SECTION II

SUMMARY OF FINDINGS,

CONCLUSIONS, AND RECOMMENDATIONS

The findings, conclusions, and recommendations resulting from investigations of the project area may be summarized as follows:

1. The Swatara Creek watershed covers 576 square miles in Schuylkill, Lebanon, Dauphin, and Berks Counties. Mine drainage pollution has apparently been occurring for more than 130 years in the watershed from coal mining in a 43-square mile headwaters area.

2. The investigations described in this report relate to an 18.7-square mile portion of the Swatara Creek headwaters area comprising ' the extreme headwaters of Swatara Creek as well as Panther and Black Creeks, and referred to as the project area.

3. The watershed's population is estimated at 132,600. Fairly well diversified employment opportunities are available in the watershed in fabricated metal products, food products, wearing apparel, textiles, printing, leather products, plastics, as well as in farming and farm products.

4. Much of the watershed is used for hunting large and small game. Little present public use is made of watershed streams.

5. Anthracite coal mining, once the mainstay of watershed headwaters are economy, has significantly declined in recent years as well as in the entire field. Anthracite production has declined from a peak of more than 100,000,000 tons in 1917 to slightly more than 8,000,000 tons during 1971. Four current operations in the project area accounted for approximately 60,000 tons of coal during 1970.

6. Significant coal reserves remain in the watershed headwaters area. However, mining is not expected to increase substantially in the near future because the remaining coal is of doubtful quality and is relatively inaccessible.

7. More than 130 years of past mining have caused acid mine drainage pollution of headwaters area streams. These include Panther Creek, Coal Run, Middle Creek, Good Spring Creek, Lower Rausch Creek, Lorberry Creek, and the main stem of Swatara Creek. In addition, Tremont Borough and Donaldson Village discharge untreated sanitary wastewaters into the watershed headwaters area.

8. Acid mine drainage is caused by numerous man-made surface and subsurface conditions.

9. Headwaters area streams have their origins in conglomerates, sandstones, and shales. Streams draining this area usually have (l) a very low solids content, (2) a pH less than 7.0, and (3) trace amounts of various metals including iron. These streams have a very low buffering capacity, and their quality is easily subject to change.

10. Subsequent severe folding of the earth's crust after the coal measures were laid down has caused project, area coal to plunge in steeply pitching veins as deep as 6,000 feet beneath the ground surface.

11. Deep mining was accomplished through slopes, shafts, drifts, and waterlevel tunnels from the ground surface. As mining proceeded deeper under the ground surface, water entered the deep mine workings, then flowed down the steeply pitching veins to points from which it could be removed by gravity or by pumping to surface streams. As a result the surface and ground waters that entered the deep mine workings flowed considerable distances over acid-producing materials before their eventual discharge as acid mine drainage.

12. An estimated 10.2 percent, or l.91 square miles, of the project area has been affected by active and inactive strip mines.

13. Several specific types of interconnection between the ground surface and deep mine workings in the project area allow surface water to enter the workings. They 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 that permit surface and ground waters to enter the mines, water also gains access to the workings through a fissured overburden caused by deep mining close to the ground surface.

14. Most surface and ground waters apparently enter abandoned deep mine workings through overlying strip mines and stream infiltration areas.

15. Gobbing practices, the pulling of pillars, interconnecting strip mines, and roof falls may alter apparent water flow routes through deep mine workings in the project area.

16. Fifty-one mine drainage discharge points were located during the investigations described in this report. The majority were associated with strip mines, followed by deep mines and refuse areas.

17. Mine drainage discharge points in addition to those observed during the field investigations probably exist under certain weather conditions not

encountered during the investigations. The conclusions and recommendations set forth in this report are based solely on the mine drainage discharge points observed during the investigations.

18. Of the 51 mine drainage discharge points located during the field investigations, 32 appear to continuously discharge mine drainage. Nineteen appear to intermittently discharge mine drainage.

19. Under average conditions, individual project area mine drainage discharges are estimated to range from 0.003 to 2.837 mgd, iron concentrations from 0.l to 71.0 mg/l, and acid concentrations from 10 to 4,420 mg/ l.

20. The combined mine drainage volumes as well as the major constituents and characteristics used for design purposes are summarized in the following:

	Design Average	**Design Wet Weather**	**Design Maximum**
Volume - mgd	5.01	8.03	177.0
pH	2.6-7.1	2.6-6.9	2.6-6.9
Total Iron			
mg/1	5.5	5.9	5.7
tons per day	0.12	0.20	4.20
Acid (as $CaCO_3$)			
mg/1	92.0	75.1	58.0
tons per day	1.92	2.51	42.7

21. During these investigations, 17 ground-water sources were also monitored within the project area. Under normal conditions, the flows from these sources ranged from 0.002 to 0.274 mgd, their pH from 3.9 to 6.4, their iron concentrations from 0.1 to l.l mg/l, and their acidities from 12 to 27 mg/l. These sources had average concentrations of 0.5 and 20 mg/l for iron and acid, respectively.

22. Of the 51 mine drainage discharges located during these investigations, 28 had pH as well as iron and acid concentrations comparable to the 17 ground-water sources monitored in the project area.

23. Four of the mine drainage discharges located and monitored during these investigations were associated with sedimentation basins at coal breakers. The quality of these discharges is dependent upon their water source quality.

24. Regulation of the discharge quality and quantity of breaker discharges is a function of the Department of Environmental Resources. Therefore, no evaluation of their pollution potential was made.

25. Consequently, 19 of the 51 mine drainage discharges located and monitored actually comprise the project area mine drainage pollution load. Under design average conditions these 19 mine drainage discharges have flows ranging from 0.039 to 2.84 mgd, iron concentrations from 0.1 to 71.0 mg/l, and acid concentrations from 25 to 4, 420 mg/l.

26. The combined pollution load from these 19 mine drainage discharges used for design purposes is summarized in the following:

	Design Average	**Design Wet Weather**	**Design Maximum**
Volume - mgd	4.25	6.49	148.0
pH	2.6-6.1	2.6-6.1	2.6-6.1
Total Iron			
mg/l	6.4	7.1	6.7
tons per day	0.11	0.19	4.14
Acid (as $CaCO_3$)			
mg/l	105.0	88.0	65.0
tons per day	1.86	2.39	40.3

27. Present mine drainage discharge limitations of the Department of Environmental Resources are as follows:

pH not less than six or greater than nine
Iron concentration not in excess of seven mg/l
No acid

28. Almost all project area mine drainage discharges meet Department iron discharge limitations. Only a few meet the pH limitation, and none meet the acid limitation.

29. Two past preventive measures have been implemented that affect project area stream flow or mine drainage discharges. One was constructed by a deep mine operator, the other by the Department.

30. Discharges from four mine drainage discharge points comprising the three deep mine pool overflows and one major refuse area contribute on the average 86, 94, and 93 percent, respectively, of the volume, iron, and acid loads. The remaining 15 mine drainage discharges contribute on the average 14, 6, and 7 percent of the volume, iron, and acid loads, respectively.

31. The Department of Environmental Resources has adopted general and specific quality criteria for all streams in the Susquehanna River Basin, of which Swatara Creek is a part. These criteria are based on the anticipated use of Swatara Creek for (a) the maintenance and propagation of coldwater 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.

32. For this report, the specific Department quality criteria used to evaluate the condition of the project area 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 l.5 mg/l

    The acid content of project area streams was used as a third criterion, although the Department has not yet adopted a specific stream acid criterion.

33. The average quality of waters observed at various locations along Swatara Creek within the project area from December 1970 through September 1971 is summarized in the following:

	Swatara Creek in Project Area
pH	3.6- 4.0
Total Iron - mg/l	l.7- 5.9
Acid (as $CaCO_3$) - mg/l	59.0-78.0

    As these data indicate, Swatara Creek waters in the project area did not comply with the Department's pH and iron criteria and are acidic.

34. The average quality of waters observed from December 1970 through September 1971 in project area tributaries of Swatara Creek is summarized in the following:

	Swatara Creek Tributaries Affecting the Project Area
pH	4.l- 5.9
Total Iron - mg/l	0.3- 2.0
Acid (as $CaCO_3$) - mg/l	10.0-59.0

Tributary sampling stations were located at their mouths.

35. Various abatement measures considered applicable to problems and conditions in the project area were reviewed during the development of alternative abatement plans.

36. Preliminary consideration was given to developing abatement plans in 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

37. Based on the investigations described in this report and previous experience, it would be prohibitively expensive and totally impractical to develop for the project area an abatement plan comprised solely of preventive measures.

38. 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 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 Department mine drainage discharge limitations.

39. In developing abatement plans, consideration was given in some cases to abating all mine drainage discharges comprising the pollution load and in others only certain of these discharges. Abatement plans were studied that would reduce the project area pollution load by 85 to 100 percent. In developing abatement plans where less than a 100 percent reduction was to

be attained, an effort was made to concentrate on those mine drainage discharges contributing the bulk of the iron and acid loads.

40. Four abatement plans were studied in detail. Two of these plans consisted solely of treatment measures. The other two included combinations of preventive and treatment measures.

41. The abatement plan recommended for construction includes preventive and treatment measures. The recommended preventive measures would first be constructed, followed by the treatment measures. Preventive measures comprising the recommended plan would be located throughout the project area. The treatment measures would consist of collecting and treating one mine drainage discharge in a treatment plant located near the headwaters of Swatara Creek.

42. The construction of the recommended abatement plan will eliminate mine drainage at 12 discharge points and reduce mine drainage at two discharge points in the project area. Mine drainage will also be reduced at two discharge points outside the project area. In addition, one discharge that was reduced by preventive measures will be collected and treated.

43. The construction of the recommended preventive measures will reduce project area mine drainage iron and acid loads by 98 and 93 percent, respectively. The recommended treatment measures will reduce the acid load by four percent and the total reductions attributable to the recommended abatement plan will approximate 98 percent. In addition, approximately 0.085 and 0.426 tons per day of iron and acid, respectively, will be abated at discharge points located outside the project area by the recommended preventive measures.

44. The costs associated with the recommended abatement plan are summarized in the following:

		Average Annual Costs					
		Initial 30 Years		Next 270 Years		300 Years	
	Project Cost	Total	Per Ton Acid Removed	Total	Per Ton Acid Removed	Total	Per Ton Acid Removed
Preventive Measures	$ 9,730,000	$ 758,000	$ 962	$ 19,800	$ 25	$ 88,400	$ 112
Treatment Measures	220,000	66,000	2,190	60,000	1,990	60,600	2,010
Total	$ 9,950,000	$ 824,000	1,007	$ 79,800	98	$ 149,000	182

45. The expected average quality of waters at various locations along Swatara Creek within the project area after implementation of the recommended plan is summarized in the following:

	Swatara Creek in Project Area
pH	5.0- 5.7
Total Iron - mg/l	0.5- l.0
Acid (as $CaCO_3$) - mg/l	15.0-35.0

If the recommended plan is implemented, Swatara Creek in the project area will meet the Department's iron criterion but will not meet its pH criterion. Although Swatara Creek will be essentially neutral, a possible exception will be downstream from the mouth of Good Spring Creek, where Swatara Creek quality will depend upon the extent of abatement measures applied on Good Spring Creek in the other two project areas.

46. Active coal mining continues on a limited scale in the project area. At the end of 1971 there remained only two active deep mines and two active strip mines being operated by one strip mine operator. These four mining operations accounted for 60,000 tons of coal during 1970. Each of these operations has a short remaining life, less than five years, limited by the amount of coal remaining after earlier deep mining, its poor quality, its accessibility, the extent of underground mine water pools, the extent and condition of past strip mining operations, and similar factors.

47. The remaining active deep and strip mines do not collect and pump mine water to the surface for discharge to project area streams. The water developed by these active operations follows established flow routes into abandoned deep mine workings from which discharges occur.

48. It would be more practical to allow water attributable to active deep and strip mines to flow into abandoned underground mine workings for collection and treatment. Mine drainage attributable to active deep and strip mines is an insignificant portion of project area mine drainage pollution.

49. A reasonable way by which active operators could assist in abating project area mine drainage would be to pay money based on coal production to the Department to help defray the costs of implementing abatement measures. The amount of money paid per ton of coal mined should be consistent with that to be paid by active operators in other portions of the anthracite field.

50. Although all Swatara Creek tributaries may not meet the Department's pH and iron criteria, their improvement will be substantive after the recommended abatement plan is implemented.

51. Serious consideration should be given to combining the recommendations of all three consulting engineering firms into a master abatement plan designed to provide desirable stream quality throughout the watershed for the least cost.

52. The factors considered significant in selecting the abatement plan recommended for construction may be summarized as follows:

a. An abatement plan comprised solely of preventive measures would be prohibitively expensive and totally impractical in the project area.

b. An abatement plan comprised solely of treatment measures would be less costly initially, and would give more positive control and more predictable results than a plan comprised solely of preventive measures.

c. A plan comprised of both preventive and treatment measures, although having higher initial costs than plans comprised solely of treatment measures, is recommended for construction.

d. The construction of preventive measures, which represents the first step of the recommended abatement plan, has the maximum cost benefit over extended periods.

e. The stage construction of preventive measures included in the recommended plan can be undertaken separately and the effectiveness of each measure evaluated.

f. 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 could 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.

g. Based on available information and data, the recommended abatement plan will accomplish the Department's objective: to provide enhanced stream quality throughout the project area.

h. The recommended abatement plan will eliminate 98 percent of the current project area mine drainage pollution load.