ACID MINE DRAINAGE ABATEMENT AND TREATMENT (AMDAT) PLAN FOR THE LITTLE RACCOON CREEK WATERSHED, JACKSON COUNTY, OHIO

by

Brett Laverty
Mia Painter
Mary Stoertz
Ohio University, Department of Geological Sciences, Athens, Ohio

J.B. Hoy
Rachael Hoy
Ohio University, Institute for Local Government Administration and Rural Development

Jennifer Last
Ohio University, Masters of Science and Environmental Studies Program

Chip Rice
Coordinator, Raccoon Creek Improvement Project

Mitchell Farley
Ohio Department of Natural Resources, Division of Mineral Resources

June 2000

TABLE OF CONTENTS

LIST OF FIGURES

SECTION 1: AMD ABATEMENT AND TREATMENT PLAN

INTRODUCTION

PURPOSE AND ORGANIZATION OF REPORT

The purpose of this report is to provide a rationale for treating Little Raccoon Creek watershed sources of acidic, sediment and metal-laden waters. Justification consists of evidence that the creek is contaminated to the point of being unable to sustain healthy aquatic communities. The rationale for treatment of particular sources is prioritized based on heavy acidity and metal loading. Because acid mine drainage is widespread in the basin, an intensive field investigation was conducted to identify (1) highly polluted tributaries, and then (2) sources of pollution within the tributaries. Users of this data should be cautioned that water quality shows extreme variability, and that these data represent discrete samples in time. They do not represent mean annual conditions, although in many cases high- and low-flow conditions were sampled. We believe that they show relative contributions of sources, allowing sources to be prioritized. There is a strong possibility that important sources could be discovered in the future, as discussed in the section *Future Monitoring*. Before detailed source reclamation is designed, water quality variation at treatment sites should be measured over a period of time to characterize variability of design parameters such as flow or acidity loading. This report measures spatial variability of water quality over a large area, at a few points in time. Treatment designs require measuring time-variability of water quality at relevant points over at least a year. Design may also warrant analyzing additional parameters that may be a concern in treatment.

This report includes, (1) mainstem loading, (2) tributary loading, and (3) source loading, described by sub-watershed. The intent of this structure is to allow sub-watershed sections to be pulled out individually for inclusion in proposals as the Raccoon Creek Improvement Committee and partners find time and funds for characterizing, monitoring and treating sources.

METHODS

A phased approach was used to prioritize sources based on acidity and metal loads. A Corning Checkmate meter was used to measure pH and specific conductance. The meter was calibrated daily.

Phase I: The Little Raccoon Creek mainstem and tributary mouths (36 sites) were sampled during a 3-day period.

Phase II: Each sub-watershed was screened over several days. Feeder streams of poor water quality based on this screening were visited on a second trip to collect grab samples.

Phase III: Point sources were identified by following poor-quality feeder streams up to the sources of acid mine drainage. Grab samples were taken, discharge was measured, and a qualitative site assessment was done to identify gob piles, ponding, or any other relevant features to the source or treatment.

Samples were collected in a triple-rinsed bucket and split into two triple-rinsed bottles. One bottle was acidified with 20% HCl solution; the other was a cubitainer with the air squeezed out of the headspace. Samples were not filtered. Samples were analyzed in Coshocton Environmental Testing Lab, and later ODNR's Cambridge lab, using the same protocol. Parameters measured were ODNR's Group I (pH, total acidity as $CaCO_3$, total alkalinity, specific conductance, total suspended solids, sulfate, total iron, total manganese, aluminum, hardness and total dissolved solids). Group I is sufficient to prioritize sources based on acidity and metal loads.

Discharge was measured for each sample in order to calculate loading (concentration x discharge), using methods appropriate to flow volume. For large discharges a pygmy meter was used. The meter was calibrated daily using 60 seconds of free spin as a criterion. For moderate discharges, a collapsible cutthroat Baski flume was used. Flume throat size (1", 2", 4" or 8") was selected to keep the stage in the flume between 0.2 and 0.5 feet. For small discharges, the flow was dammed and piped into a length of PVC to capture with a bucket using a stopwatch to measure filling time. Samples were packed in ice immediately to limit reactions, and shipped in ice to arrive at the lab on a daily basis.

Loading is calculated as the product of discharge with acidity, alkalinity or metal concentration, and is expressed in lb/day because of treatment considerations. In this report,

metal loading is the sum of the individual loads of the three Group I metals, iron, manganese and aluminum.

ABSTRACT

Little Raccoon Creek is a 38.5-mile long stream in Jackson, Vinton and Gallia Counties, and the largest tributary of Raccoon Creek. Historic coal mining activities have caused extreme pollution of the waterway from acid mine drainage and sedimentation. According to the OEPA, in the *Biological and Water Quality Study of The Raccoon Creek Basin (1995),* a steady improvement in the streams alkalinity and pH should be noted. This improvement is most likely due to the attenuation, remining and the reclamation of abandoned mines by various agencies. The biological health of the stream has similarly improved over the same period, though populations are still inhibited by acid mine drainage from several tributaries entering Little Raccoon Creek.

The Little Raccoon Creek Hydrologic Unit document identifies specific mine sites in Mulga Run, Middleton Run, Rich Run, Flint Run, Goose Run and other discrete locations for remediation. It is thought that targeted reductions in acid mine drainage pollution will provide a significant and immediate improvement in biologic response and overall stream health.

IDENTIFICATION OF THE HYDROLOGIC UNIT

NAME:	Little Raccoon Creek Watershed
TRIBUTARY TO:	Raccoon Creek of Ohio River Basin
LOCATION:	South Central Vinton County, eastern Jackson County, and northwest Gallia County, southeast Ohio.
QUADRANGLES:	USGS 7.5' quadrangle Mulga, Ohio covers main AMD area.
DRAINAGE:	155 mi^2; perennial reach is 38.5 miles long

AMD EFFECTS ON WATER QUALITY AND BIOLOGICAL RESOURCES

WATERSHED DESCRIPTION

In the Little Raccoon Creek watershed, acid mine drainage (AMD) from abandoned underground and surface coalmine spoils and coal refuse, has degraded stream water quality and damaged fish and macroinvertebrate habitat. Little Raccoon Creek's perennial reach is 38.5 miles long and has 62.5 miles of tributaries (Figure 1). The headwaters are in south central Vinton County and water flows southeast through eastern Jackson County and enters Raccoon Creek in northwestern Gallia County. The headwaters of Little Raccoon Creek are at RM 50 (that is, 50 river miles upstream from the mouth), six miles northwest of Hamden in Vinton County, with an elevation of approximately 1000 feet. At the mouth of Little Raccoon Creek, in Gallia County, the elevation is approximately 600 feet. The perennial reach of Little Raccoon Creek (RM 0.0 to RM 38.5) drops from 760 ft to 600 ft in 38.5 miles, so the gradient is about 4.2 feet per mile.

The topography is typical of southeastern Ohio, part of the unglaciated Western Allegheny Plateau bioregion, with steep rolling hills and narrow valleys, and an overall watershed relief of 400 feet. The bedrock consists of sedimentary Pottsville, Allegheny, and Conemaugh Formations of the Pennsylvanian Age. This area has an average annual precipitation of 40 inches per year (Harstine, 1991).

Little Raccoon Creek discharges approximately 400 cubic feet per second (cfs) into Raccoon Creek during high flow and less than 10 cfs during low flow. Little Raccoon Creek is a major tributary of Raccoon Creek and accounts for 22% of the drainage area of Raccoon Creek.

Improvements in stream water quality have been noted over time, resulting in improved use designation for some sections of the watershed. Ohio EPA's *Biological and Water Quality Study of The Raccoon Creek Basin (1995)* states that "Alkalinity and pH both showed increases through the period (1988 – 1995)….Those parameters showing an improvement during the period are generally considered mine drainage parameters. These improvements are most likely the result of many projects undertaken throughout the basin by various agencies to abate mine drainage problems" (pg. 128).

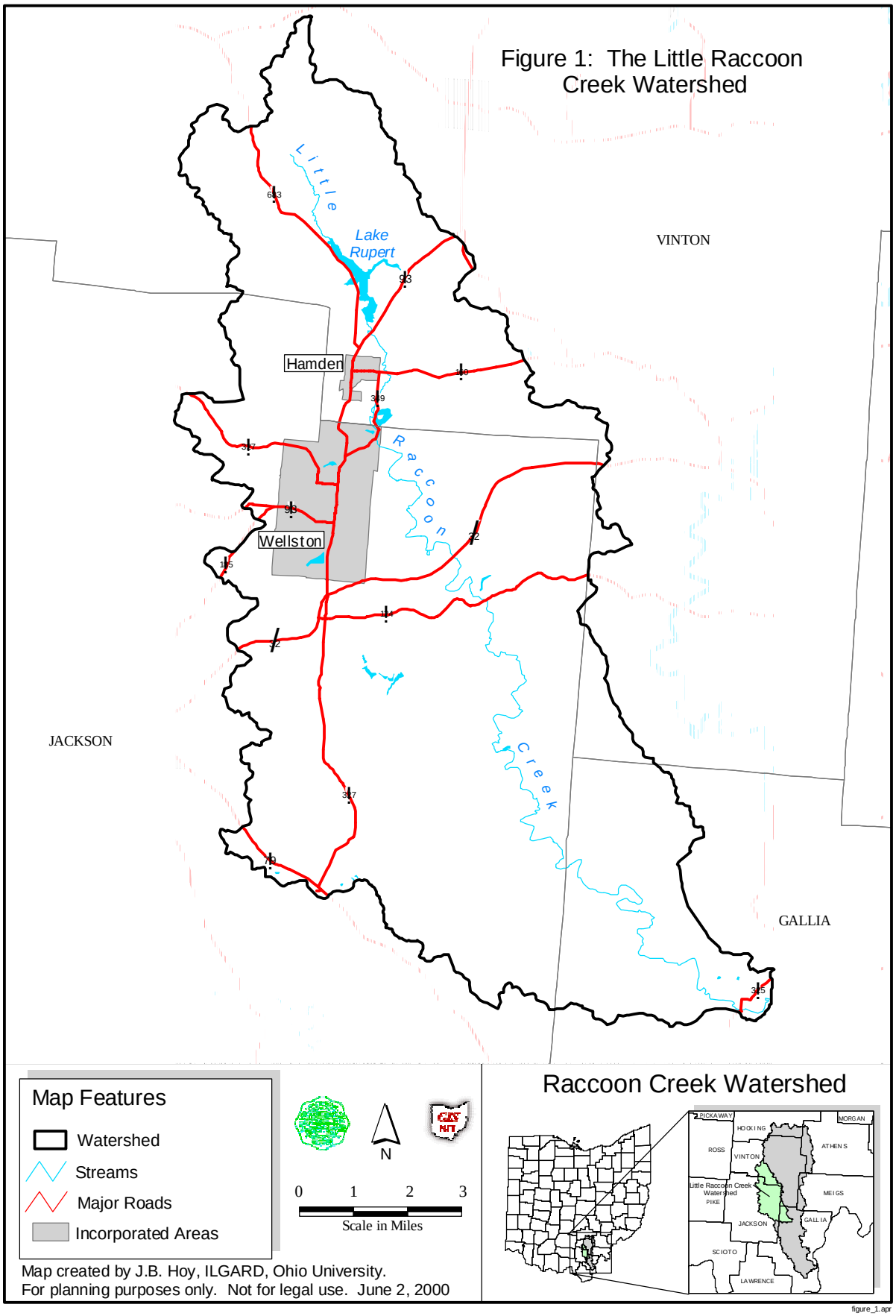


Figure 1: The Little Raccoon Creek Watershed
Little
Lake Rupert
Hamden
Wellston
Raccoon
Creek
VINTON
JACKSON
GALLIA
Map Features
Watershed
Streams
Major Roads
Incorporated Areas
N
0 1 2 3
Scale in Miles
Raccoon Creek Watershed
Map created by J.B. Hoy, ILGARD, Ohio University.
For planning purposes only. Not for legal use. June 2, 2000
figure_1.apr

Biological studies conducted by the United States Geological Survey (USGS) in 1999 led study managers to state that, in their opinion, modest reductions in acid mine drainage could lead to significant improvements in aquatic populations (personal communication-John Tertuliani, USGS Biologist).

MINING HISTORY

Coal mining occurred in approximately 22% of the Little Raccoon Creek basin. Coal has been mined underground in the watershed since at least the 1840's. Surface mining became the dominant type of mining starting in the 1930's and accounts for more than 90% of the coal removed to date. There are numerous abandoned underground mines in the watershed that are discharging AMD as well as abandoned surface mines where the AMD comes from coalmine spoils and coal refuse piles. Surface mining continues in the watershed.

Mines are found throughout the Little Raccoon Creek watershed, but those that most affect the water quality are in Jackson County between Dickason Run (RM 12.57) and Mulga Run (RM 24.45). Most of the AMD being discharged into Little Raccoon Creek comes from these tributaries. Water quality problems occur when pyritic material and other rocks are exposed to oxygen and water. Through oxidation of the pyrite, sulfuric acid is formed. As this acid passes over different rock strata surrounding the pyrite, it dissolves metals including iron, aluminum, and manganese. Acid and metals reduce the number and diversity of aquatic organisms, increase the corrosiveness of the water, limit domestic use of the water, and impair the aesthetic qualities of the water.

Water-quality levels that suggest impact by AMD are shown below (FWPCA, 1968; USEPA, 1986).

Ph	< 6
Alkalinity	< 20 mg/l
Iron	>0.5 mg/l
Manganese	>0.5 mg/l
Sulfate	> 74 mg/l
Aluminum	>0.3 mg/l
Conductivity	> 800 mhos/cm
Zinc	> 5 mg/l

WATER QUALITY

Historical Water Quality

Several studies of water quality in Little Raccoon Creek were undertaken during the past 25 years. The Ohio Biological Survey designated Little Raccoon Creek as Classification IV (surface waters grossly polluted and requiring extensive renovation to achieve Class I standards) in 1976 (USDA, 1994). The U.S. Geological Survey (Wilson, 1985 and 1988) studied Raccoon Creek, sampling ten sites in Little Raccoon Creek in 1983 and five sites in 1984-1986, and in both studies concluded that sources in the Little Raccoon Creek basin are major contributors of AMD to Raccoon Creek. Those data are included in this report (Appendix 1, Table 1). Buffer Run, Goose Run, an unnamed tributary to Little Raccoon, Mulga Run and Sugar Run were the main sub-watersheds that produced AMD.

Mainstem Water Quality

Twenty-three sampling sites were chosen along Little Raccoon Creek between tributaries and at the mouths of tributaries (Figure 2; Appendix 1, Table 1). The tributaries sampled were Sugar Run, Meadow Run, Mulga Run, Middleton Run, Rich Run, Coal Run, Flint Run,

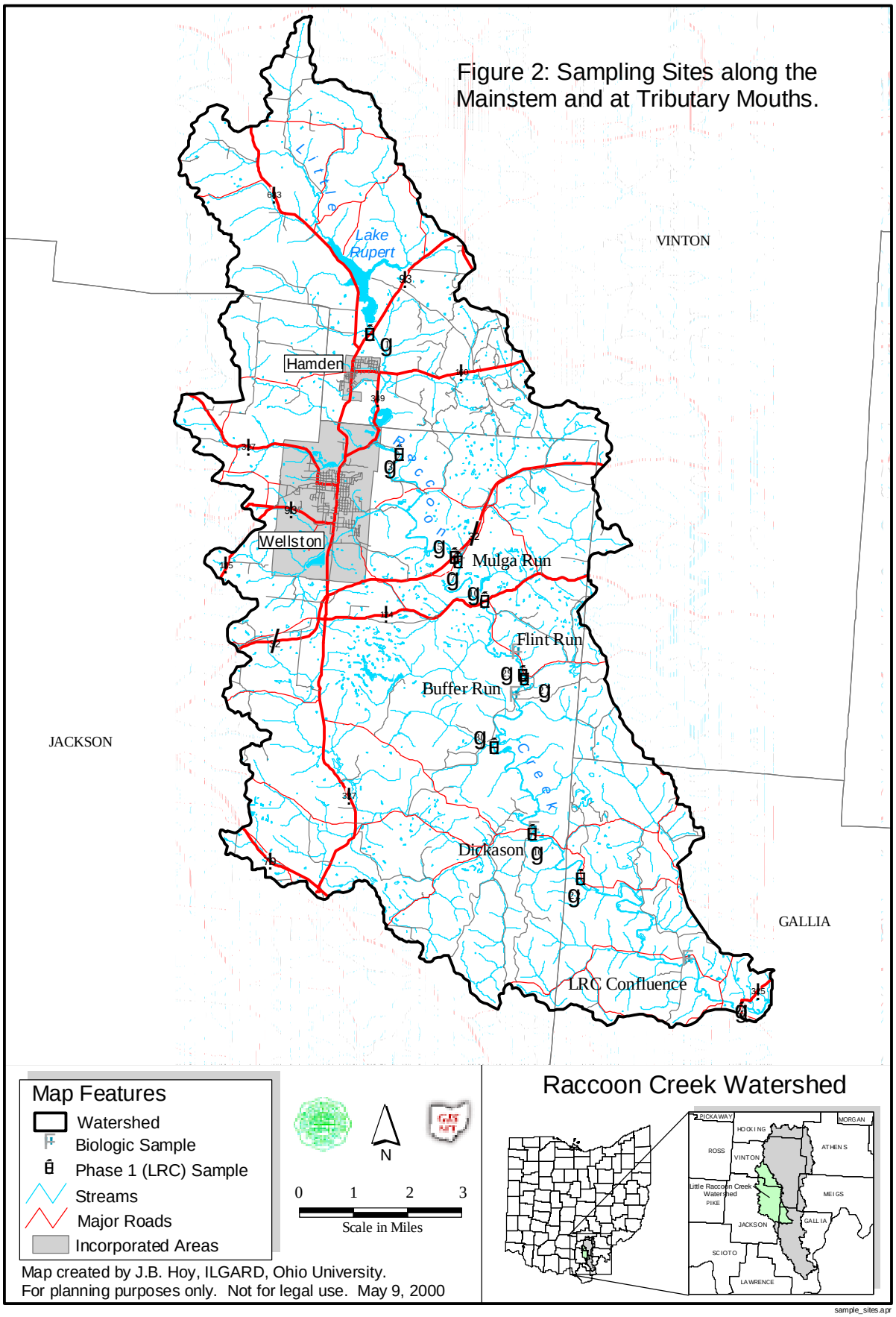


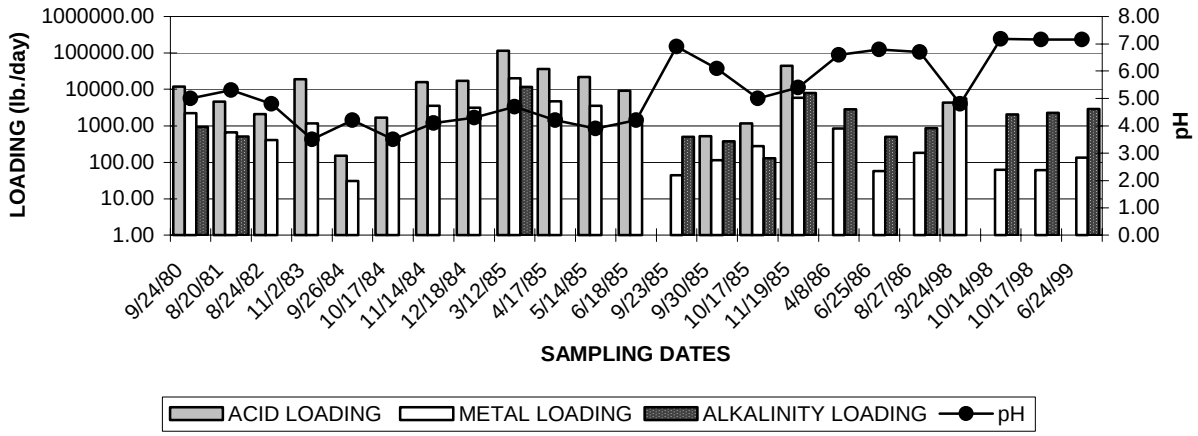
Figure 2: Sampling Sites along the Mainstem and at Tributary Mouths.
Lake Rupert
Hamden
Wellston
Mulga Run
Flint Run
Buffer Run
Dickason
LRC Confluence
VINTON
JACKSON
GALLIA
Raccoon Creek
Map Features
Watershed
Biologic Sample
Phase 1 (LRC) Sample
Streams
Major Roads
Incorporated Areas
N
0 1 2 3
Scale in Miles
Raccoon Creek Watershed
Map created by J.B. Hoy, ILGARD, Ohio University.
For planning purposes only. Not for legal use. May 9, 2000
sample_sites.apr

Greasy Run, Tar Camp Run, Goose Run, Dickason Run, Dixon Run, and Kyger Run. Those tributaries that showed serious impact by AMD are Mulga Run (RM 24.45), Middleton Run (RM 22.40), Rich Run (RM 22.22), Flint Run (RM 20.74), Greasy Run (RM 18.2), Goose Run (RM 16.41), and Dixon Run (RM 1.5 on Dickason Run, which is at RM 12.57 on Little Raccoon Creek). Buffer Run (RM 19.18) showed serious impact by AMD in other studies.

At the mouth of Little Raccoon Creek where it enters Raccoon Creek, the acidity loading ranges from 4300 lbs/day during high flow (>400 cfs) to 0 lbs/day (69 mg/l total alkalinity) during low flow (<10 cfs). Because data are variable, higher acidity loads are possible (Figure 3).

The Ohio Environmental Protection Agency's 1990 Ohio Non-point Source Assessment classified Little Raccoon Creek as Priority Classification One: "stream segments with aquatic life use impairment caused by non-point sources." The non-point sources contributing to the

Figure 3: Acidity and Metal Loading from the Mouth of Little Raccoon Creek Over Time (Wilson 1985, 1988)



classifications include sedimentation, residential sewage, industrial waste, and above all abandoned coalmine lands (USDA, 1994). Just upstream from where Little Raccoon Creek enters Raccoon Creek there is significant acidity loading and no alkalinity during high flow periods. Lake Alma and Lake Rupert, in the headwaters of Little Raccoon Creek, were targeted by Ohio EPA as lakes impacted by non-point sources associated with Priority Classification One

streams (USDA, 1994), but are not affected by AMD. Water quality analyses in the Little Raccoon Creek mainstem show increasing metal loads downstream, under high-flow conditions, with the metal loading to Raccoon Creek being 2200 lb/day iron, 2400 lb/day aluminum, and 1000 lb/day manganese (Figure 4). Low-flow loading is much smaller as shown in Figure 5. Note the change in scale in comparison to Figure 4.

While pH levels in much of Little Raccoon Creek are circum-neutral, occasionally dropping into the pH 5 range, available literature suggests that the alkalinity levels below 20 mg/l can be limiting to biota where other mine drainage constituents are present. Alkalinity levels in the Little Raccoon Creek mainstem are often below this threshold in the primary study area.

Figure 4: Acidity, Alkalinity and Metal Loading in the Little Raccoon Creek Mainstem
Under High-Flow Conditions (3/24/98 - 3/25/98)

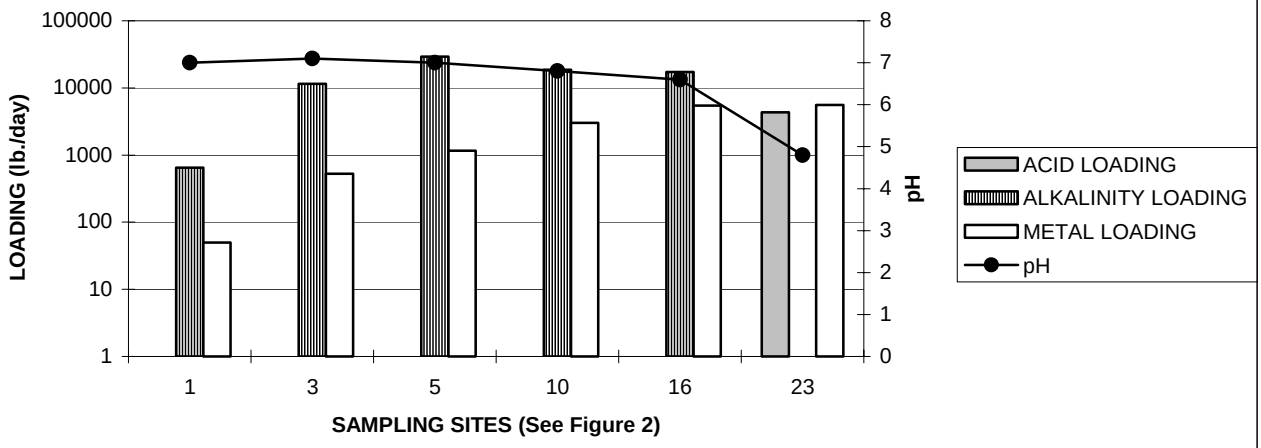
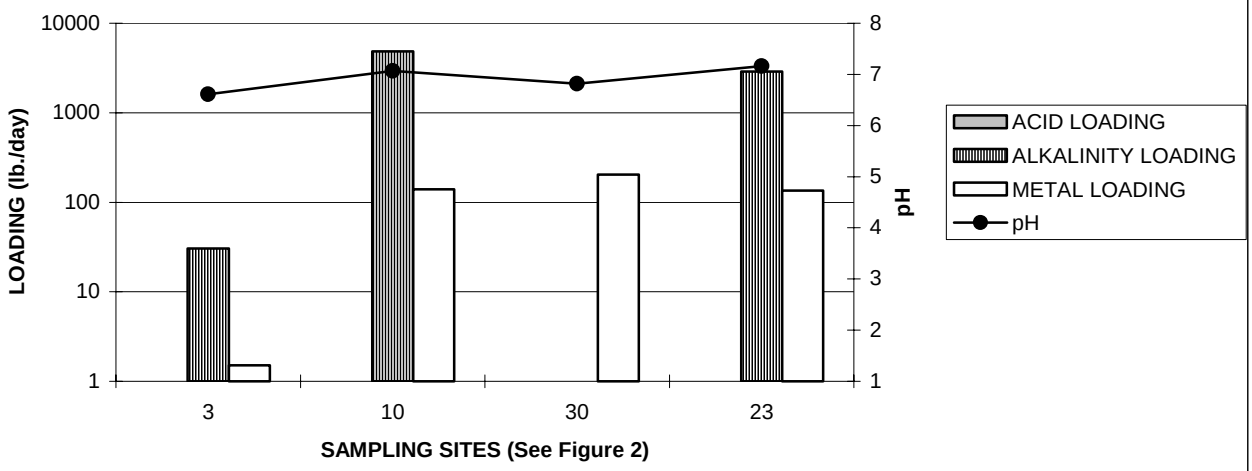


Figure 5: Acidity, Akalinity and Metal Loading in the Little Raccoon Creek Mainstem Under Low-Flow Conditions (6/22/99-6/24/99)



Tributary water quality

Of the 12 tributaries studied, six contribute 99% of the total acidity to Little Raccoon Creek, which varies from 8700 lbs/day during high flow (March, 1998) to 1000 lbs/day during low flow (June, 1999). These six priority sub-watersheds show elevated levels of acidity, conductivity, total dissolved solids (TDS) and metals, and low levels of pH and alkalinity, during both high- and low- flow periods. The six priority sub-watersheds are all located in northeastern Jackson County, where coal mining was most active. Under high-flow conditions the heavy acidity loading tributaries are Middleton Run (43%), Flint Run (42%), Mulga Run (7%), Goose Run (4%) and the 124 Seep (4%) (Figure 6). Under low-flow conditions, the total loading is much less, and the tributaries play different roles in the total: Flint Run (51%), Goose Run (29%), Mulga Run (17%), the 124 Seep (2%), and Greasy Run (1%) (Figure 7). The remaining <1% of the acidity load comes from Rich Run during low flow. While the relative role of tributaries under different conditions varies (e.g., Middleton Run is the heaviest loader under high-flow conditions, but contributes a negligible amount under low-flow conditions), Flint Run

is consistently a heavy source of acidity, and ranks as the top-priority source[1]. The tributaries are discussed in detail after the section Biological Health.

Figure 6: Percent Acidity and Metal Loading to Little Raccoon Creek from Various Tributaries Under High-Flow Conditions (3/24/98-3/25/98)

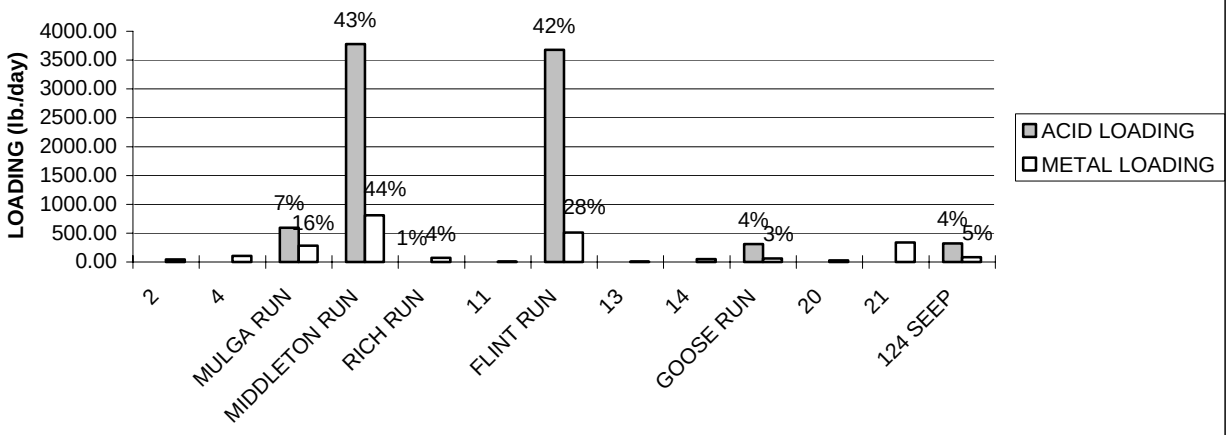
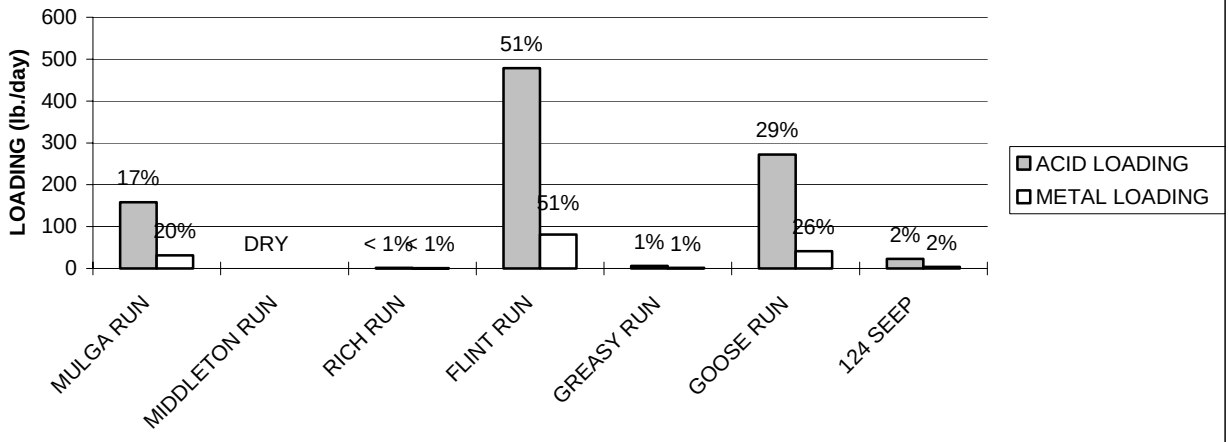


Figure 7: Percent Acidity and Metal Loading to Little Raccoon Creek from Various Tributaries Under Low-Flow Conditions (6/22/99-6/24/99)



[1] Reclamation of 60.5 acres of coal refuse and additional underground mine drainage discharges at the Buckeye Furnace Reclamation Project was completed in 1999. An 84 percent, average reduction in acidity has been observed in sampling data to date. Quarterly monitoring of Buffer Run through 2000 will yield sufficient information to determine whether this stream will merit further remediation in the future.

BIOLOGICAL HEALTH

Several groups have measured conditions in Little Raccoon Creek related to biological health, specifically habitat, macroinvertebrate populations and fish populations.

The Ohio EPA qualitatively evaluated numerous small streams in the Raccoon Creek basin during the summer of 1995 to determine the “use” designation. Three biological indices determine aquatic life uses: (1) the index of biological integrity (IBI) for fish communities, (2) the macroinvertebrate community index (ICI), and (3) the modified index of well being (MIwb). These indices measure the numbers and diversity of fish and aquatic macroinvertebrates. Several uses are designated:

- Exceptional Warm water Habitat (EWH) is the most biologically productive environment. These waters support "unusual and exceptional" assemblages of aquatic organisms, which are characterized by a high diversity of species, particularly those that are highly intolerant and/or rare, threatened, endangered, or special status. This use represents a protection goal for water resource management efforts dealing with Ohio's best water resources. None of the waters of Little Raccoon Creek have this designation.
- Warm water Habitat (WWH) defines the "typical" warm water assemblage of aquatic organisms for Ohio streams. It is the principal restoration target for the majority of water resource management efforts in Ohio. Little Raccoon Creek mainstem partially achieves WWH use designation, as does the tributary Greasy Run. Other Little Raccoon Creek waters could achieve this designation, if restored.
- Modified Warm water Habitat (MWH) applies to streams with extensive and irretrievable physical habitat modifications, for which the biological criteria for warm water habitat are not attainable. The activities contributing to the modified warm water habitat designation have been sanctioned and permitted by state or federal law. The representative aquatic assemblages are generally composed of species that are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor habitat quality. The category applies to dammed or channelized rivers, and also can be applied to streams affected by AMD, although the designation was not used in Little Raccoon Creek.
- Limited Resource Water (LRW) applies to streams that have drainage areas of less than three square miles and either lack water on a recurring annual basis, or have been

irretrievably altered to the extent that no appreciable assemblage of aquatic life can be supported; no formal biological criteria are established for this designation. OEPA stated that mining impacts cause severe degradation in Mulga Run, Flint Run, Buffer Run, and Goose Run. Poor performance of the biological communities and in-stream chemical impacts from unreclaimed acid mine drainage with no near term prospect for reclamation in these basins warrant the Limited Resource Water (LRW) – Acid Mine Drainage aquatic life use designation for these streams. The designation affects what future activities are permitted on these tributaries.

- Limited Warm water Habitat (LWH) was adopted in 1978 as a temporary variance mechanism for individual segments that had point source discharge problems and as a result could not meet Clean Water Act goals. Rich Run, Flint Run, Buffer Run, and Goose Run are currently designated LWH because of AMD. This designation is being phased out. These tributaries are being considered for LRW designation (above).

The biological health summary that follows primarily describes the macroinvertebrate community health in Little Raccoon Creek. In 1999 USGS evaluated the fish community (IBI) at two sites, one above and one below Dickason Run. The USGS IBI data is included in Appendix 2.

According to the Ohio EPA Raccoon Creek Basin Study (1995), several tributaries of Little Raccoon Creek were evaluated. Mulga Run showed high acid mine drainage impacts and contributed high amounts of sediment to the Little Raccoon Creek mainstem. Flint Run and Buffer Run were qualitatively evaluated as very poor for both macroinvertebrate and fish communities. No mayfly, stonefly, caddisfly, or tanytarsini midges were collected in these two tributaries. Less than 10 taxa total were collected from the natural substrate. In Buffer Run, coal fines made up the majority of the stream sediment.

In the 1999 USGS study (Appendix 2), sampling was not done in the tributaries, but on the mainstem directly below the confluence of the tributaries (Figure 2). Starting at the furthest upstream sites, Sites 1 (Mulga Run) and 2 (Flint Run) had identical ICI values of 30, which indicate fair water quality. These sites lacked mayfly taxa, had low numbers of caddisfly taxa, and a low EPT metric score. The low percent tolerant organisms combined with the moderate

percentages of the "Other Diptera and non-insects" metric indicate that a high proportion of the samples were made up of indicators of moderate water quality at these two sites.

After examining water quality data from both 1997 and 1999, these sites appear slightly different in potential causes of pollution and degradation. At both sites 1 and 2, sedimentation is indicated by a substrate composition of mainly silt, muck and sand. This high embeddedness limits biological productivity. Recent metal and acidity loadings data indicate that during high flow, Flint Run, and to a lesser extent, Mulga Run, can contribute high amounts of acidity to Little Raccoon Creek. Because of the relatively high volume of water in LRC, the AMD is diluted at both of these sites. In both sites, dissolved oxygen and/or AMD may be limiting the mayfly and caddisfly taxa.

Water quality in Mulga Run is highly variable and seasonally dependent. A variety of complicating factors have yielded sample results varying from pH 6.7, 0.0 mg/l acidity in February 1998 to pH 3.45, acidity 130 mg/l acidity in October 1998 (Appendix 1, Table 2). Factors contributing to this variability include the high seasonal percentage of underground mine drainage present in stream flow, the diminishing effects on alkalinity from the Jaymar Limestone Plant and the channelized flow through the large Mulga Run wetland. These factors deprive Mulga Run of a substantial percentage of its buffering capacity, yielding a significant output of acid mine drainage constituents during low flow periods.

Water quality data from 1997 indicate that below Flint Run (Site 2), pH was 6.1 at high flow, but alkalinity was low. This indicates a poor buffering capacity, even if pH is at 6.1. Furthermore, elevated metal concentrations indicate that metals and acidity due to AMD are limiting factors for the macroinvertebrate community, especially at higher flows. In the 1999 USGS study, this site had much lower macroinvertebrate abundance as compared to Site 1. The dominant organisms were Hydropsychidae (filter feeding caddisfly) and chironomidae (midge), both general indicators of moderate water quality. Water quality data (1999 USGS) indicate good alkalinity levels, neutral pH, low dissolved oxygen, and slightly elevated specific conductance at Site 2. Because macroinvertebrates are indicators of overall stream health through time, it is very likely that at high flows, AMD is a limiting pollution factor. Sedimentation and high embeddedness are a year-long factor. During the lower flow months, however, low dissolved oxygen and elevated nutrient levels may further impact the macroinvertebrate community.

Below Buffer Run (Site 3), the macroinvertebrate community shows a considerable decrease in number of taxa present, relative percentages of taxa present, and a corresponding low ICI value of 24. Previously the OEPA had characterized Buffer Run as one of the worst AMD sites in LRC. However, it should be noted that a large reclamation project was just completed within the Buffer Run tributary watershed. It is too soon to draw any conclusions regarding recovery of the biota in this watershed, or Little Raccoon Creek downstream; however, water quality monitoring is currently taking place so that future analysis can be done and recommendations can be made.

Substrate conditions at this site contain more cobble and gravel than at the two upstream sites and only moderate embeddedness. Water quality sampling in 1997 indicates elevated concentrations of metals at this site (during high flow). During the USGS sampling, it was noted that Buffer Run forms a white precipitate (aluminum) at the confluence with LRC. Metals are most likely still a problem during the low flow periods (although metals were not measured in 1999). Buffer Run appears to be substantially acid mine drainage impacted and is negatively affecting the water quality of the LRC mainstem. Furthermore, low dissolved oxygen levels may also be limiting to macroinvertebrates. Because of the low ICI value at this site and the low abundance of organisms, the biological health at this site can be characterized as poor.

The Site 4 sample, above Dickason Run, showed a moderate to good number of taxa, and even included a few mayflies. Caddisfly numbers remained similar to previous sites. Diptera increased, however, probably due to the increase in tanytarsini midges, which are a relatively intolerant midge. The EPT metric was moderate (9) and the overall ICI was high (42) relative to other LRC sites. Despite high embeddedness and sedimentation, this site has relatively good macroinvertebrate health, as indicated by its good diversity and high ICI. The diverse macroinvertebrate community seen here is most likely due to the distance downstream from some of the AMD problems. Samples taken by Wilson (1988) indicate that this site was impacted by AMD in 1986.

Site 5, below Dickason, shows a reduction in ICI (34) from the upstream Dickason site. All metrics are reduced as compared to above Dickason, except for tanytarsini midges, which increased. There appears to be some pollution input above this point, which has caused the loss of diversity and reduction in metric values. Although the caddisfly percentage is not as high as it

is at upstream sites, this could be attributed to a difference in habitat. Water quality information from 1997 shows elevated metal levels at this site, indicating that AMD is the most likely problem. Dixon Run was noted to be an AMD-impacted tributary of Dickason Run, although not a priority watershed for purposes of the LRC Hydrologic Unit Document. The 1999 USGS study showed below normal dissolved oxygen levels and elevated specific conductance at this site. The OEPA (1997) study noted that downstream of Dickason Run the ICI value was only 18, the higher value in the 1999 study (34) may indicate an increase in the biological health of this section of LRC. It should be noted that the current ICI (34) and other metrics indicate fair water quality and fair diversity.

Site 6, near Vinton, is the furthest downstream and has the best overall metrics and ICI value (44). This site has excellent diversity and a good EPT metric value (17), which is the highest of all the sites sampled. The percent mayflies are higher relative to the other sites as well. This site appears to be relatively free of AMD pollution although sedimentation is most likely still an issue. Because there is a nine-mile stretch between the Dickason Run site (RM 12.8) and the Vinton site (RM 3.4), it can be concluded that the nearest tributaries above the Vinton site are contributing negligible amounts of AMD pollution. Water quality samples taken by Wilson (1988) near this site indicate that pH and alkalinity improved over the sampling period from 1984 to 1986. Macroinvertebrate samples taken by Wilson (1988) indicate low diversity as compared to the 1999 sample. AMD-tolerant organisms such as *Sialis (*Alderfly) and chironomidae (midge) dominated the 1986 samples. It appears that the biological health and water quality at this site have experienced a drastic improvement since 1986.

It appears that much of the Little Raccoon mainstem is still impacted to various degrees by problems related to acid mine drainage. High flow periods appear to contribute the highest levels of acidity and metals to the mainstem at sites 2, 3, and 5. Site 3 (Buffer Run) is the most impacted by AMD. Extensive embeddedness is a problem for the entire length of the mainstem. Dissolved oxygen (DO) levels remain low until Dickason Run when they rise to 6.5. Explanations for the low DO include both low stream flows and an increase in water temperature as well as possible nutrient enrichment. Comparisons of the 1999 data with previous studies indicate that the biological health of sites along the mainstem has improved. Sites determined to have little to no AMD impact in this study were considered AMD-impacted in the 1988 USGS

study (Wilson 1988). Site 4 may have also improved (from poor to fair) since the 1988 study. Of the sites sampled in the 1999 USGS study, the largest AMD impact occurs below the Buffer Run tributary. In contrast, the furthest site downstream (Vinton, OH) shows essentially no AMD impact. Acid mine drainage impacts are probably limited to the mainstem above river mile 12.5 (below Dickason Run). The smallest density of organisms was found at the Buffer Run site and the greatest density was found at the Vinton, OH site, coinciding directly with the level of AMD-impact.

It should be noted that even with the high AMD impact at site 3, the ICI metrics show that there were no "tolerant organisms" in the Buffer Run sample. The ICI index is roughly based on tolerance values for organisms, which thrive in degraded environments in Ohio. Most of these tolerances are based on organic pollution, not high metals and high acidity as found in AMD. For this reason, it is possible that ICI values are over-estimated in AMD impacted areas. As of yet, there are no published indices for assessing AMD impacts. Regardless, it should be noted that the ICI's do give an accurate *relative* indication of the biological health, even in AMD-impacted areas.

TRIBUTARIES

In this and the next few sections, high-priority tributaries are discussed individually.

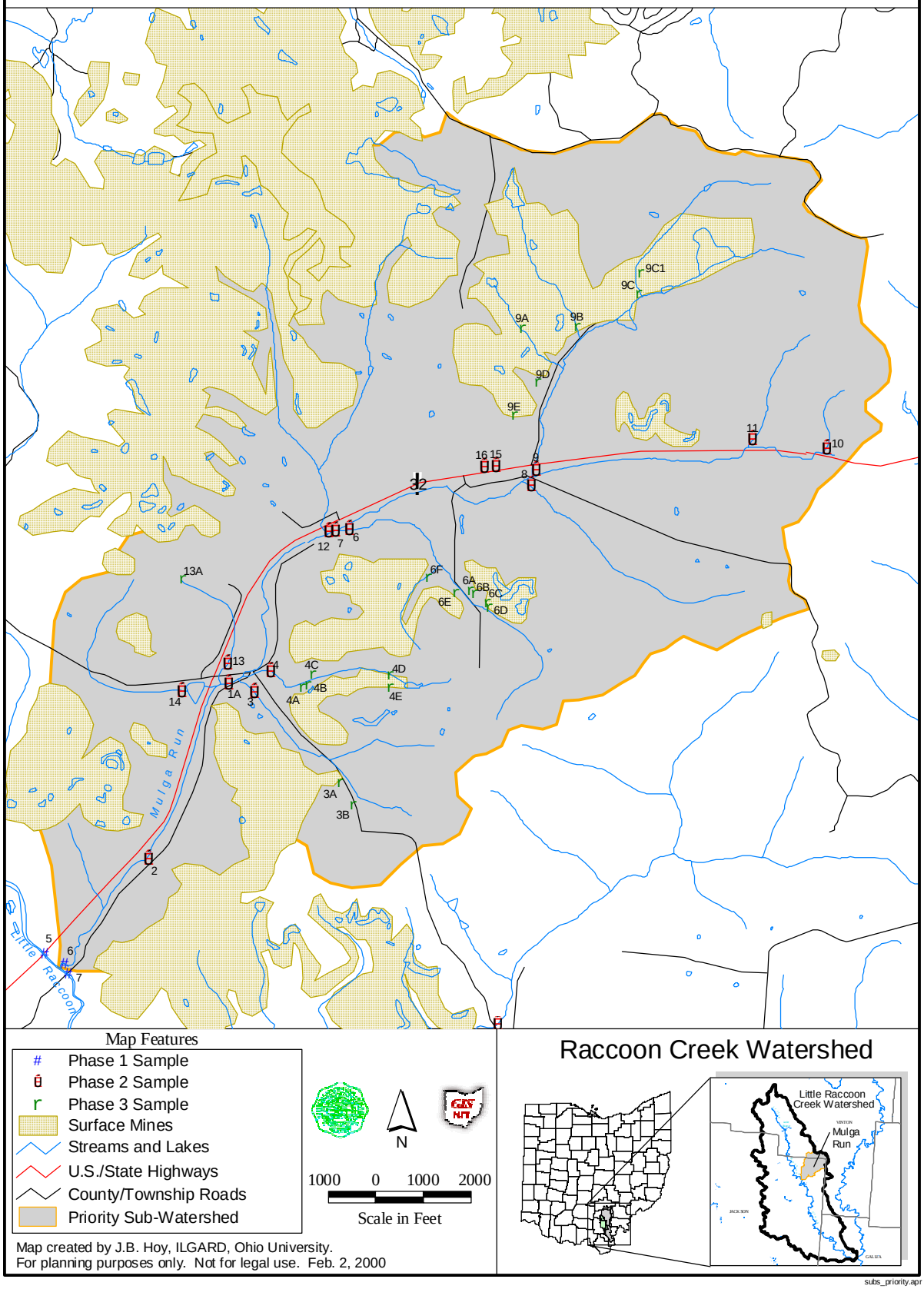
MULGA RUN

NAME:	Mulga Run
LOCATION:	Milton Township, Jackson County, Ohio
QUADRANGLE:	Mulga (sec. 2, 3, 10, and 11), McArthur (sec. 25, 26, 27, 34, 35, and 36)
DRAINAGE AREA:	7.9 mi^2

Overview

Based on available water quality data, Mulga Run (Figure 8) is the third largest contributor of acid-mine drainage (AMD) in the Little Raccoon Creek watershed. Abandoned deep-mine drainage and associated unreclaimed coal refuse piles affect Mulga Run. Sands Hill Coal Company is actively strip mining for coal in the headwaters of tributaries 4 and 6.

Figure 8: Mulga Run Sub-Watershed

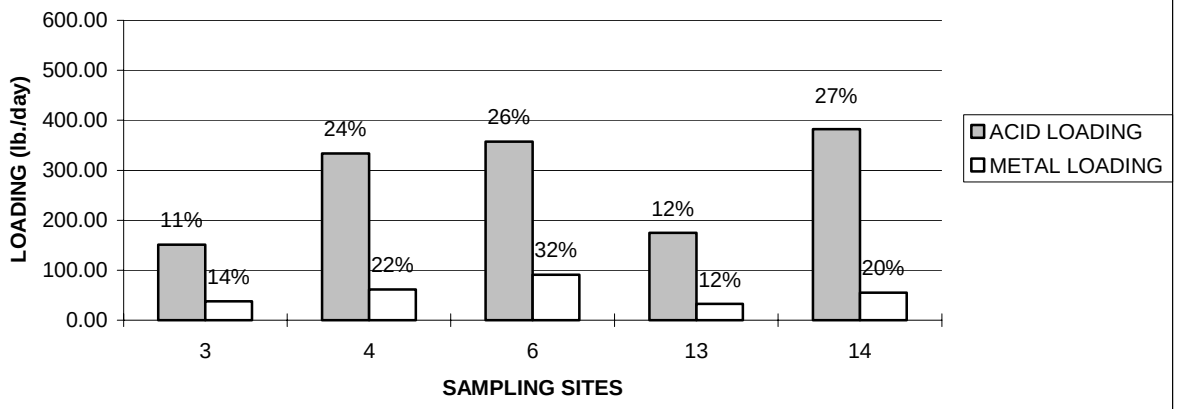


Jaymar Limestone is strip mining for limestone in the headwaters of tributary 9. During Phase I sampling it was determined that at high flow, Mulga Run contributes 7% of the acidity loading and 16% of the metal loading to Little Raccoon Creek (Figure 6). At low flow, Mulga Run contributes 17% of the acidity loading and 20% of the metal loading in the Little Raccoon Creek watershed (Figure 7). As previously noted, highly variable water chemistry in Mulga Run can be attributed to a variety of factors which reduce the streams buffering capacity at low flow. Thorough monitoring and the initiation of a remediation design will begin in late 2000.

Phase II water sampling occurred between 4/28/98 and 4/29/98 to determine which tributaries entering the Mulga Run mainstem contribute the most AMD. This phase of sampling does not include a high- and low-flow period, but is expected to provide a relative measure of sources within Mulga Run sub-watershed[2]. Five of the 12 Mulga Run tributaries contribute significant AMD to Mulga Run (Figure 9). The largest AMD-contributors during this sampling period included tributaries 6, 14, and 4. Tributary 6 contributes 26% of the acidity loading and 32% of the metal loading. Tributary 6 acidity loading ranges from about 400 to 1200 lb/day, and metal loading ranges from 90 to 500 lb/day (Appendix 1,Table 2). Tributary 14 contributes 27% of the acidity loading and 20% of the metal loading. Tributary 14 loading is about 350 lb/day and metal loading is about 50 lb/day. Tributary 4 contributes 24% of the acidity loading and 22% of the metal loading. Tributary 4 acidity loading is about 350 lb/day and metal loading is about 60 lb/day. Based on available water quality data, tributary 6 is the largest contributor of AMD in the Mulga Run sub-watershed followed by tributaries 14 and 4.

[2] As previously noted, seasonally variable water chemistry in this stream has been observed to contribute significant acidity loading to Little Raccoon Creek, with levels reaching 1746 lbs/day in October 1998 (Appendix 1, Table 2).

Figure 9: Acidity and Metal Loading into Mulga Run from All Sources (4/28/98 - 4/29/98)



Phase III water sampling occurred between 9/27/99 and 10/13/99 to locate point sources for AMD-generation in each of the affected tributaries to Mulga Run. Again, high- and low-flow periods are not represented; the purpose of the sampling was to determine relative importance of seeps. In tributary 6, the Lincoln Pit Seeps (sites 6A and 6B, Figure 8) contribute 95% of the acidity loading and 97% of the metal loading. Site 6E contributes 4% of the acidity loading and 3% of the metal loading. No Phase III point source information is available for tributary 14 due to drought conditions at the sampling time. In tributary 4, site 4E contributes 78% of the acidity loading and 77% of the metal loading. Site 4D contributes 22% of the acidity loading and 23% of the metal loading. The remaining sites contributed 1% or less to the total acidity and metal loading in Mulga Run. Based on available water quality data, sites 6A and 6B are the largest contributors of acid mine drainage in the Mulga Run sub-watershed followed by tributary 14 (discussed above under Phase II water quality sampling), and sites 4E, 4D, and 6E. These sources are described in more detail in the following sections.

Site 6 - Confluence of Mulga Run and Little Raccoon Creek, site 1A, 2 and 14

Location/Access: Site 6 at the confluence of Mulga Run is reached by traveling west on Hollingshead Road until it dead-ends at the abandoned bridge (Figure 8). The confluence is approximately 30 yards upstream from the abandoned bridge. The site is located on the Mulga Quadrangle in the southwest corner of section 10. The site is only accessible by foot travel. Mead Paper Company in Chillicothe, Ohio owns the property at the confluence. The individual in charge of the abandoned mine lands for Mead Paper Company is Steve Mathy (740-772-3472).

Site 1A is located on the corner of Hollingshead Road and Mulga Road just downstream of the Mulga Road Bridge. This site is situated just upstream from the entrance to the Mulga Run wetland and is accessible by both vehicle and foot travel. Sites 14 and 2 enter the Mulga Run mainstem below site 1A.

Site Description: The confluence of Mulga Run is situated at the outflow of a large wetland complex that extends along U.S. Route 32 almost to Mulga Run Road (Co. Rd. 39). During periods of high flow there are multiple discharge points emanating from the wetland into Little Raccoon Creek and during low-flow periods the discharge is typically limited to a single channel.

Water Quality: Acidity loading at the confluence of Mulga Run can exceed 3000 lb/day, but waters may also carry a small net alkaline load. Metal loading ranges from 30 to 1300 lb/day.

Recommendation: Continuous monitoring should be done at the confluence of Mulga Run. The purpose for this is two-fold: 1) the Mulga Run wetland provides a unique system for acid and metal removal and further study of the process may prove beneficial, and 2) water quality monitoring at the confluence of Mulga Run and at site 1A reveals increased AMD degradation below site 1A. Site 14 has the potential for large loading episodes and is therefore suspected of degrading the water quality in the Mulga Run wetland. It is recommended that monitoring begin with a monthly schedule of filtered Group I samples until the point source for the AMD

degradation and reasonable high- and low-flow conditions have been identified. Sampling sites should include sites 6, 1A, 2, and 14.

Site 3A- Mount Carmel Seeps

Location/Access: Site 3A is located on Mulga Road (Co. Rd. 39) south of U.S. 32 and north of Mount Carmel Church (Figure 8). Site 3A cannot be seen from the road, but drainage from the sight is visible along the hillside on a steep-grade section of Mulga Road (Co. Rd. 39). The site is located on the Mulga Quadrangle in the southwest corner of section 2. The site is only accessible by foot travel.

Site Description: This site is an abandoned deep-mine site most likely associated with deep-mine JKN-101. The mine entrance is not visible, but a positive-draining pond marks the most probable location of a mine entrance or hydraulic connection to the mine. The site drains along a road culvert on Mulga Rd. (Co. Rd. 39) and into the mainstem of tributary 3. This site has a large quantity of unreclaimed coal tailings extending from the mine entrance to Mulga Run Road (Co. Rd. 39).

Water Quality: Site 3A has exhibited acidity loading of 5 lb/day and less than 1 lb/day of metal loading. Site 3A is believed to be a low-priority site, but has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 3A to capture high- and low-flow conditions and to identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed. Sampling sites should only include site 3A.

Site 3B - Mount Carmel Seeps

Location/Access: Site 3B is located in the headwaters of tributary 3 just northwest of Mount Carmel church on Mulga Road. (Co. Rd. 39) (Figure 8). The site is located on the Mulga Quadrangle in the southwest corner of section 2 and the northwest corner of section 11. The site is only accessible by foot travel.

Site Description: This site is an abandoned deep-mine site most likely associated with deep-mines JKN-98 and JKN-103. The mine entrance is not visible, but a pool of standing water marks the most probable location of a mine entrance or hydraulic connection to the mine. The site drains into an open storm-water ditch along Mulga Run Road (Co. Rd. 39), which constitutes the headwaters of tributary 3. No coal refuse piles are visible around the site, but the owner of the property is using the site as an open dump.

Water Quality: During water quality sampling of potential project sites in September of 1999, Site 3B was not draining, but there was a large area of metal precipitate to indicate this site may be active during periods of higher rainfall. Site 3B is believed to be a low-priority site.

Recommendation: Continuous monitoring is recommended at site 3B, to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed. Sampling sites should only include site 3B.

Site 4A - Hollingshead Road Seeps

Location/Access: Site 4A is located near the entrance of the tributary 4 valley. This site is located on the Mulga Quadrangle on the west-central portion of section 2 (Figure 8). Access to tributary 4 is severely limited and can only be approached on foot through the north cul-de-sac section of Hollingshead Road.

Site Description: Site 4A is an abandoned deep-mine site and most likely associated with deep-mine JKN-121. The mine entrance is not visible, but a bog area and large quantities of metal precipitate on the hillside mark the most probable location of a mine entrance or hydraulic connection to the mine. A substantial quantity of unreclaimed coal refuse piles are located along the hillsides near the seep and on the opposite hillside a short distance upstream. These unreclaimed coal refuse piles are labeled 4B and 4C on Figure 8.

Water Quality: During water quality sampling of potential project sites in September of 1999, Site 4A was not draining, but there was a large area of metal precipitate to indicate this site may be active during periods of higher rainfall. No water quality information is available for this site.

Recommendation: Continuous monitoring is recommended at site 4A to capture high- and low-flow conditions and to identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed. Sampling sites should only include site 4A.

Site 4D - Hollingshead Road Seeps

Location/Access: Site 4D is located within the north fork of the headwaters of tributary 4 (Figure 8). The site, located on the Mulga Quadrangle in the west-central portion of section 2, is downstream from sedimentation ponds constructed by the Sands Hill Coal Company. Access to tributary 4 is severely limited and can only be approached on foot through the north cul-de-sac section of Hollingshead Road. It is assumed that the Sands Hill Coal Company holds property ownership.

Site Description: Site 4D is an abandoned deep-mine site and most likely associated with deep-mines JKN-128, JKN-130 and JKN-133. The mine entrance is not visible, but diffuse seeps can

be seen all along the banks and hillsides of the north fork. The microbial colony *Euglena mutabilis* can be seen in abundance along this section. Areas along the banks and hillsides contain unreclaimed coal refuse piles and other mining wastes (i.e. metal and wood timbers).

Water Quality: During this sampling period sites 4D and 4E contributed flow to the mainstem of tributary 4. No additional discharge emanated from the Sands Hill Coal Company sedimentation ponds. Site 4D exhibited acidity loading of 13 lb/day and metal loading of 5 lb/day. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Site 4D is a Little Raccoon Creek priority treatment site. Recommendations for treatment will be covered in section 1 under the heading *Proposed Treatment*. A monthly monitoring schedule of filtered Group II samples should be initiated before beginning any treatment programs in order to fully characterize a variety of acidity and metal loading ranges. Sampling sites should include the confluence of tributary 4, site 4D, and site 4E.

Site 4E - Hollingshead Road Seeps

Location/Access: Site 4E is located within the south fork of the headwaters of tributary 4 (Figure 8). Site 4E is also located downstream from sedimentation ponds constructed by the Sands Hill Coal Company. This site is located on the Mulga Quadrangle on the west-central portion of section 2. Access to tributary 4 is severely limited and can only be approached on foot through the north cul-de-sac section of Hollingshead Rd. It is assumed that the Sands Hill Coal Company holds property ownership.

Site Description: Site 4E is an abandoned deep-mine site and most likely associated with deep-mine JKN-130. The mine entrance is not visible but diffuse seeps can be seen all along the banks and hillsides of the south fork. The microbial colony *Euglena mutabilis* can be seen in abundance along this section. A large portion of the banks and hillsides contain unreclaimed coal refuse materials and other mining wastes (i.e. metal, wood timbers, and a mining car).

Water Quality: During this sampling period, only sites 4D and 4E contributed flow to the mainstem of tributary 4. No additional discharge emanated from the Sands Hill Coal Company sedimentation ponds. Site 4E exhibited acidity loading of 46 lb/day and metal loading of 18 lb/day. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Site 4E is a Little Raccoon Creek priority treatment site and recommendations for treatment will be covered in section 1 under the heading *Proposed Treatment*. It is suggested that a monthly monitoring schedule of filtered Group II samples be initiated before beginning any treatment programs in order to fully characterize a variety of acidity and metal loading ranges. Sampling sites should include the confluence of tributary 4, site 4D, and site 4E.

Site 6A and 6B - Lincoln Pit Seeps

Location/Access: Site 6B is located in the east fork of the tributary 6 headwaters (Figure 8). To reach the site, enter Sands Hill Coal Company property and follow the Lincoln Pit Haul Road to a road culvert at the base of a steep grade in the haul road. Active mining can be seen at the top of the steep grade. The site is located on the Mulga Quadrangle in the northeast corner of section 2. This site is accessible by both vehicle and foot travel. Do not enter Sands Hill Coal Company property without permission and a visitor's pass. Please contact Brenda Weber at the Hamden Office 740-384-4211.

Site Description: Site 6B is an abandoned deep-mine site and is most likely associated with the north section of the deep-mine complex JKN-38. No unreclaimed coal refuse material can be found at this site. The mine entrance is not visible, but a high-discharge seep marks the most probable location of the mine entrance or hydraulic connection to the mine. Close to this seep is an area of diffuse seeps along the bank of the road culvert and this is labeled site 6A. These diffuse seeps are also assumed to be associated with the north section of the deep-mine complex JKN-38.

Water Quality: Sites 6A and 6B have exhibited a combined acidity loading of 1200 lb/day and metal loading of 550 lb/day. These sites have not been fully characterized in terms of high- and low-flow chemical loading. It is important to note that some alkaline discharge is being added to tributary 6. In the headwaters of tributary 6, sites 6A and 6B merge with 6C and 6D to begin the mainstem of tributary 6. Site 6C is a sedimentation/runoff pond installed by Sands Hill Coal Company. In September of 1999, it was producing 50 lbs of alkalinity per day. Site 6D is a pipe draining an unknown area and is located next to site 6C. In September of 1999, it was producing 40 lbs of alkalinity per day.

Recommendation: Site 6A and 6B are Little Raccoon Creek priority treatment sites and recommendations for treatment will be covered in section 1 under *Proposed Treatment*. A monthly monitoring schedule of filtered Group II samples should be initiated before beginning any treatment programs in order to fully characterize a variety of acidity and metal loading ranges. Sampling sites should include sites 6A, 6B and a site downstream from the net alkaline discharges.

Site 6E - Deep Mine JKN-38

Location/Access: Site 6E is located downstream from the Lincoln Pit Seep in the east fork of the tributary 6 headwaters (Figure 8). To reach this site, enter the property of Sands Hill Coal Company and follow the Lincoln Pit Haul Road to a road culvert at the base of a steep grade in the haul road. The abandoned mine site is located approximately 75 yards downstream from the haul road culvert. The site is located on the Mulga Quadrangle in the northeast corner of section 2. The site is only accessible by foot travel. Do not enter Sands Hill Coal Company property without permission and a visitor's pass. Please contact Brenda Weber at the Hamden Office 740-384-4211.

Site Description: Site 6E is an abandoned deep-mine site and is most likely associated with the south section of the deep-mine complex JKN-38. No unreclaimed coal refuse materials are associated with this site. The mine entrance is not visible, but discharge from a seep marks the most probable location of the mine entrance or hydraulic connection to the mine.

Water Quality: Site 6E has exhibited acidity loading of 51 lb/day and metal loading of 17 lb/day. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 6E, to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed.

Site 6F - Deep Mine JKN -38

Location/Access: Site 6F is located in the west fork of the headwaters in tributary 6. To reach the site, enter the property of Sands Hill Coal Company and take the Lincoln Pit Haul Road. The confluence of this stream is approximately 150 yards downstream of the haul road culvert. The site is located on the Mulga Quadrangle in north-central portion of section 2. The site is only accessible by foot travel. Do not enter Sands Hill Coal Company property without permission and a visitor's pass. Please contact Brenda Weber at the Hamden Office 740-384-4211.

Site Description: Site 6F is an abandoned deep-mine site and is most likely associated with the south section of the deep-mine complex JKN-38. Some unreclaimed coal refuse materials are associated with this site. The mine entrance is not visible, but diffuse seeps along the bank of the stream mark the most probable location of the mine entrance or hydraulic connection to the mine.

Water Quality: Site 6F has exhibited acidity loading of 11 lb/day and metal loading of 3 lb/day. Site 6F is believed to be a low-priority site, but has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 6F to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed.

Site 13A - Deep Mine JKN-206

Location/Access: This site is located at the end of a dirt road on the corner of Mulga Road and U.S. Route 32. The dirt road dead-ends into a logging road that can be followed back to the mine site. The site is located on the Mulga quadrangle in the northwest corner of section 3. The site is only accessible by foot travel.

Site Description: Site 13A is an abandoned deep-mine site and is most likely associated with deep-mine JKN-206. No mine entrance is visible, but a bog area and large amounts of metal precipitate mark the most probable location of a mine entrance or hydraulic connection to the mine. The site constitutes the headwaters of tributary 13 and is the only point source of AMD in this tributary. It is believed that unaffected base flow from the surrounding watershed is mixing with and diluting the AMD-influx.

Water Quality: Site 13A has exhibited acidity loading of 18 lb/day and metal loading of 3 lb/day. Site 13A is believed to be a low-priority site, but has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 13A to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a

reassessment can be made of the impact this site has upon the sub-watershed. Sampling sites should include the confluence of tributary 13 and site 13A.

Site 14 - Mulga Road Mine Complex

Location/Access: A majority of tributary 14 occurs as a roadside ditch along Mulga Road (Co. Rd. 39) on the west side of U.S. Rt. 32. The tributary is located on the Mulga quadrangle in the central portion of section 3. The tributary is accessible by both vehicle and foot travel, but most of the land is posted as no trespassing.

Site Description: Because of poor sampling conditions and lack of access to private property no point source for AMD-generation has been located to date. The west side of tributary 14 has abandoned strip-mine lands while in the headwaters abandoned deep-mines are thought to exist. These abandoned deep-mines are most likely associated with deep mines JKN-153, JKN-81, and JKN-206.

Water Quality: During a canvas of the AMD-impacted tributaries in April 1998, site 14 was producing 380 lbs of acidity per day and 30 lbs of metals per day making this tributary the second largest AMD-producer in the Mulga Run sub-watershed. Site 14, near the Mulga Run confluence, and the upstream site 1A have under gone intensive water quality monitoring since January of 1997. Beginning in the spring of 1998, the confluence of Mulga Run began to show uncharacteristically high levels of acidity and metal loading. This trend continued until June of 1999 when levels began to dramatically decrease. This trend was not evident when the same loading data was compared with the data set from site 1A. Only 2 tributaries enter the Mulga Run mainstem below site 1A and this includes tributaries 14 and 2. Tributary 2 has shown very little AMD-generation in the past. Therefore, it is proposed that site 14 is the most likely point source for increased AMD-degradation below site 1A. The reason for the cessation of AMD degradation in June 1998 may be due to drought related conditions. Discharge from site 14 is suspected to have been decreasing since June 1998 until it was found completely dry in September of 1998.

Recommendation: Site 14 is a Little Raccoon Creek priority treatment site. Recommendations for treatment will be covered in section 1 under *Proposed Treatment*. A more intense characterization of site 14 should be completed before implementing any remediation strategy. It is recommended that monitoring begin with filtered Group I samples until high- and low-flow conditions have been sampled and point sources have been identified.

Summary of Potential Treatment Sites: Mulga Run

Site	Recommendation	Site Identification
6	Monitor	Confluence Of Mulga Run
3A	Monitor	Mt. Carmel Seeps
3B	Monitor	Mt. Carmel Seeps
4A	Monitor	Hollingshead Road Seeps
4D	Treatment	Hollingshead Road Seeps
4E	Treatment	Hollingshead Road Seeps
6A & 6B	Treatment	Lincoln Pit Seeps
6E	Monitor	Deep Mine Jkn-38
6F	Monitor	Deep Mine-Jkn-38
13A	Monitor	Deep Mine Jkn-206
14	Treatment	Mulga Road Mine Complex

RICH RUN

NAME:	Rich Run
LOCATION:	Milton Township, Jackson County, Ohio
QUADRANGLE:	Mulga (T9N, R17W, S10, 11, 12, 13, 14 and 15)
DRAINAGE AREA:	~6 mi^2

Overview

During Phase I sampling it was determined that Rich Run (Figure 10) contributes <1% of the acidity loading and 4% of the metal loading during high flow and <1% of the acidity and metal loading during low flow to the mainstem of Little Raccoon Creek (Figures 6 and 7). Most surface runoff is from reclaimed and unreclaimed strip-mined land, but it is not acidic. Acidity derives mainly from abandoned deep mines. The sub-watershed contains a large, inaccessible wetland formed by beaver damming, and provides potentially valuable waterfowl habitat. Rich Run is only a minor part of the acid mine drainage into Little Raccoon Creek, but future work may occur in the area because of the wetland. For this reason, the data are included in this report (Appendix 1, Table 3).

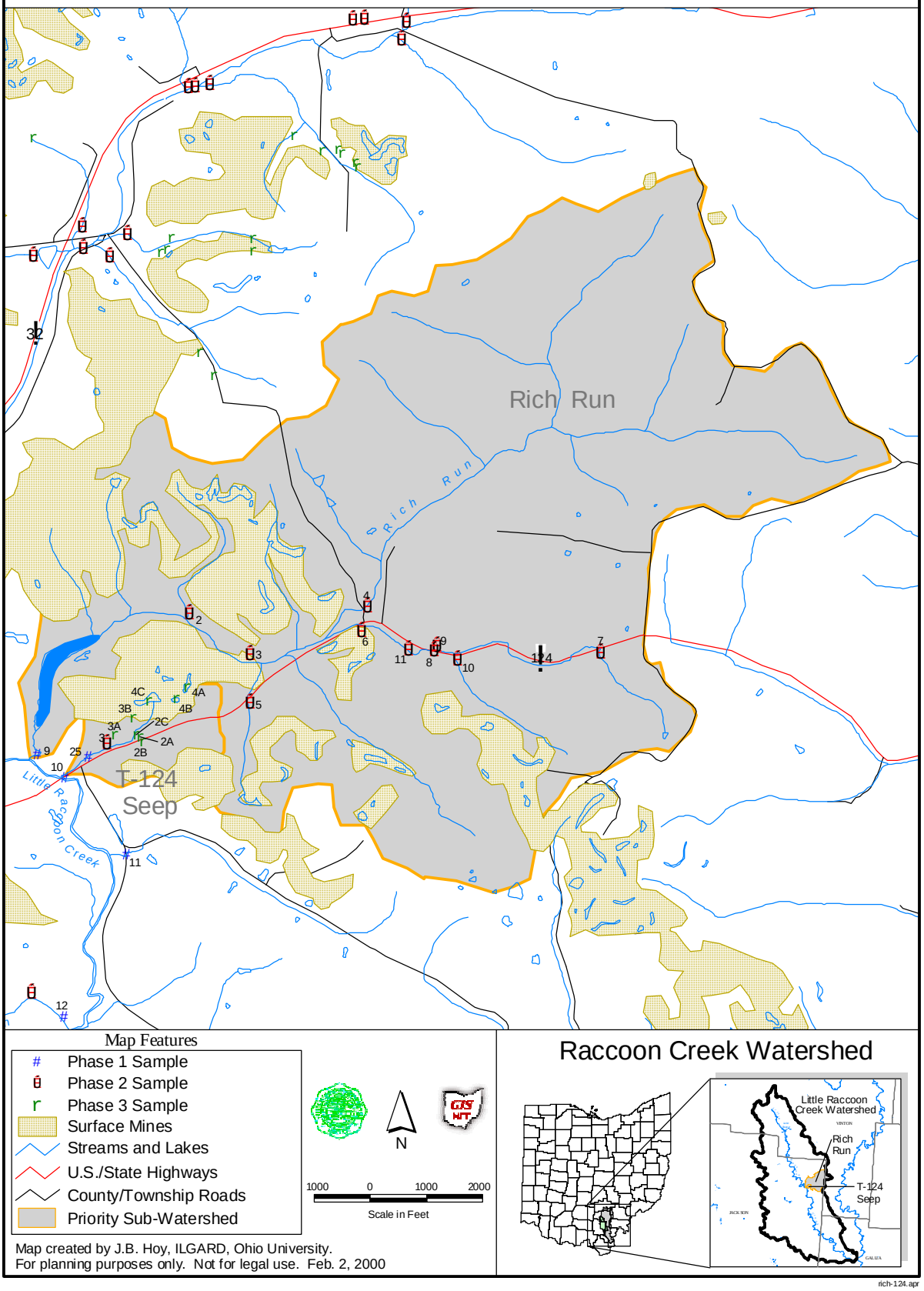
T-124 SEEP

NAME:	124 Seep Project Site
LOCATION:	Milton Township, Jackson County, Ohio
QUADRANGLE:	Mulga (T9N,17W, S14&15)
DRAINAGE AREA:	<0.5 mi^2

Overview

The 124 Seep is located along Route 124 in Jackson County (Figure 10). It is an abandoned surface coalmine draining directly into Little Raccoon Creek. During Phase I sampling it contributes 4% of the acidity loading to Little Raccoon Creek during high flow and 2% during low flow. It contributes 5% of the metal loading during high flow and 2% during low flow (Figures 6 and 7). The watershed is small, but carries a relatively large load of acidity and metals directly into Little Raccoon Creek. Construction on a remediation project will begin in the fall of 2000. Data have been included here for comparison with post-construction monitoring (Appendix 1, Table 4).

Figure 10: Rich Run and T-124 Seep Sub-Watersheds



MIDDLETON RUN

NAME:	Middleton Run
LOCATION:	Milton Township, Jackson County, Ohio
QUADRANGLE:	Mulga (S 15, 16, 21 and 22), Wellston (S 17, 18, 19 and 20)
DRAINAGE AREA:	2.28 mi^2

Overview

Middleton Run sub-watershed is affected by abandoned deep-mines, abandoned strip-mine lands and associated unreclaimed coalmine spoil (Figure 11). Abandoned surface mines affect 63% of the watershed and abandoned subsurface mines affect 5% (Childress, 1985). The environmental impact of Middleton Run on Little Raccoon Creek was established by comparing the water quality of the main tributaries entering Little Raccoon Creek during a high-flow period (3/24/98-3/25/98) and the primary acid-mine drainage (AMD) affected tributaries during a low-flow period (6/22/99-6/24/99) (Appendix 1, Table 5). During Phase I sampling it was determined that at a high-flow period, Middleton Run contributed 43% of the acidity loading and 44% of the metal loading in the Little Raccoon Creek watershed. Due to unseasonable drought conditions at the time of the low-flow monitoring, Middleton Run was not flowing (Figures 6 and 7). The confluence of Middleton Run has exhibited acidity loading of 115 to 4700 lb/day and metal loading of 23 to 975 lb/day. Based on available water quality data, Middleton Run is the second largest contributor of acid-mine drainage (AMD) in the Little Raccoon Creek watershed.

Phase II water sampling occurred in the typically low-flow period between 7/15/98 and 7/21/98, and 10/25/99 through 10/26/99. The purpose of this second phase of water sampling was to determine which tributaries entering the Middleton Run mainstem contribute AMD. It is important to note that this phase of sampling does not include a high-flow sample. During each canvas, it was determined that 5 of the 9 Middleton Run tributaries contributed significant AMD. The largest AMD contributors during each of the sampling periods included sites 2, 3, 5, and 11 (Figure 12, Figure 13). Site 2 contributed 26% of the acidity loading and 19% of the metal loading in Middleton Run in July of 1998 and 24% of the acidity loading and 16% of the metal

Figure 11: Middleton Run And Flint Run Sub-Watersheds

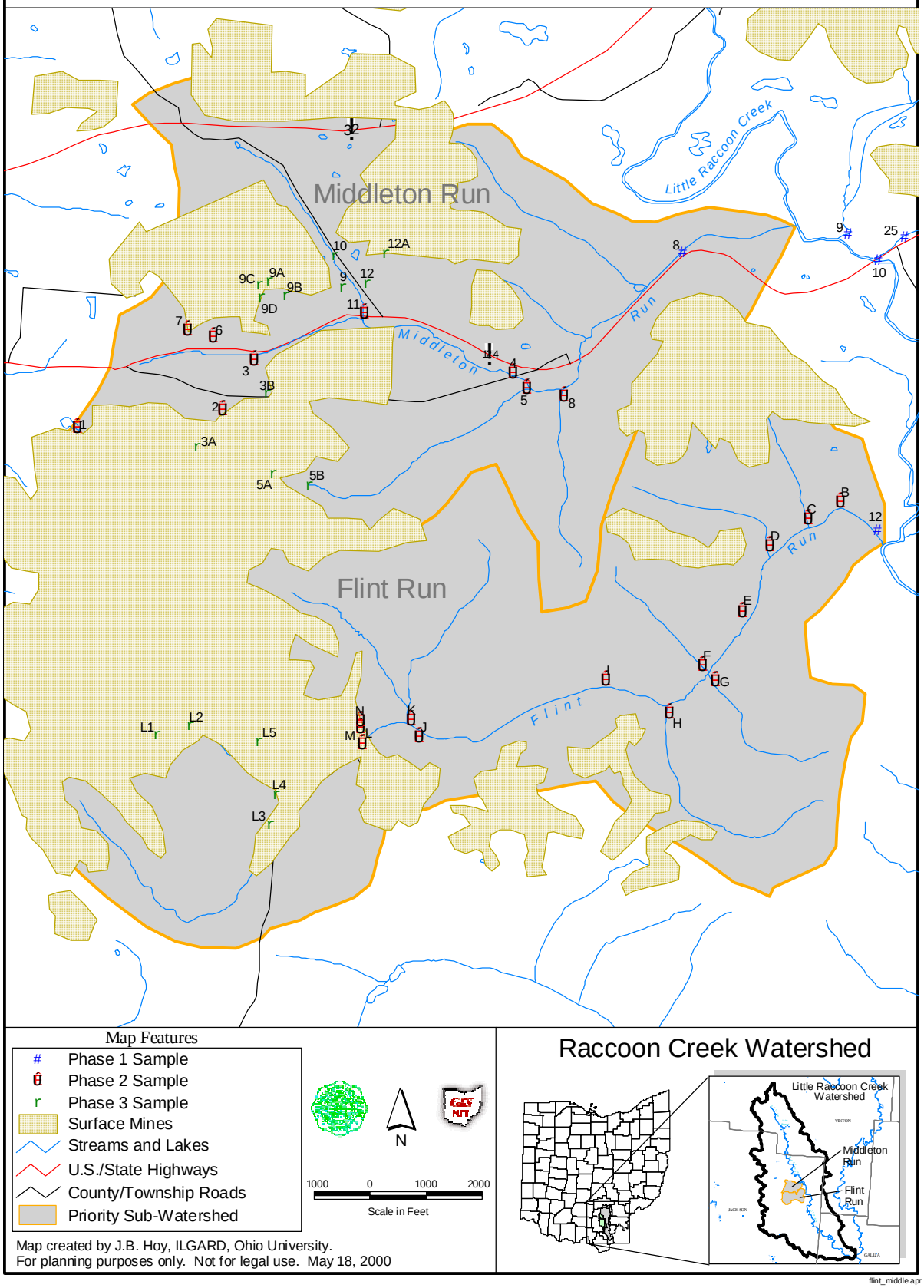


Figure 12: Acidity and Metal Loading into Middleton Run from All Sources of AMD (7/15/98, 7/21/98)

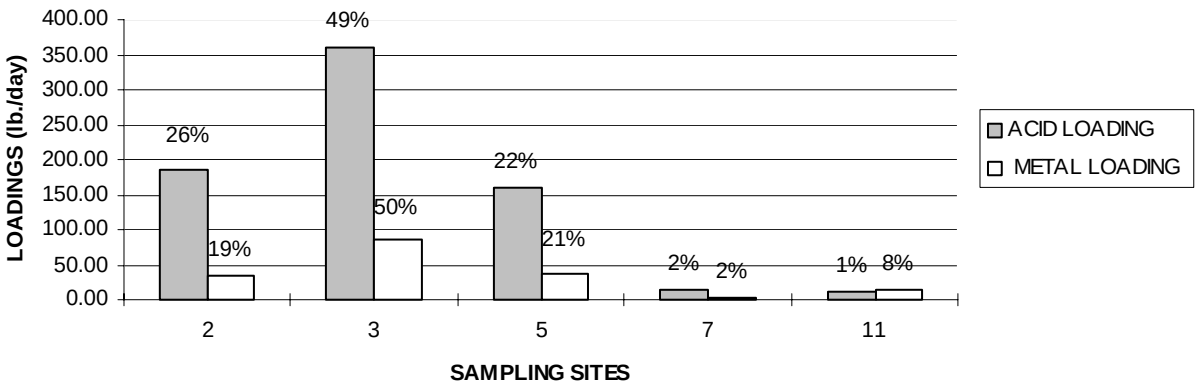
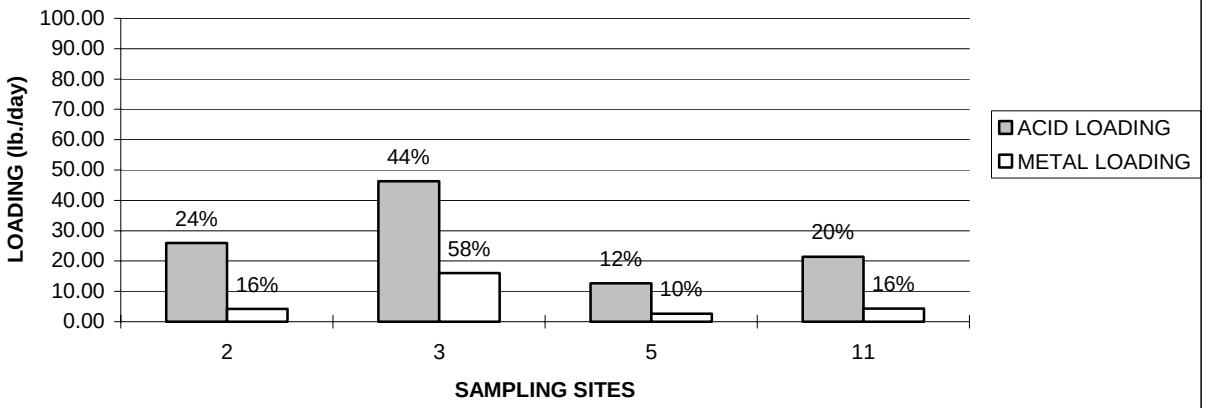


Figure 13: Acidity and Metal Loading into Middleton Run from All Sources of AMD at Low-Flow (10/25/99-10/26/99)



loading at a low-flow period in October of 1999. Site 2 has exhibited acidity loading of 26 to 187 lb/day and metal loading of 4 to 34 lb/day. Site 3 contributed 49% of the acidity loading and 50% of the metal loading in Middleton Run in July of 1998 and 44% of the acidity loading and 58% of the metal loading at a low-flow period in October of 1999. Site 3 has exhibited acidity loading of 46 to 360 lb/day and metal loading of 16 to 87 lb/day. Site 5 contributed 22% of the

acidity loading and 21% of the metal loading in Middleton Run in July of 1998 and 12% of the acidity loading and 10% of the metal loading at a low-flow period in October of 1999. Site 5 has exhibited acidity loading of 13 to 160 lb/day and metal loading of 3 to 37 lb/day. Site 11 contributed 1% of the acidity loading and 8% of the metal loading in Middleton Run in July of 1998 and 20% of the acidity loading and 16% of the metal loading at a low-flow period in October of 1999. Site 11 has exhibited acidity loading of 10 to 21 lb/day and metal loading of 4 to 15 lb/day. Site 3 is the largest contributor of AMD in the Middleton Run sub-watershed followed by sites 2, 5 and 11 respectively.

Phase III water sampling occurred between 10/25/99 and 10/26/99 to locate point sources for AMD-generation in each of the affected tributaries. It is important to note that this phase of sampling does not include a high- and low-flow sample. During this sample period, the Salem Road Seep (site 3B) contributed 29% of the acidity loading and 41% of the metal loading in Middleton Run. Site 2 contributed 16% of the acidity loading and 11% of the metal loading. Site 5B contributed 20% of the acidity loading and 20% of the metal loading. Site 9 contributed 18% of the acidity loading and 16% of the metal loading. Site 12A contributed 12% of the acidity loading and 8% of the metal loading. Site 3B is the largest contributor of AMD in the Middleton Run sub-watershed followed by sites 2, 5B, 9 and 12A respectively. These sources are described in more detail in the following sections.

Site 2 - Salem Road Seeps

Location/Access: Site 2 is located along Salem Road just west of Site 3B and east of St. Rt. 124 in Milton Township. Tributary 2 is the first stream to cross Salem Road when entering from the west. The site is located on the Wellston quadrangle in the north-central portion of section 20. This site is accessible only by foot travel.

Site Description: Site 2 consists of a small area of diffuse seeps, which during low-flow periods, combine to form the headwaters of this tributary. During high-flow periods, the tributary receives additional upstream drainage from the Broken Aro mine site. Site 2 is believed to be associated with abandoned deep-mines and sub-surface drainage from Lake Rice. Active subsidence from room and pillar mining can be observed from Lake Rice to the active seeps.

The abandoned deep mine is not listed on the USGS Abandoned Underground Mine maps. It is believed that leakage from Lake Rice is entering the abandoned mine and discharging at the seep area. No abandoned coalmine refuse piles were identified with this site.

Water Quality: Site 2 has exhibited acidity loading ranges of 26 to 187 lb/day and metal loading ranges of 5 to 25 lb/day. Site 2 is the only known source of AMD generation in this tributary and is believed to be the second largest AMD-generator in the Middleton Run sub-watershed. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Site 2 is a Little Raccoon Creek priority treatment site and recommendations for treatment will be covered in section 1 under *Proposed Treatment*. It is suggested that a monthly monitoring schedule of filtered Group II samples be initiated before beginning any treatment programs in order to fully characterize the acidity and metal loading ranges. Sampling sites should include the confluence of the site 2 tributary and the headwaters of the site 2 tributary.

3B - Salem Road Seeps

Location/Access: Site 3B is on Salem Road just west of the sawmill property in Milton Township. Site 3B is located on the second tributary to cross Salem Road when entering from the west. The site can be found on the Wellston quadrangle in the north-central portion of section 20. This site is accessible by foot travel and limited vehicle traffic. The mine complex should not be accessed by vehicle during wet periods.

Site Description: Site 3B is believed to be associated with drainage from the Broken Aro mine complex, strip mine lands, which have been abandoned since the late 1950's and a last-cut lake. Large quantities of unreclaimed mine spoil dominate the mine complex. Drainage off the site is divided between overland flow off the unreclaimed spoil and sub-surface leakage from Lake Rice (site 3A). It is believed that leakage from Lake Rice is discharging at a single seep along Salem Road. The lake appears to be acting as a storage basin for AMD products captured as runoff during precipitation events and released over time to the Salem Road seep. It is also

believed that sub-surface flow leaving Lake Rice continues to degraded as it moves through the mine spoil to Salem Road. During water sampling in October 1999, the Broken Aro site was not discharging, but the seep on Salem Road was providing the majority of the discharge to the adjacent tributary. An alternative explanation is that abandoned deep-mine site JKN-160 is also providing recharge to the seep. Further investigation of this hydrologic phenomenon is recommended.

Water Quality: Site 3B has exhibited acidity loading ranges of 87 to 360 lb/day and metal loading ranges of 16 to 46 lb/day. Site 3B is the only known source of AMD generation in the adjacent tributary. Site 3B is the largest AMD generator in the Middleton Run sub-watershed. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Site 3B is a Little Raccoon Creek priority treatment site and recommendations for treatment will be covered in section 1 under *Proposed Treatment*. It is suggested that a monthly monitoring schedule of filtered Group II samples be initiated before beginning any treatment programs in order to fully characterize the acidity and metal loading ranges. Sampling sites should include the confluence of tributary 3, site 3B, site 3A (Lake Rice), and any runoff from the Broken Aro mine complex.

Site 5B - Lake Farley Drainage

Location/Access: Site 5B is located directly behind the sawmill on Salem Road. This site is located on the Wellston quadrangle in the east-central portion of section 20 and is only accessible by foot travel.

Site Description: Site 5B is associated with leakage from the Lake Farley tailings dam (site 5A). Site 5B consists of an area of diffuse seeps along the banks of the tributary 5 valley and at the base of the tailings dam. Lake Farley is located down hill from the Broken Aro mine complex and receives periodic runoff from the site. It is believed that Lake Farley is acting as a storage basin for AMD-products captured as runoff during precipitation events and released over time to

site 5B. It is also believed that sub-surface flow leaving Lake Farley continues to degrade as it moves through the mine refuse materials to site 5B.

Water Quality: Tributary 5 has exhibited acidity loading ranges of 13 to 160 lb/day and metal loading ranges of 3 to 37 lb/day. During a low-flow period, site 5B has exhibited acidity loading of 13 lb/day and metal loading of 2 lb/day. Site 5B is the only known source of AMD generation in tributary 5. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended in tributary 5 for design purposes. The purpose of a continuous monitoring program is to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this tributary may underrate the impact of the point source(s) and warrant an upgrade in status to a priority treatment site. Monthly monitoring should include filtered Group I samples until reasonable high- and low-flow conditions have been identified after which a reassessment can be made of the site's impact upon the sub-watershed. It is recommended that water sampling include site 5 (confluence of tributary 5), site 5A (Lake Farley), and site 5B.

Site 9 - Hiram West Road Project

Location/Access: Site 9 is located on the Sands Hill Coal Company strip mine land along Hiram West Road in Milton Township. This site is located on the Wellston quadrangle in the southern corner of section 17. The site is accessible by vehicle provided that permission is granted from Sands Hill Coal Company to open the company gate. Please contact Brenda Weber at the Hamden Office for access 740-384-4211.

Site Description: Site 9 is a partially reclaimed strip-mine complex, but abandoned deep mines have been documented during recent surface mining operations. It is important to note that no deep-mines are listed on the USGS Abandoned Underground Mine maps. Reclamation activities were conducted at the site by Sands Hill Coal Company and included covering the mine spoil with Bypro®, a paper mill sludge product, and grass seeding. It is believed that AMD-

generation at the site is due to the abandoned underground mine seeps, which discharge into tributary 9. The site consists of a series of diffuse seeps along the east bank of tributary 9. Most of the seeps occur near the lower storm-water pond (site 9A), sites 9B and 9C (Figure 11). An AMD-consultant is presently under contract by the Ohio Department of Natural Resources to study remediation options for this mine site. A second source of stream degradation may be due to a landfill site west of the mine complex, which drains into tributary 9. Site 9D marks an area of diffuse seeps that appear to be draining from the landfill. Water quality sampling in October 1999 showed AMD-products present in the stream draining from site 9D. The Ohio EPA is monitoring water quality at the landfill site.

Water Quality: Site 9 has exhibited acidity loading ranges of 29 to 44 lb/day and metal loading is about 6 lb/day. The Sands Hill mine site is the only source of AMD generation in tributary 9. Site 9 is the largest generator of AMD into tributary 11. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 9 to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. Sampling should include site 9 (confluence of tributary 9), site 9B and site 9C. The sampling schedule for site 9D should include organic contaminants because of the nearby landfill. Funding has been secured to design and construct a remediation project in 2001 at site 9.

Site 12A - Middleton Run Deep Mine Site

Location/Access: Site 12A is located near the junction of St. Rt. 124 and Hiram West Road. It is the first stream draining into tributary 11 when entering Hiram West Road from the south. This site is located on the Wellston quadrangle in the west-central portion of section 16 and is only accessible by foot travel.

Site Description: Site 12A is believed to be associated with abandoned deep mine JKN-123. The mine entrance is not visible, but a large bog area at the valley head marks the most probable location of the entrance. This site drains into tributary 11 just above the confluence to the Middleton Run mainstem.

Water Quality: Site 12A has shown acidity loading of 19 lb/day and metal loading of 3 lb/day. This site is the only known source of AMD generation in tributary 12. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 12A to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed. Water sampling should include site 12 (confluence of tributary 12) and site 12A.

Site 11 - Confluence Of Tributary 11

Location/Access: Site 11 is located near the junction of St. Rt. 124 and Hiram West Road. The stream crosses underneath St. Rt. 124 via a cement culvert. This site is located on the Wellston quadrangle in the southwest corner of section 16.

Site Description: Site 11 is the confluence of tributary 11 to the mainstem of Middleton Run. The importance of site 11 is that it drains tributaries 9, 10, and 12. Tributary 10 has not previously been mentioned because its AMD-contribution has shown to be minimal. Tributary 10 begins at the confluence of tributary 9, which constitutes the headwaters for tributary 11. It is believed tributary 10 is receiving drainage from deep mine JKN-123. Visual inspection of the stream shows that degradation starts in the vicinity of a mailbox marked 372 Hiram West Road. Geochemical meters show very little degradation occurring upstream of this location. Tributary 10 has shown an acidity loading of 7 lb/day and metal loading of 2 lb/day.

Water Quality: Tributary 11 has exhibited acidity loading of 10 to 21 lb/day and metal loading of 4 to 15 lb/day. Tributary 11 is the fifth largest AMD-producer in the Middleton Run sub-watershed.

Recommendation: Continued water quality monitoring of site 11 is recommended to insure that increased degradation in any of the upstream tributaries will be noted. It is recommended that monitoring include a quarterly schedule of filtered Group I samples. It is also recommended that water sampling include site 11 (confluence of tributary 11) and site 10.

Summary of Potential Treatment Sites: Middleton Run

Site	Recommendation	Site Identification
2	Treatment	Salem Road Seeps
3B	Treatment	Salem Road Seeps
5B	Treatment	Lake Farley Drainage
9	Treatment	Hiram West Road Project
12A	Monitor	Middleton Run Deep Mine Site
11	Monitor	Confluence Of Tributary 11

FLINT RUN

NAME:	Flint Run
LOCATION:	Milton Township, Jackson County, Ohio
QUADRANGLE:	Wellston and Mulga (T9N, R17W, S28&29)
DRAINAGE AREA:	3.4 mi^2

Overview

The Flint Run sub-watershed is affected primarily by abandoned strip mine drainage and associated unreclaimed coal refuse piles (Figure 11). The environmental impact of Flint Run on Little Raccoon Creek was established during Phase I sampling by comparing the water quality of the main tributaries entering Little Raccoon Creek during a high-flow period (3/24/98-3/25/98) and the primary AMD-affected tributaries during a low-flow period (6/22/99-6/24/99) (Figures 6 and 7; Appendix 1, Table 6). At a high-flow period, Flint Run contributed 42% of the acidity loading and 28% of the metal loading in the Little Raccoon Creek watershed. At a low-flow period, Flint Run contributed 51% of the acidity loading and 51% of the metal loading in the Little Raccoon Creek watershed. Tributaries sampled during the low-flow canvas included Flint Run, Greasy Run, Goose Run, Middleton Run, Mulga Run, and the 124 Seep project area. Since the spring of 1985, the confluence of Flint Run has exhibited acidity loading ranges of 500 to 28,000 lb/day and metal loading of 80 to 3000 lb/day. Since February 1997, the average value for acidity loading has been 2000 lb/day and the average metal loading has been 400 lb/day. Based on available water quality data, Flint Run is the largest contributor of acid-mine drainage (AMD) in the Little Raccoon Creek watershed.

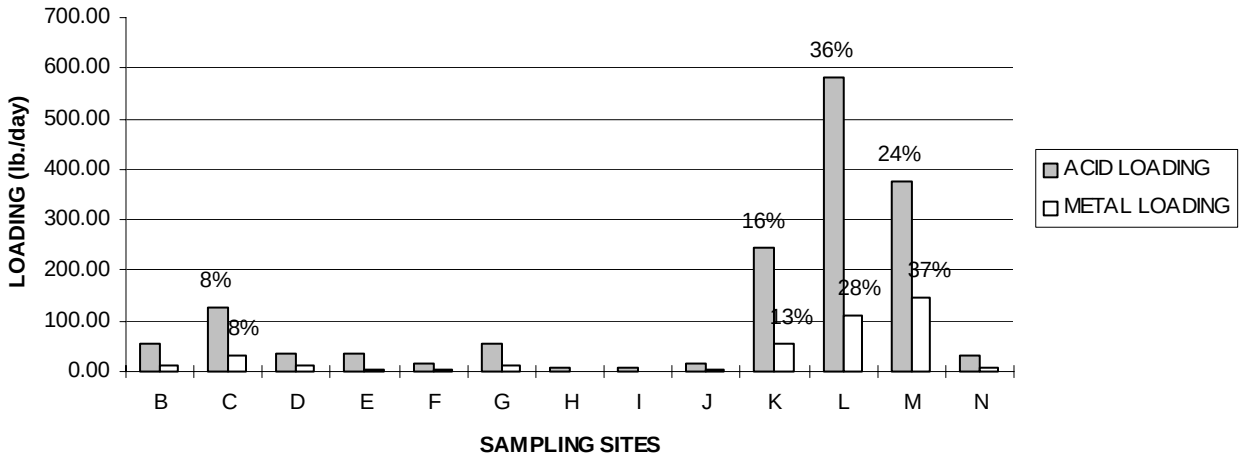
Recent hydrologic and geochemical investigations (Laverty, 2000) have indicated that 90% of the AMD generated within the Flint Run basin can be attributed to a 240-acre site in the headwaters. The site is a former coal preparation facility and mine-tailings dump operated by the Broken Aro Coal Company. The coal preparation facility is a part of a larger strip-mine complex that was active during the 1950's. It is estimated that between 1952 and 1956 the preparation plant processed approximately 400,000 tons of coal annually. The preparation plant separated marketable coal from wastes such as shale, coal fines, low-grade and non-marketable coal, and other mineral impurities such as pyrite. Prior to mining, the mine-tailings dump was an incised valley, and waste material was disposed of in either coal screening dumps in the upper valley or

piped to a series of slurry impoundments in the lower valley. The Mead Paper Corporation purchased the Broken Aro coal preparation facility and the mine-tailings dump in 1962 for timber reserves. Beginning in October of 1984, Mead began a five-phase reclamation project at the site, which included grading the site, re-routing drainage channels, applying a paper-mill sludge product for revegetation and buffering of the toxic tailings. Reclamation of the site was completed in the winter of 1987.

An investigation of the Broken Aro mine spoil is underway by Ohio University master's candidate Brett Laverty and will culminate with a master's thesis in August 2000. The main focus of this investigation is to characterize the groundwater flow system, especially the relationship between on-site strip-mine lakes and the groundwater regime, the geology and spatial extent of the mine tailings, and the extent and magnitude of AMD production. Long-term remediation goals are to reduce the acidity and metal loadings to Flint Run and to Little Raccoon Creek. The Broken Aro investigation is a combined effort of the Ohio Department of Natural Resources Division of Mineral Resources, Raccoon Creek Improvement Committee, Ohio University, West Virginia University's National Mine Land Reclamation Center, Mead Paper Company and Ohio Environmental Protection Agency Southeast District Office.

Phase II water sampling occurred between 5/24/98 and 5/25/99 (Figure 14). The purpose of this second phase of water sampling is to determine which tributaries entering the Flint Run mainstem contribute a significant amount of AMD. During the canvas, it was determined that tributaries K, L and M contributed the largest percentage of AMD. Tributary K contributed 16% of the acidity loading and 13% of the metal loading in Flint Run. Tributary K has exhibited acidity loading ranges of 160 to 250 lb/day and metal loading of 30 to 50 lb/day. Tributary L contributed 36% of the acidity loading and 28% of the metal loading in Flint Run. Tributary L has exhibited acidity loading ranges of 4700 lb/day to 85 lb/day and metal loading of 24 to 240 lb/day. Tributary M contributed 24% of the acidity loading and 37% of the metal loading in Flint Run. Tributary M has exhibited acidity loading ranges of 45 to 1700 lb/day and metal loading of 25 to 650 lb/day. Based on available water quality data, tributary L is the largest contributor of AMD in the Flint Run sub-watershed followed by tributaries M and K respectively.

Figure 14: Acidity and Metal Loading into Flint Run from All Sources (5/24/99-5/25/99)



Phase III water sampling occurred on 11/19/99 to locate point sources for AMD-generation in each of the affected tributaries. The tributary draining site L5 produced 83% of the acidity loading and 79% of the metal loading in tributary L. Site L2 produced 17% of the acidity loading and 21% of the metal loading in tributary L. Sites L5, L2, and tributary K have not been characterized in terms of high- and low-flow loading. Based on available water-quality data, site L5 and tributary M are the largest contributors of AMD in the Flint Run sub-watershed, followed by tributary K and site L2[3]. These sources are described in more detail in the following sections.

Tributary L - Lake Milton Drainage

Location/Access: Tributary L is a part of the Broken Aro investigation site located in Milton Township. The tributary is located on the Wellston Quadrangle in the southeast portion of section 29. The majority of the tributary can be accessed by vehicle. Mead Paper Company in Chillicothe, Ohio owns the majority of the property surrounding the tributary. The individual in charge of the abandoned mine lands for Mead Paper Company is Steve Mathy (740-772-3472).

[3] In light of the severity of acid mine drainage pollution emanating from Flint Run, the Ohio Division of Mineral Resources has set aside funding to begin engineering design plans in 2001 for a future remediation project.

Site Description: Tributary L is a manmade drainage that consists of two major branches: a western branch and a northern branch (Figure 11). The western branch has its origin in Lake Milton, which is labeled site L1. Lake Milton is a large strip pit lake, which is held back by an unstable mine-tailings dam. Site L2 is at the foot of the tailings dam and characterizes the discharge, which is undercutting the dam by means of a piping complex. There are no other sources of influx to the western branch of tributary L. The northern branch drains a portion of the Broken Aro investigation site and is labeled site L5. There is no other source of influx to the northern branch of tributary L. Shortly after the two branches merge the stream drains into Hothouse Lake, which is labeled site L3. The confluence of the stream into Hothouse Lake is labeled site L4. Hothouse Lake is a strip pit lake that is supported by a mine-tailings dam. The upper section of tributary L is the only source of influx into Hothouse Lake. In the southeast corner of the lake a man-made culvert diverts flow from the lake to the Flint Run mainstem. The confluence of tributary L with Flint Run is labeled site L.

Water Quality: Site L has exhibited acidity loading of 210 to 4700 lb/day and metal loading of 24 to 240 lb/day. Site L5 has exhibited acidity loading of 270 lb/day and metal loading of 80 lb/day. Site L2 has exhibited acidity loading of 60 lb/day and metal loading of 20 lb/day.

Recommendation: Site L5 is a Little Raccoon Creek priority treatment site and preliminary recommendations for treatment will be covered in section 1 under *Proposed Treatment*. Additional treatment recommendations will follow upon completion of a master's thesis by Ohio University master's candidate Brett Laverty. A range of acidity and metal loadings will be included in the final investigation.

Tributary M - Broken Aro Investigation Site

Location/Access: Tributary M drains the Broken Aro investigation site located in Milton Township. The tributary is located on the Wellston Quadrangle in the southeast portion of section 29. A large part of the tributary can be accessed by vehicle through the use of access roads. Extreme caution should be observed when driving on the coal tailings material. Poor

conditions can develop rapidly when the material becomes wet. Mead Paper Company in Chillicothe, Ohio owns a majority of the property surrounding the tributary. The individual in charge of the abandoned mine lands for Mead Paper Company is Steve Mathy (740-772-3472).

Site Description: Tributary M is a part of an ongoing study of the abandoned Broken Aro mine-tailings dumpsite. Tributary M is a result of Mead Paper's reclamation activities and it effectively captures the majority of the base flow and runoff from the Broken Aro investigation site. The study proposes that last cut, strip-pit lakes (Lake Laverty), located at a higher elevation surrounding the mine spoil are draining freely under gravity through the mine spoil and exiting a distance down the valley. Water quality analysis has shown that this water increasingly degrades as it moves down the valley through the toxic mine tailings. The components of degradation include a lowering of the pH, an increase in acid production and an increase in the concentration of dissolved metals.

Water Quality: Tributary M has exhibited acidity loading ranges of 45 to 1700 lb/day and metal loading of 25 to 650 lb/day. A large database is presently under construction to characterize the water quality of tributary M in terms of high- and low-flow chemical loading.

Recommendation: Tributary M is a Little Raccoon Creek priority treatment site and preliminary recommendations for treatment will be covered in section 1 under *Proposed Treatment*. Additional treatment recommendations will follow upon completion of a master's thesis by Ohio University master's candidate Brett Laverty. A range of acidity and metal loadings will be included in the final investigation.

Tributary K - Lake Latrobe Drainage

Location/Access: Tributary K is in the Broken Aro strip-mine complex located in Milton Township. The tributary is located on the Wellston Quadrangle in the southeast portion of section 20. A majority of the tributary has extremely limited access and can only be reached by foot travel. Lake Latrobe has limited access to vehicular traffic. Mead Paper Company in

Chillicothe, Ohio owns most of the property surrounding the tributary. The individual in charge of the abandoned mine lands for Mead Paper Company is Steve Mathy (740-772-3472).

Site Description: Tributary K enters the Flint Run mainstem below the Broken Aro investigation site and consists of a western branch and an eastern branch. The western branch has its origin in Lake Latrobe located within the Broken Aro strip-mine complex. Lake Latrobe is a large strip-pit lake supported by a mine-tailings dam. Discharge from the lake infiltrates through the tailings material of the dam and discharges at the base of the dam. A large amount of toxic mine spoil lines the perimeter of the lake. It is believed that AMD-products are generated during precipitation events as runoff interacts with the toxic mine spoil surrounding the lake. Once the AMD-products are generated they are stored in the lake and released over time at the base of the dam. It is also proposed that water infiltrating the mine-tailings dam degrades as it infiltrates through toxic mine spoil. The eastern branch of tributary K also has its origin in the Broken Aro strip-mine complex. Drainage in this section consists primarily of runoff and baseflow from the mine site.

Water Quality: Tributary K has exhibited acidity loading ranges of 160 to 250 lb/day and metal loading of 35 to 50 lb/day. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Tributary K is a Little Raccoon Creek priority treatment site and recommendations for treatment will be covered in section 1 under *Proposed Treatment*. It is suggested that a monthly monitoring schedule of filtered group 2 samples be initiated before instituting any treatment programs in order to fully characterize the acidity and metal loading ranges. Sampling sites should include the confluence of tributary K, Lake Latrobe and the western and eastern forks of the mainstem.

Summary of Potential Treatment Sites: Flint Run

Tributary	Recommendation	Site Identification
L	Treatment	Lake Milton Drainage
M	Treatment	Broken Aro Study Site
K	Treatment	Lake Latrobe Drainage

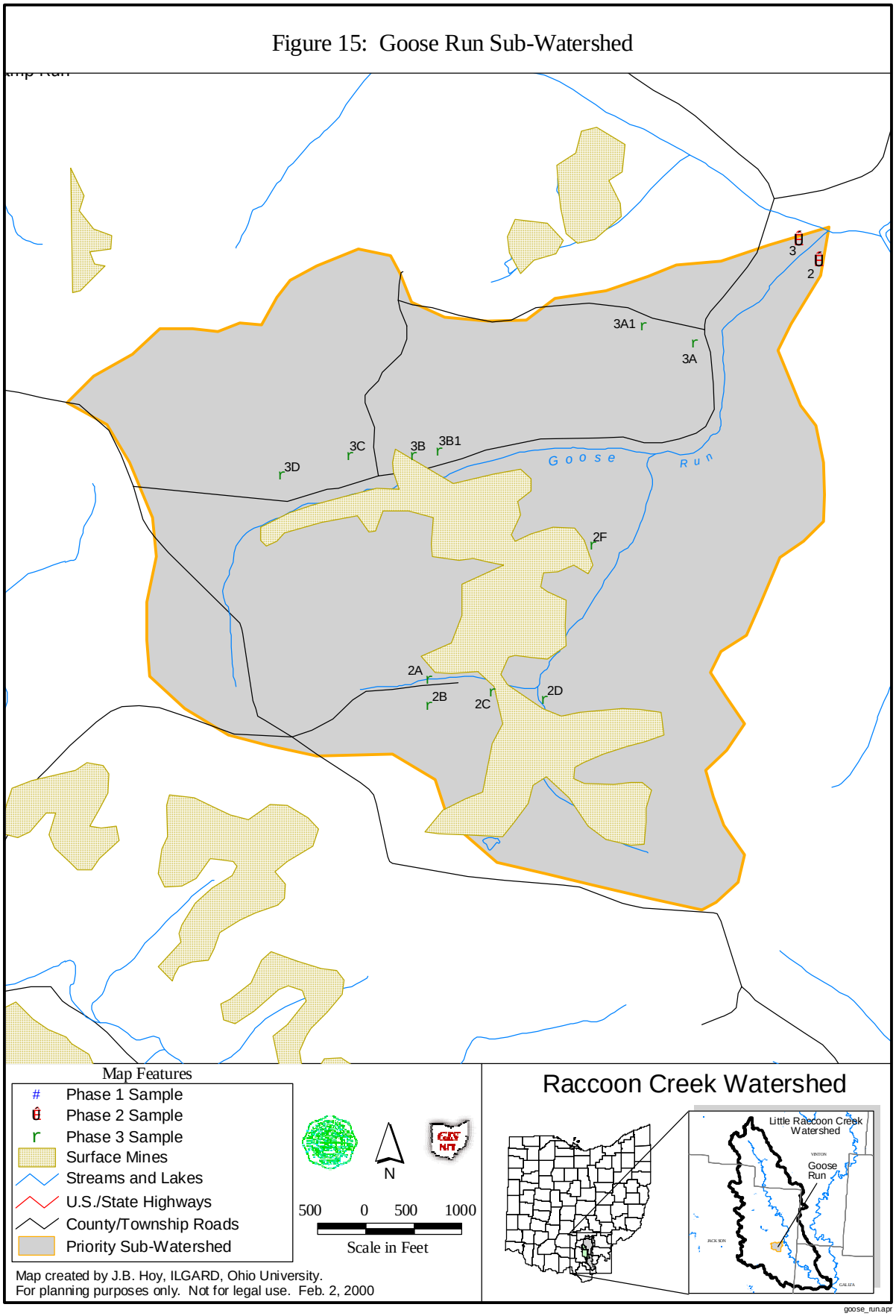
GOOSE RUN

NAME: Goose Run
LOCATION: Bloomfield Township, Jackson County, Ohio
QUADRANGLE: Mulga (S 3, 4, and 10)
DRAINAGE AREA: 1.31 mi^2

Overview

Goose Run sub-watershed (Figure 15) is affected primarily by abandoned deep-mines with some abandoned strip mine drainage and associated unreclaimed coal refuse piles. During Phase I sampling the environmental impact of Goose Run on Little Raccoon Creek was established by comparing the water quality of the main tributaries entering Little Raccoon Creek during a high-flow period (3/24/98-3/25/98) and the primary acid-mine drainage (AMD) affected tributaries during a low-flow period (6/22/99-6/24/99) (Figures 6 and 7; Appendix 1, Table 7). At a high-flow period, Goose Run contributed 4% of the acidity loading and 3% of the metal loading in the Little Raccoon Creek watershed. At a low-flow period, Goose Run contributed 29% of the acidity loading and 26% of the metal loading in the Little Raccoon Creek watershed. Tributaries sampled during the low-flow canvas included Flint Run, Greasy Run, Goose Run, Middleton Run, Mulga Run, and the 124 Seep project area. The confluence of Goose Run has exhibited acidity loading ranges of 300 to 1100 lb/day and metal loading of 50 to 250 lb/day. Based on available water quality data, Goose Run is the fourth largest contributor of acid-mine drainage (AMD) in the Little Raccoon Creek watershed.

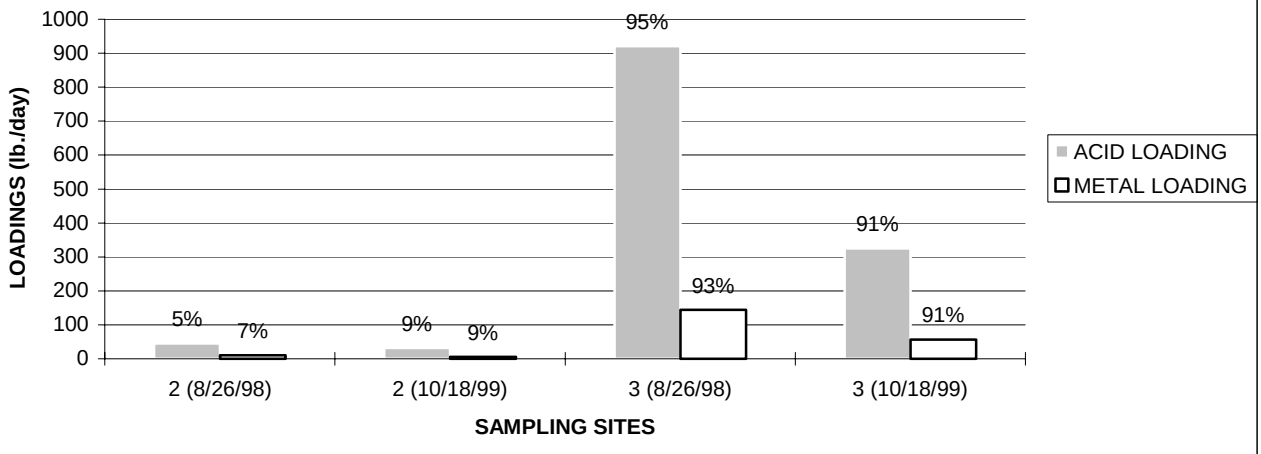
Figure 15: Goose Run Sub-Watershed



Phase II water sampling occurred on 8/26/98 and again on 10/18/99, recording low-flow conditions (Figure 16). The purpose of this second phase of water sampling is to determine which tributaries entering the Goose Run mainstem contribute a significant amount of AMD. During each canvas, it was determined that tributaries 2 and 3 contributed significant AMD. Tributary 2 contributed 5% of the acidity loading and 7% of the metal loading in Goose Run during August of 1998 and 9% of the acidity loading and 9% of the metal loading at a low-flow period during October of 1999. Tributary 2 has exhibited acidity loading ranges of 30 to 45 lb/day and metal loading of 5 to 10 lb/day. Tributary 3 contributed 95% of the acidity loading and 93% of the metal loading in Goose Run during August of 1998 and 91% of the acidity loading and 91% of the metal loading at a low-flow period during October of 1999. Tributary 3 has exhibited acidity loading ranges of 330 to 920 lb/day and metal loading of 60 to 150 lb/day. Based on available water quality data, tributary 3 is the largest contributor of AMD in the Goose Run sub-watershed followed by tributary 2.

Phase III water sampling occurred between 10/18/99 and 10/20/99 to locate point sources for AMD-generation in each of the affected tributaries. It is important to note that this phase of sampling does not include a high- and low-flow sample. In tributary 2, site 2F was producing 62% of the acidity loading and 74% of the metal loading. This was followed by site 2D which was producing 23% of the acidity loading and 33% of the metal loading in tributary 2.

Figure 16: Acidity and Metal Loading into Goose Run from All Sources (8/26/98, 10/18/99)



In tributary 3, site 3B was producing 92% of the acidity loading and 93% of the metal loading. Based on available water quality data, site 3B is the largest contributor of AMD in the Goose Run sub-watershed followed by site 2F and a host of low-priority sites. These sources are described in more detail in the following sections.

2A, 2B, and 2C- Headwaters Of Tributary 2

Location/Access: The headwaters of tributary 2 are located on the Mead reclamation site south of Goose Run Road in Bloomfield Township. These sites are located on the Mulga Quadrangle in the north-central portion of section 10. The Mead reclamation site is easily accessible by vehicle and foot travel. A locked gate secures the access road near Goose Run Road. Permission to access the Mead reclamation site should be directed to Mitch Farley at the Ohio Department of Natural Resources in Jackson, Ohio (740-286-6411). The Mead Paper Company in Chillicothe, Ohio owns the property. The individual in charge of the abandoned mine lands for Mead Paper Company is Steve Mathy (740-772-3472).

Site Description: There are 3 sites associated with the headwaters of tributary 2 including sites 2A, 2B and 2C. These sites are associated with AMD-drainage from the Mead reclamation site. The Mead property was formerly a coal strip mine and was reclaimed by the Ohio Department of Natural Resources. Reclamation activities included grading, capping the mine spoil with BYPRO® and grass seeding. Site 2A is a large area of diffuse seeps in the southwest section of the Mead reclamation area. This large wooded drainage apparently was surface-mined and unreclaimed. The confluence of the tributary is located near an abandoned hauling road that connects with the Pattonsville Township Road. Site 2B is associated with an abandoned deep-mine which is not included on the USGS Abandoned Underground Mine map series. The site is located northwest of the high wall on the Mead reclamation site. Site 2C is a small seep draining alongside the Mead reclamation access road near the high wall. This site is believed to be receiving drainage from the Mead Reclamation site.

Water Quality: Site 2A has exhibited acidity loading of 1 lb/day and less than 1 lb/day of metal loading. Site 2B has exhibited acidity loading of 1 lb/day and less than 1 lb/day of metal

loading. Site 2C has exhibited acidity loading of 10 lb/day and metal loading of 2 lb/day. Sites 2A, 2B, and 2C are believed to be low-priority sites that have not been fully characterized in terms of high- and low-flow chemical loadings.

Recommendation: Continuous monitoring should be done for the sites in the headwaters of tributary 2 to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for these sites may underrate the impact of these sites as significant point sources. It is recommended that monitoring begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact these sites have upon the sub-watershed. It is recommended that water sampling include sites 2A, 2B, and 2C.

2D - Pattonsville Church Drainage

Location/Access: Site 2D is a part of the Mead reclamation site south of Goose Run Road in Bloomfield Township. Site 2D is located at the confluence of a large drainage valley at the northeast end of the Mead reclamation site. The site is located on the Mulga Quadrangle in the northeast portion of section 10. The reclamation site is easily accessible by vehicle and foot travel. A locked gate secures the access road near Goose Run Road. Permission to access the Mead reclamation site should be directed to Mitch Farley at the Ohio Department of Natural Resources in Jackson, Ohio (740-286-6411). The Mead Paper Company in Chillicothe, Ohio owns the property. The individual in charge of the abandoned mine lands for Mead Paper Company is Steve Mathy (740-772-3472).

Site Description: Site 2D is associated with AMD-drainage from the northeast section of the Mead reclamation site. The Mead property was formerly a coal strip mine and was reclaimed by the Ohio Department of Natural Resources. Reclamation activities included grading, capping the mine spoil with BYPRO® and grass seeding. The site consists of a number of diffuse seeps along the southern bank, which drain into the stream above site 2D. Unaffected base flow from the surrounding watershed is believed to be mixing with and diluting the AMD-influx. It is believed

that AMD-generation at the site is due to the reestablishment of a water table within the mine spoil which discharges into nearby streams as base flow.

Water Quality: Site 2D has exhibited acidity loading of 13 lb/day and metal loading of 3 lb/day. Site 2D is believed to be the second largest AMD- producer in tributary 2. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 2D to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed. Sampling should include site 2D and a site up-stream which is not impacted by AMD-drainage.

2F - Mead Reclamation Seep

Location/Access: Site 2F is a part of the Mead reclamation site south of Goose Run Road in Bloomfield Township. The site is located on the Mulga Quadrangle in the east-central portion of section 3. The reclamation site is easily accessible by vehicle and foot travel. A locked gate secures the access road near Goose Run Road. Permission to access the reclamation site should be directed to Mitch Farley at the Ohio Department of Natural Resources in Jackson, Ohio (740-286-6411). The Mead Paper Company in Chillicothe, Ohio owns the property. The individual in charge of the abandoned mine lands for Mead Paper Company is Steve Mathy (740-772-3472).

Site Description: Site 2F is a Mead reclamation seep piped with corrugated PVC down the valley from the gas pipeline and the Ohio State University botany test plot. The Mead property was formerly a coal strip mine and was reclaimed by the Ohio Department of Natural Resources. Reclamation activities included grading, capping the mine spoil with BYPRO® and grass seeding. It is believed that AMD- generation at the site is due to the reestablishment of a steep sloping water table within the mine spoil which discharges at site 2F.

Water Quality: Site 2F has exhibited acidity loading of 24 lb/day and metal loading of 10 lb/day. Site 2F is believed to be the largest AMD producer in tributary 2. This site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Site 2F is a Little Raccoon Creek priority treatment site and recommendations for treatment will be covered in section 1 under *Proposed Treatment*. It is suggested that a monthly monitoring schedule of filtered Group II samples be initiated before instituting any treatment programs in order to fully characterize a variety of acidity and metal loading ranges. Sampling sites should include the confluence of the stream draining site 2F.

3A - Deep-Mine JKN-137

Location/Access: Site 3A is located just north of Goose Run Road along an abandoned hauling road in Bloomfield Township. The stream draining site 3A is one of the last streams to merge with tributary 3 before the confluence of Tarr Camp Run. The site is located on the Mulga Quadrangle in the northeast portion of section 3. The site is accessible by foot travel only.

Site Description: This site is an abandoned deep-mine site and most likely associated with deep-mine JKN-137. Site 3A is located upstream from a large waterfall created from a massive sandstone unit underlying the stream bottom at site 3A. The site consists of a small area of diffuse seeps which discharge from soil piping on the west bank of the stream just above the massive sandstone unit. It is believed that a hydraulic connection may exist between the diffuse seeps and deep-mine JKN-137. Deep-mine JKN-137 is located just west of site 3A.

Water Quality: Site 3A has exhibited acidity loading of 2 lb/day and less than 1 lb/day of metal loading. Site 3A is believed to be a low-priority site, but has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 3A to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality

information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. Sampling sites should include the confluence of the tributary draining site 3A and an upstream site to determine if additional seeps exist.

Treatment for this site has been recommended via an open limestone channel, pending the results of additional sampling. While concentrations are low in Tarr Camp Creek, seasonal loadings of acidity are quite high.

3B - Goose Run Road Seep

Location/Access: Site 3B is located on the north side of Goose Run Road just east of J.C. Cobb Road in Bloomfield Township. An abandoned hauling road runs through the site. The site is located on the Mulga Quadrangle in the west-central portion of section 3. The site is easily accessible by vehicle and foot travel. Cliff Denny, a local resident living on J.C. Cobb Road, owns the property.

Site Description: Sites3B and 3B1 are abandoned deep-mine sites associated with deep-mine JKN-138 near the confluence of the stream and abandoned deep-mine JKN-129 farther upstream. The majority of the AMD-discharge is emanating from site 3B1, which is near the confluence of tributary 3B. At site 3B1, there is a large area of unreclaimed mine refuse material and a high-flow seep is discharging from the top of the pile. Local residents describe a mine entrance near the location of the seep although no entrance is visible. Upstream from site 3B1 two open mine voids are visible in this vicinity, but they are not discharging. Local residents refer to these mines as low-yield, house coalmines.

Water Quality: The confluence of tributary 3B has exhibited acidity loading of 230 lb/day and metal loading of 60 lb/day. Site 3B1 has exhibited acidity loading of 330 lb/day and metal loading of 100 lb/day. Most of the AMD generated in tributary 3B appears to come from site 3B1, which apparently is the largest AMD-producer in the Goose Run sub-watershed. However, this site has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Site 3B1 is a Little Raccoon Creek priority treatment site and recommendations for treatment will be covered in section 1 under *Proposed Treatment*. It is suggested that a monthly monitoring schedule of filtered Group II samples be initiated before instituting any treatment programs in order to fully characterize the acidity and metal loading ranges. Sampling sites should include the confluence of the tributary 3B and site 3B1.

3C - J.C. Cobb Rd. Seep

Location/Access: Site 3C is located just west of site 3B at the intersection of Goose Run Road and J.C. Cobb Road in Bloomfield Township. The site is located on the Mulga Quadrangle in the west-central portion of section 3. The site is easily accessible by vehicle and foot travel.

Site Description: This site is an abandoned deep-mine site and is most likely associated with deep-mine JKN-145. The mine entrance is not visible, but a bog area and discharge marks the most probable location of the entrance. The site drains underneath both J.C. Cobb Road and Goose Run Road. No significant mine refuse materials were visible in this drainage.

Water Quality: Site 3C has exhibited acidity loading of 11 lb/day and of 2 lb/day of metal loading. Site 3C is believed to be a low-priority site, but has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 3C to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed.

3D - Deep-Mine Jkn-174

Location/Access: Site 3D is located just west of site 3C near the intersection of Goose Run Road and J.C. Cobb Road in Bloomfield Township. The site is located on the Mulga Quadrangle in the west-central portion of section 3. The site is only accessible by foot travel.

Site Description: This site is an abandoned deep-mine site and is most likely associated with deep-mine JKN-120. There are a number of open mine voids in this drainage, but none were discharging at the time of sampling. Local residents refer to these mines as low-yield, house coal mines. No significant mine spoil were visible in this drainage.

Water Quality: Site 3D has exhibited acidity loading of 7 lb/day and of 2 lb/day of metal loading. Site 3D is believed to be a low-priority site, but has not been fully characterized in terms of high- and low-flow chemical loading.

Recommendation: Continuous monitoring is recommended at site 3D to capture high- and low-flow conditions and identify a range of acidity and metal loadings. The limited water quality information presently available for this site may underrate the impact of the site as a significant point source. Monitoring should begin with a monthly schedule of filtered Group I samples until reasonable high- and low-flow conditions have been identified. At that time, a reassessment can be made of the impact this site has upon the sub-watershed.

Summary of Potential Treatment Sites: Goose Run[4]

Site	Recommendation	Site Identification
2	Monitor	Headwaters Of Tributary 2
2D	Monitor	Pattonsville Church Drainage
2F	Treatment	Mead Reclamation Seep
3A	Monitor	Deep-Mine Jkn-137

[4] Raccoon Creek partners are investigating the possibility of constructing a large passive treatment wetland in Goose Run near its confluence with Little Raccoon Creek. This system could be designed to further polish AMD impacted water quality entering from upstream treatment sites.

Site	Recommendation	Site Identification
3B	Treatment	Goose Run Rd. Seep
3C	Monitor	J.C.Cobb Rd. Seep
3D	Monitor	Deep-Mine Jkn-174

PROPOSED TREATMENT

TREATMENT SELECTION AND COSTS

Treatment sites have been selected according to guidelines in Appendix 3, Tables 1 and 2. Site selection and treatment is summarized in Figure 17.

Figure 17: Treatment Recommendations for Sites in Little Raccoon Creek Watershed

Basin	Site	Highest Acidity	Highest lbs./day	Description	Treatment
Middleton Run	3A	1308	361	Lake Rice	Drain and fill lake Reclaim spoils Add alkalinity (slag lined limestone channels or rock dams and below good water pond outlet)
	5A	312	160	Lake Farleigh	Limestone dam in lake with organic compost behind dam, downstream aerobic wetland
	2	314	187	Trailer/Dog site	Eliminate Lake Rice
	11A	832	19	Strip Mine	Reclaim strip mine and add alkalinity via channels
	3B	975	46	Salem Road Seep	Reclaimed strip mine above road and limestone channel below
Goose Run	3B	1213	230	Large seep on hillside	ALD and SAP on hillside strip bench, limestone channel outlet

Goose Run	2F	88	45	Tiled seep on reclaim	Stepped limestone rock dams
	3C	597	11	Roadside waterfall seep	Limestone channel and splash stack of limestone
	Other			Goose Run Mouth	Wetland
	3A			Tarr Camp Run	Limestone channel
Mulga Run	4	211	333	Stream near Sands Hill	Run through limestone beds, slag addition in upland area ponds, anaerobic wetlands not too large
	14	126	392	Mulga Road driving tour	Rock channels and anaerobic wetland
	6A & B	1092	1202	Sands Hill seep	Slag pond development, divert alkaline seep via rock channel
Flint Run	All	2409	711	Flint Run tailings pile	Eliminate lakes, slag in limestone channels, slag recharge areas, cap refuse

BENEFITS AND COST-EFFECTIVENESS

The benefits of eliminating acid mine drainage problems are difficult to quantify, although attempts have been made. Qualitatively, the benefits are ecological, aesthetic and economic. The economic impacts may be direct or indirect. Indirect benefits include diversity and abundance of fish and game for anglers and hunters, reduced erosion and siltation and consequent reduction of flood risks and downstream sedimentation. Direct economic benefits arise from restoration activities themselves, increased tourism and recreation opportunities and increased property values.

The public has collectively expressed to local officials a desire to clean U.S. streams to make them fishable and swimmable. This has resulted in the Clean Water Act and other laws, the formation of watershed groups and the establishment of the EPA. The evaluation of projects becomes a matter of comparing costs to seek the most cost-effective projects, or those that

prevent the most acidity loading or result in the most miles of healthy stream per dollar invested. The projects in this document are placed in a cost-effectiveness context (Figure 18). Although partnerships formed for stream restoration generally have not calculated their project economics in this way (an exception being the state of Maryland), the data are available and should be analyzed.

Figure 18: Treatment Costs and Cost Effectiveness

Middleton Run	
Site	**Cost**
3A - Lake Rice	
Wetland	$20,000.00
Revegetation	10,000.00
Sediment control	10,000.00
Fill Lake	36,300.00
Earthwork	67,760.00
Resoiling	31,950.00
Slag bedded channels	81,389.00
Slag filters	14,650.00
5B - Lake Farley	
Limestone dike	$90,278.00
Open limestone channels	5,787.00
Wetland	37,037.00
Earthwork	14,520.00
Resoiling	4,792.00
Revegetation	3,000.00
3B	
Open limestone channel	$33,333.00
Resoiling	3,195.00
Revegetation	1,000.00
Subtotal Construction	$464,991.00
Mobilization	46,500.00
Design	76,723.00
Monitoring	18,400.00
Total Project Cost	**$606,614.00**
Goose Run	
Site	**Cost**
3B	
Excavation and limestone basin	$17,834.00
Open limestone channel	1,389.00

Goose Run	
Site	**Cost**
2F	
Limestone splash stack Open limestone channel	$6,111.00 3,189.00
3C	
Limestone rip rap Open limestone channel	$2,315.00 833.00
3A	
Open limestone channel	$9,259.00
Subtotal Construction	$40,750.00
Revegetation	3,000.00
Sediment control	4,000.00
Mobilization	10,663.00
Design	17,223.00
Total Project Cost	**$75,636.00**
Mulga Run	
Site	**Cost**
4	
Slag leach bed (inc. excavation) Wetland	$12,481.00 9,259.00
14	
Open limestone channel Wetland	$48,611.00 10,000.00
6	
Slag leach bed Wetland	$13,669.00 9,259.00
Subtotal	$103,279.00
Revegetation	3,000.00
Resoiling	9,585.00
Sediment control	3,000.00
Mobilization	17,830.00
Design	34,174.00
Monitoring	18,400.00
Wetland Improvement	50,000.00
Total Project Cost	**$239,268.00**
Flint Run	
Site	**Cost**
All	
Cap refuse pile (1.5’ x 140 ac.)	$847,000.00
Paper mill sludge	100,750.00
Revegetation	116,250.00
Fill lakes	187,500.00
Slag bedded channels	329,444.00
Slag filters	131,000.00

Flint Run	
Sediment control	20,000.00
Mobilization	86,597.00
Design	320,000.00
Monitoring	15,840.00
Total Project Cost	**$2,154,381.00**
LRC-HU Estimate Total	**$3,075,899.00**

FUNDING OPPORTUNITIES

There are various existing funding sources, which are dedicated to AMD remediation and others that can be adapted to assist in the restoration of Little Raccoon Creek.

Ohio Division of Mineral Resources

1) Federally Funded Abandoned Mine Land Program: Federal excise taxes on coal are returned to the State of Ohio for reclamation of abandoned mine land sites that adversely affect the publics health and safety.
2) Acid Mine Drainage Set-Aside Program: Up to ten percent of Ohio's federal excise tax monies are set aside for acid mine drainage abatement. Priority is given to leveraging these funds with watershed restoration groups and other government agencies.
3) State Abandoned Mine Land Program: State excise taxes on coal and industrial minerals are dedicated to reclamation projects that improve water quality in impacted streams. Priority is given to leveraging these funds with other partners.

Office of Surface Mining, Reclamation and Enforcement

1) Appalachian Clean Streams Initiative: A line item grant process in which funds are specifically intended for acid mine drainage remediation on a project basis.
2) Direct Grants to Watershed Groups: A grant process for directly funding citizen watershed groups efforts to restore acid mine drainage impacted streams on a project basis.

Environmental Protection Agency

1) EPA Section 319 Non-point Source Grant Program: Funding is available for planning, education and remediation of watershed pollution problems including acid mine drainage.

United States Army Corps of Engineers

1) Section 905b-Water Resource Development Act (86): Recent additions to the Army Corps conventional mission includes a habitat restoration grant program for the completion of feasibility studies and project construction where a Federal interest can be verified. A principal non-Federal sponsor must be identified for this cost-share program.

United States Fish and Wildlife Service

1) Partners for Fish and Wildlife Program: This program assists private landowners by providing technical and financial assistance to establish self-sustaining native habitats.
2) Clean Water Action Plan Fund: The purpose of this fund is to restore streams, riparian areas and wetlands resulting in direct and measurable water quality improvements.

FUTURE MONITORING

PRE-CONSTRUCTION MONITORING

Intensive short-term sampling must be undertaken before design and treatment begins. Sites planned for treatment should be sampled monthly, capturing high and low flows, for one or two years.

POST-CONSTRUCTION MONITORING

Performance of restoration projects must be monitored below treatment sites and/or at confluences with major tributaries, to assess effectiveness.

LONG-TERM WATERSHED MONITORING

The primary goal of the Little Raccoon Creek Project is to achieve warm water habitat designation. A “post-audit” should be conducted every 5-10 years while restoration is underway, depending on how dramatic changes are based on spot checks, and should involve a repeat of the

study done by USGS (USGS, 1999; Appendix 2), namely discharge, field water parameters, IBI and ICI. These parameters provide a measure of the extent to which the overall goal of attaining warm water habitat has been met. For these important long-term samples, ODNR Group II parameters should be analyzed, and should include both filtered and non-filtered samples. Discharge measurements should be made at the time of sampling. In addition a 2-day watershed-wide canvas of all confluence sites should be conducted every five years.

LOW PRIORITY SITES

It is vital to conduct additional monitoring beyond that undertaken in this study to ensure that sites given lower priority in the initial screening in 1998-1999 are not heavier acidity loaders under different hydrological conditions, or as a result of active mining, subsidence, or weathering. Missing an important acidity-loader could undermine restoration efforts. Recommendations for additional monitoring are contained within sections on sub-watersheds. This sampling might be undertaken when restoration efforts focus on a particular sub-watershed. At that time, sites should be sampled quarterly, or as a minimum at high and low flows, for one or two years.

REFERENCES

Childress, C.J.O. 1985. *Classification of Stream Basins in Southeastern Ohio According to Extent of Surface Coal Mining*. U.S. Geological Water-Resources Investigations Report 84-4212, Columbus, Ohio.

Collins, H.R. 1976. *Coal Production in Ohio, 1800-1974*. Ohio Department of Natural Resources, Division of Geological Survey Bulletin 58, p. 129-130.

Federal Water Pollution Control Administration (FWPCA). 1968. *Stream Pollution by Coal Mine Drainage Upper Ohio River Basin*. U.S. Department of the Interior, FWPCA, Ohio Basin Region.

Harstine L.J. 1991. Hydrologic Atlas for Ohio. Ohio Department of Natural Resources, Division of Water Inventory Report No. 28.

Laverty, Brett. Expected completion August 2000. Hydrologic Investigation of a Partially Reclaimed Coal Tailings Pile in Southeastern, Ohio. Thesis, Ohio University.

Ohio Board on Unreclaimed Strip-Mined Lands. 1974. *Land Reborn*. Ohio Department of Natural Resources.

Ohio Department of Natural Resources (ODNR) Division of Water. 1962. *Ohio Hydrologic Atlas*. Ohio Water Plan Inventory Report 13.

Ohio Environmental Protection Agency (OEPA). 1996. *Biological and Water Quality Study of the Raccoon Creek Basin (1995)*, OEPA Technical Report Number MAS/1996-12-7.

Wilson, Karen S. 1985. *Surface-Water Quality of Coal-Mine Lands in Raccoon Creek Basin, Ohio*. U.S. Geological Survey Water-Resources Investigations Report 85-4060. Columbus, Ohio.

Wilson, Karen S. 1988. *Chemical Quality, Benthic Organisms, and Sedimentation in Streams Draining Coal-Mined Lands in Raccoon Creek Basin, Ohio, July 1984 through September 1986*. U.S. Geological Survey Water-Resources Investigations report 88-4022. Columbus, Ohio.

U.S. Department of Agriculture (USDA) and Soil Conservation Service (SCS). 1994. Little Raccoon Creek Watershed Management Plan. Unpublished.

U.S. Environmental Protection Agency (USEPA). 1986. *EPA Rapid Bioassessment Protocols for use in Streams and Rivers; Benthic Macroinvertebrates and Fish.* USEPA, Office of Water Regulations and Standards, Washington, D.C.

SECTION 2: ATTACHMENTS

APPENDIX 1: WATER QUALITY DATA

Table 1: Water Quality Data Collected at Sites in the Little Racoon Creek Basin during current study (1997-2000) and by Wilson (1985).

LRC SAMPLE SITES	SAMPLE ID#	SAMPLE DATE	BASIN	pH	S. COND. umho/cm	DISCHARGE ft^3/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
1			LITTLE RACCOON CR. BELOW LAKE RUPERT													
		*6/15/79		7.30	195.00	3.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		*9/4/79		7.70	220.00	5.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		*11/2/83		7.50	160.00	1.50	5.00	40.46	40.00	0.14	1.13	0.13	1.05	0.24	1.94	46.00
		1/22/97		7.30	186.00	11.60	0.00	0.00	27.00	0.27	16.89	< 0.1	NA	0.33	20.65	50.00
		3/24/98		7.00	141.00	6.65	0.00	0.00	18.00	0.67	24.03	0.40	14.35	0.32	11.48	63.00
	OUBLO28	10/14/98		6.98	492.00	NA	0.00	NA	23.00	0.10	NA	<0.1	NA	0.10	NA	235.00
2			SUGAR RUN													
		*09/15/80		3.80	750.00	4.90	70.00	1850.24	0.00	4.75	125.55	3.47	91.72	6.30	166.52	320.00
		*05/16/81		3.30	895.00	6.30	102.00	3466.37	0.00	6.90	234.49	5.80	197.11	6.95	236.19	430.00
		*07/21/81		3.40	1100.00	3.40	164.00	3007.85	0.00	13.39	245.58	13.89	254.75	11.44	209.82	425.00
		*07/20/82		2.80	1900.00	0.28	228.00	344.37	0.00	7.10	10.72	19.00	28.70	21.00	31.72	900.00
		*11/2/83		3.20	1570.00	0.74	159.00	634.69	0.00	6.80	27.14	10.00	39.92	16.00	63.87	780.00
		1/22/97		7.00	940.00	3.90	0.00	0.00	47.00	3.27	68.79	2.09	43.97	3.12	65.64	256.00
		2/27/98		7.50	1193.00	4.03	0.00	0.00	80.00	0.47	10.21	0.40	8.69	0.81	17.60	502.00
		3/24/98		7.40	543.00	6.65	0.00	0.00	31.00	0.47	16.86	0.10	3.59	0.70	25.12	209.00
	OUBL017	10/13/98		7.49	1994.00	0.25	0.00	0.00	119.00	0.24	0.32	0.20	0.26	0.47	0.62	1133.00
3			LITTLE RACCOON CR.BELOW LAKE ALMA													
		*7/27/81		6.30	360.00	1.70	NA	NA	28.00	0.114	1.05	0.08	0.69	2.59	23.75	135.00
		*7/23/82		6.70	302.00	1.50	NA	NA	25.00	NA	NA	NA	NA	NA	NA	84.00
		1/22/97		7.00	335.00	20.10	0.00	0.00	37.00	0.72	78.07	0.29	31.44	0.92	99.75	87.00
		3/24/98		7.10	193.00	101.92	0.00	0.00	21.00	0.41	225.41	0.30	164.93	0.25	137.44	60.00
	0UBL037	10/14/98		7.18	666.00	NA	0.00	0.00	67.00	0.39	NA	0.30	NA	0.29	NA	300.00
	DMR-LRC-017-BL	6/22/99		6.61	443.00	0.0888	0.00	0.00	63.50	0.48	0.23	1.74	0.83	0.95	0.45	189.00
4			MEADOW RUN													
		1/29/97		7.20	334.00	26.90	0.00	0.00	54.00	0.51	74.00	0.29	42.08	0.38	55.14	60.00
		3/24/98		7.30	343.00	17.25	0.00	0.00	62.00	0.36	33.50	0.50	46.53	0.25	23.26	79.00
5			LITTLE RACCOON CR. AT U.S. ROUTE 32													
		2/12/97		5.70	294.00	NA	0.00	0.00	46.00	0.73	NA	0.58	NA	0.65	NA	67.00
		3/24/98		7.00	232.00	174.55	0.00	0.00	31.00	0.63	593.19	0.30	282.47	0.30	282.47	85.00
	OUBL033	10/14/98		7.33	573.00	NA	0.00	0.00	133.00	0.54	NA	0.10	NA	0.39	NA	137.00
6			MULGA RUN													
		*11/2/83		3.20	1120.00	1.50	243.00	1966.22	0.00	14.00	113.28	18.00	145.65	11.00	89.01	910.00
		1/29/97		6.40	634.00	19.60	0.00	0.00	22.00	6.10	644.94	4.54	480.01	1.94	205.11	301.00
		2/27/98		6.70	849.00	4.51	0.00	0.00	16.00	7.30	177.60	3.30	80.28	2.17	52.79	461.00

* U.S. Geological Survey: Water Resources Investigations Report 85-4060, 1985
** Sampled By BBC ENGINEERING INC.
*** U.S. Geological Survey: Water Resource Investigations Report 88-4022, 1988

LRC SAMPLE SITES	SAMPLE ID#	SAMPLE DATE	BASIN	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
		3/24/98	MULGA RUN	6.50	626.00	7.88	14.00	595.10	0.00	3.50	148.77	2.20	93.52	0.99	42.08	502.00
	OUBL027	10/14/98		3.45	2760.00	2.49	130.00	1746.13	0.00	29.20	392.21	12.00	161.18	11.20	150.44	1850.00
	DMR-LRC-001-BL	4/28/99		4.00	1270.00	7.85	79.70	3374.91	0.00	14.90	630.94	5.90	249.84	3.64	154.14	616.00
	DMR-LRC-018-BL	6/22/99		3.39	2540.00	0.233	126.00	158.37	0.00	3.42	4.30	10.40	13.07	11.30	14.20	1358.00
7			LITTLE RACCOON CR. AT HOLLINSHEAD ROAD													
		2/12/98		5.60	293.00	NA	0.00	0.00	46.00	0.76	NA	0.46	NA	0.67	NA	69.00
		3/24/98		7.00	257.00	NA	0.00	0.00	32.00	0.80	NA	0.60	NA	0.39	NA	99.00
8			MIDDLETON RUN													
		*9/15/80		3.10	1600.00	0.63	437.00	1485.10	0.00	27.60	93.80	36.00	122.34	16.40	55.73	740.00
		*7/21/80		3.00	1200.00	0.92	288.00	1429.27	0.00	12.97	64.37	33.11	164.32	13.14	65.21	530.00
		*7/12/82		2.90	1650.00	0.38	427.00	875.28	0.00	23.00	47.15	41.00	84.04	17.00	34.85	760.00
		*11/2/83		2.90	1660.00	0.43	477.00	1106.42	0.00	22.00	51.03	44.00	102.06	22.00	51.03	890.00
		1/29/97		3.50	727.00	5.30	166.00	4745.89	0.00	7.80	223.00	19.70	563.22	6.60	188.69	293.00
		2/27/98		3.10	1002.00	2.36	217.00	2762.52	0.00	17.40	221.51	26.00	330.99	8.10	103.12	427.00
		3/24/98		3.20	959.00	3.20	219.00	3780.32	0.00	15.80	272.74	23.00	397.02	8.20	141.55	370.00
	OUBL029	10/14/98		3.27	1524.00	0.06	353.00	114.25	0.00	16.60	5.37	49.00	15.86	6.00	1.94	915.00
		6/23/99				DRY										
8A			124 STRIP PIT													
		1/12/98		3.20	888.00	NA	220.00	NA	0.00	32.60	NA	10.00	NA	3.20	NA	374.00
		2/4/98		2.90	1353.00	NA	546.00	NA	0.00	78.00	NA	44.00	NA	8.80	NA	630.00
		3/24/98		3.10	1049.00	0.074	236.00	94.21	0.00	31.20	12.45	17.00	6.79	3.84	1.53	434.00
9			RICH RUN													
		2/12/97		3.60	522.00	3.10	35.00	585.28	0.00	3.00	50.17	3.50	58.53	2.60	43.48	201.00
		3/25/98		5.30	315.00	8.88	0.00	0.00	15.00	0.55	26.35	0.10	4.79	0.84	40.24	202.00
	OUBL030	10/14/98		3.20	1406.00	0.03	229.00	37.06	0.00	10.60	1.72	25.00	4.05	3.50	0.57	800.00
	DMR-LRC-023-BL	6/22/99		3.58	723.00	0.00405	76.40	1.67	0.00	21.40	0.47	2.56	0.06	5.46	0.12	292.00
10			LITTLE RACCOON CR. AT STATE ROUTE 124													
		***7/27/81		6.30	560.00	17.00	10.00	917.03	43.00	6.53	598.82	3.00	275.11	4.41	404.41	235.00
		***7/12/82		6.60	428.00	19.00	0.00	0.00	40.00	NA	NA	NA	NA	NA	NA	140.00
		***11/2/83		5.90	705.00	12.00	30.00	1941.94	14.00	0.61	39.49	0.05	3.24	55.00	3560.23	320.00
		***9/27/84		7.20	810.00	3.60	0.00	0.00	150.00	0.08	1.55	< 0.10	NA	1.60	31.07	200.00
		***10/17/84		7.00	840.00	4.50	0.00	0.00	115.00	0.47	11.41	0.30	7.28	4.40	106.81	250.00
		***4/23/85		6.00	460.00	46.00	9.90	2456.56	8.00	0.29	71.96	0.10	24.81	1.80	446.65	190.00
		***6/18/85		7.10	535.00	23.00	0.00	0.00	39.00	0.21	26.05	0.20	24.81	2.60	322.58	190.00
		***9/24/85		8.00	620.00	4.00	0.00	0.00	130.00	0.09	2.03	NA	NA	0.34	7.34	140.00
		***12/18/85		6.00	350.00	79.00	20.00	8522.97	14.00	0.58	247.17	0.10	42.61	1.30	553.99	250.00
		***4/10/86		6.80	560.00	34.00	0.00	0.00	42.00	0.45	82.53	0.06	11.00	2.50	458.51	200.00

* U.S. Geological Survey: Water Resources Investigations Report 85-4060, 1985
** Sampled By BBC ENGINEERING INC.
*** U.S. Geological Survey: Water Resource Investigations Report 88-4022, 1988

Table 1: Water Quality Data Collected at Sites in the Little Racoon Creek Basin during current study (1997-2000) and by Wilson (1985).

LRC SAMPLE SITES	SAMPLE ID#	SAMPLE DATE	BASIN	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
		***6/25/86		7.40	500.00	9.40	0.00	0.00	75.00	0.09	4.56	0.10	5.07	0.87	44.11	110.00
10			LITTLE RACCOON CR. AT STATE ROUTE 124													
		***8/28/86		6.70	640.00	12.00	0.00	0.00	48.00	0.17	11.00	0.05	3.24	3.10	200.67	240.00
		2/12/97		5.80	356.00	109.05	0.00	0.00	24.00	1.72	1011.78	1.22	717.66	1.23	723.54	99.00
		3/25/98		6.80	287.00	231.13	0.00	0.00	15.00	1.09	1358.99	0.60	748.07	0.74	922.62	117.00
	OUBL024	10/14/98		7.03	941.00	5.85	0.00	0.00	71.00	1.09	34.38	0.40	12.62	1.99	62.77	320.00
	OUBL032	10/15/98		7.03	768.00	5.85	0.00	0.00	79.00	1.22	38.48	0.80	25.23	1.98	62.45	338.00
	DMR-LRC-021-BL	6/22/99		7.07	567.00	6.71	0.00	0.00	134.00	0.725	26.24	2.05	74.20	1.09	39.45	230.00
11			COAL RUN													
		2/5/97		6.90	434.00	2.80	0.00	0.00	54.00	0.53	8.01	1.00	15.10	0.43	6.49	163.00
		3/25/98		7.50	554.00	0.79	0.00	0.00	58.00	0.36	1.53	0.20	0.85	0.36	1.53	263.00
12			FLINT RUN													
		*** 4/23/85		2.60	1650.00	2.40	596.00	7715.99	0.00	64.00	828.56	31.00	401.33	5.30	68.62	830.00
		***6/18/85		2.60	2490.00	1.30	1040.00	7293.07	0.00	150.00	1051.89	44.00	308.55	12.00	84.15	1400.00
		***9/24/85		2.70	3200.00	4.00	1290.00	27834.51	0.00	120.00	2589.26	NA	NA	17.00	366.81	1800.00
		***6/25/86		2.50	2900.00	0.50	997.00	2689.05	0.00	140.00	377.60	62.00	167.22	16.00	43.15	1500.00
		***8/28/86		2.50	2900.00	0.71	1310.00	5017.23	0.00	240.00	919.19	72.00	275.76	17.00	65.11	2100.00
		2/12/97		2.70	1015.00	4.00	187.00	4034.93	0.00	35.20	759.52	10.90	235.19	4.47	96.45	379.00
		3/25/98		3.30	707.00	4.98	137.00	3680.31	0.00	12.70	341.17	4.60	123.57	1.69	45.40	714.00
	OUBL040	10/16/98		2.82	1908.00	0.41	363.00	795.00	0.00	38.70	84.76	20.00	43.80	10.90	23.87	1108.00
	DMR-LRC-024-BL	6/23/99		2.74	1780.00	0.24	365.00	478.45	0.00	28.20	36.96	21.20	27.79	12.50	16.39	1029.00
12a			LITTLE RACCOON CREEK BELOW FLINT RUN CONFLUENCE													
		***10/18/84		4.80	950.00	4.60	30.00	744.41	0.00	0.32	7.94	25.00	620.34	6.00	148.88	380.00
		***4/23/85		5.10	500.00	48.00	30.00	7767.77	2.00	0.45	116.52	10.00	2589.26	3.00	776.78	210.00
		***6/18/85		4.70	587.00	29.00	42.00	6570.24	2.00	0.51	79.78	23.00	3597.99	3.20	500.59	240.00
		***9/24/85		5.60	770.00	4.30	9.90	229.63	7.00	0.36	8.35	15.00	347.93	2.00	46.39	290.00
		***12/18/85		5.40	350.00	95.00	20.00	10249.14	6.00	3.60	1844.85	0.30	153.74	1.80	922.42	160.00
		***6/25/86		7.00	540.00	12.00	0.00	0.00	38.00	0.52	33.66	0.20	12.95	1.50	97.10	160.00
		***8/28/86		5.10	680.00	14.00	21.00	1585.92	4.00	0.46	34.74	0.76	57.40	3.40	256.77	290.00
13			GREASY RUN													
		2/5/97		5.50	275.00	3.30	10.00	178.01	0.00	8.10	144.19	0.90	16.02	0.40	7.12	107.00
		3/24/98		5.90	415.00	0.17	1.00	0.91	0.00	5.40	4.89	0.10	0.09	0.41	0.37	227.00
	OUBL023	10/13/98		6.41	1240.00	0.17	0.00	0.00	24.00	7.60	6.85	<0.1		2.11	1.90	975.00
	DMR-LRC-028-BL	6/23/99		6.16	1220.00	0.05	22.80	6.28	15.00	1.04	0.29	1.77	0.49	2.62	0.72	802.00
14			TARR CAMP													
		*9/16/80		6.20	170.00	0.78	NA	NA	18.00	0.26	1.09	0.20	0.84	0.83	3.49	56.00
		*8/19/81		6.50	210.00	0.26	NA	NA	16.00	0.18	0.25	0.08	0.11	0.42	0.59	52.00

* U.S. Geological Survey: Water Resources Investigations Report 85-4060, 1985
** Sampled By BBC ENGINEERING INC.
*** U.S. Geological Survey: Water Resource Investigations Report 88-4022, 1988

Table 1: Water Quality Data Collected at Sites in the Little Racoon Creek Basin during current study (1997-2000) and by Wilson (1985).

LRC SAMPLE SITES	SAMPLE ID#	SAMPLE DATE	BASIN	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
		*7/22/82	TARR CAMP	6.60	145.00	0.18	NA	NA	5.00	NA	NA	NA	NA	NA	NA	52.00
		2/5/97		5.40	90.00	12.50	10.00	674.29	0.00	1.94	130.81	2.60	175.31	0.52	35.06	29.00
		3/24/98		6.50	103.00	6.05	0.00	0.00	8.00	0.38	12.40	0.80	26.11	0.31	10.12	38.00
	OUBL020	10/13/98		6.30	136.00	0.04	0.00	0.00	12.00	0.61	0.13	0.30	0.06	0.56	0.12	46.00
15			GOOSE RUN													
		*11/1/83		2.80	1840.00	0.28	745.00	1125.25	0.00	94.00	141.98	66.00	99.69	5.40	8.16	1100.00
		2/19/97		3.80	690.00	0.70	125.00	472.00	0.00	25.30	95.53	10.40	39.27	1.16	4.38	277.00
		3/24/98		4.10	445.00	1.05	55.00	311.52	0.00	7.60	43.05	2.90	16.43	0.31	1.76	387.00
	OUBL022	10/13/98		3.04	1647.00	0.13	447.00	315.87	0.00	39.00	27.56	33.00	23.32	2.94	2.08	950.00
	DMR-LRC-030-BL	6/24/99		2.94	1250.00	0.175	288.00	271.87	0.00	14.90	14.07	25.80	24.36	3.16	2.98	234.00
16			LITTLE RACCOON CR. ON KEYSTONE ROAD ABOVE DICKASON RUN CONFLUENCE													
		*11/13/75		3.70	700.00	57.00	94.00	28902.58	1.00	NA	NA	NA	NA	NA	NA	290.00
		*8/19/81		4.20	730.00	14.00	50.00	3776.00	0.00	0.69	52.03	2.47	186.31	3.27	246.95	315.00
		*7/22/82		3.70	745.00	15.00	50.00	4045.71	0.00	11.00	890.06	4.00	323.66	3.60	291.29	320.00
		*11/1/83		3.40	975.00	18.00	179.00	17380.39	0.00	6.70	650.55	8.40	815.62	6.20	602.00	430.00
		2/19/97		6.10	387.00	NA	14.00	NA	15.00	3.12	NA	1.70	NA	1.52	NA	124.00
		3/24/98		6.60	253.00	265.48	0.00	0.00	12.00	1.82	2606.40	1.30	1861.71	0.69	988.14	130.00
17			DICKASON RUN MAINSTREAM ALONG KEYSTONE ROAD													
		2/12/97		5.90	241.00	22.20	3.00	359.26	18.00	0.40	47.90	0.15	17.96	0.66	79.04	62.00
		3/25/98		7.00	217.00	21.88	0.00	0.00	17.00	0.38	44.85	< 0.1		0.57	67.28	69.00
	OUBL021	10/13/98		6.65	658.00	0.60	0.00	0.00	24.00	0.56	1.80	< 0.1		2.57	8.25	310.00
18			DIXON RUN CONFLUENCE													
		*9/24/80		5.10	770.00	0.84	35.00	158.59	3.00	3.70	16.77	0.72	3.26	5.40	24.47	410.00
		8/19/81		4.30	800.00	0.31	65.00	108.69	NA	1.58	2.64	3.60	6.02	5.21	8.71	430.00
		7/22/82		3.50	925.00	0.26	65.00	91.16	0.00	3.40	4.77	4.90	6.87	6.00	8.42	430.00
		2/12/97		5.40	446.00	3.30	12.00	213.61	16.00	4.32	76.90	1.48	26.35	1.91	34.00	170.00
		3/25/98		6.30	406.00	4.11	0.00	0.00	12.00	4.29	95.11	1.30	28.82	1.72	38.13	195.00
	OUBL034	10/14/98		6.27	678.00	0.34	0.00	0.00	20.00	3.02	5.46	0.10	0.18	4.11	7.43	320.00
19			DICKASON RUN BELOW DIXON RUN CONFLUENCE													
		2/12/97		5.30	269.00	27.80	0.00	0.00	16.00	1.03	154.46	0.36	53.99	0.77	115.47	81.00
		3/25/98		6.80	248.00	27.08	0.00	0.00	10.00	0.94	137.32	0.30	43.83	0.60	87.65	90.00
	OUBL026	10/14/98		6.38	713.00	0.40	0.00	0.00	24.00	1.72	3.73	0.20	0.43	2.93	6.35	305.00
20			KYGER RUN													

* U.S. Geological Survey: Water Resources Investigations Report 85-4060, 1985
** Sampled By BBC ENGINEERING INC.
*** U.S. Geological Survey: Water Resource Investigations Report 88-4022, 1988

Table 1: Water Quality Data Collected at Sites in the Little Racoon Creek Basin during current study (1997-2000) and by Wilson (1985).

LRC SAMPLE SITES	SAMPLE ID#	SAMPLE DATE	BASIN	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	MnLOADING lbs/DAY	SULFATE mg/l
20		2/12/97	KYGER RUN	5.40	129.00	4.60	0.00	0.00	18.00	0.38	9.43	0.23	5.71	0.29	7.20	34.00
		3/25/98		6.90	120.00	5.60	0.00	0.00	12.00	0.39	11.78	0.40	12.08	0.22	6.65	36.00
	OUBL025	10/14/98		7.29	247.00	0.074	0.00	0.00	59.00	0.13	0.05	0.20	0.08	0.03	0.01	66.00
21			DICKASON RUN CONFLUENCE													
		*8/9/81		6.10	460.00	0.91	20.00	98.18	16.00	0.23	1.11	0.08	0.37	2.07	10.16	185.00
		*7/22/82		6.20	480.00	0.98	10.00	52.86	10.00	NA	NA	NA	NA	NA	NA	180.00
		*11/1/83		5.10	595.00	3.10	60.00	1003.34	4.00	0.96	16.05	20.00	334.45	55.00	919.73	300.00
		2/12/97		6.40	266.00	27.00	11.00	1602.10	13.00	0.93	135.45	0.40	58.26	0.90	131.08	87.00
		3/25/98		6.90	233.00	37.07	0.00	0.00	12.00	0.87	173.97	0.20	39.99	0.61	121.98	75.00
	OUBL039	10/15/98		6.63	635.00	0.38	0.00	0.00	12.00	0.86	1.76	0.10	0.20	2.47	5.06	328.00
22			LITTLE RACCOON CR.ON KEYSTONE ROAD BEFORE SPRING RUN													
		2/19/97		6.40	359.00	NA	13.00	0.00	15.00	2.41	NA	1.29	NA	1.35	NA	133.00
23			CONFLUENCE OF LITTLE RACCOON CR. AT INTERSECTION OF STATE ROUTE 325 AND WOODS MILL ROAD													
		*9/24/80		5.00	460.00	87.00	25.00	11732.57	2.00	0.180	84.47	1.45	680.49	3.09	1450.15	191.00
		*8/20/81		5.30	620.00	19.00	45.00	4612.11	5.00	0.192	19.68	3.08	315.67	3.22	330.02	275.00
		*8/24/82		4.80	640.00	13.00	30.00	2103.77	0.00	0.084	5.89	1.90	133.24	3.80	266.48	270.00
		*11/2/83		3.50	870.00	28.00	124.00	18728.96	0.00	2.900	438.02	0.04	6.04	4.70	709.89	350.00
		***9/26/84		4.20	770.00	1.40	20.00	151.04	0.00	0.150	1.13	1.00	7.55	2.90	21.90	280.00
		***10/17/84		3.50	975.00	3.50	89.00	1680.32	0.00	0.910	17.18	11.00	207.68	6.00	113.28	410.00
		***11/14/84		4.10	570.00	73.00	40.00	15751.31	0.00	2.500	984.46	3.70	1457.00	2.80	1102.59	230.00
		***12/18/84		4.30	445.00	105.00	30.00	16992.00	0.00	0.340	192.58	3.10	1755.84	2.10	1189.44	180.00
		***3/12/85		4.70	350.00	720.00	30.00	116516.57	3.00	0.900	3495.50	2.70	10486.49	1.50	5825.83	130.00
		***4/17/85		4.20	405.00	171.00	40.00	36896.91	0.00	0.600	553.45	3.10	2859.51	1.40	1291.39	180.00
		***5/14/85		3.90	540.00	81.00	50.00	21846.86	0.00	0.490	214.10	5.00	2184.69	2.60	1136.04	230.00
		***6/18/85		4.20	532.00	42.00	40.00	9062.40	0.00	0.190	43.05	2.50	566.40	2.90	657.02	210.00
		***9/23/85		6.90	610.00	5.80	0.00	0.00	16.00	0.020	0.63	< 0.1	NA	1.30	40.67	240.00
		***9/30/85		6.10	595.00	8.70	11.00	516.23	8.00	0.150	7.04	0.30	14.08	2.00	93.86	240.00
		***10/17/85		5.00	750.00	12.00	18.00	1165.17	2.00	0.020	1.29	1.40	90.62	2.90	187.72	320.00
		***11/19/85		5.40	295.00	488.00	17.00	44750.99	3.00	1.100	2895.65	0.10	263.24	1.00	2632.41	110.00
		***4/8/86		6.60	390.00	87.00	0.00	0.00	6.00	0.160	75.09	0.03	14.08	1.60	750.88	160.00
		***6/25/86		6.80	455.00	4.90	0.00	0.00	19.00	0.150	3.96	0.02	0.53	2.00	52.86	160.00
		***8/27/86		6.70	680.00	9.40	0.00	0.00	17.00	0.040	2.03	0.03	1.52	3.50	177.47	280.00
		2/19/97		6.50	333.00	NA	12.00	NA	15.00	2.70	NA	0.93	NA	1.24	NA	116.00
		3/24/98		4.80	183.00	402.34	2.00	4340.67	0.00	1.01	2192.04	1.10	2387.37	0.46	998.35	60.00

* U.S. Geological Survey: Water Resources Investigations Report 85-4060, 1985
** Sampled By BBC ENGINEERING INC.
*** U.S. Geological Survey: Water Resource Investigations Report 88-4022, 1988

Table 1: Water Quality Data Collected at Sites in the Little Racoon Creek Basin during current study (1997-2000) and by Wilson (1985).

LRC SAMPLE SITES	SAMPLE ID#	SAMPLE DATE	BASIN	pH	S. COND. umho/cm	DISCHARGE ft^3/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	MnLOADING lbs/DAY	SULFATE mg/l
	OUBL031	10/14/98		7.18	969.00	9.49	0.00	0.00	40.00	0.40	20.48	<0.1	NA	0.71	36.35	460.00
	OUBL041	10/17/98		7.16	1027.00	9.49	0.00	0.00	44.00	0.41	20.99	0.30	15.36	0.49	25.08	565.00
	DMR-LRC-029-BL	6/24/99		7.16	581.00	7.76	0.00	0.00	69.20	0.46	19.30	2.39	100.04	0.379	15.86	128.00
24			RACCOON CREEK AT ADAMSVILLE													
		2/19/97		6.80	289.00	200.00	4.00	4315.43	17.00	1.10	1186.74	0.71	765.99	0.99	1068.07	88.00
25			124 SEEP													
		2/12/97		3.20	579.00	2.40	51.00	660.26	0.00	3.37	43.63	4.51	58.39	2.84	36.77	205.00
		1/12/98		2.70	3260.00	NA	2263.00	NA	0.00	470.00	NA	2200.00	NA	10.10	NA	2715.00
		2/27/98		3.10	1014.00	0.158	198.00	168.75	0.00	22.60	19.26	14.00	11.93	2.97	2.53	401.00
		3/25/98		3.20	959.00	0.34	173.00	321.02	0.00	26.00	48.25	15.00	27.83	3.82	7.09	307.00
	DMR-LRC-022-BL	6/22/99		2.53	1900.00	0.0102	421.00	23.16	0.00	26.20	1.44	31.40	1.73	8.48	0.47	762.00
26			DEER CREEK													
		2/19/97		6.60	131.00	NA	0.00	0.00	23.00	0.32	NA	0.23	NA	0.25	NA	25.00
		3/24/98		7.00	114.00	6.56	0.00	0.00	21.00	0.38	13.45	<0.1		0.19	6.72	27.00
	OUBL038	10/15/98		7.12	206.00	0.005	0.00	0.00	79.00	3.37	0.09	0.10	0.003	1.79	0.05	38.00
27			LITTLE RACCOON CR. ABOVE BUFFER RUN CONFLUENCE													
		**2/9/96		6.10	473.00	102.30	0.00	0.00	15.00	4.56	2516.37	2.58	1423.74	2.13	1175.41	60.00
28			BUFFER RUN													
		*9/16/80		3.10	2300.00	0.69	596.00	2218.35	0.00	133.00	495.03	29.60	110.17	12.80	47.64	1280.00
		*8/19/81		3.00	2000.00	0.30	571.00	924.04	0.00	88.39	143.04	28.04	45.38	11.71	18.95	1340.00
		*7/12/82		2.50	2550.00	0.40	695.00	1499.61	0.00	160.00	345.23	37.00	79.84	13.00	28.05	1400.00
		*11/2/83		2.70	2660.00	0.35	993.00	1874.78	0.00	140.00	264.32	60.00	113.28	17.00	32.10	1900.00
		**2/9/96		3.50	1332.00	3.70	202.00	4031.69	0.00	61.00	1217.49	16.00	319.34	3.84	76.64	305.00
		3/25/98		3.20	914.00	2.81	171.00	2592.01	0.00	22.50	341.05	6.80	103.07	1.03	15.61	294.00
	DMR-LRC-027-BL	6/23/99		2.88	2100.00	0.169	300.00	273.49	0.00	8.84	8.06	25.10	22.88	8.34	7.60	238.00
	DMR-LRC-032-BL	8/9/99		2.69	2660.00	0.169	321.00	292.63	0.00	14.20	12.95	26.90	24.52	8.58	7.82	1202.00
29			LITTLE RACCOON CR. BELOW BUFFER RUN CONFLUENCE													
		**2/9/96		6.80	491.00	107.20	0.00	0.00	19.00	6.50	3758.74	4.09	2365.11	2.19	1266.41	110.00
		3/25/98		6.40	269.00	NA	0.00	0.00	8.00	1.22	NA	0.60	NA	0.49	NA	144.00
30			LITTLE RACCOON CR. BELOW GOOSE RUN CONFLUENCE													
		***9/27/84		3.60	845.00	4.30	35.00	811.84	0.00	0.36	8.35	1.30	30.15	3.40	78.86	310.00
		***10/17/84		3.30	1060.00	6.40	104.00	3590.44	0.00	1.30	44.88	6.10	210.59	5.30	182.97	420.00
		***11/14/84		3.60	740.00	43.00	74.00	17164.62	0.00	5.90	1368.53	6.20	1438.12	3.50	811.84	270.00

* U.S. Geological Survey: Water Resources Investigations Report 85-4060, 1985
** Sampled By BBC ENGINEERING INC.
*** U.S. Geological Survey: Water Resource Investigations Report 88-4022, 1988

Table 1: Water Quality Data Collected at Sites in the Little Racoon Creek Basin during current study (1997-2000) and by Wilson (1985).

LRC SAMPLE SITES	SAMPLE ID#	SAMPLE DATE	BASIN	pH	S. COND. um/ho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
		***12/19/84		4.10	535.00	76.00	55.00	22548.11	1.00	1.90	778.93	4.30	1762.85	2.80	1147.90	210.00
		***3/13/85		4.50	310.00	518.00	30.00	83827.20	0.00	2.10	5867.90	1.40	3911.94	1.10	3073.66	120.00
		***4/18/85		4.10	465.00	105.00	40.00	22656.00	0.00	1.10	623.04	4.60	2605.44	1.70	962.88	210.00
		***5/14/85		4.20	530.00	54.00	35.00	10195.20	0.00	0.58	168.95	2.30	669.97	2.60	757.36	NA
		***6/18/85		3.90	605.00	3.70	45.00	898.15	0.00	0.71	14.17	2.80	55.88	3.10	61.87	240.00
		***9/24/85		5.10	800.00	3.60	25.00	485.49	3.00	0.14	2.72	2.40	46.61	2.60	50.49	310.00
		***10/16/85		3.80	890.00	3.80	33.00	676.44	0.00	0.82	16.81	2.20	45.10	3.10	63.54	NA
		***11/20/85		5.10	370.00	169.00	27.00	24614.13	2.00	1.80	1640.94	0.40	364.65	1.60	1458.61	140.00
		***4/10/86		5.60	570.00	40.00	13.00	2805.03	4.00	1.20	258.93	0.36	77.68	2.60	561.01	220.00
		***6/25/86		5.70	570.00	8.00	5.00	215.77	3.00	0.50	21.58	0.07	3.02	2.10	90.62	200.00
		***8/28/86		3.60	870.00	14.00	51.00	3851.52	0.00	0.89	67.21	4.50	339.84	4.60	347.39	390.00
30			LITTLE RACCOON CR. BELOW GOOSE RUN CONFLUENCE													
	DMR-LRC-031-BL	6/24/99		6.82	608.00	6.938	0.00	0.00	0.00	0.55	20.55	3.79	141.84	1.12	41.92	746.00
31			JOHNSON RUN													
		10/13/98				DRY										
32			LEW JONES TRIBUTARY													
	OUBL018	10/13/98		6.67	342.00	0.10	0.00	0.00	20.00	0.53	0.30	0.20	0.11	1.23	0.69	145.00
33			KEYSTONE MINE TRIBUTARY													
		10/15/98				DRY										
34			TRIPP RUN													
	OUBL016	10/13/98		7.21	650.00	0.012	0.00	0.00	93.00	0.60	0.04	0.20	0.01	0.69	0.05	248.00
35			SPRING RUN													
	OUBL019	10/13/98		7.27	217.00	0.32	0.00	0.00	71.00	1.20	2.07	0.20	0.35	0.58	1.00	48.00
36			WAINWRIGHT TRIBUTARY													
		10/15/98		7.12	58.00											

* U.S. Geological Survey: Water Resources Investigations Report 85-4060, 1985
** Sampled By BBC ENGINEERING INC.
*** U.S. Geological Survey: Water Resource Investigations Report 88-4022, 1988

Table 2: Water quality Data Collection in the Mulga Run Sub-watershed fo the Little Racoon Creek Basin

MULGA RUN SAMPLE SITES	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTION	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
LRC #6			CONFLUENCE OF MULGA RUN													
		*11/2/83		3.20	1120.00	1.50	243.00	1966.22	0.00	14.00	113.28	18.00	145.65	11.00	89.01	910.00
		1/29/97		6.40	634.00	19.60	0.00	0.00	22.00	6.10	644.94	4.54	480.01	1.94	205.11	301.00
		2/27/98		6.70	849.00	4.51	0.00	0.00	16.00	7.30	177.60	3.30	80.28	2.17	52.79	461.00
	DMR-LRC-09	3/24/98		6.50	626.00	7.88	14.00	595.10	0.00	3.50	148.77	2.20	93.52	0.99	42.08	502.00
	DMR-LRC-33	4/28/98		6.58	711.00	7.47	0.00	0.00	25.00	1.19	47.95	0.40	16.12	1.95	78.58	279.00
	OUBL027	10/14/98		3.45	2760.00	2.49	130.00	1746.13	0.00	29.20	392.21	12.00	161.18	11.20	150.44	1850.00
	DMR-LRC-001 BL	4/28/99		4.00	1270.00	7.01	79.70	3013.77	0.00	14.90	563.43	5.90	223.10	3.64	137.64	616.00
	DMR-LRC-018 BL	6/22/99		3.39	2540.00	0.233	126.00	158.37	0.00	3.42	4.30	10.40	13.07	11.30	14.20	1358.00
	DMR-LRC-037 BL	8/9/99		5.84	2260.00	0.817	31.60	139.27	29.90	4.02	17.72	8.59	37.86	5.92	26.09	1383.00
	DMR-LRC-039 BL	9/27/99		3.25	2140.00	0.169	145.00	132.19	0.00	14.80	13.49	19.90	18.14	9.02	8.22	1490.00
1a			MULGA RUN MAINSTREAM, ABOVE WETLAND													
	DMR-LRC-002 BL	4/28/99		5.91	1200.00	6.840	27.10	999.91	23.40	22.60	833.87	3.43	126.56	2.18	80.44	581.00
	DMR-LRC-020 BL	6/22/99		2.72	3120.00	0.233	485.00	609.58	0.00	57.40	72.14	33.10	41.60	10.50	13.20	1762.00
	DMR-LRC-038 BL	8/9/99		4.73	2520.00	0.426	255.00	586.39	0.00	91.20	209.72	12.50	28.74	9.09	20.90	1803.00
	DMR-LRC-040 BL	9/27/99		2.75	2760.00	0.311	441.00	739.83	0.00	77.70	130.35	36.30	60.90	10.60	17.78	1762.00
3			CONFLUENCE OF TRIBUTARY 3													
	DMR-LRC-34	4/29/98		3.55	655.00	0.55	51.00	151.31	0.00	5.90	17.50	4.50	13.35	2.42	7.18	247.00
		9/29/99				DRY										
3a			MT. CARMEL SEEPS													
	DMR-LRC-044 BL	9/29/99		2.54	2040.00	0.00477	178.00	4.58	0.00	8.83	0.23	12.50	0.32	9.28	0.24	938.00
3b			MT. CARMEL SEEPS													
		9/29/99				DRY										
4			CONFLUENCE OF TRIBUTARY 4													
	DMR-LRC-37	4/29/98		3.05	1331.00	0.293	211.00	333.49	0.00	22.80	36.04	12.00	18.97	4.21	6.65	569.00
		9/29/99				DRY										
4a			HOLLINGSHEAD RD. SEEPS													
		9/29/99				DRY										
4d			HOLLINGSHEAD RD. SEEPS													
	DMR-LRC-042 BL	9/29/99		2.46	3880.00	0.00108	2228.00	12.98	0.00	659.00	3.84	225.00	1.31	12.30	0.07	3169.00
4e			HOLLINGSHEAD RD. SEEPS													
	DMR-LRC-043 BL	9/29/99		2.67	3570.00	0.00462	1838.00	45.81	0.00	622.00	15.50	85.10	2.12	9.00	0.22	3161.00
6			CONFLUENCE OF TRIBUTARY 6													
	DMR-LRC-35	4/29/98		3.00	1607.00	0.289	229.00	357.00	0.00	43.00	67.03	12.00	18.71	3.26	5.08	726.00
	DMR-LRC-050 BL	10/11/99		2.96	3290.00	0.204	1092.00	1201.67	0.00	369.00	406.06	54.50	59.97	7.62	8.39	2083.00

* U.S. Geological Survey: water Resources Investigations Report 85-4060, 1985
** Field Meter

Table 2: Water quality Data Collection in the Mulga Run Sub-watershed fo the Little Racoon Creek Basin

SAMPLE #	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTION	pH	S.COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
6a			LINCOLN PIT SEEPS													
	DMR-LRC-048-BL	10/11/99		2.72	5980.00	0.000498	5976.00	16.05	0.00	2067.00	5.55	445.00	1.20	20.90	0.06	4207.00
6B			LINCOLN PIT SEEPS													
	DMR-LRC-046-BL	10/11/99		2.86	5480.00	0.049	4434.00	1181.56	0.00	1720.00	458.34	302.00	80.48	18.40	4.90	4223.00
6C			SANDS HILL SEDIMENTATION POND													
	DMR-LRC-047-BL	10/11/99		6.18	1080.00	0.092	0.00	0.00	104.00	0.54	0.27	3.41	1.69	0.45	0.22	496.00
6D			ALKALINE SEEP													
	DMR-LRC-045-BL	10/11/99		5.96	2020.00	0.01796	0.00	0.00	384.00	31.70	3.07	1.32	0.13	3.78	0.37	1235.00
6E			DEEP-MINE JKN-38													
	DMR-LRC-049-BL	10/11/99		2.72	2680.00	0.00915	1029.00	50.79	0.00	289.00	14.26	51.90	2.56	4.69	0.23	1926.00
6F			DEEP-MINE JKN-38													
	DMR-LRC-051-BL	10/12/99		2.96	2140.00	0.00494	427.00	11.38	0.00	65.40	1.74	29.50	0.79	5.17	0.14	1161.00
7			MULGA MAINSTREAM, DOWNSTREAM OF SITE 6													
		4/15/98		**6.7	**670											
8			UPSTREAM OF SITE 9													
		4/15/98		**6.54	**295											
9			CONFLUENCE OF TRIBUTARY 9													
	DMR-LRC-041-BL	9/27/99		7.30	2030.00	0.0516	0.00	0.00	198.00	5.07	1.41	7.67	2.13	4.91	1.37	1120.00
	DMR-LRC-054-BL	10/13/99		7.01	2050.00	0.1450	0.00	0.00	189.00	7.06	5.52	8.90	6.96	3.46	2.71	1185.00
9A			DEEP-MINE SEEP AT JAYMAR LIMESTONE													
	DMR-LRC-058-BL	10/13/99		3.12	2500.00	0.00241	588.00	7.64	0.00	276.00	3.59	18.20	0.24	8.32	0.11	1918.00
9B			DEEP-MINE SEEP AT JAYMAR LIMESTONE													
	DMR-LRC-057-BL	10/13/99		4.49	2210.00	0.00218	596.00	7.01	0.00	298.00	3.50	25.70	0.30	14.40	0.17	2124.00
9C			DEEP-MINE SEEP AT JAYMAR LIMESTONE													
	DMR-LRC-055-BL	10/13/99		6.87	2270.00	0.0674	0.00	0.00	261.00	4.14	1.51	8.63	3.14	1.27	0.46	1259.00
9C1			MAINSTREAM IN HEADWATERS OF TRIBUTRAY 9													
	DMR-LRC-056-BL	10/13/99		6.91	2240.00	0.0674	0.00	0.00	262.00	0.046	0.02	9.02	3.28	0.563	0.20	1292.00
10			ALONG U.S. RT.32													
		4/15/98		**7.04	**393											

* U.S. Geological Survey: water Resources Investigations Report 85-4060, 1985
** Field Meter

Table 2: Water quality Data Collection in the Mulga Run Sub-watershed fo the Little Racoon Creek Basin

SAMPLE #	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTION	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
11			WATERLOO COAL LAND DRAINAGE													
		4/15/98		**6.60	**234											
12			RUMPKE LANDFILL DRAINAGE													
		4/15/98		**7.15	**1309											
13			CONFLUENCE OF TRIBUTARY 13													
	DMR-LRC-38	4/29/98		3.03	1265.00	0.181	179.00	174.77	0.00	19.30	18.84	11.00	10.74	3.04	2.97	450.00
	DMR-LRC-053-BL	10/12/99		2.74	2440.00	0.0136	478.00	35.07	0.00	28.20	2.07	37.40	2.74	5.11	0.37	1095.00
13A			DEEP-MINE JKN-206													
	DMR-LRC-052-BL	10/12/99		2.60	3170.00	0.00443	738.00	17.64	0.00	106.00	2.53	36.60	0.87	6.05	0.14	1679.00
14			MULGA ROAD MINE COMPLEX													
	DMR-LRC-36	4/29/98		3.37	962.00	0.562	126.00	381.98	0.00	4.00	12.13	10.00	30.32	4.06	12.31	902.00
		10/13/99				DRY										
15			DEEP-MINE JKN-77													
	DMR-LRC-43	7/14/98		3.88	489.00	0.406	23.00	50.37	0.00	1.57	3.44	4.10	8.98	0.79	1.73	201.00
16			DOWNSTREAM DRAINAGE FROM DEEP-MINE JKN-77													
	DMR-LRC-44	7/14/98		3.05	1128.00	0.0152	271.00	22.22	0.00	16.90	1.39	29.00	2.38	1.66	0.14	328.00

* U.S. Geological Survey: water Resources Investigations Report 85-4060, 1985
** Field Meter

Table 3: Water Quality Data Collected in the Rich Run Sub-watershed of the Little Racoon Creek Basin

SAMPLE #	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTOR	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
LRC 9			CONFLUENCE OF RICH RUN													
		2/12/97		3.60	522.00	3.10	35.00	585.28	0.00	3.00	50.17	3.50	58.53	2.60	43.48	201.00
		3/25/98		5.30	315.00	8.88	0.00	0.00	15.00	0.55	26.35	0.10	4.79	0.84	40.24	202.00
	OUBL030	10/14/98		3.20	1406.00	0.03	229.00	37.06	0.00	10.60	1.72	25.00	4.05	3.50	0.57	800.00
	DMR-LRC-023-BL	6/22/99		3.58	723.00	0.00405	76.40	1.67	0.00	21.40	0.47	2.56	0.06	5.46	0.12	292.00
2			DEEP-MINES JKN 184 AND JKN-181													
		6/20/98		*2.71	*1461											
3			RICH RUN MAINSTREAM NEAR TOP OF VALLEY													
		6/20/98		*5.20	*508											
4			DRAINAGE FROM SANDS HILL COAL CO. AT BRIDGE ON MULGA ROAD													
		6/20/98		*7.05	*531											
5			CONFLUENCE OF TRIBUTARY 5													
		6/20/98		*7.46	*460											
6			CONFLUENCE OF TRIBUTARY 6, NEAR INTERSECTION OF MULGA RD. AND ST. RT. 124													
		6/20/98		*3.65	*607											
7			MAINSTREAM NEAR CHRISTIAN BAPTIST CHURCH													
		6/20/98		*7.22	*295											
8			MAINSTREAM JUST BELOW SITE 9													
		6/20/98		*6.59	*406											
9			DEEP-MINE SEEP JKN-100, DRAINING INTO MAINSTREAM													
		6/20/98		*3.26	*1593											
10			CONFLUENCE OF TRIBUTRAY 10 AT ST. RT. 124 BRIDGE CROSSING													
		6/20/98		*7.44	*364											
11			MAINSTREAM SITE JUST DOWNSTREAM FROM SITE 10													
		6/20/98		*6.57	*440											

* Field Meter Readings

Table 4: Water Quality Data Collected in the 124 Seep Area of the Littl Racoon Creek Basin

SAMPLE #	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTOR	pH	S.COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
LRC #25			CONFLUENCE OF 124 SEEP													
		2/12/97		3.20	579.00	2.40	51.00	660.26	0.00	3.37	43.63	4.51	58.39	2.84	36.77	205.00
		1/12/98		2.70	3260.00	NA	2263.00	NA	0.00	470.00	NA	2200.00	NA	10.10	NA	2715.00
		2/27/98		3.10	1014.00	0.158	198.00	168.75	0.00	22.60	19.26	14.00	11.93	2.97	2.53	401.00
		3/25/98		3.20	959.00	0.34	173.00	321.02	0.00	26.00	48.25	15.00	27.83	3.82	7.09	307.00
	DMR-LRC-022-BL	6/22/99		2.53	1900.00	0.0102	421.00	23.16	0.00	26.20	1.44	31.40	1.73	8.48	0.47	762.00
	DMR-LRC-057	2/22/99		2.68	1060.00	0.134	396.00	286.24	0.00	30.10	21.76	19.30	13.95	4.23	3.06	130.00
	DMR-LRC-O98-BL	11/16/99		2.90	1070.00	0.0287	219.00	33.90	0.00	11.40	1.76	21.60	3.34	7.92	1.23	545.00
2			SOUTH FORK OF MAINSTREAM, ALONG ST.RT.124													
		2/4/98		3.40	1300.00	NA	164.00	NA	0.00	13.50	NA	24.00	NA	13.50	NA	405.00
	DMR-LRC-O98-BL	11/16/99		2.90	1070.00	0.0287	219.00	33.90	0.00	11.40	1.76	21.60	3.34	7.92	1.23	545.00
2A			CULVERT PIPE AT HAUL ROAD													
	DMR-LRC-099-BL	11/16/99		5.74	822.00	0.00714	0.00	0.00	61.40	0.103	0.00	0.781	0.03	1.37	0.05	342.00
2B			CULVERT DRAINING UNDER ST. RT.124													
	DMR-LRC-060	2/22/99		6.60	630.00	XXX	56.50		28.80	0.64		2.05		1.12		272.00
	DMR-LRC-100-BL	11/16/99		3.07	756.00	0.00482	123.00	3.20	0.00	2.62	0.07	14.50	0.38	3.15	0.08	408.00
2C																
	DMR-LRC-104-BL	11/16/99		2.33	2180.00	0.00257	862.00	11.95	0.00	135.00	1.87	56.50	0.78	13.20	0.18	1350.00
3			NORTH FORK OF MAINSTREAM													
		2/4/98		2.70	3600.00	NA	2540.00	NA	0.00	630.00	NA	230.00	NA	12.40	NA	3045.00
		11/16/99				DRY										
3A			BELOW UPPER FORK, NEAR CONFLUENCE													
	DMR-LRC-105-BL	11/16/99		2.19	3670.00	0.000407	2894.00	6.35	0.00	394.00	0.87	268.00	0.59	12.60	0.03	3227.00
3B			RIGHT FORK IN STRIP MINE AREA													
	DMR-LRC-106-BL	11/16/99		2.22	5390.00	0.00109	5313.00	31.24	0.00	1348.00	7.93	359.00	2.11	11.90	0.07	4124.00
4A			SMALL PIT LAKE													
	DMR-LRC-059	2/22/99		6.70	748.00	XXX	64.30	XXX	132.00	0.192	XXX	0.21	XXX	0.125	XXX	349
	DMR-LRC-103-BL	11/16/99		6.20	728.00	XXX	0.00	XXX	159.00	0.099	XXX	2.17	XXX	0.683	XXX	252
4B			LARGE PIT LAKE													
	DMR-LRC-058	2/22/99		5.43	719	XXX	38.4	XXX	7.86	0.609	XXX	0.18	XXX	0.342	XXX	268
	DMR-LRC-101-BL	11/16/99		5.51	705	XXX	15.4	XXX	12.7	0.803	XXX	1.48	XXX	0.499	XXX	349
4C			ADJACENT PIT LAKE													
	DMR-LRC-102-BL	11/16/99		4.33	439	XXX	34.6	XXX	0.00	0.244	XXX	2.32	XXX	1.11	XXX	196

Table 5: Water Quality Data Collected in the Middleton Run Sub-Watershed of the Little Racoon Creek Basin

SAMPLE #	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTOR	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
LRC #8			MIDDLETON RUN CONFLUENCE WITH LRC													
		*9/15/80		3.10	1600.00	0.63	437.00	1485.10	0.00	27.60	93.80	36.00	122.34	16.40	55.73	740.00
		*7/21/80		3.00	1200.00	0.92	288.00	1429.27	0.00	12.97	64.37	33.11	164.32	13.14	65.21	530.00
		*7/12/82		2.90	1650.00	0.38	427.00	875.28	0.00	23.00	47.15	41.00	84.04	17.00	34.85	760.00
		*11/2/83		2.90	1660.00	0.43	477.00	1106.42	0.00	22.00	51.03	44.00	102.06	22.00	51.03	890.00
		01/29/97		3.50	727.00	5.300	166.00	4745.89	0.00	7.80	223.00	19.70	563.22	6.60	188.69	293.00
	DMR LRC 03	02/27/98		3.10	1002.00	2.363	217.00	2766.03	0.00	17.40	221.79	26.00	331.41	8.10	103.25	427.00
	DMR LRC 11	03/24/98		3.20	959.00	3.200	219.00	3780.32	0.00	15.80	272.74	23.00	397.02	8.20	141.55	370.00
	OUBL029	10/14/98		3.27	1524.00	0.060	353.00	114.25	0.00	16.60	5.37	49.00	15.86	6.00	1.94	915.00
	DMR-LRC-087-BL	10/26/99		3.35	1440.00	0.049	265.00	70.04	0.00	2.71	0.72	33.60	8.88	15.80	4.18	798.00
1			ST. RT. 124 STRIP PIT OUTLET													
		07/14/98		7.30	479.00											
						DRY										
2			SALEM RD. SEEP													
	DMR LRC 45	07/15/98		2.93	1342.00	0.122	284.00	186.90	0.00	29.80	19.61	17.00	11.19	5.00	3.29	436.00
	DMR-LRC-075-BL	10/25/99		2.61	1750.00	0.015	314.00	25.92	0.00	22.30	1.84	21.00	1.73	8.40	0.69	651.00
3			CONFLUENCE OF TRIBUTRAY 3													
	DMR LRC 46	07/15/98		2.87	3330.00	0.051	1308.00	360.55	0.00	88.00	24.26	180.00	49.62	48.10	13.26	2589.00
	DMR-LRC-077-BL	10/25/99		3.07	2720.00	0.00881	975.00	46.34	0.00	197.00	9.36	94.40	4.49	46.30	2.20	2264.00
3a			LAKE RICE													
	DMR-LRC-076-BL	10/25/99		2.61	2060.00	XXX	370.00	XXX	0.00	33.70	XXX	18.60	XXX	11.90	XXX	764.00
3b			SALEM RD. SEEP													
	DMR-LRC-077-BL	10/25/99		3.07	2720.00	0.00881	975.00	46.34	0.00	197.00	9.36	94.40	4.49	46.30	2.20	2264.00
4			MIDDLETON RUN MAINSTEM													
		07/15/98		2.94	1349.00											
5			CONFLUENCE OF TRIBUTRAY 5													
	DMR LRC 47	07/15/98		3.42	920.00	0.204	145.00	159.56	0.00	0.67	0.74	22.00	24.21	11.10	12.21	409.00
	DMR-LRC-088-BL	10/26/99		3.39	1380.00	0.00755	312.00	12.71	0.00	0.21	0.01	40.70	1.66	23.60	0.96	812.00
5a			LAKE FARLEY													
	DMR-LRC-078-BL	10/25/99		2.81	1300.00	XXX	294.00	XXX	0.00	5.89	XXX	32.40	XXX	15.20	XXX	555.00

* U.S. Geological Survey: Water resources Investigations Report 85-4060, 1985

Table 5: Water Quality Data Collected in the Middleton Run Sub-Watershed of the Little Racoon Creek Basin

SAMPLE #	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTOR	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
5b			SEEPAGE BELOW LAKE FARLEY													
	DMR-LRC-079-BL	10/25/99		2.70	2080.00	0.011	554.00	31.38	0.00	39.30	2.23	57.90	3.28	36.60	2.07	1367.00
6			HILLSIDE SEEP ALONG St. Rt. 124													
		07/15/98		2.81	1846.00											
						DRY										
7			HILLSIDE SEEP ALONG St. Rt. 124													
	DMR LRC 50	07/21/98		2.68	2240.00	0.0034	798.00	14.64	0.00	123.00	2.26	20.00	0.37	5.20	0.10	1097.00
		10/26/99				DRY										
8																
		07/14/98		5.66	117.00											
9			HIRAM WEST RD. PROJECT													
	DMR LRC 49	07/15/98		3.23	1506.00	0.0342	237.00	43.72	0.00	9.30	1.72	12.00	2.21	11.40	2.10	934.00
	DMR-LRC-080-BL	10/26/99		2.82	2360.00	0.0103	524.00	29.11	0.00	39.80	2.21	49.50	2.75	22.50	1.25	1235.00
9a			LOWER STORM-WATER POND													
	DMR-LRC-082-BL	10/26/99		6.88	1140.00	XXX	0.00	0.00	160.00	0.20	XXX	2.09	XXX	0.73	XXX	418.00
9b			DIFFUSE SEEPS BELOW 9a													
	DMR-LRC-081-BL	10/26/99		2.80	2680.00	0.00155	1018.00	8.51	0.00	259.00	2.17	54.20	0.45	22.90	0.19	1704.00
9c			DIFFUSE SEEPS ABOVE 9a													
	DMR-LRC-084-BL	10/26/99		2.87	2540.00	0.00079	422.00	1.81	0.00	45.30	0.19	33.50	0.14	24.90	0.11	2540.00
9d			LANDFILL DRAINAGE													
	DMR-LRC-083-BL	10/26/99		3.09	2280.00	0.00317	500.00	8.55	0.00	161.00	2.75	21.50	0.37	19.50	0.33	1358.00
10			CONFLUENCE OF TRIBUTRAY 10													
		07/15/98		2.98	1017.00											
	DMR-LRC-085-BL	10/26/99		3.59	1030.00	0.00582	236.00	7.41	0.00	5.06	0.16	35.00	1.10	9.85	0.31	513.00
10a			JUST BELOW POND ON HIRAM WEST Rd.													
		10/26/99		5.89	643.00											
11			CONFLUENCE OF HIRAM WEST RD. DRAINAGE													
	DMR LRC 48	07/15/98		3.25	1108.00	0.0949	20.00	10.24	0.00	6.70	3.43	13.00	6.65	8.80	4.50	557.00
	DMR-LRC-089-BL	10/26/99		3.18	1610.00	0.0157	253.00	21.43	0.00	5.36	0.45	31.00	2.63	14.20	1.20	856.00

* U.S. Geological Survey: Water resources Investigations Report 85-4060, 1985

Table 5: Water Quality Data Collected in the Middleton Run Sub-Watershed of the Little Raccoon Creek Basin

SAMPLE#	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTOR	pH	S COND umhos/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
11a			MIDDLETON RUN DEEP-MINE DRAINAGE													
	DMRLRG086-EL	10/28/99		2.56	268.00	0.004	83.20	1.876	0.00	50.10	1.13	72.30	1.63	12.20	0.28	1202.00

* U.S. Geological Survey. Water resources Investigations Report 85-4060, 1985

Table 6: Water Quality Data Collected in Flint Run Sub-watershed of the Little Racoon Creek Basin

SAMPLE SITE	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTOR	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	MnLOADING lbs/DAY	SULFATE mg/l
A			CONFLUENCE OF FLINT RUN													
		* 4/23/85		2.60	1650.00	2.40	596.00	7715.99	0.00	64.00	828.56	31.00	401.33	5.30	68.62	830.00
		*6/18/85		2.60	2490.00	1.30	1040.00	7293.07	0.00	150.00	1051.89	44.00	308.55	12.00	84.15	1400.00
		*9/24/85		2.70	3200.00	4.00	1290.00	27834.51	0.00	120.00	2589.26	NA	NA	17.00	366.81	1800.00
		*6/25/86		2.50	2900.00	0.50	997.00	2689.05	0.00	140.00	377.60	62.00	167.22	16.00	43.15	1500.00
		*8/28/86		2.50	2900.00	0.71	1310.00	5017.23	0.00	240.00	919.19	72.00	275.76	17.00	65.11	2100.00
		2/12/97		2.70	1015.00	4.00	187.00	4034.93	0.00	35.20	759.52	10.90	235.19	4.47	96.45	379.00
		3/25/98		3.30	707.00	4.98	137.00	3680.31	0.00	12.70	341.17	4.60	123.57	1.69	45.40	714.00
	OUBL-040	10/16/98		2.82	1908.00	0.41	363.00	802.83	0.00	38.70	85.59	20.00	44.23	10.90	24.11	1108.00
	DMR-OUBL-002	7/27/98		3.01	1600.00	0.678	284.00	1038.68	0.00	19.90	72.78	18.00	65.83	10.20	37.30	817.00
	DMR-LRC-010-BL	5/25/99		2.92	1070.00	2.32	177.00	2215.11	0.00	18.80	235.28	10.80	135.16	5.49	68.71	439.00
	DMR-LRC-024-BL	6/23/99		2.74	1780.00	0.24	365.00	472.54	0.00	28.20	36.51	21.20	27.45	12.50	16.18	1029.00
B			SMALL TRIBUTARY CROSSING CATTLE FIELD, JUST UPSTREAM FROM CONFLUEMCE													
		7/27/98				DRY										
	DMR-LRC-003-BL	5/24/99		3.29	780.00	0.14	74.00	55.88	0.00	1.91	1.44	4.75	3.59	9.90	7.48	458.00
C			SMALL TRIBUTARY JUST UPSTREAM FROM CATTLE CROSSING AND JUST BELOW PIPELINE													
	DMR-OUBL-001	7/27/98		5.78	389.00	0.00245	4.00	0.05	0.00	2.54	0.03	0.60	0.01	5.20	0.07	165.00
	DMR-LRC-004-BL	5/24/99		3.13	629.00	0.285	81.10	124.68	0.00	3.74	5.75	8.26	12.70	8.33	12.81	328.00
D			AT THE BEGINNING OF PIPELINE ALONG FENCE ROW													
		7/27/98				DRY										
	DMR-LRC-005-BL	5/24/99		3.38	558.00	0.0832	79.10	35.50	0.00	6.36	2.85	14.20	6.37	5.26	2.36	321.00
E			TRIBUTARY CROSSING PIPELINE													
	DMR-OUBL-003	7/27/98		4.78	106.00	0.0032	2.00	0.03	0.00	0.95	0.02	0.20	0.0035	0.82	0.01	40.00
	DMR-LRC-006-BL	5/24/99		4.30	137.00	0.2270	28.80	35.27	0.00	0.513	0.63	2.99	3.66	0.398	0.49	70.00
F			TRIBUTARY CROSSING UPPER SECTION OF PIPELINE													
		7/27/98				DRY										
	DMR-LRC-007-BL	5/24/99		5.16	153.00	0.11	25.60	15.19	2.78	0.654	0.39	3.17	1.88	0.044	0.03	32.90
G			TRIBUTARY ON SOUTHERN BANK OF FLINT RUN													
	DMR-OUBL-004	7/27/98		4.59	234.00	0.0365	28.00	5.51	0.00	0.24	0.05	4.90	0.96	1.45	0.29	112.00
	DMR-LRC-008	5/24/99		4.87	248.00	0.35	29.50	55.70	2.22	0.659	1.24	4.13	7.80	1.26	2.38	139.00

* U.S. Geological Survey: Water-Resources Investigation Report 88-4022

Table 6: Water Quality Data Collected in Flint Run Sub-watershed of the Little Racoon Creek Basin

SAMPLE SITE	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTOR	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
H			TRIBUTARY AT DIVERGENCE OF PIPELINE AND FLINT RUN MAINSTREAM													
		7/27/98				DRY										
	DMR-LRC-009-BL	5/24/99		3.19	277.00	0.0289	44.00	6.86	0.00	2.90	0.45	4.23	0.66	1.59	0.25	177.00
I			SMALL TRIBUTARY CROSSING UPPER PIPELINE													
		7/27/98				DRY										
	DMR-LRC-011-BL	5/25/99		3.86	144.00	0.04469	28.30	6.82	0.00	0.65	0.16	4.31	1.04	0.87	0.21	90.60
J			SMALL TRIBUTARY DRAINING BELOW HOTHOUSE RIDGE													
	DMR-LRC-012-BL	5/25/99		3.24	805.00	0.03198	88.30	15.23	0.00	1.59	0.27	11.90	2.05	9.77	1.69	323.00
K			TRIBUTARY DRAINING LAKE LATROBE AND BROKEN ARO MINE LANDS													
	DMR-LRC-013-BL	5/25/99		3.09	1090.00	0.38	120.00	245.98	0.00	4.39	9.00	15.30	31.36	6.40	13.12	514.00
	DMR-LRC-096-BL	11/9/99		2.70	1700.00	0.15	200.00	163.99	0.00	10.60	8.69	18.90	15.50	12.80	10.50	971.00
L			OUTLET FOR HOTHOUSE LAKE													
	OUBL-007	7/28/98		3.31	1150.00	0.227	109.00	133.47	0.00	5.50	6.73	5.50	6.73	8.30	10.16	533.00
	OUBL-015	9/28/98		2.99	1624.00	0.205	190.00	210.11	0.00	10.00	11.06	9.10	10.06	11.10	12.27	767.00
	OUBL-047	11/8/98		3.20	1557.00	0.300	184.00	297.76	0.00	12.70	20.55	13.00	21.04	8.40	13.59	770.00
	OUBL-048	11/8/99		3.02	1362.00	0.300	194.00	313.95	0.00	12.80	20.71	14.00	22.66	8.30	13.43	773.00
	OUBL-067	2/14/99		3.10	888.00	1.292	685.00	4774.05	0.00	21.70	151.24	8.81	61.40	4.19	29.20	393.00
	DMR-FR-018-BL	4/25/99		2.94	1390.00	0.642	85.90	297.48	0.00	15.20	52.64	13.30	46.06	5.35	18.53	460.00
	DMR-FR-035-BL	6/15/99		2.64	1750.00	0.270	215.00	313.14	0.00	11.50	16.75	45.70	66.56	7.88	11.48	576.00
	DMR-LRC-O14-BL	5/25/99		2.69	1600.00	0.517	208.00	580.08	0.00	17.40	48.53	15.70	43.78	6.88	19.19	471.00
	DMR-FR-061-BL	8/2/99		2.65	1950.00	0.125	319.00	215.10	0.00	11.20	7.55	16.70	11.26	9.13	6.16	906.00
	DMR-LRC-094-BL	11/9/99		2.90	1550.00	0.333	226.00	405.96	0.00	18.30	32.87	16.20	29.10	9.11	16.36	710.00
L1			LAKE MILTON													
	DMR-LRC-090-BL	11/9/99		3.72	1050.00	XXX	49.60	XXX	0.00	0.598	XXX	6.86	XXX	10.00	XXX	569.00
L2			PIPING UNDERNEATH LAKE MILTON SPOIL DAM													
	DMR-LRC-091-BL	11/9/99		3.43	1080.00	0.213	48.40	55.61	0.00	0.672	0.77	6.95	7.99	10.20	11.72	579.00
L3			HOTHOUSE LAKE													
	DMR-LRC-092-BL	11/9/99		2.89	1550.00	XXX	232.00	XXX	0.00	19.900	XXX	16.60	XXX	9.22	XXX	718.00
L4			TRIBUTRAY DRAINING INTO HOTHOUSE LAKE													
	DMR-LRC-093-BL	11/9/99		2.90	1750.00	0.240	329.00	425.93	0.00	45.000	58.26	23.00	29.78	11.40	14.76	938.00

* U.S. Geological Survey: Water-Resources Investigation Report 88-4022

Table 6: Water Quality Data Collected in Flint Run Sub-watershed of the Little Raccoon Creek Basin

SAMPLE SITE	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTOR	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
L5			LAKE ADAMS DRAINAGE													
	DMR-LRC-097-BL	11/9/99		2.68	3400.00	0.0252	1979.00	269.02	0.00	438.000	59.54	106.00	14.41	23.00	3.13	2996.00
M			TRIBUTARY DRAINING FLINT RUN STUDY SITE													
	CUBL-005	7/28/98		2.80	4420.00	0.0392	2732.00	577.70	0.00	560.00	118.42	37.00	7.82	24.30	5.14	3559.00
	CUBL-014	9/28/98		2.74	4840.00	0.0130	2892.00	202.80	0.00	940.00	65.92	140.00	9.82	31.30	2.19	3961.00
	CUBL-046	11/8/98		3.10	4310.00	0.0240	2168.00	280.68	0.00	920.00	119.11	100.00	12.95	24.40	3.16	3773.00
	CUBL-069	2/14/99		2.89	3430.00	0.1830	1714.00	1691.98	0.00	565.00	557.74	73.00	72.06	17.10	16.88	2634.00
	DMR-FR-017-BL	4/25/99		2.71	4230.00	0.0450	714.00	173.32	0.00	746.00	181.09	108.00	26.22	22.30	5.41	3235.00
	DMR-LRC-015-BL	5/25/99		2.57	4750.00	0.0288	2409.00	374.25	0.00	835.00	129.72	94.80	14.73	22.50	3.50	3285.00
	DMR-FR-037-BL	6/15/99		2.58	5090.00	0.0128	2979.00	205.69	0.00	1063.00	73.40	138.00	9.53	26.30	1.82	4009.00
	DMR-FR-062-BL	8/2/99		2.40	6700.00	0.00214	3973.00	45.86	0.00	1417.00	16.36	171.00	1.97	28.90	0.33	4346.00
	DMR-LRC-095-BL	11/9/99		2.83	4160.00	0.0408	2811.00	618.66	0.00	1027.00	226.03	105.00	23.11	25.10	5.52	3811.00
N			SPRING SITE DRAINING INTO TRIBUTRAY M													
	CUBL-006	7/28/98		2.52	6950.00	0.00605	6189.00	201.98	0.00	1310.00	42.75	43.00	1.40	57.00	1.86	6966.00
		9/28/98				DRY										
		11/8/98				DRY										
	CUBL-068	2/14/99		2.56	3510.00	0.02000	2442.00	263.46	0.00	690.00	74.44	89.30	9.63	28.00	3.02	3038.00
	DMR-FR-04-BL	4/25/99		2.44	4420.00	0.00758	592.00	24.21	0.00	719.00	29.40	175.00	7.16	30.80	1.26	3688.00
	DMR-LRC-016-BL	5/25/99		2.36	3920.00	0.00278	2120.00	31.79	0.00	468.00	7.02	129.00	1.93	22.70	0.34	2667.00
	DMR-FR-036-BL	6/15/99		2.09	7830.00	0.00114	5627.00	34.60	0.00	1231.00	7.57	281.00	1.73	52.80	0.32	4091.00
		8/2/99				DRY										
		11/9/99				DRY										

* U.S. Geological Survey: Water-Resources Investigation Report 88-4022

Table 7: Water Quality Data Collected in the Goose Run Sub-watershed of the Little Racoon Creek Basin

GOOSE RUN SAMPLE SITES	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTOR	pH	S.COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Al mg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
LRC 15			CONFLUENCE OF GOOSE RUN													
		*11/01/83		2.80	1840.00	0.280	745.00	1125.25	0.00	94.00	141.98	66.00	99.69	5.40	8.16	1100.00
		2/19/97		3.80	690.00	0.70	125.00	472.00	0.00	25.30	95.53	10.40	39.27	1.16	4.38	277.00
		3/24/98		4.10	445.00	1.05	55.00	311.52	0.00	7.60	43.05	2.90	16.43	0.31	1.76	387.00
	OUBL008	8/26/98		3.92	514.00	1.545	43.00	358.37	0.00	3.48	29.00	5.70	47.50	1.70	14.17	215.00
	OUBL022	10/13/98		3.04	1647.00	0.13	447.00	315.87	0.00	39.00	27.56	33.00	23.32	2.94	2.08	950.00
	DMR-LRC-030-BL	6/24/99		2.94	1250.00	0.175	288.00	271.87	0.00	14.90	14.07	25.80	24.36	3.16	2.98	234.00
	DMR-LRC-059-BL	10/18/99		3.08	1310.00	0.255	273.00	375.52	0.00	19.70	27.10	23.60	32.46	3.69	5.08	646.00
2			CONFLUENCE OF TRIBUTARY 2													
	OUBL009	8/26/98		3.83	554.00	0.233	36.00	45.25	0.00	1.27	1.60	3.40	4.27	3.38	4.25	238.00
	DMR-LRC-060-BL	10/18/99		3.41	843.00	0.0674	88.20	32.07	0.00	2.50	0.91	8.64	3.14	4.72	1.72	328.00
2A			DIFFUSE SEEPS IN HEADWATERS OF TRIBUTARY 2													
	DMR-LRC-070-BL	10/20/99		4.87	129.00	0.00543	41.80	1.22	1.10	7.46	0.22	2.67	0.08	0.82	0.02	41.20
2B			ABANDONED DEEP-MINE DRAINAGE													
	DMR-LRC-071-BL	10/20/99		3.66	401.00	0.00766	21.20	0.88	0.00	1.34	0.06	2.29	0.09	1.34	0.06	132.00
2C			MEAD ACCESS ROAD SEEP													
	DMR-LRC-069-BL	10/20/99		3.33	687.00	0.0211	89.30	10.16	0.00	4.50	0.51	8.68	0.99	3.35	0.38	270.00
2D			PATTONSVILLE CHURCH DRAINAGE													
	DMR-LRC-072-BL	10/20/99		2.79	1520.00	0.006	401.00	12.98	0.00	81.00	2.62	12.80	0.41	7.77	0.25	611.00
2E			AREA DRAINING NORTH-WEST END OF MEAD RECLAIM													
	DMR-LRC-073-BL	10/20/99		6.20	281.00	0.019	0.33	0.03	56.10	1.31	0.14	3.10	0.32	0.186	0.02	60.10
2F			MEAD RECLAMATION SEEP													
	DMR-LRC-074-BL	10/20/99		4.40	1230.00	0.008	552.00	23.82	0.00	202.00	8.72	25.40	1.10	12.800	0.55	831.00
3			CONFLUENCE OF TRIBUTRAY 3													
		2/19/97		4.90	477.00	0.50	48.00	129.46	0.00	15.40	41.54	3.88	10.46	2.84	7.66	228.00
		3/24/98		4.10	324.00	0.94	29.00	147.05	0.00	6.70	33.97	1.50	7.61	1.20	6.08	160.00
	OUBL010	8/26/98		3.44	1060.00	1.255	136.00	920.70	0.00	8.10	54.84	11.00	74.47	2.22	15.03	467.00
	DMR-LRC-061-BL	10/18/99		3.02	1610.00	0.152	397.00	325.51	0.00	32.00	26.24	33.80	27.71	2.64	2.16	818.00
3A			DEEP-MINE JKN-137													

* U.S. Geological Survey: Water Resources Investigation report 85-4060, 1985

Table 7: Water Quality Data Collected in the Goose Run Sub-watershed of the Little Racoon Creek Basin

GOOSE RUN SAMPLE SITES	SAMPLE ID#	SAMPLE DATE	SITE DESCRIPTOR	pH	S. COND. umho/cm	DISCHARGE ft³/sec.	TOTAL ACIDITY mg/l as CaCO3	ACID LOADING lbs/DAY	TOTAL ALKALINITY mg/l as CaCO3	TOTAL IRON mg/l	IRON LOADING lbs/DAY	TOTAL Almg/l	Al LOADING lbs/DAY	TOTAL Mn mg/l	Mn LOADING lbs/DAY	SULFATE mg/l
3A	DMR-LRC-063-BL	10/19/99	DEEP-MINE JKN-137	7.01	228.00	0.00943	29.80	1.52	2.63	3.92	0.20	1.97	0.10	0.50	0.03	82.30
3B			CONFLUENCE OF GOOSE RUN Rd. SEEP													
	DMR-LRC-065-BL	10/19/99		2.81	2250.00	0.03520	1213.00	230.32	0.00	234.00	44.43	88.40	16.79	1.61	0.31	1704.00
3B1			GOOSE RUN Rd. SEEP													
	DMR-LRC-064-BL	10/19/99		2.69	2990.00	0.0389	1588.00	333.22	0.00	329.00	69.04	136.00	28.54	1.97	0.41	2280.00
3B2			UPSTREAM OF GOOSE RUN Rd. SEEP													
	DMR-LRC-066-BL	10/19/99		3.22	763.00	NO FLOW	140.00		0.00	14.60		12.80		0.71		291.00
3C			J.C.COBB Rd. SEEP													
	DMR-LRC-067-BL	10/19/99		2.67	1910.00	0.00342	597.00	11.01	0.00	44.70	0.82	48.50	0.89	1.64	0.03	881.00
3D			DEEP-MINE JKN-174													
	DMR-LRC-068-BL	10/19/99		5.77	296.00	0.04680	28.30	7.14	9.28	5.65	1.43	2.79	0.70	0.098	0.02	109.00
LRC 14			TARR CAMP CONFLUENCE													
		2/5/97		5.40	90.00	12.50	10.00	674.29	0.00	1.94	130.81	2.60	175.31	0.52	35.06	29.00
		3/24/98		6.50	103.00	6.05	0.00	0.00	8.00	0.38	12.40	0.80	26.11	0.31	10.12	38.00
	OUBL020	10/13/98		6.30	136.00	0.04	0.00	0.00	12.00	0.61	0.13	0.30	0.06	0.56	0.12	46.00
	DMR-LRC-062-BL	10/18/99		6.07	213.00	0.00261	0.00	0.00	36.20	2.49	0.04	2.33	0.03	1.12	0.02	33.80

* U.S. Geological Survey: Water Resources Investigation report 85-4060, 1985

APPENDIX 2: USGS BASELINE BIOLOGICAL DATA

United States Depar

U.S. GEOLOC

USGS
science for a changing world

John S. Tertuliani
Biologist
Ohio District

tertulia@usgs.gov
oh.water.usgs.gov

U.S. Department of the Interior
U.S. Geological Survey
6480 Doubletree Avenue
Columbus OH 43229-1111

614-430-7778
614-430-7777 FAX

Chip Rice
PO Box 494
McArthur, OH 45651

March 28, 2000

Dear Sir:

The fish data and the Index of Biological Integrity (IBI) calculations have been viewed and verified by staff of the Ohio Environmental Protection Agency (OEPA), Division of Surface Water and Planning.

As expected, the differences between my calculations of the IBI and those through OEPA staff, are parallel. The OEPA values differ by 4. The higher value downstream of Dickason Run reflects habitat quality and quantity more than water quality.

The fish data are now complete and ready for your intended use. If you have any questions or comments, please contact me at the above address.

Sincerely,

John Tertuliani

John Tertuliani
Biologist

Enclosure

PROJECT DATA
Results from selected sites in Little Raccoon Creek

Fish community results from selected sites in Little Raccoon Creek, 1999

Fish community surveys were conducted at 2 stream sites in Little Raccoon Creek in 1999. Fish were collected by electrofishing with pulsed-DC current at each stream site. One electrofishing pass was conducted at each reach on the same day. Fish were identified, measured, weighed, and checked for external anomalies such as parasites, lesions, and skeletal deformities. The fish collected were in good health. The only anomaly observed was a blackside darter blinded in one eye. Most individuals were returned to the stream after processing. Additional surface-water and (or) water-quality data for these sites can be found in the continuous-record sections of the Ohio data reports. Family names are in uppercase, scientific names are in italics, and common names are in parentheses. (Each metric is calibrated for drainage area, in square miles; RM = River Mile; -- , unknown value).

Station Name			Little Raccoon Creek above Dickason Run 99 mi2 RM 12.8		Little Raccoon Creek below Dickason Run 127 mi2 RM 12.5	
Latitude	(North)		39°00´43"		39°00´30"	
Longitude	(West)		82°27´06"		82°27´05"	
Collection Date			8/31/99		8/31/99	
FAMILY	SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	BATCH WEIGHT (g)	ABUNDANCE	BATCH WEIGHT (g)
Petromyzontidae	*Lampetra aepyptera*	least brook lamprey	--	--	1	8.3
Cyprinidae	*Notropis stramineus*	sand shiner	--	--	1	1.7
	Pimephales notatus	bluntnose minnow	2	0.5	10	7.1
Catostomidae	*Moxostoma erythrurum*	golden redhorse	--	--	1	7.2
	Hypentelium nigricans	northern hogsucker	3	6.6	6	18.9
	Catostomus commersoni	white sucker	--	--	2	6.0
	Minytrema melanops	spotted sucker	--	--	1	3.7
Esocidae	*Esox americanus vermiculatus*	grass pickerel	--	--	1	17.4
Centrarchidae	*Ambloplites rupestris*	rock bass	1	1.5	--	--
	Micropterus punctulatus	spotted bass	2	6.6	17	36.9
	Lepomis cyanellus	green sunfish	18	109.6	16	100.0
	Lepomis megalotis	longear sunfish	1	29.0	3	206.6
Percidae	*Percina maculata*	blackside darter	5	6.0	10[a]	23.5
	Etheostoma nigrum	johnny darter	5	2.3	4	1.8
NUMBER OF SPECIES			8	--	13	--
TOTAL NUMBER OF FISH			37	--	73	--

IBI RESULTS				
IBI METRIC	SAMPLE VALUE	IBI SCORE	SAMPLE VALUE	IBI SCORE
1. Total number of species	8	1	13	3
2. Number of darter species	2	1	2	1
3. Number of sunfish species	3	3	2	3
4. Number of sucker species	1	1	4	3
5. Number of intolerant species	0	1	0	1
6. Percent tolerant species	56%	1	38%	1
7. Percent omnivores	6%	5	16%	5
8. Percent insectivores	89%	5	58%	5
9. Percent top carnivores	5.6%	5	24.7%	5
10.Relative number of individuals minus tolerants	24	1	68	1
11. Percent simple lithophils	22%	3	27%	3
12. Percent DELT[b] anomalies	0%	5	0%	5
	IBI TOTAL (Modified Iwb)	32 (4.3)		36 (5.9)

[a]One fish with anomaly (blinded in one eye)

[b]Deformities, Eroded Fins, Lesions, and Tumors

United States Department of the Interior

U.S. GEOLOGICAL SURVEY

Chip Rice
PO Box 494
McArthur, OH 45651

March 28, 2000

Dear Sir:

The macroinvertebrate data and the Invertebrate Community Index calculations have been viewed and verified by staff of the Ohio Environmental Protection Agency (OEPA), Division of Surface Water and Planning.

As expected, the differences between my calculations of the ICI and those through OEPA staff, are negligible. The most consistent change is in the Total Number of Taxa, metric 1. This metric is different by one at each station with the exception of Station 5 where it was different by two. The ICI values are different by two for each station except at Station 3. My earlier statements concerning Buffer Run and Mulga Run receive stronger support from the verified set of data. The macroinvertebrate data are now complete and ready for your intended use. The fish data are not verified, yet. You will receive a verified copy as soon as possible.

If you have any questions or comments, please contact me at the above address.

Sincerely,

John Tertuliani

John Tertuliani
Biologist

Enclosure

Table 1. Invertebrate Community Index values and scores for stations 1-6, Little Raccoon Creek, Vinton, Ohio, 1999

[A score of 6, 4, 2, or 0 is assigned to each metric value based on the deviation from reference conditions. Each metric is calibrated for drainage area, in square miles. RM = River Mile]

Metric	Metric value, (ICI score) by station					
	1 below Mulga Run 70 mi^2 RM 24.2	2 below Flint Run 81 mi^2 RM 20.7	3 below Buffer Run 84 mi^2 RM 19.1	4 above Dickason Run 99 mi^2 RM 12.8	5 below Dickason Run 127 mi^2 RM 12.5	6 near Vinton, OH 148 mi^2 RM 3.4
1. Total number of taxa	27 (4)	26 (4)	19 (2)	37 (4)	25 (4)	27 (4)
2. Number of mayfly taxa	0 (0)	0 (0)	0 (0)	4 (2)	1 (0)	6 (4)
3. Number of caddisfly taxa	3 (4)	2 (4)	4 (6)	4 (6)	3 (4)	7 (6)
4. Number of Diptera taxa	13 (2)	15 (4)	10 (2)	21 (6)	15 (4)	11 (2)
5. Percent mayflies	0 % (0)	0 % (0)	0 % (0)	1.6 % (2)	0.8 % (2)	6.8 % (2)
6. Percent caddisflies	52.6 % (6)	45.8 % (6)	9.3 % (4)	7.0 % (2)	0.6 % (2)	11.2 % (4)
7. Percent Tanytarsini midges	<1 % (2)	8 % (2)	10 % (2)	59 % (6)	71 % (6)	54 % (6)
8. Percent other Diptera and non-insect	37 % (4)	42 % (4)	71 % (0)	30 % (4)	26 % (6)	27 % (6)
9. Percent tolerant organisms	7 % (6)	<1 % (6)	0 % (6)	<1 %(6)	0 % (6)	<1 %(6)
10. Qualitative EPT taxa	6 (2)	5 (2)	5 (2)	9 (4)	8 (2)	17 (6)
Invertebrate Community Index	30	30	24	42	34	44

Little Raccoon Creek Water Quality Data

NAME	DATE	TIME	DIS-CHARGE, INST. CUBIC FEET PER SECOND	WATER TEMPER-ATURE WATER (DEG C)	pH (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	OXYGEN DIS-SOLVED (MG/L)	ACIDITY (MG/L AS CACO3)	ALKA-LINITY WAT WH TOT INC FIELD (MG/L AS CACO3)
Station 1. Little Raccoon Creek below Mulga Run	7-27-99	1100	5.51	25.5	7.1	569	4.1	N/A	146
Station 2. Little Raccoon Creek below Flint Run	7-28-99	0900	5.44	24.5	7.0	597	4.7	N/A	91
Station 3. Little Raccoon Creek below Buffer Run	7-28-99	1130	5.40	24.5	7.0	651	5.2	N/A	77
Station 4. Little Raccoon Creek above Dickason Run	7-27-99	1700	6.15	27.0	7.3	764	5.1	N/A	39
Station 5. Little Raccoon Creek below Dickason Run	7-27-99	1430	6.31	25.5	7.3	766	6.3	N/A	29
Station 6. Little Raccoon Creek near Vinton, OH	7-28-99	1330	6.03	26.5	7.4	600	6.4	N/A	59

I. Below are the Qualitative Habitat Evaluation Index (QHEI) values from the USGS 1999 QHEI field sheets and a summary of the corresponding ICI and IBI values.

Sites/Metric	1-below Mulga Run	2- Below Flint Run	3- Below Buffer Run	4- Above Dickason Run	5- Below Dickason Run	6- Near Vinton, Ohio
	RM 24.2	RM20.7	RM19.1	RM12.8	RM12.5	RM3.4
QHEI	62	54	64	48	54	52
ICI	30	30	24	42	34	44
IBI	NA	NA	NA	36	40	NA

II. ICI, IBI, and QHEI values for OEPA (1995) sites that correspond with the USGS 1999 Little Raccoon Creek sites.

	RM 24.5 (below Mulga Run, site 1)	RM 11 (below Dickason, site 5)
ICI*	16	8
IBI*	36	37
QHEI	48	57

*These values are comparable to the USGS 1999 values *only* if methods utilized were similar, site locations were similar, and the same metrics were used in the computation of the ICI and IBI.

III. Ecoregion Biocriteria: Western Allegheny Plateau (WAP). (*from* OEPA 1995).

	WWH	EWH	MWH	LRW-AMD
QHEI	60	75	45	?
ICI	36	46	30	8
IBI- wading & headwater	44	50	24	18

WWH : Warmwater habitat
EWH: Exceptional warmwater habitat
MWH: Modified warmwater habitat
LRW-AMD: Limited resource water – acid mine drainage

APPENDIX 3: TREATMENT SYSTEM SELECTION PARAMETER

Site Location: _____

Notes: _____

PARAMETER LIMITATIONS OF MITIGATION TECHNOLOGIES*

Number of Samplings:		**Design Limits**									
Chemical Physical Parameters	Means, Values, Min/Max (h)	ALD	Aerobic Wetland	Anaerobic Wetland	SAP/ ASP	LSP	RAPS	OLC	Limest. Fines	Dosing Quick Lime/ Limestone	Comments
Flow (gpm)		<500 (b)	(j)	(j)	(j)	<500 (b)	(j)	(a)	*	>4 cfs (m)	
D.O. (mg/l)		<2 (f)	*	>2 (e)	>2	<2 (f)	>2	*	*	*	
Lab pH		<5	>4	>3 (d)	NET ACIDIC	<5	NET ACIDIC	*	NET ACIDIC	*	
Acidity (mg/l)		<300 (g)	NET ALK. (l)	(j)		<300 (g)		*		NET ACIDIC	
Alkal. (mg/l)		*		*		*		*			
Tot. Fe (mg/l)		*	(j)	(j)	*	*	*	*	*	*	
Fe^{+3} (mg/l)		<25	(j)	(j)	*	<25	*	*	*	*	
Fe^{+2} (mg/l)		*	<70 (c)	(j)	*	*	*	*	<100 (k)	<100 (k)	
Mn (mg/l)		*	*	*	*	*	*	*	*	*	
Al (mg/l)		<25	*	*	*	<25	*	*	*	*	
Sulfate (mg/l)		<2000	*	<2000	<2000	<2000	<2000	<2000	<2000	<2000	

*= Not applicable or not available

(a) Based on channel length and width restrictions and req'd contact time. 100% neutralization can be achieved with a 3-hr residence time; 90% with 1-hr

(b) Little experience with flows greater than 500 gpm. Suitability for flows greater than 100 gpm based on low Fe, Mn, and Al levels.

(c) Unless series of aeration unit - wetland cell combinations is provided.

(d) >3 for anaerobic wetland unless limestone is added to the substrate, in which case, pH<3 if OK.

(e) Organic layer strips for DO.

(f) Unless the metals content is very low.

(g) Unless discharge from it will pass through another treatment facility involving alklinity addition.

(h) Does not represent individual treatment locations. Representative of flows discharging from the site (three).

(I) Seep locations only.

(j) Restricted by available area at site.

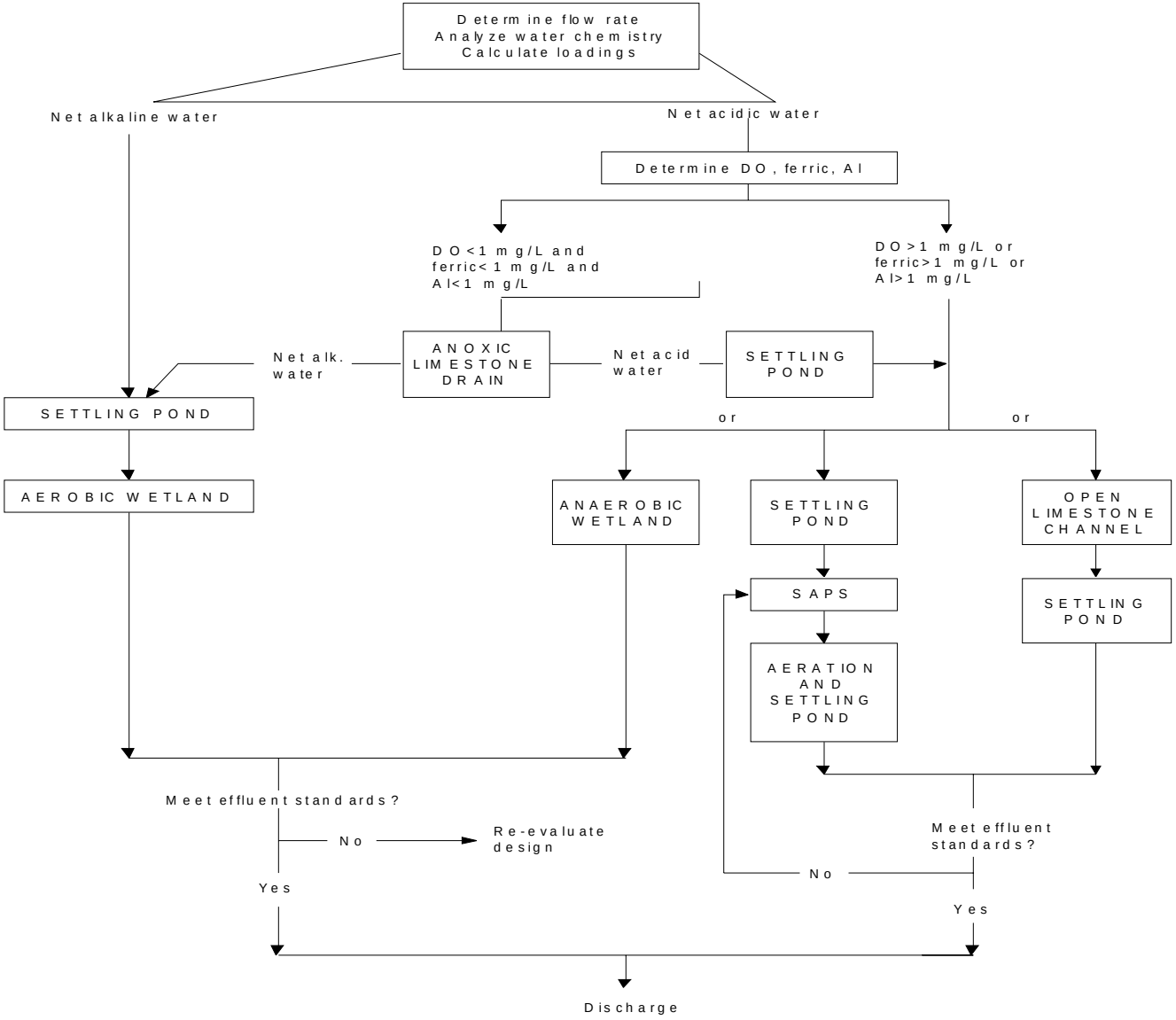
(k) If >5050 mg/l, may require post neutralization aeration and significant reaction retention.

(l) Acidic if pre-treatment precipitation is required.

(m) Drum Doser.

® Adapted from North Branch Potomac River Environmental Restoration Reconnaissance Study / Micheal Baker Jr., Inc.

Michael Baker Jr., Inc.



PRELIMINARY FLOW SHEET FOR SELECTION OF PASSIVE TREATMENTSYSTEMS

Additional treatment may be required for Mn and heavy metals
See text for further discussion and possible limitations
(Modified after Hedin et al., 1994, with additions)