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Environmental Protection Technology Series

TIOGA RIVER MINE DRAINAGE ABATEMENT PROJECT

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

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TIOGA RIVER MINE DRAINAGE ABATEMENT PROJECT

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the pollution to our environment and to our aesthetic and physical well-being requires corrective approaches that recognize the complex environmental impact these operations have.

The Industrial Environmental Research Laboratory - Cincinnati uses a multidisciplinary approach to develop and demonstrate technologies that will rectify the pollutional aspects of these operations. The Laboratory assesses the environmental and socio-economic impact of industrial and energy-related activities and identifies, evaluates and demonstrates control alternatives.

This report is an in-depth watershed study aimed at the reduction of pollution from abandoned coal mines. The area selected, in Tioga County, Pennsylvania, has been extensively strip and deep mined and is a producer of large quantities of acid drainage. The studies reported herein will guide the future demonstration work which is to reclaim the abandoned mine workings. This feasibility report is in conjunction with other related eastern coal mine reclamation demonstrations.

Reductions of more than 8,000 pounds per day of acidity can be realized through implementation of the plan described herein. This feasibility, and the demonstration it describes, will be of use to federal planners, state and local regulatory agencies, and the mining industry itself. Studies such as this point out the tremendous pollution abatement potential of good reclamation practices.

David G. Stephan, Director
Industrial Environmental Research Laboratory
Cincinnati

ABSTRACT

The Tioga River Demonstration Project in southeastern Tioga County, Pennsylvania, is essentially defined by an isolated pocket of coal that has been extensively deep and strip mined within the Pennsylvania Bituminous Coal Field. The Tioga River watershed is subjected to acid mine drainage from abandoned mines in the vicinity of the Borough of Blossburg and the Village of Morris Run. This mine drainage is discharged into Morris Run, and Coal and Bear Creeks before they enter the Tioga River. Water in these three streams generally has a pH of about 3.0 with a net acidity ranging from 200 to 1,000 milligrams per liter.

The proposed demonstration project is recommended: (1) to demonstrate effective techniques for mine drainage abatement, (2) to reduce a specific mine drainage problem, and (3) to restore portions of a mined area to their approximate original surface grade. Techniques to be demonstrated include: restoration of strip pits utilizing agricultural limestone and sewage sludge as soil conditioners, burial of acid-forming materials within strip mines that are to be restored, and reconstruction and lining of a stream channel.

Implementation of this project will result in an estimated reduction of 8,480 pounds per day of acid under average groundwater conditions. In addition, significant reductions in high flows and loadings will be accomplished from mine drainage discharges during and immediately following precipitation. An estimated reduction of 63,200 pounds of acid will result by preventing the runoff from a one-inch, twenty-four-hour rainfall from entering the deep mines. Since the study area is virtually the sole source of acid mine drainage in the watershed, these reductions should cause an improvement in river water quality. The effectiveness of these preventive measures and their costs will be determined.

This report was submitted in partial fulfillment of the requirements for Project No. 14010 HIN under the sponsorship of the Office of Research and Monitoring, U. S. Environmental Protection Agency, and the Department of Environmental Resources, Commonwealth of Pennsylvania, Harrisburg, Pennsylvania, 17120, by Gannett Fleming Corddry and Carpenter, Inc., Harrisburg, Pennsylvania, 17105.

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Mr. Robert M. Jones and Mr. Raymond F. Brague of Jones and Brague Coal Company, Blossburg, Pennsylvania, rendered valuable assistance in supplying information concerning various aspects of the study area.

Dr. Richard W. Condon, Chairman of the Department of History, Mansfield State College, Mansfield, Pennsylvania, provided material aid in loaning study area deep mine maps.

SECTION I

CONCLUSIONS

1. This study has established that it is feasible to reduce acid mine drainage discharges by restoring two strip mines and reconstructing a stream channel.

2. By accomplishing this demonstration project, an estimated daily flow reduction of 1.23 million gallons, 8,480 pounds of acid, and 550 pounds of iron will be achieved under average groundwater conditions at four mine drainage discharges comprising the bulk of the study area pollutional loadings.

3. The proposed monitoring program will characterize acid mine drainage discharge flow and quality. Results of this monitoring program will establish the effectiveness of the demonstration project and will determine which remaining pollutional loadings must be abated to achieve desired stream quality.

4. Accurate cost records developed from this demonstration project will be used as a guide for similar future abatement projects.

5. Proper enforcement of existing legislation and the easements obtained for this demonstration project will protect the integrity of the project sites after construction has been completed.

SECTION II

RECOMMENDATIONS

1. Pennsylvania has both active and abandoned mined areas contributing to water pollution. This proposed demonstration project is recommended to:

    a. Demonstrate effective techniques for mine drainage abatement.

    b. Reduce a specific mine drainage problem.

    c. Restore portions of a mined area to their approximate original surface grade.

2. Site I - Restore a strip mine, reconstruct a stream channel, and demonstrate effectiveness of agricultural limestone in establishing vegetation. This work will affect an estimated 19 acres and will be accomplished as follows:

    a. Restore a 14-acre strip mine using its spoil piles for partial fill requirements; then place a one-foot cover of select fill, which will be obtained within the site limits, to establish the final grade.

    b. Reconstruct and line 1,174 feet of stream channel across the restored strip mine to prevent infiltration of water into the underlying mine workings. Work related to this stream channel reconstruction will add approximately five acres to the total affected area.

    c. Place riprap in the reconstructed stream channel to prevent channel erosion.

    d. Analyze the final grade soil cover and place the optimum amounts of agricultural limestone, fertilizer, and grass seed on the site.

3. Site II - Restore a 60-acre strip mine and demonstrate effectiveness of sewage sludge in establishing vegetation. An estimated 65 acres in all will be affected.

    a. Restore a 60-acre Lower Kittanning coal strip mine using spoil piles for fill.

b. After the site has been restored to its final grade, place three inches of sewage sludge on a 4.3-acre test plot and scarify the sewage sludge into the top cover.

c. After the site has been restored and prior to sludge placement, construct holding or infiltration ditches immediately downhill from the test plot. Minor regrading of the adjacent ground surface and construction of infiltration ditches will add approximately five acres to the area affected.

d. Analyze the final grade soil cover and place the optimum amounts of agricultural limestone, fertilizer, and grass seed on the site. Place the appropriate amount of grass seed on the test plot after the sewage sludge has been applied and scarified into the final grade soil cover.

4. Construct and operate continuous flow monitoring stations and periodically collect grab samples to accurately determine the effectiveness of the demonstration project. Six stations are recommended:

   a. MS-1 and MS-2 to be located immediately upstream and downstream from Site I to determine whether surface water and groundwater (stream flow) is prevented from infiltrating into the underlying mine workings.

   b. MS-3 to be located at mine drainage discharge point 5 to determine the acid mine drainage flow reduction accomplished by restoring Site I.

   c. MS-4, MS-5, and MS-6 to be located at mine drainage discharge points 10, 14, and 15, respectively, to determine the acid mine drainage flow reductions accomplished by restoring Site II.

5. It is recommended that grab samples be collected once every two months at MS-1 and MS-2 and twice a month at MS-3, MS-4, MS-5, and MS-6 and that these samples be analyzed for pH, alkalinity or acidity, total iron, and sulfates. Additional analyses are recommended for heavy metals and biological parameters on a less frequent basis.

6. It is recommended that a continuous recording rain gauge be placed in the study area to supplement the stream and mine drainage flow data.

7. It is recommended that complete cost records be compiled so that actual abatement costs can be determined.

8. It is recommended that complete precipitation, as well as stream and discharge flow records, be compiled so that the actual effectiveness of the work can be measured.

9. It is recommended that measures be taken to prevent flooding, sedimentation, and further stream pollution during and immediately following construction.

10. It is recommended that the restored project sites remain undisturbed during evaluation of project effectiveness.

SECTION III

INTRODUCTION

Scope Of The Project

This report presents a determination of the feasibility of a mine drainage abatement demonstration project for a mined area in the vicinity of Morris Run Village in Tioga County, Pennsylvania. This mined area is further described in a 1968 report prepared by Gannett Fleming Corddry and Carpenter, Inc., entitled "Acid Mine Drainage Abatement Measures for Selected Areas Within the Susquehanna River Basin," referred to herein as the FWPCA Report.[1]

The specific project scope is as follows:

1. Review the history of mining, mine drainage problems, and potentially effective mine drainage abatement measures in the study area.

2. Determine the jurisdictional framework (legal authority) through which the demonstration project may be carried out.

3. Inventory geology, topography, hydrology, water quality, social and economic factors, and environmental features that would influence the value of a demonstration project in the study area.

4. Develop preliminary engineering features of a possible abatement program in sufficient detail to enable evaluation of the proposed project's feasibility.

5. Estimate the proposed project's effectiveness and stream quality improvement resulting from construction of the proposed project.

6. Determine possible benefits resulting from construction of the proposed project.

7. Develop a proposed schedule and budget to assure adequate administrative control of the proposed project.

8. Recommend a surveillance program for the project area to enable assessment of actual versus estimated effectiveness.

In May 1971, an application was submitted by the Department of Environmental Resources to the Environmental Protection Agency requesting a demonstration grant in the amount of $450,000 to construct preventive measures comprising part of the recommended abatement plan described in the FWPCA Report. This approved grant, together with $226,500 from the Department, made $676,500 available for the project. The Department then entered into a service contract with Gannett Fleming Corddry and Carpenter, Inc., effective November 30, 1972, providing that Gannett Fleming Corddry and Carpenter, Inc., would perform engineering work and services related to the project.

The Morris Run Study Area (Figure 1) comprises a portion of the Pennsylvania Bituminous Coal Field in the upper reaches of the Tioga River. Although coal has been mined in other limited areas within this watershed, the thirteen and one-half square mile study area is virtually the sole source of acid mine drainage in the watershed. It is anticipated that construction of this proposed project and an evaluation of its effectiveness will be accomplished in four years. The proposed construction at the two sites shown on Figure 2 will prevent considerable volumes of surface water from entering deep mine workings via interconnected strip mines in the Lower Kittanning seam and contributing to deep mine discharges. Because of the extensive deep mining that has been conducted under shallow cover throughout a major portion of the study area and the general inclination of the coal beds, deep mine sealing in the study area is deemed impractical.

Purpose Of The Project

The primary objective of this proposed project is to demonstrate the effectiveness of various preventive measures in eliminating or reducing acid mine drainage discharges. In order to demonstrate the effectiveness of the project, it will be necessary to (1) monitor acid mine drainage sources before, during, and after construction, and (2) maintain complete cost records relative to construction and maintenance of the preventive measures implemented.

Following reduction of acid mine drainage in the watershed by this demonstration project, water quality records can be used to determine the additional abatement needed to attain desired stream quality.

General Description Of The Project

To achieve the objectives of this project, the following abatement measures are recommended (see Figure 2):

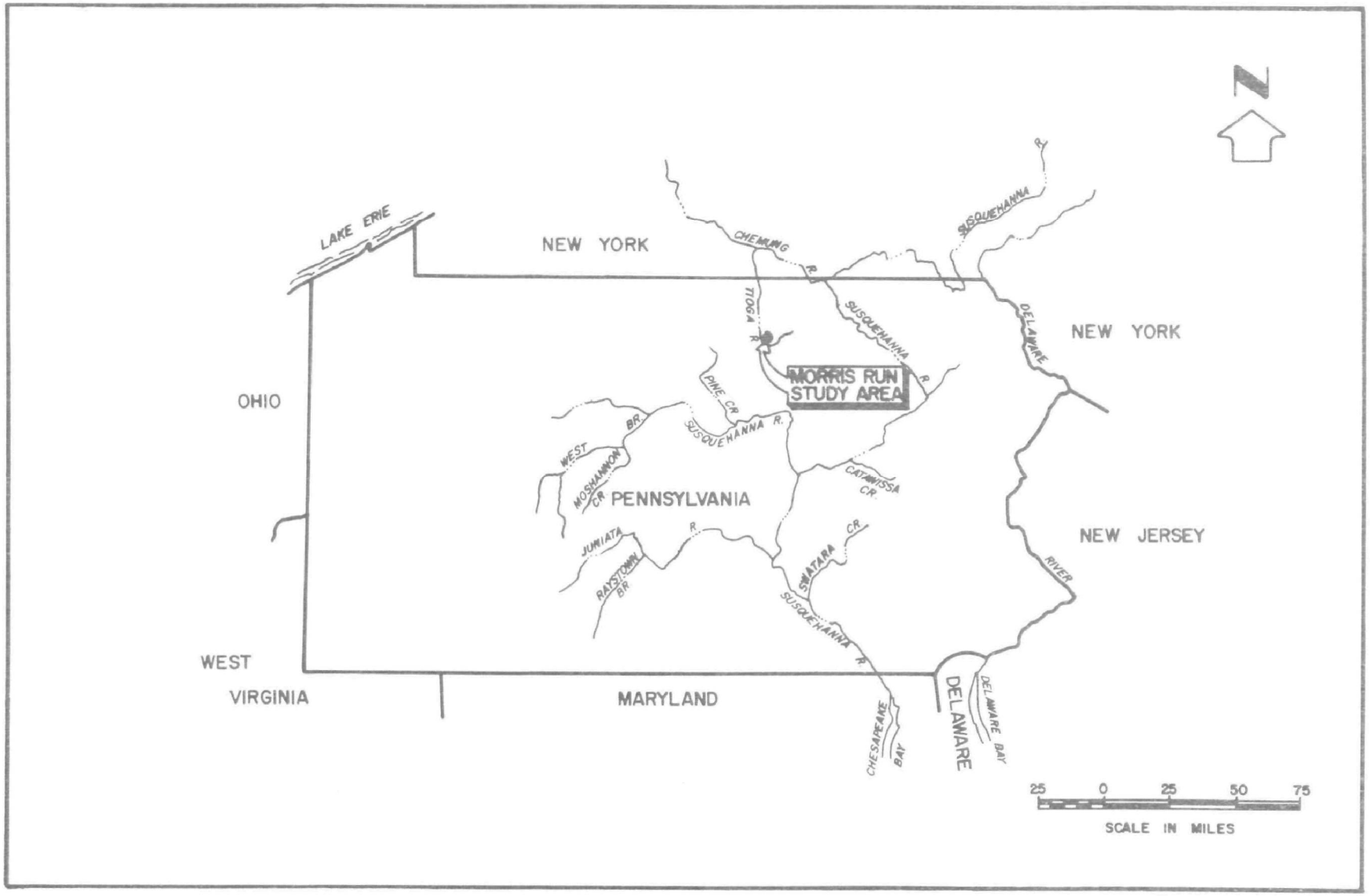


FIGURE I – LOCATION OF MORRIS RUN STUDY AREA

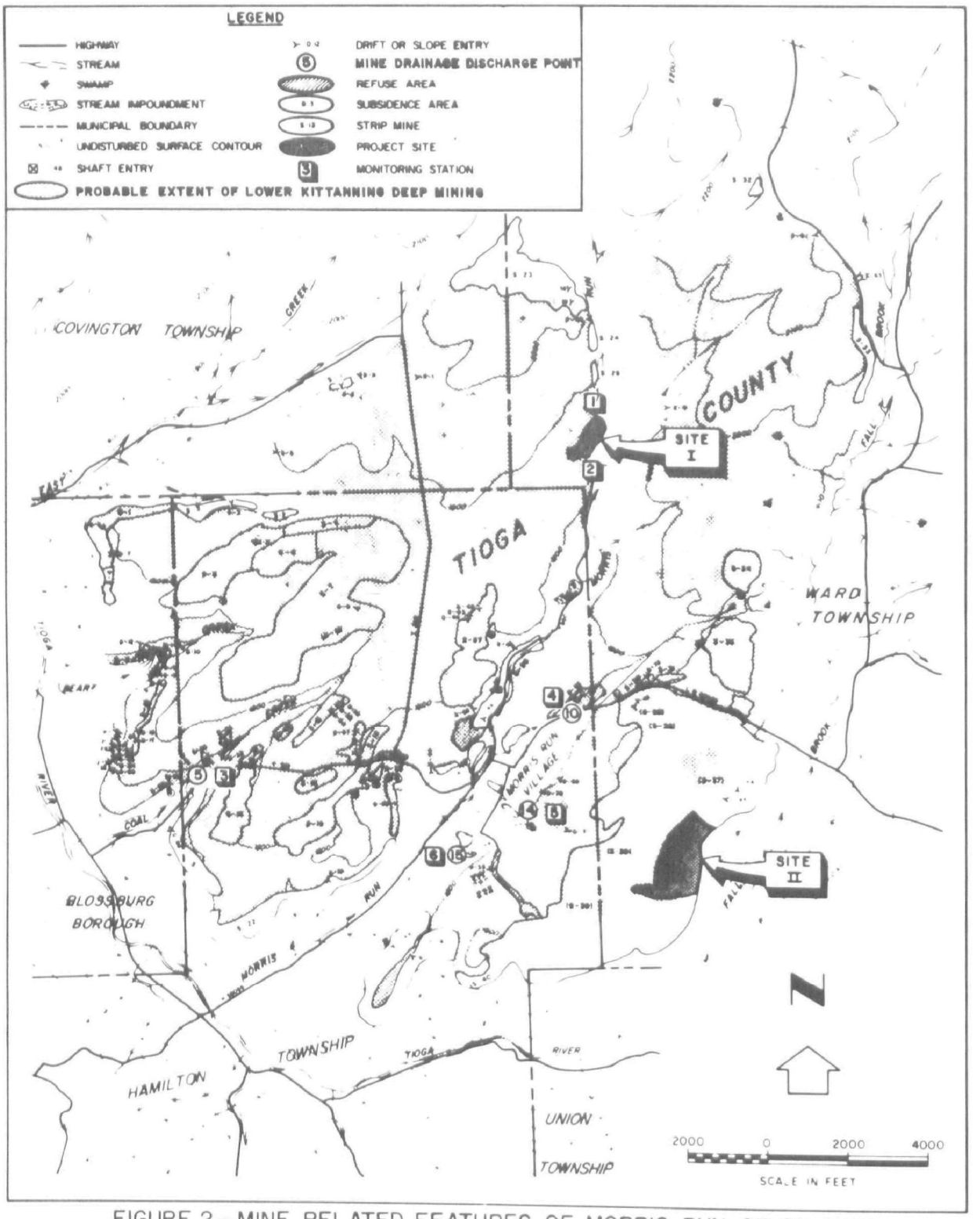


FIGURE 2 – MINE RELATED FEATURES OF MORRIS RUN STUDY AREA

Site I. Reconstruct and line approximately 1,174 feet of stream channel and restore strip mine S-26, consisting of approximately 14 acres and 168,000 cubic yards of fill, and place agricultural limestone, fertilizer, and grass seed on the restored site.

These actions would (1) prevent a stream from flowing directly into underlying deep mine workings, (2) cause a reduction in flow and a comparable reduction in pollution from mine drainage discharge point 5, and (3) allow the stream to resume its former watercourse as part of the headwaters of Morris Run.

Site II. Restore portions of improperly restored strip mines S-37 and S-39, consisting of approximately 60 acres and 422,000 cubic yards of fill. Establish a 4.3-acre test plot on the restored site and place sewage sludge and seed on the test plot to demonstrate effectiveness in establishing and maintaining vegetative growth. Place agricultural limestone, fertilizer, and grass seed on the remainder of the restored site.

Deep mine maps for the Lower Kittanning seam have been secured for the general area encompassing Site II as well as mine drainage discharge points 10, 14, and 15. These maps confirm that the three mines involved, which are drained by these three discharges, have been interconnected so extensively that the entire mined area can be considered as having one mine drainage pattern. Very little specific coal pavement elevation information was available for two of these three mines. Therefore, it was not possible to delineate where the water presently entering the mines via Site II actually emerges at specific discharge points. For purposes of this report, it was assumed that 90 percent of the water infiltrating via Site II flows to mine drainage discharge point 14 and 10 percent flows to mine drainage discharge point 10. Because of the lack of this specific information, mine drainage discharge point 15 will also be monitored.

Effectiveness Of The Project

Implementation of this demonstration project will reduce acid mine drainage at two or more discharge points. Effectiveness of the demonstration project will be determined by a gauging, sampling, and analytical program to be carried out during the life of the project. Monitoring of acid mine drainage discharges before, during, and after construction will demonstrate effectiveness of the preventive measure techniques. Compilation of accurate construction cost records will enable estimation of abatement costs on similar areas in the future.

SECTION IV

JURISDICTIONAL FRAMEWORK

Cognizant Authority

The Pennsylvania Department of Environmental Resources is the cognizant authority for this project and is authorized under Act 275 to engage in the abatement of mine drainage pollution from abandoned mines.

Act 275 enabled the Department to abate mine drainage by implementing the following laws:

1. Act 394 of June 22, 1937 (P. L. 1987) known as "The Clean Streams Law."

2. Act 443 of January 19, 1968 (P. L. 996), known as "The Land and Water Conservation and Reclamation Act."

This demonstration project will be accomplished under these enabling laws. The Deputy Secretary for Resources Management will be responsible for contracting, administering, and operating the proposed demonstration project. Personnel from bureaus within his jurisdiction will review construction plans and specifications, provide resident inspection of construction, obtain necessary property releases, and administer the project.

This administrative structure should enable accomplishment of the purposes of the project. The Department is involved in attacking all environmental problems including control of acid mine drainage from active mines and abatement of acid mine drainage from abandoned mines.

Existing And Proposed Standards

Stream quality criteria have been established by the Department for the Tioga River from its source to the point where it receives Crooked Creek, 19 miles downstream from the study area. These criteria (listed in Title 25, Rules and Regulations, Chapter 93) are:

pH
: Not less than 6.0, not to exceed 8.5.

Dissolved Oxygen
: Minimum daily average 6.0 mg/l; no value less than 5.0 mg/l.

Iron

Total iron value not to exceed 1.5 mg/l.

Temperature

Not to be increased by more than five degrees Fahrenheit above natural temperatures, nor to be increased above 58 degrees Fahrenheit.

Dissolved Solids

Not to exceed 500 mg/l as a monthly average value, not to exceed 750 mg/l at any time.

Bacteria

For the period May 15 to September 15 of any year, not to exceed 1,000 coliforms/100 ml as an arithmetic average, not to exceed 1,000 coliforms/100 ml in more than two consecutive samples, not to exceed 2,400 coliforms/100 ml in more than one sample. For the period September 16 to May 14 of any year, not to exceed 5,000 coliforms/100 ml as a monthly average value, nor to exceed this number in more than 20 percent of the samples collected during any month, nor to exceed 20,000 coliforms/100 ml in more than five percent of the samples.

Of these criteria, pH, iron, dissolved solids, and coliform bacteria are relevant to the project. At present, the Tioga River does not meet the pH, iron, and dissolved solids criteria downstream from the study area due to acid mine drainage. If these criteria can be met, public use of Tioga River waters will be increased.

These uses include a potential source of potable water and improved aquatic life habitat. Also, the Corps of Engineers has stated that some reduction could be made in the construction cost of the proposed Tioga-Hammond Reservoir if the acid load in the river were reduced sufficiently to maintain an alkaline pool in the reservoir.

This project will reduce the study area pollution load by reducing flows from individual mine drainage discharges. Discharge quality is expected to remain relatively unchanged. The reductions in flows will be accomplished as described in <u>Section III</u>, <u>General Description Of The Project</u>.

Site Acquisition

The Clean Streams Law, Act No. 117 of 1965, and the Coal Mine Sealing Act No. 490 of 1947 are sufficient authority by which easements or other access to the project sites may be obtained. All of the required easements have been obtained by the Department's Land Easement Branch. These easements cover the proposed monitoring station sites and the two proposed project sites. All the site acquisitions extend for the life of the project, including post-demonstration studies.

Authority For Funding

Authority for funding this proposed project is given to the Department through Section 16 of The Land and Water Conservation and Reclamation Act. Under Section 19 of this act, the Department is authorized to utilize any available federal program to augment funds made available by the act.

Such funding is available under Section 14 of the Federal Water Pollution Control Act, with the stipulations that federal funding not exceed 75 percentum of the actual project cost and that the project sites be protected against future mine drainage pollution.

These state and federal funds will be utilized to demonstrate methods for the abatement of acid mine drainage. During the life of this project, sufficient funds are available to maintain project effectiveness. Following project completion, the Department will continue to maintain the restored areas.

Water And Mineral Rights

Based on information obtained from local sources, surface and mineral rights for the two project sites are owned by the following:

Site I

Surface and mineral rights for this area are owned by:

Morris Run Coal Mining Company
Morris Run, Pennsylvania 16939

Site II

Surface owners of this area are:

Mr. Robert Jones
c/o J & B Coal Company
Blossburg, Pennsylvania 16912

J & B Coal Company
Blossburg, Pennsylvania 16912

Mrs. Mary Jankiewicz
R. D.
Morris Run, Pennsylvania 16939

Stephen and Martha Soporowski
Morris Run, Pennsylvania 16939

Mineral rights for Site II are owned by J & B Coal Company. One coal seam, the Brookville, still remains in place within Site II. It has not been removed since it is thin and of poor quality. By itself, this coal is probably not saleable.

The Department of Environmental Resources has secured easements for the two project sites from all of the respective surface and mineral rights owners. These easements allow ingress, egress, and regress by the Department or its assignees to perform the necessary restoration work. The easements also provide that the surface and mineral rights owners will not "voluntarily do any act or permit any act to be done that will destroy or materially hurt or change the facilities placed thereon for the purpose of the project."

Prevention Of Future Pollution

Legal protection of the project sites from future mine drainage pollution will be accomplished through Act 418 of 1971, "Surface Mining Conservation and Reclamation Act," and Act 394 of 1937, known as "The Clean Streams Act." Act 418 requires that coal mining permits be obtained from the Department of Environmental Resources. As part of an application for one of these permits, a detailed reclamation plan must be filed. The authority already exists for practical and legal protection of the project watershed. Surveillance and enforcement will be carried out by the staff of the Deputy Secretary for Environmental Protection and Regulation.

SECTION V

INVENTORY AND FORECAST

PHYSICAL CONDITIONS

General Description - The project watershed is a wooded area covering approximately thirteen and one-half square miles of a portion of the Pennsylvania Bituminous Coal Field in southeastern Tioga County (Figure 1). The study area is a Pennsylvanian age outlier within the Pennsylvania Bituminous Field. In years prior to World War II, the area was extensively deep mined. There is currently no active deep mining in the study area, nor is its resumption anticipated within the foreseeable future. Major strip mining commenced at the close of World War II. Extensive strip mining operations extracted an estimated 608,000 tons of coal during 1970. Based on available information, strip mining will continue for the foreseeable future. Mine drainage has been discharged from the study area since the start of mining.

Streams within the study area receive mine drainage from inactive deep and strip mines. These streams discharge into the Tioga River, which flows northward into the Chemung River in New York State. The Chemung River then flows into the Susquehanna River near Athens, Pennsylvania.

Although some coal exists and has been mined in sections of the Tioga River basin outside the study area, acid mine drainage pollution of the Tioga River is for all practical purposes caused solely by study area mine drainage discharges. Nine coal seams underlie the study area. From older to younger, they are Brookville, Lower Kittanning, Foot, Middle Kittanning, Freak, Upper Kittanning, Monkey, Lower Freeport, and Upper Freeport. The major geologic structure of the project area is a syncline with axis extending in a northeast-southwest direction roughly through the center of the study area (Figure 3a) and plunging toward the southwest (Figure 3b). Coal seams rise gradually to the northwest and southeast from the synclinal axis to outcrop along the hillsides.

Major Subsurface Conditions Causing Acid Mine Drainage - Extensive deep mining was conducted in the Lower Kittanning, Upper Kittanning, and Lower Freeport seams. Less extensive deep mining was conducted in the Brookville, Middle Kittanning, Upper Freeport, Foot, Freak, and Monkey seams.

During deep mining of the study area, numerous entries were driven into the coal seams. Since most deep mining was conducted below then existing ground and perched water tables, various

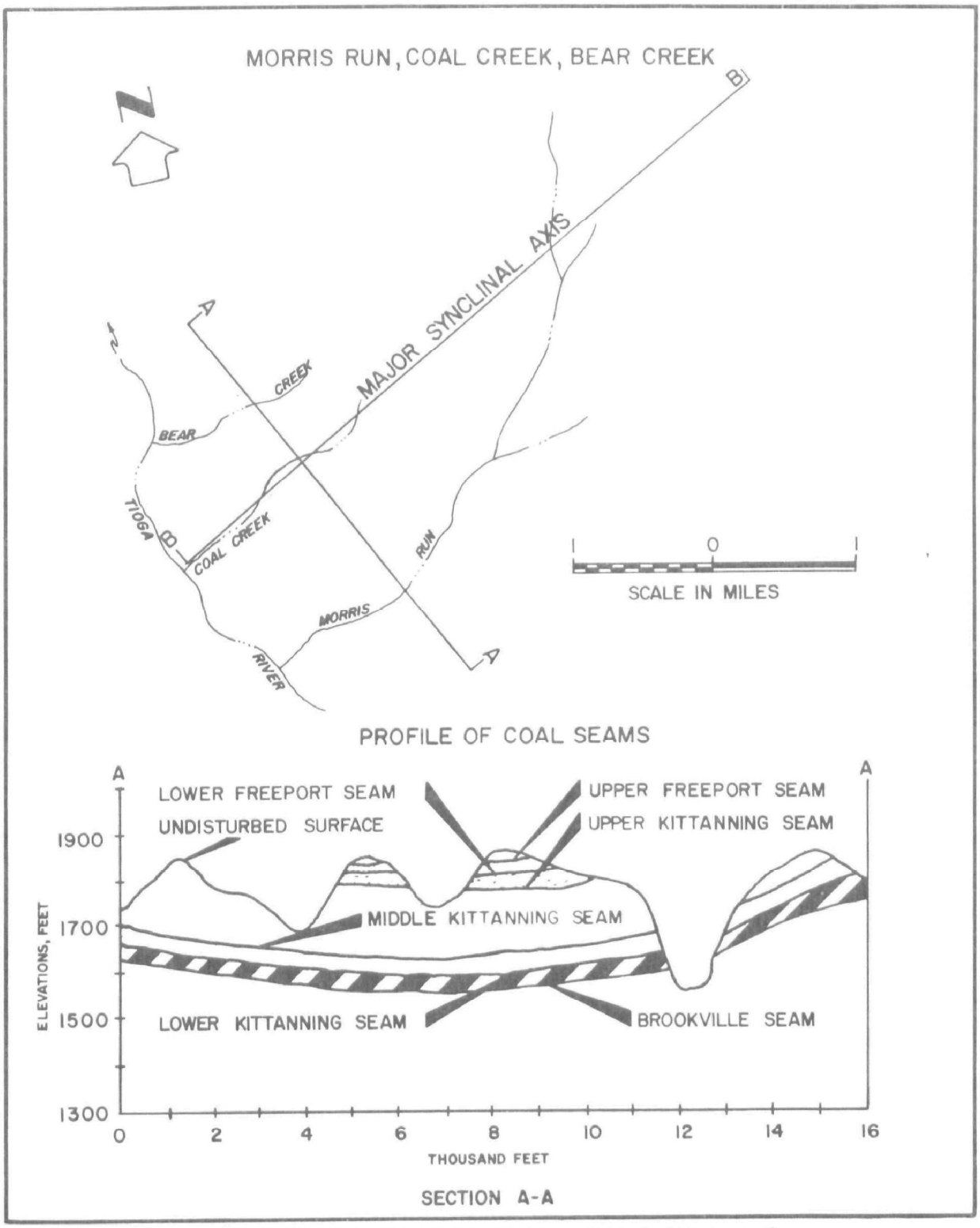


FIGURE 3a - STUDY AREA COAL SEAMS (Pictorial)

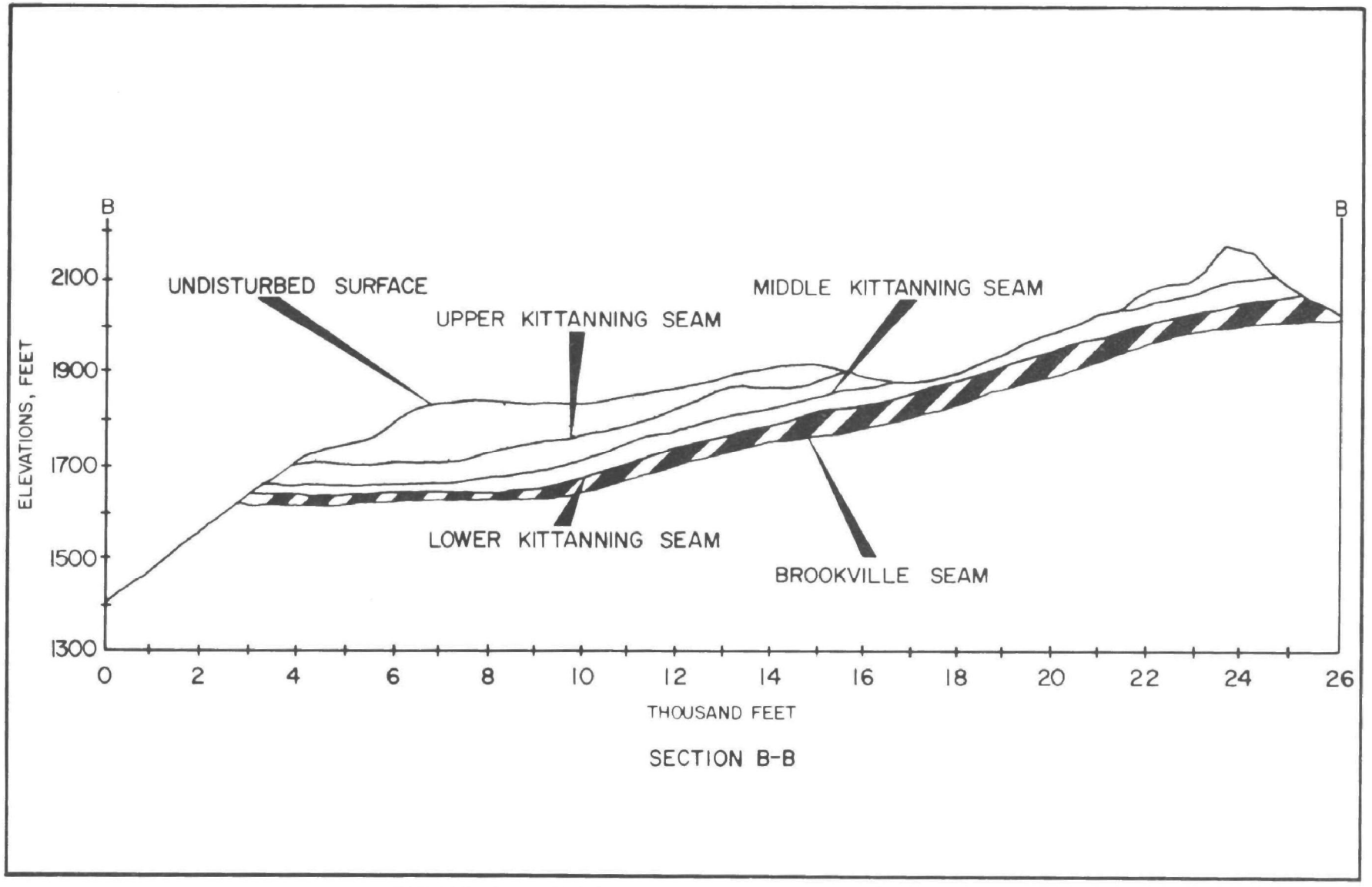


FIGURE 3b – STUDY AREA COAL SEAMS (Pictorial)

drifts were driven to allow gravity discharge of mine drainage from the workings. Gravity discharge could be ideally accomplished using drifts because of the slope and location of coal seams in relation to the ground surface. These drifts were at one of two general locations, namely, at outcrops along the southeast side of the middle and lower reaches of Morris Run as well as in low lying surface areas along the middle reaches of Bear and Coal Creeks. Deep mining was planned and conducted to allow gravity discharge of mine drainage from these drifts. Only minimal steps were taken to provide an effective barrier pillar system since such would have reduced the efficiency of the gravity mine drainage plan initially developed and subsequently used by various operators over the years. In the study area, therefore, surface and ground waters finding their way into deep mine workings may flow for considerable distances over acid-producing materials before eventually being discharged to surface streams as acid mine drainage. Seventy-two major deep mine entries exist in the study area, nine of which are located in the highwalls of strip mines. Acid mine drainage is discharged to surface streams from nine deep mine entries.

All coal seams in the study area are close to the ground surface. The lowest seam subjected to extensive underground mining, the Lower Kittanning, is only 250 feet below ground surface at its maximum depth. This deep mining has caused extensive fissuring of the overburden throughout a significant portion of the study area. In some sections, the overburden has subsided into these underground voids. This fissuring and subsidence significantly reduces surface runoff and increases ground and surface water entry into inactive deep mine workings, thereby increasing the severity of the acid mine drainage problem. Three major areas where the ground surface has subsided into underlying deep mine workings exist in the study area. In addition, four separate stretches of streambed over which surface streams infiltrate in varying degrees to underlying deep mine workings are located in the study area. This condition was created by strip mining and deep mining in and beneath the respective stretches of streambed.

The locations of deep mine entries and other features of the study area are shown on Figure 2.

Major Surface Conditions Causing Acid Mine Drainage - In 1971, strip mining was being performed in the Middle and Upper Kittanning, Freak, and Lower Freeport seams in the study area. Limited strip mining was also being performed in the Upper Freeport seam. It is estimated that 1.3 square miles of the study area was disturbed by inactive strip mines, 1.0 square mile by active strip mines. Inactive and active strip mines had disturbed approximately 17 percent of the study area ground surface.

Thirty-seven strip mines exist in the study area, thirty-four of which are inactive. As a result of past inadequate restoration, most of the strip mines in the study area serve as catch basins that collect, to varying degrees, direct precipitation, surface runoff, and groundwater. This impounded water enters deep mine workings by direct connections or infiltration and eventually discharges as acid mine drainage at one of the drifts or other discharge points. An example of this is Site II where impounded water in a strip mine eventually discharges as acid mine drainage from one or more discharge points (10, 14, or 15).

In addition, an inactive stripping operation located in the northeastern portion of the study area (Site I) provides direct access to underground workings for Morris Run stream flows. Presumably, this underground drainage discharges to Coal Creek at discharge point 5, which is recorded by MS-3.

Surface accumulations of refuse in the study area are another source of acid mine drainage. All of this refuse, in varying degrees, is acid-producing and is the source of acid mine drainage discharges during periods of wet weather.

The extent of study area strip mining, both active and inactive, as well as the locations of refuse areas, are shown on Figure 2.

Adequacy Of Physical Information - One deficiency in study area information is the lack of coal pavement elevations on the available mine maps. As described previously in Section III, General Description of the Project, the fairly extensive deep mines encompassing Site II and mine drainage discharge points 10, 14, and 15 have been interconnected. It is therefore impossible to delineate the exact routes of flow of water through these mines. By monitoring all three of these mine drainage discharge points, it is believed that this deficiency can be overcome.

WATER RESOURCES

Receiving Streams - Considerable watershed surface water quality and flow data are available. These data when combined with the proposed monitoring program data will be adequate for the project. Stream flow and quality data for the Tioga River at stations immediately upstream from the Morris Run confluence (Stream Mile 87) and seven miles farther downstream (Stream Mile 80) are shown on Table 1. Stream flow and quality information are shown for Morris Run, Coal Creek, and Bear Creek on Tables 2, 3, and 4, respectively. These data have been compiled from FWPCA, Pennsylvania Department of Health, and Corps of Engineers' records. Additional flow conditions as determined by the Corps of Engineers' "Investigative Survey"[2] for Morris Run, Coal Creek, and Bear Creek are shown on Table 5. Normal

TABLE 1

1965-1970 WATER QUALITY SAMPLING RESULTS - TIOGA RIVER

Date	Stream Flow cfs	Stream Flow l/sec	Net Alkalinity As. $CaCO_3$ mg/l	pH	Conductivity u-mho cm	Total Iron mg/l	Manganese mg/l	Sulfate mg/l
Tioga River Upstream From Morris Run Confluence (Stream Mile 87)								
7/16/65	4.0	113.3	6.9	7.0	34	-	-	-
8/23/65	3.7	104.8	15.4	6.9	153	-	-	182.0
8/24/65	3.2	90.6	-4.0	6.8	61	-	-	-
8/25/65	3.0	84.9	3.7	7.5	251	-	-	52.9
10/27/65	9.5	269.0	9.6	7.5	200	-	-	44.1
5/4/66	126.0	3,567.8	-1.2	5.7	67	0.2	0	14.7
5/18/66	117.0	3,313.0	-2.5	6.0	40	0.1	0	14.7
6/10/66	9.6	271.8	3.9	7.3	46	0.16	0.02	184.0
6/14/66	5.7	161.4	15.6	7.5	52	0.19	0	118.0
7/19/66	3.5	99.1	3.7	6.8	50	0.04	0.05	-
8/15/68	8.4	237.9	-126.	3.6	59	0.23	0.13	78.0
9/12/68	85.3	2,415.4	11.4	6.0	66	0.30	0.3	63.0
10/22/68	10.1	286.0	45.8	6.5	50	0.13	0.12	23.5
5/27/70	101.0	2,859.9	0.8	7.5	46	0.21	0.33	13.0
6/9/70	26.9	761.7	0.4	6.6	53	0.05	0.18	15.0
6/10/70	22.1	625.8	3.2	6.6	56	0.03	0.14	15.0
6/11/70	19.7	557.8	2.4	6.6	54	0.07	0.18	17.0
Tioga River 7 miles Downstream Of Project Area (Stream Mile 80)								
9/22/65	10.4	294.4	-20.1	3.2	760	-	-	364.
9/29/65	-	-	-14.8	3.6	725	-	-	350.
10/6/65	14.4	407.8	-31.3	3.5	700	-	-	350.
10/13/65	25.6	724.9	-23.7	3.4	580	-	-	302.
10/20/65	15.8	447.4	-31.1	3.5	690	-	-	401.
10/27/65	19.0	538.0	-16.9	3.5	650	-	-	316.
11/3/65	17.0	481.4	-33.4	3.8	680	-	-	308.
5/4/66	214.	6,059.6	-35.2	3.9	240	4.1	1.8	132.
5/18/66	195.	5,521.6	-47.9	3.8	250	3.0	4.0	95.5
6/8/66	18.5	523.8	-69.1	3.4	355	3.2	3.5	176.
6/14/66	30.5	863.6	-85.7	3.2	410	3.0	3.2	220.
7/19/66	11.	311.5	-215.	3.2	750	8.0	9.8	433.

(Sources: FWPCA, Pa. Dept. of Health, U. S. Army Corps of Engineers)

TABLE 2

1965-1970 WATER QUALITY SAMPLING RESULTS - MORRIS RUN NEAR MOUTH

Date	Stream Flow		Net Alkalinity As $CaCO_3$ mg/l	pH	Conductivity m-mho cm	Total Iron mg/l	Manganese mg/l	Sulfates mg/l	Calcium mg/l
5/ 4/66	6.7	189.7	-420.2	2.9	1,200	31.9	22.8	653.6	37.9
5/18/66	7.6	215.2	-403.3	3.0	1,100	12.1	61.8	705.1	40.8
6/14/66	4.5	127.4	-619.6	2.8	1,490	45.6	23.5	-	62.0
7/19/66	1.8	51.0	-703.2	2.9	1,445	64.5	12.9	1,241.0	102.0
1/12/67	1.7	48.1	-941.2	2.9	1,170	96.2	49.5	2,069.8	30.0
1/19/67	1.8	51.0	-959.1	2.9	1,750	101.8	81.0	1,537.5	68.0
1/26/67	4.1	116.1	-511.7	3.2	850	59.8	35.0	772.3	50.5
3/28/67	39.0	1,104.3	-266.6	3.1	850	18.5	17.9	591.4	14.5
4/ 4/67	12.6	356.8	-448.5	3.1	1,400	34.1	23.0	813.1	23.0
4/11/67	13.9	393.6	-393.2	3.3	1,000	30.5	-	691.2	49.0
4/18/67	10.6	300.1	-368.7	3.1	1,350	30.5	23.0	573.0	32.5
4/28/68	8.8	249.2	-911.4	3.2	830	19.8	25.0	494.8	28.0
8/16/68	1.1	31.1	-1,033.0	2.8	2,200	86.3	47.8	1,564.8	30.5
9/12/68	5.6	158.6	-791.3	3.4	2,000	80.0	54.5	3,286.1	30.6
10/21/68	1.5	42.5	-899.2	3.5	2,000	75.0	48.3	1,307.3	27.6
5/27/70	17.6	498.4	-230.	3.1	1,100	16.0	15.4	500.0	-
6/ 9/70	7.1	201.0	-395.	2.9	1,710	32.0	29.0	284.0	-
6/10/70	6.1	172.7	-420.	2.9	1,620	37.0	31.0	933.0	-
6/11/70	4.6	130.3	-432.	2.9	1,760	38.0	31.0	864.0	-

(Sources: FWPCA, Pa. Dept. of Health, U. S. Army Corps of Engineers)

TABLE 3

1965-1970 WATER QUALITY SAMPLING RESULTS - COAL CREEK NEAR MOUTH

Date	Stream Flow cfs	Stream Flow l/sec	Net Alkalinity As $CaCO_3$ mg/l	pH	Conductivity m-mho cm	Total Iron mg/l	Manganese mg/l	Sulfates mg/l	Calcium mg/l
5/ 4/66	12.5	354.0	-353.9	2.9	1,200	40.2	9.4	697.7	38.7
5/18/66	11.7	331.3	-379.3	2.9	1,300	12.5	23.3	675.7	37.6
6/14/66	4.3	121.8	-669.0	2.7	1,660	98.0	1.2	1,094.3	66.1
7/19/66	3.1	87.8	-1,029.0	2.7	1,920	141.0	8.3	1,608.3	155.5
1/12/67	3.1	87.8	-832.6	2.8	1,165	107.2	18.0	2,025.4	53.0
1/19/67	2.3	65.1	-929.3	2.8	1,800	118.2	22.1	1,515.4	99.0
1/26/67	3.4	96.3	-794.2	2.8	1,800	101.0	17.3	1,116.9	68.0
3/28/67	44.2	1,251.6	-293.6	3.1	1,050	33.0	7.4	598.8	25.0
4/ 4/67	25.2	713.6	-428.5	2.9	1,400	56.5	10.2	724.4	22.0
4/11/67	18.2	515.4	-426.7	2.9	1,200	55.5	10.7	650.5	46.0
4/18/67	9.9	280.3	-446.7	3.0	1,550	57.8	10.8	664.3	40.0
8/15/68	2.1	59.5	-1,054.7	2.7	2,200	157.6	24.0	2,816.6	59.0
9/12/68	7.0	198.2	-777.4	3.4	450	155.0	22.8	1,017.1	56.0
10/21/68	1.8	51.0	-1,146.2	3.2	2,200	156.0	26.5	1,575.4	50.0
5/26/70	11.5	325.6	-395.0	2.9	1,420	497.0	10.8	639.0	-
6/ 9/70	8.8	249.2	-522.0	2.8	1,870	98.0	11.0	869.0	-
6/10/70	7.3	206.7	-553.0	2.8	1,840	100.0	11.0	983.0	-
6/11/70	7.9	223.7	-558.0	2.7	1,890	100.0	12.0	891.0	-

(Sources: FWPCA, Pa. Dept. of Health, U. S. Army Corps of Engineers)

TABLE 4

1965-1970 WATER QUALITY SAMPLING RESULTS - BEAR CREEK NEAR MOUTH

Date	Stream Flow cfs	Stream Flow l/sec	Net Alkalinity As $CaCO_3$ mg/l	pH	Conductivity m-mho cm	Total Iron mg/l	Manganese mg/l	Sulfates mg/l	Calcium mg/l
5/ 4/66	1.9	53.8	-225.6	3.1	1,000	46.8	8.8	528.8	42.1
5/18/66	1.2	34.0	-370.8	2.9	980	14.0	19.3	477.4	29.4
6/14/66	-	-	-309.2	2.8	1,410	13.0	10.6	785.8	70.2
7/19/66	0.5	14.1	-530.8	2.8	1,700	40.3	9.2	1,226.5	159.0
1/12/67	0.9	25.5	-656.3	2.9	1,150	55.5	20.0	1,663.2	63.0
1/19/67	0.3	8.5	-636.6	2.8	1,600	60.5	21.6	1,145.8	106.5
1/26/67	0.8	22.7	-424.8	2.9	1,000	46.5	16.0	905.1	122.5
3/28/67	9.2	260.5	-266.1	3.0	1,000	21.3	7.7	547.0	36.0
4/ 4/67	2.4	68.0	-265.5	3.0	1,100	26.0	6.8	428.7	27.0
4/11/67	2.1	59.5	-252.8	3.1	940	21.0	7.8	450.9	22.5
4/18/67	1.4	39.6	-274.1	3.1	1,250	21.0	8.8	498.2	45.5
4/ 3/68	0.5	14.2	-2,516.0	3.1	750	19.0	7.4	444.2	41.5
5/27/70	1.7	48.1	-210.0	3.0	1,060	15.0	9.6	507.0	-
6/ 9/70	2.8	79.3	-228.0	3.0	1,110	11.0	9.6	481.0	-
6/10/70	0.8	22.7	-236.0	3.0	1,090.	11.0	9.7	517.0	-
6/11/70	0.8	22.7	-233.0	2.9	1,260	13.0	10.0	512.0	-

(Sources: FWPCA, Pa. Dept. of Health, U. S. Army Corps of Engineers)

flows for the Tioga River, measured at the Tioga Gauge (Stream Mile 65), have been compiled in Table 6 from data obtained from the U. S. Weather Service for the period 1941 through 1970.

TABLE 5

FLOW CONDITIONS FOR TIOGA RIVER
AND STUDY AREA STREAMS

	Flow Conditions					
	Flow Exceeded 10% of Time		Mean Flow		Once in Ten Year Low Flow	
	Flow cfs (l/sec)	Acid lbs/day (kg/day)	Flow cfs (l/sec)	Acid lbs/day (kg/day)	Flow cfs (l/sec)	Acid lbs/day (kg/day)
Tioga River (Stream Mile 87)	136 (3,851)	-- (--)	58 (1,642)	-- (--)	1.4 (39.6)	-- (--)
Morris Run	30 (849)	37,200 (16,900)	12 (340)	24,600 (11,200)	0.4 (11.3)	2,600 (1,200)
Coal Creek	13 (368)	28,000 (12,700)	10 (283)	24,800 (11,200)	2.5 (70.8)	13,500 (6,100)
Bear Creek	3 (85)	3,000 (1,400)	1 (28)	2,200 (1,000)	0.1 (2.8)	300 (100)
Tioga River (Stream Mile 75)	350 (9,911)	-- (--)	186 (5,267)	-- (--)	6.1 172.7	-- (--)

(Source: U. S. Army Corps of Engineers)

TABLE 6

1941 - 1970 NORMAL MONTHLY FLOWS
FOR TIOGA RIVER, TIOGA, PENNSYLVANIA

	Stream Flow	
	cfs	l/sec
January	271.4	7,685
February	307.3	8,702
March	778.4	22,041
April	748.6	21,197
May	541.7	15,339
June	190.7	5,400
July	77.4	2,192
August	78.0	2,902
September	52.8	1,495
October	146.8	4,157
November	311.8	8,829
December	313.0	8,863
TOTAL	3,818.2	108,116

(Source: U. S. Weather Service)

Mine Drainage Gauging, Sampling, And Analytical Program - The Department of Environmental Resources authorized Gannett Fleming Corddry and Carpenter, Inc., to begin a three-month gauging, sampling, and analytical program involving six monitoring stations. Two of the six monitoring stations (MS-1 and 2) are located immediately upstream and downstream from Site I. The purpose of flow monitoring at these two stations is to establish the water loss from a stream through infiltration into underlying deep mine workings. The other four monitoring stations (MS-3, 4, 5, and 6) have been established to monitor the respective mine drainage discharge points (5, 10, 14, and 15), some or all of which will be affected by the proposed demonstration project. Weekly trips beginning June 13, 1973, and continuing through September 13, 1973, were made to accomplish this program.

Construction of the continuous flow monitoring stations had originally been scheduled during this three-month period. This would have enabled continuous flow monitoring at all six stations for six months prior to construction of the abatement measures. Continuous flow recorders were installed at MS-1, 2, 3, 4, and 5 on March 18, 1974, and at MS-6 on May 14, 1974. During the interim period from September 1973 to March 1974, the gauging, sampling, and analytical program was continued on two-week intervals at the request of the Department.

Maximum and minimum flows and quality data obtained from the six monitoring stations from June 13, 1973, through October 16, 1973, are shown on Table 7. The data collected during this period were used to develop anticipated flow and quality data for low, average, and high groundwater conditions. During the normal hydrologic cycle, data obtained during this monitoring period would have been representative of low groundwater conditions. However, due to excess precipitation in the study area and higher than normal groundwater flows as measured at the Tioga Gauge located approximately 18 miles downstream from the study area, the monitoring data collected could not be utilized without some correction. A reduction factor was developed based on departures from the 30-year normals for precipitation and river flow. This factor was then applied to the four acid mine drainage discharges to establish their low groundwater flows. Average and high groundwater flows were then developed, using 30-year normal river flow values obtained at the Tioga Gauge. The anticipated flows and qualities of the four acid mine drainage discharges under low, average, and high groundwater conditions are shown on Table 8. These flow and quality data will be modified as necessary, based on additional monitoring (instantaneous and continuous) before project construction begins.

TABLE 7

MAXIMUM AND MINIMUM FLOWS AND QUALITY DATA FROM 6/13/73 THROUGH 10/16/73

	Monitoring Stations (1)					
	1	2 (2)	3	4	5	6
	Min. - Max.	Min. - Max.	Min. - Max.	Min. - Max.	Min. - Max.	Min. - Max.
Flow - MGD	0.11 - 3.79	0.0 - 2.62	3.23 - 9.65	1.64 - 3.78	0.98 - 3.72	0.36 - 3.26
pH Range	4.7 - 6.6	5.1 - 5.9	2.7 - 2.8	3.0 - 3.1	2.7 - 2.8	2.8 - 3.0
Alkalinity -mg/l	0	0	0	0	0	0
Acidity -mg/l	2. - 9.	5	550. - 870.	363. - 630.	1220. - 1730.	626. - 1036.
Sulfates -mg/l	9.8 - 16.1	14.0 - 19.5	1059. - 1670.	1060. - 1510.	2720. - 3470.	1690. - 2690.
Iron -mg/l	.1 - 1.0	0.4 - 0.8	37.9 - 84.5	12.9 - 46.6	22.9 - 65.2	10.1 - 22.6
Aluminum -mg/l	0.04 - 0.33	0.05 - 0.13	22.5 - 57.5	15.0 - 55.5	59.8 - 150.2	39.8 - 78.9
Manganese -mg/l	0.07 - 0.2	0.1 - 0.2	9.7 - 18.7	39.7 - 76.2	45.9 - 81.6	40.4 - 71.8
Total solids -mg/l	10. - 85.	35. - 60.	1465. - 2092.	1576. - 2153.	3271. - 4531.	2356. - 3449.

(1) Monitoring Station 1 - Immediately upstream from Site I.
Monitoring Station 2 - Immediately downstream from Site L
Monitoring Station 3 - Mine drainage discharge point 5.
Monitoring Station 4 - Mine drainage discharge point 10.
Monitoring Station 5 - Mine drainage discharge point 14.
Monitoring Station 6 - Mine drainage discharge point 15.

(2) Based on three samples only (6/13/73, 6/21/73, and 7/5/73). This station had no flow during all other visits.

TABLE 8

ACID MINE DRAINAGE FLOWS
AND MAJOR CONSTITUENTS AT EACH
DISCHARGE POINT BEFORE CONSTRUCTION (1)

Monitoring Station	Mine Drainage Discharge Point	Flow		Total Iron			Acid (as $CaCO_3$)		
		mgd	l/sec	mg/l	lbs/day	kg/day	mg/l	lbs/day	kg/day
		LOW GROUND WATER CONDITIONS							
3	5	2.52	110	66.7	1,400	635	785	16,500	7,480
4	10	1.26	55	24.6	260	118	490	5,150	2,340
5	14	0.79	34	48.3	320	145	1,525	10,050	4,560
6	15	0.32	14	17.1	50	23	830	2,220	1,010
TOTAL		4.89	214		2,030	921		33,920	15,390
		AVERAGE GROUND WATER CONDITIONS							
3	5	9.02	395	56	4,210	1,910	730	54,920	24,930
4	10	4.51	198	20	750	340	440	16,550	7,510
5	14	2.82	123	42	990	450	1,425	33,510	15,210
6	15	1.14	50	15	140	60	780	7,420	3,370
TOTAL		17.49	766		6,090	2,760		112,400	51,020
		HIGH GROUND WATER CONDITIONS							
3	5	18.65	817	45	7,000	3,180	675	104,990	47,660
4	10	9.32	408	16	1,240	560	400	31,090	14,110
5	14	5.85	256	37	1,800	820	1,350	65,860	29,900
6	15	2.37	104	13	260	120	725	14,330	6,510
TOTAL		36.19	1,585		10,300	4,680		216,270	98,180

(1) Values derived as explained on page 27.

No monitoring stations have been established on Morris Run or Coal Creek. Although reductions in flow from individual mine drainage discharges on these streams will be accomplished by the proposed project, substantial flows will continue from these sources. Since individual discharge quality is expected to remain essentially the same, water quality improvement may be difficult to measure in the streams themselves.

The continuous monitoring program for this project is scheduled to extend for approximately two and one-half years. In addition to continuous flow monitoring at the six monitoring stations, it is proposed to sample the four discharges every two weeks and to analyze those samples for their major constituents and characteristics.

Since the other two monitoring stations (MS-1 and 2) are located on the headwaters of Morris Run, which is unaffected by mine drainage, sampling will be limited to once every eight weeks. It is felt that the flow and quality data already obtained and the two and one-half years of monitoring data to be collected during the project life will be adequate for characterization purposes. Constituents and characteristics to be regularly determined are: pH, alkalinity or acidity, total iron, and sulfates. Other constituents will be monitored at less frequent intervals.

Samples were collected for more extensive analysis at monitoring stations MS-1, 3, 4, 5, and 6 on August 8, 1973, and at MS-2 on November 1, 1973. Results of these analyses are shown on Table 9. At this time, there would appear to be no utility in monitoring turbidity or temperature at the mine drainage discharge points.

Rainfall - Precipitation data have been obtained from the National Climatic Center for three stations located near the study area, namely, Canton, English Center, and Towanda. These stations are located nine miles east-southeast, 20 miles southwest, and 29 miles east-northeast, respectively, from the study area. Normal monthly rainfalls for these stations from 1941 through 1970 are shown on Table 10.

Rainfall duration and frequency data for the study area are shown on Table 11. These rainfall frequency and duration data, as well as actual rainfall and flow data, will be used to check and verify previously developed runoff coefficients, evaporation-transpiration rates, and acid mine drainage discharge flows.

A continuous recording rain gauge has been installed in the study area to supplement the flow monitoring data.

TABLE 9

COMPLETE ANALYSES OF SAMPLES TAKEN AUGUST 8, 1973 (NOVEMBER 1, 1973, FOR MS-2)

CONSTITUENT	Monitoring Station 1	Monitoring Station 2	Monitoring Station 3	Monitoring Station 4	Monitoring Station 5	Monitoring Station 6
Acidity - mg/l as $CaCO_3$ (1)	3.	7.	840.	420.	1730.	930.
Alkalinity - mg/l as $CaCO_3$ (1)	0.	0.	0.	0.	0.	0.
Aluminum - mg/l (2)	0.09	1.7	45.2	26.1	112.5	70.1
Arsenic - mg/l (2)	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Cadmium - mg/l (2)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Calcium - mg/l (2)	5.3	3.4	118.1	107.6	152.5	162.7
Chromium - mg/l (2)	0.1	< 0.1	0.1	0.1	0.1	0.1
Copper - mg/l (2)	< 0.1	< 0.1	0.3	0.2	1.5	1.1
Iron (Total) - mg/l (2)	0.1	0.7	68.3	14.0	50.6	17.3
Iron (Ferrous) - mg/l (2)	< 0.01	0.15	5.8	5.7	6.4	3.9
Lead - mg/l (2)	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Magnesium - mg/l (2)	1.4	1.8	78.2	106.2	217.5	188.1
Manganese - mg/l (2)	< 0.1	0.4	16.2	57.0	71.9	64.2
Potassium - mg/l (2)	0.1	1.8	0.1	2.1	1.4	2.1
Sodium - mg/l (2)	1.1	3.9	3.3	5.3	6.3	4.8
Zinc - mg/l (2)	< 0.1	0.1	1.8	2.0	12.9	10.5
Mercury - mg/l (3)	0.4	< 0.3	0.4	0.4	0.3	0.3
COD - mg/l (1)	8.	11.	8.	4.	8.	4.
Chlorides - mg/l Cl (1)	1.01	2.5	1.51	4.03	1.51	1.01
Cyanide - mg/l CN (1)	0.0026	< 0.0003	0.0053	0.0006	0.0042	0.0003
Fluorides - mg/l (1)	0.08	0.14	0.82	0.74	1.02	1.07
Hardness - mg/l as $CaCO_3$ (1)	18.	22.	740.	900.	1680.	1500.
Nitrates (1)	0.886	0.02	0.266	0.177	1.285	0.709
pH (1)	5.6	5.7	2.8	3.0	2.7	2.9
Specific Conductivity - MHOS/CM (1)	35.4	63.5	2000.	2000.	3660.	2840.
Sulfates - mg/l SO_4 (1)	12.	17.	1240.	1140.	2880.	2180.
Temperature - °C (Field)	17.	7.	9.	9.	10.	10.
Turbidity - J.T.U. (1)	0.66	12.	1.2	12.	0.29	0.31
Residue (Total) - mg/l (1)	26.	78.	1970.	1720.	4137.	3055.
Residue (Filterable) - mg/l (1)	0.	9.	0.4	28.4	1.6	0.8

(1) Wet Chemistry Analysis.
(2) Atomic Absorption Analysis.
(3) Flameless Atomic Absorption Analysis.

TABLE 10

NORMAL MONTHLY PRECIPITATION AT CANTON, ENGLISH CENTER, AND TOWANDA, PENNSYLVANIA

	Precipitation (inches)		
	Canton	English Center	Towanda
January	1.96	2.17	1.84
February	1.92	2.16	1.83
March	2.68	3.31	2.68
April	3.10	3.26	3.10
May	3.95	4.10	3.97
June	3.15	3.36	2.96
July	3.74	3.72	3.49
August	3.36	3.26	3.03
September	2.93	2.85	3.11
October	2.98	3.05	2.74
November	3.28	3.51	2.99
December	2.44	2.58	2.24
TOTAL	35.49	37.33	33.98

(Source: National Oceanic and Atmospheric Administration)

TABLE 11

RAINFALL FREQUENCY - DURATION TABULATION FOR SOUTHEASTERN TIOGA COUNTY, PENNSYLVANIA, IN INCHES OF WATER (1)

	Years						
Hours	1	2	5	10	25	50	100
0.5	0.75	0.9	1.2	1.38	1.58	1.78	1.9
1	0.95	1.12	1.5	1.72	2.0	2.25	2.45
2	1.18	1.4	1.85	2.2	2.45	2.8	3.0
3	1.3	1.7	2.0	2.4	2.8	3.0	3.4
6	1.7	1.9	2.5	2.9	3.4	3.8	4.0
12	1.9	2.4	3.0	3.4	4.0	4.4	4.9
24	2.32	2.74	3.50	4.09	4.74	5.10	5.73

(1) Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years. Technical Paper No. 40, U. S. Department of Commerce and National Weather Bureau, 1961.

SOCIAL AND ECONOMIC ENVIRONMENT

A large portion of the business and industrial economy of eastern Tioga County is located in the Mansfield-Blossburg area. Mansfield (population 4,114), located approximately 10 miles downstream from the study area, is the site of Mansfield State College. Within the study area, Blossburg (population 1,753) is the largest community and the center of economic activity.

The major employment opportunities in or near the study area are: the three J. P. Ward foundries, coal mining, timber cutting, and various service industries. Continued area growth is anticipated due to the presence of Mansfield State College, the probability of a modern highway network, and the development of the Tioga-Hammond Reservoir project approximately 19 miles downstream from Blossburg.

At the present time, development in the area upstream from Blossburg has been limited to coal mining, hunting camps, Fall Brook State Park, and a few small farms. Presently, recreation is confined to the private hunting camps and the state park, which is reportedly overcrowded during the summer and fall recreation season. Picknicking and camping are the only activities offered at the park.

Water quality of many tributaries and the river upstream from the study area is suitable for municipal and industrial uses. Because several communities near the study area are in need of additional water sources, good quality water is a resource of increasing importance.

A study recently prepared for the Upper Tioga River Watershed Association[3] outlined several plans to alleviate a potentially serious future water shortage. Projected population in the Mansfield area will require double the present daily water production by 1980 and nearly triple the present production by 1990. The extent to which the study area acid mine drainage is eliminated will have a bearing on the availability of Tioga River water for potable purposes.

By effecting the demonstration project, water quality in the Tioga River will be improved. This improvement will result from the reductions in acid and iron loads emanating from the affected acid mine drainage discharges. Based on average groundwater conditions, Site I restoration will cause an estimated reduction of 6,280 pounds of acid per day and 480 pounds of iron per day at mine drainage discharge point 5. Site II restoration will cause an estimated reduction of 2,200 pounds of acid per day and 70 pounds of iron per day at mine drainage discharge points 10 and 14.

In addition to municipal and industrial benefits, recreational opportunities will be enhanced. The upper Tioga River watershed has many sites suitable for recreational development, most notably the proposed Tioga-Hammond Reservoir. Fishing, hunting, picnicking, camping, and other recreational pursuits are all important assets to be developed within the upper Tioga River watershed. These potentials should be realized since the area can draw from a multi-state population.

SECTION VI

PRELIMINARY ENGINEERING

Abatement Method Description

Two abatement methods will be employed to effect this demonstration project; reconstruction and lining of a stream channel, and restoration of strip mines. Both of these measures serve the same purpose - to minimize the volume of water coming in contact with acid-forming material. Two advantages will result: the water prevented from contacting the acid-forming material will not become acid, and that water will dilute any remaining acid mine drainage discharges.

In addition, agricultural limestone and sewage sludge will be applied to the restored project sites. The effectiveness of these soil conditioners in establishing and maintaining vegetation on the restored project sites will be demonstrated.

Site I

A 14-acre strip mine will be restored and a stream channel reconstructed. This strip mine cut across a tributary of Morris Run. To prevent this stream water from reaching the stripping operation, a hole was cut into the underlying deep mine workings and the stream flow was diverted into this hole. The stripping operation was then conducted until it, too, intercepted the deep mine workings.

Proposed project work includes backfilling this 14-acre strip mine with spoil piles to meet partial fill requirements. The final cover will consist of approximately one foot of select fill containing little acid-forming material. The select fill will be obtained from within the area to be reaffected from specific spoil piles that contain a minimum amount of acid-forming material. This entire area will be graded to near original contour to re-establish the surface drainage pattern. The stream channel will be reconstructed to return the stream to its approximate original bed and gradient. The channel will be constructed across the restored strip mine, then lined with a bentonite clay and sand mixture to create an impermeable stream channel. The soil cover on the restored strip mine will be sampled and analyzed to determine fertilizer and lime requirements. Appropriate grasses for seeding will also be determined from this analysis. Possible grasses to be used on this site are Kentucky 31 Tall Fescue, Birdsfoot Trefoil (Empire Type), and Common Rye Grass.

This project work will prevent the stream flow from entering the interconnected deep mine workings and contributing to mine drainage discharge point 5.

Site II

It is proposed to restore 60 acres of an improperly restored strip mine to approximate original grade using spoil piles to meet fill requirements. After regrading has been accomplished, sewage sludge will be placed on a 4.3-acre plot on the project site. The remaining acreage will be limed and fertilized. Appropriate grasses will be sown on the entire restored project site. This restoration work will eliminate surface water runoff presently entering Site II and emerging at mine drainage discharge points 10, 14, and, possibly, 15.

Design (Preliminary) - Drawings And Specifications

The locations and outlines of the proposed project sites are shown on Figure 2. Photogrammetric coverage has been obtained for the two project sites on a horizontal scale of one inch equals 200 feet with a contour interval of five feet. These maps will be used for both preliminary and final design.

Construction work accomplished at Site I will reduce the flow at mine drainage discharge point 5. Construction work at Site II is expected to reduce the flows at mine drainage discharge points 10, 14, and, possibly, 15. These discharges, which are reduced or are not affected by the preventive measures, will continue to flow to their respective streams, as shown on Figure 2.

Site I

The existing unrestored 14-acre strip mine is shown on Figure 4, with the heavy-dashed line indicating the extent of the strip mined area. Figure 5 shows the proposed final restoration plan and the restored stream channel. The total area to be affected by strip mine restoration and stream channel reconstruction is 19 acres.

An estimated 137,300 cubic yards of spoil are needed to backfill the 14-acre strip mine. Cross sections were taken every 100 feet along the entire length of the project site. Existing and proposed final elevations and data were fed into a computer program that balanced cut and fill requirements to arrive at a total volume. The difference between cut and fill requirements was 1.5%. As a final step, 30,700 cubic yards of select fill obtained within the 19 acres of Site I will be spread approximately one foot thick over the graded area. The select fill will be obtained from within the area to be reaffected from selected spoil piles that contain a

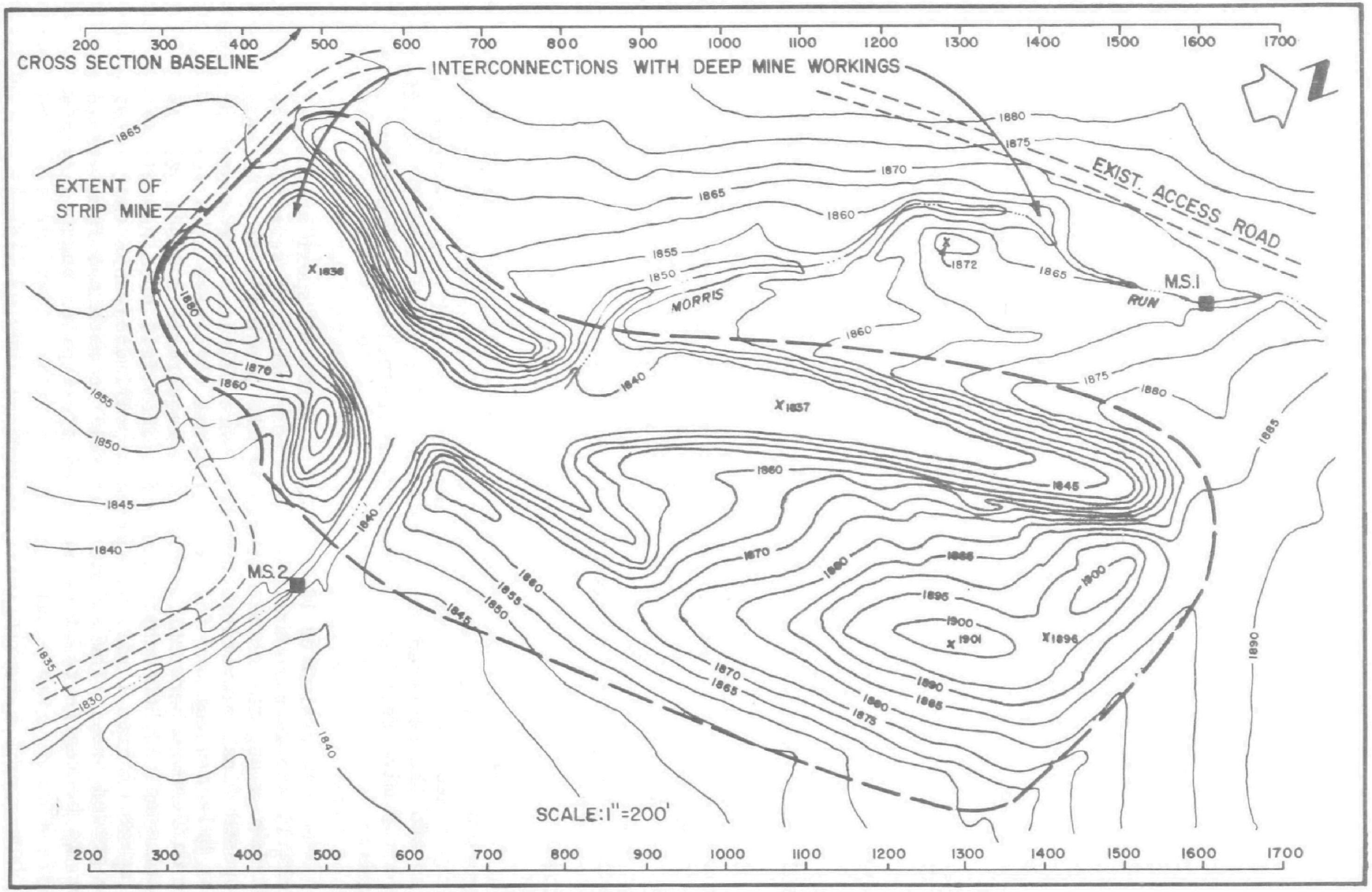


FIGURE 4 - SITE I UNRESTORED STRIP MINE

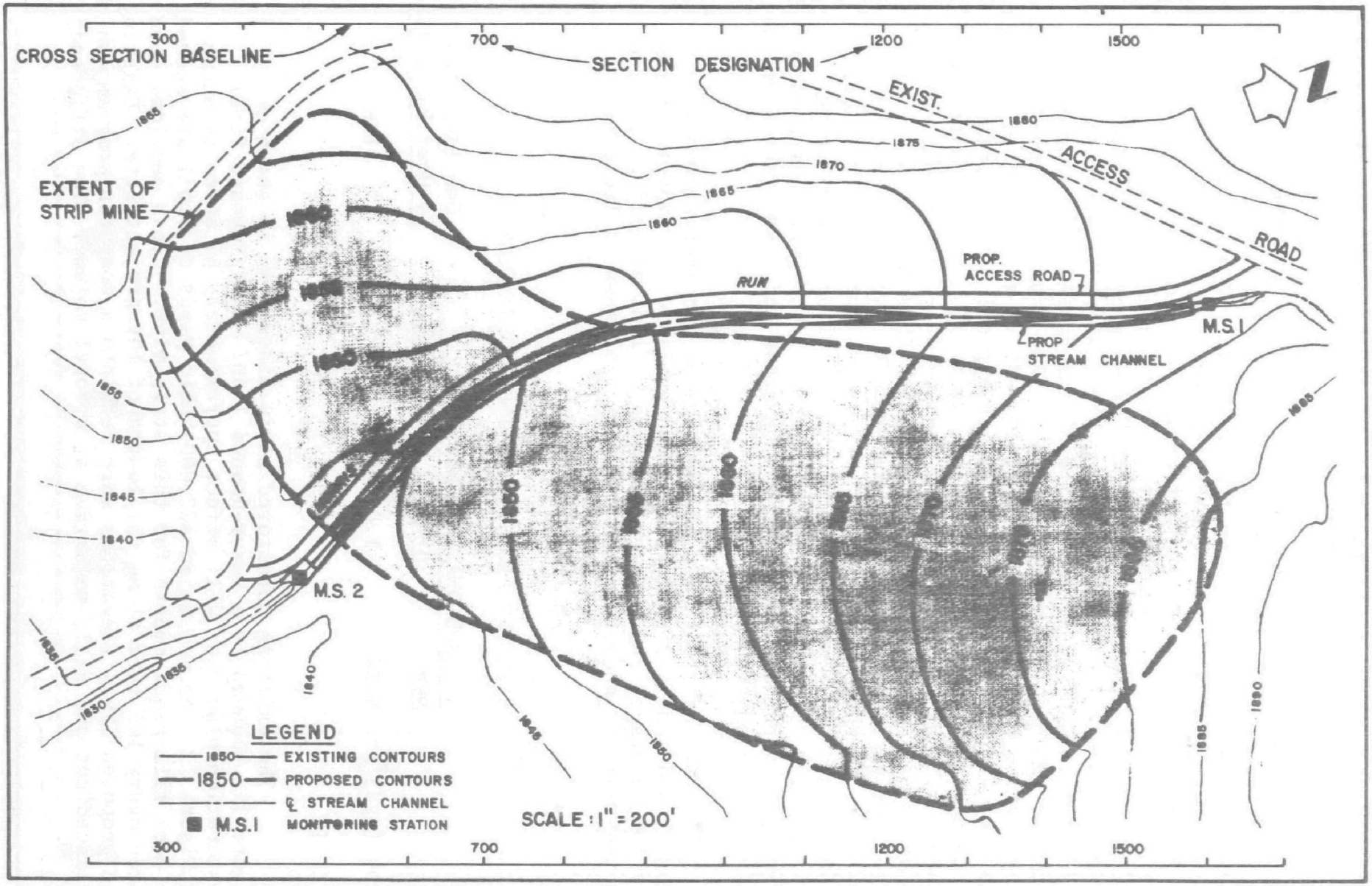


FIGURE 5 - SITE I PROPOSED FINAL RESTORATION PLAN

minimum amount of acid-forming material. Selected typical project site cross sections depicting existing and proposed finished ground elevations are shown on Figures 6, 7, 8, and 9.

Stream channel reconstruction will return the streambed to near its original location, size, and configuration. Plan and profile views of the proposed restored stream channel are shown on Figures 5, 7, 8, and 9. The detailed construction drawings will be prepared using available photogrammetric maps and field survey information. During reconstruction, the earth will be compacted to minimize water infiltration into the underlying deep mine workings. After the desired configuration and grade of the 1,174-foot section of stream channel at Site I has been constructed, it is proposed to line the channel with a one-foot thick sand and special bentonite clay mixture on a 12.5:1 weight ratio. It is also proposed to place one foot of riprap over the lining. A typical cross section of the proposed stream channel is shown on Figure 10. The reconstructed channel will pass about 900 cubic feet of water per second when the water level in the channel is five feet. This flow is about five times the anticipated surface water runoff resulting from a one-in-ten-year, 24-hour-duration rainfall and is approximately 25 percent greater than the flow that can be carried within the existing upstream and downstream banks. The transitions between the reconstructed channel and the streambed upstream and downstream from the site will be smooth.

Flow data obtained at MS-1 during the instantaneous gauging and sampling period are shown on Table 7. Expected flows for low, average, and high groundwater periods as well as the one-in-ten-year, 24-hour-duration rainfall are shown in Table 12.

TABLE 12

EXPECTED FLOWS AT MONITORING STATION 1

	GROUNDWATER CONDITIONS			One-In-10-Year
	Low	Average	High	24-Hour Rainfall
Flow (mgd)	0.22	1.03	2.22	186

Site II

The existing unrestored strip mined area is shown on Figure 11, bounded by a heavy-dashed line. The proposed final restoration plan that will affect approximately 65 acres is shown on Figure 12. An estimated 422,000 cubic yards of spoil are needed to meet fill requirements for this strip mine. Cross sections were taken every 100 feet along the length of the project site. Existing and proposed final elevations were fed into a computer program, which balanced cut and fill, to arrive at a total volume. The difference

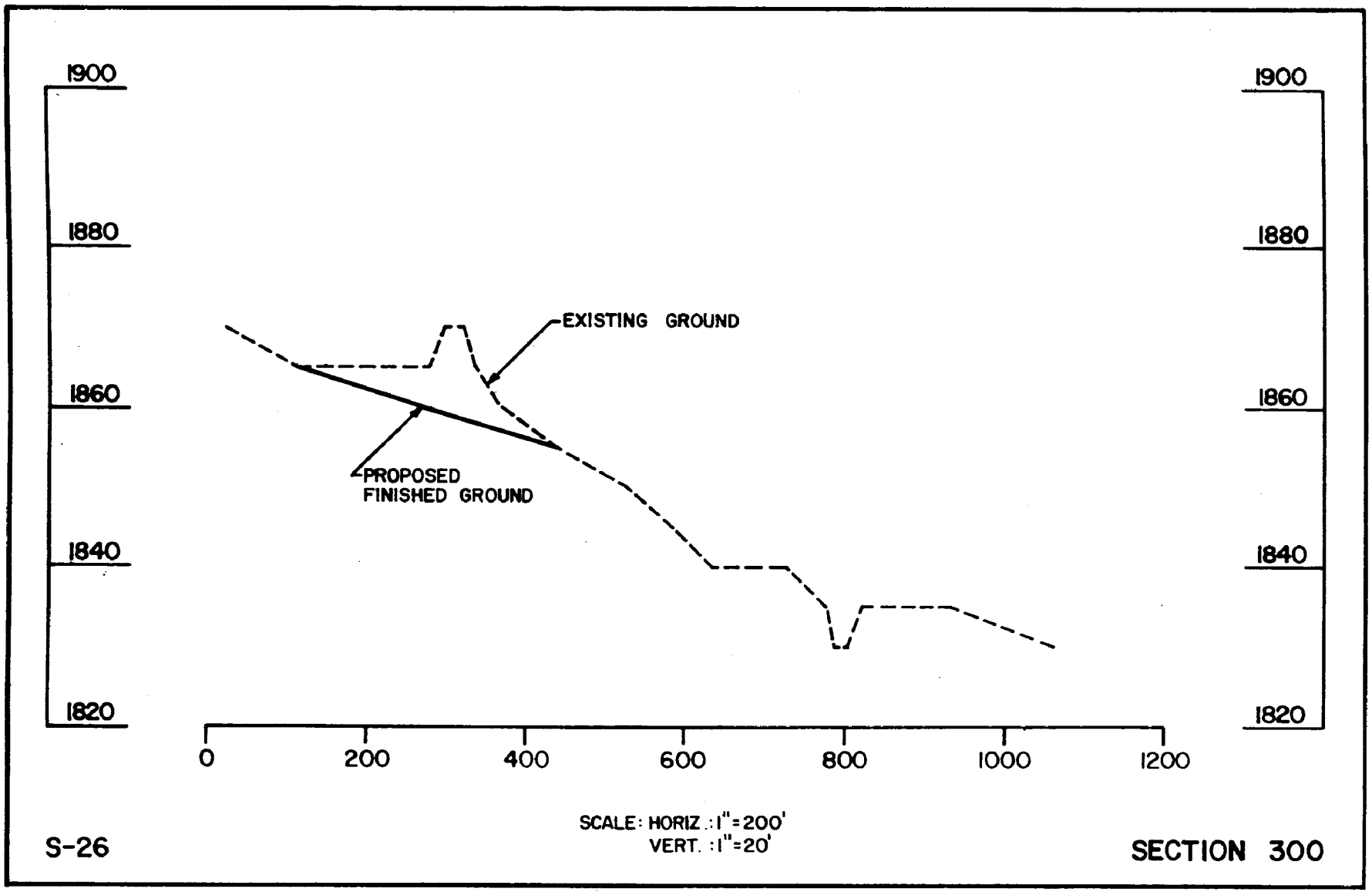


FIGURE 6 – SITE I CROSS SECTION 300

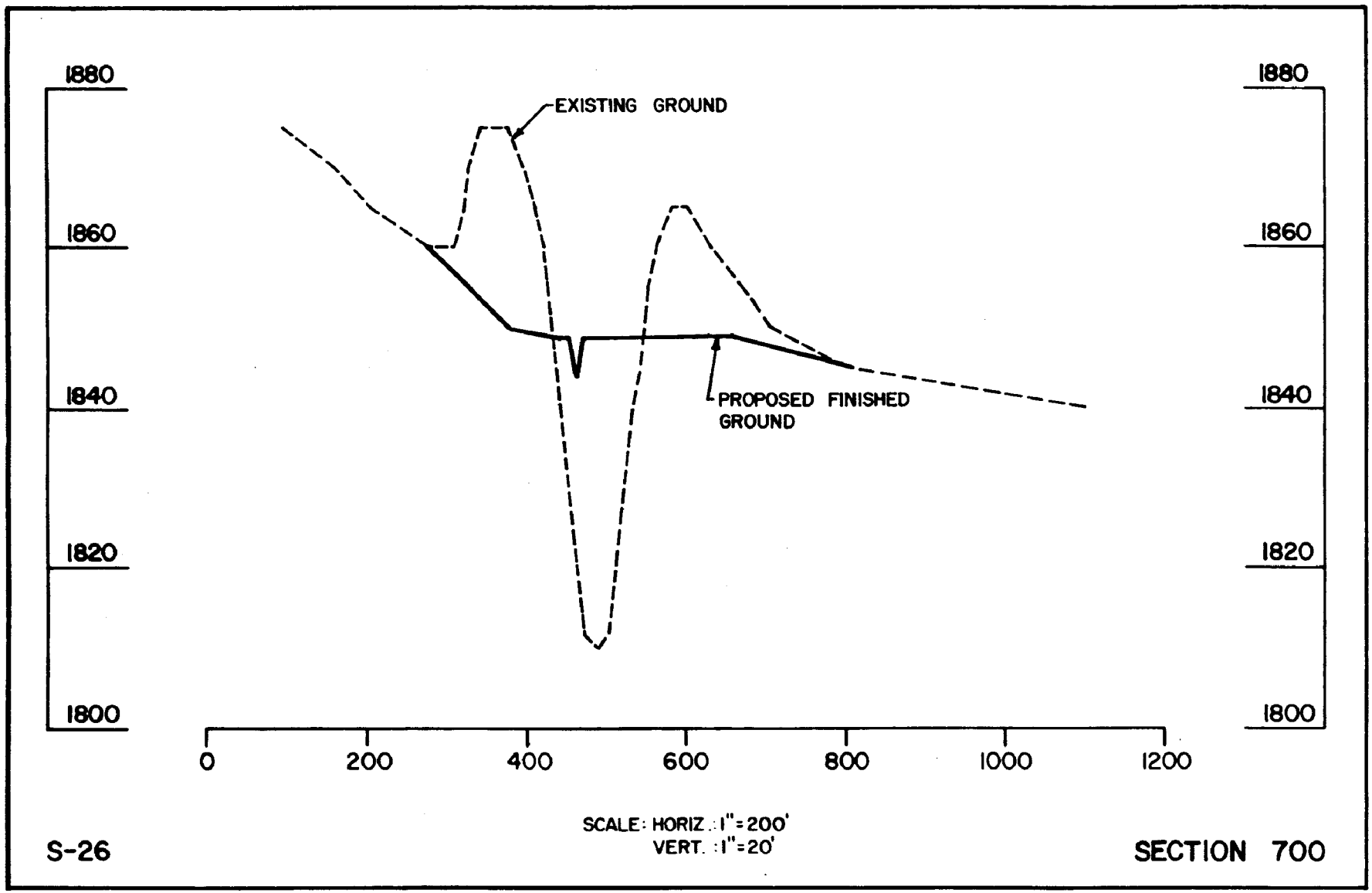


FIGURE 7 — SITE I CROSS SECTION 700

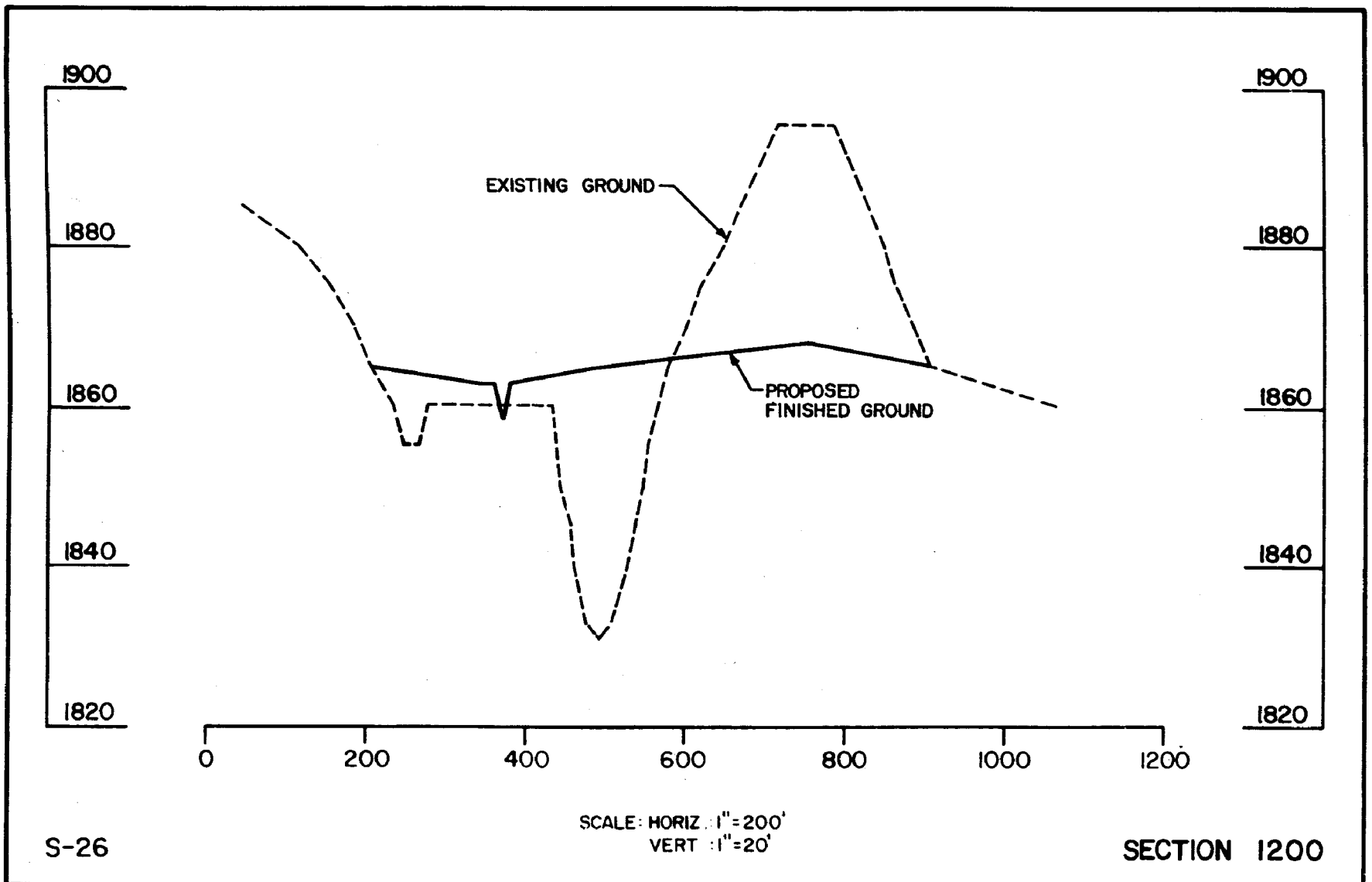


FIGURE 8 – SITE I CROSS SECTION 1200

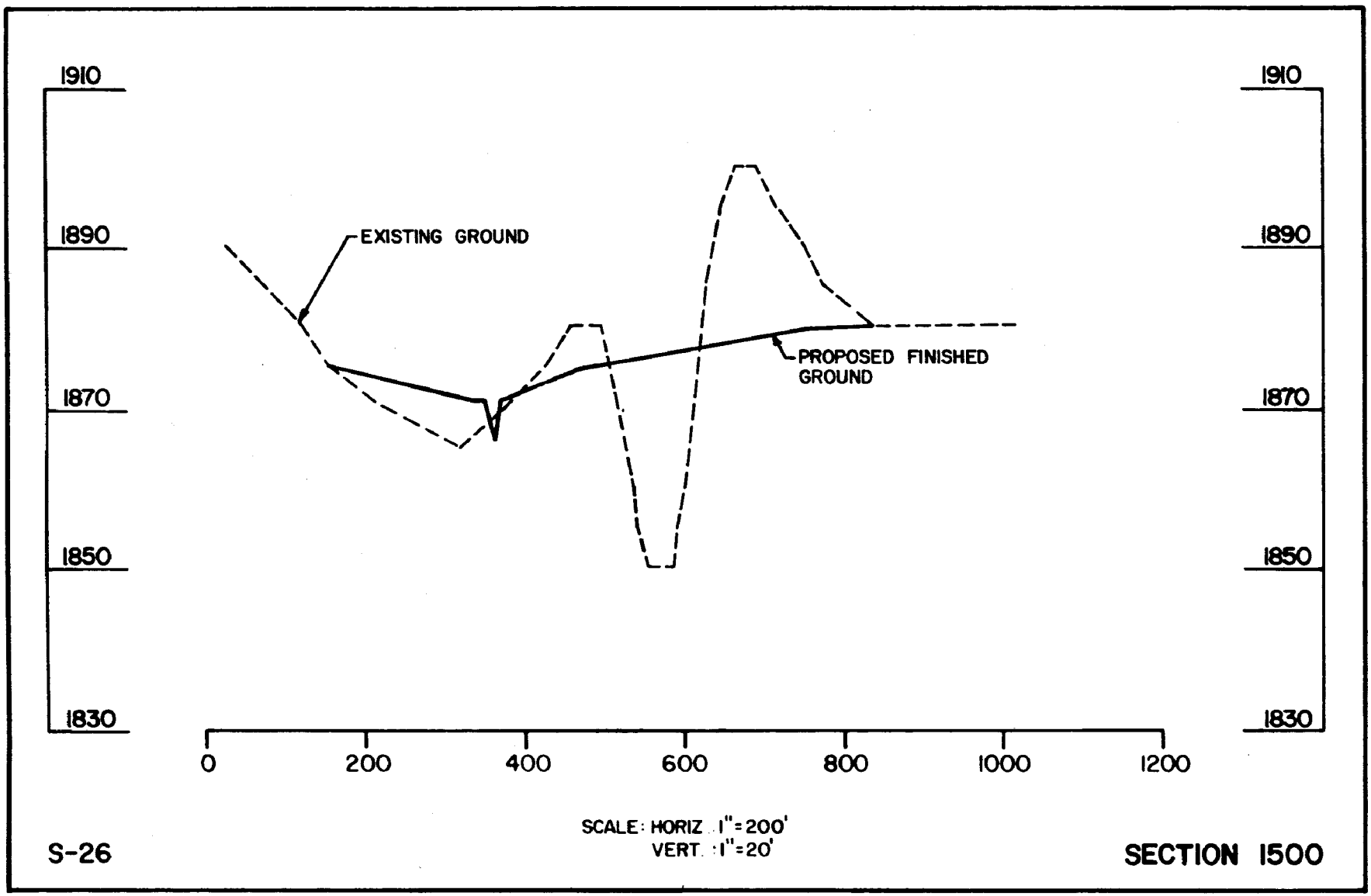


FIGURE 9 - SITE I CROSS SECTION 1500

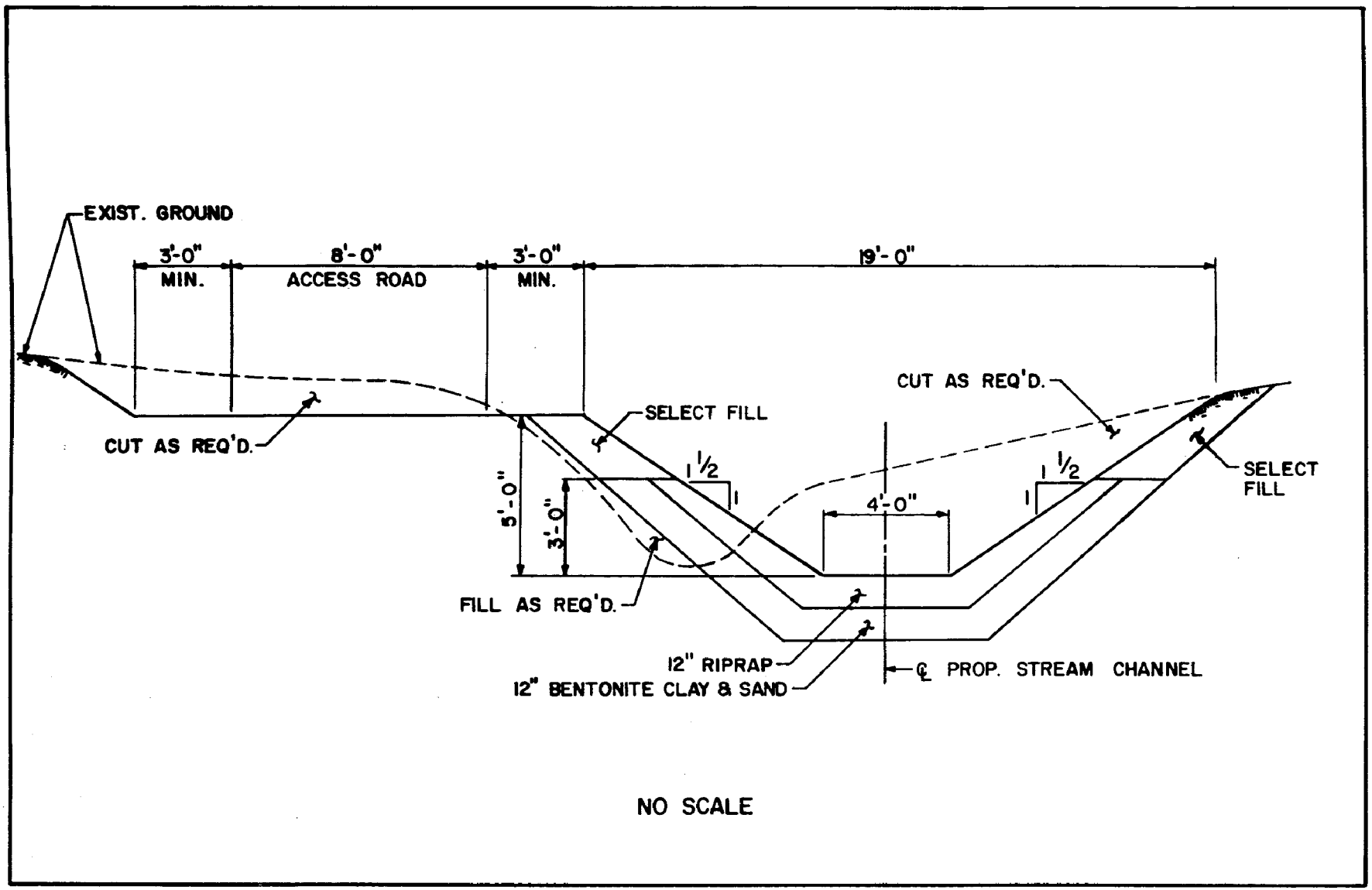


FIGURE 10 - SITE I PROPOSED STREAM CHANNEL CROSS SECTION

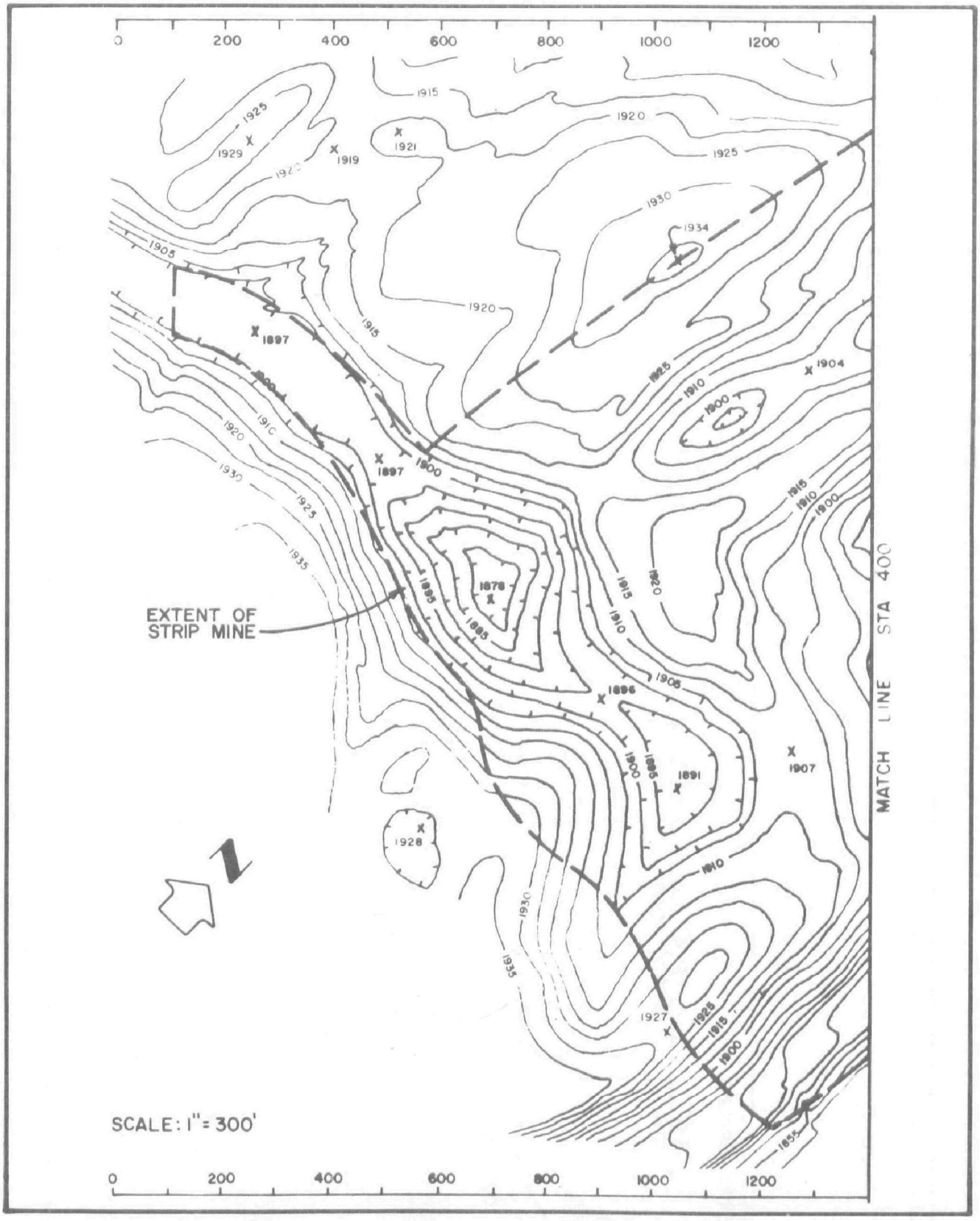


FIGURE 11 — SITE II UNRESTORED STRIP MINE

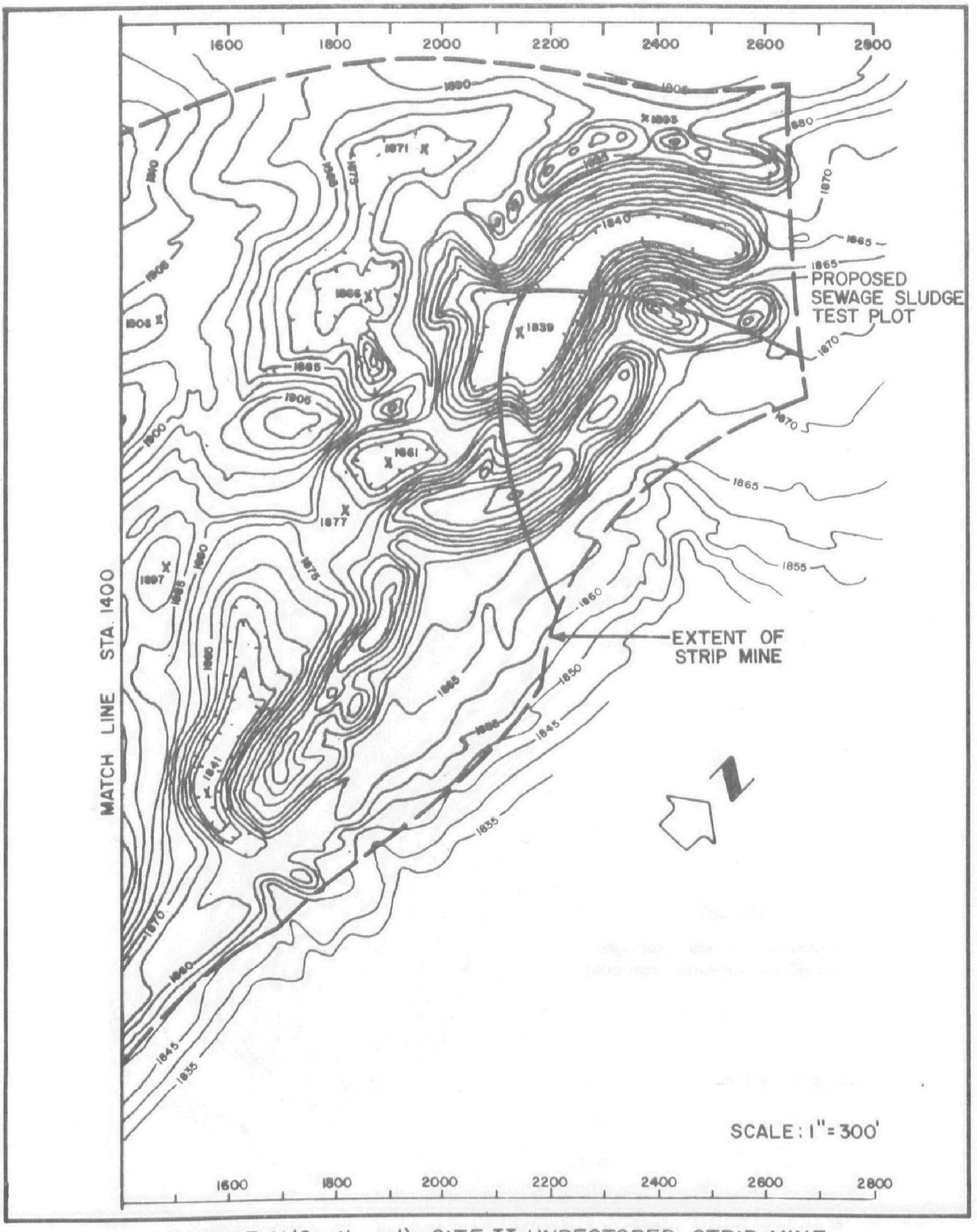


FIGURE 11(Continued)-SITE II UNRESTORED STRIP MINE

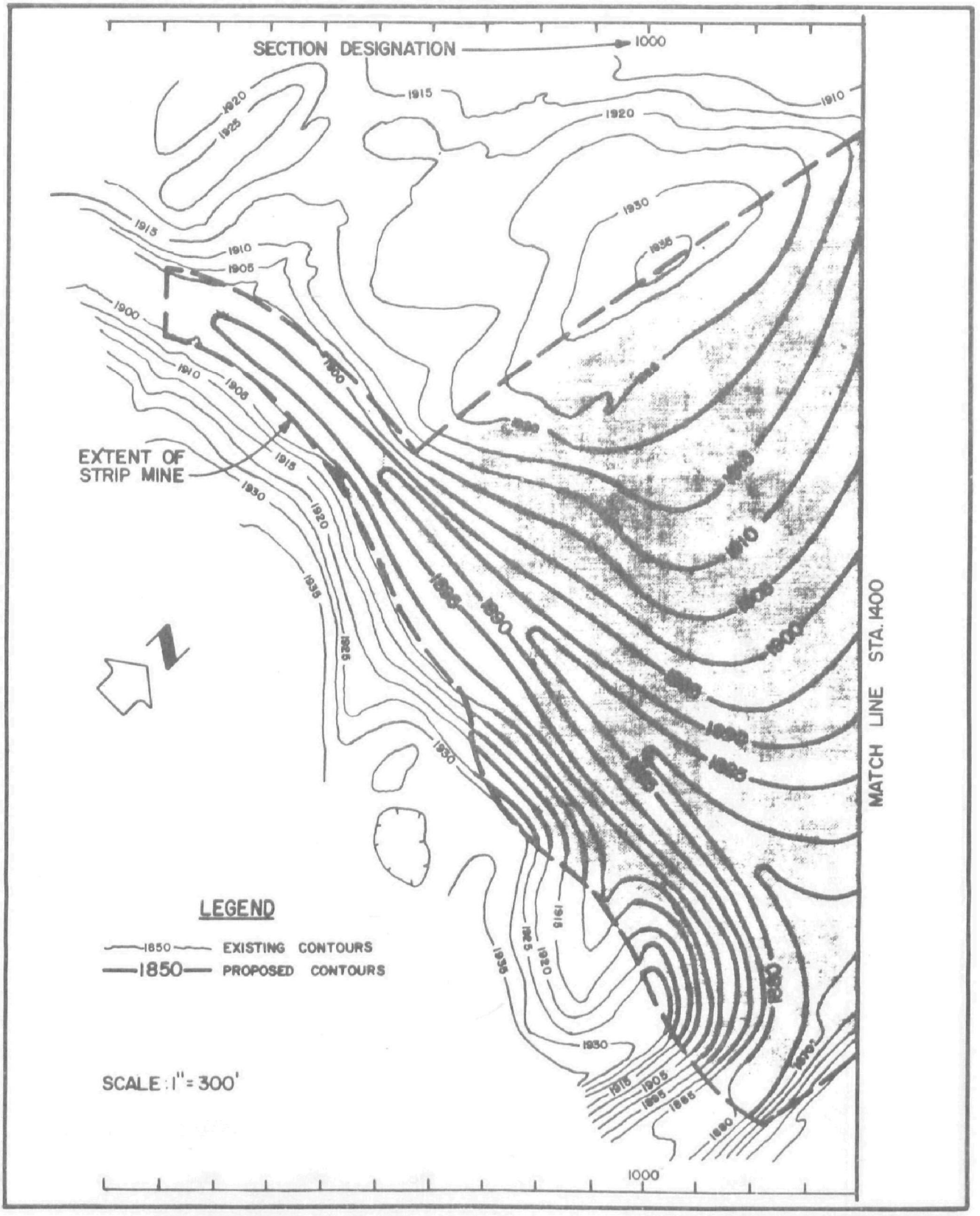


FIGURE 12 – SITE II PROPOSED FINAL RESTORATION PLAN

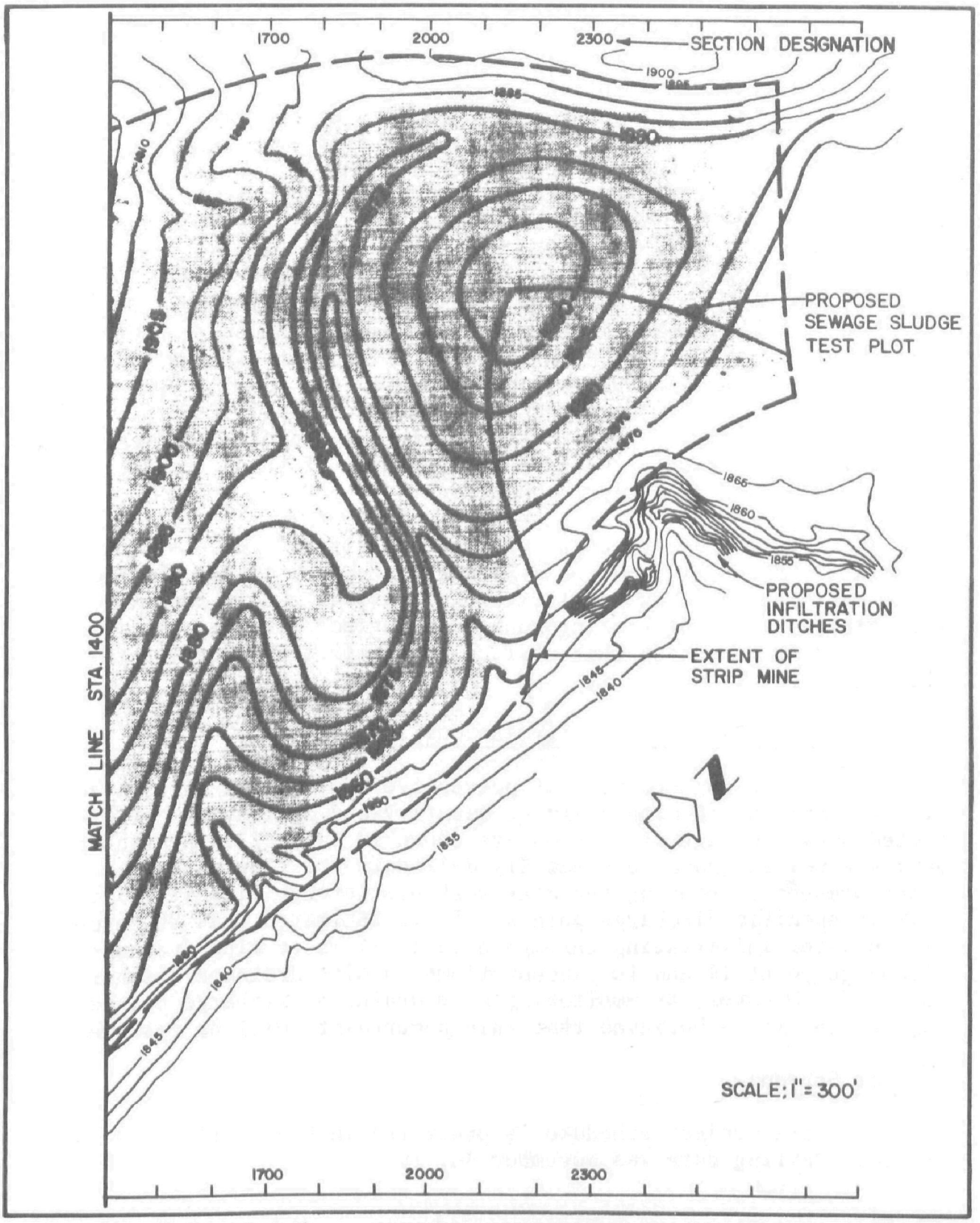


FIGURE 12 (Continued) — SITE II PROPOSED FINAL RESTORATION PLAN

between cut and fill was 0.6%. Selected typical project site cross sections with existing and proposed final ground elevations are shown on Figures 13, 14, 15, and 16.

After completion of earth moving, the surface soil will be analyzed at each project site and determinations will be made of the soil additives required to establish appropriate growths of grasses. On Site I, it is proposed to place appropriate amounts of agricultural limestone, fertilizer, and seed. On Site II, it is proposed to establish a 4.3-acre test plot (see Figure 12) to receive a three-inch application of sewage sludge. The amount of sludge required for this application (1,400 tons, assuming a sludge density of 60 pounds per cubic foot) can be obtained from the Williamsport, Pennsylvania, sewage treatment plant, located approximately 45 miles south of the study area. On the remaining Site II acreage, it is proposed to place appropriate amounts of agricultural limestone and fertilizer. All restored areas within the project sites will be revegetated. Grasses presently contemplated for seeding on the sites are Kentucky 31 Tall Fescue, Birdsfoot Trefoil (Empire Type), and Common Rye Grass at a proposed seeding rate of 20, six, and four pounds per acre, respectively. Full survival of these grasses is anticipated, barring drought conditions.

It is proposed that infiltration ditches be constructed immediately downhill from the 4.3-acre test plot. These ditches would capture and allow infiltration of surface runoff from the test plot, thereby preventing runoff to surface streams. The test plot would be graded so that surface runoff from outside the test plot would not flow onto it.

Expected Mine Drainage Quantity And Quality

After construction of preventive measures at Sites I and II, the anticipated mine drainage quantity and quality at the affected mine drainage discharges are shown in Table 13. Available data are not adequate to precisely delineate the flow pattern of water presently entering the mine workings through Site II and its exit at specific discharge points. It is estimated that 90 percent of the water infiltrating through Site II flows to mine drainage discharge point 14 and 10 percent flows to mine drainage discharge point 10. However, by monitoring mine drainage discharge points 10, 14, and 15, it is believed that this uncertainty will be resolved.

Project Schedule

The project schedule is presented in Figure 17. The project starting date was November 30, 1972.

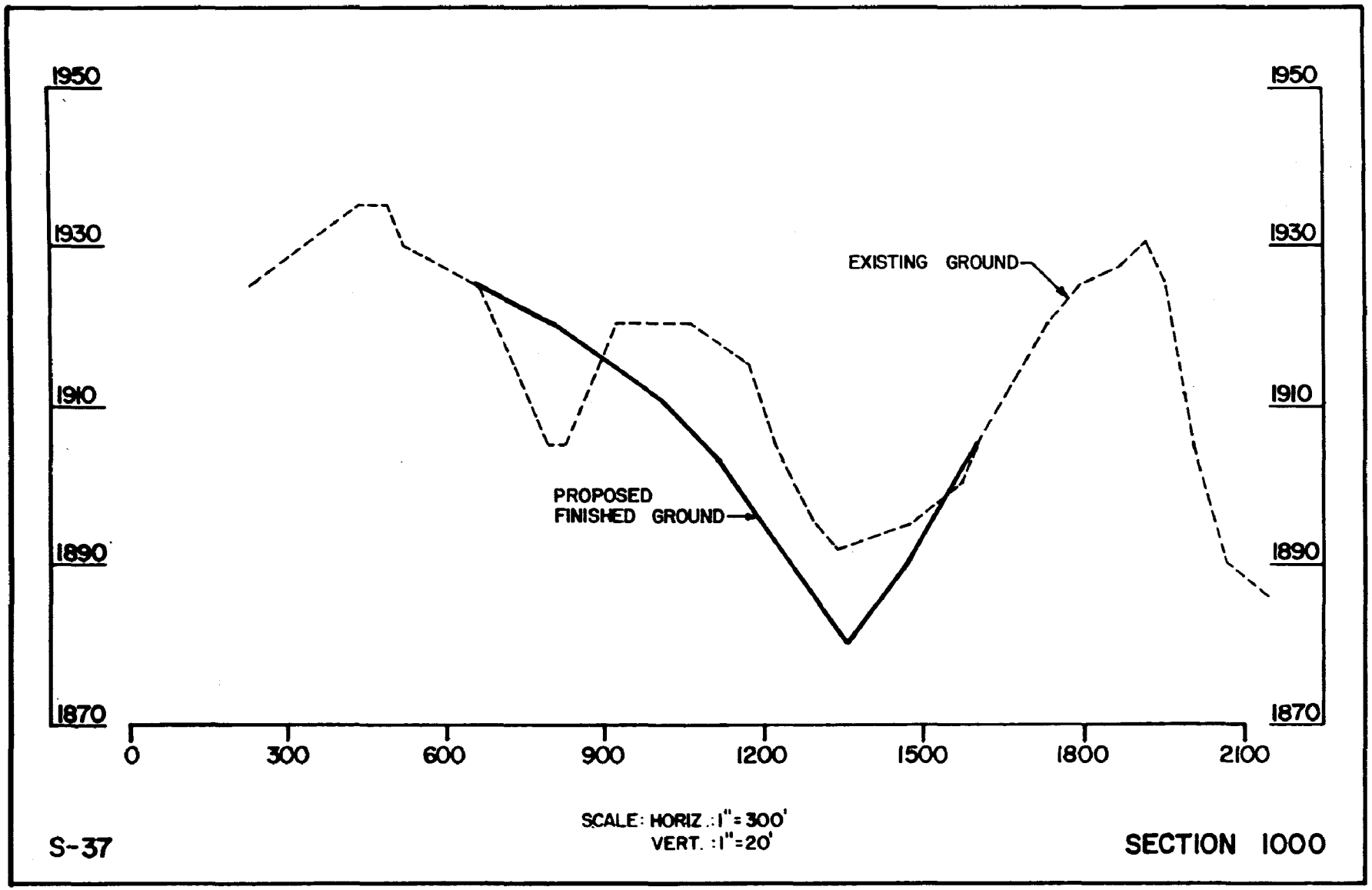


FIGURE 13 – SITE II CROSS SECTION 1000

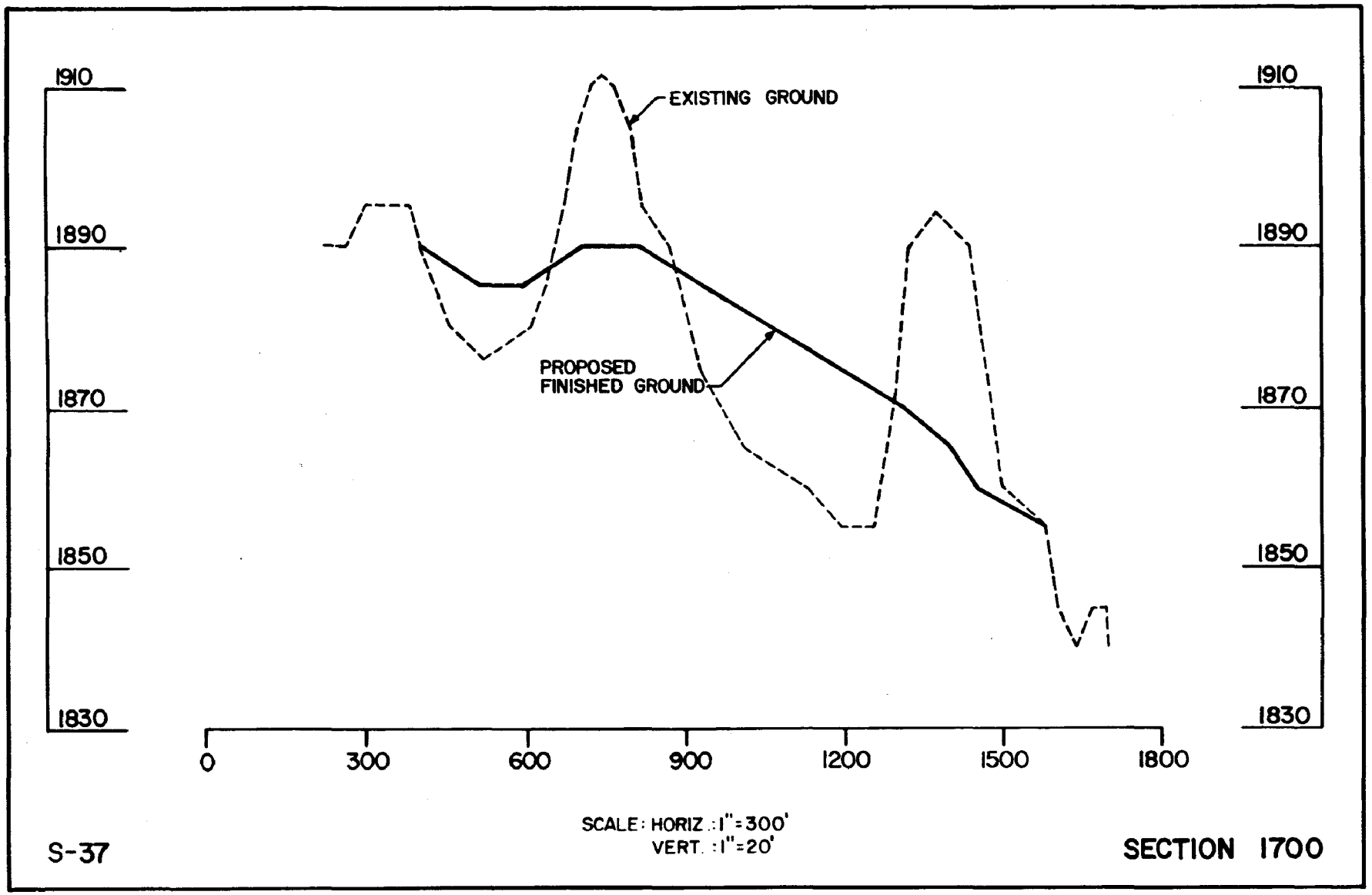


FIGURE 14 – SITE II CROSS SECTION 1700

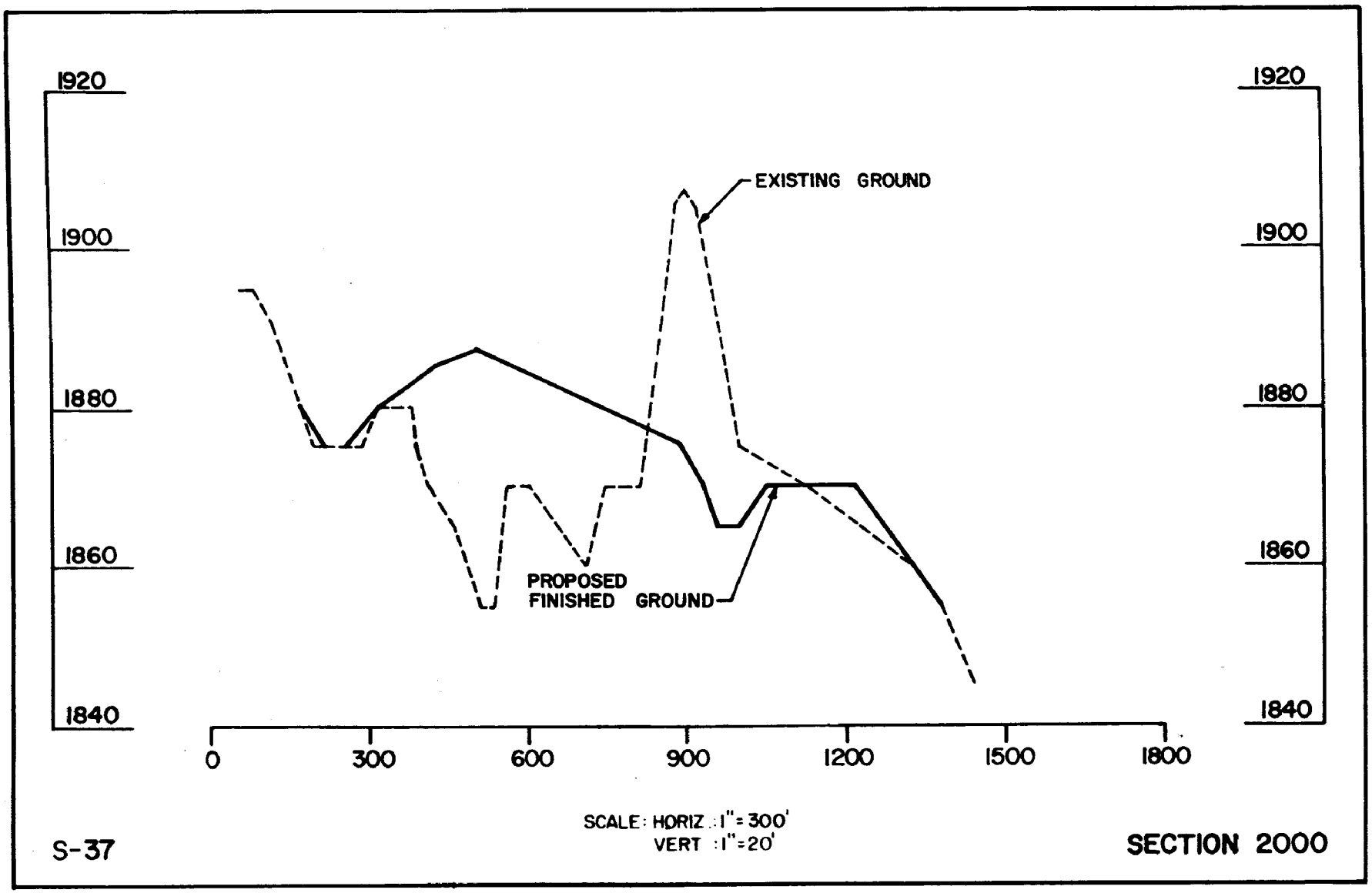


FIGURE 15 – SITE II CROSS SECTION 2000

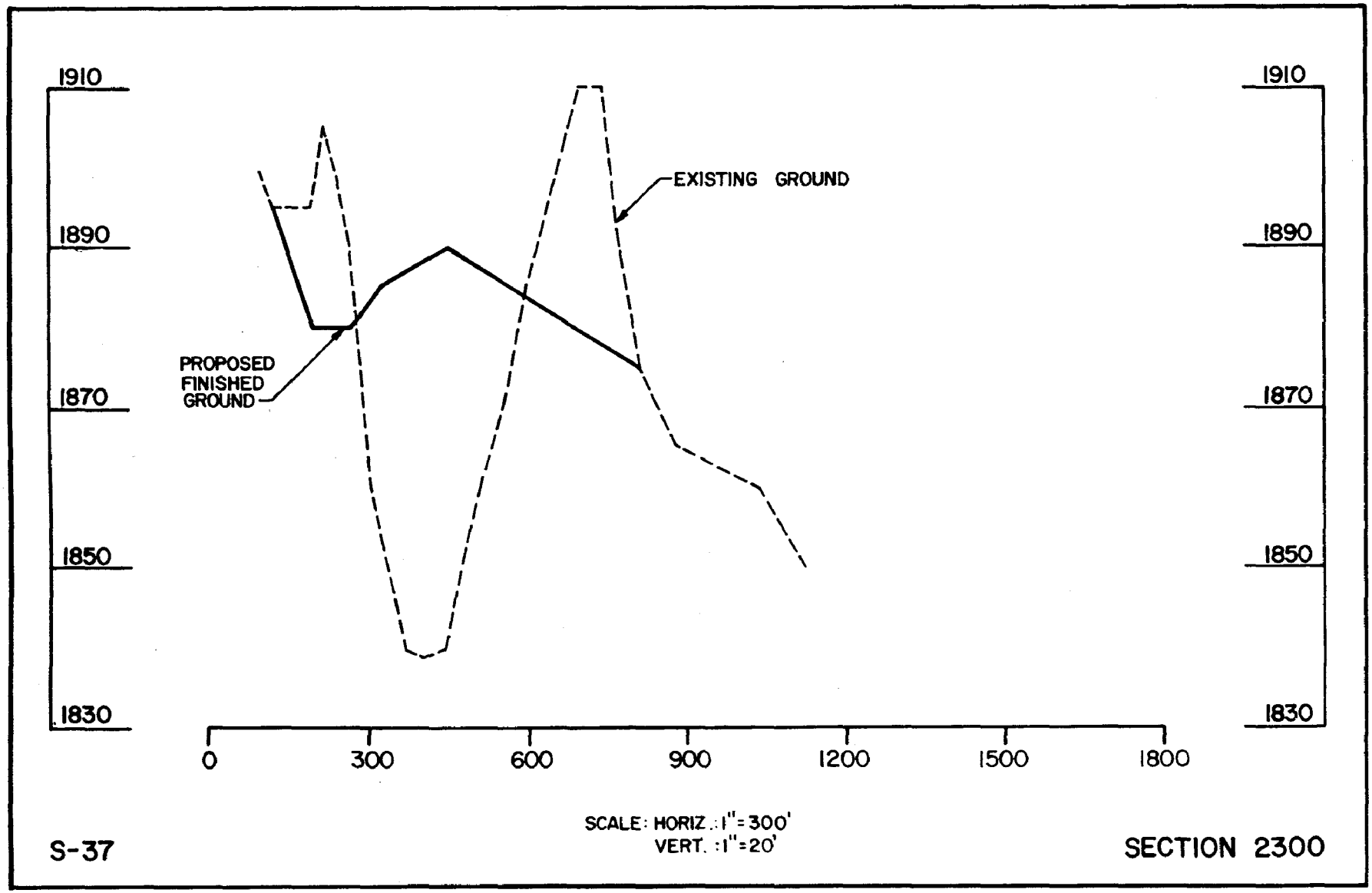


FIGURE 16 — SITE II CROSS SECTION 2300

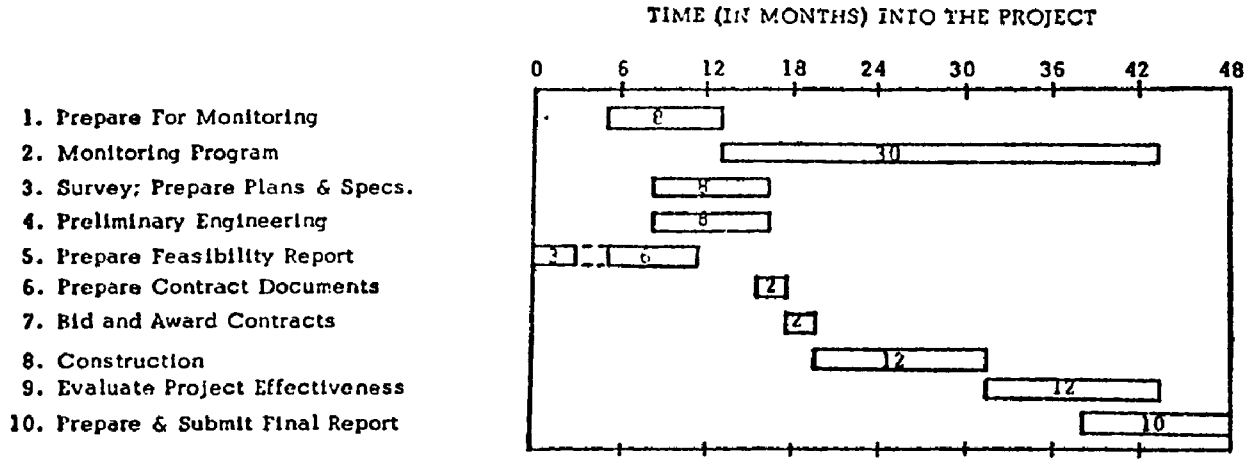
TABLE 13

ACID MINE DRAINAGE FLOWS
AND MAJOR CONSTITUENTS AT EACH
DISCHARGE POINT AFTER CONSTRUCTION

Monitoring Station	Mine Drainage Discharge Point	FLOW mgd	Reduction	l/sec	Reduction	TOTAL IRON mg/l	lbs/day	Reduction	kg/day	Reduction	ACID (as $CaCO_3$) mg/l	lbs/day	Reduction	kg/day	Reduction
						LOW GROUND WATER CONDITIONS									
3	5	2.30	0.22	101	9	66.7	1,280	120	581	54	785	15,060	1,440	6,840	650
4	10	1.25	0.01	55	--	24.6	260	--	116	2	490	5,110	40	2,320	20
5	14	0.74	0.05	32	3	48.3	300	20	135	10	1,525	9,410	640	4,270	290
6	15	0.32	----	14	--	17.1	50	--	23	--	830	2,220	---	1,010	---
		4.61	0.28	202	12		1,890	140	855	56		31,800	2,120	14,440	960
						AVERAGE GROUND WATER CONDITIONS									
3	5	7.99	1.03	350	45	56	3,730	480	1,690	220	730	48,640	6,280	22,080	2,850
4	10	4.49	0.02	197	1	20	750	--	340	--	440	16,480	70	7,480	30
5	14	2.64	0.18	116	7	42	920	70	420	30	1,425	31,380	2,130	14,240	970
6	15	1.14	----	50	--	15	140	--	60	--	780	7,420	---	3,370	---
		16.26	1.23	713	53		5,540	550	2,510	250		103,920	8,480	47,170	3,850
						HIGH GROUND WATER CONDITIONS									
3	5	16.91	1.74	741	76	45	6,350	650	2,880	300	675	95,200	9,790	43,220	4,440
4	10	9.28	0.04	406	2	16	1,240	--	560	--	400	30,960	130	14,060	50
5	14	5.48	0.37	240	16	37	1,690	110	770	50	1,350	61,700	4,160	28,010	1,890
6	15	2.37	----	104	--	13	260	--	120	--	725	14,330	---	6,510	---
		34.04	2.15	1,491	94		9,540	760	4,330	350		202,190	14,080	91,800	6,380

FIGURE 17

PROJECT SCHEDULE



Program Surveillance Measures

Results of the demonstration project will be determined by establishing reductions in pollutional loads through pre- and post-construction monitoring and comparing these reductions to the costs for the restoration work.

The evaluation of agricultural limestone and sewage sludge as soil conditioners to improve growth of vegetation will be verified by visual observations, and by cutting and weighing the crops. All results will be summarized in the final report.

Program Emergency Procedures

Among the emergencies that could occur prior to satisfactory completion of work at the project sites are: (1) flooding due to heavy precipitation and runoff during stream channel construction, (2) heavy precipitation after strip mine restoration but before a vegetative cover is established, causing loss of select fill, soil conditioners, and seed, and possibly creating a siltation problem downstream, (3) inoperative monitoring station, and (4) stream pollution by runoff of sewage sludge.

Flooding at Site I during the stream channel construction stage will be prevented by construction of temporary diversion facilities deemed adequate to handle anticipated stream flows. Post-construction flooding is not expected, since the stream channel will carry approximately five times the one-in-ten-year flow and

will integrate with the streambed upstream and downstream from the project site. Riprap will be placed in the entire 1,174-foot reconstructed stream channel on Site I. Site II topography is not conducive to flooding.

Loss of soil and additives due to heavy precipitation will be prevented by minimizing the time between placing select fill on the final grade, analyzing the soil cover, adding soil conditioners, seeding, and mulching. Once vegetation is established, this potential problem will be nearly eliminated.

Malfunctioning of one of the continuous flow monitoring stations could become a potential emergency by causing a gap in flow data being accumulated. The stations, built to withstand most natural causes during the life of the project, are not vandal-proof. Should a station become inoperative or damaged, a concerted effort will be made to get it back in operation as soon as possible.

Potential stream pollution resulting from placing sewage sludge on the proposed 4.3-acre plot will be minimized by grading the surrounding area to control surface runoff. Infiltration ditches capable of holding the runoff from a one-in-ten-year, 24-hour-duration rainfall will be constructed immediately downhill from the test plot. The locations of the proposed test plot and the infiltration ditches are shown on Figure 12. A composite sample will be obtained of the water intercepted by the infiltration ditches following the first significant rainfall. This sample will be analyzed for fecal coliforms, and a sampling program will then be established on the basis of these analytical results.

CAPITAL AND OPERATING COSTS

Site Acquisition Costs

The Department of Environmental Resources has absorbed all legal fees and administrative costs connected with the acquisition of easements for the project. All of the easements for this demonstration project have been secured. The easements obtained from the respective property owners allow the right of entry to do all work necessary for a completed project. No properties have been purchased by the Department for this project.

Construction Costs

Estimated project costs, including those for construction and engineering, are shown in Table 14.

TABLE 14

ESTIMATED PROJECT COSTS

Construction Contracts		
Site I - Restore a 14-acre strip mine and reconstruct a stream channel to prevent infiltration of surface and ground water into underlying deep mine workings.		
Clear and grub 14 acres @ $350/acre	$ 4,900	
Backfill strip mine 137,300 yd^3 @ $.40/$yd^3$	54,900	
Place one foot of select fill 30,700 yd^3 @ $.50 yd^3	15,350	
Line 1,174-foot stream channel/@ $44/ft	51,660	
Place 1,851 yd^2 of riprap in channel/@ $2 yd^2	3,700	
Lime, fertilize, and seed 19 acres @ $175/acre	3,330	
Mobilization, demobilization, and anti-pollution measures	10,000	
Sub Total	$143,840	
+ 25% Contingency Factor	35,960	
Total	$179,800	
Site II - Restore a 60-acre strip mine to prevent infiltration of surface water into underlying deep mine workings.		
Clear and grub 39 acres @ $350/acre	$ 13,650	
Backfill strip mine 422,000 yd^3 @ $.40/$yd^3$	168,800	
Haul sludge to Site II 1,400 tons @ $2/ton	2,800	
Spread sludge over 4.3-acre plot 1,735 yd^3 @ $.75/$yd^3$	1,300	
Excavate infiltration ditch below sludge plot	500	
Lime, fertilize, and seed 55.7 acres @ $175/acre	9,750	
Mobilization, demobilization, and anti-pollution measures	10,000	
Sub Total	$206,800	
+ 25% Contingency Factor	51,700	
Total	$258,500	
Total Estimated Construction Costs	$438,300	
Reserve Available for Maintenance	13,700	
Total Money Available for Construction		$452,000
Engineering Costs		
Pre- and post-construction studies and report preparation	$ 62,220	
Monitoring-gauging and sampling		
Mileage and per diem	10,996	
Laboratory charges	12,960	
Total Monitoring Costs	$ 23,956	
Detailed survey work	21,000	
Prepare construction plans and specifications	29,500	
General inspection of construction	7,500	
Publish report	2,104	
Total Engineering Costs		$146,280
Contract - Monitoring Stations		
Purchase, assemble, construct and maintain monitoring stations		40,720
Resident Inspection of Construction (By Department)		37,500
Total Project Cost		$676,500

Operating Procedures

The Department will provide administrative supervision for the project and will perform resident inspection of construction. Gannett Fleming Corddry and Carpenter, Inc., will be responsible for the engineering and evaluation aspects of the project, including the monitoring program.

Personnel Requirements

A number of administrative and technical people from the Department of Environmental Resources and Gannett Fleming Corddry and Carpenter, Inc., will be involved in the project. Specific personnel information are presented in the Implementation and Operating Plan Section. A local citizen will be hired by Gannett Fleming Corddry and Carpenter, Inc., to collect samples and maintain the monitoring stations during the course of the project.

Operating Costs

By preparing tight construction plans and specifications and by requiring contractors to adhere to them, maintenance costs should be minimized during construction. It is expected that the Department through its resident inspection of construction can materially aid in minimizing maintenance costs. As noted in Table 14, $13,700 has been placed in reserve for whatever maintenance after construction may be necessary.

SECTION VII

EFFECTIVENESS OF PROJECT

Demonstration Value - The proportion of mine drainage pollution abated will be determined at specific mine drainage discharge points within the study area. Moreover, since the study area is virtually the sole source of acid mine drainage in the Tioga River watershed, reductions made at the specific discharge points will directly affect river water quality.

Under average groundwater conditions, the estimated acid mine drainage reductions at the affected discharge points resulting from the proposed construction are seven percent in volume (1.23 million gallons), eight percent in acid loading (8,480 pounds), and nine percent in iron loading (550 pounds). Reductions under low, average, and high groundwater conditions are shown on Table 13.

In addition, implementation of this project will cause flow and loading reductions from the affected mine drainage discharges resulting from various rainfalls. Table 15 shows these anticipated reductions from 24-hour rainfalls. As shown on Table 15, the reduction at MS-3 is the same for all three rainfall accumulations because of the pool capacity in the strip mine at Site I. Anticipated runoff from rainfall accumulations greater than one inch would cause the pool in the strip mine to overflow without additional infiltration into the deep mine complex.

TABLE 15

FLOW AND LOADING REDUCTIONS
RESULTING FROM VARIOUS 24-HOUR RAINFALLS

Rainfall Accumulation (Inches)	Site	Affected Monitoring Station	Affected Mine Drainage Discharge	Flow (MG)	Acid (Pounds)	Iron (Pounds)
1	I	3	5	8.55	48,100	3,210
	II	4	10	0.14	467	19
	II	5	14	1.30	14,640	400
	Totals			9.99	63,200	3,630
2	I	3	5	8.55	48,100	3,210
	II	4	10	0.28	934	38
	II	5	14	2.60	29,280	800
	Totals			11.40	78,300	4,040
3	I	3	5	8.55	48,100	3,210
	II	4	10	0.42	1,401	57
	II	5	14	3.90	43,920	1,200
	Totals			12.90	93,400	4,470

The approximate cost per ton of acid abated has been calculated by utilizing the total tons of acid per year that will be eliminated by construction of preventive measures (1,550 tons per year under average groundwater conditions), and construction cost data. To arrive at an estimated construction cost for this project, the following items were included: (1) detailed survey work ($21,000), preparation of construction plans and specifications ($29,000), general inspection of construction ($7,000), resident inspection of construction ($37,500), and construction contracts ($452,000). Total estimated construction cost is $547,500. This cost does not include preparation of reports or monitoring. Calculating the cost of abatement for one year yields a cost of $353 per ton of acid. Since the effect of the mine drainage abatement continues every year, the unit cost can be calculated simply by dividing the one year unit cost by the number of years. For example, the unit cost of abatement for a ten-year period is $353/10 = $35.30 per ton of acid.

Reductions in acid mine drainage resulting from this demonstration project will cause an improvement in downstream Tioga River water quality. This improvement will result from decreased acid, iron, and dissolved solids loadings.

Public Benefits

This subject has been discussed in the Inventory and Forecast Section. Regarding aesthetics, the construction will significantly improve the appearance of both project sites. By utilizing the existing large piles of dirt and rock to fill the broad gashes in two separate hillsides, the areas will be restored to approximate pre-mining conditions.

SECTION VIII

IMPLEMENTATION AND OPERATING PLAN

Overall responsibility for completion of this project rests with the Department of Environmental Resources. Responsibility for performing technical services rests with Gannett Fleming Corddry and Carpenter, Inc. Technical responsibilities include, but are not limited to, monitoring, detailed survey work, preparation of construction plans and specifications, general inspection of construction, and preparation of reports.

A schedule covering design, construction, operation, and surveillance is presented in the Preliminary Engineering Section. Insofar as the acquisition schedule is concerned, the Department has secured all easements necessary for this project.

There are two potential maintenance problems associated with this project. The most serious would be the failure to establish an initial vegetative cover on the project sites. An extra ordinarily heavy rainfall and runoff could destroy the restored stream channel. As described in the Preliminary Engineering Section, it is expected that implementation of construction plans and specifications will minimize these problems. As shown in Table 14, an allocation of $13,700 has been made for anticipated maintenance during the life of the project. No additional operation and maintenance budget has been established for the post-demonstration period, since the reconstruction work is designed to require minimum maintenance. The secured easements will reduce the need for maintenance.

Financial funding of the demonstration project is jointly shared by the Department and EPA. The Department will commit 33.5 percent ($226,500) of the project costs from "Land and Water Conservation Act" funds and EPA will commit 66.5 percent ($450,000) from "Federal Water Pollution Control Act" funds. These funds have already been appropriated and will be used to pay invoices as they are submitted and approved.

Personnel involved with this project represent the Environmental Protection Agency, the Department of Environmental Resources, and Gannett Fleming Corddry and Carpenter, Inc. The Project Officer is Eugene F. Harris of the Environmental Protection Agency. Key Department personnel are A. E. Friedrich, John J. Demchalk, and Edward R. Bates, all from the Division of Mine Area Restoration, and A. E. Molinski and Natesa Jayaraman of the Ebensburg District Office for Resources Management. A Department organization chart is shown on Figure 18.

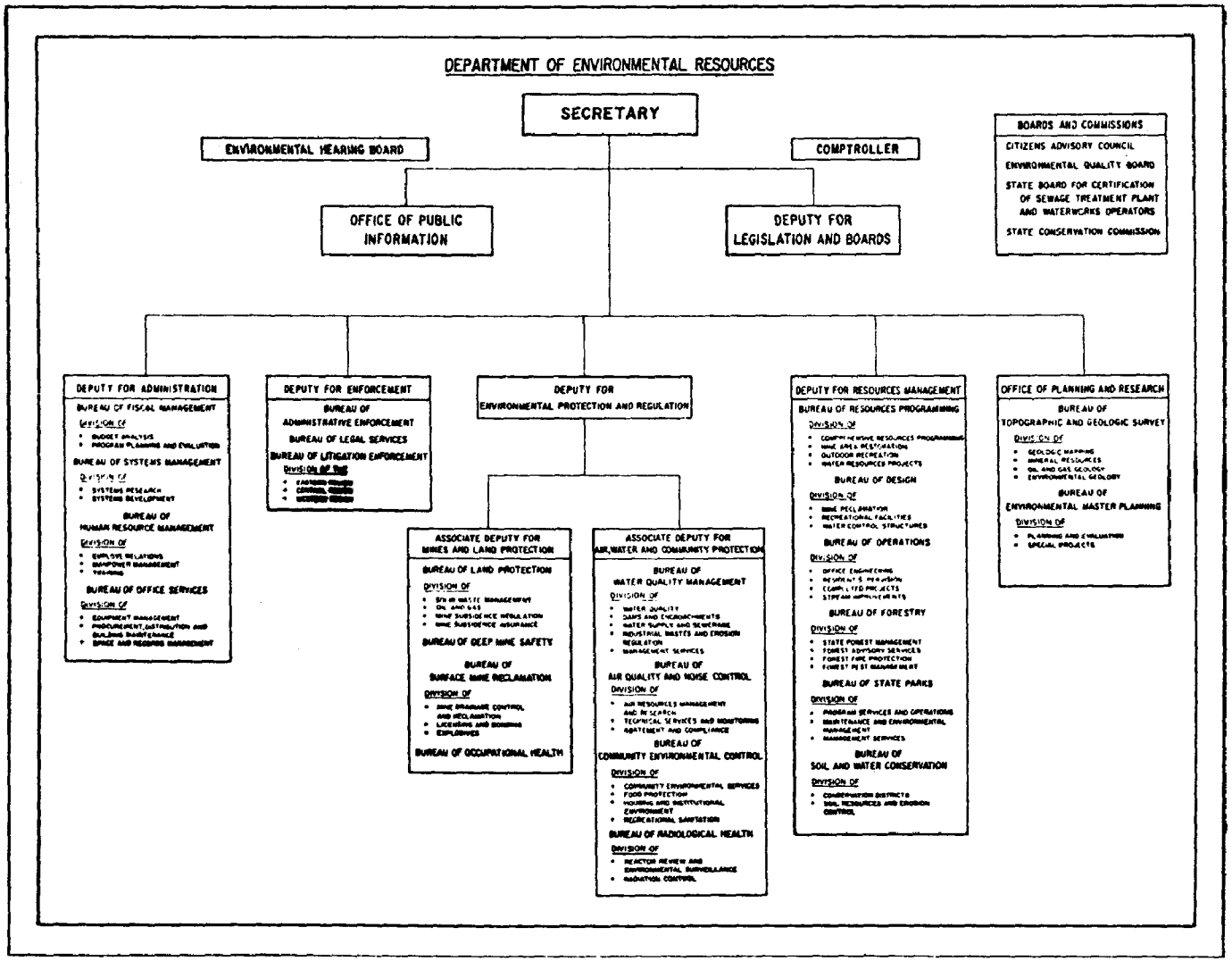


FIGURE 18-ORGANIZATION CHART DEPARTMENT OF ENVIRONMENTAL RESOURCES

Gannett Fleming Corddry and Carpenter, Inc., can draw from more than 300 employees within the Pollution Control Division to accomplish this project. General responsibility for providing the necessary technical services rests with the Mine Drainage Control Group within the Special Projects Section. The Design Section will prepare the construction plans and specifications, as well as perform the detailed survey work. General inspection of construction will be conducted by the Construction - Inspection Section.

The project schedule has been developed so that the project may be completed in an orderly manner. General supervision of construction will be carried out by Gannett Fleming Corddry and Carpenter, Inc., while the Department of Environmental Resources will provide resident supervision. Any required post-demonstration supervision and surveillance will be provided by the Department.

Responsibility for project progress and final reports rests with Gannett Fleming Corddry and Carpenter, Inc. Progress reports will be submitted on a monthly and quarterly basis during the course of this project. The final report will be prepared and submitted four years after commencing work on the project providing the project is conducted according to the proposed schedule depicted in Figure 17.

SECTION IX

REFERENCES

1. Gannett Fleming Corddry and Carpenter, Inc., "Acid Mine Drainage Abatement Measures for Selected Areas Within The Susquehanna River Basin," United States Department of the Interior, Federal Water Pollution Control Administration, Contract No. WA 66-21 (1968).

2. U. S. Corps of Engineers' Investigative Survey, "Occurrence And Effects of Mine Drainage in the Tioga River Basin," (February 1972).

3. O'Brien and Gere Engineers, Inc., "Upper Tioga Water Supply Study," Upper Tioga River Watershed Association, Blossburg, Pennsylvania, (July 1971).

SECTION X

GLOSSARY OF TERMS, ABBREVIATIONS, AND SYMBOLS

cfs	Cubic feet per second - rate of flow
Department	Pennsylvania Department of Environmental Resources
FWPCA	Federal Water Pollution Control Administration
kg/day	Kilograms per day - mass flow rate
lbs./day	Pounds per day - mass flow rate
l/sec	Liters per second - rate of flow
mgd	Million gallons per day - rate of flow
mg/l	Milligrams per liter - concentration
MS	Monitoring Station
Project Site	Recommended site for proposed pollution abatement construction
Study Area	Morris Run Study Area as defined in the 1968 FWPCA Report

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES

*Gannett Fleming Corddry and Carpenter, Inc., Harrisburg, Pennsylvania 17105

16. ABSTRACT

The Tioga River Demonstration Project in southeastern Tioga County, Pennsylvania, is essentially defined by an isolated pocket of coal that has been extensively deep and strip mined within the Pennsylvania Bituminous Coal Field. The Tioga River watershed is subjected to acid mine drainage from abandoned mines in the vicinity of the Borough of Blossburg and the Village of Morris Run.

The proposed demonstration project is recommended: (1) to demonstrate effective techniques for mine drainage abatement, (2) to reduce a specific mine drainage problem, and (3) to restore portions of a mined area to their approximate originial surface grade. Techniques to be demonstrated include: restoration of strip pits utilizing agricultural limestone and sewage sludge as soil conditioners, burial of acid-forming materials within strip mines that are to be restored, and reconstruction and lining of a stream channel.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Watersheds Mines (Excavations) Drainage Coal Mining	Pollution Abatement Tioga County, PA Acid Mine Drainage Surface Mine Reclamation	08/H, 08/G

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