

A black and white photograph of a riverbank. In the foreground, a path leads down to the water. The river reflects the sky and the surrounding trees. The background is filled with dense foliage and trees. The text is overlaid on the upper half of the image.

**Cuyahoga Riverbank
Erosion Study
in the Cuyahoga Valley
National Recreation Area**

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Recreation Area**

March 1997

**prepared for:
The Cuyahoga Valley National
Recreation Area**

prepared by:



in association with Biohabitats, Inc.

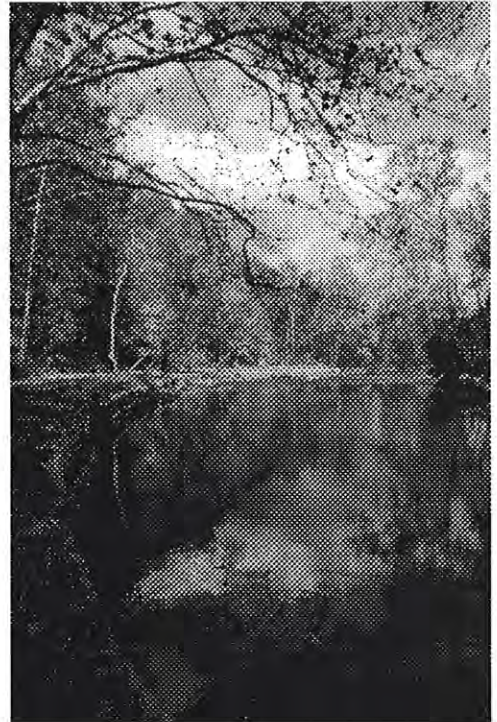


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1.0 SUMMARY AND RECOMMENDATIONS

1.1 Summary

One of the largest natural resources within the Cuyahoga Valley National Recreation Area is the Cuyahoga River. The river extends through the entire length of the CVNRA in a deep valley. The river valley contains various other resources including the Valley Railway and the Ohio and Erie Canal Towpath Trail. These man-made resources are utilized by visitors to the CVNRA. In general, the river meanders from one side of the valley to the other. At various locations the riverbank is unprotected, has eroded, and the river has moved within close proximity of, or has infringed upon the Valley Railway and/or the Towpath Trail.

This study identifies such areas and recommends a course of action to stabilize the riverbank(s) and thus protect the Valley Railway and Towpath Trail. This Study also identifies areas of riverbank in close proximity to the resources that could potentially erode, and thus should be monitored.

1.2 Recommendations

Environmental Design Group, Inc. offers the following recommendations with respect to this study:

1. Initiate repairs to riverbank beginning at areas grouped as high concern and continuing to areas of low concern. Areas grouped as high concern are in close proximity to the resource and appear to be experiencing a high or rapid rate of riverbank loss, while areas grouped as low concern are not close to the resource and have a low rate of riverbank loss, or have a stable bank. Based on the above methodology, the areas noted in this report have been grouped from highest to lowest concern, as follows:

A. Valley Railway - High Concern

Railway Mile Post 61.2/River Mile 17.8

Railway Mile Post 61.1 through 60.8/River Mile 18.43 through 18.71

B. Valley Railway - Moderate Concern

Railway Mile Post 59.7 through 59.3/River Mile 19.89 through 20.23

Railway Mile Post 57.9/River Mile 21.75

Railway Mile Post 57.7/River Mile 21.9

Railway Mile Post 57.35/River Mile 22.64

Railway Mile Post 57.25/River Mile 22.7

Railway Mile Post 55.23/River Mile 25.6

Railway Mile Post 52.5/River Mile 29.4

C. Valley Railway - Low Concern

Railway Mile Post 65.5/River Mile 12.3
Railway Mile Post 64.3/River Mile 13.6
Railway Mile Post 64.1/River Mile 14.2
Railway Mile Post 63.0/River Mile 15.7
Railway Mile Post 62.4/River Mile 16.3
Railway Mile Post 56.1/River Mile 24.47
Railway Mile Post 52.9/River Mile 29.05

D. Towpath Trail - High Concern

River Mile 17.3
Station 675+00 through 680+00/River Mile 18.8 through 19.2
Station 710+00/River Mile 19.5
Station 781+00/River Mile 20.88
Station 940+00/River Mile 24.95
Station 1010+00/River Mile 26.67
Station 1060+00/River Mile 27.6
Station 1380+00/River Mile 35.3

E. Towpath Trail - Moderate Concern

Station 530+00/River Mile 15.49
Station 650+00/River Mile 18.2
Station 1233+00/River Mile 31.65

F. Towpath Trail - Low Concern

Station 448+00/River Mile 13.4
Station 573+00/River Mile 16.51
Station 610+00/River Mile 17.19
Station 758+00/River Mile 20.45
River Mile 20.69
Station 790+00/River Mile 20.99
Station 805+00/River Mile 21.18
Station 900+00/River Mile 24.0
Station 1045+00/River Mile 27.4
Station 1075+00/River Mile 27.95
Station 1115+00/River Mile 28.76

2. Develop a program to monitor all areas. For areas of riverbank currently experiencing erosion, the rate of bank loss should be monitored and recorded. In Section 3 of this report, some areas are noted to be monitored only. Currently these areas are not in close proximity to either resource. If erosion continues such that the riverbank moves to within 20 feet of the resource, then initiate repairs. Section 3 also notes areas to be monitored that are currently stable. These areas are in close proximity to the resource and are typical places for erosion to occur. If erosion or other bank instability begins in these areas, initiate riverbank repairs.
3. Prepare permit documentation and submit to U.S. Army Corps of Engineers.

2.0 INTRODUCTION

2.1 Authorization

On August 29, 1994, the U. S. Department of the Interior, National Park Service, Cuyahoga Valley National Recreation Area, issued Task Order No. 80 for Contract No. CX 6000-0-0018 to Environmental Design Group, Inc. authorizing the Cuyahoga Riverbank Erosion Study. Subsequent authorization for additional services was issued on January 17, 1996.

2.2 Purpose and Scope

Both the Valley Railway and the Ohio and Erie Canal Towpath are of historical significance and are listed as significant cultural resources in the park's General Management Plan. The Valley Railway is listed in the National Register of Historic Places. A four-mile section of the Ohio & Erie Canal is designated a National Historic Landmark and the majority of the canal within CVNRA boundaries is listed in the National Register of Historic Places as a thematic resource.

The purpose of this study is to develop a plan of action for use by the NPS to protect portions of the these resources that are in close proximity to the banks of the Cuyahoga River. In some cases the banks are highly susceptible to erosion due to lack of protective cover. The scope of this study includes the following:

1. Identify areas of riverbank that require stabilization to protect the Valley Railway or Towpath Trail.
2. Identify areas of riverbank in close proximity to the Valley Railway or Towpath Trail that are currently stable, but should be monitored as the potential for future instability exists.
3. Prepare a description of each area including existing bank vegetation and/or artificial stabilization, areas upstream that may affect stabilization at the problem area, stream and habitat characteristics in the problem area.
4. Consider repair options at each area identified and make a recommendation.
5. Provide conceptual cost estimate and estimate of fill per lineal foot of river (below ordinary high water level) that may be required for the recommended repair option.
6. Prepare Geomorphology Study of the Cuyahoga River Valley within the CVNRA.

7. Incorporate the above items in a Study Report and recommend a course of action.
8. Provide general information required by U.S. Army Corps of Engineers for their 404 Permit Process.

3.0 PROJECT AREAS

3.1 General

On October 26, 27 & 28, 1994 staff personnel from Environmental Design Group, Inc. Biohabitats, Inc., and the National Park Service conducted a field reconnaissance of the Cuyahoga River (from Bath Road to Rockside Road) to identify the geomorphic characterization of the river, and to identify limits of riverbank that require stabilization in order to protect the Valley Railway or the Ohio and Erie Canal Towpath Trail (existing resources). The portion of the scope relative to riverbank stabilization was subsequently expanded to include the entire length of the Valley Railway (near Brecksville Road in Cleveland to Howard Street in Akron), and also to identify sections of riverbank that are in close proximity to the resources and should be monitored, even though the banks are currently stable. Field reconnaissance occurred in March and April of 1995 to identify additional areas.

As a result of the field reconnaissance, the following areas were identified. Areas adjacent to the Valley Railway are listed first, in order from north to south beginning at the north limit near Brecksville Road and Interstate 480. Areas adjacent to the Towpath Trail follow, in order from north to south beginning at Rockside Road. A summary of the following areas is provided in Table 3-1 (areas adjacent to the Valley Railway) and Table 3-2 (areas adjacent to the Towpath Trail).

3.2 Areas Adjacent to the Valley Railway

Mile Post 65.5 / River Mile 12.30

Adjacent to the Valley Railway, this area is approximately 1,000 feet long and located 3,700 feet north of Rockside Road. In this area the top of bank is approximately 40 feet from the Railway. The banks are almost vertical. Some places have herbaceous vegetation and others have bare soil with exposed roots from trees that have established themselves. A couple small slides have occurred. The river is in a straight section in this area as it was previously re-channeled to accommodate industry on the east side. The Railway is on a curve here. Because the river is in a straight section, this area is of low concern. Recommendations include rock protection at the slides to prevent further degradation of the banks and monitoring the remainder of the area. Measure the progression of the bank erosion. Implement the same repair techniques if additional slides develop, or if bank erosion begins to occur at an accelerated rate.

Mile Post 64.3 / River Mile 13.60

Adjacent to the Valley Railway, this area is approximately 350 feet long and located 2,000 feet south of Rockside Road. In this area the cut bank (west bank) adjacent to the Railway has previously experienced severe erosion and undercutting. A side channel from the west flows in a culvert under the Railway and outfall to the river here. Debris and fallen trees have created snags in the river. The

top of bank is approximately 10 feet from the Railway at its closest point and approximately 10 feet above the river water surface. The banks in this area are unprotected except for existing herbaceous vegetation and some trees. Construction drawings and specifications for repairing this area were previously prepared using gabion baskets intermixed with planting baskets to help revegetate the slope. The drawings also included a gabion headwall and wingwalls at the outfall of the culvert under the Railway. As the geometry of the river has changed in this area, the banks are no longer being eroded as they once were. Therefore the bank stabilization as previously designed is not required at this time. A portion of the original design was included in another project for repairing various culverts and bridges on the Railway, which has been completed. The banks in this area are of low concern. Recommendations for this area include revegetation of the banks.

Mile Post 64.1/ River Mile 14.2

Adjacent to the Valley Railway, this area is approximately 450 feet long and located 4,000 feet south of Rockside Road. In this area, the cut bank (west bank) is approximately 35 feet from the Railway. The bank is generally covered with herbaceous vegetation with some mature trees and some rock near water level. The bank height is approximately 15 feet above the river water surface. Some minor erosion has occurred within two feet above the water level. As the river is some distance from the Railway and the bank is relatively stable, this area is of low concern. Recommendations include monitoring to determine if erosion accelerates. If required, stabilize with rip-rap to normal high water level and revegetate remainder using bioengineering techniques.

Mile Post 63.0 / River Mile 15.70

Adjacent to the Valley Railway, this area is approximately 300 feet long and located immediately south of Hillside Road bridge over the Cuyahoga River. The southern two-thirds portion of this area is experiencing some loss of vegetation due to erosion along the bank. The bank has primarily herbaceous vegetation and some trees. Some stone is located along the bank below the water level. The top of the bank is approximately 10 feet above the river water surface. The northern one-third of this area is experiencing severe erosion and undercutting. This bank is almost vertical and unvegetated. Some small trees and herbaceous vegetation are located between the top of the bank and the Railway. The top of bank is approximately 20 feet above the river water surface. This area is of low concern at this time. The south portion of this area that is experiencing minor erosion, is approximately 30 feet from the Railway. The northern portion, experiencing severe erosion is approximately 100 feet from the Railway. Recommendations include rip-rap stabilization and bioengineering in the northern portion and additional rip-rap and revegetation of the bank in the southern portion. Monitor erosion rates to determine loss of bank. Use this to determine when improvements are necessary.

Mile Post 62.4 / River Mile 16.30

Adjacent to the Valley Railway, this area is approximately 500 feet long and located 400 feet south of Riverview Road where it previously crossed the Cuyahoga River. Currently the existing cut bank adjacent to the Railway has large rock protection extending approximately 4 feet above the river water surface. The bank above the rock has herbaceous vegetation and some small trees. Some bank erosion above the rock has occurred. The top of bank is approximately 20 feet from the Railway and 10 feet above the river water surface. This area is of low concern at this time. However, this area should be monitored, with erosion rates recorded to determine rate of bank loss.

Mile Post 61.2 / River Mile 17.80

Adjacent to the Valley Railway, this area is approximately 300 feet long and located 1,400 feet south of Fitzwater Road. This area was previously repaired as a slide had occurred and shifted the tracks. The design of the repairs include rock protection along the riverbank. However, due to budget limitations, the rock was not installed. Currently, this area is experiencing severe erosion along the cut bank where the improvements were made. The top of bank is approximately 10 feet from the Railway and 15 feet above the river water surface. This area is of high concern. Recommendations include stabilization of the previous improvements by completing the project using rip-rap and bioengineering techniques.

Mile Post 61.1 through 60.8 / River Mile 18.43 through 18.71

Adjacent to the Valley Railway, this area is approximately 1,500 feet long and located 3,500 feet south of Fitzwater Road. Currently, the cut bank has rock protection extending above the river water surface. The bank cover above the rock is herbaceous vegetation with some scattered small trees. The bank above the rock is experiencing erosion, and some small slides have developed. The top of bank is approximately 5 feet from the Railway and 15 feet above the river water surface. Portions of this area are of high concern, particularly at the south end. The recommendations include placing additional rip-rap above the existing rock, (to the normal high water level) and bioengineering techniques above the rip-rap.

Mile Post 59.7 through 59.3 / River Mile 19.89 through 20.23

Adjacent to the Valley Railway, this area is approximately 2,000 feet long and located 1,700 feet north of State Route 82. This area is experiencing moderate erosion and loss of vegetation along the bank, along with some small slides that have developed. Some bar building has developed in the river due to sediment deposits from a tributary outfalling from the west. The top of bank is approximately 12 feet from the Railway and 10 feet above the river water surface. The culverts that cross the valley railway outfall within the area. Typically the banks in this area are almost vertical and have some herbaceous vegetation with scattered small trees. These have been cut as part of the track clearing contract. Portions of the bank in this area have rock protection to 3 feet above the water level. This

area is of moderate concern. Recommendations include rip-rap at the locations currently experiencing erosion. Monitor entire area to determine if additional pockets of erosion develop.

Mile Post 57.9 / River Mile 21.75

Adjacent to the Valley Railway, this area is approximately 400 feet long and 4,000 feet south of the Station Road Bridge across the river. This area is experiencing severe erosion and bank undercutting due to lateral movement of the outside meander. The bank in this area is lined with herbaceous vegetation. The top of bank is approximately 30 feet from the Railway and 15 feet above the river water surface. This area is of moderate concern. As the top of bank is still some distance from the Railway, no immediate action is necessary. Recommendations include monitoring this area and recording erosion rates to track progress of erosion.

Mile Post 57.7 / River Mile 21.90

Adjacent to the Valley Railway, this area is approximately 450 feet long and located 4,700 feet south of the Station Road Bridge (across the river). This area is experiencing severe erosion and undercutting due to lateral movement of the outside meander. Bank cover in this area is herbaceous vegetation. The top of bank is approximately 30 feet from the Railway and 5 feet above the river water surface. This area is of moderate concern. As the top of bank is still some distance from the Railway, no immediate action is necessary. Recommendations include monitoring this area and recording erosion rates to track progress of erosion.

Mile Post 57.35 / River Mile 22.64

Adjacent to the Valley Railway, this area is 250' long and located 4,100 feet north of Vaughn Road. A culvert crossing the Railway outfalls on the bank. A slide has developed in this area. The remaining stable section of the bank has herbaceous vegetation. The bank height is approximately 12 feet with the top of bank at 12 feet from the railway at the closest point. As the river is in a curve here, the slide is approximately 30 feet from the railway. This area is of moderate concern. Recommendations include rip-rap stabilization on the bank to the normal high water level and bioengineering techniques above the rip-rap. However, the cause of the slide should be determined and addressed which may require some modification of the noted repair.

Mile Post 57.25 / River Mile 22.70

Adjacent to the Railway, this area is located 3,800 feet north of Vaughn Road. The bank in this area was previously repaired using rip-rap protection. However, the bank upstream and downstream of the repairs is experiencing erosion and undercutting due to lateral movement of the outside meander. The top of bank is approximately 10 feet from the Railway and 10 feet above the river water surface. This area is of moderate concern. Recommendations include rip-rap stabilization upstream and downstream from the existing rip-rap and tying the stabilization into the existing bank. Use bioengineering techniques above the rip-rap for repaired sections.

Mile Post 56.1 / River Mile 24.47

As part of a rail siding to Jaite Mill this area is located at a railway bridge crossing the Cuyahoga River. The river curves at this location resulting in erosion of the west bank (cut bank) for a distance of approximately 50 feet upstream and downstream of the bridge abutment. The bank height is approximately 4 feet above the river water surface, and the bank covered with herbaceous vegetation and some small trees. This area is of low concern as it is not in close proximity to the main line of the Railway. Recommendations include monitoring existing conditions and recording the progression of erosion. Repair prior to erosion developing behind the abutment using rip-rap stabilization and bioengineering techniques.

Mile Post 55.23 / River Mile 25.60

Adjacent to the Valley Railway, the area is approximately 200 feet long and located 800 feet south of Columbia Road (at Riverview Road). The top of bank is approximately 15 feet from the Railway. The bank in this area was previously protected with rock extending 2 to 3 feet above the river water surface. The bank above the rock has herbaceous vegetation and some large trees. However, erosion is occurring at the downstream end of the rock due to lateral movement of the outside meander located approximately 100 feet away from the Railway. Also, the river geometry in this area may be changing. This will increase the forces of the river on the unprotected bank which will accelerate the erosion process at this location. This area is of moderate concern. Recommendations include extending the slope stabilization using rip-rap and bioengineering techniques. Tie stabilization into the existing bank. Bioengineering techniques include joint planting above the rip-rap.

Mile Post 52.9 / River Mile 29.05

Adjacent to the Railway and located directly west of the Ticket Office in the Village of Peninsula, this area is approximately 100 feet long. The bank in this area is experiencing moderate erosion due to structural constraints (old mill components on the east bank) which cause the channel to narrow in this area, plus drain pipes that outfall on the bank. The bank has primarily herbaceous vegetation with some spotty trees. The top of bank is approximately 30 feet from the Railway and 25 feet above the river water surface. This area is of low concern. Recommendations include monitoring the area and recording the rate of erosion. Investigate revegetating banks.

Mile Post 52.5 / River Mile 29.40

Adjacent to the Railway, this area is approximately 100 feet long and located 1,400 feet south of SR 303 (in Peninsula). The bank in this area is experiencing moderate erosion due to surface water running down the bank from the Railway. The top of bank is approximately 10 feet from the Railway and 30 feet above the river water surface. Bank cover is herbaceous vegetation with small trees to the normal water surface. This area is of moderate concern. Recommendations include controlling storm water draining off the Railway. Investigate rerouting water to eliminate erosion potential. Use rip-rap and bioengineering techniques to stabilize existing erosion.

3.3 Areas Adjacent to the Towpath Trail

Station 448+00 / River Mile 13.40

Adjacent to the Towpath Trail, this area is located 500 feet south of Rockside Road. The existing bank is protected with large pieces of rock to approximately 5 feet above the river water surface. The remainder of the bank is vegetated with large trees. The area is stable, however, the bank immediately beyond the upstream end of the rock protection should be monitored as the potential for future erosion exists. This area is of low concern.

Station 530+00 / River Mile 15.49

Adjacent to the Towpath Trail, this area is located 400 feet north of Hillside Road. In this area, the top of bank is approximately 12 feet from the Trail and 15 feet above the river water surface. A 50 foot long section of bank (immediately upstream of existing rock protection along the bank) has been eroded. This area is of moderate concern. Recommendations include extending limits of existing rock protection and revegetating the bank above the rock.

Station 573+00 / River Mile 16.51

Adjacent to the Towpath Trail, this area is approximately 200 feet long and located 600 feet south of Tinkers Creek. In this area the bank is 15 to 20 feet high, with rock protection up to the water surface and woody vegetation above the rock. The bank is stable and no immediate action is necessary. Recommendations include monitoring to verify that stability remains in tact. This area is of low concern.

Station 610+00 / River Mile 17.19

Adjacent to the Towpath Trail, this area is approximately 100 feet long and located 300 feet north of Fitzwater Road. The top of bank is approximately 20 feet above the river water surface and 8 feet from the Trail. The bank has shrubby vegetation with some mature trees. Some minor exposure of soil has occurred to 3 feet above the water surface. Temporary bank repairs constructed of rock placed to up above the normal water level have been made in a small portion of this area. Recommendations include monitoring area to determine if condition of the bank worsens. If required, stabilize with rip-rap and bioengineering techniques. This area is of low concern.

River Mile 17.30

River Mile 17.30 is approximately 200 feet long, and located on the west bank of the river immediately south of the Fitzwater Road bridge. This area is not in the vicinity of either resource. However as the CVNRA will assume ownership of this bridge, it was included in this study. This area is experiencing moderate erosion and loss of vegetation along the cut bank (west bank) with point bars and side bars formed from mid channel to the east bank of the river. A side channel extending from a canal drainage structure outfalls on the east bank of the river. The top of bank is approximately 20 feet above the river water surface. This area is of a high concern, as continual progression of erosion on the west bank will eventually erode behind the bridge abutment causing failure of the approach slab. Recommendations include reestablishing and stabilizing the west bank adjacent to the abutment using rip-rap and bioengineering techniques. Stabilize the east bank at the side channel outfall using the same techniques and possibly redirect the side channel.

Station 650+00 / River Mile 18.20

Adjacent to the Towpath Trail, this area is approximately 400 feet long and located 1,400 feet south of the intersection of Canal Road (Valley View Road) and Sagamore Road. The majority of the existing bank is protected by concrete rubble that extends almost to the top of the bank. Trees have been established on the bank and are scattered between the pieces of rubble. Slightly north of the termination of the rubble, a slide has occurred where the bank is unprotected and unvegetated. The top of bank is approximately 15 feet from the Towpath Trail and 20 feet above the river water surface. An area approximately 50 feet long should be stabilized using rip-rap and bioengineering techniques to protect the Towpath Trail from encroachment. Currently this area is not critical as the Towpath Trail is still some distance from the edge of the bank. However, the remaining bank in this area that is protected should be monitored. If erosion begins in the future, then install rip-rap between concrete rubble and revegetate the slope above the rip-rap. This area is of moderate concern.

Station 675+00 through 680+00 / River Mile 18.80 through 19.20

Adjacent to the Towpath Trail, this area is approximately 1,600 feet long and located approximately 2,400 feet south of the intersection of Canal Road (Valley View Road) and Sagamore Road. Portions

of the bank has shrubby vegetation and mature trees. Within this area the NPS has repaired the bank in two locations where slides previously occurred. The entire area should be monitored 2 to 3 times per year as additional stabilization problems may occur. This area is of high concern.

Station 710+00 / River Mile 19.50

Adjacent to the Towpath Trail, this area is approximately 310 feet long and located 5,500 feet north of State Route 82. Within the area there is an unstable area approximately 110 feet long. A slip has occurred within this section with the top of bank approximately 6 feet from the Trail. The top of bank is approximately 12 feet above the river water level. There are no trees in this section which makes it more susceptible to the forces of the river. The remainder of the 310 foot area has evidence of erosion up to the normal high water level. The bank above the high water level has some herbaceous vegetation with trees scattered throughout. The root mass of the trees on either side of the unstable area are currently helping the stability of the bank. This area is of high concern. Recommendations include stabilization of the bank using rip-rap and bioengineering techniques.

Station 758+00 / River Mile 20.45

Adjacent to the Towpath Trail, this area is located approximately 500 feet north of S.R. 82. The top of bank is approximately 15 feet above the river water surface and 5 feet from the edge of the Trail. The bank has rock protection at the edge of water with woody vegetation above the rock. Two small slips have developed between the Trail and top of bank. This area is of low concern. Monitor area 2 to 3 times per year.

River Mile 20.69

As part of the access to the Towpath Trail from the Station Road Trailhead, this area is located at the east and west abutments of the bridge (formerly Station Road) crossing the river. Immediately south of the east abutment the bank is experiencing some minor erosion over a distance of approximately 50 feet. The top of bank is approximately 4 feet above the river water surface. Along the west bank an area north and south of the abutment, approximately 150 feet long, is experiencing erosion. A culvert outfall exists immediately north of the abutment. The top of bank is approximately 20 feet above the river water surface. Vegetation is primarily herbaceous with some trees. Recommendations include monitoring rate of erosion. Initiate bank repairs using rip-rap stabilization and bioengineering techniques prior to erosion occurring behind the abutments. This area is of low concern.

Station 781+00 / River Mile 20.88

Adjacent to the Towpath Trail, this area is approximately 200 feet long and located 950 feet south of the Station Road Bridge (across the river). The bank in this area is experiencing moderate erosion and undercutting due to the forces of water entering the river from Chippewa Creek on the west side. A side channel bar has developed in the river due to the configuration of the side channel entering

A side channel bar has developed in the river due to the configuration of the side channel entering the river. The banks in this area have herbaceous vegetation with small to medium sized trees. The top of bank is 4 feet from the Towpath Trail and 10 feet above the river water surface. This area is of high concern. Recommendations include rip-rap and bioengineering techniques to stabilize the bank. Also investigate realigning Chippewa Creek where it meets the river to direct the creek flow down River.

Station 790+00 / River Mile 20.99

Adjacent to the Towpath Trail, this area is 200 feet long and located 1,500 feet south of S.R. 82. The top of bank is located approximately 5 feet above the river water surface and 12 feet from the edge of the Trail. The bank has herbaceous vegetation with some mature trees. The bank is stable, however, some trees along the water's edge have partially exposed root systems as the river has undercut the bank. Recommendations include monitoring to determine if conditions worsen. Rip-rap stabilization may be required to protect trees. This area is of low concern.

Station 805+00 / River Mile 21.18

Adjacent to the Towpath Trail, this area is 100 feet long and located 2,500 feet south of S.R. 82. The top of bank is located approximately 5 feet above the water surface and 12 feet from the edge of the river. The bank has herbaceous vegetation with some mature trees. Recommendations include monitoring 2 to 3 times per year to verify stability of the bank. This area is of low concern.

Station 900+00 / River Mile 24.00

Adjacent to Towpath Trail, this area is approximately 300 feet long and located 300 feet north of Vaughn Road. This area is experiencing severe erosion and undercutting due to lateral movement of the outside meander. Bank cover includes shrubby vegetation and small trees. The top of bank is approximately 75 feet from the Towpath Trail and 10 feet above the river water surface. This area is of low concern. Recommendations include monitoring this area 2-3 times per year and recording erosion rates. Investigate revegetation of the bank to eliminate erosion.

Station 940+00 / River Mile 24.95

Adjacent to the Towpath Trail, this area is approximately 400 feet long and located 2,900 feet south of Vaughn Road. This area is experiencing severe erosion and undercutting due to lateral movement of the outside meander. A point bar has also developed in the channel. In general, the bank is vertical, and has lost its vegetative cover. Beyond the top of bank there is shrubby vegetation and small trees. The top of bank is approximately 16 feet from Towpath Trail and 15 feet above the river water surface elevation. Recommendations include rip-rap and bioengineering techniques to stabilize the bank. This area is of high concern.

Station 1010+00 / River Mile 26.67

Adjacent to the Towpath Trail, this area is approximately 200 feet long and located immediately north of Interstate 271. Currently, there are pieces of broken concrete at the edge of the water. However, above the concrete some moderate bank erosion has developed due to lateral movement of the outside meander. Bank cover above the concrete includes herbaceous vegetation with some trees. Also a normally dry side channel crosses under the Towpath Trail bridge and enters the river from the east at this location. This channel has severe erosion and bank cutting. If the channel continues to erode it will eventually affect the Towpath Trail bridge crossing it. The top of bank is approximately 10 feet from the Towpath Trail and 15 feet above the river water surface. This area is of high concern. Recommendations include bank stabilization using rip-rap and bioengineering techniques (branch layering) above the rip-rap. Install step pool/grade control structures in the side channel and stabilize channel banks using rip-rap and bioengineering techniques.

Note that the Towpath Trail in this area was damaged by erosion as a result of heavy rains that occurred on August 9, 1995 and subsequently repaired by contract in the summer of 1996. As a result, this area is now considered to be of moderate concern.

Station 1045+00 / River Mile 27.40

Adjacent to the Towpath Trail, this area is approximately 100 feet long and located 1,200 feet south of the Ohio Turnpike (crossing over the Trail). This area is experiencing some moderate bank erosion due to lateral movement of the outside meander. The bank at this location is exposed. The area beyond the top of bank is primarily shrubby vegetation and trees. The edge of water is approximately 30 feet from the Towpath Trail and 10 to 15 feet above the river water surface. This area is of low concern. Recommendations include monitoring the area and recording the rate of bank erosion. Repair this area in conjunction with River Mile 27.60 using the same techniques.

Station 1060+00 / River Mile 27.60

Adjacent to the Towpath Trail, this area is approximately 400 feet long and located immediately west of Stumpy Basin. The bank in this area is experiencing severe erosion due to lateral movement of the outside meander. The bank at this location is exposed. The area beyond the bank has herbaceous wetland cover. The top of bank is approximately 20 feet from the boardwalk and 8 feet above the river water surface elevation. If uncontrolled, the erosion will continue and eventually encroach on the boardwalk. This area is of high concern. Recommendations include bank stabilization using rip-rap and bioengineering techniques. The rare plant and historic significance of the area must be considered.

Station 1075+00 / River Mile 27.95

Adjacent to the Towpath Trail, this area is approximately 100 feet long and located 350 feet down River from the Railway bridge over the river (north of Peninsula). The bank in this area is experiencing some minor erosion due to lateral movement of the outside meander. This area is heavily wooded. The top of bank is approximately 40 feet from the Towpath Trail and 6 feet above the river water surface. This area is of low concern. Recommendations include monitoring the area and recording the rate of bank erosion. Investigate revegetating banks to stop erosion process.

Station 1115+00 / River Mile 28.76

Adjacent to the Towpath Trail, this area is 200 feet long and located 800 feet north of the Peninsula Trailhead. The bank is stable, and has rock protection to 2 feet above the river water surface, with woody vegetation above the rock. The top of bank is approximately 6 feet above the river water surface and 20 feet from the edge of the Trail. Recommendations include monitoring 2 to 3 times per year. This area is of low concern.

Station 1233+00 / River Mile 31.65

Adjacent to the Towpath Trail, this area is located 350 feet south of Riverview Road where it crosses the Railway (south of Peninsula). The bank in this area was previously repaired using gabion baskets as lateral movement by the outside meander had severely eroded the bank adjacent to the proposed Towpath Trail. Currently, the bank at the upstream and downstream ends of the gabion are experiencing minor erosion. These areas are approximately 50 to 100 feet long and 20 to 45 feet from the Towpath Trail. Bank cover in this area is herbaceous vegetation. The top of bank is approximately 13 feet above the river water surface. This area is of moderate concern. Recommendations include monitoring the area and recording the rate of erosion.

Station 1380+00 / River Mile 35.30

Adjacent to the Towpath Trail, this area is approximately 250 feet long and located immediately north of the Ira Road Bridge over the river. The bank at the south end of this area near the bridge is experiencing moderate erosion and under cutting due to deflection of the normal channel flow into the bank. This is caused by a mid-channel bar. Sediment input from a culvert outfall directly south of the bridge may be contributing to the bar forming. A slump has also formed between the Towpath Trail and River at the north end of this area. The top of bank is approximately 20 feet above the river water surface, and 10 feet from the Trail. This area is of high concern. Recommendations include bank stabilization using rip-rap at the toe and bioengineering techniques above the rip-rap near the bridge. Determine cause of the slump at the north end of the area. Take steps as required to correct the situation. It is suspected that the slump may be due to groundwater migrating from the Canal east to the river.

TABLE 3-1
TASK ORDER 80
SUMMARY OF AREAS
ADJACENT TO THE VALLEY RAILWAY

MILE POST/ RIVER MILE	LOCATION	DISTANCE*	PROBLEM/ OBSERVATIONS	ASSESSMENT	LENGTH X MAX. BANK HT. (ft.)	MEANDER	EXISTING STRUCTURES/ REPAIRS
65.5/12.30	N. of Rockside Rd.	40 ft. West Bank.	Minor slides. River previously rechanneled in this area.	Bank erosion at normal water surface.	1000 x 10	None	None
64.3/13.60	S. of Rockside Rd.	10 ft. West Bank.	Severe erosion and undercutting	Lateral movement of outside meander. Debris jam. Side channel bar	500 x 10	Outside	None
64.1/14.20	S. of Rockside Rd.	35 ft. West Bank.	Minor erosion at normal water level.	Lateral movement of outside meander	450 x 15	Outside	Existing Rocks and trees along existing bank.
63.0/15.70	Behind Canal Visitors Ctr.	30 ft. West Bank.	Erosion along banks. Loss of vegetation	Lateral movement of outside meander	300 x 20	Outside	None
62.4/16.30	SW of Tinkers Creek Road. N. of Tinkers Creek	20 ft. West Bank.	Moderate erosion along bank	Lateral movement of outside meander	500 x 10	Outside	Stabilization at TOS
61.2/17.80	SW of Frazee House, S. of Fitzwater Rd.	10 ft. West Bank.	Severe erosion along bank resulting in loss of structural improvements. Severe erosion headward of improvements	Lateral movement of outside meander. Poor location of culverts. Headward erosion adjacent to RR	300 x 15	Outside & Crossover reach	RR relocated in past, bank fill, geotextile fabric and culverts

TABLE 3-1
TASK ORDER 80
SUMMARY OF AREAS
ADJACENT TO THE VALLEY RAILWAY

MILE POST/ RIVER MILE	LOCATION	DISTANCE*	PROBLEM/ OBSERVATIONS	ASSESSMENT	LENGTH X MAX. BANK HT. (ft.)	MEANDER	EXISTING STRUCTURES/ REPAIRS
61.1- 60.8/18.43 - 18.71	SW of Frazee House, S. of Fitzwater Rd.	5 ft. West Bank.	Erosion above existing rock stabilization.	Lateral movement of outside meander	1,500 x 15	Outside	Rip-rap slopes. Large & small boulders at TOS
59.7- 59.3/19.89 - 20.23	N. of Chippewa Rd. (SR 82)	12 ft. West Bank.	Moderate erosion along TOS. Some loss of woody vegetation. Minor slides. Bar building.	Tributary sediment inputs resulting bar building and bank scour	2000 x 10	Outside	None
57.9/21.75	S. of Station Rd. Trailhead	30 ft. West Bank.	Severe erosion and bank undercutting	Lateral movement of outside meander	400 x 15	Outside	None
57.7/21.90	S. of Station Rd. Trailhead	30 ft. West Bank.	Severe erosion and undercutting	Lateral movement of outside meander	450 x 5	Outside	None
57.35/22.64	N. of Vaughn Rd.	12 ft. West Bank.	Slide, culvert outfall.	Lateral movement of outside meander. Possible groundwater inducing slide.	250 x 12	Outside	None
57.25/22.70	N. of Vaughn Rd.	10 ft. West Bank.	Severe erosion and undercutting	Lateral movement of outside meander	200 x 10	Outside	Rip-rapped slope
56.1/24.47	S. of Vaughn Rd.	Rail siding to Jaite Mill, bridge.	Minor erosion.	Lateral movement of outside meander.	100 x 4	Outside	Bridge abutment
55.23/25.60	S. of Columbia Rd.	100 ft. West Bank.	Severe erosion.	Lateral movement of outside meander.	200 x 20	Outside	Rip-rap slope

TABLE 3-1
TASK ORDER 80
SUMMARY OF AREAS
ADJACENT TO THE VALLEY RAILWAY

MILE POST/ RIVER MILE	LOCATION	DISTANCE*	PROBLEM/ OBSERVATIONS	ASSESSMENT	LENGTH X MAX. BANK HT. (ft.)	MEANDER	EXISTING STRUCTURES/ REPAIRS
52.9/29.05	W. of Ticket Office	30 ft. E. Banks.	Moderate erosion on banks	Lateral movement of outside meander. Structural constraints. Erosion from drain pipe	100 x 25	Outside	None
52.5/29.40	S. of SR 303	10 ft. East Bank.	Moderate erosion on banks. Banks vegetated	Surface water from railway.	100 x 30	Outside	None

* Estimated distance in feet between resource and bank erosion.

TABLE 3-2
TASK ORDER 80
SUMMARY OF AREAS
ADJACENT TO THE TOWPATH TRAIL

STATION /RIVER MILE	LOCATION	DISTANCE*	PROBLEM/ OBSERVATIONS	ASSESSMENT	LENGTH X MAX. BANK HT. (ft.)	MEANDER	EXISTING STRUCTURES/ REPAIRS
448+00/ 13.40	S. of Rockside Rd.	10 ft. East Bank	Potential for erosion at upstream end of existing rip-rap.	N/A	50 x 10	Outside	Large rocks and trees along existing bank.
530+00/ 15.49	N. of Hillside Rd.	12 ft. East Bank.	Erosion at TOS	Lateral movement of outside meander.	50 x 15	Outside	None
573+00/ 16.51	S. of Tinkers Creek	East Bank	Existing bank stable. Potential for future erosion	N/A	200 x 20	Outside	Rock protection on existing bank.
610+00/ 17.19	N. of Fitzwater Rd.	8 ft. East Bank	Minor exposure of soil.	Lateral movement of outside meander.	200 x 20	Outside	None
17.30	Fitzwater Road and Alexander Mill	Bridge abutment. West Bank.	Moderate erosion along bank, loss of vegetation, sediment deposition creating point bars, side bars, and closure of old mill race	Lateral movement of outside meander and mill race sediment deposition	200 x 20	Outside	Mill race
650+00/ 18.20	SW of Frazee House, S. of Sagamore Rd.	15 ft. East Bank.	Severe erosion along bank. No vegetation. Smaller boulders at TOS eroding away	Lateral movement of outside meander	400 x 20	Outside	Concrete slabs along bank & TOS

TABLE 3-2
TASK ORDER 80
SUMMARY OF AREAS
ADJACENT TO THE TOWPATH TRAIL

STATION /RIVER MILE	LOCATION	DISTANCE*	PROBLEM/ OBSERVATIONS	ASSESSMENT	LENGTH X MAX. BANK HT. (ft.)	MEANDER	EXISTING STRUCTURES/ REPAIRS
675+00- 680+00/ 18.80- 19.20	S. of Sagamore Rd.	15 ft. East Bank.	Random slides due to erosion.	Lateral movement of outside meander	1,600 x 7	Outside	Previous repairs using rip-rap in two locations.
710+00/ 19.50	N. of Chippewa Rd. (SR 82)	6 ft. East Bank.	Moderate erosion along TOS. Some loss of woody vegetation	Lateral movement of outside meander	300 x 12	Outside	None
758+00/ 20.45	N. of Chippewa Rd. (SR 82)	5 ft. East Bank.	Minor slips at top of bank.	Lateral movement of outside meander.	500 x 15	Outside	Stabilization at TOS.
20.69	Station Rd. Trailhead	At existing bridge. East and West.	Minor erosion.	Lateral movement outside meander. High velocities at bridge due to reduced channel area from abutments.	150 x 4	Outside and Inside	Bridge abutments.
781+00/ 20.88	SE of Station Rd. Trailhead	3 ft. East Bank.	Moderate erosion and undercutting	Inputs from tributary. Mid-channel bar.	200 x 4	Inside	None
790+00/ 20.99	S. of Chippewa Rd. (SR 82)	12 ft. East Bank.	Undercutting.	Lateral movement of outside meander.	200 x 5	Outside	None
805+00/ 21.18	S. of Chippewa Rd. (SR 82)	12 ft. East Bank.	Potential for future erosion and undercutting.	None	100 x 5	Outside	None
900+00/ 24.00	N. of Vaughn Rd.	75 ft. East Bank.	Severe erosion and undercutting	Lateral movement of outside meander	300 x 10	Outside	None

TABLE 3-2
TASK ORDER 80
SUMMARY OF AREAS
ADJACENT TO THE TOWPATH TRAIL

STATION /RIVER MILE	LOCATION	DISTANCE*	PROBLEM/ OBSERVATIONS	ASSESSMENT	LENGTH X MAX. BANK HT. (ft.)	MEANDER	EXISTING STRUCTURES/ REPAIRS
940+00/ 24.95	S. of Vaughn Rd.	16 ft. East Bank.	Severe erosion and undercutting	Lateral movement of outside meander. Point bar	400 x 12	Outside	None
1010+00/ 26.67	N. of Rt. 271	10 ft. East Bank.	Moderate bank erosion. Some vegetation on banks	Lateral movement of outside meander. Sediment inputs from gully	200 x 15	Outside	Concrete/debris at TOS
1045+00/ 27.40	S. of Rt. 80 (Ohio Turnpike)	30 ft. East Bank.	Moderate bank erosion. Some vegetation on banks	Lateral movement of outside meander	100 x 15	Outside	None
1060+00/ 27.60	Stumpy Basin	20 ft. East Bank.	Severe erosion adjacent to boardwalk	Lateral movement of outside meander. Point bar	400 x 8	Outside	None
1075+00/ 27.95	S. of Stumpy Basin, N. of RR bridge	40 ft. East Bank.	minor erosion on banks	Lateral movement of outside meander	100 x 6	Outside	None
1115+00/ 28.76	N. of Peninsula Trailhead	20 ft. East Bank.	Potential erosion	None	800 x 6	Outside	Rip-rap slope
1233+00/ 31.65	S. of Peninsula	20 ft. West Bank.	Minor erosion upstream and downstream of gabions.	Lateral movement of outside meander.	200 x 13	Outside	Gabions on slope
1380+00/ 35.30	N. of Ira Rd.	10 ft. West Bank.	Moderate erosion and undercutting. Slump.	Sediment input from culvert and deflection of thalweg by wing walls. Mid-channel bar. Potential groundwater induced slump.	250 x 8	Outside	None

* Estimated distance in feet between resource and bank erosion.

3.4 Geomorphic Classification

Using information gathered from the field reconnaissance as previously noted, along with data, maps and other information collected, the Cuyahoga River between Bath Road and Rockside Road is classified as a "C5" stream type with some sections of the river classified as an "F5" stream type. This is further described in Appendix "B".

4.0 STABILIZATION ALTERNATIVES

4.1 General

Appendix "B" of this report describes the possible bank stabilization and in-channel measures for "C5" and "F5" stream types with respect to outside meanders, (outside bank) inside meanders (inside bank), and cross-over reaches (straight sections of river between bends).

Note that the areas identified as project areas in Section 3 of this report are almost exclusively outside meanders.

In-channel measures as described in Appendix "B" are most cost-effective if installed prior to the river moving close to, or encroaching on the resource, thus reducing or eliminating the need for bank stabilization. Once the river has moved to close proximity of, or has encroached upon the resource, the repair/stabilization of the riverbank will be sufficient to withstand the forces of the river, thus making the installation of in-channel measures unnecessary.

Appendix "B" recommends the use of structural and non-structural bank stabilization measures for outside meanders and cross-over reaches. This coincides with the methodology used on previous stabilization projects along the river.

As noted, a number of bank stabilization projects to protect the Valley Railway and Towpath Trail have been completed prior to this study. For these projects designs using gabions, rip-rap and piling as a means of protecting the bank were considered. Rip-rap was thought to be the most economical of the three, while providing the same strength and stability as the other alternatives. Root wads were also considered. However little is known about their use on a large river such as the Cuyahoga. Also, as they are much larger than rip-rap, it is anticipated that there would be greater disturbance of the existing bank and river for their installation, as compared to rip-rap. For these reasons, rootwads were not selected as a repair alternative.

Based on the previous stabilization projects, rip-rap should extend up the bank to the river water surface elevation that typically occurs for the 2-year storm event, or to the top of bank on the inside of the meander (most stabilization projects occur at a bend in the river). In some cases a water mark is visible on the bank, which could also be considered as the water surface elevation for the 2-year storm event. Above these elevations, the velocity of the water generally decreases as the water in the river exceeds the top of the normal channel and spills over onto adjacent floodplain (on the inside of the meander).

As the velocity decreases, the erosive forces also decrease. This allows for stabilizing the bank (above the rip-rap) using vegetation. Figures 1 through 3 illustrate these repair techniques. On slopes that are 2:1 or less, the bank is revegetated using a live brush mattress (Figure 1). On slopes between 2:1 and 1.5:1, the banks are revegetated using live plant cuttings. (Figure 2). Appendix "B" notes that shrubs and trees and/or live plugs may also be used to revegetate the banks. In areas

where the river channel is narrow and the river bank is in close proximity to the resource, a live crib wall would be constructed. This allows for vertical construction which results in less fill (rock) in the river channel, thus minimizing the effects of the repair on the hydraulics of the river. Note that the above is provided as a general guide. It is recommended that each area is studied prior to initiating permanent repairs to determine the most prudent repair alternative.

A typical section is also included for temporary or emergency repairs. Typically rip-rap or broken concrete is installed along the bank up to the normal high water level in the river channel (Figure 4).

5.0 COST ESTIMATES

5.1 General

A construction cost estimate has been prepared for areas where improvements have been recommended. Cost estimates are included in Table 5-1 (areas adjacent to the Valley Railway and Table 5-2 (areas adjacent to the Towpath Trail). Note that areas recommended for monitoring do not have an associated cost estimate.

**COST ESTIMATES FOR AREAS ALONG
THE VALLEY RAILWAY**

TABLE 5-1

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST MP 65.5/RM 12.30				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	121	TN	\$65.00	\$7,865.00
Site Preparation	1	LS	\$500.00	\$500.00
Temporary Access	1	LS	\$1,000.00	\$1,000.00
Restoration	250	SY	\$3.00	\$750.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Subtotal				\$11,115.00
Contingency (25%)				\$2,778.75
ESTIMATED CONSTRUCTION COST				\$13,893.75

TABLE 5-1

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST MP 64.3/RM 13.60				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Site Preparation	1	LS	\$1,000.00	\$1,000.00
Temporary Access	1	LS	\$1,000.00	\$1,000.00
Restoration	335	SY	\$3.00	\$1,005.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	1605	LF	\$16.00	\$25,680.00
Subtotal				\$29,685.00
Contingency (25%)				\$7,421.25
ESTIMATED CONSTRUCTION COST				\$66,791.25

TABLE 5-1

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST MP 63.0/RM 15.7				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	287	TN	\$65.00	\$18,655.00
Rock Fill	518	TN	\$45.00	\$23,310.00
Suitable Backfill	432	TN	\$15.00	\$6,480.00
Site Preparation	1	LS	\$2,000.00	\$2,000.00
Temporary Access	1	LS	\$2,000.00	\$2,000.00
Restoration	1000	SY	\$3.00	\$3,000.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	1000	LF	\$16.00	\$16,000.00
Subtotal				\$72,445.00
Contingency (25%)				\$18,111.25
ESTIMATED CONSTRUCTION COST				\$90,556.25

TABLE 5-1

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST MP 61.2/RM 17.8				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	7.5	TN	\$65.00	\$487.50
Rock Fill	662	TN	\$45.00	\$29,790.00
Suitable Backfill	2281	TN	\$15.00	\$34,215.00
Site Preparation	1	LS	\$500.00	\$500.00
Temporary Access	1	LS	\$3,000.00	\$3,000.00
Restoration	333	SY	\$3.00	\$999.00
Mobilization	1	LS	\$2,000.00	\$2,000.00
Planting	600	LF	\$16.00	\$9,600.00
Subtotal				\$80,591.50
Contingency (25%)				\$20,147.88
ESTIMATED CONSTRUCTION COST				\$100,739.38

TABLE 5-1

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST MP 61.1 to 60.8/RM 18.43 to 18.71				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	773	TN	\$65.00	\$50,245.00
Site Preparation	1	LS	\$2,000.00	\$2,000.00
Temporary Access	1	LS	\$5,000.00	\$5,000.00
Restoration	1,000	SY	\$3.00	\$3,000.00
Mobilization	1	LS	\$2,000.00	\$2,000.00
Planting	1080	LF	\$16.00	\$17,280.00
Subtotal				\$79,525.00
Contingency (25%)				\$19,881.25
ESTIMATED CONSTRUCTION COST				\$99,406.25

TABLE 5-1

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST MP 59.7 to 59.3/RM 19.89 to 20.23				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	183	TN	\$65.00	\$11,895.00
Rock Fill	228	TN	\$45.00	\$10,260.00
Suitable Backfill	450	TN	\$15.00	\$6,750.00
Site Preparation	1	LS	\$500.00	\$500.00
Temporary Access	1	LS	\$1,000.00	\$1,000.00
Restoration	133	SY	\$3.00	\$399.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	200	LF	\$16.00	\$3,200.00
Subtotal				\$35,004.00
Contingency (25%)				\$8,751.00
ESTIMATED CONSTRUCTION COST				\$43,755.00

TABLE 5-1

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST MP 57.35/RM 22.64				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	661	TN	\$65.00	\$42,965.00
Rock Fill	1155	TN	\$45.00	\$51,975.00
Suitable Backfill	1620	TN	\$15.00	\$24,300.00
Site Preparation	1	LS	\$1,000.00	\$1,000.00
Temporary Access	1	LS	\$2,000.00	\$2,000.00
Restoration	333	SY	\$3.00	\$999.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	1000	LF	\$16.00	\$16,000.00
Subtotal				\$140,239.00
Contingency (25%)				\$35,059.75
ESTIMATED CONSTRUCTION COST				\$175,298.75

TABLE 5-1

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST MP 57.25/RM 22.70				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	676	TN	\$65.00	\$43,940.00
Rock Fill	1329	TN	\$45.00	\$59,805.00
Suitable Backfill	1296	TN	\$15.00	\$19,440.00
Site Preparation	1	LS	\$500.00	\$500.00
Temporary Access	1	LS	\$1,000.00	\$1,000.00
Restoration	222	SY	\$3.00	\$666.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	600	LF	\$16.00	\$9,600.00
Subtotal				\$135,951.00
Contingency (25%)				\$33,987.75
ESTIMATED CONSTRUCTION COST				\$169,938.75

TABLE 5-1

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST MP 55.23/RM 25.60				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	615	TN	\$65.00	\$39,975.00
Rock Fill	240	TN	\$45.00	\$10,800.00
Suitable Backfill	656	TN	\$15.00	\$9,840.00
Site Preparation	1	LS	\$2,000.00	\$2,000.00
Temporary Access	1	LS	\$5,000.00	\$5,000.00
Restoration	1111	SY	\$3.00	\$3,333.00
Mobilization	1	LS	\$10,000.00	\$10,000.00
Planting	1866	LF	\$16.00	\$29,856.00
Subtotal				\$110,804.00
Contingency (25%)				\$27,701.00
ESTIMATED CONSTRUCTION COST				\$138,505.00

TABLE 5-1

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST MP 52.5/RM 29.40				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	81	TN	\$65.00	\$5,265.00
Culvert (Crossing Railway)	20	LF	\$150.00	\$3,000.00
Site Preparation	1	LS	\$500.00	\$500.00
Temporary Access	1	LS	\$2,000.00	\$2,000.00
Restoration	33	SY	\$3.00	\$99.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	400	LF	\$16.00	\$6,400.00
Subtotal				\$18,264.00
Contingency (25%)				\$4,566.00
ESTIMATED CONSTRUCTION COST				\$22,830.00

**COST ESTIMATES FOR AREAS ALONG
THE TOWPATH TRAIL**

TABLE 5-2

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST STA 530+00/RM 15.49				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	132	TN	\$65.00	\$8,580.00
Rock Fill	286	TN	\$45.00	\$12,870.00
Suitable Backfill	506	TN	\$15.00	\$7,590.00
Site Preparation	1	LS	\$1,000.00	\$1,000.00
Temporary Access	1	LS	\$5,000.00	\$5,000.00
Restoration	67	SY	\$3.00	\$201.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	300	LF	\$16.00	\$4,800.00
Subtotal				\$41,041.00
Contingency (25%)				\$10,260.25
ESTIMATED CONSTRUCTION COST				\$51,301.25

TABLE 5-2

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST RM 17.3				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	484	TN	\$65.00	\$31,460.00
Rock Fill	532	TN	\$45.00	\$23,940.00
Suitable Backfill	356	TN	\$15.00	\$5,340.00
Site Preparation	1	LS	\$2,000.00	\$2,000.00
Temporary Access	1	LS	\$1,000.00	\$1,000.00
Restoration	1111	SY	\$3.00	\$3,333.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	800	LF	\$16.00	\$12,800.00
Subtotal				\$80,873.00
Contingency (25%)				\$20,218.25
ESTIMATED CONSTRUCTION COST				\$101,091.25

TABLE 5-2

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST STA 650+00/RM 18.2				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	123	TN	\$65.00	\$7,995.00
Site Preparation	1	LS	\$500.00	\$500.00
Temporary Access	1	LS	\$10,000.00	\$10,000.00
Traffic Control	1	LS	\$2,000.00	\$2,000.00
Restoration	83	SY	\$3.00	\$249.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	200	LF	\$16.00	\$3,200.00
Subtotal				\$24,944.00
Contingency (25%)				\$6,236.00
ESTIMATED CONSTRUCTION COST				\$31,180.00

TABLE 5-2

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST STA 675+00 TO 680+00/RM 18.8 TO 19.2				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	2820	TN	\$65.00	\$183,300.00
Rock Fill	1681	TN	\$45.00	\$75,645.00
Suitable Backfill	7200	TN	\$15.00	\$108,000.00
Site Preparation	1	LS	\$2,000.00	\$2,000.00
Temporary Access	1	LS	\$5,000.00	\$5,000.00
Restoration	356	SY	\$3.00	\$1,068.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	2133	LF	\$16.00	\$34,128.00
Subtotal				\$410,141.00
Contingency (25%)				\$102,535.25
ESTIMATED CONSTRUCTION COST				\$512,676.25

TABLE 5-2

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST STA 710+00/RM 19.5				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	252	TN	\$65.00	\$16,380.00
Rock Backfill	376	TN	\$45.00	\$16,920.00
Suitable Backfill	713	TN	\$15.00	\$10,695.00
Site Preparation	1	LS	\$4,000.00	\$4,000.00
Temporary Access	1	LS	\$10,000.00	\$10,000.00
Restoration	207	SY	\$3.00	\$621.00
Mobilization	1	LS	\$2,000.00	\$2,000.00
Planting	440	LF	\$16.00	\$7,040.00
Subtotal				\$67,656.00
Contingency (25%)				\$16,914.00
ESTIMATED CONSTRUCTION COST				\$84,570.00

TABLE 5-2

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST STA 781+00/RM 20.88				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	411	TN	\$65.00	\$26,715.00
Rock Fill	337	TN	\$45.00	\$15,165.00
Suitable Backfill	144	TN	\$15.00	\$2,160.00
Site Preparation	1	LS	\$2,000.00	\$2,000.00
Temporary Access	1	LS	\$5,000.00	\$5,000.00
Restoration	90	SY	\$3.00	\$270.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	600	LF	\$16.00	\$9,600.00
Subtotal				\$61,910.00
Contingency (25%)				\$15,477.50
ESTIMATED CONSTRUCTION COST				\$77,387.50

TABLE 5-2

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST STA 940+00/RM 24.95				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	470	TN	\$65.00	\$30,550.00
Rock Fill	371	TN	\$45.00	\$16,695.00
Suitable Backfill	1458	TN	\$15.00	\$21,870.00
Site Preparation	1	LS	\$2,000.00	\$2,000.00
Temporary Access	1	LS	\$5,000.00	\$5,000.00
Restoration	222	SY	\$3.00	\$666.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	1333	LF	\$16.00	\$21,328.00
Subtotal				\$99,109.00
Contingency (25%)				\$24,777.25
ESTIMATED CONSTRUCTION COST				\$123,886.25

TABLE 5-2

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST STA 1010+00/RM 26.67				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	394	TN	\$65.00	\$25,610.00
Site Preparation	1	LS	\$3,000.00	\$3,000.00
Temporary Access	1	LS	\$3,000.00	\$3,000.00
Restoration	444	SY	\$3.00	\$1,332.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	1,070	LF	\$16.00	\$17,120.00
Subtotal				\$51,062.00
Contingency (25%)				\$12,765.50
ESTIMATED CONSTRUCTION COST				\$63,827.50

TABLE 5-2

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST STA 1045+00/RM 27.40				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	191	TN	\$65.00	\$12,415.00
Rock Fill	234	TN	\$45.00	\$10,530.00
Suitable Backfill	450	TN	\$15.00	\$6,750.00
Site Preparation	1	LS	\$1,000.00	\$1,000.00
Temporary Access	1	LS	\$5,000.00	\$5,000.00
Restoration	333	SY	\$3.00	\$999.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	400	LF	\$16.00	\$6,400.00
Subtotal				\$44,094.00
Contingency (25%)				\$11,023.50
ESTIMATED CONSTRUCTION COST				\$55,117.50

TABLE 5-2

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST STA 1060+00/ RM 27.60				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	823	TN	\$65.00	\$53,495.00
Rock Fill	743	TN	\$45.00	\$33,435.00
Suitable Backfill	1152	TN	\$15.00	\$17,280.00
Site Preparation	1	LS	\$2,000.00	\$2,000.00
Temporary Access	1	LS	\$5,000.00	\$5,000.00
Restoration	889	SY	\$3.00	\$2,667.00
Mobilization	1	SY	\$1,000.00	\$1,000.00
Planting	800	LF	\$16.00	\$12,800.00
Subtotal				\$127,677.00
Contingency (25%)				\$31,919.25
ESTIMATED CONSTRUCTION COST				\$159,596.25

TABLE 5-2

TASK ORDER 80 PRELIMINARY ESTIMATE OF CONSTRUCTION COST STA 1380+00/RM 35.30				
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
Rock Rip-Rap	158	TN	\$65.00	\$10,270.00
Rock Fill	244	TN	\$45.00	\$10,980.00
Suitable Backfill	1,624	TN	\$15.00	\$24,360.00
Site Preparation	1	LS	\$500.00	\$500.00
Temporary Access	1	LS	\$1,000.00	\$1,000.00
Restoration	222	SY	\$3.00	\$666.00
Mobilization	1	LS	\$1,000.00	\$1,000.00
Planting	667	LF	\$16.00	\$10,672.00
Subtotal				\$59,448.00
Contingency (25%)				\$14,862.00
ESTIMATED CONSTRUCTION COST				\$74,310.00

6.0 MONITORING PLAN

6.1 General

The recommended action for a number of areas included in this study is monitoring the area 2-3 times a year. Monitoring includes recording the rate of erosion (loss of riverbank) for the area to use in determining when to initiate riverbank repairs. By tracking loss of riverbank, and determining the average annual loss of bank, a projection may be made as to the time remaining before the river will encroach on the resource. This will in turn allow the NPS to plan and budget for bank stabilization at certain areas, rather than react to an area where the river is on the brink of encroachment on the resource.

6.2 Monitoring Station

A minimum of two monitoring stations should be established at each area to be monitored. Each station should consist of two straight metal rods (5/8 inch diameter reinforcing steel, or equal) permanently installed in the ground. Each rod should be approximately 4 feet long. After installation, the rod should be 6" to 12" above ground level. Both rods should have the same distance exposed. The first rod should be installed approximately mid-way between the bank and the edge of the resource. The second rod should be installed approximately mid-way between the first rod and the resource, but not more than 10 feet from the first rod. A cloth or metal tape measure would be used for measuring distance. Place the zero end of the tape on top of the rod closest to the resource. The tape should be extended directly over and past the second rod to the top edge of bank. This will insure the distance is measured along the same plane each time. Rods should be placed in inconspicuous locations and such that there are no obstructions along the path of measurement. Generally, the top edge of bank, as previously noted, is the point where the topography changes abruptly having an increased slope towards the river. In areas where the top edge of bank is not obvious, an additional rod could be installed as a reference to the perceived top edge of bank.

Areas that are longer than 200 feet should have more than two monitoring stations, with a spacing of approximately 100 feet between stations. Within each area monitored, a station should be placed where the bank is closest to the resource, and where erosion of the bank is the most active.

7.0 PERMITS

7.1 Requirements

Authorization from the Corps of Engineers is required for the proposed riverbank stabilization. Application should be made as soon as possible to allow time for review. After the submittal of the application and support information to the Corps of Engineers, a review will be made to determine the type of permit required, and whether or not public notice is required. If public notice is given, both the OEPA and Corps of Engineers must approve the application as well as other Federal and State agencies. Generally, the agencies prefer designs, in which the construction can be accomplished from the banks, with minimal disturbance to the river channel. We do not expect that a public notice will be required, but rather that a National permit authorization will be sufficient for the site.

7.2 Timetable

Time frames for approvals are based on agency backlog and so, cannot be accurately predicted. Generally, the Nationwide permit process is less time consuming (30-60 days). It is important that the application be complete when submitted to avoid delays. It is often better to provide more information than is required to ensure that all questions are answered.

7.3 Channel Fill

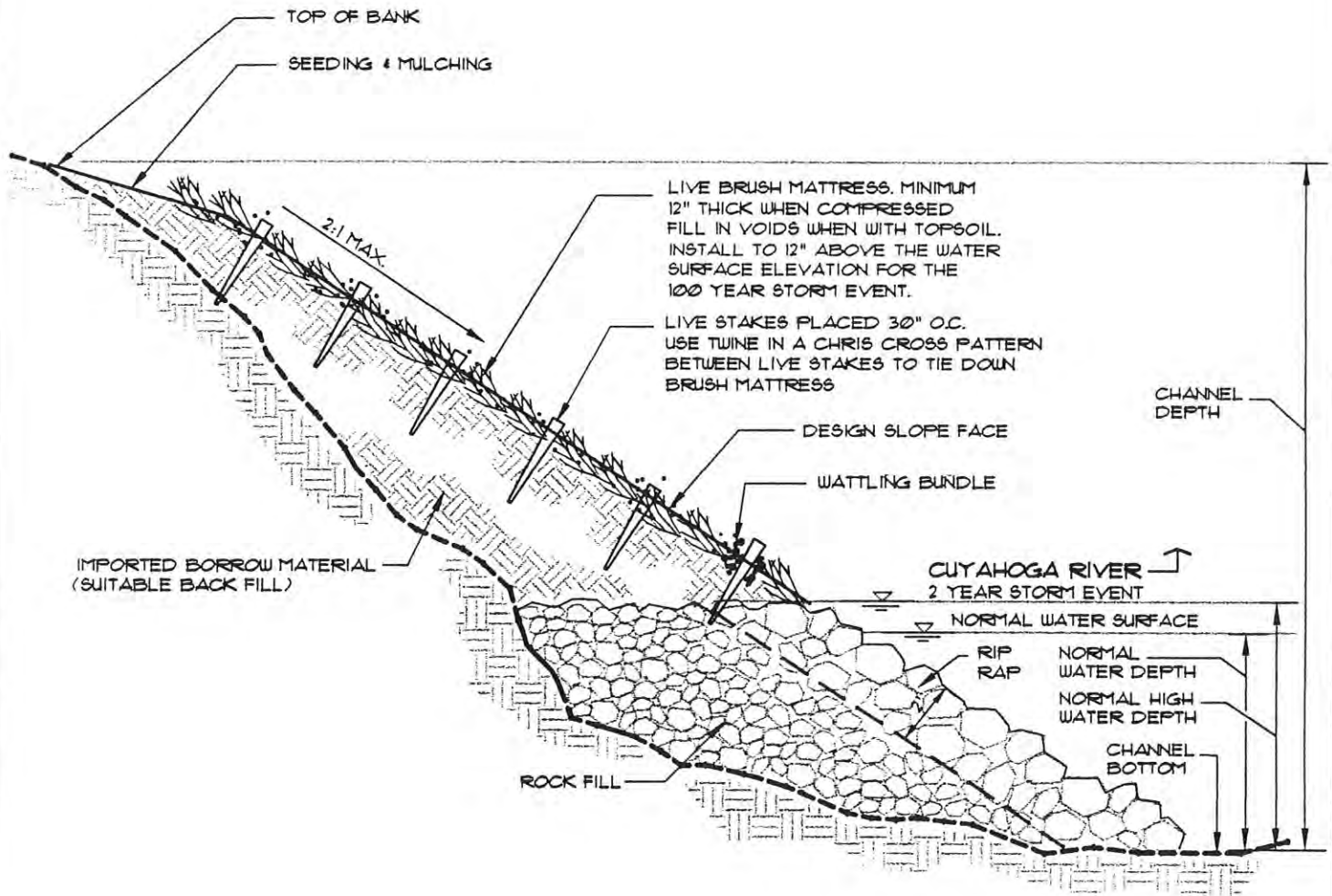
The application to the Corps of Engineers must include an estimate of fill within the river channel, and below the normal high water level. Table 7-1 (Areas Adjacent to the Valley Railway) and Table 7-2 (Areas Adjacent to the Towpath Trail) present a summary of estimated fill for each area previously noted to be repaired/stabilized. Note that areas recommended for monitoring only, do not have an estimate of fill. The volume of fill below the normal high water level was calculated based on a proposed bank slope of 1.5:1, and an existing bank slope of 0.5:1. The final quantities of fill will in all likelihood be different than those estimated in this report, as site conditions will have changed by the time repairs are implemented, and the final design for the repairs may result in a different bank slope than the 1.5:1 slope previously noted.

TABLE 7-1
TASK ORDER 80
ESTIMATE OF FILL BELOW NORMAL HIGH WATER LEVEL
AREAS ADJACENT TO THE VALLEY RAILWAY

MILE POST/ RIVER MILE	LENGTH (FT.)	EST. NORMAL WATER DEPTH (FT.)	EST. NORMAL HIGH WATER DEPTH (FT.)	EST. TOTAL CHANNEL DEPTH (FT.)	EST. FILL (CY/LF)
65.5/12.3	1,000	6	10	12	2.59
63.0/15.7	300	6	14	18	5.70
61.2/17.8	300	3	13	16	4.57
61.1/18.43	1,500	3	8	13	0.37
59.7/19.89	2,000	4	8	14	2.96
57.35/22.64	250	8	15	20	6.94
57.25/22.70	100	8	15	20	6.94
55.23/25.60	200	7	14	34	14.00
52.5/29.40	100	4	8	12	0.59

TABLE 7-2
TASK ORDER 80
ESTIMATE OF FILL BELOW NORMAL HIGH WATER LEVEL
AREAS ADJACENT TO THE TOWPATH TRAIL

STATION/ RIVER MILE	LENGTH (FT.)	EST. NORMAL WATER DEPTH (FT.)	EST. NORMAL HIGH WATER DEPTH (FT.)	EST. TOTAL CHANNEL DEPTH (FT.)	EST. FILL (CY/LF)
530+00/ 15.49	50	6	12	21	6.67
17.3	200	6	9	12	2.50
650+00/ 18.2	400	6	17	23	2.27
675+00 to 680+00/ 18.8 to 19.2	1600	2	10	12	2.59
710+00/ 19.5	310	4	10	16	4.15
781+00/ 20.88	200	6	8	10	1.78
940+00/ 24.95	400	2	6	11	1.80
1010+00/ 26.67/	200	4	11	15	1.46
1045+00/ 27.40	100	4	9	14	3.17
1060+00/ 27.60	400	4	10	12	2.59
1380+00/ 35.30	250	1	11	21	6.31



LIVE BRUSH MATTRESS WITH RIP-RAP SLOPE STABILIZATION

NOT TO SCALE

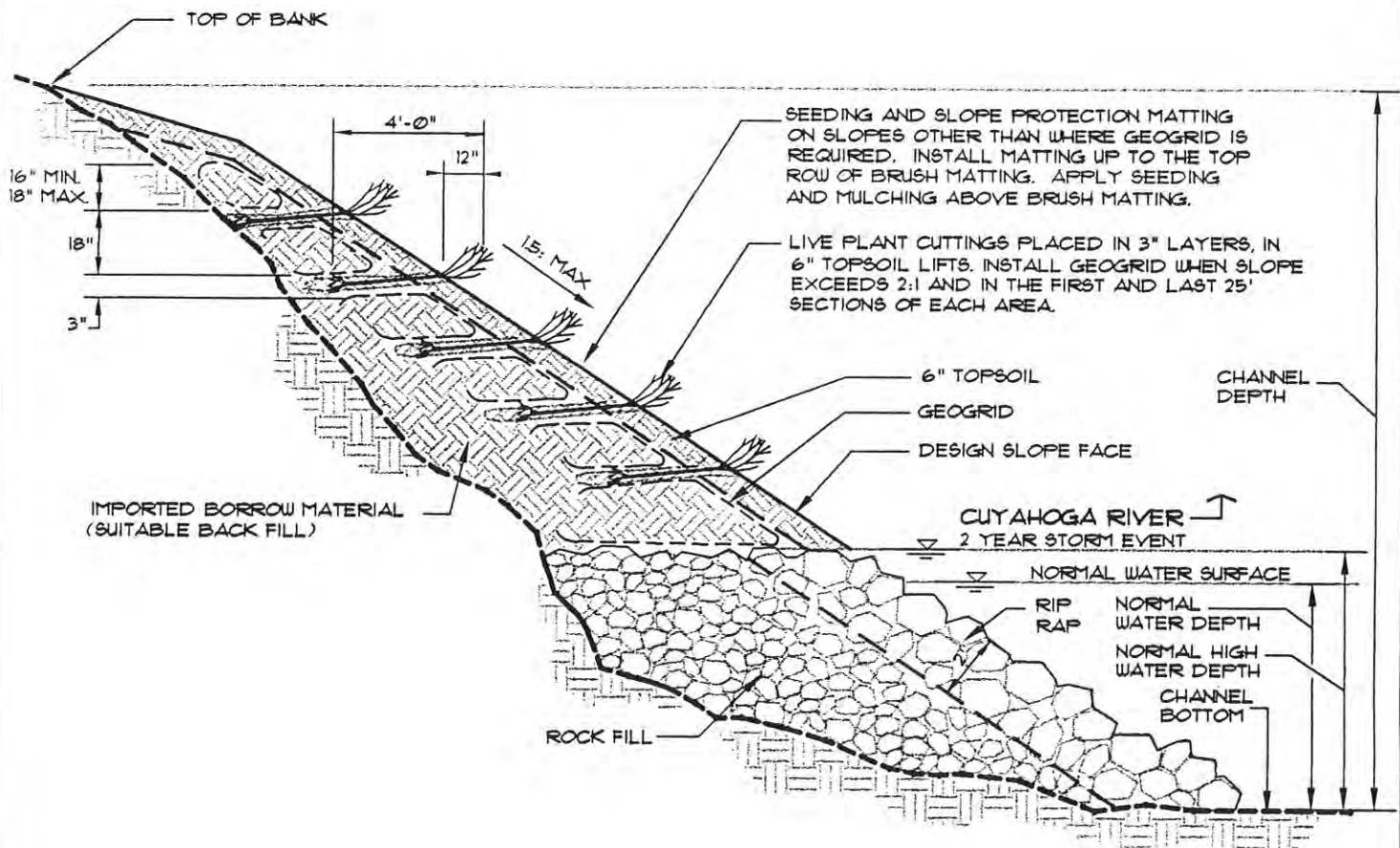
FOR USE WHERE RECONSTRUCTED BANK SLOPE IS 2:1 OR LESS



MARCH 1991

TASK ORDER 80
CUIAHOGA RIVER BANK
EROSION STUDY

FIG. 1



BRANCH LAYERING WITH RIP-RAP SLOPE STABILIZATION

NOT TO SCALE

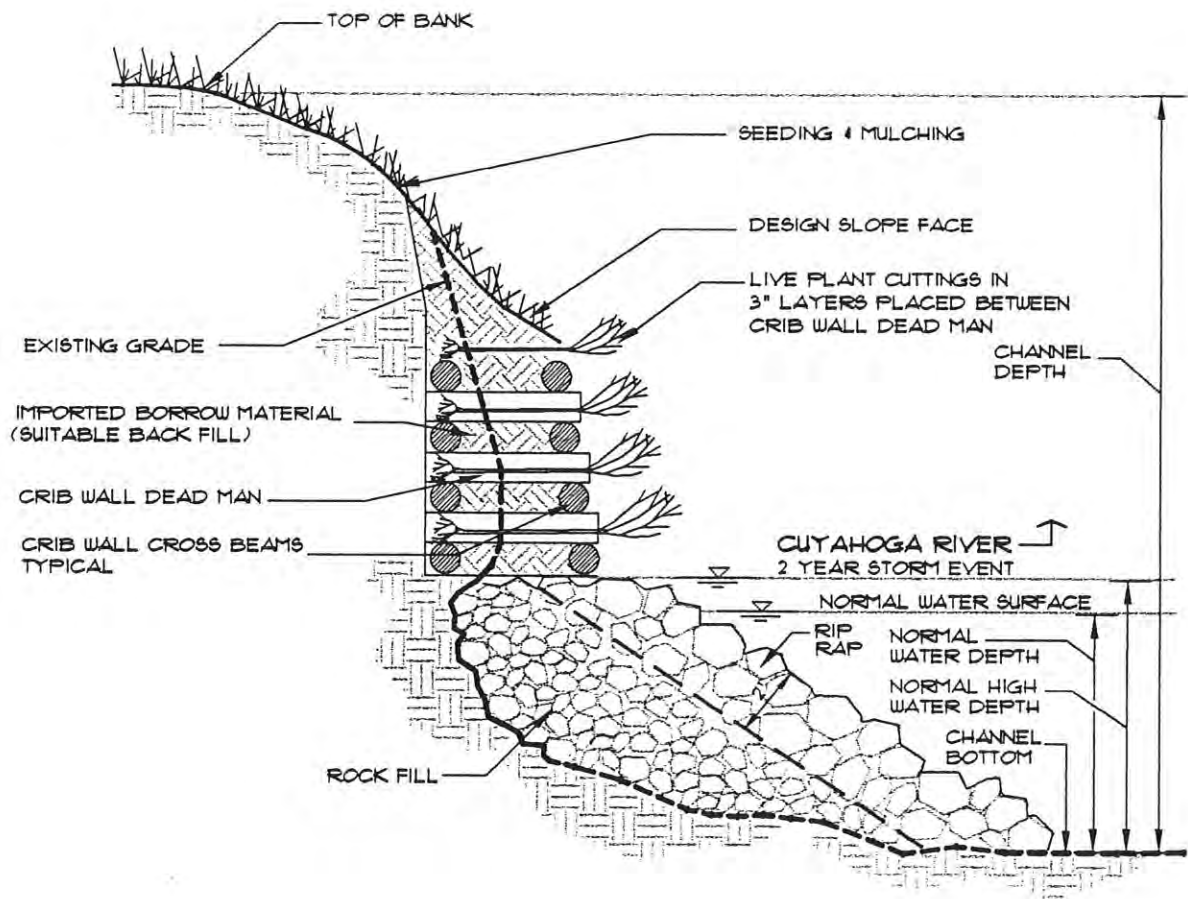
FOR USE WHERE RECONSTRUCTED BANK SLOPE IS BETWEEN 2:1 AND 1.5:1.



MARCH 1991

TASK ORDER 80
CUYAHOGA RIVER BANK
EROSION STUDY

FIG. 2



LIVE CRIB WALL WITH RIP-RAP SLOPE STABILIZATION

NOT TO SCALE

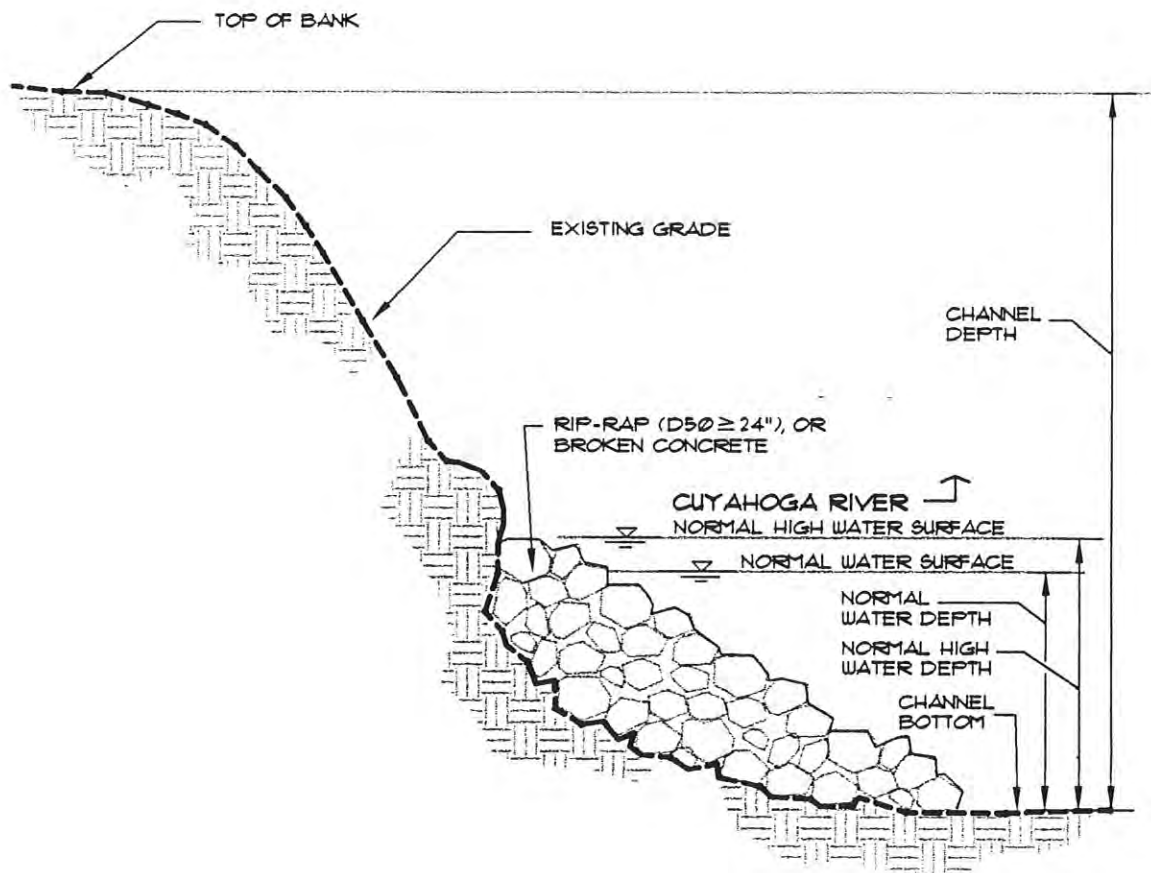
FOR USE WHERE BANKS ARE VERTICAL AND/OR DISTANCE BETWEEN TOP OF BANK AND RESOURCE PRECLUDES CONSTRUCTING A BANK SLOPE OF 15:1 (MAX.).



MARCH 1997

TASK ORDER 80
CUYAHOGA RIVER BANK
EROSION STUDY

FIG. 3



TEMPORARY / EMERGENCY SLOPE STABILIZATION

NOT TO SCALE

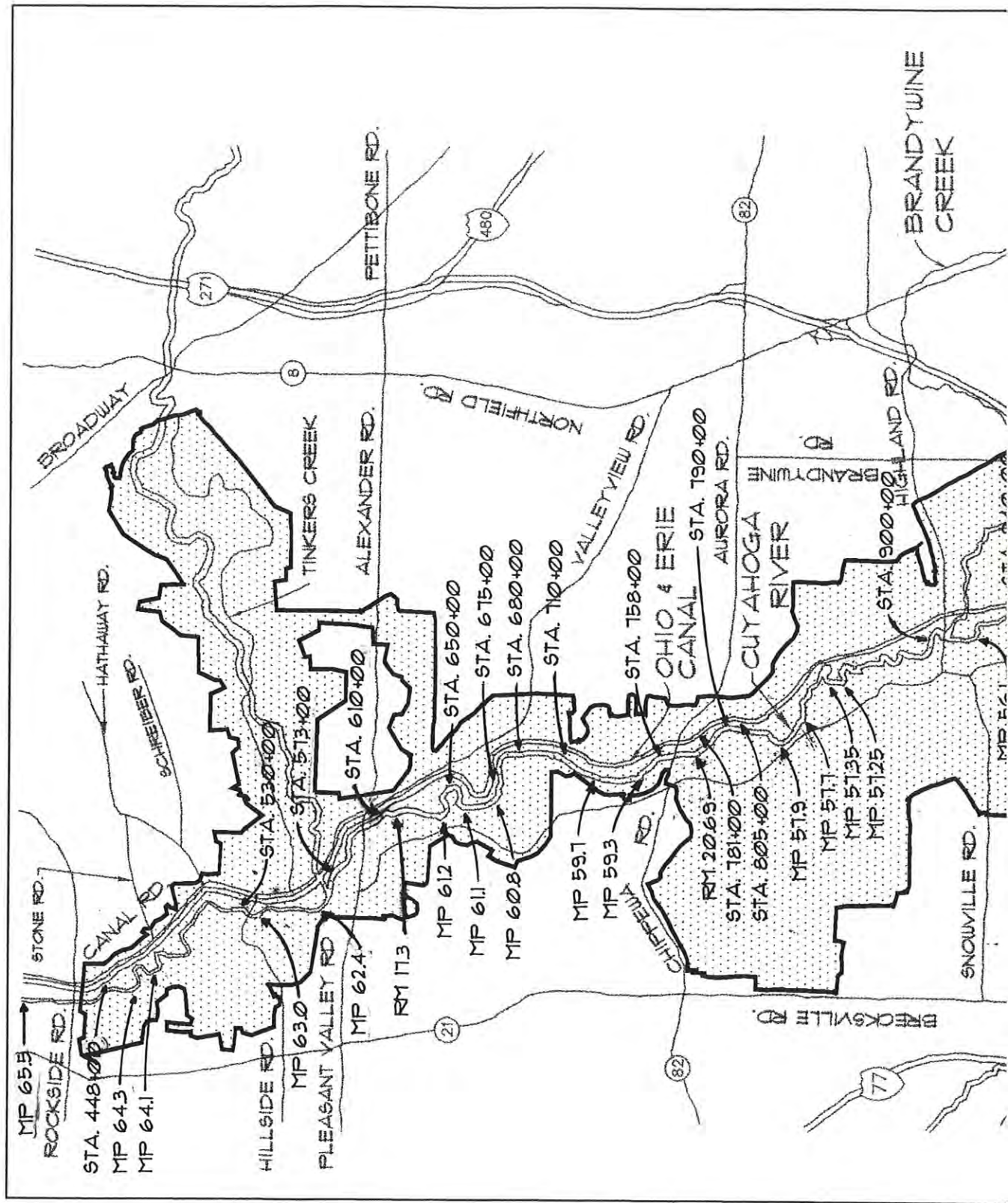


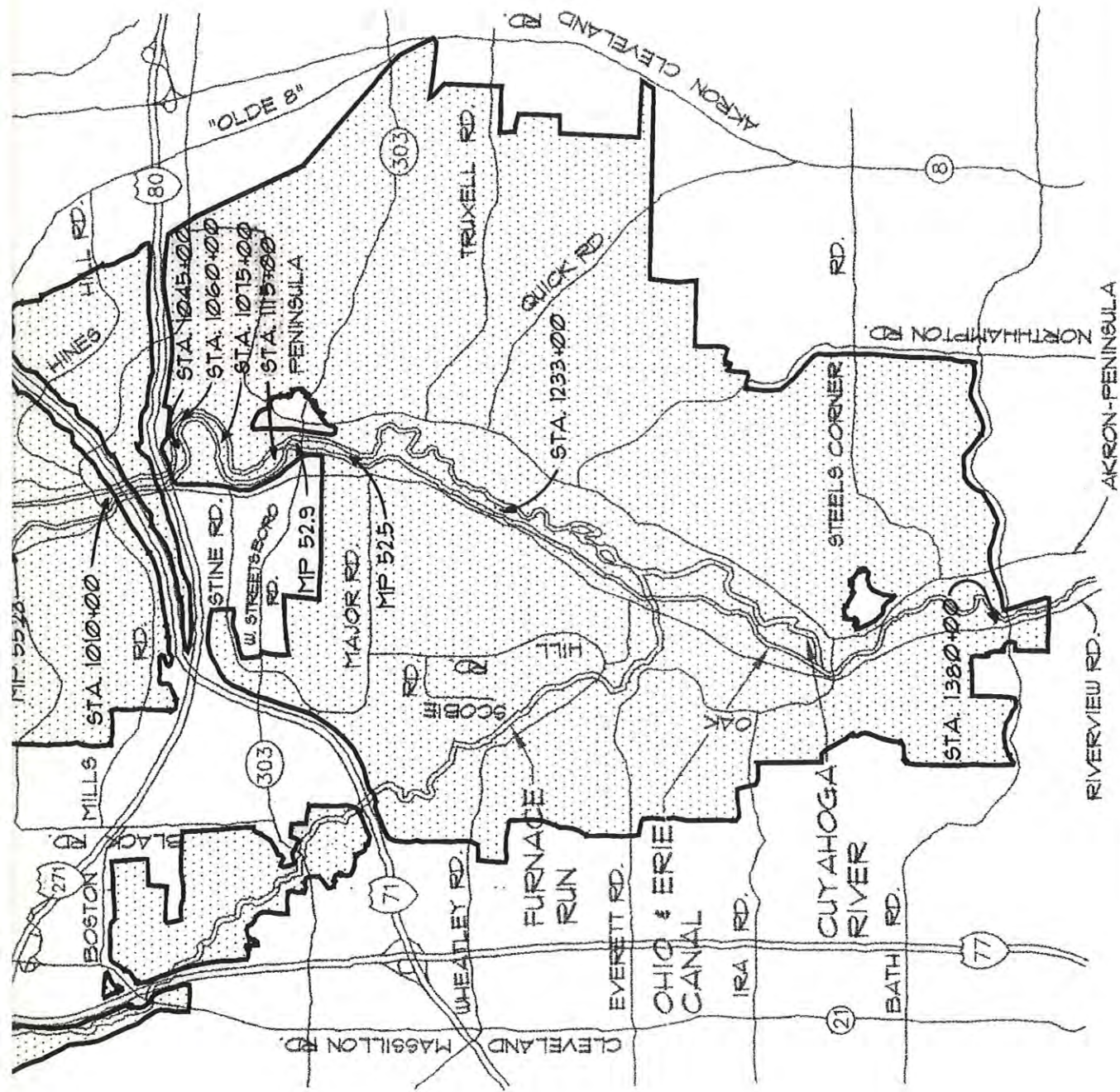
MARCH 1991

TASK ORDER 80
CUYAHOGA RIVER BANK
EROSION STUDY

FIG. 4

APPENDIX A





KEY MAP



3-2-92

1"=500'

ROCKSIDE ROAD

4263-3-3

STA. 448+00
RM. 13.40

MP 64.3
RM. 13.60

MP 64.1
RM. 14.20

TOUPATH RAIL

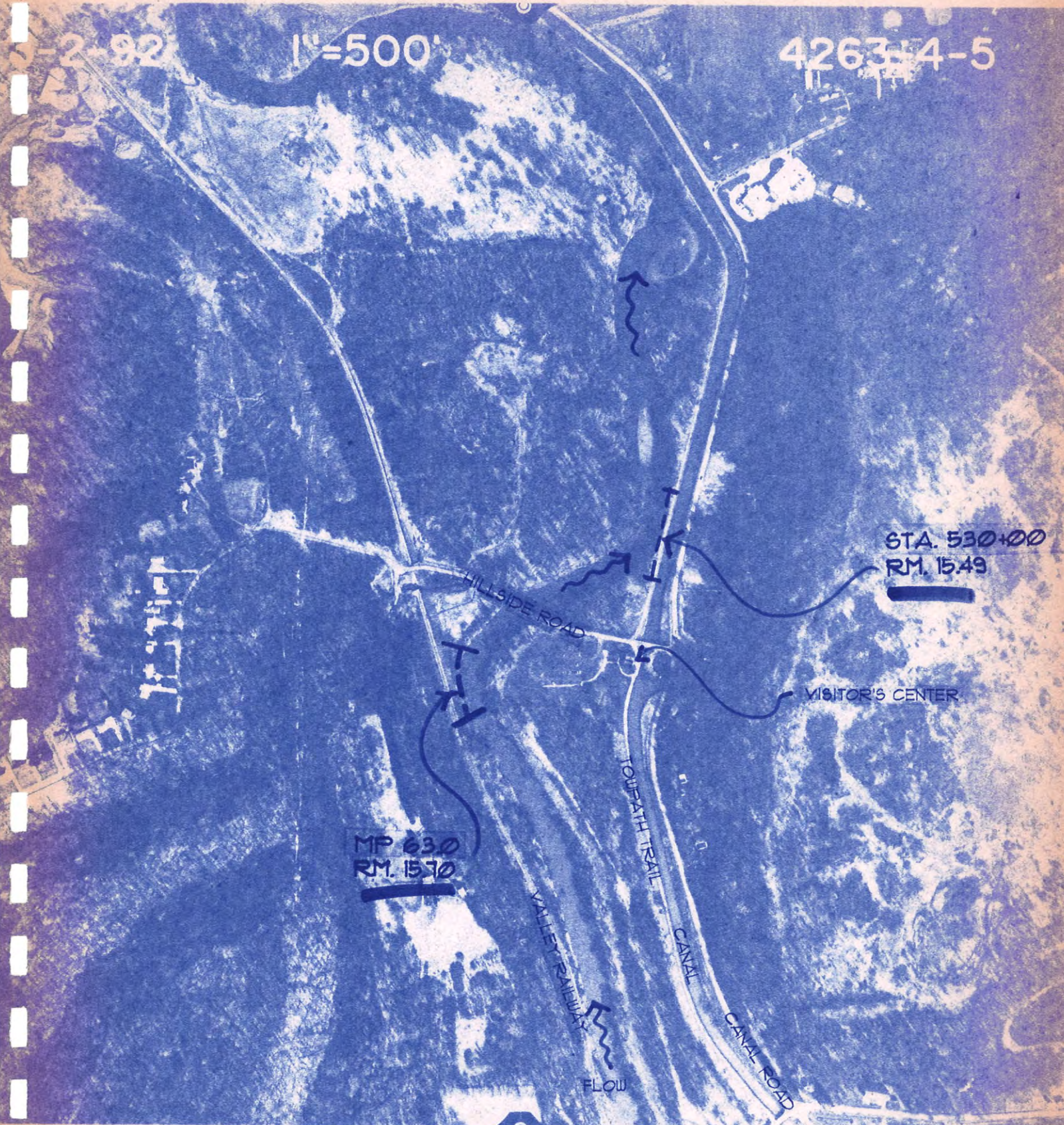
CANAL ROAD

CUYAHOGA RIVER

VALLEY RAILWAY

STONE ROAD

FLOW



2-92

1"=500'

4263-4-7



3-2-92

1"=500'

4263-5-8

PLEASANT VALLEY ROAD

STA. 610+00
RM. 1719

RM. 1730

VALEY RAILWAY

FITZWATER ROAD

CANAL ROAD

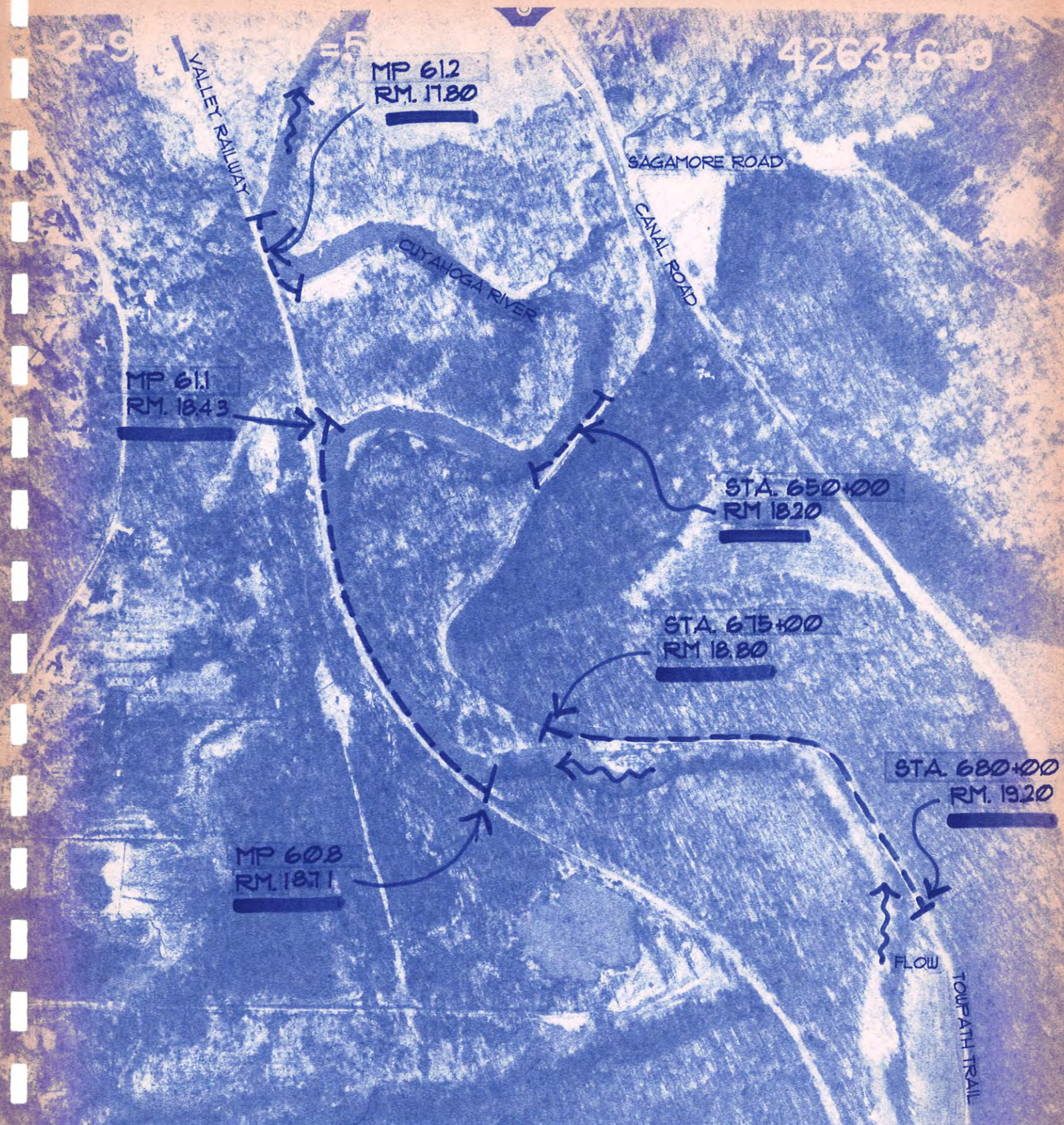
TOUPATH TRAIL

CUYAHOGA RIVER

MP 612
RM 17.80

FLOW

4263-6-9



2-92

1"=500'

4263-6-10

CANAL ROAD

FLOW

CUYAHOGA RIVER

TOUPATH TRAIL

VALLEY RAILWAY

STA. 710+00
RM. 1950

5-2-92

1"=500'

4263-6-13

MP 59.7
RM. 19.89

MP 59.3
RM. 20.23

FLOW

TOUPATH TRAIL
CUYAHOGA RIVER

STA. 758+00
RM 20.45

SR 82

3-2-92 1:500

4263-6-15



3-2-92

1"=500'

426

7-14

STA. 781+00
RM. 20.88

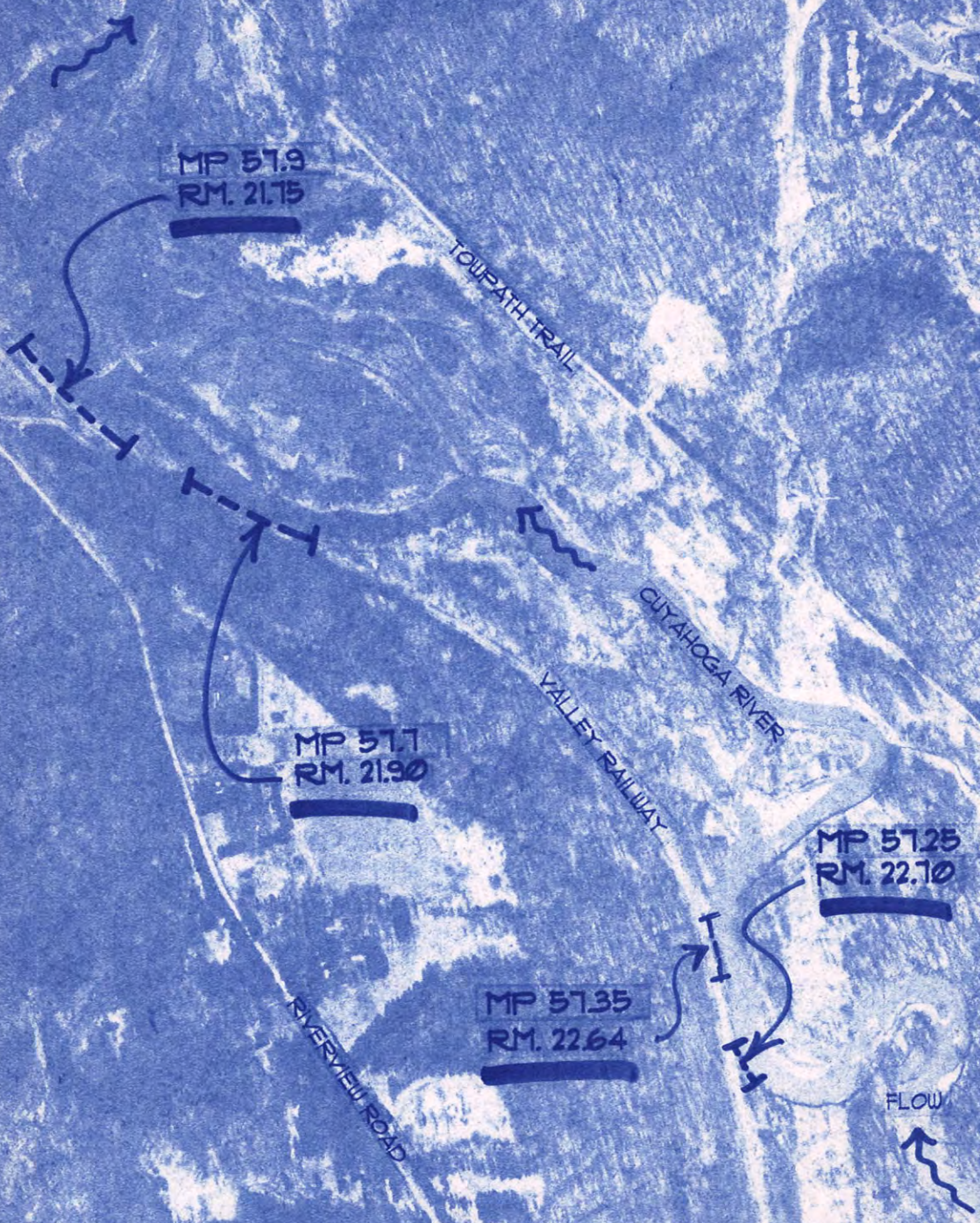
STA. 790+00
RM. 20.93

STA. 805+00
RM. 21.18

3-2-92

1"=500'

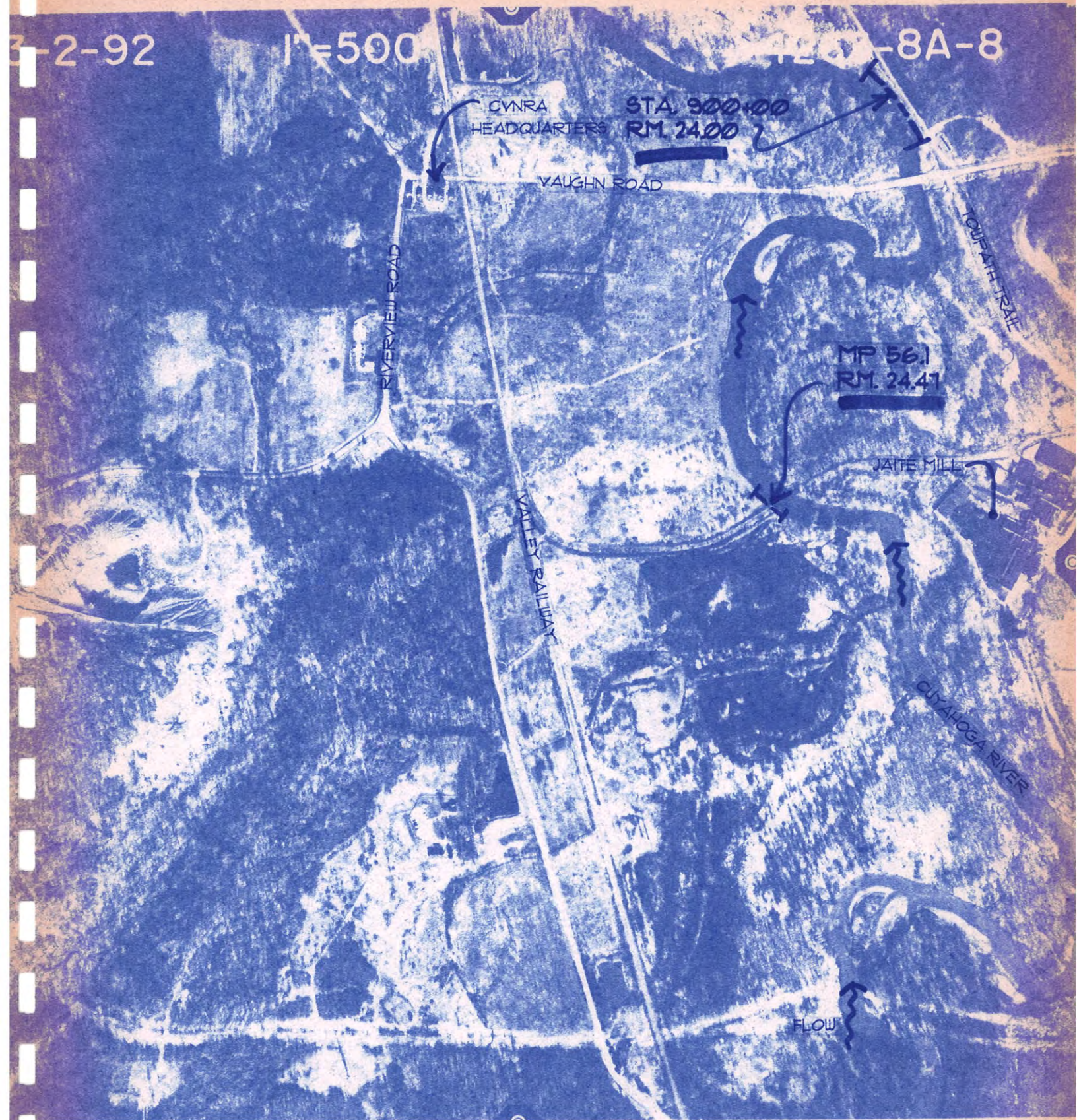
4-263-7-16



3-2-92

1"=500'

420-8A-8



3-2-92

1"=500'

426



STA. 940+00
RM. 24.95

COLUMBIA ROAD

MP 55.23
RM. 25.60

RIVERVIEW ROAD

CUYAHOGA RIVER

FLOW

VALLEY RAILWAY



1"=50'

4263-10A-10

STA. 1045+00
RM. 27.40

STA. 1060+00
RM. 27.60

STA. 1075+00
RM. 27.95

3-2-92

1"=500'

4263-10A-13

STA. 1115+00
RM. 28.76

MP 52.9
RM. 29.05

PENINSULA

SR 303

MP 52.5
RM. 29.40

RM. 29.61

TOUPATH TRAIL

FLOW

VALLEY RAILWAY

CUYAHOGA RIVER

RM. 29.73

3-2-92

1"=500'

4263-10A-15

RIVERVIEW ROAD

VALLEY RAILWAY

TOUPATH TRAIL

FLOW

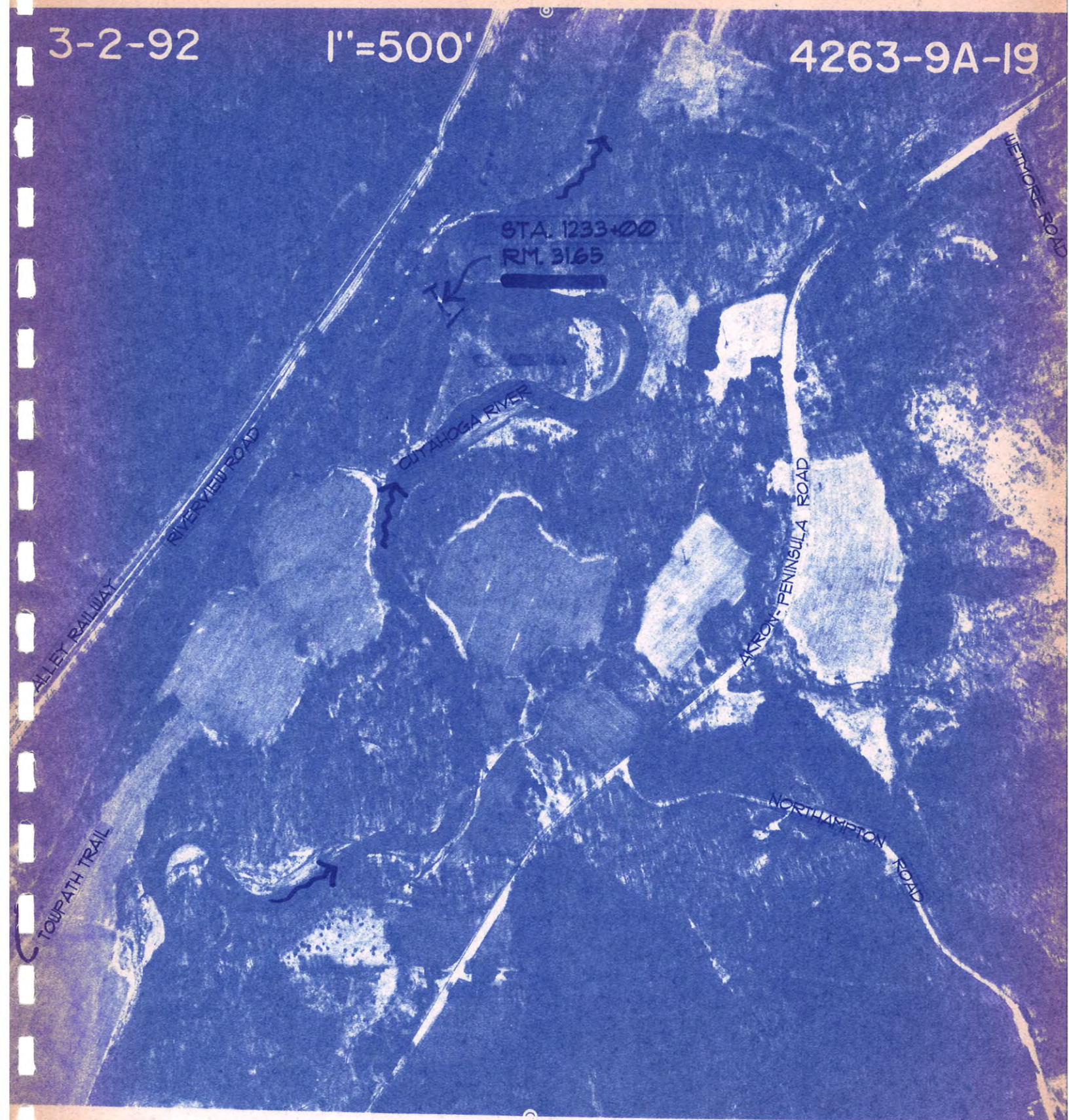
FLOW

AKRON-PENINSULA ROAD

3-2-92

1"=500'

4263-9A-19





APPENDIX B

Fluvial Geomorphological Assessment of the Cuyahoga River

Prepared for:

Cuyahoga Valley National Recreation Area
National Park Service

Prepared by:

Biohabitats, Inc.
303 Allegheny Ave
Towson, Maryland 21204

(410) 337-3659

Fluvial Geomorphological Assessment of the Cuyahoga River

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January 19, 1995

INTRODUCTION

Report Purpose

The purpose of this report is to summarize the findings of a broad geomorphic characterization (Level I) and morphological description (Level II) of the Cuyahoga River located within the Cuyahoga Valley National Recreation Area (CVNRA). This assessment was conducted to determine the predominant fluvial geomorphological characteristics of the Cuyahoga River relative to stream bank erosion and stream bank stabilization and restoration methodologies.

The purpose of the broad geomorphic characterization is to provide a general characterization that integrates landform and fluvial features of valley morphology with channel relief, pattern, shape and dimension. A Level I assessment combines the influences of climate, depositional history and life zones on channel morphology. The Level II assessment or morphological description classifies the stream into major delineative categories related to channel form and function (Rosgen, 1993).

This report does not include a complete stream "state" or condition assessment (Level III) and monitoring inventory (Level IV). Future planning considerations and restoration methodologies may warrant the completion of Level III and Level IV assessments prior to the final design process.

Study Area

The study area encompassed the Cuyahoga River Valley within the boundaries of the CVNRA located between the cities of Cleveland and Akron, in northern Ohio. The CVNRA includes 22 miles of the Cuyahoga River, portions of the Ohio and Erie Canal, and an active railroad system. Within the CVNRA, the study area extends from Bath Road to the south, to Rockside Road near the town of Independence. The study area is situated in two counties; Summit County to the south and Cuyahoga County to the north.

LEVEL I. BROAD GEOMORPHIC CHARACTERIZATION

This section includes a broad geomorphic characterization of the Cuyahoga River and associated landform including physiography, depositional history, relief, climate, soils, general river morphology.

Physiography

The Cuyahoga River flows south to north through the study area and drains to the St. Lawrence River Basin and Lake Erie at Cleveland. Within the study area, two major tributaries, Furnace Run and Tinkers Creek drain to the river. Approximately 707 square miles drain to the Cuyahoga River at Independence, as measured at a gaging station downstream of Old Rockside Road (Shindel, et.al., 1994).

The River Valley encompasses two physiographic provinces; the Southern New York section of the Appalachian Plateaus Province and the Eastern Lakes section of the Central Lowlands Province. The Appalachian Plateau is characterized by undulating to rolling hills with a level floodplain and terraces and steeply incised stream valleys. Slippage and accelerated geological erosion are evident on the very steep soils and on rough broken land throughout much of the valley in Summit County (USDA-SCS, 1990).

The Central Lowlands Province is characterized by wide expanses of level or nearly level land interrupted by sporadic sandy ridges that are the last visible remnants of glacial-lake beaches. Much of this area was swamp prior to development (Shindel, et.al., 1994).

Depositional History

The underlying parent material of the Cuyahoga River Valley consists of two general age groups - those of the glaciated Wisconsin Age of the Pleistocene epoch (18,000 to 24,000 years ago) and those formed during the period since the last glaciation (10,000 to 15,000 years ago) (USDA-SCS, 1990 & USDA-SCS, 1980). Soils of the valley walls and valley terraces were formed in glacial outwash gravel and sand deposits or from slack-water deposits of silt and clay or lacustrine material. Bedrock underlying the glacial deposits is sandstone and shale. Recent alluvium consisting of silt loam and loam material occurs in the floodplain areas .

Geologic erosion on steep slopes has removed part of the soil as it formed and constantly exposes unaltered parent material to other soil forming factors. This is evident on the steep slopes along the Cuyahoga River, where frequent slips occur (USDA-SCS, 1990).

Relief

Topographic relief (within the study area) ranges from an elevation of approximately 725 feet to 590 feet -- representing a change in elevation of 135 feet over a valley length of 95,000 linear feet or a 0.14% valley slope.

Climate

The climate of the Cuyahoga River Valley region is characterized as humid, temperate and continental. The climate following glacial retreat was considerably damper and cooler than at present. Following a long period of climatic adjustment, stabilization to the present climate occurred (USDA-SCS, 1990). Soils in the study area formed under the influence of the present climate in a region mostly dominated by deciduous hardwood forest (USDA-SCS, 1980).

The Cuyahoga River Valley region has an annual rainfall of approximately 38 inches. Monthly precipitation typically is greatest from May through July and least in October, December, and February. Of the approximate 38 inches of average annual precipitation, 6 inches reaches the water table and 2 inches of the 6 eventually discharges to streams. The pattern of stream flow differs in this region from the pattern of precipitation because of the contributions of snow melt to stream flow in the early spring and the reduction in flows by evapotranspiration from June through September (Shindel, et.al., 1994).

Soils

The following is a description of the major soil associations identified within the study area by County:

Summit County

The river valley in Summit County is predominated by soils of the Chagrin - Holly - Lodbell Association. These soils are described as nearly level, well drained, poorly drained, and moderately well drained soils formed in medium textured recent alluvium. These soils are subject to flooding. Streams flowing through these soils typically follow a meandering channel which changes course from time to time. This association is underlain by sandy and gravelly material (USDA-SCS, 1990).

The valley walls in Summit County are mostly made up of soils of the Rough Broken Land association, with several smaller areas of Chili and Glenford - Fitchville Associations.

The Rough Broken Land Association is very steep land with slopes ranging from 35% to 70%. Tributary streams to the Cuyahoga and some narrower sections of the Cuyahoga flow through this association in deeply entrenched (horizontally confined), "V" shaped valleys. The association includes some very narrow areas with prominent escarpments (sandstone bedrock) from 100 to 150 feet in height. Many of the very steep slopes are unstable and are subject to frequent slippage during the winter and spring when wet. The upper slopes are more stable than the lower slopes as the upper part consists mostly of glacial till material.

The Chili Association is described as nearly level to steep, well drained soils formed in sandy and gravelly glacial outwash. Terraces and kames occur in intricate patterns throughout the association. Sand and gravel underlies these soils and the groundwater table beneath the association is a unique and valuable asset to the county.

The Glenford - Fitchville Association is described as nearly level to moderately steep, moderately well drained and somewhat poorly drained soils formed in silty lacustrine material. Areas within this association were ponded during glacial times. The association features several narrow areas with prominent escarpments where sandstone bedrock crops out in bluffs along the valley wall. (USDA-SCS, 1990)

Cuyahoga County

The river valley in Cuyahoga County is predominated by soils of the Chagrin - Tioga - Euclid Association. These soils are described as nearly level, well drained and somewhat poorly drained soils that formed in loamy and sandy alluvium and in silty and loamy deposits. This association is on the floodplain and low terraces bounded by slope breaks to the uplands. The soils are subject to flooding. Special measures are needed on some soils of this association to control stream bank erosion and to keep channels from cutting through the soils (USDA-SCS, 1980).

The valley walls of Cuyahoga County are made up of soils of the Geeburg - Mentor Association and soils of the Oshtemo - Urban Land - Chili Association.

The Geeburg - Mentor Association is described as steep to very steep, moderately well drained and well drained soils that formed in clayey and silty lacustrine sediments, and they are found on dissected parts of terraces. These soils are typically located along the walls of deeply entrenched "V" shaped valleys and ravines, and slippage from the lower slopes is common, especially where unvegetated.

The Oshtemo - Urban Land - Chili Association is described as urban land and nearly level to very steep, well drained soils that formed in stratified loamy and sandy glacial outwash. These soils are found on outwash terraces and beach ridges. Erosion of these soils is a serious hazard on moderately steep to very steep, unvegetated slopes. (USDA-SCS, 1980)

General River Morphology

The Cuyahoga River flows in a south to north direction within the study area, through a confined valley ranging from 500' to 4,200' wide, bordered by steep slopes and man-made confinements including the Erie Canal Towpath, a railroad, several parallel roadways and bridges.

The typical river system is divided into three main components: the collection system - the upper portion and tributary headwaters; the transportation system - the main river channel; and the depositional system located at the lower end of the watershed where sediments and water are usually dispersed. The Cuyahoga River represents the principle transporting system of the watershed and is identified as a 5th order (of magnitude) stream.

The following table lists gaging station data (drainage area and stream flow discharge rates) for select locations along the River. The drainage area of the Cuyahoga River entering the CVNRA encompasses approximately 404 square miles. By the time the river exits the CVNRA it has picked up an additional 303 square miles of drainage area, representing approximately 43% of the total drainage area to that point. This indicates that of all the water carried by the Cuyahoga River through the CVNRA, almost half the drainage area (43%) and discharge (49%) enter the system through tributaries and surface runoff that pass through the CVNRA boundaries.

Gaging Station Data

Major Stations	Drainage Area	Average Daily Discharge ¹
Cuyahoga River @ Hiram Rapids ²	151 sq. mi.	262 cfs
Cuyahoga River @ Old Portage	404 sq. mi.	572 cfs
Cuyahoga River @ Independence	707 sq. mi.	1,117 cfs
Tributary Stations	Drainage Area	Average Daily Discharge ¹
Yellow Creek @ Botzum	30.7 sq. mi.	44.25 cfs
Tinker's Creek @ Bedford	83.9 sq. mi.	173 cfs

NOTE:

- 1) Average Daily Discharges for 1992 and 1993.
- 2) Station is situated upstream of study area.

The valley and channel are characterized by a gentle gradient, predominated by riffle/pool sequences. Valley slope and channel slope are 0.14% and 0.10% respectively.

The river exhibits an irregular meander pattern with oxbows, oxbow lakes, and oxbow scars predominant throughout the valley. The river is characterized by stream banks of alternating height, alternating floodplain, and an alternating thalweg. Typically, the river is moderately entrenched, with a wide floodplain on the inside meander. Stream banks are predominantly vegetated with herbaceous and woody vegetation. Point bars consist of predominantly sandy loam mixed with gravel.

Land use within the CVNRA includes rural development, several small, clustered towns, and farmland. The riparian zone immediately adjacent to the river contains the Erie Canal towpath and railroad. Many areas are farmed, several of which are plowed to the waters edge. Forested buffers exist predominantly in locations where steep slopes prohibited farming. Relic weirs and dams, related to the canal, are located in the river throughout the CVNRA. Notable are the extensive dam and bridge structures at Pennisula.

Over the years, land use changes, bank armoring, bridge placement, and channel straightening have directly influenced the river's morphology and channel geometry. Where outside meanders are constrained by the railroad or bank armoring, meander geometry is reduced causing down-cutting of the river bed, increasing scour and bank erosion, and creating pressure on the opposing bank. Side bars and mid-channel bars are often located downstream of a tributary confluence, bank armoring, avulsions, or obstructions.

LEVEL II. MORPHOLOGICAL DESCRIPTION

Methodology

River systems are highly complex, diverse settings comprised of interrelated variables that affect fluvial processes and form. The morphology of the present day channel is governed by the laws of physics through observable stream channel features and related fluvial processes. Stream (or river) morphology is directly influenced by eight major variables including channel width, depth, velocity, discharge, channel slope, roughness of channel materials, sediment load, and sediment size (Leopold, et. al. 1964). (For the purpose of this report, not all variables were identified). However, it is important to note, that all of these variables are interdependent, with a change in one resulting in channel adjustments which change the others. These variables interact to produce a stream's dominant characteristics.

The stream classification methodology used for this assessment, the Rosgen Classification System (Rosgen, 1985) quantifies a stream's variables, or morphological characteristics, into varying levels of resolution, from broad characterization to site specific descriptions. Broad levels of interpretation are useful for planning purposes whereas, the more specific are useful for evaluation and ultimately, prediction. In general, morphological characteristics are indicative of stream potential, stability, and existing "state" -- assuming fluvial systems are constantly in a state of flux.

This classification system categorizes streams into seven major types on the basis of morphological features of stream channels and landform. Key variables used in the analysis include channel gradient, bankfull width and depth, sinuosity, valley confinement, and particle size of bed materials (See Table 1).

**Fluvial Geomorphological Assessment
of the Cuyahoga River**

LEVEL II DESCRIPTION

Table 1. Stream Classification Key Variables				
Channel Type	Channel Gradient	Width/Depth Ratio	Sinuosity	Entrenchment Ratio
A	4 to 10%	< 12	Low (< 1.2)	1 to 1.4
B	2 to 4%	> 12	Moderate (> 1.2)	1.41 to 2.2
C	< 1%	> 12	High (> 1.4)	> 2.2
D	1 to 2%	> 50	Unstable	> 2.2
E	< 2%	< 12	Very High (> 1.4)	> 2.2
F	< 2%	> 12	High (> 1.4)	1 to 1.4
G	2 to 4%	< 12	Moderate (> 1.2)	1 to 1.4

Each major stream type can be further classified based upon the dominance of the following particle sizes of the bed material:

- 1 - Bedrock
- 2 - Boulder
- 3 - Cobble
- 4 - Gravel
- 5 - Sand
- 6 - Silt

Sections of streams are classified on a minimum of 20 channel widths or 2 complete cycles (wavelengths). A stream may have specific reaches classified differently. This is possible because the channel classification system is based upon key morphological variables that change throughout a watershed.

Figures 1 & 2, Rosgen Classification Stream Channel Types, illustrate typical plan and cross sectional characteristics of the seven major stream types. The channel types have been given alpha designations and channel type progresses from high (A/B) to low gradient (C/D/E/F) systems. As gradient changes there is typically a corresponding change (an increase) in streams' width/depth ratio, floodplain width, and sinuosity.

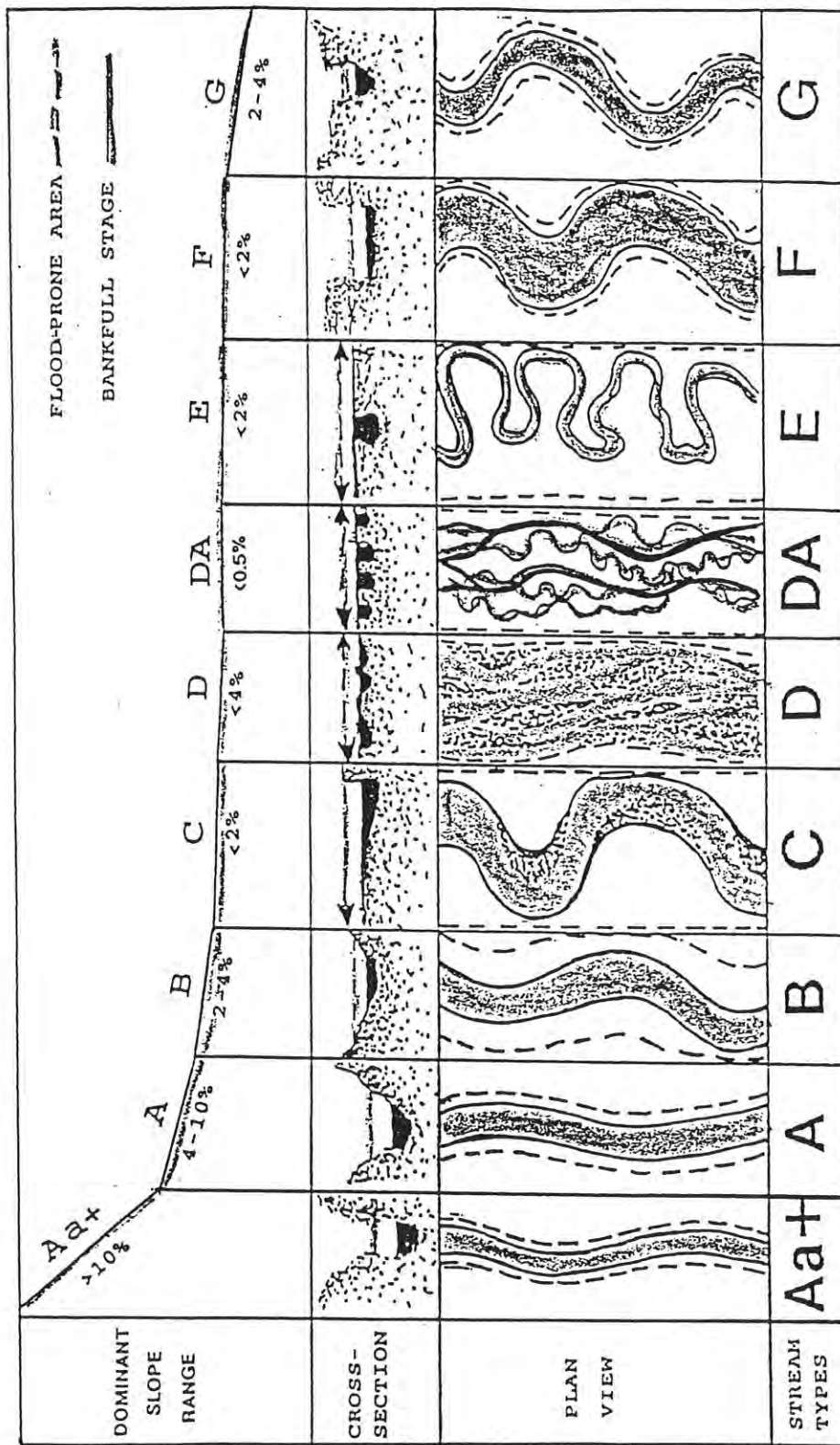


Figure 1. Longitudinal, cross-sectional and plan views of major stream types.

Dominant Bed Material	A	B	C	D	DA	E	F	G
1 BEDROCK								
2 BOULDER								
3 COBBLE								
4 GRAVEL								
5 SAND								
6 SILT/CLAY								
ENTRH.	<1.4	1.4-2.2	>2.2	N/A	>2.2	>2.2	<1.4	<1.4
SIN.	<1.2	>1.2	>1.4	<1.1	1.1-1.6	>1.5	>1.4	>1.2
W/D	<12	>12	>12	>40	<40	<12	>12	<12
SLOPE	.04-.099	.02-.039	<.02	<.02	<.005	<.02	<.02	.02-.039

Figure 3. Illustrative guide showing cross-sectional configuration, composition and delineative criteria of major stream types.

Classification

Based on field observations and data collected from maps, plans and literature, the river channel within the study area is predominantly a "C5" stream type. Some reaches were observed in the field to exhibit "F5" stream type morphology, however, without field-run data this classification cannot be confirmed.

C type channels are slightly entrenched systems which have a low gradient, high sinuosity, are dominated by riffle pool sequences, and moderate to high width-depth ratio. These streams are generally slightly entrenched and bankfull flows (typically a 1- 1.5 year storm event discharge) and larger storm events (e.g., greater than the 5 year storm event) have access to an active floodplain and are not contained within the channel. Therefore, during larger storm events, energy is dissipated onto the floodplain and the system remains fairly stable. Storm flow velocities within the channel tend to be moderate which results in some bank erosion along outside meanders and a few channel depositional features where inputs occur. C5 stream types are predominated by a sand substrate. The following are the parameters for a C stream type:

Entrenchment Ratio (ER):	> 2.2
Width/Depth Ratio (W/D)	> 12
Sinuosity (Sin.)	> 1.4
Channel Slope	< .02

The following data, gathered from map sources and field observation, supports the "C" classification. Calculations for each are shown:

Floodprone Area Width (FPA):	> 240'
Bankfull Width:	120' $\pm$
ER:	$> 240'/120' = > 2.0$
Bankfull width:	130'
Mean bankfull depth:	7'
W/D Ratio:	$130'/7' = 18.6$
Stream Length:	129,200'
Valley Length:	95,000'
Average Sin.:	$129,200'/95,000' = 1.36$
Relief	135'
Stream Length:	129,200'
Channel Slope:	$135'/129,200' = 0.10\%$

F type channels are similar to C's in that they are meandering, highly sinuous, riffle/pool, low gradient systems with a moderate to high width-depth ratio. The major difference is that F's are more entrenched than C's, and conversely, laterally unstable with high bank erosion rates. These streams are generally entrenched to such a degree that the bankfull flows and non-catastrophic flood flows may be contained within the channel and therefore, do not have access to a traditional wide floodplain for volume storage, energy dissipation, and sediment deposition. Consequently, storm flow velocities tend to be high within the channel itself which can result in a significant increase in bank erosion and channel depositional features.

F channel morphology is often indicative of a change from a previous channel morphology in response to changes in the watershed. For example, C type channels with erodible materials may respond to increases in runoff volumes or peak discharge durations by down-cutting, lateral bank erosion, or aggradation. The channel morphology will change as the stream attempts to adjust to its new energy regime. F channels are often thought of as "evolutionary" though it is important to note that natural F type geometries do occur and that major stream type morphologies are a function of valley landform, soil materials, and surface flow patterns. The following are the parameters for an F stream type classification:

ER	< 1.4
W/D	> 12
Sin	> 1.4
Slope	< .02

Management Interpretations for the Cuyahoga River

The following are general management interpretations for C5 and F5 stream types:

C5 stream type:

- Sensitivity to Disturbance (including increases to stream flow magnitude and timing and/or sediment increases): Very High
- Recovery Potential (assumes natural recovery once cause of instability is corrected): Fair
- Sediment Supply (includes suspended and bedload from channel derived sources and/or from stream adjacent slopes): Very High
- Stream bank Erosion Potential: High
- Vegetation Controlling Influence (vegetation that influences width/depth ratio-stability): Very High

The following bank stabilization and in-channel measures are considered for stream bank stabilization in the Cuyahoga River exhibiting a C5 stream type:

OUTSIDE MEANDERS

- **Do Nothing** - The Cuyahoga River will naturally migrate cross valley, eroding outside meander bends and building inside point bars. As long as this process does not effect existing resources, this process should be allowed to continue. It should be noted that cross valley migration will most likely accelerate as discharges to the river increase due to upstream development.
- **Remove Obstructions to Meander Migration** - An option may include construction bridges to allow the river to migrate cross valley without obstructions. This option will most likely be cost prohibitive, and therefore is not recommended.
- **Stabilize Outside Bends with Structural and Non-Structural Measures** - A host of structural and non-structural bank stabilization measures can be employed to arrest erosion and stabilize outside meander bends. Bank stabilization treatments can vary depending on their location relative to the bankfull discharge, or dominate discharge. Treatment measures below the bankfull elevation should consist of primary structural solutions while treatment above the bankfull elevation can include non-structural approaches. Recommended measures include:

BELOW BANKFULL

- Rock (Natural angular rock placed randomly to replicate natural features)
- Gabion Baskets
- Piling

ABOVE BANKFULL

- Live Branch Layering
 - Live Brush Mattress
 - Live Crib Wall
 - Live Plugs
 - Shrub and Tree Planting
- **Stabilize Outside Bends with In-Stream Structures** - Rock or log vanes can be used to "roll" off high flows away from the outside bank. These vanes emerge from the invert of the stream in the center of the channel and extend up to the bankfull elevation. They are placed so they are pointed upstream at an approximate angle of 30° from the bank. Vanes intercept the velocity vectors along the outside bank and roll them toward the center of the channel, creating a back-eddy effect for a distance downstream of the vane. Vanes can be used alone or in combination with the other measures described above.

INSIDE MEANDERS

- **Inside meanders should require no stabilization.** A well formed point bar that allows floodwaters access to the floodplain should be sustained.

CROSS-OVER

- **Stabilize Cross-Over Reaches with Structural and Non-Structural Measures** - If the River's meander geometry is in equilibrium with it's discharge then very little stabilization measures would be required to stabilize banks. However, this may not be the case and there are some areas of the River experiencing erosion in cross-over reaches, particularly immediately downstream of outside meanders. When necessary, these sections should be stabilized with a combination of structural and non-structural measures including:
 - Toe Rock tailing out (Natural angular rock placed randomly to replicate natural features)
 - Live Fascine w/wo Branch Layering
 - Live Brush Mattress
 - Live Plugs
 - Shrub and Tree Planting

F5 stream type:

- Sensitivity to Disturbance (including increases to stream flow magnitude and timing and/or sediment increases): Very High
- Recovery Potential (assumes natural recovery once cause of instability is corrected): Poor
- Sediment Supply (includes suspended and bedload from channel derived sources and/or from stream adjacent slopes): Very High
- Streambank Erosion Potential: Very High
- Vegetation Controlling Influence (vegetation that influences width/depth ratio-stability): Moderate

The following restoration and management strategies are considered for stream bank stabilization in the Cuyahoga River exhibiting an F5 stream type:

OUTSIDE MEANDERS & INSIDE MEANDERS

- **Do Nothing** - This is NOT an option with an F5 stream type due to entrenchment.
- **Lower the Floodprone Area** - An F5 stream type is entrenched, meaning that discharges exceeding the dominate discharge do not have access to their floodplain, and consequently are trapped within the active channel. To take stress off of the stream banks, the floodprone area on the inside of the point bars should be lowered to match the dominate discharge. This in combination with the other bank stabilization measures specified above for C5 stream types will stabilize outside meanders. Lowering the flood prone area may require significant disturbance to Park land and significant earthwork costs. These factors make lowering the flood prone area prohibitive. However bank stabilization procedures as described for "C5" stream types is still effective.
- **Inside meanders should require no stabilization.** A well formed point bar that allows floodwaters access to the floodplain should be sustained.

CROSS-OVER

- **Stabilize Cross-Over Reaches with Structural and Non-Structural Measures** - If the River's meander geometry is in equilibrium with it's discharge then very little stabilization measures would be required to stabilize banks. However, this may not be the case and there are some areas of the River experiencing erosion in cross-over reaches, particularly

immediately downstream of outside meanders. These sections should be stabilized with a combination of structural and non-structural measures including:

- Toe Rock tailing out (Natural angular rock placed randomly to replicate natural features)
- Live Fascine w/wo Branch Layering
- Live Brush Mattress
- Live Plugs
- Shrub and Tree Planting

CONCLUSION

The Cuyahoga River within the CVNRA is a highly complex, diverse setting comprised of interrelated variables that affect fluvial processes and form. The morphology of the channel is related to fluvial processes and is directly influenced by a set of interdependent variables. A change in one of these variables results in channel adjustments which change the other variables. These variables interact to produce a stream's dominant characteristics and "classification".

The Cuyahoga River (within the study area) is predominantly a "C5" classification. In general, this means that the river system is a low gradient, slightly entrenched, highly sinuous system, with a moderate to high width-depth ratio. The channel is dominated by riffle/pool sequences and carries a high sediment load (bedload) that is predominantly sand. The channel pattern is meandering, with banks of alternating height; the outside meander bank higher than the inside meander bank. Typically, some bank erosion is found along the outside meander, with the inside meander consisting of a stable, vegetated bar. During larger flows, energy is dissipated onto the floodplain and the system remains fairly stable.

Stream bank erosion potential is high where the river is confined and does not have access to a floodplain, either by valley confinement or man-made structures. The system is sensitive to disturbance, which includes changes in stream flow magnitude, timing or sediment increases -- symptoms usually associated with a watershed with increasing development and uncontrolled stormwater runoff. The natural recovery potential of the system is fair, assuming the cause of the instability is corrected (i.e. managing previously uncontrolled stormwater runoff).

However, the river system has a very high recovery potential if the cause of instability is addressed and the proper restoration techniques are implemented. Recommended restoration methodologies proven successful for C5 rivers include both watershed management strategies and in-stream stabilization measures. Watershed management strategies should consist of comprehensive stormwater management to replicate "pre-development" runoff rates, erosion and sediment control for construction sites, reforestation, stream buffer management and reforestation, and tributary stream restoration. This will require the cooperation of many governmental agencies, as there are numerous towns, cities and counties within the water shed for this river. In-stream measures include vegetative stabilization of stream banks, bank toe protection, rock/log vanes.

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