CONCLUSIONS

A. Basin Division

I. The survey has indicated that the portions of the Chartiers Creek Drainage Basin which are polluted by acid mine waters may be considered as two distinct areas, designated as the northern and southern zones and principally separated by Robinson Run, shown on Plate 2. The division is made on the basis of percent of major sources present and percent contribution of acid mine water to Chartiers Creek.

2. The northern zone is bounded by U. S. Rt. 22, Pa. Rt. 60 and Robinson Run, and it contains more than 90% of the major and minor sources and contributes approximately 60% of the total pollution into Chartiers Creek. Over 1,700 acres of completely unreclaimed strip mines and over 1,600 acres of randomly reclaimed strip mines are present in this zone of the basin.

3. The southern zone lies south of Robinson Run and contains only five major sources which drain deep mines and it contributes approximately 40% of the average daily acid load into Chartiers Creek. This zone has not been as extensively strip mined as the northern zone because the coal generally does not outcrop in this area. The high percentage of acid contribution into Chartiers Creek is due to the fact that the large subsurface area drains through relatively few sources.

B. Pollution Sources

1. Major Sources

a. There are 43 major sources and approximately 250 minor sources in the Chartiers Creek Basin. A major source is defined as one which produces over 1,000 lbs. of acid load/day during periods of maximum flow. The average acid contribution for most of the major sources measured over the period of one hydrologic year (13 months) is substantially less. The locations of the major sources are shown on the maps included in Appendix AII and Appendix BII.

b. Of the 43 major sources, only five individual or compound sources discharge an average of more than 1,000 lbs. of acid load/day for the entire hydrologic year. These are: sources 4971-4967 (Millers Run): 4041 and 6048 (North Branch Robinsons Run); 4962-4963 (Robinson Run); and 6005 (Campbells Run). Eleven of the major sources discharge on the average of between 500 and 1,000 lbs. of acid load/day. These are: 4834, 4805, and 4810 (North Branch Robinsons Run); 4962, 4654, 4951-4952, 4019, 4055, 4034, 4153 (Robinson Run); and 6022 (Campbells Run).

c. The 43 major sources of pollution contribute on the average of 32,000 lbs. of acid load/day into the waters of the Chartiers Creek Drainage

Basin. During periods of heavy rainfall this pollution load can triple, i.e., acid load can increase to over 100,000 lbs. per day.

d. There appears to be a definite correlation between randomly reclaimed strip mines and the presence of major sources. Collier and South Fayette Townships, which lie east of North Branch Robinsons Run, contain very few major sources. This is probably due to the fact that a major portion of the strip mines have been reclaimed in these townships. On the other hand, the presence of many major sources in North Fayette Township (Allegheny County) and Robinson Township (Washington County) Is probably due to the unreclaimed condition of many of the strip mines in that area.

2. <u>Slugging:</u>

a. All the major sources increased their acid load during periods of heavy rainfall, but a source which increased Its average acid flow by a factor of four or more was considered to be a serious slugger.

b. The slugging index, which is the ratio between the average and maximum acid load of the source, describes the potential of the source to increase its acid flow during periods of rainfall.

c. The slugging index of the major sources generally increases as the percentage of pollution contribution decreases. These sources have the potential to periodically produce acid slugs which could overcome the alkalinity of the stream if left unabated, even though normally they produce an acid load less than 500 lbs. a day. Based on the readings taken at the 43 major sources, the major tributary to Chartiers Creek most affected by slugging is Robinson Run.

d. Although the cost of abatement of the sluggers is relatively high in comparison with the pollution reduction obtained, treatment of the sluggers should be considered a very necessary part of the acid mine water abatement. A high slugging index (4X and above) indicates that restored alkalinity could be overcome and aquatic life, which may begin to thrive in restored streams, could be destroyed.

3. Treatment Facilities:

Construction of treatment facilities may be necessary for some major sources in the Chartiers Creek Drainage Basin to sufficiently improve the quality of water in the major tributaries to a point where it will support aquatic life. However, such facilities do not provide a cure for the problem and are only a temporary solution. They require continuous operation and maintenance. Over a period of years the cost could be higher than the cost of surface restoration of strip mines and/or filling of the deep mines. Limestone neutralization is a suitable method of treatment for certain sources which are high in acidity and very low (less than 25 ppm) in iron. Treatment facilities should be constructed after most of the improvement in natural drainage has been made so that the amount of acid water which must be treated will be minimal.

4. Priority:

The following table presents the major sources arranged according to recommended priority of abatement. The priority numbers are assigned to each source in descending order of the Percentage of Acid Contribution into Chartiers Creek. For the purpose of comparison, we have included the maximum measured acid load of the sources. Also included in the table is the slugging index.

Priority No.	Major Source No.	Maximum Lbs./Day Acid	Avg. Lbs./Day Acid Hydrologic Year	% Acid Contribution into Chartiers Creek	Slugging Index
1	4971-4967	21,654	9314	28.5	2
2	4041	4,410	2360	9.0	2
3	6005	5,040	1810	7.0	3
4	4805,4804,4824	8,450	1329	3.5	6
5	6048	2,765	1260	3.5	2
6	4952-4951	3,403	1216	3.5	3
7	4654	3,240	1075	2.5	3
8	4962-4963	3,629	1058	2.5	4
9	4972	2,373	948	2.5	3
11	4801-4802	5,040	774	2.5	7
12	4055	4,356	740	2.0	6
13	4034	2,880	710	2.0	4
14	4834	1,890	688	2.0	3
15	4019	2,680	590	1.5	4
16	6022	1,282	550	1.5	2
17	4957-4956	2,807	522	1.5	5
18	4816-4815	3,163	494	1.5	6

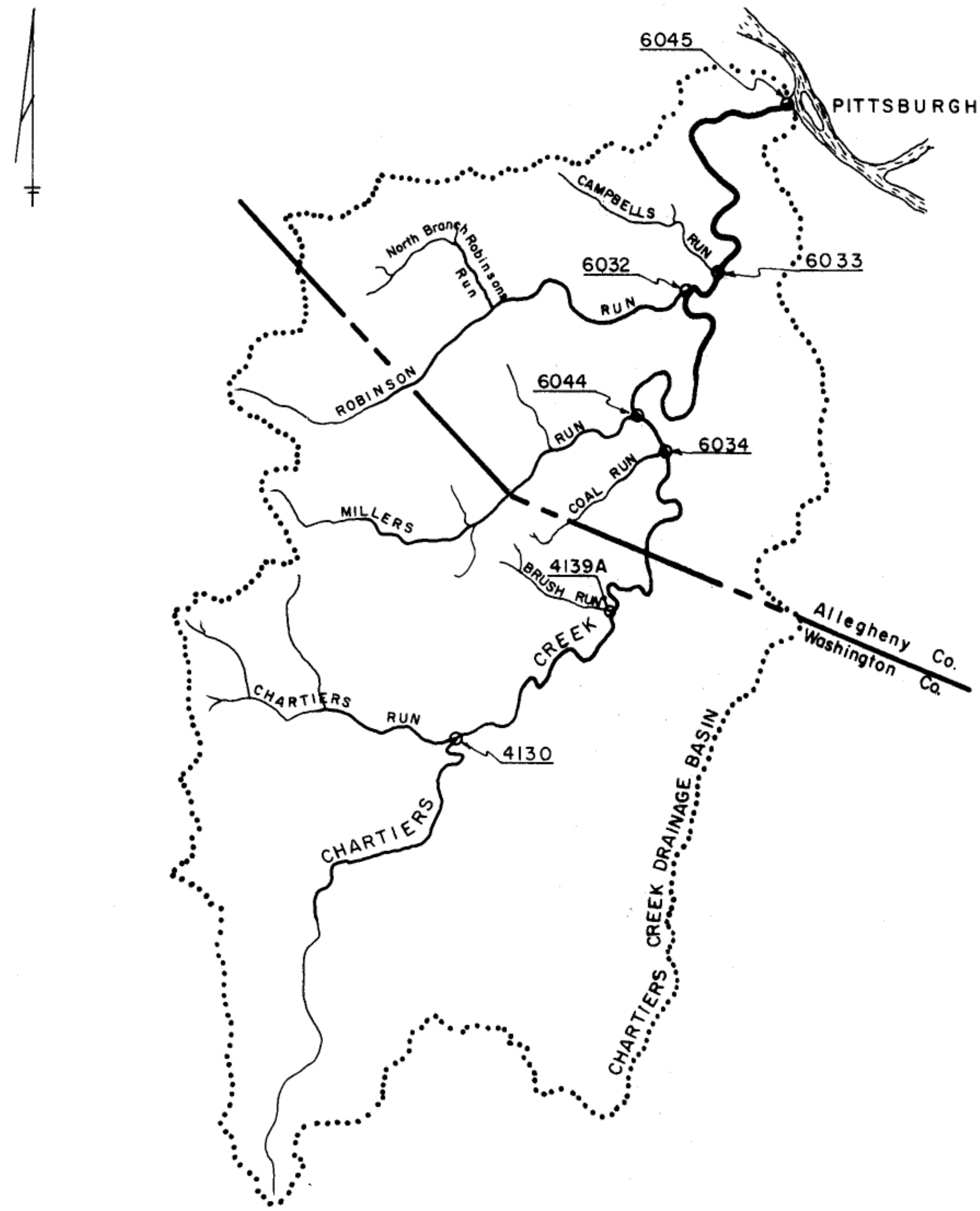
Priority No.	Major Source No.	Maximum Lbs./Day Acid	Avg. Lbs./Day Acid Hydrologic Year	% Acid Con tribution into Char- tiers Creek	Slugging Index
19	4153	1,690	491	1.5	3
20	6002	I,274	466	I.5	3
21	4006	1,010	439	1.0	2
22	4031	1,670	410	1.0	4
23	4845	3,456	371	I.0	9
24	4829	3,924	370	I.0	II
25	4688	I,004	325	I.0	3
26	6001	1,620	313	1.0	5
27	4838	1,231	289	1.0	4
28	4820	1,782	272	1.0	6
29	4045	1,260	261	1.0	5
30	6034-6035	I,464	252	I.0	6
31	4655	1,240	232	0.5	5
32	4039	1,460	220	0.5	7
33	4850	1,968	209	0.5	9
34	4808	1,197	187	0.5	6

C. Stream Water Quality

1. Polluted Streams:

a. The Chartiers Creek Drainage Basin contains three major tributary streams whose water quality has been heavily polluted by acid mine drainage. They are: Millers Run, Robinson Run (including its North Branch), and Campbells Run. The water analysis of these streams at the gauging stations (Plate 3) are as follows:

I) Gauging Station 6044 - Millers Run: All the specific ions tested exceed the quality limits established by the Pennsylvania Sanitary Water Board. All of the acid mine drainage pollution is contributed by major sources 4971 and 4967. The two sources contribute on the average of 10,000 lbs. acid load/day into Millers Run of which over 7,500 lbs is discharged into the main stem of Chartiers Creek. However, because industrial sources along Millers Run contribute high alkaline loads, the average net acid load discharged into Chartiers Creek is only 620 lbs per day.



CHARTIERS CREEK DRAINAGE BASIN

MAJOR POLLUTED TRIBUTARIES and STREAM GAUGING STATIONS

Plate No. 3

	Maximum	Minimum	Average
pH	7.7	3.7	5.8
Acidity (mg/l)	232	38	96
Alkalinity (mg/l)	176	16	65
Acid Load (lbs/day)	21,584	2,000	7,646
Alkaline Load (lbs/day)	28,000	1,211	7,026
Iron (mg/l)	56.25	2.5	22.4
Manganese (mg/l)	17.0	0.6	3.3
Sulfate (mg/l)	4,500	400	1,004
Hardness (mg/l)	1,190	460	783

2) Gauging Station 6032 - Robinson Run: Robinson Run, including its North Branch, has very poor quality water. Acid mine drainage from abandoned mines has destroyed completely any buffering capability of the stream. Calculations show that the major sources of pollution located in Robinson Run subwatershed on the average contribute over 66% of the total acid load discharged by Robinson Run into Chartiers Creek. The remaining 34% is contributed by many minor sources.

	Maximum	Minimum	Average
pH	5.4	3.0	4.3
Acidity (mg/l)	290	42	175
Alkalinity (mg/l)	12	0	3
Acid Load (lbs/day)	65,424	2,670	26,620
Alkaline Load (lbs/day)	3,220	0	472
Iron (mg/l)	10.0	1.0	3.9
Manganese (mg/l)	7.0	2.6	4.3
Sulfate (mg/l)	1,625	350	1,039
Hardness (mg/l)	1,700	610	936

3) Gauging Station 6033 - Campbells Run: Campbells Run has poor quality water. Acid concentrations exceeded alkaline concentrations in every sample obtained. The iron concentrations have been within the limits established by the Sanitary Water Board, whereas manganese and sulfate concentrations have been higher than maximum allowable to support aquatic life.

	Maximum	Minimum	Average
pH	5.5	2.7	3.9
Acidity (mg/l)	252	134	204
Alkalinity (mg/l)	24	0	4
Acid Load (lbs/day)	10,004	990	4,794
Alkaline Load (lbs/day)	1,280	0	17
Iron (mg/l)	7.5	1.5	3.5
Manganese (mg/l)	5.6	0.2	2.8
Sulfate (mg/l)	1,450	700	1,058
Hardness (mg/l)	1,750	760	1,028

b. Brush Run was also polluted when the study was initiated; however, the water quality of Brush Run has improved considerably since the neutralization of source 4138, which is an active mine discharge, began in January, 1969. The results of the water analysis are as follows:

I) Gauging Station 4139-A - Brush Run: Periodic readings at the mouth of Brush Run were initiated in January, 1969, after the neutralization plant for active source 4138 was in operation.

	Maximum	Minimum	Average
pH	8.9	6.9	7.5
Acidity (mg/l)	124	56	78
Alkalinity (mg/l)	226	62	133
Iron (mg/l)	13.7	1.3	5.1
Manganese (mg/l)	1.4	0.4	.75
Sulfate (mg/l)	1250	450	875
Hardness (mg/l)	1470	720	1165

2) The following table shows a comparison of the average parameters of source 4138 before and after the operation of the neutralization facility:

	Source 4138	
	Before	After
pH	4.6	7.8
Acidity (mg/l)	588	65
Alkalinity (mg/l)	0	104
Iron (mg/l)	69	20.5
Manganese (mg/l)	5.3	2.3
Sulfate (mg/l)	4412	3480
Hardness (mg/l)	1020	1905

2. Unpolluted Streams:

a. Chartiers Run is the only major tributary of Chartiers Creek which is unpolluted. The water analysis indicates the following:

I) Gauging Station 4130 - Chartiers Run: Chartiers Run has fair quality water. Alkaline concentration exceeded acid concentration in II of 12 readings. Calculations Indicate that the maximum acid concentration was achieved at the time of the minimum flow.

	Maximum	Minimum	Average
pH	8.0	4.6	6.8
Flow (cfs)	22.2	1.2	8.1
Acidity (mg/l)	358	6	80
Alkalinity (mg/l)	144	4	102
Acid Load (lbs/day)	7557	196	2461
Alkaline Load (lbs/day)	13,900	34	5739
Iron (mg/l)	10.0	0.2	2.9
Manganese (mg/l)	6.0	0.3	2.3
Sulfate (mg/l)	1500	325	710
Hardness (mg/l)	1380	362	776

b. Although heavily polluted from many other sources, Chartiers Creek itself has fair quality water with respect to pollution from acid mine drainage. This is caused by the dilution from clean streams in the basin and neutralization by industrial waste and sewage from communities in the watershed. The water analysis is as follows:

I) Gauging Station 6045 - Chartiers Creek Mouth: Alkaline concentration exceeded acid concentration in 8 out of 12 readings.

	Maximum	Minimum	Average
pH	7.8	5.5	6.3
Acidity (mg/l)	54	16	33
Alkalinity (mg/l)	138	8	70
Acid Load (lbs/day)	196,640	7,940	42,087
Alkaline Load (lbs/day)	565,340	1,380	100,470
Iron (mg/l)	3.75	.18	1.8
Manganese (mg/l)	2.7	.01	1.5
Sulfate (mg/l)	1000	175	542
Hardness (mg/l)	1170	190	563

D. Surface Drainage

I. The natural surface drainage patterns have been disrupted by both strip and deep mining.

2. Many small tributary streams are flowing into sink holes which have formed due to subsidence of the ground surface over deep mine operations. Flows in these tributaries range between 5 and 300 gpm. The sink holes are a direct connection with the deep mine and contribute to the slugging ability of some of the sources.

3. Water is also entering the deep mines through abandoned mine shafts. Eleven mine shafts were located in the Chartiers Creek Drainage Basin. Of the II, four were completely open, and surface water was observed entering the shafts. These are shown on the Inventory Maps included in Appendix BII. Other pertinent data is included in Appendix CH.

4. The most important factor which has caused disruption of the surface drainage is the strip mines. Strip mines in the Chartiers Creek Basin occupy approximately 5,900 acres. About I,500 acres are reclaimed and contribute only slightly to the daily acid load of the basin. The remaining strip mines are randomly reclaimed or unreclaimed and allow about 2,800 gpm of surface water to enter into deep mines. Some of the strip mines in the Chartiers Creek Drainage Basin do not directly affect the acid load of Chartiers Creek because subsurface runoff from these strip mines enters deep mines which outlet in adjacent drainage basins.

5. It is estimated that restoration of drainage through strip mined areas would reduce the amount of surface runoff entering the deep mines by 60%. If the strip mines were completely restored and revegetated, up to 75% of the runoff could be prevented from entering the deep mines.

6. Surface drainage connected with deep mine refuse dumps is a contributing factor to the acid water pollution of Chartiers Creek. Research work performed by others on mine dump material from several different sources indicates that a highly acid leachate is formed by the percolation of water through this type of material. The lack of vegetation cover on most of the mine dumps allows the flushing of the acid material during periods of heavy rainfall. This causes a slug of acid material to be washed into the streams periodically.

7. There are at least 63 deep mine refuse dumps in the Chartiers Creek Drainage Basin and they occupy surface areas from less than one acre to more than 30 acres. The dumps are a contributing factor to the acid mine water in the Chartiers Creek Drainage Basin and may be considered as a major cause of slugging because:

a. They are usually composed of the draw slates, sulfur balls and other carbonaceous materials which are high in pyrite content.

b. The pyritic materials in the piles, when exposed to oxygen, moisture and heat, will convert into acid-producing material.

c. The lack of vegetation permits rapid runoff of precipitation which carries the acid-producing materials into the streams, causing not only pollution but also silting.

All of these mine dumps are on private property. A description of the dumps is given in tabular form in Appendix CII of this report. The locations of the dumps are shown on the Inventory Maps in Appendix BII.

8. Six of the mine dumps are also sources of air pollution, because they are in some stage of burning.

9. The dumps could be a source of borrow material for the reclamation of or improvement of drainage in some of the abandoned strip mines. However, if used as borrow material, the mine dump material should be covered with non-combustible material to reduce the risk of combustion.

E. Subsurface Drainage

I. Subsurface drainage is predominantly controlled by the geologic structure of the coal seam. Water entering the deep mines through percolation from the ground surface or openings caused by deep or strip mining generally flows down dip until it discharges at one of the sources.

2. Subsurface water also enters the Chartiers Creek Drainage Basin from outside the limits of the surface watershed. The Pittsburgh Coal seam outcrops north and northwest of the topographic boundary of Chartiers Creek Drainage Basin. Water entering the deep mines through strip mines or other openings in adjacent stream basins eventually discharges into Chartiers Creek. For example, approximately two miles northwest of Midway in the Racoon Creek Drainage Basin, the predominant structure at the base of the coal is the Candor Dome. Coal maps show that the area along the outcrop has been stripped. Water entering the southeastern half of the dome will discharge at source 4006 or source 4810 in the Chartiers Creek Basin.

3. Watertight sealing of the majority of deep mine openings discharging acid mine water may not be feasible based on:

a. Sealing will only temporarily prevent coal mine drainage discharges. Eventually the discharge could break out in other locations due to lack of sufficient coal barriers between deep and strip mines. Field investigations revealed that stripping operations have broken into deep mines. In some places acid mine water is emerging from the deep mines out of the openings created by the stripping operations; in other instances, good quality water has been observed to enter the deep mines through the openings.

b. The locations and discharges of some of the major sources (4971-4967, 4972, 6034 and 6035) indicate the deep mines are interconnected, because the sources drain large areas which have been mined by different operators. This is substantiated by the W.P.A. Coal Map and the coal mine maps obtained from local companies. In some cases, large hydrostatic heads in excess of 50 ft. (source 4971) could be developed by using watertight bulkheads.

4. Construction of grout curtains along the coal outcrops in conjunction with the deep mine sealing in the areas north of Robinson Run may be unfeasible because of the miles of outcrop exposed and/or strip mined. Restoration of the strip mines in this area probably would be a more permanent solution to the acid mine water problem and also eliminate the possibility of having a breakout of acid water at a later date should the grout curtain and/or mine seals fail. Restoration of the strip mines will not totally eliminate the problem of acid mine water in this area.

5. The majority of strip mines located south of Millers Run do not contribute any large volume of acid mine water into Chartiers Creek or its tributaries, because the coal does not outcrop in the southern portion of the basin except in the area near Canonsburg. No major sources of pollution were found in this area.

F. Hydrologic-Year Study

The following conclusions-may be drawn from the 13-month survey of the Chartiers Creek Drainage Basin:

I. The discharge of acid mine drainage in the Chartiers Basin is directly related to the amount of surface precipitation

2. Slugging caused by high amounts of precipitation over short periods of time is possibly the greatest threat to establishing a tolerable equilibrium between acid mine drainage and flow in the tributaries of the basin.

3. The effect of precipitation on the individual sources varies the parameters (pH, acidity, iron, sulfate, manganese and flow) of the source greatly where extensive unreclaimed stripping has taken place. This is because large volumes of water enter the deep mines through the strip pits.

4. The variability of the parameters for 18 of the major sources are shown graphically on Dwg. 68077 DII I - 18 included in Appendix DII of this report. The graphs were drawn for sources which have averaged over 500 lbs. acid load/day. Several possible conclusions may be drawn from the study of these water quality charts:

a. Iron Concentrations:

I) The iron concentration generally decreased in magnitude during June through August, 1968, which was considered a period of high discharge.

2) Iron concentration increased in September, 1968, through January, 1969, during which time the flow from the sources generally was on the decline.

3) The iron concentration decreased sharply in February of 1969 during which time the flows from the sources generally increased.

4) March and April of 1969 could be considered high iron periods with the flow generally remaining at normal to below normal levels.

5) Iron concentration began an upward swing during May and June of 1969 and the flows showed a slight increase over the previous months.

6) Iron concentration does not seem to be related to the temperature of the source. At only one source, 4810, of the 13 plotted did the Iron concentration continuously decrease with Increasing temperature. The other 12 sources showed inconclusive results.

7) Use of maximum-minimum temperature vs. Iron plots showed that at seven sources (4971, 4967, 6035, 4962, 4963, 6022 and 4654) Iron concentration decreased with a decrease in temperature. At five other sources (4810, 4041, 6034, 6048 and 6002) the Iron concentration increased with a decrease in temperature. Source 4972 showed a very small (I degree) change in temperature and no conclusion was drawn. Sources 4971, 4967, 4972, 6035 and 6034 are considered to result from deep mines with a minimum interference from strip mining.

b. <u>Acidity vs.</u> <u>Flow:</u>

I) Only generalizations concerning the relationship of acidity to flow can be drawn from the study of the graphs plotted for 18 of the major sources.

2) There Is some correlation between acidity and flow in that acidity usually increases with a decrease in flow.

3) The initial readings of many of the major sources taken In May and June of 1968 seem to indicate that the mines were being flushed out of excess acid materials formed during times of lower flow because the acidity increased with flow. A reverse trend usually occurred after the flush out and acidity decreased as flow decreased in the majority of cases.

4) Additional flush outs did not occur during the hydrologic year of May, 1968, through June, 1969.

5) With extended readings (perhaps 2 to 3 year cycles) it may be possible to predict the flow or precipitation necessary to cause flushing of the individual sources.

6) When readings on two sources are compared, there does not seem to be any correlation between the flow in gallons per minute and their acid concentrations.

7) The rapid entry of the surface waters Into deep mines through unreclaimed strip mines seems to be the most prevalent cause of flushing out and slugging of some of the sources.

5. The highest flows from the major sources were recorded during May and June, 1968, which was a period of above-average precipitation. This is shown on Plate 4, which indicates the annual precipitation in the Pittsburgh area for a ten-year period.