

## SECTION II

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### SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The findings, conclusions, and recommendations resulting from investigations of the Watershed are summarized below:

1. The Watershed covers approximately 170 square miles in Clinton and Centre Counties. Apparently mine drainage pollution has been occurring in the Watershed for approximately 130 years.
2. The Watershed's population is estimated at 3,070. Although the brickmaking, coal and clay mining, as well as pulpwood industries exist within the Watershed, employment opportunities are limited. Employment opportunities for Watershed inhabitants in industry, commerce, and education exist in the nearby communities of Lock Haven, Bellefonte, and State College.
3. Most of the Watershed is used for hunting large and small game. Some public trout fishing is available in several streams tributary to Beech Creek. No other use is currently made of Watershed streams.
4. Several federal and Commonwealth agencies have expressed a desire to develop the recreational potential of the area within and adjacent to the Watershed. The abatement of mine drainage pollution within the Watershed is expected to enhance the prospects for further development of the recreational uses of streams and woodlands within the Watershed.
5. Beech Creek is the only major source of acid mine drainage reaching Bald Eagle Creek. Fish and other forms of aquatic life are found along the entire length of Bald Eagle Creek. The Department fears that a low flow condition in Bald Eagle Creek created by regulated discharge from the newly constructed Foster J. Sayers Reservoir, coupled with a high discharge from Beech Creek, could adversely affect aquatic life in Bald Eagle Creek downstream from its confluence with Beech Creek.
6. Deep mining for coal and clay has ceased within the Watershed but reserves still exist. Strip mining for coal and clay is now the only method used and will probably continue for the foreseeable future. Four coal-stripping operations accounting for an annual production of approximately 250,000 tons are currently being conducted in the Watershed.
7. Acid mine drainage in the Watershed is caused by numerous natural and man-made subsurface and surface conditions.
8. Coal mining within the Watershed has been largely confined to a belt approximately three miles wide and 10 miles long. Twenty-three square miles, or 14 percent of the Watershed, are underlaid with coal.
9. Since most deep mining was performed in beds below the then existing ground-water table, an extensive gravity system for draining mine waters through the workings was employed. The practice of gobbing, which refers to discarding refuse in the mine workings, was also common. Therefore, surface and ground waters that enter deep mine workings flow for considerable distances over and through acid-producing materials before eventual discharge as acid mine drainage.
10. An estimated four percent, or seven square miles, of the Watershed has been disturbed by currently inactive coal and clay strip mines; 0.5 percent, or 0.8 square mile, by currently active strip mines.
11. A number of specific types of interconnection between the ground surface and deep mine workings in the Watershed allow surface water to enter the workings. These include deep mine entries, subsidence areas, stream infiltration areas, and strip mines. In addition to specific points of connection between the ground surface and deep mine workings through which surface and ground waters enter the workings, surface and ground waters gain access to

deep mine workings through an extensively fissured overburden caused by deep mining close to the ground surface.

12. Most surface and ground waters apparently enter abandoned deep mine workings through strip mines and the fissured overburden.
13. Gobbing practices, the pulling of pillars, and roof falls may block, restrict, or alter apparent water flow routes through Watershed deep mine workings.
14. A total of 184 mine drainage discharge points were located during the investigations described in this report. The majority were associated with strip mines, followed by deep mine entries and refuse areas.
15. The majority (145) of mine drainage points found during the investigations are located on Beech Creek North Fork and its tributaries as well as on Sandy Run and its tributaries. Seventeen others are located on the south side of Beech Creek between Kato Village and Logway Run. The remaining mine drainage discharge points are scattered throughout the Watershed down to and including Twin Run. No mine drainage discharge points are located downstream from the confluence of Twin Run and Beech Creek.
16. Mine drainage discharge points in addition to those observed in the Watershed during the field investigations probably exist under certain weather conditions not encountered during the investigations. Conclusions and recommendations set forth herein are based solely upon the mine drainage discharge points observed during the investigations.
17. Of the 184 mine drainage discharge points located during the field investigations, 160 appear to continuously discharge mine drainage. Twenty-four appear to intermittently discharge mine drainage.
18. Under average conditions, individual Watershed mine drainage discharges are estimated to range from 0 to 2,160 gpm, iron concentrations from 0.1 to 265 mg/l, and acid concentrations from 0 to 2,450 mg/l.
19. Combined mine drainage volumes as well as major constituents and characteristics used for design purposes are summarized in the following:

	<u>Design Average</u>	<u>Design Wet Weather</u>	<u>Design Maximum</u>
Volume - mgd	14.8	25.2	526
pH	3.3	3.0	3.7
Total Iron			
mg/l	26	27	23
tons per day	1.62	2.82	49.8
Acid (as CaCO <sub>3</sub> )			
mg/l	400	420	350
tons per day	24.6	43.9	753

20. Present Sanitary Water Board mine drainage discharge limitations are as follows:
  - pH not less than six or greater than nine
  - Iron concentration not in excess of seven mg/l
  - No acid
21. Discharges from most Watershed mine drainage discharge points meet Sanitary Water Board iron discharge limitations. Few meet the pH and acid limitations.
22. The analytical procedures used in determining acidity and alkalinity for this

report were adopted by the Sanitary Water Board in 1966. If the procedures utilized before 1966 had been used, a number of mine drainage discharges and streams described in this report as acidic would be designated alkaline.

23. Discharges from relatively few mine drainage discharge points account for most Watershed pollution loads. On the average, an estimated 13 discharges contribute 90 percent of the iron loads. Thirty-two discharges contribute 90 percent of the acid loads.
24. Virtually all mine drainage discharge points contributing most Watershed pollution loads are located in its upper reaches. On the average, an estimated 97 percent of its iron loads and 88 percent of its acid loads originate in the Beech Creek North Fork and Sandy Run basins. The major exception is the Big Run basin, where several significant mine drainage discharges are located.
25. The Sanitary Water Board has adopted general and specific quality criteria for all surface streams in the Bald Eagle Creek Basin, of which Beech Creek is a part. These criteria are based upon the anticipated use of Bald Eagle Creek Basin surface streams for (a) the maintenance and propagation of cold and warm water fish; (b) water supply for domestic, industrial, livestock, wildlife, and irrigation purposes; (c) fishing and water contact sports; (d) power; and (e) treated waste assimilation. The Bureau of Sanitary Engineering has recommended to the Sanitary Water Board that drainage from abandoned mines be controlled throughout the entire Watershed as part of the overall Watershed program ultimately implemented.
26. For this report, specific Sanitary Water Board quality criteria used to evaluate the condition of Watershed streams and to determine the effectiveness of alternative abatement plans were:
  - a. a pH not less than 6.0 or greater than 8.5
  - b. a total iron concentration not exceeding 1.5 mg/l

The acid content of Watershed streams was used as a third criterion, although the Sanitary Water Board has not yet adopted a specific stream acid criterion.

27. The average quality of waters observed at various locations along Beech Creek from the fall of 1968 to the fall of 1969 is summarized in the following:

	Upstream	Downstream
	<u>Portion</u>	<u>Portion</u>
pH	3.7-3.8	4.1-4.2
Total Iron - mg/l	2.2-3.7	0.3-0.4
Acid (as CaCO <sub>3</sub> ) - mg/l	59-74	43-48

As these data indicate, Beech Creek waters did not comply with the Sanitary Waters Board's pH criterion and are acidic. The Board's iron criterion was met in the lower reaches of Beech Creek but not in its upper reaches.

28. The average quality of waters observed from the fall of 1968 to the fall of 1969 in tributaries of Beech Creek, including its North and South Forks, is summarized in the following:

	<u>Mined Areas</u>		<u>Non-Mined Areas</u>	
	MD	No MD	Coal	Coal
	<u>Discharges</u> <u>Noted</u>	<u>Discharges</u> <u>Noted</u>	<u>Present</u>	<u>Not Present</u>
pH	2.9-6.5	5.2-6.6	6.2	6.1-6.5
Total Iron - mg/l	0.1-35	0.1-0.2	0.3	0.1-0.2
Acid (as CaCO <sub>3</sub> ) - mg/l	13-542	17-22	21	18-19

Most tributary sampling stations were located at their mouths.

29. Most Watershed acid mine drainage pollution loads are attributable to a few mine drainage discharges to tributaries of Beech Creek. On the average, an estimated 99 percent of the iron and 97 percent of the acid loads originate in areas drained by Beech Creek North Fork, Tributary L, Sandy Run, Tributary R, Logway Run, and Big Run. Except for Big Run, these tributaries are of the poorest quality in the Watershed.
30. The quality of other Watershed tributaries is generally good. With the exception of pH, all these tributaries for the most part meet Sanitary Water Board specific stream quality criteria. No significant difference in the quality of these tributaries exists, although they drain: (a) areas containing mine drainage discharges, (b) mined areas in which there are no apparent mine drainage discharges, (c) non-mined areas in which coal is present, and (d) areas in which no coal is known to exist.
31. Watershed tributaries draining non-mined areas containing coal and those draining areas apparently without coal occasionally do not comply with the Board's pH criterion. Moreover, these streams are at times acidic. Iron is also present, although the Board's iron criterion is met under all runoff conditions.
32. For this report, all known abatement measures considered theoretically sound were reviewed without regard to the extent of previous usage to determine their applicability in reducing or eliminating acid mine drainage in the Watershed. Ten of the abatement measures reviewed were used singly or in combination in developing abatement plans for the Watershed. These abatement measures are listed in the following:

Preventive Measures

- Inundate Deep Mine Workings
- Reconstruct Stream Channels
- Construct Surface- or Ground-Water Diversion Ditches, or Both
- Restore Strip Mines
- Move Refuse into Strip Mines
- Eliminate Deep Mine Workings
- Excavate and Restore Subsidence Areas
- Close Deep Mine Entries
- Chemically Neutralize Strip Mine Contents

Treatment Measures

- Chemically Neutralize, Oxidize, and Settle Mine Drainage in Treatment Facilities

33. Preliminary consideration was given to developing abatement plans in each of three categories:

- (a) Abatement plans based solely on the construction of preventive measures
  - (b) Abatement plans based solely on the construction of treatment measures
  - (c) Abatement plans based on the construction of combinations of preventive and treatment measures.
34. Based on the investigations described in this report, it would be prohibitively expensive and totally impractical to develop for the Watershed an abatement plan comprised solely of preventive measures.
  35. For abatement plans comprised of preventive measures supplemented by treatment measures, estimates of acid mine drainage reductions attributable to preventive measures were made on the basis of estimated increases in runoff coefficients, volumes of surface water kept from deep mine workings, and similar factors. In the preliminary design of treatment measures, due allowance was made for acid mine drainage reductions attributable to preventive measures. Treatment measures were designed to meet current Sanitary Water Board mine drainage discharge limitations.
  36. In developing abatement plans, consideration was given in some cases to abating all mine drainage discharges and in others only certain discharges. Abatement plans were studied that would reduce Watershed mine drainage pollution loads from 90 to 100 percent. In developing abatement plans where less than a 100 percent reduction was to be attained, effort was made to concentrate on the most polluted tributaries and mine drainage discharges contributing 90 percent of the iron and acid loads.
  37. Seven abatement plans were studied in detail. Two of these plans consisted solely of treatment measures. The balance included combinations of preventive and treatment measures.
  38. The abatement plan recommended for construction includes preventive and treatment measures. The recommended preventive measures would first be constructed. At some future date treatment measures would be constructed. Preventive measures comprising the recommended abatement plan would be located throughout the Watershed but concentrated in the upstream portion. Treatment measures consisting of three treatment plants would be located in the upstream portion of the Watershed.
  39. The abatement plan recommended for construction will eliminate mine drainage at 48 discharge points and reduce mine drainage at four points. In addition, mine drainage from 30 discharge points would be collected and treated in the three treatment plants.
  40. Recommended preventive measures will reduce Watershed mine drainage acid and iron loads by approximately 40 percent. Recommended treatment measures will reduce loads by approximately 52 percent. Total reductions attributable to the recommended abatement plan including both preventive and treatment measures will approximate 92 percent.
  41. Costs associated with the recommended abatement plan are summarized in the following:

		<u>Average Annual Costs</u>					
		<u>Initial 30 Years</u>		<u>Next 270 Years</u>		<u>300 Years</u>	
<u>Project Cost</u>		<u>Per Ton Acid</u>		<u>Per Ton Acid</u>		<u>Per Ton Acid</u>	
		<u>Total</u>	<u>Removed</u>	<u>Total</u>	<u>Removed</u>	<u>Total</u>	<u>Removed</u>
Preventive Measures	16,100,000	1,141,000	264	1,200	0.30	115,000	27
Treatment Measures and Collection Systems							
	5,300,000	739,000	188	554,800	141	574,000	145
Total	21,400,000	1,880,000	227	556,000	67	689,000	83

42. The estimated average quality of waters at various locations along Beech Creek after implementation of the recommended abatement plan is summarized in the following:

	<u>Upstream Portion</u>	<u>Downstream Portion</u>
pH	6.0-6.2	6.4-6.6
Total Iron - mg/l	0.3-0.4	0.2-0.3
Acid (as CaCO <sub>3</sub> ) - mg/l	18-20	16-18

The entire length of Beech Creek on the average will meet Sanitary Water Board pH and iron quality criteria if the recommended abatement plan is implemented. The downstream reaches of Beech Creek will meet the Board's pH and iron criteria under all conditions of discharge. However, it will continue to be slightly acidic. Bald Eagle Creek will be adversely affected by Beech Creek without the recommended abatement plan. With the recommended plan, it will be protected.

43. The estimated average quality of waters in Beech Creek tributaries, including the North and South Forks, after implementation of the recommended abatement plan is summarized in the following:

	<u>Mined Areas</u>		<u>Non-Mined Areas</u>	
	<u>MD Discharges</u>	<u>No MD Discharges</u>	<u>Coal Present</u>	<u>Coal Not Present</u>
	<u>Noted</u>	<u>Noted</u>		
pH	3.7-6.6	5.2-6.6	6.2	6.1-6.5
Total Iron - mg/l	0.1-2.0	0.1-0.2	0.3	0.1-0.2
Acid (as CaCO <sub>3</sub> ) - mg/l	12-66	20	20	10-20

44. Virtually all abatement measures comprising the recommended plan are confined to six Beech Creek tributaries: Beech Creek North Fork, Tributary L, Sandy Run, Tributary R, Logway Run, and Big Run.
45. Although these six tributaries will not meet Sanitary Water Board pH and iron criteria for all discharge conditions after the recommended plan is implemented, their improvement will be substantive.

46. Items considered significant in selecting the abatement plan recommended for construction are summarized in the following:
- a. An abatement plan comprised solely of preventive measures would be prohibitively expensive and totally impractical in the Watershed.
  - b. An abatement plan comprised solely of treatment measures would give more positive control and more predictable results than a plan comprised solely of preventive measures. However, most plans consisting solely of treatment measures are considerably more costly, in terms of project and long-term costs, than plans comprised of preventive and treatment measures.
  - c. Collection and treatment of acid mine drainage discharges from all 184 discharge points located during the field investigations would not guarantee the elimination of mine drainage pollution. This is due to the general scattering of acid-producing materials throughout the Watershed and the mine drainage discharges expected during extremely severe precipitation.
  - d. The recommended abatement plan for all practical purposes has the lowest project and long-term costs of all plans investigated.
  - e. The construction of preventive measures, which represents the first step of the recommended abatement plan, is more costly initially than treatment measures and collection systems but results in the maximum cost benefit over extended periods.
  - f. The stage construction of preventive measures included in the recommended plan can be undertaken separately and the effectiveness of each measure evaluated.
  - g. After the construction and evaluation of all recommended and any necessary additional preventive measures, the recommended treatment measures could be designed and constructed. The design of treatment measures would be based on a review of the latest data on existing and desired stream quality. The stage construction of each treatment measure could be separately undertaken and its effectiveness evaluated.
  - h. Based on available information and data, the recommended abatement plan will accomplish the Department's major objective: to protect Bald Eagle Creek under all flow conditions in Bald Eagle and Beech Creeks.
  - i. The recommended abatement plan will eliminate 92 percent of current Watershed mine drainage pollution loads. In addition it will significantly improve the quality of tributaries receiving the most pollution. Watershed stream quality will be acceptable for existing uses and for most foreseeable future uses.