CHAPTER II (a)

SUMMARY AND CONCLUSIONS

This study has shown that the mine-related pollutant sources and natural sources of alkalinity in the West Branch headwaters area comprise a very complicated interdependent and/or interrelated network. Both sources are subject to wide variation in quality and volume as the result of uncontrollable factors such as topography, hydrology, location of the pollutant sources, and meteorological conditions. The mine-related sources are also uniquely non-amenable to effective treatment by standard abatement techniques. Although this study was originally specified for the West Branch watershed above Cherry Tree, it eventually became apparent that full consideration of the actual pollution control problem involved must include a study of all factors for the river system up to and including Curwensville Reservoir.

The major elements effecting pollution control in this section of the West Branch are indicated schematically in Figure II-1. This figure is color-coded to emphasize the wide variety of material normally entering the stream and the fact that despite the complex mixture, this section of the West Branch, fortuitously, is a natural self-neutralizing system under conditions prevailing in 1971. A stream-mile schematic indicating town locations along the West Branch is shown in Figure 11-2.

In subsequent discussions of percentages of pollution contributed by various sources, the total acid pollution (100% basis) is that coming from all measurable, known uncontrolled sources exclusive of the acidity being generated by Lancashire No. 20 and Lancashire No. 15 pool, and not including the high flow acid slugs which develop within the West Branch itself. Under basic stream flow conditions, the total acid pollution loading for the study area as defined is about 50,000 ppd.

MAJOR ELEMENTS EFFECTING POLLUTION CONTROL

A brief discussion of each of the elements indicated in Figure II-1 will help to define the nature of the pollution problem which has evolved from this study:

(a) Active Mine Drainage - Lancashire No. 20 is the only acid generating active mine discharging directly into the West Branch, but this effluent (which averaged 2,900 ppd acidity in 1971) is receiving complete treatment by the Barnes and Tucker Co. and constitutes no present problem. However,

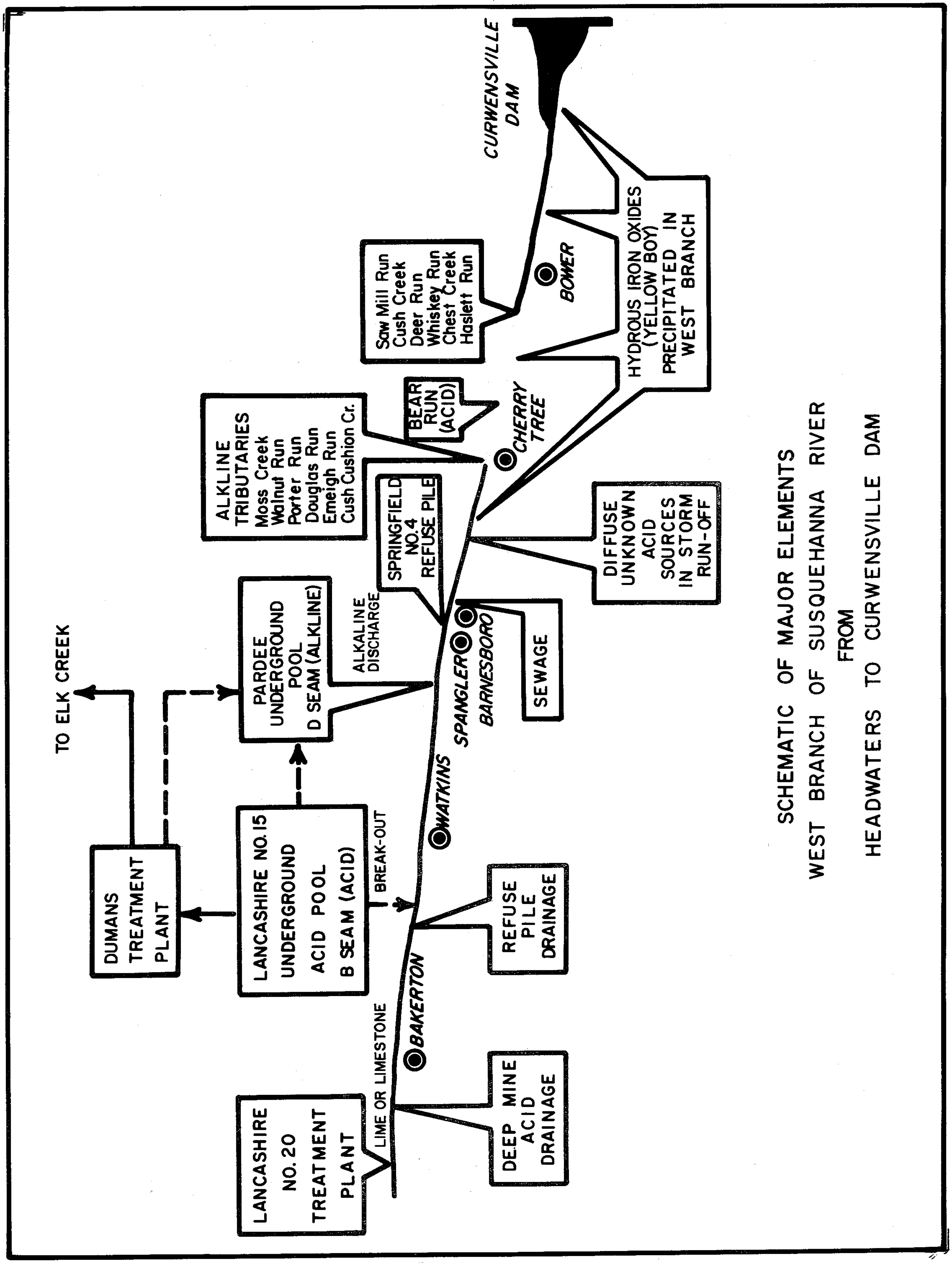
SCHEMATIC OF MAJOR ELEMENTS
WEST BRANCH OF SUSQUEHANNA RIVER
FROM
HEADWATERS TO CURWENSVILLE DAM
CURWENSVILLE DAM
LANCASHIRE NO. 20 TREATMENT PLANT
LIME OR LIMESTONE
DEEP MINE ACID DRAINAGE
BAKERTON
LANCASHIRE NO. 15 UNDERGROUND ACID POOL B SEAM (ACID)
BREAK-OUT
REFUSE PILE DRAINAGE
DUMANS TREATMENT PLANT
TO ELK CREEK
WATKINS
PARDEE UNDERGROUND POOL D SEAM (ALKLINE)
ALKALINE DISCHARGE
SPANGLER
BARNESBORO
SEWAGE
SPRINGFIELD NO. 4 REFUSE PILE
DIFFUSE UNKNOWN ACID SOURCES IN STORM RUN-OFF
ALKLINE TRIBUTARIES
Moss Creek
Walnut Run
Porter Run
Douglas Run
Emeigh Run
Cush Cushion Cr.
BEAR RUN (ACID)
CHERRY TREE
Saw Mill Run
Cush Creek
Deer Run
Whiskey Run
Chest Creek
Haslett Run
BOWER
HYDROUS IRON OXIDES (YELLOW BOY) PRECIPITATED IN WEST BRANCH

FIGURE II-1

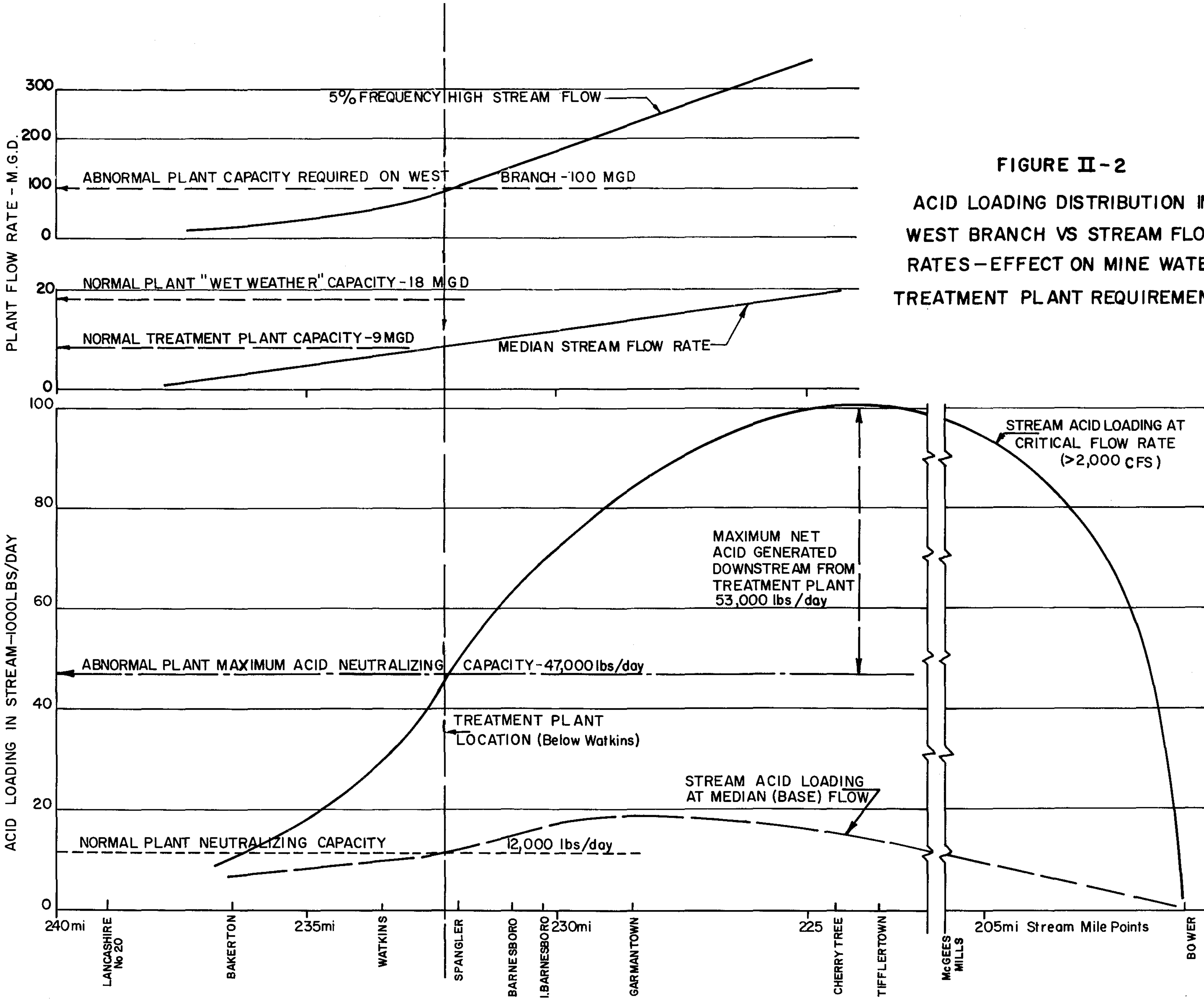

FIGURE II-2

ACID LOADING DISTRIBUTION IN WEST BRANCH VS STREAM FLOW RATES—EFFECT ON MINE WATER TREATMENT PLANT REQUIREMENTS this flow is critical to the integrity of waters in the West Branch and continuous treatment must be applied to maintain a consistent neutral influent to Curwensville Reservoir. Lancashire 24B and 24D mine waters are alkaline and are discharged without treatment into the Allegheny watershed.

(b) Drainage From Recently Abandoned Mines - Lancashire No. 15 is the latest mine in this category and is the source of a constant yield of about 8 MGD of drainage containing from 50,000 to 200,000 ppd acidity under present pool control operating conditions. This flow, when allowed to accumulate uncontrolled, was the cause of the serious breakout in the Watkins area in 1970. The Duman treatment plant is now completely neutralizing this flow and diverting the treated effluent into the Allegheny watershed. This flow, however, is the major pollution threat to Curwensville Reservoir and lower reaches of the West Branch, and hence must be kept under perpetual control. The cost of this control in 1971 was $2,500 per day or $912,500 per year.

(c) Abandoned Deep Mine Drainage - There are two general types of deep mine drainage in the study area:

TYPE I: Strongly acid drainage (300 to 1,200 ppm acidity) which emanates from old workings in the B-seam coal and flows almost directly into the West Branch in the watershed area above Spangler. Under basic stream flow conditions, these sources contribute an average of 20,000 ppd acidity which is about 29% of the total acidity generated by all sources above Spangler and 99% of the total deep mine acid drainage above Spangler. There is no possibility of impounding any of these discharges before they enter the West Branch, or sealing them off effectively.

TYPE II: Weakly alkaline waters (50 to 150 ppm) which originate in old workings in the D-seam coal and discharge primarily into tributaries which enter the West Branch below Spangler. These present alkaline flows are not sufficient to neutralize more than 6,000 ppd of acidity (maximum) or about 10 percent of the normal acid production.

(d) Refuse Pile Drainage: Within the study area, 6 million tons of refuse are contained in 12 refuse pile areas, all of which are in essentially direct contact with a flowing stream. Acidity loadings from these piles range from 36,000 to maximums of about 100,000 ppd during periods of heavy rainfall. Under basic stream flow conditions, refuse pile drainage contributes 70% of the total uncontrolled acid generated in the study area. The unfortunate locations of these tremendous masses of material usually inserted between a stream and a railroad and/or an inhabited road in narrow valleys makes the consideration of any effective abatement treatment impossible because of exorbitant costs which cannot be justified on any basis.

(e) Diffuse "Unknown" Acid Sources: This is the major surprise element that developed during the course of the study. A complete stream sampling program conducted during a period of high stream flow (2,300 cfs of Bower during Sept. 1971) showed a maximum stream acidity loading of 130,000 ppd below Spangler in contrast to 50,000 ppd above Spangler, the location of most of the known acid sources. The data showed conclusively that it was possible for an acid slug of 50,000 ppd magnitude to be generated gradually during a 5% frequency high flow period, ostensibly within the West Branch system itself. This slug would be completely beyond the control of any mine water treatment facility installed above Spangler (to neutralize normal acid loads), and is of sufficient magnitude to lower the pH of the West Branch to the 3 to 4 range throughout a twenty mile reach near McGees Mills. This slug could easily kill off any fish stocked in the headwaters area at least 6 times per year.

Calculations have indicated that this diffuse acid loading could be originating from acidic refuse sediments distributed along a ten mile length of stream bank below Spangler. This diffuse acid source, the reality of which was confirmed by additional tests in June, 1972, should be investigated more fully in future studies of pollution generation during high flow conditions.

(f) Alkaline Tributaries: There are 12 major alkaline streams and several unnamed alkaline creeks which discharge into the West Branch below Spangler. These streams contribute alkali loadings ranging from 29,000 to 210,000 ppd depending upon rainfall. This is more than is required to neutralize any normal acid loading in the West Branch.

Since the watershed is quite small and narrow, variations in stream loadings due to rainfall are identical for both acid and alkaline sources, hence a natural self neutralization system is operative in this watershed under all flow conditions. The data from this study show the West Branch will maintain a constant pH range of 6 to 7 at Bower Station at all flow levels, but that stream acidities above Bower can undergo broad fluctuations harmful to fish life due to the acid slug effect which occurs during high flow periods. This self neutralizing capacity of the West Branch is a very important phenomenon of which full advantage should be taken. The water quality produced naturally by the stream at Bower is sufficient to support an acceptable level of game fish production in Curwensville Reservoir. There is no reason why this situation should not be permanent as long as the deep mine waters from Lancashire No. 20 and Lancashire No. 15 pool are properly controlled.

(g) Sewage Pollution: Raw sewage is being added to the West Branch and its tributaries throughout the whole study area as none of the communities in the area have sewage treatment plants. However, all communities must make provisions for sewage treatment within the next few years. There are several possibilities in the study area (particularly in the Barnesboro area) where advantage could be taken of new technology for the simple conjoint treatment of mine water (stream water) and sewage, with underground effluent disposal in abandoned mine workings. Systems of this type could perform a partial stream neutralization function and could result in great savings in sewage plant capital and operating costs for these small towns in which populations are steadily decreasing. A tentative proposal for a co-treatment system has been incorporated as a quick-start project.

(h) Hydrous Oxide (Yellow Boy) Precipitation: Since the West Branch between Spangler and Bower Station is a natural neutralization basin, all of the precipitated hydrous oxides of iron and aluminum settle out on the bottom of this portion of the stream. These oozy sediments accumulate during basic flow conditions to appreciable depths in the deeper, slow moving sections of the stream. A very significant observation was made regarding the disposition and effect of these sediments on Curwensville Reservoir during the Agnes flood period in June 1972, which has strong bearing on the recommendations which will follow. Before the flood, the stream bottom was covered quite generally with a thick layer of yellow boy.

After the flood, no yellow boy remained, and the stream bottom was made up of clean pebbles. Obviously, all of the yellow boy was washed downstream into Curwensville Reservoir. However, the thousands of tons of yellow boy that must have been involved had no apparent effect on the game fish in the reservoir, since Fish Commission personnel advised that good fishing was reported during the weeks immediately following the flood. This is strong in situ evidence that sediments allowed to accumulate in the West Branch from natural neutralization and suddenly slugged into the reservoir, do not have any serious immediate effect on fish life in the reservoir.

Since January 1968 when Lancashire No. 20 treatment plant went into operation, water quality (resulting from natural neutralization in the West Branch) within Curwensville Reservoir has been sufficient to support a satisfactory fish population (breakout period excepted). During the period January 1968 through June 1972 (1,642 days), an average of 5,000 ppd of iron or 10,000 ppd hydrous oxide sludge has precipitated in the West Branch and has eventually been transported into the reservoir during periods of high flow. This average deposition of 5 tons per day (a total of 8,210 tons) has had no discernible harmful effect on the fish life in Curwensville Reservoir.

This observation is supported by additional in situ evidence in that the heavy precipitation of hydrous oxides which occurred within the reservoir itself over a four month period during the 1970 breakout had no permanent effect on aquatic life, since fish populations were back to normal by September 1971.

The important pertinent conclusion to be drawn from these observations is that the West Branch above Curwensville Reservoir could be allowed to continue to function as a natural neutralization plant without any danger to aquatic life due to the presence of precipitated solids.

UNDERGROUND POOL DIVERSION

While monitoring the flows from the various deep mine sources, the important observation was made that a direct correlation exists between the Lancashire No. 15 pool level (B-seam) and the alkaline discharge from Pardee No. 61 drainage drift (D-seam). The flow records show that there is a critical level in Lancashire No. 15 pool (about 1480 feet) above which approximately 0.5 MGD of B seam water flows into the D-seam; and below which the flow reverses. At high pool levels (as occurred during the breakout when the pool was above 1500 feet), all strongly acid water from B-seam flowing into D-seams is completely neutralized and discharged into the West Branch at Spangler.

From this data, it appears possible to prevent the diversion of 0.5 MGD from the D-seam into Lancashire No. 15 pool by maintaining the pool operating level between 1480 and 1500 feet. This flow cut-off, together with the normal decrease in the mine water coincident with increased degree of inundation, would result in a net reduction in the flow at the Duman's plant of 1.0 MGD, which would result in an immediate perennial savings in Duman treatment costs of $250 per day, ($92,000 per year).

Additional study of the hydrology of the deep mine pool complex should permit ultimate underground water flow management to induce maximum diversions to take full advantage of the natural alkali-generating capacity of the limestone strata adjacent to the D-seam. A quick-start project which would exploit pool diversion potential to attain greatly reduced operating costs for the Duman plant is presented in the recommendations section.

POLLUTION CONTROL ALTERNATIVES

From the above discussion, it is clear that the nature of the several pollution sources in the study area imposes severe limitations on the selections of any abatement treatment methods. Several of the standard abatement approaches can be eliminated immediately:

1. Hydraulic Mine Sealing: This would be ineffective because of the hydrogeologic features of the area which would permit underground pool levels to rise to elevations sufficient to develop hydrostatic pressures which the weak outcrop structures could not withstand. The net effect would be a breakout of the sealed mines within short periods of time in other locations within the watershed, possibly of the type experienced in 1970.

2. Treatment of Acid Loadings at the Source Points: This is completely impractical for deep mine discharges because of their scattered locations and lack of acreage in the narrow valleys to install treatment facilities. Control of individual refuse pile drainage, which is the major contaminant, is also unrealistic since it could only be attained by complete plant treatment of the entire stream flow below each pile location.

3. Relocation and Revegetation of Refuse Piles: This is essentially a physical (and economic) impossibility because of the lack of available acreage within the narrow, inhabited valleys through which run roads, power lines, and railroads essential to the local communities and mining industry. The virtual encirclement of these huge rock masses by operating facilities of all types and the streams (with which they are in direct contact) precludes all possibility of moving these piles any effective distance away from the stream beds.

4. Treatment of the Combined Sources in One Plant: Since 78% of the total acid pollutant load flows into the West Branch above Spangler during basic flow periods, it would be possible to build a treatment plant near Spangler. This would be required, however, to process the full flow of the West Branch, which at that point is 3 to 4 MGD. Three factors make this possibility very remote:

    (a) since all pollution sources discharge directly into the West Branch, the full stream flow must be treated at all times.

    (b) stream flows at Spangler could be expected to reach 100 MGD at the 5% frequency level, hence any plant would require this maximum capacity because flood plain acreage is not available for adequate surge storage reservoirs in this area.

    (c) despite this tremendous size, a plant at Spangler would provide no control for the huge acid slugs generated below it during high flow periods. The overall control problem for full stream treatment at Spangler is summarized graphically in Figure II-2, which compares the stream acid loadings at basic and 5% frequency flow levels as a function of stream mile points, and indicates the sizes of treatment plants that would be required at Spangler (or any other selected location).

Assuming that mine water treatment plant capital costs average $100,000 per MGD capacity and the most feasible location to be at Spangler (from a volume capacity standpoint), a plant cost of $10 million could be involved which would insure full stream protection only 95% of the time. The justification for such an expenditure will be discussed in a later section.

ABATEMENT TREATMENT COSTS VS. ECONOMIC JUSTIFICATION

Ultimately, the selection of an optimum abatement program for the study area must be influenced by the capital and operating cost of the treatment methods being considered, and rational justification for the investments required. An FWPCA study published in 1968 [(1)] assigned the following abatement benefit values to the two stream reaches within the study area: (see figure 11-3).

Using these abatement benefit values as guidelines, the following general conclusions can be drawn regarding the economic limitations for any abatement measures:

1. conditions in the study area are such that no more than 30 miles of stream (between Barnesboro and Bower) could possibly be restored to fishing and recreational use under the most ideal abatement treatment costs for which could easily range from $20 to $30 million. This is completely unrealistic in terms of the FWPCA benefit values for this reach.

2. the major (and essential) abatement benefit to be attained in the study area is that of protecting the recreational waters of the Curwensville Reservoir from any degradation. This requires the continuous treatment of 8 to 10 MGD from the Duman plant at a present cost of $2,500 per day ($900,000 per year). It also requires that the Lancashire No. 20 treatment plant must operate continuously to treat 2 to 3 MGD. The present total continuous cost, therefore, for protecting Curwensville Reservoir

FIGURE 11-3

WATER USE BENEFITS
ASSOCIATED WITH MINE DRAINAGE POLLUTION ABATEMENT
IN THE WEST BRANCH HEADWATERS AREA [1]/

			STREAM REACH	
			Headwater to Bower Station	Bower Station Curwensville Dam [2]/
	Affected Reach	Miles	31	21
1.	Recreation and Aesthetics	Annual Value	$18.600	$650.000
		Weighted Points	494	9,250
2.	Municipal & Industrial Water	Annual Value	--	--
		Weighted Points	39.8	--
3.	Fish & Wildlife	Annual Value (Fish days)	$ 5,800	$ 34,600
		Weighted Points	494	7,700
4.	Agriculture	Annual Value	$ 2,500	--
		Weighted Points	296.4	1,930
	Total Benefits	Annual Value	$26,900	$684,600
		Weighted Points	1,423	21,195

Notes:

1. See Reference 1 (FWPCA Report)
2. Includes Curwensville Reservoir Area

is about $1.2 million per year, about double the annual abatement value assigned by FWPCA. The reduction of this high treatment cost, therefore, should be the prime target in any abatement program.

3. since recreation, aesthetics, and fishing are the main benefits desired in the West Branch headwater area, these benefits might be made available within the watershed at a justifiable cost by converting one of the tributaries into an improved fishing stream. Moss Creek is one possibility and a quick-start project for its potential benefication has been included.

The foregoing summary defines the basic essential factors involved in any abatement treatment selection. The abatement procedures proposed in the following section of recommendations are based upon the unusual set of restrictions involved in the study area.