



Most of the time, Doan Brook seems a peaceful, harmless trickle. We cross it without a thought. Most of us don't even really know that it is there. Sometimes when it rains, though, Doan Brook wakes up and gives us a shake to remind us of the power that it has to shape the land. Then, briefly, the brook mocks our efforts to control it. It turns roadways into whitewater rapids; it forces its way into buildings and destroys their contents; it erodes its banks, threatening the streets that run along them; it eats at the dams that we have thrown across its path.

Concern about flooding along Doan Brook rises and falls with the flood waters. Each large flood generates a wave of interest and a call for action. By the time a study is made and a solution proposed, the sense of urgency created by the flood has receded. Funding is hard to come by, and work is postponed. In effect, the community's decision over the years has been that we can live with an occasional flood along Doan Brook. This chapter explores the nature, origins, and impacts of Doan Brook's floods.

## 7.1 A History of Doan Brook Floods

The earliest reported flood on Doan Brook occurred in 1901, when a flash flood roared down Cedar Hill from the Heights. Entire neighborhoods were inundated. Flooding was relatively rare in 1901, but high water has been a regular occurrence since the 1920s, when true urbanization of the upper watershed began. Readily available flood records are incomplete, but it seems that at least once each decade the brook erupts above ground in University Circle, reminding us that it once flowed there. Significant floods left 10 to 11 feet of water in the Circle in 1959 and 1975. Lesser floods in 1962, 1976, during the 1980s, and in 1994 also inundated the area. General flooding in the lower watershed was reported in 1929, during the 1940s, and in 1956. Table 7-1 summarizes records of the more damaging floods.

The worst Doan Brook flood occurred in August 1975, when a man was swept to his death in a culvert near the intersection of East 105th Street and East Boulevard. With University Circle under eleven feet of water, the Sears Library and

other buildings at Case Western Reserve University (CWRU) were flooded, causing the destruction of 11,850 books and damage to almost 100,000 other books and maps. Other University Circle buildings were also flooded, and there was extensive destruction in the parks both upstream and downstream from University Circle. Both of the Shaker Lake dams were damaged, with severe damage at Horseshoe Lake. In addition, erosion of the stream bank in the Doan Brook gorge threatened Fairhill Road near its intersection with Kemper Road. Total monetary losses from this flood were estimated at over \$10,000,000.

Although other floods have not been as serious as the one in August 1975, news of flooding along the brook has been a recurring refrain. Water has flowed over Horseshoe Lake dam at least four times, resulting in serious damage and subsequent repairs to the dam. Repairs made in 1997 were intended to make the dam safer during future overtopping. The brook banks near Fairhill and Kemper were damaged repeatedly by flood erosion between 1959 and 1976, when a definitive slope repair was

<b>Table 7-1</b>		
<b>An Incomplete History of Doan Brook Flooding</b>		
<b>Date</b>	<b>Description</b>	<b>Technical Data</b>
1901	A flood roars down Cedar Hill and inundates entire neighborhoods.	
June 1929	A flood washes out some sections of the retaining walls along Doan Brook.	
1940s	Horseshoe Lake dam overtops and the south end of the embankment washes out.	
1956	Eleven floods between May and August seriously damage the stream banks, retaining walls, and adjacent developments within the City of Cleveland.	For a Single Storm (date unknown): Rainfall: 3" Peak flow = 2,500 cfs
June 1, 1959	A major flood leaves water 10 feet deep in University Circle. Horseshoe Lake dam partially fails. The bank of the brook along Fairhill just downstream from Kemper erodes so that the north curbing of Fairhill is exposed.	Rainfall: 3" in < 1 hr. Peak flow = 18,000 cfs Return Period = 50 yr.
June 4, 1962	Flooding leaves 3 to 4 feet of water in University Circle.	Rainfall: 1.5" in < 1/2 hr. Return Period = 10 yr.
July 28, 1964	A more minor flood occurs, bringing the Lower Shaker Lake dam close to overtopping.	
July 17, 1968	A relatively minor flood washes away the banks along Fairhill Road to within 6 feet of the pavement at one point. There is also damage at Fairhill and East Blvd.	
August 24, 1975	A rainfall of 6 inches falls on the Doan Brook watershed and results in a flood depth of 11 feet in low areas of University Circle. The storm causes severe flood damage and is followed	First Storm: Rainfall: 3.25" in < 1 day at the Lower Lake; over 6" in some areas. Return Period = 50 yr.
August 29-31, 1975	by a second storm and flood of nearly equal magnitude 4 days later. A man swept into a culvert near East 105th Street and East Boulevard is killed during the first storm. The stream bank near the intersection of Fairhill and Kemper Roads fails due to erosion. Horseshoe Lake dam is severely damaged by overtopping.	Second Storm: Rainfall: 3.5" in 3 days at Lower Lake.
July 14, 1976	The University Circle area floods with several feet of water. Horseshoe Lake dam overtops and is severely eroded, leaving the downstream side of the stonework exposed.	Rainfall: 3.5" to 4.5"; time unknown, but < 1 day.
July 1990	Flooding along the lower brook, including a drowning.	
August 13, 1994	A storm causes traffic disruption and property damage in University Circle and damage to Horseshoe Lake dam.	

performed. Minor damage to bridges and retaining walls and disruption of traffic along Martin Luther King, Jr., Boulevard is a regular occurrence in the lower watershed. After the 1975 flood, CWRU decided that it was best to

simply get out of the brook's way and moved facilities that could be damaged out of the reach of the flood waters. They also installed water-tight "submarine" doors to keep the brook out of some buildings. Partly as a result

of this action by CWRU and partly because subsequent floods have been less severe, no major damage has been caused by more recent floods.

## 7.2 Where Does the Water Come From? Watershed Runoff Patterns

The history of Doan Brook flooding makes it clear that the most damaging floods along the brook occur at University Circle. Flooding there results from a combination of the hydrology of the watershed and the design of the University Circle culvert, which periodically interact to dump an overwhelming quantity of water into University Circle.

The Circle lies at the base of the Escarpment and near the middle of the Doan Brook watershed.<sup>1</sup> Water in the brook (as it passes through the University Circle culvert) originates in five distinct areas:

- The Plateau upstream from the Lower Shaker Lake (57% of the University Circle watershed);
- The Plateau that drains to the brook between the Lower Shaker Lake and the Martin Luther King, Jr., Boulevard (MLK) detention basin (9% of the University Circle watershed);
- The Plateau and Escarpment that were part of the former Giddings Brook drainage area (18% of the University Circle watershed);
- The Plateau and Escarpment that drain to the Cedar Glen storm sewer (12% of the University Circle watershed);
- The Lake Plain and Escarpment that drain to the Euclid Avenue storm sewer (4% of the University Circle watershed).

When the brook enters the University Circle culvert, it carries runoff from the Plateau that originates both upstream and downstream from the Lower Shaker Lake. Just downstream from the main culvert inlet, two large storm

sewers — the Giddings Brook culvert<sup>2</sup> and the Cedar Glen sewer — connect with the main University Circle culvert. These two storm sewers carry the runoff from the former Giddings Brook watershed and the Euclid Heights area, respectively. A third storm sewer intersects the main culvert at Euclid Avenue. The total drainage area that contributes flow to University Circle is approximately 5,560 acres, or 74 percent of the Doan Brook watershed. (See Figure 5-4 and Table 5-1 for a summary of drainage areas at critical points in the watershed.)

Because of the Shaker Lakes, flow from the Plateau upstream from the Lower Shaker Lake reaches University Circle much later than flow from areas downstream from the lake. In fact, runoff from the area upstream from the lakes plays a minor role in University Circle flooding. The slope of the land and the density of the urban area are moderate upstream from the lakes, so water collects relatively slowly. More important, runoff must pass through the lakes before it reaches University Circle. The lakes play a critical role by storing and slowly releasing water that flows through them (see *What Do the Lakes Do?*). As a result, downstream floods are much smaller than they would otherwise be.<sup>3</sup>

Unlike water that flows through the lakes, water that originates downstream from the Lower Shaker Lake finds few barriers in its path as it flows toward University Circle. The areas that drain into the downstream brook channel and into the Cedar Glen sewer and the Giddings Brook culvert are the denser urban neighborhoods that lie on the western edge of the Plateau and on the Escarpment. Water from these areas collects quickly and takes an unobstructed path through the storm sewer network to the brook at University Circle.<sup>4</sup> As a result, the sharp, high flood peaks from these areas

(which together make up about 39 percent of the watershed at University Circle and 28 percent of the brook's total drainage area) reach the stream much sooner than the flow making its way through the Shaker Lakes. Figure 7-1 is a schematic representation of the timing and magnitude of flows from upstream and downstream from the Lower Shaker Lake as they reach University Circle. It clearly shows the relative contributions of runoff that originates upstream and downstream from the lakes.

## 7.3 Why Is There a Flood? The Brook Under Duress

The reasons that the fast-flowing runoff from the uncontrolled areas of the Plateau and Escarpment so often overwhelms the brook at University Circle can be summarized in two phrases: *Giddings Brook* and *the impact of urbanization*. As Chapter 5 discusses in detail, the urban watershed, with its abundant buildings, pavement, and storm sewers, sends far more water into Doan Brook than flowed into the brook under pre-development conditions. The average annual runoff to the stream from a given area may be three times as great as it was in Nathaniel Doan's time, and a five-year flood<sup>5</sup> may be four times as large. The extra watershed area added by the diversion of Giddings Brook into Doan Brook further increases floods, so that the annual runoff is as much as four times greater and the five-year flood may be increased by a factor of five.

The culverts and channels that were built in the lower Doan Brook watershed beginning in the late 19th century might have been adequate to carry the brook before urbanization and before the Giddings Brook diversion, but

1 See Chapter 3 for a discussion of watershed topography and the definition of the Escarpment and other topographic regions.

2 This culvert runs down Baldwin Road and is sometimes called the Baldwin Road culvert or sewer.

3 For example, during a moderate flood that might occur once in five years, the Shaker Lakes are estimated to reduce the peak flow from the upstream watershed by about one-half and to delay the peak flow downstream from the Lower Shaker Lake for over two hours.

4 Runoff that does not pass through a lake or other structure that would slow and reduce the peak flow is referred to as uncontrolled runoff. Areas that are not upstream from a control structure such as a dam or detention basin are called uncontrolled drainage areas.

5 See Appendix H for a definition of the 5-year flood.



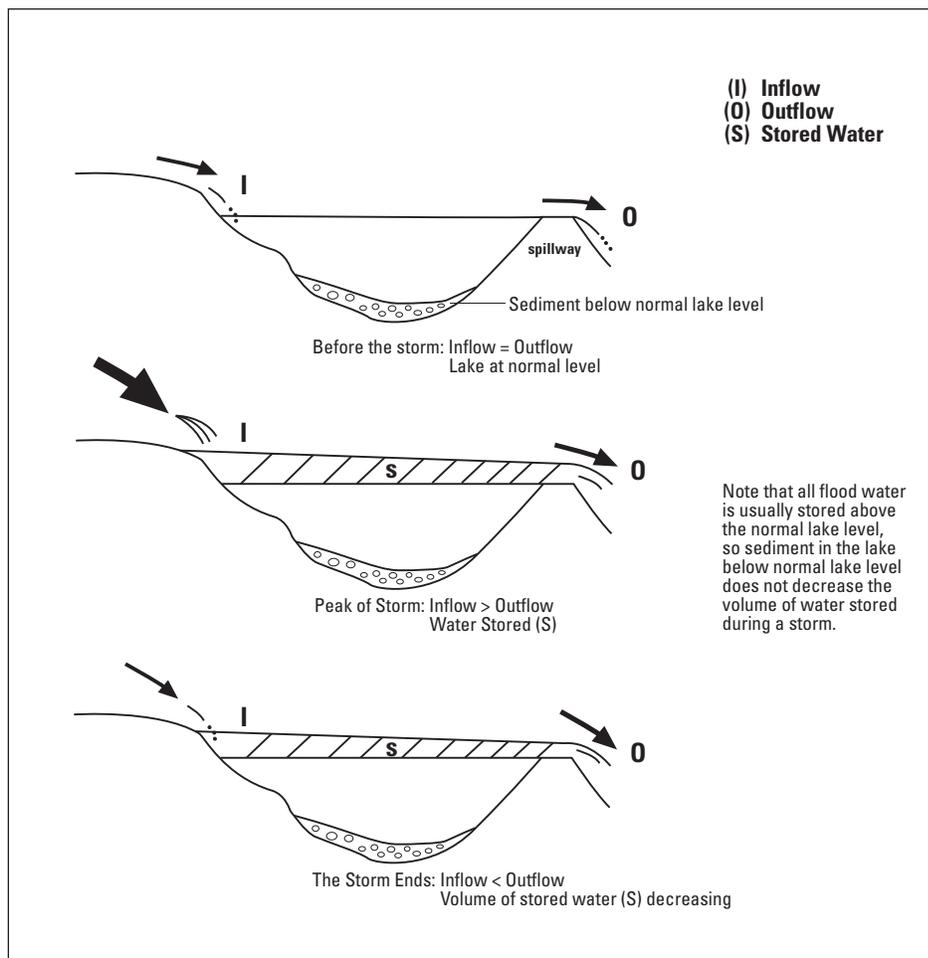
**What Do the Lakes Do? Lake Sedimentation and Flood Storage**

When flooding and the Shaker Lakes are discussed, two topics often come up: 1) the lakes' ability to reduce downstream flooding, and 2) sediment in the lakes. How do lakes reduce downstream flooding? Does sediment in the lakes change their flood control potential?

When the weather is dry, lakes store water at or below the elevation of the lowest open outlet. For Horseshoe Lake, that elevation is the lip of the semi-circular overflow spillway at the dam. For the Lower Shaker Lake, that elevation is the top of the stone spillway under the "Lovers' Lane" bridge at the west end of the lake. Sediment generally accumulates in the lakes below the dry weather lake elevation (that is, below the crest of the spillway).

When a storm begins, water starts to flow into the lake faster than it can flow out over the spillway, and the water surface in the lake rises (see Figure 7-2). As the water surface goes up, the flow out of the lake (over the spillway) increases. The elevation of the lake at the end of the storm and the peak outflow from the lake depend upon the balance of the rate of inflow, the water surface elevation, and the outflow rate during the storm. The lakes slow and reduce downstream flood peaks by forcing water to leave the lake more slowly than it flows in and thus storing water during the storm.

The ability of the Shaker Lakes to ease flooding in University Circle is *not* increased by *dredging the lakes*. Dredging has no impact on flood control because the volume of water stored during a storm is the volume contained in the layer of water *between the lakes' water surface at the beginning of the storm and the*



**Figure 7-2** Lakes: Sediment Storage and Storm Flows

*water surface at the end of the storm.* This layer of water lies above the spillway elevation and is not filled as sediment accumulates.

The storage and slow release of storm water by the Shaker Lakes plays an important role in

reducing flooding at University Circle. Although periodic dredging is necessary to preserve the health and aesthetics of the lakes, dredging (or failing to dredge) has no impact on University Circle flooding.<sup>10</sup>

10 If lake dredging were to be used in combination with a program that kept the lakes almost empty during dry periods, dredging could change the lakes' ability to store flood water. It is very unlikely that the Shaker Lakes will ever be managed in this way.

of shorter culverts that were pieced together over the years as the stream was pushed farther and farther out of sight. The result of the culvert's piecemeal construction is a pipe with different shapes and sizes and different capacities along its length. Illustrations that show the profile and shape of the culvert are included in Appendix H.

Whenever the culvert's capacity is exceeded, water in the pipe begins to flow under pressure, backing up in the pipe and eventually flooding up through manholes and then into streets and buildings. If the culvert is completely overwhelmed, as in the 1975 flood, it can no longer carry the water that rushes down the Escarpment, and Doan Brook once again flows above ground through University Circle. Estimates indicate that the culvert can carry no more than about 2,000 cfs<sup>11</sup> without some flooding. When the culvert is partially blocked with debris, as it frequently is, its capacity is reduced, and flooding will occur at lower flows.<sup>12</sup>

Estimates made in the 1960s indicate that the capacity of the culvert will be exceeded more than once every two years. More recent estimates suggest that the culvert's capacity will only be exceeded once in about every ten years. The history of flooding at University Circle suggests that the true frequency of flooding may be somewhere between these two estimates: minor flooding seems to occur every three to five years, with a significant flood about one year in six.<sup>13</sup>

The culverts and stone-lined channels along MLK downstream from University Circle are also too small for the urban brook. The capacity of the channels varies along the stream, as does the amount that the stream must rise before it flows out of the park and onto the

adjacent roadway. The most frequent flooding occurs near the downstream end of the brook, between St. Clair Avenue and the Conrail Railroad tracks. Here, recent estimates indicate that the brook can be expected to leave a foot or more of water in the road for a short time as often as once a year. Once in ten years, this area and the area upstream from St. Clair can be expected to be several feet under water. Once in 50 years, flooding can be anticipated along much of MLK downstream from Euclid Avenue.

The culvert that carries Doan Brook under I-90 and Site 14 into Lake Erie was designed to carry the flow generated by the 100-year storm.<sup>13</sup> Recent calculations did not include storms larger than the 50-year storm, but they confirm that the culverts have enough capacity to carry the 50-year flow.

## 7.6 What Can We Do? Solutions to Flooding

We began this chapter by saying that the community has, over the years, decided to live with occasional flooding on Doan Brook. Most of the work done in recent years, aside from the construction of the Martin Luther King, Jr., Boulevard (MLK) detention basin and occasional removal of debris from the University Circle culvert, has concentrated on restoring flood-damaged sections of the channel to their previous condition. Little effective work has been done to address the underlying causes of flooding. Given that Doan Brook is a confined stream in a fully developed watershed, what can we do to reduce flooding in the future? How important is it to prevent future floods?

Floods in an urban stream can be reduced in

three basic ways: by *reducing runoff* (the inflow to the stream); by *storing and slowly releasing runoff*; and by *increasing the capacity of the stream* so that it can carry higher flows without flooding. We will look at each of these approaches in general terms here, saving more detailed discussion of actual measures that might be taken for Chapter 8.

- *Reducing runoff* — Once a watershed is fully urbanized, as the Doan Brook watershed is, it is difficult to make dramatic reductions in runoff. However, small measures can be taken throughout the watershed to reverse some of the impacts of urbanization. These include (among others): redesigning parking lots so that they encourage infiltration rather than runoff; re-landscaping with natural vegetation that retains rainfall; and disconnecting downspouts from storm sewers so that water can run onto the ground surface and infiltrate.
- *Storing and slowly releasing runoff* — Lakes and other impoundments store and slowly release stormwater runoff. The Shaker Lakes effectively perform this function for much of the upper watershed, and the MLK detention basin was an attempt to increase the storage and slow release of some of the inflow to Doan Brook between the lakes and University Circle. Additional flood storage capacity could be added to the Doan Brook watershed by building either a few large impoundments or a number of small impoundments.

Large flood storage projects tend to be just that — large — and adding new large impoundments in an urban area like the Doan Brook watershed is difficult and expensive. New flood storage capacity would be most effective in the uncontrolled part of the watershed upstream from University

11 Cubic feet per second. A basketball's volume is about one cubic foot. Imagine basketballs flowing past you at the rate of 2,000 per second.

12 Flooding in University Circle is exacerbated by the fact that Euclid Avenue is higher than the streets upstream, so that a sort of lake is formed upstream from Euclid Avenue when the brook escapes from the culvert.

13 See Appendix H for an explanation of how floods are estimated and definitions of the 50- and 100-year floods.

### Impact on Flooding: What Does the MLK Detention Basin Do?

In 1997, the City of Cleveland took advantage of some available funding and built a flood detention basin on Doan Brook just upstream from the entrance to the University Circle culvert (immediately downstream from MLK). Although the basin was intended to reduce the five- and ten-year floods in the lower watershed, subsequent studies performed during the NEORS Doan Brook Study have shown that the basin will have little or no impact on floods that occur less than about once in ten years, and will have significant impact only during very large floods (as large or larger than a flood that would occur once in fifty years). How, then, did the basin come to be built?

To answer this question, we must look at the history of flood studies on Doan Brook. The first major study of Doan Brook flooding was performed by Stanley Engineering Company in 1964. Not surprisingly, the study concluded that flooding in University Circle came primarily from three sources: runoff directly to the brook downstream from the Lower Shaker Lake; the Giddings Brook culvert; and the Cedar Glen sewer. A smaller contribution to flooding came from the Euclid Avenue sewer. Construction of a detention basin on Doan Brook *upstream* from MLK (on Cleveland land that is leased by Cleveland Heights) was recommended as one of a number of measures that could be taken to alleviate University Circle flooding.

As proposed in the Stanley report, the detention basin had the potential to reduce the peak flow in University Circle by about 23 or 24% during a five- to ten-year flood by using MLK as a dam to back water up into the Doan Brook gorge. Even with this much flow reduction, the Stanley detention basin would not have eliminated flooding in University Circle during the five- to ten-year floods unless it was combined with a number of other proposed measures, including enlargement of the University Circle culvert.

Over thirty years after the detention basin was originally proposed, the City of Cleveland began to move ahead with a detention basin project almost identical to that originally recommended by Stanley. Significant opposition from the public and the Cleveland Heights city government arose because of the unavoidable damage to the Doan Brook gorge (see Chapter 2), and because of questions about whether the basin would, by itself, make a worthwhile reduction to downstream floods. In response, Cleveland moved the basin downstream from MLK onto City of Cleveland land that is not leased by Cleveland Heights. The design of the basin was significantly changed, so that the restriction to the outflow and the volume of water that would be detained were dramatically less than those proposed by Stanley. Hydraulic calculations performed to evaluate the new design do not seem to have accounted for the fact that the



**Figure 7-3** The flood detention basin on Doan Brook just downstream from Martin Luther King, Jr., Boulevard. Photograph by L.C. Gooch.

redesigned basin and outlet provided much less flow restriction and flood storage than the original design. In addition, analyses made as part of the NEORS Doan Brook Study suggest that inflows to the basin will be somewhat lower than those estimated by Stanley. Because of the design changes and the lower inflows, the detention basin is expected to have little or no impact on the five- to ten-year events for which it was built and to have no significant impact on flooding in University Circle except during floods that occur less frequently than once in fifty or 100 years.

Circle. This is the heavily urban area in the Cedar Glen sewer and Giddings Brook watersheds, where it would be almost impossible to build a new lake or detention basin.

It would be somewhat easier to add a number of small storage and release areas in the uncontrolled Doan Brook watershed upstream from University Circle. For example, small ponds and wetlands could be added in open areas adjacent to the stream or in road medians. New parking lot designs could include storage that would delay runoff from small and moderate storms. A sustained effort to install small retrofit storage areas in the Giddings Brook culvert and Cedar Glen sewer watersheds could have a significant cumulative impact on flooding.

- *Increasing the capacity of the stream* — Regardless of the number of new storage basins and the reduction in runoff that is achieved in the Doan Brook watershed, it is unlikely that we can reduce the flow in the stream enough to prevent relatively frequent flooding in University Circle and Rockefeller Park unless we also increase the capacity of the culverts and the channels.

The capacity of the University Circle culvert could be increased by simply installing a larger pipe, or by “daylighting” the brook; that is, by building a new above-ground channel in University Circle. Either approach would be expensive and difficult in such a heavily urban area. Increasing channel capacity in Rockefeller Park would be easier in some places but would conflict with the road or with the historic Schweinfurth bridges in others.



**Figure 7-4** Erosion around the end of the trash rack upstream from Martin Luther King, Jr., Boulevard is one result of high flows in Doan Brook. Photograph by L. C. Gooch

For flood control, as for many other problems faced by Doan Brook, there is no single easy solution. Coordinated implementation of many measures over many years will be needed to decrease flooding. In addition, it will be necessary to evaluate the importance of preventing an occasional flood and weigh it against the importance of other changes that might, for example, improve the brook’s water quality or aquatic habitat. The process of evaluating options and priorities and developing a watershed management plan is the subject of Chapters 8 and 9.

