Groundwater seeping from the Berea Sandstone forms icicles in the old quarry in Doan Brook gorge. Photograph by L. C. Gooch.

Men travel far to see a city, but few seem curious about a river. Every river has, nevertheless, its individuality, its great silent interest. Every river has, moreover, its influence over the people who pass their lives within sight of its waters.

— H.S. Merriman

The Sowers

3 The Shape of the Brook: Physical Features That Form the Stream

If you mention Doan Brook to the average Clevelander, the most likely response will be a blank look and a question: "Doan Brook? Where's that?" Yet, chances are that the person who asks the question has walked or driven along the brook at one time or another. Many know the Shaker Lakes well, occasionally stroll beside the stream in the Cultural Gardens, or fish near the brook's mouth in Gordon Park. Few realize that the stream that flows from the Shaker Lakes is also the heart of the parks downstream.

In this chapter, we begin our exploration of today's Doan Brook by looking at the stream's location and important physical features. To start, we follow the brook from its origins in Shaker Heights to its outlet at Lake Erie, thus placing it in the context of the surrounding landscape. Then, we expand our view to include the brook's watershed — the land that gives water to the stream. Diving beneath the ground surface, we look at the relationship between the brook and groundwater. To complete our understanding of the physical brook, we look at the topography of the stream and its watershed and at the geology that shaped the landscape and gave the brook its character. In later chapters, we will use the physical framework developed here to understand Doan Brook's biology and hydrology and evaluate the impact of human actions, both past and future, on the brook.

3.1 Where Is It? The Brook's Location

The simplest way to describe Doan Brook to most people is to tell them that the brook flows west (toward downtown Cleveland) along North Park Boulevard from Horseshoe Lake and continues along North Park until North Park merges with Martin Luther King, Jr., Boulevard (MLK) (see Figure 3-1). The stream then follows MLK all the way to Lake Erie at Gordon Park.

Some elaboration of this basic description provides a more complete picture of the brook's layout and of how the stream fits into the surrounding city. To place the brook in its surroundings, we will trace it from its upstream end, considering all three branches of its headwaters, and work our way downstream into Lake Erie. Figure 3-1 shows the course of the stream as it is described in the text.

The north and middle branches of Doan Brook flow in from the east to form the "horseshoe" of Horseshoe Lake. The north branch can be traced upstream to its origin by driving east along Shelburne Road from the northern arm of the lake. The modern stream begins south of Shelburne at Warrensville Center Road. The middle branch can be traced from the south arm of the lake by traveling east along South Park Boulevard to the stream's beginning at the intersection of South Park with Shaker Boulevard and Warrensville Center.[1]

Downstream from Horseshoe Lake, the joined north and middle branches flow within the wooded area between North Park and South Park. The brook is visible from either road at the Lower Shaker Lake and can occasionally be glimpsed in other places. Just upstream from the Lower Shaker Lake, the branch that flows from Horseshoe Lake is joined by the south branch of the stream.

1 Originally, the headwaters of all three branches of Doan Brook were considerably farther east. The stream channels were diverted into culverts and filled in during development. See Chapter 5 for more discussion.

Lake Erie

Site 14 Dredge Spoil Area

Gordon Park

I-90

CSX Railroad

East 105th St.

St. Clair Avenue

Rockefeller Park

Superior Ave.

Euclid Ave.

Mayfield Rd.

Rockefeller Park Lagoon

Wade Park

Wade Park Lagoon

University Circle Culvert

University Circle

Ambler Park

Railroad and Rapid Transit

Euclid Heights Blvd.

Coventry Rd.

Doan Brook Gorge

Cedar Rd.

Warrensville Center Rd.

Shaker Heights Parks

Lee Rd.

Lower Shaker Lake

Lily Pond Marsh

Nature Center at Shaker Lakes

Horseshoe Lake

North Park Blvd.

Fairhill Rd.

Fairmount Blvd.

Shelburne Rd.

Shaker Blvd.

West Park

South Park Blvd.

Watershed Boundary

South Woodland Rd.

Belvoir Blvd.

Canterbury Golf Club

Martin Luther King, Jr., Blvd.

Marshall Lake

Green Lake

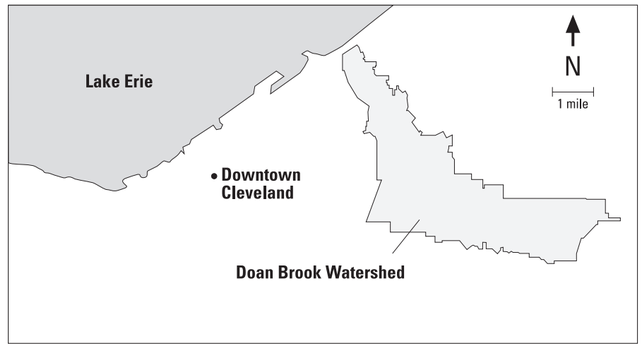
Van Aken Blvd.

Shaker Heights Country Club

Richmond Rd.

N

0 miles 1



Location Map

Doan Brook Watershed

Parklands And Other Open Land

Brook Location Facts (see Figure 3-1)

Doan Brook Length:	About 8.4 miles (along the north branch)
Watershed Area:	11.7 square miles 7,500 acres

Location: Doan Brook arises in Shaker Heights (three branches) and flows west and northwest through Shaker Heights, Cleveland Heights, University Circle, and Cleveland. The brook reaches Lake Erie near the eastern edge of Gordon Park in Cleveland. The stream is the center of the Shaker Lakes parks, Ambler Park, Rockefeller Park, and the Cultural Gardens.

Lakes: There are four lakes on Doan Brook: Horseshoe Lake (sometimes called Upper Shaker Lake) at the confluence of the north and middle branches; Green and Marshall Lakes on the south branch; and the Lower Shaker Lake downstream from the confluence of the north and south branches. Two additional lagoons, the Wade Park Lagoon and the Rockefeller Park Lagoon, sit next to the brook. These lagoons are filled from the City of Cleveland drinking water system and drain into the brook.

Culverts: There are two significant culverts on Doan Brook. One, the University Circle culvert, carries the stream for just under a mile from the intersection of Ambleside and MLK to a point behind the Cleveland Museum of Art. The other carries the brook for 3,300 feet beneath I-90 and the U.S. Army Corps of Engineers Site 14 dredge spoil landfill and into Lake Erie.

Doan Brook's south branch originates on the Canterbury Golf Club golf course east of the intersection of South Woodland Road and Belvoir Boulevard. It flows southwest along the west edge of the course until it crosses Belvoir (at Farnsleigh Road), where it enters a culvert that carries it under Van Aken shopping center to the southeast corner of the Shaker Heights Country Club golf course (just west of the intersection of Warrensville Center and Farnsleigh). The stream runs north and west through the golf course until it enters Green Lake southeast of the intersection of South Woodland and Lee Roads. From Green Lake, the south branch continues west into Marshall Lake, then turns north, cutting across a corner of the Shaker Heights High School campus and continuing through the wooded area between South Park and West Park Boulevards. It joins the main stream in the marsh near the Nature Center at Shaker Lakes.

After the confluence in the Nature Center marsh, Doan Brook passes through the Lower Shaker Lake and follows North Park to the merge with MLK. The stream crosses under MLK and parallels the road northeast down the steep hill. At the bottom of the hill (just a little before the intersection of MLK and Ambleside Drive), the brook disappears into a large pipe called the University Circle (or Doan Brook) culvert.

Doan Brook is hidden underground for almost a mile in a series of connected pipes that run along the west edge of the Case Western Reserve University campus and the west side of the lagoon by the Cleveland Museum of Art. The brook emerges from the culvert at the bottom of the hill behind (northwest of) the art museum, near the intersection of East Boulevard and East 105th Street. After a few hundred yards of open channel, the brook dives underground again into a culvert that carries it through the intersection and into Rockefeller Park. The brook then flows through the park, sometimes on one side of MLK and sometimes on the other, almost as far as Lake Erie. Just upstream from the intersection of MLK and Interstate 90, the brook enters yet another long culvert. This final pipe carries the stream for over half a mile under the Corps of Engineers Site 14 dredged material landfill and into Lake Erie.

3.2 Where Does the Water Come From? The Doan Brook Watershed

The three branches of Doan Brook can easily be traced by looking at a map. But where does the water in the brook come from? Doan Brook, like every stream, is surrounded by a *watershed*[2] — that is, an area of land over which water running along the ground surface (called *runoff* or *surface runoff*) will eventually flow into the stream. The watershed's shape, topography, and land use determine the amount and quality of the water in the stream. Any exploration of Doan Brook must therefore encompass the watershed as well as the brook itself. In this section, we look at the watershed outline, defining the part of the landscape that drains into Doan Brook. We will consider the watershed's topography in a later part of this chapter and watershed land use in Chapter 5.

The Doan Brook watershed is an 11.7 square mile area located in Cleveland, Cleveland Heights, and Shaker Heights (Figure 3-1). The watershed is shaped something like a backward comma, with a narrow top along Lake

2 Also called a drainage area or drainage basin.

Figure 3-2 Horseshoe Lake lies at the confluence of the north and middle branches of Doan Brook. Photograph by L. C. Gooch.

Erie to the north, a wider middle, and a somewhat narrow tail that points east.

In the northern part of the watershed, near Lake Erie, almost all drainage reaches the stream from a narrow strip of land between the stream and a point about one half mile to the east. Rain that falls more than a few hundred feet west of the stream flows directly into Lake Erie, without ever entering the brook.

Upstream from University Circle, the watershed turns east and widens out to the north and south, until, at Coventry Road, it extends from near Mayfield Road as far south as Van Aken Boulevard. The watershed then narrows again, until it only includes the area between Fairmount Boulevard (or sometimes a few blocks north) and Van Aken. The eastern boundary of the watershed generally lies between Green and Richmond Roads.

Most runoff reaches Doan Brook via storm sewers, which collect water from yards, rooftops, and streets and give it an underground expressway directly to the stream. Storm sewers in some areas have been rerouted so that they divert water from outside the natural watershed into Doan Brook, thus making the current watershed larger than the brook's original drainage area.[3] Although most runoff reaches the brook via the storm sewers, a small amount of water flows directly to the stream from its immediate surroundings.

3.3
Why Does the Brook Flow When It Isn't Raining? The Contribution of Groundwater

3.3.1
The Influence of the Groundwater System

Just as Doan Brook has a surface water drainage area — an area over which rain that falls and remains on the ground surface flows into the brook — the stream also has a groundwater drainage area.[4] Rain that falls within the groundwater drainage area and soaks into the ground (*infiltrates*) eventually flows to the brook, entering the stream through its bed and banks. Groundwater flow is much slower than surface water flow, since water that is absorbed into the groundwater reservoir is released gradually.

Because of the ground's slow absorption and release of water, the groundwater system is a kind of regulator for flow in the stream. Flood peaks are lowered as water is absorbed into the ground, to be released over a period of hours, days or weeks, long after the peak surface runoff has passed downstream. Some of the water from spring rains is released to the stream during the drier parts of the summer, maintaining flow in the stream (called *base flow*) even when there has been no recent rain. The steady trickle of base flow in Doan Brook during dry periods is critical to the health of the stream's aquatic environment. We will see in Chapter 5 that human activities have changed the brook's groundwater system and the base flow, just as they have changed its surface watershed.

3 Changes to the watershed's original size and shape will be discussed more thoroughly in Chapter 5.

4 Groundwater is the term used to refer to water that soaks into the soil and then flows within the matrix of soil or rock particles. Many people picture groundwater as a series of streams flowing in caverns beneath the ground. This is only rarely the case. Most of the time, and certainly in the Doan Brook watershed, groundwater works its way through the soil or rock itself, winding tortuously among the soil particles or through small fissures in the rock. If you dig into the groundwater zone beneath the Doan Brook watershed, all you will find is wet soil or rock.

Groundwater Use in the Doan Brook Watershed

Water supply in Cleveland is now taken from Lake Erie, so there is little modern groundwater use in the Doan Brook watershed. However, groundwater was once an important resource here. Water from springs or wells was used by many of the early settlers as their primary water supply.

In Wade Park, in what is now part of the Japanese Garden at the Cleveland Botanical Garden, there was a drinking water spring "…to which people from miles around came with jugs, pails and bottles, on foot, with boy's wagons, and in buggies and on bicycles." (Mead 1956).

Shaker Elder James Prescott wrote of the Shaker Mill Family (who lived southwest of the current intersection of North Park and Coventry):

> *They have an excellent spring of pure, soft, water — a never failing spring, coming out from between two sand stones, which has been running for more than fifty years, and how much longer we cannot tell. It is used for washing, bathing, and cooking purposes. It is carried in pipes to the kitchen and pumped into the boilers.*

— James Prescott, 1880

3.3.2 Doan Brook's Groundwater System

Groundwater systems are complicated, and they are hidden, so it is more difficult to define Doan Brook's groundwater drainage area than it is to define its surface watershed. A stream's groundwater drainage area may not be the same as the surface water drainage area. In fact, there are typically several different groundwater systems (or *aquifers*[5]) stacked one on top of the other beneath a single surface watershed. Each of these stacked aquifers, which are separated by almost water-tight layers of rock or clayey soil, may have a different drainage area. That is, infiltrated rainfall may reach each of the stacked aquifers from a different part of the overlying land surface.

Because groundwater systems are hidden and complex, a great deal of study is required to define the precise interactions of groundwater with any given stream. The groundwater systems that underlie the Doan Brook watershed have never been examined in detail, but we can make the following generalizations about the brook's interactions with the local groundwater:

- There is a shallow groundwater aquifer that probably corresponds approximately to the surface watershed in the upper Doan Brook watershed. Water from this shallow aquifer enters the brook through the stream's bed and banks. Most rain that falls in the upper part of the Doan Brook surface watershed and is absorbed into the ground probably ends up in this surface aquifer and eventually flows into Doan Brook. The clayey and silty glacial till soils (see Section 3.5) that make up the aquifer resist the flow of water, so rainfall infiltrates slowly and inches its way through the soil toward the stream.
- There is probably a shallow aquifer in the lower watershed similar to the one in the upper watershed. Soils in the lower watershed are generally thin layers of sand, silt, or clay laid down under ancient lakes (see Section 3.5). Rain will infiltrate into these soils and move toward the stream relatively quickly.
- There are deeper aquifers in rock layers that lie under the shallow soils in the upper watershed. In the far eastern part of the watershed, these rock layers pass completely under the brook and have little or no contact with the stream. As the stream cuts down through the rock in the Doan Brook gorge, water from the aquifers within the rock layers seeps into the stream.[6] The water that emerges in the gorge originally enters the aquifers where the rock layers are near the surface or in contact with another aquifer. Flow into the bedrock aquifers occurs in many places over an area much larger than the Doan Brook surface watershed. The deeper rock layers found under the upper watershed are absent beneath the lower watershed.

To summarize, there are shallow aquifers in the upper and lower Doan Brook watersheds and also some deeper aquifers beneath the upper watershed. The shallow aquifers absorb and slowly release some of the rain that falls in the watershed, reducing flood flows and increasing flows during dry periods. Because of differences in the upper and lower watershed soils, the shallow aquifer in the upper watershed will absorb less rainfall and release it more slowly than the shallow aquifer in the lower watershed. The deeper aquifers also contribute to dry weather flow by carrying some water from both inside of and outside of the surface watershed to the brook.

5 An aquifer is a layer of soil or rock that is capable of transmitting significant quantities of water. Some material, such as clay, can transmit very little water and will not generally be thought of as an aquifer. Other material, such as sand, gravel, or sandstone, can transmit significant quantities of water.

6 Groundwater can be seen seeping from the rock layers in the sides of the Doan Brook gorge and on the face of the steep hill between the lower and upper watersheds.

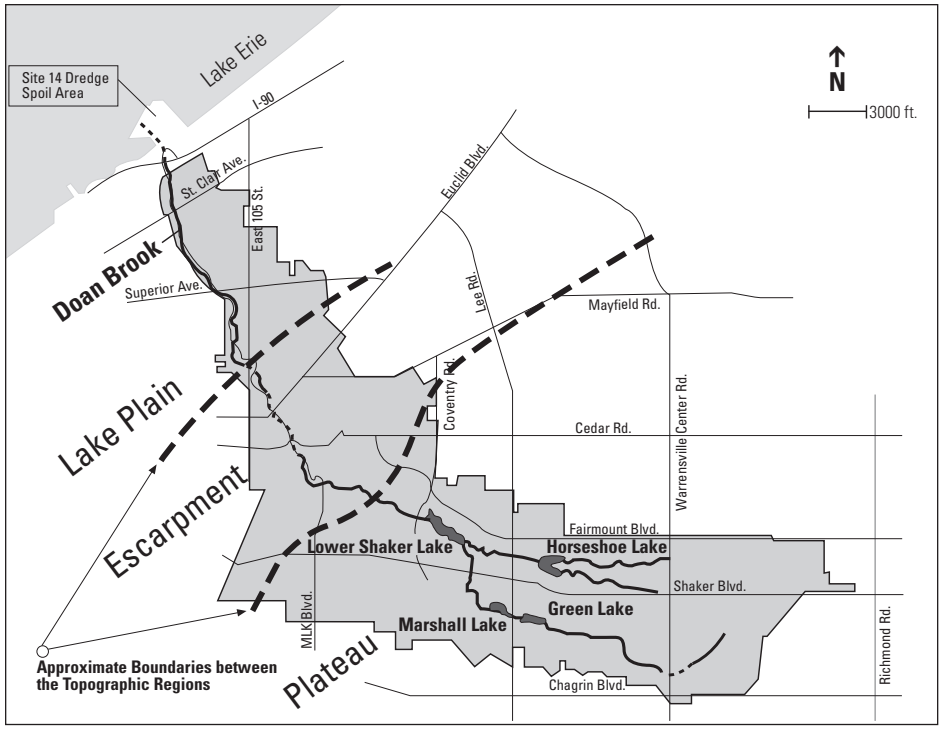


Figure 3-3 Topographic Regions of the Doan Brook Watershed

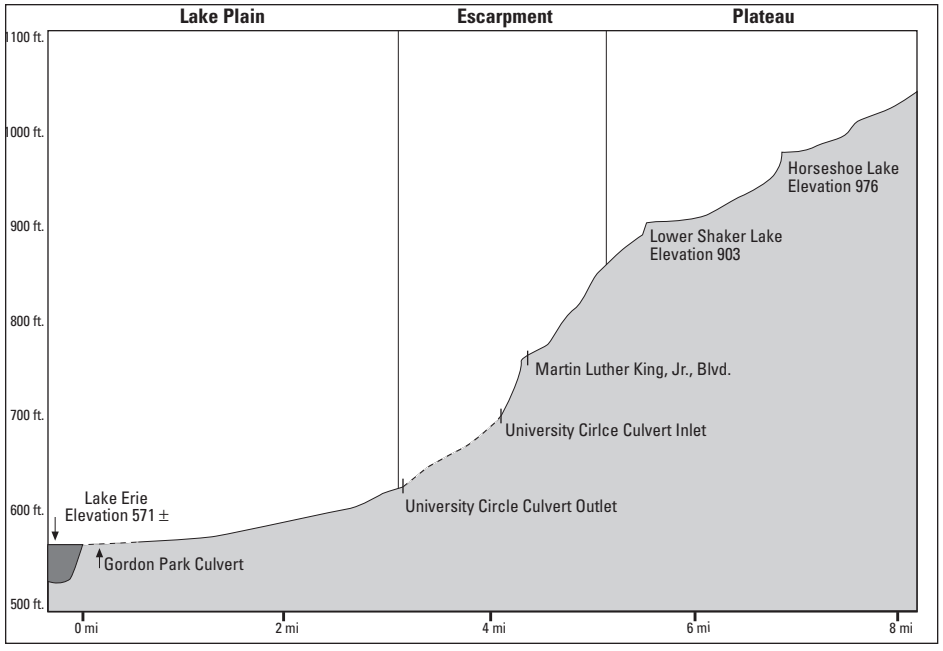


Figure 3-4 Profile of Doan Brook

3.4 How Is It Shaped? Brook and Watershed Topography

Over the millenia, Doan Brook and the glaciers that preceded it have shaped the land of the Doan Brook watershed into the topography we see today. The brook, like any stream, has an intimate relationship with the surrounding land. The topography shapes the brook, determining how much water flows to the stream, how much energy the stream can gather as it runs downhill, and how much water the stream must carry in a flood. At the same time, the stream shapes the topography, cutting channels, ponding to fill flood plains, and eroding waterfalls. A good understanding of the stream and watershed topography is needed if one is to grasp how the stream will behave in a drought or in a flood.

The Doan Brook watershed is made up of three distinct areas, each of which has its own character (see Figures 3-3 and 3-4). These areas are:

- The **Lower Watershed**, or **Lake Plain**, is the relatively flat area that immediately adjoins Lake Erie, extending as far south as the hill just northwest of the Cleveland Museum of Art. The watershed here is generally level and prone to puddles, with soils made up of layers of fine sands, silts, and clays. Occasional ridges parallel to the Lake Erie shore break the otherwise uniform terrain. Doan Brook takes a meandering course through a broad, shallow valley across the Lake Plain.
- The **Escarpment** (formally called the Portage Escarpment) is the sloped section of land that joins the Lake Plain with the higher ground to the south and east. Along Doan

Brook, the Escarpment extends from the base of the hill northwest of the Cleveland Museum of Art to a point near the intersection of Bellfield Avenue (Roxboro School) and North Park Boulevard. Watershed slopes in the lower part of the Escarpment are relatively gentle, while steeper and longer slopes are found as you move farther up. The soils along the Escarpment are generally thin tills or silty clay, with shale or sandstone bedrock exposed in many places along the stream. Rainfall runs quickly into the brook from the steep Escarpment slopes, and the stream channel takes an almost straight track down the hill from the Plateau.

- The **Plateau** includes the entire upper watershed above the uphill edge of the Escarpment. This part of the watershed, which is the northwest margin of the Appalachian Plateau, is characterized by rolling topography and thin clayey silt glacial till soils. Bedrock is generally shale, with some sandstone. Along the brook, the upper watershed begins at a point near the intersection of Bellfield and North Park. The boundary between the Escarpment and the Plateau runs northeast and southwest from this point. Although the land is steeper here than in the Lake Plain, slopes are gentle enough that the brook cuts a winding channel through the broad, shallow valley of its flood plain.

The shape of Doan Brook results from the watershed's topography. The moderate slopes of the Plateau and the shallow slopes of the Lake Plain allow the brook to meander and create shallow valleys. The steep Escarpment leads to a straight, fast-flowing stream that has carved out a gorge as it cut its way down to the Lake Plain. In the next section, we will explore

Experiencing Topography Firsthand: The Watershed by Bicycle

For a bicyclist, the intersections of the Lake Plain with the Escarpment and the Escarpment with the Plateau are easy to identify. If you begin in the Lake Plain at Lake Erie and ride away from the lake along the Doan Brook (following the Martin Luther King, Jr., Boulevard (MLK) bike path), the riding is flat and easy — almost effortless. Easy riding continues until you reach the traffic circle at the intersection of East Boulevard, East 105th Street, and MLK.

At this point, you have come to the intersection of the Lake Plain with the bottom of the Escarpment, and you are about to begin scaling the Escarpment. The climb starts with the short, sharp hill that leads to Wade Park. Past University Circle, you continue to climb, pausing to catch breath on an occasional level spot. First you must overcome the main face of the Escarpment — the long steep hill along Edgehill Road, MLK, Cedar Road, or Fairhill Road. Above the main face, you have a more gradual climb until you reach a point where the land begins to level off. This point, which is generally a bit west of Coventry Road, is the intersection of the Escarpment and the Plateau.

Once you have reached the Plateau, the land begins to roll a bit, but maintains a gentle uphill trend to the watershed boundary. If you continue riding east to a point just west of Richmond Road, you will suddenly find yourself coasting down hill as you cross the watershed boundary into the Chagrin River watershed or one of the other adjoining watersheds.

Figure 3-5 Doan Brook cascades over the edge of the Berea Sandstone as it works its way down the Portage Escarpment. Photograph by L. C. Gooch.

how the watershed's three distinct topographic regions were formed. The impact of this topography on the stream's behavior is one of the topics of Chapter 7.

3.5 The Bones of the Doan: Watershed Geology and Soils

The geology of a watershed is the framework upon which watershed topography is built. Although details of Doan Brook's geology may be of interest primarily to geology buffs (who should see Appendices E and F), a basic understanding is a useful underpinning for an effort to manage the watershed.

The three topographic regions of the Doan Brook watershed, the Lake Plain, the Escarpment, and the Plateau, were created by the intersection of the uplifted Appalachian Mountains to the east with the gouged-out basin of the ancestor of today's Lake Erie. About 600 million years ago, all of northeast Ohio was covered with an intermittent inland sea. When the predecessors of today's Appalachian Mountains began to rise to the east, soil eroded from the mountains and was carried into the sea and deposited in a series of layers of mud, silt, and sand. Erosion continued for many millions of years. Over time, buried layers of sediment were compressed into rock, becoming the layers of sandstone and shale that now underlie the upper watershed and can be seen in the Doan Brook gorge.

Eventually (about 300 million years ago), the sea retreated for the last time. Long after this, beginning about 2 million years ago, glaciers advanced from the north. They enlarged existing river valleys to create the basins of the ancestral Great Lakes, gouging Lake Erie into the still rising edge of the Appalachian Mountains. As the mountains rose, they elevated the layers of sedimentary rock laid down by the inland sea, thus creating the Plateau topographic region. The advancing glaciers cut through the sedimentary rock to carve the edge of the lake into the Plateau.

When the glaciers finally retreated, only about 15,000 years ago, they left a layer of jumbled clay, silt, and sand called *glacial till* on the surface of the Plateau's shale and sandstone. This glacial till forms the soil and shallow subsurface material of the upper watershed. As the glaciers continued to retreat, the ancestor of Lake Erie was trapped between the edge of the glacier to the north and the edge of the Appalachians to the south. The lake, much larger than today's Lake Erie, carved a series of cliffs into the edge of the Appalachian Plateau. These cliffs, at the intersection of the Plateau and the ancient lake, are the topographic region that is now called the Escarpment.

As the lake ate at the edge of the Plateau, new sediments were carried from the uplands and deposited in the lake, forming the layers of silt, sand, and clay that we now find beneath the lower watershed. Over time, the lake retreated toward its current shore, leaving the flat Lake Plain crossed by a series of ridges that attest to the locations of past shores and beaches.