2.0 DESCRIPTION OF STUDY REACHES

2.1 Introduction

This section describes the project area in its current state. The description is based on review of existing technical reports and research on historical records relevant to the river; on observations made during the reconnaissance and sampling phases of the study; and on studies and reports completed specifically to support this study (Appendices E, F, and H).

The study area was the lower Mahoning River between RM 12 (near Lowellville, OH) and RM 46 (near Warren, OH). The OHW marks defined the lateral extent of the study. There were ten dams in this stretch of river (Figure 2).

The most significant population center in the basin is Youngstown-Warren , Ohio, with a 1990 Metropolitan Statistical Area population of 600,895 persons. Industrial towns in the basin experienced extreme population losses during the decade between the 1980 and 1990 censuses. During this period, the population of Youngstown City, for example, declined from 139,759 to 95,706 persons, a loss of 31.5%.

The Mahoning River basin is underlain with abundant mineral resources. Minerals currently being extracted include bituminous coal, natural gas, oil, limestone, clay, sand, and gravel. Coal mining has been most intense in the southern and particularly the southeastern portion of the basin. In recent years oil and gas extraction activities have intensified in the western part of the drainage basin.

Important basin industries include those related to the manufacturing of cement, ceramics, electrical power, chemicals, petroleum, and primary metals, as well as mineral extraction, dairy farming and lumbering. Of these, by far, the most significant local economic activity has been the manufacture of iron and steel.

The dramatic decline of the basic steel industry is reflected in the decrease of employment in manufacturing (Standard Industrial Code 33) in Mahoning and Trumbull Counties from more than 65,000 at its peak to about 6,500 today.

According to Ohio Water Quality Standards (Chapter 3745-1 of the Administrative Code), the Mahoning River mainstem is designated for use as a warm water habitat, as an agricultural water supply, as a recreation site, and as an industrial water supply.

2.2 Physical Setting

The lower Mahoning River is located in northeastern Ohio. This study dealt with the reach that flows north through the community of Leavittsburg, then hooks through the City of Warren and turns south, passing through Niles, McDonald, Girard, Youngstown, Campbell, Struthers, and Lowellville, near the Ohio-Pennsylvania border (Figure 2).

The lower Mahoning River between Warren and Lowellville is divided into a series of reaches separated by small dams. In the slackwater pools upstream from each dam, velocities decrease and river tends to widen and deepen.

Where the river has been channelized, such as in the Struthers area, the banks are steep and contain a large proportion of slag. Where the banks are generally unaltered they are composed of soil. The unaltered banks rise vertically about two feet from the water surface and level off.

Visibility in the water, even under the best conditions, is limited to about two feet. The color of the water tends towards olive, and small, intermittent patches of sheen were noted in all reaches of the river.

The river passes through industrial, residential, and undeveloped areas. There are many water intakes and discharges. In spite of this, the river supports a thriving riparian zone that forms a lush canopy over most of the river. Access to the river is difficult in most areas. A more thorough description of the current ecological condition of the river is given in section 2.5.

For the purpose of this report, each of the dams was named based on the community where it is located and a nearby bridge, street, or other significant landmark. Table 2 details this nomenclature. The reaches formed between each dam were also named based on their location. Reaches and dams in this report will be referenced by those names.

2.2.1 Hydrology and Hydraulics

The Mahoning River drains 1,132 square miles of northeastern Ohio and westcentral Pennsylvania between the approximate limits of 40°47' to 41°40' north latitude and 80°22' to 81°15' west longitude. About 1,085 square miles, or 96% of the drainage basin, is in the Ohio counties of Ashtabula, Geauga, Trumbull, Portage, Mahoning, Stark and Columbiana, and the remaining 4% drains Lawrence County in Pennsylvania.

The Mahoning River is 108 miles long. It rises in Columbiana County, Ohio, about 12 miles southeast of Alliance. It then flows generally northward to a point near Warren, Ohio, where it turns towards the southeast and flows through the communities of Warren, Niles, and Youngstown, Ohio, and then into Pennsylvania. Twelve miles after it crosses the state line, the Mahoning River joins the Shenango River to form the Beaver River in Pennsylvania. The drainage areas, stream lengths, and slopes of the Mahoning river and its major tributaries are presented in Table 3.

Water resources in the relatively small Mahoning River basin have been very intensively developed. There are five reservoirs within the basin which store 30,000 acre-feet or more (total combined maximum storage 339,170 acre-feet), and which very dramatically influence the hydrology of the Mahoning River. Pertinent information on these large reservoirs is summarized in Table 4.

Besides these five major lakes, there are numerous other small water supply and recreation storage impoundments, including eleven which have surface areas of 90 acres or more.

The 1976 USACE report summarized the flow characteristics of the lower Mahoning River. According to the report, "Flows in the lower 46 miles of the Mahoning River are influenced by natural precipitation events, upstream operation of the five major reservoirs, municipal waste water releases, and consumptive industrial river water usages. The normal low (flow) period in the watershed is experienced in the July through October time period when ambient temperatures are the highest. Conversely, the normal high flow period encompasses the February through May time period when ambient temperatures steadily increase from their winter minimums. Currently (1976), the Pittsburgh District (of the USACE) is scheduled to maintain a minimum flow schedule of 145 Cubic Feet per Second (CFS) at Leavittsburg from the middle of November to the middle of March. A minimum Leavittsburg flow is maintained at 310 CFS throughout June, July, and August. The minimum flow schedule at Youngstown corresponds to about 225 CFS from November through March with a peak flow of about 480 CFS during the last fifteen days of July."

The ten low head dams located in the study area strongly influence the hydraulics of the lower Mahoning River. The nine reaches formed by the dams vary in length from two to ten miles. Figure 2 show their locations.

Common to each dam is an upstream slackwater pool and a downstream tailwater. Figure 4 is a photograph showing a slackwater pool, a dam, a tailwater, and the beginning of a free flowing river zone. Figure 5 is an elevation profile of the project area.

A turbulent tailwater is found directly downstream of each dam. Typically, water spilling over the dam collects in a basin-like scour hole at its base. These basins tend to be small, no more than fifty yards in length, appear to contain highly oxygenated water (based on the amount of whitewater observed), and feature strong, disorganized currents. Generally, these basins narrow and become shallower near the tail of the basin, where the water exits with elevated velocity. The riverbed topography is irregular, often with large rocks and pronounced shoals. The shoals are formed by strong currents and are composed of cobbles, gravel, coarse sands, and/or sands. They are generally free of silts. In some areas, large rocks or slag deposits located at the tail of the basin help to create short rapids.

The free flowing river reaches exhibit natural pool/riffle sequences and the natural pools tend to be much smaller than those pooled by the dams. Most of the river south of Warren that falls into the free flowing category is 2-6 feet deep. Mid-channel sediments here are composed of coarse sands and gravel. Sediments outside of the channel consist of deep deposits of silts. Much of the river between Warren and Leavittsburg is shallower and slightly faster, but still has substantial deposits of near-shore silts.

The ponding of water and the slowing and diffusing of the mid-channel current mark the change from the free-flowing zone to slackwater. In the pooled zone the river widens and deepens, typically increasing in width by 10-20 percent while reaching depths of 8-12 feet. The mid-channel current becomes less distinct, but the pattern of sediment deposition is the same; coarse sand and gravel mid channel, with deep deposits of silts outside of the channel. The slackwater pool zones vary in length roughly proportionally with the height of the dams forming them. The highest dams, the Warren-Summit Street Dam and the Girard-Liberty Street Dam, form the largest slackwater pools.

2.2.2 Ordinary High Water Determination

The ordinary high water (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 defines the lateral extent of Federal jurisdiction. This law states that "...the bed of navigable streams includes lands below the OHW 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. Based on historical usage from commercial navigation, the Mahoning River is regulated as navigable waters from its mouth upstream to RM 41.

In May-June 1998, an OHW study was conducted along the Mahoning River in order to define the lateral boundaries for the Mahoning River Environmental Dredging Reconnaissance Study and to facilitate right-of-entry for the restoration project. The OHW study area included the entire Mahoning River Environmental Dredging Reconnaissance Study area: a 34.2 mile reach of the of the Mahoning River located in Trumbull and Mahoning Counties, OH, between river miles 11.85 (nominally RM 12, the OH-PA state line) and 46.18 (nominally RM 46). A total of 31 sites were selected along the 34 mile study reach: one located both upstream and downstream of each of 10 dams located in the study reach, one just downstream of the study reach at mile 9.9, and the other 10 sites located within mid-reaches between various dams.

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 OHW line, and Zone C is the area located above the OHW line. These zones are illustrated on Figure 3.

Zone A is generally characterized by soil free, water scoured, sandy or rocky shorelines, dominated almost exclusively by water tolerant trees such as black willow, silver maple, and sycamore. Herbaceous plants are almost entirely lacking in Zone A except where the slopes are gentle enough to support emergent wetlands in pockets of sediment along the shoreline.

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. Pioneer species are annual, non-aquatic, herbaceous plants, which can quickly colonize continually disturbed areas, such as riverbanks. Species typical of Zone B include silver maple, willows, dogwood, ninebark, wingstem, and garlic mustard.

Zone C, above the OHW line, has defined soil layers, which include top soil and leaf litter. There are no scour marks or silt deposition layers. Silt is 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 such as oaks and hickories.

Elevations of the OHW water line, the river pool, and the last high water event were then determined. This was accomplished using a hand level to tie unknown elevations to known reference points such as dam elevations, United States Geological Survey (USGS) standard discs, and historical high water reference points. Where there were no elevation reference points, pool elevations were determined from the 1960 USACE High Water Profile, Mahoning River. Photographs were taken of the OHW mark at each site. The OHW profile for the study reach was then plotted. The profile for the last high water event, which occurred 16 April 1998, was also plotted as a slope validity check. Site locations and elevation data are presented in Appendix D, Table 1.

The elevation of the OHW line ranged between 3 to 8 feet above the water surface elevation at normal flows at sites located directly upstream of the dams. The elevation of the OHW line ranged between 5.3 and 11.1 feet above the pool at sites located directly downstream of dams, depending on the height of the dam (Table 1, Appendix D). This line corresponds approximately to a 3-year flood. Along the Mahoning River study reach, the vegetation of Zone A was dominated by silver maple, black willow, and sycamore with occasional obligate wetland species such as swamp dock, peppermint, moneywort, yellow iris, aquatic milkweed, and peltandra. Zone B was dominated by silver maple, black willow, sycamore, box elder, cottonwood, and slippery elm, with an understory of silky cornel, tall coneflower, wing-stem, reed canary grass, poison ivy, joe-pye-weed, spotted touch-me-not, riverbank grape, sourweed, horse nettle, and garlic mustard. Zone C was dominated by black cherry, white ash, tree-of-heaven, hawthorn, and staghorn sumac, with an understory of multi-flora rose, burdock, and virginia creeper. Table 2, Appendix D, lists observed vegetation with associated water regimes and relative abundance, for Zones A, B, and C. As can be seen in this table: Zones A, B, and C, respectively, contained 20.4%, 10.7%, and 0% obligate wetland species; 44.9%, 29.3%, and 8% facultative wetland species; 12.2%, 18.7%, and 22% facultative species; 10.2%, 26.7%, and 36% facultative upland species; 12%, 14.7%, and 8% pioneer species; and 0%, 0%, and 26% upland species.

2.2.3 Geology

The Mahoning River drains a glaciated portion of the Allegheny Plateau physiographic province. South of Warren, the Mahoning watershed is underlain predominantly by the Pottsville and Allegheny Formations, both of which are of Pennsylvanian age and include interbedded sandstones, shales, claystones and thin limestone and coal beds. North of Warren the Mississipian Cuyahoga Formation, which consists of shale and sandstone, predominates. Within the entire project area, the Mahoning River valley is underlain by the Cuyahoga Formation, whereas the uplands along the river are underlain by the Pennsylvanian units.

The entire Mahoning watershed is mantled by glacial materials, predominantly the Wisconsin-age Lavery and Hiram tills. From south of Warren to the state line, the river valley is occupied primarily by outwash gravels. Water well logs indicate that there are up to 70 feet of clay and other surficial materials above bedrock in the river valley, though in some areas bedrock intrudes directly into the river channel.

Empirical observations made during the reconnaissance and sampling phases of this study suggested that most of the river is indeed underlain by a stiff clay layer. In the northern reaches around Warren, compacted, layered clay (logged by the drill crew as clayshale) was encountered beneath this clay layer. Sediments deposited onto this clay layer consisted of sand, coarse sand, and gravel. When encountered in the approximate main channel (based on current flow) these sediments were generally free of silts. In some cases, these sediment deposits were minimal and the clay layer was encountered almost immediately. Silt-based sediments have been deposited universally on both sides of the main river channel. These sediments are black, smell like oil, create a sheen when disturbed, and are the consistency of pudding when mixed. In some places, this layer was more than three feet thick. A thin layer (0.5"-2") of brown, natural-looking silts covered the black silts. Silts were not observed in the main channel, immediately below dams, and in rapids. These are areas subject to continuous scouring. Schematics of typical sediment deposition patterns are shown on Figure 6 and Figure 7.

2.2.4 Climate

The climate of the Mahoning River basin is temperate and humid. Normal monthly air temperatures range from about 25°F in January to 70° in July. The average annual temperature is about 48°F and temperatures of 90°F and above, and 32° and below, are normally recorded 10 days and 150 days per year, respectively. Extremes of 108°F and minus 27°F have been recorded within the basin. Precipitation is well distributed throughout the seasons, with the normal annual levels varying from 35 inches in the southern portion of the basin to 40 inches per year in the northern section. The monthly normal precipitation is usually highest in June or July (about 3.8inches) and lowest in February (about 2.2 inches).

2.3 History of Industrial Activity

Prior to 1800, the Mahoning River served as a highway for early explorers, trappers and traders (U.S. Fish and Wildlife). Between 1800 and 1850, industrialization based on water power came to Ohio. Beginning around 1900, and continuing for nearly three-quarters of a century, the lower Mahoning River supported one of the most intensely industrialized steel-producing regions in the world. Steel mills, railroads, and support industries used the river for cooling and process water. Today, only vestiges of these industries remain active, but the legacy of heavy industrialization remains in the form of contaminated sediments.

2.3.1 Description of Industrial Development Along the River

The Mahoning River Valley was one of the most active industrial areas in the world for much of this century. In 1920 the steel industry in the Mahoning River Valley produced 9 percent of all pig iron produced in the United States (American Iron and Steel Industry, 1925). During the period between 1920 and 1970, the river served 15 primary steel plants and 35 plants in steel related industries. Peak water use by industry was over 1.5 billion gallons per day, equivalent to 4-5 times the normal river discharge (Schroeder, Appendix E). The river not only received industrial waste from the mills, but also heated cooling water that further degraded it. According to the U.S. Fish and Wildlife Service (Appendix F), "water temperature in the Mahoning exceeded 95 degrees Fahrenheit over 25 percent of the year in 1964 and reached a maximum of 108 degrees at Lowellville (Testa, 1997)".

In the 1970s steel mills began to close. By 1990, employment in the steel industry had been reduced by 80 percent and most of the mills along the river had been razed (U.S. Fish and Wildlife Service). Today, only a few working mills still exist.

Waste water treatment of discharges into the Mahoning River have increased dramatically in recent years. The Youngstown Waste Water Treatment Plant (WWTP) is the largest municipal discharge to the Mahoning or Beaver River. The 1991 plant rehabilitation and capacity expansion (35 to 90 million gallons per day) of secondary level sewage treatment at Youngstown contributed to improvement of the water quality of the Mahoning and Beaver Rivers. The Boardman, Girard, Warren, Niles, Campbell, and Struthers, Ohio WWTPs were also upgraded from primary to secondary or advanced secondary level treatment between 1987 and 1988, and other significant treatment improvements have been achieved at additional basin WWTP facilities. These major municipal WWTP upgrades have resulted in very significant recent improvements in stream concentrations of ammonia and dissolved oxygen. However, there are still numerous combined sewer overflow (CSO) sites in the older basin sewer systems, and these along with sanitary sewer overflows (SSO) contribute to regular sanitary problems in the river. Studies and negotiations on CSO and SSO problems are ongoing.

2.3.2 History of Low Head Dams

Not too much is known about the history of the ten dams in the project area. The Youngstown-Mahoning Avenue Dam appears on a map of Youngstown from 1868 (Wallings Ohio Atlas of 1868). It is associated with a grist mill. The Girard-Liberty Avenue Bridge Dam once had a lock and a canal, according to Trumbull County property maps, and is owned by McDonald Steel, according to Ohio Department of Natural Resources (ODNR), Division of Water records. Those same records identify the Youngstown-Crescent Street Dam as belonging to the USX, the steel conglomerate. The Lowellville-First Street Dam has a gate valve that must have served some purpose, but that purpose has not been identified.

The history of some dams can be inferred from their location. The Warren-Summit Street Dam is associated with the defunct power plant to which it connects, but neither the dam nor the slackwater pool it forms appears on property maps from 1930. The Warren-Main Street Substation Dam is used to supply water to Warren Consolidated Industries (WCI), a steel manufacturer. The Leavittsburg-Lovers Lane Dam is connected to a water intake pump-house presumed to be municipal. The Warren-North River Road Dam deflects water to CSC, an industrial wastewater treatment plant. The Haselton-Center Street Dam and Struthers-Bridge Street Dam are both located in areas once dominated by steel mills and probably supplied their process water. Property maps indicate that the river has been re-channelized near the Haselton-Center Street Dam, but do not indicate when this was done.

Each of the dams was inspected to determine its construction and its current condition and use. Other sources, including the Youngstown Historical Society and the Ohio Historic Preservation Office, were contacted for information about the history of the dams. The ODNR, Division of Water, provided permit information on two of the dams. Table 5 summarizes the results of the dam inspections and research.

2.3.3 Description of Historical Pollution

Steelmakers were not alone in polluting the Mahoning River. Many support industries also used the river indiscriminately. According to Schroeder (Appendix E), "the Mahoning River carried away the industrial waste from the heavy industry in the valley and the partially treated domestic waste from over 600,000 residents. The river received pickling liquor, electroplating discharges, coke quench water, cutting and lubricating oils, scale, and virtually all other waste materials that were most easily disposed of by discharge into the river. The Mahoning River received over 70,000 pounds of cutting oil and lubricating oil each day." Schroeder further indicates that Mahoning River water contained high concentrations of metals (copper, zinc, lead, chromium, iron, nickel and cadmium), cyanide, ammonium nitrogen, and phenols. Highly elevated levels of fecal coliform were common. It is also likely that the river received constant doses of airborne particulate contaminants from industrial and residential smokestacks and chimneys. The Mahoning River, for most of this century, was heavily contaminated with industrial and domestic wastes, as well as being severely affected by temperature elevations due to industrial use.

2.4 Existing Sediment / Bank Contamination

This section provides details about the sampling program undertaken to characterize existing conditions in the Mahoning River. The results of the sampling are also presented.

2.4.1 Introduction: Existing Data and the Need for Additional Sampling

The water quality in the Mahoning River has improved dramatically in the last quarter of a century, but aquatic life continues to struggle. It has been widely reported that the sediments of the Mahoning River are grossly contaminated. It has also been reported that the banks are "oil-soaked". Cursory examinations made during this study, however, suggested that the term "oil-soaked" bank is a serious misnomer. There is little if any evidence that the original riverbanks have been soaked with oil or other contaminants to any significant degree. Rather, the primary problem is with oil enriched and otherwise contaminated deposits that have formed within the reaches of the mainstream dams along the river. These deposits have been capped by silt and vegetation, and now resemble bank. According to the 1996 OEPA report "The Mahoning River is 108.3 miles long and, downstream from Leavittsburg, has historically been one of the most polluted of any stream or river in Ohio". The 1988 Ohio Department of Health , "Swimming, Wading, Fish Consumption Advisory For Mahoning River" (Appendix A) cites the presence of high concentrations of PAHs in Mahoning River sediments, as well as low concentrations of Mirex, phthalate esters, and polychlorinated biphenyls (PCBs) in fish taken from the river.

While data generated prior to this study was sufficient to suggest a human health risk exists, it was not sufficient to determine the risks posed to workers who might handle the sediments in a removal project, or the regulatory status of dredged sediments once removed. Without this, it was impossible to determine how and where the contaminated sediments could be disposed of, and impossible to estimate a cost for that disposal. A new, more comprehensive sampling program was indicated.

The sampling program developed for this study needed to address these questions: 1.) What is the chemical composition of the contamination in the sediments? 2.) What would be the regulatory status of dredged sediments? 3.) Is there likely to be a degradation of water quality related to sediment disturbance during dredging activities?, and 4.) Are sediments layered into high contamination and low contamination zones or is the contamination distributed homogeneously?

2.4.2 Methods of Investigation

The sampling program was divided into four parts; a landfill profiling study, a vertical profiling study, a standard elution study, and a limited bank study. Sample locations are shown on Figure 2.

The landfill profiling study was designed to answer the question, "What would be the regulatory status of dredged sediments?". To do this, samples were drawn from the river at (nominally) one-mile intervals. Most of these samples were taken by hand using a stainless steel hand auger that had been rigorously decontaminated prior to use. The hand auger allowed soft sediment samples to be drawn from up to five feet below the sediment-water interface, but its usefulness was limited in coarse and hard sediments.

The landfill profiling samples were composed mostly of near-shore silts, where available. These silts were favored over other substrates where possible because they looked and smelled contaminated. In some cases, the silts were augmented with coarser sediments taken from mid-channel using a drilling rig (this work is described elsewhere in this section). The samples were composited; packed into pre-cleaned, chemically inert sample jars; sealed; placed into coolers with ice under a Chain of Custody; and sent for analysis.

The analytical suite for the landfill profiling samples consisted of a test for flammability, a test for corrosiveness, a test for reactive sulfides and cyanide content, and a test for leachable toxic organic compounds (the Toxicity Characteristic Leaching Procedure, or TCLP). These are the tests to determine if the sediments would be considered "characteristic wastes" under Federal Hazardous Waste regulations (40 CFR 262). In addition, the sediments were tested for PCB content. The PCB tests were run to determine if the sediments are "Toxic Wastes" (as defined in 40 CFR 760 et seq.). Disposal facilities require this information to determine whether or not they are permitted to handle a particular waste.

The vertical profile study was designed to answer the questions "What is the chemical composition of the contamination in the sediments?", and, "Are sediments layered into high contamination and low contamination zones or is the contamination distributed homogeneously?". To do this, it was necessary to obtain an undisturbed continuous sediment sample from the sediment water interface to the natural riverbed substrate. Part of this sample would be separated into layers based on morphological differences, or if none were noted, into four-foot long sections. Another part of the sample would be saved for compositing to be counted as one of the samples in the landfill profiling study. Since the 1976 USACE report indicated that sediment build-up was maximized immediately upstream from each dam, it was decided that sediment core samples should be taken mid-stream immediately upstream from each dam.

Vertical profile samples were taken within 50 yards of each dam using a portable drill rig fixed to a floating plant that could be disassembled, moved, and reassembled. The floating plant was transported in parts, craned or winched to the water's edge, and assembled. Sampling was done with a pre-cleaned steel split barrel sampler (3" diameter by 5' long), driven by a 140-pound hammer by hand with the aid of a portable cathead. Sampling proceeded until refusal was encountered (defined by movement of the sampler less than 6 inches after fifty hammer blows) or until the "inferred limit of contamination" was reached. The inferred limit of contamination is the depth at which contamination is no longer visible or detectable with an organic vapor detector. A geologist logged the process and described the sample on a drilling log before the sample was processed. The geologist also determined the inferred limit of contamination.

The intent of the vertical profile sampling was to determine whether the chemical composition of the contamination varied with morphological changes or with sediment depth, based on four-foot intervals. However, at no time did a vertical profiling sample yield more than one sample, which was by definition a sample from the first four feet of sediment. In fact, sample recovery mid-channel was found to be generally poor and consisted of scoured coarse sand, gravel, and clay. It was felt that analysis of these sediments alone would not accurately represent the bulk of the sediments, and would provide misleading information regarding contamination levels. Therefore these mid-channel samples were augmented with near-shore silts taken from the first four feet of sediment within 30 yards of the original drilling location.

The vertical profile samples were handled and shipped as described previously in this section. Vertical profile samples were analyzed for Total Recoverable Petroleum Hydrocarbons (TRPH), Volatile Organic Chemicals (VOCs), Semi-Volatile Organic Chemicals (SVOCs), pesticides, pH, Target Analyte List (TAL) metals, Cyanide, Herbicides, Total Organic Carbon (TOC) and PCBs (total). This extensive suite was used to "fingerprint" the sediment contaminants and provide details of contamination not covered by current regulations that still might have negative health implications for workers or for the public. Three of these samples were also analyzed for Dioxin/Furans, and three were analyzed for Volatile Organic Compounds using the EnCore method. The three Dioxin/Furan samples and the three EnCore VOC samples were taken concurrently with the three standard elution samples, at the Warren-Main Street Substation Dam, the Girard-Liberty Street Dam, and at the Lowellville-First Street Dam. In total, 10 vertical profile samples were taken.

It was not possible to get the floating plant to all of the dams. Consequently, two of the vertical profile samples were taken exclusively by hand. The Haselton-Center Street Dam was sampled by hand because the "slackwater" pool was so small and narrow it created a chute, forming very strong and dangerous currents. The Struthers-Bridge Street Dam was sampled by hand because property access at the only practical launch site could not be secured.

The standard elution study was designed to answer the question "Is there likely to be a degradation of water quality related to sediment disturbance during dredging activities?" To determine this, it was necessary to obtain representative sediment and water samples at three locations. Water samples were taken immediately upstream from the floating plant, at the inferred mid-channel at mid-depth. Sediment samples were drawn from the same material taken for the landfill profiling study.

The standard elution test measures the amount of contamination released to ambient water when sediments in the water are disturbed. This test is performed in a laboratory under controlled conditions using actual sediment and water from the river. The sediment samples are mixed vigorously with river water to extract contaminants from the sediment into the water. The contamination in the water is then measured and compared to the contamination levels extant in the water prior to mixing with the sediments. This provides a measure of the likely release of contamination from the sediments to the water if they are disturbed during dredging operations.

This testing was performed pursuant to Section 401 permitting requirements. A "Section 401" permit regards the monitoring and mitigation of water quality degradation related to dredging operations. It will be necessary to obtain such a permit for any dredging performed in the Mahoning River. The suite of analytical tests run on the water before and after extraction is similar to that of the vertical profile. It includes SVOCs, Pesticides, PCBs (by isomer), Herbicides, TAL Metals, and Cyanide.

Limited bank sampling was also performed to assess the potential for contamination to have migrated into and under the riverbanks. Such contamination would negatively impact valuable riparian habitat, including nesting areas, as well as introduce the potential for contaminants to reenter the river channel. Bank samples were taken at fixed distances laterally away from the river in order to develop a cross section of contamination in the riverbank. Bank sampling was conducted at three locations; above the Leavittsburg-Lovers

Lane Dam, at the Girard-Liberty Street Dam, and below the Lowellville-First Street Dam. This provided bank information in the "Upper Control" area (Leavittsburg), in the approximate middle of the study area (Girard), and at the lower end of the project area (Lowellville). Due to budget restrictions the sample taken at Lowellville was tested for TRPH only. In order to compare data from the bank samples with the samples taken from the river, the samples taken at Leavittsburg and at Girard were tested for TRPH, VOCs, SVOCs, Pesticides, Total Metals, Cyanide, Dioxins, Herbicides, TOC and PCBs. Notes from the bank investigation are included in Appendix G.

2.4.3 Volume Estimation

Appendix H describes the methods used to determine the volume of sediment in the lower Mahoning River. A total volume estimate of 462,000 cubic yards of sediment was obtained for the river. With the exception of a large sediment deposit in the North Warren Reach, the volume of sediment deposits in the upper four reaches was much less than the volume estimate for the remaining reaches. The heaviest sediment deposits were found in the Girard and Niles Pools. The 1976 USACE report estimated that there are an additional 286,000 cubic yards of contaminated material in the riverbanks.

2.4.4 Sampling Results and Analyses

The results of sampling performed for this study confirmed some long-held beliefs about the conditions in the Mahoning River, but challenged others. Mahoning River sediments were found to be highly contaminated, as anticipated. However, assumptions based on earlier reports about the pattern of sediment distribution were incorrect, and volume estimates were low. In addition, some contaminants were not found as abundantly as reported earlier, but other contaminants were found to be far more abundant. These findings are detailed in this section.

2.4.4.1 Physical Distribution and Properties

While localized intrusions of bedrock extend into the river in some places, and there are some significant deposits of cemented and loose mill slag, iron ore, and other materials, the sediments of the Mahoning River are generally composed of four layers described below (Figure 6). A stiff clay layer underlies most of the riverbed. This universal clay layer forms an impermeable seal through which water and water-borne contamination cannot pass. On top of this layer is usually a thin layer (0"-6") of coarse sand and gravel, with some cobbles. Black, contaminated silts make up the third layer. These black silts dominate the riverbed landscape, forming drifts and deposits found to be at least five feet deep in some places and presumed to be much deeper immediately upstream of each dam. The black silts are covered with a thin layer (<1") of brown silts, which is presumed to be relatively healthy.

For the purpose of discussion in this report, the part of the river where the current was the strongest was considered to be the "main channel". Intuitively, it seemed the main channel should always be in the approximate middle of the river at any given point. In fact, the main channel meandered from the center to the right or left bank and back. Sometimes the meandering was predictable based on the convolutions of the river. Sometimes it was not. Figure 7 is a schematic showing the distribution of sediments in relation to a meandering main channel, in a given stretch of river.

In fast water, and in the inferred main channel of the river, sediment deposits consisted mostly of the sand and gravel layer. This conclusion was supported by *information developed in the drilling (vertical profiling) program. Recoveries in* the main channel from drilled samples were very low and consisted mainly of coarse sand, gravel, and clay. No silts were recovered from the main channel. Outside of the fast-water zone and the inferred main channel, deposits of black silts were found from the Warren-North River Road Dam to the Lowellville-1st Street Dam.

There was one known exception to this black silt distribution pattern. A four-foot core of undisturbed silt sample was recovered at the Youngstown-Crescent Street Dam from sediments in the inferred main channel. The silts in this area were very dark brown, not black, but were otherwise similar to the black silts found elsewhere in the river. It was later determined that this sample had an extremely high iron content, explaining at once the brownish hue of the core (due to the presence of iron oxide), and the extraordinary density of the sample that allowed it to be deposited in the main channel.

2.4.4.2 Chemistry

The black silts of the Mahoning River were visibly contaminated. They were deep black and shiny, and did not look like a natural deposit. They tended to drop quickly out of suspension. They had septic and petroleum odors. They evolved a substantial sheen when disturbed and left metal tools coated with an oily hydrophobic layer. They mixed readily and take on a viscous liquid character once disturbed. In the approximately 12 weeks of field- work performed for this study, not a single living organism was found in the black silts. Conversely, the coarser sediments looked normal and contained (sometimes abundant) evidence of life. It was expected that samples taken from the black silts would show heavy contamination while samples taken from heavier sediments would show considerably less contamination. With one exception (at the Haselton-Center Street Dam), this was the case.

In order to interpret the data generated from the samples taken in the study area, it was necessary to take samples outside of the area known to be contaminated, to use for comparison against all of the other samples (a "background sample"). Since impairment of the river is thought to begin in earnest downstream from Leavittsburg, the samples from above the Leavittsburg-Lovers Lane Dam (called the "Upper Control" or "Ucontrol" samples) were used as background samples.

The river is in attainment of WWH goals above the Leavittsburg-Lovers Lane Dam.

The following is a summary of significant analytical exceedences compared to the Upper Control samples on a reach by reach basis. This information is summarized in Table 6. Complete data tabulations are presented in Appendix I. Reach nomenclature is presented in Table 3 and reach locations are shown on Figure 2.

Contaminant levels for the same analyte detected in the Upper Control samples (from the Upper Control area) are presented parenthetically next to each reported value (from the clean-up area) for the sake of comparison. The units of measurement are the same for both values. The significance of these detections with regard to environmental regulations is discussed in Section 2.9.

Many detections of PCBs and SVOCs occurred. Only significant detections will be reported in the following discussion. For the sake of this discussion, all detections that exceed New York Standards (see section 2.9, and the tables in Appendix L) are considered "significant" (they have an adverse biological impact) and are reported here. Detections of PCBs from the Landfill Profile program are reported rather than detections from the Vertical Profile program because the Landfill Profile detections identify individual species of PCBs rather than simply reporting totals. This allows ready comparison with the New York standards. PCB detections are reported by their commercial name, "Aroclor", followed by the PCB species number.

In the Leavittsburg Reach (about RM 45 to RM 42.87)...
There were no significant TRPH or TOC exceedences in this reach. Arsenic, barium, manganese, and mercury were detected at somewhat elevated levels.

There were three significant SVOC detections: Benzo (a) anthracene, Benzo (b) fluoranthene, and Chrysene. These detections were in the range of 30 to 39 ug/kg, which corresponds to concentrations in ug per gram of TOC present in the sample of 5.5 to 7.2. The New York Standard Sediment Criteria for organics are expressed in these units of ug/g TOC (Section 2.9). There were no significant PCB hits.

In the North Warren Reach (RM 42.87 to RM 40.05)...

TRPH was detected at 2100 mg/kg (Not Detected, (ND)), TOC was detected at 18,500 mg/kg (4920). Silver, arsenic, barium, cadmium, cobalt, antimony, selenium, and mercury were detected at somewhat elevated levels. Chromium was detected at 236 mg/kg (16.3), copper at 111 mg/kg (19.7), iron at 65,400 mg/kg (28,800), manganese at 1330 mg/kg (274), nickel at 224 mg/kg (37.1), lead at 78.2 mg/kg (22.1), zinc at 187 mg/kg (58.9), and calcium at 3010 mg/kg (1230).

There were eight significant SVOC detections: Benzo (a) anthracene, Benzo (b) fluoranthene, Benzo (k) fluoranthene, Benzo (a) pyrene, Chrysene, Ideno (1,2,3 –cd) pyrene, Pentachlorophenol, and Phenol. These were in the range of 130 to 310 ug/kg (7 to 17 ug/g TOC). There were five significant detections of PCBs in this reach: two hits for Aroclor 1260, two hits for Aroclor 1248, and one hit for Aroclor 1254. These were in the range of 70 to 600 ug/kg (4 to 33 ug/g TOC).

In the South Warren Reach (RM 40.05 to RM 36.80)...

TRPH was detected at 33,100 mg/kg (ND). TOC was detected at 23,500 mg/kg (4920). Cyanide was detected at 14 mg/kg (ND). Silver, arsenic, barium, cadmium, cobalt, antimony, selenium, thallium, and mercury levels were all somewhat elevated. Chromium was detected at 461 mg/kg (16.3), copper was detected at 716 mg/kg (19.7), iron was detected at 131,000 mg/kg (28,800), manganese was detected at 1250 mg/kg (274), nickel was detected at 524 mg/kg

(37.1), lead was detected at 272 mg/kg (22.1), zinc was detected at 972 mg/kg (58.9), and calcium was detected at 9270 mg/kg (1230).

There were five significant SVOC detections: Benzo (a) anthracene, Benzo (b) fluoranthene, Bis (2-Ethylhexyl) phthalate, Chrysene, and Phenanthrene. These were in the range of 1,200 to 5,600 ug/kg (50 to 240 ug/g TOC). There were seven significant detections of PCBs in this reach: three hits for Aroclor 1260, two for Aroclor 1254, and two for Aroclor 1248. These were in the range of 56 to 1,700 ug/kg (2 to 73 ug/g TOC). The pesticide 4,4'-DDD was also detected at a significant level of 7.8 ug/kg (0.33 ug/g TOC).

In the Niles Reach (RM 36.30 to RM 26.97)...

TRPH was detected at 1840 mg/kg (ND). TOC was detected at 40,400 mg/kg (4920). Silver, barium, beryllium, cobalt, nickel, antimony, selenium, vanadium, mercury, and sodium were all detected at somewhat elevated levels. Chromium was detected at 96.1 mg/kg (16.3), copper was detected at 72.1 mg/kg (19.7), iron was detected at 65,900 mg/kg (28,800), manganese was detected at 635 mg/kg (274), lead was detected at 99.3 mg/kg (22.1), zinc was detected at 597 mg/kg (58.9), and calcium was detected at 10,400 mg/kg (1230).

There were six significant detections of SVOCs: Benzo (a) anthracene, Benzo (b) fluoranthene, Benzo (a) pyrene, Chrysene, Phenol, and 3-methylphenol and 4-Methylphenol. These were in the range of 59 to 290 ug/kg (1 to 7.2 ug/g TOC). There were eighteen significant detections of PCBs in this reach: seven hits for Aroclor 1260, six hits for Aroclor 1254, and five hits for Aroclor 1248. These were in the range of 60 to 8,200 ug/kg (1 to 200 ug/g TOC).

In the Girard Reach (RM 26.97 to RM 23.16)...

TRPH was detected at 7310 mg/kg (ND). TOC was detected at 48,200 mg/kg (4920). Aluminum, silver, beryllium, nickel, vanadium, sodium, and mercury were detected at somewhat elevated levels. Arsenic was detected at 73.7 mg/kg (17.0), barium at 91.6 mg/kg (35.1), cobalt at 36.9 mg/kg (12.7), chromium at

56.8 mg/kg (16.3) copper at 114 mg/kg (19.7), iron at 359,000 mg/kg (28,800), manganese at 4,260 mg/kg (274), lead at 415 mg/kg (22.1), antimony at 6.7 mg/kg (0.14), selenium at 5.1 mg/kg (0.32), zinc at 777 mg/kg (58.9), and calcium at 9,450 mg/kg (1230).

There were five significant detections of SVOCs: Benzo (a) anthracene, Chrysene, 2,4-Dimethylphenol, Phenol, and 3-methylphenol and 4-Methylphenol. These were in the range of 130 to 2,300 ug/kg (2 to 48 ug/g TOC). There were four significant detections of PCBs in this reach: one hit for Aroclor 1260, two hits for Aroclor 1254, and one hit for Aroclor 1248. These were in the range of 100 to 5,300 ug/kg (2 to 110 ug/g TOC).

In the North Youngstown Reach (RM 23.16 to RM 21.11)...

TRPH was detected at 841 mg/kg (ND). TOC was detected at 14,800 mg/kg (4920). Silver, arsenic, barium, beryllium, cobalt, chromium, copper, lead, antimony, vanadium, and mercury were all detected at somewhat elevated levels. Iron was detected at 149,000 mg/kg (28,800), manganese at 2,220 mg/kg (274), zinc at 188 mg/kg (58.9), and calcium at 8,130 mg/kg (1230).

There were no significant SVOC detections. There was one significant detection of PCBs; a hit for Aroclor 1260 at 130 ug/kg (8.78 ug/g TOC). The pesticide gamma-Chlordane was detected at a significant level of 2.6 ug/kg (0.18 ug/g TOC).

In the South Youngstown Reach (RM 21.11 to RM 18.20)...

TRPH was detected at 1150 mg/kg (ND). TOC was detected at 70,100 mg/kg (4920). Silver, barium, beryllium, cadmium, cobalt, chromium, copper, nickel, lead, antimony, selenium, thallium, mercury, sodium, and magnesium were all detected at somewhat elevated levels. Iron was detected at 153,000 mg/kg (28,800), manganese at 1530 mg/kg (274), zinc at 236 mg/kg (58.9), and calcium at 34,100 (1230).

There were nine significant detections of SVOCs: Acenapthene, Benzo (a) anthracene, Benzo (b) fluoranthene, Benzo (k) fluoranthene, Benzo (a) pyrene, Chrysene, Fluoranthene, Ideno (1,2,3-cd) pyrene, and Phenanthrene. These were in the range of 47,000 to 340,000 ug/kg (670 to 4,850 ug/g TOC). There was one significant detection of PCBs in this reach: one hit for Aroclor 1260 at 130 ug/kg (1.85 ug/g TOC). The pesticide Endrin Ketone was detected at a significant level of 120 ug/kg (1.71 ug/g TOC).

In the Struthers-Campbell Reach (RM 18.20 to RM 16.28)...
TRPH was detected at 58,000 mg/kg (ND). TOC was detected at 152,000 mg/kg (4920). Silver, aluminum, arsenic, nickel, and thallium were detected at somewhat elevated levels. Barium was detected at 117 mg/kg (35.1), beryllium at 2.1 mg/kg (0.57), cadmium at 2.2 mg/kg (0.11), chromium at 116 mg/kg (16.3), copper at 128 mg/kg (19.7), iron at 88,500 mg/kg (28,800), manganese at 1590 mg/kg (274), lead at 6920 mg/kg (22.1), antimony at 2.8 mg/kg (0.14), zinc at 877 mg/kg (58.9), mercury at 0.15 mg/kg (0.0085), sodium at 430 mg/kg (123), calcium at 55,000 mg/kg (1230), and magnesium at 11,400 mg/kg (3730).

There were ten significant detections of SVOCs: Benzo (a) anthracene, Benzo (b) fluoranthene, Benzo (a) pyrene, Chrysene, 2,4-Dimethylphenol, Ideno (1,2,3-cd) pyrene, 2-Methylphenol, 4-Nitrophenol, Phenol, and 2-Methylphenol and 4-Methylphenol. These were from 300 to 4,800 ug/kg (2 to 32 ug/g TOC). There was one significant detection of PCBs in this reach: a single hit for Aroclor 1260 at 270 ug/kg (1.78 ug/g TOC).

In the Lowellville Reach (RM 16.28 to RM 13.05)...
TRPH was detected at 44,100 mg/kg (ND). TOC was detected at 92,000 mg/kg (4920). Arsenic, cobalt, nickel, vanadium, and sodium were detected at somewhat elevated levels. Silver was detected at 4.1 mg/kg (0.053), barium at 162 mg/kg (35.1), cadmium at 5.0 mg/kg (0.11), chromium at 276 mg/kg (16.3), copper at 216 mg/kg (19.7), iron at 148,000 mg/kg (28,800), manganese at 1590

mg/kg (274), lead at 700 mg/kg (22.1), antimony at 2.9 mg/kg (0.14), thallium at 4.1 mg/kg (1.2), zinc at 3710 mg/kg (58.9), mercury at 0.39 mg/kg (0.0085), calcium at 21,600 mg/kg (1230), and magnesium at 11,400 mg/kg (3730).

There were seven significant detections of SVOCs: Benzo (a) anthracene, Benzo (b) fluoranthene, Benzo (a) pyrene, Chrysene, Ideno (1,2,3-cd) pyrene, Phenol, and 3-Methylphenol and 4-Methylphenol. These were from 190 to 3,400 ug/kg (2 to 37 ug/g TOC). There were three significant detections of PCBs in this reach: one hit for Aroclor 1260, one hit for Aroclor 1254, and one hit for Aroclor 1248. These were from 270 to 1,600 ug/kg (2.9 to 17.4 ug/g TOC).

Data developed from bank sampling are included in Appendix G, along with descriptions of bank sampling activities. These data indicated that contamination existed under the riverbanks in a defined zone, as shown in Figure 7. Bank sample contamination chemistry is similar to that of other river sediments, displaying elevated levels of TOC, TRPH, metals, PCBs and SVOCs.

There are some interesting things about these sediment and riverbank data. TRPH and TOC levels generally became more elevated as sampling proceeded downstream from the Lowellville Reach. Most of the SVOC detections were of PAHs, except for some phthalate detections. The abundance of different types of metals and SVOCs detected increased as sampling proceeded downstream, but their overall concentrations do not necessarily increase. This probably reflects the chemistry of the process wastes released into the reach, and contraindicates the movement of contaminated sediments downstream. The level of iron found in the Girard reach at the Youngstown-Crescent Street Dam, was remarkable. This sample is discussed briefly in Section 2.4.4.1. At 359,000 mg/kg, iron made up 35.9 percent of the sample. It was reported that the river had been dredged commercially near McDonald to recover iron ore in the 1960s. This finding would seem to support those reports.

Dioxin screening analyses were conducted with detections at five locations: in Leavittsburg (Leavittsburg Reach; bank sample), at the Warren-Main Street Substation Dam (South Warren Reach; sediment sample), at the Girard-Liberty Street Dam (Niles Reach; bank and sediment sample), and at the Lowellville-First Street Dam (Lowellville Reach; sediment sample). Dioxins are a very toxic class of chemicals commonly generated as a by-product of heavy industry. However, the levels at which dioxins were detected in Mahoning River sediments are not thought to be significantly higher than typical urban background concentrations. Dioxin detections are tabulated in Appendix I. A discussion of the significance of the dioxin detections as they relate to health issues is presented in Appendix J. Possible regulatory issues pertaining to the dioxin detections are discussed in Section 2.9.

2.4.4.3 Water Quality

The results of the standard elution testing indicated no substantial release of PCBs, SVOCs, pesticides, or herbicides to the river water during laboratory testing. Significant releases of these constituents into the water column are not expected during dredging. Some minor releases of mostly benign metals are likely.

The elution tests indicated that some metals are released when the sediment is vigorously disturbed. At the Warren-Main Street Substation Dam, iron and manganese were detected in post-extraction water at about five times the level at which they were detected in the background water sample taken at the same location. Nickel and sodium levels were also significantly elevated. At the Girard-Liberty Street Dam, post-extraction manganese and sodium levels were almost double compared to background water taken at the same location. Arsenic was also detected at a low level where the background water sample had no detection of arsenic at all. At the Lowellville-First Street Dam, post-extraction potassium and magnesium levels were near double compared to the background water sample taken at the same location. This data is tabulated in Appendix I.

According to Ohio Water Quality Standards (Chapter 3745-1 of the Administrative Code), these detections were not significant. The detected levels exceeded drinking water standards but were within water quality standards appropriate for the Mahoning River. The Mahoning River is not used as a source of drinking water.

One possible exception regards the presence of mercury. Mercury was found in all three standard elution samples at levels exceeding water quality standards both prior to, and following extraction procedures. However, the before and after levels did not differ significantly, indicating that disturbance due to dredging would not cause a significant release of mercury.

2.5 Current Ecological Conditions

This discussion is based on empirical observations made during the reconnaissance and sampling phases of this study.

A lush canopy and riparian zone buffers the river from its industrial surroundings, at least visually, for much of its length. Many aquatic birds were observed in the riparian zone, including a large population of great blue herons, belted kingfishers, and a large population of adult and juvenile wood ducks. Adult owls and hawks were observed in the canopy.

Mammals and reptiles were observed in and around the river and in the riparian zone as well. Evidence of beaver was found along the entire project corridor. Some evidence of deer was also found. Both adult and juvenile snapping turtles were seen swimming in the river.

Detailed information regarding aquatic vertebrate and invertebrate populations is included in Section 3.2. Documentation of degraded aquatic health including OEPA established indices reflecting organism and fish health is also provided in Section 3.2.

2.6 Remaining Industrial Pollution Sources

In early June, 1998, sixteen Federal regulatory databases, five state regulatory databases, and fourteen miscellaneous databases were searched as part of this study for evidence of recent or ongoing discharges of pollutants into the Mahoning River and the surrounding area. The results of the search indicated that the Mahoning River was, and continues to be, subject to dumping, accidental discharge, discharge related to equipment failure, and discharge permit violation episodes that have contributed to the degradation of the water quality, sediment quality and aquatic life. The pollutants include, but are not limited to, benzene, oil and grease, unspecified petroleum hydrocarbons, waste acids, wastewater, sewage, ash, coal tar and PCBs. These pollutants were released to the air, the ground, and directly into the Mahoning River or its tributaries.

While there are still both point and non-point sources of pollution in the Mahoning River valley, it is negligible relative to the prolonged and truly enormous contaminant loading that occurred during that region's previous industrial era, present loading is essentially negligible. For instance, as recently as 1977, United States Environmental Protection Agency Region V (Amendola, et al.) reported the average net discharge from the nine major Mahoning River valley steel plants exceeded 400,000 pounds per day (lbs/day) of suspended solids, 70,000 lbs/day of oil and grease, 9,000 lbs/day of ammonia-nitrogen, 500 lbs/day of cyanide, 600 lbs/day of phenolics, and 800 lbs/day of zinc. The oil discharge was equivalent to over 200 barrels of oil per day, or the equivalent energy to heat nearly 30,000 average sized homes. To put these numbers in perspective, the million-gallon Monongahela River Ashland oil spill of 1988 was characterized as one of the most severe inland oil spills in the nation's history. However, by comparison, the much smaller Mahoning River chronically received the equivalent of more than four Ashland oil spills every year for decades. Current levels of oil seeping into the Mahoning River are a minute fraction of the historic quantities.

2.7 Other Existing Pollution Sources

Most of the remaining pollution sources are industrial in nature, as previously detailed. Other sources of pollution, albeit smaller, contribute to the degradation of water and sediment quality in the river system. These sources are detailed below.

2.7.1 Combined Sewage Overflows

A municipality generally produces two types of sewage: sanitary sewage, which is public and commercial wastewater, and stormwater sewage, which collects surficial water from private property and municipal roadways during storm events. For the first three-quarters of this century, it was common to use sanitary sewers as a convenient way to channel stormwater runoff to the nearest drainage via a Wastewater Treatment Plant, or WWTP.

WWTPs were designed to meet the demand of a given number of people with a given overflow capacity. In a situation where population is increasing or where the efficiency of a WWTP drops with age, that overflow capacity becomes less. In a storm event, it becomes increasingly easy to exceed the capacity of a WWTP. Those exceedences are manifested in a combined sewage overflow (CSO); that is to say; the combined volume of raw sewage and stormwater runoff becomes so great as to overwhelm the WWTP and flow through the plant without being processed. The result is a release of raw sewage.

The actual contribution of CSOs to the current degraded state of the river is not known, but degradation due to raw sewage release is indicated by elevated fecal bacteria levels. According to the 1996 OEPA report, elevated levels of fecal bacteria were recorded at eight Mahoning River mainstem stations from Warren to below the Ohio-Pennsylvania state line. Sources of fecal bacteria include sanitary sewage overflows (SSOs), CSOs, unsewered areas, and WWTPs. No significant fecal coliform bacteria problems existed at or above Leavittsburg. The OEPA report recommends that, "Locations and impacts of CSOs and SSOs need to be documented. High concentrations of fecal coliform bacteria and lead detected in the Youngstown area and the Ohio-Pennsylvania state line may be due to CSO/SSO problems."

2.7.2 Non-Point (Agriculture)

Non-point sources are basically contaminated sources associated with rain or industrial run-off that, simply put, do not enter the river through a pipe or culvert. Typical non-point sources include runoff of agricultural chemicals from farmland into the river or one of its tributaries, uncontrolled run-off from parking lots and junkyards, or as seen on some of the Mahoning River, run-off from slag piles (Figure 8).

Non-point sources do contribute to the overall degradation of water quality. However, the overall water quality of the Mahoning River is acceptable, even though the sediment quality is not. According to information supplied by the OEPA, non-point sources are not considered to have a major effect on the current degraded state of Mahoning River (Appendix K). They are therefore not considered further.

2.7.3 Other

Several other sources probably contribute to the degradation of river water and sediment quality. These include wildcat sewerage, wildcat dumping, and aerial deposition. In this context, the term "wildcat" means "un-permitted". Pollution introduced into the Mahoning River from its tributaries probably contributes to the degradation of river water and sediment quality as well.

Wildcat sewerage refers to unregulated sewers that empty directly into the river without treatment. Several suspected discharging wildcat sewers were noted during the reconnaissance. It is probable that many of the pipes that were not discharging when they were observed were also wildcat sewers, but it is not possible to estimate the total contribution of wildcat sewage with existing information. Wildcat discharges were observed mostly in the Leavittsburg and North Warren reaches.

Wildcat dumping may also contribute to the degradation of water and sediment quality. Trash has accumulated in many places on the river. Rusted drums were observed on the riverbank in some locations. Some sediments appeared to consist of foundry sands or sandblasting grit. It is possible to state that there is some negative impact to the river due to wildcat dumping, but it is not possible to assess the impact of this dumping with information currently available.

The same can be said of deposits of airborne particulates. Coke mills and steel mills are notorious producers of soot and ash. Coal-fired home heaters, where extant, also contribute greatly to airborne soot and ash production. Airborne soot and ash deposited in the Mahoning River Valley would likely end up in the river as direct fallout or as a constituent of rainfall runoff. According to Estenik (See Appendix J), the dioxins found in sediment and bank samples likely originated from aerial deposition.

The contribution of tributaries to the problems of the Mahoning River has not been thoroughly investigated. The 1996 OEPA report indicated that some of the Mahoning River's tributaries were in non-attainment of water quality standards, and that some tributary sediments contained metals at a toxic level (as defined in the New York (Ontario) standard discussed in Section 2.9).

2.8 Recreational Uses of the Lower Mahoning River

A river of the Mahoning River's size and character typically offers good small-boating, fishing, swimming, and wildlife observation opportunities. In spite of the natural beauty of the valley, the Mahoning River appears to be used in a very limited way. This statement is supported by observations made during the 12 weeks of fieldwork for this study, many are described in the remaining paragraphs of this section. It is likely that the river is appreciated as a scenic background, primarily by users of the adjacent public parks, including Packard Park and Perkins Park near Warren. In the opinion of the Fish and Wildlife Service, there is very little public use of the lower Mahoning River in spite of water quality improvements over the last 20 years.

Many of the waterfront houses in Warren have boat docks, but no recreational boaters or canoers were observed at any time in the study area, in spite of the fact that there is a canoe livery immediately upstream of Leavittsburg. Some ropes and swings were observed indicating there might be swimming, but no swimming was observed. The riparian zone is lush, photogenic, and supports abundant wildlife, but no wildlife or photography enthusiasts were encountered during fieldwork.

A small number of fishermen were encountered at various spots along the entire length of the study area. These fishermen suggested that fishing is productive, but were concerned about contamination in the fish. One person was seen camping in the riparian zone. One person said that he hunted deer successfully in the riparian zone. One person said that he trapped beaver and muskrat along the length of the river, but focused his efforts in the upper Mahoning River.

2.9 Regulatory Issues

In order to assess the probable regulatory status of dredged Mahoning River sediments and excavated bank sediments, contaminant types and levels determined in the sampling programs were compared to Federal regulatory levels. The result of this comparison is that no Mahoning River sediments were found to be Hazardous Wastes or Toxic Wastes under Federal regulations, but nearly all of the sediments were found to be too contaminated to safely allow unrestricted disposal.

Wastes that fall into this category are usually handled as "Residual Wastes". Residual wastes are allowed to be landfilled at permitted, secure facilities. Such facilities usually have permits allowing them to take only specific wastes. When a waste such as Mahoning River Sediment is not specifically listed on a landfill's permit, a modification to the permit must be made to include that waste. While this is not an uncommon procedure, the modification may be subject to public review and approval.

In some cases, such as in the case of using contaminated sands and gravels in the production of asphalt, residual wastes can be recycled into a usable product where its contamination would either be destroyed or immobilized. This is referred to as "beneficial re-use". Mahoning River sediments may be too contaminated to use in this manner.

The toxicity of the sediments in-situ can be demonstrated by comparing Mahoning River sediment contaminant levels with New York State sediment standards. These standards are detailed in the New York State, Department of Environmental Conservation, Division of Wildlife and Division of Marine Resources document, "Technical Guidance Document for Screening Contaminated Sediments, July 1994". The New York standards are based on the Ontario, Canada standards. These standards were chosen because they contain comprehensive and rigorous sediment quality evaluation criteria.

There are two sections of the standards that are directly applicable to Mahoning River sediments. The first section defines acceptable non-polar organic contamination levels in sediment. The second section defines acceptable metal contamination levels in sediment.

The first section, which regards non-polar organic contamination, is divided into four subsections: Human Health Bioaccumulation, Benthic Aquatic Life Acute Toxicity, Benthic Aquatic Life Chronic Toxicity and Wildlife Bioaccumulation. The contamination levels presented in this section are expressed in units of ug/g Organic Carbon (OC). In order to evaluate the Mahoning River sediments, the analytical findings were converted into these units. Appendix L presents a summary table of the comparison of Mahoning River sediments to the New York standards.

Based on a comparison of Mahoning River sediment contaminant levels with these criteria, Mahoning River sediments exceed the fresh water sediment criteria for Human Health Bioaccumulation, Benthic Aquatic Life Chronic Toxicity and/or Wildlife Bioaccumulation. Every Mahoning River sediment sample compared to these standards exceeded at least one of these criteria.

The second directly applicable section presents criteria for evaluating metals contamination in sediments. These criteria are found in Table 2 of the New York standard, "Sediment Criteria for Metals". Table 2 is divided into two levels of contamination: the "Lowest Effect Level" and the "Severe Effect Level". Sediments are considered "contaminated" if either of the criteria is exceeded. If both criteria are exceeded, the impact to this river is considered to be severe. If only the Lowest Effect Level is exceeded, the impact to this river is considered to be moderate.

Every sediment sample originating downstream from the Leavittsburg Reach that was compared to the New York standard exceeded both Lowest Effect Level and the Severe Effect Level criteria for several different metals. The impact to the this stretch of the river due to metals contamination is therefore considered "severe." The Upper Control sample (sample number EN98MR-UC-1-VU, about RM 45) and the sample from the Leavittsburg Reach (sample number EN98MR-LE-3-VU, about RM 43) had exceedences only for the Lowest Effect Level. The impact to this stretch of the river due to metals contamination is therefore considered "moderate."

The New York standards are not enforceable in Ohio, but are being considered as applicable guidelines for the protection of human health and Mahoning River biota. Based on the New York standards, Mahoning River sediments are contaminated, and, as such, severely impact Mahoning River biota with possible impacts to human health.

The Ohio Department of Health (DOH) has recognized such a possible impact to human health for at least a decade. The agency issued a Human Health Advisory dated July 23, 1988 (Appendix A), for the Mahoning River from the Northeast Bridge Road in Warren, Ohio, extending downstream to the Pennsylvania state border through Mahoning and Trumbull Counties. This advisory is due to the presence of PAHs, PCBs, and pesticides in the sediments. This advisory advises against contact with the sediment on the river bottom and along the banks. Consumption of fish caught within the area was discouraged. This advisory was reissued in 1997 and included limits on fish consumption.

In conclusion, contaminated sediments will need to be removed (or dredged) from the river if biotic improvement is to be expected, and if the river is to be used by the public as a recreational resource. The dredged sediments and excavated bank sediments, while not a "Hazardous Waste" by definition, should be handled as a regulated residual waste. Appendix M contains a letter from the OEPA supporting this position.