Abstract of the report:

BASELINE STUDY OF THE HYDROLOGY AND MORPHOLOGY OF LITTLE SEWICKLEY CREEK, SEWICKLEY, PA.

by

William S. Neubeck

1979

(This abstract was prepared for the Little Sewickley Creek Watershed Association by Sarah L. Shockey and Howard Shockey. Mr. Neubeck did not participate in preparing the abstract and should not be held responsible for any inaccuracies or misinterpretations of his report that might be discovered in this paper.)

Copies of this abstract and of the complete report are available from

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INTRODUCTION

The Little Sewickley Creek Watershed study was undertaken to provide baseline information on the hydrology and morphology of Little Sewickley Creek in its present rural state. (Hydrology is the study of water on the surface of the land, in the soil, in underlying rock layers, and during evaporation and precipitation. Morphology is the study of the origin of land forms and how they are affected by erosion. A watershed is the area which supplies water to a stream from surface runoff and from ground water runoff.)

Dr. Marie Morisawa, an authority on hydrology in the Department of Geology at the State University of New York at Binghamton, was asked by the Watershed Association to direct the study, and Mr. William Neubeck, a graduate student working with Dr. Morisawa, spent two months in the summer of 1979 collecting data about Little Sewickley Creek and its watershed. His analysis and presentation of the data provide a baseline to which more data about the stream can be added and which can supply information to governmental agencies, builders, and others concerned with responsible land use planning and development. Dr. Morisawa and Mr. Neubeck considered this study to be especially important since few small streams and watersheds have been studied before urbanization.

The formal analysis of the data and description of the work involved in the data collection were presented by Mr. Neubeck as a thesis for his Master of Arts' degree in geology. This paper is a highly abridged version of Mr. Neubeck's thesis. His general observations and conclusions are in this report, but data, analytical methods, scientific references, etc., have been omitted. This abstract has not been prepared under the auspices of Mr. Neubeck so any limitations and inaccuracies should not be attributed to him. The complete Neubeck report is available from the Little Sewickley Creek Watershed Association.

As part of his study, Mr. Neubeck installed two permanent water level recorders and four rain gauges. These currently are being monitored by the Watershed Association and the data are being added to that collected by Mr. Neubeck.

Mr. Neubeck's thesis included the following information:

1. Basic data concerning the stream's environment, i.e., geology, topography, soils and climate.

2. Analysis of the hydrologic data collected in June and July, 1979.

3. An overall description of the stream and its tributaries in terms of its drainage properties, channel morphology, and erosion and sedimentation characteristics.

4. Land-use data for correlation with the above information and comparison with other watersheds in the region.

Mr. Neubeck reached these conclusions:

1. Since Little Sewickley Creek Watershed is in a rural condition and is similar to other rural watersheds in the region, it can be used as a standard against which the effects of urbanization on other basins in the area, and on Little Sewickley Creek, can be determined. Low runoff rates, long lag times between rainfall and stream rise, low peak water runoff, high drainage efficiency, and slow increase in downstream channel enlargement characterize the watershed.

2. Urbanization has a pronounced effect oh hydrologic and morphologic characteristics of streams. The recent construction of Maronda Homes has had easily recognizable effects on the tributary that drains the area. Maintaining equilibrium of Little Sewickley Creek and its tributaries will require careful planning of future developments in the area to prevent the effects of increased runoff.

3. The infrequent flooding in the basin of Little Sewickley Creek is due to vegetative cover, soil types, topography, efficiency of the drainage system, the beaver dams, and the length of time that the watershed has remained in its natural state.

4. Roads and bridges related to the stream and its tributaries have deteriorated to the point where drainage efficiency is in jeopardy and human property and safety are threatened.

Mr. Neubeck made the following recommendations:

1. Strong laws and strict enforcement are needed to control construction in environmentally sensitive areas such as steep slopes, floodplains, and landslide-prone areas to insure the safety of man, property and the stream.

2. More data are needed on stream flow to define better the hydrologic character of the watershed. This study was not conclusive but rather serves as a base for comparison with future studies.

3. Stream-related structures should be carefully inspected and repaired as soon as possible.

4. The watershed should be preserved in its natural state to insure the continued health of the stream and for aesthetic reasons. The Little Sewickley Creek Watershed contains some of the most scenic areas in the Pittsburgh region.

PHYSICAL ASPECTS OF THE STUDY AREA

Geographic Setting

Little Sewickley Creek drains a small watershed which lies in portions of seven municipalities (Franklin Park, Sewickley Hills, Sewickley Heights, Bell Acres, Leet Township, Edgeworth and Leetsdale). Most of the watershed is presently in a rural state while surrounding areas are suburban residential, urban and industrial.

Geology

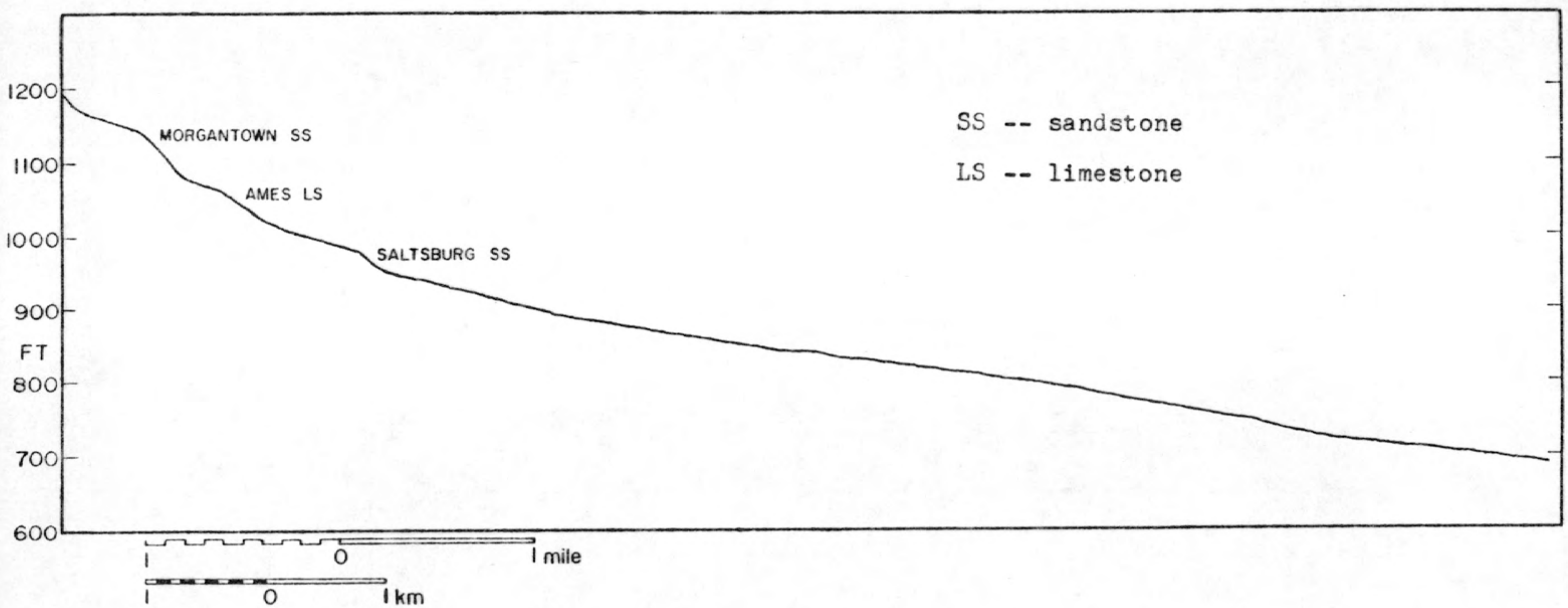
Types of rock layers, jointing, effects of continental glaciers and topography are aspects of the geology of the watershed. The Pittsburgh red-beds (consisting of red siltstone, shales and claystones) are interlayered among the more stable sandstone and limestone layers. As the continental glaciers receded, the melting water deposited large terraces of silt, sand and gravel, resulting in an abnormally wide flood plain at elevations below 1000 feet. Vertical jointing allows deep percolation of water and the resultant increase in local water pressure has a great influence on land slides. Steep hillslopes and many small hills and valleys within the area characterize the topography of the watershed.

The longitudinal profile of the main trunk of Little Sewickley Creek is shown in the figure on page 4. Changes in slope as noted in the upper portion of the profile result from variations in resistance to erosion for different types of bedrock. The erosion-resistant rock layers are indicated on the profile. Below the Saltsburg sandstone the smooth profile indicates that stream equilibrium has been established despite variations in bedrock resistance.

LAND USE

The way in which rain water moves from the place it lands to the mouth of a stream is dependent on the state of the land surface. This section provides land use data for the watershed in its present state, and describes past trends by comparing these data with land use data from 1938.

Land use data were obtained from two sets of aerial photos provided by the Pennsylvania State Geologic Survey: a 1938 set, and a 1973 set updated where possible in 1979 by field checks. The table below



Longitudinal Profile -- Main Trunk of Little Sewickley Creek summarizes the results.

Land Use in the Little Sewickley Creek Watershed

Use	Percent of Total Area 1938	Present
Forest	59.0	65.6
Grassland	38.6	28.1
Residential	2.4	5.5
Commercial	0.0	0.5
Industrial	0.0	0.3

Runoff is highest for the residential, commercial and industrial categories because these areas have a high percentage of impermeable area (e.g., asphalt, rooftops). Grasslands have moderate to low runoff and forested areas have very low runoff.

Since 93.7% of the watershed is presently covered either by forest or by grasslands, flooding in the basin is infrequent. Water retention capacity is very high and percent runoff is low, so that much time is required for water to reach the stream. This results in low peak discharges and long lag times. In addition, most of the urbanized high runoff area is located near the mouth. The only exceptions to this at present are the Maronda Homes development and developments in the northern headwaters along Camp Meeting Road. The only section adversely affected by urbanization and associated storm water drainage at this time is the section below Woodland Road.

Because land use in the area has changed little in 41 years, the stream has great stability. Forested area has actually increased by 11.2%, grasslands have decreased by 27.2%, and residential areas have increased by 129.2%. The latter still represents less than 6% of the total watershed area. Thus, the stream has established and maintained its equilibrium under the constraints of its natural environment. This is in marked contrast to other more urbanized watersheds in the region whose problems are related to attempts by the streams to cope with upsets in equilibrium resulting from rapidly changing conditions.

SURFACE HYDROLOGY

Baseline data include rainfall data, base flow of the stream, storm hydrographs, runoff data, flow parameters in relation to channel width and depth, and general analysis of the stream and its tributaries.

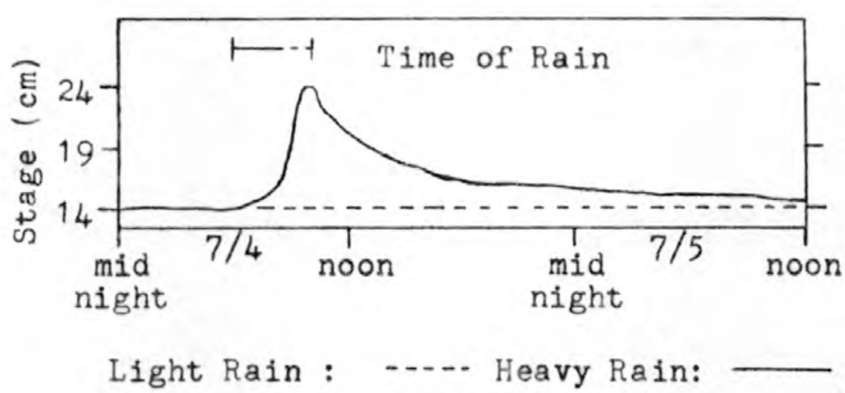
Method of Study

Four rain gauges installed within the watershed allowed collection of rainfall data and calculation of total rainfall for the watershed. Two continuous water-level recording gauges (stage recorders) were installed on the main trunk of Little Sewickley Creek. Measurements of width, depth and velocity were made at several monitoring stations along the stream, and were used for the hydraulic geometry analysis. Volume and rate of water flow were calculated. Stage/discharge rating curves were constructed for each section. Many more readings need to be taken, especially at higher flows, to define the curves better and improve their accuracy.

Storm Flow Characteristics

One of the best ways to learn about a stream is to study its reaction to rain. Although the number of heavy rains that occured in the watershed during the time of data collection were few, data collected were sufficient for the purpose of establishing a baseline.

A hydrograph from a water-level recorder is shown below for a storm on July 4, 1979. The curve indicates the rise in stream level (change in stage) from surface runoff and from water flowing through the soil. It shows a rapid rise followed by a slow tapering off toward base flow, and it follows the pattern for a natural watershed. Lag time (the amount of time between the middle of the rainfall and the peak on the hydrograph) is affected by moisture content of the soil, intensity of rain, steepness of slopes, vegetation, and degree of urbanization. The lag time of 1 3/4 hours for this hydrograph is indicative of the natural state of the watershed. Compare this to a lag time of 15 minutes which has been noted for a stream similar to Little Sewickley Creek but heavily urbanized.



Storm Hydrograph

Flooding

Flooding is a natural adjustment by a stream to an increase in discharge. When the volume and intensity of rain exceed the drainage system's ability to remove water, the banks overflow; so the ability of a stream to carry efficiently large volumes of water determines the frequency of flooding. Drainage efficiency depends on slope, drainage pattern, soil moisture, infiltration capacity, vegetation, and percentage of impervious area.

Another author has found that on the average, bankfull conditions are reached in a stream every 1.58 years. However, local residents have stated that the number of floods along Little Sewickley Creek is far below this average. Even during Hurricane Agnes in 1972 the only flooding that occured was in the Quaker Village Shopping Center and in Nichols Field just above Beaver Road, and this was caused by a backwater effect from the Ohio River, not excessive flow in the creek. A report on neighboring watersheds indicates that the number of floods is greater and flash floods are more severe on more urbanized streams. Few floods occur along Little Sewickley Creek because of the lack of urbanization.

Two beaver dams enhance the stream's ability to transmit storm runoff without flooding. The ponds they create retard water from the headwaters and release it more slowly to the lower section. However, if the beavers continue to expand, migrate, and build dams, they will inundate more land which will later become swamp. This could be detrimental since beavers show no regard for the properties or structures of man.

Hydraulic Geometry

Discharge, the volume of water that passes a given data station at a given time, is found by multiplying together the average depth, the average velocity, and the width of the stream. This study found that the amount of increase in discharge at a given point on the stream after a rainfall corresponded to an increase in the velocity and depth of the water. The high rate of increase in velocity is probably caused by the steep hillslopes in the watershed. This increased velocity at higher flows allows more rapid removal of the water, resulting in lower peak discharge -- another reason for infrequent flooding. Width showed very little increase since few data for bankfull or very high flows were recorded. During lower flows the water is confined to the lower portion of the channel which is, in general, steeper sided than the upper channel banks. Again, more data need to be gathered, particularly at higher flows.

"Downstream hydraulic geometry" is a technique for measuring a stream's method of handling the increasing amounts of water (from tributaries, springs, etc.) that enter it between its headwaters and its mouth. Measurements taken at ten monitoring stations under normal discharge conditions show that the greatest change in Little Sewickley Creek is in width: the stream is eroding its banks much more than it is deepening its channel. Deepening is hindered because resistant siltstone and sandstone that falls into the channel from undercutting of the red-beds acts to protect the channel bed. Average velocity increases somewhat in the downstream direction at a given discharge frequency. These findings differ from those found in studies of more urbanized creeks in the region, where major changes occured in depth or velocity rather than in width.

GEOMORPHOLOGY

Tributaries

The map on page 9 shows the locations of tributaries discussed below. These tributaries are quite steep and only the larger ones have flood plain development in the lower reaches. The discharge measurements are typical for streams in a rural state. To better explain the nature of the tributaries, four of them are described in some detail.

Tributary 2 has a deep, straight, steep-sided valley that is almost completely forested. There is no flood plain development and in cross section the valley has almost a perfect V-shape. Channel width is about 3 feet. Small amounts of excess sediment occur near the mouth, derived from landslides and/or construction activity from three houses in Quaker Heights, located in the upper headwaters. A large duck pond located near the top of the valley is now completely filled with sediment. Landslides are numerous in the lower parts of the channel and occur mostly in the red beds. Most of the debris is removed by the swiftly flowing water after storms.

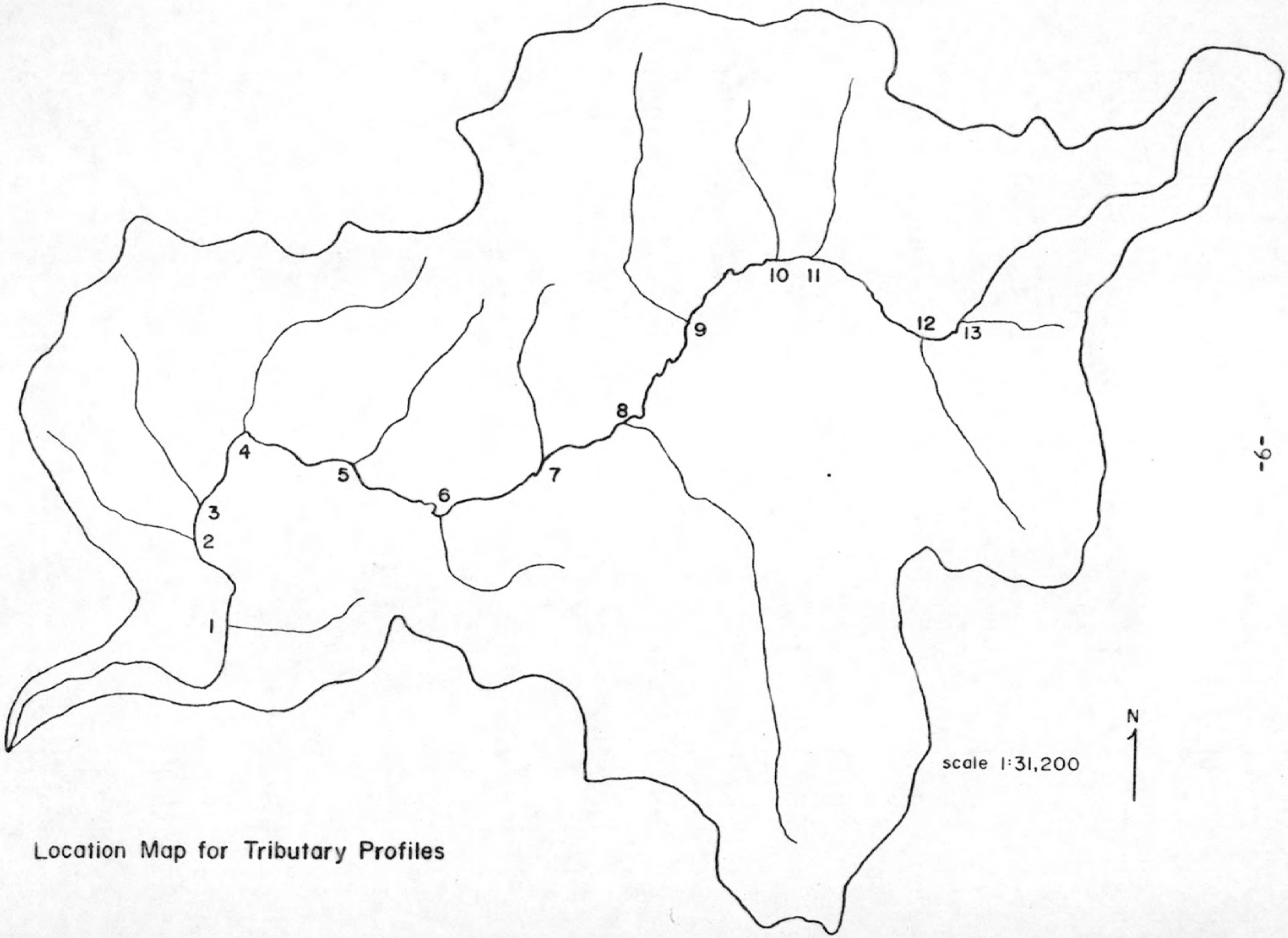
Tributary 3 is also V-shaped but the bottom and channel are wider (6--10 feet), probably because of greater discharge since it drains a larger area and the headwaters are located on a golf course. The lower section is forested. Near the top the tributary forks into two branches. Debris from landslides, greater than in tributary 2, and the lack of a sediment basin contribute a greater amount of excess sediment.

Tributary 4 is a larger tributary whose two major branches have headwaters along Camp Meeting Road. The west branch and lower section run roughly parallel to Sevin Road. The east branch and lower section show flood plain development. Valley walls are steep in the headwaters and become shallower toward the mouth. Both branches have residential developments in the headwaters along Camp Meeting Road and Witherow Road. The tributary is in essentially a natural forested state with two major exceptions:

1. The west branch and lower section is parallel to the road and runs adjacent to it in many places. In sections where the stream bed has been altered flow velocity is increased. In other sections culverts carry the stream beneath the road and water has backed up behind them. This has caused sediment to be deposited upstream from the culverts and the road to be undermined in many places. The road requires constant maintenance.

2. Developments in the headwaters have caused an increase in runoff resulting in greater erosion of the banks and numerous small landslides in the red beds.

Tributary 9 is a combination of forest and cropland in the lower and middle sections while the headwaters lie on a golf course near Camp Meeting Road. The tributary has a developing flood plain in the



Location Map for Tributary Profiles

lower section which narrows upstream, after a split into two main branches, to a steep V-shape. Forest cover is mature in the upper middle section causing ground cover to be reduced. Landslides are common, though in this tributary many occur high on the valley slopes. The most notable man-induced change is seen in the western branch whose headwaters lie on the Sewickley Heights Golf Course. The course is drained through 5 ponds and a number of drainage pipes which empty directly into the tributary valley at the top of the slopes. There is nothing on the valley walls to inhibit the flow and numerous rills have formed on the valley sides, caused by flow from these pipes. The western branch itself has two stems, the westernmost of which has a landfill site at the head of the valley. At the time of inspection the landfill was bare and the edge facing downstream had a vertical drop of 30 to 40 feet.

Pool-Riffle Sequence Analysis

Other studies have shown that streams in equilibrium have a predictable relationship among bends, pools, riffles and point bars that is independent of the material in the channel banks and bed. That relationship is present in Little Sewickley Creek. The small log dams that were constructed many years ago to form pools for the stocked fish are mostly intact and functioning well where they coincide with the natural pool spacing, and have been destroyed, or adjacent banks have been badly eroded, where they did not coincide with natural pool spacing.

Erosion and Sedimentation: Natural Alterations

Erosion and sedimentation in a stream channel are natural processes by which the stream alters its channel so that equilibrium is achieved. The biggest natural alteration which causes large stream channel changes is the undercutting of the banks on meander bends. As a result trees may fall into the channel and obstruct it, forcing the water to go under, over or around the trees. In most cases the water erodes beneath the log, forming a large pool, while upstream from the log a bar builds up from the backwater effect caused by the obstruction. Often these changes are minor and temporary. In a few places, however, the water has gone around the tree rather than under it, causing acute erosion of the bank.

Another natural occurrence, which is less frequent but causes more harm to man, is landsliding and slumping initiated by stream undercutting. This problem is most acute in areas where the stream flows at the base of steep, unstable slopes, usually on red beds. Bank erosion by the stream causes a mass movement of the slope when the supporting material is carried away by the stream. One such area is located on Little Sewickley Creek Road just above its intersection with Woodland Road. A recent slide is visible and another is imminent. It is difficult to tell when it will slide again, but the slide will probably occur after a long period of rain. Another area exhibiting mass movement above the stream is along Audubon Road in Sewickley Hills, where slow creep is undermining the road. There are a number of other areas where slope movements of various magnitudes are occuring, some of which are stream-related.

Erosion and Sedimentation: Man-induced Alterations

The lower urbanized section of Little Sewickley Creek undergoes high rates of erosion caused by a number of alterations to the stream. Channelization in the form of rip-rapping and cement walls increases the flow efficiency of the stream which in turn increases its erosive capabilities. At one time cement slabs lined the stream banks below Woodland Road. Undercutting by the stream eventually wore through these thick slabs and they fell into the channel. The section of rapid bank erosion above Nichols Field is intensified by the straight, high-velocity section upstream causing accelerated erosion. The problem is compounded by numerous storm water pipes which efficiently transfer runoff into the stream causing higher peak discharges. Thus, increased erosion in this section is caused by (1) increased runoff due to the high percentage of impermeable area, (2) higher peak discharges because of the efficiency of the stormsewers, and (3) higher flow velocities from channelization.

Channel constriction is another means by which man has altered the channel shape. Most often this occurs in the vicinity of bridges. If the space beneath the bridge is too small to accomodate high discharges a backwater effect upstream results in sedimentation and a reduction in bankfull channel capacity. As the water passes through the constriction, its velocity is increased and this, along with its decreased sediment load, causes erosion of the bridge structure and the channel downstream. An excellent example of this is found on Fern Hollow tributary at the bridge for Pony Hollow Road. Constriction and concrete chunks eroded from the walls below the bridge are apparent.

One of the biggest problems in the watershed at this point is the decrepit condition of the stream-associated structures. Undercutting of a retaining wall at the upper end of Walker Park and decay of walls along Fern Hollow Road are examples of structures in need of repair or replacement to insure unobstructed flow of the main stream and tributaries.

In general, sediment discharge from the stream at its mouth has been small because of the dams and retention ponds along the main trunk. However, the large cement dam near Woodland Road is now completely filled in, as is the retention pond in Sewickley Hills near the border of Franklin Park. Now only the two beaver dams serve to trap sediment.

Maronda Homes--A Case Study in Erosion and Sedimentation

The Maronda Homes development site is located just off Magee Road in the headwaters of tributary 13. Construction began in 1976 and presently there are over 25 houses completed, with more under construction. Though an erosion-siltation plan was filed for the project, it was not implemented and the result was serious erosion of the land and fill areas in the headwaters of the tributary. Steepness fluctuates substantially in the upper section of the tributary and most of the sediment from the development has accumulated in relatively flat sections, some of which are caused by natural log dams. Fresh bar deposits are over 12 inches thick in two or three places, and one deposit is at least 24 inches thick just above a large log dam which has a vertical drop of 3 feet. Most of the sediment has been caught above this dam. Below the dam erosion has caused channel enlargement greater than 3 feet for a distance of 50 to 60 feet. Downstream, material eroded from the enlarged section has been deposited, decreasing the channel capacity. In general, the tributary has been seriously altered by the development. Further reactions can be expected. According to one study, channel enlargement caused primarily by urbanization becomes apparent about 4 years after construction and continues for about 26 years. Such enlargement from increased runoff is already beginning below Maronda Homes. The stream is beginning to remove some of the sediment now that the development site has been properly seeded. Runoff water now has little sediment and is able to pick up the material in the channel.

The damage to this tributary, though acute, is not uncommon. Much of it could have been prevented had the cleared area been properly seeded and a sediment basin constructed. Unfortunately it is now too late, but further enlargement can be stopped by installing a detention pond to retard high flows and reduce flow velocity.

CONCLUSIONS

Mr. Neubeck's study provides a great deal of information about the Little Sewickley Creek Watershed. Since the data were acquired while the Watershed is still in a relatively natural state, the study should prove especially valuable in helping plan future development. Many of Mr. Neubeck's conclusions will be refined as additional data are accumulated and added to his. Making such refinements is a continuing project for the Little Sewickley Creek Watershed Association.

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March 25, 1980

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