DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF MINING AND RECLAMATION

TECHNICAL STUDY
FOR
A PETITION TO DESIGNATE AREAS UNSUITABLE FOR MINING

MUDDY RUN WATERSHED
CAMBRIA COUNTY

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I. EXECUTIVE SUMMARY

In 1996, the Reade Township Municipal Authority (RTMA) submitted a petition to the Department of Environmental Protection (Department) to designate approximately 3,200 acres of the Muddy Run watershed as "unsuitable for mining." RTMA's stated purpose was the protection of their public water supply wells from potential, adverse mining-related impacts. RTMA's petition alleged that surface mining activities could destroy or seriously degrade the source aquifers tapped by the township's public water supply wells, and could adversely impact other local surface and groundwater resources. RTMA provided supporting evidence documenting mining-related impacts to a private water well within the Muddy Run watershed, and provided an outline of deleterious mining-induced impacts in adjacent watersheds. RTMA also noted that the Department had previously designated the adjacent watersheds of Upper Powell Run, Bells Gap Run, and Little Muddy Run as unsuitable for surface mining activities. The Department accepted RTMA's petition in May of 1997 and subsequently delineated an unsuitable for mining technical study area based on the issues raised in the petition.

The technical study area is located in Reade Township in the northeastern corner of Cambria County. The study area comprises a significant portion of the headwater area of the Muddy Run watershed located north and east of the town of Blandburg. The eastern border of the watershed is the drainage divide along the higher elevations of the Allegheny Mountain. The Muddy Run watershed is bordered by the Little Muddy Run watershed to the north and northeast, and by the Powell Run watershed to the south and southeast. State Game Lands comprise much of the easternmost part of the Muddy Run study area.

In the early 1990s, RTMA replaced an unfiltered surface water source (Powell Run Reservoir) with two deep wells. The wells were drilled to provide potable water and were located within the Muddy Run watershed. These wells have a combined sustained yield of approximately 936,000 gallons/day and supply over 550 facilities. The wells provide the township with ample potable water that requires little or no treatment. The source aquifer is the fractured calcareous sandstones of the lower Mauch Chunk, Loyalhanna and Burgoon Formations, which lie stratigraphically beneath the coal-bearing strata in the watershed.

Coal seams ranging from the Mercer upward to the Mahoning occur and outcrop along hillsides and stream valleys throughout, and adjacent to, the Muddy Run study area. Certain coal seams within the general area of the RTMA wells are characterized by acidic overburden, and are in close stratigraphic proximity to the underlying high-quality regional aquifers that supply the township's public water. Surface coal mining has occurred within the Muddy Run watershed on a continuing basis since the 1940s. There has been extensive surface mining of the Brookville and Clarion coals, Lower, Middle, and Upper Kittanning coals, and the Lower and Upper Freeport coals, with over 40 surface mine permits issued since 1946. During the 1930s, several underground mines extracted the Lower Kittanning coal locally. Most mining was in the southern, western, and northern portions of the study area. There are three active surface mines just northwest of the study area. Two recent operations within the central part of the study area mined the Mercer, Brookville, and Clarion coals. No alternate public water supply sources have been identified in the event the aquifers of the RTMA wells become degraded by future mining operations.

Overburden analysis results indicate the presence of high-sulfur zones and the absence of calcareous strata within the Lower Kittanning, Clarion, Brookville, and Mercer coal intervals. There is significant potential for production of acid mine water from the mining of these coals. Strata associated with the Upper and Lower Freeport coals and the Upper and Middle Kittanning coals often contain high-sulfur zones; however, they also contain intervals of calcareous strata.

Fifty-two discharge sites were identified within the study area. Most discharges are associated with the mining of more than one coal. All but two postmining discharges are acidic. Mine discharges throughout the study area are characterized by low pH and high concentrations of sulfate, aluminum, iron, and manganese.

Springs are associated with all of the mined coal formations within the Muddy Run study area. Chemical analyses indicate that many of the springs show at least some influence from mining. Springs down gradient of mined areas of the Upper Freeport, Lower Freeport, and Upper Kittanning seams generally tend to be alkaline with elevated sulfate concentrations and, in some cases, elevated metals concentrations. Springs located down gradient of mined areas of the Mercer, Brookville, Clarion, and Lower Kittanning seams generally tend to be acidic with elevated metals and sulfate concentrations.

Twenty-two private water supply wells were investigated for mining-induced impacts as part of the technical study. Private water wells penetrate formations ranging from above the Mahoning coal downward to below the Mercer coals. The influence of surface mining on the wells studied was similar to that seen for springs. Wells penetrating strata located at and above the Upper Kittanning coal in areas down gradient of historically mined areas tended to be alkaline with varying degrees of elevated sulfates and metals concentrations. Wells located down gradient of historically mined areas and penetrating strata at or below the Middle Kittanning coal seam tended to be more severely impacted by mine drainage, and were often acidic with high metals and sulfate levels.

Bioassessment surveys, conducted during the course of this technical study, found Muddy Run to be biologically impaired from the Route 253 bridge to a point approximately 0.75 miles upstream, just downstream of the confluence of a major tributary. This tributary receives substantial mine drainage and does not support aquatic life. A small, surface stream contributes to this tributary less than 0.5 miles upstream. This small stream supports life despite naturally occurring limiting factors, such as periods of low baseflow, which can serve to decrease biological abundance and diversity. The headwaters of Muddy Run, immediately below and above the mine drainage influenced tributary were considered biologically un-impaired. This is primarily due to the influx of significant spring flow, which supports macroinvertebrate populations. No fish were found during the technical study.

Alternatives

The Department has identified the following alternatives for consideration by the Environmental Quality Board concerning this petition.

(1) Consider designating all coals within the Muddy Run petition area

(2) Consider designating certain coals within the Muddy Run petition area as unsuitable for mining.

(3) Consider designating none of the Muddy Run petition area as unsuitable for mining. This alternative would allow for consideration of the effects of proposed mining operations through the permit review process, by evaluation of the hydrologic impacts of mining specific coals within specific areas.

II. INTRODUCTION

The Petition Process

In this report, the term "petition" refers to a formal action by an interested party requesting that the Department designate a specified area as unsuitable for surface coal mining.

The unsuitable for mining petition process obligates the Department to consider petitions, review available information, conduct studies, provide for public participation by proper notifications and public hearings, and make recommendations to the Environmental Quality Board for rulemaking.

The Department is required by the Surface Mining Conservation and Reclamation Act and the Clean Streams Law to designate areas as unsuitable for surface mining when the Department determines that reclamation pursuant to the requirements of the Act is not technologically or economically feasible. In addition, the Department may designate an area as unsuitable for all or certain types of coal mining operations if such operations will: 1) be incompatible with existing state or local land use plans or programs; 2) affect fragile or historic lands where such operations would result in significant damage to important historical, cultural, scientific, and aesthetic values and natural systems; 3) cause a substantial loss or reduction in long-range productivity of food or fiber products or water supply, including aquifers and aquifer recharge areas; or 4) substantially endanger life and property in natural hazard areas, including areas subject to frequent flooding and areas of unstable geology.

Legislative Authority

Legal Background

Although a formal procedure for designating areas unsuitable for mining was not made part of Pennsylvania statutes until 1980, the notion that certain areas may be unsuitable for mining is not new to Pennsylvania law. Common law principles of nuisance, trespass and riparian rights sometimes prevented or limited surface mining activities in certain areas because of their proximity to homes or businesses. Local zoning ordinances have also prevented mining in certain areas to protect public health, safety, and welfare.

Indeed, the current statutory language has antecedents that can be traced back several decades. These earlier statutory provisions had two basic themes, which are still important. First, the General Assembly concluded that mining was not permissible within certain distances of roads, parks, buildings, and similar facilities. The first statutory recognition of concern about the proximity of mining to such facilities was manifest in the Reclamation Act. Even before backfilling of mine excavations to approximate original contour was required, the General Assembly had more stringent requirements concerning backfilling and other mining activities where the operation was within specified distances of any group of five dwelling units, any public building, school, church, community or institutional building, cemetery, public recreation area, or public highway (Section 10 of the Bituminous Coal Open Pit Mining Conservation Act, as amended by Act 531 of 1961, P.L. 1210; and Section 4.2(b) and Section 5 of the Act, as amended by Act No. 133 of 1963, P.L. 238). In 1971, when the General Assembly amended the Act to require backfilling to approximate original contour, it also added a prohibition against opening pits for surface mining activities within "one hundred feet of the outside line of the right-of-way for any public highway

or within three hundred feet of any occupied dwelling, unless released by the owner thereof, or any public building, school, park, or community or institutional building or within one hundred feet of any cemetery, or the bank of any stream" (Section 4.2(c) of Act No. 147 of 1971, P.L. 554). Variances to these buffer zones were granted only if the interests of the public and landowners would be protected. The Commonwealth Court sustained the constitutionality of Section 4.2(c) in Harger v. Commonwealth, Department of Environmental Resources, 9 Pa. Commonwealth Ct. 482, 308, A.2d 171 (1973).

The second theme of these earlier statutory provisions is implicit in the ability of the Commonwealth to deny surface mining permits where the operator has failed to demonstrate that mining can be accomplished without causing pollution to the waters of the Commonwealth. To the extent that certain areas are extremely difficult if not impossible to mine without causing pollution, the laws protect such areas from being mined. The Clean Streams Law, originally enacted in 1937, was amended in 1945 (P.L. 435) to require operators to submit plans for addressing acidic mine drainage. The 1945 amendments defined acid mine drainage as pollution for the first time, and to some extent prohibited such discharges. The constitutionality of that prohibition was sustained in Sanitary Water Board v. Sunbeam Coal Corp., 77 Dauph. 264 (1961).

Although the Court said that the law might cause some operators to permanently treat discharges, it recognized that "the need for clean, wholesome water supply continues indefinitely." The Court concluded: "We realize that the burden thus placed upon the operator is great, but the public need out of which it is born, is correspondingly great" (77 Dauph. at 273-74). The Clean Streams Law was further amended in 1965 to impose a mandatory duty on the Commonwealth to deny permits where pollution was likely to occur. Section 315(a) of these amendments, P.L. 372, Act 194 of 1965, provided in part: "A permit shall not be issued if the board shall be of the opinion that the discharge from the mine would be or become detrimental to the public health, animal, or aquatic life or the use of the water for domestic or industrial consumption or recreation." The Courts have held that the operator has the burden of demonstrating in a permit application that the proposed operation will not cause pollution of the waters of the Commonwealth in Harmon Coal Co. v. Commonwealth, Dept. of Environmental Resources, 34 Pa. Commonwealth Ct. 610, 384 A.2d 289 (1978). The operator's ability to mine without causing pollution may largely depend on the characteristics of the site. These characteristics include the quality and composition of coal seams and associated rock, and local groundwater gradients and movement. In denying some surface mining permit applications, the Department recognizes that certain areas cannot be mined by anyone, using existing technology, without causing pollution. Similarly, in 1980, the General Assembly, in effect, prohibited the Department from issuing permits where the proposed surface mining operation would cause the contamination or diminution of the quality or quantity of water supplies unless the operator could demonstrate the availability of an alternate supply of comparable quality and quantity. To the extent that applicants cannot meet the requirements of Section 4.2(f), the Act prohibits such areas from being surface mined.

Statutory Authority for the Petition Process

These two legally established regulatory concepts, buffer zones and permit denials to protect water quality and quantity, continue to form the core of the statutory provisions protecting certain areas from being mined. The October 10, 1980 amendments to three Pennsylvania statutes retained these provisions and added a new program known as the Areas Unsuitable for Mining Program. The key provisions, in this regard, can be found in Section 4.5 of the Surface Mining Conservation and Reclamation Act (as amended by Act 155 of 1980, P.L. 835), Section 6.1 of the Coal Refuse Disposal Control Act (as amended by Act 154 of 1980, P.L. 807), and Sections 315(h)-(o) of The Clean Streams Law (as amended by Act 157 of 1980, P.L. 894), which are based on Section 522 of the federal Surface Mining Control and Reclamation Act of 1977, 30 U.S.C. Section 1272. The 1980 amendments establish a formal process for designating areas as unsuitable for mining and for terminating such designations.

III. DESCRIPTION OF THE PETITION AND PETITION AREA

The Petitioner

The petition was submitted by Mr. James Thompson on behalf of the RTMA. The RTMA was established in 1989 to consolidate several small community water systems including the towns of Blandburg, Hollentown, Fallentimber, Flinton, and Van Ormer, as well as to provide service to areas of Reade Township that had no community water systems. In addition to providing residential and commercial water use, the RTMA provides fire protection to these communities via hydrants every 1,000 feet throughout the public water system's 19 miles of waterlines.

The current primary source of water used by the RTMA is from two water wells, Muddy Run #1 and Muddy Run #2, located within the Muddy Run watershed near the Reade Township Sportsman's Club, north of Blandburg, and adjacent to the main branch of Muddy Run (Figure 1).

The combined sustained yield for both wells is approximately 936,000 gallons/day. The RTMA supplies over 550 service accounts. The wells were drilled in 1993 and 1994, using part of the nearly 5 million dollars provided to the RTMA by a Rural Economic Development grant.

Petition Allegations

In submitting the petition, the RTMA filed allegations under the criteria listed in 25 Pa.Code §86.122(b)(3). RTMA alleged that surface and underground mining has adversely affected surface waters and groundwater in areas within and in the general vicinity of the petition area. To support the allegations, the RTMA submitted various information from existing Department technical studies, which documented acidic discharges to surface waters and groundwater degradation from abandoned mining operations in watersheds adjacent to Muddy Run (see Figure 1). RTMA also submitted information on the water quality and quantity of the RTMA supply wells. The petitioner alleged that surface mining activities could destroy or seriously degrade the aquifers and aquifer recharge areas used for the township's public water supply and other local surface and groundwater resources. RTMA alluded to adverse effects on a private water well within the Muddy Run watershed that occurred after mining was conducted, and to the previous deleterious effects of mining operations in three adjacent watersheds. The petitioner indicated that sufficient information, concerning water quality degradation and water supply loss, is contained in Departmental files to warrant designation as unsuitable for mining.

Milestone Dates

On March 21, 1996, the Department received the petition requesting the designation of 3,200 acres of the Muddy Run watershed located in Reade Township, Cambria County, as unsuitable for mining. The Department determined the petition to be complete and acceptable for technical study in April of 1997. The petitioner was notified accordingly on May 1, 1997.

Notification of the receipt and acceptance of the petition was made to persons with known mineral ownership, surface ownership, and other interested parties on May 12, 1997. Notification to the general public was made on May 10 and 17, 1997, in the Progress, Clearfield, Pennsylvania, on May 11 and 18, 1997 in The Tribune Democrat, Johnstown, Pennsylvania, and in the Pennsylvania Bulletin on May 17, 1997 (27 Pa.B. 2476). In early 1998, local landowners were notified by mail of an opportunity to provide comments on the petition at a public hearing. The hearing was held on February 26, 1998 at Glendale High School.

Technical study fieldwork, including water sampling and site reconnaissance, began in 1997. Subsequently, the technical study process was suspended in early 1999 due to "takings" litigation involving an unrelated unsuitable for mining case. The technical study process was re-activated in December of 2003. In May of 2004, a second round of notification letters were sent to solicit input from new property owners within the technical study area. This was done to address surface and mineral tracts that may have been sold, transferred, or sub-divided since the initial round of notification letters.

The Petition Area

The petition area is located in Reade Township in the northeastern corner of Cambria County. The petition area comprises a significant portion of the headwater area of the Muddy Run watershed located north and east of the town of Blandburg. The Muddy Run watershed within Cambria County, and within Clearfield County to the north, has historically been an area of extensive surface mining.

The original petition area encompassed approximately 3,200 acres of the Muddy Run watershed headwater area, located south of State Route 253 and east of Township Road T-564 and State Route 1024. The Department's initial technical study area expanded the petition area to include the entire headwaters area of the Muddy Run watershed. This area included approximately 5,127 acres located upstream and south of Township Road T-534. The study area was later revised to delete acreage north of State Route 253 in order to maintain focus on the RTMA well field and immediate environs. The final revised technical study area is approximately 3,691 acres. The boundaries of the final technical study area are shown on Figure 1.

Surface Drainage

Muddy Run flows to the northwest through a broad bowl-shaped valley dissected by several tributaries and intermediate hills of moderate relief. The eastern border of the watershed is the drainage divide along the higher elevations of the Allegheny Mountain. The watershed study area is bordered by the Little Muddy Run watershed to the north and northeast, and by the Powell Run watershed to the south and southeast.

Muddy Run receives drainage from many surface mined areas, and except for the extreme headwater areas, the stream is highly acidic, and contains high concentrations of iron, manganese, and aluminum. Coal seams outcrop along the slopes of the watershed. Land use within the petition study area has historically been coal mining and commercial timber operations, with rural residential housing located along major and secondary highways. There is very limited agricultural usage. State Game Lands comprise much of the extreme eastern part of the Muddy Run study area.

Three watersheds adjacent to Muddy Run have previously been designated as unsuitable for mining: Upper Little Muddy Run, Upper Powell Run, and Bells Gap Run (see Figure 1). The Upper Little Muddy Run area is located northeast of Muddy Run in Gulich Township, Clearfield County and Reade Township, Cambria County. The surface minable coal reserves of the Lower Kittanning, Clarion No. 1, Clarion No. 2 and Mercer coal seams were designated unsuitable for mining in 1988. The final designated acreage was 4,608 acres. The Upper Powell Run area is located southeast of Muddy Run in Reade Township, Cambria County and Antis Township, Blair County. The surface minable coal reserves in this surface water drainage basin, east of Route 865 were designated unsuitable for mining in 1986. The final designated acreage was 960 acres. The Bells Gap Run area is located south of Muddy Run in Dean and Reade Townships, Cambria County and Antis and Logan Townships, Blair County. The surface minable coal reserves of the Lower Kittanning, Clarion and Mercer coals in the surface water drainage basin was designated unsuitable for mining in 1990. The final designated acreage was 11,700 acres.

IV. TECHNICAL STUDY

Mining History

Over forty surface mines and at least ten underground mines operated within, and immediately adjacent to, the Muddy Run study area. The locations of known recorded mine sites are shown in Figure 2 (map pocket).

The Miller No.1 underground mine of the Glasgow Coal Mining Company was operated during the 1930s and mined the Lower Kittanning coal in the northwest part of the study area. Also during the 1930s, Merrit Coal Company's Mine No.3 deep mined the Lower Kittanning coal just north of the town of Blandburg. There are presently no active underground mines within the Muddy Run study area.

Eight different coal formations were surface mined within the Muddy Run study area from the 1940s through the 1990s (see Table 1). The first surface mine permit was issued within the Muddy Run study area in 1946. The 1940s and 1950s also saw several small "country bank" deep mines, which are located along the coal croplines. These mines, represented on Figure 2 by a crossed pick and hammer symbol, are of limited extent, and are confined to single coal seams. Most of the surface coal mining operations have been concentrated in the southern, western, and northern portions of the study area (Figure 2). Approximately 80% of the surface mine permits have areas that were added by later revisions to the original permit. Surface mining also has occurred above the two Lower Kittanning underground mines. Twenty-two mines mined more than one coal seam. Eleven of the surface mines mined three or more coals.

Geologic Structure

Regional Structure. The geologic structure of Pennsylvania's bituminous coal region may conveniently be described according to several levels of scale. At the largest scale, the entire Appalachian Plateau in western Pennsylvania is part of a major structural basin referred to as the Appalachian Coal Basin or Allegheny Synclinorium. The northern portion is often referred to as the Pittsburgh-Huntingdon Basin. The basin may be visualized as a broad spoon-shaped structure, in which the youngest strata are at the center of the spoon and successively older strata become exposed toward the outer edge of the spoon. Consequently, a bed such as the Upper Freeport coal of the Allegheny Group, which is present at the land surface at elevations of approximately 2000 feet above sea level at the northern and eastern margins of the coalfield, is present in the southwestern corner of Pennsylvania at an elevation several hundred feet below sea level and beneath many hundreds of feet of younger rocks.

The next level of structural scale includes the large synclines and anticlines in the eastern portion of the bituminous coalfield. The major features, from southeast to west, are the Wellersburg syncline (which contains the George's Creek Coalfield), the Deer Park anticline (which is devoid of coal), the Berlin syncline (which contains rocks as young as the lower Monongahela Group), the Negro Mountain Anticline, a broad syncline that runs from Johnstown to the Youghiogheny dam, the Laurel Ridge anticline, the Ligonier syncline, and the Chestnut Ridge anticline. Structural relief decreases northwestward in a step-like fashion from the well-defined folds of the southeastern side of the plateau where anticlines rise 800 to 2500 feet above adjacent synclines.

The next level of structural scale includes small deviations in folding from the broader synclines and anticlines and faults. Faults are more prevalent near the eastern margin of the coalfield in northern Cambria and Clearfield Counties and rare to the west. Joints and lineaments are other structural features that can be important from a mining standpoint because they can affect the stability of a mine roof and can convey groundwater.

Local Structure. The Muddy Run study area is situated on the eastern flank of the Wilmore syncline, a regional geologic structure of downward folded strata within the Appalachian Plateaus physiographic province. Within the study area, strata dip at a rate of 3-6 % in a northwesterly direction, toward the axis of the Wilmore syncline (map pocket Figure 3). The syncline's axis is the linear trace of the lowest position of the dipping strata, which form the structural trough of the syncline. The axis of the structural trough of the Wilmore syncline is generally level, plunging very slightly to the southwest.

A transverse strike slip fault occurs within the northern portion of the Muddy Run study area. This fault trends N. 56.5° W. from its origin near the Cambria and Blair County line northeast of Blandburg. Along the northern side of the study area, the fault roughly parallels the flow of the main stem of Muddy Run, crosses the Curtis Run tributary, and extends directly toward and through the town of Utahville, northwest of the study area (map pocket Figure 3). There is a variable vertical displacement across this fault, with the northern side being displaced downward. Vertical displacement ranges from approximately 20 ft in the eastern part of the study area to approximately 80 ft in the northwestern part of the study area. Extensive fracturing typically characterizes this type of structural disruption. Any localized concentration of fractures could have pronounced effects on vertical permeability, and could greatly influence the direction and volume of groundwater flow in that area.

As a result of the structural folding and surface topography found throughout the region, stratigraphic units exposed at the surface within the Muddy Run study area range in age from the relatively young Glenshaw Formation of the Pennsylvanian System through the older Mauch Chunk Formation of the Mississippian System. Within the Muddy Run study area, the Glenshaw Formation of the Conemaugh Group, the Glen Richey, Laurel Run, Mineral Springs, Millstone Run, and Clearfield Creek Formations of the Allegheny Group, the Pottsville Group, and the underlying Mauch Chunk Formation are exposed at the surface. In addition to these surface exposures, the Loyalhanna Formation and the underlying Burgoon Sandstone Formation were identified in several drill holes within the study area. A generalized stratigraphic column for the Muddy Run study area is shown in Figure 4.

Stratigraphic Sequence

In descending order, the following rock units exist at the surface, or at shallow depths (within 500 feet vertically of the Muddy Run stream valley), within the study area.

Conemaugh Group

The Conemaugh Group includes rocks that occur stratigraphically above the Allegheny Group and below the Pittsburgh coal. The Conemaugh Group is noted for its lack of minable coals, and was originally called the Lower Barren Measures for that reason (Rogers, 1858). Flint (1965) divided the Conemaugh Group into two formations, based on the presence of marine limestones. The Casselman Formation extends downward from the base of the Pittsburgh coal to the top of the Glenshaw Formation (Ames limestone). It contains lithologies similar to the underlying Glenshaw Formation, but has more freshwater limestones, no marine deposits, thin sporadic coals, and fewer red beds. The Glenshaw Formation extends downward from the top of the Ames limestone to the top of the Allegheny Group (Upper Freeport coal). It consists of sandstone, siltstone, claystone (including red beds), limestone, and coal. Four major marine zones are present within the Glenshaw Formation: the Ames, Woods Run, Pine Creek, and the Brush Creek.

The total stratigraphic thickness of the Conemaugh Group in western Pennsylvania can be as much as 1,000 ft, but erosion within the Muddy Run study area has reduced the Conemaugh Group to a maximum thickness of less than 100 ft. The Casselman Formation and upper Glenshaw Formation have been eroded within the study area, so that only the lower half of the Glenshaw Formation is exposed at the surface, with the thickest subsurface deposits occurring in the extreme northwestern, western, and southwestern portions of the study area. The Mahoning coal was recorded in several drill holes from this area, and has been mined northwest of the study area, near the axis of the Wilmore syncline where the Glenshaw Formation is thicker and more commonly occurs.

Allegheny Group

The Allegheny Group includes the rocks between the Conemaugh Group above and the Pottsville Group below. The Allegheny Group is defined stratigraphically by the top of the Upper Freeport coal down to the base of the Brookville coal. The thickness of the Allegheny Group in the Muddy Run study area averages about 225 ft. It contains all of the coals mined in the area, except the Mercer coals of the

underlying Pottsville Group. The main lithologies of the Allegheny Group include clay, shale, claystone, siltstone, sandstone, and coal. Widespread coal deposits occur extensively and regularly throughout the Allegheny Group. The coal formations are usually less than two feet thick, but can commonly occur up to 4 feet thick. The upper part of the group occasionally contains calcareous shales and thin freshwater limestone beds above and below the Upper Freeport coal. The Johnstown limestone interval, situated between the Upper and Middle Kittanning coals, is poorly developed within the study area. The Vanport limestone, noted elsewhere beneath the Lower Kittanning coal, is not known to occur or be present in this area.

The Allegheny Group contains five formations (Figure 4): the Glen Richey Formation extending downward from the top of the Upper Freeport coal to the base of the Lower Freeport coal, the Laurel Run Formation extending from the base of the Lower Freeport coal to the base of the Upper Kittanning coal, the Mineral Springs Formation extending from the base of the Upper Kittanning coal to the base of the Middle Kittanning coal, the Millstone Run Formation, extending from the base of the Middle Kittanning coal to the base of the Lower Kittanning coal, and the Clearfield Creek Formation extending from the base of the Lower Kittanning coal to the base of the Brookville coal.

The Brookville coal is also known as the Clarion #1 coal. The Clearfield Creek Formation also contains the Clarion #2 coal (called the Clarion coal in this report), and the Clarion #3 coal. These five formations are defined solely by their coal marker beds, and are not based on differences in lithology. The only characteristic lithologic differences that occur within the Allegheny Group are the presence of calcareous shales and freshwater limestones in the upper part of the group. When using drill hole information, the correlation of coals best defines the stratigraphy of the group. The Allegheny Group is exposed at the surface throughout the entire Muddy Run study area, except along the main stem of Muddy Run in the central portion of the study area, where the lower surface topography as resulted in the erosion of these formations.

Pottsville Group

The Pottsville Group is the oldest stratigraphic unit within the Pennsylvanian System. It extends downward from base of the Allegheny Group (base of the Brookville coal) to the unconformity forming the top of the Mississippian Mauch Chunk Formation. Sandstones and sandy shales are the predominant lithology of the Pottsville Group, although claystones and several thin coals are also present. The one to three coals, which are commonly identified within this interval, are called the Mercer coals. Based on drill hole information, the stratigraphic thickness of the Pottsville Group in the Muddy Run study area ranges from approximately 60 to 85 ft, with rapid lateral changes in thickness being common.

Mississippian Strata

The Mauch Chunk Formation is the oldest formation that outcrops within the Muddy Run study area. This formation is exposed along the main valleys of the two branches of Muddy Run in the central portion of the study area (map pocket Figure 3). This formation is composed of a sequence of red shales and siltstones with intercalated beds of gray shales, gray sandstones, green shales and siltstones, and calcareous sandstones or siliceous limestones in the lower part of the formation. The bottom of the

formation is the top of the Loyalhanna Formation. Although drill logs from drill holes used in this study identified the Mauch Chunk Formation, only three drill holes penetrated the entire interval of the Mauch Chunk Formation. The formation thickness was reported to range from 99 to 214 ft.

The Loyalhanna Formation occurs from the Mauch Chunk Formation downward to the top of the Burgoon Formation. This formation does not outcrop within the Muddy Run study area, but is widespread and regional in extent, and is exposed along the entire eastern side of the Allegheny Mountain located to the east of the Muddy Run watershed. This formation is a light gray, medium to coarse grained highly calcareous sandstone. Within four drill hole records used in this study, the Loyalhanna Formation was identified has having a total thickness ranging from 51 to 87 ft. The uppermost units of the Burgoon Formation were penetrated in the same four drill holes, and consisted of light gray to white siliceous sandstones with thin gray inter-beded shale.

Groundwater Hydrology of Bituminous Coalfields

Within the bituminous coalfields of southwestern Pennsylvania, drainage basins tend to be small with marked relief. In combination with the region's humid climate, this produces a groundwater system that can be readily broken into distinct parts – local (shallow), intermediate, and regional (Poth, 1963). Superimposed on these systems (particularly on the shallow system) are distinct zones of increased groundwater flow defined by the density and interconnection of rock fractures.

The local flow system underlies hills and discharges to local streams and, to some extent, springs above stream level. In some areas, local systems include water that is "perched" above beds of lower permeability. This groundwater moves laterally and discharges as springs above stream level. The hills constitute "hydrologic islands" as described by Poth (1963). A discrete groundwater flow system operates within each hydrologic island and is hydrologically segregated from the local groundwater flow systems in adjacent islands. The base of the local flow system (particularly for islands adjacent to smaller streams) lies below the level of the stream valleys bordering the island. It is defined by the maximum depth at which groundwater, originating within the hydrologic island, will flow upward to discharge in the adjacent stream valley. Recharge to the local system is completely from within the hydrologic island. Discharge from the local system is into the adjacent stream valleys with some leakage into the deeper intermediate and regional groundwater flow systems. In areas adjacent to larger streams and rivers, local groundwater that leaks downward may commingle with intermediate or even regional flow, which is rising to discharge within the valley. The local flow system is the area of the most active groundwater circulation. It is the zone that contributes water to the vast majority of domestic wells.

The intermediate groundwater flow system is recharged by shallower systems. Recharge usually takes place at the drainage basin divide that defines the recharge area. Flow passes beneath two or more hydrologic islands and discharges in valleys above the lowest level of the drainage basin. Flow rates and residence times are generally between those of local and regional groundwater flow systems, probably varying from years to decades, depending on the level of the intermediate system and the length of the flow path.

A deep, regional groundwater flow system, which lies beneath the level of the hydrologic islands and intermediate flow system, operates independently of the shallower systems. The base of the regional

system is the fresh water/saline water contact. Recharge to the regional system is from major drainage basin divides and leakage from multiple shallower (local and intermediate) systems.

Regional Aquifers and Public Water Wells

The Muddy Run study area is situated on the flank of the Wilmore syncline. This regional structural influence establishes some basic controls over the flow of groundwater within this setting. Within a synclinal structural setting, a percentage of groundwater will leak downward from local flow systems to deeper strata. Water may also move from groundwater recharge areas along the flank of the syncline and flow in the direction of the strata's inclination. This flow path may be primarily within specific hydrostratigraphic units, or within individual layers of strata.

As groundwater flows within an aquifer formation down the flank of a syncline, it commonly comes under increasing pressure within the formation. Therefore, the down-structure region of a syncline is commonly an area of increasing head due to the layered heterogeneity of the coal measures. This structural setting may result in confined or semi-confined aquifers within the intermediate groundwater flow system. Water supply wells developed below the confining layers in these down-structure settings will often be artesian. Regional groundwater flow that has reached the bottom of a synclinal trough may also remain in the subsurface and continue flowing in the direction of the plunge of the syncline. [It is important to note that secondary rock openings, such as joints, zones of fracture concentration and bedding-plane partings, are commonly the main groundwater flow paths on the Appalachian Plateaus. These secondary permeability features profoundly influence groundwater flow in local and intermediate flow systems. Delineation of a contributing area to a well or well field completed in these types of fractured bedrock units is difficult due to the complexity introduced by discrete rock fractures.]

This conceptual groundwater flow model indicates that the up-structure region of the Muddy Run study area should be an area of groundwater infiltration and downward recharge to lower aquifers, and that there is the potential for down-structure lateral flow within formations in a direction toward the axis of the syncline. Moving down-structure within the study area, there is the potential for upward flow of groundwater from intermediate aquifer zones, such as the Mauch Chunk and Loyalhanna Formations.

Typically, public water supply wells tapping Pottsville Group strata along the Allegheny Mountain front produce poor quality, acidic, high-iron and high-manganese water. In contrast, Mauch Chunk and Loyalhanna Formation wells typically produce excellent quality alkaline water with low iron and manganese content. The Burgoon Formation normally produces good quality water, however, slightly elevated iron and manganese levels can occur in areas where the Burgoon Formation contains abundant pyrite.

RTMA Well Field

The RTMA purchased the Blandburg Water Company in 1991. The Blandburg water system utilized unfiltered surface water from the Powell Run Reservoir as its source. The Powell Run Reservoir had been permitted as a public water source since December 20, 1910. In 1991, the RTMA initiated drilling of a test well (Powell Run #1) to obtain water from a regional groundwater source. On September 19, 1991, the RTMA was issued a permit to use the Powel Run #1 test well as a temporary water source.

Powell Run #1 Test Well

The Powell Run #1 test well, located just southeast of Blandburg near the Powell Run Reservoir, was constructed as a 6-inch diameter well to a total depth of 474 ft. The well was cased to a depth of 42 ft. Water samples collected during aquifer tests in August of 1991 indicated that the Powell Run #1 test well produced water with elevated iron (1.19 mg/l) and manganese (0.21 mg/l) concentrations. Public use of the Powell Run #1 well, with its high iron and manganese levels, would require a filtration facility.

In 1996, Casselberry & Associates (Casselberry), submitted a report to the RTMA describing the previous development work conducted on the Powell Run #1 test well and a description of the geology and water quality encountered in the well. Casselberry reported the following stratigraphic intervals. The Pottsville Group was drilled through from the surface to a depth of 101 ft. The Mauch Chunk Formation was identified from 101 to 315 ft, the Loyalhanna Formation from 315 to 380 ft, and the Burgoon Formation from a depth of 380 to 474 ft. In the report, Casselberry outlines the interconnection of poorer quality water-bearing zones of the Pottsville Group with the underlying higher quality water in the Mauch Chunk / Loyalhanna aquifer sequence. Casselberry made a case that the water quality of the Powell Run #1 well would be greatly improved by extending the casing downward through the entire Pottsville Group. To investigate this possibility, he conducted a down-hole video survey of the well in September of 1993. This video survey revealed the presence of poor quality water-bearing zones at depths of 63, 73, 89, and 123 ft below ground level. The low static water level in the Powell Run #1 well, at 217 ft, caused water from these shallow water-bearing zones to cascade down the borehole and allowed for the collection of water samples with a discrete interval bailer.

Analysis of these water samples showed iron concentrations ranging from 1.5 to 3.5 mg/l. With increased depth, the first significant improvement in water quality (iron <1.0 mg/l) identified by Casselberry was in water flowing from a fracture zone at a depth of 166 ft. Water-bearing fracture zones containing good quality water were also detected at depths of 187 ft and from 302 to 309 ft. No water-bearing zones were detected by the video survey below a depth of 309 ft. Based upon the results of the video survey, Casselberry recommended extending the well casing to a depth of 155 ft to improve water quality. Subsequent attempts to install the casing to this depth were unsuccessful. Casing could only be advanced to a depth of 133 ft.

After re-casing the Powell Run #1 test well, an 80-gpm capacity pump was installed at a depth of 304 ft, and the well was put into service on September 29, 1993 (pump installation below 304 ft was impossible due to fractured rock obstructing the borehole at this depth). The well was pumped continuously at 80 gallons per minute (gpm) from September 29 through October 13, 1993 and then re-sampled for chemical analysis. Water level measurements taken by RTMA personnel during this period suggest that the Powell Run #1 well had a sustained yield potential approaching 100 gpm. The quality of water produced by the Powell Run #1 well was greatly improved by extending the well casing to 133 ft, and closing off any direct flow of water from the Pottsville Group. By limiting any direct contribution of water from the Pottsville Group strata, the well water's pH rose from 6.6 to 7.1, iron concentrations decreased from 1.19 to 0.46 mg/l, and manganese levels decreased from 0.21 to 0.13 mg/l.

The Department allows for treatment of iron and manganese via the injection of a sequestering agent, if the aggregate iron and manganese content is less than 1.0 mg/l. With this treatment and chlorination, an

emergency temporary permit for the Powell Run #1 well was issued by the Department, while the RTMA proceeded to develop a drilling program for other test wells to supply the township's water needs.

McElheny Test Well

On June 24 –26, 1993, a test well was drilled by the RTMA on the McElheny property, located on the north side of Powell Run just southwest of Blandburg. The McElheny test well was constructed as a 6-inch diameter well to a total depth of 297 ft, with the first 52 ft cased. In a September 17, 1998, letter to the Department's Bureau of Mining and Reclamation, Casselberry provided the following information about the McElheny test well.

The Pottsville Group was drilled through from the surface to a depth of 54 ft, the Mauch Chunk Formation was encountered from 54 to 183 ft, the Loyalhanna Formation was encountered from 183 to 254 ft, and the Burgoon Formation was identified from 254 to 297 ft.

Small fractures were penetrated in the Mauch Chunk Formation at depths of 57, 62, 67, 76, 81, 85, 89, and 95 ft. These numerous water-bearing horizons produced a small blown yield of 50 gpm. Drilling was temporarily terminated at a depth of 122 ft, and the well began to flow artesian at a rate of 30 gpm. Water samples collected from this artesian overflow indicated that the water-bearing strata of the Mauch Chunk Formation had water chemistry with a pH of 5.4, a specific conductivity of 740 μS, a sulfate content of 380 mg/l, and iron concentrations up to 10 mg/l. Casselberry asserted that the high dissolved solids, high sulfate, low pH, and high iron content of this water indicated the influence of acidic mine drainage.

Two large water-bearing fracture zones were penetrated in the Loyalhanna Formation at depths of 183 to 184 and 197 to 199 ft. The entire fractured Loyalhanna Formation produced a blown yield of 300 gpm. No water-bearing strata were encountered in the underlying Burgoon Formation. Following the completion of drilling, the artesian overflow of the entire well was measured at 110 gpm. Water samples collected from the artesian overflow had a water chemistry with a pH of 6.41, a sulfate content of 320mg/l, a specific conductivity of 604 μS, and iron concentrations as high as 10 mg/l. The sulfate content and specific conductivity of the artesian overflow from the McElheny well improved slightly with the additional flow from the higher capacity water-bearing strata of the Loyalhanna Formation. However, because the sulfate and specific conductance values were still elevated, Casselberry's conclusion was that the Loyalhanna Formation aquifer at this well site is also impacted by acidic mine drainage.

Muddy Run #1 Township Water Well

In 1993, Casselberry was hired by the RTMA to conduct a groundwater exploration program within Reade Township. The goal was to find and develop a high quality groundwater source to replace the RTMA's unfiltered surface water supply, the Powell Run Reservoir.

Casselberry determined that the best aquifer units within the area were within the Mauch Chunk / Loyalhanna / Burgoon aquifer sequence. This group of rocks underlies all coal formations and has a large outcrop area along the western flank of the Allegheny Mountain. Casselberry reported that he has

successfully completed public water projects for other Cambria County municipalities by targeting this aquifer sequence. The success of these development projects documents that these regional aquifers are a reliable source of high yield, excellent quality groundwater.

The major water-bearing horizons in the Mauch Chunk to Burgoon aquifer sequence typically are the calcareous sandstone strata at the base of the Mauch Chunk Formation, limestones of the underlying Loyalhanna Formation, and sandstones of the Burgoon Formation. The shale strata lying in the upper portion of the Mauch Chunk Formation confine the underlying Mauch Chunk sandstones, Loyalhanna limestone and Burgoon sandstone. The confining effect of the shales in the upper portion of the Mauch Chunk Formation causes the aquifer system to operate under artesian aquifer conditions along the western flank of Allegheny Mountain throughout much of Cambria County.

Large yields are available from the Mauch Chunk / Loyalhanna / Burgoon aquifer sequence only in areas where the aquifer lies relatively close to the surface and has a large recharge area. Casselberry determined that the optimum locale for developing wells tapping a regional aquifer system in Reade Township lies in the Muddy Run valley, near the contact between the Mauch Chunk Formation and the overlying Pottsville Group. Based upon the fracture-trace mapping, Casselberry identified several potential test well sites lying on, or in close proximity to, fracture-trace features (Figure 5). The first site selected for test drilling in the Muddy Run valley was near the Sportsman Club north of Blandburg, near the outcrop contact between the Pottsville Group and Mauch Chunk Formations.

The Muddy Run #1 well was constructed as a double-cased, 8-inch diameter well. The geologic log and construction details of the Muddy Run #1 well are shown in Figure 6. Casselberry's 1993 report states that 22 discrete fracture zones were encountered within the Muddy Run #1 well. These fractured intervals had widths ranging from several inches up to 14 ft. The large number of fractures within the Muddy Run #1 well indicates a successful fracture-zone location. Casselberry noted that the 108 ft thickness of the Loyalhanna Formation in the Muddy Run #1 well was far higher than the typical 60 ft thickness for this unit. Casselberry's analysis of the well log indicated that the well penetrated the Mauch Chunk Formation from the surface to a depth of 86 ft, the Loyalhanna Formation from 86 ft to 194 ft, and the Burgoon Formation from 194 ft to the bottom of the well at 197 ft. Drilling was terminated at 197 ft because of the presence of abundant pyrite crystals observed in the Burgoon Formation strata. This mineral represents a potential source of high iron concentrations in groundwater.

The Muddy Run #1 well produced a yield of 500 gpm at the conclusion of the test drilling. Based upon the test drilling information, it appeared that all of the water produced by the well was flowing from the Loyalhanna Formation. Immediately following the conclusion of the test drilling process, the well overflowed its casing at a discharge rate of 170 gpm. The artesian discharge of the well fell steadily from 170 gpm in early June to 80 gpm in late August, 1993. From late August through the end of the pumping tests in mid-September, the artesian overflow of the well was stable at 80 gpm. Following the pumping test program, the well was "shut-in" with a sealing well cap.

The Muddy Run #1 well was sampled per the Department's protocol (*New Source Sampling M*atrix) at the conclusion of the 48-hour pumping test. The results are summarized in Table 2. Chemical analyses indicate that the Muddy Run #1 well produces alkaline, soft water meeting all current Primary and Secondary Drinking Water Standards for public groundwater supplies.

Muddy Run #2 Township Water Well

After review of Casselberry's December 20, 1993 report, the RTMA decided to drill a second public water well in the Muddy Run valley. The primary purpose for developing a second site was to establish a back-up well to Muddy Run #1.

In the fall of 1994, a second well was developed at a fracture-trace intersection approximately 2050 ft down valley from the Muddy Run #1 well (Figure 5). This well site was approved for exploration during the Department's September 13, 1993 *Sanitary Survey* and is referred to as the Muddy Run #2 well. Muddy Run #2 was constructed as a triple-cased, 8-inch diameter well. The construction details and geologic log of Muddy Run #2 are shown in Figure 7. A summary of the geologic information reported in the well log, modified from Casselberry (1995), is as follows:

A thin mantle of colluvial soil extends from ground level to a depth of 7 ft. From 7 ft to a depth of 102 ft, shale and sandstone strata typical of the Pottsville Group were encountered. These Pottsville Group strata are dominated by gray to light gray, massive, micaceous, sandstone beds and contain numerous water-bearing fracture zones. The Pottsville Group fracture zones produced an aggregate yield of 75 gpm during drilling. Because of a high iron content in this water, these Pottsville Group water-bearing zones were cased off. From the base of the Pottsville group at 102 ft to a depth of 201 ft, green to gray sandstone and shale strata typical of the Mauch Chunk Formation were penetrated. The Mauch Chunk Formation strata contained numerous calcareous horizons. The upper 10 ft of the Mauch Chunk Formation strata were composed of fine-grained, shaley, calcareous sandstone strata. Casselberry believed that this relatively "tight" 10-foot thick rock unit at the top of the Mauch Chunk Formation provided a confining bed for the underlying rock strata.

Casselberry (1995) reports that four discrete, water-bearing, fractured, intervals were penetrated in "clean" medium to coarse-grained sandstone units within the Mauch Chunk Formation. These water-bearing zones produced a blown yield of 120 gpm during drilling. Immediately after penetration of these water-bearing zones, the well became a flowing artesian well.

Siliceous limestone strata typical of the Loyalhanna Limestone were penetrated from the base of the Mauch Chunk Formation at 201 ft to a depth of 252 ft. A well-developed fracture zone was encountered at the based of the Loyalhanna Limestone. After penetrating this fracture zone, the yield of the well increased from 120 to 425 gpm.

From the base of the Loyalhanna Limestone at 252 ft to the bottom of the well at 272 ft, massive, light gray to white, siliceous sandstone strata typical of the Burgoon Formation were encountered. These Burgoon Formation strata contained no significant fractures and produced little water.

Immediately following cessation of the drilling, the Muddy Run #2 well had an extremely large artesian over-flow of 250 gpm. The great bulk of this water appeared to issue from the fracture zone at the base of the Loyalhanna Limestone. Repeated measurements for a month-long period revealed that the artesian flow fluctuated in a narrow range of 220 to 250 gpm. Field analyses of water samples collected from the well suggested that it produced alkaline, good quality water having a low iron content (iron values ranging from 0.2 to 0.4 mg/l). Table 2 contains the complete chemical analysis results.

In order to limit the potential for the leakage of high-iron water from the Pottsville Group downwards into the underlying Mauch Chunk/Loyalhanna aquifer sequence, Casselberry (1995) states that the water level at well Muddy Run #2 should not be allowed to decline below the base of the upper Mauch Chunk Formation confining beds. Casselberry recommended a 112-foot drawdown limit for the Muddy Run #2 well.

The Muddy Run #2 well produces alkaline, moderately hard water, which meets all current drinking water standards for public groundwater supplies with the exception of the secondary limits set for iron and manganese. The iron level recorded at the conclusion of the pumping test was 0.38 mg/l, which exceeds the drinking water limit of 0.30 mg/l. The manganese level recorded at the end of the pumping test was 0.15 mg/l, which exceeds the secondary drinking water limit of 0.05 mg/l. Water samples also were collected at well Muddy Run #2 at the 12-hour and 24-hour marks of the pumping test. These samples were analyzed for several inorganic parameters. The purpose of this "incremental" sampling was to assess the stability of Muddy Run #2's water quality. The water sampling data indicated that the chemistry of water produced by Muddy Run #2 was extremely stable during the pumping test.

Casselberry concluded that although the Mauch Chunk/Loyalhanna aquifer sequence tapped by the RTMA wells appears to have a fairly low potential for pollution (the aquifer is confined and much of its recharge area lies in the rugged woodlands along the upper flank of the Allegheny Mountain), test drilling results suggest that this aquifer has been polluted by acidic mine drainage in at least one locale in the Reade Township area (the McElheny test well in Powell Run). Considering this, Casselberry strongly recommended that the RTMA conduct a wellhead protection area delineation study and implement a wellhead protection plan at the Muddy Run #1 and #2 well sites.

Delineation of RTMA Well Field Recharge Area

Based on Casselberry's well location work, the conceptual groundwater flow model of the Appalachian Plateaus, and the yield and artesian characteristics of the Muddy Run #1 and #2 wells, the recharge area for the wells appears to be primarily from the area east of the well field along the upper flank of the Allegheny Mountain, where the Mauch Chunk/Loyalhanna/Burgoon units are at, or near, the surface (map pocket Figure 3). Additional recharge to these units could occur via leakage from superjacent water-bearing units in the lower Allegheny and Pottsville Groups. The amount of recharge from the lower Allegheny and Pottsville units would be dependent on the direction and magnitude of vertical gradients within the groundwater system. This vertical flow would be greatly influenced by the density and location of secondary permeability features.

The RTMA wells were designed and constructed to be reasonably well isolated from the Pottsville Group rock units due to that horizons deleterious water quality. Tests conducted during the development of the RTMA wells indicate increasing pressure with depth and upward flow from the lower Mauch Chunk units to the overlying Pottsville units. This precludes mine drainage impacted groundwater from migrating from the Pottsville strata to the public supply source aquifer. The confining nature of the Mauch Chunk shales was also supported by the lack of response at pumping test observation wells located above the aquitard horizon. The pollution potential for the RTMA wells would therefore appear to be low. However, the lateral extent and hydraulic conductivity of the confining units is not known. In the western Pennsylvania coal measures, rock units, such as shales, that behave as aquitards locally can be compromised over a relatively short lateral distance depending on conditions such as, proximity to

stream valleys and the existence of vertical fracture sets. An additional concern would be the potential reversal of gradients between the Pottsville units and the deeper public water supply aquifer due to over-pumping of the RTMA wells. If the wells were to be pumped without regard to the relative potentials within the confining units, aquifer units and the overlying groundwater system, groundwater could leak in substantial quantities, depending the vertical permeability of the aquitard, from the Pottsville units to the lower Mauch Chunk units in response to the new gradients. Casselberry did address this later concern in his reports to RTMA. In order to limit the potential for leakage of poor quality water from the Pottsville Group units, Casselberry established recommended maximum drawdown thresholds for the RTMA well field. The thresholds were designed to ensure that existing gradients across the confining units were not reversed.

There is a level of uncertainty that accompanies all groundwater evaluations, particularly those conducted in fractured bedrock settings, such as Pennsylvania's bituminous coal measures. This is due to the need to simplify complex fracture-flow systems. This simplification is often accomplished by using the "continuum" approach for a representative volume of aquifer. For this simplification to be reasonable, the number of fractures and their interconnectedness must be numerous and distributed throughout the aquifer. Standard porous media approaches are then used to model the groundwater flow regime.

Groundwater tests conducted to date are not sufficient to characterize conditions beyond the immediate vicinity of the RTMA wells or to assess the localized impact of a discrete, highly transmissive fracture set. Therefore, although unlikely, the potential does exist for hydrologic communication between the RTMA supply aquifer and the superjacent coal-bearing units. The elevated sulfate and specific conductance levels measured at the McElheny test well appear to confirm some degree of communication from the coal-bearing strata to the lower aquifer units. Additional hydrogeologic studies, i.e., a full-blown groundwater contribution evaluation, would be necessary to refine the local conceptual groundwater flow model and further increase the level of confidence regarding the degree of interconnection between the RTMA source aquifer and the coal-bearing units.

Overburden Analysis

Overburden analyses have been performed on samples from 35 drill holes within the Muddy Run study area. Overburden analysis results were obtained from permit records for the C & K Coal Co. mines Cambria #36 and Cambria #51, the Cloe Mining Co., Inc. Lewis #1 mine, Penn Grampian Coal Co. Oshall #1 and Smith #1 mines and Bell Resources' Mulhollen and Hommer mines. The locations of these overburden drill holes are shown in Figure 8 (map pocket).

The quantity and quality of alkaline and acid forming material within strata overlying coals to be mined may be used in the prediction of potential acid mine drainage. Alkaline material generally occurs in the form of calcium carbonate, whereas acid-producing material is generally represented by iron sulfide minerals, such as pyrite. Chemical analyses of overburden materials generally report results of alkalinity concentrations as neutralization potential (NP). This is expressed as an equivalency of tons of calcium carbonate per 1,000 tons of overburden. Potential acidity is represented by total sulfur and is reported as weight percent. Values of NP and percent sulfur determined for samples recovered from overburden holes located within the study area, along with descriptions of the lithologic units identified in each of these holes, are given in Appendix Table 3. Tables 3 and 4 summarize coal thickness and interburden

data for the study area. Figure 10 shows the overburden analysis histograms and lithologic descriptions for the overburden drill holes used in this study (sulfur values are on the left of the drill log, NP values on the right).

Methods currently in use in the interpretation of the chemical analyses of overburden material are based upon research conducted by diPretoro (1986), diPretoro and Rauch (1987), Erickson and Hedin (1988), Smith and Brady (1990), and Brady et al. (1994). These studies found that, in general, overburden containing sulfur concentrations greater than 0.5 percent and exhibiting an NP of less than 30, had a significant potential for the production of acidic mine drainage. Conversely, overburden that contained total sulfur concentrations of less than 0.5 percent and NP greater than 30 generally resulted in alkaline postmining water quality. In comparing the relative abundance and distribution of alkaline and potentially toxic materials, a NP value greater than 30 is not considered valid unless the material reacted when acid was applied, indicating that the sample contained calcium carbonate, and not some less reactive (less neutralizing) alkaline mineral. When acid is applied to each sample, a qualitative rating is given to the intensity of the produced fizz reaction. The rating system includes categories of no reaction, a slight reaction, a moderate reaction, and a strong reaction. Determination of the potential water quality expected to result from mining activities within a given area must also consider the initial chemical quality of the natural water system and the various effects of past and present mining methods on water quality.

Overburden data and water quality trends associated with recent surface mining in the area immediately northwest of state route SR253 found that strata higher than the Middle Kittanning horizon contains some calcareous intervals that can serve to neutralize and prevent acid mine drainage. The calcareous strata is not laterally consistent between drill holes, but there is a prevalence of calcareous strata within the general stratigraphic interval. The calcareous unit most regularly identified was the Johnstown limestone (Brady, 2004). Overburden data reviewed during this technical study show a distinct paucity of calcareous material below the Middle Kittanning horizon (see figure 10). The data does however indicate several significant calcareous zones associated with Middle Kittanning, Upper Kittanning, Lower Freeport and Upper Freeport overburdens. Overburden testing results from two recent Bell Resources operations (Mulhollen and Hommer) north of state route SR253 confirm the presence of significant NP zones associated with Upper Freeport – Lower Freeport interburden.

Mine Discharges

There were 52 mine discharge sites identified within the Muddy Run study area that had water chemistry information available. The locations of these mine discharge sites are shown in Figure 11 (map pocket). Mining permit records contained water chemistry analyses for 45 of the discharge sites, 12 sites were described within the 1971 Operation Scarlift Report No. SL-155, and twelve discharge sites were sampled specifically during the course of this study. Eight of the original twelve Scarlift discharge sites were later sampled as permit monitoring points, seven of the permit monitoring sites were again sampled as part of this study, and one site, D-4 near the town of Blandburg, was sampled as part of the Operation Scarlift study, as part of the permitting process, and as a current site during this study. Most of the 12 discharge sites specifically sampled during this study were sampled at least once a month, over a 16-month period from May 1997 through August 1998.

Complete chemical analysis results for the mine discharge sites identified in this study are given in Appendix Table 4. Table 5 is a summary of the mine discharge chemistry. Relating discharge quality to a single coal seam is problematic due to the fact that the majority of surface mining operations extracted multiple coal seams. Also, many of the mine sites and discharges are decades old and historical records are sketchy. Only five of the discharges were related to a mining location where a single coal seam (Brookville coal) was mined. Thirteen of the discharge sites were associated with mining locations where two different coals were mined, usually the Brookville and Clarion coals. The remaining discharge sites are located near areas where from three to six coal seams were mined.

It was beyond the scope of this technical study to conduct an in-depth hydrologic investigation into the source of each and every mine discharge within the Muddy Run watershed. The five discharges located immediately down-structure of the two single-seam Brookville mine sites may be relied upon with a high level of confidence to show "Brookville" water quality. These discharges show pH values ranging from 2.7 to 4.6, sulfate concentrations ranging from 93 to 2487 mg/l, maximum concentrations of iron ranging from 2.1 to 211.4 mg/l, maximum concentrations of manganese ranging from 1.2 to 64.1 mg/l, and maximum concentrations of aluminum ranging from 13.3 to76.5 mg/l.

Discharges D-33 and D-34 occurred on permit #11850106 after mining was completed on that site. These discharges emanate on the permit directly down gradient from an area where the Mercer, Brookville and Clarion coal seams were mined, along with smaller amounts of Lower Kittanning coal. The discharges exhibit low pH, acidity values approaching 1000 mg/l, and very high metals concentrations. Iron and manganese concentrations often exceed 100 mg/l, while aluminum concentrations at times approach 60 mg/l. Because of these discharges, the Department released no bonds on permit #11850106 and required C & K Coal Company to treat the discharge. C & K treated the discharges with a combination of passive and chemical treatment systems until the company went into bankruptcy. The Department is in the process of collecting the bonds on the site.

Discharge D-14 occurs down gradient of an area where C & K Coal Company mined the Clarion and Brookville coal seams on permit #11840112. While the Department found that C & K had caused this discharge, the discharge was eventually determined to be "diminimus" in that the flow did not reach the receiving stream and the stream showed no signs of degradation from the discharge.

All but two postmining discharges within the Muddy Run study area are acidic. Most discharges are characterized by low pH and high concentrations of sulfate, aluminum, iron, and manganese. The two alkaline discharges, D-40 and D-42, do have elevated concentrations of metals (5.0 – 10.0 mg/l) and high levels of sulfate (300-700 mg/l).

Springs

Springs are associated with groundwater discharges at outcrops of coal formations, sandstones, and other geologic formations within the Muddy Run study area. The locations of 26 spring sample sites used in this study are shown in Figure 11 (map pocket). Fifteen of these springs were private water supplies. The locations and surface elevations of the springs were compared with stratigraphic intervals of coals and other geologic formations. Cross-sections, which include each of the 26 springs, are shown in Figure 12. There were 16 different stratigraphic intervals identified as spring sources (see Table 6). These stratigraphic intervals range from sandstones positioned 30 to 40 ft above the Upper Freeport coal

downward to a lower Mauch Chunk sandstone interval located 20 to 25 ft above the Loyalhanna Formation. Table 6 contains chemistry information on concentrations of iron, manganese, and sulfate in springs.

A listing of the complete water chemistry analyses for the 26 springs described in this study is given in Table 7. In order to identify those water analysis results in Table 7, which indicate the effects of mining, reported values exceeding certain limits are highlighted for pH and concentrations of iron, manganese, and sulfate. Any reported value for iron that is ≥1.0 mg/l is highlighted. This is well above natural background levels for iron in spring water flowing from formations associated with bituminous coals in central and western Pennsylvania (Lighty et al., 1995; McElroy, 1997). The value of 1.0 mg/l used for highlighting iron concentrations in Table 7 also is well above the EPA minimum standard of 0.3 mg/l for iron in drinking water. An iron content of 1.0 mg/l is the approximate iron concentration at which water visibly appears discolored to most people, and they might consider obtaining an iron filtering system for their household water supply. However, suspended solids can also affect total iron determinations, so an iron concentration > 1.0 in the presences of elevated suspended solids may not indicate an influence from mining.

All reported values for manganese that are ≥0.50 mg/l in Table 7 also are highlighted to clearly identify those samples that have been affected by mining activities. Manganese concentrations in spring water that are greater than 0.50 mg/l are generally higher than natural background levels, which in spring water of central and western Pennsylvania is almost always less than 0.10 mg/l, and usually less than 0.05 mg/l (Lighty et al., 1995; McElroy 1997). However, there are exceptions to this generalization, as is illustrated by the water quality data collected from spring SP-12, discussed later in this report, and it is not uncommon for spring emanating from Pottsville strata on the Appalachian Plateau in unmined areas to exhibit manganese concentrations approaching 1.0 mg/l. The highlighted concentration level of 0.50 mg/l for manganese is well in excess of the EPA minimum standard of 0.05 mg/l for drinking water, but is generally the level at which mineral deposits first appear in household plumbing and appliances, and some people consider obtaining a water filtering system.

All pH values lower than 4.0 are highlighted in Table 7. The natural background level of pH in spring water that flows from unmined coals, sandstones, and other strata associated with bituminous coal formations in central and western Pennsylvania is almost always greater than 4.0 and less than 7.0 (Williams and McElroy, 1991; McElroy, 1997; Lighty et al., 1995). It is also well established that coal mining in areas where the coal overburden is without neutralization potential usually results in surface and subsurface discharge water having a pH range of 2.5 to 4.0 (Rose and Cravotta, 1998). The EPA recommended lowest level for the pH of drinking water is 5.0.

All sulfate values ≥ 75 mg/l in Table 7 are highlighted as well. Sulfate concentrations greater than 75 mg/l are highlighted to show the possible influence of coal mining on spring water quality. Within central and western Pennsylvania, the natural background level of sulfate in groundwater unaffected by coal mining is normally less than 50 mg/l, and is rarely in the 50 to 100 mg/l range (Herb, et al., 1983; Stoner et al., 1987; Williams and McElroy, 1991; Lighty et al., 1995, 1996; McElroy, 1997), even when an unmined coal formation is the aquifer. In 1968, the U.S. Department of Interior reported that sulfate levels greater than 75 mg/l were indicators of the influence of acidic mine drainage upon surface waters of the upper Ohio River basin. In a recent study of the effects of coal mine discharges on stream water

quality in Cambria and Somerset Counties (Williams et al., 1996), the U. S. Geological Survey continued to use sulfate concentrations >75 mg/l as an indicator of the influence of acid mine drainage. The EPA recommended standard for sulfate concentration in drinking water is ≤ 250 mg/l. The highlighted numbers in Table 7 are meant to draw attention to water quality analysis that suggest a possible influence from mining operations, however, an occasional elevated parameter which is not consistent with the remaining data set, may indicate sampling and/or analytical error.

The following discussion briefly describes the springs identified in this study and relates their water quality to mining activities within the Muddy Run watershed. The springs are described in order from the highest to the lowest stratigraphic interval (see Table 6).

Near the northwestern border of the study area, there are three springs sourced by water flowing through formations positioned stratigraphically at or above the Upper Freeport coal. Private water supply spring SP-25 flows from sandstones located 30 to 40 ft above the Upper Freeport coal. Over nine years of sampling (1979-1988), there were no significant changes in concentrations of metals or sulfate. Sulfate levels remained within the background range of 9 to 68 mg/l. From the middle of 1988 up through 1991, the spring was reported as dry. No more samples were collected from SP-25 until 1997, when one sample was obtained. That sample showed an iron concentration of 3.1 mg/l and the sulfate level of 210 mg/l.

Private water supply spring SP-26 flows from a sandstone interval which occurs 20 to 30 ft above the Upper Freeport coal, and is located in very close proximity to spring SP-25. During two years of premining sampling of SP-26 during 1987 and 1988, there were minor amounts of metals present and background sulfate levels ranged from 16 to 78 mg/l. Beginning in 1988, and continuing through 1989, specific conductance, alkalinity, and sulfate concentrations all rose substantially in SP-26, showing a clear affect from alkaline mine drainage. While two samples collected in 1989 show elevated iron concentrations, and one of those samples show an elevated manganese concentration, the final sample of record collected from SP-26 on 10/10/89 showed iron and manganese levels each of 0.01 mg/l.

Private water supply spring SP-24 flows from the stratigraphic horizon of the Upper Freeport coal. This spring shows elevated sulfate concentrations throughout its sampling history from 1979 up through 1989.

Private water supply spring SP-23 is located on a hill in the northwest part of the study area that has never been mined. However, because this spring has been a monitoring point for other surface mines on nearby hills, there is over 17 years (1980-1997) of water quality information for this spring. Spring SP-23 flows from strata approximately 20 ft below the Upper Freeport coal. In 69 water samples, the concentrations of iron and manganese have remained minimal (iron < 0.50 mg/l, manganese < 0.15 mg/l) and the background levels of sulfate have never exceeded 39 mg/l.

Spring SP-19 flows from the stratigraphic interval of the Lower Freeport coal. This spring contributes to the headwater flow of an unnamed tributary to Muddy Run in the northwest part of the study area. The few samples collected from this spring during the early 1980s show no effect of mining, only natural background metals concentrations and sulfates less than 10 mg/l. Prior to 1997, there was no mining of the Lower Freeport coal immediately up-gradient of this site.

Spring SP-20 flows from a sandstone interval situated approximately 30 ft below the Lower Freeport coal. This spring is located near SP-19, and also has contributed to the headwater flow of the unnamed tributary to Muddy Run in the northwest part of the study area. Unlike nearby springs SP-19 and SP-23, spring SP-20 discharges from a hillside above an old Upper Kittanning highwall. This hillside has been mined or remined four times by different companies. Spring SP-20's water chemistry shows widely varying water quality over time. Episodic up-gradient mining appears to have impacted the spring chemistry, however, the variability of the data, especially in terms of sulfate concentrations, also suggest a potential problem with the sampling history such as mixed sampling locations.

Spring SP-21 was sampled from a sandstone unit situated 5 ft stratigraphically lower than SP-20, and is located just to the northeast, also above an old Upper Kittanning highwall. SP-21 was sampled twice in 1994, prior to the most recent remining operations in this area. Metals concentrations were minimal, and sulfate levels were just slightly elevated above natural background levels.

SP-22 is located along the hillside above an old Upper Kittanning highwall, approximately 1000 ft north-northeast of spring sites SP-20 and SP-21. SP-22 was only sampled twice, both samples show alkaline water with low metals concentrations, however, the second sample shows much higher sulfate levels, indicating an influence from alkaline mine drainage.

Spring SP-2 flows from a hillside on the Reade Township High School property, near the intersection of highways SR1024 and SR865. This spring is in close proximity to a hilltop mine site were several coals were surface and underground mined over the years. This spring was minimally affected by mine drainage when first sampled in 1978. While the spring has remained alkaline with generally low metals concentrations, sulfates appear to have increased slightly in the ensuing years, but usually have remained below the secondary drinking water level of 250 mg/l.

Private water supply spring SP-8, located approximately 1,000 ft north of spring SP-2, also is sourced by groundwater flow from the Upper Kittanning coal interval. Spring SP-8 was the water supply for the Robert Rannels household, according to permit records, and untreated water samples were collected from the plastic outlet pipe of the springhouse. This spring was sampled between 1980 and 1984 as a monitoring point for a surface mine on the Lower, Middle, and Upper Kittanning coals. This mine was situated farther to the north and down-structure of the SP-8 spring. While the last sample collected from SP-8 showed a sulfate level of 161 mg/l, it was otherwise unaffected by mining.

Viewed collectively, the monitoring data collected from springs emanating from the Upper Kittanning, Lower Freeport and Upper Freeport coals and overburdens in mined areas show alkaline water quality with elevated sulfates and metals concentrations that generally meet mine drainage limitations, but that sometimes exceed the secondary drinking water standards for iron, manganese and sulfates.

Private water supply SP-3 flows from the stratigraphic interval of the Middle Kittanning coal. This spring was the water supply for the Francis Nole household, and is located just north of highway SR1024 and several hundred feet from spring SP-2 on the Reade Township High School property. This spring also is within several hundred feet and immediately down-structure of a hilltop site where the Upper and Middle Kittanning coals were surface mined. Spring SP-3 was sampled from June 1981 until December 1990 as a monitoring point for this mining operation. Mining started in January 1978 and was completed by February 1985. The quality of SP-3 was essentially unchanged during the monitoring period, with the

exception of sulfate, which appears to have increased, but which remained below the recommended drinking water level of 250 mg/l.

Four springs were sampled which flow from the stratigraphic interval of the Lower Kittanning coal. All four springs are located near the southwest corner of the study area. Spring SP-1 is located along highway SR865 and springs SP-4, SP-5, and SP-6 are located close to each other along highway SR1024 (see Figure 11).

Private water supply spring SP-1 is located just east of highway SR865 and was the water supply for the households of Elwood Dixon and Lewis Wagner. This spring flows from the stratigraphic interval of the Lower Kittanning coal and is located within several hundred feet of a large hilltop mine site where the Lower, Middle and Upper Kittanning coals were surface mined. In April 1976, prior to mining of this site, the spring had an iron concentration of 0.20 mg/l and a natural background sulfate level of 30 mg/l. Sulfate levels indicate that sometime between 1983 and 1986 the spring was affected by mine drainage. The four samples collected after 1983 were all treated water, however, so an evaluation cannot be made of mining's influence on the alkalinity and metals concentrations of the spring.

Spring SP-4 emanated from the Lower Kittanning coal interval as a groundwater discharge into the roadside ditch along highway SR1024 north of the town of Blandburg. This roadside spring, located down gradient of surface and deep mined areas, was sampled just once, in July of 1984. The spring was alkaline, but the reported iron concentration was 19.59 mg/l, the manganese concentration was 7.88 mg/l, and the sulfate concentration was 495 mg/l.

Private water supply spring SP-5 flows from the Lower Kittanning coal interval and is located along highway SR1024 between springs SP-4 and SP-6 (Figure 11). Spring SP-5 was the water supply for the Gertrude McCartney household, and was sampled at the spring house on the property. Two water samples were collected from SP-5, one in 1985 and one in 1986. Both samples show the spring to be affected by acidic mine drainage.

Private water supply spring SP-6 also flows from the Lower Kittanning coal interval, and also is located along highway SR1024 a few hundred feet west of SP-5. This spring was the water supply for the R. Grossman household and was sampled once on March 21, 1985. An untreated water sample was collected from the garden spigot, and a treated water sample was collected from the kitchen tap. The untreated water sample had an aluminum content of 28.39 mg/l, a manganese content of 16.71 mg/l, a sulfate level of 411 mg/l, a pH of 4.1, and an acidity of 152 mg/l. The treated water sample had an aluminum content of 1.34 mg/l, a manganese content of 2.76 mg/l, a sulfate level of 218 mg/l, a pH of 4.9, and an acidity of 22 mg/l.

Two springs were identified that flow from the stratigraphic interval of the Clarion coal. One spring was located in the southwest part of the study area and one spring is located in the north central part of the study area. Private water supply spring SP-7 flows from the Clarion coal stratigraphic interval, and is located several hundred feet north of highway SR1024, farther north and down-structure from springs SP-5 and SP-6. Spring SP-7 emanates from the hillside below the D.W. McCartney farmhouse and flows downhill into an agricultural pond. This spring was sampled once on March 20, 1984. The reported iron concentration was less than 0.30 mg/l. The slightly elevated manganese content was 0.57 mg/l, and the reported sulfate concentration was 103 mg/l.

Private water supply spring SP-17 also flows from the Clarion coal interval. This spring was the water supply for the E. Rudzinski household, and was sampled from the overflow pipe of the spring house. The spring is located along the southern hillside of the Curtis Run valley in the north central part of the Muddy Run study area. This spring was sampled once on May 10, 1984. The reported iron content for the spring was less than 0.10 mg/l, however the manganese concentration was 1.20 mg/l and the sulfate level was 138 mg/l. The spring water had a pH of 5.5 and an acidity of 72 mg/l.

Three springs were identified that flow from the Brookville coal interval. Two springs are located in the southwest part of the Muddy Run study area, and one spring is situated in the northeast part of the watershed. Private water supply SP-9 flows from the Brookville coal horizon and was the source of water for the Mertle Winger household. Spring SP-9 is located along township road T564, approximately 1000 ft north of highway SR1024. Following a complaint by Mertle Winger that her spring water had just gone bad, her water supply spring was sampled on September 2, 1986. The water sample analysis indicated that the Winger household spring was affected by acidic mine drainage. The spring had an iron content of 224 mg/l, a manganese content of 10.9 mg/l, a sulfate level of 1080 mg/l, a pH of 5.4, and an acidity of 484 mg/l.

Private water supply SP-10 flows from the stratigraphic interval of the Brookville coal. This spring was the water supply for the Margaret D. McCartney household. The spring is located approximately 1,250 ft north of highway SR1024 and the same distance east of township road T564. This hillside spring is located down-slope from two different recent surface mine sites, and has been a water monitoring point for over 14 years. The spring is also located a few hundred feet down-gradient, directly down-structure, and west of a more recent surface mining operation where the Brookville and Clarion coals were mined from 1992 to 1994. A dramatic change in water quality of this spring has occurred during the past 14 years. Figure 13 shows the pronounced changes in sulfate, manganese, iron, and pH through time. An investigation conducted by hydrogeologists at the Department's Cambria District Mining Office concluded that the spring was degraded by one of the nearby surface mining operations.

Spring SP-16 is located on the R. Barr property in the northern part of the Muddy Run study area. Spring SP-16 is situated on a hillside on the southern side of Curtis Run, a tributary to Muddy Run. This spring was only sampled once, in November 1979, as a background sample point for a surface mine located to the west and down-structure. The results of the 1979 sample indicate that SP-16 had a pH of 3.4, an acidity of 100 mg/l, an iron concentration of 2 mg/l, and a manganese content of 52 mg/l. The sulfate concentration was 864 mg/l.

There were three springs identified in the Muddy Run study area that flow from the stratigraphic interval of the Mercer coals. All of these springs are located in the central part of the study area. Two springs are associated with the Mercer coal that is situated 50 to 55 ft below the Brookville coal, and one spring flows from the Mercer coal found approximately 80 ft below the Brookville coal.

Spring SP-15 emanated from the stratigraphic interval of the Mercer coal situated 50 to 55 ft below the Brookville coal. Spring SP-15 was sampled once on July, 17, 1984, as a background sample for a surface mine permit that was issued in April of 1988. Spring SP-15 was sampled at a road ditch on the eastern hillside of the Muddy Run valley, approximately 1,500 ft upstream of highway SR253. The pH of the water sample was 6.3 and the sulfate level was 128 mg/l. The iron concentration was 3.58 mg/l

and the manganese concentration was 1.08 mg/l. Previous mining had occurred up gradient of SP-15 on the Brookville, Clarion and Lower Kittanning coals.

Private water supply SP-18 is located along highway SR253 between Muddy Run and Curtis Run, and serves as the water supply spring for the Anthony Matthew household. This spring is situated along the southern hillside valley of Curtis Run, and flows from the stratigraphic interval of the Mercer coal found 50 to 55 ft below the Brookville coal. Since 1950 there have been several surface mining operations in close proximity to this water supply spring (Figure 11). SP-18 was affected by mine drainage when first sampled in 1979. It appears that the spring worsened significantly between 1979 and when it was next sampled in 1985, although the six-year sampling hiatus complicates this interpretation. SP-18 was sampled numerous time between 1985 and 1997, and those data show the spring to be badly degraded by acidic mine drainage, with no obvious changes in quality between 1985 and 1997.

Water supply spring SP-14 is located at the Reade Township Sportsman's Club, several hundred feet north-northeast of the RTMA Muddy Run #2 well. Spring SP-14 flows from the Mercer coal interval situated approximately 80 ft below the Brookville coal. This spring is an alternate water supply to the Reade Township Sportsman's Club. A nearby surface mining operation on the Brookville and Clarion coals was conducted between 1992 and 1994, although it appears that little or no mining took place up gradient of SP-14. The SP-14 spring was sampled 52 times since May of 1984 as a monitoring point for this adjacent surface mine. The quality of SP-14 is typical of background for springs emanating from Pottsville rocks on the Appalachian Plateau; it is mildly acidic with low sulfate concentrations, and relatively low metals concentrations.

Viewed collectively, within the study area, springs located down gradient of mined areas on the Lower Kittanning, Clarion, Brookville, and Mercer coal seams are generally affected by acidic mine drainage, and often produce water that does not meet typical mine permit effluent limits or recommended drinking water levels.

Two springs were sampled within the Muddy Run study area that flow from sandstone units of the lower part of the Mauch Chunk Formation, from sandstone strata situated approximately 20 to 25 ft above the top of the Loyalhanna Formation. These two springs are situated along the center of the Muddy Run valley, approximately 1,500 ft up-stream and up-structure of the RTMA Muddy Run #1 well. Spring SP-11 is a channel flow from a wetland area located at the confluence of the two main headwater tributaries of Muddy Run (see Figure 11). Spring SP-12 flows from the nearby hillside at a site located approximately 200 ft to the northeast, downstream and on the eastern side of the valley.

Spring SP-11 was sampled once in 1991, as a background sample for a nearby surface mine on the Brookville and Clarion coals, that was mined between 1992 and 1994. The SP-11 spring was not sampled again until this study of the Muddy Run watershed. As part of this study, the spring was again located and sampled 21 times between May 1997 and August 1998. During this period the water quality of the spring changed significantly as the flow of the spring changed. The changes in spring flow and related changes in water quality are seasonal. Figure 14A shows the seasonal changes in pH and concentrations of aluminum, iron, and manganese. Figure 14B shows the seasonal changes in pH, sulfate concentration, and flow rate of the spring. Between May and October of 1997, the flow decreased from a range of 60 to 75 gpm to a range of 10 to 25 gpm. During these months of lower spring flow, the pH ranged from 5.9 to 6.2, sulfates ranged from 22 to 74 mg/l, aluminum concentrations were always less

than 0.66 mg/l, and elevated manganese concentrations ranged from 0.65 to 2.8 mg/l (avg. 1.48 mg/l). Iron concentrations ranged from 0.32 to 0.86 mg/l during the first few months when spring flow was high (60 to 75 gpm), but increased to a range of 0.84 to 2.83 mg/l (avg. 1.49 mg/l) when spring flow dropped off to a range of 10 to 25 gpm. The sulfate concentrations in SP-11 indicate a possible slight influence from mining, but generally are less than 100 mg/l.

Spring SP-12, located on the eastern side of the Muddy Run valley, approximately 200 ft northeast of spring SP-11, also flows from a lower Mauch Chunk sandstone unit situated stratigraphically 20 to 25 ft above the underlying Loyalhanna Formation. The SP-12 spring also was sampled once in November 1991, as a background sample point for the 1992 to 1994 Brookville-Clarion surface mine located approximately 1000 ft to the west on the hill on the other side of Muddy Run. The 1991 sample had a pH of 6.2, an acidity of 3 mg/l, and an alkalinity of 17 mg/l. The sulfate concentration was 44 mg/l. All metals were at background levels. The aluminum concentration was < 0.50 mg/l, the iron concentration was < 0.30 mg/l, and the manganese concentration was 0.26 mg/l. The flow of the spring was reported as 25 gpm.

There were no other samples collected from this spring until May 1997. Starting in May 1997 through August 1998, there were 21 samples collected from spring SP-12 as part of this study of the Muddy Run watershed. During 1997 and 1998 the water quality of spring SP-12 also varied in response to spring flow rates, in a manner similar to SP-11, but the range of variations were not as great as those noted for spring SP-11. The quality of SP-12, while showing a depressed pH, net acidity, and somewhat elevated aluminum and manganese levels, is fairly typical of springs emanating from sandstone formations along the Allegheny front, and does not indicate an influence from mining.

Private Water Wells

There are more than 60 private water supply wells within, and adjacent to, the Muddy Run study area. This study deals with the water quality and geologic setting of 22 private water wells, which were located in proximity to mining operations. The locations of the 22 private water wells analyzed in this study are shown in Figure 11 (map pocket).

The stratigraphic interval of each of the 22 private water wells was determined and compared with stratigraphic intervals of coals and other geologic formations within the Muddy Run study area and by constructing geologic cross sections which included the depth interval of each water well and all surrounding drill hole information. Geologic cross sections containing the 22 private water wells are shown in Figure 16. The stratigraphic interval identified for each water well and its depth relative to coal formations is given in Table 8. The stratigraphic intervals of the water wells ranged from the highest interval starting approximately 50 ft above the Mahoning coal, at the top of well W-21, downward to the deepest stratigraphic position, located approximately 10 ft above the top of the Mauch Chunk Formation at the bottom of well W-12. Figure 15 shows the approximate stratigraphic position determined for the 22 private water supply wells, and the coal formations penetrated by each water well. Most of the water wells penetrate at least one coal formation, and nearly half of the wells penetrate two or more coals.

The water well depth interval summary given in Table 8 also contains summary information on the concentrations of iron, manganese, and sulfate reported for water samples from these wells. A listing of the complete water chemistry analyses for the 22 private water wells is given in Table 9. Reported values are highlighted for pH, iron, manganese, and sulfate that exceed the limits previously discussed; specifically, all iron values ≥1.0 mg/l, all manganese values ≥0.50 mg/l, all pH values <4.0, and all sulfate values ≥75 mg/l are highlighted.

The following discussion briefly describes the 22 private water wells identified in this study and relates their water quality to coal mining activities within the Muddy Run watershed. The water wells are described in stratigraphic order, from the highest to the lowest stratigraphic intervals penetrated by the wells (see Table 8 and Figure 15).

There are seven private water wells that are situated stratigraphically above the Upper Freeport coal and whose well depths extend downward through the Upper Freeport coal. Three of these wells are deep enough to also penetrate through the Lower Freeport coal. Two of the wells originate above the Mahoning coal interval, two wells originate at the approximate stratigraphic position of the Mahoning coal, and three of the wells originate in strata between the Mahoning and Upper Freeport coal intervals (Figure 15).

Private water well W-21 is developed in the highest stratigraphic interval, with the top of the well situated approximately 50 ft above the Mahoning coal. It is the deepest drilled private water well analyzed in this study, being 185 ft deep and extending to a depth approximately 75 ft below the Lower Freeport coal. W-21 is located just southwest of the intersection of township roads T534 and T535, approximately 1000 ft west and northwest from several surface mines in the northwest corner of the study area, and is the private water supply for the Mark Naylor household. The water well is cased to a depth of 20 ft, and its water is drawn from a sump pump positioned at a well depth of 175 ft. W-21 was sampled 17 times between 1987 and 1998, as a monitoring point for three of the several adjacent surface mines. The water in W-21 is highly alkaline. Beginning in 1989, the sulfate concentrations in the well appear to have increased, but consistently remained below the recommended drinking water threshold of 250 mg/l. With the exception of the last sample (collected in 1998), the iron and manganese concentrations in the W-21 well show no trends, and are typical of local natural groundwater, although they occasionally exceed recommended secondary drinking water levels. The last sample does show much higher iron and manganese concentrations than the previous sampling data, but this increase is not accompanied by an increase in sulfate levels.

Private water well W-19 is the private water supply for the Wayne Hamilton household. The well is located a few hundred feet west of township road T535 and the permit boundaries of several surface mines located in the northwest corner of the study area (Figure 11). Well W-19 is located approximately 1000 ft southeast and directly up-structure of well W-21. Private water well W-19 is 100 ft deep, and extends from 15 ft above the Mahoning coal to 25 ft below the Upper Freeport coal. The upper 25 ft of the well is cased.

Well W-19 was sampled nine times between January 1987 and October 1989. W-19 is moderately alkaline with very low metals concentrations. (One sample collected in 1987 showed elevated metals, but also was affected by high suspended solids.) The sulfate concentrations in the well have been

unusually variable, with no apparent meaningful pattern or trend. On two occasions sulfate levels in the well did slightly exceed the secondary recommended level 250 mg/l, but each time the next sampling showed very low sulfate concentrations.

Private water well W-20 is the private water supply for the Lynn Traveny household, and is located a few hundred feet east of well W-19, east of township road T535 and just within or near the permit boundaries of several surface mines located in the northwest corner of the study area (Figure 11). Well W-20 is 110 ft deep and the upper 25 ft are cased. Well W-20 is 10 ft deeper than well W-19 and it penetrates from the stratigraphic interval of the Mahoning coal, 60 to 65 ft above the Upper Freeport coal, downwards to 45 to 50 ft below the Upper Freeport coal, most likely through the Lower Freeport coal interval. The bottom of nearby well W-19 only extends 25 ft below the Upper Freeport coal. Several episodes of surface mining have occurred near and up-gradient of W-20. Throughout the sampling period, the water in W-20 was alkaline with elevated iron, manganese and sulfate concentrations, showing a clear influence from alkaline mine drainage.

Private water well W-18 is located just west of township road T535, approximately 1000 ft south of well W-19, near the border of Cambria and Clearfield Counties (Figure 11). Well W-18 is the private water supply for the Laverne Lovell household, and is 75 ft deep. The top of well W-18 is situated near the stratigraphic interval of the Mahoning coal. The depth of the well extends downward to approximately 5 ft below the Upper Freeport coal. Between April 1983 and October 1988, this well was sampled 13 times as a monitoring point for a bordering surface mine on the Middle and Upper Kittanning coals. The data for W-18 show highly variable metals concentrations, but sulfates in the well have been low throughout the sampling period. W-18 is unaffected by mine drainage.

Private water well W-17 is located several hundred feet east of well W-18, on the east side of township road T535, also just north of the county line. Well W-17 also was sampled as a monitoring point for the Middle and Upper Kittanning surface mine bordering the well to the south and southeast, directly up-structure. Well W-17 is the private water supply for the William Bradford household. The well is 100 ft deep and the upper 20 ft are cased. The top of the well is situated approximately 45 to 50 ft above the Upper Freeport coal, and the well extends downward 50 to 55 ft below the Upper Freeport coal, most likely through the Lower Freeport coal interval.

Untreated water samples from well W-17 were collected from the kitchen tap, twice in 1983 and once each in 1984, 1986, and 1988. The water in W-17 is mildly alkaline with generally low metals and sulfate concentrations; however, the last sample shows some indication of an increase in iron, manganese, and sulfate concentrations in the well.

Private water well W-22 is located approximately 1000 ft east of township road T534, at the Frederick Heverly residence located on the north side of township road T534. Well W-22 is situated within several surface mine permit areas, and several hundred feet north and down-structure from several other surface mines in the northwest corner of the study area (Figure 11). The upper 20 ft of the Heverly water supply well is cased. The total depth of the well is unknown. The top of well W-22 is situated 30 ft above the Upper Freeport coal, and the well extends downward to at least 10 ft below the Upper Freeport coal interval.

Between November 1988 and February 1997, well W-22 was sampled 24 times as a monitoring point for two surface mines. Based on sulfate concentrations, W-22 has been affected by mine drainage throughout the monitoring period. Because all samples from the well are reportedly treated, and because three different treatment systems have been in place on the well, metal and alkalinity concentrations are difficult to interpret. However, high metals concentrations were detected on several occasions despite treatment.

Private water well W-16 is the water supply for the Robert Lovell household. Well W-16 is located just north of township road T570, approximately 1200 ft south of the Cambria / Clearfield County border, in the northwest part of the Muddy Run study area. Well W-16 is a hand-dug well that is 18 to 20 ft deep. Stratigraphically, the top of well W-16 is situated approximately 45 ft below the Mahoning coal interval and 15 ft above the Upper Freeport coal. The well extends to a depth that is 3 to 5 ft below the Upper Freeport coal.

Untreated water from well W-16 was collected from the kitchen tap on 22 occasions between April 1983 and June 1992. Well W-16 was a monitoring sample point for an adjacent surface mine on the Middle and Upper Kittanning coals. The location of well W-16 is included within the permit area for this surface mine (see Figure 11). Sulfate levels show W-16 to be unaffected by mine drainage. The well does suffer occasionally from elevated iron concentrations, which, due to the low sulfate concentrations, appear to be unrelated to mining.

There are six private water wells that are situated stratigraphically between the Upper Freeport coal and the Middle Kittanning coal (Table 8 and Figure 15). Three wells extend downward through strata between the Lower Freeport coal and the Upper Kittanning coal. Two of these wells are deep enough to encounter strata below the Upper Kittanning coal. One of these wells also encounters the entire interval between the Upper Freeport and Lower Freeport coals. The depth intervals of three other wells occur within the strata between the Upper and Middle Kittanning coals. One of these wells may extend downward through the Middle Kittanning coal.

Private water well W-13 is the water supply of the Wendell Hollihen household. Well W-13 is located just north of state route SR253, approximately 750 ft northeast of Curtis Run and 1300 ft south of the Cambria – Clearfield County line, in the north central portion of the Muddy Run study area. The well is 95 ft deep and is situated stratigraphically from the approximate position of the Upper Freeport coal downward through the Lower Freeport coal to a depth of 5 ft below the Upper Kittanning coal.

Well W-13 was sampled three times, once in 1979 and twice in 1985, as a background sample point for a nearby surface mine on the Mercer, Brookville, Clarion, and Lower Kittanning coals. The sampling frequency of W-13 was sporadic, the background sampling on W-13 was affected by high suspended solids, and some aspects of the sampling results appear otherwise questionable, so the data from W-13 do not warrant detailed discussion.

Private water well W-14 is located approximately 400 ft south of well W-13, along the south side of state route SR253, in the north central part of the study area. Well W-14 is the water supply for the Rick Folk household. The well is 60 ft deep, extending downward from the approximate stratigraphic interval of the Lower Freeport coal to a depth of 20 to 25 ft below the Upper Kittanning coal. This well was sampled as a background sample point for the nearby surface mining operation, which commenced

operations in March of 1989. Wells W-13 and W-14 were sampled on the same three dates in 1979 and 1985. As with W-13, the sampling frequency of W-14 was sporadic, the background sampling was affected by high suspended solids, and some aspects of the sampling results appear otherwise questionable, so the data from W-14 do not warrant detailed discussion.

Private water well W-2 is the water supply for the Gloria Austin household. Well W-2 is located along state route SR1024, near the southeast corner of the road intersection between state route SR865 and SR1024 in the southwest part of the Muddy Run study area, northwest of Blandburg. The upper 20 ft of well W-2 is cased, but the total depth of the well is unknown. The stratigraphic position of the top of the well is 20 ft below the Lower Freeport coal and 25 ft above the Upper Kittanning coal. The bottom of the well is at least 40 ft below the Lower Freeport coal and 5 ft above the Upper Kittanning coal. The depth of the well may extend through the Upper Kittanning coal as well. Water from well W-2 was sampled only once, in relationship to an adjacent surface mine on the Kittanning and Freeport coals. On April 9, 1986, a treated water sample was collected from the outside spigot of the Austin residence. The iron concentration of the treated water was <0.30 mg/l and the manganese concentration was <0.05 mg/l, but the sulfate concentration was elevated at 194 mg/l, still below the recommended level of 250 mg/l. Several mining operations occurred up-gradient of W-2, which would account for the elevated sulfate concentrations.

Private water well W-1 is the water supply of the Robert Myers household. This well is hand dug and is 20 ft deep. The well is located along the west side of state route SR865, due west of Blandburg. The top of well W-1 is positioned at the Upper Kittanning coal interval or just above, and is 55 ft above the Middle Kittanning coal. The bottom of the well is situated 10 to 20 ft below the Upper Kittanning coal and 35 ft above the Middle Kittanning coal.

Well W-1 was sampled 32 times from the kitchen tap of the Robert Myers residence, as a monitoring point for the adjacent surface mine which started mining in January of 1978. Premining water sample analyses were not available. Between 1979 and 1990, when monitoring ceased, the quality of the water in W-1 changed in that sulfate, alkalinity, conductance, iron, and manganese concentrations all progressively increased, although not substantially. Sulfate concentrations remained below the recommended level of 250 mg/l, but did increase enough to indicate an influence from mining. Iron and manganese concentrations each remained below 1.0 mg/l, but increased enough to likely be noticeable to the water supply users.

Private water well site W-6 represents three adjacent wells, which have been the water supply for the Robert Rannels household. These wells are located approximately 1200 ft northeast of the road intersection of state routes SR865 and SR1024, in the southwest part of the Muddy Run study area. One of the Rannels water supply wells is hand dug to a depth of 8 ft. This well has been sampled four times. An older well of unknown depth also has been sampled four times on the same dates, and a newer well of unknown depth has been sampled twice, once on the same day as sampling of the other two Rannels wells. Analysis results for all three wells are given in Tables 8 and 9.

Stratigraphically, the hand-dug well occurs from 10 to 15 ft below the Upper Kittanning coal interval, downward to 18 to 23 ft below the Upper Kittanning coal interval. This well depth is situated from 40 to 45 ft above the Middle Kittanning coal, downward to 32 to 37 ft above the Middle Kittanning coal. Although the total well depths for the other two Rannels wells are unknown, the tops of these wells occur

at the same approximate stratigraphic position as the hand-dug well, that is 10 to 15 ft below the Upper Kittanning coal.

The W-6 Rannels water supply wells were sampled on five occasions between September 1983 and November 1985, in relationship to a surface mine on the Lower, Middle, and Upper Kittanning coals that was located approximately 600 ft directly north and down structure from the well. Surface mining started at this site in October 1979 and was completed, with the site backfilled, by December 1987. All water samples from the wells were collected while mining was underway at this mine site. With the exception of one slightly elevated sulfate concentration, the dug well was not affected by mine drainage on the four occasions it was sampled. The "old well" data show a more pronounced influence from mine drainage, but given the lack of information concerning well depth and the variability of the chemistry, few conclusions can be drawn regarding the source or timing of the apparent mining-related impacts. The two samples on the "new well," also of unknown depth and construction, show alkaline water with varying metals concentrations and a sulfate concentration that implies a slight influence from mining.

Private water well W-5 is the water supply for the Winfield Scott household, and is located approximately 400 ft south-southeast and up-structure of well W-6, in the southwest part of the Muddy Run study area. The depth of this well is unknown, but the top of the well occurs at the stratigraphic position 15 to 20 ft below the Upper Kittanning coal and 35 to 40 ft above the Middle Kittanning coal. This well may penetrate through the Middle Kittanning coal interval.

Well W-5 was sampled only once, on March 4, 1977, as a background sample for a large surface mine located just northwest of Blandburg, approximately 1100 ft directly up structure from well W-5. The water sample had an iron concentration of 0.26 mg/l, and an elevated sulfate level of 135 mg/l.

Private water well W-4 is situated below the Lower Kittanning coal interval, and has been the water supply for the household of Gustav Becquet and Charles Shade. This well is located along the north side of state route SR1024, approximately 1400 ft east of the intersection of state route SR1024 and township road T564, north of the town of Blandburg. Well W-4 is a dug well that is at least 5 ft deep. The top of the well occurs at the stratigraphic position 10 to 15 ft below the Lower Kittanning coal, and 50 to 55 ft below the Middle Kittanning coal interval.

Well W-4 was sampled only once, on March 21, 1985, as a background sample point for a surface mine on the Brookville and Clarion coals that is located over 1000 ft to the northeast, mainly down structure from the well. This surface mine began mining operations in February of 1992.

The water sample of well W-4 was collected untreated from the kitchen tap, and showed that the well water was degraded by manganese and sulfate. The elevated manganese concentration was 5.16 mg/l, and the sulfate concentration was 256 mg/l. The iron concentration was minimal, reported as <0.30 mg/l. The pH of the well water was 5.0, and the reported acidity was greater than alkalinity.

Private water well W-3 is the water supply for the Howard and Janet Himes household. The well is located along the south side of state route SR1024, approximately 800 ft west of the intersection of SR1024 and township road T564. The well is 65 ft deep, and occurs stratigraphically from 10 to 20 ft below the Lower Kittanning coal to a depth 75 to 85 ft below the Lower Kittanning coal. This well penetrates through the Clarion and Brookville coal intervals.

Four water samples were collected from well W-3, as monitoring point samples for two nearby surface mines operated by the same company. All four samples from this well show that the groundwater in the Brookville/Clarion intervals at this location is impacted by acidic mine drainage, with low pH values, and high acidity, iron, manganese, and sulfate concentrations.

Private water well W-7 is the water supply for the Jerald Jacoby household. Well W-7 is located along the western side of township road T564, approximately 500 ft north of the intersection of T564 and state route SR1024. Well W-7 also is situated approximately 800 ft north-northeast of well W-3. Two water samples from well W-7 were collected from a basement spigot before the water was treated. Both samples indicate an influence from mining in that sulfate concentration are elevated beyond what one would expect for background groundwater quality. The water in W-7 was slightly acidic, although relatively typical for its stratigraphic position. The iron concentrations in the two samples from this well are somewhat contradictory.

Private water wells W-8 and W-9 also are developed in strata between the Clarion and Brookville coals. These wells are deep enough to extend downwards through much or all of strata between the Brookville coal and the shallowest Mercer coal (Figure 16). Wells W-10 and W-11 also are developed in strata between the Brookville coal and the shallowest Mercer coal. Although their total well depths are unknown, they may extend downward through the Mercer coal interval.

Private water well W-9 is the water supply for the Willard Welch household. The well is located along the western side of township road T564, approximately 1200 ft north of the road intersection of T564 and state route SR1024, in the southwest part of the study area. Well W-9 is a dug well that is 50 ft deep. Stratigraphically, the top of well W-9 is at or 5 ft below the Clarion coal interval, 20 ft above the Brookville coal, and 75 ft above the shallowest Mercer coal. The bottom of well W-9 is 50 to 55 ft below the Clarion coal interval, 30 ft below the Brookville coal, and 25 ft above the shallowest Mercer coal.

Well W-9 was sampled only once, on November 21, 1979, in connection with the sampling program for a surface mine which started mining one month earlier. That sample shows the water in the well to be net alkaline, with an elevated iron concentration, and a sulfate concentration (110 mg/l) that indicates a slight influence from mine drainage.

Private water well W-8 has been the water supply for the household of Robert Beers and Mertle Winger. This private water well is located just a few hundred feet southwest of well W-9, along the west side of township road T564, in the southwest part of the Muddy Run study area. Well W-8 also is approximately 700 ft north of water well W-7. Well W-8 is 80 ft deep. The top of well W-8 is situated 5 to 10 ft below the Clarion coal interval, 20 to 25 ft above the Brookville coal, and 80 to 85 ft above the shallowest Mercer coal. The bottom of well W-8 is positioned 85 to 90 ft below the Clarion coal interval, 55 to 60 ft below the Brookville coal, and at or 5 ft above the shallowest Mercer coal.

Untreated W-8 well water has been sampled five times at the kitchen tap of the Beers/Winger residence in connection with water sampling for three nearby surface mines. The first three samples of W-8 indicate a slight influence from mine drainage based on elevated sulfate levels in two of the three samples. Sometime between the third sample collected in March of 1985 and the fourth sample collected

in July of 1986, W-8 worsened substantially, in that the acidity, iron, manganese, and sulfate concentrations all increased greatly, showing a severe impact from acidic mine drainage.

Well W-10 is located along the east side of township road T564, approximately 1,500 ft north of the intersection of T564 and state route SR1024, in the southwest part of the Muddy Run study area. Well W-10 is situated about 200 ft northeast of well W-9. The top of well W-10 occurs near the outcrop of the Brookville coal. The depth of well W-10 is unknown. If well W-10 is more than 50 ft deep, there is a high probability that the depth of the well intercepts the shallowest Mercer coal.

Untreated well water from well W-10 was collected from the outside spigot of the McCartney residence 38 times between January 1981 and August 1995, as a monitoring sample point for a Brookville-Clarion surface mine located 1,500 ft to the east. Throughout its sampling history, the quality of W-10 was severely impacted by acidic mine drainage. The quality of the well appears to have gradually improved over the fourteen-year monitoring period, although it remained substantially impacted when last sampled in 1995. Natural attenuation of the mine drainage that was affecting the water quality associated with the Brookville/Clarion horizons is the most likely explanation of this gradual improvement in the quality of W-10.

Private water well W-11 is the water supply for the D. Wilkins household. Well W-11 is located along the west side of township road T564, approximately 2,000 ft north of the intersection of T564 and state route SR1024, in the southwest part of the study area. Well W-11 is situated approximately 700 ft northwest and down-structure from well W-10. The depth of well W-11 is unknown. The stratigraphic position of the top of well W-11 is approximately 15 ft below the Brookville coal interval, and 35 ft above the shallowest Mercer coal.

Well W-11 was only sampled once, on March 18, 1985, as a background sample for a surface mine on the Brookville and Clarion coals that commenced mining operations in 1992. The Brookville/Clarion mine site is located approximately 2,000 ft east of well W-11. The March 1985 water sample was collected untreated from the kitchen tap of the Wilkins residence. The water sample had a slightly elevated iron content of 0.84 mg/l and an elevated sulfate level of 152 mg/l. The manganese content was <0.50 mg/l.

Private water well W-15 is the water supply for the Terry Matthew household. Well W-15 is located on the south side of state route SR253, approximately 700 ft southwest of where SR253 crosses Curtis Run, between Curtis Run and Muddy Run in the north-central part of the study area. The well is 35 ft deep. The top of the well is positioned stratigraphically 47 ft below the Brookville and 10 to 13 ft below the Mercer coal. The bottom of well W-15 is 82 ft below the Brookville coal and 45 to 48 ft below the Mercer coal.

Well W-15 was sampled 32 times from the outside spigot of the Terry Matthew residence, as a monitoring sample point for an adjacent surface mine on the Mercer, Brookville, Clarion, and Lower Kittanning coals. The well is situated along the northern border of the permit area of this surface mine, and the eastern part of the mined area is situated directly up-structure from the well. Mining at this site started in March of 1989, and the site was completely backfilled by August 1992. The first two samples collected from W-15 show a well slightly degraded by acidic mine drainage and the remaining samples show a well severely degraded by acidic mine drainage. This apparent change in quality happened

sometime between 1986 and 1988, and before mining began on the adjacent mining site for which W-15 was a monitoring point, raising issues about the reliability of the first two background sample analysis on this well.

Well W-12 is located stratigraphically between the Mercer coal horizon and the top of the Mauch Chunk Formation. The well depth is 80 feet. The well supplies water for the Reade Township Sportsman's Club. Well W-12 served as a monitoring point for several nearby surface mining operations and was sampled 41 times between 1984 and 1997. With the exception of one anomalous, and highly questionable, sulfate spike in July of 1996, and an occasional spurious-looking iron and acidity determination, the well chemistry does not indicate mine drainage impacts.

Taken collectively, the available sampling data on private water supply wells in the Muddy Run watershed provide a picture that is consistent with that provided by the spring and discharge sampling data. While there are exceptions, in general wells tapping strata associated with the Mahoning, Upper Freeport, Lower Freeport, and Upper Kittanning coal seams produce mildly to moderately alkaline water, often with low metals concentrations. This observation is consistent with what is known concerning the chemical characteristics of the overburden of these coal seams. These rock units often include calcium carbonate at high enough concentrations to impart significant alkalinity to the groundwater. Wells penetrating these units and that have had substantial amounts of surface mining take place up gradient of their locations, more often than not remain alkaline, but show impacts from alkaline mine drainage in the form of increased sulfate concentrations, and sometimes in the form of increased metals concentrations. If the up gradient mining is close and extensive, the alkaline mine drainage impacts are sometimes significant enough to impair the uses of the well.

As one moves downward through the stratigraphic column, the severity of the mine drainage impacts on the wells increases. This observation is again consistent with what is known about the chemistry of the rocks associated with the lower stratigraphic units. Occurrences of significant calcium carbonate are rare in the overburden associated with the Lower Kittanning and Middle Kittanning coals in this area, and are nonexistent in the overburden of the Mercer, Brookville, and Clarions seams. Wells drilled into the Pottsville and Lower Allegheny strata in unmined areas are typically neutral to mildly acid, with low sulfate levels, but sometimes with problematic levels of iron and manganese. Wells in these strata located directly down gradient of historical mining operations often are substantially affected by acidic mine drainage, and are of a low pH, with elevated acidity, iron, manganese, and sulfate concentrations. In general, the worst water quality is typically associated with the stratigraphically lowest seams, which are the Mercers, Brookville, and Clarion.

Muddy Run Bioassessment

Stream Water Quality

Preliminary water quality sampling occurred at the end of July and August 2003. Water samples were collected on a routine monthly basis from October 2003 to June 2004 (March was cancelled because of weather conditions). Sampling sites are located at main-stem sites, mouths of tributaries, and discharges. Field parameters that were sampled include: air and water temperature, field pH, and flow measurements. Stream flow was measured using a Marsh-McBirney digital meter to determine velocity at approximately 6/10 of the stream depth at 0.5 to 1-foot intervals along the stream cross

section. Also, a 90-degree weir was placed at Site 9 to obtain measurements where the flow was too low for meter use. Water samples were collected at various stations from the mouth to the headwaters by the grab method using a 500 ml bottle and one 125 ml bottle (fixed with nitric acid for all metal analyses). Chemical analysis of the samples was conducted at the Department's Harrisburg laboratory using their prescribed Standard Methods. The following lab parameters were processed: conductivity, total dissolved solids, total soluble solids, lab pH, alkalinity, dissolved calcium, dissolved magnesium, sulfates, dissolved aluminum, dissolved iron, and dissolved manganese. Water quality will be described going upstream from Site 28, just south of Route 253 on the main-stem of Muddy Run, in correlation with its effects on macroinvertebrate populations.

Macroinvertebrates

Macroinvertebrates are susceptible to pollution that negatively impacts the benthic environment and water chemistry. The majority of their lifecycles are in the water, among a specific locality of stream substrate, detritus, or aquatic vegetation. The presence of a large abundance and diversity of aquatic insects is generally an excellent indicator of optimal aquatic conditions. The opposite suggests natural or anthropogenic limiting factors. A previous study of Muddy Run was conducted by the Susquehanna River Basin Commission (SRBC) as part of an overall survey of the West Branch Susquehanna Sub-basin during the period of July through November 2002. In addition to the ongoing monitoring and planning of the Sub-basin, the SRBC is contracted through the Department to assess certain waters of the Commonwealth for impairment. Impaired aquatic conditions are based on unmet standards or designated uses. The Department utilizes its Statewide Surface Waters Assessment Program (SSWAP) to list degraded waters that need a Total Maximum Daily Load (TMDL) calculation report and implementation strategy as required by the federal Clean Water Act Section 303(d). Acid mine drainage impairs the majority of Muddy Run, as with other tributaries of the Clearfield Creek and the greater West Branch of the Susquehanna River.

In 2002, the SRBC listed Muddy Run as impaired at two sites due to metals loading and low pH. Muddy Run was sampled at its mouth at the T-550 bridge near Madera, Clearfield County (Site MUDD 0.3, 40°49'09" N, 78°26'13" W). The second site is located at the SR-729 bridge near Beccaria, Clearfield County (Site MUDD 4.5, 40°46'08", 78°26'50"). Site MUDD 4.5 is approximately 4 miles from Route 253 and the northern edge of the unsuitable for mining technical study area. According to the June 2003, West Branch Susquehanna Sub-basin Survey:

> "Muddy Run, severely impaired by acid mine drainage (AMD), flowed into Clearfield Creek with high levels of total suspended solids, magnesium, sulfate, iron, manganese, zinc, and aluminum. The habitat was non-supporting at the upstream site (MUDD 4.5) due to extremely large amounts of AMD flocculent and precipitates covering the streambed. There were no macroinvertebrates found in either sample from Muddy Run."

In 2003-2004, as part of the Muddy Run unsuitable for mining technical study, bioassessments of 100-meter stream reaches were conducted upstream on multiple sites on the main-stem of Muddy Run and its headwater tributaries. Bioassessments were conducted according to the Department's *Standardized Biological Field Collection And Laboratory Methods* and the *Statewide Surface Waters* Assessment Program (SSWAP), both modifications of the manual: *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish*. (2nd edition, 1999),

Office of Water, EPA 841-B-99-002, July 1999 (Barbour, M.T.; J. Gerritsen, B.D. Snyder, J.B. Stribling). SSWAP is a standardized and comprehensive statewide method used to delineate non-impaired, good quality waters and waters impaired by non-point source (NPS) and point source (PS) impacts. SSWAP was designed for an efficient evaluation of water conditions for future, more in-depth studies such as NPS/PS intensive follow-up reviews, anti-degradation surveys, Exceptional Value/High Quality designation studies, and TMDL development.

Each site was sampled in "best available" single habitat of riffles or series of riffles with fast and slow velocity flows. Benthic macroinvertebrates were collected using 2 to 3 kicks from an approximately one-meter kick-net. The macroinvertebrates were identified to Family level and counted in the field. The total number of recognizable Families and the relative abundance of individuals for each site were recorded. Abundance was described with the following ranges: rare (0-3), present (3-10), common (11-24), abundant (25-99), and very abundant (100+).

A Hilsenhoff biotic index number was designated for each taxa and used in bio-statistical analysis. The Hilsenhoff index (modified for PA use), which numerically ranges from 0 to 10, indicates tolerance of the benthic community to water pollution. Generally, aquatic insects with a zero tolerance are commonly found in clean, well-oxygenated water. Streams impacted by mine drainage precipitate, agricultural waste, or excess sediment deposition tends to be dominated with higher numbered Families.
The aquatic habitat evaluation was done on the RBP Riffle/Run Prevalence form. It consists of rating twelve habitat parameters to derive a qualitative score used to supplement bioassessment results. The range of habitat score totals for sampling stations are rated a number between 0 and 240. The scores reflect general habitat conditions of poor (≤ 60), marginal (61-120), sub-optimal (121-180), and optimal (181-240). Abundances, corresponding Hilsenhoff biological tolerance indices, and habitat scores for each station were evaluated to see if they meet certain stream criteria that indicate either impairment, or no impairment. Table 10 summarizes the May 2004 qualitative bioassessment of sites with macroinvertebrate life in the Muddy Run technical study area. Sample stations and corresponding water quality are described going upstream.

Site 28, near the Route 253 bridge, is void of life and the benthic environment is laden with metal precipitate. Low pH and alkalinity, high acidity, sulfates, and metals loading indicated mine drainage influence.

Site 28

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
7/29/03	69.40	56.80	581.00	648.00	2.00	4.30	3.90	0.00	39.90	32.80	109.80	320.60	6.61	0.60	8.84	*
10/31/03	66.30	50.10	414.00	320.00	8.00	4.30	4.10	2.80	23.50	20.40	72.60	165.10	4.87	0.66	5.89	Begin
11/25/03	26.00	40.20	480.00	380.00	N/A	4.40	4.10	2.40	26.80	25.30	73.20	170.40	5.71	1.01	7.17	2004
12/19/03	26.70	36.10	666.00	510.00	< 2.00	4.10	3.80	0.00	36.90	38.40	90.40	306.40	7.83	2.25	12.70	
1/22/04	27.00	34.30	703.00	562.00	10.00	4.10	3.70	0.00	21.00	20.30	97.00	319.40	5.00	1.37	6.40	1379.00
2/27/04	N/A	N/A	627.00	534.00	4.00	4.80	4.00	1.80	36.80	35.10	77.00	297.20	6.76	1.26	11.60	1522.00
4/30/04	75.20	54.10	585.00	468.00	4.00	4.40	3.80	0.00	32.60	33.80	67.40	245.70	6.78	1.59	10.30	^5280.00
5/27/04	N/A	N/A	552.00	528.00	2.00	4.20	3.80	0.00	30.30	29.90	76.00	247.50	5.66	0.99	8.86	^2324.00
6/23/04	75.00	57.00	690.00	738.00	< 2.00	4.30	3.80	0.00	44.30	39.90	71.20	316.80	7.33	1.06	12.60	^999.00

The tributary that parallels Cambria Mills Road contributes mine drainage to Muddy Run less than a quarter mile upstream of Site 28. Two sampling sites are on this tributary. Site 26 is located closest to the mouth, near the Sportsman Club Road and is dead. Low pH and alkalinity, high acidity, sulfates, and metals loading indicated mine drainage influence.

Site 26

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
7/29/03	68.70	58.60	1277.00	1418.00	< 2.00	3.80	3.20	0.00	92.50	74.00	204.60	569.60	17.70	5.55	1.83	*
10/31/03	67.10	50.30	834.00	864.00	< 2.00	4.00	3.50	0.00	55.20	42.30	106.40	347.40	10.10	2.39	13.70	Begin
11/25/03	26.70	38.40	684.00	566.00	< 2.00	4.20	3.60	0.00	47.70	31.60	80.60	300.10	7.43	1.89	7.80	2004
12/19/03	25.10	33.60	814.00	604.00	< 2.00	3.80	3.50	0.00	56.70	41.10	87.60	348.30	8.89	2.52	9.21	
1/22/04	26.00	32.30	997.00	804.00	< 2.00	3.70	3.40	0.00	34.80	25.50	127.40	459.10	6.47	1.76	6.16	334.00
2/26/04	N/A	N/A	848.00	748.00	8.00	4.30	3.60	0.00	56.70	45.20	95.60	397.60	10.06	2.25	13.50	480.00
4/30/04	75.20	35.40	728.00	580.00	< 2.00	4.30	3.60	0.00	52.40	37.70	67.80	291.80	6.32	1.64	8.02	2360.00
5/27/04	N/A	N/A	791.00	730.00	< 2.00	4.30	3.60	0.00	54.50	40.30	84.60	333.40	7.08	2.05	9.55	515.00
6/23/04	75.00	57.00	999.00	986.00	4.00	4.20	3.40	0.00	72.70	55.40	102.00	449.50	11.90	3.05	16.00	155.00

Site 19 is further upstream near the Cambria Mills Road bridge; its flow source is made up of primarily mine drainage. Low pH and alkalinity, high acidity, sulfates, and metals loading indicated mine drainage influence.

Site 19

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
7/29/03	71.90	57.50	1772.00	2326.00	4.00	3.70	2.90	0.00	147.00	102.00	323.80	901.10	28.30	13.30	10.90	Begin
10/31/03	70.80	53.90	1254.00	1240.00	6.00	3.80	3.00	0.00	77.80	47.50	215.40	471.00	18.60	7.26	5.55	2004
11/25/03	27.60	41.50	979.00	756.00	< 2.00	4.20	3.20	0.00	66.40	34.60	152.60	383.10	12.50	6.96	4.33	
12/19/03	26.40	39.20	1229.00	912.00	< 2.00	3.40	3.00	0.00	79.50	46.10	183.20	473.80	16.30	7.56	5.28	
1/22/04	26.00	39.30	1458.00	1084.00	< 2.00	3.30	2.90	0.00	51.20	31.40	251.20	636.20	12.00	5.43	4.11	LF
2/27/04	N/A	N/A	1376.00	1178.00	6.00	4.40	3.00	0.00	82.90	47.70	243.00	586.10	22.10	9.34	6.76	LF
4/30/04	75.20	60.20	928.00	766.00	12.00	4.00	3.20	0.00	63.20	36.20	127.00	353.00	10.30	5.26	4.12	LF
5/27/04	N/A	N/A	1214.00	1110.00	14.00	4.10	3.10	0.00	84.40	55.30	153.00	474.30	13.20	4.42	6.77	LF
6/23/04	73.00	56.00	375.00	382.00	< 2.00	4.20	3.90	0.00	14.20	19.00	84.80	147.50	8.11	0.59	4.99	LF

Approximately one-half mile upstream on Muddy Run is Site 17. Poor water quality eliminates aquatic life here. Although tributaries more than a one-quarter mile above contribute water that is a little more alkaline and of higher pH, metals begin to come out of solution just upstream. Low pH and alkalinity, high acidity, sulfates, and metal loading indicated mine drainage influence.

Site 17

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
7/29/03	68.30	54.60	430.00	490.00	6.00	4.30	3.90	0.00	19.90	23.30	109.40	244.30	6.42	0.36	7.12	*
10/31/03	71.00	50.10	293.00	294.00	4.00	4.30	4.20	3.80	12.90	14.70	81.40	104.70	4.44	0.26	4.24	Begin
11/25/03	25.50	41.90	302.00	224.00	2.00	4.40	4.10	2.40	12.90	15.40	86.60	108.20	5.57	0.28	4.77	2004
12/19/03	25.50	38.30	332.00	248.00	< 2.00	4.40	4.10	2.60	14.10	16.70	87.40	134.10	5.93	0.31	4.99	
1/22/04	27.00	36.80	387.00	286.00	4.00	4.30	4.00	1.60	9.00	11.30	89.80	170.50	3.99	0.37	3.58	^1263.00
2.26/04	N/A	N/A	346.00	292.00	2.00	4.60	4.20	3.80	15.70	18.10	70.80	135.70	5.43	0.19	5.41	887.00

4/30/04	75.20	51.90	320.00	246.00	4.00	4.80	4.00	1.40	13.30	16.40	93.60	129.80	5.15	0.32	4.63	^3020.00
5/27/04	N/A	N/A	302.00	284.00	< 2.00	4.70	4.00	3.60	10.40	13.00	98.40	106.00	4.26	0.34	3.72	^1809.00
6/23/04	67.00	55.00	391.00	378.00	2.00	4.40	3.90	0.00	17.00	20.50	79.20	160.00	5.73	0.39	6.24	844.00

The first tributary fed by a mining impacted spring (discharge 16a). However, the water quality allows for the presence of macroinvertebrates at Site 16. A total of 6 Families (true fly, 2 stoneflies, and 3 caddisflies) and an abundance range of 50-175 individuals were counted. The macroinvertebrates collected exhibited low to mid-tolerance to water pollution. The aquatic habitat was considered optimal. Relative abundance, Hilsenhoff tolerance indices, and the habitat score contributed to an equal number of stream criteria representing no impairment and impairment at this station. In some cases, this would indicate borderline conditions where positive or negative changes to the site could influence future designations. Some springs, with low alkalinity and cold temperatures, can have natural limiting factors that decrease abundance and diversity. This and the addition of mine drainage (parameters that would also include metals concentrations in solution and low enough to support aquatic life), play a role in less productivity of macroinvertebrates at this site, but not to the point of impairment. After taking this in account, the aquatic life appeared to be not impaired at this site. Other water quality parameters such as elevated acidity, sulfates, and metals loading indicated possible mine drainage influence.

Discharge 16a

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
11/24/03	51.20	48.90	174.30	48.00	< 2.00	4.70	4.70	7.40	8.51	8.62	28.00	74.60	3.03	0.08	1.47	Same
12/18/03	25.50	48.20	174.70	138.00	< 2.00	4.70	4.60	6.80	7.88	8.64	29.40	67.50	3.32	< 0.02	1.52	as
1/22/04	24.40	47.40	160.40	116.00	2.00	4.70	4.60	7.00	1.58	1.53	29.00	65.60	0.54	< 0.02	0.25	16

*Reference water quality data for discharge (November-January), similar to sampling site 16.

Site 16

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
7/29/03	66.40	47.30	120.00	126.00	< 2.00	4.80	5.00	8.20	9.55	5.38	11.40	45.10	0.95	< 0.02	0.59	*
10/30/03	63.30	49.40	165.40	174.00	2.00	4.70	4.70	7.20	7.57	7.88	37.40	56.20	3.03	0.10	1.37	Begin
11/24/03	51.20	49.00	167.10	104.00	10.00	4.70	4.70	7.00	7.98	8.06	36.40	80.70	2.92	0.09	1.40	2004
12/18/03	25.50	46.70	169.10	128.00	< 2.00	4.80	4.60	6.80	7.46	7.95	31.00	77.40	3.01	< 0.02	1.36	
1/22/04	24.40	45.50	153.50	122.00	4.00	4.70	4.60	6.60	0.60	0.56	29.00	59.10	0.23	< 0.02	0.09	531.00
2/26/04	N/A	N/A	152.10	118.00	4.00	4.80	4.70	7.00	8.55	7.29	24.80	64.80	2.19	< 0.02	1.02	329.00
4/30/04	74.40	47.30	174.70	146.00	< 2.00	4.90	4.60	6.80	7.97	8.37	34.20	64.10	3.15	< 0.02	1.39	703.00
5/24/04	71.40	47.40	167.90	158.00	4.00	4.80	4.60	8.00	7.47	7.80	35.40	65.20	3.08	0.20	1.26	715.00
6/23/04	67.00	48.00	137.70	136.00	2.00	4.80	4.70	10.60	8.65	6.13	18.40	47.60	1.75	0.02	0.81	^392.00

Site 14 is adjacent to Site 16 on the main-stem of Muddy Run before the confluence of the spring. Its flow comes from a second major tributary (Site 12) and the main-stem of Muddy Run (Site 5). Despite mine drainage contributions from the major tributary, if appears the habitat is influenced by main-stem macroinvertebrate migration. At site 14, a total of 6 Families (dobsonfly, alderfly, 2 stoneflies, and 2 caddisflies) and an abundance range of 69-245 individuals were counted. The macroinvertebrates collected exhibit low to mid-tolerance to water pollution, but are dominated by low tolerant biota. The aquatic habitat was considered optimal. Relative abundance, Hilsenhoff

tolerance indices, and the habitat score combine to indicate no impairment to aquatic life at this station (due to the reasoning previously mentioned). Low pH and alkalinity, high acidity, sulfates, and metals loading indicated mine drainage influence.

Site 14

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
7/29/03	66.20	57.30	480.00	538.00	4.00	4.20	3.80	0.00	22.50	27.60	107.80	254.00	7.06	0.68	8.37	*
10/31/03	62.60	47.80	348.00	360.00	6.00	4.30	4.00	1.00	13.70	16.60	87.40	141.40	5.42	0.46	5.79	Begin
11/24/03	51.20	46.90	356.00	294.00	< 2.00	4.30	3.90	0.80	14.60	19.10	92.20	155.60	5.95	0.37	5.95	2004
12/18/03	25.50	35.60	432.00	332.00	< 2.00	4.20	3.90	0.00	16.40	22.10	88.80	195.10	7.30	0.70	7.14	
1/22/04	24.40	32.70	505.00	392.00	4.00	4.10	3.80	0.00	12.30	16.80	96.80	212.80	6.25	0.45	6.13	^732.00
2/26/04	N/A	N/A	403.00	350.00	< 2.00	4.60	4.00	2.00	16.40	19.90	77.40	178.80	6.32	0.37	6.95	487.00
4/30/04	74.40	53.00	292.00	222.00	< 2.00	4.70	4.00	2.00	12.00	14.50	91.20	125.10	4.39	0.32	4.14	^2317.00
5/24/04	71.60	57.00	283.00	258.00	< 2.00	4.70	4.00	2.40	11.40	13.90	89.40	102.90	3.67	0.38	3.79	^1094.00
6/23/04	67.00	51.00	512.00	546.00	< 2.00	4.70	3.70	0.00	20.10	26.80	74.80	197.20	7.20	0.80	0.88	452.00

A major tributary enters less than 300 feet upstream of Site 14. Site 12's major flow comes from two mine discharges (source in the abandoned mine land south of the technical study area). As a result, no macroinvertebrates were found due to low pH and metals loading. Although biological systems are more tolerant of iron, it comes out of solution at a pH of 3.50 or higher and by its nature generates greater acidity when forming hydrated iron oxides. Low pH and alkalinity, high acidity, sulfates, and metals loading indicated mine drainage influence.

Site 12

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
7/29/03	65.50	56.10	607.00	626.00	6.00	4.20	3.60	0.00	27.40	32.50	125.80	285.00	7.85	2.51	12.10	*
10/31/03	63.60	47.60	817.00	732.00	< 2.00	4.00	3.50	0.00	33.00	51.40	148.80	354.20	14.90	1.38	19.40	Begin
11/24/03	51.20	47.30	821.00	758.00	< 2.00	4.30	3.50	0.00	32.20	49.50	143.60	319.20	15.90	1.11	18.70	2004
12/18/03	25.50	32.70	877.00	746.00	2.00	4.30	3.50	0.00	33.00	50.50	139.40	397.50	16.90	1.35	19.20	
1/22/04	24.40	37.40	282.00	208.00	8.00	4.40	4.70	7.40	11.40	10.00	59.80	124.50	2.65	0.41	3.19	204.00
2/26/04	N/A	N/A	803.00	762.00	6.00	4.20	3.60	0.00	30.90	45.90	131.20	374.90	14.20	0.76	17.60	^226.00
4/30/04	74.40	57.20	851.00	556.00	2.00	4.20	3.40	0.00	32.70	49.90	135.80	396.40	16.30	1.47	18.70	809.00
5/24/04	71.20	62.00	737.00	768.00	< 2.00	4.30	3.40	0.00	27.70	44.00	115.00	323.00	12.40	1.28	1.57	^344.00
6/23/04	67.00	59.00	971.00	1008.00	< 2.00	4.70	3.30	0.00	35.60	55.50	138.60	419.00	16.00	16.60	20.70	210.00

A small, surface stream (Site 8) contributes to this tributary less than a half mile upstream of its confluence with Muddy Run. Portions of the stream flow through forested wetland. A total of 5 Families (crayfish, mayfly, dragonfly, stonefly, and caddisfly) and an abundance range of 133-175 individuals were counted. The macroinvertebrates collected exhibited low to mid-tolerance to water pollution, but are dominated by mid-tolerant biota. The aquatic habitat was considered optimal. Relative abundance, Hilsenhoff tolerance indices, and the habitat score contributed to an equal amount of stream criteria representing both no impairment and impairment to aquatic life at this station. This would normally indicate borderline conditions; but some small streams have naturally-occurring limiting factors, especially periods of low flow, that decrease abundance and diversity. Based on data results, the aquatic life appeared to be not impaired at this site. Water quality does not indicate mine drainage influence.

Site 8

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
11/25/03	24.90	37.50	146.90	118.00	12.00	5.80	6.50	9.80	9.66	5.05	0.00	38.90	< 0.20	0.10	0.22	Begin
12/18/03	21.30	32.70	154.70	110.00	< 2.00	5.60	6.00	8.60	9.80	5.25	8.00	43.70	< 0.20	0.02	0.22	2004
1/22/04	26.00	31.40	161.40	104.00	4.00	5.30	6.20	8.60	5.28	2.78	12.00	36.90	< 0.20	0.16	0.08	LF

The two mine discharges were sampled at Sites 7 and 9 along an old mining road, just off Sawmill Road in Blandburg. Site 7 originates from an old mine drainage treatment pond (Discharge 7a) and flows through coal refuse. Site 9 (Discharge 9b) emanates from, and flows through, coal refuse. A small discharge (9a) enters just below Site 9. Low pH and alkalinity, high acidity, sulfates, and metal loading indicated mine drainage influence.

Discharge 7a

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
11/25/03	27.50	48.20	1290.00	1498.00	< 2.00	3.90	3.20	0.00	46.90	68.00	246.60	623.60	26.10	2.50	28.80	Same
12/18/03	21.30	48.90	1335.00	1200.00	< 2.00	3.20	3.20	0.00	46.40	88.00	239.80	652.50	26.80	2.82	31.20	as
1/22/04	27.30	42.70	1314.00	108.00	< 2.00	3.10	3.20	0.00	29.10	50.60	252.00	680.40	18.20	1.79	19.60	7

*Reference water quality data for discharge (November-January), similar to sampling site 7.

Site 7

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis.Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
7/29/03	70.10	59.00	1494.00	1994.00	4.00	4.10	3.10	0.00	58.60	110.00	320.60	719.00	30.90	9.98	38.30	*
10/30/03	59.00	48.90	1288.00	1684.00	< 2.00	4.40	3.20	0.00	51.60	82.90	252.60	625.50	27.40	8.53	32.40	Begin
11/24/03	50.70	49.20	1237.00	1118.00	10.00	3.80	3.20	0.00	44.60	73.70	224.00	582.30	25.30	5.41	28.40	2004
12/18/03	21.30	34.80	1260.00	1176.00	< 2.00	3.70	3.20	0.00	42.90	79.50	238.00	625.90	24.90	5.60	28.10	
1/22/04	25.00	40.10	1266.00	1088.00	< 2.00	3.50	3.20	0.00	46.30	81.00	240.60	624.40	26.80	6.41	30.50	LF
2/26/04	28.90	43.10	1322.00	1330.00	10.00	4.70	3.30	0.00	48.20	77.50	237.40	669.70	23.70	9.90	30.90	68.00
4/30/04	73.50	54.60	1229.00	1080.00	10.00	4.30	3.20	0.00	45.00	80.50	214.80	598.30	25.90	5.49	28.70	646.00
5/24/04	71.60	54.60	1175.00	1474.00	< 2.00	4.20	3.20	0.00	43.90	75.20	214.80	548.10	25.60	5.61	28.90	182.00
6/22/04	64.00	54.00	1274.00	1598.00	< 2.00	4.10	3.20	0.00	47.50	80.00	217.40	600.40	26.20	7.21	30.10	174.00

Discharge 9b

*Reference water quality data for discharge (November-January), similar to sampling site 9.

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
11/25/03	28.10	47.50	1522.00	1478.00	N/A	N/A	3.20	0.00	62.00	86.20	280.60	734.20	30.30	1.54	39.00	Same
12/18/03	21.30	45.80	956.00	822.00	4.00	3.60	3.40	0.00	35.20	59.00	186.40	416.60	19.10	0.36	19.80	as
1/22/04	27.70	37.90	848.00	710.00	< 2.00	3.70	3.50	0.00	32.40	55.50	144.00	383.90	13.70	0.50	19.80	9

Site 9

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
8/7/03	70.10	57.30	850.00	1120.00	< 2.00	3.90	3.50	0.00	32.60	49.00	192.00	434.90	17.00	0.30	17.60	**
10/30/03	60.40	49.40	762.00	904.00	12.00	3.90	3.60	0.00	29.90	44.70	166.60	287.70	14.60	0.21	16.50	Begin

11/25/03	50.70	48.20	780.00	670.00	10.00	3.90	3.50	0.00	29.10	41.10	172.80	363.90	17.00	6.77	14.50	2004
12/18/03	21.30	42.40	828.00	674.00	< 2.00	3.80	3.50	0.00	31.00	51.00	163.80	380.10	16.40	0.29	17.00	
1/22/04	27.70	38.80	941.00	808.00	2.00	3.70	3.50	0.00	26.00	40.30	186.00	479.00	14.80	0.20	14.60	LF
2/26/04	28.90	31.80	1020.00	1046.00	28.00	4.30	3.60	0.00	39.10	63.80	224.60	529.20	24.60	0.63	23.40	LF
4/30/04	75.50	52.40	701.00	564.00	6.00	4.20	3.60	0.00	27.00	41.50	152.00	286.80	12.80	0.21	14.00	180.00
5/24/04	65.00	51.00	613.00	656.00	10.00	4.30	3.60	0.00	23.60	35.20	142.80	256.00	11.30	0.38	12.10	162.00
6/22/04	63.00	53.00	880.00	1114.00	< 2.00	4.20	3.50	0.00	34.50	54.50	160.60	400.70	17.10	0.23	19.40	14.00

Discharge 9a

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
10/30/03	61.10	47.60	1034.00	1296.00	10.00	4.00	3.50	0.00	41.90	68.30	199.60	479.00	19.90	0.70	25.70	Begin
11/24/03	50.70	48.20	990.00	962.00	< 2.00	3.80	3.50	0.00	38.90	62.70	170.80	494.90	18.70	0.62	23.20	2004
12/18/03	21.30	39.30	917.00	682.00	< 2.00	3.80	3.50	0.00	34.50	61.50	155.80	440.00	15.90	0.52	21.00	
1/22/04	27.10	43.80	995.00	826.00	8.00	3.50	3.50	0.00	24.10	37.10	199.00	522.50	13.70	0.19	13.70	LF
2/26/04	28.90	37.50	1149.00	1172.00	6.00	4.40	3.50	0.00	46.20	79.70	205.20	589.10	24.10	0.57	28.00	LF
4/30/04	73.50	54.50	830.00	672.00	4.00	4.20	3.50	0.00	33.60	56.90	140.20	377.80	13.10	0.45	19.60	LF
5/24/04	68.00	56.60	924.00	1152.00	2.00	4.20	3.50	0.00	35.60	62.50	162.40	414.70	15.50	0.66	21.50	LF
6/22/04	63.00	53.00	984.00	1294.00	< 2.00	4.30	3.50	0.00	38.80	67.90	143.00	467.00	17.40	0.83	22.90	LF

Site 5 is located adjacent to Site 12 on the main-stem of Muddy Run. Water quality suports the presence of macroinvertebrates. A total of 8 Families (mayfly, dobsonfly, 3 stoneflies, and 3 caddisflies) and an abundance range of 150-257 individuals were counted. The macroinvertebrates collected exhibited low to mid-tolerance to water pollution, but are dominated by low tolerant biota. The aquatic habitat was considered optimal. Relative abundance, Hilsenhoff tolerance indices, and the habitat score contributed to a majority of stream criteria that represents no impairment to aquatic life at this station. Low pH, and alkalinity, and elevated acidity, sulfates, and metals loading indicated mine drainage influence.

Site 5

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
7/29/03	65.50	57.00	218.00	286.00	< 2.00	4.70	4.30	6.60	11.80	10.20	41.20	81.60	2.71	0.03	1.77	*
10/31/03	61.70	47.30	157.50	176.00	2.00	4.70	4.60	6.40	8.09	6.98	57.60	53.00	1.99	0.12	1.38	Begin
11/24/03	51.20	47.30	190.30	156.00	< 2.00	4.30	4.30	5.20	8.21	8.54	58.20	79.00	2.85	0.14	2.15	2004
12/18/03	25.50	37.00	190.90	144.00	< 2.00	4.70	4.40	5.80	8.34	8.96	54.60	70.10	2.99	0.10	1.97	
1/22/04	24.40	33.40	187.40	136.00	< 2.00	4.70	4.40	5.40	5.58	5.83	35.40	70.30	2.06	< 0.02	0.88	528.00
2/26/04	N/A	N/A	165.10	140.00	6.00	4.90	4.80	7.00	10.04	7.88	36.80	67.20	1.96	0.11	1.26	261.00
4/30/04	74.40	52.50	171.80	474.00	4.00	4.80	4.40	5.40	7.99	7.86	54.60	59.80	2.46	0.11	1.70	1508.00
5/24/04	74.60	56.10	138.00	96.00	< 2.00	4.80	4.50	6.40	6.42	5.74	62.80	56.10	1.63	0.14	1.09	750.00
6/23/04	67.00	55.00	173.80	174.00	< 2.00	4.80	4.70	10.20	10.70	8.01	54.00	65.90	1.72	0.35	1.55	^242.00

Site 4 is approximately ¾ mile upstream just below the confluence of a spring (Site 2) and the headwaters of Muddy Run (Site 3a). A total of 6 Families (true fly, 3 stoneflies, and 2 caddisflies) and an abundance range of 166-336 individuals were counted. The macroinvertebrates collected exhibited low to mid-tolerance to water pollution, but are dominated by low tolerant biota. The aquatic habitat was considered optimal. Relative abundance, Hilsenhoff tolerance indices, and the habitat score contributed to a majority of stream criteria that represents no impairment to aquatic life at this station. Low pH, and alkalinity, and elevated acidity, sulfates, and metals loading indicated mine drainage influence.

Site 4

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
8/7/03	69.60	51.80	241.00	290.00	< 2.00	4.50	4.40	5.60	11.50	11.50	44.00	101.10	4.09	< 0.02	2.21	*
10/30/03	56.00	47.60	177.00	194.00	6.00	4.70	4.40	5.60	8.04	8.21	37.00	67.50	2.73	0.03	1.56	Begin
11/25/03	27.70	43.80	166.90	144.00	< 2.00	N/A	4.30	4.80	6.71	7.55	39.20	69.60	2.94	0.04	1.42	2004
12/18/03	21.30	39.90	180.60	132.00	6.00	4.40	4.40	5.40	7.89	8.47	38.60	68.80	3.28	0.03	1.57	
1/22/04	28.20	38.80	227.00	152.00	8.00	4.30	4.40	5.40	6.29	7.33	48.20	86.60	2.83	< 0.02	1.32	273.00
2/26/04	27.60	39.90	195.90	856.00	4.00	4.80	4.60	6.60	10.80	10.00	36.40	81.40	3.28	0.03	1.67	104.00
4/30/04	69.60	47.40	157.70	114.00	4.00	4.80	4.40	5.20	6.71	6.98	37.00	54.90	2.35	< 0.02	1.21	879.00
5/24/04	68.10	51.20	131.80	108.00	< 2.00	4.80	4.40	6.80	5.49	5.36	33.00	41.60	1.59	0.04	0.91	488.00
6/22/04	64.00	49.00	205.00	204.00	< 2.00	4.70	4.40	9.20	9.59	9.51	33.80	71.30	3.06	0.04	1.77	176.00

This spring's water quality, like Site 16, shows signs of mine drainage influence, but allows the presence of macroinvertebrates. A total of 7 Families (beetle, mayfly, 3 stoneflies, and 2 caddisflies) and an abundance range of 169-339 individuals were counted. The macroinvertebrates collected exhibited low to mid-tolerance to water pollution, but were dominated by low tolerant biota. The aquatic habitat was considered optimal. Relative abundance, Hilsenhoff tolerance indices, and the habitat score contributed to a majority of stream criteria that represents no impairment to aquatic life at this station. Low pH, and alkalinity, and elevated acidity, sulfates, and metals loading indicated mine drainage influence.

Site 2

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
8/7/03	69.60	49.60	235.00	288.00	< 2.00	4.70	4.50	6.60	12.50	11.50	45.60	99.80	3.75	0.02	2.02	*
10/30/03	53.20	48.50	150.00	148.00	6.00	4.70	4.80	7.00	8.31	6.92	23.40	60.30	1.76	0.02	1.03	Begin
11/25/03	27.70	47.30	192.00	204.00	2.00	N/A	4.20	3.60	6.55	8.57	50.20	63.10	3.98	0.05	1.80	2004
12/18/03	21.30	46.00	134.00	94.00	< 2.00	4.70	4.80	7.20	7.93	6.30	20.80	53.90	1.45	< 0.02	0.79	
1/22/04	28.20	44.70	177.80	144.00	< 2.00	4.60	4.70	7.20	6.55	6.10	31.00	75.10	1.79	< 0.02	0.91	99.00
2/26/04	27.60	42.80	194.00	154.00	2.00	4.80	4.60	7.20	10.60	9.54	33.00	75.80	2.83	0.04	1.49	67.00
4/30/04	69.60	45.50	114.40	108.00	4.00	4.80	4.90	7.40	6.60	5.03	19.80	43.30	0.99	0.07	0.56	223.00
5/24/04	70.50	46.40	103.60	86.00	4.00	4.80	4.90	8.80	5.98	4.51	19.00	40.90	0.77	< 0.02	0.47	120.00
6/22/04	64.00	47.00	180.90	148.00	10.00	4.80	4.70	10.40	10.20	8.38	27.20	73.40	2.33	0.02	1.31	124.00

The main-stem of Muddy Run flows through forested areas south of the abandoned mine lands, at the southern end of the technical study area. Some of its runoff travels through mine lands. One source of flow, Site 3c, is a mine discharge (sample taken 9/22/04 indicated: air temperature-79.3°F, water temperature-50.3°F, conductivity-1090 mg/l, TDS-994 mg/l, TSS-4.0 mg/l, lab pH-3.2, alkalinity-0.00 mg/l, dissolved calcium-26.3 mg/l, magnesium-50.2 mg/l, acidity-352 mg/l, sulfates-493 mg/l, dissolved aluminum-48.6 mg/l, dissolved iron-0.76 mg/l, dissolved manganese-11.1 mg/l, and flow-165 gpm). Water quality improves downstream at Site 3a. Site 3a is located near the confluence with the spring. A total of 5 Families (2 stoneflies and 3 caddisflies) and an abundance range of 51-166 individuals were counted. The macroinvertebrates collected exhibited low to mid-tolerance to water pollution, but were dominated by low tolerant biota. The aquatic habitat was considered optimal. Relative abundance, Hilsenhoff tolerance indices, and the habitat score contributed to a majority of stream criteria that represents no impairment to aquatic life at this station. Low pH, and alkalinity, and elevated acidity, sulfates, and metals loading indicated mine drainage influence.

Site 3a

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis.Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
8/7/03	69.60	59.10	240.00	272.00	< 2.00	4.40	4.10	2.60	8.35	11.20	53.00	90.00	4.23	0.03	2.62	*
10/30/03	54.30	46.50	215.00	216.00	10.00	4.40	4.20	3.60	7.56	10.10	53.60	86.90	4.01	0.05	2.27	Begin
11/25/03	27.70	47.30	118.40	100.00	6.00	N/A	4.90	7.20	7.03	5.54	16.20	46.50	1.18	0.03	0.65	2004
12/18/03	21.30	36.10	214.00	166.00	< 2.00	4.30	4.20	4.00	7.57	9.86	50.40	92.70	4.51	0.03	2.05	
1/22/04	28.20	33.20	286.00	190.00	2.00	4.20	4.20	3.60	6.70	9.76	67.00	123.10	4.40	0.03	1.97	^174.00
2/26/04	27.60	33.80	205.00	336.00	< 2.00	4.70	4.30	4.80	8.26	10.30	42.00	78.20	3.94	0.04	1.98	^37.00
4/30/04	69.60	49.40	237.00	180.00	< 2.00	4.60	4.10	3.20	8.22	11.30	58.80	92.80	4.51	0.03	2.23	518.00
5/24/04	70.50	55.70	157.70	152.00	< 2.00	4.40	4.20	5.20	5.17	6.15	42.00	55.10	2.32	0.07	1.31	288.00
6/22/04	64.00	55.00	238.00	240.00	< 2.00	4.80	4.10	6.80	8.84	11.30	49.00	91.30	4.20	0.10	2.53	54.00

Curtis Run is a tributary to Muddy Run and enters north of Route 253. Its headwaters begin in the northeast portion of the technical study area. No aquatic life was found at Site 40. Low pH, and alkalinity, and high acidity, sulfates, and metals loading indicated mine drainage influence.

Site 40

Sample Date	Air T (F*)	Water T (F*)	Conductivity (umhos/cm)	TDS mg/l	TSS mg/l	Field pH	Lab pH	Alka. mg/l	Dis. Ca mg/l	Dis. Mg mg/l	Acid. mg/l	Sulf. mg/l	Dis. Al mg/l	Dis. Fe mg/l	Dis. Mn mg/l	Flow gpm
12/19/03	27.80	33.90	376.00	292.00	< 2.00	4.20	4.10	3.60	13.40	19.50	110.40	168.90	10.90	0.37	4.91	*
2/27/04	N/A	N/A	344.00	296.00	8.00	4.70	4.10	3.40	11.40	16.90	87.00	148.60	7.88	0.39	4.24	361.00
4/30/04	75.20	56.40	355.00	308.00	2.00	4.30	4.00	1.80	12.60	18.40	119.00	153.70	8.96	0.32	4.32	1319.00
5/27/04	N/A	N/A	348.00	350.00	< 2.00	4.30	4.00	3.60	10.90	17.30	115.20	140.90	8.06	0.41	4.11	826.00
6/23/04	73.00	60.00	1435.00	1484.00	< 2.00	4.40	3.00	0.00	95.70	55.20	233.00	586.70	23.10	10.40	7.84	139.00

Historical stream quality data

Appendix Table 5 contains historical stream sampling data for multiple monitoring points throughout the watershed. The location of corresponding stream monitoring points are shown on Figure 11 (map pocket). Long-term trends typically fall into two categories: (1) a general increase in mining-related constituents, including metals, acidity, and sulfates during the monitoring period and, (2) persistent indications of mine drainage impacts throughout the monitoring period.

Fish

On February 26 and 27, 2004, seven sites with potential fish populations were sampled on the main-stem Muddy Run and its headwater tributaries. Sampling was conducted using a Smith-Root, Model #LR-24, direct current pulse electro-fisher. The electro-fishing runs included a single pass for a 100-meter stream reach upstream of each site. No fish were found. According to a study by Cooper and Wagner (1974), no fish are found in waters that are less than 4.5 in pH and acidity greater than 15 mg/l. They also suggest that brook trout begin to colonize at pH levels in the high 4.0s, more ideally in the low 5.0s. Acidic conditions and heavy metals can cause an ionic imbalance by reacting to hydrogen in the water and decrease sodium uptake in the blood during respiration (Brown and Sadler, 1989). It is also possible that pH and metal loading fluctuate enough not to sustain populations.

Although acidity was high in most potential sites, the pH ranges and lower metal concentrations made prospecting worthwhile. Aquatic habitat, food supply, and the cold oxygenated water in these sections would possibly support populations of several types of trout, sculpin, and other cold-water fish species if migration from downstream were feasible. Stocking might also be an option.

Wetlands

A field verifications of wetlands indicated on the USFWS National Wetland Inventory Blandburg quad map were conducted by Environmental Studies Section staff on August 19 and 23, 2004. Seventeen wetland areas were shown on the map within the UFM study area boundaries. Approximately seven additional wetland areas were noted in the field. Out of a total of 24 areas, nineteen were located in the vicinity of the Muddy Run drainage and five were located in the vicinity of the Curtis Run drainage.

Eighteen wetland areas are man-made, sediment and erosion control/AMD treatment ponds associated with past mine operations. One emergent wetland area is the result of seepage from a series of AMD treatment ponds. One scrub-scrub wetland area and four, forested wetland area are natural geographic features, although the hydrology is influenced by some mine drainage. The wetlands' value consists of natural filtration, flood control within the watershed, and unique habitat for wildlife.

Pennsylvania Game Commission personnel conducted field reviews of the study area during September of 2004. The Game Commission reviewed two wetland areas identified on National Wetland Inventory maps. The first was palustrine forested, broad-leaf deciduous, temporarily flooded wetland. The wetland was populated by sphagnum moss, cattails, sedge and ferns. Dominant tree species included birch and red maple. The Game Commission characterized the wetland as having low to moderate value in plant and wildlife diversity. The second wetland, located adjacent to the east side of Cambria Mill Road, was decribed as a palustrine, scrub shrub, broad-leaf deciduous, seasonally flooded wetland. Catttails, purple aster, sensitive fern, jewel weed, skunk cabbage, rushes, sedges, silky dogwood, winter berry, ash, willow, and aspen populated the wetland. The wetland was characterized as exhibiting a moderate value in terms of plant and wildlife habitat. The Game Commission also noted that numerous small (0.01 to 0.05 acres) wetlands are present in the study area. These wetlands have resulted through the intervention of human activities and provide localized habitat diversity.

Wildlife and Habitat

The wildlife and terrestrial habitat of the proposed Muddy Run UFM area resembles two adjacent UFM areas, Upper Little Muddy Run to the east and Upper Powell Run to the south. The technical study for the Upper Powell Run found "a total of 188 species of birds and mammals are likely to occur or have historically occurred within or adjacent to the Powell Run watershed." in the PA Fish and Wildlife Database. In both UFM areas, the Pennsylvania Game Commission confirmed the presence of a variety of birds, including ruffed grouse and turkey. There were also signs of white-tailed deer, black bear, and gray squirrel. Osprey and Beaver were sighted at Little Muddy Run. Evidence of rattlesnake and bobcat were found near Powell Run. Habitat for all the species mentioned above was considered average to above average. Environmental Studies Section personnel observed white-tailed deer, grouse, ring-necked pheasant, turkey, squirrels, and chipmunks during the 2003-2004 study.

Similar vegetation occurs in the region of Muddy Run, Little Muddy Run, and Powell Run. The geography is characterized as generally forested with mixed hardwoods of oaks and maples, interspersed with evergreens. In the Upper Little Muddy Run, Upper Powell Run watersheds, dominant species included black oak and red maple. Sassafras, eastern white pine and eastern hemlock were also documented. Dominant herbaceous plants noted were mountain laurel, striped maple, common greenbrier, and sweet fern.

The Pennsylvania Game Commission did not have record of any threatened or endangered bird or mammal present within the study area.

V. COAL RESERVE AND ECONOMIC IMPACT ASSESSMENT

Coal Reserves

According to Faill's assessment (Faill et al., 1989) of minable coal reserves in northeastern Cambria county:

> "….The principle local coal seams, in order of their minable resources, are the Lower Kittanning, Middle Kittanning, Upper Kittanning, Upper Freeport, and Lower Freeport. Proximate and ultimate analyses of local coal seams show a range in fixed-carbon values from 66 to 74 percent on a moisture- and ash-free basis; volatile matter ranges from 26 to 33 percent on a moisture- and ash-free basis. Based on the classification of the American Society for Testing and Materials (1980), these coals range from "high-volatile-A bituminous" to "medium-volatile bituminous" coals. The heat value on a moisture- and ash-free basis for these coals ranges from 13,050 to 15,690 Btu per pound, and on an as-received basis, the heat value varies from 10,780 to 14, 250 Btu per pound. …. "

The "principle" coal seams identified by Faill are present only in the western portions of the study area where they have been substantially mined. Therefore, the following estimate of recoverable coal reserves primarily covers the eastern, un-mined portions of the technical study area. The primary coal seams in the eastern portion of the study area include the Lower Kittanning, Clarion, Brookville and Mercer coals.

The estimate has been developed using available coal exploration data and local mining information within and adjacent to the upper Muddy Run watershed. Estimated recoverable reserves equate to the calculated amount of coal believed to be recoverable from the delineated area. [For reference, a resource in a "naturally occurring concentration or deposit of coal in the earth's crust, in such form and amount that economic extraction is currently or potentially feasible." Resources may be hypothetical (undiscovered) or identified. "Reserves" are those parts of an identified resource "that meet specified minimum physical and chemical criteria related to current mining and production practices, including those of quality, depth, thickness, rank, and distances from point of measurement" (Wood et al., 1983).]

This coal reserve estimate is not intended to be a full reserve valuation. A complete valuation would include, among other things, a detailed examination of the local support infrastructure, the local labor force, water supplies, medical services, timber rights, mineral assay labs, etc. That type of assessment is beyond the scope of this technical study. Therefore, certain assumptions were made regarding recoverability of coal reserves based on local historical mining activities. For example, local

infrastructure, such as wash plants, highways, and railroads, which has historically supported local underground and surface mining activities, along with the local availability of a suitable skilled and semi-skilled labor force, were assumed to be sufficient to support the additional local coal extraction represented by the reserves under review. Additionally, the Lower Kittanning, Clarion, Brookville and Mercer coals have all been mined in the immediate area. It was therefore assumed that these coals meet the minimum physical and chemical criteria necessary to be of economic value.

The stratigraphic distribution and regional correlation of coals and other lithologies within the Muddy Run study area were determined from the evaluation of 298 drill hole records. Drill holes located within the study area as well as drill holes located within approximately 1000 ft of the boundaries of the study area were used. The lithologic records included: 20 drill holes from the Art Minds Coal Co., Inc., 89 drill holes from the Cambria Coal Co., 64 drill holes from C & K Coal Co., 20 drill holes from Cloe Mining Co., Inc., 16 drill holes from Fran Contracting, Inc., 9 drill holes from the Glendale Contracting Co., 3 drill holes from Sky Haven Coal Co., Inc., 34 drill holes from Penn Grampian Coal Co., 18 drill holes from the Rich Coal Co., 5 drill holes from R. T. Noel, Inc., 16 drill holes from Swistock Associates Coal Co., and the four water well holes drilled by the Reade Township Municipal Authority. Twenty-eight of the 298 drill holes also contained overburden analysis data. The locations of all drill holes and overburden holes used in this study are shown in Figure 8 (map pocket), and are listed in Appendix Table 1, along with surface elevations and total depths of each hole.

After an extensive evaluation of these exploration drill records, ten different coals were identified and correlated throughout the study area. With increasing depth, they are: the Mahoning coal, the Upper Freeport coal, the Lower Freeport coal, the Upper Kittanning coal, the Middle Kittanning coal, the Lower Kittanning coal, the Clarion #3 coal, the Clarion coal (also known as the Clarion #2 or upper Clarion), the Brookville coal (also known as the Clarion #1 or the lower Clarion), and three seams of the Mercer coal.

A complete listing of the lithologies, formation names, and depth intervals for all stratigraphic units used in this study are shown in Appendix Table 2. Figure 17 shows several geologic cross-sections, which depict the typical lithologies and stratigraphic correlations of coals identified in drill holes within the study area. A complete set of stratigraphic cross sections using each of the 298 drill holes that were part of this study, and accompanying reference maps, are presented in the Appendix.

In the following discussion of coal formations, the possible presence and frequency of occurrence of a particular coal within the study area does not include unrecorded weathered coals that may have been present at the surface, i.e., where an exploration drill hole was located along a coal cropline.

Only two drill holes within the study area encountered the Mahoning coal. A one-foot thick seam and a two-foot thick seam were identified. The occurrence of this coal within the study area is limited because most of the Conemaugh Group has been eroded. The Conemaugh Group only occurs on hilltops in the extreme northwestern, western, and southwestern portions of the study area, where the Pennsylvanian stratigraphic section thickens towards the axis of the trough of the Wilmore syncline. There is no record of the Mahoning coal being mined within the study area, but it has been mined extensively to the west of the study area.

The Upper Freeport coal was identified in 29 of the 298 drill holes that were used in the study. The Upper Freeport coal always was identified as a single coal seam, with no splits or riders. Within the study area, the Upper Freeport coal ranged in thickness from 0.5 to 3.4 ft (avg. 2.1 ft). The Upper Freeport coal has been surface mined extensively in the western downdip portion of the study area.

The Lower Freeport coal was identified in 42 of the drill holes. In 41 holes, the Lower Freeport coal was identified as a single coal seam, ranging in thickness from 0.2 to 3.4 ft (avg. 1.7 ft). The Lower Freeport coal was a split seam in only one drill hole. In this hole each split seam was 0.5 ft thick. The Lower Freeport coal has been surface mined extensively in the western down-structure portion of the study area.

The Upper Kittanning coal was identified in 78 drill holes. In 75 holes there was a single seam of the Upper Kittanning coal. Coal thickness ranged from 0.5 to 3.0 ft (avg. 1.7 ft). In three other holes the Upper Kittanning coal was a split coal of two seams. The thickness of each of the split seams ranged from 0.6 to 0.7 ft. The Upper Kittanning coal has been surface mined extensively in the northern, western, and southwestern portions of the study area, particularly during the 1980s and 1990s.

The Middle Kittanning coal was identified in 59 drill holes within the Muddy Run study area. In all of the drill holes, the Middle Kittanning coal was identified as a single coal seam. The thickness of the Middle Kittanning coal ranged from 1.3 to 5.0 ft (avg. 2.7 ft). The Middle Kittanning coal has been extensively surface mined in the western portion of the study area.

The Lower Kittanning coal was identified in 34 drill holes. In 30 of the drill holes the Lower Kittanning coal was a single coal seam, with a coal thickness ranging from 0.4 to 7.3 ft (avg. 1.9 ft). In 4 other holes the Lower Kittanning coal was a split coal of two seams. The split seams ranged in thickness from 0.5 to 6.2 ft (avg. 1.8 ft). Within the study area, the Lower Kittanning coal has been surface mined more extensively than any other coal. Local underground mining typically occurred on the Lower Kittanning coal. Surface mines were located in the western, southwestern, and north central portions of the study area. The underground mines were developed in the northwestern and southwestern portions of the study area.

The Clarion #3 coal was identified in 6 drill holes within the north-central portion of the Muddy Run study area. This discontinuous, single seam coal ranged in thickness from 0.2 to 2.0 ft (avg. 1.2 ft).

The Clarion coal was identified in 72 drill holes. This coal also has been called the Clarion #2 coal or the upper Clarion coal. In the 66 holes, which contained a single seam of the Clarion coal, the thickness ranged from 0.2 to 4.2 ft (avg. 2.3 ft). Five of the drill holes contained two split seams and one hole contained three split seams. The thickness of the split seams ranged from 0.2 ft to 3.0 ft (avg. 1.6 ft). The Clarion coal has been mined mostly in the central and southern portions of the study area, in conjunction with mining of the underlying Brookville coal.

The Brookville coal was identified in 93 drill holes within the study area. The Brookville coal also has been called the Clarion #1 coal or the lower Clarion coal. In the 91 holes containing a single seam of the Brookville coal, the coal thickness ranged from 0.2 to 9.1 ft (avg. 2.0 ft). The other two drill holes each contained two split seams. The thickness of the split seams ranged from 0.9 to 4.3 ft (avg. 2.6 ft). Some of the earliest surface mines permitted within the Muddy Run study area were on the Brookville coal in

the eastern and southern portions of the study area. More recently, several surface mines mined the Brookville coal in the central portion of the study area.

The Mercer coal was identified in 50 drill holes. The Mercer coal interval within the Pottsville Group actually contains one to three coal seams, which may be discontinuous throughout the region. Many of the holes drilled within the study area did not penetrate deep enough to encounter all of the Mercer seams. However, 16 drill holes identified two Mercer seams, and 6 other holes identified three Mercer seams. The thickness range of the shallowest Mercer seam, which was identified in all 50 drill holes, ranged from 0.2 to 4.5 ft (avg. 1.9 ft). One surface mine, operating from 1989 to 1992, mined the shallowest Mercer coal, along with the Brookville, Clarion, and Lower Kittanning coals, in the central part of the study area.

The vertical distances determined for the stratigraphic depths between each of the ten coal formations, as well as the thicknesses of the Mauch Chunk, Loyalhanna, and Burgoon Formations are summarized in Table 4. The depth of the base of each coal formation was used to calculate the vertical distances between coals.

Only one hole contained both the Mahoning and Upper Freeport coals. The vertical spacing was 63.0 ft. Only two holes contained both the Upper Freeport and Lower Freeport coals. The average spacing between these coals was 37.8 ft, with distances ranging from 37.0 to 38.5 ft. Nine holes were drilled through the Lower Freeport coal and the Upper Kittanning coal, with an average vertical spacing between the coals of 47.0 feet, with distances widely ranging from 21.5 to 63.7 ft. Within 38 drill holes, the average vertical distance between the Upper Kittanning coal and the Middle Kittanning coal was 53.0 ft, with values ranging from 31.0 to 60.8 ft.

Within 12 holes, the average vertical distance between the Middle Kittanning coal and the Lower Kittanning coal was 19.1 ft, ranging widely from as little as 8.8 to 41.5 ft. In 17 holes the average vertical distance between the Lower Kittanning coal and the Clarion coal was 51.1 ft, ranging widely from 33.3 to 81.2 ft. In only the five holes which contained both the Clarion #3 coal and the Clarion coal, the vertical distance between the coals only varied from 19.0 to 22.0 ft, with an average spacing of 20.3 ft. The Clarion and Brookville coals were both identified in 54 drill holes, with an average vertical spacing of 13.7 ft (a range of 5.2 to 28.1 ft). Thirty-two holes contained both the Brookville and the shallowest Mercer coal. In these drill holes the average vertical spacing between the coals was 42.0 ft, with distances ranging from 27.0 to 65.0 ft. Other than the discontinuous Clarion #3 coal, all other coals are widespread throughout the study area and have a fairly consistent range of thickness. Of course, the Mahoning and Upper Freeport coals mainly are found in the higher topographic areas of the extreme western portions of the Muddy Run study area, where they have not yet been eroded away. Likewise, only the deeper coals, such as the Lower Kittanning, Clarion, Brookville, and Mercer coals remain in the eastern up-structure portion of the study area.

For the purposes of this assessment, minable reserves are limited by the following restrictions: seam thickness, coal partings, weathered outcrop margins, and barrier restrictions around buildings, streams, utilities, etc. Required spacing of drill holes for accurate correlation of coal beds varies with depositional environment of the coal-bearing rocks. The required spacing typically ranges from 2,000 to 8,000 feet (Wood et al., 1983). Appropriate spacing for the western Pennsylvania deltaic sequences under assessment in the Muddy Run watershed would typically be lower than the 2,000-foot standard suggested

by Wood. Reliability categories for classification of coal resources on the basis of distance between data points (outcrop or drill hole data) have been standardized by the U.S. Geological Survey (USGS) as follows (Energy Information Administration, 1999):

> ****Measured resources*** **:** 0 to ¼ mile from data point - refers to coal for which estimates of the rank and quantity have been computed to a high degree of geologic assurance, from sample analyses and measurements from closely spaced and geologically well known sample sites.
> ****Indicated resources*** **:** ¼ to ¾ mile from data point – refers to coal for which estimates of the rank, quality, and quantity have been computed to a moderate degree of geologic assurance, partly from sample analyses and measurements and partly from reasonable geologic projections.
> ***Inferred resources*****:** ¾ to 3 mile from data point – refers to coal of a low degree of geologic assurance in unexplored extensions of demonstrated resources for which estimates of the quality and size are based on geologic evidence and projection. Quantitative estimates are based on broad knowledge of the geologic character of the bed or region where few measurements or sampling points are available and on assumed continuation from demonstrated coal for which there is geologic evidence.
> ***Hypothetical resources*****:** more than 3 miles from data point
>
> * *Measured and Indicated resources* are summed to *Demonstrated resources* in some publications.

The USGS's underground recovery rate of 50% (USBM, 1993) was deemed to be appropriate for the coal reserves. Higher recovery rates have been used for local reserve valuations, however, the lateral inconsistency of the coal beds (common and abrupt lateral facies changes) and the considerable out-of-seam dilution associated with underground production supports the 50% rate. A recovery rate of 85% was used for local surface mining operations. Accepted minimum coal seam thickness thresholds of 14 inches and 28 inches (Eggleston et. al., 1990) were used respectively for defining surface mining and underground minable reserves. Coal seam partings were not considered in the assessment where the parting made up less than 50% of the coal seam. A maximum overburden thickness to coal seam thickness ratio of 15**:**1 was used to delineate economically minable coal via surface mining methods. [For example: The 15:1 stripping ratio leads to a 1500-foot strip cut target zone, as measured from the outcrop, based on the extraction of four feet of target coal (two 2-foot seams), a resultant 60-foot highwall, and a 4% average cover slope (topographic slope minus average coal seam dip).]

As discussed previously, due to historic mining patterns and local geology, this reserve estimate will focus on the lower Allegheny and Pottsville Group coals (Lower Kittanning, Clarion, Brookville and Mercer coal seams) in the eastern portion of the study area. Constraints on future mining exist in the western (west of township road T-564) and southwestern portions (between state route 1024 and the technical study area boundary) of the study area. These constraints include extensive previous surface mining and the presence of roads and structures. Approximately 2,500 acres are delineated within the eastern portion of the study area by the lowest coal seam (Mercer coal) outcrop. Previous surface mining has impacted approximately 800 acres. Approximately 850 acres of the eastern portion of the study area (located along the Muddy Run stream valley and the extreme northeastern portion of the study area) fall below the Mercer outcrop. The remaining estimated reserves are as follows: Lower Kittanning - 30 acres; Clarion - 200 acres; Brookville- 275 acres; and Mercer- 245 acres. The estimated minable

reserves total approximately 750 acres. Table 11 breaks down the reserves into acreages based on the previously outlined USGS reliability classifications.

Table 11. Coal Reserve Acreage separated by reserve reliability classification.

Coal Seam	USGS Reserve Reliability classification			
	Measured	Indicated	Inferred	Hypothetical
Lower Kittanning		30		
Clarion	134	66		
Brookville	182	93		
Mercer		25	220	

Table 12 provides reserve estimates by seam. Coal seam thicknesses were taken from Table 3, which contains a summary of coal thickness and frequency of occurrence for the ten coals identified in this study. The Clarion #3 seam was not considered due to insufficient drill hole data and the apparent discontinuous nature of the seam. Also, the Lower Kittanning, Clarion, Brookville, and Mercer coals, as characterized by the available drill hole data, are of insufficient average thickness to consider underground mining as a viable option. Therefore, the following economic assessment focuses on potential surface mining activities within the lower Allegheny and Pottsville Group coals. Average single seam thickness was used to calculate "In-place Tons." As previously outlined, an 85% recovery rate (15% mining loss) was assumed for surface mining operations.

Table 12. Estimate of Strippable Coal Reserves for Muddy Run Study Area

Coal Seam	Coal Thickness (avg.) feet	Coal Area (acres)	In-Place Tons (based on 1800 tons/acre-foot)	Adjusted Tons (minus 15% mining loss)
Lower Kittanning	1.9	30	102,600	87,210
Clarion	2.3	200	828,000	703,800
Brookville	2.0	275	990,000	841,500
Mercer	1.9	245	837,900	712,215

Economic Assessment

The coal reserves that may be sterilized by an unsuitable for mining designation can be used to estimate economic impacts on local wages and tax revenues. Employment and coal production estimates are based on the Department's *Annual Report on Mining Activities* (2001). To reflect local conditions, Cambria and Clearfield county data was included.

In 2001, the 587 surface mine employees in Cambria and Clearfield counties produced approximately 4.75 million tons of coal, for an average productivity rate of approximately 8,100 tons/worker/year. According to the U.S. Department of Energy's Energy Information Administration, bituminous coal

prices ranged from $23.92/short ton to $26.57/short ton (avg. $24.90/short ton) over the ten years from 1993 to 2003. Spot prices for some northern Appalachian coals have spiked dramatically (surpassing $60/ton for high quality, metallurgical coal) in mid- to late-2004. There is not indication that these types of dramatic increases will be realized for the lower Allegheny and Pottsville Group coals in Cambria and Clearfield counties. However, in order to give some weight to the recent upward turn in prices, the ten-year high coal price, of $26.57/short ton, was used to calculate the value of the local coal reserves.

The estimated employment impacts assume the following:

- Direct employment: Average annual salary per surface mine worker …. $36,000
- Direct service employment: Average annual salary per service worker …$30,000 (2/mine worker)
- Indirect service employment: Average annual salary per indirect worker..$30,000 (2/mine worker)

Table 13 outlines the estimated economic impacts by individual coal seam. The total estimated value of the minable reserves for all four seams is approximately $62.3 million.

Table 13. Estimated Economic Impacts for Individual Coal Seams

	Mercer	Brookville	Clarion	Lower Kittanning
Coal tonnage	712,215	841,500	703,800	87,210
Coal value (at $26.57/ ton)	$18.9 million	$22.4 million	$18.7 million	$2.3 million
Royalty (at $2.00/ ton)	$1.42 million	$1.68 million	$1.4 million	$0.17 million
Direct Employment				
Man years	90	104	87	10.8
Wages	$3.24 million	$3.74 million	$3.13 million	$0.39 million
Direct Service Employment				
Man years	180	208	174	21.6
Wages	$5.4 million	$6.24 million	$5.22 million	$0.65 million
Indirect Service Employment				
Man years	180	208	174	21.6
Wages	$5.4 million	$6.24 million	$5.22 million	$0.65 million
Tax Revenues				
Local wage tax (1%)	$0.14 million	$0.16 million	$0.14 million	$0.017 million
State income tax (3%)	$0.42 million	$0.49 million	$0.41million	$0.05 million

Federal income tax (20%**)**	$2.8 million	$3.24 million	$2.7 million	$0.34 million

VI. TECHNICAL STUDY FINDINGS

(1) Stratigraphic analysis of 298 drill hole records, and mining history information from permit files and field observations, indicate that eight coal formations have been mined within the Muddy Run study area and contiguous areas. All geologic formations dip to the northwest, from the headwaters of Muddy Run along the Allegheny Mountain to the structural trough of the Wilmore Syncline located approximately one mile northwest of the study area.

(2) Two parallel faults trend from southeast to northwest through the Muddy Run study area. One of these faults and numerous fracture zones were encountered during drilling of the township's two water supply wells, which are located along Muddy Run in the central portion of the study area.

(3) The highly fractured calcareous sandstones of the Loyalhanna and Burgoon Formations and the lower sandstone units of the overlying Mauch Chunk Formation are the confined aquifers, which provide the high quality, high volume, artesian flow that supplies the RTMA's public water system. These aquifers occur throughout the Muddy Run study area and underlie the superjacent coal-bearing strata.

(4) The recharge area for the RTMA wells appears to be primarily from the area east of the well field along the upper flank of the Allegheny Mountain, where the Mauch Chunk/Loyalhanna/Burgoon units are at, or near, the surface. Additional recharge to these units could occur via leakage from superjacent water-bearing units in the lower Allegheny and Pottsville Groups. The amount of recharge from the Pottsville lower Allegheny units would be dependent on the direction and magnitude of vertical gradients within the groundwater system. This vertical flow would be greatly influenced by the density and location of secondary permeability features.

(5) The RTMA wells were sited, designed and constructed to be reasonably well isolated from local coal- bearing rock units. Tests conducted during the development of the RTMA wells indicate increasing pressure with depth and upward flow from the lower Mauch Chunk units to overlying units. This precludes mine drainage impacted groundwater from migrating from the coal measure strata to the public supply source aquifer. Additionally, maximum drawdown thresholds were established to ensure that existing gradients across the confining units were not reversed.

(6) Based on available information, the potential for mining-related pollution of the RTMA wells would appear to be low. There is however a level of uncertainty that accompanies all groundwater evaluations, particularly those conducted in fractured bedrock. This is due to the need to simplify complex fracture-flow systems. In the case of the RTMA well field, the lateral extent and hydraulic conductivity of the confining units is not known. Groundwater tests conducted to date are not sufficient to characterize conditions beyond the immediate vicinity of the RTMA wells or to assess the localized impact of a discrete, highly transmissive fracture set. Therefore, although unlikely, the potential does exist for hydrologic communication between the RTMA supply aquifer and the superjacent coal-bearing units.

(7) Surface mining has occurred within the Muddy Run study area on a continuing basis since the 1940s. There has been extensive surface mining of the Brookville coal, Clarion coal, Lower, Middle, and Upper Kittanning coals, and the Lower and Upper Freeport coals, with 45 surface mine permits issued since 1946. Nearly half of the surface mines in the study area mined more than one coal, and most mine sites were later repermitted, often for deeper coals. During the 1930s, several underground mines extracted the Lower Kittanning coal.

(8) Overburden analysis results from 35 drill holes indicate the presence of high sulfur zones and the absence of any alkaline strata associated with the Lower Kittanning, Clarion, Brookville, and Mercer coals. There is significant potential for production of acid mine water from mining of these coals. In fact, these lower Allegheny and Pottsville Group coals have produced acidic mine drainage and are responsible for the degradation of Muddy Run. Strata associated with the Upper and Lower Freeport coals and the Upper and Middle Kittanning coals often contain high sulfur concentrations, but they sometimes may also contain intervals of alkaline strata with some neutralization potential. These coal seams have the potential of being mined without causing pollution, but need to be evaluated on a case-by-case basis.

(9) Fifty-two mine discharges were identified within the study area. Fifty of these were acidic mine water with elevated concentrations of metals and sulfate. Most of the discharges occur where several coals were mined together, or different coals were remined over the years. Discharges are associated with mine sites of every coal formation mined within the study area. Mine discharges throughout the study area are characterized by low pH and high concentrations of sulfate, aluminum, iron, and manganese.

(10) Coal mining has significantly impacted the water quality and aquatic community of Muddy Run. As a result of coal mining activities, all stream sections of Muddy Run and its tributaries within the study area, except for the headwaters in the eastern portion of the study area, are acidic with low pH and have high concentrations of aluminum, iron, and manganese. Biological surveys conducted during this technical study indicate that slightly less than a mile of Muddy Run, upstream of the Route 253 bridge to a point of significant spring-fed flow, is biologically impaired. This can be attributed to two major tributaries with substantial flow from mine drainage sources. Approximately 1.5 miles of Muddy Run upstream of the spring inflow is considered not impaired, despite some mine drainage influences. Mine discharges from abandoned mine land, forested runoff, and a major spring contribute flow from the southeast portion of the study area. Curtis Run's headwaters begin in the northeast portion of the technical study area and enter Muddy Run to the north of Route 253. It was considered impaired from mine drainage. No fish were found during the course of the technical study

(11) Springs are associated with groundwater discharges along outcrops of each of the coals mined within the Muddy Run study area. Springs located down gradient of surface mined areas often showed an influence from mining, with springs associated with strata between the Upper Kittanning and Mahoning seams typically being alkaline and springs associated with coal seams at the Lower Kittanning level and below often being acidic.

(12) Private water wells penetrate formations ranging from above the Mahoning coal downward to below the Mercer coals. The influence of mining on the wells studied was similar to the pattern of influence seen on the springs. Essentially, wells located down gradient of mined areas and penetrating strata located at or above the Upper Kittanning seam were often affected by alkaline mine drainage, while wells down gradient of mined areas and penetrating strata at or below the Lower Kittanning coal were often acidic with elevated metals and sulfates.

(13) Underground mining of the Lower Kittanning coal seam and surface mining of the Brookville, Clarion, Lower, Middle, and Upper Kittanning, Lower and Upper Freeport coal seams have greatly influenced hydrology of the headwaters of Muddy Run. Several past underground mining operations in the western portion of the technical study area have negatively influenced the quality of private wells, springs, and surface drainage. The resulting water quality is generally low pH with high concentrations of acidity, sulfates, and metals.

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