MEMORANDUM REPORT NO. 156

LAKE PARK BLUFF STABILITY AND PLANT COMMUNITY ASSESSMENT: 2003

MILWAUKEE COUNTY WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

INTERAGENCY STAFF FOR THE LAKE PARK BLUFF STABILITY AND PLANT COMMUNITY ASSESSMENT REPORT

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MILWAUKEE COUNTY, WISCONSIN

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September 2004

Inside Region $ 5.00
Outside Region $ 10.00

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TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

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Chapter I

INTRODUCTION

BACKGROUND

Bluff stability conditions are important considerations in planning for the protection and sound development and redevelopment of lands located along the Lake Michigan shoreline. Bluff stability and shoreline erosion conditions in Southeastern Wisconsin were surveyed in 1977, and subsequently in Racine County in 1978 and 1982, and in Milwaukee County, in 1989 and 1995.[1] However, bluff stability within Lake Park, which used to be the historic shoreline of Lake Michigan, as shown in Figure 1, was not previously assessed due to the construction of Lincoln Memorial Drive (previously Shore Drive), expansion of Bradford Beach and construction of the Linnwood Avenue Water Treatment Plant creating a new shoreline and protecting the park area from direct impacts of the Lake Michigan wave-induced erosion forces. This historic nearshore area comprised within Lake Park offers a variety of recreational opportunities and is an important feature of the communities surrounding this park system.[2]

In April 2002, Milwaukee County requested that the Regional Planning Commission assist the County in an assessment of the bluff stability within Lake Park. Although the bluffs within Lake Park are not subject to wave-induced erosion, these bluffs have demonstrated a history of erosion in selected areas, especially in the southern bluffs that run adjacent to Wahl Avenue (formerly Park Avenue) as shown in Map 1.[3] As part of the bluff stability analysis, a vegetation survey on these bluffs was also included as part of this study, in order to assess the quality and diversity of the existing plant community, which is intimately tied to the long-term bluff stability.

This bluff stability and plant community assessment was prepared over the period from August 21, 2002, through February 17, 2003. This report provides the technical data intended to help guide the development of the Master Plan for Lake Park by the Milwaukee County Department of Parks, Recreation and Culture regarding the protection and long-term stability of these bluffs for future generations.

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[1]*SEWRPC Community Assistance Planning Report No. 163*, A Lake Michigan Shoreline Erosion Management Plan for Milwaukee County, Wisconsin, *October 1989; SEWRPC Technical Report No. 36*, Lake Michigan Shoreline Recession and Bluff Stability in Southeastern Wisconsin: 1995, *December 1997.*

[2]*Planning and Design Institute, Inc.* Milwaukee County Lakefront Park System: North Harbor – McKinley – Lake Park Sites Master Plan Concepts, *November 1989.*

[3]*Information provided by Milwaukee County Department of Parks, Recreation and Culture; and Lake Park Friends.*

Figure 1

WAVE CUT TERRACE AT LAKE PARK MILWAUKEE: 1907

Source: E.C. Case, Wisconsin: Its Geology and Physical Geography, *Hendee-Bamford-Crandall Company, Milwaukee, Wisconsin, 1907.*

STUDY AREA

The Lake Park bluff stability and vegetation community study area was focused on approximately 30 acres of land, comprised mostly within the eastern portions of the park, in Milwaukee County as shown on Map 1. Lake Park is located in the northeast and southeast one-quarters of U.S. Public Land Survey Section 15, Township 7 North, Range 22 East, in the City of Milwaukee. It is about 1.1 miles long northeast-southwest, and varies from about 200 to 1,200 feet in width. There are several paved roads and walkways that provide access to various areas throughout the park, and some open, grassy areas, but the majority of the park has established grass and forest areas. The western part of the park is flat, with the eastern part of the park encompassing about six large ravines ranging from approximately 50 to 80 feet in height. The eastern border of the park is characterized by a steep bluff, which was the historical shoreline of Lake Michigan, as shown in Figure 1 (see also Appendix A).

Lake Park was largely designed by Frederick Law Olmsted and his firm in the late 19th century, and it reflects Olmsted's theory of design by creating public spaces within the contours of existing topographical features. The park accommodates diverse uses, including lawn bowling, pitch-putt golfing, rugby, soccer, softball, tennis courts, picnic areas, nature trails for hiking and bike riding, and restaurant facilities located in a historic pavilion which was rented for special events, such as weddings and receptions. Winter activities include lighted ice skating and cross-country skiing.[4] The foot trail system meanders throughout the park and into the ravines using foot bridges, some paving and lighting, which provides access to unique green space areas for observing wildlife and vistas along the shores of Lake Michigan.

Lake Park provides wildlife and educational opportunities due to its location adjacent to the shores of Lake Michigan, relatively large size that provides significant green space among high-density residential developments, and quality. A variety of mammals, ranging in size from large animals like the northern white-tailed deer to small animals like the gray squirrel, are found within Lake Park. Lake Park has also been documented to contain more than 200 species of birds that consist of both resident breeding populations of birds and migrant birds as shown in Appendix B.[5] Eight of these bird species were listed as threatened or endangered federally and in the State of Wisconsin and 28 bird species are listed as species of special concern within the State of Wisconsin (Appendix B). The park is also part of an important migration corridor for birds in the spring and fall, so it is a very popular place for bird watching. Habitat along the entire Lake Michigan shoreline is an important part of the Central Flyway.[6] For example, bird species, such as peregrine falcons which are federally endangered, use the park at some point as they move along the lakeshore in both resident pairs and migrants (see Appendix B). In

[4]*Planning and Design Institute, Inc.*, op. cit.

[5]*Information provided by Brian Boldt, Tim Vargo, Paul Hunter, and others "Birds in Lake Park," http://home.wi.rr.com/phunter1/lakeparkbirds.html, August 2002.*

[6]Dr. Peter Dunn, Assistant Professor, Department of Biological Sciences, University of Wisconsin-Milwaukee.

Map 1

LAKE PARK BLUFF STABILITY ASSESSMENT LOCATION PROFILES: 2002

Source: SEWRPC.

addition, University of Wisconsin-Milwaukee faculty has been and continues to utilize Lake Park as a standard part of their teaching biological sciences curriculum.

HISTORIC BLUFF PHYSICAL CHARACTERISTICS

Prior to the sale of tribal lands, inclusive of the Lake Park area, to settlers in 1835, the land had to be surveyed. Hence, a government-funded survey was conducted by William A. Burt, Department Surveyor of the Michigan Territory, of the Lake Park area in February 1835. The bluffs along the shoreline of Lake Michigan were described as generally rolling and were about 60 to 80 feet in height, very steep, and erosion slides were observed. In general, the township was dominated by white and black oak, sugar maple, basswood, and beech, as well as other species, including hickory, elm, white ash, ironwood, and aspen.[7] The City of Milwaukee Board of Commissioners described the southern portions of Lake Park as sparsely vegetated and heavily eroded and the northern portion of the park as "well wooded," which corresponds to early drawings of Lake Park and Mr. Burt's original survey notes that described the northern area as "well timbered."[8] This description also agrees with the historic photos depicted in Figures 2 and 3, which show the lack of vegetation on the southern bluffs and well-vegetated northern bluffs within Lake Park, respectively. Mr. Christian Wahl, president of the Board of Commissioners, further described the northern bluffs of Lake Park as "a high plateau skirting Lake Michigan and ending toward the lake in a precipitous bluff from 80 to 100 feet about the water's edge, with more or less a sandy beach below. This plateau is cut at right angles by a number of deep ravines, two of them densely wooded."[9]

The City of Milwaukee announced plans to build Lake Park in 1860 and acquired the land necessary to build it in the year 1890, as well as several other parks in the County, including Riverside, Kosciuszko, Humboldt, Mitchell, and Washington Parks.[10] From 1891 through 1895 Frederick Law Olmsted and his firm developed a design for the Lake, Riverside, and Washington Parks and made frequent visits to review the construction progress during this time. Much of the original design plan, as shown in Map 2, has been constructed and is still currently being maintained, as shown on Map 1. It is important to note that many of the bluffs adjacent to the Lake Michigan shoreline and internal ravines of Lake Park showed signs of instability, primarily by the absence of vegetation on the slopes, as shown in Appendix A. The base of the shoreline bluffs of Lake Michigan were further described as sand beach running the entire length of the park, as shown on Map 3. Over the years, many of the areas within and along the historic shoreline of Lake Park have been modified through both natural and human activities.

Some of the most notable human-related impacts to areas adjacent to, and within, Lake Park include filling of several ravines, as shown on Map 3. As part of the Olmsted's original design, one ravine, as shown on Map 3, was nearly completely filled to create a meadow in 1898 and required 40,000 cubic yards of fill and fertilized with 1,500 cubic yards of barnyard manure.[11] This meadow was subsequently developed into a six-hole golf course in 1903. Most of the grading related to the construction of trails, roads, bridges, and walkways throughout much of the park were completed in the mid to late 1890s.[12] Shore Drive, currently Lincoln Memorial Drive, which runs

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[7]*Information provided by the Wisconsin Historical Society.*

[8]Ibid.

[9]*Christian Wahl, chapter entitled "Public Park System in the City," in the book:* History of Milwaukee County from its First Settlement to the Year 1895, *Volume I, editors, Howard Louis Conrad, 1895.*

[10]*Information provided by the Wisconsin Historical Society and Lake Park Friends.*

[11]*Eighth Annual Park Commission Report (1899).*

[12]*Information provided by Dolores Knopfelmacher,* Fact Sheet: Short History of Lake Park, *August, 2001.*

Figure 2

SOUTHERN BLUFFS OF LAKE PARK ALONG SHORE DRIVE/LINCOLN MEMORIAL DRIVE: 1929 AND 2003

SHORE DRIVE: JULY 17, 1929

LINCOLN MEMORIAL DRIVE: FEBRUARY 11, 2003

Source: Milwaukee County Department of Parks, Recreation and Culture and SEWRPC.

Figure 3

EAST RAVINE ROAD BRIDGE AT THE EASTERN ENTRANCE OF LAKE PARK: 1905 AND 2003

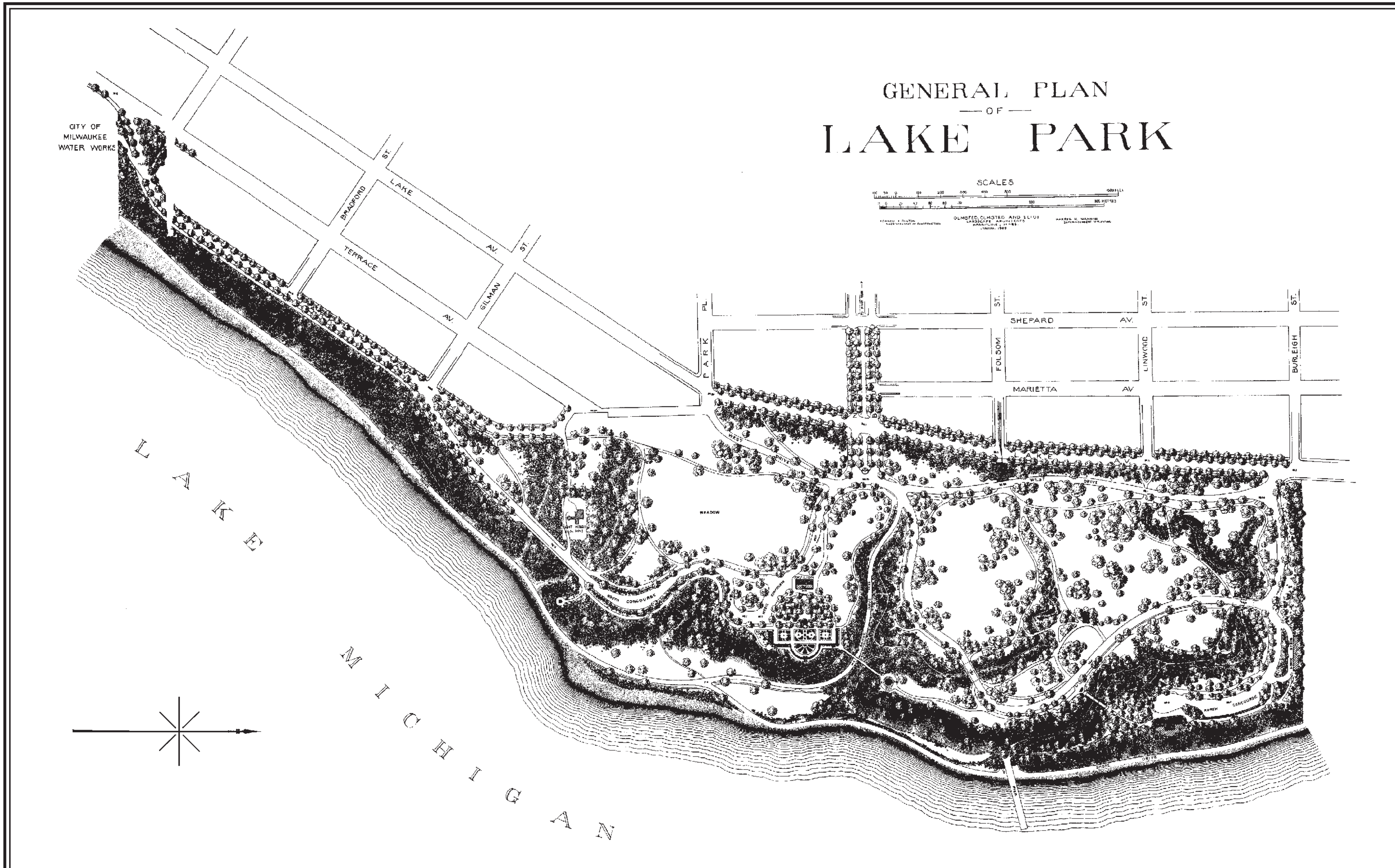
LAKE PARK: 1905

LAKE PARK: 2003

Source: Milwaukee County Department of Parks, Recreation and Culture and SEWRPC.

Map 2

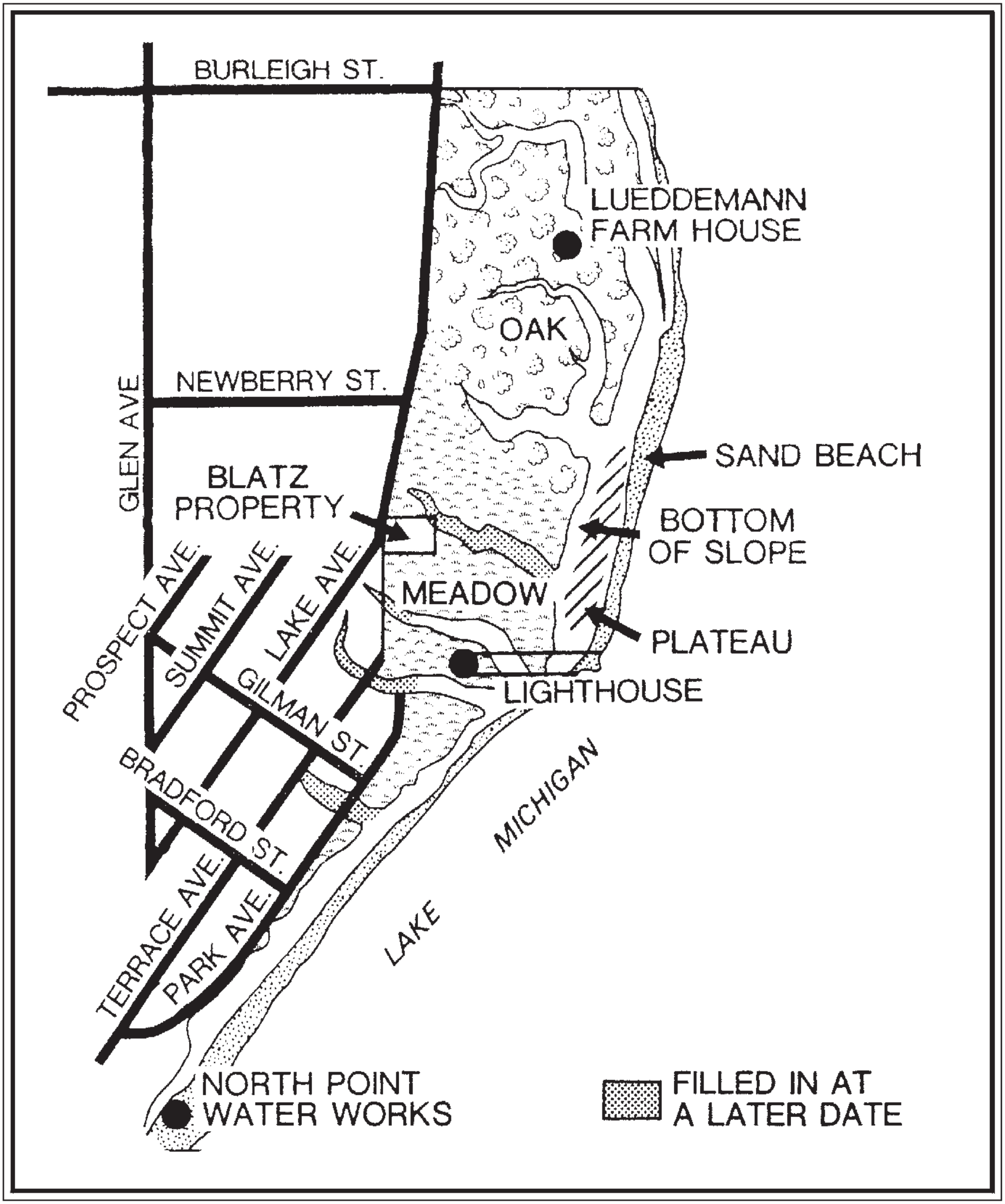
ORIGINAL DESIGN PLAN OF LAKE PARK DEVELOPED BY FREDERICK OLMSTED: JANUARY 1895



Source: Milwaukee County Department of Parks, Recreation and Culture.

Map 3

LAKE PARK TOPOGRAPHIC FEATURES: 1891



Source: First Annual Park Commission Report, 1892.

along the toe of slope of a large portion of the southern bluffs of Lake Park was also constructed during these early years as part of the original design (see Figure 2). Since the construction of this roadway, there have been efforts over the years to protect it from being destroyed by an actively eroding shoreline (see Appendix A, Figures A-1 and A-2). Finally, in 1929 Shore Drive was extended through the north end of the Park and renamed Lincoln Memorial Drive. More recently, Lincoln Memorial Drive has been reconstructed in 1999 and 2000. The construction and maintenance of this shoreline roadway has, and continues to, protect against wave-induced erosion from Lake Michigan along the entire extent of the bluffs within Lake Park.

According to correspondences between Mr. Olmsted and Milwaukee County throughout the 1890s, Wahl bluff seems to have been one of the most unstable bluff areas within Lake Park. This instability seemed partly due to construction of Wahl Avenue at the top of this slope. Annual reports indicates that Mr. Olmsted and his firm worked on stabilizing the Wahl bluff for approximately 10 years in the late 1900s.[13] Hence, historic photos in 1890, as shown in Figure A-3 in Appendix A, and 1929, as shown in Figure 2, indicate that the bluffs contained only limited vegetation on the slopes. In addition, recreational uses, such as skiing, sledding, and motorcycling on the Wahl bluff seems to have caused further destabilization that necessitated the reconstruction and replanting some time in the 1930s. There has not been any known major reconstruction of the Wahl bluff since the 1930s. However, there has been documented killing and cutting of trees and brush along these southern bluffs of Lake Park to improve vistas to Lake Michigan over many years and as recently as September 2001.[14]

Given this record of extensive regrading within the Wahl bluff area and documented filling of ravines, it is likely that regrading of bluffs throughout the entire park system was also completed. A large proportion of the historic photos of the bluffs demonstrated little to no vegetation, which is indicative of active bluff recession, as shown in Appendix A (see Historic Bluff Vegetation Community below). Within these areas it would be impractical, if not impossible, to plant vegetation on the bluff slopes without regrading them to more stable slopes. In addition, the exposed soils were not likely of good enough quality to support vegetation. Therefore, fill was probably brought in and distributed among the slopes prior to planting in order to provide a good substrate and a more-stable slope angle. This assumption is also consistent with the observation that all of the bluff slopes included in this study contained the same surface soil types (see Bluff Characteristics in Chapter III of this report).

HISTORIC BLUFF VEGETATION COMMUNITY

The historic vegetation community was shown to be very different from the existing vegetation community among the bluffs of Lake Park. Many of the bluffs within Lake Park, including some of the ravines, contained very little or no vegetation on them as shown in the historic photos taken throughout the period between 1890 and 1928 in Appendix A (Figures A-1 through A-8). However, additional photos also indicate that areas among the northern portion of the park were preserved to a greater extent than the southern portions as shown in Figures A-9 through A-12 in Appendix A. The bluffs that were directly exposed to the wave action and changing water levels of Lake Michigan demonstrated the greatest amounts of erosion, which has a concomitant affect on bluff recession rates.[15]

Despite excessive erosion shown in the documented historic photos dated in the late 1800s and early 1900s, an attempt to characterize the historic bluff vegetative community was made using historic photographs. The most notable difference in vegetation was the vast open areas of grasses and other herbaceous vegetation throughout a large portion of the park system, as shown in Figures 2, 4, 5, and Appendix A. The Wahl bluffs from

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[13] *Information provided by Lake Park Friends.*

[14] *Information provided by the Milwaukee County Department of Parks, Recreation and Culture; "Saw-toting bandit creates lake view: someone cleared vegetation near homes overlooking lake," By Whitney Gould of the Journal Sentinel staff, Last Updated: September 25, 2001.*

[15] *SEWRPC Technical Report No. 36*, op. cit.

approximately the location of the lighthouse south to well beyond the Bradford Beach area were comprised of grasses and other herbaceous vegetation. The northern portions of the park contained the greatest extent of wooded areas that seemed much better preserved than in any other areas of the park. The ravine slopes ranged from being densely wooded to sparse trees to being entirely composed of grasses and other herbaceous vegetation to having very little vegetation at all.

Frederick Law Olmsted developed a planting list for Lake Park in 1891 which consisted of approximately 188,000 trees and shrubs distributed among nine different sections of the park.[16] Many of these species among the planting list are nonnative to the State of Wisconsin or to this regional climate. For example, about 78 percent, or 67 out of the 86 species recommended for planting in Lake Park are considered nonnative species to this midwestern regional climate of the State of Wisconsin. Many of the tree and shrub species, approximately 100,000 in total, came primarily from French nurseries.[17] Although the records of the exact locations and quantities of all of these tree and shrub species within the park are not known, nearly all of these plants listed in the original planting plan were not observed during the recent reconnaissance. Hence, based upon the areas surveyed by SEWRPC staff within Lake Park, only about 5 to 20 percent of the 86 species identified in the original planting plan currently exist within the park. Assuming that all 86 species were planted, the majority of these species do not appear to have survived. This may reflect the fact that they were not adapted to this region and were planted outside their physiological range, as defined in terms of rainfall, soils, nutrients, or temperature, among others. Conversely, black locust, which was not among the species set forth in Olmsted's original planting plan, is currently one of the dominant species, especially within the southern bluffs adjacent to Wahl Avenue (see Appendix C). This plant is currently considered to be an exotic invasive plant species with noted good qualities for stabilizing bluff slopes; however, this plant aggressively outcompetes native plant species, causing a reduction in the abundance and diversity and general health of the vegetative community as a whole. Since this species was not on the original planting list, it is likely to have been introduced for bluff stabilization purposes within this area of the park, and is most likely to have been planted during the 1930s as part of the reconstruction of the southern bluffs of Lake Park.[18] In contrast, another exotic invasive plant species, the European buckthorn, was on the original planting list which indicated a planting quantity of 500 plants. The European buckthorn observed on the site during the recent reconnaissance may or may not have developed from this planting, but the buckthorn has become a dominant shrub on the southern bluffs of the park. As with the black locust, its aggressive nature presents a significant problem for the long-term management of vegetative community in the park.

The vegetative community of the park, therefore, reflects a significant degree of human intervention in this natural system. The nature of these interventions has evolved over time, as the state-of-the-art of landscaping has changed and evolved. The current vision for the landscaping of the park should be clearly articulated. Initially based upon nonnative plant stock, the flora of the park currently reflects this heritage. Nevertheless, current landscape management practices would suggest that the nonnative species be replaced over time with plants native to Southeastern Wisconsin and better suited to withstanding the particular climatic regime of the region. This suitability ensures better survival of the plants and will contribute to the longer-term stability of the bluffs. However, the means, methods, and period over which plant species are replaced within the park may have repercussions for bluff stability, and is a process that needs to be approached with caution.

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[16] *National Park Service, Frederick Law Olmsted National Historic Site, planting list for Lake Park, Milwaukee, Wisconsin.*

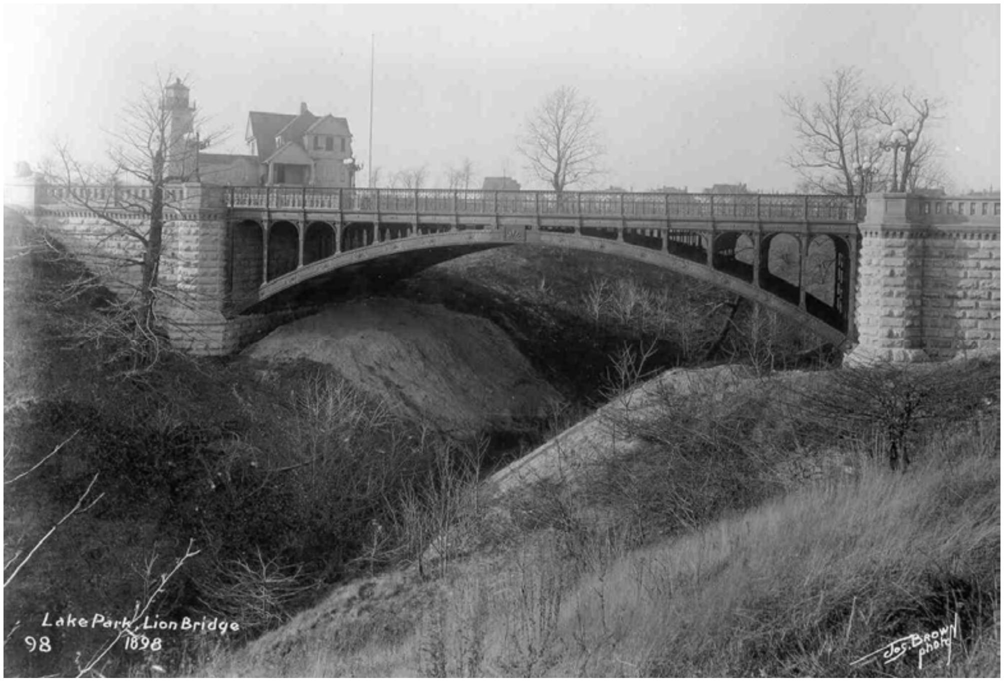
[17] *Eighth Annual Park Commission Report (1899).*

[18] *Information provided by Milwaukee County Parks, Recreation and Culture.*

Figure 4

LAKE PARK LION BRIDGE CROSSING RAVINE NEAR LIGHTHOUSE: 1898 AND 2003

LAKE PARK: 1898



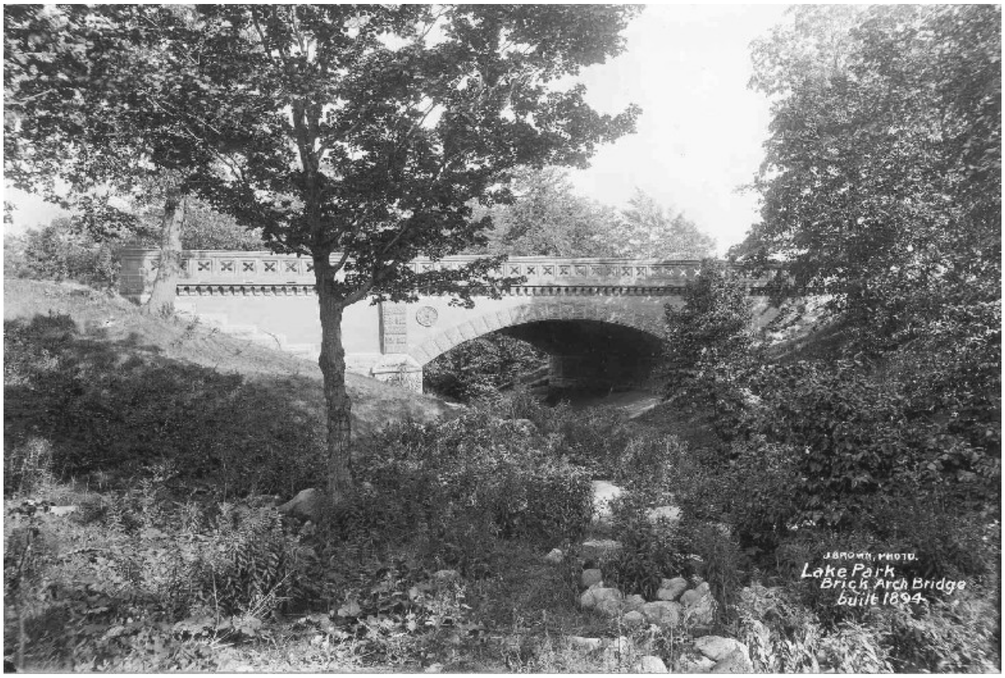
LAKE PARK: 2003

Source: Milwaukee County Department of Parks, Recreation and Culture and SEWRPC.

Figure 5

BRICK ARCH BRIDGE AT THE NORTHERN ENTRANCE OF LAKE PARK: 1894 AND 2003

LAKE PARK: 1894



LAKE PARK: 2003

Source: Milwaukee County Department of Parks, Recreation and Culture and SEWRPC.

Chapter II

BLUFF EROSION PROCESSES

INTRODUCTION

Bluff recession is an essentially natural process. However, the two major contributing factors that increase Lake Park bluffs susceptibility to recession are natural and human factors and how they interrelate. The principal natural factors controlling bluff recession susceptibility are topography, geology, and rainfall. The human activities include cut-and-fill, construction for roadways, construction of buildings, and loss of stabilizing vegetation. Topography influences rill and stream erosion that, in turn, influence slope angle and gradient. The steeper the slope, the more susceptible it is to sliding. Human activities are constantly reshaping the contours of the land and, thus, altering the natural slope. Thus, an understanding of both the natural and human influences on the dynamics and properties of bluff erosion processes is important in any documentation of the current conditions regarding bluff recession within areas of Lake Park. This chapter describes the various factors which may contribute to bluff recession, including groundwater seepage, freeze-thaw action, the type of bluff materials, vegetative cover, and precipitation.

BLUFF EROSION

Southeastern Wisconsin bluffs are composed of unconsolidated sediments, primarily sands and silts that slough off in shallow layers. Bluff recession encompasses many phenomena involving lateral and down slope movement of earth materials, such as, rock, soil, and/or artificial fill. It may cover a broad category of events, including mudslides, debris flows, rock falls, and soil creep. Bluff erosion occurs in the form of toe erosion, slumping, sliding, flow, surface erosion, and soliflucation or fluidization. Bluff recession can occur as a sudden, short-lived event, as a slow-moving slide mass, or as imperceptibly slow-moving soil creep. Bluff recession may occur almost anywhere, from man-made slopes to natural, pristine ground; most slides often occur in areas that have experienced sliding in the past. Bluff recession events can be caused by weaknesses in the rock and soil, the occurrence of heavy rainfall or snowmelt, or construction activity changing some critical aspect of the geologic or hydrologic environment.

On all slopes, gravity creates shear stresses which act to move material in the slope to a lower elevation. The shear stress forces acting on the materials in the bluffs are primarily determined by the weight of the soil and the water mass in the bluff, water pressures in the bluff, and external loads, such as building and vibrations. Bluff materials have a shear strength which, in stable slopes, is greater than the stresses. The shear strength depends on the properties of the soil and the moisture content, which is, in part, determined by soil drainage. Bluffs fail when either the shear stress is increased or the shear strength is decreased, altering the balance of forces until the stresses exceed the resisting soil strength.

Types of Slope Failure

One of the most common types of slope failure is sliding. Slides of rock or soil involve downward displacement along one or more failure surfaces (also referred to as a discontinuity, rupture, or slip surface). The material from the slide may be broken into a number of pieces or remain as a single, intact block. The two forms of slides most common to Southeastern Wisconsin slopes are rotational and translational slides. Rotational sliding involves movement turning about a specific point, where translational sliding is movement down slope on a path roughly parallel to the slip surface. The most common example of a rotational slide is a slump, which has a strong, backward rotational component and a curved upwardly concave failure surface. Rotational slides involve the slumping or sliding of a fairly large mass of materials. The slide mass rotates and often the top of the slump block is tilted toward the slope face. Slumps usually take place suddenly and can cause extensive damage, since they can result in a large recession of the bluff. Translational slides involve a surface layer of several inches to a few feet thick, sliding parallel to the face of the slope on a plane. Transition slides can occur either rapidly or slowly. Figure 6 illustrates the two types of slope failures. The distinction between rotational and translational slides is useful in the planning and design of control measures. As shown in Figure 7, a rotational slide may restore equilibrium in the unstable mass by creation of a more stable geometry, which decreases the driving momentum, and stops movement of the slide. Thus, bluff slopes undergoing rotational sliding may experience a period of relative stability following the slope failure. Translational sliding, however, may progress continuously if the slope surface is sufficiently inclined, and fallen material is removed from the base of the slope by wave action or some other means.

Slides and slumps are common throughout Wisconsin, especially along streams and lakes. Slides are commonly initiated when the bottom of a slope is removed (by running water or human activity), thereby steepening the overall slope to the point that a landslide will occur.

A second major type of slope failure is a flow. Flows consist of a slurry of loose rocks, soil, organic matter, air and water moving down slope in the manner similar to a viscous fluid. They are distinguished from slides by having high water content and are thoroughly deformed internally during movement.[1] While flows can dominate the failure, they are commonly observed as a minor component or extension of the toe (bottom of the landslide) of a slide or fall. Some flow commonly occurs at the toe of slump during and relatively soon after a sliding failure. Since slump blocks rotate such that the top of the block is often tilted back towards the bluff, surface water can accumulate in the depressions and saturate the underlying soil. Flows occur when intense rains saturate the surface layer of soil, or in the spring as ice melts near the soil surface. Flows can also occur where groundwater discharges along the bluff face through layers of silt and fine sand. If these more permeable soil layers are located between less permeable clay layers, removal of sediment by flow through groundwater seepage, referred to as sapping, can occur, and cause undercutting which creates an unstable slope subject to slumping and sliding. A type of flow known as soil creep is an extremely slow and steady process which may persist over long periods of time. The slow-to-rapid lateral extensional movements of rock or soil masses on almost level ground are known as lateral spreads or fluidization. In fine-grained soils, such as quick clays, lateral spreading occurs if the soils are remolded or disturbed by construction or grading. Loose, granular soils commonly produce lateral spreads through the process of fluidization. Fluidization is the transformation of a granular material from a solid state into a liquefied state as a consequence of increasing the water pressure in the spaces between the grains of sand.[2] Fluidization is caused by the vibration of the earth produced by an earthquake or continuous highway vibration. A similar phenomenon called solification is often caused by freeze-thaw activity. Slope failure due to solification results in the slow, viscous down slope flow of water saturated material over an impermeable base. During the thawing period, there is a buildup of excess moisture within the superficial soil mass. Because of underlying impermeable frozen ground, the pore pressure cannot be dissipated and, thus, shear resistance decreases. Also, the

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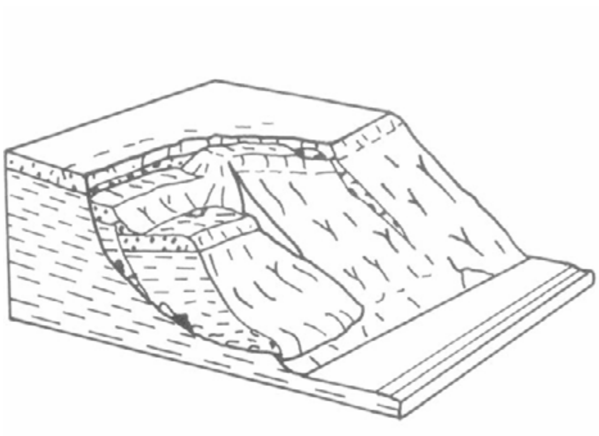
[1]*A.E. Kehew,* Geology for Engineers and Environmental Scientists, *Second Edition, Englewood Cliffs, New Jersey, Prentice-Hall, pages 357-393, 1995.*

[2]Ibid.

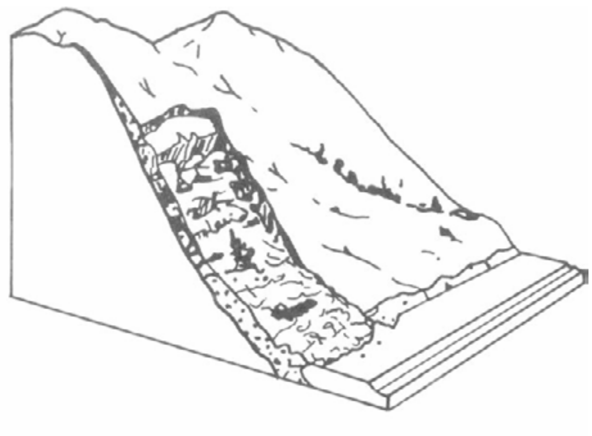
Figure 6

COMMON TYPES OF SLOPE FAILURES IN LAKE MICHIGAN COASTAL BLUFFS

ROTATIONAL SLIDING



TRANSLATIONAL SLIDING

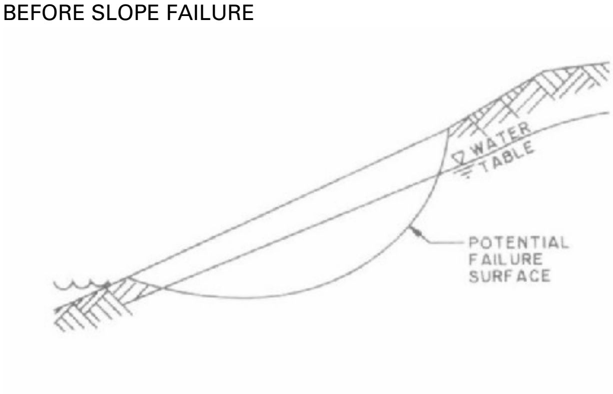


Source: *David J. Varnes, "Slope Movement and Types of Processes," Landslides: Analysis and Control, Transportation Research Board, National Academy of Sciences, Washington, D.C. Special Report 175, Chapter 2, 1978.*

Figure 7

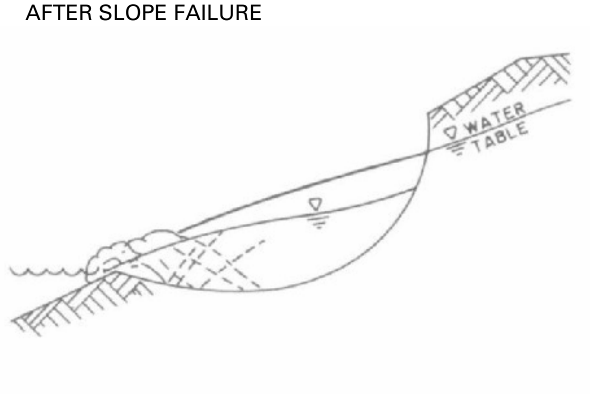
EFFECT OF ROTATIONAL SLIDING ON SLOPE STABILITY

BEFORE SLOPE FAILURE



SAFETY FACTOR = 1.0 AT TIME OF FAILURE

AFTER SLOPE FAILURE



SAFETY FACTOR = 1.5 AFTER FAILURE

Source: *J. David Rogers, "Slope Stability Evaluations of Various Geologic Situations," Choice of Input Parameters for Slope Stability Analysis, 1986.*

growth of crystals within the soil during winter months weakens the structure of the soil. The amount of moisture in a soil prior to thawing will affect the shear strength after it has thawed; the higher the moisture content before thawing, the greater the reduction in shear strength after thawing. The net result is reduced shear resistance, or strength, causing even gentle slopes to fail. Solification can also occur in unconsolidated material which overlies bedrock.

A third type of slope failure is sheet wash and rill and gully erosion. Both sheet wash and rill and gully erosion result from surface water runoff flowing over the top of the bluff and over the slope face itself. Sheet wash is the unconfined flow of water over the soil surface during and following a rainfall. Depths of flows are generally less than one-tenth of an inch, and raindrop impact is the dominant factor in the detachment of soil particles. Once the particles are detached, they are transported down slope at a rate determined by the water runoff rate, slope steepness, vegetative cover, and roughness of the surface, and by the transportability of the detached soil particles, which is a function of particle size and density. In contrast to sheet wash, rills and gullies are formed by the channelized flow of water over the soil surface. Rill and gully formation tends to follow zones of weakness established by desiccation, cracking, and differences in soil expansion due to the cycles of freezing and thawing and wetting and drying. On the Lake Park bluffs the rills are generally destroyed during the winter months by freeze-thaw activity and solification, but the gullies may exist for years.

Groundwater Seepage

Groundwater seepage can affect bluff stability in several ways. In most areas along the Lake Michigan shoreline, groundwater moves toward the Lake and, in some places, discharges either at the toe of the bluff or from the bluff face. Saturated soil conditions decrease the grain-to-grain contact pressure in the soil and reduce the frictional resistance of the material to stress. Groundwater also adds weight to the bluff, further increasing stress on the slope. In addition, groundwater seepage creates a seepage pressure in the direction of water flow. This pressure is of particular importance in granular soils, such as sands and silts, and is of lesser importance when the clay content of the soils is fairly high. Groundwater seepage was observed in only limited bluff areas within Lake Park and is not considered to be a major factor contributing to bluff instability within the park.

Vegetative Cover

Vegetation modifies the simple form of the hydrologic cycle. It does this in several ways, all of which reduce the amount of water actually present on a slope at any time. First, in a vegetated area the plants intercept some of the precipitation before it reaches the soil. Often a considerable amount of water can be stored on the surface of leaves and stems. Some of this water will eventually drip from the vegetation and reach the ground, but it may do so after the peak of the storm has passed. Some of it will be evaporated from the leaves or stems and return to the atmosphere without reaching the ground. Plants transpire through their stems and leaves. The water lost through transpiration is replaced by water obtained from the soil by capillary action. Hence, the amount of surface water and, in the case of deep-rooted plants, the groundwater is reduced.

As well as reducing the amount of water present on a slope, vegetation can increase the stability of the slope, because large plants can act as a physical barrier, slowing the rate of overland flow or buttressing a slope and possibly reducing the extent of mass movement. More significantly, vegetation roots bind the soil together; fine roots near the surface can reduce the likelihood of surface erosion, and deeper root networks can bind together different soil layers into a larger unit which can increase strength and reduce potential for failure. Contrary to what many people believe, the roots of large trees spread far beyond the drip line (an imaginary line under the edge of the canopy). In fact, fine feeder roots, which are normally in the upper 12 inches of the soil, can spread two or three times as far as the drip line, and roots of different trees of the same species can graft together forming a strong lattice with great soil-holding capability.

Several layers of plant foliage multiply the benefits discussed above. Ideally, a site will support low ground-covers, small shrubs, taller shrubs, and small and large trees.[3] Due to the complex root network formed by various

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[3] *Department of Ecology, Managing Vegetation on Coastal Slopes, http://www.ecy.wa.gov/ecyhome.html, 2000.*

combinations of tree and shrub species, potentially unstable slopes are held together and the resistance of the soil to slipping, sliding, and washing away is increased. Slopes susceptible to soil creep as shown in Figure 8 are also held in check, to some degree, by the presence of vegetation. The ability of plants to absorb water and slow its velocity also allows time for soils to reduce rates of absorption and discharge of water more effectively.

Precipitation

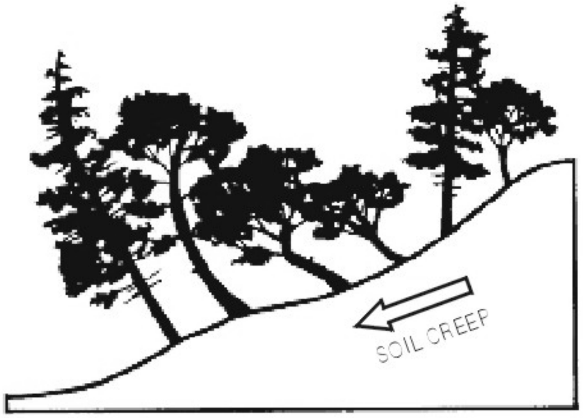
Rainfall has a pronounced effect on landscape (slope) development. It has the capacity to erode and undermine slope surfaces and when absorbed increases pore water pressure and weight. It also lubricates inherently weak zones of rock and soil, and can assist in removing support along the toe (bottom) of a slope, such as running water in a stream acting on the base of its banks. Generally, it is assumed that unusually high precipitation or changes in existing conditions can initiate bluff recession in areas where steep slopes and soils have experienced bluff recession in the past and where adequate vegetative cover had not been established.

CONCLUSION

Because bluff slope stability is influenced by a number of dynamic factors, slope failure is a process that occurs in an abrupt, unpredictable, fashion, as opposed to a uniform, relatively stable continuous fashion. After each incremental slope failure, the soil masses tend to temporarily assume a stable configuration until the net effect of the many influencing factors decreases slope stability, thus precipitating another incremental failure. Because of the dynamic nature of the coastal erosion processes, it is important to periodically document bluff stability conditions and to evaluate methods for predicting future conditions. The determination of the stability of the bluffs within Lake Park as of 2002, as well as an evaluation of the methodology for predicting such conditions, forms the content of the subsequent chapters of this report.

Figure 8

INDICATIONS OF SOIL CREEP



SOIL CREEP CAUSES DISTINCTIVE TIPPED TREES AND CURVED FORM OF TREE TRUNKS OVER TIME.

DISTINCTIVE TIPPED AND CURVED TREES WITHIN THE SOUTHERN BLUFFS OF LAKE PARK. PHOTO WAS TAKEN NEAR THE BOTTOM OF PROFILE 3 (SEE MAP 1 FOR LOCATION) LOOKING SOUTH FEBRUARY 11, 2003.

DISTINCTIVE BARE ROOTS UNDER TREES WITHIN THE SOUTHERN BLUFFS OF LAKE PARK. PHOTO WAS TAKEN NEAR THE BOTTOM OF PROFILE 2 (SEE MAP 1 FOR LOCATION) LOOKING SOUTH FEBRUARY 11, 2003.

Source: SEWRPC.

Chapter III

INVENTORY FINDINGS AND ANALYSIS

INTRODUCTION

Bluff stability conditions are important considerations in preservation, development, and management decisions for lands located within Lake Park. Such conditions may change over time, since they are related, in part, to changes in conditions, such as groundwater levels, the type and extent of vegetation existing, and precipitation patterns.

The data on bluff stability are presented by individual profile locations. Thirteen such profiles were measured, as shown on Map 1. These profiles vary in length from approximately 90 to 160 feet and 80 to 100 feet in height, as shown in Figure 9, and generally have been selected based upon park characteristics such as topography, shape, and recreational use. The profiles represent a combination of bluffs facing Lake Michigan and road sites, as well as internal ravine sites.

The data and analyses reported herein were conducted to evaluate the general conditions in areas throughout Lake Park. The evaluation of specific locations within the park for detailed design of bluff protection measures will require further site-specific analyses by a professional geotechnical or coastal engineer.

INVENTORY AND ANALYSIS PROCEDURES

The bluff stability characteristics of each shoreline site were determined under this study utilizing inventory data collected on bluff characteristics from field surveys conducted during August, 2002. The following section describes the methods used to identify and evaluate the various factors relating to bluff stability. The bluff characteristics and stability analyses were conducted with the assistance of Ms. Lindsay Anderson, a University of Wisconsin-Madison engineering masters degree student.

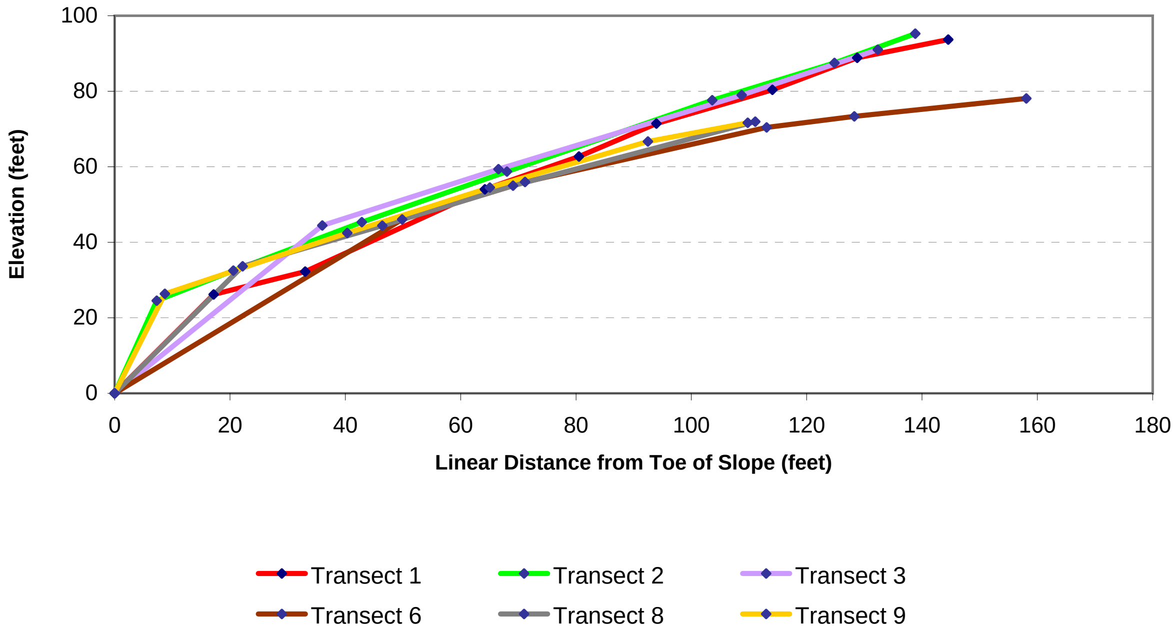
Bluff Characteristics

The bluffs within Lake Park exhibit a variety of height, slope, composition, and vegetative cover conditions. These conditions affect the potential degree and rate of bluff recession in the study area. During August 2002, field surveys were conducted to measure the geometry of the bluff slope. Measurements of the geometry of the bluff slope were conducted at 13 sites, the general location of which are set forth on Map 1. These measurements provided a basis for site-specific assessments of the bluff conditions at the selected locations. Bluff profiles were measured using a 100-foot tape measure and inclinometer. Slope segments were documented in a manner suitable for entering into a computer program used for analyzing the bluff stability. At each profile site, observations were also made on the bluff material, presence of groundwater seeps, vegetation type and percent cover (see also Bluff Vegetation Cover Characteristics section below), presence of bluff protection, and determined the global

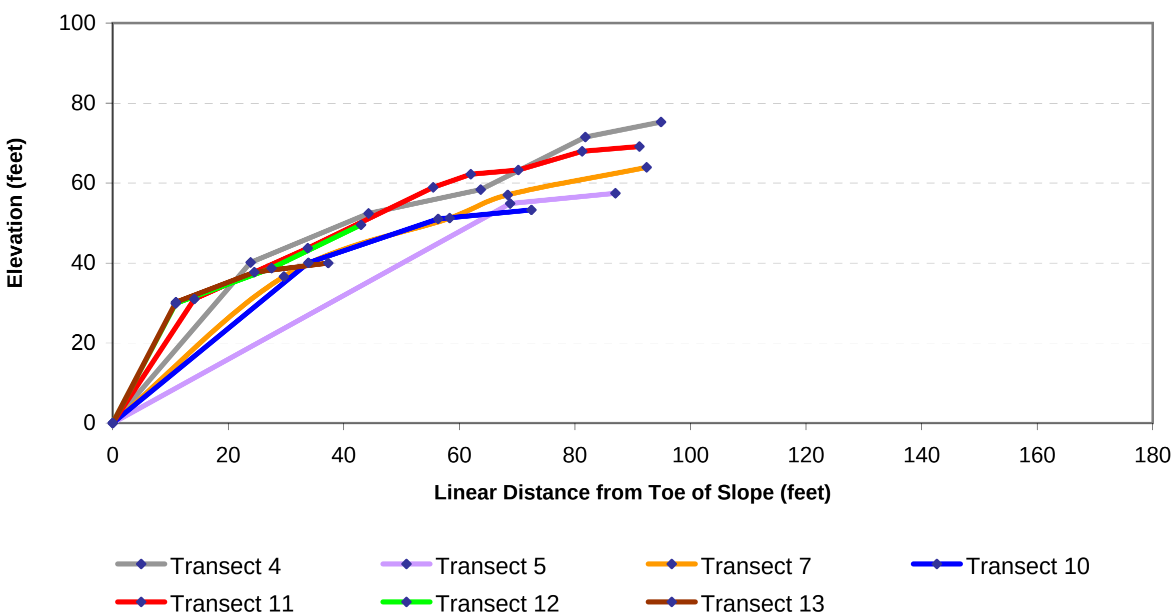
Figure 9

SLOPE PROFILES AMONG TRANSECTS FACING LAKE MICHIGAN AND ROAD SITES VERSUS RAVINE SITES WITHIN LAKE PARK: AUGUST 2002

LAKE AND ROAD FACING SITES



RAVINE SITES



Source: SEWRPC.

positioning system (GPS) location, as shown in Table 1. Since there were no available boring logs recorded on bluffs within Lake Park, the underlying stratigraphy was estimated using historical geologic records, observations at exposed surfaces, soil boring data from nearby areas, and previous studies. Hence, for this study the surficial material in the Lake Park area is characterized generally as Ozaukee till, commonly described as a reddish fine-grained silty clay till.

Bluff Stability

Using the field survey data described above, slope stability measurements were prepared for each profile site. Slope stability analyses were performed for the bluffs using modified versions of the computer program STABL.[1] The program is based upon the Modified Bishop Method for estimating slope stability and the potential for failures and can generate circular failure surfaces, sliding block surfaces, and irregularly shaped surfaces. It is capable of evaluating the effects of different soil and groundwater conditions, earthquakes, and surcharge loadings. Bluff slope data used as inputs to the program include the geometry of the slope, bluff stratigraphy interfaces, soil properties, and estimated groundwater elevations.

This particular method of analysis is most applicable to circular-shaped, or rotational, failure surfaces. For each potential failure surface, the resisting forces or strength parameters, such as soil cohesion and friction, and the driving forces, such as the soil mass along the failure surface and pore water pressures, are determined and a corresponding safety factor calculated. A safety factor is defined as the ratio of the forces resisting shear to the forces promoting shear along the failure surface. Thus, a safety factor less than or equal to 1.0 indicates that the forces promoting failure are greater than or equal to the forces resisting failure. Typically, computer-based applications of this method are used to generate randomly 100 potential failure surfaces and corresponding safety factors for a given bluff site.[2] The 10 failure surfaces with the lowest safety factors are identified and used to derive estimates of bluff stability. In the application of this model to the Lake Park bluff data set, the division between failing and nonfailing bluffs was set at a safety factor of 1.2, as opposed to the theoretical division value of 1.0, in order to include marginally stable bluffs.[3] Hence, slopes with a safety factor greater than 1.2 are considered stable.[4]

The analysis procedure generates and evaluates a number of potential failure surfaces in order to identify the most critical, and the most likely, failure surface. The 10 potential failure surfaces with the lowest safety factors are identified and plotted. The Bishop method is a "method of slices" procedure, in that the analysis divides a potential sliding mass into a number of vertical sections. The forces exerted in a vertical direction are taken into account, while the difference between the horizontal forces across a section, or between sections, are ignored. This deterministic analysis technique is the same as used in the 1977, 1989, and 1995 studies among Lake Michigan shoreline areas within Southeastern Wisconsin.[5]

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[1]*J.A. Chapman, T.B. Edil, and D.M. Mickelson,* Effectiveness of Analysis Methods for Predicting Long Term Slope Stability on Lake Michigan Shorelines, *University of Wisconsin-Madison, December 1996.*

[2]*P.J. Bosscher, T.B Edil, and D.M. Michelson, "Evaluation of Risks of Slope Instability along a Coastal Reach,"* Proceedings of the Vth International Symposium on Landslides, *Lausanne, Switzerland, 1988. See also J.A. Chapman, T.B. Edil, and D.M. Mickelson,* op. cit.

[3]*J.A. Chapman, Tuncer B. Edil, and D.M. Mickelson,* op. cit.

[4]*T.B. Edil and M.N. Schultz, "Landslide Hazard Potential Determination Along a Shoreline Segment,"* Engineering Geology, *Volume 19, pages 159-172, 1983.*

[5]*D.M Mickelson, L. Acomb, N. Brouwer, T.B. Edil, C. Fricke, B. Haas, D. Hadley, C. Hess, R. Kluak, Nlasca, and A.F. Schneider, Shore Erosion Study, Technical Report,* Shoreline Erosion and Bluff Stability Along Lake Michigan and Lake Superior Shorelines of Wisconsin, *Wisconsin Coastal Management Program, February 1977; SEWRPC Community Assistance Planning Report No. 163,* A Lake Michigan Shoreline Erosion Management Plan for Milwaukee County, Wisconsin, *October 1989; SEWRPC Technical Report No. 36,* Lake Michigan Shoreline Recession and Bluff Stability in Southeastern Wisconsin: 1995, *December 1997.*

Table 1

BLUFF PROFILE CHARACTERISTICS WITHIN LAKE PARK: AUGUST 2002

Profile Number	Bluff Material	Seep Present	Proportion of Vegetation Cover[a] (percent)	Bluff Face Protection	Top of Slope Description	Toe of Slope Description	Location (latitude/ longitude)
1	Ozaukee till	No	80	No	Grass, houses, road	Sidewalk, Lincoln Memorial Drive	4-28-817E/ 47-68-122N
2	Ozaukee till	No	60	No	Grass, houses, road	Sidewalk, Lincoln Memorial Drive	4-28-815E/ 47-68-228N
3	Ozaukee till	No	70	No	Grass, houses, road	Sidewalk, Lincoln Memorial Drive	4-28-957E/ 47-68-351N
4	Ozaukee till	No	70	Boulders, debris asphalt	Grass, lighthouse	Intermittent stream	4-29-128E/ 47-68-387N
5	Ozaukee till	No	10	No	Grass	Trail system, intermittent stream	4-29-090E/ 47-68-568N
6	Ozaukee till	No	70	No	Grass	Trail system, grass, athletic field	4-29-160E/ 47-68-499N
7	Ozaukee till	No	80	No	Grass, concrete trail	Trail system, intermittent stream	4-29-154E/ 47-68-517N
8	Ozaukee till	No	70	No	Lake Park Pavilion concrete driveway	E. Ravine Road	4-29-227E/ 47-68-872N
9	Ozaukee till	No	60	No	Grass, sidewalk	Sidewalk, Lincoln Memorial Drive	4-29-256E/ 47-68-960N
10	Ozaukee till	No	50	No	Grass	Intermittent stream	4-29-220E/ 47-68-923N
11	Ozaukee till	No	70	No	Grass	Intermittent stream	4-29-375E/ 47-69-188N
12	Ozaukee till	No	60	No	Grass	Intermittent stream	4-29-274E 47-69-395N
13	Ozaukee till	No	40	No	Grass, sidewalk	Intermittent stream	4-29-177E 47-69-414N

[a]*This category includes nonwoody ground layer and woody shrub layer vegetation beneath the tree canopy vegetation.*

Source: SEWRPC.

Bluff Vegetation Cover Characteristics

SEWRPC staff used a modified line-intercept method to quantitatively sample the vegetation community among the bluffs at Lake Park, Milwaukee, during August 2002.[6] This vegetation survey was conducted concurrently with the physical measurements of the geometry of the bluff slope survey outlined above. Thirteen pre-determined profiles ranging from 20 to 50 meters in length that extended perpendicular up the face of the slope was used. At each 1.0 meter increment, all species overlapping the line were tallied for each of the three vegetation strata: tree, shrub, and ground layer (i.e., herbaceous). This, then, gave a cover value for each species in each stratum category. Trees were defined as woody plant species with a trunk diameter of greater or equal to 4.0 inches. Shrubs were defined as woody plant species with a trunk diameter of less than 4.0 inches. The ground

[6]*J.E. Brower, J.H. Zar, and C.N. von Ende*, Field and Laboratory Methods for General Ecology, Third Edition, *Wm. C. Brown Publishers, 1990.*

layer consisted of nonwoody vegetation. For analysis, both the absolute and relative cover values for each species in each stratum were determined for each profile (see Appendix C).

BLUFF STABILITY ANALYSIS

The inventory and analysis findings relating to bluff conditions within Lake Park are discussed below.

Figure 10 shows the 10 most critical slope safety factors for each of the 13 profiles measured within Lake Park (see Appendix D for the STABL output plots for each profile). As previously mentioned above, slopes with a safety factor greater than 1.2 are considered stable.[7] The groundwater level in the study area was not measured, but was assumed to be no higher than 50 feet below the top of the bluff. Thus, a water level 50 feet below the bluff top is considered a worst-case scenario. Where the bluff is greater than 50 feet high, the factor of safety was found for both the worst-case scenario and when the water level is one-fourth of the bluff height. These two water level situations are considered to represent a range of conditions in the study area for the purpose of this project.

The stability results imply that some of the bluffs in the Lake Park area are unsafe, specifically Profiles 1 and 2 that are part of the southern bluffs of the park as shown on Map 1. Resultant safety factor values for Profile 3 are close to the 1.2 limit. When considering these model results, it is important to note that previous analyses of bluff slope stability along Lake Michigan indicated that the deterministic application of Bishop's Method correctly predicted the occurrence of failures, failure magnitude, and failure location within a specific profile site in about 70 percent of the cases.[8] The model also correctly predicted the extent of the bluff top recession in about 55 percent of the cases studied. Hence, the model output has some limitations and is expected to not correctly predict the occurrence of failures in 30 percent of the cases studied. Given that the model output results for Profile 3 were fairly close to the 1.2 safety factor value, it is concluded that this slope is marginally unstable.

Field observations indicated that nearly all of the bluff areas studied were vegetated (see Figures 2 through 5 in Chapter I), which indicates that there has not been any recent erosion as opposed to historic observations among Lake Park bluffs in the late 1800s and early 1900s, as shown in Figures A-1 to A-8 in Appendix A. Although the southern bluffs appeared to be well-vegetated, there were distinctive observations of leaning trees, curved tree trunks, exposed tree roots, and fallen trees which are indicative of active soil creep or recession occurring on these southern bluffs of Lake Park (see Vegetation Indicators of Slope History and Stability below). In addition, there was also evidence of recession on the top of the southern bluffs, as shown in Figure 11, which was not observed among other bluffs within Lake Park.

The results of the stability analysis also corroborate historic observations that the southern bluffs were unstable, whereas the northern bluffs were stable. Hence, park managers spent great efforts in attempting to stabilize the southern bluffs (see Historic Bluff Physical Characteristics in Chapter I of this report), which included construction of 850 feet of lineal barricade at the foot of the bluff along Wahl Avenue in 1897.[9] These bluffs were characterized by none to very little vegetation until major reconstruction and planting of trees and shrubs, primarily black locust and sumac species, occurred in the mid-1930s to stabilize the eroding slopes.[10] Although there is evidence of active recession of the bluffs within this area of the park as noted above, there has not been any known documented major failure of these bluffs within the southern portion of Lake Park since 1930. Hence,

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[7]*T.B. Edil and M.N. Schultz, "Landslide Hazard Potential Determination Along a Shoreline Segment,"* op. cit.

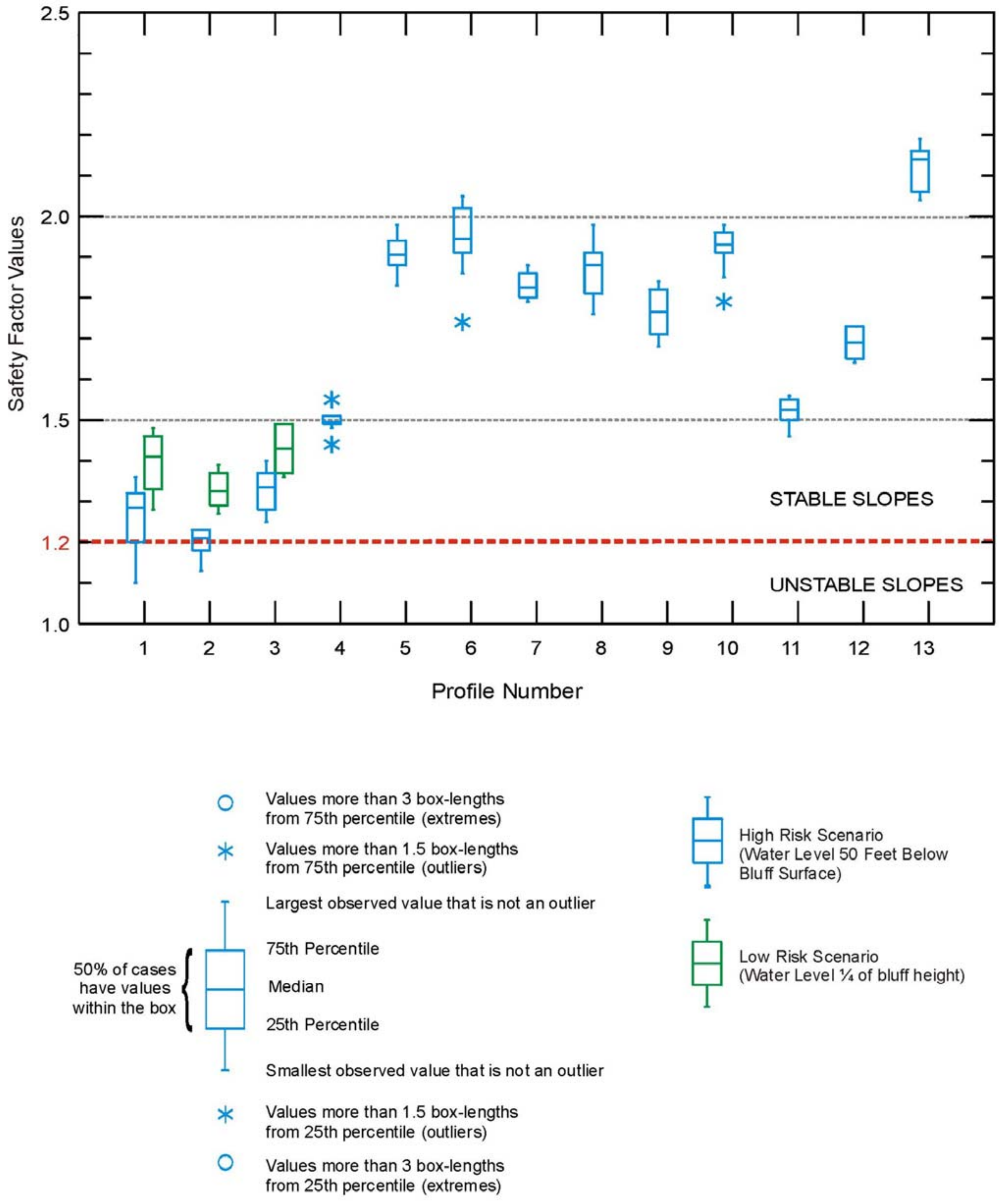
[8]*SEWRPC Technical Report No. 36,* op. cit.

[9]*Eighth Annual Park Commission Report (1899).*

[10]*Information provided by Lake Park Friends.*

Figure 10

SLOPE STABILITY ANALYSIS AMONG BLUFF PROFILES WITHIN LAKE PARK, MILWAUKEE, WISCONSIN: 2002



Source: SEWRPC.

Figure 11

TOP BLUFF EROSION WITHIN LAKE PARK

DISTINCTIVE MOWED GRASS AND BLUFF EROSION WITHIN THE SOUTHERN BLUFFS OF LAKE PARK. PHOTO WAS TAKEN NEAR THE TOP OF PROFILE 1 (SEE MAP 1 FOR LOCATION) LOOKING SOUTH, FEBRUARY 11, 2003.

DISTINCTIVE MOWED GRASS, BLUFF EROSION, AND TRASH DEBRIS WITHIN THE SOUTHERN BLUFFS OF LAKE PARK. PHOTO WAS TAKEN NEAR THE TOP OF PROFILE 1 (SEE MAP 1 FOR LOCATION) LOOKING NORTH, FEBRUARY 11, 2003.

Source: SEWRPC.

the reconstruction, plantings, and natural vegetation of the southern bluffs in the 1930s are likely to have assisted in keeping these areas stabilized over this approximately 70-year period.

Vegetation Indicators of Slope History and Stability

The type, age, health, and abundance of vegetation growing on a bluff site can offer valuable clues to determine slope stability. Even the presence of stumps and fallen trees can tell a story to a knowledgeable observer. This section discusses these clues and what they may indicate. Vegetative indicators are interpreted in combination with soil and geological data.

Curved Trunks

Trees on a slope curved, as shown in Figure 8, are usually the result of a slow, gradual soil creep. Care should be exercised in clearing sites like this because you may destabilize an already marginally stable area. There were observations of curved trunk trees as shown in Figure 8, but these were only located within the southern bluffs among Lake Park slopes, specifically Profiles 1 through 3 (see Map 1 for profile locations).

Trees Tipped Downslope

On sites with shallow soils and steep slopes, this may indicate mechanical shifting of materials and signal the potential for a slope failure. There were many observations of tipped trunk trees, as shown in Figure 8, among the southern slopes of Lake Park, specifically Profiles 1 through 3. There were no observations of tipped trees in other bluffs of Lake Park.

Groups of Trees Growing Across the Slope in a Line

Lines of trees growing across a slope may indicate two conditions. First, a slide may have caused bare ground in the recent past, subsequently offering a site for germination and growth of fast-growing trees. Chances are good that the slide is active and periodic. The age of trees growing in this manner can be a clue to when the slide occurred. Second, a line of trees may also indicate an area of perched water or groundwater seepage that, in turn, may indicate a layer of impervious material underlying a deposit of sandy soil. These sites usually are unstable and should be investigated geologically. There was no evidence of trees growing in this manner among bluffs within Lake Park nor was there any evidence of significant groundwater seeps.

Bluff Faces without Vegetation

Sections of bluffs devoid of vegetation can indicate many different situations. Generally, a bare bluff face suggests a site is either too steep to support vegetation or that recurrent erosion precludes the establishment of plants. This is common on exposed bluff faces comprised of glacial till. As previously mentioned, there were no major areas among bluffs of Lake Park without vegetation.

Downed Trees

The presence of downed trees may indicate several things. In sites where rooting is shallow, wind may cause trees to blow down. Shallow rooting can be the result of wet soils, like those found in wetlands, or can be caused by shallow soils underlain by impervious layers that resist penetration of roots.

Fallen trees may also result from adjacent clearing or excessive tree removal within the stand, which often exposes previously stable trees to unusual wind stresses. In some cases, diseases, such as root rot, may cause substantial windthrow on a site. Another potential and common cause of downed trees is a slope disturbance, such as excavation of the toe or previous thinning, which leads to local erosion undermining downslope portions of the root mass. This condition becomes obvious when bare roots and "caves" are observed under trees, as shown in Figure 8.

Whatever the cause of fallen trees, the results are similar: accelerated erosion, destabilization of the slope, and substantial disturbance to the area. These sites should be examined carefully to determine the cause, impact and severity of a disturbance. Any remedial actions deemed necessary should be accomplished quickly. There were many observations of indiscriminant tree cutting among the southern portion of bluffs within Lake Park. There were also some observations of downed trees and trees with bare roots exposed among the southern bluffs within the park, as shown in Figure 8. There was no evidence of tree cutting, extensive downed trees, or trees with bare roots among any other bluffs within Lake Park.

Single Dominant Species and Even-Aged Stand

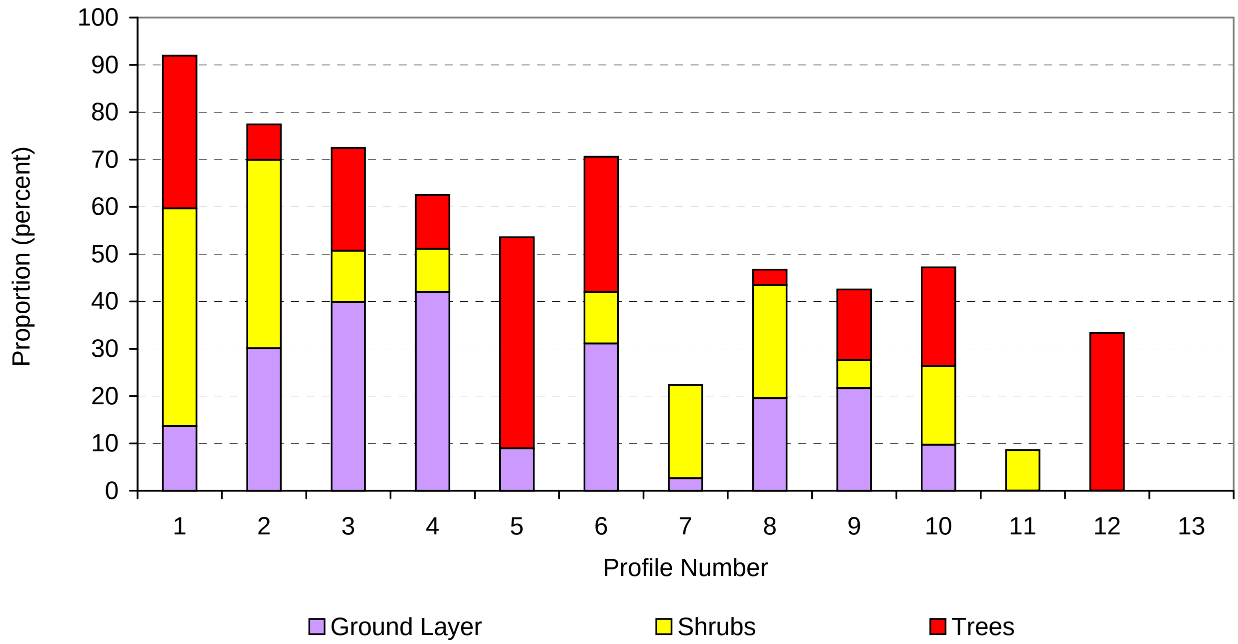
Occurrence of a predominantly single-species, even-aged stand of shrubs or trees, can indicate a fairly recent, large-scale, mass soil movement. A plant community similar to that described above, though apparently indicating a stable site, hints at the presence of recurrent large scale disturbances. Linear down-slope "stripes" of such vegetation commonly mark the paths of debris avalanches. These vegetation types are sometimes associated with high water tables, shallow soils, and marginally stable slopes. They are often adjacent to wetlands and underlain by impervious soils. They tend to be extremely difficult to manage successfully in terms of stabilization. It is often impossible to attain shoreline amenities, such as views, on these sites because they are predominantly deciduous, and, even when fully vegetated, are barely stable. In many cases attempts at forest thinning can cause blowdown and subsequent erosion. There were no observations of bluffs dominated by a single species among bluffs within the park, as shown in Figure 12 (see Appendix C).

Single-age stands can also indicate past clearing or tree removal. The presence of old stumps and their size and condition can be used to estimate how long ago the trees were removed. Tree rings can also indicate how old the trees were when cut. There is evidence that trees within the middle to northern portions of the park are significantly older than trees within the southern portion of Lake Park. More specifically, Profiles 1 through 3 contained fairly even-aged younger tree stands with canopies much less developed than bluffs within the rest of Lake Park, which is consistent with historic information of the park (see Historic Bluff Vegetation Characteristics in Chapter I of this report). In addition, there were many stumps observed among areas of the southern bluffs near Profiles 1 through 3, which indicates that the trees and shrubs among these bluffs were indiscriminately cleared out. This chronic type of disturbance continually opens up the canopy and allows more light penetration to the under story vegetation, which gives exotic invasive species, such as buckthorn, garlic mustard, and burdock among others, a chance to establish and thrive. Therefore, this may also be related to the higher amounts of exotic

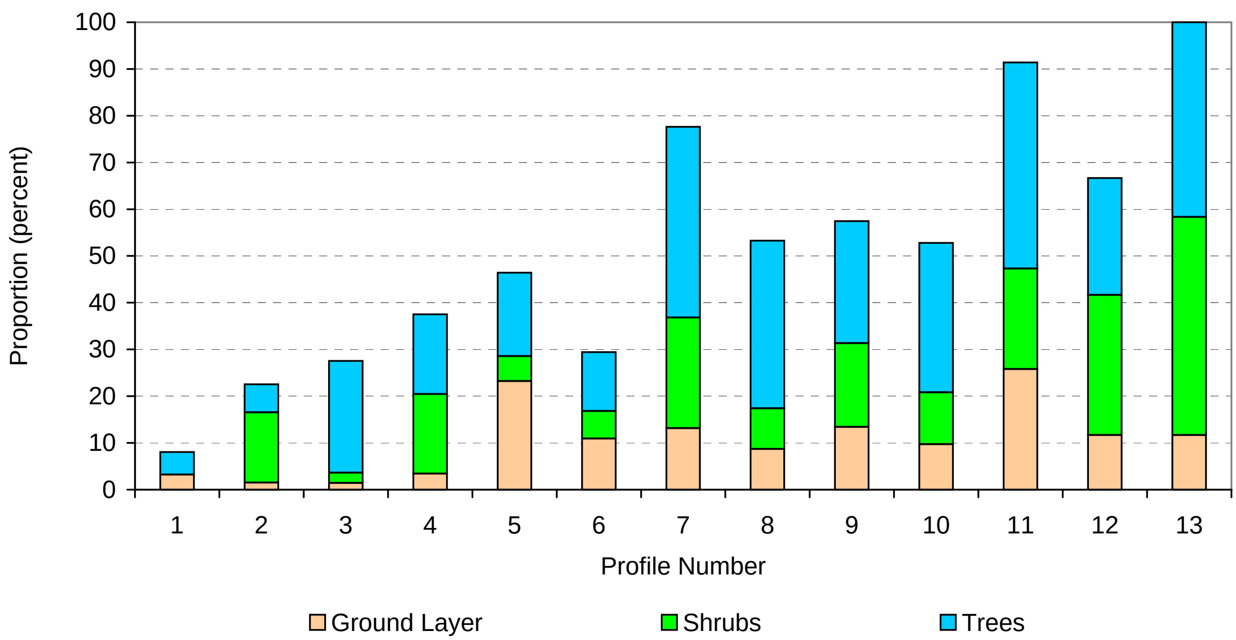
Figure 12

PROPORTION OF EXOTIC VERSUS NATIVE PLANT SPECIES COVERAGE AMONG TREE, SHRUB, AND GROUND LAYER VEGETATION CATEGORIES FOR EACH TRANSECT WITHIN LAKE PARK: AUGUST 2002

EXOTIC PLANT SPECIES



NATIVE PLANT SPECIES



NOTE: Vegetation categories are defined as follows: trees are woody plant species with a trunk diameter of greater than or equal to 4.0 inches, shrubs are woody plant species with a trunk diameter of less than 4.0 inches, and ground layer consists of nonwoody vegetation.

Source: SEWRPC.

invasive species in the southern portion of the park compared to the rest of Lake Park, as shown in Figure 12 (see Bluff Vegetation Community section below).

Dead/Dying Trees

Bluffs with large numbers of dead or dying trees indicate that there is cause for concern. Look for insect or disease incidence, signs of past wildfire, changes in local hydrology, or other probable causes. Healthy vegetation is important to long-term stability of Lake Park bluffs. There were no observations of extensive areas with dead or dying trees, except for within Profile 2. Profile 2 demonstrated several areas in the upper and middle portions that contained discrete areas with dead vegetation ranging from approximately 10 to 20 feet in diameter. These areas were very abrupt and not indicative of the general vegetation patterns among the slopes, because the ground layer, shrub, and trees within these areas were all devoid of foliage. Hence, these discrete areas seemed more likely to be the result of an herbicide application rather than some indication of poor vegetation community health or disease outbreak.

Multi-Species, Multi-Age Vegetation

A site that has a wide variety of vegetation of various ages, is usually stable. A variety of vegetation (ground-covers, shrubs, and trees of deciduous and evergreen species) often indicates the site has not been recently disturbed and that local soil movements are likely to be stabilized naturally by the surrounding vegetation. Each plant, from the smallest herb to the largest tree, contributes a stabilizing influence to the soil through its root mass. Some plants have shallow, fibrous roots; others have deep roots. Together they form a strong mat that resists erosional stresses. The bluffs among Lake Park all exhibited a diverse vegetative community in terms of both species and cover types, as shown in Table 1 and Figure 12.

BLUFF VEGETATION COMMUNITY

Based on analysis of the original surveyor's records and surveys of remnants of native forest in this portion of Milwaukee County, the presettlement vegetation of the Lake Park area consisted of mesic forest dominated by such trees as beech, basswood, white ash, hickories, and red and white oaks. The herbaceous ground flora was probably very diverse. Most likely, a cooler, moister microclimate existed in the small ravines leading to Lake Michigan, enabling a few species with more northerly affinities, such as hemlock, Canada yew, white cedar, and associated ground layer species, to exist locally. Land use activities through time have eliminated most of the more-sensitive native species, replacing them with common natives and exotics, such as garlic mustard and buckthorn. The ground flora, especially, has become depauperate. Of the bluff profiles sampled, those most resembling the native condition are those at the northern end of the park, where the canopy of native trees is relatively intact, and the ground flora is, at least in selected areas, fairly diverse. In fact, several trees within the northern end of the park have recently been estimated to be 130 to 175 years old, which is much older than Lake Park itself.[11]

Based upon the current vegetative survey in August 2002, the plant species abundance and diversity among ground layer, shrub, and tree species is generally indicative of a poor to moderately healthy vegetation plant community. Although this vegetative survey was not comprehensive of the entire Lake Park system, because this study was primarily focused on assessment of the bluff stability, it is generally a good representation of the overall quality and diversity of plant vegetation within the park.

The vegetation survey results indicate that there are three important patterns in the abundance and distribution of plant vegetation community among the bluffs within Lake Park. First, exotic invasive plant species persist throughout the entire park system, as shown in Figure 12. Second, Figure 12 also shows that the exotic species are well-represented among the ground, shrub, and tree layers throughout all the bluffs, except in the northern bluff portions of Lake Park (i.e. Profiles 11 through 13). Third, the highest proportion of exotic invasive plant species currently resides within the southern portions of Lake Park and seems to decrease towards the northern portions,

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[11] *Richard Barloga,* Preliminary Vegetation Inventory of Lake Park Wooded Ravines and Bluff Slopes, *July 2002.*

as shown in Figure 12. This apparent continuum of exotic versus native plant species within Lake Park are probably the result of a variety of reasons, including current and historic management activities, recreational use, position, construction, or slope failures, among others (see Historic Bluff Physical Characteristics in Chapter I of this report).

Although nuisance exotic plant species are present throughout the bluffs within Lake Park, the composition of exotic plant species, as shown in Figure 13, indicates that about 70 to 100 percent of the proportion of the total exotics is comprised of only seven species. For example, within the tree category, black locust and Norway maple are the dominant exotic species. The shrub category is dominated by honeysuckle, buckthorn, and Highbush-Cranberry[12] exotic species, while the ground layer is predominantly composed of two species, including garlic mustard and burdock. This indicates that management efforts to control these species would potentially be targeting 70 to 100 percent of the exotic plant problem among bluffs within the park. For a brief physical and life history description, as well as a discussion of alternative control treatments for each of these dominant exotic species contained within Lake Park, see Appendix E.

The Lake Park Friends had also recently commissioned naturalist Richard Barloga to complete a separate comprehensive vegetation inventory of the wooded ravines and bluff slopes within Lake Park, as shown on Map 4.[13] The vegetation survey was completed during May, June, and July of 2002, which is during the same summer SEWRPC staff completed the slope stability and vegetation survey of this report. This vegetative survey identified five separate sites as shown on Map 4 and generally described as follows:

- Site 1 included the bluff slopes south of the lighthouse;
- Site 2 included the Wolcott ravines (i.e. the Lighthouse Ravines);
- Site 3 included the pavilion to Girl Scout Ravine;
- Site 4 included the northwest ravine to Lake Drive; and
- Site 5 included the bluffs from East Ravine Road north to Kenwood Boulevard.

Results of the County vegetation survey, as shown in Figure 14, indicate that the southern portions of Lake Park contain a low floral diversity and floristic value and can be classified more as a weedy type of vegetation community. In contrast, the northern portions of Lake Park contain a higher floral diversity and floristic value and can be classified as an essentially more-natural vegetation community worthy of protection. Results further indicate and support the aforementioned conclusions of this study that there is a continuum of a poor-quality vegetation community in the southern portions of Lake Park to a moderately good-quality vegetation community in the northern areas. This increase in vegetation community quality is also inversely correlated with the presence of nonnative exotic plant species. More specifically, exotic plant species are most abundant within the poor-quality vegetation in the southern portions of Lake Park and least abundant within the moderately good-quality northern areas of the park. The proportions of exotic plant species, based upon the County survey, among the areas of Lake Park are also consistent with survey results from this study.

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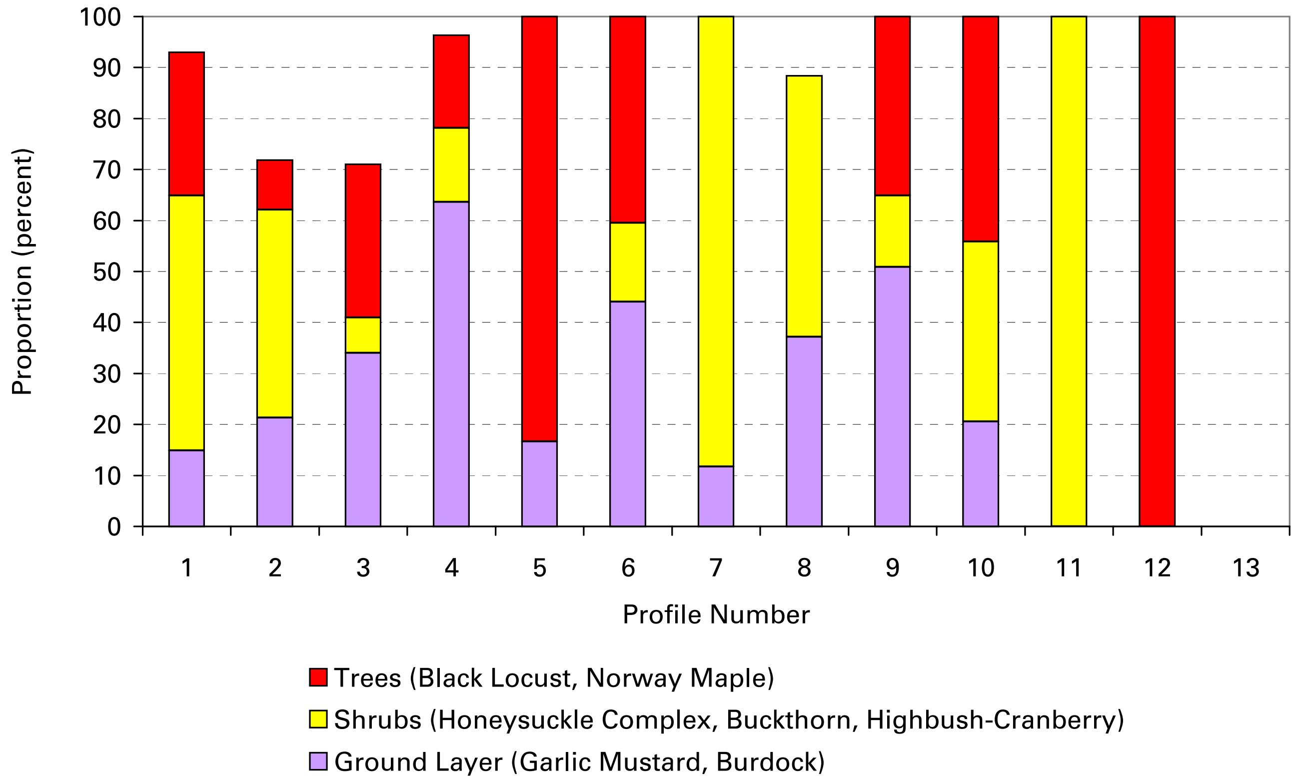
[12]*Note: European highbush-cranberry* (Viburnum opulus*) is a dominant nonnative shrub species found within Lake Park and this plant is generally considered to be a "potentially" invasive species and so is included as part of this exotic invasive species discussion. Source: Wisconsin State Herbarium, University of Wisconsin-Madison, 160 Birge Hall, 430 Lincoln Drive, Madison, Wisconsin 53706-1381, http://www.botany.wisc.edu/herbarium/, January 2003.*

[13]*Richard Barloga,* op. cit.

Figure 13

PROPORTION OF DOMINANT EXOTIC PLANT SPECIES COVERAGE AMONG TREE, SHRUB, AND GROUND LAYER VEGETATION CATEGORIES WITHIN LAKE PARK: AUGUST 2002



Source: SEWRPC.

When compared to the bluff stability analysis, this pattern among the vegetation community indicates that the most unstable bluffs within the southern portions of Lake Park, as shown in Figure 10 are also associated with the highest amounts, equaling 70 to 90 percent, of exotic invasive plant species, as shown in Figure 12. As previously mentioned, the bluff stability analysis does not account for vegetation on the slope, but it is a major contributing factor to the ultimate stability of a slope. So, although the ground, shrub, and trees among the southern bluffs of Lake Park are dominated by exotics plant species, these are the major factor in keeping these slopes stable.

CONCLUSIONS

Based upon the inventory and analyses of the bluff stability and vegetation factors at 13 locations in Lake Park, the following conclusions can be made:

- Overall, Lake Park contains bluffs which range from marginally stable to stable.

- Bluffs within the southern portion of the park are potentially much more unstable compared to bluffs within the rest of Lake Park, with the southern-most bluff, indicated by Profiles 1 through 3 on Map 1 and in Figure 10, being marginally stable. The remaining bluffs to the north all have safety factors of 1.35 to 2.0 and are considered stable.

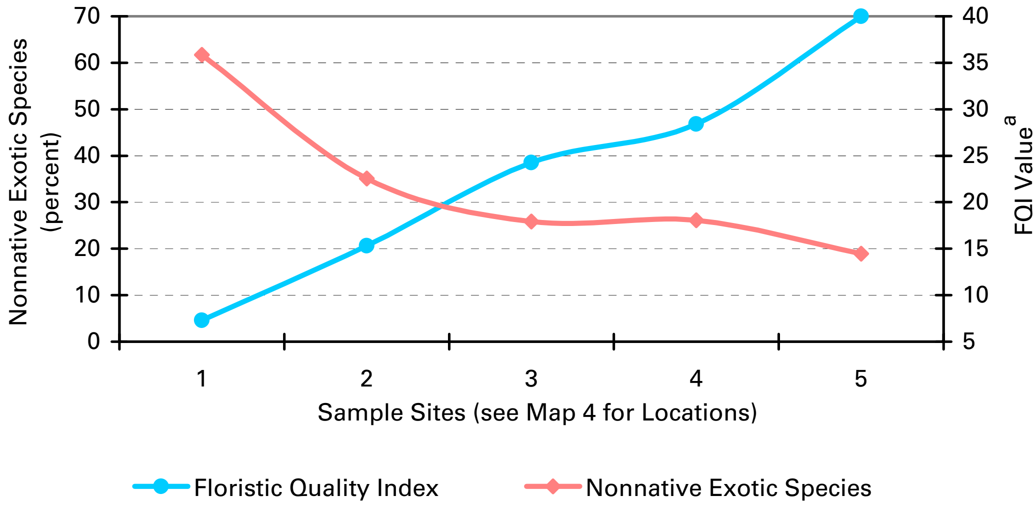
Map 4

PRELIMINARY VEGETATION INVENTORY OF LAKE PARK BLUFFS AND WOODED RAVINES: SUMMER 2002

Source: Richard Barloga and SEWRPC.

Figure 14

NONNATIVE EXOTIC SPECIES AND FLORISTIC QUALITY INDEX (FQI) SUMMARY OF THE VEGETATION COMMUNITY AMONG BLUFF AND RAVINE SITES WITHIN LAKE PARK: SUMMER 2002



[a] *Floyd Swink and Gerould Wilhelm, "Floristic Quality Assessment,"* Plants of the Chicago Region*, 4th Edition, Indiana Academy of Science, Indianapolis, Indiana, 1994, pp. 11-18.*

Source: Richard Barloga and SEWRPC.

- The high proportion of exotic plant species throughout Lake Park, and the southern portions of the park in particular, indicate that this is an extensive problem and may ultimately continue to reduce the biological plant diversity and abundance and overall wildlife habitat value and recreational and educational opportunities, as well as potentially compromise slope stability in the park.

- Although the ground, shrub, and tree layers among the southern bluffs of Lake Park are dominated by exotic plant species, these are the major factor in keeping these slopes stable. Hence, management alternatives within this area will be limited.

Chapter IV

FACTORS TO BE CONSIDERED IN DEVELOPING MANAGEMENT MEASURES

INTRODUCTION

Lake Park contains relatively stable bluffs with a poor-to-moderately good quality vegetation community. Based upon the inventory of bluff stability and vegetation, several factors are recommended to be considered to ensure the continued maintenance and future protection of this high-quality park system. These factors are related to slope stability and quality of the vegetation community, both of which are recommended to be addressed together as part of the long-term park maintenance and enhancement. This chapter presents factors recommended to be considered in developing park management measures based upon the bluff stability and vegetation surveys conducted in August 2002 in Lake Park.

BLUFF STABILITY MEASURES

The following measures are considered viable for bluff stability purposes:

- Conduct of annual inspections of the slopes within Area C as shown on Map 5, specifically between Profile 3 and continuing as far south as the walkway bridge to Bradford Beach pavilion. The bluffs adjacent to the aforementioned walkway bridge are partially beyond the limits of the study area, however, based upon aerial and topographic maps are very similar in character. These inspections should include observations of active soil slumping, as well as other failure indicators, such as curved or tipped trees, falling trees, etc. (see Vegetation Indicators of Slope History and Stability section in Chapter III).

- Limiting mowing all the way to the edge of the top of the slope within Area C as shown on Map 5, inclusive of maintained grassy areas extending further south of the study area, may reduce susceptibility of bluff erosion and encourage slope stability. This would allow an additional five- to 10-foot strip of vegetation to grow to a taller height along the top of the slope and will discourage traffic from walking and riding on the edge of the top of the slope. This management action could be coupled with planting of grasses and sedges with more-extensive rooting and pleasing appearance (see Figure 11).

- Placement of signage and receptacles, and conduct of public informational programming, to encourage local residents and park visitors not to dump or throw trash, such as grass clippings, brush, and related garden waste and other litter, down the slopes of these bluffs (see Figure 11).

Map 5

RECOMMENDED PLANT COMMUNITY PLAN FOR LAKE PARK BLUFF: 2002

Source: SEWRPC.

- Public informational programming could also include elements to discourage clear cutting of trees and/or herbicide applications by local residents to improve scenic vistas of Lake Michigan that may lead to the destabilization and ultimate failure of the bluff slopes.

BLUFF VEGETATION MEASURES

While portions of the Lake Park bluffs have been dedicated as parkland since the late 19th century, the activities of humans have greatly changed the plant and animal communities. Some of the significant changes to the bluff's ecosystem include the following:

- Reduced diversity and health of vegetative communities on the bluffs;

- Introduction of nonnative species to the area and spread of invasive species;

- Increased erosion due to changes in hydrology and vegetative communities, and the creation of vagrant trails, paths, and roads; and

- Increased presence of mature tree cover.

If degradation of the native plant communities continues, it has the potential to reduce the ability of the bluff's plant communities to serve their important functions within the local ecosystem. The composition and structure of vegetation must be such that the required levels for nesting, travel routes, concealment, and protection from weather are met for each of the major animal species within the park, as well as important migratory bird species. Diversity is the key to ecological health and sustainability. Based upon the results of the vegetative survey it is apparent that several exotic invasive species of plants, like European buckthorn, black locust, and garlic mustard are taking over the bluffs and crowding out native species (see Figures 12 and 13). The development of increased exotics species is likely reducing the wildlife habitat on the bluff and in the Lake Park ecosystem as a whole. Additionally, the park is likely losing desirable wildflowers, trees, and shrubs because the native species cannot compete with these aggressive exotic species.

Based upon the analysis of the vegetative community among bluffs within Lake Park there are three distinctive areas that have been identified within the park, as shown on Map 5, that can be considered to form the basis for management recommendations. Area A, approximately eight acres in size, located in the northern portion of the park bluffs, contains the highest amount of native plant species compared to bluffs within the rest of the park. During the inventory survey, this was also the only area where approximately six to eight whitetail deer were observed bedding down in the afternoon. Area B, approximately 11 acres in size, located in the middle portion of the park, contains bluffs comprised of approximately 10 to 50 percent exotic invasive species and seems to be a transition area between Areas A and C (see Map 5). Area B contained a well-established tree canopy much like Area A, however, there were greater amounts of invasive plant species than Area A. As shown on Map 5, Area C, also about 11 acres in size, contains bluffs comprised of approximately 50 to 90 percent exotic invasive species and represents the most disturbed area of the park. This area is the most accessible to the public, due to its narrow corridor and also contains the highest and steepest slopes compared to the rest of the bluffs within the park.

The following management measures are considered viable for vegetation management purposes:

- Protect and enhance the native biodiversity among bluffs within Lake Park to achieve the fullest possible ecological restoration of plant communities over the long-term by eliminating exotic species by appropriate means. However, these management efforts to restore native vegetation are not recommended to compromise the stability of the slopes. Thus, measures such as mass herbicide treatments, which may lead to their ultimate failure, especially in Area C, are not recommended. Hence, management alternatives within Area C will be limited (see Map 5), due to the high proportions of exotic species that currently exist in this area and that are contributing to keeping the bluffs stable.

- Give priority to protecting and enhancing the highest-quality plant community areas prior to the lower-quality areas within Lake Park. Therefore, management activities to control exotic invasive species should be initiated in Areas A and B prior to Area C, because Area C is the most disturbed and degraded (see Map 5).

- Consider an integrated long-term management plan element targeted at addressing the localized bluff stability and vegetation community quality conditions within the southern bluffs of Lake Park, specifically within Area C (see Map 5). This planning effort should include involving a multi-discipline team of managers and interested citizen group representatives. The objective of this management measure would be to initially implement demonstration projects at one or two locations within Area C. The demonstration projects would be designed to encourage vegetative cover which provides proper root formation for bluff stabilization, coupled with plant aesthetics and height limitations to allow for scenic overlooks or vistas of Lake Michigan. This process of stabilization and revegetation of the slopes would rely primarily on native plant species.

- Establish monitoring protocol to annually or bi-annually assess changes in the vegetation community among the bluffs within Lake Park. This will assist in determining the success of management efforts throughout the park.

- Restoration and maintenance of the system of hiking trails located along the bluffs, especially Area C which contains the steepest and highest bluffs (see Map 5), within the park through signage or construction of boardwalks with steps and rails. This will encourage use of the trails among the bluffs and help reduce localized vagrant paths and widespread erosion from human traffic.

- Develop public informational programming to educate the local community and park visitors about the bluffs ecosystem and proposed management activities. Public education is an important component of a plant management program and should include information and education on:

  — The types of plants in Lake Park and their value to bluff stability and wildlife;

  — The preservation of existing stands of desirable plants;

  — The identification of nuisance exotic species and methods of preventing their spread; and

  — Alternative methods for controlling existing nuisance plants, including the positive and negative aspects of each method (for preliminary information see Appendix E).

- The public information program could also consider involving University of Wisconsin-Milwaukee faculty from the biological and geological sciences, or other educators, and urban planning departments, which would greatly add to the educational opportunities of this park for students, as well as be invaluable for the long-term understanding and protection of this resource.

- Continue to involve volunteers of local residents and park visitors through invitation as appropriate to participate in ongoing management efforts within the park. This activity currently is being carried out at a high level by the Friends of Lake Park.

- Consider sharing experiences with other bluff stabilization projects already in progress or completed throughout the Southeast coastal Lake Michigan region to assist in promoting successful bluff stability and restoration projects. See, for example, Appendix F for a list of native vegetation plant species as well as restoration recommendations developed from the Atwater Park Bluff Planting Project, in the Village of Shorewood.

Chapter V

SUMMARY AND CONCLUSIONS

SUMMARY

This study on the bluff stability and plant community assessment of bluffs within Lake Park is intended to help guide the development of the management measures for Lake Park by the Milwaukee County Department of Parks, Recreation and Culture. The objectives of this study are to determine the bluff stability and relative quality of the plant community among the bluffs within Lake Park and to provide guidance to be considered as programs are developed related to the long-term protection and maintenance of bluff stability and vegetation quality of the park.

The analyses indicate that Lake Park contains relatively stable bluffs with a poor-to-moderately good-quality vegetation community. The bluffs within the southern portion of the park are more unstable compared to bluffs within the rest of Lake Park. There are exotic plant species located throughout Lake Park, particularly in the southern portions of the park. This chapter presents the key findings of the bluff stability and vegetation community analysis conducted in August 2002, in Lake Park as well as the recommended management measures related to the protection, quality and long-term stability of these bluffs within this park.

CONCLUSIONS AND FINDINGS RELATED TO BLUFF STABILITY

The findings of the SEWRPC bluff stability analysis of Lake Park are summarized below.

- As indicated in early Milwaukee County Park Commission Reports and illustrated in Maps 2 and 3, many of the areas within and along the historic shoreline of Lake Park have been modified through human activities that include filling of ravines, regrading of slopes, tree and shrub plantings, as well as construction of buildings, trails, roads, bridges, and walkways.

- As indicated in early Milwaukee County Park Commission Reports and illustrated in Appendix A, many of the bluffs within Lake Park were stabilized over the years to avoid erosion.

- There has been no known documented reconstruction or major failure among the bluffs of Lake Park since the mid 1930s, when the County reconstructed and planted the southern bluffs of the park adjacent to Wahl Avenue. Hence, these efforts have assisted in keeping these areas stabilized for more than 70 years.

- As indicated in Figure 9 the southern bluffs, specifically Profiles 1 through 3 (see Map 5), are the tallest and steepest bluffs within Lake Park.

- As indicated in Figure 10 and Appendix C, the results of the bluff stability analysis demonstrate that the slopes within the southern portion of Lake Park, specifically Profiles 1 through 3 (see Map 5), are the most unstable compared to bluffs within Lake Park.

- As indicated in Figure 8, there is evidence of active recession of the bluffs within the southern portion of Lake Park, specifically adjacent to and within the areas of Profiles 1 through 3 (see Map 5). Evidence of such recession includes a relatively high proportion of curved tree trunks, tipped trees, and downed trees.

- As indicated in Figure 11, there is evidence of active top recession of the bluffs within the southern portion of Lake Park, specifically adjacent to and within areas of Profiles 1 and 2 (see Map 5).

- Field surveys indicate evidence of cutting of trees and shrubs and dead patches of vegetation among the southern portions of the bluffs, specifically areas adjacent to Wahl Avenue (see Map 5). These activities could potentially be contributing to the instability and compromising the long-term stability of the southern bluffs of Lake Park.

CONCLUSIONS AND FINDINGS RELATED TO BLUFF VEGETATION COMMUNITY

The findings of the SEWRPC vegetation community analysis of Lake Park are summarized below.

- As indicated in early Milwaukee County Park Commission Reports and illustrated in Appendix A, the northern portions of the Lake Park contained the greatest extent of wooded areas and is much better preserved than in any other areas of the park.

- As shown in Figures 2 through 5 and Appendix A, in the early periods of park history, a large portion of the bluffs, including the internal ravines throughout Lake Park, were comprised of vast open areas of grasses, sparse trees, and, in some areas, no vegetation at all.

- The plant community within Lake Park currently provides wildlife habitat and refuge for a variety of mammal species and more than 200 resident and migrant bird species.

- As indicated in Figure 12 and Appendix C, results of the vegetation survey show that there is a significant proportion of exotic plant species located throughout Lake Park. The southern portions of the park, in particular, are dominated by exotic species, thereby reducing the biological plant diversity and abundance, overall wildlife habitat value, and recreational and educational opportunities, as well as potentially compromising slope stability in the park.

- As indicated in Figure 13 and Appendix C, approximately 70 to 100 percent of total number of exotics plant species are comprised of only seven species that include black locust, Norway maple, honeysuckle, buckthorn, Highbush-Cranberry, garlic mustard, and burdock. Thus, management efforts to control these species would potentially be targeting 70 to 100 percent of the exotic plant problem among bluffs within the park.

- As indicated in Figure 14 and Map 4, results of the Milwaukee County vegetation survey show that there is a continuum of poor-quality, weedy-type of vegetation community in the southern portions of Lake Park that contains a low floral diversity and floristic value to a more natural moderately good-quality vegetation community in the northern areas of the park that contains a higher floral diversity and floristic value worthy of protection.

- Although there is a high proportion of exotic invasive plant species, as indicated in Figures 12 through 14 and Appendix C, among the southern bluffs of Lake Park, these plants are the major factor keeping these slopes stable. Hence, management alternatives within this area will be limited.

- Observations of cutting of trees and shrubs among the southern portions of the bluffs, specifically areas adjacent to Wahl Avenue (see Map 5), have potentially exacerbated the exotic plant species problem among these slopes contributing to the degradation and poor quality of the vegetative community.

POTENTIAL MANAGEMENT MEASURES

In order to assist in the management of the bluff stability and plant community within Lake Park, it is recommended that the Milwaukee County Department of Parks, Recreation and Culture consider the following:

- Protect and enhance the native biodiversity among bluffs within Lake Park using means that will not compromise the stability of the slopes.

- Give priority to protecting and enhancing the highest-quality plant community areas.

- Consider a long-term management strategy within the southern bluffs of Lake Park that encourages establishment of native vegetative cover to provide for bluff stabilization, while enhancing biological diversity and in selected sites maintaining scenic overlooks and vistas of Lake Michigan.

- Establish a monitoring protocol to annually assess changes in slope stability and vegetation community among the bluffs within Lake Park to assist in determining problem areas or changes in bluff recession and success of management efforts throughout the park.

- Limit mowing and establish native grass species with suitable root structure and aesthetics near the top of the slope to reduce susceptibility of bluff erosion and encourage slope stability.

- Restore and maintain the system of hiking trails located along the bluffs to encourage use of the trails among the bluffs and help reduce localized vagrant paths and widespread erosion from human traffic.

- Develop public informational programming to inform the local community and park visitors about the bluffs ecosystem and proposed management activities, as well as public educational programming through local educational institutions, including programming on:

    — Factors affecting bluff stability;

    — The role of vegetation in minimizing bluff erosion;

    — The types of plants in Lake Park and their value to bluff stability and wildlife;

    — The preservation of existing stands of desirable plants;

    — The identification of nuisance exotic species and methods of preventing their spread;

    — Alternative methods for controlling existing nuisance plants, including the positive and negative aspects of each method; and

    — The negative affects of dumping or throwing trash, such as grass clippings, brush, and related garden waste and other litter, down the slopes of these bluffs.

- Promote continued involvement of volunteers, local residents and park visitors as well as interested educators, through invitations to participate in ongoing management efforts and use of the park by students, as a means of ensuring the long-term understanding and protection of this resource.

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APPENDICES

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Appendix A

HISTORIC PHOTOS OF VARIOUS AREAS WITHIN LAKE PARK MILWAUKEE, WISCONSIN: 1893-1928

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Figure A-1

LAKE MICHIGAN SHORE IMPROVEMENTS AT THE SOUTH END OF LAKE PARK LOOKING SOUTH: JUNE 16, 1917

Source: Milwaukee County Department of Parks, Recreation and Culture.

Figure A-2

LAKE MICHIGAN SHORE IMPROVEMENTS AT THE NORTH END OF LAKE PARK LOOKING SOUTH AND PIER THAT WAS CONSTRUCTED FOR SHORE PROTECTION: JUNE 16, 1917

Source: Milwaukee County Department of Parks, Recreation and Culture.

Figure A-3

LAKE MICHIGAN BLUFFS NEAR THE LIGHTHOUSE OF LAKE PARK LOOKING SOUTH: 1890

Source: Milwaukee County Department of Parks, Recreation and Culture.

Figure A-4

LAKE MICHIGAN BLUFFS NEAR THE NORTH END OF LAKE PARK LOOKING NORTH: SEPTEMBER 19, 1928

Source: Milwaukee County Department of Parks, Recreation and Culture.

Figure A-5

RAVINE BLUFFS WITHIN LAKE PARK LOOKING WEST: 1904

Source: Milwaukee County Department of Parks, Recreation and Culture.

Figure A-6

LION BRIDGE RAVINE JUST SOUTH OF LIGHTHOUSE WITHIN LAKE PARK LOOKING EAST TOWARDS LAKE MICHIGAN: 1899

Source: Milwaukee County Department of Parks, Recreation and Culture.

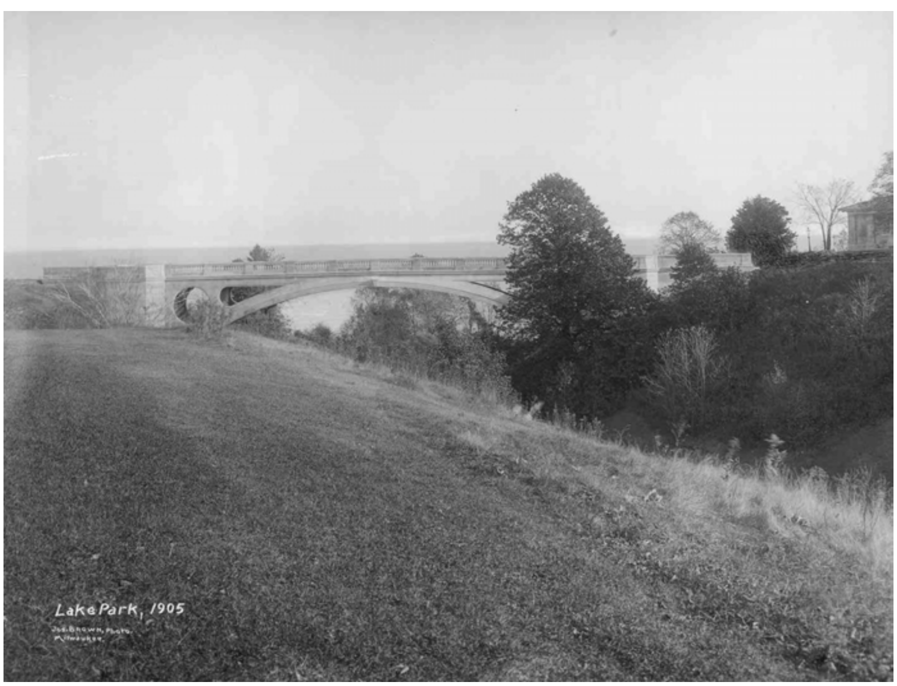
Figure A-7

EAST RAVINE ROAD BRIDGE AND PAVILION AT THE EASTERN ENTRANCE OF LAKE PARK AND EARLY CONSTRUCTION OF SHORE DRIVE ADJACENT TO LAKE MICHIGAN LOOKING NORTHWEST: 1905

Source: Milwaukee County Department of Parks, Recreation and Culture.

Figure A-8

EAST RAVINE ROAD BRIDGE WITHIN LAKE PARK LOOKING EAST TOWARDS LAKE MICHIGAN: 1905



Source: Milwaukee County Department of Parks, Recreation and Culture.

Figure A-9

STEEL FOOT BRIDGE WITHIN THE NORTHERN PORTION OF LAKE PARK: 1892

Source: Milwaukee County Department of Parks, Recreation and Culture.

Figure A-10

RAVINE WITHIN LAKE PARK: FEBRUARY 4, 1918

Source: Milwaukee County Department of Parks, Recreation and Culture.

Figure A-11

MILITARY REVIEW AT THE RUNNING TRACK WITHIN LAKE PARK: SEPTEMBER 19, 1915

Source: Milwaukee County Department of Parks, Recreation and Culture.

Figure A-12

WISCONSIN GUN CLUB TOURNAMENT AT THE NORTH END OF LAKE PARK LOOKING SOUTHEAST FROM THE TOP OF THE BLUFF: JUNE 13, 1920

Source: Milwaukee County Department of Parks, Recreation and Culture.

Appendix B

LIST OF BIRD SPECIES KNOWN TO OCCUR WITHIN LAKE PARK: 2003

Scientific (family) and Common Name	Scientific Name
Gaviidae – Loon	
Red-Throated Loon	*Gavia stellata*
Common Loon[a]	*Gavia immer*
Podicipedidae – Grebe	
Pied-Billed Grebe	*Podylimbos podiceps*
Horned Grebe	*Podiceps auritus*
Phalacrocoracidae – Cormorant	
Double-Crested Cormorant	*Phalacrocorax auritus*
Ardeidae – Heron, Bittern	
American Bittern[a]	*Botaurus lentiginosus*
Great Blue Heron[a]	*Ardea herodias*
Green Heron	*Butrodes striatus*
Black-Crowned Night Heron[a]	*Nycticorax nycticorax*
Cathartidae – New World Vulture	
Turkey Vulture	*Cathartes aura*
Anatidae – Duck, Geese, Swan	
Tundra Swan	*Cygnus columbianus*
Mute Swan[d]	*Cygnus olor*
Canada Goose	*Branta canadensis*
Wood Duck	*Aix sponsa*
Green-Winged Teal	*Anas crecca*
American Black Duck[a]	*Anas rubripes*
Mallard	*Anas platyrhynchos*
Blue-Winged Teal	*Anas discors*
Northern Shoveler	*Anas clypeata*
Gadwall	*Anas strepera*
American Wigeon[a]	*Anas americana*
Canvasback[a]	*Aythya valisineria*
Redhead[a]	*Aythya americana*
Ring-Necked Duck	*Aythya collaris*
Lesser Scaup[a]	*Aythya affins*
Common Goldeneye[a]	*Bucephala clangula*
Ross's Goose	*Chen rossii*
White-Cheeked Pintail	*Anas bahamensis*
Greater Scaup	*Aythya marila*
King Eider[e]	*Somateria spectabilis*
Harlequin Duck	*Histrionicus histrionicus*
Surf Scoter	*Melanitta perspicillata*
White-Winged Scoter	*Melanitta fusca*
Black Scoter	*Melanitta nigra*
Long-Tailed Duck	*Clangula hyemalis*
Bufflehead	*Bucephala albeola*
Hooded Merganser	*Lophodytes cucullatus*
Common Merganser[a]	*Mergus merganser*
Red-Breasted Merganser[a]	*Mergus serrator*
Ruddy Duck	*Oxyura jamaicensis*
Accipitridae – Hawk, Kite, Eagle	
Osprey[b]	*Pandion haliaetus*
Bald Eagle[c]	*Haliaeetus leucocephalus*
Cooper's Hawk	*Accipiter cooperi*
Sharp-Shinned Hawk	*Accipiter striatus*
Northern Harrier[a]	*Circus cyaneus*
Broad-Winged Hawk	*Buteo platypteris*
Red-Tailed Hawk	*Buteo jamaicensis*

Appendix B (continued)

Scientific (family) and Common Name	Scientific Name
Falconidae – Caracaras, Falcon	
American Kestrel	*Falco sparverius*
Peregrine Falcon[b,c]	*Falco peregrinus*
Merlin[a]	*Falco columbarius*
Phasianidae – Partridge, Grouse, Turkey, Quail	
Wild Turkey[e]	*Meleagris galloparvo*
Rallidae – Rail, Gallinule, Coot	
American Coot	*Fulca americana*
Gruidae – Crane	
Sandhill Crane	*Grus canadensis*
Whooping Crane	*Grus americana*
Charadriidae – Lapwing, Plover	
Black-Bellied Plover	*Pluvialis squatarola*
Semipalmated Plover	*Charadrius semipalmatus*
Piping Plover[c,e]	*Charadrius melodus*
Killdeer	*Charadrius vociferus*
Scolopacidae – Sandpiper, Phalarope	
Greater Yellowlegs	*Tringa melanolueca*
Lesser Yellowlegs	*Tringa flavipes*
Solitary Sandpiper	*Tringa solitaria*
Willet	*Catoptrophorus semipalmatus*
Ruddy Turnstone	*Arenaria interpres*
Red Knot	*Calidris canutus*
Sanderling	*Calidris alba*
Semipalmated Sandpiper	*Calidris pusilla*
Western Sandpiper	*Calidris mauri*
Least Sandpiper	*Calidris minutilla*
White-Rumped Sandpiper	*Calidris fuscicollis*
Baird's Sandpiper	*Calidris bairdii*
Pectoral Sandpiper	*Calidris melanotos*
Purple Sandpiper	*Calidris maritima*
Dunlin	*Calidris alpina*
Red Phalarope[e]	*Phalaropus fulicaria*
Laridae – Gull, Tern	
Bonaparte's Gull[a]	*Larus philadelphia*
Ring-Billed Gull	*Larus delawarensis*
Herring Gull	*Larus argentatus*
Little Gull[a,e]	*Larus minutus*
Thayer's Gull	*Larus thayeri*
Iceland Gull	*Larus glaucoides*
Glaucous Gull[e]	*Larus hyperboreus*
Caspian Tern[b]	*Sterna caspia*
Common Tern[a]	*Sterna hirunda*
Forster's Tern[b]	*Sterna forsteri*
Black Tern	*Chlidonias niger*
Columbidae – Pigeon, Dove	
Rock Dove[d]	*Columba livia*
Mourning Dove	*Zenaida macroura*
Cuculidae – Cuckoo	
Black-Billed Cuckoo	*Coccyzus erythropthalmus*
Yellow-Billed Cuckoo[a]	*Coccyzus americanus*

Appendix B (continued)

Scientific (family) and Common Name	Scientific Name
Strigidae – Owl	
Eastern Screech Owl	*Otus asio*
Great Horned Owl	*Bubo virginianus*
Snowy Owl	*Nyctea scandiaca*
Long-Eared Owl[a]	*Asio otus*
Caprimulgidae – Goatsucker	
Common Nighthawk	*Chordeiles minor*
Apodidae – Swift	
Chimney Swift	*Chaetura pelagica*
Trochilidae – Hummingbird	
Ruby-Throated Hummingbird	*Archilocus colubris*
Alcedinidae – Kingfisher	
Belted Kingfisher	*Megaceryle alcyon*
Picidae – Woodpecker	
Red-Bellied Woodpecker	*Melanerpes carolinus*
Red-Headed Woodpecker[a]	*Melanerpes erythrocephalus*
Yellow-Bellied Sapsucker	*Sphyrapicus varius*
Downy Woodpecker	*Picoides pubescens*
Hairy Woodpecker	*Picoides villosus*
Pileated Woodpecker	*Dryocopus pileatus*
Northern Flicker	*Colaptes auratus*
Tyrannidae – Flycatcher	
Eastern Wood-Pewee	*Contopus virens*
Willow Flycatcher	*Empidonax traillii*
Least Flycatcher	*Empidonax minimus*
Eastern Phoebe	*Sayornia phoebe*
Great-Crested Flycatcher	*Myiarchus crinitus*
Hirundinidae – Swallow	
Purple Martin	*Progne subris*
Tree Swallow	*Iridoprocne bicolor*
Northern Rough-Winged Swallow	*Stelgidopteryx serripennis*
Bank Swallow	*Riparia riparia*
Cliff Swallow	*Pertocheliden pyrrhonota*
Barn Swallow	*Hirundo rustica*
Corvidae – Jay, Crow	
Blue Jay	*Cyanocitta cristata*
American Crow	*Corvus brachyrhynchos*
Paridae – Chickadee	
Black-Capped Chickadee	*Parus atricapillus*
Sittidae – Nuthatch	
Red-Breasted Nuthatch	*Sitta canadensis*
White-Breasted Nuthatch	*Sitta carolinensis*
Certhiidae – Creeper	
Brown Creeper	*Certha familiaris*
Troglodytidae – Wren	
House Wren	*Troglodytes aedon*
Winter Wren	*Troglodytes troglodytes*
Sedge Wren	*Cistothorus platensis*
Marsh Wren	*Cistothorus palustrus*
Regulidae – Kinglet	
Golden-Crowned Kinglet	*Regulus satrapa*

Scientific (family) and Common Name	Scientific Name
Ruby-Crowned Kinglet[a]	*Regulus calendula*
Sylviidae – Gnatcatcher	
Blue-Gray Gnatcatcher	*Polioptila caerulea*
Turidae – Thrush	
Veery	*Catharus fuscenscens*
Gray-Cheeked Thrush	*Catharus minimus*
Swainson's Thrush[a]	*Catharus ustulatus*
Hermit Thrush	*Catharus guttatus*
Wood Thrush	*Hylocichla mustelina*
American Robin	*Turdus migratorius*
Mimidae – Mockingbird, Thrasher	
Gray Catbird	*Dumetalla carolinensis*
Northern Mockingbird	*Mimus polyglottos*
Brown Thrasher	*Toxostoma rufum*
Motacillidae – Pipit	
American Pipit	*Anthus spinoletta*
Bombycillidae – Waxwing	
Cedar Waxwing	*Bombycilla cedorum*
Sturnidae – Starling	
European Starling[d]	*Sturnus vulgaris*
Vireonidae – Vireo	
Red-Eyed Vireo	*Vireo olivaceus*
Yellow-Throated Vireo	*Vireo flavifrons*
Warbling Vireo	*Vireo gilvus*
Red-Eyed Vireo	*Vireo olivaceus*
Parulidae – Warbler	
Blue-Winged Warbler	*Vermivora pinus*
Golden-Winged Warbler	*Vermivora chrysoptera*
Tennessee Warbler[a]	*Vermivora peregrina*
Nashville Warbler	*Vermivora ruficapilla*
Northern Parula	*Parula americana*
Yellow Warbler	*Dendroica patechia*
Chestnut-Sided Warbler	*Dendroica pensylvanica*
Magnolia Warbler	*Dendroica magnolia*
Cape May Warbler[a]	*Dendroica tigrina*
Black-Throated Blue Warbler[a]	*Dendroica caerulescens*
Yellow-Rumped Warbler	*Dendroica coronata*
Black-Throated Green Warbler	*Dendroica virens*
Blackburnian Warbler	*Dendroica fusca*
Palm Warbler	*Dendroica palmarum*
Bay-Breasted Warbler	*Dendroica castanea*
Blackpoll Warbler	*Dendroica striata*
Cerulean Warbler[b]	*Dendroica cerulea*
Black-and-White Warbler	*Mniotilta varia*
American Redstart	*Setophaga ruticilla*
Worm-Eating Warbler[b]	*Helmitheros vermivorus*
Ovenbird	*Seiurus aurocapillus*
Northern Waterthrush	*Seiurus noveboracensis*
Louisiana Waterthrush[a]	*Seiurus motacilla*
Common Yellowthroat	*Geothlypis trichas*
Wilson's Warbler	*Wilsonia pusilla*
Mourning Warbler	*Oporonis philadelphia*
Canada Warbler	*Wilsonia canadensis*

Appendix B (continued)

Scientific (family) and Common Name	Scientific Name
Thraupidae – Tanager	
Scarlet Tanager	*Piranga rubra*
Cardinalidae – Cardinal	
Northern Cardinal	*Cardinalis cardinalis*
Rose-Breasted Grosbeak	*Pheucticus ludovicianus*
Indigo Bunting	*Passerina cyanea*
Emberizidae – Emberizid	
Eastern Towhee	*Pipilo erythrophthalmus*
Clay-Colored Sparrow	*Spizella pallida*
American Tree Sparrow	*Spizella arborea*
Chipping Sparrow	*Spizella passerine*
Field Sparrow	*Spizella pusilla*
Lark Bunting[e]	*Calamospiza melanocorys*
Le Conte's Sparrow[a]	*Ammodramus leconteii*
Savannah Sparrow	*Passerculus sandwichensis*
Harris's Sparrow	*Zonotrichia querula*
Henslow's Sparrow[b]	*Ammodramus henslowii*
Fox Sparrow	*Passerella iliaca*
Song Sparrow	*Melospiza melodia*
Lincoln's Sparrow	*Melospiza lincolnii*
Swamp Sparrow	*Melospiza Georgiana*
White-Throated Sparrow	*Zonotrichia albicollis*
White-Crowned Sparrow	*Zonotrichia leucophrys*
Dark-Eyed Junco	*Junco hymealis*
Snow Bunting	*Plectrophenax nivalis*
Icteridae – Blackbird	
Bobolink	*Dolichonyx oryzivorus*
Red-Winged Blackbird	*Agelius phoeniceus*
Rusty Blackbird	*Euphagus carolinus*
Common Grackle	*Quiscalus quiscula*
Brown-Headed Cowbird	*Molothrus ater*
Baltimore Oriole	*Icterus galbula*
Fringillidae – Finch	
Pine Grosbeak	*Pinicola enucleator*
Purple Finch	*Carpodacus purpureus*
House Finch	*Carpodacus mexicanus*
Common Redpoll	*Carduelis flammea*
Pine Siskin[a]	*Carduelis pinus*
American Goldfinch	*Carduelis tristis*
Passeridae – Old World Sparrow	
House Sparrow[d]	*Passer domesticus*

NOTE: Total number of bird species: 204
Number of alien, or nonnative, bird species: 4 (2 percent)

[a]*State-designated species of special concern and fully protected by federal and state laws under the Migratory Bird Act.*

[b]*State-designated endangered or threatened species.*

[c]*Federally designated endangered or threatened species.*

[d]*Alien, or nonnative, bird species.*

[e]*Species that rarely occur within Lake Park.*

Source: Information provided by Lake Park Friends web site, http://home.wi.rr.com/phunter1/lakeparkbirds.html, "Birds of Lake Park," February 19, 2003.

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Appendix C

PRELIMINARY VEGETATION SURVEY OF LAKE PARK MILWAUKEE, WISCONSIN AUGUST 21, 2002

Observer: Dr. Lawrence A. Leitner, PhD, Principal Specialist-Biologist, Southeastern Wisconsin Regional Planning Commission.

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Table C-1

PRELIMINARY VEGETATION SURVEY OF THE PROPORTIONS OF COVER OF GROUND SPECIES AMONG BLUFF PROFILES WITHIN LAKE PARK: AUGUST 21, 2002

		Profiles												
		1	2	3	4	5	6	7	8	9	10	11	12	13
	Length of profile (meters)	50	35	35	27	25	35	21	26	33	25	28	20	20
Common Name	Species Name	Species Composition (percent)												
Garlic Mustard[a]	*Alliaria officinalis*	47.6	40.5	35.1	52.5	27.8	64.0	16.7	61.5	61.7	50.0			
Wild Leek	*Allium tricoccum*									4.2				
Burdock[a]	*Arctium minus*	33.3	11.9	24.5	35.0		10.0							
Enchanter's Nightshade	*Circaea lutetiana*					27.8	8.0							
Canada Thistle[a]	*Cirsium arvense*		4.8											
White Avens	*Geum canadense*									4.2				
Creeping Charlie[a]	*Glechoma hederacea*		14.0											
Daylily[a]	*Hemerocallis fulva*		9.5											
Dame's Rocket[a]	*Hesperis matronalis*		10.5											
Virginia Waterleaf	*Hydrophyllum virginianum*				7.5	11.1	6.0	58.3	15.4	4.2				
Yellow Jewelweed	*Impatiens pallida*					22.2					50.0	12.5		
Motherwort[a]	*Leonurus cardiaca*				5.0				7.7					
Catnip[a]	*Nepeta cataria*		4.8	8.8										
Virginia Creeper	*Parthenocissus* sp.		4.8	3.5										
Mayapple	*Podophyllum peltatum*						12.0			4.2				
False Solomon's Seal	*Smilacina racemosa*											12.5		
Starry False Solomon's Seal	*Smilacina stellata*	19.1				11.1								
Deadly Nightshade[a]	*Solanum dulcamara*		23.8	3.5										
Zigzag Goldenrod	*Solidago flexicaulis*							25.0		21.3		29.2	71.4	71.4
Woodland Meadow Rue	*Thalictrum dioicum*								15.4			33.3	28.6	28.6
White Trillium	*Trillium grandiflorum*											12.5		
- -	Proportion exotic species (percent)	80.9	95.3	96.4	92.5	27.8	74.0	16.7	69.2	61.7	50.0	0.0	0.0	0.0
- -	Proportion native species (percent)	19.1	4.7	3.6	7.5	72.2	26.0	83.3	30.8	38.3	50.0	100.0	100.0	100.0

[a]*Nonnative exotic species to the State of Wisconsin.*

Source: SEWRPC.

Table C-2

PRELIMINARY VEGETATION SURVEY OF THE PROPORTIONS OF COVER OF SHRUB SPECIES AMONG BLUFF PROFILES WITHIN LAKE PARK: AUGUST 21, 2002

		Profiles												
		1	2	3	4	5	6	7	8	9	10	11	12	13
	Length of profile (meters)	50	35	35	27	25	35	21	26	33	25	28	20	20
Common Name	Species Name	Species Composition (percent)												
Boxelder	*Acer negundo*				21.7					6.2				
Yellowbud Hickory	*Carya cordiformis*													17.8
Shagbark Hickory	*Carya ovata*												11.1	
Alternate-Leaved Dogwood	*Cornus alternifolia*											14.3		14.3
Hawthorn	*Crataegus* sp.		6.8											
Wahoo	*Euonymus atropurpureus*											7.1		
Green Ash	*Fraxinus pennsylvanica*		11.0											
Witchhazel	*Hamamalis virginiana*													32.1
Black Walnut	*Juglans nigra*		5.5											
Hybrid Honeysuckle[a]	*Lonicera* x *bella*	47.4	20.5	38.9	21.7		25.0		40.0		10.0			
White Mulberry[a]	*Morus alba*			27.8										
Ironwood	*Ostrya virginiana*												16.7	
Chokecherry	*Prunus virginiana*			16.7	43.5	100.0	35.0	54.5	26.7	68.8	40.0	50.0	72.2	35.7
European Buckthorn[a]	*Rhamnus cathartica*	52.6	37.0				20.0					10.7		
Staghorn Sumac	*Rhus typhina*		4.1											
Black Locust[a]	*Robinia pseudoacacia*		15.1											
Lilac[a]	*Syringa vulgaris*			16.7										
European Highbush-Cranberry[a]	*Viburnum opulus*				13.0		20.0	45.4	33.3	25.0	50.0	17.8		
- -	Proportion exotic species (percent)	100	72.6	83.4	34.7	0.0	65.0	45.4	73.3	25.0	60.0	28.5	0.0	0.0
- -	Proportion native species (percent)	0.0	27.4	16.6	65.3	100.0	35.0	54.6	26.7	75.0	40.0	71.5	100.0	100.0

[a]*Nonnative exotic species to the State of Wisconsin.*

Source: SEWRPC,

Table C-3

PRELIMINARY VEGETATION SURVEY OF THE PROPORTIONS OF COVER OF TREE SPECIES AMONG BLUFF PROFILES WITHIN LAKE PARK: AUGUST 21, 2002

		Profiles												
		1	2	3	4	5	6	7	8	9	10	11	12	13
	Length of profile (meters)	50	35	35	27	25	35	21	26	33	25	28	20	20
Common Name	Species Name	Species Composition (percent)												
Boxelder	*Acer negundo*			15.9			18.4		8.3	5.4				
Norway Maple[a]	*Acer platanoides*			9.5	16.0	71.4	38.8							
Sugar Maple	*Acer saccharum*											34.1		80.0
Shagbark Hickory	*Carya ovata*												14.3	
Hawthorne	*Crataegus* sp.				16.0		12.2			14.5	10.5			
Beech	*Fagus grandifolia*											14.6		
White Ash	*Fraxinus americana*										13.2	19.5		
Green Ash	*Fraxinus pennsylvanica*	13.0	44.4	36.5	28.0			48.4	22.2	9.1			14.3	
Apple[a]	*Malus pumila*								8.3				57.1	
White Mulberry[a]	*Morus alba*	17.4						51.6	61.1					
Ironwood	*Ostrya virginiana*											9.8		
Black Cherry	*Prunus serotina*									16.4	10.5			
Red Oak	*Quercus rubra*									9.1	31.6	14.6		
Black Locust[a]	*Robinia pseudoacacia*	69.6	55.6	38.1	40.0		60.6			27.3	7.9			
Basswood	*Tilia americana*					28.6				18.2	26.3	7.3	14.3	20.0
- -	Proportion exotic species (percent)	87.0	55.6	47.6	56.0	71.4	69.4	51.6	69.4	27.3	7.9	0.0	57.1	0.0
- -	Proportion native species (percent)	13.0	44.4	52.4	44.0	28.6	30.6	48.4	30.6	72.7	92.1	100.0	42.9	100.0

[a]*Nonnative exotic species to the State of Wisconsin.*

Source: SEWRPC.

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Appendix D

SLOPE STABILITY ANALYSIS OUTPUT PLOTS FOR PROFILES WITHIN LAKE PARK

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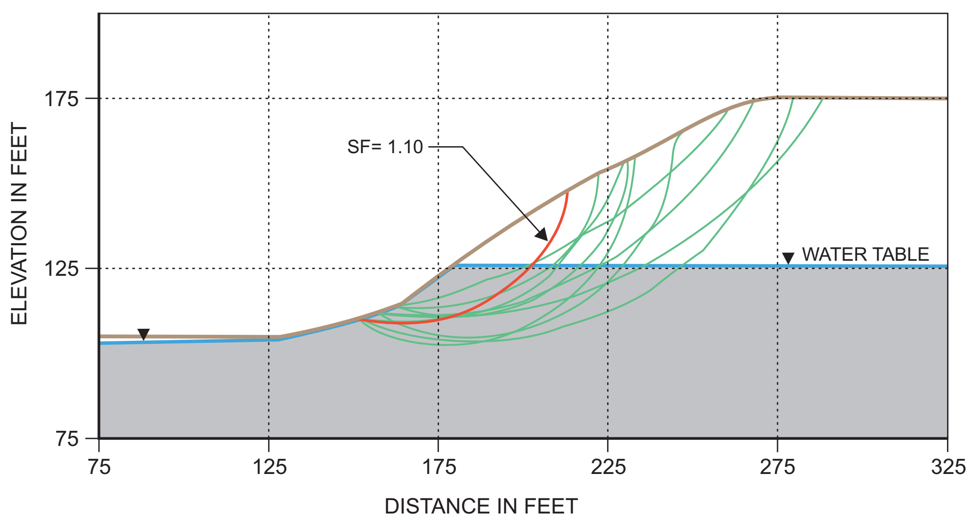
PROFILE 1 (High)



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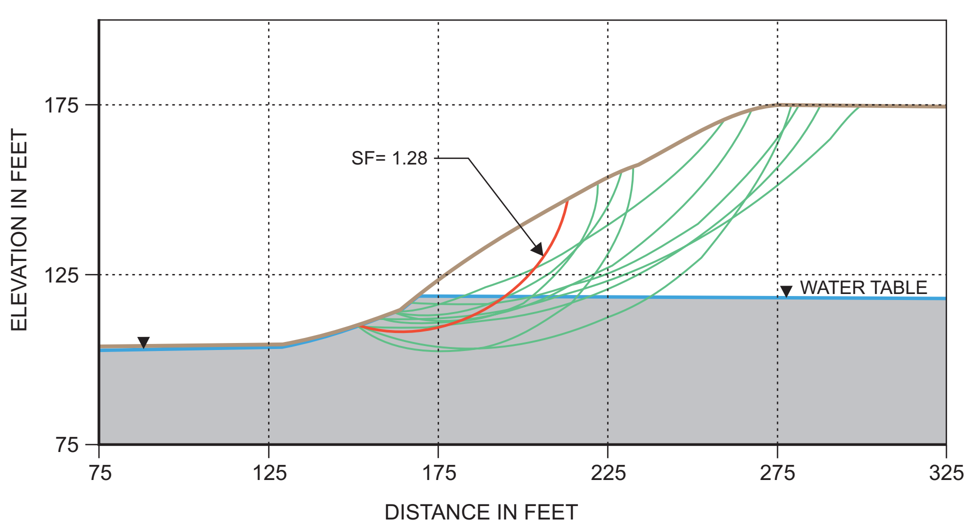

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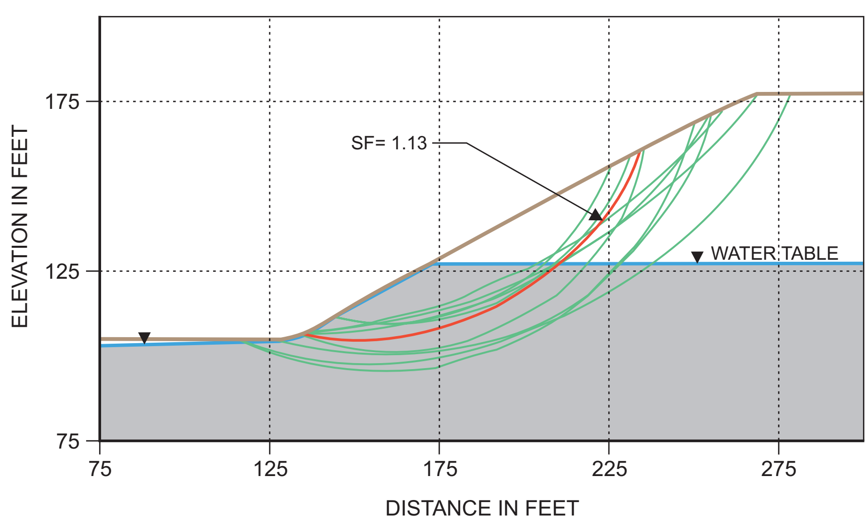

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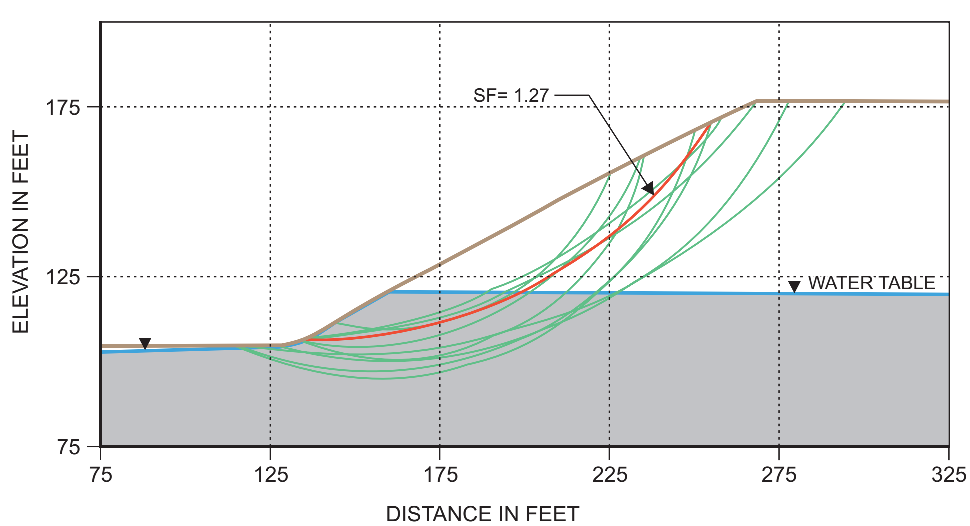

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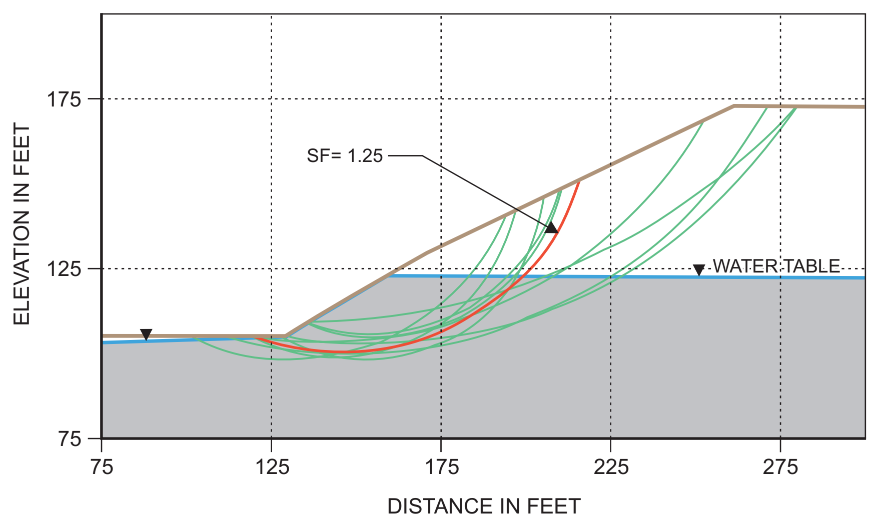

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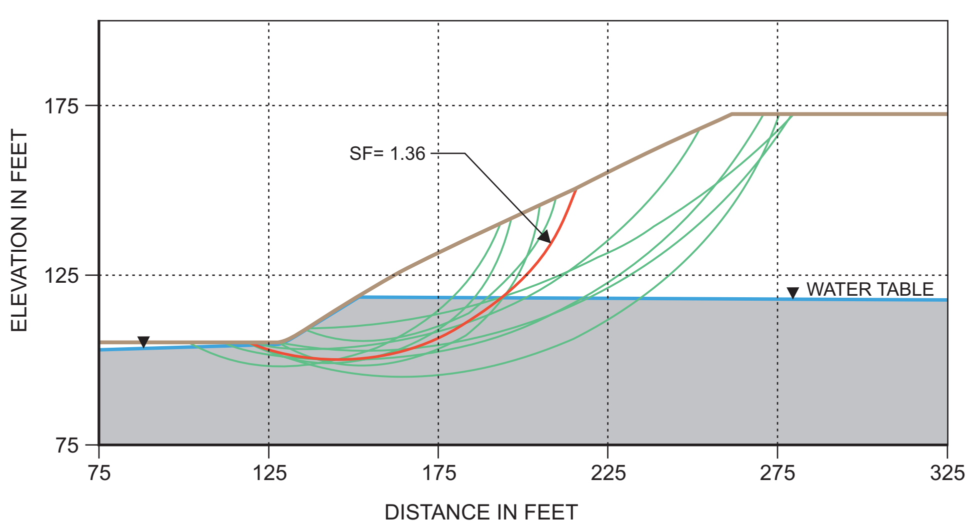

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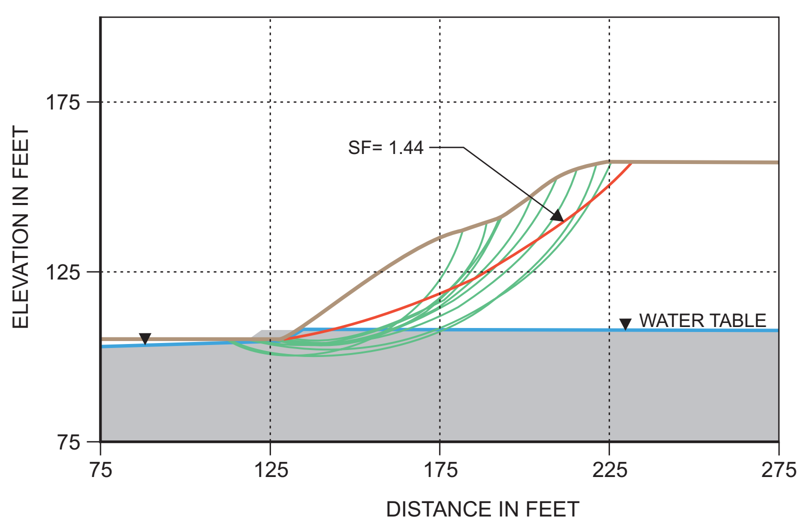

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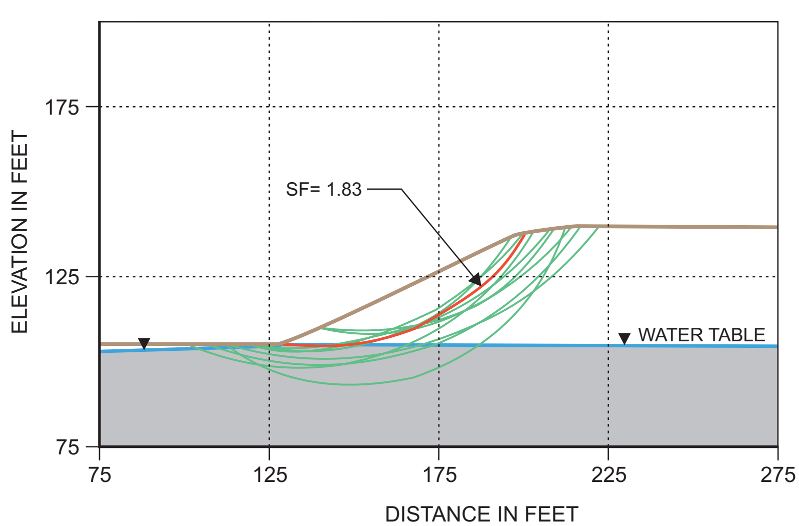

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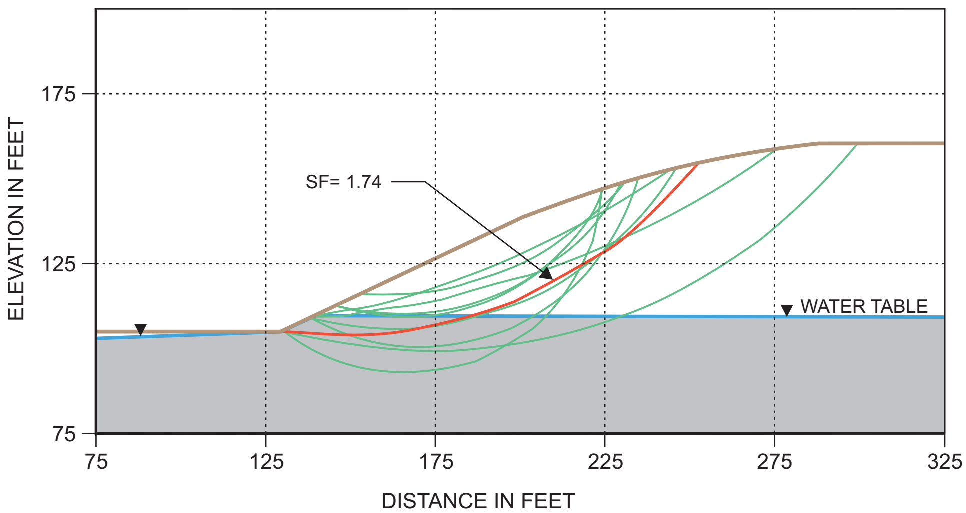

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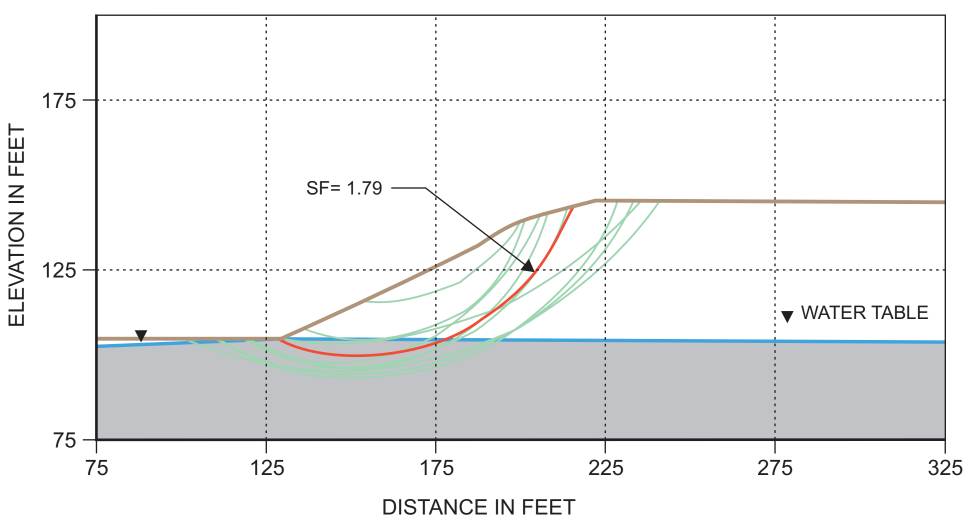

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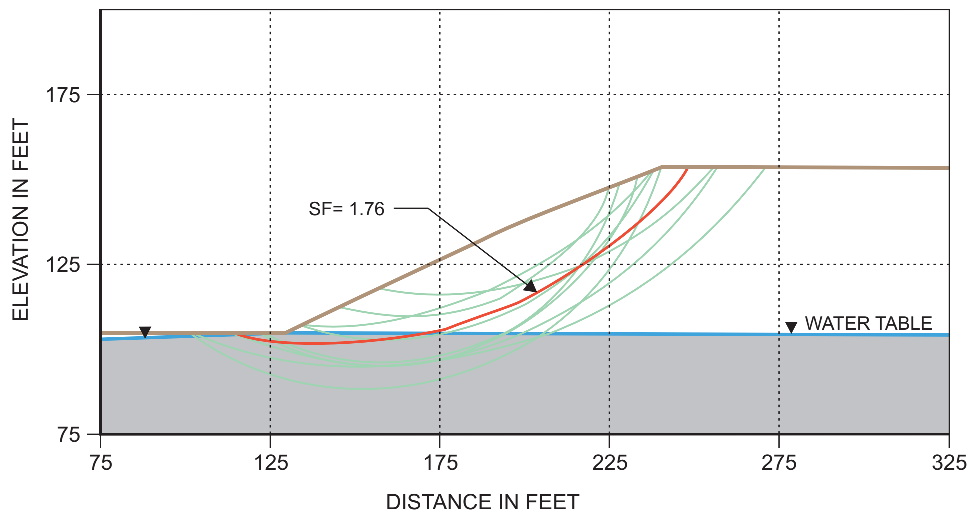

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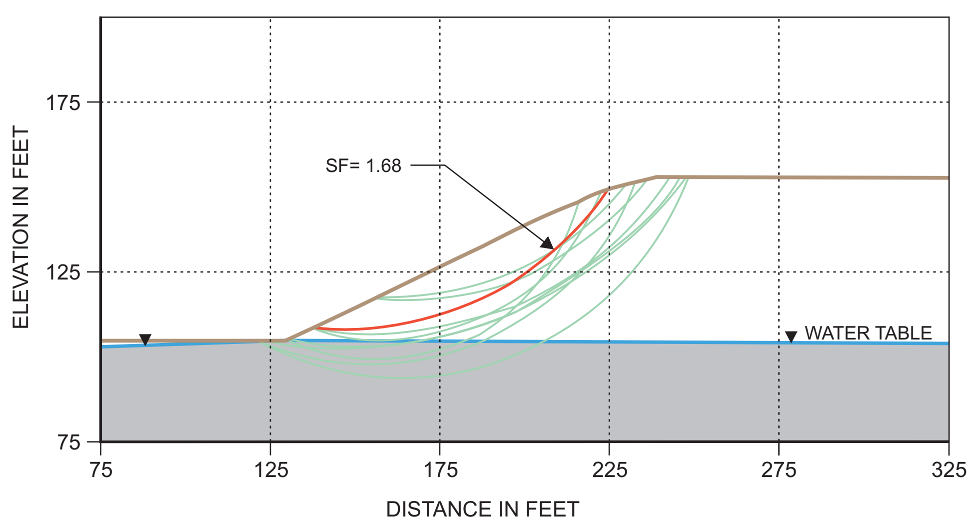

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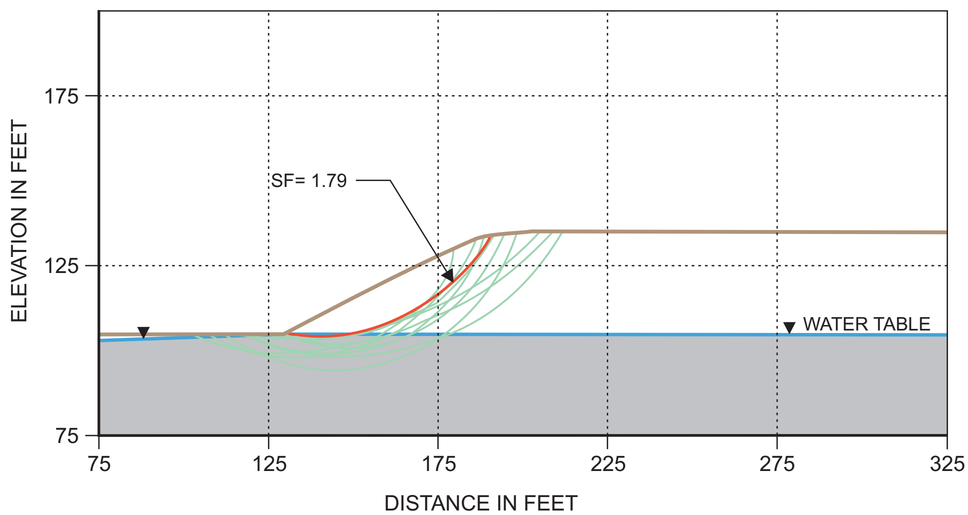

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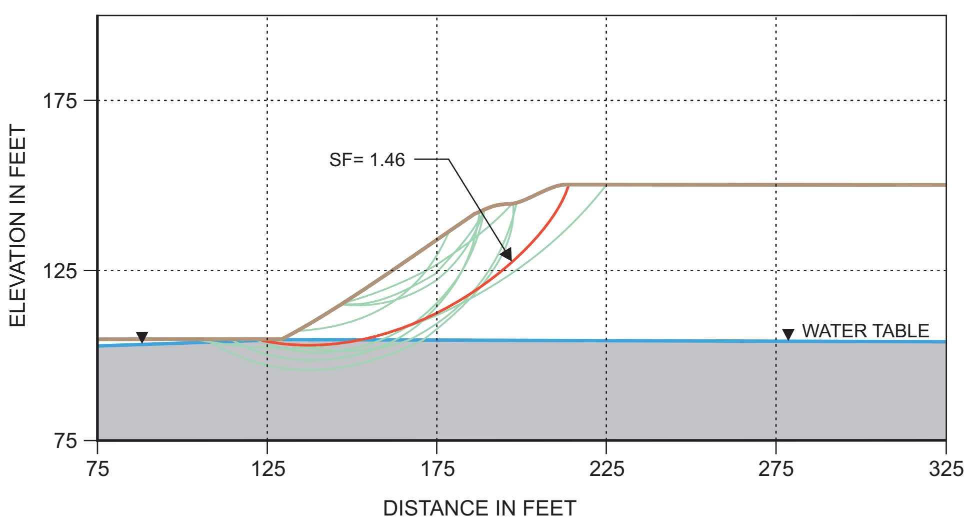

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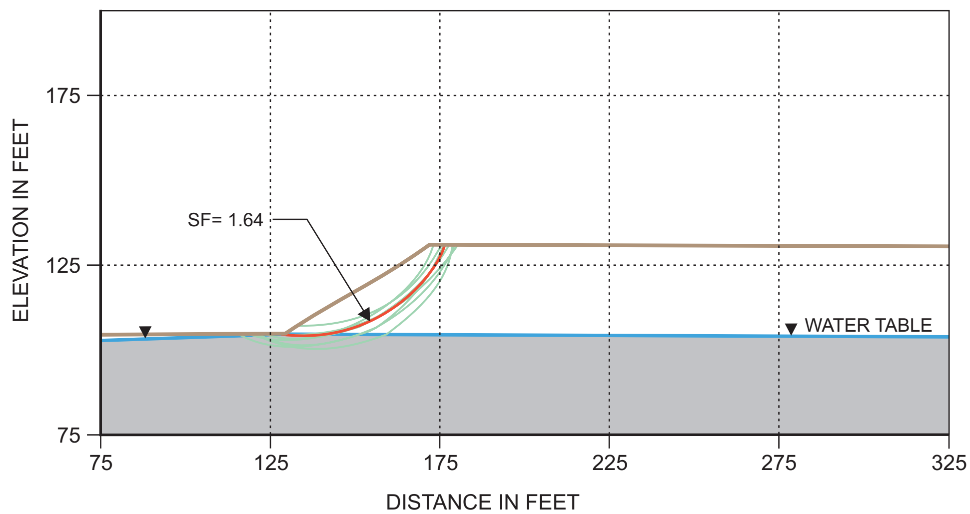

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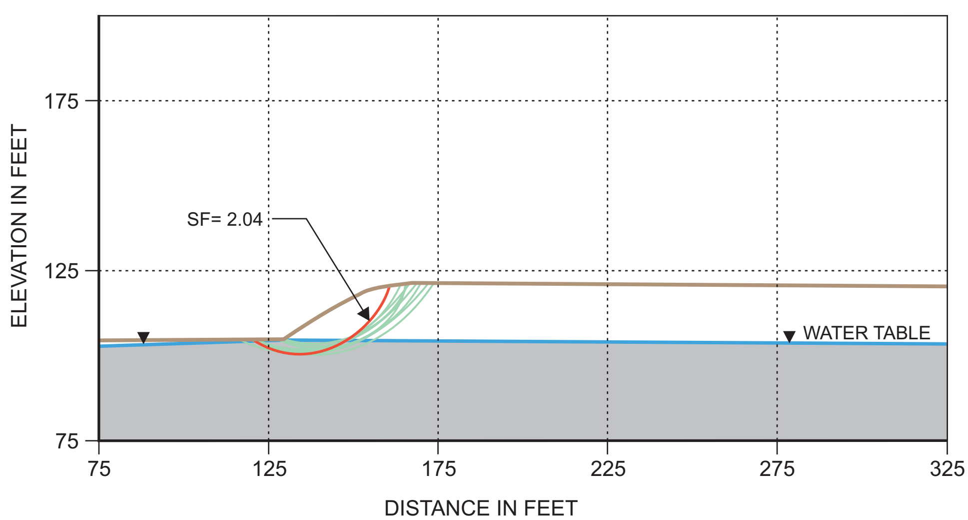

Appendix E

DESCRIPTION/LIFE HISTORY, DISTRIBUTION, HABITAT, AND CONTROL METHODS OF DOMINANT NONNATIVE EXOTIC INVASIVE SPECIES FOUND WITHIN LAKE PARK

Trees

Scientific name:	Common Name:
Acer platanoides	Norway maple
Robinia pseudoacacia	Black locust

Shrubs[a]

Lonicera spp.	Honeysuckle complex
Rhamnus cathartica	European buckthorn

Ground Cover

Alliaria officinalis	Garlic mustard
Arctium minus	Burdock

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[a]*European Highbush-Cranberry (*Viburnum opulus*) is a dominant nonnative shrub species found within Lake Park. However, this plant is generally considered to be a "potentially" invasive species, and, therefore, is not included as part of this appendix.*

Source: Wisconsin State Herbarium, University of Wisconsin-Madison, 160 Birge Hall, 430 Lincoln Drive, Madison, Wisconsin 53706-1381, http://www.botany.wisc.edu/herbarium/, January 2003.

NORWAY MAPLE (*Acer platanoides*)

Description/Life History

Norway maple has large leaves similar to sugar maple. Break a leaf or stalk, and a drop of white sap will show if it is Norway maple. Fall foliage is yellow (exception: cultivars, such as "Crimson King," which have red leaves in spring or summer and may have red leaves in autumn). The leaves turn color late, usually in November. This tree suppresses growth of grass, garden plants, and forest understory beneath it, at least as far as the drip-line. Its wind-borne seeds can germinate and grow in deep shade. The presence of young Norway maples in our woodlands is increasing. Our mixed deciduous forests will give way to pure stands of Norway maple in the next century unless we control its spread now.

Distribution and Habitat

The Norway maple is native across Europe. Introduced to North America, where it is considered a common, invasive species. Originally, it was planted along city streets and in parks. It frequently escapes from cultivation to grow in disturbed woods and roadways. The Norway maple is normally found in humid temperate regions. The Norway maple grows in full sun or light shade. It is tolerant of many soils, easy to transplant. It will grow in almost any well-drained soil.

Control Methods

Mechanical

Norway maple seedlings and small or shallow-rooted plants may be pulled from the ground when the soil is moist. Larger plants may be dug out, including the root systems, using a spading fork or weed wrench. The Norway maple may be cut down, the stump ground out, or clip off any regrowth.

The tree may be girdled: cut through the bark and growing layer (cambium) all around the trunk, about six inches above the ground. Girdling is most effective in spring when the sap is rising, and from middle to late summer when the tree is sending down food to the roots. Clip off any regrowth.

Chemical

Cut a hole (several holes in larger trees) downward into the growing layer, and apply glyphosate. Follow label directions for injection. This is most effective from middle to late summer. Clip off any regrowth or treat with glyphosate.

Treat foliage with glyphosate herbicide. Use an envelope dauber (small sponge-topped bottle), following label directions for "wiper" method. Add a drop of food color for visibility or use a foam spray. Avoid dripping on nontarget plants, because glyphosate kills most plants except moss. If it rolls off waxy or grass-like foliage, use additional sticker-spreader. Deciduous trees move nutrients down to the roots in late summer. Glyphosate is particularly effective at this time. Several invasive exotics retain their foliage after native plants have lost theirs, and resume growth earlier in spring than most natives. This allows you to treat them without harming the natives. However, the plant must be growing for the herbicide to work, and more may be needed in cold weather because growth is slower.

Description/Life History

BLACK LOCUST (*Robinia pseudoacacia*)

Black locust is a leguminous deciduous tree that grows from 30 to 80 feet tall. It is often attacked by stem borers and other insects, causing deformed growth and dieback. It has a shallow, fibrous root system and spreads by underground rhizomes. Young saplings have smooth, green bark; older trees have deep, furrowed, shaggy, dark bark with flat-topped ridges. Leaves are alternate and pinnately compound with seven to 21 leaflets. Leaflets are thin, elliptical, dark green above, and pale beneath. Smaller branches are armed with heavy, paired thorns. Flowers are pea-like, fragrant, white and yellow, and born in large drooping racemes. Seed pods are shiny, smooth, narrow, flat, two to four inches long, and contain four to eight seeds. Black locust stands are easy to identify in spring because they typically form multiple-stemmed clones and are slow to leaf out. They produce showy flower clusters in May or June.

Black locust is a translocated deciduous tree that is frequently found in upland prairies, savannas, roadsides, old fields, and woodlots in Wisconsin. Black locust prefers humid climates with sandy, loamy, well-drained soils in open, sunny locations. The tree is native to the slopes and forest margins of Southern Appalachia and the Ozarks. It was introduced throughout Wisconsin in the early 1900's because its aggressive growth pattern and extensive root system discourage soil erosion. Black locust wood is also valued for its durability and high fuel value, and provides good forage for bees.

Distribution and Habitat

Black locust produces abundant seeds, but a thick seed coat hinders consistently successful seed germination. The plant typically reproduces vegetatively by root suckering and stump sprouting. Root suckers arise spontaneously from established root systems, sprouting new shoots and interconnecting fibrous roots to form extensive, dense groves of clones. Damage to roots or stems (e.g. from fire, wind, cutting, disease, etc.) stimulates vigorous sprouting, root suckering, and lateral spread. Black locust is susceptible to severe insect damage from locust borers, locust leaf miners, and locust twig borers.

Black locust commonly occurs in disturbed habitats like pastures, degraded woods, thickets, old fields, and roadsides. Successful reproduction via vegetative runners has contributed to the naturalization of black locust in upland forests, prairies, and savannas. Because dense clonal stands shade out most understory vegetation, such tree groves can be detrimental to native vegetation.

Control Methods

Mechanical

Cutting black locust stimulates sprouting and clonal spread. For this reason, some suggest to avoid simply cutting the stems. Mowing and burning temporarily control spreading, but mowing seems to promote seed germination, and burning stimulates sprouting. Girdling is ineffective because it kills the stem, but does not prevent sucker formation. Annual haying may be adequate to control first-year seedlings and prevent spreading in prairie communities. Bulldozing may be an option on disturbed lands.

Chemical

The extensive root system of black locust spreads herbicides over large areas. Basal stem application is preferred for treatment, because it is selective and easy to apply. The herbicide should be applied in a band at least six inches high all around the trunk, approximately 12 inches from the ground. Triclopyr formulated for dilution in diesel fuel or mineral oil is currently the herbicide of choice for black locust. Both diesel fuel and mineral oil release volatile organic compounds into the immediate area. Although more expensive, mineral oil is potentially less toxic to neighboring organisms. The triclopyr/oil mixture may also be applied to a girdle cut at standing height or to cut stumps.

For small isolated plants or thick patches under five feet in height, such as those resulting from cutting or fire, fisamine ammonium can be applied as a foliar spray. Fisamine ammonium kills plants by inhibiting leaf bud growth and flower formation in the spring. Fisamine ammonium should be applied at the end of the growing season. In order to effectively curb regeneration, every branch or stem must be sprayed, because missed stems will leaf out. Triclopyr mixed with water may also be used effectively as a foliar spray in the latter half of the growing season.

Glyphosate can be applied to foliage of actively growing trees using a hand sprayer (1.0 to 1.5 percent active ingredient solution). However, foliar glyphosate spray should not be applied in high-quality natural areas, because it is a nonselective herbicide. Black locust stems can be cut at the base with brush cutters, chainsaws, or hand tools; stumps should be treated immediately with a 20 percent active ingredient solution of glyphosate. The treatment works best when applied in late summer, early fall, or during the dormant season.

SHRUBS

HONEYSUCKLE COMPLEX (*Lonicera* spp.)

Description/Life History

Exotic bush honeysuckles are dense, upright, deciduous shrubs that grow to three to 10 feet in height with shallow root systems; opposite, simple, and oval or oblong leaves; and yellow, orange, or red berries with many seeds. Tartarian honeysuckle has smooth, hairless, bluish-green leaves. The shaggy-barked older stems and branches of the shrub are often hollow. Flowering occurs during May and June, and produces fragrant, tubular flowers, arranged in pairs. Flowers of this species are generally pink to crimson in color, in contrast to other honeysuckle species that generally produce white flowers that yellow as they age.

Bush honeysuckles are easy to find in early spring, because they begin leaf development one to two weeks before native shrubs and hold their foliage until November. These species can be discerned from a distance during their flower and fruit periods in late spring and midsummer.

The widespread distribution of bush honeysuckles is aided by birds, which consume the ripened fruit in summer and disperse the seeds over long distances. Thus, plants commonly grow under tall shrubs, trees, or power lines that serve as perches. The seeds appear to require a cold stratification period to break dormancy. Seedlings establish in sparse vegetation and their vigorous growth inhibits development of native shrub and ground layer species through shading and depletion of soil moisture and nutrients. Honeysuckles may also produce allelopathic chemicals that inhibit growth of surrounding native competitors.

Distribution and Habitat

Bush honeysuckles are native to Asia and Western Europe. Tartarian honeysuckle was introduced to North America as an ornamental in 1752. Bush honeysuckles have naturalized from New England south to North Carolina and west to Iowa. They have become widespread in Wisconsin, largely due to horticultural plantings, especially in more urban southern and eastern Wisconsin. However, there are pockets of infestation in rural areas where honeysuckles were planted to improve wildlife habitat.

This species of shrubby honeysuckle has a broad tolerance of various moisture regimes and habitats and, thus, can invade a wide variety of native habitats. Bush honeysuckles thrive in sunny, upland habitats, including forest edges, roadsides, pastures, and abandoned fields. Invasion from nearby plantings or disturbed areas is stimulated by habitat disturbances, such as grazing. Woodland areas are most susceptible to invasion by this species, but they can also be found in fens, bogs, and lakeshores.

Control Methods
Mechanical
Since honeysuckle roots are fairly shallow, small- to medium-sized plants can often be dug or pulled. Plants are particularly easy to remove in spring when the soil is moist. A shovel or grubbing hoe will often loosen the roots enough to allow a fairly large plant to be pulled. In sensitive areas, this type of physical removal may disturb the soil and lead to more invasions, in which case it should be avoided. Soil should be tamped down to discourage further establishment of honeysuckle seedlings. Native seeds or cover crop can also be planted in the disturbed areas.

In fire-adapted communities, spring prescribed burning may kill seedlings and top-kill larger plants, although results have been mixed. Resprouts may occur, so repeated prescribed burning annually or biennially for several years may be necessary.

Mechanical control methods must be repeated for at least three to five years in order to stop new plants emerging from the seed bank.

Chemical
For bush honeysuckles control Rodeo® or Roundup® is recommended for application on cut stumps within high-quality natural areas, restorations, and degraded areas. Rodeo®, Roundup®, or Krenite® foliar sprays are recommended for use in more degraded areas. Garlon 3A® seems to be ineffective as a controlling agent.

Bush honeysuckles can be controlled by cutting the stems at the base with a brush cutter, chain saw, or other tools. After cutting, stumps should be treated immediately with a 20 percent active ingredient of a glyphosate solution using a low-pressure, hand-held sprayer, sponge applicator, or contact solution bottle. Two cuts per year, the first in early spring followed by one in early autumn, are recommended. If not followed by herbicide treatment, cuts made in winter will encourage vigorous resprouting when the plants come out of dormancy. Triclopyr formulated for water dilution is not effective on this species; triclopyr formulated for dilution in diesel fuel can be used for application on cut stumps throughout the year, although winter application has in some cases proven to be 100 percent effective, whereas spring treatment has shown 70 to 80 percent effectiveness. If stump treatment is not done at the time of cutting, foliage on the resprouts may be sprayed, taking care to avoid non-target plants.

When burning is not possible, a 1.5 percent active ingredient glyphosate solution can be sprayed to cover the foliage. Spraying after the plant blooms (usually in June) may kill mature and seedling plants. Spraying prior to the emergence of native shrubs and ground flora is the safest time to spray without impacting native species. In wetlands, glyphosate formulated for use over water must be used.

Chemical control methods should be repeated over several years and done in combination with replanting as discussed in the mechanical section above.

Description/Life History

EUROPEAN BUCKTHORN (*Rhamnus cathartica*)

The European buckthorn can grow as a shrub or small tree that can reach 20 feet in height and 10 inches in diameter. The shrubs have spreading, loosely branched crowns that stem from a few to several branches at the base. The bark is generally gray to brown with prominent, often elongate, light colored or silvery lenticels. Cutting a branch of this species exposes yellow sapwood and a pinkish to orange heartwood.

The dioeciously common buckthorn may be somewhat easier to spot when the female plants are in fruit by the clusters of black, rounded fruit. Leaves are typically smooth on both surfaces, dull green in color, and ovate-elliptic in shape, and possess minute teeth on the margins. Twigs often have thorn-like spurs.

The buckthorn aggressively competes with local flora through long distance dispersal ability, prolific reproduction by seed, wide habitat tolerance, and high levels of phenotypic plasticity (adjusting physical appearance to maximize environmental conditions). Buckthorns produce a fruit that is eaten by birds, and the severe laxative effect of these fruits distributes the seeds. Buckthorns can also prolifically resprout from cut or damaged stems. This species flowers from May through June and fruit ripen in August through September. Under full sun conditions, they can produce seed a few years after establishment. Fruit production may be delayed for 10 to 20 years in shaded habitats.

Distribution and Habitat

This species has originated in Eurasia and is currently well established and rapidly spreading in Wisconsin. They were planted in hedgerows in Wisconsin as early as 1849. They have become naturalized from Nova Scotia to Saskatchewan, south to Missouri, and east to New England.

Once established, common buckthorn has the potential to spread very aggressively in large numbers, because they thrive in habitats ranging from full sun to shaded understory. They are a problem in the understory of southern oak, oak-beech, maple, and riparian woods, prairies, and savannas. This species also appears in thickets, hedgerows, pastures, abandoned fields, roadsides, and on rocky sites. It grows particularly well on well-drained soils and does not appear to be adversely affected by nutrient-poor soils.

Control Methods

As with all invasive species, buckthorns are most effectively controlled by recognizing their appearance early and removing isolated plants before they begin to produce seeds. With large infestations, the largest seed-producing plants should be removed first.

Mechanical

Prescribed burns in early spring and fall may kill seedlings (especially in the first year of growth), larger stems, and top-killed mature buckthorns, although this method has met with mixed results. Burning is preferable for fire-adapted communities, but should not be used if it adversely affects the community. Burning annually or biannually to control buckthorns may need to be continued for five or six or more years depending on the extent of establishment and the seed bank, which generally lasts two to three years. In addition, the initial one or two burns may stimulate resprouts. It is often difficult to burn in dense buckthorn stands, as the understory is typically well shaded, allowing little fuel buildup.

In areas where the use of chemicals is a concern, small patches of plants up to 0.5-inch diameter can be pulled when the soil is moist. Larger plants, 0.5-inch to 1.5-inches in diameter, can be dug or pulled with a variety of other equipment. Soil disturbance, which favors buckthorn establishment, will result from these techniques and should be tamped down to minimize reseeding. In addition, spreading a cover crop or native seed on these disturbed areas helps further control reestablishment.

Girdling (removing phloem connection of roots to shoots while retaining the xylem connection of shoots to roots) or cutting stems between December and March may not be very effective, unless followed by an application of glyphosate herbicide.

Restoring natural water levels in wetlands with artificially lowered water tables has also been successful in controlling buckthorn species.

Chemical

Chemical control methods are best done during the fall when most native plants are dormant and, yet, buckthorns are still actively growing. This lessens the risk of affecting nontarget plants and allows easy recognition, because the leaves are still green. Control treatments are also effective in the growing season, but there is more risk of affecting nontarget plants, and the effectiveness of the treatment is generally lower. Winter application of chemicals has proven successful, as well, and further lessons the risk of damaging nontarget species.

For buckthorn control, Rodeo®, Roundup®, or Trimec® (not near desirable trees) are recommended for application on cut surfaces for high-quality natural areas, restorations, and degraded areas. Trimec® (a formulation of 2,4-D, MCCP, and dicamba) effectively controls buckthorn, but should not be used in savannas or woodlands, because it moves readily in soil and can kill nearby trees. Garlan 3A, Garlan 4, and Rodeo® are recommended for use in more degraded areas.

During the growing season, cutting stems off near ground level and treating them with glyphosate successfully curbs sprouting. Immediately after cutting, a 20 to 25 percent active ingredient glyphosate should be applied to the stumps. Resprouts should be cut and treated again, or sprayed with a hand sprayer of 1.5 percent active ingredient glyphosate solution to the foliage. Garlan 3A® or Roundup® is also recommended (50 percent Roundup® concentration) for cut stump treatment. In wetland use Rodeo® (a glyphosate solution approved for use near/over water). Autumn is the best time to cut and treat stumps. Foliar application of glyphosate herbicide using a backpack sprayer is also effective, but less selective.

For severely disturbed sites, a 20 to 25 percent active ingredient triclopyr solution diluted in water can be sprayed with a low-pressure hand sprayer, a spray bottle, or sponge applicator to freshly cut stumps. A 12.5 percent active ingredient triclopyr (formulated for oil dilution) solution is also effective as a cut stump treatment. Basal bark application of 6 percent active ingredient triclopyr (formulated for oil dilution) solution or 2,4-D (12.5 percent active ingredient) in diesel fuel also effectively controls buckthorns. As a supplemental method, use Garlon 4® as a dormant-season basal bark treatment, cut stems, then spray resprouts with Garlon and spray foliage with Rodeo®.

Treatment for common buckthorn in the spring and fall with a mixture of 25 percent active ingredient triclopyr (formulated for oil dilution), a spreading agent (10 percent), and diesel fuel (65 percent) has been successful in Missouri. The triclopyr concentration can be increased to 30 percent in the dormant season. For stems larger than two inches, spray all the way around the stem. Smaller stems can be sufficiently controlled by spraying only on one side. This treatment may not be effective on larger trees.

Fosamine, a nonselective bud inhibitor for woody species, can be applied as a basal bark treatment in the fall at 3 percent active ingredient concentration in water.

Description/ Life History

Garlic mustard is a cool-season biennial herb that ranges from 12 to 48 inches in height as an adult flowering plant. Leaves and stems emit the distinctive odor of onion or garlic when crushed (particularly in spring and early summer), and help distinguish the plant from all other woodland mustard plants.

First-year plants appear as basal rosettes in the summer season that consist of a cluster of three or four round, scallop-edged, dark green leaves rising two to four inches in length. First-year plants remain green through the following winter, making it possible to check for the presence of this plant in wooded areas throughout the year.

Second-year plants generally produce one or two flowering stems with numerous small white flowers that have four separate petals. Garlic mustard begins vegetative growth very early in the spring, and blooms in southern Wisconsin from May through early June and die after producing seeds. This species is the only plant of this height in the woodlands of Wisconsin with white flowers in May.

Fruits begin to ripen in mid-July, and are disseminated in August. Fruits are slender capsules one- to 2.5-inches long that produces a single row of oblong black seeds with ridged seed coats. Stem leaves are alternate and triangular in shape, have large teeth, and can be two to three inches across in flowering plants. Petioles are longer on the leaves towards the base. Garlic mustard can also be distinguished by its taproot, which is slender, white, and “s”-shaped at the top of the root.

This species produces hundreds of seeds per plant that become viable within days of initial flowering. The seeds are believed to be dispersed on the fur of mammals, such as deer, horses, and squirrels; by flowing water; and by human activities. In Wisconsin, seeds lie dormant for 20 months prior to germination, and may remain viable for up to five years. Seeds germinate in early April.

Distribution and Habitat

Garlic mustard is an exotic species introduced from Europe presumably by early settlers for its supposed medicinal properties and for use in cooking. It is widely distributed throughout the northeastern and Midwestern United States from Canada to South Carolina and west to Kansas, North Dakota, and as far west as Colorado and Utah. In Wisconsin, the plant is currently concentrated in the southeastern and northeastern counties, although distribution records indicate its presence is nearly statewide.

Garlic mustard grows in upland and flood plain forest and savannas, and residential yards, but is only occasionally found in full-sunlight habitats. It typically invades shaded areas, especially disturbed sites, such as residential yards and along roadsides. It cannot tolerate acidic soils. The invasion of forests usually begins along the wood’s edge, and progresses via streams, campgrounds, and trails.

Control Methods

Mechanical

Minor infestations can be eradicated by hand-pulling at or before the onset of flowering, or by cutting the flower stalk as close to the soil surface as possible just as flowering begins (cutting a couple of inches above-ground level is not quite as effective). Cutting prior to this time may promote resprouting. Cutting flowering plants at the ground level has resulted in 99 percent mortality and eliminates seed production. A scythe monofilament weed whip, or power brush cutter may be helpful if the infestation covers a large area. When pulling, the upper half of the root must be removed in order to stop buds at the root crown from sending up new flower stalks. Pulling is very labor intensive, and can result in soil disturbance, damaging desirable species, and bringing up seeds from the seed bank. These results can be partially prevented by thoroughly tamping soil after pulling. However, if seed bank depletion is desired, the soil should be left in a disturbed state to encourage further germination, and plants removed annually. In general, cutting is less destruction that pulling as a control method, but can be done only during flower stalk elongation. Pulling can be done at any time when the soil is not frozen. If flowering has progressed to the point that viable seed exists, remove the cut or pulled plants from the area. Because seeds remain viable for up to five years, it is essential that an area is monitored and plants removed for at least five years after the initial control effort.

For larger infestations, fall or early spring burning may be effective. First-year plants are killed by fire, if the fire is hot enough to remove all leaf litter. However, the bare soil enhances survival of seedlings that germinate after the fire and the total population may increase after the fire. Dense populations may be controlled most effectively by fall burning, when leaf litter provides adequate fuel. Spring burns should be conducted early enough to minimize possible injury to spring wildflowers. Three to five years of burning are required, and should be followed by hand pulling or cutting of small populations produced from the seed bank. Garlic mustard plants hit by fire are generally killed. Because most woodland fires are patchy, flame torches may be useful in areas not burned in entirety.

Combinations of spring burning, hand pulling, and cutting flowering stems techniques works well in controlling this species.

Chemical

For garlic mustard control Roundup® foliar spray is recommended within high-quality natural areas, restorations, and degraded areas. Roundup®, 2,4-D amine, or Mecamine foliar sprays are recommended for use in restorations and more degraded areas.

Severe infestations can be controlled by applying a 1 to 2 percent active ingredient solution of glyphosate to the foliage of individual plants and dense patches during late fall or early spring. At these times, most native plants are dormant, but garlic mustard is green and vulnerable. Glyphosate is a nonselective herbicide that will kill nontarget plants if it comes into contact with them. Managers should exercise caution during application, and not spray so heavily that herbicide drips off the target species. Herbicide use is safest for native plants if utilized during the dormant season. Garlic mustard will grow much longer than the native plants, as long as there is no snow cover and the temperature is greater than 35 degrees Fahrenheit. An early spring application of triclopyr at a 1 percent active ingredient concentration in solution with water has been used, resulting in a 92 percent rosette mortality rate. The foliage of individual plants could be sprayed with either a 2 percent Roundup®, an amine formulation of 2,4-D, or a 1 percent solution of Mecamine during spring or fall when most native vegetation is dormant.

DESCRIPTION/LIFE HISTORY

BURDOCK (*Arctium minus*)

Burdock is a common weed of old farms, introduced from Europe and now widespread throughout Wisconsin. It's most commonly recognized in the fall by the brown cockleburs, which are 0.5- to 0.75-inch round balls of barbed spikes. Burdock has huge leaves, especially at the base of the plant up to 12 to 14 inches across, dark green, dull, somewhat heart-shaped, and somewhat similar to rhubarb. Flowers are small, lavender or pink, and similar in shape to thistle blossoms. The plant can reach heights of five feet and have a large branched crown with dozens of cockleburs.

Distribution and Habitat

Burdock is an opportunistic species native to the United States. Look for burdock in disturbed habitats, roadsides, vacant lots, and fields. It grows throughout North America, except in the Deep South. Extremely prolific, it will inhabit many environments disturbed by humans. Burdock is aggressively opportunistic on disturbed soil and tends to shade out smaller, herbaceous flora. Burdock can be easy to control, because they reproduce only by seed and take two years to become mature plants.

Control Methods

Mechanical

Repeated tilling is effective in controlling the biennial plant. Burdock roots can be severed below ground to kill the plant. Mowing will eliminate above-ground growth, but the foliage will quickly grow back.

Chemical

Burdock produces a rosette during its first year and develops a large tap root the second. Tardon herbicide or 2-4,D can be used to kill the above-ground growth in either the rosette or second-year growth.

Source: R. Hoffman and K. Kearns, Bureau of Endangered Resources, Department of Natural Resources, Madison, Wisconsin, Publ ER-090 97, Wisconsin Manual of Control Recommendations for Ecologically Invasive Plants, *1997; S. Packard and C.F. Mutel,* The Tallgrass Restoration Handbook for Prairies, Savannas, and Woodlands, *Island Press, Washington D.C., 1997. ISBN: 1-55963-319-0.*

Appendix F

RECOMMENDED NATIVE PLANT SPECIES LIST AND SEEDING AND PLANTING IMPLEMENTATION RECOMMENDATIONS FOR LAKE PARK BLUFFS

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PLANT SPECIES RECOMMENDED BY THE SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION TO STABILIZE THE LAKE PARK BLUFFS

Scientific Name	Common Name
Agrostis stolonifera	Redtop grass
Aster lateriflorus	Calico aster
**Convolvulus sepium (Americanus)*	Hedge bindweed
**Cornus racemosa*	Gray dogwood
**Cornus stolonifera*	Red osier dogwood
Dactylis glomerata	Orchard grass
**Desmodium glutinosum*	Pointed tick trefoil
Erythronium albidum	White trout lily
Erythronium americanum	Yellow trout lily
Fraxinus pennsylvanica	Green ash
Hamamelis virginiana	Witch hazel
Juglans nigra	Black walnut
**Juniperus communis*	Common juniper
Lolium multiflorum	Annual rye
**Oenothera biennis*	Evening primrose
**Parthenocissus inserta*	Thicket creeper
Parthenocissus quinquefolia	Virginia creeper
Poa pratensis	Kentucky bluegrass
Populus balsamifera	Balsam poplar
Populus tremuloides	Quaking aspen
**Prunus americana*	Wild plum
Prunus virginiana	Choke cherry
Prunus serotina	Black cherry
**Rhus glabra*	Smooth sumac
Rhus typhina	Staghorn sumac
**Rubus occidentalis*	Black raspberry
**Shepherdia canadensis*	Buffalo berry
Symphoricarpos albus	Snow berry
Thuja occidentalis	White cedar
Tilia americana	Basswood
Tsuga canadensis	Hemlock
Viburnum lentago	Nannyberry
Vitis riparia	Riverbank grape
**Xanthoxylum americanum*	Prickly ash

*Plant species recommended for planting at and toward the top of the bluff.

NOTES:

1. Tree and shaded groundlayer species should be planted between the mid-bluff and toe of the bluff.

2. Seeds, rhizomes, tubers, and transplants of native species should be collected from native stocks occurring within 100 miles of the project site in order to reestablish an upland plant community that is genetically compatible with surrounding native plant communities.

3. Any seeding rates established should be based upon the use of live, viable seed.

4. Native seed mixture weights should be based upon screen cleaned seed. A chaff or inert portion consisting of between 10 and 20 percent of the total weight is considered to be properly cleaned seed.

5. Trees selected for transplanting should be three-feet saplings to pole-sized. A three-inch-thick layer of mulch should be established around each tree beginning about 10 inches away from the trunk. Plastic guards should also be installed around the trunks to protect the trees from sun scalding and herbivory by rodents.

BLUFF SEEDING AND PLANTING IMPLEMENTATION RECOMMENDATIONS

Based upon information provided by the Village of Shorewood Department of Public Works (DPW) staff involved in the assessment, planning, and implementation of the Atwater Park Bluff Planting Project (ABPP)[1], the following points to consider are listed below. These recommendations summarize some of the "lessons learned" and/or other important considerations from a site approximately one mile north of Lake Park, which would be relevant for a bluff stabilization project within Lake Park. The goal of the Atwater Park Bluff Planting Project was to both improve the view to Lake Michigan while protecting the long-term stability and biodiversity of the bluffs.

- **Multiple Year Plan—**The ABPP is in its fourth year, and the Village of Shorewood has been restoring a section of bluff every year (see View A and B in Figure F-1). First, the trees were cut and removed, but the stumps and root systems were kept intact to control erosion while the new native grasses and shrubs became established (see View C in Figure F-1). Since most of the tree species on this bluff were comprised of black locust, the stumps were chipped and treated with herbicide (Garland) to avoid regrowth of this exotic invasive species (see Appendix E in this report). Second, the new shrubs were planted and then a special "Lake Bluff" seed mix was planted around the shrubs to also control erosion, while the shrubs established themselves (see View D in Figure F-1)

- **Watering—**Newly seeded and planted rootstock and shrubs need frequent and adequate amounts of water, especially within the first couple of years. View B in Figure F-1 indicates there was limited germination of native seed (i.e. bare patches of ground), due primarily to lower than normal rainfall immediately following planting and to inadequate supplemental watering to this newly restored area. This left the slopes more susceptible to erosion as well as re-invasion by exotics invasive plant species.

- **Monitoring and Maintenance—**To date, the ABPP has been a success in terms of bluff stability and development of a more diverse and abundant native plant vegetation community. It is important to note that this success is largely attributed to sound planning, a team approach, and the dedication of resources and staff to continue to monitor and maintain the newly restored slopes as well as eradication efforts to control the exotic invasive species that continue to invade the bluff (see View B and D in Figure F-1). Exotic invasive species control comprises a large portion of the management effort on the bluffs in Atwater Park and should be a major element in any bluff restoration project.

- **Planting Methods**—The Village of Shorewood DPW staff have modified their original planting methods, which has led to a lower proportion of exotics species on the bluffs. Historically, the Village would herbicide an entire section and then plant shrubs and grasses. They subsequently found this one time herbicide treatment to be ineffective, as many exotic species grew along with the new seedings and plantings. Currently, the Village treats an entire section with herbicide, and then lets it grow for a while. They then apply a second herbicide treatment and prepare the seedbed and seed the grasses. After the grasses start to become established, the shrubs are planted.

- **Erosion Control**—There was limited use of either erosion control fencing or matting materials for this project. However, retaining walls were erected in some sections adjacent to the paved switchbacks, water runoff devices were also installed in selected areas of the slope, and erosion control blanket material was successfully used in the steepest slopes of the Atwater bluff.

- **Site Access**—The Village of Shorewood DPW further discovered that removal of all of the woody tree vegetation has increased public use of and access to the bluffs. Subsequently, increased erosion

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[1]*The Village of Shorewood and the School District of Shorewood, "The Shorewood Bulletin" (www.villageofshorewood.org), Autumn, 2003.*

has occurred in certain areas of the bluffs. This issue may not be a factor in the future as the shrub layers become more established, however, during the past several years of the ABPP this has been a factor and should be considered an important element in any bluff restoration project. The DPW have had some success discouraging this increased human traffic in some areas of the bluff by planting native shrubs that are difficult to walk through (i.e. contain thorns or spines).

- **Native Shrub Species**—Native shrub species that have been successfully established and are currently thriving on the Atwater Park Bluffs so far include Isanti (red osier) Dogwood, Black Chokecherry, and Staghorn Sumac. Shrubs that have not done as well include Regents Serviceberry and Gray Dogwood, largely because smaller transplants were used. The success of the Red osier dogwood (*Cornus stolonifera*) on these nonwetland clay soils is hardly a surprise. Good populations of Red osier dogwood can be seen on clay soils adjacent to Lake Michigan at a number of locations in the Southeast Region such as Harrington Beach State Park.

Figure F-1

PHOTOS OF ATWATER PARK BLUFF PLANTING PROJECT AREAS DATED APRIL 23, 2004

VIEW A

Northern top bluff of Atwater Park indicates the first sections to be restored as part of the Atwater Park Bluff Planting Project dated April 23, 2004. Note the various grass and shrub layers established.

VIEW B

Middle portion of the top bluff of Atwater Park indicates the most recently restored areas on the bluffs dated April 23, 2004. Note the exposed soil with limited germination success, due to drought conditions during the critical establishment of the newly seeded and planted area. These areas are more susceptible to erosion as well as to invasion of exotic invasive species such as garlic mustard, which has established itself (dark green leafy areas) in clumps on these barren slopes.

VIEW C

Southern to central portion of Atwater Park Bluff's that indicates the preservation of stumps, which help to stabilize the bluff, amongst the native shrub and grass plantings as part of the Atwater Park Bluff Planting Project dated April 23, 2004.

VIEW D

Northern portion of the top bluff of Atwater Park that indicates the spacing of newly planted shrubs and grasses as part of the Atwater Park Bluff Planting Project dated April 23, 2004. Note the dark green leafy areas associated with many of the upper tier shrubs in the photo, which are the exotic invasive plants of garlic mustard that need to be eradicated or it will come to dominate the site.