

ENGINEERING GEOLOGY OF DAM SITE AND
SPILLWAY AREAS FOR THE MONROE RESERVOIR,
SOUTHERN INDIANA

by
JOHN D. WINSLOW
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WILTON N. MELHORN

Indiana Department of Conservation
GEOLOGICAL SURVEY
Report of Progress No. 19

1960

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GEOLOGICAL SURVEY
John B. Patton, State Geologist
Bloomington

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ENGINEERING GEOLOGY OF DAM SITE AND SPILLWAY AREAS FOR THE MONROE RESERVOIR, SOUTHERN INDIANA

By John D. Winslow, Gary R. Gates, and Wilton N. Melhorn¹

ABSTRACT

The Salt Creek drainage basin in Monroe, Brown, and Jackson Counties, Ind., was studied to provide basic information for the planning of the Monroe Reservoir. This report principally concerns the dam site and spillway areas of the proposed reservoir.

Four units, defined on the basis of engineering characteristics, are present in the reservoir area. Impermeable siltstones of the Borden Group form the valley walls along Salt Creek and will confine the reservoir. Rocks of a second unit, the Harrodsburg and Salem Limestones, cap the ridges high above flood-pool level (556 feet). The two remaining units consist of unconsolidated materials in the valley of Salt Creek. Terrace deposits above the flood plain are sandy to gravelly silts. Valley-fill deposits as much as 70 feet thick are present in the valley of Salt Creek. Clayey silts predominate in the valley fill and form a satisfactory foundation material of low permeability for the dam.

Two spillway locations have been considered for the Monroe Reservoir. The first, a short distance from the dam site, would require a channel through about 90 feet of bedrock, the upper 50 feet of which would be the Harrodsburg Limestone. This site would be near the dam, and rock excavated from the spillway channel could be used as fill material in the dam. A second potential spillway site lies about 1 mile south of the dam. Here the spillway channel would cut through 40 feet of material, 20 to 30 feet of which are unconsolidated sediments and the remainder is siltstone belonging to the Borden Group.

INTRODUCTION

Field and laboratory investigations for the Salt Creek drainage basin in Monroe, Brown, and Jackson Counties, Ind., were made to provide basic geologic information for the planning of the Monroe Reservoir. In addition, the engineering characteristics of geologic materials in the Salt Creek drainage basin at the proposed dam site and upstream from it have been interpreted from the geologic data.

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This report summarizes the more significant geologic factors that will influence the design, construction, and maintenance of the proposed Monroe Reservoir.

The Monroe Reservoir is designed for flood control and to increase low flow, but it will serve many other purposes. The economics and uses of the reservoir described by the Indiana Flood Control and Water Resources Commission (1956) are beyond the scope of this report.

The drainage area for the proposed reservoir covers 441 square miles (fig. 1). The gross storage capacity of the reservoir will be 446,000 acre-feet. A normal pool level at 538 feet above sea level has been planned and will create a reservoir surface area of 10,700 acres. Maximum flood pool is to be 556 feet above sea level, and thus there will be 18,500 acres of water surface. Plate 1 indicates the approximate position of the dam and alternate spillways.

LOCATION

The Monroe Reservoir will occupy the valley of Salt Creek in parts of southeastern Monroe County, southwestern Brown County, and northwestern Jackson County in southern Indiana (fig. 1). The proposed dam site is approximately 2 miles east of Harrodsburg and 11 miles south of Bloomington.

The dam site and reservoir area lie between lat 38°59' and 39°10' N. and between long 86°15' and 86°32' W. This area occupies parts of the Allen's Creek, Belmont, Clear Creek, Elkinsville, Heltonville, Oolitic, and Unionville Quadrangles. Topographic maps of these quadrangles (72-minute series) have been published by the U. S. Geological Survey.

ACKNOWLEDGMENTS

The authors are grateful to the U. S. Army Corps of Engineers and to the Indiana Flood Control and Water Resources Commission for some of the data used in the preparation of this report.

METHODS OF INVESTIGATION

Field investigation of the geology of the Salt Creek drainage basin, supplemented by study of aerial photographs of the area, provided most of the information presented in this report. A geologic map of the materials at the dam site and spillway areas was pre-

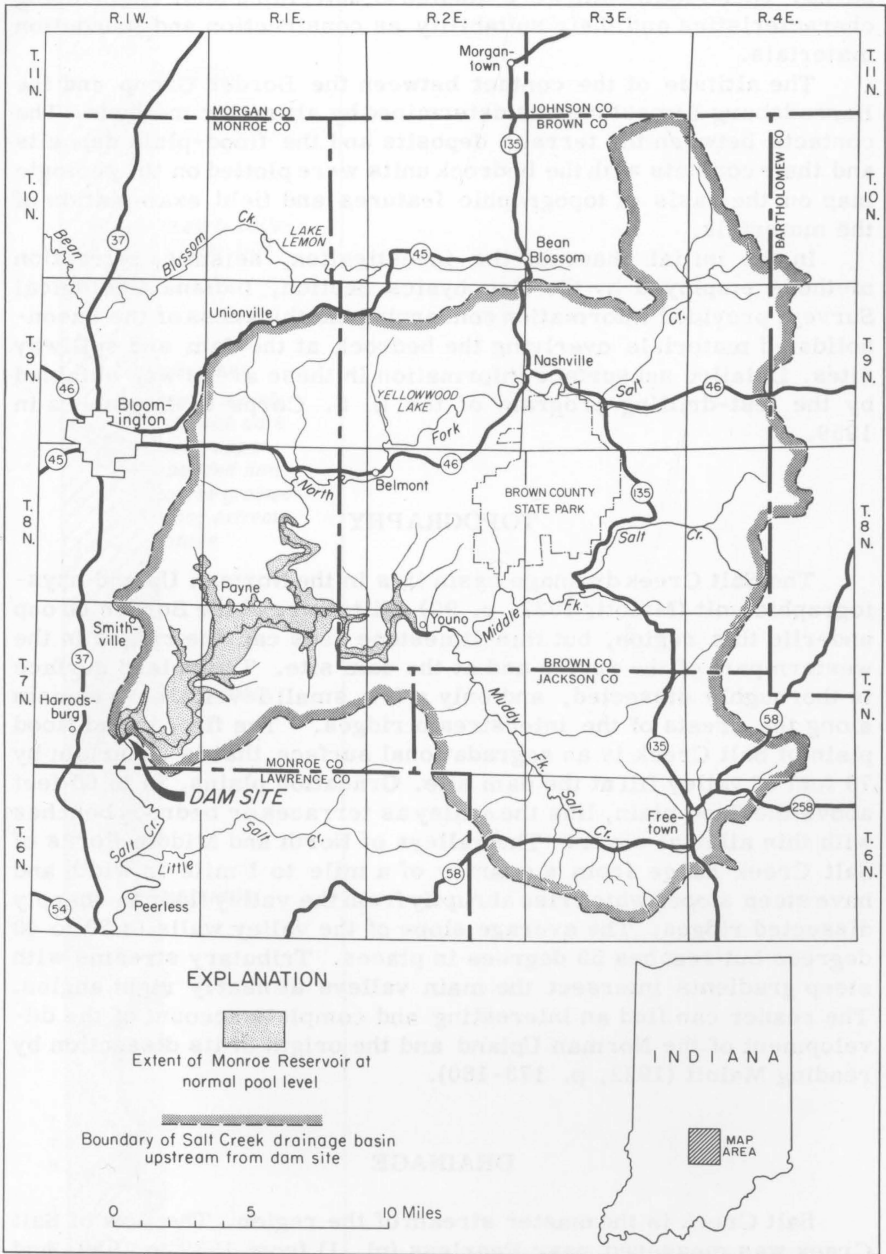


Figure 1.--Map showing the Salt Creek drainage basin upstream from the Monroe Reservoir dam site and the extent of the reservoir at normal-pool level.

pared. These materials were studied to determine their engineering characteristics and their suitability as construction and foundation materials.

The altitude of the contact between the Borden Group and the Harrodsburg Limestone was determined by altimeter methods. The contacts between the terrace deposits and the flood-plain deposits and their contacts with the bedrock units were plotted on the geologic map on the basis of topographic features and field examination of the materials.

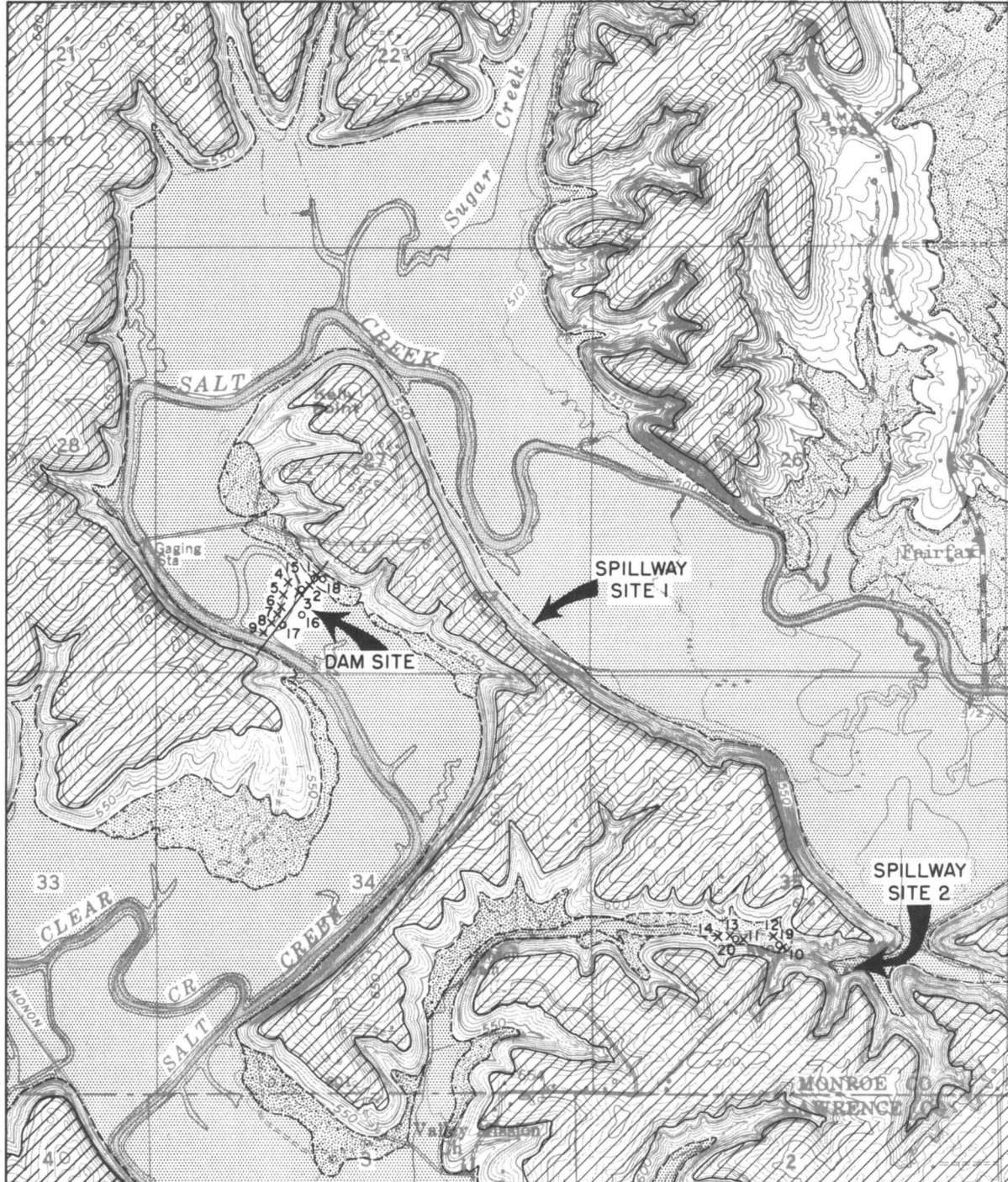
In the initial phase of the investigation, seismic refraction methods employed by the Geophysics Section, Indiana Geological Survey, provided information concerning the thickness of the unconsolidated materials overlying the bedrock at the dam and spillway sites. Detailed subsurface information in these areas was obtained by the test-drilling program of the U. S. Corps of Engineers in 1959.

TOPOGRAPHY

The Salt Creek drainage basin lies in the Norman Upland physiographic unit (Malott, 1922, p. 90). Siltstones of the Borden Group underlie this region, but thin limestone beds cap the ridges in the western part of the region and at the dam site. The upland surface is thoroughly dissected, and only a few small level tracts remain along the crests of the interstream ridges. The flat, broad flood plain of Salt Creek is an aggradational surface that is underlain by 70 feet of valley fill at the dam site. Gradation plains, 20 to 60 feet above the flood plain, line the valley as terraces or bedrock benches with thin alluvial cover. The valleys of North and Middle Forks of Salt Creek range from a quarter of a mile to 1 mile in width and have steep slopes which rise abruptly from the valley floor to sharply dissected ridges. The average slope of the valley walls is 30 to 40 degrees but reaches 55 degrees in places. Tributary streams with steep gradients intersect the main valleys at nearly right angles. The reader can find an interesting and complete account of the development of the Norman Upland and the origin of its dissection by reading Malott (1922, p. 173-180).

DRAINAGE

Salt Creek is the master stream of the region. The flow of Salt Creek was measured near Peerless (pl. 1) from 1939 to 1950, and the flow of the North Fork of Salt Creek has been observed near



EXPLANATION

QUATERNARY SYSTEM

UNIT 4
Flood-plain deposits
Mainly clayey silts with admixed sands

UNIT 3
Terrace deposits
Alluvial clayey sandy silts, gravelly in part; colluvial clayey gravels; and lacustrine clayey silts

MISSISSIPPIAN SYSTEM

UNIT 2
Harrodsburg and Salem Limestones
Lower part of Harrodsburg Limestone is mainly impure crinoidal limestone interbedded with dark calcareous siltstone; geodes abundant; upper part is coarse crystalline medium-bedded limestone. Salem Limestone, fine- to coarse grained porous limestone, is present only along extreme northwestern border above 670 altitude

UNIT 1
Borden Group
Shaly and massive siltstones; impermeable; jointed in places

— Bedrock contact

- - - Boundary of unconsolidated materials

⊙ Corp of Engineers hole UC-201
See figure 2

○²⁰ Auger hole
Number refers to table 3

×¹³ Seismic station
Number refers to table 2

Base from U. S. Geological Survey quadrangle maps, scale 1:24,000

GEOLOGIC MAP OF MONROE RESERVOIR DAM AND SPILLWAY SITES, MONROE COUNTY, INDIANA

Geology by Gary R. Gates and Wilton N. Melhorn, 1958.



Belmont from 1946 to the present. On the basis of stream-flow records and observations made on Salt Creek near the dam site (pl. 1) in 1955, the average flow has been estimated as 483 cubic feet per second (Indiana Flood Control and Water Resources Commission, 1956). The stream is classed as underfit by the authors because meanders of the present stream have radii that are generally smaller than the radii of the incised meanders of Salt Creek Valley, and because the stream is small in comparison with the width of its valley. Salt Creek is cutting its banks at a few sharp bends in the valley, however. The underfit condition is a consequence of the large amount of glacial melt water that drained through and enlarged the valley in Pleistocene time.

The Borden Group is sufficiently impermeable to permit direct runoff of most precipitation rather than infiltration to the water table. Some flooding of low areas follows each moderate to severe storm in the Salt Creek drainage area because of the low permeability of bedrock and unconsolidated materials. The limestone units that cap the ridges in the western part of the area are cavernous and are overlain by relatively impermeable soil. Thus runoff to the streams normally is rapid, whether over the surface or through solution channels. The silty to clayey flood-plain soils are sufficiently impermeable so that most runoff is over the land surface.

Weathering, mass wasting, and erosion of the siltstones and soils provide considerable clay, silt, and fine sand for the streams draining the region. Salt Creek has a low gradient (about 2 feet per mile); this is much lower than the gradients of its tributary streams. The flow of Salt Creek is not fast enough to transport the sediment supplied by the faster flowing tributaries that descend the steep tributary valleys. For this reason the tributaries are aggrading the valley of Salt Creek. During floods, much material is deposited on the flood plain because of the slow velocity of the water. When the dam is completed, most of the fine-grained material presently carried downstream will be deposited in the reservoir, and thus the amount of storage will be reduced. Reservoir siltation problems will be serious if vegetal cover is removed from slope areas of the basin because this removal would result in the rapid erosion of the silty soils.

STRATIGRAPHY

Bedrock formations of the area consist of siltstones of the Borden Group and the Harrodsburg and Salem Limestones of Mississippian age. Terrace and flood-plain deposits overlie the bedrock along the lower parts of the valley walls. For the purposes of

the present report, the several formations have been arranged into units according to their engineering characteristics. These are: unit 1, the Borden Group; unit 2, the Harrodsburg and Salem Limestones and their residual soils; unit 3, the terrace deposits along the valley walls above the flood plain; and unit 4, the alluvium that forms the valley-fill deposits. The Harrodsburg and Salem Limestones lie above the proposed flood-pool level of the reservoir.

The bedrock formations dip southwestward about 30 feet per mile in the dam site and spillway areas. The northward-southward trending Mt. Carmel Fault lies about 6 miles east of the dam site, but the fact that it is present in the area does not affect the engineering considerations of the reservoir project. Below the proposed reservoir level, impermeable shales are present on both sides of the fault, and leakage through it is improbable.

UNIT 1

The rocks of the Borden Group (Mississippian age) constitute unit 1 on plate 1. These rocks, descriptions of which are in table 1, form the impermeable basin that will confine the reservoir waters and provide potential borrow material that can be used in embankment construction. Only the upper part of unit 1 is exposed in the dam site area, but middle formations of the group are exposed in the part of the proposed reservoir in southern Brown County.

The engineering characteristics of the rocks in unit 1 are very similar except for local biohermal lenses of limestone. Stockdale (1931, p. 251) described a bioherm that is about 3 miles northeast of the dam site. This bioherm is 65 feet thick. This type of limestone does not present leakage problems because of the small size of the bioherm (less than 2 miles in diameter). No bioherms are known to exist in the dam site and spillway areas.

In the dam site area, exposures of unit 1 consist of approximately 15 feet of blue-gray shaly sandy siltstone at the top and 65 feet of medium-brown massively bedded siltstone along the upper valley walls. A 90- to 100-foot section of blue-gray clayey siltstone underlies the massive siltstone and forms the valley walls beneath the valley fill.

Vertical joints are common in Borden rocks and may extend for long distances. The joints probably will not cause serious leakage problems. Rocks at the east end of the reservoir have low permeability; these rocks are described in table 1.

Table 1.-Formations of the Borders Group included in unit 1, Monroe Reservoir area

| Formation | Locations of exposures | Lithologic description |
|---|--|---|
| Edwardsville Formation (includes Floyds Knob Formation ¹) | Upper beds exposed near dam site; middle unit forms valley walls beneath flood plain at dam site; exposed at higher altitudes east of Monroe County-Brown County line. | Predominantly tan massive siltstone, thin (15 ft) shaly siltstone at top at dam site; blue-gray clayey siltstone common in middle of formation (as much as 100 ft thick); discontinuous biohermal limestone lenses or beds (as much as 65 ft thick) may be present near base. |
| Carwood Formation | Exposed along extreme east edge of Monroe County and in Brown County. | Blue-gray shaly siltstone interbedded with thin resistant coarse-grained siltstone beds. |
| Locust Point Formation | Exposed along extreme east edge of Monroe County and in Brown County. | Alternating beds of tan massive resistant siltstone and blue-gray shaly siltstone. |
| New Providence Shale | Not exposed. | |

¹ Floyds Knob not recognized consistently in reservoir area.

UNIT 2

Lying above the monotonous section of siltstone in unit 1 are 30 to 35 feet of limestone and siltstone of the lower part of the Harrodsburg Limestone. This highly variable transition zone is overlain by the pure limestones of the upper part of the Harrodsburg Limestone and of the Salem Limestone. These limestone beds and the transition zone are included in unit 2. Plate 1 shows the areal distribution of this unit in the dam and spillway area. Unit 2 caps the ridges from the dam site to the Mt. Carmel Fault 6 miles to the east. The limestones of unit 2 are above flood-pool level and do not present a leakage problem.

The lower part of the Harrodsburg Limestone is an alternating sequence of lenticular clayey crinoidal limestones and calcareous siltstones at the base and massive limestone and shale beds near the top. Many geodes characterize this part of the Harrodsburg. The upper part of the Harrodsburg is light-gray coarse-grained medium-bedded limestone that is nonporous and well cemented. The Salem Limestone (or Indiana limestone) is light gray and fine grained to coarse grained and is generally massive bedded and porous. The Harrodsburg is about 70 feet thick near the dam site, and the Salem is as much as 100 feet thick a few miles to the west.

UNIT 3

Numerous terrace deposits are present along the valley walls of Salt Creek and its tributaries. The terrace materials constitute unit 3 and consist of brown silty clayey sand, blue-gray clayey silt, gravelly clayey silt, or other related types of deposits. Some terraces overlie bedrock benches, but others apparently are not related to the position or configuration of the underlying bedrock surface. There are thin colluvial deposits at many places along the valley. Water saturated sands mixed with gravel, silt, and clay are found at Payne in the S½ secs. 31 and 32, T. 8 N. , R. 1 E. , and 1 mile west of Youno in the NE¼ sec. 2, T. 7 N. , R. 1 E. These two large terrace deposits as well as many smaller ones have surfaces 50 to 60 feet above the Salt Creek flood plain. Low-lying terraces, such as those, for example, 1 mile north of Fairfax in the S½ sec. 24 and NW¼ sec. 25, T. 7 N., R. 1 W., rise only 20 to 30 feet above the flood plain. The Fairfax terrace deposit consists of only 35 to 40 feet of unconsolidated material, but the terrace deposits at Payne are at least 70 feet thick. Aerial photographs and U. S. Geological Survey 72-minute topographic quadrangle maps show patchy distribution of smaller terraces along nearly every tributary valley of Salt Creek.

The textural and compositional features of these terrace deposits are difficult to generalize from the meager amount of control gained from a few auger holes. The sediments containing coarse material are poorly sorted and are composed of chert and geode fragments, granite, quartzite, and siltstone pebbles. Poorly sorted sands have much admixed fine material and constituents similar to those listed above. Nearly all the coarser sediments are oxidized and noncalcareous. The blue-gray clayey silts are very similar to much of the material beneath the flood plain which is described in unit 4.

The upper part of most of the terraces will be above normal pool level. Precautionary measures will be necessary to retard erosion of the terraces and consequential siltation in the reservoir. Nearby Lake Lemon is currently undergoing rapid siltation because vegetal cover has been removed from terraces of this type.

UNIT 4

Unit 4 includes all unconsolidated material in the flood-plain and valley-fill deposits of Salt Creek Valley. The maximum thickness of valley fill beneath the dam site is about 69 feet. (See tables

Table 2.-Thickness of unconsolidated materials (unit 4) overlying bedrock determined from

| Seismic Station | Location | Thickness of unconsolidated material overlying bedrock (feet) |
|-----------------|-----------------|---|
| 1 - - - | Dam site | 21 |
| 2 - - - | Dam site | 48 |
| 3 - - - | Dam site | 52 |
| 4 - - - | Dam site | 38 |
| 5 - - - | Dam site | 68 |
| 6 - - - | Dam site | 52 |
| 7 - - - | Dam site | 49 |
| 8 - - - | Dam site | 37 |
| 9 - - - | Dam site | 45 |
| 10 - - - | Spillway site 2 | 31 |
| 11 - - - | Spillway site 2 | 22 |
| 12 - - - | Spillway site 2 | 27 |
| 13 - - - | Spillway site 2 | 22 |
| 14 - - - | Spillway site 2 | 19 |

2 and 3.) Valley-fill materials are similar to the clayey silt part of the terrace deposits in unit 3. Blue-gray clayey silt is the predominant material in the valley. Light-brown clayey silt is found above the water table. Colluvial gravel is sparsely admixed with silt at some places in the valley fill near the valley walls. Clay-sized materials generally make up less than 30 percent of the total material and probably average considerably less than this percentage.

The texture of the materials of unit 4 varies both vertically and laterally, and individual beds are indeterminate. Most of the valley fill consists of medium sized silt, and only small amounts of very fine-grained or fine-grained sand are present. Quartz is the major constituent of the silt, but small amounts of mica, feldspar, carbonates, and small rock fragments are present. Illite and chlorite are the most abundant clay minerals in unweathered parts of the valley fill. Montmorillonite is found in the surface materials of the flood plain. Chert and siltstone pebbles make up most of the larger sized grains of the deposit. Organic matter is common throughout the valley-fill deposits but becomes more abundant be

Table 3.-Records of exploratory test holes showing thickness and character of unconsolidated materials

[All test holes were drilled to "refusal," presumably the bedrock surface.]

| Test hole No. | Location | Altitude of land surface above sea level (feet) | Material | Depth below surface (feet) | |
|---------------|-----------------|---|---|----------------------------|------|
| | | | | From | To |
| 15 | Dam site | 504.2 | Brown clayey silt | 0 | 9 |
| | | | Gray clayey silt | 9 | 63 |
| | | | Bedrock surface | 63 | |
| 16 | Dam site | 505.4 | Brown clayey silt | 0 | 5 |
| | | | Gray clayey silt | 5 | 25 |
| | | | Gray clayey silt, some organic material | 25 | 30 |
| | | | Gray clayey silt with some pebbles | 30 | 68.5 |
| | | | Bedrock surface | 68.5 | |
| 17 | Dam site | 506.3 | Brown clayey silt | 0 | 5 |
| | | | Gray clayey silt | 5 | 48 |
| | | | Gray clayey silt with some pebbles | 48 | 60 |
| | | | Bedrock surface | 60 | |
| 18 | Dam site | 524.2 | Brown clayey silt with numerous pebbles | 0 | 5 |
| | | | Brown clayey silt | 5 | 10 |
| | | | Gray clayey silt with some pebbles | 10 | 35 |
| | | | Gray clayey silt | 35 | 38.7 |
| | | | Bedrock surface | 38.7 | |
| 19 | Spillway site 2 | 597 (est.) | Gray clayey silt | 0 | 5 |
| | | | Gray clayey silt with some pebbles | 5 | 20 |
| | | | Bedrock surface | 20 | |
| 20 | Spillway site 2 | 577(est.) | Gray clayey silt | 0 | 5 |
| | | | Gray clayey silt with some pebbles | 5 | 20 |
| | | | Bedrock surface | 20 | |

low about 25 feet. The materials in the valley fill should provide a satisfactory dam foundation.

DAM SITE DESCRIPTION

Plate 1 shows the location of the dam site across the narrow part of the valley of Salt Creek in the SW¼ sec. 27, T. 7 N., R. 1 W. The dam will be an earthen structure, with an impermeable clay core, founded on the clayey to sandy silt valley-fill materials. The northeast abutment will be against the thin colluvial terrace deposits

that mantle the siltstones of the Borden Group on that side of the valley, and the other abutment will lie directly against the siltstone that forms the southwest wall of the valley. The conduit will be founded on siltstone beneath the dam on the southwest side of the valley.

Although the Borden siltstones are porous, they are not permeable, and thus leakage through these rocks will be negligible. The Borden contains a few thin limestone beds, but in the dam site area none are believed to be sufficiently thick or cavernous enough to present a leakage problem. During the exploratory drilling program of the U. S. Corps of Engineers along the centerline of the dam, circulation of drilling fluid was lost while the Borden siltstones of unit 1 were being cored in several test holes. The reason for this circulation loss is indeterminate because limestone was not encountered and the core was essentially continuous. Very thin crinoidal limestone layers and (or) horizontal joints (bedding planes) may have served, however, as an avenue for water escape while drilling in the Borden was taking place. Some seepage may occur through the valley-fill materials, especially where the silt is sandy to gravelly, but these materials are not sufficiently permeable to cause serious leakage problems.

Figure 2 shows the variation of mechanical properties with depth for a hole on the northeast bank of the valley of Salt Creek. (See plate 1 for location.) On the basis of triaxial compression tests (fig. 2), most of the material is of medium consistency.

The upper 25 feet is characterized by material with natural moisture contents between the liquid and plastic limits (upper and lower limits of plasticity). This means that the naturally occurring materials are in a plastic state. When liquid limits are between 30 and 50 percent moisture, soil-water suspensions are generally classified as medium plasticity clays (fig. 2). The clay bed from 20 to 24 feet beneath the surface presents foundation problems that will influence the design of the dam. This high plasticity or "fat" clay has a liquidity index near 1.0 and has almost no strength. A middle "nonplastic" zone was reported from about 30 to 45 feet. The Atterberg limits show that a sample of the material near the bottom is characterized by low plasticity and has a low natural moisture content.

These characteristics probably will not extend across the width of the valley of Salt Creek at the dam site. Colluvial materials are present in the upper and lower parts of the test-hole section described above, but these materials are generally confined to the valley fill nearest the bedrock surface. The silty clays in the upper part of the test hole probably are a result of reworking the valley-fill material by flood-plain processes. The materials lying below

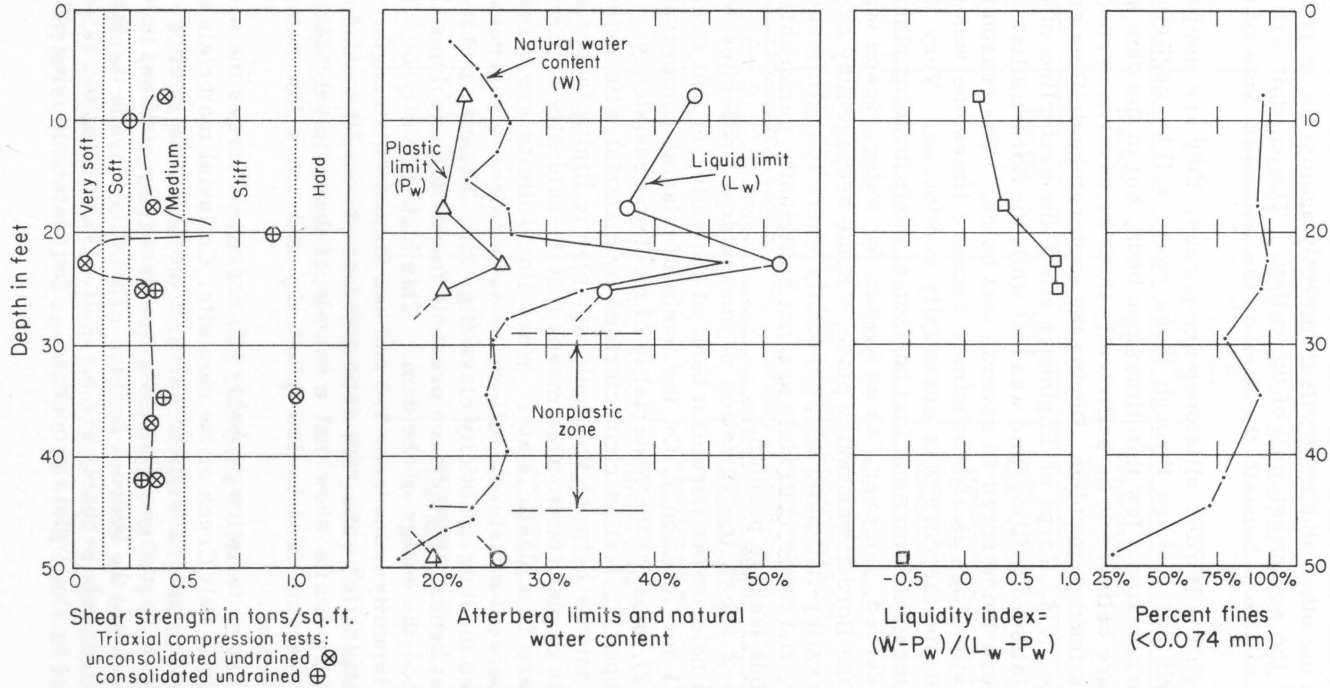


Figure 2.--Variation of engineering properties with depth for undisturbed samples (Denison sampler) from U. S. Corps of Engineers hole UC-201 on dam center-line. Data courtesy of U. S. Corps of Engineers.

25 to 30 feet probably have not been reworked and may have been precompacted by thicker valley fill that has subsequently been removed.

SPILLWAY SITE DESCRIPTIONS

The spillway of the Monroe Reservoir may be located at either of two sites. Site 1 (pl. 1) is across the narrow part of the bedrock ridge in the southeast corner of sec. 27, T. 7 N., R. 1 W., and site 2 is through the eastward-westward-trending valley in the SW¼ sec. 35, T. 7 N., R. 1 W. Site 1 will require less excavation and is situated near the dam so that the material removed from the spillway can be used as fill material in the dam structure. The disadvantage of site 1 is that the material to be excavated essentially is all bedrock (siltstone of the Borden Group and Harrodsburg Limestone). The advantage of site 2 (pl. 1) is that the crest of the ridge is lower and about 20 feet of unconsolidated valley-fill deposits overlie the bedrock. (See tablet for depth to bedrock as determined from seismic records and table 3 for records of test holes.) The bedrock is siltstone of the Borden Group which can be more readily excavated than can the limestones. The disadvantage of site 2 is that it is somewhat distant (about 1 mile) from the dam site, and thus it might not be economical to use the material removed as fill at the dam. An excessively long cut and a high water table also present problems at this site.

LOCAL CONSTRUCTION MATERIALS

Construction materials available locally include Borden siltstones and the Harrodsburg Limestone for fill material and the clayey residual limestone soils along the crests of the ridges, which may be suitable for use in the clay core of the dam. Deposits of sand and gravel suitable for concrete aggregate or filter material have not been observed in the area.

The Borden siltstones that will be excavated in the construction of the conduit and spillway can be used as permeable fill material in the dam and as subgrade material for access roads. The rock is relatively soft and weathers fairly rapidly to a clayey silt when it is exposed at the surface, but weathering is negligible when the rock is protected by thin cover.

The clayey middle and lower soil zones formed on the Harrodsburg Limestone constitute the principal deposits of clay in the vicinity of the dam site. A thin organic-rich zone at the top should

not be utilized as clay core material. The soil overlying the limestone averages about 12 feet in thickness, the lower 6 feet of which is the rather fat red clay. The red- to tan-gray middle soil zone is siltier in texture than the soil below but probably contains sufficient clay to be used in the core of the dam. The liquid limits and plastic limits of these clay soils probably range from 60 to 90 percent moisture and 30 to 50 percent moisture, respectively, and the material should compact well. Because the limestone soils are relatively thin the borrow areas are likely to be large.

The flood-plain and terrace deposits are predominantly silt. No good source of sand and gravel for cement aggregate or filter material is known in the valley. Some terrace deposits contain sand and gravel, but size analyses indicate that silt and clay constitute generally about 50 percent of these materials.

CONCLUSIONS

The geologic investigation of the valley of Salt Creek indicates that it is a suitable area for construction of the Monroe Reservoir. The dam site, spillway sites, and the entire region of the reservoir are within the siltstones of the Borden Group. The Borden siltstones and the moderately thick (as much as 70 feet) valley-fill deposits have low permeability, and leakage through these materials should be minor. These materials will provide suitable foundations for dam and spillway construction.

Geologically, two satisfactory spillway sites are available. Final selection of the spillway location will depend upon the estimated costs of excavating and of transporting materials.

Sand and gravel for cement aggregate and for filter material in the dam are not plentiful in the vicinity of the reservoir structures. These materials probably will be obtained either by washing the gravelly silt terrace deposits or by importing sand and gravel from other areas. The clayey residual limestone soil along the crests of the ridges is suitable for the impermeable clay core of the dam. Suitable fill materials are available in the area for use as random fill in the construction of the dam. The Harrodsburg Limestone can be used to face the dam structure to protect the silty fill material in the dam from wave action and erosion.

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