STUDY RESULTS

STUDY RESULTS

ANALYSIS OF SAMPLING PROGRAM

The modular sampling approach utilized in this watershed study fulfilled the needs of the pilot program. Acid producing modules were rapidly isolated and intensively studied. Large amounts of potentially effective abatement work were then recommended based on the results of one or two sample and flow measurements at each station. The modular sampling system also proved to be easily adaptable to various degrees of watershed pollution. By redefining the water quality limits of polluted and unpolluted modules, the modular system was easily applied to both Moshannon and Clearfield Creeks, which greatly vary in the magnitude of their AMD pollution.

Skelly and Loy's sampling program involved 1105 different sample station locations throughout both watersheds. These stations were generally sampled only once or twice, and required an average of 4 man-hours total sampling time per station. Past watershed studies have always utilized Weirs or surveyed cross sections and monthly sampling for at least a year prior to making abatement recommendations. During project SL-155, it was determined that this type of more accurate, repetitious sampling generally requires approximately 27 man-hours per station involved. Based on this, the modular sampling program required only about 13.5% of the time and related costs that the regular sampling requires yet is an estimated 65% as accurate as the regular programs.

To further emphasize the time and cost savings of the modular approach, a regular sampling program involving the same number of field workers and vehicles to sample the 1105 stations in these two watersheds would have required about 7.4 man-years to complete as opposed to the 1 man-year required for the modular approach.

Two problems were encountered with the sampling program, neither of which adversely affected the results obtained. It was extremely difficult, in fact impossible, to get consistent, accurate stream flow measurements on main streams and large tributaries, especially during higher flow conditions. This lack of accuracy was attributed to several factors. Samplers sometimes found it difficult to wade the width of the larger streams, and widths and representative average depths and velocities were sometimes approximated. In addition, the equation used to calculate flows, using an elliptical streambed shape, was not extremely accurate on very broad, relatively shallow streams. This difficulty with large flow calculations did not adversely affect the goals of the project because the data that was obtained was sufficient to classify modules as polluted or unpolluted. The point source discharges, which were "grab" sampled were much more important in determining acid loads from polluted modules and recommending abatement work. The lack of accuracy in main stream flows did, however, make it impossible to determine accurate net gains or losses in flow between main stream samples. This prohibited the use of materials balance schematics, which are difficult enough to balance accurately even with data obtained using weirs and surveyed cross sections.

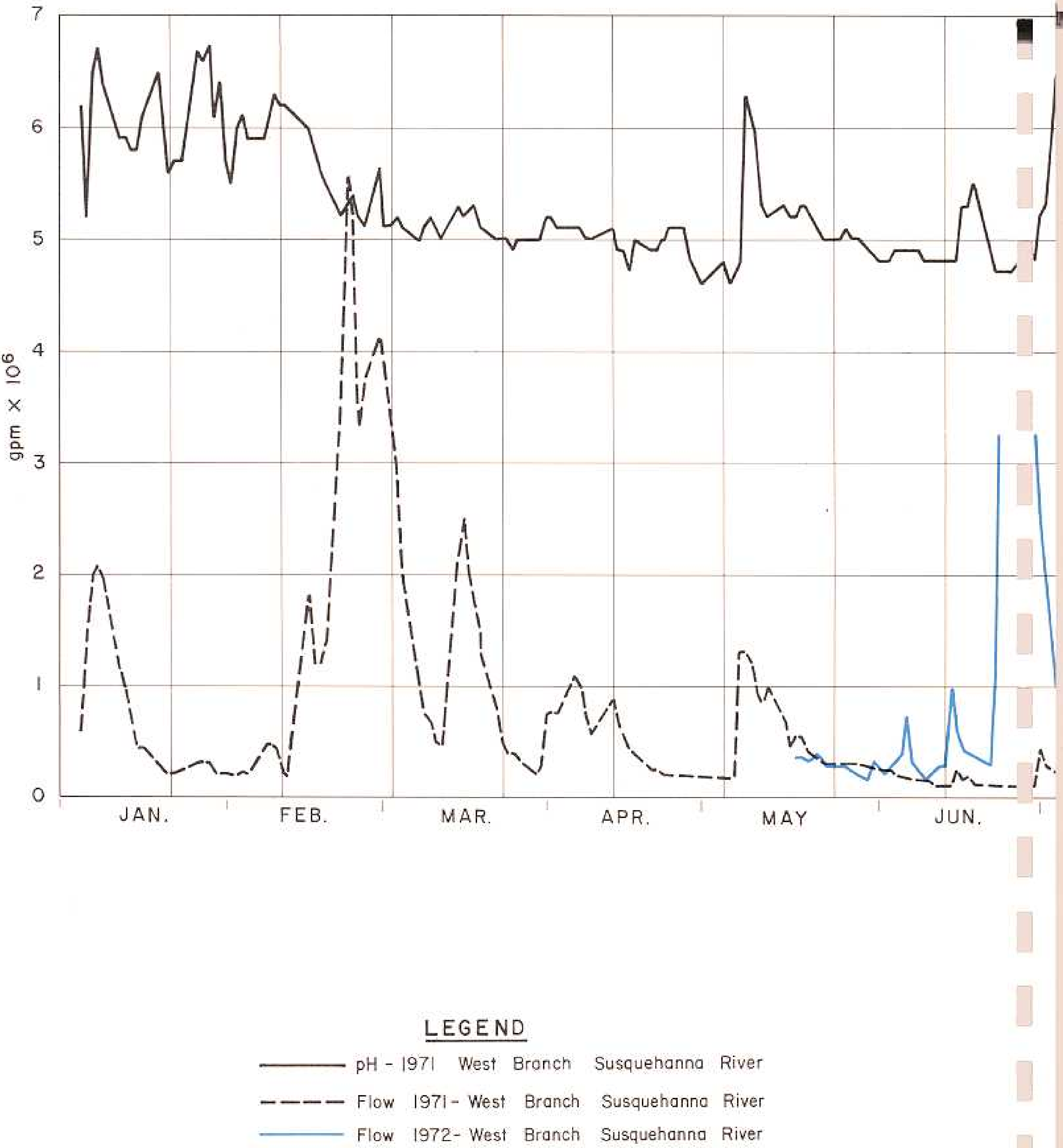
Some problems were also encountered where samples were taken in zones of poor mixing, such as along stream banks just down-stream from acid discharges on the same side of the stream. This was only a problem in the few instances where streams were too deep or swift to walk across, and presented no major difficulties.

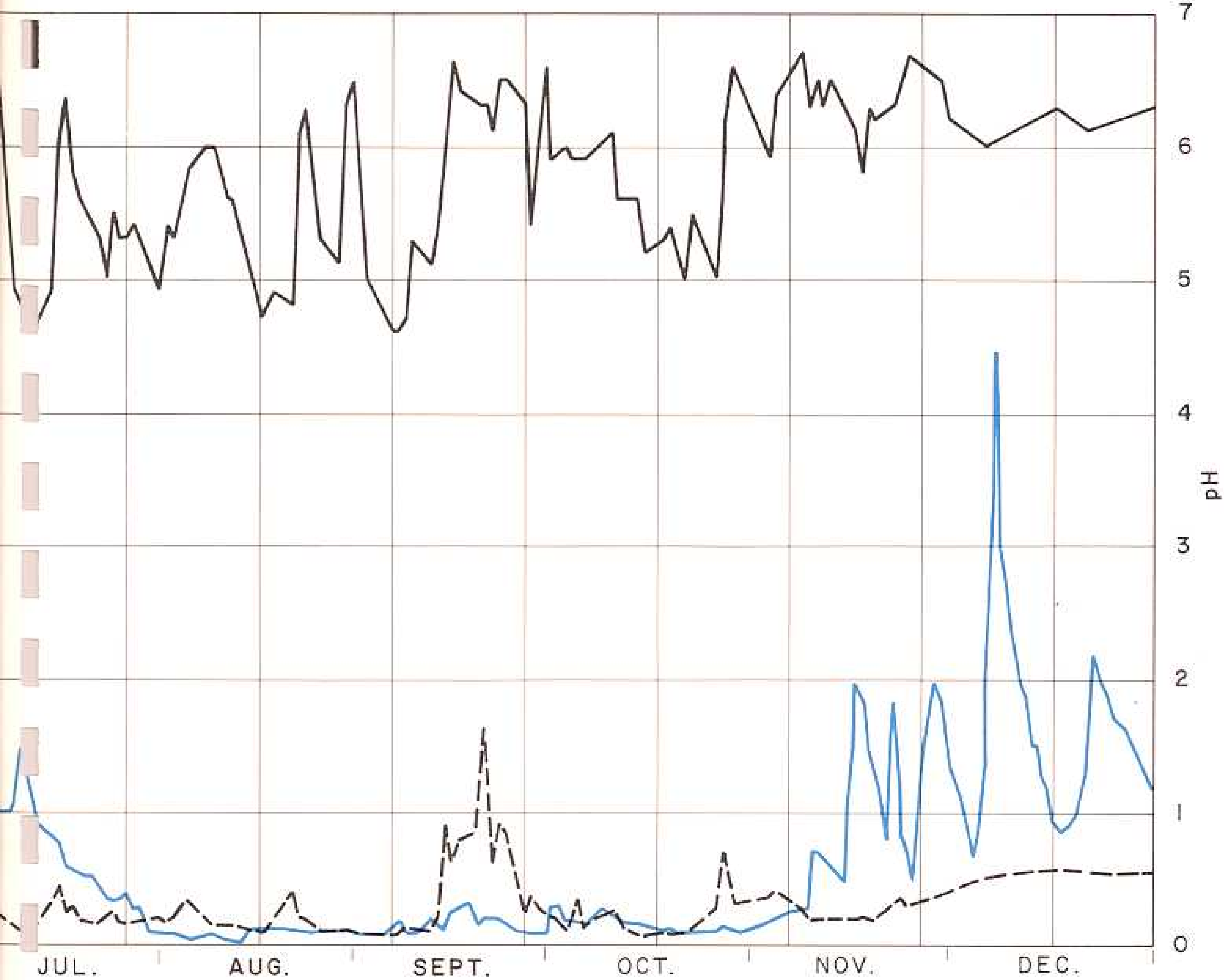
The pilot program has effectively demonstrated that worthwhile abatement recommendations can be made with the limited amount of data collected in each area during this program. Thus, the modular program and grab sampling method, with perhaps two thirds of the accuracy but only one fifth of the time and costs involved in a normal sampling program appears to be much more satisfactory for this type of large general water-shed study. This approach appears particularly useful in light of the fact that the energy crisis has encouraged increased mining activity, resulting in high acid load variabilities. New mining is continuously affecting old mines by altering the discharge now paths, the amount of acid production and the applicable abatement techniques. Sampling data, as a result, becomes quickly outdated. The high cost of obtaining highly accurate data appears unwarranted considering that the time span over which the data remains accurate is short.

FLOW ADJUSTMENTS

An understanding of the response of stream flow and acid production to seasonal precipitation changes was determined necessary to evaluate the minimal amount of water quality data obtained at each sample station.

To achieve this, accurate West Branch flow and pH data for recent and normal years was obtained from Penelec's Shawville Generating Station located on the West Branch of the Susquehanna River between Moshannon and Clearfield Creeks. The Shawville station monitors the flow and quality of the West Branch water, which it uses in its boilers. The river has a large, heavily mined drainage area west of this point. The similarities between the hydrologic conditions within the study area and those within the larger West Branch's drainage area above Shawville provide a basis for comparison of their relative flow and flow responses to certain seasonal conditions. The seasonal conditions that affect these stream flows are precipitation, spring melts and vegetative activity. The Shawville data was p1otted on a graph of river flow versus pH for consecutive weekdays, which appears on the following pages.

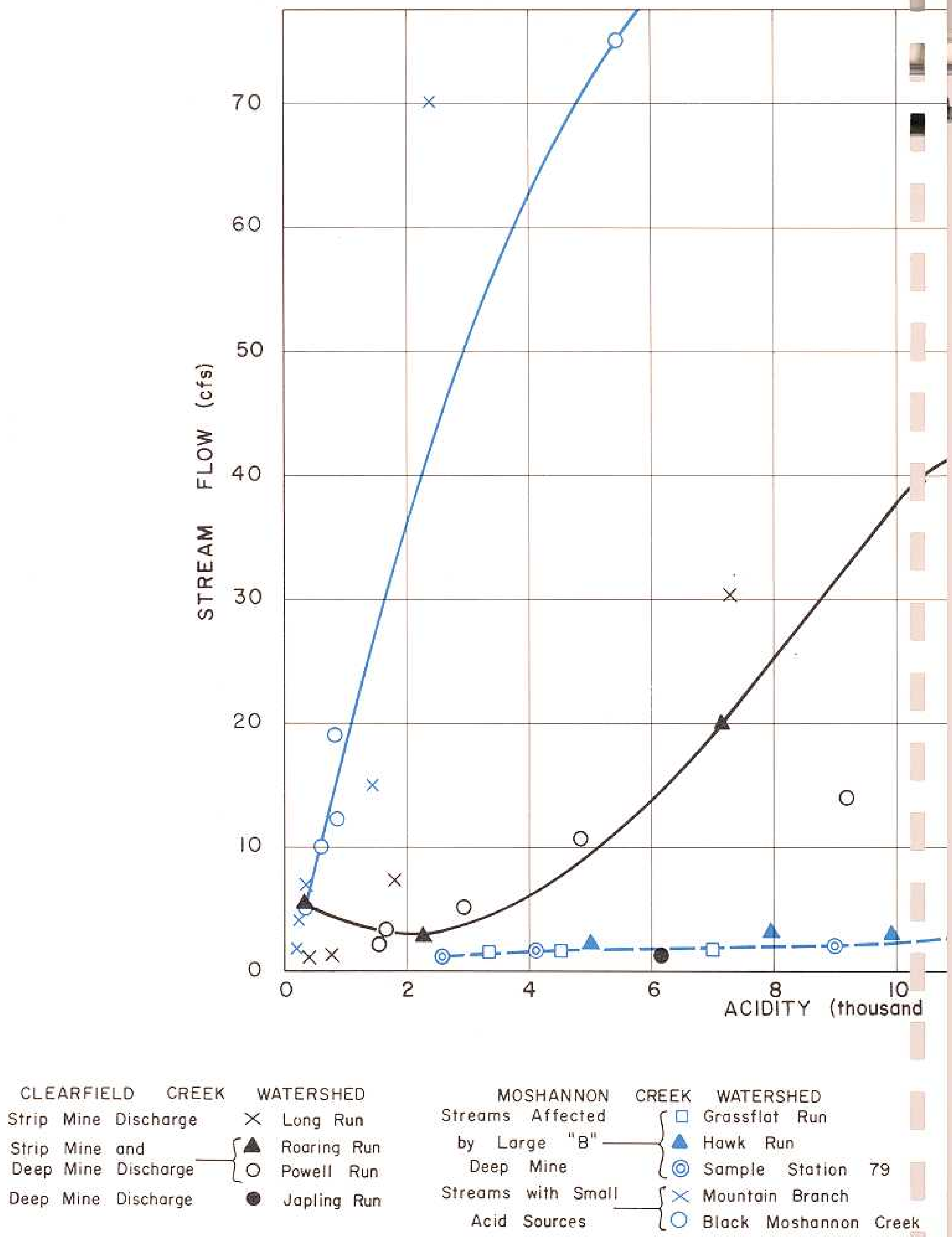

7
6
5
4
3
2
1
0
gpm × 10^6
JAN.
FEB.
MAR.
APR.
MAY
JUN.
LEGEND
pH - 1971 West Branch Susquehanna River
Flow 1971 - West Branch Susquehanna River
Flow 1972 - West Branch Susquehanna River

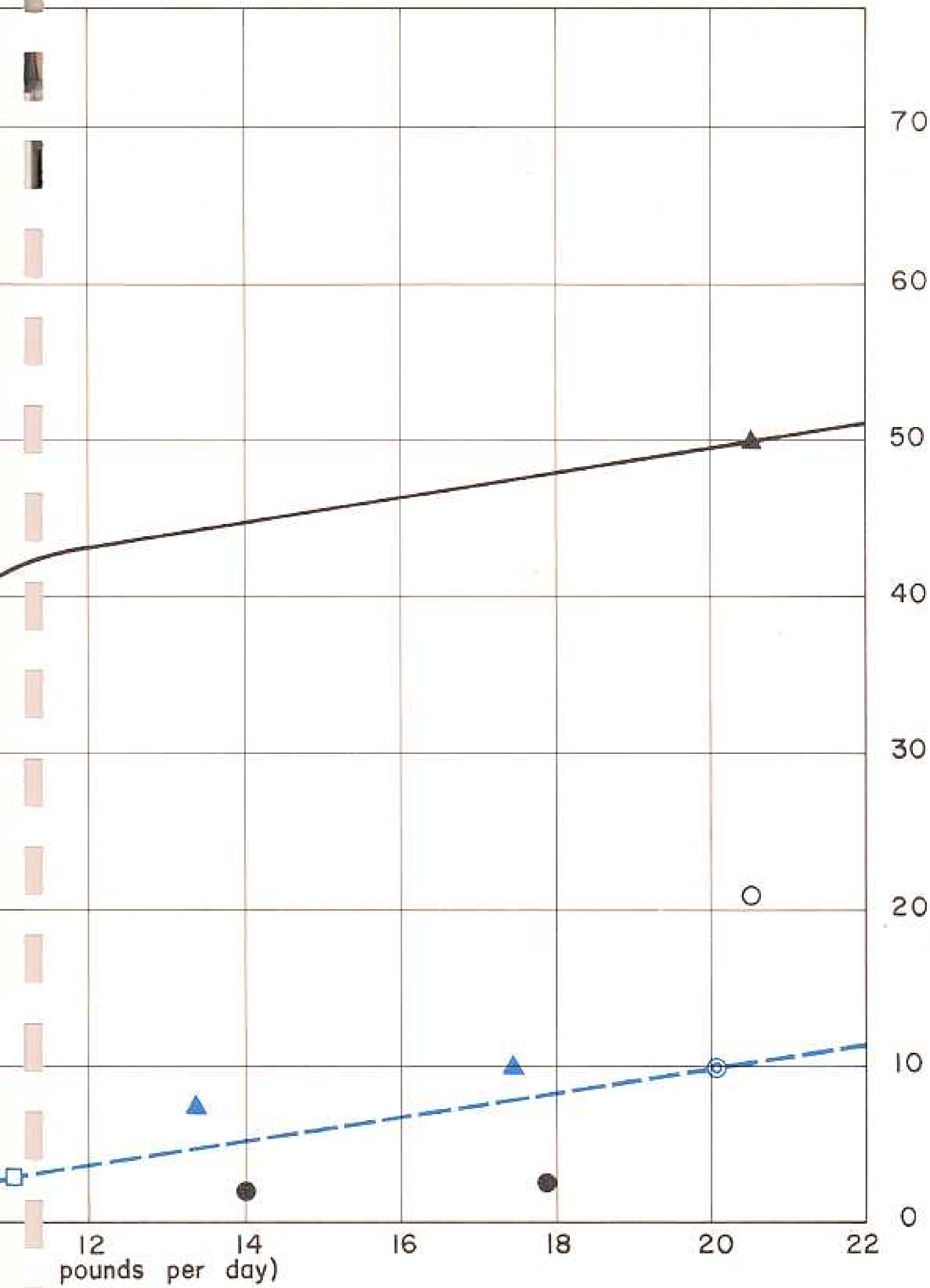


RIVER FLOW & pH ANALYSIS
West Branch Susquehanna River at Shawville

From the flow portion of the graph the average yearly flow was found to be 1,330 cfs, a rate exceeded in only 25% of the year's daily measurements. This is true because half of the total yearly flow recorded at the Shawville station passes that point in the first 3 1/2 months of the year. Flows then run 20-30% below the yearly average during the summer months during which time the pH fluctuates widely, frequently dropping below 5.0. This flow pattern is apparently common for the Upper West Branch Watershed, as it seems to be repeating in 1973. The Shawville data also suggests that slugging is a significant factor in a watershed's acid mine drainage production capabilities. Increases in flow after high rainfall periods are accompanied by decreases in pH, apparently the result of large amounts of acid being flushed from bony refuse dumps, spoil banks, and some deep mines. As flows subsequently subside to normal levels, PH increases.

Acid loadings and flow variations for individual tributaries to Moshannon and Clearfield Creeks, obtained during the pilot program, were also analyzed. Graphs of flow versus acid pounds per day consistently showed that numerous polluted modules' acid production increased proportionately with increases in flow. The Recorded Stream Flow vs. Acid lbs/day graph appears on the following pages.


STREAM FLOW (cfs)
70
60
50
40
30
20
10
0
0
2
4
6
8
10
ACIDITY (thousand
CLEARFIELD CREEK WATERSHED
Strip Mine Discharge
Long Run
Strip Mine and Deep Mine Discharge
Roaring Run
Powell Run
Deep Mine Discharge
Japling Run
MOSHANNON CREEK WATERSHED
Streams Affected by Large "B" Deep Mine
Grassflat Run
Hawk Run
Sample Station 79
Streams with Small Acid Sources
Mountain Branch
Black Moshannon Creek



RECORDED STREAM FLOW vs. ACID (lbs./day)

TRIBUTARIES TO
CLEARFIELD CREEK & MOSHANNON CREEK WATERSHEDS

A close inspection of this Shawville and pilot program acidity versus flow information indicated that, at least during the study period, acidity concentrations generally increased as stream flows increased. Thus, high rainfall periods did not improve stream water quality through dilution, as previously suspected. Instead, water quality remained the same or got worse as stream flows increased. Based on this information, stream flows could be increased or decreased to represent yearly average flows without misrepresenting the relative acid loads or water quality. This led to the successful use of the Shawville flow data to adjust stream flows obtained during pilot program sampling.

One of the basic advantages of the modular sampling program employed here was that all recommendations were based on only minimal sample data - one or two samples at each point source or stream station. This minimized the time required and the costs involved in the sampling program. It is virtually impossible with such sampling to obtain flow values that are indicative of yearly flows, especially when much of the sampling was done in the dry summer and fall months. To remedy this situation, variations between daily flow and the yearly average flow of the West Branch at Shawville, 1330 cfs, were used to adjust the stream flows obtained in the modular sampling program. The West Branch's flow at Shawville for any given date in the study period was divided by the river's average 1972 flow to yield a constant for that given date. The constants obtained, one for each day of the study period, reflected the relationship between the flow on any given day and the average yearly flow of the West Branch. Since the West Branch, Moshannon and Clearfield Creek's drainage areas are similar in all respects except size, it was felt that the daily flow variations represented by the constants for the West Branch would also apply to the two creeks and all flows within their watersheds. Thus, all surface flows obtained during the pilot program were adjusted to represent yearly average flows using the constants derived from the West Branch data. Where the West Branch's flow was above the average, the constants were less than 1.0 and the flows were adjusted downward, and where the daily flows were below the yearly average, they were increased accordingly. The table of daily flow constants calculated from Shawville's West Branch data is presented on the following pages.

STREAM AND DISCHARGE

JULY

Date	Constant
3	.6
5	.6
6	.55
7	.4
10	.67
11	.71
12	.76
13	.82
14	1.05
17	1.14
18	1.14
19	1.38
20	1.69
21	1.79
24	1.5
25	2.31
26	1.94
27	3.64
28	5.0
31	6.32

AUGUST

Date	Constant
1	6.67
2	7.06
3	7.06
4	9.23
7	17.14
8	10.91
9	10.91
10	9.23
11	12.5
14	10.5
15	8.57
16	5.46
17	5.0
18	5.46
21	5.46
22	6.0
23	6.67
24	6.32
25	6.32
28	6.0
29	5.0
30	5.46
31	6.0

SEPTEMBER

Date	Constant
1	6.67
5	7.5
6	7.5
7	4.29
8	3.75
11	7.5
12	3.0
13	4.29
14	. 5.46
15	2.4
18	1.71
19	4 .0
20	3.0
21	3.0
22	3.0
25	4.8
26	6.0
27	10.0
28	5.88
29	5.46

FLOW ADJUSTMENT CONSTANTS

OCTOBER NOVEMBER DECEMBER

Date	Constant	Date	Constant	Date	Constant
2	2.0	3	2.93	1	.79
3	2.0	6	2.36	4	.93
4	3.24	7	2.2	5	.6
5	3.24	8	2.04	6	.28
6	3.43	9	.83	7	.13
9	2.22	10	.83	8	.19
10	2.36	13	1.00	11	.29
11	2.46	14	1.06	12	.33
12	3.45	15	.29	13	.4
13	3.64	16	.3	14	.4
16	3.77	17	. 39	15	.49
17	4.55	20	.79	18	.61
18	4.55	21	.3	19	.69
19	4.14	22	.71	20	.55
20	4.55	24	1.04	21	.45
23	4.4	27	.3	22	.27
24	4.35	28	.33	26	.3
25	4.35	29	.42	27	.37
26	3.55	30	.41	28	.44
27	3.9			29	.5
30	4.38				
31	3.9				

Deep mine discharges were excluded from this flow adjustment technique because of the general nature of many deep mine pools. Although the levels of the pools within the mines may fluctuate in response to daily conditions, the discharge flows from such pools are not particularly influenced by daily rainfall, but rather they respond to longer term climatic conditions and exhibit a large lag period behind surface flow variations. Since the deep mine discharges could not be expected to vary in accordance with surface flows, they were not adjusted at all. However the flow measurements obtained for deep mine discharges are lower than the yearly averages because the sampling was completed during a relatively dry season.

GENERAL RESULTS

The pilot program basically confirmed many facts that were already known or strongly suspected about the study area. The major sources of acidity within the Moshannon and Clearfield Creek Watersheds are the Allegheny Group coal measures. These coals are not the only sources of acid, however. The pyritic nature of the underlying Pottsville Group sandstones contributes a certain background acidity to those streams originating east of the edge of the coal measures. This is the case in the portion of Black Moshannon Creek that lies outside the coal measures, where natural acidity keeps the stream's pH in the 5.0 to 5.5 range.

The major area of acid mine drainage production within the study area is defined by the limits of the Houtzdale-Snow Shoe Syncline. The Allegheny Group Clarion and Lower Kittanning coals are the principal acid producing seams within the syncline, and are also the most intensively mined seams within the study area. Both of these coals and their associated overburden are pyritic throughout both watersheds. The Pottsville Group's Lower Mercer clay, which lies stratigraphically beneath the Allegheny Group strata, produces some acid in the north-central portion of the Clearfield Creek Watershed, where it was most heavily mined. The Allegheny Group Middle Kittanning, Upper Kittanning and Lower Freeport seams also produce acid locally. The Upper Freeport coal is non-pyritic throughout the study area.

The major acid production in the study area generally occurs within the Houtzdale Syncline, which underlies much of the Moshannon Creek Watershed and the southern two-thirds of the Clearfield Creek Watershed. Regional erosion of the syncline has brought the add "A" and "B" coals relatively close to the surface, and downcutting of the local streams has resulted in extensive outcropping of the Allegheny Group coals along valley walls. In such areas, the generally thick "A" and "B" coals were extensively deep and strip mined, compounding the probability and seriousness of acid production.

Areas in which the acid producing "A" and "B" coals are relatively deeply buried, and were not mined, such as the southwestern and northwestern portions of Clearfield Creek's Watershed, were generally not major add sources. Although the upper coals of the Allegheny Group have been very heavily mined in some of these areas, acid formation is minor and overall stream qualities are good.

The modular watershed index maps in the report pocket illustrate the pilot program findings. Red shaded areas report what modules, sources of add mine drainage with pH's generally below 4.0. The streams within these areas suffer severe acid pollution. Blue shaded areas represent unpolluted modules, in which pH's are above 4.0 and water is not to be considered severely polluted. Streams which are severely polluted by acid mine drainage from acid sources upstream from the unpolluted modules are indicated with red hatchures where they pass through that unpolluted module.

One important finding made during the pilot program was that the majority of the acid mine drainage emanated from a few relatively small but extremely polluted modules. This is evident from the proportion of polluted to unpolluted modules or areas on the module maps of the two watersheds included in the pocket at the back of this report. This eliminated the necessity of considering entire watersheds for abatement measures, and more intensive abatement feasibility determinations could be made within the smaller acid producing sub-modules.

Intensive sampling within the polluted modules revealed acid mine drainage emanating from old deep mine drifts, air shafts, blow-outs, bony piles, and areas in which deep mines had be9n partially stripped out. Many discharges from the ineffective WPA deep mine air seals, which were constructed in the late 1930's, were noted. Other acid sources were unreclaimed strip mines and seepages from spoil, bony or directly from tile coal outcrops. The abundance of yellowboy in stream channels and the proximity of many bony and spoil piles to those channels has created local siltation and erosion problems. The vast amount of mining in the watersheds increases the complexity of the acid mine drainage abatement problem in this region.

The distribution and water quality effects of acid producing zones with in the watershed were primary considerations in priority establishment.

Clearfield Creek Watershed

The single, most important finding of the pilot program in the Clearfield Creek Watershed was that it actually has two distinct regimes differentiated by relative water quality and by the nature and size of the pollution sources involved. The watershed can be divided into a northern and a southern regime, with the dividing line located just south of Muddy Run, upstream from Clearfield Creek's largest polluters - Middle Penn No.4 Mine in the Japling Run watershed and the Brookwood Shaft Mine in Muddy Run Watershed. The Brookwood Shaft Mine was studied under project No. SL-155.

Clearfield Creek itself maintains fairly good water quality throughout the length of the southern regime. The explanation for this is evident from the Watershed Index Map which indicates polluted and unpolluted modules. Most of the tributaries of Clearfield Creek in this southern regime are within unpolluted modules and are alkaline in nature. The acid loads discharging from relatively few polluted modules within this regime are fairly rapidly neutralized by the large amounts of alkaline water in the creek. Therefore, the acidity contributed by these polluted modules does not render Clearfield Creek acid, but does through its neutralization decrease the alkalinity of the stream. The iron and occasionally acid slugs that enter Clearfield Creek even after the neutralization process, do degrade the stream, however, at the downstream end of the southern regime near sample station 29.71, Clearfield Creek waters range from slightly acid to slightly alkaline with an average 8 mg/l alkalinity and 345 mg/l sulfate content. Any abatement work in this southern regime will greatly improve the quality of Clearfield Creek. Less acid, iron and sulfate will be discharged into the stream, less of the stream's natural alkalinity will be consumed in neutralizing the acid, and the quality of the entire creek will, as a result, be greatly improved. It is felt that with a relatively small amount of abatement work, the southern regime of Clearfield could become an excellent fresh water recreation and fishing area.

The northern Clearfield Creek regime presents an entirely different problem. The entire length of Clearfield Creek within this regime is severely polluted by two major deep mine discharges from the Brookwood Shaft, discharging to Muddy Run, and the Middle Penn No.4 Mine, discharging to Japling Run and Clearfield Creek. Skelly and Loy's "Muddy Run Watershed Mine Drainage Study," Project No. SL-155, showed the Brookwood Shaft to be discharging an average of 17,000 pounds per day acid to Muddy Run, and the pilot program showed the Middle Penn Mine to be discharging an average of 35,000 pounds per day acid to Japling Run and Clearfield Creek. The total acid load from these two discharges is 52,000 pounds per day, which represents 90% of the average 57,000 pounds per day acid load measured at the mouth of Clearfield Creek. Even if, as suspected, the acid load at the mouth of

Clearfield Creek is somewhat low and that measured at the Middle Penn No.4 Mine is somewhat high, the two deep mine discharges are still contributing greater than one-half of the acid load observed at the mouth of Clearfield Creek. This high percentage of Clearfield Creek's total acid load at the mouth does not consider the effects of neutralization of large additional amounts of acidity by the alkaline water entering the stream. It is felt that, without these two major deep mine discharges, Clearfield Creek could probably neutralize nearly all other acid entering it, thus maintaining fairly good water quality. The remaining relatively minor acid mine drainage discharges to Clearfield Creek originate in two acid producing areas in the northern regime just north of Madera and in the northeastern corner of the watershed, as indicated by the polluted modules on the Watershed Module Map.

The purpose and scheme of abatement for the pollution sources within northern regime differs somewhat from that presented for the southern regime. Feasible abatement projects are recommended in many of the northern regime's polluted modules but they will be ineffective in restoring the quality of Clearfield Creek or the West Branch of the Susquehanna <u>until the effects of the deep mine discharges from the Brookwood Shaft and Middle Penn No.4 Mine are eliminated or significantly reduced.</u> Work in the other abatement areas of the northern regime will, of course, greatly improve the water quality of many of the tributaries to which they discharge, but even 100% abatement of all other acid discharges within the regime would be insufficient to effectively upgrade the quality of Clearfield Creek as long as Brookwood and Middle Penn continue to discharge.

Moshannon Creek Watershed

The mined portion of the Moshannon Creek Watershed, unlike that of Clearfield Creek, cannot be divided into regimes of different overall water quality. Acid discharges exist throughout the portion of the watershed underlain by the coal measures. Nearly all tributaries to the creek are acid, and the entire length of Moshannon Creek, except for its extreme headwaters, is grossly polluted by acid mine drainage. Many of the tributaries to Moshannon Creek are constantly degraded by year-round acid discharges. A few tributaries simply receive periodic slugs of acid that are sufficient to limit or prohibit biological activity while not necessarily seriously degrading the streams.

The only notable tributaries that were not seriously degraded by acid mine drainage throughout most of their length were Black Moshannon Creek, Cold Stream, Mountain Branch, Black Bear Run, Sixmile Run and Sevenmile Run. The first three of these streams receive large acid discharges near their mouths, and thus are polluted by acid mine drainage when they reach Moshannon Creek. The latter three streams showed no signs of pollution.

Moshannon Creek's acid load is largely of deep mine origin. Major deep mine discharges were located along Moshannon Creek south of Osceola Mills, along Little Beaver and Coal Runs, Trout Run, Cold Stream, Laurel Run, One Mile Run, Wolf Run, and all tributaries west of the creek from Hawk Run north to Crawford Run.

These major deep mine discharges and countless other smaller acid sources to degrade Moshannon Creek to the point where no amount of at source abatement using present technological means could restore the stream to acceptable water quality for most purposes.

The largest single deep mining complex in the study area discharges into all of Moshannon Creek's western tributaries from Hawk Run north to Weber Run. This vast, interconnected group of "B" seam deep mines extends westward to Alder Run, south to Emeigh Run, and east to Moshannon Creek, underlying at least 4,300 acres of land. Within this complex the coal dips southeastward, dropping several hundred feet and creating very large hydraulic heads along Moshannon Creek. The deep mines within this complex discharge an unadjusted acid load of over 66,000 pounds per day to nine tributaries in this portion of the watershed. Despite the large acid loads and the profound effects they have on the tributaries, Moshannon Creek and the West Branch below the creek, there presently is no technically feasible way of abating this acid. The shallow overburden, strip mined outcrops, small crop barriers and large potential hydraulic heads within the mines make deep mine sealing impossible, and the expense of a treatment plant of sufficient size to handle the entire discharge of this complex is prohibitive. Thus, there is no feasible solution now or in the near future to the acid mine drainage problems posed by this "B" seam complex.

EXPLANATION OF MAPPING

All of the abatement area texts within the report are titled with the name of the major watershed within which they lie - either the Moshannon or Clearfield Creek Watershed. Abatement areas are also identified by a letter designation from A through Y both in the text and on the accompanying Mine Development Drawings.

Each abatement area is shown on a Mine Development Drawing, most of which are located in the pocket at the back of this report. The complexity in size and extent of the abatement areas was such that, in some cases, several abatement areas are shown on a single map and in other cases, some abatement areas were so large that, they required more than one Mine Development Drawing.

There are a total of thirteen Mine Development Drawings for the twenty-five abatement areas presented in this report. Two of the abatement area maps are small enough to be shown on single 8 1/2" by 11 " paper, and these have simply been included in the text. The remaining eleven larger Mine Development Drawings are found in the pocket at the end of this report.

The confusion resulting from such an extensive collection of Mine Development Drawings was solved by the use of an indexing system. The pocket at the back of this report contains the eleven abatement area maps and two Index Maps, one each for the Clearfield and Moshannon Creek Watersheds. These Index Maps are the two most important maps in the report. They delineate the area covered by the individual Mine Development Drawings. The letter designation of all of the abatement areas is also shown on the Index Maps. In addition, the Index Maps show the polluted and unpolluted modules within each watershed, the major product of the modular sampling program. The polluted modules are shaded in red and the unpolluted modules in blue on these maps. Thus, it is possible to examine a single Index Map, for the Clearfield Creek Watershed, for example, and determine the distribution of polluted modules at a glance and which polluted modules lie within the designated abatement areas. The number, size, and location of the polluted modules gives some indication of the extent and severity of the acid mine drainage problems throughout the watersheds. The locations of the Mine Development Drawings, which contain the abatement areas, give an indication of how the recommended abatement plan for each watershed has dealt with the polluted modules within the watershed. These Index Maps, showing the locations of the thirteen Mine Development Drawings and the polluted and unpolluted module classifications, are found in the pocket at the back of this report.

PROBLEMS ENCOUNTERED

Aside from the difficulties mentioned in connection with the sampling program, there were only two major problems that plagued the pilot program. The active mining versus abatement conflict made certain much needed abatement recommendations difficult or impossible to include. The location and acquisition of important deep mine mapping was also a problem.

The active mining versus abatement problem is one that applies not only to the Clearfield and Moshannon Creek Watersheds, but to the entire coal-mining portion of the state. The largest acid mine drainage source areas in both watersheds have been and still are the sites of the heaviest mining activity. The primary sources of acid mine drainage in these polluted modules are the old deep mines, but the major mining emphasis has switched to surface mining in recent years. The conflict here is between abatement and surface mining, because the surface mining permits tie up all land overlying many of the deep mines. This was the case in both watersheds in the study area, but particularly within the Houtzdale Syncline in the Moshannon Creek Watershed, as is mentioned in Abatement Area T. Many areas exist where vast acreages are under water quality permits kept active by only the minimum required amount of active mining. Within these water quality permits are frequently numerous old strip and deep mines upon which some type of effective abatement work could be done. These old mining sites are often being kept under active permits because the strip mine operators intend to restrip portions of the old cuts at a later date. Many of these old cuts contain mineable coal, but the added expenses of the restripping operation and the required reclamation of both the new and old portions of the cut offset potential profits, and such operations would be only marginal at present. Therefore, the operators frequently hold these areas under an active permit waiting for the time in the near future when the nation's coal economy reaches the point where such restripping operations are profitable.

A potential solution to this dilemma involves two steps which would limit mining in major acid producing areas, enabling state and federal financed abatement work to proceed, and affect at least partial reclamation in some other areas presently held under active permit.

The first portion of this suggestion, the limitation of active mining in acid-producing areas or on acid-producing coal seams, can be accomplished by coordination and cooperation between active mine operators and the Department of Environmental Resources in the planning of future mining. This would entail a shift of mining concentration from the acid coals such as the Clarion-Brookville, and Lower Kittanning to the alkaline and non-acid coals such as the Middle and Upper Kittanning, the Freeports and higher coals.

Once the heavy mining activity shifts out of the existing polluted modules, effective abatement recommendations can be made for these areas.

The second step, if taken immediately, can produce almost immediate abatement action. A bounty or incentive of perhaps $100 to $200 per acre could be offered to all strip miners who restrip older cuts. This will help to defray the previously mentioned additional expenses encountered in restripping operations, changing them from marginal to profitable. In the process, these strip miners are required by law to reclaim both new and old portions of their strip mine areas. Pennsylvania's strip mine reclamation laws are presently stringent enough to assure that the reclamation of these old strips by the strip miners will be as effective as any reclamation directly financed by the Department of Environmental Resources, and much cheaper per acre. This suggestion offers a simple, cheap solution to the problems of reclaiming the vast number of old, unreclaimed strip mines throughout the coal mining portions of the state. This suggested bounty applies only to the acreage of unreclaimed strip mines that are reclaimed. This bounty could even be more specific by authorization only for acid producing seams.

The second problem encountered, the location and acquisition of old mine mapping information, is one which worsens every year. This was not a critical problem during this pilot program, because several extremely cooperative sources of mine maps were located, as mentioned in the Acknowledgements to this report. Lack of mine mapping did, however, prevent the formulation of specific abatement recommendations in several areas. There were several instances during the study where collections of mine maps had recently been destroyed or given away because they were considered useless. In addition, many mining and land companies are finding it to their advantage to collect all of the mine mapping they can obtain and lock it away for their own private use. At least one known collection of mine maps was inaccessible during the study for this reason.

There are several possible related solutions to this problem. The United States Bureau of Mines presently maintains a mine map repository in Pittsburgh, in which photocopies of mine maps are kept. This collection was used extensively during the study and proved invaluable. However, the collection is incomplete. Mapping for most of the larger deep mines is available, but there are numerous small to medium sized mines for which the United States Bureau of Mines has no mapping. Some of this mapping is known to exist because it was obtained from other sources during the study. It would be of advantage to the Department of Environmental Resources if some method could be devised to assist the United States Bureau of Mines, which already has all of the necessary photocopying facilities, in obtaining these old maps which are so rapidly disappearing from circulation.

The second possible solution to this problem follows along similar lines, and was suggested by Skelly and Loy earlier in the study. This solution involves the contracting of an engineering firm to compile some type of composite maps of all obtainable mine mapping information, at least for the acid-producing coal seams within the hottest modules of the state. This mapping would essentially be an updated version of the old WPA mapping, which was extremely helpful, although outdated.

A third suggestion, which would be most helpful if used in conjunction with one of the first two, involves the location and utilization of mine mapping that should already be on record at the Department of Environmental Resources. All active coal mining operations in the state since 1947 have been required by law to submit updated mine maps at regular intervals. The filing system used to classify these mine maps is so complex that very few of the maps, which are known to exist, could actually be obtained. Perhaps a new classification system based on township, watershed or mine name could be devised, and another file of copies of these mine maps established. This would be a great aid in any future acid mine drainage abatement projects.

Implementation of any or all of these suggestions would greatly decrease the time spent dealing with the problems mentioned, and would be invaluable in all future acid mine drainage studies. Acid mine drainage from abandoned deep mines is going to be a problem in Pennsylvania for many years to come. Deep mine data is becoming more difficult to obtain each year. A massive cataloguing of presently available deep mine data will be necessary to enable future generations to effect solutions to a growing water supply and pollution problem.