

WYOMING VALLEY MINE DRAINAGE
POLLUTION ABATEMENT PROJECT

PENNSYLVANIA DEPARTMENT OF HEALTH
BUREAU OF SANITARY ENGINEERING
DIVISION OF MINE DRAINAGE

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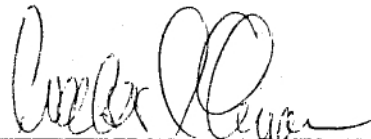
COMMONWEALTH OF PENNSYLVANIA
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PREFACE

This publication sets forth three alternate plans to control pollution from underground mine water pools which are being controlled by the Commonwealth to protect the residents of the Wyoming Valley against flooding and subsidence. The report is the second preliminary engineering plan prepared by the Department of Health dealing with abatement of abandoned mine drainage pollution in the northern anthracite field.

Implementation of the recommendations in the first report released in 1967 and entitled "Lackawanna Valley Mine Drainage Pollution Abatement Project" and this report would result in a significant improvement in the water quality of the North Branch of the Susquehanna River, one of Pennsylvania's most scenic streams.



Walter A. Lyon, Director
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FOREWORD

The Northern Anthracite Coal Field (Northern Field) extends in a northeasterly direction from the Borough of Shickshinny to Forest City, a distance of approximately sixty miles. The average width of the Northern Field is approximately four miles. Major surface streams draining the Northern Field consist of the Lackawanna and Susquehanna North Branch (Susquehanna) Rivers. The Lackawanna River drains the northeastern portion of the Northern Field--this area being known as the Lackawanna Basin. The Susquehanna River, after its confluence with the Lackawanna River, flows for approximately twenty-six miles through the southwestern portion of the Northern Field--this area being known as the Wyoming Basin. On Plate I there are shown the locations of the Northern Field, the Lackawanna and Wyoming Basins, and the Lackawanna and Susquehanna Rivers.

In February, 1967, there was submitted to the Pennsylvania Department of Health, Bureau of Sanitary Engineering, a report covering the collection and treatment of the major mine drainage (MD) discharges in the Lackawanna Basin; namely, the so-called Duryea and Old Forge discharges. During the course of the Lackawanna Basin investigations and studies, major Wyoming Basin underground mining with accompanying pumping was still being conducted on the south side off the Susquehanna River by various coal companies, primarily Blue Coal Corporation (Blue Coal) and Glen-Nan Coal Company (Glen-Nan). For all practical purposes, pumping from terminated deep mining operations on the north side of the Susquehanna River had ceased by 1962. By 1964, pools in deep mine workings located principally on the north side of the Susquehanna River had risen to the point where they were suspected of contributing to surface subsidence. Basement flooding believed to originate from high pool elevations occurred in 1967. Toward the middle and latter part of 1967, it became apparent that major Wyoming Basin underground mining operations located on the south side of the Susquehanna River were being rapidly terminated. Blue Coal announced its abandonment of the Huber and Sugar Notch deep mining operations, and subsequently ceased pumping at these workings and the adjacent Delaware-Pine Ridge, South Wilkes-Barre, Loomis and Truesdale mines. Consequently water elevations in the deep mine workings located principally on the south side of the Susquehanna River started to rise. These rising mine waters began forming vast underground pools which could, it was felt, also contribute to surface subsidence and basement flooding.

The effects of cessation of pumping operations in the Wyoming Basin had been studied by "The Technical Committee on the Abatement of Mine Drainage of the North Branch of the Susquehanna River" (Committee) during 1964 and 1967. The Committee concluded that rising mine water pools in the Wyoming Basin previously controlled by pumping could be expected to continue to be a major contributing factor in causing serious damage in various populated areas overlying the abandoned deep mines. In October, 1967, the Pennsylvania Department of Mines and Mineral Industries (M&MI) advanced before the Committee a plan designed

to minimize these problems. This plan consisted of (1) constructing an overflow structure at the Buttonwood air shaft to control water levels in abandoned deep mines lying generally on the north side of the Susquehanna River, and (2) drilling boreholes and installing high capacity, low lift pumps in deep mine workings of both the Delaware-Pine Ridge and South Wilkes-Barre mines to control water levels in abandoned deep mines lying generally on the south side of the Susquehanna River (Plan). It was recognized that the Plan would cause large volumes of MD not meeting Sanitary Water Board limitations to be discharged to the Susquehanna River. This report sets forth findings, conclusions, and recommendations resulting from a preliminary engineering investigation and study authorized by the Pennsylvania Department of Health to determine the most feasible and economical method for collecting and treating MD discharges caused by the Plan.

The locations of MD discharges comprising the Plan are shown on Plate I.

EXISTING WYOMING BASIN MD DISCHARGES

Based upon pool behavior in abandoned mine workings and information obtained from M&MI personnel, it appears that interconnections between various mines in the Wyoming Basin have allowed the formation of three pools; namely, the Delaware Complex (Delaware), South Wilkes-Barre Complex (South Wilkes-Barre), and Buttonwood Complex (Buttonwood) pools. The extent of these pools is shown on Plate I. In September, 1968, M&MI provided relief for waters in the Buttonwood pool by completing construction of a drainage ditch which allows gravity overflow to Solomon Creek at the site of the Buttonwood colliery air shaft. Currently, deep well pumps at the Delaware colliery shaft, previously operated by Blue Coal, are being used by M&MI to control Delaware pool levels on a temporary and limited basis until that portion of Plan facilities applicable to the Delaware pool can be installed. The South Wilkes-Barre pool is continuing to rise and at present has no relief.

In addition to discharges from the Delaware and Buttonwood pools, other current Wyoming Basin MD discharges include those of Blue Coal and Glen-Nan which continue to pump at various locations in the southwestern portion of the Wyoming Basin, and the Mocanaqua gravity outfall which relieves isolated pools in the West End mine. The independent pools located at the northern extremity of the Wyoming Basin are apparently relieved through the Susquehanna River bottom. In addition, there are undoubtedly other areas in the Wyoming Basin where pools are relieved through the Susquehanna River bottom.

The general locations of all known major existing MD discharges in the Wyoming Basin are shown on Plate I. Also shown on Plate I are the known MD discharge points located at the downstream end of the Lackawanna Basin.

DELAWARE POOL HYDRAULICS

Based upon information obtained from M&MI personnel, it appears that there is presently no significant communication between the Delaware and Buttonwood pools. It is believed, however, that should liquid levels in the Delaware pool be allowed to rise from their current elevation of approximately +467 to approximately +540, waters in the Henry and Dorrance mines might migrate to the Buttonwood pool.

There is direct communication between the Delaware and South Wilkes-Barre pools. Information obtained from M&MI personnel indicates that there are significant interconnections and weak points in adjacent workings above elevation +400 which allow mine waters to pass freely between these pools above this elevation. Accordingly, it is planned by M&MI as a part of the Plan to allow both pools to come to the same average equilibrium elevation. The proposed average equilibrium elevation to be established by M&MI is between +475 and +500.

PROPOSED M&MI PLAN FOR DELAWARE POOL

To implement the Plan, it is proposed by M&MI to drill three boreholes each thirty-six inches in diameter, into the flooded, worked-out area of the Hillman vein in the Delaware-Pine Ridge mine. From ground surface to the Hillman vein there will be a vertical drop of approximately 219 feet. Two 8,000 GPM pumps and one 6,000 GPM pump will be installed in the boreholes. As previously indicated, it is planned to maintain the Delaware pool at an elevation of +475 to +500. According to M&MI personnel, design intent is to have the two 8,000 GPM pumps remove average Delaware pool make volumes and to use the 6,000 GPM pump for stand-by service. It has been assumed by M&MI that sufficient capacity will be available in the underground voids to provide storage for those make volumes in excess of anticipated average volumes. A typical columnar section of the proposed Delaware pool boreholes is shown on Plate II-A.

Major premises and factors involved in the selection of the proposed pump installation site by M&MI personnel were:

1. Make volumes equal to the total rated capacity of the three proposed pumps can be removed, thereby controlling Delaware pool elevations.
2. Lifting large volumes of MD for shorter heights will be more economical than continued use of the established pumping site.
3. Pollutional characteristics of the MD may be minimized by withdrawing at an elevation above that currently in use at the established pumping site.

DELAWARE POOL MAKE AND QUALITY

Based upon the estimates of M&MI personnel, a summary of Delaware pool make volumes anticipated upon completion of construction of all Plan facilities is presented in the following:

<u>Ground Water Level Period</u>	<u>GPM</u>	<u>Make</u> <u>MGD</u>
Maximum	17,000	24.5
Average	16,000	23.0
Minimum	15,000	21.6

These estimates are based upon previous pumping information obtained during operation of the Delaware shaft pumps.

Principal chemical constituents of the MD to be pumped from the proposed Delaware pool boreholes include acidity and iron. Based on available analytical data, the average pH of MD currently discharged at the Delaware shaft is 5.6; acid (as CaCO₃) and iron concentrations currently average 140 and 120 mg/l respectively. Until such time as the proposed boreholes are drilled, current discharge quality and previous experience must be relied upon to estimate the quality of MD discharged from the proposed pumps. For planning purposes, it is estimated that when the proposed Delaware pool pumps are placed in operation, average pH, and acid and iron concentrations will equal current Delaware shaft values. When MD quality stabilizes (stabilized conditions), it is further estimated that pH will average 5.9; acid and iron concentrations are expected to average 100 and 80 mg/l respectively.

SOUTH WILKES-BARRE POOL HYDRAULICS

Based upon information obtained from M&MI personnel, it appears that there is no significant communication between the South Wilkes-Barre and Buttonwood pools. Barrier pillars between these two pools are considered to be sound.

As noted hereinbefore, interconnections and weak points in the barrier pillars separating the South Wilkes-Barre and Delaware pools above elevation +400 allow mine waters to pass freely between these two pools. It is planned by M&MI to maintain the Delaware and South Wilkes-Barre pools in equilibrium with each other between elevations +475 and +500.

Immediately adjacent to the southwestern limits of the South Wilkes-Barre pool lie the abandoned Number 7 and Alden mines, which in turn are adjacent to the presently active Wanamie and Glen-Nan mines. It appears that pool waters in the Alden and Number 7 mines do not now, and will not in the future, significantly contribute to the South Wilkes-Barre pool make. It further appears that the ultimate cessation of pumping at the Wanamie and Glen-Nan mines will have no visible effect on the pool hydraulics or make of the South Wilkes-Barre pool. When all pumping ceases at the southwestern end of the Wyoming Basin, pool waters herein are expected to be relieved through surface eruptions, the Susquehanna River bottom, and the Mocanaqua gravity outfall.

PROPOSED M&MI PLAN FOR SOUTH WILKES-BARRE POOL

To implement the Plan, it is proposed by M&MI to drill three boreholes, each thirty-six inches in diameter, into the flooded, worked-out area of the Abbott vein in the South Wilkes-Barre mine. The Abbott vein is considerably higher than the Bottom Red Ash and Baltimore veins from which MD has been pumped in the past. From ground surface to the Abbott vein, there will be a vertical drop of approximately 185 feet.

Two 8,000 GPM pumps and one 6,500 GPM pump will be installed in the boreholes. According to M&MI personnel, design intent is to have the two 8,000 GPM pumps remove average South Wilkes-Barre pool make volumes and to use the 6,500 GPM pump for stand-by service. It has been assumed by M&MI that sufficient capacity will be available in the underground voids to provide storage for those make volumes in excess of anticipated average volumes. A typical columnar section of the proposed South Wilkes-Barre pool boreholes is shown on Plate II-B.

Major premises and factors involved in selecting the proposed South Wilkes-Barre pool pump installation site by M&MI personnel were the same as for the Delaware pool; namely:

1. Make volumes equal to the total rated capacity of the three proposed pumps can be removed thereby controlling South Wilkes-Barre pool elevations.
2. Lifting large volumes of MD for shorter heights will be more economical than resumption of pumping at former pump sites.
3. Pollutational characteristics of the MD may be minimized by withdrawing at an elevation considerably above that used at former pump sites.

SOUTH WILKES-BARRE POOL MAKE AND QUALITY

Based upon estimates of M&MI personnel, a summary of South Wilkes-Barre pool make volumes anticipated upon completion of construction of all Plan facilities is presented in the following.

<u>Ground Water Level Period</u>	<u>GPM</u>	<u>Make</u>	<u>MGD</u>
Maximum	30,000		43.2
Average	16,000		23.0
Minimum	8,600		12.4

These estimates are based on pumping information obtained by M&MI personnel during past periods of deep mining activity throughout the South Wilkes-Barre pool area.

Principal chemical constituents of the MD to be pumped from the proposed South Wilkes-Barre pool boreholes include acidity and iron. Until such time as the proposed boreholes are drilled, previous experience must be relied upon to estimate the quality of MD discharged from the proposed pumps. It is estimated that when the proposed South Wilkes-Barre pool pumps are placed in operation, pH will average 4.4; acid (as CaCO₃) and iron concentrations are expected to average 2,500

and 1,200 mg/l respectively. When MD quality stabilizes, it is further estimated that pH will average 5.5; acid and iron concentrations are expected to average 600 and 300 mg/l respectively.

BUTTONWOOD POOL HYDRAULICS

As noted hereinbefore, there is presently no significant communication between the Buttonwood and South Wilkes-Barre pools nor the Buttonwood and Delaware pools. Said condition will continue as long as M&MI maintains Delaware pool elevations between +475 and +500 as proposed under the Plan. There also appears to be no significant communication between the Buttonwood and Number 7 mine pools. Furthermore, there does not appear to be significant communication between the Buttonwood and independent pools located at the northern extremity of the Wyoming Basin.

BUTTONWOOD AIR SHAFT

As noted hereinbefore, the elevation of the Buttonwood pool is controlled by the gravity discharge of pool waters through the Buttonwood colliery air shaft to Solomon Creek. MD from the Buttonwood pool overflows to the drainage ditch leading from the air shaft to Solomon Creek at elevation +519. The overflow structure includes a flap gate which controls the back-up of Solomon Creek waters into the air shaft during high stream flows, and a vertical slide gate by which pool levels can be raised to an elevation of approximately +524. A columnar section of the air shaft is shown on Plate II-C.

Major premises and factors involved in the selection of the Buttonwood air shaft by M&MI personnel as the site at which to control Buttonwood pool elevations under the Plan were:

1. Gravity discharge can be obtained with minimal construction effort.
2. Gravity discharge at this site will control Buttonwood pool elevations as necessary to attain Plan objectives.

BUTTONWOOD POOL MAKE AND QUALITY

Based upon estimates of M&MI personnel a summary of Buttonwood pool make volumes anticipated upon completion of construction of all Plan facilities is presented in the following:

<u>Ground Water Level Period</u>	<u>GPM</u>	<u>Make</u>	<u>MGD</u>
Maximum	15,000		21.6
Average	7,500		10.8
Minimum	7,000		10.1

Principal chemical constituents of the MD discharged from the Buttonwood air shaft include acid and iron. Based on available analytical data, the average pH of MD currently discharged is 5.2; acid (as CaCO₃) and iron concentrations currently average 425 and 240 mg/l respectively. When MD quality stabilizes, it is estimated that pH will average 5.3; acid and iron concentrations are expected to average 300 and 180 mg/l respectively.

EFFECT OF PROPOSED LACKAWANNA BASIN PROJECT ON WYOMING BASIN POOLS

As noted hereinbefore, a report was submitted to the Department of Health in February, 1967 covering the collection and treatment of major MD discharges in the Lackawanna Basin. In said report, the project recommended for construction consisted essentially of lowering Number 9 pool levels via pumps to be installed in boreholes drilled to the Pittston vein in the vicinity of the Phoenix shaft. Number 9 pool MD, after being pumped to the surface, would flow by gravity to a treatment plant situated in the immediate vicinity of the Phoenix shaft. The recommended Lackawanna Basin project would result in Number 9 pool levels being maintained at an elevation of from +530 to +545. Shown on Plate I is the location of the Phoenix shaft.

Based upon information obtained from M&MI personnel, it appears that there is not now, nor will there be in the future, any significant communication between the Number 9 pool and the Wyoming Basin. Therefore, facilities comprising the Wyoming Basin Plan and/or the Lackawanna Basin project may be constructed without any significant variation in pool hydraulic and MD design conditions noted in this or the February, 1967 report.

SANITARY WATER BOARD MINE DRAINAGE DISCHARGE LIMITATIONS

Present Sanitary Water Board (SWB) mine drainage discharge limitations applicable to active coal mining operations are as follows:

pH	6-9
Acidity	None
Total Iron	Not greater than 7 mg/l
Aluminum, Sulfate, Manganese, etc.	As determined to be necessary

On the basis of the hereinbefore noted quality data for both initial and stabilized conditions, Plan discharges will not meet current SWB pH, acid and iron requirements for active coal mining operations. Based on discussions with Bureau of Sanitary Engineering personnel, it appears that the Bureau will recommend to the SWB that its current pH, acid and iron limitations for active operations be applied to Plan discharges under all conditions of flow in the Susquehanna River and its tributaries. Accordingly the pH acid and iron limitations hereinbefore noted have been used exclusively in evaluating mine drainage treatment requirements under the Plan.

For purposes of this report, Plan discharges are hereinafter referred to as AMD.

TREATMENT PROCESS

Various treatment processes capable of producing an effluent meeting current SWB mine drainage discharge limitations are available. The lime neutralization and oxidation treatment process appears at this time to be the most economical means of meeting the SWB's current limitations. This type of treatment, consisting of the following has therefore been used for purposes of this report:

1. Acid neutralization and pH adjustment with lime.
2. Ferrous iron oxidation.
3. Ferric hydroxide precipitation and thickening.
4. Ferric hydroxide sludge dewatering using vacuum filters with gypsum as a conditioning agent.
5. Landfilling of vacuum filter sludge cake in abandoned Wyoming Basin strip mines.

ESTIMATED MINE DRAINAGE VOLUMES AND CHARACTERISTICS USED FOR DESIGN PURPOSES

The proper planning of AMD conveyance and treatment facilities requires that design volumes and constituents be established. On the basis of information and data obtained from M&MI personnel, past experience, and discussions with Bureau of Sanitary Engineering personnel, the volumes and constituents of Plan discharges used for the preliminary design of conveyance and treatment facilities are as follows:

	<u>Initial Conditions</u>	<u>Stabilized Conditions</u>
Delaware Pool		
Volume - MGD		
Peak rate	31.7	31.7
Average daily over the year	23	23
Acidity (Average)		
mg/l as CaCO ₃	140	100
Tons/day	13.4	9.6

	<u>Initial Conditions</u>	<u>Stabilized Conditions</u>
Iron (Average)		
mg/l	120	80
Tons/day	11.5	7.7
South Wilkes-Barre Pool		
Volume - MGD		
Peak rate	32.4	32.4
Average daily over the year	23	23
Acidity (Average)		
mg/l as CaCO ₃	2,500	600
Tons/day	240	57.5
Iron		
mg/l	1,200	300
Tons/day	115	28.8
Buttonwood Pool		
Volume - MGD		
Average daily during maximum ground water level periods	21.6	21.6
Average daily over the year	10.8	10.8
Acidity		
mg/l as CaCO ₃ (Average)	425	300
Tons/day (1)	38.3	27
Iron		
mg/l (Average)	240	180
Tons/day (1)	21.6	16.2

- (1) Based on average daily volume during maximum ground water level periods because of limited storage capacity in mine workings.

On the basis of previous experience, it has been assumed for purposes of this report that stabilized conditions will be realized approximately five years after discharge commences. M&MI personnel anticipate that the proposed Delaware and South Wilkes-Barre pumps will be placed in operation by the middle of 1970. Therefore, stabilized conditions should be realized by the middle of 1975. It is further assumed for purposes of this report that the Buttonwood air shaft overflow will reach stabilized conditions by the middle of 1975, and that initial conditions will be experienced at all three Plan discharge sites in mid-1970.

CONVEYANCE AND TREATMENT ALTERNATIVES

Various combinations of AMD conveyance and treatment facilities were reviewed as part of investigations and studies reported herein. Three alternatives so reviewed were deemed of sufficient merit for subsequent study in detail. The conveyance and treatment alternatives studied in detail are generally described in the following:

Alternate 1:

Construct a treatment plant in the immediate vicinity of each of the Plan discharge sites. The proposed location of the treatment plant to serve the Delaware discharge is at the eastern end of the Wilkes-Barre municipal golf course in the immediate vicinity of the proposed discharge. The proposed location of the treatment plant to serve the South Wilkes-Barre discharge would be in an area located immediately east of the proposed discharge, and the plant to serve the existing Buttonwood discharge would be in the area located opposite the air shaft on the north side of Solomon Creek. Pump discharges and overflow from the Buttonwood air shaft would be conveyed by gravity to each proposed treatment plant site. Discharge from the Delaware treatment plant would be to Mill Creek. Discharges from the South Wilkes-Barre and Buttonwood treatment plants would be to Solomon Creek. The length of conveyance and outfall sewers to be constructed under Alternate 1 would be approximately 1,300 feet.

Alternate 2:

Construct two treatment plants--one to serve the Delaware discharge, and a second to serve the combined South Wilkes-Barre and Buttonwood discharges. The proposed location of the treatment plant to serve the Delaware discharge would again be at the eastern end of the Wilkes-Barre municipal golf course in the immediate vicinity of the proposed discharge. The proposed location of the treatment plant to serve the South Wilkes-Barre and Buttonwood discharges would be in the area located immediately opposite the Buttonwood air shaft on the north side of Solomon Creek. Delaware pump discharges would be conveyed by gravity to the proposed Delaware treatment plant site; South Wilkes-Barre pump discharges would be conveyed by gravity along Solomon Creek to the proposed treatment plant site in the vicinity of the Buttonwood air shaft. The Buttonwood discharge would be conveyed by gravity directly across Solomon Creek to the same proposed treatment plant site. Discharge from the Delaware treatment plant would be to Mill Creek; discharge from the treatment plant receiving South Wilkes-Barre and Buttonwood discharges would be to Solomon Creek. The length of conveyance and outfall sewers to be constructed under Alternate 2 would be approximately 4,700 feet.

Alternate 3:

Construct a single treatment plant to serve all three Plan discharges. The proposed location of the single plant would be in the area located opposite the Buttonwood air shaft on the north side of Solomon Creek. Delaware pump discharges would be conveyed by gravity along Mill Creek and the Susquehanna River to the proposed treatment plant site. South Wilkes-Barre pump discharges would be conveyed by gravity along Solomon Creek to the vicinity of the Buttonwood air shaft

from which point the combined South Wilkes-Barre and Buttonwood discharges would be conveyed by gravity to the treatment plant site. Discharge from the proposed treatment plant would be to Solomon Creek. The length of conveyance and outfall sewers to be constructed under Alternate 3 would be approximately 38,000 feet.

COST ESTIMATES

Treatment facilities could be constructed to receive AMD discharges under anticipated initial or stabilized conditions, or at any number of quality conditions between these two extremes. The operating, maintenance, and administrative (operating) costs incurred as the result of constructing treatment facilities for initial conditions would decrease with time until stabilized conditions were realized. Preliminary estimates have been prepared for construction, project, and yearly operating costs likely to be incurred in connection with implementation of the various AMD conveyance and treatment alternates described hereinbefore for both initial and stabilized conditions. A summary of project and total annual cost estimates is presented in the following:

	<u>Initial Conditions (Mid-1970)</u>	<u>Stabilized Conditions (Mid-1975)</u>
Alternate 1		
Project Costs		
Conveyance Sewers	\$ 235,000	\$ 235,000
Treatment and Disposal Facilities	19,800,000	13,815,000
Total	20,035,000	14,050,000
Annual Costs		
First Year after Discharge Commences (1970 - 1971)		
Fixed	1,300,000	---
Operating	4,650,000	---
Total	5,950,000	---
Fifth Year after Discharge Commences (1975 - 1976) and Thereafter		
Fixed	1,300,000	914,000
Operating	3,510,000	3,400,000
Total	4,810,000	4,314,000

	Initial Conditions <u>(Mid-1970)</u>	Stabilized Conditions <u>(Mid-1975)</u>
Alternate 2		
Project Costs		
Conveyance Sewers	745,000	745,000
Treatment and Disposal Facilities	18,220,000	12,735,000
Total	18,965,000	13,480,000
Annual Costs		
First Year after Discharge Commences (1970 - 1971)		
Fixed	1,233,000	---
Operating	4,150,000	---
Total	5,383,000	---
Fifth Year after Discharge Commences (1975 - 1976) and Thereafter		
Fixed	1,233,000	877,000
Operating	3,100,000	3,020,000
Total	4,333,000	3,897,000
Alternate 3		
Project Costs		
Conveyance Sewers	9,140,000	9,140,000
Treatment and Disposal Facilities	16,700,000	11,690,000
Total	25,840,000	20,830,000
Annual Costs		
First Year after Discharge Commences (1970 - 1971)		
Fixed	1,680,000	---
Operating	3,780,000	---
Total	5,460,000	---
Fifth Year after Discharge Commences (1975 - 1976) and Thereafter		
Fixed	1,680,000	1,355,000
Operating	2,850,000	2,760,000
Total	4,530,000	4,115,000

For purposes of this report, all construction cost estimates have been based on current price levels. Furthermore, conveyance sewer construction costs have been increased approximately twenty per cent and treatment plant construction costs approximately thirty per cent for purposes of estimating project costs. These increases for purposes of estimating project costs cover engineering, lands and rights-of-way, and other costs associated with the design and construction of conveyance and treatment facilities. Fixed costs have been based on an amortization period of thirty years and five per cent interest.

In preparing construction cost estimates, allowance was made for the use of piling to support all structures located on the north side of Solomon Creek in the area opposite the Buttonwood air shaft. Additional allowance was made to provide for flood protection facilities and the lining of Solomon Creek channel at this site. Yearly operating costs include an allowance for hauling vacuum filter sludge cake to abandoned Wyoming Basin strip mines, and preparing and closing said strip mines after they are filled with sludge cake.

DISCUSSION OF CONVEYANCE AND TREATMENT ALTERNATIVES STUDIED IN DETAIL

A discussion of the conveyance and treatment alternates studied in detail for purposes of this report is presented in the following:

Alternate 1:

Project costs for Alternate 1 (initial and stabilized conditions) are slightly more than for Alternate 2, but considerably less than for Alternate 3. Total annual costs for Alternate 1 (initial and stabilized conditions) are more than for Alternate 2 and for all practical purposes equal to those for Alternate 3. Annual operating costs for Alternate 1 (initial and stabilized conditions) are higher than the annual operating costs for Alternates 2 and 3. The proposed treatment plant sites are located in areas where ample room is currently available for expansion should such be necessary. The construction of Alternate 1 conveyance and treatment facilities at each Plan discharge site could be accomplished as funds become available and some reduction in AMD pollution realized as these facilities are placed in operation. AMD conveyance and treatment facilities constructed for initial conditions would result in considerably higher project and annual fixed costs than comparable costs for facilities constructed for stabilized conditions. For all practical purposes, annual operating costs after the fifth year would be the same as incurred for facilities constructed for stabilized conditions.

Alternate 2:

Project costs for Alternate 2 (initial and stabilized conditions) are slightly less than for Alternate 1, and significantly less than for Alternate 3. Total annual costs for Alternate 2 (initial and stabilized conditions) are less than total annual costs for Alternates 1 and 3; annual operating costs fall between those of Alternates 1 and 3. The proposed treatment plant sites are located in areas where ample room is currently available for expansion should such be necessary. Alternate 2 has the same basic advantage as Alternate 1 in that construction of AMD conveyance and treatment facilities can logically proceed on a step-wise schedule as funds become available.

Comments made in discussing Alternate 1 relative to project, and annual, fixed and operating costs for initial and stabilized conditions apply equally to Alternate 2.

Alternate 3:

Project and total annual costs for Alternate 3 (initial and stabilized conditions) are higher than for Alternates 1 and 2. Annual operating costs for Alternate 3 (initial and stabilized conditions) are less than for Alternates 1 and 2. The difference, though, between Alternate 2 and Alternate 3 annual operating costs is not significant. In addition, construction difficulties associated with locating the Delaware conveyance sewer along the Susquehanna River and from the Susquehanna River to the proposed treatment plant site could significantly increase the estimated project costs for this Alternate. Under Alternate 3, conveyance and treatment facilities capable of handling all AMD must be constructed in their entirety before any AMD reduction can be realized. Although adequate room is currently available in the area of the proposed treatment plant site, expansion of facilities, should such be necessary, would be more difficult than under Alternates 1 and 2.

Comments made in discussing Alternate 1 relative to project, and annual, fixed and operating costs for initial and stabilized conditions apply equally to Alternate 3.

SCHEDULING THE DESIGN AND CONSTRUCTION OF
AMD CONVEYANCE AND TREATMENT FACILITIES

Several major considerations which bear directly on the Plan will affect the time schedule for final design and construction of AMD conveyance and treatment facilities. These major considerations are summarized in the following:

Determination of Hydraulic Feasibility

Although it is felt that the Plan will control Wyoming Basin mine water pools as anticipated, it is the opinion of M&MI personnel that because of the many unknown factors associated with the abandoned deep mine workings, nothing short of actual installation and operation of the proposed pumping facilities will establish with certainty the hydraulic feasibility of the Plan. It is currently anticipated that a minimum of one year would be needed to establish hydraulic feasibility, including the verification of estimated discharges at all three Plan discharge sites.

Construction of Surface Reclamation Facilities

Based on information obtained from M&MI personnel, M&MI is considering the construction of surface reclamation facilities in the Wyoming Basin, although at this time no specific facilities have been proposed. The construction of surface reclamation facilities could result in a decrease in the AMD volumes and improvement in the AMD characteristics used herein for the preliminary design of AMD conveyance and treatment facilities. Past experience indicates that the total cost over extended periods of time for an AMD abatement plan comprised of surface reclamation and treatment facilities would be less than the cost of an AMD abatement plan comprised solely of treatment facilities. It therefore appears that a study should be made of the surface reclamation facilities applicable to Wyoming Basin conditions, and the combination of surface reclamation and treatment facilities that would result in the lowest cost for AMD pollution abatement determined. These surface reclamation facilities should then be constructed and their effectiveness determined. It is anticipated that a minimum of four years would be necessary to complete the study and the construction and evaluation of the recommended surface reclamation facilities. The study to determine surface reclamation facilities applicable to Wyoming Basin conditions could commence immediately.

Verification of Mine Drainage Characteristics

As noted hereinbefore, anticipated discharge quality has been estimated on the basis of the best information and data currently available. As with the determination of hydraulic feasibility, nothing short of actually installing and operating the pumps will enable the quality of mine drainage discharges to be verified. It currently appears that all three Plan discharges should be operated for a minimum of three years in order to establish with a high degree of certainty the quality estimated at stabilized conditions.

On the basis of the information presented in this section, the more prudent course appears for the Commonwealth to adopt an AMD pollution abatement schedule for Plan discharges from the Wyoming Basin wherein sufficient time is allocated, among other things, for (1) verifying the hydraulic feasibility of the Plan, (2) studying, constructing, and evaluating surface reclamation facilities, and (3) verifying discharge quality. Allowing time for completion of final design, and the preparation of construction plans and specifications, and the construction of AMD conveyance and treatment facilities, it appears that an abatement plan capable of eliminating AMD pollution could not be made operative prior to the middle of 1975. On the basis of previous experience, it appears that a more realistic target date would be mid-1977. In order to minimize the affects of AMD pollution on the Susquehanna River during the period from the start of discharge to the completion of construction of conveyance and treatment facilities, Plan discharges could be controlled to make maximum use of the River's assimilative capacity.

RECOMMENDED CONVEYANCE AND TREATMENT ALTERNATIVE

On the basis of (1) costs, (2) anticipated problems associated with the construction of conveyance sewers along the Susquehanna River, (3) the merits of step-wise construction of conveyance and treatment facilities, (4) the advisability of studying and evaluating Plan hydraulic feasibility, surface reclamation facilities and discharge quality, and (5) time requirements for the preparation of final design, construction plans and specifications, and the construction of AMD conveyance and treatment facilities, it is recommended that the Commonwealth at this time adopt for construction the AMD conveyance and treatment facilities required for stabilized conditions under Alternate 2. Before AMD conveyance and treatment facilities required for stabilized conditions under Alternate 2 are constructed it is recommended that (1) the hydraulic feasibility of the Plan be verified, (2) the applicability of surface reclamation facilities be studied, and economically justified surface reclamation facilities constructed and evaluated, and (3) mine drainage characteristics be verified.

A preliminary basis of design for AMD conveyance and treatment facilities required for stabilized conditions under Alternate 2 is presented on Exhibit A; preliminary construction and project cost estimates on Exhibit B; and total annual cost estimates on Exhibit C. The preliminary basis of design and cost estimates presented on these Exhibits are based on the AMD volumes and characteristics presented hereinbefore. Should M&MI proceed with the construction of surface reclamation facilities, the size and cost of these conveyance and treatment facilities could be expected to decrease. On Plate III there are shown the locations of the conveyance and treatment facilities recommended for construction.

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

A summary of findings, conclusions, and recommendations resulting from investigations and studies reported herein is presented in the following:

1. "The Technical Committee on the Abatement of Mine Drainage of the North Branch of the Susquehanna River" concluded in 1967 that rising mine water pools in the Wyoming Basin previously controlled by pumping could be expected to be a major contributing factor in causing serious damage in various populated areas overlying abandoned deep mines.
2. The Plan proposed by the Department of Mines and Mineral Industries for controlling mine water pool elevations throughout the major portion of the Wyoming Basin consists of (a) continuing to operate the overflow structure at the Buttonwood air shaft to control water levels in abandoned deep mines lying generally on the north side of the Susquehanna River, and (b) drilling boreholes and installing high capacity, low lift pumps in deep mine workings of both the Delaware-Pine Ridge and South Wilkes-Barre mines to control water levels in abandoned deep mines lying generally on the south side of the Susquehanna River. It was recognized that the Plan would result in large

volumes of mine drainage not meeting current Sanitary Water Board limitations to be discharged to the Susquehanna River.

3. When current pumping ceases at the southwestern end of the Wyoming Basin, pool waters therein are expected to be relieved through surface eruptions, the Susquehanna River bottom, and the Mocanaqua gravity outfall. These pool waters are not expected to have any significant effect on the Plan proposed by the Department of Mines and Mineral Industries.
4. Facilities comprising the Wyoming Basin Plan and/or the Lackawanna Basin project, covered in a report to the Department of Health in February, 1967, may be constructed without any significant variation in pool hydraulics and AMD design conditions noted in this or the February, 1967 report.
5. Current Sanitary Water Board mine drainage pH, acidity and iron discharge limitations applicable to active coal mining operations were used in preparing the preliminary basis of design for purposes of this report. The process used in the preliminary design of treatment facilities was the lime neutralization-oxidation process with vacuum filtration of sludge and the landfilling of vacuum filter sludge cake in abandoned Wyoming Basin strip mines for disposal.
6. The AMD conveyance and treatment alternative recommended for construction consists of two treatment plants--one to serve the Delaware discharge and a second to serve the combined South Wilkes-Barre and Buttonwood discharges. The proposed location of the treatment plant to serve the Delaware discharge would be at the eastern end of the Wilkes-Barre municipal golf course in the vicinity of the proposed discharge. The proposed location of the treatment plant to serve the South Wilkes-Barre and Buttonwood discharges would be in the area located immediately opposite the Buttonwood air shaft on the north side of Solomon Creek.
7. Before AMD conveyance and treatment facilities are constructed, it is recommended that (a) the hydraulic feasibility of the Plan be verified, (b) the applicability of surface reclamation facilities in the Wyoming Basin be studied, and economically justified surface reclamation facilities constructed and evaluated, and (c) mine drainage characteristics be verified.
8. Allowing time for completion of final design, preparation of construction plans and specifications, and the construction of AMD conveyance and treatment facilities, it appears that an abatement plan capable of eliminating AMD pollution resulting from Plan discharges could be made operative by 1977. In order to minimize the effects of AMD pollution on the Susquehanna River prior to the construction of AMD conveyance and treatment facilities, Plan discharges could be controlled so that maximum use is made of the River's assimilative capacity.

9. On the basis of current price levels, the project cost of the recommended AMD conveyance and treatment facilities for handling Plan discharges is estimated at \$13,480,000, annual fixed costs at \$877,000, and annual operating, maintenance and administrative costs at \$3,020,000.
10. The preliminary basis of design and cost estimates presented in this report for the recommended AMD conveyance and treatment facilities are based on anticipated Plan discharge volumes and characteristics noted hereinbefore. Should the Department of Mines and Mineral Industries proceed with the construction of surface reclamation facilities, the size and cost of the conveyance and treatment facilities recommended for construction could be expected to decrease.

EXHIBIT A

COMMONWEALTH OF PENNSYLVANIA
Department of Health

Control And Treatment Of Mine Drainage In The Wyoming Basin

Preliminary Basis of Design -
Alternate 2 - Stabilized Conditions

Conveyance Sewers

Delaware Pumped Discharges

Sewer From Pumped Discharges To Delaware

Treatment Plant Site

Material	PVC lined concrete
Length	500 feet
Diameter	42 inches
Capacity at minimum slope	40.0 MGD
Maximum discharge rate	31.7 MGD

South Wilkes-Barre Pumped Discharges

Sewer From Pumped Discharges To South Wilkes-Barre -

Buttonwood Treatment Plant Site

Material	PVC lined concrete
Length	3,900 feet
Diameter	48 inches
Capacity at minimum slope	32 MGD
Maximum discharge rate	32.4 MGD

EXHIBIT A (Continued)

Buttonwood Air Shaft Gravity Discharge
 Sewer From Buttonwood Air Shaft Overflow To South
 Wilkes-Barre - Buttonwood Treatment Plant Site

Material	PVC lined concrete
Length	300 feet
Diameter	42 inches
Capacity at minimum slope	26 MGD
Maximum discharge rate	21.6 MGD

	<u>Delaware Plant</u>	<u>South Wilkes-Barre - Buttonwood Plant</u>
Treatment Facilities		
Area - acres	6	12.6
Total Daily Volume - MGD	23	44.6
Acidity (as CaCO ₃)		
mg/l	100	455
Tons/day	9.6	84.5
Iron		
mg/l	80	240
Tons/day	7.7	45.0
Alkali Requirements For AMD Neutralization, Oxidation And Precipitation - Quicklime (95% CaO)		
Tons/day	5.8	51
Oxidation - Flocculation Tanks		
Number	2	4
Dimensions (L x W x D) - feet	46x46x15	45x45x15
Oxygen Requirements - lbs/hr.	92	536
Detention Time - min.	30	30
Clarifier - Thickeners		
Number	3	6
Dimensions (Diam. x D) - feet	147x10	205x6
Detention Time - hrs.	4.0	4.8
Overflow Rate - GPD/ft ²	453	224
Solids Loading - ft ² /T/day	1,500	1,500
Sludge Drum Filters		
Sludge Resulting From Neutralization, Oxidation And Precipitation		
Dry Solids - tons/day	33.9	132.5
Volume at 1.5% Dry Solids - MGD	0.53	2.08
Sludge Conditioning Chemical Requirements		
Gypsum (CaSO ₄ .2H ₂ O) - tons/day	7.7	45.0
Number	10	20
Dimensions (Diam. x L) - feet	12x12	12x24
Hydraulic Loading - gal/ft ² /hr.	4.9	4.8
Solids Loading - lbs/ft ² /hr.	0.62	0.61
Sludge Cake		
Weight at 25% Dry Solids - tons/day	136	530
Volume at 25% Dry Solids - yd ³ /day	158	616

EXHIBIT B

COMMONWEALTH OF PENNSYLVANIA
Department of Health

Control And Treatment Of Mine Drainage In The Wyoming Basin

Preliminary Construction And Project Cost Estimates -
Alternate 2 - Stabilized Conditions

	<u>Delaware Plant</u>	<u>South Wilkes-Barre - Buttonwood Plant</u>
Construction Costs		
Conveyance Sewers and Appurtenant Facilities	\$ 60,000	\$ 510,000
AMD Treatment and Sludge Dewatering Facilities		
Control-filter building	990,000	3,120,000
Oxidation-flocculation tanks	104,000	112,000
Clarifier-thickener tanks	445,000	1,540,000
Interunit and effluent piping	28,000	45,000
Site preparation	25,000	250,000
Piling	---	400,000
Stream channel lining	---	15,000
Vehicles for hauling sludge cake	40,000	80,000
Fence and access road	23,000	68,000
Rail spur	300,000	30,000
Contingencies and miscellaneous	495,000	1,700,000
Subtotal	\$2,450,000	\$ 7,360,000
Total	\$2,510,000	\$ 7,870,000
Project Costs		
Conveyance Sewers and Appurtenant Facilities	\$ 80,000	\$ 665,000
AMD Treatment and Sludge Dewatering Facilities	3,180,000	9,555,000
Total	\$3,260,000	\$10,220,000

EXHIBIT C

COMMONWEALTH OF PENNSYLVANIA
Department of Health

Control And Treatment Of Mine Drainage In The Wyoming Basin

Preliminary Annual Cost Estimates –
Alternate 2 - Stabilized Conditions

	Delaware <u>Plant</u>	South Wilkes-Barre - <u>Buttonwood Plant</u>
Fixed Costs Attributable To Project Costs (1)	\$212,000	\$ 665,000
Operating Costs (2)		
Supervision and labor (3)	340,000	495,000
Power	90,000	225,000
Chemicals (lime and gypsum)	125,000	900,000
Maintenance and repair	55,000	160,000
Hauling sludge cake; includes preparing and closing strip mines	80,000	275,000
Contingencies and miscellaneous	70,000	205,000
Subtotal	\$760,000	\$2,260,000
Total	\$972,000	\$2,925,000
Unit Costs (4)		
Dollars/1,000 gal.	0.116	0.237
Dollars/ton of acid removed	278	108
Dollars/ton of iron removed	380	212

- (1) 30 year amortization period; 5% interest
- (2) Includes conveyance facilities
- (3) Includes sludge hauling
- (4) On basis of fixed and operating costs

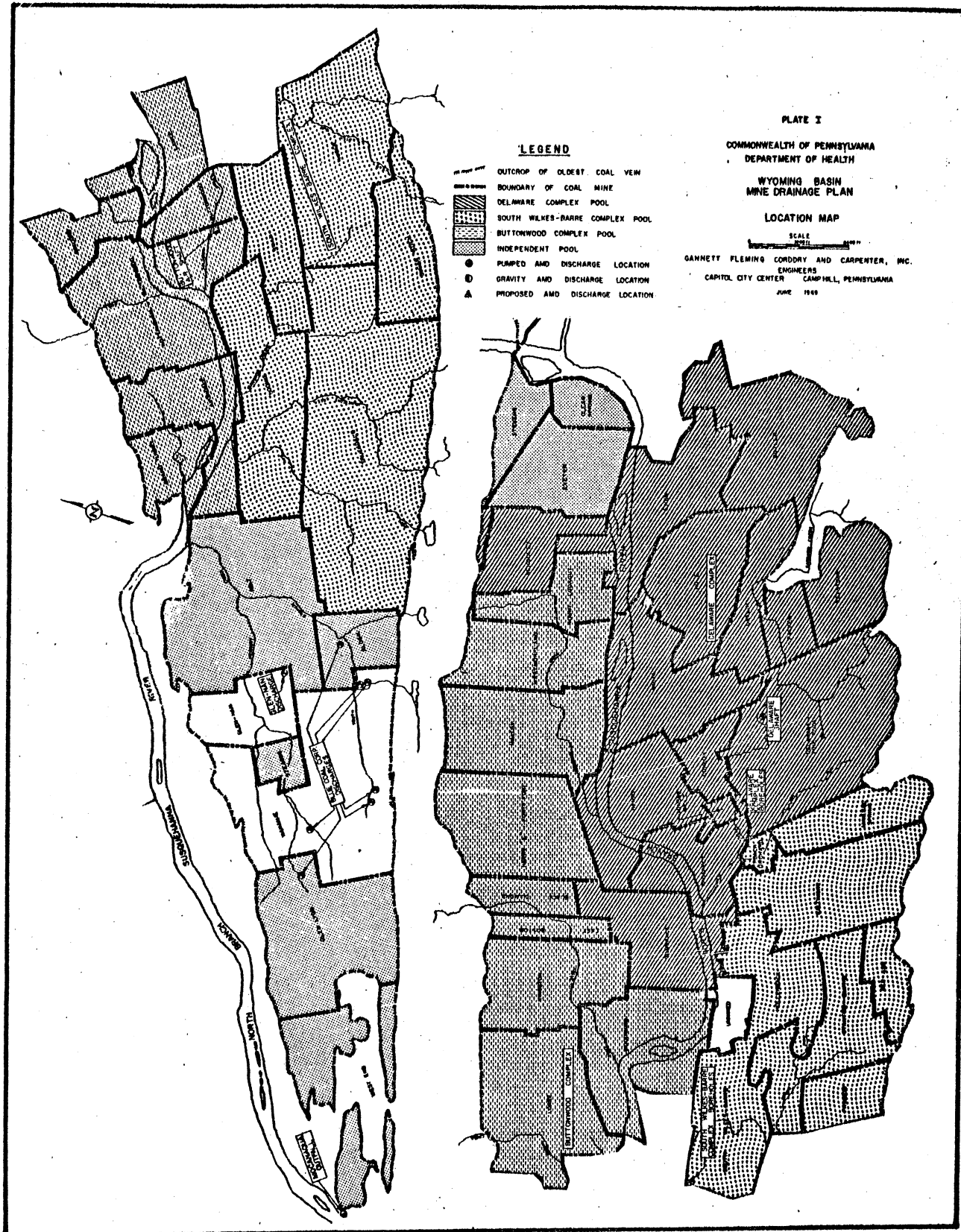


PLATE I

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF HEALTH

WYOMING BASIN
MINE DRAINAGE PLAN

LOCATION MAP

SCALE
1" = 1 MILE

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
ENGINEERS
CAPITOL CITY CENTER CAMP HILL, PENNSYLVANIA
JUNE 1959

LEGEND

- OUTCROP OF OLDEST COAL VEIN
- BOUNDARY OF COAL MINE
- DELAWARE COMPLEX POOL
- SOUTH WILKES-BARRE COMPLEX POOL
- SUTTONWOOD COMPLEX POOL
- INDEPENDENT POOL
- PUMPED AND DISCHARGE LOCATION
- GRAVITY AND DISCHARGE LOCATION
- PROPOSED AND DISCHARGE LOCATION

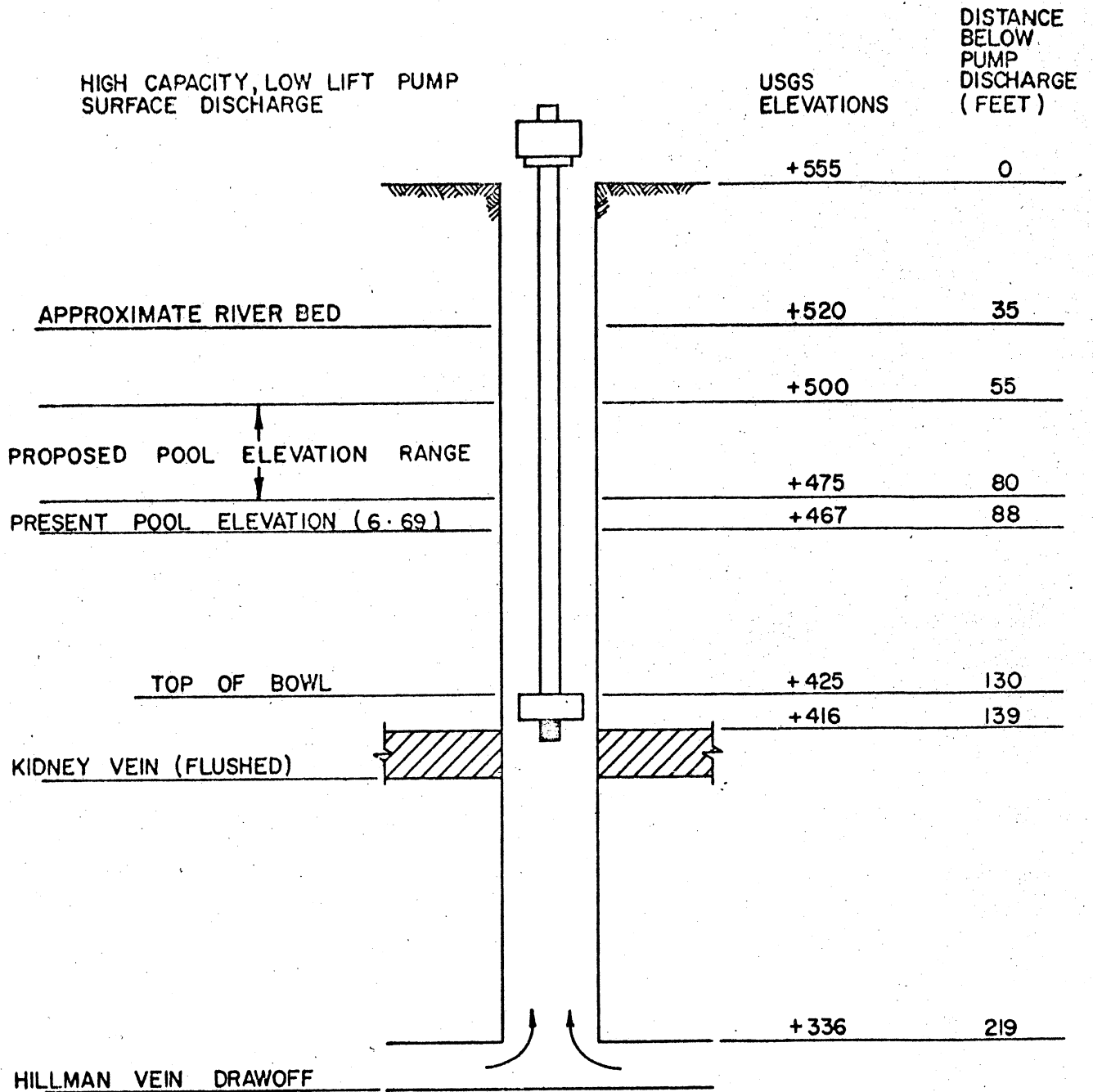


PLATE II-A

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF HEALTH

WYOMING BASIN MINE DRAINAGE PLAN

TYPICAL COLUMNAR SECTION
DELAWARE POOL

GANNETT FLEMING CORDDRY & CARPENTER, INC.
JUNE 1969

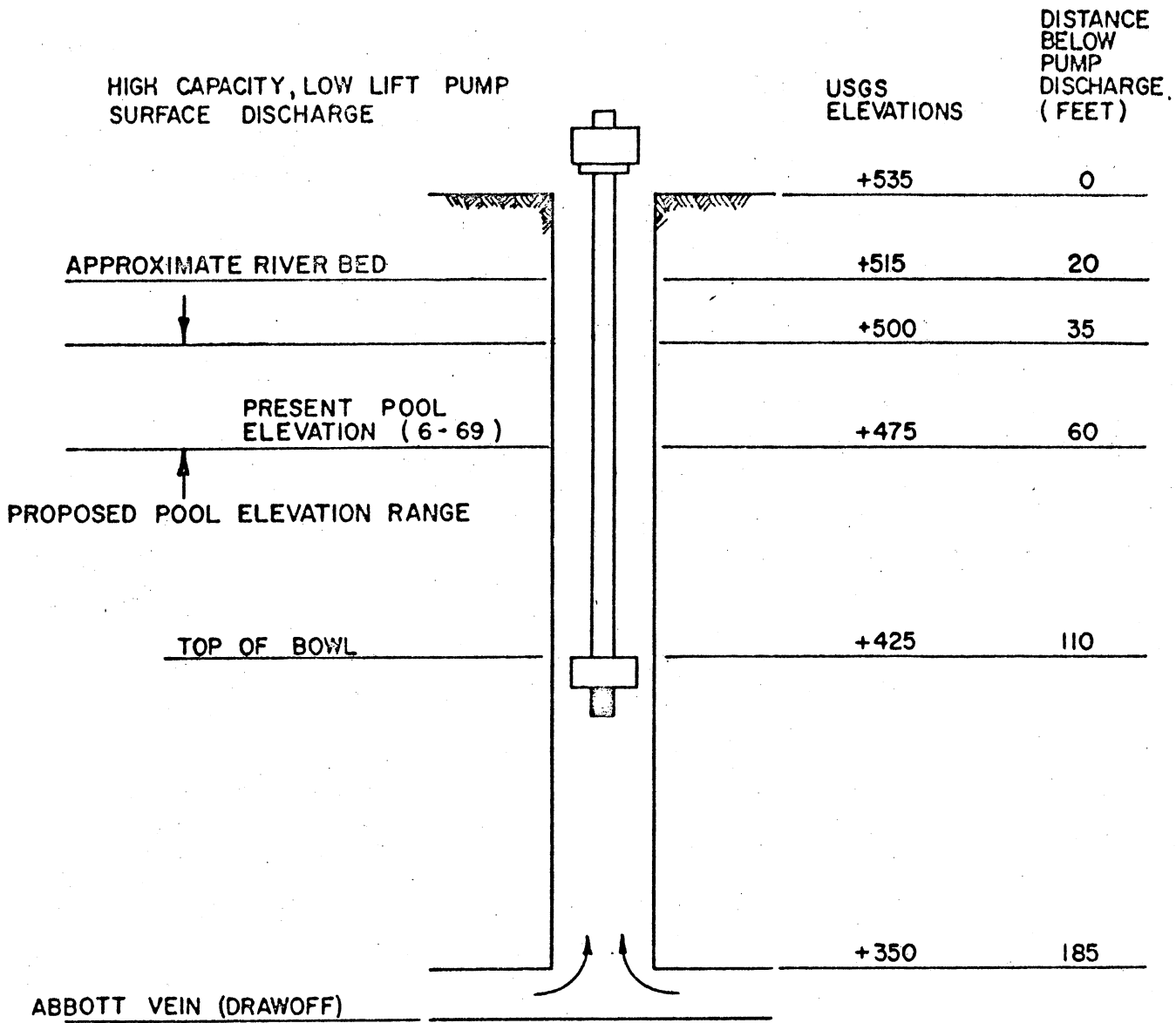


PLATE II-B
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF HEALTH
WYOMING BASIN MINE DRAINAGE PLAN

TYPICAL COLUMNAR SECTION
SOUTH WILKES-BARRE POOL

GANNETT FLEMING CORDRY & CARPENTER, INC.
 JUNE 1939

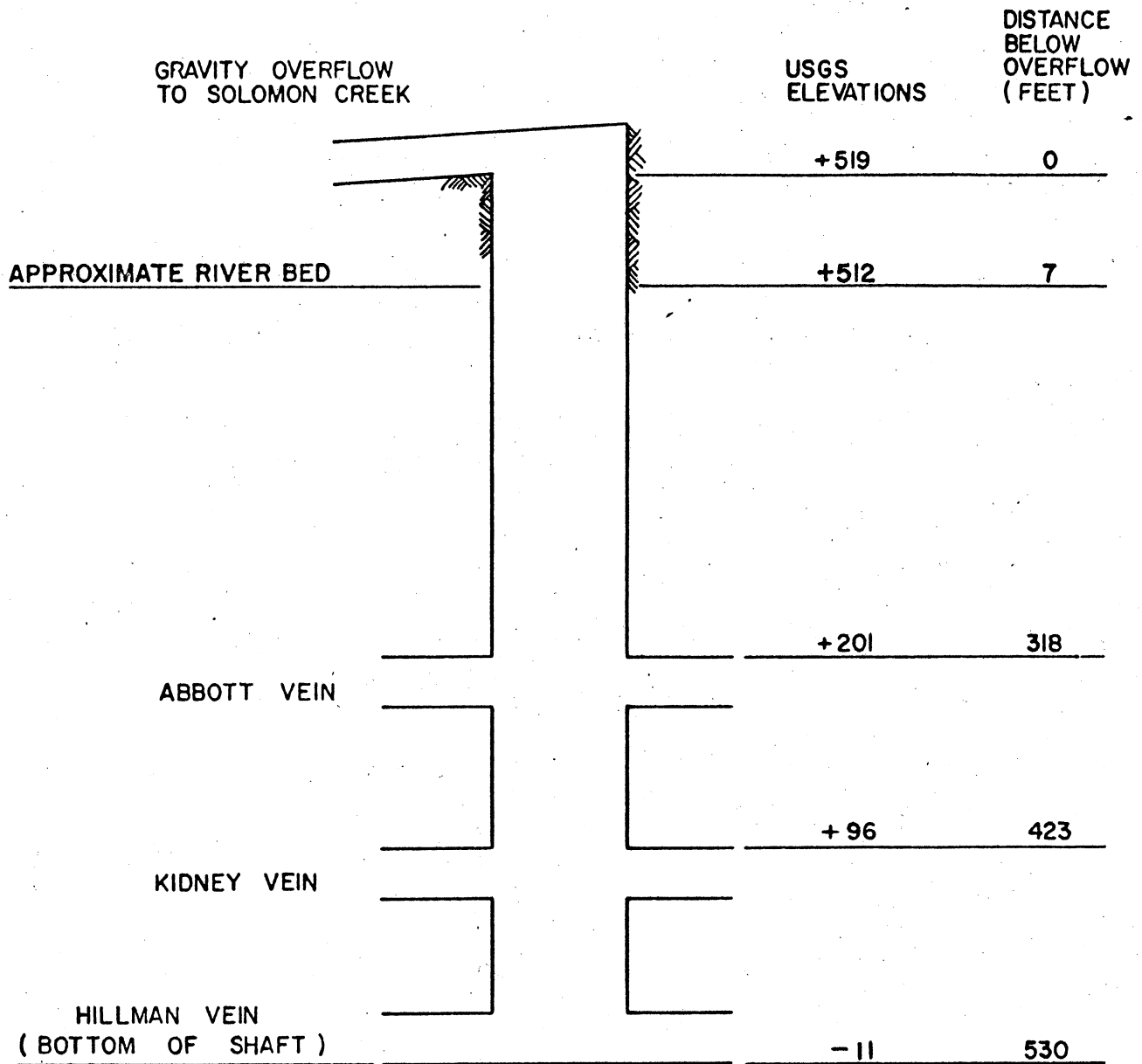


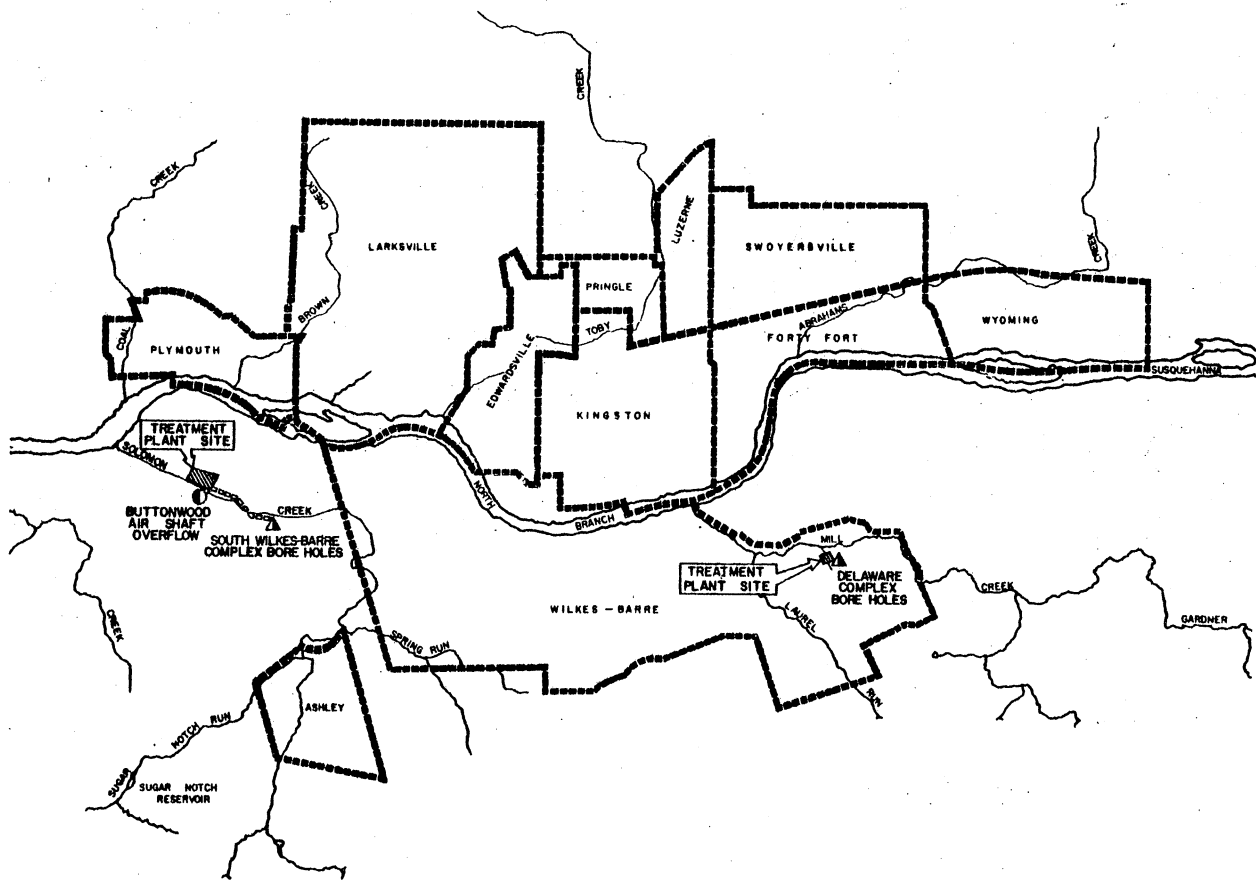
PLATE II-C
 COMMONWEALTH OF PENNSYLVANIA
 DEPARTMENT OF HEALTH

WYOMING BASIN MINE DRAINAGE PLAN

COLUMNAR SECTION
 BUTTONWOOD AIR SHAFT

GANNETT FLEMING CORDDRY & CARPENTER, INC.
 JUNE 1969

PLATE III
 COMMONWEALTH OF PENNSYLVANIA
 DEPARTMENT OF HEALTH
 WYOMING BASIN
 MINE DRAINAGE PLAN
 RECOMMENDED COLLECTION AND
 TREATMENT SYSTEM



SCALE
 4000 FT. 8000 FT.

GANNETT FLEMING CORDRY AND CARPENTER, INC.
 ENGINEERS
 CAPITOL CITY CENTER CAMP HILL, PENNSYLVANIA
 JUNE 1969

LEGEND

- CONVEYANCE SEWER
- MUNICIPAL BOUNDARY
- GRAVITY AND DISCHARGE LOCATION
- △ PROPOSED AND DISCHARGE LOCATION