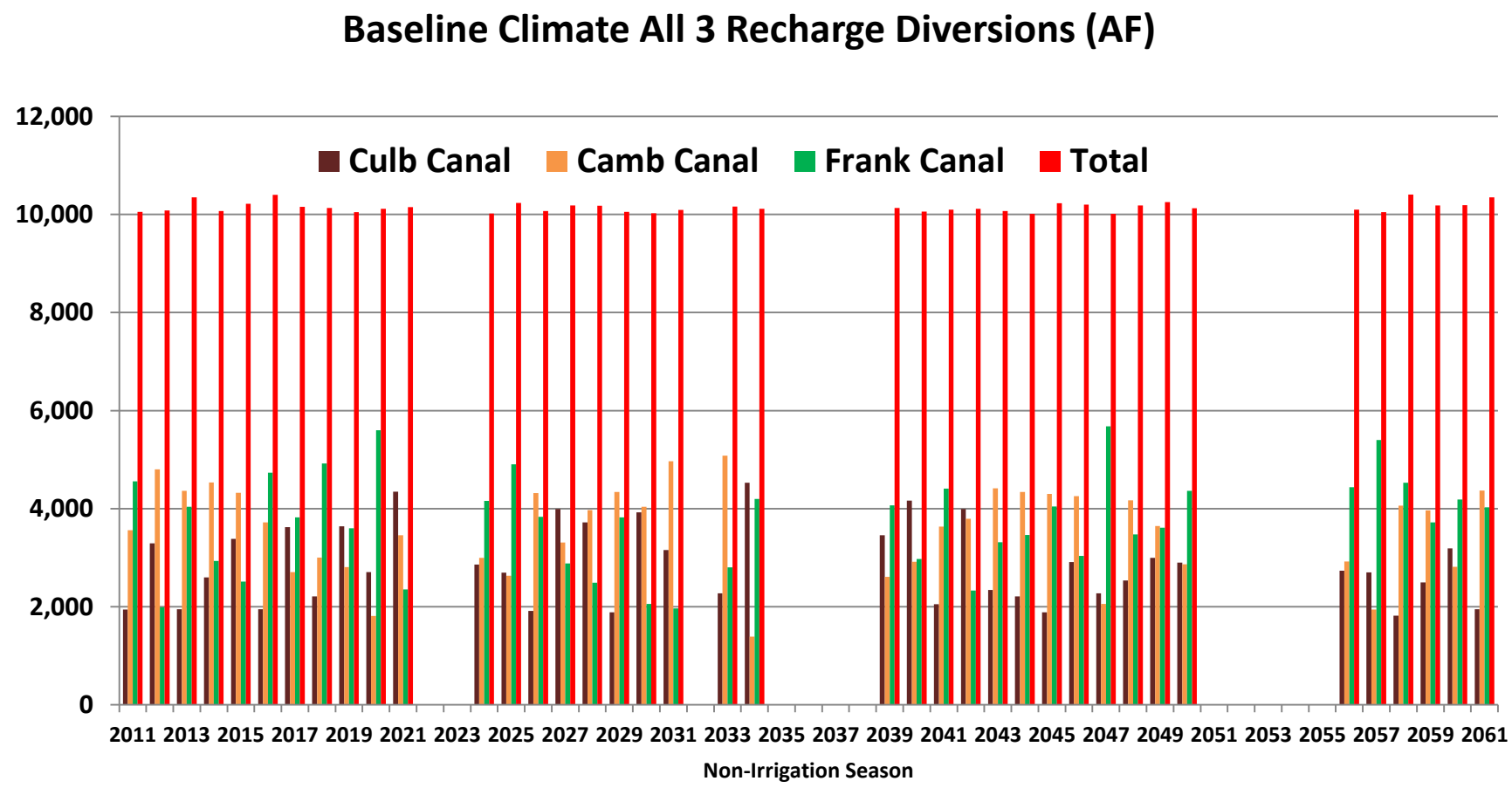
Non-Irrigation Season Canal Recharge

Franklin Canal Recharge Diversions



Non-Irrigation Season Canal Recharge

Culbertson, Cambridge, Franklin (Combined) Canal Recharge Diversions



Non-Irrigation Season Canal Recharge

Evaluation Metrics

- Canals often able to divert close to 10,000 af limit during Non-Compact Call Years
- Culbertson Canal shows most variability – only Frenchman Creek as source
- Franklin Canal shows greatest consistency in recharge diversions for single canal configurations
- All three canals operating together consistently can divert near 10,000 af limit when allowed

Summary
Swanson Reservoir Pump-Back

- Under alternative considered, Swanson Pump-Back options could increase FCID supplies and Swanson Lake Levels, but with reduced Harlan County Lake levels and NBID supplies
- Different operations could be considered for Swanson Lake Pump-Back projects
- Larger pump-back diversions appear to be available

Summary

Downstream Exchange for Harlan County Lake

- Thompson Creek Reservoir site could allow for greater Franklin Canal deliveries and higher Harlan County Lake levels
- Slight negative impact to Guide Rock flows possible
- Potential for larger storage capacity
- Other sites (Beaver Creek) could have different benefits (downstream of Guide Rock diversion)

Summary
Non-Irrigation Season Recharge

- Culbertson, Cambridge, and Franklin Canals all have recharge potential for non-irrigation season diversions
- Consistent supplies of at least 10,000 af
- Additional modeling beneficial – connecting ground water model

Questions?

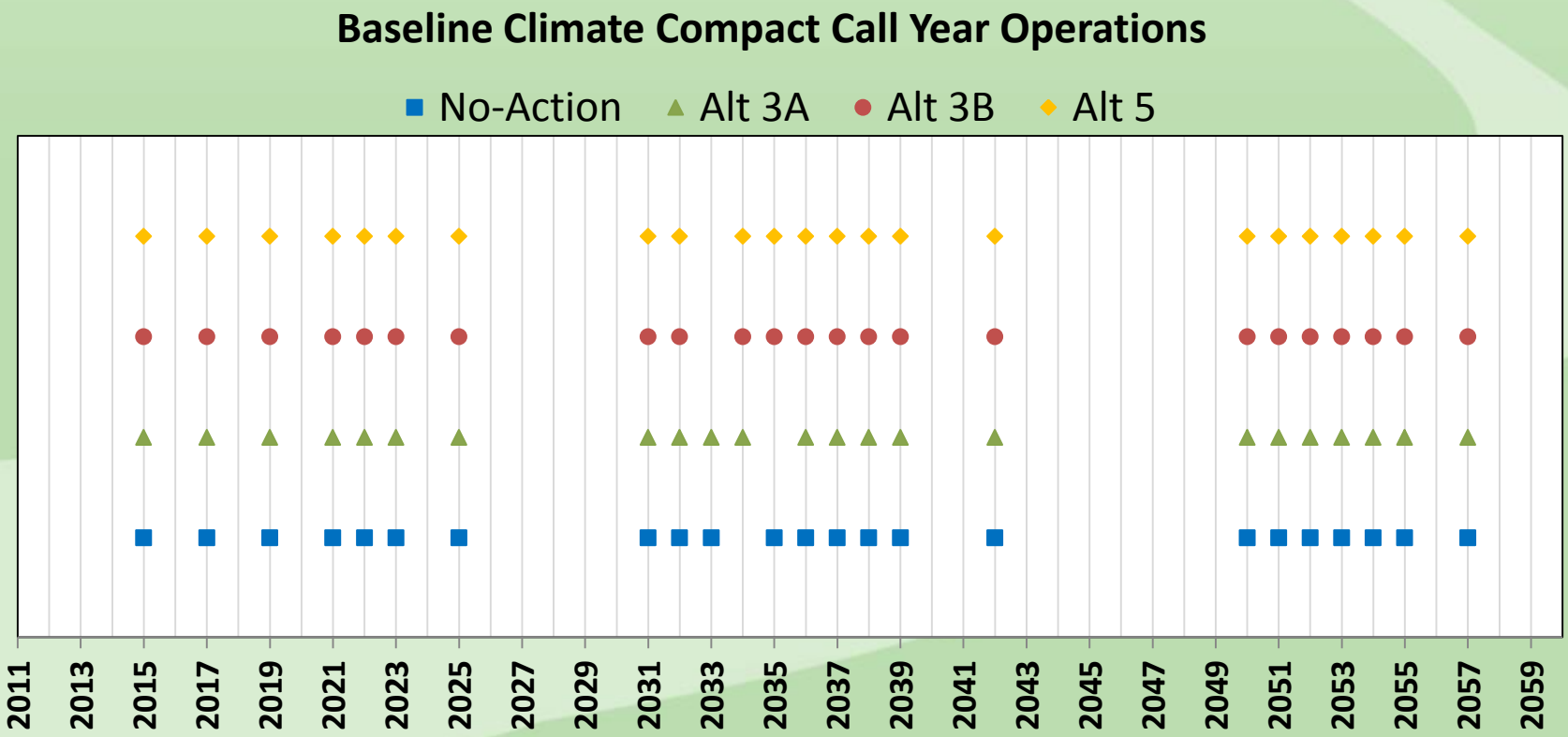
Costs

Alternative Description	Field Cost	Noncontract[2] Cost	Construction Cost
1C: 25,000 AF Expansion of Lovewell Reservoir	$44,000,000	$15,000,000	$59,000,000
3A: Swanson Reservoir Augmentation – New Frenchman Creek Pipeline	$27,000,000	$9,000,000	$36,000,000
3B: Swanson Reservoir Augmentation – New Republican River Pipeline	$61,000,000	$21,000,000	$82,000,000
5A: New Thompson Creek Dam	$68,000,000	$24,000,000	$92,000,000

Overview of Nebraska Alternatives

Swanson Reservoir Pump-Back

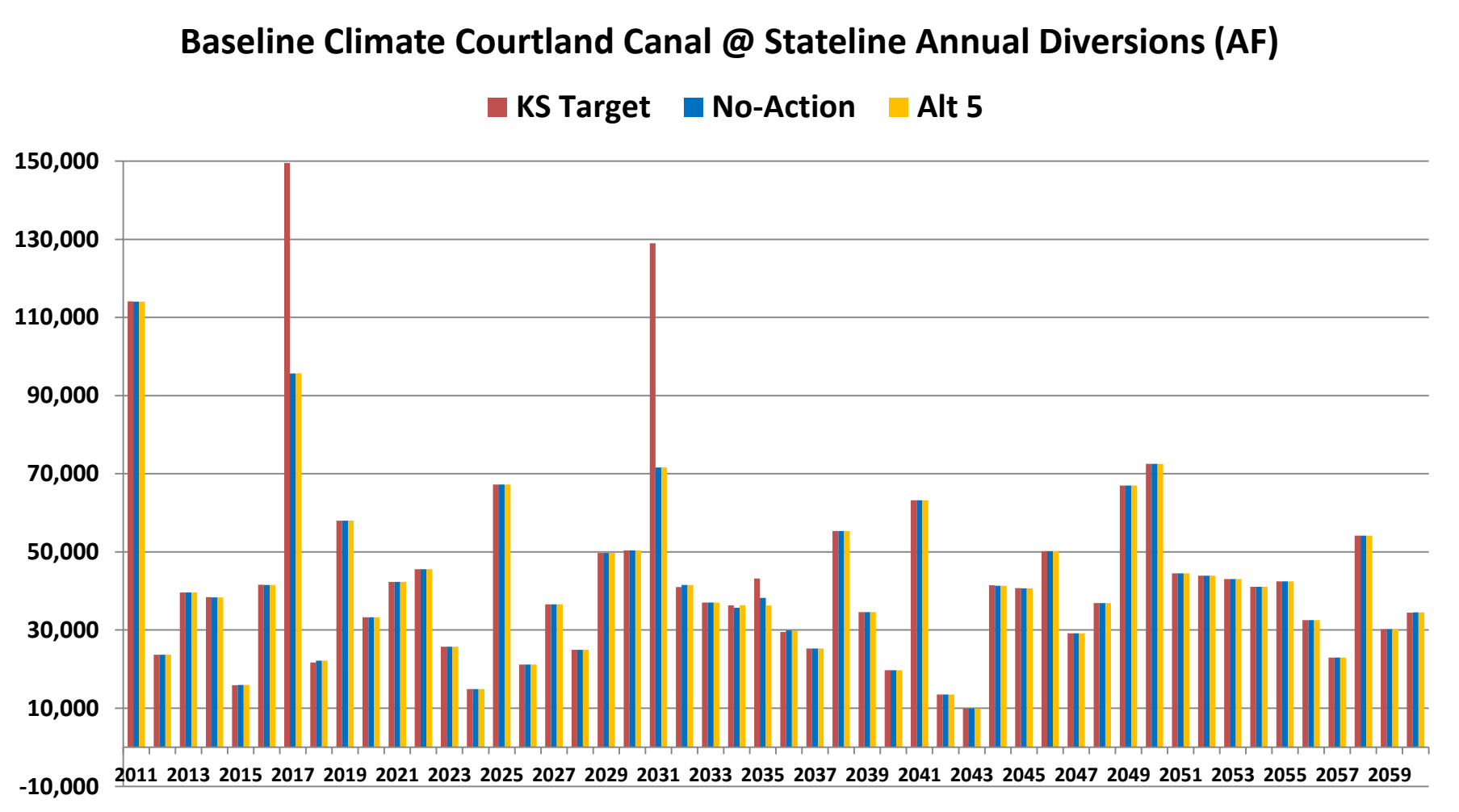
Compact Call Years

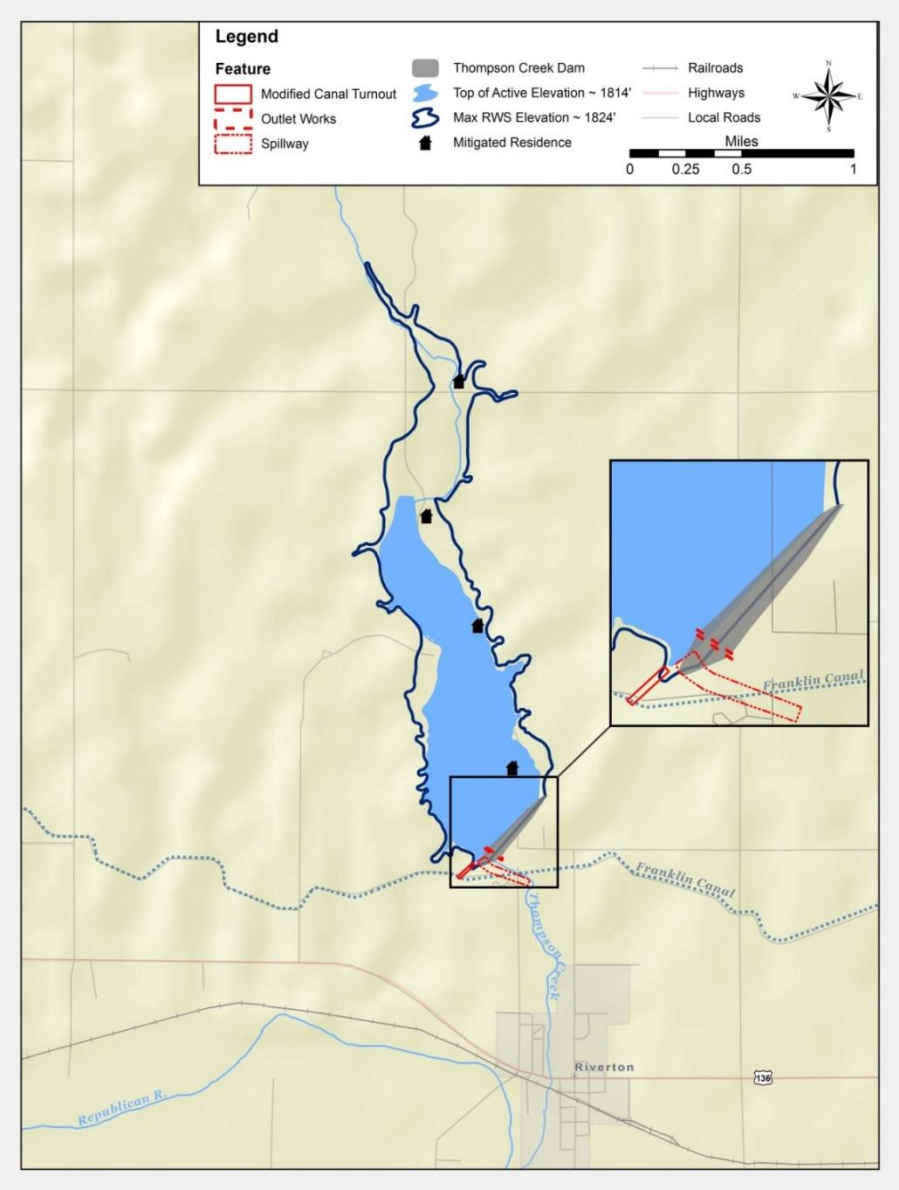


Overview of Nebraska Alternatives

Thompson Creek Dam

Courtland Canal Flows at State Line



Overview of Nebraska Alternatives

Thompson Creek Dam