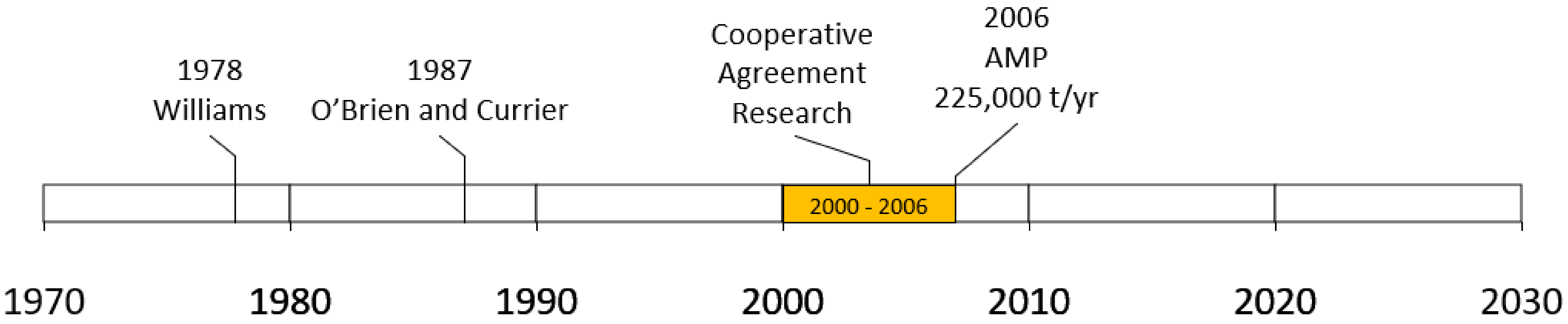
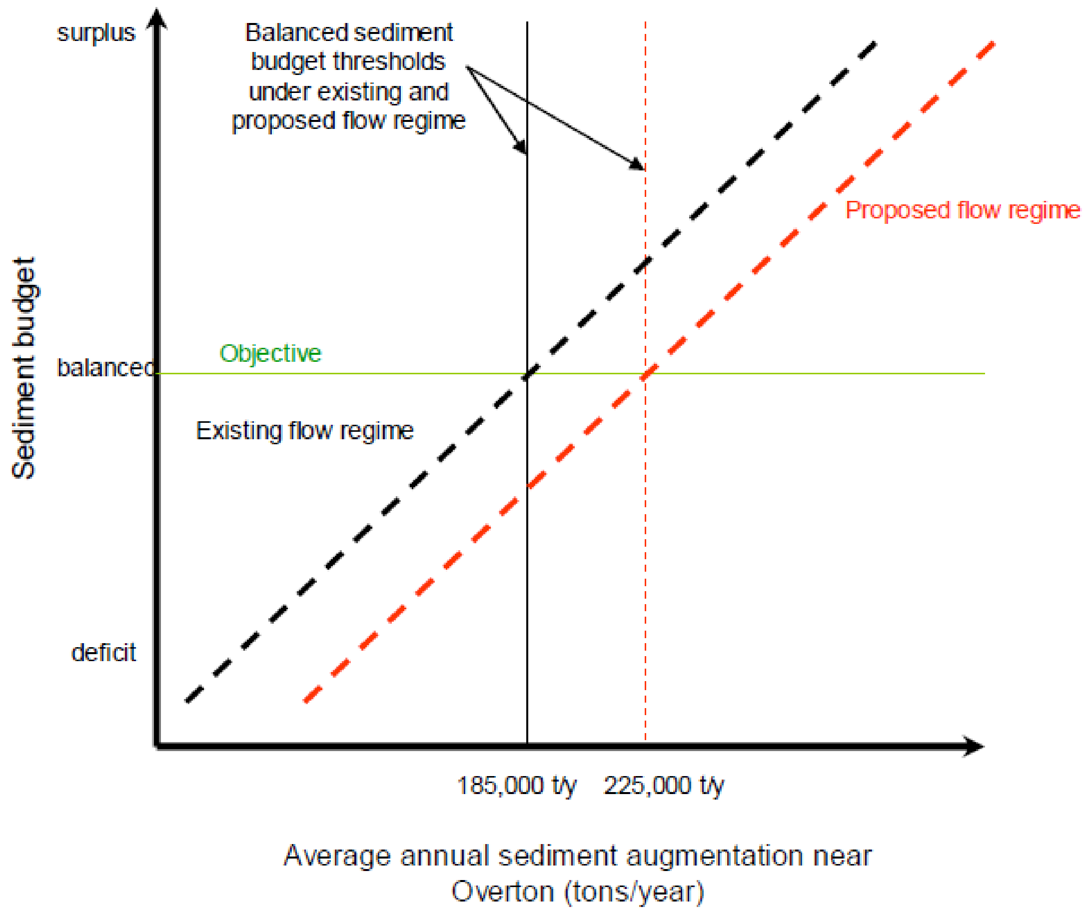
Sediment Augmentation



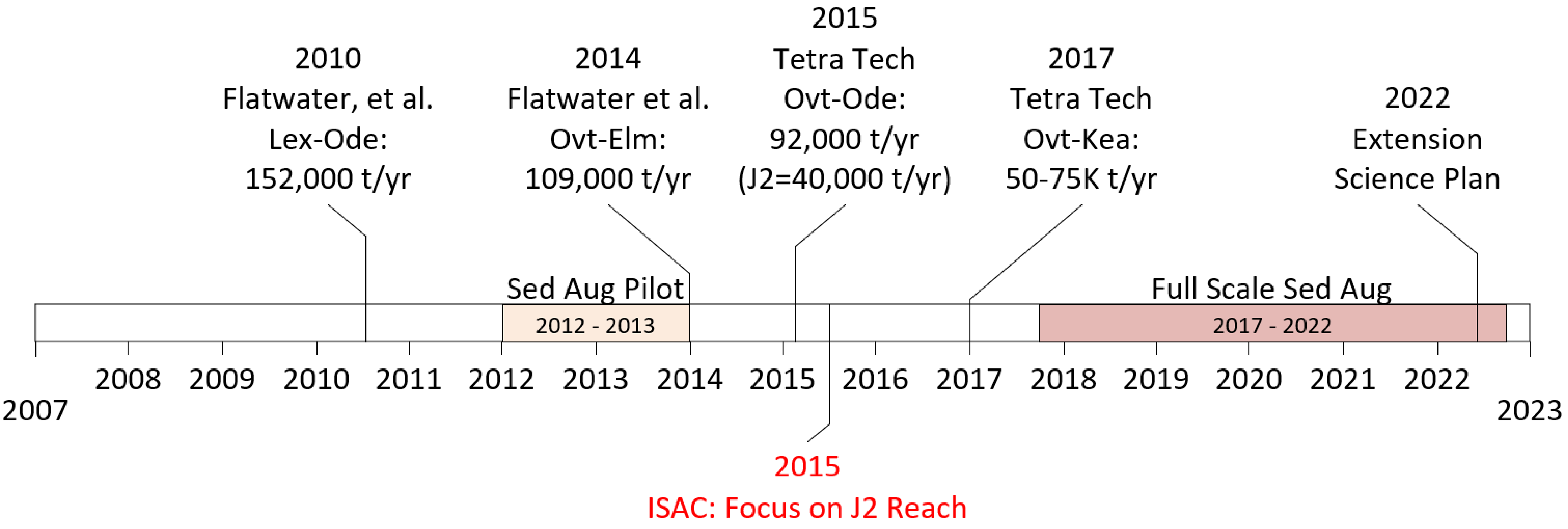
PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Sediment 1: Sediment augmentation balances the sediment budget.



Sediment augmentation near Overton to 185,000 tons/yr under existing flow regime and 225,000 tons/year under the Governance Committee proposed flow regime achieves a sediment balance to Kearney.

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM


2010
Flatwater, et al.
Lex-Ode:
152,000 t/yr
2014
Flatwater et al.
Ovt-Elm:
109,000 t/yr
2015
Tetra Tech
Ovt-Ode:
92,000 t/yr
(J2=40,000 t/yr)
2017
Tetra Tech
Ovt-Kea:
50-75K t/yr
2022
Extension
Science Plan
Sed Aug Pilot
2012 - 2013
Full Scale Sed Aug
2017 - 2022
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2015
ISAC: Focus on J2 Reach

Extension Big Question #3: Is sediment augmentation necessary to create and/or maintain suitable* whooping crane habitat?

**Channels with ≥ 650 ft maximum width unobstructed by dense vegetation (MUCW) are highly suitable for whooping crane roosting.*

Management Hypothesis: Sediment augmentation is necessary to halt narrowing and incision in the south channel downstream of the J-2 Return.

X-Y Graph

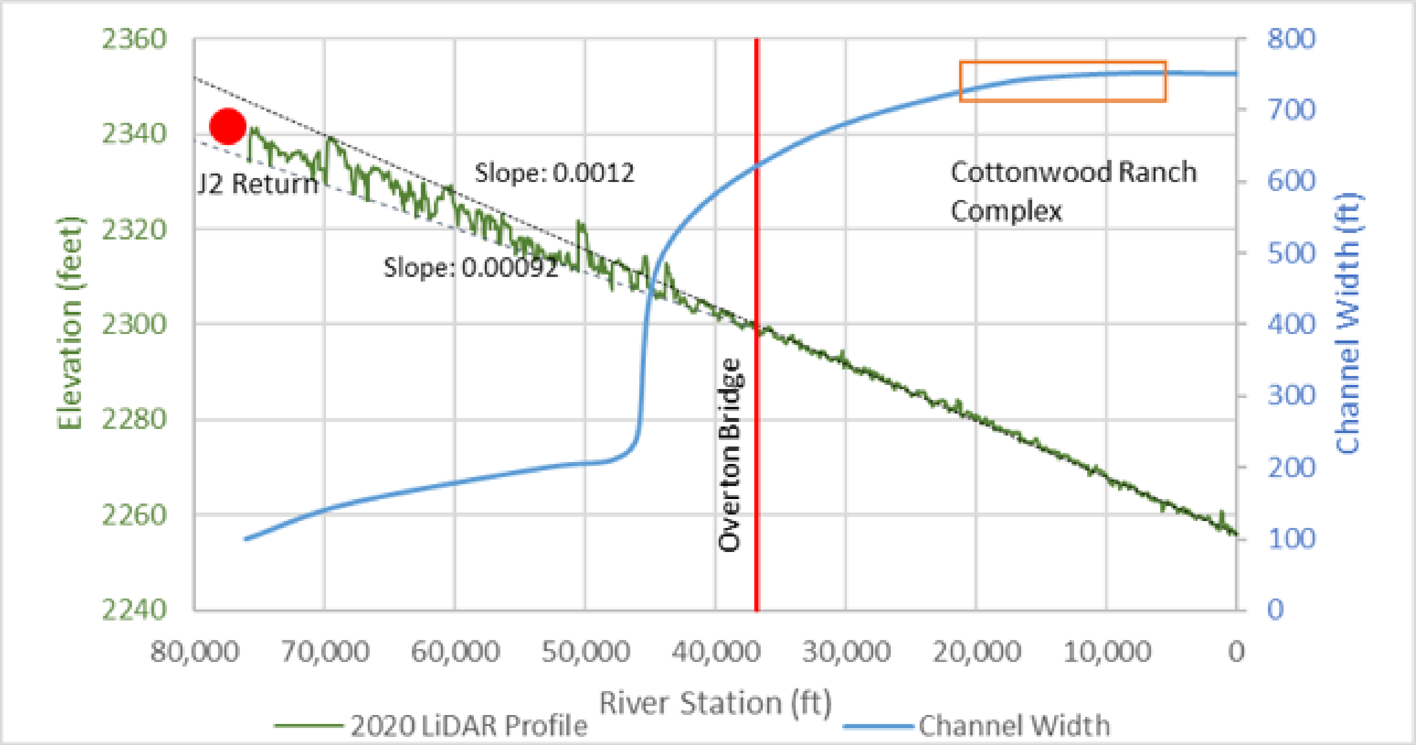
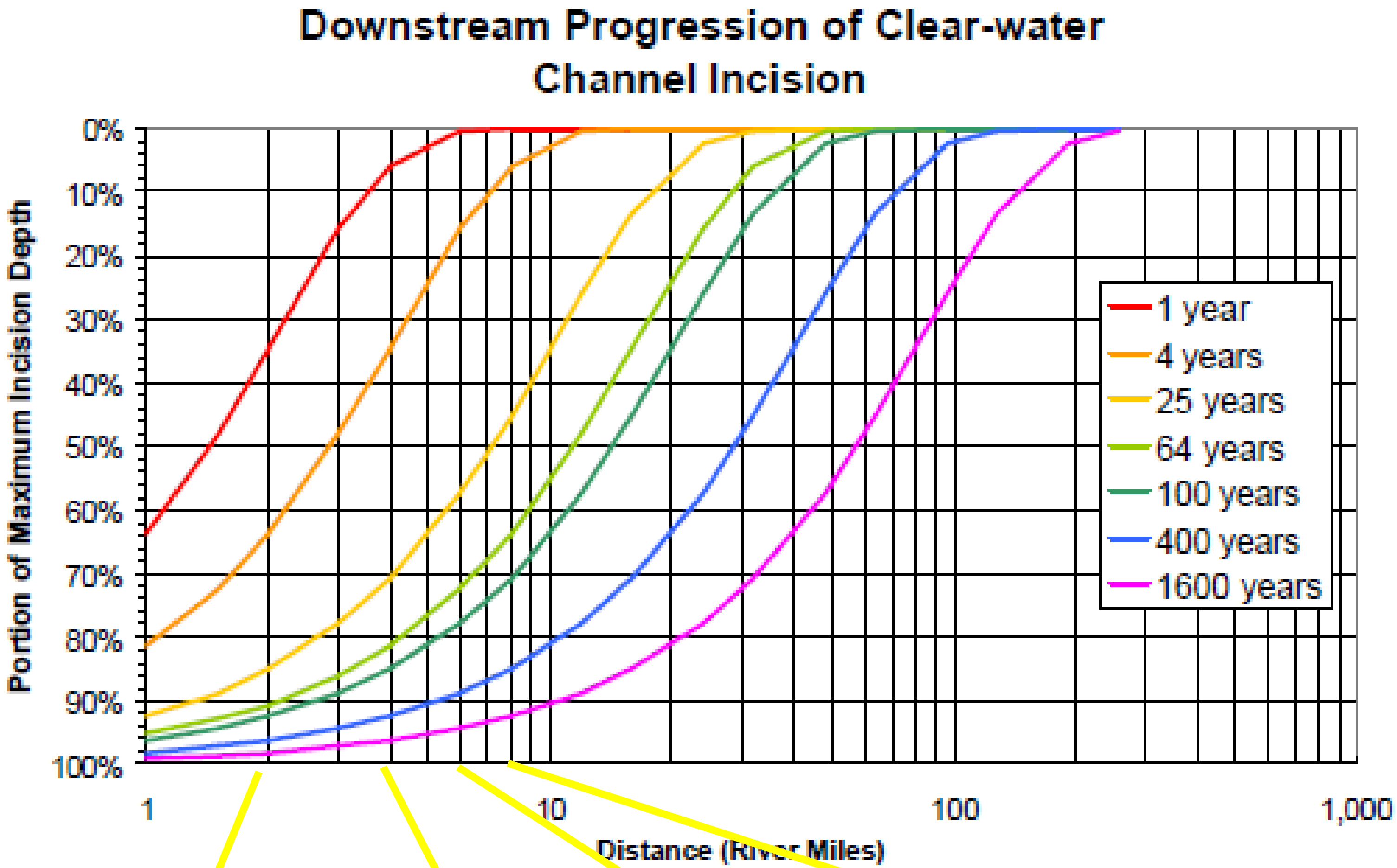
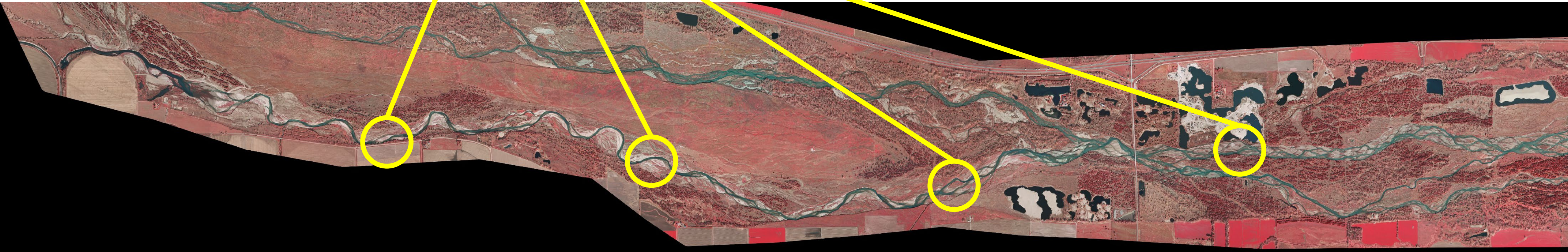


Figure 1. Full scale sediment augmentation (60,000 – 80,000 tons annually in south channel below J-2 Return) is necessary to offset the sediment deficit and halt narrowing and incision that has caused the upper portion of the south channel to transition to a narrow meandering planform, which is much less suitable for WC roosting. If incision is not halted, the affected reach will continue to expand downstream past the Overton bridge, reducing habitat suitability at the Cottonwood Ranch complex.

PLATTE RIVER RECOVERY IMPLEMENTATIO



Murphy et al. 2004. Figure 4.16 Estimated downstream progression of clear-water channel incision of the Platte River, based on de Vries as presented by Graf (1998).

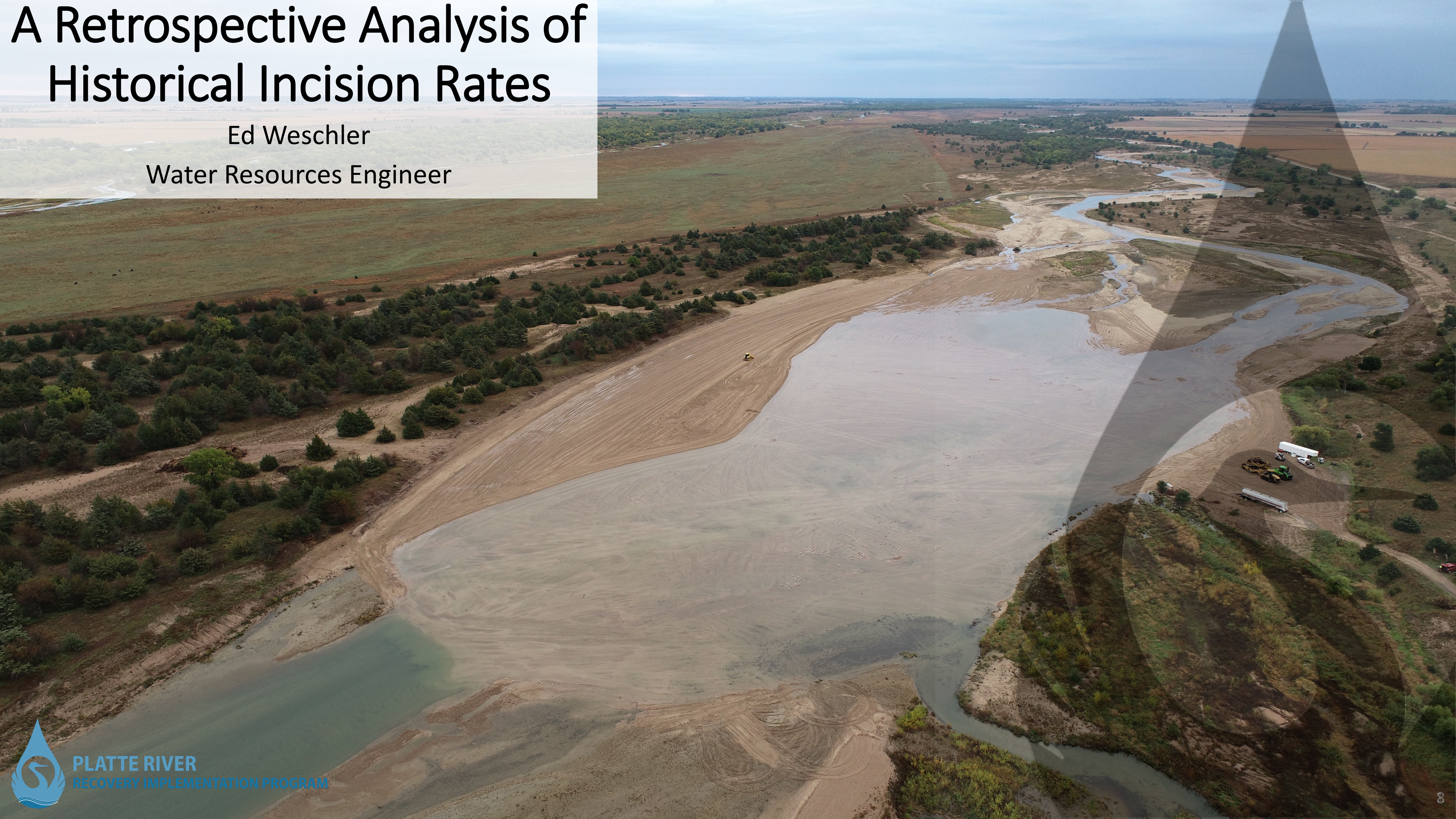


1. Looking backward: spatiotemporal trends
2. Augmentation implementation & response
3. Channel form & habitat

Specific gage: supplemental information

A Retrospective Analysis of Historical Incision Rates

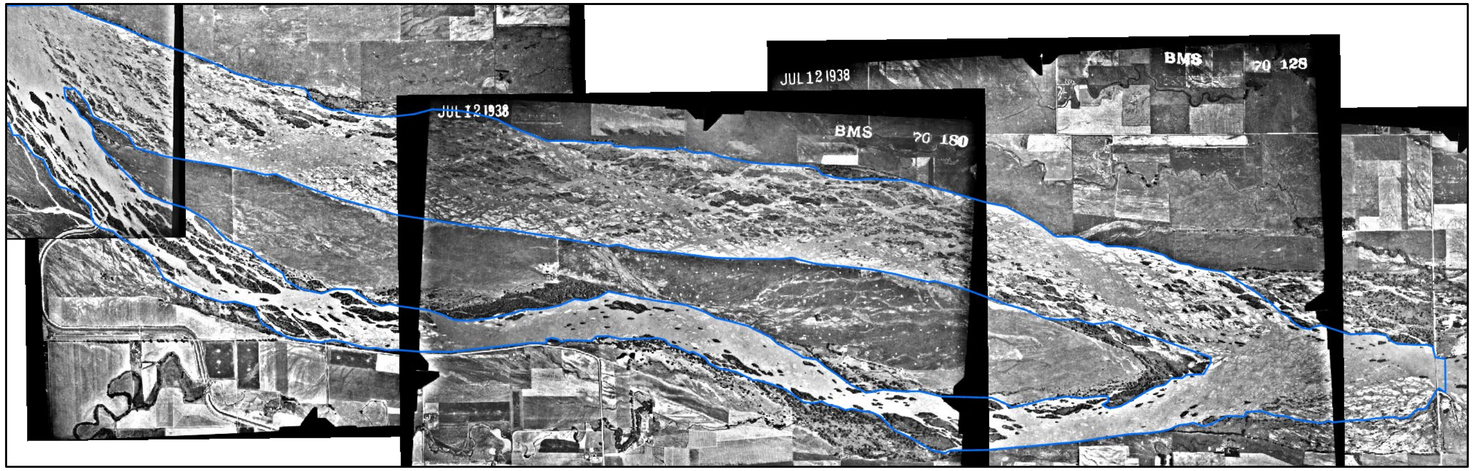
Ed Weschler
Water Resources Engineer



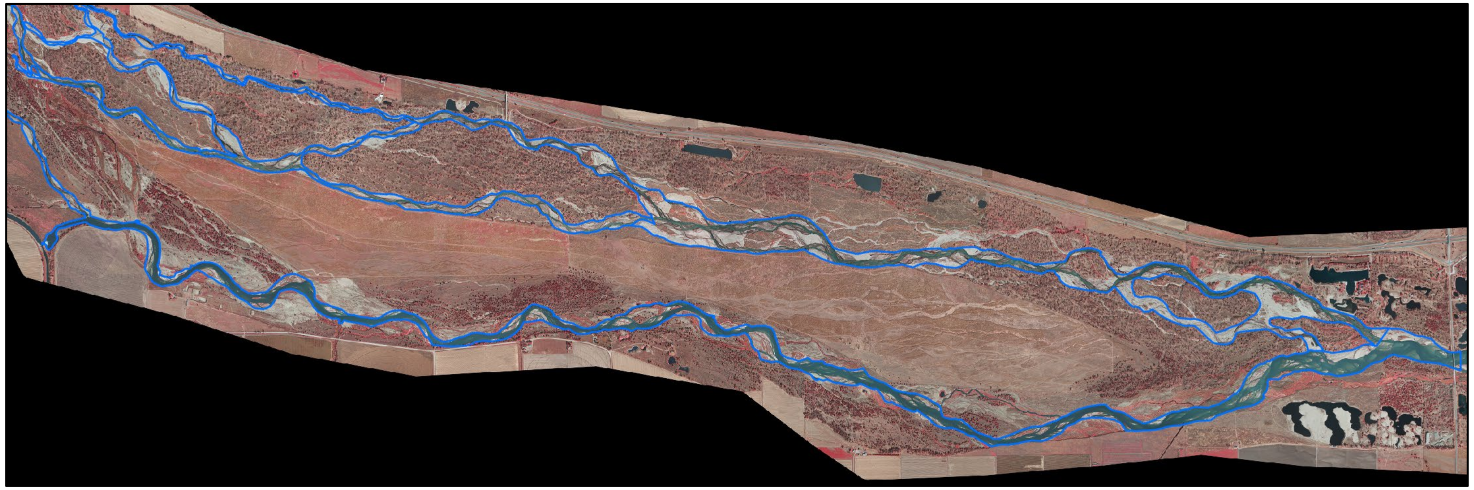
PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

From a mile wide and an inch deep to…

1938

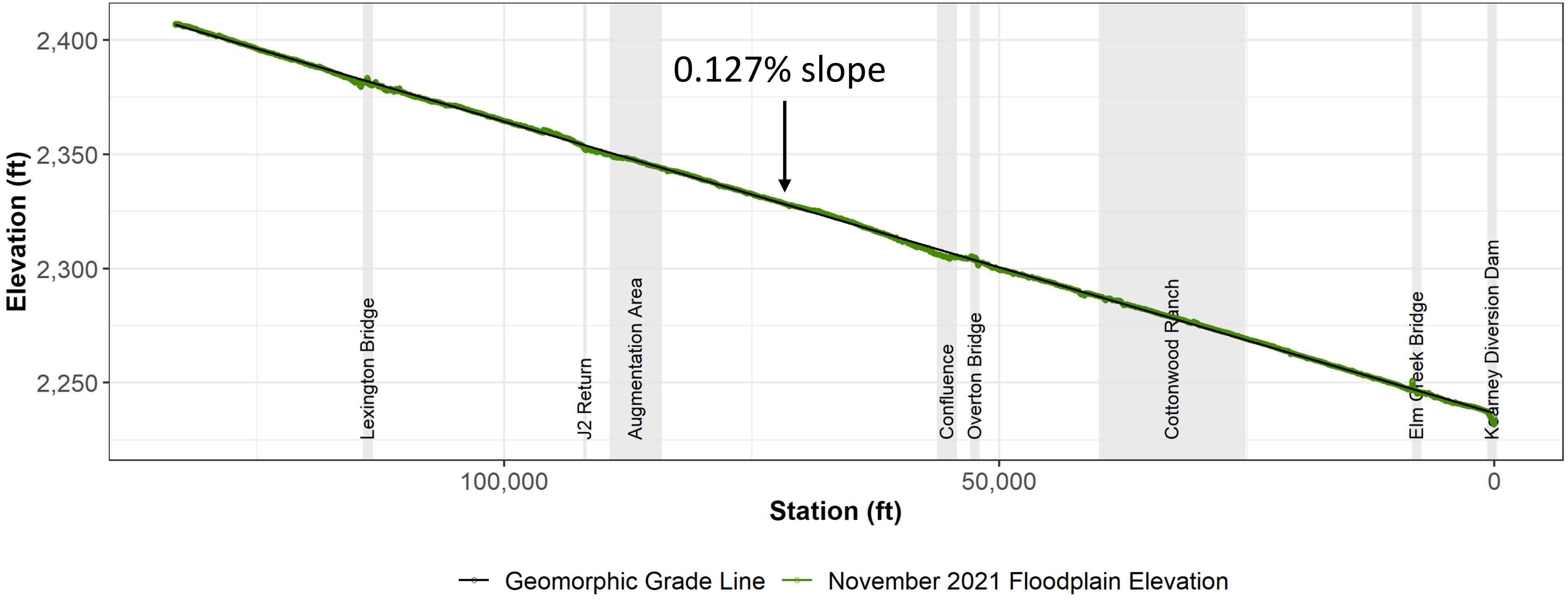


2016



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

First Steps: Geomorphic Grade Line

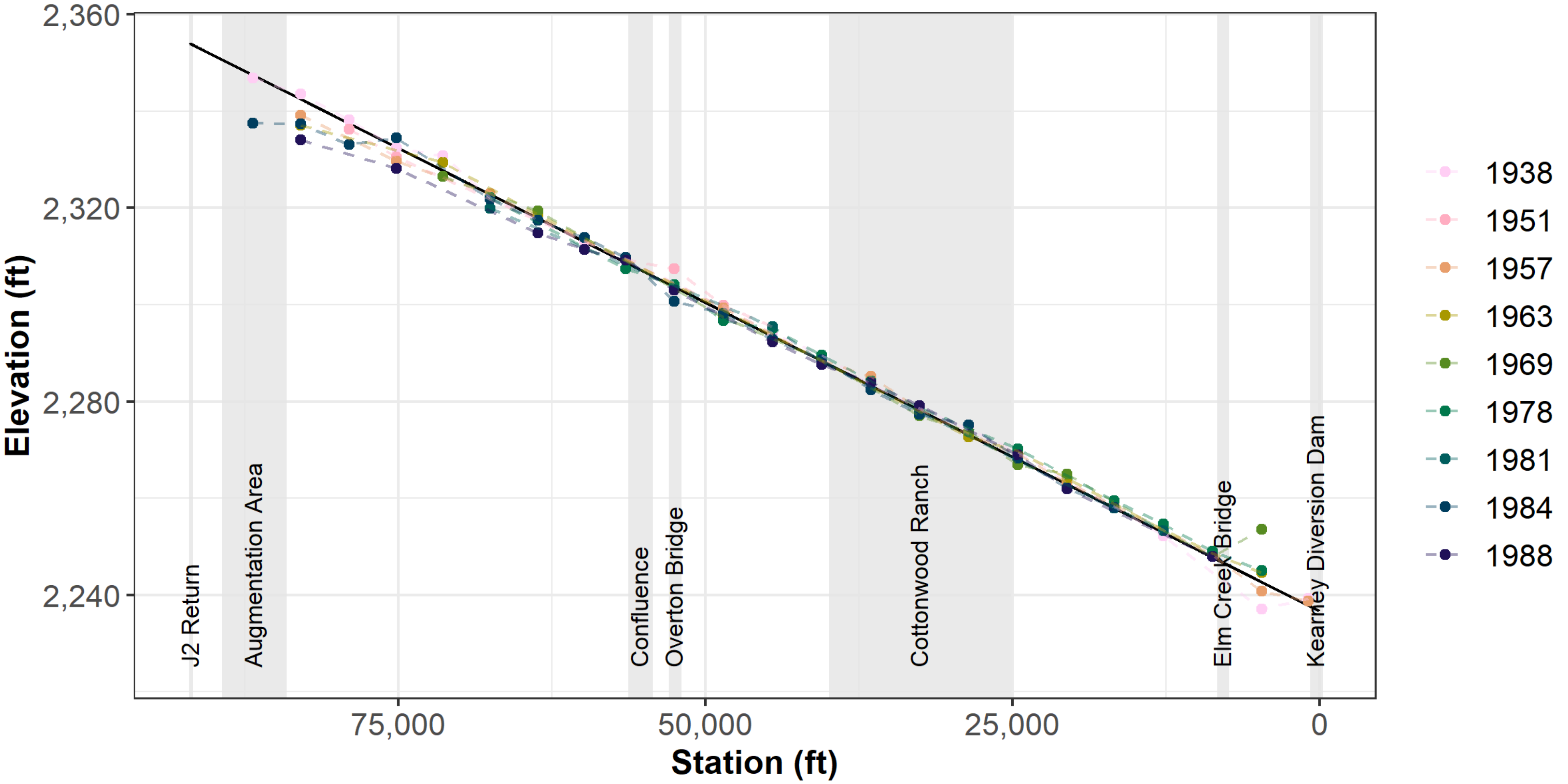


PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Historical Imagery Analysis

Take-aways:

- ***1938 closely followed our GGL***
- ***Small sample size and high uncertainty***

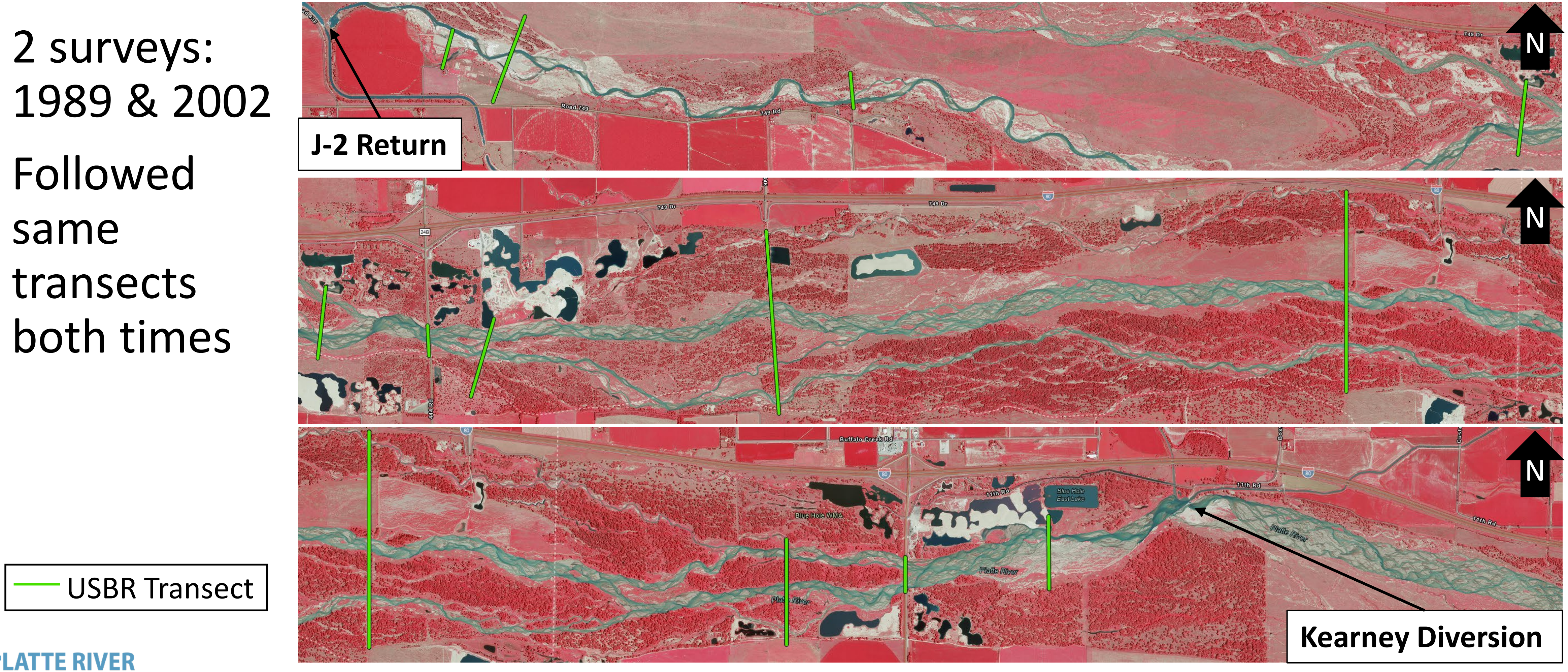


Methods are detailed in report.

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

USBR Transects - Background

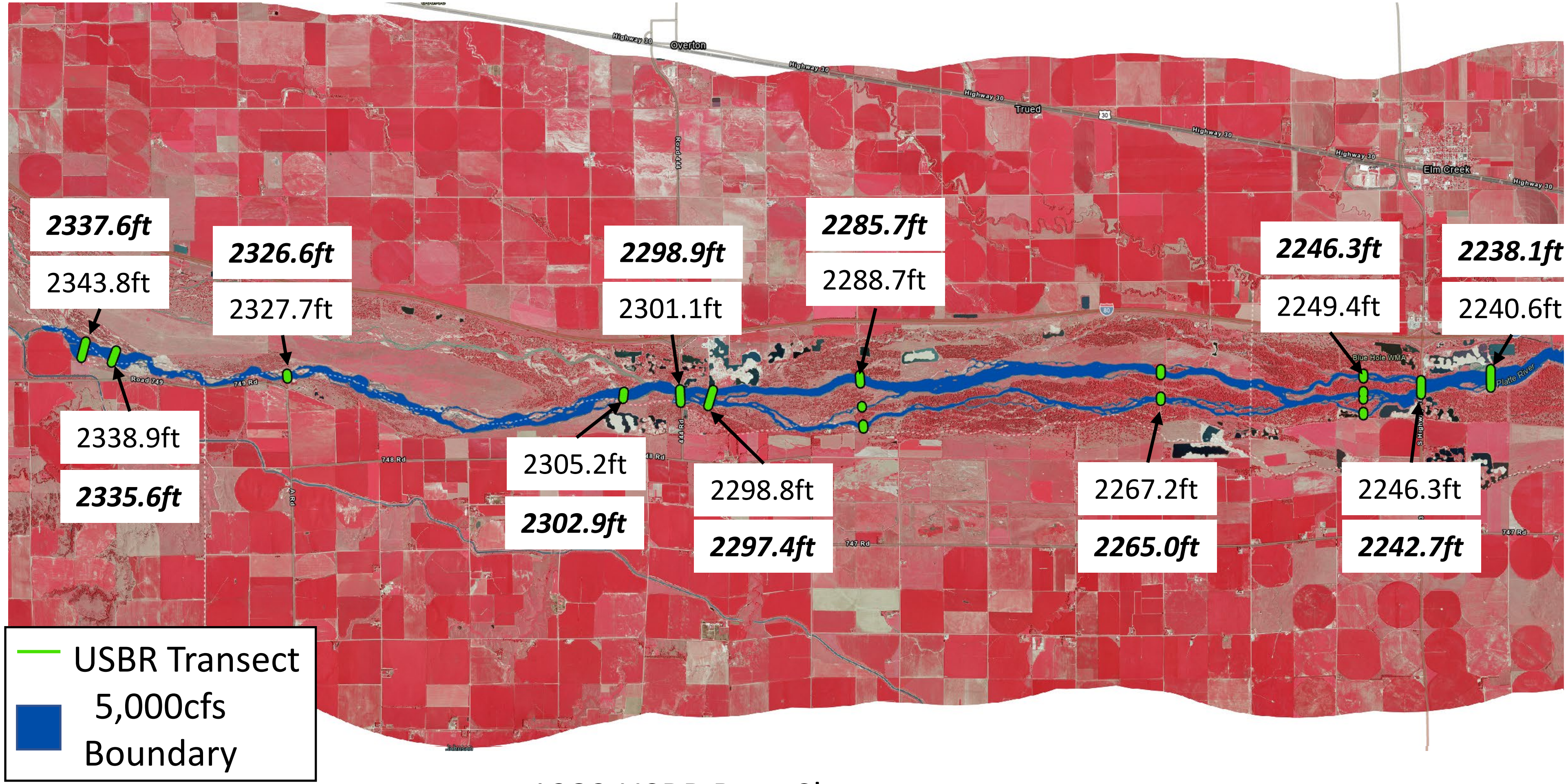
- 2 surveys: 1989 & 2002
- Followed same transects both times



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

USBR Transects – Method

- Transects Clipped
- Calculated Average Elevation
- Calculated ***Thalweg***

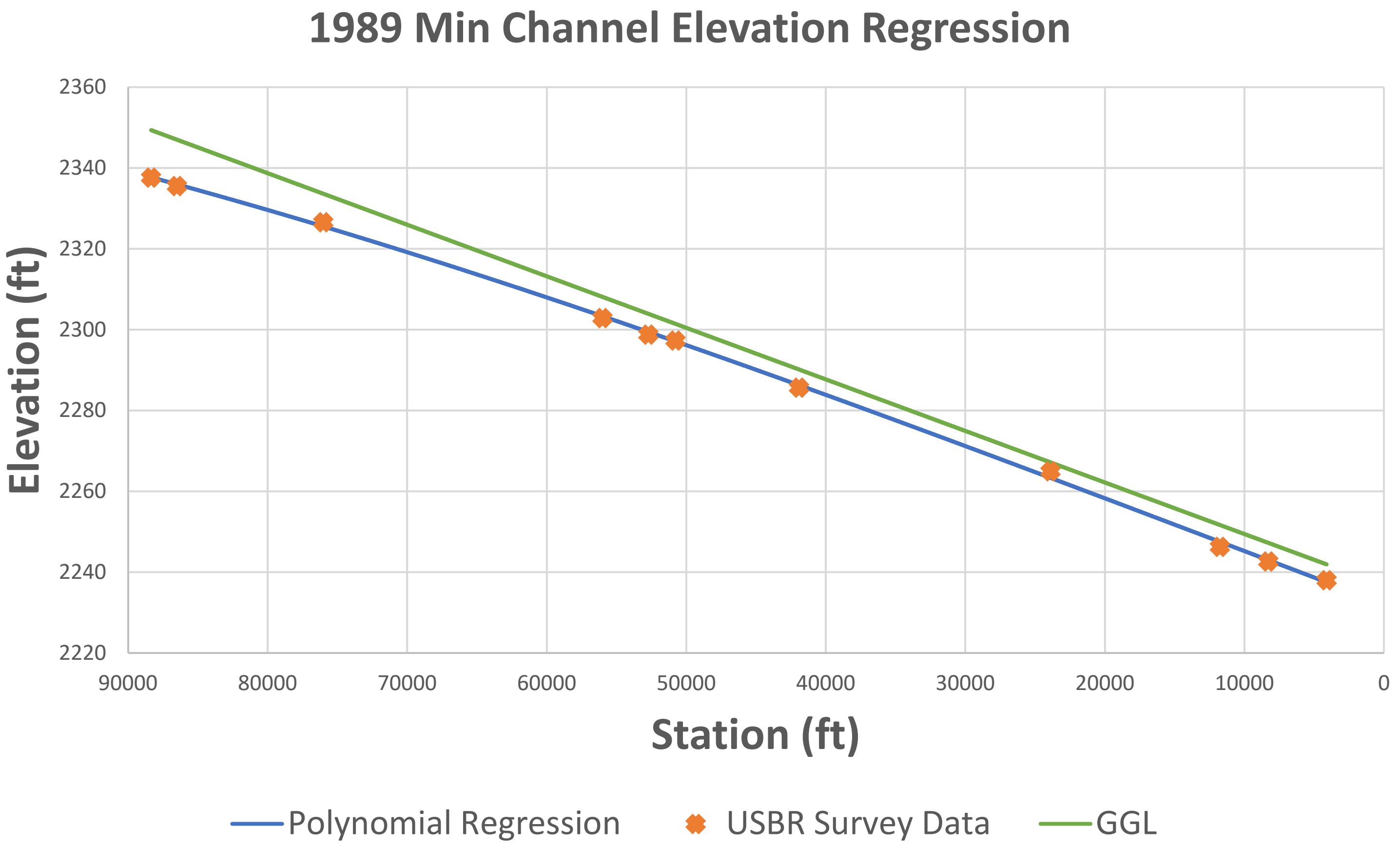


1989 USBR Data Shown

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

USBR Transects – Initial Findings

- 3rd order regression
- Applied to mean and thalweg elevations for: 1989 & 2002
- 1989 thalweg shown
- Applied Splined 3rd order regression to 2016 elevations
- Remaining plots in outline



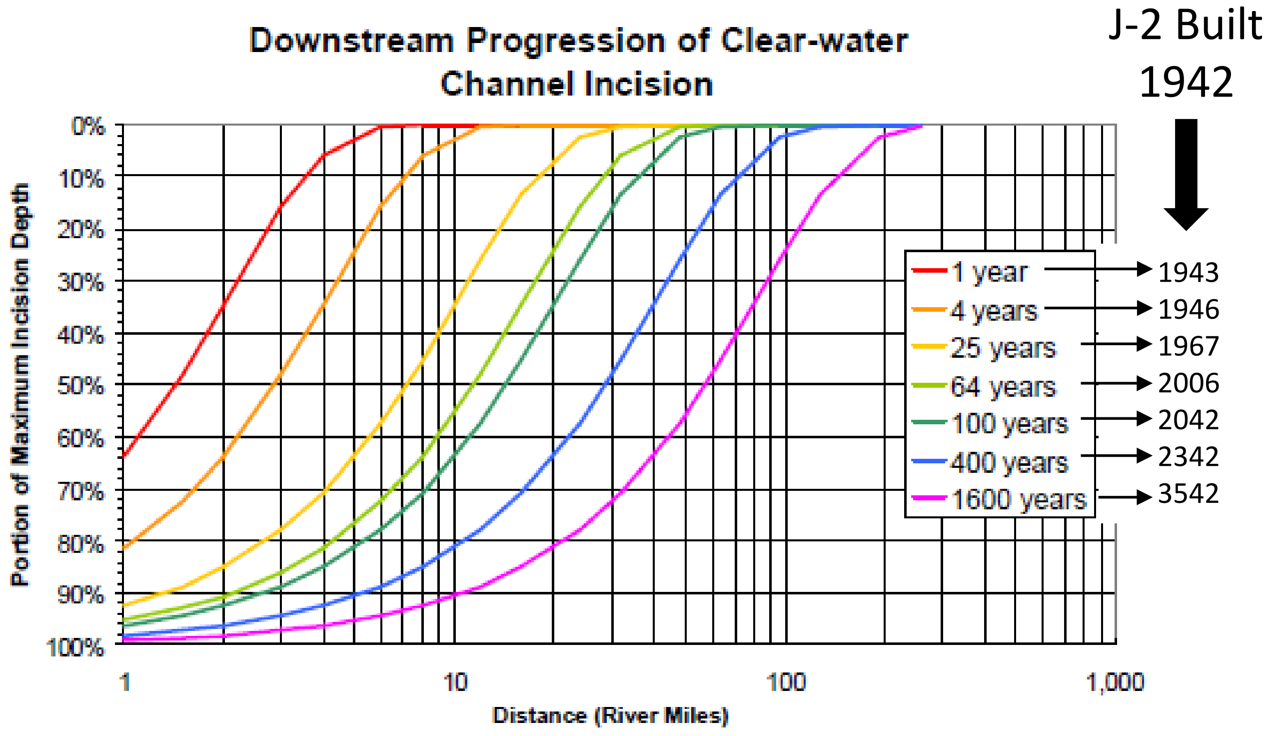
PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

From Initial Findings to Useful Results

- Murphy et al (2004) provide a tool where:

X_{axis} = Distance downstream of a clearwater return

$$Y_{\text{axis}} = \left(\frac{Incision\ Depth\ at\ Point}{Max\ Incision\ Depth}\right) * 100$$

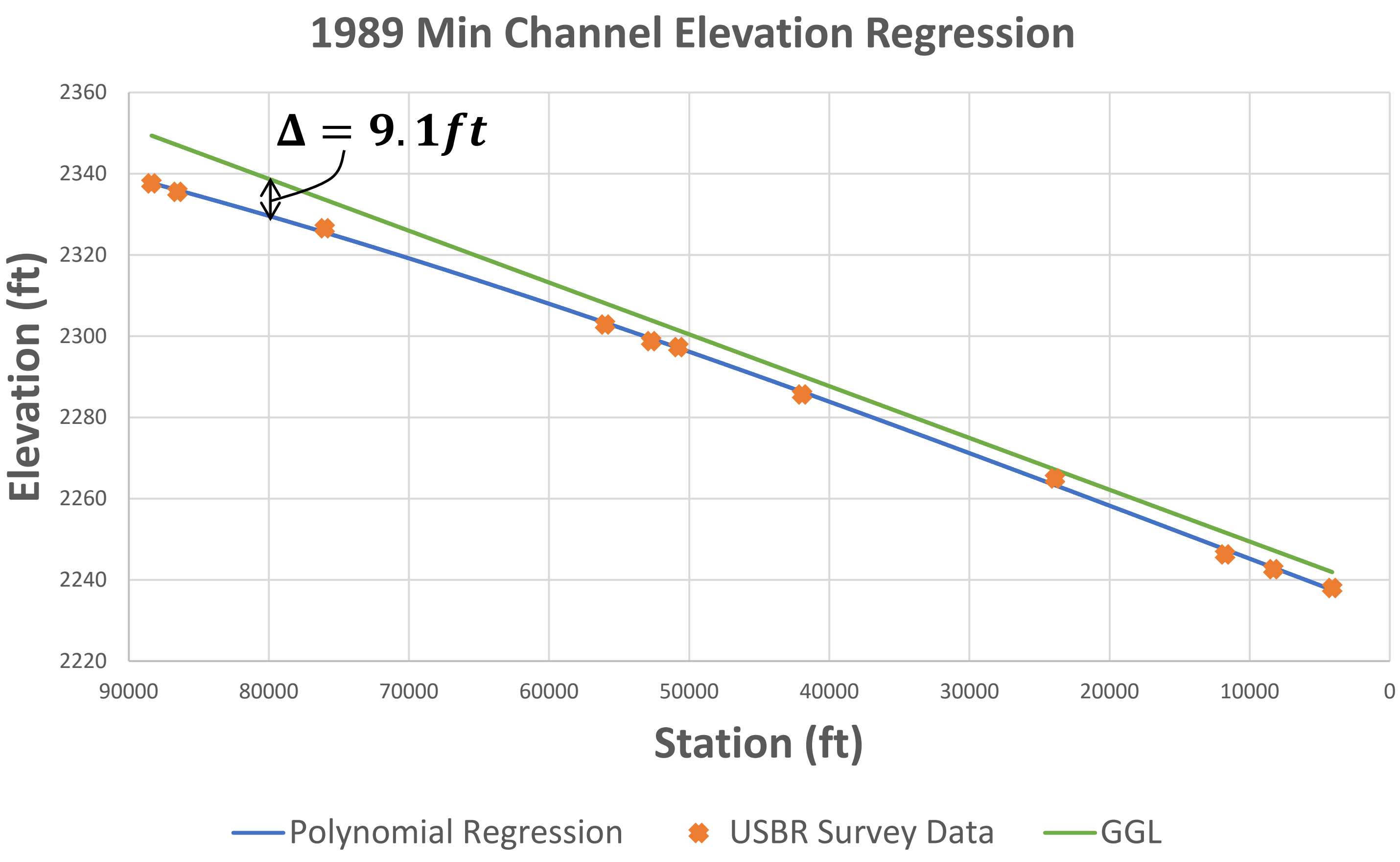


Murphy Approach Applied to USBR - **Thalweg**

<u>Example Calculation</u>

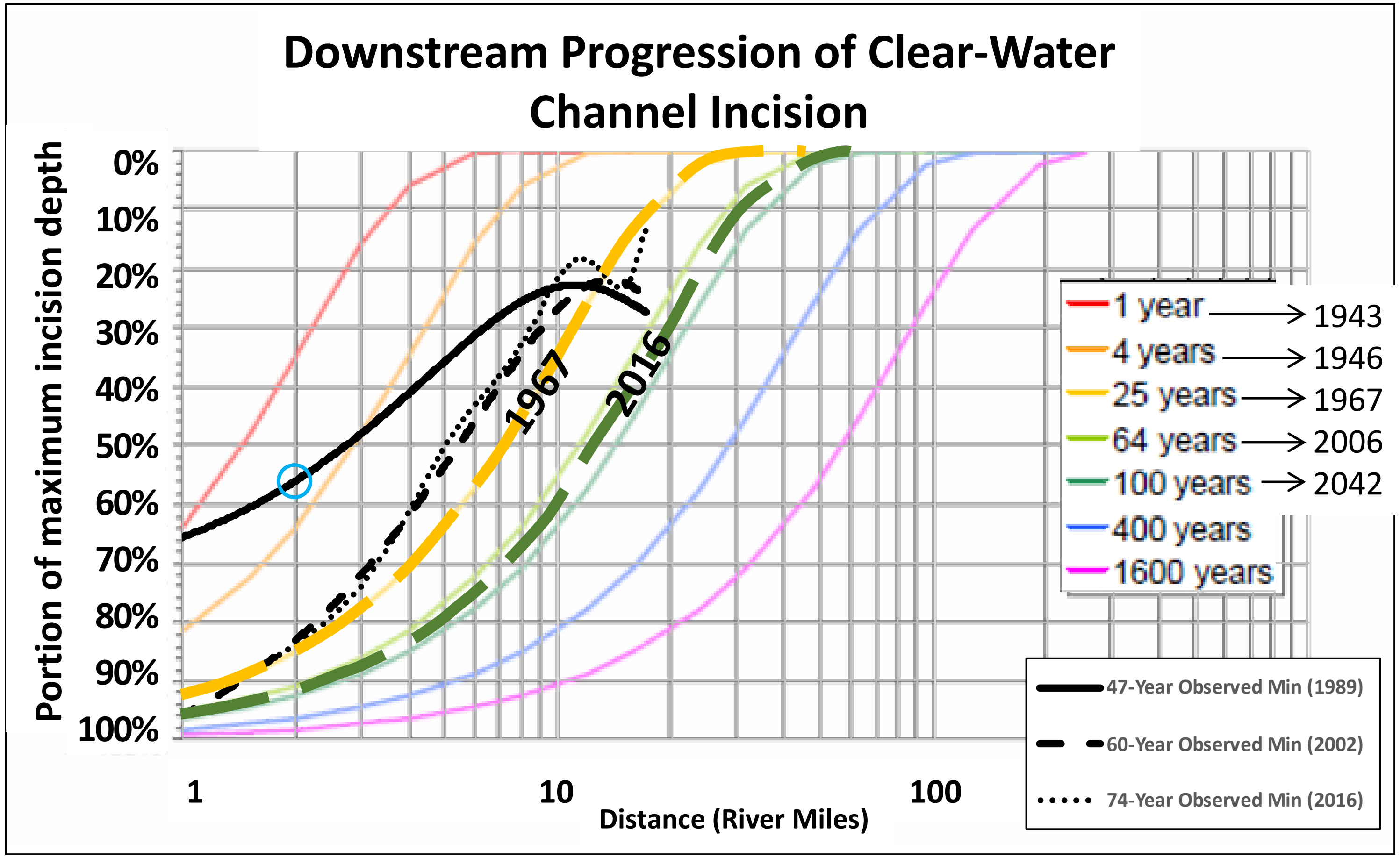
- $Y = \left(\frac{Incision\ Depth\ at\ Point}{Max\ Incision\ Depth}\right) * 100$
- $Max\ Incision\ Depth =$ $16.45ft\ (found\ via\ 2016\ LiDAR)$
- $Incision\ Depth\ at\ Point =$ $\left(GGL_{stn_{80000}} - Poly_{stn_{80000}}\right) = 9.1ft$
- $Y_{stn_{80000}} = \left(\frac{9.1ft}{16.45ft}\right) * 100 =$

55.3%



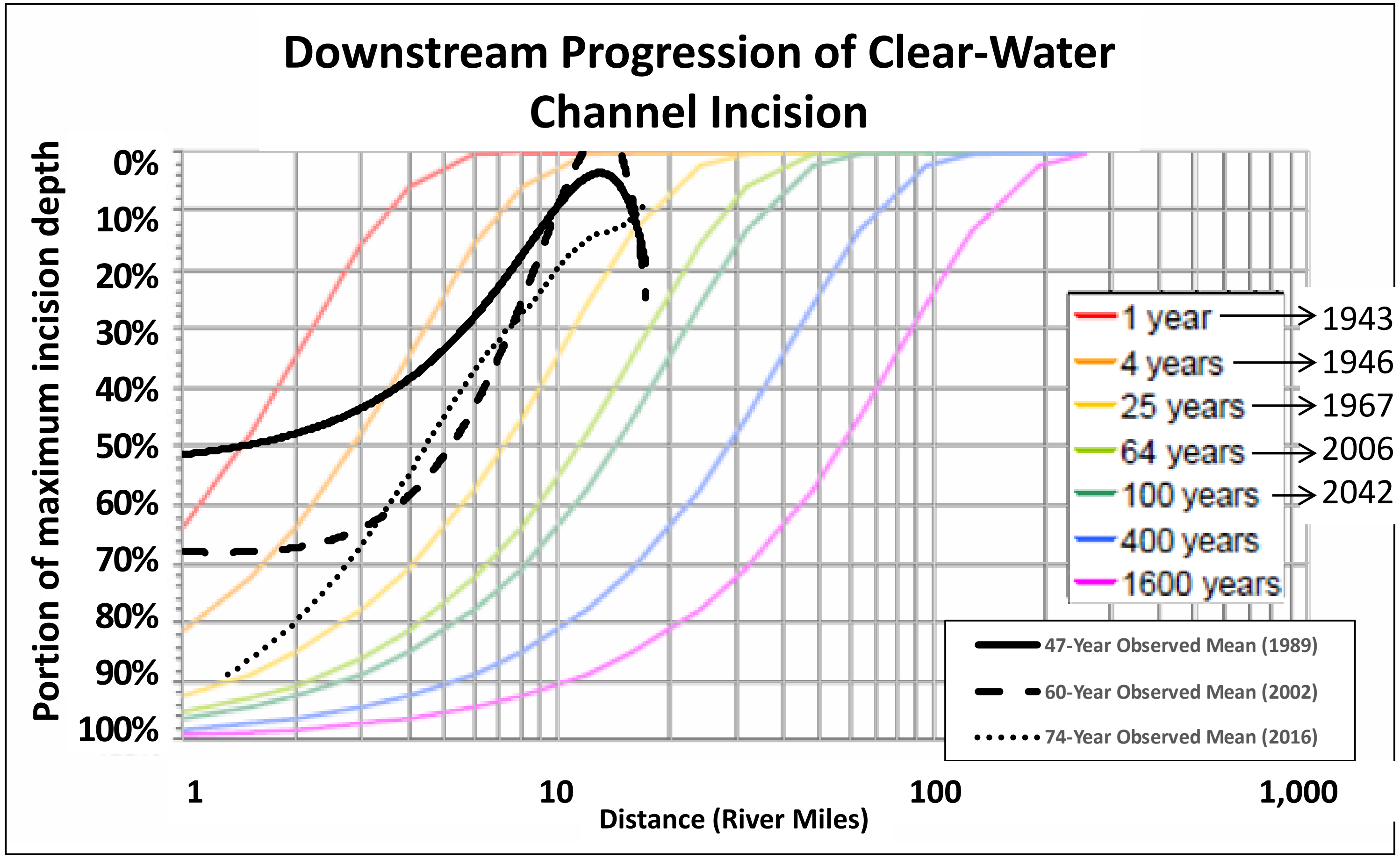
PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Murphy Approach Applied to USBR - **Thalweg**



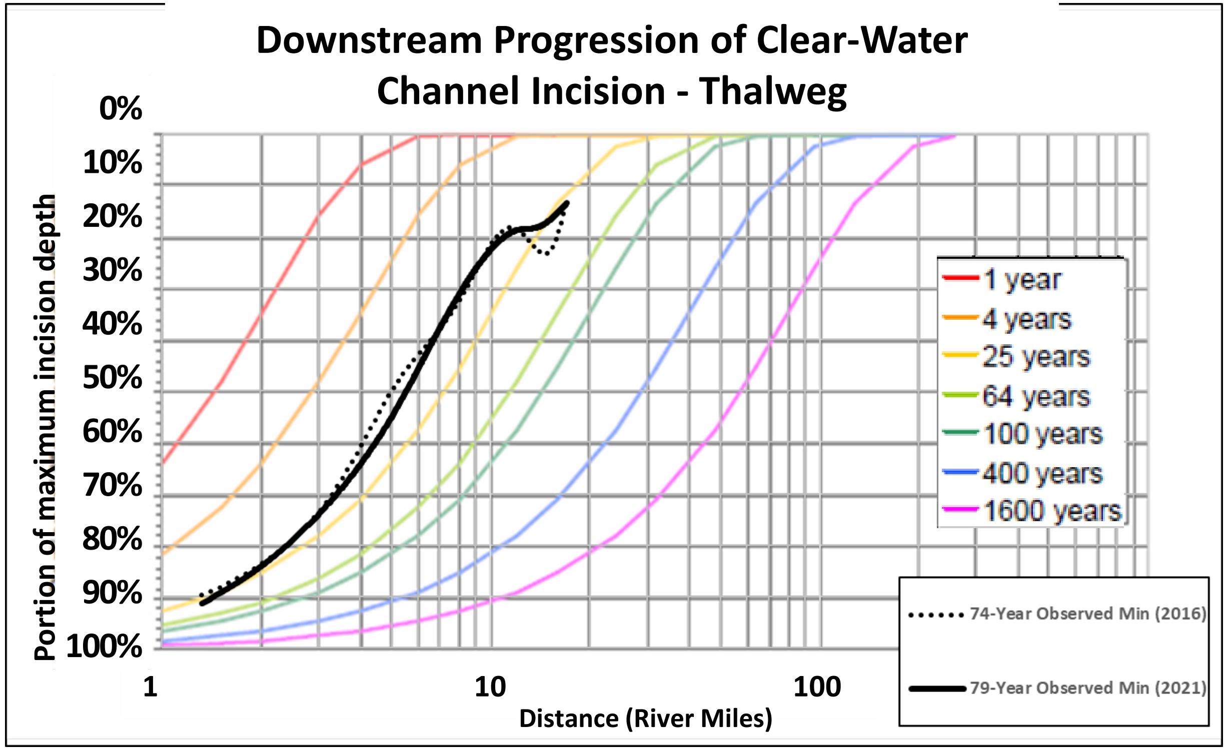
PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

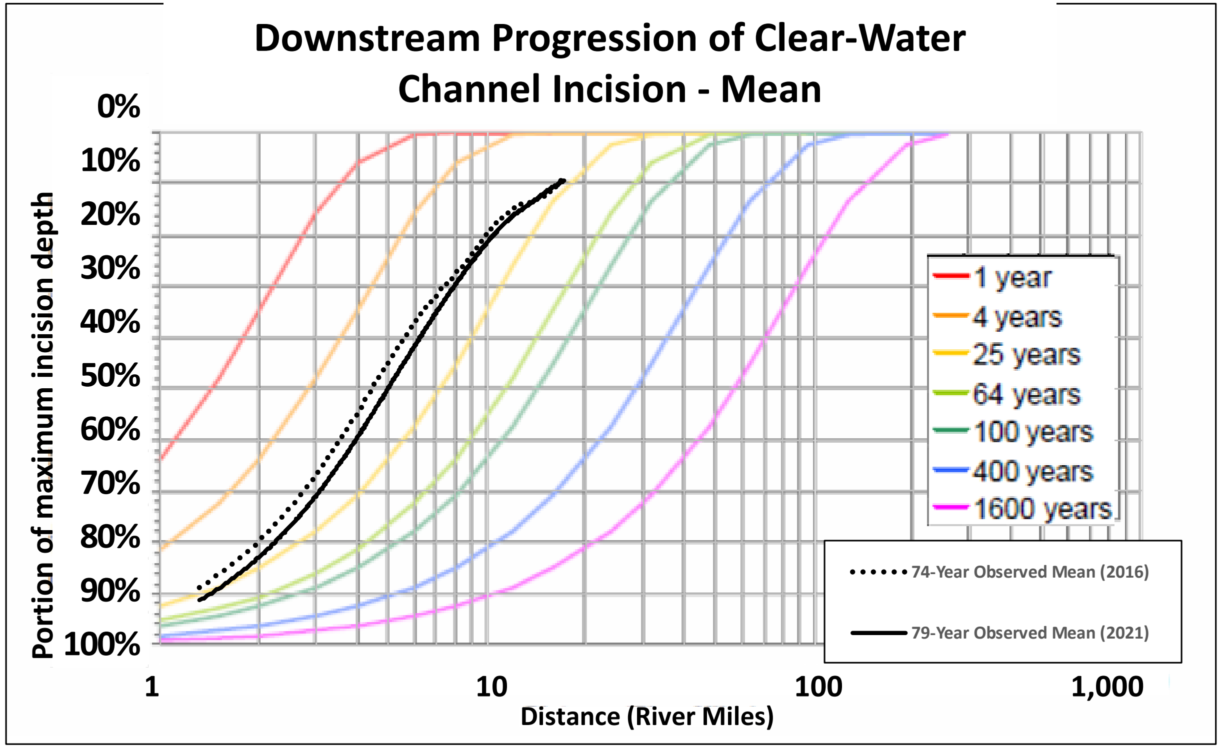
Murphy Approach Applied to USBR – **Mean Channel Elevation**



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Murphy Approach Applied to LiDAR – 2016 & 2021 Longitudinal Profiles





PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Questions?

Shifting Gears: Full Scale Augmentation

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

2017 Sediment Augmentation

Year	Augmentation (Cubic Yards)
2017	23,000

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

2018 Sediment Augmentation

Year	Augmentation (Cubic Yards)
2017	23,000
2018	42,870

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

2019 Sediment Augmentation

Year	Augmentation (Cubic Yards)
2017	23,000
2018	42,870
2019	42,333

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

2020 Sediment Augmentation

Year	Augmentation (Cubic Yards)
2017	23,000
2018	42,870
2019	42,333
2020	57,650

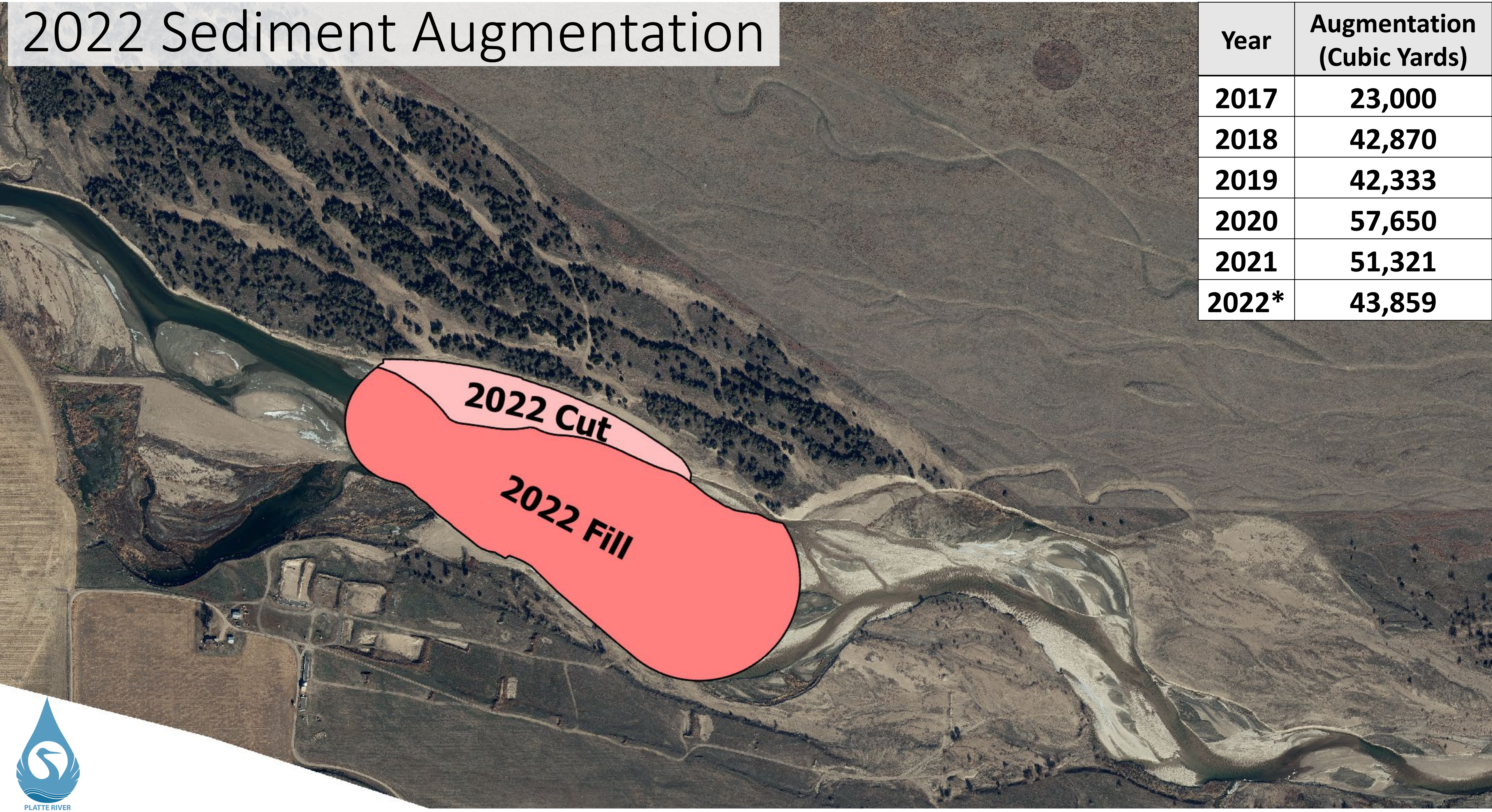
PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

2021 Sediment Augmentation

Year	Augmentation (Cubic Yards)
2017	23,000
2018	42,870
2019	42,333
2020	57,650
2021	51,321

2022 Sediment Augmentation

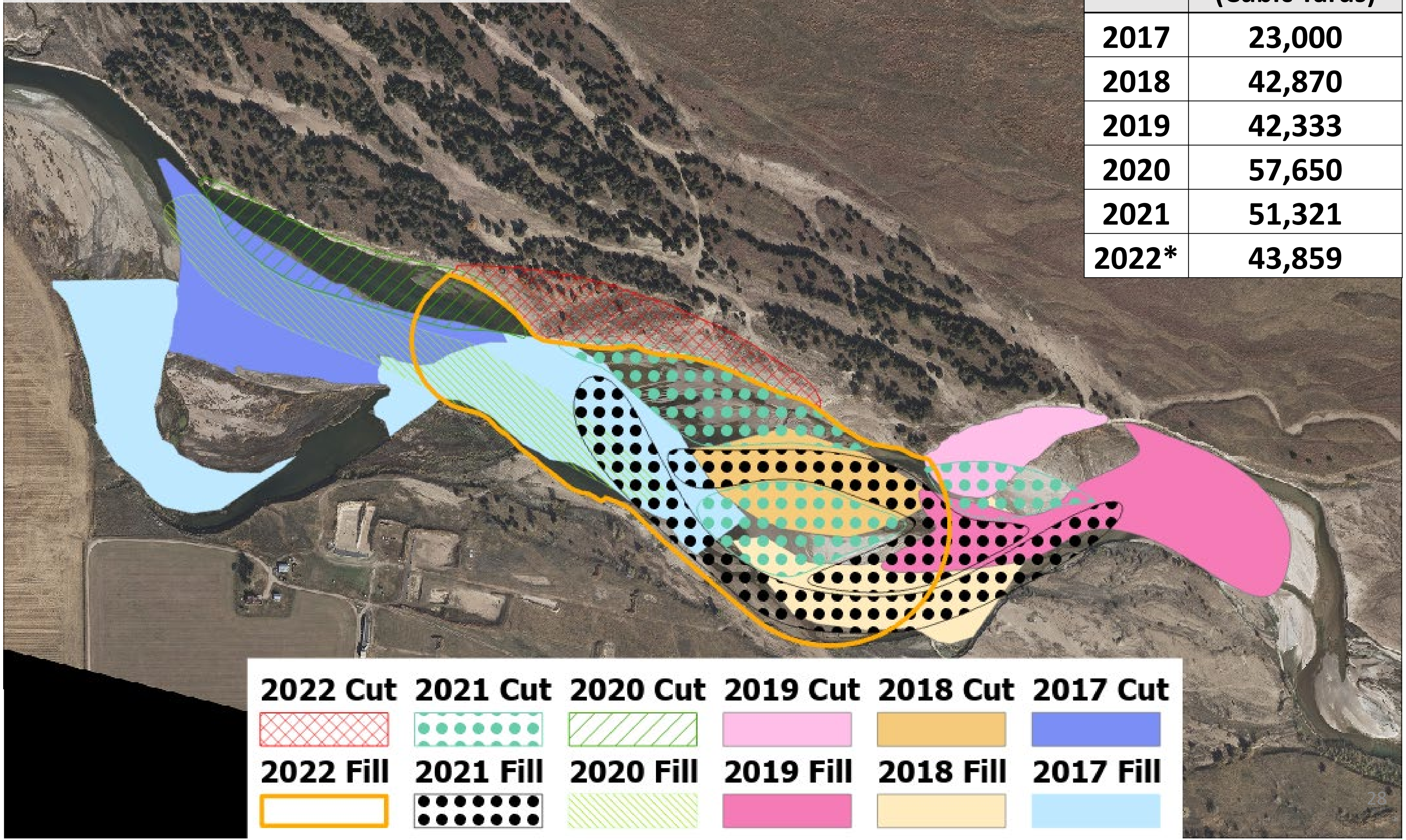
Year	Augmentation (Cubic Yards)
2017	23,000
2018	42,870
2019	42,333
2020	57,650
2021	51,321
2022*	43,859



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

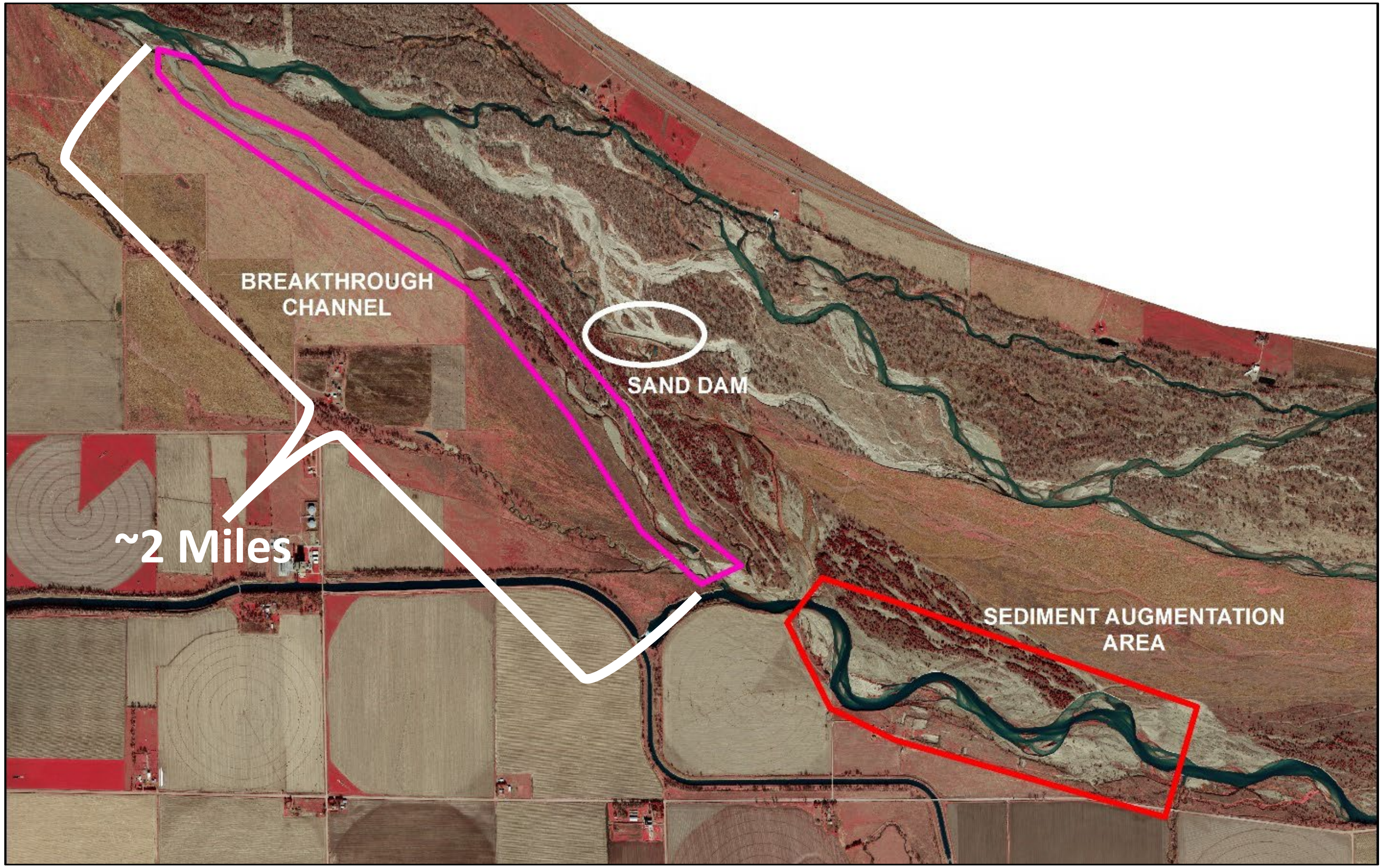
2017-2022 Projects

Year	Augmentation (Cubic Yards)
2017	23,000
2018	42,870
2019	42,333
2020	57,650
2021	51,321
2022*	43,859



Additional Sediment Input: Breakthrough Channel

- A 2-mile breakthrough channel formed at berm



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Breakthrough Channel: Additional Sediment Source

- Start of the channel
- Some evidence of occasional flow in historic high channel

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Breakthrough Channel: Additional Sediment Source

- Channel reactivated in 2016
- Remained active through fall 2019

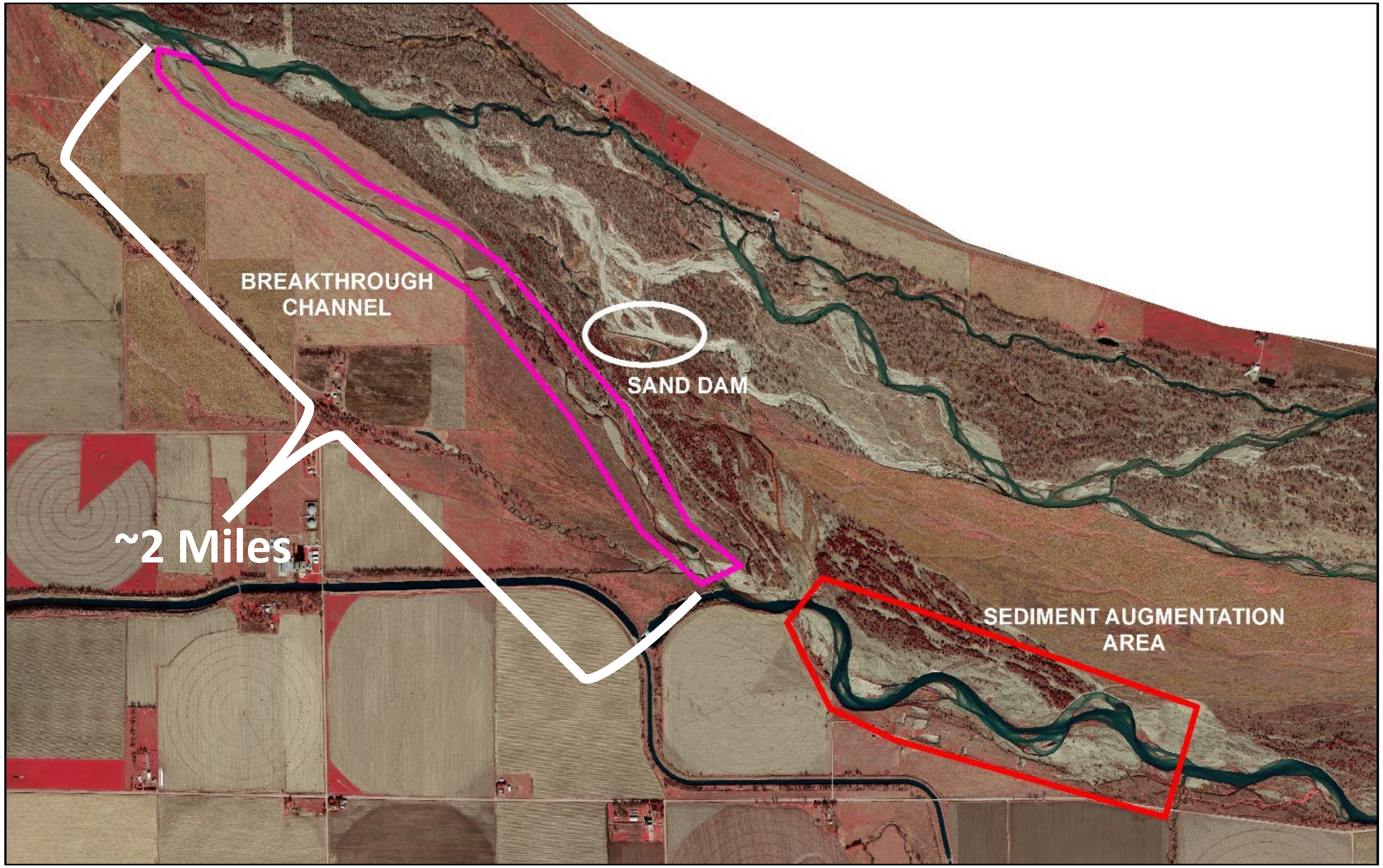
PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Breakthrough Channel: Additional Sediment Source

- Cut off in 2019
- Has remained stable since

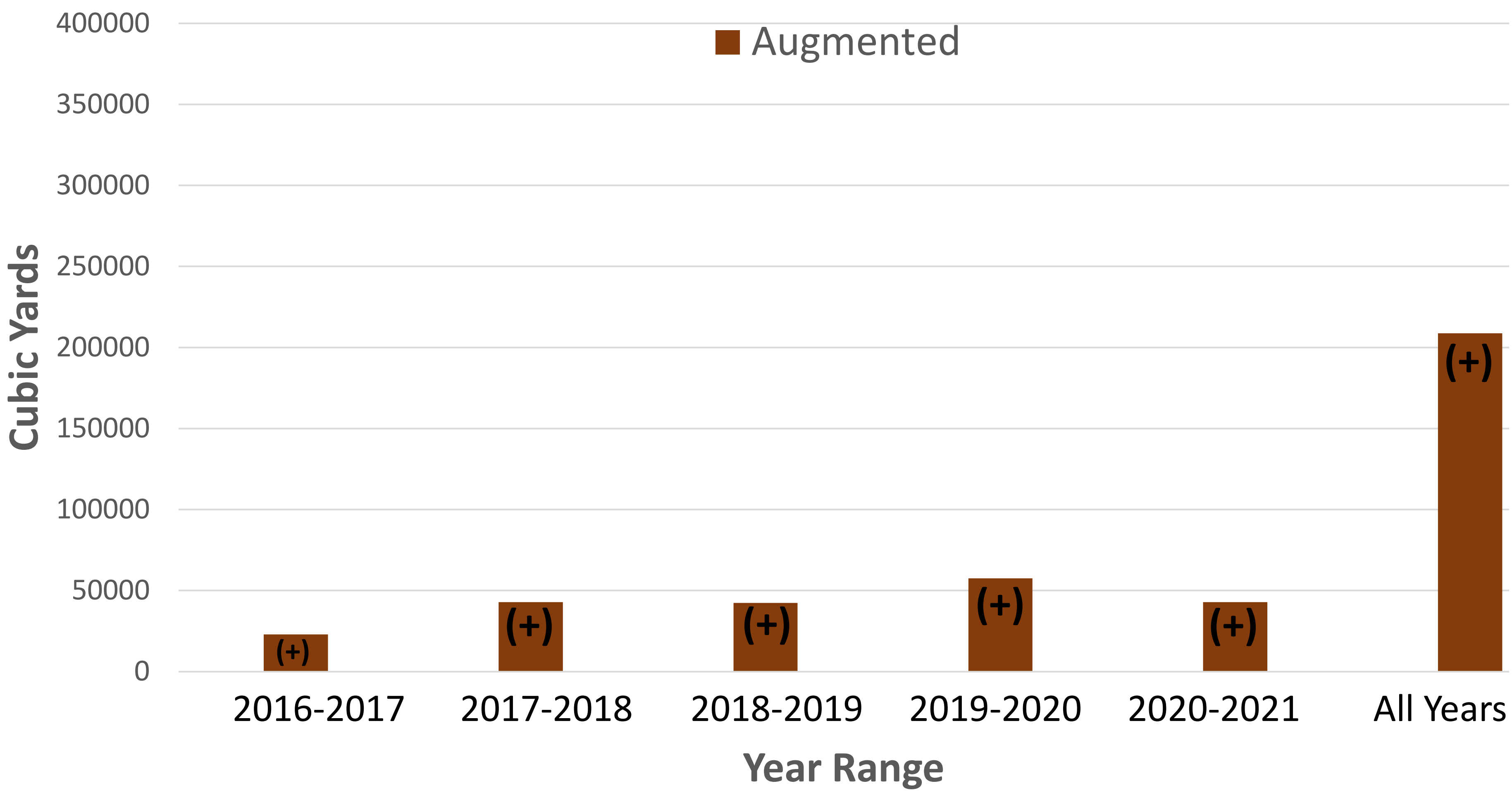
Additional Sediment Input: Breakthrough Channel

- Lateral Erosion & in 2-mile breakthrough reach contributed sediment for 3 years



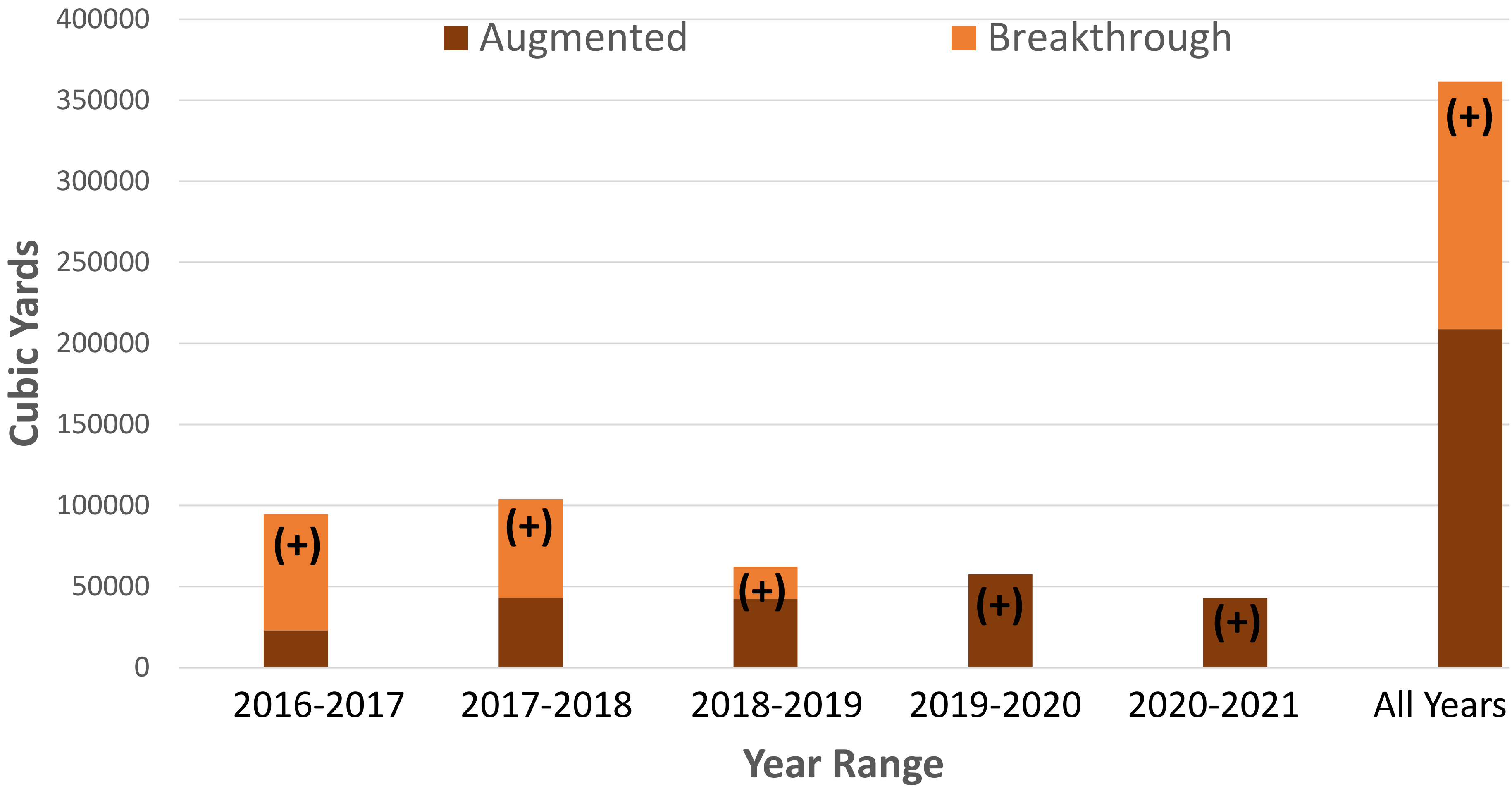
PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Sediment Augmentation: One Big Sandbox

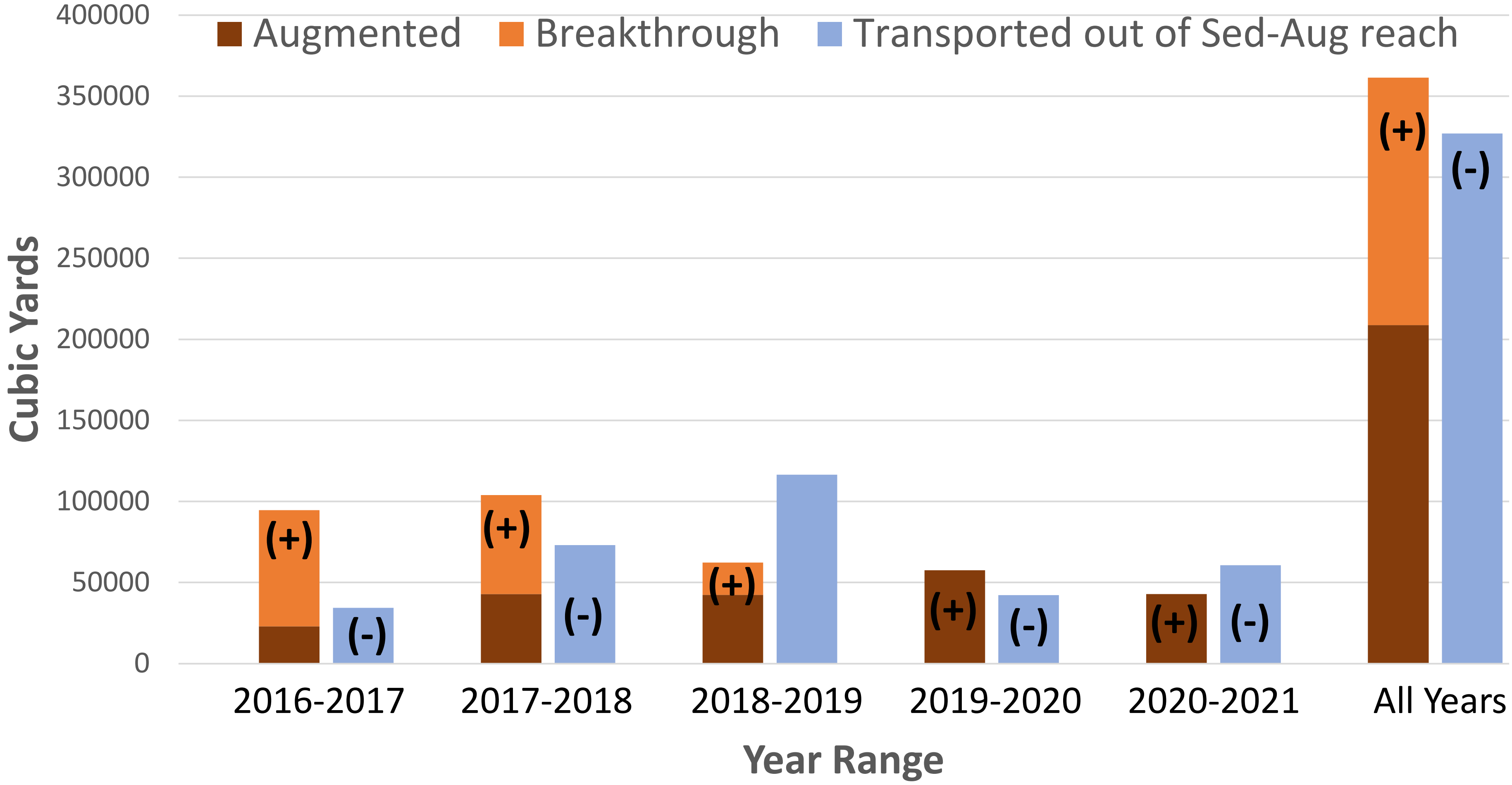


PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Sed-Aug: One Big Sandbox



Sed-Aug: One Big Sandbox



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Questions?

Change since augmentation:

Relative elevation and longitudinal profile analysis

Sarah Fancher, PhD

Fluvial Geomorphologist

Introduction

Extension Big Question #3
Is sediment augmentation necessary to create and/or maintain suitable whooping crane habitat?

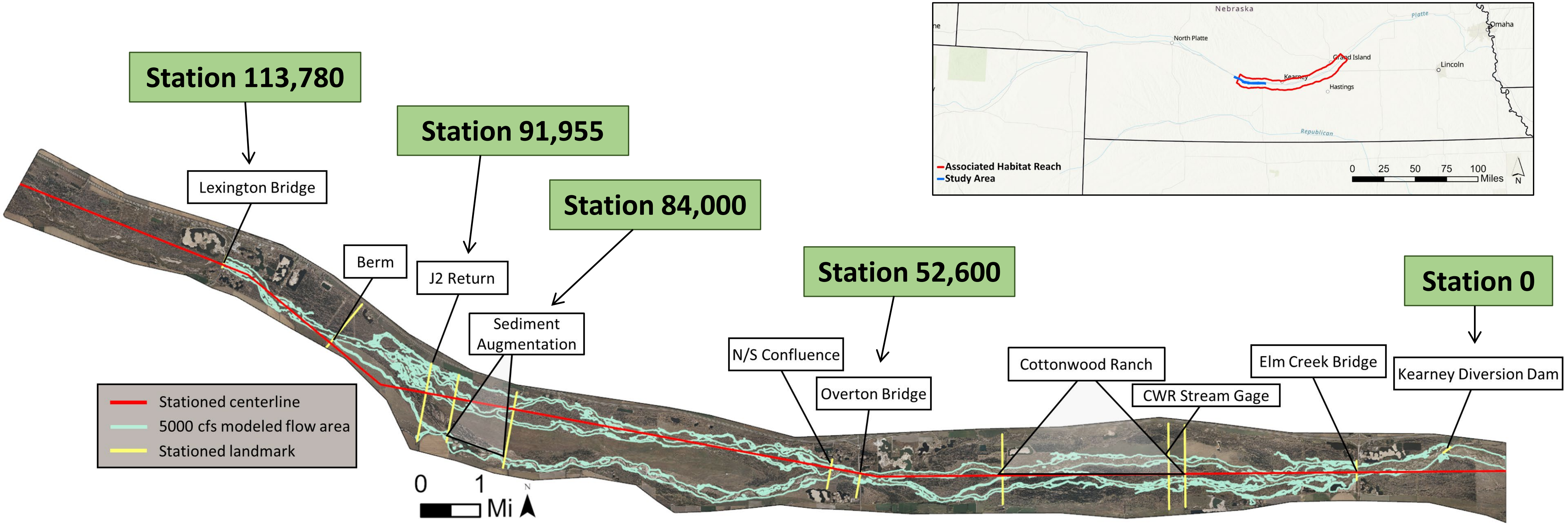
→ **Can we detect change since sediment augmentation began?**

<u>3 components of analysis:</u>

1) Relative elevation model & longitudinal profile
2) Thalweg longitudinal profile
3) Average cross-sectional elevation longitudinal profile

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Geographic Context and Stationing

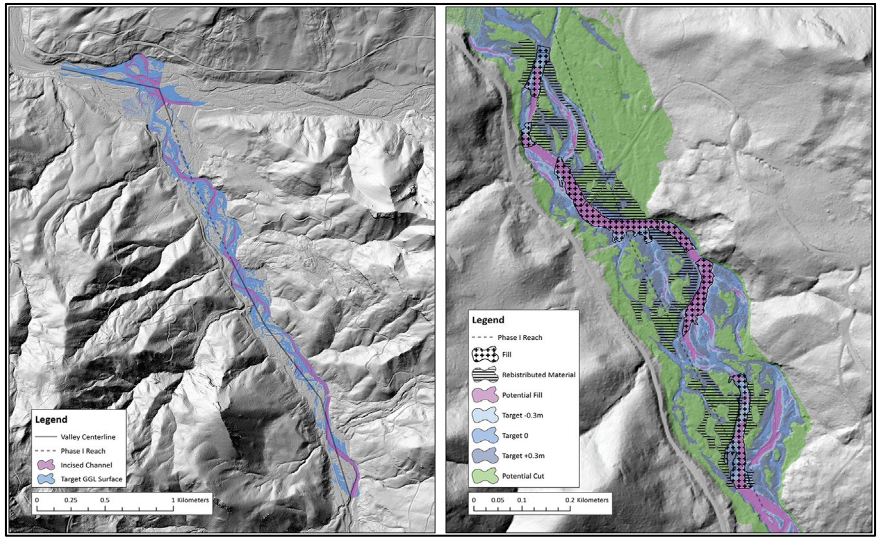


PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

1) Relative Elevation

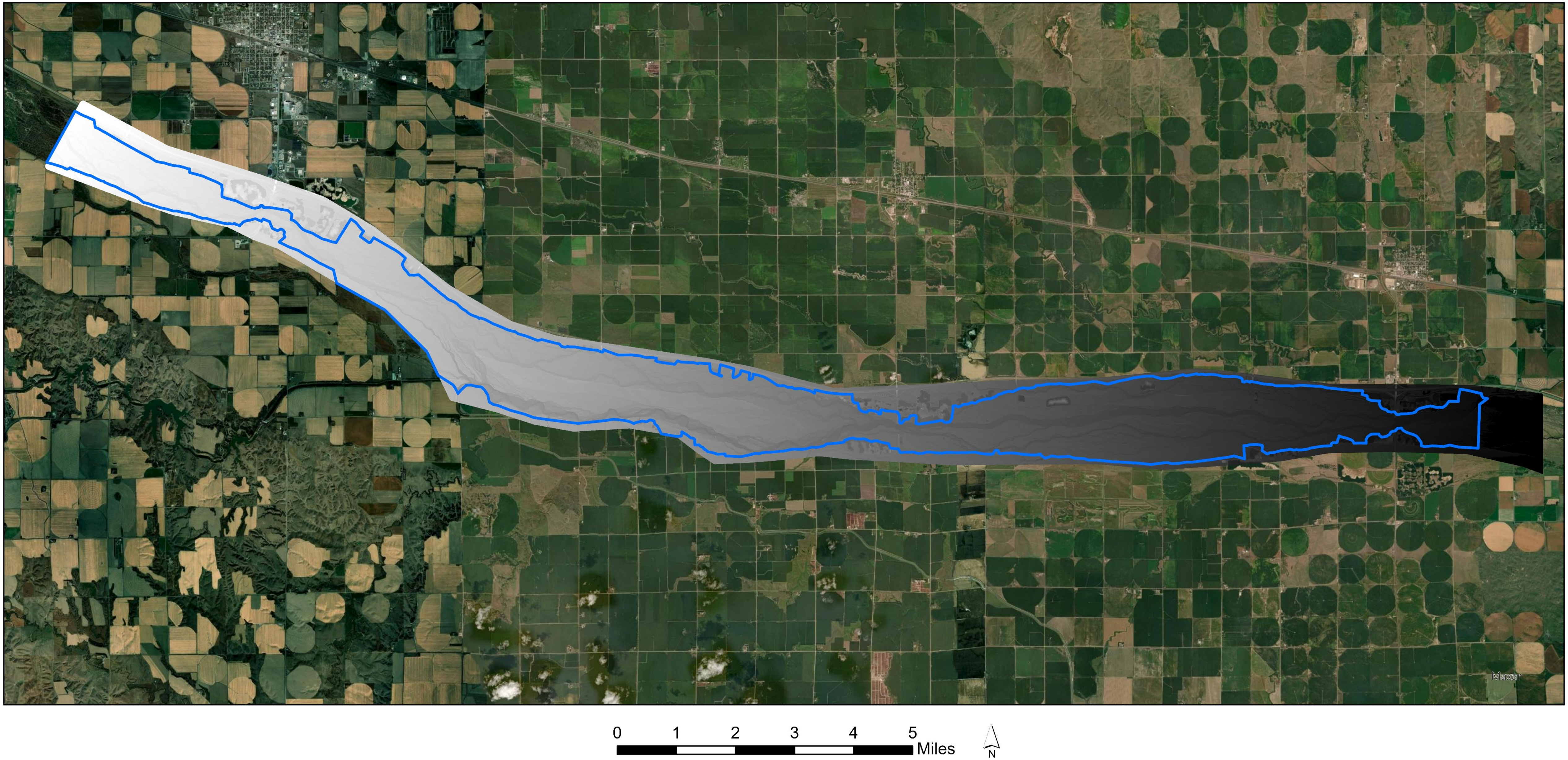
- Deviation from average floodplain elevation (or other surfaces)
- We used a Geomorphic Grade Line (GGL) to represent average floodplain elevation *(Powers et al., 2019)*

Example of height above water REM for the Flathead River, MT. Image courtesy of Montana State Library.

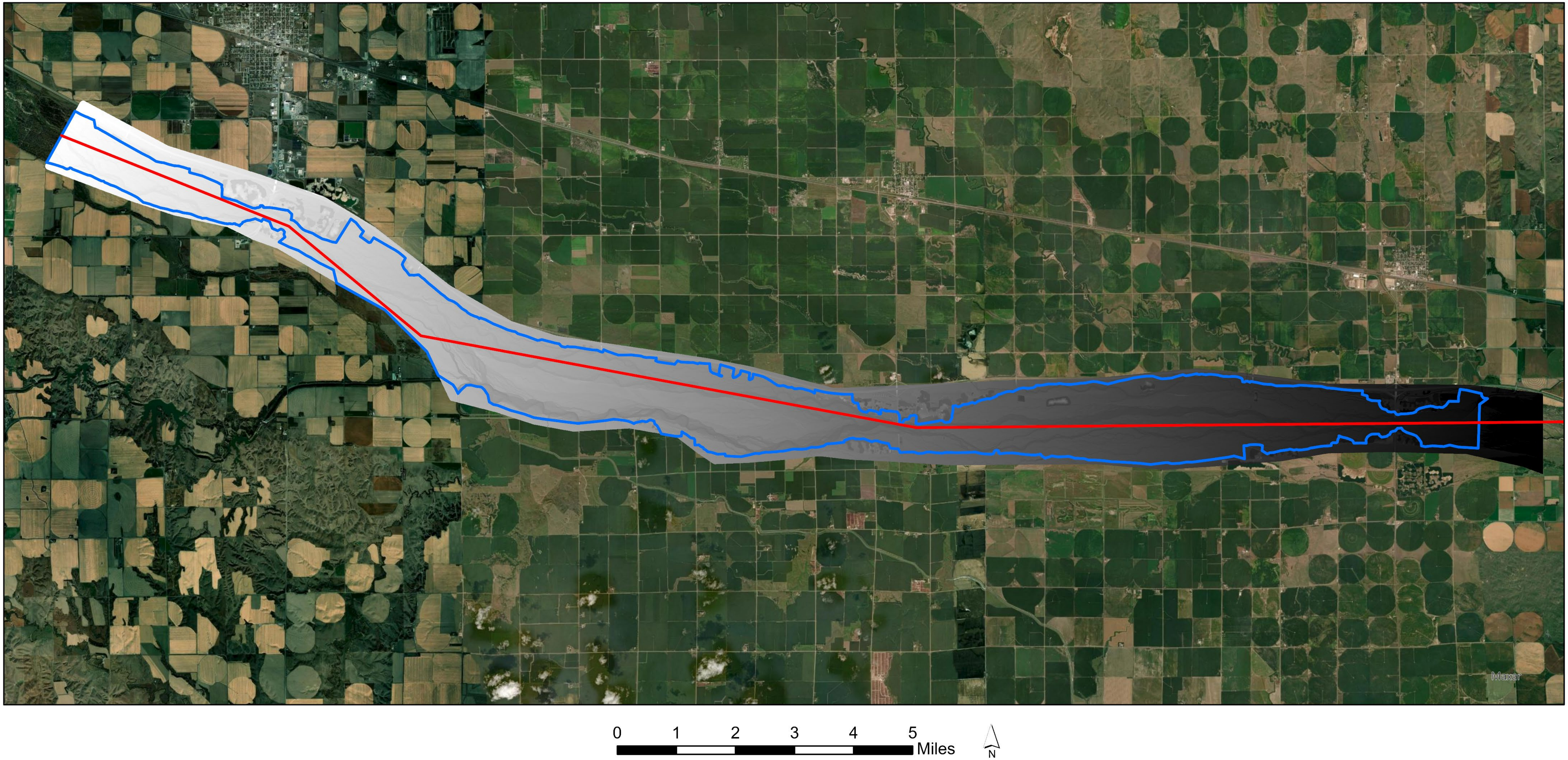


Powers et al., (2019) Figure 7. GGL REMs can be used to identify areas of cut and fill for valley bottom restoration.

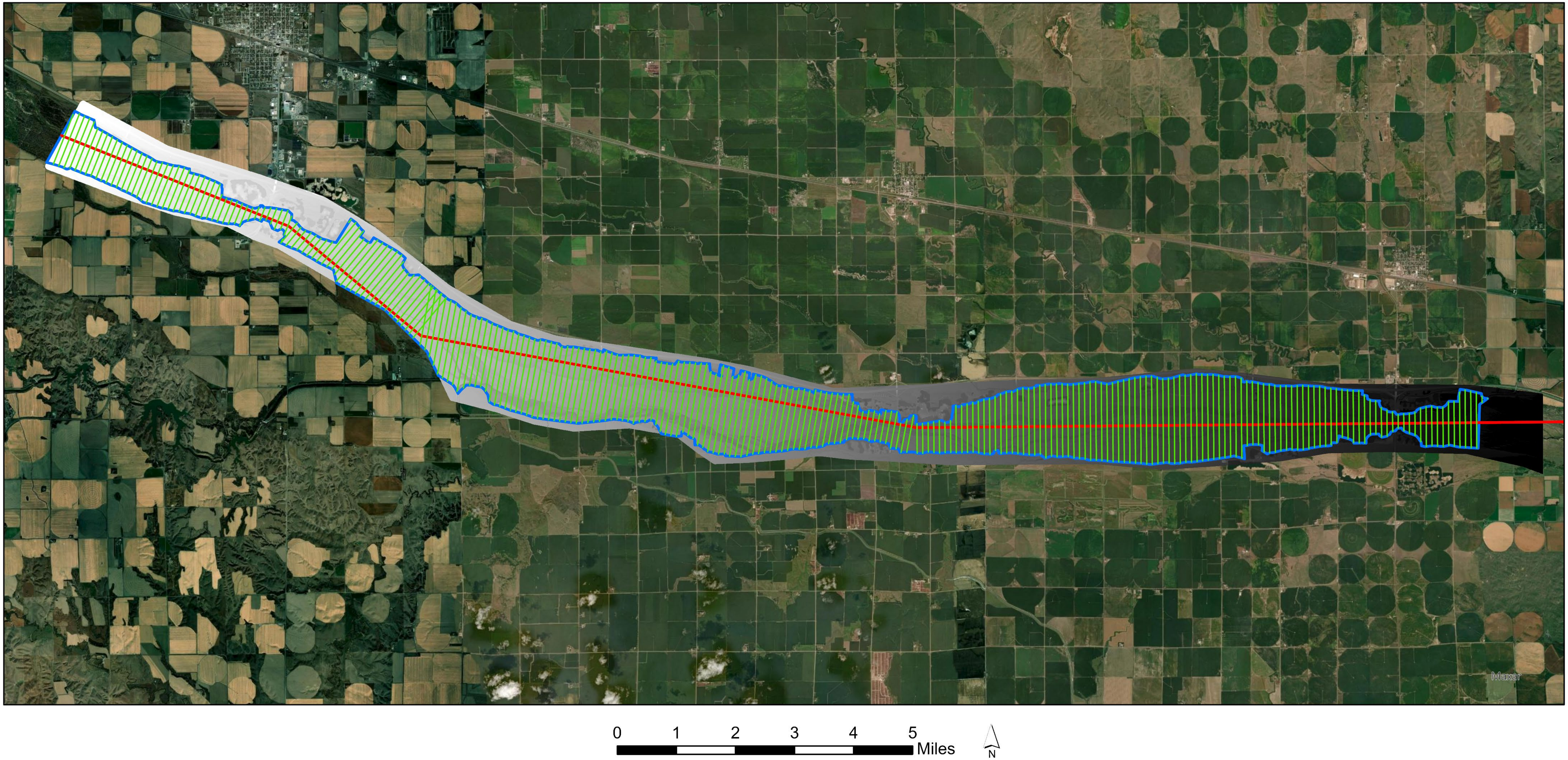
Methods: Relative Elevation



Methods: Relative Elevation

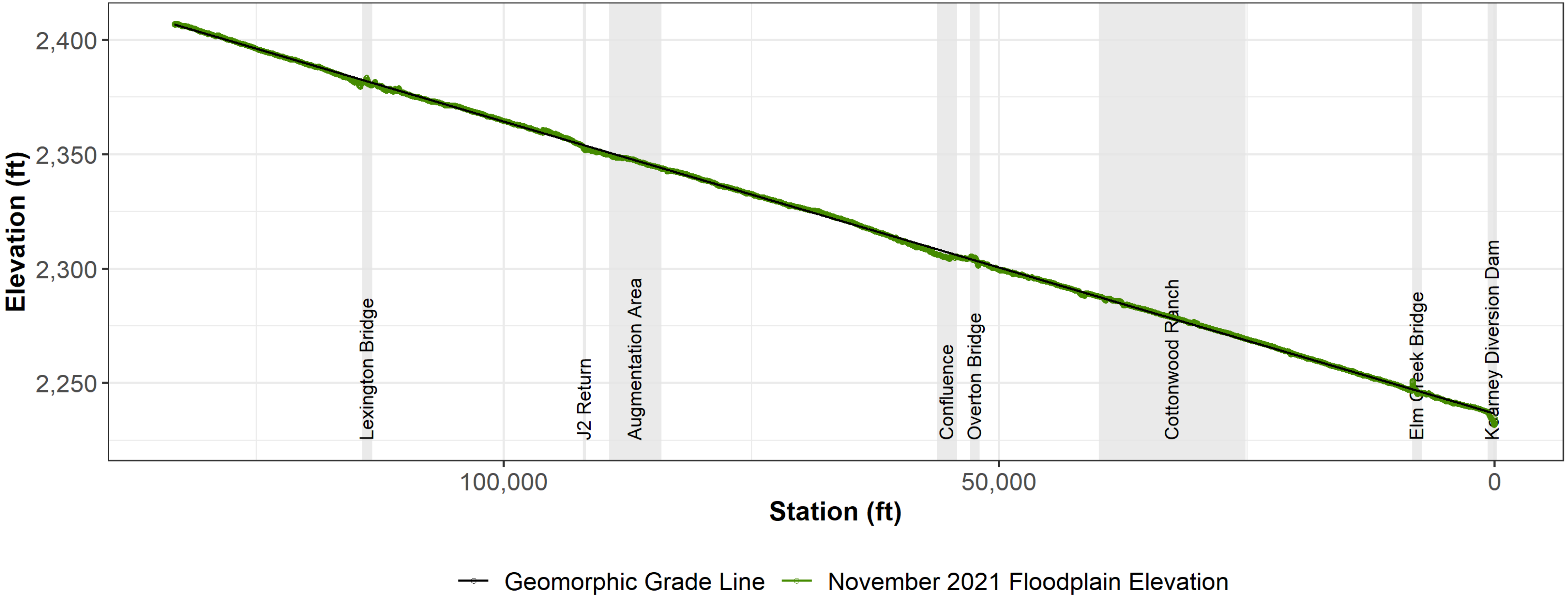


Methods: Relative Elevation



Methods: Relative Elevation

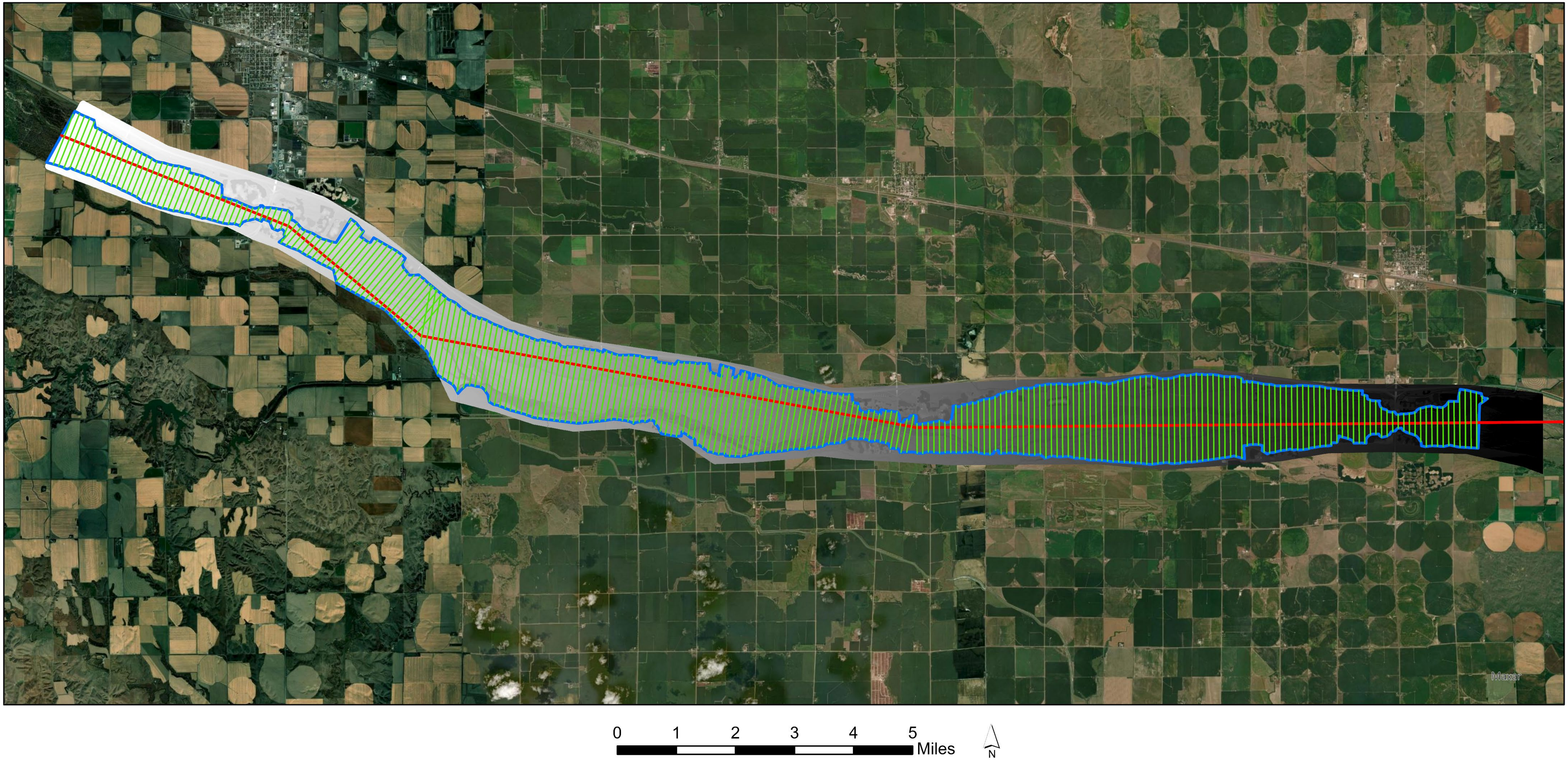
Geomorphic grade line



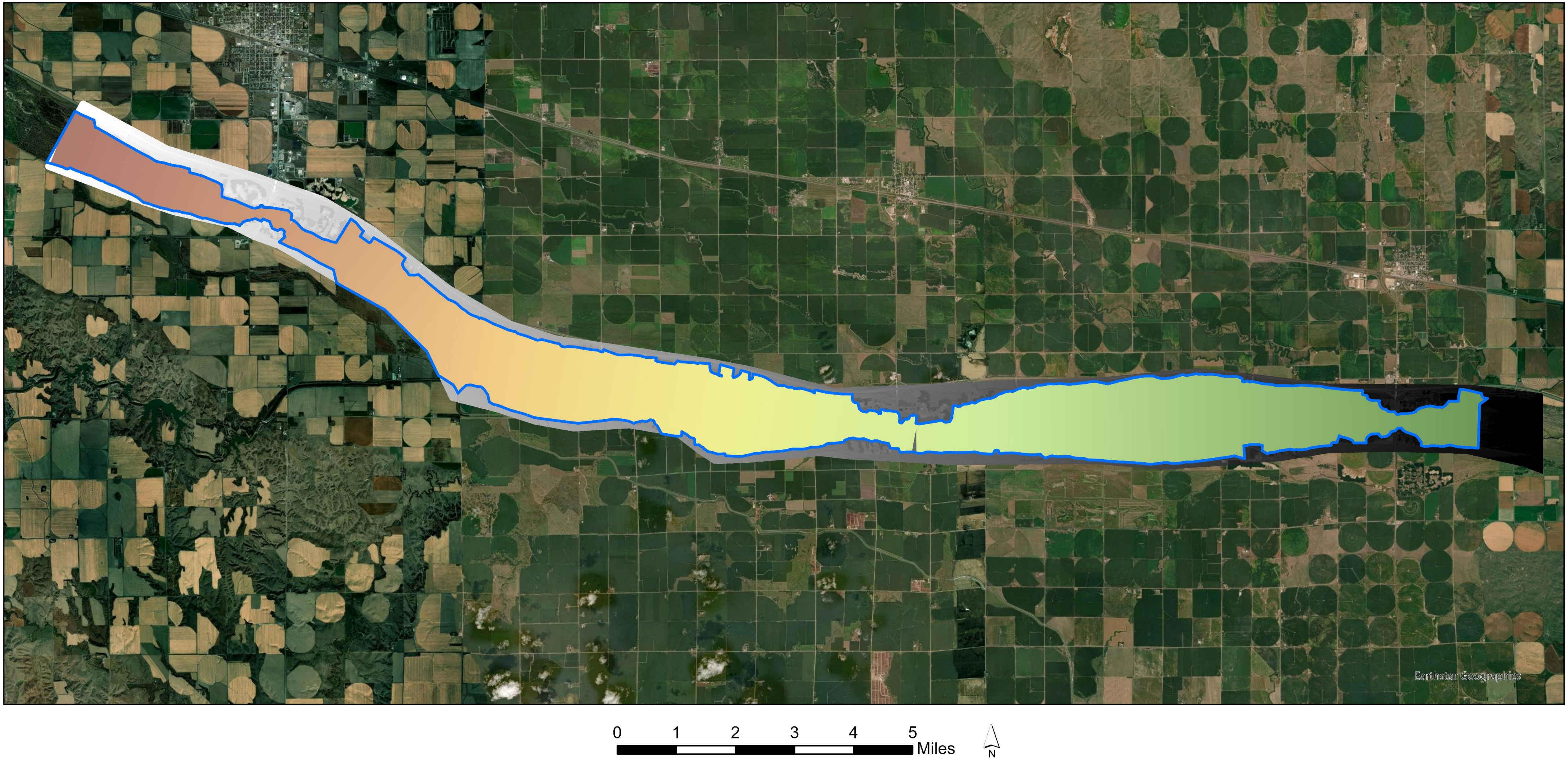
$$y = 0.001276x + 2237$$

$R^2 = 0.99$

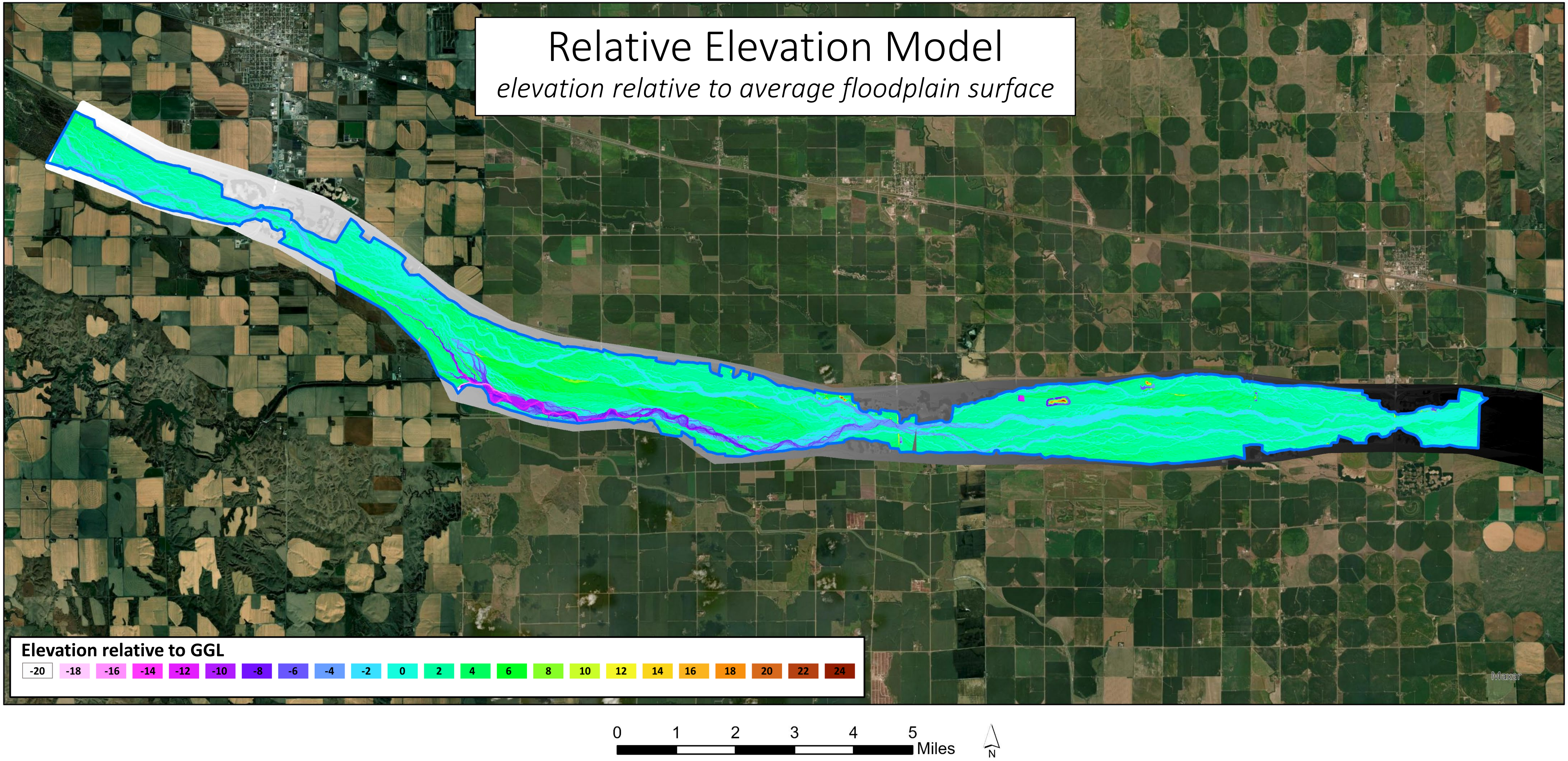
PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM



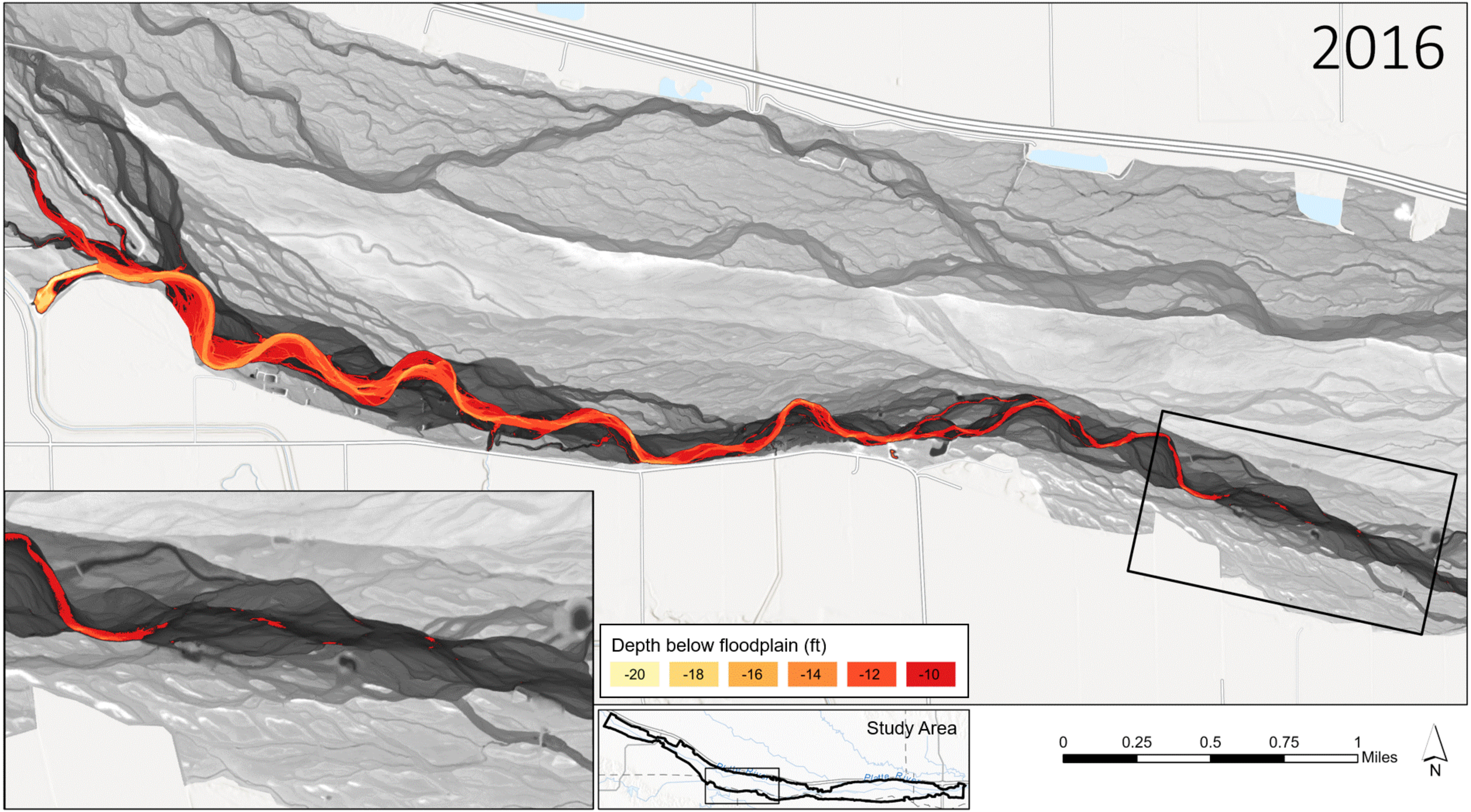
Methods: Relative Elevation



Methods: Relative Elevation

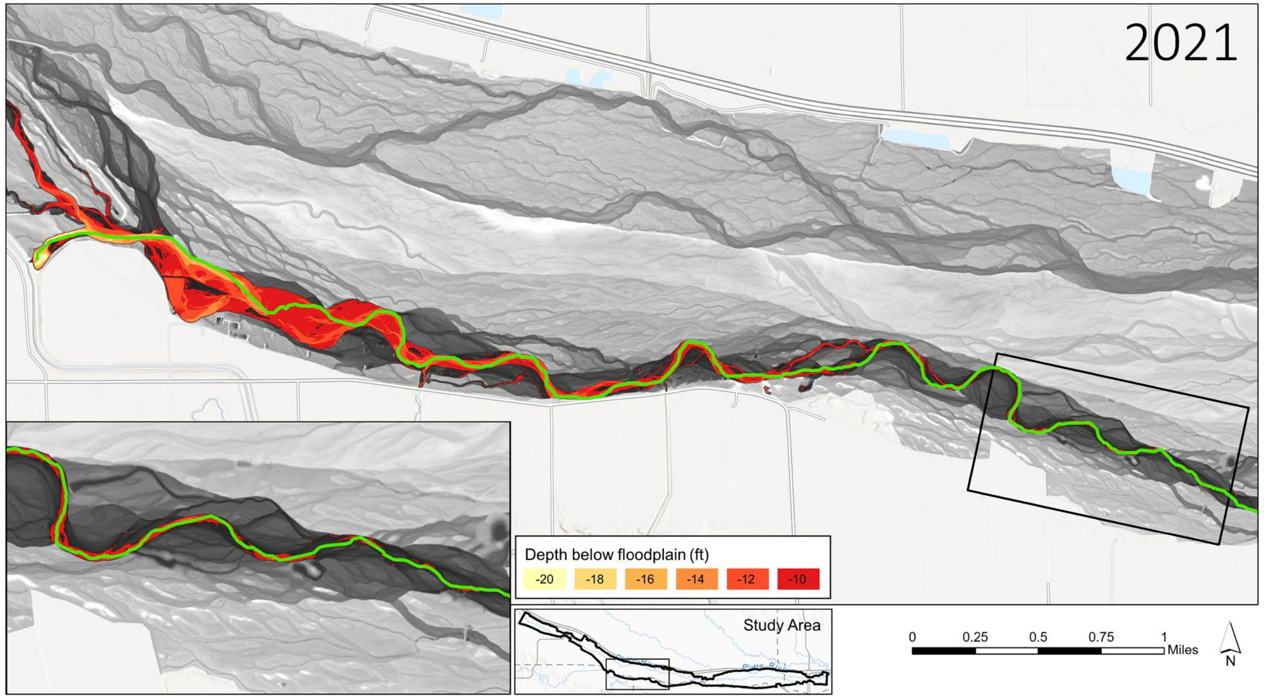


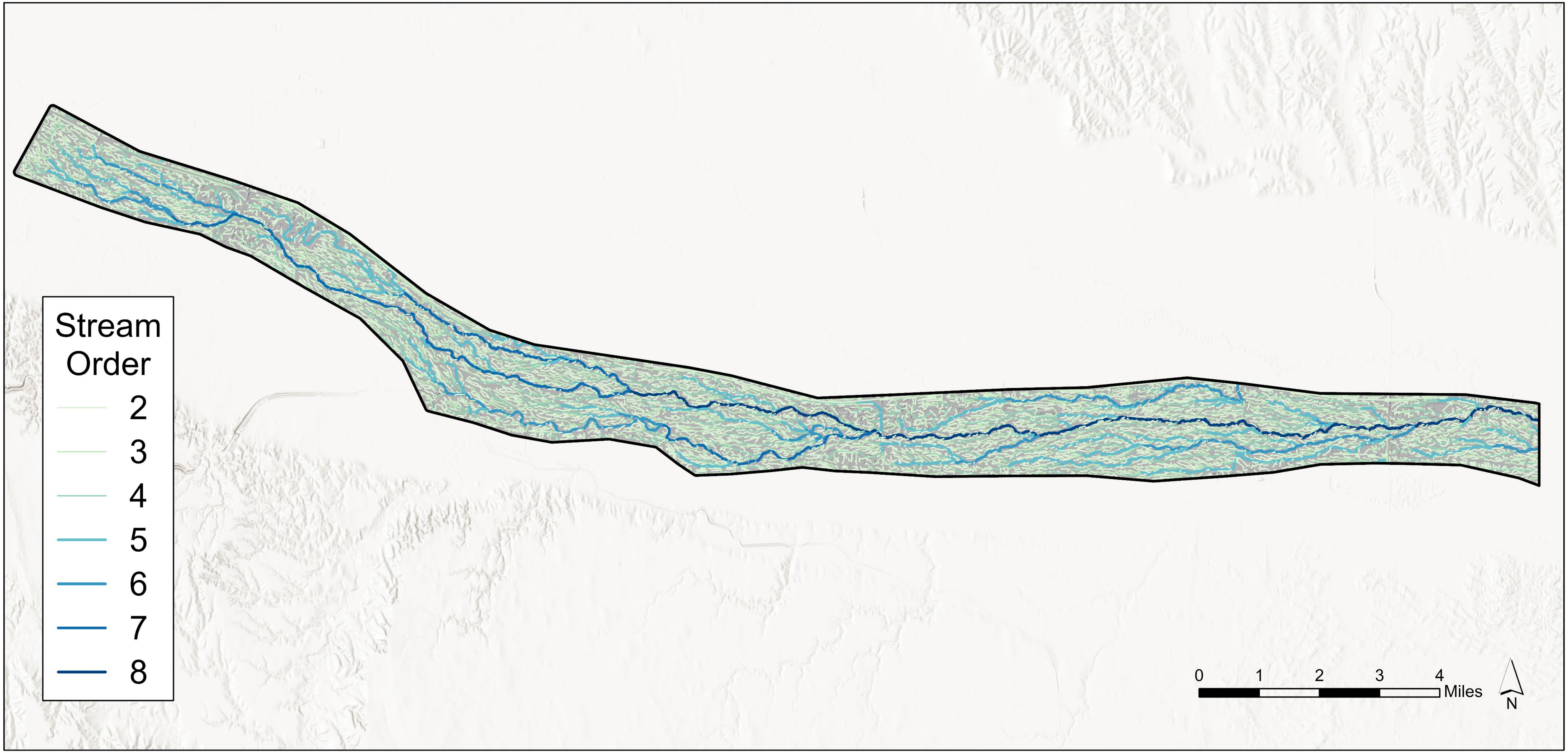
Methods: Relative Elevation


2016
Depth below floodplain (ft)
-20
-18
-16
-14
-12
-10
Study Area
0
0.25
0.5
0.75
1
Miles
N

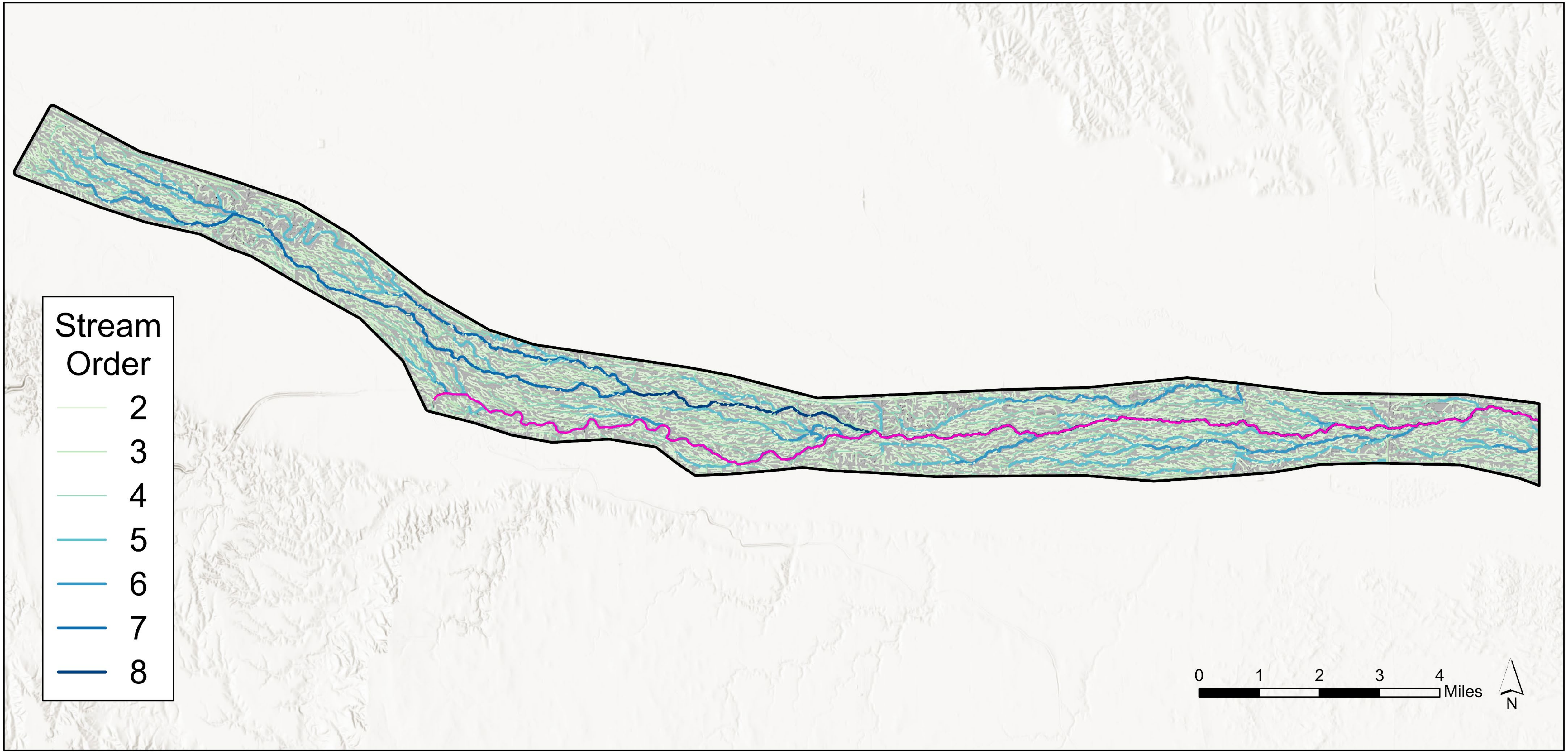
Sampling Method

- Sample elevation and relative elevation along channel thalweg
- Used flow accumulation raster to generate thalweg lines

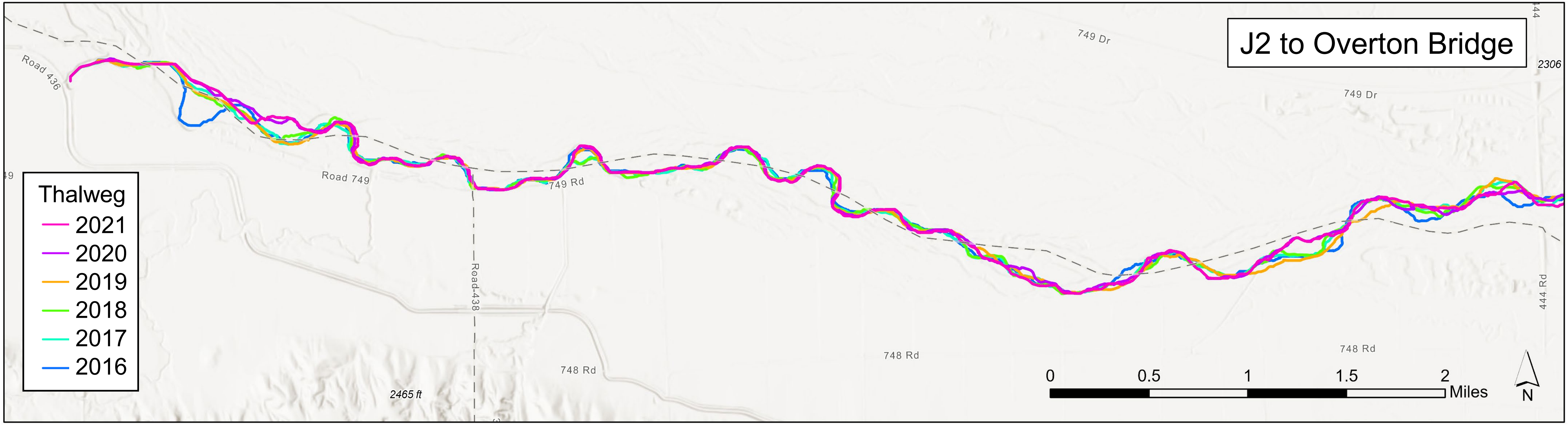


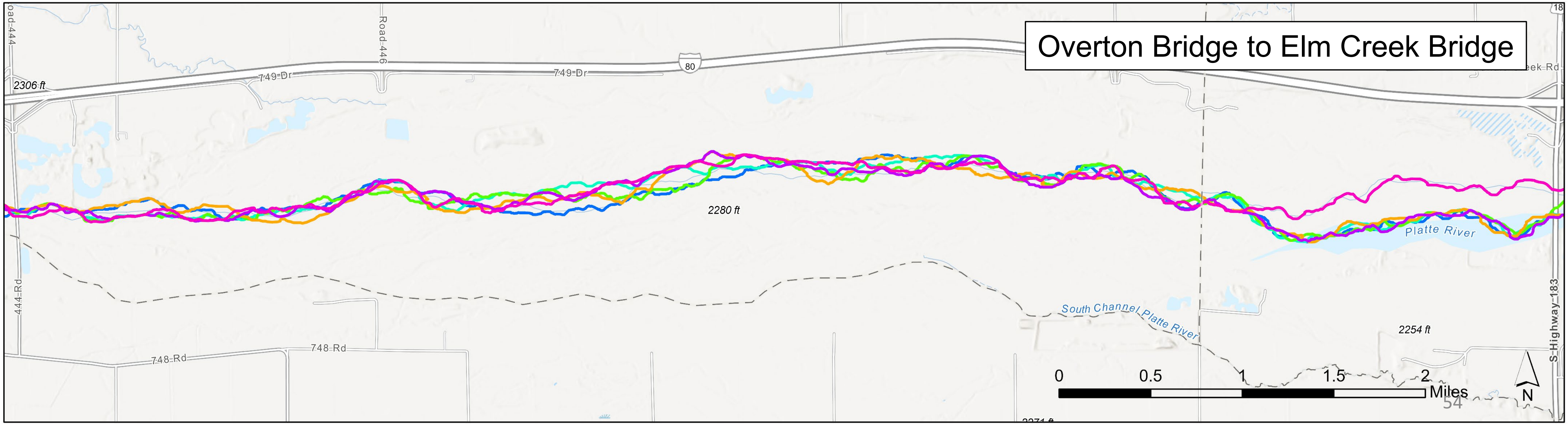


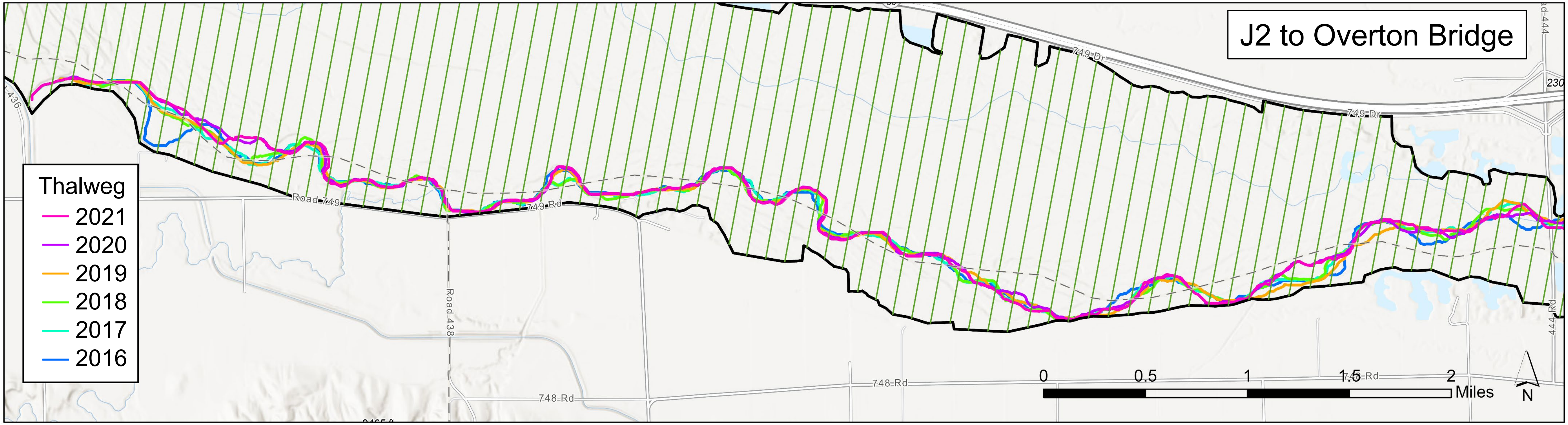
Methods: Thalweg generation

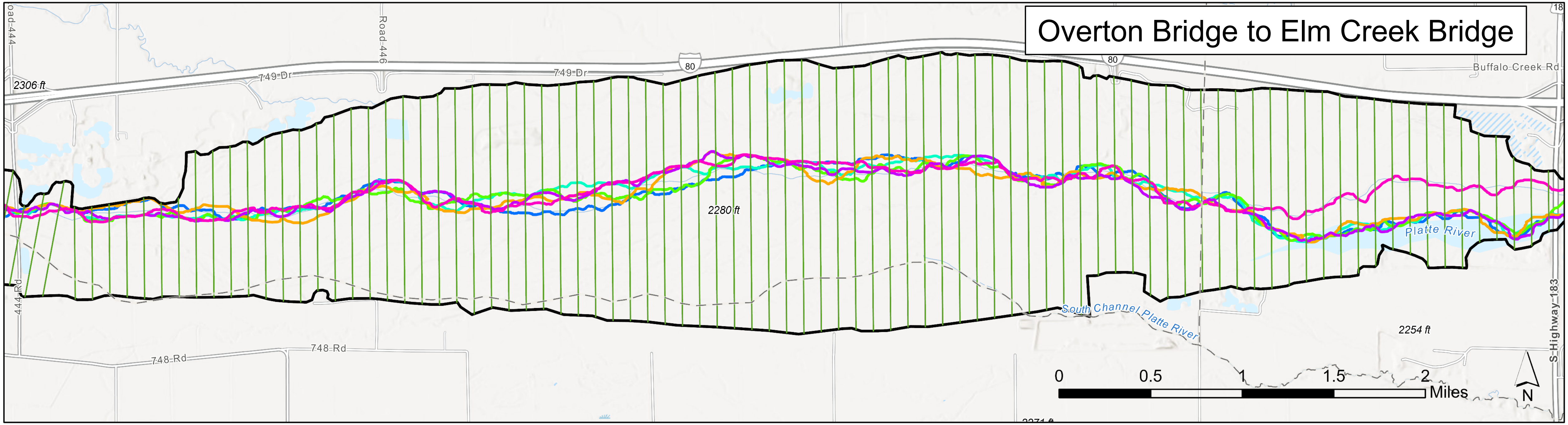


Methods: Thalweg generation


J2 to Overton Bridge
Thalweg
2021
2020
2019
2018
2017
2016
Road 436
Road 749
749 Rd
749 Dr
748 Rd
Road 438
444 Rd
2306
2465 ft
0
0.5
1
1.5
2
Miles
N

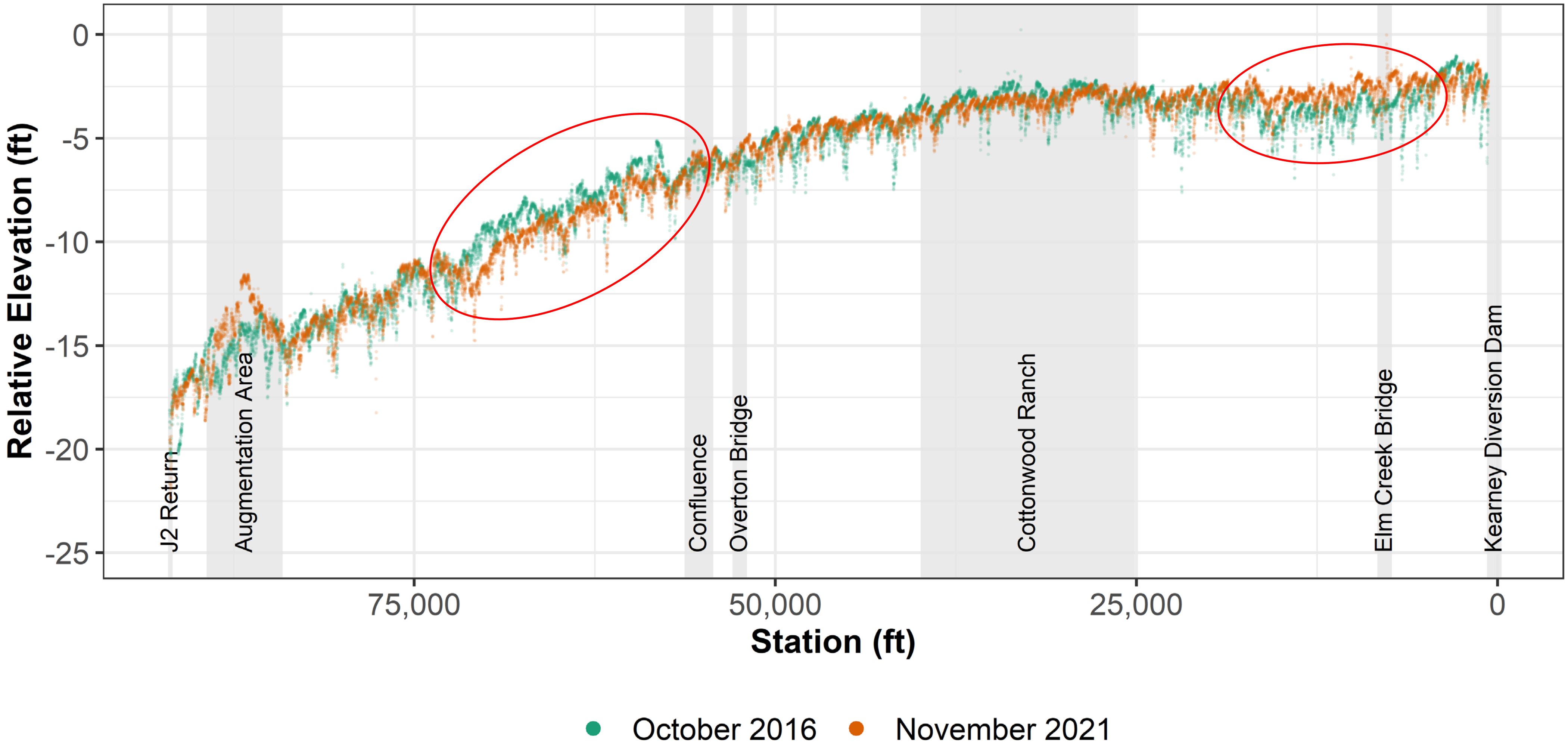

Overton Bridge to Elm Creek Bridge
749 Dr
80
Road 446
444 Rd
748 Rd
2306 ft
2280 ft
2254 ft
Platte River
South Channel Platte River
S Highway 183
0
0.5
1
1.5
2
Miles
N


J2 to Overton Bridge
Thalweg
2021
2020
2019
2018
2017
2016
Road 749
749 Rd
749 Dr
Road 438
748 Rd
0
0.5
1
1.5
2
Miles
N


Overton Bridge to Elm Creek Bridge
749 Dr
Road 446
80
2306 ft
2280 ft
2254 ft
Buffalo Creek Rd
Platte River
South Channel Platte River
748 Rd
444 Rd
S Highway 183
0
0.5
1
1.5
2
Miles
N

Longitudinal profile of relative elevation

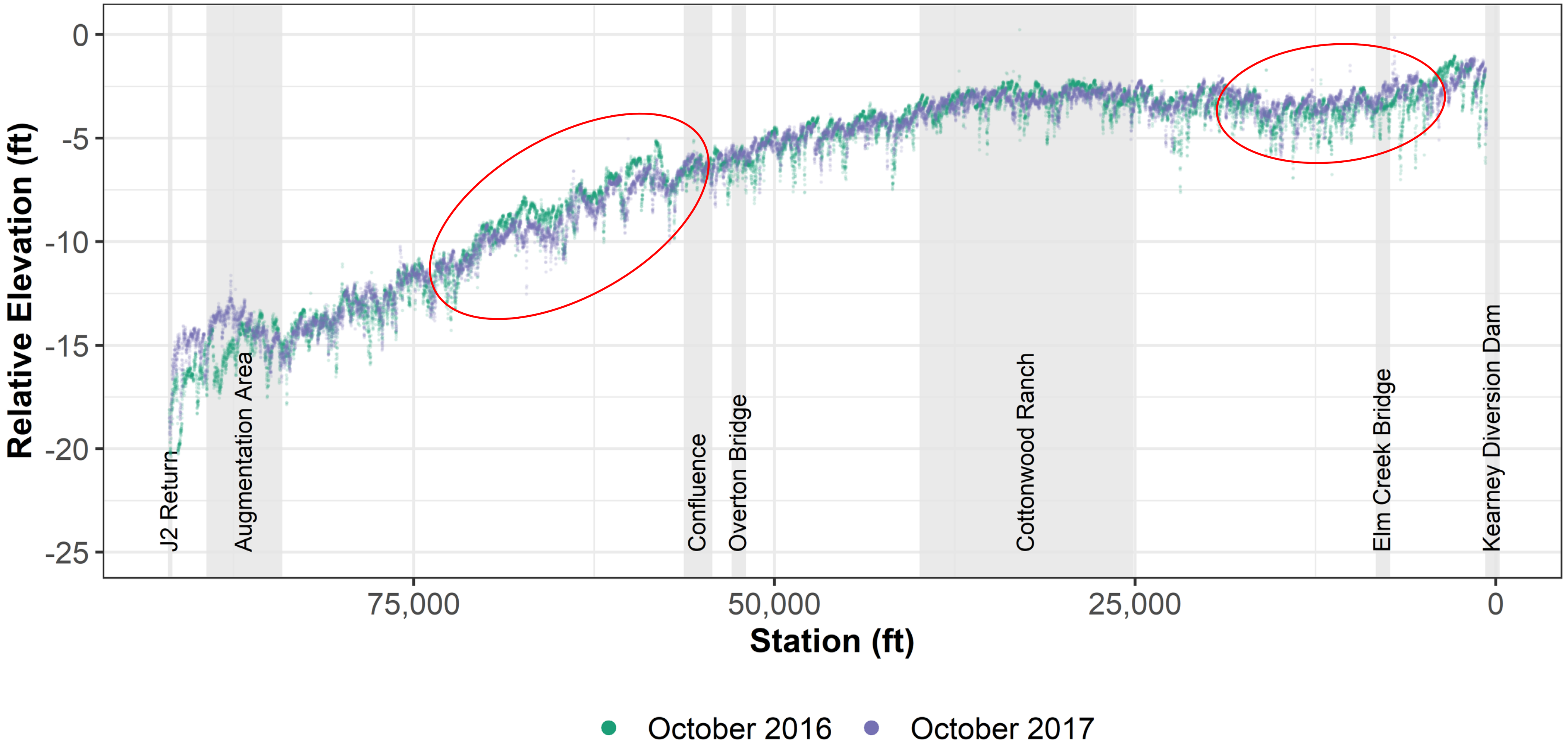
Thalweg relative to GGL



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Longitudinal profile of relative elevation

Thalweg relative to GGL

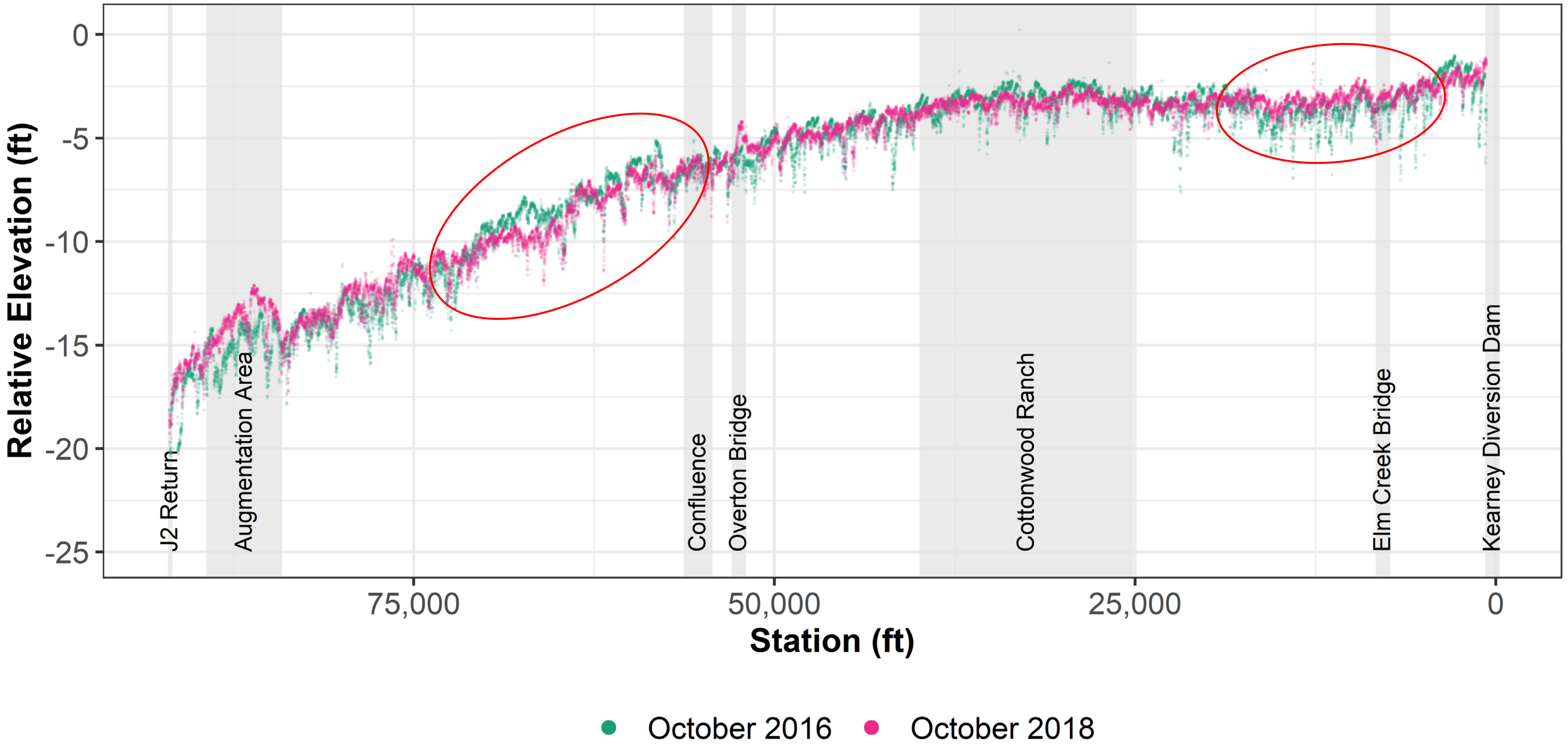


PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

Results: Relative Elevation

Longitudinal profile of relative elevation

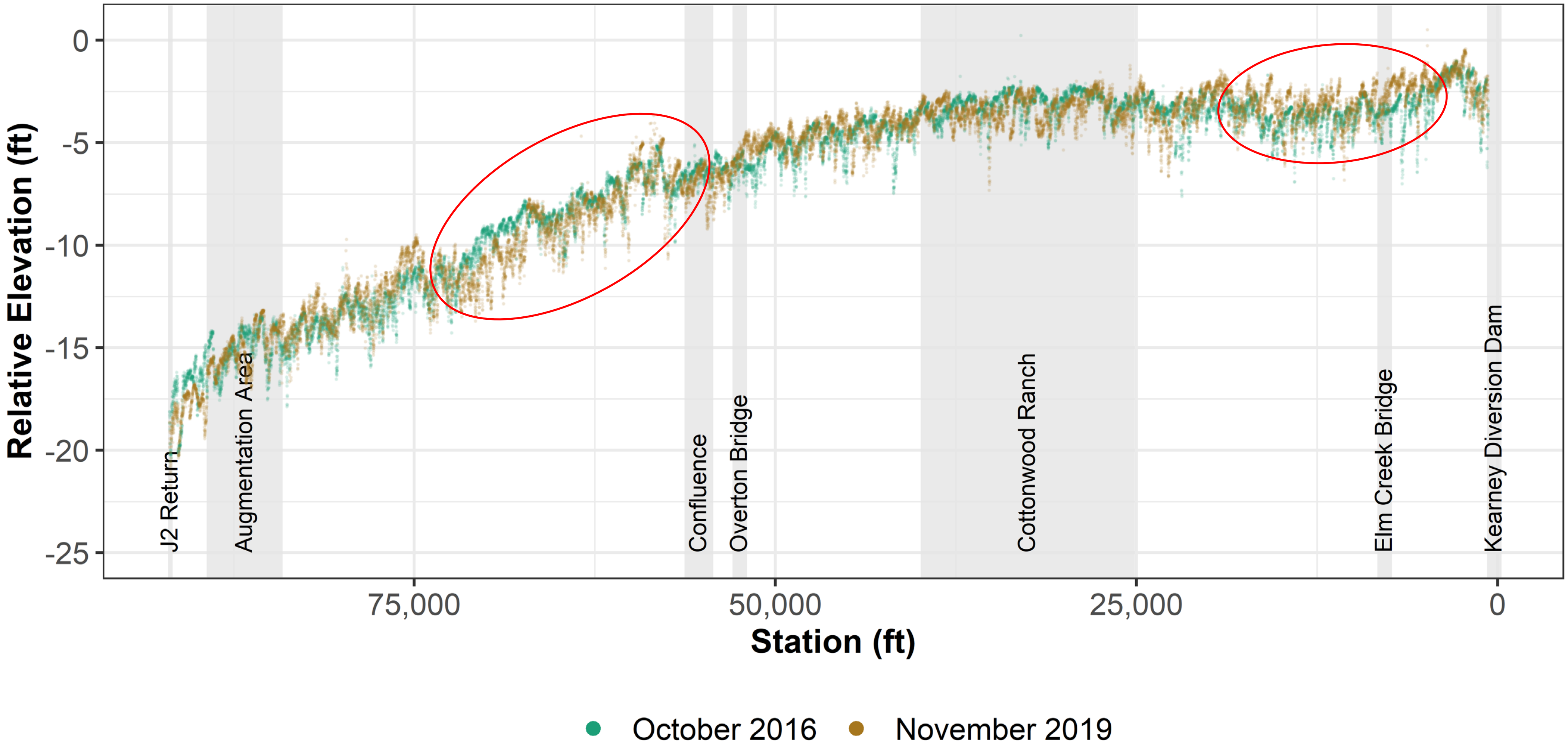
Thalweg relative to GGL



PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

Longitudinal profile of relative elevation

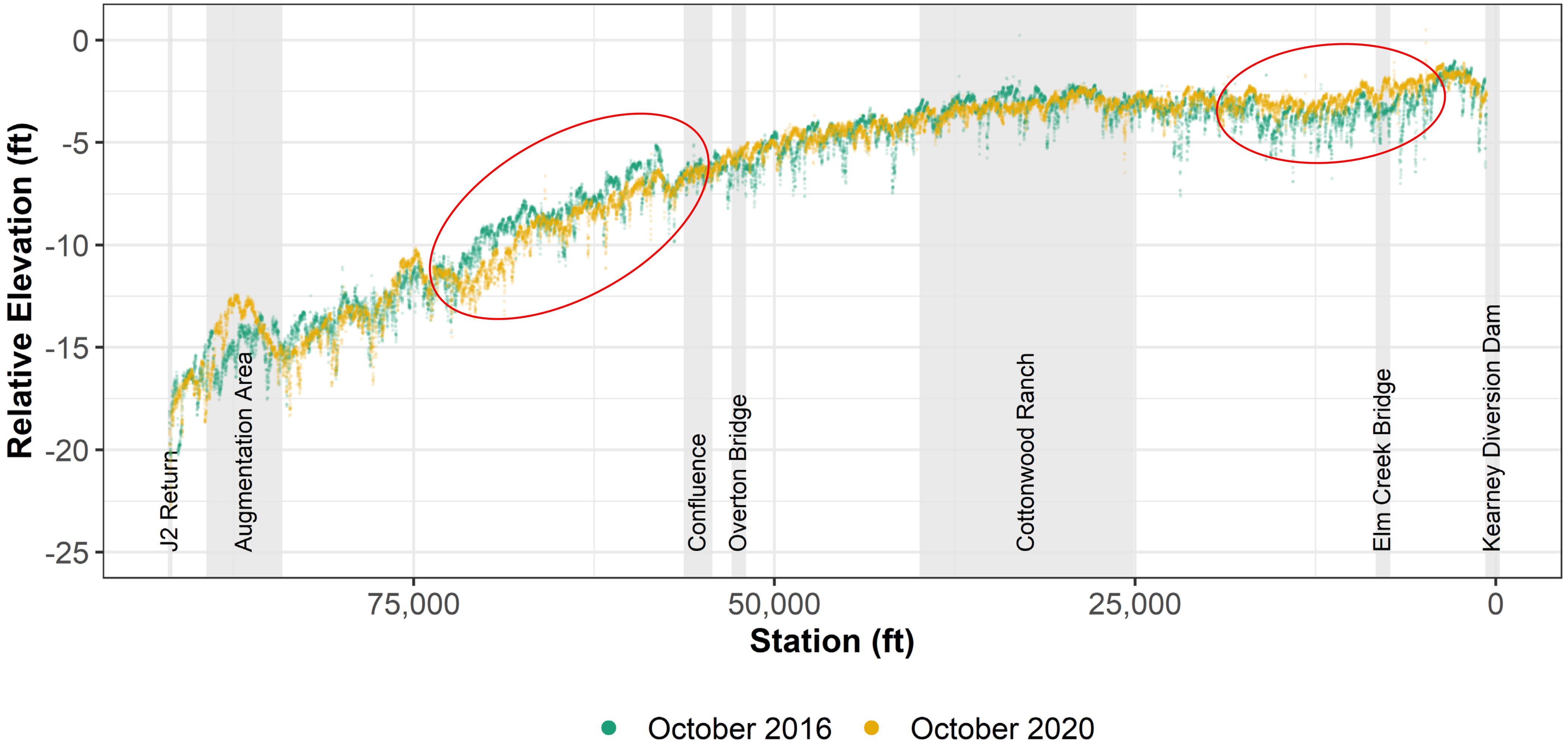
Thalweg relative to GGL



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Longitudinal profile of relative elevation

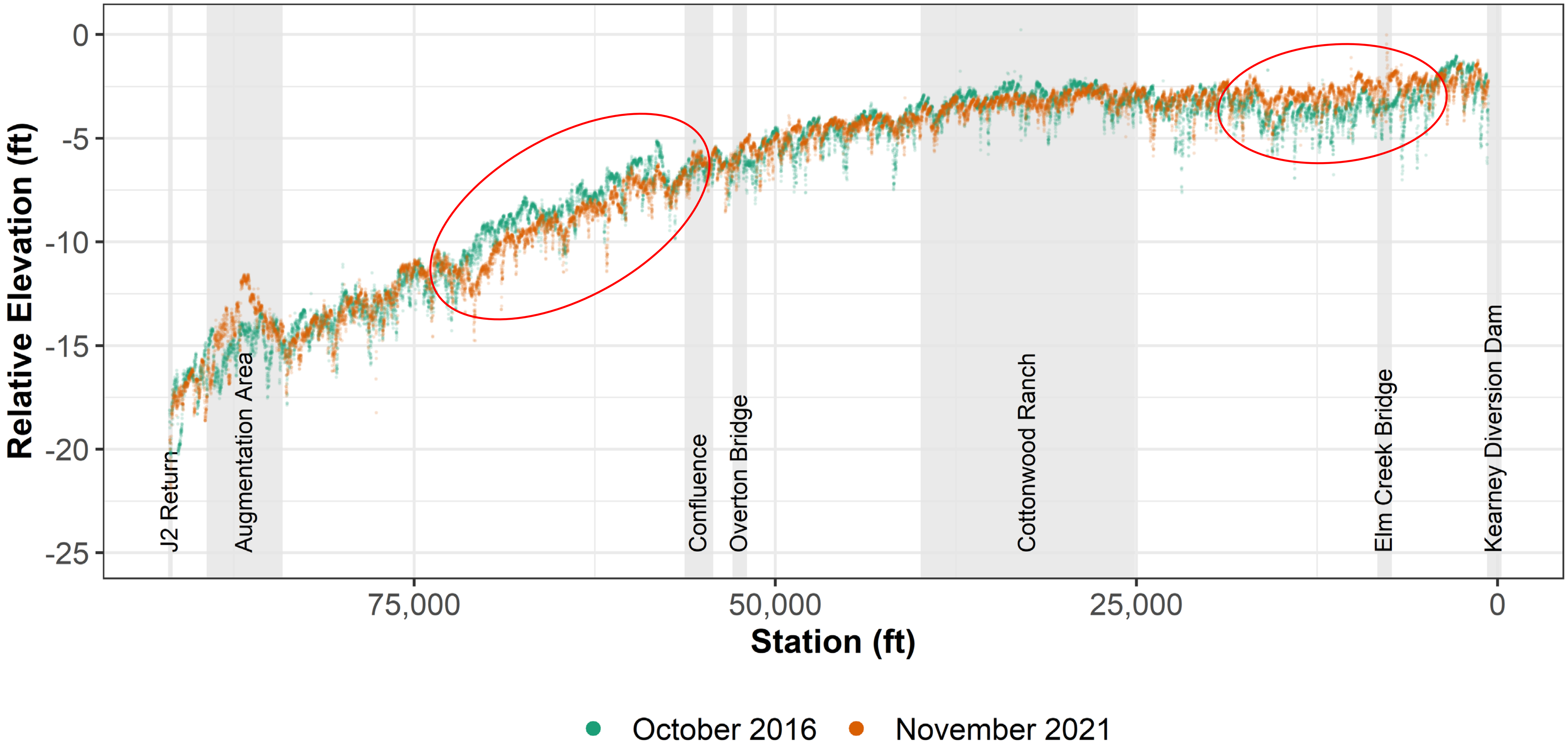
Thalweg relative to GGL



PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

Longitudinal profile of relative elevation

Thalweg relative to GGL

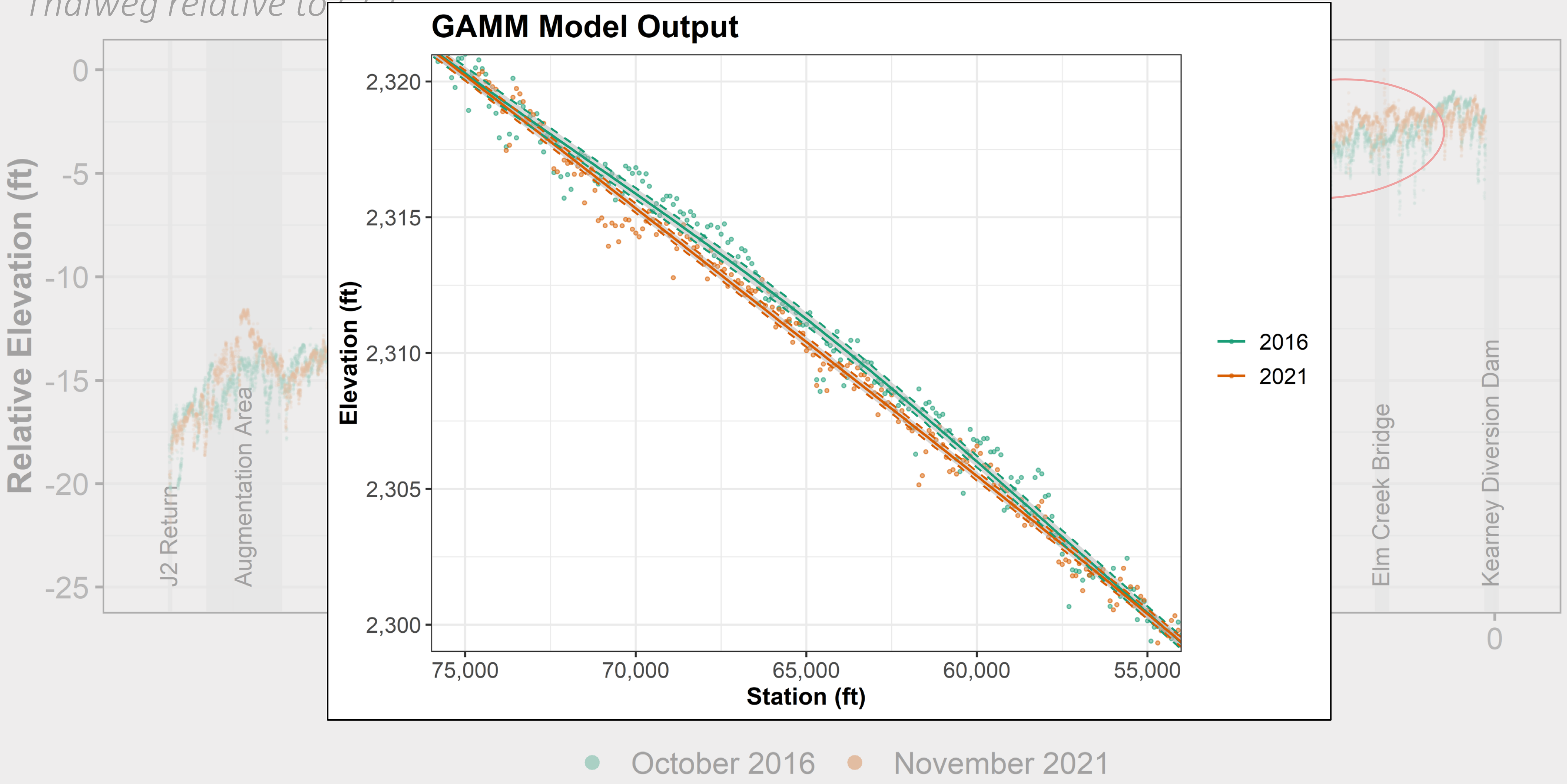


Additional statistical methods?

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

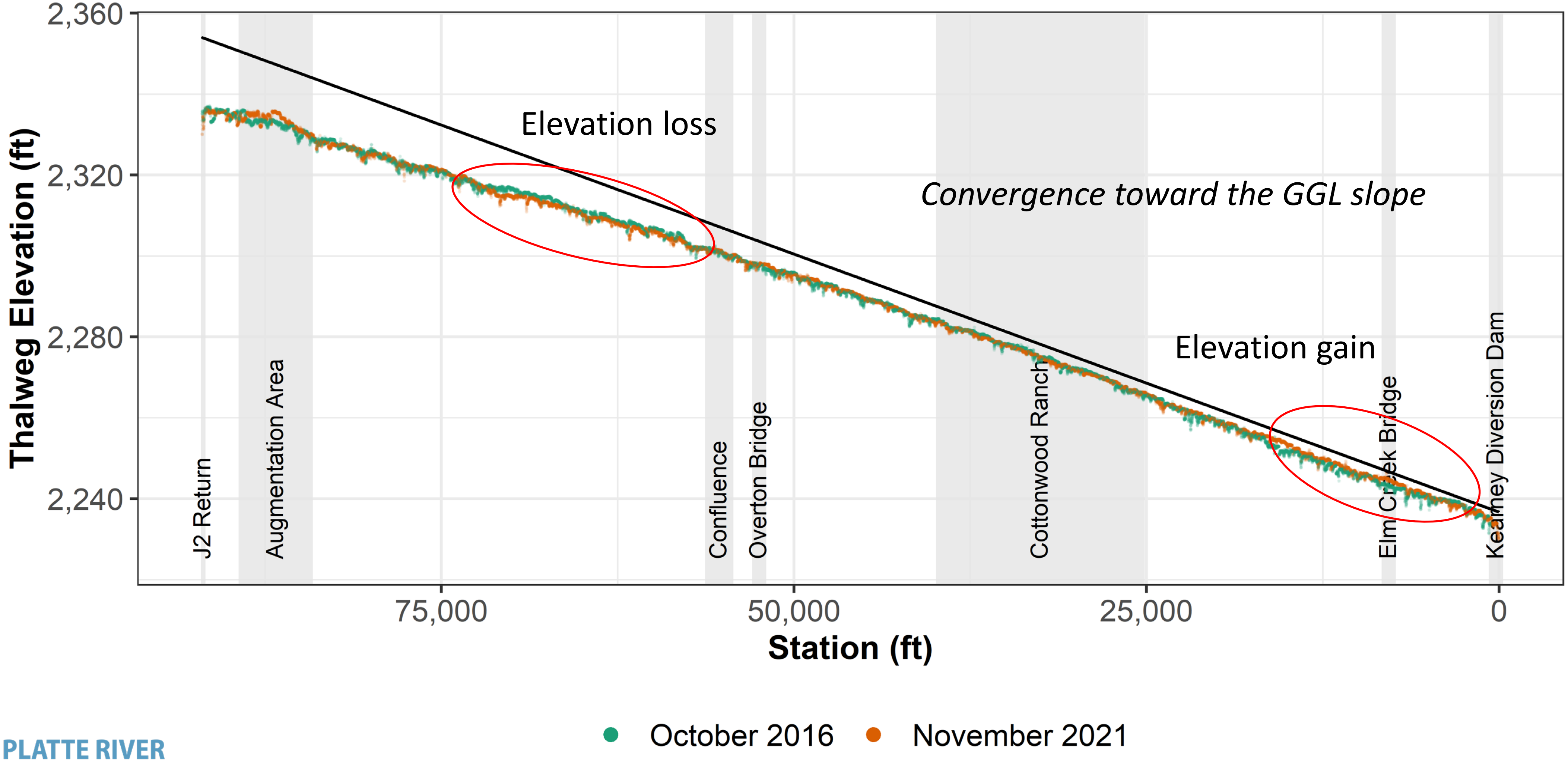
Longitudinal profile of relative elevation

Thalweg relative to



Additional statistical methods?

2) Longitudinal profile of channel thalweg



PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

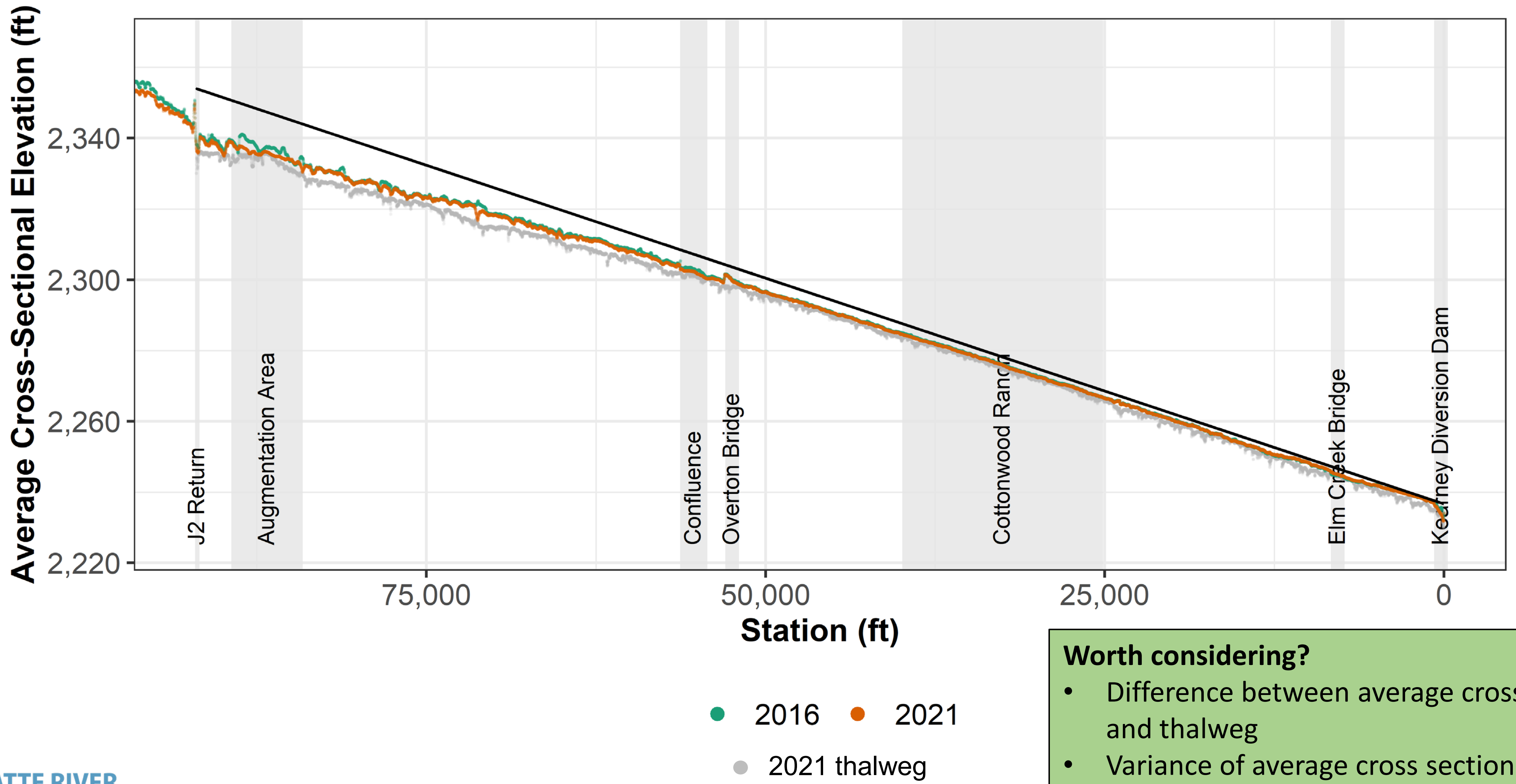
3) Average Cross Sectional Elevation

- Average elevation of the same transects
- Clipped by 5,000 cfs modeled flow

Transects shown every 500 ft, but sampled at 5 ft

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Longitudinal profile of average XS elevation

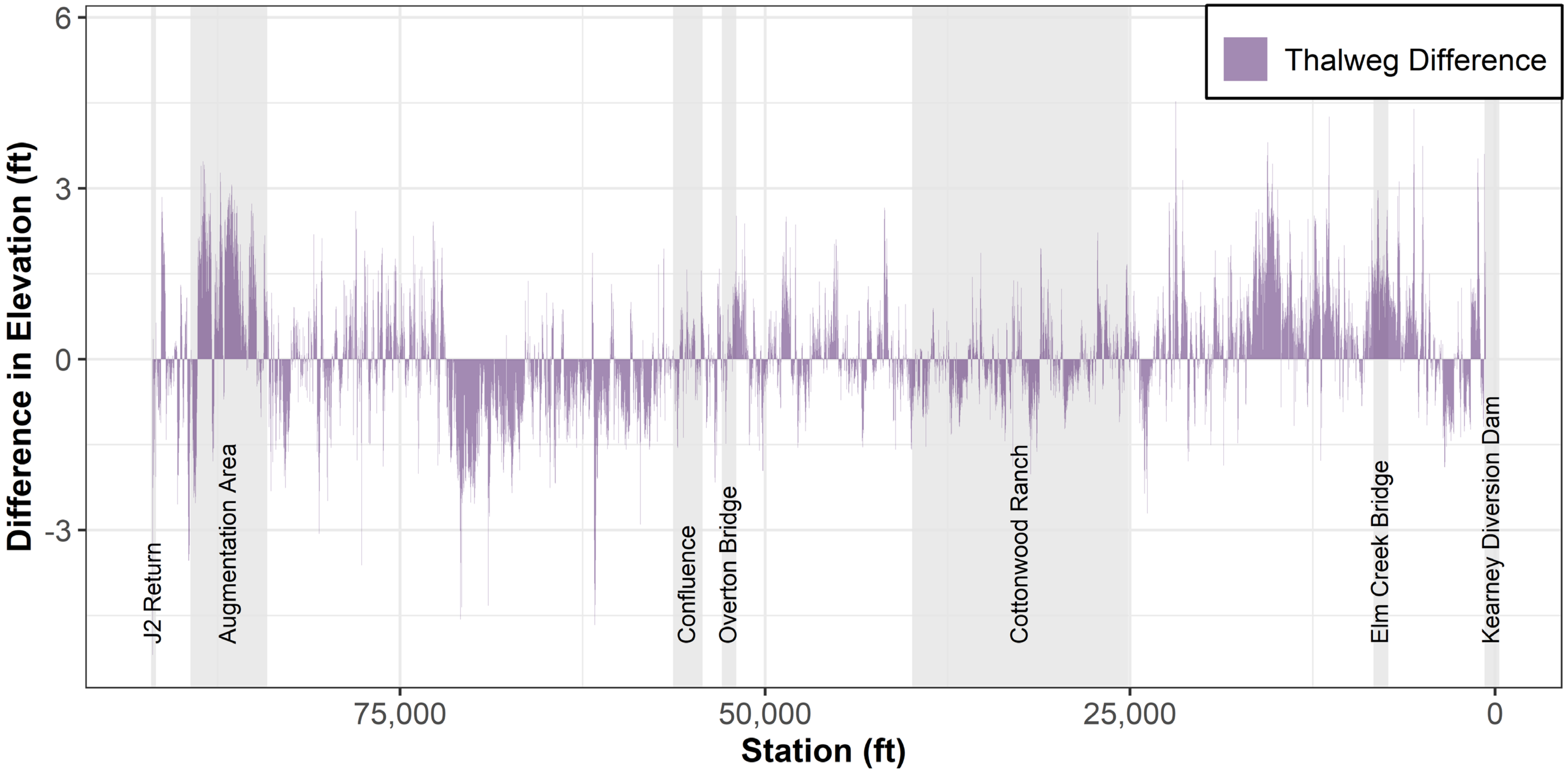


Worth considering?

- Difference between average cross-sectional and thalweg
- Variance of average cross section from upstream to downstream?

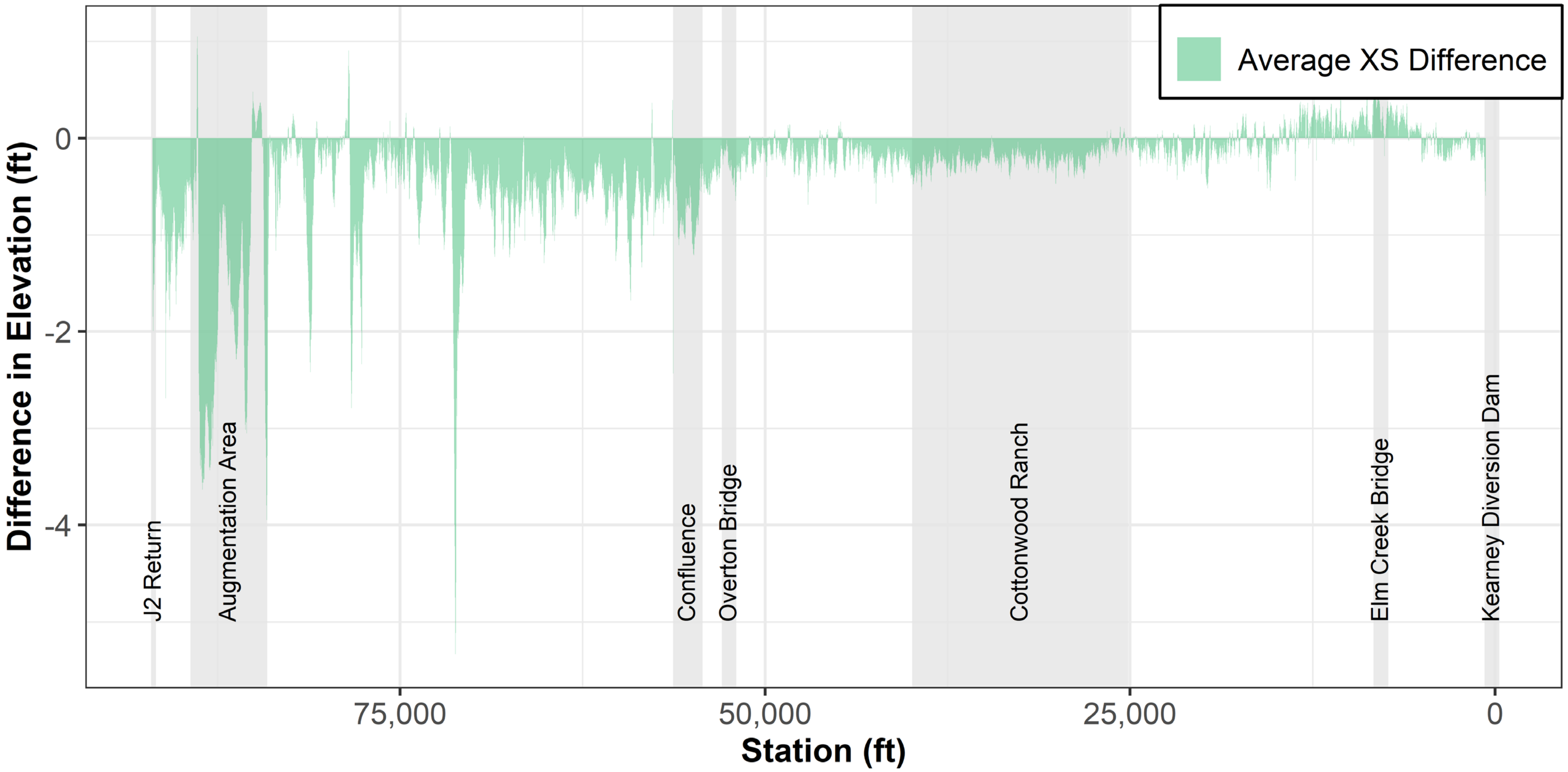
PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Differences between 2016 and 2021



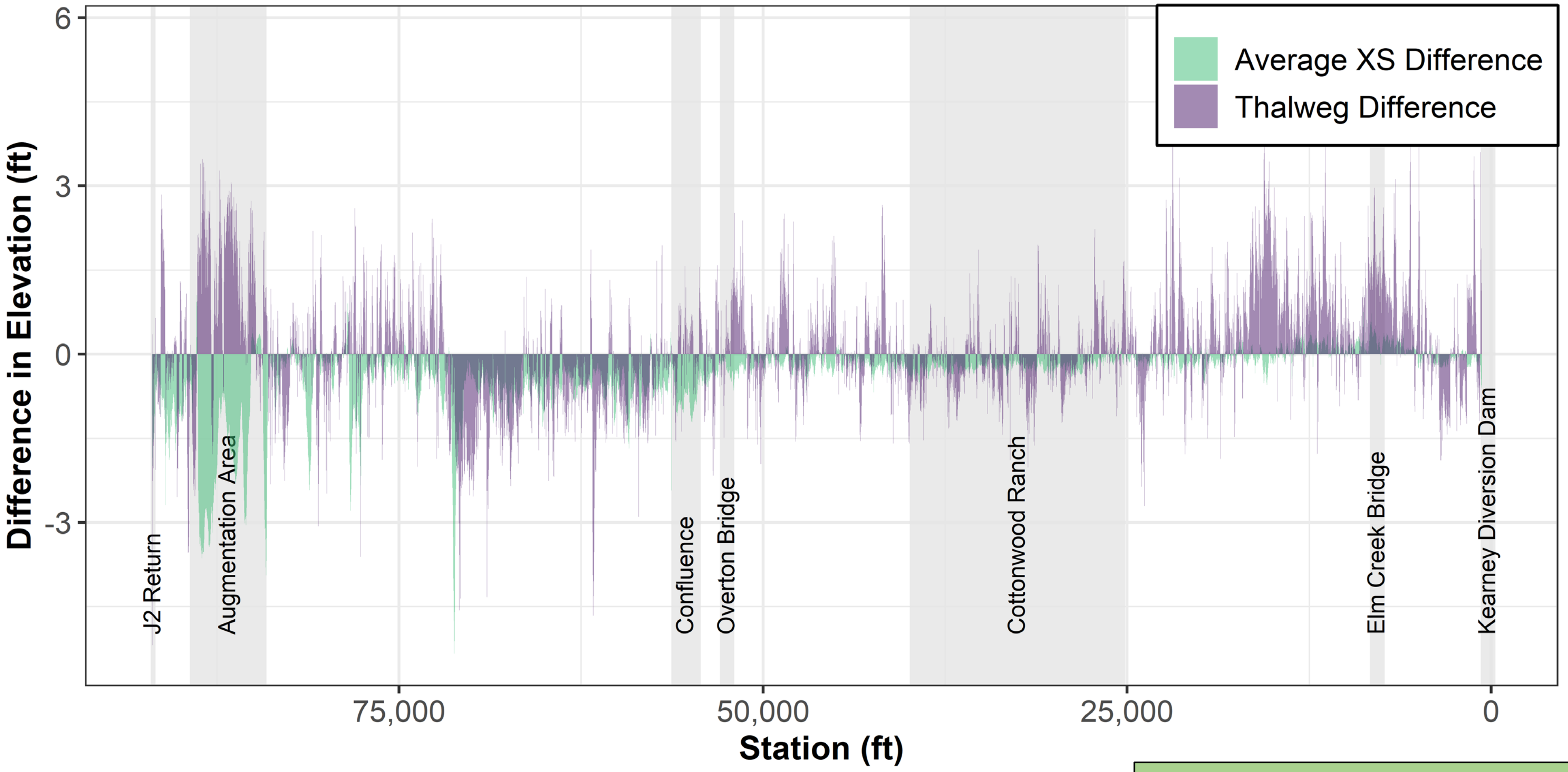
PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Differences between 2016 and 2021



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

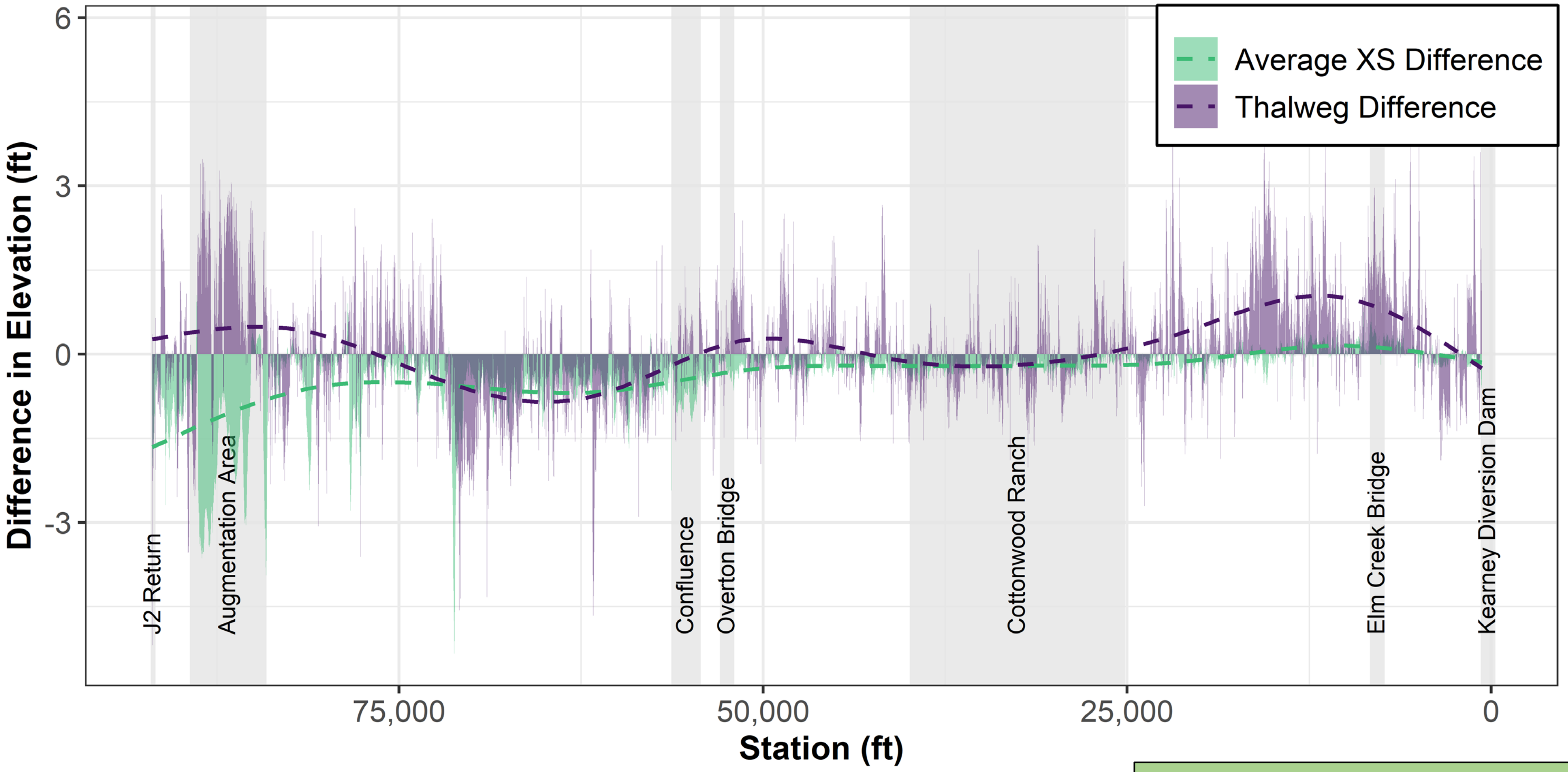
Differences between 2016 and 2021



Worth considering?
- Categorized changes of thalweg/average XS combination

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Differences between 2016 and 2021



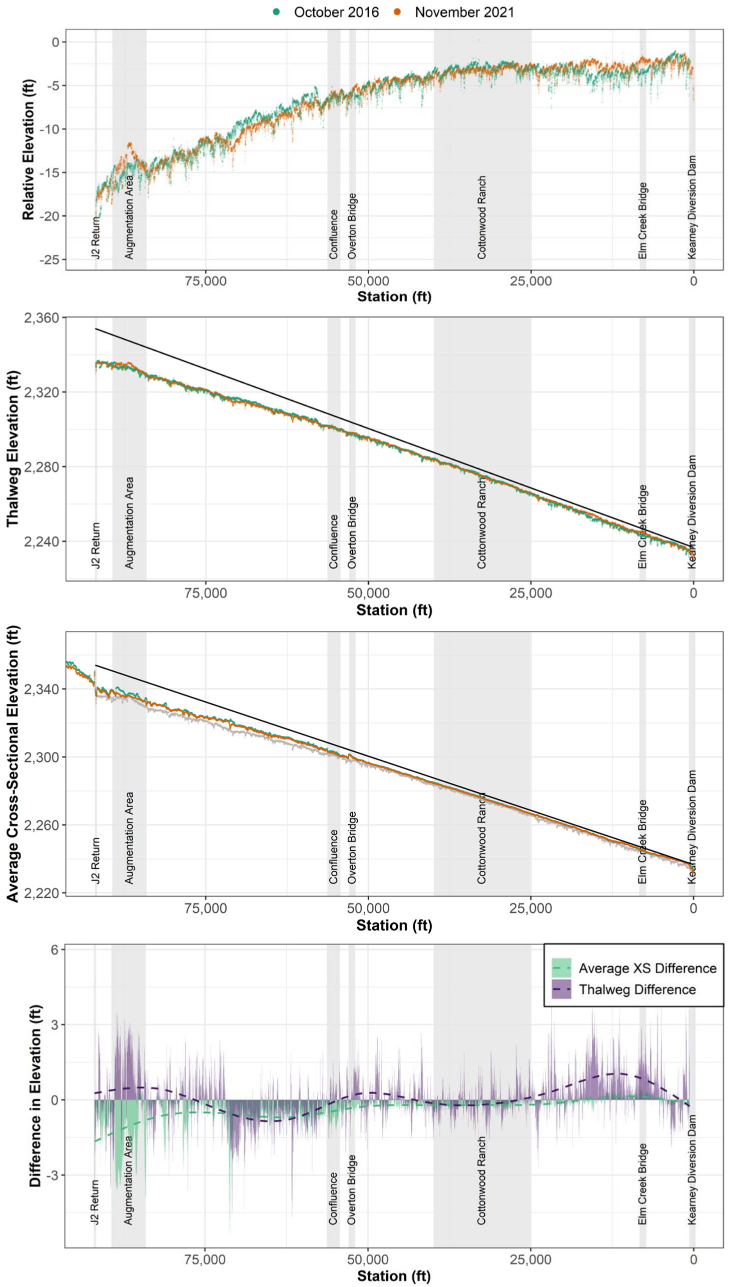
Worth considering?

- Categorized changes of thalweg/average XS combination

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

Observations

- Relative elevation
  - Incision upstream of Overton Bridge
  - Could be asymptotic relationship
  - Aggradation upstream of Elm Creek Bridge
- Thalweg
  - Approaches GGL slope (parallel)
- Average cross-sectional elevation
  - Approaches GGL slope
  - Variability decreases downstream of Overton Bridge
  - Difference from thalweg decreases downstream of Overton Bridge
- Patterns of 2016–2021 differences
  - Categories of combined change could indicate process



PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

Conclusion and Questions

- Detecting differences
  - Further suggestions to statistically model the data?
- Comparing between years
  - How do we quantify the “end” of the incision-affected reach with our data?
  - How to incorporate flow variability?
- Relating to process
  - Is it worthwhile to categorize combined differences in thalweg and cross-sectional change?


Thank you!
PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Change since augmentation:
Volume and Channel Characteristics

Libby Casavant

Water Resources Engineer

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Questions to answer:

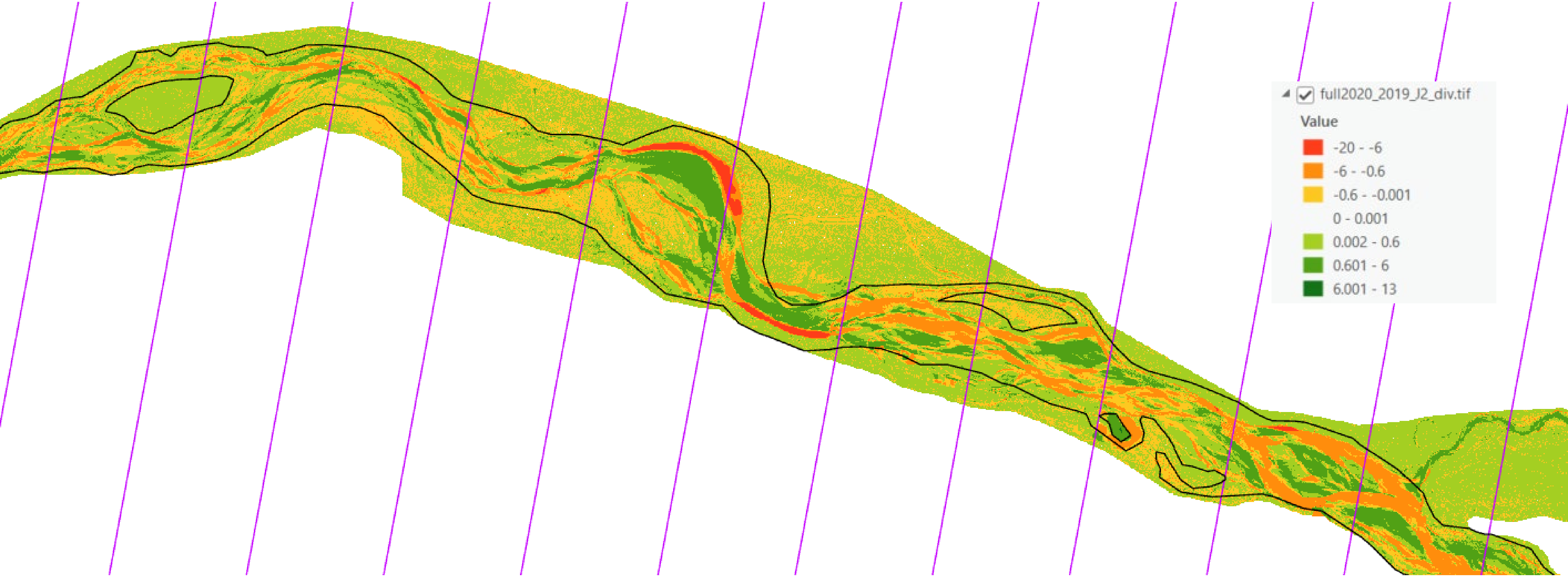
- What volumes of sediment are depositing and eroding and why?
  - Created year by year difference surfaces from LiDAR data

- How about lateral erosion? Is it a source and how important is it?
  - Delineated lateral erosion for each year

- How has channel width, slope and length changed since sediment augmentation began?
  - Calculated wetted width, length and slope

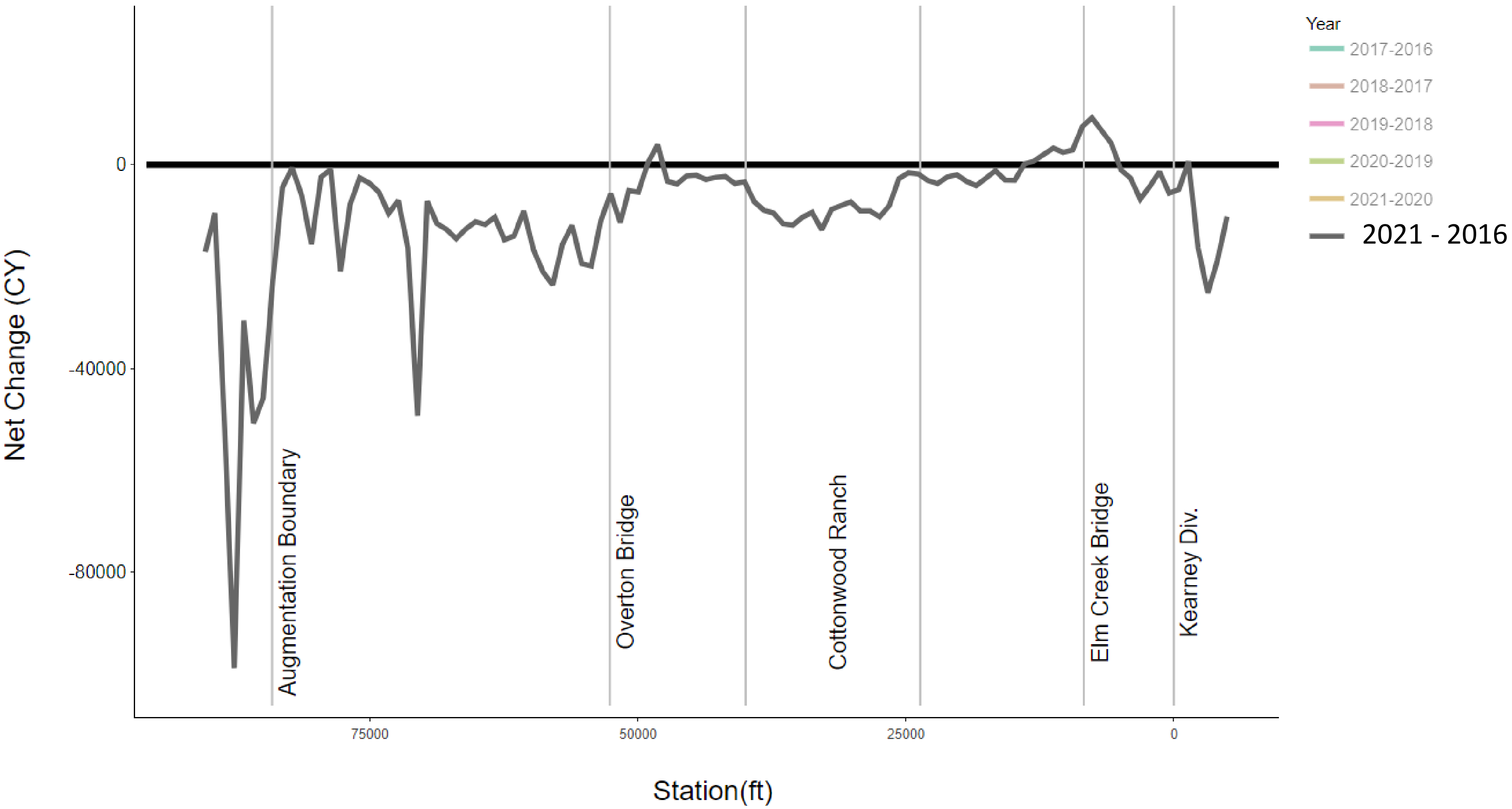
PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Volume Change Analysis-
Method

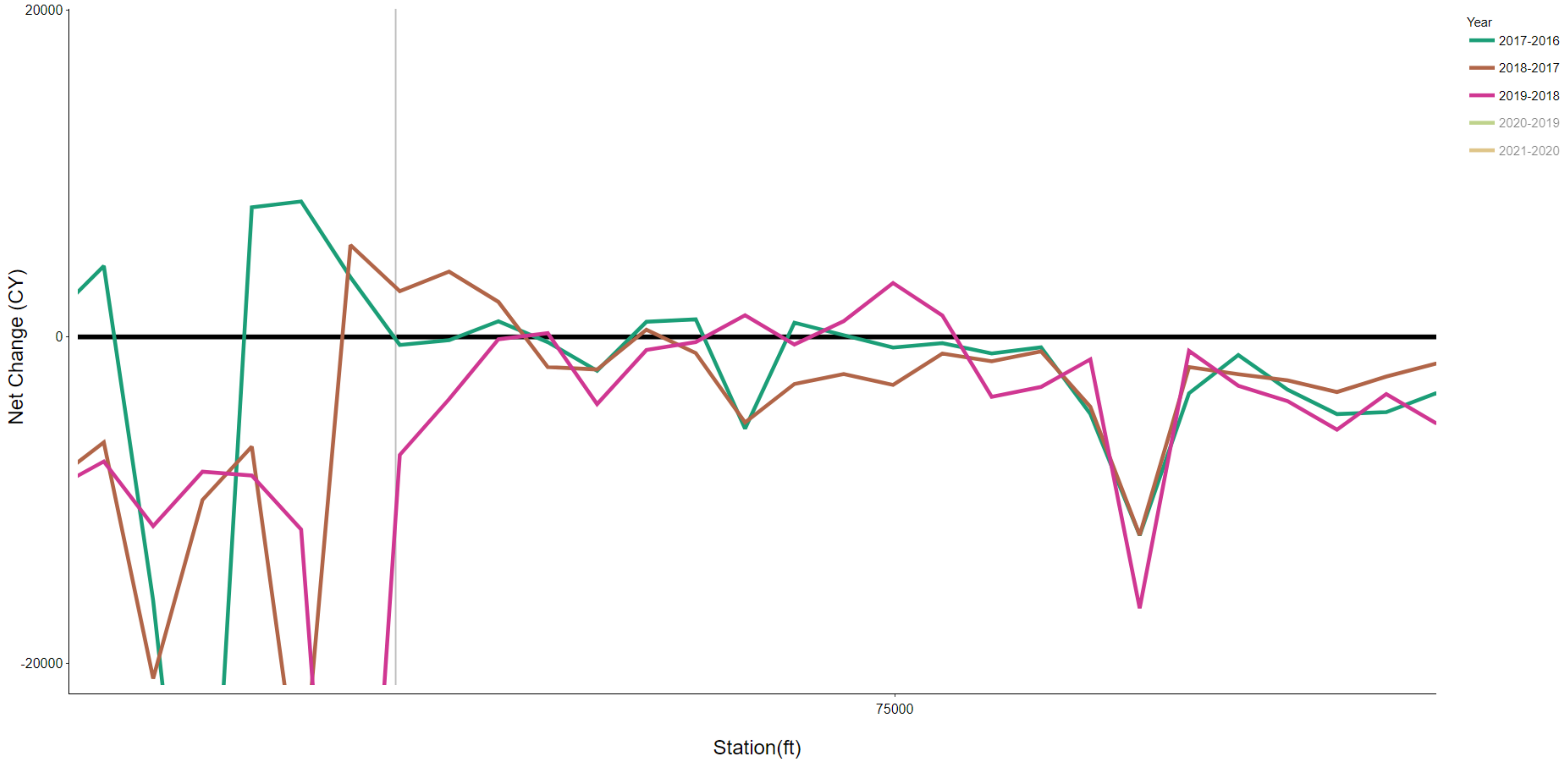


Volume Change Analysis-

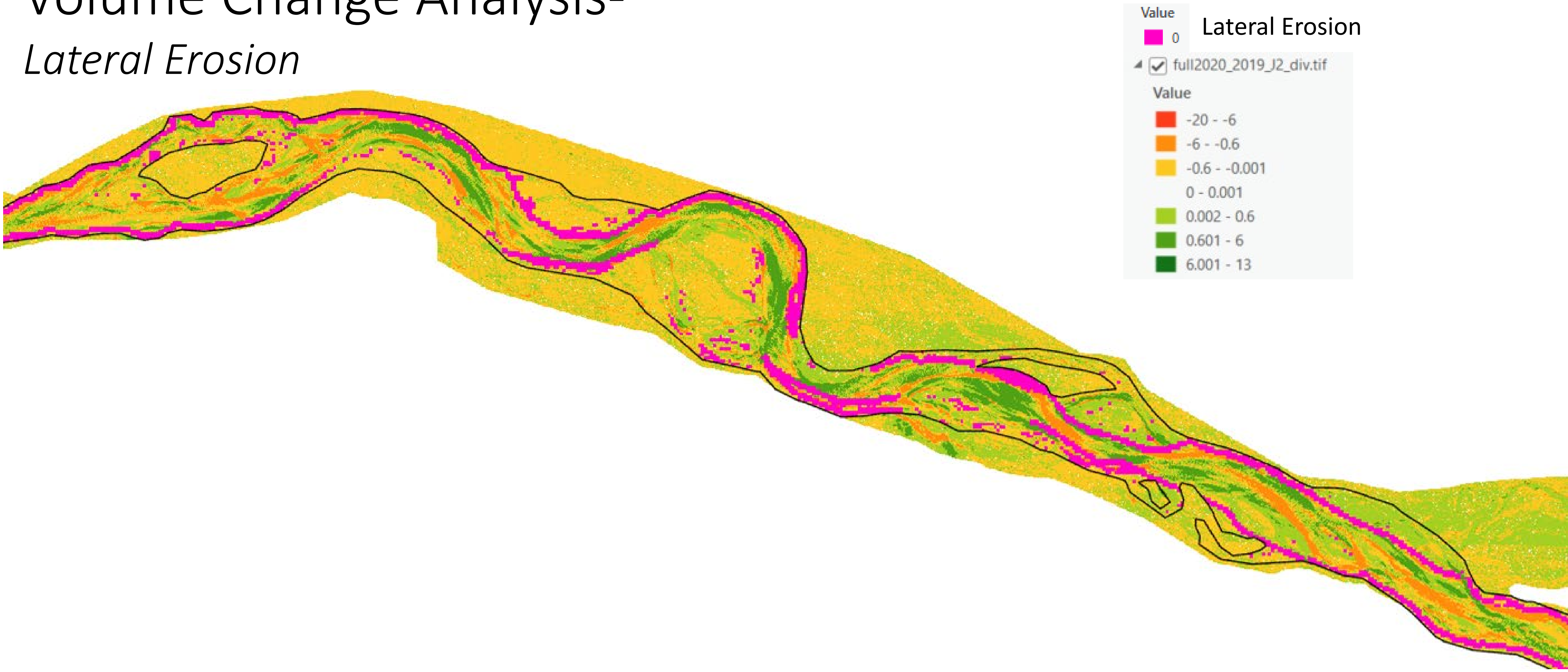
Total Change Results



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM


20000
0
-20000
Net Change (CY)
75000
Station(ft)
Year
2017-2016
2018-2017
2019-2018
2020-2019
2021-2020

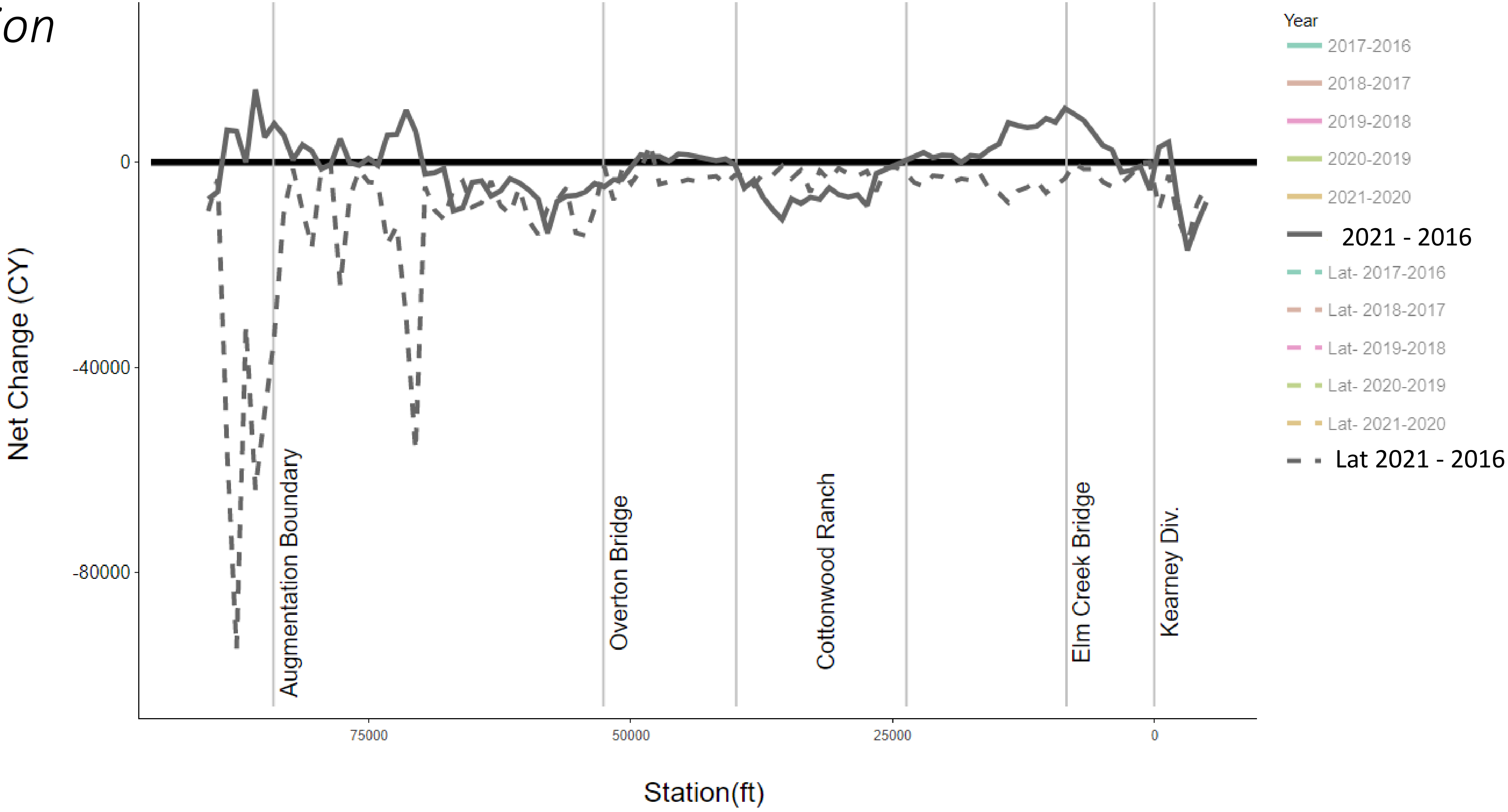
Volume Change Analysis-
Lateral Erosion



file:///D:/ISAC/LibbyFigs/Net_nolat2.html

Volume Change Analysis-

Lateral Erosion

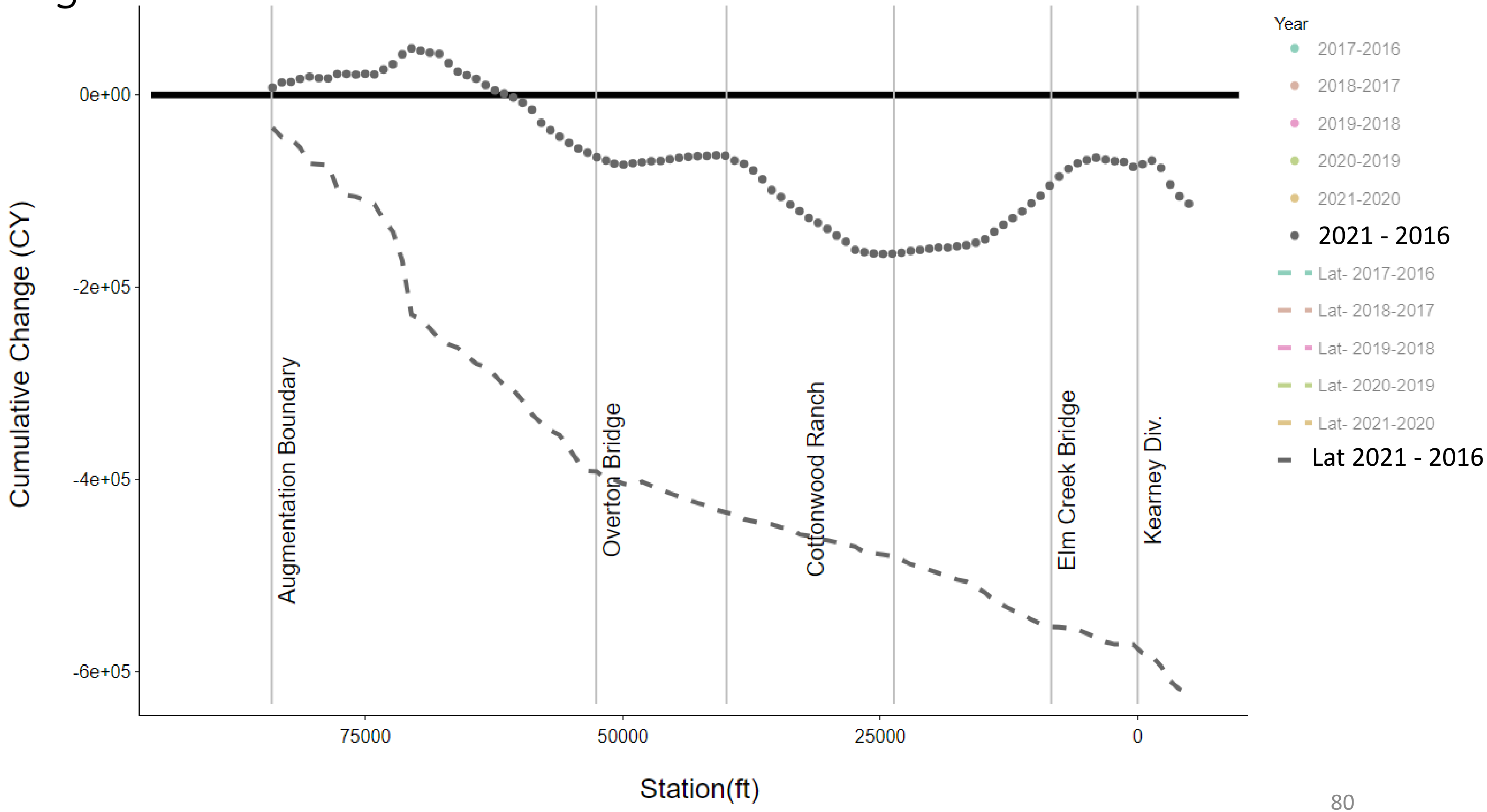


PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

file:///D:/ISAC/LibbyFigs/Cum_nolat2.html

Volume Change Analysis-

Cumulative Change



PLATTE RIVER RECOVERY IMPLEMENTATION PRO(

Volume Change Analysis-

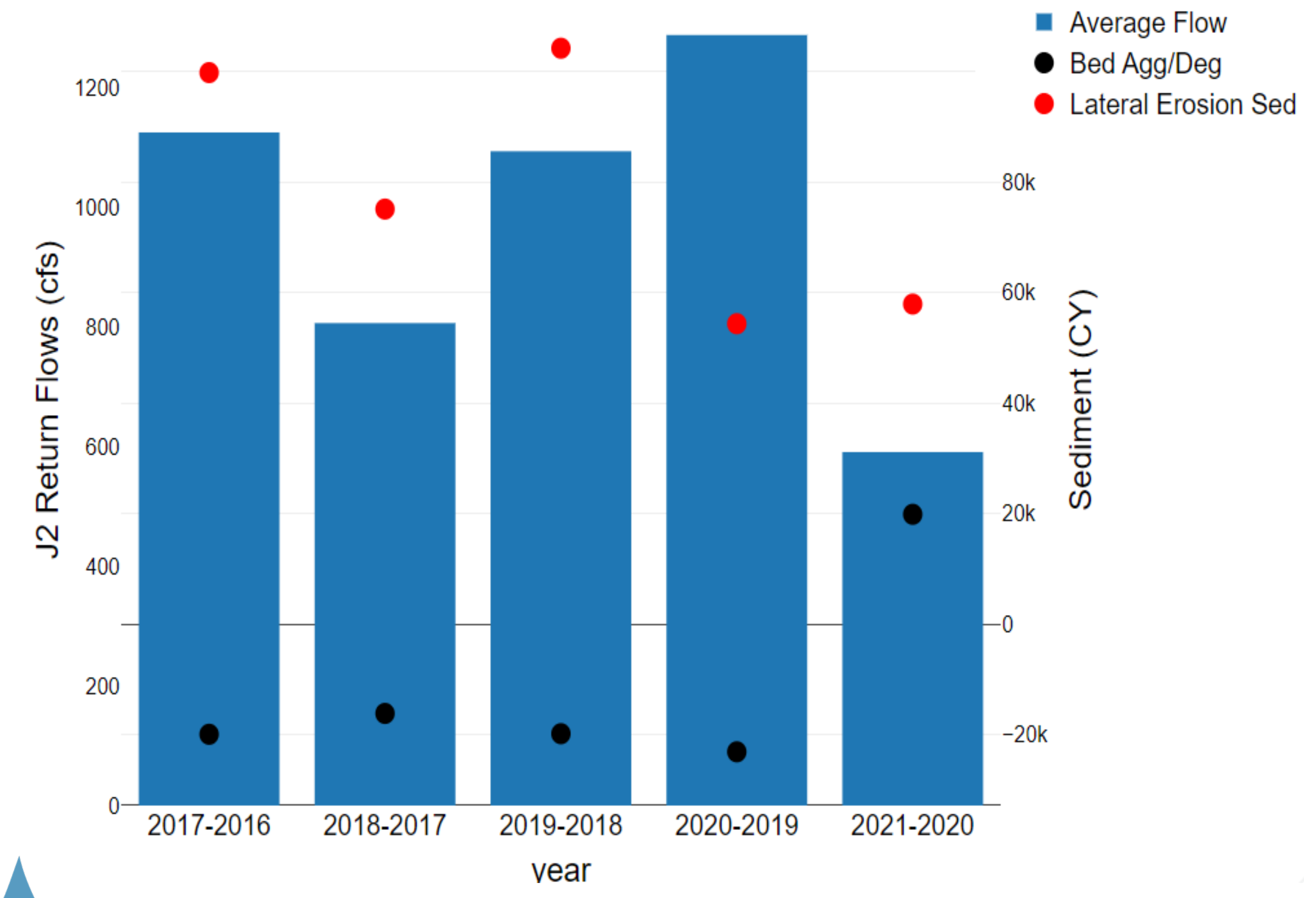
Cumulative Change

	Downstream augmentation boundary to Overton Bridge			Overton Bridge to Kearney Diversion Dam		
Year	**Total Volume Change (yd^3)**	**Lateral Erosion (yd^3)**	**Bed Agg/Deg[a] (yd^3)**	**Total Volume Change (yd^3)**	**Lateral Erosion (yd^3)**	**Bed Agg/Deg (yd^3)**
2017-2016	-119,727	-99,822	-19,900	7,420	-25,874	33,294
2018-2017	-91,262	-75,130	-16,100	-131,298	-42,402	-88,896
2019-2018	-124,036	-104,235	-19,800	-75,918	-76,623	705
2020-2019	-77,462	-54,386	-23,100	11,611	-21,540	33,151
2021-2020	-38,039	-57,940	19,900	-14,821	-13,552	-1,269
2021-2016	**-450,526**	**-320,175**	**-64,600**	**-203,006**	**-179,990**	**-10,241**

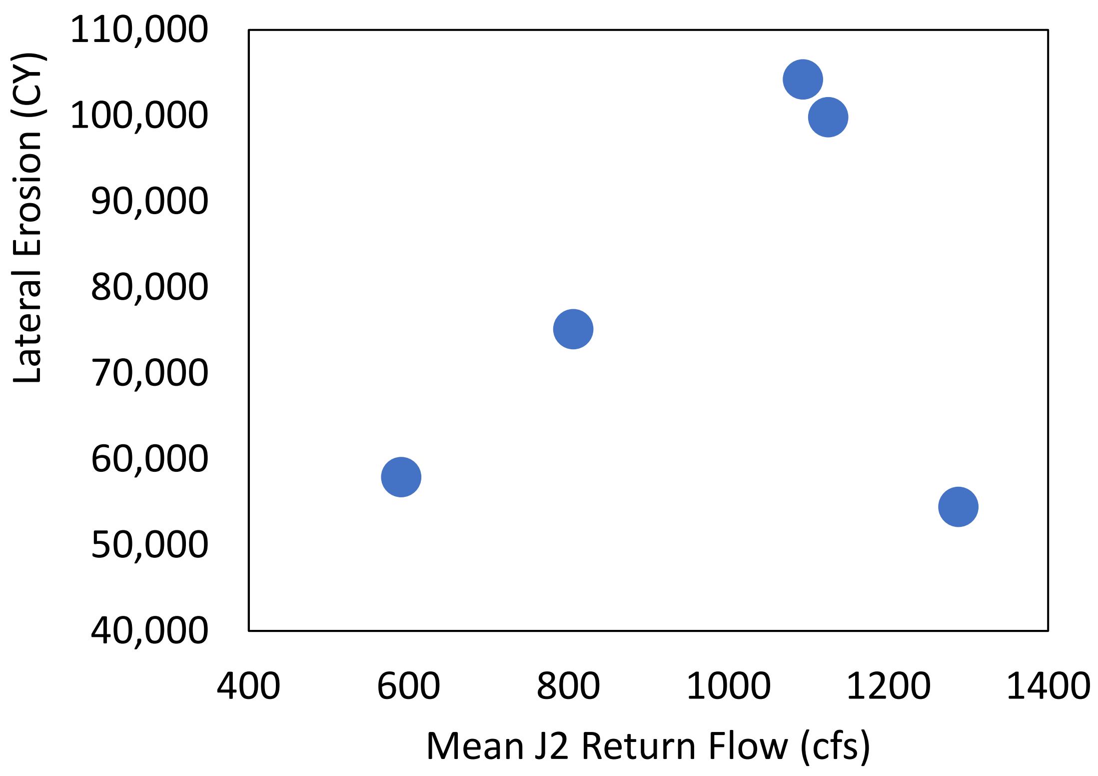
[a]Bed Agg/Deg indicates total volume change minus lateral erosion.

Volume Change Analysis-

Trends with J2 Return Flow



Correlation between mean flow and lateral erosion?

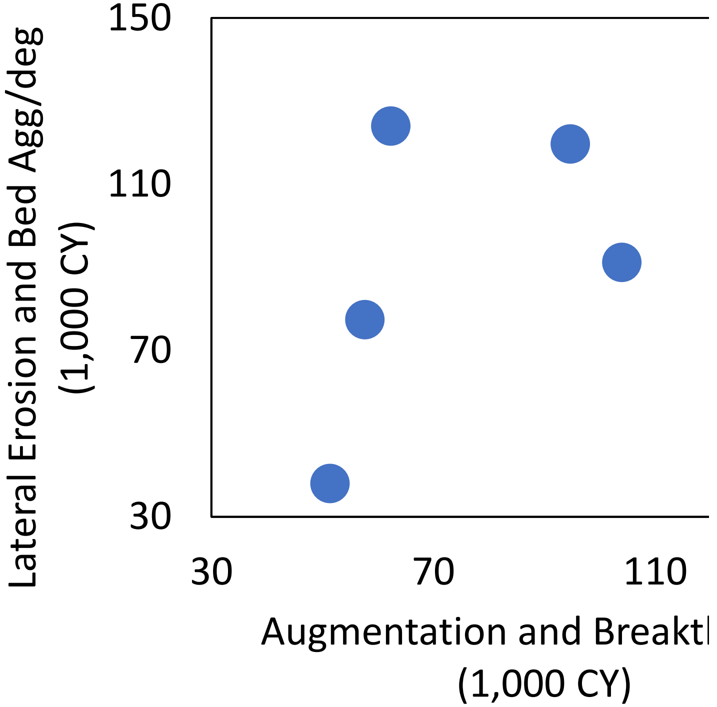


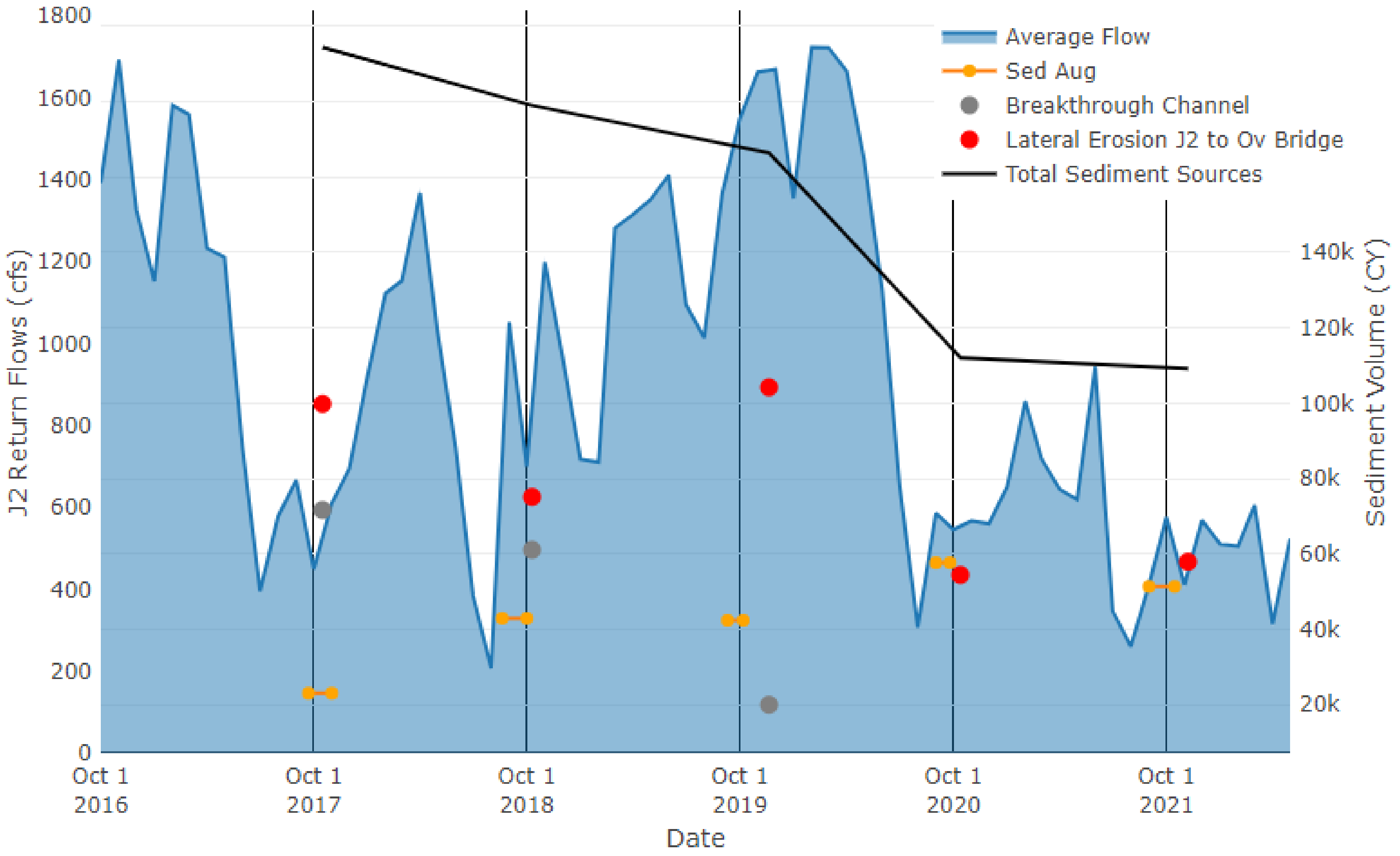
*Erosion and Agg/Deg Values are Only from the Aug Area to Overton Bridge

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Volume Change A

Trends with J2 Return





*Erosion and Agg/Deg Values are Only from the Aug Area to Overton Bridge

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

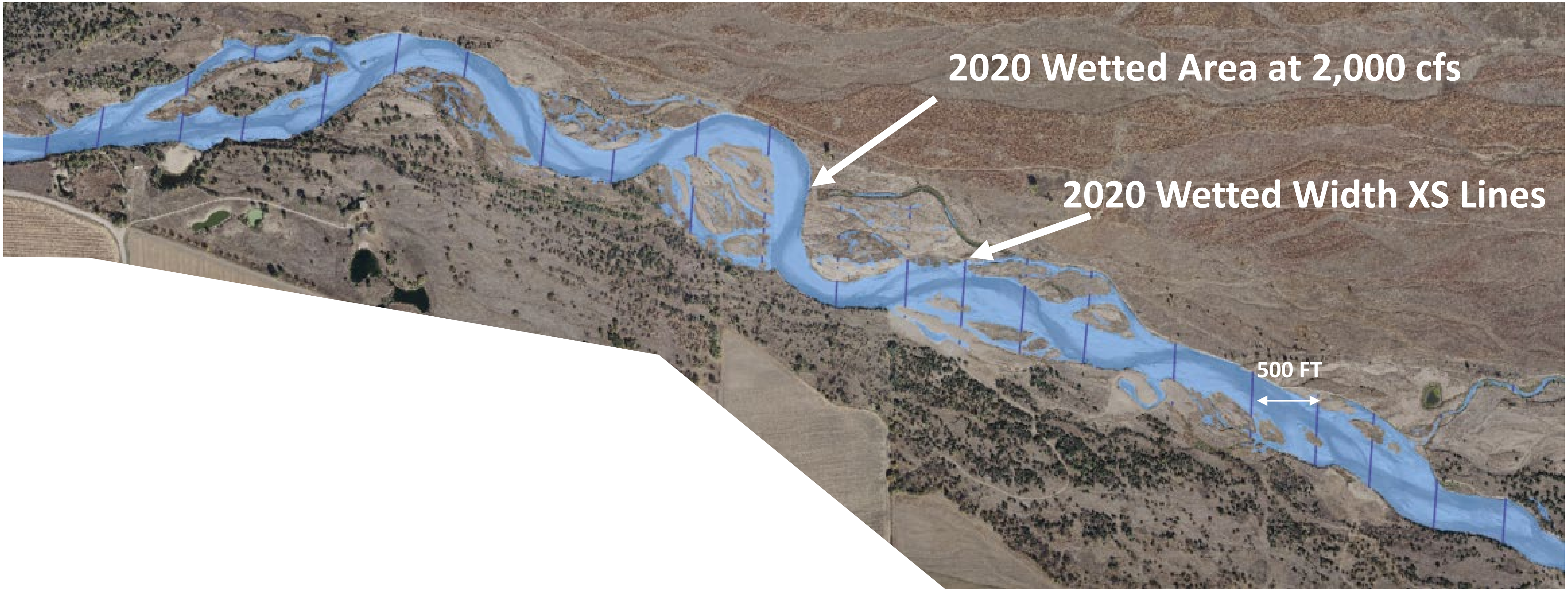
Questions for ISAC related to Volume Change

1. Is it reasonable to consider the total volume change leaving an upstream reach as volume delivered (input) to the downstream reach?
2. Is there any way we can normalize our results by annual flow?

3. What might be causing the high swings of aggradation and degradation downstream of Overton Bridge?

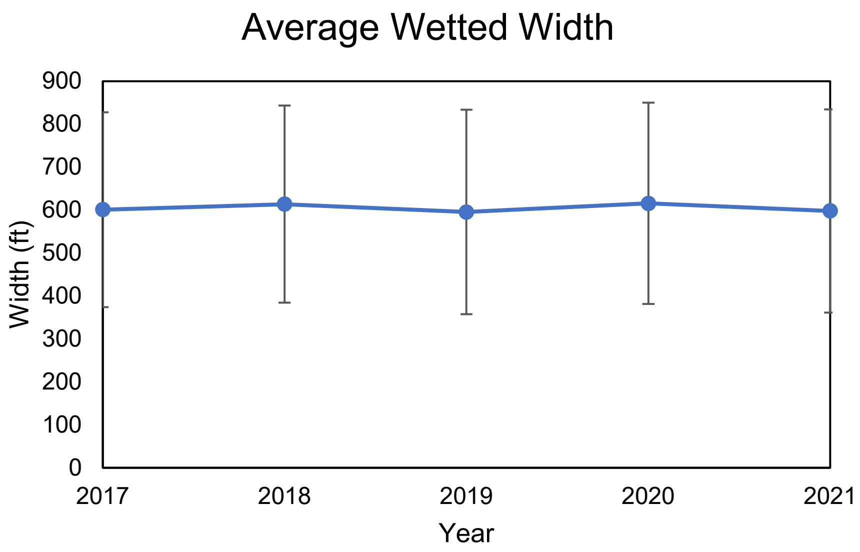
4. We've seen that lateral erosion is a major source of sediment, what are some pros and cons of relying on lateral erosion for sediment augmentation?

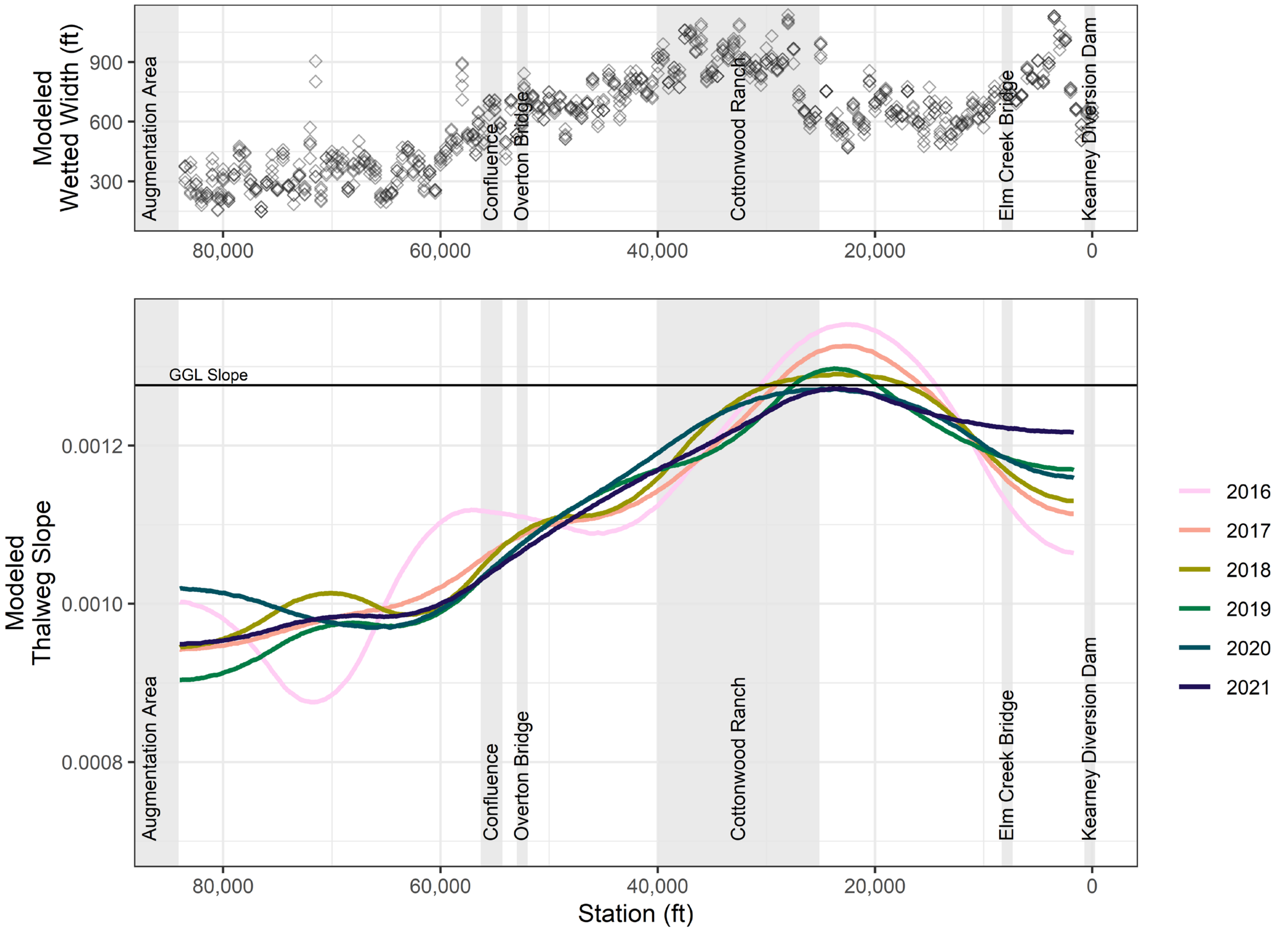
Channel Characteristics- *Wetted Width Method*



PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Channel Characteristics- *Wetted Width*

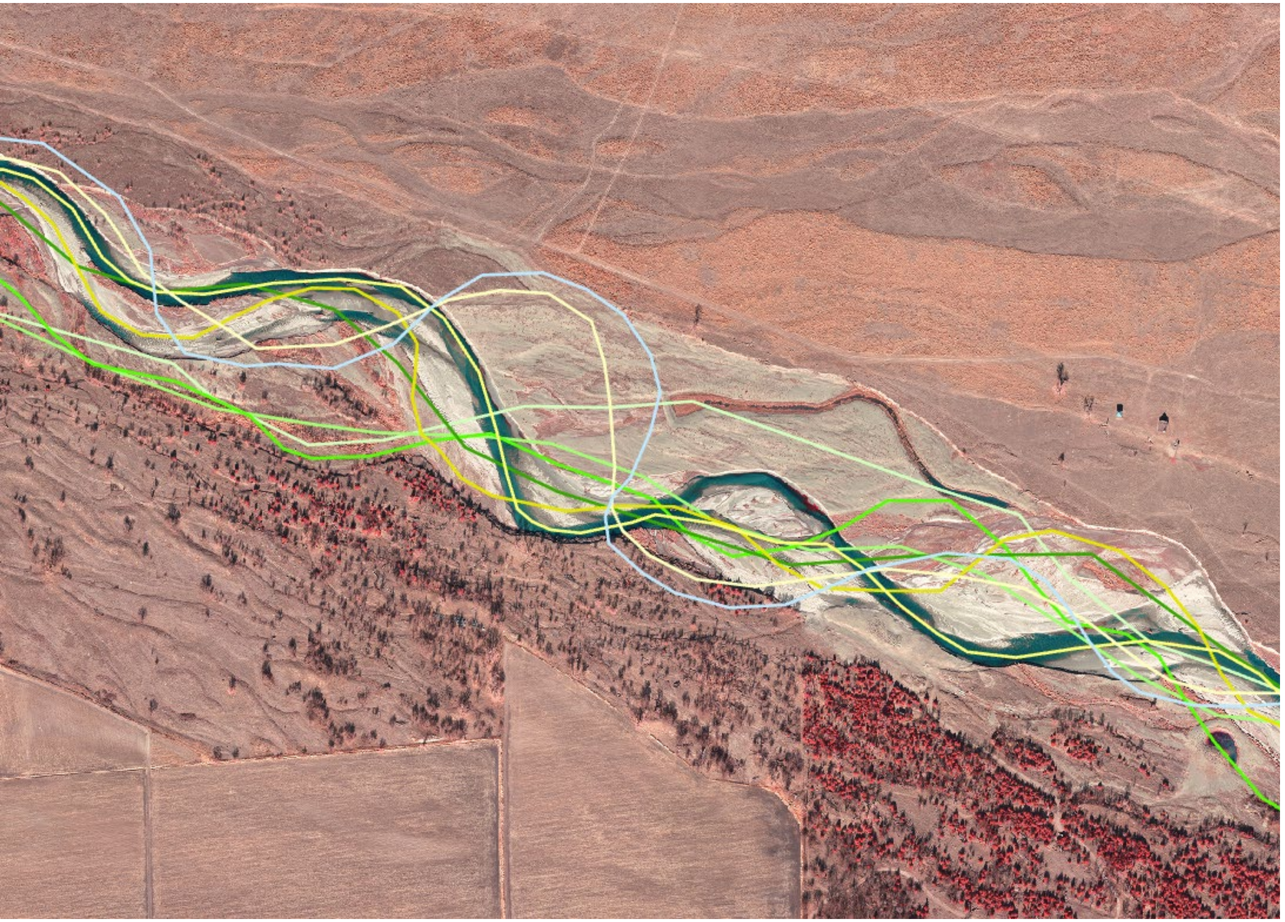


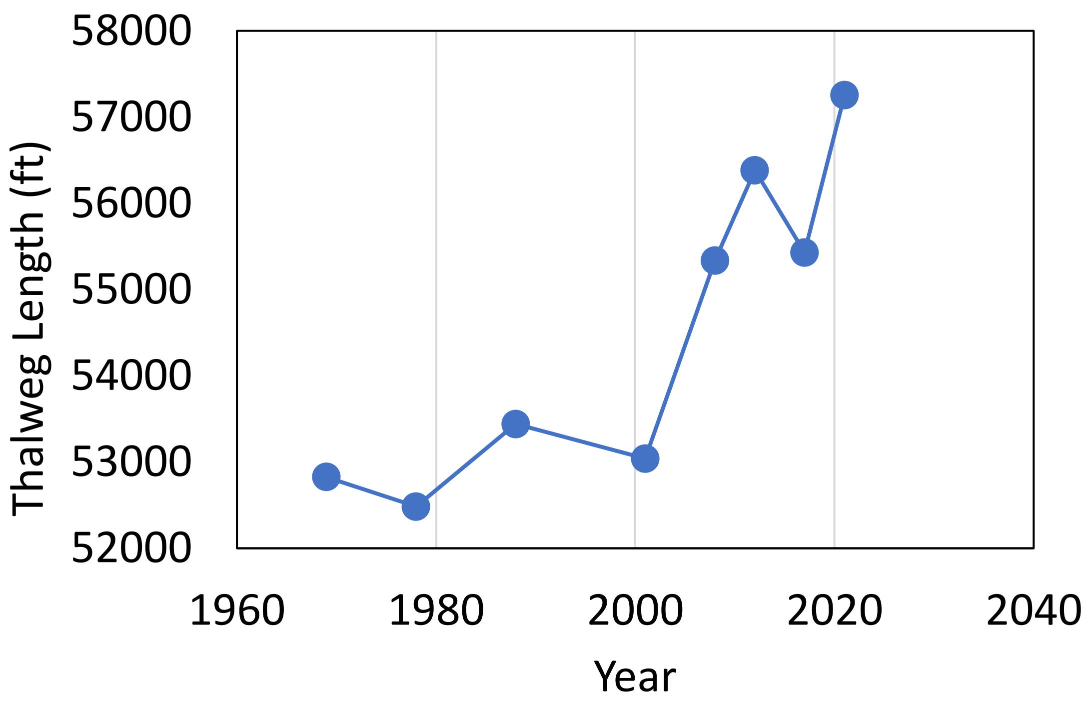


Slopes are calculated in a moving window of 10 points or 50 feet.

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

Channel Characteristics- *Thalweg Length*





Questions for ISAC related to Wetted Width

1. Would a lower, more common flow (e.g. 1,200 cfs) be more appropriate to assess change?

2. How do we quantitatively reconcile channel planform with slope or other variables?

3. Generally, how do we quantify inflection points or thresholds so that we can examine change through time?

4. We are in in the process of quantifying braid index and BRI. What other habitat metrics should we consider?

Thank you!

Supplementary-
Braid Index

$$Braid\ Index = \frac{\Sigma(length\ of\ all\ channels)}{length\ of\ main\ channel}$$

Year	Average Braid Index Upstream of Overton Bridge	Average Braid Index Downstream of Overton Bridge
2009	1.9	3.7
2012	2.0	4.2
2015	2.4	4.7
2017	2.3	6.2
2019	2.3	5.5
2021	2.2	5.2
Ave.	**2.2**	**4.9**

file:///D:/ISAC/LibbyFigs/BI2.html

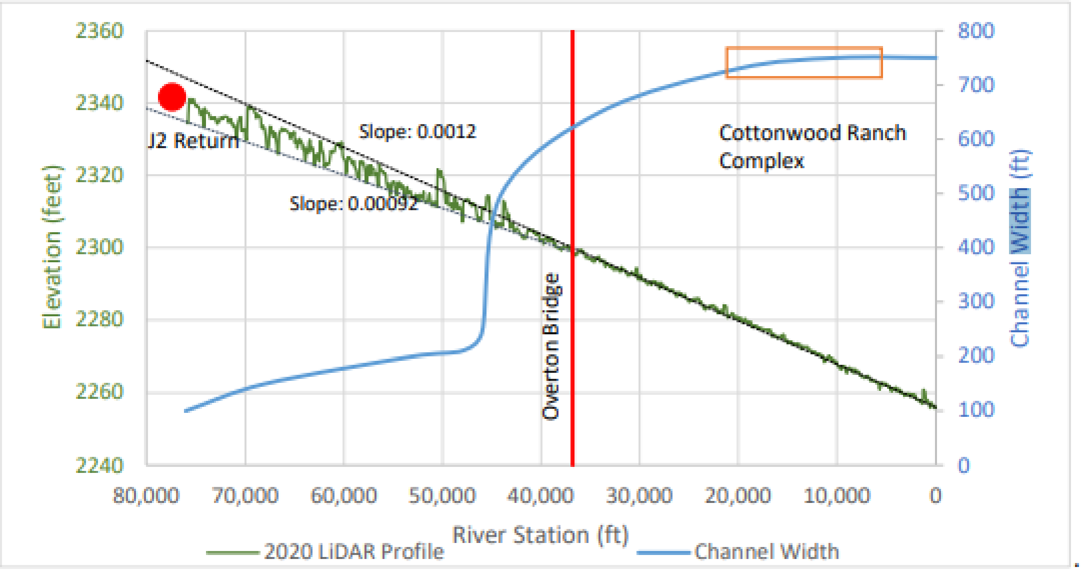
Wetted Width-
Science Plan

Extension Big Question #3: Is sediment augmentation necessary to create and/or maintain suitable whooping crane habitat?

*Channels with ≥ 650 ft maximum width unobstructed by dense vegetation (MUCW) are highly suitable for whooping crane roosting.

Management Hypothesis: Sediment augmentation is necessary to halt narrowing and incision in the south channel downstream of the J-2 Return.

X-Y Graph



Full scale sediment augmentation (60,000 – 80,000 tons annually in south channel below J-2 Return) is necessary to offset the sediment deficit and halt narrowing and incision that has caused the upper portion of the south channel to transition to a narrow meandering planform, which is much less suitable for WC roosting. If incision is not halted, the affected reach will continue to expand downstream past the Overton bridge, reducing habitat suitability at the Cottonwood Ranch complex.

Alternative Hypotheses:

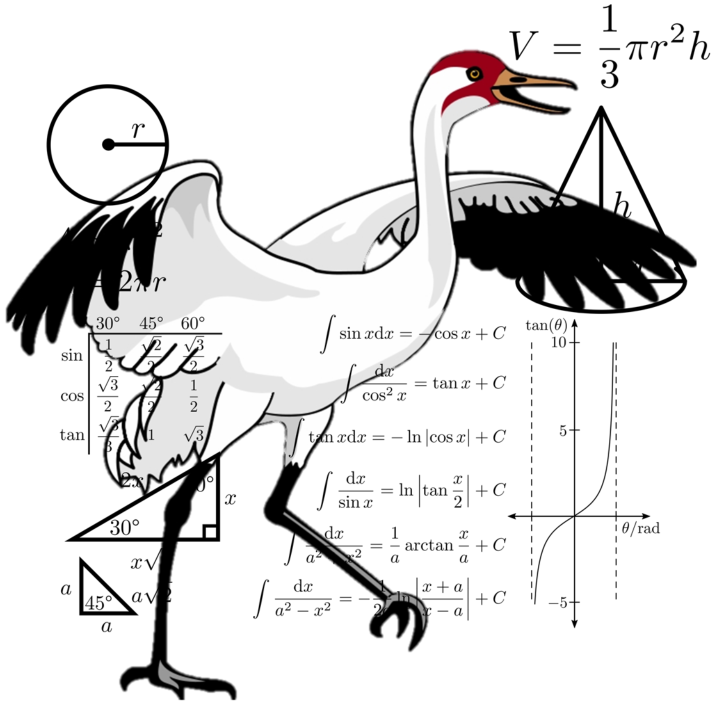
- More or less sediment must be augmented to offset the south channel deficit.
- Augmentation at alternative locations will halt narrowing and incision.
- Full scale augmentation is not feasible over the long term – not enough supply.
- Incision and narrowing progresses downstream so slowly that augmentation is not necessary.
- Mechanical channel widening will halt narrowing and incision at habitat complexes.

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

Sediment Augmentation Conclusion

What does this mean for sediment augmentation?

- Major findings
  - Incision 2002–2021 less than 1989–2002
  - Incision not widespread, but “hot spot” around Station 70,000
  - Average cross-sectional elevation decreasing (2002–2021)
    - However, width does not change
  - Lateral erosion is significant in the J2 to Overton Bridge reach
    - Channel length increased, especially since early 2000s
  - Sediment augmentation accounts for less than the total sediment leaving the reach
    - Sediment has been roughly in balance downstream of Overton bridge



Management options

1. Continue sediment augmentation as-is
2. Increase sediment augmentation
3. Stop sediment augmentation
4. Alter sediment augmentation
    - Sand dam high flow allowance
    - Relocate sediment augmentation
5. Other ideas?

- **The ISAC recommends focusing all appropriate actions for creating habitat (i.e., vegetation removal, sediment augmentation, flow management) in the south channel upstream of Overton and intensively monitoring responses to these actions, in particular determining if sediment augmentation maintains or increases channel width.** If the intensive monitoring does not demonstrate benefits of these actions in the south channel below the J2 return, then it's unlikely that benefits will be observed anywhere else.
- **We recommend that the Program base sediment augmentation decisions on thoroughly measured, multiple lines of evidence that have first been proven in an intensively monitored area (i.e., south channel below the J2 return; see Q4). We recommend using the following highest priority lines of evidence:**
    - **apply geomorphic change detection techniques (GCD) to green LIDAR, using methods developed by Dr. Joseph Wheaton of the USGS and colleagues[1];**
    - **analyze trends in transects, cross-sections, and other geomorphic metrics of interest derived from planform maps;**
    - **assess the magnitude of change in the longitudinal profile; and**
    - **specific gage analysis, reporting confidence intervals for changes in slope.**
- **For each of these lines of evidence, we recommend that the Program:**

---

[1] https://sites.google.com/a/joewheaton.org/www/Home/research/projects-1/morphological-sediment-budgeting