EXECUTIVE SUMMARY

The purpose of this addendum is to add data from 2022 to previously presented figures, tables, and analysis contained in the Sediment Augmentation Data Synthesis Compilation from August 2023. The text of this document only refers to the 2022 data. The original report should be referenced for full methods and discussion. The List of Figures and Tables presents the updated items. Figure and table numbers have been preserved from the August 2023 report to enable easy comparison.

2022 was the driest year since sediment augmentation began in 2017. Lower flow resulted in reduced sediment transport along the reach. Evidence of this can be seen in the higher than usual aggradation in the augmentation project area and along the J2 channel (Figures 3.7 – 3.9). The erosional “hot spot” at station 70,000 continues to be an area with lower average cross-sectional elevations (Figure 3.13) and active lateral erosion (Figure 4.11B), however, bed aggradation occurred in that area over the last year (Figure 4.11C) and thalweg elevations recovered to match the surrounding grade. Downstream of the Overton Bridge, little change occurred except for the area between Elm Creek Bridge and the KCD. That area experienced erosion due to a levee breach and associated channel adjustment at the Blue Hole East habitat area (Figure E1). Water was drawn through the breach and into a sandpit where a large depositional splay formed. Water then re-entered the river channel, reshaping it to accommodate the new dominant flow path. As shown in Figures 4.11- 4.12, this change had a net erosional effect on the river as bed and levee material remained in the sandpit (outside our analysis area) and erosion occurred in the channel downstream from the breach (Figure E2).

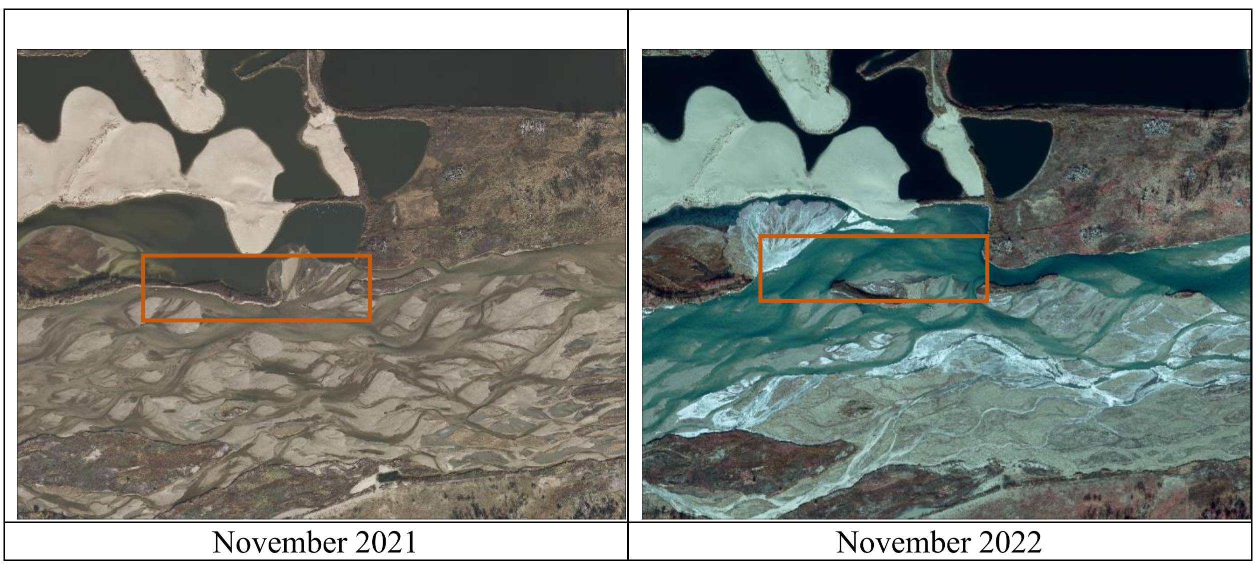

Figure E1. Aerial imagery from 2021 (left) and 2022 (right). The red box shows the levee breach location.

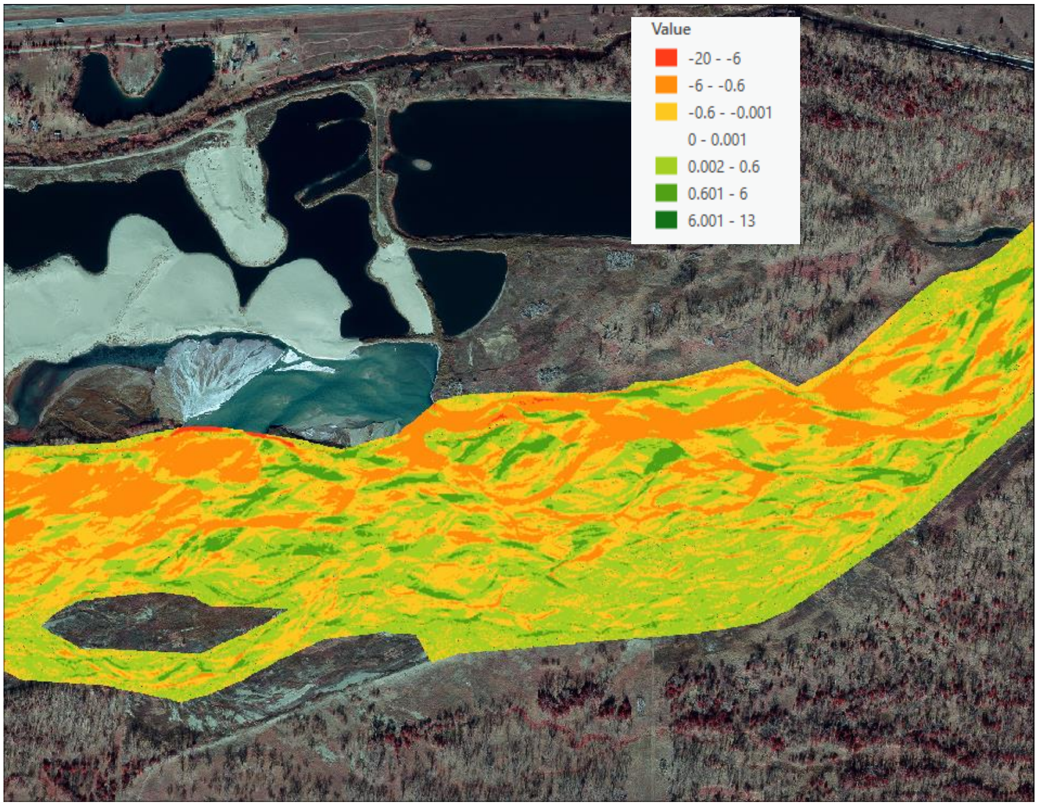

Figure E2. Difference raster from 2022 to 2021 at the breach site. The raster is clipped to the analysis area. Orange, red, and yellow indicate erosion, while green indicates aggradation. The legend gives the magnitude of elevation change in feet. Widespread erosion is visible in the northern half of the channel, upstream and downstream of the breach.

Apart from the levee breach, patterns of aggradation and degradation observed in 2022 were similar to 2021. Adding 2022 data has not changed broader conclusions or findings regarding sediment augmentation.

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CHAPTER 3 Evaluation of longitudinal change after sediment augmentation

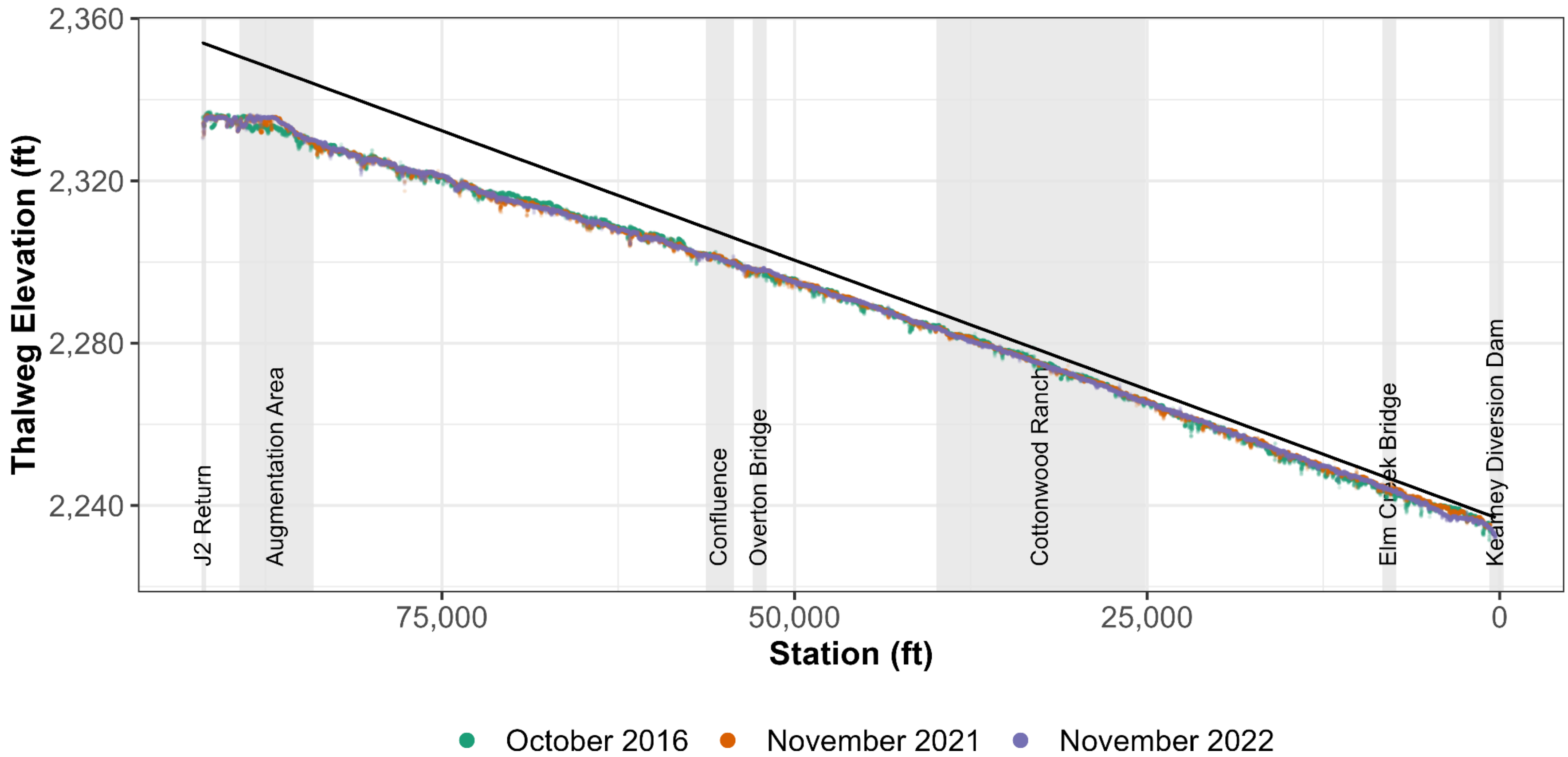

Figure 3.6. Longitudinal profiles of thalweg elevation in 2016 (green), 2021 (orange), and 2022 (purple). The Geomorphic Grade Line (GGL) is shown in black as a reference for the magnitude of channel incision. The addition of the 2022 profile shows that thalweg elevations continue to diverge from the GGL upstream of the Overton Bridge.

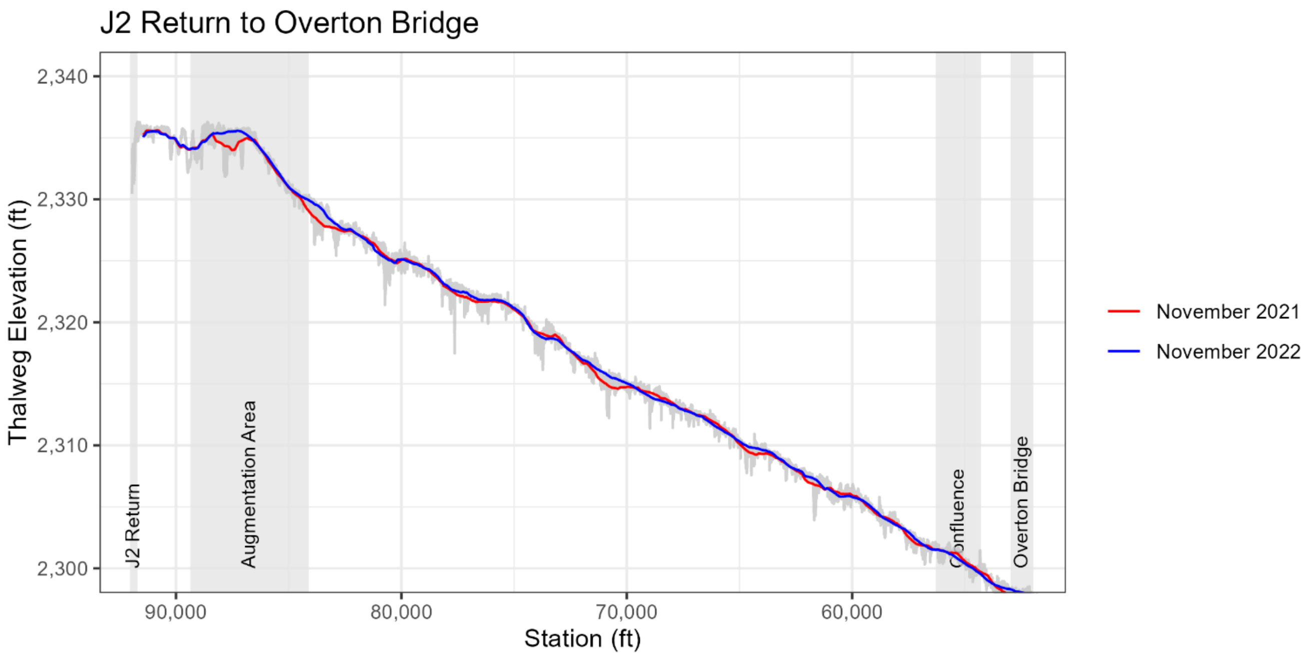

Figure 3.7. 2021–2022 annual moving average (1,005 ft) longitudinal profiles between J2 Return and Overton Bridge. Gray area behind profiles indicates the range of values for 2021–2022. Several low-elevation areas (Stations 96,000, 70,000) have seen aggradation over the past year.

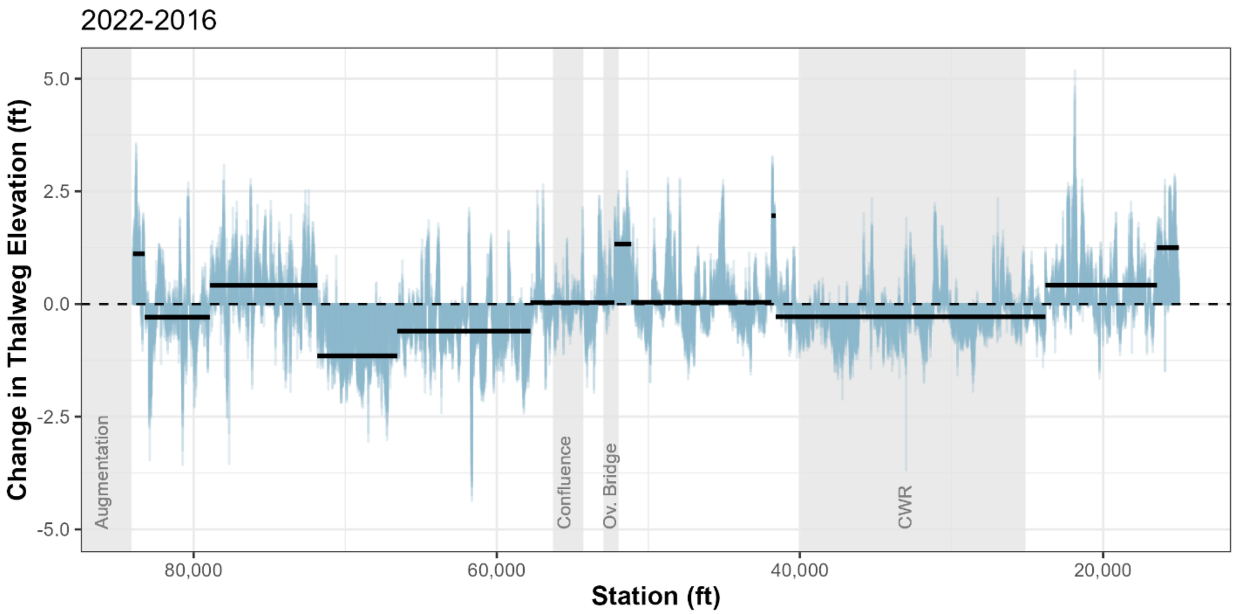

Figure 3.8 2016–2022 thalweg changepoint analysis results. Differences in thalweg elevations are shown in blue. Mean segment change values are shown in black. Negative numbers indicate thalweg incision and positive indicate thalweg aggradation. Compared to the 2016 – 2021 analysis, there is a new region of positive change in the augmentation area, and two areas of average positive change became more positive near Overton Bridge and the Kearney Diversion.

Table 3.1 2016–2022 thalweg changepoint analysis results.

Station Range	Segment Length (mi)	Thalweg Elevation Change (ft)		
		Mean	Minimum	Maximum
84000 - 83225	0.1	1.2	-1.5	2.9
83225 - 78920	0.8	0.4	-1.7	5.2
78920 - 71840	1.3	-0.3	-3.7	2.3
71840 - 66570	1.0	2.0	0.7	3.3
66570 - 57780	1.7	0.0	-1.7	2.8
57780 - 52230	1.1	1.3	0.3	2.9
52230 - 51125	0.2	0.0	-2.0	2.7
51125 - 41870	1.8	-0.6	-4.4	2.1
41870 - 41600	0.1	-1.2	-3.1	1.1
41600 - 23800	3.4	0.4	-3.5	3.1
23800 - 16445	1.4	-0.3	-3.6	2.7
16445 - 15000	0.3	1.1	-1.0	3.6

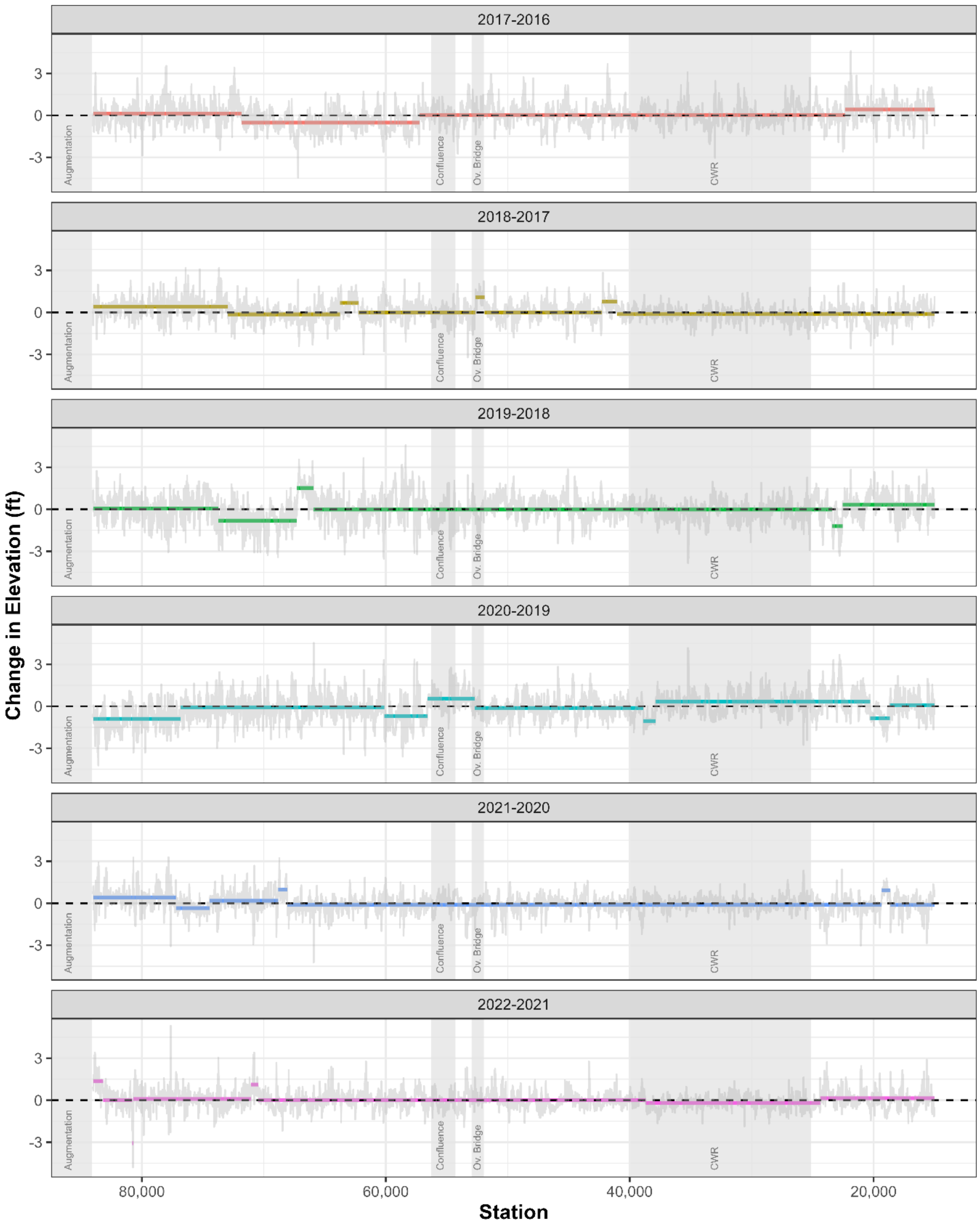

Figure 3.9. Annual changepoint analysis results of change in thalweg elevation between years. Colored lines show mean change values of changepoint segments. Light gray lines show at-a-station thalweg elevation difference. Average changes in 2022 remained close to zero with the exception of two aggradational areas: one in the augmentation project area and another at station 70,000.

Table 3.2. Average thalweg changes upstream and downstream of Overton Bridge with mean flow for comparison. The 2021 – 2022 year experienced the lowest average flow since augmentation began and had the second highest increase in elevation on the J2 Return Channel. Average change on the reach downstream of Overton Bridge was slightly degradational.

Year	**Mean Thalweg Change (ft)**		**Mean Flow (cfs)**	
	J2 Return Channel	**Downstream of Overton**	**Overton Bridge**	**J2 Return**
2016–2017	-0.17	0.11	1,780	1,099
2017–2018	0.13	-0.05	1,289	807
2018–2019	-0.10	0.04	2,082	1,155
2019–2020	-0.26	0.05	2,127	1,225
2020–2021	0.04	-0.06	1,008	589
2021-2022	0.09	-0.04	767	453

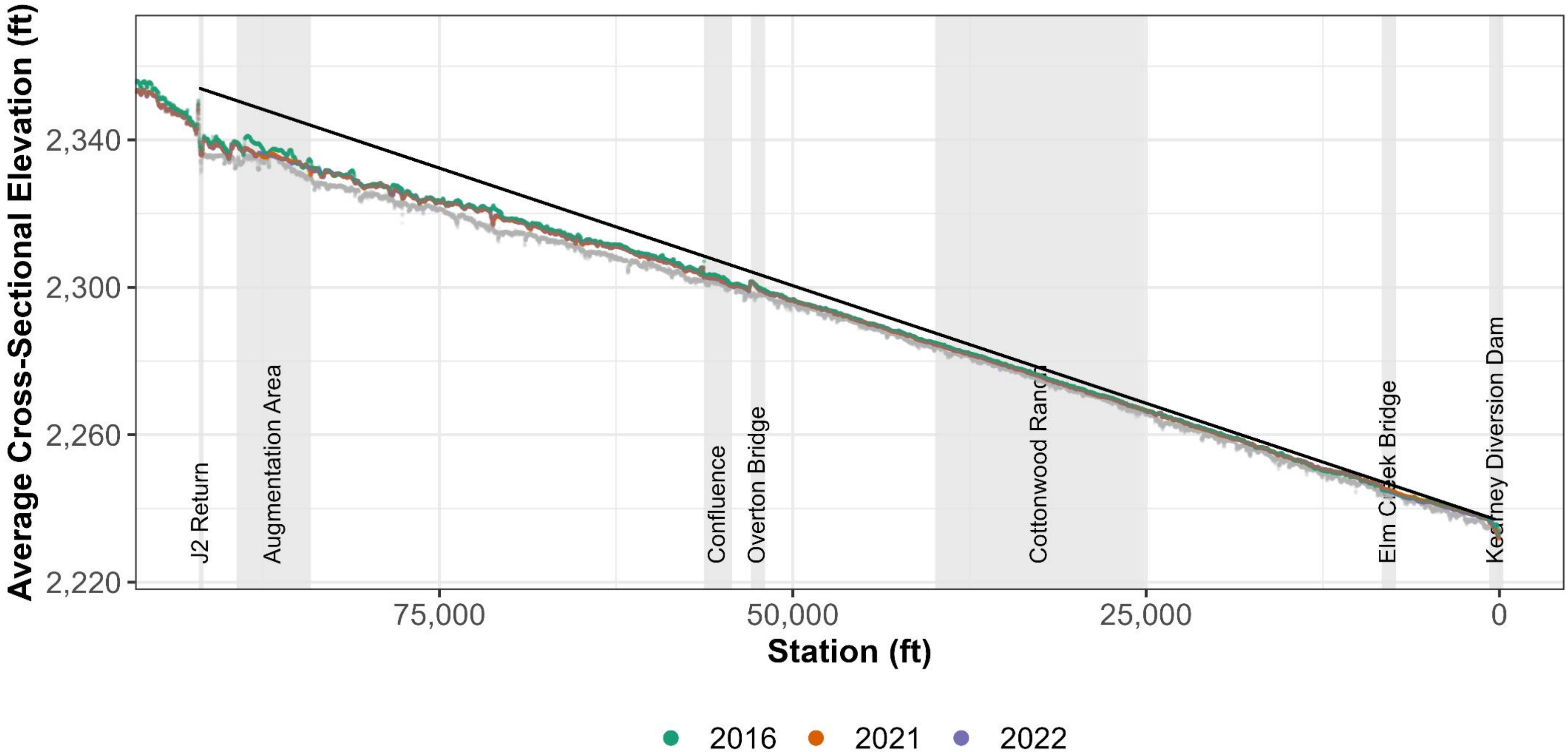

Figure 3.12. Average cross-sectional elevation longitudinal profile. Very little change occurred between 2021 (orange) and 2022 (purple). Elevations upstream of the Overton Bridge continue to diverge from the slope of the GGL (black).

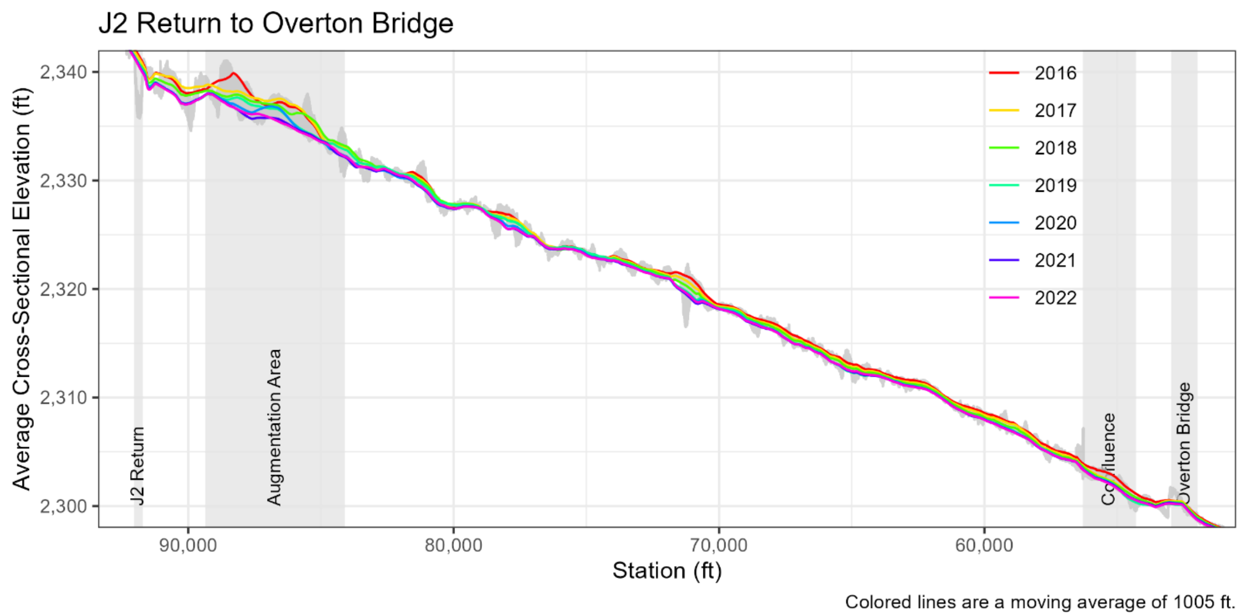

Figure 3.13. Average cross-sectional elevation longitudinal profile in the J2 Return channel. Colored lines are a moving average of 1005 ft and gray lines show the range of values for 2016–2022. Very little changed occurred from 2021 to 2022.

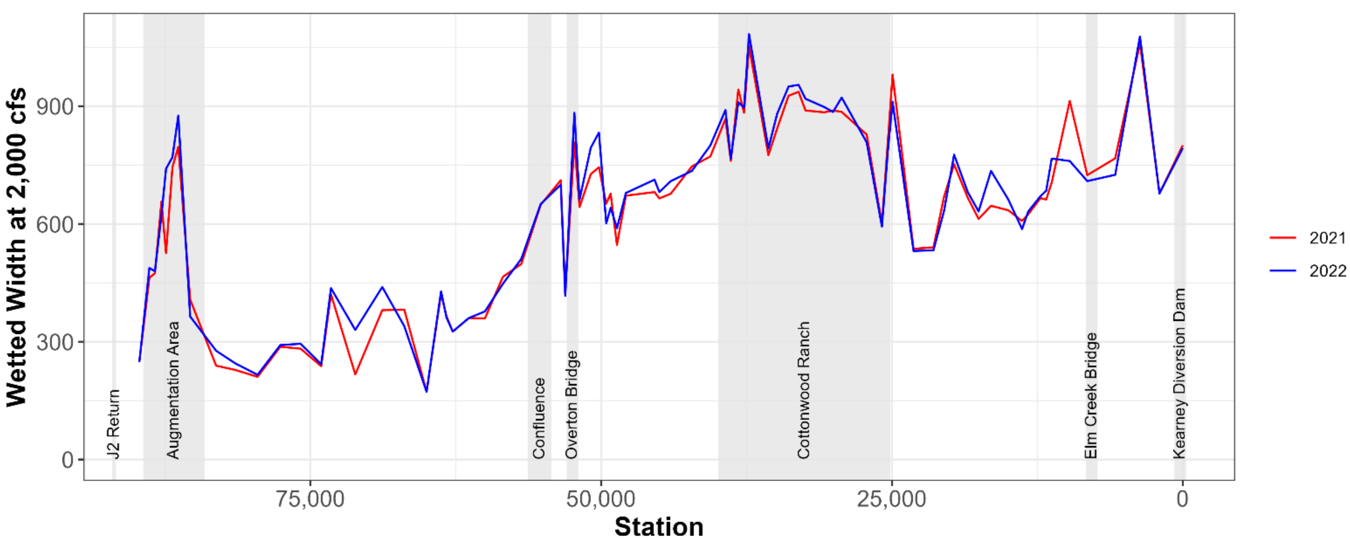

Figure 3.15 Wetted width at HEC-RAS cross-sections in 2021–2022. In most areas, wetted width was stable. Two larger changes occurred at stations 9,715 and 71,140. In the first case, wetted width increased near station 70,000 due to apparent reconnection of a side channel. In the second case, wetted width decreased in 2022 as an off-channel pond became inaccessible to flow.

Table 3.3 Mean wetted width and standard deviation (SD) in three reaches, measured at 78 HEC-RAS cross-section locations. Augmentation beginning in 2017 increased width in Reach 1. Flooding in 2015 caused Reach 3 to widen between 2012 and 2016. In 2022, wetted widths increased and became more variable in Reach 1, and increased slightly in reaches 2 and 3.

	Reach 1 J2 to Augmentation Boundary		**Reach 2 Augmentation Boundary to Overton**		**Reach 3 Overton to KCD**	
Year	**Mean (ft)**	**SD (ft)**	**Mean (ft)**	**SD (ft)**	**Mean (ft)**	**SD (ft)**
2009	290	90	440	130	490	150
2012	190	40	360	120	480	140
2016	280	60	350	120	720	160
2017	510	200	380	150	740	150
2021	540	180	360	140	760	130
2022	574	216	375	132	764	132

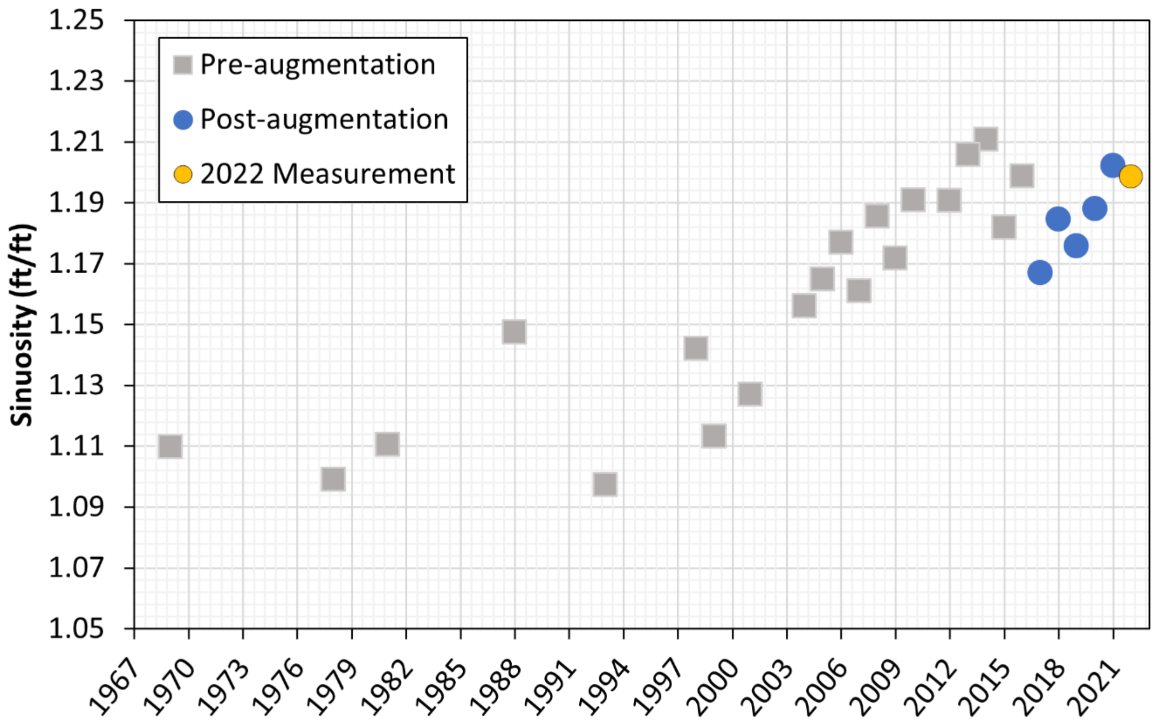

Figure 3.17 Ratio of thalweg to straight-line length (sinuosity) in the J2 Return Channel between 1969 and 2022. Figure shows a trend in increasing sinuosity beginning in the early 2000s. Sinuosity declined in 2017 due to the construction of a meander cutoff as part of augmentation operations. Despite the cutoff, the trend of increasing sinuosity continued during the augmentation experiment. 2022 sinuosity remained in-line with the current increasing pattern, though the value is slightly lower than 2021.

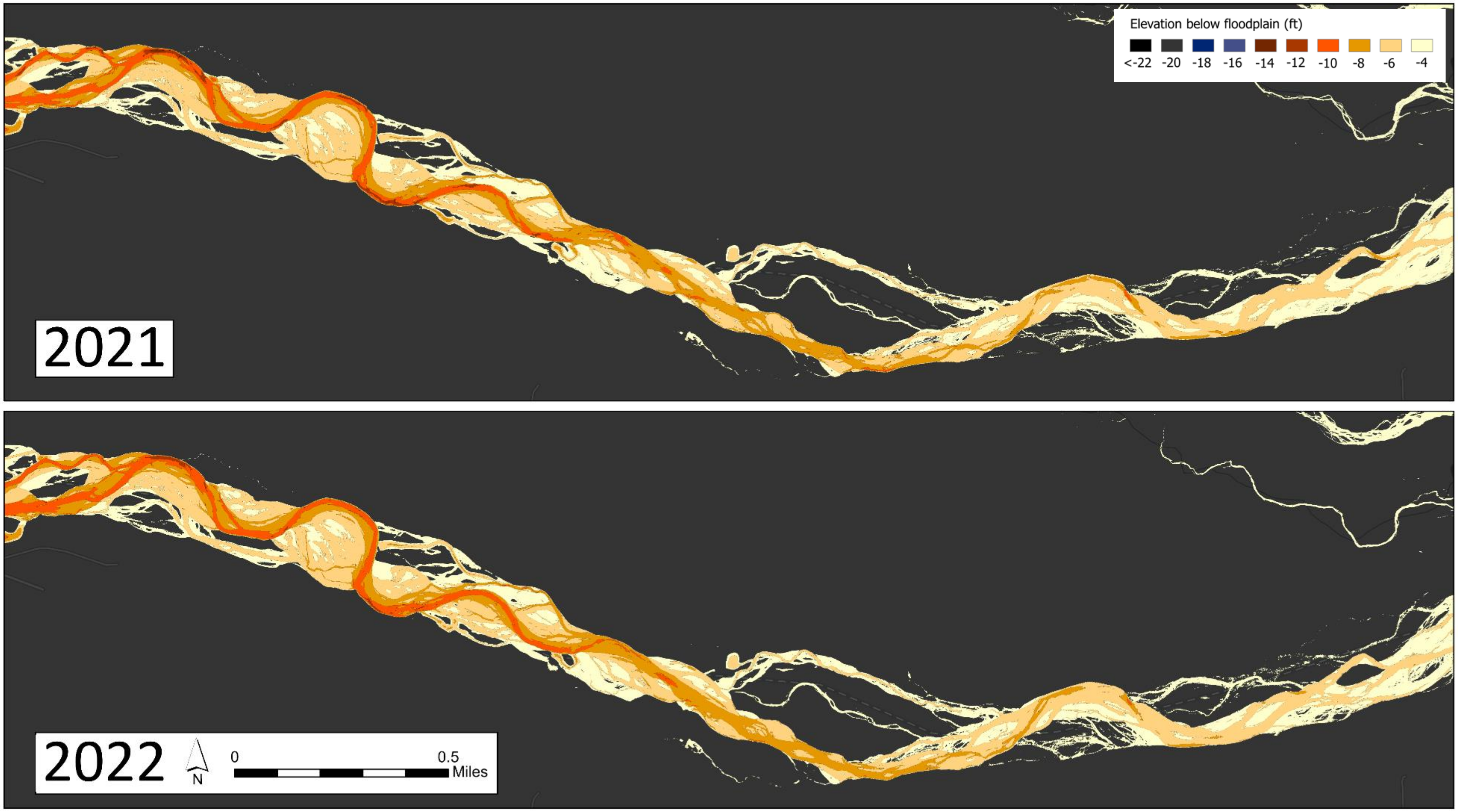

Figure 3.19. Relative elevation models (REMs) of the downstream section of the J2 Return Channel ending at Station 58,000. The relative elevation model is contoured into 2 ft intervals below -4 ft relative to the floodplain. Only slight changes occurred since last year. Downstream progression of incision is not apparent, and a few deeper holes have shifted from dark red (-12 ft) to red (-10 ft).

CHAPTER 4 Volume change analysis

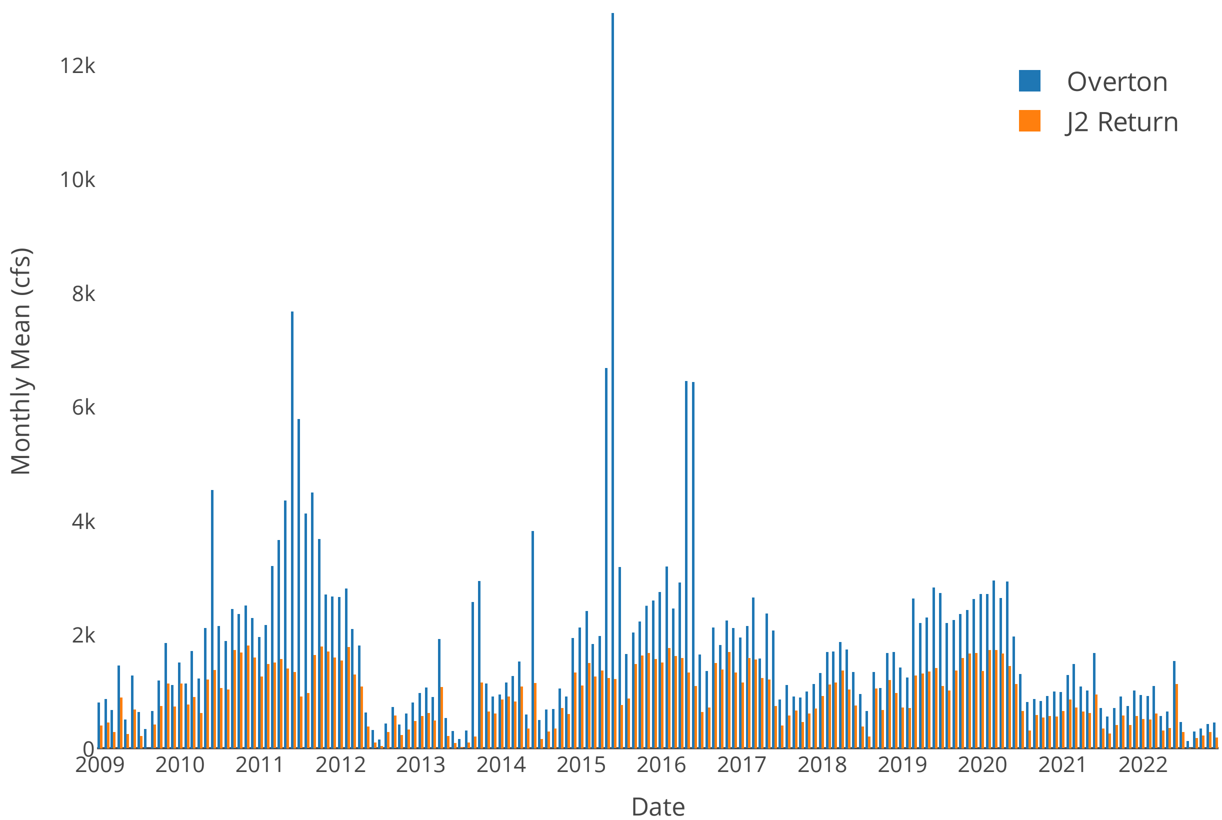

Figure 4.2 Monthly mean discharge from CNPPID to the J2 Return Channel and at the USGS Overton gage from 2009 to 2022. Flows at both locations were low in 2022.

Table 4.2 Sediment added to the J2 Return Channel. The breakthrough channel was dry in 2022, so augmented material was the only known sediment source.

	Breakthrough Channel Volume (yd^3)	Augmented Volume (yd^3)	Total (yd^3)
2009 – 2016	262,000–268,300	0	262,000–268,300
2016 – 2017	71,600	23,000	94,600
2017 – 2018	61,100	42,900	104,000
2018 – 2019	19,900	42,300	62,200
2019 – 2020	0	57,700	57,700
2020 – 2021	0	51,300	51,300
2021 – 2022	0	43,300	43,300

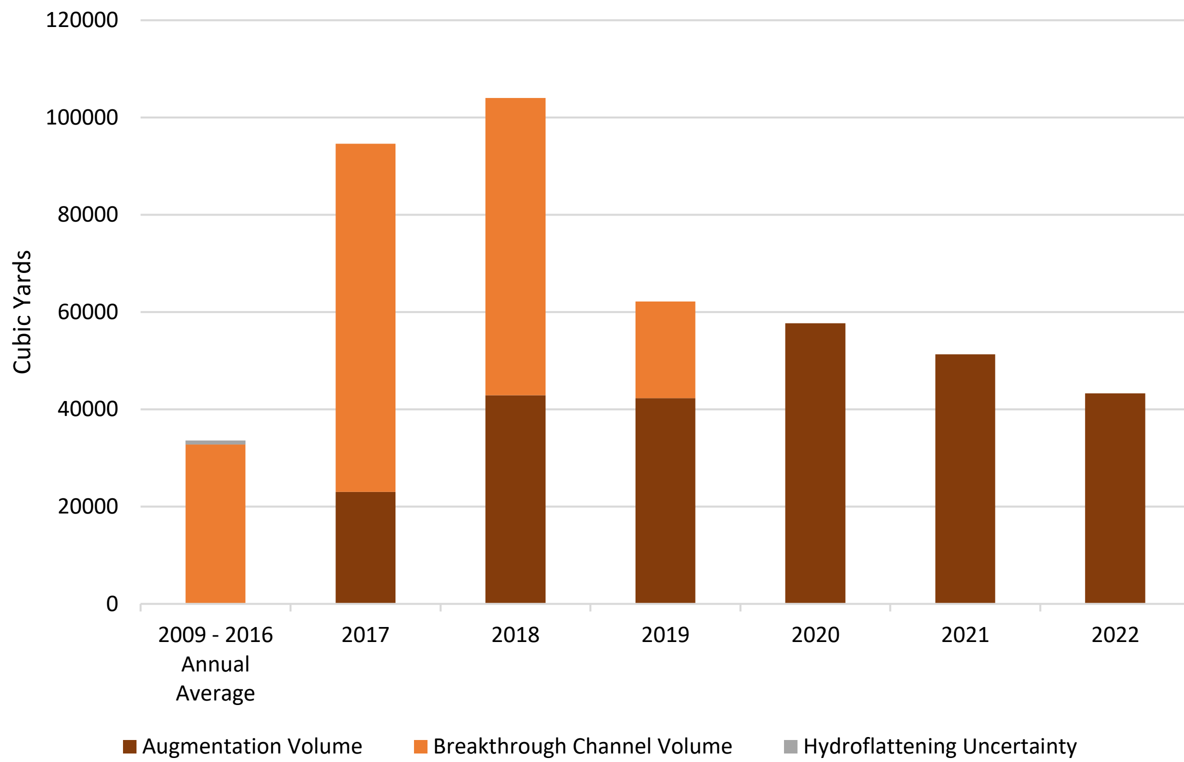

Figure 4.3 In 2022, 43,300 yd^3 were augmented into the channel. This is within our target range of 40,000 – 60,000 yd^3.

Table 4.1. Vertical accuracy estimates for the LiDAR DEM surfaces from each year for wet and dry areas. Accuracy values represent 95% confidence in the estimate. 2022 accuracies were similar to previous years.

Year	Dry Accuracy (ft)	Wet Accuracy (ft)
2009	0.249	NA
2012	0.137	NA
2016	0.142	0.258
2017	0.183	0.383
2018	0.100	0.350
2019	0.100	0.750
2020	0.183	0.258
2021	0.113	0.247
2022	0.174	0.469

Table 4.2. Pre- and Post-augmentation volume change broken into two reaches. Negative values indicate net degradation for the reach. Green cells indicate a decrease in degradation from pre- to post-augmentation. With the inclusion of 2022 data, we observed an overall decrease in each category of erosion (lateral, bed, and total) compared to the pre-augmentation period.

	Augmentation Boundary to Overton Bridge (yd^3/yr)		Overton Bridge to KCD (yd^3/yr)	
	Pre-Augmentation	Post-Augmentation	Pre-Augmentation	Post-Augmentation
Lateral	-63,000	-59,800	-154,400	-40,200
Bed	-59,700 to -42,000	-18,300	-46,100 to 23,700	-16,300
Total	-122,700 to -105,000	-78,100	-200,400 to -130,700	-56,600

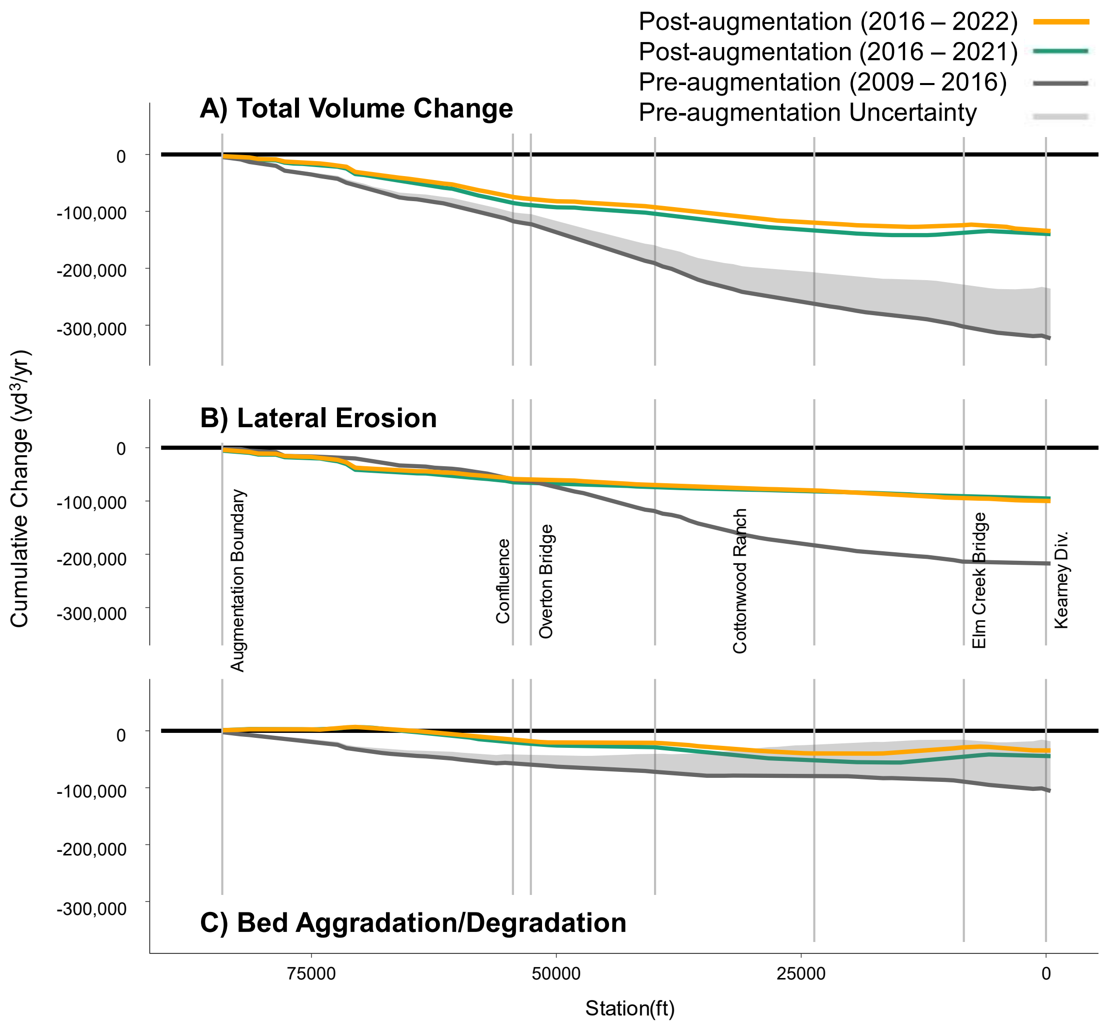

Figure 4.8. Cumulative volume change in the pre- and post-augmentation time periods. Lines represent the running sum of all change starting at the downstream end of augmentation projects. Gray shaded area represents the uncertainty in the pre-augmentation period due to lacking bathymetry data. Inclusion of the 2022 data (orange) led to very slight changes that for the most part decreased the yearly averages.

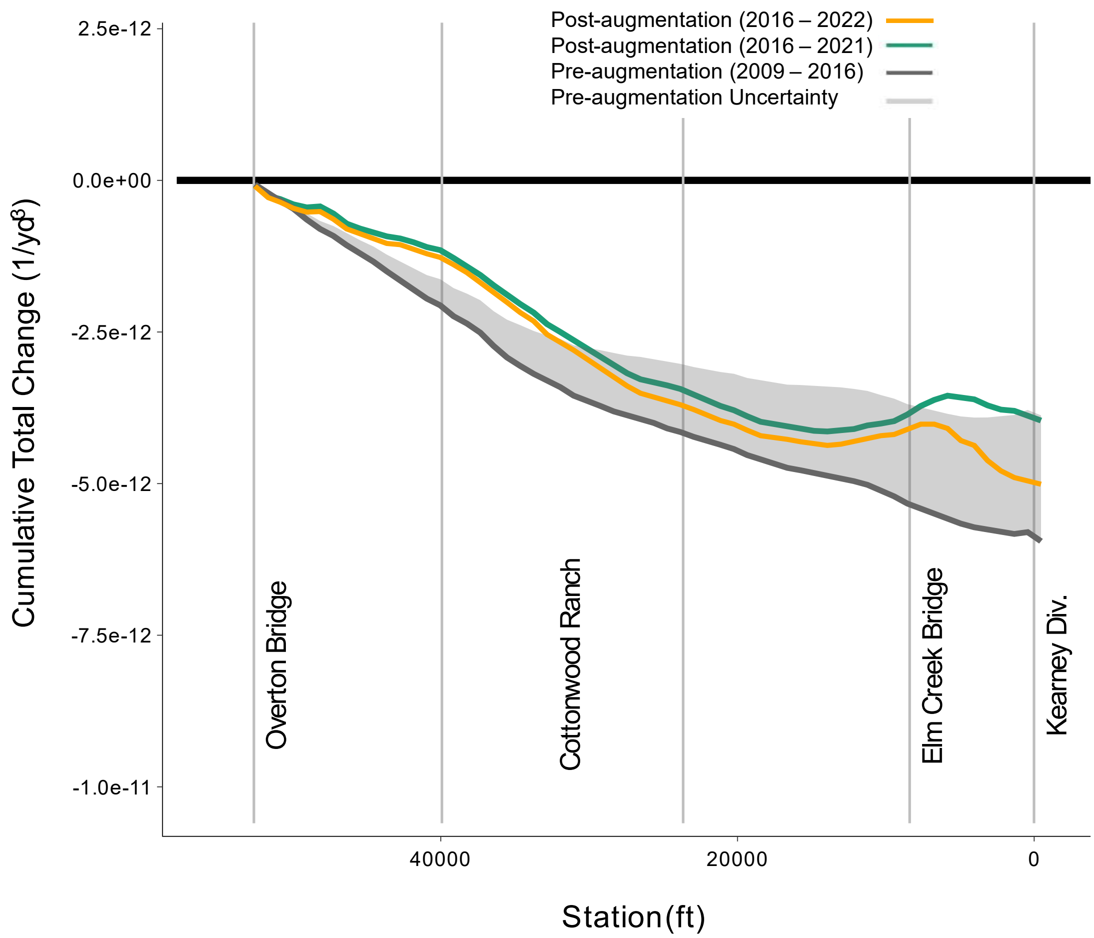

Figure 4.9. Cumulative total volume change downstream of the Overton Bridge. Values are normalized by flow at the Overton USGS gage. Pre- and post-augmentation total volume changes are very similar when normalized for the different amounts of flow that occurred during these periods. This pattern is maintained with the inclusion of 2022 data. The drier conditions enhanced degradation slightly compared to 2016 – 2021 data (green)

Table 4.5 Summary of flow during the pre- and post-augmentation periods.

	Pre-augmentation		Post-Augmentation	
	J2 Return	Overton Bridge	J2 Return	Overton Bridge
Average Daily Flow (cfs)	960	2,150	880	1,650
Maximum Daily Flow (cfs)	2,030	15,300	1,500	9,750

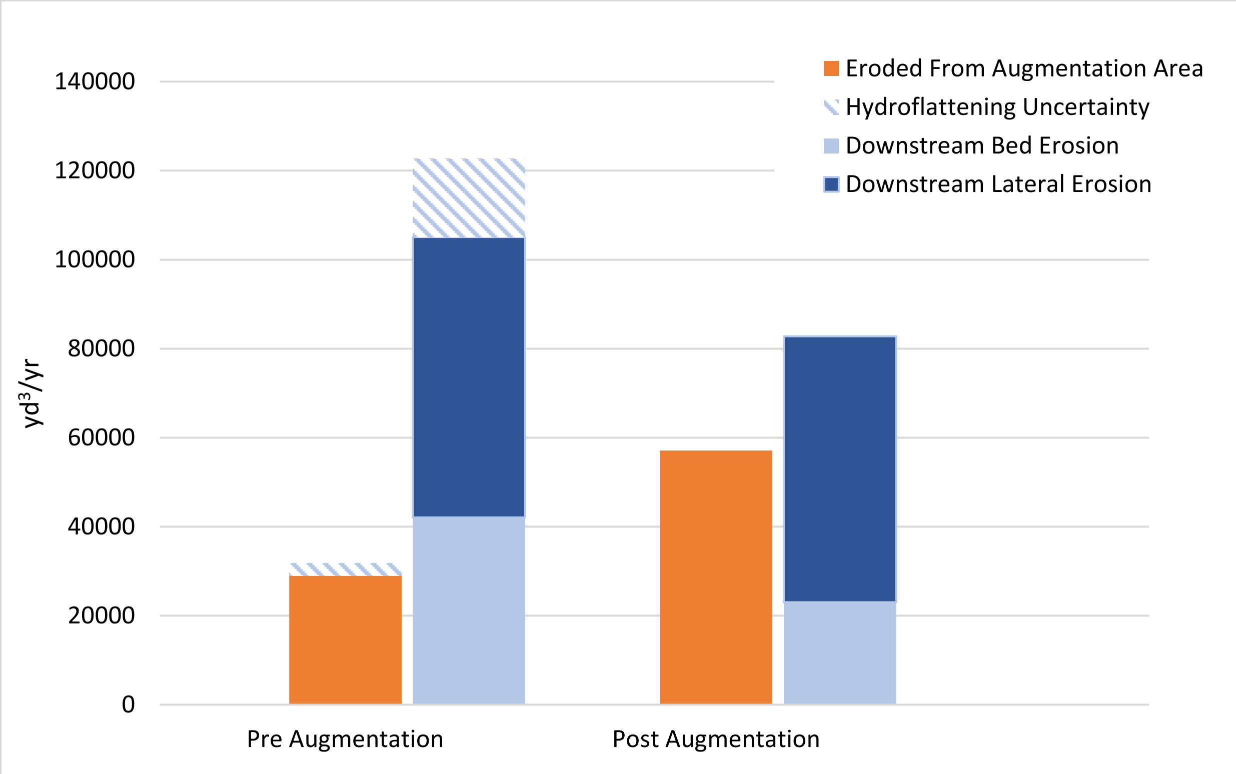

Figure 4.10 Volumes eroded from the J2 Return Channel upstream and within the augmentation project area (orange), and downstream of augmentation projects to the Overton Bridge (blue) in pre- and post-augmentation periods. In the post augmentation period, upstream sediment supply increased and downstream bed erosion decreased. The similarity between the values of increase and decrease indicate that sediment is leaving the augmentation area and reducing bed erosion downstream. Inclusion of 2022 data shows slightly less average erosion from the augmentation area. This is reasonable given lower J2 Return flows in 2022.

Table 4.6 Post-augmentation year-by-year volume change divided into two reaches at Overton Bridge. Negative values indicate net degradation or erosion. In 2022, less erosion occurred in the upstream reach, while more occurred in the downstream reach compared to the previous year. The downstream increase was primarily due to the levee breach at Blue Hole East (see Figure E1).

	Downstream augmentation boundary to Overton Bridge			**Overton Bridge to KCD**		
	Total Volume Change (yd^3)	**Lateral Erosion (yd^3)**	**Bed Agg/Deg (yd^3)**	**Total Volume Change (yd^3)**	**Lateral Erosion (yd^3)**	**Bed Agg/Deg (yd^3)**
2017-2016	-117,200	-76,800	-40,300	18,500	-23,300	41,800
2018-2017	-91,100	-39,300	-51,800	-170,300	-18,300	-152,000
2019-2018	-123,800	-73,900	-49,900	-116,300	-50,300	-66,000
2020-2019	-77,500	-40,200	-37,400	12,100	-26,600	38,700
2021-2020	-38,900	-41,600	2,700	-2,100	-300	-1,900
2022-2021	-26,500	-28,600	2,100	-85,500	-19,800	-65,700

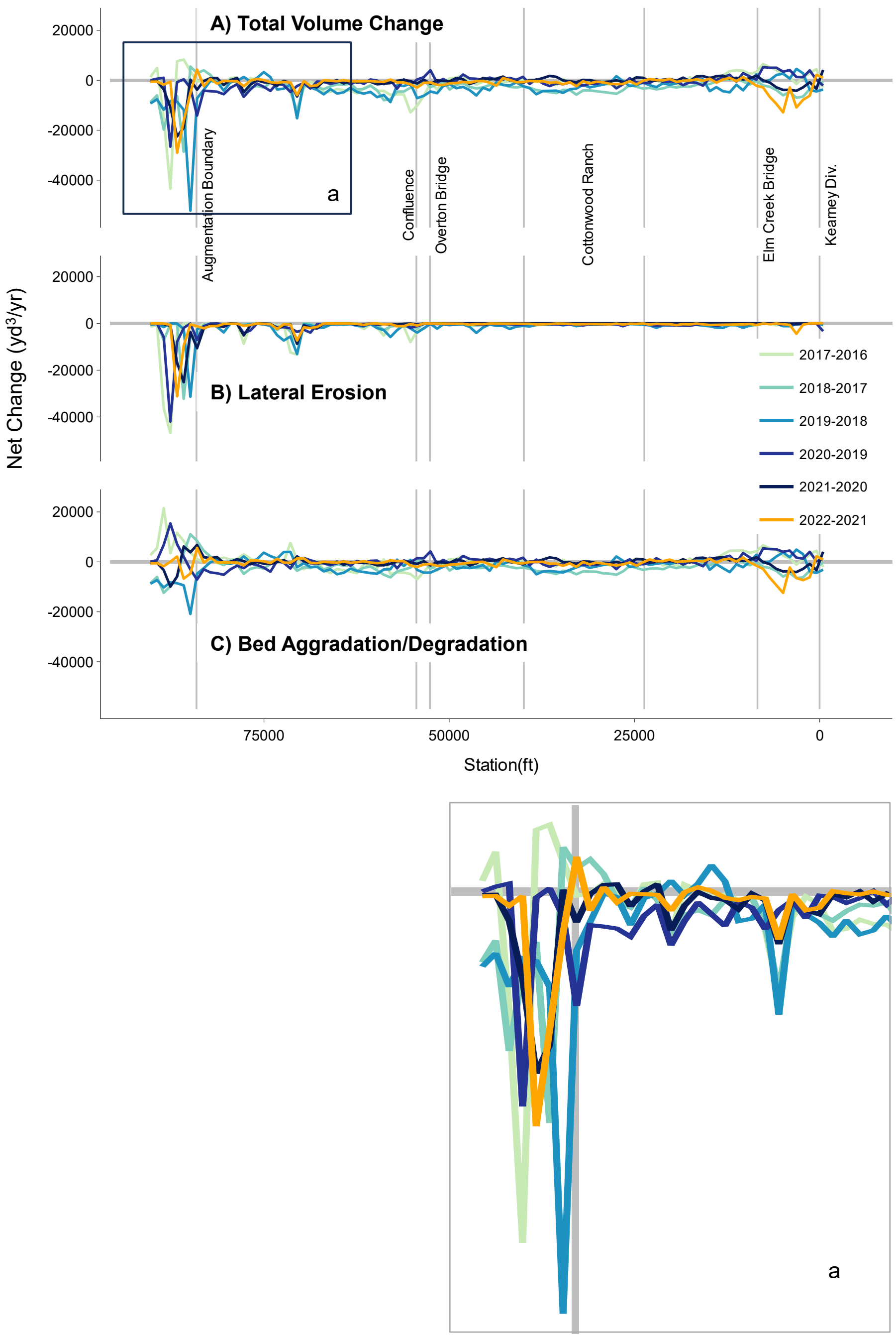

Figure 4.11 Post-augmentation year-by-year net volume change. Inset 'a' depicts change near the augmentation project site. In 2022, bed and lateral erosion decreased compared to previous years.

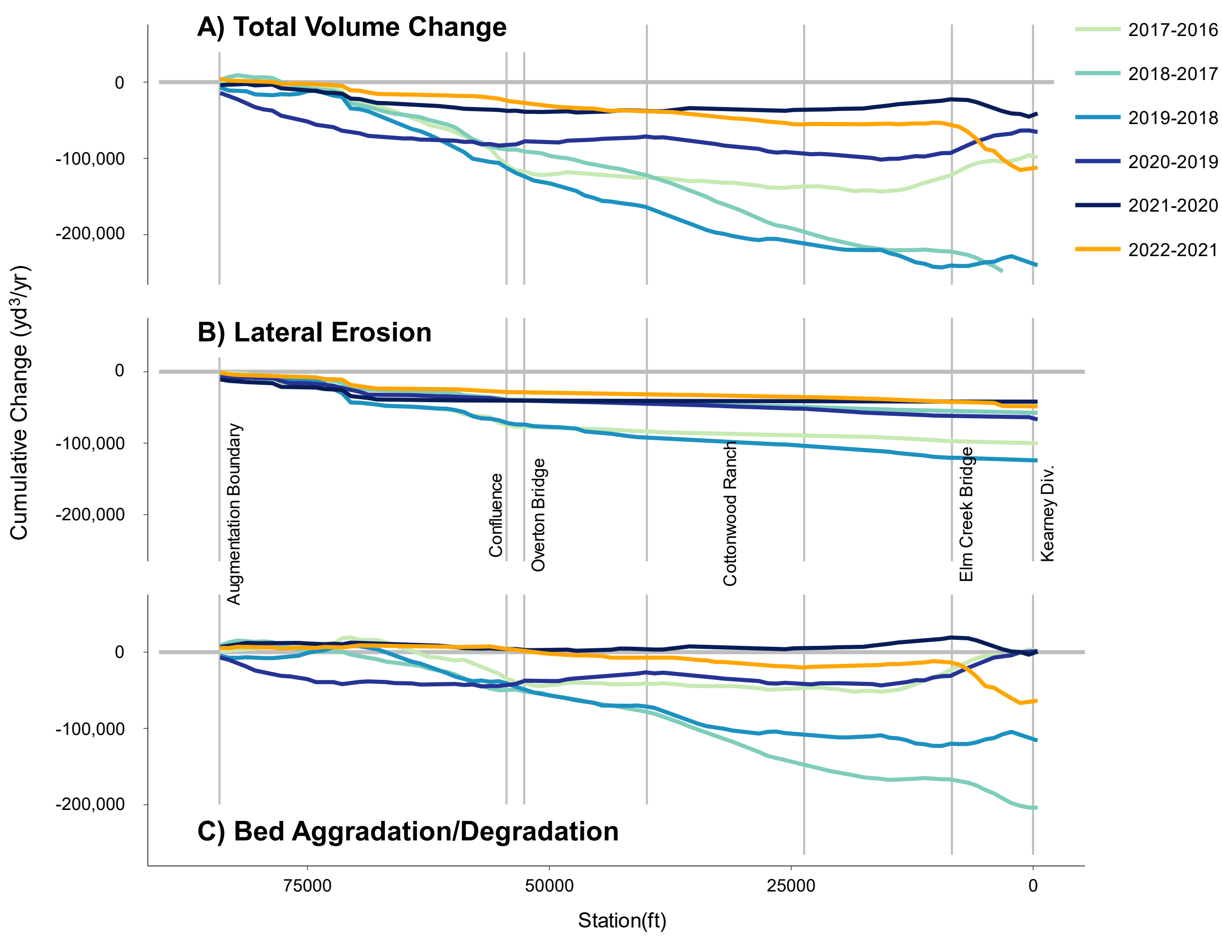

Figure 4.12 Cumulative year-by-year volume change in the post-augmentation period. (A) Lines represent the running sum of all change starting at the downstream end of augmentation projects. The nearly flat lines downstream of Overton Bridge indicate very little lateral erosion occurred (B). Steep slopes indicate high local change, such as the high bed degradation at Cottonwood Ranch from 2017–2019 (C). In 2022, little change occurred except for downstream of Elm Creek Bridge where a levee breach caused lateral erosion and channel adjustment resulted in high bed degradation (see Figure E2).