Appendix F2 – Assessment of Controls (Stormwater Management Assessment)

Wexford Annual Physical Assessment 2021

November 2022

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1 INTRODUCTION

Harford County Department of Public Works initiated physical geomorphic monitoring at the tributary to Church Creek in the Wexford community in 2005. Monitoring has been performed by KCI Technologies, Inc. (KCI) and URS Corporation (URS) at the Wexford site from 2005 to 2021 to meet criteria in the County's NPDES MS4 permit. The site consists of a 2,400 linear foot reach, located downstream of MD Route 7 (Philadelphia Rd) in Aberdeen, Maryland on an unnamed tributary to Church Creek (Figure 1). Within the survey reach, two extended detention stormwater facilities were built in 2006. The first drains all of Antrim Ct. and a portion of Ashford Dr. totaling 7.55 acres. The second pond drains Tralee Cir. and Kerry Ct. totaling 26.41 acres.

The goal of the project is to evaluate the effectiveness of Maryland's 2000 Stormwater Regulations design criteria for controlling the channel protection volume (Cpv) and to assess the geomorphic stability of the stream channel in the assessment reach. This is accomplished through geomorphic monitoring and fulfills the conditions of the County's MS4 permit listed under section IV.F.2 – Stormwater Management Assessment in the Assessment of Controls portion of the County's current permit.

Assessment techniques include an annual survey of permanently monumented channel cross-sections and longitudinal profiles. Cross-sectional and longitudinal profile surveys were conducted in 2005 to establish baseline conditions of channel geometry and slope. Baseline surveys were conducted to enable comparisons with subsequent annual assessments to determine whether lateral or vertical migration of the channel has occurred. Methods, data, and results from the 2021 monitoring period are detailed in this report along with comparisons to previous year's results to investigate changes in channel geometry and stability over time.

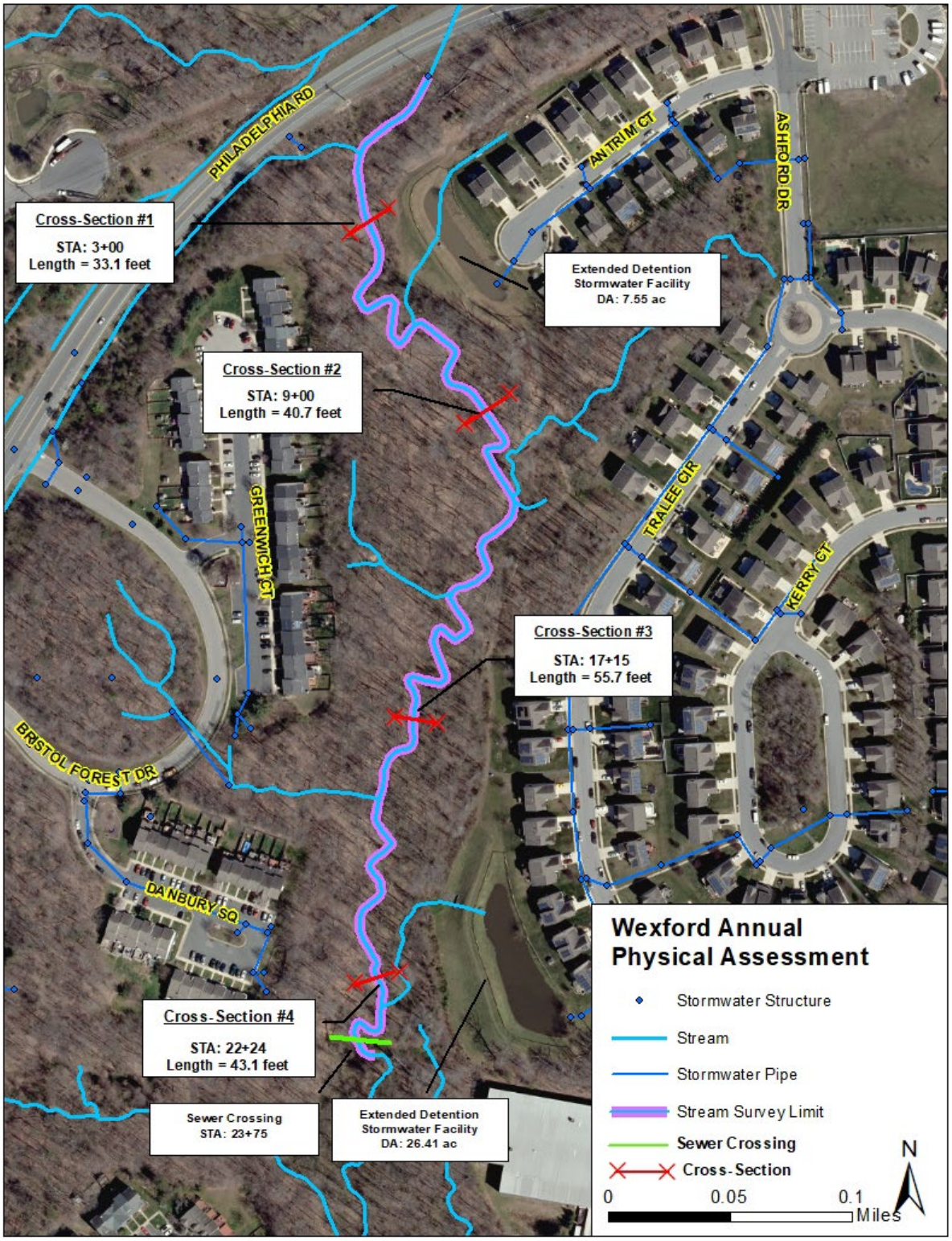


Figure 1 - Stream Survey Limits and Cross-Section Locations

2 METHODS

2.1 GEOMORPHIC ASSESSMENT METHODS

A longitudinal profile of the assessment reach was surveyed in 2005 and annually through 2021 using a laser level, calibrated stadia rod, and 300-foot measuring tape. The profile was established along the channel thalweg and included a survey of breakpoints in and between bed features and delineation of riffles, runs, pools, and glides. A survey of the bankfull elevation (where discernible), top of bank, and water surface was also performed. The longitudinal profile from 2005 was plotted to serve as the baseline for comparison during subsequent years. The profile from 2021 and previous surveys were also plotted and used to track changes that occurred in the bed sequences and channel slope (Figure 2). Profile data can be found in Appendix B.

To establish locations where fluvial geomorphic characteristics of the channel could be measured and compared over time for assessing bed and bank stability, permanent cross-sections were established during the 2005 monitoring effort at four locations within the assessment reach. Rebar monuments were established on either side of the channel to mark the cross-section locations and to maintain repeatable elevation controls. The location of each monument was recorded using a GPS unit capable of sub-meter accuracy. Cross-sections were surveyed annually from 2005 through 2021 using a laser level, calibrated stadia rod, and measuring tape. The cross- sectional surveys captured features of the floodplain, monuments, and all pertinent channel features including:

- Top of bank
- Bankfull elevation
- Edge of water
- Limits of point bar and instream depositional features
- Thalweg
- Floodprone elevation

Longitudinal profile and cross-section data were entered into *The Reference Reach Spreadsheet* version 4.3L (Mecklenberg 2006) for data analysis and graphical interpretation. Profile and cross-section data collected during 2005 provided the baseline conditions to which subsequent monitoring events were overlaid and compared to assess whether any measureable changes occurred.

Bankfull elevations were selected based upon field observed bankfull indicators and used to calculated measures of channel geometry. Because bankfull indicators are not always easily discernible from year to year and best professional judgment is often required to determine bankfull elevations in incised channels, top of bank features were also measured. Top of low bank cross-sectional areas were also calculated and used to generate values that are directly comparable between each monitoring effort.

3 RESULTS AND CONCLUSIONS

3.1 FLUVIAL GEOMORPHIC ASSESSMENT - 2021

The seventeenth year of longitudinal profile and cross-sectional surveys was completed on December 14 and 16, 2021. Photographs depicting the overall site conditions are presented in Appendix A. The longitudinal profile data was used to calculate the water surface slope for the channel (Table 1) and can be found in Appendix B. In addition, the profile surveyed during 2021 was plotted and superimposed on the 2005-2021 surveyed profile data (Section 3.2).

Table 1 - Results of longitudinal profile survey- 2021

Reach	Slope
Wexford	1.5%

Cross-sectional surveys were analyzed at each of the four permanent monitoring locations to determine bankfull width, mean depth, width/depth ratio, and overall cross-sectional area. Results of the cross-sectional measurements are included in Table 2. Appendix B presents the 2021 cross-section data. All four cross-sections classify as unstable F4 type channels.

Table 2 - Results of cross-sectional survey analysis- 2021

Cross-section	Bankfull Width (ft)	Mean Depth (ft)	Width/ Depth Ratio	Entrench-ment ratio	Bankfull Velocity (ft/s)	Bankfull Discharge (cfs)	Shear Stress (lb/ ft^2)	Flood Prone Area (ft^2)	Bank-full Area (ft^2)	Top of Bank Area (ft^2)
2021 Survey Data										
XS 1	10.0	1.1	9.2	2.2	3.2	31.8	0.85	21.9	10.7	69.4
XS 2	20.1	0.9	21.6	1.2	2.9	53.6	0.81	23.9	18.7	75.8
XS 3	16.4	0.9	17.6	1.3	2.9	44.1	0.83	21.8	15.2	89.9
XS 4	15.2	0.7	20.3	1.3	2.8	31.3	0.67	19.1	11.3	50.0

3.2 COMPARISON OF LONGITUDINAL PROFILE 2005-2021

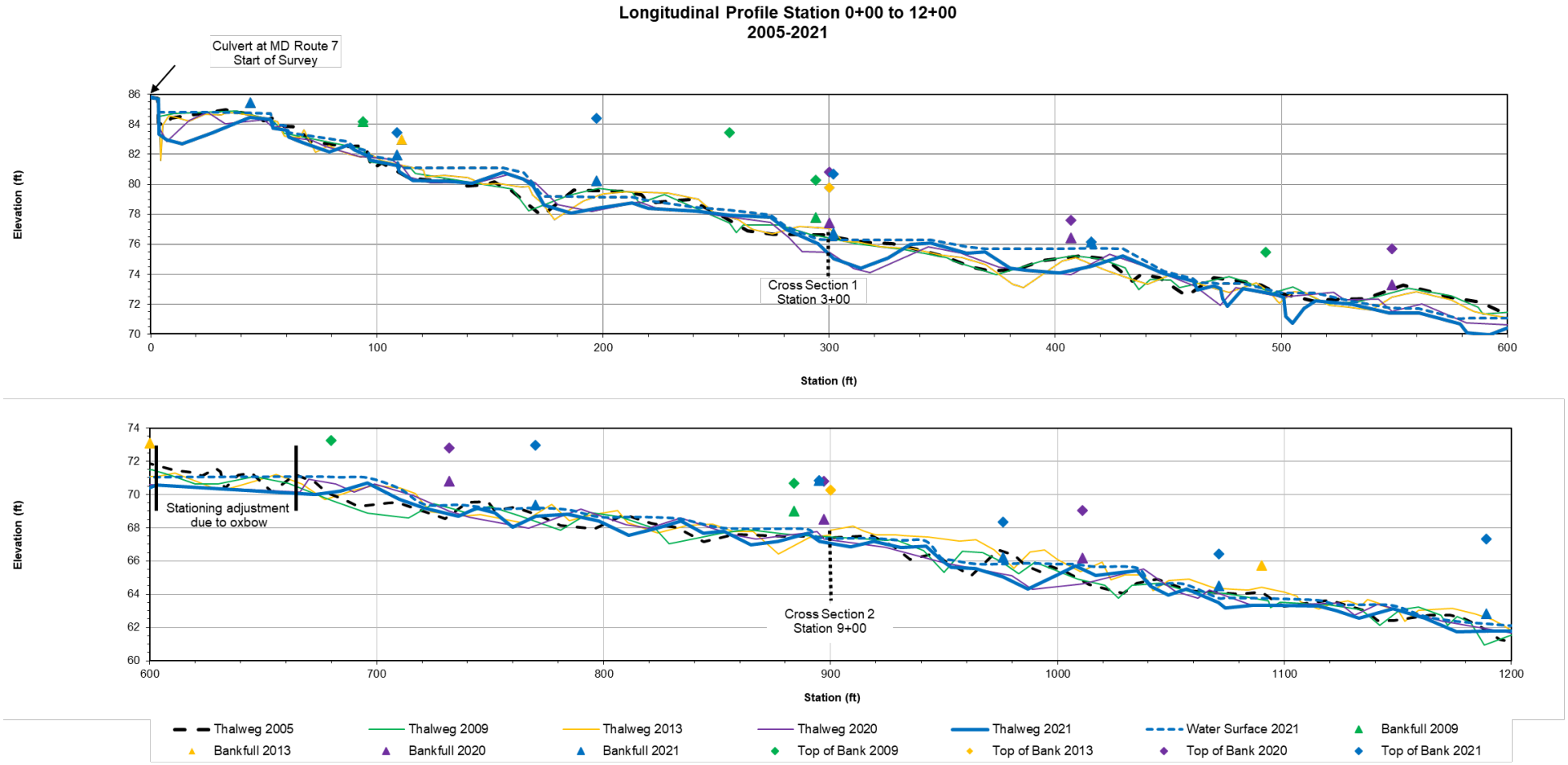
The longitudinal profile data from the 2021 survey was analyzed to calculate the slope of the reach. As during previous monitoring efforts, the channel slope from 2005 to 2021 has remained constant from 1.44% in 2005 to 1.50% in 2021. Small fluctuations are normal as differences can occur in the calculated slope due to changes in stationing and measurement error over the survey reaches and likely reflect only minor changes in slope over time.

In addition to the slope comparisons, the profile surveyed during 2021 was plotted and superimposed on the plots of prior year profiles surveyed from 2005 through 2021 (Figure 2). In an effort to better graphically present the data, years 2005, 2009, 2013, 2020, and 2021 are plotted to better distinguish changes. Bed features exhibited evidence of the continually shifting and dynamic nature of this system, including deposition in some pools and bars, deepening of

other pools, and shifting locations of riffle crests. In 2020, an oxbow cutoff was created around STA 5+25 (Figure 3, Figure 4). This cutoff bypassed a 70 foot meander bend. KCI surveyed the new channel and adjusted the stationing throughout the rest of the survey to account for the change. Stationing between STA 5+25 and 8+00 was difficult to match with previous surveys due to this change in channel length and stationing. In 2021 the cutoff remained and has further developed into the main channel.

Throughout the current survey there is a trend of slight bed erosion, especially between station 13+00 and 22+00 where the most fluctuations can be seen between 2020 and 2021. The bed erosion is most notable within pool deepening rather than within riffle sections. The average slope of the entire study reach is 1.50%, however there is variability in portions of the channel that are both less than and greater than the average with a decrease in slope moving from upstream to downstream. From station 0+00 to 6+00 the slope is 2.6%. Slope in the middle section of the reach, 6+00 to 18+00, is 1.4% and the lower portion, 18+00 to 24+00, is 0.6%. As the slope decreases towards the bottom of the reach there is less energy and lower flow velocities which is likely contributing to the yearly changes in aggrading and eroding in the bottom portion of the survey. The channel appears unable to transport the sediment load contributed from upstream sources, which results in large mid-channel and lateral bar formation comprised of loose sand and gravel, which overwhelms the channel and causes frequent shifts in bedform. These depositional features increase near-bank stresses resulting in erosion of the bank and bed. The stream banks and bed near the sewer encasement at station 23+75 continue to degrade and the area should continue to be monitored (Photo on pg. 29 and 30 of Appendix A). The most notable changes in channel bed between 2020 and 2021 are:

- Plunge pool lengthened by 27 feet at the MD 7 culvert, STA 0+07 to 0+44
- Pool length shortened by 8 feet at STA 4+73
- Two foot deep pool created at STA 5+02 to 5+15
- Filling in of pool at STA 2+53
- 70 foot Oxbow cutoff remained around STA 5+25
- Bed erosion of 0.2 feet from STA 5+81 to 5+95
- Riffle crest created at STA 10+08
- Decreasing of riffle crest by 0.3 feet at STA 13+00
- Pool lengthened by 13 feet and deepened by 0.8 feet at STA 16+15
- Pool lengthened by 17 feet at STA 17+61
- Pool depth increase of 0.4 feet at STA 18+16
- Pool depth increase of 1.0 foot at STA 19+60
- Pool depth increase of 0.6 feet at STA 20+06
- Pool depth increase of 0.5 feet at STA 22+00
- Pool length increase of 8 feet at STA 22+95


Longitudinal Profile Station 0+00 to 12+00
2005-2021
Culvert at MD Route 7
Start of Survey
Elevation (ft)
Station (ft)
Cross Section 1
Station 3+00
Stationing adjustment
due to oxbow
Cross Section 2
Station 9+00
Thalweg 2005
Thalweg 2009
Thalweg 2013
Thalweg 2020
Thalweg 2021
Water Surface 2021
Bankfull 2009
Bankfull 2013
Bankfull 2020
Bankfull 2021
Top of Bank 2009
Top of Bank 2013
Top of Bank 2020
Top of Bank 2021

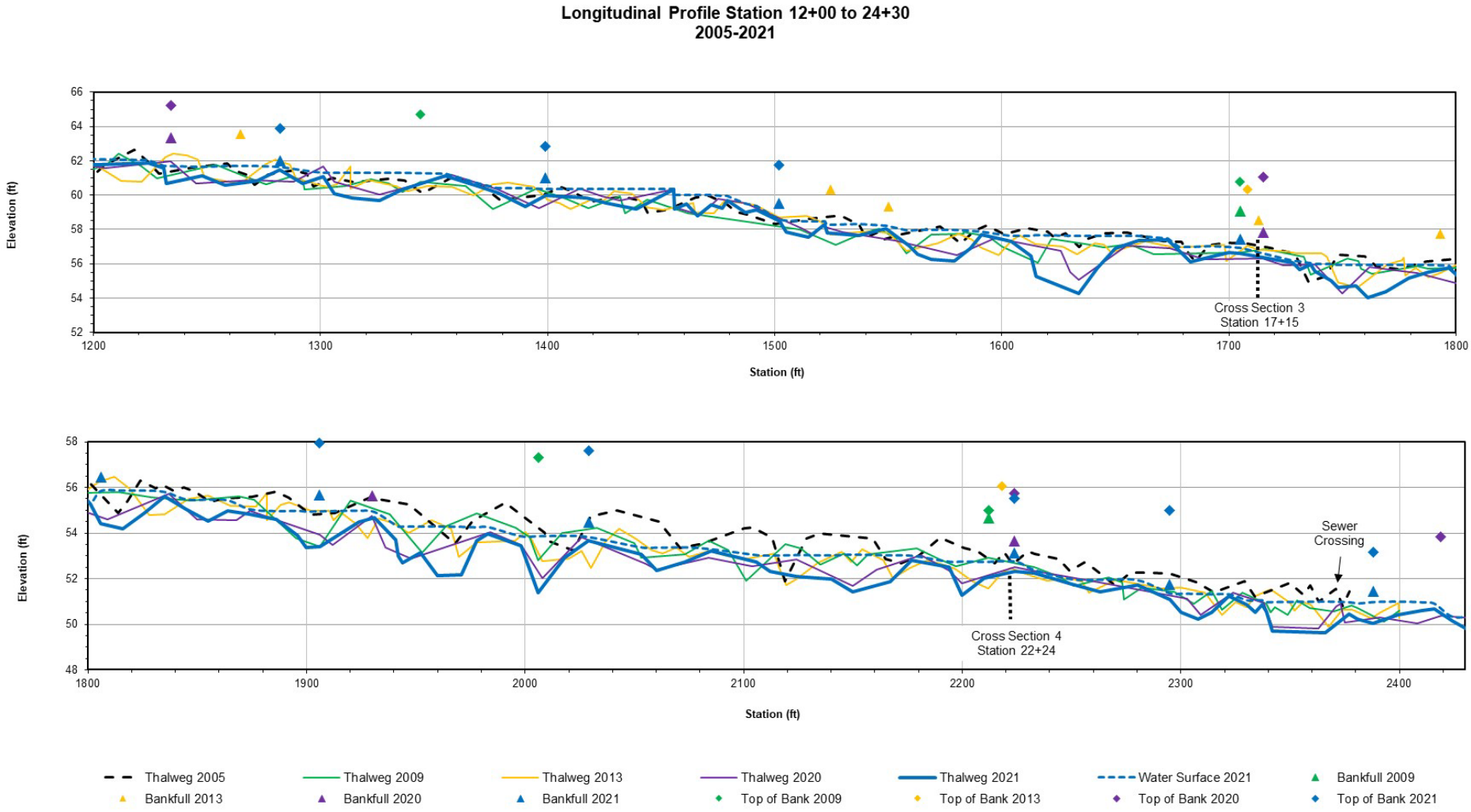


Figure 2 - Longitudinal Profile Overlays 2005-2021

Figure 3 - Facing downstream at upstream end of cutoff

Figure 4 - Facing upstream at downstream end of cutoff

3.3 COMPARISON OF CROSS-SECTIONS 2005-2021

Cross-section surveys from seventeen years of monitoring were analyzed at each of the four permanent monitoring locations to compare bankfull width, mean depth, width/depth ratio, and overall cross-sectional area. Since field determination of bankfull elevation in incised systems is difficult to identify and repeat over time, top of low bank elevation was used to track changes in the cross-sectional dimensions listed below. To compare the stability of reaches over time, the percent increase in top of bank cross-sectional area from 2005 through 2021 is shown in Figure 5. The greatest changes in top of bank cross-sectional area occurred at Cross-section 2 and Cross-section 4, which are located at stations 9+00 and 22+24.

Each cross-section is described in detail below. Cross-section survey data can be found in Appendix B of this report. In an effort to better graphically present the data, years 2005, 2009, 2013, 2017, 2018, 2019, 2020, and 2021 are plotted to better distinguish changes over time.

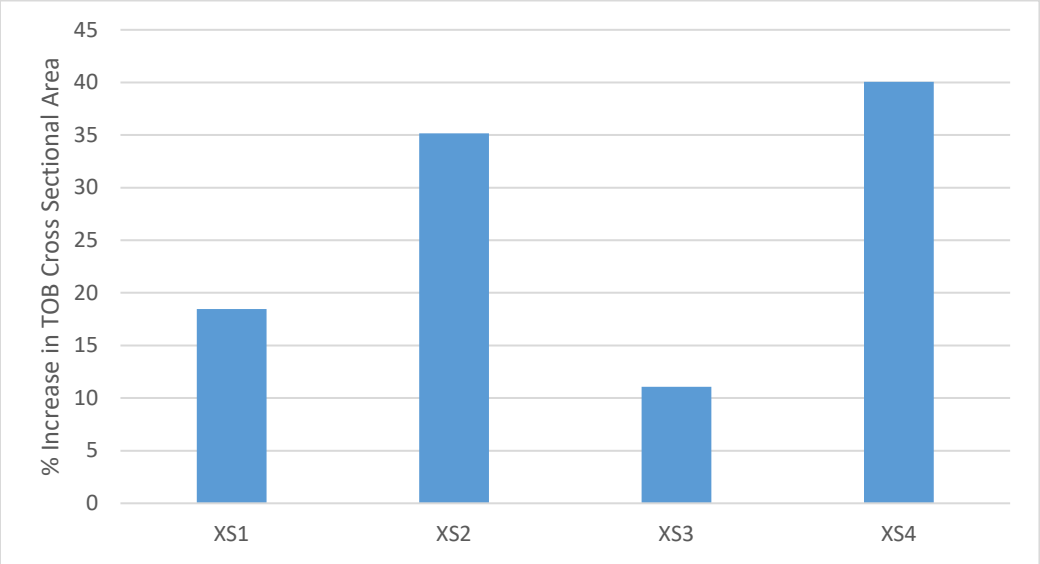


Figure 5 - Percent increase in top of low bank cross-sectional area from 2005-2021

CROSS-SECTION 1: STATION 3+00

Cross-section 1 had previously been the most stable, but saw significant bed erosion between 2017 and 2018. Currently, only a small deepening of the thalweg occurred between 2020 and 2021 of approximately 2 inches and the thalweg shifted one foot towards the right bank over the same period. Between 2017 and 2018, significant deposition on the left side of the channel along with bed incision on the right side were visible in the survey (Table 3, Figure 6). Photos facing downstream between 2017 and 2021 below (Figure 7) help visualize how much this cross-section has changed in a matter of a few years. In 2017, cross-section 1 was characterized as a shallow riffle with a uniform bottom. In 2021, the riffle has migrated upstream and the cross section located at a pool that has increased considerably in mean depth and has moved to the right side of the channel. About 0.75 feet of large cobble has been deposited on the left side of the channel while about 1.75 feet of erosion has scoured out the right side of the channel since 2017. (Figure 7). A large pool developed directly downstream of the cross-section in 2018. Between 2018 and 2019 this pool began filling in, but deepened about 5" in the 2020 survey and has remained near that depth in 2021. The bankfull width has decreased since 2019 along with the bankfull area and top of bank area both having decreased between 2020 and 2021.

Table 3 - Cross-section 1 Measurements

Year	Bankfull Width (ft)	Mean Depth (ft)	Width/ Depth Ratio	Entrench-ment ratio	Bankfull Velocity (ft/s)	Bankfull Discharge (cfs)	Shear Stress (lb/ ft^2)	Flood Prone Area (ft^2)	Bankfull Area (ft^2)	Top of Bank Area (ft^2)
2005	11.3	0.6	30.0	1.2	3.8	42.9	0.52	21.2	11.3	70.4
2009	18.3	0.7	26.5	1.2	4.1	54.6	0.59	21.6	12.6	73.7
2013	17.0	0.6	28.5	1.2	3.7	37.6	0.50	20.9	10.1	75.4
2017	18.0	0.6	28.1	1.2	3.9	44.9	0.54	21.6	11.5	72.7
2018	11.4	1.1	10.4	2.9	2.5	30.5	0.93	32.8	12.4	81.5
2019	11.8	1.0	11.3	1.8	3.1	38.0	0.91	21.7	12.3	80.6
2020	10.4	1.1	9.2	2.1	3.2	37.7	0.95	22.0	11.8	83.4
2021	10.0	1.1	9.2	2.2	3.2	31.8	0.85	21.9	10.7	69.4

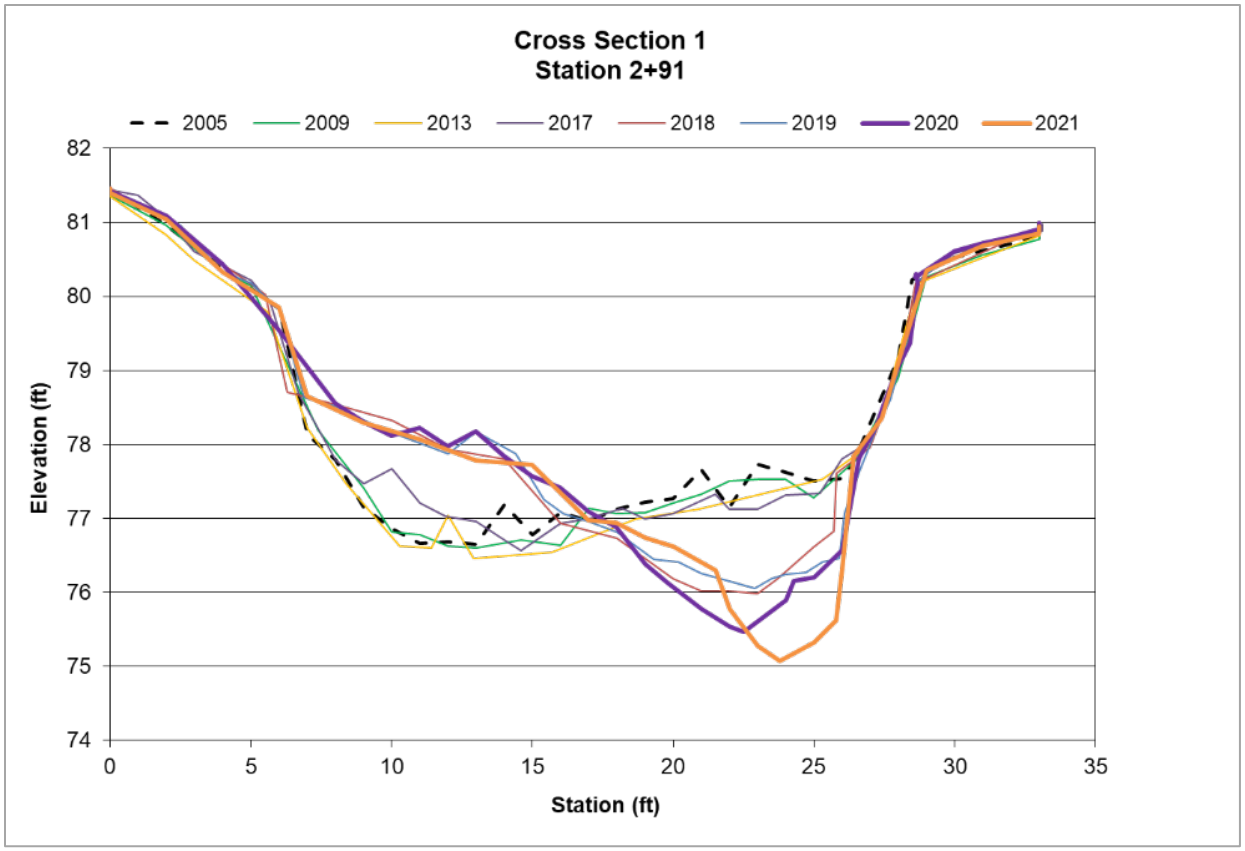


Figure 6 - Cross-section 1 Overlay 2005-2021

Figure 7 - Cross-section 1 facing downstream, 2017 (top), 2021 (bottom)

CROSS-SECTION 2: STATION 9+00

In the vicinity of Cross-section 2, approximately 1.1 feet of bed erosion occurred between 2005 and 2021. Additionally, approximately 3.1 feet of bank erosion has occurred on the left bank. The left bank and bed erosion have caused an increase in the bankfull area by 10.0 ft^2 and an increase in the top of bank area of 21.5 ft^2 (Table 4, Figure 8). The greatest increase in the left bank erosion occurred between 2009 and 2013. Between 2020 and 2021 there was no increase in bank erosion, however, there was 3-6" of bed erosion along the thalweg.

Table 4 - Cross-section 2 Measurements

Year	Bankfull Width (ft)	Mean Depth (ft)	Width/ Depth Ratio	Entrench-ment ratio	Bankfull Velocity (ft/s)	Bankfull Discharge (cfs)	Shear Stress (lb/ ft^2)	Flood Prone Area (ft^2)	Bankfull Area (ft^2)	Top of Bank Area (ft^2)
2005	18.3	0.5	38.4	1.2	3.2	28.0	0.41	21.9	8.7	54.3
2009	19.7	0.9	22.6	1.2	4.7	80.6	0.72	23.5	17.1	54.1
2013	19.9	0.6	33.8	1.1	3.6	42.7	0.49	22.5	11.8	60.0
2017	20.4	0.7	29.2	1.1	4.1	58.6	0.59	22.5	14.2	63.5
2018	21.4	0.8	26.3	1.1	2.1	36.8	0.74	23.2	17.4	70.3
2019	21.3	0.8	26.9	1.1	2.6	44.5	0.72	23.3	16.8	73.3
2020	20.4	0.8	24.1	1.2	2.7	47.1	0.75	23.7	17.3	73.4
2021	20.1	0.9	21.6	1.2	2.9	53.6	0.81	23.9	18.7	75.8

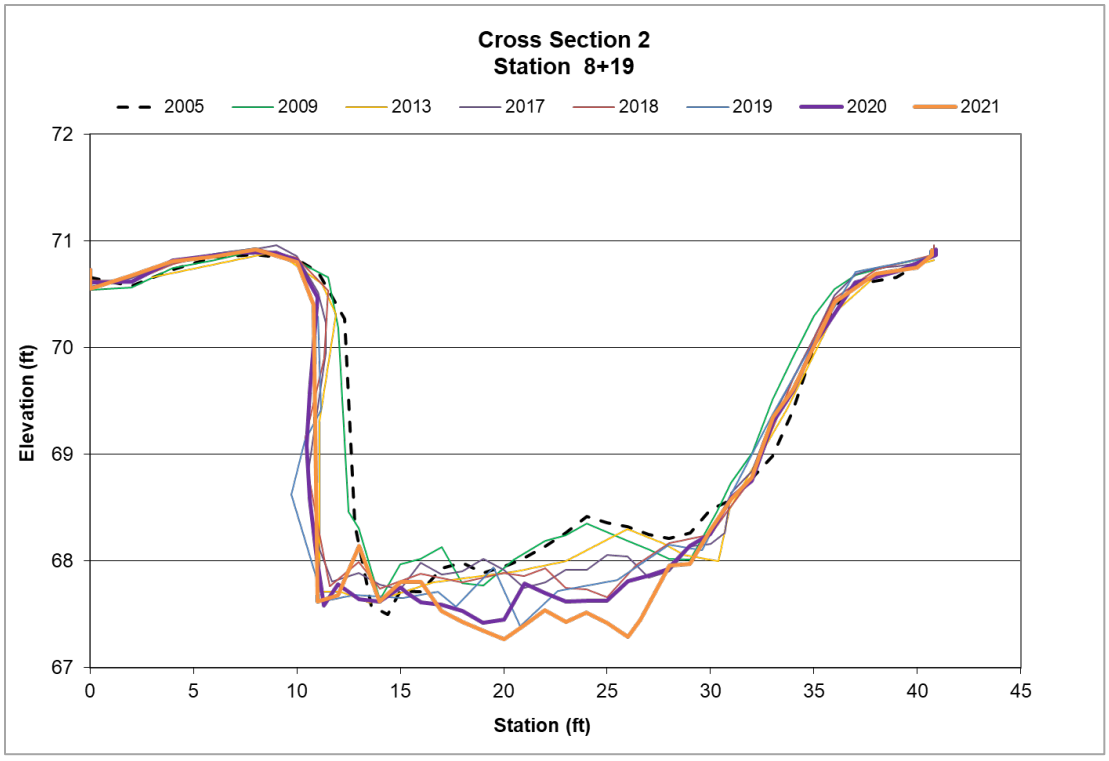


Figure 8 - Cross-section 2 Overlay 2005-2021

CROSS-SECTION 3: STATION 17+15

Cross-section 3 was moderately stable with signs of both aggradation and erosion prior to 2018 when considerable bed erosion occurred between 2017 and 2018 along the left side of the channel. The most evident change is the shift of the thalweg from the right side of the channel to the left (Table 5, Figure 9). Photos facing downstream between 2017 and 2021 below (Figure 10) help visualize how much this cross-section has changed in a matter of a few years. Between 2017 and 2018, approximately 1 foot of bed erosion occurred on the left side of the channel while 0.6 feet of deposition occurred on the right side of the channel. The bed was mostly stable between 2018 and 2019 with a small amount of aggradation on the left side of the channel. Between 2019 and 2020 approximately 4 inches of bed erosion occurred along the left bank while the depositional bar on the right side of the bed increased. Approximately 3-4" of bed aggradation occurred in the thalweg between 2020 and 2021 along with a slight widening of the depositional bar along the right bank. The banks have remained very stable between 2017 and 2021.

Table 5 - Cross-section 3 Measurements

Year	Bankfull Width (ft)	Mean Depth (ft)	Width/ Depth Ratio	Entrench-ment ratio	Bankfull Velocity (ft/s)	Bankfull Discharge (cfs)	Shear Stress (lb/ ft^2)	Flood Prone Area (ft^2)	Bankfull Area (ft^2)	Top of Bank Area (ft^2)
2005	13.2	0.7	18.1	1.7	4.1	39.3	0.58	22.2	9.6	80.8
2009	14.0	0.7	21	1.4	3.9	36.7	0.55	19.8	9.3	84.0
2013	15.8	0.9	18.5	1.3	4.7	63.7	0.72	19.8	13.5	91.1
2017	15.0	0.7	21.1	1.2	4.2	44.1	0.60	17.6	10.6	85.2
2018	14.3	0.7	19.5	1.2	1.9	20.2	0.65	17.6	10.4	90.6
2019	15.5	0.9	16.9	1.3	2.9	40.5	0.81	19.4	14.2	89.4
2020	15.5	1.0	16.3	1.3	2.9	42.7	0.82	20.9	14.8	92.2
2021	16.4	0.9	17.6	1.3	2.9	44.1	0.83	21.8	15.2	89.9

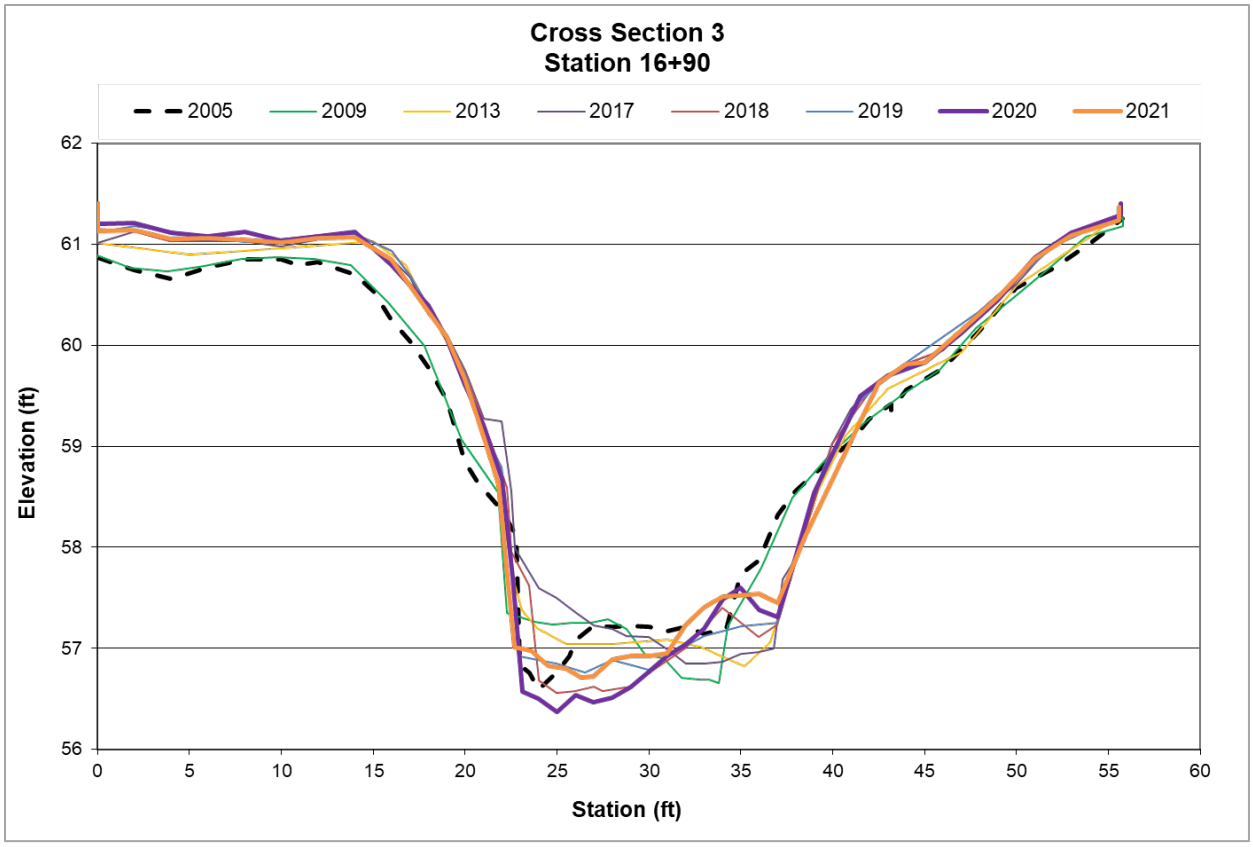


Figure 9 - Cross-section 3 Overlay 2005-2021

Figure 10 - Cross Section 3 facing downstream, 2017 (top), 2021 (bottom)

CROSS-SECTION 4: STATION 22+24

Cross-section 4 previously experienced the most change from 2005 to 2017; however it appears to have since stabilized through 2021 (Table 6, Figure 11). Similar to the other cross-sections, the greatest bed erosion took place between 2009 and 2013. Between the 2013 and 2021 surveys, there was 1.5 feet of left bank erosion and approximately 0.45 feet of bed aggradation. While the channel bed material contains more cobble material in the upstream portions of the channel, the bed material of Cross-section 4 consists of mostly depositional sand and gravel, which is easily transported during high flows. This cross section has remained mostly stable between the 2017 and 2021 surveys, with only minor bed and bank erosion.

Table 6 - Cross-section 4 Measurements

Year	Bankfull Width (ft)	Mean Depth (ft)	Width/ Depth Ratio	Entrench-ment ratio	Bankfull Velocity (ft/s)	Bankfull Discharge (cfs)	Shear Stress (lb/ ft^2)	Flood Prone Area (ft^2)	Bankfull Area (ft^2)	Top of Bank Area (ft^2)
2005	12.4	0.5	23.5	1.3	3.4	22.2	0.44	16.3	6.6	36.7
2009	13.8	0.4	31.6	1.1	3.0	18.2	0.37	14.5	6.0	41.1
2013	13.7	0.7	20.0	1.2	4.0	37.6	0.57	17.0	9.4	47.5
2017	15.0	0.9	16.5	1.3	4.9	67.0	0.77	20.2	13.7	50.6
2018	15.1	0.7	21.0	1.2	1.9	21.2	0.66	18.5	10.9	51.4
2019	15.9	0.8	18.8	1.3	3.0	40.6	0.76	19.9	13.5	50.6
2020	15.4	0.8	19.6	1.2	2.8	34.6	0.70	18.6	12.2	51.4
2021	15.2	0.7	20.3	1.3	2.8	31.3	0.67	19.1	11.3	50.0

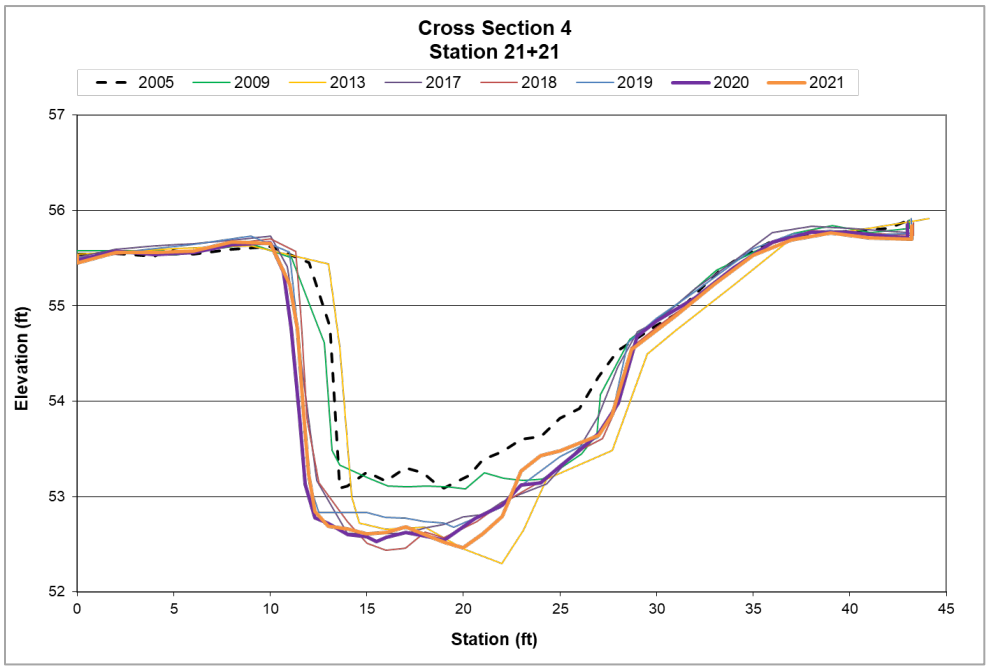


Figure 11 - Cross-section 4 Overlay 2005-2021

3.5 CONCLUSIONS

The seventeenth year of monitoring results indicate that the Wexford site continues to degrade over time. The upstream half of the reach, station 0+00 to 12+00, remains relatively stable with a moderate increase in bar formation and bed material comprised of larger cobble substrate. Cross-section 1, located at station 3+00, was previously the most stable, but between 2017 and 2018 large amounts of bed deposition and incision occurred while the banks have remained stable. No major changes occurred between 2020 and 2021 at Cross-section 1, only a slight deepening of the thalweg. As the survey continues downstream, a decrease in slope occurs with a transition to smaller gravel and sand substrate along with an increase in bar formation and transverse riffles. Pools in this part of the reach continue to both deepen and fill in, in addition to upstream and downstream shifting of riffle crests. Cross-section 3 had also actively changed between 2017 and 2018, with the thalweg migrating from the right side of the channel to the left. Between 2020 and 2021 approximately 4 inches of bed aggradation occurred along the thalweg, while the right-side bar feature continued to increase. Station 16+00 to 23+00 experienced the greatest fluctuation between 2020 and 2021 with changes occurring primarily within the pool features. Previously, cross-section 4 was the most unstable, with significant increases in cross-sectional area, but remained moderately stable this year in comparison to the 2017 survey. Cross-section pebble counts in future surveys could help identify bed material changes and if material composition has any effect on the stability at each cross-section. Continued monitoring will help identify areas of increased degradation and help further enhance the long-term data set allowing for more definitive conclusions and trend analysis.

It is important to note that the changes in channel cross-section dimension that occurred between the 2017 and 2018 surveys may be due to two factors. First, 2018 was a very wet year with rainfall amounts well above normal. Average annual rainfall in the Baltimore area is near 42 inches. Data through the end of September, just prior to the 2018 field survey at Wexford was 53.5 inches. A higher frequency of storm events and total discharge can have an impact on channel geometry. In addition to the total rainfall, a major flood event occurred on August 31, 2018 that likely resulted in much of the channel erosion and bed down-cutting and shifting observed in the cross-section results in October 2018. The USGS stream gage on James Run, located just to the southwest of the Wexford study area, recorded a gage height near 11 feet, compared to typical storms resulting in maximum stage between 4-5 feet. Likewise, the peak discharge recorded at the gage was near 9,000 cfs compared to typical storm peaks between 50-1,000 cfs. In 2019 and 2020, less extreme weather events occurred which resulted in less extreme changes in bed geomorphology between 2018 and 2019. No notable flooding events occurred in 2021, which resulted in moderate fluctuations from the previous year.

4 REFERENCES

Mecklenburg, D. 2006. The Reference Reach Spreadsheet- For Channel Survey Data Management. V 4.3L. Ohio Department of Natural Resources.

Rosgen, D.L. 2006. Watershed Assessment of River Stability & Sediment Supply (WARSSS).Wildland Hydrology. Pagosa Springs, CO.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, CO.

Appendix A

Photographic Log 2021 Longitudinal Profile

STA 0+00 - Upstream

STA 0+00 - Downstream

STA 0+50 - Upstream

STA 0+50 - Downstream

STA 1+00 - Upstream

STA 1+00 - Downstream

STA 1+50 - Upstream

STA 1+50 - Downstream

STA 2+00 - Upstream

STA 2+00 - Downstream

STA 2+50 - Upstream

STA 2+50 - Downstream

XS-1 STA 3+00

XS-1 Upstream

XS-1 Downstream

XS-1 Right Bank

XS-1 Left Bank

STA 3+00 - Upstream

STA 3+00 - Downstream

STA 3+50 - Upstream

STA 3+50 - Downstream

STA 4+00 - Upstream

STA 4+00 - Downstream

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XS-3 STA 17+15

XS-3 Upstream

XS-3 Downstream

XS-3 Right Bank

XS-3 Left Bank

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STA 18+00 - Downstream

STA 18+50 - Upstream

STA 18+50 - Downstream

STA 19+00 - Upstream

STA 19+00 - Downstream

STA 19+50 - Upstream

STA 19+50 - Downstream

STA 20+00 - Upstream

STA 20+00 - Downstream

STA 20+50 - Upstream

STA 20+50 - Downstream

STA 21+00 - Upstream

STA 21+00 - Downstream

STA 21+50 - Upstream

STA 21+50 - Downstream

XS-4 STA 22+24

XS-4 Upstream

XS-4 Downstream

XS-4 Right Bank

XS-4 Left Bank

STA 22+00 - Upstream

STA 22+00 - Downstream

STA 22+50 - Upstream

STA 22+50 - Downstream

STA 23+00 - Upstream

STA 23+00 - Downstream

STA 23+50 - Upstream

STA 23+50 - Downstream

STA 24+00 - Upstream

STA 24+00 - Downstream

Facing downstream above sewer encasement

Facing upstream below sewer encasement

Facing RB at sewer crossing

Facing LB at sewer crossing

Appendix B

Longitudinal Profile and Cross-section 2021 Data

Station	Bed Surface	Water Surface	Bankfull	Top of Bank	Description
0+00	85.77	85.83			CULVERT INVERT
0+3.4	85.71	85.73			CULVERT APRON
0+3.6	83.33	84.81			APRON FACE, IN POOL
0+7.0	82.99	84.80			MP
1+4.0	82.70	84.79			MP
2+7.0	83.44	84.79			MG
0+44.0	84.49	84.75	85.43	86.68	TOR
0+53.0	84.34	84.71			MR
0+54.0	83.75	84.05			MR
0+60.0	83.60	83.90			MR
0+61.0	83.17	83.46			MR
0+67.0	82.78	83.31			MN
0+79.0	82.14	83.02			MP
0+87.0	82.59	82.86			
0+90.0	82.27	82.47			MR
0+96.0	81.87	82.24			MR
0+97.0	81.62	81.92			MR
1+09.0	81.23	81.61	81.96	83.47	MN
1+10.0	80.83	81.10			MN
1+16.0	80.23	81.10			MP
1+31.0	80.20	81.10			MP
1+42.0	80.07	81.08			MP
1+56.0	80.78	81.10			MG
1+65.0	80.35	80.78			TOR
1+69.0	79.91	80.10			MR
1+72.0	79.13	79.45			BOR
1+74.0	78.61	79.17			MN
1+86.0	78.09	79.19			MP
1+97.0	78.39	79.16	80.25	84.39	MG
2+13.0	78.76	79.15			TOR
2+20.0	78.37	78.89			
2+41.0	78.19	78.45			MR
2+56.0	77.95	78.30			MR
2+74.0	77.82	77.97			MR
2+81.0	76.97	77.17			MR
2+95.0	76.03	76.31			BOR
3+02.0	75.05	76.28	76.72	80.66	XS1
3+14.0	74.38	76.30			MP
3+26.0	75.09	76.30			
3+36.0	76.00	76.30			
3+45	76.07	76.27			TOR
3+61	75.38	75.82			MN
3+69	75.50	75.71			MP
3+80	74.40	75.70			
3+87	74.26	75.71			MP
4+02	74.06	75.71			MP
4+16	74.52	75.72	76.14	76.14	MG
4+30	75.23	75.70			TOR
4+48	74.02	74.19			MR
4+61	73.55	73.68			
4+63	72.94	73.44			US OF FALLEN TREE
4+70	73.24	73.42			MR
4+73	73.03	73.34			MN
4+74	72.38	73.37			MP @ FALLEN TREE
4+76	71.87	73.37			MP @ FALLEN TREE
4+83	73.05	73.36			TOR
4+98	72.65	72.85			TOP OF HEADCUT (CLAY)
5+01	72.44	72.74			
5+02	71.18	72.74			CLAY HEADCUT
5+05	70.72	72.75			MP
5+10	71.72	72.75			MG
5+15	72.24	72.76			MG
5+31	71.99	72.20			MR
5+48	71.41	71.73			
5+61	71.42	71.72			
5+79	70.67	71.04			
5+82	70.08	71.05			MP
5+92	69.96	71.06			MP
6+03	70.58	71.05			MG
6+73	69.98	71.08			MP
6+84	70.22	71.04			MP
6+96	70.69	71.01			
7+10	69.72	70.36			MP
7+21	69.19	69.41			BOR
7+36	68.68	69.38			MP
7+44	69.18	69.27			MR
7+52	68.89	69.14			
7+60	68.04	69.14			MP
7+70	68.69	69.19	69.36	72.98	
7+84	68.81	69.09			MR
7+98	68.42	68.65			BOR

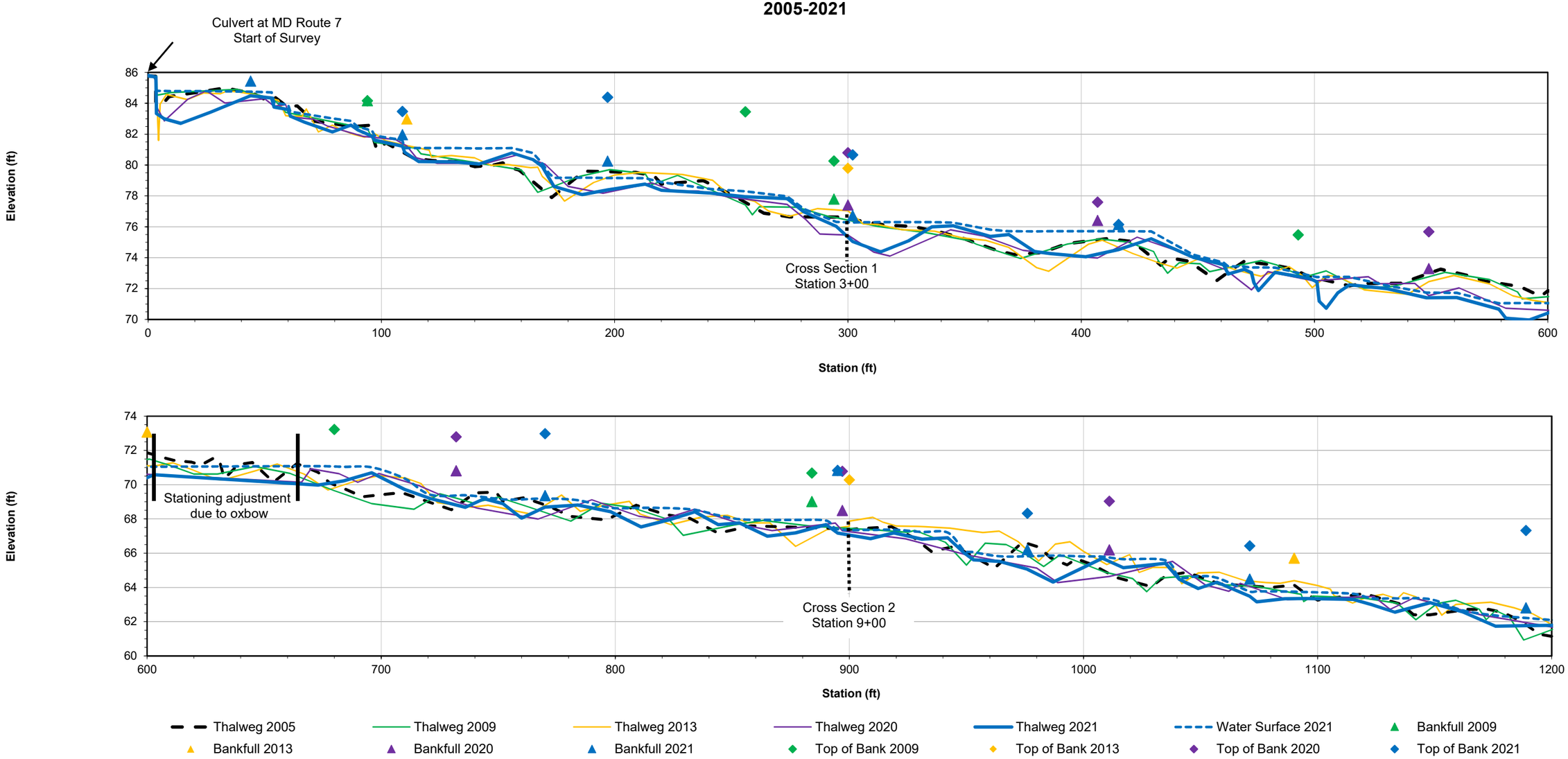
Station	Bed Surface	Water Surface	Bankfull	Top of Bank	Description
8+11	67.53	68.65			MP
8+23	67.95	68.63			TOR
8+34	68.41	68.53			MR
8+44	67.67	68.21			MP
8+53	67.77	67.98			
8+65	66.99	67.94			MP
08+77	67.19	67.94			
08+90	67.67	67.90			
08+95	67.18	67.40	70.83	70.83	XS2
09+09	66.85	67.36			
09+19	67.19	67.37			
09+31	66.82	67.24			
09+42	66.90	67.20			
09+49	66.01	66.16			
09+53	65.61	66.06			
09+64	65.52	65.82			MR
09+76	65.06	65.82	66.21	68.33	MN
09+87	64.31	65.86			MP
10+00	65.17	65.81			MG
10+08	65.70	65.80			TOR
10+17	65.15	65.65			
10+35	65.41	65.58			
10+41	64.47	64.60			BOR
10+49	63.94	64.65			MP
10+57	64.30	64.56			TOR
10+71	63.49	63.76	64.49	66.43	BOR
10+74	63.16	63.77			MP
10+86	63.34	63.76			
10+95	63.35	63.73			
11+15	63.30	63.63			
11+23	62.99	63.36			
11+33	62.56	63.36			
11+48	63.11	63.31			
11+62	62.57	62.66			
11+76	61.74	62.36			
11+89	61.77	62.22	62.81	67.33	
12+01	61.79	62.10			
12+24	61.88	62.06			
12+31	61.55	61.70			BOR
12+32	60.69	61.69			MP
12+48	61.15	61.67			
12+58	60.57	61.69			MP
12+72	60.83	61.69			
12+82	61.48	61.67	62.01	63.90	TOR
12+92	60.68	61.44			
13+01	61.08	61.32			
13+06	60.10	61.28			
13+14	59.86	61.30			MP
13+26	59.71	61.31			
13+36	60.35	61.28			MG
13+55	61.13	61.26			TOR
13+69	60.55	60.70			MR
13+78	60.11	60.40			MN
13+90	59.35	60.40			
13+99	59.99	60.38	60.98	62.83	
14+17	59.83	60.38			
14+26	59.54	60.38			
14+39	59.20	60.37			
14+56	60.33	60.34			ON EMB LOG
14+56	59.20	60.00			DS OF LOG
14+61	59.47	60.02			
14+66	58.81	60.00			
14+72	59.45	60.00			
14+77	59.25	59.97			MR
14+79	59.70	59.98			MR
14+87	58.99	59.53			
14+92	59.16	59.35			
15+02	58.48	58.57	59.53	61.75	
15+05	57.85	58.54			
15+15	57.56	58.46			
15+22	58.30	58.46			
15+23	57.80	58.29			
15+37	57.67	58.31			
15+49	58.03	58.23			
15+59	57.06	57.94			MP
15+63	56.56	57.95			MP
15+69	56.25	57.95			
15+79	56.15	57.95			
15+86	56.91	57.93			
15+91	57.72	57.88			TOR
16+04	57.30	57.63			BOR

Station	Bed Surface	Water Surface	Bankfull	Top of Bank	Description
16+13	56.47	57.62			MP
16+15	55.26	57.66			MP
16+34	54.28	57.64			MP
16+42	55.75	57.65			MG
16+50	56.92	57.65			
16+60	57.37	57.62			
16+73	57.39	57.49			
16+78	56.74	57.00			
16+83	56.13	57.00			
16+92	56.43	57.01			
17+00	56.68	56.99			
17+05	56.61	56.91	57.44		XS3
17+28	56.07	56.20			BOR
17+31	55.67	56.12			
17+36	55.97	56.04			
17+38	55.58	55.98			US WOODY DEBRIS
17+45	55.02	55.97			MP, DS WOODY DEBRIS
17+48	54.61	55.96			MP
17+56	54.72	55.95			MP
17+61	54.02	55.94			
17+69	54.39	55.94			
17+79	55.16	55.95			
17+88	55.51	55.96			
17+97	55.74	55.90			
18+01	55.27	55.33			BOR
18+06	54.40	55.86	56.44	59.79	MP
18+16	54.19	55.87			MP
18+26	54.90	55.87			MG
18+35	55.61	55.81			TOR
18+45	55.05	55.48			MN
18+55	54.52	55.47			MP
18+64	54.98	55.44			MG
18+74	54.82	55.05			TOR
18+86	54.59	54.97			
18+96	53.90	54.98			MP
19+00	53.38	54.95			MP
19+06	53.40	54.96	55.67	57.96	MP
19+24	54.49	54.99			
19+31	54.69	54.93			TOR
19+41	53.72	54.33			
19+42	52.98	54.29			MP
19+44	52.69	54.29			
19+52	53.13	54.29			
19+60	52.15	54.30			MP
19+71	52.18	54.28			
19+78	53.67	54.26			MG
19+83	53.97	54.27			TOR
19+98	53.43	53.87			BOR
20+06	51.38	53.87			MP @ TREE
20+18	52.92	53.88			MG
20+29	53.66	53.83	54.46	57.63	TOR
20+53	53.06	53.38			BOR
20+60	52.37	53.37			
20+73	52.72	53.38			
20+85	53.22	53.30			
21+06	52.75	53.04			
21+12	52.32	53.02			
21+24	52.11	53.04			MP
21+40	51.98	53.03			MP
21+50	51.42	53.06			MP
21+67	51.87	53.03			
21+77	52.79	53.01			TPR
21+94	52.49	52.75			BOR
22+00	51.27	52.76			MP
22+10	52.03	52.74			MG
22+24	52.32	52.76	53.13	55.51	XS4
22+33	52.25	52.38			BOR
22+50	51.77	51.98			MN
22+63	51.44	51.96			
22+80	51.73	51.94			MR
22+95	51.10	51.36	51.75	55.01	BOR
23+00	50.52	51.35			MP
23+08	50.23	51.34			MP
23+14	50.54	51.32			
23+22	51.22	51.32			
23+30	50.85	51.06			
23+34	50.54	51.06			
23+37	50.86	51.06			
23+39	50.57	50.98			
23+42	49.72	50.98			
23+66	49.61	51.00			US OF SEWER

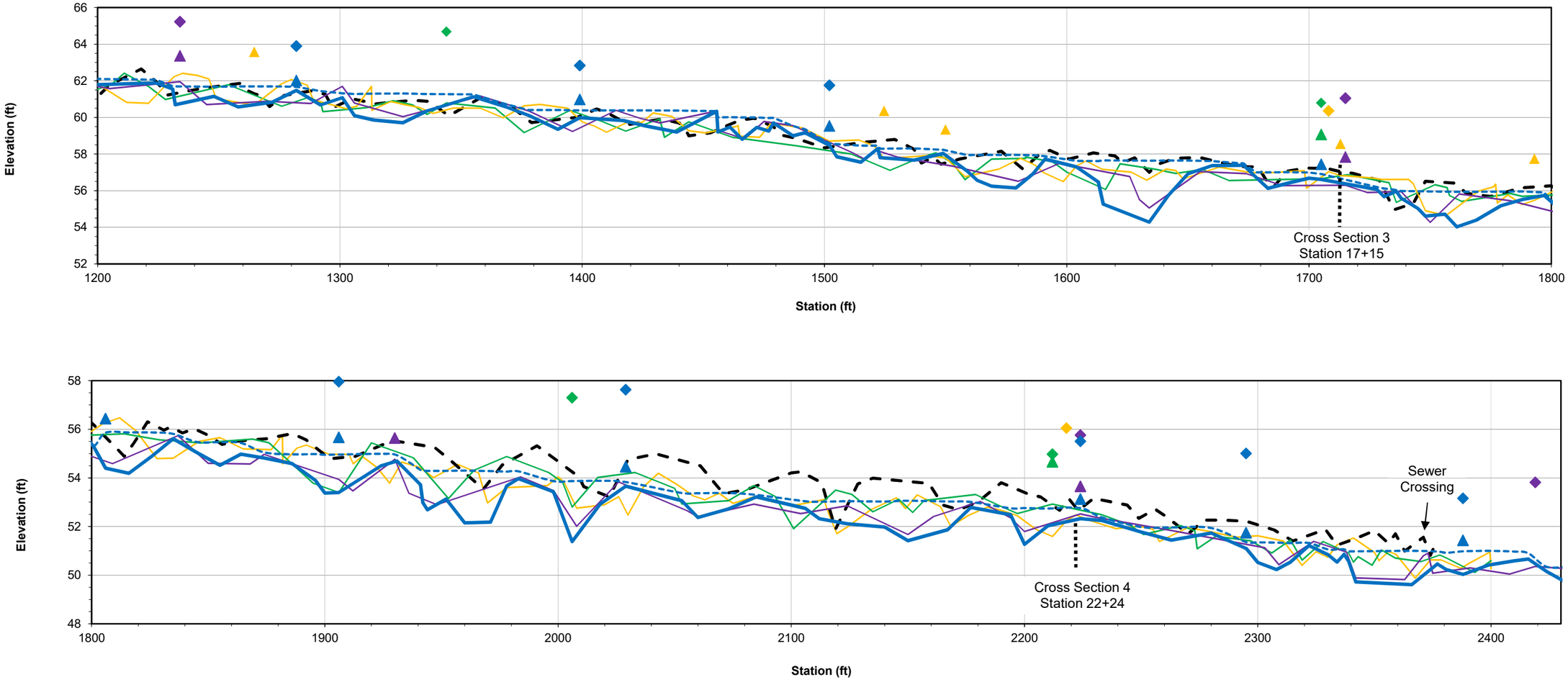
Station	Bed Surface	Water Surface	Bankfull	Top of Bank	Description
23+77	50.46	50.97			US SIDE OF ENCASEMENT
23+81	50.22	50.92			DS SIDE OF ENCASEMENT
23+88	50.03	50.98	51.43	53.16	
23+99	50.42	51.00			
24+10	50.59	50.97			TOR
24+16	50.66	50.90			MR
24+24	50.14	50.34			BOR
24+34	49.61	50.36			MN
24+39	48.43	50.38			MP
24+44	49.28	50.38			MG
24+50	49.08	50.37			MP
24+59	48.51	50.33			AT FLAG
24+67	48.88	50.39			
24+78	50.04	50.34			TOR-END

WEXFORD
Annual Physical Assessment

Longitudinal Profile Station 0+00 to 12+00
2005-2021



Longitudinal Profile Station 12+00 to 24+30
2005-2021



WEXFORD
Annual Physical Assessment
Cross section data

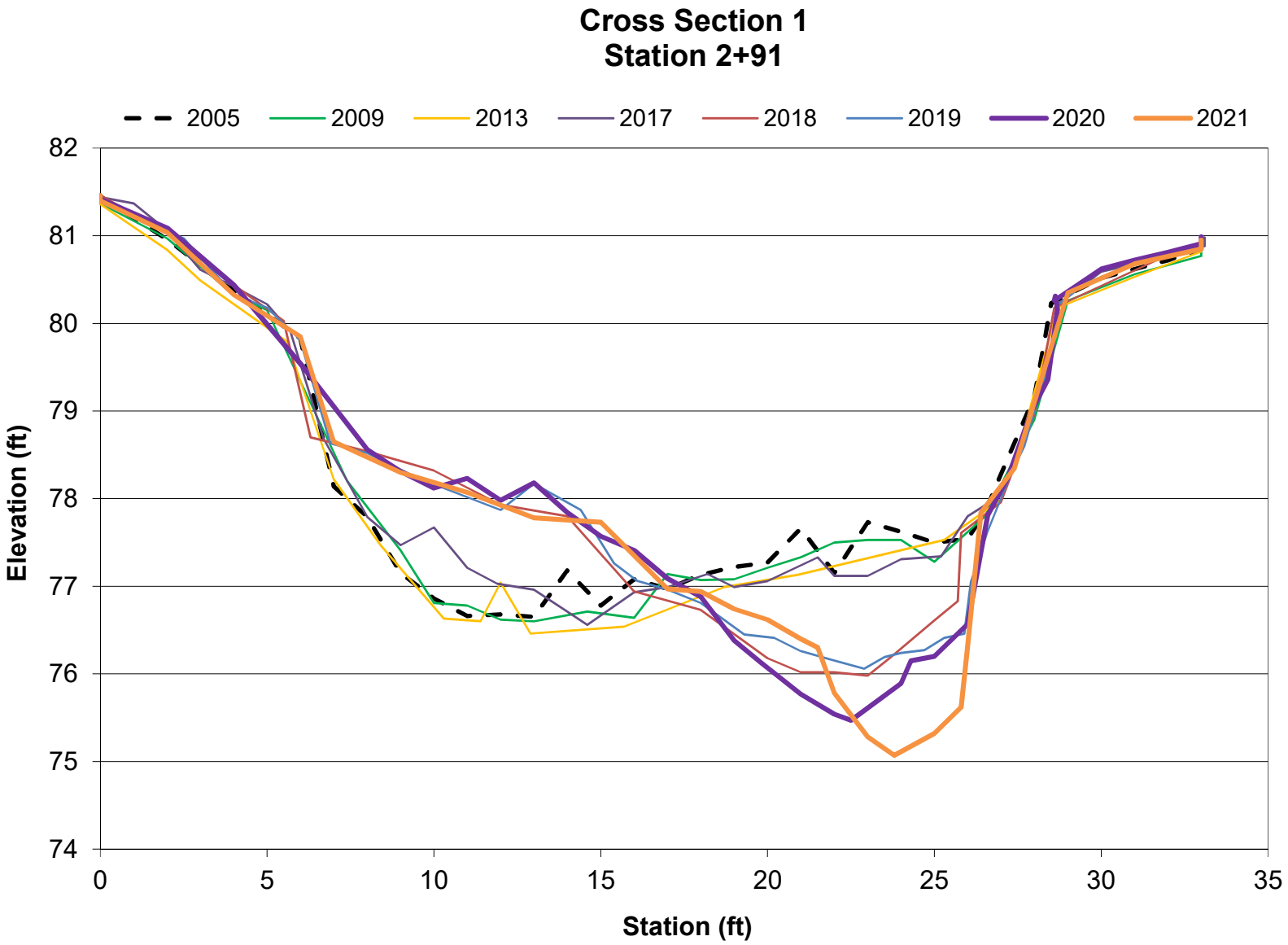
Cross Section 1 at Profile Station 2+91

Surveyed on December 14, 2021

HI
85.75

Station	Rod	Bed Surface	Description
0.0	4.31	81.44	L PIN
0.0	4.37	81.38	GROUND AT PIN
2.0	4.73	81.02	
4.0	5.44	80.31	
6.0	5.92	79.83	
7.0	7.12	78.63	BOTTOM OF BENCH
9.0	7.47	78.28	
11.0	7.70	78.05	
13.0	7.99	77.76	
15.0	8.04	77.71	
17.0	8.80	76.95	
18.0	8.83	76.92	
19.0	9.03	76.72	BKFL
20.0	9.15	76.60	
21.0	9.37	76.38	
21.5	9.47	76.28	LEOW
22.0	9.99	75.76	
23.0	10.49	75.26	
23.8	10.70	75.05	WD=1.23
25.0	10.45	75.30	
25.8	10.15	75.60	
26.0	9.45	76.30	REOW
26.4	7.93	77.82	
27.4	7.42	78.33	
28.2	6.42	79.33	
29.0	5.42	80.33	
31.0	5.09	80.66	RTOB
33.0	4.92	80.83	GROUND AT PIN
33.0	4.82	80.93	R PIN

Description key: L=left, R=right, B=bank, BKF=bankful,
HI = height of instrument, EW=edge of water, TO=top


Cross Section 1
Station 2+91
2005
2009
2013
2017
2018
2019
2020
2021
82
81
80
79
78
77
76
75
74
Elevation (ft)
0
5
10
15
20
25
30
35
Station (ft)

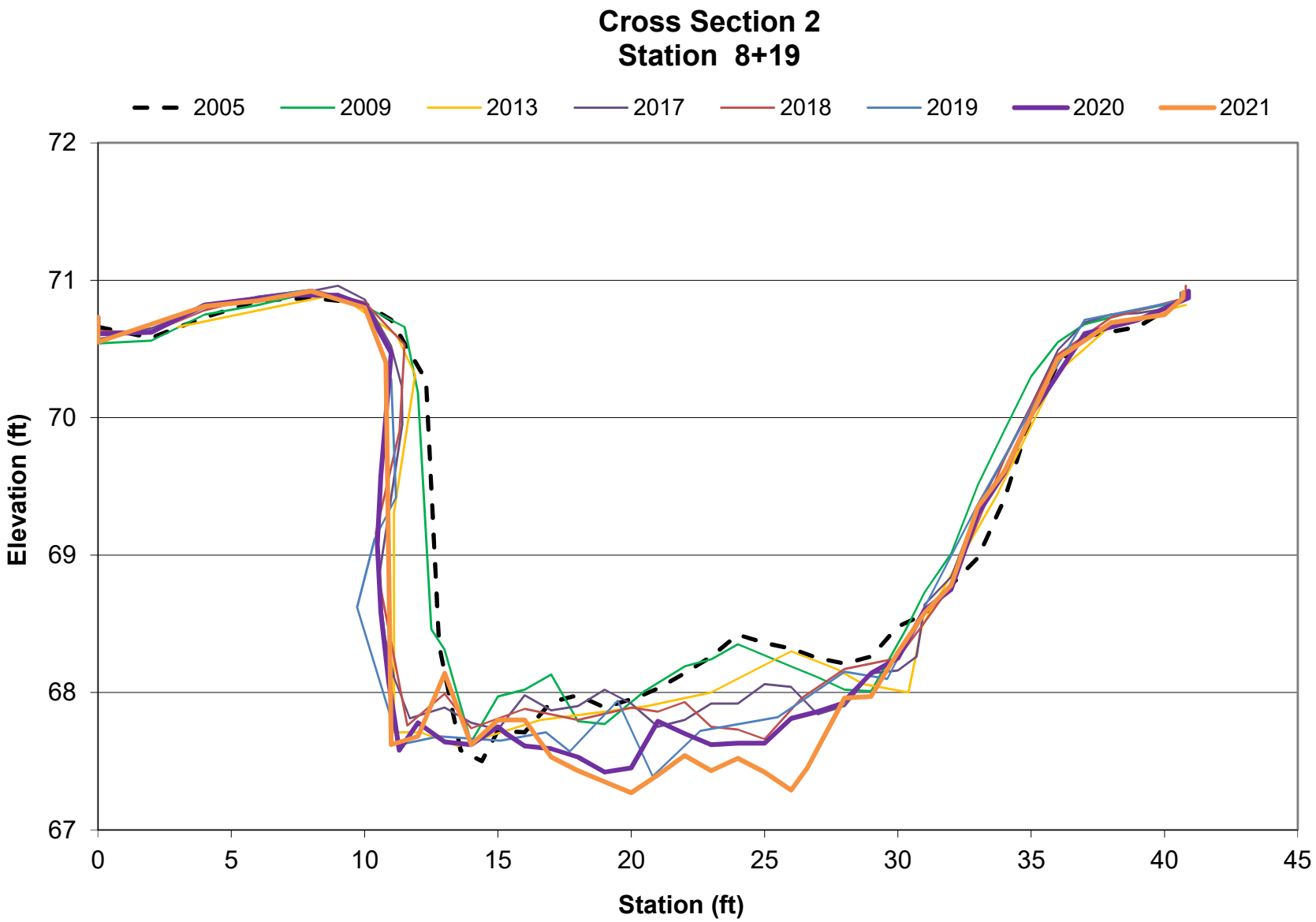
WEXFORD
Annual Physical Assessment
Cross section data

Cross Section 2 at Profile Station 8+19
Surveyed on December 14, 2021

HI
76.01

Station	Rod	Bed Surface	Description
0.0	5.37	70.64	L PIN
0.0	5.55	70.46	GROUND @ PIN
2.0	5.42	70.59	
4.0	5.29	70.72	
6.0	5.25	70.76	
8.0	5.18	70.83	LTOB
10.0	5.30	70.71	
10.8	5.70	70.31	EDGE OF BANK
11.0	8.48	67.53	TOE OF BANK
12.0	8.42	67.59	
13.0	7.96	68.05	ON ROCK
14.0	8.48	67.53	
15.0	8.30	67.71	
16.0	8.30	67.71	
17.0	8.57	67.44	
18.0	8.67	67.34	LEOW
19.0	8.75	67.26	
20.0	8.83	67.18	WD=0.22
21.0	8.70	67.31	
22.0	8.56	67.45	
23.0	8.67	67.34	
24.0	8.58	67.43	
25.0	8.68	67.33	
26.0	8.81	67.20	
26.6	8.65	67.36	REOW
28.0	8.14	67.87	
29.0	8.13	67.88	
30.0	7.81	68.20	
31.0	7.52	68.49	
32.0	7.32	68.69	
33.0	6.75	69.26	
34.0	6.49	69.52	
35.0	6.09	69.92	
36.0	5.67	70.34	RTOB
38.0	5.41	70.6	
40.0	5.35	70.66	
40.7	5.23	70.78	GROUND @ PIN
40.7	5.19	70.82	R PIN

Description key: L=left, R=right, B=bank, BKF=bankful,
HI = height of instrument, EOW=edge of water, TO=top


Cross Section 2
Station 8+19
2005
2009
2013
2017
2018
2019
2020
2021
72
71
70
69
68
67
Elevation (ft)
0
5
10
15
20
25
30
35
40
45
Station (ft)

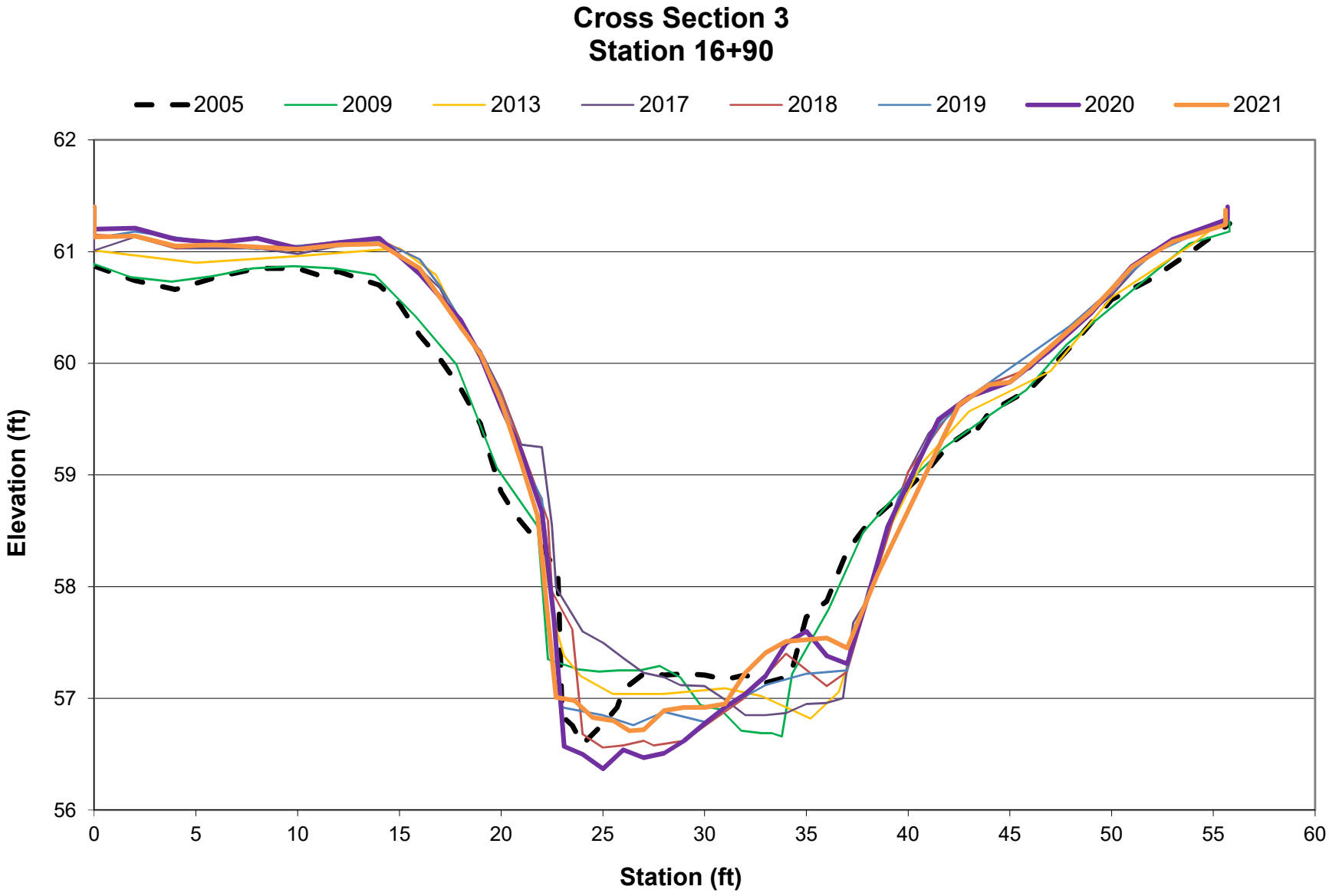
WEXFORD
Annual Physical Assessment
Cross section data

Cross Section 3 at Profile Station 15+99
Surveyed on December 14, 2021

HI
66.63

Station	Rod	Bed Surface	Description
0.0	5.33	61.30	L PIN
0.0	5.60	61.03	GROUND @ PIN
2.0	5.59	61.04	
4.0	5.68	60.95	
6.0	5.67	60.96	
8.0	5.69	60.94	
10.0	5.71	60.92	
12.0	5.67	60.96	
14.0	5.66	60.97	LTOB
16.0	5.88	60.75	
18.0	6.40	60.23	SLOPE
19.0	6.65	59.98	
20.0	7.07	59.56	
21.0	7.63	59.00	
21.8	8.10	58.53	
22.2	8.84	57.79	
22.7	9.72	56.91	
23.6	9.75	56.88	EOW
24.5	9.90	56.73	
25.5	9.93	56.70	
26.3	10.02	56.61	WD=0.3
27.0	10.01	56.62	
28.0	9.84	56.79	
29.0	9.81	56.82	
30.0	9.81	56.82	EOW
31.0	9.78	56.85	
32.0	9.50	57.13	
33.0	9.32	57.31	
34.0	9.22	57.41	
36.0	9.19	57.44	RBNKFL
37.0	9.28	57.35	
38.5	8.62	58.01	
42.5	7.10	59.53	
44.0	6.92	59.71	
45.0	6.90	59.73	
47.0	6.58	60.05	
49.0	6.26	60.37	
51.0	5.87	60.76	
53.0	5.64	60.99	
55.6	5.49	61.14	GROUND @ PIN
55.6	5.36	61.27	R PIN

Description key: L=left, R=right, B=bank, BKF=bankful,
HI = height of instrument, EOW=edge of water, TO=top


Cross Section 3
Station 16+90
2005
2009
2013
2017
2018
2019
2020
2021
Elevation (ft)
62
61
60
59
58
57
56
0
5
10
15
20
25
30
35
40
45
50
55
60
Station (ft)

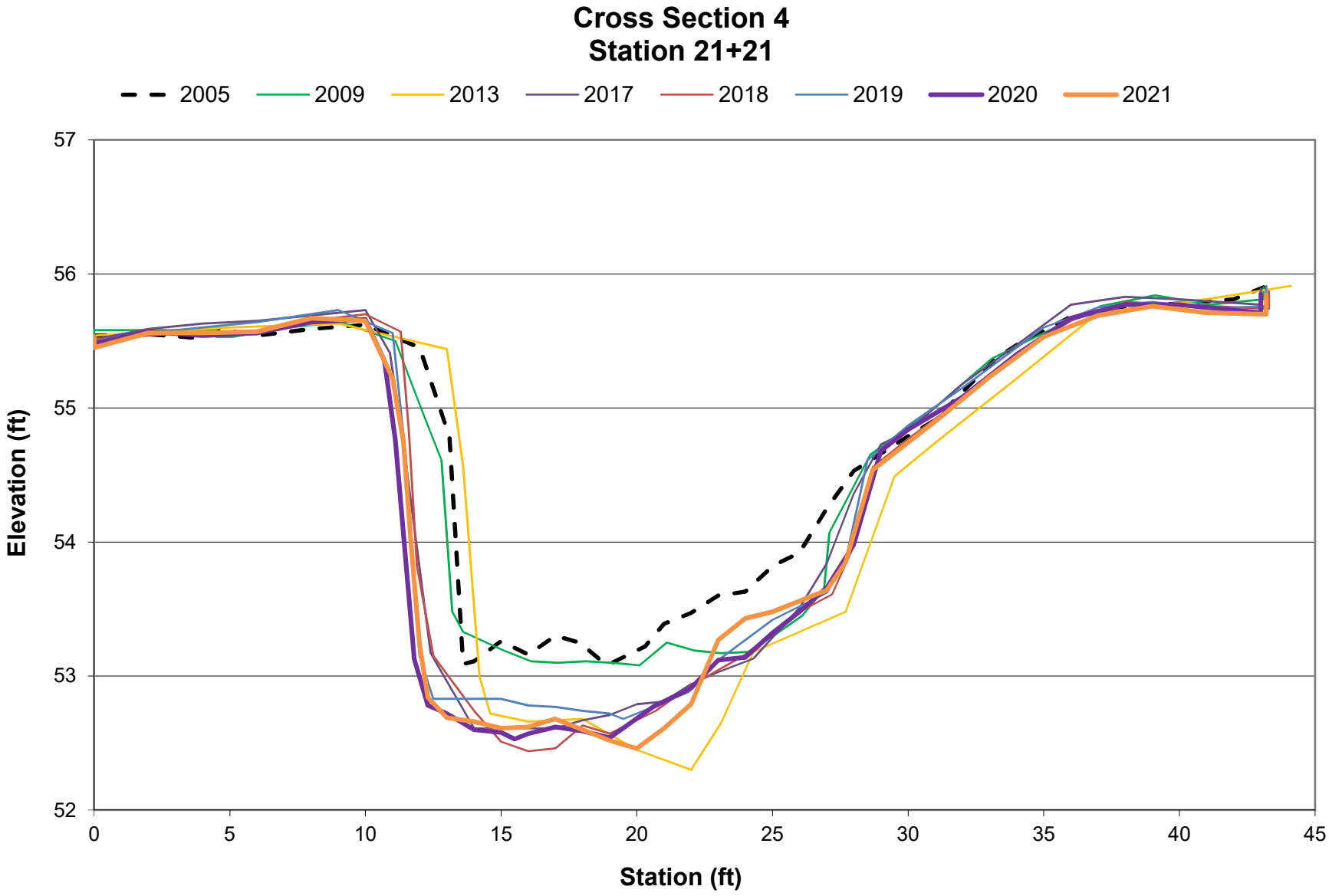
WEXFORD
Annual Physical Assessment
Cross section data

Cross Section 4 at Profile Station 21+21
Surveyed on December 16, 2021

HI
57.37

Station	Rod	Bed Surface	Description
0.0	1.98	55.39	L PIN
0.0	2.06	55.31	GROUND @ PIN
2.0	1.95	55.42	
4.0	1.95	55.42	
6.0	1.94	55.43	
8.0	1.84	55.53	
10.0	1.86	55.51	LTOB
11.0	2.29	55.08	
11.4	2.76	54.61	
11.7	3.57	53.80	
12.0	4.28	53.09	
12.3	4.67	52.70	LEOW
13.0	4.82	52.55	
14.0	4.85	52.52	
15.0	4.90	52.47	
16.0	4.89	52.48	
17.0	4.83	52.54	
18.0	4.91	52.46	
19.0	4.99	52.38	
20.0	5.05	52.32	WD=0.44
21	4.9	52.47	
22.0	4.72	52.65	REOW
23.0	4.24	53.13	RBNKFL
24.0	4.08	53.29	
25.0	4.03	53.34	DEP
27.0	3.87	53.50	DEP
27.7	3.66	53.71	DEP
28.7	2.97	54.40	
31.0	2.61	54.76	
33.0	2.28	55.09	
35.0	1.98	55.39	
37.0	1.82	55.55	
39.0	1.75	55.62	
41.0	1.8	55.57	
43.2	1.81	55.56	GROUND @ PIN
43.2	1.67	55.70	R PIN

Description key: L=left, R=right, B=bank, BKF=bankful,
HI = height of instrument, EOW=edge of water, TO=top


Cross Section 4
Station 21+21
2005
2009
2013
2017
2018
2019
2020
2021
Elevation (ft)
57
56
55
54
53
52
0
5
10
15
20
25
30
35
40
45
Station (ft)