IV. PROPOSED PLAN FOR AMD ABATEMENT GOALS AND OBJECTIVES

Although the major natural resource in the Wyoming Valley is anthracite coal*, its importance to the present and future economy of the area is limited due to the flooded condition of the deep mines. Nevertheless, this coal is a potential energy source for the Commonwealth and can be a significant factor in the national energy needs. Therefore, the existence of these coal reserves and their potential importance to the State and the. Nation should be a fact for consider-ation in any AMD abatement plan for the study area.

Since both water and land resources are affected by active and abandoned mining operations, the ideal abatement plan should provide the following:

a. Eliminate present discharges of AMD into Commonwealth waters and restore clean streams for beneficial use by the public.
b. Prevent basement flooding, subsidence, mine fires and air pollution problems.
c. Stimulate "higher and better use" of abandoned strip mine and waste bank land.
d. Provide and account for future mining activities in the area on a non-interference basis, if possible.

If the plan could fulfill all of the aforementioned major objectives without introducing new problems or detrimental side effects, then it would be more readily endorsed by local, state and federal agencies. Moreover, such an endorsement would encourage active participation and financial support by those agencies.

PREVENTION OF WATER LOSSES INTO THE DEEP MINES.

Surface water losses and groundwater recharge into abandoned deep mines is the major cause of AMD pollution and basement flooding in and beyond the study area. The occurrence of land subsidence in some parts of the area is closely related to the fluctuation of mine pool levels in the abandoned mines. Therefore, the prevention or reduction of the present loss of water into the mine pools is the logical and most effective method that can be employed to abate AMD pollution, as well as to partially solve other mine related problems.

** 765 million tons of recoverable reserves as of 1970; W.E. Edmonds, Pennsylvania Geologic Survey*

The present mine water recharge also constitutes a major obstacle to the possibility of future deep mining. Therefore, in addition to resolving problems relating to AMD abatement, the prevention of water losses could renew interest in the resumption of deep mining.

Present sources of recharge to the mine pools are as follows:

1. Streambed water losses.
2. Runoff losses in abandoned strip mine areas.
3. Direct discharges of raw sewage, storm water and industrial waste into strip pits and deep mines.
4. Groundwater flow through fracture zones into the deep mines from aquifers (water bearing strata) rimming the coal basin.
5. Water losses from sewers and water supply pipelines.

The magnitude of each of the above sources of loss is discussed in Part III of this Report. Prevention of mine pool recharge from these sources by the methods suggested in the proposed plan of abatement, are expected to achieve most of the major objectives previously described (Goals and Objectives - a through d).

The Mill Creek watershed is underlain by portions of two major mine pool complexes ("South-East" and "North-West"). The proposed abatement methods for the watershed will therefore reduce the present AMD discharges from both Complexes.

In addition to the Mill Creek watershed, the adjacent Solomon, Warrior and Nanticoke Creek watersheds are also contributors to the recharge of the South-East Complex. A previous study* concluded that Warrior Creek, Nanticoke Creek and a small part of the Solomon Creek were the sources of recharge into the "Upper Mine Pools" within this Complex. The "inflow" or recharge of these Upper Pools is the source of AMD discharges, or outflow, from the Askam Borehole (see Figure 4). The three South Wilkes-Barre Boreholes are the major AMD discharge points of the SB Pool Complex "Lower Mine Pools". The major sources of the Lower Pool recharge are located in portions of the Mill Creek and Solomon Creek watersheds, and include some overflow from the "Upper Pools". The latter source consists of the recharge sources in the Warrior and Nanticoke Creek watersheds that exceed the discharge from the Askam Borehole.

** SL 181-3*

One of the specific objectives of the Mill Creek watershed study is to select feasible AMD abatement projects that, together with the abatement proposed in the adjacent watersheds, will decrease or eliminate the present AMD discharges from the South Wilkes-Barre Boreholes.

MULTI-PURPOSE APPROACH TO AMD ABATEMENT

Abatement measures considered in this Report consist of reducing the present mine pool recharge from surface and groundwater inflow sources. In addition to a reduction in AMD discharges from boreholes, the proposed abatement measures will provide the following additional benefits:

1. Reduce mine pool levels that are associated with basement flooding and subsidence problems.
2. Provide facilities for the collection of runoff from mine area restoration projects constructed by local business and non-profit agencies to upgrade land use.
3. Provide facilities for the collection of runoff from active or restored strip mined areas, where the runoff does not reach area streams.
4. Reduce the high cost of dewatering the deep mines in the event deep mining is reactivated in the restored areas. Dewatering and the cost of high pumping rates to support mining operations was a major cause of deep mining cessation in the Wyoming Valley Coal Basin. Reduction of pool levels stemming from the proposed abatement measures should materially influence the extent of necessary dewatering and substantially reduce the pumping rates required to sustain mining activities if the deep mines are made operational. Since present DER regulations require that mine discharge effluents meet acceptable standards, the reduced pumping rates necessary to maintain dewatering of the deep mines would also reduce future cost of treatment of AMD from active deep mines. In addition to the economic benefits that would be realized by the Mining Industry and coal consumers, the dewatering and reactivation of deep mining would considerably reduce the number and magnitude of AMD discharges

from adjacent "abandoned" deep mines. Accordingly, the Department's responsibility to abate AMD discharges from "abandoned" deep mines would be lessened without detriment to the environment or ecological balance.

5. The projected water supply needs within and without the study area exceed the available developed water sources. It is estimated that from 30 to 50% of the output from developed water sources is being lost through leakage in transmission pipelines and distribution systems. Those same losses aggravate the AMD pollution problem by recharging the mine pools which results in an increase in the volume of AMD discharges into the Susquehanna River and its tributary streams. Therefore, prevention of leakage from pipelines will increase the available water supply, reduce the need to develop additional water supply sources to meet projected demand, and benefit the AMD abatement program through the reduction of pipeline water losses that now recharge the mine pools. Additional high quality water sources can be developed by interception of groundwater that presently recharges the deep mine pools. Drilled wells and grout curtains along the rim of the coal basin can be used individually or in combination to intercept the groundwater, prevent recharge of the mine pools and augment the future water supply needs within and beyond the study area.

The multi-purpose benefits that can be derived from the proposed AMD abatement projects are expected to encourage participation by both private and public interests. The financial participation by other interests in any of the proposed multi-purpose projects will reduce individual contributions to project costs and provide multiple benefits to all concerned. At this writing, consideration is being given by the Department for a multi-purpose flood control/AMD abatement project in Hicks Creek area of the Wyoming Valley (Exeter).

PROPOSED ABATEMENT PROJECTS

The basic concept of abating AMD in the study area is to reduce the recharge of deep mine pools by "clean" water sources which result in a corresponding reduction of AMD discharge. This concept is generally referred to as "at source" abatement.

The proposed abatement projects fall under two major categories:

a. Projects that can be constructed under the "Land and Water Conservation and Reclamation Act" (Act 443).

b. Joint-Venture projects that can be partially or totally financed by other available "on-going" State and Federal Programs, including possible participation by local interests.

Analysis of data collected within the scope of this study was sufficient for the determination of costs and benefits to be derived from the projects that fall under category a.

Review of available reports and data collected by others, supports the conclusion that additional AMD abatement projects in category b. may be considered for the study area. Although some projects in category b. are expected to be very beneficial to AMD abatement, the available data is insufficient to determine cost and projected benefits to be derived from these joint-venture projects. Therefore, the AMD projects proposed for consideration by the Department are reported under two groupings; Definite Projects and Projects which require additional information and analysis that was not within the scope of this study.

Definite Projects: Six projects are proposed in the Mill Creek watershed. The location and extent of each project, as well as a summary of cost and the expected benefits are presented in Figure 13, page 101. A detailed description and breakdown of each project is presented in Appendix A . The estimated construction cost of these six projects is $7,211,100 and the expected annual water loss prevention is 3,850 MG/year. Five projects are directly related to the reduction of recharge to the South-East Mine Pool Complex, which results in the direct abatement of the AMD discharges from the South Wilkes-Barre Boreholes. Construction of these five projects in the Mill Creek watershed are expected to reduce the present AMD discharge from the boreholes

by 3,000 MG/year, or approximately 32% of the mean annual AMD discharge from the boreholes.

A breakdown of the proposed abatement projects in both watersheds that are directly related to the present discharges from the South Wilkes-Barre Boreholes are summarized below:

WATERSHED	NO. OF PROJECTS	ESTIMATED COST $	ESTIMATED BENEFITS		
			LOSSES PREVENTED MG/YEAR	ACID * REMOVAL LBS/DAY	COST $/LB/DAY
MILL CREEK	5	6,417,100	3,008	24,700	259.8
SOLOMON CREEK	5	3,628,500	726	5,965	608.3
SUB-TOTAL **	10	10,045,600	3,734	30,665	327.6

* *Based on present acid concentration of 360 ppm in the AMD discharges from the South Wilkes-Barre Boreholes (1973/74 acid concentration 638 ppm)*

** *Total proposed "Definite Projects."*

Since the present mean annual discharge from the South Wilkes-Barre Boreholes is 9,400 MG/year and the projected reduction in mine pool recharge is 3,734 MG/year, implementation of the proposed projects could reduce the present discharges by $\frac{3,734}{9,400} \times 100 = 40\%$.

The projected AMD reduction of 40% takes into consideration, the strip mined areas that were reclaimed by local interests and reflects conditions that existed during the study period. Restoration of active strip mines and the regrading of abandoned strippings by local interests will increase the derived benefits of the proposed projects. However, the anticipated increase in the reported benefits can be realized only if the drainage from future land restoration efforts is conveyed into the restored streams. The additional benefits to be derived from future land restoration are equivalent to 4.1 lbs/day of acid removal per acre of restored land.

The abatement projects proposed for Gardner Creek and the lower, reaches of Mill Creek will reduce the streambed losses that recharge the North-West Mine Pool Complex. It should be noted that the Gardner Creek project will also prevent highly acid waste bank seepage from contaminating the low base flow of the stream. During higher flows, the dilution effect offsets the high concentration of the acid

AMD ABATEMENT PROJECTS

PROJECT	COST	ANNUAL STREAM LOSS PREVENTED (MG)	ANNUAL ACID LOAD PREVENTED (LBS./DAY)	COST $/LB./DAY
UPPER COAL BROOK (1)	$1,824,000	409	3386	$539
MINED AREA RESTORATION	$1,129,000	366	3031	$372
TOTAL	$2,953,000	775	6417	$460
FOX HILL FLUME	$ 431,900	120	994	$435
LOWER COAL BROOK	$ 1,135,500	469	3883	$292
LAUREL RUN	$ 654,900	540	4471	$147
MILL CREEK	$1,611,800	1545 (2)	10951	$147
GARDNER CREEK	$ 424,000	401	1655	$256
TOTAL ALL PROJECTS	$ 7,211,100	3850	28371	$254

(1) INCLUDES PORTIONS OF SOLOMON CREEK WATERSHED
(2) LOWER REACHES OVERLIE THE N.W. MINE COMPLEX

LEGEND

- ABATEMEMENT PROJECT – MAIN CHANNEL WITH REACH NUMBER
- COLLECTOR CHANNEL
- WATERSHED LIMIT
- MINED AREA RESTORATION
- MINE POOL BARRIER PILLAR
- BREACHED BARRIER PILLAR

1000 0 1000 2000
SCALE IN FEET

NOTES

1. BASE MAP IS U.S.G.S. 7½ MIN. QUADRANGLE. (WILKES-BARRE EAST & PITTSTON, PENNA.)
2. BASE DATA RELATED TO COAL MINING, MINE POOLS & BARRIER PILLARS EXTRACTED FROM REPORTS PUBLISHED BY THE U.S. BUREAU OF MINES, THE U.S. GEOLOGICAL SURVEY & THE PA. GEOLOGIC SURVEY.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

AMD ABATEMENT STUDY

MILL CREEK
PROJECT NO. SL 181-4
LUZERNE CO., PENNA.

PROPOSED ABATEMENT MEASURES

DATE		FIGURE No.
DEC. 1976		13

seeps. The estimated costs and benefits that will be derived from reduced water losses to the North-West Mine Pool Complex are summarized in the following:

PROJECT LOCATION	ESTIMATED COST $	ESTIMATED BENEFITS				
		LOSSES PREVENTED MG/YEAR	ACID REMOVAL LBS/DAY		COST IN $/LB/DAY	
			(1)	(2)	(1)	(2)
GARDNER CREEK	424,000	401	1,655	855	256	496
MILL CREEK*	370,000	450	1,884	973	196	380
TOTAL	794,000	851	3,539	1,828	(224)	(434)

* *Lower Stretch of the Main Stem*
(1) Based on 182 ppm acid concentration (Buttonwood Tunnel)
(2) Based on 94 ppm acid concentration (Plainsville Borehole)

Analysis of the relationship between precipitation, mine pool fluctuation and AMD discharges in the North-West Mine Pool Complex was not within the scope of this study. However, continuous water level fluctuations at selected locations within the North-West and South-East Complexes were recorded for the duration of this study and are shown in Figure 5,p.17. These mine pool records and the recorded AMD discharges from the Buttonwood Tunnel and the Plainsville Borehole will facilitate the correlation between the conditions observed during the present study (1975-1976) period and further studies. Such correlation is essential to evaluate the recharge sources and abatement measures that will be necessary to alleviate the AMD discharges from the North-West Mine Pool Complex.

Although the relationship between water losses and AMD discharges in the North-West Complex are yet to be determined, the following observations were made:
The estimated total outflow from the Plains Borehole for the period 5/1/75-4/30/76 is 1,400 million gallons. Consequently, the reported 851 MG/year stream losses in Gardner Creek and Mill Creek that contribute to the North-West Complex amount to 60%
(851 x 100 = 60%) of the Plainsville Borehole AMD discharges. 1,460

A further reduction of this AMD discharge can be anticipated after construction of the multi-purpose flood control/AMD abate-

ment project now being considered by the Department for Hicks Creek. Correlation of the changes in borehole discharge and mine pool levels will facilitate evaluation of recharge sources and abatement measures needed to reduce AMD discharges from the entire North-West Mine Pool Complex. Previously reported data* and information obtained by verbal and written communications*, indicates that the drilling of the Plainsville Borehole was expected to reduce the acid and iron concentration in the Buttonwood Tunnel discharges. Comparison between the acid and iron concentrations in the Buttonwood Tunnel discharges prior to and after drilling the Plainsville Borehole are presented in TABLES X and XI. These TABLEs reveal a reduction of acid and iron concentration at the Buttonwood Tunnel. The reduced concentrations are attributed to shortening the path and detention time of water movement in the mine pools by construction of the borehole at Plainsville. When the mine pool level is below the outlet of the Plainsville Borehole, the Buttonwood Tunnel becomes the only known single-point discharge outlet of AMD for the North-West Complex. Therefore, when the Plainsville Borehole is not discharging, the benefits from the proposed Gardner Creek project will be much higher because of the higher acid concentration of the Buttonwood Tunnel discharges.

ADDITIONAL ABATEMENT MEASURES.

A considerable reduction in the present borehole discharges is expected from the prevention of pipeline leakage. The extent of the pipeline leakage was discussed in Section III. Although the available information indicates that the leaky pipelines over the South-East Complex contribute from 25% to 40% of the South Wilkes-Barre Borehole discharges, additional studies are required to determine the location of the leaks and the scope of required repairs. Nevertheless, the AMD abatement benefits that can be derived from the prevention of pipeline leakage are summarized as follows:

** J.R. Hollowell, 1973*

MEAN ANNUAL AMD FROM S. W-B BOREHOLES				EXTENT OF PIPELINE LEAKAGE IN PERCENT OF BOREHOLE DISCHARGE					
				25%			40%		
DISCHARGE		ACIDITY		ANNUAL LOSS		ACID LOAD LBS/DAY	ANNUAL LOSS		ACID LOAD LBS/DAY
(MG)	(MGD)	CONC. ppm	LOAD LBS/DAY	(MG)	(MGD)		(MG)	(MGD)	
9,400	25.75	360	77,219	2,350	6.44	19,305	3,760	10.30	30,887

Comparison between AMD abatement by preventing pipeline leakage and abatement by the construction of the ten proposed "Definite Projects" in Mill Creek and Solomon Creek, indicates the following:

1. Prevention of pipeline leakage can achieve AMD abatement benefits that are similar to the benefits expected from the construction of the ten proposed "Definite Projects."
2. The accrued benefits to the proposed AMD abatement program by also including benefits derived by the prevention of pipeline leakage are expected to reduce borehole discharges by approximately 65%. Based on the average cost of $327.60/lb/ day for the ten proposed projects, the equivalent value of AMD abatement by the prevention of pipeline leakage is 56,646,700. Benefits and respective cost values are:

DESCRIPTION	DISCHARGE		ACIDITY		COST ($)	
	MG	MGD	CONC. ppm	LOAD LBS/DAY	$/LB/DAY	PROPOSED EXPENDITURE
Ten (10) Proposed "Definite Projects"	3,734	10.23	360	30,665	327.6*	10,045,600
Prevention of Pipeline Leakage†	2,350	6.44	360	19,305	327.6	6,324,300
"SUB-TOTAL"	6,084	16.67	360	49,970	327.6	16,369,900
TOTAL AMD DISCHARGE	9,400	25.75	360	77,219		
"SUB-TOTAL" Benefits (% of Total Discharge)	← ← ← ← ← ← ← ← ← 64.7 % → → → → → → → → → → →					

† *25% of the Mean Annual Borehole Discharges*
* *Derived Value*

Interception of groundwater flow through the rim of the coal basin into the mine pools will reduce recharge of the pools with subsequent reduction of AMD discharges from the mine pool outlets. The

extent of AMD abatement that can be realized by the interception of groundwater flow can be determined by conducting additional investigations and field tests to demonstrate the suitability of various interception methods. Groundwater interception methods, cost estimates and the. resulting AMD abatement benefits were described in a previous Report*. Geologic conditions outside the coal measures allow the use of pumping and artesian wells, as well as horizontal galleries (gravity wells) to intercept groundwater flow. The initial cost of a typical six-well installation was estimated at S100,000. The estimated operating cost for the six wells was $6,000 per year. For a useful life of 40 years, the equivalent lump sum of $190,278 was derived for a 300 gallon per minute installation. Interception of 300 GPM is equivalent to the abatement of 1,296 lbs of acid per day. Therefore, the cost per pound of acid removal by the use of
the six-well installation is: $190,278 : 1,296 lbs/day = S146.8/lb/day.

The intercepted water can be conveyed into the restored stream channels (where streambed losses are prevented) or used for water supply. In the latter case, the water produced could be sold and the cost/benefit ratio of AMD abatement by interception of groundwater would be considerably improved.

At the present writing, it is estimated that at least 4 MGD of groundwater flow can be intercepted above the coal measures in the Solomon and Mill Creek watersheds. Reduction of AMD discharges by 4 MGD is equivalent to 15.5% of the annual mean discharges from the South Wilkes-Barre Boreholes.

It should be noted that the difference in elevation between the groundwater table outside the coal measures and the level of the mine pools is substantial along the margins of the Wyoming and Lackawanna Valleys. Therefore, the interception of groundwater along the rim of the coal basin could significantly reduce the present recharge of all the mine pools in the coal basin.
On-going planning by local agencies and water supply utilities indicate that development of additional water supply sources is required prior to 1980 to provide for the projected growth. Therefore, the interception of groundwater flow into the coal basin, and

SL 181-3; p. 83 and Appendix C, p. C-34

reduction of the high waterline leakage can provide a significant additional amount of needed water supply within the Wyoming and Lackawanna Valleys. The dual purpose uses (AMD abatement and water supply) that are derived by the interception of groundwater and by reduction of waterline leakage will help resolve present and future pollution and water supply problems in the area. Therefore, serious consideration should be given to undertake a study of pipeline leakage and to conduct a demonstration project for groundwater interception in the study area. The results obtained can apply to other similar areas within the Wyoming and Lackawanna Valleys as well as to other coal basins in Pennsylvania where groundwater and pipeline leakage recharges deep mine pools.