ANALYSIS OF POSTDREDGING BED-LEVEL CHANGES IN SELECTED REACHES OF WHEELING CREEK, EASTERN OHIO, 1985-87

By G. F. Koltun

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CONVERSION FACTORS

For the convenience of readers who prefer to use metric (International System) units, rather than the inch-pound terms used in this report, the following conversion factors may be used:

Multiply inch-pound unit	By	To obtain metric unit
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A Geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Sea Level Datum of 1929."

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ABSTRACT

From July through September 1985, selected stream reaches in the Wheeling Creek basin were dredged and levees were constructed to reduce the frequency of out-of-bank flooding. The Wheeling Creek basin, which is located predominantly in Belmont County, Ohio, has been extensively mined for the extraction of bituminous coal. Much of the coal has been removed by means of surface mining—a process known to be associated with large increases in sediment yields. Because of the presence of unreclaimed and actively operating surface mines, State and County officials were concerned that the dredged reaches may rapidly fill with sediments, thus reducing or eliminating the benefits gained by dredging. The U.S. Geological Survey, in cooperation with the Ohio Department of Natural Resources, undertook a study to collect and document evidence of gross streambed fill or scour in and around four dredged reaches.

Changes in thalweg and width-averaged bed elevations were monitored for approximately 1 1/2 years following dredging by periodically surveying cross-section profiles at a total of 21 sites—4 in the community of Lafferty, 5 in Crabapple, 7 in Maynard, and 5 in Crescent.

A bed-stabilization period of less than 6 months was observed following dredging in each of the four reaches. During that period, the bed materials changed from poorly consolidated to firm. Changes in width-averaged bed elevations that occurred after this bed-stabilization period ranged from -0.1 to 0.4 foot. Of the 21 cross sections monitored, 19 exhibited changes of -0.1 to 0.1 foot during that same period. Thalweg elevations similarly exhibited little change after the bed-stabilization period. The maximum change in thalweg elevation observed after the bed-stabilization period was 0.3 foot; however, net changes at 17 of the 21 cross sections were 0.1 foot or less during that same period.

INTRODUCTION

Background

The Ohio Department of Natural Resources, Division of Reclamation, is currently reclaiming some areas in the Wheeling Creek basin. There is a concern that the creek is rapidly filling with sediments originating from surface-mined areas and coal refuse piles and that the deposition of sediments has resulted in a loss of channel conveyance, causing increased frequency of out-of-bank flooding in the basin. The Division of Reclamation provided funds to dredge selected reaches of Wheeling Creek to increase the stream's flood-carrying capacity. Levees were constructed from dredged materials to help retain flood waters in the main channel. Dredging and levee construction began in the Wheeling Creek basin in July 1985 and ended in September of the same year.

Dredging before completing planned reclamation is generally not done because unreclaimed areas have the potential to yield large quantities of sediment, which may quickly fill the dredged reach. The advisability of dredging as a means to mitigate out-of-bank flooding before completion of reclamation efforts has not been studied in the Wheeling Creek basin. Even without the additional complexity introduced by the presence of unreclaimed areas, channel modifications, as a means to mitigate out-of-bank flooding, can have unexpected results. For example, 17 feet of scour occurred over a 10-year period at one site on Cane Creek in western Tennessee following channelization aimed at reducing the frequency of out-of-bank flooding (Simon and Hupp, 1986). The U.S. Geological Survey, in cooperation with the Ohio Department of Natural Resources, Division of Reclamation, began a study to monitor postdredging changes in streambed elevations. Specific emphasis was placed on documenting trends in the occurrence of gross streambed fill or scour, if they should occur.

Purpose and Scope

The purpose of this report is to document evidence of gross streambed fill or scour in and around four dredged segments of Wheeling Creek. The four stream reaches addressed in this study are located in the communities of Lafferty, Crabapple, Maynard, and Crescent, all of which are within Belmont County, Ohio (fig. 1).

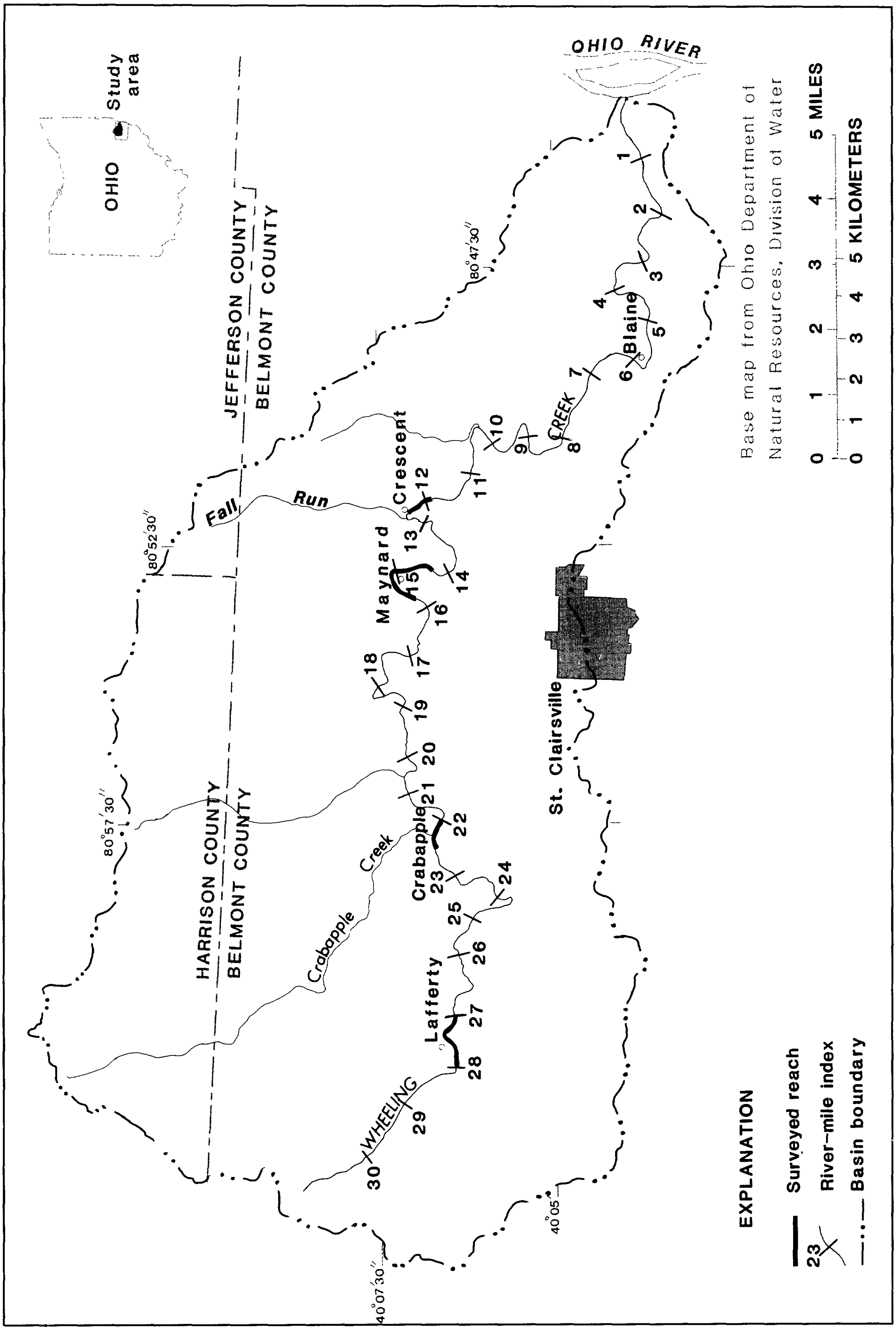


Figure 1.--Location of study basin and dredged stream reaches.

Because of the short period over which this study was conducted, no conclusive information can be provided about long-term or subtle short-term trends in streambed fill or scour.

Selected Basin and Stream Characteristics

The topography of the Wheeling Creek basin is hilly and characterized by V-shaped valleys and broad, rounded hills. The basin is unglaciated. Relief on Wheeling Creek is approximately 560 feet from source to mouth, a distance of approximately 30 miles.

The geology of the basin is characterized by horizontally layered sedimentary rock. Exposed strata include shale, sandstone, siltstone, limestone, and coal. These strata are part of the Conemaugh and Monongahela Formations of Pennsylvanian age and the Dunkard Group of Pennsylvanian and Permian age. The soils of the upper and middle parts of the basin generally are part of the Lowell-Westmoreland association and its related soils. The lower reach, essentially below the Village of Blaine, contains soils of the Elkinsville-Nolin Variant-Brookside association. All of these soils are moderately erodible and well drained to moderately well drained (U.S. Department of Agriculture, 1981).

Suspended-sediment and bed-load data were collected by the U.S. Geological Survey at four locations on Wheeling Creek during four storm events in 1983. Data for those four storm events showed that bed load (sediment transported on or near the streambed) was only a small part (less than 1 percent) of the total load (Kolva and Koltun, 1987) even though one of the four storm events produced the peak discharge for the year. Particle-size analyses of suspended-sediment samples collected during those same four storm events indicated that silt-and-clay-sized particles generally composed about 90 percent of the samples by weight.

METHODS OF STUDY

Cross-section profiles were measured at one location upstream and downstream, and at two to five locations within each of four dredged reaches located in the communities of Lafferty, Crabapple, Maynard, and Crescent. Stream cross-section profiles were surveyed six times during the study period to provide documentary evidence of stream-channel fill or scour. A cross-section profile consists of a set of ground-point elevations and their associated horizontal distances from some fixed reference point.

Elevation reference marks (ERM) were established at each site for which cross-section profiles were to be determined. ERMs were established using third-order differential-leveling methods and referenced to sea level.

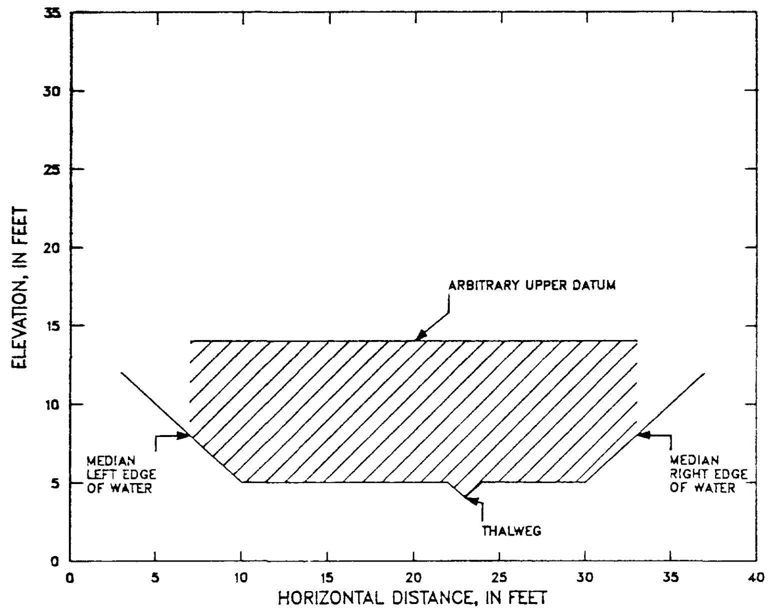
Elevations of ground points within a cross section were determined to the nearest 0.1 foot by differential-leveling methods. Horizontal distances (stationing) were determined using a tag line placed normal to the direction of flow and consistently referenced to one of the established ERMs. By convention, horizontal stationing was assumed to increase from left to right when looking in the downstream direction. At a minimum, ground-point elevations and their corresponding horizontal stations were determined at those points that marked significant changes in transverse streambank and bed slope.

Cross-section profiles were surveyed just before dredging, soon after dredging, and approximately semi-annually after that. One set of cross-section profiles was surveyed within 60 days after the occurrence of the peak discharge for the 1986 water year. Because of the relatively short period over which data were collected, the scope of this study was limited to assessment of gross trends in stream-channel scour and fill. Graphic and quantitative methods were used in this assessment.

The graphic assessment was made by (1) overlaying plots of cross-section profiles measured over the duration of the study, and (2) overlaying plots of thalweg (minimum cross-section) elevations determined at each site against downstream distance in the reach as measured over the duration of the study. Both graphical techniques provide a qualitative assessment of trends—one within a given cross-section and the other within a given stream reach.

Gross trends in stream-channel scour and fill were assessed by computing changes in cross-sectional area over time. Cross-sectional area was computed at each site by use of median observed left and right edges of water as horizontal boundaries and a constant arbitrary datum positioned at some point well above the bed as the upper vertical boundary. The above-mentioned boundaries were chosen to disregard changes in cross-sectional area attributable to scour or settling or other changes in the shape of levees. The lower vertical boundary consisted of the measured bed profile. Areas within the aforementioned boundaries were computed with the trapezoidal rule—a numerical method for approximating the area under a curve. Because the upper vertical boundaries were arbitrary, the areas computed have little meaning by themselves; however, the change in area over time is meaningful. In order to facilitate comparisons between cross-section sites, the change in area at each site was divided by the channel width used in its area calculation (the distance between the median right and left edges of water). (See figure 2 for a schematic diagram of the procedure outlined above.) The resulting value represents the width-averaged change in bed elevation in the channel and consequently is independent of channel size. The width-averaged change in bed elevation, if negative, indicates scour and, if positive, indicates fill.

A. Shaded region represents area between boundaries on first measurement.



B. Shaded region represents area between boundaries on second measurement.

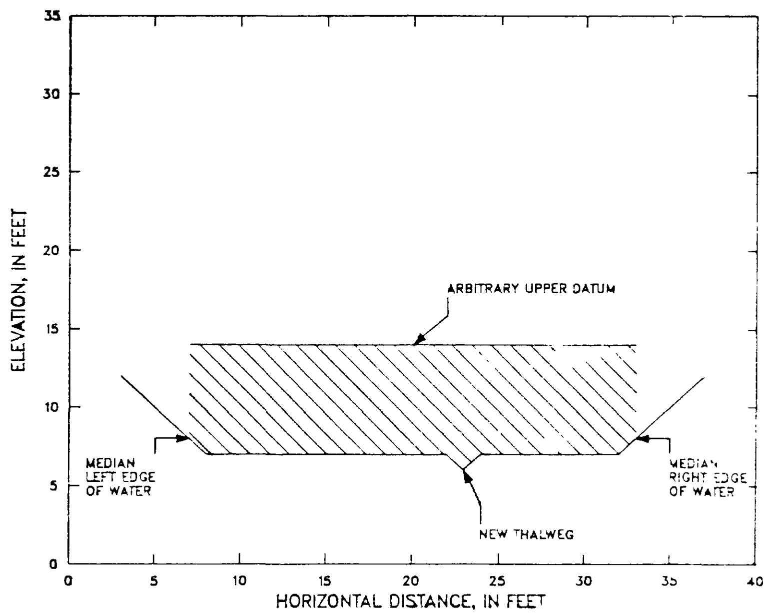
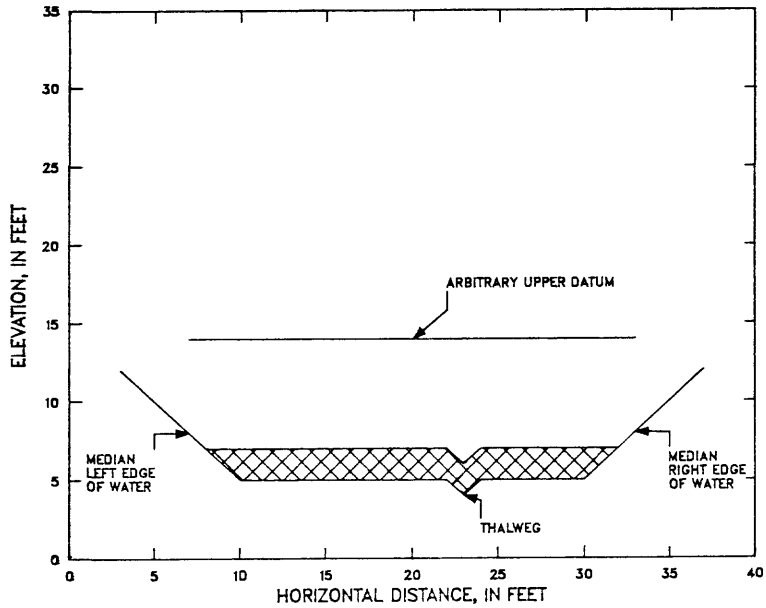


Figure 2.—Schematic of method used to compute width-averaged changes in bed elevation.

C. Shaded region represents difference in area between first and second measurements caused by changes in streambed elevations.



D. Area of shaded region in diagram C is distributed over distance between median observed left and right edges of water: height of shaded region equals width-averaged change in bed elevation.

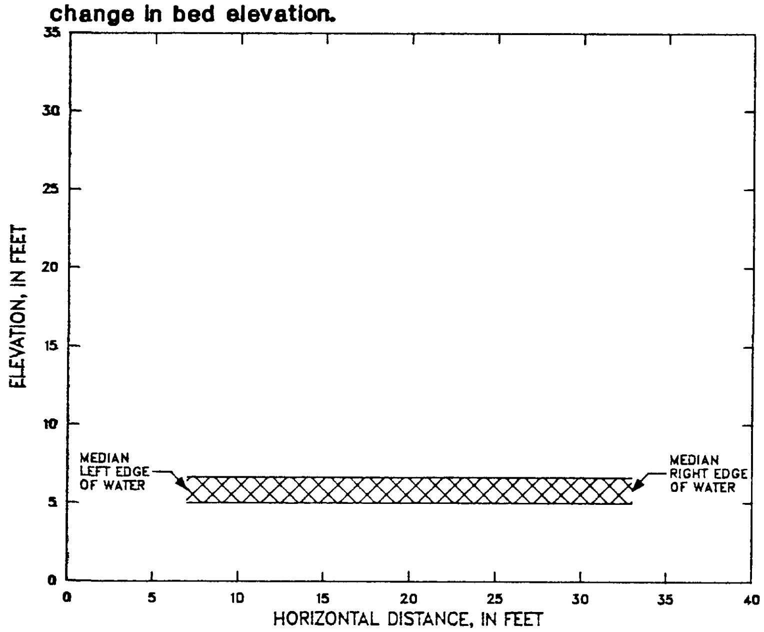


Figure 2.--Schematic of method used to compute width-averaged changes in bed elevation--Continued.

ANALYSIS OF POSTDREDGING BED-LEVEL CHANGES

Trends in Channel Fill or Scour

Changes in width-averaged bed elevation that occurred over time between cross-section profile measurements are summarized in table 1. The largest observed postdredging changes in width-averaged bed elevation generally occurred between the measurements in August through October 1985 (the first postdredging profile measurements) and those in January 1986. These changes reflect a period of bed stabilization, which could be expected following dredging due to consolidation of loose materials. The changes also are consistent with observations recorded by survey crews, indicating that the streambed in the dredged reaches changed from poorly consolidated to firm in that same period. What may be more meaningful in assessing longer-term trends are changes observed between consecutive profile measurements beginning with the measurements in January 1986 and cumulative changes in width-averaged bed elevation that occurred between the measurements in January 1986 and those in April 1986, October 1986, and April 1987.

Information on trends is provided by looking at the signs and magnitudes of changes in width-averaged bed elevations. Changes over time in average bed elevation that are uniformly of one sign suggest, but do not guarantee, real and consistent trends. On the other hand, those cross sections that exhibit width-averaged bed-elevation changes of alternating sign do not imply any such trends and may suggest that bed elevations for the period are varying around some near-equilibrium elevation.

None of the cross sections monitored in this study changed in width-averaged bed elevation with sufficient consistency and magnitude to suggest a definitive trend. Knowledge of width-averaged changes in bed elevation, coupled with basic graphical cross-section data does, however, offer explanations about probable mechanisms for some of the observed changes.

Site A-2, located in the community of Lafferty at river mile[1] 27.59, exhibited a 0.1-foot cumulative increase in width-averaged bed elevation between the measurements in January 1986 and April 1987. The changes observed at this site are explained by the fact that this site is located immediately downstream of a bend in the river. Centrifugal force acting on the flow of water around a bend raises the water surface at the concave bank (in this case the right bank) and lowers the water surface at the convex bank (Petersen, 1986). This water-surface rise, coupled with energy loss along the bed, produces a transverse velocity that moves sediments transported on or

[1]A river mile is the distance, in miles, from the downstream terminus of a river.

Table 1.—*Change in width-averaged bed elevations for selected sites in four reaches of Wheeling Creek*

		Change in width-averaged bed elevation, in feet							
Reach name	Site code	Pre-dredging to Aug-Oct/85	Aug-Oct/85 to Jan/86	Jan/86 to Apr/86	Apr/86 to Oct/86	Oct/86 to Apr/87	Jan/86 to Apr/87	Channel width (feet)	River-mile index
Lafferty	A-1	0.0	-0.3	0.0	-0.1	0.0	0.0	15.0	27.94
	A-2	-1.4	.6	.0	.0	.1	.1	14.5	27.59
	A-3	-0.5	.1	-0.1	.0	-0.1	-0.1	13.0	27.36
	A-4	.0	.0	-0.1	.1	.0	.0	16.0	27.02
Crabapple	B-1	.0	-0.3	.0	.0	.0	.0	22.0	22.31
	B-2	-2.8	.9	.0	.0	-0.1	-0.1	27.0	22.22
	B-3	-2.0	.5	.2	.0	-0.1	.1	31.0	22.15
	B-4	-1.1	.2	.0	-0.1	-0.1	-0.2	31.0	22.08
	B-5	-0.1	-0.3	.0	.0	.0	.0	31.0	22.03
Maynard	C-1	.0	-0.2	.1	.0	.0	.1	41.5	15.86
	C-2	-1.8	-0.3	.0	.0	.0	.1	31.0	15.35
	C-3	-1.8	-0.3	.1	.0	.0	.0	37.0	15.14
	C-4	-2.2	.2	.0	.0	-0.1	.0	46.0	15.02
	C-5	-1.3	.1	.0	.1	-0.1	.0	39.5	14.68
	C-6	-0.3	-0.3	.0	.0	.0	.0	36.0	14.50
	C-7	.1	-0.1	-0.1	.1	.0	.0	39.0	14.30
Crescent	D-1	-0.3	-1.1	.0	.0	.0	.0	53.0	12.45
	D-2	-2.5	.0	.1	.3	.0	.4	50.5	12.36
	D-3	-2.2	.3	.1	.0	.0	.1	48.5	12.23
	D-4	-3.4	.4	.0	.0	.0	.0	32.5	12.12
	D-5	.0	-0.3	-0.1	.1	-0.1	-0.1	47.5	11.95

near the streambed toward the convex bank, and builds a point bar at that location. A plot of selected cross-section profiles measured at site A-2 over the study period (fig. 3), clearly shows that a point bar has developed on the convex bank as energy considerations dictate. The solid line represents the predredging cross-section profile, and the dotted line represents the first postdredging profile.

Site D-2, located in the community of Crescent at river mile 12.36, was another site where readily explainable changes in width-averaged bed elevation occurred. The width-averaged bed elevation increased by 0.4 foot between the measurements in January 1986 and April 1987; this was the largest net change observed at any of the cross sections during that period. The changes that were observed in this cross section are attributed to the formation of a bar extending downstream from a pier supporting the Belmont County Route 5 bridge located approximately 300 feet upstream. The bar, formed by deposition of sediment in a reduced-velocity region behind the pier, had been gradually extending downstream since dredging was completed. Figure 4 is a plot of selected cross-section profiles measured at this site. The small hump present between stations 30 and 50 in the October 1986 and April 1987 profiles is part of the point bar. The solid and dotted lines in figure 4 have the same meanings as were defined for figure 3.

Changes in Thalweg Elevations

Plots of cross-section thalweg elevations against distance for each reach are shown in figures 5 through 8. These plots show selected thalweg profiles measured over the duration of this study. The reader is cautioned that the plots are exaggerated in the vertical. For purposes of comparison, the degree of vertical exaggeration in the plots was held roughly equal even though the actual scales differ from plot to plot. Without vertical exaggeration, most observed post-dredging changes in thalweg elevations would be barely perceptible on plots of this size. Thalweg elevations were measured only at the cross-section locations listed in table 2. Distances between measured thalweg elevations have been connected by straight lines as a graphical aid and do not necessarily reflect actual variations between cross sections.

All cross-section sites located upstream and downstream from the dredged reaches, with the exception of the most downstream site in the community of Lafferty (fig. 5), exhibited some reduction in thalweg elevation between the predredging and April 1987 profile measurements. Cross-section sites located within dredged reaches generally displayed little change in thalweg elevations after the initial bed-stabilization period.

Table 2.—*Thalweg elevations for indicated cross-section locations and survey dates*

Reach name	Site code	River-mile index	Distance from upstream site (feet)	Thalweg elevation, in feet above sea level, on date: Pre-dredging	August 1985	October 1985	January 1986	April 1986	October 1986	April 1987
Lafferty	A-1	27.94	0	[a]1,015.9		1,015.8	1,015.5	1,015.5	1,015.5	1,015.6
	A-2	27.59	1,870	1,012.3		1,010.8	1,011.6	1,011.7	1,011.6	1,011.7
	A-3	27.36	3,045	1,011.0		1,010.5	1,010.8	1,010.8	1,010.8	1,010.7
	A-4	27.02	4,860	1,007.4		1,007.4	1,007.4	1,007.4	1,007.5	1,007.6
Crabapple	B-1	22.31	0	[b]923.0		923.1	922.8	922.8	922.8	922.8
	B-2	22.22	490	920.6		918.6	919.4	919.4	919.4	919.2
	B-3	22.15	840	920.0		917.8	918.5	918.7	918.8	918.8
	B-4	22.08	1,200	918.4		917.8	917.7	917.8	917.7	917.7
	B-5	22.03	1,485	917.9		917.8	917.6	917.5	917.6	917.6
Maynard	C-1	15.86	0	[c]845.8		845.8	845.6	845.5	845.5	845.6
	C-2	15.35	2,705	840.5		838.8	838.5	838.6	838.7	838.6
	C-3	15.14	3,800	838.0		836.3	835.9	835.9	836.0	835.9
	C-4	15.02	4,415	837.5		835.7	835.2	835.3	835.5	835.4
	C-5	14.68	6,230	833.1		832.0	831.9	832.0	831.9	831.9
	C-6	14.50	7,175	830.4		830.4	830.0	830.0	830.0	830.0
	C-7	14.30	8,230	828.6		828.5	828.4	828.3	828.5	828.4
Crescent	D-1	12.45	0	[d]804.8	803.1			802.6	802.6	802.5
	D-2	12.36	490	804.1	802.5		802.5	802.5	802.4	802.5
	D-3	12.23	1,150	802.9	800.3		800.6	800.6	800.6	800.6
	D-4	12.12	1,750	801.4	799.2		799.4	799.4	799.4	799.4
	D-5	11.95	2,630	798.4	798.4		798.1	798.1	798.2	798.1

[a]All sites in this reach surveyed September 1984.
[b]All sites surveyed in December 1984.
[c]Site C-1 surveyed in February 1985; site C-2 surveyed December 1984; all other sites in this reach surveyed September 1984.
[d]All sites surveyed July 1985.

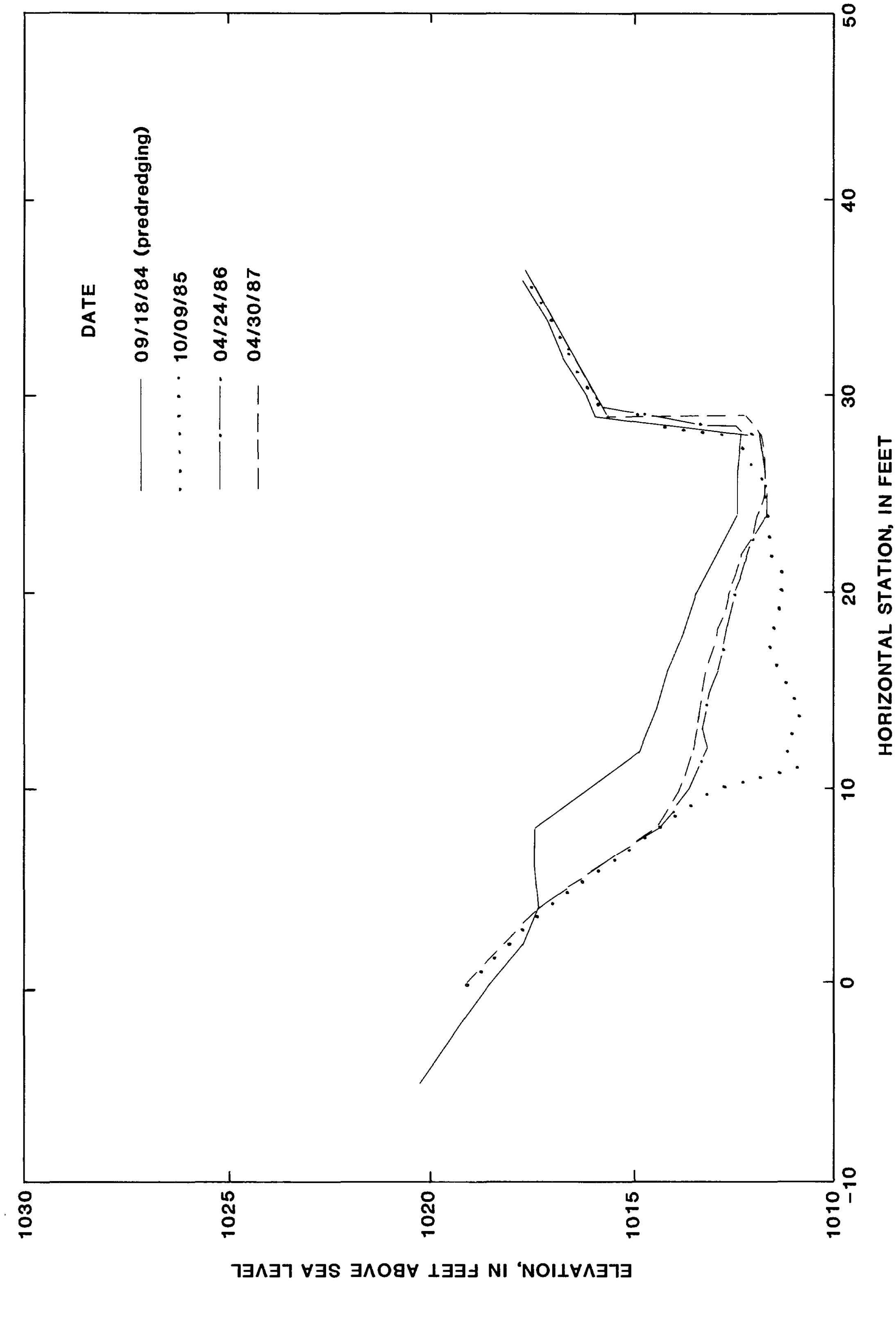


Figure 3.—Selected cross-section profiles at site A-2 (river mile 27.59) in Lafferty, Ohio.

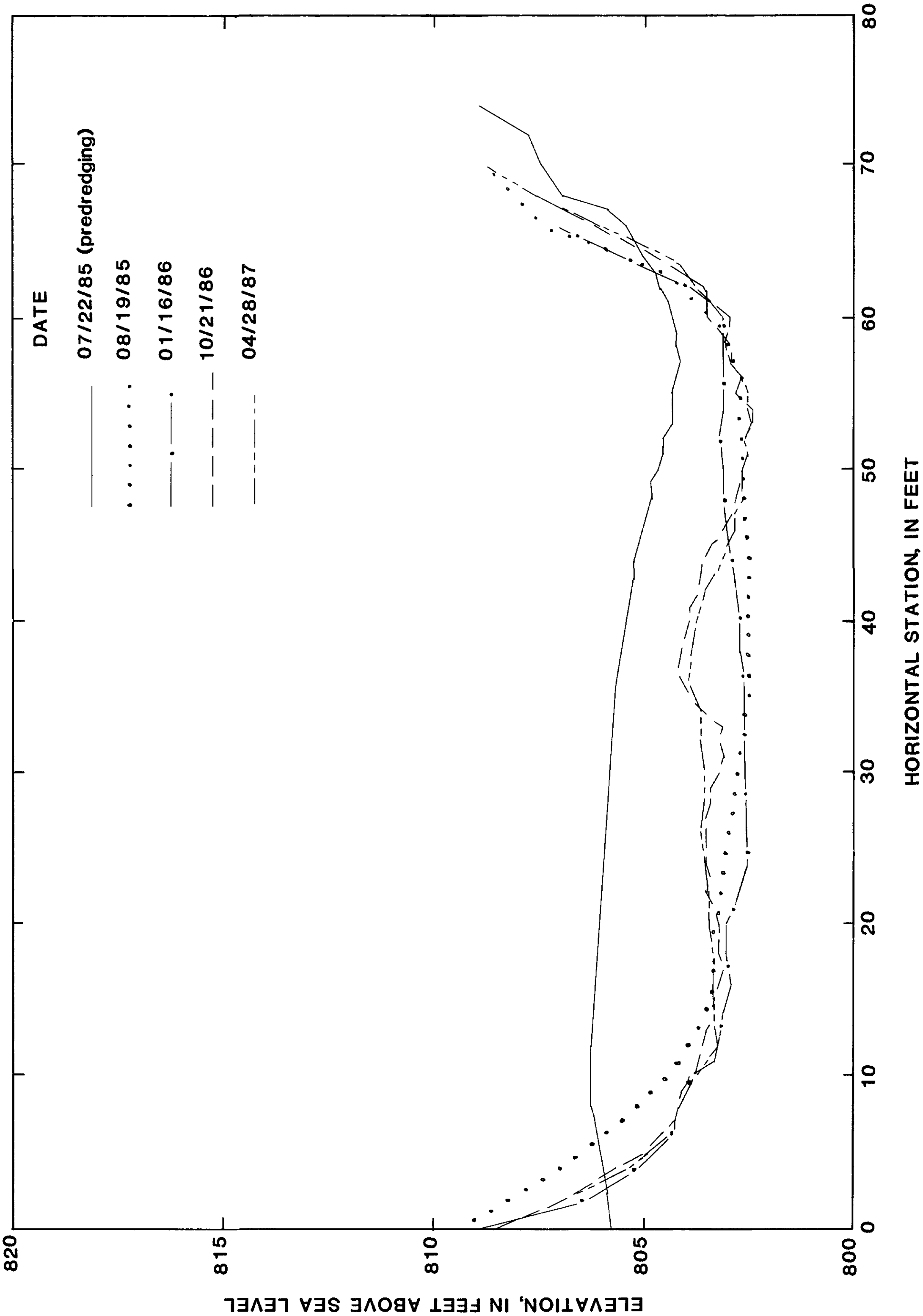


Figure 4.--Selected cross-section profiles at site D-2 (river mile 12.36) in Crescent, Ohio.

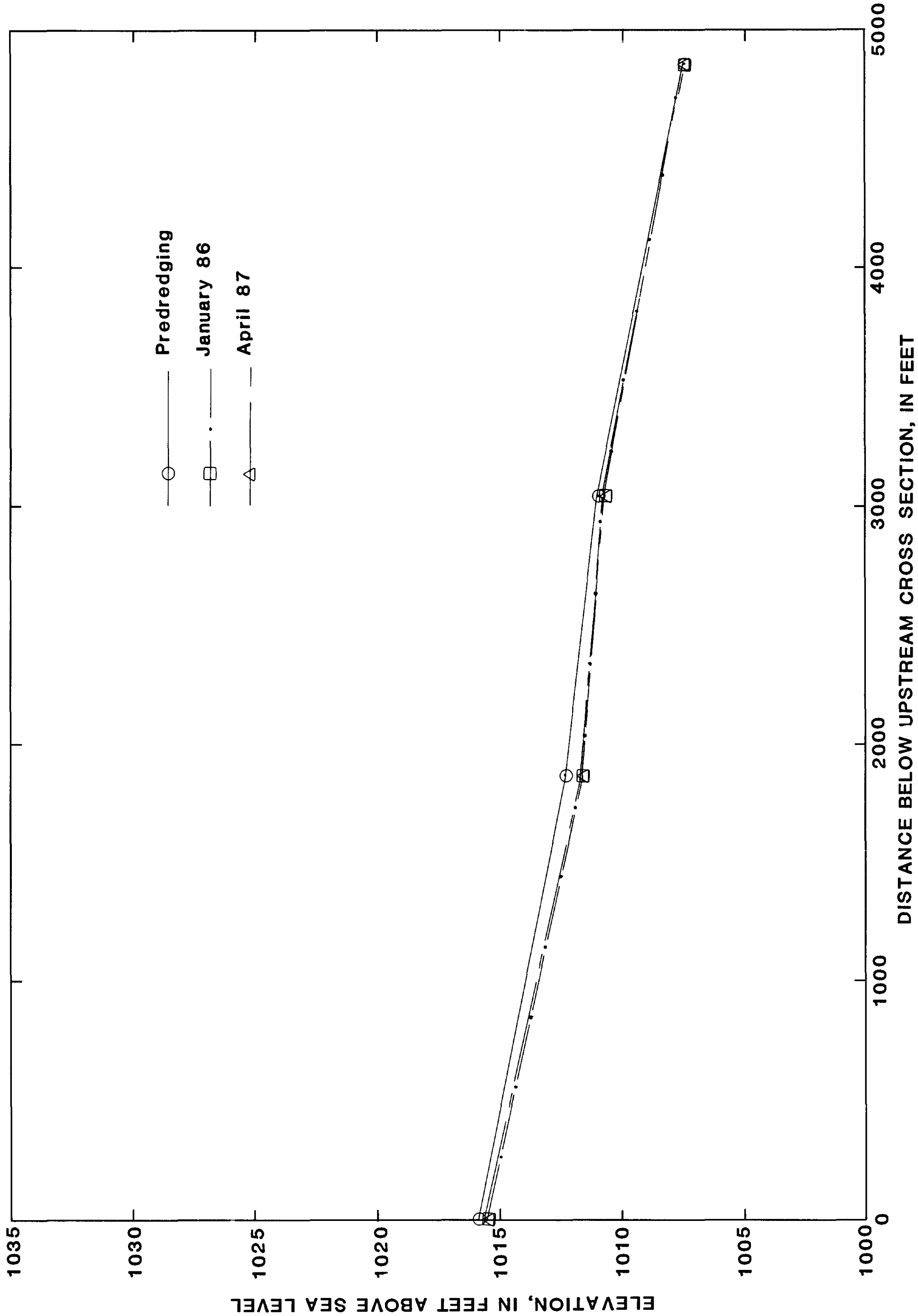


Figure 5.--Selected thalweg measurements against distance below upstream cross section in the Lafferty reach.

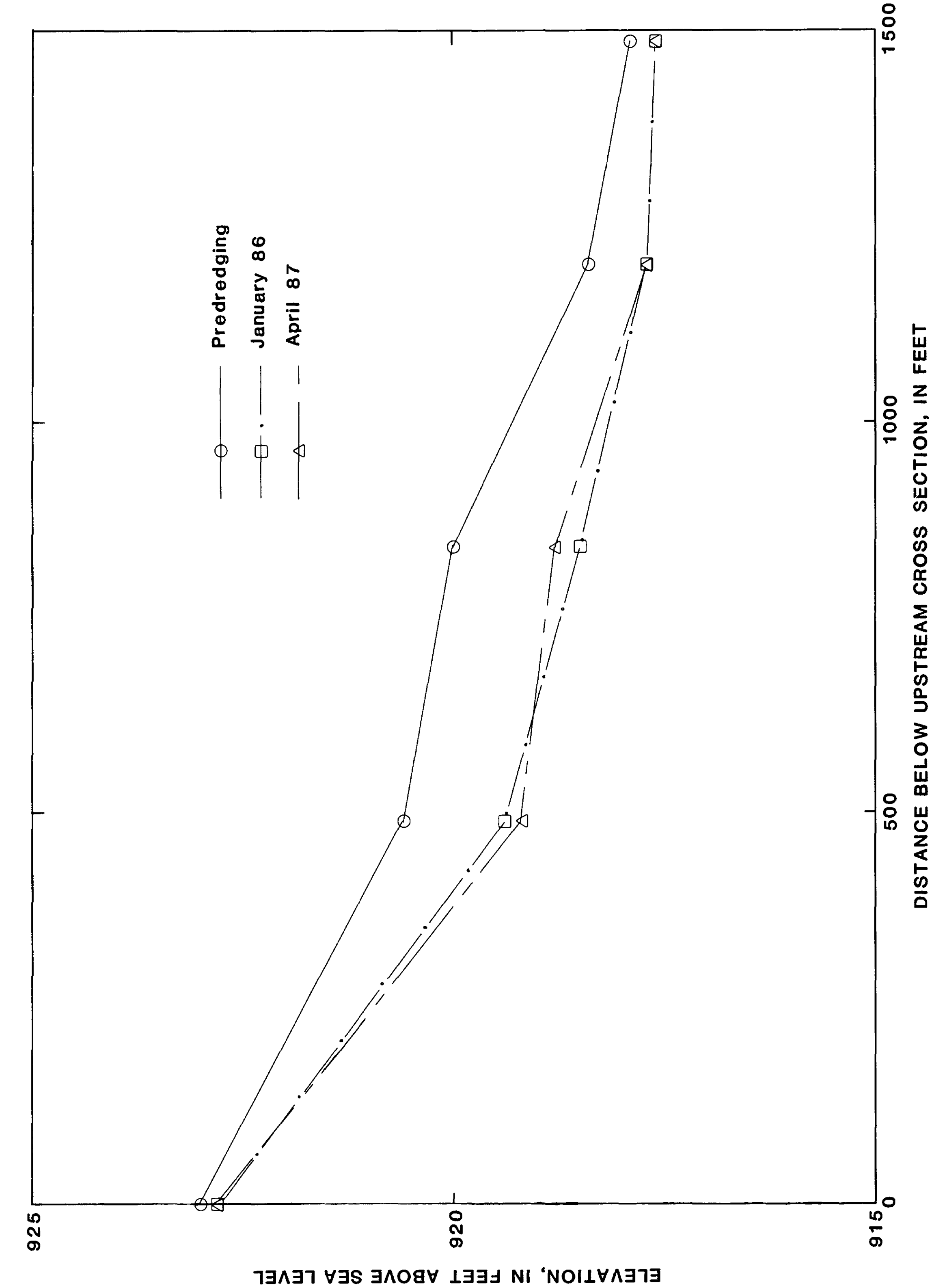


Figure 6.--Selected thalweg measurements against distance below upstream cross section in the Crabapple reach.

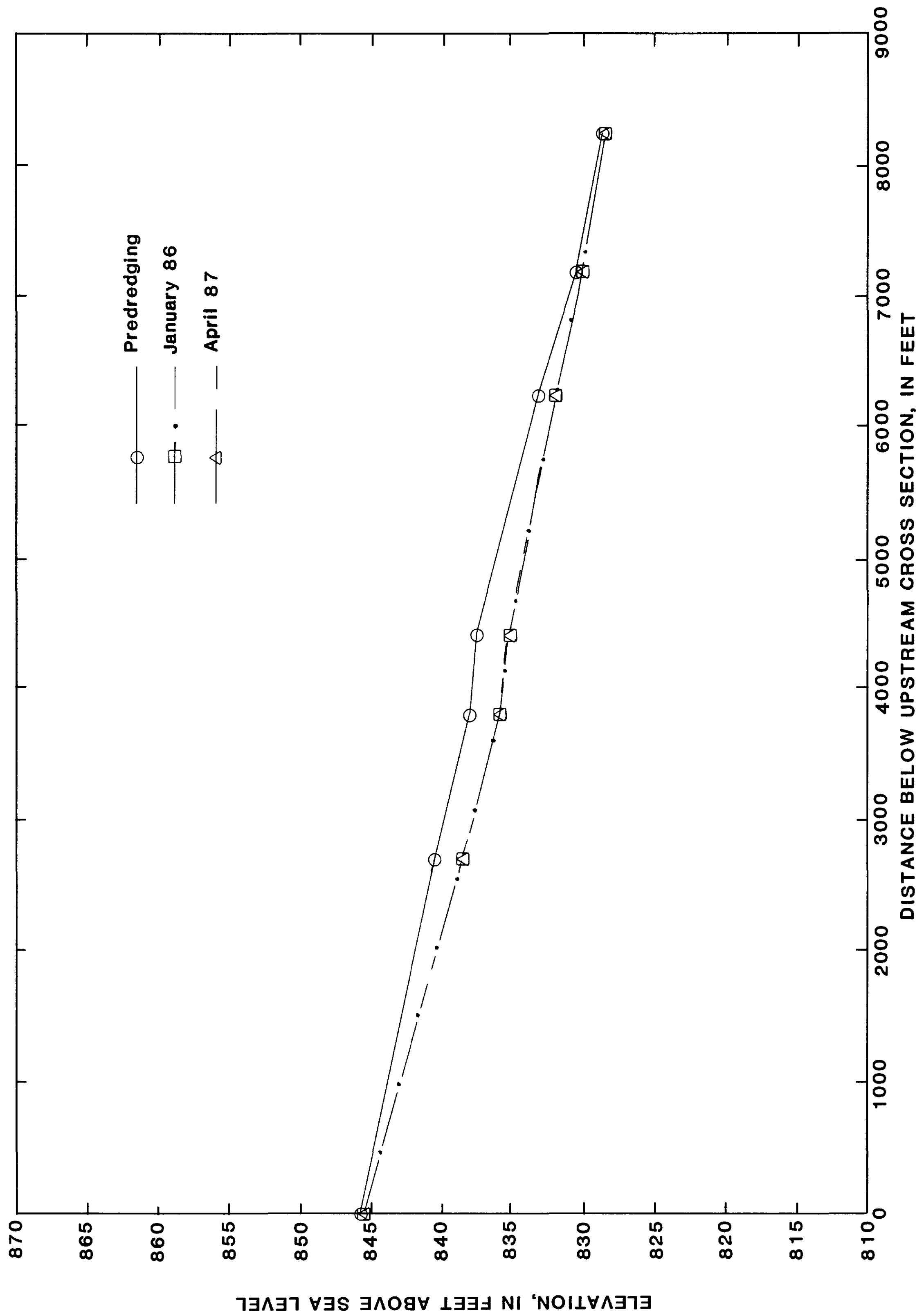


Figure 7.--Selected thalweg measurements against distance below upstream cross section in the Maynard reach.

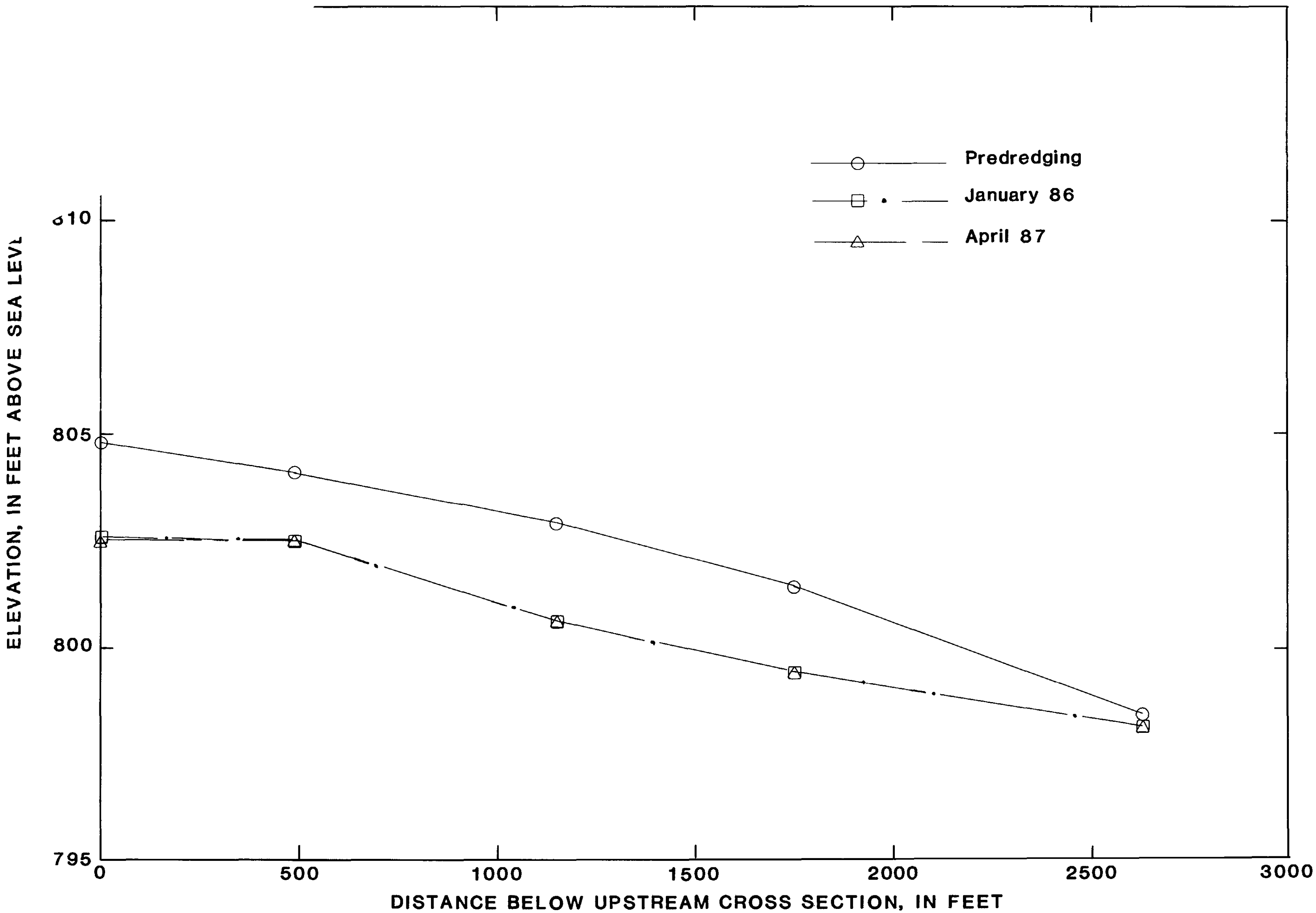


Figure 8.--Selected thalweg measurements against distance below upstream cross section in the Crescent reach.

CONCLUSIONS

Dredging causes localized changes in stream-channel width, depth, and longitudinal slope, as well as bed- and bank-material composition, all of which can affect rates of scour or fill. Active surface mining, reclamation, and agricultural activities in the Wheeling Creek basin provide additional complications that make the long-term physical effects of dredging on stream-channel geometry even more uncertain. In general, cross sections monitored in this study did not change in the width-averaged bed elevations with sufficient consistency and magnitude to suggest definitive trends. Changes in width-averaged bed elevation that occurred after an initial bed-stabilization period of less than 6 months were in the range of -0.1 to 0.4 foot. Of the 21 cross sections monitored, changes in the range of plus or minus 0.1 foot occurred at 19 during that same period.

Plots of thalweg elevations measured over the duration of this study show characteristics that corroborate the results observed with the width-averaged bed elevations. Specifically, little change in thalweg elevations was observed after an initial bed-stabilization period. The maximum change in thalweg elevation observed between January 1986 and April 1987 was 0.3 foot; however, net changes of 0.1 foot or less occurred at 17 of the 21 cross sections during that same period.

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