For it so falls out
That what we have, we prize not to the worth
While we enjoy it; but, being lack'd and lost,
Why, then we rack the value, then we find
The virtue that possession would not show us

Wm. Shakespeare
I am indebted to many people and organizations for aid in this study.

I wish to thank the Society of Sigma Xi for Grant-In-Aid of Research Funds, which were most helpful in meeting financial obligations of this study. I also wish to thank the Research Committee of the Department of Geology and Mineralogy for departmental Grant-In-Aid funding, as well as support for photographic supplies.

Members of the staff of the department have been most helpful to my progress.

I especially wish to thank Dr. Garry D. McKenzie and Dr. Russell O. Utgard for their sympathetic ears and well-placed thoughts as they provided guidance throughout all phases of this study.
<table>
<thead>
<tr>
<th>CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontispiece</td>
<td>11</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>iii</td>
</tr>
<tr>
<td>Figures</td>
<td>v</td>
</tr>
<tr>
<td>Tables</td>
<td>vi</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Outline of Environmental Geology</td>
<td>3</td>
</tr>
<tr>
<td>Inventory of the Physical Environment</td>
<td>13</td>
</tr>
<tr>
<td>Bedrock Geology</td>
<td>13</td>
</tr>
<tr>
<td>Glacial Geology</td>
<td>25</td>
</tr>
<tr>
<td>Mineral Resources and Economic Geology</td>
<td>35</td>
</tr>
<tr>
<td>Soils</td>
<td>41</td>
</tr>
<tr>
<td>Slopes</td>
<td>52</td>
</tr>
<tr>
<td>Water Quantity</td>
<td>56</td>
</tr>
<tr>
<td>Water Quality</td>
<td>66</td>
</tr>
<tr>
<td>Inventory Conclusion</td>
<td>74</td>
</tr>
<tr>
<td>Physical Parameters and Land Use</td>
<td>75</td>
</tr>
<tr>
<td>Reservoirs</td>
<td>76</td>
</tr>
<tr>
<td>Sanitary Landfills</td>
<td>85</td>
</tr>
<tr>
<td>Recreation</td>
<td>89</td>
</tr>
<tr>
<td>Conclusions</td>
<td>95</td>
</tr>
<tr>
<td>References Cited</td>
<td>98</td>
</tr>
<tr>
<td>Appendix: Topographic Maps</td>
<td>104</td>
</tr>
<tr>
<td>Number</td>
<td>Table Title</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Soil Characteristics and Land-Use Limitations</td>
</tr>
<tr>
<td>2</td>
<td>Ground Water Quality</td>
</tr>
<tr>
<td>3</td>
<td>Surface Water Quality</td>
</tr>
</tbody>
</table>
INTRODUCTION

In this discussion I attempt to describe the effects of the physical environment, specifically geology and geologically-related factors, on present and future utilization of the Big Darby Creek Watershed. Situated in west central Ohio (Figure 1), this watershed comprises major portions of Union, Logan, Champaign, Madison, Franklin, and Pickaway counties, and a small part of northeastern Clark County. With a total area of 574 square miles, the Big Darby Creek Watershed is one of the most important in the Scioto River Basin.

The watershed as it exists today is composed primarily of farming land and farming communities. Corn, soybeans, and grains are important crops, and the raising of livestock also plays a part in the area's economy. Population growth has been slow; the largest town, West Jefferson, recorded only 3,664 people in the 1964 census. This compares with an 1880 population of 720. Other villages, with their 1970 populations, are Plain City (2,254), Mechanicsburg (1,686), North Lewisburg (840), Milford Center (753), Darbydale (743), and Harrisburg (556). Smaller towns, such as Fox, Orient, Darbyville, and Woodstock, are scattered throughout the watershed.

Before white settlement, the watershed was home to tribes of Mingo, Piqua, and Wyandot Indians. Darby Creek was named after a Wyandot Chief who lived along the stream in what is now

1
Union County. The tribes were largely removed from the area by a series of military campaigns in the late 1700s. Militia under General Mcintosh, Major Lewis, and Colonel Todd played a major role in driving the Indians away (Hove, 1889).

The first permanent white resident of the area, Jonathan Alder, came to Darby Creek at the age of seven, under the stress of Indian capture. He was raised by the Indians, and his story, retold in Hove (1889), is a fascinating bit of Ohio's history. Jonathan Alder's cabin stands today several miles from its original site, now next to Forest Chapel Cemetery on the west bank of Big Darby Creek, where he is buried.

An influx of white settlers in the early 1800s provided the nucleus of the farming culture that was to rise on some of the most fertile soil of the "wilderness". Before the Civil War, some homes were employed as stations on the underground railroad for runaway slaves. An extensive Mennonite and Amish community that has developed on the flat land southwest of Plain City provides the area with rich cultural contrast.

Outline of Environmental Geology

A discussion of the environmental geology of the area should be prefaced with a brief description of this newly evolving field. Although there are many definitions of environmental geology, a concise and workable one is that of Flawn.
(1970), who calls it

"The application of geology to problems arising out of the interaction of the human colony on earth."

A unifying theme of all definitions of environmental geology is the awareness that the actions of humans, more than those of any other organisms, can modify the earth. All cultures seem to include in their philosophies an explanation of the culture's interaction with the earth, whether it is oriental coexistence with nature, or occidental conquering of nature. Man's ability as a geomorphic agent is attested by his creation of huge excavations, as in mining areas, such as Bingham Canyon, Utah, and by the alteration of the natural flow of streams with the construction of dams, levees, channelization projects, and the construction of buildings and structures in the stream areas.

Effects are secondary as well as primary. The impact of construction of a housing development over farmland, as is happening on the Big Darby Creek Watershed, permanently alters the land, and may render it irretrievable for agricultural utilization. The effects of such a subdivision go far beyond its boundaries, by first increasing the load of sediment delivered to streams, and later the runoff from storms. Downstream sites suffer in response to both these factors.

Environmental geologists encompass many divisions of the geological field. Hydrologists are environmental through study of the effects of water quantity and water quality on humans.
and the effect of humans on the water. Economic Geologists are environmental through their extraction of resources from the earth. The local effects of resource extraction may be extreme, and are becoming less popular during this time of expanding environmental awareness. Even structural geology has input to environmental responses, as at Waco, Texas, where Hayward (1970) correlated a fault zone with house populations, property values, and Republicans. In this report I consider the effect of geology on the land-use planning process. This approach is similar to that employed by several state geological surveys and by the U.S. Geological Survey, although reports of these agencies are considerably more elaborate than this one. Some reports, such as a study of the Saskatoon area (Christiansen, 1970) are primarily concerned with the production of original data, whereas, such as a recent symposium on the Pueblo vicinity (Bonison, 1972), have more information about the capability of land to sustain various uses. The capability and suitability of land to accommodate the human colony forms a major portion of other reports, such as some produced in Illinois (Hackett and McComas, 1969; McComas, 1968). These reports include extensive series of maps, detailing most areas of concern.

In this report on the Big Darby Creek Watershed, an inventory of some of the geologic factors of the area is followed by a discussion of the benefits and constraints these factors
will have on future development in the area. This study also is intended to determine the status of information on the watershed's geology, and the applicability of this information to the planning process.

Few attempts have been made to determine applicability of scientific data to problems not envisioned during the data's original development. In the case of the Big Darby Creek Watershed, the original data were produced as bedrock geology reports, water reports, soils reports, and information concerning specific parameters. These were not primarily created with their influence on land-use planning in mind; their applicability to the problems of land-use planning forms much of this discussion.

Land-use planners are establishing a uniform method of physical inventory, capability determination, and suitability analysis for the study of areas to determine optimal uses of land (J. Marshall, Ohio Department of Natural Resources, pers. comm.). This study of the Big Darby Creek Watershed is limited to an inventory of the geological portion of the physical environment and a discussion of the influence of this on selected land-use problems. A previous series of land-use planning reports, covering most of the watershed, were written in conjunction with the Ohio State University College of Agriculture Extension Service. These studies, of which Baker, Harrod, and
Ansbach (1941) is typical, concerned agricultural land use, and confined recommendations to farm management, crop raising, and livestock concerns. More recent land-use studies such as Area Study #1 of the Mid-Ohio Regional Planning Commission (1971), which discusses southwestern Franklin County, comment on zoning, school needs, industrial siting, and sewer programs. Comprehensive study of all such parameters and land-use problems is beyond the writer's capability, both in terms of knowledge and time.

Maps included in this report are drawn at a scale of 1:250,000, or about four miles to the inch. Use of a larger scale was precluded because the resultant map size would have been excessive. It was felt that much of the detail which could be presented on a map scale of 1:125,000 could also be presented on the selected scale of 1:250,000, which permitted rendering the watershed on two page-sized plates, meeting the requirements for thesis work. Inclusion of maps as an integral portion of the text allows more convenient reference to items under discussion than placement of maps in a rear map pocket. With the large number of maps contained in this report, ease of reference is important.

Original data for the figures included in this report, where represented on maps, are at many scales. Correlation and ease of comparison required that compilation herein be at one
scale. For some subjects, such as soils of Champaign County, extreme detail of data exists, while for other subjects, as glacial geology of Union County, statewide maps are the only source. The scale selection of 1:250,000 is a compromise between such extremes.

Figures 2 and 3 detail town and county locations, and names of important watercourses. Map A represents the area upstream of the junction of Big Darby Creek and Little Darby Creek, and Map B represents the area downstream of this junction. The two maps are joined along the match line indicated, and are numbered as one figure. The legend for both maps is presented on Map B. The base map is reproduced from the Columbus and Marion 1:250,000 scale topographic maps. The reader is cautioned that photoreproduction of maps in this report may lead to distortion of scale, especially near map edges.

The physical inventory of the geology of the Big Darby Creek Watershed, including discussion of bedrock geology, glacial geology, mineral resources, soils, water quantity and water quality, forms the first major portion of this report.
INVENTORY OF THE PHYSICAL ENVIRONMENT

Bedrock Geology

A thick mantle of glacial debris covers the consolidated bedrock nearly everywhere in the Big Darby Creek Watershed. Bedrock exposures are limited to areas of the eastern portion of the watershed, where stream erosion has formed outcrops, and along the northwestern portion of the watershed, where the Bellefontaine Outlier, an erosional remnant, forms a bedrock high (Moses, 1922).

The rock units found beneath the watershed dip, at least one degree toward the east, off the flank of the Cincinnati Arch. The rocks are not complicated by the presence of major faults or folds.

The bedrock geology of the watershed is given in Figure 4, and Figure 5 summarizes general stratigraphic column for the northwestern and southeastern portions of the watershed. Two major rock types are found; limestones and associated dolomites underlie the western four-fifths of the watershed, with shales found under the eastern section.

These rocks were deposited in a shallow sea that covered mid-continent North America during the Silurian and Devonian Periods. Regression that occurred between the periods is evidenced locally by an unconformity with patches of sandstone at the base of the Devonian.

13
FIGURE 4
BEDROCK GEOLOGY

OLENTANGY AND OHIO SHALES
COLUMBUS AND DELAWARE LIMESTONES
DETROIT RIVER GROUP
UNCONFORMITY
BASS ISLANDS GROUP

after Bowmocker (1965)
Descriptions of these rocks included here are adapted from Stout (1941) and Stout, Ter Steeg, and Lamb (1943). Only the uppermost rock strata, immediately underlying the glacial deposits, are described, as they have the most direct relation to environmental concerns.

Rocks of the Upper Silurian Bass Islands Group underlie most of the Big Darby Creek Watershed. These rocks are encountered primarily in water-well drilling, and their similar appearance prevents easy differentiation into formations. Summerson (1959a,b) assigned Silurian rocks found in the Madison Stone Company Quarry along Little Darby Creek near Georgeville to the Haisin River Formation of the Bass Islands Group. Stout (1941) discusses the division of the Bass Islands Group (which he called Monroe) into formations, saying,

"... The strata in the entire Monroe are similar in physical properties, stratigraphic make-up, and chemical components."

He further discusses the entire group of Bass Islands Dolomites as presenting

"... a shelly, very thin, thin, medium, or massive structure. Such variations may be found in almost any quarry face or throughout any considerable part of the entire section... the color range is wide but in general the tints exhibited are some shade of brown or dark bluish grey... In texture the stone changes from hard and dense to open, sugary, or even cavernous. Parts are very definitely laminated through the effects of thin paper-y partings of dark colored matter or of the concentration of organic compounds. Breccias, mud cracks, and ripple marks are common impressions. In the Bass Islands dolomites the fossils are not abundant, are small
Figure 5
Stratigraphic Columns
1" = 50' Vertical Scale

After Morin 1922, Hubbard 1918
in size, and are usually preserved as oases."
The description by Summermon of the Raisin River Formation as an
grainaceous, buff dolomite in thinly-laminated to massive beds,
with scarce, non-definitive fossils, fits well into the Bass
Islands Group description.

On the geologic map (Fig. 4) all of the Bass Islands
Group is mapped together. Although the rocks may appear
superficially similar, it is likely that formations other than
the Raisin River Formation, probably the Tymochtee and Put-In-
Bay Formations, will be encountered.

An unconformity marks the Silurian-Devonian boundary
in this portion of Ohio. Relief along the surface varies, and
local sandstone or clay lenses are present.

Along the eastern edge of the Bell's Outlier in
the northeastern corner of the watershed, rocks of the Detroit
River Group overlie the Bass Islands Group. The Lucas Formation
of the Detroit River Group is represented in this area, and has
been described by Moses (1922) as,

"... commonly a compact, thin bedded, dark to gray
dolomite. It is usually banded, contains some chert,
and locally contains calcite crystals in cavities and
inbedded in the rock."

Thickness of the Detroit River Group at the outlier is recorded
as ten to twenty feet.

The Detroit River Group is missing from the eastern
portion of the watershed, where the Bass Islands Group is
directly overlain by the Columbus Limestones. Stout (1941)
described the Devonian Columbus Limestone as,

"... massive in bedding, somewhat earthy in appearance,
and light gray to light brown in color ... It changes
from a low magnesian limestone in the upper portion to
a limy dolomite in the lower part. Locally chert is
present either in definite layers or as scattered
nodules. The thickness of the formation, where
normally developed, changes from 85 to 125 feet."

At the top of the Columbus Limestone is typically found
a "bone bed", which was described by Wells (1944) as formed of
orinoidal debris, conodonts, oostromodes, foraminifera, and fish
plates, teeth, bones, and scales. Overlying the "bone bed", and
forming the bedrock of the eastern watershed, are the Delaware
Limestone, the Olentangy Shale, and the Ohio Shale. As indicated
on Figure 5, the Delaware Limestone and Olentangy Shale are not
found on the Bellefontaine Outlier, where the Ohio Shale directly
overlies the Columbus Limestone. None of the area of the Outlier
drained by Big Darby Creek, however, has Ohio Shale bedrock.

Stout (1941) described the Delaware Limestone as follows.

"It varies in character from shales with thin limestone
layers to massive limestones with only bedding plane
partings of shaly matter ... in general faunally fossil-
iferous ... the composition is that of impure limestones."

The Delaware Limestone is not differentiated from the Columbus
Limestone on Figure 4.

The Olentangy and Ohio Formations are shales, and differ

19
from the carbonate bedrock of the rest of the Big Darby Creek Watershed. Found only in Pickaway County, the Clentancy Shale is a gray, siliceous, calcareous shale, and the Ohio Shale is composed of gray and black fissile shales, with some pyrite and organic matter.

Environmental aspects of the bedrock geology of the Big Darby Creek Watershed have been directly influenced by both small-scale and large-scale erosional features that developed before deposition of the Pleistocene glacial debris. Drainage channels of the Teays Stage formed valleys through an area that had, at least partially, karst topography.

Small-scale features have been described by Summerson (1959b) from the Madison Stone Company Quarry. The Columbus Limestone is typically 50 feet thick in this area, but only the lower 7 to 10 feet is exposed in this quarry. Summerson states, "The presence of caves -- in addition to the channeled surface, the sinks, and the fractures in the Madison quarry -- suggests a widespread solution surface sometime in the past."

The soil layer that formed on this probably late pro-glacial solution surface is a deep-red clay derived from limestone weathering. Summerson found no evidence for contamination of this red clay from the overlying glacial deposits. He studied the solution features, and described the cavities as follows.
"Some of the residual, soil-filled depressions and cavities are funnel shaped, and are two to five feet deep and two to three feet wide. Others are elongate fractures, three to ten inches wide, which extend downward from ten to twelve feet into the bedrock, forming irregular fissures, branching and enlarging into cavities of various shapes; these are up to three feet or more in diameter."

The description fits that of an ancient karst surface, which presents interesting problems to the environmental geology of the watershed. Pfann (1970) has described unexpected collapse that occurs in present karst areas. This ancient karst surface does not present dramatic collapse hazards, but where exposed may cause difficulties in siting foundations of large structures, such as buildings and dams. For smaller buildings, such as single family dwellings, the thickness of overlying glacial drift is sufficient to prevent the solution surface from presenting problems.

The surface, and the extensively-fractured limestone and dolomite bedrock, form openings through which ground water and contamination from septic tanks, landfill sites, and other sources, may move.

Pre-glacial erosion established not only the karst topography, but also the extensive Twears River drainage system. This system produced a topography that had much more relief than the present watershed surface. From the present nearly level surface, there is great variation in depth to the bedrock surface. This

21
depth influences the suitability of land for sanitary landfills, stone quarries, industrial sites, and construction of utilities, as well as other land uses.

A map of contours on bedrock surface (Fig. 6) shows the existence of several pre-glacial valleys through the present watershed. Figure 6 is derived from Norris and Spicer (1958) and Schmidt (1958), who presented data only for the counties illustrated. Such data have not been generated for other areas of the watershed. Historically, maps of this nature have been created by contouring elevations of bedrock surfaces found in drilling wells for water and oil. This method is not suited to detailed site investigations, as well spacing may not be suitable to delineate all features. Where drilling of numerous test holes is impractical and detailed data are required, geophysical methods such as the seismic studies described by Stewart (1971) from the Barre-Montpelier region of Vermont may be utilized. Stewart was attempting to determine on the basis of seismic velocity and correlation with known well records, buried sand and gravel deposits. A byproduct of his study was accurate delineation of the bedrock surface.

Norris and Spicer (1958) mapped the Teays Valley by well records and earth resistivity measurements. They describe the Teays as
BIG DARBY CREEK WATERSHED
MAP B

FIGURE 6

CONTOURS ON BEDROCK SURFACE

Contours —1000—
elevations in feet

50 foot contours —750—

Sources cited in text
"... a mature stream ... The Teays River was the master stream for the drainage from a large part of the Appalachian region in late Tertiary time."

Named from an abandoned valley near St. Albans, West Virginia, the major Teays River valley lay to the South and West of the Big Darby Creek Watershed. Figure 1 details a typical cross section through a Teays River tributary valley, now filled with glacial debris.

The area of the watershed was influenced by, but not covered during, pre-Illinoian glaciation (Stout, Van Steeg, and Lamb, 1943). Deep Stage drainage system covered the watershed from post-Teays to pre-Illinoian time. During this stage, drainage from the area of the present Big Darby Creek Watershed was divided, flowing southeast and southwest. This stage did not have a major effect on the bedrock surface, as it was not of the duration of the Teays Stage.

Glacial Geology

Data for and discussion of the unconsolidated glacial glacial and recent deposits are given on a county-by-county basis, from the northern to southern watershed. Clark County is not specifically discussed in this and subsequent sections, as the area of this county drained by the Big Darby Creek Watershed is very small, and resembles the adjacent portions of Champaign County.

25
Figure 8 summarizes the major features of the unconsolidated deposits, products of both late Wisconsinan (25,000 years before present) glaciation and recent alluvial processes. Thick ground moraine is typical of most of the watershed. The thick clayey till deposits contain lenses of sand and gravel. The northern edge of the watershed is bounded by the Powell Moraine, and the western edge by the Cable Moraine. These end moraines, deposited by the retreating glacier, have a gently rolling topography which contrasts the surrounding level till plains. The London Moraine, a subdued feature, crosses the watershed at the Franklin County–Pickaway County line. Present courses of Big Darby and Little Darby Creeks follow glacial outwash and valley train deposits, and contain recent alluvium.

The glacial deposits found on the Big Darby Creek Watershed directly influence, through their chemical and physical properties, utilization that may be made of the land. Slopes, soils, drainage characteristics, and mineral resources are some of the factors related to glacial geology.

Logan County

The southeastern corner of Logan County drains into the Scioto River through the Big Darby Creek Watershed. In pleasant contrast to the flatness of much of the watershed, this area has a hilly topography provided by the Powell End Moraine. Although
Foreyth (1956) does not discuss other moraines in this portion of the watershed, Goldthwait et al. (1967) include the northern portion of the Cable Moraine as a distinct end moraine. Glacial deposits of Logan County are thinner than elsewhere on the watershed, as they lie on the Bellefontraine Outlier. Ground moraine is present in some areas, and recent alluvial deposits are found along stream courses. A small esker is reported from the southeastern corner of the county. Foreyth questions whether the feature should be identified as an esker, since it is less than a mile long, less than 20 feet high, only about 200 feet wide, and composed entirely of sand without a cover of till. A small area of kamee is found to the south of the esker. The kames have a thin covering of till.

Champaign County

According to Hill (1878),

"The name Champaign admirably expresses the character of the county; for, although in a few places a little hilly, as a whole, the surface is very level and made up of plains."

The eastern portion of Champaign County, drained by the Big Darby Creek Watershed, contains elements of both the hilly and level areas. A recent study by Quinn (1972) provides information about the glacial geology of Champaign County.

The Late Wisconsinan glaciation left the Cable End
Moraine on the western margin of the watershed, which is
described by Quinn thus:

“Cable Moraine drift consists of thick till interspersed
with thin sand, or sand and gravel, layers. Well logs in
the Mechanicsburg area indicate drift thicknesses of over
200 feet. The drift generally thins northerly in
response to the rising bedrock surface ... Thinnest drift
(2 to 20 feet) is in the vicinity of North Lewisburg.”

Janssen (1964) traced the Cable Moraine to the west, and found
it overlain by extensive outwash deposits. On the eastern edge
of the moraine such outwash does not exist. A small portion
of the Powell Moraine extends into Champaign County. Quinn
found this moraine to be richer in clay than the Cable Moraine,
by about 20 percent.

Ground moraine deposits mantle the bedrock east of the
Cable Moraine, and generally exceed 20 feet in thickness. The
ground moraine grades eastward into the till plain of central
Ohio. Recent alluvial deposits along stream courses complete
the unconsolidated deposits of Champaign County.

Union County

The glacial geology of Union County typifies a problem
encountered in compilation of environmental reports. Other
counties of the watershed have sources for detailed information
about their glacial geology; for Union County the only source is
the Glacial Map of Ohio (Goldthwait et al., 1967). This map
cites unpublished data for its representation of the glacial deposits of Union County. Figure 8 contains the information obtainable from the statewide map.

South of Big Darby Creek is a continuation of the central Ohio till plain. It may be assumed that the till plain of Union County is similar to the till plain elsewhere, containing thick clayey drift with sand and gravel lenses. North of Big Darby Creek, in the western half of the county, is the Powell End Moraine. The most detailed description of this moraine is found in Foryth (1956); she says the Powell Moraine

"... shows good morainic development ... Till of the Powell moraine occurs generally like a mixture of silt and clay, the silt predominating slightly. Pebbles are common."

This description is not from Union County, but may be assumed to apply.

Recent alluvial deposits are not indicated on the Glacial Map of Ohio, but are observed in the valley of Big Darby Creek. Outwash and valley train deposits, although not indicated on Figure 8, might also be expected from this area.

Madison County

The northern third of Madison County is drained by Big Darby Creek and Little Darby Creek.

Goldthwait (1959) describes the ground moraine area.
southwest of Plain City as one of the flattest sections of Ohio. Till thicknesses in this area often exceed 200 feet. Sand and gravel lenses are common in the till plain, and approach 30 feet thick. Their importance is discussed by Goldthwait, who says,

"Outwash deposits of small extent, often reported by drillers as gravel 'streams' or 'pockets', are common in the glacial till and are the source of water for approximately half the farm and home wells in Madison County."

Figure 7 illustrates a Teays Stage drainage valley filled by glacial deposits, and shows these sand and gravel lenses.

Outwash gravel and sand deposits found along Big Darby Creek and Little Darby Creek are described by Goldthwait:

"By postglacial erosion the streams in Madison County have removed much of the valley train deposits, leaving remnants of sand and gravel as terraces above the floodplains on the sides of the valleys ... The maximum thickness of the valley train deposits, including the terrace deposits, is about 40-50 feet. The present streams flow 20 feet or more below the terrace levels."

Recent alluvium is confined to stream valleys. Deposits of the London and Moraine are not found outside the extreme eastern edge of the watershed in Madison County. The main London Moraine is south of the watershed.

Franklin County

The western portion of Franklin County is covered, with the exception of the valleys of Little and Big Darby Creeks,
by ground moraine. Coldstream (1956) describes this till by saying,

"The surface till in Franklin County ranges from 1-90 feet in thickness. This till is clay and silt rich, although it also contains many pebbles and even boulders to five feet in diameter. The surface till has been dated by radioactive carbon analysis of wood. A log found in a sand pocket in the upper till just south of Harrisburg was 21,600 years old. Deposited with the till were masses of sand and gravel. These sand and gravel masses are found in the till as posa or lens-shaped masses ten to fifty feet long."

The London End Moraine crosses the southwestern corner of the county, and contains more sand and gravel than the ground moraine.

Valley train and outwash deposits of sand and gravel, as well as recent alluvial material, are found along present stream courses.

Well logs from Brown, Prairie, and Pleasant townships of western Franklin County indicate unconsolidated material averages 100 feet thick over bedrock. Wells closer to present creeks show shallower depth to bedrock, 40-60 feet.

Pickaway County

Ground moraine, valley train, end moraines, kame and alluvial deposits compose the Pleistocene and Recent geology of Pickaway County. As shown on Figure 6, and explained in Schuster (1952), the Pickaway till plain, a continuation of
the Late Wisconsinan ground moraine, covers most of the Big Darby Creek Watershed in Pickaway County. Although bedrock has been reported from Darby Creek, till and associated deposits usually average 100 to 300 feet thick. The ground moraine contains lenses of sand and gravel. The low (10-20 foot) London Moraine is found on the northern edge of the Pickaway till plain. As mapped by Schuster, the moraine ends at Big Darby Creek. He thought it likely that the moraine extended west across Big Darby Creek, but erosion prevented him from establishing its presence. Mapping of Schuster has been followed in compiling Figure 8. On the more recent Glacial Map of Ohio (Goldthwait et al., 1967), the London Moraine is indicated as continuous from Pickaway to Franklin Counties. More recent data, from uncited sources, may have permitted him to make this correlation. Lack of access to such data led to the writer’s decision to utilize older sources.

Valley train deposits are found along Big Darby Creek. Sandy composition and good drainage has contributed to development on these deposits. Two kames near Fox, and recent alluvium in flood plains, complete the unconsolidated deposits in Pickaway County.

Mineral Resources and Economic Geology

The mineral resources related to the geology of the
Big Darby Creek Watershed are presently limited to limestone and sand and gravel. Orton (1878) mentioned the use of sand from the lenses at the Silurian-Devonian unconformity for use in plaster, but such use is no longer made. Bowers (1972), who summarized producing sites for limestone and for sand and gravel in Ohio, recorded two producing sites of limestone on the watershed, both in Madison County. American Aggregates Corporation operates the Darby Limestone Division on Big Darby Creek south of Plain City, and Madison Stone Company operates the quarry near Georgesville described by Summerson (1959a,b). Several sites of sand and gravel production exist, most notably Olen Corporation along Big Darby Creek, West Jefferson Sand and Gravel Company on Little Darby Creek, and Mechanisburg Sand and Gravel Company of the Cable Horne.

Depth to bedrock surface, as explained above, is important in resource extraction. American Aggregates Corporation and Olen Corporation are within a few miles of each other along Big Darby Creek; shallow bedrock surface permits American Aggregates to profitably extract limestone, deeper bedrock surface confines Olen Corporation to extraction of sand and gravel.

Figure 9 indicates the existence of more gravel pits than those mentioned above. Compiled from 7.5 minute topographic maps (see Appendix), and field checked, many of the quarries
BIG DARBY CREEK WATERSHED
MAP B

FIGURE 9
MINERAL RESOURCES
QUARRIES x

other indicators

ORCHARDS *
CEMETERIES ♦

sites underlined discussed in text

adapted from U.S.G.S. 7½' quadrangles
shown are no longer operating. Defunct quarries included on
Figure 9 more fully indicate the extent of sand and gravel
resources. Orchards and cemeteries are also indicated on
Figure 9. Orchards require well-drained soil, a quality that
is often associated with sand and gravel deposits. Cemeteries
are also located in areas of good drainage that may indicate
sand and gravel. Presence of these features can thus be
combined with analysis of soil types and drainage channels to
indicate potential reserves of sand and gravel. The presence
of resources does not imply they must be used; careful study
will be required before any orchards or cemeteries are removed
to allow extraction of resources. Further detailed exploration
of the geology of the watershed may lead to discovery of new
deposits in as-yet undetected buried glacial drainageways, but
such deposits must not be relied upon as future resource areas.

Problems of urban expansion's effects on aggregate
production are typified in the Big Darby Creek Watershed. The
resources exist, and their extraction is a benefit to the
Columbus metropolitan area, but a significant aesthetic draw-
back accompanies living near the extraction sites. Residents
of such areas express discontent, and may begin to seek zoning
resolutions to remove the industries.

Consumer unwillingness to pay high prices for bulk
commodities as limestone or sand and gravel require that extrac-
tion be done near the site of ultimate use. Zoning measures
forcing aggregate producers to seek more remote sites would
be reflected in higher construction costs.

Rising environmental consciousness is dictating protection
measures to control noise pollution, air pollution, and water
pollution. These measures may also be reflected in an increased
cost.

Ultimate utilization of the limestone and sand and gravel
resources of the Big Darby Creek Watershed will depend on these
factors and on rate of westward growth of the Columbus metro-
politan area.

A potential resource of the watershed is the production
of hydrocarbons from the Ohio Shale. Stout (1941) cites the
distillation of kerosene from the Ohio Shale during the 1850s
at the town of Buena Vista on the Ohio River. Orton (1888)
discusses Ohio Shale petroleum, saying,

"Although no great accumulations of oil are found in the
shales proper, it would be wrong to infer that they are
poor in petroleum. On the contrary, they contain much
more than any of the strata with which they are associated,
the great sandstone reservoirs not excepted, but it is in
a distributed condition that the petroleum occurs."

Small quantities of oil and gas are obtainable directly from the
shale, with higher potential production from associated sandstone
lenses. A detailed program of exploration is required to
determine the future role of petroleum as a geologic resource of the Big Darby Creek Watershed.

Soils

The soils of the Big Darby Creek Watershed, derived from weathering of Late Pleistocene glacial deposits discussed above, exert direct influence upon utilization that can be made of the land. The discussion of soils in this report is on a county-by-county basis. Their areal distribution and characteristics are discussed. Some soils are present throughout the watershed, and their characteristics are discussed only at their first mention. The Soils Map, Figure 10, presents the soils in associations. Differentiation into individual soils is based on detailed study; it is beyond the scale of this map to cover that detail. A variety of sources, with differing degrees of detail, were utilized in compiling the map and discussion (Baker, 1960; Powell and Ritchie, 1966; Powell and Siegenthaler, 1967; Ritchie, 1961; Ritchie, Powell, and Siegenthaler, 1971; Smith, 1955, 1961).

Following the county-by-county presentation is a discussion of some important influences of soils on land use of the watershed.

Logan County

41
BIG DARBY CREEK WATERSHED
MAP B
FIGURE 10
SOILS

- Blount-Norley-Pewamo
- Fox-Lippincott (incl. Algiers in Logan Co.)
- Pitchin-Sloan
- Westland-Fox-Tavas
- Miami-Crosby-Brookston-Celina
- Brookston-Crosby (incl. Kokomo in Madison Co.)
- Crosby-Brookston-Celina
- Sloan-Fox
- Miami-Celina
- Ockley-Kel
- 627-671 (incl. 6288 in Union Co.)
Four soil associations are found in the southeast corner of Logan County. On the north side of Big Darby Creek, associated with the area of the Powell Moraine, are found 622 and 623 soils. These soils are described by Powell and Siegenthaler.

"The upland landscape is nearly level to moderately steep. The soils have formed in limy, glacial lake-influenced clay till. The 622 soils which dominate the association are light colored and poorly drained. They lie on nearly level to gently sloping relief. 623 soils are light colored, moderately well drained, and occupy gently sloping to moderately steep areas."

Along Big Darby Creek is found a Blount-Morley-Pewamo soil association. Powell and Siegenthaler describe this association by saying,

"The landscape is marked generally by nearly level to moderately steep upland relief. A few steeper slopes occur along the sides of stream valleys. The soils formed in limy clay loam glacial till. The light colored, somewhat poorly drained Blount soils, which lie on nearly level to gently sloping relief, are the most extensive in the association. Morley soils, which occupy gently sloping to steep areas, are light colored and moderately well to well drained. The Pewamo soils are dark colored, very poorly drained and occupy nearly level to depressed relief."

The area of the Cable Moraine (Fig. 8) has soils of the Miami-Crosby-Brockton-Celina association. Although limited in areal distribution in Logan County, these soils, with varying associations, are widespread throughout the watershed. They are described by Powell and Siegenthaler.

"The landscape ... is characterized by nearly level to steep upland relief. The soils have formed in limy loam glacial till. Miami soils are the most extensive
in the association. They are light colored, well drained, and lie on gently sloping to steep areas. The Crosby soils are light colored and somewhat poorly drained. These soils occupy nearly level to gently sloping relief. Brookston soils are dark colored and very poorly drained. They are found on nearly level to depressed areas, or in swales. The Celina soils are light colored, moderately well drained and occur on gently sloping to sloping relief."

The kame and esker deposits of Logan County have the distinctive Fox-Algers-Lippincott soil association. The above cited reference discusses this association, saying,

"... the landscape is characterized by nearly level to gently sloping relief. Fox soils are light colored and well drained. They formed in limy sand and gravel deposits and occupy nearly level to gently sloping rises and slightly higher areas of stream second bottoms. The Lippincott soils are dark colored and poorly drained. These soils formed in limy sand and gravel deposits on level relief. Algers soils are light colored, poorly drained, and formed in stream sediments on level areas of first bottoms."

Champaign County.

The Miami-Crosby-Brookston-Celina association of the Cable Moraine continues into Champaign County. Along major drainageways on the east side of the moraine, a Pitchin-Sloom soil association is found. These soils are not recognized outside Champaign County. Ritchie (1961) described the Pitchin silty clay loam, formed on outwash terraces, as,

"... dark colored, very poorly drained ... and very highly productive. It formed on calcareous gravelly material high in silt on nearly level to depressed areas of terraces."
Sloan silty clay loam is described as formed on lacustrine terraces, and

"... is dark colored, very poorly drained ... and very highly productive ... It occurs on nearly level to depressed areas of first bottoms."

The association of Pitchin-Sloan soils with drainageways may lead to flood problems.

The northwest corner of Champaign County has a Westland-Fox-Tawas soil association. These soils are situated along Big Darby Creek, similar to the Blount-Horley-Pawmos soils of Logan County. Westland silty clay loam is described by Ritchie as

"... dark colored, very poorly drained ... and highly productive ... It formed in silty deposits underlain by calcareous sand and gravel at 36 inches or more on level to depressed areas of terraces."

Tawas is an organic soil, described by Ritchie as a muck that is

"... very poorly drained, and highly productive. It developed on woody and fibrous material underlain at 12 to 42 inches by sand and gravel."

The Fox silt loam has been described above.

The ground moraines of eastern Champaign County is covered by a Brockton-Crosby soil association.

Union County.

Big Darby Creek in Union County is associated with Fox-Lippincott soils, indicative of higher sand and gravel concentra-
tions. As in neighboring Logan County, the area of the Powell Moraine is mantled by 622-623 soils; in Union County 6288 soil is also found with this association. 6288 is described by Powell and Ritchie (1966) as a silty clay that is

"... a dark colored, very poorly drained soil that occurs on level to depressed upland areas in 'Big Bear Swamp'."

Big Bear Swamp is outside the Big Darby Creek Watershed, but upland swamps do occur in the Powell Moraine, and 6288 soils may be expected.

The Blount-Worley-Pewamo association of Logan County continues along the north side of Big Darby Creek. South of the creek, the ground moraine is covered with a Brookston-Crosby soil association.

Madison County

The till plain of Madison County is covered by Brookston-Crosby soils, with locally associated Kokomo soils. Smith (1958) described Kokomo soils as

"... very dark colored, very high in productivity, but very poorly drained in their natural state. They developed from highly calcareous glacial till and occur on flat to depressed areas of till plains."

Problems of intercounty correlation are evident with Madison County soils. Kokomo soils are not recognized in neighboring Union County. Pitchin-Sloan soils of Champaign
County are not recognized in Madison County.

Miami-Celina soils are found along Spring Fork, Little Darby Creek, and Big Darby Creek. These are typically bounded by a Crosby-Brockton-Celina association. Little Darby Creek, south of its junction with Spring Fork, is associated with Sloan and Fox soils.

Franklin County

The pattern of Miami-Celina soils along Little Darby Creek and Big Darby Creek, as well as Hellbranch Run, surrounded by Crosby-Brockton-Celina soils, continues into the western portion of Franklin County. The southern portion of Big Darby Creek in Franklin County flows through an area of Oakley-Bel soils. These soils are described by Baker (1960).

"Oakley soils formed in 42 inches or more of silt over calcareous sand and gravel on nearly level second bottoms. They are well drained. Bel soils formed in nearly level first bottoms. They are moderately well drained. These soils are highly productive."

Pickaway County

The Oakley-Bel association continues along Big Darby Creek through Pickaway County. Miami-Celina soils are present south of Orient for several miles, between the Oakley-Bel association near the creek, and the association of Crosby-Brockton-Celina soils on the till plains.
Soil parameters, and their relationship to land use capabilities and limitations, are presented in Table 1. Soils of Table 1 are covered individually, as characteristics of soils vary within associations. Approximately qualitative divisions were constructed by each of the investigators from which Table 1 is adapted (Hitchie, Powell, and Siegenthaler 1971; Powell and Hitchie, 1966; and Smith 1958). Terms for these divisions have been modified on this table, on a qualitative scale in order of increasing limitations for land use of slight, some, moderate, and severe.

Data for slopes, sanitary landfills, and recreation are presented for utilization in discussion below. Fox, Miami, and Oakley soils are naturally well drained, and have the lowest level of seasonal high water table. For other soils a combination of seasonal high water level and poor natural drainage forms the controlling land-use limitations. For soils along drainageways, flooding is a limiting factor.

Impermeability of glacial till, which forms the ground and end moraines of the watershed, causes poor natural drainage. The seasonal high water table is often at or close to the surface.

An important limitation on development capabilities of the Big Darby Creek Watershed is the generally poor ability of the land to accommodate septic tanks. The expense of central
### Table 1

<table>
<thead>
<tr>
<th>Soil</th>
<th>Slope (°)</th>
<th>Natural Drainage</th>
<th>Depth to Seasonal High Water Table (ft)</th>
<th>Productivity</th>
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<td>moderate</td>
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<tr>
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<td>0-1</td>
<td>very high</td>
</tr>
<tr>
<td>Celma</td>
<td>0-6</td>
<td>moderate</td>
<td>2-3</td>
<td>mod. high</td>
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<tr>
<td>Creasy</td>
<td>0-6</td>
<td>impervious</td>
<td>0-1</td>
<td>mod. high</td>
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<tr>
<td>Fell</td>
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<td>moderate</td>
<td>4-5</td>
<td>mod. high</td>
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<tr>
<td>Fox</td>
<td>0-6</td>
<td>well</td>
<td>4</td>
<td>very high</td>
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<tr>
<td>Kokomo</td>
<td>level</td>
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<td>-</td>
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</tr>
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<td>very poor</td>
<td>0-1</td>
<td>very high</td>
</tr>
<tr>
<td>Miami</td>
<td>2-12</td>
<td>well</td>
<td>2-3</td>
<td>mod. high</td>
</tr>
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<td>Morley</td>
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<td>moderate to well</td>
<td>-</td>
<td>moderate</td>
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<td>Ockley</td>
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<td>3</td>
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<td>-</td>
<td>high</td>
</tr>
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<td>-</td>
<td>very high</td>
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<td>very high</td>
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<td>-</td>
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Sources cited in text
### Soil Characteristics and Land-Use Limitations

**Table 1**

<table>
<thead>
<tr>
<th>SOILS</th>
<th>Septic Tank Limitations</th>
<th>Recreation Limitations</th>
<th>Cemeteries &amp; Sanitary Landfill Limitations</th>
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<tr>
<td>Brookstn</td>
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<td>severe</td>
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<tr>
<td>Crooky</td>
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<td>moderate</td>
<td>mod-ma</td>
</tr>
<tr>
<td>Eel</td>
<td>severe</td>
<td>moderate</td>
<td>mod-ma</td>
</tr>
<tr>
<td>Fox</td>
<td>slight</td>
<td>mod-ma</td>
<td>mod-ma</td>
</tr>
<tr>
<td>Kokomo</td>
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<td>-</td>
</tr>
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<td>severe</td>
<td>severe</td>
</tr>
<tr>
<td>Malik</td>
<td>severe</td>
<td>all-eway</td>
<td>all-eway</td>
</tr>
<tr>
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<td>-</td>
</tr>
<tr>
<td>Oakley</td>
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<td>slight</td>
<td>slight</td>
</tr>
<tr>
<td>Powako</td>
<td>none</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pitchin</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sloan</td>
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<td>severe</td>
<td>severe</td>
</tr>
<tr>
<td>Tawas</td>
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<td>Westland</td>
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<tr>
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</table>

*Sources cited in text*
sanitary sewer systems and hazards of open sewage lagoons may make these methods of sewage disposal impractical. Instead, rural and subdivision development are often based on septic tank disposal systems. The low permeability of the soil, combined with seasonal high water table, create serious limitations for septic tank disposal systems on the watershed.

Soils of the watershed are generally high in agricultural productivity. Powell and Ritchie (1966) estimate production figures as ranging from 43 to 100 bushels per acre of corn for 622 soils, to 90 to 160 bushels of corn per acre for Sloan soils. The variation in figures for each soil allows for differing soil management practices. Most of the soils of the watershed approximate the figures for Sloan soils. High agricultural productivity and proximity to market must be considered in planning future land use of the watershed.

Slopes

Another geologically related factor in the inventory of the physical environment that forms a restraint on land use is the slope of land. McHarg (1971) discusses factors of slopes in his study of the Potomac River Basin, and points out that lands best suited, by their slope, for agricultural use, are also best suited for urbanization.

52
The City and Regional Planning Division of the School of Architecture at Ohio State University has published a course manual for Physical Elements of Urban Development (Anderson, 1972) that includes extensive discussion of slopes and their utilization. They discuss the uses to which various slopes may be put, and summarize these data in a division of slope categories:

- Under 1% - With artificial drainage areas are suitable for agricultural and large scale production like commercial; drainage problems restrict residential and commercial uses
- 1-3% - Suitable for most uses
- 3-5% - Suitable for general agriculture, as well as smaller industrial, commercial, and residential uses
- 5-10% - Limited for industrial, commercial, and residential uses; agricultural utilization requires use of erosion control techniques
- 10-15% - Can be suitable for non-cultivated agricultural uses, as well as careful subdivision residential construction; not feasible for either industrial or commercial
- 15-30% - Residential use, with attention to slope stability engineering problems, and non-cultivated agriculture; unsuitable for all else
- Over 30% - Uses virtually restricted to pastures and forests

Recreational utilization may be made of land with any slope, activities vary from level ball fields to vertical mountain climbing.

Different studies utilize different breakdowns of slopes.
the division presented here is applicable to areas like the Big Darby Creek Watershed, where extensive level areas exist.

Figure 11 is three photographs of areas with typical slopes of the watershed. The Appendix contains sections of topographic maps with locations of the photographs marked.

Flatland of ground moraine areas (Fig. 11A) is suitable, with artificial drainage, for many uses. Problems of steeper slopes are confined to areas of Powell and Cable Moraines (Fig. 11B) and areas along flood-plain edges of Big and Little Darby Creeks, especially along lower Big Darby Creek in Pickaway County. In this area, slopes are forested, with land of the flood plain below and till plain above under cultivation.

Instability of slopes is not at present a hazard on the watershed. Visual inspection of areas with higher slopes (Fig. 11B, c) show the existence of minor slump features, seldom exceeding 15 feet across. More detailed inspection would probably expose many such features.

Construction of houses at the top of slopes overlooking the lower Big Darby Creek valley has begun. Desire to enjoy the view of the valley may lead to some homeowners finding themselves an integral part of that view.

Stability of slopes is a typical environmental problem that, because it is not recognized as a hazard now, might be ignored as a future problem. Caution in planning and in construction
FIGURE II A

Typical Ground Marine Area
FIGURE 118

Typical Slopes of the Cable Moraine
FIGURE 11C
Typical Slopes Along Little Darby Creek
should be exercised when building upon or altering land-use of areas with higher slopes on the watershed.

Water Quantity

Another major factor in the physical environment of an area is water supply. Two major parameters of supply are quantity and quality. Although surface and ground water are indivisible in nature, for the ease of discussion and treatment of data, they will be separated below in terms of both quantity and quality.

Groundwater Quantity

Figure 12 is a map of the underground water resources of the Big Darby Creek Watershed, compiled from Schmidt (1960, 1961). There are three major sources for underground water: buried sand and gravel deposits, valley train and outwash deposits, and bedrock.

Glacial till which mantles the bedrock contains water in the sand and gravel lenses discussed above. These lenses yield supplies of 5 to 25 gallons per minute, adequate for residential use. Higher yields require extensive exploration. Sand and gravel deposits bearing water are also found in buried valleys of the Teays River system, as illustrated in Figure 7,
BIG DARBY CREEK WATERSHED
MAP B

FIGURE 12

AVAILABILITY OF UNDERGROUND WATER

- 1000 GPM
- 450 GPM from sand and gravel
- 100-500 GPM from bedrock
- 100-500 GPM from S & G
- 100-500 GPM - morainal
- 5-25 GPM
- 5-10 GPM

after Schmidt (1960,1961)
and yields to 250 gallons per minute may be developed from them.
The map pattern for 100 to 500 gallons per minute from sand
and gravel deposits presents, southwest of Plain City and near
western Union and eastern Champaign Counties, a rough outline
of Tews Stage drainage channels as presented on the map of
contours on the bedrock surface (Fig. 6).

Sand and gravel lenses within the till are a source of
limited water supply of 5 to 10 gallons per minute in the area
of the Cable Moraine. Water supplies of 100 gallons per minute
may be developed where these deposits overlie bedrock.

A second source for ground-water supply is from valley
train and outwash deposits that are associated with some of the
present drainage courses of the watershed. Norris (1959) discus-
ses valley-train deposits and water supply, saying

"Ohio's most abundant sources of ground-water supply
are valley-train deposits of sand and gravel which receive
recharge, when wells in them are pumped heavily, by the
induced infiltration of streamflow. The most extensive
valley train deposits ... are in the Little Darby Creek
valley near West Jefferson."

He goes on to say

"Among the factors to be considered in the development
of a ground-water supply, by inducing infiltration from
streams, are (1) the permeability and thickness of the
aquifer; (2) the amount of water available from storage
in the aquifers, which can be tapped between periods of
abundant replenishment; (3) the streamflow in dry periods;
and (4) the rate at which infiltration can be induced
into the aquifer. The latter two factors become increas-
ingly important where ground-water storage is small, as
in the valley-train deposits of Madison County."
Valley-train deposits of the Big Darby Creek Watershed are found near West Jefferson, as Morris pointed out, as well as in the vicinity of Big Darby Creek below its junction with Little Darby Creek, and near the mouth of Big Darby Creek. These deposits produce ground-water yields of up to 450 gallons per minute.

The third major ground-water source is the bedrock. Ground water supplies are not developed from the Olentangy and Ohio Shales, as yields typically are less than 5 gallons per minute. Wells from carbonate bedrock produce yields to 500 gallons per minute. Municipal wells are commonly drilled into the limestone or dolomite bedrock to obtain required yields.

Surface Water Quantity

There are two major concerns with surface water supply, the amount of water present during flood stage, and the amount of water available during drought. Flood stage levels determine capability for construction sites and the need for flood control programs. Low flow levels determine the amount of water that will be available for recharge of aquifers and surface-water withdrawal.

Data for both these parameters have been presented in several statistical frameworks. One method for the presentation of flood data is in terms of the number of years, or recurrence
interval, between water levels. Figure 13 is a recurrence interval chart for Big Darby Creek at Darbyville, from Cross and Webber (1959). The highest recorded discharge of Big Darby Creek postdated information on Figure 13. This highest flow of 49,000 cubic feet per second, was from the storms of January 1959, which dumped rain on a melting snowpack over frozen ground.

This compares with an average flow of 429 cubic feet per second (Cross, 1968). The 1913 flood was probably of similar magnitude to the 1959 flood, but lack of a recording station prevented accurate determination of discharge.

Floods on the watershed may also result from intense summer thunderstorms.

Low flow data are presented on the flow duration curve (Fig. 14). Adapted from Norris (1959), this flow duration curve presents the percentage of time a flow level is equaled or exceeded. Figure 14 includes for comparison a flow duration curve for the Mad River of western Ohio. The Mad River is underlain by permeable sand and gravel deposits, which recharge the river and sustain low flow. Darby Creek has a lower level of low flow due to extensive coverage of the watershed by impermeable till. Norris (1959) comments on the low flow curve for Big Darby Creek, and the curve as a response to groundwater storage:

"A comparison of Darby Creek with ... other streams in
Figure 1a
Flow Duration Curves
Dabby Creek and Mad River
after Norris (1959)

Cubic Feet Per Second Per Square Mile

Percent of time indicated discharge was equaled or exceeded

0.1 0.2 0.5 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 95 99
Ohio shows that Darby Creek ranks among the 10 percent of the streams that have the smallest natural storage in their drainage basins."

This indicates little ground water recharge to low flow of Big Darby Creek, and thus an unreliable surface-water supply.

Water Quality

Data are available for the Big Darby Creek Watershed covering both ground and surface water quality (Schmidt, 1960, 1961; U.S. Geological Survey, 1968, 1969, 1970, 1971; Youngquist et al., 1963), and are presented in Tables 2 and 3, with sampling sites indicated on Figure 15. Both tables express concentrations in parts-per-million (ppm), which, at the concentrations discussed, equal milligrams-per-liter (mg/l). These terms will be utilized interchangeably. Table 1, Surface Water Quality, lists both permissible and desirable standards for water quality parameters discussed, as determined by the Federal Water Pollution Control Administration (Committee on Water Quality, 1968). The Committee defined the two types of criteria as:

"Permissible criteria - Those characteristics and concentrations of substances in raw surface waters which will allow the production of a safe, clear, potable, aesthetically pleasing, and acceptable public water supply ... after treatment.

Desirable criteria - Those characteristics and concentrations of substances in the raw surface waters which represent high quality water in all respects for use as public water supplies."

66
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GROUND WATER QUALITY

s-sand  ls-limestone
gr-gravel dol-dolomite

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**SURFACE WATER QUALITY**

**TABLE 3**
Good quality water will meet or exceed desirable criteria, and poor quality water will not meet permissible criteria. Water between the two standards is satisfactory.

Groundwater Quality

The data on quality of ground water, Table 2, indicate that levels of chloride and pH are within standards. The Public Health Service (1962) reports that sulfate is detectable by taste at a concentration of 250 ppm, with no deleterious effects noticed until the concentration exceeds 600 ppm. Of the three wells that exceed PHS standards for sulfate, only well 15 presents a major health hazard. Concentrations of iron, dissolved solids, and hardness as CaCO₃ in the ground water are excessive. The Public Health Service (1962) recommends a limit of .3 mg/l for iron, which imparts a bitter and astringent taste to liquids and is readily detectable at concentrations of 1.8 mg/l. Although no toxicologic effects are known at such low concentrations, iron will stain clothing and plumbing fixtures. A major water quality parameter that exceeds desirable standards everywhere, and permissible standards at most sites, is dissolved solids content. Dissolved solids impart a mineral taste to water, have some physiological effects, and cause corrosion damage. Another parameter with high concentration is hardness as CaCO₃. No limit

69
BIG DARBY CREEK WATERSHED
MAP A

FIGURE 15
SAMPLING SITES FOR WATER QUALITY

STREAMS
INTERMITTENT
POPULATION CENTERS
COUNTY LINES

MATCH LINE

0 1 MILES 4 8

70
BIG DARBY CREEK WATERSHED
MAP B

FIGURE 15

SAMPLING SITES FOR WATER QUALITY

Underground Water Sampling Sites  1h
Surface Water Sampling Sites  A

sources cited in text
for hardness is shown on Table 2, as the Committee on Water Quality explains:

"A single criterion for maximum hardness in public water supply is not possible. Hardness in water is largely the result of the geological formations with which the water comes in contact ... A criterion for objectionable hardness must be tailored to fit the requirements of each community. Hardness more than 300-500 mg/l as CaCO₃ is excessive for public water supply. Many consumers will object to water harder than 150 mg/l. In other communities, the criterion for maximum water hardness is considerably less than 150 mg/l. A moderately hard water is sometimes defined as having hardness between 60 to 120 mg/l."

Hem (1970) reports no objectionable behavior of water such as inhibiting the formation of soap lather or creation of scale on plumbing fixtures, until the hardness exceeds a level of "100 mg/l or more". Ground water of the Big Sandy Creek Watershed derives hardness from its intimate association with limestone bedrock and sand and gravel. Hardness is removable by treatment, but its presence may have benefits in reduction of circulatory diseases (Perry, 1971).

Surface Water Quality

Data of surface water quality (Table 3) is adapted from U.S. Geological Survey reports (1968, 1969, 1970, 1971) and Schmidt (1960), and covers more parameters than ground-water quality data discussed above. Several surface water quality parameters have similar values to ground water values. Surface
water sulfate concentrations parallel ground water values in lying above desirable standards, but withing permissible levels. Dissolved solids and hardness values of surface waters are high, two samples exceeded permissible criteria and all samples were close to this limit. Surface-water hardness values are high, but less than ground-water values. Surface water has higher chloride concentration than ground water, perhaps a response to surface runoff of untreated farm wastes and dumping of inadequately treated municipal sewage. Farm wastes that infiltrate may have chloride removed through chemical reaction with clay minerals of the soil before the wastes enter ground-water supplies. Seasonal variance of chloride values, attributable to salting of highways in winter, is not detectable. Surface pH is more basic than ground-water pH.

Other parameters of surface water quality include nitrate, fluoride, and phosphorus. Nitrate values are less than permissible criteria, but greater than desirable. The hazard of methemoglobininemia is not present at nitrate levels found. Fluoride criteria vary with average annual maximum daily air temperature; concentrations found in surface waters of the Big Darby Creek Watershed are within the most stringent of these criteria. Limits for phosphorus concentration are not yet established. Phosphorus is essential for plant growth, but
excess levels may lead to problems of eutrophication. Levels of phosphorus required for eutrophication vary with other water quality parameters, and need to be established for each situation. They have not been established for the Big Darby Creek Watershed.

Inventory Conclusion

This partial inventory of the physical environment of the Big Darby Creek Watershed presents geologically-related factors that influence the ability of the land to accommodate growth of the Columbus metropolitan area. A complete inventory of the watershed's environment would also include consideration of such factors as climate, biology, and a more exhaustive analysis of the human colony.
PHYSICAL PARAMETERS AND LAND USE

Application of the physical inventory to selected future problems on the Big Darby Creek Watershed forms the second major section of this report.

The writer's limited exposure to the broad spectrum of land-use planning has led to the decision to consider only selected potential problems of land use on the watershed: floods, water supply, landfill siting, and recreational needs.

Land-use reports often consider factors beyond these; construction of sewers and sewage treatment plants will be very important in future watershed development. Franklin County is considering siting a sewage treatment plant in Darbydale, which would permit development of areas now restricted because of septic-tank problems (E. Cooper, Mid-Ohio Planning Commission, pers. comm.). The factor of zoning is more often related to cultural patterns of transportation routes, church sites, and present land utilization than to physical parameters. These considerations are better suited to study by interdisciplinary task forces.

Some land-use problems have been discussed with the inventory above. Those discussed below are not intended to make this a comprehensive report about the geological influences on growth of the human colony; they are only some concerns that may become important in the watershed's future.
Reservoirs

Man's responses to flooding take many forms. Control of rivers through structural methods as levees, reservoirs, and channelization has long been popular. It is recognized that flood damage may also be reduced through floodproofing structures on the flood plain and careful control of watershed vegetation.

Ohioans are not exempt from the desire of western cultures to control their environment. Flooding, and the desire to control flooding, have long been a part of life in the Scioto River Valley.

Alward and Burdick (1916) discuss a flood control reservoir on Big Darby Creek in their report to the Franklin County Conservancy District. Their study centered on comparison of benefits from two proposals, the first placing flood control reservoirs on only the Upper Scioto River and Olentangy River; the second adding to these reservoirs on Alum, Walnut, Deer, and Darby Creeks. They considered the first plan more feasible.

"On the main valley the difference in flood heights with a complete system of basins as against only the two proposed, is so slight that the territory benefited by the former and not the latter is confined to a narrow fringe along the foot of the high ground bordering the valley. At Circleville the difference in amount of protection afforded would be very slight. ... The difference in cost above Circleville of a complete system of basins and of only the two basins at Dublin and Delaware is $5,949,000 ... This difference in cost would have to be assessed against the proportion located below Columbus, and there can be no doubt but that the benefits there will not warrant this extra cost."

76
Alvord and Burdick selected a reservoir location on Big Darby Creek downstream from the more recently proposed location for the Army Corps of Engineers reservoir site (Fig. 16). Costs of the flood control reservoir on Big Darby Creek increased from $1.4 million for Alvord and Burdick to an estimated $66 million for the Army Corps. Alvord and Burdick expressed the feeling that costs from protection of primarily agricultural land far outweighed the benefits. Subsequent population growth might have led them to reevaluation of their data, but it is doubted they would have reached different conclusions.

The Army Corps of Engineers has recently considered construction of a flood control reservoir on Big Darby Creek. Figure 16 indicates the difference in reservoir area between permanent pool and maximum flood retention stage. The reservoir presently has inactive status, as support for this project of the State of Ohio has been withdrawn. Such status does not prevent Ohio's support from being reinstated in the future, and the project resumed. The reservoir and dam had problems, including the pre-Pleistocene erosion surface. Extensive core drilling was required before siting of the foundation.

Renshaw (1961) summarized approaches to flood control as follows.

"Since the enactment of the Flood Control Act of 1936, flood losses have continued to mount in spite of very large expenditures for flood control... While the
BIG DARBY CREEK WATERSHED
MAP B

FIGURE 16
RESERVOIR SITES
U.S. Army Corps of Engineers Flood Control Reservoir

Maximum Flood Stage
elev. 888.0'

Conservation Pool
elev. 831.0'

City of Columbus Water Supply Reservoir
elev. 910'

sources cited in text
increase in flood damage published by such agencies as the Weather Bureau can partly be attributed to floods of greater severity and to better reporting, the most important factor contributing to increased losses is persistent invasion of the flood plain."

The State of Ohio, through the Flood-Plain Management and Land-Use Planning Divisions of the Department of Natural Resources, is attempting to cope with the problem of expansion onto floodplains. Programs like flood-plain zoning for recreation and parking recognize the inevitability of flooding. Zoning ordinances also meet federal requirements for flood insurance.

The future of flood control structures on Big Darby Creek is uncertain at this writing. Local and state opposition to reservoir construction, strong flood-plain zoning, and a minimal cost-benefit ratio, may combine with an increased awareness of the general public to render expensive reservoirs obsolete.

The flood control reservoir is not the only planned reservoir on the Big Darby Creek Watershed. The City of Columbus is planning construction of a water supply reservoir on Upper Big Darby Creek (Fig. 16). This reservoir is in preliminary engineering stages at this writing, and detailed plans are not yet available.

The decision of Columbus to construct reservoirs for water supply, rather than relying exclusively on withdrawing ground water from the Scioto River Valley, continues to be debated.
Planners express confusion about ground water, preferring surface water reservoirs that can be seen (R. Cooper, Mid-Ohio Regional Planning Commission, pers. comm.).

The water to be impounded is of questionable quality, from both general watershed characteristics discussed above and inadequate sewage treatment at Plain City. Impoundment may cause water quality changes, such as thermal stratification and oxygen depletion (Symons, 1969).

One of the most difficult problems of reservoirs, a problem whose ultimate solution is essential to the success of the reservoir, is that of sedimentation. Also termed allitation, the process of displacing the volume of water in a reservoir by a volume of sediment transported by tributary streams as bed or suspended load, has been the subject of an extensive study in Ohio (Kahn, 1965).

The sediment content of streams depends on many factors. The quantity of water effects the load carried, with a large stream transporting more sediment than a small stream. Load also varies with stream velocity; fine sediments settle in quiet water but remain suspended in turbulent water. Such settling, as streams enter quiet reservoirs, causes sedimentation problems. The load of a stream is also related to land use; open cropland produces more sediment than protected forest or pasture. Urbanization seals off land from erosion.
Land use on the Big Darby Creek Watershed is primarily agricultural. While flat lands, such as the till plains, reduce the force of erosion and the amount of sediment produced, extensive open cropland offsets this advantage. A 1935 study of land utilization (Sitterly et al., 1935) showed that townships on the watershed have as much as 97 percent of their land as farms, with 50 to 70 percent of the total in harvested crops. Progressive conservation techniques may lessen runoff, but such techniques are not universally applied. The till-plain lands were swampy, and, as described above, have poor natural drainage. The need for prevention of erosion is not immediately obvious to the local land owner. In a study of land use in Madison County (Baker et al., 1941) farmers viewed improvement of drainage as having more importance than erosion control.

The location of the City of Columbus water supply reservoir in a cropland section of the watershed may increase siltation problems and shorten the useful life of the reservoir.

One concern for estimating reservoir life is trap efficiency, what portion of the sediment load of a stream is trapped in a reservoir. Hahn (1955) discusses trap efficiency thus:

"It depends primarily on two factors: sediment characteristics and detention time of inflow. The most important sediment characteristics are the size distribution, shape and specific gravity of the particles. Detention time depends on a number of items: capacity inflow relation, average annual inflow, character of flow duration, shape or reservoir and operation of the outlets."
Fine, platy particles would be least likely deposited. A small capacity reservoir receiving large inflow would quickly fill, as would one without sediment trapping basins on tributary streams.

Another factor in sedimentation is the capacity-watershed ratio. Hahn says:

"Capacity-watershed ratio C/W is the ratio of the capacity of the reservoir in acre feet to the area of the drainage basin in square miles. Thus it is the storage capacity in acre feet per square mile of drainage area. When the C/W is low, the reservoir has a large drainage area relative to its storage capacity and may normally be expected to lose capacity by sedimentation at a faster rate than a reservoir with a high C/W."

Hahn limits the useful life of a reservoir to containing less than 60 percent sediment, although he cites other studies suggesting that sediment percentages as high as 80 percent may be permissible. For the purpose of water supply, 60 percent is a reasonable figure.

A smaller reservoir than the proposed Columbus reservoir was studied (Zahn, 1955) in a similar till plain location, but outside the Big Darby Creek Watershed. Madison Lake, on Deer Creek, was constructed in 1946 for recreational purposes. It impounded 594 acre feet from a drainage area of 57 square miles, for a C/W ratio of 10. Madison Lake lost 18.1 percent of its capacity to sediment in eight years.

Yountquist et al. (1960) discuss reservoir sites of the
Seloto River Basin, including the site proposed by Columbus. They compute a capacity of 13.1 billion gallons for this site. With a watershed area of 244 square miles, this yields a C/W ratio of 164. If data from a small reservoir are applicable to a larger one, the 16 fold increase in C/W ratio from Madison Lake to the Columbus reservoir would indicate a 16 fold increase in reservoir life. This yields and estimated 400 year life for the Columbus reservoir. Greater trap efficiency of the larger reservoir (90% compared to 50%) would lower this figure.

A more useful method for estimating the life of a reservoir is to use the rate of erosion and calculate how long it would take for that sediment volume to fill the reservoir. For the City of Columbus reservoir, the calculation proceeds thus:

\[ L = \left( \frac{V/365}{W} \right) \times 0.6 \]

- \( L \) = life of reservoir in years
- \( W \) = rate of erosion = 360 tons/m²/yr (Hubble and Collar, 1960)
- \( A \) = area of watershed above reservoir = 244 m²
- \( W \) = weight of sediment = 50 lbs/ft³
- \( V \) = volume of reservoir in ft³ = 1,751,000,000 ft³
- \( 0.6 \) = useful reservoir life

\[ L = \frac{1,751,000,000}{360 \times 2,000 \times 244} \times 0.6 \]

\[ = 359 \text{ years} \]

The two answers for the estimated life of the Columbus water supply reservoir are comparable.

Changing land use may significantly alter this estimate.
of reservoir life. Urbanization increases sedimentation rate through removal of soil. Knott (1975) found annual sediment production of 26,000 tons per year for construction sites, compared with 310 tons per year from open space, on the Colma Creek Basin of California. Similar data need to be generated for the Big Darby Creek Watershed to assess the impact of construction on sediment rate and reservoir life.

The planned dam for the Columbus reservoir might also encounter foundation problems. The Columbus reservoir will be impounding a major aggregate resource area, and a cost-benefit analysis must include lost resources.

The Ohio Department of Natural Resources is, at this writing, making an environmental impact study of the Columbus proposal (S. Harvath, Ohio D.N.R., pers. comm.). Further discussion here would be unnecessary duplication of their work.

Future expansion of the Columbus metropolitan area will affect the potential for reservoir construction on the Big Darby Creek Watershed, and alternatives for water supply need to be studied.

Sanitary Landfills

Disposal of solid wastes is a cultural problem influenced by geologic parameters. Rapid growth of population and living standards has produced an attendant boom in discarded bottles,
cans, construction materials, and garbage, which must be disposed. The National League of Cities and the U. S. Conference of Mayors, in an article in the Columbus Dispatch of 10 June, 1973, stated that the nation's cities are running out of trash disposal sites. Columbus is part of this trend, the article states, as Columbus' facility is expected to last only six more years.

Disposal of refuse in open burning dums is no longer considered acceptable by air pollution monitors or neighbors of the dump site. Technology for recycling waste, although advancing rapidly, has not yet, and may never, render solid waste disposal sites obsolete.

An attractive alternative to dumps for many cities is the sanitary landfill. Although some environmental hazards may exist, a properly executed landfill is a minimal nuisance during and after operation. A sanitary landfill is defined by the American Society of Civil Engineers (as quoted in Hughes, Leonen, and Parvoden, 1971) as

"...a method of disposing of refuse on land without creating nuisances or hazards to public health or safety by utilizing the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each day's operation, or such more frequent intervals as may be necessary."

Thus compaction and covering, with prevention of pollution, make
a landfill sanitary.

Several potential pollution problems exist with landfills. Production of carbon dioxide and methane gases, and some subsidence from incomplete compaction may occur. The major geologic problem is the formation of leachate, a solution of refuse in percolating water. Leachate contains a high content of dissolved solids, and may transport pathogens from landfill sites to groundwater. Hughes (1967) compiled analyses of leachates, and found them typically high in, but not limited to, iron, calcium, magnesium, chloride, and sulfate.

Prevention of leachate intrusion into ground-water supplies is a problem that must be dealt with, either through original selection of an optimum site, or engineering modification to less suitable areas.

Cartwright and Sherman (1969) presented a summary of criteria for evaluation of landfill sites. They indicated that a 30-50 foot thickness of unconsolidated material, preferably glacial till, lake silt or clay, loess, but not sand and gravel, should overlie bedrock. Till or clay is only slightly permeable, and prevents rapid movement of leachate into ground water. Ion exchange purifies leachate as it moves through clay minerals in soils. Sand and gravel often lack many clay minerals, and are not effective in such purification. Unfractured shale
bedrock is most suitable for construction of landfill sites. Sandstone and fissured carbonate rocks permit rapid leachate movement to ground water. Carbonate rocks of the Big Darby Creek Watershed contain such fissures. A high water table, typical of the watershed, inhibits dry landfill sites. Deep wells, either into bedrock or sand and gravel that has a thick, impermeable cover, indicate suitability of site. Depressions like swamps, stream floodplains, and other areas near surface water are unsuitable for landfill siting.

The best landfill sites of the watershed are where thick glacial till overlies shale bedrock. Throughout most of the watershed, adequate thicknesses of till exist over the fractured carbonate bedrock to permit slow infiltration and ion exchange purification of leachate. Fractured bedrock makes such thick till an absolute requirement. As discussed with soils, much of the watershed has a high seasonal water level, and would require extensive engineering to make a site suitable for use as a landfill.

The writer found no sanitary landfills on the watershed. Dumps are very common.

A map of sanitary landfill sites often accompanies reports of this nature. Requirements of scale, combined with the need for detailed site investigation, and engineering capability for landfill construction, renders such a map beyond this study.
Landfill siting on the watershed will need to have detailed site study, to probe for sand and gravel lenses which might carry leachate contaminates to ground-water supplies, to determine engineering required to alleviate high ground-water levels, and to determine sources of soil for cover operations. Search for geologically and socially suitable sites should be prior to population expansion onto the watershed.

Recreation

Land that may, for reasons such as flooding or mineral extraction, have little other use, is often suggested for utilization as recreational land. Environmentalists often suggest that the optimum utilization for any land is for recreational purposes; as of this writing designation of Big Darby Creek as a scenic river is pending in a court case.

The relationship of recreation and geology is not often seen. Topography, soils development, and streams are all part of the geologic environment and contribute to the recreational resources of an area. Table 1 shows some soils having limitations for recreation. These limitations are either poor drainage or flooding. Flood prone land is ideal for recreation, loss of a days hiking can not compare with loss of houses.

Present recreational resources of the watershed are illustrated on Figure 17, and discussed below.
Nos. 1, 3, and 8 are golf courses. Developed on rolling
and moraines and till plain, they serve a single recrea-
tional need. The Marysville Country Club (No. 8) has a
pond enhancing adjacent residential development which
may serve recreational needs.

Nos. 4 and 5 are private camps Ken-Jockey and Wissalohican
which do not serve as public recreational resources.
No. 10 is a private lake at Battelle Memorial Institute
impounded for cooling their atomic reactor.

No. 6 is the Plain City Fairground.

No. 7 is a roadside rest on Big Darby Creek. This small
area, with well, rest facilities, shelter, and picnic
tables, had users from Cincinnati and Indianapolis
when visited by the writer. Not shown on the map is
another rest area, on I-71 west of Harrisburg. This
area does not serve local recreation needs, but does
divert transient use from other sites.

No. 2 is the only major public recreation area of the
watershed, the Big Darby Creek Metropolitan Park.
Operated by the City of Columbus, its site on bluffs
overlooking the stream valley features playfields, pic-
nic areas, a lodge, and nature trails.

No. 9 is the private pond of the Brush Lake Fishing Club.
Impounded on a depression on the Cable Moraine, this
BIG DARBY CREEK WATERSHED
MAP B

FIGURE 17
RECREATION AREAS

site explained in text
lake removes fishing pressure from public sections of streams.

Extensive use is made of the Darby Creeks for public fishing. Over 90 species of fish are found.

A recent study of Ohio recreation (Swearingen et al., 1972) analyzed present and needed facilities for eight types of recreation. By 1985 the report predicts that more facilities will be needed on the watershed for boating, fishing, golf, hunting, camping, picnicking, hiking, swimming, outdoor games, and pleasure driving.

The report stated that pleasure driving is a major source of recreation; a 73% growth is expected between 1970 and 1985. No major changes need take place for pleasure driving on the watershed. Flatness of the till plain, offset by gentle hills of end moraine areas and farming communities, make pleasure driving relaxing. Many of the farm roads are scenic, and offer respite from the concrete monotony of interstate highways. Southwest of Plain City, horse-drawn vehicles of the Amish present a glimpse of another culture. Influence of the developing energy crises upon pleasure driving remains to be seen.

According to the study of Ohio recreation

"Walking for pleasure is second only to pleasure driving as the most popular outdoor recreation activity engaged in by Americans."
Opportunities for walking are now limited on the Big Darby Creek Watershed. Present trails are confined to park areas. The proposed North Country Trail, stretching from Vermont to North Dakota, will travel along the Cable Moraine through the watershed. Trails outside the watershed have been established along abandoned railroad right-of-ways and under utility lines. Neither of these are likely of the Big Darby Creek Watershed; railroads are active and utility land is used for agricultural purposes.

Opportunities for horseback riding, bicycling on the flat till plains, and canoeing the free flowing streams also exist on the watershed. Proposed reservoirs, if constructed, would provide more recreational resources similar to Big Darby Creek Park, at the expense of alternatives such as free flowing stream fishing and canoeing.

Geology controls the level till plains, the hills of the end moraines, and the valleys of the streams, all of which are a basis for recreational activities. Planning of future recreational areas will be based on opportunities related to the geology of the Big Darby Creek Watershed.
CONCLUSIONS

This study of the Big Darby Creek Watershed has covered some of the influences of geology upon the human colony. Although dramatic geological problems like volcanoes and earthquakes are not present, more subtle influences of bedrock, glacial geology, resource extraction, soils, slopes, water quantity and water quality effect capabilities for development.

Silurian and Devonian age bedrock is composed of shales and carbonates. The eastern portion of the watershed has shale bedrock, which is not suitable for development of water supplies, and may cause slope stability problems where exposed along the lower course of Big Darby Creek. Most of the watershed is underlain by limestone and dolomite bedrock. This rock is fractured, and has surface relief of up to several hundred feet from pre-glacial weathering. The fractures, while providing channels for movement of underground water, may cause problems for siting foundations of heavy structures.

The bedrock is mantled by thick unconsolidated deposits from Pleistocene glaciation. Clayey till of the central Ohio till plain, with local sand and gravel lenses, forms most of the deposits. End moraines provide local relief to the surface topography. Till is largely impermeable, and not suited for the development of water supplies. The local sand and gravel lenses are suitable for development of restricted supplies.
Along stream beds are found valley-train and outwash sand and gravel deposits, as well as recent alluvium. These provide substantial supplies of water.

Both the glacial deposits and the underlying bedrock provide mineral resources of the watershed. Sand and gravel are extracted from the valley-train and outwash deposits. Where near the surface, limestone is worked for crushed rock. These resources are meeting present demand from westward expansion of the Columbus metropolitan area. Resources may, in the future, be lost to reservoir flooding or zoning. A potential resource is petroleum from shale bedrock. Careful evaluation of the rock will have to be made to determine if this resource actually exists.

The soils of the watershed are derived from the Wisconsinan till. These soils, when artificially drained, are highly productive. Their high clay content makes them practically impermeable; combined with high seasonal water table, the impermeability forms major drawbacks to septic tank sewage disposal systems, and thus is a restraint on development.

The watershed is flat, instability of slopes is a problem only in end moraine areas and along stream valleys. Future development will magnify this problem; it should not be ignored.

Water is obtainable from both surface and underground
sources. Groundwater quantities are more predictable than surface water; both have quality drawbacks. Concerns of inadequate sewage treatment, as well as overall quality problems, will affect water when impounded in proposed reservoirs.

Big Darby Creek is a potential site for both an Army Corps of Engineers Flood Control Reservoir and a City of Columbus water supply reservoir. Plans for the flood control reservoir are presently inactive, those for the water supply reservoir are progressing. The water supply reservoir has an estimated life of 400 years.

Sites for sanitary landfills on the watershed are restricted only by funds available to engineer them. Adequate till thicknesses exist in most places to prevent infiltration of leachate into ground water. Problems of seasonal high water table must be reduced by proper engineering.

Demand for recreation on the watershed will increase with growth of the Columbus metropolitan area. Some recreation resources exist, but more development of all types of facilities is needed.

Environmental geology is a new field of geology that attempts to bridge the gap between science and society. Studies, such as this one of the Big Darby Creek Watershed, must become an integral part of the land-use planning process in the future.
REFERENCES CITED


Anderson, Lars T., 1972, Physical Elements of Urban Development—Course Manual: City and Regional Planning Division, School of Architecture, Ohio State University

Baker, F.J., 1960, Soil Areas of Franklin County, Ohio: Ohio Department of Natural Resources Division of Lands and Soil; map with text


Cross, W. F., 1968, Flow Duration of Ohio Streams: Ohio Department of Natural Resources Division of Water, Bull. 42, p.48

Cross, W. F., and Z.B. Welker, 1959, Floods in Ohio: Ohio Department of Natural Resources Division of Water, Bull. 32 pg. 230-237

98


Kahn, Charles L., 1955, Reservoir Sedimentation in Ohio: Ohio Department of Natural Resources Division of Water, Bull. 24, 97 pgs.


Lowe, Henry, 1889, Historical Collections of Ohio: Henry Lowe and Son, Columbus, 2 Vols.


99
Hubbs, J.H., and C.R. Collier, 1960, Quality of Surface Water in Ohio 1946-1958; Ohio Department of Natural Resources Division of Water, Report 14, Ohio Water Plan Inventory, 371 pgs.


Mid-Ohio Regional Planning Commission, 1973, Area Study #1: mimeograph, 11 pgs.

Moses, Clarence F., 1922, Geology of the Bellefontaine Outlier; unpublished M.A. Thesis, Ohio State University, 98 pgs.

Morris, Stanley B., 1959, The Water Resources of Madison County, Ohio; Ohio Department of Natural Resources Division of Water, Bull. 33, 63 pgs.


100


Powell, Kenneth and A. Ritchie, 1966, An Inventory of Ohio Soils-Ulson County: Ohio Department of Natural Resources Division of Lands and Soil, Progress Report No. 27, 36 pg.

Powell, Kenneth L., and V.L. Siegenthaler, 1967, General Soil Map of Logan County: Ohio Department of Natural Resources Division of Lands and Soil, map with text.


Ritchie, Alexander, 1961, An Inventory of Ohio Soils - Champaign County: Ohio Department of Natural Resources Division of Lands and Soil, Progress Report No. 19, 32 pg.


Schmitt, James J., 1965, The Ground-Water Resources of Franklin County, Ohio; Ohio Department of Natural Resources Division of Water Bulletin 30, 97 pg.

Schmitt, James J., 1960, Upper Darby Creek Basin Underground Water Resources: Ohio Water Plan Inventory Map No.6, Ohio Department of Natural Resources Division of Water.

Schmitt, James J., 1961, Scioto River Basin (Middle Portion) Underground Water Resources: Ohio Water Plan Inventory Map No.8, Ohio Department of Natural Resources Division of Water.


101
Sitterly, J.R., R.H. Baker, and J.L. Falconer, 1935, Major Land-Use Problems Areas and Land Utilization in Ohio 1935; Ohio Agricultural Experiment Station Bull., No. 79, 71 pg.

Smith, T.R., 1956, Soil Areas of Madison County, Ohio; Ohio Department of Natural Resources Division of Lands and Soil, map with text

Smith, T.R., 1961, Soil Areas of Pickaway County; Ohio Department of Natural Resources Division of Lands and Soil, map and text

Stewart, David P., 1971, Geology for Environmental Planning in the Barre-Montpelier Region, Vermont; Water Resources Department, Vermont Geological Survey, Environmental Geology No. 1

Stout, Wilbur, 1941, Dolomites and Limestones of Western Ohio; Geological Survey of Ohio Fourth Series, Bull. 42, 428 pg.


102


Wells, John M., 1941, Middle Devonian Bone Beds of Ohio; Bull. of the Geological Society of America, Vol. 55, pgs 273-302

APPENDIX: TOPOGRAPHIC MAPS

As explained above, the base map for figures in this report is adapted from the Columbus and Marion sheets of the U.S. Geological Survey 1:250,000 scale topographic map series. Topographic maps at a scale of 1:24,000, or about 2,000 feet to the inch, also exist for the Big Darby Creek Watershed. Although these more detailed maps were not utilized in presenting results of this study, they have great value. Figure A1 illustrates coverage of the watershed by 1:24,000 scale (7'/min.) topographic maps.

Three examples have been selected from these maps to illustrate some facets of their coverage of the watershed. These are presented as Figures A2-a, A2-b, and A2-c, which correspond to Figures 11A, 11B, and 11C respectively. Map A2-a is from the Plain City sheet, and is typical of the till plain southwest of Plain City. Flatness of Figure 11A is evident in the wide spacing of 5 foot contours. Poor drainage is reflected in intermittent ditches. Map A2-b, from the North Lewisburg sheet, is typical of the Cable Moraine in Champaign County. Rolling hills, ponds, and intermittent streams characterize this area. Figure A2-c shows the junction of Little Darby Creek and Big Darby Creek. From the Galloway map, this area shows 10 foot contour spacing of the slopes of Figure 11C. Flat flood plain
BIG DARBY CREEK WATERSHED
MAP B

FIGURE A1
7½ MINUTE TOPOGRAPHIC
MAPS
and flat till plain contrast with the slopes along the creeks.

Topographic maps are continually updated, and provide a chronicle of development. Their use in studying the physical environment of an area is invaluable.