Lower Mahoning River, Pennsylvania
Environmental Dredging Reconnaissance Study

FINAL REPORT

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EXECUTIVE SUMMARY

This Lower Mahoning River Environmental Dredging Reconnaissance Study was conducted by the United States Army Corps of Engineers (USACE) pursuant to Section 312 of the Water Resources Development Act of 1990, as amended by Section 205 of the Water Resources Development Act of 1996. The amended Section 312 provides for the removal of contaminated sediments within "navigable waters" for the purpose of ecosystem restoration and identifies the Mahoning River, Ohio and Pennsylvania, due to the severity of contamination, as one of five rivers in the nation given top priority for removal and remediation of contaminated sediments.

Planning for projects to remove and remediate contaminated sediments is conducted in two phases: a reconnaissance phase and a feasibility phase. This report was prepared as part of the reconnaissance phase study, which is 100% federally funded. The feasibility phase requires identification of a local sponsor to cost share on a 50% Federal to 50% non-Federal basis.

The Mahoning River is 108 miles long, rising in Columbiana County, Ohio and flowing northward to Warren, Ohio and then southeasterly to New Castle, Pennsylvania, where it joins the Shenango River to form the Beaver River. In 1999, the Corps completed a reconnaissance study of a 31-mile stretch of the Lower Mahoning River located in northeastern Ohio, from Warren, Ohio (River Mile 42.9), to the Ohio-Pennsylvania border (River Mile 11.85). The reconnaissance study included a biological assessment, a sediment investigation, and an analysis of potential restoration alternatives. Based on the study findings, removal of contaminated material was recommended.

The purpose of this reconnaissance study was to complement the Ohio study and determine problems and opportunities for ecosystem restoration related to contaminated sediments in the Lower Mahoning River in Pennsylvania. The area of study included the 12-mile reach of the Lower Mahoning River that lies between the Ohio-Pennsylvania state line and the river's confluence with the Shenango River at New Castle.

The Lower Mahoning River in Pennsylvania has been identified as being moderately to severely impaired due to contaminated sediments originating from upstream industrial activity in the Ohio reaches of the river. The Lower Mahoning River project goal was to identify the activities and level of funding necessary to remediate the Lower Mahoning River within the study reach. The remediation, as conceived for this study, is intended to restore the aquatic ecosystem to the biotic integrity existing on a model reach of the Lower Mahoning River located just upstream of the study area. The success of the Lower Mahoning River, Pennsylvania, Environmental Dredging Project is linked to the restoration of the upstream Ohio portion of the Lower Mahoning River and the elimination of the Ohio Department of Health Public Health Advisory. The objective is to reestablish a fishable and swimable stream in compliance with the mandates of the Clean Water Act.

Restoration of the riverine habitat will benefit the aquatic ecosystem and serve as a focus for the revitalization of recreation along the Lower Mahoning River. The riparian corridor is mostly intact and aesthetically appealing. The principal opportunity is to return the river and its ecosystem to a healthy condition, thus allowing the river to become a scenic recreational resource that will serve as a focus for the revitalization of the Lower Mahoning River. This, in turn, would lead to economic benefits for the area.

In contrast to the Ohio portion of the Mahoning River, where the watershed is highly urbanized and historically intensely industrialized, the Pennsylvania portion of the Mahoning River was and continues to be primarily undeveloped. There are few urban areas in this portion of the basin. The city of New Castle is located between the confluence of the Mahoning and Shenango rivers. The communities of Edinburg and North Edinburg are located on the southern and northern sides of the river, respectively, at approximately RM 7. Land uses in the river basin also include rail and highway transportation corridors, a rails-to-trails corridor, agriculture, and coal mining.

The findings of the Pennsylvania sediment study revealed that the surficial silts and sands within the stream channel exhibited contamination concentrations above those reported in the control reach, but lower than those reported in (composited 0-4 feet-deep) sediments collected along the Ohio reach of the Mahoning River. The contaminants of concern were identified as total recoverable petroleum hydrocarbons (TRPH), polycyclic aromatic hydrocarbons (PAHs), chromium, copper, lead, and zinc. As with the Ohio sediments, no significant concentrations of pesticides/herbicides, volatile organic compounds, or PCBs were reported. In general, the banks exhibited contaminant concentrations similar to the channels. Where vertical profiling was performed, deeper bank materials exhibited higher TRPH concentrations than surface bank materials. In addition, samples collected at or near the bank/water interface exhibited higher TRPH concentrations than samples collected further upslope but below ordinary high water line.

The results of the biological assessment reflect a potentially recovering ecosystem. Although degraded, the fishery showed a trend towards improvement when compared to historical conditions. The Pennsylvania Fish and Boat Commission fish sampling data from 1999 also indicates a possible rebound of the fishery in the Mahoning River. Overall, it appears that the lower 12 miles of the Mahoning River, though degraded in comparison to the reference area, supports a viable biotic community that could be enhanced through restoration activities.

Based on previously collected information as well as the data collected for this study, six restoration alternatives, identified as Plan 1 to Plan 6, were formulated and evaluated. Recommendations for implementation were analyzed based on their costs, technical feasibility, and their potential socio-economic and environmental impacts.

The selection of a preferred alternative plan is based upon considering anticipated actions in the Ohio reach of the river, which include: (1) no action is taken in Ohio or (2) action is taken in Ohio. The preferred alternatives are:

(1) If no action is taken in Ohio, the potential benefits of extensive work in the downstream Pennsylvania reach of the river are considered limited by the upstream conditions. Therefore, the preferred alternative under this scenario is the selective habitat enhancement plan (Plan 2). The total project cost for Plan 2 could be scoped to suit specific objectives.

(2) If action is taken in Ohio, the potential benefits of compatible actions in Pennsylvania may be maximized. Therefore, if action is taken upstream, the preferred alternative is alternative Plan 5, Hydraulic Dredging and Bank Excavation of the Entire Reach. The total project cost for Plan 5, including engineering and design, is $42.4 million and detailed in Table 4-6 and Table 4-9. Construction cost are cost-shared on a 65% Federal to 35% non-Federal basis.

Identification of a non-Federal sponsor will allow the study process to continue. The sponsor must agree to pay one-half of the cost of the Feasibility Study, the next step in the restoration effort. The Feasibility Study is estimated to cost in the range of $1.5 to $2 million. Once a non-Federal sponsor is identified, a project study plan will better define the Feasibility Study cost.

1.0 INTRODUCTION

1.1 Study Authority

This Lower Mahoning River, PA Environmental Dredging Reconnaissance Study was conducted by the United States Army Corps of Engineers (USACE) pursuant to Section 312 of the Water Resources Development Act of 1990, as amended by Section 205 of the Water Resources Development Act of 1996. The amended Section 312 provides for the removal of contaminated sediments within "navigable waters" for the purpose of ecosystem restoration, if such removal is requested by a non-federal sponsor, and if that sponsor has agreed to pay 50 percent of the cost of removal and 100 percent of the cost of disposal. Planning for projects to remove and remediate contaminated sediments is conducted in two phases: a reconnaissance phase and a cost-shared feasibility phase. This report was prepared as part of the reconnaissance phase study.

1.2 Purpose and Scope

The Mahoning River lies mostly in northeastern Ohio. The portion of the Mahoning River below Warren, Ohio at River Mile (RM) 46 is referred to as the "lower Mahoning River." This reconnaissance study addresses problems and opportunities for ecosystem restoration throughout the reach of the lower Mahoning River that lies between the Ohio-Pennsylvania state line (RM-11.85) and the River's confluence with the Shenango river at New Castle, PA (RM 0), which is degraded because of contaminated sediments (Plate 1). Although there has been limited industry and few significant sources of pollution in this 12-mile reach of the Mahoning River, sediments are likely to be contaminated because of intense historical industrial pollution upstream in the Warren/Youngstown, Ohio corridor. River Miles referred to in this report are USACE River Miles, and differ from Ohio Environmental Protection Agency (OEPA) River Miles used in OEPA's reports.

Previous studies have indicated that sediments and riverbanks of the Mahoning River are contaminated, but a comprehensive multi-disciplinary investigation directed specifically towards the restoration of the river has not been undertaken. These previous studies included assessments of sediments, bank materials, fish, water quality, and river biota in the Mahoning River. In addition to the review of existing information, this reconnaissance study also included both a biological assessment and a sediment quality survey. One investigation focused on determining the chemical and physical characteristics of contaminated river sediments and bank materials, and provided an estimate of the volume of contaminated materials. The other investigation was a quantitative assessment of the instream biological condition of the river.

Based on historical information as well as the data collected for this study, various restoration alternatives were formulated and evaluated. Recommendations for implementation were presented based on their benefits to the aquatic ecosystem, costs, and feasibility, as well as their impacts on natural, cultural, and socioeconomic resources.

1.3 Prior Studies

In 1998, the Corps prepared a reconnaissance study of the Ohio portion of the lower Mahoning River which described the historical sources of pollution, and the occurrence of contaminated sediments upstream of the 12-mile reach evaluated in the present study. The study (hereafter also referred to as "the Ohio study") focused on a 31-mile stretch of the Mahoning River, from Warren Ohio (RM 42.9) to the Ohio-Pennsylvania border (RM 11.85). The reconnaissance study included a biological assessment, a sediment investigation, and an analysis of potential restoration alternatives. Based on the findings of the Ohio study, the preferred restoration plan included the dredging of all contaminated sediments in the river; the removal of five of the nine dams along the study reach; and the removal of contaminated bank materials (USACE, 1999a).

Three other reports provided historical sediment and water quality information relevant for the present reconnaissance study: (1) the "Report on the Feasibility Study on the Removal of Bank and River Bottom Sediments in the Mahoning River (USACE, Pittsburgh District, June 1976), (2) "Chemical Analysis of Sediments and Fish from the Mahoning River, Lawrence County, Pennsylvania" (USFWS, 1992), and (3) "Biological and Water Quality Study of the Mahoning River Basin (OEPA, 1996).

The 1976 USACE study examined the characteristics of the bottom sediments and oil-soaked bank materials of the Mahoning River, the impact of these contaminated materials on water quality, and various alternatives for reducing their adverse impacts. The study focused on the heavily industrialized reach of the Mahoning River from Warren, Ohio to its confluence with the Shenango River at New Castle, Pennsylvania. The findings showed that sediments along this stretch of the river violated the U.S. Environmental Protection Agency (USEPA) sediment quality criteria. In addition, the banks of the Mahoning River from RM 13 to RM 36.8 were found extensively soaked with oil residue. The remedial alternative recommended in this report included the dredging and landfilling of contaminated sediments from the river throughout the study area, as well as selective removal of contaminated bank material. The study also recommended the demolition of low-head dams at RMs 6.9, 13.0, and 21.1 (USACE, Pittsburgh District, June 1976).

The 1992 USFWS study focused on the 12-mile stretch of the Mahoning River in Lawrence County, Pennsylvania. The scope of the study included sampling of fish and sediments along this stretch of the river to determine whether contamination was present to the same degree that it was in Ohio reaches previously investigated. The sampling revealed organic polychlorinated biphenyls (PCBs), selected pesticides, polycyclic aromatic hydrocarbons (PAHs), and trace/heavy element contamination in localized sediment "hotspots" and in fish. However, the results showed that the Pennsylvania portion of the river had somewhat lower concentrations of PAHs than the Ohio reaches of the river. The report indicated that several known toxic contaminants detected in the study reach exceeded USEPA 1977 Guidelines for moderate and heavy pollution classification for disposal of Great Lakes harbor sediments (USFWS, 1992).

The 1996 OEPA Biological and Water Quality Study was based on comprehensive chemical, physical, and biological sampling conducted in the Mahoning River Basin study area during the summer and early fall of 1994. The study focused on determining the extent to which warmwater habitat (WWH) aquatic life use designations assigned in the Ohio Water Quality Standards (WQS) were either attained or not attained; to determine if use designations assigned to a given water body were appropriate and/or attainable; and determine if any changes in the ambient biological, chemical or physical indicators had taken place over time. The study showed that all sampling locations between Warren, Ohio (RM 42.9) and the Beaver River (RM 0) exhibited non-attainment of water quality standards. In addition, the report concluded that there was little or no indication that Mahoning River sediments were less contaminated in 1994 compared to prior years. During the period between 1980 and 1994, there was only a slight improvement in the use attainment status for the lower half of the Mahoning River. The presence of contaminated sediments was identified as the main reason that the river ecosystem failed to respond to decreased pollutant loads (OEPA, 1996).

2.0 DESCRIPTION OF STUDY AREA

The Mahoning River is 108 miles long, rising in Columbiana County, Ohio and flowing northward to Warren, Ohio and then southeasterly to New Castle, Pennsylvania where it joins the Shenango River to form the Beaver River. The project area for this reconnaissance study included the 12-mile reach of the lower Mahoning River that lies between the Ohio-Pennsylvania state line (RM 11.85) and the river's confluence with the Shenango River at New Castle, PA (RM 0). The lower Mahoning River in Pennsylvania has been identified as being moderately to severely impaired due to contaminated sediments originating from historical industrial activity in upstream reaches of the river.

2.1 Sources of Contamination

The Mahoning River basin is underlain with abundant mineral resources, giving rise to extensive coal mining, manufacturing of iron and steel, and supporting industries. From around 1900 until the mid-1970s, the lower Mahoning River supported one of the most intensely industrialized steel-producing regions in the world. By 1970, there were approximately 15 plants in steel production and 35 plants in steel related industries. Steel mills, railroads, and support industries used the river for cooling and process water. Other industrial effluents discharged to the river included pickling liquors, electroplating discharges, coke quench water, and cutting and lubricating oils. The river water contained high concentrations of metals (copper, zinc, lead, chromium, iron, nickel, cadmium), cyanide, ammonium nitrogen, and phenols. In the 1970s, the steel mills began to close. Currently, most of the steel mills have been razed, leaving only a few working mills in existence.

Historically, the lower Mahoning River has been severely impacted by untreated or poorly treated industrial and municipal discharges. Municipal wastewater treatment was nonexistent until the mid-1950s. Since the 1950s, significant reductions in the volumes of wastewater, total suspended solids, oil and grease, total iron and total phenols have occurred, primarily because of partial or complete shutdowns of steelmaking facilities and advances in water treatment. During the 1980s, most of the municipal wastewater treatment plants (WWTPs) attained secondary or better levels of wastewater treatment. The upgrades resulted in significant improvements in dissolved oxygen (DO) and ammonia nitrogen.

The Village of Lowellville (Ohio) was the last major WWTP to upgrade to secondary treatment, which became final in 1992. Located at RM 12.2, this facility is the nearest point-source discharge upstream of the Pennsylvania state line. The New Castle Sanitation Authority's WWTP discharges to the Mahoning River at RM 0.2.

2.2 Socioeconomic Setting

The estimated 1999 population of Lawrence County, Pennsylvania was 94,508, a decrease from the 1997 estimated population (95,281) and the 1990 enumerated population (96,246). New Castle, Pennsylvania, the largest city in the county, had a 1997 estimated population of 26,500, a decline from the 1990 enumerated population of 28,334. Towns and communities along the lower Mahoning River in Pennsylvania include Edinburg (1990 population 3,240), Hillsville (est. 2000 population 600), North Edinburg, Peanut, and Robinson.

In contrast to the Ohio portion of the Mahoning River, where the watershed is highly urbanized and historically intensely industrialized, the Pennsylvania Mahoning River basin was and continues to be primarily undeveloped. There are few urban areas in this portion of the river basin. The city of New Castle is located between the confluence of the Mahoning and Shenango Rivers. The communities of Edinburg and North Edinburg are located on the southern and northern sides of the river, respectively, at approximately RM 7. Land uses along the river also include rail and highway transportation corridors, a rails-to-trails corridor, agriculture and coal mining.

The railroad tracks located along the north side, or the left descending bank, of the river are owned and operated by CSXT; the railroad tracks located along the south side of the river are owned and operated by Conrail. The rail-to-trail Stavich Bicycle Trail was created on the roadbed of the Penn-Ohio Railway, which was last operated in 1933. The bike trail, which extends from New Castle, PA to Struthers, OH, is 12 miles in length.

Several major utility easements traverse the river corridor including electrical, telephone, and gas lines. Table 2-1 summarizes utilities identified from the 1965 USACE base mapping, USGS 7.5-minute quadrangle mapping, and reconnaissance observations. In addition, drainage culverts discharging stormwater to the river are located throughout the study area.

Table 2-1
Known Utility Crossings

Base Map Sheet #	Utility Name	River Mile
23	Pennsylvania Power Co.	9.9
23	Bell Telephone Co.	9.9
22	Tennessee Gas Pipeline Co. (4 underground lines)	8.3
21	Pennsylvania Power Co.	6.9
20	Pennsylvania Power Co.	5.4
19	Pennsylvania Power Co.	4.5
19	Bell Telephone Co.	4.5
18	Columbia Gas Co. of Pennsylvania (underground lines)	2.9
18	Pennsylvania Power Co.	2.6
17	Pennsylvania Railroad Telephone	1.8
17	Pennsylvania Railroad Power	1.8
17	Bell Telephone Co.	0.4
17	Pennsylvania Power Co.	0.4
16	Pennsylvania Railroad Telephone	0.2
16	Pennsylvania Railroad Power	0.2

2.3 Natural Environment

2.3.1 Climate

The climate in the Mahoning River basin is temperate and humid. Average maximum and minimum temperatures (Fahrenheit) range from 36 and 18 degrees in January to 85 and 59 degrees in July. Precipitation averages about 38 inches and is evenly distributed throughout the year. The average seasonal snowfall is 38 inches, with an average of 24 days with one inch or more of snow on the ground (USDA, 1982).

2.3.2 Geology and Soils

The Mahoning River drains a glaciated portion of the Allegheny Plateau physiographic province. South of Warren, Ohio, the Mahoning watershed is underlain by the Pottsville and Allegheny Formations, which are of Pennsylvanian age and include interbedded sandstones, claystones and thin limestone, and coal beds. The Mahoning River Valley is underlain by the Cuyahoga Formation while the uplands along the river are underlain by the Pennsylvanian units. The Allegheny Formation underlies most of Lawrence County. The entire Mahoning watershed is mantled by glacial materials. The river valley is occupied primarily by outwash gravels south of Warren. Well logs indicate that up to 70 feet of clay and other surficial materials lie above the bedrock in the river valley, although in some areas, the bedrock intrudes directly into the river channel (USACE, 1999a; USDA, 1982).

Soils along the Mahoning River are predominately of the Conotton-Chili-Holly association. These deep soils were formed in glacial outwash and alluvium; they inherited many of their physical and chemical properties from this glacial material. Conotton soils are found on outwash plains, kames, eskers, and terraces. They are sandy and gravelly and are droughty during dry periods; they are dominantly gently sloping to very steep. Chili soils are found on outwash plains, kames and terraces. They are deep and well drained and underlain by sand and gravel. Holly soils are found on flood plains. They are poorly drained and frequently flooded, and have a high water table (USDA, 1982).

Upland soils along the Mahoning River Valley are in the Ravenna-Canfield-Frenchtown, Canfield-Ravenna-Loudonville, and Udothents-Canfield-Ravenna associations. The first two associations are level to steep, poorly drained to well drained, and formed in glacial till. The last association is level to steep, poorly drained to excessively drained, and formed in materials from strip mines and glacial till (USDA, 1982).

Other soils along the river are in the Braceville, Chagrin, Lobdell, Ravenna, Holly, and Sloan series. The Braceville, Chagrin, Lobdell and Ravenna soils are silt loams that occur in floodplains and qualify as prime farmland (USDA, 1982, 1983). The Holly and Sloan soils are silt loams that occur in outwash plains, terraces, floodplains, and moraines. The Holly, Sloan and some Braceville soils qualify as lands of state importance (USDA 1982, 1983). Holly and Sloan soils are hydric and may support wetlands. The Braceville, Chagrin, and Lobdell soils may have inclusions of hydric components (USDA, undated).

2.3.3 Wetlands

Riverine wooded and emergent wetlands that are influenced by river hydrology, occur adjacent to the river channel and below the ordinary high water line throughout the study reach. Major emergent wetlands are located closest to the river channel, primarily in gently sloped, depositional areas, and on islands.

According to the US Fish and Wildlife Service National Wetlands Inventory maps (USFWS National Wetlands Inventory Internet site, Wetlands Interactive Mapper Tool, 1977 base photos), palustrine groundwater-fed wetlands also occur throughout the riparian corridor, primarily between RMs 2 and 3 and in the vicinity of RMs 6, 8, 10, and 12. Palustrine wetlands near RMs 2 and 3 are primarily emergent wetlands. Palustrine wetlands near RMs 8-12 are deciduous forests while those near RM 6 are mostly forested with some shrub-scrub wetland. Human activities have eliminated wetlands along several stretches of the river.

2.3.4 Water Quality

The USEPA STORET data base contains Mahoning River water quality sampling data from five federal and state agencies (USEPA, USACE, US Geological Survey (USGS), Ohio Environmental Protection Agency (OEPA), and Pennsylvania Department of Environmental Protection (PaDEP)] for the Pennsylvania reach of the Mahoning River.

Intermittent water quality sampling has been conducted at various locations throughout the Mahoning River (PA) study area, beginning as early as 1964. More specifically, historical sampling sites were located between RM 0.71 and RM 10.5, with the most frequently sampled location being RM 7 at the State Route (SR) 224 bridge in Edinburg, PA. PaDEP has also collected aquatic invertebrate samples at the SR 224 bridge (Hasse, 2001). The control reach for this study is a free-flowing reach of the Mahoning River located upstream of the Warren-Youngstown industrialized corridor and downstream of the Levittsburg, Lovers Lane Dam, between RM 43.0 and 46.2. This is the same control reach used in the Mahoning River, OH study.

Water quality throughout the Pennsylvania reach of the Mahoning River generally meets State water quality criteria. Table 2-2 summarizes the Pennsylvania water quality criteria for the Mahoning warm water habitat for selected parameters recorded by the USACE since 1990 and compares the criteria to maximum observations in the Pennsylvania reach. State water quality criteria exceedences have been recorded only for total iron and dissolved oxygen. (Data prior to 1990 were excluded because they were not considered representative of current conditions.)

Table 2-2
Mahoning River, PA Maximum and Minimum Values 1990 to 1999 and State Water Quality Criteria

Parameter	Units	PaDEP Water Quality Criteria for the Mahoning River	Maximum Observed Value in Pennsylvania (1990 through 1999)	
			Year-round	May-October
pH (laboratory)	pH units	6.5 (minimum)	7.11 (minimum)	7.03 (minimum)
pH (laboratory)	pH units	8.5 (maximum)	8.07 (maximum)	8.07 (maximum)
Total Iron	mg/L	1.0	3.48	3.48
Cadmium	mg/L	0.01	<0.002	<0.002
Total Chromium	mg/L	0.1	0.015	0.015
Copper	mg/L	0.02	0.0159	0.0159
Nickel	mg/L	0.1	<0.04	<0.04
Zinc	mg/L	0.2	0.105	0.105
Dissolved Oxygen	mg/L	5.0 (minimum)	-	4.9 (minimum)

Between 1970 and 1999, as industrial and municipal discharges to the Mahoning River were reduced, decreasing warm-season mean total iron concentrations illustrate a trend towards improving water quality. Table 2-3 provides the mean and standard deviation of iron data disaggregated by location and time period. Generally, concentrations in the control reach (upstream of historical and current industrial activity) are lower than in the Ohio and Pennsylvania study reaches, as would be expected. Mean, warm season, concentrations are also lower in the 1990s than in the 1970s.

Figure 2-1 provides a snapshot of total iron concentrations for Mahoning River, PA water samples collected between May and October 1999, compared to the control reach. The control reach is a free-flowing reach of the Mahoning River located upstream of the Warren-Youngstown industrialized corridor and downstream Levittsburg, Lovers Lane Dam, between RMs 43.0 and 46.2. Of the observations that year, only one value (collected from the Mahoning River at RM 20) slightly exceeded he PaDEP maximum iron water quality criterion of 1.0 of 1.0 mg/L. These data indicate that, although iron periodically exceeds the criterion, water quality, with respect to iron, continues to improve.

Table 2-3

Lower Mahoning River May through October Water Quality Statistical Analyses for Period of Record, Mean (Standard Deviation) Total Iron (µg/L)[1]

Sampling Period	Pennsylvania (RM 0-12)	Ohio (RM 12-43)	Control (RM 43-47)
1970-1979	1.65 (0.98)	2.80 (1.71)	0.93 (0.32)
1980-1989	0.93 (0.67)	1.29 (0.67)	0.98 (0.57)
1990-1999	1.26 (0.72)	1.05 (0.41)	0.87 (0.19)

[1] 349 observations

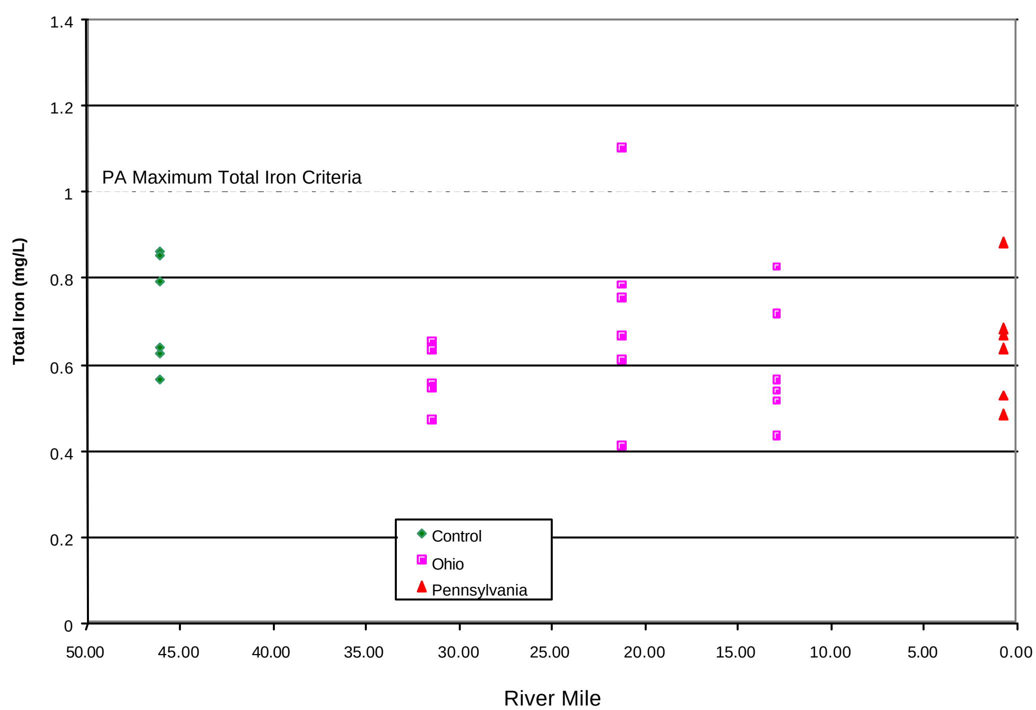

Figure 2-1

May through October 1999 Lower Mahoning River Water Quality Analyses, Total Iron (µg/L)

Dissolved oxygen data also demonstrated a trend towards improving water quality throughout the same period. The data show the partial recovery of conditions necessary for a healthy aquatic habitat even though the sediments remain contaminated. Table 2-4 provides the mean and standard deviation of dissolved oxygen data disaggregated by location and time for the warm season. As can be seen in Table 2-4, for all sampling periods, dissolved oxygen concentrations were higher in the control reach than downstream reaches, as would be expected. This also demonstrated a trend towards improvement throughout the Pennsylvania reach when compared to the Ohio reach.

Figure 2-2 provides a snapshot of the 1999 data, the most recent year available. All observations occur within the warmer part of the year (May through October) when lower dissolved oxygen levels are likely to occur. Of the observations in that year, all met or exceeded the PaDEP criterion of 5.0 mg/L. The 1999 dissolved oxygen data also exhibited an oxygen sag downstream of the control reach, where the lowest values were observed in he Youngstown, Ohio reach and moderate recovery occurred in the Pennsylvania reach. More depressed oxygen concentrations occur throughout the Ohio reach of the lower Mahoning River because there are greater oxygen-demanding loads to the river. Further downstream in the Pennsylvania study reach, a modest recovery is observed. These data indicate that dissolved oxygen concentrations continue to increase with time in the Pennsylvania portion of the Mahoning River.

Table 2-4
Lower Mahoning River May through October Water Quality Statistical Analyses for Period of Record, Mean (Standard Deviation) Total Dissolved Oxygen Data (mg/L)[1]

Sampling Period	Pennsylvania (RM 0-12)	Ohio (RM 12-43)	Control (RM 43-47)
1970-1979	4.9 (1.4)	5.2 (1.6)	6.7 (1.0)
1980-1989	4.2 (1.8)	6.1 (1.7)	8.3 (0.6)
1990-1999	7.4 (1.0)	6.9 (1.2)	5.2 (1.6)

[1] Forty zero values were discarded, leaving 578 measurements. The zero values occurred in three sampling events in the 1990s and all but three of the forty are associated with river mile 21.2. These zeros are interpreted as missing values rather than zero values.

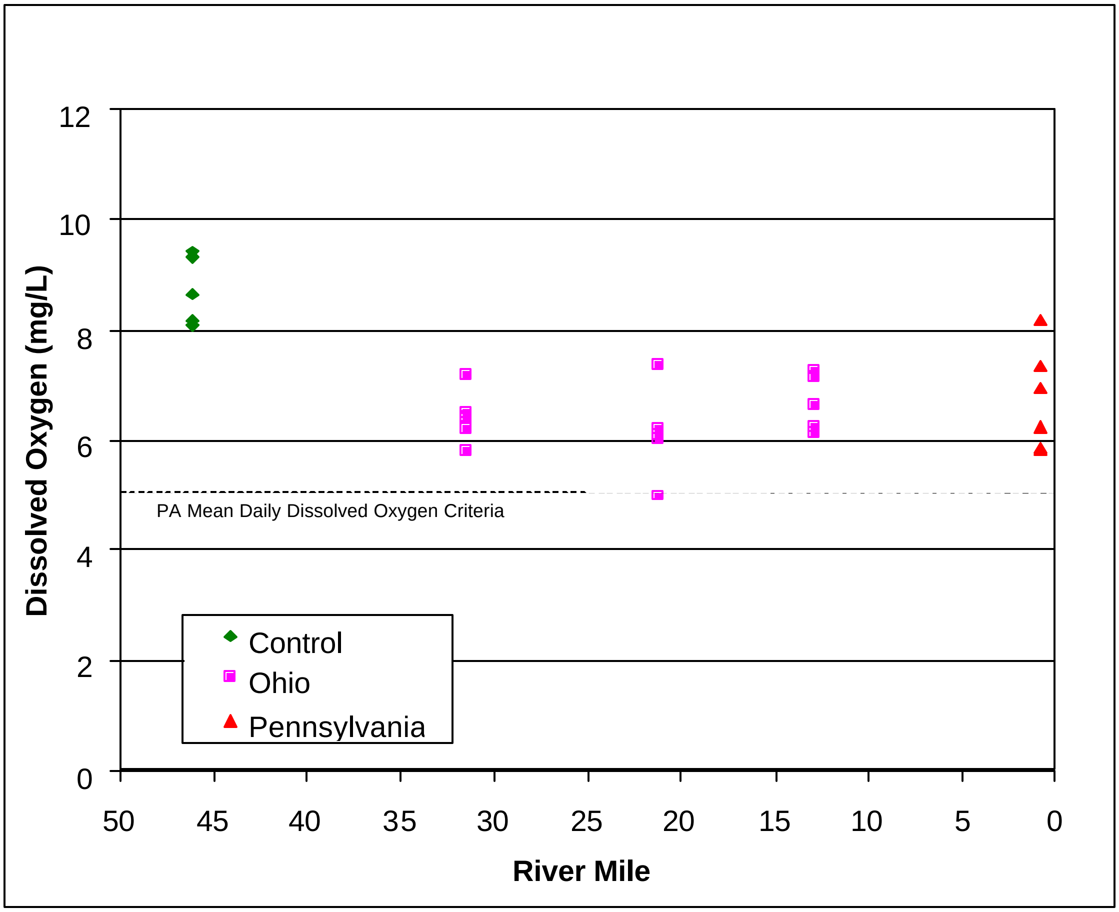

Figure 2-2

1999 May through October Lower Mahoning River Water Quality, Total Dissolved Oxygen (mg/L)

2.3.5 Hydrology and Hydraulics

The Mahoning River drains 1,132 square miles of northeastern Ohio and west-central Pennsylvania. Approximately 1,085 square miles, or 96% of the watershed, lies in Ohio and the remaining 4% lies in Lawrence County, Pennsylvania. The Mahoning River is 108 miles long with 11.85 miles of that length stretching from the Ohio-Pennsylvania border to the Mahoning River's confluence with the Shenango River to form the Beaver River.

Five reservoirs constructed in the watershed have a capacity of 29,000 acre-feet (ac-ft) or more. Information on these reservoirs, all in Ohio, is summarized in Table 2-5. In addition to these reservoirs, there are several other storage impoundments for water supply and/or recreation, including 11 that have a surface area of 90 acres or more.

Table 2-5
Major Reservoirs in the Mahoning River Basin

Reservoir	Year complete and operational	Owner	Tributary Drainage Area (mi^2)	Total Storage Capacity (ac-ft)	Summer Conservation Pool Storage[1] (ac-ft)
Milton Reservoir	1917	State of Ohio	273	29,770	21,600
Meander Creek Lake	1931	Mahoning Valley Sanitary District	84	35,400	None
Berlin Lake[2]	1943	USACE	248	91,200	37,200
Mosquito Creek Lake	1944	USACE	98	104,100	69,400
Michael J. Kirwan Reservoir	1966	USACE	81	78,700	52,900
		TOTAL	**784**	**339,170**	**181,100**

[1] Available for flow augmentation

[2] The amount of storage available for low-flow augmentation depends on storage withdrawn for water supply. The minimum low-flow storage capacity is 37,200 ac-ft.

Flow data are available for the years 1944 through the present. From 1944 through 1990, the U.S. Geological Survey (USGS) maintained the gage on the Mahoning River at Lowellville, Ohio (03099500). Since 1990, the Corps has maintained the gage. This gage, located at RM 12.9 and approximately 1 mile west of the Ohio-Pennsylvania border, records flows for a drainage area of 1,073 square miles. Since there are no significant tributaries to the Mahoning in Pennsylvania, this gage is representative of the flow patterns throughout the final 12 miles of the Mahoning River.

The Mahoning River has been regulated by one or more reservoirs throughout the entire period of record. Therefore, a direct statistical analysis of annual peak-flow measurements to determine flood flows is not possible. However, FEMA (1978) estimated the 100-year and 10-year discharges at the mouth of the Mahoning (drainage area of 1,130.4 square miles) to be 32,300 cubic feet per second (cfs) and 17,300 cfs, respectively. Analysis of the gauged record suggests that the 2-year discharge is approximately 9,200 cfs. The three highest recorded annual peak flows during that period were 21,000 cfs (1/21/59), 20,000 cfs (5/27/46), and 19,150 cfs (4/12/94). Mean flow at the gage is approximately 1,300 cfs.

The ordinary high water (OHW) determination (Section 2.3.6; Appendix A) reports that the OHW level in the Pennsylvania portion of the Mahoning River occurs at elevations less than the July 28, 1999 event that peaked at 5,600 cfs at the Lowellville gage. Therefore, the OHW is estimated to correspond to a water surface elevation less than a 2-year event.

Ten low-head dams are located in the Mahoning River above RM 12 (and outside of the study area). These dams influence the hydraulics of the river by creating long pools upstream of each dam and a turbulent tailwater directly downstream. A largely breached dam exists within the study area at RM 6.85 (Figure 2-3). Remnants of the abutments and rubble remain.

Figure 2-3. Remnants of Edinburg Dam at Mahoning River Mile 6.85

2.3.6 Ordinary High Water

The OHW mark is a distinct line along the shore, which has been established by fluctuations in the water level, with enough frequency and duration to change the character of both the vegetation and soil from upland to riverbed. Sections 9 & 10 of the River and Harbor Act (1899 and 1966) established Federal jurisdiction over navigable waters, and the OHW level defines the lateral extent of Federal jurisdiction. This law states that "…the bed of navigable streams includes lands below the ordinary high water line and the exercise of the power to regulate commerce within the bed of a navigable stream is not an invasion of any private property right for which the US must make compensation". Periodic high water events therefore have an observable and permanent effect on the shoreline. Since the vegetation and soils of lands located below the OHW line are aquatic (hydric), or transitional between wetland and upland, this area is also jurisdictional wetland.

Between August 24 and August 31, 1999, an OHW study (Appendix A) was conducted along the Mahoning River in order to define the lateral boundaries for the Mahoning River, Pennsylvania Environmental Dredging Reconnaissance Study and to facilitate right-of-entry for the proposed restoration project. The OHW study area included the entire Mahoning River, Pennsylvania Environmental Dredging Reconnaissance Study area: an 11.85 mile reach of the of the Mahoning River located in Lawrence County, PA, between RM 0 (the confluence of the Mahoning River with the Shenango River) and 11.85 (Hillsville, PA). Eleven sites were selected along the study reach, approximately one site per mile. In addition, sites were also selected upstream and downstream of the dam located at RM 6.85 in Edinburg, PA.

The OHW line was determined using the "physical fact" method, as defined in the 1965 USACE report entitled "Ordinary High Water." This method requires a detailed visual investigation of the banks for reliable determination of the OHW line. At each of the sites, observations were made of riverbank terracing; soil type; vegetation community composition and density; and comparative growth rates between similar plant communities located at different elevations. Banks were then characterized into three distinct zones, where Zone A is the area between the river and Zone B, Zone B extends from Zone A to the ordinary high water line, and Zone C is the area located above the OHW line. These zones are described in Appendix A and summarized below.

Zone A is generally characterized by soil-free, water-scoured, sandy or rocky shorelines, and dominated by water-tolerant trees. Herbaceous wetland and pioneer plants are present in Zone A where the slopes are gentle enough to support emergent wetlands in pockets of sediment along the shorelines, on sandbars, and islands. Pioneer species are annual, non-aquatic, herbaceous plants, which can quickly colonize continually disturbed areas, such as riverbanks.

Zone B is generally covered in layers of deposited silt of varying thickness, with little or no organic matter, no signs of soil horizons, and mottled hydric soil at the bottom of soil profiles. Typically, the high side of this Zone ends at a relatively steep vertical slope. The vegetation of Zone B is similar to that found in Zone A but there is more diversity, greater numbers of aquatic herbaceous plants, and great numbers of pioneer species.

Zone C, above the ordinary high water line, has defined soil layers, which include topsoil and leaf litter. There are no scour marks or silt deposition layers. Silt is only observable in this zone only for a short time after high water events, as succeeding rains wash the silt into the humus. Vegetation of this zone is typical of mesic forests with a complete understory, typically dominated by upland species.

The OHW line, the river pool, and the last high water event were then determined. The OHW profile for the study reach, the 100-year flood profile, and the 1960 low flow channel profile were then plotted (Figure 2-4). In addition, the last high water event, which occurred July 29, 1999 (Lowellville gage 6.25 ft or 5,600 cfs), was plotted as a slope validity check.

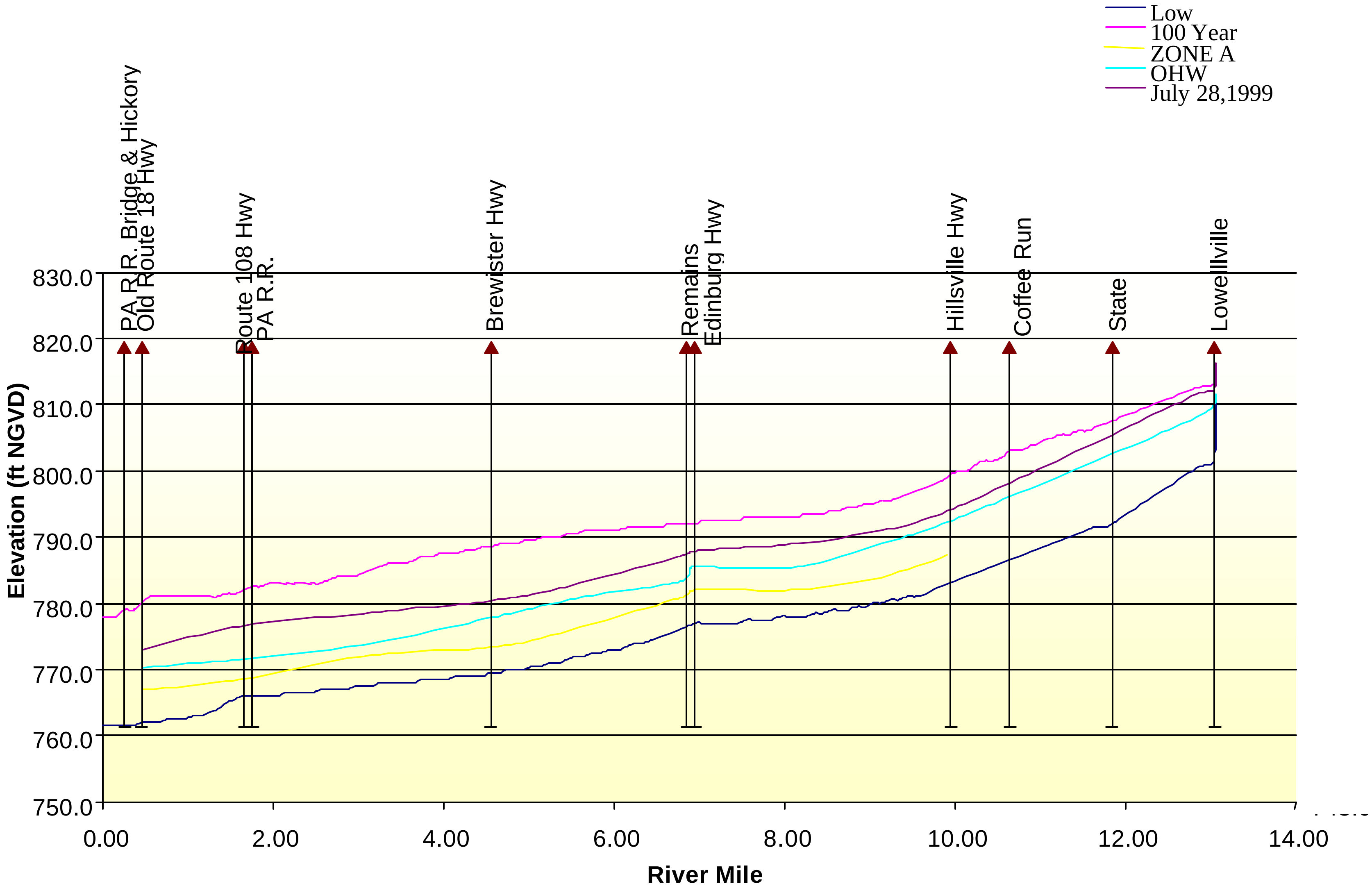

Figure 2-4

Mahoning River, PA Ordinary High Water Profile

August 1999

The OHW level averaged approximately 8 feet above the river pool. At the Edinburg dam, the OHW line was 6 feet above the pool upstream of the dam and 10 feet above the pool downstream of the dam. This level corresponds approximately to a 3-year flood.

The OHW report (Appendix A) also included the US Fish and Wildlife Service's wetland indicator status or tolerance to aquatic regimes for each plant species present. According to the U.S. Fish and Wildlife Service, "Plant species that occur in wetlands, as used in the National List, are defined as species that have demonstrated an ability to achieve maturity and reproduce in an environment where all or portions of the soil within the root zone become, periodically or continuously, saturated or inundated during the growing season". They developed a wetland fidelity system where obligate (OBL) species are those restricted to wetlands (>99%); facultative wet species (FACW) are those that usually occur in wetlands (67 - 79%); facultative species are those that equally occur in wetlands and non-wetlands (34 - 66%); and facultative upland plants (FACU) are species that usually occur in non-wetlands (67 - 99%) but are occasionally found in wetlands (1 to 33 %). Zones A, B, and C, respectively, contained 29.4%, 6.4%, and 0% obligate wetland species; 38.2%, 26.6%, and 19.6% facultative wetland species; 8.8%, 17%, and 17.9% facultative species; 2.9%, 27.7%, and 39.3% facultative upland species; 19.1%, 13.8%, and 7.1% pioneer species; and 1.5%, 8.5%, and 16.1% upland species.

2.4 Existing and Potential River Uses

Downstream of approximately RM 39 to the confluence with the Shenango River, the Mahoning River has historically been one of the most polluted streams in Ohio and Pennsylvania. The State of Ohio posted a Human Health Advisory in 1988 for the Mahoning River for the reach between RM 41.5 and RM 12.8 (near the state line). This advisory cautioned against "contact" with sediments and frequent fish consumption. Ohio's current (2001) sediment contact and fish consumption advisory specifically cautions against the consumption of white crappie, smallmouth bass spotted bass, and walleye (ODH, 2001). Pennsylvania's current (2001) Public Health Advisory, however, does not include sediment contact and does not apply to fish from the Mahoning River (PaDEP, 2001).

The existing intact, biologically healthy, and aesthetically appealing riparian corridor is an extremely valuable resource. Not only is the healthy riparian corridor an integral component for successful stream restoration, it is also of sufficient quality to attract recreational enthusiasts. However, because of the degraded state of the river, the recreational potential of the Pennsylvania reach of the Mahoning River, which has been designated as a warm water fishery by the PaDEP, is currently underutilized.

The project goal is to restore the aquatic ecosystem of the Pennsylvania reach of the Mahoning River, utilizing multi-metric biological indicators to measure success and the same control or reference reach as was used in the 1998 Mahoning River Ohio Reconnaissance study. This reference reach was also located on the lower Mahoning River in Ohio, but upstream of all principal industrial sources of sediment contamination (between RMs 43.0 and 46.2). This goal is tied to restoration of the upstream Ohio portion of the lower Mahoning River, and the elimination of the Ohio Department of Health Public Health Advisory. The objective is to reestablish a fishable and swimable stream in compliance with the mandates of the Clean Water Act.

The principal opportunity is to return the river and its ecosystem to a healthy condition, allowing it to become a scenic recreational resource that could serve as a focus for the revitalization of the lower Mahoning River communities. Additional potential benefits from successful ecosystem restoration will be the removal of the existing public health advisory, enhancement of the native fishery, and recreational opportunities that pose no environmental or health concerns. This, in turn, would lead to economic benefits for the area.

2.5 Landfill Regulatory Issues

To determine the potential regulatory status of dredged Mahoning River sediments and bank materials, representative samples were collected and submitted for laboratory analysis. Landfill profiling samples were collected from the top 6 inches of sediment within the stream channel at RM 6.9. Landfill profiling samples were also collected from river banks at several transect locations and at various depths, as follows: RM 4.6 (1-1.5 foot depth), RM 6.9 (0.5-5.5 foot depth), RM 7 (1-4.3 foot depth) and RM 10.6 (1-2 foot depth). The samples were analyzed using the Toxicity Characteristic Leaching Procedures (TCLP) to determine whether the materials would require disposal as hazardous wastes. The results indicated that the dredged materials would not have to be treated as hazardous or toxic wastes.

Under current Pennsylvania regulations, however, dredged materials are regulated as "residual wastes." Residual wastes are defined as non-hazardous industrial waste. They include waste materials produced by industrial, mining, and agricultural operations. Residual waste does not include material defined by law as hazardous; however, it does include "near hazardous" wastes that are not covered by hazardous waste regulations. Nearly 400 facilities in Pennsylvania have PaDEP permits to process or dispose of residual wastes.

Residual wastes are regulated by the PaDEP Bureau of Land Recycling and Waste Management. In a recent Final Rulemaking, the PaDEP Environmental Quality Board recently revised 25 PA Code Chapters 250 and 287–299 dealing with Residual Wastes. In commentary associated with the new regulations, it was stated that dredged materials were included with residual wastes because, in many instances, they have physical and chemical qualities similar to those of residual waste. In addition, the residual waste regulations may provide more opportunities for reuse than the municipal wastes regulations. For example, the use of dredged material may qualify as a coproduct in some instances.

As discussed in Section 4.2.1, beneficial reuse may be preferable to landfill disposal in that it represents significant cost savings and preserves diminishing landfill space. If the dredged materials are to be landfilled, however, one of the nearest potential disposal locations may be the Carbon Limestone facility, just over the Ohio state line. Other facilities include the Seneca Landfill in Allegheny County, PA or the NW Sanitary Landfill in Butler County, PA. Analytical testing requirements vary for each landfill. Costs for disposal will also vary.

During the feasibility study, any additional sample analyses performed for disposal characterization should include parameters established by the waste receiving facilities. Also, additional analytical protocols may be required to investigate potential reuse scenarios for the material.

3.0 PROBLEMS AND OPPORTUNITIES

3.1 Sediment Contamination

3.1.1 Previous Studies

Feasibility Study on the Removal of Bank and River Bottom Sediments in the Mahoning River, Pittsburgh District (USACE, 1976).

For the 1976 USACE feasibility study, sediment and water quality data from 24 sampling stations were evaluated. The sampling data, compiled from three different sources, covered the reach of the Mahoning River from RM 1.8 to RM 46.2. The sediment samples were analyzed for oil and grease, fecal coliform, volatile solids, chemical oxygen demand, and metals; the analytical results were compared to the USEPA Pollutant Index. The "Pollutant Index" (PI) was developed by determining the percent of each constituent on a dry weight basis and dividing this percentage by the USEPA-determined percentage for polluted sediment. A number equal to or greater than one for any one of the constituents would characterize the sediment as polluted. The following findings were reported:

- Sediment samples from all in-stream locations, except in the control reach (RM 46.2) were characterized as polluted, since their respective PI values were greater than 1.

- Elevated zinc levels in the bottom sediment contributed most heavily to each sample's overall pollution rating.

- The oil and grease in river bottom sediment, identified in the reach located between RM 24 and RM 1.8, was the second most significant contaminant, with concentrations ten or more times greater than the USEPA PI value.

Chemical Analysis of Sediments and Fish from the Mahoning River, Lawrence County, Pennsylvania (USFWS, 1992).

For the USFWS's 1992 study of the sediments and fish of the Pennsylvania reach of the Mahoning River (RMs 0–12), ten surface sediment samples were collected. Seven of these were collected from the river channel of the study reach and one was collected from riverbank materials. In addition, two background samples were collected from Hickory Run, a right-descending bank tributary which confluences with the Mahoning River at RM 2. The samples were collected from the top 4 inches of sediments found in depositional areas at the edge of the river. The sediment samples were analyzed for metals, organochloride compounds, and polycyclic aromatic hydrocarbons (PAHs); the analytical results were compared to the USEPA (1977) guidelines for classification of Great Lakes sediments. The study was deliberately biased to seek out fined-grained sediments that would represent the worst-case degree of chemical contamination. The following findings were reported:

- The inorganic analysis showed that concentrations of many elements were an order of magnitude higher in the Mahoning River samples when compared to the Hickory Run background samples: including chromium, copper, iron, mercury, molybdenum, nickel, lead, and zinc.

- Many of elements exceeded "heavily polluted" guidelines established by the USEPA (1977) for the classification of Great Lakes sediments.

- Organochloride compounds detected included PCBs in most of the Mahoning River, Pennsylvania samples, and dieldrin in the one bank sample collected.

- PAHs were detected in low concentrations in the background samples, but were reported at least one order of magnitude higher in the Mahoning River sediments. PAH concentrations observed in surface sediments samples collected from the Pennsylvania reach of the Mahoning River were somewhat lower than concentrations observed in samples collected by the USEPA from Ohio reach of the river.

- The riverbank sample contained higher concentrations of PCBs and PAHs than the sediment samples collected from the river channel.

USACE Mahoning River Environmental Dredging Reconnaissance Study, Trumbull and Mahoning Counties, Ohio (USACE, 1999).

The USACE Mahoning River Ohio Environmental Dredging Reconnaissance Study addressed problems and opportunities for ecosystem restoration related to contaminated sediments in the lower Mahoning River, located in northeastern Ohio. The study area included approximately 31 miles of the lower Mahoning River from Warren, Ohio (RM 42.9 to the Ohio-Pennsylvania border (RM 12). For this study, in-stream sediment samples were collected at ten locations, including two "upper control" locations and eight downstream locations. In addition, riverbank samples were collected at three locations. The samples were analyzed for total recoverable petroleum hydrocarbons (TRPH), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, pH, target analyte list (TAL) metals, cyanide, herbicides, Total Organic Carbon (TOC) and total PCBs. The analytical results were compared to samples collected from the upper control. The following findings were reported:

- When compared to the upper control reach samples, Mahoning River sediment samples exhibited elevated levels of TRPH, SVOCs, TOCs, PCBs, and metals. Most of the SVOC contaminants were PAHs.

- TRPH and TOC concentrations generally became more elevated as sampling proceeded downstream from the control reach; however, SVOCs and metal concentrations did not necessarily increase as sampling proceeded downstream.

- Riverbank sampling results indicated that contamination exists in a defined zone. The contaminants identified in the bank samples were similar to those identified in the river sediments.

Results of Supplemental River Bank Sediment Sampling Conducted on 14, 17, and 18 September 1998 along the Mahoning River, Ohio, (USACE, 1999b).

As a supplement to The USACE Mahoning River Ohio Environmental Dredging Reconnaissance Study, May 1999, which focused on characterizing in-stream sediments in July and September 1998, USACE personnel conducted a cursory survey of the quality and distribution of bank sediments/soils of the lower Mahoning River in Ohio. A total of 57 bank material samples were collected from 31 core holes in 11 transects, which were distributed between RM 16.2 and RM 40.95. Transect locations were purposefully biased to represent a "worse case" scenario. The sediment samples were analyzed for TRPH or oil and grease, metals, PCBs, and PAHs. Select samples were also analyzed for VOCs, SVOCs, pesticides, herbicides, dioxins and total cyanide. The following findings were reported:

- The contaminated bank materials were found to have similar chemical compositions to and occur at similar locations and elevations as the contaminated near-shore channel deposits. The bank areas, however, were typically capped by a relatively clean, vegetated layer that resembled natural banks.

- It was suggested that the "oil-soaked banks" described in previous studies were actually "contaminated deposits that formed in the old river channel."

- The bank sample analyses confirmed visual findings that (1) the sediment cap samples were relatively clean, (2) the deeper bank sediments were contaminated, and (3) there was a distinct horizontal and vertical limit to the extent and distribution of the contaminated soils/sediments in the river banks, with the deeper, most contaminated materials lying closest to the soil/water interface.

- TRPH /oil and grease concentrations were found to correlate well with the concentrations reported for other contaminants of concern, such as PCBs and heavy metals.

3.1.2 Current Study

For the current study, sediment quality sampling and analyses were conducted on in-stream and bank sediments/soils along the Pennsylvania reach of the lower Mahoning River. Sections from the "Sampling and Analysis Report, Lower Mahoning River," which outlines the complete sampling plan for this reconnaissance study, are provided in Appendix B; the complete sampling and analysis report is available in the Pittsburgh District files separately. Sampling of surface (0 to 6 inches) in-river and bank sediments was performed at seven transects located at RMs 1.7, 4.2, 6.8, 6.9, 8.8, 10.6, and RM 46.2 (the control reach).

Additional sampling was conducted to characterize the quality and vertical/horizontal distribution of contaminated material in the riverbanks. Six bank sampling transects were selected at RMs 0.4, 4.6/4.7, 6.8, 9.9, 11.2 and 11.25, where transect locations were biased to represent a "worse case" scenario and sample cores were driven to resistance. All samples collected were analyzed for TRPH. Select samples were also analyzed for the USEPA's priority pollutant VOCs, SVOCs, target analyte list metals, pesticides, herbicides, PCBs and cyanide.

Where appropriate, the sediment quality and quantity data collected during the current reconnaissance study were compared to the data from previous studies. Pennsylvania data was compared primarily to data collected during the 1999 Mahoning River Ohio Environmental Dredge Reconnaissance Study, to demonstrate differences between conditions in the Pennsylvania reach and those further upstream and closer to the sources of historical pollution. Although there were some differences between sample analyses and sample collection methodologies in the two studies, the intent of both studies was to characterize the quality and vertical/horizontal distribution of contaminated sediments and bank materials. All studies demonstrated a general trend towards decreasing concentrations of contamination with distance from historical sources.

In-Stream Sampling Results

For the current reconnaissance study, a minimum of four sediment samples were collected along each of the seven transects. Samples were collected utilizing a 2-inch diameter sampler, which was manually pushed into the river bottom until refusal was encountered. Recovery in the river proper was noted to be poor; this was likely because the advancement of a manually-pushed auger is limited in coarse or hard sediments. As shown in the boring logs provided in the Sediment Sampling and Analysis Report (April, 2000), refusal in the river proper typically occurred between the depth of 2 to 4 feet. Field screening using a photoionization detector (PID) revealed that, in all cases, the sediment collected from the 0- to 6-inch interval exhibited the highest PID readings. Based on the visual observation and PID readings, all of the sediment samples submitted for laboratory analysis were from the 0- to 6-inch depth interval. These samples are therefore considered to be surface samples.

For the Mahoning Ohio Reconnaissance in-stream sediment quality survey, one mid-channel sediment quality sample was collected upstream of each of the ten existing low-head dams. Samples were extracted utilizing a 3-inch diameter split barrel sampler, driven by a 140-pound hammer to resistance. Material from each core, which averaged 4 feet deep, was composited for analyses. When recovery was poor because material was too coarse, these composited samples were supplemented with the addition of near-shore silts. For the landfill profiling samples (TCLP) which were also collected upstream of each dam, a hand auger was utilized.

Although sediment sampling techniques and sampling depths varied between the Pennsylvania Mahoning study and the Ohio Mahoning study, some general observations can be made when evaluating the analytical results. Additional sampling during a feasibility analysis is recommended to confirm the findings outlined below.

The following summarizes the results of the Mahoning River, Pennsylvania in-stream sediment quality analyses.

- The highest TRPH concentrations occurred at RM 6.8. Mean TRPH concentrations reported at upstream transects (RM 10.6 and 8.8) were several times higher than mean TRPH concentrations reported at downstream transects (RM 4.2 and 1.7).

- The sediment samples did not exhibit contamination by pesticides/herbicides, PCBs, or VOCs. Only trace concentrations of select compounds were reported.

- Total SVOCs (mostly PAHs) were highest at RM 10.6 and 6.9 (~60 ppm); these concentrations were over one order of magnitude above concentrations observed in the control reach at RM 46.2 (~5 ppm).

- Mean chromium, lead, and copper concentrations were over three times above control reach concentrations (15.4 ppm, 22.3 ppm, and 14.8 ppm, respectively), while the mean zinc level was over ten times above the control reach concentration (54.4 ppm).

The following observations were made when comparing the analytical results from the in-river sediment sampling in the Pennsylvania Mahoning with in-river sediment sampling in the Ohio Mahoning:

- Mean TRPH concentrations reported in the Ohio transects were over one order of magnitude above the mean TRPH concentrations reported in the Pennsylvania transects. The highest concentrations were reported at around RM 16 and RM 37 in the Ohio reach. The highest TRPH concentration documented in the Pennsylvania reach was at RM 6.8, upstream of the only low-head dam in this reach.

- Total SVOC concentrations (mostly PAHs) did not appear to decrease as a function of distance from the former industrial sources. However, with the exception of one outlier (2,089 ppm reported in a sample collected upstream of the Youngstown-Hasselton Center Street Dam in the Ohio reach at RM 18.2), the concentrations reported in the Ohio and Pennsylvania samples were within the same order of magnitude.

- As with the Pennsylvania samples, Ohio sediments did not exhibit contamination by pesticides/herbicides or VOCs; however, low concentrations of PCBs were reported in a five of the sediment samples collected from the Ohio reach of the Mahoning River.

- The highest concentrations of chromium, copper, zinc, and lead occurred in Ohio samples. The mean lead concentration reported in Ohio was over one order of magnitude above the mean lead concentration reported in Pennsylvania (Figures 3-1and 3-2).

River Bank Sampling Results

Bank sampling conducted during the Pennsylvania Mahoning River Reconnaissance study included the collection of both surface (0 to 6 inches) and subsurface soil samples. At some locations, only surface samples were collected; at other locations, both surface and deeper samples were collected. Where deeper samples were collected and distinct soil horizons were analyzed, trends could be inferred from the data. Visual observations (Figure 3-3) reported during sampling indicated that a relatively clean layer of surface sediments was found above a more contaminated subsurface layer. The analytical data appeared to support this observation.

In addition to comparing surface and deeper bank samples, an attempt was made to determine how contamination appeared to vary as a function of distance from the former industrial sources.

The following trends were observed in the bank sampling results.

- Riverbank TRPH concentrations were within the same order of magnitude as the in-stream TRPH concentrations.

- Where vertical profiling was performed, deeper bank materials generally exhibited higher levels of TRPH contamination than surface bank materials (Figure 3-4).

- TRPH concentrations were generally higher at the bank/water interface than at overbank sample locations.

- No evidence was observed to suggest contamination by pesticides/herbicides, PCBs, or VOCs.

- Total SVOCs (mostly PAHs) were highest (~170 ppm) at RM 6.9, upstream of the only lowhead dam located within the Pennsylvania reach of the Mahoning River. PAH concentrations were elevated above those reported in the control reach (RM 46.2) even at the furthest downstream sample locations (RM 4.2 and 1.7).

Figure 3-1: Contaminant Concentrations in Sediments from the Stream Channel

Figure 3-2: Metal Concentrations in Sediments from the Stream Channel

Figure 3-3. Underlying dark sediments observed at the water/bank interface.

- Metal concentrations observed in bank samples were within the range of those observed in the stream channel. However, chromium, lead and zinc were generally reported at higher concentrations in the stream channel than in the banks.

In summary, the results of the sediment sampling and analysis conducted in the Pennsylvania reach of the lower Mahoning River revealed that the surficial fine-grained sediments located within the stream channel exhibited contamination above control reach levels, but lower than levels observed in the 0 to 4-feet deep composited samples collected in the Ohio reach. The contaminants of concern were identified as petroleum hydrocarbons, PAHs, chromium, copper, lead, and zinc. As with the Ohio sediments, no significant concentrations of pesticides/herbicides, VOCs, or PCBs were reported. In general, the banks exhibited contaminant concentrations similar to the channels. Where vertical profiling was performed, deeper bank materials exhibited higher levels of TRPH contamination than surface bank materials. In addition, samples collected at or near the bank/water interface exhibited higher TRPH concentrations than samples collected from overbank areas.

3.2 Biological Assessment

Current ecological conditions in the Mahoning River have been described in an OEPA Report (OEPA, 1996) and summarized by the USACE for the lower portion of the Mahoning River above the Pennsylvania-Ohio state line (USACE, 1999a). The Mahoning River is located in the Erie-Ontario Lake Plain ecoregion. It has a WWH designation from the OEPA and PaDEP.

All sampling sites in the Mahoning River downstream from Warren Consolidated Industries and the Warren Wastewater Treatment Plant at RM 35.4 to the Beaver River (RM 0) exhibited non-attainment of water quality standards (OEPA, 1996). River quality begins to deteriorate significantly at about RM 39 (OEPA, 1996).

The greatest declines in the biological community metrics coincided with high to very high stressor and exposure indicator levels. The poor rating of the response indicators and exposure indicators extended downstream of the Pennsylvania state line (RM 12) despite generally low stressor levels from the state line to the mouth (OEPA, 1996).

A biological assessment (Damariscotta, 2000; Appendix C) was conducted of the Mahoning River in Lawrence County, Pennsylvania, to complement a biological assessment conducted earlier in the lower Mahoning River upstream of the Pennsylvania-Ohio state line (USACE, 1999a and Schroeder, 1998). The study area included the 12-mile section of the Mahoning River in Lawrence County, Pennsylvania that extends from the state line to its confluence with the Shenango River (RM 0) at New Castle, Pennsylvania.

Eight sampling sites were selected between the state line (RM 12) and the mouth of the Mahoning River (RM 0) (Damariscotta, 2000). The assessment procedures focused on three primary and two secondary OEPA-developed biotic indices to be consistent with the procedures used in the biological assessment conducted upstream of the study area (OEPA, 1996, Schroeder, 1998, Yoder and Rankin, 1999). The primary indices were:

- Invertebrate Community Index (ICI), used to measure overall macroinvertebrate community condition
- Qualitative Habitat Evaluation Index (QHEI), used to assess riverine habitat quality as an empirical quantified evaluation
- Index of Biotic Integrity (IBI), used to measure ecological impairment of a given river compared to relatively non-impacted rivers in the same ecoregion

The secondary indices were:

- Modified Index of Well Being (MIwb), used to measure the health of the fish community
- Deformities, Eroded Fins, Lesions, or Tumors (DELT) index, used to assess the physical health of the fish population.

Measured values for the above biotic indices are presented in Table 3-1 and are plotted against RM and shown in Figure 3-5. The reference value and mean Ohio study area value are also given for each index. The OEPA established that the reference zone for the Mahoning River quality was RMs 39–46. The reference values for the indices are reported in OEPA, 1996.

Figure 3-4. River Bank TRPH Concentrations

3.2.1 Invertebrate Community Index

The ICI compares the invertebrate populations in a stretch of the river to a reference area.

- The mean ICI score for the eight Pennsylvania sampling locations was 20.
- The mean ICI value reported for the Mahoning River in Ohio between RM 39 and RM 12 was 9.1 (Schroeder, 1998).
- The mean ICI value for the reference zone of river was 30 (Schroeder, 1998).
- None of the sampling locations generated the score of 34 necessary for a WWH designation.

These values indicated poor river quality and severe degradation as compared to the reference zone. The Pennsylvania reach of the Mahoning River shows overall higher ICI values than the Ohio study area, indicating improved invertebrate community quality as the river progresses downstream. This finding potentially exists because the Pennsylvania reach is relatively free flowing and is not influenced by low head dams. Additionally, it is assumed that greater concentrations of contaminated sediments and commensurably less suitable physical habitat for benthic organisms exist in the Ohio study area than in the Pennsylvania section of river. Generally, the total number of taxa tends to decrease in larger rivers or in the same river as it becomes larger flowing downstream because of a decrease in habitat types as the river becomes larger.

Table 3-1
Biological Indices Values for the Mahoning River in Pennsylvania and Ohio

INDEX	INDEX VALUES			
	Mahoning River Pennsylvania RMs 0–12 (Mean SD)[a]	Mahoning River Ohio RMs 12–35 (Mean SD)[b]	Reference Zone Ohio RMs 39–46 (Mean SD)[b]	Warm Water Habitat Criteria[c]
Invertebrate Community Index	20 4.3	9.1 4	30 8	34
Qualitative Habitat Evaluation Index	74.9 4.3	64 13	58 14	60
Index of Biotic Integrity	29.8 6.1	22 5	28 4	40
Modified Index of Well Being	5.9 2.6	5.5 1.3	7.6 0.7	8.7
Deformities, Eroded fins, Lesions, or Tumors	<0.1 0	14 7	5.6 3	<3

[a] Source: Damariscotta, 1999
[b] Source: Schroeder, 1998
[c] Source: OEPA, 1996

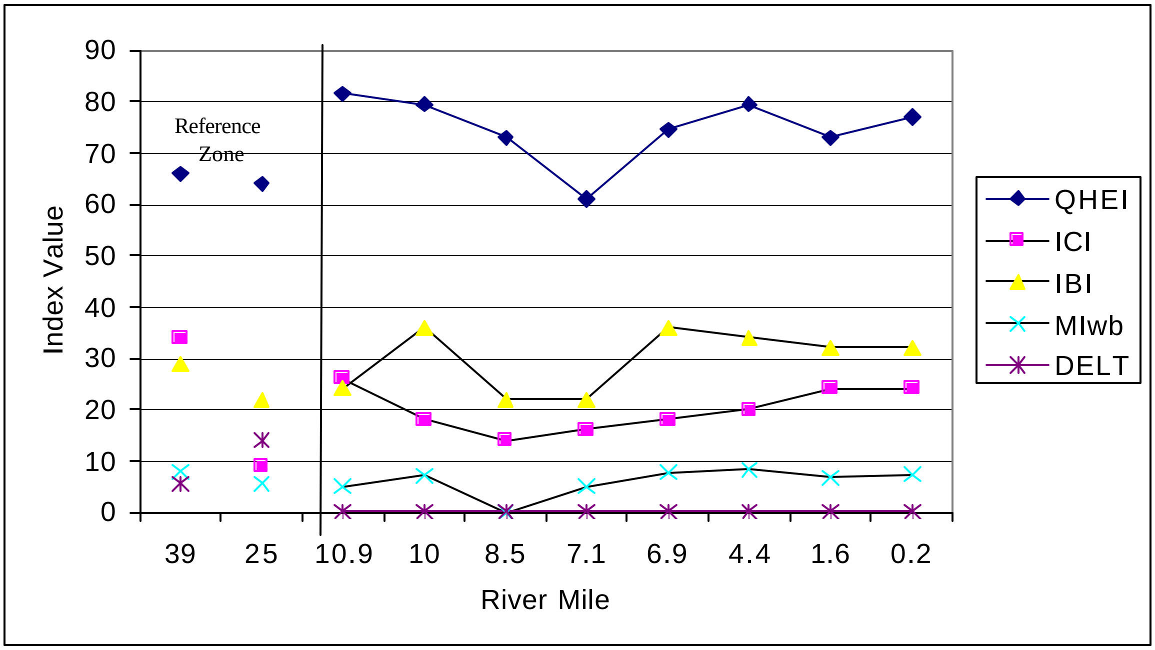

Figure 3-5. QHEI, ICI, IBI, MIwb, and DELT Indices for the Mahoning River, Lawrence County, Pennsylvania. Mean indices values for the Reference Zone and the Mahoning River RMs 12 to 35 (Trumbull and Mahoning Counties, Ohio) are also shown.

3.2.2 Qualitative Habitat Evaluation Index

The QHEI is a measure that evaluates the physical quality of the stream. The biotic health of a river is related to the river's physical structure and to the quality of its water and sediments. Biotic diversity and health are functions of habitat type and availability as they relate to inherent quality considerations. In essence, the quality of the habitat controls the composition of the biotic community in the absence of any other limiting factors. The QHEI is based on habitat metrics in the general categories of substrate; instream cover; channel morphology; riparian zone and bank erosion; pool/glide and riffle/run quality; and gradient.

A maximum QHEI score is 100. The minimum score necessary to achieve the WWH designation in this region is a value of 60. Higher scores generally indicate higher quality physical habitat and the potential for greater biotic integrity. The WWH designation is mutually dependent on other biotic indices and minimum associated point values.

- All QHEI values for the eight sampling locations in Pennsylvania averaged 74.9.
- The mean value for sampling locations in Ohio between RM 12 and RM 39 was 64 (Schroeder, 1998).
- The reference site score was 58 (Schroeder, 1998).
- The WWH minimum score is 60.

All sampling stations in Pennsylvania exceeded the WWH minimum. The greatest declines in the biological community metrics coincided with high stressor and exposure indicator levels. The QHEI data indicate that environmental stresses along the lower 12 miles of the Mahoning River are depressing the potential diversity of the aquatic macroinvertebrate populations, but the populations are generally improved over the upstream Ohio section. The data suggests that there is adequate substrate and cover, the depths of the pools and riffles offer suitable habitat, and the river is fairly stable. In the absence of any known significant source of water quality pollution, it is assumed that limiting toxic conditions exist within the substrate. The lack of overall pollution-sensitive taxa supports this assumption.

3.2.3 Index of Biotic Integrity

The Index of Biological Integrity examines 12 different quantifiable fish community metrics. The value of each metric is compared to the value expected at a reference site where human influence has been minimal. A rating of 5, 3, or 1 is assigned to each metric according to whether its value approximates (5), deviates some (3), or strongly deviates (1) from the value expected at a reference site. The maximum IBI score possible is 60 and the minimum is 12.

The individual IBI metrics measure attributes that are presumed to correlate with biotic integrity. Although no one metric alone can indicate this consistently, all of the IBI metrics combined include the redundancy that is needed to accomplish a consistent and sensitive measure of biotic integrity and a requirement when the system being evaluated is complex. The metrics examined three broad categories: species richness and composition, trophic composition, and fish abundance and condition.

- The study section of the Mahoning River in Pennsylvania had a mean IBI of 29.8.
- The Ohio portion of the Mahoning River between RM 12 and RM 39 had a mean value of 22 (Schroeder, 1998).
- The reference zone value was 28 (Schroeder, 1998).
- The WWH score criterion is 40.

Overall, the lack of pollution intolerant species, percent abundance of tolerant species, and lack of intolerant darter and sucker species in the study area contributed heavily to the calculated IBI for this stretch of river.

The Pennsylvania study area supports a viable fishery. This is validated by the number of DELT anomalies, number of insectivores, and total number of individuals, all of which contribute positively to increasing the IBI value.

Whenever structures (e.g., logs) were encountered during sampling, there was an increase in species numbers and diversity. This was reflected at stations where structures existed that apparently supplied habitat to fish species not encountered at the sampling stations where similar structures were absent.

3.2.4 Modified Index of Well Being

The MIwb combines fish species numbers, biomass, and diversity to generate a value used as an indicator of water quality. The combination of these measures is presumed to provides better information than scores generated by the individual values. The MIwb utilizes the weight and species composition of the fish community as well as the abundance of the various species. The biomass component of the MIwb excludes "highly" pollution tolerant species, hybrids, or exotic species. The MIwb has no upper limit, although scores seldom exceed 10.

- The mean index value for the Pennsylvania sampling stations was 5.9.
- The mean value for the Mahoning River between RM 12 and RM 39 was 5.5 (Schroeder, 1998).
- The reference zone MIwb value was 7.9, suggesting that less than optimum river conditions exist outside of the area of assumed sediment contamination. One Pennsylvania sampling station exceeded the reference value and a second approached it.
- The WWH score criterion was 8.7. None of the Pennsylvania sampling locations generated the prerequisite WWH score.

While the MIwb values were below the Ohio WWH criteria, the data suggest that values consistent with the quality of the reference zone are achievable in the lower 12 miles of the Mahoning River.

3.2.5 Deformities, Eroded Fins, Lesions, or Tumors

The proportion of individuals with DELT conditions is a metric that is sensitive to environmental degradation as an indicator of fish health. The DELT value is part of the ICI metric, but because it is sensitive to environmental degradation, it is used as an indicator of fish disease or pollution. Thus, the higher the proportion of affected fish in a sampling area, generally the greater the degradation and the lower the IBI score. For a river the size of the Mahoning, one would expect less than 0.1 percent of the total number of species exhibiting DELT in a high quality waterway.

- All Pennsylvania samples contained less than 0.1 percent of the individuals with any identifiable problems.
- The mean DELT value between RM 12 and RM 35 was 14 (Schroeder, 1998).
- The reference zone value for the Mahoning River was 5.6 percent (Schroeder, 1998).
- The WWH criteria value is <3 percent.

The data indicates that the lower reaches of the Mahoning River deviate little from reference sites in this region.

Summary

The results of the biological assessment reflect a potentially recovering ecosystem (Table 2.2). The fishery remains degraded, but has improved from a historically severely polluted condition and shows a healthy condition for the level of present recovery. The Pennsylvania Fish and Boat Commission (PFBC) fish sampling data from 1999 also indicates a possible rebound of the fishery in the Mahoning River (PFBC, 1999). Overall, it appears that the lower 12 miles of the Mahoning River, though degraded in comparison to the reference area, supports a viable biotic community that could be enhanced through restoration activities.

4.0 PLAN FORMULATION

The preferred alternative plan recommended for the Ohio reach of the Mahoning River is dredging (hydraulic and mechanical) of contaminated bed material, removal of contaminated bank materials, and selected dam removals (USACE, 1999a). Since the fate of the Pennsylvania reach of the Mahoning is linked to the Ohio reach, it is essential to evaluate restoration of the Pennsylvania Mahoning considering restoration efforts upstream. However, it is unclear when, or if, the recommendations for the Ohio Mahoning will be implemented. Therefore, the following plan formulation will consider both implementation of the preferred alternative in Ohio and no action as a basis.

Furthermore, a comparison of biological, sediment, and soil conditions in the Pennsylvania Mahoning and the Ohio Mahoning shows that the Pennsylvania Mahoning exhibits impaired, but improved conditions compared with the Ohio Mahoning. The current plan formulation process acknowledges these differences.

In this section, several alternatives are considered and evaluated for ecosystem restoration in the Pennsylvania reach of the Mahoning River. They are:

- No action
- Bed material removal (dredging)
- Bank material removal
- In-situ bioremediation of bed and bank material
- Bed and bank material stabilization/capping
- Habitat enhancement
- Dam removal

4.1 No Action Alternative

The No Action Alternative will continue the gradual improvement observed in the biological assessment. However, it is not clear when, or if, a satisfactory equilibrium point will be reached under the no action alternative. The potential for improvement is also influenced by actions taken upstream in the Ohio Mahoning. If dredging and dam removal are conducted as recommended (USACE, 1999a), the potential for enhancing recovery exists unless the dredging and dam removal release contaminated sediments that subsequently settle in the Pennsylvania Mahoning. If such releases are successfully mitigated, the restoration activities proposed for Ohio would remove potential sources of contaminants to Pennsylvania, increase the stretch of free-flowing waters and, therefore, increase potential fish habitat, and aid in the natural transport of sediments through the Ohio and Pennsylvania reaches of the river. However, since reservoirs capture sediment from 784 mi^2 of the 1,132-mi^2 watershed (69%), a natural balance of sediment flow through the river is unlikely to occur.

4.2 Other Alternatives

This study, and others, have documented the existence of contaminated sediments in the riverbed, contaminated soil in the riverbanks, and impaired biological conditions. The alternatives considered here focus on removal or containment of all or part of the contaminated materials and improvements to the habitat structure of the river.

4.2.1 Bed Material Removal (Dredging)

Removal of contaminated bed material in the river by dredging has been recommended as part of the Ohio study and was recommended in an earlier study by the Corps that included the Pennsylvania reach of the Mahoning (USACE, 1976). The dredging process consists of removal of sediments, dewatering, and either treatment or disposal. Mitigation to prevent releases of sediment downstream during dredging is also an important component of the process. The following sections address:

- Dredging methods;
- Mitigation measures;
- Dewatering;
- Treatment; and
- Disposal.

Dredging Methods

Dredging methods include hydraulic (e.g., cutterhead, horizontal auger, dust pan, matchbox, plain suction); mechanical (e.g., clamshell bucket, backhoe, bucket ladder, dipper, dragline); and specialty (e.g., PNEUMA® Pump, Dry Dredge™, SoliFlo℠) (SMWG, 2000). Hydraulic dredging uses a suction pump to collect sediment admixed with water. The sediment-water mixture is pumped to a de-watering basin, which is designed to allow water to drain out the bottom. If necessary, this water can be routed to a water treatment system prior to discharge back to the river. Where large rocks and debris are present, it may be necessary to remove coarse material using mechanical dredging before hydraulic dredging can be conducted.

Mechanical dredging would involve the use of a clamshell dredge of a type designed to minimize disturbance to the water column during dredging. Dredged material would be loaded onto watertight trucks and transported to a centrally located holding basin. It is expected that the mechanical dredge would incorporate substantially less water in the dredged material than the hydraulic dredge. Consequently, the total holding volume required for the mechanically dredged sediments is expected to be less than that required for the hydraulically dredged sediments. However, mechanical dredging is less effective at removing sediment from recessed areas. Another potential dredging option is to combine mechanical removal of sediments with hydraulic transport of the material to the dewatering basin.

There are several different options for the type of equipment on which either the mechanical or hydraulic dredge could be mounted: (1) an amphibious excavator; (2) a small floating plant; or (3) a "long-stick" excavator. However, the generally shallow nature of the Mahoning during typical flows precludes the use of the amphibious excavator and the small floating plant. Therefore, the recommended option is the use of a tracked crane or tracked "long-stick" excavator, which has a reach of about 50 feet, to mount the dredge.

Selection of an effective dredging strategy depends, in part, on the volume of sediments to be removed and their location. Table 4-1 summarizes the volume estimates obtained during a field survey. The table provides estimates of the mean depth and width of contamination at each transect where samples were taken.

The depth of contamination was estimated based on the Photo Ionization Detector (PID) screening measurements and laboratory data. In each of the river transects the highest PID readings were recorded in the top 0.5 feet and diminished with depth. For this reason, all riverbed laboratory samples were taken from this depth. Depth of contamination was estimated at one-half of the mean boring depth at each transect. In the river, boring depths ranged from one to four feet with an average of 2.4 feet.

Volume estimates assume depths and widths at each transect are representative of conditions between transects. Table 4-1 shows that the volume of contaminated sediments is much greater from the Ohio-Pennsylvania border (RM 11.85) to RM 6.8. In this 5.05-mile stretch, 159,700 yd^3 (86%) of the total estimated volume is found. Potential dredging limits for RM 0.0 to 6.8 are adjacent to the banks and approximately symmetrical. Limits for RM 6.8 to 11.85 cover the entire channel width. These limits should be refined in the feasibility analysis.

Table 4-1
Estimated Volume of Contaminated Sediments

River Mile	Transect	Mean depth (ft)	Mean width (ft)	Volume (yd^3)	Volume per mi (yd^3)
0		1.1	10		
				3,700	2,176
1.7	1	1.1	10		
				9,900	3,960
4.2	2	1.6	20		
				11,400	4,385
6.8	3	1.4	10		
				2,200	22,000
6.9	4	1.2	160		
				69,100	36,368
8.8	5	1.2	150		
				55,400	30,778
10.6	6	0.9	150		
				33,000	26,400
11.85		0.9	150		
Total				184,700	15,586

It is recommended that dredging activity focus on RM 6.8 to the Ohio-Pennsylvania border (RM 11.85). In this reach, an estimated width of dredging varies, but approximates 150 to 160 feet. Using the long-stick excavator requires access to be developed along the river, either with roads along both banks, or with a temporary road constructed in the existing riverbed as dredging progresses. If dredging is a part of the preferred alternative, this choice is influenced by the strategy adopted for addressing contaminated soils in the banks and enhancing habitat (both of these alternatives are evaluated separately). However, given the nature of the banks along the Mahoning (heavily vegetated), constructing a temporary road within the existing riverbed is the preferred option. In fact, it is likely that two parallel roads will be required to cover the 160-foot dredging width with a 50-foot dredging apparatus.

Two additional advantages to constructing temporary roads within the banks of the Mahoning are: 1) the roads may be used to reach and remove contaminated bank soils, and 2) the temporary road material, if properly selected, could be spread on the river bottom after dredging to improve the river substrate. These considerations are discussed later.

Access roads to the river would also be required at approximately one-mile intervals. Therefore, five access locations are required to support dredging operations from RMs 6.8 to 11.85.

Mitigation Measures

The dredging operation may lead to an increase in turbidity, and may introduce hydrocarbons into the water column. Extensive disturbance of the river channel resulting from construction of temporary roads in the channel could also adversely affect water quality. Therefore, mitigation measures should be incorporated into the overall dredging plan to minimize temporary effects downstream of the dredging operations.

The following options are available to reduce adverse water quality effects:

- Oil booms – An option to mitigate hydrocarbons released as a result of dredging is to deploy oil booms downstream of the dredging operation. These collect and absorb floating hydrocarbons but do not absorb water. This option is recommended as a cost-effective method.

- Silt curtains – Silt curtains are silt fences placed downstream of dredging and road construction operations. This has been found to a cost-effective method of reducing turbidity and is recommended.

- Coffer cells – Coffer cells involve the construction of temporary walls around a section of river, effectively isolating it from flowing waters, to control release of sediments and contaminants. Since the Mahoning River dredging would be relatively shallow, but over large areas, this option would not be cost-effective.

Dewatering

Dredged material is a sediment water mixture with a water content exceeding in situ values. For hydraulic dredging, it is expected that the sediment:water ratio would be roughly 1:10. For mechanical dredging, the ratio is expected to be approximately 1:1. The observed water content of sediments sampled for this project based on 21 measurements is 1:0.31, by weight, and ranged from 1:0.10 to 1:0.52. These values are consistent with those measured in the Ohio reach, which averaged 1:0.33 by weight, but ranged from 1:0.1 to 1:0.6. Although the ultimate disposal of the sediments will determine the desirable degree of dewatering, it is generally advantageous to dewater dredged sediments prior to disposal. A target water content of 26 percent, by weight, was used for this analysis.

Dewatering alternatives may need to be evaluated using pilot scale testing of the actual dredged sediments. Alternatives considered include:

- Settling and draining – Sediments are placed in a holding (dewatering) basin to allow the sediment to settle out, leaving a layer of water above it. The basin is designed with a gravel underdrain to allow water to drain from the bottom of the sediment pile while the upper layer of water is pumped out periodically. Water leaving the basin may require treatment prior to discharge to the river, as discussed later. The rate at which separation of the sediment-water occurs would need to be determined experimentally. The separation rate combined with the anticipated dredging rate will influence the size of the dewatering basins. This dewatering approach is recommended.

- Natural drying – Sediments are spread out and allowed to dry in the sun. This approach is inexpensive, but requires a large drying area and equipment to turn it to complete drying. Confirmation that water infiltrating into the ground and evaporating into the atmosphere would pose no contamination danger to groundwater or air would need to be obtained. Some preliminary dewatering in a holding basin would likely be required to permit transportation of hydraulically dredged materials. This approach is not recommended.

- Other – Other options including filter presses, industrial centrifuges, evaporators, and stabilization by addition of amendments were also considered. Each of these options requires the construction of structures to hold the dewatering equipment. Continuing maintenance is also required. These options are not recommended because they are not well suited for the significant water content anticipated for the dredged materials.

For the purpose of sizing the recommended dewatering basins, it is assumed that hydraulically dredged material will require a basin volume equal to 125 percent of the estimated sediment volume and that mechanically dredged material will require a volume equal to 110 percent of the estimated sediment volume. Based on a sediment volume of 159,700 yd^3, the basin volumes are then 199,600 yd^3 and 175,700 yd^3, respectively. These volumes may need to be adjusted based on the actual water content, dewatering rate, and dredging rate.

Dewatering basins are designed to maximize capture of solids and meet suspended solids criteria in the discharge of water. Their shape and size may be highly variable, however, for this analysis, it will be assumed that they will be between 5 and 10 feet in depth.

For hydraulically dredged material, this will require a total surface area of between 12.4 and 24.7 acres, not including the area required for the berms and access. Since sediments may be pumped without a booster station up to two miles, the required area would be divided between two basins.

For mechanically dredged material, dewatering will require a total surface area of between 10.9 and 21.8 acres, not including the area required for berms and access. Mechanically dredged material may be trucked or pumped so it may require two basins or one larger, centrally located basin.

The berms of the holding basins are designed according to dam construction regulations with 6H:1V sidewalls. The material to construct the berms would be obtained from an off-site borrow source and transported to the work site(s) for grading and compaction. A 1-foot layer of gravel would be placed at the base of the holding basins to collect water, which would then be directed, to a corrugated metal piping system for discharge or treatment.

Treatment

Treatment must be considered for both the dewatered sediments and the separated water prior to discharge to the river.

Treatment for the dewatered sediments depends on contaminant concentrations and ultimate disposal methods. Based on the results of the analytical testing conducted for this study, which are consistent with the results in the Ohio study, the sediments are "non-hazardous" as defined in 40 CFR 261. Therefore, no treatment is anticipated prior to disposal. Additional sampling to confirm these findings should be performed as part of the feasibility analysis.

The separated water must not contain excessive quantities of pollutants including suspended solids. The standard elution data collected for this study suggests that the water associated with the dredged sediments would not be contaminated. However, some treatment may be required before discharge back to the river. Options include obtaining an NPDES permit for direct discharge to the river and indirect discharge through a Publicly-owned Treatment Works (POTW). Potential treatment components for on-site treatment and discharge under an individual NPDES permit include oil-water separation, carbon filtration, and sand filtration. Discharge to a POTW would require a cooperative, nearby treatment facility.

Disposal

The ultimate disposition of dewatered and treated sediments may include several options: capping in place, beneficial reuse, off-site landfills, bioremediation, and thermal treatment.

Beneficial reuse considers dredged materials as a resource rather than a waste product. Further evaluation of dredging in the Mahoning River should include consultation with the steering committee and potential cost-share partners to identify potential beneficial uses. These may include use as a construction material for road or paving operations, fill material for preparing industrial or commercial building sites, fill material for strip mine reclamation, or fill for land fill covers. The application as fill material for building sites could be applied in the context of a brownfield redevelopment under Pennsylvania's Act 2, the "Land Recycling and Environmental Remediation Act." The challenge for beneficial use is the identification of options that require the volume of materials available, at the time that the materials are available. However, when successful, beneficial use may represent significant cost savings and preserve diminishing landfill space.

In-situ bioremediation, stabilization, and capping are considered later in this report as treatment alternatives. Thermal treatment has not been considered further because it is more expensive than off-site landfill disposal. If a beneficial reuse option cannot be identified, landfill disposal is the preferred option because it is technically and legally feasible, based on the analytical test results, and more cost-effective than thermal treatment.

One of the closest potential landfill locations may be the Carbon Limestone facility, just over the Ohio state line. Other facilities include the Seneca Landfill in Allegheny County, PA or the NW Sanitary Landfill in Butler County, PA. Transportation costs to the landfill facility are based on an average distance to these facilities from the center of the project area.

4.2.2 Bank Material Removal

Removal of contaminated soils from the river banks by excavation has been recommended as part of the Ohio study and was recommended for the Ohio reach of the Mahoning in an earlier study by the Corps (USACE, 1976). However, in the 1976 USACE study, it was concluded that bank materials in the Pennsylvania reach were not sufficiently contaminated to warrant excavation and the destruction of the riparian habitat. The excavation process consists of removal of contaminated soils, and either treatment or disposal. Mitigation to prevent releases of sediment downstream during excavation is also an important component of the process.

Selection of an effective excavation strategy depends, in part, on the volume of sediments to be removed and their location. Table 4-2 summarizes the volume estimates obtained during three field surveys. The table provides estimates of the mean depth and width of contamination at each transect where samples were taken. The mean widths given are divided equally between the two banks. For example, the mean width of 16.8 feet at transect 1 represents 8.4 feet on each bank. Volume estimates assume depths and widths at each transect are representative of conditions between transects. The table also shows that the volume of contaminated sediments is greater at the Ohio-Pennsylvania border (RM 11.85) and modestly diminishes to the confluence with the Shenango River (RM 0.0), primarily due to the decreasing estimated depth of contamination. However, the volume of contaminated bank soils is much more consistent throughout the study area than was observed earlier for contaminated river sediments.

Table 4-2

Estimated Volume of Contaminated Bank Soils

River Mile	Transect	Mean depth[1] (ft)	Mean width[1] (ft)	Volume (yd^3)	Volume per mi (yd^3)
0		1.2	16.8		
				6,700	3,941
1.7	1	1.2	16.8		
				11,500	4,600
4.2	2	1.6	16.8		
				16,800	6,462
6.8	3	3	12		
				600	6,000
6.9	4	2.4	12		
				13,400	7,053
8.8	5	3.6	12		
				15,200	8,444
10.6	6	3.6	12		
				10,600	8,480
11.85		3.6	12		
Total				**74,800**	**6,312**

[1] Width and depth increased by 20% to reflect sampling uncertainty.

If left in place, the bank material represents a potential source of contamination. Bank materials would be expected to erode into the Mahoning River over time and potentially leach contaminants into the river and groundwater.

Removal is complicated by the existence of a densely vegetated riparian buffer along the river. Excavation access from the shore is likely to result in unacceptable degradation of the riparian environment. However, it may be possible to perform excavation of the most accessible contaminated bank soils using the roads constructed for the dredging operations. The most accessible soils are also most likely to be a continuing threat to the river since they are potentially more vulnerable to erosion. It is recommended that bank excavation be limited to areas within OHW determination. This constraint will limit the potential environmental impacts, reduce real estate costs and focus on those contaminated bank soils most likely to be reintroduced to the river during floods.

If the dredging operations are implemented as described earlier, temporary roads will be constructed in the river from RMs 6.8 to 11.85, therefore, contaminated bank material removal in the lower part of the river will not be further considered. An estimated 39,800 yd^3 of contaminated soils exist in the upper reach. If one assumes that 50 percent of these soils can be removed while maintaining the riparian condition, then 19,900 yd^3 (27 percent of the total) would be remediated. Based on the assumptions given, total area affected by excavation would be approximately 7.4 acres plus buffer areas needed to insure stable side slopes. Assuming an additional 10 percent for buffers, the affected area is approximately 8.1 acres[1]. After removal, the effectiveness of the operation can be evaluated and the ecosystem in the river monitored to determine if additional removals are necessary.

Removed soils must also be treated and finally disposed. It is anticipated that these soils will exhibit similar characteristics to the dewatered river sediments and can be disposed of with the sediments using the same processes. Average water content (percent moisture), based on 77 measurements, was 41 percent by weight. However, water content of bank soils is sensitive to river levels and recent precipitation events and is expected to be variable. To the extent possible, removal of bank soils should occur when they are as dry as possible.

4.2.3 In-situ Bioremediation, Stabilization, and Capping of Bed and Bank Material

In situ bioremediation is the process of using microorganisms to destroy hazardous contaminants or to transform them into less harmful forms. The microorganisms will act against the contaminants only when they have the compounds necessary to produce the energy and nutrients needed to create more cells. In very few instances can this happen within the natural environment where the conditions occurring at the site of contamination can produce enough compounds to degrade the contaminants without human intervention. This process is called intrinsic bioremediation. However, the most common type of in situ bioremediation, engineered bioremediation, uses engineered systems to create and supply the microorganisms that would encourage the growth of more organisms and optimizes the environment in which the organisms must carry out the detoxification reactions.

[1] Easements for 100% of the bank area will be required although excavation is estimated to occur at 50% of the bank. Approximately 12 of the 16.2 acres would be above OHW and require easements.

Engineered treatments include solidification/stabilization, biological treatment, chemical treatment methods, and ground freezing. Solidification/stabilization immobilizes the sediment and contaminants by treating them with reagents that fix or solidify them. These reagents neutralize or bind the pollutants to reduce their mobility, usually through leaching. Problems associated with this type of treatment include inaccuracies in reagent placement, erosion, long-term monitoring requirements, the inability of the procedure to remove/detoxify contaminants, and the difficulty in adjusting solidification mixtures/agents for subaqueous settings. This technique also has not been accepted as treatment for contaminated sediment and would not be practicable in an area where there is the potential for disruption to the solidified mass.

Biological treatment of the soils can treat a wide range of organic contaminants, but not inorganics. Aerobic biological treatment effectively treats soils with organic materials and requires a continual supply of oxygen; therefore, it is not feasible for bottom sediments where organic concentrations and oxygen demands are high. Anaerobic biological treatment uses organisms that survive in an oxygen deficient environment to help combat the pollutants; however, the degradation is slower and applies to fewer compounds.

Chemical treatment of contaminated soils includes neutralization, precipitation, oxidation, and chemical dechlorination. Numerous problems exist with each of these treatments, but all *in situ* chemical treatments have a potential for secondary impacts. Therefore, it is limited to situations where the contaminated area can be contained during treatment or where the stream can be diverted. Another disadvantage with this method is the necessity of ensuring all treatment reagents are thoroughly mixed with the contaminated soil.

The use of ground freezing has been successfully employed for the construction of dams and tunnels in order to cut off water and support loads. Recently, the use of ground freezing for the treatment of contaminants in soils has been considered. It involves placing refrigeration probes into the contaminated area and allowing them to cool, thereby, allowing ice crystals to grow and form a wall of frozen sediment. The disadvantage to this method is that the process is slow and expensive because each probe can only freeze an area of about 1.5 feet in diameter, therefore, precluding it from use in areas with large volumes of contamination.

Solidification/Stabilization mixes reactive materials with solids, semi-solids, and sludges to immobilize contaminants. Disadvantages to this method entail many critical parameters including the selected stabilizing agents, other additives, waste-to-additive ratio, mixing variables, and curing conditions. Most of these depend upon the physical and the chemical make-up of the waste. Some tests show success in treating oily sludges and solvent-contaminated sludges and soils, but the most success with solidification/stabilization technologies has been the treatment of inorganic waste streams.

Numerous variations are available for this alternative. The most successful have been the cement-based and the silicate-based solidification. The cement-based method mixes the waste directly with the cement, whereas, the silicate-based waste uses a siliceous material and suitable setting agents to mix with the waste.

The use of a geosynthetic liner over the bank to minimize sloughing of material or other transfer of contaminants from the banks to the river could also be utilized. The liner would need to extend six feet onto the shore of the bank, which provides sixteen linear feet along the bank. The use of riprap placed over the liner would stabilize the bank. Natural vegetation may also be employed to stabilize the bank and to control erosion.

Disadvantages to using the stabilization method include the likelihood that ongoing maintenance would be required and possible adverse effects of the contaminated material left at the site through migration to the surface.

4.2.4 Habitat Enhancement

"Fish habitat is a place, or set of places, in which a single fish, a population, or an assemblage of fish can find the physical, chemical, and biological features needed for life, including suitable water quality, passage routes, spawning grounds, feeding and resting sites, and shelter from predators and adverse conditions. Principal factors controlling the quality of the available aquatic habitat include streamflow conditions, physical structure of the channel, water quality (e.g., temperature, pH, dissolved oxygen, turbidity, nutrients, alkalinity), the riparian zone, and "other living components" (Federal Interagency Stream Working Group, 1998).

Among the conclusions of the biological assessment performed as part of this study are that while the fishery is degraded, it has improved from a worsened state and that overall the Pennsylvania reach of the Mahoning does support a viable biotic community that can be further enhanced through restoration activities. Specific habitat weaknesses raised as part of that assessment were that there was a lack of in-stream physical structure and a "cementitious" type substrate.

A variety of habitat improvement devices are available including, but not limited to check dams, boulder placement, deflectors, bank cover, submerged shelters, migration barriers, gravel traps, and gravel placement. Key to successful habitat creation for all of these measures is placement within stable stream channels exhibiting characteristics compatible with the proposed structure(s). Rosgen (1996) has evaluated several of these habitat devices for their suitability with respect to various types of channels. Any attempts at artificially improving habitat in the Mahoning River should include assessment of the channel type and the applicability of candidate measures for the channel type.

Addition of substrate, i.e. gravel, would not only offer the potential to improve habitat, but would replace material removed as part of the dredging process. As noted before, if appropriately selected, the material used to create the temporary in-stream roads could be distributed throughout the streambed after the road section is no longer needed. This clean substrate would provide surfaces suitable for colonization by benthic organisms and supplement the fishery habitat. Care would be required to restore bed elevations to their pre-restoration level to avoid undesirable changes in the hydraulic regime and, potentially, flooding risks. Consideration must also be given to movement of added bed materials during flood events.

It is also essential that any dredging or bank excavation not degrade existing habitat and that natural stream morphology be preserved or enhanced. Particular attention must be directed toward careful construction and removal of the proposed in-stream roads. (In very shallow areas, the need for in-stream roads may be avoided by the selection of dredging and excavation vehicles capable of working in shallow water.) It is recommended that the first section of the river to be addressed be used as an opportunity to evaluate the processes for construction and removal before proceeding to other sections.

Habitat structures may be placed at a variety of locations throughout the entire stretch of the Mahoning River in Pennsylvania. These structures could supplement stabilization of stream banks in locations where removal of contaminated sediments is conducted. In fact, many bioengineered streambank stabilization techniques are similar to, or are compatible with, habitat structures. With the exception of adding structures complimentary to required streambank stabilization, it is recommended that if dredging, bank excavation, or any other construction-related restoration activities are implemented in the Ohio or Pennsylvania reaches of the Mahoning River, a period of at least two years should be allowed to pass before adding additional structures. This will allow the river to adjust to the other restoration activities and allow better planning for appropriate habitat structures in the adjusted river.

4.2.5 Dam Removal

A single partial dam exists in the Pennsylvania reach of the Mahoning River at RM 6.85. Originally breached at some time before 1976, its remains have been subjected to the river flows for over twenty years, further reducing the effects of the former dam. Except for the abutments secured in the riverbanks, the residue of the dam has created a small pool upstream and a riffle/rapids section downstream. Unless it is determined that the dam residue is an impediment to fish populations (it is most likely an asset), no further removal is recommended.

4.3 Plan Formulation

Six alternative plans have been formulated based on the strategies described in the previous sections. These plans are intended to describe the range of feasible options available for restoration of the Pennsylvania reach of the Mahoning River. The alternative plans are:

1. Plan 1. No action. No further action is taken. Further improvements to the ecosystem rely on natural processes.

2. Plan 2. Selective habitat restoration. Place improved substrate and structure at key locations in the river for fisheries habitat enhancement.

3. Plan 3. Hydraulic dredging and bank excavation of upper sub-reach. Removal of contaminated sediments and bank materials from the reach of river located between RM 6.8 and 11.85. All contaminated in-stream sediments and accessible contaminated bank materials will be removed, using mechanical dredging equipment. Improve habitat substrate. Dispose of dredged materials in a landfill if beneficial uses are not identified.

4. Plan 4. Mechanical dredging and bank excavation of upper sub-reach. Removal of contaminated sediments and bank materials from the reach of the river located between RM 6.8 and 11.85. All contaminated in-stream sediments and accessible contaminated bank materials will be removed, using mechanical dredging equipment. Improve habitat substrate. Dispose of dredged materials in a landfill if beneficial uses are not identified.

5. Plan 5. Hydraulic dredging and bank excavation of entire reach. Removal of contaminated sediments and bank materials from the entire study area, located between RM 0 and 11.85. All contaminated in-stream sediments and accessible contaminated bank materials will be removed using hydraulic dredging equipment. Improve habitat substrate. Dispose of dredged materials in a landfill if beneficial uses are not identified.

6. Plan 6. Mechanical dredging and bank excavation of entire reach. Removal of contaminated sediments and bank materials from the entire study area, located between RM 0 and 11.85. All contaminated in-stream sediments and accessible contaminated bank materials will be removed using mechanical dredging equipment. Improve habitat substrate. Dispose of dredged materials in a landfill if beneficial uses are not identified.

4.4 Cost and Benefit Analysis

Costs and benefits of the six plan alternatives are analyzed using the following categories:

1. Cost
2. Natural resource cost
3. Cultural resource cost
4. Aquatic ecosystem benefit
5. Economic and social benefit
6. Federal interest

In addition, important issues requiring focused investigation as part of a feasibility study are identified. The results are discussed below and summarized in Table 4-3. Based on this analysis, the preferred plan will be identified.

4.4.1 Cost

Cost estimates were prepared in accordance with ER 1110-2-1302, Civil Works Cost Engineering, as it applies to a reconnaissance level study. The total estimated cost of the plans, excluding real estate costs, ranges from zero for the no action alternative to $39 million for the entire reach mechanical dredging/bank excavation alternatives (Plans 5 and 6). A specific cost estimate for selective habitat enhancement (Plan 2) has not be developed because it will be highly variable depending on the specific proposals for adding structure and substrate. However, the costs for this plan are expected to be well below the four dredging plans (Plans 3, 4, 5, and 6). A more specific assessment of habitat enhancement should be completed during the feasibility stage if this alternative is pursued.

Plans 3 and 4 are identical with the exception of the type of dredging equipment employed – hydraulic (Plan 3) and mechanical (Plan 4). The difference in the costs between these two plans results from the differing size of the dewatering basins and water treatment costs. Total costs for hydraulic and mechanical dredging are estimated at $29.7 million and $27.9 million, respectively. These cost estimates are developed from Tables 4-4, 4-5, and 4-8.

Plans 3 and 4 require construction access either by temporary road crossings over an active rail line at approximately RM 8 and RM 11.3 or by the bike trail (rails-to-trails). The feasibility of using the bike trail for construction access should be evaluated in the next study phase.

Plan 5 may be compared directly with Plan 3 because they both employ hydraulic dredging. However, Plan 5 includes dredging and bank excavation throughout the entire 11.85-mile study reach rather than just the upper reach included in Plan 3. The total cost for Plan 5 is estimated at $42.4 million. Compared with Plan 3, Plan 5 would result in the removal of 24 percent more contaminated river sediments and bank material at a 43 percent increase in cost. The costs for Plan 5 are developed from Tables 4-6 and 4-9.

Plan 6 may be compared directly with Plan 4 because they both employ mechanical dredging. However, Plan 5 includes dredging and bank excavation throughout the entire 11.85-mile study reach rather than just the upper reach included in Plan 4. The total cost for Plan 6 is estimated at $40.5 million. Compared with Plan 4, Plan 6 would result in the removal of 24 percent more contaminated river sediments and bank material at a 45 percent increase in cost. The costs for Plan 6 are developed from Tables 4-7 and 4-9.

4.4.2 Natural and Cultural Resource Cost

Natural and cultural resource costs represent negative effects the proposed plans may have on the natural and cultural resources in the vicinity including consideration of mitigation activities. More information on these resources is found in a subsequent chapter.

The No Action Alternative, by definition, would not create additional negative impacts on the natural resources in the Pennsylvania reach of the Mahoning River. Selective habitat enhancement (Plan 2) would be expected to generate some impact because of the activity of construction vehicles, but with appropriate planning, these impacts should be negligible. Construction activities associated with the dredging and excavation alternatives (Plans 3, 4, 5, and 6) could be substantial and must be mitigated to make the project successful. Impacts to instream habitat, riparian vegetation, and downstream reaches could be significant, but can be mitigated by careful planning and attentive implementation. However, the potential negative natural resource effects of Plans 5 and 6 are approximately double those of Plans 3 and 4 because the construction area is approximately doubled.

Similarly, the No Action Alternative would not create additional negative impacts on the cultural resources adjacent to the study area. These resources are described more fully in a subsequent section. Selective habitat enhancement (Plan 2) should have negligible effects on cultural resources. Construction access roads are the only potential effect and can be located to avoid potentially significant resources. Cultural resources should also be avoidable in the dredging/excavation plans (Plans 3, 4, 5, and 6). Construction access roads, mobilization and laydown areas, and dewatering basins should be located to avoid known resources. Plans 5 and 6 would approximately double potential resource impacts compared to Plans 3 and 4 because the construction areas are double.

Table 4-3

Summary of Alternative Plan Analysis

	Plan					
	1. No Action	2. Selective Habitat Enhancement	3. Upper Sub-Reach Hydraulic Dredging	4. Upper Sub-reach Mechanical Dredging	5. Entire Reach Hydraulic Dredging	6. Entire Reach Mechanical Dredging
Cost(millions)[1]	$0	Variable	$29.7	$27.9	$42.4	$40.5
Natural Resource Cost	None	Negligible during construction	Impacts during dredging and excavation must be mitigated. Impacts are potentially greater in Plans 5 and 6 because they cover all 11.85 river miles.			
Cultural Resource Cost	None	Negligible	Cultural resource sites exist adjacent to the river, but can be avoided. Plans 5 and 6 must avoid sites in the lower and upper parts of the river.			
Aquatic Ecosystem Benefit	Low	Moderate	High	High	High	High
Economic/Social Benefit	Low	Moderate	High	High	High	High
Federal Interest	Not applicable	Under separate authority	Yes	Yes	Yes	Yes
Further Issues	Rate of natural attenuation	Extent and selection of habitat structures and substrate enhancement	Refine extent of sediment and bank contamination. Assess feasibility of instream roads. Research effects of bank excavation on riparian habitat. Investigate use of rail trail in lieu of temporary rail crossings. Select hydraulic or mechanical dredging equipment.			

[1] Excluding real estate.

Table 4-4

Cost Estimate for Upper Sub-Reach Hydraulic Dredging

Item	Quantity	Unit	Unit Price[5]	Amount
CONSTRUCTION ITEMS				
Mobilization and Demobilization	1	JOB	$220,000	$220,000
Clearing and Grubbing from Land	None Required	Acre	$6,700	
Clearing and Grubbing from Water	None Required	Acre	$13,000	
Site Development: laydown area	1	JOB	$61,000	$61,000
Construction Access Roads (36' width)	2,400	LF	$90	$216,000
Temporary Instream Roads (20' width)	53,328	LF	$40	$2,133,120
Removal of Instream Roads (30% of construction)	53,328	LF	$12	$639,936
Dredging of Sediments (Hydraulic)	159,700	CY	$18	$2,874,600
Construction of Dewatering Basins	199,600	CY	$12	$2,395,200
Water Treatment (if needed)	439,810,000	Gallon	$0.0022	$967,582
Sediment Treatment	None Required	Ton		
Sediment Transportation	237,200	Ton	$9	$2,134,800
Sediment Disposal (landfill)	237,200	Ton	$20	$4,744,000
Utility/Facility Relocation	10	Facility	$4,000	$40,000
Total Construction Costs				$16,426,238
LANDS AND DAMAGES				
Easement Administrative Costs (tracts)	3	Easement	$15,000	$45,000
Easement Administrative Costs (road)	1	Easement	$100,000	$100,000
Easement (laydown and storage)	10	Acre	$750	$7,500
Easement (temporary road)	30	Acre	$1,000	$30,000
Easement (dewatering basins)	24.7	Acre	$750	$18,525
Total Lands and Damages				$201,025
RELOCATIONS	None Required			
ENVIRONMENTAL COMPLIANCE AND REQ'D MITIGATION[3]	1	JOB	$1,642,624	$1,642,624
ENGINEERING AND DESIGN[1]	1	JOB	$1,642,624	$1,642,624
CONSTRUCTION MANAGEMENT[2]	1	JOB	$1,396,230	$1,396,230
			Subtotal	$21,308,741
			Contingencies[4]	$5,327,185
			Total Costs	$26,636,000

1.Engineering and Design is estimated as 10% of construction costs.
2.Construction Management is estimated as 8.5% of construction costs.
3.Environmental compliance is estimated as 10% of construction costs.
4.Contingencies are estimated as 25% of total costs.
5. 2001 costs.

Table 4-5

Cost Estimate for Upper Sub-Reach Mechanical Dredging

Item	Quantity	Unit	Unit Price[5]	Amount
CONSTRUCTION ITEMS				
Mobilization and Demobilization	1	JOB	$220,000	$220,000
Clearing and Grubbing from Land	None Required	Acre	$6,700	
Clearing and Grubbing from Water	None Required	Acre	$13,000	
Site Development: laydown area, dewatering	2	JOB	$61,000	$122,000
Construction Access Roads (36' width)	2,400	LF	$90	$216,000
Temporary Instream Roads (20' width)	53,328	LF	$40	$2,133,120
Removal of Instream Roads (30% of construction)	53,328	LF	$12	$639,936
Dredging of Sediments (Mechanical)	159,700	CY	$18	$2,874,600
Construction of Dewatering Basins	175,700	CY	$12	$2,108,400
Water Treatment (if needed)	33,460,000	Gallon	$0.0022	$73,612
Sediment Treatment	None Required	Ton		
Sediment Transportation	237,200	Ton	$9	$2,134,800
Sediment Disposal (landfill)	237,200	Ton	$20	$4,744,000
Utility/Facility Relocation	10	Facility	$4,000	$40,000
Total Construction Costs				$15,306,468
LANDS AND DAMAGES				
Easement Administrative Costs (tracts)	3	Easement	$15,000	$45,000
Easement Administrative Costs (road)	1	Easement	$100,000	$100,000
Easement (laydown and storage)	10	Acre	$750	$7,500
Easement (temporary road)	30	Acre	$1,000	$30,000
Easement (dewatering basins)	21.8	Acre	$750	$16,350
Total Lands and Damages				$198,850
RELOCATIONS	None Required			
ENVIRONMENTAL COMPLIANCE AND REQ'D MITIGATION[3]	1	JOB	$1,530,647	$1,530,647
ENGINEERING AND DESIGN[1]	1	JOB	$1,530,647	$1,530,647
CONSTRUCTION MANAGEMENT[2]	1	JOB	$1,301,050	$1,301,050
			Subtotal	$19,867,661
			Contingencies[4]	$4,966,915
			Total Costs	$24,835,000

1.Engineering and Design is estimated as 10% of construction costs.
2.Construction Management is estimated as 8.5% of construction costs.
3.Environmental compliance is estimated as 10% of construction costs.
4.Contingencies are estimated as 25% of total costs.
5. 2001 costs.

Table 4-6

Cost Estimate for Entire Reach Hydraulic Dredging

Item	Quantity	Unit	Unit Price[5]	Amount
CONSTRUCTION ITEMS				
Mobilization and Demobilization	1	JOB	$220,000	$220,000
Clearing and Grubbing from Land	None Required	Acre	$6,700	
Clearing and Grubbing from Water	None Required	Acre	$13,000	
Site Development: laydown area	1	JOB	$61,000	$61,000
Construction Access Roads (36' width)[6]	5,520	LF	$90	$496,800
Temporary Instream Roads (20' width)[6]	122,654	LF	$40	$4,906,176
Removal of Instream Roads (30% of construction)[6]	122,654	LF	$12	$1,471,853
Dredging of Sediments (Hydraulic)	184,700	CY	$18	$3,324,600
Construction of Dewatering Basins	230,900	CY	$12	$2,770,800
Water Treatment (if needed)	508,660,000	Gallon	$0.0022	$1,119,052
Sediment Treatment	None Required	Ton		
Sediment Transportation	274,300	Ton	$9	$2,468,700
Sediment Disposal (landfill)	274,300	Ton	$20	$5,486,000
Utility/Facility Relocation[6]	23	Facility	$4,000	$92,000
Total Construction Costs				$22,416,981
LANDS AND DAMAGES				
Easement Administrative Costs (tracts)	3	Easement	$15,000	$45,000
Easement Administrative Costs (road)[6]	1	Easement	$230,000	$230,000
Easement (laydown and storage)	10	Acre	$750	$7,500
Easement (temporary road)	69	Acre	$1,000	$69,000
Easement (dewatering basins)	28.6	Acre	$750	$21,450
Total Lands and Damages				$372,950
RELOCATIONS	None Required			
ENVIRONMENTAL COMPLIANCE AND REQ'D MITIGATION[3]	1	JOB	$2,241,698	$2,241,698
ENGINEERING AND DESIGN[1]	1	JOB	$2,241,698	$2,241,698
CONSTRUCTION MANAGEMENT[2]	1	JOB	$1,905,443	$1,905,443
			Subtotal	$29,178,770
			Contingencies[4]	$7,294,693
			Total Costs	$36,473,000

1.Engineering and Design is estimated as 10% of construction costs.
2.Construction Management is estimated as 8.5% of construction costs.
3.Environmental compliance is estimated as 10% of construction costs.
4.Contingencies are estimated as 25% of total costs.
5. 2001 costs.
6. Quantities estimated by multiplying the selective estimates by 2.3 (proportional to river length).

Table 4-7

Cost Estimate for Entire Reach Mechanical Dredging

Item	Quantity	Unit	Unit Price[5]	Amount
CONSTRUCTION ITEMS				
Mobilization and Demobilization	1	JOB	$220,000	$220,000
Clearing and Grubbing from Land	None Required	Acre	$6,700	
Clearing and Grubbing from Water	None Required	Acre	$13,000	
Site Development: laydown area	4	JOB	$61,000	$244,000
Construction Access Roads (36' width)[6]	5,520	LF	$90	$496,800
Temporary Instream Roads (20' width)[6]	122,654	LF	$40	$4,906,176
Removal of Instream Roads (30% of construction)[6]	122,654	LF	$12	$1,471,853
Dredging of Sediments (Mechanical)	184,700	CY	$18	$3,324,600
Construction of Dewatering Basins	203,200	CY	$12	$2,438,400
Water Treatment (if needed)	38,700,000	Gallon	$0.0022	$85,140
Sediment Treatment	None Required	Ton		
Sediment Transportation	274,300	Ton	$9	$2,468,700
Sediment Disposal (landfill)	274,300	Ton	$20	$5,486,000
Utility/Facility Relocation	23	Facility	$4,000	$92,000
Total Construction Costs				$21,233,669
LANDS AND DAMAGES				
Easement Administrative Costs (tracts)	3	Easement	$15,000	$45,000
Easement Administrative Costs (road)[6]	1	Easement	$230,000	$230,000
Easement (laydown and storage)	10	Acre	$750	$7,500
Easement (temporary road)[6]	69	Acre	$1,000	$69,000
Easement (dewatering basins)		Acre	$750	$18,900
Total Lands and Damages	25.2			$370,400
RELOCATIONS	None Required			
ENVIRONMENTAL COMPLIANCE AND REQ'D MITIGATION[3]	1	JOB	$2,123,367	$2,123,367
ENGINEERING AND DESIGN[1]	1	JOB	$2,123,367	$2,123,367
CONSTRUCTION MANAGEMENT[2]	1	JOB	$1,804,862	$1,804,862
			Subtotal	$27,655,664
			Contingencies[4]	$6,913,916
			Total Costs	$34,570,000

1.Engineering and Design is estimated as 10% of construction costs.
2.Construction Management is estimated as 8.5% of construction costs.
3.Environmental compliance is estimated as 10% of construction costs.
4.Contingencies are estimated as 25% of total costs.
5. 2001 costs.
6. Quantities estimated by multiplying the selective estimates by 2.3 (proportional to river length).

Table 4-8

Cost Estimate for Upper Sub-Reach Bank Excavation

Item	Quantity	Unit	Unit Price [5]	Amount
CONSTRUCTION ITEMS				
Mobilization and Demobilization	1	JOB	$220,000	$220,000
Clearing and Grubbing from Land	None Required	Acre	$6,700	
Clearing and Grubbing from Water	8.1	Acre	$13,000	$105,300
Site Development: laydown area[6]	None Required	JOB	$61,000	
Construction Access Roads[6]	None Required	LF	$90	
Temporary Instream Roads[6]	None Required	LF	$40	
Removal of Instream Roads[6]	None Required	LF	$12	
Excavation	19,200	CY	$28	$537,600
Sediment Treatment	None Required			
Sediment Transportation	28,500	Ton	$9	$256,500
Sediment Disposal (landfill)	28,500	Ton	$20	$570,000
Utility/Facility Relocation[6]	None Required	LF	$4,000	
Total Construction Costs				$1,689,400
LANDS AND DAMAGES				
Easement Administrative Costs (tracts)	20	Easement	$15,000	$300,000
Easement (bank excavation)	12	Acre	$1,000	$12,000
Total Lands and Damages				$312,000
RELOCATIONS	None Required			
ENVIRONMENTAL COMPLIANCE AND REQ'D MITIGATION[3]	1	JOB	$168,940	$168,940
ENGINEERING AND DESIGN[1]	1	JOB	$168,940	$168,940
CONSTRUCTION MANAGEMENT[2]	1	JOB	$143,599	$143,599
			Subtotal	$2,482,879
			Contingencies[4]	$620,720
			Total Costs	$3,104,000

1.Engineering and Design is estimated as 10% of construction costs.
2.Construction Management is estimated as 8.5% of construction costs.
3.Environmental compliance is estimated as 10% of construction costs.
4.Contingencies are estimated as 25% of total costs.
5. 2001 costs.
6. No additional costs if completed with dredging.

Table 4-9

Cost Estimate for Entire Reach Bank Excavation

Item	Quantity	Unit	Unit Price[5]	Amount
CONSTRUCTION ITEMS				
Mobilization and Demobilization	1	JOB	$220,000	$220,000
Clearing and Grubbing from Land	None Required	Acre		
Clearing and Grubbing from Water[6]	18.6	Acre	$13,000	$241,800
Site Development: laydown area[7]	None Required	JOB	$61,000	
Construction Access Roads[7]	None Required	LF	$90	
Temporary Instream Roads[7]	None Required	LF	$40	
Removal of Instream Roads[7]	None Required	LF	$12	
Excavation	37,400	CY	$28	$1,047,200
Sediment Treatment	None Required			
Sediment Transportation	55,500	Ton	$9	$499,500
Sediment Disposal (landfill)	55,500	Ton	$20	$1,110,000
Utility/Facility Relocation	None Required	LF	$4,000	
Total Construction Costs				$3,118,500
LANDS AND DAMAGES				
Easement Administrative Costs	46	Easement	$15,000	$690,000
Easement (bank excavation)[6]	28	Acre	$1,000	$28,000
Total Lands and Damages				$718,000
RELOCATIONS	None Required			
ENVIRONMENTAL COMPLIANCE AND REQ'D MITIGATION[3]	1	JOB	$311,850	$311,850
ENGINEERING AND DESIGN[1]	1	JOB	$311,850	$311,850
CONSTRUCTION MANAGEMENT[2]	1	JOB	$265,073	$265,073
			Subtotal	$4,725,273
			Contingencies[4]	$1,181,318
			Total Costs	$5,907,000

1.Engineering and Design is estimated as 10% of construction costs.
2.Construction Management is estimated as 8.5% of construction costs.
3.Environmental compliance is estimated as 10% of construction costs.
4.Contingencies are estimated as 25% of total costs.
5. 2001 costs.
6. Quantities estimated by multiplying the selective estimates by 2.3 (proportional to river length).
7. No additional costs if completed with dredging.

4.4.3 Aquatic Ecosystem Benefit

The Pennsylvania reach of the Mahoning River has experienced a partial recovery as is demonstrated by the biological assessment performed as part of this study. Additional improvements may be achieved as measured by various biotic indices including the Invertebrate Community Index (ICI), the Index of Biotic Integrity (IBI), the Modified Index of Well Being (MIwb), Deformities, Eroded Fins, Lesions and Tumors (DELT), and the Qualitative Habitat Evaluation Index (QHEI). The degree to which these measures will improve with any particular action is speculative so a monitoring program is important to determine if anticipated benefits are being realized.

The aquatic ecosystem benefit of no action (Plan 1) is considered low. The river has made improvements as discharges upstream have been reduced or eliminated. However, the ability to make further improvements may be limited by the existence of contaminated banks and sediments as well as the dams located upstream in Ohio.

According to the biological assessment, two factors limiting habitat are a lack of structure and poor substrate. Selective improvements (Plan 2) to these two factors are expected to produce moderate benefits to the aquatic habitat beyond what the river can accomplish on its own.

The dredging/excavation alternatives (Plans 3, 4, 5, and 6) have a high potential for improving the aquatic ecosystem by removing contaminated bank and sediment material. A component of all of these plans is to improve substrate conditions throughout the work areas as contaminated river sediments are removed. Because Plans 5 and 6 address the entire 11.85-mile study area, the potential benefits of Plans 5 and 6 would be somewhat greater than Plans 3 and 4. However, as noted before, construction for all three of these plans must be conducted so that damage to the habitats is not permitted.

Conditions in the Ohio reach of the river contribute to the ability of the river in Pennsylvania to improve. If no action is taken in Ohio, these conditions may limit the benefits of any of the plans applied to the Pennsylvania reach.

4.4.4 Economic/Social Benefit

Economic and social benefits derived from a restoration project in the Pennsylvania Mahoning River include increases in recreation activities, extractive use benefits for municipal and industrial water users, and non-user benefits. Quantification of these benefits is beyond the scope of this study so comments are qualitative. A useful reference for further assessment is a study by Dr. Richard Thorn of the University of Pittsburgh (1981).

Potential benefits in recreational uses include fishing, swimming, and boating. The increase in fishing would result from a general increase in aquatic wildlife diversity, but particularly from restoration of the smallmouth bass and other warmwater fish populations to the Mahoning River. Diversification of aquatic wildlife and continued improvements in water quality could also result in increases in boating, and perhaps swimming uses.

Extractive use benefits relate to improvements in water quality that permit increases in withdrawals for municipal water supply and industrial process or cooling water. Two factors limiting this benefit for this project are: 1) water quality is already supportive of many municipal or industrial uses and 2) little evidence exists that water supply needs in the region are unmet.

Non-user benefits are defined as those benefits accruing to individuals who do not make direct use of the resource including aesthetic, existence, and option benefits. Aesthetic benefits include the pleasures derived from being surrounded by and observing a healthy ecosystem, e.g. bird watching. Existence benefits are derived from awareness that a resource exists and contributes to community life without the user actually visiting the resource. Option benefits are derived from choices that are available for the use of a resource. A polluted resource may have little or no option benefits while a restored resource offers new ways in which that resource may be used.

The six plans are assessed qualitatively with a designation of low, moderate, and high. The no action alternative offers low potential for economic and social benefits. Although further improvements to the river are expected with no action, these improvements are limited. Selective habitat enhancement should result in moderate social/economic benefits primarily by improvement of the fishery and therefore improvement of the resource for fishing and boating. The dredging/excavation plans should maximize economic and social benefits, especially if parallel efforts are undertaken in the Ohio reach of the Mahoning.

4.4.5 Federal Interest

This study was conducted pursuant to Section 312 of the Water Resources Development Act of 1990, as amended by Section 205 of the Water Resources Development Act of 1996. The amended Section 312 provides for the removal of contaminated sediments within “navigable waters” for the purpose of ecosystem restoration. Under the authority of Section 312, there is no requirement that a benefit-cost ratio be computed to determine a Federal Interest.

A Federal interest exists when a project demonstrates an improvement in the environment, is cost-effective, and is in the public interest. Section 307(a) of WRDA 1990 identifies a role for the Corps when improving the function and value of riparian wetlands and EC 1105-2-210 acknowledges the value of modification of substrate in improving environmental quality. Based on these criteria, a Federal interest does exist in performing the dredging/excavation plans (Plans 3, 4, 5, and 6) to generate the benefits derived from the ecosystem restoration. Federal interest for the selective habitat enhancement would be determined under separate authority, most likely Section 206. The no action alternative does not require a definition of Federal interest.

4.4.6 Further Issues

The evaluation of the alternative plans has been based on the information derived as part of this study as well as information available in the literature or developed by others. This reconnaissance study has identified several issues that should be addressed in greater detail in the feasibility phase.

A primary issue affecting all of the plan formulation alternatives is the effect of action or inaction in the Ohio reach of the river. If no action is taken in the Ohio reach, this limits the effectiveness of actions in the Pennsylvania reach. If action is taken in Ohio, there will be implications for Pennsylvania. First, actions in Ohio and Pennsylvania should be compatible and coordinated and, second, dredging, excavation, and dam removal operations in Ohio could result in releases of contaminants and sediments to Pennsylvania that may change the conditions in Pennsylvania. Therefore, the feasibility study should evaluate potential effects of Ohio actions on the Pennsylvania options.

Beyond this general issue, further investigation is warranted on issues specific to each alternative plan, as follows:

- Plan 1: No action
  - What is the expected rate of natural attenuation of contaminants, and what are the limits to continued self-cleansing?
- Plan 2: Selective habitat enhancement
  - What types of habitat structures are most appropriate for the Mahoning River?
  - How many structures are appropriate and where should they be located?
  - What is the optimum type of substrate enhancement and how extensively should it be placed?
  - Will modifications in the operations of upstream Corps reservoirs improve habitat conditions?
  - Should habitat enhancement be pursued under the Authority of Section 206?
- Plans 3, 4, 5, and 6: Dredging, bank excavation, and substrate placement
  - Confirm extent of sediment and bank contamination through additional sampling.
  - Assess feasibility of instream roads and the use of construction equipment capable of operating in shallow riverine environments as well as in the deeper pools.
  - Research effects of bank excavation on riparian vegetation.
  - Investigate use of the rails-to-trails easement in lieu of temporary rail crossings for construction access.
  - Select hydraulic or mechanical dredging equipment.

4.5 Preferred Alternative

Based on the preceding analysis, the preferred alternative can not be determined without considering anticipated actions in the Ohio reach of the river. The Corps has completed a reconnaissance study of the Ohio reach and is seeking cost share partners for the feasibility study. The preferred alternative for Pennsylvania is dependent on the course of action pursued in Ohio.

If no action is taken in Ohio the potential benefits of extensive work in the downstream Pennsylvania reach of the river are considered limited by the upstream conditions. Therefore, the preferred alternative under this scenario is either no action (Plan 1) or selective habitat enhancement (Plan 2). If, however, action is taken in Ohio to implement the recommended dredging, bank excavation, and dam removal, the potential benefits of compatible actions in Pennsylvania may be maximized. Therefore, the preferred alternative is Plan 5, Hydraulic Dredging and Bank Excavation of Entire Reach. This plan consists of the following components:

- Selective dredging from RMs 0 to 11.85
- Selective bank excavation of 50% from RM 0 to 11.85
- Replacement of substrate in dredged areas, assuring natural stream morphology
- Possible additional excavation in banks adjacent to pooled and/or depositional areas in the lower Mahoning River
- Beneficial reuse of dredged and excavated materials or landfill for disposal
- Biological monitoring to document improvements to the ecosystem

Hydraulic dredging is more suitable than mechanical dredging in this environment because contaminated in-stream sediments and bank soils are very soft, fine grained, and pudding-like. Furthermore, the sediments are distributed in areas with difficult access. Hydraulic dredging would enable the removal of contaminated materials with less disruption then mechanical dredging to riparian vegetation and allow spot removal of in-stream muck while leaving coarser materials in place. The coarser materials provide structure for habitat. A combination of hydraulic and mechanical dredging may be necessary where mechanical dredging facilitates hydraulic dredging.

Dredging and bank excavation of the entire reach (Plans 5 and 6) is preferred over dredging and bank excavation of the upper sub-reach (Plans 3 and 4) because it focuses on removing the most surface area of contamination. The success of ecosystem restoration will be maximized by reducing potential surface contact with contaminated sediments. The feasibility study should address the optimum balance between costs and benefits in finalizing the selection. As stated above, hydraulic dredging is recommended over mechanical dredging, and therefore Plan 5 is the preferred alternative.

If Plan 5 is selected, it is recommended that long-term biological monitoring be performed to document improvements to the ecosystem.

5.0 REAL ESTATE

The purpose of this section is to outline the real estate issues for the preferred alternative, to discuss the real estate interests needed to implement the plan and to provide a cost estimate to acquire those interests.

The real estate considerations for this environmental dredging project are complex for several reasons. The first is the application of the Government's rights under navigation servitude. The navigation servitude is defined as the Government's dominant right to use, control and regulate the navigable waters of the United States and the submerged lands there-under for various commerce-related activities, such as navigation and flood control. This power derives from the Commerce Clause of the U.S Constitution (U.S. CONST. Art. I, §8, cl.3). The limit of the navigational servitude rights, for this project, is the OHW mark on each bank. All lands lying at or below the existing OHW elevation are considered part of the servitude rights and can be used by the Government without paying just compensation to the adjacent landowner. Application of these rights is determined by evaluating whether the waterway is navigable. The Mahoning River is considered a navigable waterway of the United States of America; therefore, the navigational servitude rights apply. Therefore, only the lands that lie outside the limits of the servitude are included in this section.

The preferred alternative calls for the removal of the material in the river by hydraulic dredging methods within the servitude between River Miles 0 and 11.85, and selective bank remediation consisting of removal of 50% of the bank material, also located between River Miles 0 and 11.85 and extending outside of the servitude limits.

The hydraulic dredging method requires dewatering basins of between 14.3 and 28.6 acres. This section includes costs for the entire 28.6 acres. Most of the bank work will be below the existing OHW elevation and will consist of placing a geotextile fabric and stone on the banks. However, portions of the banks will be remediated by excavating them to a point 20 feet back from the ordinary high water line. A real estate interest will be required for these areas. The real estate interest, or estate, that will be acquired for the bank remediation is a modified standard temporary work-area easement. Normally, excavating and replacing material is considered a project feature that requires a permanent real estate interest for operation and maintenance. The excavation work for this project, however, is intended solely to remove contaminated material from the banks and re-build the banks where necessary. The banks will then be allowed to return to their natural condition. No permanent real estate rights are needed for operation and maintenance purposes; therefore, only a temporary work-area easement is recommended for removal of the bank deposits. The bank excavation work consists of approximately 28 acres of land. (The term of the easement should be sufficient to re-stabilize the banks.)

Temporary road easements are also needed for access roads to the river. Access to the river is excellent from the right bank. The Norfolk-Southern railroad parallels the right bank from a point near the mouth of the Mahoning River all the way to the State line. The riverward track of a formerly two track system has been removed thus permitting easy access by construction equipment. Only in a few scattered areas does the river diverge significantly from the railroad. One of these areas can be used as a site for the dewatering basins. The left bank is occupied by the CSX railroad tracks; access from this side is not recommended. The total amount of temporary road easement is estimated to be 69 acres.

A 10-acre site needed for contractor laydown and storage areas will be acquired using the standard temporary work-area easement. A disposal site for the dredge and excavated material has not been included because the preferred alternative calls for the beneficial re-use of the material. A beneficial re-use considers the material to be an asset instead of a liability. As such, the material may be used as fill material on commercial or industrial land, the restoration of brownfield sites or as cover in a licensed landfill.

No residences, farms or businesses have to be relocated as part of the preferred alternative, although some utility/facility relocations are included for submarine crossings. Attorney's Opinions of Compensability for these facilities will be prepared during the feasibility phase of the study to determine the Government's responsibilities to provide a replacement utility/facility.

The value of the land, including administrative costs, is estimated to be $1,180,000. A breakdown of unit costs, as well as the costs for the alternative plans, is provided in Section 4.4.1.

6.0 ENVIRONMENTAL ASSESSMENT

6.1 Cultural Resources

A survey of historic and archaeological sites along and within 0.5 mile on either side of the river was conducted using resources at the Pennsylvania Bureau for Historic Preservation and Bureau of Environmental Quality (Appendix D and Plate 1). Eleven historic sites were identified within this corridor; six of these were located within the Mahoning River floodplain. One site, the bridge over the Mahoning River at Covert's Crossing (RM 4.64), has been determined by the Pennsylvania State Historic Preservation Office to be eligible for the National Register of Historic Places. A total of 22 archaeological sites and surveys were identified in the corridor. Twenty of these sites were located in close proximity to the river channel, and eight of these, including one survey site, were located within the floodplain. The archaeological survey site, Site "A", RM 3, was at a proposed wetland mitigation site for the Beaver Valley Expressway. If Plan 2, 3, 4, or 5 is implemented, action should be taken in consultation with the State Historic Preservation Office to avoid or mitigate any potential impact to the bridge at Covert's Crossing.

6.2 Natural Resources

The USFWS, Pennsylvania Game Commission, PFBC, and Pennsylvania Department of Conservation and Natural Resources (PaDCNR) were contacted (Appendix E) requesting information on Federal and State-listed threatened or endangered species in the vicinity of the Mahoning River from the Pennsylvania state line to the Mahoning River's confluence with the Shenango River. The PaDCNR identified one state-endangered species, the Crepis rattlesnake root (*Prenanthes crepidinea*) as being documented in a small wooded floodplain along the River near Robinson (approximately RM 10.5). The other agencies identified no listed species as occurring in the project area. If Plan 2, 3, 4, or 5 is implemented, actions should be taken in consultation with the PaDCNR to avoid or mitigate any potential impact to the Crepis rattlesnake root.

6.3 Hazardous, Toxic, and Radiological Waste

A database search for hazardous material sites was performed for the Mahoning River, along the 12-mile stretch from the Ohio border to the confluence with the Shenango River. The search areas included a half-mile distance from the river along the study area. Seven sites were identified in the database and mapped on Plate 1.

1. 1B Diesel Service, Inc. located on Route 422, is a RCRIS Small Quantity Generator of hazardous wastes.

2. United States Cement Company, located at 6969 Center Road in Lowellville, Ohio, is a RCRIS Small Quantity Generator of hazardous wastes.

3. Browning-Ferris Industries of Ohio, located at 8100 State Line Road in Lowellville, Ohio, is a licensed municipal solid waste landfill.

4. Sunoco Gas Station/Pit Stop, located at 319 Liberty Street in New Castle, is a regulated underground storage tank facility and a RCRIS Small Quantity Generator of hazardous wastes. No leaking tanks have been reported.

5. Zonolite, owned by WR Grace and Company, is located in Ellwood City, PA. It is a CERCLIS facility listed as a No Further Remedial Action Planned site. This designation is assigned if a site undergoes initial investigation and is found to contain no contamination, minimal levels of contamination, or the contamination was already removed.

6. Tic Toc Food Mart, located at 1001 Mount Jackson Road in New Castle, is a regulated underground storage tank facility. No leaks have been reported.

7. Reed Oil Co./Last Minute Mart, located at 511 Montgomery Avenue in New Castle, is a regulated storage tank site and a RCRIS Small Quantity Generator of hazardous wastes.

Based on their locations, none of these facilities will be impacted by the proposed project plans.

7.0 SUMMARY AND CONCLUSIONS

This Lower Mahoning River Environmental Dredging Reconnaissance Study was conducted by the United States Army Corps of Engineers (USACE) pursuant to Section 312 of the Water Resources Development Act of 1990, as amended by Section 205 of the Water Resources Development Act of 1996. The amended Section 312 provides for the removal of contaminated sediments within "navigable waters" for the purpose of ecosystem restoration. Planning for projects to remove and remediate contaminated sediments is conducted in two phases: a reconnaissance phase and a feasibility phase. This report was prepared as part of the reconnaissance phase study.

The Mahoning River is 108 miles long, rising in Columbiana County, Ohio and flowing northward to Warren, Ohio and then southeasterly to New Castle, Pennsylvania, where it joins the Shenango River to form the Beaver River. In 1999, the Corps completed a reconnaissance study of a 31-mile stretch of the Lower Mahoning River located in northeastern Ohio, from Warren, Ohio (River Mile 42.9) to the Ohio-Pennsylvania border (River Mile 11.85). The reconnaissance study included a biological assessment, a sediment investigation, and an analysis of potential restoration alternatives. Based on the study findings, removal of contaminated material was recommended.

The purpose of this reconnaissance study was to complement the Ohio study and determine problems and opportunities for ecosystem restoration related to contaminated sediments in the Lower Mahoning River in Pennsylvania. The area of study included the 12-mile reach of the Lower Mahoning River that lies between the Ohio-Pennsylvania state line and the river's confluence with the Shenango River at New Castle. The Lower Mahoning River in Pennsylvania has been identified as being moderately to severely impaired due to contaminated sediments originating from upstream industrial activity in the Ohio reaches of the river.

The Lower Mahoning River project goal was to identify the activities and level of funding necessary to remediate the Lower Mahoning River within the study reach. The remediation, as conceived for this study, is intended to restore the aquatic ecosystem to the biotic integrity existing on a model reach of the Lower Mahoning River located just upstream of the study area. The success of the Lower Mahoning River Environmental Dredging Project is linked to the restoration of the upstream Ohio portion of the Lower Mahoning River and the elimination of the Ohio Department of Health Public Health Advisory. The objective is to reestablish a fishable and swimable stream in compliance with the mandates of the Clean Water Act.

Restoration of the riverine habitat will benefit the aquatic ecosystem and serve as a focus for the revitalization of recreation along the Lower Mahoning River. The riparian corridor is mostly intact and aesthetically appealing. The principal opportunity is to return the river and its ecosystem to a healthy condition, thus allowing the river to become a scenic recreational resource that will serve as a focus for the revitalization of the Lower Mahoning River. This, in turn, would lead to economic benefits for the area.

Work for this reconnaissance study of the Pennsylvania reach of the Lower Mahoning River included an evaluation of historical data and the collection of new data. The historical data was obtained from previous studies, published reports, and other sources of information. The existing data was reviewed to characterize the natural, cultural, and socioeconomic resources within the study area; to ascertain water resource and ecosystem problems and opportunities; to identify ongoing and previous water resource and ecosystem planning efforts; and to identify relevant entities with responsibility for water and related land resource decision making.

In contrast to the Ohio portion of the Mahoning River, where the watershed is highly urbanized and historically intensely industrialized, the Pennsylvania portion of the Mahoning River was and continues to be primarily undeveloped. There are few urban areas in this portion of the basin. The city of New Castle is located between the confluence of the Mahoning and Shenango rivers. The communities of Edinburg and North Edinburg are located on the southern and northern sides of the river, respectively, at approximately RM 7. Land uses in the river basin also include rail and highway transportation corridors, a rails-to-trails corridor, agriculture, and coal mining.

In addition to the review of existing information, the scope of work for this reconnaissance study included two field investigations. One field investigation, the sediment quality study, included an assessment of river sediment and bank materials. The other investigation included a quantitative assessment of the instream biological condition of the river.

The sediment quality study consisted of three elements: (1) sampling and analysis of river sediments and bank materials, (2) a landfill profiling study, and (3) a standard elution study. The primary goal of the sediment sampling and analysis study was to assess the vertical and horizontal extent of contamination; determine the chemical and physical characteristics of contaminated river sediments and bank materials; and provide a basis for estimating the volume of contaminated materials. The sediment study was conducted not only to assess the distribution, quantity and quality of contaminated sediments/soils within the study area, but also to facilitate the selection of alternatives for the remediation, removal, and disposal/treatment of dredged material.

As part of the field investigation, sampling of river and bank sediments was performed along several transects. Sediment samples were collected and submitted for laboratory analysis. Where appropriate, the sampling results for the Pennsylvania study were compared to those from the Ohio study.

The findings of the Pennsylvania sediment study revealed that the surficial silts and sands within the stream channel exhibited contamination concentrations above those reported in the control reach, but lower than those reported in (composited 0-4 feet-deep) sediments collected along the Ohio reach of the Mahoning River. The contaminants of concern were identified as total recoverable petroleum hydrocarbons (TRPH), polycyclic aromatic hydrocarbons (PAHs), chromium, copper, lead, and zinc. As with the Ohio sediments, no significant concentrations of pesticides/herbicides, volatile organic compounds, or PCBs were reported. In general, the banks exhibited contaminant concentrations similar to the channels. Where vertical profiling was performed, deeper bank materials exhibited higher TRPH concentrations than surface bank materials. In addition, samples collected at or near the bank/water interface exhibited higher TRPH concentrations than samples collected further upslope but below the ordinary high water line.

The findings of the landfill profiling study were used to determine the potential regulatory status of dredged Mahoning River sediments and bank materials. The results indicated that the dredged materials would not have to be treated as hazardous or toxic wastes. Under current state regulations, however, dredged materials are regulated as “residual wastes.” Residual wastes are defined as non-hazardous industrial waste.

The biological assessment was conducted throughout the 12-mile long study area to characterize existing biological conditions, while complementing previous studies conducted along the Ohio reach of the Lower Mahoning River. Eight sampling sites were selected between the state line and the mouth of the Mahoning River. The assessment procedures focused on three primary and two secondary Ohio EPA-developed biotic indices, consistent with the procedures used in the Ohio study.

The results of the biological assessment reflect a potentially recovering ecosystem. Although degraded, the fishery showed a trend towards improvement when compared to historical conditions. The Pennsylvania Fish and Boat Commission fish sampling data from 1999 also indicates a possible rebound of the fishery in the Mahoning River. Overall, it appears that the lower 12 miles of the Mahoning River, though degraded in comparison to the reference area, supports a viable biotic community that could be enhanced through restoration activities.

Based on previously collected information as well as the data collected for this study, various restoration alternatives were formulated and evaluated. Recommendations for implementation were presented based on their costs and technical feasibility, as well as their potential impacts on natural, cultural, and socioeconomic resources.

The preferred alternative plan recommended for ecological restoration of the Ohio reach of the Mahoning River is dredging (hydraulic and mechanical) of contaminated bed material, removal of contaminated bank materials, and selected dam removals. Since the fate of the Pennsylvania reach of the Mahoning is linked to the Ohio reach, it is essential to evaluate restoration of the Pennsylvania Mahoning considering restoration efforts upstream. Therefore, the plan formulation of alternatives and selection of a preferred alternative considered two possible actions for the Ohio portion, which include: (1) no action is taken in Ohio or (2) action is taken in Ohio, as the basis.

Six alternative plans have been formulated. These plans are intended to describe the range of feasible options available for restoration of the Pennsylvania reach of the Mahoning River. The alternative plans are:

1. Plan 1. No action. No further action is taken. Further improvements to the ecosystem rely on natural bioremediation and attenuation processes.

2. Plan 2. Selective habitat restoration. Place improved substrate and structure at key locations in the river for fisheries habitat enhancement.

3. Plan 3. Hydraulic dredging and bank excavation of upper sub-reach. Removal of contaminated sediments and bank materials from the reach of the river located between RM 6.8 and 11.85. All contaminated in-stream sediments and accessible contaminated bank materials will be removed using hydraulic dredging equipment. Improve habitat substrate. Dispose of dredged materials in a landfill if beneficial uses are not identified.

4. Plan 4. Mechanical dredging and bank excavation of upper sub-reach. Removal of contaminated sediments and bank materials from the reach of the river located between RM 6.8 and 11.85. All contaminated in-stream sediments and accessible contaminated bank materials will be removed, using mechanical dredging equipment. Improve habitat substrate. Dispose of dredged materials in a landfill if beneficial uses are not identified.

5. Plan 5. Hydraulic dredging and bank excavation of entire reach. Removal of contaminated sediments and bank materials from the entire study area, located between RM 0 and 11.85. All contaminated in-stream sediments and accessible contaminated bank materials will be removed using hydraulic dredging equipment. Improve habitat substrate. Dispose of dredged materials in a landfill if beneficial uses are not identified.

6. Plan 6. Mechanical dredging and bank excavation of entire reach. Removal of contaminated sediments and bank materials from the entire study area, located between RM 0 and 11.85. All contaminated in-stream sediments and accessible contaminated bank materials will be removed using mechanical dredging equipment. Improve habitat substrate. Dispose of dredged materials in a landfill if beneficial uses are not identified.

Based on the preceding summary the preferred alternative is:

(1) If no action is taken in Ohio, the potential benefits of extensive work in the downstream Pennsylvania reach of the river are considered limited by the upstream conditions. Therefore, the preferred alternative under this scenario is the selective habitat enhancement (Plan 2). The total project cost for Plan 2 could be scoped to suit specific objectives.

(2) If action is taken in Ohio to implement the recommended dredging, bank excavation, and dam removal, the potential benefits of compatible actions in Pennsylvania may be maximized. Therefore, if action is taken upstream, the preferred alternative is alternative Plan 5, Hydraulic Dredging and Bank Excavation of Entire Reach. The total project cost for Plan 5 is $42.4 million.

Plan 5 is preferred over Plan 6 because hydraulic dredging is considered more effective than mechanical dredging for this type of environment. Also, Plan 5 is preferred over Plan 3 because it focuses on removing the most surface area of contamination. Reducing potential surface contact with contaminated sediments will maximize the success of ecosystem restoration.

During the feasibility study, additional sampling should be performed to refine and supplement the analytical data collected during the reconnaissance study. In addition, the volumes of contaminated materials should be reassessed so that the estimates prepared during this study can be further refined. A map showing the location of contaminated sediments should also be prepared during the feasibility phase.

With respect to real estate, the preferred alternative calls for the removal of the material in the river by hydraulic dredging methods within the servitude between River Miles 0 and 11.85, and selective bank remediation consisting of removal of 50% of the bank material, also located between River Miles 0 and 11.85 and extending outside of the servitude limits.

Additionally, the hydraulic dredging method requires dewatering basins of between 14.3 and 28.6 acres. This section includes costs for the entire 28.6 acres. Most of the bank work will be below the existing OHW elevation. However, portions of the banks will be remediated by excavating above OHW. A real estate interest will be required for these areas. The real estate interest, or estate, that will be acquired for the bank remediation is a modified standard temporary work-area easement. The excavation work for this project is intended solely to remove contaminated material from the banks and re-build the banks where necessary. The banks will then be allowed to return to their natural condition. No permanent real estate rights are needed for operation and maintenance purposes; therefore, only a temporary work-area easement is recommended for removal of the bank deposits. The bank excavation work consists of approximately 28 acres of land. (The term of the easement should be sufficient to re-stabilize the banks.)

Temporary road easements are also needed for access roads to the river. Access to the river is excellent from the right bank. The Norfolk-Southern railroad parallels the right bank from a point near the mouth of the Mahoning River all the way to the State line. The riverward track of a formerly two track system has been removed thus permitting easy access by construction equipment. The total amount of temporary road easement is estimated to be 69 acres.

A 10-acre site needed for contractor laydown and storage areas will be acquired using the standard temporary work-area easement. A disposal site for the dredge and excavated material has not been included because the preferred alternative calls for the beneficial re-use of the material. A beneficial re-use considers the material to be an asset instead of a liability. As such, the material may be used as fill material on commercial or industrial land, for the restoration of brownfield sites or as cover in a licensed landfill.

No residences, farms or businesses have to be relocated as part of the preferred alternative, although some utility/facility relocations are included for submarine crossings. Attorney's Opinions of Compensability for these facilities will be prepared during the feasibility phase of the study to determine the Government's responsibilities to provide a replacement utility/facility.

The value of the land, including administrative costs, is estimated to be $1.18 million. A breakdown of unit costs, as well as the costs for the alternative plans, is provided in Section 4.4.1.

Environmental considerations associated with the preferred alternative include: socio-economic; cultural and natural resources; hazardous, toxic, and radiological waste (HTRW); fish and wildlife; endangered species; public involvement; and environmental benefits. Environmental documentation would involve preparation of an environmental assessment (EA) and finding of no significant impact (FONSI) or an environmental impact statement (EIS and record of decision (ROD). The estimated cost for environmental compliance is approximately $2.44 million.

Total project cost, including engineering and design, for the preferred alternative is detailed in Table 4-6 and Table 4-9 and equals $42.4 million. Construction cost is cost-shared on a 65% Federal to 35% non-Federal basis.

Identification of a non-Federal sponsor will allow the study process to continue. The sponsor must agree to pay one-half of the cost of the Feasibility Study, the next step in the restoration effort. The Feasibility Study is estimated to cost in the range of $1.5 to $2 million. Once a non-Federal sponsor is identified a project study plan will better define the Feasibility Study cost.

8.0 RECOMMENDATIONS

It is recommended that this reconnaissance report be used as a technical reference document to facilitate further dialog between the USACE and non-Federal agencies including the Commonwealth of Pennsylvania and local Lawrence County officials, for further study efforts. It is further recommended that, after receipt of a letter of intent to be the cost-sharing partner for the feasibility phase, this report be used as a basis for the preparation of a draft Feasibility Study Cost-Sharing Agreement (FCSA) that contains a Project Study Plan (PSP). Completion of the draft FCSA/PSP would allow the conduct of a Reconnaissance Review Conference, if required, between the representatives of the local sponsor and the USACE, and certification of the reconnaissance phase of study. Reconnaissance certification could then be followed by final negotiations and execution of the FCSA/PSP by the local sponsor and the USACE.

Raymond K. Scrocco
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District Engineer
Pittsburgh District

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10.0 ACRONYMS AND ABBREVIATIONS

Ac-ft	Acre-foot
Cfs	Cubic Feet/Second
DELT	Deformities, Eroded Fins, or Tumors
DO	Dissolved Oxygen
FCSA	Feasibility Study Cost-Sharing Agreement
Ft	Foot
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
Mi	Mile
MIwb	Modified Index of Well Being
NPDES	National Pollutant Discharge Elimination System
ODH	Ohio Department of Health
OEPA	Ohio Environmental Protection Agency
OHW	Ordinary High Water
PaDCNR	Pennsylvania Department of Conservation and Natural Resources
PaDEP	Pennsylvania Department of Environmental Protection
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PEM1	Palustrine Emergent Persistent
PEM2	Nonpersistent Emergent Persistent
PFBC	Pennsylvania Fish and Boat Commission
PFO1	Palustrine Forested Broad-leaved Deciduous
POTW	Publicly-owned Treatment Works
Ppm	Parts per Million
PSP	Project Study Plan
PSS1	Palustrine Shrub-Scrub Broad-leaved Deciduous
PUB	Palustrine Unconsolidated Bottom
QHEI	Qualitative Habitat Evaluation Index
RM	River Mile
SR	State Route
SVOCs	Semivolatile Organic Compounds
TRPH	Total Recoverable Petroleum Hydrocarbons
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOCs	Volatile Organic Compounds
WWH	Warm Water Habitat
WWTP	Wastewater Treatment Plant
Yd	Yard

Appendix A

Ordinary High Water Determination

Appendix B

Sediment and Analysis Report

Appendix C

Biological Assessment of the Mahoning River, Lawrence County, Pennsylvania, River Mile 0 through River Mile 12

Appendix D

Cultural Resources Inventory

Appendix E

Agency Consultations for Threatened and Endangered Species

Appendix F

Quality Control Certification