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degree of: Master of Science

in Engineering Geology

It is entitled LAND USE AND LANDSLIDING IN
PRICE HILL, CINCINNATI, OHIO

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**LAND USE AND LANDSLIDING IN PRICE HILL,
CINCINNATI, OHIO**

A thesis submitted to the

Division of Research and Advanced Studies
of the University of Cincinnati

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requirement for the degree of

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of the College of Arts and Sciences

2002

by

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ABSTRACT

An engineering geology study of chronic landsliding on a 168-acre hillslope on the western side of Mill Creek Valley in Price Hill, Cincinnati, Ohio finds that most of the landsliding can be associated with past land use initiated over the last 195 years. The majority of the hillside has moved or is in quasi-equilibrium from human activity. Historic quarry operations, deforestation, clear cutting, grading for housing (both historic and ongoing), road construction, loading of the slope from dumping (landfill, construction debris, etc), and modification of the natural hydrology have set the stage for past and ongoing destabilization of the hillside.

Research of past land use patterns and examination of historic photographs, maps, newspaper accounts, directories, and books complemented mapping of human landforms, instability features, and surface water drainage. The majority of the study data was collected in the field however; historical documentation revealed landsliding and/or preexisting human made features that today would not be recognized in a traditional field investigation. Additionally, some of the landforms identified in the study area could be validated as landslide or human made features by examination of the historical data. Examination of the historic record and past human landforms that at present may be completely or partially indistinct gives a different perspective on the extent of hillside instability. A stake survey combined with inclinometers may be necessary to delineate the true extent of ground movement in areas absent of human made earthen landform, structure, or lacking historical data, especially on the lower portions of the hillslope where the overburden thickens.

Thorough examination of the historic record in conjunction with a careful field study of the amount of hillside disturbance and movement allows the public and professionals to make prudent decisions on future hillside use and development. Further, Geographical Information Systems (GIS) provided a vehicle to preserve the field data (mapped at 1:1200) and land use patterns for future reference.

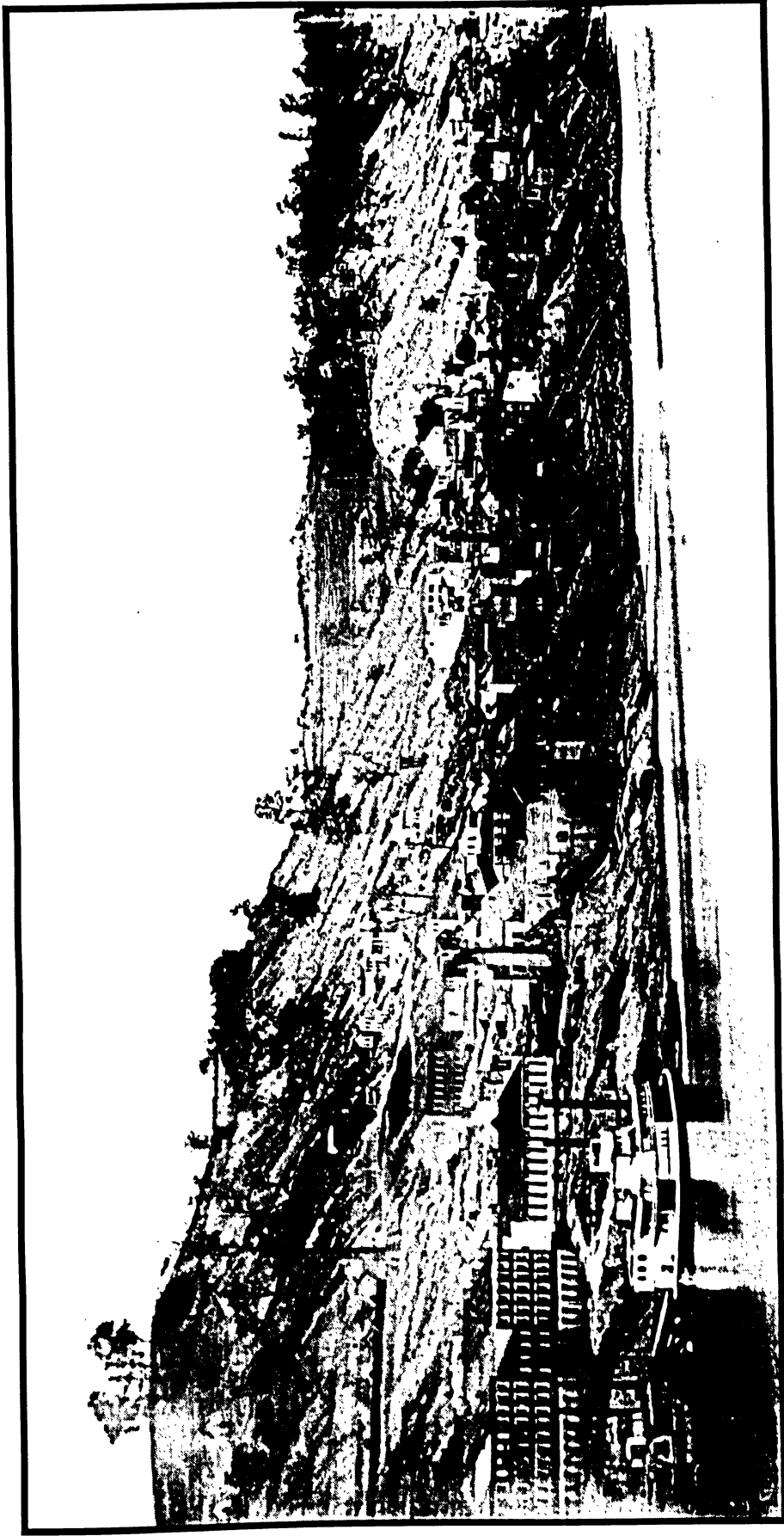
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ACKNOWLEDGEMENTS

I had two goals in mind when I came back; the first was to complete a degree left unfinished. Dr. Joseph Agnello, Professor of Speech Pathology, an expert in stuttering therapy and voice recognition, early in life persevered in overcoming a huge stuttering hurdle. Completing my M.S. degree was a hurdle that for a time was off in the distance but as I got closer to it, I saw that I could not only clear it but do so without falling. Because of my father I went back to finish my degree, as he always encouraged me and was best qualified to tell me “it’s never too late”. Thanks Dad. Dr. Paul Potter’s visitations with me over the years while he tended to his banking, was encouraging as he would never fail to mention that the department would always welcome me back. The second goal of my project was to pursue a problem that had broad appeal and would be of benefit to the public. Dr. David Nash and Dr. Thomas Lowell welcomed me back, allowing me to pursue my second goal and complete my research as I saw it. Their encouragement and support as an advisory team was exceptional and paramount from day one in completing this project.

Thanks goes out to the City of Cincinnati’s Richard Pohana for suggesting the study area that had such a rich history of landsliding. Dr. Barry Maynard’s review of the manuscript and suggestions on the final presentation was particularly helpful. I would also like to thank the Cincinnati Historical Society and staff whose resources and helpfulness provide an invaluable public service. The Price Hill Historical Society’s Rob Geiger was very helpful in supplying information pertinent to the history of the study area. I am also indebted to Cincinnati Toastmaster’s # 472 Glenn Bathalter for his guidance on public speaking.

Lastly I’d like to dedicate this paper to the next generation of scientist so that they may not forget the past in particular little Madison Agnello, Zachary Agnello, and Jacob Jarboe. As Jacob would say “To infinity and beyond”!



Frontispiece-Left half of picture is the south-facing slope of Mt. Adams in 1848. Foreground is the Ohio River. One story building just above the white paddleboat is the Passenger Depot for the Little Miami Railroad. The building to the immediate right of the Little Miami Depot is the water works for the City of Cincinnati. Right of top center is a terraced hillside in the vicinity of Eden Park, possibly for some of Nicholas Longworth's vineyards. The extreme right side of the photograph is the area of Fulton, which extended all the way to the Columbia-Tusculum area, known for steamboat building. Courtesy of the Public Library of Cincinnati and Hamilton County, Plate 7 from the Cincinnati Panorama of 1848.

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Plate III. Relative Stability Map of Lower Price Hill, Cincinnati, Ohio

CHAPTER 1: INTRODUCTION AND PURPOSE OF THE STUDY

The primary purpose of this research is to determine the cause of chronic landsliding on a hillside in Lower Price Hill west of downtown Cincinnati. A secondary purpose is to document the spatial and temporal distribution of landsliding. To accomplish these objectives, one non-traditional approach will be to examine the long forgotten history of the area and relate the heretofore-unrecognized importance of prior land use to landsliding. The study is intended to aid city officials, geotechnical engineers, and more importantly private individuals, contractors, and developers to be better informed and be able to make prudent decisions regarding hillside development.

In an early phase of the study, past construction activity on the hillside was recognized and so the history of the area was researched along with past historic records of landslides. Recognizing human-made landforms, landslide features, and examining the historical record is key to identifying the extent of the problem and addressing remediation.

Although, Cincinnati is well known for its slope instability problems, damage from landsliding continues to mount. Fleming and Taylor (1980) reported that Hamilton County, Ohio damage from landslides for a 6-year period from 1973 to 1978 totaled \$31 million excluding \$30 +/- million in damages associated with the Mt. Adams landslide in 1974. Pohana (1992) reported from 1983-1992 \$8.8 million for repairs associated with historic landslide damages with another \$8.5 million projected for repairs from 1993-

1997. Lennertz (1997) a geotechnical engineer reported, in 1996, a year of exceptional rainfall, damages from landsliding in Hamilton County exceeded \$10 million dollars.

An engineering geology study was undertaken to examine the western hillslope of the Mill Creek Valley adjacent to downtown Cincinnati. The Lower Price Hill study area encompasses a 168-acre (Figure 1.1) hillslope, with the intersection of Lehman Road and Radcliff Drive in the vicinity of geographically prominent Bald Knob bounding the study area to the north. The southern boundary is Elberon Avenue from the Warsaw-Waldvogel Viaduct to Mt. Hope. State Street and the crest of the hillslope loosely border the eastern and western boundary of the study area, respectively. The area was identified and referred to the researcher as needing further investigation by the Engineering Geologist for the City of Cincinnati, Mr. Richard Pohana. The real estate on the hillslope within the study area is composed of predominately unimproved (i.e. no structure) parcels with a scattering of residential single family homes and, to a lesser extent, condominium and apartment complexes.

The demand to develop the last vestige of unimproved land within the City of Cincinnati is strong especially hillside ground that commands a view. Housing and unimproved land with a view can typically command a premium over its suburban counterpart that lacks a view (Figure 1.2). Near the top of the slope, the unimproved area below residential housing, condominiums, and apartment building, has a long history of being clear-cut to maintain the view. The view from the study site is one of the best in

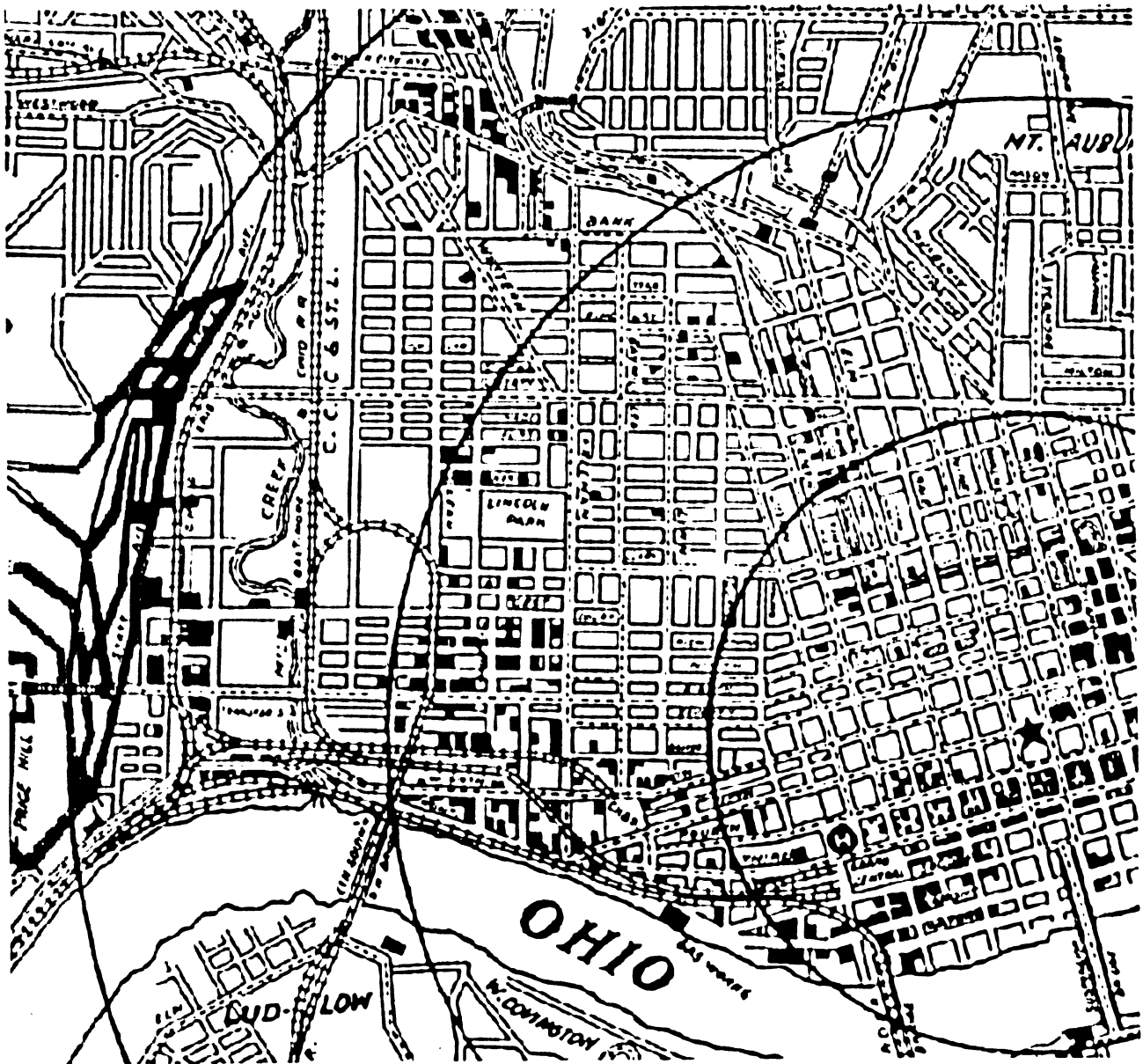


Figure 1.1 Location map of study area showing extensive roadway pattern (solid) developed on the Price Hill hillside. The star in lower right quadrant of map represents location of Fountain Square in 1900. Concentric circles represent miles out from Fountain Square. The study area is approximately two miles out from the Central Business District of Cincinnati. Note the partially channelized Mill Creek with several meander loops still present at this time. Also, note the location of Lincoln Park in the center of the map future site of the Union Terminal. Map courtesy of the Cincinnati Historical Society dated May 1900.

Cincinnati. New construction above the crest of the hillslope attempts to maximize the city and river view. The location of CitiRama (2000) proposed by the Greater Cincinnati Home Builders Association (HBA) on Morrow Place off Maryland Avenue is a prime example of this. Housing is staggered on a diagonal to the street, to maximize housing density with a view of the Mill Creek Valley, City of Cincinnati, and the Ohio River.

Early on the State Geologist, Edward Orton (1873, p423) proclaimed the colluvial slopes a “disadvantage” for what today he might have called infrastructure and housing, correctly predicting that the City of Cincinnati would have “increased outlay in foundations” with “frequent slides occurring along the steeper slopes”. The City of Cincinnati officially recognized landsliding as a problem in the study area by naming the Price Hill hillslope as the first hillslope (City of Cincinnati Planning Commission, 1976) to be designated as an EQD district. Hillsides within the City of Cincinnati limits classified as Environmental Quality Districts (EQD) have been delineated to assist in the prudent development of landslide prone areas. Initial and ongoing review of proposed improvements to the hillslope is paramount in curtailing damage from landsliding.

Price Hill Residential Sales Compiled from Multiple Listing Service of Greater Cincinnati as of 2/2001				
	Avg. Sale Price Hill	# of Sales	River View Advertised	# of Sales
Three Year Average	\$63,000	765	\$122,900	44
Five Year Average	\$61,000	1197	\$114,500	74

Figure 1.2 Price Hill Residential Sales

Small residential projects have initiated slope movement that often extends to adjoining parcels. Construction projects within the EQD district involve an initial review by the City Planning Department with assistance from the City Engineering Geologist and/or the Geotechnical Engineer when necessary. Often a private consultant/geotechnical engineer is involved with the initial site study. Geotechnical oversight should be utilized throughout the project. Residential construction is stagnant on the hillslope probably due to the high cost of geotechnical work, which can significantly impact residential building costs.

The study area has a high density of landslides damaging both infrastructure and residential housing. Although the vast majority of the hillside is available for development and platted for residential development, housing is conspicuously absent. There are numerous residential sized parcels platted for single family homes that either remain unimproved or represent failed early development efforts. Plat maps from the 1800's show a smattering of houses on the hillside that no longer exist and were presumably damaged by landsliding. There are, however, several building foundations, walls, fence posts, and earthen embankments for roadways observed in the field, which serve as direct evidence of early improvements to the hillside. Personal photographs examined show evidence of hillside farming and terracing within the study area. All the major arterial roads (Elberon, Maryland, Glenway, Warsaw, and Lehman) date from the early 1800's and have a long history of repairs due to landsliding. In the past twenty-five years the City of Cincinnati has invested approximately 1.5 million dollars to stabilize landslides on these roads (excludes current Lehman Road project).

CHAPTER 2: HISTORIC OVERVIEW OF CINCINNATI

Introduction

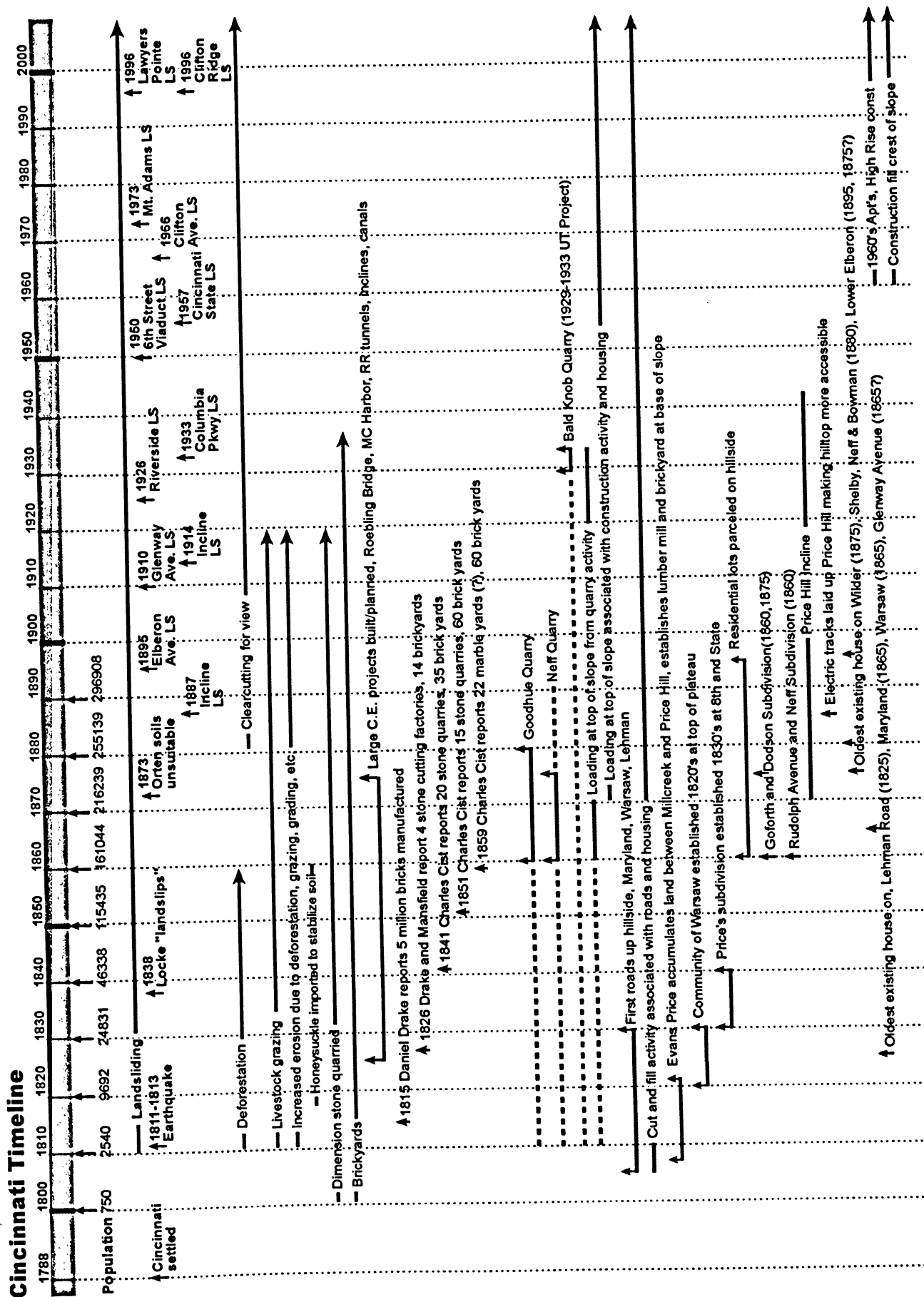
The significant impact human activity plays on Cincinnati's hillsides warrant a brief review of the history of the area. Figure 2.1 is a timeline of human activity in Cincinnati and on the study area hillside, correlated with known landsliding in the study area and several well-documented deep landslides outside the study area.

Humans' are a significant geomorphic agent moving earth, for housing, transportation needs, and for natural resources (Marsh 1864, Selby 1996, Hooke 2000). The ability for human's to move earth; set's the stage for slope failure. Human activity (study area) on the hillslope is evident from dumping near the crest, grading for roads midslope (above existing housing), to the pervasive honeysuckle growing on the hillside and imported to curtail erosion from lumbering activity. Much as you would find in Europe, a large portion of the hillside (study area) was unsuccessfully subdivided into residential lots. Cincinnati's early population growth and success as a premier place to live, has translated into today's problem. The preponderance of evidence (direct and indirect) for failed human activity on the hillslope attests to the difficult nature of utilizing the hillside.

The repeated pattern of instigating landslides reflects on Cincinnati's inability to head the historic record. Interpretation of the morphology of the hillslope (within the study area) is difficult without knowing the history of human activity. Lastly, examination of the historic records can help assess the amount and nature of movement on the hillslope.

Figure 2.1 Cincinnati Timeline. The following page shows events in Cincinnati (blue) and events within the study area (yellow) related to human activity and landsliding.

Cincinnati Timeline



Early History of Cincinnati

The history of Cincinnati is important in understanding the impact humans have had on the hillslope study area. Below is a broad description of Cincinnati that will set the stage for a more specific description of human activity in the study area.

John Cleves Symmes advertised the land between the Miami's (Figure 2.2) in 1788 as having "excellent soil and climate, absence of mountains, level country, stone quarries, never-failing springs, rivulets and mill streams" (Fenneman, 1916). The Symmes purchase encompassed 311,682 acres (Burke, 1994) and in 1792 Symmes was selling half-acre town lots in conjunction with four acre out-of-town lots (Wallace, 1958). Thus, with Cincinnati the jumping off point, development progressed north up the fertile Mill Creek Valley.

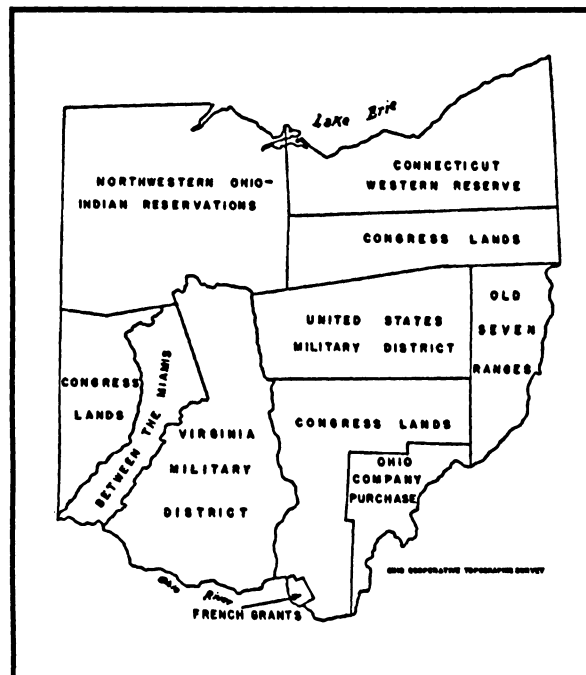


Figure 2.2 Principal land grants and surveys with the Symmes purchase, being approx. the lower third of the land "Between the Miami's". Modified from Wright (1953).

The first description of the area was by early frontiersman and surveyors who described Ohio as being heavily forested (Ford & Ford, 1881). Symmes original survey party purportedly got lost during several overcast days because the tree canopy was so dense in the Mill Creek Valley. Early renderings portray the hillside in the vicinity of Cincinnati as being densely wooded (James, 1886). Originally “the slopes of the ‘hills’ about the city were clad in green and generally wooded” (Nickles).

Cincinnati’s population exploded in the early 1800’s, growing rapidly from 750 in 1800 to 115,435 in 1850 (Figure 2.3). Cincinnati was one of the nation’s fastest expanding cities and by 1840 was the sixth largest city in the United States (Debow, 1854). In the interval from 1810 to 1840, Cincinnati’s population grew at a rate of 4444%. This early

CINCINNATI POPULATION & PERCENTAGE GROWTH		
1800	750	
1810	2,540	239%
1820	9,642	279%
1830	24,831	157%
1840	46,338	87%
1850	115,435	149%
1860	161,044	40%
1870	216,239	34%
1880	255,139	18%
1890	296,908	16%

Figure 2.3 Population data from Debow (1854), Weil (1887).

population growth forced people out from the original settlement in search of natural resources, building sites, and land for agricultural use. Additionally, some large scale civil engineering projects were undertaken and others planned in the middle to late 1800's as a result of Cincinnati's tremendous population growth. These projects included inclines, canals, the Roebling Suspension Bridge, railroad lines and tunnels, filling in and straightening of the Mill Creek, and a harbor and dock area in the lower Mill Creek Valley (Figure E.15).

Another impact on the hillsides due to Cincinnati's growth was deforestation. The strong demand for natural resources including lumber in a rapidly growing city probably led to widespread deforestation by 1850 in the immediate vicinity of Cincinnati. Drake (1815 p140) reported that wood was the "chief article of fuel", with beech, ash, hickory, sugar tree, oak, red maple, honey locust, and buckeye mostly used and was obtained from the "surrounding hills". Lumber was needed for housing, fuel, and steamboat construction. Steamboat construction (1815-1900) was carried out just west of Sawyers Point, along a two and one-half mile stretch, in an area at that time called Fulton, after Robert Fulton the first financially successful steamboat builder (White, 1999). In 1847 the town of Fulton produced, thirty-four steamboats, four steam ships, two barges, one brig, and one ship. A world famous panoramic series of daguerreotype photographs (Fontayne and Porter, 1848) taken in 1848 (see Frontispiece) and held by the Cincinnati Public Library clearly show the Mt. Adams hillside modified and stripped of vegetation. A similar broad historical photograph of the adjacent western side of the Mill Creek Valley could not be

located, but with a heavy demand for lumber, this area would undoubtedly have also been stripped.

The hillside areas were also used for agriculture; plowed for crops, terraced for vineyards, and grazing (Hedeen, 1994). Nicholas Longworth a well-known Cincinnati viticulturist had vineyards in the community of Warsaw, west of the study area (Giglierano and others, 1988). In the 1820's Catawba grapes produced by Longworth were in demand and renowned worldwide. A southern facing slope was preferred, terracing was common, and a forty-mile stretch along the Ohio River was purported to have vineyards. Remnant vines still grow on the Cincinnati hillsides.

Livestock grazing on the "sloping hills" of Cincinnati was common in the 1800's (Clopper, 1845). Livestock grazing on the hillside may have been a factor in the destruction of vegetation, formation of terraces, and accelerated erosion. Cincinnati's meatpacking industry was thriving by 1818 and led the nation until the 1860's. In 1833 eighty-five thousand hogs were packed, and in 1848, five hundred thousand (Morris, 1953). Stephen Wilder was a prominent pork packer and it appears that family members owned land from the top of the Price hillside all the way down to the Mill Creek. There is evidence of an abandoned fenced area midslope (study area) above the Warsaw-Waldvogel Viaduct that probably dates to the early 1900's.

Amur (1855-60) and Japanese (1806) honeysuckle are prolific on Cincinnati hillsides (Gamestetter, 2000). Both were imported into the U. S. in the 1800's (Dirr, 1990). The

honeysuckle was introduced to the Cincinnati area to combat erosion that was extensive after deforestation and is now considered a noxious weed by the Cincinnati Park Board and geologists.

Quarrying of limestone is another example of human activity that had an impact on the hillslope. Most of the quarries in Cincinnati operated from early 1800 to 1920.

Limestone was quarried predominately for building stone (i.e. buildings, foundations, retaining walls; Nickles p78, Locke p210, Bownocker 1915 p22), and to a lesser extent for lime mortar, roadbeds, and pavements (Orton, 1873, p378, Cist 1841, p67). The primary source of Cincinnati limestone was the Hill Quarry beds and River Quarry beds referred to by Orton (1873). The most desirable section of the Hill Quarry beds was the upper 50 feet (Fenneman 1916, p177) of the Fairview formation. Drake (1826 p.125) described the hillslopes of Cincinnati near the summit as “naked perpendicular cliffs”, where the upper Fairview limestone stood in vertical relief. The top of the hillslope in Price Hill above State Street, due to fill placement over the brow and stripping of the upper Fairview for limestone, exhibits very little of this early description. At one time the ridgeline surrounding Cincinnati was well defined with twenty rock quarries (Fenneman, 1916), and there may have been numerous other small pockets of quarry activity. The shale excavated in stone quarries had little value except for fill. Mt Hope (lower Fairview) limestone beds although not as desirable were sometimes quarried (Nickles 1901-1906).

The Covenant-First Presbyterian Church built in 1875 (Figure F.25) and located at corner of Eighth and Elm Street was constructed of limestone taken from the Neff quarry located on the Cincinnati Bible College property (Hannibal & Davis 1996, Bullard 1999).

By 1909 however, Bownocker (1915 p.19) reported that only a few quarries in Cincinnati were in operation. Fenneman reported only two working stone quarries in Cincinnati in 1915. One exception to this was Bald Knob (Figure F.18) in Price Hill near the intersection of Lehman Road and Radcliff Drive. Bald Knob was quarried extensively for rock and shale to be used as engineered fill for the Union Terminal Project (1929-1933). Several eight cubic yard steam shovels were used to strip Bald Knob.

Construction of the approach to Union Terminal necessitated the filling in of an area called Lincoln Park. Up to four million cubic yards of shale was excavated from Bald Knob to raise the approach to Union Terminal and tracks above the floodplain (elevation 495 feet). A total of six million cubic yards of fill was placed in the Mill Creek Valley covering 240 acres to an average depth of sixteen feet (Figure A.4, A.5, & F.20), with no significant excavation being needed in the flood plain (Railway Age, 1931).

Another land use was brick (building and paver) manufacturing plants, which were prolific in Cincinnati from the early 1800's to 1930's. Paver brick manufacturing plants were prolific from 1880-1930's in Ohio (Blakenbeker, 1999). It was a common site to see bee hive kilns and tall smokestacks lining the Mill Creek Valley in the vicinity of Cincinnati, just north of the Ohio River. The area supplied an abundant source of clay. Drake (1815) reports five million brick's manufactured annually from clay stripped from the terraces between the settlement of Cincinnati and the Ohio River.



Figure 2.4 Headline caption for article in the Times Star now the Cincinnati Enquirer dated January 31, 1930.

Cist (1859, p262) describes a dry brick process in which brick is made from quarried shale. Orton (1873 p378) reports shale being used for brick, tile, and pottery manufacturing. Fenneman (1916, p179) reports a dry press brick manufacturing plant on the west bluff of the Mill Creek Valley utilizing the Kope shale. Nickles (1901-1906) stated that exposure of the Kope was “limited” except in the “ravines... and cuttings in the lower slopes of the hills.” Additionally a geographic “notch” between Bald Knob and the adjacent southern plateau may have been a limestone quarry and later a shale quarry (prior to Union Terminal project) for brick manufacturing. Shale is a common source material for paver bricks and shale pavers are typically dark reds (Blakenbeker). Abundant brick litters the Price Hill hillside some of which are labeled 20th Century, Grant Star (Figure F.26), etc.

Early evidence for working of the limestone quarries and brick manufacturing can be found in several early buildings of Cincinnati. The Betts house at 416 Clark Street is purported to be the oldest (1804) house in Cincinnati still in its original location and is constructed of brick with a limestone foundation. William Betts was a brick maker and originally held a 111 acre tract surrounding his house (Pulfer, 1997). Drake (1815) states that a building constructed on the Ohio River banks between 1812-1814 had a foundation footprint of 62 feet by 87 feet and a height of 110 feet, consumed 6,620 perches of limestone, 90,000 brick, 14,800 bushels of lime, and 81,200 cubic feet of lumber.

Extensive use of natural resources and the growing demand can best be illustrated by citing some early statistics. Drake and Mansfield (1826) reported in 1826, 4 stone cutting factories, 3 limekilns, and 14 brickyards with ten million brick being produced annually. They also commented that the “hills furnished inexhaustible quantities of limestone”. Charles Cist (1841, 1851, 1859) as the census taker for Cincinnati reported 1 hydraulic cement and marble dust factory, 20 stone quarries, and 35 brick yards in 1841; 15 stone quarries and 60 brickyards in 1851; and 22 marble yards (?) and 60 brickyards in 1859.

Earthquakes

A natural event that occurred in Cincinnati was earthquake tremors in the Mill Creek Valley originating from the New Madrid fault epicenter 300 miles southwest of Cincinnati. Earthquake tremors can lead to consolidation of the soil and consequently an increase in pore water pressure with a corresponding decrease in soil strength that may lead to slope failure. The most severe tremor in Cincinnati toppled chimneys and poorly constructed buildings in the Mill Creek Valley and is classified on the Mercalli scale as a VII or VIII. The quake tremor propagated up the unconsolidated river deposits of the Ohio River and Mill Creek. Daniel Drake (1815) gave a graphic written accounting of earthquake tremors that shook Cincinnati intermittently from December 16th, 1811 to March 6th, 1813.

History of Price Hill

Evans Price established the first community west of the Mill Creek by accumulating land between the Mill Creek and the top of the hillslope from 1807-1821 in the vicinity of what was to become the Price Hill Incline. A lumber mill and brick yard was established by Price as early as 1817 at the base of the slope near 8th and State to provide building materials for development of his land (Figure E.1). Additionally, a residential subdivision was established by Price in 1821 in the same location and called Prospect Hill (Cinc. Enquirer, 1961). The community of Warsaw located due west approximately one mile from the crest of the hillslope dates to 1827 (Price Hill News 1963, Geiger 1999). The Community of Warsaw was the first establishment on the plateau.

Price's son's built the Price Hill Incline which at it's at peak carried 1.5 million passengers in 1894. The Price Hill Incline was located at the bottom of the hillslope in the vicinity of 8th Street where it turns uphill onto Glenway Avenue (Figure F.6). The Incline climbed a grade of 48% with a change in elevation of 350 feet. The track was 800 feet long and was supported on limestone abutments that probably extended to bedrock on the upper portions of the slope. The Incline was constructed from 1873-1877 and operated until 1943, having separate freight and passenger tracks. At least several landslides have been documented and associated with the Price Hill Incline (Wagner and Wright, 1968). The landslides occurred in 1887, 1910, and 1914. The 1910 landslide (Figure F.7) involved the ground north of the Incline between Warsaw and Glenway and closed the Incline down for over a month while repairs were carried out. The 1914 landslide damaged the 38' x 12' depot at the foot of the incline "by the sliding of the

ground on which it stood". Historical photographs appear to show the Kope exposed midslope (Figure F.6) and the toe of the hillslope being excavated (Figure F.7) near and just north of the Incline.

Shortly after the settlement of Cincinnati in 1788 several roads were cleared and constructed up the Price Hill hillside. Crossing the Mill Creek and climbing the western hillside of the Mill Creek Valley were formidable barriers to development of the plateau. The first roads to reach the valley summit were Lehman, Warsaw, Maryland Avenue, and later Glenway Avenue (Geiger, 2000). Lehman Road may have existed as early as 1805 (Cincinnati Enquirer, 1962) affording the Lehman family access to their property. Prior to 1800, there may have been an access road-trail because the first Ohio president, William Henry Harrison, had a hunting lodge above Lehman Avenue. Warsaw Avenue was initially a toll road and dates to 1820's (Price Hill News, 1963). Maryland Avenue probably posts dates Warsaw Avenue. Early on, Glenway Avenue was described as a steep and difficult ravine to traverse. These first roads came partway up the hill on a diagonal and then followed the existing drainage pattern.

The first roads also served as access to the hillside for lumbering, stone quarries, and surveying parties. These roads were the first cut and fill activity in the area and they formed catchments and redirected surface water runoff. Later (1860's and 1880's), a second and third bench, above and below past and present day roadways, were graded for housing (see Appendix G for housing dates). This cut and fill activity associated with housing was the second phase of removal of lateral support and loading of the hillside.



Figure 2.5 This map shows the pre-1876 drainage pattern. The last vestige of the roughly trending east-west drainage on the hillslope present today is outlined in red. Grading along with cut and fill activity has indiscriminately buried the natural drainage.

There were numerous attempts to facilitate development of the hillside via roads that today show up as “paper streets”. Paver brick, building brick, slag, and limestone float (2-3 inch bedded, 3-7 inches across) litter the hillside and in some instances represent roadways or attempts to construct a road. The presence of roadbeds is evidence of extensive human presence on the hillside. Roadbeds become loci for landsliding due to cut and fill activity.

Walls in the Study Area

Numerous limestone walls constructed in the 19th and early 20th Century exists in the study area and represents some of the first attempts to hold the hillside in place. Most of these walls are in poor condition and failing. The Earth Surface Process Group (1987) reporting to the Smale Commission identified the poor condition of walls within the City of Cincinnati and the city is addressing this issue. Failure of limestone walls in the study area is attributed to creep, landsliding, and erosion from water. Several limestone walls are failing due to the erosive action of surface water, eroding mortar and causing them to topple. Additionally, extensive concrete cantilevered gravity walls constructed in the 1930's are located through out the study area. The large concrete retaining walls located just north of the Incline at the bend in Wilder Avenue near Warsaw and some of the Warsaw-Waldvogel Viaduct walls exhibit translational movement with little or no tilting. Both areas are the sites of deep base failure landslides. However, overall these walls seem to be in good shape with landslide masses occasionally topping the walls (e.g. Elberon Avenue). When replacing existing walls, the city must weigh the economics of

constructing the walls higher in active landslide areas versus long term maintenance costs associated with landslides topping the wall.

Historic Landsliding in Cincinnati

One hundred and sixty three years ago Locke (1838 p.208) gave this description of landsliding in Cincinnati:

“The hills and banks of streams become generally rounded in form, and are not broken except by slides, which in the wet season take place in portions of several rods (16.5 feet=1 rod) in extent, especially where the marl is predominant, and where the trees have been cut down and the roots which bound the soil together have become rotten. Occasionally these land slips carry a few trees along with them.”

The State Geologist, Edward Orton (1873, p423) proclaimed the colluvial slopes a “disadvantage” for what today he might have called infrastructure and housing, correctly predicting that the City of Cincinnati would have “increased outlay in foundations” with “frequent slides occurring along the steeper slopes”. Further, Orton states, that

“These shales have scarcely tenacity enough to hold their place in steep descents when acted on by water and by ice; still less when they have been removed from their original beds, can they be made to cohere; and they thus form treacherous foundations for buildings erected on them or for roadways constructed in them.”

Landsliding has been a problem in Cincinnati since the early to mid 1800's with deep (>5 feet in depth) landsliding probably going unrecognized. Beginning in the early 1900's landsliding was better documented as the city infrastructure expanded. Early descriptions and landslides give evidence to the long history and pattern of instability. Below are few of the better-known deep landslides that have occurred in the 1900's with a brief description:



Figure 2.7 Location map for historic landslides. Note that most of these large landslides were associated with construction projects that probably involved preconstruction engineering analysis. George Kessler map is courtesy of Cincinnati Historical Society.

- **Riverside-Harrison School, 1926-1930.** In 1926 an extensive base failure landslide was initiated west of downtown Cincinnati in the vicinity of the Riverside Harrison School by removal of the toe of the slope (Exon 1929, Von Schlichten 1935). Excavation along 1968 feet at the base of the slope with a 39-foot high cut in unconsolidated deposits led to movement extending 1509 feet upslope. Ground disturbance extended below the terraced cut face as the ground bulged 15 feet. The landslide encompassed a surface area of approximately 87 acres.
- **Columbia Parkway Road Construction, 1933.** A large landslide associated with road construction, note the height and lateral extent of the scarps in Figure A.6. The landslide extends downslope with the toe surfacing at the cut for the railroad tracks below the Parkway (Figure A.7). Photographs are labeled “Law Office”, probably from the City of Cincinnati.
- **Warsaw-Waldvogel Viaduct, Price Hill, 1950-present.** Deep base failure landslide resulting from the construction of the viaduct. The aerial size of the landslide is indicated by the 400-foot long tension crack that opened up 500 feet upslope from the lower ground disturbance (human). Inclinator data shows the landslide is still moving today. See photograph Figure F.4.
- **Cincinnati State (formerly Cincinnati Technical College), 1957.** Landslide associated with I-75 highway construction in 1957 cost \$425,000 to remediate (Durrell p77).
- **Clifton Avenue 1966-1972.** Landslide associated with the construction of an apartment building and adjoining parking lot near and below the lower bend in Clifton Avenue. Figure B.4 is an outstanding oblique aerial photograph of the well-developed Clifton landslide. The head scarp of this slide was 30 feet high and 180 feet long. Immediately east of the landslide is the site of the Bellevue Incline. The landslide was attributed to loading (from construction of the apartment building) of the “natural slope”. The right and left flank of the landslide is still visible today (from the Carew Tower, Figure F.22). A series of water main leaks recorded by an engineer for the City of Cincinnati from 1966-1970 is listed in Appendix F (Figure F.1). Ongoing repairs to infrastructure may often go unreported in monetary evaluation of long-term damages from landsliding.
- **Mt. Adams/I-471 Interchange, 1973-1980.** A structurally supported seven-foot vertical cut near the toe of the Mt. Adams hillslope (Fleming and others, 1981) initiated ground movement that led to remedial costs well exceeding \$22 million. One hundred and sixty large diameter piers (Figure F.24) tied backs into bedrock were utilized to stabilize the deep-seated movement.

- **Lawyers Pointe, Anderson Township, 1996.** A deep landslide occurred in glacial material in an upscale subdivision. The landslide damaged several homes, 500 feet of road, and utilities.

CHAPTER 3: LANDSLIDING AND HISTORY OF LOWER PRICE HILL

The following sections describe landsliding within eight subareas of the study site (Figure 3.1) starting from the southern end at Elberon Avenue and ending at Bald Knob.

GOODHUE ROCK QUARRY AREA (1)

The quarries identified in the study area probably operated from early 1800 to 1880 (excluding Bald Knob, Figure 3.2). Shale excavated from the rock quarries had limited use. Most of the quarry spoils was probably dumped over the ridge creating an oversteepened load on the colluvial wedge below the quarry operation. Nickles (1901-1906 p98) stated that the best fossil hunting could be done in the “dumps” from the quarry operations, referencing one of eleven quarries being “found on Price Hill near Elberon Avenue, and near Mt. Hope Road”.

A substantial well developed landslide complex exists below the Goodhue Quarry area (Figure 3.3). The surficial deposits at the southern end of the quarry are overly thick at the ridge crest and cantilevered pier and crib walls hold the upper hillside back. The retaining structures surround a substantial portion of the hillside at the southern end of Davenport Street, indicating that there is more fill uphill of the structure. Additionally, there are several subtle and subdued discontinuous vertical offsets ($<24'' \pm$) in the relatively flat plateau area upslope and roughly parallel to the main head scarp/crest of the hillslope that delineate more up slope fill and past minor ground movement. The Davenport Rock quarry ends just north of the residence at 562 Davenport in an abrupt 30-

STUDY AREA (BOLD)
PRICE HILL
SUB-AREAS LABELED 1-8
CORRESPOND TO TEXT

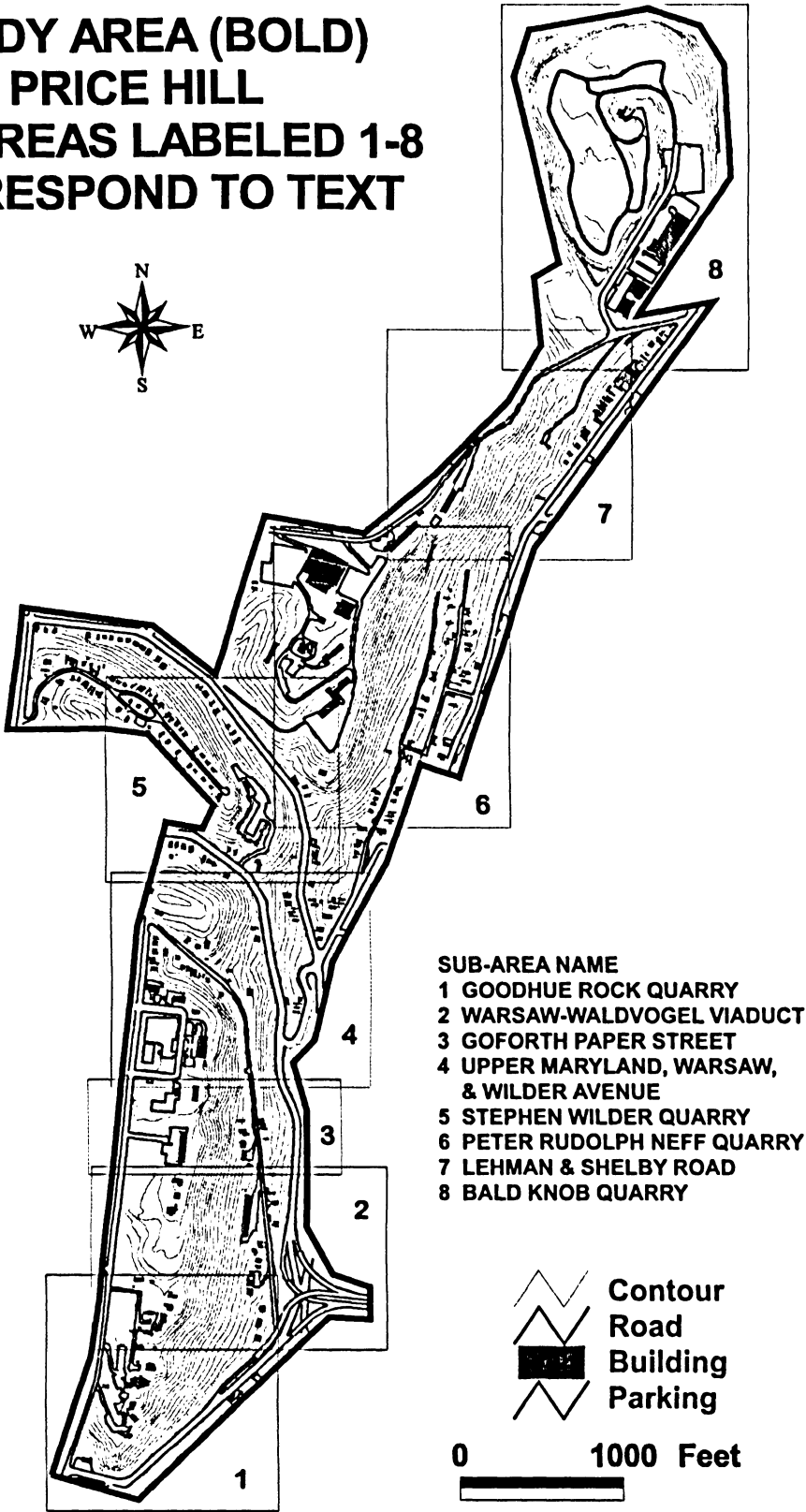


Figure 3.1 Sub-areas located within the study area of Lower Price Hill.

foot high vertical limestone and shale outcrop. Historical records (Figure E.2, 1869 Titus Map) indicate that two large tracts of ground (Figure 3.3) encompassing Davenport Street (at onetime called Goodhue Street) were owned by D. F. Goodhue and G. W. Goodhue. The Goodhue's occupations were listed as freestone, stoneyards, and real estate in the Williams Cincinnati Directory from 1867 to 1880 (Figure 3.4). The house (562 Davenport) furthest north and approximately 140 feet from the end of the quarry face dates to 1874. The Goodhue rock quarry appears to have been worked from 1867 to 1880, possibly having been worked earlier than 1867 by Goodhue or others. Some occupations of the Goodhue's prior to 1867 listed them as foundry (1860), stove and grate manufacturer (1855), and coal yard (1850-51). They may have used lime for fluxing in the production of iron ore. Significant quantities of coke (? by product of baking coal absent of O₂) and lesser quantities of slag are located on the hillslope below Davenport Street.

Early Williams Cincinnati Directory (1862, 1863) maps show a small street running east-west off of Maryland Avenue just above the Warsaw-Waldvogel Viaduct, up to Mt. Hope Road. It appears that this street would have crossed over the rock quarry and Davenport Street. There is no evidence of this street today. In addition, below the northern end of the Davenport rock quarry on the hillslope is evidence of a possible road terrace (running parallel to the contours) with a limestone wall on the uphill side. An early (1900's) photograph of this area was examined and showed the area at midslope possibly being worked for crops. This road and wall may have been constructed on a preexisting scarp and at the southern end grades into a scarp on a large well-developed slump.

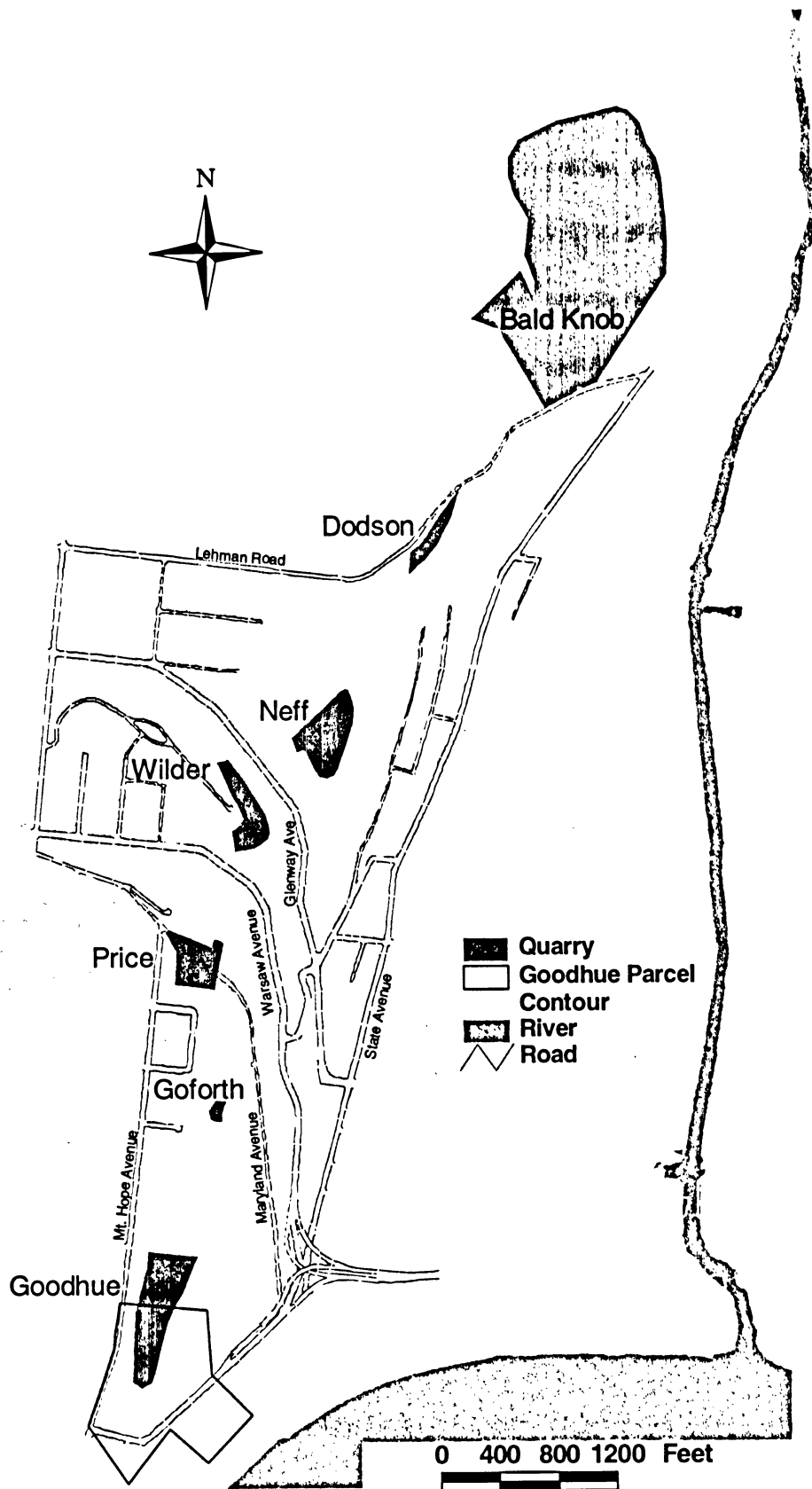


Figure 3.2 Rock quarries identified in the study area. Note that the combined Goodhue parcels front out onto the Ohio River.

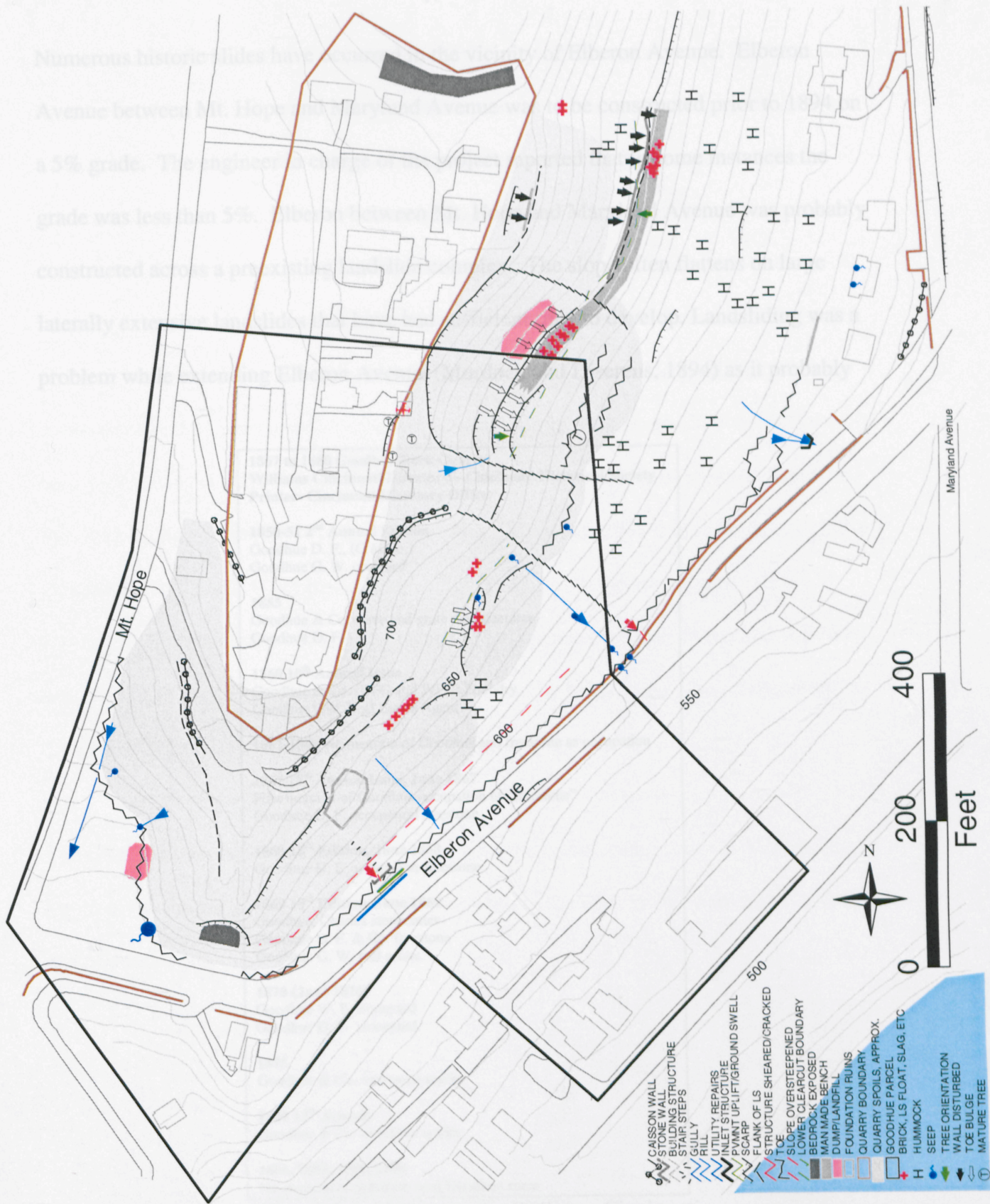


Figure 3.3 Engineering geology map of the Goodhue Quarry Area.

Numerous historic slides have occurred in the vicinity of Elberon Avenue. Elberon Avenue between Mt. Hope and Maryland Avenue was to be constructed prior to 1894 on a 5% grade. The engineer in charge of the project reported that in some instances the grade was less than 5%. Elberon between Mt. Hope and Maryland Avenue was probably constructed across a preexisting landslide complex. The slope often flattens on large laterally extensive landslides that have had sufficient time to develop. Landsliding was a problem while extending Elberon Avenue (Murdock and Diserens, 1894) as it probably

1867 to 1880 Goodhue Rock Quarry Williams Cincinnati Directory – Cincinnati Historical Society Printer- Cincinnati Directory Office 1850-51 2nd Annual Edition Goodhue D. F., (G & Co.) Goodhue G. W. coalyard 1855 Goodhue & Co. stove and grate manufacturer Goodhue D. F. 1860 10th Annual Issue Goodhue & Co. (DFG and WFG) Foundry Goodhue GW, Real Estate Agent 1861-1866 No mention of Goodhue and freestone as occupation 1867 17th Annual Issue, June 1867 First mention of Goodhue occupation of “freestone” Goodhue D. F. occupation freestone 1868 18th Edition, June 1868 Goodhue D. F. occupation-freestone 1869 19th Edition, June 1869 Goodhue, Charles stonecutter Goodhue D. F. & Co. freestone Goodhue G. W. real estate 1870 (June 1870) Goodhue W. F. stoneyard Goodhue D. F. stoneyard 1875 Goodhue & Co. free stone works 1880 13th Annual Goodhue & Co. freestone works 1881, 1882, 1885, 1890 No mention of freestone with Goodhue name

Figure 3.4 Listings in the Williams Cincinnati Directory for Goodhue.

was for most hillside roads. Construction of Elberon was started with a \$100,000 county bond but due to landsliding, another \$75,000 was needed to complete the road. In April-May of 1963 a landslide (Cinc. Enq 1963, Post Times-Star 1963) described as “an act of God” encompassed an area 300 feet parallel to Elberon Avenue and extended upslope 200+ feet to Davenport Avenue. Soil rose above the Elberon retaining wall at a rate of between 2-12 inches per hour. The landslide blocked three of four lanes of traffic and clean-up crews removed 400-500 cubic yards of debris per day. The landslide damaged a home at the end of Davenport located at 524-526 Davenport and engulfed the backyard of the residence at 530 Davenport. The Cincinnati Enquirer (1963) also reported that a 100-foot long section of Elberon Avenue was closed on October 1931 due to landsliding. The area immediately below the Kulla Viken Condominiums at the southern end of Davenport and southwest of the 1963 landslide has a limestone foundation and wall that was the site of another residential structure damaged by landsliding. No reference to this damaged structure could be found in the literature.

The City of Cincinnati has constructed numerous pier walls along Elberon Avenue to stabilize the roadway embankment. Elberon Avenue has been an expensive road to build and maintain.

Year	Costs	Wall Len.
1974	\$115,253	750'
1984	\$67,382	100'
1991	\$172,798	256'
1993	\$150,000	360'

Figure 3.5 City of Cincinnati Land-slide Correction Projects 1974-1993, (Pohana & Jamison, 1993).

WARSAW-WALDVOGEL VIADUCT AREA (2)

The area above the Warsaw-Waldvogel Viaduct is the site of a deep base failure slide and mirrors the Mt. Adams landslide that occurred on the opposite side of the valley (Figure 2.7). This landslide occurred in 1949 after the toe of the slope was cut for construction of the Warsaw-Waldvogel Viaduct. The retaining walls and associated footers rest on unconsolidated deposits and several walls failed by sliding and translating laterally outward with little or no tilting. Twenty-three months after construction was completed, an extension crack developed (at approximately the 690 foot elevation) running 400 feet parallel to the contour, 375 feet upslope from the viaduct walls. It should be noted that a scarp (showing vertical offset) was never described in the original engineering report (City of Cincinnati, 1953). A five-foot wide stone and mortar drainage ditch was constructed (1951) above the extension crack to keep surface water out of the landslide mass. The drainage ditch is partly covered today due to creep and/or landsliding (Figure D.9). A subdued discontinuous series of roughly arcuate scarps lie directly below the full length of the drainage ditch and have replaced the 1951 tension crack and represent ongoing ground movement. These scarps appear inactive, however the City has installed inclinometers at the base of the slope that still show movement of the landslide mass which exhibits multiple failure surfaces as deep as sixty feet below grade (Nutting, 1991 & 1996). It appears that the relatively slow movement of the landslide is just keeping ahead of the weathering process, resulting in the subdued scarps.

A five-foot diameter drainage tunnel was constructed in the 1950's under the uphill curb of lower Maryland Avenue to dewater the hillslope and extends for 200 feet along the

bedrock/colluvial interface. Originally the tunnel was not pumped, but since 1992, the City has been actively pumping the tunnel. The City has plans to construct a buttress embankment at the toe of the slope and the new bridge structure will be able to accommodate some lateral movement (Pohana, 2000).

The deep slide can be described as translational at the upper portion above Maryland Avenue and grades into a deep rotational movement. Today, the scarp below the drainage ditch can be described as subdued but well defined compared to the shear movement (toe of landslide) at the bottom of the slope that is best delineated by inclinometers. A general observation that can be applied to most of the study area is that landslide features near the top of the slope are often well or better defined than features at the bottom that are sometimes indistinct where surficial deposits are thicker. It appears that ground displacement at the top of slide does not correspond with toe morphology indicating internal deformation and consolidation of the slide mass or gross low amplitude bulging.

Small Residential Project & Associated Landslide on Maryland Avenue

Smaller landslide masses (secondary landslides) have occurred within the larger Warsaw-Waldvogel Viaduct landslide (host landslide). One of several examples (Figure 3.7) of a secondary landslide is located directly above the viaduct on Maryland Avenue where a small residential construction project caused a landslide that threatened the adjacent housing. A builder made a 12 foot vertical cut in the hillslope between two residential homes at 2325-2341 Maryland Avenue in 1979 leaving an approximate 100 foot wide

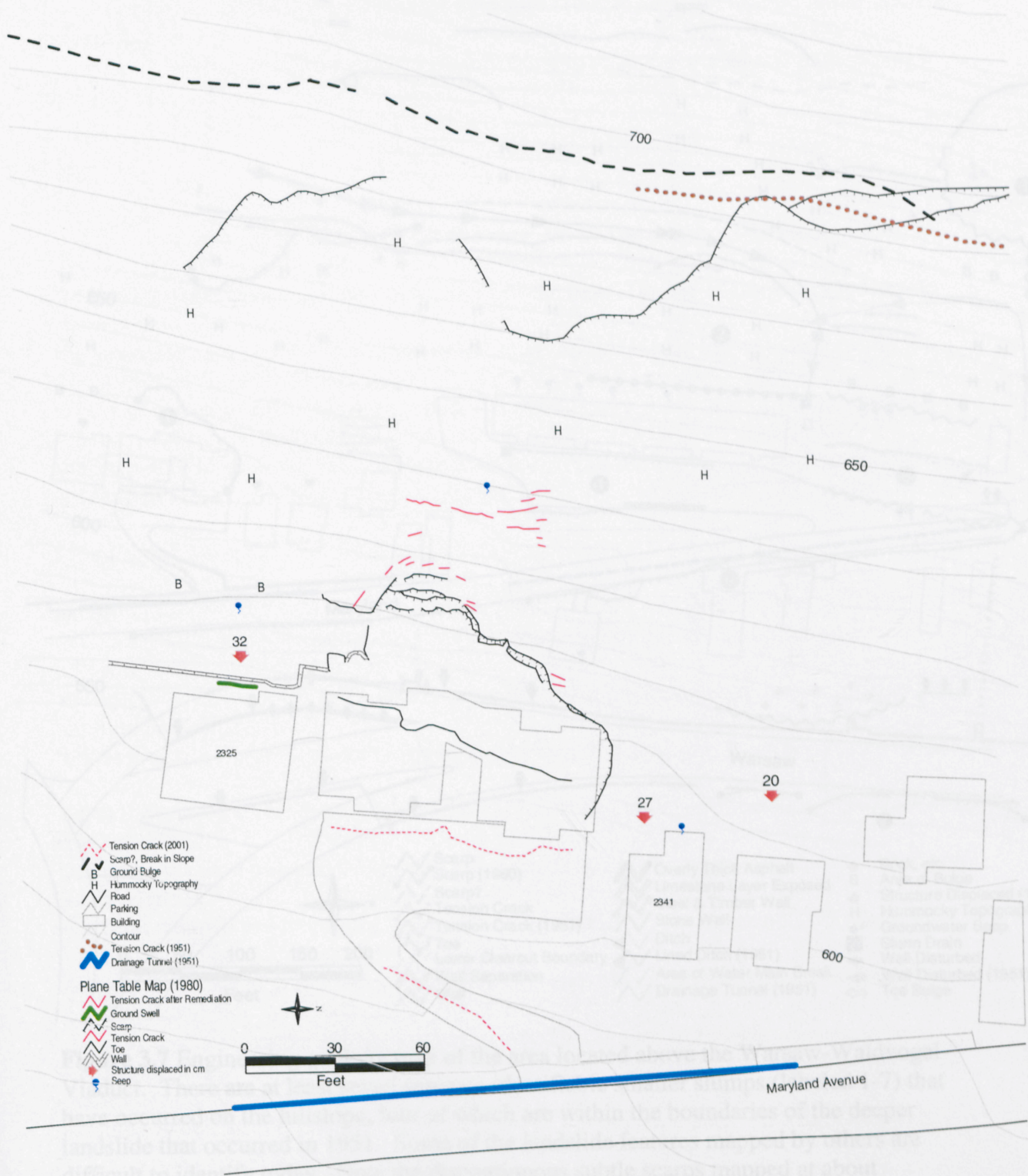


Figure 3.6 Plane table map of landslide features above Maryland Avenue mapped by Aytuna and Brian, 1980.

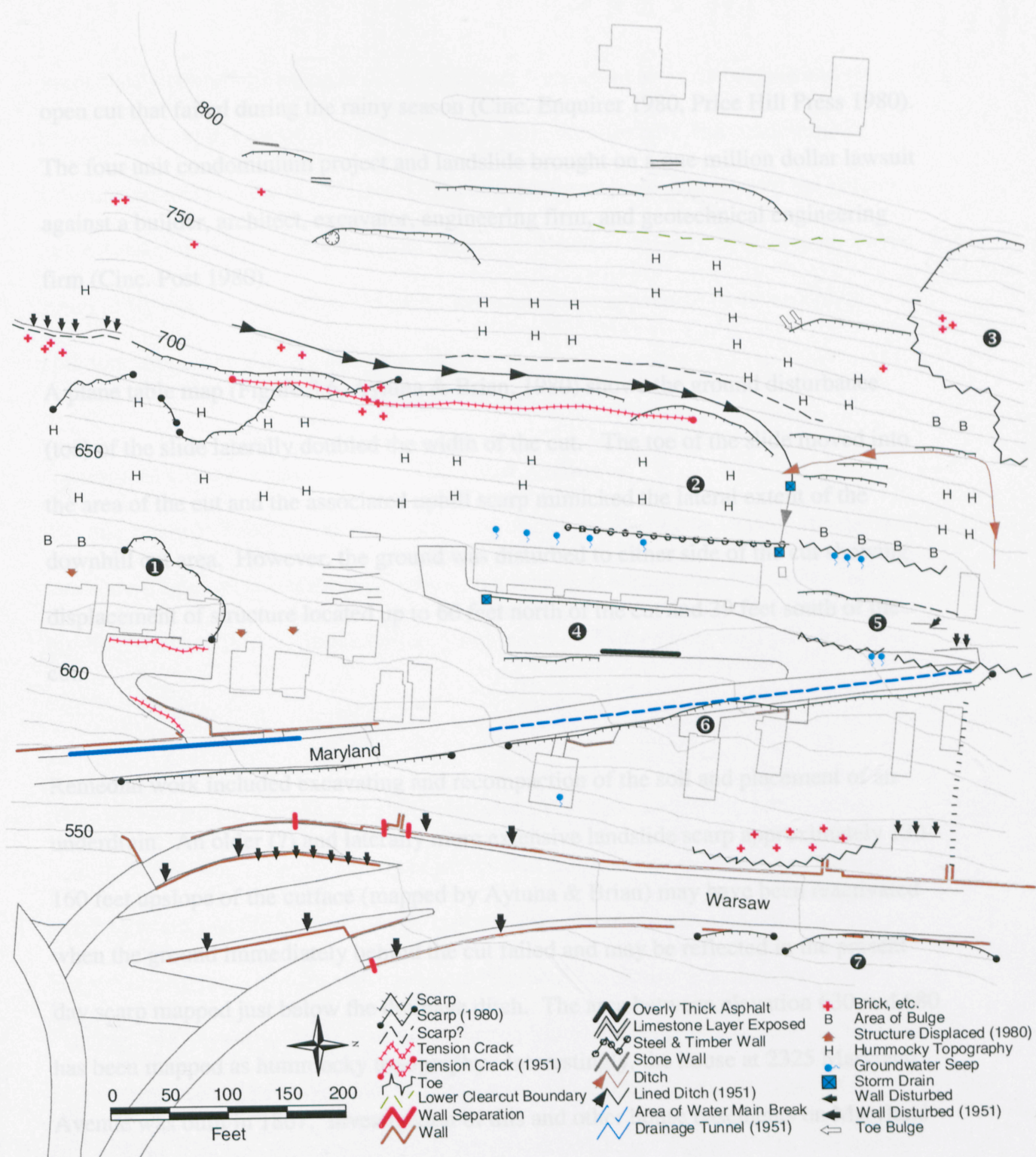


Figure 3.7 Engineering geology map of the area located above the Warsaw-Waldvogel Viaduct. There are at least seven separate identifiable smaller slumps (labeled 1-7) that have occurred on the hillslope, four of which are within the boundaries of the deeper landslide that occurred in 1951. Some of the landslide features mapped by others are difficult to identify today. Note the discontinuous subtle scarps mapped at about elevation 695 and close to the break in topography between the upper steeper positioned soils associated with the Fairview and the lower slope. Also see Figure F.3.

open cut that failed during the rainy season (Cinc. Enquirer 1980, Price Hill Press 1980). The four unit condominium project and landslide brought on a one million dollar lawsuit against a builder, architect, excavator, engineering firm, and geotechnical engineering firm (Cinc. Post 1980).

A plane table map (Figure 3.6, Aytuna & Brian, 1980) shows the ground disturbance (toe) of the slide laterally doubled the width of the cut. The toe of the slide moved into the area of the cut and the associated uphill scarp mimicked the lateral extent of the downhill cut area. However, the ground was disturbed to either side of the cut showing displacement of structure located up to 66 feet north of the cut and 39 feet south of the cut.

Remedial work included excavating and recompaction of the soil and placement of an underdrain. An older (?) and laterally more extensive landslide scarp approximately 130-160 feet upslope of the cutface (mapped by Aytuna & Brian) may have been reactivated when the ground immediately behind the cut failed and may be reflected in the present day scarp mapped just below the drainage ditch. The area between elevation 630 and 680 has been mapped as hummocky topography. Interestingly, the house at 2325 Maryland Avenue was built in 1867. Investigation of this and other house basements on Maryland Avenue appear to have rigid foundations (partial basements with what appears to be massive walls on the upslope side of the house).

Today the southern area of the former landslide is exhibiting accelerated creep (i.e.

immediately behind the house at 2325 Maryland Avenue the slope is bulging and pine trees planted exhibit curving trunks (Figure D.10)). Additionally, the condominium project concrete parking pad (Figure D.16) and driveway located in front of the project exhibits tension cracks that at this time can be attributed to differential settlement and/or creep of fill placed downhill of the excavated site. There appears to be no retaining structure supporting this embankment fill.

Apartment Complex above Lower Maryland Avenue

The apartment buildings located at 2361-2369 Maryland Avenue in 1984 experienced a landslide (Figure F.3) behind the complex that moved to within a foot of the rear of the building (Pohana, 1991). Remediation consisted of a 185-foot long steel pier wall with timber lagging.

The area immediately north of the pier wall and west of the swimming pool for the apartment building is bulging and was interpreted as a toe with an associated upslope subdued scarp. At the base of the toe, groundwater is seeping out immediately west of the swimming pool. On the eastern edge of the pool the ground has slumped and is bulging. Additionally, the asphalt pavement on Maryland Avenue has been uplifted just below pool area. The 1938 aerial photo shows a broad area cleared of trees and a topographic bench in the location of the apartment building. The origin of this benched topography is uncertain. The apartment building was constructed in 1967 (?) and exhibits no signs of distress. However, the western edge of the parking lot and steps in front of the building has separated and the eastern edge of the parking lot exhibits slump features

as the asphalt is several feet thick in places (Figure D.11).

GOFORTH PAPER STREET AREA (3)

In the middle to late 1800's, tracts of land associated with paper streets were subdivided for residential lots. A remnant bench that represents Goforth (Paper) Street is located above the housing at 2393-2425 Maryland Avenue. An examination of the plat clearly shows that the area was to be developed for residential housing (Figure E.2).

Goforth Street and the associated residential lots were platted in the middle to late 1800's. The three houses on Maryland Avenue below Goforth date 1880, 1885, and 1885. Assuming the street terrace was completely constructed (maps from various time periods support this) and gauging from the platted parcel associated with the street, 84% of the street bench has become indistinct due to soil creep and/or landsliding. The southern end of Goforth has been overridden by a moderate sized slump that extends to the top of the slope. The remaining preserved street terrace ground surface grades back into the hillside, reflective of slumping, with an associated subtle toe just behind the existing residential housing. The wood frame house below Goforth at 2421 Maryland Avenue is in duress due to ground movement. The exterior front wall of the house is bowed out and the interior door casings are out of plumb.

There is an extensive buttressed limestone wall (Figure F.10), supporting the housing terrace and Goforth Street that is bulging outward on the western side of Maryland

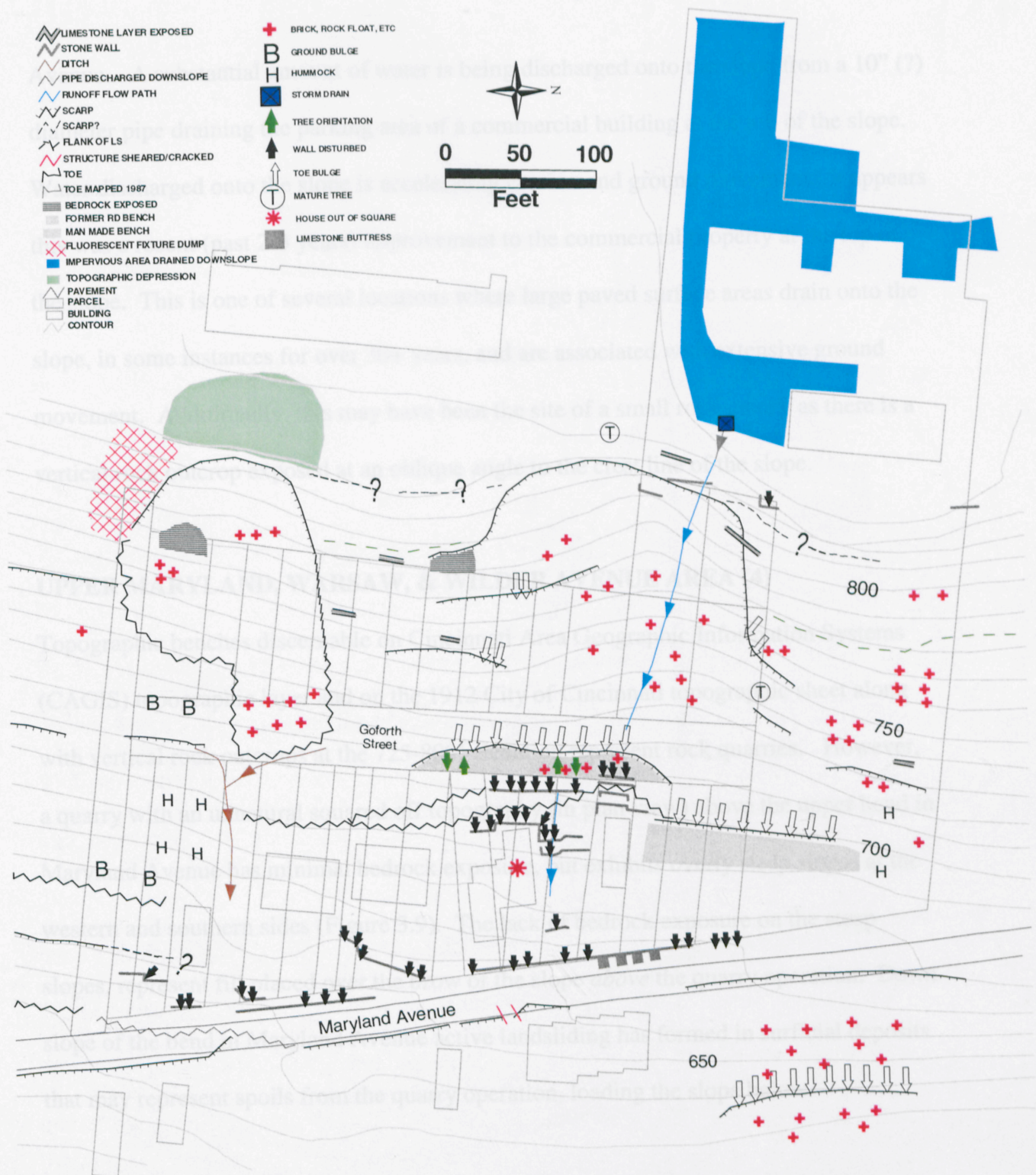


Figure 3.8 Engineering geology map of Goforth Subdivision. Goforth Street and underutilized residential lots above Maryland Avenue. Note that the large commercial parking pad (shown in blue) culvert empties onto the hillslope. This is also the probable site of a small rock quarry in the scalloped northwest quadrant of the Goforth parcels. Additional evidence for the rock quarry includes a rock outcrop exposed at an oblique angle to the crest (trends north-south) of the hillslope.

Avenue. A substantial amount of water is being discharged onto the slope from a 10" (?) diameter pipe draining the parking area of a commercial building at the top of the slope. Water discharged onto the slope is accelerating erosion and ground movement. It appears this was a recent (past 2-3 years) improvement to the commercial property at the top of the slope. This is one of several locations where large paved surface areas drain onto the slope, in some instances for over 30+ years, and are associated with extensive ground movement. Additionally, this may have been the site of a small rock quarry as there is a vertical rock outcrop exposed at an oblique angle to the crest line of the slope.

UPPER MARYLAND, WARSAW, & WILDER AVENUE AREA (4)

Topographic benches discernable on Cincinnati Area Geographic Information Systems (CAGIS) topographic layer and on the 1912 City of Cincinnati topographic sheet along with vertical rock outcrops at the 725-800' elevation represent rock quarries. However, a quarry with an unnatural squared off topography (in plan view) above the upper bend in Maryland Avenue has minimal bedrock exposure, but exhibits overly steep slopes at the western and southern sides (Figure 3.9). The lack of bedrock exposure on the steep slopes, represent fill placed over the brow of the slope *above* the quarry operation. Down slope of the bend in Maryland Avenue active landsliding has formed in surficial deposits that may represent spoils from the quarry operation, loading the slope below.

The natural drainage pattern has been buried/obscured by the construction of Maryland Avenue and Warsaw Avenue. On Maryland Avenue, the buried preexisting creek that flowed along the bedrock surface now forms a sub-roadway conduit for groundwater that



Figure 3.9 Engineering geology map of Maryland, Warsaw, & Wilder Avenue Area.

exits below the outer curve of the roadway. A seep (Figure D.17) that flows year round and has been flowing at least since 1937 (verbal communication with local resident) is located just below the bend in Maryland Avenue. Directly below this, on Wilder Avenue and in line with the buried (by humans) drainage are large gravity walls that show seepage at the foot of the wall and effervescence staining due to seepage. The deep landslide roughly encompasses the area of Wilder Avenue, extending to the west to Warsaw Avenue and probably past Glenway Avenue to the east. This landslide is probably associated with the cut and fill work for Wilder Avenue and the extensive excavation made below on Glenway Avenue (Figure F.7 & F.8) in the early 1900's.

The upper portion of Maryland Avenue past the incline abutments has been closed to vehicular traffic due to slope movement that occurred in 1987 (Pohana, 1991). The preexisting landslide caused the water main break, which further damaged the eastern downhill side of Maryland Avenue. The eastern side of Maryland Avenue asphalt is overly thick (>18 inches) indicating long-term patching and movement of the hillside below Maryland Avenue. A scarp cuts through and defines the eastern edge of Maryland Avenue. The surficial deposits below Maryland Avenue are predominantly fill, with the toe of the slide just above the wall on Warsaw Avenue. This landslide is contiguous with the landslide mapped immediately north of and just below the upper bend in Maryland Avenue.

STEPHEN WILDER QUARRY AREA (5)

Another quarry is located on the former Wilder parcel between Glenway and Warsaw Avenue (Figure 3.10). The Wilder Quarry just east of Ring Place is now the location of the West View Condominium complex at 2500 Warsaw Avenue (Figure F.12) which was constructed in 1969 and converted to condominiums in the early 1980's.

The 1912 City of Cincinnati topographic sheet shows a thin bench parallel to and below the northern end of Ring Place. There is a vertical rock outcrop at the western boundary of the condominium complex representing the last working face of the quarry. A significant slump is located at the eastern end of the condominium complex. The landslide is in and being driven by fill from quarry spoils and subsequent dumping by contractors and past maintenance personnel. The eastern boundary of the parking lot is supported with a cantilevered pier wall installed in 1982 when the apartment complex converted to condominiums. The ground has slumped a minimum of 8+ feet in front of the wall since 1982, allowing the granular back fill to move between the piers (no lagging present), resulting in localized failures in the asphalt driveway. Pier walls (with or without lagging) typically define the uphill extent of slope failure within the study area.

The City of Cincinnati has installed approximately a nine hundred foot pier retaining wall on the upslope side of Glenway Avenue essentially encircling the majority of the area encompassing the quarry.

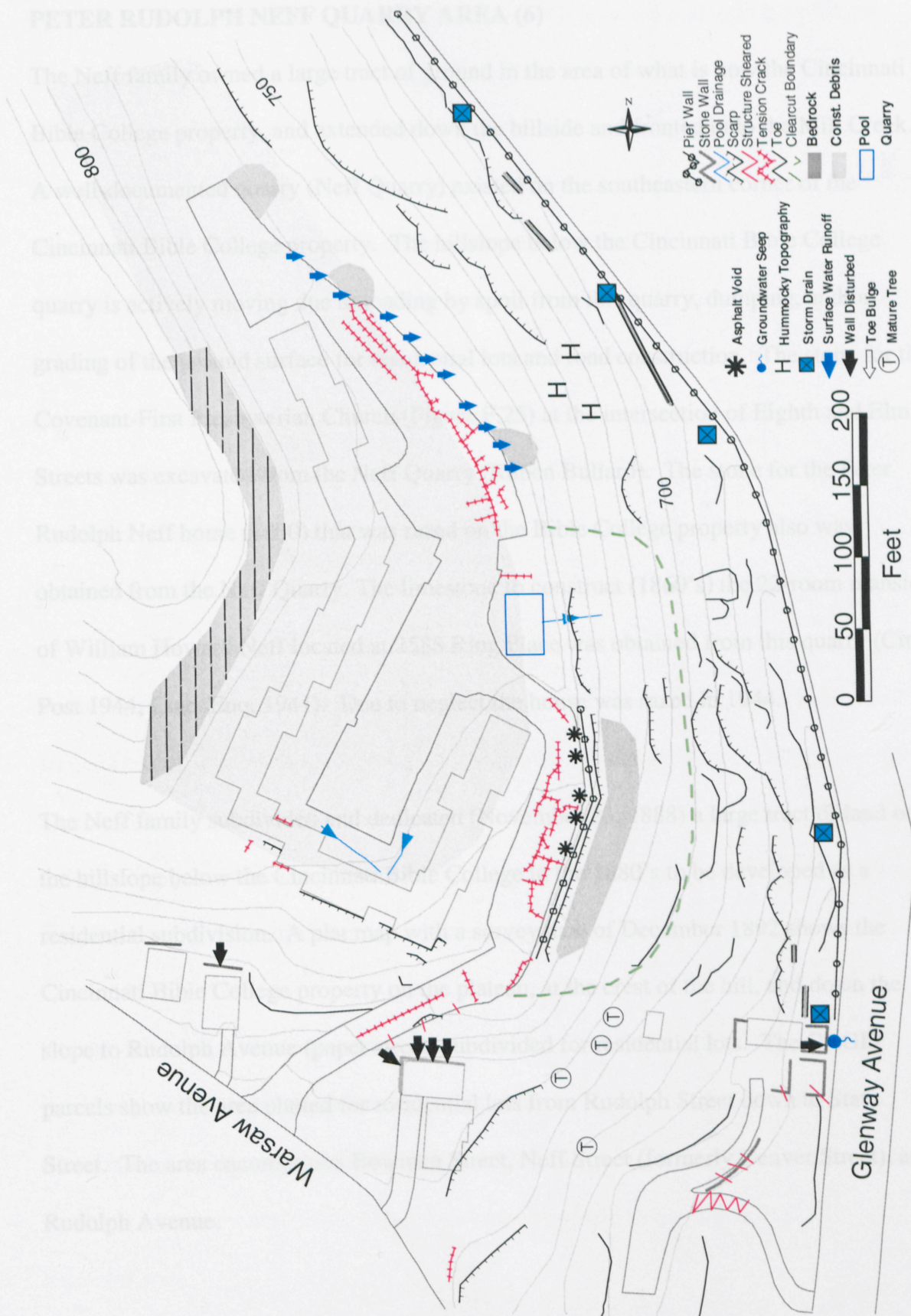


Figure 3.10 Engineering geology map of the Stephen Wilder Quarry Area.

PETER RUDOLPH NEFF QUARRY AREA (6)

The Neff family owned a large tract of ground in the area of what is now the Cincinnati Bible College property, and extended down the hillside and fronted onto the Mill Creek. A well-documented quarry (Neff Quarry) existed on the southeastern corner of the Cincinnati Bible College property. The hillslope below the Cincinnati Bible College quarry is actively moving due to loading by spoil from this quarry, dumping, and/or grading of the ground surface for residential lots and road construction. The stone for the Covenant-First Presbyterian Church (Figure F.25) at the intersection of Eighth and Elm Streets was excavated from the Neff Quarry (Ruben Bullard). The stone for the Peter Rudolph Neff home (1860) that was razed on the Bible College property also was obtained from the Neff Quarry. The limestone to construct (1860's) the 22-room mansion of William Howard Neff located at 2588 Ring Place was obtained from this quarry (Cinc. Post 1944, Cinc. Enq. 1941). Due to neglect the house was razed in 1944.

The Neff family subdivided and dedicated (November 23, 1888) a large tract of land on the hillslope below the Cincinnati Bible College in the 1880's to be developed as a residential subdivision. A plat map with a survey date of December 1892 shows the Cincinnati Bible College property on the plateau, at the crest of the hill, and down the slope to Rudolph Avenue (paper street) subdivided for residential lots. The CAGIS parcels show the area platted for residential lots from Rudolph Street down to State Street. The area encompasses Bowman Street, Neff Street (formerly Denver Street), and Rudolph Avenue.

Lower Price Hill suffers from urban blight, however it is worth noting that within the platted Neff subdivision between Rudolph and State Street there are 154 platted residential lots with only 32 lots being utilized for housing, leaving 89% of the land unimproved (Figure 3.13). There is only one house (abandoned) located uphill of Neff Street within the subdivision. The remaining homes are located between Bowman and Neff Street. Prior to the subdivision the area was the site of a Civil War hospital and officers quarters and the Neff family is purported to have had a cottage in the same vicinity. At least one house below Neff Street is in distress due to ground movement (Figure D.8). The wood frame house at 1412 Neff Street uphill (western) limestone foundation is bulging several feet along with the associated wall on either side of the house. The wall exhibits a history of repairs and the house is out of square.

Rudolph Avenue shows up on several maps dating from the 1800's (Figure E.2, 5, 6, 7, 8, 10, & 11). However, today Rudolph Avenue is indistinct for most of its length, except for a well-defined level topographic bench of approximately 10,000 square feet (Figure 3.11 & 3.12). The parcel tract associated with Rudolph Avenue encompasses 66,000 square feet; thus, approximately 85% of street has become indistinct due to ground movement.

Above the Rudolph Avenue is a topographic bench (10-15 feet wide) at elevation 730 feet that extends laterally and parallel to the contours for six hundred feet (Figure 3.12). Although no conclusive evidence (in the field or historic maps) could be found, this is probably a human made bench. The bench is starting to exhibit slump like characteristics.



Figure 3.11 Engineering geology map, Neff Quarry Area below the Bible College.

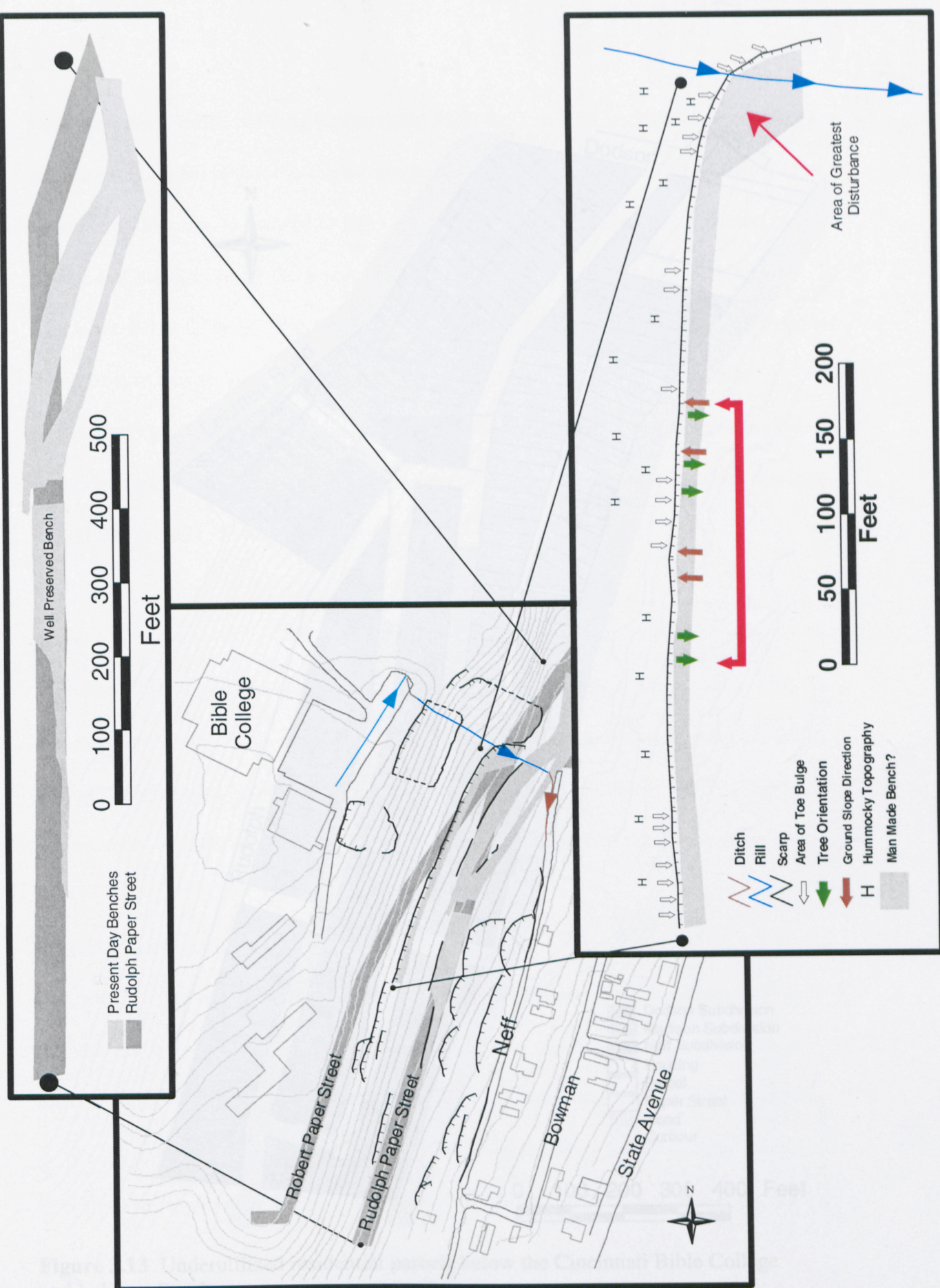


Figure 3.12 Engineering geology of the Neff Subdivision showing “paper streets”.

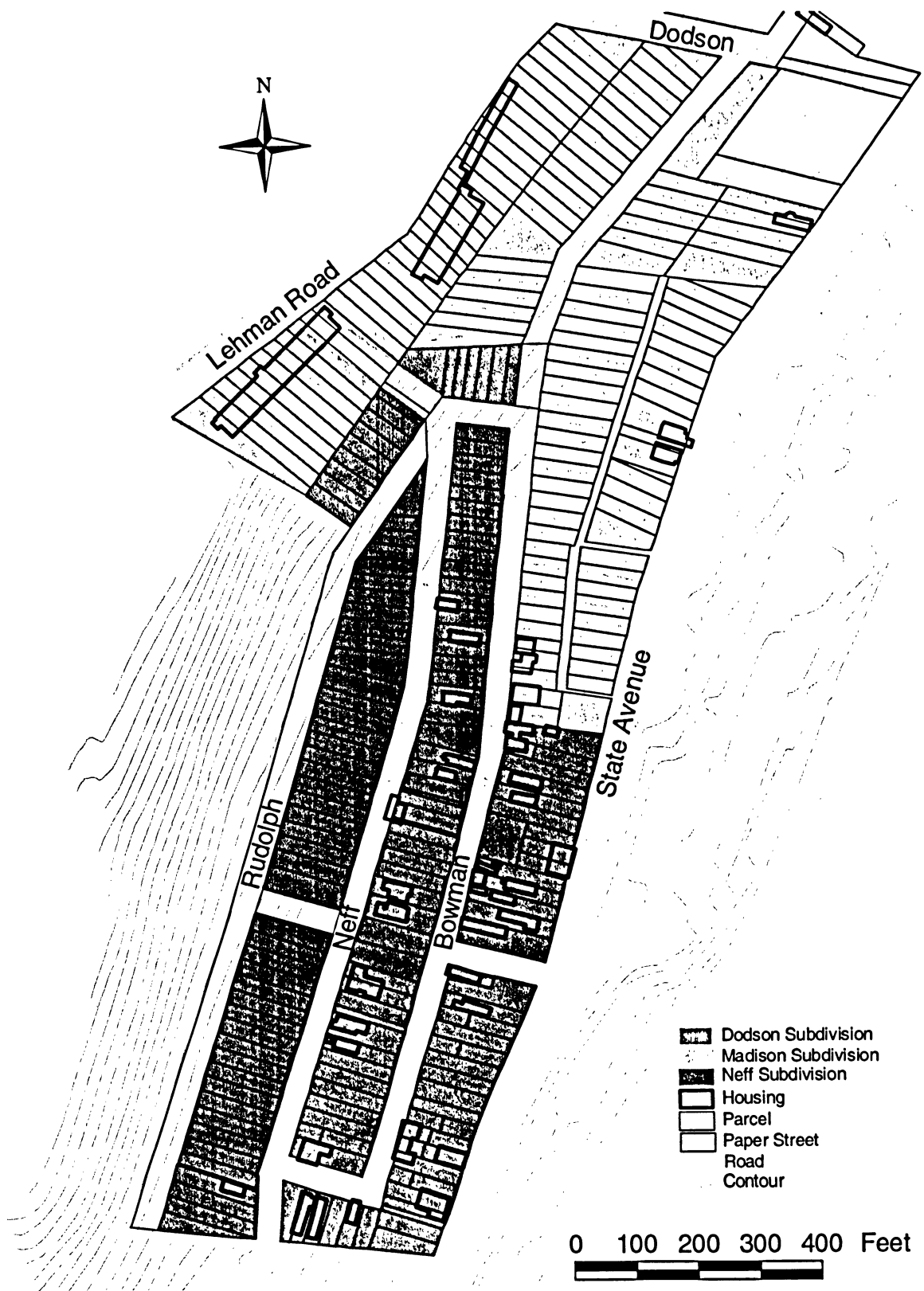


Figure 3.13 Underutilized residential parcels below the Cincinnati Bible College and Lehman Road.

Just below the Crouch building (constructed 1966-68?) on the Cincinnati Bible College property is a landslide that has the morphology of an earth flow. The foundation for the Crouch building was excavated in 1965 and uncontrolled fill was probably placed over the crest of the hillside for the asphalt roadway that runs along the eastern edge of the Cincinnati Bible College. The area surrounding the Crouch Building forms a topographic pervious area that collects surface water around the perimeter and the associated groundwater probably flows out towards the free face of the slope where fill was placed. Remediation consists of a steel pier and timber retaining wall that was installed at a cost of \$80,000 in 1994 (Kidd, 2000).

At the northern end of the Neff Subdivision, a substantial amount of water comes down the hillside causing one homeowner to dig a ditch to redirect the surface water. This rill was traced upslope to the top of the hill to where a large portion of the Cincinnati Bible College parking area is drained by a concrete culvert onto the hillside. A deep landslide whose lower boundaries could not be clearly defined has formed below the drain.

LEHMAN & SHELBY ROAD AREA (7)

The northern end of the study area below Lehman Road and extending down to State Street exhibits landsliding associated with an area that was extensively graded for residential lots and roadways in the late 1800's. The subdivision for the Estate of Wm. B. Dodson was platted December 31, 1875 and the residential lots are clearly visible on CAGIS at the location of the apartment buildings at 2691 & 2701 Lehman Road and on the hillslope below and to the north (Figure 3.13).

Landsliding is prevalent below Lehman Road and the aforementioned apartment building complex constructed in 1960's (Figure 3.14). The apartment building is in the former location of a quarry. On the eastern edge of the parking lot for the lower apartment building is an older cantilevered pier wall. The wall defines the uphill extent of ground movement, as evidenced by the rough exposed surface (poured without forms) of the cantilever piers (Figure D.12). The head scarp shows a minimum vertical offset of five feet. Part way down the slope below the pier wall, an eight-inch diameter concrete culvert empties onto the slope and drains the parking area for the upslope apartment complex. The ground exhibits classic stair step topography with morphological features of both multiple toes and/or scarps. The landslide is extending laterally across the slope as evidenced by fresh scarps at the southern boundary. At the southern end above the active scarp, the landslide is progressing upslope, as evidenced by an arcuate low relief scarp due to removal of lateral support. The toe of another landslide mass truncates the northern edge of the stair step slump. There is evidence (clay and siltation) of an ephemeral sag pond impounded by (Figure D.15) what has been interpreted as a series of scarps that also exhibits bulging due to removal of lateral support. The lower boundary of this slide is poorly defined. Below the ephemeral sag pond, several small discontinuous bulges were interpreted as toes and are subtle slide features.

The plat record shows that Shelby Road at one time ran across the midslope scarp set in the vicinity of the ephemeral sag pond and connected to Bowman Avenue. A resident who grew up in the neighborhood in the early 1960's and who frequented this area stated that a two-track road connected Shelby to Bowman and that he did not recall the stair step

topographic feature as it exists today. This oral communication and the proximity of the drain located at the top of the landslide, suggests the bulk of the slump is attributable the development of the apartment building. This ground may very well have exhibited slide topography prior to the apartment building being constructed. Additionally, the area is platted for residential lots and there is evidence of a street (Dodson) that ran uphill (east-west) just north and downhill of the apartment building. The 1912 City of Cincinnati topographic sheet shows a level bench area where the apartment building is now located and was the site of a small rock quarry and/or a bench created to rest horses. There is also abundant rock float on the hillside probably from quarry activity or the bedrock cut necessary for the construction of Lehman Road.

Between Lehman Road and Shelby Road is a large active slump (Figure 3.15). The head scarp is parallel to and located on the downhill side of Lehman Road. The head scarp has resulted in repeated patching and overly thick asphalt on the eastern downhill third of Lehman Road. Surface water on the road sheets over the curb, at the downslope area of greatest disturbance. Further, fill was placed over the downhill side of Lehman Road during the Union Terminal project (Figure F.16), loading the hillslope above Shelby Road. The toe of this slide is not well defined, however an examination of Shelby Road (gravel road) and comparison with the platted parcel associated with it shows the ground to be bulging in this area (Figure 3.15). Shelby Road is clearly encroaching on the downhill residential parcels due to bulging of the hillside.



Figure 3.14 Engineering geology map of Lehman and Shelby Road Area.

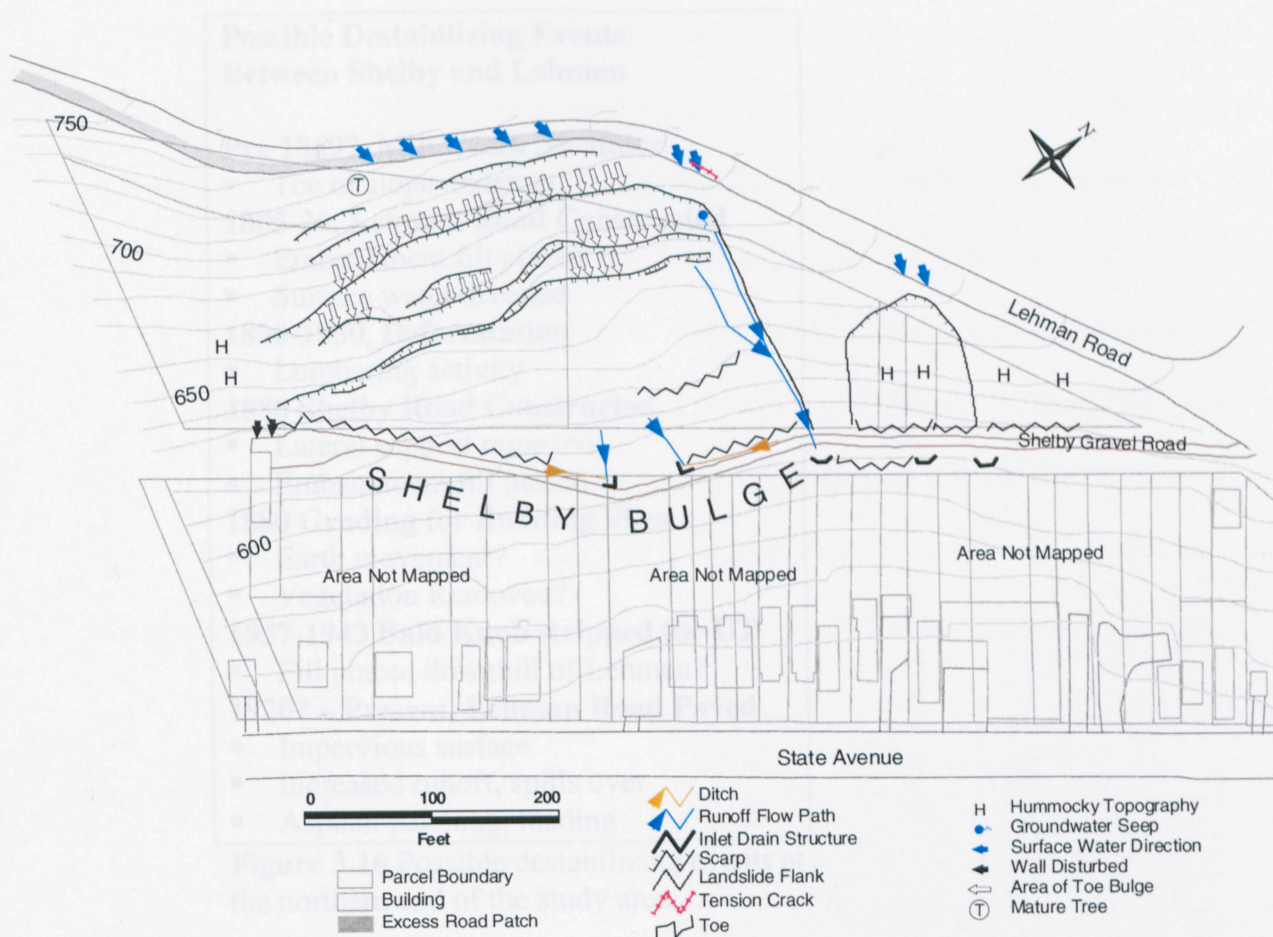


Figure 3.15 Engineering geology map of the Shelby Road Bulge below Lehman Road.

Bald Knob at the northern end of the study area was quarried as a source for engineered fill for the Union Terminal Project (1929-1933) located in an area at that time called Lincoln Park. Quarry activity on Bald Knob involved blasting (Railway Age, 1931). Lastly, a meander bend of the Mill Creek that has been infilled (Figure E.3) cut into the toe of the slope below the Shelby Road bulge and may represent a non-human landslide cause. The area below Shelby and State Avenue was not mapped but if deep landsliding has occurred in this area, it may be difficult to ascertain by a field investigation alone.

**Possible Destabilizing Events
Between Shelby and Lehman**

Pre 1869?, Mill Creek Meander

- Toe of slope undercut

1805-20, Lehman Road Constructed

- Embankment fill placed
- Surface water diverted

1800-1850, Deforestation

- Lumbering activity

1880 Shelby Road Constructed

- Lateral support removed
- Embankment fill placed

1880 Grading for Building Sites

- Earth movement?
- Vegetation Removed?

1937-1943 Bald Knob stripped for UT

- Fill placed downhill of Lehman?

1920? – Present, Lehman Road Paved

- Impervious surface
- Increased runoff, spills over
- Asphalt patching, loading

Figure 3.16 Possible destabilizing events at the northern end of the study area.

BALD KNOB QUARRY AREA (8)

Bald Knob at the northern end of the study area was quarried as a source for engineered fill for the Union Terminal Project (1929-1933) located in an area at that time called Lincoln Park. Quarry activity on Bald Knob involved blasting (Railway Age, 1931). Excavation at Bald Knob encompassed the removal of over 4 million cubic yards of bedrock, with explosives placed twenty feet on center, parallel to and twenty feet back from the working quarry face. A typical charge was 1200 pounds made up of 30% gelatin in 4.5-inch sticks. Shale was excavated to raise the railroad terminal and tracks above the floodplain. Landsliding appears to have been common (Figure A.5) as the fill was dumped by railroad cars (Figure A.4) and later hydro-compacted (Figure E.20). Six

million cubic yards of fill was placed in the Mill Creek Valley covering 240 acres to an average depth of sixteen feet (Railway Age, 1931). The Union Terminal Project required minimal excavation work in the valley. An aerial photograph from 1938 shows that Bald Knob was extensively quarried for limestone and shale. Later (1980's) the excavated notch just south of Bald Knob was filled in with up to 16 feet of uncontrolled fill from sedimentation removed from the channelized Mill Creek (Bullard). Additionally, Bald Knob was probably quarried prior to the Union Terminal Project. The 1912 City of Cincinnati topographic sheet strongly indicates quarry activity in the vicinity of Bald Knob. Figure F.18 is a photo of Bald Knob at the start of the Union Terminal project.

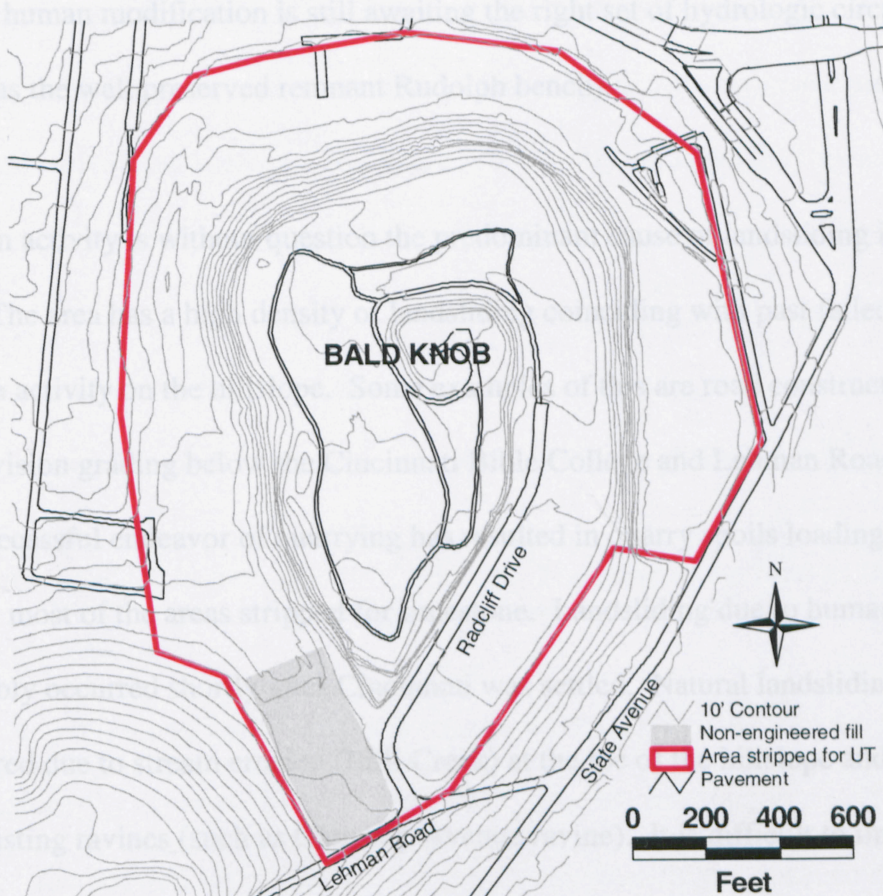


Figure 3.17 Bald Knob Area. Red outline depicts approximate area stripped for the Union Terminal Project from 1929-1933. Gray shaded area was infilled with uncontrolled fill in the 1980's. The Kope-Fairview contact is well exposed in this area.

CHAPTER 4: CONCLUSIONS & RECOMMENDATIONS

Conclusions

Landsliding from the layman's perspective has been "viewed as a randomly distributed phenomenon" (Jones p. 138, 1992) and in some instances attributed to an "act of god". Within the study area, landsliding is strongly correlated with man's disturbance of the underlying geologically weak unconsolidated deposits. In a relatively short time span (200 years) humans have reshaped the hillslope, disturbing the natural geologic processes that have shaped the hillslope over thousands of years. In some instances landsliding has occurred for some time (e.g. 150+ years), while in other instances incipient slope failure due to human modification is still awaiting the right set of hydrologic circumstances (such as the well preserved remnant Rudolph bench).

Human activity is without question the predominant cause of landsliding in the study area. The area has a high density of landsliding coinciding with past failed or abandoned human activity on the hillslope. Some examples of this are road construction and subdivision grading below the Cincinnati Bible College and Lehman Road. In contrast, the successful endeavor of quarrying has resulted in quarry spoils loading the hillslope below most of the areas stripped for limestone. Landsliding due to human activity probably occurred shortly after Cincinnati was settled. Natural landsliding may have occurred due to stream erosion (Mill Creek) at the toe of the hillslope and due to along preexisting ravines (such as Glenway Avenue ravine). It is difficult to imagine that any natural process since the last glacial episode would have had such a broad effect on the hillside equilibrium as human activity. However, the change in grade above and below

elevation 700 (approximately) and the concavity of the hillslope may be evidence for broad creep and consolidation of the soil that is still be going on today. Nutting (1996) reports deep creep near the bedrock interface on the order of 0.1” to 0.2” per year.

Often multiple human events associated with landsliding have occurred from different portions of the slope (lower-mid-upper) and led to a convoluted and overlapping history of instability. It is evident from the field map that most of the hillslope in the study area has failed.

Surface water redirected and concentrated onto the hillslope via roads, buried drainage channels, discharge pipes, broken water lines, and overcapacity sewer mains, usually correspond with landsliding. Humans have not only reshaped the topography but also drastically altered the surface and subsurface hydrology.

Recommendations & Future Studies

Recommendations that have arisen as a result of this study include:

- Consultants involved in civil engineering/geology projects should appreciate and investigate the human history of the area. The current plat records should be examined along with older plat records and maps to assess prior activity and changes to the hillslope.
- Engineering analysis should be conservative taking into account the past gross failure of the hillslope, in many instances all the way to the crest of the slope. The vast majority of the study hillslope has failed, possibly resulting in a well-developed failure surface. Landsliding is occurring irrespective of slope (i.e. largest landslides are now located where the slope flattens) and often failure is above the associated Kope soils extending into the associated soils of the Fairview. Additionally, the hillslope should be closely examined for compound landslides, its effect on the subsurface hydrology, and hence the stability of the slope.

- Surface water drainage (e.g. paved parking areas, etc.) onto the hillslope that does not conform to current building code needs to be redirected into storm drains. In some instances groundwater (invert of former creek drainage at valley constriction, specifically below the bend in upper Maryland Avenue) should be intercepted and diverted into storm drains. Storm drains that traverse the hillslope need to be upgraded to be able to handle peak storm flows.
- More rigorous oversight from beginning to end of small and large hillslope (already defined as EQD areas) residential/commercial construction projects, perhaps requiring a sign off by a geotechnical firm at the start and finish of project. A geologist should be included in the initial and ongoing site investigation.
- An untapped deterrent to minimizing damages from landsliding can be achieved by educating the public and professionals (engineers, real estate agents, contractors, etc.) on the landslide issues inherent to Cincinnati. Awareness of landsliding should result in avoidance of building on landslide prone areas or at the very least lead to a more informed decision regarding hillslope development.
- Consideration should be given to alternate low impact uses of the hillslope. Alternate uses might include a city owned green belt or perhaps a small park system (at one time a park system (Figure 2.7) was proposed for most of the hillside areas). Wildlife on the hillside is abundant, as this has become a natural corridor for animal migration.
- Inclometers should be installed to define the lower boundary of gross ground movement across and below the lower slope. Future studies should measure the bulging-vertical upheaval below/at the lower slope that inclinometers may fail to pick up by surveying a network of stakes and/or tiltmeters periodically over a 5-10 year period in deep landslide prone areas.
- The driving mechanism (loading, cut, etc.) and the location (lower-mid-upper slope) of landslide initiation should be closely investigated to better understand the dynamics of the hillside and coalescing landslide masses. A study of the “natural” soil consolidation, creep, and formation of colluvium on the hillslope should be undertaken to better understand deep landsliding in Cincinnati.
- Delineating areas of high probability of landsliding on the hillslope can create broad hazard maps for geologist to concentrate their field investigations on. Such areas can be identified on the hillslope prior to a field investigation and can aid or supplement relative stability mapping (see Plate III). These areas can be delineated by examining the separation of topographic lines or flattening of slope, unimproved platted residential sized parcels, linear parcels that probably define paper/past streets, past buried natural drainage paths, development activity above the crest of the hillslope, and probable quarry/spoil locations.
- Human activity initiated landsliding that will continue to be a problem for some time to come. Thus, public awareness campaigns and city budgeting for landslide

remediation will always be necessary to address landslide problems. Further, it may be impractical to curtail human activity on the hillslope. Ironically, the latest modification to the hillslope witnessed in May of 2001 was the use of a four wheel All Terrain Vehicle (ATV) below the Cincinnati Bible College. This ATV was following paths of least resistance namely along landslide scarps, which were being rounded, further obscuring the landform. The ATV formed new paths that have become rutted, funneling abnormal amounts of surface water downhill.

- Because of the slow movement and onset of landsliding an opportunity exists to study landsliding in different stages of development and weathering. Evolution of landsliding could be classified into different stages (i.e. young vs. mature) of development, and related to destabilizing factors which may date the landslide. Although several landslides occurred in 1800's one slide may be young and another mature allowing elimination of variables and study of groundwater/surfacewater role in landsliding. Additionally all data has been preserved on a CD-ROM for future investigations of the degradation of landsliding and human created morphology.
- Economic studies of landsliding should take into account the damage to housing and losses associated with early land purchase (devalued). Because of the slow rate of damage and the unrecognized ubiquitous nature of landsliding in Cincinnati, residential damage early on went unreported. Often, the homeowner can not keep up with the repairs and the property is abandoned. Fleming and Johnson (1994) counted numerous vacant lots with building foundations west of Cincinnati along Hillside Avenue presumably damaged by landsliding.

Closing Remarks

The U. S. Geological Survey Open-File Report 00-450 (Spiker and Gori, 2000) addresses a national ten-year strategy for mitigating and substantially reducing losses associated with landsliding. The strategy involves "mapping and assessments of landslide hazards nationwide" and "envision[s] a society that is fully aware of landslide hazards and routinely takes action to reduce both the risk and costs associated with those hazards".

Locally the strategy should entail three initiatives, first being the education of the public and professionals (Olshansky & Rogers, 1992), second, the comprehensive mapping of landslide prone areas and third the establishment of a public landslide database.

In 1989, the City of Cincinnati responded to minimize the possibility of repeating past mistakes by hiring a geotechnical unit, which included an engineering geologist and geotechnical engineer. The proactive education of the public and in some instances professionals can go a long way to curtailing landsliding. Anderson Township Board of Trustees (1999) has recommended just such action and printed a preliminary overview of the problem for the public entitled “Buying/Building on Anderson Hillsides”.

Although Orton (1873) recognized the problem early on, the geotechnical community has taken a long time to acknowledge the spatial and temporal distribution of landsliding in Cincinnati. However, public awareness of landsliding seems to be confined to the mudslides along Columbia Parkway that often make the “news” during the rainy season. The shallow mudslides are more of a nuisance to city maintenance crews than the deeper long-term destructive landsliding that is infrequently reported by the media. The slow rate of movement typical of landsliding in Cincinnati and human’s repeated modification of the hillslope has led to obscure landforms that consequently go unrecognized. In historic landslide prone areas such as lower Maryland Avenue, the community seems to be “unaware” of the problem. The public should be made aware of problem areas via dissemination of landslide information through seminars, real estate inspections & property disclosure forms (completed by the seller), and a public database.

No one group should take on the burden of educating the public, but it will take a concerted effort of several groups and disciplines working together. An assertive campaign should be undertaken to heighten the awareness of landsliding in Cincinnati. A logical starting point for a broad audience would be the local real estate community and

the residential home builder's trade group. Continuing education courses for real estate professionals on environmental issues make no mention of landsliding, although monetary damages and remediation from landsliding probably far exceeds all of the combined "traditional" environmental problems addressed in a real estate transaction.

The State of Ohio Real Estate disclosure form that is mandatory in most real estate transactions does not sufficiently address the landsliding problem in Cincinnati. The form should be modified to reflect the local geology. Further, purchasers of real estate in landslide prone areas would be prudent to make a geologic report (Potter, 1996) a contingency of the sale; much like a whole house inspection is requested in most transactions today. The geologic investigation should not be limited to the immediate parcel under consideration but should be expanded to adjoining parcels and suspect terrain. In California, a site investigation by a geologist is mandatory for real estate transactions in certain designated geological hazard areas. Geologists need to be relied upon more frequently for field investigations and should be involved in the initial and ongoing site investigation. Further, landslide damages can often be caused by "mismanagement of slope drainage and stability both during and after construction" (Alexander 1989). Often times, especially on smaller residential projects, ongoing site visits and follow up at completion of the project is minimal to nonexistent.

Landsliding in Cincinnati and the extent of instability is difficult to ascertain unless a geologist performs a thorough investigation. Almost every site investigation within the City of Cincinnati limits will have a history of human activity. Because of this, geologic

mapping in an urban setting can be problematic in the interpretation of landforms. A geologist is best equipped to interpret human made and influenced landforms. Geologic mapping of landslide prone areas needs to be carried out systematically by geologist walking broad areas, as there is no shortcut for an accurate database to be established. These investigations take much time, but as the landslide database grows the process will be expedited somewhat. The need for a geological input however, will not be diminished as site conditions can change even in well-mapped landslide prone areas.

The final product of the geologist's landslide mapping efforts should be an interpretive map accessible to the public and a more detailed map available to professionals. A landslide Internet database should be maintained and made available to the public at a nominal/free cost. A quasi-public system is already in place to store landslide data and location information (Cincinnati Area Geographic Information Systems).

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APPENDIX A: HILLSLOPE DESTABILIZATION

Hillslope destabilization for this study leading to landsliding can be broken down into internal and external factors (Figure A.1). External factors (those impacting the colluvial wedge) can be further divided into human and non-human events that lead to hillslope failure. An example of a human event would be a construction cut made at the bottom of the hillslope, thus removing lateral support of the upslope soil and hence a landslide. A non-human example would be stream erosion cutting into the toe of the hillslope, also effectively removing lateral support, leading to the formation of a landslide. Internal factors include the inherent strength of the soil to support a load. Some soils are more suitable for foundations than others, such as sand and gravel which would serve in general as a better foundation base than clay.

A destabilizing event combined with precipitation and a corresponding rise in the water table can trigger a landslide. However, a landslide trigger may be a misnomer within the context of this study. Trigger implies an instantaneous response, and in Cincinnati, it is more appropriate to refer to a “trigger” as a destabilizing factor. Failure of a human-modified slope is often temporally dependent on precipitation and a subsequent threshold rise in the piezometric surface. Thus, if anything should be called a trigger in Cincinnati, it would be precipitation. Landsliding and quasi-stability within the study area can span many years. In some instances modification to the natural hillslope grade may directly coincide (e.g. several days to several months) with slope movement, while other human-made modifications to the hillslope are poised to fail (e.g. fill placed for an unsupported parking pad ten years ago or an earthen berm constructed 130 years ago) under a yet to be

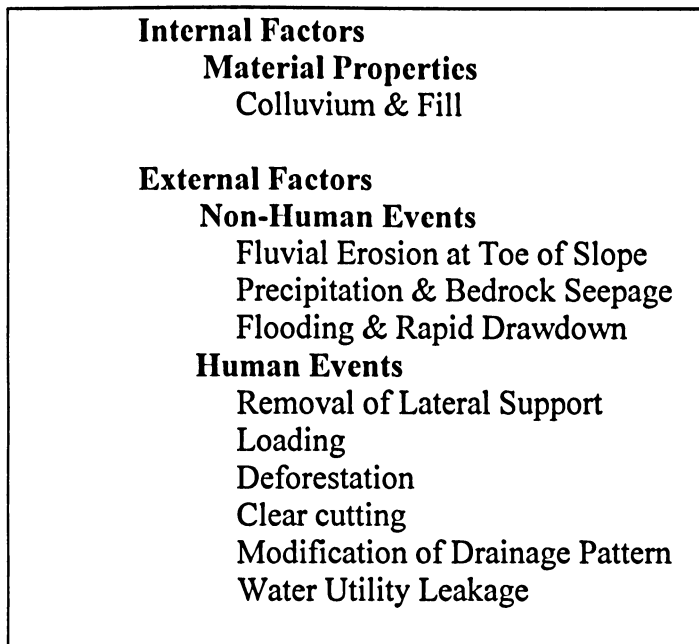


Figure A.1 Hillslope destabilizing factors that may lead to landsliding within the study area.

established critical hydrologic regime. An example of quasi-stability is an earthen embankment initially acting as a small catchment for surface water, gradually over time forming a larger and larger catchment as slumping continues and develops into a landslide with shear surfaces.

The field investigation focused on identifying human events (i.e. loading, toe removal, redirection of surface water discharge, etc.) associated with hillslope destabilization.

This study was based on historical and empirical data, which sometimes may be a partial analysis of the problem. Due to multiple human events that may be closely spaced in time and occurring in the same area, it is sometimes difficult to associate landsliding with a single destabilizing event within the study area without doing a stability analysis. Other studies (Shurman & Slosson, 1992) especially those involving litigation involve a team

approach to the problem and include the expertise of an engineering geologist (focus of this study), a geotechnical engineer (material testing for strength and stability), and a groundwater hydrologist (water budget). However, some events leading to landsliding (e.g. quarry spoils loading the hillslope and extensive vertical cuts left open during the rainy season) can be predicted based on past landslide records and empirical observations.

Internal Factors: Description & Properties of Colluvium

Colluvium is the primary natural surficial deposit underlying the *study area* (based on an overview of available boring logs and field observations). Thus, this section is limited to a discussion on colluvium. However, the colluvial wedge lies on top of and interfingers with glacial and alluvial soils that may be inherently weak or weaker than the colluvium and this is an area that needs further study.

Colluvium, derived from the physical and chemical weathering of the flat-lying Ordovician limestone and shale, drapes the Mill Creek Valley sides in the vicinity of downtown Cincinnati. Colluvium consists of a stony silty clay with up to 20% limestone clasts (Fleming and Johnson 1994, Lerch et al 1982). The colluvium is subject to downslope movement and was identified as a poor foundation material by a geologist as early as 1873 (Orton p.423).

The predominant *in situ* materials within the study area are colluvial soils derived principally from the underlying Kope formation and to a lesser extent from the Fairview formation. The Kope formation is up to 230 feet thick (Ford, 1965) with a shale to

limestone ratio of 5:1. The Kope formation is overlain by the Fairview formation, which is up to 135 feet thick with a shale to limestone ratio of 3:1. Bassarab and Huff (1969) report that the clay mineralogy of the Kope and Fairview consist predominately of illite with some mixed illite-montmorillonite (representative samples 67-87%) and to a lesser extent chlorite and vermiculite (representative sample 13-33%). A study completed for the Union Terminal project (Railway Age, 1933) reports the Bald Knob (Kope) shale as being able to absorb 24% water and swelling 32% in volume.

When a landslide occurs in colluvium, shear surfaces develop and soil strength values reach a residual value along the failure surface that is less than the peak strength value found in undisturbed colluvium. Existing areas of past landsliding essentially become more susceptible to ongoing movement than colluvium that has not failed given similar environmental conditions.

Internal Factors: Description of Fill

Non-engineered fill is prevalent throughout the study area. Fill consists of quarry spoils (i.e. discarded shale), colluvium (primarily from road cut and fill), refuse material from moderate sized landfills (wood, metal, etc.) to small scale (yard waste) dumping, construction rubbish, concrete debris, slag, coke, brick, fluorescent light fixtures, glass, asphalt (overly thick pavement due to patching), gravel, and clay. The largest volume of fill is probably derived from quarry spoils (perhaps more than 35% of the upper hillslope has been loaded with spoils), road/housing cut and fill, and dumping (slag, construction debris, etc.) in that order respectively.

Slaking is when shale disintegrates and crumbles when saturated with water and exposed to air (Jackson, 1997). Potter (1996, p.89) reports that the Kope shale is friable and slakes readily upon wetting. Quarry spoils (excavated shale) loading the study area hillslope would be subject to slaking and then would behave mechanically similar to colluvium which is derived from the weathering of the bedrock over time. The State of Kentucky Method 64-513 measures the durability and resistance to weathering of shale. Thelen & Associates (1992a & 1992b) reported the average slake durability (State of Kentucky Method 64-513) of the Kope shale at 37 and 51 (Figure A.2). Values less than 50 typically behave more like soil, than shale (rock); values from 51-95 are classified as intermediate shale, with values greater than 95 classified as rock. It should be noted that some samples were taken from shale already subjected to weathering (i.e. described as slightly weathered gray, to brown/olive-brown in color).

SLAKE DURABILITY TEST					
Glenway Avenue					
Boring	Depth	Description	% Water	Durability	Description of Fragments After Test
3	5.1-5.2	Gray	3.7	53.8	Slightly rounded intact pieces, trace fragments
3	6.5-6.7	Gray	7.4	10.5	Fragments and slivers.
3	10.5-10.6	Gray	3.3	79.9	Intact pieces, trace fragments.
3	14.5-14.7	Gray	2.6	63.9	Rounded intact pieces, trace fragments and slivers.
Elberon Avenue					
1	3.2-3.4	Gray slight weath.	7.9	33.6	Frag. and slivers, some slightly rounded pieces.
1	5.7-5.9	" " "	6.9	48.1	Fragments, some rounded intact pieces.
1	10.5-10.7	Gray	4.4	61.7	Intact slightly rounded pieces, some frag. & slivers.
1	12.2-12.4	Gray	5.0	63.0	Fragments, some rounded intact pieces, trace slivers.
6	2.5-3.3	Gray-trc olive brn	11.4	20.1	Rounded piece (1), trace fragments.
8	2.5-3.0	Gray-trace brown	9.1	10.5	Fragments and slivers.
12	2.5-3.5	Olive brn, brn+gry	12.7	20.4	Rounded pieces (3), trace fragments.

Figure A.2 Modified and extracted from Thelen & Associates (1992).

External Factors: Non-Human Events

Non-human external factors leading to landsliding can include fluvial undercutting at the toe of the slope, rapid drawdown, groundwater seepage along limestone solution channels (bedrock seepage), and excessive precipitation.

Fluvial Erosion at the Toe of the Slope

Erosion by a meander loop of the Mill Creek cut into the toe of the hillslope in the northern end of the study area. This meander was eliminated between 1907 and 1912, when the Mill Creek was straightened for canal navigation (Figure E.3). Landsliding in this area may predate any human influence on the hillslope. Another large meander loop migrating in an easterly direction at the southern end near the Ohio River confluence was eliminated in the 1800's, further straightening the Mill Creek (Figure E.6 & E.14).

Additionally the southern end of the study area below Elberon (between Mt. Hope and Maryland Avenue) is on the cut bank side of the Ohio River (Figure E.8).

Precipitation, Bedrock Seepage, Flooding & Rapid Drawdown

The correlation between precipitation and landsliding is well documented in the literature. Fleming and Johnson (1994) reported "abrupt movement episodes" in deep landslides associated with excessive precipitation. Olson (1988) found a correlation with deep slope movement in Cincinnati and 3 year average rainfall records. Thin, colluvial, rapid earth flows are a common occurrence along Columbia Parkway during prolonged periods of heavy precipitation.

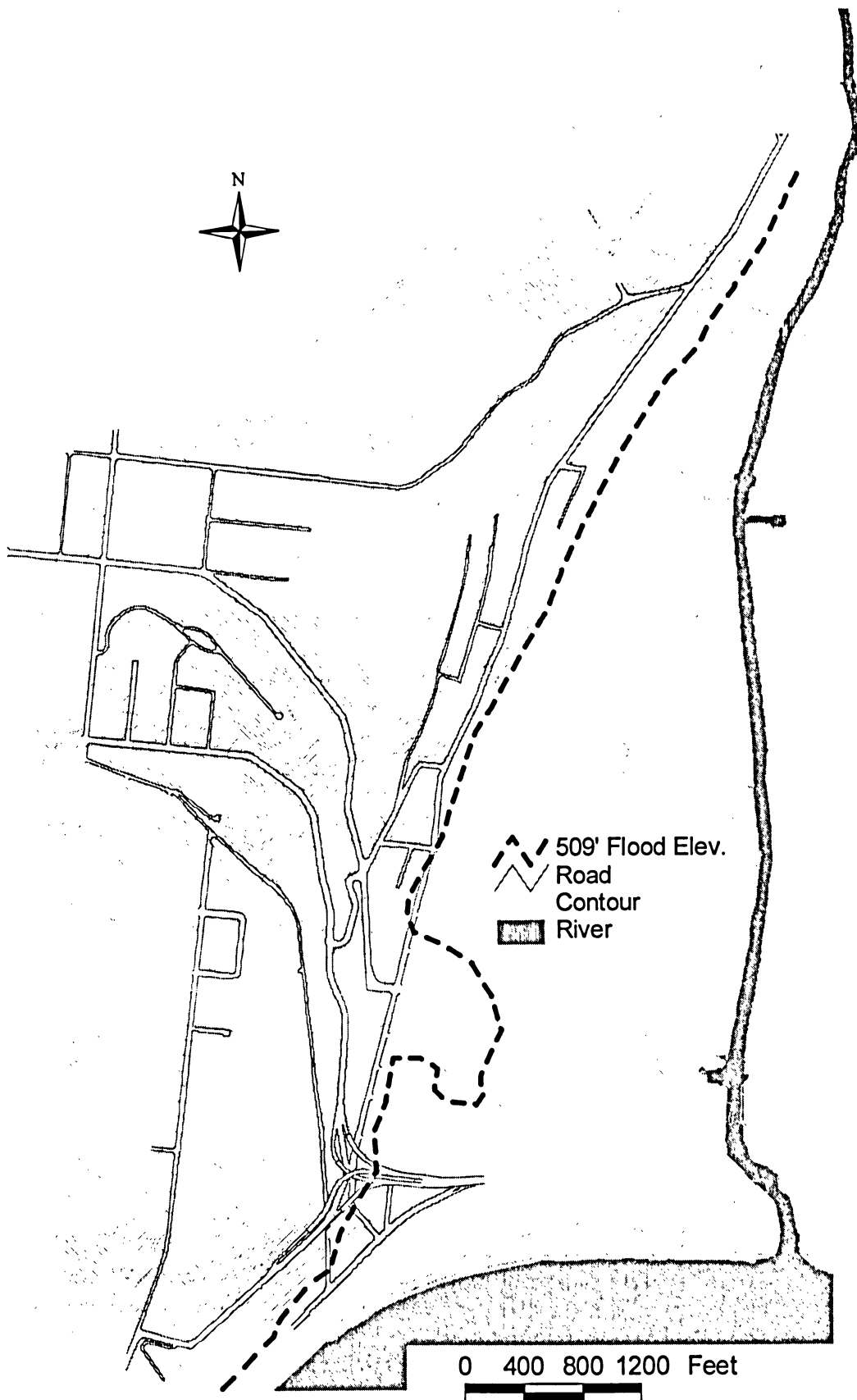


Figure A.3 1937 Flood saturated the toe of the hillslope reaching elevation 509.

Durrell (Spieker & Durrell, 1961) reports that bedrock seepage occurs along bedding planes and joints with domestic wells drilled in the Upper Ordovician typically running dry during the summer months. Baum (1994) modeling ground water flow in a thin colluvial slide west of Cincinnati in Delhi noted that bedrock seepage played a minor role at the onset of failure.

Saturation at the base of the hillslope from flooding with a subsequent rapid drawdown leading to elevated pore water pressure and subsequent loss in soil strength may lead to slope failure. Springer et al. (1985) attributed large-scale slumps along the Ohio River to rapid drawdown following flooding. The Mill Creek Valley has been subject to repeated flooding prior to the flood protection measures taken in 1948. A significant flood occurred along the Mill Creek Valley in 1937 during which floodwater reached an elevation of 509 feet (Figure A.3). Flood level records prior to 1773 are not recorded. Floodwaters prior to 1773 probably exceeded the 509-foot elevation level.

External Factors: Human Events

Human events leading to destabilization of the hillslope includes; loading of the hillslope, removal of lateral support, deforestation and clear cutting, modification of the natural hydrology, and water utility leakage.

Loading & Removal of Lateral Support

Excavation of the Kope and Fairview from Bald Knob and infilling of the lower Mill Creek Valley (Figure A.4) with the excavated shale and limestone was associated with

landsliding (Figure A.5) for temporary embankment fill in the 1930's. Cut and fill activity associated with transportation routes (Figure A.6 & A.7) and placement of fill at the crest of the slope have led to numerous slope failures. The City of Cincinnati (Pohana et al, 1993) attributed the bulk of the city's landslide remediation projects to pre-1940 roadways with improper embankment construction. Historical landsliding probably dates too shortly after roadway construction. In Cincinnati, Baum (1983) and

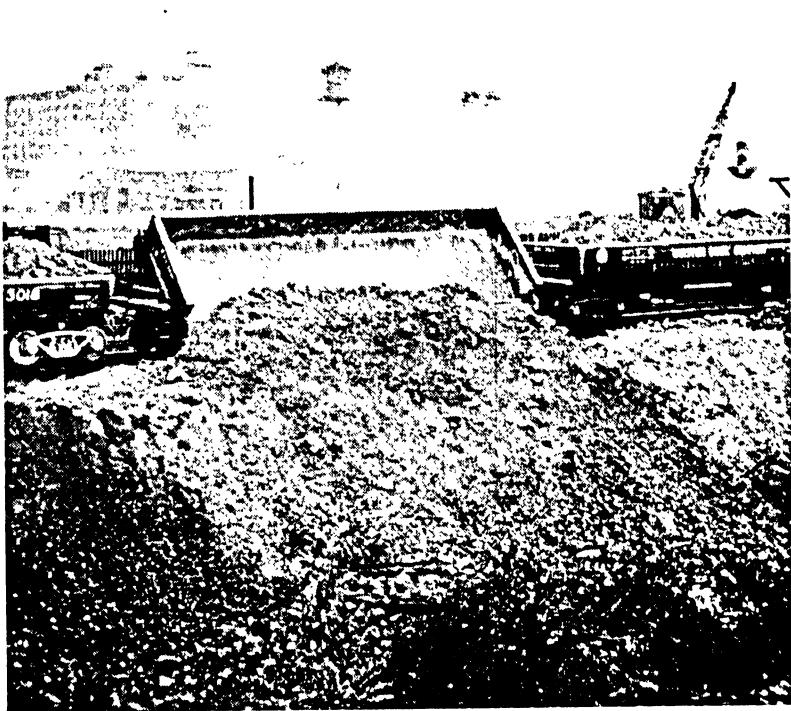


Figure A.4 Mill Creek Valley being infilled with shale and limestone stripped from Bald Knob. This soil would be very similar to quarry spoils from the 1800's with the exception that more limestone float would be present. Photograph from the George Stowitts collection (1929-1933).

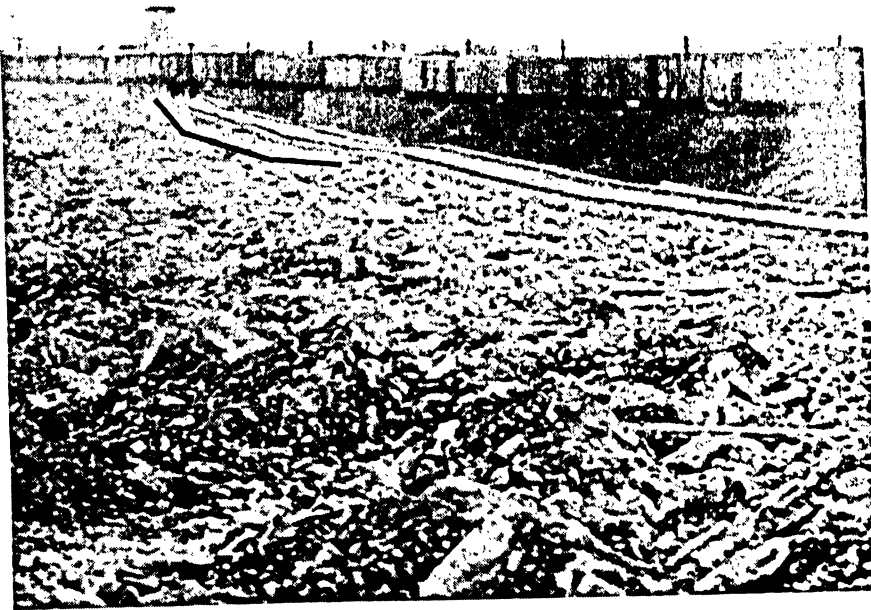


Figure A.5 Bald Knob fill dominates this photograph. Note the railroad tracks are disrupted in the area outlined due to embankment failure. Photograph from the George Stowitts collection (1929-1933).

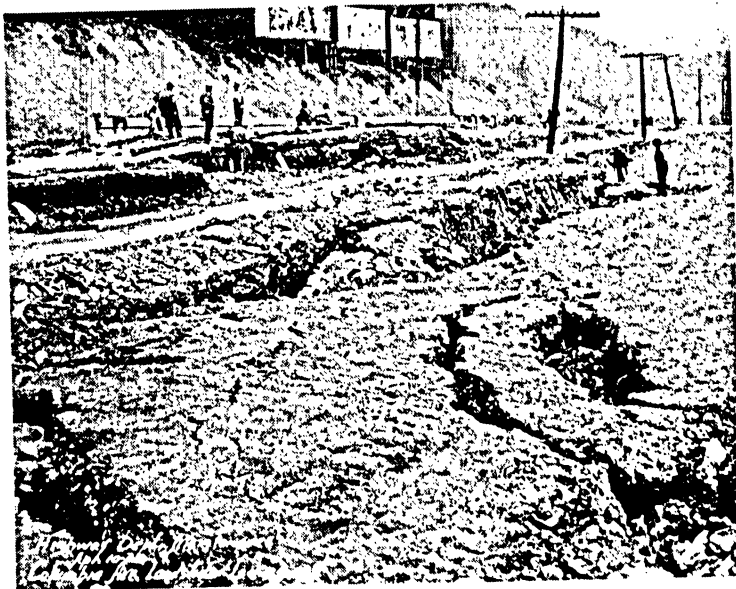


Figure A.6 Columbia Avenue in 1930 being widened and soon will be called Columbia Parkway. Note the height and lateral extent of the landslide scarp running longitudinal to the roadway. This is probably one of the deep landslide areas identified by Olson (1988). Photograph courtesy of the University of Cincinnati Library.

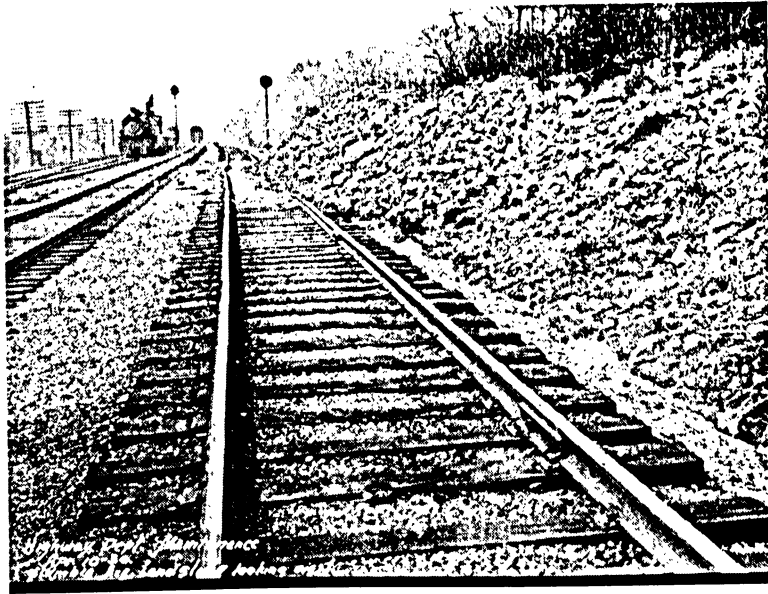


Figure A.7 This is the toe of the landslide identified in Figure A.6. Note that the toe of this landslide has surfaced at the broad cut for the railroad tracks. Photograph courtesy of the University of Cincinnati Library.

Pohana (1983) associated landsliding with substantial fill emplaced at the top of the hillslope and grading and clear cutting, respectively. Yahne (1974) analyzed 49 slumps in an eleven square mile area, just north of downtown Cincinnati, attributing all to either grading (8%), cut (43%), or fill (49%) activity.

Deforestation, Clear cutting, and Removal of Vegetation by Grazing

For this study, deforestation is differentiated from clear cutting by the extent of tree removal (i.e. widespread lumbering activity vs. cutting down of trees for the view, respectively). An increased incidence of shallow sliding and erosion following deforestation from lumber harvesting has been well documented in the literature

(Montgomery et al 1999; Marsh, 1864). Landsliding following deforestation has occurred up to 20 years after lumber harvesting. Clear cutting with in the study area at the top of the hillslope to improve the view can be laterally extensive. Reistenberg (1994) showed that the white ash tree with a deep penetrating taproot, found on the Cincinnati hillslope, can increase the shear strength of soil, stabilizing shallow (<1 meter) colluvial soils. Widespread shallow landsliding near the top of the hillslope associated with deforestation may load the lower slope and causing further landsliding downslope. Trees and vegetation can also aid in draining the soil through evapotranspiration.

Grazing by animals on hillsides has led to formation of terracettes and stripping of the vegetation. Loss of vegetation and formation of terracettes modify the slope hydrology leading to increased erosion.

Modification of Slope Hydrology

The first roads (early 1800's) up the hillslope consisted of a crude two track earthen bench. These early roads acted as collectors of surface water, concentrating and impeding the natural flow of the hillside runoff and allowing saturation of the hillside due to scarification. Later these pervious surfaces were paved, acting as collectors of surface water and in some instances failed to contain the surface water, directing water onto the hillside below the road. Many of the asphalt road surfaces in the study area today fail to channel water into storm drains; instead, water sheets over the down hill side of the road onto the hillslope. Residential and commercial building improvements located on and above the hillslope have modified storm water runoff and infiltration. Several storm

drains for commercial and residential buildings located at the top of the plateau discharge onto the slope and are associated with large landslide slumps. Metropolitan storm manholes within the study area exhibit signs of overflowing due to lack of capacity during peak flow. These storm sewers are saturating the hillside and contributing to landsliding and erosion.

The pre-existing natural drainage pattern (prior to 1800) was substantially altered in the study area and filled in as roadways ran on a diagonal across the hillslope and then followed the natural drainage pattern up the hillslope (Figure 2.5). Maryland, Warsaw, and Glenway Avenue existed prior to 1875, and the natural drainage was infilled near the middle to upper reaches of the hillslope. Containment and redirection into storm drains of the subsurface drainage has not been provided for below the infilled roadways where they parallel the preexisting drainage. Evidence for this may be the extensive seepage below the upper bend in Maryland Avenue and Warsaw Avenue. Active landsliding is occurring below the bend in each road.

Rills not associated with landsliding on the hillside, where no associated upslope causal mechanism could be determined, may represent water discharged onto the hillside from prior use of the land by humans at the top of the slope. Such an area is located at the upper portion of Maryland Avenue just past the Incline abutments and upslope of Maryland Avenue. Dry (i.e. no mortar) limestone walls are failing in several areas due to rill erosion.

Water Utility Leakage

Water utility leakage from storm drains and municipal drinking water may accelerate a preexisting landslide or cause failure of preexisting stable ground (Figure A.8 & A.10). Typically landslides have led to breaks in conduit and accelerated existing slides. An example of this is Maryland Avenue where the street has been closed off to vehicular traffic. The pavement on the downhill side of Maryland Avenue is overly thick indicating the landslide predates and caused the waterline break which accelerated the preexisting landslide (Figure A.9).



Figure A.8 Water main break at the West View Condominium. The water main break caused the ground adjacent to the building to drop several inches and the down slope soil to bulge.

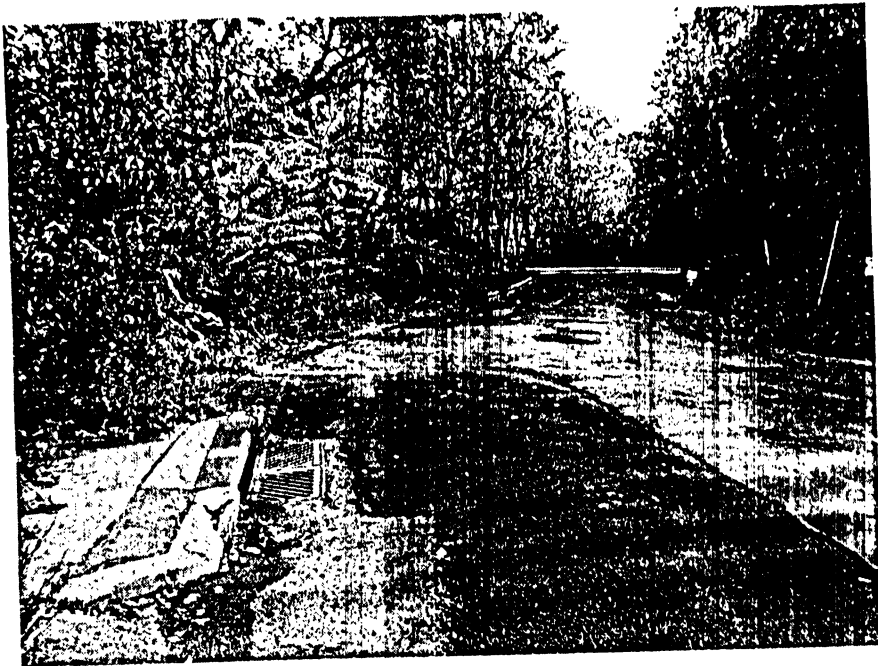


Figure A.9 Upper Maryland Avenue closed off to vehicular traffic to due a break in the water main that accelerated the preexisting landslide. Note the asphalt patch on the down hill side of the road.

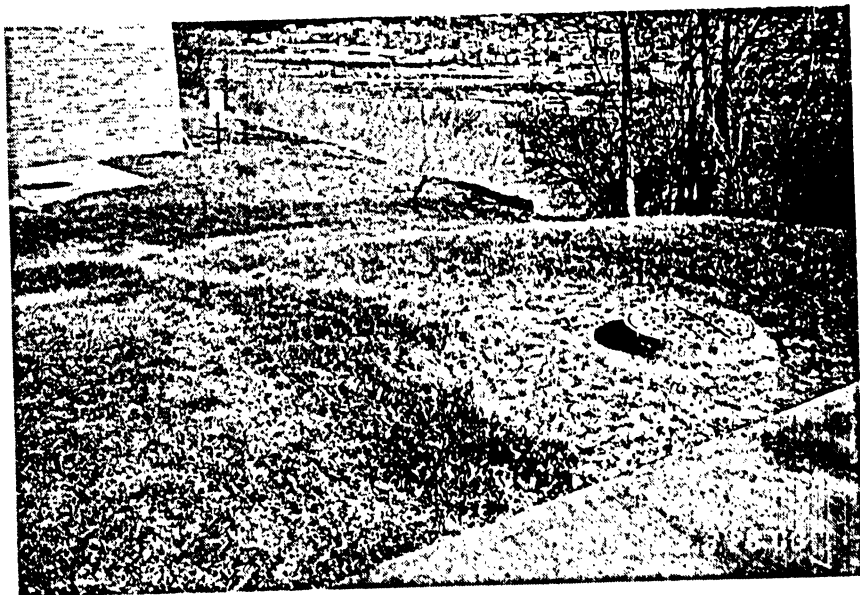


Figure A.10 Storm drain located below Lehman Road shows evidence of overflowing. Note the dead grass around the manhole cover and the path which is directed to the swale and down the hillside.

APPENDIX B: BEDROCK GEOLOGY, SURFICIAL GEOLOGY, AND LANDSLIDING

Introduction

Engineering geology of the study area encompassed mapping exposures of bedrock, surficial deposits, and landslide features. Exposed bedrock ledges were mapped in the field, indicate shallow soil cover. Surficial deposits consisted of mapping evidence of human modification of the hillslope. Landslide features were mapped in detail to show the relation to human modification of the hillslope.

Bedrock Geology

The upper portion of the Fairview formation is well exposed in a vertical rock outcrop immediately north of Davenport Avenue and at the West View Condominiums at 2500 Warsaw Avenue. Both outcrops represent the working face of rock quarries. Bedrock where exposed in the field was mapped whether it was an individual limestone ledge showing through the overburden or a small localized outcrop. Exposed limestone ledges have been mapped as linear features. The Kope is exposed in a landslide scar at the southern end of the study area above Elberon Avenue and at the northern end at Bald Knob.

The Kope-Fairview contact is well exposed at an approximate elevation of 660 feet at the northern end of the study area in the vicinity of Bald Knob (Figure B.1). The Kope-Fairview contact has been expressed in the past, as a topographic break in the hillslope

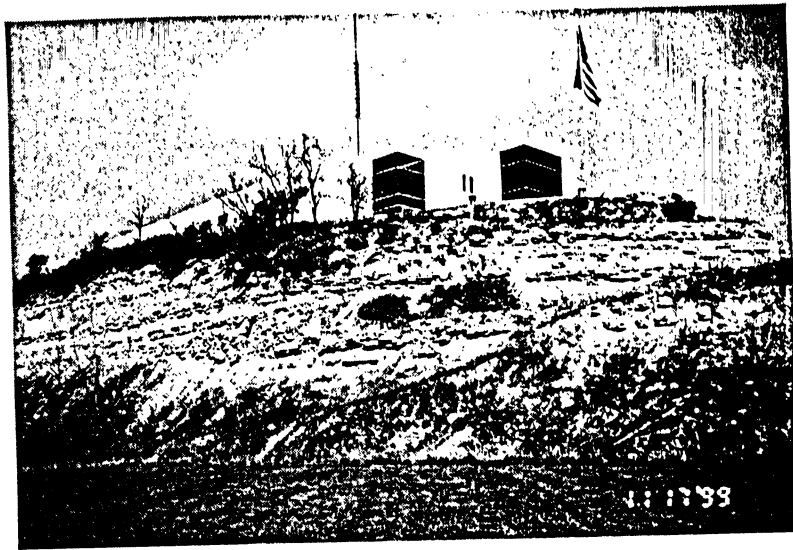


Figure B.1 Kope and Fairview exposed at Bald Knob on Radcliff Drive. Upper half of outcrop is the Fairview formation and lower half is the Kope. Level foreground area is uncontrolled fill.

and in the field is indistinct throughout much of the study area due to landsliding, grading, and cut & fill activity of humans. However, the topographic break is most prominent above lower Maryland Avenue at approximately 700 feet above mean sea level (Figure 2.6). In a highly disturbed area, the topographic break may not be the surficial expression of the bedrock contact between the Kope-Fairview. Ford (1974) places the Kope-Fairview contact between 660 at the northern end to elevation 710 at the southern end of the study area.

Surficial Geology

Very little residual soil exists on the surface of the hillslope within the study area. Sheet wash was extensive from the early 1800's to middle 1800's due to deforestation (see Frontispiece). The overburden profile in the study area consists predominantly of colluvium at depth; however, most of the ground surface has been disturbed by human

activity. The disturbed ground can be broken down into undifferentiated fill, areas of cut and fill associated with roads & housing, quarry spoils (inferred from the topography), dumps, and urban ground (prevalent housing and/or shallow soil cover on plateau).

Human disturbances include grading activity as evidenced by the ground contour, presence of surficial paver and flagstone, proximity to structures (limestone walls & foundations), and plat records. Areas of cut and fill were delineated which typically represented roadways, platted in the 1800's, associated benches for housing (2nd & 3rd terrace, above and below the existing roadbed), and possibly tier farming. Quarry spoils were inferred from proximal location to stone quarries and in some instances overly thick deposits at the top of the slope. Quarry spoils consisted mainly of shale excavated from the Fairview formation.

Undifferentiated fill and dumping near the crest of the slope is prevalent throughout the study area. The dumps/fill consists of small areas (<100 sq. ft) from construction contractors and individuals to a moderate sized landfill (16,000 sq. ft.) such as can be found below the Cincinnati Bible College (Figure B.2 and B.3). The cumulative effect of small localized dumping, through the years, should not be underestimated; it loads the crest of most of the hillside. Colluvium was mapped if determined to be in situ with little human activity and no evidence of landsliding (possibly representing the virgin slope).



Figure B.2 Concrete debris dumped by a contractor or maintenance personnel load the hillslope below the West View Condominiums above Glenway Avenue.



Figure B.3 Large landfill and landslide located below the Cincinnati Bible College property.

Landsliding

Landsliding and creep are pervasive throughout the study area. For the purpose of this study, soil creep is defined here as the slow imperceptible downward movement of soil, in areas without apparent evidence of past landsliding. Rates of creep are generally reported on the order of millimeters per year. Subtle hillslope human features (such as non-vertical fence posts, etc.) can be mistakenly interpreted as creep if a thorough investigation of the adjacent area is not conducted to rule out landsliding. Creep is a natural process acting on the colluvial slope throughout the study area. Mapping of creep in the study area was limited due to the high density and lateral extent of landsliding. Indirect evidence of soil creep in the field includes soil on top of walls and individual limestone blocks pushed out in the upper portions of retaining walls. Prior to human activity (European) in the study area, creep and weathering of the bedrock was probably the primary geomorphic process acting on the hillslope.

The majority of the hillslope within the study area can be defined as landslide debris (see Plate I). Landsliding in the study area is broadly defined as the downward and outward movement of soil with associated shear surfaces. The expression of soil shearing at the surface is represented by landslide scarps, flanks, and toes (Figure B.4). Shallow landsliding is considered to be in soil predominately less than five feet deep. Deep landsliding is in soils greater than five feet deep with the majority of the landslide mass being deep. Soil is defined in the engineering sense and can consist of any unconsolidated deposits above bedrock including fill, colluvium, alluvium, etc. The study

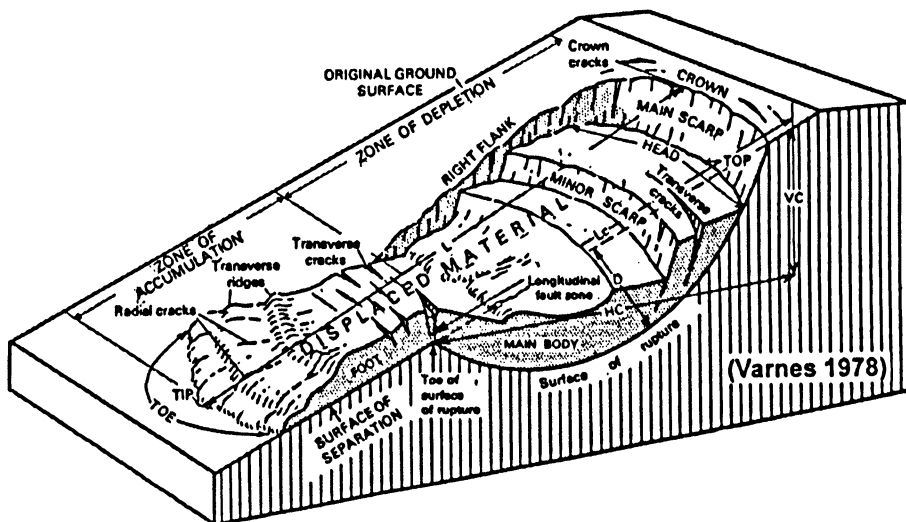
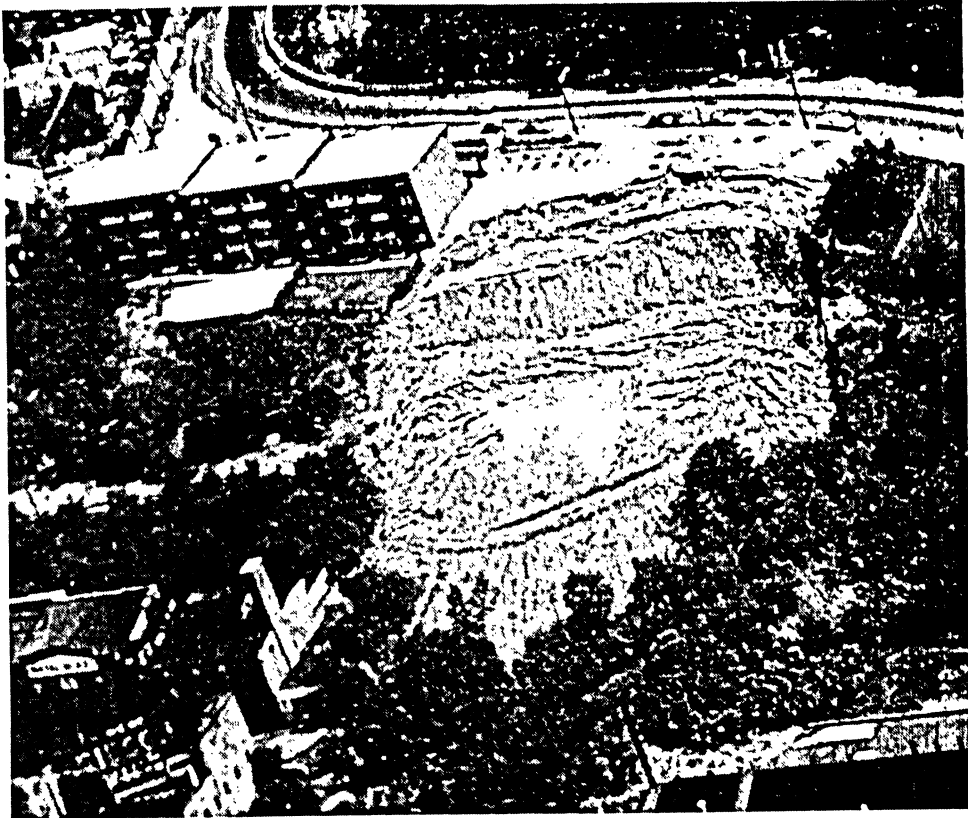


Figure B.4 Large well developed landslide slump below the lower bend in Clifton Avenue. The landslide occurred in 1966 and involved litigation. Varnes (1978) block diagram illustrates landslide features. Photo courtesy of the City of Cincinnati.

area is composed of distinct landslide complexes that have been acting on the hillslope in some instances for well over a hundred years.

Types of Landslides

Landsliding in the study area mainly consists of deep rotational slumps, deep base failure translational-rotational slumps, translational movement, and rapid earth flows (Figure B.5). Deep landslides are defined as having a depth of over five feet, with shallow landslides being less than five feet.

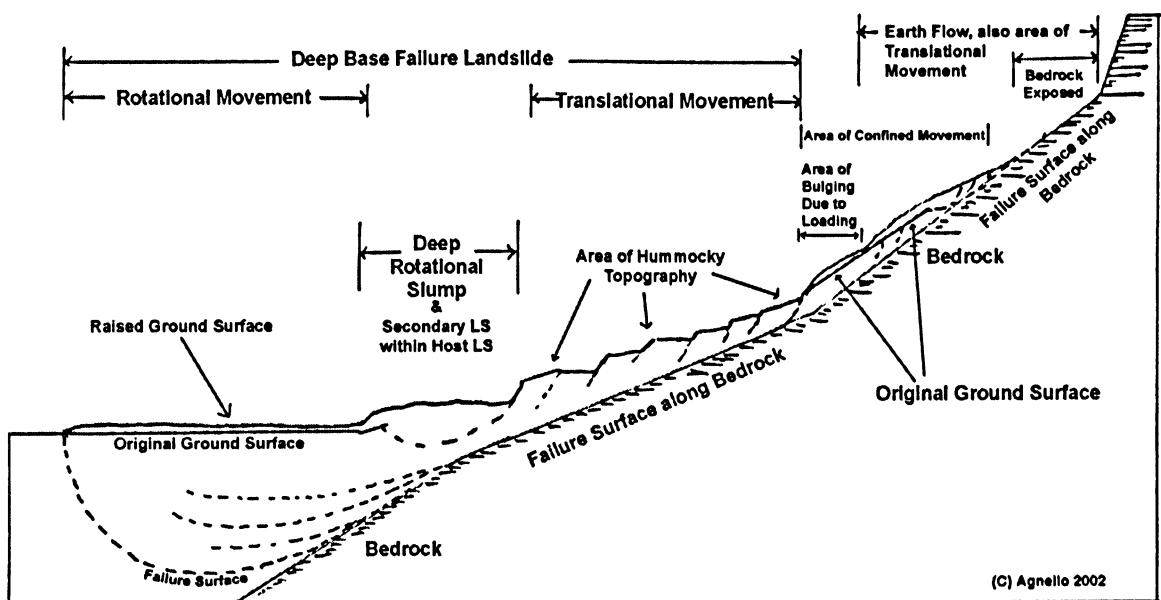


Figure B.5 Schematic showing landslides types in the study area.

Deep rotational slumps in the study area can range from 15,000 to more than 100,000 square feet in surface area. The smaller slumps typically have a well-defined toe, scarp, and flanks. The larger, deep rotational slumps have well-defined scarp(s) with associated toe(s) or bulging. Typically, the head scarp is located near the crest of the hillslope with what appear to be several scarps located mid to upper slope and a lower associated toe(s).

Flanks are often indistinct shear zones. Some of these deep extensive landslides contain smaller landslide masses; representing compound landslides (Figure 3.7 & B.9).

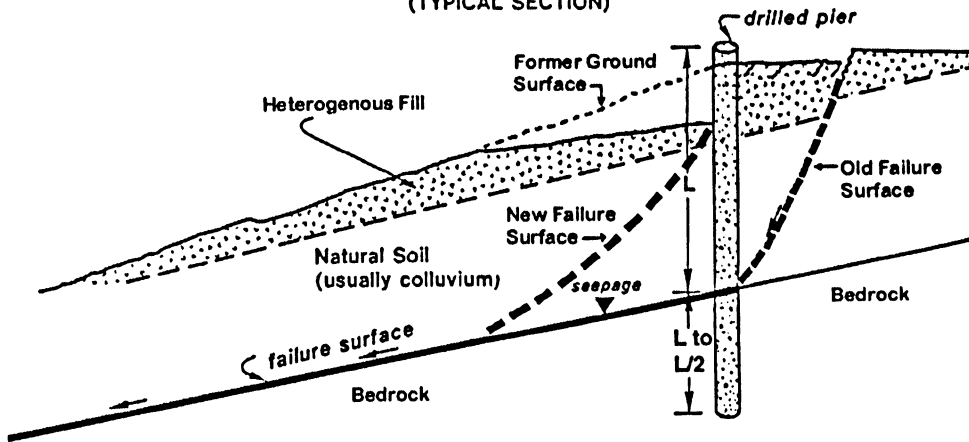
Deep base failure landslides within the study area are the result of laterally extensive vertical man-made cuts near the toe of the slope. In some instances, retaining wall panels have moved straight out in response to removal of lateral support. The ground may be subject to vertical uplift where the overburden has been removed. Lower boundaries of the surface manifestation of the landslide are often indistinct, laterally extensive, and maybe difficult to locate in the field in the absence of human-made structure. The mechanics of the landslide appear to be a translational-rotational movement. The upper portion of the landslide is typically translational becoming a rotational movement where the overburden thickens.

Shallow translational movement is evident in the field, usually with an uphill scarp and associated bench and downhill hummocky topography. Certain areas have been delineated on the field map (Plate I) as hummocky topography and represent past ground movement. Hummocky ground in some instances may be devoid of any linear landslide features.

Areas of rapid earth flow have occurred in the shallow overburden cover, typically leaving bedrock exposed. Rapid earth flows can occur due to saturation of the hillslope from the discharge of swimming pools, such as the landslide that occurred below the West View Condominium pool.

DRILLED SHAFTS (PIERS) FOR STABILIZING FAILED SLOPES

(TYPICAL SECTION)



LONGITUDINAL PIER SPACING

(TYPICAL)

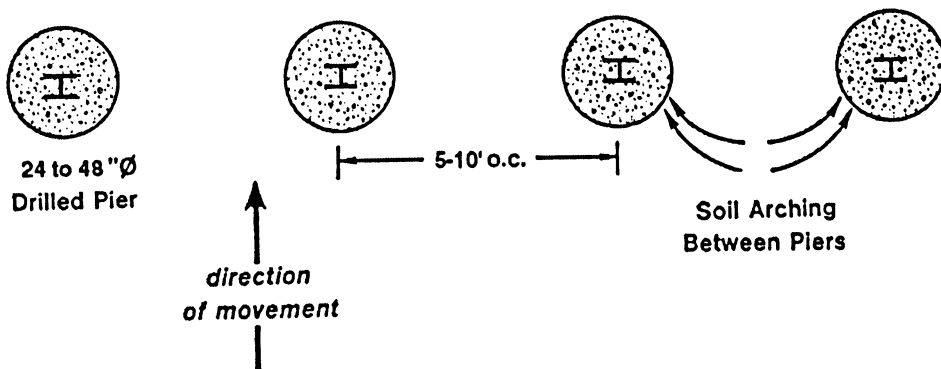


Figure B.6 Typical pier wall design modified from Nethero (1975) and Pohana (1993,1992). Concrete precast lagging is often placed between piers to compensate for the new scarp that develops in front of the piers and retain the granular fill behind the piers/lagging.

Observations on Landslide Morphology

Scarps near the crest of the hillslope, where bedrock is near the surface, may be difficult or impossible to recognize in the field due to lack of a reference point (e.g. lack of an upslope crown area located in soil). Additionally, the upper bounds of sliding near the crest of the hillslope are often defined/redefined by pier and/or crib walls (Figure B.6). Although not as common as a landslide mass enlarging up and down the hillslope, sometimes the distal end of subdued scarps exhibit fresh movement, suggesting that the landslide mass is enlarging laterally. Subtle and subdued landforms (Figure B.7) are subject to misinterpretation and may be bedrock-controlled landforms (Fleming and Johnson 1994, pB15). In the field, upon locating a topographic bench, four possibilities exist; 1) it may be underlain by bedrock; 2) it may be a human-made feature; 3) it may be a subdued landslide feature; and 4) it may be a combination of the last two. Careful field observations may clarify the origin of the bench by tracing the feature laterally to its termination and by examining the adjacent upslope and downslope topography (Figure 3.12).

Landslide toes had the most morphological variability in the field, ranging from an obvious thrusting, burying trees or human made objects, to a subtle or pronounced bulge (ground or wall). Toe morphology may also be expressed as an oversteepened slope, as found above much of Elberon Avenue east of Mt. Hope. The lower portion of the hillslope above Elberon is very steep and looks as if wheel barrows of soil were dumped, producing small hummocks (low relief and closely spaced). Movements in the toe

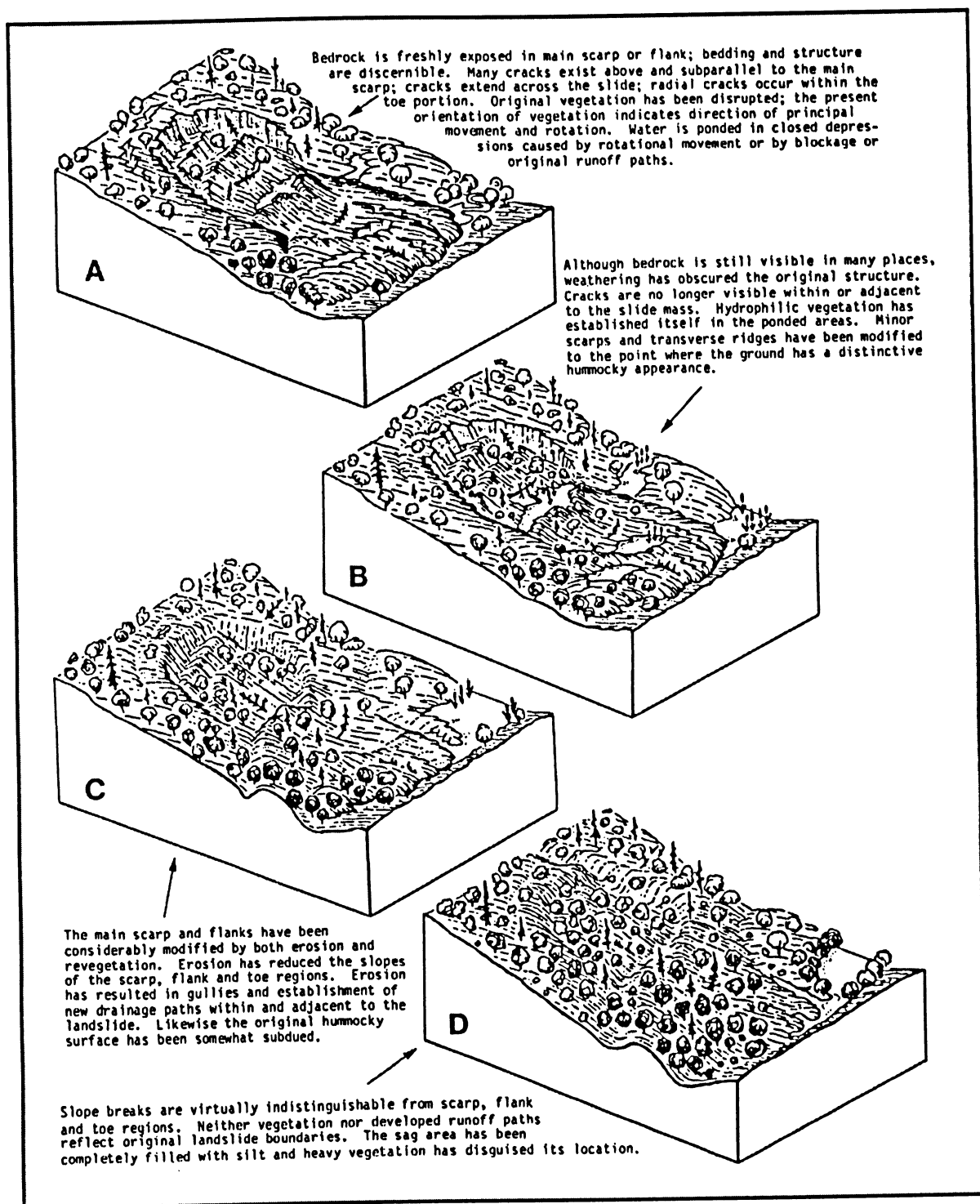


Figure B.7 Modification of landslide features over time. From Wieczorek, 1984.

above Elberon is evident where the concrete steps have been sheared (Figure D.2).

Additionally this area has a documented history of landsliding.

Cruden and Varnes (1996 p. 46) have defined active landsliding as evidence of ground movement within the past twelve months (cycle of seasons). Delineation of active versus inactive landsliding within the study area using this definition would be misleading and difficult to verify in the field without inclinometer data. Slope movement in Cincinnati can be deceptively slow, with several years passing with little or no movement. The hillside processes are highly dynamic with one portion of a landslide mass exhibiting fresh movement (i.e. open tension cracks) while the remaining mass shows little sign of movement. Landslides are deemed active even if only a portion is subject to movement. Landslides within the study area are typically active, unless the landslide mass has completely moved out of its original location (such as a rapid earth flow/slide) or has been stabilized with engineering methods. It should be noted that very few landslides in the study area have been stabilized. Stabilization of landslides by pier walls is the preferred method of retaining road embankments and soil near the crest of the slope for housing, as remediation of the entire landslide mass is cost prohibitive. Active landslide movement should be verified by inclinometer data over a statistically significant period of time (3 to 5 years) to encompass a precipitation of a sufficient duration.

Rate of Movement, Confined Movement, and Compound Landslides

Rate of Movement

Deep sliding occurs in episodic movement ranging from a few centimeters to 48.8

centimeters per day (Fleming and Johnson 1994; Von Schlichten 1935). Field observations reported in the 1950's involving the Warsaw-Waldvogel Viaduct deep landslide indicate movement on the order of inches over a several month period (City of Cincinnati, 1953). Presently, inclinometer data indicates movement on the order of 1-2" per 10-year interval (Pohana, 2000). More typically, Pohana (1993) reported movement associated with embankment fills of several inches per year. At the other end of the spectrum are shallow translational landslides in thin colluvial cover that move on the order of several feet per hour, leaving bedrock exposed at the slip surface.

Confined Movement

McCandless (1976) measured the bulking (increase in volume) in a noncomplex small slump located in Burnett Woods, just north of the University of Cincinnati, reporting that bulking occurs in the landslide mass. When the zone of accumulation exceeds the zone of depletion, the landslide mass is said to be dilating (Cruden and Varnes, 1996). This is true when a noncomplex slump has matured, with a distinct failure surface and toe. However, Hutchinson (1988) described a landslide mass that has "confined movement", (Figure B.8) with confined movement the landslide mass has a head scarp with a poorly defined lower boundary represented as a bulge. There is no distinct failure surface in the toe-bulge area. It appears that the zone of depletion (area of volume decrease) may exceed the zone of accumulation (area of volume increase), suggesting compression.

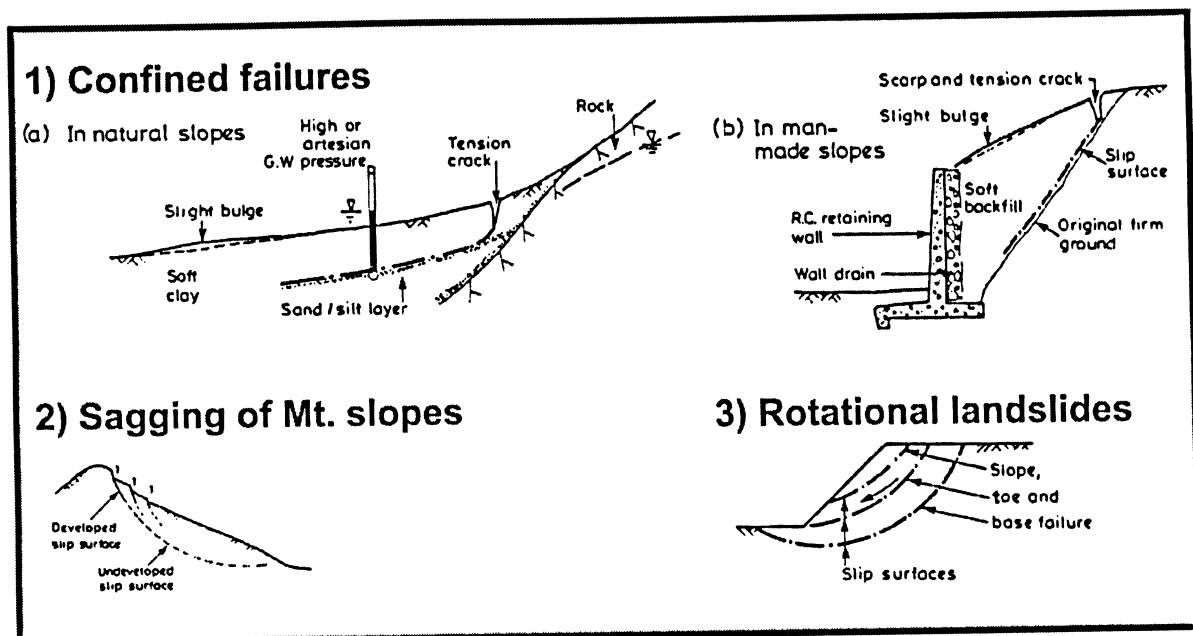


Figure B.8 Illustration 1 & 2 shows confined movement on hillslopes and mountain slopes. Illustration 3 shows hillslope, toe, and base failure. From Hutchinson, 1988.

Confined movement in Cincinnati has largely gone unrecognized in the past and may be prevalent. Confined movement is difficult to ascertain without a comprehensive field survey over time, or careful examination of human-made landforms and structure, which in essence gives a loose baseline to work from. In addition, deep landslides encompassing broad areas may necessitate a stake survey to ascertain the limits and amount of vertical uplift.

Compound Landslides

Multiple destabilizing events by humans may lead to what Cronin (1992) has referred to as “compound landslides” (Figure B.9). A compound landslide contains smaller “secondary” landslides within the body of the broader “host” landslide. As with most of the study area, the area above the Warsaw-Waldvogel Viaduct can be considered a compound landslide. Cronin states that a compound landslide is a “mechanically and

hydrologically discontinuous entity”. A stability analysis should take into account the secondary landslide masses within the host landslide, so as not to lead to an erroneous stability analysis.

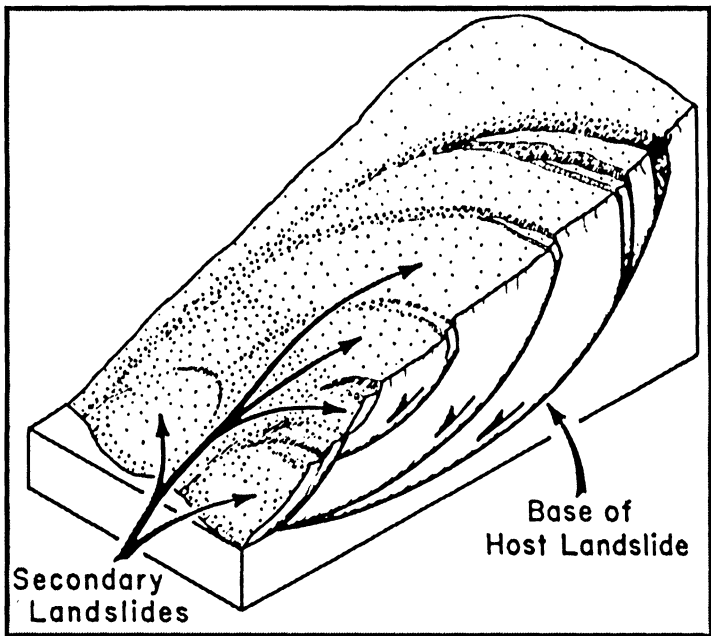


Figure B.9 Block diagram of a compound landslide with smaller secondary landslides located inside larger host landslide. Compound landslides are common in the study area. From Cronin, 1992.

APPENDIX C: RELATIVE STABILITY

This study uses the method outlined by Hoexter et al (1976) for relative-stability (RS) analysis. An engineering geologic map is constructed from field observations and then converted to a relative-stability map with broad interpretive categories of stable, potentially unstable, and unstable areas. The relative-stability map is intended to aid public officials, contractors, the public, engineers, architects, planners, and real estate professionals. Additionally, the RS map and Engineering Geology map is meant to be used as an aid to guide site specific investigations.

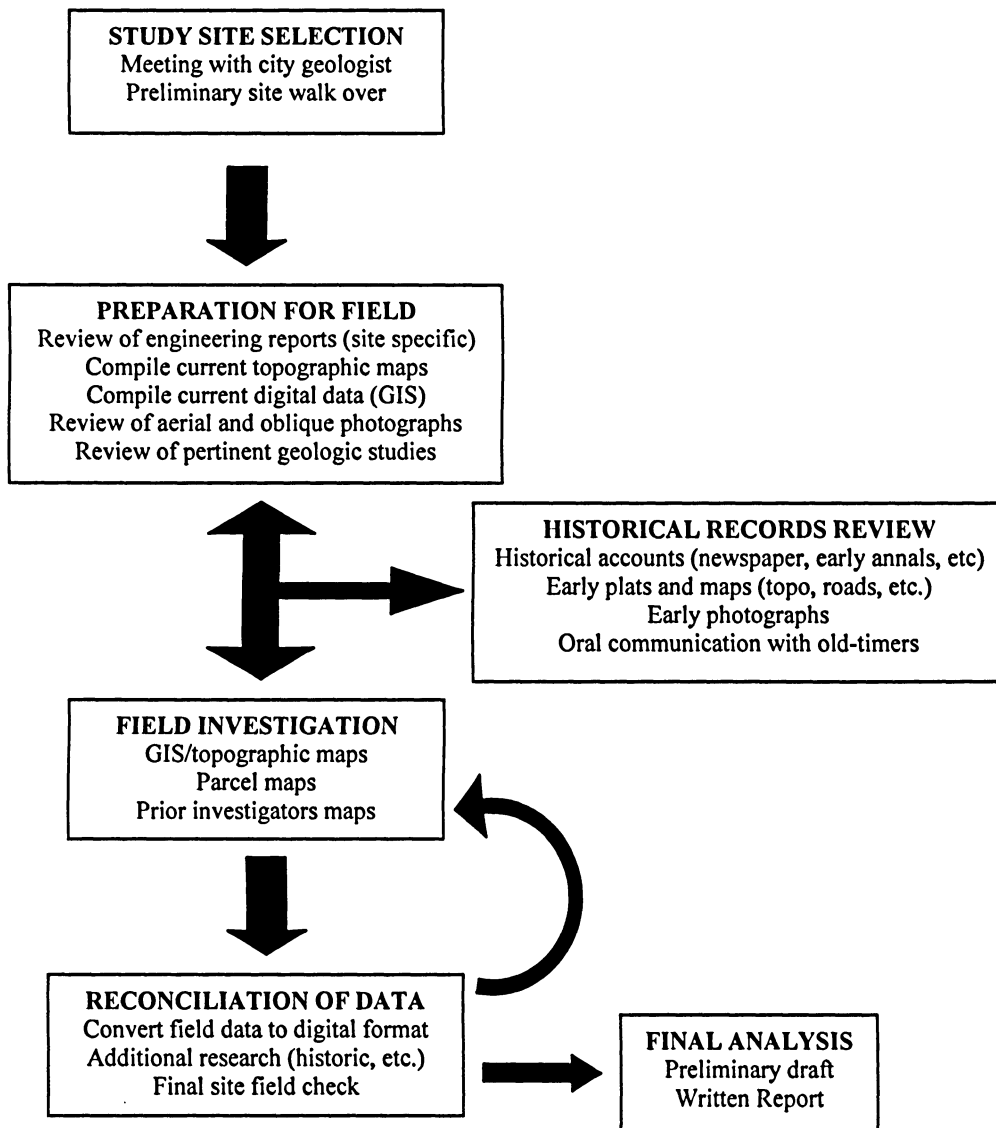
This study is broad in nature and not a substitute for site specific engineering. An engineering geologist should be utilized for a site-specific investigation in the analysis of landforms and materials. An engineering geologist and geotechnical engineer should be consulted where structure is involved or when any modification to the existing hillslope is planned (i.e. changes to surface water drainage, cut and fill activity, etc.).

RELATIVE STABILITY MAP

UNIT	DESCRIPTION
Landslide Prone Areas (High Confidence) Deep Complex.....Actively moving ground. Part of large landslide mass may exhibit active movement. Typically large laterally extensive landslide(s) with one or more boundary poorly defined, maybe secondary landslides within host, landslide mass may (or may not) exhibit extensive catch areas for surface water with drainage pattern moderately developed. Typically episodic movement <2 inches/year. Inclimeters needed to define boundary and active movement. Isolated secondary deep slumps may be active, typically well defined and located within larger host landslide complex. Shallow.....Typically undulating terrain with lower profile scarp than deep landslide. May also be described as translational movement or earth slide sometimes grading into flow or combination of, due to predominant fine grain composition and saturation of soil.	
Potential for Movement or Dormant (Possibly Moving, Moderate Confidence) Deep & Dormant.....Relative to age of potential driving mechanism, landslide mass has shown little ongoing movement but has distinctive low relief instability features not fully developed or possibly older weathered and vegetated landform (i.e. subdued scarp, poorly defined toe). Maybe contiguous with adjoining active area of movement. Area of deep unconsolidated soil. Typically very little distinguishing landslide features. Possibly active with weathering keeping pace. May need inclinometers to adequately define boundaries, damage to man made structure typically the biggest clue. Typically area of past significant human activity. Sometimes hummocky topography. Shallow & Dormant.....No open tension cracks, vegetated scarps, hummocky topography. Areas of shallow unconsolidated deposits, sometimes hummocky topography, and little distinguishing landform. Potential for movement. Undifferentiated.....Potential for movement. Subsurface data lacking to establish deep vs. shallow, and/or field investigation not completed. Undiff. Not Investigated...Potential for/or past movement based on adjacent upslope field investigation. Areas not field investigated.	
Stable Bedrock.....Bedrock exposed or probably near the surface (i.e. within a 2 feet) on low slope. Can also be bedrock exposed in vertical outcrop or on hillslope. Urban.....Urban ground predominately residential housing, low to flat slope, very low landslide potential. Wall.....Walls currently supporting uphill ground doing adequate job, mostly pier walls. Wall?.....Wall predominantly doing its job, but in localized area failing to support uphill ground, leaving asphalt voids, drop in pavement, etc. Includes pier walls, gravity walls etc.	
Definition: Deep- majority of landslide mass or overburden is greater than five feet deep from ground surface to lower shear surface. Shallow- majority of landslide mass or overburden is less than five feet deep from ground surface to lower shear surface.	

APPENDIX D: METHODS

Field data was collected over a 7-month period during the fall and winter months of 1999-2000 when vegetation/foliage was sparse. Approximately 650 hours were spent recording data in the field. The area above Elberon Avenue from Maryland to Mt. Hope was mapped in less detail due to time constraints. The study followed the flow chart below:



A non-traditional approach was implemented in this study by utilizing such tools as historic maps, historic newspaper accounts, and the CAGIS parcel map. Human's ability to move "great quantities of earth" and modify the landscape was recognized by James (1886-87) as problematic in the study of the surficial geology of Cincinnati. Mapping of a human modified landscape and associated instability features poses a unique challenge. Even with a careful investigation, it may be possible to misinterpret landforms. A review of historic documents and the parcel map is paramount in establishing an accurate interpretation of the surficial geology. Further, investigation of the same landslide prone area by different investigators with the same level of experience can lead to a different interpretation of areas of instability (Carrara and others, 1995, p138-139). For this reason alone, it is important to map all evidence of human activity, landforms, and geology in the field. Time may reveal that previously mapped stable human landforms are now loci for a landslide or perhaps a landform that was misinterpreted.

Photographs (Figures D.1-D.28) best illustrate instability features mapped in the field. Additionally, evidence of human activity was mapped in detail and became more evident by carrying the parcel map into the field.

1:1200 scale maps produced by Cincinnati Area Geographic Information Systems (CAGIS) were used in the field. CAGIS maps were detailed, showing utilities, buildings, walls, roads, paved surfaces, ten-foot and two-foot contour lines, and parcels. The CAGIS maps utilized southern Ohio NAD 1983 datum. As CAGIS utilizes U.S. customary units (foot), field data was recorded and reported in this unit of measurement.

In an urban setting, Geographical Information Systems (GIS) data layers supply a wealth of control points. From these control points, pertinent features were mapped with a Brunton Pocket Transit and Thommen Altitronic Traveller altimeter following standard field methods (Compton, 1982). Due to the broad expanse and steep slope however, a grid system with fluorescent paint and orange survey tape was laid out on several portions of the hillside to facilitate mapping. GIS data also reveals paper streets and plat boundaries that for the most part have changed very little in the past 100 years. Discrete parcel boundaries allow the investigator to analyze past use of the land to aid in a landslide study.

The CAGIS orthophotograph for the study area was also viewed, but did not have the resolution necessary to adequately assess ground features. In an attempt to speed up the fieldwork, low altitude oblique aerial photographs were taken from a helicopter with a medium format camera. Aerial photographs were viewed at the Hamilton County Soil and Water Conservation District spanning the years 1938 to 1990, in approximate 5-year intervals. Subtle features and the majority of landslide features were not recognizable from the photographs. The City of Cincinnati topographic sheets (2) of 1912 was examined at a scale of 1:4800. Subsurface information was examined in various geotechnical-engineering reports. Historic data (e.g. newspaper articles, historic photographs, historic maps and plats) on landsliding was also collected and studied (see Appendix E, F, & G). Sources included the Public Library of Cincinnati (newspaper articles & photos), Cincinnati Historical Society (city directory, books, maps, etc), Price

Hill Historic Society, University of Cincinnati Geology Library, and the Hamilton County Court House (ownership and plat records). Historic dates of housing are summarized in Appendix H and were obtained from the Hamilton County Auditor's web page.

The software utilized to view CAGIS data and input the geology was Environmental Systems Research Institute, Inc program ArcView GIS version 3.2 (AV 3.2). All data was archived to a CD-ROM. Field maps were digitized using a digitizing tablet. Additional data such as old roadways and historic land use were digitized through the ArcView GIS software. Slide features were photographed in the field with a 35mm camera and digitized with a flatbed scanner. Mapping symbols used in final presentation of the digital field map utilized AV 3.2 default symbols. In the future, the graphic symbols can be converted to a more robust set of symbols. The USGS Open File Report 95-525 addresses the standardization of digital cartographic symbols. Field data was mapped at the 1:1200 scale with the exception of the plane table mapping (1:400 scale) done at 2325-2341 Maryland Avenue by Aytuna & Brian (1980). The data can be viewed at a larger scale than mapped using ArcView GIS; however, this will impart an erroneous level of detail to the reader.

The following figures are photographs which represent typical features mapped in the field and recorded on the engineering geology field map:

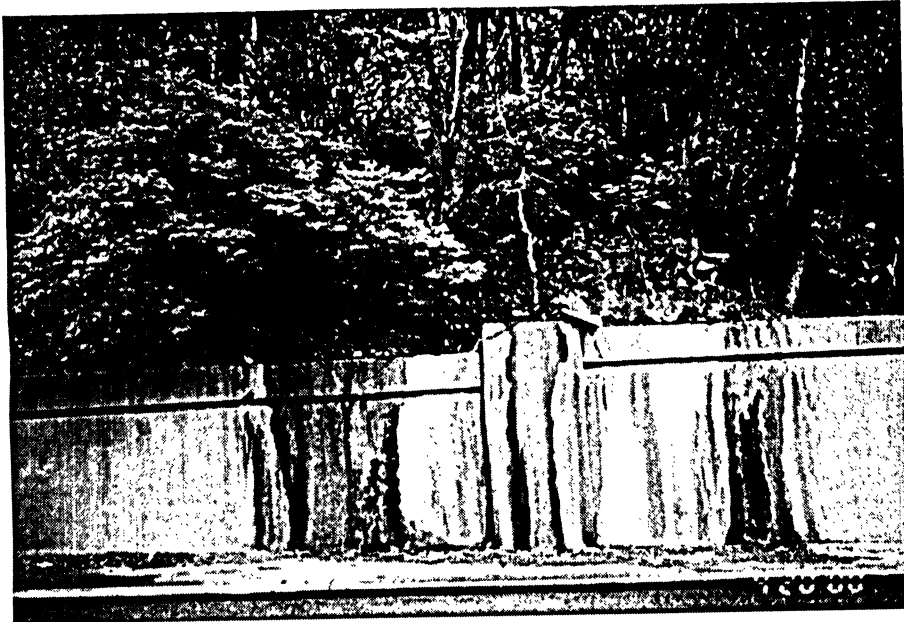


Figure D.1 Landslide toe and seep on Elberon Avenue.



Figure D.2 Steps displaced above Elberon Avenue.



Figure D.3 Landslide toe burying a tire, located below Maryland Avenue, north of the Incline.



Figure D.4 Landslide toe located off of River Road in asphalt parking lot. Illustrates subtle nature of uplifted toe area, readily apparent because it crosses man-made feature. Real estate sign is eighteen inches high.



Figure D.5 Tree being buried by deep slump above Maryland Avenue at the south end of Goforth Street.

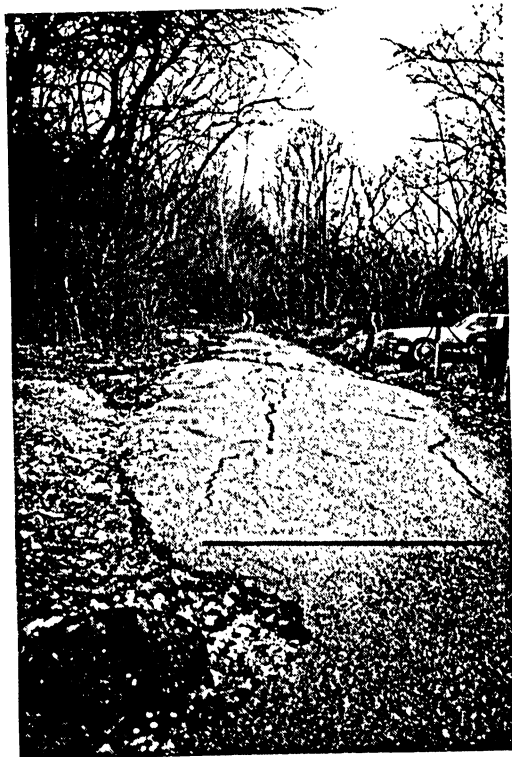


Figure D.6 Asphalt pavement uplifted past the horizontal line at the northern end of Bowman Street. Tension cracks run parallel to axis of street.



Figure D.7 Shelby gravel road. Early documentation shows this road as being straight.



Figure D.8 Neff Street. Wall bulges into house.

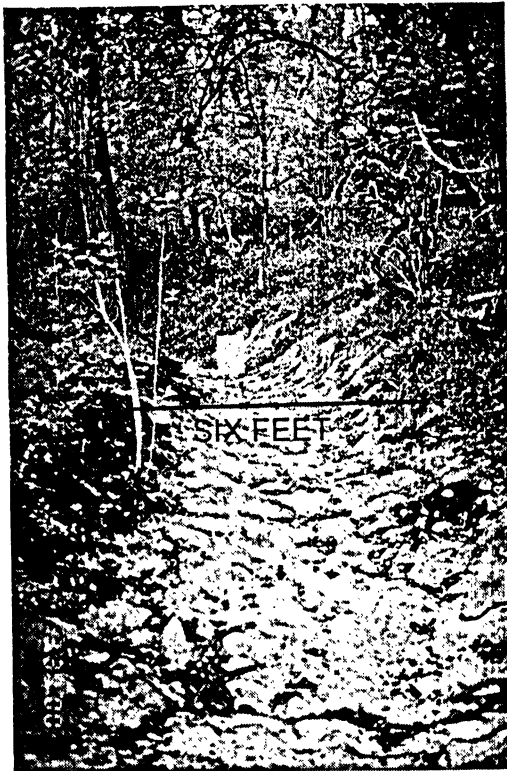


Figure D.9 Stone and concrete drainage ditch located above Warsaw-Waldvogel Viaduct to keep surface water out of landslide mass. Initially six feet wide, gradually closes up until only one foot wide (horizontal line in upper photo) at southern end due to creep and/or landsliding.



Figure D.10 Hillside bulge and/or creep. Note the curving tree trunks. Site of remediated landslide in 1982.

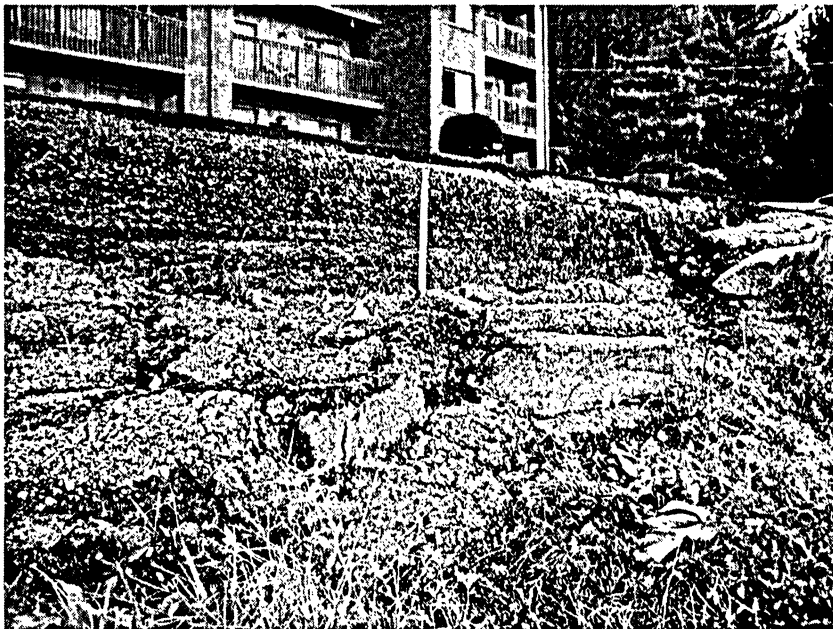


Figure D.11 Maryland Avenue apartment complex asphalt parking pad. Vertical tape is extended out one foot for scale.

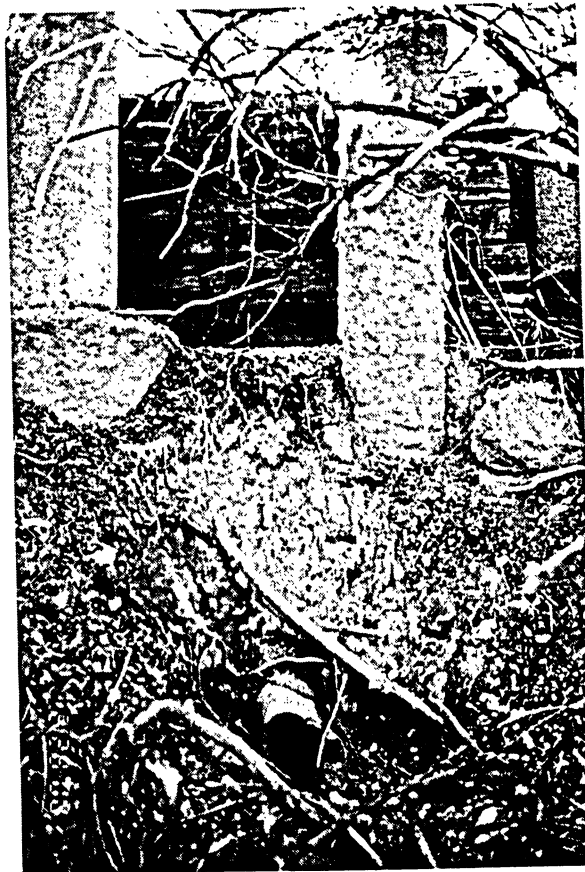


Figure D.12 Failure in front of pier wall. Note concrete pipe (lower photo) that drains the entire parking lot (upper photo) onto the hillside.



Figure D.13 Lehman Avenue asphalt patching on the down hill side of the road. Note new tension cracks already forming. Water sheets over the down hill curb in the upper portion of the road.

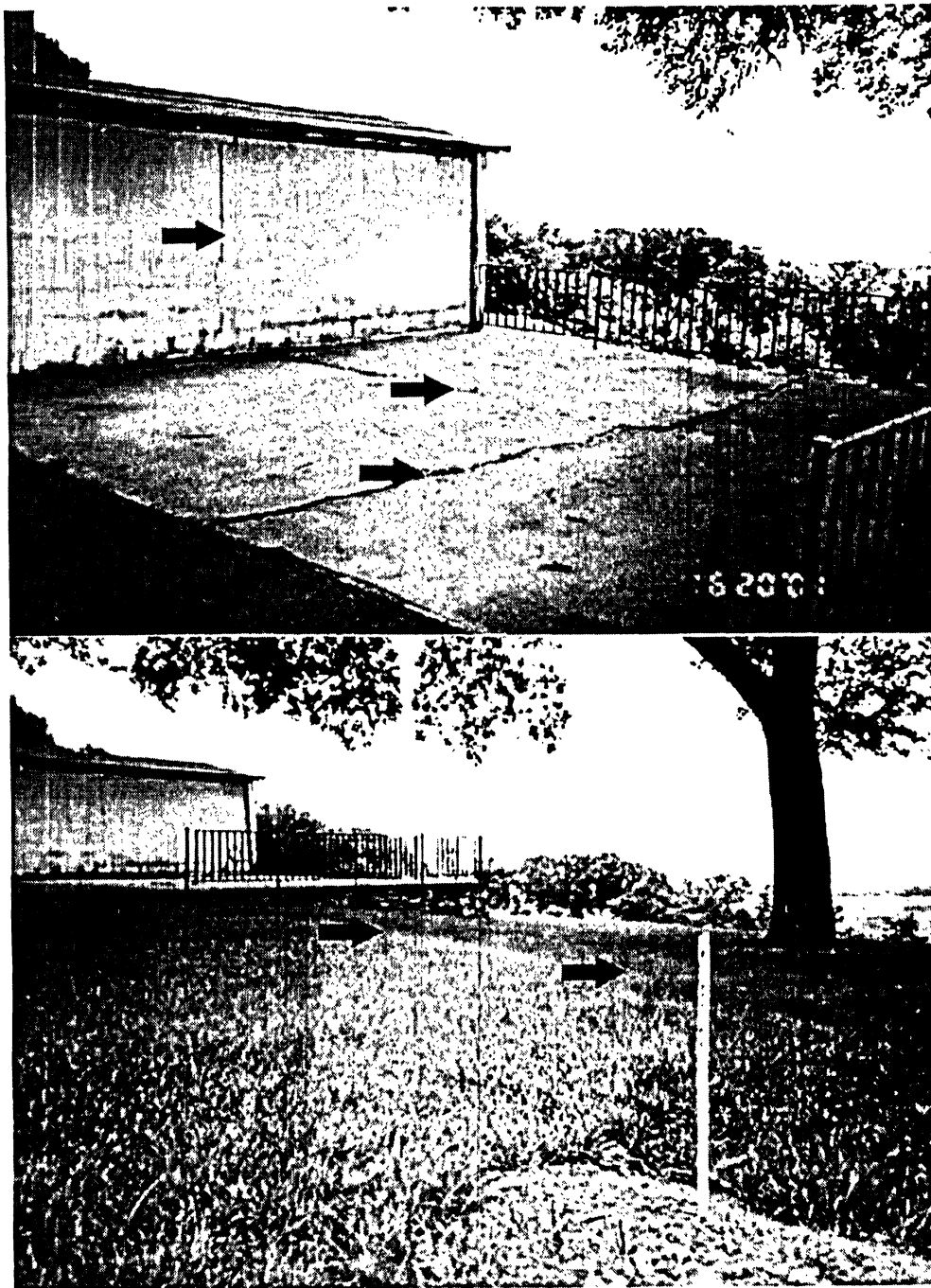


Figure D.14 Subtle vertical offset in topography lines up with cracked parking pad and cracked cinder block wall. Feature also follows the general trend of the crest of the hillslope to the north of site. Photograph is looking north-east into the Mill Creek Valley.



Figure D.15 Sag pond located on landslide below Lehman Avenue. Silt and clay indicate ponding of surface water.

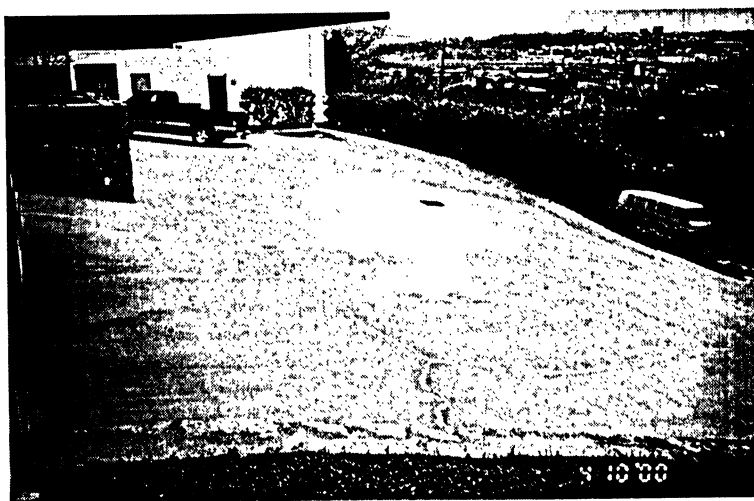


Figure D.16 Tension cracks in unbuttressed embankment fill due to creep and/or settlement.



Figure D.17 Seepage (arrows) flows year round at this location below the bend in Maryland Avenue on Warsaw Avenue. This seep was used in 1937 during the flood for drinking water; domestic well pit is located up slope.

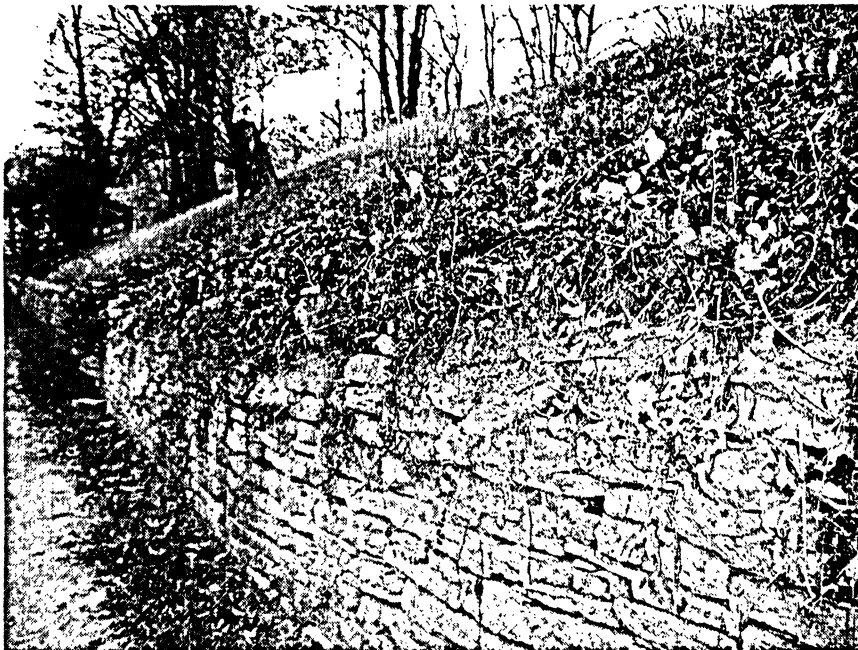


Figure D.18 One of the few sites where creep can be accurately identified. Upper portion of wall is pushed out, area located below the Cincinnati Bible College on Glenway Avenue.



Figure D.21 Series of limestone walls just above Maryland Avenue. Goforth Avenue terrace (arrow) as seen looking west from Maryland Avenue.



Figure D.22 Clear cutting and topping of trees for the view. Note that deck supports are braced against the foundation.



Figure D.23 Spectacular view of downtown Cincinnati after clear cutting.



Figure D.24 Limestone rubble pile located midslope.



Figure D.25 Upper Fairview outcrop represents last working face of the Goodhue quarry. Photo taken near the end of Davenport Street.



Figure D.26 Separation of curb/upper wall on Wilder Avenue. Tape measure is extended one foot and shows drop in pavement.



Figure D.27 Limestone rubble, slag, and brick gathered from a three foot radius. Located midslope below Davenport Street. Mechanical pencil for scale.



Figure D.28 Concrete 5" x 5" square fence posts located midslope below Davenport Street. Probably dates from early 1900's.



Figure D.29 Rudolph Avenue bench located below the Cincinnati Bible College and above Neff Street. Remnant bench is approximately fifty feet wide by two hundred feet long before becoming indistinct.



Figure D.30 Limestone rubble and paver brick used as road base for Rudolph Avenue.

APPENDIX E: HISTORIC MAPS

This historical data set represents early maps referred to in the text and is included for reference.

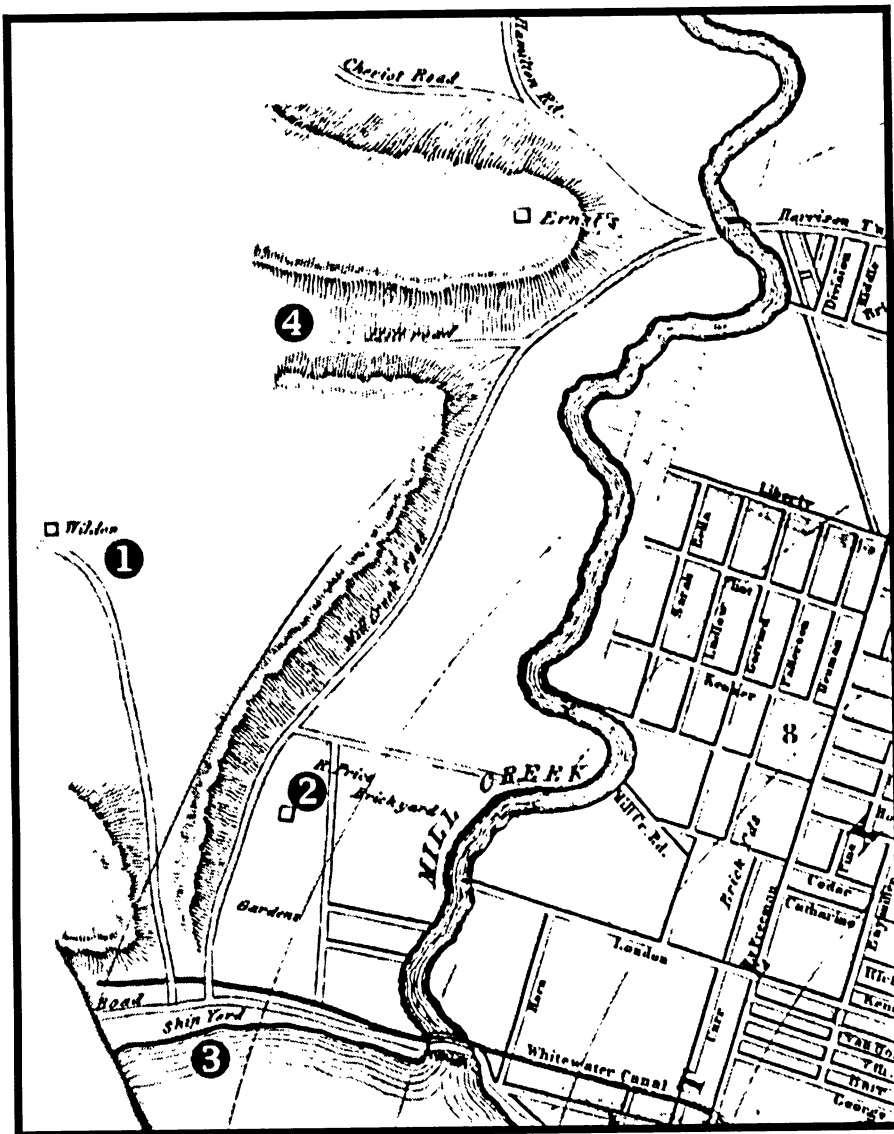


Figure E.1 At the top of the slope (#1) shows “Wilder” accessed by Maryland Avenue. Wilder was probably a prominent pork packer. At the bottom of the slope (#2) is E. Price’s brick and lumberyard. Note the shipyard at location 3. Hill Road (#4) and the Mill Creek Road along the bottom of the slope are today, Lehman Road and State Avenue respectively. From the 1846 Williams Cincinnati Directory, the Collection of the Cincinnati Historical Society.

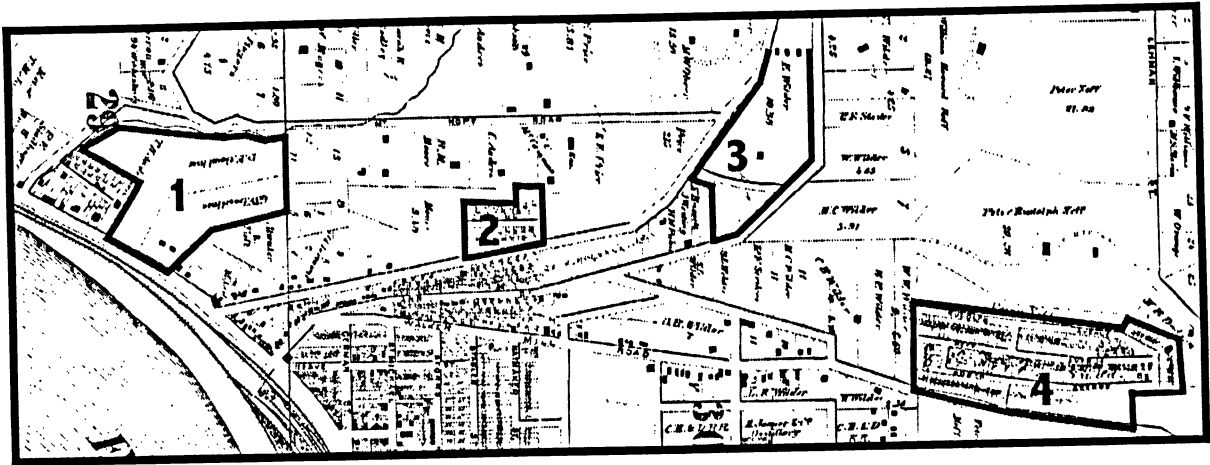


Figure E.2 Area 1 is composed of two parcels owned by D.F. Goodhue and G.W. Goodhue and encompasses the Goodhue Rock Quarry. Area 2 is the Goforth Subdivision above Maryland Avenue. Area 3 is Wilder parcel, note the street that is nonexistent today connecting Maryland Avenue to Warsaw Avenue. Area 4 is the Neff Subdivision, the upper most street, Rudolph, shows up as a paper street today on CAGIS. Note that at this time Glenway Avenue does not exist and is described as a steep sided ravine. From the Titus Atlas of Hamilton County Ohio, 1869.

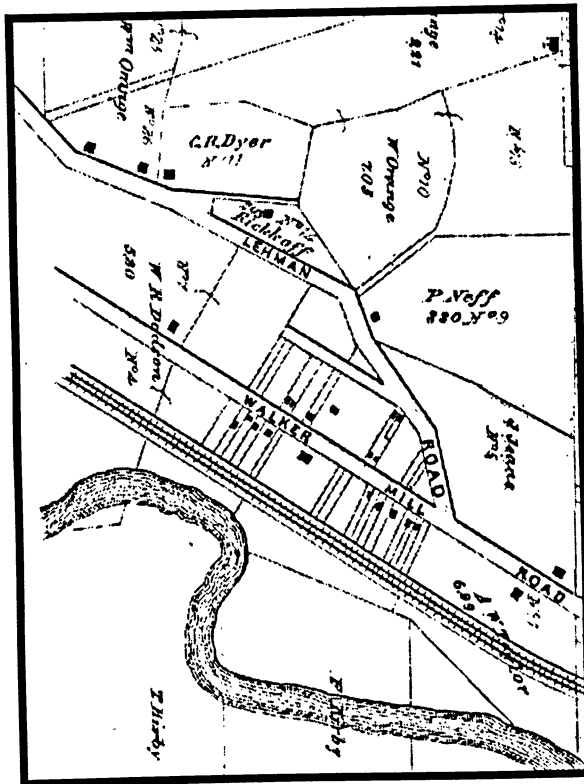


Figure E.3 North end of study area. Walker Mill is now State Avenue. Note the Mill Creek meander is cutting into the toe of the hillslope. The road located midslope between Lehman and Walker Mill is a gravel road today called Shelby. From the Titus Atlas of Hamilton County, Ohio 1869.

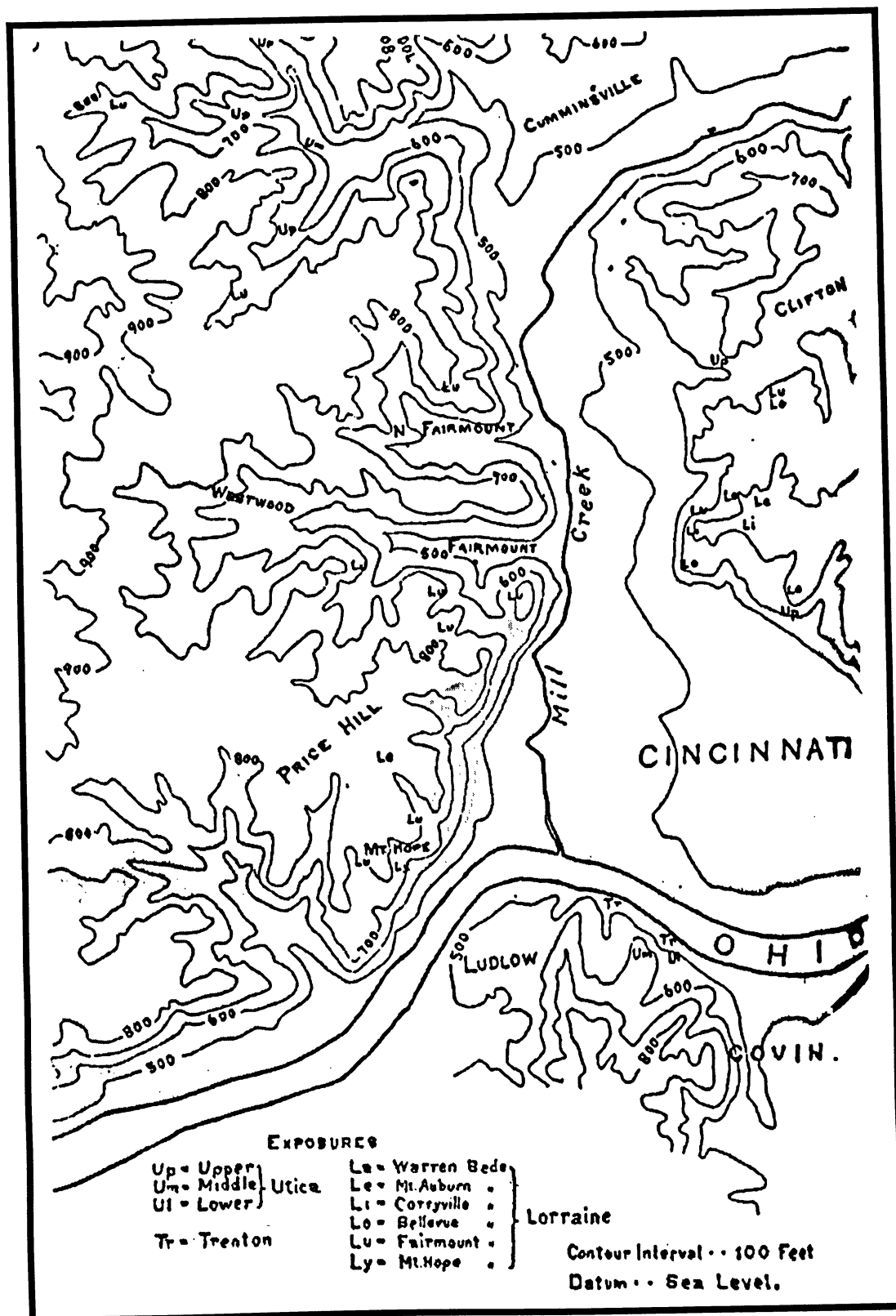


Figure E.4 Lu denotes exposure of the Fairmont bedrock formation and thus probable quarry locations. Study area is shaded in gray. Map modified (cropped) from Nickles (1906).

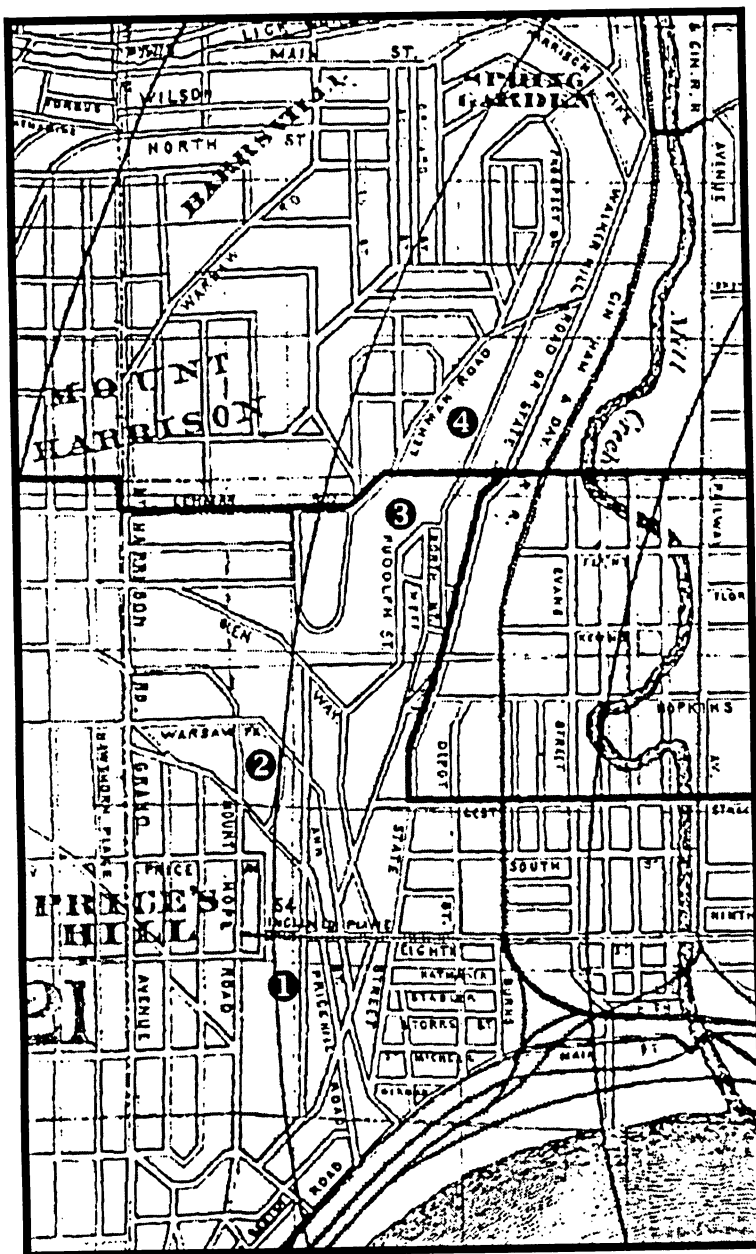


Figure E.5 Note the road (#1) that extends from Elberon to Glenway located above lower Price Hill Road (Maryland Avenue). The road has probably been located near the break in slope between the soils associated with the Kope and Fairview. Sporadic evidence exists in the field consisting of several man-made benches that may have been an attempt to construct this road. The two roads (#2) connecting Maryland and Warsaw no longer exist today. In the Neff Subdivision, Rudolph Street (#3) connects to Glenway Avenue. The lower street (#4) in the Neff Subdivision (Bowman) is depicted running all the way to Lehman Road. From the 1875 D.J. Kenny New Map of Cincinnati and Suburbs, the Collection of the Cincinnati Historical Society.

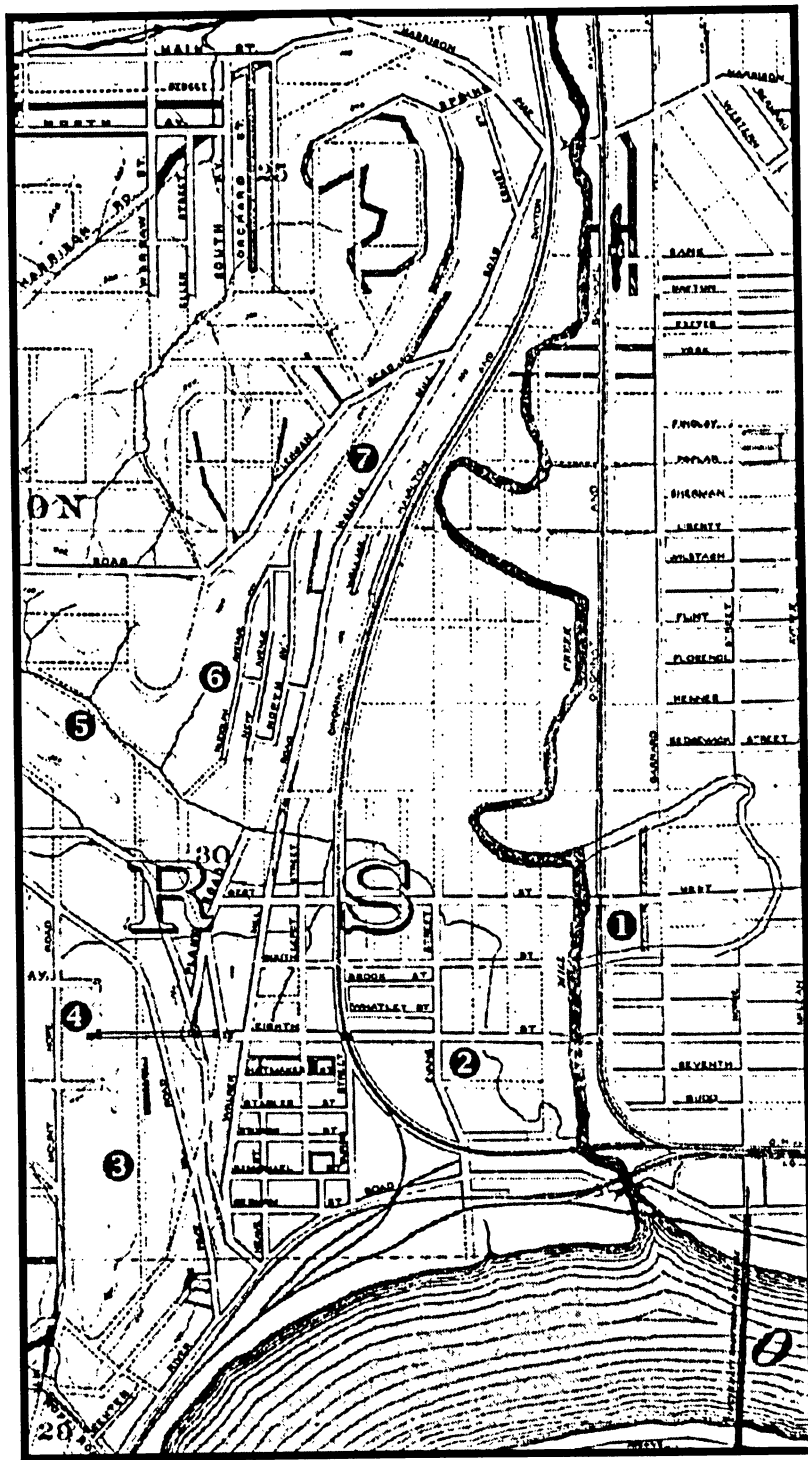


Figure E.6 This map shows a large meander loop (#1) of the Mill Creek has been eliminated. Note the creek system (#2) that drains the middle of the study area and follows the paths of upper Glenway, Warsaw, and Maryland Avenue. In this map, the street (#3) above Maryland Avenue is dashed probably indicating that it is planned. Note the Incline (#4), Glenway dashed in (#5), Rudolph Avenue is not dashed (#6), and the connector from Neff Subdivision to Lehman is dashed (#7). From 1876 A.E. Tripp, C.E. Map, the Collection of the Cincinnati Historical Society.

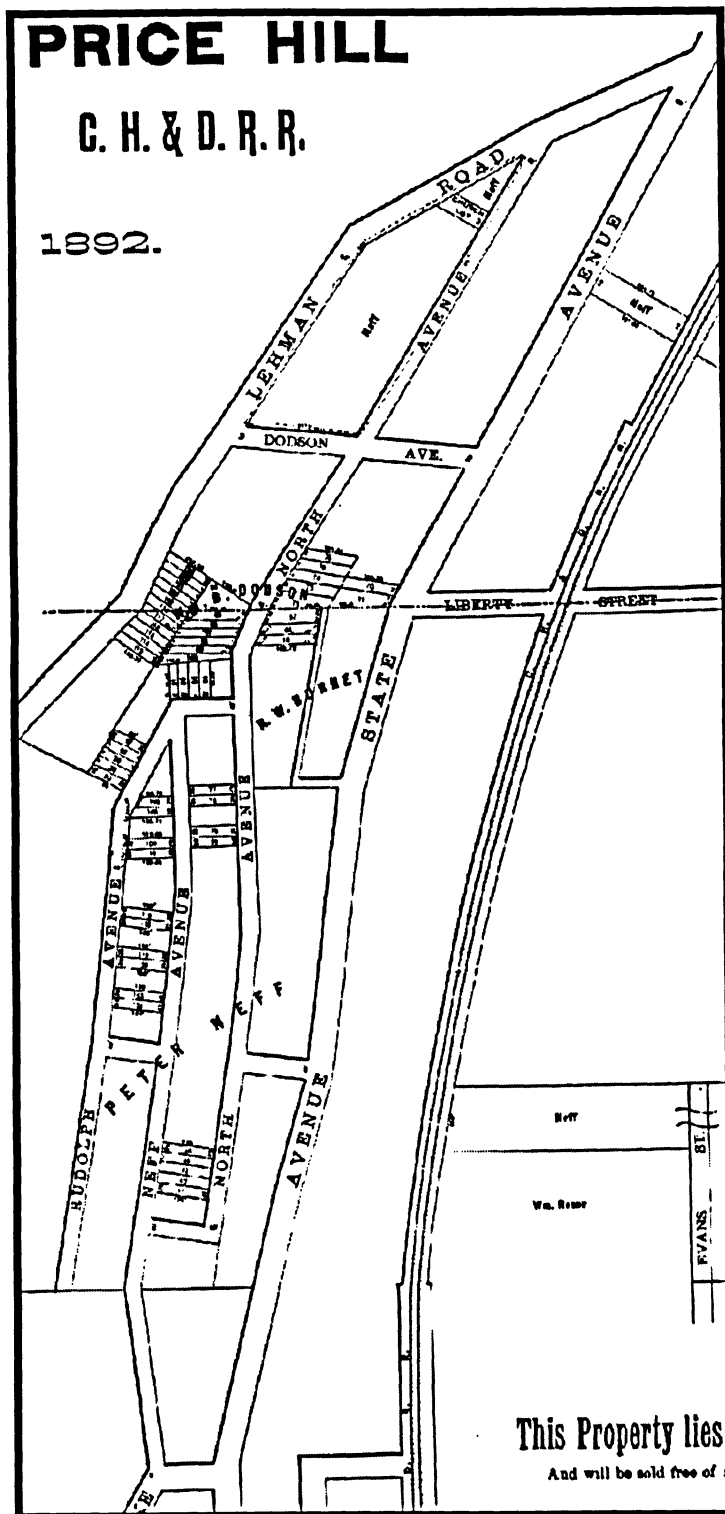


Figure E.7 This is a map advertising for sale “Fine Building Lots on Price Hill” in the Neff Subdivision. Note the alley/street located under R.W. Burnet and the parcels in the Wm. B. Dodson Subdivision. Note North Avenue (today known as Bowman & Shelby) crosses a street called Dodson and runs north to Lehman. From 1892 Assignee’s Sale, Wm. Howard Neff Property, Collection of the Cincinnati Historical Society.

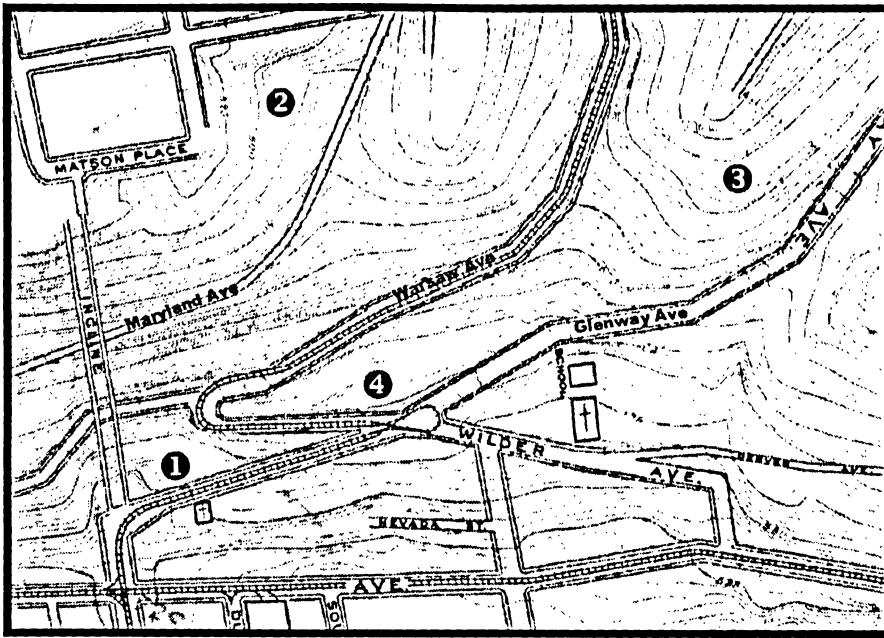


Figure E.9 City of Cincinnati Topographic Survey of 1912. Location #1 is the site of a landslide in 1910. Note the “squared off topographic contours” in upper Maryland Avenue (#2). Note the flattening of the slope (contours spread apart) above and below Warsaw Avenue at midslope. Between Warsaw and Glenway Avenue is deep landslide today (#4). The bench (#3) above Glenway Avenue is the location of a former quarry.

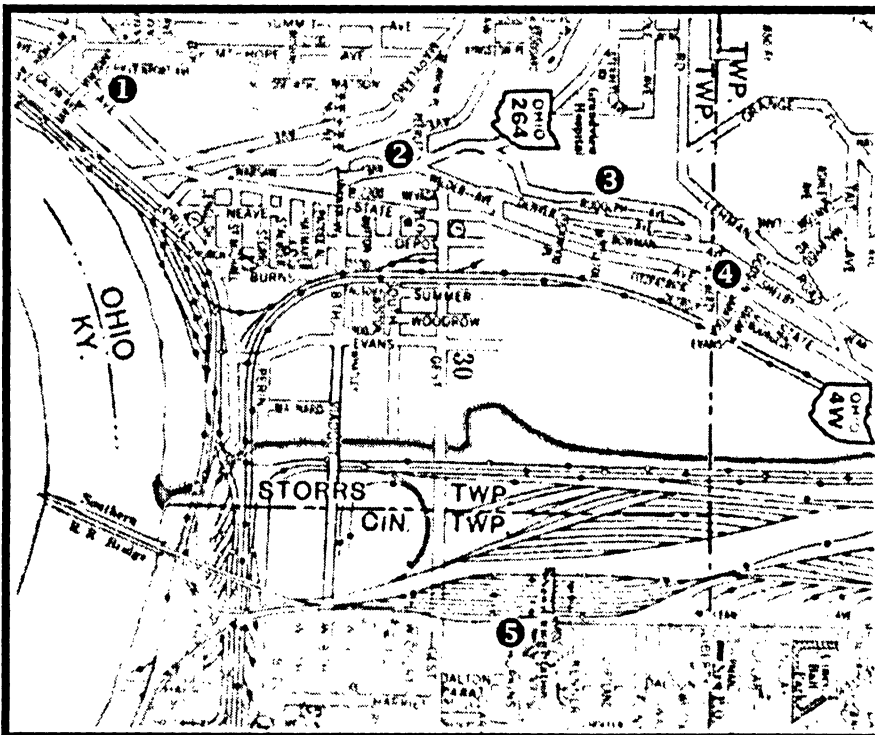


Figure E.10 1930's Sohio Road Map showing New Union Station (#5). Davenport (#1) is shown connecting to Ansonia, which runs between Mt. Hope and Elberon. Peerless (#2) is a paper street today. Again, Rudolph (#3) is clearly shown connecting to Glenway. Bowman (#4) is clearly shown crossing Dodson and connecting to Shelby.

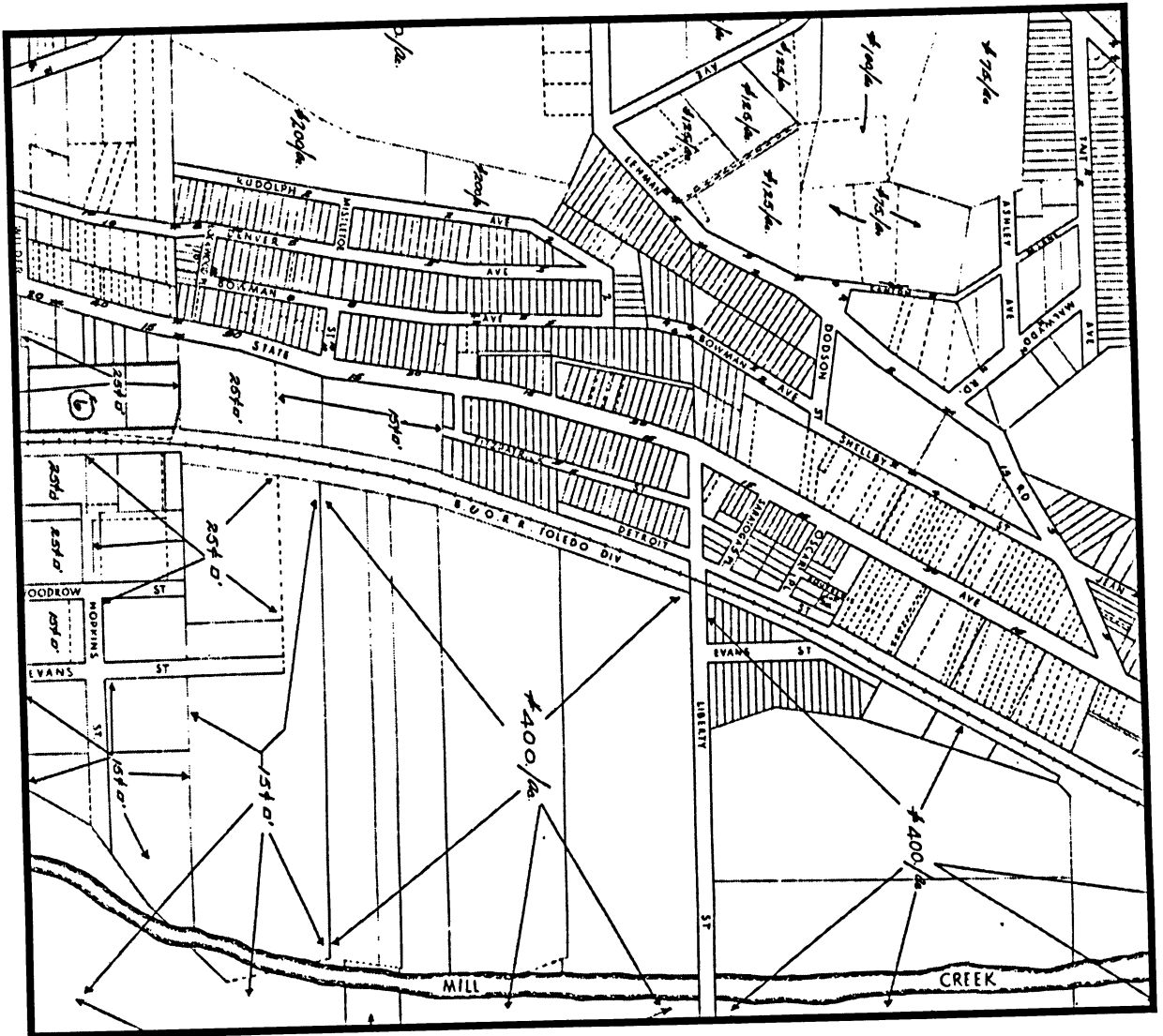


Figure E.11 The 1937 Hamilton County Auditor's map clearly shows the Mill Creek straightened and the road pattern at the northern end of the study area. Map courtesy of Jack Osterbrink.

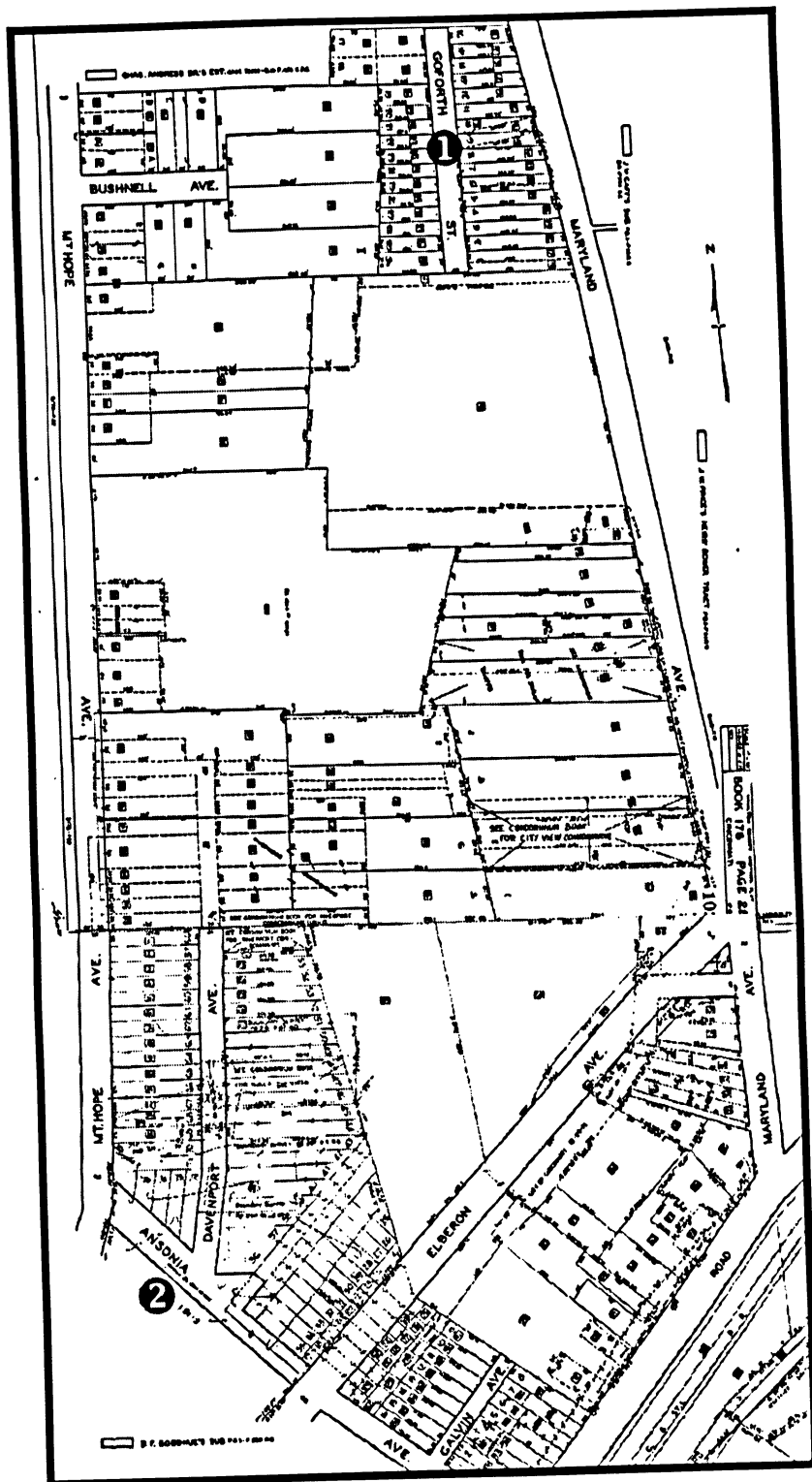


Figure E.12 Current Hamilton County plat record showing Goforth paper street (#1) with upslope “landlocked” residential parcels. This map also show Ansonia (#2) which at one time was a street used to access Davenport and connected Mt. Hope to Elberon. The northern end of Davenport is an undedicated street.

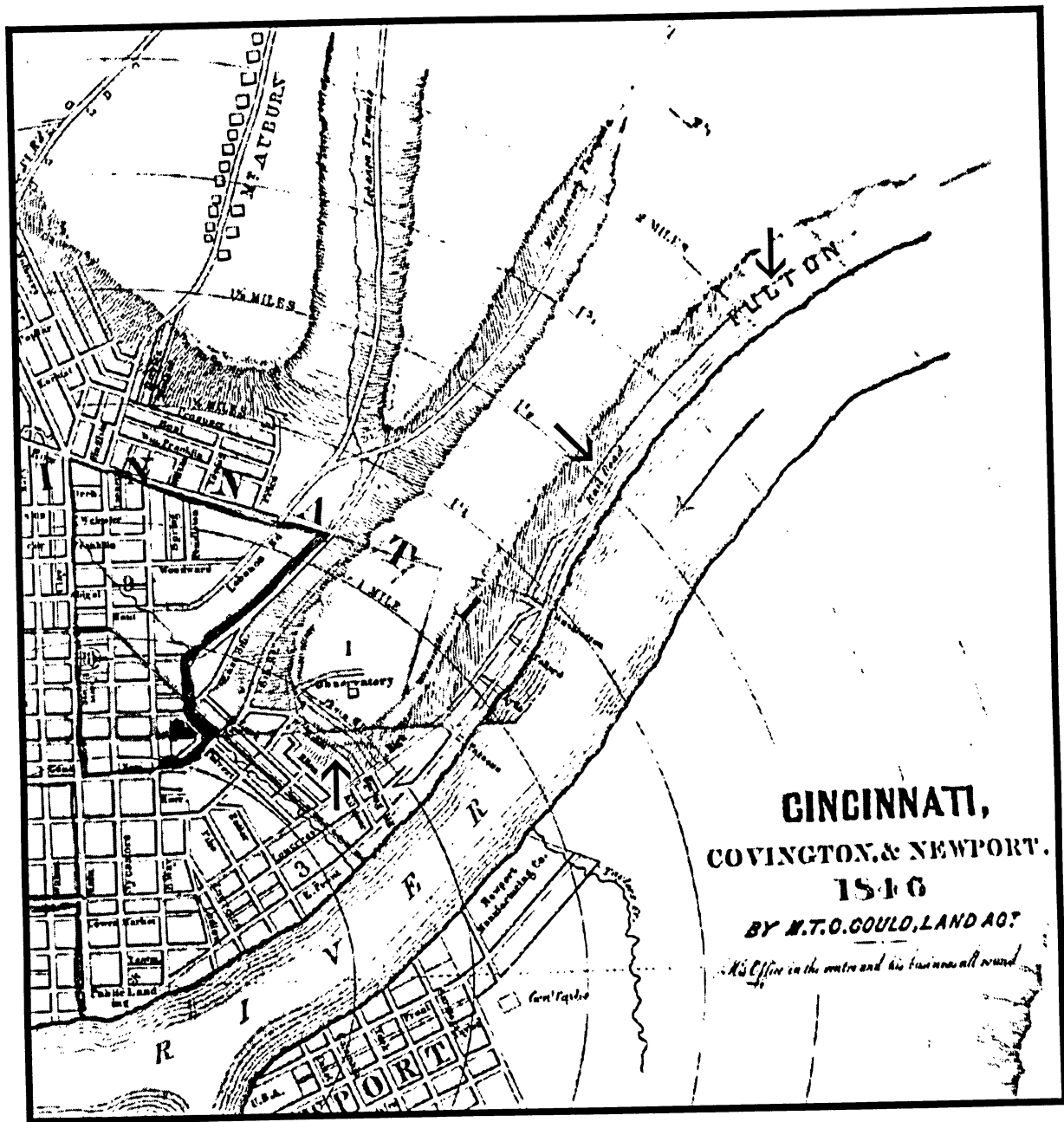


Figure E.13 The arrow on the left show roads on the Mt. Adams hillside in the area of a deep landslide in the 1970's. The middle arrow shows the location of early railroad tracks located midslope on the hillside. The right most arrow points out the town of Fulton that ran from just east of downtown Cincinnati all the way to the Columbia-Tusculum area near Lunken Airport. Fulton was a town known for its steamboat construction. From the 1846 Williams Cincinnati Directory, the Collection of the Cincinnati Historical Society.

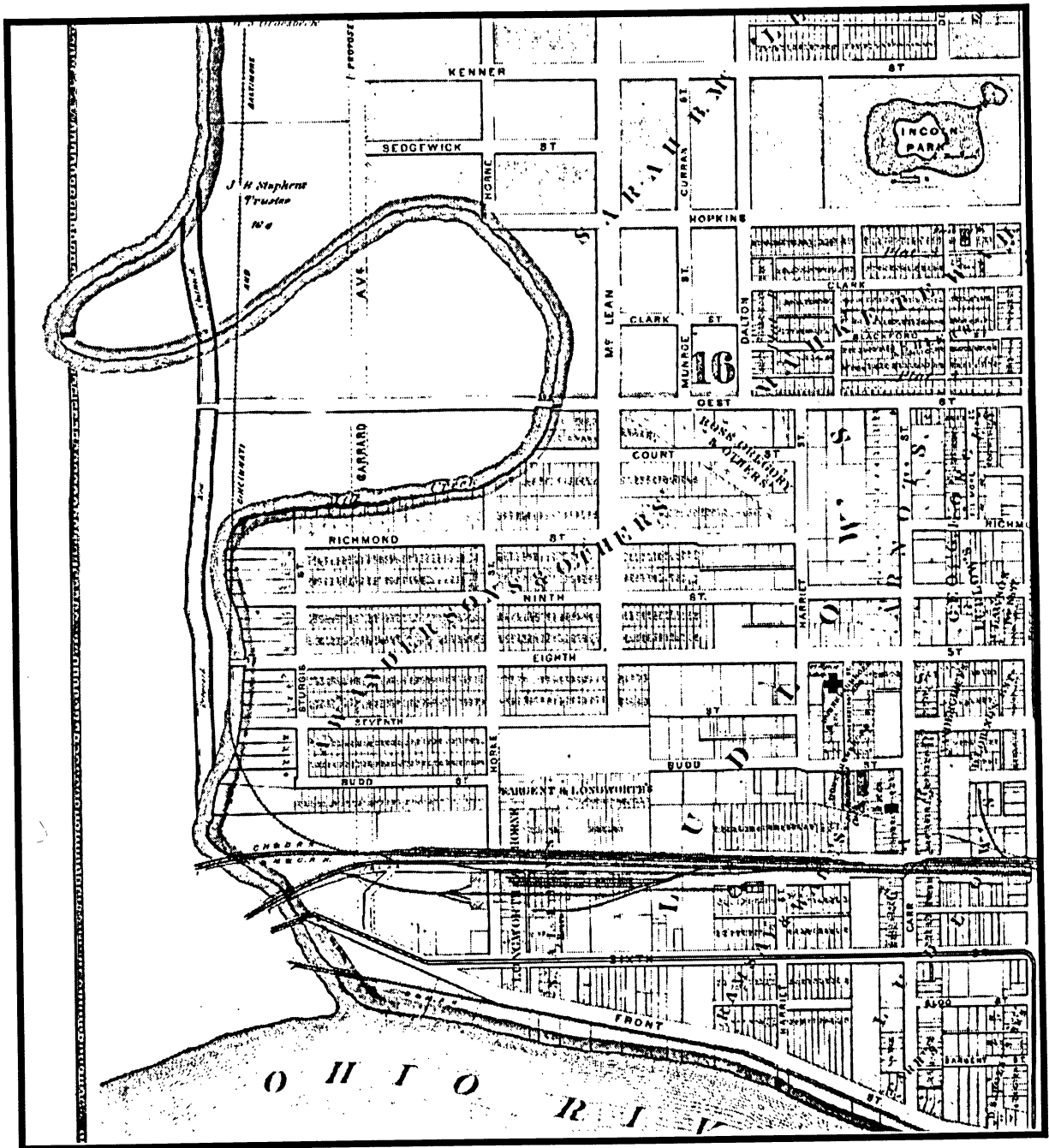


Figure E.14 Map shows a portion of the soon to be straightened and channelized Mill Creek. In the upper right corner is Lincoln Park future site of an asphalt parking lot and driveway for Union Terminal. From the Titus' Atlas of Hamilton County Ohio, 1869.

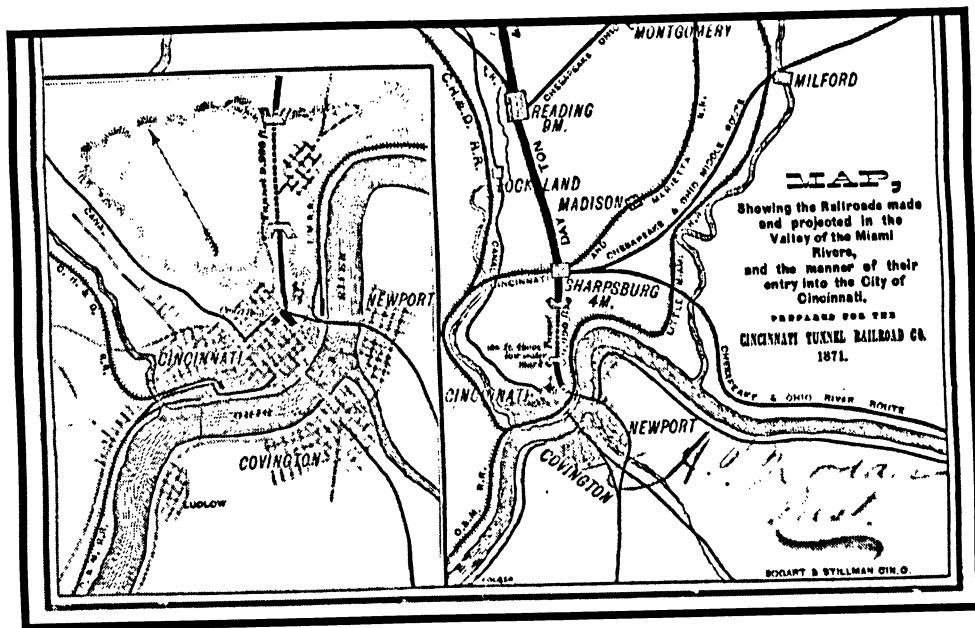


Figure E.16 Map showing railroads and proposed 9900' rock tunnel northeast of downtown Cincinnati in 1871. From the personal collection of the author.

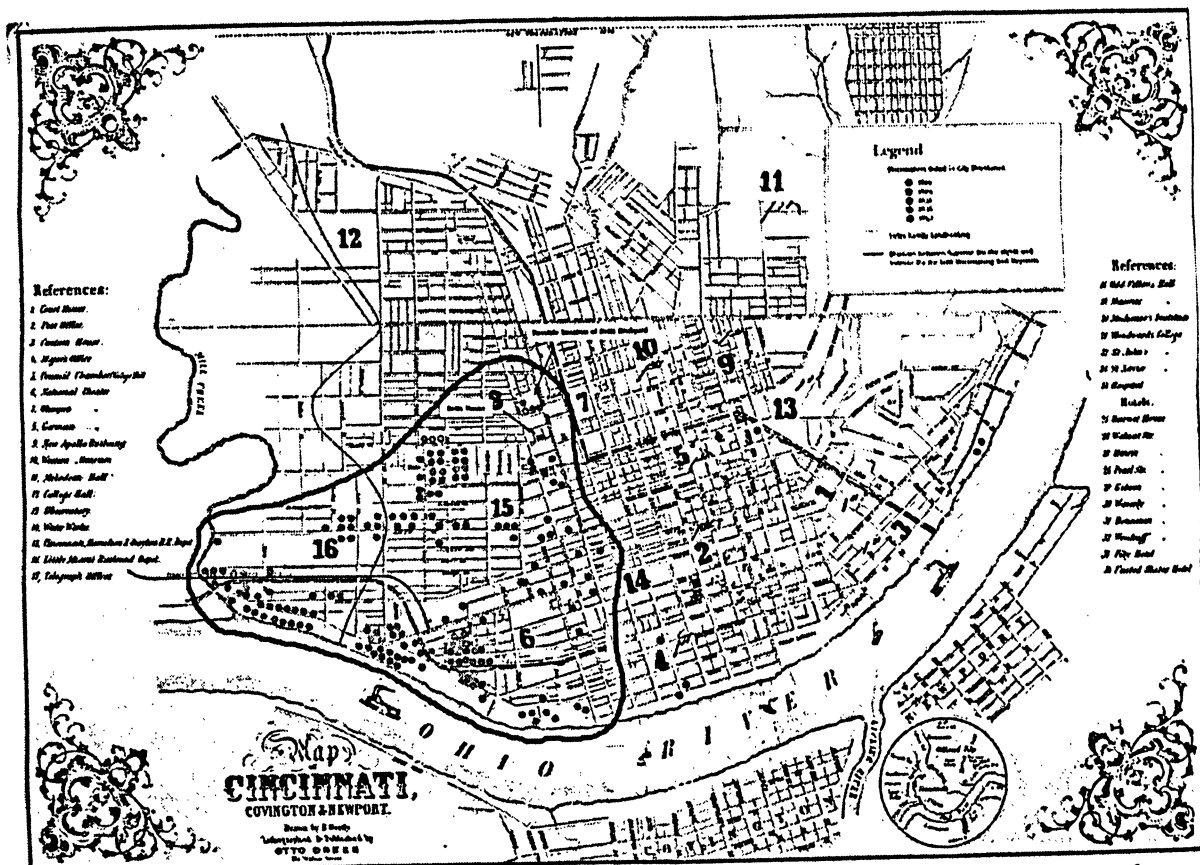


Figure E.17 Map showing location (dots within outlined area) of brick yards in early 1800's. Most of the yards utilized the alluvial clay deposits in the valley. An exception was the dry brick process that utilized shale. One such plant was reported on the western side of the Mill Creek Valley in the vicinity of Cincinnati by Fenneman (1916).

APPENDIX F: ILLUSTRATIONS & PICTURES

This appendix contains various historic and recent pictures along with the historic document below.

Listed below is a record of the water main from May 2, 1966 to April 26, 1970. This goes from the time the main broke in the original right of way until the main in the new right of way was removed from service.				
5/2/66	Six-inch water main removed from service due to break, probably caused by heavy fill placed over main.			
9/14/67	New six-inch line placed in service from Clifton to Renner. New main was installed in relocated R/W.			
5/22/68	Main line leak repaired.			
5/31/68	"	"	"	"
2/10/69	"	"	"	"
2/19/69	"	"	"	"
4/30/69	"	"	"	"
9/24/69	"	"	"	"
9/29/69	"	"	"	"
10/1/69	"	"	"	"
4/6/70	"	"	"	"
4/7/70	"	"	"	"
4/8/70	"	"	"	"
4/20/70	"	"	"	"
4/26/70	Main line leak; main removed from service.			
All the leaks listed on the new line were joint leaks due to ground movement. There were no pipe ruptures.				

Figure F.1 Water main repairs associated with Clifton Avenue landslide.
From the City of Cincinnati.

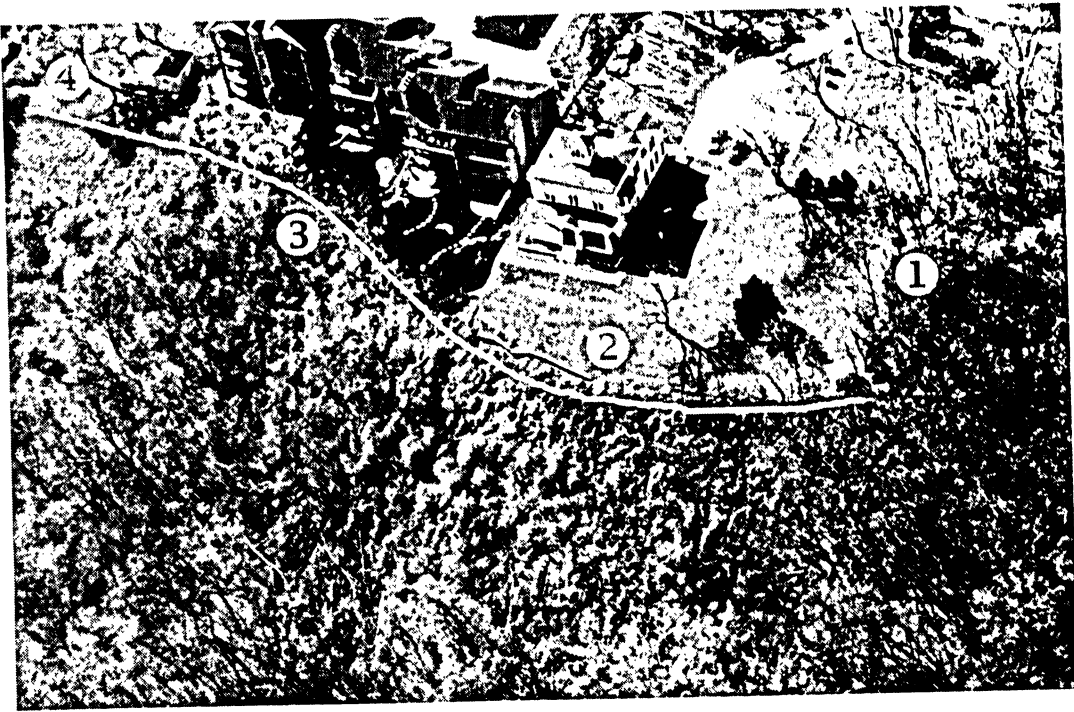


Figure F.2 Oblique aerial photograph. Area 1 is the northern end of the Goodhue Rock Quarry. The white line follows the crest of the hillslope. Note in area 2 the crest of the hillslope is concave in and in area 3 concave out. Below area 3 is a large landslide slump. Area 4 is the location of the photographs from Figure D.14.

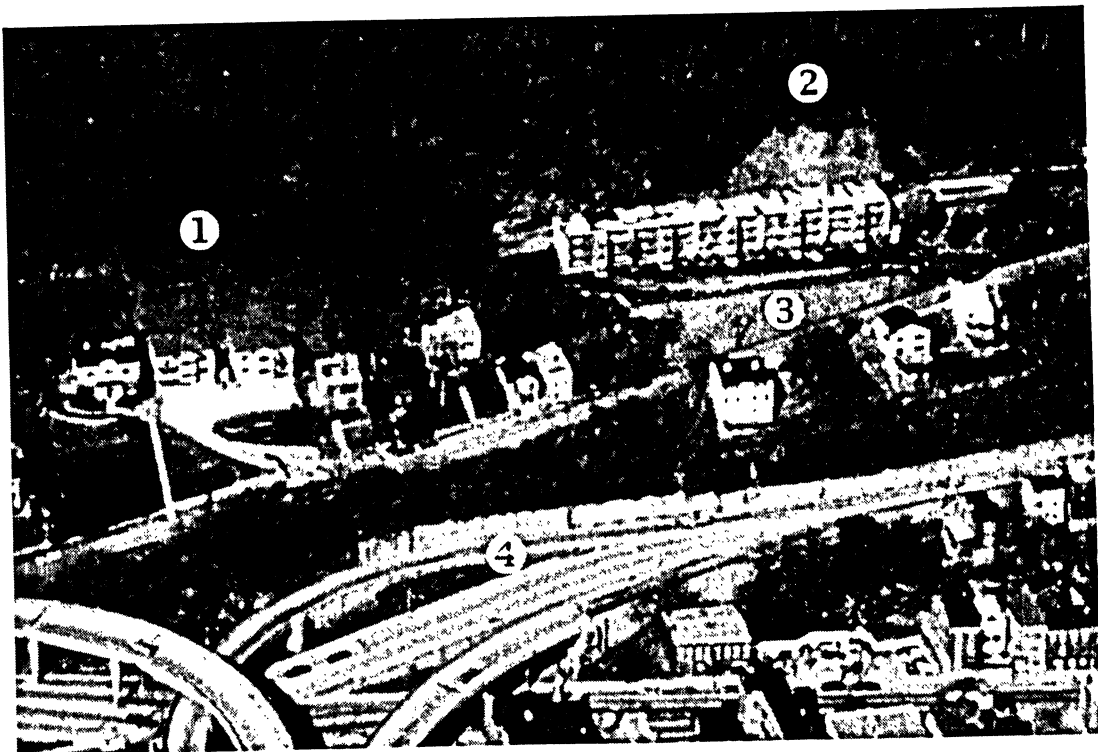


Figure F.3 Oblique aerial photograph taken in 1992. Area 1 is the location of a landslide that occurred in 1982. Below area 2 is a landslide slump that came to within one foot of the apartment building. Area 3 exhibits slump characteristics today. Area 4 is the Warsaw-Waldvogel Viaduct wall panels. Courtesy of City of Cincinnati.



Figure F.4 Construction of the Warsaw-Waldvogel Viaduct in 1950.

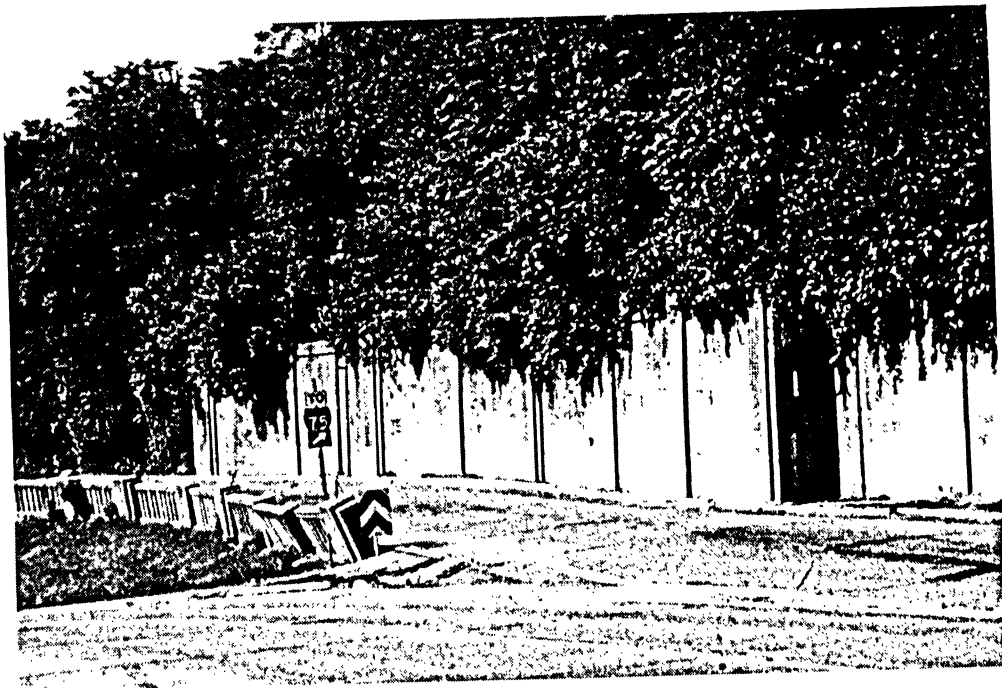


Figure F.5 Warsaw-Waldvogel Viaduct. Picture taken in 1990. Note the concrete railing is tilted out due to ground movement. Compare to Figure F.4. Photograph courtesy of the City of Cincinnati.

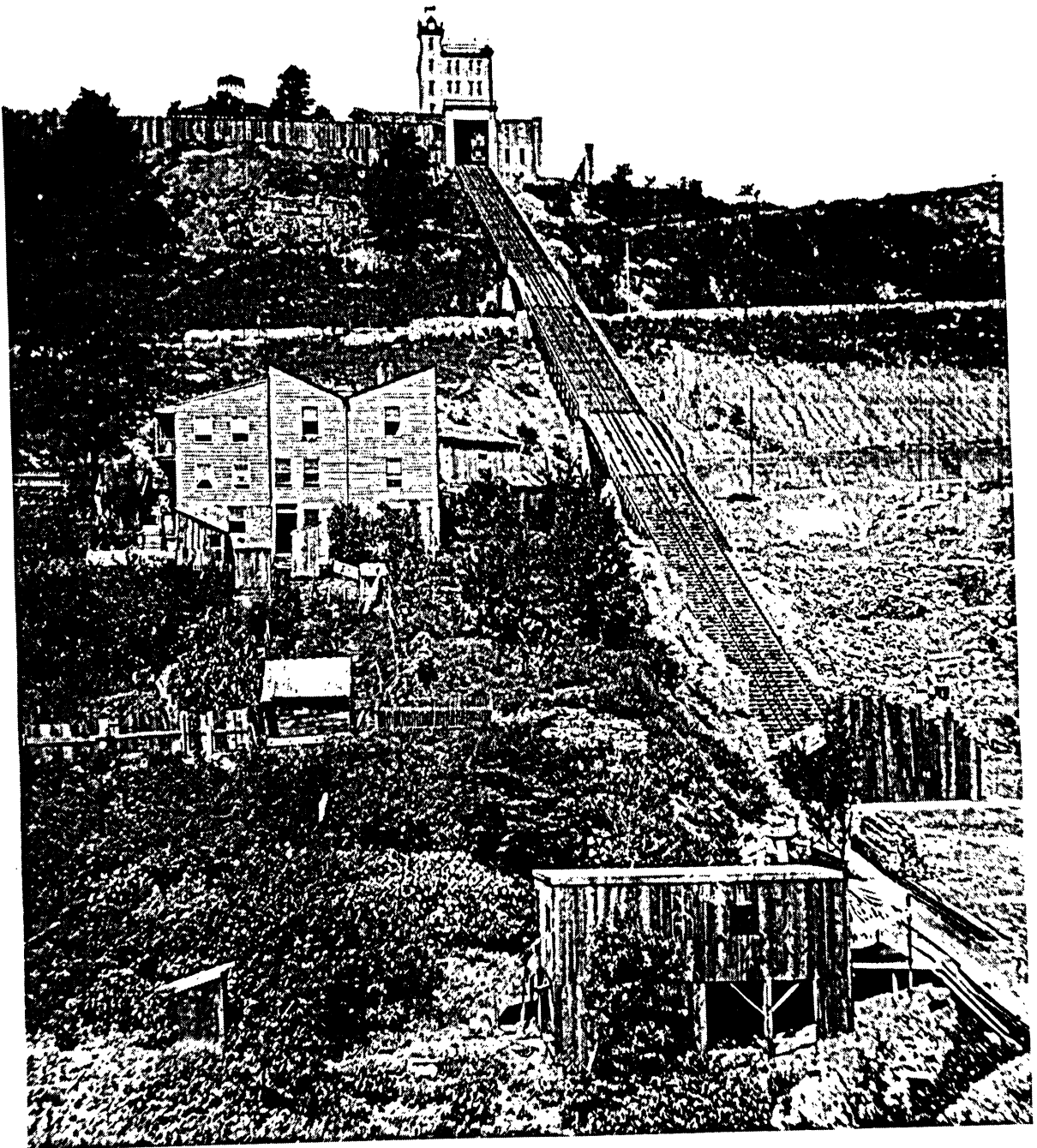


Figure F.6 Early photograph (1869-70) showing the passenger side of the Price Hill Incline. The Price Hill Incline had separate passenger and freight tracks. The freight track for the Incline has not yet been constructed. The Incline crosses over Maryland Avenue near the top of the photograph and the road in the middle of the photograph is Warsaw Avenue. The Kope formation appears to be exposed between Maryland and Warsaw Avenue north of the Incline. Note the sheet piling at the bottom of the Incline track for the access pit that's below grade. Also note the rubble below Warsaw Avenue on the hillslope north of the Incline. The Incline was in operation from 1873-1943. From the Cincinnati Historical Society collection.



Figure F.7 Upper photograph (1910) shows toe of landslide on Glenway Avenue just north of the Incline. Lower two photographs (early 1900's) show the widening of Glenway Avenue and the toe of the hillslope and/or the landslide mass being excavated below the bend in Wilder Avenue. From the Cincinnati Historical Society collection.

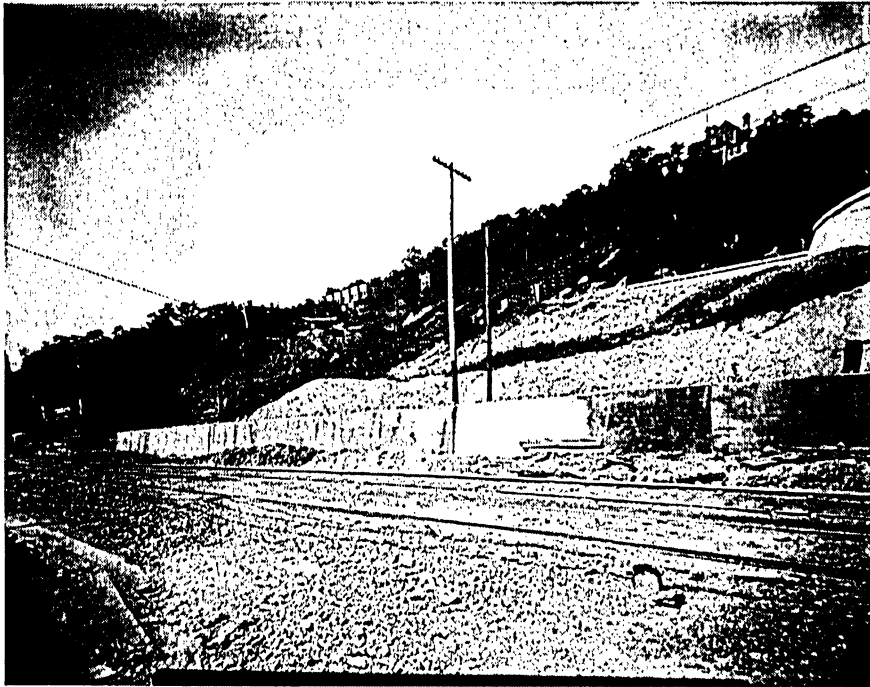


Figure F.8 Foreground is Glenway Avenue. Upper right of photograph shows Wilder retaining wall. Photograph taken looking southwest towards the Incline. From the Cincinnati Historical Society collection.



Figure F.9 Glenway Avenue near the base of the former Incline looking northwest away from the former Incline location. Compare to Figure F.7 and F.8.



Figure F.10 Area 1 is a buttressed limestone wall above Maryland Avenue and located below the Goforth Street terrace. Area 2 is the Incline house. Photograph courtesy of the University of Cincinnati.

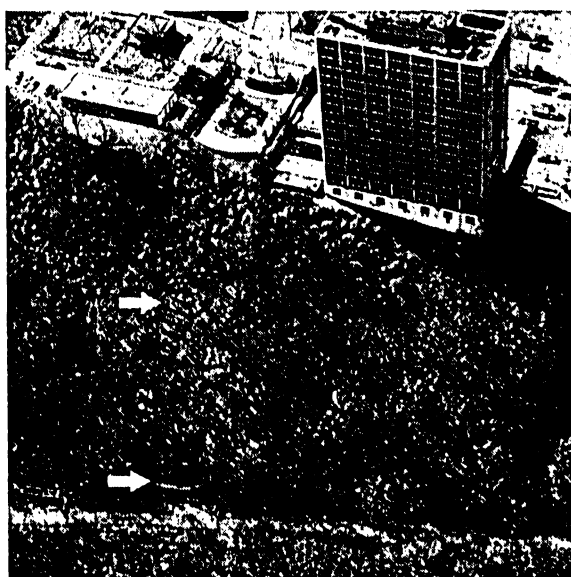


Figure F.11 Road in lower portion of the oblique aerial photograph is Maryland Avenue. Arrows point to the abutments remaining on the hillside that supported the Incline. Queens Tower is at the top of the hillside.



Figure F.12 West View Condominiums (arrow) as seen from the Mill Creek Valley looking towards the west. This is the former site of a rock quarry.



Figure F.13 Warsaw Avenue in 1992 prior to pier wall correction project by the City of Cincinnati. Disheveled nature of the sidewalk is indicative of landsliding. The ground surface below Warsaw Avenue in this area is indistinct. Photograph courtesy of the City of Cincinnati.



Figure F.14 Oblique aerial photograph of the Cincinnati Bible College parking lot and hillslope above Neff Street. A large portion (area outlined in white) of the parking lot drains down the hillside onto a highly disturbed area. Note the pier wall in front of the building in the upper left corner of the photo. Also note the swimming pool for an apartment building in the lower right corner empties onto the hillslope.

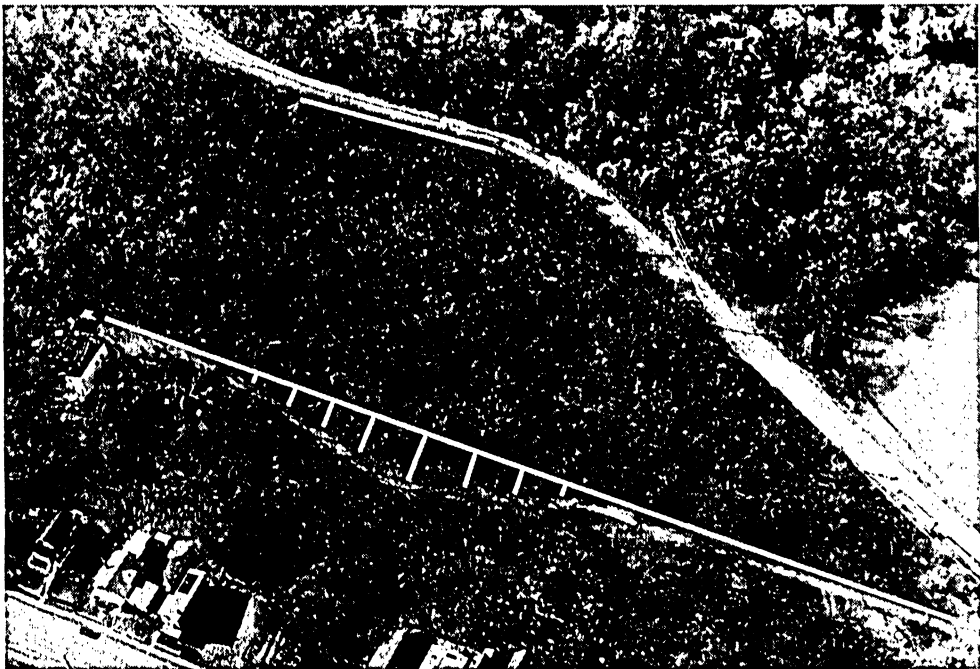


Figure F.15 Oblique aerial photograph of Shelby Road below Lehman Road. Upper white line below Lehman Road is an area where surface water sheets over the curb and onto the hillslope. The lower white lines emphasize the bulge in Shelby Road which is a gravel road.

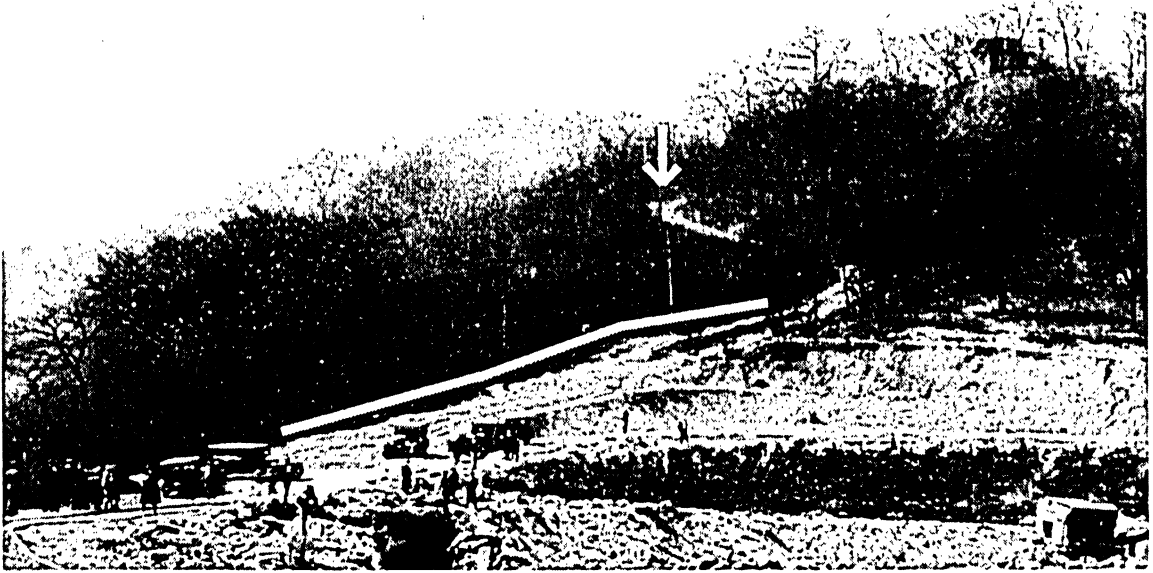


Figure F.16 Photograph taken in 1930 looking southwest up Lehman Road (arrow). White line is above area that appears to be fill placed to widen Lehman Road. Hillslope cut in right foreground of photograph was partially filled in with uncontrolled fill in the 1980's. Photograph courtesy of the University of Cincinnati.

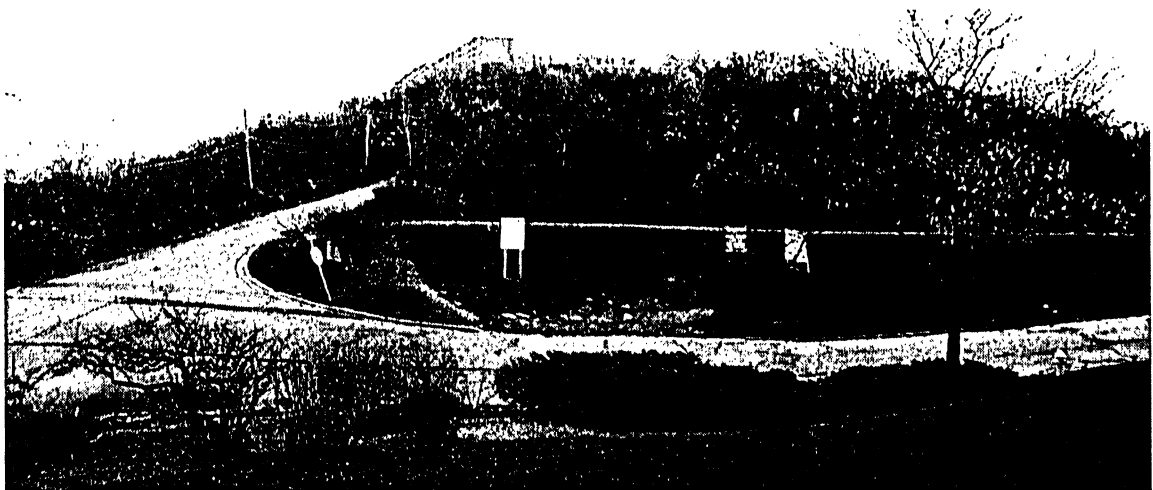


Figure F.17 Foreground is Radcliff Drive. Road on left side of photo is Lehman Road. Level area in middle ground is uncontrolled fill placed in area excavated for the Union Terminal project. Compare to Figure F.16.

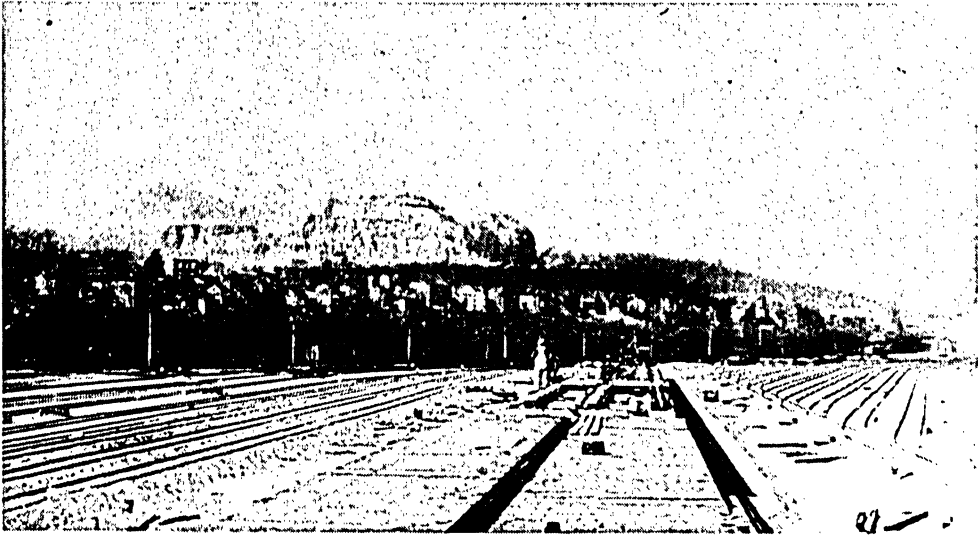


Figure F.18 Bald Knob as viewed from the Mill Creek Valley in 1930. Bald Knob was probably worked for limestone prior to the Union Terminal project. Photograph courtesy of the University of Cincinnati.



Figure F.19 Bald Knob as seen today from the Carew Tower.

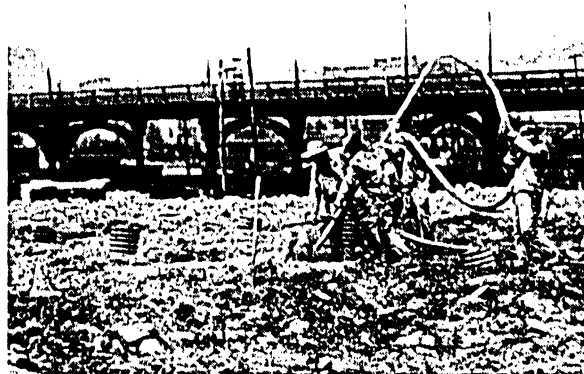


Figure F.20 Hydrocompaction of excavated Bald Knob shale in the Mill Creek Valley. Photo courtesy of the University of Cincinnati.



Figure F.21 A rare photo taken from Bald Knob showing quarry spoils (gray shale, light areas on the hillslope) placed down slope of a rock quarry in Clifton. Photo courtesy of the University of Cincinnati.



Figure F.22 Photograph taken from the Carew Tower. White outline delineates the area of the Clifton Avenue landslide. Compare the vegetation cover on the hillslope to Figure F.21.



Figure F.23 Columbia Avenue in the early 1900's. Photo courtesy of the University of Cincinnati.

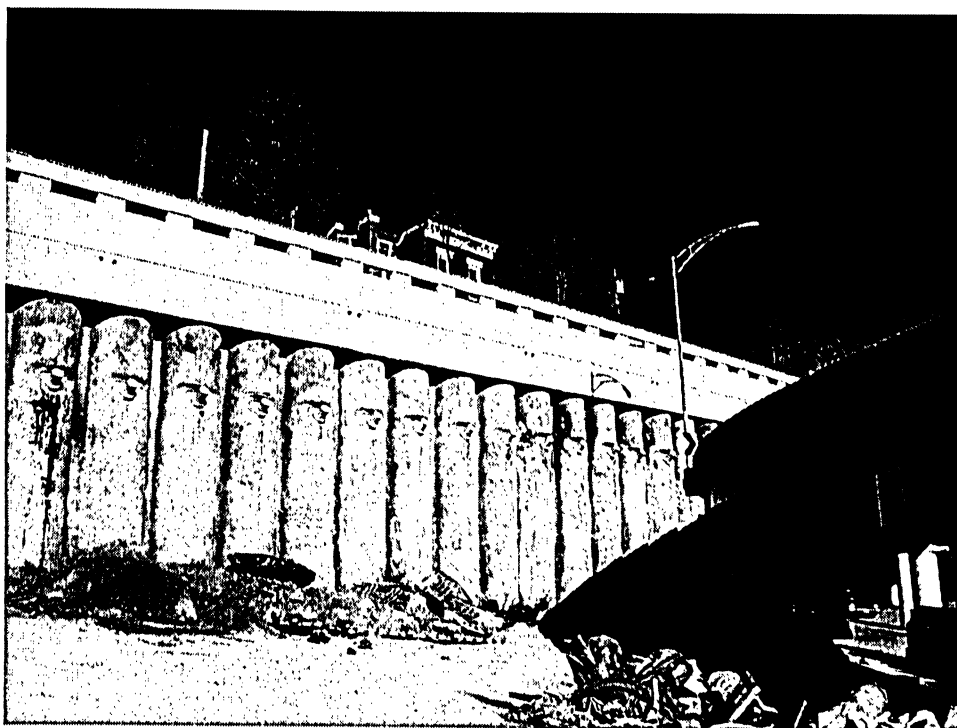


Figure F.24 Mt. Adams pier wall. At one time this was one of the costliest landslides in the United States. On the right of the photo is I-471, the reason the toe of the hillslope was excavated.

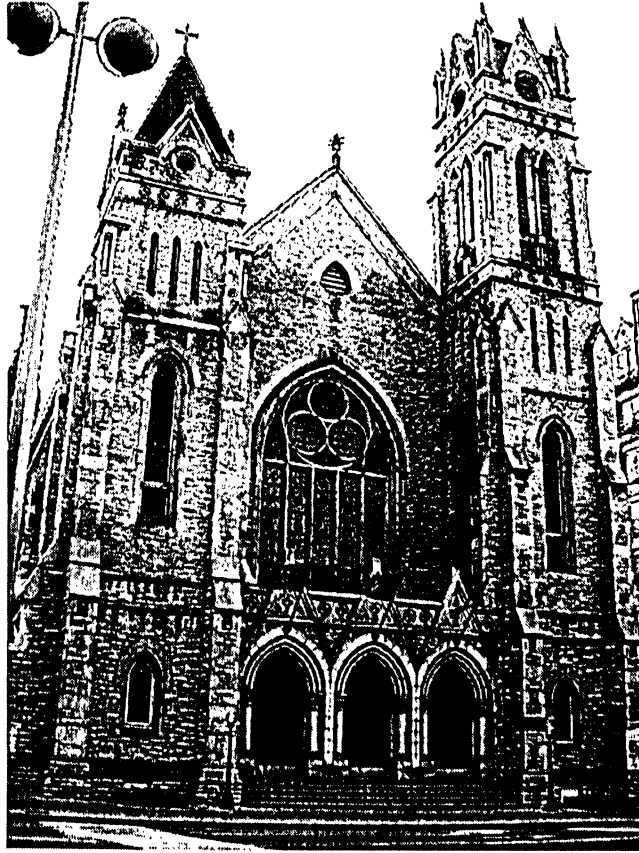


Figure F.25 Limestone for the Covenant-First Presbyterian Church built in 1875 came from the Neff Quarry located on the Cincinnati Bible College property.



Figure F.26 Paver brick found above Maryland Avenue on the undeveloped hillside.

APPENDIX G: HISTORICAL DATES

Appendix G represents the CAGIS database for the historic layer and includes paper streets, roads, subdivision, major construction projects and housing data. The data set contains most of the housing and major historical dates with in the study area.

APPENDIX G: HIST. DATES				DATE SOURCE	REMARKS
ID	CONST. ACT.	HIST. DATE	NAME		
1	Paper Street		Peerless	Cagis plat, Sohio Map 1930's	Connects Glenway to Warsaw
2	Paper Street		Unnamed Alley 1	Cagis plat	Connects Glenway to Wilder
3	Paper Street	1860's	Goforth	Titus Atlas Map 1869	Access to Maryland located @ S end or at midpoint
4	Paper Street		Plane Alley	Cagis plat	Follows border of former quarry
5	Paper Street	1892-	Unnamed Alley 2	1892 survey plat	Below Bowman
6	Paper Street	1869-	Morrow Place	Titus Atlas Map 1869, 1875 Kenny Map	Connects Maryland & Warsaw, proximate location
7	Paper Street	1862-	Goodhue	Williams Cinti Dir. 1862 & 1863, 1869 Titus Map	Connects Mt Hope & Maryland, maybe loc. S of plot
8	Paper Street	1860's	Mistletoe	Titus Atlas Map 1869	Connects Rudolph to Neff
9	Paper Street	1860's	Rudolph	1892 plat, 1875 Kenny M, 1869 Titus M, 1900 M,	1876 Tripp M, 1930's Sohio M, Part. topo bench still preserved
10	Paper Street	1869-	Neff Ext.	1875 Kenny Map, 1869 Titus Map	Connects Rudolph & Dodson
11	Paper Street	1892+/-	Dodson 2	1892 survey plat	Connects Neff to Lehman
12	Paper Street	1875-	Bowman	1875 Dodson plat, 1875 Kenny Map, 1892 plat	Also called North St, little preserved of road
13	Paper Street	1875-	Dodson 1	1875 Dodson plat, 1892 plat	Connects Lehman to State
14	Paper Street	1892+/-	Robert Avenue	1892 survey plat	Lower portion visible 1912 topo, proximate loc.
15	Paper Street	1875	Rudolph Ext.	1875 Kenny Map, etc.	Connects Neff Subdivision to Glenway
16	Paper Street	1862	Unnamed Road	Williams Cinti Dir. 1862	West of Lehman
17	Paper Street	1862	Unnamed Alley 3	Williams Cinti Dir. 1862	West of Lehman
18	Paper Street	1862	Unnamed Alley 4	Williams Cinti Dir. 1862	West of Lehman
101	Road	1820+/-	Lehman Road	Article, PH Historical Soc., Housing 1825	1 of 3 early roads up hillside, probably the 1st
102	Road	1869	Shelby Road	1869 Titus Atlas Map etc, House 1880	House @ end of St dated 1880, gravel road
103	Road	1800's	State Avenue	Various	Early 1800's, 8th & State site of Price development
104	Road	1860's	Neff	Titus Atlas Map 1869, Housing 1880	Dedicated in 1888, site of Civil War Officers Quarters & Hospital
105	Road	1860's	Bowman	Titus Atlas Map 1869, Housing 1880	Dedicated in 1888,
106	Road	1892	Neff Ext.	1892 plat	Probably predates 1890
107	Road	1862	Wilder Avenue	Williams Cinti Dir. 1862, Housing 1875	Includes Gest Street
108	Road	1869	Wilder Ext.	Titus Atlas Map 1869	
109	Road	1869	Glenway Ext	Titus Atlas Map 1869	
110	Road	1875	Glenway Avenue	1875 Kenny Map, Housing 1865?	Reported as difficult ravine to traverse pre 1875
111	Road	1820+/-	Warsaw Road	PH Historical Society, Housing 1865	1 of 3 early roads, probably 2nd, early toll road
112	Road	1820+/-	Maryland Avenue	PH Historical Society, Housing 1865	1 of 3 early roads, upper portion closed due to LS
113	Road	1895	Elberon Road	PH Historical Society, Housing 1875?, 1895	Connected Mt Hope to Maryland
201	Subdivision	1860's	Goforth Subdivision	Titus Atlas Map 1869	Upper portion may have been site of small quarry
202	Subdivision	1860's	Neff Subdivision	Titus Atlas Map 1869	Site of Civil War Officers barracks & hospital.
203	Subdivision	1875	Dodson Subdivision	1875 Dodson plat	Apt. Bldg. upslope const. 1966
901	Other Const.	1950	6th Street Viaduct	Engineering report	Major road imp. & site of deep LS
902	Other Const.	1870's	Price Hill Incline	Various	Operated from 1873 to 1943
903	Other Const.	1938	Wilder & Glenway Int.	Wall dated 1938	Existed prior to 1938

APPENDIX G, HOUSING DATES							
Dates, complete Maryland (to 2700 block), Bowman, Neff (Denver), & Wilder.							
Address	Street	Age	Bldg Type	Address	Street	Age	Bldg Type
1308	Bowman	1880	Res.	2317	Maryland	1865	Res.
1317	Bowman	1880	Res.	2325	Maryland	1867	Res.
1325	Bowman	1880	Res.	2430	Maryland	1875	Res.
1326	Bowman	1880	Res.	2349	Maryland	1880	Res.
1310	Bowman	1883	Res.	2351	Maryland	1880	Res.
1442	Bowman	1883	Res.	2422	Maryland	1880	Res.
1332	Bowman	1885	Res.	2425	Maryland	1880	Res.
1420	Bowman	1885	Res.	2612	Maryland	1883	Res.
1426	Bowman	1885	Res.	2305	Maryland	1885	Condo
1434	Bowman	1885	Multi-3	2347	Maryland	1885	Res.
1443	Bowman	1885	Res.	2419	Maryland	1885	Res.
1437	Bowman	1891	Res.	2421	Maryland	1885	Res.
1306	Bowman	1895	Res.	2424	Maryland	1887	Res.
1319	Bowman	1896	Res.	2426	Maryland	1887	Res.
1419	Bowman	1900	Res.	2428	Maryland	1887	Res.
1440	Bowman	1900	Res.	2623	Maryland	1888	Res.
1429	Bowman	1905	Res.	2627	Maryland	1888	Res.
1403	Bowman	1906	Res.	2343	Maryland	1890	Res.
1412	Bowman	1908	Res.	2364	Maryland	1890	Condo-2
1421	Bowman	1908	Res.	2392	Maryland	1890	Res.
1401	Bowman	1918	Res.	2362	Maryland	1891	Condo-2
562	Davenport	1873	Res.	2625	Maryland	1895	Res.
542	Davenport	1875	Res.	2629	Maryland	1898	Res.
530	Davenport	1909	Res.	2631	Maryland	1899	Res.
554	Davenport	1983	Condo HR	2633	Maryland	1907	Res.
558	Davenport	1983	Condo-HR	2388	Maryland	1910	Res.
548	Davenport	1990	Condo-HR	2393	Maryland	1910	Multi-2
523	Elberon	1875	Res.	2416	Maryland	1915	Res.
423	Elberon	1890	Multi-2	2630	Maryland	1915	Res.
412	Elberon	1900	Res.	2378	Maryland	1920	Res.
419	Elberon	1905	Res.	2628	Maryland	1922	Res.
403	Elberon	1910	Res.	2634	Maryland	1923	Res.
370	Elberon	1915	Res.	2311	Maryland	1926	Condo
366	Elberon	1922	Res.	2370	Maryland	1928	Res.
2308	Glenway	1865	Multi-2	2639	Maryland	1937	Res.
2344	Glenway	1865	Multi-2	2607	Maryland	1941	Res.
2404	Glenway	1865	Multi-2	2607	Maryland	1941	Res.
2310	Glenway	1875	Multi-2	2801	Maryland	1953	Res.
2324	Glenway	1875	Multi-2	2809	Maryland	1953	Res.
2320	Glenway	1883	Multi-2	2367	Maryland	1967	Apt.
2680	Lehman	1825	Res.	2415	Maryland	1976	Res.
2935	Lehman	1850	Res.	2417	Maryland	1976	Multi-2
2828	Lehman	1865	Res.	2329	Maryland	1988	Condo
2304	Lehman	1875	Res.	2331	Maryland	1988	Condo
2308	Lehman	1888	Res.	2333	Maryland	1988	Condo
2807	Lehman	1896	Res.	2327	Maryland	1989	Condo
2691	Lehman	1966	Apt.	2408	Maryland	1991	Res.
2701	Lehman	1966	Apt.	2410	Maryland	1991	Res.
2700	Lehman	1982	College	2412	Maryland	1991	Condo

APPENDIX G, HOUSING DATES cont.			
Address	Street	Age	Bldg. Type
810	Matson Pl	1964	Apt, HR
2525	Morrow Pl	1892	Res.
494	Mt. Hope	1918	Kulla Viken
1222	Neff	1880	Res.
1300	Neff	1880	Multi-2
1207	Neff	1884	Res.
1263	Neff	1885	Res.
1213	Neff	1890	Res.
1219	Neff	1890	Res.
1234	Neff	1890	Res.
1209	Neff	1891	Res.
1223	Neff	1895	Res.
1237	Neff	1900	Res.
1232	Neff	1908	Res.
1412	Neff	1908	Res.
1241	Neff	1910	Res.
1239	Neff	1911	Res.
1233	Neff	1915	Res.
1240	Neff	1923	Res.
1244	Neff	1925	Res.
1246	Neff	1926	Res.
2605	Ring Place	1894	Multi-2
2526	Ring Place	1895	Res.
2525	Ring Place	1898	Multi-2
1627	Shelby	1880	Res.
1704	Shelby	1906	Res.
2396	Warsaw	1865	Res.
2350	Warsaw	1870	Res.
2358	Warsaw	1870	Multi-2
2378	Warsaw	1875	Multi-2
2354	Warsaw	1880	Multi-2
2346	Warsaw	1886	Res.
2500	Warsaw	1969	Condo-Apt
2328	Wilder	1875	Res.
2387	Wilder	1875	Res.
2393	Wilder	1875	Multi-2
2404	Wilder	1875	Multi-2
2342	Wilder	1884	Multi-3
2345	Wilder	1884	Multi-2
2391	Wilder	1885	Multi-2
2338	Wilder	1894	Res.
2318	Wilder	1895	Res.
2343	Wilder	1895	Multi-2
2341	Wilder	1900	Res.
2324	Wilder	1915	Res.
2395	Wilder	1920	Multi-2
2336	Wilder	1924	Multi-2
2353	Wilder	1945	Multi-2
2600	Bushnell	1969	Apt.