MILLARD BLUFF
SLOPE STABILITY ANALYSIS

PROJECT SITE:

MILLARD PARK

Highland Park Lake County, Illinois

PREPARED FOR:

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EXECUTIVE SUMMARY

Millard Park is a beautiful and historic park property along the Illinois North Shore section of Lake Michigan in Highland Park, Illinois. An existing path runs from the south end of the bluff and up along the edge of the bluff, through a garden on the plateau and up to the north end to a pavilion. At this north end a relict path could be taken as a means to descend the bluff and arrive back at the beach. Millard Park and bluff path have a large number of visitors and walkers each day. Unfortunately the relict section of trail at the north end of the bluff along with the bluff edge trail along the southern portion of the bluff has been closed off to the public due to failed sections of the bluff face and tree damage to the stairs to the beach on the relict trail.

The Park District of Highland Park (PDHP) has retained V3 Companies (V3) to evaluate the slope stability of the bluff portion of the park site and provide recommendations for improving slope stability and establishing top of bluff set-backs for trail access. V3 visited the Millard Park bluff on Friday, April 30, 2021 to collect information, photographs, and field measurements. This section of bluff spans approximately 1,300 feet north to south. The top of the bluff edge starts on the south being approximately 20 feet higher than the lake and steadily increases in height the first 300 feet until it reaches a garden area, where it levels off and widens as it spans the remaining 1,000 feet, ultimately reaching a high point approximately 75 feet above the lake.

Along the entire face of the bluff locations of past slope failures, as well as areas with a steep slope having a high potential for a future slope failure, are present. Some of these potential slope failure areas come right up to the edge of the bluff along the existing path. Slope measurements were taken at various points along the bluff face. V3's observations and measurements found areas of stability tended to have an approximate slope of two feet horizontal to 1 foot vertical (2H:1V). Observations of the surrounding slope and tree conditions indicated these steep slopes had high potential for future failure.

The property beachfront has existing structures intended to prevent loss of beach sand material. The main structures in place are six pile driven jetty walls perpendicular to the shore extending from the base of the bluff out into the lake. The walls range in length from approximately 70 feet to 150 feet. The five main sheet pile walls are approximately 330 feet apart, creating four separate sections, which have been labeled to better identify and group bluff characteristics. **Exhibit 1** (see **Appendix**) illustrates this existing condition; each section label representing the area or section to the north of the assigned label.

In addition to the sheet pile (jetty) walls a concrete seawall was constructed between the two main sheet pile jetties bounding Section B. Portions of the wall are damaged and allow overtopping water to flow back towards the lake, scouring out the sand behind the lowered concrete wall. Looking at aerial photos of this area (**Figure S.1** below) it is clear that in locations where the seawall is still intact the bluff appears to have somewhat less failure and erosion. Other than the sheet pile jetties and broken section of concrete wall, no existing structures appeared to be in place to prevent erosion at the toe of the bluff.

Given the existing bluff conditions and cyclical fluctuations of Lake Michigan water levels, there are a number of solutions appropriate for the PDHP to consider as means to address existing bluff failures and to minimize the potential for future bluff slope failures or extreme loss of land at the top of the bluff.

__Figure S.1__ *Aerial Photo of the Seawall in Section B*

Solutions range from low-cost, high potential for future failures to high-cost, low potential for future failure. One approach for cost efficiency and ongoing observation is placing a number survey points along the bluff face to monitor movement of the bluff face. These survey points may then be geospatially referenced each year in order to establish locations of critical bluff face movement, allowing for focused remediation of actively moving bluff zones.

Construction solutions to remediate existing conditions will involve the following basic protective and stabilizing elements: (1) tree removal and management to reduce disruption of the surficial soil and underlying layers, (2) restore grades of 2 horizontal to 1 vertical where practicable along the bluff face, (3) regrade portions of the top of the bluff to remove the existing path and re-direct any accumulating drainage from going to the Lake Michigan bluff face, (4) vegetative plantings and management along exposed bare soil locations, which may include placement and integration of topsoil for an initial planting medium (plantings with root systems integrating into the underlying clay face are anticipated), (5) restore the integrity of the relict concrete seawall to preserve the sand and cobble to the elevation of the top of the original seawall and allow access along the entire bluff toe, and (6) provide adequate toe protection for the bluff in order to minimize the potential for substantial loss of sections at the top of the bluff due to excavation of the toe by wave action from elevated Lake Michigan water levels.

CHAPTER 1 INTRODUCTION

Millard Bluff is a part of Millard Park. Historical aerial photography for this area appears to date back to 1939 with the park, bluff, and beach still visible. The Park encompasses about 1,300 feet of the bluff starting on the south at the end of Ravine Drive going north. Currently at the south end of the park there is a parking lot and the start of a trail that goes up the bluff, through a flower garden at the top of the bluff, and then down the bluff reaching the beach at the north end of the park. The northern trail down to the beach has been damaged and is no longer an appropriate trail for pedestrians, especially since the final lower stair access to the beach has been destroyed (see **Figure 1.10** below).

Figure 1.10 *Destroyed stair access to beach – also a location expected to fail in the immediate future.*

The historical photographs do a good job of showing the variation in lake levels over the years. Notably the aerial photographs from 1961 and 2012 when lake levels were headed towards historic lows as well as 1974 when the lake was near historic highs. These aerial photos, as well as **Figure 1.11**, given on the following page, help show the natural and fluctuating cycle of Lake Michigan water levels.

1961 1974 2012

Figure 1.11 *Historical Aerial Photographs with Corresponding Water Level Elevations.*

Looking at past historical aerial photographs it can also be seen that the 5 main pile driven jetty walls were already in place back in 1939 with a 6th added sometime between 1961 and 1974. The photos throughout the years clearly show that the jetty walls do have a positive impact on preserving the beachfront and presumably the bluff as well. The aerial photographs clearly show that the jetties minimize sand loss and help preserve beachfront, especially during high lake levels.

Although the historical aerial photographs clearly show the changes in lake levels over the years and the corresponding variance in beachfront, the photographs do not do a good job of depicting the bluff face condition through the years. Even so, it is understood that wave action along the bluff does contribute significantly to bluff erosion and slope failure. Meaning that during periods when the lake water levels are lower the bluff is less likely to experience continuous wave action producing large slope failures and erosion than during periods when lake water levels are high and wave action pounds the bluff toe.

Lake Michigan water level have risen since 2013 and reached record highs in 2020, resulting in increased erosion and bluff toe failures which in turn produced sloughing and slope failures up the bluff. Overall, the severity and type of slope failures on the bluff varied from location to location, but we have chosen to highlight three aspects in **Chapter 2 Site Observations** that capture the main issues and discussion points: (1) bluff erosion and slope failure, (2) trees in failure zone, (3) soil layer saturation and seepage.

CHAPTER 2 SITE OBSERVATIONS

2.1 BLUFF EROSION, SLOUGHING AND SLOPE FAILURE

Erosion is the natural process of soil loss due to exposure to physical forces such as wind, rain, and wave action. Erosion can be slow and gradual or abrupt and extreme depending on the environment and soil conditions. As erosion occurs on the bluff it tends to start further down the slope which in turn increases the slope above which eventually results in a slope failure. This slope failure can be small, but can also be large enough to uproot full grown trees.

Starting from the south end of Millard Bluff the erosion was minimal and the slope was stable. The slope was measured to be just less that 2H:1V and there was a good amount of beachfront between the toe of the bluff and the edge of the lake (**Figure 2.10**).

Progressing north along the bluff and up the trail, the slope steepens and the beachfront shrinks. V3 measured a slope of 4H:3.25V at the middle point of Section C where the bluff is unsafe to traverse. Just north of that slope measurement the first major slope failure occurs at the north end of Section C (**Figure 2.11**). This figure shows a vertical drop of about 5'. This slope failure came right up to the edge of the bluff with multiple trees overhanging the failure.

<u>Figure 2.10</u> *South end of Millard Park with intact beach.*

<u>Figure 2.11</u> *Slope failure at top of bluff on north end of Section C.*

Section B was the worst section for bluff failure condition. Multiple large slope failures exist along the entire bluff. The south end and middle had slope failures with a vertical drop of almost 20' right up to the top of the bluff (**Figure 2.12**). It was not possible to acquire slope measurements at the bottom of these failures, however, it was clear from looking at the bluff that once a failure occurred the resulting slope was around a 2H:1V or even shallower. In fact, this sloughing was quite noticeable along the top of the bluff. There were clear areas where the slope was steep and had previously failed and below it the bluff leveled out until it reached another failure and the process repeated.

Figure 2.12 *Large slope failure in Section B*

Section A did not show the same magnitude of failure as the previous section but it did have steep slopes that would likely lead to failures, that is, in addition to the existing toe failure at the lakeshore. V3 took a slope measurement at the south end of Section A which demonstrated the previously discussed sloughing. The slope towards the top of Section A was measured to be 2H:1.5V while the slope further down the bluff was measured to be less than a 2H:1V.

At the north end of the bluff the relict trail leads down towards the beach. On the beach it is clear that the lakes high water levels are affecting the bluff. For almost the entirety of Sections A and B the bluff has eroded or failed (**Figure 2.13**). Wave action had reached the toe of the bluff and, in some areas, created near vertical drops in excess of 20’ (**Figure 2.14**). Farther south down the beach, the erosions and failures became less extreme. Likely the jetties were capturing sand and creating more beachfront which made it harder for the waves to reach the toe of the bluff (**Figure 2.15**). The concrete seawall in Section B seemed to do a similar job except for the area where the seawall had failed and allowed waves to scour out sand from behind the seawall (**Figure 2.16**). South of Section B the beachfront increased and the erosion along the toe of the bluff became minimal.

Figure 2.13 *Bluff erosion along the beach in Sections A & B.*

Figure 2.14 *Major erosion at the very north end of Millard Park.*

Figure 2.15 *Beach front that had been protected due to the existing jetty.*

Figure 2.16 *Scouring that is occurring behind the breached seawall.*

2.2 TREES IN FAILURE ZONES

Along with erosion and slope failure V3 observed multiple trees in potential slope failure zones particularly at the top of the bluff. Over time the erosion in and around a tree can slowly remove the sand and soil around the root system, undermining the tree. This was especially evident towards the north end of Section C where V3 measured the 5’ vertical drop that was caused by a slope failure (**Figure 2.21**). The tree undermining process was also visible, although to a less extreme extent, at the north end of Section A where the relict path came down the bluff face (**Figure 2.22**).

Figure 2.21 *Exposed root system due to erosion at north end of Section C.*

Figure 2.22 *Exposed root system at the north end of Millard Park.*

Figure 2.23 *Fallen tree along the beach showing the uprooting that can occur.*

Although trees and their root systems can often assist with slope stabilization, when they fail, they can contribute to larger and more significant slope failures. This is because the root ball and extra soil pulls out of the slope resulting in a larger failure zone. This could be seen along the beach front where trees had fallen onto the beach and large sections of bluff vegetation and topsoil were pulled away from the slope (**Figure 2.23**).

2.3 SOIL LAYERS, SATURATION, SEEPAGE AND DRAINAGE

In addition to wind and rain causing erosion on the surface of the bluff, seepage and soil layers within the bluff can also be a contributing factor. A geotechnical report was done for the bluff with 4 borings drilled to a depth of 60 feet in order to better understand the makeup of the bluff and better understand the subsurface conditions. The borings, as well as observations along the exposed bluff, indicate that the soils at the bluff consist primarily of very stiff to hard clays with localized zones of softer and stiffer clays. The clays are also interstratified with very few sand and silt layers.

During times of heavy precipitation, or other saturating events, these sand layers can liquefy and flow down the bluff resulting in more erosion. Therefore the few existing locations of this interstratified sand layers is a benefit to stability of the Millard Bluff. Liquification can also occur to a lesser extent with the clay layers. During the site investigation along the beach, it was evident that subsurface saturation was indeed liquifying the soil and flowing out of the bluff (**Figure 2.31**). This type of erosion can be very dangerous due to the fact that it occurs below the surface and can go unseen until the slope finally fails.

Figure 2.31 *Liquifying soil seeping out the face of the bluff along the beach due to excessive soil saturation.*

Soil saturation is very normal especially during times of heavy rain or when groundwater is present. However, the northeastern Illinois had been experiencing drier than normal weather conditions prior to the inspection and three out of the four soil borings didn't encounter groundwater until approximately 58 feet deep, which is practically the bottom of the bluff. These conditions led us to believe that there may be another source contributing to the soil saturation and subsequent erosion, such as surface runoff and bluff flow.

Figure 2.32 *Sprinkler head at the top of the bluff on the south end of the flower garden.*

Figure 2.33 *Fire hydrant at the northern end of Millard Park on the west side of the bluff.*

While inspecting the bluff multiple water structures were found that would lead V3 to believe there may be unnecessary water infiltration into the subsurface which could be contributing the soil saturation and erosion. Along the top of the bluff within the flower garden sprinkler heads were seen as well as a fire hydrant located north of the flower garden (**Figure 2.32** and **Figure 2.33**). V3 could not determine if either were still in use, but in the event that water was being provided to the area, it could be a culprit in regards to over-saturation of the subsurface soils. In addition to the observed water systems a storm sewer inlet was found on the west side of the bluff as well as a large structure east of the bluff in Lake Michigan (**Figure 2.34** and **Figure 2.35**). It could not be determined if the MWRD interceptor structure in Lake Michigan was used as an outlet for any of the Millard Park bluff drainage. It should be noted that along the bluff in areas of past failure sections the presence of broken clay pipe that would suggest some sort of drainage system was previously put in place to assist in subsurface drainage (**Figure 2.36**). If there was a drainage system previously put in place it would be a fair guess that past erosion has hindered, if not completely ruined, the effectiveness of the drainage system leading to more subsurface saturation.

Figure 2.34 *Drainage inlet found along Millard Park path.*

Figure 2.35 *Probable MWRD interceptor sewer structure at bottom of bluff.*

Figure 2.36 *Piece of clay pipe. Possibly a section of an old drainage system.*

CHAPTER 3 SITE STABILITY ANALYSIS

3.1 BLUFF STABILITY REPORT

A geotechnical engineering slope stability analysis of Millard Bluff was performed in order to determine the existing condition of the Sylwester Millard Park bluff along Lake Michigan and provide insight into potential future restoration/stabilization practices. The full text of the report prepared by O'Brien & Associates, Inc. Consulting Engineers and dated June 15, 2021 (OBA Job No. 21024) is contained in the Appendix. The analysis is based on use of the best available Lake County GIS topography for this area and is considered to be reasonably representative for this bluff, given the incorporation of soils information taken from soil borings performed by OBA for this analysis. Even so, the topography is necessarily general, having been performed at the county scale and also does not reflect either the site-specific topography or the ongoing movement and erosion of portions of the bluff. For detailed calculations at specific locations, survey sections should be obtained if refinement of the analysis is desired.

In summary, the Millard Park bluff has sections that are observed to be unstable and sections that appear to be stable. OBA indicates the bluff is potentially at risk for global failure due to the toe becoming de-stabilized through high lake levels and wave scouring action. Also, the clay composition of the bluff means careful attention to bluff drainage should be a priority so as to minimize potential saturation of the clay.

Three primary results of the analysis for consideration by the PDHP are listed as follows:

1. Top of bluff drainage is critical for bluff stability,
2. Toe stabilization is critical for bluff stability, and
3. Stable slopes for this bluff should be at a 2 horizontal to 1 vertical or flatter.

With regard to item 1, V3 observed areas on the top of bluff where the existing path system was serving as a stormwater runoff collection and conveyance system, delivering accumulated and focused water to the bluff face. OBA recommends that this kind of top of bluff drainage be re-directed to locations having stability on the ravine side in such a manner as to minimize the potential for reducing ravine stability.

With regard to item 2, the OBA borings indicate the high section of the bluff is basically clay throughout (see Sections A through C on **Exhibit 1** in the **Appendix**), with only perhaps minor sand and silt inclusions, but no thick water bearing layers. Even so, the clay can become unstable when saturated with water as when trees are upended, sloughing creates mid-slope shelving or cracks along the top form, providing a mechanism for water entry into the underlying clay. Of particular concern is the bluff toe, which being exposed to direct attack by wave action, can become liquified and highly unstable, resulting in a top to bottom slope failure. Without adequate toe protection, the slope will slough and slide, seeking a minimum 2 horizontal to 1 vertical slope. The wave attack at the toe is a significant concern due to ongoing removal of clay material lost to the lake causing ongoing bluff encroachment.

With regard to item 3, the desired slope of 2 horizontal to 1 vertical may be obtained through appropriate slope management involving tree removal, slope re-grading and vegetative plantings. Ultimately, a stable 2 horizontal to 1 vertical slope may not be possible without adequate bluff toe protection.

CHAPTER 4 SITE RECOMENDATIONS

4.1 OPPORTUNITIES FOR IMPROVEMENT AND STABILITY

V3 has completed its slope stability analysis of Millard Bluff. The analysis was performed to determine the existing condition of the Sylwester Millard Park bluff along Lake Michigan and provide insight into potential future restoration/stabilization practices. It should be noted that V3 briefly reviewed the condition of the interior ravine system and overall found it to be a stable system, with the exception of portions of the retaining wall and steep slopes adjacent the interior park access road (also, the drainage system should be checked for continuity and function). However; the primary stated area of concern and where the stability analysis was performed was the east side of the bluff facing Lake Michigan.

The stability analysis indicated clear concern for the overall stability of the Millard Park bluff (see the **Chapter 3 Site Stability Analysis** section above and the full report contained in the Appendix). It is clear that high lake levels, some topside drainage and steep slopes are combining to reduce the stability of the bluff face with the result that portions are sloughing and failing.

Solutions to this situation range from low-cost, high potential for future failures to high-cost, low potential for future failure. One approach for cost efficiency may be the placement of a number survey points along the bluff face. These survey points may then be monitored in order to establish locations of critical bluff face movement, allowing for focused remediation of actively moving bluff zones. **Initial survey point establishment is estimated at $2,500 with annual monitoring at $1,000.** It should be noted that this process necessarily involves a duration over a period of years to establish clear trends. During this evaluation period critical portions may be subject to failure. Therefore, V3 recommends construction solutions to remediate existing conditions which involve the following basic protective and stabilizing elements further described in separate sections below:

1. Tree removal and management to reduce disruption of the surficial soil and underlying layers (section **4.2** below),
2. Restoration of slope grades of 2 horizontal to 1 vertical or flatter where practicable along the bluff face (section **4.3** below),
3. Regrading of areas at the top of the bluff to remove the existing path and re-direct any accumulating drainage away from the Lake Michigan bluff face (section **4.4** below),
4. Incorporate vegetative plantings and management along exposed bare soil locations, which may include placement and integration of topsoil for an initial planting medium (plantings with root systems integrating into the underlying clay face are anticipated – section **4.3** below),
5. Restore the integrity of the relict concrete seawall to preserve the sand and cobble to the elevation of the top of the original seawall and allow access along the entire bluff toe (section **4.5** below), and
6. Provide adequate toe protection for the bluff in order to minimize the potential for substantial loss of sections at the top of the bluff due to excavation of the toe by wave action from elevated Lake Michigan water levels (section **4.5** below).

These construction activities are further evaluated in the following individual sections to provide guidance regarding probable critical areas of concern for action by the Park District of Highland Park.

<u>With regard to Conceptual Opinions of Probable Construction Cost Please Note:</u> V3 does not warrantee or guarantee that conceptual opinions of probable construction cost can be realized due to significant factors outside of V3's control, such as time of bid, means and methods, construction cost inflation, etc.

4.2 TREE REMOVAL AND MANAGEMENT

Erosion is a naturally occurring event that can cycle in intensity based on weather or lake levels and although it is a natural occurrence there are measures that can be taken to slow the process down or minimize its effects. One aspect of reducing the impact of erosion, sloughing and slope failure is to reduce weight and soil layer stresses. It may be seen from the report images above that many trees are exerting significant local pressure on the bluff face soil layers. During storm events, and particularly when combined with high winds, tree root systems are subject to tearing out from the slope, destroying local stability and adversely impacting other downslope trees. As an illustration, we have seen other locations along the North Shore where significant slope failure occurred by just one large diameter tree overtopping and destroying a 20-foot wide, 50-foot long corridor extending from the top to toe of the bluff.

The necessary solution is to remove all at-risk trees to minimize weight and soil overturning pressure. Ideally removal of all trees for this particular bluff is recommended with the initial focus on high-risk trees mentioned above. By removing these trees, PDHP would be minimizing the risk of a storm or erosion knocking over the trees, causing larger slope failures. Over the course of time perhaps all bluff trees could be removed, but if not possible, then selective tree removal and ongoing management of trees on steeper slopes would be appropriate for this bluff face. For those locations where trees have already overturned and damaged the underlying soil layers, exposing the underlying clay to saturation and failure, V3 recommends re-grading of the local area, at a minimum, as discussed in the **Slope Grading** section below.

V3 estimates that the entire 4-acre bluff could be cleared of trees for a cost between **$80,000 and $100,000.** Upon completion of clearing sections of trees, topsoil should be used to cover the exposed slopes and a grass heavy native seed mix should be installed in impacted areas. These costs are not included in this tree clearing estimate, but are included below in **Slope Grading**.

4.3 SLOPE GRADING TO INCREASE SLOPE STABILITY

Restoration of sections of the existing bluff face to a stable 2 horizontal to 1 vertical slope or flatter are recommended for necessary slope stability. Similar to the prioritization activities mentioned above in the **Tree Removal** section, restoration of stable slopes along the entire bluff face is desired but perhaps impracticable with the PDHP budgetary constraints, therefore V3 recommends prioritizing sections of the bluff for ongoing re-grading, restoration and maintenance as budgetary opportunities allow. Any bluff face grading activities must be accompanied by incorporation of native plantings and vegetation suitable for bluff face slopes. These plantings will improve slope stability by establishing strong, deep root systems, thereby reducing rainfall runoff and improving overall slope integrity.

V3 estimates that approximately **$6,000 of seed** would be required to cover the entire 4-acre bluff face. V3 also estimates approximately 1 acre of exposed clay slopes would cost **$100,000 to be hand graded and topsoiled**.

4.4 TOP OF BLUFF TRAIL REMOVAL AND GRADING FOR DRAINAGE

The top of bluff trail has been compromised and is expected to be relocated due to the high potential for future top of bluff edge slope sloughing and sliding failures. The slope stability report suggests the zone of potential failure could be as much as twenty feet back from the present top edge of bluff.

Therefore, V3 recommends relocation of the trail to an alignment a minimum of thirty feet back from the present top of bluff edge. As a part of this effort, V3 recommends re-grading of the previous path alignment where accumulated runoff drainage was inadvertently being directed to the edge of bluff (**Figure 4.41** below). This re-grading should be performed in such a manner as to direct the accumulated drainage to a more suitable outlet

Figure 4.41 *Existing top of bluff path being used to focus accumulations of drainage to bluff top edge*

such as the stable ravine and installed storm drainage system to the west side of Millard Park (preservation of ravine stability must also be a priority in this construction effort).

It should be noted that a more detailed survey is required as part of this effort for effective re-grading of the top of bluff area to minimize top of bluff drainage from affecting the bluff face. **It is V3's understanding that the construction of path removal and replacement could be self-performed by the PDHP staff.**

4.5 LAKESIDE BLUFF TOE PROTECTION

Bluff toe protection should be taken as a high priority by the PDHP. The slope stability report summarized in the **Chapter 3 Site Stability Analysis** section above informs about the risk of continued bluff encroachment due to sloughing sliding and failure without adequate toe protection. Two aspects are believed by V3 to be important. One is restoration of the existing seawall elevations where damage has occurred, resulting in lowered beach sand and cobble elevations at the bluff face toe leading to increased slope failure due to direct and continuous wave assault on the bluff toe. V3 recommends this section of concrete be brought back to grade to restore the beach toe elevations to historic levels as may be seen on **Exhibit 5** in the **Appendix**.

The cost of concrete wall repair or sheet pile wall installation between Section B is estimated between $25,000 and $50,000 depending on choice of material and total length of wall repair.

The most critical section of toe protection though are those sections illustrated on **Exhibit 4** in the **Appendix**. Large stone rip-rap should be placed in such a manner as to protect the two failing bluff toe sections in order to reduce the potential for global top of bluff to toe of bluff slope failure. The stability report indicates the bluff stability to be potentially less than a factor of safety of 1, meaning the potential for failure is real, the slope not having sufficient stability to resist the natural forces affecting the slope.

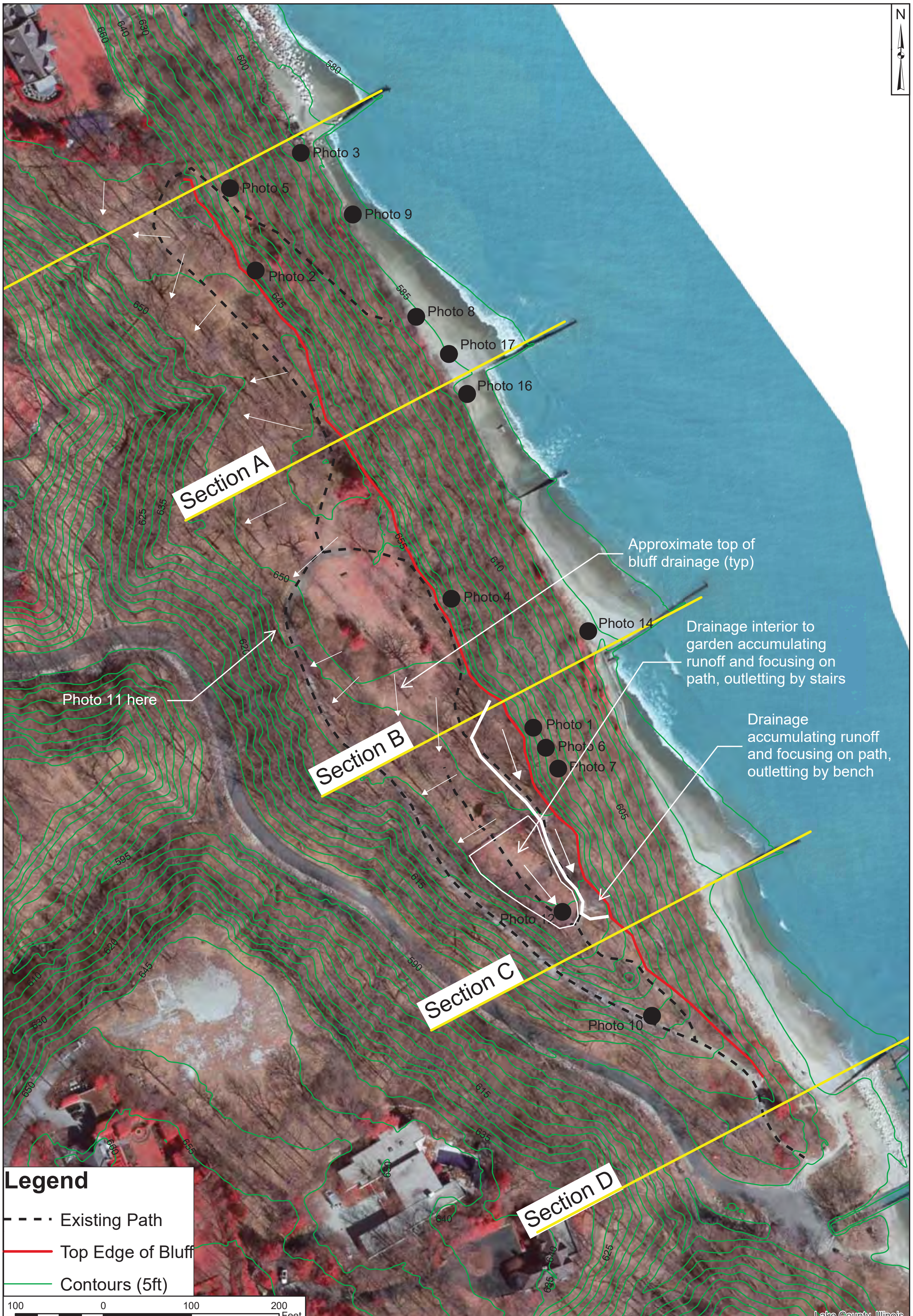
The cost of 450 feet of toe of bluff protection (Section A and Section B) is estimated between $1,000,000 and $1,200,000.

4.6 ADDITIONAL RECOMMENDATIONS

Finally, a couple of other issues should be mentioned for future consideration and potential remediation. One is V3's recommendation for signage related to relict sheet pile fragments being exposed during high Lake Michigan water levels and seen in **Figure 2.35** above. These relict structures pose a risk to swimmers and waders, particularly for this section of beach. Installation of warning signage for beachgoers should be evaluated by the PDHP.

Another consideration is the relict drainage and other utility structures that may be present, which may direct surface water to collect underground along the utility corridor, increasing local saturation causing local slope failure (and potentially leading to larger slope failures). It may be that **Figure 2.36** above illustrates this situation. Identification and assessment of these utilities should be performed at some time in the future to absolutely minimize water penetration causes of slope sloughing or failure. One such situation is the abandoned water system that should be checked for type of abandonment. If the pipe has been damaged and allows water entry and exit within the subsurface bluff soil layers, subsurface water accumulations can be happening without any obvious surface evidence. V3 noticed various broken sections of iron and clay pipe on the ravine and bluff faces.

APPENDIX A
EXHIBITS



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PROJECT NO.:	210275
CREATED BY:	SAV
DATE:	06/29/2021
SCALE:	See Scale Bar
CLIENT:	Park District of Highland Park 636 Ridge Road Highland Park, IL 60035
BASE LAYER:	Lake County Aerial (2018)
TITLE:	**EXISTING CONDITIONS AND PROBLEM AREAS**
SITE:	Millard Park Bluff Slope Stability Analysis Highland Park
EXHIBIT:	1.0

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Millard Bluff Exhibit Photos

Picture 1: Vertical drop due to slope failure.

Picture 2: Slope Failure.

Picture 3: Major erosion and slope failure at beach.

Picture 4: Tree in slope failure zone.

Picture 5: Exposed root system due to erosion.

Picture 6: Exposed root system due to erosion.


Picture 7: Tree in slope failure zone.


Picture 8: Tree failure showing uprooting.


Picture 9: Soil seepage at base of bluff along beach.


Picture 10: Storm sewer inlet.


Picture 11: Fire hydrant still in use?


Picture 12: Sprinkler head still in use?


Picture 13: Aerial photo of deteriorating seawall on southern half of Section B.

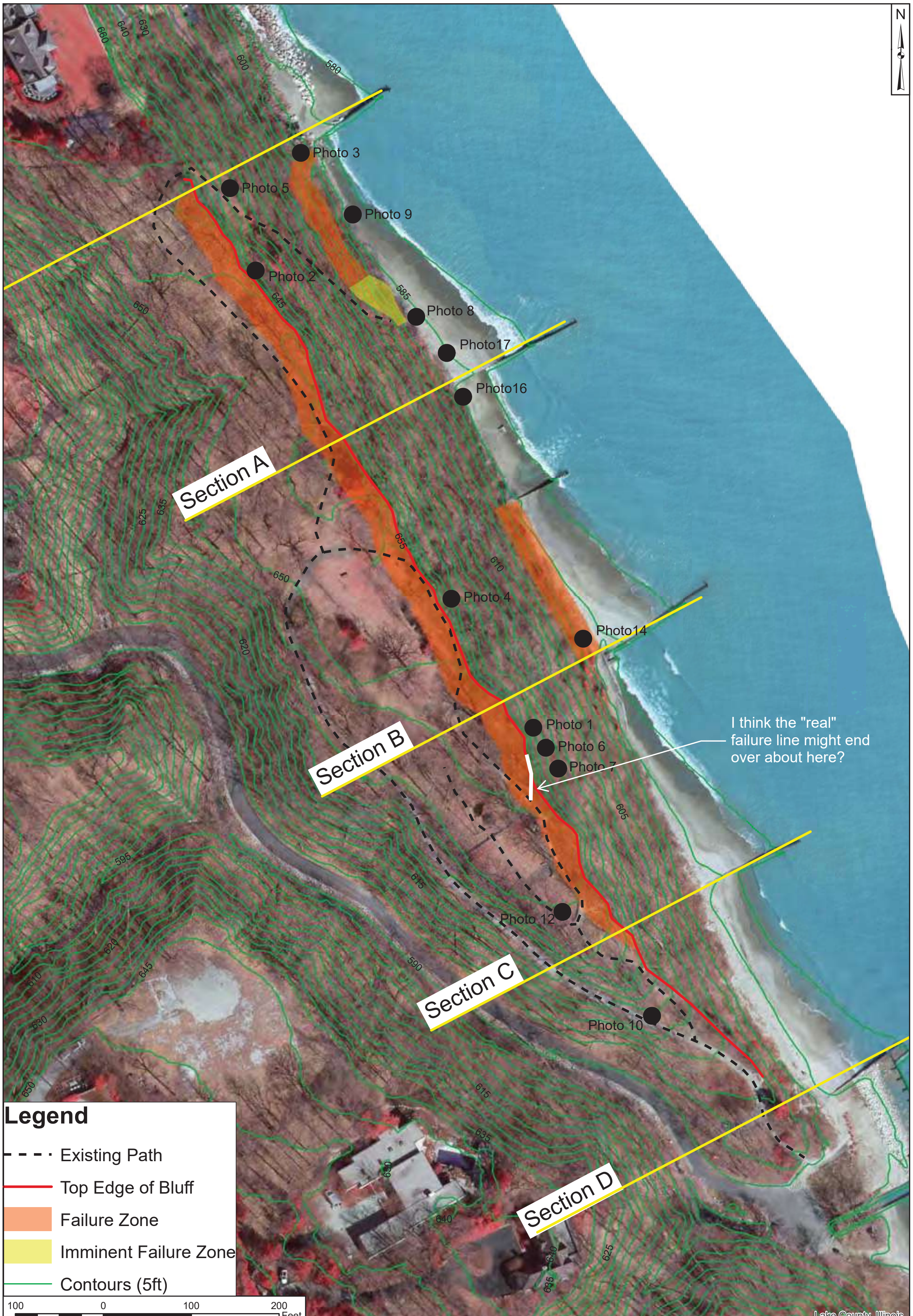

Picture 14: Washout occurring behind the seawall on the south of Section B.


Picture 15: Slope failure behind seawall on south half of Section B.


Picture 16: Priority Tree Removal area on north end of Section B looking south.


Picture 17: Priority Tree Removal area on south end of Section A looking north.


Picture 18: Aerial photo of slope failure on north end of Section A.



7325 Janes Avenue Woodridge, IL 60517 630.724.9200 phone www.v3co.com Visio, Vertere, Virtute... *"The Vision To Transform With Excellence"*	PROJECT NO.: 210275 CREATED BY: SAV DATE: 06/29/2021 SCALE: See Scale Bar	CLIENT: Park District of Highland Park 636 Ridge Road Highland Park, IL 60035 BASE LAYER: Lake County Aerial (2018)	TITLE: **SLOPE FAILURE ZONES** SITE: Millard Park Bluff Slope Stability Analysis Highland Park EXHIBIT: 2.0

N:\2021\210275\Drawings\ArcGIS\NR\Exh2_Slope Failure Zones.mxd

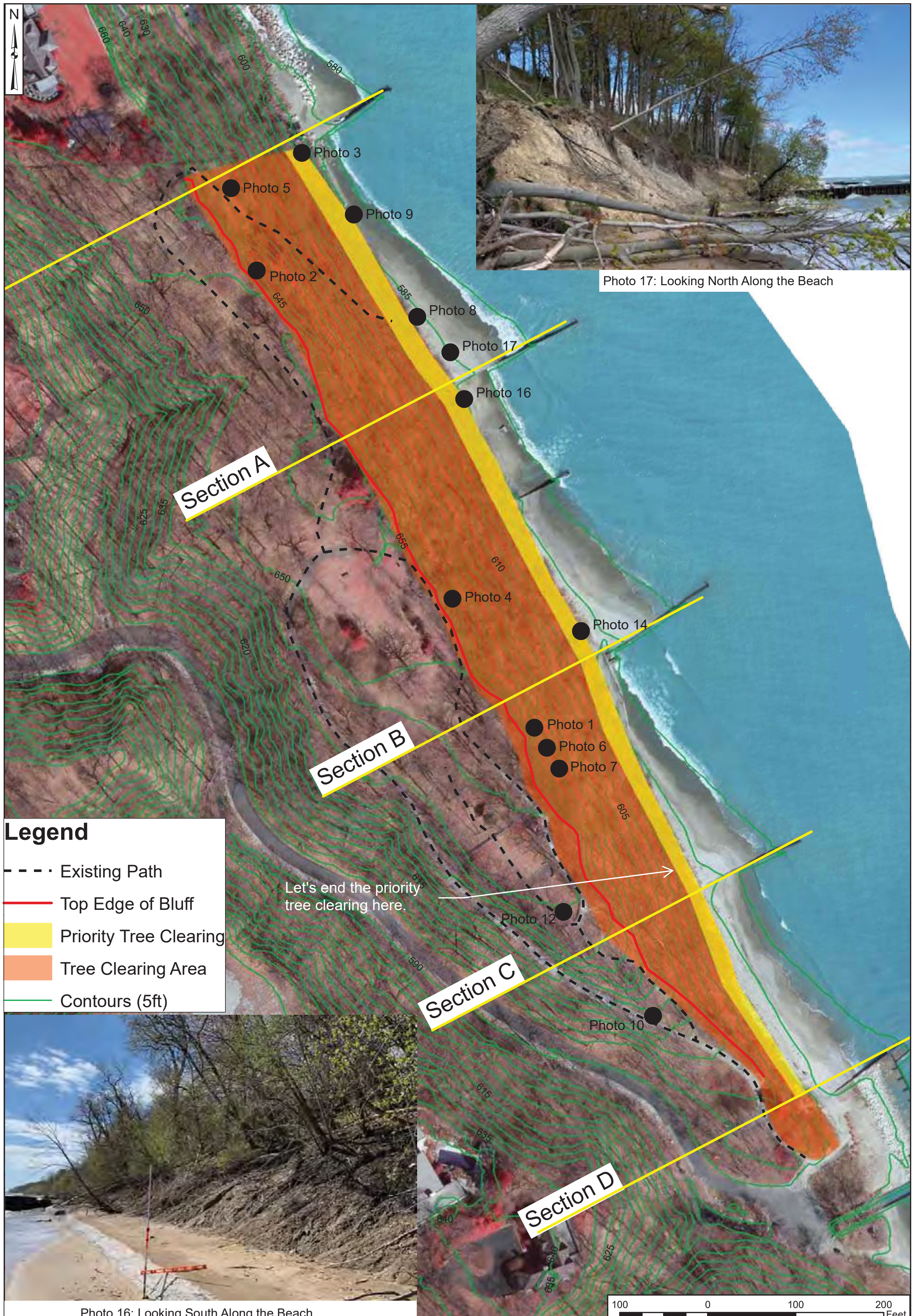
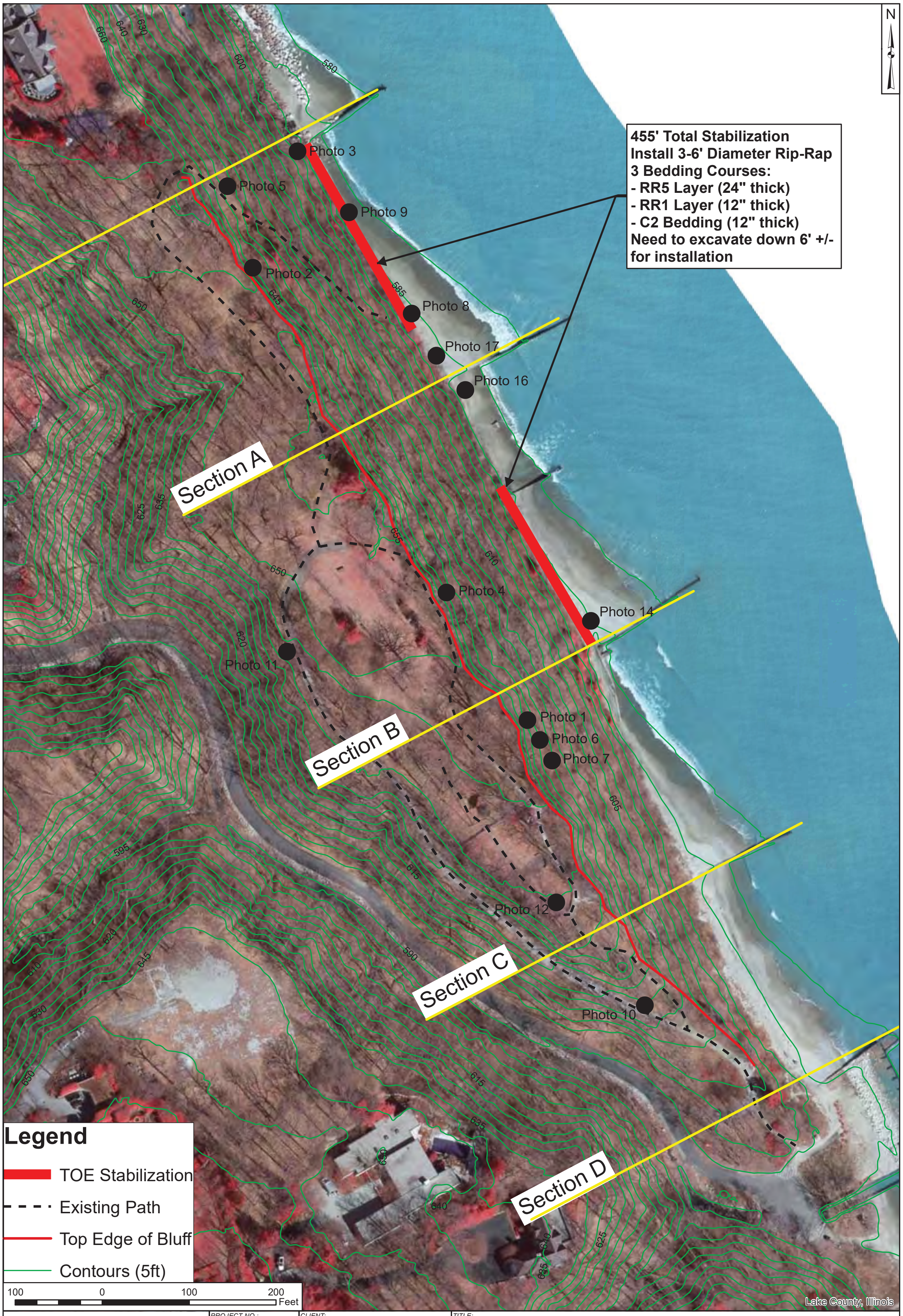


Photo 17: Looking North Along the Beach

Photo 16: Looking South Along the Beach

7325 Janes Avenue Woodridge, IL 60517 630.724.9200 phone www.v3co.com	PROJECT NO.: 210275 CREATED BY: SAV	CLIENT: Park District of Highland Park 636 Ridge Road Highland Park, IL 60035	TITLE: **TREE CLEARING**	
Visio, Vertere, Virtute... *"The Vision To Transform With Excellence"*	DATE: 06/29/2021 SCALE: See Scale Bar	BASE LAYER: Lake County Aerial (2018)	SITE: Millard Park Bluff Slope Stability Analysis Highland Park	EXHIBIT: 3.0

N:\2021\210275\Drawings\ArcGIS\NR\Exh3_Tree Clearing.mxd



V3 — 7325 Janes Avenue, Woodridge, IL 60517, 630.724.9200 phone, www.v3co.com	PROJECT NO.: 210275 CREATED BY: SAV	CLIENT: Park District of Highland Park, 636 Ridge Road, Highland Park, IL 60035	TITLE: **TOE STABILIZATION**	
Visio, Vertere, Virtute... *"The Vision To Transform With Excellence"*	DATE: 07/01/2021 SCALE: See Scale Bar	BASE LAYER: Lake County Aerial (2018)	SITE: Millard Park Bluff Slope Stability Analysis, Highland Park	EXHIBIT: 4.0

N:\2021\210275\Drawings\ArcGIS\NR\Exh4_TOE Stabilization.mxd

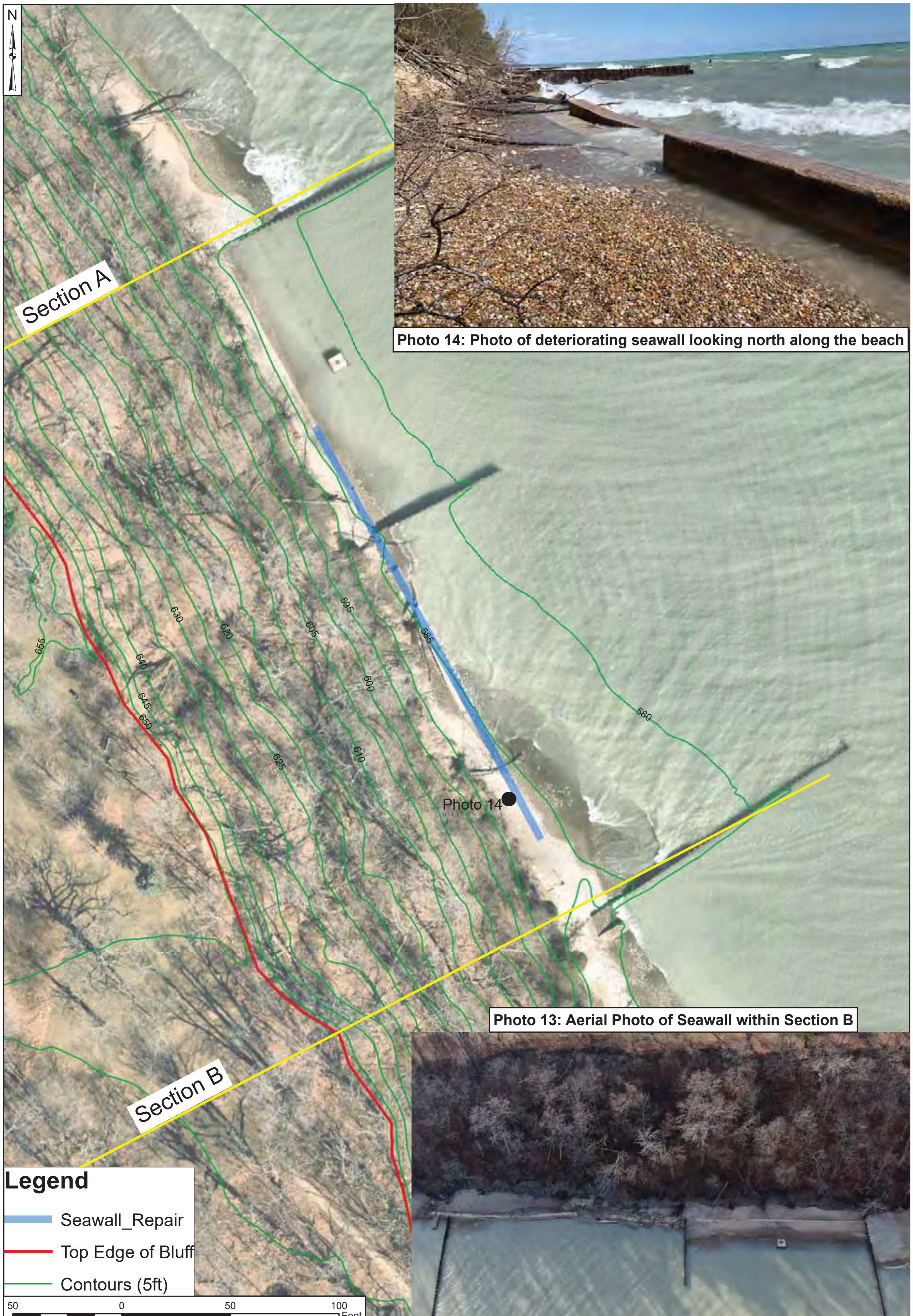
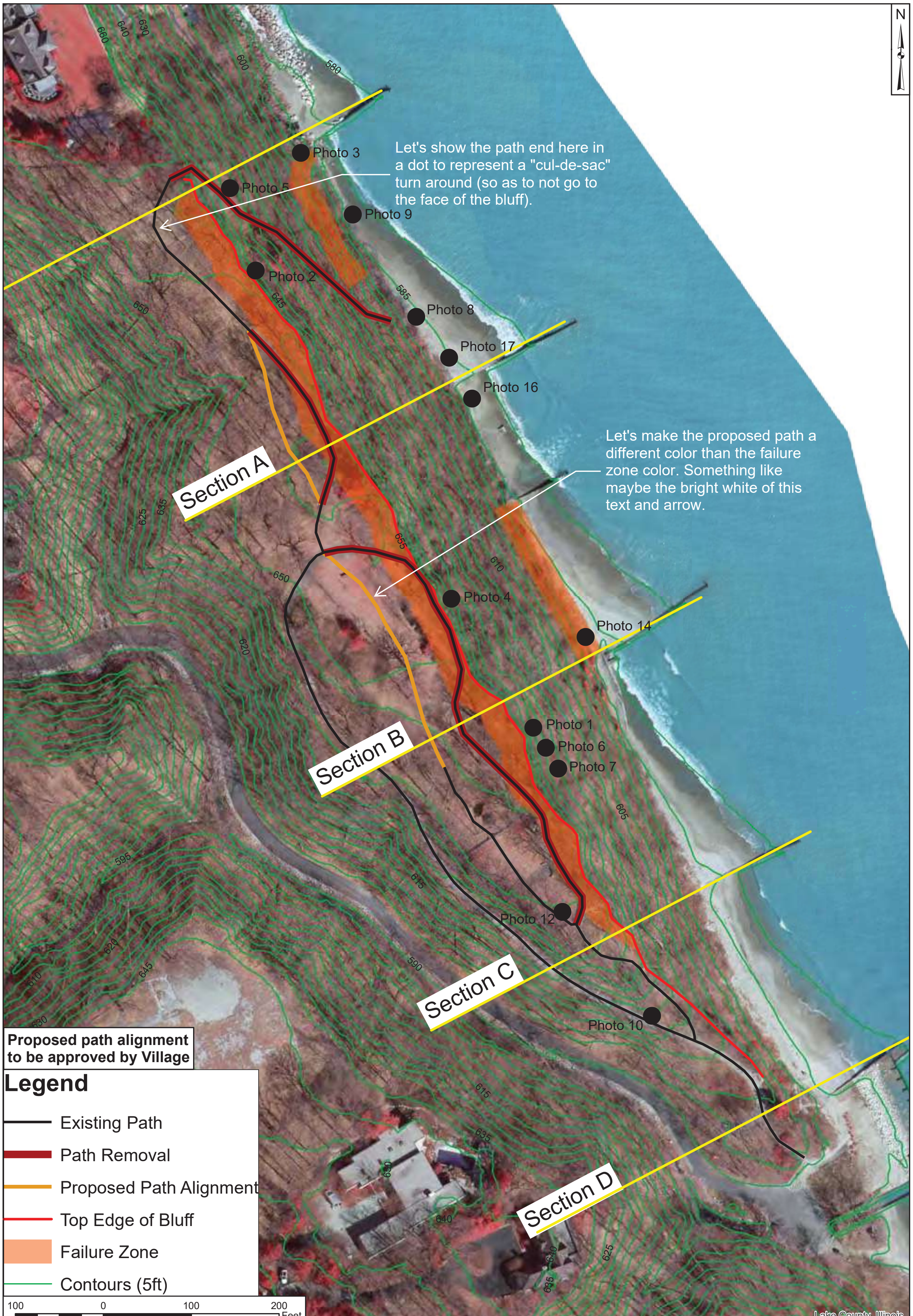


Photo 14: Photo of deteriorating seawall looking north along the beach

Photo 13: Aerial Photo of Seawall within Section B

7325 Janes Avenue Woodridge, IL 60517 630.724.9200 phone www.v3co.com Visio, Vertere, Virtute... *"The Vision To Transform With Excellence"*	PROJECT NO.: 210275 CREATED BY: SAV	CLIENT: Park District of Highland Park 636 Ridge Road Highland Park, IL 60035	TITLE: **CONCRETE SEAWALL REPAIR**
	DATE: 06/29/2021 SCALE: See Scale Bar	BASE LAYER: ESRI Basemap Aerial	SITE: Millard Park Bluff Slope Stability Analysis Highland Park EXHIBIT: 5.0

N:\2021\210275\Drawings\ArcGIS\NR\Exh5_Seawall Repair.mxd



7325 Janes Avenue Woodridge, IL 60517 630.724.9200 phone www.v3co.com Visio, Vertere, Virtute... *"The Vision To Transform With Excellence"*	PROJECT NO.: 210275 CREATED BY: SAV	CLIENT: Park District of Highland Park 636 Ridge Road Highland Park, IL 60035	TITLE: **PATH ALIGNMENT**
	DATE: 06/29/2021 SCALE: See Scale Bar	BASE LAYER: Lake County Aerial (2018)	SITE: Millard Park Bluff Slope Stability Analysis Highland Park — EXHIBIT: 6.0

N:\2021\210275\Drawings\ArcGIS\NR\Exh6_Path Alignment.mxd

APPENDIX B
GEOTECH REPORT

O'BRIEN & ASSOCIATES, INC.
CONSULTING ENGINEERS
766 W. Algonquin Road, Arlington Heights, IL 60005
Phone 847-398-1441 * Fax 847-398-2376

June 15, 2021

V3 Companies
7325 Janes Avenue
Woodridge, IL 60517

Attention: Mr. Michael Famiglietti P.E.
Director of Construction

OBA Job No. 21024

Re: Geotechnical investigation for the existing lakeshore bluffs, Millard Park, Highland Park, Illinois

Dear Mr. Famiglietti:

The following report presents the results of the geotechnical investigation performed for the existing lakeshore bluffs located in Millard Park, Highland Park, Illinois. A total of four (4) borings (B-1 through B-4) were performed at the site, and the results of the borings, along with a location diagram and general notes, are included in this report.

The park is located at the end of Ravine Drive along the Lake Michigan shoreline. According to the City of Highland Park GIS topographic data, the upper portion of the main bluff varies from approximately elevation 645 to elevation 657, with the higher elevation areas located in the northern portion of the park. The GIS topography shows the bluff having an approximately 1.5 horizontal to 1.0 vertical (1.5H:1V) slope to approximately elevation 640 and then a 2H:1V slope down to the beach. The current Lake Michigan water level is at approximately elevation 580.5, which is down approximately 20 inches from the record levels of June of 2020.

Significant sloughing, slides and erosion have occurred in both the upper or top of bluff and lower or beach bluff sections along the park. Currently, with the failures that have occurred, many areas of the bluff are much steeper than what is shown on the Highland Park GIS system.

Lake Michigan has been at historically high water levels until recently and significant erosion has occurred at the base of the bluff from wave action. With the erosion and loss of soil at the base of the bluff, the overall bluff slope steepens and additional slumping and sliding occurs. In addition, there are sand layers near the base of the bluff and these sand seams have been exposed by the erosion (and subsequent loss of vegetation). During prolonged periods of heavy precipitation, these sand layers will liquefy and flow down the bluff resulting in more erosion.

There are significant areas of failure in the upper bluff where slides, slumping and sloughing have resulted in near vertical slopes in some areas. These upper bluff failures or scarps occur not only because of the overall steepening of the slope, but also from surface tension cracks in weak zones (as the soil dries) and slumping or sloughing where localized sandy or silty deposits or where vegetation cover changes.

The failure and movement of the bluff downward towards the beach normally occurs slowly during dry and low water conditions, but dramatic movement can occur quickly during major storm events and during high water conditions.

The purpose of this report is to describe the subsurface conditions encountered in the borings, to analyze the data obtained including performing global stability analyses to evaluate the bluff slope conditions and to discuss the findings relative to the bluff erosion and failures that have occurred.

The boring locations were established by O'Brien & Associates, Inc. field personnel without the aid of sophisticated surveying techniques and as such are considered to be approximate. The elevation of the borings are indicated on the boring logs and the boring elevations were estimated using the Highland Park GIS topographic information.

The borings were performed during the period June 3 through June 8, 2021 using Diedrich track mounted drilling rigs with hollow stem augers. Representative samples were obtained in the borings employing split spoon sampling procedures in accordance with ASTM Specification D-1586. Samples obtained in the field were returned to our laboratory for further examination and testing. Split spoon sampling involves driving a 2.0 inch outside diameter split-barrel sampler into the soil with a 140-pound weight falling freely through a distance of 30 inches. The number of blows required to advance the sampler the last 12 inches is termed the Standard Penetration Resistance (N) and is included on the boring logs. The N value is an indication of the relative density and strength of the soil.

The testing program consisted of performing water content, density and either unconfined compression or calibrated penetrometer tests on the cohesive samples recovered. Water content testing was performed the non-cohesive samples. In addition, a torvane shear strength test was performed on a representative portion of the softer clay soils These tests were performed upon representative portions of the samples obtained in the field. The results of all testing performed, along with a visual classification of the material based upon both a textural analysis and the Unified Soil Classification System, are indicated on the boring logs.

As indicated on the boring logs, a thin layer of topsoil was present at the ground surface. The topsoil was underlain by a brown and gray very stiff to hard clay that extended to a depth of 11.0 to 12.0 feet below ground surface. The brown and gray clay was underlain by a stiff to hard gray clay that generally become stiffer with depth. A softer clay zone was noted within the gray clay in boring B-2 from 20.0 to 28.0 feet below ground surface. The gray clay extended to the maximum depth of boring B-1 (60 feet below ground surface) and to a depth of 58.5 feet below ground surface in borings B-2 through B-4. Below the gray clay in boring B-2 through B-4 were medium dense sands that extended to the maximum depth of the borings, 60 feet below ground surface. The stratification lines shown on the boring logs represents the approximate boundary between soil types, and the actual transition may be gradual or vary between sampling depths.

Water was noted at a depth of 19.0 feet below ground surface in boring B-1 and at a depth of 57.0 to 58.5 feet below ground surface in borings B-2 through B-4. The water encountered in boring B-1 is likely associated with a sand or silt seam that was present within the gray clay layer. Fluctuations in the amount of water accumulated and in the hydrostatic water table can be anticipated depending upon variations in precipitation and surface runoff. The water level observations provide an approximate indication of the groundwater levels at the time the borings were drilled. Longer term observations using piezometers would be necessary to more accurately establish groundwater conditions at the site.

The borings indicate that the soils at the site consist primarily of very stiff to hard clay soils with localized zones of softer and stiffer clays in the upper gray clay. From the results of the borings and observations along the exposed bluff, the clay soils are also interstratified with occasional sand and silt layers. Slope stability analyses were performed on the bluff slope based on the existing topography from the Highland Park GIS. The slope stability analysis was performed using the Xstabl slope stability program (Bishop’s method) to determine the critical factor of safety. The results of the slope stability analyses are included with this report.

The slope stability analyses was performed assuming normal (dry) conditions, wet or saturated conditions and also assuming the condition where tension cracks develop in the top part of the slope (a condition that occurs when the clay soils dry out and then become saturated). The results of the slope stability analyses are summarized in the table below and wet (saturated) soil conditions were assumed for all of the cases:

Case	Critical Factor of Safety (F.S.)
Bluff Stability - Normal (Dry) Condition	1.3
Bluff Stability - Wet (Saturated) Condition	0.9
Bluff Stability - Tension Crack (Saturated) Condition	0.9

The results of the slope stability analyses show factors of safety less than 1.0 for both the saturated and “cracked or tension” condition. These conditions, along with the erosion at the base of the bluff have likely occurred to varying degrees along the bluff and resulted in the failures are that now present at the site. Slope failure is difficult to predict because of the local variation in soil and groundwater conditions, weather conditions and lake levels, and the type and amount of vegetation that is present on the bluff. And obviously, for current conditions where steeper slopes are present, the factor of safeties should be considered marginal at best. More defined slope stability analyses can be performed, but these would require a more accurate and up to date site topography.

In summary, the failures appear to be a combination of failures in both the upper and lower bluff, with the erosion from the high lake levels the most significant factor in the bluff deterioration. Continued movement should be expected until the overall bluff slope approaches 2H:1V and will occur more quickly during wet periods and periods of heavy precipitation.

A number of corrective measures can be taken to help stabilize the bluff. The bluff can be flattened so that the overall bluff slope is approximately 2H :1V. Vegetation (native plants) can be planted to create a good root system that will reduce runoff and help strengthen and stabilize the slope. Revetment stone can be placed at the base of the bluff to minimize erosion from storm events. A retaining wall can be constructed at the top of the bluff to prevent further failure from tension cracks and to minimize bluff recedence, and also help in flattening the slope.

Remedial measures that are not recommended include installation of gabion baskets and use of wick drains. While gabion walls have many great uses (streams, ravines and other drainage pathways are very good examples), we have never seen a gabion basket successfully work long term on a bluff. Too many inherent instability problems eventually manifest themselves and the walls move (and more often that not fail). The movement can include global stability issues (the gabions essentially rest on the surface), drainage issues (when the back of the basket clogs as runoff brings sediment down the bluff), infinite slope failures (these are shallow slides within the upper 3' to 6' that are separate from global stability and are worse when fill conditions exist) and the general bluff recession that is occurring all along the Lake Michigan shoreline. Wick drains require a continuous well-defined, permeable water bearing layer, which was not present in any of the borings.

For the evaluation of the slope and design of any remedial improvements, the following soil parameters can be used:

Material Description	Cohesion (psf)	Friction Angle	Unit Weight (pcf)
Very Stiff to Hard Brown and Gray	150	28°	130
Stiff to Very Stiff Gray Clay	100	28°	130
Very Stiff to Hard Gray Clay	200	28°	135
Medium Dense Sand	0	30°	125

The sloping ground surface in the front of any improvement will result in a reduced passive resistance and this needs to be considered in the design of the improvement. Stockpiles of material or equipment should not be placed near the top of the walls. Allowances should also be made for any surcharge loads adjacent to the walls. Proper downslope drainage is critical to maintaining the bluff stability by removing excess water, limiting hydrostatic pressures and preventing unnecessary bluff erosion.

The analysis and recommendations presented in this report are based upon the data obtained from the soil borings performed at the indicated locations and from any other information discussed in this report. This report does not reflect any variations which may occur away from the boring locations. In addition, the soil samples cannot be relied on to accurately reflect the strata variations that usually exist between sampling locations. The nature and extent of such variations may not become evident until repairs are initiated. If variations appear evident, it will be necessary to reevaluate the recommendations of the report.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No other warranties, either expressed or implied, are intended or made. Also note that O'Brien & Associates, Inc. is not responsible for any claims, damages, or liability associated with any other party's interpretation of this report's subsurface data or reuse of the report's' subsurface data or engineering analyses without the express written authorization of O'Brien & Associates, Inc.

If there are any questions with regard to the information submitted in this report, or if we can be of further assistance to you in any way, please do not hesitate to contact us.

Very truly yours,

O'BRIEN & ASSOCIATES, INC.

Dixon O'Brien,
P.E. Vice President
DOB/vb
enc.

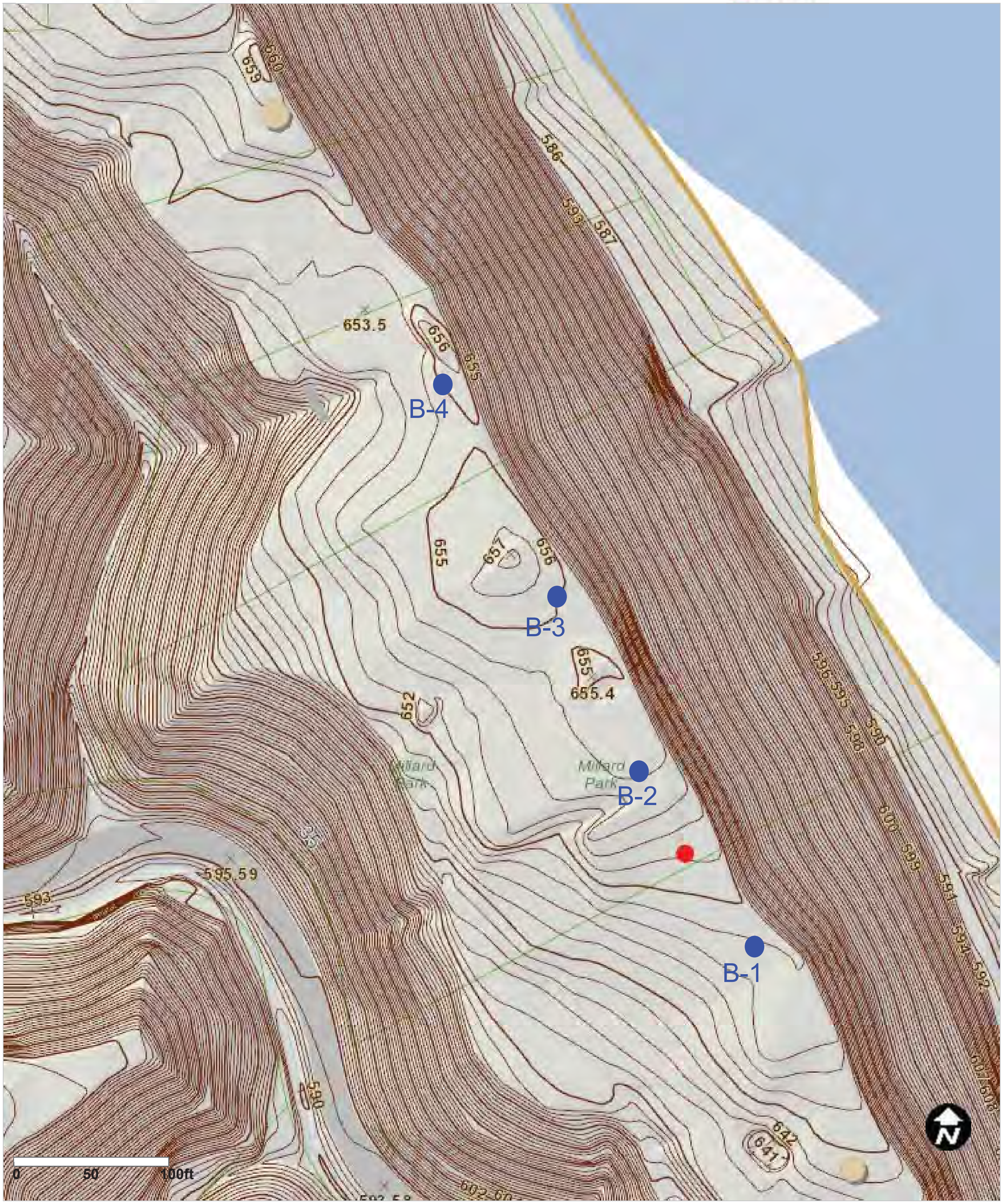
DIXON O'BRIEN
#062-042196
LICENSED
PROFESSIONAL
ENGINEER
OF
ILLINOIS

EXP. 11/30/2021

Millard Park - Soil Boring Location Diagram

MapOffice™ ***Millard Park Location Diagram***

Created By mgp inc



Map created on **June 15, 2021**.

OBA Job No. 21024

LOG OF BORING NO. B–1

CLIENT	BORING LOCATION
V3 Companies	See Boring Location Diagram
PROJECT LOCATION	PROJECT DESCRIPTION
Millard Park, Highland Park, IL	Bluff and Lakeshore Evaluation

DEPTH (ft.) BELOW GROUND SURFACE	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DISTANCE	DESCRIPTION OF MATERIAL	ELEVATION	STANDARD PENETRATION "N"	Qp (tsf)	Qu (tsf)	MOISTURE CONTENT (%)	UNIT DRY WEIGHT (pcf)	REMARKS
				GROUND SURFACE ELEVATION	*649*						
	1	AS		TOPSOIL–brown	*648*				20		
	2	SS		LEAN CLAY–brown & gray– very stiff to hard (CL) Possible Fill		9	3.0	2.8	16	112	
5.0	3	SS			*643*	18	4.5+	4.4	15	119	
	4	SS		LEAN CLAY–brown & gray– hard (CL)		25	4.5+	6.0	14	121	
10.0	5	SS			*638*	17	4.5+	6.2	14	121	
	6	SS		LEAN CLAY–gray– stiff to very stiff (CL)		14	2.75	2.5	15	119	
15.0	7	SS				13	2.25	2.3	15	120	
20.0	8	SS		▼	*625.5*	16	1.75	1.6	16	117	
25.0	9	SS		LEAN CLAY–gray– very stiff to hard (CL)		21	2.75	2.5	15	119	
30.0	10	SS				19	3.25	3.2	15	120	

CONTINUED ON FOLLOWING PAGE

WATER LEVEL OBSERVATIONS	
Water Level While Drilling –19'	▼
Water Level After Boring Dry	▽
	▽

OBA
O'BRIEN & ASSOCIATES, INC.
CONSULTING ENGINEERS
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(847)398–1441 * FAX(847) 398–2376

BORING STARTED	June 3, 2021		
BORING COMPLETED	June 3, 2021		
RIG	D–25	FOREMAN	DJ
DRAWN	VPB	APPROVED	DOB
OBA JOB No. 21024		SHEET	1 OF 2

LOG OF BORING NO. B-1

CLIENT	BORING LOCATION
V3 Companies	See Boring Location Diagram
PROJECT LOCATION	**PROJECT DESCRIPTION**
Millard Park, Highland Park, IL	Bluff and Lakeshore Evaluation

DEPTH (ft.) BELOW GROUND SURFACE	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DISTANCE	DESCRIPTION OF MATERIAL	STANDARD PENETRATION "N"	Qp (tsf)	Qu (tsf)	MOISTURE CONTENT (%)	UNIT DRY WEIGHT (pcf)	REMARKS
				GROUND SURFACE ELEVATION 649						
				LEAN CLAY—gray— very stiff to hard (CL)						
35.0	11	SS			18	3.0	2.7	16	119	
40.0	12	SS			16	2.75	2.8	15	119	
45.0	13	SS			20	3.75	3.5	15	121	
50.0	14	SS			35	4.5+	3.7	13	120	
55.0	15	SS			31	3.75	3.9	17	115	
60.0	16	SS		589	35	3.5	3.4	16	117	

END OF BORING

WATER LEVEL OBSERVATIONS	
Water Level While Drilling	-19'
Water Level After Boring	Dry

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(847)398-1441 * FAX(847) 398-2376

BORING STARTED	June 3, 2021		
BORING COMPLETED	June 3, 2021		
RIG	D-25	FOREMAN	DJ
DRAWN	VPB	APPROVED	DOB
OBA JOB No. 21024		SHEET	2 OF 2

LOG OF BORING NO. B-2

CLIENT	BORING LOCATION
V3 Companies	See Boring Location Diagram
PROJECT LOCATION	**PROJECT DESCRIPTION**
Millard Park, Highland Park, IL	Bluff and Lakeshore Evaluation

DEPTH (ft.) BELOW GROUND SURFACE	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DISTANCE	DESCRIPTION OF MATERIAL		STANDARD PENETRATION "N"	Qp (tsf)	Qu (tsf)	MOISTURE CONTENT (%)	UNIT DRY WEIGHT (pcf)	REMARKS
				GROUND SURFACE ELEVATION	*654*						
	1	AS		4" TOPSOIL FILL—brown							
	2	SS		LEAN CLAY—brown & gray—hard (CL) Possible Fill		13	4.0		14		
5.0	3	SS			*648*	23	4.0		12		
	4	SS		LEAN CLAY—brown & gray—hard (CL)		24	4.0		14		
10.0	5	SS				16	3.0	2.7	17	113	
	6	SS			*642*						
				LEAN CLAY—gray—stiff to very stiff (CL)		13	3.0	2.8	14	123	
15.0	7	SS				11	2.0	2.1	14	122	
20.0	8	SS				12	2.0	1.9	15	119	
25.0	9	SS		***Torvane @ −24.0' Shear Strength = 1,020psf***		9	1.0	0.9	18	114	
30.0	10	SS				9	1.5	1.6	17	116	

CONTINUED ON FOLLOWING PAGE

WATER LEVEL OBSERVATIONS			
Water Level While Drilling −58.5'		BORING STARTED	June 8, 2021
Water Level After Boring −58.0'		BORING COMPLETED	June 8, 2021
		RIG D-50	FOREMAN J/D
		DRAWN VPB	APPROVED DOB
		OBA JOB No. 21024	SHEET 1 OF 2

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LOG OF BORING NO. B-2

CLIENT	BORING LOCATION
V3 Companies	See Boring Location Diagram
PROJECT LOCATION	PROJECT DESCRIPTION
Millard Park, Highland Park, IL	Bluff and Lakeshore Evaluation

GROUND SURFACE ELEVATION **654**

DEPTH (ft.) BELOW GROUND SURFACE	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DISTANCE	DESCRIPTION OF MATERIAL	STANDARD PENETRATION "N"	Qp (tsf)	Qu (tsf)	MOISTURE CONTENT (%)	UNIT DRY WEIGHT (pcf)	REMARKS
				LEAN CLAY—gray— stiff to very stiff (CL)						
35.0	11	SS			14	3.0	3.4	15	119	
40.0	12	SS			15	2.5	2.7	16	118	
45.0	13	SS			16	1.5	1.8	16	117	
50.0	14	SS			18	2.75	2.5	16	118	
55.0	15	SS			16	3.0	2.1	17	115	
				595.5						
60.0	16	SS		SILTY SAND w/CLAY—gray— medium dense (SM) *594*	21			16		

END OF BORING

WATER LEVEL OBSERVATIONS
Water Level While Drilling −58.5'
Water Level After Boring −58.0'

OBA

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BORING STARTED	June 8, 2021		
BORING COMPLETED	June 8, 2021		
RIG	D-50	FOREMAN	J/D
DRAWN	VPB	APPROVED	DOB
OBA JOB No. 21024		SHEET	2 OF 2

LOG OF BORING NO. B-3

CLIENT	BORING LOCATION
V3 Companies	See Boring Location Diagram
PROJECT LOCATION	**PROJECT DESCRIPTION**
Millard Park, Highland Park, IL	Bluff and Lakeshore Evaluation

GROUND SURFACE ELEVATION **655**

DEPTH (ft.) BELOW GROUND SURFACE	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DISTANCE	DESCRIPTION OF MATERIAL	STANDARD PENETRATION "N"	Qp (tsf)	Qu (tsf)	MOISTURE CONTENT (%)	UNIT DRY WEIGHT (pcf)	REMARKS
	1	AS		8" WOODCHIPS						
	2	SS		LEAN CLAY—brown & gray— very stiff to hard (CL) Possible Fill	14	3.5	3.4	22	99	
5.0	3	SS			13	2.5		15		
	4	SS			14	4.5	1.9	16	98	
				646.5						
10.0	5	SS		LEAN CLAY—brown & gray— hard (CL)	18	4.5	3.9	15	105	
				644						
	6	SS		LEAN CLAY—gray— stiff to very stiff (CL)	14	3.25	2.8	14	121	
15.0	7	SS			12	3.5	3.7	14	121	
20.0	8	SS			10	2.0	1.8	16	119	
25.0	9	SS			12	1.5	1.8	16	118	
30.0	10	SS			11	2.25	2.1	16	117	

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WATER LEVEL OBSERVATIONS	
Water Level While Drilling	-58.5'
Water Level After Boring	-57.0'

O'BRIEN & ASSOCIATES, INC.
CONSULTING ENGINEERS
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(847)398-1441 * FAX(847) 398-2376

BORING STARTED	June 8, 2021		
BORING COMPLETED	June 8, 2021		
RIG	D-50	FOREMAN	J/D
DRAWN	VPB	APPROVED	DOB
OBA JOB No. 21024		SHEET	1 OF 2

LOG OF BORING NO. B-3

CLIENT	BORING LOCATION
V3 Companies	See Boring Location Diagram
PROJECT LOCATION	**PROJECT DESCRIPTION**
Millard Park, Highland Park, IL	Bluff and Lakeshore Evaluation

GROUND SURFACE ELEVATION ***655***

DEPTH (ft.) BELOW GROUND SURFACE	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DISTANCE	DESCRIPTION OF MATERIAL	STANDARD PENETRATION "N"	Qp (tsf)	Qu (tsf)	MOISTURE CONTENT (%)	UNIT DRY WEIGHT (pcf)	REMARKS
				LEAN CLAY—gray— stiff to very stiff (CL)						
35.0	11	SS			16	2.5	2.7	16	118	
40.0	12	SS			16	3.0	2.7	15	120	
45.0	13	SS			20	1.5		16		
50.0	14	SS			19	2.5	3.4	16	119	
55.0	15	SS			13	2.5	2.8	16	117	
				596.5						
60.0	16	SS		SILTY SAND—gray— medium dense (SM) ***595***	25			16		

END OF BORING

WATER LEVEL OBSERVATIONS	
Water Level While Drilling −58.5'	▼
Water Level After Boring −57.0'	▽
	▽

OBA

O'BRIEN & ASSOCIATES, INC.
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766 W. ALGONQUIN RD./ARLINGTON HTS., IL 60005
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BORING STARTED	June 8, 2021		
BORING COMPLETED	June 8, 2021		
RIG	D-50	FOREMAN	J/D
DRAWN	VPB	APPROVED	DOB
OBA JOB No. 21024		SHEET	2 OF 2

LOG OF BORING NO. B-4

CLIENT	BORING LOCATION
V3 Companies	See Boring Location Diagram
PROJECT LOCATION	PROJECT DESCRIPTION
Millard Park, Highland Park, IL	Bluff and Lakeshore Evaluation

GROUND SURFACE ELEVATION 655

DEPTH (ft.) BELOW GROUND SURFACE	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DISTANCE	DESCRIPTION OF MATERIAL	STANDARD PENETRATION "N"	Qp (tsf)	Qu (tsf)	MOISTURE CONTENT (%)	UNIT DRY WEIGHT (pcf)	REMARKS
	1	AS		2" WOODCHIPS, 8" TOPSOIL FILL						
	2	SS		LEAN CLAY—brown & gray— very stiff to hard (CL) Possible Fill	15	4.5	3.8	15	121	
5.0	3	SS			24	3.75	3.7	15	105	
	4	SS		646.5	23	4.5+	5.5S @9%	15	119	
10.0	5	SS		LEAN CLAY—brown & gray— hard (CL) 644	15	4.5	4.4	17	108	
	6	SS		LEAN CLAY—gray— stiff to very stiff (CL)	11	2.25	2.8	16	118	
15.0	7	SS			11	2.25	2.5	15	119	
20.0	8	SS			10	2.25	2.3	16	117	
25.0	9	SS			9	1.5	1.6	17	115	
30.0	10	SS			14	3.0	3.4	15	119	

CONTINUED ON FOLLOWING PAGE

WATER LEVEL OBSERVATIONS	
Water Level While Drilling	-58.5'
Water Level After Boring	-57.5'

BORING STARTED	June 8, 2021
BORING COMPLETED	June 8, 2021
RIG D-50	FOREMAN J/D
DRAWN VPB	APPROVED DOB
OBA JOB No. 21024	SHEET 1 OF 2

OBA
O'BRIEN & ASSOCIATES, INC.
CONSULTING ENGINEERS
766 W. ALGONQUIN RD./ARLINGTON HTS., IL 60005
(847)398-1441 * FAX(847) 398-2376

LOG OF BORING NO. B-4

CLIENT	BORING LOCATION
V3 Companies	See Boring Location Diagram
PROJECT LOCATION	**PROJECT DESCRIPTION**
Millard Park, Highland Park, IL	Bluff and Lakeshore Evaluation

DEPTH (ft.) BELOW GROUND SURFACE	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DISTANCE	DESCRIPTION OF MATERIAL	STANDARD PENETRATION "N"	Qp (tsf)	Qu (tsf)	MOISTURE CONTENT (%)	UNIT DRY WEIGHT (pcf)	REMARKS
				GROUND SURFACE ELEVATION **655**						
				LEAN CLAY—gray— stiff to very stiff (CL)						
35.0	11	SS			16	3.0	3.5	15	120	
40.0	12	SS			14	2.5	3.2	15	119	
45.0	13	SS			13	2.75	2.8	16	119	
50.0	14	SS			15	2.5	2.7	16	118	
55.0	15	SS			16	3.0	3.0	17	113	
				596.5						
60.0	16	SS		WELL GRADED SAND—gray— medium dense (SW) **595**	19			14		

END OF BORING

WATER LEVEL OBSERVATIONS
Water Level While Drilling −58.5'
Water Level After Boring −57.5'

O'BRIEN & ASSOCIATES, INC.
CONSULTING ENGINEERS
766 W. ALGONQUIN RD./ARLINGTON HTS., IL 60005
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BORING STARTED	June 8, 2021		
BORING COMPLETED	June 8, 2021		
RIG	D-50	FOREMAN	J/D
DRAWN	VPB	APPROVED	DOB
OBA JOB No. 21024		SHEET	2 OF 2

GENERAL NOTES

CLASSIFICATION

Chicago Building Code Textural Soil Classifications and Unified Soil Classifications are used.

Cohesionless Soils

Relative Density	No. of Blows per foot N
Very Loose	0 to 4
Loose	4 to 10
Medium	10 to 30
Dense	30 to 50
Very Dense	Over 50

Cohesive Soils

Consistency	Unconfined Compressive Strength - qu (tsf)
Very Soft	Less than 0.25
Soft	0.25 - 0.5
Medium	0.5 - 1.0
Stiff	1.0 - 2.0
Very Stiff	2.0 - 4.0
Hard	Over 4.0

TERMINOLOGY

Streaks are considered to be paper thick. **Lenses** are considered to be less than 2 inches thick. **Layers** are considered to be 6 inches or less thick. **Stratum** are considered to be greater than 6 inches thick.

DRILLING AND SAMPLING SYMBOLS

SS:	Split Spoon 1-3/8" I.D., 2" O.D.	HS:	Housel Sampler
ST:	Shelby Tube 2" O.D., except where noted	WS:	Wash Sample
AS:	Auger Sample	FT:	Fish Tail
DB:	Diamond Bit - NX: BX: AX	RB:	Rock Bit
CB:	Carboloy Bit - NX: BX: AX	WO:	Wash Out
OS:	Osterberg Sampler		

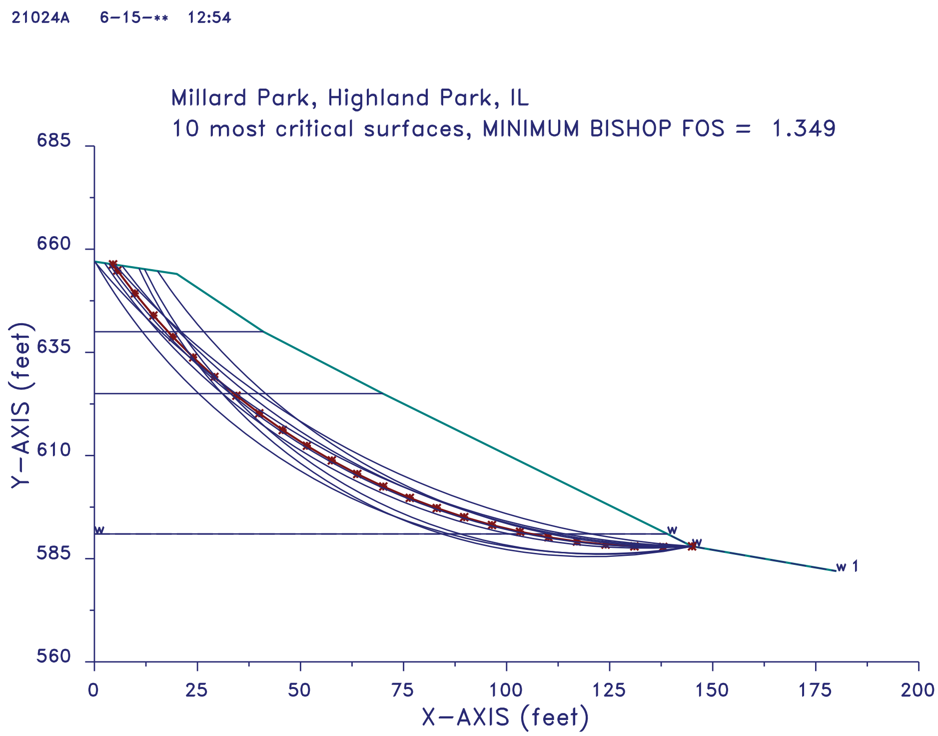
Standard "N" Penetration: Blows per foot of a 140 lb. hammer falling 30" on a 2" O.D. Split Spoon

WATER LEVEL MEASUREMENT SYMBOLS

WL:	Water	WD:	While Drilling
WCI:	Wet Cave In	BCR:	Before Casing Removal
DCI:	Dry Cave In	ACR:	After Casing Removal
WS :	While sampling	AB:	After Boring

Water levels indicated on the boring logs are the levels measured in the boring at the times indicated. In pervious soils, the indicated elevations are considered reliable ground water levels. In impervious soils, the accurate determination of ground water elevations is not possible in even several day's observation, and additional evidence on ground water elevations must be sought.

Normal Conditions
OBA Job No. 21024



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```

Problem Description : Millard Park, Highland Park, IL

SEGMENT BOUNDARY COORDINATES
----

6 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	657.0	20.0	654.0	1
2	20.0	654.0	41.0	640.0	1
3	41.0	640.0	70.0	625.0	2
4	70.0	625.0	139.0	591.0	3
5	139.0	591.0	145.0	588.0	4
6	145.0	588.0	180.0	582.0	4

3 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	640.0	41.0	640.0	2
2	.0	625.0	70.0	625.0	3
3	.0	591.0	139.0	591.0	4

ISOTROPIC Soil Parameters
----

4 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	130.0	130.0	150.0	28.00	.000	.0	1
2	130.0	130.0	100.0	28.00	.000	.0	1
3	135.0	135.0	200.0	28.00	.000	.0	1
4	125.0	125.0	.0	30.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 4 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	.00	591.00
2	139.00	591.00
3	145.00	588.00
4	180.00	582.00

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 20.0 ft
and x = 145.0 ft

Each surface terminates between x = .0 ft
and x = 20.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

7.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 25 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	145.00	588.00
2	138.00	587.85
3	131.00	587.99
4	124.02	588.43
5	117.06	589.17
6	110.13	590.21
7	103.26	591.54
8	96.45	593.16
9	89.72	595.07
10	83.07	597.26
11	76.52	599.74
12	70.09	602.50
13	63.78	605.52
14	57.60	608.81
15	51.57	612.37
16	45.69	616.17
17	39.99	620.23
18	34.46	624.52
19	29.12	629.04
20	23.97	633.79
21	19.04	638.76
22	14.32	643.93
23	9.82	649.29
24	5.56	654.85
25	4.52	656.32

**** Simplified BISHOP FOS = 1.349 ****

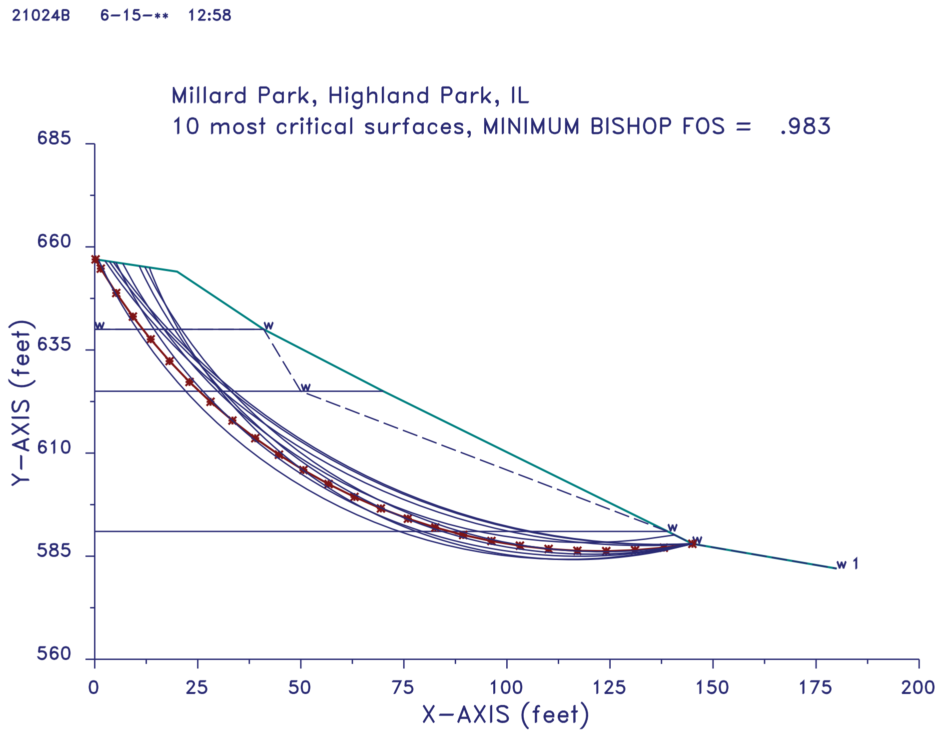
The following is a summary of the TEN most critical surfaces

Problem Description : Millard Park, Highland Park, IL

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.349	137.88	751.99	164.14	145.00	4.52	2.763E+07
2.	1.349	144.10	760.87	172.88	145.00	6.69	2.620E+07
3.	1.350	137.13	752.19	164.37	145.00	3.54	2.834E+07
4.	1.352	133.44	746.33	158.75	145.00	2.49	2.903E+07
5.	1.356	148.34	781.89	193.92	145.00	.03	3.159E+07
6.	1.361	140.74	739.22	151.28	145.00	15.31	2.034E+07
7.	1.361	157.60	791.78	204.17	145.00	4.91	2.811E+07
8.	1.369	123.29	710.09	124.00	145.00	12.14	2.270E+07
9.	1.373	122.56	727.46	141.26	145.00	.20	3.065E+07
10.	1.376	120.45	706.46	120.98	145.00	10.82	2.365E+07

* * * END OF FILE * * *

Saturated Conditions
OBA Job No. 21024



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Problem Description : Millard Park, Highland Park, IL

SEGMENT BOUNDARY COORDINATES
----

6 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	657.0	20.0	654.0	1
2	20.0	654.0	41.0	640.0	1
3	41.0	640.0	70.0	625.0	2
4	70.0	625.0	139.0	591.0	3
5	139.0	591.0	145.0	588.0	4
6	145.0	588.0	180.0	582.0	4

3 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	640.0	41.0	640.0	2
2	.0	625.0	70.0	625.0	3
3	.0	591.0	139.0	591.0	4

ISOTROPIC Soil Parameters
----

4 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	130.0	130.0	150.0	28.00	.000	.0	1
2	130.0	130.0	100.0	28.00	.000	.0	1
3	135.0	135.0	200.0	28.00	.000	.0	1
4	125.0	125.0	.0	30.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 6 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	.00	640.00
2	41.00	640.00
3	50.00	625.00
4	139.00	591.00
5	145.00	588.00
6	180.00	582.00

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 20.0 ft and x = 145.0 ft

Each surface terminates between x = .0 ft and x = 20.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

7.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 26 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	145.00	588.00
2	138.06	587.06
3	131.09	586.46
4	124.09	586.21
5	117.09	586.31
6	110.11	586.76
7	103.15	587.54
8	96.25	588.68
9	89.40	590.15
10	82.64	591.96
11	75.98	594.11
12	69.43	596.58
13	63.01	599.37
14	56.74	602.48
15	50.63	605.89
16	44.69	609.61
17	38.95	613.61
18	33.41	617.89
19	28.09	622.44
20	23.01	627.25
21	18.16	632.30
22	13.58	637.59

23	9.26	643.10
24	5.22	648.82
25	1.47	654.73
26	.20	656.97

**** Simplified BISHOP FOS = .983 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Millard Park, Highland Park, IL

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	.983	122.56	727.46	141.26	145.00	.20	2.194E+07
2.	.983	123.29	710.09	124.00	145.00	12.14	1.631E+07
3.	.985	120.45	706.46	120.98	145.00	10.82	1.693E+07
4.	.987	133.44	746.33	158.75	145.00	2.49	2.119E+07
5.	.988	117.74	709.55	124.57	145.00	5.16	1.950E+07
6.	.993	137.13	752.19	164.37	145.00	3.54	2.086E+07
7.	.995	137.88	751.99	164.14	145.00	4.52	2.038E+07
8.	.997	114.52	709.49	125.26	145.00	.90	2.164E+07
9.	1.001	116.19	694.41	110.24	145.00	13.26	1.613E+07
10.	1.006	119.14	715.51	127.19	140.69	6.79	1.749E+07

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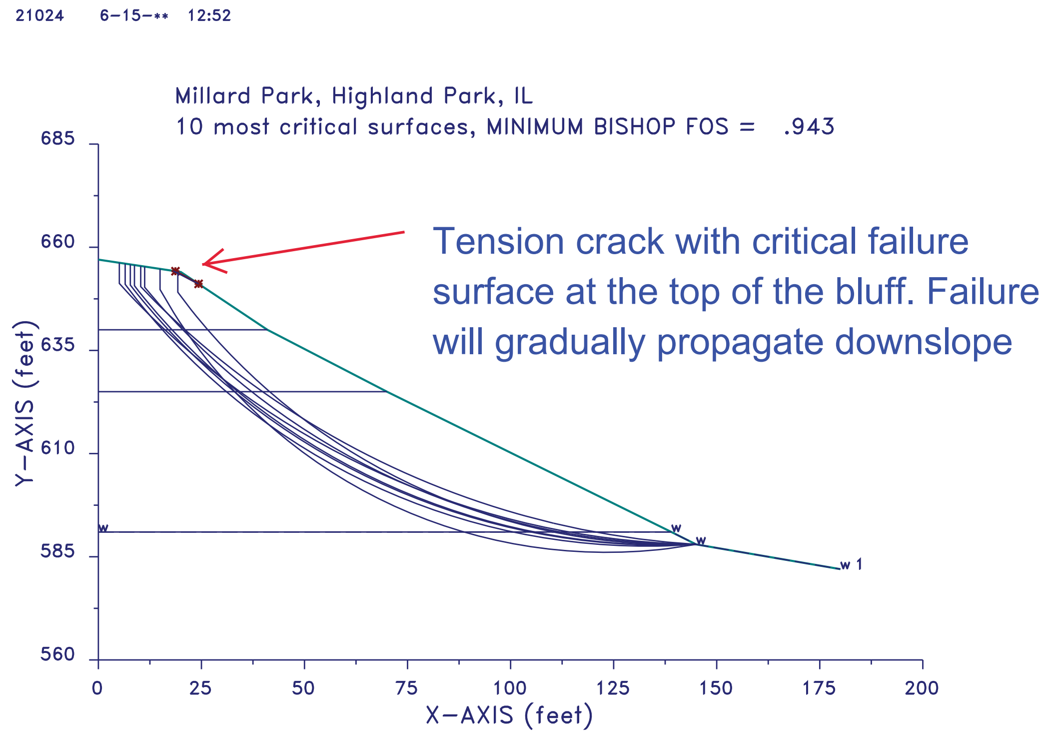
Tension Crack Failure
OBA Job No. 21024



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******************************************
```

Problem Description : Millard Park, Highland Park, IL

SEGMENT BOUNDARY COORDINATES
----

6 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	657.0	20.0	654.0	1
2	20.0	654.0	41.0	640.0	1
3	41.0	640.0	70.0	625.0	2
4	70.0	625.0	139.0	591.0	3
5	139.0	591.0	145.0	588.0	4
6	145.0	588.0	180.0	582.0	4

3 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	640.0	41.0	640.0	2
2	.0	625.0	70.0	625.0	3
3	.0	591.0	139.0	591.0	4

A CRACKED ZONE HAS BEEN SPECIFIED

Depth of crack below ground surface = 5.00 (feet)
Maximum depth of water in crack = 5.00 (feet)
Unit weight of water in crack = 62.40 (pcf)

Failure surfaces will have a vertical side equal to the specified depth of crack and be affected by a hydrostatic force according to the specified depth of water in the crack

----

ISOTROPIC Soil Parameters
----

4 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	130.0	130.0	150.0	28.00	.000	.0	1
2	130.0	130.0	100.0	28.00	.000	.0	1
3	135.0	135.0	200.0	28.00	.000	.0	1
4	125.0	125.0	.0	30.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 4 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	.00	591.00
2	139.00	591.00
3	145.00	588.00
4	180.00	582.00

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced

along the ground surface between x = 20.0 ft
and x = 145.0 ft

Each surface terminates between x = .0 ft
and x = 20.0 ft

Unless further limitations were imposed, the minimum elevation
at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

7.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined
within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 2 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	24.31	651.13
2	18.70	654.20

**** Simplified BISHOP FOS = .943 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Millard Park, Highland Park, IL

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	.943	-1007.65	-1229.13	2144.83	24.31	18.70	1.759E+06
2.	1.063	-485.56	-339.70	1114.32	24.31	18.14	1.066E+06
3.	1.343	144.10	760.87	172.88	145.00	11.22	2.591E+07
4.	1.344	137.88	751.99	164.14	145.00	8.75	2.737E+07
5.	1.347	137.13	752.19	164.37	145.00	7.76	2.809E+07
6.	1.351	133.44	746.33	158.75	145.00	6.51	2.879E+07
7.	1.353	157.60	791.78	204.17	145.00	10.28	2.772E+07
8.	1.354	148.34	781.89	193.92	145.00	5.08	3.125E+07
9.	1.357	140.74	739.22	151.28	145.00	19.26	2.011E+07
10.	1.367	123.29	710.09	124.00	145.00	14.97	2.255E+07

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