IC bureau of mines information circular 8456

# SURFACE MINE RECLAMATION, MORAINE STATE PARK, PENNSYLVANIA



UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

1970

# SURFACE MINE RECLAMATION, MORAINE STATE PARK, PENNSYLVANIA

By Lewis M. McNay

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UNITED STATES DEPARTMENT OF THE INTERIOR
Walter J. Hickel, Secretary

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# SURFACE MINE RECLAMATION, MORAINE STATE PARK, PENNSYLVANIA

by

Lewis M. McNay[1]

## ABSTRACT

Description of methods employed and cost data are given for surface-mined land reclamation in Moraine State Park, Butler County, Pa. This project was conducted under the authority of the Appalachian Regional Development Act; a total of 177 acres of land was rehabilitated for specific land use purposes. The use of large equipment expedited the project work, and similar results could be anticipated on similar reclamation programs.

## INTRODUCTION

This Bureau of Mines report has been prepared to provide the general public, private industry, and Federal and State Governments with current surface mine reclamation data on the methods and costs of a reclamation project where project specifications required that the disturbed lands be returned to their original contour. The data on this project have been assembled in such a fashion that the equipment costs throughout the Appalachian Region or the Nation may be substituted to determine approximate project costs in an area with similar conditions.

The Moraine State Park project was the first under the Appalachian Surface Mine Reclamation Program in which the Commonwealth of Pennsylvania and the Federal Government (represented by the Bureau of Mines) entered into a cooperative agreement to reclaim and restore surface-mined lands.[2] The project involved approximately 117 acres of surface-mined lands adjacent to a 3,200-acre lake (Lake Arthur).

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[1]Geologist, Division of Environmental Activities, Bureau of Mines, Washington, D.C.

[2]With the signing of Public Law 89-4, the Appalachian Regional Development Act of 1965, the Secretary of the Interior was authorized under Section 205, Mining Area Restoration, of this Act, to make certain financial contributions to States of the region to reclaim and restore lands which had been surface mined prior to March 9, 1965. This Act further qualifies Federal involvement by (a) restricting reclamation only to nonprivately owned lands and (b) limiting the maximum Federal funding to 75 percent of the total project costs.

This project was designed to cope with conditions resulting from past surface and underground mining:

1. Elimination of acid mine water seeping or flowing from abandoned underground mine workings which would be detrimental to the ecological environment in and around the proposed Lake Arthur.

2. Backfilling and regrading of surface-mined areas to original contour to eliminate public hazards associated with open pits, highwalls, exposed deep mine openings, and water containments.

3. Reduction of erosion on barren outslopes and highwalls.

4. Restoration of esthetic values.

Since the completion of the reclamation project described in this report, another project in Moraine State Park has been authorized under the Appalachian Regional Development Act. This project was designed to eliminate the potential pollution of the lake by grouting and sealing 35 abandoned oil and gas wells scattered throughout, but within, the limits of the proposed Lake Arthur. Project work was still underway at the time of this writing.

## ACKNOWLEDGMENT

The Moraine State Park reclamation project was a cooperative effort between the Pennsylvania Department of Mines and Mineral Industries and the Bureau of Mines, U.S. Department of the Interior.

Special acknowledgment is made to the contribution by Adrian D. Davis, Sr., and Adrian D. Davis, Jr., Contractors, Homer City, Pa.

## LOCATION

Moraine State Park, a 15,000-acre recreational facility, located in Brady, Franklin, Muddy Creek, and Worth Townships, Butler County, Pa., is east of the intersection of U.S. Route 422 and Interstate Route 79. This site was selected to serve the six-county Pittsburgh Region, and it is strategically situated within a 60-mile radius of approximately 4 million people. The park attendance is expected to exceed 1 million people annually (fig. 1).

Butler County lies in the Allegheny Plateau, a region characterized by a rolling topography with moderately broad valley bottoms (fig. 2). The general altitude of the plateau is about 1,100 feet with a local relief of 200 to 400 feet.

The topography in Moraine State Park ranges from 1,170 feet along the major drainage channel in the park to 1,520 feet along the hill crests along the northern park boundary. The major drainage channel is Muddy Creek. This creek with its tributaries will feed the proposed 3,200-acre Lake Arthur.

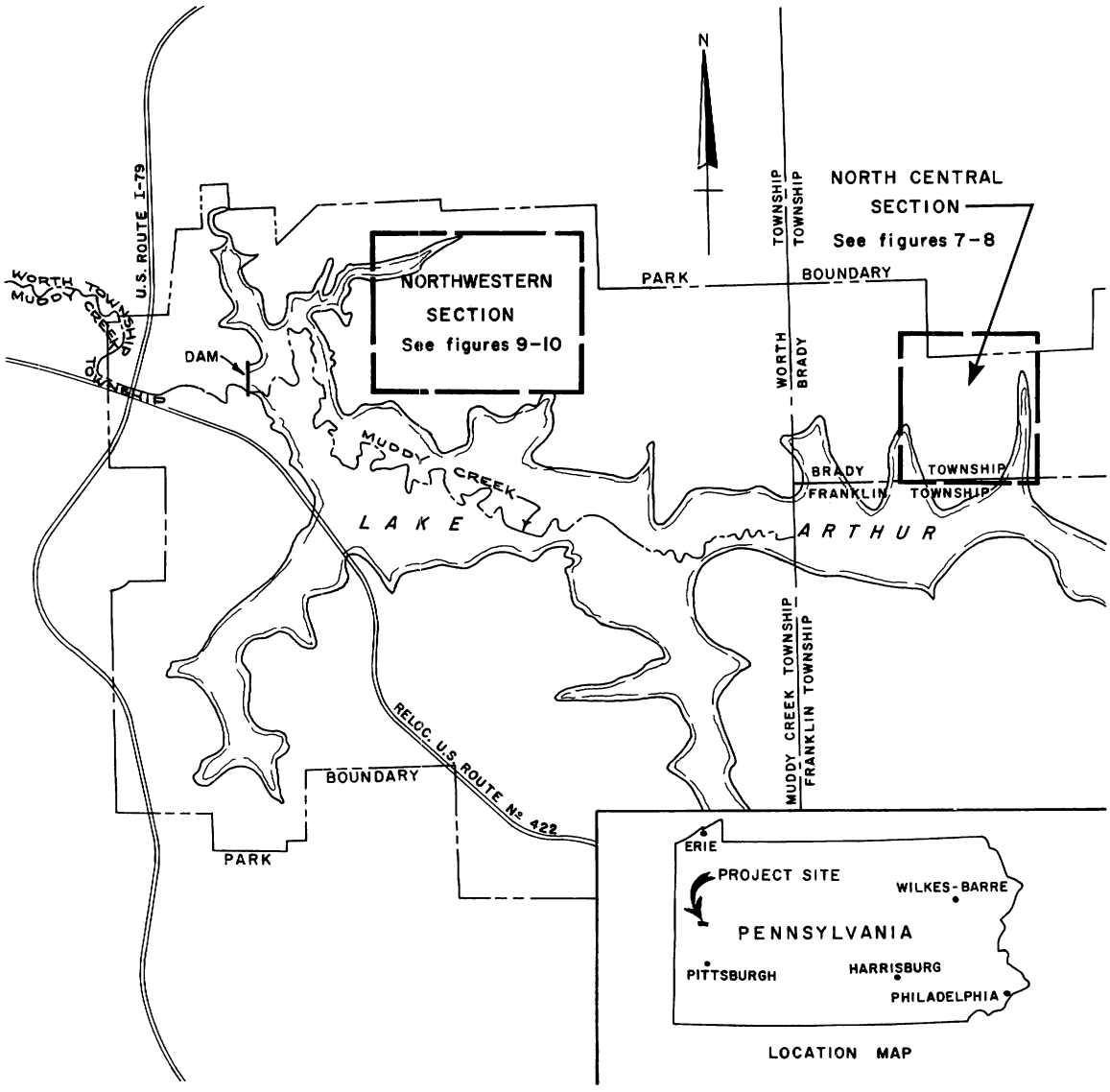


FIGURE 1. - Project Locations, Moraine State Park, Butler County, Pa.

The restoration project was conducted in two main areas, the North Central Section and the Northwestern Section. These two sections are adjacent to the northern edge of the proposed lake site (fig. 1). The North Central Section is located in Brady Township. The Northwestern Section situated in Worth Township is visible from U.S. Route 422.

## GEOLOGY

The outcropping strata in Moraine State Park consist of the Allegheny and Conemaugh Formations of Pennsylvanian age. These consolidated rocks exhibit characteristics similar to all coal measures: (a) they consist of diversified layers of sandstone, siltstone, shale, clay, coal, and freshwater limestone, and (b) they can vary in thickness from absent to tens of feet within a very

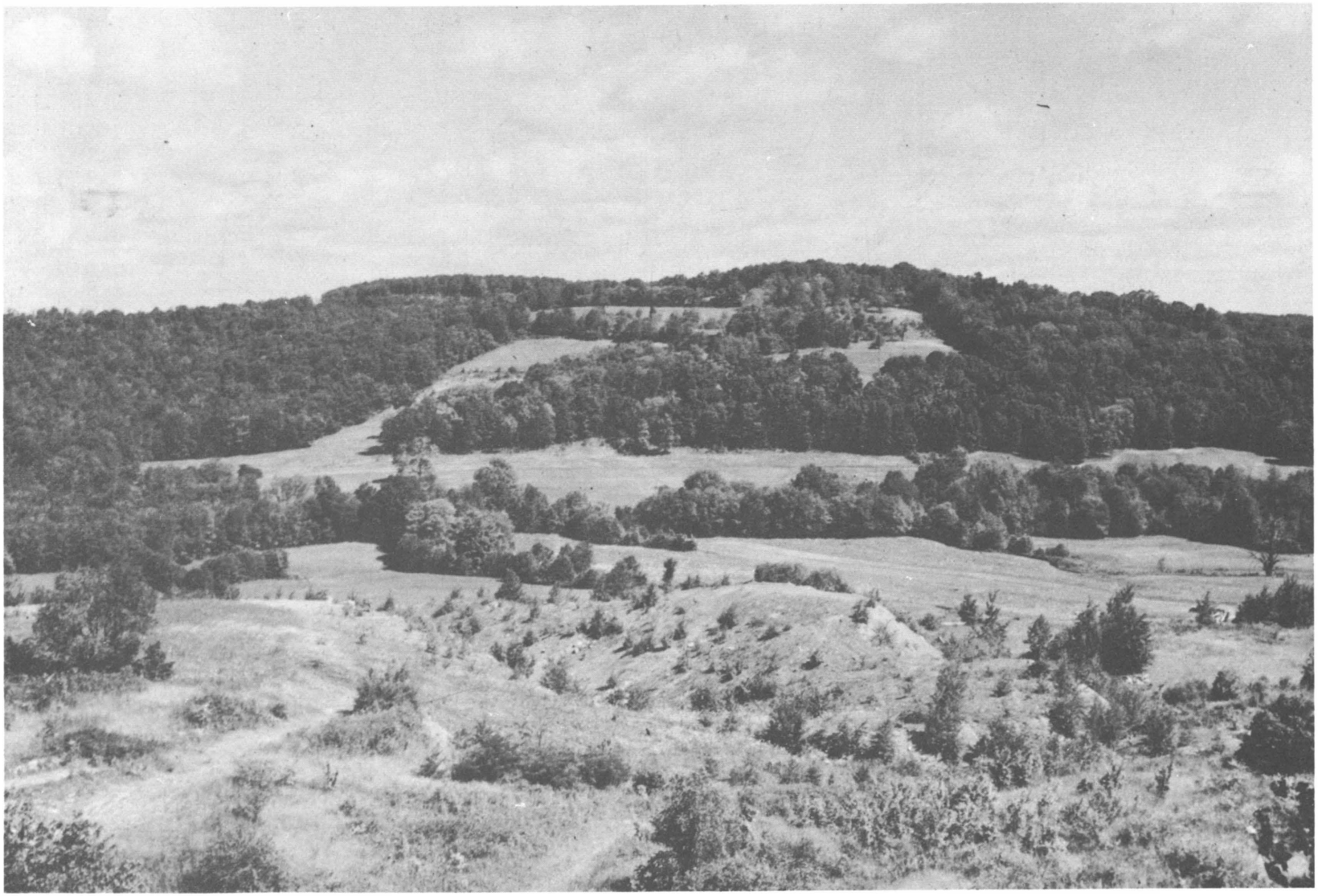

FIGURE 2. - Rolling Topography Characteristic of the Allegheny Plateau Throughout Western Pennsylvania. (Note surface-mined area in center foreground.)

short distance. Four important coalbeds, namely, Middle and Upper Kittanning and Lower and Upper Freeport, crop out within the park boundaries. The Upper Kittanning coal is not sufficiently thick to be mined in this area. A generalized stratigraphic section in Moraine State Park would average approximately 200 feet in thickness (fig. 3).

The Middle Kittanning and the Upper Freeport coals were mined in the North Central Section. The Middle Kittanning coal crops out along the valley bottom and was underground mined prior to surface mining. It has been reported

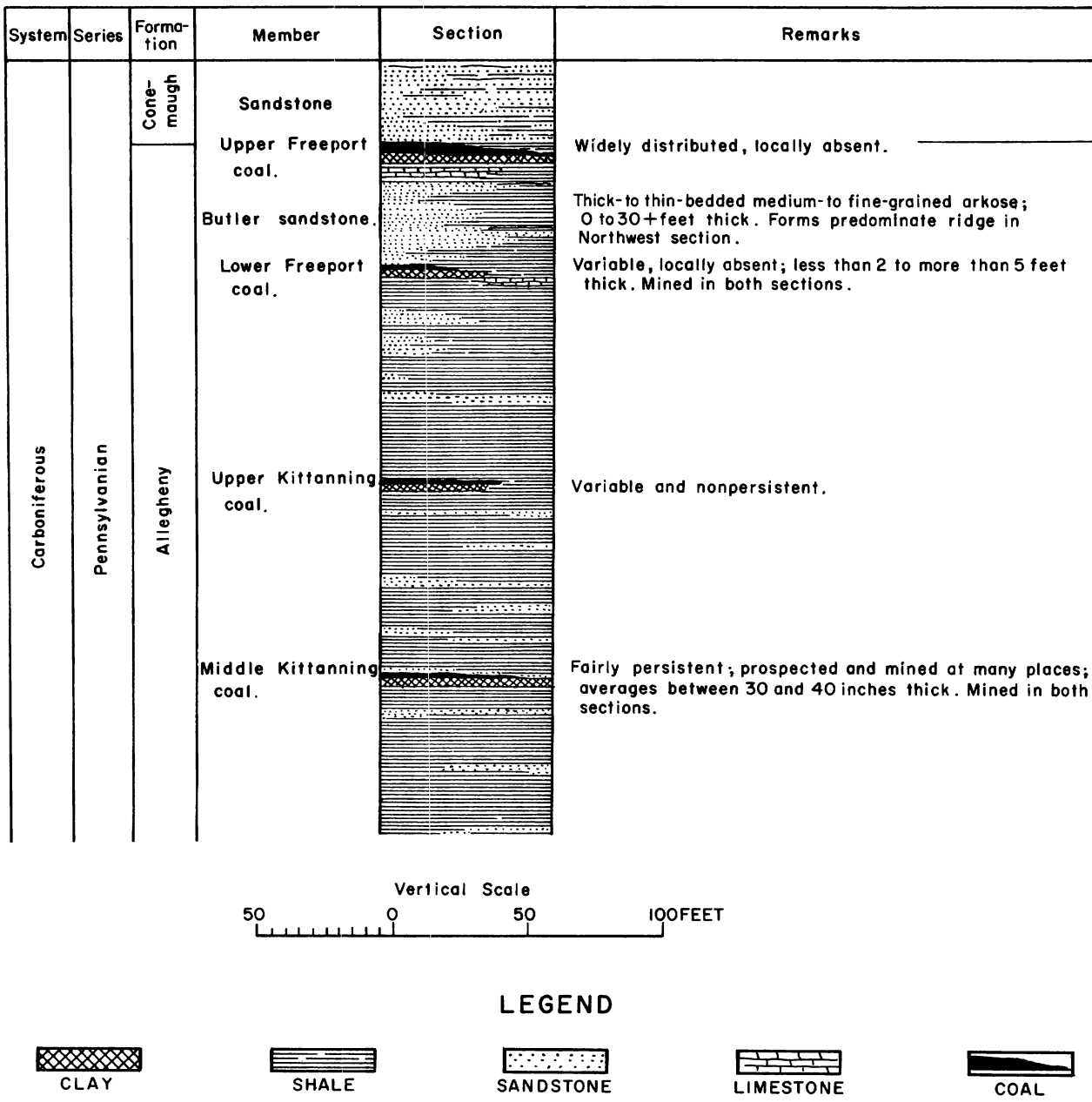


FIGURE 3. - Generalized Stratigraphic Column in the Project Area.

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that the Middle Kittanning coal was 3 feet thick or more in many of the northern townships of Butler County.[3] The Upper Freeport coal was stripped along the upper bench in this section.

The Middle Kittanning and the Lower Freeport coals were stripped in the Northwestern Section. The Lower Freeport coal was reported to be approximately 50 inches thick with one small shale parting in the upper half of the bed. The Middle Kittanning is approximately 15 inches thick in this area.

The Conemaugh Formation is poorly exposed throughout the park; however, it is known that most of the high ridges are capped by this sandstone formation.

A thin veneer of unconsolidated materials of Quaternary age has been deposited along Muddy Creek valley bottom. This material consists predominately of sand, silt, and clay particles which have been transported by glacial melt waters or normal stream action.

The structure of the Allegheny and Conemaugh Formations within the park boundaries displays a simple attitude which dips gently toward the southeast. The axis of this broad northeast-southwest trending anticlinal structure (Homewood Anticline) lies to the northwest of the park boundary.

## HYDROLOGY

Muddy Creek, the southernmost tributary of Slippery Rock Creek, is the main stream flowing through Moraine State Park. The Muddy Creek Watershed which drains 58.5 square miles will supply the water for the proposed 3,200-acre Lake Arthur. The small tributaries of Muddy Creek are Bear Run, Big Run, Shannon Run, and Swamp Run.

The alkaline condition of the water flowing in Muddy Creek is normally favorable to the support of aquatic plant and animal life and to the development of the major recreational facility. However, during periods of unusually high rainfall and the winter and spring snow melts, the stream is subject to an increased inflow of acid mine drainage.

The acid water pollution in Muddy Creek is directly attributed to past surface and underground extraction of coal from approximately 66 mines which have been located on the five productive coal seams in the watershed. This pollution originates predominately from unsealed abandoned underground mine shafts, slopes, and adits. Surface mining is believed to contribute less than 20 percent of the total pollutant;[4] however, surface mining is indirectly responsible for escape of acid water pollution because surface mining frequently intersects and exposes abandoned underground mine workings.

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[3] Ashly, G. H. Bituminous Coal Fields of Pennsylvania. Part 1, General Information on Coal. Pennsylvania Topographic and Geologic Survey Bull. M6, 1928, 241 pp.

[4] Pennsylvania Department of Health. Report on Pollution of Slippery Rock Creek. Pub. 8, Jan. 21, 1965, 76 pp.

The water quality of Muddy Creek is inversely related to the amount of water flow in the watershed. The increase in acid content is attributed to greater inflow of acid mine water from underground mines predominately during periods of high surface water runoff. The acid load in Muddy Creek has been measured at 630 pounds of acid per day.[5]

## CONDITION OF SITES PRIOR TO RECLAMATION

The two project sites, referred to as the North Central Section and the Northwestern Section, are located adjacent to the northern shore of the proposed Lake Arthur. These two areas which cover approximately 177 acres are but a small portion of the total 15,000-acre park; however, they are situated in areas designed to receive a high flow of park visitors.

Bituminous coal was extensively mined throughout the area using both underground and surface recovery techniques. Most of the mining occurred prior to World War II and in comparison with modern coal mining operations these mines were relatively small and of short duration. The last surface mining in and around the project sites was conducted about 1945.

Surface mine regulations in the mid-1940's were minimal, and little effort was made by operators to reclaim or restore the disturbed acreages. Little or no backfilling of the surface excavations was required; the large percentage of rock and dirt existing in the pit bottoms was the result of sliding and spalling of rock from the highwall.

The surface condition of the project areas was characterized by irregular mounds and pits, fill benches, vertical highwalls, and a variety of trees and plants (figs. 4-6).

The North Central Section (fig. 7), the smaller of the two project sites, covered about 57 acres. The area was comprised of two units with somewhat contrasting conditions. The Middle Kittanning coal was mined in the lower area to the southeast. Overburden from this operation has been cast over a wide area, including part of the adjacent valley bottom. In the larger area to the northwest contour strip mining took place in the Upper Freeport coal; the essentially flat-lying coal seam cropped out horizontally around the hill. As a result, a large isolated island was created within the stripped area. The highwall height averaged about 45 feet throughout this section.

The Northwestern Section consisted of approximately 120 disturbed acres. As depicted by the irregular patterns of the contour lines the surface configuration was very rough (fig. 9). The Middle Kittanning coal was mined in the lower cut and the Lower Freeport was extracted in the larger disturbed area. The highwall heights averaged 45 to 50 feet; however, a few heights in excess of 75 feet existed.

Surface mining operations exposed several underground mine workings throughout the project areas. Many of these openings were not only a public

[5]Work cited in footnote 4.

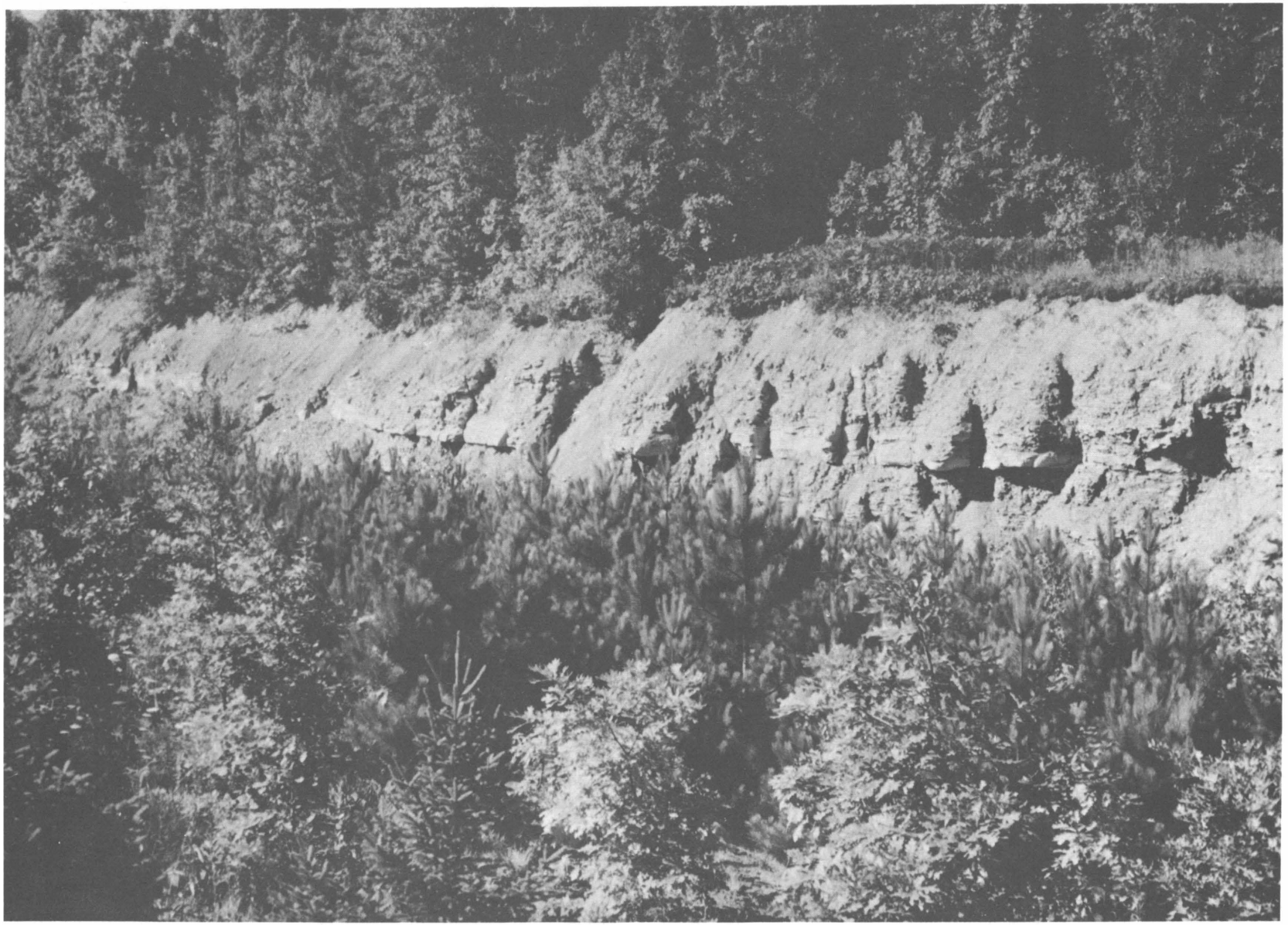

FIGURE 4. - View of North Central Section Prior to Reclamation.

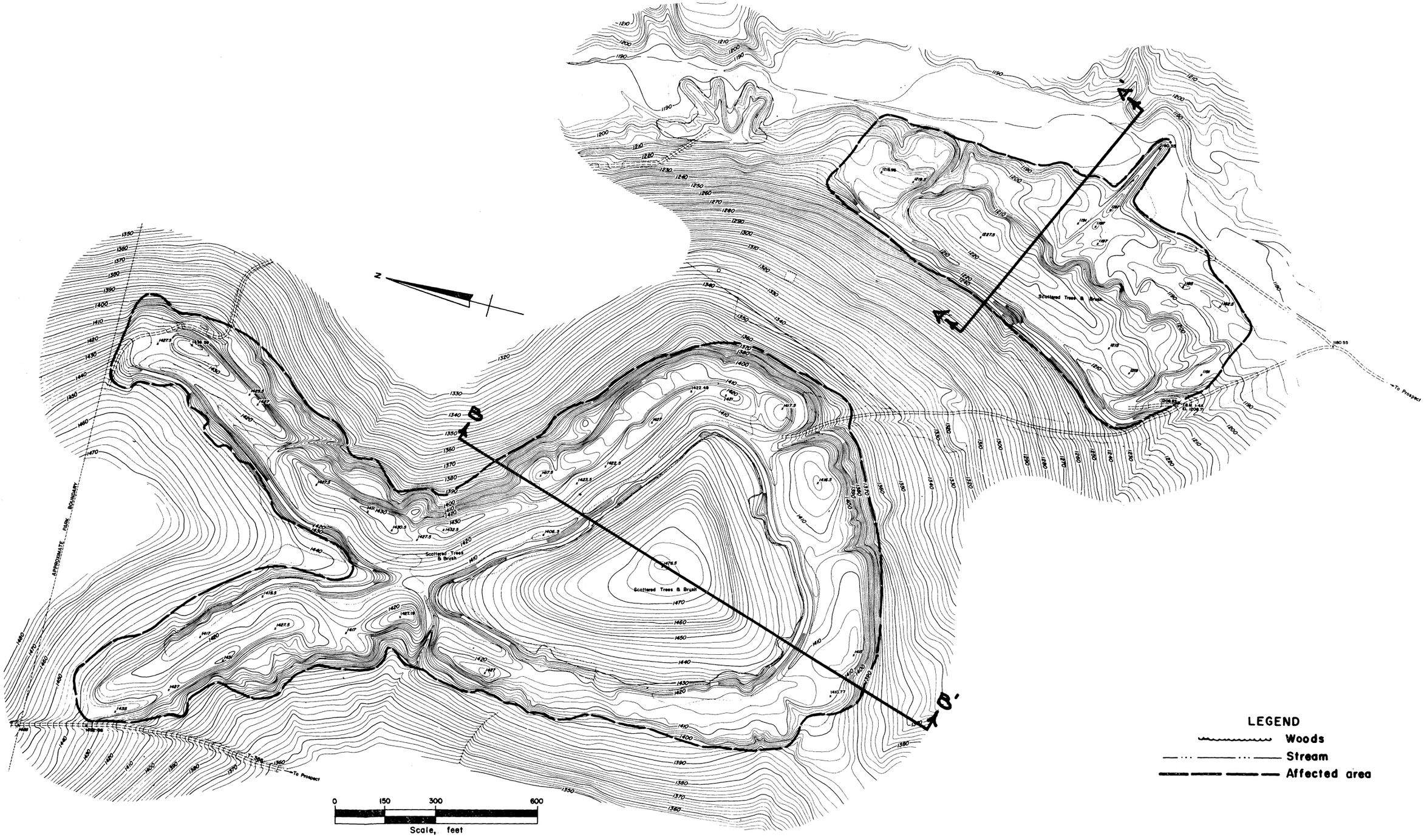


FIGURE 7. - Contour Map of North Central Section Prior to Reclamation.

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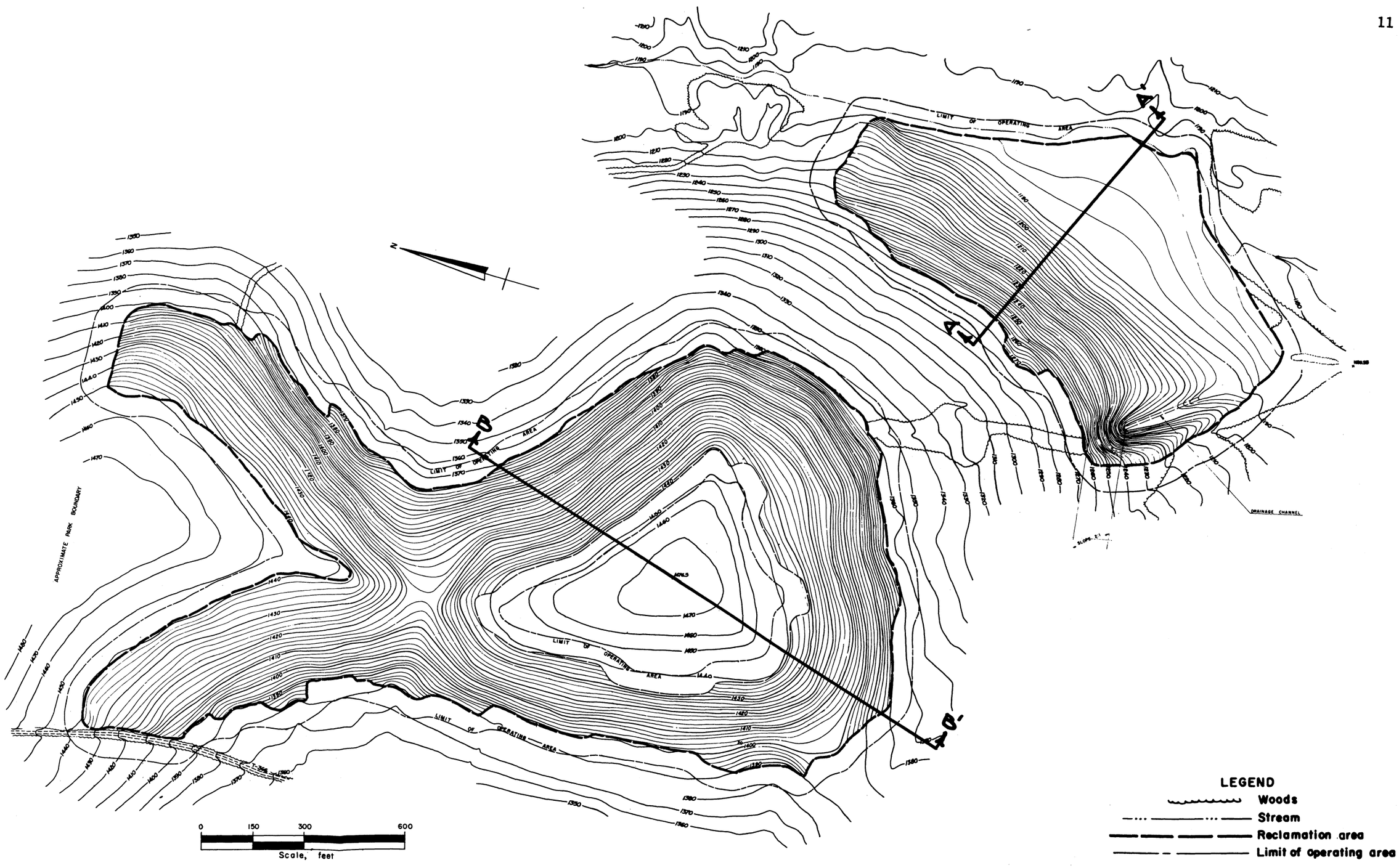


FIGURE 8. - Contour Map of North Central Section Following Reclamation.

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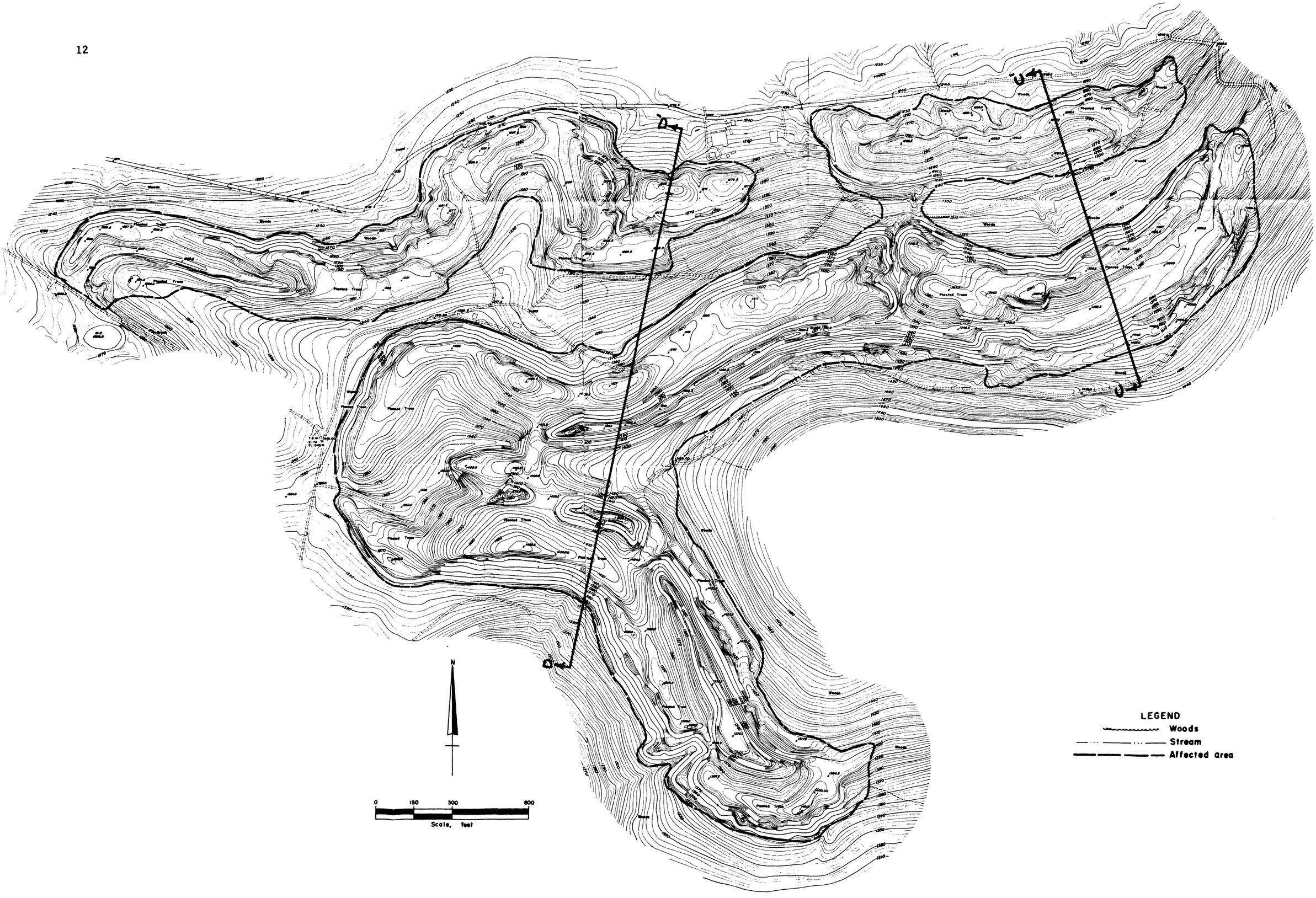


FIGURE 9. - Contour Map of Northwestern Section Prior to Reclamation.

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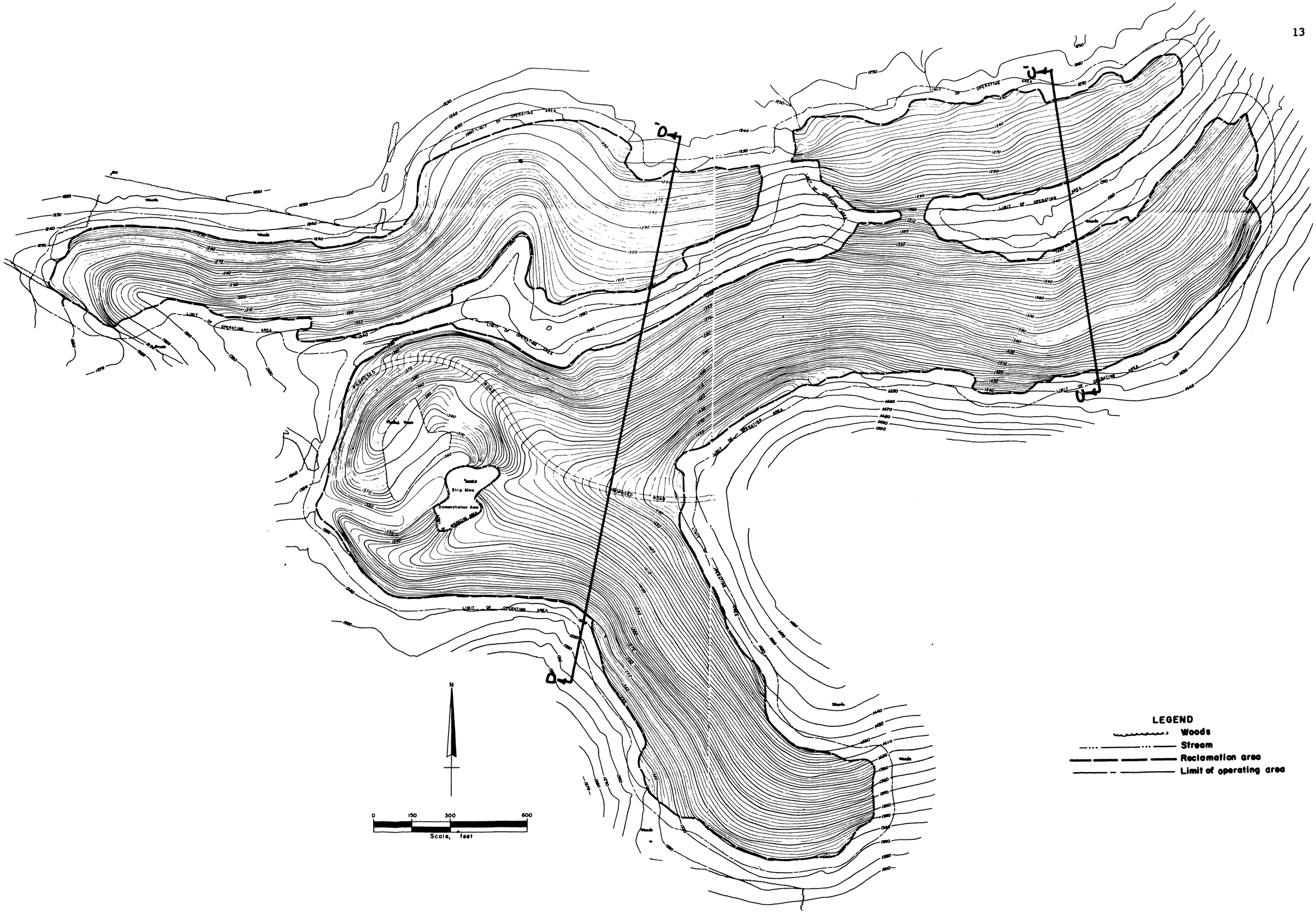


FIGURE 10. - Contour Map of Northwestern Section Following Reclamation.

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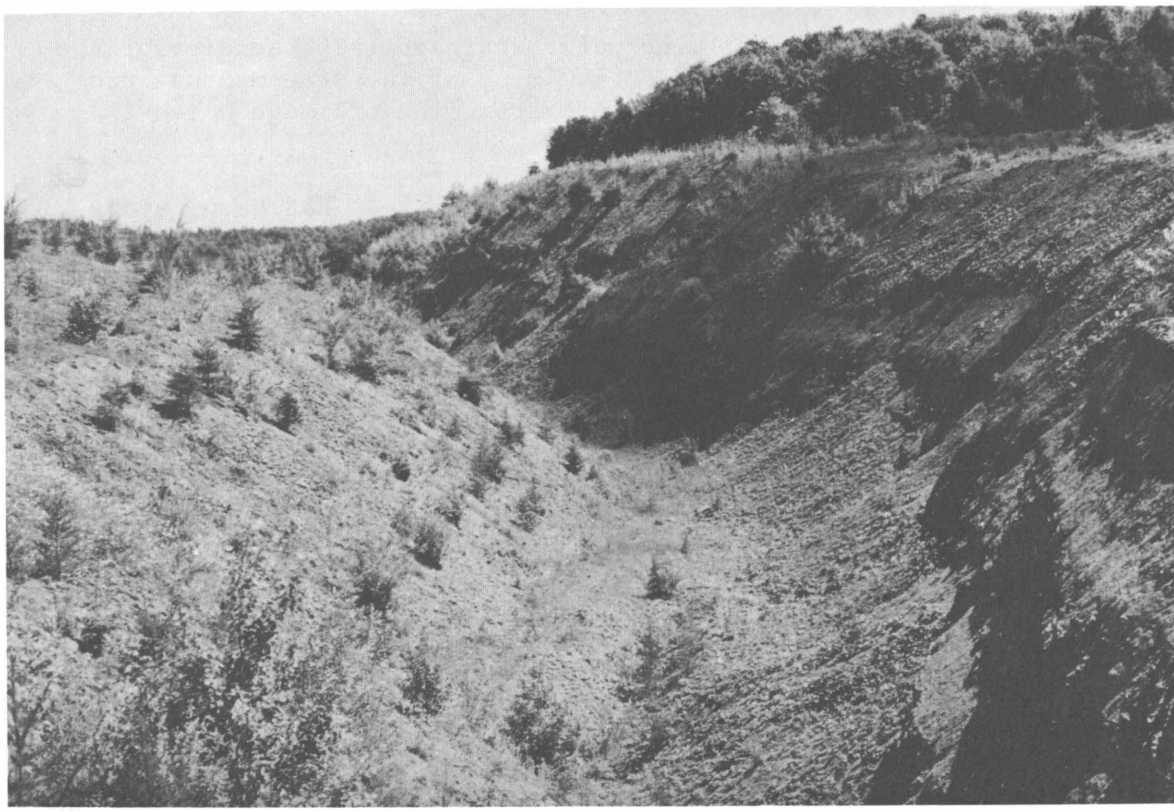

FIGURE 5. - Typical Appearance of Northwestern Section Prior to Reclamation.

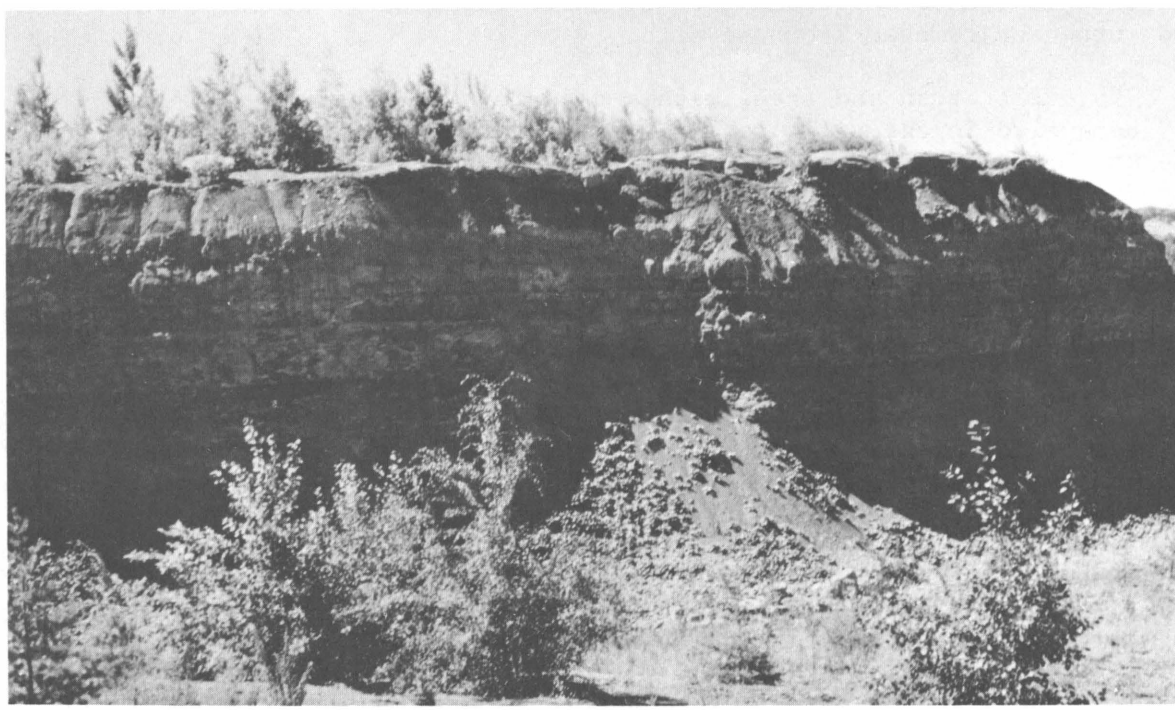

FIGURE 6. - Highwall Escarpment (80 Feet) in the Northwestern Section.

safety hazard, but also a source of mine water drainage. The acidity of the mine water was measured to have a pH 3 to 4. Many of the stream beds were coated with "yellow boy," an iron precipitate from mine drainage which smothers bottom flora and fauna.

A substantial vegetative cover over the project areas had been established since mining terminated 25 years ago. Many of the trees had been planted under State programs, while many of the grasses and legumes were volunteer growth.

## PROJECT SPECIFICATIONS

The reclamation and restoration work in Moraine State Park involved the clearing, excavating, backfilling, and regrading of the disturbed lands in the project areas. This work was conducted in accordance with the rules and regulations of the Land Reclamation Board, Pennsylvania Department of Mines and Mineral Industries, and the Pennsylvania Bituminous Coal Open Pit Conservation Act, unless otherwise required.

The following project specifications are excerpts from the project contract.

### Preparation of Sites

All vegetation within and immediately adjacent to the project areas is to be removed or disposed of by the following procedure:

> "a. All trees with a diameter of 1-1/2 inches or greater, measured 12 inches above the ground, shall be uprooted or cut down and burned or removed from the site.
>
> "b. All brush and trees with a diameter less than 1-1/2 inches may be buried in the fill area. If inspector should determine that the accumulation of brush and/or trees to be excessive the contractor will be required to remove or spread the material over a greater area.
>
> "c. In the fill area, all tree stumps with a diameter greater than 1-1/2 inches which are not uprooted may be left in place.
>
> "d. All brush and trees which are to be buried must be buried in the pit on the opposite side from the highwall and covered with at least three feet of fill."

### Backfilling and Terracing

Because of the location of the project areas to the proposed Lake Arthur and other recreational and education facilities within Moraine State Park, the project specifications required that the disturbed lands be restored to approximately their original contour or to a contour compatible to the surrounding terrain. This involved moving a vast amount of spoil bank material back into the strip pits.

Specific backfilling specifications required:

"a. All rocks in excess of 1 cubic yard to be disposed of and other rough rock must be covered with at least 6 inches of the best available material.

"b. No depressions to retain water which may seep through the spoil and produce acid drainage will be permitted.

"c. All toxic material is to be buried in strip pits with at least three feet of cover.

"d. The best available fine spoil and top soil is to be used for the surface cover in the reclaimed areas.

"e. A drainage channel will be constructed at the downstream end of the lower seam in the North Central Section according to the contract specifications."

### Contractor's Responsibility

Upon completion of the work the contractor was required to restore the land which he has affected outside the project area. He was to return this land to its original elevation, contour, and condition existing prior to commencing project work; restore or replace all improvements to the land (including structures, buildings, fences, landscaping, etc.) which may have been removed or damaged by or as a result of the project work.

## PROJECT WORK

The actual project work consisted of site preparation, backfilling, and terracing the surface pits to original contour.

### Preparation of Sites

The initial work effort was directed toward improving the project sites to provide access roads and clean the overburden spoil of the vegetative overgrowth for the larger earthmoving equipment. The work involved the clearing, grubbing, and disposal of brush and trees (fig. 11). This task was performed by a Series 3-T Caterpillar D-7 Bulldozer[6] equipped with blade and rootrake. The rootrake was found to be ineffective because of the small size of trees and brush found on the project sites. The vegetation, however, was easily handled and removed by the D-7's blade.

The average time required to clear the sites ranged from 2.5 hours per acre in the North Central Section to 3.5 hours per acre in the Northwestern Section. This difference in operating time is attributed to (a) the steeper terrain in the Northwestern Section and (b) adverse winter weather conditions during work in the Northwestern Section.

[6]Reference to specific makes or models of equipment is made to facilitate understanding and does not imply endorsement by the Bureau of Mines.

FIGURE 11. - Clearing and Burning Brush and Trees Prior to Site Reclamation.

Table 1 presents data on site preparation time and costs.

TABLE 1. - Summary of site preparation costs

| Section | Work, hours | Acres | Time/acre, hours | Average[1] D-7 cost per hour | Cost/acre |
|---|---|---|---|---|---|
| North Central..... | 148 | 57.3 | 2.58 | $13 | $33.54 |
| Northwestern..... | 424 | 120.2 | 3.52 | 13 | 45.76 |
| Average..... | - | - | 3.22 | 13 | 41.86 |

[1]Average cost of operating a D-7 Caterpillar as found in Rental Rate Blue Book, 1965, National Research and Appraisal Company.

## Backfilling and Terracing

The two project sites were returned to their original contour (figs. 8 and 10) by moving approximately 1.4 million cubic yards of overburden. The slope to which the disturbed area was returned averaged 10°. Locally, original slopes ranging up to 13° existed in the Northwestern Section. Figure 12 illustrates the profile of the two project areas prior to reclamation and the configuration of the areas after completion of the restoration work.

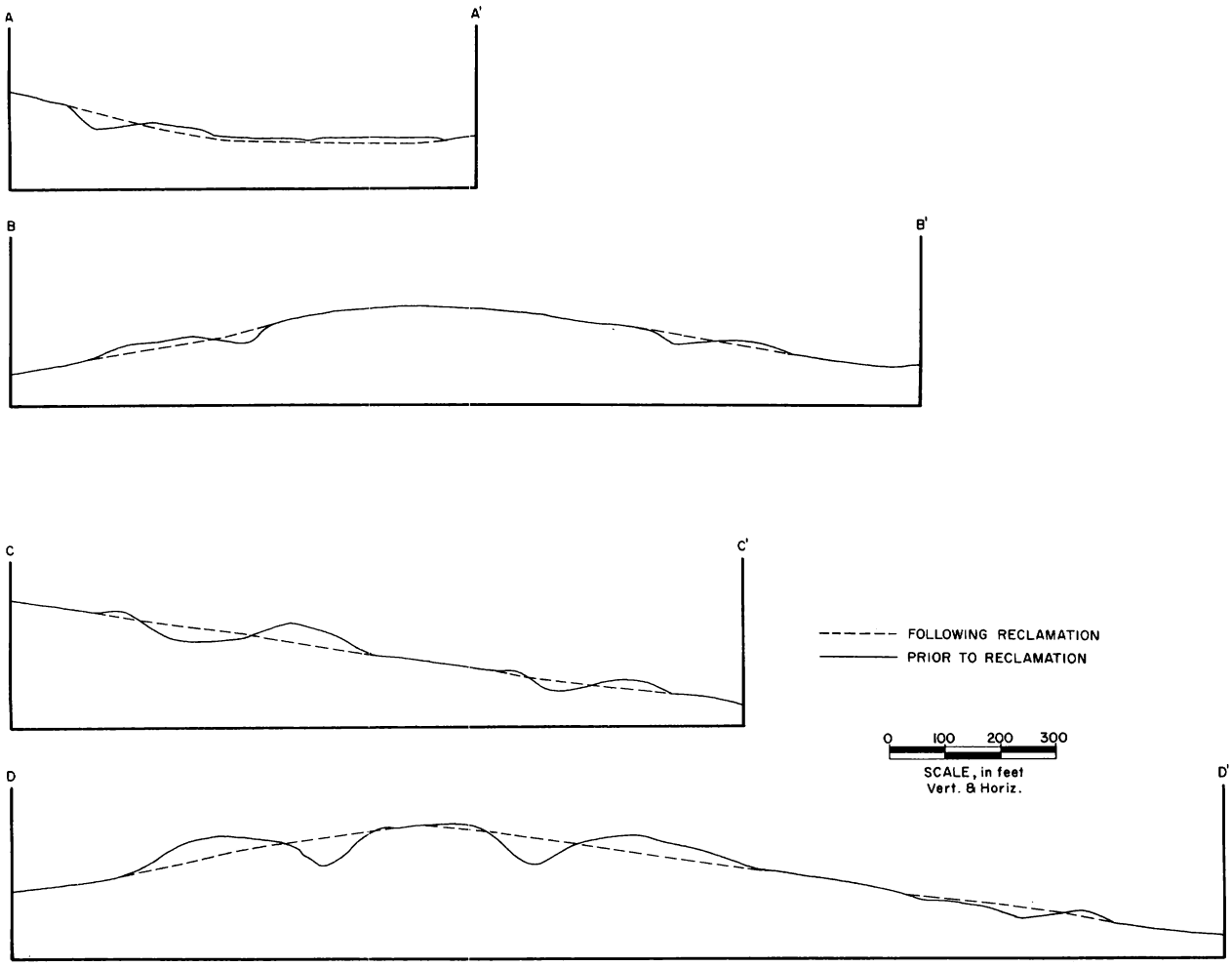


FIGURE 12. - Profiles Illustrating the Before and After Configuration of Surface in Project Areas.

Project work in the North Central Section was conducted during the summer and fall months. The spoil material consisted predominately of weathered shale and siltstone with intermixed sandstone slabs. The only difficulty in the reclamation of this section was encountered on the lower seam in the southeast unit. Beneath the Middle Kittanning coalbed there is a clay bed which when water-soaked made it practically impossible for the equipment to maintain adequate traction while moving the overlying material in the outcrop area. The distance material had to be transported in the North Central Section averaged between 250 to 300 feet along the upper seam and greater than 600 feet along the lower seam (fig. 12).

Reclamation in the Northwestern Section was done during the fall, winter, and early spring months. The spoil material was similar to that found in the North Central Section, except that there was a greater number of sandstone blocks distributed throughout the spoil. The work efficiency suffered somewhat in this phase of the project because the ground was frozen a substantial

portion of time during the winter. This setback was offset to a large extent by using a bulldozer equipped with a ripper to break the frozen spoil. The average distance the spoil material had to be transported increased to about 400 feet while a few sections covered more than 600 feet (fig. 12).

In June 1967 the initial equipment which was deployed to the North Central Section included two Series 18-A Caterpillar D-9 bulldozers (fig. 13). A Series 66-A Caterpillar D-9 equipped with Boulderson blade and a Series 14-A Caterpillar D-8 were added to the work force late in July. A second Series 14-A Caterpillar D-8 arrived at the project site in August.

Total equipment deployed to move the spoil material included:

| Number | Type | Accessory equipment |
|---|---|---|
| 2 | 18-A Caterpillar D-9..... | None. |
| 1 | 66-A Caterpillar D-9..... | Boulderson blade. |
| 1 | 46-A Caterpillar D-8..... | Ripper. |
| 2 | 14-A Caterpillar D-8..... | U-blades. |
| 3 | Westinghouse 20-ton scrapers | None. |

By mid-September all project work except the grading of a drainage ditch was completed in the North Central Section (fig. 14), and the equipment was transferred to the Northwestern Section (fig. 15). The final grading on the drainage ditch was delayed because the area was too wet to be effectively graded at that time. This work was completed in December.

In December, the contractor working under a codicil to the original agreement removed material from five coal refuse banks from areas to be inundated by the proposed lake. This material was buried in the surface pits in the Northwestern Section. The volume of this acid-producing material was negligible when compared to the volume of strip-spoil moved. Three Westinghouse scrapers and two Euclid trucks performed the work. This work did not interfere with the original reclamation work nor was the cost of this work borne by the original project contract.

Removal of the refuse banks was completed in March, at which time the Westinghouse scrapers were assigned to the original reclamation project. A Series 46-A Caterpillar D-8 was used to assist the scrapers (fig. 16).

The reclamation work in the Northwestern Section was completed in May 1968 (fig. 17).

About 29 hours of total equipment time per acre were required to complete the reclamation objectives in the North Central Section as compared to the 51 hours of operating time per acre required in the Northwestern Section. Essentially two factors influenced this increase in working hours:

1. To return the mined areas to their original contour the North Central Section required moving approximately 5,000 cubic yards per acre while the Northwestern Section with its deeper excavations required about 9,000 cubic yards per acre.

FIGURE 13. - Backfilling of Surface-Mined Area in the North Central Section.

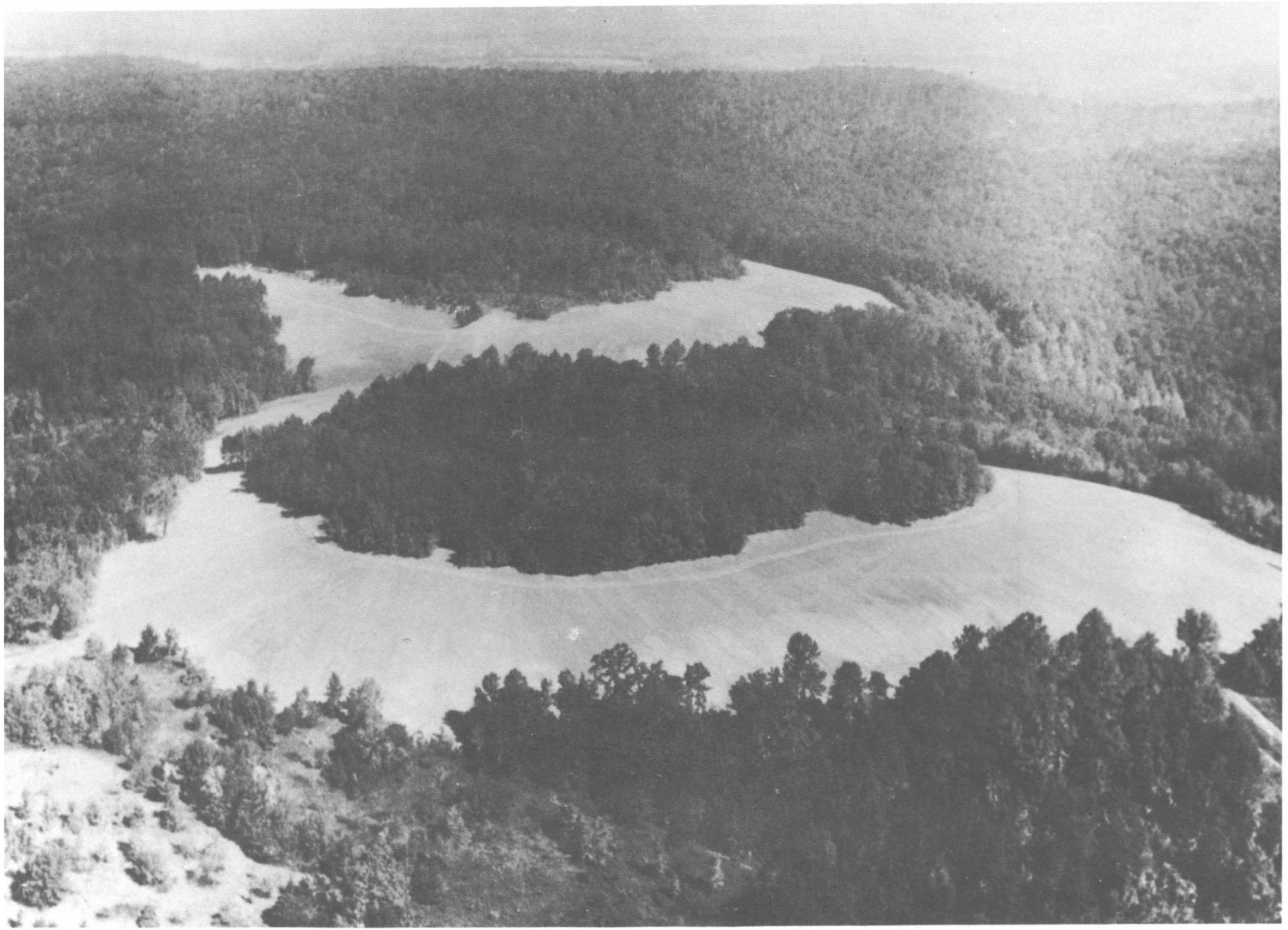

FIGURE 14. - Aerial View of the North Central Section Following Backfilling and Grading.

FIGURE 15. - Scene of Reclamation Work Before the Scrapers Were Added to Working Force. Note the distance the material had to be transported.

FIGURE 16. - Bulldozer Assisting Scraper in the Northwestern Section.

FIGURE 17. - View of Completed Backfilling and Grading in the Northwestern Section.

2. The distance that the equipment had to travel was significantly greater in the Northwestern Section as indicated in previous paragraphs. Although there was a substantial increase in the quantity of material and the pushing distance, the operating time and costs were held to a minimum because of equipment modification and operating procedures. (See Discussion.)

A breakdown of total equipment time required to complete the backfilling and terracing phase of the reclamation project is presented in table 2.

TABLE 2. - Summary of equipment time

| Equipment model (series) | North Central Section | | Northwestern Section | |
|---|---|---|---|---|
| | No. of pieces | Work, hours | No. of pieces | Work, hours |
| D-9 (66-A)..... | 1 | 384 | 1 | 1,352 |
| D-9 (18-A)..... | 2 | 1,018 | 2 | 2,116 |
| D-8 (46-A)..... | - | - | 1 | 848 |
| D-8 (14-A)..... | 2 | 270 | 2 | 1,388 |
| Scrapers..... | - | - | 3 | 432 |
| Total..... | - | 1,672 | - | 6,136 |

The average cost of material moved was $0.16 per cubic yard in the North Central Section and $0.15 per cubic yard in the Northwestern Section (table 3). These costs are based solely on operating equipment time and do not include repair and maintenance costs, support equipment, and office facilities.

TABLE 3. - Summary of reclamation costs[1]

| Section | Total work, hours | Acres | Time/ acre, hours | Average[2] cost of equipment per hour | Cost/acre | Cost/ cubic yard |
|---|---|---|---|---|---|---|
| North Central.. | 1,672 | 57.3 | 29 | $26.88 | $780 | $0.16 |
| Northwestern... | 6,136 | 120.2 | 51 | 27.50 | 1,402 | .15 |

[1]Does not include site preparation costs presented in table 1.
[2]Average cost of operating all Caterpillar equipment used in the reclamation work as found in Rental Rate Blue Book, 1965, National Research and Appraisal Company.

Adequate drainage provisions were made during the reclamation operation. A ditch was constructed in the North Central Section in the southern tip of the area mined for Middle Kittanning coal. A seal was placed (under a separate project contract) at the mine mouth. A second drainage was constructed in the Northwestern Section by laying a concrete pipe in an existing drainage channel (fig. 18) from the Upper Freeport coal seam to prevent erosion of the reclaimed area by mine drainage seepage from the underground mine. The outlet was immediately above the reclaimed lower section, and consequently a channel (fig. 19) was constructed to divert the water around the reclaimed area.

FIGURE 18. - Area Where a Concrete Drainage Pipe Was Laid to Control Erosion of Reclaimed Land.

FIGURE 19. - Ditch Constructed to Divert Water Flowing From an Underground Mine in the Northwestern Section.

## VEGETATION OF PROJECT SITES

The establishment of a vegetative cover on the reclaimed areas was not included in the Federal-State cooperative contract for the restoration of the surface-mined areas. The revegetation operations were conducted by the Pennsylvania Department of Forests and Waters after the reclamation work had preliminary approval by the Federal and State project representatives. The reclamation work in the North Central Section was completed in the fall and the area was immediately prepared for planting. The North Central Section received chemical treatment (8-1/4 tons of 10-10-10 fertilizer and 110 tons of standard ground limestone) before grasses were sowed. The quantity of grasses applied to the area were as follows:

| | Pounds |
|---|---|
| Common rye grass... | 440 |
| Timothy..... | 220 |
| Orchard grass..... | 275 |
| Common clover..... | 110 |
| Bird's-foot trefoil | 110 |

Figure 23 shows a view of the North Central Section during the final inspection of the project in May 1968. Grasses were not sown in the Northwestern Section; however, volunteer growth was observed at several locations during the May inspection.

In addition to the application of grasses, trees were planted on an 8- by 8-foot spacing in the North Central and Northwestern Sections. Evergreens were planted in May 1968; the type and number of trees included:

| | Number |
|---|---|
| Red pine..... | 17,500 |
| White pine..... | 16,800 |
| Banks pine..... | 2,800 |
| Pilch pine..... | 1,400 |
| Australian pine.... | 2,100 |
| White spruce..... | 14,000 |
| Norway spruce..... | 9,800 |

A 70- to 75-percent survival was estimated in April 1969. At this time, deciduous trees, such as red oaks and red maple, were introduced to the Northwestern Section.

## DISCUSSION

The reclamation of 177 acres at Moraine State Park, Butler County, Pa., was the first mined-land restoration project under the Appalachian Regional Development Act. The fine texture of the spoil material facilitated its movement, and except for a few large sandstone slabs no major earthmoving obstacles were encountered. Although most of the project work was conducted during the winter months, only 5 work days were lost.

The reclamation work, which ran approximately $800 per acre in the North Central Section and $1,400 per acre in the Northwestern Section, is costly when compared to basic reclamation cost necessary to satisfy many of the current State surface reclamation laws. This project, however, was to repair the affected acreage to a higher and more specific land use which is not the case in basic reclamation and was undertaken long after the original surface mining had ceased and the mining equipment had left the site. Consequently, these costs are applicable only when the reclaimed land is intended for multiple use or special objectives as outdoor recreation, residential, commercial, or industrial development, cropland or wildlife habitats, and/or when reclamation is accomplished at a late date, and/or when reclamation is performed by persons other than the mine operators.

Operating costs per cubic yard of material moved were less in the Northwestern Section than the North Central Section even though (a) the average distance the overburden had to be moved was greater; (b) the number of cubic yards of spoil necessary to reclaim an acre of disturbed land was almost doubled; (c) the spoil contained a greater number of sandstone slabs; and (d) the spoil was frozen during the winter months (fig. 20).

These lower operating costs in the Northwestern Section are attributable to:

1. The project equipment arrived at the North Central Section at various intervals throughout the project work.

2. The total work force had developed efficient working procedures by the time work began in the Northwestern Section. At the outset of project work the bulldozers operated individually; however, shortly after a month had expired a team approach was initiated which resulted in a more systematic reclamation effort. This proved advantageous in regard to support assistance and equipment maintenance; and the project inspectors could more easily evaluate the actual work accomplished.

3. The Caterpillar D-9, equipped with a Boulderson blade (fig. 21), significantly increased the number of cubic yards moved per haul cycle as compared to the machines equipped with the normal or U-blades.

4. The scrapers were instrumental in an early completion of reclamation work (fig. 22). These machines not only have a greater load capacity than the bulldozers but they also have the advantage of speed over the bulldozers.

It was found that the use of large equipment, such as the scrapers and bulldozers equipped with the Boulderson blade, expedited the project work. Similar results could be anticipated on any reclamation program which would be conducted under similar physiographic conditions and of comparable magnitude to the Moraine State Park project.

FIGURE 20. - Project Work in the Northwestern Section Under Adverse Weather Conditions.

FIGURE 21. - Comparison of the Moving Capacity of Two Types of Blades: Boulderson Blade (Foreground) and U-Blade (Background).

FIGURE 22. - Scrapers Move More Material Per Haul Cycle.

FIGURE 23. - View of Plant Survival in North Central Section After One Growing Season (July 1968).

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