

MILWAUKEE COUNTY



Department of Administrative Services

**Architecture, Engineering & Environmental Services
600 W. Plankinton Ave., 6th Floor
Milwaukee, Wisconsin 53203**

REQUEST FOR PROPOSAL FOR

Sheridan Bluff Stability

PROJECT NO. WP083801

August 2026

Project : Sheridan Bluff Stability
 Project No.: WP083801
 Subject : REQUEST FOR PROPOSAL (RFP)

Milwaukee County Department of Administrative Services is requesting proposals from qualified consultants for professional consulting services to complete conceptual designs for bluff stabilization and related work at Milwaukee County's Sheridan Park.

I. GENERAL PROJECT DESCRIPTION

Sheridan Park is owned and operated by Milwaukee County Department of Parks, Recreation and Culture. Sheridan Park is a 132-acre park situated along Lake Michigan's shoreline and is located at 4800 S. Lake Dr. Cudahy, WI. See Figure 1. One of the park's defining features is its steep coastal bluffs adjacent to the shoreline. These bluffs are vulnerable to erosion and slope instability causing bluff recession that threatens park-owned assets, privately-owned assets, and other public infrastructure.

A study completed in 2025 by Milwaukee County identified the Sheridan Park bluffs as one of the least resilient bluffs in the county and one of the highest priorities for remediation. The study identified two potential project locations within the park. Area 1 is in the north end of the park just east of South Sheridan Drive between East Allerton Avenue and East Armour Avenue. Area 2 is at the south end of the park between East Munkewitz Avenue and East Pulaski Avenue. See Figure 2.

The 2025 study offered two potential solutions for each of the project areas. The concepts for Area 1 focus on slowing bluff recession through shoreline protection, including either new and repaired armor stone groins or buttress fill at the toe of the bluff combined with an armor stone revetment. For Area 2 the concepts focus on removing or abandoning the threatened roadway, restoring the area with native deep-rooted vegetation, or slowing bluff recession through shoreline protection with the installation of new armor stone groins. Please see Milwaukee County Lake Michigan Bluff Repairs Report May 30, 2025, GZA GeoEnvironmental.

The general scope of work is to perform concept development and an alternatives analyses. The analyses shall include a review of previous studies, and the collection of additional data as needed in order to evaluate concepts from the 2025 bluff study to determine final remedies for each project area (Areas 1 & 2). The consultant shall prepare a Design Letter Report which will include the results of the analyses and preliminary designs and estimates for the completion of an initial regulatory review of the selected concepts. It will be part of a future scope of work to generate 30/60/90/Final design plans and estimates.

A consultant will be hired initially to complete Task 1 through Task 3 below. The County may, but will not be obligated to, extend the consultant agreement to include future scope of work. The County, at its own discretion, reserves the right to pursue the process of hiring a different consultant for future work. The scope and fees and TBE requirements will be reviewed and renegotiated, if necessary, at the time consideration is given to adding the next phases of work to the consultant's contract. All tasks after Task 4 are contingent on additional funding. At this time, consultants are to provide pricing for Tasks 1-3 only.

II. SCOPE OF CONSULTANT SERVICES

The successful consultant shall provide all services as specified per the standard terms and conditions of the Milwaukee County Department of Administrative Services Consultant Agreement for Professional Services AIA B221 (copy will be emailed upon request).

Task 1 Project Management

- A. Consultant to attend regular meetings with county staff. Attend and lead a kick-off meeting and one (1) project management meeting monthly to discuss and review the current project status. Consultant is to budget one hour of staff time for each monthly meeting.
- B. Consultant to plan for up to three meetings with WDNR regarding permit feasibility and correspondence. Consultant is to budget one hour of staff time for each meeting, and include Milwaukee County staff on correspondence with regulatory agencies.
- C. Consultant to attend and lead public information meetings. For purposes of this RFP budget, two (2) meetings are anticipated. One at the conceptual design phase, after meeting with the WDNR to confirm permit feasibility. A second meeting to occur after completion of the final design. The consultant shall budget two hours for each public information meeting.

Task2 Review Existing Data and Data Collection

- A. Review previous studies
- B. Consultant to perform necessary geotechnical borings or other testing as necessary to determine the efficacy and constructability of potential bluff stabilization remedies.
- C. Consultant to perform necessary survey including topographic and bathymetric surveys, if necessary, to determine efficacy and constructability of potential remedies.

Task 3 Concept Development and Alternatives Analyses and Design Letter Report

- A. The consultant shall assemble a design project team to perform the scope of services and requirements outlined herein. In the design development phase the consultant shall investigate the two alternatives described in GZA's report as named above and at least one additional alternative for each project area. The initial designs and estimates shall be sufficiently complete to determine the feasibility, efficacy, and permit ability of the concepts and to select final remedies.
- B. Consultant shall develop cost estimates for the respective alternatives, including an evaluation of life cycle costs and operational/maintenance costs. Consultant will provide cost estimates for review and incorporate Milwaukee County's comments into letter report.
- C. Consultant shall generate conceptual design plans for initial regulatory review prior to generating 30% plans (future scope). Consultant to provide conceptual design plans to County for review and incorporate county's comments into revised plans prior to transmittal to regulatory agency.
- D. Consultant to coordinate with County staff and regulatory agency to define design conditions prior to beginning 30% and incurring those design fees until authorized to do so.
- E. Consultant shall prepare a Design Letter Report incorporating results of alternatives analyses and cost estimates in support of Milwaukee County selecting preferred concepts.
- F. Design to adhere with Milwaukee County Coastal Management Guidelines.

Please note, a consultant will be hired initially to complete work through Task 3. The County may, but will not be obligated to, extend the consultant agreement to include future Task 4 through Task 6. The County, at its own discretion, reserves the right to pursue the process of hiring a different Consultant for Phase 4. Work in Phase 4 would include but is not exclusive to: completion of project designs through construction documents, bidding assistance, and construction administration.

Task 4 Preliminary and Final Design (future scope)

- A. Consultant to prepare Preliminary Design (30%) based on conceptual report. Consultant to provide preliminary plans to County for review. Consultant to incorporate county's comments into revised plans.
- B. Consultant to prepare 60%/90%/final design plans. Consultant will provide draft design plans at each stage for county review and incorporate comments into revised plans.
- C. Consultant to transmit permit set at the 30% stage.
- D. Consultant to prepare cost estimates at each stage of the design process including 30%/60%/90% and final design.

Task 5 Bidding Assistance & Services (future scope, anticipated 2029)

- A. Consultant to prepare and process all applicable permits and fees, and be reimbursed for respective fees on the next invoice once permits are approved.
- B. Consultant to prepare project technical specifications and bid item descriptions and quantities
- C. Consultant to document all information requested by bidders and interpretation of bidding documents in writing to the owner.
- D. Consultant will attend pre-bid meeting

Task 6 Construction Administration (future scope, anticipated 2029)

- A. Consultant will attend pre-construction meeting.
- B. Consultant to provide submittal reviews
- C. Answer Requests for Information (RFI) submitted by the general contractor with Milwaukee County review and approval.
- D. Consultant to provide limited construction inspections as needed (level of effort to be negotiated)
- E. Consultant to provide construction inspection reports
- F. Prepare and submit punch list, substantial completion and acceptance documentation for the project.
- G. Consultant to complete as-built documentation.

III. QUALITY CONTROL

- a. Milwaukee County reserves the right to request partial or full reimbursement from consultants for change orders resulting from errors and omissions in the services they are contracted to provide.

IV. PROJECT SCHEDULE

- | | |
|---|-----------|
| a. Issue Request for Proposal | 8/5/2026 |
| b. Proposals Due | 8/26/2026 |
| c. Contract Award (approximately) | 10/1/2026 |
| d. Estimated Conceptual Design (through Task 3) | 5/31/2027 |
| e. Estimated Project Completion (Task 4) | 4/30/2028 |

V. PRE-PROPOSAL MEETING

There will be an optional pre-proposal meeting on August 13, 2026, at 10 AM. The meeting will be hosted via Microsoft TEAMS. Please contact Kevin Driscoll at (414) 528-1210 or kevin.driscoll@milwaukeecountywi.gov to attend the meeting. Please contact us at least two hours prior to the start of the meeting.

There will also be an optional, weather dependent, site visit on August 13, 2026, at 1 PM. Participants can meet at the corner of South Sheridan Drive and East Armour Avenue.

VI. Submission Requirements

The proposal shall conform to Milwaukee County's Proposal Preparation, Submission and Evaluation Guidelines (see Exhibit 1). Consultant to transmit 4 hardcopies to Attention of Kevin Driscoll at 600 N. Plankinton Ave., Suite 600, Milwaukee, WI 53203. Please limit proposals to 20 pages. The proposal shall include the Consultant Proposal Form (Exhibit 2) and the following information:

- a. Cover Page: Include project number and name, project location, consultant's name, address, telephone number, FAX number, e-mail address, proposal date, etc.

- b. Table of Contents: Include an identification of the material by section and page number.
- c. Letter of Transmittal: The name and description of the organization submitting the proposal briefly stating the proposer's understanding of the service to be provided.
- d. Description of the Organization: A description of the organization submitting the proposal. Include the name, size, legal status (corporation, partnership, etc.), professional registration/certification, major type of activity or areas of consulting.
- e. Description of the Organization's Experience: Include a list of similar projects that the consultant has participated with during the past five years. Attach a separate sheet for each project, up to five maximum, giving a brief description of each project, the consultant's participation, and a client contact reference and phone number. Provide a list of three (3) references that can be contacted with questions regarding your past work. Provide a description of your firm's experience with sustainable design, green infrastructure, or related work.
- f. Description of Project Team/Resumes: Provide an organizational structure of the consultant's project team, including any subconsultants to be used for this project. Include the name of the Principal in Charge of this project along with the name, occupation and title of the Project Manager who will be in charge of this project.

Provide a one-page resume for each individual involved in the project, and include their name, title, address, telephone number, e-mail address, fax number, duties for the project, professional registration, a brief description of related experience including time contribution in this capacity to past projects, and Proposals. Provide a description of your staff's experience with sustainable design or related work.

- g. Sub-Consultants: Indicate the names and addresses of any sub-consultants and/or associates proposed to be used in this project. State the capacity they would be used in and the approximate percentage of the total services they would provide. Also state their past experience in the field.
- h. Project Approach: Provide a description of challenges you anticipate in this project and how you propose to overcome them. Discuss how you plan to staff the project to efficiently complete the work effort.
- i. Project Schedule to Completion: Provide a timetable and relationship of tasks which are necessary to complete this project as noted in the "Project Schedule" section of this RFP.
- j. Constant Effort: Include a spreadsheet/matrix listing the names, classifications, hourly rates and hours to be spent by each required task to complete the project as described in this RFP.
- k. TBE Firm Goals (DBE Firm Goals – Federal Funded Projects): The Targeted (Disadvantaged) Business Enterprise participation goal for this project/contract is 9.39%.
 - i. Office of Economic Inclusion (OEI) is responsible for monitoring and enforcing Milwaukee County's Targeted Business Enterprise (TBE) Program for inclusion of small business. Targeted firms include DBE firms certified under the Unified Certification Program following Federal regulations and WBE and MBE certifications from the State of Wisconsin DOA.

For a non-certified firm bidding or proposing as Prime, participation may be obtained utilizing a TBE firm, whether DBE, MBE, or WBE. This allows for

increased participation by providing opportunities for multiple certifications to be included in the project.

For a TBE firm bidding or proposing as Prime, the goal must be satisfied using DBE subcontractors or sub-consultants. MBE and WBE certifications count as additional participation once the goal is achieved through DBE participation. Any work a TBE Prime self-performs would be counted as additional participation in excess of the participation provided by subcontractors or sub-consultants.

Compliance reporting is accomplished from collection of data in the Diversity Management and Compliance System, utilizing B2GNow software. Prime contractors are required to report payments received from the County and amounts paid to subcontractors in the system. Subcontractors will receive an automated email requesting them to confirm the amounts and whether the terms of the prompt payments policy were followed. There is no cost to the Prime or any subcontractor, the only requirement is to become a registered user and complete the one hour webinar training.

- ii. Contact the Community Business Development Partners Office at 414-278-4747 or cbdp@milwaukeecountywi.gov for questions related to TBE and DBE requirements.

- l. **Quality Control:** Submit a contract document quality control plan. Quality control is to be performed by individuals not assigned to the project on an ongoing basis.
- m. **Fee Proposal:** Proposers must include a cost proposal table/matrix identifying costs for each task which includes names, classifications, hourly rates, and hours to be spent by each required task to complete this project as described in this RFP. Proposers should summarize by tasks and include a total amount in a highlighted cell. All salary, subcontractors, travel, expenses and materials costs should be listed and also included in the amount. Any project services and corresponding costs that the Proposer feels were omitted from the RFP should be in the cost proposal on a separate line(s) and identified as an additional service.

VII. CONSULTANT SELECTION

- a. Proposers must recognize this is not a bid procedure, and a Professional Services agreement will not be awarded solely on the basis of the low fee proposal. Milwaukee County reserves the right to accept or reject any and all proposals, issue addenda, request clarification, waive technicalities, alter the nature and/or scope of the proposed project, request additional submittals, and/or discontinue this process.

The proposal evaluation team will be made up of three to five individuals with technical knowledge of the requirements and familiarity with the project. Depending on the number and quality of the proposals, Milwaukee County may decide to conduct interviews of a short-list of consultants. The evaluation team may select up to three consultants to attend an interview, which, if required, will be held 9/8/2026. The interview will be evaluated based on project team, experience and qualifications, project understanding, and the overall presentation.

The project manager will post this RFP, as well as any pre-proposal meeting minutes, sign in sheets, addendums and other information related to this project to the Milwaukee County Construction RFP website:

<http://county.milwaukee.gov/ConstructionBidsandR23075.htm>

The consultant should consider information on this website to be part of the official RFP. Please check the site frequently. To allow time for proposal preparation, Milwaukee County will not post anything new within two days of the proposal due date.

VIII. GENERAL REQUIREMENTS

- a. **Ordinary and reasonable expenses and materials that are directly attributable to work performed will be reimbursed. Supplies for field investigations and travel expenses will only be reimbursed if pre-approved and must be included within the cost proposal. When mileage is reimbursed, it will be at the current IRS rate. Mark-up on reimbursable expenses is not allowed, only actual costs. These costs are included in the “not to exceed” amount of the contract. Itemized statement of expenses must be submitted along with invoices. Separate reimbursement for overhead expenses.**
- b. The selected consultant and/or any contractor affiliated with the prime consultant shall be prohibited from submitting bids in the construction bidding process for this project.
- c. Selected consultant shall follow Milwaukee County Code of Ethics as follows: No person(s) with a personal financial interest in the approval or denial of a Contract being considered by a County department or with an agency funded and regulated by a County department, may make a campaign contribution to any County official who has approval authority over that Contract during its consideration. Contract consideration shall begin when a Contract is submitted directly to a County department or to an agency until the Contract has reached final disposition, including adoption, County Executive action, proceeding on veto (if necessary) or departmental approval.
- d. The selected consultant must be an Equal Opportunity Employer.
- e. The proposal shall conform with all attached documents and exhibits. All proposals should use this RFP and its attachments as the sole basis for the proposal. The issuance of a written addendum are the only official method through which interpretation, clarification or additional information will be given.
- f. All costs for preparing a proposal, attending the selection interview if required, or supplying additional information requested by Milwaukee County, is the sole responsibility of the submitting party. Material submitted will not be returned.
- g. The proposal must be submitted digitally as a PDF document.
- h. With the signing and submission of a statement or proposal the submitting consultant certifies that the standard terms and conditions of the Agreement for Professional Services (that will be used to contract with the selected consultant) has been read and understood and that the submitting consultant is ready, willing and able to sign the agreement when requested without making any substantive changes.
- i. **Fee Proposal:** The fee for this project shall be clearly stated as a **not-to-exceed sum and individual direct salary rates/hour (AIA B221) Agreement** for these services. A dollar amount for reimbursable items as described in the proposal should also be clearly stated.
- k. **Example Projects:** Milwaukee County Code of General Ordinances, Chapter 32, Section 40(5)(i) requires each proposer to identify all current contracts and any contracts held within

the preceding five (5) years with federal, state, or local governmental entities. The disclosure must include:

- The name of the governmental entity;
- A general description of the services provided; and
- The start and end dates of each contract.

Please submit your proposal via e-mail no later than **3:00 P.M. on Thursday, August 26, 2026**, to:

The proposals shall be addressed and submitted to:

Kevin Driscoll
kevin.driscoll@milwaukeecountywi.gov

Thank you for your interest in working with Milwaukee County on this project. Please direct any questions about this RFP to Kevin Driscoll at (414) 528-1210 or kevin.driscoll@milwaukeecountywi.gov.

Sincerely,

Kevin R. Driscoll, P.E.
Principal Engineer – Civil

Cc: Tim Detzer, P.E. – Milwaukee County DAS, Principal Engineer – Environmental
Sarah Toomsen, P.L.A., LEED AP – Milwaukee County Parks, Director of Planning
Christopher Kubacki, P.E. – Milwaukee County Parks, Planning Manager

LISTING OF EXHIBITS

- 1 – PROPOSAL PREPARATION, SUBMISSION AND EVALUATION GUIDELINES
- 2 – FEE TABLE – ITEMIZED WITH EMPLOYEE HOURS
- 3 – PROJECT LOCATION MAP
- 4 – MAP OF SHERIDAN BLUFF UTILITIES IN PROJECT AREA
- 5 – COUNTY BLUFF SLOPE REPAIR REPORT
- 6 – SHERIDAN PARK CONCEPTUAL DRAWINGS (GZA)
- 7 – MILWAUKEE COUNTY PARKS COASTAL MANAGEMENT GUIDELINES
- 8 – CONSULTANT PROPOSAL

EXHIBIT 1

PROPOSAL PREPARATION, SUBMISSION AND EVALUATION GUIDELINES

PROPOSAL PREPARATION, SUBMISSION & EVALUATION

I. Explanation to Prospective Offerors

Any prospective offeror desiring an explanation or interpretation of this RFP must request it in writing no later than seven business days before the last date for submission of proposals. Requests should be directed to the individual in charge at the address listed in the RFP. Any information given to a prospective offeror concerning a solicitation will be furnished promptly to all other prospective offerors as an amendment to the RFP, if that information is necessary in submitting offers or if the lack of it would be prejudicial to any other prospective offerors.

II. Complete Proposals

Proposals shall represent the best efforts of the offerors and will be evaluated as such. Proposals must set forth full, accurate, and complete information as required by this section and other sections of this RFP.

III. Unnecessarily Elaborate Proposals

Brochures or other presentations beyond those sufficient to present a complete and effective response to this solicitation are not desired and may be construed as unnecessarily elaborate and an indication of the offeror's lack of cost consciousness. Elaborate art work, expensive paper and binding, and expensive visual and other presentation aids are neither necessary nor desired. Concise and clear proposals are sought.

IV. Retention of Proposals

All proposal documents shall be retained by the County and therefore, will not be returned to the offerors. The County will not pay for preparation of proposals or for proposals that are retained by the County.

V. Examination of Proposals

Offerors are expected to examine the Site, Statement of Work and all instructions and attachments in this RFP. Failure to do so will be at the offeror's risk.

VI. Legal Status of Offeror

Each offeror must provide the following information in its proposal:

- A. Name of the offeror;
- B. Whether offeror is a corporation, joint venture, partnership (including type of partnership), or individual;
- C. Copy of any current license, registration, or certification to transact business in the State of Wisconsin if required by law to obtain such license, registration, or certification. If the offeror is a corporation or limited partnership and does not

provide a copy of its license registration, or certification to transact business in the State of Wisconsin, the offeror shall certify its intent to obtain the necessary license, registration or certification prior to contract award or its exemption from such requirements; and

D. Copies of any current license, registration or certification required in RFP;

E. If the offeror is a partnership or joint venture, names of general partners or joint venturers.

VII. Organization of Offeror

Each proposal must further contain a chart showing the internal organization of the offeror and the numbers of regular personnel in each organizational unit.

VIII. Offerors Authorized Agent

Each proposal shall set forth the name, title, telephone number, and address of the person authorized to negotiate in behalf of the offeror and contractually bind the offeror, if other than the person signing the proposal.

IX. Price Schedule Submission

Offerors are to submit prices for each item identified in the Proposal. Offers for services other than those specified will not be considered. The prices set forth in the schedule will be used for evaluation purposes and for establishing a contract price. Milwaukee County reserves the right to accept or reject any and all Proposals.

X. Certification and Representations

Offerors shall return with their proposal resumes and any other documents as may be requested in the RFP.

XI. Signing of Offers

The offeror shall sign the proposal and print or type its name on the form. Erasures or other changes must be initialed by the person signing the offer. Offers signed by an agent shall be accompanied by evidence of that agent's authority, unless that evidence has been previously furnished to the County.

XII. Proposal Guarantee

By submitting a proposal the offeror guarantees that it will keep its initial offer open for at least 60 days.

XIII. Acknowledgement of Amendments

Offerors shall acknowledge receipt of any amendment to this solicitation by signing and returning the amendment or by letter or telegram including mailgrams. The County must receive the acknowledgment by the date and time specified for receipt

of offers. Offeror's failure to acknowledge an amendment may result in rejection of the offer.

XIV. Late Proposals and Modifications and Withdrawals of Proposals

Any proposal received at the office designated in the solicitation after the exact time specified for receipt will not be considered.

XV. Proposal Evaluation Criteria

Following a list of general criteria which will be used to evaluate the proposals:

- a. Quality and responsiveness to the RFP. Weight: 20%
- b. Project approach and understanding, including strategy to perform requested work and time schedule. Weight: 30%.
- c. Qualifications and experience. Weight: 35%
- d. Fee and hourly rates. Weight: 15%.

XVI. Staffing

Consultant shall provide, at its own expense, all personnel required in performing the services under this agreement. Such personnel shall not be employees of Owner.

The offeror must describe his or her qualifications and experience to perform the work described in this RFP. Information about experience should include direct experience with the specific matter and similar facilities. Areas of expertise of each proposed staff member shall be provided (i.e., engineering, economics, architecture, planning). Specific examples of similar or related projects previously conducted shall cite:

- Name of client organization
- Name, address, and current telephone number of client contact person
- Contract number and inclusive dates
- Contract amount

Offeror shall provide the following information for every resume:

- Full name
- Title and areas of specialty
- Affiliation (that is, staff of offeror or subconsultant)
- Experience directly related to the proposed project
- Education/training

- Individual personnel hours and percentage of total project time which will be devoted to the proposed project in total and broken down by task. (See suggested matrix below)
- Resumes shall be included for all personnel expected to work on the project. Only resumes of staff or subconsultant staff employed by or under contract with the firm as of the date of proposal submission are to be included.

EXHIBIT 2

FEE TABLE – ITEMIZED WITH EMPLOYEE HOURS

Table of task items listed per individual

TASK	NAME OF EMPLOYEE 1	NAME OF EMPLOYEE 2	ETC.....	EXPENSE S	SUB TASK	TASK TOTAL
	HOURLY RATE W/OH	HOURLY RATE W/OH	ETC.....		TOTAL	
DESCRIPTION						
1. TASK 1	Number of Hrs/Task	Number of Hrs/Task				
2. TASK 2						
3. TASK 3						
4. TASK 4						
5. TASK 5						
6. Task 6						
TOTAL HOURS						
TOTAL COST						
% OF TIME						

TOTAL FEE

EXHIBIT 3

PROJECT LOCATION MAP

FIGURE 1





Milwaukee County Parks - Sheridan Park Sheridan Park Bluff Stability Project Areas

- Sheridan Park
- Sheridan Park Bluff Stability Project Area 1
- Sheridan Park Bluff Stability Project Area 2

FIGURE 2

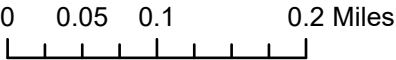


EXHIBIT 4

MAP OF SHERIDAN BLUFF UTILITIES IN PROJECT AREA

Sheridan Bluff



Legend

- We Energies Ground-Mounted Electrical Point
- We Energies Electrical Pole Points
- We Energies Electrical Pole Points
- ★ Storage Tank Points
- HVAC Equipment Points
- Grounds Equipment Points
- Structure-Related Equipment Points

▭ Polygons representing properties owned by M

- Sign Points
- Site Amenity Points
- Electrical Equipment Points
- Structure-Related Equipment Points

— We Energies Low-Pressure Gas Main Lines

— We Energies Underground Electrical Lines

— Fence Lines

▨ SEWRPC Wetland Polygons

— <all other values>

Storm Sewer Structure Points

OWNER

- County

Storm Sewer Pipe Lines

OWNER

— County

— Municipal

● Water Structure Points

● MMSD Sanitary Manhole Points

— MMSD Sanitary Pipe Lines

● Plumbing Equipment Points

— Water System Pipe Lines

▭ MCPARKS_EDIT.MCPARKS.Easement_Ply

● MMSD Sanitary Manhole Points

▭ Building Polygons

— Street Centerlines with Address Ranges

N



0 0.02 0.04 0.08 0.12 0.16 Miles

EXHIBIT 5

A - COASTAL ANALYSIS AND BASIS FOR DESIGN REPORT

B - MILWAUKEE COUNTY LAKE MICHIGAN BLUFF REPAIRS REPORT



Known for excellence.
Built on trust.



COASTAL ANALYSIS AND BASIS OF DESIGN REPORT

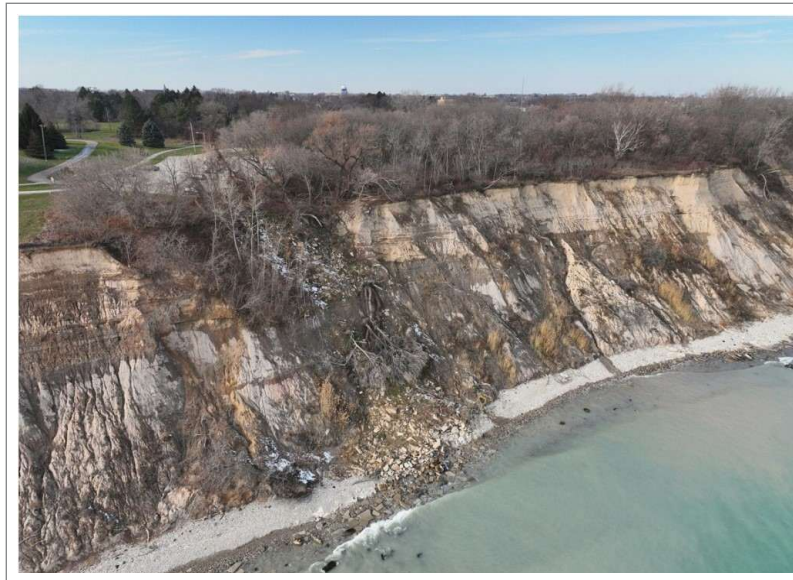
Milwaukee County Bluff Repairs

Milwaukee County, Wisconsin

Milwaukee County Project No. WY062509

May 30, 2025

GZA File No. 20.0158819.00



PREPARED FOR:



MILWAUKEE COUNTY
Administrative Services

Milwaukee County Department of Administrative Services
Milwaukee, Wisconsin

GZA GeoEnvironmental, Inc.

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May 30, 2025
File No. 20.0158819.00

Mr. Tim Detzer, P.E.
Milwaukee County Department of Administrative Services
633 West Wisconsin Avenue, 10th Floor
Milwaukee, Wisconsin 53203

Re: Coastal Analysis and Basis of Design Report
Milwaukee County Bluff Repairs
Milwaukee County, Wisconsin
Milwaukee County Project No. WY062509

Dear Mr. Detzer:

GZA GeoEnvironmental, Inc. (GZA) is pleased to present the attached Coastal Analysis and Basis of Design Report ("Report") for the 13 Milwaukee County-owned parks located on the Lake Michigan shoreline in Milwaukee County, Wisconsin (collectively, the "Sites"). This Report is meant to supplement and support GZA's Concept Plan Set and Milwaukee County Lake Michigan Bluff Repairs Report, dated May 30, 2025, provided under separate cover, by highlighting and quantifying the coastal factors influencing shoreline stability and, subsequently, bluff stability and resiliency. Furthermore, this Report summarizes GZA's data collection, analysis, and design recommendations for the shoreline and bluff toe. Analyses were performed to characterize the water levels, waves, ice, and sediment transport conditions at the Sites.

We appreciate the opportunity to provide services for this project. Please feel free to contact Mr. Veriotti at (224) 275-2123 or via email at dan.veriotti@gza.com with questions.

Very truly yours,

GZA GeoEnvironmental, Inc.

Dan Veriotti, P.E.
Associate Principal
Coastal Engineer/Vice President

J:\158800to158899\158819 MKE Cnty Lake MI Bluffs\Report\FINAL 20.0158819.00 Coastal Analysis and Basis of Design Rpt_ Mke County 5-30-25.docx

Attachments



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May 30, 2025

File No. 20.0158819.00

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APPENDICES

APPENDIX A LIMITATIONS

APPENDIX B COASTAL STRUCTURE EVALUATION SUMMARY



1.0 INTRODUCTION

Over 12 miles of Lake Michigan’s shoreline are held in public trust by the Milwaukee County Parks System (“County”). As follows (from north to south) parks that include Lake Michigan shoreline are:

- Doctors Park;
- Big Bay Park;
- Linnwood Revetment at Lake Park;
- Bradford Beach/Lake Park;
- McKinley Park;
- Veterans Park;
- Cupertino Park;
- South Shore Park;
- Bay View Park;
- Sheridan Park;
- Warnimont Park;
- Grant Park; and
- Bender Park.

The Milwaukee County Lake Michigan bluffs are regarded as an important recreational and ecological resource and, as such, there are special considerations for balancing the amount of development and use at the bluffs, while maintaining a stable ecosystem. During periods of high water levels on Lake Michigan, the shoreline and adjacent bluff toe (base) can erode, causing slope instability and significant bluff crest recession. The ongoing coastal erosion and slope instability are threatening to change the bluffs and surrounding parkland in ways that could cause public safety hazards, loss of habitat, and impacts to recreation, public access, and man-made structures.

Milwaukee County provided a list of five high priority parks (Group 1), which included Big Bay Park, Lake Park/Linnwood Revetment, Sheridan Park, Bay View Park, and Warnimont Park. The remaining parks comprise Group 2 (secondary priority). Through our evaluation of the coastal conditions and risk assessment, we recommend prioritizing the Linnwood Revetment instead of the entirety of Lake Park, and adding Grant Park to the high priority parks (Group 1). The remaining parks were considered lower priority, but were still evaluated by GZA.

To identify and establish priority project areas for repair and/or stabilization measures, a risk and resiliency assessment was performed for the shoreline and bluffs within the project areas. This Coastal Analysis and Basis of Design Report (“Report”) is meant to supplement and support GZA’s risk assessment and Bluff Repairs Report by highlighting and quantifying the coastal factors that influence shoreline stability and, subsequently, bluff stability and resiliency. Furthermore, this Report summarizes GZA’s data collection, analysis, and design recommendations for the shorelines and bluff toes. Analyses were performed to characterize the water levels, waves, ice, and sediment transport conditions at the park locations. Recommendations are provided for the selected design condition as resilient criteria that can be used in support of preliminary design. Please note that this Report is subject to the Limitations provided in **Appendix A**.

2.0 COASTAL ANALYSIS

A coastal analysis was performed to define the existing design conditions (water levels and waves), select the resilient design criteria, determine the requirements for shoreline protection, and directly compare with the existing conditions. Other considerations included sediment transport processes, ice, existing beach slope and volume, and beach material composition.



2.1 WATER LEVELS

Wave and ice conditions are the primary forces considered in our analyses for the bluffs and coastal structure resiliency. Nearshore Lake Michigan waves are limited in height due to the depth of water at the toe of a bluff or structure (“depth-limited” condition). Therefore, the water level, which changes the depth of water at the toe of a structure during a significant storm, is the most important factor considered for coastal protection design. The International Great Lakes Datum of 1985 (IGLD 85) was used as vertical datum to report water levels and coastal calculations. The current water level (January 28, 2025), reported by National Oceanic and Atmospheric Association (NOAA) Station 9087057 (Milwaukee), was 577.50 feet IGLD 85. In the Milwaukee County area, IGLD 85 may be converted to the North American Vertical Datum of 1988 (NAVD 88) using the formula $NAVD\ 88 = IGLD\ 85 + 0.5$ feet. The elevations used in this Report reference IGLD 85.

Lake Michigan water levels vary in the long-term due to factors such as evaporation, regional precipitation, and tributary flows. A coastal structure’s vulnerability and the design water levels are influenced by two variables: static lake level (level without any waves) and locally induced storm surge (fluctuation of the water level due to storms, typically in the range of 1 to 2 feet). The total water level (TWL) during a storm is the still water level and the wave runup (wave vertical elevation on a shoreline or structure), which is important for the selection of coastal protection structure crest elevation. For design water levels, it is important to consider both long- and short-term water levels; however, the levels must be analyzed independently, as different factors influence each component. Periods of high and low water levels tend to persist for years. For example, record high monthly levels occurred in October 1986 and June 2020 (582.37 feet), while a record low level was recorded in January 2013 (576.01 feet). With the Milwaukee gauge data extending only to 1970, the gauge at Calumet Harbor, Illinois (with records beginning in 1903) was also reviewed, showing that a record historic low water level occurred in March 1964 (575.95 feet).

The maximum daily recorded lake level in Milwaukee was 583.0 feet on January 11, 2020, during a significant storm from the northeast. **Figure 1** shows the Milwaukee water levels between 1970 and 2024.

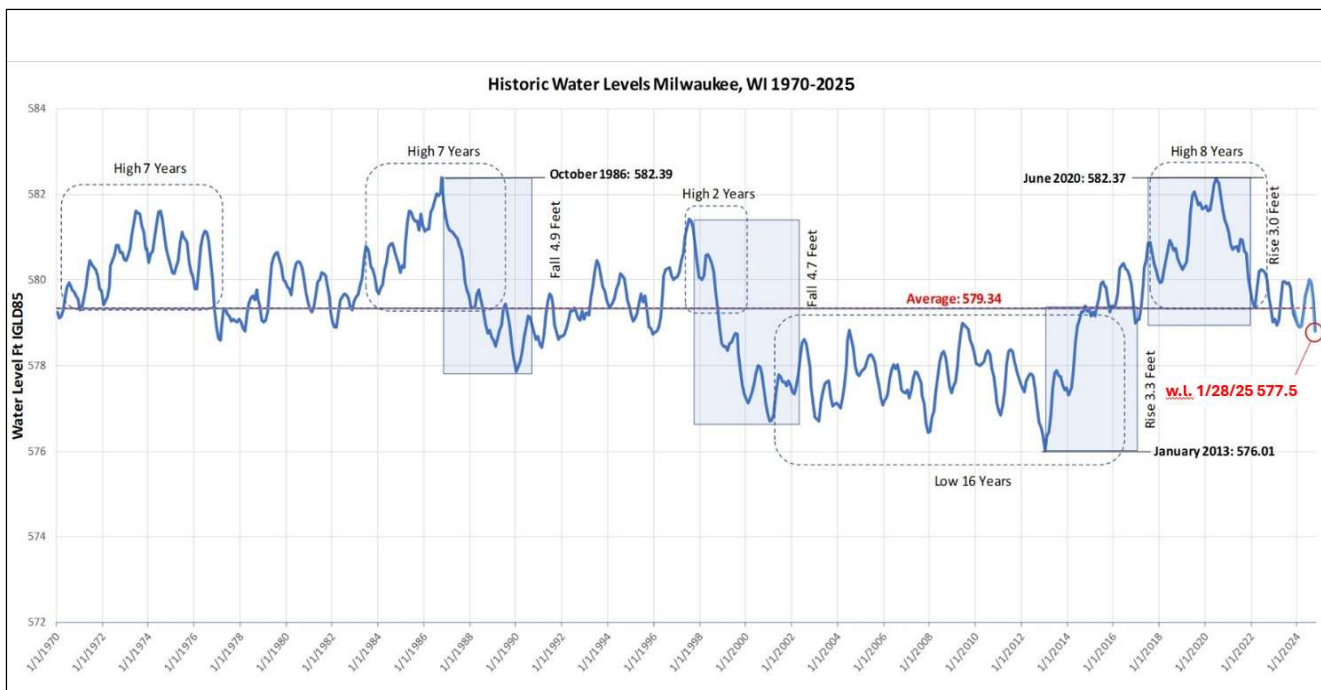


Figure 1. Milwaukee Water Levels (1970-2025)



GZA performed an independent coastal analysis for this project, including water levels as a return period event (10-, 20-, 50-, and 100-year). For reference, a 10-year event has a 10% annual chance of occurrence, while a 100-year event has a 1% annual chance. We also reviewed published design documents by others (U.S. Army Corps of Engineers' [USACE] *Design Water Level Determination on the Great Lakes* [1993, 2013]) and *Wave Height and Water Level Variability on Lakes Michigan and St. Clair* (2012). **Table 1** summarizes our recommendations for design water levels. The Federal Emergency Management Agency (FEMA) established a Base Flood Elevation (BFE), which is the water elevation associated with the 100-year recurrence flood interval. The BFE for the project area is 583.3 feet IGLD 85, which is very close to GZA's value shown in **Table 1**. For conversion to NAVD 88 datum, add 0.5 feet to the values shown in the table.

Table 1. Summary of Design Water Levels (feet IGLD 85)

Return Period (Years)	Water Level (GZA)	Water Level (USACE)
10	581.9	582.2
20	582.1	582.5
50	583.0	583.2
100	583.3	583.5

2.2 OFFSHORE WAVES

The USACE's Wave Information Studies database (WIS)¹ provides long-term offshore wave climatology from hindcast modeling and is routinely used in coastal studies. There are over 24 miles between Doctors Park (northernmost park) and Bender Park (southernmost park), and the WIS database includes nine monitoring stations between these parks. However, only one station was selected for this study (Station ST94053) for the following reasons:

- The offshore wave data are similar at these stations, with very small value differences.
- The nearshore wave height is limited by the water depth, also known as a depth-limited condition. As a result, the waves generally break using an estimated 0.8 ratio, meaning that in 5 feet of water depth, the maximum wave at breaking point will be 4 feet.
- The waves undergo several transformations when they propagate to shallow water and the single most important item for the design nearshore wave height is the water level at the time the wave encounters the nearshore. Therefore, the offshore waves are of secondary importance, especially for mild offshore slopes.

Station ST94053, shown on **Figure 2**, is located at the north end of the project area in deep water (200 feet). The extreme wave height analysis for Station ST94053 is shown in **Figure 3**.

¹ USACE, Wave Information Studies: <https://wisportal.erdc.dren.mil/>.

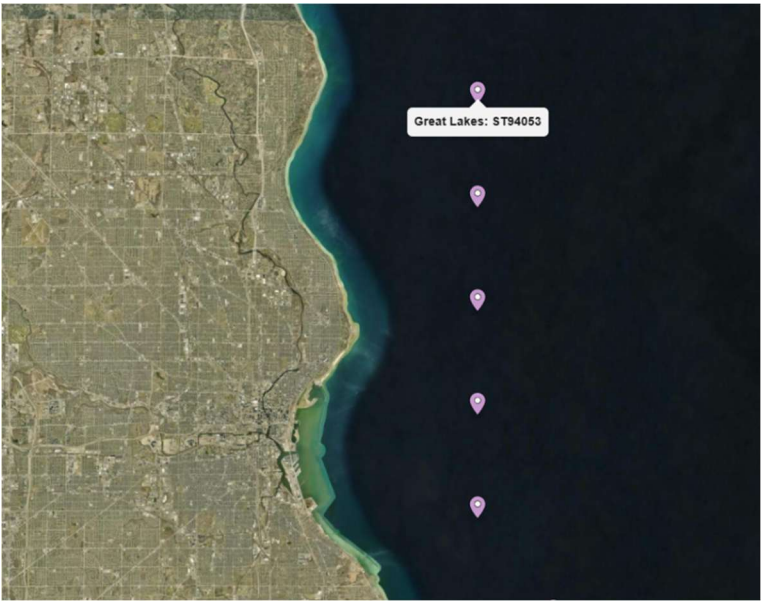


Figure 2. ST94053 Location Map

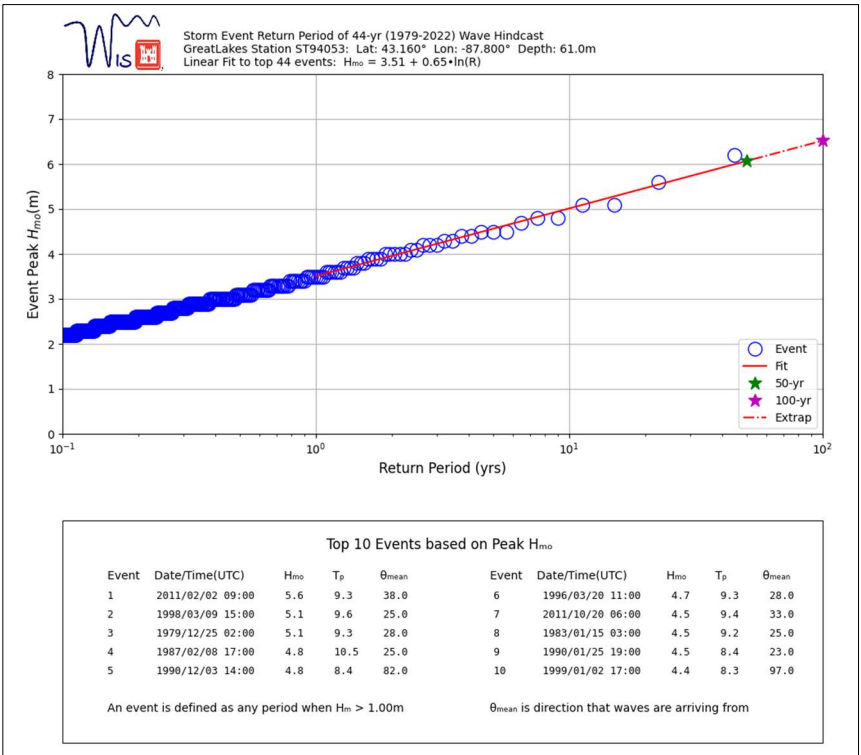


Figure 3. ST94053 Offshore Waves

Table 2 provides a summary of the offshore wave return period data at Station ST94053. The largest offshore wave was 18.4 feet from a northeast storm (February 2, 2011).

Table 2. Offshore Waves Summary at ST94053

Return Period (years)	Offshore Wave (feet)
10	16.43
20	17.90
50	19.86
100	21.34

2.3 BEACH AND OFFSHORE SLOPES

For this study, the beach slopes were calculated from the water's edge to the toe of the nearest bluff. Offshore lakebed slopes were calculated from the water's edge (surveyed level) to a reference depth of 10 feet below water surface elevation, as well as 10 to 20 feet below water surface elevation for comparison. The Wisconsin Department of Natural Resources (WDNR) collected bathymetric data along select transects in the project area, extending to deep water (minimum 4,000 feet offshore in up to 50 feet of water depth) in 2012. **Figure 4** shows an example of a plotted bathymetric transect at Grant Park (location and elevation data) and **Figure 5** shows a direct comparison of the transect using the USACE 2020 LiDAR data, with data that is well in agreement for the slope up to 10 feet of water depth. It is noted that the LiDAR data extends only to the 570.0 feet IGLD 85 elevation, therefore, the deeper slopes could not be verified. However, we believe that the deeper water lakebed elevation does not significantly change with time.

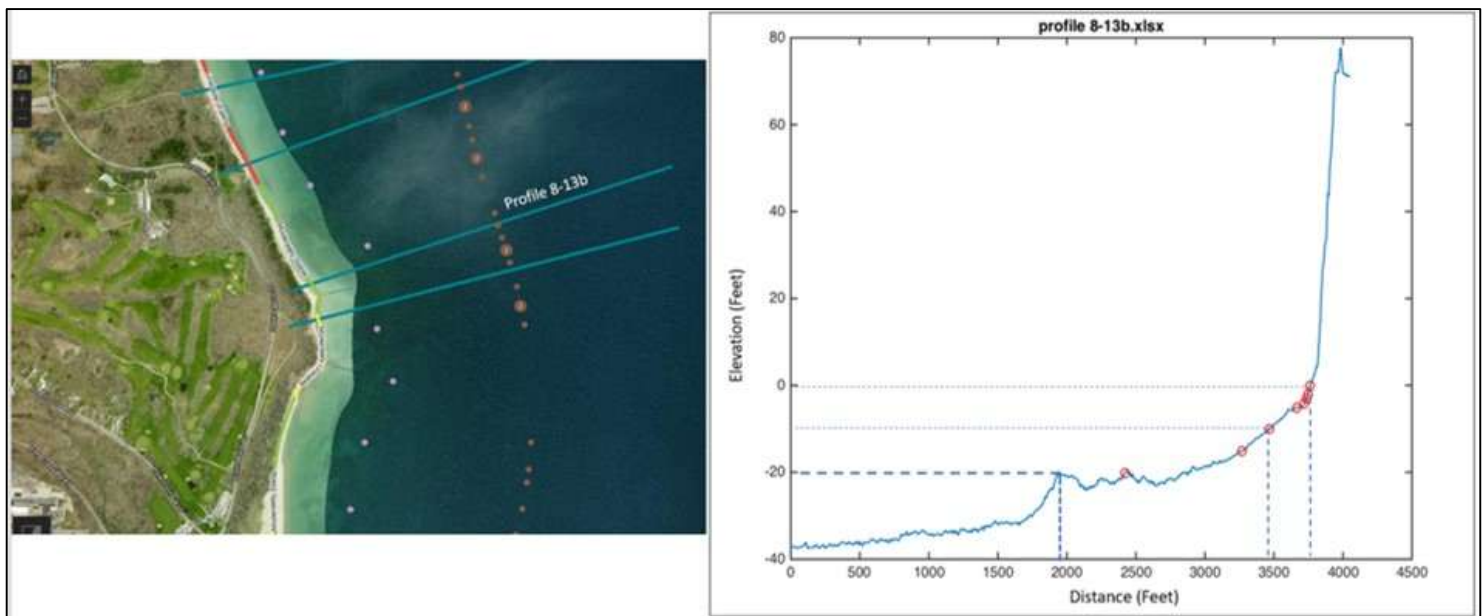


Figure 4. Grant Park Offshore Lakebed Transect Location and Profile Elevation

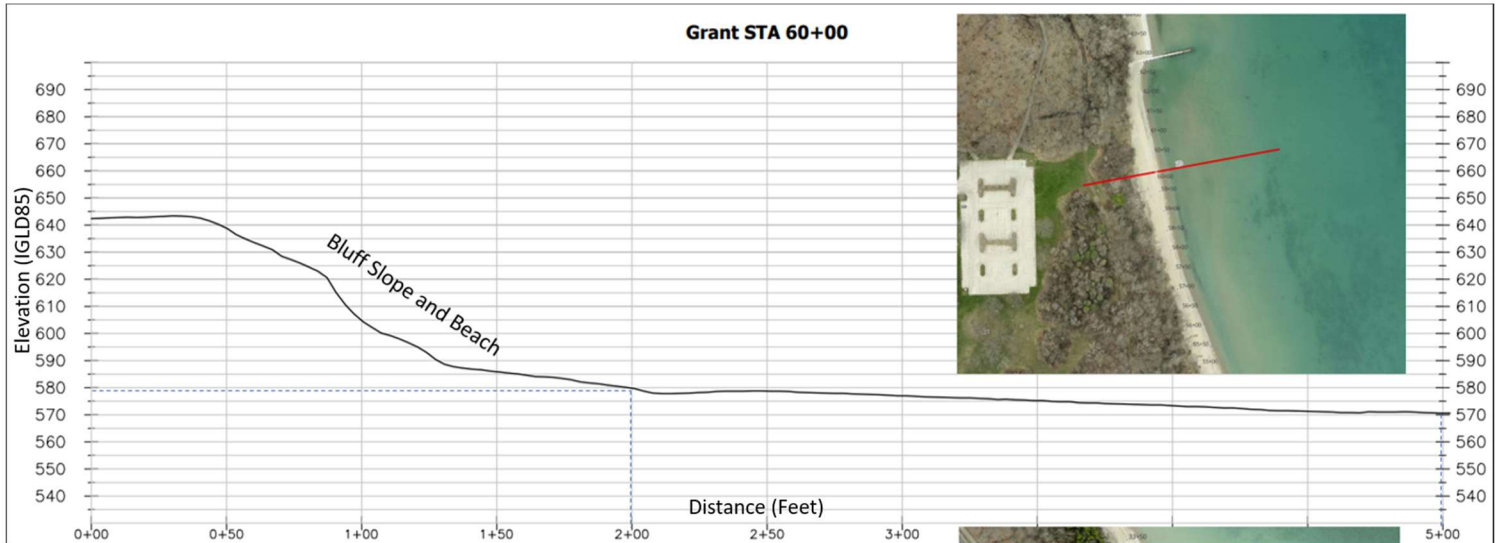


Figure 5. Grant Park LiDAR Profile Elevations

The offshore slopes were calculated at the various parks that have available slope transect data, as summarized in **Table 3**.

Table 3. Offshore Slope Ratios (Vertical to Horizontal)

Location	Water Depth: 0 to 10 feet	Water Depth: 10 to 20 feet
Grant Park	1:30	1:85
Big Bay Park	1:50	1:75
Bender Park	1:50	1:16
Warnimont Park	1:60	1:15
Sheridan Park	1:60	1:175
Lake Park	1:100	1:50
Doctors Park	1:125	1:85

The offshore slope is generally mild, between 0 and 10 feet of water depth, and slope ratios vary between 1:30 (Vertical:Horizontal) for Grant Park and 1:125 for Doctors Park. Based on GZA's coastal assets inventory for Milwaukee County in August 2020,² the reported offshore slopes varied between 1:50 and 1:100 and were in general agreement with our new findings. The offshore slopes are steeper, between 10 and 20 feet of water depth for Warnimont Park (1:15) and Bender Park (1:16), but very mild for the rest of the project sites.

As waves travel from deep water to the surf (breaking) zone, they undergo various transformations. The wave steepness (ratio of wave height to length) increases and when reaching a limiting value, they break, dissipating energy and inducing nearshore currents. The waves break in a water depth of approximately 0.8 to 1.0 feet of the wave heights, depending on the offshore slope (higher breaking waves occur for steeper slopes). Offshore wave breaking due to water depth is known as a depth-limited condition, therefore, the nearshore surf zone with limited depths, up to 10 feet, and the offshore slope are important for determining the wave energy impacting the shoreline.

Based on the aerial survey data collected, the parks have average beach slopes (computed from the water's edge to the bluff toe and along the entire park reach), as shown in **Table 4**. The visually observed beach material composition (per

² Milwaukee County Coastal Assets Inventory and Assessment Report, Lake Michigan Shoreline, Milwaukee County, Wisconsin Project No. 5741-19805, dated August 25, 2020, GZA File No. 20.0156562.00.

the Unified Soil Classification System [USCS]) is also shown in **Table 4**. Note that the parks' beach slopes were calculated as an average in open areas without coastal structures. The calculated values and beach compositions varied between 1:6.5 (Big Bay Park) with gravel, and Sheridan Park and Grant Park (1:10) with medium sand with gravel. Bradford Beach, South Shore, and McKinley Park beach slopes were calculated using USACE 2020 LiDAR data.

Table 4. Park Beach Slopes (Vertical to Horizontal) and Material Composition

Location	Average Beach Slope (Vertical: Horizontal)	Beach Material Composition
Doctors Park	1:8	cobbles, pebbles, gravel
Big Bay Park	1:6.5	sand, pebbles, gravel
Lake Park-Linnwood	-	stone revetment, no beach
Bradford Beach	1:20	medium, fine sand
McKinley Park	1:25	medium sand
Veterans Park	-	stone revetment, sheet piling, no beach
Cupertino Park	-	stone revetment, no beach
South Shore Park	1:15	gravel, medium to coarse sand
Bay View Park	1:7	gravel, medium sand, cobbles
Sheridan Park	1:7	medium sand, gravel, concrete rubble
Warnimont Park	1:7	gravel, clay, sand
Grant Park	1:10	medium sand, gravel
Bender Park	1:9	medium sand, gravel

2.4 BEACH MATERIAL STABILITY CONSIDERATIONS

The project area shorelines quickly respond to the water level variations and significant storms. Shallow water, shallow offshore slope, and coarse-grained sediments generally promote more stable beach slopes. The grain size directly influences the stability of the beach slope (i.e., the coarser the material, the more stable the slope). **Figure 6** shows a typical plot of the grain size influence on the beach slope.

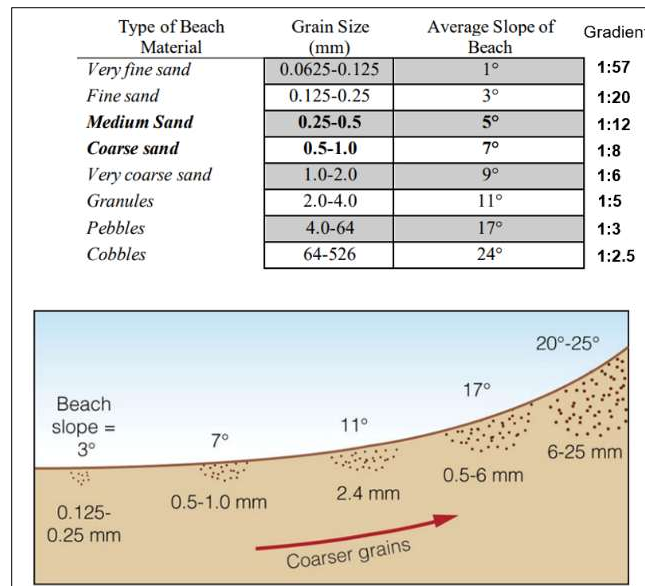


Figure 6. Beach Grain Sizes and Slopes (Hyndman, 2017)

The plot shows that medium sand will have a 1:12 stable slope after placement, while a steeper stable slope will be achieved for coarse sand (1:8), gravel (1:5), and pebbles (1:3). The plot is in general agreement with the existing slopes and material properties reported in **Table 4** above.

2.5 SEDIMENT TRANSPORT OVERVIEW

The net movement of sediment in the project area is from north (updrift direction) to south (downdrift direction). Longshore Sediment Transport (LST) is the transport of sediment in the littoral zone parallel shoreline due to obliquely approaching waves and induced currents. Storm waves can move significant annual volumes of sediment along the shoreline.

Various coastal structures (groins, jetties, detached breakwaters) can impact this process by trapping a portion of the LST. Some of the parks have groin fields, provided as a series of shore-perpendicular structures. These are intended to stabilize the beaches and counteract the shoreline erosion. By design, a groin maintains the updrift (north) beach, and a series of groins are required to protect both sides. Most of the existing groins in the parks were built as an open concrete frame and piers, as shown in **Figure 7**. The groin structures allow some sediment transport through the open spaces and are beneficial by providing partial sediment retention and reducing the incoming wave energy during storms from most directions (except straight east with waves perpendicular to the shoreline). Most existing park groin structures show significant deterioration and are in need of immediate rehabilitation. Some groin sections failed (especially at the offshore end) and require immediate improvements.



Figure 7. Sheridan Park Groin Field

Cross-shore Sediment Transport (CST), is the transport of sediment in the littoral zone perpendicular to the shoreline. The intensity of the LST and CST increases with larger waves and more intense storms. In an ideal situation, the sediment budget is in balance (the beach profile is stable) and the sediment volumes in (positive) and out (negative) of the project



area are equal. Balanced sediment transfer is rarely the case and a net negative imbalance would result in beach and bluff erosion. The LST annual rates fluctuate as a result of variable water levels and a reduction in the sediment supply. In recent years, man-made armoring of the shoreline and bluffs resulted in a significant reduction of the eroded material that used to be a positive source of sediment to the regional LST.

As recently reported by the USACE (*Sediment Budget for the North Illinois Shore from the Wisconsin Border to Wilmette Harbor*, 2019), at the border between Wisconsin and Illinois, approximately 60,000 to 90,000 cubic yards per year (yd^3/yr) were the calculated range of the LST net rate before 1986. The most recent 2019 calculation, reported based on monitoring results, was approximately 16,000 yd^3/year . Therefore, the LST has significantly reduced, likely due to the decrease in natural sediment supply. In the absence of sediment sources from natural erosion, the surficial erosion of sediment in the nearshore area is frequently documented. This will result in deepening of the nearshore water depths, potentially exposing the underlying clay bed and allowing more wave energy to impact the shoreline. This process is called downcutting. While the annual downcutting rates are small, it is a long-term concern for the project area.

Based on the *South Shore Breakwater Design Report* (Baird, July 2024), a cross-shore beach profile evolution at Bay View Park was modeled with a specialized computer model for a long (40- to 50-year) timeframe. The results show that the predicted lakebed scour is between 0.5 and 0.6 inches per year (in/yr), or up to 2.5 feet over 50 years.

2.6 ICE CONSIDERATIONS

The ice load forces are considered in the coastal protection structures, with a revetment design methodology based on ice thickness. The National Snow & Ice Data Center, Great Lakes Ice Charts were reviewed. The maximum ice thickness recorded in the Milwaukee Harbor area was 3 feet in January 1978, with typical ice thickness up to 1 foot. Considering the typical ice thickness up to 1 foot for design, the shoreline protection structures will be governed by the wave loads.

2.7 COASTAL STRUCTURE EVALUATION

Based on field visits and collected data, GZA ranked the shoreline structures (condition and vulnerability) based on visible storm damages, material quality, stone displacements, wave overtopping potential, risk calculator, etc. There are various types of structures in the project areas that used different materials, such as:

- Groins with open concrete frame, pre-cast concrete;
- Seawalls: cast-in-place concrete, steel sheet piling (SSP);
- Stormwater outfalls: concrete pipes; and
- Backshore revetments: heavy riprap, armor stone, concrete rubble.

Generally, the majority of these structures are old and in need of rehabilitation. Some of the outfalls appeared to be newer and in good conditions. The structure evaluation is provided in **Appendix B**.

2.8 BASIS OF DESIGN AND COASTAL CALCULATIONS

For design of Great Lakes shoreline protection structures, the USACE typically uses the 10- and 20-year water levels in its design set of conditions, with the computed 10- and 20-year offshore waves. For the (10, 20) [Water Level, Offshore Wave] and (20, 10) sets of water level and offshore waves, the more conservative results are usually selected as resilient design criteria.



In recent years, the resilient criteria selected by FEMA for Lake Superior exceeded USACE's methodology. The change in resilient criteria came as Lake Superior water levels reached a 100-year mark over the last few years. Similarly, high Lake Michigan water levels recorded in June/July 2020, prompted attention to what a reasonable, resilient design water level to use is. The 100-year water level was used in the design of some shore protection structures, along with a 50-year offshore wave height, such as the Duluth, Minnesota shoreline projects on Lake Superior, and the McKinley Marina breakwaters on Lake Michigan. These are examples of projects built in special conditions (deep water and/or steep offshore slopes).

Based on our design analysis and built projects on Lake Michigan with mild offshore slopes, GZA typically recommends considering the (50, 20) water level and offshore wave for wave design calculations in support of shoreline improvements. A 50-year water level of 583.0 feet was adopted for this study, along with a 20-year 17.9-foot offshore wave height.

Standard computer desktop tools were used to transform the offshore waves to the nearshore (shallow water). The wave transformation analyses used the following standard USACE-approved methodologies:

- Goda Method (1985): nearshore wave height transformation;
- Van Der Meer and Stam (1992): wave overtopping rates; and
- Mase (1989): wave runup on impervious beach slopes for irregular waves.

Using the shoreline positioning at the historic long-term average water level (579.34 feet), the following significant wave heights were calculated during the 50-year water level for different beach profile slopes, as shown in **Table 5**.

Table 5. Nearshore Significant Wave Heights

Design Water Level (feet)	Water Depth (feet)	Offshore Slope (V:H)	Wave Height (feet)
583	3.66	1:30	4.19
583	3.66	1:50	3.95
583	3.66	1:60	3.89
583	3.66	1:100	3.8
583	3.66	1:125	3.77

The wave heights on the selected beach reference positioning slightly vary (up to 0.4 feet) based on the nearshore slope. Grant Park (1:30 slope) has the largest waves, with Lake Park and Doctors Park (1:100 and 1:125 slopes, respectively) having the smallest waves. It is noted that the differences are small.

For beach runup, the following values were calculated, as shown in **Table 6**. The $R_{2/100}$ is the wave runup exceeded by 2% of all the wave crests, and typically used in coastal calculations. The runup was calculated on open shorelines, with no structures.

Table 6. Beach Wave Runup

Beach Slope (V:H)	Beach Wave Runup (feet IGLD 85)
1:6.5 (Big Bay)	591.7
1:7 (Bay View, Sheridan, Warnimont)	591.3
1:9 (Bender)	589.9
1:10 (Grant)	589.4
1:20 (Bradford)	586.9
1:25 (McKinley)	586.3



As expected, the beach wave runup is largest for the parks with a steeper beach slope (Big Bay Park, Bay View Park, Sheridan Park, and Warnimont Park) and smallest for mild beach slopes (McKinley Park and Bradford Beach). There is a significant 5.4-foot calculated difference between the maximum and minimum wave runups for the different park beach slopes. Our calculations do not account for the presence of coastal structures (breakwater, groins), which will significantly diminish the calculated wave runup potential. The significant beach wave runup clearly indicates the need for coastal protection at the bluff toe for the high priority sites: Big Bay Park, Grant Park, Sheridan Park, Bay View Park, and Warnimont Park.

2.8.1 Stone Revetments

Coastal calculations were performed assuming a design life of 50 years for a stone revetment placed along the shore, and considering the wave scour potential of 0.6 in/yr, or up to 2.5 feet at the end of 50 years. The required stone sizing was calculated based on the toe elevation being 2.5 feet lower and assuming a beach offshore slope of 1:20.

A minimum stone density of 165 pounds per cubic foot (pcf) was selected. The crest-required elevation was selected based on calculated wave overtopping rates, with a standard width of 3 times the armor stone widths. A filter/underlayer of stone will be provided under the armor stone on top of the regraded slope with geotextile fabric.

Standard computer desktop tools were used to transform the 20-year offshore wave during the 50-year water level to the nearshore (shallow water), as noted above, with the additional methodologies:

- Hudson's Equation (1953, 1959): revetment stone sizes.

The calculations were performed for a typical stone revetment placed in the nearshore water (no beach) and also as backshore (when a beach exists, primarily for bluff stability) with results summarized in **Table 7**.

Table 7. Coastal Design Calculations Summary-Stone Revetments

Design Water Level (feet)	Water Depth (feet)	Stone Range	Minimum Structure Crest (feet)
583.0	574.5	2.0 to 4.5 tons, Nearshore	589.0
583.0	580.0	400 to 800 pounds, Backshore	590.0

It is noted that for the near-shore revetment placed at 574.5 feet elevation, the minimum structure crest for allowable wave overtopping rates is 1-foot lower than the revetment placed at 580.0 feet; this is due to the minimum elevation selected for bluff stability.

2.8.2 Stone Groins and Detached Breakwaters

Similar calculations were performed for stone groins and detached stone breakwater, with results summarized in **Table 8**.

Table 8. Coastal Design Calculations Summary-Stone Groins and Detached Breakwaters

Design Water Level (feet)	Water Depth (feet)	Stone Range	Minimum Structure Crest (feet)
583.0	574.0	3.0 to 5.0 tons, Groins	586.0
583.0	575.5	1.5 to 3.0 tons, Breakwaters	586.0



2.8.3 Linnwood Revetment

Based on a review of Milwaukee County aerial photographs, the Linnwood revetment was constructed before 1937. At that time, there was a sandy beach in front of the shoreline. Armor stone was added between 1937 and 1951, with a curved armored headland built at the north end of Bradford Beach.

Based on our field evaluation of the Linnwood revetment on June 10, 2024, the following deficiencies were recorded:

- Majority of stone was undersized - heavy riprap gradation, 0.2 to 1.0 tons with some in the smaller 0.2- to 0.5-ton range;
- A few larger stones (over 4.0 tons) were not interlocking well with the smaller stones;
- Two project areas along approximately 400 lineal feet of shoreline where stones were missing that created large voids filled with gravel and sand;
- Some sections included primarily concrete rubble, not interlocking well;
- Severe headland damage with displaced stone and undersized stone; and
- No toe stone observed.

From the LiDAR data, the revetment had an average crest elevation of 590.0 feet IGLD 85 and a toe at an average of 577.0 feet at the curved headland and 579.0 along the toe of the existing revetment straight alignment north of the headland. For preparing proposed improvements, the revetment was separated into two project areas, labeled Area 4 and Area 5 in the project plans.

Project Area 4 is approximately 1,560 feet long and includes the north section of the existing Linnwood Revetment in Lake Park. This section of the existing revetment was in generally poor condition with an average structure condition rank of "D" and generally low risk related to the consequence of revetment failure. Some areas of the revetment showed signs of washout and overtopping behind the existing revetment. In general, the existing armor stone material at Project Area 4 was too large, of irregular sizes, and contained significant void spaces with little to no filter layer below the armor stone layer. These void spaces allow for the migration of material from behind the revetment into the lake.

The proposed project repair for Area 4 includes salvaging stone that is in good condition and in the required range for slope stability, as shown below:

- Two rows of toe stone (minimum 4 tons each) embedded at an elevation of 576.5 feet;
- Two layers of 1.25 to 3.0 tons; and
- Crest elevation of 589.0 feet.

There also is the possibility of salvaging existing stone materials that fit the underlayer stone range, which is 250 to 600 pounds.

Project Area 5 is 225 feet long and includes the south section of the existing Linnwood Revetment adjacent to Bradford Beach, with the eroded curved headland. Since 2000, the headland recessed over 50 feet from its original built extent. This section of the revetment was in generally poor to failing condition, with an average structure condition rank of "F" and moderate risk related to the consequence of revetment failure related to the presence of Bradford Beach south of the headland. The revetment in Project Area 5 predominantly consisted of concrete rubble and the project team observed significant signs of shoreline erosion and severe stone displacement.



For proposed project repairs, the following are recommended:

- Two rows of toe stone (minimum 4 tons each) embedded at an elevation of 574.5 feet;
- Two layers of 2.0 to 4.5 tons; and
- Crest elevation of 589.0 feet.

Like Area 4, there also is the possibility of salvaging the existing stone materials that fit the underlayer range of 400 to 900 pounds. Restoring the headland can be performed as follows:

- Along the original built curved footprint. This would have the added benefit of improving sand sediment retention at Bradford Beach and enhancing the resiliency of the beach area. In addition, the upland area can be restored for improved habitat and recreational activities.
- Straight alignment using Area 4 design in shallower water. This would have the benefit of saving on the construction costs; however, due to the small project area, the construction savings would not be substantial.

We recommend that Area 4 be restored, as described above, along with the Area 5 curved headland. If a project phased approach is selected, we recommend making the restoration of the curved headland a priority.

2.9 STRUCTURE MAINTENANCE AND MONITORING PROGRAM

Generally, it is difficult to forecast the maintenance costs for coastal structures, such as rubblemound revetments, groins, and breakwaters. Actual maintenance costs vary depending on the exposure of the structure to storm events (number, magnitude-design event or more, and duration). Typically, maintenance work may be required to address long-term degradation of the structure while repair work may be required in response to a specific significant storm event. In reality, proactive maintenance of rubblemound structures is rarely performed. Rather, some visible damage to the structure is often the trigger to undertake maintenance or repair works.

Degradation of construction materials exposed to the dynamic shoreline environment, such as abrasion and fracturing of quarried stone, along with changes in the condition of the lakebed, may eventually require maintenance/repair work, as well as damage caused by severe storms (especially in excess of the selected design event).

For planning purposes, the average annual maintenance cost may be estimated as a percentage of the original construction cost for the structure. For example, the USACE (Buffalo District) typically assumes a maintenance cost of 2% to 3% (of the construction cost) per year for the economic analysis of shoreline protection over the project life. This is consistent with the Southeastern Wisconsin Regional Planning Commission (SEWRPC) recommending 2.5% to 3% per year.

The available information suggests that the average annual maintenance cost for rubblemound structures may be on the order of 2% to 3% of the initial construction cost. GZA recommends a 2.5% average annual maintenance cost. It is important to note that this is a budgetary planning exercise and very useful when repairs will have to be performed some years after project construction, to make sure the repair budget will be available at that time.

We also recommend a shoreline and coastal monitoring program. This may be performed every five years, which allows for the proactive planning for maintenance. We recommend an aerial survey coupled with beach survey to wading depth along established reference cross-sections and an engineering site visit. A report will be prepared showing any changes from the as-built conditions with recommendations for improvements as needed, which will apply to both beach nourishment and structure repairs.



3.0 FINDINGS AND RECOMMENDATIONS

The water levels, storm intensities, and beach profile responses are dynamic. These dynamic factors directly impact the wave runup potential and the stability of the bluff toes. Coastal protection in the form of shoreline and backshore stone revetments, groins, and detached breakwaters with sand fill was found to be required, as shown in the project plans. The following is a summary of our findings and recommendations used in GZA's risk assessment and concept repair/stabilization designs, using the project areas designation in the project plans:

- Doctor's Park:
 - Area 1: Create a small groin field by providing a new groin structure and repair the two existing groins with added sand fill.
 - Area 2: Provide a backshore revetment for the existing ravine or rehabilitate the existing groin and add sand fill.
- Big Bay Park:
 - Area 3: Provide riprap protection on top of the existing bulkhead to protect against wave overtopping eroding the bluff slope. Alternatively, provide new groin structures and rehabilitate the existing one to create a groin with sand fill.
- Linnwood Revetment:
 - Area 4: Rehabilitate the existing revetment with salvaging the existing materials that are appropriate sizes and quality. Add a toe stone and new armor stone on the slope.
 - Area 5: Rehabilitate the existing revetment like Area 4. This alternative assumes a straight alignment rehabilitation of the revetment, along the eroded existing headland position. Alternatively, rehabilitate the revetment in slightly deeper water along the curved alignment originally constructed. The second alternative presents some significant advantages.
- Bay View Park:
 - Areas 11 and 12: Select the proposed stone revetment by others (Baird and Associates).
- Sheridan Park:
 - Area 14: Rehabilitate two existing groins and provide two new structures with beach fill to create a goring field. Alternatively, provide an armor stone revetment with riprap above the revetment crest to armor the lower bluff slope.
 - Area 15: Provide new groins with beach fill to create a groin field. Also, provide a backshore stone revetment for the bluff toe stability.
- Warnimont Park
 - Area 16: Provide two shore-attached groins with detached stone breakwaters and sand fill to create beach cells. Alternatively, provide a shoreline revetment to protect the shoreline.
- Grant Park
 - Area 16: Provide new groins with beach fill to create a groin field.
 - Areas 23 and 24: Provide a backshore revetment.



As we anticipate the cross-shore transport to be significant, we propose conducting an offshore sand mining survey. The goal of this investigation is to find potential borrow sources of sand that could be used for beach nourishment using hydraulic dredging, which would be cost effective. A survey vessel would be equipped with a sub-bottom profiler (type of sonar system - a geophysical survey tool that uses sound to map beneath the seafloor). Surface grab samples will be collected for mechanical analyses, along with sediment vibracoring (small-diameter cores that can be collected to approximately 30 feet below the lakebed). The investigation will provide the following:

- Estimate the thickness and volume of available sand layers; and
- Determine the grain size and percent fines for suitability as a borrow source.

We believe that if the offshore sand mining survey results are favorable, establishing a regional sediment supply source for the parks can provide an important and feasible long-term option for maintaining stable beaches. If the County considers this as a potential project, we recommend an early coordination meeting with the WDNR and USACE to first discuss regulatory permitting requirements and the material testing program. Depending on the size of the offshore project area to investigate and required material testing details, we estimate that the sand mining survey cost may vary between \$50,000 and \$100,000. Some state grants, e.g. the Wisconsin Coastal Management-Coastal Resource and Community Planning Grant, might be able to assist with paying for the study fees.

The existing offshore profiles of the various project area surf zones from 0 to 10 feet of water depth are mild or very mild. Incoming waves will be depth-limited and the amount of shoreline protection increases. However, we recommend performing a new detailed bathymetric survey from the beach and extending, to a minimum, -10 feet of water depth to verify our study data.

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APPENDIX A

Coastal Limitations



COASTAL LIMITATIONS

USE OF REPORT

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the proposal and/or report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the contract documents, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

STANDARD OF CARE

2. GZA's findings and conclusions are based on the work conducted as part of the scope of services set forth in the proposal and/or report and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. If conditions other than those described in this report are found at the subject location(s), or the design has been altered in any way, GZA shall be so notified and afforded the opportunity to revise the report, as appropriate, to reflect the unanticipated changed conditions.
3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.
4. In conducting our work, GZA relied upon certain information made available by public agencies, Client, and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Inconsistencies in this information which we have noted, if any, are discussed in the report.
5. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced, which were made available to GZA at the time of our evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.

COMPLIANCE WITH CODES AND REGULATIONS

5. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

ADDITIONAL SERVICES

6. GZA recommends that we be retained to provide services during any future site observations, design, implementation activities, construction and/or property development/redevelopment. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.



APPENDIX B

Coastal Structure Evaluation Summary

APPENDIX B COASTAL STRUCTURE EVALUATION SUMMARY								
Str_Num	Park	STA	STA_End	Type	Material	Approx_Length (ft)	Condition	Vulnerability
1	Doctors	18+60	-	Groin	Concrete Block	125	F	D
2	Doctors	16+15	-	Groin	Concrete Block	110	F	D
3	Doctors	14+25	-	Groin	Concrete Block	100	F	F
4	Doctors	12+40	-	Groin	Concrete Block	125	F	F
5	Doctors	8+50	13+50	Retaining Wall	Corrugated Steel	500	C	C
6	Doctors	8+50	-	Groin	Concrete Block	130	F	F
7	Doctors	2+75	8+50	Seawall	CIP Concrete	575	F	C
8	Doctors	0+00	2+75	Revetment	Riprap	275	F	C
9	Big Bay	6+80	14+50	Seawall	CIP Concrete	770	B	C
10	Big Bay	6+80	-	Groin	CIP Concrete	20	B	B
11	Big Bay	3+00	6+80	Seawall	CIP Concrete	380	B	B
12	Big Bay	3+00	3+45	Access	CIP Concrete	45	B	C
13	Big Bay	2+60	-	Groin	Concrete Block	150	B	C
14	Big Bay	0+50	-	Outfall	CIP Concrete	20	A-	A
15	Big Bay	0+00	3+00	Revetment	Armor Stone	300	B	B
16	Lake - Linnwood	20+00	28+50	Revetment	Armor Stone	850	D	C
17	Lake - Linnwood	12+40	20+00	Revetment	Rubble, Stone	760	D	D
18	Lake - Linnwood	4+60	12+40	Revetment	Riprap	780	A	A
19	Lake - Linnwood	2+00	4+60	Revetment	Riprap	300	F	F
20	Lake - Linnwood	0+40	2+00	Revetment	Armor Stone, Riprap	160	D	D
21	Cupertino	0+00	13+50	Revetment	Armor Stone, Riprap	1350	A	A
25	South Shore	20+30	21+50	Revetment	Riprap	120	D	F
26	South Shore	9+25	20+30	Revetment	Armor Stone	1130	B+	A
27	South Shore	8+60	-	Groin	Armor Stone, CIP Concrete	45	A	A
28	South Shore	2+60	-	Groin	Armor Stone, CIP Concrete	50	A	A
29	South Shore	0+00	9+25	Revetment	Armor Stone	1090	A	A
30	South Shore	0+00	9+25	Seawall	CIP Concrete	1090	A	A
31	South Shore	17+50	56+00	Breakwater	Armor Stone	3750	C	B
32	South Shore	-37+50	17+50	Breakwater	Armor Stone	5100	A-	B
33	South Shore	-61+00	-38+00	Breakwater	Armor Stone	2300	D	D
34	Bay View	16+30	-	Outfall	CIP Concrete	20	B	D
35	Bay View	11+25	-	Outfall	CIP Concrete, Tile Pipe	25	F	B
36	Sheridan	9+60	96+60	Seawall	SSP	100	A	A
37	Sheridan	88+75	-	Outfall	CIP Concrete, Riprap	20	B	A
38	Sheridan	87+60	96+60	Revetment	Armor Stone	900	B	A
39	Sheridan	54+30	87+60	Revetment	Waste	3330	D	D
40	Sheridan	48+80	-	Outfall	CIP Concrete	135	D-	C
41	Sheridan	41+25	-	Groin	Interlocking Precast Concrete	170	D-	D
42	Sheridan	39+25	-	Groin	Interlocking Precast Concrete	170	F	D
43	Sheridan	37+25	-	Groin	Interlocking Precast Concrete	165	F	D
44	Sheridan	35+25	-	Groin	Interlocking Precast Concrete	150	F	D
45	Sheridan	33+25	-	Groin	Interlocking Precast Concrete	150	F	D
46	Sheridan	31+25	-	Groin	Interlocking Precast Concrete	150	F	D
47	Sheridan	29+25	-	Groin	Interlocking Precast Concrete	130	F	D
48	Sheridan	27+25	-	Groin	Interlocking Precast Concrete	140	F	D
49	Sheridan	27+60	-	Outfall	CIP Concrete	25	C-	C
50	Sheridan	25+25	-	Groin	Interlocking Precast Concrete	165	D	D
51	Sheridan	23+25	-	Groin	Interlocking Precast Concrete	165	F	D
52	Sheridan	23+25	-	Groin	CIP Concrete	80	C	D
53	Sheridan	21+00	-	Groin	Interlocking Precast Concrete	165	F	D
54	Sheridan	21+00	-	Groin	CIP Concrete	80	C	D
55	Warnimont	71+80	-	Pier	Interlocking Precast Concrete	50	F	F
56	Warnimont	69+80	-	Pier	Interlocking Precast Concrete	80	F	F
57	Warnimont	35+75	-	Outfall	CIP Concrete	20	F	F
58	Warnimont	32+45	-	Outfall	CIP Concrete	75	D	D
59	Grant	62+85	-	Groin	Concrete Block	165	D	D
60	Grant	44+80	45+60	Revetment	Riprap	80	F	F
61	Grant	31+75	-	Groin	Concrete Block	360	F	F
62	Grant	25+25	-	Groin	Concrete Block	350	F	F
63	Grant	0+00	-	Jetty	Multiple	280	C-	D
64	Bender	55+00	59+00	Beach/Wetland Cell	Armor Stone	400	A	A
65	Bender	41+50	55+00	Revetment	Armor Stone, CIP Concrete	1350	A-	A
66	Bender	35+50	42+25	Beach Cell	Multiple	675	A	A
68	Bender	37+00	-	Groin	Armor Stone	250	D	F
69	Bender	32+50	36+50	Wetland Cell	Armor Stone	400	B	A
70	Bender	0+25	32+50	Revetment	Armor Stone	3225	B+	B+



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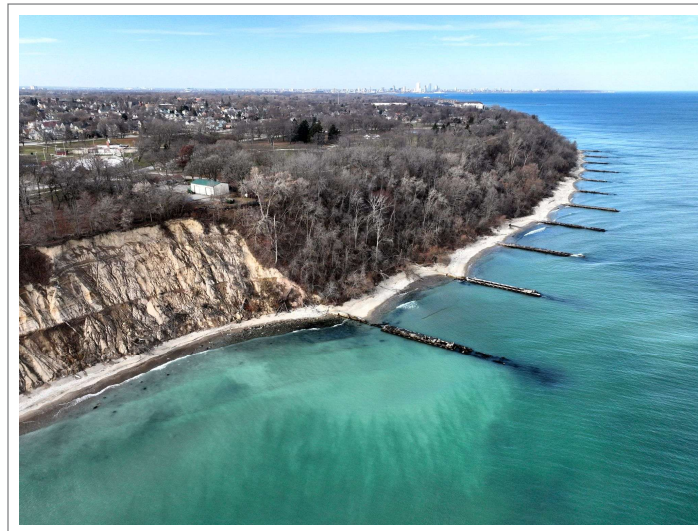
MILWAUKEE COUNTY LAKE MICHIGAN BLUFF REPAIRS REPORT

Milwaukee County, Wisconsin

Milwaukee County Project No. WY0625091

May 30, 2025

File No. 20.0158819.00



PREPARED FOR:



MILWAUKEE COUNTY
Administrative Services

Milwaukee County Department of Administrative Services
Milwaukee, Wisconsin

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May 30, 2025
File No. 20.0158819.00

Mr. Tim Detzer, P.E.
Milwaukee County Department of Administrative Services
633 West Wisconsin Avenue, 10th Floor
Milwaukee, Wisconsin 53203

Re: Milwaukee County Lake Michigan Bluff Repairs Report
Milwaukee County, Wisconsin
Milwaukee County Project No. WY0625091

Dear Mr. Detzer:

GZA GeoEnvironmental, Inc. (GZA) and Resolution Studio, LLC (Resolution Studio) are pleased to present the attached Milwaukee County Lake Michigan Bluff Repairs Report ("Report") for the 13 Milwaukee County-owned parks located on the Lake Michigan shoreline in Milwaukee County, Wisconsin ("Site"). The Report provides a discussion of our scope of work, findings, conclusions, and recommendations. The information contained herein was developed by GZA and is based on our evaluation, field work, and current understanding of the project.

We appreciate the opportunity to provide services for this project. Please feel free to contact us at (262) 754-2560 with questions.

Very truly yours,

GZA GeoEnvironmental, Inc.

Ian J. Mosbrucker, P.E.
Project Manager/Geotechnical Engineer

Jesse D. Graham, P.E.
Associate Principal

Dan Veriotti, P.E.
Associate Principal

James F. Drought, P.G.
Principal/Vice President

J:\158800to158899\158819 MKE Cnty Lake MI Bluffs\Report\FINAL 20.0158819.00 Lake MI Bluff Repairs Rpt_Milw County 5-30-25.docx

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APPENDIX I	TOP 50 SAFETY PRIORITIZATION TABLE



1.0 INTRODUCTION

The Milwaukee County Department of Parks, Recreation, and Culture owns and maintains 13 parks on the western shoreline of Lake Michigan, as follows:

- Doctors Park;
- Big Bay Park;
- Linnwood Revetment at Lake Park;
- Bradford Beach/Lake Park;
- McKinley Park;
- Veterans Park;
- Cupertino Park;
- South Shore Park;
- Bay View Park;
- Sheridan Park;
- Warnimont Park;
- Grant Park; and
- Bender Park.

Many of the parks contain coastal bluffs that have experienced erosion and instability due, in part, to fluctuating lake levels and strong storm events. These factors have accelerated the deterioration of the conditions along the shoreline, thus increasing the need for stabilization measures and repairs to protect the parks' assets and land. A Park Location Map is provided as **Figure 1**.

GZA and Resolution Studio (herein collectively referred to as the "Project Team") were commissioned to evaluate the parks' bluffs and provide a strategic plan for stabilizing and repairing the bluffs at the 13 parks listed above. Bay View Park, Big Bay Park, Linnwood Revetment at Lake Park, Sheridan Park, and Warnimont Park were assigned as high priority for the project, due to damage those parks sustained in a 2020 storm event.

The Project Team's services were conducted in general accordance with our Proposal for Lake Michigan Bluff Repairs, GZA File No. 20.P000510.24, dated December 13, 2023. The findings, conclusions, and recommendations that the Project Team derived from our evaluation are provided in this Milwaukee County Lake Michigan Bluff Repairs Report ("Report") and are subject to the Limitations provided in **Appendix A**. Elevations provided herein and in the GIS Experience reference the North American Vertical Datum of 1988 (NAVD 88) and are based on multiple photogrammetry surveys performed by the Project Team and the LiDAR contour elevations available on the Milwaukee County Land Information Office GIS portal and are assumed to be accurate to approximately the nearest foot.

1.1 SUPPLEMENTAL DOCUMENTS AND DATA

Supplemental to this Report, the Project Team created several documents, files, and a web-based application to improve functionality of the data collected for the project and to provide a basis of design for conceptual repair alternatives ("Concept[s]") evaluated. In addition to this Report, GZA provided supplemental documents and data portals, including:

- An ArcGIS Experience Builder web application ("GIS Experience") and associated Geographic Information System (GIS) webmaps;
- A Microsoft Excel file including data and calculations related to various aspects of the project to Milwaukee County as backup for the data displayed in this Report and in the GIS Experience;



- A supplemental plan set titled, “Milwaukee County Park Bluff Conceptual Repair Alternatives” (“Concept Plan Set”), dated May 30, 2025; and
- A supplemental Coastal Analysis and Basis of Design Report, dated May 30, 2025.

To better display the project data collected and analysis results, the Project Team created the GIS Experience¹ and associated GIS webmaps, which provide a more visual representation of the project data collected, analyses results, and recommendations compared to this Report. The user can also actively alter project prioritization parameters to better reflect Milwaukee County’s priorities.

The Project Team provided a Microsoft Excel file, “Milwaukee County Bluffs Spreadsheet Package,” including data and calculations related to various aspects of the project, to Milwaukee County as backup for the data displayed in this Report and in the GIS Experience. The Excel file can be utilized to adjust input values to better fit Milwaukee County’s priorities for evaluating risk in the future or to refine rankings to match changes in the shoreline environment.

Additionally, the Project Team created the Concept Plan Set, dated May 30, 2025, which visualizes the Concepts prepared by the Project Team. The Concept Plan Set also serves as a basis for the material and excavation quantities used to develop the Opinions of Concept Project Cost presented in **Section 7.0**.

Lastly, the Project Team produced a supplemental Coastal Analysis and Basis of Design Report, dated May 30, 2025, to provide a summary of coastal analysis methodologies and parameters used in the creation of recommendations pertaining to conceptual coastal structures shown in the Repair Plan Set. The Coastal Analysis and Basis of Design Report also has a more detailed discussion of the Project Team’s recommendations regarding the Linnwood Revetment.

1.2 TERMS AND DEFINITIONS

The Project Team provides the following list of terms and definitions that are relevant to understanding the project methodology and results. Some of the terms may also be defined in the sections in which they are introduced.

CELL(S) - 100- to 200-foot-long sections of the bluff slopes that were assessed by the Project Team and ranked for condition and vulnerability to perform the risk assessment.

CONCEPT(S) - Conceptual repair alternatives evaluated for mitigating identified deficiencies at the project areas identified by the Project Team.

CONCEPT PLAN SET - Set of plans titled Milwaukee County Park Bluff Conceptual Repair Alternatives, dated May 30, 2025. This plan set displays the project areas identified and Concepts recommended. The Concept Plan Set serves as the basis for material and excavation quantities for budgeting costs associated with the Concepts.

CONDITION - The visual status of the bluff slopes, as determined by the Project Team, compared to the typical, stable bluff in Milwaukee County.

FACTOR OF SAFETY [FoS] - The ratio of the forces and/or moments acting to resist failure of the slope to the forces and/or moments acting to induce failure of the slope. A greater FoS is generally perceived as a more stable slope.

FAILING - A visually assessed condition of a bluff in which active or recent sloughs, slumps, slides, or other slope failure types are currently observed.

GIS EXPERIENCE - Visualization tool created by the Project Team to provide an interactive summary of work completed for this project.

¹ Available at: <https://tinyurl.com/5n6v69dv>.



MARGINALLY STABLE - Bluff condition in which the estimated FoS is between 1.0 and 1.3. Estimated via visual assessment or determined via a slope stability modeling program.

PARK USAGE MULTIPLIER - Park-specific multiplier applied to the safety rankings of that park. The multiplier uses the park geometry and visitation data to adjust safety rankings to account for the probability that an individual is using the park near the bluff slopes and/or crest.

POSSIBLE FAILURE ZONE - Distance from bluff crest to the surface intersection of a theoretical 2.5H [Horizontal]: 1V [Vertical] Slope cut from the current bluff toe. Used to calculate land replacement values.

REPLACEMENT VALUE - The dollar value of land, structures, and neighboring property within or within proximity to the possible failure zone.

RESILIENCY - Numerically defined as the product of the condition value (unitless) and the vulnerability value (unitless) of a cell. In nonnumerical terms, the Project Team defines resiliency as the ability of the assessed feature to resist or recover quickly from further degradation.

RISK - Numerically defined as a replacement cost dollar value multiplied by the resiliency value of the bluff in a specific Cell. By nonnumerical definition, risk is the expected dollar cost associated with current bluff instability and potential future instability within that bluff Cell.

STABLE - Bluff condition in which the estimated FoS is greater than 1.3. Estimated via visual assessment or determined via a slope stability modeling program.

UNSTABLE - Bluff condition in which the estimated FoS is less than 1.0. Estimated via visual assessment or determined via a slope stability modeling program.

VULNERABILITY - Numerically defined as the average value of seven vulnerability factors ranked by the Project Team. By nonnumerical definition, vulnerability is a measure of how susceptible a bluff Cell is to future erosion based on observable features.

VULNERABILITY FACTORS - Seven unique attributes of bluff slopes and shorelines, defined by the Project Team, that contribute to vulnerability of bluff slopes to erosion and instability. These factors include: 1) Coastal Protection Presence; 2) Beach Volume; 3) Beach Material; 4) Vegetation Quality; 5) Perched Groundwater Presence; 6) Crest Proximity to Surface Water and Wetlands; and 7) Bluff Type.

1.3 PURPOSE, SCOPE OF SERVICES, AND SUMMARY

Milwaukee County ("County") has over 12 miles of shoreline along Lake Michigan of variable conditions and vulnerabilities to changing environmental conditions. With recent increases in Lake Michigan water level and increases in the frequency and intensity of large storm events, the County shoreline and bluffs are more susceptible to the detrimental effects of erosion and bluff instability. The purpose of this project was to find efficient ways to preserve and enhance the County parks for the enjoyment of current and future generations. GZA's objectives for this project were to evaluate the resiliency, vulnerability, and risk of the existing park bluffs; identify and conceptualize repairs or improvements at targeted project areas; and aid in development a strategic plan for implementing those repairs and improvements at the 13 shoreline parks. To achieve our objectives, GZA:

- Reviewed previous work in or near the park areas completed by GZA;
- Subcontracted a local consulting firm to perform photogrammetry surveys using Unmanned Aerial Systems (UAS, "Drones") for producing updated Digital Elevation Models (DEM) and contours for the 13 County parks;



- Developed a system for A, B, C, D, and F rankings of the existing condition, vulnerability, and safety of the County bluffs;
- Ranked Cells of the bluffs using the results of the Drone surveys and performed site visits to verify and revise these rankings;
- Utilized the condition and vulnerability rankings to assess the resiliency and risk of the bluffs;
- Utilized safety rankings to identify areas of possible safety hazard(s) to the general public and park maintenance staff;
- Created a GIS Experience to assist with visualizing the resiliency and risk distribution across the various parks and to better identify and display potential project areas;
- Identified 25 project areas that included distribution across the 13 County parks;
- Utilized allowance budget to perform four geotechnical borings at potential high-risk areas to better understand subsurface conditions in those areas. GZA also performed and/or subcontracted laboratory testing to further enhance the data collected in those areas;
- Created a Coastal Analysis and Basis of Design Report, provided under separate cover, summarizing methodologies and recommendations specific to coastal structures, recommended as conceptual repairs, at the 25 project areas;
- Evaluated the 25 project areas and developed multiple Concepts;
- Produced a Repair Plan Set to display the Concepts and to serve as a basis for facilitating cost evaluation of the alternatives;
- Prioritized projects based on cost, risk mitigation, safety improvement, and park enhancement; and
- Produced this Report summarizing our work and recommendations.

In general, areas with low resiliency and high risk are present within the 13 County parks evaluated; however, most of the park bluffs are generally high resiliency and low risk. Based on GZA's assessment, approximately 71% of the bluffs assessed were ranked as having a "B" resiliency or higher, compared to the 19% that were ranked as having a "D" or lower resiliency. Additionally, risk values in the lower resiliency areas are generally low compared to the cost to fully mitigate the ongoing instability in those areas. GZA attempted to develop unique and "greener" alternatives compared to the traditional approach of "gray" hard armoring of the bluff and shoreline. A detailed summary of GZA's methodology and results is included in the following sections.

2.0 PROJECT BACKGROUND

2.1 EXISTING PARK CONDITIONS

To better organize the project, GZA numbered the 13 County parks located on the Lake Michigan shoreline from north to south, and stationing was established per park that runs from south to north. Several parks/areas were combined into groups based on their proximity. **Table 2-1** summarizes the County-assigned parks and a Park Location Map is provided as **Figure 1**.



Table 2-1. Numbered Milwaukee County Parks With Stationings

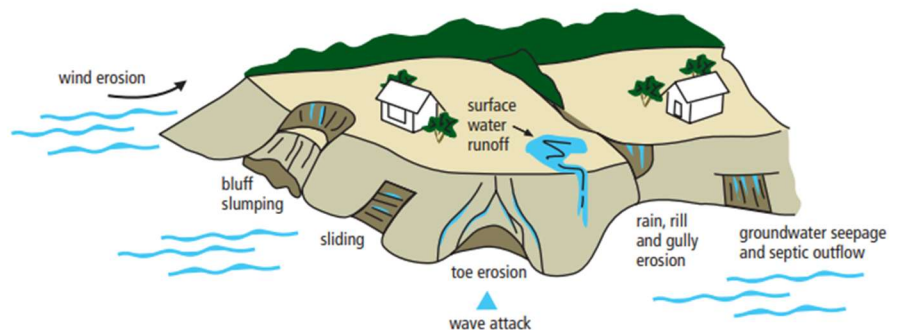
Park Name	Park Number	Stationing Range	Town/Village/City Location	Approximate Percentage of Stabilized Shoreline ¹
Doctors	1	0+00 to 22+00	Bayside	0%
Big Bay	2	0+00 to 14+50	Whitefish Bay	50% ²
Linnwood Revetment	3	0+00 to 28+00	Milwaukee	66% ³
Bradford/Lake	4	0+00 to 70+00	Milwaukee	100%
McKinley	5	0+00 to 34+00	Milwaukee	100%
Juneau/Veterans	6	0+00 to 46+00	Milwaukee	100%
Cupertino	7	0+00 to 14+00	Milwaukee	100%
South Shore	8	0+00 to 46+00	Milwaukee	100%
Bay View	9	0+00 to 42+00	Milwaukee	0% ⁴
Sheridan	10	0+00 to 96+00	St. Francis/Cudahy	0% ⁵
Warnimont	11	0+00 to 75+50	Cudahy	0%
Grant	12	0+00 to 90+50	South Milwaukee	20% ⁶
Bender	13	0+00 to 60+00	Oak Creek	100%

Notes:

1. "Stabilized Shoreline" was defined by presence of visually stable revetments, seawalls, beaches, or filled areas.
2. Remaining 50% of Big Bay Park shoreline has an overtopped seawall.
3. Remaining 34% of Linnwood Revetment has overtopped revetments or concrete rubble mound revetments.
4. Approximately 2,000 feet (48%) of the Bay View Park shoreline are well protected by the central section of the South Shore breakwater, and an additional 600 feet (14%) are partially protected by the south section of the breakwater.
5. Approximately 2,800 lineal feet (29%) of Sheridan Park shoreline have a groin field that maintains a relatively stable shoreline, but is beyond its design life.
6. An additional approximately 2,000 feet (22%) of Grant Park shoreline are partially stabilized with individual groins or pairs of groins that have exceeded the design life, but still maintain a relatively stable shoreline.

2.2 BLUFF STABILITY AND CHANGING ENVIRONMENTAL CONDITIONS

Increases in Lake Michigan water levels, the frequency of large storm events, and the intensity of storm events have led to destabilization of the bluffs in the County. Generally, the observed destabilization is caused by larger waves and increased energy in the nearshore environment causing more erosion and material loss at the bluff toe (bottom). Removal of material at the bottom of the slope is one of four ways slopes can change to become destabilized. Three additional ways are: 1) addition of material or weight (force) at the top of the slope; 2) seismic forces; or 3) reduction of soil shear strength. The third of these changes can be caused by groundwater presence, surface water infiltration, freeze thaw cycles, or soil grain reorientation due to occurrence of a slope failure. The image (right) shows a few of the factors that can contribute to slope instability.²



² Image: USACE, 2023. *Living on the Coast*. Page 10; USACE and University of Wisconsin; Detroit, MI; 2023.



In geotechnical engineering terms, a slope is said to be stable, marginally stable, or unstable, depending on its Factor of Safety (FoS) against failure. A slope's FoS is calculated as a ratio of the forces and/or moments acting to resist failure of the slope to the forces and/or moments acting to induce failure of the slope. Resisting forces are generally derived from the soil's shear strength (e.g. internal friction and/or cohesion of the soil), whereas driving forces are generally derived from gravity. Changes in soil porewater pressures can act to alter both resisting and driving forces. A higher FoS is generally indicative of a more stable slope. A FoS less than 1.0 indicates that the slope is likely unstable. A FoS from 1.0 to 1.3 is considered to be marginal in that variations in soil type and/or porewater pressure within the soil profile may cause the modeled slope to become unstable. A FoS greater than 1.3 is considered to generally be stable for residential and low traffic sites not subject to significant changes in porewater pressures or external loading. Higher FoSs may be required for specific slopes, such as earthen dams or highway embankments.

A report published by the Southeastern Wisconsin Planning Commission (SEWRPC) recommended that the County adopt the following minimum design FoSs for bluff slopes along Lake Michigan, based on the intensity of use near those bluff slopes³. The table below summarizes SEWRPC report recommendations.

Table 2.2. SEWRPC Minimum Design FoS Recommendations

Intensity of Use	Applicable Activities/Facilities	Minimum Design Factor of Safety ¹
Low (Passive) ²	Agricultural or open space use; primary or secondary environmental corridors; and woodlands.	1.1
Light/Moderate ³	Park and recreational uses; ⁴ barn/garage/shed; small, buried utilities; and tile beds.	1.1-1.2
Heavy/Active	Infrastructure; ⁵ occupiable buildings and structures; retaining walls; and storage	1.3-1.5

Notes:

1. These minimum design FoSs exemplify those that engineers may use to find the bluff edge setback appropriate to the associated land use intensity.
2. No buildings.
3. No occupiable buildings.
4. Including golf courses and swimming pools.
5. Including bridges and high-risk utilities.

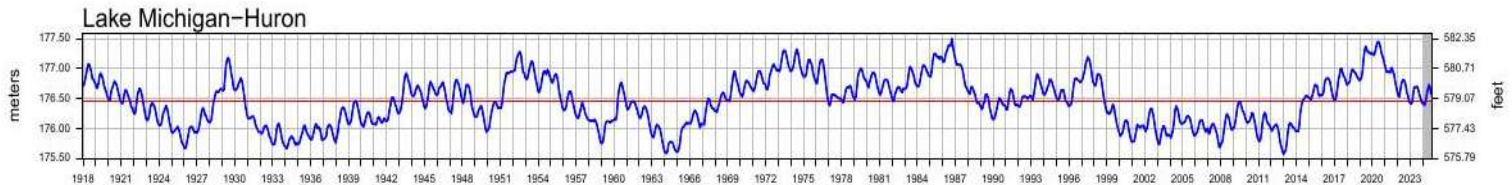
Bluff slope stability in the County area is dependent on numerous factors, including but not limited to, bluff condition, bluff soil type, local wave runup elevations, Lake Michigan water levels, storm event recurrence and severity, groundwater presence, vegetation, and the presence of shoreline protection. Vulnerability and risk related to the bluffs can vary significantly within the same park area and even within several hundred feet in some areas. The factors that influence destabilization potential are also dependent on each other and can generally fall into two main categories: coastal-related or land-related. These two categories are not standalone and can, and regularly do, influence one another. For example, lesser beach volumes can lead to larger wave runup, causing erosion of the bluff toe, and, therefore, causing a lower FoS (coastal factors influencing land factors); or vegetation can help retain beach sediments, reduce wave runup elevations, and, therefore, provide a buffer area for reducing bluff toe erosion and maintaining a stable FoS (land factors influencing coastal factors).

Since August 2020, Lake Michigan water levels have exhibited a drop from 2020 to 2022, and a relatively steady level from 2022 to present, with some typical seasonal variation. An illustration, produced by the United States Army Corps of Engineers (USACE) showing historic fluctuations in water levels on Lake Michigan is provided below. As a result of this

³ SEWRPC, 2021. *Milwaukee County Coastline Management Guidelines - Memorandum Report No. 248*, Table 3.1; SEWRPC; Waukesha, WI; February 2021.



reduction in water level, erosion has reduced since 2020. However, delayed effects of the shoreline erosion caused by the high water levels in 2020, are still revealing themselves on the bluffs in the form of slope failures and observable instability across the County. Furthermore, due to reduction in the longshore sediment supply caused by increases in hard armoring across the west shore of Lake Michigan, beaches have generally not recovered to the previous volumes and remain susceptible to larger waves propagating into the shoreline and bluff toes.



Notes:

1. Red Line = Measured Period Average Water Level.
2. Blue Line = Monthly Average Water Level.
3. Elevations shown are presented in International Great Lakes Datum (IGLD 85)

The observable and well documented changes in the shoreline environment of Lake Michigan are causing instability and loss of land on the County bluffs. These changes justify the need for this project to identify and prioritize projects meant to mitigate the County's risk associated with bluff instability and the associated loss of land.

3.0 SITE DATA COLLECTION AND RECONNAISSANCE PROGRAM

GZA utilized multiple sources and methodologies to obtain the data that were utilized in execution of this project. The sources and methodologies included:

- Drone flights;
- Publicly available GIS data;
- Publicly available soil and geotechnical data;
- Pedestrian reconnaissance/field visits;
- Coastal engineering analysis;
- Geotechnical borings and laboratory testing; and
- In-house experience.

The data obtained via these sources are further discussed and compiled in the following sections and in the GIS Basemap that is included with the previously linked and discussed GIS Experience.

3.1 DRONE FLIGHTS

Resolution Studio performed Drone flights at the 13 project parks. The use of Drones allowed for quick and effective video collection, photographs, existing elevation data, and providing detailed information in otherwise difficult to access areas. The quantity of the Drone-collected data improved the quality of the evaluations, as compared to a traditional pedestrian survey. Oblique images and video provided a bird's-eye view of the bluffs, beaches, shoreline, and surrounding areas that would have otherwise been unobtainable from the ground. Drone-collected oblique imagery is available for viewing and



download on the GIS Experience in the Resiliency & Risk Map layer, titled “Oblique Images (2024),” and in the Bluff Photo Viewer Webapp.

Using photogrammetry and the concept of "Structure from Motion" (SfM), a series of high-resolution images captured by the Drones were post-processed into high-resolution orthophotos. SfM also produces a three-dimensional (3D) point cloud, from which surfaces, DEMs, and elevation contours were derived. The Drones included high-accuracy, real-time-kinematic (RTK) positioning systems to geotag the captured images. Further accuracy and quality assurance/quality control were implemented using a series of over 350 field-based GNSS (aka GPS) points that were collected as 'ground control' or 'check points' (GCP/CP). 3D surface data, collected by Drones, provided a detailed representation of the existing bluff conditions that could not be safely achieved with traditional survey techniques. Project elevation and DEM data are available for viewing and download on the GIS Experience in the Resiliency & Risk Map layer, titled “Contours (2024),” and “Digital Elevation Models (2024),” respectively.

3.2 PUBLICLY AVAILABLE GIS DATA

The Project Team utilized several publicly available GIS databases to supplement the project. The databases included:

- Milwaukee County Land Information Office - [Interactive Map](#)⁴
 - Parcel data;
 - LiDAR contour data; and
 - Historic orthoimagery.
- The Association of State Floodplain Managers (ASFPM) Flood Science Center – [Wisconsin Shoreline Inventory and Oblique Photo Viewer](#)⁵
 - Historic oblique imagery; and
 - Bathymetry profiles.
- Wisconsin Department of Natural Resources (WDNR) - [Surface Water Data Viewer](#)⁶
 - Mapped wetland data.
- National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management - [Digital Coast Data Access Viewer](#)⁷
 - LiDAR contour data; and
 - Orthoimagery.

3.3 PUBLICLY AVAILABLE SOIL AND GEOTECHNICAL DATA

The Project Team reviewed and utilized publicly available geotechnical data for assessing the bluff stability where GZA’s in-house geotechnical sources were not available. The data utilized included the following:

⁴ Available at: <https://apps.geocortex.com/webviewer/?app=00d9853f922845a5841e0123918a449a>.

⁵ Available at: <https://floodscience.maps.arcgis.com/apps/instant/minimalist/index.html?appid=c47ab45bb8c046e099a46df28837ca88>.

⁶ Available at: <https://dnrm.wi.gov/H5/?Viewer=SWDV>.

⁷ Available at: <https://coast.noaa.gov/dataviewer/#/>.



- Edil and Mickelson, 1995. *Overconsolidated Glacial Till in Eastern Wisconsin*. Transportation Research Record No. 1479, Pg. 99. National Academy Press, 1995.
- Singh et al, 1983. *A Study of The Geotechnical Properties of Milwaukee Area Soils*. ASCE [American Society® of Civil Engineers] Geotechnical Engineering Division. October 17-19, 1983.
- Southeast Wisconsin Regional Planning Commission (SEWRPC), 1988. *A Lake Michigan Shoreline Erosion Management Plan for Northern Milwaukee County Wisconsin, Community Assistance Planning Report No. 155*. SEWRPC. December 1988.
- SEWRPC, 1989. *A Lake Michigan Shoreline Erosion Management Plan for Milwaukee County Wisconsin, Community Assistance Planning Report No. 163*. SEWRPC. October 1989.
- SEWRPC, 1995. *Lake Michigan Shoreline Recession and Bluff Stability In Southeastern Wisconsin: 1995, Technical Report No. 36*. SEWRPC. December 1997.

3.4 PEDESTRIAN RECONNAISSANCE/FIELD VISITS

The Project Team conducted targeted field visits to assist with refining and verifying the condition and vulnerability rankings along the bluffs. Evaluating potential high-risk areas or areas that were obscured from the Drone reconnaissance were the primary objective during these field visits. GZA also documented revetment stone sizes, beach grain sizes, and existing structure conditions.

Big Bay Park could not be accessed for a field visit due to ongoing construction on a collapsed utility in the neighboring Buckley Park.

3.5 COASTAL ENGINEERING ANALYSIS

GZA conducted a coastal engineering analysis and basis of design for the project areas identified during the project. Key elements of these analyses included historical high water levels, design water levels, offshore wave analyses, design storm recurrence interval, and beach material composition. GZA published a Coastal Analysis and Basis of Design Report, dated May 30, 2025, supplementary to this Report, summarizing the analyses performed in greater detail. The Coastal Analysis and Basis of Design Report also serves as a basis for design for the various coastal structures recommended herein.

3.6 GEOTECHNICAL BORINGS AND LABORATORY TESTING

As part of the allowance work for the project, the Project Team conducted a series of five geotechnical soil borings (BAYVIEW-SB-01, BAYVIEW-SB-01A, SHERIDAN-SB-02, SHERIDAN-SB-03, and WARNIMONT-SB-04) at identified potential high-risk areas in Bay View, Sheridan, and Warnimont Parks. The locations of the borings were determined based on the resiliency and risk analysis performed as part of this project and are discussed in detail later in this Report. Borings were advanced to depths of 60 to 90 feet below ground surface (bgs) to terminate below the Lake Michigan water level. Select soil samples collected during the subsurface exploration were submitted for additional lab testing to better refine the conceptual repair designs for the respective boring areas. Details regarding the soil borings and associated laboratory testing are provided in **Section 6.0**. Locations of the borings are provided in **Figures 2 and 3**.

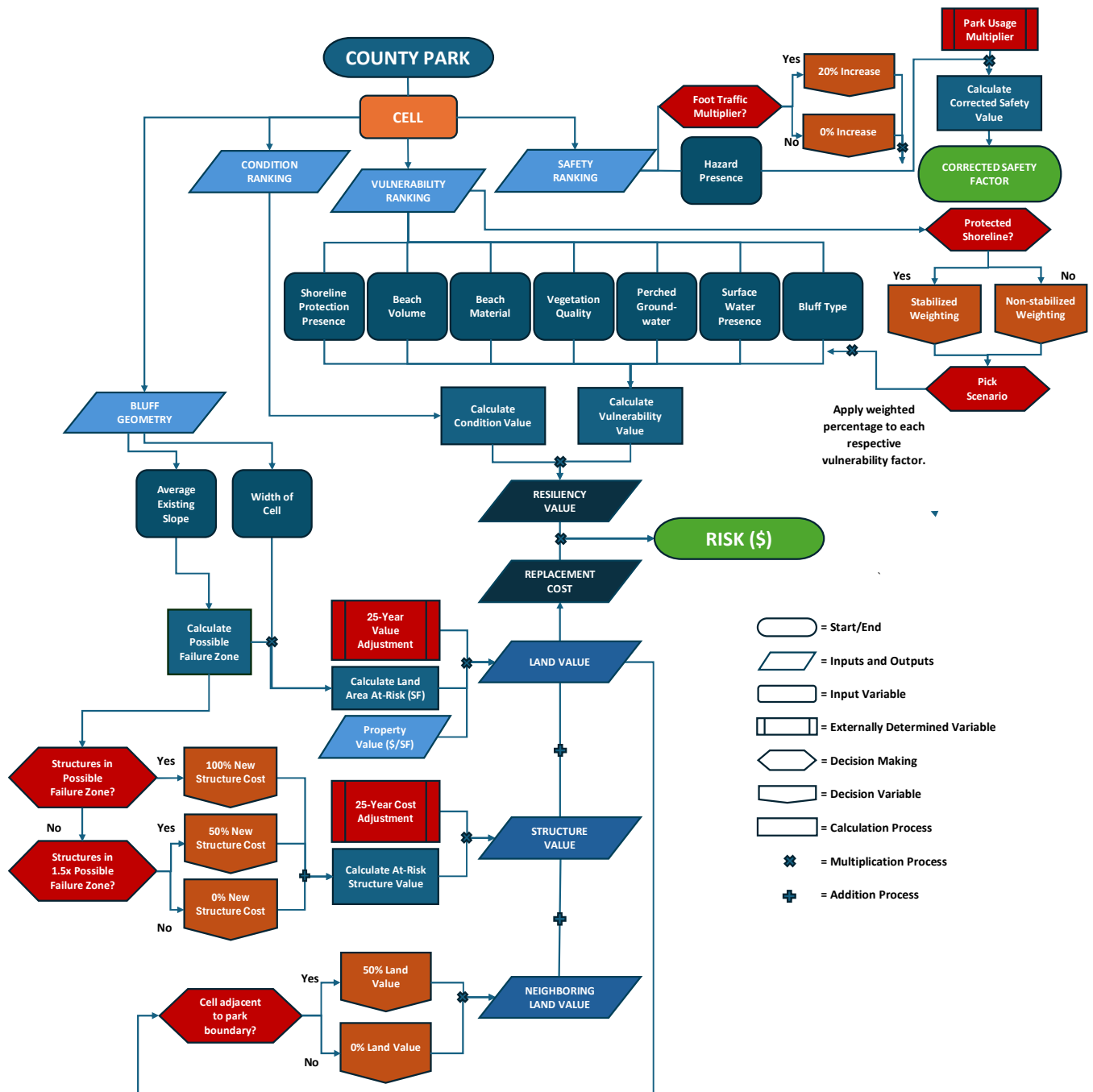


3.7 IN-HOUSE EXPERIENCE

GZA has completed numerous projects on the western shoreline of Lake Michigan. In doing so, GZA has compiled an internal library of coastal and geotechnical data in the County and other neighboring counties. During this project, we relied on that experience and data to make some recommendations where other types of data may not have been available or useful.

4.0 RANKING AND ANALYSIS METHODOLOGY AND RESULTS

To better assess the County bluffs and prioritize potential project areas, the Project Team developed a project-specific methodology for ranking bluff condition, vulnerability, and safety. Due to the highly variable nature of the bluffs and shoreline, the Project Team assessed the parks in 100- to 200-foot Cells. GZA assigned condition and vulnerability rankings based on the observations and experiences detailed in **Section 3.0**. Using the product of numerical values of the condition and vulnerability rankings, a resiliency value was obtained. The resiliency value was then multiplied by the replacement cost for land, structures, and neighboring property to obtain the risk value for that Cell. This methodology is simplified in the flow chart below and further detailed in the following subsections.



To determine prioritization of bluff repair projects, the Project Team utilized the calculated resiliency and risk values. Due to the assessment process, these values are subjective. When possible, the Project Team attempted to use quantitative data to determine condition and vulnerability scores. There is some degree of subjectivity in the ranking given the natural variability in the soils, vegetation, and various other materials that make up and influence the bluffs' stability. The rankings assigned were based on our experience performing work on the County bluffs and the need to account for the County's priorities.



Because Linnwood Revetment is not a bluff slope, this methodology was not utilized to evaluate that park/structure. Instead, the Project Team utilized the methodology developed and performed by GZA, as reported in the *Milwaukee County Coastal Assets Inventory and Assessment Report*, dated August 25, 2020.⁸ The results of the Linnwood Revetment assessment are discussed and presented separately.

GZA provided a separate spreadsheet file summarizing the analysis inputs and equations for each park to the County as part of our project deliverables package. PDF tables of the condition, vulnerability, and various other inputs are provided in **Appendix B**.

4.1 CONDITION RANKING

The Project Team defined the current condition of the bluff Cells based on a scale of typical qualitative, visually assessed bluff conditions observed in the County. The rankings included A, B, C, D, and F, which were assigned numerical values of 0.2, 0.4, 0.6, 0.8, and 1.0, respectively. The more stable (A-rank) existing condition is represented by a lower value (0.2) and is indicative that the bluff is generally in a better condition. The following ranking system was used to define the bluff conditions:

Table 4-1. Bluff Condition Rankings

Rank	A	B	C	D	F
Value	0.2	0.4	0.6	0.8	1.0
Descriptor	Visually stable	Marginally stable, minor vegetation disturbance	Marginally stable, initial signs of instability and/or vegetation disturbance, toe erosion	Visually unstable, significant toe erosion or tension cracking	Actively failing

4.2 VULNERABILITY RANKING

Many factors can contribute to bluff vulnerability to future erosion and instability. For this project the Project Team defined and quantified vulnerability using seven factors:

1. Coastal Protection Presence;
2. Beach Volume;
3. Beach Material;
4. Vegetation Quality;
5. Perched Groundwater Presence;
6. Crest Proximity to Surface Water and Wetlands; and
7. Bluff Type.

Three of these factors (Coastal Protection Presence, Beach Volume, Beach Material) are coastal related and the remaining four are land (geotechnically) related.

The seven vulnerability factors identified were ranked at each bluff Cell on a scale of A, B, C, D, and F with numerical values of 0.2, 0.4, 0.6, 0.8, and 1.0, respectively. The individual vulnerability factor values were also assigned a weighted percentage before being summed together to produce an aggregate score for vulnerability. The weighting varied based

⁸ *Milwaukee County Coastal Assets Inventory and Assessment Report, Lake Michigan Shoreline, Milwaukee County, Wisconsin Project No. 5741-19805*, dated August 25, 2020, GZA File No. 20.0156562.00.



on three different scenarios modeled: 1) GZA Recommended; 2) High Water Levels; and 3) Control Scenario. Tables showing the vulnerability ranking system and weighting are provided below.

$$Vt = \sum Vf_i \times P_i \text{ where } \sum P_i = 1$$

VULNERABILITY = SUMMATION OF (FACTOR VULNERABILITY VALUE_i x WEIGHTED PERCENTAGE_i)

V_{f_i} = Individual vulnerability factor value.

P_i = Weighted percentage assigned to respective, individual vulnerability factor.

V_t = Summation of the seven vulnerability factors adjusted for weighting.

Table 4-2. Bluff Vulnerability Rankings

Rank	A	B	C	D	F
Value	0.2	0.4	0.6	0.8	1.0
Vulnerability Factor	Descriptor				
<u>Coastal Protection Presence</u>	Well protected or armored shoreline	Protected by offshore breakwater	Indirectly protected by nearby structures, including large beach and concrete riprap	Unprotected	Unprotected and south of existing coastal protection
<u>Beach Volume</u>	Greater than 60,000 CF ¹	45,000 to 60,000 CF ¹	30,000 to 45,000 CF ¹	15,000 to 30,000 CF ¹	0 to 15,000 CF ¹
<u>Beach Material</u>	Cobbles and gravel	Gravel and sand	Sand	Silty sand with exposed clay	Clay or no beach
<u>Vegetation Quality</u>	Fully vegetated with native species	Fully vegetated with invasives or non-native species	Partially vegetated with fallen/tilted trees present	Trace vegetation, grasses mostly, some exposed soil, fallen/tilted trees prevalent	Unvegetated, exposed soil
<u>Perched Groundwater Presence</u>	No seepage/flows observed, granular layers not observed	Thin (<2 feet), dry granular layers observed	Large (>2 feet), dry granular layers observed	Signs of flows observed	Active seepage and/or flows observed
<u>Crest Proximity to Surface Water/Wetlands</u>	Wetlands or surface water not observed	Surface water or wetland observed within 100 feet	Surface water or wetland observed within 50 feet	Surface water, wetland, or storm outlet observed on slope	Wetlands overflowing crest and onto slope
<u>Bluff Type</u>	Graded or reinforced	Landscaped	Natural	N/A	N/A

Notes:

1. CF = Cubic feet.



Table 4-3. Vulnerability Weighting

		Weighted Percentage (Non-Stabilized Shoreline)			Weighted Percentage (Stabilized Shoreline)		
Scenario Number		1	2	3	1	2 ¹	3
Vulnerability Factor	Coastal Protection Presence	25%	50%	14%	0%	0%	0%
	Beach Volume	18%	33%	14%	0%	0%	0%
	Beach Material	4%	17%	14%	0%	0%	0%
	Vegetation Quality	7%	0%	14%	30%	0%	25%
	Perched Groundwater Presence	14%	0%	14%	20%	0%	25%
	Crest Proximity to Surface Water/Wetlands	11%	0%	14%	10%	0%	25%
	Bluff Type	21%	0%	14%	40%	0%	25%

Notes:

1. High water level prioritization did not apply to stabilized shorelines.

For shorelines where permanent, engineered protection or stabilization measures were in place, the coastal related factors related to the shoreline or Lake Michigan water levels (Coastal Protection Presence, Beach Volume, and Beach Material) were disregarded (0% weighted) and weighted percentage was reassigned to other factors. This was done to account for the presence of a stabilized shoreline while still evaluating vulnerability associated with land-based factors.

4.3 SAFETY RANKING

The Project Team evaluated safety on the bluffs using a custom ranking system similar to the condition and vulnerability ranking systems; however, safety rank was not used as a factor contributing to the resiliency and risk analysis. Hazard presence related to safety near the bluff slope was ranked on a scale of A, B, C, D, and F with values of 0.2, 0.4, 0.6, 0.8, and 1.0, respectively and as defined in the table below.

Table 4-4. Bluff Hazard Presence Rankings

Rank	A	B	C	D	F
Value	0.2	0.4	0.6	0.8	1.0
Descriptor	No hazards identified	Barricade present, slip/trip/fall hazard present, self-arrest likely possible	No barricade present, slip/trip/fall hazard present, self-arrest likely possible	Barricade present, fall from height or unstable ground hazards present, self-arrest likely not possible	No barricade present, fall from height or unstable ground hazards present, self-arrest likely not possible

The rankings were assigned to bluff Cells based on the lowest ranked area within that section. Therefore, safety rankings may only apply to a small portion or portions of the bluff Cell if a potentially unsafe portion(s) was identified.

Next, using the analyzed park's visitation data and geometry, a "Park Usage Multiplier" was applied to the ranking value to create a corrected safety value and ranking. This unitless Park Usage Multiplier was defined by the equation below and was meant to serve as a way to represent the probability that an individual visiting the park is near the bluffs or shoreline relative to the other parks.

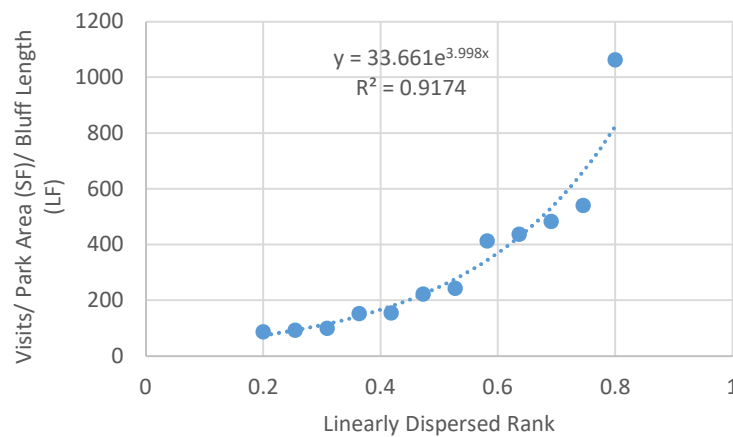


Table 4-5. Park Usage Multipliers

Park Name	Visits per Shoreline Length per Park Area (Visits/Foot)	Park Usage Multiplier ¹
Doctors	106	0.28
Big Bay	122	0.31
Linnwood Revetment	N/A	N/A
Bradford	1,452	0.84
McKinley	369	0.55
Juneau/Veterans	732	0.70
Cupertino	244	0.46
South Shore	1,275	0.81
Bay View	149	0.36
Sheridan	232	0.45
Warnimont	95	0.26
Grant	457	0.60
Bender	153	0.36

Notes:

1. Based on the trend line equation $M = 33.661e^{3.998x}$ where “M” is the park usage multiplier and “X” is linearly dispersed, ranking values correlated to the rankings of visits per shoreline length/area set to range from 0.2 to 0.8. See graph below.



Lastly, a multiplier of 125% was added to areas of concentrated traffic on the bluff slopes. The Project Team determined concentrated traffic areas based on our on-Site observations and generally applied to official and unofficial paths and stairs that direct visitors to the bluff crest or down the bluff slope. This factor is adjustable in the summary spreadsheet that was provided to the County and can be changed to weight concentrated traffic areas more or less than the 125% factor utilized by the Project Team. The results of the safety ranking analysis are provided in the lower right panel of the “Comparison Tool” page on the GIS experience and are also presented in **Appendix C** in the “Resiliency Rank, Scenario S” column. The Project Team’s recommendations on how the County should use the safety rankings are discussed in **Section 8.4**.



4.4 RESILIENCY

As previously discussed, resiliency is numerically defined by the product of the current condition and the vulnerability of the bluffs. In nonnumerical terms, the Project Team defined resiliency as the ability of the assessed feature to resist or recover from further degradation. For bluffs with low vulnerability and that are in good condition, a resulting resiliency score will be high, reflecting the low potential in degradation from its current condition, or relatively low costs associated with repair. Conversely, a bluff with current signs of instability and a similar vulnerability will have a lower resiliency due to the greater chance of destabilization on account of the current instability. Therefore, higher calculated resiliency values are representative of low resiliency by definition and vice versa for low resiliency values.

A color-coded map showing the resiliency ranks and values for each bluff Cell is provided in the GIS Experience on the “Resiliency & Risk Map” page, and can be turned on and off in the “Analysis” layer. Clicking on individual Cells will display the condition and vulnerability rankings that went into producing the resiliency rank for that Cell. The Resiliency & Risk Map displays the GZA-Recommended vulnerability weighting by default. To view other weighted scenarios, the user should refer to the “Comparison Tool” page. The resiliency calculation results are also provided in **Appendix C**.

To assist with comparing resiliency of the bluff Cells, resiliency values for individual bluff Cells were ranked and color coded, as shown in the following table.

Table 4-6. Resiliency Value Ranking and Color Coding

Rank	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
Value	<0.067	0.133	0.200	0.267	0.333	0.400	0.467	0.533	0.600	0.667	0.733	>0.733
Color Code												

4.5 RISK

For this project, risk is numerically defined as an estimated replacement cost dollar value multiplied by the calculated resiliency of the bluff in that Cell. In nonnumerical definition, risk is the expected dollar cost associated with current bluff instability and potential future instability within that bluff Cell. To evaluate risk, the Project Team defined the replacement costs associated with bluff instability on the County bluffs. Three general replacement costs were identified: 1) Land Value; 2) Structure Value; and 3) Neighboring Land Value. These replacement costs and the Project Team’s methodology for evaluating them are discussed in the following subsections.

A color-coded map showing the risk values for the bluff Cells is provided in the GIS Experience on the “Resiliency & Risk Map” page, and can be turned on and off in the “Analysis” layer. Clicking on individual Cells will display the individual replacement costs and resiliency rankings that went into producing the risk value for that Cell. The Resiliency & Risk Map displays the GZA-Recommended vulnerability weighting by default. To view risk for other weighted scenarios the user should refer to the “Comparison Tool” page. The replacement cost and risk calculation results are also provided in **Appendix C**.

To assist with comparing risk of the bluff Cells, risk was assigned to categories ranging from low, low-moderate, moderate, moderate-high, and high risk. These categories were set to include the risk values and color coding shown in the following table.

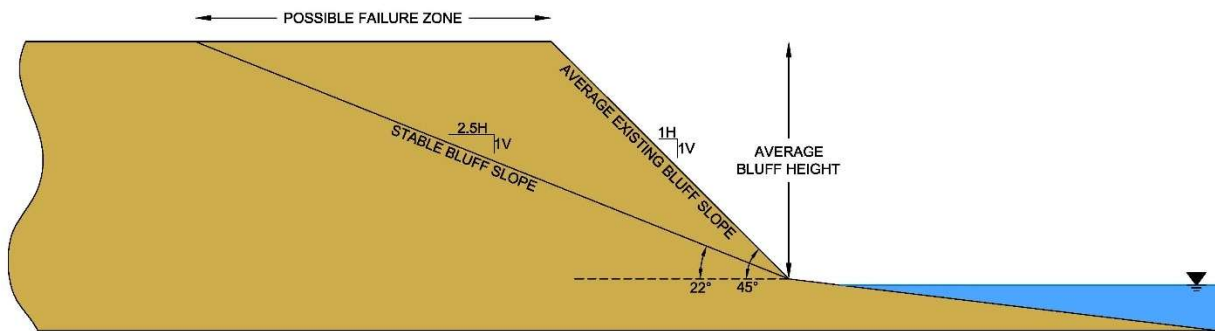
Table 4-7. Risk Category, Value, and Color Coding

Risk Descriptor	Low	Low-Moderate	Moderate	Moderate-High	High
Risk	<\$25,000	\$25,000 - \$100,000	\$100,000 - \$250,000	\$250,000 - \$500,000	>\$500,000
Color Code					



4.5.1 Replacement Cost: Land Value

To determine the value of land that could be lost due to slope failure or movement, the Project Team compared the average existing slope of the bluff Cell to the steepest, typically stable slope of 2.5H [Horizontal]:1V [Vertical] in Milwaukee County. It should be noted that slopes shallower than 2.5H:1V may still experience failure; however, such failures would likely require a series of unlikely events to occur simultaneously. Additionally, slopes steeper than 2.5H:1V may remain stable in particular circumstances, such as soils with greater than average cohesion or internal friction angles. Average slopes of the Cells were determined using “zonal statistics” in GIS taken from the digital elevation models that were developed by the Project Team. The GIS tool reported the average gradient (slope) of the grid points within the bluff Cell as a percent slope. Using this methodology, a “Possible Failure Zone” was established. Taller bluffs with steeper slopes had larger Possible Failure Zones, therefore, more land value was at risk than smaller bluffs with more gradual slopes that had smaller Possible Failure Zones. Slopes already less steep than 2.5H:1V were given a Possible Failure Depth of 1-foot to account for possible surface erosion.



$$\text{POSSIBLE FAILURE ZONE} \times \text{SECTION LENGTH} = \text{AT-RISK LAND AREA}$$
$$\text{AT-RISK AREA} \times \text{25-YEAR ADJUSTED LAND VALUE} = \text{AT-RISK LAND VALUE}$$

The land area at risk was multiplied by the average typical land values of properties adjacent to the parks. Property land values were obtained from publicly available tax assessment data. However, because assessed land values are not always representative of market land values, an assessment ratio (assessed value/market value) of 90% was utilized to adjust the current assessed land values to more accurately reflect market values. Additionally, the Project Team also applied a 2.6% property value increase on an annual compounding basis to correct property values to a 25-year future value. The increase of 2.6% was utilized based on a 20-year average, 4.9% increase year-over-year (YOY) of the single-family home price index in Wisconsin⁹ minus the 20-year breakeven inflation rate of 2.3%.¹⁰ The Client can adjust these percentages as it sees fit in the provided Excel workbook. A 25-year adjusted value was utilized because 25 years is the midpoint of the 50-year design life of this project. The current and 25-year adjusted land values for the County parks evaluated are provided in the table below. The Project Team utilized the 25-year adjusted land values in our analyses.

⁹ FHFA, 2024. *House Price Index Data Sets*, April 2004 to April 2024 Milwaukee WI, Adjusted for Seasonal Variation; Federal Housing Finance Agency [FHFA]; <https://www.fhfa.gov/data/hpi/datasets?tab=quarterly-data>; July 2024.

¹⁰ FRED, 2024. *20-Year Breakeven Inflation Rate (T20YIEM)*, September 2024. <https://fred.stlouisfed.org/series/T20YIEM>. Federal Reserve Bank of St. Louis. September 2024.



Table 4-8. Current and 25-Year Adjusted Land Values

Park	Current Land Value (\$/SF)	25-Year Adjusted Land Value (\$/SF)
Bay View Park	\$18.28	\$34.74
Big Bay Park	\$22.64	\$43.01
Sheridan Park	\$11.96	\$22.72
Warnimont Park	\$15.43	\$29.31
Bradford/Lake Parks	\$38.46	\$73.06
McKinley Park	\$34.12	\$64.82
Bender Park	\$12.97	\$24.63
Cupertino Park	\$15.31	\$29.09
Doctors Park	\$22.02	\$41.82
Grant Park	\$12.25	\$23.27
South Shore Park	\$25.41	\$48.27
Juneau/Veterans Parks	\$100.69	\$191.27

Notes:

1. \$/SF = dollars per square-foot.

4.5.2 Replacement Cost: Structure Value

The replacement costs of structures or infrastructure adjacent to the bluff slopes were implemented into the overall replacement cost value when located within the Possible Failure Zone. Additionally, 50% of the replacement cost of the structure or infrastructure was applied if located within 1.5 times the Possible Failure Zone. Values of structures and infrastructure located adjacent to or on the bluff slopes were determined using publicly available data,¹¹ RS Means® construction cost data, and the Project Team’s experience with projects on the Lake Michigan shoreline. The Project Team also applied a 1.8% construction replacement cost increase on an annually compounding basis to normalize replacement costs to a 25-year future value. A 1.8% multiplier was utilized based on a 15-year average of 4.1% YOY increase of construction costs in the Milwaukee market¹² minus 2.3% for breakeven inflation rate. The replacement values utilized in our analysis are provided on the following table.

Table 4-9. Current and 25-Year Adjusted Structure Values

Structure	Current Structure Value	Unit	25-Year Adjusted Structure Value	Unit
Bike/Walking Path	\$70	LF	\$109	LF
Structure - Single Family	\$500,000	EA	\$781,024	EA
Structure - Multi-Story High Rise	\$8,000,000	EA	\$12,496,386	EA
Public Road (2 lane, asphalt)	\$280	LF	\$437	LF
Private Road	\$150	LF	\$234	LF
Revetment	\$2,500	LF	\$3,905	LF

¹¹ Milwaukee County, 2020. *Milwaukee County Coastal Resources Inventory*. Milwaukee County, Environmental Services Unit; Milwaukee, WI; October 7, 2020.

¹² Mortenson, 2024. *Milwaukee, Construction Cost Index Q2 2024*, June 2009 to June 2024 (2020 Removed due to COVID19); <https://www.mortenson.com/cost-index/milwaukee>; Mortenson Construction; July 2024.



Structure	Current Structure Value	Unit	25-Year Adjusted Structure Value	Unit
Historic Concrete Stairs	\$150	SF	\$234	SF
Parking Lot	\$75	SF	\$117	SF
Storm Water Outfall Repair	\$500,000	EA	\$781,024	EA
Intake Structure Repair	\$1,000,000	EA	\$1,562,048	EA
Wooden Stair Access	\$700	LF	\$1,093	LF
Underground Utilities	\$2,000	LF	\$3,124	LF
Sheet Piling (15' exposed, w/ tiebacks)	\$2,700	LF	\$4,218	LF
Storage Structure (County Owned)	\$260,000	EA	\$406,133	EA
Concrete Seawall	\$2,690	LF	\$4,202	LF
Short Pile-Lagging Seawall	\$1,000	FL	\$1,562	LF

4.5.3 Replacement Cost: Neighboring Land Value

Because bluff slope movement on one property can affect structures and land on another property, the Project Team included replacement cost value for at-risk land and structures from neighboring properties into the bluff Cells adjacent to park property boundaries. This additional value was implemented by adding the land value of 50% of the Possible Failure Zone from a 200-foot section of bluff on the adjacent property. Neighboring structure values within this area were also included for these bluff Cells.

5.0 PROJECT AREAS AND CONCEPT NARRATIVES

Using the results of the resiliency and risk analysis, the Project Team identified 25 project areas across the County parks. Project areas were chosen for having high risk potential, low resiliency rank, low safety rank, and/or for general improvement of the selected area. Multiple Concepts were then developed for the project areas. Narratives for the project areas and Concepts are included below and are also summarized on the “Project Areas and Concepts” page on the GIS Experience. A table summarizing the project areas and Concepts is included in **Appendix D**. A plan set for the project areas and Concepts was provided separately as the Concept Plan Set previously, discussed herein. Additional details regarding slope grading, preloaded beach cells, native vegetation, slope safety measures, and permitting are discussed in **Section 7.0**.

5.1 PROJECT AREA 1 - DOCTORS PARK (STA 8+00 TO 12+50)

Project Area 1 is located on the Doctors Park shoreline and has a resiliency rank of “B” and moderate risk due to ongoing erosion and degradation of a metal seawall structure at the toe of the existing bluff slope. The existing metal, pile, and lagging seawall has a condition ranking of “C” and was damaged in several locations at the time of the Project Team’s Site visit. Project Area 1 was chosen as a proactive measure to mitigate the initial signs of increased instability within an area that has been generally stable. The Concepts evaluated by the Project Team are focused on improving the shoreline protection of Project Area 1 and would likely require construction via barge due to the difficult access from the bluff slope.



5.1.1 Concept 1: Construct Backshore Revetment

Concept 1 for Project Area 1 includes removal of the existing seawall, restructure and replacement with a low-crested, backshore revetment along the existing bluff toe. This Concept is considered the “greener” of the two Concepts evaluated and could be buried in sand to hide its presence during periods of average to low water level.

5.1.2 Concept 2: Perform Armor Stone Groin Improvements

Concept 2 for Project Area 1 recommends groin structure improvements to two existing groins and construction of one additional groin structure within the vicinity of the project area. The two existing groin structures have structure condition rankings of “F” and improvements to the structures would include removal and replacement of dilapidated portions of the concrete blocks and/or addition of stone to enhance sediment retention during larger storm events. For these improvements, the Project Team also recommended preloading the groin cells with imported sand to mitigate the potential for downcutting of the nearshore lakebed adjacent to the groins.

5.2 PROJECT AREA 2 - DOCTORS PARK (STA 0+00 TO 2+00)

Project Area 2 is located on the Doctors Park shoreline and includes an adjacent ravine that extends west from the shoreline, up the bluff slope, near the existing south boundary of the park. Concepts prepared for Project Area 2 are focused on improving shoreline protection and mitigating ongoing erosion within the existing ravine. The area was identified as having a resiliency rank of “D+,” primarily due to ongoing erosion on the shoreline. Project Area 2 has a low risk due to lack of proximity to existing structures and relatively stable adjacent slope; however, a residential structure, located off North Beach Drive, is also near the ravine and may become affected by the ravine if erosion continues. Due to the project area’s proximity to the residential neighbor, additional coordination and access agreements may be required for ravine repairs. The following Concepts were evaluated for Project Area 2 and both Concepts would likely require construction via barge. Limited access may be available via the area near the top of the ravine off East Fox Lane, but would require additional evaluation.

5.2.1 Concept 1: Install Ravine Reinforcement and New Armor Stone Revetment

For Concept 1 in Project Area 2, the Project Team recommends regrading and reinforcing the existing ravine using various channel stabilization methodologies. The various methodologies for reinforcing the ravine vary from “greener” to “grayer,” but additional evaluation from a civil engineer with stormwater management experience will be required to better determine which methodologies are most feasible. Additionally, the Project Team evaluated construction of a new armor stone revetment along the existing shoreline. Due to the current, recessed condition of the shoreline, the revetment would have minimal impact on the surrounding area.

5.2.2 Concept 2: Install Ravine Reinforcement with Groin Improvements and Backshore Revetment

Concept 2 for Project Area 2 utilizes a similar repair for the ongoing ravine erosion that was evaluated for Concept 1. Additionally, the Project Team evaluated utilizing groin improvements and construction of a backshore revetment for protection of the project area shoreline. Groin improvements would consist of reconstruction of one decayed groin structure, with a structure condition ranking of “F,” that is largely submerged in Lake Michigan near the park’s southern property boundary. The new groin cell should be preloaded with imported sand material to minimize impacts on the surrounding shoreline. Groin improvements would allow for a smaller, backshore revetment to be constructed instead of the armor stone revetment recommended in Concept 1.



5.3 PROJECT AREA 3 - BIG BAY PARK (STA 6+75 TO 14+00)

Project Area 3 is located at Big Bay Park and includes an existing, concrete bulkhead and the bluff crest of the park. Project Area 3 slopes have an average resiliency rank of “C+” and a moderate-high risk due to the replacement value of the bulkhead at the toe of the slope. The existing bulkhead has a condition ranking of “B” based on good condition of the concrete and observed signs of significant overtopping erosion. Isolated areas of the bluff crest also showed signs of ongoing erosion caused by surface water runoff and foot traffic. Because Project Area 3 has also shown a lack of beach recovery since the high water levels of 2020, the goal of the recommended repairs would be to protect the shoreline from further destabilization and erosion above the existing bulkhead. Based on the existing conditions and geometry, the recommended Concepts would likely be performed via barge.

5.3.1 Concept 1: Install Overtopping Protection and Bulkhead Reinforcement

For Concept 1 in Project Area 3, the Project Team recommends riprap overtopping protection above the existing concrete bulkhead. Additionally, a small section of armor stone revetment and the addition of large toe boulders at the base of the bulkhead were recommended to reinforce the existing bulkhead. We recommend that the slope crest be considered for establishing a buffer area of native vegetation and an invasive species management area to promote successful growth of native species. A professional ecologist should be consulted to provide additional Site-specific details regarding native species planting and maintenance and invasive species management.

5.3.2 Concept 2: Perform Groin Maintenance and Construct Additional Armor Stone Groins

Concept 2 at Project Area 3 utilizes groin maintenance and additions of new groin structures to reduce wave energy along the park’s shoreline. The repair would include the addition of three groin structures and maintenance/repairs to one existing groin structure (structure condition rank “B”). We recommend that the new and repaired groin structures be preloaded with imported sand material to mitigate the potential for downcutting of the adjacent nearshore. Preloaded groins would also enhance the usability of the lakefront at Big Bay Park by increasing the beach presence. Additionally, Concept 2 would implement the large toe boulder reinforcement and a native vegetation program like those recommended in Concept 1.

5.4 PROJECT AREA 4 - LINNWOOD REVETMENT (STA 12+40 TO 28+00)

Project Area 4 includes the north section of the existing Linnwood Revetment in Lake Park. This section of the existing revetment is in generally poor condition with an average structure condition rank of “D” and generally low risk related to the consequence of revetment failure. Some areas of the revetment show signs of washout and overtopping behind the existing revetment. In general, the existing armor stone material at Project Area 4 is too large and contains significant void spaces with little to no filter layer below the armor stone layer. These void spaces allow for the migration of material from behind the revetment into the lake. The Concept prepared for Project Area 4 focuses on improving shoreline protection of the area.

5.4.1 Concept 1: Perform Maintenance of Existing Armor Stone Revetment

Concept improvements at Project Area 4 are limited to coastal structure maintenance and native vegetation plantings. The Project Team evaluated a Concept that includes the addition of geotextile and additional filter material landward of the existing revetment. New armor stone sizes are also recommended for the revetment. Additionally, this Concept would reutilize existing oversized armor stone to add a row of toe boulders across the project area extent. Lastly, we recommend that a native vegetation buffer area be established near the crest of the revetment to establish a deep-rooted zone to



better withstand revetment overtopping, if experienced. This Concept could be constructed from the shoreline as access appears to be available.

5.5 PROJECT AREA 5 - LINNWOOD REVETMENT (STA 2+00 TO 5+25)

Project Area 5 includes the southern section of the existing Linnwood Revetment adjacent to Bradford Beach that forms an eroded headland. This section of the revetment is in generally poor to failing condition with an average structure condition rank of “F” and moderate risk related to the consequence of revetment failure related to the presence of Bradford Beach south of the headland. The revetment in Project Area 5 predominantly consists of concrete rubble and the Project Team observed significant signs of shoreline erosion. The Concepts proposed for Project Area 5 are focused on improving shoreline protection and should be constructable from land, as the area is accessible from North Lincoln Memorial Drive.

5.5.1 Concept 1: Install New Armor Stone Revetment

For Concept 1 at Project Area 5, the Project Team recommends the construction of a new armor stone revetment along the existing shoreline alignment. This revetment should mitigate the ongoing erosion at the Linnwood headland to slow shoreline recession rates in that area. The recommended revetment would consist of geotextile, filter stone, armor stone, and toe boulders and have a standard revetment construction methodology. Permitting for this option may be less demanding as compared to Concept 2, since the proposed revetment alignment would follow closer to the existing shoreline to minimize quantities of fill on the lakebed. Removal of existing vegetation may be required to facilitate revetment construction.

5.5.2 Concept 2: Reconstruct Headland and Install Armor Stone Revetment

The Project Area 5, Concept 2 design includes a similar revetment construction to that recommended in Concept 1; however, with Concept 2, the Project Team also recommends reconstruction of the headland to roughly match its shape in 2000. Since 2000, the headland has recessed over 50 feet from its original extent eastward into Lake Michigan. The new revetment would then wrap around the perimeter of the restored headland to mitigate the potential for future headland recession. Restoring the headland would have the added benefit of improving sand sediment retention at Bradford Beach and enhancing the resiliency of the beach area. Permitting for this Concept may be challenging due to fill placement on the lakebed.

5.6 PROJECT AREA 6 - BRADFORD/LAKE PARK (STA 12+00 TO 13+00)

Project Area 6 is located on the bluff slopes near Bradford Beach within Lake Park. The project area includes an informal trail that extends down the bluff slope and does not appear to have been constructed by the Milwaukee County Parks Department. The bluff slope has a resiliency rank of “A” and a low risk; however, it has a safety rank of “C-.” Park visitors appear to be using the area as a shortcut to access the Bradford Beach pedestrian bridge. The trail is steep and covered with roots. The Project Team also observed signs of erosion on the path. The Concepts prepared for Project Area 6 focused on improving safety in the area.

5.6.1 Concept 1: Abandon Access Trail and Install Barriers

Concept 1 for Project Area 6 implements the use of barriers to abandon the informal access trail. Barriers could be installed at the bottom and top of the trail to discourage use of the trail from either direction. Additionally, signage should be installed, along with the barriers, to discourage trail use and to highlight alternative access to the Bradford Beach pedestrian bridge.



5.6.2 Concept 2: Enhance Access Trail with Stairs and Landings

Concept 2 for Project Area 6 would formalize the existing trail by constructing stairs, landings, and handrails. The area would then be easier and safer for park visitors. Some removal of trees and vegetation may be necessary to facilitate construction and a structural engineer will be needed to design the stairs, landings, and foundations for the structure. Signage highlighting alternative handicap access should also be included as part of this Concept.

5.7 PROJECT AREA 7 - BRADFORD/LAKE PARK (STA 0+00 TO 4+50)

Project Area 7 is located on the bluff slopes near Bradford Beach within Lake Park. The project area includes an existing green space near where East Water Tower Road comes down the bluff to North Lincoln Memorial Drive from North Terrace Avenue. The area is outside of County property and is owned by the City of Milwaukee Water Works. The area has a resiliency rank of "A" and is low risk; therefore, the primary focus of the Concept prepared for Project Area 7 was to improve the visual appearance and ecological value of the area.

5.7.1 Concept 1: Coordinate Native Vegetation Trial Program

Project Area 7 has one Concept for implementing a native vegetation trial program in partnership with the City of Milwaukee Water Works. The native vegetation trial program would replace turf grass with native plant species, bio swales, and additional habitat improvement measures. Our concept includes additional locations for the recommended trial program at several other project areas herein. A professional ecologist, assigned to each trial area, would be needed to monitor the status of the area and to recommend a maintenance schedule. The results of the various trial programs could be used to implement additional native vegetation and natural restoration areas in the future. The area could also be used to train County and City of Milwaukee staff on how to observe and maintain native vegetation. Project Area 7 is also utilized by visitors as a hill running area, but erosion is starting to develop on that portion of the slope. The Concept also includes a recommendation for a reinforcement layer to mitigate the ongoing erosion.

5.8 PROJECT AREA 8 - MCKINLEY/JUNEAU/VETERANS PARKS (STA 20+50 TO 41+00 AND STA 0+00 TO 16+00)

Project Area 8 includes sections of the bluff slopes located in McKinley, Juneau, and Veterans Parks. The project area has resiliency ranks of "A-" or "A" and is generally low risk. The area is highly visible and one of the most frequented areas of the County parks system due to its location on the Oak Leaf Trail and proximity to downtown Milwaukee. The majority portion of the bluffs within this area currently belong to the various private landowners that have structures located along the bluff crest. During our Site visits, the Project Team noted that some of the adjacent landowners control invasive vegetation on their slopes by clear cutting. The existing vegetation may be of little ecological value; however, the vegetation does provide some protection to the bluffs. Additionally, the clear-cut areas are particularly unsightly. The Project Team developed one Concept for improving the visual and ecological values of the area, while also enhancing protection from surface erosion using deep-rooted, native vegetation.

5.8.1 Concept 1: Coordinate Native Vegetation Incentive Program

For Concept 1, the Project Team recommended developing a program to incentivize the adjacent private landowners to remove invasive species and revegetate their bluff slopes with deep-rooted native species and implement other habitat improvements. The County could work with the City of Milwaukee and other local entities to fund and spread awareness of the program. Additionally, establishing a community advocacy group for the area may also spread awareness and encourage participation in the program.



5.9 PROJECT AREA 9 - CUPERTINO PARK (STA 10+00 TO 13+00)

Project Area 9 is located on the bluff slopes in Cupertino Park. The project area includes an existing, wooded, green space near the north end of the park. The area has a resiliency rank of “A” and is low risk. The Concept prepared for Project Area 9 focuses on improving the visual and ecological values of the area.

5.9.1 Concept 1: Coordinate Native Vegetation Trial Program

The Concept for Project Area 9 involves the creation and implementation of a trial program to clear invasive species, trim existing trees, and plant native vegetation on the bluff slopes. As part of the trial program, the area may be used to design future larger, native vegetation programs at other parks or as an area to train staff on how to maintain and manage native vegetation. The trial program would enhance park views, appearance, and ecological diversity.

5.10 PROJECT AREA 10 - SOUTH SHORE PARK (STA 11+50 TO 27+00)

Project Area 10 is located on the bluff slopes in South Shore Park. The project area includes an existing wooded green space near the center of the park. The area has a resiliency rank of “A” and is low to moderate risk. The Concept prepared for Project Area 10 focuses on improving the visual and ecological value of the area.

5.10.1 Concept 1: Coordinate Native Vegetation Trial Program

The Concept for Project Area 10 involves the creation and implementation of a trial program to clear invasive species, trim existing trees, and plant native vegetation on the bluff slopes. As part of the trial program, the area may be used to design future, larger, native vegetation programs at other parks or as an area to train staff on how to maintain and manage native vegetation. The trial program would enhance park views, appearance, and ecological diversity.

5.11 PROJECT AREA 11 - BAY VIEW PARK (STA 17+00 TO 24+00)

Project Area 11 is located on the shoreline of Bay View Park, has resiliency ranks of “B+” to “A-,” and has moderate to low risk. The Project Team prioritized this area based on observations of initial signs shoreline erosion and proximity to an area that shows signs of significant shoreline erosion and bluff slope instability. The County provided the Project Team with conceptual plans for shoreline improvement prepared by Baird & Associates that include Project Areas 11 and 12.

5.11.1 Concept 1: Armor Stone Revetment Per Baird & Associates

Concepts for mitigating ongoing shoreline erosion at Project Area 11 are limited to construction of a revetment structure. The Project Team recommends proceeding with implementation of the plans prepared by Baird & Associates for Project Area 11.

5.12 PROJECT AREA 12 - BAY VIEW PARK (STA 0+00 TO 17+00)

Project Area 12 is located adjacent to Project Area 11 on the shoreline, bluff slope, and bluff crest of Bay View Park and has an average resiliency rank of “F” and high to moderate risk values. The high-risk area present in Project Area 12 is concentrated to the park’s southern boundary due to the presence of a sheet pile on the neighboring property that may be affected by the ongoing bluff instability. The Project Team observed a lack of shoreline protection, unstable bluff slopes, groundwater seepage, safety concerns, and erosion near neighboring assets at Project Area 12. Project Area 12 has a history of ongoing bluff recession, but has displayed a noticeable increase in recession rate since the South Shore



Breakwater rehabilitation project that occurred from 2007 to 2008. The Concepts outlined below for Project Area 12 focus on protecting the shoreline and improving slope stability to mitigate risk associated with the ongoing loss of park land.

The Project Team performed a geotechnical boring at Project Area 12 (BAYVIEW-SB-01) to provide additional soils information for the area. The results of the soil boring are discussed in **Section 6.0**.

5.12.1 Concept 1: Construct Revetment with Slope Grading, Native Vegetation, and Access Path

Similar to the Concept recommended for Project Area 11, Concept 1 for Project Area 12 recommends proceeding with the shoreline protection plans developed by Baird & Associates. However, due to the active bluff slope instability present in Project Area 12, slope grading is also recommended. Recommended grading includes cutting the slope at a 2.5 H: 1 V slope to achieve a more stable slope and would also include paths for access and benches for breaks in the slope. Additionally, the Project Team recommends the addition of native vegetation buffer areas near the regraded slope crest and the addition of riprap slope protection near the southern property boundary abutting the neighboring sheet pile wall. Communication with the south neighboring property may be necessary prior to implementation of grading mitigations.

5.12.2 Concept 2: Construct Revetment with Crest Grading, Native Vegetation, Lookout Area, and Barriers

Concept 2 for Project Area 12 reduces the grading quantity recommended in Concept 1 to focus on the crest portion of the bluff slope. The Project Team recommends an excavation of a 3H:1V slope at the crest of the slope to remove weight from the top of the slope. Performing grading of the bluff crest will increase the FoS of the bluff slope, but may not achieve a stable FoS. Additionally, the crest grading limits can be revised provided additional fill material to achieve a cut-fill balance for the construction of the revetment designed by Baird & Associates. The crest cutting should be performed prior to construction of the revetment to mitigate the potential for slope failures during the construction of the revetment. Concept 2 also includes installation of a native vegetation buffer area at top of the slope, barriers to improve safety, and a viewing area to allow park visitors to safely view the bluffs and shoreline. Riprap protection near the southern property boundary, similar to Concept 1, is also recommended.

5.13 PROJECT AREA 13 - BAY VIEW PARK (OFFSHORE BREAKWATER)

Project Area 13 is located on the Bay View Park offshore breakwater. This project area was intended as an alternative or supplemental repair related to the Concepts provided for Project Area 12; however, after discussing this Concept with the County, it was determined that no further evaluation was necessary. As such, no plan has been prepared as part of the Concept Plan Set.

The Concept discussed for Project Area 13 was focused on reducing the wave energy impacting the Bay View Park shoreline by improving the existing offshore breakwater structure. The existing offshore breakwater in Project Area 13 is low crested and has been damaged across its extent. The *Milwaukee County Coastal Assets Inventory and Assessment Report*, dated August 25, 2020, provides the Bay View Breakwater with condition and resiliency scores of "D."

5.14 PROJECT AREA 14 - SHERIDAN PARK (STA 41+00 TO 48+50)

Project Area 14 is present on the shoreline and bluff slope of Sheridan Park between East Allenton Avenue and East Armour Avenue. Project Area 14 resiliency ranks range from "B" to "F" and the area has moderate-high risk values. The Project Team observed signs of shoreline erosion, seepage, and corresponding bluff instability at Project Area 14. It is possible that this area of localized instability was caused/enhanced by the existing, dilapidated outfall structure present at the north edge of the unstable area. Due to having limited space near the crest of the slope, our recommended Concepts for Project Area 14 focus on slowing bluff crest recession by improving shoreline protection. Additionally, both Concepts would likely



need to be performed via barge due to the limited space available near South Sheridan Drive, and may require permits from state and federal agencies.

Due to Project Area 14's proximity to adjacent residential properties and the Oak Leaf trail, the Project Team elected to perform a geotechnical boring near the crest of the area (SHERIDAN-SB-02). A discussion of conditions encountered in the boring are provided in **Section 6.0**.

5.14.1 Concept 1: Install New Armor Stone Groins, Repair Existing Groins, and Install Barriers

Project Area 14, Concept 1 outlines improving shoreline stability by constructing two new armor stone groins and performing maintenance repairs on two existing concrete block groins (structure condition rankings of D- and F). The new and repaired groin beach cells would also be preloaded with sediment dredged from offshore sources to mitigate the potential for detrimental effects south of the project area. Additionally, installation of barriers at the top of the slope are also recommended. This Concept will not actively stabilize the bluff slope due to the presence of groundwater; however, the improved shoreline resiliency should also slow the bluff crest recession to mitigate risk associated with possible future slope movements.

5.14.2 Concept 2: Add Buttress Fill at Toe of Slope and Install Armor Stone Revetment

Concept 2 at Project Area 14 utilizes a buttress fill constructed at the toe of the slope along with an armor stone revetment and riprap slope protection to improve shoreline stability. Like Concept 1, a barrier is also recommended at the top of the slope to enhance safety. Compared to Concept 1, this concept increases the stability of the slope, while also increasing the stability of the shoreline. However, this alternative may have more of an impact on the lake since the filled lakebed area would be increased. Additional analyses may be required to determine if the new revetment will have an impact on the adjacent groin structures.

5.15 PROJECT AREA 15 - SHERIDAN PARK (STA 00+00 TO 21+00)

Project Area 15 includes a section of South Sheridan Drive and the bluff slopes/shoreline of Sheridan Park between East Munkwitz Avenue and East Pulaski Avenue. The average resiliency rank of the bluffs within Project Area 15 is "F" and the area's risk values range from moderate to high. This area of Sheridan Park consists of steep (up to 1H:1V slope), unstable bluff slopes with low-volume beaches. Relatively high bluff crest recession rates, likely influenced by the Sheridan Park groin field present north of the project area, have been observed. Project Area 15 slopes are currently encroaching on a section of South Sheridan Road giving the area some of the highest risk totals per Cell when compared to the other project areas. The crest of the bluffs within Project Area 15 are currently unsafe making repairs difficult to implement. Due to the bluff crest proximity to City of Cudahy property and the height of the bluff, grading of the bluff slope would be dangerous and cost prohibitive. Therefore, Concepts prepared by the Project Team focused on mitigating risk by abandoning assets within the area and slowing bluff crest recession via shoreline protection and deep rooted, native vegetation.

The Project Team performed a geotechnical boring at Project Area 15 (SHERIDAN-SB-03) to provide additional soils information for the area. The results of the soil boring are discussed in **Section 6.0**.

5.15.1 Concept 1: Remove Road and Perform Natural Restoration by Installing Barriers and Native Vegetation

Due to the cost and impact on the lakeshore associated with grading of the bluff slope within Project Area 15, the Project Team recommends Concept 1, including vacation and the removal of the section of South Sheridan Drive between East Munkwitz Avenue and East Pulaski Avenue. Additionally, a barrier and native vegetation buffer area could also be installed to close visitor access to the bluff crest. This Concept will require the cooperation and approval of the local authorities for



the abandonment of the recommended section of South Sheridan Drive. This Concept does not increase stability of the bluff slope and the bluff crest and shoreline will likely continue to recede; however, removal of the existing road and implementation of native vegetation reduces risk associated with the area and will slow the recession rate compared to the historical rate.

5.15.2 Concept 2: Remove Road and Perform Natural Restoration with Construction of Preloaded Armor Stone Groins

Concept 2 for Project Area 15 is the “grayer” of the two options recommended, as it includes the installation of seven armor stone groins, preloaded with sand sediment, to slow erosion at the toe of the existing slope. It also uses a similar approach to Concept 1 by vacating and removing the same section of South Sheridan Road and adding a native vegetation buffer area and barriers near the bluff crest. Additionally, this Concept recommended construction of parking lots at the north and south ends of the road abandonment to maintain the parking availability that South Sheridan Road provided. This repair option will not fully mitigate the potential for slope instability, as groundwater seepage is still prevalent on the slopes; however, the addition of the groins and beach cells will decrease the shoreline recession rate to be lower than Concept 1 and over time, vegetation may establish on the bluff slope. Access for groin installation may be feasible via the road that accesses the City of Cudahy pump station at the south end of Sheridan Park. The County would have to further evaluate the access area and work with the City of Cudahy to achieve access permission.

5.16 PROJECT AREA 16 - WARNIMONT PARK (STA 44+00 TO 75+00)

At a length of 3,100 feet, Project Area 16 is the largest continuous project area identified by the Project Team. The area includes a large section of the bluff slopes and shoreline of Warnimont Park. The resiliency ranks within Project Area 16 range from “D” to “F” with moderate to high risk. The majority of Warnimont Park, including areas outside of the project areas identified, consists of unstable bluff slopes; however, Project Area 16 also has one of the highest average bluff crest recession rates in the County, even when compared to areas of Warnimont Park further to the south. Due to its size, slope grading is cost prohibitive and not recommended for Project Area 16; therefore, recommended Concepts focus on slowing bluff crest recession rates by mitigating shoreline erosion with structures that are more tolerant to possible slope failures/movements.

Based on information provided by the County, Project Area 16 also includes areas of soils contaminated with lead that are near an existing parking lot and a dumping site. If shoreline erosion measures are not implemented across the majority of Project Area 16, special attention should still be given to the area of contamination near the existing parking lot.

The Project Team performed a geotechnical boring at Project Area 16 (WARNIMONT-SB-04) to provide additional soils information for the area. The results of the soil boring are discussed in **Section 6.0**.

5.16.1 Concept 1: Install Offshore, Detached Breakwater with Preloaded Beach Cells and Native Vegetation

Ongoing shoreline erosion is prevalent in Project Area 16 and is contributing to the unstable bluff slopes. Additionally, the area has numerous indicators of groundwater seepage on the bluff slope. For Concept 1, the Project Team focused on slowing bluff recession by mitigating the bluff toe erosion. Repairs include the construction of a series of offshore, detached breakwaters with a preloaded beach area to reduce wave energy in the nearshore environment. Additionally, a native vegetation buffer area with barriers and signage at the top of the slope are recommended. In the future, dune grass plantings in preloaded beach areas could be implemented along the shoreline. This Concept will not stabilize the existing slopes within the project area, but will provide an area at the bottom of the slope for future slope movements to accumulate without damaging the breakwater structures. Over time, vegetation should reestablish on bare/destabilized sections of the slope. WDNR and USACE permit approvals may be required for the detached breakwaters and construction would largely be performed via barge.



5.16.2 Concept 2: Buffer Terrace and Armor Stone Revetment with Native Vegetation

Concept 2 for Project Area 16 is similar in principle to Concept 1 in that the Project Team focused on slowing the bluff crest recession by controlling the shoreline recession. For this Concept, repairs consist of the addition of a buffer terrace at the bottom of the slope and an armor stone revetment to protect the shoreline. The buffer terrace will serve as access for future revetment maintenance, while also providing an area for slope movements to accumulate without damaging the revetment structure. Like Concept 1, over time, vegetation will reestablish on the bluff slopes as the bluff crest slowly recedes. Access for revetment and buffer terrace construction may be feasible via the road that accesses the City of Cudahy pump station at the north end of Warnimont Park. The County would have to further evaluate the access area and work with the City of Cudahy to achieve access permission.

5.17 PROJECT AREA 17 - WARNIMONT PARK (STA 24+00 TO 32+00)

Warnimont Park is one of the longest sections of undeveloped shoreline in the Milwaukee County Park System. It is remote in certain areas and access via vehicle can be difficult. The Concept prepared for Project Area 17 includes recommendations for constructing an area for improving emergency response capabilities in the park and additional provisions for enhancing park safety.

5.17.1 Concept 1: Improve Access for Rescue Professionals and First Responders

To increase park safety and emergency response time, the Project Team recommends the construction of an emergency response access point and adaptations that include installation of barriers, rerouting trails, and installation of signage informing park visitors of the unstable slope dangers.

5.18 PROJECT AREA 18 - WARNIMONT PARK (STA 19+50 TO 22+00)

Project Area 18 includes a section of unstable bluff slopes and trails at Warnimont Park. The existing trails come near unstable and undermined portions of the bluff crest. The resiliency of the bluff slopes in Project Area 18 is "F," the risk is moderate-high, and the uncorrected safety rank is "F." The Concept prepared for Project Area 18 is focused on increasing park safety.

5.18.1 Concept 1: Install Barriers and Relocate Trails

The Concept for increasing park safety at Project Area 18 includes recommendations for the installation of barriers, rerouting trails, and installation of signage informing park visitors of the unstable slope dangers.

5.19 PROJECT AREA 19 - WARNIMONT PARK (STA 11+00 TO 16+00)

Project Area 19 includes a section of unstable bluff slopes and trails at Warnimont Park. The existing trails come near unstable and undermined portions of the bluff crest. The resiliency of the bluff slopes in Project Area 19 range from "C" to "F," the risk is moderate, and the uncorrected safety ranks range from "C" to "F." The Concept prepared for Project Area 19 is focused on increasing park safety.

5.19.1 Concept 1: Install Barriers and Relocate Trails

The Concept for increasing park safety at Project Area 19 includes recommendations for the installation of barriers, rerouting trails, and installation of signage informing park visitors of the unstable slope dangers.



5.20 PROJECT AREA 20 - GRANT PARK (STA 58+00 TO 63+00)

Project Area 20 is located in Grant Park and includes a section of unstable bluff and shoreline erosion likely enhanced by the presence of a groin north of the project area and groundwater seepage. The area has resiliency ranks of “D-” and “F,” with moderate-high risk, and uncorrected safety ranks of “C” and “F.” There is also an existing parking lot adjacent to the project area. The Concepts prepared for Project Area 20 focus on improving park safety, mitigating groundwater seepage, and slowing shoreline erosion rates.

5.20.1 Concept 1: Construct Backshore Revetment with Wick Drains, Barriers, and Trail Relocation

Concept 1 for Project Area 20 includes recommendations for construction of a backshore revetment to mitigate shoreline erosion and installation of wick drains to reduce groundwater seepage on the bluff adjacent to the parking lot. Additionally, barriers and signage are recommended with some areas of the park trails being rerouted away from the bluff crest due to safety concerns. Construction of the backshore revetment would likely have to be performed via barge due to lack of access from Grant Park Drive; however, wick drains are typically installed from the top of the bluff via directional drilling and could be completed with minimal impact to existing infrastructure at the top of the slope.

5.20.2 Concept 2: Install New Armor Stone Groins with Preloaded Beach Cells, Native Vegetation, and Barriers

The Project Team recommends the construction of two new armor stone groins for Concept 2 for Project Area 21. Additionally, the groin cells would be preloaded with beach sediment to mitigate the potential for detrimental effects south of the project area. The preloaded groin cells provide a beach buffer area for future slides off the bluff slope to accumulate, thus reducing the potential for damage to the groin structures and eliminating the necessity for wick drains to be installed, as recommended in Concept 1. Construction of the groins would likely be performed via barge due to lack of access from Grant Park Drive. Barriers, signage, and relocated trails like those recommended in Concept 1 are also included in Concept 2.

5.21 PROJECT AREA 21 - GRANT PARK (STA 46+00 TO 54+00)

Project Area 21 includes a section of the bluff crest at Grant Park. The project area has resiliency ranks ranging from “D” to “F,” moderate risk, and uncorrected safety ranks of “C” and “F.” The bluff slopes within the project area are unstable or showing initial signs of instability; however, the area’s lack of proximity to existing structures keeps its risk lower than other comparable areas. Therefore, the Project Team focused one Concept on increasing park safety within Project Area 21.

5.21.1 Concept 1: Install Barriers and Relocate Trails

The Concept for increasing park safety at Project Area 21 includes recommendations for the installation of barriers, rerouting trails, and installation of signage informing park visitors of the unstable slope dangers.

5.22 PROJECT AREA 22 - GRANT PARK (STA 44+00 TO 45+50)

Project Area 22 includes a section of Grant Park bluff slopes and shoreline that functions as an access trail to the beach. The area has a history of filling and miscellaneous repairs, including small sections of the slope covered with gabion basket stairs and a small revetment present on the shoreline. Over time, the access trail has become rutted, eroded, and very steep, making it a safety hazard. Additionally, at the slope adjacent to the access path, the Project Team observed signs of slope instability and groundwater seepage. The area has a resiliency rank of “D,” moderate risk, and an uncorrected safety



rank of “D.” Two Concepts were evaluated by the Project Team for Project Area 22 that focus on increasing safety, improving accessibility (Concept 1 only), and stabilizing the bluff slope.

5.22.1 Concept 1: Regrade Slope, Construct Switchback Access Trail, and Install Wick Drains

Concept 1 for Project Area 22 focuses on improving accessibility to the beach by reconstructing the existing access trail and stabilizing the existing bluff slope. Construction for Concept 1 includes regrading of the bluff surface to a 2.5H:1V slope, including a switchback path, reconstructing and expanding the existing armor stone revetment at the shoreline, installation of directionally drilled wick drains to mitigate groundwater seepage, and riprap slope protection/swales along the access area boundaries. Compared to Concept 2, Concept 1 will enhance accessibility of the park and promote using an established beach access path instead of unofficial access trails that are also present nearby. This area could also be adapted for use as an access point for emergency services, if needed.

5.22.2 Concept 2: Abandon Existing Lake Access, Install Barriers, and Install Wick Drains

Concept 2 at Project Area 22 implements closure of the existing gabion basket access trail by removing the gabion baskets, repairing the eroding trail, and installing barriers and signage to discourage foot traffic. Concept 2 also includes installation of wick drains like those recommended in Concept 1. When compared to Concept 1, Concept 2 is the more cost-effective and less environmentally impactful option, but does reduce park usability.

5.23 PROJECT AREAS 23 AND 24 - GRANT PARK (STA 25+50 TO 31+50)

Project Areas 23 and 24 were presented together in the Concept Plan Set due to proximity and similar conditions; however, the Concepts recommended for these areas could be treated as standalone projects and be performed separately, if the County deems necessary. The project areas include sections of the bluff crest and shoreline at Grant Park that have a history of relative stability compared to the surrounding area, but have recently experienced surficial slides and bluff toe erosion. The history of stability was likely influenced by the presence of two groin structures within the project areas. The project area slopes have resiliency ranks ranging from “C” to “F,” moderate-high risk, and uncorrected safety ranks of “C” and “F.” The groins present within the project areas have structure condition ranks of “F.” The Concepts prepared by the Project Team for Project Area 23 focus on improving safety and protecting the shoreline from future erosion. Construction recommended for Project Areas 23 and 24 would likely require the use of a barge unless access can be arranged via Grant Park Beach. Access from Grant Park Beach may require the temporary closure of the beach due to safety concerns.

5.23.1 Concept 1: Construct Backshore Revetment, Perform Groin Maintenance, Install Barriers, and Relocate Trails

For Concept 1 at Project Areas 23 and 24, the Project Team recommends installation of two sections of backshore revetment to protect the existing shoreline. Additionally, barriers and signage are also recommended at the top of the slope. The existing groins within the project area appear to still be functioning during periods of low water, but are regularly overtopped during periods of high water. By adding additional protection in the backshore, the shoreline is protected without having to potentially increase the footprints of the existing groin structures. This Concept would have minimal impact on the lakebed compared to Concept 2.

5.23.2 Concept 2: Construct Backshore Revetments, Install Barriers, and Relocate Trails

As an alternative to Concept 1, Concept 2 implements improvements to the existing groins to increase sediment retention in the area during periods of high water levels. Additionally, like in Concept 1, a backshore revetment is also recommended south of the existing groins and barriers with signage at the crest of the slope. Improvements to existing groin structures



would likely include reconstructing sections of the groins and raising the crest of the groins to increase performance during high water levels. These improvements may necessitate the expansion of the groin footprints.

5.24 PROJECT AREA 25 - BENDER PARK (STA 0+00 TO 2+00)

Project Area 25 includes the bluff crest near the southern boundary of Bender Park. Currently, this area has an unstable bluff slope and a crest barricade that is failing. It is also adjacent to an eroding ravine that approaches the County property from the south neighboring property. The area has a resiliency rank of “C+,” high risk, and an uncorrected safety rank of “D.” One Concept has been prepared for Project Area 25, which focuses on improving the safety of the area and monitoring the ongoing erosion south of Bender Park.

5.24.1 Concept 1: Install Barriers, Relocate Trails, and Implement Monitoring Program

The Concept for increasing park safety at Project Area 25 includes recommendations for the installation of barriers, rerouting trails, and installation of signage informing park visitors of the unstable slope dangers. Additionally, we recommend implementing a monitoring program for the area to document ongoing erosion caused by the neighboring ravine. The monitoring program should consist of annual visits to the area to take photos and installation of survey points may also assist with documenting changes at the project area. If erosion caused by the ravine continues to advance onto Bender Park, the County may want to pursue discussions with the neighbor to the south to initiate mitigating the problem.

6.0 **PROJECT ALLOWANCE WORK: SUBSURFACE EXPLORATION AND LABORATORY TESTING PROGRAM**

As part of the project allowance work, GZA conducted a subsurface exploration program consisting of five soil borings, BAYVIEW-SB-01 and BAYVIEW-SB-01A (collectively SB-01), SHERIDAN-SB-02 (SB-02), SHERIDAN-SB-03 (SB-03), and WARNIMONT-SB-04 (SB-04), to provide additional geotechnical data at Project Areas 12, 14, 15, and 16, respectively. The approximate locations of the soil borings are presented on **Figure 3** and detailed in the soil boring logs provided in **Appendix E**. GZA staff observed and logged the soil borings. Details pertaining to methodologies and results of the soil borings performed are described below.

6.1 SOIL BORINGS

GZA’s subcontractor, Drill Point, Inc. (Drill Point) of Waterford, Wisconsin drilled five soil borings at locations determined by the Project Team and presented on **Figure 3**. The borings, SB-01 through SB-04, were drilled from October 16 to 18, 2024, to depths of 60, 90, 90, and 90 feet bgs, respectively (approximate boring termination depths at El. 572 to 595.7 [+/- 1 foot]). Boring BAYVIEW-SB-01 encountered refusal during drilling and was moved west to the BAYVIEW-SB-01A location shown on **Figure 3**. For simplicity, the results of these soil boring were combined and are generally referred to as boring SB-01 herein. The actual termination depths of the borings are noted on the boring logs in **Appendix E**.

Drill Point used a Diedrich D-120, truck-mounted drill rig and hollow-stem auger drilling techniques to advance the soil borings to the termination depths. Split-spoon soil samples were obtained in accordance with ASTM D1586, *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*. The SPT consists of driving a 1½-inch inside-diameter (ID) sampler for at least 18 inches with a 140-pound hammer falling 30 inches. The number of blows required for each 6 inches of penetration was recorded, and the number of blows required to drive the sampler from 6 to 18 inches of penetration is the SPT N-value, a commonly used indicator of soil density and consistency. Pocket penetrometer testing was also performed on cohesive soils to aid in the soil’s in-situ consistency estimation. Undisturbed Shelby tube samples were also attempted where soft to stiff cohesive soils were encountered. Refer to the boring logs in **Appendix E** for more



information. Soil samples were collected in the split-spoon sampler and were stored in sealed, labeled, glass jars. Samples were classified in general accordance with ASTM D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*.

6.2 FIELD AND LABORATORY TESTING PROGRAM

Soil samples were classified and checked in the field to determine approximate plasticity (for cohesive soils) and grain-size distribution (for granular soils). SPT N-values and/or pocket penetrometer testing results were utilized to evaluate relative density/consistency of the soils encountered and are recorded on the boring logs.

Laboratory tests were performed on select soil samples to aid in soil classification. The testing included natural moisture content, plasticity characterization (Atterberg Limits), grain-size distribution, unit weight, direct shear, and consolidated-undrained triaxial compression, and unconfined compressive strength. Results of the laboratory tests are summarized on the boring logs in **Appendix E** and the laboratory summary report in **Appendix F**.

6.3 GENERALIZED SUBSURFACE CONDITIONS

A generalized description of the subsurface conditions encountered at the soil boring locations are summarized below. Refer to the boring logs in **Appendix E** for more specific information. Formation names of the glacial till layers discussed herein are in general reference to the glacial till layers observed and reported in SEWRPC Technical Report No. 36.¹³

6.3.1 Topsoil

Approximately 6 to 14 inches of topsoil were present in the borings. The surficial topsoil layer generally consisted of brown to dark brown, lean clay (ASTM Soil Type: CL) with trace sand and organics. Topsoil was identified by the soil coloration, composition, and the presence of organic material. SPT N-values were generally not recorded in the topsoil layer. Laboratory testing was not performed on the topsoil samples.

6.3.2 Upper, Glacial Till Soils (Ozaukee Till)

At boring location SB-01, the surficial topsoil layer was underlain by a layer of upper, glacial till soils. This layer of till soils is commonly referred to as the Ozaukee till formation and was encountered from bottom of topsoil to approximately 19.3 feet bgs (El. 612.7). The Ozaukee till soil type was generally uniform and consisted of lean clay and sandy, lean clay (CL) with trace gravel. The Ozaukee till layer was identified by its red-brown color with white-gray staining and was not encountered in the other soil borings.

The Ozaukee till layer had SPT N-values ranging from 14 to 30 blows per foot (bpf) and pocket penetrometer readings of 2.0 to greater than 4.5 tons per square foot (tsf), indicating stiff to hard soil consistency. Moisture contents of three tested samples ranged from about 14% to 21% with an average of approximately 18%, by weight. Fines content (percentage of material passing a No. 200 sieve) of one sample tested was 92%, by weight. The Ozaukee till layer was not encountered in borings SB-02, SB-03, or SB-04.

One unconfined compressive (UC) strength test and dry density test were performed on an Ozaukee till Shelby tube sample collected at 13.5 to 14.5 feet bgs in boring SB-01. The sample exhibited a UC strength of 2.01 tsf and a dry density of 107.3

¹³ SEWRPC, 1995. *Lake Michigan Shoreline Recession and Bluff Stability In Southeastern Wisconsin: 1995, Technical Report No. 36*. SEWRPC, December 1997.



pounds per cubic foot (pcf). One Atterberg limit test was performed on the sample which exhibited a liquid limit of 41 and a plasticity index of 25, corresponding to medium plasticity.

6.3.3 Upper/Middle, Glacial Till Soils (Oak Creek Till)

A second layer of glacial till was encountered at variable depths and sequence in the soil borings. This glacial till layer is commonly known as the Oak Creek till formation and was encountered below the surficial topsoil in borings SB-02, SB-03, and SB-04. The Oak Creek till was also encountered in boring SB-01 at the base of the Ozaukee till layer at a depth of approximately 19.3 feet bgs. The Oak Creek till layer extended to the termination depths of borings SB-01 and SB-02. In borings SB-03 and SB-04, the Oak Creek till layer terminated at depths of approximately 63.9 and 68.5 feet bgs, respectively. The Oak Creek till was also interbedded with layers of silt and sand that are further discussed in the following section. The Oak Creek till soil type generally consisted of sandy, lean CLAY (CL) and silty clay (CL-ML) with occasional silt (ML) layers. The layer is generally gray to brown-gray with occasional orange staining where encountered near the ground surface.

The Oak Creek till layer had SPT N-values ranging from 7 to 47 bpf, and pocket penetrometer readings of 0.75 to greater than 4.5 tsf, indicating medium-stiff to hard soil consistency. Moisture contents of 27 tested samples ranged from about 7% to 24% with an average of approximately 16%, by weight. Fines content of 14 samples tested ranged from about 70% to 100%, with an average of approximately 84%, by weight.

Four dry density tests were performed on an Oak Creek till Shelby tube samples collected at various depths in borings SB-01, SB-02, and SB-03. The samples exhibited dry densities ranging from 119 to 124 pcf and an average of approximately 122 pcf. Ten Atterberg limit tests were performed on Oak Creek till samples, which exhibited liquid limits of 0 to 37 and plasticity indices of nonplastic (0) to 18, indicating nonplasticity to low plasticity. Two consolidated-undrained triaxial shear strength (CU Triaxial) tests were performed on samples ST-18 and ST-6 from borings SB-01 and SB-03 and one direct shear test was performed on ST-9 from boring SB-01. Results of the CU Triaxial and direct shear tests are provided in **Appendix F**.

6.3.4 Interglacial Silt and Sand Soils

Interbedded with the various till layers were layers of silt and sand that resulted from the various interglacial phases of soil deposition in the area. The interglacial soils were generally granular and consisted of dense to very dense, poorly-graded sand (SP), poorly-graded sand with silt (SP-SM), silty sand (SM), and nonplastic silt (ML). The interglacial soils were generally light brown to gray in color. The interglacial soil layer was variable in depth and extent, but was encountered from 38.5 to 45 feet bgs in boring SB-01, from 63.5 to 78.5 feet bgs in boring SB-02, from 18.5 to 53.5 feet bgs and from 83.5 to termination depth of 90 feet bgs in boring SB-03, and from 23.5 to 45 feet bgs in boring SB-04.

The interglacial till layer had SPT N-values ranging from 11 to 50 bpf with an average of 40 bpf, indicating generally dense conditions. Moisture contents of eight tested samples ranged from about 1% to 21%, with an average of approximately 11%. Fines content of 11 samples tested ranged from 6% to 95%, by weight, with an average of 37%. Atterberg limit tests were performed on two samples, SS-15 and SS-12 from borings SB-01 and SB-04, respectively. Samples exhibited liquid limits of non-plastic (0) and plasticity indices of 0, indicating nonplasticity.

6.3.5 Lower Glacial Till (New Berlin Till)

A third glacial till layer was encountered in boring SB-04 at approximately 63.5 feet bgs and extended to boring termination depth at 90 feet bgs. This glacial till layer is commonly known as the New Berlin till formation and consisted of uniform, sandy, lean clay (CL) that was gray with brown streaks. The New Berlin till may have also been encountered near the bottom of SB-02 from 83.5 to 90 feet bgs; however, presence of a unique, organic rich peat (PT) layer made determining the till formation difficult.



The New Berlin till layer had SPT N-values ranging from 29 to greater than 50 bpf, and pocket penetrometer readings of greater than 4.5 tsf, indicating hard soil consistency. Moisture contents of two tested samples ranged from about 11% to 19%, with an average of approximately 15%. Fines content of sample SS-20 from boring SB-04 was 68%, by weight. Atterberg limit tests were performed on the same sample and exhibited a liquid limit of 27 and plasticity index of 9, indicating low plasticity.

The unique peat layer encountered at the bottom of boring SB-02 had a moisture content of 91%, by weight, and a pocket penetrometer reading of 4.25 tsf, indicating hard soil consistency.

6.3.6 Bedrock

Bedrock was not encountered in the soil borings, but based on publicly available geologic data, bedrock is anticipated to be at approximately 100 to 150 feet bgs and consist of Silurian Age, Racine Formation Dolomite.

6.4 GROUNDWATER

Groundwater was encountered during drilling in soil borings SB-01, SB-02, and SB-04 at depths of 38.5, 59.3, and 38.5 feet bgs (approximate El. 593.5, 605, and 647.2), respectively. Groundwater was not encountered in soil boring SB-03 during drilling. Groundwater was not present in the boreholes after drilling either due to borehole collapse or inadequate stabilization time. Due to the relatively low permeability of the native glacial till soils, it is anticipated that the groundwater observed in the soil borings was perched in the more permeable, granular or silty layers. Fluctuations of the groundwater table will likely occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the soil borings were performed. Therefore, groundwater levels during construction of stabilization measures or at other times may be different than the levels indicated on the boring logs.

6.5 GEOTECHNICAL DATA USE AND FUTURE APPLICABILITY

The Project Team utilized the geotechnical data obtained as part of the Project Allowance to refine and check feasibility of the Concepts prepared for the Project Areas near where the soil borings performed. The Project Team did not perform a complete slope stability analysis for each of the Project Areas near the soil boring locations; however, slope stability analyses should be performed in the future stages of planning and design for Project Areas and Concepts that include regrading of the bluff slopes. The soil boring and laboratory data collected may be used by the county or future consultants to enhance the accuracy of the slope stability analyses performed.

7.0 **OPINIONS OF CONCEPT PROJECT COST AND PRIORITIZATION**

The following section summarizes the Project Team's opinions regarding Concept project cost and Concept project prioritization. This information is also summarized in the GIS Experience under the "Cost and Prioritization" page and in the Spreadsheet Package.

7.1 OPINION OF CONCEPT COST SUMMARY

To determine the potential cost range for the recommended Concept projects, the Project Team utilized the various quantities estimated for the Concept Plan Set and assigned unit rates to each quantity. Unit rates established for material quantities were determined based on the Project Team's experience with similar projects and other public and private, Lake Michigan shoreline stabilization protection projects in the region. Additionally, certain material unit rates were



increased based on project area accessibility. For example, a 25% increase in armor stone revetment cost was applied if the project area was potentially only accessible via barge. The costs provided do not include anticipated yearly maintenance costs; however, native vegetation costs do include additional costs for maintenance during the first three years of establishment since these costs are likely mandatory for successful native vegetation establishment. The table below summarizes our unit rates for the materials and the tables provided in **Appendix G** summarizes the Concept material quantities, costs related to the material, and total cost ranges of the Concepts.

Table 7-1. Unit Rates for Concept Materials

Item Number	Item Name	Unit	Low	Engineer's Est.	High	25-Year
1	Armor Stone Revetment (Land Based)	LF	\$2,520	\$3,600	\$4,680	\$5,623
2	Armor Stone Revetment (Barge Based)	LF	\$3,150	\$4,500	\$5,850	\$7,029
3	Backshore Revetment (Land Based)	LF	\$1,750	\$2,500	\$3,250	\$3,905
4	Backshore Revetment (Barge Based)	LF	\$2,328	\$3,325	\$4,323	\$5,194
5	Armor Stone Groin (Footprint Length, Land)	LF	\$2,100	\$3,000	\$3,900	\$4,686
6	Armor Stone Groin (Footprint Length, Barge)	LF	\$3,150	\$4,500	\$5,850	\$7,029
7	Armor Stone Breakwater (Footprint Length, Barge)	LF	\$3,500	\$5,000	\$6,500	\$7,810
8	Sand Beach Fill (Trucking)	CY	\$42	\$60	\$78	\$94
9	Sand Beach Fill (Barge)	CY	\$63	\$90	\$117	\$141
10	Sand Beach Fill (Dredge)	CY	\$32	\$45	\$59	\$70
11	Existing Groin Rehabilitation	LF	\$700	\$1,000	\$1,300	\$1,562
12	Native Vegetation	SY	\$11	\$16	\$21	\$25
13	Invasive Species Management/Clearing	SY	\$5	\$7	\$9	\$11
14	Rip Rap Slope/Overtopping Protection	SF	\$11	\$15	\$20	\$23
15	Wooden Barrier with Signage	LF	\$21	\$30	\$39	\$47
16	2-Ton Toe Stone - Scour Protection	LF	\$280	\$400	\$520	\$625
17	General/Buttress Fill	CY	\$10	\$14	\$18	\$22
18	Stairs, Landing, Handrail	LF	\$490	\$700	\$910	\$1,093
19	Geocell	SF	\$7	\$10	\$13	\$16
20	Slope Grading and Material Export	CY	\$25	\$35	\$46	\$55
21	Gravel Path	SF	\$11	\$15	\$20	\$23
22	Road Removal/Restoration	SF	\$7	\$10	\$13	\$16
23	Parking Lot	SF	\$53	\$75	\$98	\$117
24	Emergency Access Road	LF	\$105	\$150	\$195	\$234
25	Abandoned + Clearing New Trail	LF	\$7	\$10	\$13	\$16
26	Wick Drains	EA	\$7,000	\$10,000	\$13,000	\$15,620
27	Demolition (Ex. Ret. Wall)	LF	\$4	\$5	\$7	\$8
28	Ravine Reinforcement	SY	\$8	\$11	\$14	\$17

The following table summarizes the anticipated total cost range for the Concept projects recommended. Additionally, the 25-year adjusted estimate is also presented. Low side and high side estimates were used to establish the cost range and are based on a $\pm 30\%$ variance from the engineer's estimate. Cost variance was determined based on the Project Team's



experience and, generally, will result from construction variables such as material rejection rates, structure settlement, tolerances, mobilization cost variance, stone material costs, stone material placed density, and the occurrence rate of unanticipated conditions.

Table 7-2. Total Cost Ranges for Project Area Concepts

Park	Project Area and Concept	Shoreline Length (Feet)	Low Estimate	Engineer's Estimate	High Estimate	25-Year Adjusted Estimate
Doctors Park	P1 C1	450	\$930,000	\$1,330,000	\$1,730,000	\$2,080,000
Doctors Park	P1 C2	450	\$890,000	\$1,270,000	\$1,650,000	\$1,990,000
Doctors Park	P2 C1	225	\$710,000	\$1,010,000	\$1,320,000	\$1,580,000
Doctors Park	P2 C2	225	\$1,130,000	\$1,610,000	\$2,090,000	\$2,510,000
Big Bay Park	P3 C1	1200	\$680,000	\$960,000	\$1,250,000	\$1,510,000
Big Bay Park	P3 C2	1200	\$2,210,000	\$3,150,000	\$4,100,000	\$4,920,000
Linnwood	P4 C1	1600	\$4,130,000	\$5,890,000	\$7,660,000	\$9,210,000
Linnwood	P5 C1	250	\$820,000	\$1,170,000	\$1,520,000	\$1,830,000
Linnwood	P5 C2	250	\$980,000	\$1,410,000	\$1,830,000	\$2,200,000
Bradford/ Lake Park	P6 C1	150	\$6,000	\$8,000	\$11,000	\$13,000
Bradford/ Lake Park	P6 C2	150	\$80,000	\$120,000	\$150,000	\$180,000
Bradford/ Lake Park	P7 C1	500	\$160,000	\$230,000	\$300,000	\$360,000
Juneau/ McKinley Park	P8 C1	3000	\$600,000	\$860,000	\$1,120,000	\$1,350,000
Cupertino Park	P9 C1	300	\$20,000	\$30,000	\$40,000	\$50,000
South Shore Park	P10 C1	1600	\$140,000	\$200,000	\$260,000	\$310,000
Bay View Park	P11&12 C1	2375	\$6,590,000	\$9,410,000	\$12,240,000	\$14,710,000
Bay View Park	P11&12 C2	2375	\$5,790,000	\$8,270,000	\$10,750,000	\$12,920,000
Sheridan Park	P14 C1	700	\$1,250,000	\$1,790,000	\$2,330,000	\$2,790,000
Sheridan Park	P14 C2	700	\$2,140,000	\$3,060,000	\$3,980,000	\$4,780,000
Sheridan Park	P15 C1	2250	\$860,000	\$1,220,000	\$1,590,000	\$1,910,000
Sheridan Park	P15 C2	2250	\$8,190,000	\$11,700,000	\$15,210,000	\$18,270,000
Warnimont Park	P16 C1	3100	\$25,730,000	\$36,760,000	\$47,790,000	\$57,420,000
Warnimont Park	P16 C2	3100	\$8,570,000	\$12,250,000	\$15,920,000	\$19,130,000
Warnimont Park	P17 C1	725	\$150,000	\$220,000	\$280,000	\$340,000
Warnimont Park	P18 & 19 C1	900	\$60,000	\$80,000	\$110,000	\$130,000
Grant Park	P20 C1	600	\$1,540,000	\$2,200,000	\$2,860,000	\$3,430,000
Grant Park	P20 C2	600	\$940,000	\$1,340,000	\$1,740,000	\$2,090,000
Grant Park	P21&22 C1	950	\$1,200,000	\$1,720,000	\$2,240,000	\$2,690,000
Grant Park	P21&22 C2	950	\$130,000	\$180,000	\$240,000	\$290,000
Grant Park	P23&24 C1	900	\$1,820,000	\$2,600,000	\$3,380,000	\$4,060,000
Grant Park	P23&24 C2	900	\$1,110,000	\$1,580,000	\$2,060,000	\$2,470,000
Bender Park	P25 C1	250	\$7,000	\$10,000	\$13,000	\$16,000



7.2 OPINION OF PROJECT PRIORITIZATION

Project area Concepts were prioritized primarily using the risk evaluation and opinions of cost developed by the Project Team. Additionally, projects are prioritized by average safety ranking improvement per Cell and average Cell resiliency in the project areas. The tables included in **Appendix H** show how the projects could be prioritized based on various parameters. Additionally, the GIS Experience and Spreadsheet Package provide an interactive format for adjusting priorities and filtering projects to display the user's desired results.

The highest priority Concepts and project areas are shown below, based on various ranking parameters. The costs and risk values utilized herein are based on the projected engineer's estimate of cost, which utilizes the "GZA Recommended" Vulnerability scenario (Scenario 1).

Table 7-3. Highest Priority Concepts and Project Areas

Priority Rank	Ranking Parameter						
	Least Resilient	Risk per Foot Shoreline	Risk Mitigated/Cost Ratio	Total Risk	Risk Mitigated %	Total Combined Safety Value Improvement	Average Safety Value Improvement per Cell
1	Warnimont, PA16	Warnimont, PA17	Big Bay, PA3, C1	Warnimont, PA16	Bay View, PA11/12, C1	Sheridan, PA15, C1/2	Grant, PA21/22 C1
2	Warnimont, PA17	Warnimont, PA16	Grant, PA21/22, C2	Sheridan, PA15	Doctors, PA2, C1	Grant, PA21/22, C1	Grant, PA20, C1/2
3	Sheridan, PA15	Warnimont, PA18/19	Big Bay, PA3, C2	Warnimont, PA17	Doctors, PA2, C2	Bay View, PA11/12, C1	Bradford, PA6, C2
4	Grant, PA20	Sheridan, PA15	South Shore, PA10, C1	Warnimont, PA18/19	Big Bay, PA3, C1	Grant, PA21/22, C2	Bender, PA25, C1
5	Warnimont, PA18/19	Bender, PA25	Bay View, PA11/12, C1	Bay View, PA11/12	Sheridan, PA14, C2	Grant, PA23/24, C1/2	Grant, PA21/22, C2
6	Grant, PA23/24	Big Bay, PA3	Sheridan, PA15, C1	Big Bay, PA3	Big Bay, PA3, C2	Grant, PA20, C1/2	Grant, PA23/24, C1/2
7	Grant, PA21/22	Grant, PA23/24	Grant, PA20, C2	Grant, PA23/24	Grant, PA20, C1	Bay View, PA11/12, C2	Sheridan, PA15, C1/2
8	Bay View, PA11/12	Sheridan, PA14	Grant, PA23/24, C1	Grant, PA21/22	Warnimont, PA16, C1	Warnimont, PA16, C1/2	Bradford, PA6, C1
9	Doctors, PA2	Grant, PA20	Sheridan, PA16, C2	Sheridan, PA14	Grant, PA20, C2	Sheridan, PA14, C1/2	Sheridan, PA14, C1/2
10	Sheridan, PA14	Grant, PA21/22	Sheridan, PA15, C2	Grant, PA20	Grant, PA23/24, C1	Warnimont, PA18/19, C1	Bay View, PA11/12, C1

Notes:

PA# = Project Area Number

C# = Concept Number

Various other ranking parameters are available in the Spreadsheet Package and GIS Experience provided to the County as supplemental documentation.



8.0 GENERAL CONSIDERATIONS

The following section summarizes and provides additional detail to general recommendation made regarding the various Concepts presented. A discussion of additional design phase procedures and permitting requirements is also included.

8.1 SLOPE GRADING

The design team recommended a typical regraded slope of 2.5H:1V on limited sites where space, access, and bluff height provided acceptable conditions for slope regrading. Additionally, we recommend that relatively flat benches or slope breaks a minimum of 6 feet wide be utilized on regraded slopes. The benches should be spaced a maximum of every 100 feet as measured on the slope. These slope breaks will mitigate the potential for “infinite slope” style failures that can occur on longer, regraded slopes, while also providing a location to control surface water runoff. Temporary erosion control products, such as sediment logs and matting, will also be necessary on regraded slopes to slow surface water flow while vegetation reestablishes. Steeper slopes up to 2H:1V may also be possible to implement and achieve an adequate factor of safety; however, vegetation may not establish without special provisions such as turf reinforcement mats or hydroseeding application and these slopes may be more difficult to construct. Slopes steeper than 2H:1V may be necessary to match adjacent grades where regrading is not being performed. In these locations, riprap cover with an appropriate geotextile underlayment should be utilized to slow the flow of surface water and to cover the slope. Riprap channels may also be necessary to convey water downslope at these locations.

Slope regrading was not the primary repair concept methodology for the project areas evaluated for several reasons. First, the cost associated with cut and fill operations is high for the park slope areas due to the difficulty in access and potential safety concerns. Second, if cut and fill balance was maintained on the larger bluff areas, the filled area would substantially impact the lakebed at several of the project areas due to adjacent structures near the bluff crest and/or ecological resources near the bluff crest requiring fill to be placed in the lake. Third, created regraded slopes would also require maintenance of the vegetation used to revegetate the slope. Continued maintenance of such large areas was determined to not be cost effective and difficult due to staffing limitations.

8.2 NATIVE VEGETATION

The Project Team recommended various native vegetation implementations at Project Areas 3 through 10, 12, 15, 16, and 22; however, native vegetation could be used at many of the other parks and project areas to enhance the ecological value of the areas where planted. Proper vegetation management along bluffs also represents a critical opportunity to enhance slope stability and reduce erosion risks in our coastal areas. While forested bluffs can appear stable, it can be beneficial to reduce canopy coverage to allow grasses and forbs to establish on the ground plane. Likewise, dense, invasive shrubs, such as buckthorn (*Rhamnus spp*) and honeysuckle (*Lonicera spp*), block sunlight and eliminate the possibility of a grass or forb understory. Urban forestry management stands out as a particularly effective technique for improving bluff resilience by offering both immediate and long-term benefits for slope stabilization.

While the County can directly implement these practices on park land, there is also significant potential to expand these benefits through a pilot program offering incentives to private landowners. By encouraging proper forest management on private bluffs through technical assistance, tax relief, and cost-sharing opportunities, the County can create a comprehensive approach to bluff stabilization that improves bluffs adjacent to park land. A sample vegetation management plan is presented below and outlines specific vegetation management strategies that can be applied on both public and private lands to enhance bluff stability while improving overall forest health.



Future vegetation management plans should address three key vegetation concerns, invasive understory species, poor quality canopy trees, and aging trees, which present potential bluff instability and safety hazards. The goal is to restore native plant communities while ensuring public safety and long-term forest health, which will contribute to resiliency and potentially improve bluff stability.

1. Invasive Understory Management

Establish a three-phase approach to control invasive herbaceous plants and shrubs. Begin with early spring surveys to identify and map priority areas of invasive species concentration. Site visits by the Project Team indicated dense populations of buckthorn (*Rhamnus spp*) and honeysuckle (*Lonicera spp*), and various invasive annual and perennial species. Mechanical removal through hand-pulling and cutting is effective for small populations and should focus first on satellite populations before they become established. For larger areas of invasive species, targeted selective herbicide is more effective. Larger shrubs should be cut, with stumps treated with herbicide to prevent regrowth. Plantings of native understory species such as woodland sedges, forbs, and shrubs will stabilize soil, establish competition, and prevent reestablishment of invasive species.

2. Poor Quality Canopy Management

Address invasive or undesirable tree species through a gradual removal and replacement strategy. A full inventory of box elder, locust, ash, and other invasive or undesirable trees, noting their size, condition, and location, will provide a baseline. Prioritize removal based on poor health, proximity to high-use areas, and potential to impact desired native species. Phase removals over three to five years to minimize ecological disruption and maintain canopy coverage. Replace removed trees with climate-adapted native species such as oak, hickory, and maple, selecting species appropriate for each Site's soil and light conditions.

3. Aging Tree Safety Management

Conduct comprehensive tree risk assessments of mature trees, particularly those near trails, structures, actively eroding bluffs, or gathering areas. Document trees showing signs of decay, structural weakness, or declining health. Implement a hazard reduction program that includes full removal; or crown cleaning, selective pruning, and removal of dangerous limbs. Where complete removal is necessary, some dead trees located away from high-use areas can be retained to provide wildlife habitat. Create a replacement schedule that anticipates future canopy gaps and maintains age diversity in the forest structure.

Native vegetation areas on slopes should also implement an erosion control product while vegetation establishes. Establishment may take up to three years; therefore, maintenance of the erosion control should also be included in budgets. Removal of existing vegetation without proper maintenance and installation of erosion control on slopes could result in destabilization and erosion of the slope.

8.3 GROIN AND BREAKWATER CELL PRELOADING AND SAND RESOURCE EXPLORATION

The construction of new groin and offshore breakwaters in Wisconsin has been generally limited in recent years due to changes in permitting regulations by the WDNR. These changes are primarily due to the influence that these structures can have on the longshore sediment transport in nearshore adjacent areas, if not constructed properly. That is, sediment transport may be dramatically reduced adjacent to offshore and groin structures causing downcutting and erosion of the adjacent bluff slopes. However, municipal authorities have often received special permission to construct and maintain these structures if determined to be necessary.

To mitigate the potential for impacting longshore sediment transport, the Project Team recommends preloading groin and breakwater cells with sand sediment. The sand sediment can be imported from on-land sources (e.g., quarries and sand



and gravel pits); however, large quantities of sand delivered by truck to difficult-to-access areas may become cost prohibitive. Due to the relatively large size of some of the projects, it may be more cost effective to evaluate offshore dredging resources for the sand. These sand resources are typically present in deeper water where sand and other granular material is deposited by currents.

An exploration program consisting of the following may be appropriate for determining if offshore dredging resources are available to the County:

- Desktop mapping of known offshore sand deposits to target potential resources;
- Collection of near surface grab samples for mechanical analysis (for grain size distribution);
- Collection of near surface grab samples for environmental testing; and
- Collection of offshore vibracore samples to estimate the variability, thickness, and volume of available sand deposits.

After samples are analyzed, the suitability of the borrow source material is evaluated by comparing the grain size distribution data between the borrow source and the native existing beach sand where beach nourishment and/or preloading is proposed. If the borrow source material is determined to be acceptable, the coastal engineer will calculate quantities based on comparing the borrow source material to the existing shoreline sand and calculating an overfill factor (i.e., calculate the volume of sand needed for beach fill and estimate the sediment losses before a stable beach slope is created). The contractor will then mobilize and begin dredging the borrow source material, it is then hydraulically pumped on the shoreline where it dewatered until ready for final beach grading. As the nourishment/preloading quantity increases, the sand dredging and placement unit price decreases due to offsetting of the large mobilization costs/economy of scale.

8.4 SLOPE SAFETY

While evaluating slope safety was not the primary objective for this project, the Project Team determined it was necessary to recommend Concepts that would serve to improve park visitor safety in accessible areas near unstable slopes. The Project Team understands that the County trail system is a valuable, well-utilized asset for park visitors' views and to immerse visitors in nature. The ability to do so without barriers enhances that experience. However, in recent years, there have been several situations in which park visitors had accidents on or were stranded on the bluff slopes. Additionally, other neighboring counties with similar bluff slopes along the Lake Michigan shoreline, have begun to implement additional safety measures to enhance accessibility for emergency responders, improve safe access areas, increase awareness of unsafe areas, and inhibit park visitor access to potentially unsafe areas.

Based on of Safety Ranking evaluation, as discussed in **Section 4.3**, the Project Team recommended the installation of barriers, signage, and possible relocation of several sections of County park trails to prevent visitors from getting too close to the edge. Also, the Project Team recommended enhancing emergency responder accessibility at one project area and improving existing access paths in two project areas. The Project Team identified various areas where park safety can be improved in Project Areas 6 and 12 through 25. The recommendations made were generally based on the table below.



Table 8-1. Project Area Safety Improvements

Safety Rank	Recommendation	Minimum Offset Distance from Bluff Crest (Feet)	Additional Details
A	Barriers not required.	N/A	N/A
B	Consider evaluating condition of existing barriers.	At crest	Unless slope resiliency ranking is "C" or lower. See "C" Safety Rank row below.
C	Install barriers or consider improving access on bluff slope.	6	Unless slope resiliency ranking is "D" or lower. See "D" Safety Rank row below.
D	Consider relocating barriers/trails if within offset.	10	N/A
F	Install barriers and relocate trails within offset distance. Improve or close bluff access areas where present.	10 or 15	Use 15-foot offset for areas with corrected safety ranks of "D" or lower.

Appendix I provides a list of the 50 lowest-ranked Cells for safety. We recommend that the County utilize the uncorrected safety rankings to prioritize sites for safety improvement, then use the corrected safety rankings to further prioritize. Cells identified for safety improvements should be visited and further evaluated by County staff prior to finalizing the location of said improvements. We also recommend that other adjacent Cells be visited when mobilizing to further evaluate areas for safety improvements. The GIS Experience Comparison Tool may be helpful to visualize other Cells in the area that may need safety improvements. Additional vegetation clearing may be necessary to maintain and/or enhance views after trails are relocated.

8.5 DESIGN PHASE PROCEDURES

Following review and final prioritization of the recommended projects, additional engineering will be required to provide more detailed analyses of the project areas and the proposed Concepts. Initiating the design phase will require evaluations by coastal, civil, geotechnical, and structural engineers in addition to professional ecologists depending on the project. Furthermore, some of the Concepts prepared will require coordination with other local authorities, federal authorities, and private landowners.

8.6 PERMITTING

Permitting for the recommended Concepts has been considered and discussed with the County throughout the design process. Local, state, and federal (e.g., USACE) permits may be required depending on the project. Local filling permits may apply to the various recommended projects. These permits can vary depending on municipality and should be evaluated on a case-by-case basis with the governing municipality in that area.

Adding to the complexity for permitting of these projects is the presence of granted lakebed area that is present along 22.5 miles of County shoreline. This lakebed grant area extends approximately 2,400 feet into Lake Michigan from the existing shoreline and gives permitting authority over the use of the lakebed to the County in those areas. According to SEWRPC Community Assistance Planning Report No. 155, the WDNR has authority under Section 401 of the Federal Water Pollution Control Act to review and grant water quality certification to projects within the granted lakebed area. Additionally, the WDNR has permitting authority regarding grading and removal of topsoil where the graded area exceeds 10,000 square feet. Further conversations with the WDNR will be needed prior to proceeding with construction or maintenance of coastal structures on or near the Lake Michigan shoreline. Decisions regarding the state's role in permitting of these projects should be determined prior to commencement of the design phase.



USACE permits are required for many of the recommended Concepts. Projects with impacts to less than 500 feet of shoreline and with placement less than 1 cubic yard of material per linear foot of shoreline below the Ordinary High Water Mark (OHWM) may only require a Nationwide permit from the USACE. Projects with greater impact areas or material placement volumes may need a General permit, if outside of the Lakebed Grant area and with less than 2,000 feet of shoreline impact, or an Individual permit if not meeting the requirements of the Nationwide or General permits. The County should communicate with USACE on a project-by-project basis to verify the federal permitting requirements.

9.0 SUMMARY AND RECOMMENDATIONS FOR FUTURE WORK

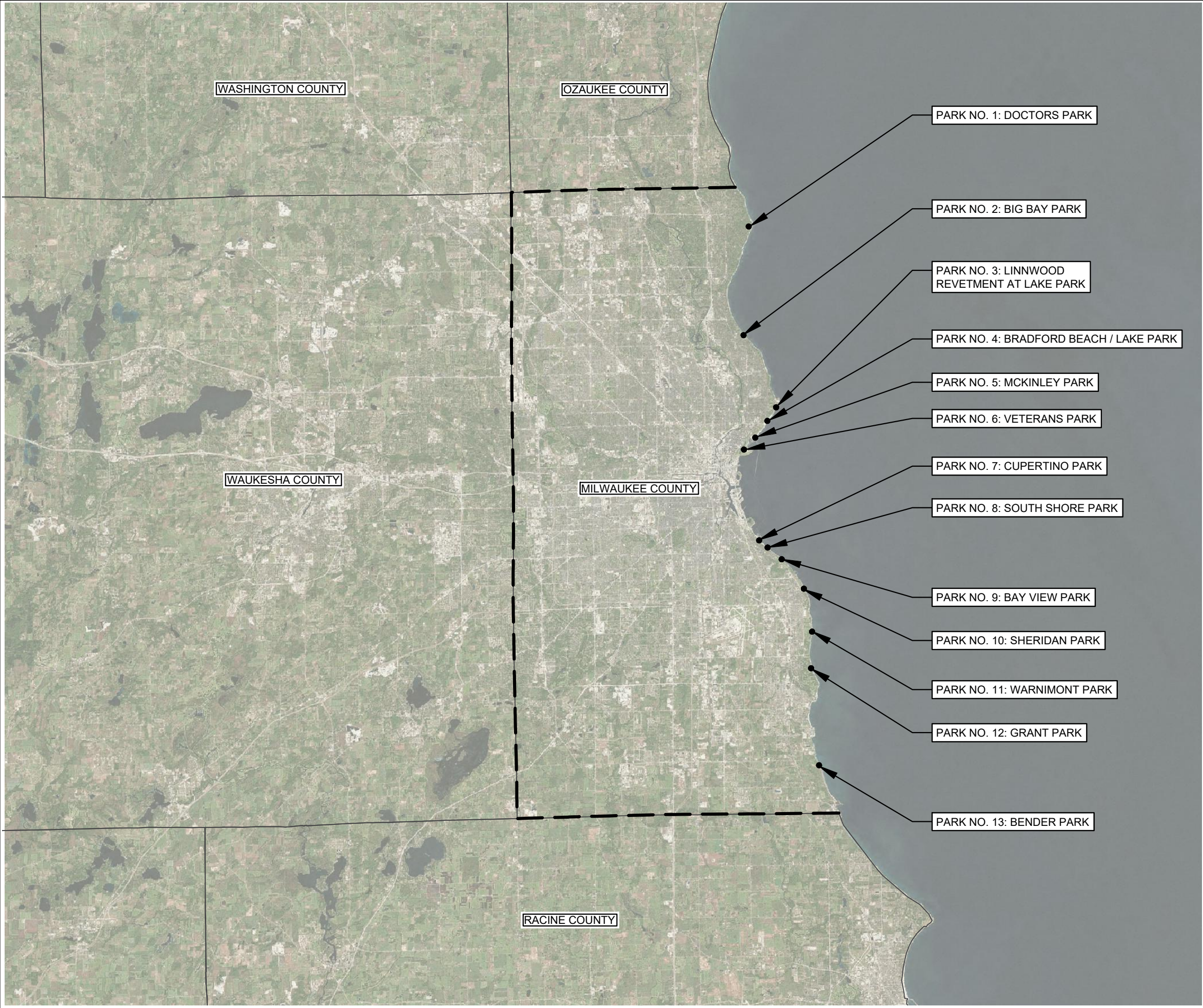
The Project Team is available to train County staff on the use of the GIS Experience web application and Microsoft Excel Spreadsheet Package to facilitate the intended use and interpretation of the data presented. We recommend that the Project Team be retained to assist County staff, as needed. Additionally, we recommend the Project Team be retained to assist the County with specialized review of design documents related to the Concept projects recommended. The Project Team is also available to prepare RFP documentation related to preparing design documents for future shoreline and bluff-related projects at the County parks.

It should be noted that bluff stability, as discussed herein, was based on a limited number of geotechnical borings and laboratory data. To account for localized variations in the subsurface soil profile, additional, project-specific borings should be planned for during the project design phase. GZA is available to assist with performing additional geotechnical borings or analyses for future bluff stability-related projects.



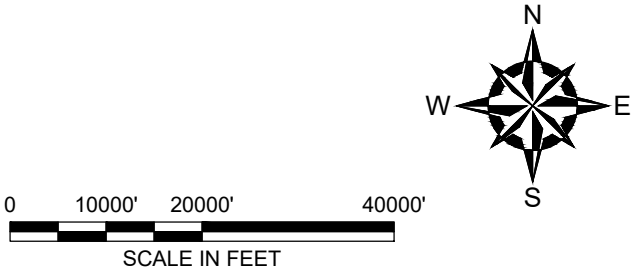
FIGURES

© 2016 - GZA GeoEnvironmental, Inc. GZA-\\GZAWAUKESHA\JOBS\158800T0158899\158819 MKE CNTY LAKE MI BLUFFS\FIGURES\CAD\TYPICAL DETAILS\DWG\GZA_20.0158819.00_TITLESHEETS.DWG F1 PARK LOCATION MAP



LEGEND

- MILWAUKEE COUNTY BOUNDARY
- COUNTY BOUNDARY



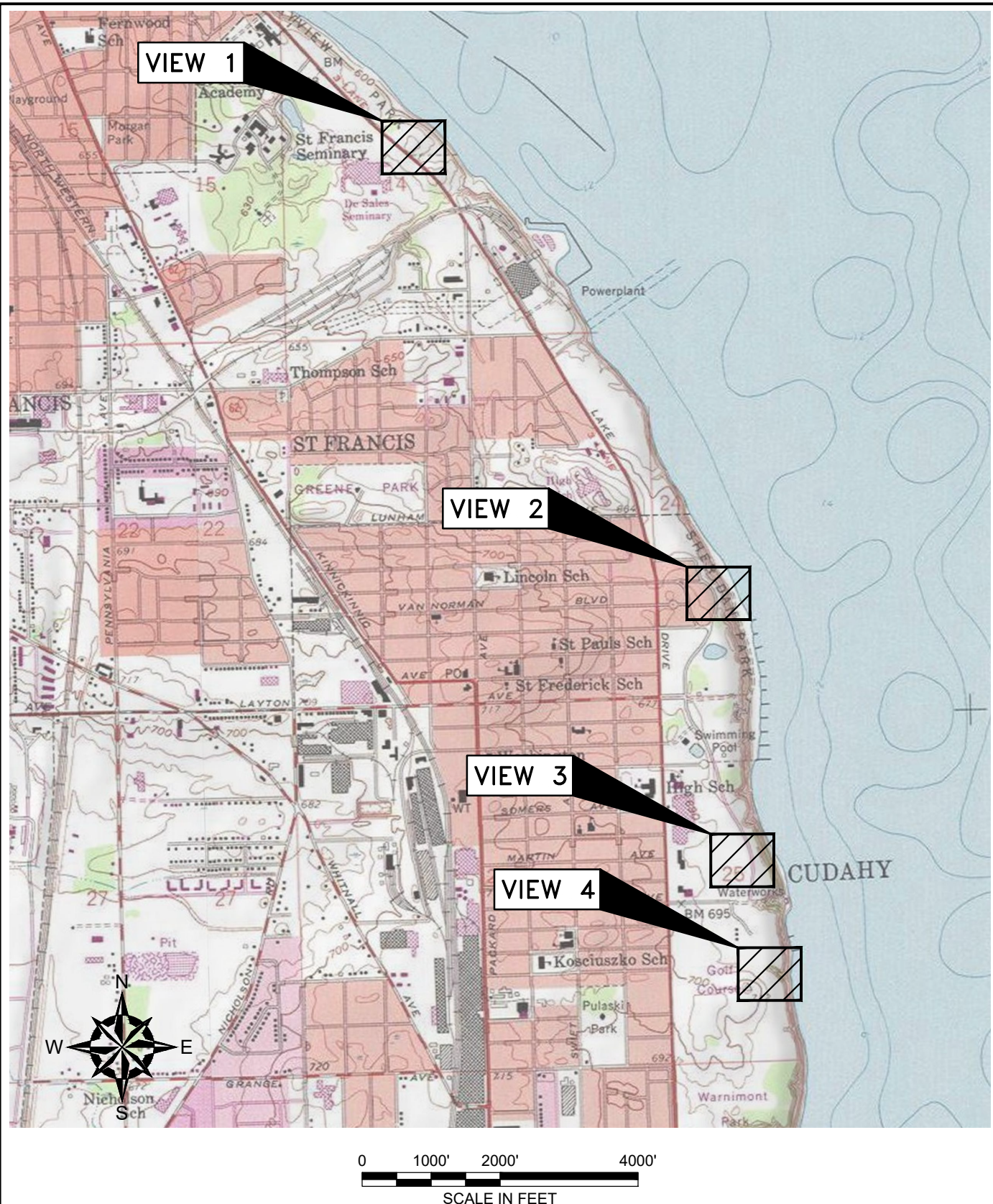
NO.	ISSUE/DESCRIPTION	BY	DATE

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MILWAUKEE COUNTY PARKS BLUFF ASSESSMENT
MILWAUKEE COUNTY, WISCONSIN

PARK LOCATION MAP

PREPARED BY:  GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MILWAUKEE COUNTY DEPARTMENT OF ADMINISTRATIVE SERVICES 633 WEST WISCONSIN AVE., 10TH FLOOR MILWAUKEE, WISCONSIN 53203	
PROJ MGR: IJM	REVIEWED BY: JDG	CHECKED BY: DV	FIGURE 1 SHEET NO. 1 OF 3
DESIGNED BY: IJM	DRAWN BY: CJB	SCALE: AS NOTED	
DATE: FEBRUARY, 2025	PROJECT NO. 20.0158819.00	REVISION NO. 0	



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MILWAUKEE COUNTY PARKS BLUFF ASSESSMENT MILWAUKEE COUNTY, WISCONSIN				PREPARED BY:  GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MILWAUKEE COUNTY DEPARTMENT OF ADMINISTRATIVE SERVICES 633 WEST WISCONSIN AVE., 10TH FLOOR MILWAUKEE, WISCONSIN 53203				
SITE LOCATION PLAN				PROJ MGR:	IJM	REVIEWED BY:	DV	CHECKED BY:	ERH	FIGURE 2
				DESIGNED BY:	IJM	DRAWN BY:	HKP	SCALE:	AS NOTED	
				DATE:	FEBRUARY, 2025	PROJECT NO.	20.0158819.00	REVISION NO.	0	



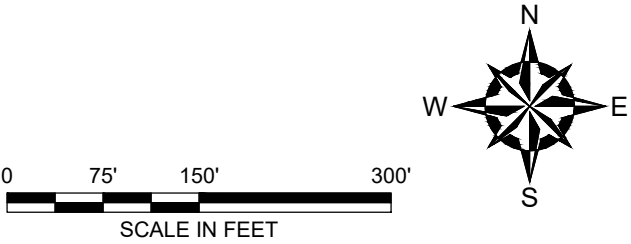
GENERAL NOTES

1. AERIAL MAP UNDERLAY DEVELOPED FROM INTEGRATED BING MAP SERVICE PROVIDED IN AUTOCAD SOFTWARE.
2. THE USE OF AERIAL PHOTOGRAPHY CAN OFTEN MAKE BUILDINGS AND OTHER SITE FEATURES APPEAR TO BE OVERLAPPING AND DISTORTED WHEN OVERLAID WITH ACTUAL SITE FEATURES.
3. THE PURPOSE OF THIS DRAWING IS TO LOCATE, DESCRIBE, AND REPRESENT THE POSITIONS OF GZA SOIL BORING LOCATIONS IN RELATION TO THE SUBJECT SITES. THIS DRAWING IS NOT CONSIDERED A LAND SURVEY. THE LOCATIONS SHOWN SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.
4. HORIZONTAL DATUM REFERENCED TO THE NORTH AMERICAN DATUM OF 1983 (NAD83), WISCONSIN STATE PLANE, SOUTH ZONE, US FOOT.
5. VERTICAL DATUM REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

LEGEND

SB-01  GZA SOIL BORING LOCATION

BORING LOCATION TABLE			
BORING NAME	NORTHING	EASTING	ELEV.
BAYVIEW-SB-01	365,079'	2,540,497'	631'
BAYVIEW-SB-01A	365,081'	2,540,481'	632'
SHERIDAN-SB-02	358,498'	2,544,740'	664'
SHERIDAN-SB-03	354,640'	2,545,279'	683'
WARNIMONT-SB-04	352,966'	2,545,511'	686'



NO.	ISSUE/DESCRIPTION	BY	DATE

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MILWAUKEE COUNTY PARKS BLUFF ASSESSMENT
MILWAUKEE COUNTY, WISCONSIN

BORING LOCATION PLAN

PREPARED BY:



GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:

MILWAUKEE COUNTY DEPARTMENT OF
ADMINISTRATIVE SERVICES
633 WEST WISCONSIN AVE., 10TH FLOOR
MILWAUKEE, WISCONSIN 53203

PROJ MGR: IJM	REVIEWED BY: DV	CHECKED BY: JDG	FIGURE 3 SHEET NO. 3 OF 3
DESIGNED BY: IJM	DRAWN BY: HKP	SCALE: AS NOTED	
DATE: FEBRUARY, 2025	PROJECT NO. 20.0158819.00	REVISION NO. 0	



APPENDIX A

LIMITATIONS



GEOTECHNICAL LIMITATIONS

Use of Report

1. GZA GeoEnvironmental, Inc. (GZA) prepared this Report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the Proposal for Services and/or Report. Use of this Report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the contract documents, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

Standard of Care

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in Proposal for Services and/or Report, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. If conditions other than those described in this Report are found at the subject location(s), or the design has been altered in any way, GZA shall be so notified and afforded the opportunity to revise the Report, as appropriate, to reflect the unanticipated changed conditions.
3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.
4. In conducting our work, GZA relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Inconsistencies in this information which we have noted, if any, are discussed in the Report.

Subsurface Conditions

5. The generalized soil profile(s) provided in our Report are based on widely-spaced subsurface explorations and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then become evident, it will be necessary to reevaluate the conclusions and recommendations of this Report.
6. In preparing this Report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein which were made available to GZA at the time of our evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.
7. Water level readings have been made in test holes (as described in this Report) and monitoring wells at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the level of the groundwater however occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The water table encountered in the course of the work may differ from that indicated in the Report.
8. GZA's services did not include an assessment of the presence of oil or hazardous materials at the property. Consequently, we did not consider the potential impacts (if any) that contaminants in soil or groundwater may have on construction activities, or the use of structures on the property.



9. Recommendations for foundation drainage, waterproofing, and moisture control address the conventional geotechnical engineering aspects of seepage control. These recommendations may not preclude an environment that allows the infestation of mold or other biological pollutants.

Compliance with Codes and Regulations

10. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

Cost Estimates

11. Unless otherwise stated, our cost estimates are only for comparative and general planning purposes. These estimates may involve approximate quantity evaluations. Note that these quantity estimates are not intended to be sufficiently accurate to develop construction bids, or to predict the actual cost of work addressed in this Report. Further, since we have no control over either when the work will take place or the labor and material costs required to plan and execute the anticipated work, our cost estimates were made by relying on our experience, the experience of others, and other sources of readily available information. Actual costs may vary over time and could be significantly more, or less, than stated in the Report.

Additional Services

12. GZA recommends that we be retained to provide services during any future: site observations, design, implementation activities, construction and/or property development/redevelopment. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.



APPENDIX B

CONDITION AND VULNERABILITY INPUTS



May 30, 2025
File No. 20.0158819.00
gan Bluff Repairs Report

Condition, Vulnerability, and Structure Input Table																							
Park	1			Vulnerability Ranks								Bluff Geometry		Beach Volume	Foot Traffic Multiplier	Structures							Neighbor Proximity Trigger
Ref Slope (V/H)	0.4			Shor Pro	Bea Vol	Bea Mat	Veg Qual	Per GW	Surf Wat	Bluf Typ	Safe					Struct No. 1	Quant.	Proximity	Struct No. 2	Quant.	Proximity	Struct No. 3	
	STA. Start	Finish	Shore Bluff	Condition Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Gradient	Height	Cu. Ft.									
	0	100	yes	C	F	F	B	B	A	D	C	A	0.27	96	11292	no	2	1	20	Yes			
	100	200	yes	C	F	F	B	B	A	A	C	A	0.42	97	13372	no				No			
	200	300	yes	C	F	F	B	B	A	A	C	A	0.49	99	10679	no				No			
	300	400	yes	A	A	F	B	B	A	A	C	A	0.48	93	7579	no				No			
	400	500	yes	A	A	F	B	B	A	A	C	A	0.50	92	5511	no				No			
	500	600	yes	A	A	F	D	B	A	A	C	A	0.55	92	4000	no				No			
	600	700	yes	A	A	F	D	B	A	A	C	A	0.55	88	5448	no	17	1	60	No			
	700	800	yes	A	A	F	D	B	A	A	C	A	0.53	92	8700	no				No			
	800	900	yes	B	B	D	B	B	B	A	C	A	0.52	92	23526	no	19	100	1	No			
	900	1000	yes	B	B	D	B	B	B	A	C	A	0.53	92	28370	no	19	100	1	No			
	1000	1100	yes	B	B	D	C	B	D	A	C	A	0.54	95	19855	no	19	100	1	No			
	1100	1200	yes	B	B	D	C	B	D	A	C	A	0.57	94	16648	no	19	100	1	No			
	1200	1300	yes	B	B	D	B	B	D	A	C	A	0.54	93	27109	yes	14	120	1	No			
	1300	1400	yes	B	B	C	B	B	A	A	C	A	0.50	90	32895	yes	14	100	1	No			
	1400	1500	yes	A	B	C	B	B	A	A	C	A	0.43	90	43125	yes	14	100	1	No			
	1500	1600	yes	A	B	B	B	B	A	A	C	A	0.36	89	50447	yes				No			
	1600	1700	yes	A	B	B	B	B	A	A	C	A	0.32	86	51695	yes				No			
	1700	1800	yes	A	B	C	B	B	A	A	B	A	0.29	87	44720	yes	1	225	1	No			
	1800	1900	yes	A	B	B	C	B	A	A	B	A	0.30	84	48136	yes	1	250	1	No			
	1900	2000	yes	A	B	B	C	B	A	A	D	B	0.39	83	58310	yes	1	210	1	No			
	2000	2100	yes	A	B	C	C	B	A	C	B	A	0.19	39	30546	yes	1	195	1	No			
	2100	2200	yes	A	B	D	C	B	A	A	D	B	0.44	76	20194	yes				Yes			



APPENDIX B – CONDITION AND VULNERABILITY INPUTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

BIG BAY PARK

Condition, Vulnerability, and Structure Input Table																										
Park	2			Vulnerability Ranks								Bluff Geometry		Beach Volume	Foot Traffic Multiplier	Structures								Neighbor Proximity Trigger		
Ref Slope (V/H)	0.4			Shor Pro	Bea Vol	Bea Mat	Veg Qual	Per GW	Surf Wat	Bluf Typ	Safe					Struct No. 1	Quant.	Proximity	Struct No. 2	Quant.	Proximity	Struct No. 3	Quant.		Proximity	
	STA. Start	Finish	Shore Bluff	Condition Rank	1	2	3	4	5	6	7	8	Gradient	Height	Cu. Ft.		1	450	1	9	1	1	18	100	1	
					Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank														
	0	200	no	A			B	C	A	A	A	A	0.41	66		yes	1	450	1	9	1	1				Yes
	200	400	yes	A	A	F	C	B	C	A	B	A	0.52	69	3730	yes	14	240	1				18	100	1	No
	400	600	yes	B	A	F	C	B	C	A	C	A	0.55	70	3447	no	1	200	10				18	200	1	No
	600	800	yes	C	A	F	F	B	D	A	C	A	0.53	71	243	no	1	150	30	1	50	10	18	200	1	No
	800	1000	yes	C	A	F	F	B	D	A	C	A	0.55	78	1	no	1	200	40				18	200	1	No
	1000	1200	yes	C	A	F	F	B	D	A	C	A	0.55	79	1	no	1	200	25				18	200	1	No
	1200	1400	yes	C	A	F	F	B	D	A	C	A	0.55	79	1	no	1	200	20				18	200	1	No
	1400	1450	yes	B	A	F	F	B	D	A	C	A	0.55	68	1	no	1	50	30				18	50	1	Yes

Condition, Vulnerability, and Structure Input Table																									
Park	4			Vulnerability Ranks								Bluff Geometry		Beach Volume	Foot Traffic Multiplier	Structures									Neighbor Proximity Trigger
Ref Slope (V/H)	0.4			Shor Pro	Bea Vol	Bea Mat	Veg Qual	Per GW	Surf Wat	Bluf Typ	Safe					Struct No. 1	Quant.	Proximity	Struct No. 2	Quant.	Proximity	Struct No. 3	Quant.	Proximity	
STA. Start	Finish	Shore Bluff	Condition Rank	1 Rank	2 Rank	3 Rank	4 Rank	5 Rank	6 Rank	7 Rank	8 Rank	Gradient	Height	Cu. Ft.											
0	200	no	A				A	A	A	A	A	0.23	64		no	4	200	1				Yes			
200	400	no	A				A	A	A	A	A	0.27	63		no	4	200	1				No			
400	600	no	A				B	A	A	A	A	0.31	49		yes	4	150	1				No			
600	800	no	A				B	A	A	A	A	0.40	61		yes	1	200	1				No			
800	1000	no	A				B	A	A	A	A	0.45	65		yes	1	200	1				No			
1000	1200	no	A				B	A	A	A	A	0.48	69		yes	1	200	1	14	45	1	8	200	1	No
1200	1400	no	A				B	A	A	A	C	0.44	72		yes	1			18	1	1				No
1400	1600	no	A				B	A	A	A	A	0.49	74		no										No
1600	1800	no	A				B	A	A	A	A	0.55	75		no										No
1800	2000	no	A				B	A	A	A	A	0.57	76		no										No
2000	2200	no	A				B	A	A	A	A	0.49	74		no										No
2200	2400	no	A				B	A	A	A	A	0.51	71		no										No
2400	2600	no	A				B	A	A	A	A	0.55	73		no										No
2600	2800	no	A				B	A	A	A	A	0.55	72		no										No
2800	3000	no	A				B	A	A	A	A	0.57	71		no										No
3000	3200	no	A				B	A	A	A	A	0.55	67		yes										No
3200	3400	no	A				B	A	A	A	A	0.61	70		no										No
3400	3600	no	A				B	A	A	A	A	0.52	65		no										No
3600	3800	no	A				B	A	A	A	A	0.43	65		no										No
3800	4000	no	A				B	A	A	A	A	0.40	57		no										No
4000	4200	no	A				B	A	A	A	A	0.45	58		yes										No
4200	4400	no	A				B	A	A	A	A	0.43	62		no										No
4400	4600	no	A				B	A	A	A	A	0.49	61		no										No
4600	4800	no	A				B	A	A	A	A	0.44	57		yes	7	3500	1							No
4800	5000	no	A				B	A	A	A	A	0.43	67		yes										No
5000	5200	no	A				B	A	A	A	A	0.44	58		no										No
5200	5400	no	A				B	A	A	A	A	0.44	58		no										No
5400	5600	no	A				B	A	A	A	A	0.46	57		no										No
5600	5800	no	A				B	A	A	A	A	0.45	50		no	1	50	1							No
5800	6000	no	A				B	A	C	A	A	0.30	36		yes	1	200	1							No
6000	6200	no	A				B	A	D	A	A	0.43	43		no	1	50	1							No
6200	6400	no	A				B	A	D	A	A	0.46	56		no										No
6400	6600	no	A				B	A	D	A	A	0.45	65		no										No
6600	6800	no	A				B	A	D	A	A	0.41	68		no										No
6800	7000	no	A				B	A	A	A	A	0.44	76		no										Yes



May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

Condition, Vulnerability, and Structure Input Table																									
Park Ref Slope (V/H)	5 0.4			Vulnerability Ranks								Bluff Geometry		Beach Volume	Foot Traffic Multiplier	Structures									Neighbor Proximity Trigger
	Shor Pro			Bea Vol	Bea Mat	Veg Qual	Per GW	Surf Wat	Bluf Typ	Safe	Struct No.					Quant.	Proximity	Struct No.	Quant.	Proximity	Struct No.	Quant.	Proximity		
				1	2	3	4	5	6	7	8					1			2			3			
STA. Start	STA. Finish	Shore Bluff	Condition Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Gradient	Height	Cu. Ft.											
0	200	no	A				B	A	A	A	A	0.32	65		no	1	200	1	14	60	1				Yes
200	400	no	A				B	A	A	A	A	0.33	67		yes	1	400	1	18	1	1				No
400	600	no	A				B	A	A	A	A	0.35	61		no	1	200	1							No
600	800	no	A				B	A	A	A	A	0.35	74		no	1	200	1							No
800	1000	no	A				B	A	A	A	A	0.31	73		no	1	200	1							No
1000	1200	no	A				B	A	A	A	A	0.30	68		no	1	200	1							No
1200	1400	no	A				B	A	A	A	A	0.28	64		no	1	225	1							No
1400	1600	no	A				B	A	A	A	A	0.25	59		yes	1	510	1	14	50	1				No
1600	1800	no	A				A	A	A	A	A	0.25	51		yes										No
1800	2000	no	A				B	A	A	A	A	0.31	47		yes										No
2000	2200	no	A				B	A	A	A	A	0.35	41		no										No
2200	2400	no	A				B	A	A	A	A	0.43	46		no										No
2400	2600	no	A				B	A	A	A	A	0.35	43		yes	14	85	1							No
2600	2800	no	A				B	A	A	A	A	0.41	50		no										No
2800	3000	no	A				B	A	A	A	A	0.43	48		no										No
3000	3200	no	A				B	A	A	A	A	0.45	54		no										No
3200	3400	no	A				B	A	A	A	A	0.49	55		no										Yes



APPENDIX B – CONDITION AND VULNERABILITY INPUTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

JUNEAU/VETERANS PARKS

Condition, Vulnerability, and Structure Input Table																									
Park	6			Vulnerability Ranks								Bluff Geometry		Beach Volume	Foot Traffic Multiplier	Structures								Neighbor Proximity Trigger	
Ref Slope (V/H)	0.4			Shor Pro	Bea Vol	Bea Mat	Veg Qual	Per GW	Surf Wat	Bluf Typ	Safe					Struct No. 1	Quant.	Proximity	Struct No. 2	Quant.	Proximity	Struct No. 3	Quant.		Proximity
STA. Start	STA. Finish	Shore Bluff	Condition Rank	1 Rank	2 Rank	3 Rank	4 Rank	5 Rank	6 Rank	7 Rank	8 Rank	Gradient	Height	Cu. Ft.		1			2			3			
0	200	no	A				B	A	A	A	A	0.25	39		yes	1	400	1							Yes
200	400	no	A				B	A	A	A	A	0.31	38		yes	1	400	1							No
400	600	no	A				B	A	A	A	A	0.40	41		yes	1	400	1							No
600	800	no	A				B	A	A	A	A	0.43	47		yes	1	400	1							No
800	1000	no	A				B	A	A	A	A	0.44	59		yes	1	400	1							No
1000	1200	no	A				B	A	A	A	A	0.47	62		no	1	200	1							No
1200	1400	no	A				C	A	A	B	A	0.45	66		no	1	200	1							No
1400	1600	no	A				B	A	A	B	A	0.48	68		no	1	200	1							No
1600	1800	no	A				B	A	A	B	A	0.48	70		no	1	400	1							No
1800	2000	no	A				B	A	A	B	A	0.50	75		no	1	400	1							No
2000	2200	no	A				B	A	A	B	A	0.45	75		no	1	300	1							No
2200	2400	no	A				C	A	A	B	A	0.40	76		no	1	200	1							No
2400	2600	no	A				B	A	A	A	A	0.25	64		no	1	200	1	3	2	2				No
2600	2800	no	A				B	A	A	A	A	0.23	59		yes	1	200	1	3	2	2	14	105	1	No
2800	3000	no	A				B	A	A	A	A	0.33	58		no	1	200	1	8	100	1				No
3000	3200	no	A				B	A	A	A	A	0.25	48		no	3	2	2	1	200	1				No
3200	3400	no	A				B	A	A	A	A	0.26	30		no	3	2	2	1	200	1				No
3400	3600	no	A				C	A	A	B	A	0.37	68		no	1	200	1							No
3600	3800	no	A				B	A	A	A	A	0.35	67		no	3	1	2	1	200	1				No
3800	4000	no	A				B	A	A	A	A	0.27	67		no	3	2	2	1	200	1				No
4000	4200	no	A				B	A	A	B	A	0.32	67		no	3	2	2	1	200	1				No
4200	4400	no	A				B	A	A	A	A	0.21	28		no	3	2	2	1	200	1				No
4400	4600	no	A				B	A	A	A	A	0.37	63		no	3	2	2	1	200	1				Yes



APPENDIX B – CONDITION AND VULNERABILITY INPUTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

CUPERTINO PARK

Condition, Vulnerability, and Structure Input Table																								
Park	7			Vulnerability Ranks								Bluff Geometry		Beach Volume	Foot Traffic Multiplier	Structures								Neighbor Proximity Trigger
Ref Slope (V/H)	0.4			Shor Pro	Bea Vol	Bea Mat	Veg Qual	Per GW	Surf Wat	Bluf Typ	Safe					Struct No.	Quant.	Proximity	Struct No.	Quant.	Proximity	Struct No.	Quant.	
				1	2	3	4	5	6	7	8	1					2			3				
STA. Start	Finish	Shore Bluff	Condition Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Gradient	Height	Cu. Ft.										
0	200	no	A				B	A	A	B	A	0.52	17		no									Yes
200	400	no	A				B	A	A	B	A	0.62	23		no									No
400	600	no	A				B	A	A	B	A	0.63	24		no									No
600	800	no	A				B	A	A	B	A	0.67	24		no									No
800	1000	no	A				C	A	A	B	A	0.67	24		no									No
1000	1200	no	A				A	A	A	B	A	0.58	18		no	17	1	5						No
1200	1400	no	A				A	A	A	B	A	0.28	15		yes	1	150	1						Yes



APPENDIX B – CONDITION AND VULNERABILITY INPUTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

SOUTH SHORE PARK

Condition, Vulnerability, and Structure Input Table																								
Park	8			Vulnerability Ranks								Bluff Geometry		Beach Volume	Foot Traffic Multiplier	Structures								Neighbor Proximity Trigger
Ref Slope (V/H)	0.4			Shor Pro	Bea Vol	Bea Mat	Veg Qual	Per GW	Surf Wat	Bluf Typ	Safe					Struct No. 1	Quant.	Proximity	Struct No. 2	Quant.	Proximity	Struct No. 3	Quant.	
STA. Start	Finish	Shore Bluff	Condition Rank	1 Rank	2 Rank	3 Rank	4 Rank	5 Rank	6 Rank	7 Rank	8 Rank	Gradient	Height	Cu. Ft.		1	20	5	13	1	1			
0	200	no	B				C	A	A	B	A	0.64	43		no									Yes
200	400	no	A				B	A	A	B	A	0.62	40		no									No
400	600	no	A				B	A	A	B	A	0.74	42		no									No
600	800	no	A				B	A	A	B	A	0.62	42		no									No
800	1000	no	A				B	A	A	B	A	0.59	43		no	1	20	5	13	1	1			No
1000	1200	no													no									No
1200	1400	no	A				B	A	A	B	A	0.58	38		no	1	200	5	13	1	1			No
1400	1600	no	A				B	A	A	B	A	0.59	34		no	1	200	5						No
1600	1800	no	A				B	A	A	B	A	0.60	33		no	1	200	5						No
1800	2000	no	A				B	A	A	B	A	0.61	32		no	1	200	5						No
2000	2200	no	B				B	A	A	B	A	0.60	29		no	1	200	5	6	120	1			No
2200	2400	no	A				B	A	A	B	A	0.46	25		no	1	200	5						No
2400	2600	no	A				B	A	A	B	A	0.27	9		no	1	100	5						No
2600	2800	no													no									No
2800	3000	no													no									No
3000	3200	no													no									No
3200	3400	no													no									No
3400	3600	no	A				B	A	A	B	A	0.21	16		no									No
3600	3800	no	A				B	A	A	B	A	0.22	17		no									No
3800	4000	no	A				B	A	A	B	A	0.22	13		no									No
4000	4200	no	A				B	A	A	B	A	0.16	11		yes									No
4200	4400	no	A				B	A	A	B	A	0.37	17		no	8	1000	1						No
4400	4600	no	A				B	A	A	A	A	0.29	18		no	8	500	1						Yes



APPENDIX B – CONDITION AND VULNERABILITY INPUTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

BAY VIEW PARK

Condition, Vulnerability, and Structure Input Table																									
Park Slope	9			Vulnerability Ranks								Bluff Geometry		Beach Volume	Foot Traffic Multiplier	Structures									Neighbor Proximity Trigger
Ref Slope (V/H)	0.4			Shor Pro	Bea Vol	Bea Mat	Veg Qual	Per GW	Surf Wat	Bluf Typ	Safe					Struct No. 1	Quant.	Proximity	Struct No. 2	Quant.	Proximity	Struct No. 3	Quant.	Proximity	
				1	2	3	4	5	6	7	8					Gradient	Height	Cu. Ft.							
STA. Start	Finish	Shore Bluff	Condition Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank														
0	200	yes	F	D	F	A	F	F	A	C	D	0.77	44	3026	no	16	75	1							Yes
200	400	yes	F	D	F	A	F	F	A	C	D	0.72	50	3213	no										No
400	600	yes	F	D	F	A	F	F	A	C	D	0.85	52	1528	no										No
600	800	yes	F	D	F	C	F	F	A	C	D	0.93	48	2017	no										No
800	1000	yes	F	F	F	C	D	F	A	C	D	0.86	40	2741	no										No
1000	1200	yes	D	F	F	A	D	F	A	C	C	0.67	26	9497	no	1	200	100							No
1200	1400	yes	F	B	F	A	F	F	A	C	C	0.70	35	1676	no	1	200	55							No
1400	1600	yes	C	B	F	B	C	D	A	C	C	0.47	39	9195	no	1	100	1							No
1600	1800	yes	B	B	D	A	B	C	A	B	B	0.33	41	28430	yes	9	1	1	1	400	20				No
1800	2000	yes	B	B	C	A	B	A	A	B	B	0.30	37	43294	yes	1	200	1							No
2000	2200	yes	B	B	C	B	B	A	A	C	B	0.39	40	36229	yes	1	200	1							No
2200	2400	yes	A	B	A	B	B	A	A	C	B	0.42	42	159183	no	1	200	1							No
2400	2600	yes	A	B	A	B	B	A	A	C	B	0.39	42	170512	no	1	200	1							No
2600	2800	yes	A	B	A	B	B	A	A	C	B	0.41	43	132786	no	1	200	1							No
2800	3000	yes	A	B	A	C	B	A	A	C	B	0.45	45	101690	no	1	200	1							No
3000	3200	yes	A	B	A	C	B	A	A	C	A	0.45	45	104110	yes	14	50	1	1	500	15				No
3200	3400	yes	A	B	A	C	B	A	A	C	B	0.49	44	157167	no	1	200	1	4	100	100	15	200	100	No
3400	3600	yes	A	B	A	C	B	A	A	C	B	0.53	44	139323	no	1	200	1							No
3600	3800	yes	A	B	A	C	B	A	A	C	B	0.56	41	133194	no	1	200	1							No
3800	4000	yes	A	B	A	C	B	A	A	C	B	0.56	41	95817	no	1	200	1							No
4000	4200	yes	A	A	A	C	B	A	A	C	B	0.58	43	76088	no	1	150	1	6	150	15				Yes



APPENDIX B – CONDITION AND VULNERABILITY INPUTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

SHERIDAN PARK

Condition, Vulnerability, and Structure Input Table																									
Park	10			Vulnerability Ranks								Bluff Geometry		Beach Volume	Foot Traffic Multiplier	Structures									Neighbor Proximity Trigger
Ref Slope (V/H)	0.4			Shor Pro	Bea Vol	Bea Mat	Veg Qual	Per GW	Surf Wat	Bluf Typ	Safe					Struct No. 1	Quant.	Proximity	Struct No. 2	Quant.	Proximity	Struct No. 3	Quant.	Proximity	
STA. Start	STA. Finish	Shore Bluff	Condition Rank	1 Rank	2 Rank	3 Rank	4 Rank	5 Rank	6 Rank	7 Rank	8 Rank	Gradient	Height	Cu. Ft.		1			2			3			
0	200	yes	D	C	D	C	D	F	A	C	D	0.87	91	28299	no										Yes
200	400	yes	F	F	D	C	D	F	A	C	D	0.91	103	16940	no										No
400	600	yes	F	F	D	C	D	F	A	C	D	0.91	105	15169	no										No
600	800	yes	F	F	D	B	D	F	A	C	F	1.02	104	16181	yes	4	200	75	1	50	100				No
800	1000	yes	F	F	F	B	F	F	A	C	D	0.91	100	11304	no	4	200	75							No
1000	1200	yes	F	F	F	A	F	F	A	C	D	1.01	101	9742	no										No
1200	1400	yes	F	F	F	A	F	F	A	C	D	0.92	100	9760	no										No
1400	1600	yes	F	F	F	B	F	F	A	C	D	0.92	99	14489	no										No
1600	1800	yes	F	F	F	B	F	F	A	C	F	0.91	102	9730	no	1	150	60							No
1800	2000	yes	F	F	F	B	F	F	A	C	D	0.93	106	6790	no										No
2000	2200	yes	D	F	D	B	C	A	A	C	C	0.71	107	17947	no	17	1	80	17	1	100	8	500	95	No
2200	2400	yes	B	A	B	C	C	A	A	C	A	0.60	100	50830	no										No
2400	2600	yes	B	A	A	C	B	A	A	C	A	0.57	91	85804	no										No
2600	2800	yes	B	A	A	C	B	A	A	C	A	0.48	91	81855	no	9	1	1							No
2800	3000	yes	C	A	A	B	B	A	D	B	A	0.41	87	105652	yes	1	600	1							No
3000	3200	yes	B	A	A	A	B	A	B	B	A	0.50	87	108719	yes	1	160	1							No
3200	3400	yes	B	A	C	A	B	A	A	C	A	0.52	89	40034	no	1	200	100							No
3400	3600	yes	B	A	D	A	B	A	A	C	A	0.59	92	28028	no	1	200	100							No
3600	3800	yes	B	A	D	A	C	A	B	C	A	0.56	99	25293	no	1	150	50							No
3800	4000	yes	B	A	C	B	C	A	D	C	A	0.56	102	31091	no										No
4000	4200	yes	B	A	B	B	B	A	D	C	A	0.54	101	52903	no										No
4200	4400	yes	C	B	C	C	A	B	A	C	A	0.54	96	42280	no	1	250	50							No
4400	4600	yes	F	F	F	A	D	D	A	C	F	0.68	88	8080	yes	1	200	35	4	200	85				No
4600	4800	yes	F	F	C	A	D	D	A	C	F	0.70	81	30030	yes	1	200	35							No
4800	5000	yes	B	A	B	A	B	A	A	C	A	0.52	77	57296	no	1	200	60							No
5000	5200	yes	B	A	A	A	B	A	A	C	A	0.51	77	64596	no	1	200	30							No
5200	5400	yes	C	D	D	A	A	D	A	A	A	0.40	77	23653	no										No
5400	5600	yes	C	D	D	A	A	A	A	B	A	0.39	70	29998	no										No
5600	5800	yes	C	D	C	A	A	A	A	B	A	0.31	67	35591	yes										No
5800	6000	yes	B	C	C	A	A	A	A	B	A	0.33	66	35058	no										No
6000	6200	yes	B	C	C	A	A	A	A	A	A	0.30	66	30256	no	1	90	1							No
6200	6400	yes	B	C	C	A	A	A	A	A	A	0.36	55	32958	no										No
6400	6600	yes	B	C	C	A	A	A	A	A	A	0.36	54	37038	no										No
6600	6800	yes	B	C	C	A	A	A	A	A	A	0.36	52	42657	no										No
6800	7000	yes	B	C	C	A	A	A	A	A	A	0.35	52	35684	no										No
7000	7200	yes	B	C	C	A	A	A	D	A	A	0.34	49	30854	no										No
7200	7400	yes	B	C	C	A	A	A	A	A	A	0.40	46	36612	no										No
7400	7600	yes	B	C	C	A	A	A	A	A	A	0.41	44	38499	no										No
7600	7800	yes	B	C	C	A	A	A	A	A	A	0.50	47	36820	no										No
7800	8000	yes	B	C	C	A	A	D	A	A	A	0.52	43	32928	no										No
8000	8200	yes	B	C	D	A	A	A	A	A	A	0.53	41	27225	no										No
8200	8400	yes	B	C	C	A	A	A	A	A	A	0.52	40	31255	no										No
8400	8600	yes	C	C	D	A	A	A	A	A	C	0.60	42	21578	no	1	90	1							No
8600	8800	yes	B	B	C	A	A	A	A	A	A	0.47	41	39101	no	1	200	1	6	50	1				No
8800	9000	yes	A	A	A	A	A	A	A	A	A	0.40	34	60384	no	1	200	1	6	200	1				No
9000	9200	yes	A	A	B	A	A	A	A	A	A	0.31	28	57646	no				6	200	1				No
9200	9400	yes	A	A	B	A	A	A	A	A	A	0.27	22	59358	no				6	200	1				No
9400	9600	yes	A	A	B	A	A	A	A	A	A	0.25	25	50021	no	14	5	10	6	200	1				Yes



APPENDIX B – CONDITION AND VULNERABILITY INPUTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

WARNIMONT PARK

Condition, Vulnerability, and Structure Input Table																							
Park	11			Vulnerability Ranks								Bluff Geometry		Beach Volume	Foot Traffic Multiplier	Structures							Neighbor Proximity Trigger
Ref Slope (V/H)	0.4			Shor Pro	Bea Vol	Bea Mat	Veg Qual	Per GW	Surf Wat	Bluf Typ	Safe					Struct No. 1	Quant.	Proximity	Struct No. 2	Quant.	Proximity	Struct No. 3	
STA. Start	Finish	Shore Bluff	Condition Rank	1 Rank	2 Rank	3 Rank	4 Rank	5 Rank	6 Rank	7 Rank	8 Rank	Gradient	Height	Cu. Ft.		3	1	95					
0	200	yes	C	D	D	B	C	F	D	C	B	0.49	36	26860	no							Yes	
200	400	yes	B	D	D	B	B	F	D	C	A	0.65	62	29162	no							No	
400	600	yes	A	D	D	B	B	A	D	C	A	0.71	39	27795	no							No	
600	800	yes	B	D	D	B	B	F	D	C	A	0.57	61	17613	no							No	
800	1000	yes	C	D	F	B	B	F	D	C	A	0.60	92	14476	no							No	
1000	1200	yes	C	D	F	B	C	F	D	C	B	0.57	92	12863	yes							No	
1200	1400	yes	D	D	F	B	D	F	D	C	F	0.72	93	9457	yes							No	
1400	1600	yes	F	D	F	B	D	F	D	C	C	0.63	100	9227	yes							No	
1600	1800	yes	D	D	F	B	D	F	D	C	C	0.61	100	6946	no							No	
1800	2000	yes	D	D	F	B	D	F	D	C	C	0.72	102	8217	no							No	
2000	2200	yes	F	D	F	B	D	F	D	C	F	0.69	100	8306	yes							No	
2200	2400	yes	D	D	F	B	C	F	D	C	D	0.60	108	8803	no							No	
2400	2600	yes	D	D	F	B	C	F	F	C	F	0.58	107	14453	yes							No	
2600	2800	yes	D	D	F	B	D	F	D	C	C	0.56	94	11203	no							No	
2800	3000	yes	F	F	F	B	F	F	D	C	D	0.80	100	8992	yes							No	
3000	3200	yes	F	F	F	B	F	F	D	C	D	0.71	103	14905	yes							No	
3200	3400	yes	D	C	D	B	C	F	D	C	B	0.55	89	22000	no	9	1	1				No	
3400	3600	yes	D	D	F	A	D	F	D	C	C	0.56	88	14553	no	9	1	1				No	
3600	3800	yes	D	D	F	A	C	F	D	C	C	0.57	87	12299	no							No	
3800	4000	yes	F	D	F	A	D	F	D	C	D	0.64	97	4723	no							No	
4000	4200	yes	F	D	F	A	F	F	D	C	D	0.76	92	8311	no							No	
4200	4400	yes	F	D	F	A	F	F	D	C	D	0.72	92	8777	no							No	
4400	4600	yes	F	D	F	A	F	F	D	C	D	0.84	91	2110	no							No	
4600	4800	yes	F	D	F	A	F	F	D	C	D	0.85	94	7334	no							No	
4800	5000	yes	F	D	F	A	F	F	D	C	D	0.93	95	5468	no							No	
5000	5200	yes	F	D	F	A	F	F	D	C	D	0.96	99	2409	no							No	
5200	5400	yes	F	D	F	A	F	F	D	C	D	0.90	97	4457	no							No	
5400	5600	yes	F	D	F	A	F	F	D	C	D	0.86	95	5773	no							No	
5600	5800	yes	F	D	F	A	F	F	D	C	F	0.86	100	9104	no							No	
5800	6000	yes	D	D	F	A	D	F	D	C	F	0.90	100	10260	yes							No	
6000	6200	yes	D	D	F	A	D	F	B	C	F	0.91	100	13457	yes							No	
6200	6400	yes	D	D	F	A	D	F	B	C	F	0.87	101	13603	yes							No	
6400	6600	yes	F	D	F	A	F	F	B	C	F	0.93	96	7018	yes							No	
6600	6800	yes	F	D	F	A	F	F	B	C	F	0.95	95	5512	no	8	2500	75				No	
6800	7000	yes	F	F	F	A	F	F	B	C	F	0.78	106	5615	no							No	
7000	7200	yes	F	F	F	A	F	F	D	C	F	0.85	104	12384	no							No	
7200	7400	yes	F	F	F	A	F	F	D	C	F	0.85	106	10378	no							No	
7400	7550	yes	D	F	F	A	F	D	B	C	D	0.96	96	6610	no	9	1	60				Yes	



APPENDIX B – CONDITION AND VULNERABILITY INPUTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

GRANT PARK

Condition, Vulnerability, and Structure Input Table																								
Park	12			Vulnerability Ranks								Bluff Geometry		Beach Volume	Foot Traffic Multiplier	Structures								Neighbor Proximity Trigger
Ref Slope (V/H)	0.4			Shor Pro	Bea Vol	Bea Mat	Veg Qual	Per GW	Surf Wat	Bluf Typ	Safe					Struct No. 1	Quant.	Proximity	Struct No. 2	Quant.	Proximity	Struct No. 3	Quant.	
STA. Start	STA. Finish	Shore Bluff	Condition Rank	1	2	3	4	5	6	7	8	Gradient	Height	Cu. Ft.		1			2			3		
0	200	no																						Yes
200	400	no																						No
400	600	no																						No
600	800	no	A				B	A	A	C	A	0.38	34	556279	no									No
800	1000	no	A				B	A	A	C	A	0.42	62	415231	no									No
1000	1200	no	A				B	A	A	C	A	0.45	70	368482	no									No
1200	1400	no	A				B	A	A	C	A	0.46	70	290186	no									No
1400	1600	no	A				B	A	A	C	A	0.46	71	218280	no									No
1600	1800	no	A				B	A	A	C	A	0.48	73	125521	no									No
1800	2000	yes	B	F	B	C	B	A	A	C	B	0.62	90	51476	no									No
2000	2200	yes	D	F	C	C	B	A	A	C	B	0.73	98	31814	no	1	200	100						No
2200	2400	yes	F	F	F	A	D	F	D	C	B	0.79	100	12504	no	1	200	100						No
2400	2600	yes	C	B	D	A	C	F	D	C	B	0.74	98	24911	yes	1	200	100						No
2600	2800	yes	D	B	D	B	B	F	A	C	F	0.74	96	24716	yes	1	200	75						No
2800	3000	yes	F	F	C	C	F	F	A	C	F	0.78	94	32777	no	1	210	75						No
3000	3200	yes	B	F	C	C	B	C	A	C	C	0.59	96	32147	no	1	200	60						No
3200	3400	yes	C	B	C	C	B	B	A	C	C	0.53	91	44903	no									No
3400	3600	yes	C	B	D	C	B	F	A	C	C	0.55	87	26332	no	1	210	40						No
3600	3800	yes	D	B	D	C	C	F	A	C	C	0.54	89	27696	no									No
3800	4000	yes	C	B	D	C	C	F	A	C	C	0.57	92	28437	no									No
4000	4200	yes	B	B	D	C	C	F	D	C	C	0.59	88	25901	no	1	210	50						No
4200	4400	yes	B	B	D	C	C	F	D	C	C	0.66	85	21130	no	1	120	35						No
4400	4600	yes	D	D	D	C	D	F	A	C	D	0.59	74	16541	yes									No
4600	4800	yes	D	D	D	C	C	D	A	C	F	0.66	69	21761	yes	6	1	85	14	50	1			No
4800	5000	yes	D	D	D	C	C	F	D	C	C	0.62	66	19783	no									No
5000	5200	yes	D	D	D	C	D	F	D	C	C	0.68	65	16854	no									No
5200	5400	yes	D	D	F	C	F	F	A	C	F	0.67	74	13680	no									No
5400	5600	yes	C	D	D	C	C	F	D	C	C	0.75	77	25045	no									No
5600	5800	yes	D	F	D	C	C	F	D	C	C	0.78	76	29992	no									No
5800	6000	yes	F	F	D	C	D	F	A	C	D	0.67	75	18889	yes									No
6000	6200	yes	D	F	F	C	C	C	A	C	F	0.63	59	11719	yes									No
6200	6400	yes	B	B	D	C	B	B	A	C	C	0.53	55	23364	yes									No
6400	6600	yes	A	B	A	C	B	A	F	C	B	0.47	50	66909	yes	14	150	1						No
6600	6800	yes	A	B	B	C	C	A	A	C	B	0.55	50	46204	yes									No
6800	7000	yes	A	B	B	C	B	A	A	C	B	0.66	53	58631	yes									No
7000	7200	yes	A	B	A	C	B	A	A	C	B	0.57	55	66688	yes									No
7200	7400	yes	A	B	B	C	B	A	B	C	C	0.53	55	58168	yes									No
7400	7600	yes	A	B	B	C	B	A	D	C	B	0.55	37	58425	yes									No
7600	7800	yes	A	D	B	C	B	A	D	C	B	0.55	47	48320	yes									No
7800	8000	yes	A	D	C	C	B	A	D	C	B	0.47	58	34387	yes									No
8000	8200	yes	B	D	D	B	B	A	D	C	C	0.56	62	28797	yes									No
8200	8400	yes	B	D	D	B	B	A	D	C	B	0.60	64	27936	yes									No
8400	8600	yes	B	D	C	B	B	F	D	C	B	0.61	66	31582	yes									No
8600	8800	yes	C	D	C	B	B	F	D	C	B	0.60	71	32098	yes									No
8800	9000	yes	B	D	C	B	B	F	D	C	B	0.62	81	30661	no									No
9000	9050	yes	B	D	F	B	A	F	D	C	B	0.61	81	6548	no	3	1	150						Yes

Condition, Vulnerability, and Structure Input Table																									
Park	13			Vulnerability Ranks								Bluff Geometry		Beach Volume	Foot Traffic Multiplier	Structures									Neighbor Proximity Trigger
	Shor Pro			Bea Vol	Bea Mat	Veg Qual	Per GW	Surf Wat	Bluf Typ	Safe	Struct No. 1					Quant.	Proximity	Struct No. 2	Quant.	Proximity	Struct No. 3	Quant.	Proximity		
Ref Slope (V/H)	0.4			1	2	3	4	5	6	7	8														
STA. Start	STA. Finish	Shore Bluff	Condition Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Rank	Gradient	Height	Cu. Ft.											
0	200	no	C				C	B	D	C	D	0.72	136		yes	5	85	50	6	175	50			Yes	
200	400	no	B				D	B	D	C	C	0.59	108		no	6	200	50						No	
400	600	no	B				D	B	D	C	C	0.64	109		no	6	200	50						No	
600	800	no	B				D	B	F	C	C	0.65	104		no	6	200	50						No	
800	1000	no	B				D	B	D	C	C	0.59	109		no	6	200	50						No	
1000	1200	no	B				D	B	D	C	C	0.64	131		no	6	200	50						No	
1200	1400	no	B				D	B	F	C	C	0.51	113		no	6	200	50						No	
1400	1600	no	B				C	B	D	C	C	0.59	104		no	6	200	50						No	
1600	1800	no	B				C	B	F	C	C	0.57	112		no	6	200	50						No	
1800	2000	no	B				C	B	D	C	C	0.61	138		no	6	200	50						No	
2000	2200	no	B				C	B	D	C	C	0.57	110		no	6	200	50						No	
2200	2400	no	B				C	B	D	C	C	0.51	107		no	6	200	50						No	
2400	2600	no	B				C	B	D	C	C	0.45	106		no	6	200	50						No	
2600	2800	no	B				B	B	F	C	C	0.50	95		no	5	100	50	6	200	50			No	
2800	3000	no	A				A	A	A	A	A	0.40	99		yes	6	200	50						No	
3000	3200	no	A				A	A	A	A	A	0.30	99		yes	6	200	50						No	
3200	3400	no	C				B	A	F	A	C	0.34	99		yes	9	1	1						No	
3400	3600	no	A				A	A	A	A	A	0.29	96		yes	4	100	1	8	1000	5	1	50	1	No
3600	3800	no	A				A	A	A	A	A	0.29	93		yes	4	200	1	8	2000	5	1	200	1	No
3800	4000	no	A				A	A	A	A	A	0.35	104		yes	4	210	1	8	2000	5	1	330	1	No
4000	4200	no	A				A	A	B	A	A	0.33	88		yes	4	210	1	8	2000	5	1	205	1	No
4200	4400	no	A				A	A	A	A	A	0.25	57		yes	4	200	1	8	2000	5	1	200	1	No
4400	4600	no	A				A	A	A	A	A	0.31	57		yes	4	200	1	8	2000	5	1	200	1	No
4600	4800	no	A				A	A	A	A	A	0.28	62		yes	4	100	1	8	1000	5	1	275	1	No
4800	5000	no	A				A	A	C	B	A	0.33	74		no	6	160	5						No	
5000	5200	no	A				A	A	B	B	A	0.38	62		no	6	200	5						No	
5200	5400	no	A				A	A	B	B	A	0.36	62		no	6	200	5						No	
5400	5600	no	A				A	A	F	B	A	0.37	69		no	6	180	5						No	
5600	5800	no	A				A	A	A	B	A	0.40	87			6	200	50						No	
5800	6000	no	C				C	A	A	C	B	0.50	73		no									Yes	



APPENDIX C

REPLACEMENT VALUE, RISK, AND RESILIENCY RANK TABLES



APPENDIX C – REPLACEMENT VALUE, RISK, AND RESILIENCY RESULTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

DOCTORS PARK

Park	1	Replacment Value				Risk			Resiliency Value				Resiliency Rank			
Ref Slope (V/H)	0.4															
STA. Start	STA. Finish	Land	Structure	Neighbor	Total	Scenario			Scenario				Scenario			
						1	2	3	1	2	3	S	1	2	3	S
0	100	\$4,182	\$0	\$2,091	\$6,273	\$2,689	\$3,388	\$2,366	0.429	0.540	0.377	0.051	C-	D+	C+	A
100	200	\$39,245	\$0	\$0	\$39,245	\$15,305	\$21,192	\$12,783	0.390	0.540	0.326	0.051	C+	D+	B-	A
200	300	\$188,605	\$0	\$0	\$188,605	\$73,556	\$101,847	\$61,431	0.390	0.540	0.326	0.051	C+	D+	B-	A
300	400	\$153,835	\$0	\$0	\$153,835	\$13,845	\$15,383	\$13,186	0.090	0.100	0.086	0.051	A-	A-	A-	A
400	500	\$187,430	\$0	\$0	\$187,430	\$16,869	\$18,743	\$16,065	0.090	0.100	0.086	0.051	A-	A-	A-	A
500	600	\$258,228	\$0	\$0	\$258,228	\$23,978	\$29,266	\$25,085	0.093	0.113	0.097	0.051	A-	A-	A-	A
600	700	\$248,177	\$203,066	\$0	\$451,243	\$41,901	\$51,141	\$43,835	0.093	0.113	0.097	0.051	A-	A-	A-	A
700	800	\$240,355	\$0	\$0	\$240,355	\$22,319	\$27,240	\$23,349	0.093	0.113	0.097	0.051	A-	A-	A-	A
800	900	\$219,383	\$156,205	\$0	\$375,587	\$74,044	\$80,125	\$68,679	0.197	0.213	0.183	0.051	B+	B	B+	A
900	1000	\$240,480	\$156,205	\$0	\$396,685	\$78,204	\$84,626	\$72,537	0.197	0.213	0.183	0.051	B+	B	B+	A
1000	1100	\$255,441	\$156,205	\$0	\$411,646	\$91,738	\$93,306	\$89,386	0.223	0.227	0.217	0.051	B	B	B	A
1100	1200	\$295,312	\$156,205	\$0	\$451,516	\$100,624	\$102,344	\$98,044	0.223	0.227	0.217	0.051	B	B	B	A
1200	1300	\$257,303	\$209,314	\$0	\$466,618	\$102,656	\$99,545	\$95,990	0.220	0.213	0.206	0.064	B	B	B	A
1300	1400	\$191,158	\$109,343	\$0	\$300,501	\$51,514	\$56,094	\$48,080	0.171	0.187	0.160	0.064	B+	B+	B+	A
1400	1500	\$59,326	\$109,343	\$0	\$168,669	\$14,457	\$15,742	\$13,494	0.086	0.093	0.080	0.064	A-	A-	A-	A
1500	1600	\$4,182	\$0	\$0	\$4,182	\$329	\$335	\$311	0.079	0.080	0.074	0.064	A-	A-	A-	A
1600	1700	\$4,182	\$0	\$0	\$4,182	\$329	\$335	\$311	0.079	0.080	0.074	0.064	A-	A-	A-	A
1700	1800	\$4,182	\$485,406	\$0	\$489,589	\$37,768	\$45,695	\$36,369	0.077	0.093	0.074	0.064	A-	A-	A-	A
1800	1900	\$4,182	\$27,336	\$0	\$31,518	\$2,251	\$2,732	\$2,341	0.071	0.087	0.074	0.064	A-	A-	A-	A
1900	2000	\$4,182	\$22,962	\$0	\$27,144	\$2,288	\$2,353	\$2,482	0.084	0.087	0.091	0.064	A-	A-	A-	A
2000	2100	\$4,182	\$21,322	\$0	\$25,504	\$2,223	\$2,550	\$2,332	0.087	0.100	0.091	0.064	A-	A-	A-	A
2100	2200	\$64,808	\$0	\$32,404	\$97,213	\$9,582	\$11,017	\$9,999	0.099	0.113	0.103	0.064	A-	A-	A-	A



APPENDIX C – REPLACEMENT VALUE, RISK, AND RESILIENCY RESULTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

BIG BAY PARK

Park	2	Replacment Value				Risk			Resiliency Value				Resiliency Rank			
Ref Slope (V/H)	0.4															
STA. Start	STA. Finish	Land	Structure	Neighbor	Total	Scenario			Scenario				Scenario			
						1	2	3	1	2	3	S	1	2	3	S
0	200	\$35,129	\$830,229	\$17,565	\$882,922	\$60,039	\$0	\$61,805	0.068	0.000	0.070	0.069	A-	A	A-	A-
200	400	\$337,669	\$682,615	\$0	\$1,020,284	\$96,198	\$108,830	\$99,113	0.094	0.107	0.097	0.069	A-	A-	A-	A-
400	600	\$404,964	\$862,251	\$0	\$1,267,215	\$260,684	\$270,339	\$260,684	0.206	0.213	0.206	0.055	B	B	B	A
600	800	\$367,717	\$862,251	\$0	\$1,229,968	\$411,161	\$442,789	\$442,789	0.334	0.360	0.360	0.055	C+	C+	C+	A
800	1000	\$459,339	\$862,251	\$0	\$1,321,590	\$441,789	\$475,772	\$475,772	0.334	0.360	0.360	0.055	C+	C+	C+	A
1000	1200	\$452,806	\$862,251	\$0	\$1,315,057	\$439,605	\$473,420	\$473,420	0.334	0.360	0.360	0.055	C+	C+	C+	A
1200	1400	\$468,280	\$862,251	\$0	\$1,330,530	\$444,777	\$478,991	\$478,991	0.334	0.360	0.360	0.055	C+	C+	C+	A
1400	1450	\$98,733	\$215,563	\$49,367	\$363,663	\$81,045	\$87,279	\$87,279	0.223	0.240	0.240	0.055	B	B	B	A



APPENDIX C – REPLACEMENT VALUE, RISK, AND RESILIENCY RESULTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

BRADFORD/LAKE PARK

Park	4	Replacment Value				Risk			Resiliency Value				Resiliency Rank			
Ref Slope (V/H)	0.4															
STA. Start	STA. Finish	Land	Structure	Neighbor	Total	Scenario			Scenario				Scenario			
						1	2	3	1	2	3	S	1	2	3	S
0	200	\$14,611	\$87,475	\$7,306	\$109,391	\$4,376	\$0	\$4,376	0.040	0.000	0.040	0.128	A	A	A	A-
200	400	\$14,611	\$87,475	\$0	\$102,086	\$4,083	\$0	\$4,083	0.040	0.000	0.040	0.128	A	A	A	A-
400	600	\$14,611	\$65,606	\$0	\$80,217	\$4,171	\$0	\$4,011	0.052	0.000	0.050	0.160	A	A	A	B+
600	800	\$14,611	\$21,869	\$0	\$36,480	\$1,897	\$0	\$1,824	0.052	0.000	0.050	0.160	A	A	A	B+
800	1000	\$279,335	\$21,869	\$0	\$301,204	\$15,663	\$0	\$15,060	0.052	0.000	0.050	0.160	A	A	A	B+
1000	1200	\$400,439	\$94,504	\$0	\$494,943	\$25,737	\$0	\$24,747	0.052	0.000	0.050	0.160	A	A	A	B+
1200	1400	\$257,780	\$9,669	\$0	\$267,449	\$13,907	\$0	\$13,372	0.052	0.000	0.050	0.481	A	A	A	C-
1400	1600	\$507,532	\$0	\$0	\$507,532	\$26,392	\$0	\$25,377	0.052	0.000	0.050	0.128	A	A	A	A-
1600	1800	\$737,340	\$0	\$0	\$737,340	\$38,342	\$0	\$36,867	0.052	0.000	0.050	0.128	A	A	A	A-
1800	2000	\$822,570	\$0	\$0	\$822,570	\$42,774	\$0	\$41,129	0.052	0.000	0.050	0.128	A	A	A	A-
2000	2200	\$517,428	\$0	\$0	\$517,428	\$26,906	\$0	\$25,871	0.052	0.000	0.050	0.128	A	A	A	A-
2200	2400	\$536,798	\$0	\$0	\$536,798	\$27,914	\$0	\$26,840	0.052	0.000	0.050	0.128	A	A	A	A-
2400	2600	\$726,045	\$0	\$0	\$726,045	\$37,754	\$0	\$36,302	0.052	0.000	0.050	0.128	A	A	A	A-
2600	2800	\$730,446	\$0	\$0	\$730,446	\$37,983	\$0	\$36,522	0.052	0.000	0.050	0.128	A	A	A	A-
2800	3000	\$765,191	\$0	\$0	\$765,191	\$39,790	\$0	\$38,260	0.052	0.000	0.050	0.128	A	A	A	A-
3000	3200	\$682,158	\$0	\$0	\$682,158	\$35,472	\$0	\$34,108	0.052	0.000	0.050	0.160	A	A	A	B+
3200	3400	\$883,733	\$0	\$0	\$883,733	\$45,954	\$0	\$44,187	0.052	0.000	0.050	0.128	A	A	A	A-
3400	3600	\$535,018	\$0	\$0	\$535,018	\$27,821	\$0	\$26,751	0.052	0.000	0.050	0.128	A	A	A	A-
3600	3800	\$161,411	\$0	\$0	\$161,411	\$8,393	\$0	\$8,071	0.052	0.000	0.050	0.128	A	A	A	A-
3800	4000	\$14,611	\$0	\$0	\$14,611	\$760	\$0	\$731	0.052	0.000	0.050	0.128	A	A	A	A-
4000	4200	\$234,135	\$0	\$0	\$234,135	\$12,175	\$0	\$11,707	0.052	0.000	0.050	0.160	A	A	A	B+
4200	4400	\$154,847	\$0	\$0	\$154,847	\$8,052	\$0	\$7,742	0.052	0.000	0.050	0.128	A	A	A	A-
4400	4600	\$425,931	\$0	\$0	\$425,931	\$22,148	\$0	\$21,297	0.052	0.000	0.050	0.128	A	A	A	A-
4600	4800	\$184,978	\$820,075	\$0	\$1,005,053	\$52,263	\$0	\$50,253	0.052	0.000	0.050	0.160	A	A	A	B+
4800	5000	\$171,095	\$0	\$0	\$171,095	\$8,897	\$0	\$8,555	0.052	0.000	0.050	0.160	A	A	A	B+
5000	5200	\$201,164	\$0	\$0	\$201,164	\$10,461	\$0	\$10,058	0.052	0.000	0.050	0.128	A	A	A	A-
5200	5400	\$176,728	\$0	\$0	\$176,728	\$9,190	\$0	\$8,836	0.052	0.000	0.050	0.128	A	A	A	A-
5400	5600	\$275,624	\$0	\$0	\$275,624	\$14,332	\$0	\$13,781	0.052	0.000	0.050	0.128	A	A	A	A-
5600	5800	\$188,847	\$5,467	\$0	\$194,314	\$10,104	\$0	\$9,716	0.052	0.000	0.050	0.128	A	A	A	A-
5800	6000	\$14,611	\$21,869	\$0	\$36,480	\$2,189	\$0	\$2,554	0.060	0.000	0.070	0.160	A	A	A-	B+
6000	6200	\$102,106	\$5,467	\$0	\$107,573	\$6,885	\$0	\$8,606	0.064	0.000	0.080	0.128	A	A	A-	A-
6200	6400	\$256,129	\$0	\$0	\$256,129	\$16,392	\$0	\$20,490	0.064	0.000	0.080	0.128	A	A	A-	A-
6400	6600	\$255,984	\$0	\$0	\$255,984	\$16,383	\$0	\$20,479	0.064	0.000	0.080	0.128	A	A	A-	A-
6600	6800	\$77,986	\$0	\$0	\$77,986	\$4,991	\$0	\$6,239	0.064	0.000	0.080	0.128	A	A	A-	A-
6800	7000	\$270,164	\$0	\$135,082	\$405,247	\$21,073	\$0	\$20,262	0.052	0.000	0.050	0.128	A	A	A	A-



APPENDIX C – REPLACEMENT VALUE, RISK, AND RESILIENCY RESULTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

McKINLEY PARK

Park	5	Replacment Value				Risk			Resiliency Value				Resiliency Rank			
Ref Slope (V/H)	0.4															
STA. Start	STA. Finish	Land	Structure	Neighbor	Total	Scenario			Scenario				Scenario			
						1	2	3	1	2	3	S	1	2	3	S
0	200	\$12,965	\$87,475	\$6,482	\$106,922	\$5,560	\$0	\$5,346	0.052	0.000	0.050	0.133	A	A	A	B+
200	400	\$12,965	\$47,939	\$0	\$60,904	\$3,167	\$0	\$3,045	0.052	0.000	0.050	0.167	A	A	A	B+
400	600	\$12,965	\$21,869	\$0	\$34,834	\$1,811	\$0	\$1,742	0.052	0.000	0.050	0.133	A	A	A	B+
600	800	\$12,965	\$21,869	\$0	\$34,834	\$1,811	\$0	\$1,742	0.052	0.000	0.050	0.133	A	A	A	B+
800	1000	\$12,965	\$21,869	\$0	\$34,834	\$1,811	\$0	\$1,742	0.052	0.000	0.050	0.133	A	A	A	B+
1000	1200	\$12,965	\$21,869	\$0	\$34,834	\$1,811	\$0	\$1,742	0.052	0.000	0.050	0.133	A	A	A	B+
1200	1400	\$12,965	\$24,602	\$0	\$37,567	\$1,953	\$0	\$1,878	0.052	0.000	0.050	0.133	A	A	A	B+
1400	1600	\$12,965	\$110,437	\$0	\$123,402	\$6,417	\$0	\$6,170	0.052	0.000	0.050	0.167	A	A	A	B+
1600	1800	\$12,965	\$0	\$0	\$12,965	\$519	\$0	\$519	0.040	0.000	0.040	0.167	A	A	A	B+
1800	2000	\$12,965	\$0	\$0	\$12,965	\$674	\$0	\$648	0.052	0.000	0.050	0.167	A	A	A	B+
2000	2200	\$12,965	\$0	\$0	\$12,965	\$674	\$0	\$648	0.052	0.000	0.050	0.133	A	A	A	B+
2200	2400	\$95,869	\$0	\$0	\$95,869	\$4,985	\$0	\$4,793	0.052	0.000	0.050	0.133	A	A	A	B+
2400	2600	\$12,965	\$92,942	\$0	\$105,907	\$5,507	\$0	\$5,295	0.052	0.000	0.050	0.167	A	A	A	B+
2600	2800	\$52,027	\$0	\$0	\$52,027	\$2,705	\$0	\$2,601	0.052	0.000	0.050	0.133	A	A	A	B+
2800	3000	\$110,264	\$0	\$0	\$110,264	\$5,734	\$0	\$5,513	0.052	0.000	0.050	0.133	A	A	A	B+
3000	3200	\$207,973	\$0	\$0	\$207,973	\$10,815	\$0	\$10,399	0.052	0.000	0.050	0.133	A	A	A	B+
3200	3400	\$335,884	\$0	\$167,942	\$503,826	\$26,199	\$0	\$25,191	0.052	0.000	0.050	0.133	A	A	A	B+



APPENDIX C – REPLACEMENT VALUE, RISK, AND RESILIENCY RESULTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

JUNEAU/VETERANS PARKS

Park	6	Replacment Value				Risk			Resiliency Value				Resiliency Rank			
Ref Slope (V/H)	0.4															
STA. Start	STA. Finish	Land	Structure	Neighbor	Total	Scenario			Scenario				Scenario			
						1	2	3	1	2	3	S	1	2	3	S
0	200	\$38,255	\$43,737	\$19,127	\$101,119	\$5,258	\$0	\$5,056	0.052	0.000	0.050	0.174	A	A	A	B+
200	400	\$38,255	\$43,737	\$0	\$81,992	\$4,264	\$0	\$4,100	0.052	0.000	0.050	0.174	A	A	A	B+
400	600	\$1,156	\$0	\$0	\$1,156	\$60	\$0	\$58	0.052	0.000	0.050	0.174	A	A	A	B+
600	800	\$289,046	\$43,737	\$0	\$332,783	\$17,305	\$0	\$16,639	0.052	0.000	0.050	0.174	A	A	A	B+
800	1000	\$539,189	\$43,737	\$0	\$582,926	\$30,312	\$0	\$29,146	0.052	0.000	0.050	0.174	A	A	A	B+
1000	1200	\$932,095	\$21,869	\$0	\$953,964	\$49,606	\$0	\$47,698	0.052	0.000	0.050	0.139	A	A	A	B+
1200	1400	\$732,557	\$21,869	\$0	\$754,426	\$60,354	\$0	\$52,810	0.080	0.000	0.070	0.139	A-	A	A-	B+
1400	1600	#####	\$21,869	\$0	\$1,112,323	\$75,638	\$0	\$66,739	0.068	0.000	0.060	0.139	A-	A	A	B+
1600	1800	#####	\$43,737	\$0	\$1,194,266	\$81,210	\$0	\$71,656	0.068	0.000	0.060	0.139	A-	A	A	B+
1800	2000	#####	\$43,737	\$0	\$1,501,569	\$102,107	\$0	\$90,094	0.068	0.000	0.060	0.139	A-	A	A	B+
2000	2200	\$761,694	\$32,803	\$0	\$794,497	\$54,026	\$0	\$47,670	0.068	0.000	0.060	0.139	A-	A	A	B+
2200	2400	\$54,716	\$21,869	\$0	\$76,585	\$6,127	\$0	\$5,361	0.080	0.000	0.070	0.139	A-	A	A-	B+
2400	2600	\$38,255	\$21,869	\$0	\$60,123	\$3,126	\$0	\$3,006	0.052	0.000	0.050	0.139	A	A	A	B+
2600	2800	\$38,255	\$136,679	\$0	\$174,934	\$9,097	\$0	\$8,747	0.052	0.000	0.050	0.174	A	A	A	B+
2800	3000	\$38,255	\$33,584	\$0	\$71,839	\$3,736	\$0	\$3,592	0.052	0.000	0.050	0.139	A	A	A	B+
3000	3200	\$38,255	\$21,869	\$0	\$60,123	\$3,126	\$0	\$3,006	0.052	0.000	0.050	0.139	A	A	A	B+
3200	3400	\$38,255	\$21,869	\$0	\$60,123	\$3,126	\$0	\$3,006	0.052	0.000	0.050	0.139	A	A	A	B+
3400	3600	\$38,255	\$21,869	\$0	\$60,123	\$4,810	\$0	\$4,209	0.080	0.000	0.070	0.139	A-	A	A-	B+
3600	3800	\$38,255	\$21,869	\$0	\$60,123	\$3,126	\$0	\$3,006	0.052	0.000	0.050	0.139	A	A	A	B+
3800	4000	\$38,255	\$21,869	\$0	\$60,123	\$3,126	\$0	\$3,006	0.052	0.000	0.050	0.139	A	A	A	B+
4000	4200	\$38,255	\$21,869	\$0	\$60,123	\$4,088	\$0	\$3,607	0.068	0.000	0.060	0.139	A-	A	A	B+
4200	4400	\$38,255	\$21,869	\$0	\$60,123	\$3,126	\$0	\$3,006	0.052	0.000	0.050	0.139	A	A	A	B+
4400	4600	\$38,255	\$21,869	\$19,127	\$79,251	\$4,121	\$0	\$3,963	0.052	0.000	0.050	0.139	A	A	A	B+



APPENDIX C – REPLACEMENT VALUE, RISK, AND RESILIENCY RESULTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

CUPERTINO PARK

Park	7	Replacment Value				Risk			Resiliency Value				Resiliency Rank			
Ref Slope (V/H)	0.4															
STA. Start	STA. Finish	Land	Structure	Neighbor	Total	Scenario			Scenario				Scenario			
						1	2	3	1	2	3	S	1	2	3	S
0	200	\$58,526	\$0	\$29,263	\$87,789	\$5,970	\$0	\$5,267	0.068	0.000	0.060	0.099	A-	A	A	A-
200	400	\$120,207	\$0	\$0	\$120,207	\$8,174	\$0	\$7,212	0.068	0.000	0.060	0.099	A-	A	A	A-
400	600	\$124,898	\$0	\$0	\$124,898	\$8,493	\$0	\$7,494	0.068	0.000	0.060	0.099	A-	A	A	A-
600	800	\$143,001	\$0	\$0	\$143,001	\$9,724	\$0	\$8,580	0.068	0.000	0.060	0.099	A-	A	A	A-
800	1000	\$142,749	\$0	\$0	\$142,749	\$11,420	\$0	\$9,992	0.080	0.000	0.070	0.099	A-	A	A-	A-
1000	1200	\$82,242	\$406,133	\$0	\$488,374	\$27,349	\$0	\$24,419	0.056	0.000	0.050	0.099	A	A	A	A-
1200	1400	\$5,818	\$16,402	\$2,909	\$25,128	\$1,407	\$0	\$1,256	0.056	0.000	0.050	0.124	A	A	A	A-



APPENDIX C – REPLACEMENT VALUE, RISK, AND RESILIENCY RESULTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

SOUTH SHORE PARK

Park	8	Replacment Value				Risk			Resiliency Value				Resiliency Rank			
Ref Slope (V/H)	0.4															
STA. Start	STA. Finish	Land	Structure	Neighbor	Total	Scenario			Scenario				Scenario			
						1	2	3	1	2	3	S	1	2	3	S
0	200	\$388,246	\$0	\$194,123	\$582,369	\$93,179	\$0	\$81,532	0.160	0.000	0.140	0.173	B+	A	B+	B+
200	400	\$347,126	\$0	\$0	\$347,126	\$23,605	\$0	\$20,828	0.068	0.000	0.060	0.173	A-	A	A	B+
400	600	\$468,963	\$0	\$0	\$468,963	\$31,889	\$0	\$28,138	0.068	0.000	0.060	0.173	A-	A	A	B+
600	800	\$363,673	\$0	\$0	\$363,673	\$24,730	\$0	\$21,820	0.068	0.000	0.060	0.173	A-	A	A	B+
800	1000	\$327,979	\$1,564,235	\$0	\$1,892,214	\$128,671	\$0	\$113,533	0.068	0.000	0.060	0.173	A-	A	A	B+
1000	1200		\$0		\$0											
1200	1400	\$283,302	\$1,583,917	\$0	\$1,867,219	\$126,971	\$0	\$112,033	0.068	0.000	0.060	0.173	A-	A	A	B+
1400	1600	\$268,515	\$21,869	\$0	\$290,384	\$19,746	\$0	\$17,423	0.068	0.000	0.060	0.173	A-	A	A	B+
1600	1800	\$264,287	\$21,869	\$0	\$286,156	\$19,459	\$0	\$17,169	0.068	0.000	0.060	0.173	A-	A	A	B+
1800	2000	\$261,394	\$21,869	\$0	\$283,263	\$19,262	\$0	\$16,996	0.068	0.000	0.060	0.173	A-	A	A	B+
2000	2200	\$236,356	\$490,483	\$0	\$726,839	\$98,850	\$0	\$87,221	0.136	0.000	0.120	0.173	B+	A	A-	B+
2200	2400	\$78,938	\$21,869	\$0	\$100,807	\$6,855	\$0	\$6,048	0.068	0.000	0.060	0.173	A-	A	A	B+
2400	2600	\$9,654	\$0	\$0	\$9,654	\$656	\$0	\$579	0.068	0.000	0.060	0.173	A-	A	A	B+
2600	2800		\$0		\$0											
2800	3000		\$0		\$0											
3000	3200		\$0		\$0											
3200	3400		\$0		\$0											
3400	3600	\$9,654	\$0	\$0	\$9,654	\$656	\$0	\$579	0.068	0.000	0.060	0.173	A-	A	A	B+
3600	3800	\$9,654	\$0	\$0	\$9,654	\$656	\$0	\$579	0.068	0.000	0.060	0.173	A-	A	A	B+
3800	4000	\$9,654	\$0	\$0	\$9,654	\$656	\$0	\$579	0.068	0.000	0.060	0.173	A-	A	A	B+
4000	4200	\$9,654	\$0	\$0	\$9,654	\$656	\$0	\$579	0.068	0.000	0.060	0.216	A-	A	A	B
4200	4400	\$9,654	\$117,154	\$0	\$126,807	\$8,623	\$0	\$7,608	0.068	0.000	0.060	0.173	A-	A	A	B+
4400	4600	\$9,654	\$58,577	\$4,827	\$73,057	\$3,799	\$0	\$3,653	0.052	0.000	0.050	0.173	A	A	A	B+



APPENDIX C – REPLACEMENT VALUE, RISK, AND RESILIENCY RESULTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

BAY VIEW PARK

Park	9	Replacment Value				Risk			Resiliency Value				Resiliency Rank			
Ref Slope (V/H)	0.4															
STA. Start	STA. Finish	Land	Structure	Neighbor	Total	Scenario			Scenario				Scenario			
						1	2	3	1	2	3	S	1	2	3	S
0	200	\$371,440	\$316,315	\$185,720	\$873,474	\$655,106	\$669,664	\$598,954	0.750	0.767	0.686	0.307	F	F	D-	B-
200	400	\$388,451	\$0	\$0	\$388,451	\$291,339	\$297,813	\$266,367	0.750	0.767	0.686	0.307	F	F	D-	B-
400	600	\$472,603	\$0	\$0	\$472,603	\$354,452	\$362,329	\$324,071	0.750	0.767	0.686	0.307	F	F	D-	B-
600	800	\$473,512	\$0	\$0	\$473,512	\$361,899	\$394,594	\$351,752	0.764	0.833	0.743	0.307	F	F	F	B-
800	1000	\$376,792	\$0	\$0	\$376,792	\$301,433	\$351,672	\$279,902	0.800	0.933	0.743	0.307	F	F	F	B-
1000	1200	\$184,722	\$0	\$0	\$184,722	\$116,111	\$128,074	\$101,333	0.629	0.693	0.549	0.230	D	D-	D+	B
1200	1400	\$256,820	\$10,934	\$0	\$267,755	\$174,041	\$151,728	\$168,303	0.650	0.567	0.629	0.230	D	D+	D	B
1400	1600	\$95,628	\$10,934	\$0	\$106,562	\$38,362	\$38,362	\$36,536	0.360	0.360	0.343	0.230	C+	C+	C+	B
1600	1800	\$6,947	\$781,024	\$0	\$787,971	\$148,589	\$157,594	\$135,081	0.189	0.200	0.171	0.192	B+	B	B+	B+
1800	2000	\$6,947	\$21,869	\$0	\$28,816	\$4,364	\$4,995	\$3,952	0.151	0.173	0.137	0.192	B+	B+	B+	B+
2000	2200	\$6,947	\$21,869	\$0	\$28,816	\$4,940	\$5,379	\$4,611	0.171	0.187	0.160	0.192	B+	B+	B+	B+
2200	2400	\$31,540	\$21,869	\$0	\$53,409	\$3,815	\$3,561	\$3,662	0.071	0.067	0.069	0.153	A-	A-	A-	B+
2400	2600	\$6,947	\$21,869	\$0	\$28,816	\$2,058	\$1,921	\$1,976	0.071	0.067	0.069	0.153	A-	A-	A-	B+
2600	2800	\$23,885	\$21,869	\$0	\$45,754	\$3,268	\$3,050	\$3,137	0.071	0.067	0.069	0.153	A-	A-	A-	B+
2800	3000	\$86,777	\$21,869	\$0	\$108,645	\$7,916	\$7,967	\$8,071	0.073	0.073	0.074	0.153	A-	A-	A-	B+
3000	3200	\$84,895	\$82,008	\$0	\$166,903	\$12,160	\$12,240	\$12,399	0.073	0.073	0.074	0.096	A-	A-	A-	A-
3200	3400	\$140,454	\$21,869	\$0	\$162,322	\$11,826	\$11,904	\$12,058	0.073	0.073	0.074	0.153	A-	A-	A-	B+
3400	3600	\$185,035	\$21,869	\$0	\$206,904	\$15,074	\$15,173	\$15,370	0.073	0.073	0.074	0.153	A-	A-	A-	B+
3600	3800	\$206,058	\$21,869	\$0	\$227,927	\$16,606	\$16,715	\$16,932	0.073	0.073	0.074	0.153	A-	A-	A-	B+
3800	4000	\$205,839	\$21,869	\$0	\$227,708	\$16,590	\$16,699	\$16,915	0.073	0.073	0.074	0.153	A-	A-	A-	B+
4000	4200	\$237,580	\$602,170	\$118,790	\$958,539	\$60,251	\$51,122	\$65,728	0.063	0.053	0.069	0.153	A	A	A-	B+



APPENDIX C – REPLACEMENT VALUE, RISK, AND RESILIENCY RESULTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

SHERIDAN PARK

Park	10	Replacement Value				Risk			Resiliency Value				Resiliency Rank			
Ref Slope (V/H)	0.4															
STA. Start	STA. Finish	Land	Structure	Neighbor	Total	Scenario			Scenario				Scenario			
						1	2	3	1	2	3	S	1	2	3	S
0	200	\$559,281	\$0	\$279,641	838921.95	\$445,827	\$447,425	\$441,033	0.531	0.533	0.526	0.379	C-	D+	C-	C+
200	400	\$654,395	\$0	\$0	654395.48	\$500,145	\$567,143	\$467,425	0.764	0.867	0.714	0.379	F	F	D-	C+
400	600	\$665,849	\$0	\$0	665848.8	\$508,899	\$577,069	\$475,606	0.764	0.867	0.714	0.379	F	F	D-	C+
600	800	\$721,993	\$92,942	\$0	814934.73	\$617,022	\$679,112	\$558,812	0.757	0.833	0.686	0.592	F	F	D-	D+
800	1000	\$641,010	\$87,475	\$0	728484.97	\$587,991	\$655,636	\$541,160	0.807	0.900	0.743	0.379	F	F	F	C+
1000	1200	\$689,489	\$0	\$0	689488.68	\$551,591	\$597,557	\$492,492	0.800	0.867	0.714	0.379	F	F	D-	C+
1200	1400	\$644,290	\$0	\$0	644289.67	\$515,432	\$558,384	\$460,207	0.800	0.867	0.714	0.379	F	F	D-	C+
1400	1600	\$636,731	\$0	\$0	636731.32	\$513,933	\$573,058	\$473,000	0.807	0.900	0.743	0.379	F	F	F	C+
1600	1800	\$649,162	\$16,402	\$0	665563.51	\$537,205	\$599,007	\$494,419	0.807	0.900	0.743	0.473	F	F	F	C-
1800	2000	\$684,265	\$0	\$0	\$684,265	\$552,299	\$615,838	\$508,311	0.807	0.900	0.743	0.379	F	F	F	C+
2000	2200	\$529,880	\$870,842	\$0	\$1,400,722	\$704,363	\$933,815	\$608,314	0.503	0.667	0.434	0.284	C-	D-	C	B-
2200	2400	\$378,243	\$0	\$0	\$378,243	\$55,115	\$50,432	\$60,519	0.146	0.133	0.160	0.095	B+	B+	B+	A-
2400	2600	\$304,029	\$0	\$0	\$304,029	\$38,221	\$32,430	\$41,695	0.126	0.107	0.137	0.095	A-	A-	B+	A-
2600	2800	\$178,625	\$781,024	\$0	\$959,649	\$120,642	\$102,363	\$131,609	0.126	0.107	0.137	0.095	A-	A-	B+	A-
2800	3000	\$17,976	\$65,606	\$0	\$83,582	\$16,478	\$11,702	\$18,627	0.197	0.140	0.223	0.118	B+	B+	B	A-
3000	3200	\$200,147	\$17,495	\$0	\$217,642	\$24,251	\$17,411	\$24,873	0.111	0.080	0.114	0.118	A-	A-	A-	A-
3200	3400	\$229,169	\$0	\$0	\$229,169	\$34,048	\$30,556	\$31,429	0.149	0.133	0.137	0.095	B+	B+	B+	A-
3400	3600	\$334,793	\$10,934	\$0	\$345,727	\$56,304	\$55,316	\$51,365	0.163	0.160	0.149	0.095	B+	B+	B+	A-
3600	3800	\$318,623	\$16,402	\$0	\$335,024	\$59,347	\$53,604	\$57,433	0.177	0.160	0.171	0.095	B+	B+	B+	A-
3800	4000	\$334,833	\$0	\$0	\$334,833	\$61,227	\$49,109	\$65,053	0.183	0.147	0.194	0.095	B+	B+	B+	A-
4000	4200	\$300,230	\$0	\$0	\$300,230	\$48,895	\$36,028	\$51,468	0.163	0.120	0.171	0.095	B+	A-	B+	A-
4200	4400	\$276,629	\$27,336	\$0	\$303,965	\$76,860	\$79,031	\$67,741	0.253	0.260	0.223	0.095	B	B	B	A-
4400	4600	\$412,862	\$109,343	\$0	\$522,205	\$395,384	\$452,578	\$343,163	0.757	0.867	0.657	0.592	F	F	D	D+
4600	4800	\$395,171	\$21,869	\$0	\$417,040	\$285,970	\$305,829	\$250,224	0.686	0.733	0.600	0.592	D-	F	D	D+
4800	5000	\$197,592	\$10,934	\$0	\$208,526	\$28,002	\$22,243	\$26,215	0.134	0.107	0.126	0.095	B+	A-	A-	A-
5000	5200	\$186,512	\$21,869	\$0	\$208,381	\$25,006	\$16,670	\$23,815	0.120	0.080	0.114	0.095	A-	A-	A-	A-
5200	5400	\$4,544	\$0	\$0	\$4,544	\$1,480	\$1,908	\$1,246	0.326	0.420	0.274	0.095	B-	C	B	A-
5400	5600	\$4,544	\$0	\$0	\$4,544	\$1,363	\$1,908	\$1,090	0.300	0.420	0.240	0.095	B-	C	B	A-
5600	5800	\$4,544	\$0	\$0	\$4,544	\$1,266	\$1,727	\$1,013	0.279	0.380	0.223	0.118	B-	C+	B	A-
5800	6000	\$4,544	\$0	\$0	\$4,544	\$753	\$969	\$623	0.166	0.213	0.137	0.095	B+	B	B+	A-
6000	6200	\$4,544	\$9,841	\$0	\$14,385	\$2,137	\$3,069	\$1,808	0.149	0.213	0.126	0.095	B+	B	A-	A-
6200	6400	\$4,544	\$0	\$0	\$4,544	\$675	\$969	\$571	0.149	0.213	0.126	0.095	B+	B	A-	A-
6400	6600	\$4,544	\$0	\$0	\$4,544	\$675	\$969	\$571	0.149	0.213	0.126	0.095	B+	B	A-	A-
6600	6800	\$4,544	\$0	\$0	\$4,544	\$675	\$969	\$571	0.149	0.213	0.126	0.095	B+	B	A-	A-
6800	7000	\$4,544	\$0	\$0	\$4,544	\$675	\$969	\$571	0.149	0.213	0.126	0.095	B+	B	A-	A-
7000	7200	\$4,544	\$0	\$0	\$4,544	\$792	\$969	\$727	0.174	0.213	0.160	0.095	B+	B	B+	A-
7200	7400	\$4,985	\$0	\$0	\$4,985	\$741	\$1,063	\$627	0.149	0.213	0.126	0.095	B+	B	A-	A-
7400	7600	\$7,534	\$0	\$0	\$7,534	\$1,119	\$1,607	\$947	0.149	0.213	0.126	0.095	B+	B	A-	A-
7600	7800	\$108,241	\$0	\$0	\$108,241	\$16,082	\$23,091	\$13,607	0.149	0.213	0.126	0.095	B+	B	A-	A-
7800	8000	\$110,168	\$0	\$0	\$110,168	\$20,145	\$23,503	\$17,627	0.183	0.213	0.160	0.095	B+	B	B+	A-
8000	8200	\$115,976	\$0	\$0	\$115,976	\$18,887	\$27,834	\$15,905	0.163	0.240	0.137	0.095	B+	B	B+	A-
8200	8400	\$102,938	\$0	\$0	\$102,938	\$15,294	\$21,960	\$12,941	0.149	0.213	0.126	0.095	B+	B	A-	A-
8400	8600	\$161,059	\$9,841	\$0	\$170,900	\$41,748	\$61,524	\$35,157	0.244	0.360	0.206	0.284	B	C+	B	B-
8600	8800	\$71,782	\$217,125	\$0	\$288,907	\$37,145	\$50,077	\$33,018	0.129	0.173	0.114	0.095	A-	B+	A-	A-
8800	9000	\$4,544	\$802,893	\$0	\$807,436	\$32,297	\$32,297	\$32,297	0.040	0.040	0.040	0.095	A	A	A	A-
9000	9200	\$4,544	\$781,024	\$0	\$785,568	\$37,034	\$41,897	\$35,912	0.047	0.053	0.046	0.095	A	A	A	A-
9200	9400	\$4,544	\$781,024	\$0	\$785,568	\$37,034	\$41,897	\$35,912	0.047	0.053	0.046	0.095	A	A	A	A-
9400	9600	\$4,544	\$781,024	\$2,272	\$787,840	\$37,141	\$42,018	\$36,016	0.047	0.053	0.046	0.095	A	A	A	A-



APPENDIX C – REPLACEMENT VALUE, RISK, AND RESILIENCY RESULTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

WARNIMONT PARK

Park	11	Replacment Value				Risk			Resiliency Value				Resiliency Rank			
Ref Slope (V/H)	0.4															
STA. Start	STA. Finish	Land	Structure	Neighbor	Total	Scenario			Scenario				Scenario			
						1	2	3	1	2	3	S	1	2	3	S
0	200	\$98,580	\$0	\$49,290	\$147,871	\$67,176	\$65,063	\$63,373	0.454	0.440	0.429	0.097	C	C	C	A-
200	400	\$346,890	\$0	\$0	\$346,890	\$103,076	\$101,754	\$95,147	0.297	0.293	0.274	0.048	B-	B-	B-	A
400	600	\$250,576	\$0	\$0	\$250,576	\$31,501	\$36,751	\$28,637	0.126	0.147	0.114	0.048	A-	B+	A-	A
600	800	\$270,668	\$0	\$0	\$270,668	\$80,427	\$79,396	\$74,240	0.297	0.293	0.274	0.048	B-	B-	B-	A
800	1000	\$450,164	\$0	\$0	\$450,164	\$210,291	\$216,079	\$192,927	0.467	0.480	0.429	0.048	C-	C-	C	A
1000	1200	\$408,227	\$0	\$0	\$408,227	\$194,199	\$195,949	\$181,953	0.476	0.480	0.446	0.121	C-	C-	C	A-
1200	1400	\$607,895	\$0	\$0	\$607,895	\$392,527	\$389,053	\$375,158	0.646	0.640	0.617	0.302	D	D	D	B-
1400	1600	\$538,335	\$0	\$0	\$538,335	\$434,513	\$430,668	\$415,287	0.807	0.800	0.771	0.181	F	F	F	B+
1600	1800	\$509,618	\$0	\$0	\$509,618	\$329,068	\$326,155	\$314,507	0.646	0.640	0.617	0.145	D	D	D	B+
1800	2000	\$662,007	\$0	\$0	\$662,007	\$427,468	\$423,685	\$408,553	0.646	0.640	0.617	0.145	D	D	D	B+
2000	2200	\$617,010	\$0	\$0	\$617,010	\$498,016	\$493,608	\$475,980	0.807	0.800	0.771	0.302	F	F	F	B-
2200	2400	\$529,251	\$0	\$0	\$529,251	\$335,696	\$338,721	\$314,526	0.634	0.640	0.594	0.193	D	D	D+	B+
2400	2600	\$487,987	\$0	\$0	\$487,987	\$317,889	\$312,312	\$301,158	0.651	0.640	0.617	0.302	D	D	D	B-
2600	2800	\$399,147	\$0	\$0	\$399,147	\$257,735	\$255,454	\$246,331	0.646	0.640	0.617	0.145	D	D	D	B+
2800	3000	\$736,100	\$0	\$0	\$736,100	\$641,458	\$662,490	\$609,911	0.871	0.900	0.829	0.242	F	F	F	B
3000	3200	\$659,053	\$0	\$0	\$659,053	\$574,318	\$593,148	\$546,073	0.871	0.900	0.829	0.242	F	F	F	B
3200	3400	\$352,200	\$781,024	\$0	\$1,133,224	\$641,081	\$574,167	\$621,654	0.566	0.507	0.549	0.097	D+	C-	D+	A-
3400	3600	\$371,292	\$781,024	\$0	\$1,152,316	\$737,482	\$706,754	\$684,805	0.640	0.613	0.594	0.145	D	D	D+	B+
3600	3800	\$385,046	\$0	\$0	\$385,046	\$242,029	\$236,162	\$220,026	0.629	0.613	0.571	0.145	D	D	D+	B+
3800	4000	\$532,225	\$0	\$0	\$532,225	\$425,780	\$408,039	\$395,367	0.800	0.767	0.743	0.193	F	F	F	B+
4000	4200	\$644,123	\$0	\$0	\$644,123	\$524,500	\$493,828	\$496,895	0.814	0.767	0.771	0.193	F	F	F	B+
4200	4400	\$596,918	\$0	\$0	\$596,918	\$486,061	\$457,637	\$460,479	0.814	0.767	0.771	0.193	F	F	F	B+
4400	4600	\$698,476	\$0	\$0	\$698,476	\$568,759	\$535,498	\$538,824	0.814	0.767	0.771	0.193	F	F	F	B+
4600	4800	\$726,508	\$0	\$0	\$726,508	\$591,585	\$556,990	\$560,449	0.814	0.767	0.771	0.193	F	F	F	B+
4800	5000	\$794,479	\$0	\$0	\$794,479	\$646,933	\$609,100	\$612,884	0.814	0.767	0.771	0.193	F	F	F	B+
5000	5200	\$845,482	\$0	\$0	\$845,482	\$688,464	\$648,203	\$652,229	0.814	0.767	0.771	0.193	F	F	F	B+
5200	5400	\$784,022	\$0	\$0	\$784,022	\$638,418	\$601,084	\$604,817	0.814	0.767	0.771	0.193	F	F	F	B+
5400	5600	\$741,765	\$0	\$0	\$741,765	\$604,009	\$568,687	\$572,219	0.814	0.767	0.771	0.193	F	F	F	B+
5600	5800	\$780,762	\$0	\$0	\$780,762	\$635,763	\$598,584	\$602,302	0.814	0.767	0.771	0.242	F	F	F	B
5800	6000	\$813,304	\$0	\$0	\$813,304	\$520,514	\$498,826	\$483,335	0.640	0.613	0.594	0.302	D	D	D+	B-
6000	6200	\$817,055	\$0	\$0	\$817,055	\$494,902	\$501,127	\$448,213	0.606	0.613	0.549	0.302	D	D	D+	B-
6200	6400	\$797,062	\$0	\$0	\$797,062	\$482,792	\$488,865	\$437,246	0.606	0.613	0.549	0.302	D	D	D+	B-
6400	6600	\$796,157	\$0	\$0	\$796,157	\$614,178	\$610,387	\$568,684	0.771	0.767	0.714	0.302	F	F	D-	B-
6600	6800	\$806,198	\$292,884	\$0	\$1,099,082	\$847,863	\$842,630	\$785,059	0.771	0.767	0.714	0.242	F	F	D-	B
6800	7000	\$757,093	\$0	\$0	\$757,093	\$621,898	\$656,148	\$562,412	0.821	0.867	0.743	0.242	F	F	F	B
7000	7200	\$810,573	\$0	\$0	\$810,573	\$700,567	\$702,496	\$648,458	0.864	0.867	0.800	0.242	F	F	F	B
7200	7400	\$821,994	\$0	\$0	\$821,994	\$710,438	\$712,395	\$657,595	0.864	0.867	0.800	0.242	F	F	F	B
7400	7550	\$612,655	\$781,024	\$306,327	\$1,700,006	\$1,078,290	\$1,178,671	\$971,432	0.634	0.693	0.571	0.193	D	D-	D+	B+



APPENDIX C – REPLACEMENT VALUE, RISK, AND RESILIENCY RESULTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

GRANT PARK

Park	12	Replacement Value				Risk			Resiliency Value				Resiliency Rank			
Ref Slope (V/H)	0.4															
STA. Start	STA. Finish	Land	Structure	Neighbor	Total	Scenario			Scenario				Scenario			
						1	2	3	1	2	3	5	1	2	3	5
0	200		\$0		\$0											
200	400		\$0		\$0											
400	600		\$0		\$0											
600	800	\$4,654	\$0	\$0	\$4,654	\$391	\$0	\$326	0.084	0.000	0.070	0.139	A-	A	A-	B+
800	1000	\$26,489	\$0	\$0	\$26,489	\$2,225	\$0	\$1,854	0.084	0.000	0.070	0.139	A-	A	A-	B+
1000	1200	\$89,916	\$0	\$0	\$89,916	\$7,553	\$0	\$6,294	0.084	0.000	0.070	0.139	A-	A	A-	B+
1200	1400	\$100,687	\$0	\$0	\$100,687	\$8,458	\$0	\$7,048	0.084	0.000	0.070	0.139	A-	A	A-	B+
1400	1600	\$108,323	\$0	\$0	\$108,323	\$9,099	\$0	\$7,583	0.084	0.000	0.070	0.139	A-	A	A-	B+
1600	1800	\$147,816	\$0	\$0	\$147,816	\$12,417	\$0	\$10,347	0.084	0.000	0.070	0.139	A-	A	A-	B+
1800	2000	\$365,906	\$0	\$0	\$365,906	\$80,499	\$107,333	\$71,090	0.220	0.293	0.194	0.278	B	B-	B+	B-
2000	2200	\$516,065	\$21,869	\$0	\$537,934	\$252,060	\$344,278	\$221,321	0.469	0.640	0.411	0.278	C-	D	C	B-
2200	2400	\$574,708	\$21,869	\$0	\$596,576	\$507,090	\$517,033	\$460,216	0.850	0.867	0.771	0.278	F	F	F	B-
2400	2600	\$528,538	\$21,869	\$0	\$550,407	\$214,659	\$165,122	\$207,582	0.390	0.300	0.377	0.347	C+	B-	C+	C+
2600	2800	\$516,329	\$21,869	\$0	\$538,198	\$249,109	\$229,631	\$233,732	0.463	0.427	0.434	0.869	C	C	C	F
2800	3000	\$537,797	\$22,962	\$0	\$560,759	\$416,564	\$448,607	\$400,542	0.743	0.800	0.714	0.695	F	F	D-	D-
3000	3200	\$352,078	\$21,869	\$0	\$373,947	\$96,158	\$119,663	\$85,474	0.257	0.320	0.229	0.417	B	B-	B	C
3200	3400	\$257,975	\$0	\$0	\$257,975	\$71,864	\$77,392	\$70,759	0.279	0.300	0.274	0.417	B-	B-	B-	C
3400	3600	\$277,162	\$22,962	\$0	\$300,124	\$105,472	\$102,042	\$102,900	0.351	0.340	0.343	0.417	C+	C+	C+	C
3600	3800	\$264,195	\$0	\$0	\$264,195	\$126,814	\$119,769	\$126,814	0.480	0.453	0.480	0.417	C-	C	C-	C
3800	4000	\$313,962	\$0	\$0	\$313,962	\$113,026	\$106,747	\$113,026	0.360	0.340	0.360	0.417	C+	C+	C+	C
4000	4200	\$329,173	\$22,962	\$0	\$352,135	\$93,567	\$79,817	\$96,586	0.266	0.227	0.274	0.417	B	B	B-	C
4200	4400	\$388,685	\$13,121	\$0	\$401,807	\$106,766	\$91,076	\$110,210	0.266	0.227	0.274	0.417	B	B	B-	C
4400	4600	\$277,378	\$0	\$0	\$277,378	\$158,502	\$170,125	\$152,162	0.571	0.613	0.549	0.695	D+	D	D+	D-
4600	4800	\$318,533	\$56,624	\$0	\$375,158	\$201,513	\$230,097	\$188,651	0.537	0.613	0.503	0.869	D+	D	C-	F
4800	5000	\$273,406	\$0	\$0	\$273,406	\$167,168	\$167,689	\$162,481	0.611	0.613	0.594	0.417	D	D	D+	C
5000	5200	\$309,647	\$0	\$0	\$309,647	\$192,866	\$189,917	\$191,096	0.623	0.613	0.617	0.417	D	D	D	C
5200	5400	\$349,260	\$0	\$0	\$349,260	\$213,548	\$232,840	\$207,560	0.611	0.667	0.594	0.695	D	D-	D+	D-
5400	5600	\$416,404	\$0	\$0	\$416,404	\$190,951	\$191,546	\$185,597	0.459	0.460	0.446	0.417	C	C	C	C
5600	5800	\$429,022	\$0	\$0	\$429,022	\$279,477	\$297,455	\$264,768	0.651	0.693	0.617	0.417	D	D-	D	C
5800	6000	\$352,675	\$0	\$0	\$352,675	\$269,545	\$305,652	\$251,911	0.764	0.867	0.714	0.695	F	F	D-	D-
6000	6200	\$250,047	\$0	\$0	\$250,047	\$145,742	\$186,702	\$131,453	0.583	0.747	0.526	0.869	D+	F	C-	F
6200	6400	\$157,906	\$0	\$0	\$157,906	\$31,581	\$35,792	\$30,679	0.200	0.227	0.194	0.521	B	B	B+	C-
6400	6600	\$91,027	\$164,015	\$0	\$255,042	\$22,954	\$18,703	\$24,776	0.090	0.073	0.097	0.347	A-	A-	A-	C+
6600	6800	\$155,379	\$0	\$0	\$155,379	\$12,874	\$13,466	\$13,318	0.083	0.087	0.086	0.347	A-	A-	A-	C+
6800	7000	\$241,706	\$0	\$0	\$241,706	\$19,336	\$20,948	\$19,336	0.080	0.087	0.080	0.347	A-	A-	A-	C+
7000	7200	\$192,061	\$0	\$0	\$192,061	\$13,993	\$14,084	\$14,267	0.073	0.073	0.074	0.347	A-	A-	A-	C+
7200	7400	\$159,815	\$0	\$0	\$159,815	\$13,470	\$13,851	\$13,698	0.084	0.087	0.086	0.521	A-	A-	A-	C-
7400	7600	\$115,149	\$0	\$0	\$115,149	\$10,692	\$9,980	\$11,186	0.093	0.087	0.097	0.347	A-	A-	A-	C+
7600	7800	\$150,596	\$0	\$0	\$150,596	\$16,996	\$19,075	\$16,350	0.113	0.127	0.109	0.347	A-	A-	A-	C+
7800	8000	\$104,710	\$0	\$0	\$104,710	\$12,565	\$14,659	\$11,967	0.120	0.140	0.114	0.347	A-	B+	A-	C+
8000	8200	\$210,857	\$0	\$0	\$210,857	\$53,015	\$61,851	\$48,196	0.251	0.293	0.229	0.521	B	B-	B	C-
8200	8400	\$244,332	\$0	\$0	\$244,332	\$61,432	\$71,671	\$55,847	0.251	0.293	0.229	0.347	B	B-	B	C+
8400	8600	\$259,527	\$0	\$0	\$259,527	\$73,409	\$69,207	\$68,218	0.283	0.267	0.263	0.347	B-	B-	B	C+
8600	8800	\$278,437	\$0	\$0	\$278,437	\$118,137	\$111,375	\$109,784	0.424	0.400	0.394	0.347	C	C	C+	C+
8800	9000	\$330,661	\$0	\$0	\$330,661	\$93,530	\$88,176	\$86,917	0.283	0.267	0.263	0.278	B-	B-	B	B-
9000	9050	\$80,415	\$0	\$40,208	\$120,623	\$36,876	\$38,599	\$33,085	0.306	0.320	0.274	0.278	B-	B-	B-	B-



APPENDIX C – REPLACEMENT VALUE, RISK, AND RESILIENCY RESULTS

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

BENDER PARK

Park	13	Replacment Value				Risk			Resiliency Value				Resiliency Rank			
Ref Slope (V/H)	0.4															
STA. Start	STA. Finish	Land	Structure	Neighbor	Total	Scenario			Scenario				Scenario			
						1	2	3	1	2	3	S	1	2	3	S
0	200	\$749,256	\$703,312	\$374,628	\$1,827,196	\$635,864	\$0	\$657,791	0.348	0.000	0.360	0.380	C+	A	C+	C+
200	400	\$423,080	\$781,024		\$1,204,105	\$308,251	\$0	\$313,067	0.256	0.000	0.260	0.228	B	A	B	B
400	600	\$500,455	\$781,024		\$1,281,479	\$328,059	\$0	\$333,185	0.256	0.000	0.260	0.228	B	A	B	B
600	800	\$497,585	\$781,024		\$1,278,610	\$337,553	\$0	\$358,011	0.264	0.000	0.280	0.228	B	A	B-	B
800	1000	\$437,879	\$781,024		\$1,218,903	\$312,039	\$0	\$316,915	0.256	0.000	0.260	0.228	B	A	B	B
1000	1200	\$610,720	\$781,024		\$1,391,744	\$356,287	\$0	\$361,854	0.256	0.000	0.260	0.228	B	A	B	B
1200	1400	\$304,936	\$781,024		\$1,085,961	\$286,694	\$0	\$304,069	0.264	0.000	0.280	0.228	B	A	B-	B
1400	1600	\$418,536	\$781,024		\$1,199,560	\$278,298	\$0	\$287,894	0.232	0.000	0.240	0.228	B	A	B	B
1600	1800	\$403,325	\$781,024		\$1,184,349	\$284,244	\$0	\$307,931	0.240	0.000	0.260	0.228	B	A	B	B
1800	2000	\$578,359	\$781,024		\$1,359,383	\$315,377	\$0	\$326,252	0.232	0.000	0.240	0.228	B	A	B	B
2000	2200	\$412,310	\$781,024		\$1,193,334	\$276,854	\$0	\$286,400	0.232	0.000	0.240	0.228	B	A	B	B
2200	2400	\$286,918	\$781,024		\$1,067,942	\$247,763	\$0	\$256,306	0.232	0.000	0.240	0.228	B	A	B	B
2400	2600	\$156,963	\$0		\$156,963	\$36,415	\$0	\$37,671	0.232	0.000	0.240	0.228	B	A	B	B
2600	2800	\$229,096	\$402,227		\$631,323	\$136,366	\$0	\$151,518	0.216	0.000	0.240	0.228	B	A	B	B
2800	3000	\$4,926	\$0		\$4,926	\$197	\$0	\$197	0.040	0.000	0.040	0.095	A	A	A	A-
3000	3200	\$4,926	\$0		\$4,926	\$197	\$0	\$197	0.040	0.000	0.040	0.095	A	A	A	A-
3200	3400	\$4,926	\$781,024		\$785,950	\$160,334	\$0	\$212,207	0.204	0.000	0.270	0.285	B	A	B-	B-
3400	3600	\$4,926	\$49,205		\$54,131	\$2,165	\$0	\$2,165	0.040	0.000	0.040	0.095	A	A	A	A-
3600	3800	\$4,926	\$109,343		\$114,270	\$4,571	\$0	\$4,571	0.040	0.000	0.040	0.095	A	A	A	A-
3800	4000	\$4,926	\$127,932		\$132,858	\$5,314	\$0	\$5,314	0.040	0.000	0.040	0.095	A	A	A	A-
4000	4200	\$4,926	\$114,264		\$119,190	\$5,244	\$0	\$5,960	0.044	0.000	0.050	0.095	A	A	A	A-
4200	4400	\$4,926	\$109,343		\$114,270	\$4,571	\$0	\$4,571	0.040	0.000	0.040	0.095	A	A	A	A-
4400	4600	\$4,926	\$109,343		\$114,270	\$4,571	\$0	\$4,571	0.040	0.000	0.040	0.095	A	A	A	A-
4600	4800	\$4,926	\$73,807		\$78,733	\$3,149	\$0	\$3,149	0.040	0.000	0.040	0.095	A	A	A	A-
4800	5000	\$4,926	\$0		\$4,926	\$315	\$0	\$345	0.064	0.000	0.070	0.076	A	A	A-	A-
5000	5200	\$4,926	\$0		\$4,926	\$296	\$0	\$296	0.060	0.000	0.060	0.076	A	A	A	A-
5200	5400	\$4,926	\$0		\$4,926	\$296	\$0	\$296	0.060	0.000	0.060	0.076	A	A	A	A-
5400	5600	\$4,926	\$0		\$4,926	\$355	\$0	\$443	0.072	0.000	0.090	0.076	A-	A	A-	A-
5600	5800	\$5,801	\$0		\$5,801	\$325	\$0	\$290	0.056	0.000	0.050	0.076	A	A	A	A-
5800	6000	\$181,209	\$0	\$90,604	\$271,813	\$78,282	\$0	\$65,235	0.288	0.000	0.240	0.152	B-	A	B	B+



APPENDIX D

PROJECT AREA AND CONCEPT SUMMARY TABLE



APPENDIX D – PROJECT AREA AND CONCEPT SUMMARY TABLE

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

Park	Project Area	Stationing	Problem	Concept 1	Concept 2
1. Doctors Park	1	8+00 to 12+50	Damaged seawall	Remove damaged seawall, construct backshore revetment	New armor stone groin, Existing groin maintenance, preloaded beach cells
	2	0+00 to 2+25	Ravine erosion and shoreline erosion	Ravine reinforcement and armor stone revetment	Ravine reinforcement, armor stone groin, preloaded beach cell, backshore revetment
2. Big Bay Park	3	2+50 to 14+50	Damaged seawall, crest instability/erosion	Rip Rap seawall overtopping protection, armor stone revetment on north end, toe stone, wooden barrier with signage, invasive species management, native vegetation	Armor stone groin, existing groin maintenance, pre-loaded beach cell, invasive species management, native vegetation
3. Linnwood Revetment at Lake Park	4	12+50 to 28+50	Damaged Revetment, shoreline erosion	Reconstruct armor stone revetment, native vegetation	N/A
	5	2+00 to 4+50	Eroded headland	Armor stone revetment	Fill to previous headland footprint, armor stone revetment, native vegetation
4. Bradford and Lake Park	6	12+00 to 13+50	Slope safety	Abandon path and add wooden barriers with signage	Enhance access with stairs, landings, handrails
	7	0+00 to 5+00	Native vegetation trial program	Plant native vegetation, install reinforced hill running area	N/A
5/6. McKinley and Juneau Parks	8	0+00 to 24+00 and 0+00 to 16+00	Native vegetation incentive program	Native vegetation on upper portion of bluff, invasive species management on lower portion	N/A
7. Cupertino Park	9	10+00 to 13+00	Native vegetation trial program	Native vegetation and invasive management.	N/A
8. South Shore Park	10	11+50 to 27+50	Native vegetation trial program	Native vegetation	N/A
	11	16+50 to 23+75	Shoreline erosion	Armor stone revetment per Baird	N/A
9. Bayview Park	12	0+00 to 16+50	Shoreline erosion	Armor stone revetment per Baird, 2.5H:1V grading, native vegetation, gravel path	Armor stone revetment per Baird, crest regrading, native vegetation, invasive species management, gravel lookout, wooden barriers
10. Sheridan Park	14	41+00 to 48+75	Slope instability, detrimental structure, maintain existing structures	Armor stone groins, maintain existing groins, pre-loaded beach cell, wooden barriers with signage	Buttress fill, armor stone revetment, wooden barriers
	15	0+00 to 22+50	Protect existing structures, slope instability, shoreline erosion, adaptation	Road removal and restoration, wooden barriers, native vegetation	Road removal and restoration, parking lot, armor stone groins, preloaded beach cells, backshore revetment, wooden barriers, native vegetation
11. Warnimont Park	16	44+50 to 75+50	Shoreline erosion/instability, protect shoreline/water quality, slope safety	Offshore breakwater, preloaded beach cells, native vegetation, wooden barriers	Revetment with buffer terrace, native vegetation, wooden barriers
	17	35+50 to 42+75	Park and slope safety	Emergency access road from 32nd Division Memorial Highway	N/A
	18	19+50 to 22+50	Slope safety	Wooden barriers, remove/relocate existing Milwaukee county trails	N/A
	19	10+50 to 16+50	Slope safety	Wooden barriers, remove/relocate existing Milwaukee county trails	N/A
12. Grant	20	57+50 to 63+50	Bluff and Shoreline Erosion, Slope Safety	Backshore revetment, wick drains, wooden barriers, relocated/remove Milwaukee county trails	Armor stone groins, pre-loaded beach cells, wooden barriers, relocate/abandon Milwaukee county trails
	21	46+00 to 54+00	Slope Safety	Wooden barriers, remove/relocate existing Milwaukee county trails	N/A
	22	43+50 to 45+00	Slope Safety, Instability and Damaged Structure	Regrade to 2.5H:1V, switchback path, wick drains	abandon access, wooden barriers, wick drains
	23	26+00 to 32+00	Slope Safety, Shoreline Erosion/ Instability	Existing groin maintenance, wooden barriers, relocate trails	Backshore revetment, wooden barriers, relocate trails
	24	21+00 to 24+00	Shoreline Erosion/ Instability	Backshore revetment, existing groin maintenance, wooden barriers, relocate trails	Backshore revetment, wooden barriers relocate trails
13. Bender Park	25	0+00 to 2+50	Ravine and bluff erosion	Wooden barriers, remove/relocate existing Milwaukee county trails, ravine monitoring program	N/A



APPENDIX E

BORING LOGS



GZA GeoEnvironmental, Inc.
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KEY TO SYMBOLS

CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin

LITHOLOGIC SYMBOLS (Unified Soil Classification System)

	CL: USCS Low Plasticity Clay
	CL-ML: USCS Low Plasticity Silty Clay
	CLS: USCS Low Plasticity Sandy Clay
	ML: USCS Silt
	PT: USCS Peat
	SC: USCS Clayey Sand
	SM: USCS Silty Sand
	SP-SM: USCS Poorly-graded Sand with Silt
	SW: USCS Well-graded Sand
	SW-SM: USCS Well-graded Sand with Silt
	TOPSOIL: Topsoil

RELATIVE DENSITY/ CONSISTENCY

Granular Soils (Sands, Gravels)

N-Value	Relative Density
0 - 4	Very Loose
5 - 10	Loose
11 - 30	Medium Dense
31 - 50	Dense
> 50	Very Dense

Cohesive Soils (Clays, Some Silts)

PP-Value (tsf)	Consistency
< 0.25	Very Soft
0.25 - 0.5	Soft
0.5 - 1.0	Medium Stiff
1.0 - 2.0	Stiff
2.0 - 4.0	Very Stiff
> 4.0	Hard

MINOR COMPONENTS

Percentage	Descriptor
1 - 5	Trace
5 - 15	Little
15 - 30	Some
30 - 50	With

SOIL MOISTURE

DRY	No Free Moisture
MOIST	Wet to Touch, No Free Moisture
WET	Free Moisture

DRILLING STATISTICS

Number of Boreholes:	4
Total Length of Drilling:	330
Total Number of Samples:	91

TESTING:

Water Content:	44
Dry Density:	5
Atterberg Limits:	15
Sieve Analysis:	29
Unconfined:	1
Direct Shear:	0
Pocket Pen:	69

ABBREVIATIONS

LL	LIQUID LIMIT (%)	SS	SPLIT SPOON SAMPLER
PI	PLASTIC INDEX (%)	PID	PHOTOIONIZATION DETECTOR
W	MOISTURE CONTENT (%)	UC	UNCONFINED COMPRESSION
NP	NON PLASTIC	ppm	PARTS PER MILLION
P#200	PERCENT PASSING NO. 200 SIEVE (FINES)	ETR	ENERGY TRANSFER RATIO
PP	POCKET PENETROMETER (TSF)	DD	DURING DRILLING
NE	NOT ENCOUNTERED	AD	AFTER DRILLING
NM	NOT MEASURED	MC	MODIFIED CALIFORNIA SAMPLER
ST	SHELBY TUBE SAMPLER		



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BORING NUMBER BAYVIEW-SB-01

PAGE 1 OF 2

CLIENTMilwaukee County DAS

PROJECT NUMBER20.0158819.00

DATE STARTED10/18/24COMPLETED10/18/24

DRILLING CONTRACTORDrill Point, Inc.

DRILLING METHOD3-1/4" ID HSA

LOGGED BYRJD

DRILL RIGDiedrich D-120

CHECKED BYIJM

HAMMERAuto

PROJECT NAMEMilwaukee County Bluff Repairs

PROJECT LOCATIONMilwaukee County, Wisconsin

GROUND ELEVATION632 feet, NAVD 88HOLE SIZE7-1/4 inches

NORTHING365079EASTING2540497

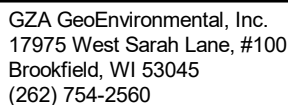
GROUND WATER LEVELS (ft, bgs):

DATE	TIME	DEPTH	CASING	STAB
10/16/24	DD	38.5	HSA	
10/16/24	AD	DRY	NONE	

GEOTECH WITH REMARKS AND ELEV V2 - GINT STD US LAB GDT - 2/19/25 13:37 - J:\GEOTECH PROJECTS\GINT PROJECT DATABASES\20.0158819.00 MILWAUKEE COUNTY PARKS (OCT 2024).GPJ

DEPTH (ft)	Elevation (ft, NAVD 88)	GRAPHIC LOG	MATERIAL DESCRIPTION	REMARKS	SAMPLE TYPE NUMBER (Depth Interval)	RECOVERY (inches)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			FINES CONTENT (%)
											LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
0			Surface: Turf Grass with 6" Topsoil											
5	630		SS-1: Hard, sandy lean CLAY (CL), medium plasticity; trace Gravel, fine to coarse; reddish brown, rootlets, white and gray staining, moist		SS-1 (1-2.5)	17	5-7-10 (17)	4.5+						
			SS-2: Hard, sandy lean CLAY (CL), medium plasticity; trace Gravel, fine to coarse; reddish brown, rootlets, white and gray staining, moist		SS-2 (3.5-5)	18	4-10-20 (30)	4.5+		14.4				
	625		SS-3: Hard, lean CLAY (CL), medium plasticity; little Sand, medium; trace Gravel, fine; reddish brown, rootlets, white and gray staining, moist		SS-3 (6-7.5)	18	5-10-17 (27)	4.5+						
10			SS-4: Hard, lean CLAY (CL), medium plasticity; little Sand, medium; trace Gravel, fine; reddish brown, rootlets, white and gray staining, moist		SS-4 (8.5-10)	18	4-7-9 (16)	4.5+		18.3				
	620		SS-5: Hard, lean CLAY (CL), medium plasticity; trace Sand, fine to coarse; trace Gravel, fine; reddish brown, copper and gray staining, moist		SS-5 (11-12.5)	18	3-6-8 (14)	4.25						
15			ST-6: Hard, lean CLAY (CL), medium plasticity; little Sand, fine to coarse; trace Gravel, fine; reddish brown, copper and gray staining, moist	1	ST-6 (13.5-14.5)	11		4.5	107	20.8	41	16	25	92
	615		SS-7: Upper 6": Very dense, well-graded SAND (SW), fine- to coarse-grained; gray, moist Lower 12": Stiff, lean CLAY with GRAVEL (CL), low plasticity; little Sand, medium to coarse; reddish brown, moist	2	SS-7 (16-17.5)	18	18-26-38 (50+)	1.5		17.9				
20			SS-8: Upper 9": Very stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; reddish brown, moist Lower 9": Very stiff, SILT (ML), nonplastic; trace Sand, fine to coarse; gray, moist	3	SS-8 (18.5-20)	18	2-4-5 (9)	2.0						
	610		ST-9: Stiff to very stiff, SILT (ML), nonplastic; little Sand, fine to coarse; gray, moist		ST-9 (20-21.5)	16		1.5-2.0	119	17.1	NP	NP	NP	88
25			SS-10: Stiff, lean CLAY with sand (CL), low plasticity; trace Gravel, fine to coarse, brown, moist		SS-10 (23.5-25)	18	2-3-6 (9)	1.5		15.0				75
	605		ST-11: Lean CLAY with sand (CL), low plasticity; trace Gravel, fine to coarse, brown, moist	4	ST-11 (26-28)	13					28	13	15	85
30			SS-12: Stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine to coarse, brown, moist		SS-12 (28.5-30)	4	6-7-10 (17)	1.5						

REMARKS	1. Hit an obstruction after pushing 1 ft. 2. Spoon was bowed after recovery 3. Augers met refusal on likely cobbles/ boulders at 18 ft bgs. Hole was offset approximately 16 feet to the west to BAYVIEW-SB-01A location (N: 365079, E: 2540497) and blind drilled to 18.5 ft bgs. 4. Bottom of Shelby tube crushed. Qp not measured.
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PAGE 2 OF 2

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT LOCATION Milwaukee County, Wisconsin

DEPTH (ft)	Elevation (ft. NAVD 88)	GRAPHIC LOG	MATERIAL DESCRIPTION	REMARKS	SAMPLE TYPE NUMBER (Depth Interval)	RECOVERY (inches)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			FINES CONTENT (%)
											LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
30														
	600													
35			SS-13: Very stiff, sandy lean CLAY with GRAVEL (CL), low plasticity; brown, moist		SS-13 (33.5-35)	18	2-4-8 (12)	2.5		15.8				
	595													
40			SS-14: Upper 6": Medium stiff, sandy SILT (ML), nonplastic; gray, wet Middle 8": Hard, sandy lean CLAY with GRAVEL (CL), low plasticity; gray, moist Lower 4": Dense, well-graded SAND with SILT (SW-SM), fine- to coarse-grained; little Gravel, fine; gray, moist		SS-14 (38.5-40)	18	8-10-25 (35)	0.5- 4.5						
	590													
45			SS-15: Upper 5": Dense, silty SAND (SM), fine- to coarse-grained; little Gravel, fine; gray, wet Lower 13": Dense, well-graded SAND with SILT (SW-SM), fine- to coarse-grained; gray, moist		SS-15 (43.5-45)	18	15-18-23 (41)			21.3 3.0	NP NP	NP NP	NP NP	26 11
	585													
50			SS-16: Very stiff, sandy lean CLAY (CL), low plasticity; gray, moist		SS-16 (48.5-50)	18	3-5-8 (13)	3.75		17.9				
	580													
55			SS-17: Stiff, lean CLAY with sand (CL), low plasticity; trace Gravel, fine; gray, moist		SS-17 (53.5-55)	18	5-5-6 (11)	1.75						
	575		ST-18: Very stiff to hard, lean CLAY with sand (CL), low plasticity; trace Gravel, fine; gray, moist		ST-18 (56-58)	24		3.5- 4.5+	124	12.1	25	14	11	77
60			SS-19: Hard, lean CLAY (CL), low plasticity; some Sand, fine; trace Gravel, fine; gray, moist		SS-19 (58.5-60)	18	3-7-21 (28)	4.5+		16.5				
End of boring at 60 ft bgs. Hole backfilled with cuttings and covered with sod.														
REMARKS														



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BORING NUMBER SHERIDAN-SB-02

PAGE 1 OF 3

CLIENTMilwaukee County DAS

PROJECT NUMBER20.0158819.00

DATE STARTED10/16/24COMPLETED10/16/24

DRILLING CONTRACTORDrill Point, Inc.

DRILLING METHOD3-1/4" ID HSA

LOGGED BYCJB

DRILL RIGDiedrich D-120

CHECKED BYIJM

HAMMERAuto

PROJECT NAMEMilwaukee County Bluff Repairs

PROJECT LOCATIONMilwaukee County, Wisconsin

GROUND ELEVATION664.3 feet, NAVD 88HOLE SIZE7-1/4 inches

NORTHING358498EASTING2544741

DATE	TIME	DEPTH	CASING	STAB
10/17/24	DD	59.3	HSA	
10/17/24	AD	DRY	NONE	

GROUND WATER LEVELS (ft, bgs):

GROUND WATER
LEVELS (ft, bgs):

GEOTECH WITH REMARKS AND ELEV V2 - GINT STD US LAB GDT - 2/9/25 13:37 - J:\GEO TECH PROJECTS\GINT PROJECT DATABASES\20.0158819.00 MILWAUKEE COUNTY PARKS (OCT 2024).GPJ

DEPTH (ft)	Elevation (ft, NAVD 88)	GRAPHIC LOG	MATERIAL DESCRIPTION	REMARKS	SAMPLE TYPE NUMBER (Depth Interval)	RECOVERY (inches)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			FINES CONTENT (%)
											LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
0			Surface: Turf Grass with 6" Topsoil											
			SS-1: Very stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; brown, moist		SS-1 (1-2.5)	16	6-6-7 (13)	3.0						
5	660		SS-2: Very stiff, lean CLAY (CL), low plasticity; trace Sand, fine to medium; light brown with gray mottling, moist		SS-2 (3.5-5)	16	3-4-6 (10)	2.5-3.0		14.7				
			SS-3: Very stiff to hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; light brown upper 14", lower 3" gray, moist	1	SS-3 (6-7.5)	18	3-7-9 (16)	3.0-4.5+						
10	655		SS-4: Very stiff, lean CLAY (CL), low plasticity; trace Sand, fine to medium; trace Gravel, fine; gray, moist		SS-4 (8.5-10)	17	2-5-7 (12)	3.0		15.3				94
			SS-5: Stiff, sandy lean CLAY (CL), low plasticity; light brown to gray, moist	2	SS-5 (11-12.5)	3	3-5-7 (12)	1.75						
15	650		SS-6: Medium stiff to stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist		SS-6 (13.5-15)	18	2-3-5 (8)	1.0-2.0		15.3				
			SS-7: Medium stiff to stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist	3	SS-7 (16-17.5)	18	2-3-4 (7)	0.75-1.25						
20	645		ST-8: Silty CLAY (CL-ML), low plasticity; little Sand, fine to medium; gray, moist	4	ST-8 (18-20)	12			120	15.5	20	14	6	88
			SS-9: Medium stiff to stiff, lean CLAY with sand (CL), low plasticity; trace Gravel, fine; gray, moist		SS-9 (23.5-25)	18	3-3-5 (8)	0.75-1.5		16.0				84
25	640													
30	635		SS-10: Medium stiff, lean CLAY with sand (CL), low plasticity; trace Gravel, fine; gray, moist		SS-10 (28.5-30)	18	2-3-5 (8)	0.5-1.0		15.2				

- REMARKS
1. Brown to gray color change at 7.25 ft bgs.
 2. Sample likely disturbed
 3. 0.25" Sand seam at 16.5 ft bgs.
 4. Pocket pen could not be used in the field.



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BORING NUMBER SHERIDAN-SB-02

PAGE 2 OF 3

CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin

GEOTECH WITH REMARKS AND ELEV V2 - GINT STD US LAB.GDT - 2/9/25 13:37 - J:\GEO TECH PROJECTS\GINT PROJECT DATABASES\20.0158819.00 MILWAUKEE COUNTY PARKS (OCT 2024).GPJ

DEPTH (ft)	Elevation (ft, NAVD 88)	GRAPHIC LOG	MATERIAL DESCRIPTION	REMARKS	SAMPLE TYPE NUMBER (Depth Interval)	RECOVERY (inches)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			FINES CONTENT (%)
											LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
30														
35	630		SS-11: Medium stiff, lean CLAY with sand (CL), low plasticity; trace Gravel, fine; gray, moist		SS-11 (33.5-35)	18	3-3-5 (8)	0.75- 1.0						
40	625		SS-12: Medium stiff to stiff, lean CLAY with sand (CL), low plasticity; trace Gravel, fine; gray, moist		SS-12 (38.5-40)	18	3-3-5 (8)	0.5- 1.5		18.8				
45	620		SS-13: Medium stiff, lean CLAY (CL), low plasticity; little Sand, fine to medium; trace Gravel, fine; gray, moist		SS-13 (43.5-45)	18	3-4-5 (9)	0.5- 1.0		18.1				88
50	615		SS-14: Very stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist		SS-14 (48.5-50)	18	5-9-14 (23)	3.0- 4.0						
55	610		SS-15: Hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist	5	SS-15 (53.5-55)	18	9-9-13 (22)	4.5+		19.0				
60	605		SS-16: Upper 9": Hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist Middle 5": Medium dense, clayey SAND (SC), fine- to medium-grained; gray, wet Lower 4": Very stiff to hard, sandy lean CLAY (CL), low plasticity; trace gravel, fine; gray, moist	6	SS-16 (58.5-60)	18	6-9-13 (22)	3.5- 4.5+						
			SS-17: Hard, lean CLAY (CL), low plasticity; little Sand, fine to coarse; trace Gravel, fine; gray, moist		SS-17 (61-62.5)	18	9-9-18 (27)	4.5+		15.0	34	16	18	89
	600		SS-18: Upper 5": Hard, lean CLAY (CL), low plasticity; trace Sand, fine to coarse; trace Gravel, fine; gray, moist		SS-18 (63.5-65)	18	19-36-50 (50+)	4.5+						

- REMARKS
- Silty seams less than 0.25" present in sample.
 - Silt seam at 61.5 ft bgs about 0.25" thick



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BORING NUMBER SHERIDAN-SB-02

CLIENTMilwaukee County DAS

PROJECT NAMEMilwaukee County Bluff Repairs

PROJECT NUMBER20.0158819.00

PROJECT LOCATIONMilwaukee County, Wisconsin

DEPTH (ft)	Elevation (ft, NAVD 88)	GRAPHIC LOG	MATERIAL DESCRIPTION	REMARKS	SAMPLE TYPE NUMBER (Depth Interval)	RECOVERY (inches)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			FINES CONTENT (%)
											LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
65			Lower 13": Very dense, clayey SAND (SC), fine- to coarse-grained; trace Gravel, fine; gray, moist											
70	595		SS-19: Upper 16": Very dense, clayey SAND (SC), fine- to coarse-grained, trace Gravel, fine; gray, moist Lower 2": Very dense, poorly graded SAND with SILT (SP-SM), fine- to medium-grained; light brown, moist		SS-19 (68.5-70)	18	15-21-47 (50+)	2.0						
75	590		SS-20: Very dense, poorly graded SAND with SILT (SP-SM), fine- to coarse-grained; trace Gravel, fine; gray to light brown, moist		SS-20 (73.5-74.3)	8	27-50/5" (50+)							
80	585		SS-21: Very dense, poorly graded SAND with SILT (SP-SM), fine-grained; trace Gravel, fine; gray to light brown, moist		SS-21 (78.5-79.5)	12	17-50/5" (50+)							8
85	580		SS-22: Upper 10": Very dense, clayey SAND (SC), fine- to medium-grained, gray, wet Lower 8": Hard, lean CLAY (CL), low plasticity; some Sand, fine; trace Gravel, fine; dark gray, moist		SS-22 (83.5-85)	18	19-24-30 (50+)			17.9				
90	575		SS-23: Hard, PEAT (OL), low plasticity; dark brown, organic odor, wood chips, low density, moist		SS-23 (88.5-90)	18	4-15-29 (44)	4.0-4.5		91.0				
End of boring at 90 ft bgs. Hole backfilled with cuttings and covered with sod.														
REMARKS														

GEOTECH WITH REMARKS AND ELEV V2 - GINT STD US LAB GDT - 2/9/25 13:37 - J:\GEOTECH PROJECTS\GINT PROJECT DATABASES\20.0158819.00 MILWAUKEE COUNTY PARKS (OCT 2024).GPJ



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Brookfield, WI 53045
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BORING NUMBER SHERIDAN-SB-03

PAGE 1 OF 3

CLIENT	Milwaukee County DAS	PROJECT NAME	Milwaukee County Bluff Repairs		
PROJECT NUMBER	20.0158819.00	PROJECT LOCATION	Milwaukee County, Wisconsin		
DATE STARTED	10/16/24	COMPLETED	10/17/24		
DRILLING CONTRACTOR	Drill Point, Inc.	GROUND ELEVATION	683.3 feet, NAVD 88		
DRILLING METHOD	3-1/4" ID HSA	HOLE SIZE	7-1/4 inches		
LOGGED BY	CJB	CHECKED BY	IJM		
DRILL RIG	Diedrich D-120	NORTHING	354640		
	HAMMER	EASTING	2545279		
GROUND WATER LEVELS (ft, bgs):	DATE	TIME	DEPTH	CASING	STAB
	10/17/24	AD	DRY	NONE	

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DEPTH (ft)	Elevation (ft, NAVD 88)	GRAPHIC LOG	MATERIAL DESCRIPTION	REMARKS	SAMPLE TYPE NUMBER (Depth Interval)	RECOVERY (inches)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			FINES CONTENT (%)
											LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
0			Surface: Turf Grass with 6" Topsoil											
	680		SS-1: Hard, sandy silty CLAY (CL-ML), low plasticity; light brown with gray mottling, moist		SS-1 (1-2.5)	16	4-5-7 (12)	4.5+						
5			SS-2: Upper 6": Very stiff, sandy SILT (ML), low plasticity; light brown, moist to wet Lower 10": Very stiff, silty CLAY with sand (CL-ML), low plasticity; light brown with orange staining, moist		SS-2 (3.5-5)	16	3-8-8 (16)	2.5- 3.0						
	675		SS-3: Very stiff, silty CLAY with sand (CL-ML), low plasticity; trace Gravel, fine; light brown, moist		SS-3 (6-7.5)	18	4-5-7 (12)	3.0		12.8	20	14	6	73
10			SS-4: Very stiff, silty CLAY with sand (CL-ML), low plasticity; trace Gravel, fine; light brown, orange staining, moist		SS-4 (8.5-10)	18	3-5-7 (12)	2.5						
	670		SS-5: Very stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist		SS-5 (11-12.5)	18	3-3-6 (9)	2.5		14.9				
15			ST-6: Very stiff to hard, lean CLAY with sand (CL), low plasticity; trace Gravel, fine; gray, moist		ST-6 (14-16)	24		3.5- 4.0	124	13.8	25	12	13	77
	665		SS-7: Sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist		SS-7 (16-17.5)	2	3-6-14 (20)	Dist.						
20			SS-8: Upper 5": Stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist Lower 13": Dense, poorly graded Sand with SILT (SP-SM), fine- to medium-grained; light brown, moist		SS-8 (18.5-20)	18	8-19-23 (42)	2.0						
	660		SS-9: Dense, SILT with SAND (ML), nonplastic; light brown, moist		SS-9 (23.5-25)	18	15-16-17 (33)			11.3				80
25				1										
	655		SS-10: Dense, poorly graded SAND with SILT (SP-SM), fine- to medium-grained; light brown, moist		SS-10 (28.5-30)	18	11-17-20 (37)							
30														

REMARKS	1. Paused drilling for 10/16/2024.
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CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin

DEPTH (ft)	Elevation (ft. NAVD 88)	GRAPHIC LOG	MATERIAL DESCRIPTION	REMARKS	SAMPLE TYPE NUMBER (Depth Interval)	RECOVERY (inches)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			FINES CONTENT (%)
											LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
30														
	650		SS-11: Upper 4": Very dense, silty SAND (SM), fine- to coarse-grained; trace Gravel, fine, brown, moist Lower 14": Very dense, silty SAND (SM), fine- to medium-grained; light brown, moist		SS-11 (33.5-35)	18	10-19-32 (50+)			10.7				45
35														
	645		SS-12: Very dense, poorly graded SAND with SILT (SP-SM), fine- to medium-grained; trace Gravel, fine; light brown to tan, moist		SS-12 (38.5-40)	18	15-23-35 (50+)							6
40														
	640		SS-13: Upper 8": Very dense, silty SAND (SM), fine- to medium-grained; light brown, moist Lower 10": Very dense, poorly graded SAND with SILT (SP-SM), fine- to medium-grained, trace Gravel, fine; light brown to tan, moist		SS-13 (43.5-45)	18	17-30-31 (50+)							
45														
	635		SS-14: Very dense, silty SAND (SM), fine- to coarse-grained; white to tan, moist		SS-14 (48.5-50)	18	25-32-40 (50+)			1.0				16
50														
	630		SS-15: Upper 10": Dense, well-graded SAND with SILT (SW-SM), fine- to coarse-grained; trace Gravel, fine; light brown, moist Lower 7": Very stiff, to hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray moist		SS-15 (53.5-55)	18	21-23-22 (45)	3.0-4.0						
55														
	625		SS-16: Very stiff, sandy lean CLAY (CL), low plasticity; gray, moist		SS-16 (58.5-60)	18	9-16-23 (39)	2.5-3.0		23.9	34	23	11	
60														
	620		SS-17: Hard, lean CLAY (CL), low plasticity; gray, moist		SS-17 (63.5-65)	18	5-14-21 (35)	4.5+		21.5	37	21	16	100
REMARKS														



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BORING NUMBER SHERIDAN-SB-03

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CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin

GEOTECH WITH REMARKS AND ELEV V2 - GINT STD US LAB.GDT - 2/9/25 13:37 - J:\GEOTECH PROJECTS\GINT PROJECT DATABASES\20.0158819.00 MILWAUKEE COUNTY PARKS (OCT 2024).GPJ

DEPTH (ft)	Elevation (ft, NAVD 88)	GRAPHIC LOG	MATERIAL DESCRIPTION	REMARKS	SAMPLE TYPE NUMBER (Depth Interval)	RECOVERY (inches)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			FINES CONTENT (%)
											LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
65														
615														
70			SS-18: Hard, lean CLAY (CL), low plasticity; gray and brown, moist		SS-18 (68.5-70)	18	6-14-23 (37)	4.5+						
610														
75			SS-19: Hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist	2	SS-19 (73.5-75)	18	8-18-29 (47)	4.5+		12.3				70
605														
80			SS-20: Hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist		SS-20 (78.5-80)	18	8-13-19 (32)	4.5+						
600														
85			SS-21: Upper 5": Stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist Lower 13": Very dense, poorly graded SAND with SILT (SP-SM), fine- to medium-grained; light brown to tan, moist		SS-21 (83.5-85)	18	12-27-35 (50+)	2.25		2.4				
595														
90			SS-22: Very dense, poorly graded SAND with SILT (SP-SM), fine- to medium-grained; light brown to tan, moist		SS-22 (88.5-90)	18	22-34-52 (50+)							7

End of boring at 90 ft bgs. Hole backfilled with cuttings and bentonite grout and covered with sod.

REMARKS 2. Slow drilling, driller poured water down augers to provide lubrication.

CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin

DATE STARTED 10/17/24

COMPLETED 10/17/24

GROUND ELEVATION 685.7 feet, NAVD 88 **HOLE SIZE** 7-1/4 inches

DRILLING CONTRACTOR Drill Point, Inc.

NORTHING 352967

EASTING 2545511

DRILLING METHOD 3-1/4" ID HSA

LOGGED BY CJB

CHECKED BY IJM

**GROUND WATER
LEVELS (ft, bgs):**

DATE	TIME	DEPTH	CASING	STAB
10/18/24	AD	38.5	HSA	
10/18/24	AD	NM	NONE	

REMARKS	DEPTH (ft)	Elevation (ft. NAVD 88)	GRAPHIC LOG	MATERIAL DESCRIPTION	REMARKS	SAMPLE TYPE NUMBER (Depth Interval)	RECOVERY (inches)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			FINES CONTENT (%)
												LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
	0														
		685		Surface: Turf Grass with 14" Topsoil											
				SS-1: Upper 2": TOPSOIL Lower 14": Very stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; light brown, rootlets, moist		SS-1 (1-2.5)	16	3-5-5 (10)	3.5						
	5			SS-2: Stiff, sandy lean CLAY with GRAVEL (CL), low plasticity; light brown, orange staining, moist to wet		SS-2 (3.5-5)	12	4-5-5 (10)	1.5		7.2				
		680													
				SS-3: Very stiff, sandy lean CLAY with GRAVEL (CL), low plasticity; light brown, orange staining, moist to wet	1	SS-3 (6-7.5)	16	2-5-6 (11)	3.0-4.0						
				SS-4: Hard, lean CLAY with sand (CL), low plasticity; trace Gravel, fine, gray, moist		SS-4 (8.5-10)	14	2-6-8 (14)	4.0-4.5+		12.6	26	12	14	84
	10														
		675		SS-5: Hard, lean CLAY with sand (CL), low plasticity; trace Gravel, fine, gray, moist		SS-5 (11-12.5)	18	3-6-8 (14)	4.0-4.5+						
				SS-6: Hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine, gray, moist	2	SS-6 (13.5-15)	18	3-7-9 (16)	4.5+						
	15														
		670		SS-7: Upper 10": Medium stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine, gray, moist Middle 5": Stiff, sandy SILT (ML), low plasticity; gray, moist to wet Lower 3": Very stiff, sandy lean CLAY (CL), low plasticity; gray, moist		SS-7 (16-17.5)	18	2-3-5 (8)	1.0-2.5						
				SS-8: Stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist		SS-8 (18.5-20)	18	2-4-4 (8)	1.5-2.0		18.7				
	20														
		665													
				SS-9: Medium dense, sandy SILT (ML), nonplastic; light brown, moist		SS-9 (23.5-25)	14	3-9-9 (18)							53
	25														
		660													
				SS-10: Medium dense, poorly graded SAND with SILT (SP-SM), fine- to medium-grained; light brown, moist		SS-10 (28.5-30)	16	7-12-15 (27)							
	30														
REMARKS	1. 0.25" Silt seam a 6.7 ft bgs. 2. Rig chatter at 13 ft bgs.														



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BORING NUMBER WARNIMONT-SB-04

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CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin

GEOTECH WITH REMARKS AND ELEV V2 - GINT STD US LAB.GDT - 2/9/25 13:37 - J:\GEOTECH PROJECTS\GINT PROJECT DATABASES\20.0158819.00 MILWAUKEE COUNTY PARKS (OCT 2024).GPJ

DEPTH (ft)	Elevation (ft, NAVD 88)	GRAPHIC LOG	MATERIAL DESCRIPTION	REMARKS	SAMPLE TYPE NUMBER (Depth Interval)	RECOVERY (inches)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			FINES CONTENT (%)
											LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
30														
35	655		SS-11: Medium dense, silty SAND (SM), fine- to medium-grained; trace Gravel, fine; light brown to brown, moist		SS-11 (33.5-35)	18	9-13-16 (29)			4.8				14
40	650		SS-12: Soft, SILT (ML), low plasticity; trace Sand, fine to medium; gray, wet		SS-12 (38.5-40)	18	4-4-10 (14)	0.5		18.5	NP	NP	NP	95
45	645		ST-13: No Recovery	3	ST-13 (42-42.5)	4								
45	640		SS-14: Upper 8": Medium dense, well-graded SAND with SILT (SW-SM), fine- to coarse-grained; gray, moist to wet Lower 8": Medium dense, sandy SILT (ML), nonplastic; gray, wet	4	SS-14 (43.5-45)	16	7-5-6 (11)			15.4				58
50	635		SS-15: Very stiff, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, wet		SS-15 (48.5-50)	18	5-5-7 (12)	3.5		21.5				
55	630		SS-16: Hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray, moist to wet		SS-16 (53.5-55)	18	6-8-11 (19)	4.5+						
60	625		SS-17: Very stiff, lean CLAY (CL), low plasticity; little Sand, fine to medium; trace Gravel, fine; gray, moist		SS-17 (58.5-60)	18	5-8-11 (19)	3.0- 4.0		20.4				90
			SS-18: Hard, lean CLAY (CL), low plasticity; trace Sand, fine; gray, moist		SS-18 (63.5-65)	18	16-37-43 (50+)	4.5+						

REMARKS	3. Attempted Shelby Tube at 42 feet bgs. Tube refusal after about 6", no recovery.
	4. Attempted Shelby Tube at 43.5 feet bgs, could not push, performed split spoon instead. Driller reported some sand heaving.



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CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

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GEOTECH WITH REMARKS AND ELEV V2 - 2/9/25 13:37 - J:\GEOTECH PROJECTS\GINT PROJECT DATABASES\20.0158819.00 MILWAUKEE COUNTY PARKS (OCT 2024).GPJ

DEPTH (ft)	Elevation (ft, NAVD 88)	GRAPHIC LOG	MATERIAL DESCRIPTION	REMARKS	SAMPLE TYPE NUMBER (Depth Interval)	RECOVERY (inches)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			FINES CONTENT (%)
											LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
65	620		SS-19: Hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray with brown streaks, white mottling, moist		SS-19 (68.5-70)	18	12-20-33 (50+)	4.5+			27	18	9	68
70	615		SS-20: Hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray with brown streaks, white mottling, moist		SS-20 (73.5-75)	18	9-19-27 (46)	4.5+	11.4					
75	610		SS-21: Hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray with brown streaks, white mottling, moist		SS-21 (78.5-80)	18	8-18-27 (45)	4.5+						
80	605		SS-22: Hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray with brown streaks, white mottling, moist		SS-22 (83.5-85)	18	5-10-27 (37)	4.5+						
85	600		SS-23: Hard, sandy lean CLAY (CL), low plasticity; trace Gravel, fine; gray with brown streaks, white mottling, moist	5	SS-23 (88.5-90)	18	5-11-18 (29)	4.5+		19.3				
90			End of boring at 90 ft bgs. Hole backfilled with cuttings and bentonite grout and covered with sod.											

REMARKS 5. Wet spoils/cuttings at 88 ft bgs.



APPENDIX F

LABORATORY TESTING RESULTS



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TABULATION OF LABORATORY DATA

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CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin

Boring Number	Sample Number	Depth ft, bgs	Natural Moisture %	Dry Unit Weight (pcf)	Sieve Data: Percent Passing By Weight*					Atterberg Limits			USCS Class.*	UC Strength (tsf)	Date Tested Technician
					3/4"	No. 4	No. 10	No. 40	No. 200	LL	PL	PI			
BAY VIEW-SB-01	SS-2	3.5	14.4	107.3											11/18/2024 GZA
BAY VIEW-SB-01	SS-4	8.5	18.3												11/18/2024 GZA
BAY VIEW-SB-01	ST-6	13.5	20.8						92	41	16	25	CL	2.01	10/25/2024 GEOTEST
BAY VIEW-SB-01	SS-7	16	17.9												11/18/2024 GZA
BAY VIEW-SB-01	ST-9	20	18.7	117.2					88	NP	NP	NP	ML		10/31/2024 GESTRA
BAY VIEW-SB-01	SS-10	23.5	15.0						75						11/18/2024 GZA
BAY VIEW-SB-01	ST-11	26							85	28	13	15	CL		10/25/2024 GEOTEST
BAY VIEW-SB-01	SS-13	33.5	15.8												11/18/2024 GZA
BAY VIEW-SB-01	SS-15	43.5	21.3			100	97	62	26	NP	NP	NP	SM		11/18/2024 GZA
BAY VIEW-SB-01	SS-15B	43.9	3.0			94	82	42	11						11/18/2024 GZA
BAY VIEW-SB-01	SS-16	48.5	17.9												11/18/2024 GZA
BAY VIEW-SB-01	ST-18	56	12.1	123.6					77	25	14	11	CL		10/31/2024 GESTRA
BAY VIEW-SB-01	SS-19	58.5	16.5												11/18/2024 GZA
SHERIDAN-SB-02	SS-2	3.5	14.7	120.1											11/18/2024 GZA
SHERIDAN-SB-02	SS-4	8.5	15.3						94						11/18/2024 GZA
SHERIDAN-SB-02	SS-6	13.5	15.3												11/18/2024 GZA
SHERIDAN-SB-02	ST-8	18	15.5						88	20	14	6	CL-ML		10/25/2024 GEOTEST
SHERIDAN-SB-02	SS-9	23.5	16.0						84						11/18/2024 GZA
SHERIDAN-SB-02	SS-10	28.5	15.2												11/18/2024 GZA
SHERIDAN-SB-02	SS-12	38.5	18.8												11/18/2024 GZA
SHERIDAN-SB-02	SS-13	43.5	18.1						88						10/25/2024 GEOTEST
SHERIDAN-SB-02	SS-15	53.5	19.0												11/18/2024 GZA
SHERIDAN-SB-02	SS-17	61	15.0						89	34	16	18	CL		10/25/2024 GEOTEST
SHERIDAN-SB-02	SS-21	78.5						100	8						10/25/2024 GEOTEST
SHERIDAN-SB-02	SS-22	83.5	17.9												11/18/2024 GZA
SHERIDAN-SB-02	SS-23	88.5	91.0												11/18/2024 GZA

*Soil samples with particles greater than 3/8" (9.5 mm) in diameter may not conform to minimum sample mass per ASTM D6913. Laboratory and observational soil classifications may differ accordingly.



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TABULATION OF LABORATORY DATA

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CLIENT Milwaukee County DAS

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PROJECT LOCATION Milwaukee County, Wisconsin

Boring Number	Sample Number	Depth ft, bgs	Natural Moisture %	Dry Unit Weight (pcf)	Sieve Data: Percent Passing By Weight*					Atterberg Limits			USCS Class.*	UC Strength (tsf)	Date Tested Technician
					3/4"	No. 4	No. 10	No. 40	No. 200	LL	PL	PI			
SHERIDAN-SB-03	SS-3	6	12.8						73	20	14	6	CL-ML		10/25/2024 GEOTEST
SHERIDAN-SB-03	SS-5	11	14.9												11/18/2024 GZA
SHERIDAN-SB-03	ST-6	14	13.8						77	25	12	13	CL		11/25/2024 GESTRA
SHERIDAN-SB-03	SS-9	23.5	11.3						80						11/18/2024 GZA
SHERIDAN-SB-03	SS-11	33.5	10.7						45						11/18/2024 GZA
SHERIDAN-SB-03	SS-12	38.5			100	98	91	65	6						10/25/2024 GEOTEST
SHERIDAN-SB-03	SS-14	48.5	1.0		100	87	72	42	16						11/18/2024 GZA
SHERIDAN-SB-03	SS-16	58.5	23.9							34	23	11			11/18/2024 GZA
SHERIDAN-SB-03	SS-17	63.5	21.5						100	37	21	16	CL		10/25/2024 GEOTEST
SHERIDAN-SB-03	SS-19	73.5	12.3						70						11/18/2024 GZA
SHERIDAN-SB-03	SS-21	83.5	2.4												11/18/2024 GZA
SHERIDAN-SB-03	SS-22	88.5				100	100	93	7						10/25/2024 GEOTEST
WARNIMONT-SB-04	SS-2	3.5	7.2												11/18/2024 GZA
WARNIMONT-SB-04	SS-4	8.5	12.6						84	26	12	14	CL		10/25/2024 GEOTEST
WARNIMONT-SB-04	SS-8	18.5	18.7												11/18/2024 GZA
WARNIMONT-SB-04	SS-9	23.5				100	100	98	53						10/25/2024 GEOTEST
WARNIMONT-SB-04	SS-11	33.5	4.8			100	98	79	14						11/18/2024 GZA
WARNIMONT-SB-04	SS-12	38.5	18.5						95	NP	NP	NP	ML		10/25/2024 GEOTEST
WARNIMONT-SB-04	SS-14	43.5	15.4						58						11/18/2024 GZA
WARNIMONT-SB-04	SS-15	48.5	21.5												11/18/2024 GZA
WARNIMONT-SB-04	SS-17	58.5	20.4						90						11/18/2024 GZA
WARNIMONT-SB-04	SS-20	73.5	11.4						68	27	18	9	CL		10/25/2024 GEOTEST
WARNIMONT-SB-04	SS-23	88.5	19.3												11/18/2024 GZA
Maximum Values:			91.0	123.6	100	100	100	100	100	41	23	25		2.0	
Minimum Values:			1.0	107.3	100	87	72	42	6	0	0	0		2.0	
Average Value:			16.8	117.0	100	97	91	73	63	23	12	10		2.0	
Number of Tests Performed:			44	4	2	7	7	8	29	14	14	14		1	

*Soil samples with particles greater than 3/8" (9.5 mm) in diameter may not conform to minimum sample mass per ASTM D6913. Laboratory and observational soil classifications may differ accordingly.

GZA LAB SUMMARY - GINT STD US LAB GDT - 1/16/25 17:06 - J:\GEO\TECH PROJECTS\GINT PROJECT DATABASES\20.0158819.00 MILWAUKEE COUNTY PARKS (OCT 2024)\GPJ



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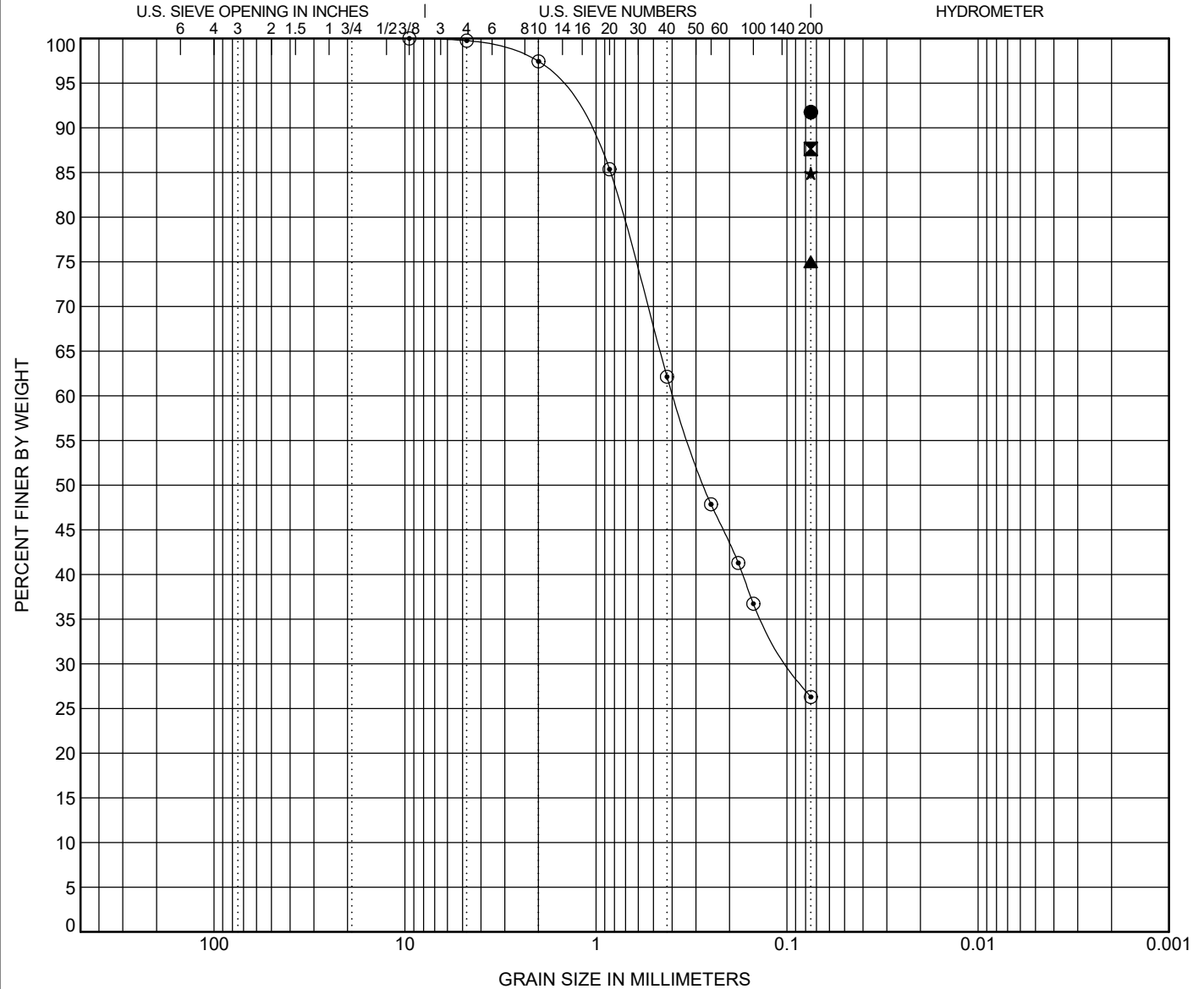
GRAIN SIZE DISTRIBUTION

CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification (USCS)					LL	PL	PI	Cc	Cu
● BAY VIEW-SB-01	13.5	LEAN CLAY(CL)					41	16	25		
☒ BAY VIEW-SB-01	20.0	SILT(ML)					NP	NP	NP		
▲ BAY VIEW-SB-01	23.5										
★ BAY VIEW-SB-01	26.0	LEAN CLAY with SAND(CL)					28	13	15		
⊙ BAY VIEW-SB-01	43.5	SILTY SAND(SM)					NP	NP	NP		
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● BAY VIEW-SB-01	13.5	0.075						91.8			
☒ BAY VIEW-SB-01	20.0	0.075						87.7			
▲ BAY VIEW-SB-01	23.5	0.075						75.0			
★ BAY VIEW-SB-01	26.0	0.075						84.9			
⊙ BAY VIEW-SB-01	43.5	9.5	0.393	0.096		0.2	73.5	26.3			



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Brookfield, WI 53045
(262) 754-2560

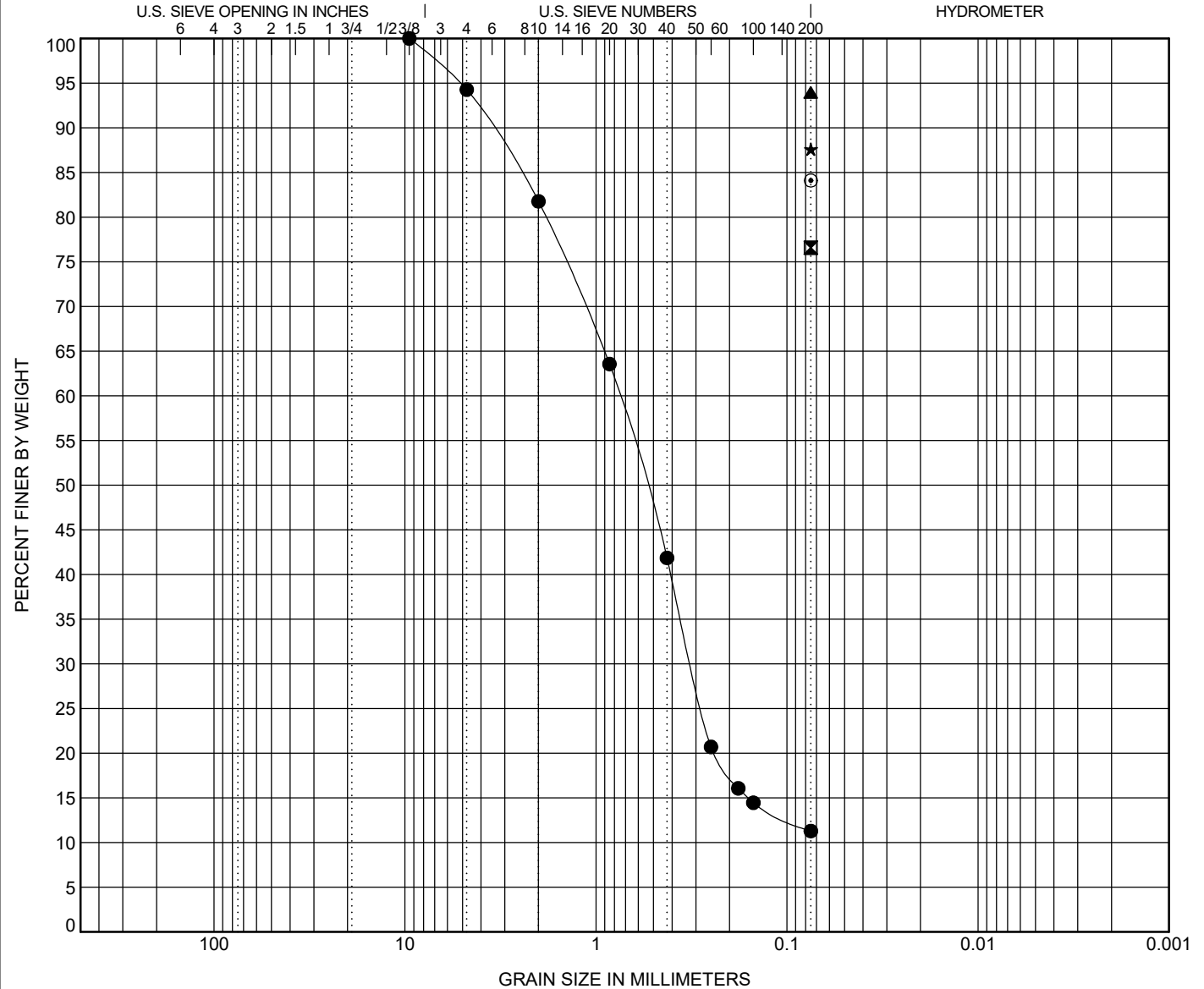
GRAIN SIZE DISTRIBUTION

CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification (USCS)					LL	PL	PI	Cc	Cu
● BAY VIEW-SB-01	43.9									2.32	13.40
☒ BAY VIEW-SB-01	56.0	LEAN CLAY with SAND(CL)					25	14	11		
▲ SHERIDAN-SB-02	8.5										
★ SHERIDAN-SB-02	18.0	SILTY CLAY(CL-ML)					20	14	6		
⊙ SHERIDAN-SB-02	23.5										
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● BAY VIEW-SB-01	43.9	9.5	0.759	0.316		5.7	83.0	11.3			
☒ BAY VIEW-SB-01	56.0	0.075						76.6			
▲ SHERIDAN-SB-02	8.5	0.075						94.0			
★ SHERIDAN-SB-02	18.0	0.075						87.6			
⊙ SHERIDAN-SB-02	23.5	0.075						84.1			

GRAIN SIZE 2 -MKE - GINT STD US LAB.GDT - 1/16/25 16:41 - J:\GEOTECH PROJECTS\GINT PROJECT DATABASES\20.0158819.00 MILWAUKEE COUNTY PARKS (OCT 2024).GPJ



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Brookfield, WI 53045
(262) 754-2560

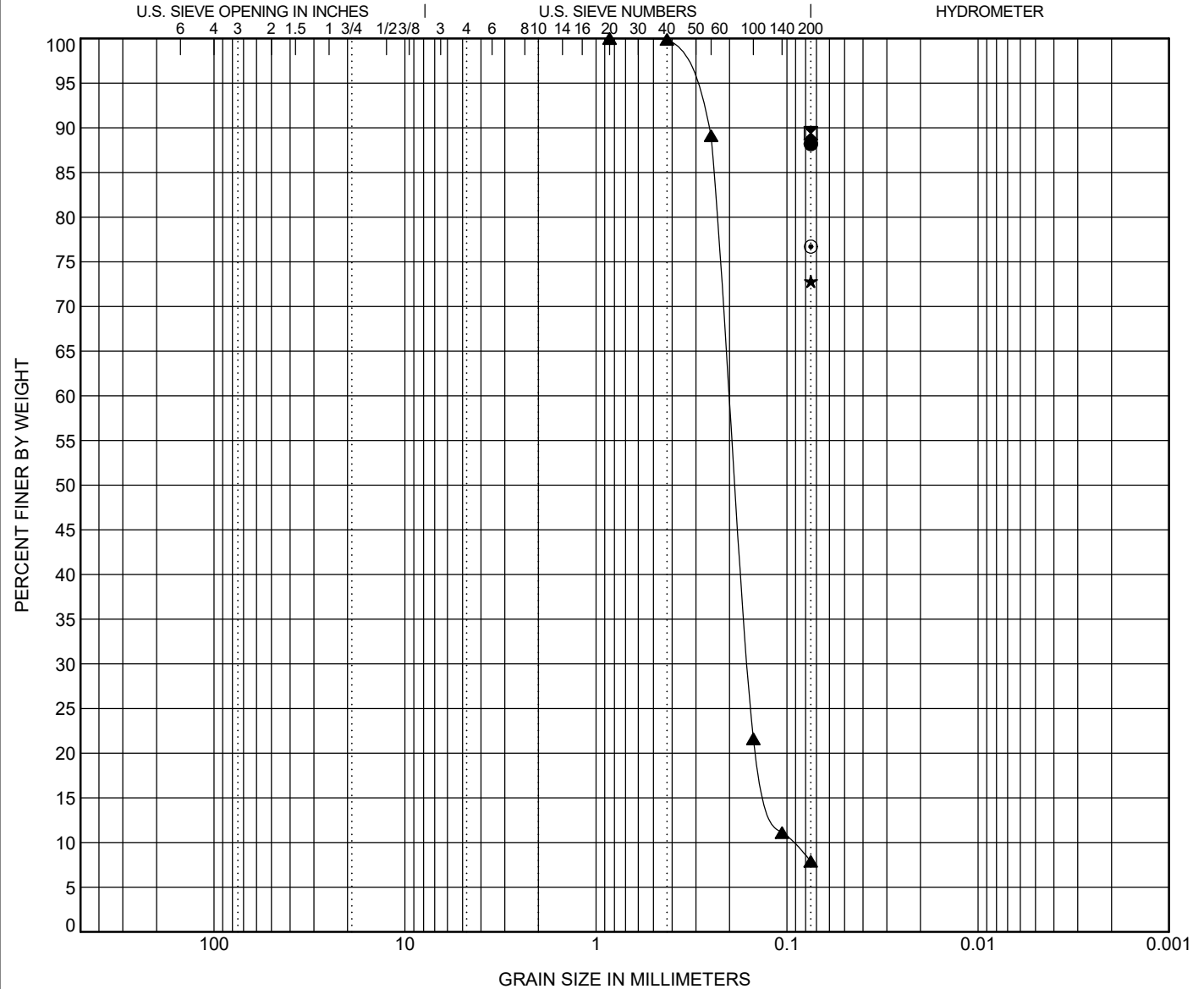
GRAIN SIZE DISTRIBUTION

CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin





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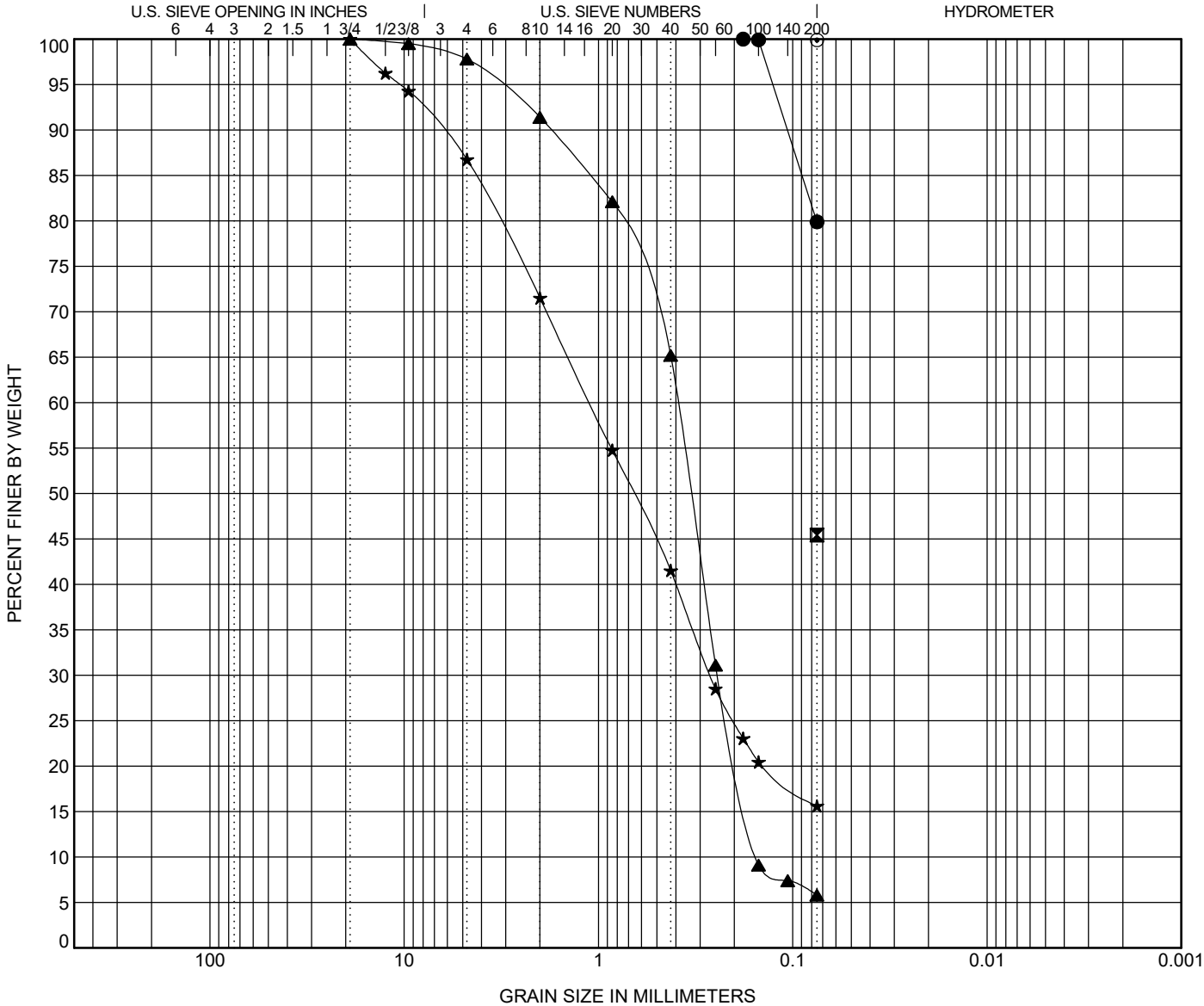
GRAIN SIZE DISTRIBUTION

CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin





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Brookfield, WI 53045
(262) 754-2560

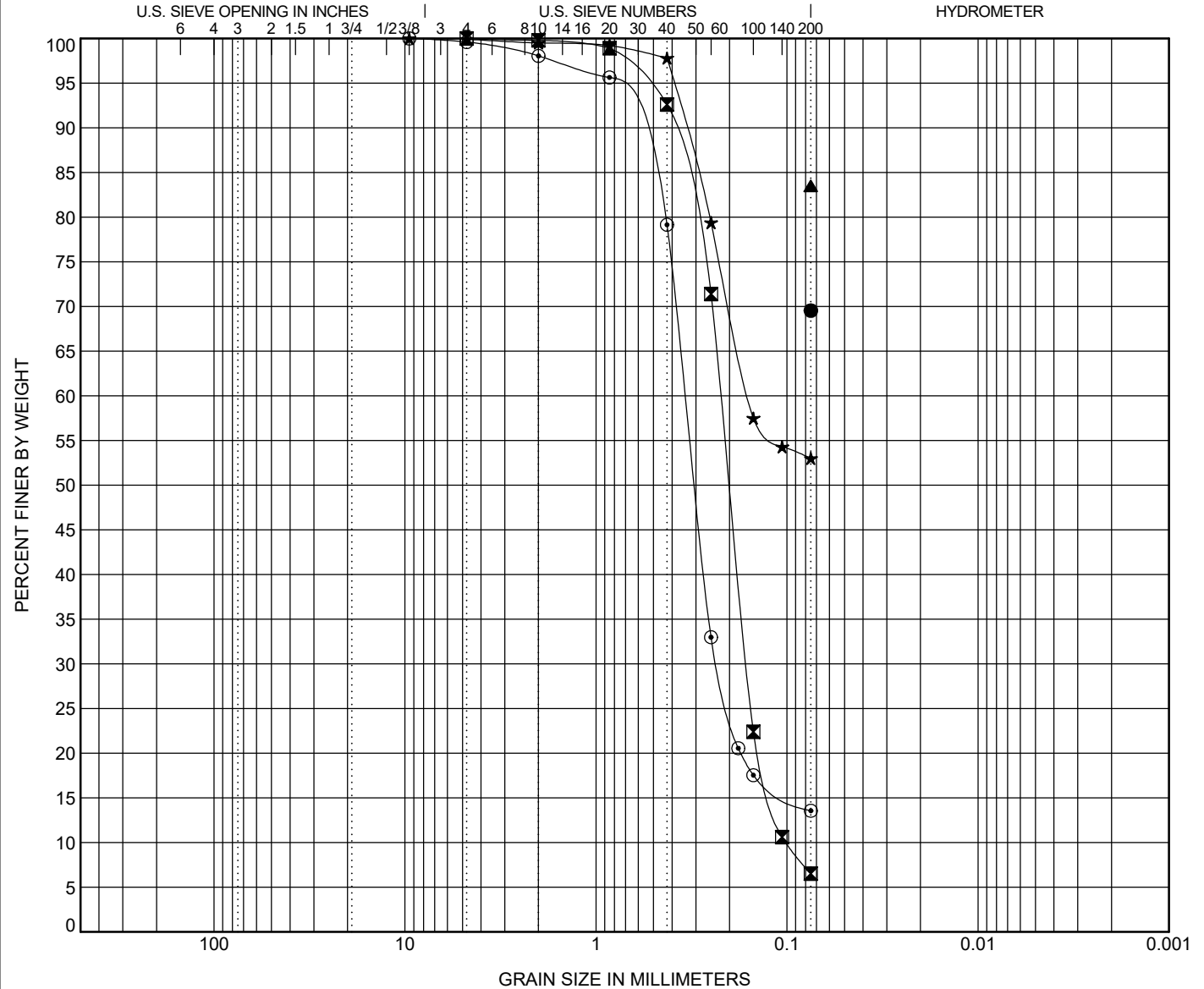
GRAIN SIZE DISTRIBUTION

CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE	DEPTH	Classification (USCS)					LL	PL	PI	Cc	Cu
● SHERIDAN-SB-03	73.5										
☒ SHERIDAN-SB-03	88.5									1.18	2.20
▲ WARNIMONT-SB-04	8.5	LEAN CLAY with SAND(CL)					26	12	14		
★ WARNIMONT-SB-04	23.5										
⊙ WARNIMONT-SB-04	33.5										
BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay	
● SHERIDAN-SB-03	73.5	0.075						69.5			
☒ SHERIDAN-SB-03	88.5	4.75	0.222	0.162	0.101	0.0	93.5	6.5			
▲ WARNIMONT-SB-04	8.5	0.075						83.5			
★ WARNIMONT-SB-04	23.5	9.5	0.159			0.1	46.9	53.0			
⊙ WARNIMONT-SB-04	33.5	9.5	0.341	0.231		0.4	86.1	13.6			

GRAIN SIZE 2 - MKE - GINT STD US LAB.GDT - 1/16/25 - 16:41 - J:\GEO TECH PROJECTS\GINT PROJECT DATABASES\20.0158819.00 MILWAUKEE COUNTY PARKS (OCT 2024).GPJ



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Brookfield, WI 53045
(262) 754-2560

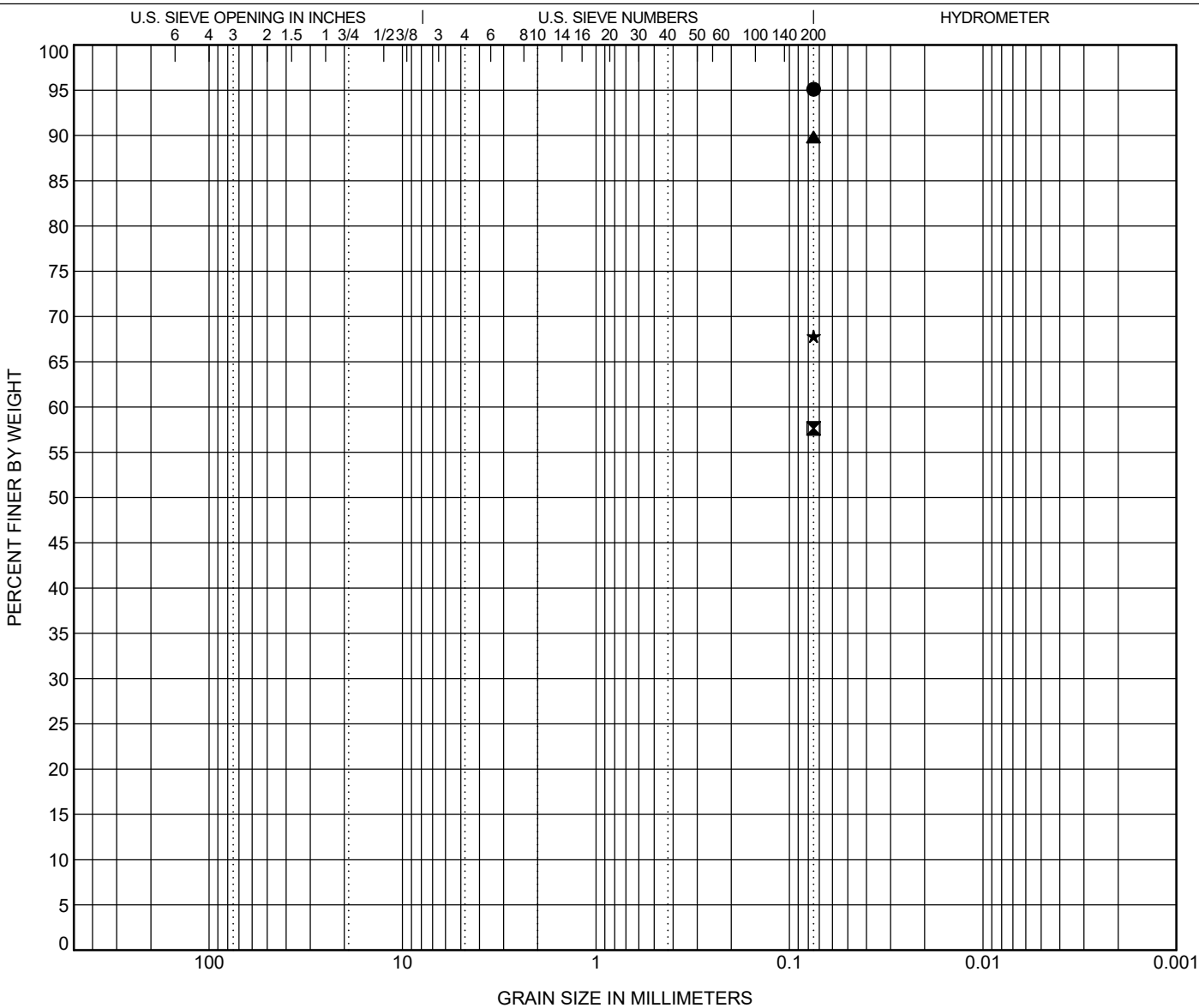
GRAIN SIZE DISTRIBUTION

CLIENT Milwaukee County DAS

PROJECT NAME Milwaukee County Bluff Repairs

PROJECT NUMBER 20.0158819.00

PROJECT LOCATION Milwaukee County, Wisconsin



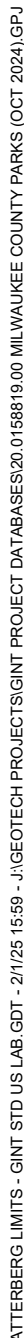
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BOREHOLE DEPTH		Classification (USCS)						LL	PL	PI	Cc	Cu
●	WARNIMONT-SB-04 38.5	SILT(ML)						NP	NP	NP		
■	WARNIMONT-SB-04 43.5											
▲	WARNIMONT-SB-04 58.5											
★	WARNIMONT-SB-04 73.5	SANDY LEAN CLAY(CL)						27	18	9		
BOREHOLE DEPTH		D100	D60	D30	D10	%Gravel	%Sand	%Silt		%Clay		
●	WARNIMONT-SB-04 38.5	0.075						95.1				
■	WARNIMONT-SB-04 43.5	0.075						57.6				
▲	WARNIMONT-SB-04 58.5	0.075						89.8				
★	WARNIMONT-SB-04 73.5	0.075						67.8				

GRAIN SIZE 2 -MKE - GINT STD US LAB.GDT - 1/16/25 16:41 - J:\GEOTECH PROJECTS\GINT PROJECT DATABASES\20.0158819.00 MILWAUKEE COUNTY PARKS (OCT 2024).GPJ



CLIENT	Milwaukee County DAS	PROJECT NAME	Milwaukee County Bluff Repairs
PROJECT NUMBER	20.0158819.00	PROJECT LOCATION	Milwaukee County, Wisconsin

[illegible]



GESTRA Engineering, Inc.

191 W. Edgerton Ave

Milwaukee, WI 53207

Phone: (414) 933-7444; Fax: (414) 933-7844

**Laboratory Test Results of
Amount of Soil finer than #200 Sieve**

Project Name: Milwaukee County Bluffs
Project Number: 24354-40
Project Location: Milwaukee, WI
ASTM Designation: D1140

Date: October 29, 2024
Report To: GZA
GZA #: 20.0158819.00

Boring Number	BAYVIEW SB-01							
Sample Number	ST-6	ST-9	ST-18					
Soak Time (to the nearest 10 min.)	400	300	420					
Weight of Pan (g)	135.7	96.7	78.5					
Weight of Wet Soil and Pan (g)	527.7	489.7	442.3					
Weight of Wet Soil (g)	392.0	393.0	363.8					
Weight of Dry Soil and Pan (g)	461.9	427.9	399.9					
Weight of Dry Soil (g)	326.2	331.2	321.4					
Weight of Soil and Pan after Wash (g)	162.6	137.6	153.8					
Weight of Soil after Wash (g)	26.9	40.9	75.3					
Percentage of Material Passing #200 (%)	91.8	87.6	76.6					
Moisture Content (%)	20.2	18.7	13.2					

Boring Number								
Sample Number								
Soak Time (to the nearest 10 min.)								
Weight of Pan (g)								
Weight of Wet Soil and Pan (g)								
Weight of Wet Soil (g)								
Weight of Dry Soil and Pan (g)								
Weight of Dry Soil (g)								
Weight of Soil and Pan after Wash (g)								
Weight of Soil after Wash (g)								
Percentage of Material Passing #200 (%)								
Moisture Content (%)								

Performed by: SM/ C. Schneider

Reviewed by: Nicole Merkes

Geotechnical-Structural-Pavement-Construction Material



Laboratory Test Results of Atterberg Limits of Soil

Project Name: Milwaukee County Bluffs Date: November 5, 2024
Project Number: 24354-40 Client: GZA
Project Location: Milwaukee, WI GZA #: 20.0158819.00
ASTM Designation: D4318 (Method A)

Sample Information

Type of Sample Shelby Tube
Boring Number BAYVIEW SB-01
Sample Number 6
Depth of Sample 13.5-14.5

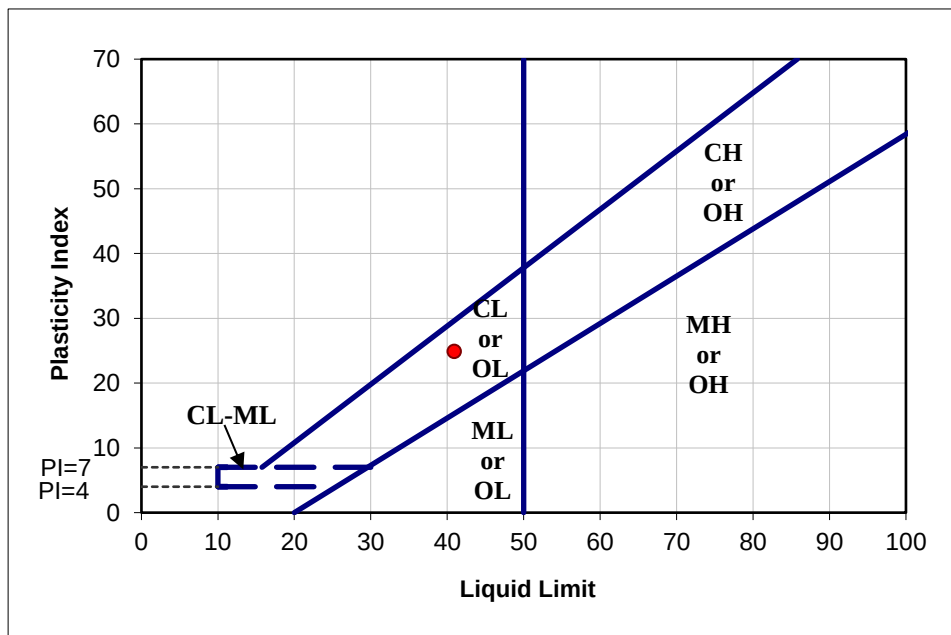
Determination of Liquid Limit

Cup Number			
Weight of Cup (g)	18.85	19.40	18.83
Weight of Wet Soil and Cup (g)	40.49	41.18	40.11
Weight of Dry Soil and Cup (g)	34.33	34.85	33.82
Moisture Content (%)	39.8	41.0	42.0
Blow Counts	30	25	20

Determination of Plastic Limit

Cup Number		
Weight of Cup (g)	7.19	7.44
Weight of Wet Soil and Cup (g)	13.38	14.20
Weight of Dry Soil and Cup (g)	12.50	13.26
Moisture Content (%)	16.6	16.2

Compilation of Test Results



Liquid Limit	<u>41</u>
Plastic Limit	<u>16</u>
Plasticity Index	<u>25</u>
USCS Symbol	<u>CL</u>

Performed by: S. McLafferty

Reviewed By: Nicole Merkes

GESTRA Engineering, Inc.



GESTRA Engineering, Inc

191 W. Edgerton Ave

Milwaukee, WI 53207

Phone: (414) 933-7444; Fax: (414) 933-7844

Shelby Tube Extraction Form

Project Name:	<u>Milwaukee County Bluffs</u>	Date:	<u>November 4, 2024</u>
Project Number:	<u>24354-40</u>	Client:	<u>GZA</u>
Projection Location:	<u>Milwaukee, WI</u>	GZA #:	<u>20.0158819.00</u>
ASTM Designation:	<u>D2488</u>		

Sample Information

Boring Number	<u>BAYVIEW SB-01</u>	
Sample Number	<u>ST-6</u>	qp: 3.5
Depth of Sample	<u>13.5-14.5</u>	

Recovery: 11" (bottom 1" remains in damaged portion of shelly tube).

Soil Description: Lean clay, brown with dark brown and orange, moist, very stiff, trace sand.



BOTTOM

TOP

Preformed By: S. McLafferty

Reviewed By: Nicole Merkes

Laboratory Test Results of Unconfined Compressive Strength of Soil

Project Name: Milwaukee County Bluffs
Project Number: 24354-40
Project Location: Milwaukee, WI
ASTM Designation: D2166

Date: November 4, 2024
Report To: GZA
GZA #: 20.0158819.00

Test Data

Deformation dial reading (0.001 in.)	Sample stress (psf)
0	0
20	540
40	1441
60	2336
80	3015
100	3480
150	4014
200	3772
250	3238

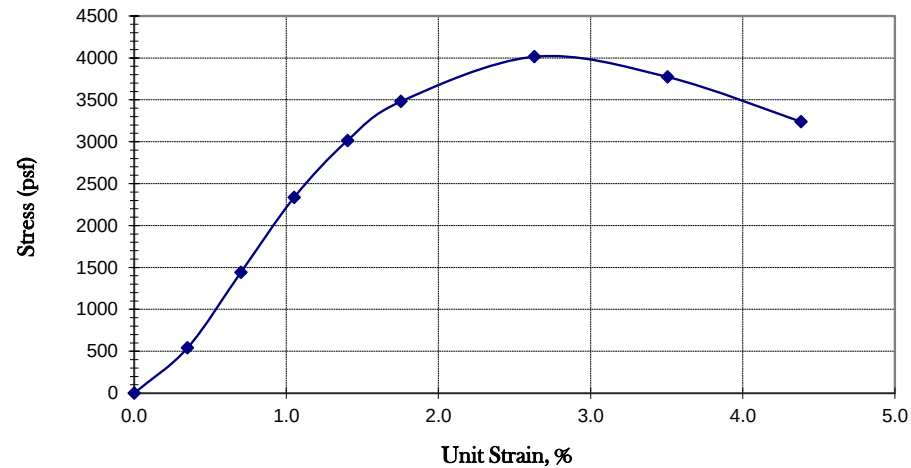
Sample Information

Boring no.: BAYVIEW SB-01
Sample no.: ST-6
Depth of Soil: 13.5-14.5
Description of Soil: Strain Rate Lean clay, brown with dark brown and orange, moist, very stiff, trace sand.
(in/min): 0.060

Diameter (in) 2.86

Area (sq. in.): 6.40

Height (in.): 5.70



UC Strength, Q_u (tsf) 2.01
Wet Density (pcf) 129.6
Dry Density (pcf) 107.3
Moisture Content (%) 20.8

Remarks Preformed in place of consolidated undrained due to low recovery.
Sample fractured along weathered surfaces (orange and dark brown in color).

Performed By: S. McLafferty

Reviewed By: Nicole Merkes
GESTRA Engineering, Inc.



Laboratory Test Results of Atterberg Limits of Soil

Project Name: Milwaukee County Bluffs Date: October 31, 2024
Project Number: 24354-40 Client: GZA
Project Location: Milwaukee, WI GZA #: 20.0158819.00
ASTM Designation: D4318 (Method A)

Sample Information

Type of Sample Shelby Tube
Boring Number BAYVIEW SB-01
Sample Number 9
Depth of Sample 20' - 22'

Non Plastic- SILT

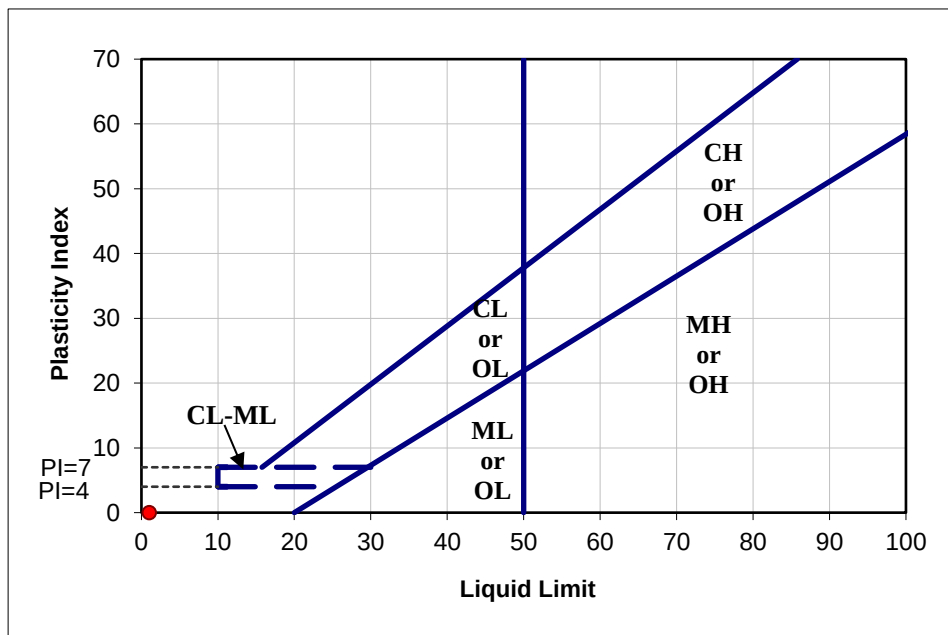
Determination of Liquid Limit

Cup Number			
Weight of Cup (g)			
Weight of Wet Soil and Cup (g)			
Weight of Dry Soil and Cup (g)			
Moisture Content (%)	#DIV/0!	#DIV/0!	#DIV/0!
Blow Counts			

Determination of Plastic Limit

Cup Number		
Weight of Cup (g)		
Weight of Wet Soil and Cup (g)		
Weight of Dry Soil and Cup (g)		
Moisture Content (%)	#DIV/0!	#DIV/0!

Compilation of Test Results



Liquid Limit	NP
Plastic Limit	NP
Plasticity Index	NP
USCS Symbol	N/A

Performed by: B. Bills

Reviewed By: Nicole Merkes

GESTRA Engineering, Inc.

Geotechnical-Structural-Pavement-Construction Material



DIRECT SHEAR TEST AASHTO T-236

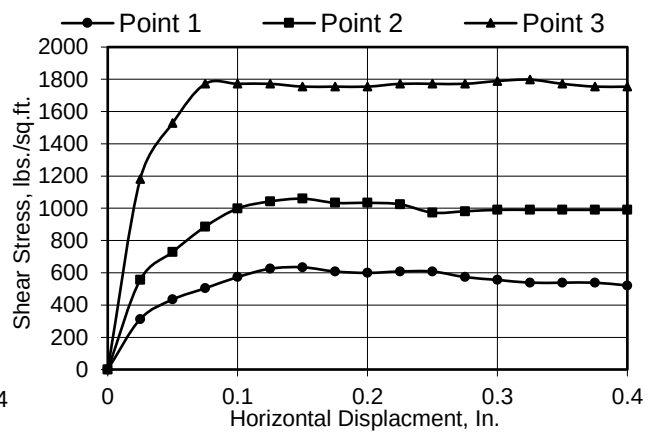
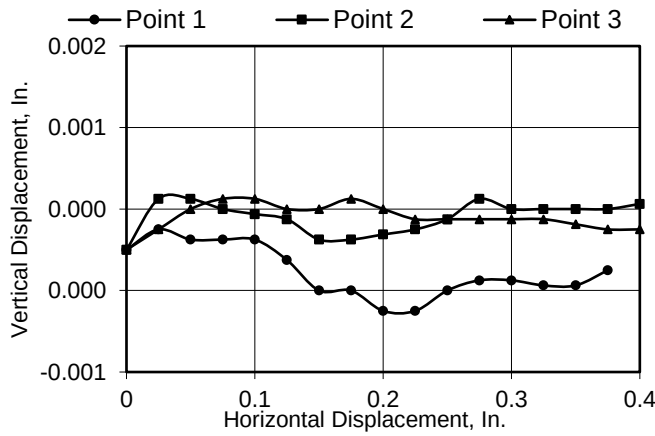
GESTRA Engineering, Inc

191 W. Edgerton Ave

Milwaukee, WI 53207

Phone: (414) 933-7444; Fax: (414) 933-7844

Project Name: Milwaukee County Bluffs	Point No.: 1	2	3
Project No.: 24354-40	Stress (PSI): 5	10	20
Project Location: Milwaukee, WI	Initial Moisture: 17.7%	17.7%	17.7%
Client: GZA	Final Moisture: 15.2%	14.6%	14.3%
GZA #: 20.0158819.00	Initial Dry Density: 97.9 pcf	97.5 pcf	97.8 pcf
Date Tested: 10/28/2024	Final Dry Density: 100.1 pcf	100.2 pcf	100.7 pcf
Sample Boring: BAYVIEW SB-01	Initial Height: 1.0"	1.0"	1.0"
Sample Number: ST-9	Strain Rate: 1.1 percent/min.		
Description: Silt, gray, moist, stiff.			



Remarks:

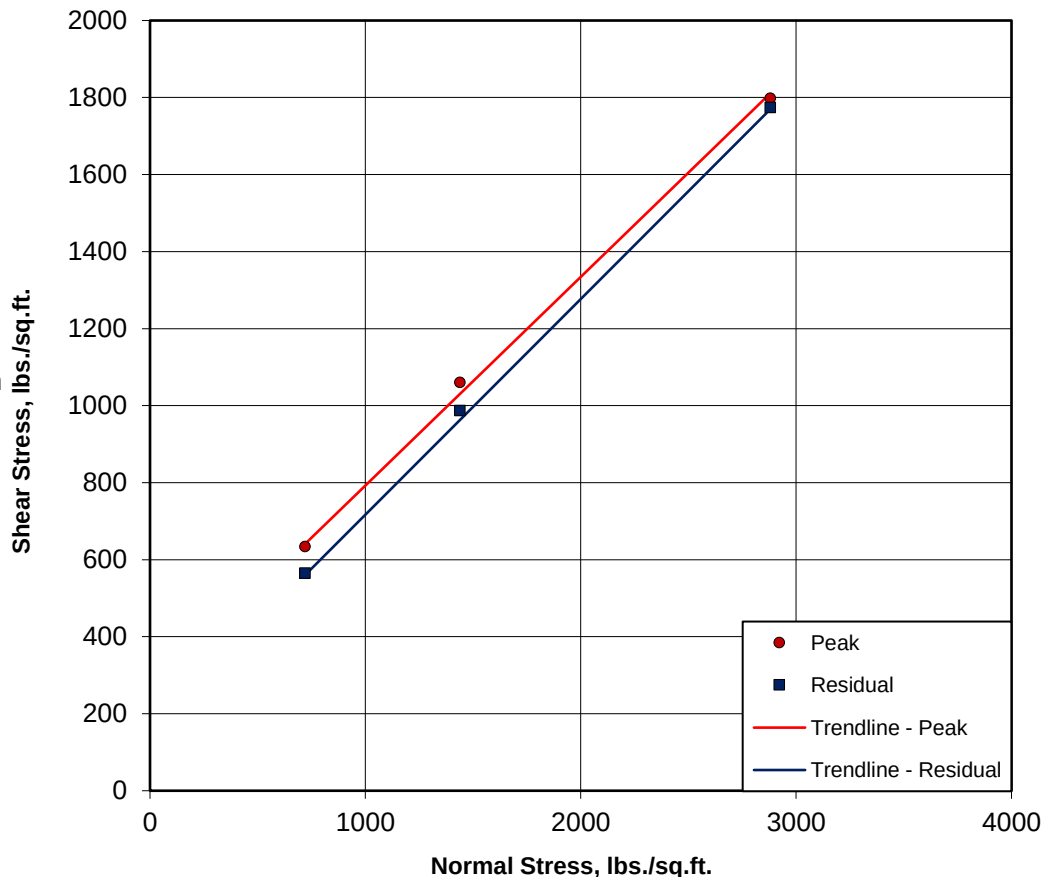
Portion of sample retained on No. 10 sieve was removed.

Sample was nominally compacted and allowed to consolidate under normal load.

Sample was tested in saturated condition.

Angle of Internal Friction:

$\phi = 28.4^\circ$ (residual)
 29.2° (peak)



Performed By: S. McLafferty

Reviewed By: Nicole Merkes



GESTRA Engineering, Inc

191 W. Edgerton Ave

Milwaukee, WI 53207

Phone: (414) 933-7444; Fax: (414) 933-7844

Laboratory Test Results of Moisture Content, Organic Content, and Density of Soil

Project Name: Milwaukee County Bluffs
Project Number: 24354-40
Project Location: Milwaukee, WI
ASTM Designation: D2216, D2974 (Method A), D7263

Date: October 28, 2024
Report To: GZA
GZA # 20.0158819.00

Boring Number	BAYVIEW SB-01									
Sample Number	ST-9									
Cup Number										
Weight of Cup (g)	26.52									
Weight of Wet Soil and Cup (g)	66.54									
Weight of Dry Soil and Cup (g)	60.71									
Weight of Soil and Cup After Burn (g)										
Weight of Sample for Density (lbs)	2.8795									
Diameter (in)	2.851									
Length(in)	5.602									
Moisture Content (%)	17.1									
Organic Content (%)										
Wet Density (pcf)	139.1									
Dry Density (pcf)	118.9									

*Dry Density preformed in place of consolidated undrained test to get density for direct shear.

Boring Number										
Sample Number										
Cup Number										
Weight of Cup (g)										
Weight of Wet Soil and Cup (g)										
Weight of Dry Soil and Cup (g)										
Weight of Soil and Cup After Burn (g)										
Weight of Sample for Density (lbs)										
Diameter (in)										
Length(in)										
Moisture Content (%)										
Organic Content (%)										
Wet Density (pcf)										
Dry Density (pcf)										

Performed by S. McLafferty

Reviewed by Nicole Merkes



GESTRA Engineering, Inc

191 W. Edgerton Ave

Milwaukee, WI 53207

Phone: (414) 933-7444; Fax: (414) 933-7844

Shelby Tube Extraction Form

Project Name:	<u>Milwaukee County Bluffs</u>	Date:	<u>October 28, 2024</u>
Project Number:	<u>24354-40</u>	Client:	<u>GZA</u>
Projection Location:	<u>Milwaukee, WI</u>	GZA #:	<u>20.0158819.00</u>
ASTM Designation:	<u>D2488</u>		

Sample Information

Boring Number	<u>BAYVIEW SB-01</u>	
Sample Number	<u>ST-9</u>	qp: 1.5
Depth of Sample	<u>20'-22'</u>	

Recovery: 16" (bottom 1" remain in damaged portion of shelby tube)

Soil Description:

Top 1.5": Slough (silty clay, brown, moist).

Bottom 14.5": Silt, gray, moist (to wet at bottom of shelby tube sample), stiff.



BOTTOM

TOP

Preformed By: S. McLafferty

Reviewed By: Nicole Merkes



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Client:
GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:
8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Number: 14594

Sample Date: 10/25/2024

Sampled By: Client

Field ID: BAYVIEW SB-01, ST-11, 26-28'

Specimen Information

Specimen ID: BAYVIEW SB-01, ST-11, 26-28

Specimen Size: Tube

Test Result

Closure Drops	Water Content	Liquid Limit
22	28.6	28
28	26.8	27
32	26.2	27

Water Content at 25 Drops: 27.8

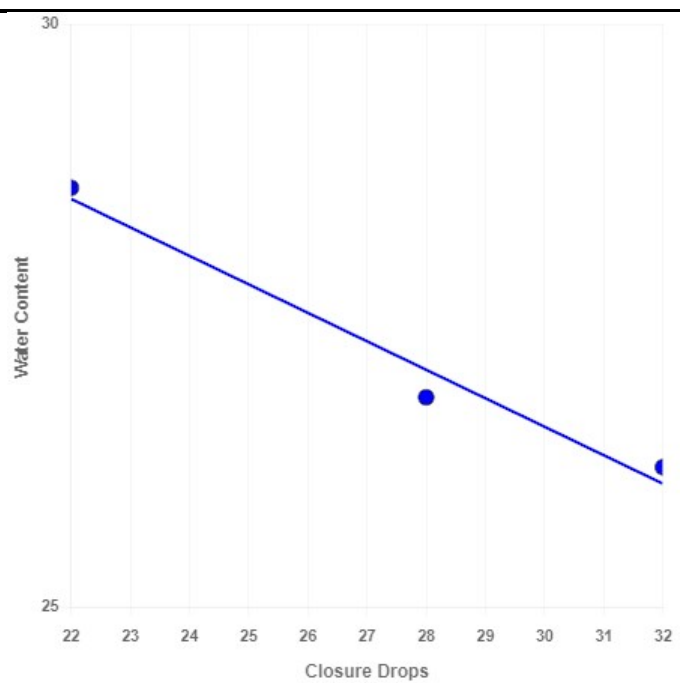
Liquid Limit: 28

Trial 1
Plastic
Limit: 13

Trial 2
Plastic
Limit: 13

Plastic
Limit: 13

Plasticity Index: 15



Test Completed Date: 12/03/2024

Lab Technician: Rebecca Walker



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Material Finer than 200 Sieve

D1140 / T88

Report #: MFS-000009-00

Client:

GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:

8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date:	10/25/2024	Sampled By:	Client
Sample No:	14594	Field ID:	BAYVIEW SB-1, ST-11, 26-28'

Specimen Information

Specimen ID: BAYVIEW SB-1, ST-11, 26-28	Specimen Size: Tube
--	----------------------------

Test Results

Percentage for Material Finer Than 75 μm (No. 200) Sieve:	84.9
Test Completed Date:	12/02/2024
Test Completed By:	Sara Prichard Branta



191 W. Edgerton Ave
Milwaukee, WI 53207
(414)933-7444

Report On: Test Report Attachment

Lab No: 24-14380

Report No: 24-14380

Project No: 24354-40

Cust No: 0109

Page 1 of 17

Client: GZA GeoEnvironmental
Mr Ian Mosbrucker
17975 West Sarah Lane
Suite 100
Brookfield, WI 53045

Project: Milwaukee County Bluffs

Location:

Report Date: 11/08/2024

Sample Date: 10/28/2024

Sampled By: Client

Remarks: See attached for Milwaukee County Bluffs test results.

Orig: GZA GeoEnvironmental Attn: Mr Ian Mosbrucker
(1-ec copy)
1-cc Laboratory

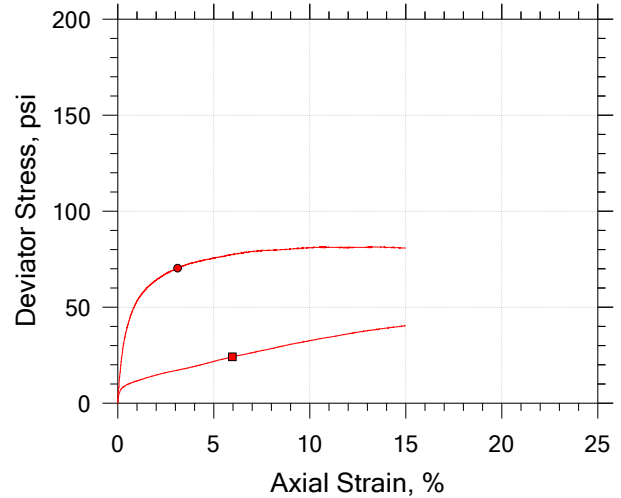
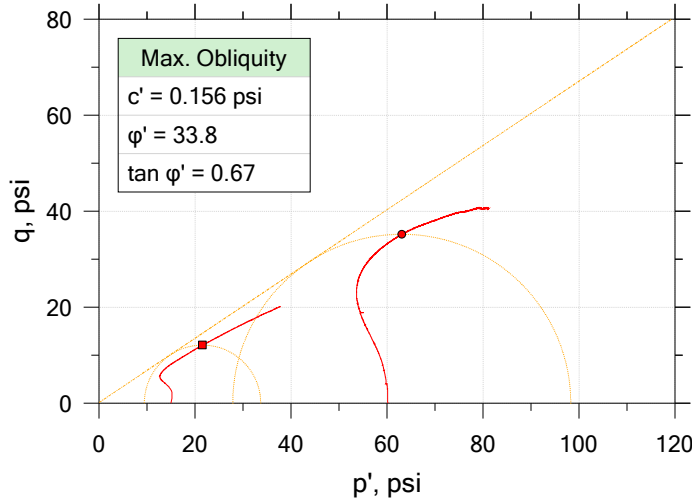
Respectfully Submitted,

Shane Savin, P.E., CMT Department Manager

THIS REPORT APPLIES ONLY TO THE STANDARDS OR PROCEDURES INDICATED AND TO THE SAMPLE(S) TESTED AND/OR OBSERVED AND ARE NOT NECESSARILY INDICATIVE OF THE QUALITIES OF APPARENTLY IDENTICAL OR SIMILAR PRODUCTS OR PROCEDURES, NOR DO THEY REPRESENT AN ONGOING QUALITY ASSURANCE PROGRAM UNLESS SO NOTED. THESE REPORTS ARE FOR THE EXCLUSIVE USE OF THE ADDRESSED CLIENT AND ARE NOT TO BE REPRODUCED WITHOUT WRITTEN PERMISSION.

REPORT CREATED BY ElmTree SYSTEM

Consolidated Undrained by ASTM D4767



Symbol	■	●		
Sample ID	ST-18	ST-18		
Depth	56'-58'	56'-58'		
Test Number	1	2		
Initial				
Height, in	5.684	5.706		
Diameter, in	2.828	2.862		
Moisture Content (from Cuttings), %	12.1	11.9		
Dry Density, pcf	123.	128.		
Saturation (Wet Method), %	87.3	103.0		
Void Ratio	0.375	0.311		
Final				
Moisture Content, %	12.6	10.8		
Dry Density, pcf	126.	130.		
Cross-Sectional Area (Method A), in ²	6.176	6.359		
Saturation, %	100.0	100.0		
Void Ratio	0.341	0.288		
Back Pressure, psi	169.0	168.8		
Vertical Effective Consolidation Stress, psi	14.98	60.17		
Horizontal Effective Consolidation Stress, psi	15.00	60.23		
Vertical Strain after Consolidation, %	0.3982	0.7261		
Volumetric Strain after Consolidation, %	1.159	2.235		
Time to 50% Consolidation, min	0.000	0.000		
Shear Strength, psi	12.12	35.22		
Strain at Failure, %	5.97	3.11		
Strain Rate, %/min	0.01670	0.01670		
Deviator Stress at Failure, psi	24.24	70.43		
Effective Minor Principal Stress at Failure, psi	9.432	27.85		
Effective Major Principal Stress at Failure, psi	33.67	98.29		
B-Value	0.91	0.91		

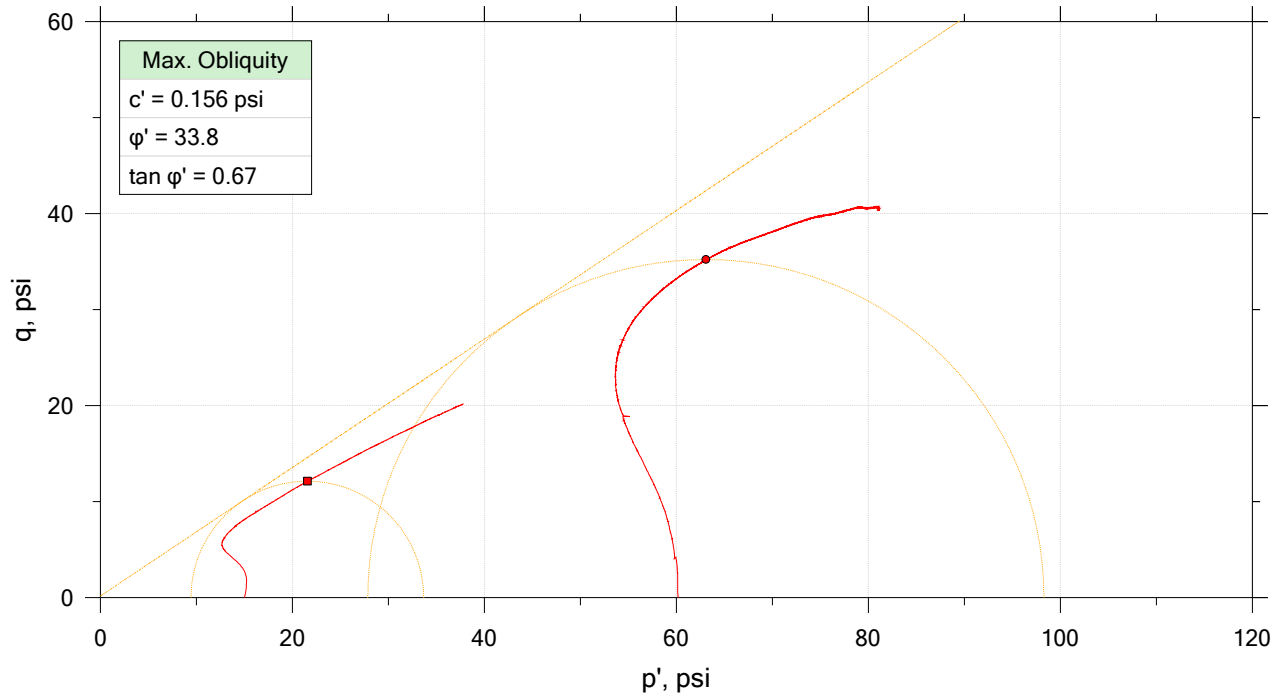
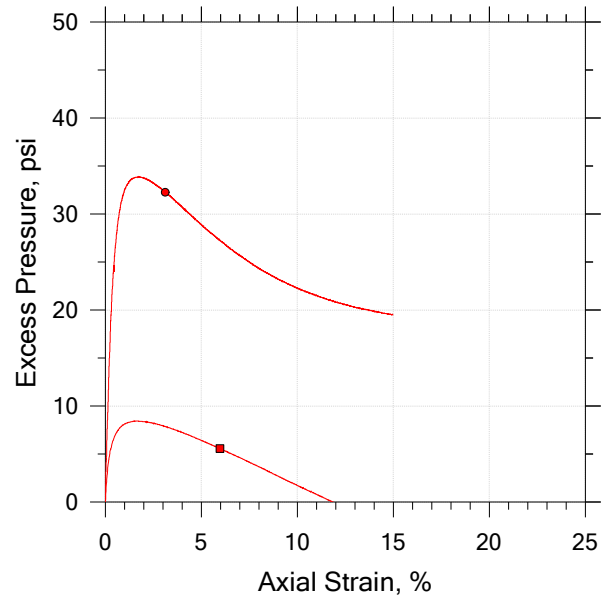
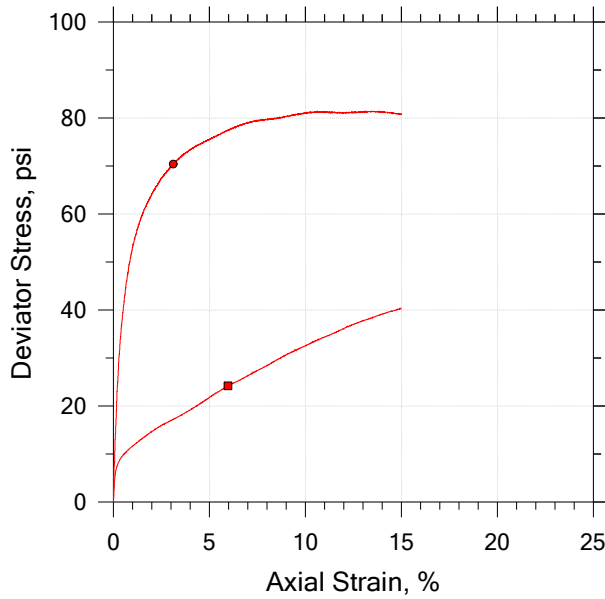
Notes:

- Before Shear Saturation set to 100% for phase calculation.
 - Moisture Content determined by ASTM D2216.
 - Deviator Stress includes membrane correction.
 - Values for c and ϕ determined from best-fit straight line for the specific test conditions.
- Actual strength parameters may vary and should be determined by an engineer for site conditions.



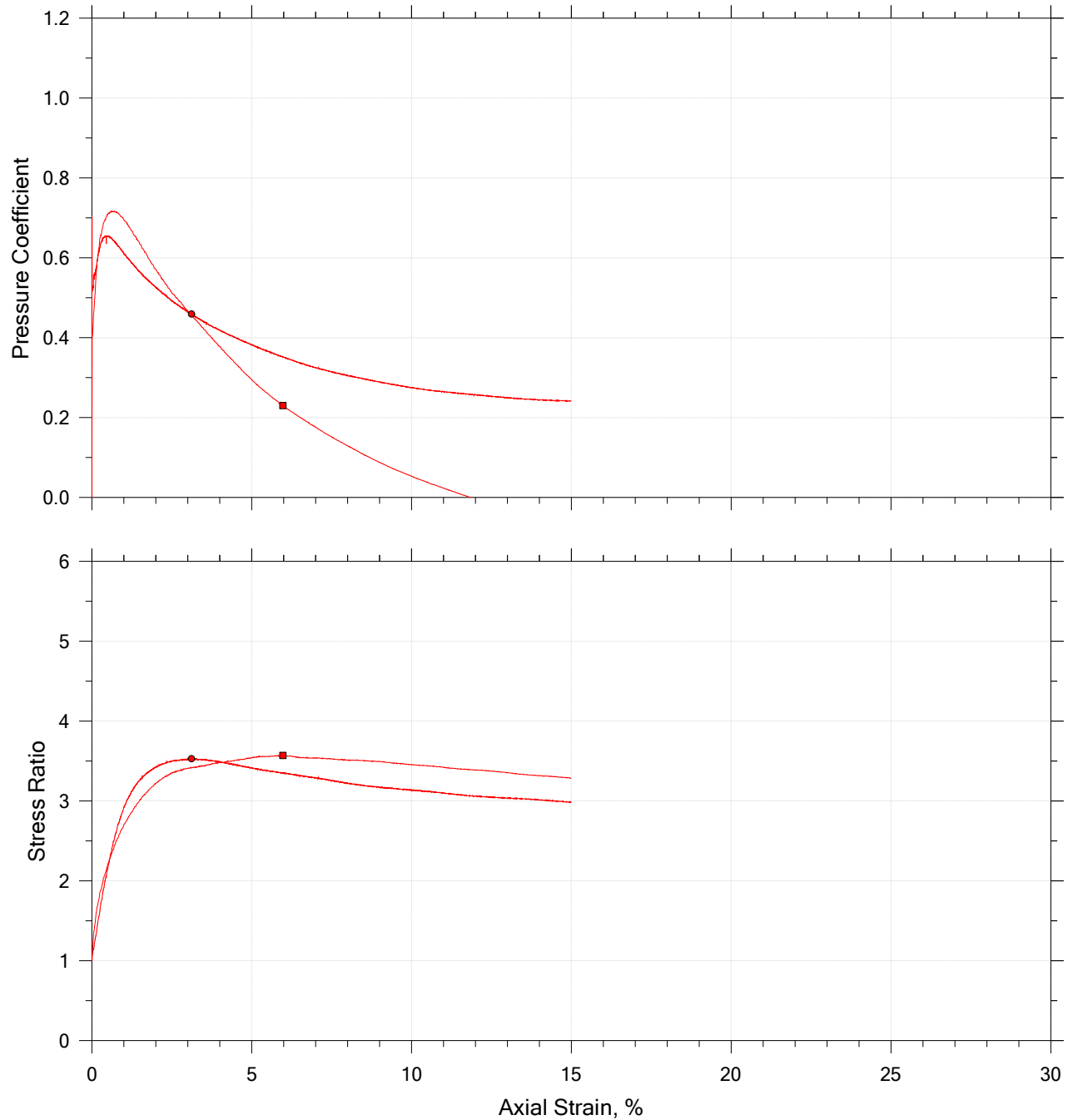
	Project Name: Milwaukee County Bluff	Location: Milwaukee, WI	Project Number: 24354-40
	Boring Number: BAYVIEW SB-01	Tester: S. McLafferty	Checker: N. Merkes
	Sample Number: ST-18	Test Date: 10-31-2024	Depth: 56'-58'
	Test Number: 1	Preparation: Shelby Tube	Elevation:
	Client: GZA	Classification:	Group Symbol:
	Description: Lean clay, gray, most, very stiff, trace sand and gravel. Sand lamination present 2.5" from bottom on first point.		
	Remarks:		

Consolidated Undrained by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	ST-18	1	56'-58'	S. McLafferty	10-31-2024	N. Merkes	11-8-2024	BAYVIEW SB-01, ST-18, 15psi.dat
●	ST-18	2	56'-58'	S. McLafferty	11-4-2024	N. Merkes	11-8-2024	BAYVIEW SB-01, ST-18, 60psi.dat
	Project Name: Milwaukee County Bluff			Location: Milwaukee, WI			Project Number: 24354-40	
	Boring Number: BAYVIEW SB-01			Tester: S. McLafferty			Checker: N. Merkes	
	Sample Number: ST-18			Test Date: 10-31-2024			Depth: 56'-58'	
	Test Number: 1			Preparation: Shelby Tube			Elevation:	
	Client: GZA			Classification:			Group Symbol:	
	Description: Lean clay, gray, most, very stiff, trace sand and gravel. Sand lamination present 2.5" from bottom on first point.							
	Remarks:							

Consolidated Undrained by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	ST-18	1	56'-58'	S. McLafferty	10-31-2024	N. Merkes	11-8-2024	BAYVIEW SB-01, ST-18, 15psi.dat
●	ST-18	2	56'-58'	S. McLafferty	11-4-2024	N. Merkes	11-8-2024	BAYVIEW SB-01, ST-18, 60psi.dat

	Project Name: Milwaukee County Bluff		Location: Milwaukee, WI		Project Number: 24354-40	
	Boring Number: BAYVIEW SB-01		Tester: S. McLafferty		Checker: N. Merkes	
	Sample Number: ST-18		Test Date: 10-31-2024		Depth: 56'-58'	
	Test Number: 1		Preparation: Shelby Tube		Elevation:	
	Client: GZA		Classification:		Group Symbol:	
	Description: Lean clay, gray, most, very stiff, trace sand and gravel. Sand lamination present 2.5" from bottom on first point.					
	Remarks:					



GESTRA Engineering, Inc

191 W. Edgerton Ave

Milwaukee, WI 53207

Phone: (414) 933-7444; Fax: (414) 933-7844

Shelby Tube Extraction Form

Project Name:	<u>Milwaukee County Bluffs</u>	Date:	<u>October 29, 2024</u>
Project Number:	<u>24354-40</u>	Client:	<u>GZA</u>
Projection Location:	<u>Milwaukee, WI</u>	GZA #:	<u>20.0158819.00</u>
ASTM Designation:	<u>D2488</u>		

Sample Information

Boring Number	<u>BAYVIEW SB-01</u>	
Sample Number	<u>ST-18</u>	qp: 3.5
Depth of Sample	<u>56'-58'</u>	

Recovery: 24" (bottom 8.5" remain in damaged portion of shelby tube)

Soil Description: Lean clay, gray, moist, very stiff, trace sand and gravel, sand laminations.



BOTTOM

TOP

Preformed By: S. McLafferty

Reviewed By: Nicole Merkes



Laboratory Test Results of Atterberg Limits of Soil

Project Name:	Milwaukee County Bluffs	Date:	October 31, 2024
Project Number:	24354-40	Client:	GZA
Project Location:	Milwaukee, WI	GZA #:	20.0158819.00
ASTM Designation:	D4318 (Method A)		

Sample Information

Type of Sample	Shelby Tube
Boring Number	BAYVIEW SB-01
Sample Number	18
Depth of Sample	56'-58'

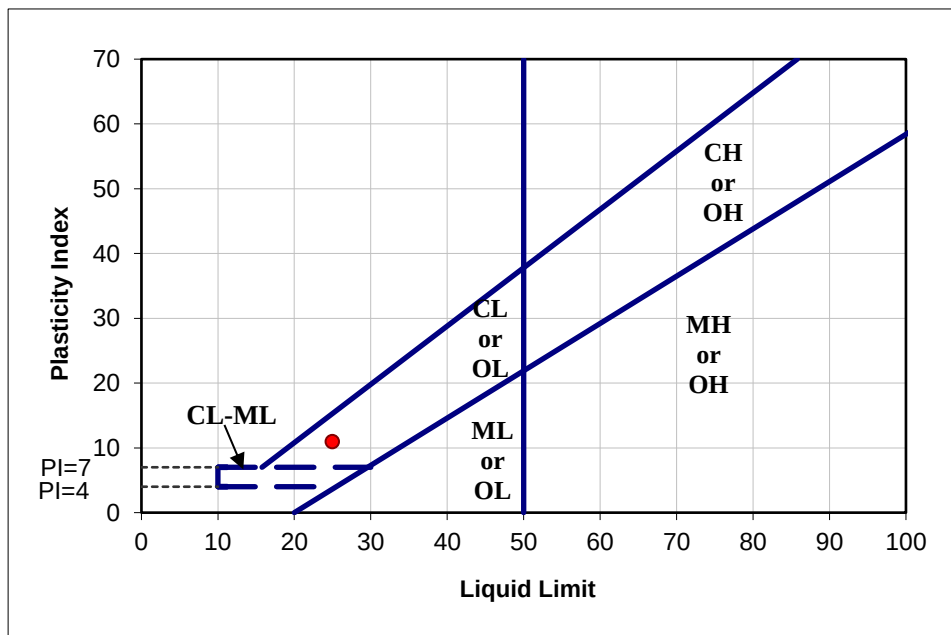
Determination of Liquid Limit

Cup Number			
Weight of Cup (g)	18.74	18.85	18.63
Weight of Wet Soil and Cup (g)	38.41	40.67	39.72
Weight of Dry Soil and Cup (g)	34.55	36.35	35.35
Moisture Content (%)	24.4	24.7	26.1
Blow Counts	30	24	19

Determination of Plastic Limit

Cup Number		
Weight of Cup (g)	7.15	7.25
Weight of Wet Soil and Cup (g)	13.41	13.44
Weight of Dry Soil and Cup (g)	12.65	12.67
Moisture Content (%)	13.8	14.2

Compilation of Test Results



Liquid Limit	25
Plastic Limit	14
Plasticity Index	11
USCS Symbol	CL

Performed by: B BillsReviewed By: Nicole Merkes

GESTRA Engineering, Inc.



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Unit Weight of Soil

ASTM D7263

Report #: UWS-1-000003-00

Client:

GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:

8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date:	10/25/2024	Sample No:	14595
Technician:	Client	Field ID:	SHERIDAN-SB-02, ST-8, 18-20'

Specimen Information

Specimen ID: SHERIDAN-SB-02, ST-8, 18-20'	Specimen Size: Tube
--	----------------------------

Test Results

Method B - Tube

Moist / Total Unit Weight (lb/ft ³)	Dry Unit Weight (lb/ft ³)	Water Content (%)
138.7	120.1	15.5
Visual Description:	brown Clay, trace sand and gravel	Sample Type: Intact
Test Date:	11/25/2024	Lab Technician: Craig Englund

Sara Prichard Branta

Sara Prichard Branta, Staff Engineer
Dec 02, 2024



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Client:
GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:
8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Number: 14595

Sample Date: 10/25/2024

Sampled By: Client

Field ID: SHERIDAN-SB-02, ST-8, 18-20'

Specimen Information

Specimen ID: SHERIDAN-SB-02 ST-8, 18-20'

Specimen Size: Tube

Test Result

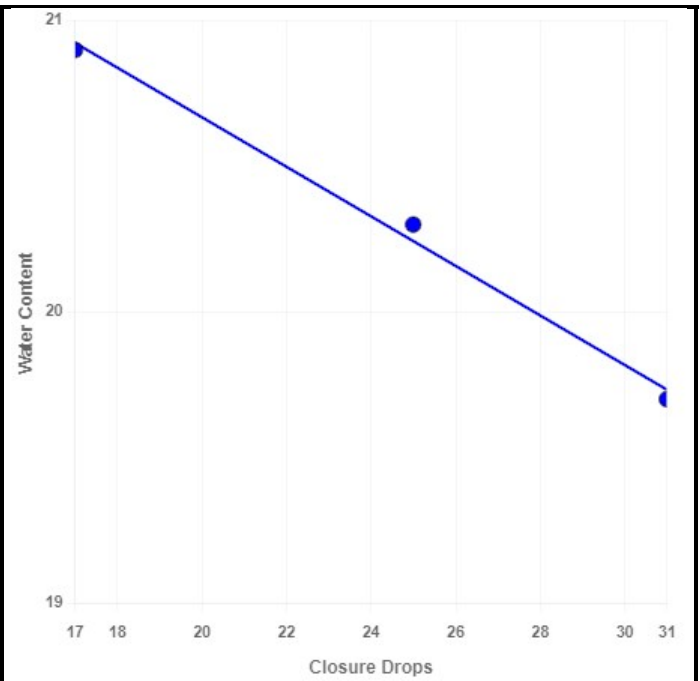
Closure Drops	Water Content	Liquid Limit
17	20.9	20
25	20.3	20
31	19.7	20

Water Content at 25 Drops: 20.2

Liquid Limit: 20

Trial 1 Plastic Limit:	13	Trial 2 Plastic Limit:	14	Plastic Limit:	14
------------------------------	----	------------------------------	----	-------------------	----

Plasticity Index: 6



Test Completed Date: 12/03/2024

Lab Technician: Rebecca Walker



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Material Finer than 200 Sieve

D1140 / T88

Report #: MFS-000010-00

Client:

GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:

8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date:	10/25/2024	Sampled By:	Client
Sample No:	14595	Field ID:	SHERIDAN-SB-02, ST-8, 18-20'

Specimen Information

Specimen ID: SHERIDAN-SB-02 ST-8, 18-20'	Specimen Size: Tube
---	----------------------------

Test Results

Percentage for Material Finer Than 75 µm (No. 200) Sieve:		87.6
Test Completed Date:	12/02/2024	Test Completed By: Sara Prichard Branta



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Material Finer than 200 Sieve

D1140 / T88

Report #: MFS-000001-00

Client:

GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:

8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date:	10/25/2024	Sampled By:	Client
Sample No:	14596	Field ID:	SHERIDAN-SB-02 ST-13, 43.5-45'

Specimen Information

Specimen ID: SHERIDAN-SB-02 ST-13, 43.5-45'	Specimen Size: Jar
--	---------------------------

Test Results

% Moisture Content of Test Sample:		18.1	
Percentage for Material Finer Than 75 µm (No. 200) Sieve:		88.2	
Test Completed Date:		11/19/2024	Test Completed By:
			Sara Prichard Branta



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Material Finer than 200 Sieve

D1140 / T88

Report #: MFS-000002-00

Client:

GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:

8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date:	10/25/2024	Sampled By:	Client
Sample No:	14597	Field ID:	SHERIDAN-SB-02, S-17, 61-62.5'

Specimen Information

Specimen ID: SHERIDAN-SB-02, S-17, 61-62.5'	Specimen Size: Jar
--	---------------------------

Test Results

% Moisture Content of Test Sample:		15.0	
Percentage for Material Finer Than 75 μm (No. 200) Sieve:		89.4	
Test Completed Date:		11/19/2024	Test Completed By:
			Sara Prichard Branta



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Client:
GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:
8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Number: 14597

Sample Date: 10/25/2024

Sampled By: Client

Field ID: SHERIDAN-SB-02, S-17, 61-62.5'

Specimen Information

Specimen ID: SHERIDAN-SB-02, S-17, 61-62.5'

Specimen Size: Jar

Test Result

Closure Drops	Water Content	Liquid Limit
20	35.2	34
27	33.1	33
32	32.3	33

Water Content at 25 Drops: 33.9

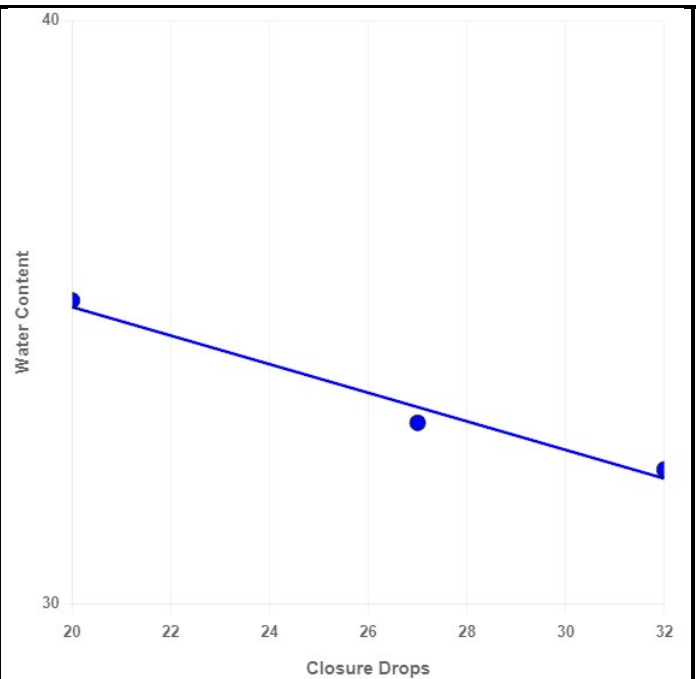
Liquid Limit: 34

Trial 1
Plastic
Limit: 16

Trial 2
Plastic
Limit: 15

Plastic
Limit: 16

Plasticity Index: 18



Test Completed Date: 11/21/2024

Lab Technician: Rebecca Walker



Sieve Analysis Report

ASTM C136 & C117

Report #: MFC136-000001-00

West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Client:
GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:
8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date: 10/25/2024
Sample No: 14598
Sampled By: Client
Field ID: SHERIDAN-SB-02, S-21, 78.5-80'
Soil Boring

Application:

Specimen Information

Specimen ID: SHERIDAN-SB-02, S-21, 78.5-80'

Sieve Graph:

Sieve Analysis Data - ASTM C136

Sieve Size	% Passing
No 20 (850 µm)	100.0
No 40 (425 µm)	99.9
No 60 (250 µm)	89.1
No 100 (150 µm)	21.6
No 140 (106 µm)	11.1
No 200 (75 µm)	7.9

Lab Technician: Hitendra Soni

Test Date: 11/18/2024



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Material Finer than 200 Sieve

D1140 / T88

Report #: MFS-000003-00

Client:

GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:

8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date:	10/25/2024	Sampled By:	Client
Sample No:	14599	Field ID:	SHERIDAN-SB-03, S-3, 6-7.5'

Specimen Information

Specimen ID: SHERIDAN-SB-03 S-3, 6-7.5'	Specimen Size: Jar
--	---------------------------

Test Results

% Moisture Content of Test Sample:		12.8	
Percentage for Material Finer Than 75 µm (No. 200) Sieve:		72.8	
Test Completed Date:		11/19/2024	Test Completed By:
			Sara Prichard Branta



GESTRA Engineering, Inc

191 W. Edgerton Ave

Milwaukee, WI 53207

Phone: (414) 933-7444; Fax: (414) 933-7844

Shelby Tube Extraction Form

Project Name:	<u>Milwaukee County Bluffs</u>	Date:	<u>November 25, 2024</u>
Project Number:	<u>24354-40</u>	Client:	<u>GZA</u>
Projection Location:	<u>Milwaukee, WI</u>	GZA #:	<u>20.0158819.00</u>
ASTM Designation:	<u>D2488</u>		

Sample Information

Boring Number	<u>SHERIDAN-SB-03</u>	
Sample Number	<u>ST-6</u>	qp: 3.0
Depth of Sample	<u>14'-16'</u>	

Recovery: 25"

Soil Description: Lean clay, gray, moist, very stiff, trace sand and gravel.

Top 3": Slough (sandy lean clay, brown, moist).



BOTTOM

TOP

Preformed By: S. McLafferty

Reviewed By: Nicole Merkes



Laboratory Test Results of Atterberg Limits of Soil

Project Name: Milwaukee County Bluffs Date: November 26, 2024
Project Number: 24354-40 Client: GZA
Project Location: Milwaukee, WI GZA #: 20.0158819.00
ASTM Designation: D4318 (Method A)

Sample Information

Type of Sample Shelby Tube
Boring Number SHERIDAN-SB-03
Sample Number 6
Depth of Sample 14'-16'

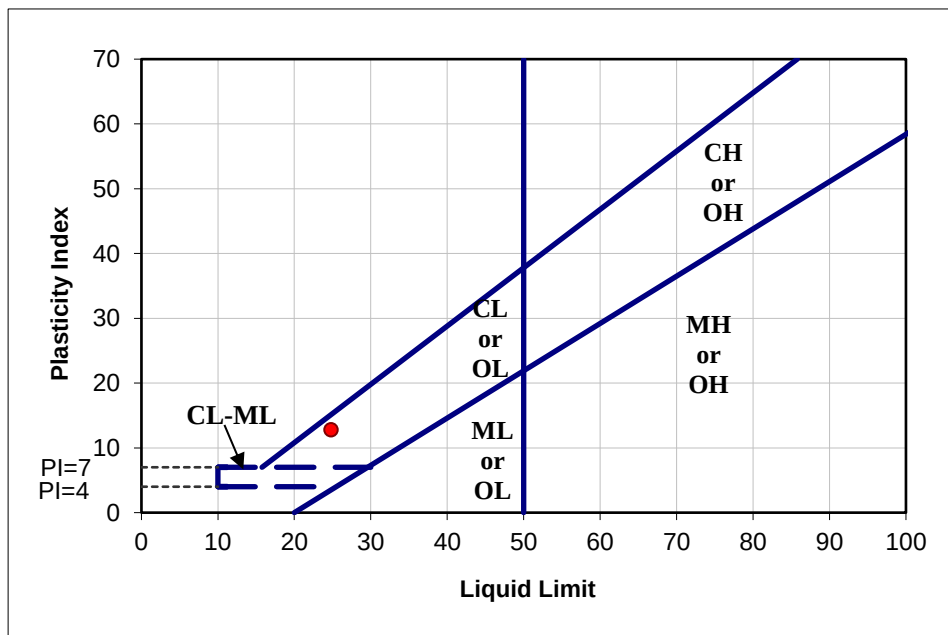
Determination of Liquid Limit

Cup Number			
Weight of Cup (g)	20.52	24.23	24.33
Weight of Wet Soil and Cup (g)	39.25	46.19	47.36
Weight of Dry Soil and Cup (g)	35.61	41.81	42.70
Moisture Content (%)	24.1	24.9	25.4
Blow Counts	35	22	17

Determination of Plastic Limit

Cup Number		
Weight of Cup (g)	7.44	7.19
Weight of Wet Soil and Cup (g)	12.36	15.57
Weight of Dry Soil and Cup (g)	11.83	14.65
Moisture Content (%)	12.1	12.3

Compilation of Test Results



Liquid Limit	<u>25</u>
Plastic Limit	<u>12</u>
Plasticity Index	<u>13</u>
USCS Symbol	<u>CL</u>

Performed by: T Stevens

Reviewed By: Nicole Merkes

GESTRA Engineering, Inc.



Sieve Analysis Report
ASTM C136 & C117

Report #: MFC136-000002-00

West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Client:
GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:
8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date: 10/25/2024
Sample No: 14600
Sampled By: Client
Field ID: SHERIDAN-SB-03, S-12, 38.5-40'
Soil Boring

Application:

Specimen Information

Specimen ID: SHERIDAN-SB-03, S-12, 38.5-40'

Sieve Graph:

Sieve Analysis Data - ASTM C136

Sieve Size	% Passing
3/4 in (19 mm)	100.0
3/8 in (9.5 mm)	99.5
No 4 (4.75 mm)	97.8
No 10 (2 mm)	91.4
No 20 (850 µm)	82.1
No 40 (425 µm)	65.2
No 60 (250 µm)	31.1
No 100 (150 µm)	9.1
No 140 (106 µm)	7.4
No 200 (75 µm)	5.8

Lab Technician: Craig Englund

Test Date: 11/08/2024



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Material Finer than 200 Sieve

D1140 / T88

Report #: MFS-000004-00

Client:

GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:

8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date:	10/25/2024	Sampled By:	Client
Sample No:	14601	Field ID:	SHERIDAN-SB-03, S-17, 63.5-65'

Specimen Information

Specimen ID: SHERIDAN-SB-03, S-17, 63.5-65'	Specimen Size: Jar
---	--------------------

Test Results

% Moisture Content of Test Sample:		21.5	
Percentage for Material Finer Than 75 µm (No. 200) Sieve:		99.9	
Test Completed Date:		11/19/2024	Test Completed By:
			Sara Prichard Branta



Sieve Analysis Report

ASTM C136 & C117

Report #: MFC136-000003-00

West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Client:
GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:
8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date: 10/25/2024
Sample No: 14602
Sampled By: Client
Field ID: SHERIDAN-SB-03, S-22, 88.5-90'
Soil Boring

Application:

Specimen Information

Specimen ID: SHERIDAN-SB-03, S-22, 88.5-90'

Sieve Graph:

Sieve Analysis Data - ASTM C136

Sieve Size	% Passing
No 4 (4.75 mm)	100.0
No 10 (2 mm)	99.8
No 20 (850 µm)	98.9
No 40 (425 µm)	92.6
No 60 (250 µm)	71.4
No 100 (150 µm)	22.4
No 140 (106 µm)	10.6
No 200 (75 µm)	6.5

Lab Technician: Hitendra Soni

Test Date: 11/18/2024



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Client:
GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:
8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Number: 14601

Sample Date: 10/25/2024

Sampled By: Client

Field ID: SHERIDAN-SB-03, S-17, 63.5-65'

Specimen Information

Specimen ID: SHERIDAN-SB-03, S-17, 63.5-65'

Specimen Size: Jar

Test Result

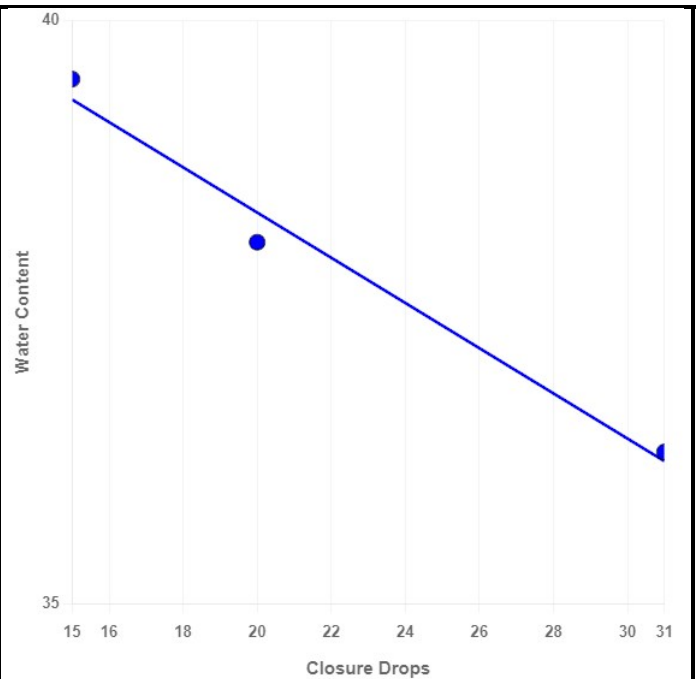
Closure Drops	Water Content	Liquid Limit
15	39.5	37
20	38.1	37
31	36.3	37

Water Content at 25 Drops: 37.4

Liquid Limit: 37

Trial 1 Plastic Limit:	21	Trial 2 Plastic Limit:	21	Plastic Limit:	21
------------------------------	----	------------------------------	----	-------------------	----

Plasticity Index: 16



Test Completed Date: 11/21/2024

Lab Technician: Hitendra Soni



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Client:
GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:
8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Number: 14599

Sample Date: 10/25/2024

Sampled By: Client

Field ID: SHERIDAN-SB-03, S-3, 6-7.5'

Specimen Information

Specimen ID: SHERIDAN-SB-03, S-3, 6-7.5'

Specimen Size: Jar

Test Result

Closure Drops	Water Content	Liquid Limit
17	21.4	20
24	20.3	20
29	19.9	20

Water Content at 25 Drops: 20.3

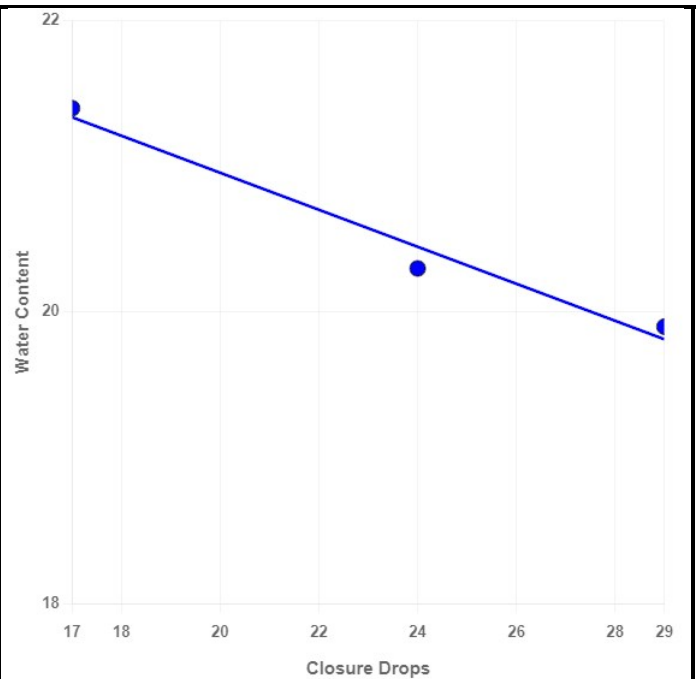
Liquid Limit: 20

Trial 1
Plastic
Limit: 14

Trial 2
Plastic
Limit: 14

Plastic
Limit: 14

Plasticity Index: 6



Test Completed Date: 11/21/2024

Lab Technician: Rebecca Walker



191 W. Edgerton Ave
Milwaukee, WI 53207
(414)933-7444

Report On: Test Report Attachment

Lab No: 24-14707

Report No: 24-14707

Project No: 24354-40

Cust No: 0109

Page 1 of 10

Client: GZA GeoEnvironmental
Mr Ian Mosbrucker
17975 West Sarah Lane
Suite 100
Brookfield, WI 53045

Project: Milwaukee County Bluffs
GZA #: 20.0158819.00

Location:

Report Date: 12/05/2024

Sample Date: 12/04/2024

Sampled By: Client

Remarks: See attached for lab results for SHERIDAN-SB-03, ST-6

Orig: GZA GeoEnvironmental Attn: Mr Ian Mosbrucker
(1-ec copy)
1-cc Laboratory

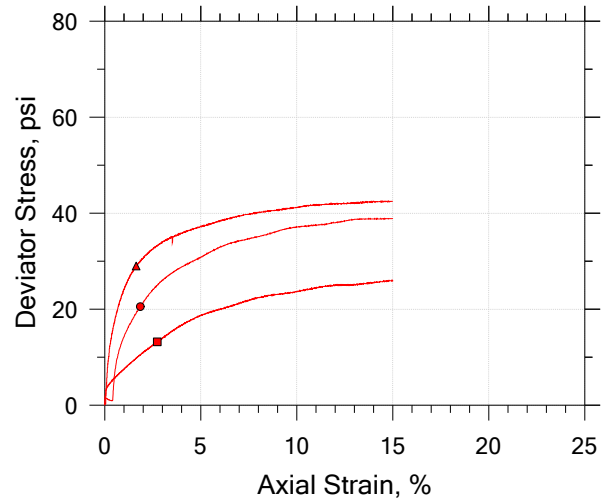
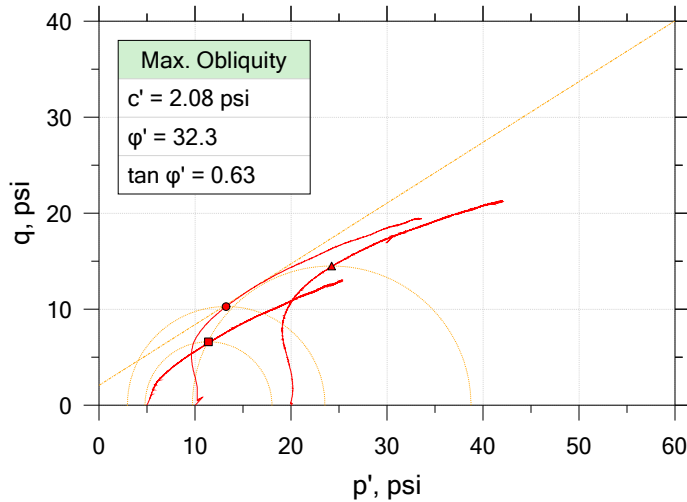
Respectfully Submitted,

Nicole Merkes,

THIS REPORT APPLIES ONLY TO THE STANDARDS OR PROCEDURES INDICATED AND TO THE SAMPLE(S) TESTED AND/OR OBSERVED AND ARE NOT NECESSARILY INDICATIVE OF THE QUALITIES OF APPARENTLY IDENTICAL OR SIMILAR PRODUCTS OR PROCEDURES, NOR DO THEY REPRESENT AN ONGOING QUALITY ASSURANCE PROGRAM UNLESS SO NOTED. THESE REPORTS ARE FOR THE EXCLUSIVE USE OF THE ADDRESSED CLIENT AND ARE NOT TO BE REPRODUCED WITHOUT WRITTEN PERMISSION.

REPORT CREATED BY ElmTree SYSTEM

Consolidated Undrained by ASTM D4767



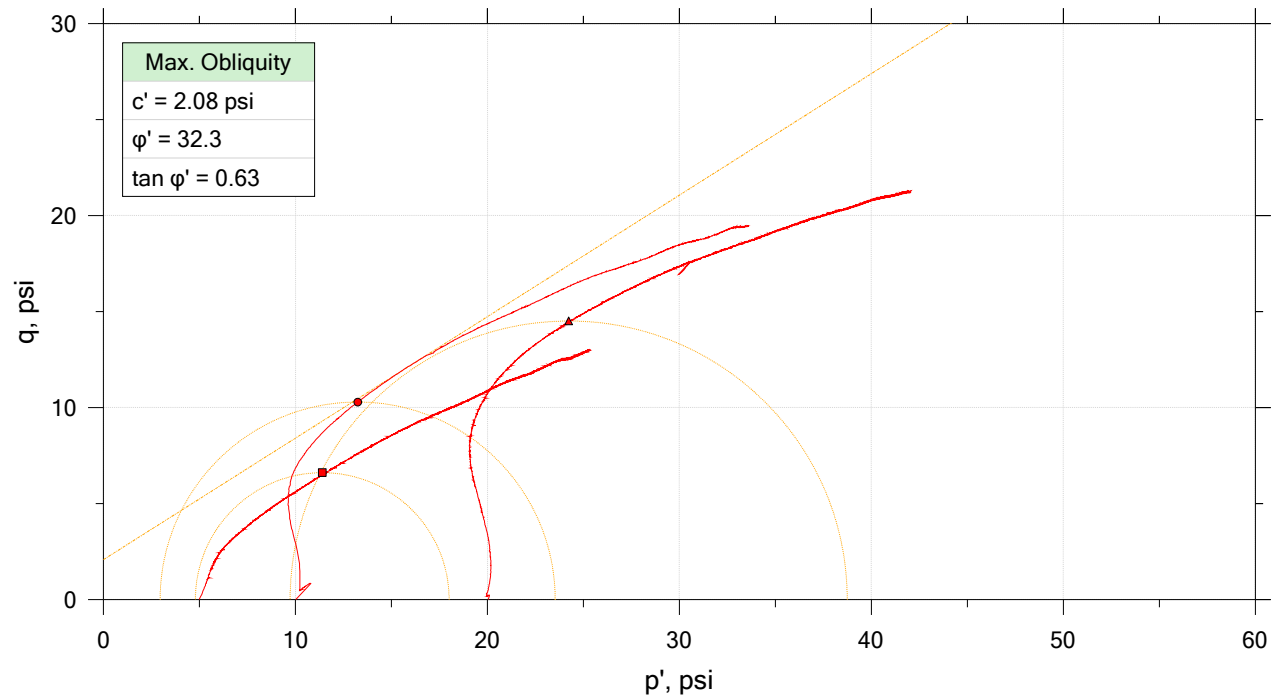
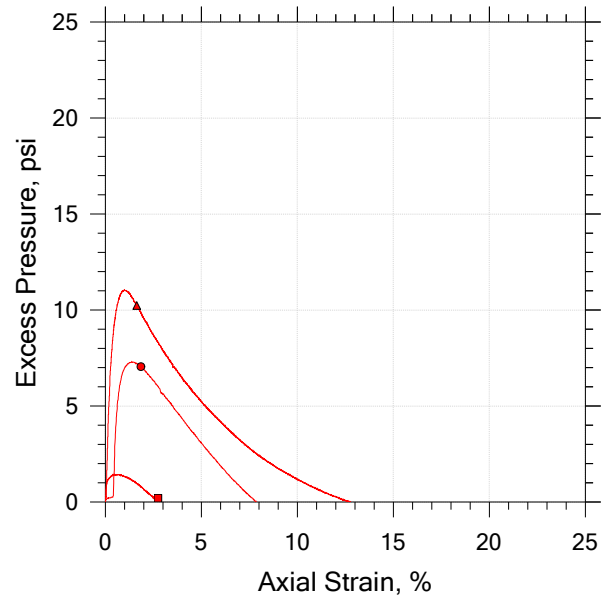
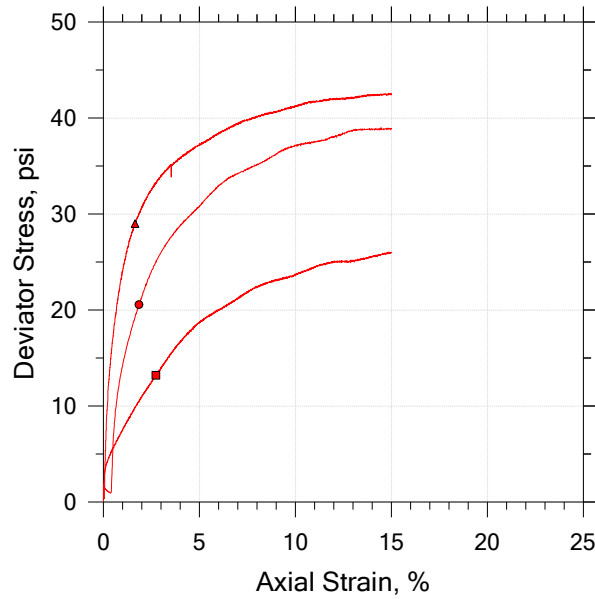
Symbol	■	●	▲	
Sample ID	ST-6	ST-6	ST-6	
Depth	14'-16'	14'-16'	14'-16'	
Test Number	1	2	3	
Initial				
Height, in	5.699	5.686	5.673	
Diameter, in	2.857	2.848	2.865	
Moisture Content (from Cuttings), %	14.2	13.4	13.6	
Dry Density, pcf	124.	127.	125.	
Saturation (Wet Method), %	107.2	112.1	105.9	
Void Ratio	0.357	0.322	0.345	
Final				
Moisture Content, %	12.7	11.4	12.5	
Dry Density, pcf	126.	129.	126.	
Cross-Sectional Area (Method A), in ²	6.361	6.317	6.413	
Saturation, %	100.0	100.0	100.0	
Void Ratio	0.342	0.309	0.337	
Back Pressure, psi	106.0	169.0	168.9	
Vertical Effective Consolidation Stress, psi	4.983	10.02	20.02	
Horizontal Effective Consolidation Stress, psi	4.994	10.01	20.05	
Vertical Strain after Consolidation, %	0.06354	-0.004261	0.3075	
Volumetric Strain after Consolidation, %	0.2580	0.4677	1.153	
Time to 50% Consolidation, min	0.000	0.000	0.000	
Shear Strength, psi	6.608	10.29	14.51	
Strain at Failure, %	2.73	1.85	1.64	
Strain Rate, %/min	0.01670	0.01670	0.01670	
Deviator Stress at Failure, psi	13.22	20.58	29.01	
Effective Minor Principal Stress at Failure, psi	4.788	2.954	9.727	
Effective Major Principal Stress at Failure, psi	18.00	23.53	38.74	
B-Value	0.95	0.89	0.91	

Notes:
 - Before Shear Saturation set to 100% for phase calculation.
 - Moisture Content determined by ASTM D2216.
 - Atterberg Limits determined by ASTM D4318.
 - Deviator Stress includes membrane correction.
 - Values for c and ϕ determined from best-fit straight line for the specific test conditions.
 Actual strength parameters may vary and should be determined by an engineer for site conditions.



	Project Name: Milwaukee County Bluffs	Location: Milwaukee, WI	Project Number: 24354-40
	Boring Number: SHERIDAN-SB-03	Tester: S. McLafferty	Checker: N. Merkes
	Sample Number: ST-6	Test Date: 11/25/24	Depth: 14'-16'
	Test Number: 1	Preparation: Shelby Tube	Elevation:
	Client: GZA	Classification:	Group Symbol:
	Description: Lean clay, gray, moist, very stiff, trace sand and gravel.		
	Remarks:		

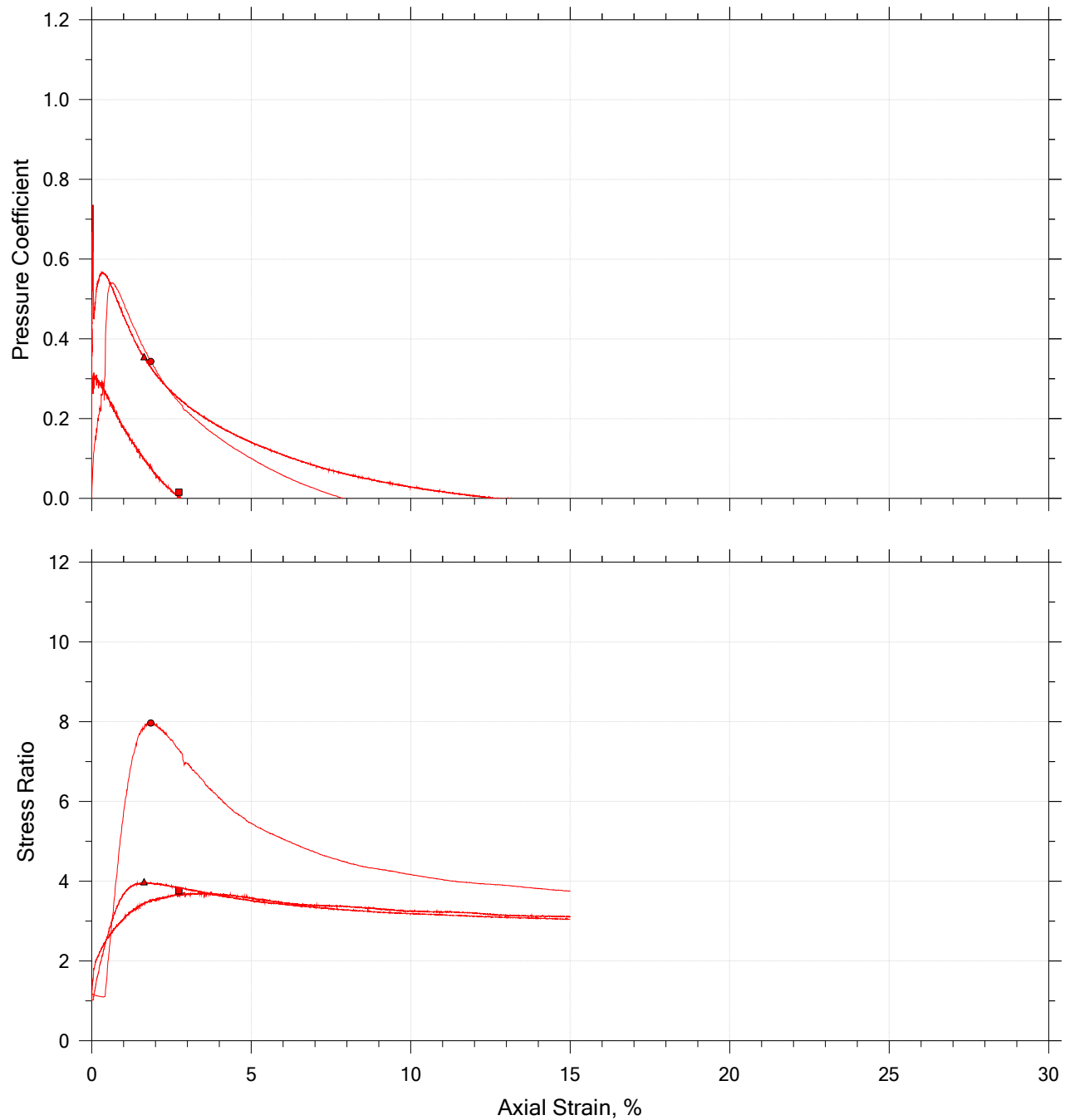
Consolidated Undrained by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	ST-6	1	14'-16'	S. McLafferty	11/25/24	N. Merkes	12/5/24	SHERIDAN-SB-03, ST-6, 5 PSI.dat
●	ST-6	2	14'-16'	S. McLafferty	11/15/24	N. Merkes	12/5/24	SHERIDAN-SB-03, ST-6, 10 PSI.dat
▲	ST-6	3	14'-16'	S. McLafferty	12/2/2024	N. Merkes	12/5/24	SHERIDAN-SB-03, ST-6, 20 PSI.dat

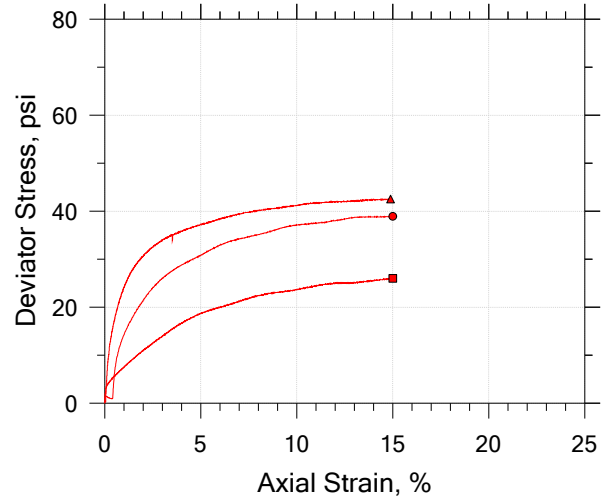
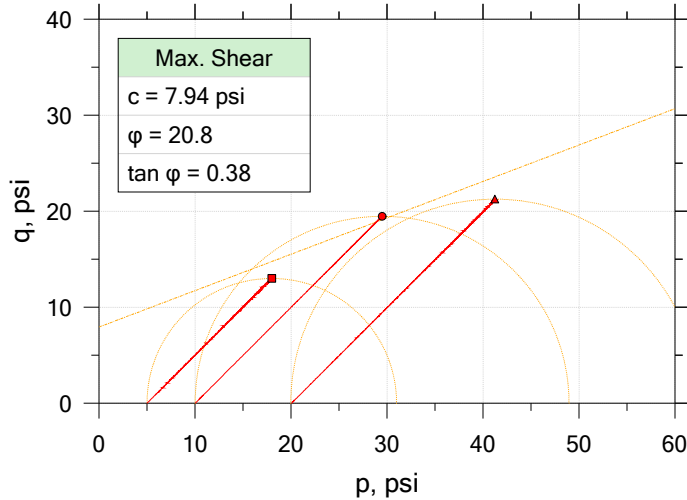
	Project Name: Milwaukee County Bluffs	Location: Milwaukee, WI	Project Number: 24354-40
	Boring Number: SHERIDAN-SB-03	Tester: S. McLafferty	Checker: N. Merkes
	Sample Number: ST-6	Test Date: 11/25/24	Depth: 14'-16'
	Test Number: 1	Preparation: Shelby Tube	Elevation:
	Client: GZA	Classification:	Group Symbol:
	Description: Lean clay, gray, moist, very stiff, trace sand and gravel.		
	Remarks:		

Consolidated Undrained by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	ST-6	1	14'-16'	S. McLafferty	11/25/24	N. Merkes	12/5/24	SHERIDAN-SB-03, ST-6, 5 PSI.dat
●	ST-6	2	14'-16'	S. McLafferty	11/15/24	N. Merkes	12/5/24	SHERIDAN-SB-03, ST-6, 10 PSI.dat
▲	ST-6	3	14'-16'	S. McLafferty	12/2/2024	N. Merkes	12/5/24	SHERIDAN-SB-03, ST-6, 20 PSI.dat
	Project Name: Milwaukee County Bluffs			Location: Milwaukee, WI			Project Number: 24354-40	
	Boring Number: SHERIDAN-SB-03			Tester: S. McLafferty			Checker: N. Merkes	
	Sample Number: ST-6			Test Date: 11/25/24			Depth: 14'-16'	
	Test Number: 1			Preparation: Shelby Tube			Elevation:	
	Client: GZA			Classification:			Group Symbol:	
	Description: Lean clay, gray, moist, very stiff, trace sand and gravel.							
	Remarks:							

Consolidated Undrained by ASTM D4767



Symbol	■	●	▲	
Sample ID	ST-6	ST-6	ST-6	
Depth	14'-16'	14'-16'	14'-16'	
Test Number	1	2	3	
Initial				
Height, in	5.699	5.686	5.673	
Diameter, in	2.857	2.848	2.865	
Moisture Content (from Cuttings), %	14.2	13.4	13.6	
Dry Density, pcf	124.	127.	125.	
Saturation (Wet Method), %	107.2	112.1	105.9	
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Final				
Moisture Content, %	12.7	11.4	12.5	
Dry Density, pcf	126.	129.	126.	
Cross-Sectional Area (Method A), in ²	6.361	6.317	6.413	
Saturation, %	100.0	100.0	100.0	
Void Ratio	0.342	0.309	0.337	
Back Pressure, psi	106.0	169.0	168.9	
Vertical Effective Consolidation Stress, psi	4.983	10.02	20.02	
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Vertical Strain after Consolidation, %	0.06354	-0.004261	0.3075	
Volumetric Strain after Consolidation, %	0.2580	0.4677	1.153	
Time to 50% Consolidation, min	0.000	0.000	0.000	
Shear Strength, psi	13.00	19.47	21.26	
Strain at Failure, %	15.0	15.0	14.9	
Strain Rate, %/min	0.01670	0.01670	0.01670	
Deviator Stress at Failure, psi	26.00	38.95	42.52	
Effective Minor Principal Stress at Failure, psi	12.32	14.13	20.66	
Effective Major Principal Stress at Failure, psi	38.32	53.08	63.19	
B-Value	0.95	0.89	0.91	

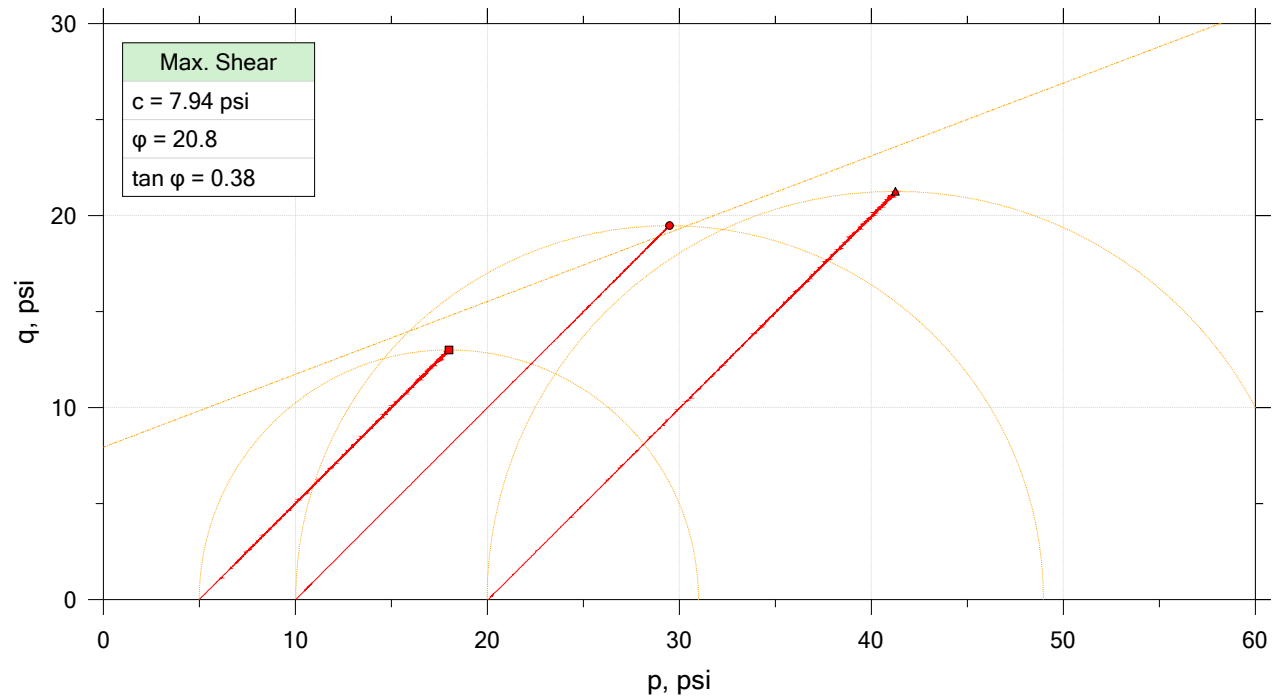
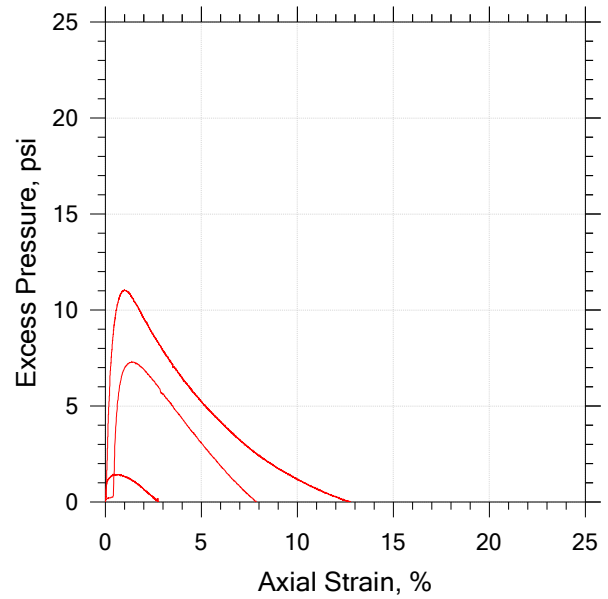
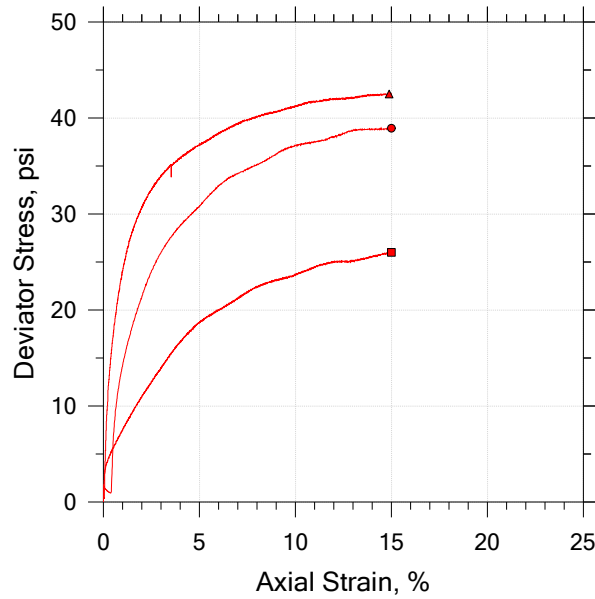
Notes:

- Before Shear Saturation set to 100% for phase calculation.
 - Moisture Content determined by ASTM D2216.
 - Atterberg Limits determined by ASTM D4318.
 - Deviator Stress includes membrane correction.
 - Values for c and ϕ determined from best-fit straight line for the specific test conditions.
- Actual strength parameters may vary and should be determined by an engineer for site conditions.



	Project Name: Milwaukee County Bluffs	Location: Milwaukee, WI	Project Number: 24354-40
	Boring Number: SHERIDAN-SB-03	Tester: S. McLafferty	Checker: N. Merkes
	Sample Number: ST-6	Test Date: 11/25/24	Depth: 14'-16'
	Test Number: 1	Preparation: Shelby Tube	Elevation:
	Client: GZA	Classification:	Group Symbol:
	Description: Lean clay, gray, moist, very stiff, trace sand and gravel.		
	Remarks:		

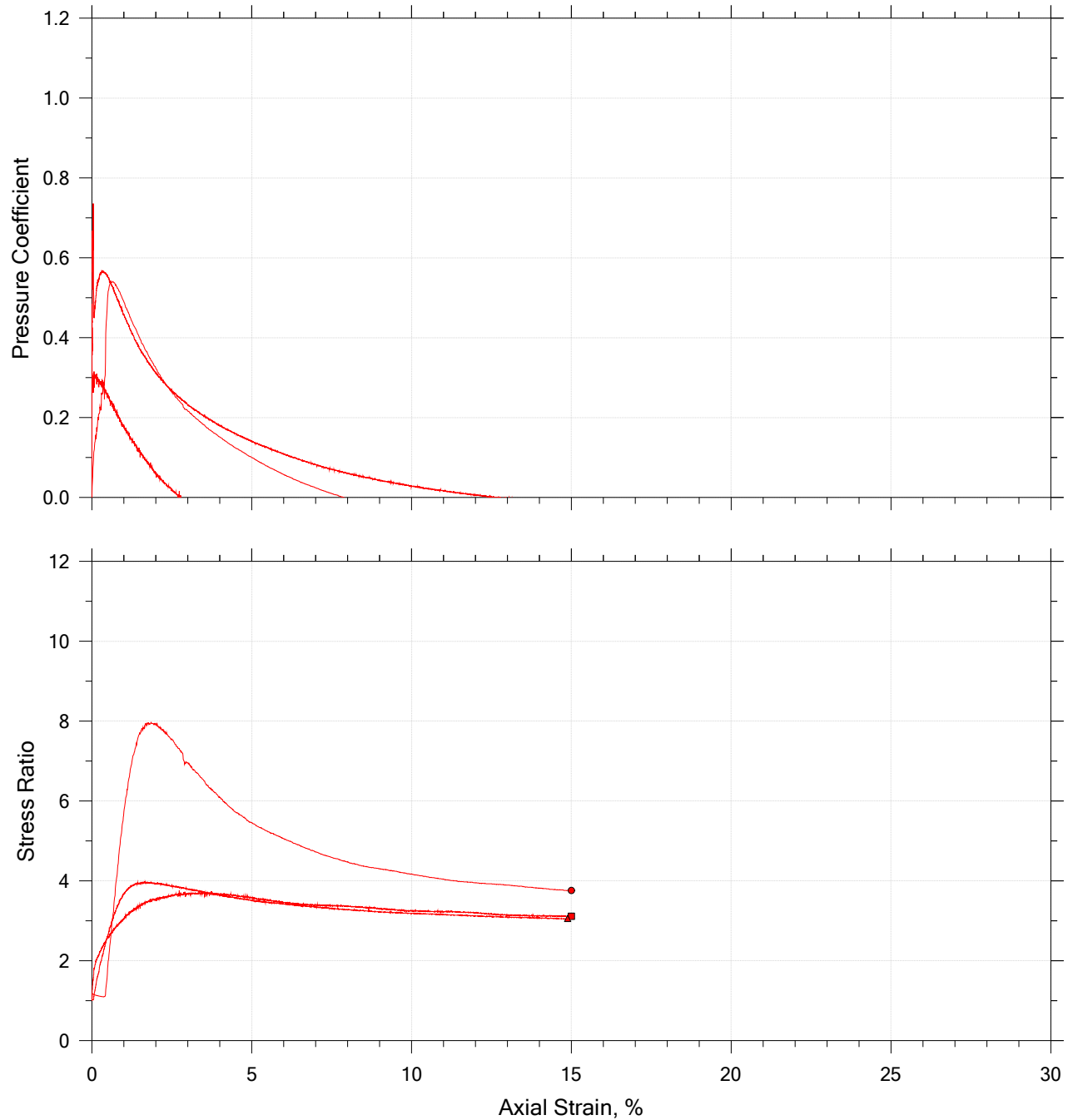
Consolidated Undrained by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	ST-6	1	14'-16'	S. McLafferty	11/25/24	N. Merkes	12/5/24	SHERIDAN-SB-03, ST-6, 5 PSI.dat
●	ST-6	2	14'-16'	S. McLafferty	11/15/24	N. Merkes	12/5/24	SHERIDAN-SB-03, ST-6, 10 PSI.dat
▲	ST-6	3	14'-16'	S. McLafferty	12/2/2024	N. Merkes	12/5/24	SHERIDAN-SB-03, ST-6, 20 PSI.dat

	Project Name: Milwaukee County Bluffs	Location: Milwaukee, WI	Project Number: 24354-40
	Boring Number: SHERIDAN-SB-03	Tester: S. McLafferty	Checker: N. Merkes
	Sample Number: ST-6	Test Date: 11/25/24	Depth: 14'-16'
	Test Number: 1	Preparation: Shelby Tube	Elevation:
	Client: GZA	Classification:	Group Symbol:
	Description: Lean clay, gray, moist, very stiff, trace sand and gravel.		
	Remarks:		

Consolidated Undrained by ASTM D4767



	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
■	ST-6	1	14'-16'	S. McLafferty	11/25/24	N. Merkes	12/5/24	SHERIDAN-SB-03, ST-6, 5 PSI.dat
●	ST-6	2	14'-16'	S. McLafferty	11/15/24	N. Merkes	12/5/24	SHERIDAN-SB-03, ST-6, 10 PSI.dat
▲	ST-6	3	14'-16'	S. McLafferty	12/2/2024	N. Merkes	12/5/24	SHERIDAN-SB-03, ST-6, 20 PSI.dat
	Project Name: Milwaukee County Bluffs			Location: Milwaukee, WI			Project Number: 24354-40	
	Boring Number: SHERIDAN-SB-03			Tester: S. McLafferty			Checker: N. Merkes	
	Sample Number: ST-6			Test Date: 11/25/24			Depth: 14'-16'	
	Test Number: 1			Preparation: Shelby Tube			Elevation:	
	Client: GZA			Classification:			Group Symbol:	
	Description: Lean clay, gray, moist, very stiff, trace sand and gravel.							
	Remarks:							



GESTRA Engineering, Inc.

191 W. Edgerton Ave

Milwaukee, WI 53207

Phone: (414) 933-7444; Fax: (414) 933-7844

**Laboratory Test Results of
Amount of Soil finer than #200 Sieve**

Project Name: Milwaukee County Bluffs
Project Number: 24354-40
Project Location: Milwaukee, WI
ASTM Designation: D1140

Date: November 25, 2024
Report To: GZA
GZA #: 20.0158819.00

Boring Number	SHERIDAN-SB-03							
Sample Number	ST-6							
Soak Time (to the nearest 10 min.)	300							
Weight of Pan (g)	71.9							
Weight of Wet Soil and Pan (g)	622.4							
Weight of Wet Soil (g)	550.4							
Weight of Dry Soil and Pan (g)	555.8							
Weight of Dry Soil (g)	483.9							
Weight of Soil and Pan after Wash (g)	184.5							
Weight of Soil after Wash (g)	112.6							
Percentage of Material Passing #200 (%)	76.7							
Moisture Content (%)	13.8							

Boring Number								
Sample Number								
Soak Time (to the nearest 10 min.)								
Weight of Pan (g)								
Weight of Wet Soil and Pan (g)								
Weight of Wet Soil (g)								
Weight of Dry Soil and Pan (g)								
Weight of Dry Soil (g)								
Weight of Soil and Pan after Wash (g)								
Weight of Soil after Wash (g)								
Percentage of Material Passing #200 (%)								
Moisture Content (%)								

Performed by: SM/ C. Schneider

Reviewed by: Nicole Merkes

Geotechnical-Structural-Pavement-Construction Material



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Material Finer than 200 Sieve

D1140 / T88

Report #: MFS-000005-00

Client:

GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:

8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date:	10/25/2024	Sampled By:	Client
Sample No:	14603	Field ID:	WARNIMONT-SB-04 S-4, 8.5-10'

Specimen Information

Specimen ID: WARNIMONT-SB-04, S-4, 8.5-10'	Specimen Size: Jar
---	---------------------------

Test Results

% Moisture Content of Test Sample:		12.6	
Percentage for Material Finer Than 75 µm (No. 200) Sieve:		83.5	
Test Completed Date:		11/19/2024	Test Completed By:
			Sara Prichard Branta



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Material Finer than 200 Sieve

D1140 / T88

Report #: MFS-000006-00

Client:

GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:

8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date:	10/25/2024	Sampled By:	Client
Sample No:	14605	Field ID:	WARNIMONT-SB-04, S-12, 38.5-40'

Specimen Information

Specimen ID: WARNIMONT-SB-04, S-12, 38.5-40'	Specimen Size: Jar
---	---------------------------

Test Results

% Moisture Content of Test Sample:	18.5
Percentage for Material Finer Than 75 µm (No. 200) Sieve:	95.1
Test Completed Date:	11/19/2024
Test Completed By:	Sara Prichard Branta



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Material Finer than 200 Sieve

D1140 / T88

Report #: MFS-000007-00

Client:

GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:

8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date:	10/25/2024	Sampled By:	Client
Sample No:	14606	Field ID:	WARNIMONT-SB-04, S-20, 73.5-75'

Specimen Information

Specimen ID: WARNIMONT-SB-04, S-20, 73.5-75'	Specimen Size: Jar
---	---------------------------

Test Results

% Moisture Content of Test Sample:		11.4	
Percentage for Material Finer Than 75 µm (No. 200) Sieve:		67.8	
Test Completed Date:		11/19/2024	Test Completed By:
			Sara Prichard Branta



Sieve Analysis Report
ASTM C136 & C117

Report #: MFC136-000004-00

West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Client:
GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:
8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Date: 10/25/2024
Sample No: 14604
Sampled By: Client
Field ID: WARNIMONT-SB-04, S-9, 23.5-25'
Soil Boring

Application:

Specimen Information

Specimen ID: WARNIMONT-SB-04, S-9, 23.5-25'

Sieve Graph:

Sieve Analysis Data - ASTM C136

Sieve Size	% Passing
3/8 in (9.5 mm)	100.0
No 4 (4.75 mm)	99.9
No 10 (2 mm)	99.5
No 20 (850 µm)	99.2
No 40 (425 µm)	97.8
No 60 (250 µm)	79.4
No 100 (150 µm)	57.5
No 140 (106 µm)	54.3
No 200 (75 µm)	53.0

Lab Technician: Craig Englund

Test Date: 11/08/2024



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Client:
GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:
8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Number: 14606

Sample Date: 10/25/2024

Sampled By: Client

Field ID: WARNIMONT-SB-04, S-20, 73.5-75'

Specimen Information

Specimen ID: WARNIMONT-SB-04, S-20, 73.5-75'

Specimen Size: Jar

Test Result

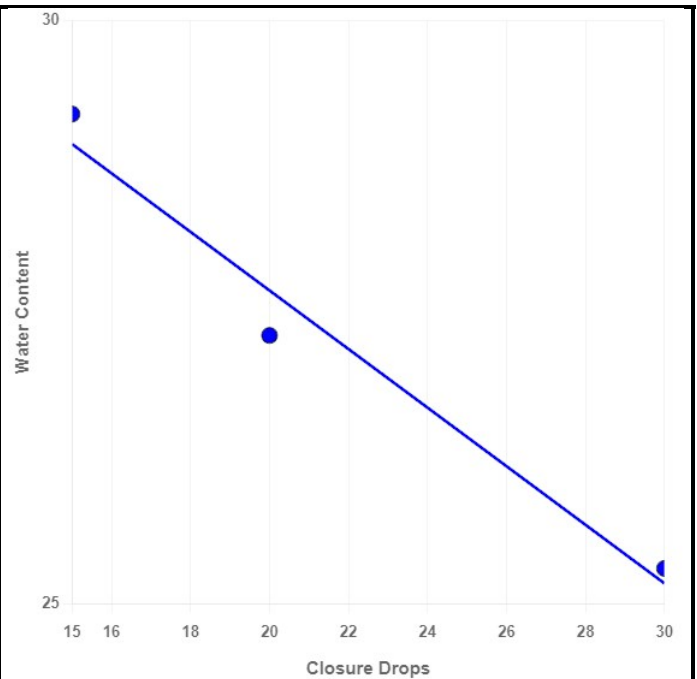
Closure Drops	Water Content	Liquid Limit
15	29.2	27
20	27.3	27
30	25.3	26

Water Content at 25 Drops: 26.4

Liquid Limit: 26

Trial 1 Plastic Limit:	17	Trial 2 Plastic Limit:	18	Plastic Limit:	18
------------------------------	----	------------------------------	----	-------------------	----

Plasticity Index: 8



Test Completed Date: 11/21/2024

Lab Technician: Hitendra Soni



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

LL PL and PI of Soil

D4318 / T89 & T90

Report #: LIM-000005-00

Client:
GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:
8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Number: 14605

Sample Date: 10/25/2024

Sampled By: Client

Field ID: WARNIMONT-SB-04, S-12, 38.5-40'

Specimen Information

Specimen ID: WARNIMONT-SB-04, S-12, 38.5-40'

Specimen Size: Jar

Test Result

Liquid Limit: Non-Plastic

Plastic Limit: Non-Plastic

Plasticity Index: Non-Plastic

Test Completed Date: 11/22/2024

Lab Technician: Rebecca Walker



West Allis
2135 S. 116th Street
West Allis, WI 53227
Phone: 888-436-8378
Fax: 414-321-8359

Client:
GZA Geoenvironmental
17975 West Sarah Lane
Brookfield, WI 53045

Project:
8415 (20.0158819.00)
MKE County Bluffs
MKE
Milwaukee, WI

Sample Information

Sample Number: 14603

Sample Date: 10/25/2024

Sampled By: Client

Field ID: WARNIMONT-SB-04, S-4, 8.5-10'

Specimen Information

Specimen ID: WARNIMONT-SB-04, S-4, 8.5-10'

Specimen Size: Jar

Test Result

Closure Drops	Water Content	Liquid Limit
20	26.4	26
27	25.3	26
33	24.7	26

Water Content at 25 Drops: 25.7

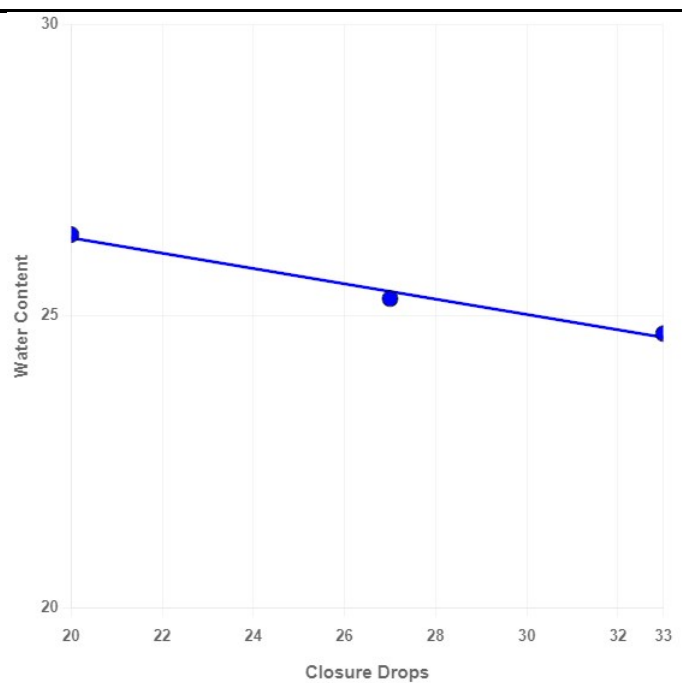
Liquid Limit: 26

Trial 1
Plastic
Limit: 11

Trial 2
Plastic
Limit: 12

Plastic
Limit: 12

Plasticity Index: 14



Test Completed Date: 11/22/2024

Lab Technician: Rebecca Walker



APPENDIX G

CONCEPT COST SUMMARY TABLES



APPENDIX G – CONCEPT COST SUMMARY TABLES

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

OPINION OF COST - LOW ESTIMATE

OPINION OF COST - LOW ESTIMATE															
	Doctors Park				Big Bay Park		Linnwood Revetment			Bradford/ Lake Park			Juneau/ McKinley Park	Cupertino Park	South Shore Park
Item Name	P1 C1	P1 C2	P2 C1	P2 C2	P3 C1	P3 C2	P4 C1	P5 C1	P5 C2	P6 C1	P6 C2	P7 C1	P8 C1	P9 C1	P10 C1
Armor Stone Revetment (Land Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$4,095,000	\$819,000	\$957,600	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Revetment (Barge Based)	\$0	\$0	\$708,750	\$0	\$94,500	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Backshore Revetment (Land Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Backshore Revetment (Barge Based)	\$931,000	\$0	\$0	\$477,138	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Land Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Barge Based)	\$0	\$567,000	\$0	\$567,000	\$0	\$1,701,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Breakwater (Footprint Length, Barge)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Trucking)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Barge)	\$0	\$113,400	\$0	\$81,900	\$0	\$302,400	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Dredge)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Groin Maintenance	\$0	\$210,000	\$0	\$0	\$0	\$140,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Native Vegetation	\$0	\$0	\$0	\$0	\$29,120	\$29,120	\$30,240	\$0	\$6,720	\$0	\$0	\$92,960	\$435,680	\$14,560	\$97,440
Invasive Species Management	\$0	\$0	\$0	\$0	\$14,700	\$14,700	\$0	\$0	\$2,940	\$0	\$1,593	\$0	\$168,070	\$6,370	\$42,630
Rip Rap Slope/Overtopping Protection	\$0	\$0	\$0	\$0	\$210,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Wooden Barrier with Signage	\$0	\$0	\$0	\$0	\$18,900	\$18,900	\$0	\$0	\$0	\$5,880	\$0	\$0	\$0	\$0	\$0
2-Ton Toe Stone - Scour Protection	\$0	\$0	\$0	\$0	\$308,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
General/Buttress Fill	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$17,640	\$0	\$0	\$0	\$0	\$0	\$0
Stairs, Landing, Handrail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$80,850	\$0	\$0	\$0	\$0
Geocell	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$67,200	\$0	\$0	\$0
Slope Grading	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Gravel Path	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Road Removal/Restoration	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Parking Lot	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Emergency Access Road	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Abandoned Trail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Wick Drains	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Demolition (Ex. Ret. Wall)	\$1,400	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Ravine Reinforcement	\$0	\$0	\$37,730	\$37,730	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
CONCEPT PROJECT TOTALS:	\$932,400	\$890,400	\$708,750	\$1,126,038	\$675,220	\$2,206,120	\$4,125,240	\$819,000	\$984,900	\$5,880	\$82,443	\$160,160	\$603,750	\$20,930	\$140,070



APPENDIX G – CONCEPT COST SUMMARY TABLES

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

OPINION OF COST - LOW ESTIMATE																	
	Bay View Park		Sheridan Park				Warnimont Park				Grant Park						Bender Park
Item Name	P11&12 C1	P11&12 C2	P14 C1	P14 C2	P15 C1	P15 C2	P16 C1	P16 C2	P17 C1	P18 & 19 C1	P20 C1	P20 C2	P21&22 C1	P21&22 C2	P23&24 C1	P23&24 C2	P25 C1
Armor Stone Revetment (Land Based)	\$5,418,000	\$5,418,000	\$0	\$1,764,000	\$0	\$0	\$0	\$7,812,000	\$0	\$0	\$1,386,000	\$0	\$604,800	\$0	\$0	\$0	\$0
Armor Stone Revetment (Barge Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Backshore Revetment (Land Based)	\$0	\$0	\$0	\$0	\$0	\$3,587,500	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$1,793,750	\$700,000	\$0
Backshore Revetment (Barge Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Land Based)	\$0	\$0	\$756,000	\$0	\$0	\$2,730,000	\$0	\$0	\$0	\$0	\$0	\$840,000	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Barge Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Breakwater (Footprint Length, Barge)	\$0	\$0	\$0	\$0	\$0	\$0	\$6,650,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Trucking)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$84,000	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Barge)	\$0	\$0	\$201,600	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Dredge)	\$0	\$0	\$0	\$0	\$0	\$384,300	\$18,900,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Groin Maintenance	\$0	\$0	\$280,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$381,500	\$0
Native Vegetation	\$227,360	\$161,280	\$0	\$0	\$311,360	\$311,360	\$156,800	\$156,800	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Invasive Species Management	\$0	\$11,760	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Rip Rap Slope/Overtopping Protection	\$63,525	\$16,013	\$0	\$189,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$69,300	\$0	\$0	\$0	\$0
Wooden Barrier with Signage	\$8,925	\$31,500	\$14,700	\$14,700	\$42,000	\$42,000	\$25,200	\$25,200	\$21,000	\$44,100	\$10,500	\$10,500	\$18,900	\$25,200	\$25,200	\$25,200	\$5,775
2-Ton Toe Stone - Scour Protection	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
General/Buttress Fill	\$0	\$0	\$0	\$176,400	\$0	\$0	\$0	\$578,200	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Stairs, Landing, Handrail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Geocell	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Slope Grading	\$735,000	\$121,275	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$367,500	\$0	\$0	\$0	\$0
Gravel Path	\$137,550	\$30,450	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$39,900	\$0	\$0	\$0	\$0
Road Removal/Restoration	\$0	\$0	\$0	\$0	\$504,000	\$504,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Parking Lot	\$0	\$0	\$0	\$0	\$0	\$630,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Emergency Access Road	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$126,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Abandoned Trail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$4,550	\$12,600	\$840	\$840	\$5,250	\$5,600	\$0	\$0	\$1,400
Wick Drains	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$140,000	\$0	\$98,000	\$98,000	\$0	\$0	\$0
Demolition (Ex. Ret. Wall)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Ravine Reinforcement	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
CONCEPT PROJECT TOTALS:	\$6,590,360	\$5,790,278	\$1,252,300	\$2,144,100	\$857,360	\$8,189,160	\$25,732,000	\$8,572,200	\$151,550	\$56,700	\$1,537,340	\$935,340	\$1,203,650	\$128,800	\$1,818,950	\$1,106,700	\$7,175



APPENDIX G – CONCEPT COST SUMMARY TABLES

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Lake Michigan Bluff Repairs Report

OPINION OF COST - ENGINEER'S ESTIMATE															
Item Name	Doctors Park				Big Bay Park		Linnwood Revetment			Bradford/ Lake Park			Juneau/ McKinley Park	Cupertino Park	South Shore Park
	P1 C1	P1 C2	P2 C1	P2 C2	P3 C1	P3 C2	P4 C1	P5 C1	P5 C2	P6 C1	P6 C2	P7 C1	P8 C1	P9 C1	P10 C1
Armor Stone Revetment (Land Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$5,850,000	\$1,170,000	\$1,368,000	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Revetment (Barge Based)	\$0	\$0	\$1,012,500	\$0	\$135,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Backshore Revetment (Land Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Backshore Revetment (Barge Based)	\$1,330,000	\$0	\$0	\$681,625	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Land Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Barge Based)	\$0	\$810,000	\$0	\$810,000	\$0	\$2,430,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Breakwater (Footprint Length, Barge)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Trucking)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Barge)	\$0	\$162,000	\$0	\$117,000	\$0	\$432,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Dredge)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Groin Maintenance	\$0	\$300,000	\$0	\$0	\$0	\$200,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Native Vegetation	\$0	\$0	\$0	\$0	\$41,600	\$41,600	\$43,200	\$0	\$9,600	\$0	\$0	\$132,800	\$622,400	\$20,800	\$139,200
Invasive Species Management	\$0	\$0	\$0	\$0	\$21,000	\$21,000	\$0	\$0	\$4,200	\$0	\$2,275	\$0	\$240,100	\$9,100	\$60,900
Rip Rap Slope/Overtopping Protection	\$0	\$0	\$0	\$0	\$300,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Wooden Barrier with Signage	\$0	\$0	\$0	\$0	\$27,000	\$27,000	\$0	\$0	\$0	\$8,400	\$0	\$0	\$0	\$0	\$0
2-Ton Toe Stone - Scour Protection	\$0	\$0	\$0	\$0	\$440,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
General/Buttress Fill	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$25,200	\$0	\$0	\$0	\$0	\$0	\$0
Stairs, Landing, Handrail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$115,500	\$0	\$0	\$0	\$0
Geocell	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$96,000	\$0	\$0	\$0
Slope Grading	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Gravel Path	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Road Removal/Restoration	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Parking Lot	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Emergency Access Road	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Abandoned Trail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Wick Drains	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Demolition (Ex. Ret. Wall)	\$2,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Ravine Reinforcement	\$0	\$0	\$53,900	\$53,900	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
CONCEPT PROJECT TOTALS:	\$1,332,000	\$1,272,000	\$1,012,500	\$1,608,625	\$964,600	\$3,151,600	\$5,893,200	\$1,170,000	\$1,407,000	\$8,400	\$117,775	\$228,800	\$862,500	\$29,900	\$200,100



APPENDIX G – CONCEPT COST SUMMARY TABLES

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Lake Michigan Bluff Repairs Report

OPINION OF COST - ENGINEER'S ESTIMATE																
Item Name	Bay View Park		Sheridan Park			Warnimont Park				Grant Park						Bender Park
	P11&12 C1	P11&12 C2	P14 C1	P14 C2	P15 C1	P15 C2	P16 C1	P16 C2	P17 C1	P18 & 19 C1	P20 C1	P20 C2	P21&22 C1	P21&22 C2	P23&24 C1	P23&24 C2
Armor Stone Revetment (Land Based)	\$7,740,000	\$7,740,000	\$0	\$2,520,000	\$0	\$0	\$0	\$11,160,000	\$0	\$0	\$1,980,000	\$0	\$864,000	\$0	\$0	\$0
Armor Stone Revetment (Barge Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Backshore Revetment (Land Based)	\$0	\$0	\$0	\$0	\$0	\$5,125,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$2,562,500	\$1,000,000
Backshore Revetment (Barge Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Land Based)	\$0	\$0	\$1,080,000	\$0	\$0	\$3,900,000	\$0	\$0	\$0	\$0	\$0	\$1,200,000	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Barge Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Breakwater (Footprint Length, Barge)	\$0	\$0	\$0	\$0	\$0	\$0	\$9,500,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Trucking)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$120,000	\$0	\$0	\$0	\$0
Sand Beach Fill (Barge)	\$0	\$0	\$288,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Dredge)	\$0	\$0	\$0	\$0	\$0	\$549,000	\$27,000,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Groin Maintenance	\$0	\$0	\$400,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$545,000
Native Vegetation	\$324,800	\$230,400	\$0	\$0	\$444,800	\$444,800	\$224,000	\$224,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Invasive Species Management	\$0	\$16,800	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Rip Rap Slope/Overtopping Protection	\$90,750	\$22,875	\$0	\$270,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$99,000	\$0	\$0	\$0
Wooden Barrier with Signage	\$12,750	\$45,000	\$21,000	\$21,000	\$60,000	\$60,000	\$36,000	\$36,000	\$30,000	\$63,000	\$15,000	\$15,000	\$27,000	\$36,000	\$36,000	\$36,000
2-Ton Toe Stone - Scour Protection	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
General/Buttress Fill	\$0	\$0	\$0	\$252,000	\$0	\$0	\$0	\$826,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Stairs, Landing, Handrail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Geocell	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Slope Grading	\$1,050,000	\$173,250	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$525,000	\$0	\$0	\$0
Gravel Path	\$196,500	\$43,500	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$57,000	\$0	\$0	\$0
Road Removal/Restoration	\$0	\$0	\$0	\$0	\$720,000	\$720,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Parking Lot	\$0	\$0	\$0	\$0	\$0	\$900,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Emergency Access Road	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$180,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Abandoned Trail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$6,500	\$18,000	\$1,200	\$1,200	\$7,500	\$8,000	\$0	\$2,000
Wick Drains	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$200,000	\$0	\$140,000	\$140,000	\$0	\$0
Demolition (Ex. Ret. Wall)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Ravine Reinforcement	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
CONCEPT PROJECT TOTALS:	\$9,414,800	\$8,271,825	\$1,789,000	\$3,063,000	\$1,224,800	\$11,698,800	\$36,760,000	\$12,246,000	\$216,500	\$81,000	\$2,196,200	\$1,336,200	\$1,719,500	\$184,000	\$2,598,500	\$1,581,000



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Lake Michigan Bluff Repairs Report

OPINION OF COST - HIGH ESTIMATE

	Doctors Park				Big Bay Park		Linnwood Revetment			Bradford/ Lake Park			Juneau/ McKinley Park	Cupertino Park	South Shore Park
Item Name	P1 C1	P1 C2	P2 C1	P2 C2	P3 C1	P3 C2	P4 C1	P5 C1	P5 C2	P6 C1	P6 C2	P7 C1	P8 C1	P9 C1	P10 C1
Armor Stone Revetment (Land Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$7,605,000	\$1,521,000	\$1,778,400	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Revetment (Barge Based)	\$0	\$0	\$1,316,250	\$0	\$175,500	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Backshore Revetment (Land Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Backshore Revetment (Barge Based)	\$1,729,000	\$0	\$0	\$886,113	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Land Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Barge Based)	\$0	\$1,053,000	\$0	\$1,053,000	\$0	\$3,159,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Breakwater (Footprint Length, Barge)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Trucking)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Barge)	\$0	\$210,600	\$0	\$152,100	\$0	\$561,600	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Dredge)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Groin Maintenance	\$0	\$390,000	\$0	\$0	\$0	\$260,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Native Vegetation	\$0	\$0	\$0	\$0	\$54,080	\$54,080	\$56,160	\$0	\$12,480	\$0	\$0	\$172,640	\$809,120	\$27,040	\$180,960
Invasive Species Management	\$0	\$0	\$0	\$0	\$27,300	\$27,300	\$0	\$0	\$5,460	\$0	\$2,958	\$0	\$312,130	\$11,830	\$79,170
Rip Rap Slope/Overtopping Protection	\$0	\$0	\$0	\$0	\$390,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Wooden Barrier with Signage	\$0	\$0	\$0	\$0	\$35,100	\$35,100	\$0	\$0	\$0	\$10,920	\$0	\$0	\$0	\$0	\$0
2-Ton Toe Stone - Scour Protection	\$0	\$0	\$0	\$0	\$572,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
General/Buttress Fill	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$32,760	\$0	\$0	\$0	\$0	\$0	\$0
Stairs, Landing, Handrail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$150,150	\$0	\$0	\$0	\$0
Geocell	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$124,800	\$0	\$0	\$0
Slope Grading	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Gravel Path	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Road Removal/Restoration	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Parking Lot	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Emergency Access Road	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Abandoned Trail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Wick Drains	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Demolition (Ex. Ret. Wall)	\$2,600	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Ravine Reinforcement	\$0	\$0	\$70,070	\$70,070	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
CONCEPT PROJECT TOTALS:	\$1,731,600	\$1,653,600	\$1,316,250	\$2,091,213	\$1,253,980	\$4,097,080	\$7,661,160	\$1,521,000	\$1,829,100	\$10,920	\$153,108	\$297,440	\$1,121,250	\$38,870	\$260,130



APPENDIX G – CONCEPT COST SUMMARY TABLES

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

OPINION OF COST - HIGH ESTIMATE																	
	Bay View Park		Sheridan Park				Warnimont Park				Grant Park						Bender Park
Item Name	P11&12 C1	P11&12 C2	P14 C1	P14 C2	P15 C1	P15 C2	P16 C1	P16 C2	P17 C1	P18 & 19 C1	P20 C1	P20 C2	P21&22 C1	P21&22 C2	P23&24 C1	P23&24 C2	P25 C1
Armor Stone Revetment (Land Based)	\$10,062,000	\$10,062,000	\$0	\$3,276,000	\$0	\$0	\$0	\$14,508,000	\$0	\$0	\$2,574,000	\$0	\$1,123,200	\$0	\$0	\$0	\$0
Armor Stone Revetment (Barge Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Backshore Revetment (Land Based)	\$0	\$0	\$0	\$0	\$0	\$6,662,500	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$3,331,250	\$1,300,000	\$0
Backshore Revetment (Barge Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Land Based)	\$0	\$0	\$1,404,000	\$0	\$0	\$5,070,000	\$0	\$0	\$0	\$0	\$0	\$1,560,000	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Barge Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Breakwater (Footprint Length, Barge)	\$0	\$0	\$0	\$0	\$0	\$0	\$12,350,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Trucking)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$156,000	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Barge)	\$0	\$0	\$374,400	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Dredge)	\$0	\$0	\$0	\$0	\$0	\$713,700	\$35,100,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Groin Maintenance	\$0	\$0	\$520,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$708,500	\$0
Native Vegetation	\$422,240	\$299,520	\$0	\$0	\$578,240	\$578,240	\$291,200	\$291,200	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Invasive Species Management	\$0	\$21,840	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Rip Rap Slope/Overtopping Protection	\$117,975	\$29,738	\$0	\$351,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$128,700	\$0	\$0	\$0	\$0
Wooden Barrier with Signage	\$16,575	\$58,500	\$27,300	\$27,300	\$78,000	\$78,000	\$46,800	\$46,800	\$39,000	\$81,900	\$19,500	\$19,500	\$35,100	\$46,800	\$46,800	\$46,800	\$10,725
2-Ton Toe Stone - Scour Protection	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
General/Buttress Fill	\$0	\$0	\$0	\$327,600	\$0	\$0	\$0	\$1,073,800	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Stairs, Landing, Handrail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Geocell	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Slope Grading	\$1,365,000	\$225,225	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$682,500	\$0	\$0	\$0	\$0
Gravel Path	\$255,450	\$56,550	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$74,100	\$0	\$0	\$0	\$0
Road Removal/Restoration	\$0	\$0	\$0	\$0	\$936,000	\$936,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Parking Lot	\$0	\$0	\$0	\$0	\$0	\$1,170,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Emergency Access Road	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$234,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Abandoned Trail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$8,450	\$23,400	\$1,560	\$1,560	\$9,750	\$10,400	\$0	\$0	\$2,600
Wick Drains	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$260,000	\$0	\$182,000	\$182,000	\$0	\$0	\$0
Demolition (Ex. Ret. Wall)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Ravine Reinforcement	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
CONCEPT PROJECT TOTALS:	\$12,239,240	\$10,753,373	\$2,325,700	\$3,981,900	\$1,592,240	\$15,208,440	\$47,788,000	\$15,919,800	\$281,450	\$105,300	\$2,855,060	\$1,737,060	\$2,235,350	\$239,200	\$3,378,050	\$2,055,300	\$13,325



APPENDIX G – CONCEPT COST SUMMARY TABLES

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

OPINION OF COST - 25-YEAR ADJUSTED ENGINEER'S ESTIMATE															
	Doctors Park				Big Bay Park		Linnwood Revetment			Bradford/ Lake Park			Juneau/ McKinley Park	Cupertino Park	South Shore Park
Item Name	P1 C1	P1 C2	P2 C1	P2 C2	P3 C1	P3 C2	P4 C1	P5 C1	P5 C2	P6 C1	P6 C2	P7 C1	P8 C1	P9 C1	P10 C1
Armor Stone Revetment (Land Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$9,137,982	\$1,827,596	\$2,136,882	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Revetment (Barge Based)	\$0	\$0	\$1,581,574	\$0	\$210,877	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Backshore Revetment (Land Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Backshore Revetment (Barge Based)	\$2,077,524	\$0	\$0	\$1,064,731	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Land Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Barge Based)	\$0	\$1,265,259	\$0	\$1,265,259	\$0	\$3,795,777	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Breakwater (Footprint Length, Barge)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Trucking)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Barge)	\$0	\$253,052	\$0	\$182,760	\$0	\$674,805	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Dredge)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Groin Maintenance	\$0	\$468,614	\$0	\$0	\$0	\$312,410	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Native Vegetation	\$0	\$0	\$0	\$0	\$64,981	\$64,981	\$67,480	\$0	\$14,996	\$0	\$0	\$207,440	\$972,219	\$32,491	\$217,437
Invasive Species Management	\$0	\$0	\$0	\$0	\$32,803	\$32,803	\$0	\$0	\$6,561	\$0	\$3,554	\$0	\$375,048	\$14,215	\$95,129
Rip Rap Slope/Overtopping Protection	\$0	\$0	\$0	\$0	\$468,614	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Wooden Barrier with Signage	\$0	\$0	\$0	\$0	\$42,175	\$42,175	\$0	\$0	\$0	\$13,121	\$0	\$0	\$0	\$0	\$0
2-Ton Toe Stone - Scour Protection	\$0	\$0	\$0	\$0	\$687,301	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
General/Buttress Fill	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$39,364	\$0	\$0	\$0	\$0	\$0	\$0
Stairs, Landing, Handrail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$180,417	\$0	\$0	\$0	\$0
Geocell	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$149,957	\$0	\$0	\$0
Slope Grading	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Gravel Path	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Road Removal/Restoration	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Parking Lot	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Emergency Access Road	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Abandoned Trail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Wick Drains	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Demolition (Ex. Ret. Wall)	\$3,124	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Ravine Reinforcement	\$0	\$0	\$84,194	\$84,194	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
CONCEPT PROJECT TOTALS:	\$2,080,648	\$1,986,925	\$1,581,574	\$2,512,750	\$1,506,752	\$4,922,951	\$9,205,463	\$1,827,596	\$2,197,802	\$13,121	\$183,970	\$357,397	\$1,347,267	\$46,705	\$312,566



APPENDIX G – CONCEPT COST SUMMARY TABLES

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

OPINION OF COST - 25-YEAR ADJUSTED ENGINEER'S ESTIMATE																	
Item Name	Bay View Park		Sheridan Park				Warnimont Park				Grant Park						Bender Park
	P11&12 C1	P11&12 C2	P14 C1	P14 C2	P15 C1	P15 C2	P16 C1	P16 C2	P17 C1	P18 & 19 C1	P20 C1	P20 C2	P21&22 C1	P21&22 C2	P23&24 C1	P23&24 C2	P25 C1
Armor Stone Revetment (Land Based)	\$12,090,254	\$12,090,254	\$0	\$3,936,362	\$0	\$0	\$0	\$17,432,459	\$0	\$0	\$3,092,856	\$0	\$1,349,610	\$0	\$0	\$0	\$0
Armor Stone Revetment (Barge Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Backshore Revetment (Land Based)	\$0	\$0	\$0	\$0	\$0	\$8,005,497	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$4,002,749	\$1,562,048	\$0
Backshore Revetment (Barge Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Land Based)	\$0	\$0	\$1,687,012	\$0	\$0	\$6,091,988	\$0	\$0	\$0	\$0	\$0	\$1,874,458	\$0	\$0	\$0	\$0	\$0
Armor Stone Groin (Footprint Length, Barge Based)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Armor Stone Breakwater (Footprint Length, Barge)	\$0	\$0	\$0	\$0	\$0	\$0	\$14,839,459	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Trucking)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$187,446	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Barge)	\$0	\$0	\$449,870	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sand Beach Fill (Dredge)	\$0	\$0	\$0	\$0	\$0	\$857,564	\$42,175,303	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Groin Maintenance	\$0	\$0	\$624,819	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$851,316	\$0
Native Vegetation	\$507,353	\$359,896	\$0	\$0	\$694,799	\$694,799	\$349,899	\$349,899	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Invasive Species Management	\$0	\$26,242	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Rip Rap Slope/Overtopping Protection	\$141,756	\$35,732	\$0	\$421,753	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$154,643	\$0	\$0	\$0	\$0
Wooden Barrier with Signage	\$19,916	\$70,292	\$32,803	\$32,803	\$93,723	\$93,723	\$56,234	\$56,234	\$46,861	\$98,409	\$23,431	\$23,431	\$42,175	\$56,234	\$56,234	\$56,234	\$12,887
2-Ton Toe Stone - Scour Protection	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
General/Buttress Fill	\$0	\$0	\$0	\$393,636	\$0	\$0	\$0	\$1,290,252	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Stairs, Landing, Handrail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Geocell	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Slope Grading	\$1,640,151	\$270,625	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$820,075	\$0	\$0	\$0	\$0
Gravel Path	\$306,942	\$67,949	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$89,037	\$0	\$0	\$0	\$0
Road Removal/Restoration	\$0	\$0	\$0	\$0	\$1,124,675	\$1,124,675	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Parking Lot	\$0	\$0	\$0	\$0	\$0	\$1,405,843	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Emergency Access Road	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$281,169	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Abandoned Trail	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$10,153	\$28,117	\$1,874	\$1,874	\$11,715	\$12,496	\$0	\$0	\$3,124
Wick Drains	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$312,410	\$0	\$218,687	\$218,687	\$0	\$0	\$0
Demolition (Ex. Ret. Wall)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Ravine Reinforcement	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
CONCEPT PROJECT TOTALS:	\$14,706,372	\$12,920,990	\$2,794,504	\$4,784,554	\$1,913,197	\$18,274,090	\$57,420,894	\$19,128,843	\$338,183	\$126,526	\$3,430,570	\$2,087,209	\$2,685,942	\$287,417	\$4,058,982	\$2,469,598	\$16,011



APPENDIX H

PROJECT AREA CONCEPT PRIORITIZATION TABLE



APPENDIX H – PROJECT AREA AND CONCEPT PRIORITIZATION TABLE

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

Park	Project Area and Concept	Shoreline Length (Feet)	Low Estimate	Engineer's Estimate	High Estimate	25-Year Adjusted Cost	Total Risk (Scenario 1)	Total Replacement Cost	Average Resiliency Value	Risk/Cost Ratio	Risk/ Shoreline Length (\$/Foot)	Cost/ Shoreline Length (\$/Foot)	Estimated Risk Mitigated	Risk Mitigated/Cost Ratio	Total Combined Safety Value Improvement	Average Safety Value Improvement/ Cell
Doctors Park	P1 C1	450	\$930,000	\$1,330,000	\$1,730,000	\$2,080,000	\$447,000	\$2,102,052	0.212	0.34	\$990	\$2,960	35%	0.117	0.000	0.000
Doctors Park	P1 C2	450	\$890,000	\$1,270,000	\$1,650,000	\$1,990,000	\$447,266	\$2,102,052	0.212	0.35	\$990	\$2,820	30%	0.106	0.000	0.000
Doctors Park	P2 C1	225	\$710,000	\$1,010,000	\$1,320,000	\$1,580,000	\$91,550	\$234,123	0.403	0.09	\$410	\$4,490	81%	0.073	0.000	0.000
Doctors Park	P2 C2	225	\$1,130,000	\$1,610,000	\$2,090,000	\$2,510,000	\$91,550	\$234,123	0.403	0.06	\$410	\$7,160	67%	0.038	0.000	0.000
Big Bay Park	P3 C1	1200	\$680,000	\$960,000	\$1,250,000	\$1,510,000	\$2,175,259	\$7,848,307	0.266	2.27	\$1,810	\$800	60%	1.364	0.000	0.000
Big Bay Park	P3 C2	1200	\$2,210,000	\$3,150,000	\$4,100,000	\$4,920,000	\$2,175,259	\$7,848,307	0.266	0.69	\$1,810	\$2,630	50%	0.347	0.000	0.000
Linnwood	P4 C1	1600	\$4,130,000	\$5,890,000	\$7,660,000	\$9,210,000	N/A	N/A	0.560	N/A	N/A	\$3,680	N/A	N/A	N/A	N/A
Linnwood	P5 C1	250	\$820,000	\$1,170,000	\$1,520,000	\$1,830,000	N/A	N/A	0.820	N/A	N/A	\$4,680	N/A	N/A	N/A	N/A
Linnwood	P5 C2	250	\$980,000	\$1,410,000	\$1,830,000	\$2,200,000	N/A	N/A	0.820	N/A	N/A	\$5,640	N/A	N/A	N/A	N/A
Bradford/ Lake Park	P6 C1	150	\$6,000	\$8,000	\$11,000	\$13,000	\$13,907	\$267,449	0.052	1.74	\$90	\$50	0%	0.000	0.160	0.160
Bradford/ Lake Park	P6 C2	150	\$80,000	\$120,000	\$150,000	\$180,000	\$13,907	\$267,449	0.052	0.12	\$90	\$800	-57%	-0.066	0.321	0.321
Bradford/ Lake Park	P7 C1	500	\$160,000	\$230,000	\$300,000	\$360,000	\$14,527	\$328,174	0.046	0.06	\$30	\$460	10%	0.006	0.000	0.000
Juneau/ McKinley Park	P8 C1	3000	\$600,000	\$860,000	\$1,120,000	\$1,350,000	\$75,079	\$1,351,724	0.056	0.09	\$30	\$290	24%	0.021	0.000	0.000
Cupertino Park	P9 C1	300	\$20,000	\$30,000	\$40,000	\$50,000	\$28,756	\$513,503	0.056	0.96	\$100	\$100	0%	0.000	0.000	0.000
South Shore Park	P10 C1	1600	\$140,000	\$200,000	\$260,000	\$310,000	\$291,799	\$3,564,321	0.078	1.46	\$180	\$130	18%	0.257	0.000	0.000
Bay View Park	P11&12 C1	2375	\$6,590,000	\$9,410,000	\$12,240,000	\$14,710,000	\$2,454,450	\$4,042,883	0.503	0.26	\$1,030	\$3,960	96%	0.249	1.706	0.131
Bay View Park	P11&12 C2	2375	\$5,790,000	\$8,270,000	\$10,750,000	\$12,920,000	\$2,454,450	\$4,042,883	0.503	0.30	\$1,030	\$3,480	37%	0.110	0.997	0.077
Sheridan Park	P14 C1	700	\$1,250,000	\$1,790,000	\$2,330,000	\$2,790,000	\$835,110	\$1,751,966	0.399	0.47	\$1,190	\$2,560	33%	0.153	0.710	0.142
Sheridan Park	P14 C2	700	\$2,140,000	\$3,060,000	\$3,980,000	\$4,780,000	\$835,110	\$1,751,966	0.399	0.27	\$1,190	\$4,370	59%	0.162	0.710	0.142
Sheridan Park	P15 C1	2250	\$860,000	\$1,220,000	\$1,590,000	\$1,910,000	\$6,089,823	\$8,801,889	0.691	4.99	\$2,710	\$540	5%	0.237	2.248	0.187
Sheridan Park	P15 C2	2250	\$8,190,000	\$11,700,000	\$15,210,000	\$18,270,000	\$6,089,823	\$8,801,889	0.691	0.52	\$2,710	\$5,200	38%	0.200	2.248	0.187
Warnimont Park	P16 C1	3100	\$25,730,000	\$36,760,000	\$47,790,000	\$57,420,000	\$10,445,373	\$13,783,821	0.767	0.28	\$3,370	\$11,860	43%	0.121	0.725	0.045
Warnimont Park	P16 C2	3100	\$8,570,000	\$12,250,000	\$15,920,000	\$19,130,000	\$10,445,373	\$13,783,821	0.767	0.85	\$3,370	\$3,950	24%	0.205	0.725	0.045
Warnimont Park	P17 C1	725	\$150,000	\$220,000	\$280,000	\$340,000	\$3,056,934	\$4,443,852	0.710	13.90	\$4,220	\$300	0%	0.000	0.387	0.077
Warnimont Park	P18 & 19 C1	900	\$60,000	\$80,000	\$110,000	\$130,000	\$2,611,486	\$3,872,344	0.666	32.64	\$2,900	\$90	0%	0.000	0.616	0.088
Grant Park	P20 C1	600	\$1,540,000	\$2,200,000	\$2,860,000	\$3,430,000	\$694,764	\$1,031,745	0.666	0.32	\$1,160	\$3,670	47%	0.149	1.008	0.336
Grant Park	P20 C2	600	\$940,000	\$1,340,000	\$1,740,000	\$2,090,000	\$694,764	\$1,031,745	0.666	0.52	\$1,160	\$2,230	42%	0.215	1.008	0.336
Grant Park	P21&22 C1	950	\$1,200,000	\$1,720,000	\$2,240,000	\$2,690,000	\$1,040,362	\$1,986,655	0.537	0.60	\$1,100	\$1,810	25%	0.152	2.015	0.336
Grant Park	P21&22 C2	950	\$130,000	\$180,000	\$240,000	\$290,000	\$1,040,362	\$1,986,655	0.537	5.78	\$1,100	\$190	6%	0.348	1.703	0.284
Grant Park	P23&24 C1	900	\$1,820,000	\$2,600,000	\$3,380,000	\$4,060,000	\$1,424,823	\$2,233,467	0.631	0.55	\$1,580	\$2,890	39%	0.211	1.077	0.215
Grant Park	P23&24 C2	900	\$1,110,000	\$1,580,000	\$2,060,000	\$2,470,000	\$1,424,823	\$2,233,467	0.631	0.90	\$1,580	\$1,760	19%	0.174	1.077	0.215
Bender Park	P25 C1	250	\$7,000	\$10,000	\$13,000	\$16,000	\$635,864	\$1,827,196	0.348	63.59	\$2,540	\$40	0%	0.000	0.285	0.285



APPENDIX I

TOP 50 SAFETY PRIORITIZATION TABLE



APPENDIX I – TOP 50 SAFETY PRIORITIZATION TABLE

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

Rank	Park Name	Cell Number	Stationing Start	Stationing End	Safety Rank (GZA)	Safety Value (Corrected)	Safety Rank (Corrected)	Vulnerability Ranking
1	Grant Park	14	2600	2800	F	0.869	F	C
2	Grant Park	24	4600	4800	F	0.869	F	D+
3	Grant Park	31	6000	6200	F	0.869	F	D+
4	Sheridan Park	4	600	800	F	0.592	D+	F
5	Sheridan Park	23	4400	4600	F	0.592	D+	F
6	Sheridan Park	24	4600	4800	F	0.592	D+	D-
7	Grant Park	15	2800	3000	F	0.695	D-	F
8	Grant Park	27	5200	5400	F	0.695	D-	D
9	Sheridan Park	9	1600	1800	F	0.473	C-	F
10	Warnimont Park	7	1200	1400	F	0.302	B-	D
11	Warnimont Park	11	2000	2200	F	0.302	B-	F
12	Warnimont Park	13	2400	2600	F	0.302	B-	D
13	Warnimont Park	30	5800	6000	F	0.302	B-	D
14	Warnimont Park	31	6000	6200	F	0.302	B-	D
15	Warnimont Park	32	6200	6400	F	0.302	B-	D
16	Warnimont Park	33	6400	6600	F	0.302	B-	F
17	Warnimont Park	29	5600	5800	F	0.242	B	F
18	Warnimont Park	34	6600	6800	F	0.242	B	F
19	Warnimont Park	35	6800	7000	F	0.242	B	F
20	Warnimont Park	36	7000	7200	F	0.242	B	F
21	Warnimont Park	37	7200	7400	F	0.242	B	F
22	Grant Park	23	4400	4600	D	0.695	D-	D+
23	Grant Park	30	5800	6000	D	0.695	D-	F
24	Bender Park	1	0	200	D	0.380	C+	C+
25	Sheridan Park	1	0	200	D	0.379	C+	C-
26	Sheridan Park	2	200	400	D	0.379	C+	F
27	Sheridan Park	3	400	600	D	0.379	C+	F
28	Sheridan Park	5	800	1000	D	0.379	C+	F
29	Sheridan Park	6	1000	1200	D	0.379	C+	F
30	Sheridan Park	7	1200	1400	D	0.379	C+	F
31	Sheridan Park	8	1400	1600	D	0.379	C+	F
32	Sheridan Park	10	1800	2000	D	0.379	C+	F
33	Warnimont Park	12	2200	2400	D	0.193	B+	D
34	Warnimont Park	20	3800	4000	D	0.193	B+	F
35	Warnimont Park	21	4000	4200	D	0.193	B+	F
36	Warnimont Park	22	4200	4400	D	0.193	B+	F
37	Warnimont Park	23	4400	4600	D	0.193	B+	F



APPENDIX I – TOP 50 SAFETY PRIORITIZATION TABLE

May 30, 2025

File No. 20.0158819.00

Lake Michigan Bluff Repairs Report

Rank	Park Name	Cell Number	Stationing Start	Stationing End	Safety Rank (GZA)	Safety Value (Corrected)	Safety Rank (Corrected)	Vulnerability Ranking
38	Warnimont Park	24	4600	4800	D	0.193	B+	F
39	Warnimont Park	25	4800	5000	D	0.193	B+	F
40	Warnimont Park	26	5000	5200	D	0.193	B+	F
41	Warnimont Park	27	5200	5400	D	0.193	B+	F
42	Warnimont Park	28	5400	5600	D	0.193	B+	F
43	Warnimont Park	38	7400	7550	D	0.193	B+	D
44	Bay View Park	1	0	200	D	0.307	B-	F
45	Bay View Park	2	200	400	D	0.307	B-	F
46	Bay View Park	3	400	600	D	0.307	B-	F
47	Bay View Park	4	600	800	D	0.307	B-	F
48	Bay View Park	5	800	1000	D	0.307	B-	F
49	Warnimont Park	15	2800	3000	D	0.242	B	F
50	Warnimont Park	16	3000	3200	D	0.242	B	F

EXHIBIT 6

CONCEPTUAL DRAWINGS (BY GZA)

FOR LAKE MICHIGAN BLUFF REPAIRS AT SHERIDAN PARK

© 2025 - GZA GeoEnvironmental, Inc. GZA-I-1588070158809\158819 MKE CNTY LAKE MI BLUFFS\FIGURES\CAD\10. SHERIDAN\PRODUCTION DRAWINGS\GZA_20.0158819.00_SHERIDAN PARK_V4.DWG PARK OVERVIEW MAY 28, 2025 9:15AM COLIN BYRON



LEGEND

APPROXIMATE SHERIDAN PARK BOUNDARY

PROJECT AREA

MILWAUKEE COUNTY TRAIL

0250'500'1000'1500'

SCALE IN FEET

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MILWAUKEE COUNTY PARKS BLUFF ASSESSMENT SHERIDAN PARK CUDAHY, WISCONSIN			
SHERIDAN PARK AND PROJECT AREAS			
PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MILWAUKEE COUNTY DEPARTMENT OF ADMINISTRATIVE SERVICES 633 WEST WISCONSIN AVE., 10TH FLOOR MILWAUKEE, WISCONSIN 53203	
PROJ MGR: IJM	REVIEWED BY: JDG	CHECKED BY: DV	DRAWING NO. 10.0 SHEET NO. 42 OF 74
DESIGNED BY: IJM	DRAWN BY: CJB	SCALE: AS NOTED	
DATE: MAY, 2025	PROJECT NO. 20.0158819.00	REVISION NO.	

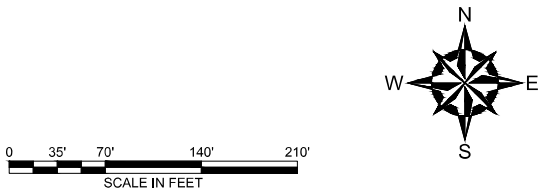
© 2025 - GZA GeoEnvironmental, Inc. GZA-158819-MKE CNTY LAKE MI BLUFFS\FIGURES\CAD\10. SHERIDAN\PRODUCTION DRAWINGS\GZA_20.0158819.00_SHERIDAN PARK_VA.DWG PROJECT AREA 14 EXISTING CONDITIONS MAY 29, 2025 9:18AM COLIN BYRON



- LEGEND**
- -610--- EXISTING MAJOR TOPOGRAPHIC CONTOUR LINE
 - EXISTING MINOR TOPOGRAPHIC CONTOUR LINE
 - - - - - APPROXIMATE SHERIDAN PARK BOUNDARY
 - PROJECT AREA
 - - - - - MILWAUKEE COUNTY TRAIL
 - P14 PHOTO LOCATION
 - BORING LOCATION DRILLED BY DRILL POINT INC. AND OBSERVED BY GZA ON 10-16-2024
 - BLUFF INSTABILITY
 - SLOPE SAFETY CONCERN

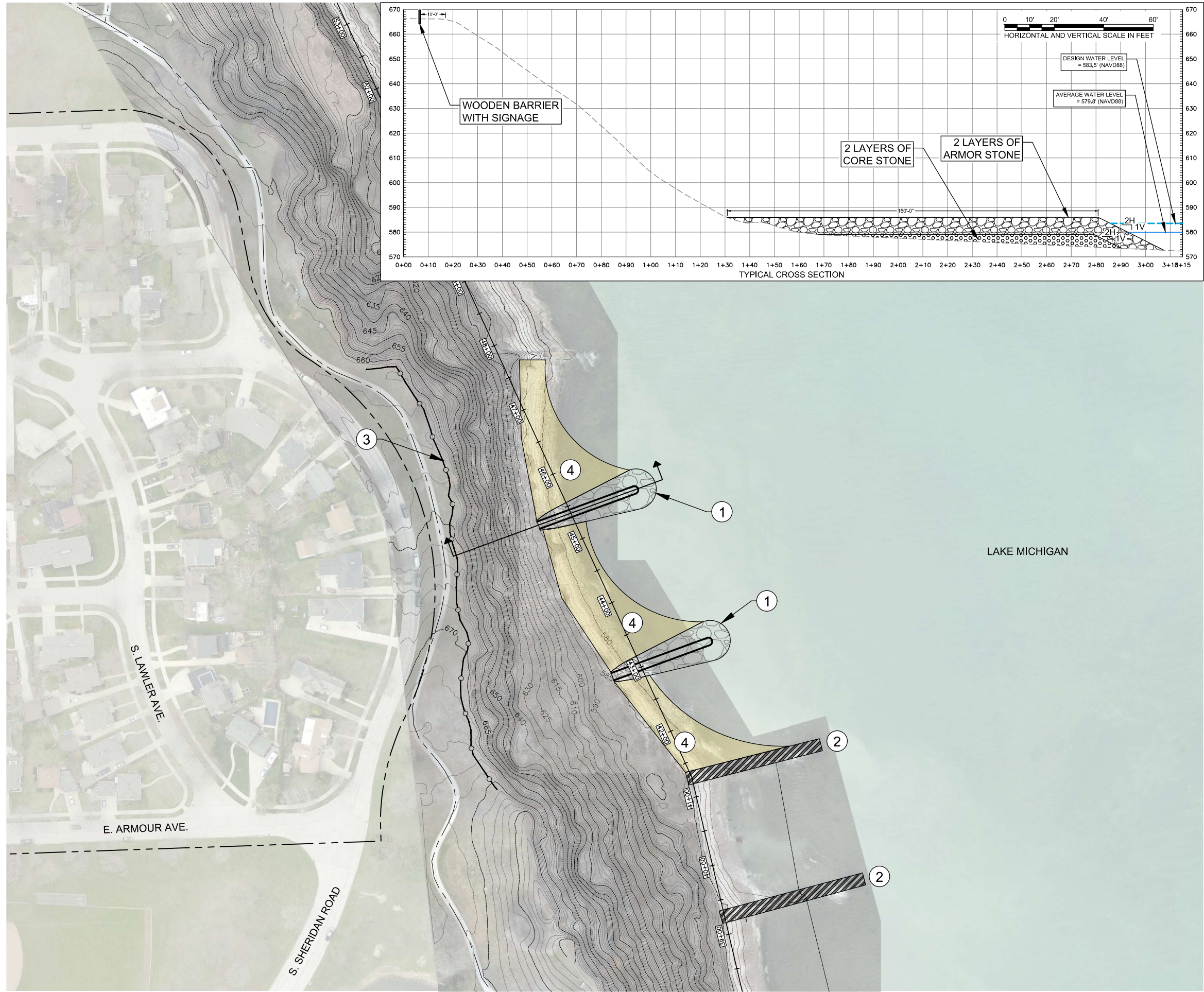


TYPICAL PROJECT AREA 14 CONDITIONS



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PROJECT AREA 14 EXISTING CONDITIONS			
PREPARED BY:  GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MILWAUKEE COUNTY DEPARTMENT OF ADMINISTRATIVE SERVICES 633 WEST WISCONSIN AVE., 10TH FLOOR MILWAUKEE, WISCONSIN 53203	
PROJ MGR: IJM	REVIEWED BY: JDG	CHECKED BY: DV	DRAWING NO. 10.1 SHEET NO. 43 OF 74
DESIGNED BY: IJM	DRAWN BY: CJB	SCALE: AS NOTED	
DATE: MAY, 2025	PROJECT NO. 20.0158819.00	REVISION NO.	

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SHERIDAN PARK CONCEPT 1 - ESTIMATED QUANTITIES AND DETAILS				
FEATURE NUMBER	FEATURE	QUANTITY	UNIT	SHEET NO. / DETAIL NO.
1	ARMOR STONE GROIN	360	LF	14.2
2	MAINTENANCE ON EXISTING GROIN	400	LF	N/A
3	WOODEN BARRIER WITH SIGNAGE	700	LF	N/A
4	SAND BEACH FILL	3,200	CYDS	N/A

0

35'

70'

140'

210'

SCALE IN FEET

N

E

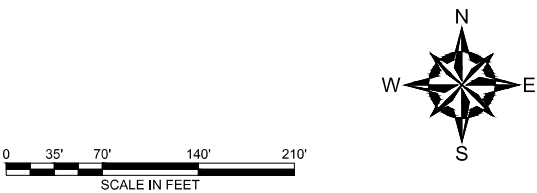
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NO.	ISSUE/DESCRIPTION	BY	DATE
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MILWAUKEE COUNTY PARKS BLUFF ASSESSMENT SHERIDAN PARK CUDAHY, WISCONSIN			
PROJECT AREA 14 - CONCEPT 1			
PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MILWAUKEE COUNTY DEPARTMENT OF ADMINISTRATIVE SERVICES 633 WEST WISCONSIN AVE., 10TH FLOOR MILWAUKEE, WISCONSIN 53203	
PROJ MGR: IJM	REVIEWED BY: JDG	CHECKED BY: DV	DRAWING NO. 10.2 SHEET NO. 44 OF 74
DESIGNED BY: IJM	DRAWN BY: CJB	SCALE: AS NOTED	
DATE: MAY, 2025	PROJECT NO. 20.0158819.00	REVISION NO.	

	EXISTING MAJOR TOPOGRAPHIC CONTOUR LINE
	EXISTING MINOR TOPOGRAPHIC CONTOUR LINE
	APPROXIMATE SHERIDAN PARK BOUNDARY
	WOODEN BARRIER WITH SIGNAGE
	BUTTRESS FILL
	FILTER STONE
	ARMOR STONE REVETMENT
	CROSS SECTION LOCATION

SHERIDAN PARK CONCEPT 2 - ESTIMATED QUANTITIES AND DETAILS				
FEATURE NUMBER	FEATURE	QUANTITY	UNIT	SHEET NO. / DETAIL NO.
1	BUTTRESS FILL	18,000	CYDS	N/A
2	ARMOR STONE REVETMENT	700	LF	(14.0) 1
3	RIP RAP SLOPE COVER	18,000	SF	(14.0) 3
4	WOODEN BARRIER WITH SIGNAGE	700	LF	N/A



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MILWAUKEE COUNTY PARKS BLUFF ASSESSMENT SHERIDAN PARK CUDAHY, WISCONSIN			
PROJECT AREA 14 - CONCEPT 2			
PREPARED BY:  GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MILWAUKEE COUNTY DEPARTMENT OF ADMINISTRATIVE SERVICES 633 WEST WISCONSIN AVE., 10TH FLOOR MILWAUKEE, WISCONSIN 53203	
PROJ MGR: IJM	DESIGNED BY: IJM	REVIEWED BY: JDG	CHECKED BY: DV
DATE: MAY, 2025	DRAWN BY: CJB	PROJECT NO. 20.015889.00	SCALE: AS NOTED REVISION NO.
			DRAWING NO. 10.3 SHEET NO. 45 OF 74

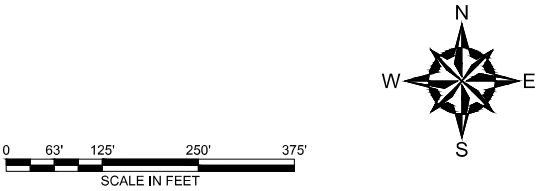
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- LEGEND**
- -610 --- EXISTING MAJOR TOPOGRAPHIC CONTOUR LINE
 - EXISTING MINOR TOPOGRAPHIC CONTOUR LINE
 - - - - - APPROXIMATE SHERIDAN PARK BOUNDARY
 - PROJECT AREA
 - - - - - MILWAUKEE COUNTY TRAIL
 - P15 PHOTO LOCATION
 - ★ BORING LOCATION DRILLED BY DRILL POINT INC. AND OBSERVED BY GZA ON 10/16/24 AND 10/17/24
 - BLUFF INSTABILITY
 - SLOPE SAFETY CONCERN



TYPICAL PROJECT AREA 15 CONDITIONS



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MILWAUKEE COUNTY PARKS BLUFF ASSESSMENT SHERIDAN PARK CUDAHY, WISCONSIN			
PROJECT AREA 15 EXISTING CONDITIONS			
PREPARED BY:  GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MILWAUKEE COUNTY DEPARTMENT OF ADMINISTRATIVE SERVICES 633 WEST WISCONSIN AVE., 10TH FLOOR MILWAUKEE, WISCONSIN 53203	
PROJ MGR: IJM	REVIEWED BY: JDG	CHECKED BY: DV	DRAWING NO. 10.4 SHEET NO. 46 OF 74
DESIGNED BY: IJM	DRAWN BY: CJB	SCALE: AS NOTED	
DATE: MAY, 2025	PROJECT NO. 20.0158819.00	REVISION NO.	

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LEGEND

-610-

EXISTING MAJOR TOPOGRAPHIC CONTOUR LINE

EXISTING MINOR TOPOGRAPHIC CONTOUR LINE

APPROXIMATE SHERIDAN PARK BOUNDARY

MILWAUKEE COUNTY TRAIL

ROAD REMOVAL AND RESTORATION

NATIVE VEGETATION

WOODEN BARRIER AND SIGNAGE

SHERIDAN PARK CONCEPT 1 - ESTIMATED QUANTITIES AND DETAILS				
FEATURE NUMBER	FEATURE	QUANTITY	UNIT	SHEET NO. / DETAIL NO.
1	ROAD REMOVAL AND RESTORATION	72,000	SF	N/A
2	NATIVE VEGETATION	27,800	SY	14.3 1.2
3	WOODEN BARRIER AND SIGNAGE	2,000	LF	N/A

0

63'

125'

250'

375'

SCALE IN FEET

N

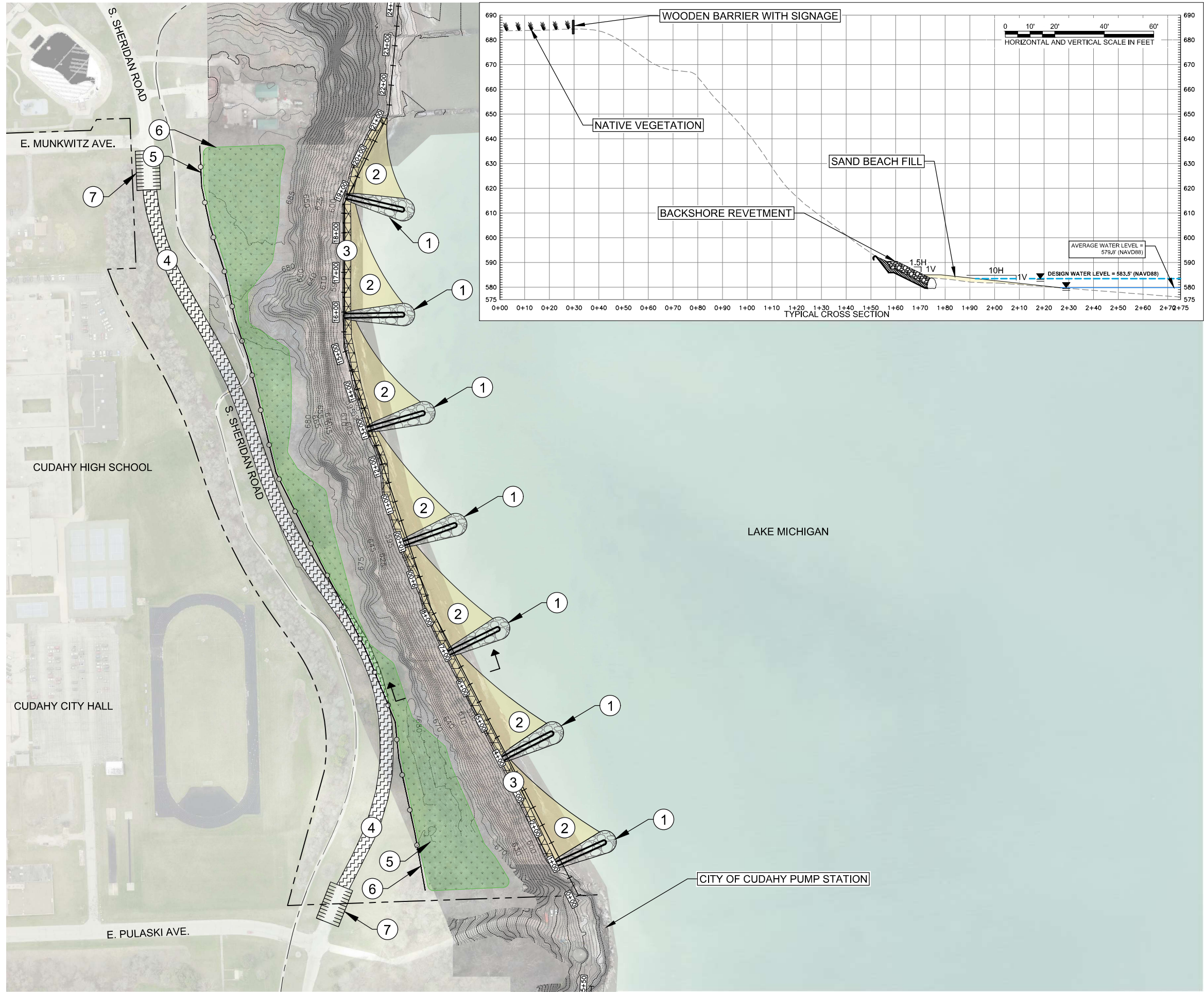
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NO.	ISSUE/DESCRIPTION	BY	DATE
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MILWAUKEE COUNTY PARKS BLUFF ASSESSMENT SHERIDAN PARK CUDAHY, WISCONSIN			
PROJECT AREA 15 - CONCEPT 1			
PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MILWAUKEE COUNTY DEPARTMENT OF ADMINISTRATIVE SERVICES 633 WEST WISCONSIN AVE., 10TH FLOOR MILWAUKEE, WISCONSIN 53203	
PROJ MGR: IJM	REVIEWED BY: JDG	CHECKED BY: DV	DRAWING NO. 10.5 SHEET NO. 47 OF 74
DESIGNED BY: IJM	DRAWN BY: CJB	SCALE: AS NOTED	
DATE: MAY, 2025	PROJECT NO. 20.0158819.00	REVISION NO.	

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LEGEND

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SHERIDAN PARK CONCEPT 2 - ESTIMATED QUANTITIES AND DETAILS				
FEATURE NUMBER	FEATURE	QUANTITY	UNIT	SHEET NO. / DETAIL NO.
1	ARMOR STONE GROIN	1,300	LF	(14.1)
2	SAND BEACH FILL	12,200	CYDS	N/A
3	BACKSHORE REVETMENT	2,050	LF	(14.0) 2
4	ROAD REMOVAL AND RESTORATION	72,000	SF	N/A
5	NATIVE VEGETATION	27,800	SY	(14.3) 1.2
6	WOODEN BARRIER WITH SIGNAGE	2,000	LF	N/A
7	PARKING LOT	12,000	SF	N/A

NO.		ISSUE/DESCRIPTION		BY	DATE
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MILWAUKEE COUNTY PARKS BLUFF ASSESSMENT SHERIDAN PARK CUDAHY, WISCONSIN					
PROJECT AREA 15 - CONCEPT 2					
PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MILWAUKEE COUNTY DEPARTMENT OF ADMINISTRATIVE SERVICES 633 WEST WISCONSIN AVE., 10TH FLOOR MILWAUKEE, WISCONSIN 53203			
PROJ MGR: IJM	REVIEWED BY: JDG	CHECKED BY: DV	DRAWING NO. 10.6 SHEET NO. 48 OF 74		
DESIGNED BY: IJM	DRAWN BY: CJB	SCALE: AS NOTED			
DATE: MAY, 2025	PROJECT NO. 20.0158819.00	REVISION NO.			

EXHIBIT 7

MILWAUKEE COUNTY COASTAL MANAGEMENT GUIDELINES

MILWAUKEE COUNTY COASTLINE MANAGEMENT GUIDELINES



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MEMORANDUM REPORT
NUMBER 248

**MILWAUKEE COUNTY
COASTLINE MANAGEMENT GUIDELINES**

Prepared by the
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INTRODUCTION AND PURPOSE

1



Credit: Milwaukee County

1.1 BACKGROUND

In 2019, Milwaukee County requested that the Southeastern Wisconsin Regional Planning Commission (SEWRPC) prepare a set of coastline management guidelines intended to be used by County staff to evaluate projects affecting County-owned assets with respect to coastline area impacts. To develop the guidelines, SEWRPC conducted an inventory of existing conditions, including natural resources and urban development along the Milwaukee County Lake Michigan coastline; a review of existing municipal, State, and Federal coastline management guidelines/policies and best management practices; and an examination of trends in the stability of the Lake Michigan bluffs within the County. This process also involved community outreach through which the County was able to share information and gather feedback from municipal representatives and community stakeholders in regards to coastline management.

Coastline Management Definitions

For the purposes of this report, coastline management is defined as a means by which the County may mitigate coastline impacts, such as shoreline erosion or bluff recession.¹ Coastline management may incorporate structural or nonstructural measures. Examples of structural coastline management measures include retaining walls within a bluff slope, shoreline revetments, and breakwaters. Examples of nonstructural coastline management measures include regulations or guidelines for land uses or development, such as promoting landscape management techniques that are appropriate for bluffs. Whether located on-shore or near off-shore, structural and nonstructural coastline management techniques are intended to mitigate or prevent damage from the impacts of coastline dynamics.

¹ Definitions of coastline management terms used in this report are presented in Appendix A.

Coastline Dynamics²

Coastlines are dynamic environments that are constantly changing under the influence of many factors, including natural processes and human activity. The impacts that factors have upon coastlines can vary significantly and may result in coastline changes that are abrupt and easy to see, as with bluff face failure, or discreet and gradual, as with lakebed erosion. Ultimately changes in bluff or beach shape depend on the feature's composition and how the feature handles various forms of water. Composition factors for coastal dynamics include geology, soil composition, and vegetation. Water factors for coastal dynamics, depicted in Figure 1.1, include Lake Michigan water levels, storms, stormwater runoff, and groundwater.

The potential impacts of coastline dynamics are contingent upon bluff and beach geology and soil composition, including glacial deposits. The properties of a coastline area's geology and soil influence the movement of stormwater and groundwater within that area and contribute to that area's resistance to variances in lake water levels and the erosive forces of waves. Soil properties also influence an area's ability to support different types of vegetation, which can stabilize the feature by intercepting precipitation, holding soil in place, and removing groundwater through transpiration. In addition, a bluff's soil composition affects its ability to hold its shape.

Lake Michigan water levels change at varying durations and water levels in the Great Lakes are primarily controlled by natural processes. Changes in Lake Michigan water levels occur seasonally, from year to year, and cyclically over decades, primarily due to changes in hydrology.³ Over the course of one year, Lake Michigan water levels undergo regular seasonal fluctuations, with levels typically at their lowest in fall/early winter and at peak levels in summer.⁴

Storm influences on Lake Michigan water levels can include the impact of high wind events, also called storm surge or seiche. Storm impacts can also be influenced by the Lake Michigan water level. During periods of low water levels, the waters retreat from coastline bluffs and beaches, allowing newly exposed bluffs and beaches to foster vegetation or grow through substrate addition (accretion). With shallower waters along the shoreline, wave energy also dissipates within the nearshore lakebed, which protects the beach and bluffs. When Lake Michigan water levels rise, the water encroaches upon the shoreline and creates deeper waters closer to lakeside bluffs. As result, wave energy increases along the shoreline and the bluff toe and portions of the bluff slope can become exposed to breaking waves.

1.2 NEED FOR COASTLINE MANAGEMENT GUIDELINES

Milwaukee County has a substantial interest in protecting County-owned assets along Lake Michigan. County-owned lakefront lands feature diverse, high-quality natural resources, support unique resource-oriented recreational opportunities, and provide access to exceptional views. As County-owned lakefront lands are also the site of municipally owned infrastructure, including storm sewers and outfalls, it is also in the County's interest to ensure that local governments can access and maintain such infrastructure in a manner that would not negatively impact County-owned coastline assets.

In the 1970s, high water levels in the Great Lakes caused widespread bluff recession and extensive damage to coastline property. The Wisconsin Coastal Management Program (WCMP) subsequently funded studies to identify areas susceptible to erosion and to examine potential structural and nonstructural approaches to mitigate coastline impacts.⁵ The studies, which indicated that structural erosion control

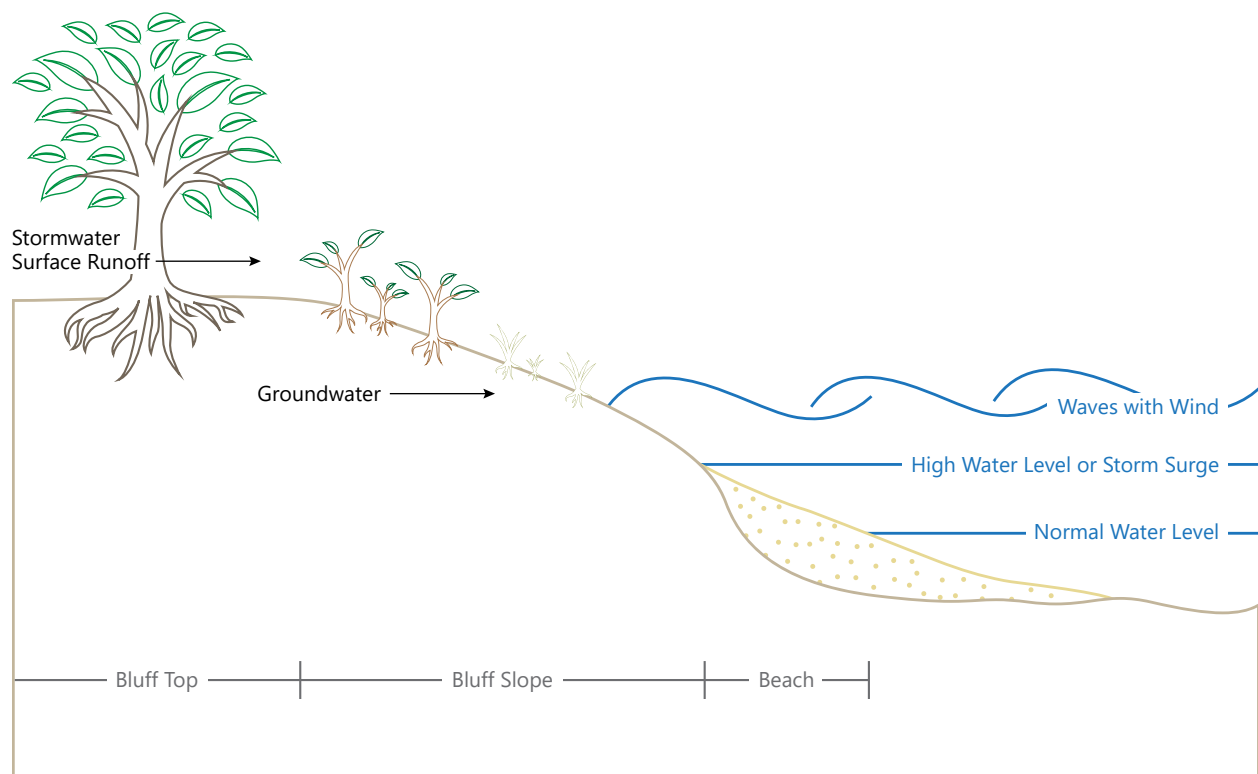
² Numerous references were used to summarize coastal dynamics, including *Community Assistance Planning Report No. 163, A Lake Michigan Shoreline Erosion Management Plan for Milwaukee County, Wisconsin (SEWRPC 1989)*; *Living with the Lakes (Gauthier and Manninen, 1999)*; *Living on the Coast (Keillor 2003)*; *Managing Coastal Hazard Risks on Wisconsin's Dynamic Great Lakes Shoreline (Luloff and Keillor 2016)*; and *Protecting Coastal Investments (Ohm 2016)*. Additional resources used to develop this report are listed in Appendix B.

³ The net water supply to a lake is positive when the sum of water contributors, including precipitation, tributary rivers or streams, and groundwater flows, is greater than the amount of water lost via evaporation and outflows.

⁴ See Appendix C for a historical depiction of such seasonal, annual, and cyclical changes in Lake Michigan water levels.

⁵ A.R. Luloff and P. Keillor, *Managing Coastal Hazard Risks on Wisconsin's Dynamic Great Lakes Shoreline, Wisconsin Coastal Management Program, 2016*.

Figure 1.1
Water-Related Components of Coastline Dynamics



Source: SEWRPC

strategies generally did not prove practical or effective, called for nonstructural preventative approaches to protect facilities, infrastructure, and new development from coastline impacts. Several Wisconsin communities initiated such nonstructural preventative approaches after high and record-breaking Great Lakes water levels in 1985 and 1986, which caused extensive flooding, shoreline erosion, and significant property damage.⁶ Subsequent studies found that nonstructural preventative approaches like guidelines for development and land and water management practices initiated by these communities effectively reduced the risk of coastline impacts.⁷

Water levels in the Great Lakes rose significantly again in 2019. As Lake Michigan water levels approached the lake's highest measured level, sections of bluffs along Milwaukee County's coastline collapsed. Bluff sloughs in Sheridan and Warnimont Parks carried away several trees and positioned infrastructure in the County-owned parks closer to the new bluff edge. These properties and others along Milwaukee County's lakefront are becoming increasingly vulnerable to coastline impacts. As indicated by the aforementioned studies and reports,⁸ lakefront property may be best protected from future coastline impacts through the implementation of coastline management guidelines based upon best practices as identified in previous studies and analyses.

⁶ K. Dolan and H. Hendrickson, *Protecting the Coastal Zone Through Growth Management: The Experience of Five Coastal States*, National Network for Environmental Management Studies, 1989.

⁷ International Joint Commission Levels Reference Study Board, *Levels Reference Study: Great Lakes-St. Lawrence River Basin—Annex 2: Land Use and Management*, 1993; National Research Council, *Managing Coastal Erosion*, 1990.

⁸ Including *Community Assistance Planning Report (CAPR) No. 155*, A Lake Michigan Shoreline Erosion Management Plan for Northern Milwaukee County, Wisconsin (1988); *CAPR No. 163*, A Lake Michigan Shoreline Erosion Management Plan for Milwaukee County, Wisconsin (1989); and *Memorandum Report No. 156*, Lake Park Bluff Stability and Plant Community Assessment: 2003, Milwaukee County, Wisconsin (2004).

1.3 PURPOSE

The purpose of this report is to establish a set of coastline management guidelines for Milwaukee County to utilize as follows:

- To maintain the unique coastline resources that support recreational opportunities within County-owned lakefront lands
- To proactively manage the risks that coastline impacts present to the public, to County-owned assets, and to other publicly owned infrastructure
- To mitigate adverse coastline impacts and protect County-owned assets adjacent to Lake Michigan
- To standardize and expedite the process by which the County responds to local government requests to conduct land-disturbing activities while managing municipally owned infrastructure within County-owned lakefront lands
- To address the interests of the public and owners of property in proximity to County-owned lakefront land in maintaining a view of Lake Michigan through County-owned land
- To prioritize programs and activities in a manner that accounts for the vulnerability and value of coastline resources and County-owned assets



Credit: Milwaukee County

2.1 INTRODUCTION

It is important to collect and collate sufficient amounts of pertinent information when devising strategies as part of a planning effort. Correspondingly, this report contains an inventory of numerous factors relevant to managing Milwaukee County's Lake Michigan coastline. As noted in Section 1 of this report, coastline areas are under the influence of numerous forces. Many of the factors and forces that influence the County's coastline are described within this inventory of natural resources and urban development. The Southeastern Wisconsin Regional Planning Commission maintains inventories of natural resources, land uses, and other existing conditions through the organization's regional planning programs. Critical inventory information for this Section came primarily from two reports prepared by the Regional Planning Commission: *A Lake Michigan Shoreline Erosion Management Plan for Northern Milwaukee County, Wisconsin*⁹ and *A Lake Michigan Shoreline Erosion Management Plan for Milwaukee County, Wisconsin*,¹⁰ which were developed with the purpose of assisting public and private lakefront property owners by providing more definitive information and proper guidelines and procedures for protecting property from shoreline erosion. Supplemental existing conditions inventoried for this report include an account of municipal coastline management strategies as well as National and State efforts and best practices related to coastline management. This section also sets forth a summary of the community input process undertaken for the development of this report and the results of that process.

2.2 EXISTING CONDITIONS

The geographical area inventoried for this report includes lands within the jurisdiction of nine municipalities that border Milwaukee County's Lake Michigan coastline. These municipalities include the Villages of Bayside, Fox Point, Shorewood, and Whitefish Bay and the Cities of Cudahy, Milwaukee, Oak Creek, St. Francis, and

⁹ SEWRPC Community Assistance Planning Report No. 155 (December 1988) was initiated upon the request of local communities within northern Milwaukee County.

¹⁰ SEWRPC Community Assistance Planning Report No. 163 (October 1989) was initiated upon Milwaukee County's request.

South Milwaukee. The study area utilized in this report, the Coastline Management Study Area, includes County-owned parcels located within 430 feet of the Milwaukee County Lake Michigan shoreline.¹¹

Lands along the County's Lake Michigan coastline feature some of the best remaining natural resources in the County—many of which are within County-owned lands—intermixed with assorted urban development. Correspondingly, coastline management techniques vary along the County's Lake Michigan coastline from maintaining relatively natural bluff slopes and beaches with set-back development to establishing highly armored development with man-made defenses at the water's edge. An inventory of elements, including natural resources; urban development; factors influencing coastline stability; and coastline management policies, zoning, and design guidelines, relevant to coastline management along Milwaukee County's Lake Michigan coastline follows.

Natural Resources Inventory

Bedrock Geology, Glacial Deposits, and Soils

Knowledge of bedrock geology, glacial deposits, and soils is important to land use and other public facility planning. Bedrock elevations along the Milwaukee County coastline¹² vary from 600 feet above sea level to fewer than 400 feet above sea level. The generalized depth to bedrock¹³ ranges from 50 to 300 feet along the Milwaukee County coastline.¹⁴ As the depth to bedrock varies, so does the thickness of glacial deposits covering the bedrock: expanses of the coastline where the bedrock is farthest from the land surface are filled with hundreds of feet of glacial deposits. The properties of glacial deposits, which influence the ability of bluffs to resist erosive processes, ultimately affect the severity and rate of bluff recession. Bluffs along the Milwaukee County coastline are largely composed of unconsolidated glacial till and glacial deposits consisting primarily of erodible sand and silt.

Like glacial deposits, soil properties also influence the ability of bluffs to withstand erosive force. Soil properties affect the rate and amount of stormwater runoff as well as the type of vegetative cover that the bluffs and coastline can support—thereby affecting the severity of surface erosion on the face, and at the top, of the bluffs. Glacial deposits and soil properties are also important considerations in the evaluation of shallow groundwater seepage from the bluff face, which can play a significant role in bluff stability.

Surface Water Resources

Surface water resources, which include lakes and streams, constitute a particularly valuable element of the natural resource base; such resources enhance the County's aesthetic quality, influence the County's physical development, and provide valuable recreational opportunities. The primary surface water feature relative to the Milwaukee County coastline is Lake Michigan, which makes up the entire eastern boundary of the County. The Lake Michigan shoreline through Milwaukee County, which measures approximately 32 miles in length, was an early focus for County parkland acquisition and the major focus of water-related activities in the County.

The State of Wisconsin holds navigable water in trust for the public under the Public Trust Doctrine. However, the State Legislature can authorize a lakebed grant through special legislation to convey defined areas of lakebed lands to specified local units of government for clearly defined public purposes, such as a park or beach or for navigation. Any facilities constructed on lakebed grant areas must be widely available to the public and support the primary purpose for which the State Legislature made the grant. As of 2015, the County had authority over the lakebed lands along approximately 22.5 linear miles of Milwaukee County's 32-mile Lake Michigan coastline.¹⁵

¹¹ *The Coastline Management Study Area, established using a similar approach to that of the Milwaukee County Coastal Resources Inventory (discussed later in this Section), is determined using the Milwaukee County shoreline as of 2015.*

¹² *Bedrock elevations for Southeastern Wisconsin are documented in SEWRPC Technical Report No. 37, Groundwater Resources of Southeastern Wisconsin (June 2002).*

¹³ *Generalized depth to bedrock in the Southeastern Wisconsin Region is documented in SEWRPC Technical Report No. 37, Groundwater Resources of Southeastern Wisconsin (June 2002).*

¹⁴ *It should be noted that actual depth-to-bedrock information for specific localities can only be verified by onsite drilling.*

¹⁵ *The City of Milwaukee has authority over 2.8 miles of Milwaukee County's Lake Michigan coastline and the State of Wisconsin maintains sole authority of the remaining 2.3 miles.*

As shown on Map 2.1, surface water resources also include minor natural and man-made lakes and ponds ranging from five to 49 acres in size,¹⁶ most of which are park lagoons within County-owned lands. The County's coastline area also features four major streams, or streams that maintain, at a minimum, a small continuous flow throughout the year—except under unusual drought conditions. These major streams include Oak Creek and the Kinnickinnic, Menomonee, and Milwaukee Rivers, which comprise a majority of Milwaukee County's parkway system.

Each of the major streams within the County's coastline area defines a major watershed, including the Oak Creek Watershed and the Kinnickinnic River, Menomonee River, and Milwaukee River Watersheds, and are tributary to Lake Michigan. Also tributary to Lake Michigan are the numerous smaller natural watercourses and artificial drainageways within localized catchment areas. Watersheds and tributaries play an important role in relation to coastlines: watershed drainage contributes to the particles in coastal waters that help supply beach materials, tributary waterways form gullies and ravines at the bluff edge, and runoff that flows directly into coastal waters can erode materials from coastline bluffs.

Surface waters are susceptible to degradation through improper land use development and management. Water quality can be degraded by excessive pollutant loads, including nutrient loads; from sanitary sewer overflows; and from construction and other urban runoff (e.g., sediment, road salt, heavy metals, oil, and trash).¹⁷ Surface water quality may also be adversely affected by the excessive development of riparian areas, streambank failure, the filling of wetlands,¹⁸ and by coastal beach and bluff erosion, which can contribute substantial amounts of sediment to coastal waters. Thus, it is important that existing and future development in riparian areas and wetland buffer areas be managed carefully to avoid further water quality degradation and to enhance the recreational and aesthetic values of surface water resources.

Floodplains

Floodplains are the wide, gently sloping areas contiguous to, and usually lying on both sides of, a stream or river channel, often containing wetlands. For planning and regulatory purposes, floodplains are normally defined as the areas adjacent to rivers, streams, and lakes that are inundated during the 1-percent-annual-probability (100-year recurrence interval) flood event. Floodplain areas often contain important natural resources, such as high-value riparian woodlands, wetlands, and refuges for wildlife, and, therefore, are compatible with nature-based uses for park and open space uses, such as hiking, bird watching, and nature study.¹⁹

Floodplain mapping for Milwaukee County was updated as part of a Federal Emergency Management Agency (FEMA) "Map Modernization Program." The updated maps were approved by the Wisconsin Department of Natural Resources (WDNR) and FEMA in 2008. Minor revisions were made to the maps in 2009. Map 2.1 depicts floodplains as identified in the FEMA mapping in 2009. As shown on the map, floodplains extend along the County's entire Lake Michigan coastline.

Wetlands

Wetlands are important resources for the ecological health and diversity of the County. They can support a significant diversity of flora and fauna and provide essential breeding, resting, and feeding grounds and escape cover for many forms of fish and wildlife. Wetlands trap sediments, nutrients, and other water pollutants, helping to protect water resources from siltation and pollution. In addition, wetlands naturally store excess runoff temporarily, contributing to the stabilization of lake levels and streamflows and flood mitigation by providing areas for floodwater impoundment and storage.

¹⁶ Major lakes, lakes of 50 acres or more, are typically part of a surface water resource inventory but there are no such lakes within Milwaukee County.

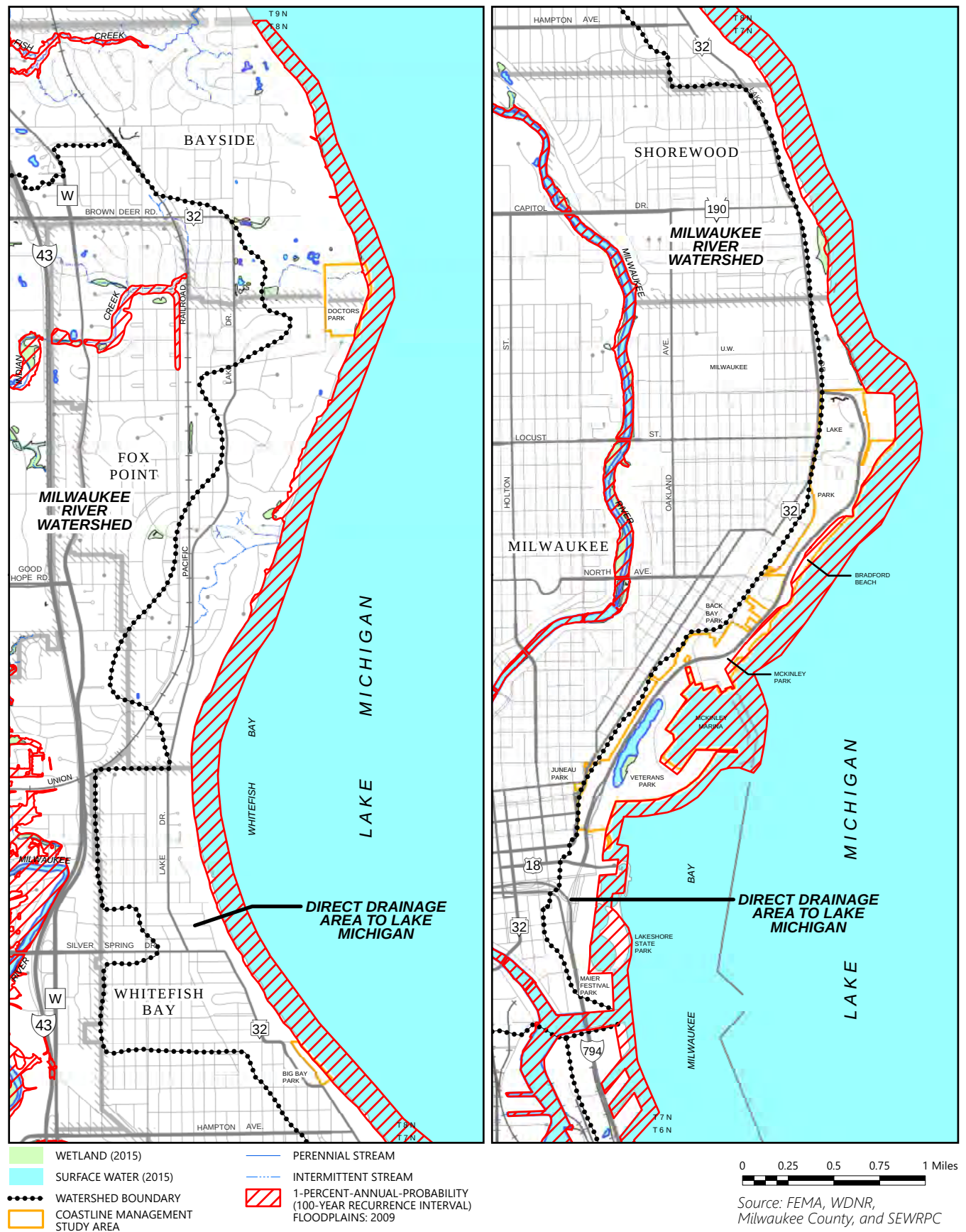
¹⁷ It may be noted that many park lagoons within County-owned lands are in an ecologically compromised state, suffering from excessive nutrients, sedimentation, aquatic invasive species, and low biological oxygen levels, which restricts recreational fishing opportunities.

¹⁸ The filling of wetlands removes valuable nutrient and sediment traps while adding nutrient and sediment sources.

¹⁹ Floodplain areas are generally not well suited to urban development, not only because of the flood hazard, but also because of the presence of high water tables and, generally, of soils poorly suited to urban uses.

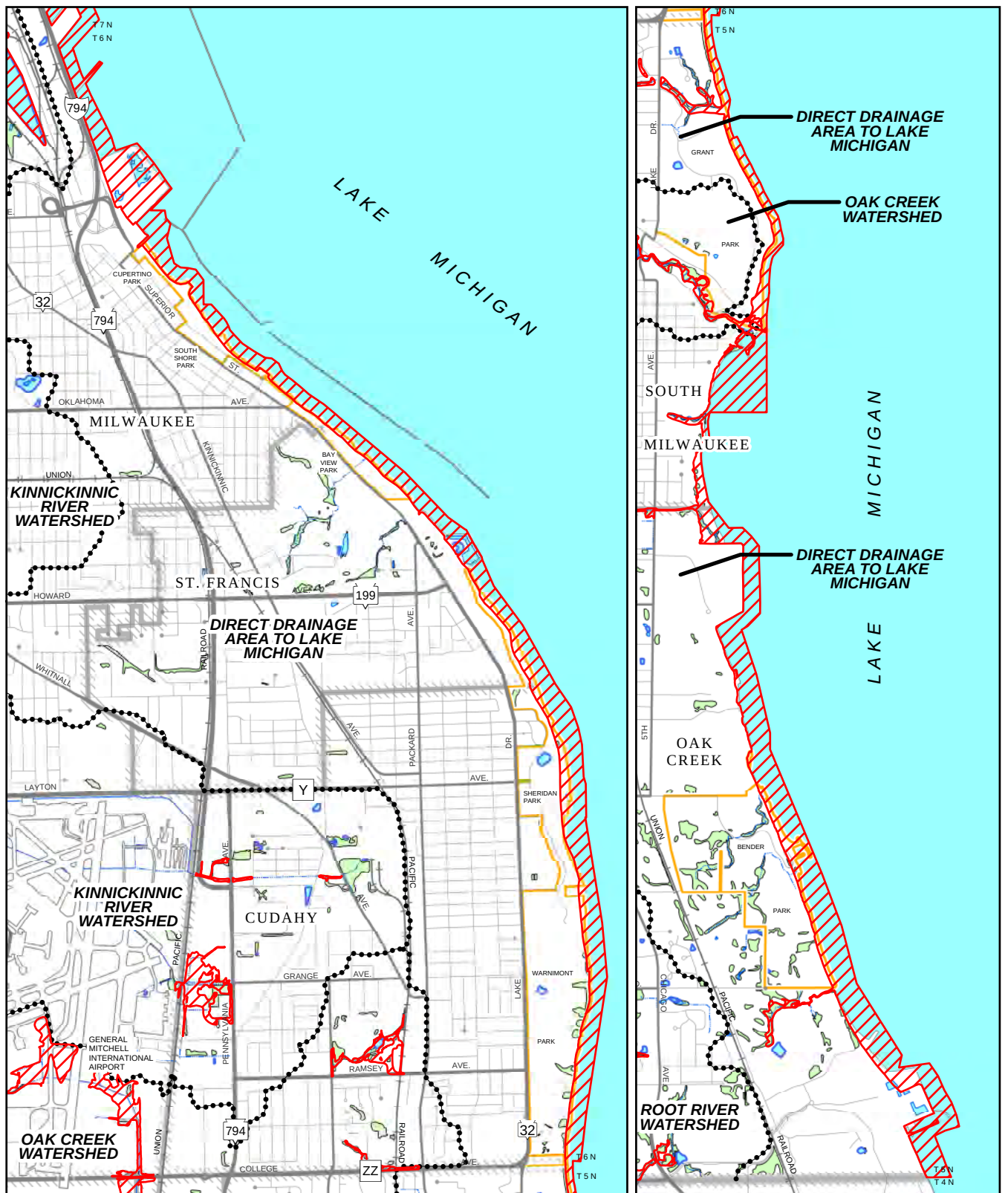
Map 2.1

Surface Waters, Wetlands, and Floodplains Along the Milwaukee County Lake Michigan Coastline



Map 2.1

Surface Waters, Wetlands, and Floodplains Along the Milwaukee County Lake Michigan Coastline



Additional advantages are provided by coastal wetlands, which are differentiated by their location alongside a waterbody. Great Lakes coastal wetlands can help to protect the coastline and coastline properties. As wave energy dissipates within vegetated coastal wetlands, the coastline may be protected from potentially erosive damage associated with storm surges and high water levels.

Map 2.1 shows the location and extent of wetlands in the County,²⁰ including coastal wetlands, in 2015. Numerous permanent wetland types²¹ are found within County-owned parks, one of which—the Warnimont Bluff Fens in Warnimont Park—has been designated a “Wetland Gem” by the Wisconsin Wetland Association.²²

Groundwater Resources

Surface water and groundwater are interrelated components of a single hydrologic system. In Milwaukee County, groundwater resources often provide the base flow of streams and sustain wetland and surface water levels. Groundwater resources also serve to moderate water temperatures, promote water quality, and support fish and aquatic life habitat. As groundwater is susceptible to deterioration in quality and to depletion in quantity as a result of contamination and overuse, the protection of this valuable resource is an important consideration for any land use planning and policy development effort.

Along the Milwaukee County coastline, groundwater generally flows toward the lake and discharges into Lake Michigan either at, or below, the base of the bluff, or seeps out of the bluff face at some elevation above the Lake’s water level. While groundwater inflow represents an important portion of the total water budget of Lake Michigan, the occurrence, distribution, direction, and quantity of groundwater flow impact the stability of bluff slopes. As certain unconsolidated glacial deposits within the study area may act as water-bearing units, the presence of groundwater and seepage pressure in the direction of groundwater flow can add weight to the bluff and reduce the frictional resistance of the bluff to stress forces thereby reducing bluff slope stability.

Woodlands

Woodlands are defined as those upland areas one acre or more in size having 17 or more deciduous trees per acre, each measuring at least four inches in diameter at breast height, and having 50 percent or more tree canopy coverage.²³ Under good management, woodlands can serve a variety of beneficial functions, including reducing heat islands and improving air and water quality. Woodlands provide an attractive natural resource, immeasurable scenic beauty, and recreational opportunities. In addition, woodlands contribute to sustaining a diversity of plant and animal life by providing flora and fauna habitat.

As shown in Map 2.2, woodlands occur in scattered locations throughout the Coastline Management Study Area. Existing woodlands in the County, many of which required a century or more to develop, could be destroyed through mismanagement or by invasive species within a comparatively short time period. The destruction of woodlands along hillsides, ravines, and bluff areas contributes to rapid stormwater runoff, the sedimentation of lakes and streams, bluff failure, and the destruction of wildlife habitat.

Bluffs and Ravines

Bluffs and the ravine systems that cut through the bluffs adjacent to Lake Michigan make up regionally rare ecological and landscape features. Bluffs and ravines create unique microclimates that allow more northerly orientated species of flora and fauna to persist farther south in Wisconsin than is typical for the rest of the State. It has been well documented that Milwaukee County falls within Wisconsin’s Ecological Tension Zone, an area of mixing for northern and southern ecosystems, due to the presence of Lake Michigan and its ability to moderate local climate conditions. The majority of the ravines in the County are located within the following County-owned parks: Bender, Doctors, Grant, Lake, and Warnimont Parks. These parks, along with Bay View and Sheridan Parks, also contain the largest and tallest bluffs in the County.

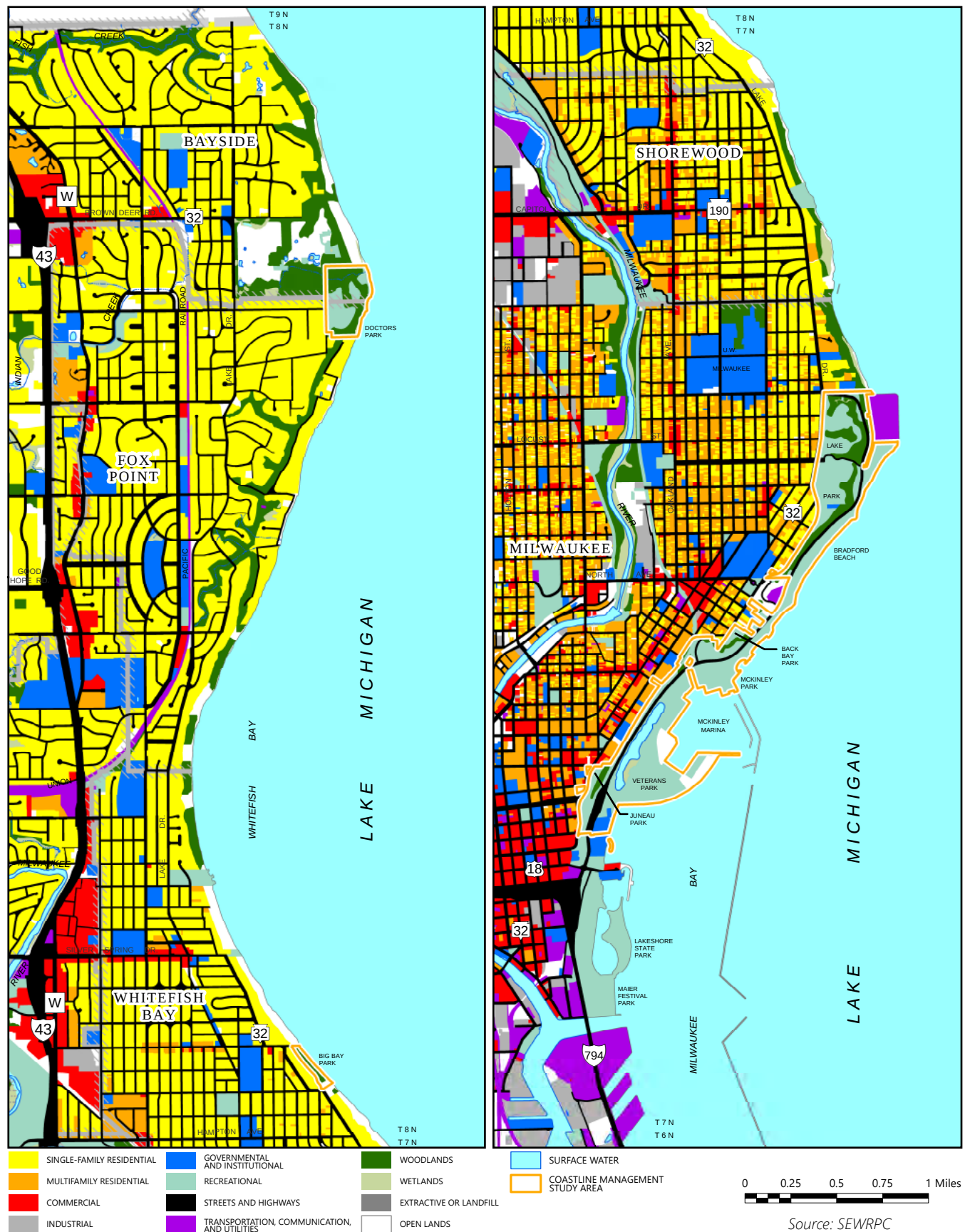
²⁰ As delineated by the Southeastern Wisconsin Regional Planning Commission (SEWRPC).

²¹ As defined by the Wisconsin Department of Natural Resources (WDNR).

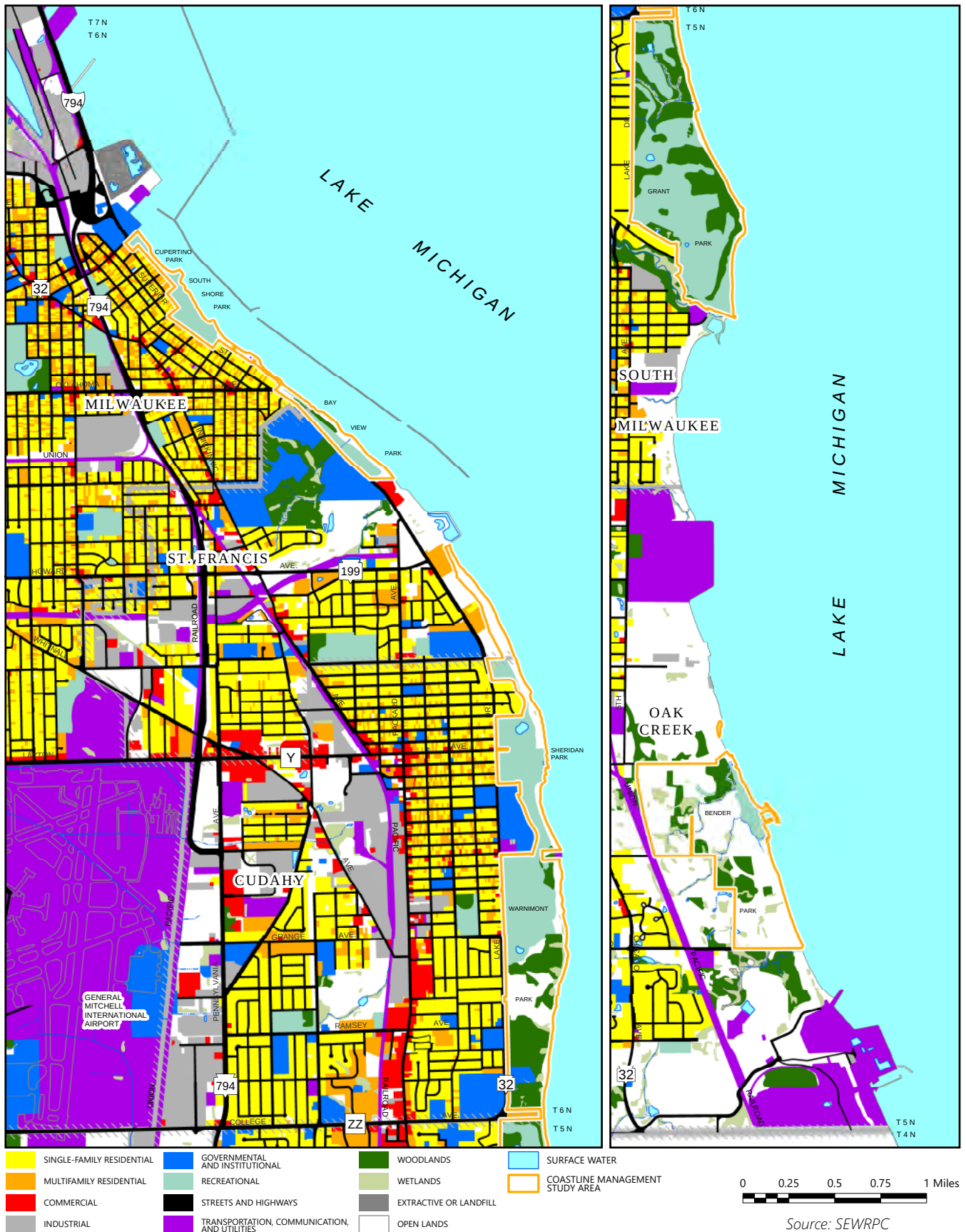
²² “Wetland Gems” are considered to be critically important to the State’s biodiversity.

²³ Coniferous tree plantations and reforestation projects are also classified as woodlands.

Map 2.2
Generalized Land Use Within Milwaukee County: 2015



Map 2.2
Generalized Land Use Within Milwaukee County: 2015



The bluffs along Milwaukee County's Lake Michigan coastline exhibit a variety of height, slope, composition, vegetative cover, and groundwater conditions, which affect the degree and rate of bluff recession. Field surveys conducted to measure the geometry of the bluff slope in 1995²⁴ indicated that bluff heights along the Milwaukee County coastline ranged from approximately 25 feet to 140 feet. Bluffs within the northern and southern extents of the County were higher than the central portion of the County, where conditions ranged from the absence of natural bluffs to bluffs of up to 25 feet in height.

While bluffs and ravines define and shape the coastline, they are also natural features that are continually changing under the influence of natural forces such as wind and water. Various factors that contribute to bluff and ravine erosion include wave action, groundwater seepage, precipitation runoff, lake level elevation, freeze-thaw action, lake ice movement, and the type of vegetative cover. Ravines incorporated into municipal infrastructure systems, which aggregate and convey stormwater within a watershed to a nearby waterbody, and bluffs with stormwater outfalls, where stormwater is deposited in a nearby waterbody, are particularly susceptible. As stormwater systems efficiently convey large volumes of water through ravines and along bluffs, stormwater runoff and ravine water volumes increase with increases in impervious surfaces due to urban development and exacerbate erosion.

Natural Areas, Critical Species Habitat Sites, and Geological Sites

Natural and geological resources in the Region are inventoried by the Southeastern Wisconsin Regional Planning Commission as part of the regional natural areas and critical species habitat protection and management planning program.²⁵ The comprehensive inventory systemically identifies high-quality natural areas, critical species habitat sites, and sites having geological significance as defined by the Regional Planning Commission. Natural areas, critical species habitat sites, and significant geological sites along Milwaukee County's Lake Michigan coastline as of 2009 are shown on Map 2.3. This inventory is likely to grow to reflect additional occurrences of endangered or threatened species or species of special concern²⁶ that were documented within County-owned parks during extensive surveys conducted by Milwaukee County Parks staff since 2010.

Natural Areas

Natural areas are tracts of land or water so little modified by human activity, or sufficiently recovered from the effects of such activity, that they contain intact native flora and fauna communities believed to be representative of the landscape before European settlement. Natural areas are classified into one of three categories: natural areas of statewide or greater significance (NA-1), natural areas of countywide or regional significance (NA-2), and natural areas of local significance (NA-3).²⁷ Natural areas along Milwaukee County's Lake Michigan coastline as of 2009, which together encompassed 185 acres, are listed in Table 2.1.

Critical Species Habitat Sites

Critical species habitat sites are sites located outside of natural areas where the chief value lies in the site's ability to support rare, threatened, or endangered species. Such sites constitute critical habitat that is important to ensure survival of a particular species or group of species of special concern. Critical species habitat sites along Milwaukee County's Lake Michigan coastline as presented in the 2009 update to regional natural areas plan are depicted on Map 2.3 and listed in Table 2.1.

Aside from sites identified under the regional natural areas planning program, additional significant habitat resources have also been identified within County-owned park and open space sites. Such sites are notable for supporting "species of greatest conservation need" for at least a portion of their lifecycles. As classified

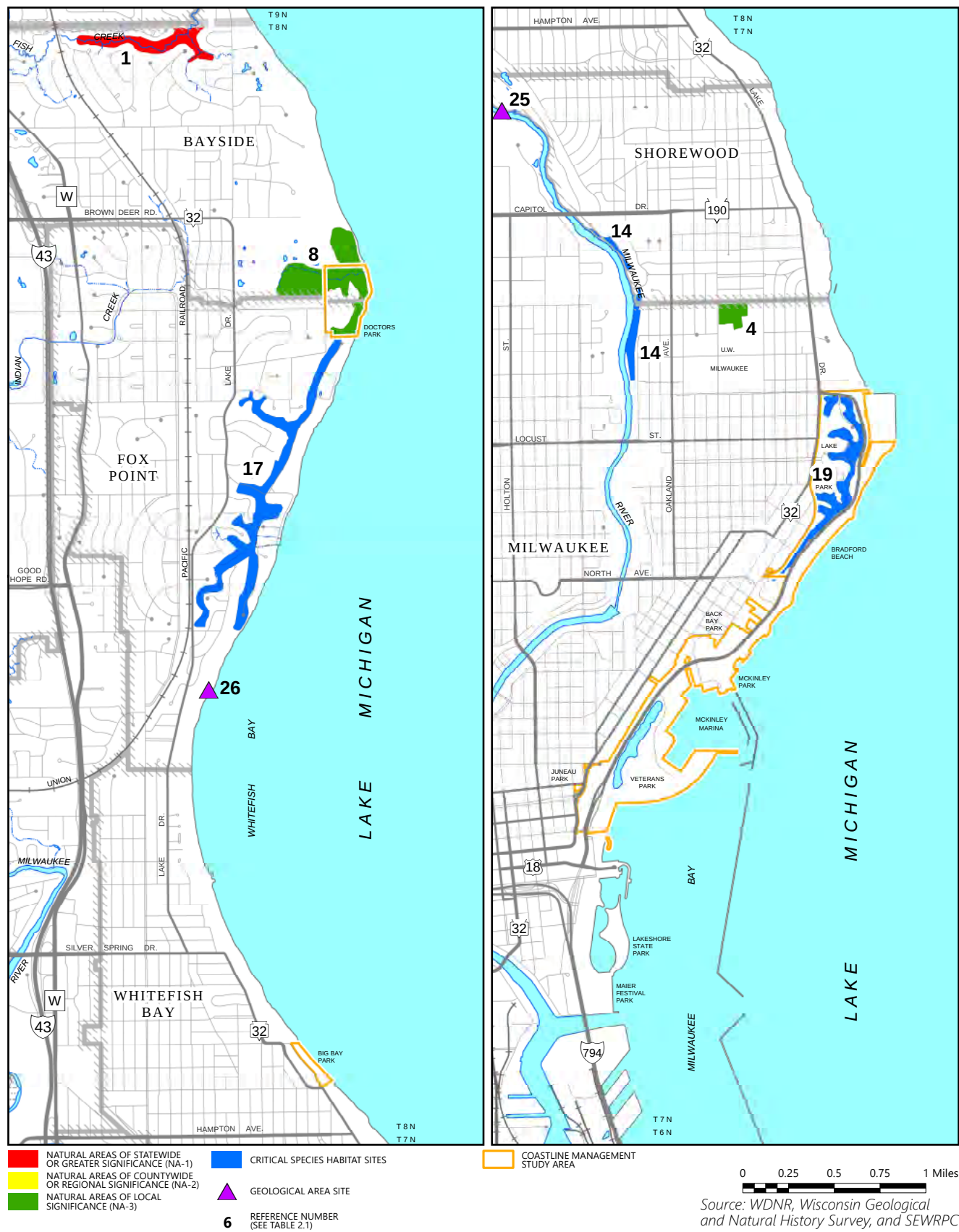
²⁴ Conducted at 192 sites to provide a basis for site-specific assessments of the bluff conditions as part of SEWRPC Technical Report No. 36, Lake Michigan Shoreline Recession and Bluff Stability in Southeastern Wisconsin: 1995.

²⁵ SEWRPC's inventory of natural and geological resources was initially conducted in 1994 and updated in 2009 as part of the regional natural areas and critical species habitat protection and management plan.

²⁶ As listed by the State of Wisconsin or the Federal government.

²⁷ Classification of an area into one of these three categories is based upon consideration of the diversity of plant and animal species and community types present; the structure and integrity of the native flora and fauna community; the extent of disturbance from human activity, such as logging, agricultural use, and pollution; the commonness of the plant and animal community; unique natural features; the size of the site; and the educational value of the site.

Map 2.3
Natural Areas, Critical Species Habitat Sites, and Significant Geological Sites
Along the Milwaukee County Lake Michigan Coastline: 2009



Map 2.3

Natural Areas, Critical Species Habitat Sites, and Significant Geological Sites Along the Milwaukee County Lake Michigan Coastline: 2009

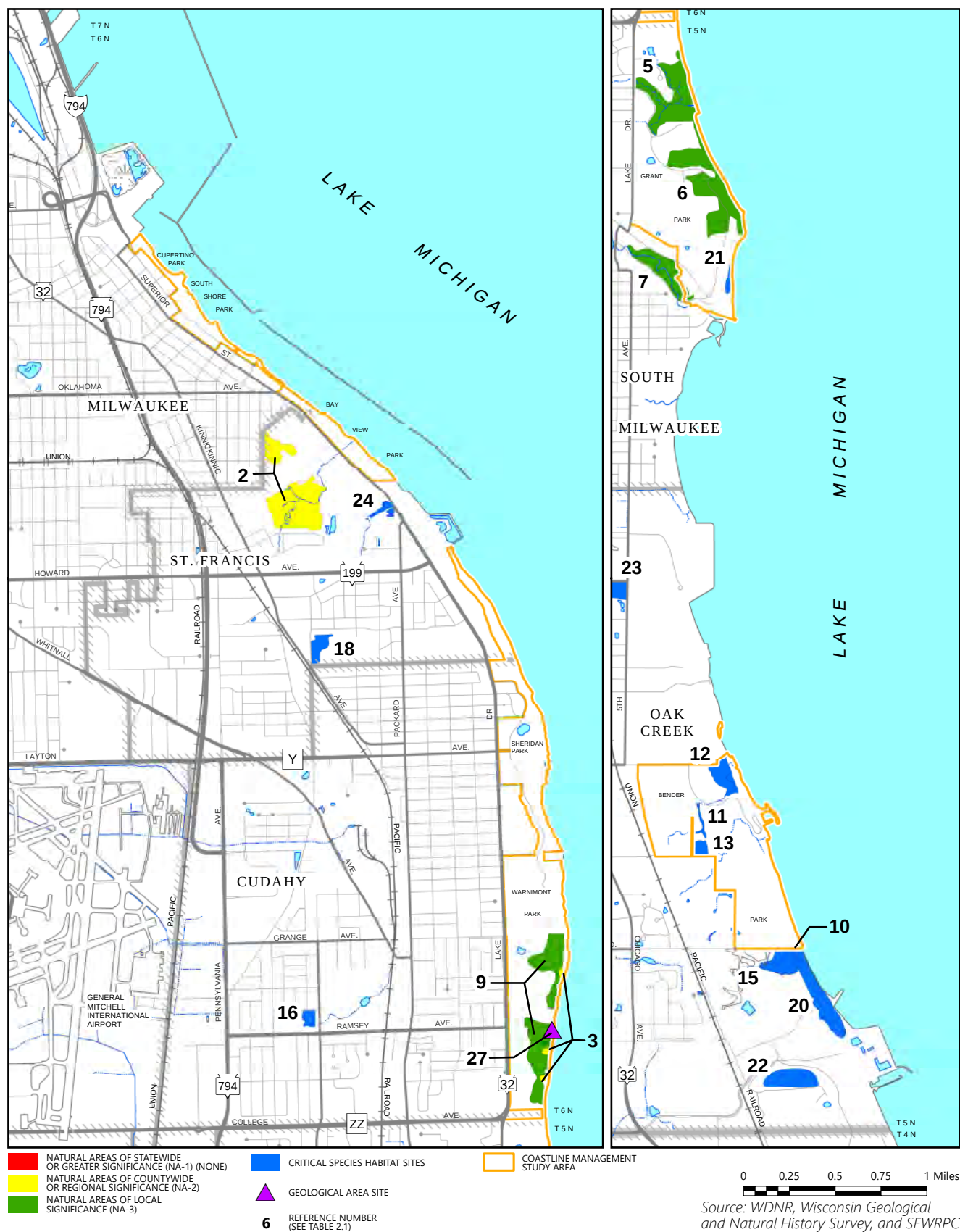


Table 2.1
Natural Areas, Critical Species Habitat Sites, and Significant Geological Sites
Along the Lake Michigan Coastline: 2009

Natural Areas		
Number on Map 2.3	Site Name	Size (acres)
NA-1		
1	Fairy Chasm State Natural Area	33
Total		33
NA-2		
2	St. Francis Seminary Woods	52
3	Warnimont Park Fens	2
Total		54
NA-3		
4	Downer Woods	11
5	Grant Park Woods - Old Growth	42
6	Grant Park Woods - South	45
7	Oak Creek Parkway Woods	24
8	Schlitz Audubon Center/Doctors Park Woods and Beach	72
9	Warnimont Park Woods	47
Total		241
Total Natural Areas		328
Critical Species Habitat Sties		
Number on Map 2.3	Site Name	Size (acres)
10	Bender Clay Banks and Ravine - South	2
11	Bender Park Stream and Meadow	2
12	Bender Park Woods - North	11
13	Bender Park Woods - South	5
14	Cambridge Avenue Woods	17
15	Clay Ravine Woods	12
16	Cudahy Park Woods	4
17	Fox Point Bluffs and Ravines	93
18	Greene Park Woods	7
19	Lake Park Woods	46
20	Oak Creek Bluffs and Beach - South	24
21	Oak Creek Bluffs and Beach-North	4
22	Oak Creek Power Plant Woods	16
23	Schmidt/Johnson Woods	6
24	Trestle Ravine Woods	3
Total		252
Significant Geological Sites		
Number on Map 2.3	Site Name	Classification
25	Estabrook Park - Lincoln Park Area	38
26	Whitefish Bay Shore Exposure	2
27	Warnimont Park Clay Banks	16
Total		56

Source: Wisconsin Department of Natural Resources, Wisconsin Geological and Natural History Survey, and SEWRPC

by the WDNR, species of greatest conservation need are species with low abundance and/or distribution within their natural range as well as declining species that demonstrate downward trends in their populations or habitat even though they may currently be well distributed, common, or abundant in part or all of their range. The WDNR lists species of greatest conservation need in the State-wide wildlife action plan.²⁸

Flora and Fauna Resources

County-owned parks play a major role as a repository for Milwaukee County's remaining biodiversity. Extensive surveys conducted by Milwaukee County Parks staff have documented numerous flora and fauna species of concern using resources within County-owned parks. As the surveys have only been conducted for 30 percent of eligible areas, additional flora and fauna species may have yet to be documented using resources within County-owned parks. Without the proper management of such areas and the resources within them, or with the loss of buffer lands around those areas, many species of flora and fauna could become more vulnerable to genetic isolation, ecological degradation, and, ultimately, local extinction.

Significant Geological Sites

Significant geological sites are identified on the basis of scientific importance, significance in industrial history, natural aesthetics, ecological qualities, educational value, and public access potential. Sites of geological importance are classified as being of statewide significance (GA-1), of countywide or regional significance (GA-2), or of local significance (GA-3). Significant geological sites identified along the Milwaukee County coastline as of 2009 are shown on Map 2.3 and listed in Table 2.1.

Environmental Corridors and Isolated Natural Resource Areas

Identifying areas in which concentrations of the best remaining elements of the natural resource base occur is one of the most important tasks the Commission carries out under the regional planning program. These important, high-value elements of the natural resource base, many of which are described in preceding parts of this inventory, include rivers, streams, lakes and associated riparian buffers and floodplains; wetlands; woodlands; prairies; wildlife habitat areas; wet, poorly drained, and organic soils; and rugged terrain and high relief topography. The presence of natural resource-related features, including park and open space sites, natural areas, historic sites, and scenic viewpoints, are also considered in distinguishing such areas. When distinguished on a map, these natural resource and resource-related elements form an essentially linear pattern of relatively narrow and elongated areas that have been termed "environmental corridors" by the Regional Planning Commission. Environmental corridors and isolated natural resource areas along Milwaukee County's Lake Michigan coastline are shown on Map 2.4.

Environmental corridors and isolated natural resource areas and the resources that they contain serve many beneficial purposes. Lands within environmental corridors and isolated natural resource areas can serve to store flood waters away from developed areas and promote water quality by filtering runoff before it enters surface waters. Such lands also provide wildlife habitat and dispersal corridors for the movement of wildlife.²⁹ Environmental corridors and isolated natural resource areas contribute to the natural heritage and beauty of the Region and provide recreational opportunities in scenic outdoor settings. The preservation of such areas in essentially natural, open uses is vital to maintaining a high level of environmental quality and quality of life in the Region.

Environmental Corridors

Environmental corridors contain concentrations of important, high-value natural resource elements that often form a linear pattern of relatively narrow, elongated areas in the landscape. Primary environmental corridors, which contain a variety of the aforementioned elements and natural resource-related features, are at least 400 acres in size, two miles in length, and 200 feet in width.³⁰ Significant portions of Milwaukee

²⁸ Wisconsin Department of Natural Resources, *Wisconsin Wildlife Action Plan: 2015-2025*, 2015.

²⁹ As noted in the 1989 Lake Michigan shoreline erosion management plan for Milwaukee County, many of the bluffs, parks, and other open areas along the County's coastline constitute significant wildlife habitat areas—providing important habitat for migrating birds along the Mississippi flyway.

³⁰ As of 2015, the study area did not contain any secondary environmental corridors, which contain concentrations of important, high-value natural resource elements and have significant environmental and recreational value like primary environmental corridors but are smaller in area—encompassing at least 100 acres in size and one mile in length.

Map 2.4
Environmental Corridors and Isolated Natural Resource Areas
Along the Milwaukee County Lake Michigan Coastline: 2015



Map 2.4
Environmental Corridors and Isolated Natural Resource Areas
Along the Milwaukee County Lake Michigan Coastline: 2015



County's Lake Michigan coastline are classified as a primary environmental corridors.³¹ These primary environmental corridors contain a composite of some of the County's best remaining woodlands, wetlands, and wildlife habitat areas—and have immeasurable environmental and recreational value.

Isolated Natural Resource Areas

Isolated natural resource areas also contain concentrations of important, high-value natural resource elements albeit within a smaller area than an environmental corridor. Isolated natural resource areas range from five to 100 acres in size and are physically separated from primary environmental corridors. Isolated natural resource areas may provide the only available wildlife habitat within the vicinity, lend natural diversity and aesthetic character, and serve as good locations for park or open space uses. Isolated natural resource areas along Milwaukee County's Lake Michigan coastline include a variety of isolated wetlands, woodlands, and wildlife habitat areas.

Urban Development Inventory

The significant value of Milwaukee County's Lake Michigan coastline extends well-beyond the extents of the study area. The coastline provides a unique setting for development and opportunities that attract users from throughout the greater Milwaukee area. The County's Lake Michigan coastline is of enormous value in regards to both the economy and quality of life within Milwaukee County and the Southeastern Wisconsin Region. It is therefore important to take into account how coastline management can be implemented to maintain a desirable and usable shoreline for private property owners as well as for the general public.

Land Use

Urban development along Milwaukee County's Lake Michigan coastline was initially devoted primarily to handling waterborne commerce, with later coastline development for boating facilities, residential use, industrial use, and park and open space. As shown on Map 2.2, which depicts generalized land use³² along the Milwaukee County coastline, the most prevalent land uses as of 2015 were residential uses, open space, recreational uses, and woodlands. Residential uses in proximity to the County's Lake Michigan boundary are primarily single-family and are concentrated within the northern and southern extents of the County within the Villages of Bayside, Fox Point, Shorewood, and Whitefish Bay and the Cities of Cudahy and South Milwaukee. Multi-family residential uses are concentrated within the Cities of Milwaukee and St. Francis.

As previously noted, intermixed with urban development along Milwaukee County's Lake Michigan coastline are some of the best remaining natural resources in the County—many of which are within County-owned park and open space sites. County-owned parks account for a significant proportion of the recreational lands along Milwaukee County's Lake Michigan border. These parklands include approximately 382 acres within Lake Michigan North, a cluster of parks comprised of Back Bay, Bradford Beach, and Juneau, Lake Park, McKinley, and Veterans Parks; approximately 856 acres within Lake Michigan South, which is comprised of Bay View, Cupertino, Grant, Sheridan, South Shore, and Warnimont Parks; as well as additional scattered County-owned parks, including Big Bay Park, Bender Park, and Doctors/Tietjen Park, which together amount to approximately 367 acres.

Infrastructure

Port Milwaukee

Port Milwaukee is a County-owned multi-modal transportation and distribution center located near the confluence of the Kinnickinnic, Menomonee, and Milwaukee Rivers that supports domestic and international supply chains. The Port features a total of 18 berths to serve vessels and barges, direct connections to Interstate Highway 794/94 (IH 794/IH 94) and to the Union Pacific (UP) and Canadian Pacific (CP) Railways, and is the only Lake Michigan port Federally approved to access the Mississippi River inland waterway system. In 2020, the Port handled approximately 2.3 million metric tons of cargo, playing a significant role in supporting the local, regional, and State economy.

³¹ Other areas classified as primary environmental corridors in Milwaukee County—many of which are within County-owned park and open space sites—are located along major rivers and their tributaries and in large wetland areas.

³² The 2015 land use inventory is generalized to account for differences in the land use categories used by the nineteen municipalities with the County.

Coastline dynamics can have significant direct impacts on Port operations. Water levels are an important consideration for Port operations. Cargo restrictions may be required during low water levels in order to ensure that berths can service vessels. High water levels can expose berths, terminals, other Port infrastructure, vessels, and cargo to damage from flooding, the extent of which can be drastically increased during periods of stronger wave action and/or extreme weather events.

Stormwater Infrastructure

Numerous communities along Milwaukee County's coastline utilize stormwater drainage systems designed to efficiently carry large amounts of stormwater that discharge into Lake Michigan. In such cases, precipitation and other runoff intercepted from impervious surfaces is directed into stormwater sewer systems that discharge into the Lake via outfalls located along the coastline.

Stormwater infrastructure that discharges into the Lake can be potentially damaging to the coastline and is susceptible to damage from coastline impacts. Negative impacts from such outfalls include declines in water quality and erosion. These impacts can be exacerbated during periods of heavy rainfall as high amounts of stormwater, the volume of which fluctuates with the amount of precipitation collected in a stormwater system, may be conveyed and discharged over relatively short time spans. Increases in water volume and speed can significantly increase the erosive impact of stormwater discharge. In addition, stormwater infrastructure can be susceptible to potential damage from coastline impacts particularly as result of high water levels in the Lake. High lake levels can flood an outfall and cause debris to enter stormwater infrastructure, or subject stormwater infrastructure to damage from erosion around outfalls. The general locations of outfalls in Milwaukee County that discharge into Lake Michigan are shown on Map 2.5.

Historic Sites and Districts

The City of Milwaukee and municipalities to the north contain residential uses that are designated as historic sites and/or exist within a historic district.³³ These sites and districts are shown on Map 2.6 and listed on Table 2.2. Historic sites and districts within the Lake Michigan Coastline Management Area often have important recreational, educational, and cultural value. Preserving these sites and districts helps to retain historic elements that give an area a distinctive identity and may provide tangible benefits, such as stabilizing property values and encouraging overall neighborhood improvement. It is important that coastline protection measures are sensitive to historic considerations in order to avoid adversely affecting the aesthetic qualities, vistas, and coastline uses historically and traditionally enjoyed by area residents.

Current Coastline Stabilization Activities and Practices

National and State Coastline Management Efforts

The U.S. Army Corps of Engineers (USACE), which has been involved in civil works projects in the Nation's coastal zones since its establishment in 1802, began conducting research on coastal processes in 1930.³⁴ Since formalizing the Federal government's role in unifying and coordinating the coastal management efforts of multiple states with coastal resources, USACE has become a leading environmental preservation and restoration agency that maintains a rigorous research and development program in support of water resources. USACE's Chicago District now has jurisdiction for Wisconsin's entire Great Lakes coastline, providing technical expertise and assistance to address coastline impacts like erosion and flooding.

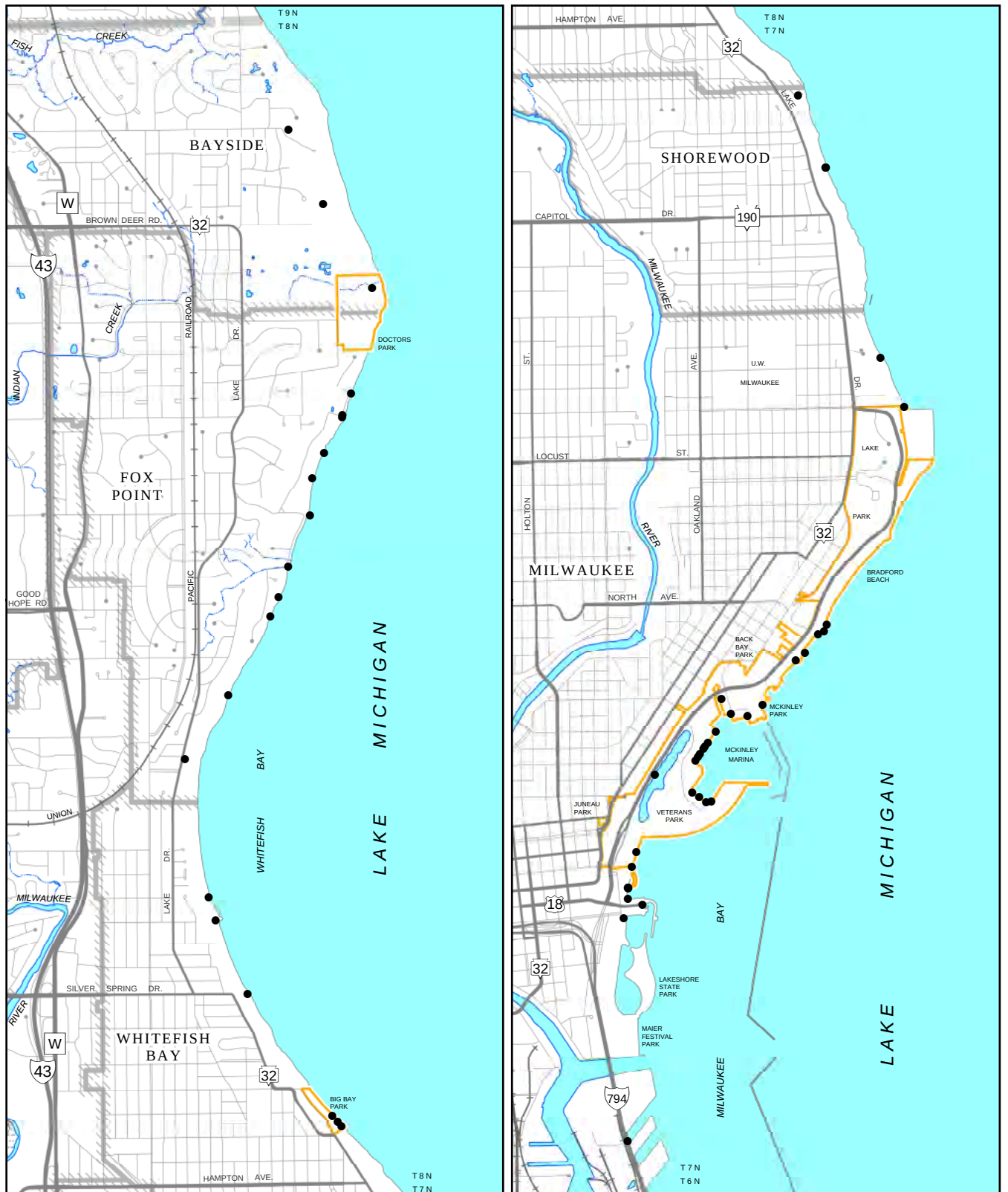
Passage of the Coastal Zone Management Act in 1972 established the National Coastal Management Program (NCMP), whose mission is to ensure the conservation and responsible use of the Nation's coastal resources. The voluntary program instituted a means by which states with coastal resources (including Great Lakes states), local governments, and other partners may access Federal funding for implementing coastal management programs. State and local governments and other partners meeting basic requirements are given the flexibility to design unique programs that best address their coastal challenges. The program encourages partnering governments and organizations to develop and implement coastal zone management

³³ *A historic site is a property that was the location of a significant event, activity, building, structure, or archaeological resource; a historic district is a geographically definable area possessing a significant concentration, linkage, or continuity of sites, buildings, or structures that are united by plan or by physical development.*

³⁴ *J.R. Houston, Coastal Engineering Research in the Corps of Engineers. Journal of Coastal Research, Vol. 4, No. 2 (Spring 1988).*

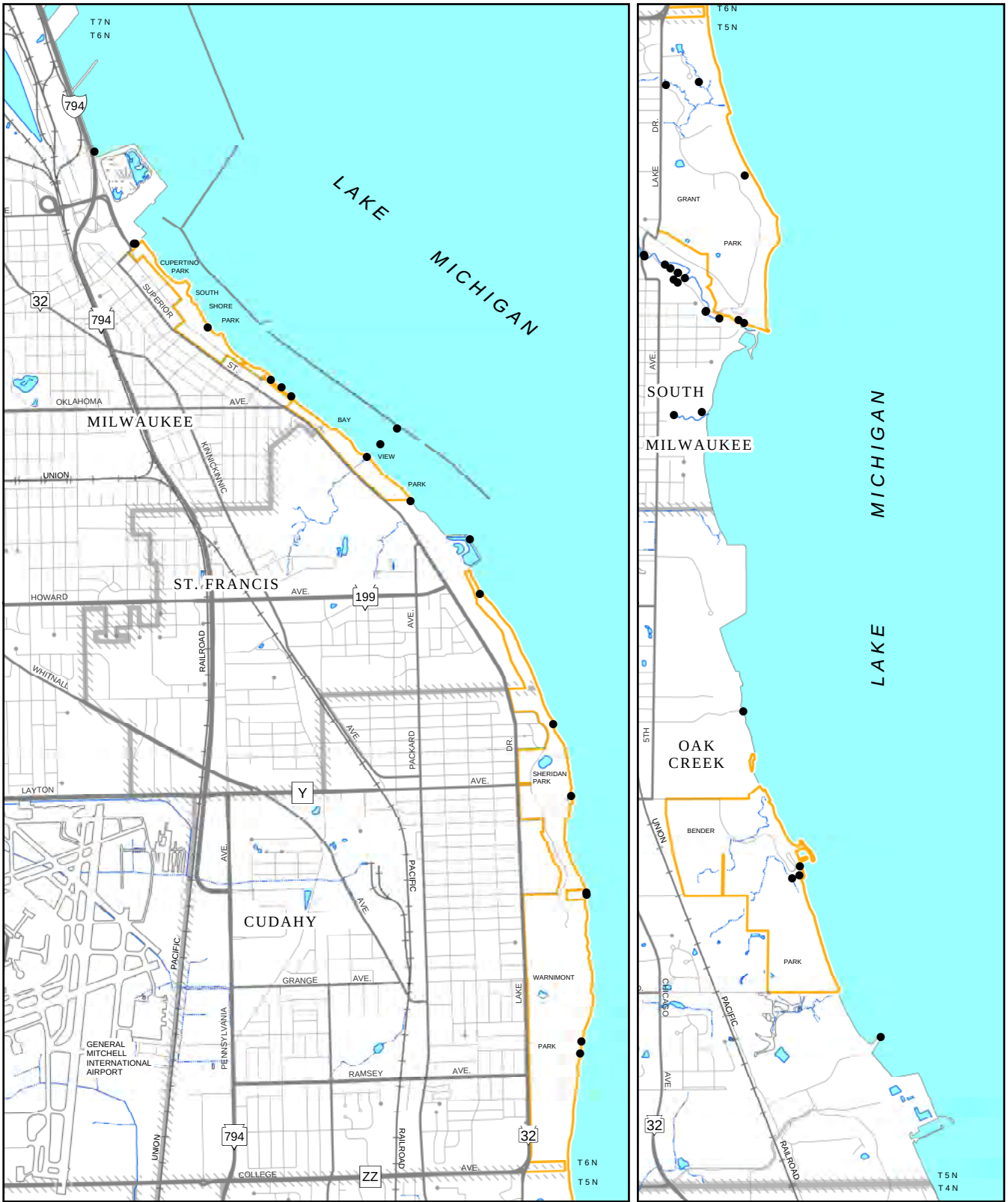
Map 2.5

Stormwater Outfalls Along the Milwaukee County Lake Michigan Coastline



Source: Milwaukee County Municipalities, Milwaukee County, Wisconsin Coastal Management Program, and SEWRPC

Map 2.5
Stormwater Outfalls Along the Milwaukee County Lake Michigan Coastline



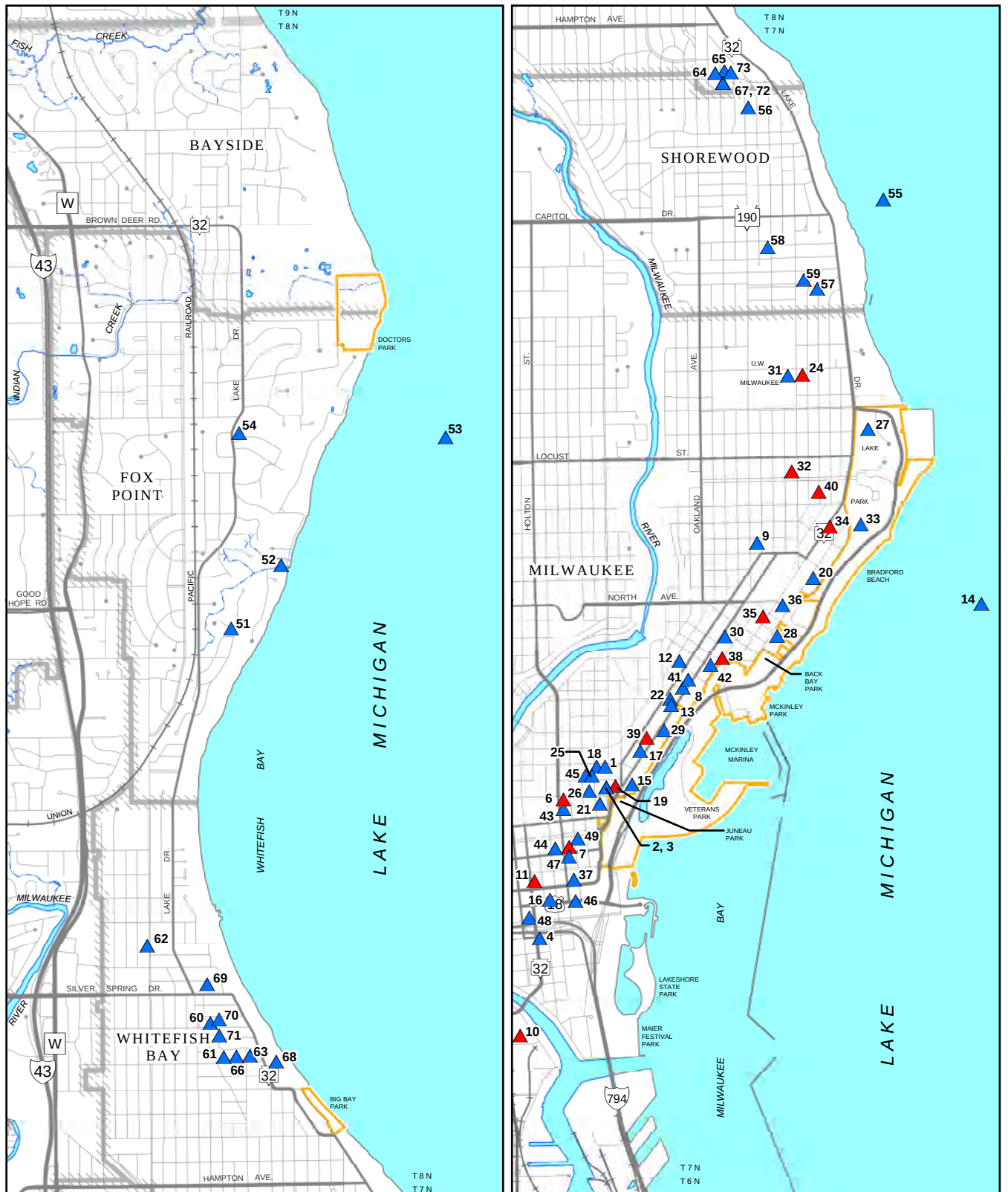
- STORMWATER OUTFALL
- ▭ COASTLINE MANAGEMENT STUDY AREA

0 0.25 0.5 0.75 1 Miles

Source: Milwaukee County Municipalities, Milwaukee County, Wisconsin Coastal Management Program, and SEWRPC

Map 2.6

Historic Sites and Districts Along the Milwaukee County Lake Michigan Coastline



Map 2.6
Historic Sites and Districts Along the Milwaukee County Lake Michigan Coastline

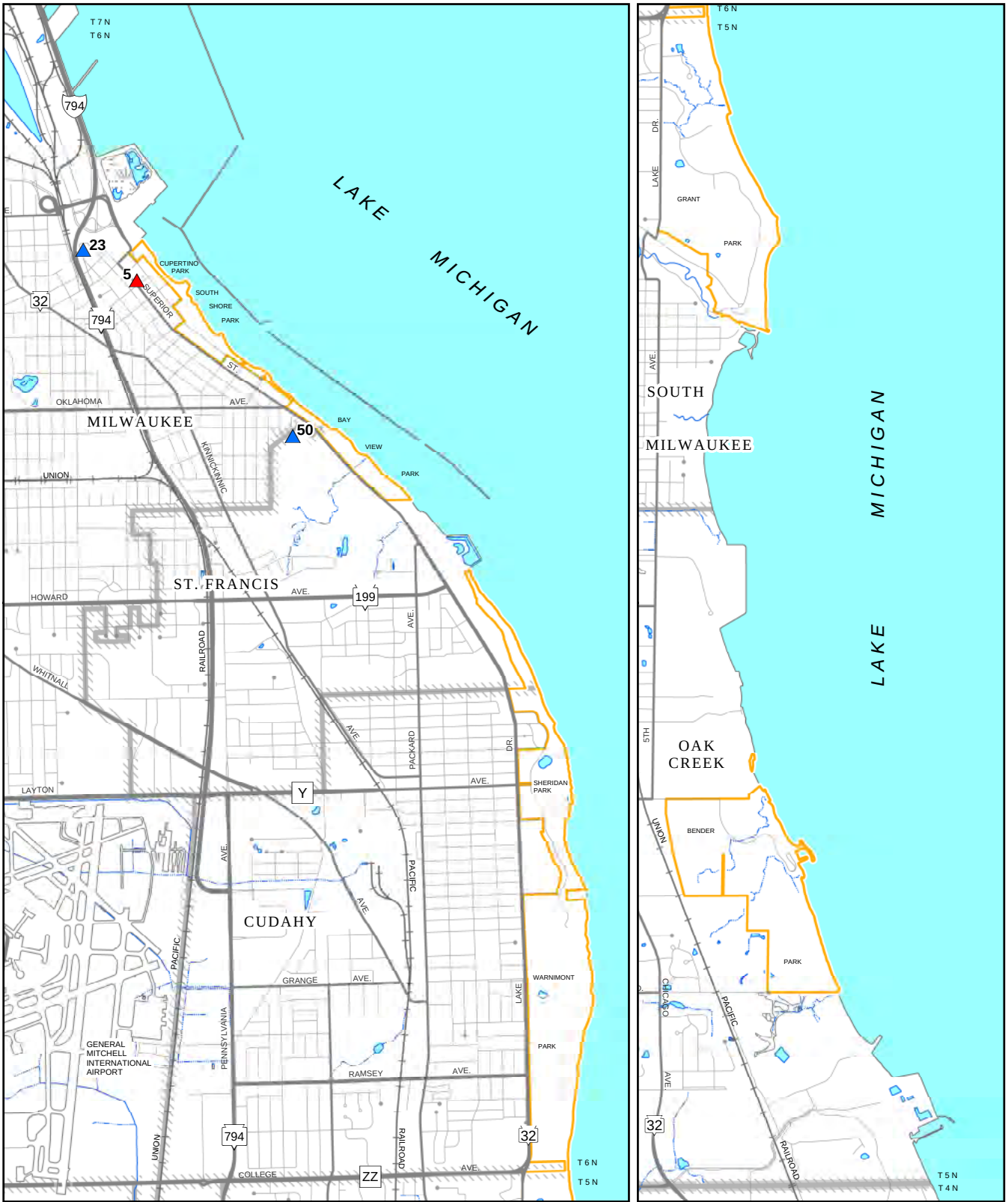


Table 2.2
Historic Sites and Districts Located near the Milwaukee County Coastline: 2015

Number on Map 2.6	Local Government and Historic Site or District Name	Designation Type ^a	Year Listed
1	Village of Fox Point Albert and Edith Adelman House	S	2005
2	Mary L. Nohl Art Environment	S	2005
3	Milwaukee Shipwreck (Steam Screw)	S	2015
4	Starke Meyer House	S	1985
5	Village of Shorewood Appomattox Shipwreck	S	2005
6	George E. Morgan House	S	1985
7	Henry A. Meyer House	S	1985
8	Seneca W. and Bertha Hatch House	S	1985
9	Thomas Bossert House	S	1985
10	Village of Whitefish Bay Barfield-Staples House	S	1985
11	Frank J. Williams House	S	1985
12	Fred W. Ullius Jr. House	S	1987
13	Frederick Sperling House	S	1985
14	G.B. Van Devan House	S	1985
15	George Gabel House	S	1985
16	Halbert D. Jenkins House	S	1985
17	Harrison Hardie House	S	1985
18	Herman Uihlien House	S	1983
19	Horace W. Hatch House	S	1985
20	John F. Mcewens House	S	1985
21	Paul S. Grant House	S	1985
22	Rufus Arndt House	S	1985
23	William Van Altena House	S	1985
24	City of Milwaukee Abbott Row	S	1983
25	All Saints' Episcopal Cathedral Complex	S	1974
26	Astor on The Lake	S	1984
27	Baumbach Building	S	1983
28	Bay View Historic District	D	1982
29	Cass-Juneau Street Historic District	D	1988
30	Cass-Wells Street Historic District	D	1986
31	Charles Allis House	S	1975
32	Charles Quarles House	S	1979
33	East Oregon and South Barclay Industrial Historic District	D	2014
34	East Side Commercial Historic District	D	1986
35	Elias R. Calkins Double House	S	1990
36	Emanuel D. Alder House	S	1991
37	Emba (Self-Unloading Barge) Shipwreck	S	2013
38	Exton Apartments Building	S	1997
39	Federal Building	S	1973
40	First Church of Christ Scientist	S	1989
41	First Unitarian Church	S	1974
42	First Ward Triangle Historic District	D	1987
43	Frederick C. Bogk House	S	1972
44	Immanuel Presbyterian Church	S	1974
45	Joseph B. Oliver House	S	1990
46	Joseph Schlitz Brewing Company Saloon	S	1977
47	Kenwood Park-Prospect Hill Historic District	D	2002
48	Knapp-Astor House	S	1980
49	Knickerbocker Hotel	S	1988

Table continued on next page.

Table 2.2 (Continued)

Number on Map 2.6	Local Government and Historic Site or District Name	Designation Type ^a	Year Listed
	City of Milwaukee (continued)		
50	Lake Park	S	1993
51	Lloyd R. Smith House	S	1974
52	Mcintosh-Goodrich Mansion	S	2000
53	Milwaukee Western Fuel and Oil Company	S	1992
54	Milwaukee-Downer Quad	S	1974
55	Newberry Boulevard Historic District	D	1994
56	North Point Light House	S	1984
57	North Point North Historic District	D	2000
58	North Point South Historic District	D	1979
59	North Point Water Tower	S	1973
60	Northwestern Mutual Life Insurance Company, Home Office	S	1973
61	Prospect Avenue Apartment Buildings Historic District	D	1990
62	Prospect Avenue Mansions Historic District	D	1990
63	Prospect Hill Historic District	D	2005
64	Sanford R. Kane House	S	1991
65	Shorecrest Hotel	S	1984
66	Sixth Church of Christ Scientist	S	1980
67	St. John's Roman Catholic Cathedral	S	1974
68	St. Paul's Episcopal Church	S	1974
69	The State Bank of Wisconsin/Bank of Milwaukee Block	S	1984
70	Wisconsin Consistory Building	S	1994
71	Wisconsin Leather Company Building	S	2005
72	Women's Club of Wisconsin	S	1982
	City of St. Francis		
73	Henni Hall	S	1974

^a Includes sites and districts listed on the National Register of Historic Places and located within one half-mile of the Milwaukee County coastline.

^b Codes signify designation type as follows: D-District; S-Site

Source: The Wisconsin Historical Society and SEWRPC

plans with the goal of preserving, protecting, developing, and, where possible, restoring or enhancing coastal communities and resources.

In 1978, the Wisconsin Coastal Management Program (WCMP) was established under the NCMP with the following objectives:

- To improve the implementation and enforcement of existing state regulatory and management policies and programs affecting key coastal uses and areas
- To improve the coordination of existing policies and activities of governmental units and planning agencies on matters affecting key coastal uses and areas
- To strengthen local governmental capabilities to initiate and continue effective coastal management consistent with identified state standards and criteria
- To provide a strong voice to advocate for the wise and balanced use of the coastal environment and for the recognition of the uniqueness of the coastal environment in federal, state, and local policies
- To increase public awareness and opportunity for citizens to participate in decisions affecting the Great Lakes resources

To meet these objectives, WCMP has developed numerous resources, including a review of publicly-funded coastal erosion and shore protection studies done in Wisconsin from 1930 to 2007³⁵ and informative publications on coastline dynamics focused on protecting coastline property.³⁶ While guidance on coastline management strategies has evolved since the inception of the NCMP, Federal and State recommendations present best practices that account for the benefits and challenges presented by a variety of coastline management measures.

Recommended Best Practices

Low-Impact Adaptive Practices

A crucial approach to low-impact coastline management is adapting to natural coastal processes, which ultimately requires a property owner to recognize that development cannot be protected from coastline dynamics indefinitely. It is vital for coastline property owners to be familiar with their property in relation to key reference points, including the shoreline, which is generally the water's edge or ordinary high-water mark (OHWM),³⁷ accounting for lake level; and bluff features, including the location of the bluff toe, crest, and height. As lakeside land is constantly under the influence of coastline dynamics, these initial reference points are certain to change but may help property owners to place development at a setback from the bluff and shoreline that provides a protective buffer during the course of that development's useful life.³⁸

Another low-impact practice is recognizing the impacts of vegetation on coastline property. Vegetation can stabilize a property's lakeside area between development and the coastline bluff by intercepting precipitation, holding soil in place, and removing groundwater through transpiration. However, vegetation may detract from the lake view—often a preferred feature of lakeside property—for development set back from the bluff. Thus, in developing a lakeside property, it is advisable to maintain beneficial vegetation while providing a lake view via a detached, semi-permanent structure located closer to the bluff crest. Designing such a structure that can be relocated relatively easily is considered a low-impact practice for its ability to avert coastline alterations. Similar low-impact coastline management methods include relocating existing structures threatened by coastal impacts and constructing homes that can be easily moved, as with modular construction. It should also be noted that adapting to natural coastal processes may entail forgoing the occupation of a structure on or the development of a property threatened by coastal impacts.

Promoting Bluff Stability

Federal and State guidelines also recommend multiple methods of promoting bluff stability as means of managing coastline impacts. One such method is to regrade coastline bluffs to create a gradual slope. Another bluff stability practice is to prevent stormwater from flowing over the bluff. Stormwater from precipitation and snowmelt, which increases with development of impervious surfaces, can erode the bluff top and bluff face and affect bluff stability. Managing stormwater on site in a manner that prevents runoff from flowing over the bluff top or face can mitigate stormwater impacts to bluffs.

At the same time, negative impacts to bluff stability can occur as stormwater infiltration increases within a coastline property. Increases in stormwater infiltration can raise groundwater levels and magnify the negative impacts of seeps and springs. Bluff stability practices therefore also include managing infiltration and groundwater levels on coastline property. Utilizing bluff dewatering drainage systems and planting or maintaining appropriate vegetation are some techniques for moderating groundwater levels. Bluff stability is also improved through protection of the bluff toe and shoreline, as through natural shoreline protection techniques.

³⁵ P. Keillor, *Modern Studies of Coastal Erosion in Wisconsin, Wisconsin Coastal Management Program, 2011.*

³⁶ *Such documents include Living with the Coast (2003) and Adapting to a Changing Coast (2016).*

³⁷ *As defined by the Wisconsin Supreme Court in 1914, the OHWM is defined as "the point on the bank or shore up to which the presence and action of the water is so continuous as to leave a distinct mark either by erosion, destruction of terrestrial vegetation or other easily recognized characteristic."*

³⁸ *Additional information relating to such setbacks is set forth in Section 3 of this report.*

Nature-Based Shore Protection

Federal and State guidance recommending the restoration of natural shoreline defenses include shore protection measures like the creation of artificial beaches or nourishment of existing beaches and the establishment of living revetments and living seawalls.³⁹ Creating artificial beaches and nourishing existing beaches can help protect the coastline by reducing wave energy and by providing sediment that the lake can transport to accumulate on other beaches. Artificial and nourished beaches may retain sand by incorporating vegetation or other obstructions, such as dune grass or fencing. Living revetments and living seawalls also incorporate vegetation, such as native wetland plants, for the establishment or restoration of coastal wetlands.

Structural Shore Protection

Federal and State guidance recommend structural shore protection methods as a last resort and primarily to prevent damage to structures that would be challenging to relocate or replace. Shore protection structures should be site-specific and designed by an experienced professional. Examples of structural shore protection methods include armoring of the lakebed, which entails the piling of submerged stone nearshore parallel to the coastline to dissipate wave energy. Additional structural coastline management measures include shore-parallel structures, such as revetments, seawalls, and breakwaters, and shore-perpendicular structures, such as jetties and groins. Revetments, which are sloped piles of stone or concrete, and seawalls, which include more accessible vertical or sloped structures, are protective hardscapes that deflect wave energy at the water's edge. Breakwaters, on the other hand, are hardscaped structures situated offshore. Groins and jetties, which may be constructed of stone, concrete, or other materials, extend from the land into the water with the purpose of inhibiting littoral drift, or the movement of sediment along the water's edge.

Federal and State guidance also recommend inspecting and improving existing protective structures. Structures that have issues or provide inadequate protection may be repairable or may provide salvageable materials for better coastline management applications. Due to their potential to adversely affect nearby coastline areas and their susceptibility to failure as result of natural forces, structural shore protection measures are less favorable solutions compared to other coastline management measures.

Coastline Management in Milwaukee County

In 2020, Milwaukee County completed a comprehensive study identifying its coastal resources, including facilities, assets, and infrastructure, to assess their vulnerability to extreme weather. The study was funded by a coastal resilience grant from the National Oceanic and Atmospheric Administration (NOAA), administered by WCMP, aimed at helping the County to plan and prepare for hazards like shoreline recession, bluff failure, beach erosion, coastal flooding, and damage to waterfront infrastructure. An important step initiating the County's preparedness for extreme weather events, the study may also be of value as the County pursues additional grants related to coastline management, which may promote increased State and Federal investment in funding coastline management projects within the County.

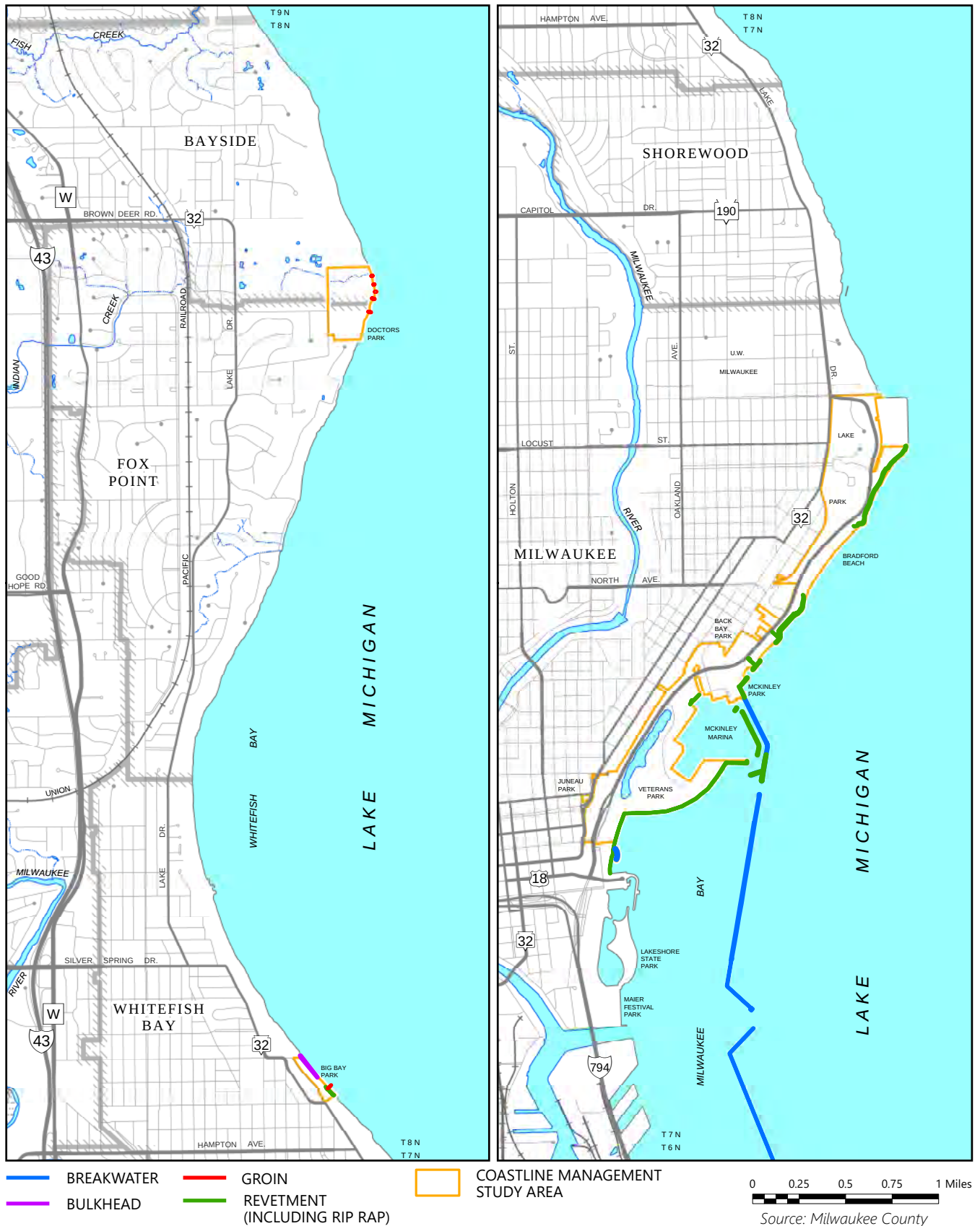
Shoreline protection structures, erosion control measures intended to reduce coastal erosion, are among the County's assets inventoried in the study. Such structures provide an artificial protective barrier against direct wave and ice attacks on the beach and bluff toe, increase the extent of the beach to absorb wave energy by dissipating wave energy, and/or by stabilizing bluff slopes. Shoreline protection structures inventoried in the study, including breakwaters, bulkheads, groins, and revetments (or rip rap), are shown on Map 2.7 and summarized in Table 2.3. As shown on the map, Grant and Warnimont Parks have the least structural shoreline protection. However, while numerous groins adorn the Sheridan Park shoreline, Sheridan and Warnimont Parks suffered extensive damage in 2019. This contrast can be attributed, at least in part, to the potential for shore protection structures to adversely affect nearby coastline areas or to otherwise fail during extreme weather events or high lake levels.

Trends in Coastline Stability

The features and composition of Milwaukee County's Lake Michigan coastline are significant factors in the coastline's stability, which can be compromised by beach or bluff erosion. In addition to detailed information on the natural resources presented in this inventory, the 1989 Milwaukee County shoreline erosion

³⁹ *Living revetments and living seawalls are much like traditional revetments and seawalls, which are described with coastline management terminology in Appendix A in their objective to help prevent shoreline and bluff toe erosion.*

Map 2.7
Shoreline Protection Structures Along the Milwaukee County Coastline: 2019



Map 2.7
Shoreline Protection Structures Along the Milwaukee County Coastline: 2019

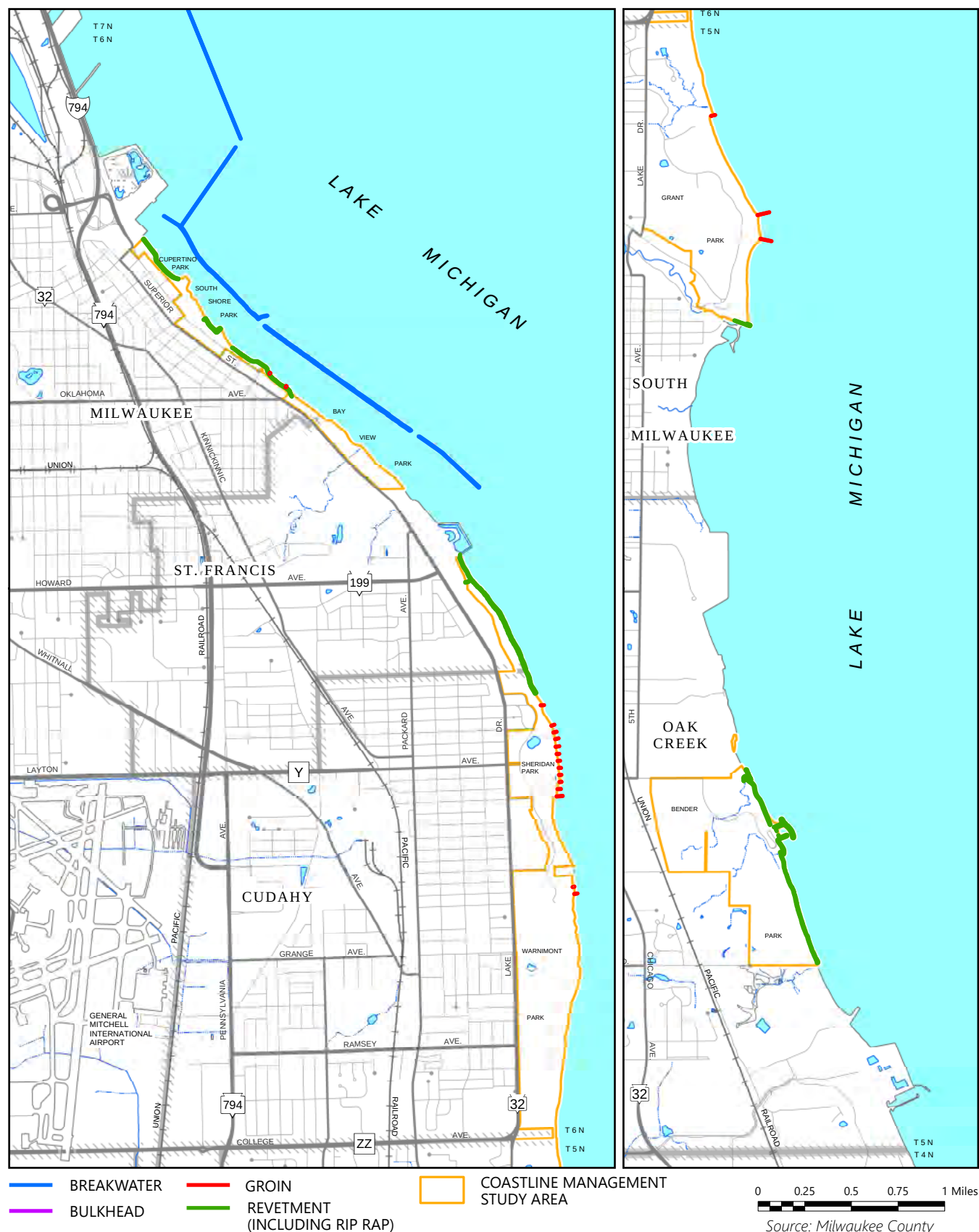


Table 2.3
Shoreline Protection Structures Along the Milwaukee County Coastline: 2019

Park Name	Shoreline Protection Structure			
	Breakwater	Bulkhead	Groin	Revetment
Bay View Park	X			
Bender Park				X
Big Bay Park	X	X	X	X
Bradford Beach				X
Cupertino Park				X
Doctors Park			X	
Grant Park			X	X
McKinley Marina	X			X
McKinley Park	X			X
Sheridan Park			X	
South Shore Park	X		X	X
Veterans Park	X			X
Warnimont Park			X	

Source: Wisconsin Department of Natural Resources and SEWRPC

management plan contains field surveys and a stability analysis of the County's coastline that describe coastline erosion and trends in coastline stability. Though coastline characteristics, like beach widths and slopes, have evolved since field surveys were conducted for the 1989 plan due to coastline dynamics, the plan's inventory and analysis are critical to understanding the County's current coastline conditions.

Bluff and beach erosion are the primary forms of erosion occurring along the Milwaukee County Lake Michigan coastline. Factors that contribute to bluff instability and bluff and beach erosion include wave action, groundwater seepage, and stormwater runoff. The impact of these factors is dependent on the composition of and vegetation present on bluffs and beaches as well as the presence of any shore protection structures⁴⁰ and can be exacerbated by fluctuations in lake levels, freeze-thaw weathering, and land disturbance caused by human activity.⁴¹ Lakebed erosion, or downcutting, contributes to bluff toe erosion along the Milwaukee County coastline and is exacerbated by changes in lake levels. As nearshore sand and sediment are carried away by wave action, the lakebed becomes exposed to turbulent waters that wear away and deepen the lake bottom.

Bluff slope failure along the Milwaukee County Lake Michigan coastline can occur in a variety of manners. The two most common forms of bluff slope failure in the County are translational slides and rotational slides. Translational slides occur when a single mass or a few closely related masses of soil or rock move quickly downslope in a planar manner. Rotational slides (or slumps) are classified as a soil mass with a curved rupture surface moving slowly downslope. Bluff slope failures in the County also occur as creeping, sloughing, and solifluction.⁴² A proportionately small part of the County's coastline is subject to rock or soil fall, which is associated with extreme undercutting and near-vertical cliffs. Beaches along the Milwaukee County coastline are subject to erosion via littoral drift, where coastline sediment is transported via longshore currents.⁴³

⁴⁰ While shore protection measures can mitigate the impact of wave action, it should be noted that wave action combined with high lake levels can damage shore protection measures such as revetments, bulkheads, breakwaters, and groins.

⁴¹ Such land-disturbing activities may include—but are not limited to—landscape management, the removal of invasive species, accessing infrastructure, and constructing permanent structures or other facilities.

⁴² See Appendix A for definitions of coastline terminology.

⁴³ While longshore currents within the County's coastal zone may move northerly or southerly in response to the direction of the incident waves, the net sediment transport along the County's coastline is southerly. Thus, beaches in the County exhibit accretion on the north side of groins, piers, and other structures while erosion occurs on the southerly side of such structures. As noted in CAPR No. 163, the net transport rate of littoral materials southward along the Milwaukee County shoreline is estimated at 8,000 cubic yards annually.

The County's Lake Michigan bluffs experience occasional and sometimes massive recession. Extreme weather—and high lake levels—exacerbate bluff recession and can cause severe damage to the County's coastline. One SEWRPC report⁴⁴ documents recession rates in the County averaging up to approximately 13 feet annually between 1963 and 1985,⁴⁵ which resulted in an average annual loss of nearly 330,000 cubic yards of shore material and about 2.7 acres of land. In 1985 and 1986, record-breaking water levels in Lake Michigan⁴⁶ caused extensive flooding, shoreline erosion, and significant property damage. A subsequent report⁴⁷ documented average bluff recession rates of 10 feet annually between 1963 and 1995, including recession rates associated with major storm events as high as 100 feet per year. As Lake Michigan water levels rose significantly again in 2019, sections of bluffs along Milwaukee County's coastline collapsed with bluff sloughs in Sheridan and Warnimont Parks carrying away trees and positioning County-owned infrastructure in the parks closer to the new bluff edge. County-owned parks suffered damage estimated at more than \$8 million in January 2020 due to a major storm event with high waves and record-breaking Lake Michigan water levels.⁴⁸ Lake Michigan's water level continued to exceed the maximum average monthly water level documented over the previous 100 years for nine continuous months through August 2020.

The approximate location of the bluff crest and toe along the Milwaukee County Lake Michigan coastline as of 2015 is shown in Map 2.8.⁴⁹ With high and rapidly changing lake levels anticipated in the future, it is important to continue to monitor and assess bluff stability as extreme weather events are expected to continue to occur in the future, potentially with increased severity due to the effects of climate change.

Municipal Coastline Management Methods

Municipalities within Milwaukee County that are situated along the Lake Michigan coastline generally utilize an assortment of coastline management strategies to protect existing property and proposed development from potential bluff instability and erosion/recession hazards. Some such methods are establishing bluff setbacks, conducting site specific bluff stability studies, and constructing coastline protection structures. In Milwaukee County, multiple municipalities that border Lake Michigan regulate development around and activity relating to lake bluffs within their jurisdiction.⁵⁰ Descriptions of existing coastline management strategies utilized by municipalities located along the County's Lake Michigan boundary follow.

City of Oak Creek

The City of Oak Creek zoning ordinance places requirements related to coastline management on development within the Lakefront Overlay District. Development within the Lakefront Overlay District is required to include coastline stabilization and lakefront access plans for Plan Commission review and approval. In addition, conditional use permits for lakefront development require plans for approval by the Common Council that take into account site topography, ordinary high water elevations, and surface water flow and controls.

Village of Bayside

In acknowledging the danger of disturbing the natural runoff of surface and percolating water and adding to the problem of erosion of ravine and lake bluffs, the Village of Bayside has established Land Development Ordinances related to coastline management. Per these ordinances, landscaping and construction of a building or structure on a lot along a ravine or lake bluff are subject to special requirements.

⁴⁴ SEWRPC Community Assistance Planning Report No. 163.

⁴⁵ *The average incorporated bluff crest recession measurements and shoreline recession measurements for the portions of the County coastline without bluffs.*

⁴⁶ *USACE provides vital public engineering and planning services to reduce risks from disasters and has measuring Great Lakes water levels since 1918.*

⁴⁷ SEWRPC Technical Report No. 36.

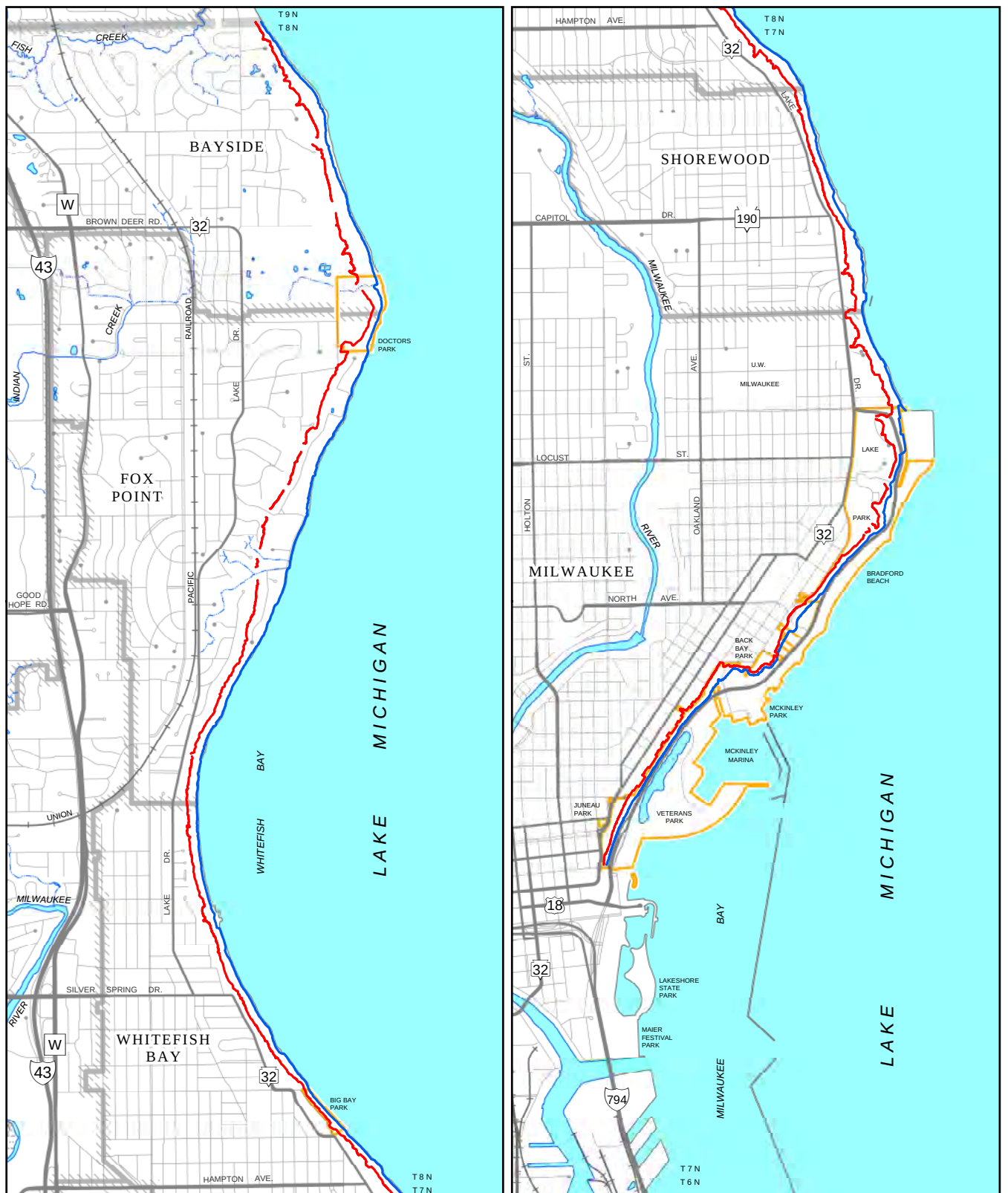
⁴⁸ *It is estimated that Port Milwaukee suffered \$2 million of damage during the same storm event.*

⁴⁹ *Based on data provided to SEWRPC by the Wisconsin Coastal Management Program and adjusted in various locations to align with 2015 topographic data based on Lidar, a remote sensing method that uses light to measure elevation.*

⁵⁰ *Some municipalities' lake bluff regulations also relate to the bluffs of ravines that are tributary to Lake Michigan.*

Map 2.8

Approximate Bluff Crest and Bluff Toe Locations Along the Milwaukee County Lake Michigan Coastline



Note: Based on 2015 Lidar Topo but aligned in various locations to data provided to SEWRPC by Wisconsin Coastal Management Program

Source: University of Wisconsin Sea Grant Institute, Milwaukee County, and SEWRPC

Map 2.8

Approximate Bluff Crest and Bluff Toe Locations Along the Milwaukee County Lake Michigan Coastline



BLUFF CREST
BLUFF TOE

Note: Based on 2015 Lidar Topo but aligned in various locations to data provided to SEWRPC by Wisconsin Coastal Management Program

COASTLINE MANAGEMENT STUDY AREA

0 0.25 0.5 0.75 1 Miles

Source: University of Wisconsin Sea Grant Institute, Milwaukee County, and SEWRPC

The construction of a building or structure on a lot along the lake bluff must be limited to the flat area of a lot at the top of the lake bluff. The foundations or footings of any building or structure on a lot along the lake bluff must be on or below the surface of the flat area at the top of the bluff; cantilever over the lake bluff is prohibited. In addition, any building or structure may be required to be set back a specified number of feet from the edge of the lake bluff. The construction of a building or structure on a lot along the lake bluff also requires certification by a registered professional engineer that certain criteria are met. These criteria include that the construction methods, footings, and materials are adequate so as not to either disturb the natural runoff of surface or percolating water or to create or increase lake bluff erosion and that any excavation for the construction will not adversely affect any building or structure on adjoining lots.

The only structures permitted to be constructed in whole or in part on or below the lake bluff are retaining walls that are designed by a registered professional engineer for the purpose of preventing or impeding lake bluff erosion or slippage. In addition, such retaining walls are only permissible if the opinion of the Village Manager is that the construction, footings, and materials of the proposed retaining walls are adequately designed to prevent and impede bluff erosion and provide proper drainage for surface and percolating water. In addition, the alteration of any natural vegetation on a ravine or lake bluff with an average slope of 12 degrees or more is prohibited without a permit approved by the Village Manager upon finding that the proposed work is minor in nature and primarily for the improvement and care of the plant life involved.

Village of Fox Point

The Village of Fox Point municipal code, which acknowledges the potential for unstable soil conditions, underground water pressure, and disruptions to natural drainage patterns to compromise bluff stability along Lake Michigan and its tributary ravines, incorporates numerous requirements related to coastline management. To administer regulations relating to the Lake Michigan bluff slope or the bluff of tributary ravines, the code defines “top of the bluff” as the area on a lot that is up-slope of the Village of Fox Point bluff line delineated by SEWRPC.⁵¹ Most of the regulations related to coastline management in the Village’s municipal code are within Chapter 285, Stormwater Management, Erosion Control, and Bluff Regulation.

The Village of Fox Point has established special requirements for the division or subdivision of any parcel containing land on a ravine or lake bluff. These special requirements may be met if either the opinion of the Village Board is that the proposed lot contains sufficient area landward of a lake or ravine exclusive of the area on the face of the lake or ravine bluff to permit construction or the opinion of the Village Board is that the area and topography of the proposed lot—with the lake or ravine bluff area included in determining the parcel’s open area setback requirements—would make construction possible.

The construction of retaining walls built for the purpose of preventing and impeding bluff erosion requires certification from the Director of Public Works/Village Engineer that the construction methods, footings, and materials of the proposed retaining walls are adequately designed to prevent and impede bluff erosion and provide proper drainage for surface and percolating water. New construction is allowed to cantilever over the top of lake or ravine bluffs but construction of a building or structure downslope from the top of or at the foot of a ravine or lake bluff is prohibited in much of the Village. The exception to this provision relates to land along North Beach Drive, which features existing development at the foot of the bluff of Lake Michigan and tributary ravines.⁵² The Village also prohibits the deposit of yard waste and other refuse on a ravine or lake bluff.

Village of Shorewood

Requirements related to coastline management as set forth in the Village of Shorewood zoning ordinance apply to properties located in Lake Drive Districts 1 (R-1) and 4 (R-4). Development is required to be set back from the bluff area at a distance sufficient to allow the natural runoff or percolation of water. In addition, requirements call for the footings, materials, and construction methods used for any building or structure to not adversely affect the natural runoff or percolation of water or to otherwise cause or promote either coastline erosion or the degradation of nearby structures.

⁵¹ *The bluff line is the area where slopes steeper than six horizontal to one vertical (6H:1V) transition to slopes shallower than 6H:1V measured perpendicular to the one-foot contour lines across the entire parcel.*

⁵² *Subject to certification by the Director of Public Works/Village Engineer that the planned construction will be done with minimum soil or natural cover disturbance and provides adequate drainage for surface and percolating water*

Village of Whitefish Bay

In the Village of Whitefish Bay, requirements related to coastline management apply to properties located on the bluff of Lake Michigan within District 1, the Lake Shore Residence District, or District 1A, Single-Family Residence District. These requirements necessitate that a registered professional engineer with certain qualifications⁵³ certify the safety of any proposed building or structure within 100 feet of the top edge of the bluff. The registered professional engineer is specifically required to certify the following:

- A proposed building or structure will not adversely affect existing buildings or structures on adjacent or adjoining sites
- A proposed building or structure will not adversely disturb ravine or lake bluff, interfere with surface or subsurface drainage, or create new or exacerbate existing problems of erosion and recession
- The drainage system will not adversely affect adjacent or adjoining properties
- There is no danger to a proposed or existing building or structure and its occupants from slippage of the slope above or below the proposed building or structure

The engineer's certification is required to be accompanied by a technical report that includes the following:

- Recommendations regarding site preparation, foundation design, lateral earth pressure, and support of slabs on grade
- The stability of the bluff slope before, during, and after construction of a proposed building or structure
- The effect of the construction of a proposed building or structure on natural drainage in the area, including the effect on any existing measures designed to improve natural drainage

The Village of Whitefish Bay also requires owners of property on the bluff of Lake Michigan within District 1 or District 1A to certify that they are aware of potential problems related to lake shore erosion as well as being aware of potential solutions, such as the need to garner a permit to add fill in compliance with Village ordinances, and their costs. A memorandum of each property owner's certification is to be kept on record with the Milwaukee County Register of Deeds.

In addition, the Village of Whitefish Bay municipal code declares the Lake Michigan shore⁵⁴ as necessary to protecting the bluff and to preserving lakefront property and land within the Village, deeming it an offense to remove sand, gravel, stone, etc. from the Lake Michigan shore.

⁵³ *Qualifications include a minimum of 10 years of geotechnical experience involving foundation investigation/engineering and shoreline slope stability evaluation.*

⁵⁴ *The shore or beach of Lake Michigan is defined as the space between the lake's high-water mark and low-water mark.*

Credit: Milwaukee County

3.1 OVERVIEW

This section sets forth goals, guidelines, and requirements designed to enable Milwaukee County to evaluate and manage potential coastline impacts to County-owned assets.⁵⁵ The guidelines offer a framework for promoting bluff slope stability within County-owned lands along the Lake Michigan coastline. The guidelines will serve as a reference tool as the County considers conducting work or evaluates proposals from property owners, Friends Groups and other organizations, municipalities, and others interested in conducting work that could impact bluff slope stability within County-owned lands along the Lake Michigan coastline.

Any and all parties interested in conducting such work should prepare and submit to the County a scope of work as laid out in this Section. Applicable work may include—but is not limited to—development, such as the construction of infrastructure, occupiable buildings, and other facilities; landscape management, such as the removal and/or pruning of vegetation, including invasive species; landscape restoration; the maintenance of existing infrastructure; and shore protection modifications and structures. Proposal requirements set forth herein would be supplementary to the application that such property owners, organizations, and municipalities would need to complete a proposed bluff project.⁵⁶ While the guidelines and requirements set forth in this section are to serve as a tool by which the County can evaluate a scope of work, the County may adjust the guidelines and requirements presented in this report as necessary.

A critical component of coastline management as set forth in this report is the Coastline Management Zone (CMZ).⁵⁷ The CMZ incorporates a stable bluff slope and an appropriate site-specific distance from the existing

⁵⁵ County-owned assets include lands and facilities that are adjacent to the waters of Lake Michigan.

⁵⁶ A Parks Improvement Project (PIP) form is required for all proposed park improvements. Information on project considerations that should be addressed by community project requests and on the project request review process are set forth in the County's Community Project Request Guide.

⁵⁷ The Coastal Management Setback is based on recommendations for bluff setbacks published by the University of Wisconsin Sea Grant Institute in 2008. Established to provide bluff setbacks for new development and redevelopment along Lake Michigan, the Coastal Management Setback is intended to protect structures and properties from slope erosion and failure without reliance on shore protection measures.

bluff crest for development. As depicted in Figure 3.1, the CMZ encompasses the projected 60-year bluff recession distance from the current bluff toe, future stable slope distance, an additional distance of 100 feet, and any features lakeside from the bluff toe. The future stable slope distance is calculated from the existing bluff toe to the future stable bluff crest using the ratio of a one-foot vertical rise to a 2.5-foot horizontal run.⁵⁸ The projected 60-year bluff recession distance⁵⁹ is calculated using a minimum recession rate of one foot per year—unless information revealed during the site analysis necessitates using a greater recession rate per year. The additional 100-foot distance provides for uncertainties related to future recession rates, stable slope angles, the effect of nearby shore protection structures, fluctuations in Lake Michigan water levels, and other factors.

Once the CMZ is established in relation to a proposal,⁶⁰ the Milwaukee County Coastal Resources Inventory, which sets forth the vulnerability and value of County-owned assets in the Lake Michigan Coastline Management Zone, may be used to prioritize implementation activities and help the County conduct long-range capital planning. Additional information on implementation is presented in Section 4 of this report.

This report uses a study area that encompasses the full extent of the Lake Michigan coastline in Milwaukee County and includes the County-owned land adjacent to the waters of Lake Michigan outlined on Map 3.1. While this report and its guidelines and requirements apply only to County-owned facilities and land within the study area, local municipalities are encouraged to consider the addition of similar goals and guidelines for applicable local proposals within their own jurisdictions.

3.2 COASTLINE MANAGEMENT GOALS

- Protect Milwaukee County's financial investment in County-owned assets within the Lake Michigan Coastline Management Zone
- Protect the ecology, resources, and natural character of County-owned lands within the Lake Michigan Coastline Management Zone
- Provide efficiency and consistency when reviewing proposals for a scope of work to be completed within the Lake Michigan Coastline Management Zone

3.3 COASTLINE MANAGEMENT GUIDELINES

Guidelines/Objectives

Milwaukee County will seek to attain the following as part of long-term management of the Lake Michigan Coastline Management Zone:

- Ensure appropriate public access to and recreational opportunities within the Lake Michigan Coastline Management Zone without compromising the stability of the Lake Michigan bluff slope or the integrity of the Lake Michigan shoreline.
- Ensure access for the maintenance of stormwater facilities within the Lake Michigan Coastline Management Zone.
- Limit land-disturbing activities within the Lake Michigan Coastline Management Zone that adversely impact natural functions of the land.⁶¹

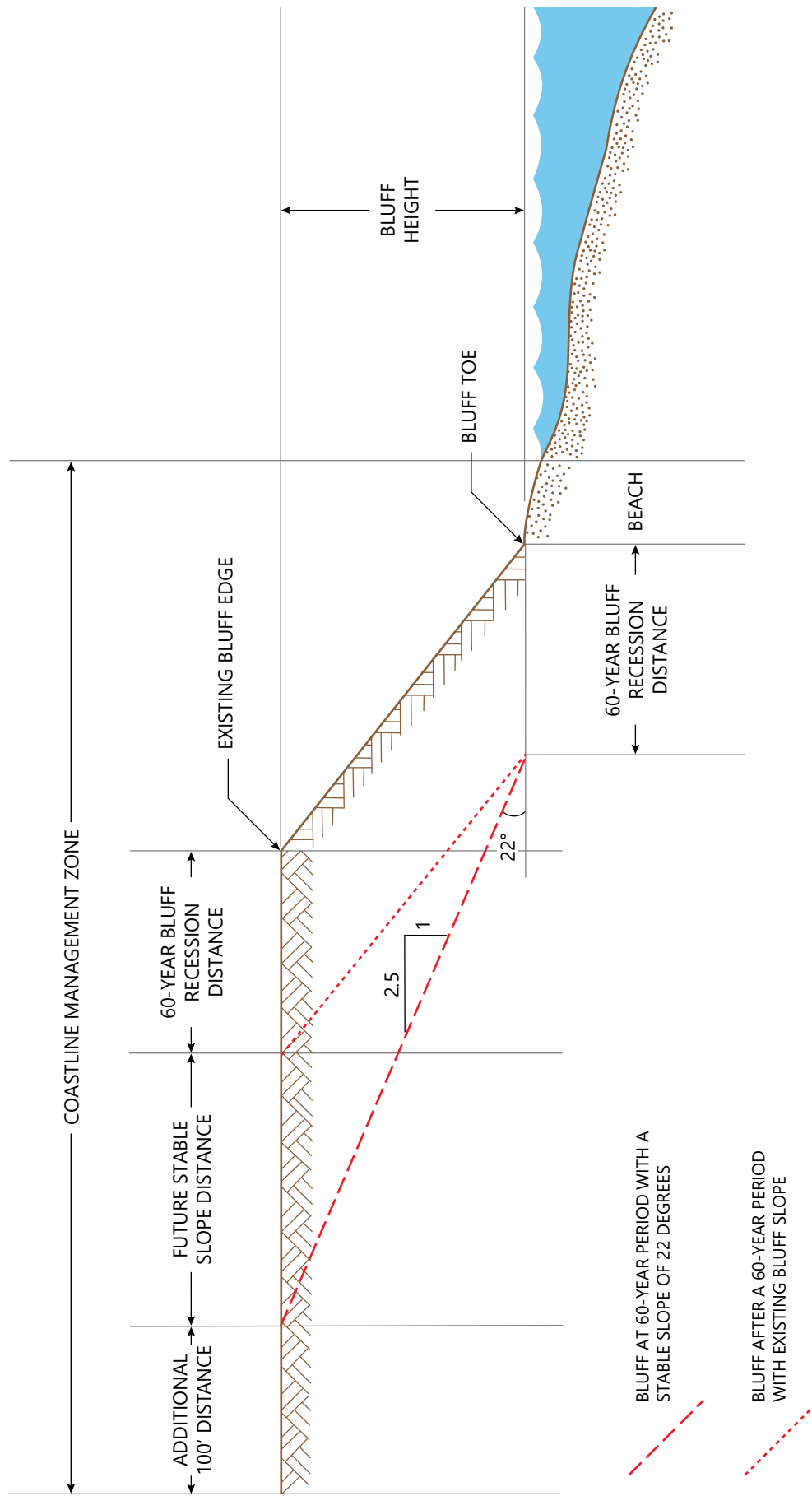
⁵⁸ The stable slope of 2.5 to 1 is an average estimate that will vary depending on bluff geology, including soil types, and other conditions.

⁵⁹ The 60-year bluff recession distance is designed to accommodate bluff recession over a time period that is twice that of a typical home mortgage loan.

⁶⁰ The CMZ, calculated as described in this Section, needs to be determined for each PIP to account for site-specific conditions. Due to coastline dynamics, the locations of the bluff toe and bluff crest will likely change over time from the 2015 conditions shown on Map 2.7.

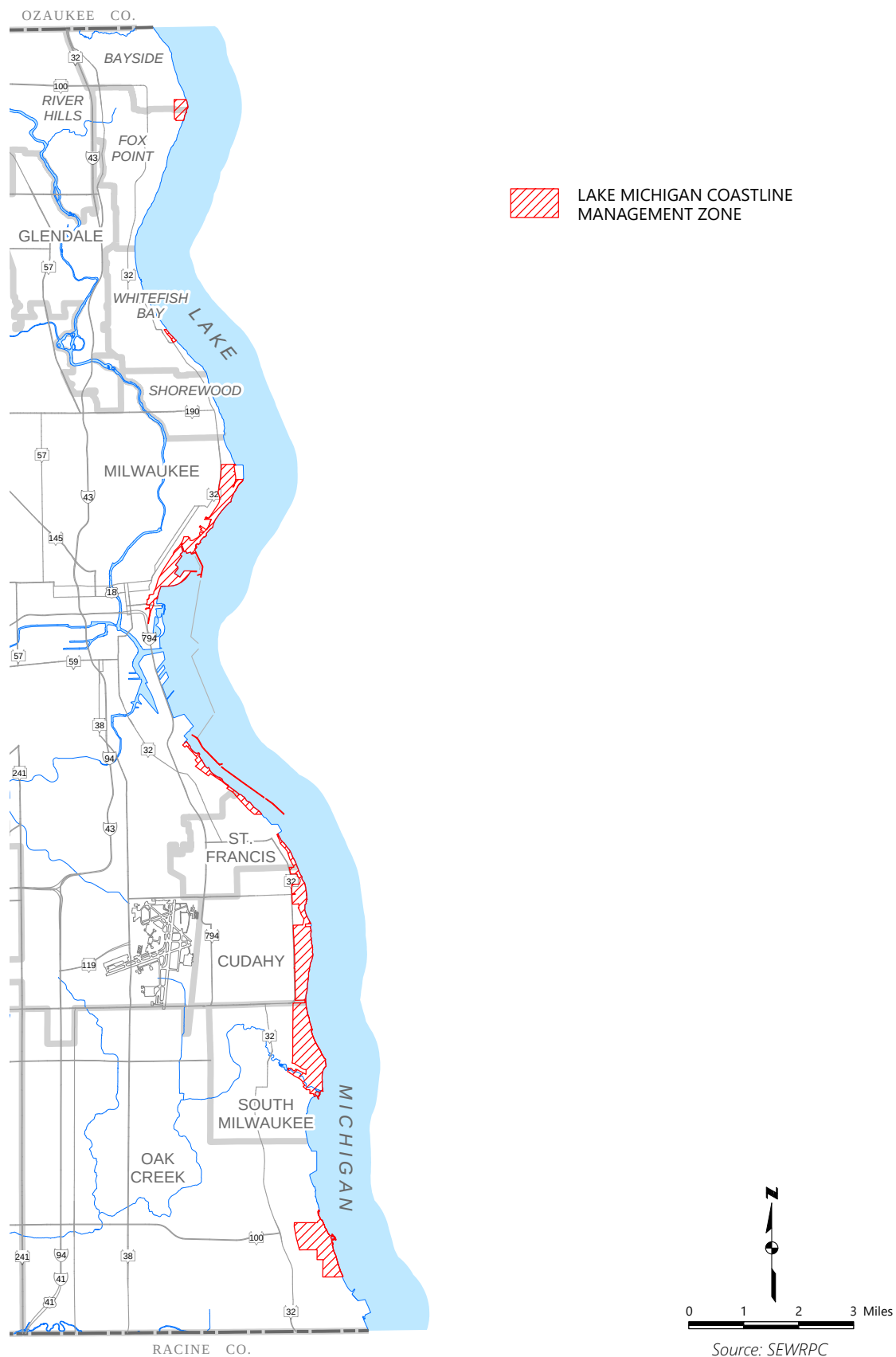
⁶¹ Land disturbing activities may include—but are not limited to—landscape management, the removal of invasive species, accessing stormwater infrastructure, and constructing permanent structures or other facilities.

Figure 3.1
Coastline Management Zone: 2020



Source: University of Wisconsin Sea Grant Program and SEWRPC

Map 3.1 Lake Michigan Coastline Management Zone: 2019



- Prevent erosion and sedimentation that would be detrimental to or increase the area of the natural drainage system.
- Assess bluff conditions around existing facilities and infrastructure within the Lake Michigan Coastline Management Zone in order to identify both short- and long-term detrimental impacts.
- Severely limit actions that may detrimentally alter natural and ecologically stable conditions characteristic of the Lake Michigan coastline.
- Preserve or enhance the natural character and aesthetic values of the Lake Michigan viewshed in a sustainable way.
- Preserve undeveloped areas within the Lake Michigan Coastline Management Zone that contain a unique or sensitive resource, including—but not limited to—areas designated by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) as environmental corridors or isolated natural resource areas.
- Account for areas protected by the Public Trust Doctrine and lakebed grants issued to Milwaukee County.⁶²

Guidelines for Proposed Development

For work involving the construction of infrastructure, occupiable buildings, and other facilities within the Lake Michigan Coastline Management Zone, the following guidelines should apply:

- A proposal prepared by a Professional Engineer (P.E.) or Registered Architect (R.A.) licensed in the State of Wisconsin should be submitted to assess compliance with these guidelines and requirements. Any proposal for infrastructure and/or buildings shall adequately assess surface and subsurface soil conditions to address the proposed design.
- Stormwater management within the Lake Michigan Coastline Management Zone should meet the following requirements:
 1. Stormwater produced on-site should be directed away from the bluff, potentially landward, and stormwater discharges to groundwater should be limited;
 2. Low-impact development (LID) stormwater management practices⁶³ should be properly modified for the bluff top or constructed as far from the bluff crest as possible; and
 3. Maintain existing stormwater drainage patterns to protect tributary ravines.

Guidelines for Proposed Landscape Management

- A proposal for a scope of work for landscape management within the Lake Michigan Coastline Management Zone, including but not limited to the removal of invasive species, should be prepared by a Landscape Architect licensed by the State of Wisconsin and shall include a landscape management plan that meets the following requirements:
 1. Inventory the existing vegetation, including the variances in heights of existing low groundcovers; size, species, and health of shrubs and trees, specifying any proposed alterations to existing vegetation;⁶⁴ and

⁶² Under the Public Trust Doctrine, the State of Wisconsin holds navigable water in trust for the public. In addition, through special legislation, the State Legislature has authorized a lakebed grant making Milwaukee County the trustee of 22.5 linear miles of Milwaukee County's 27.6 miles of Lake Michigan coastline. Any facilities constructed on lakebed grant areas must be widely available to the public and support the primary purpose for which the Legislature made the grant.

⁶³ Including but not limited to rain barrels, rain gardens, and porous pavements.

⁶⁴ The use of mulch material is discouraged.

2. Describe the vegetation that is to be removed and the means by which the vegetation will be removed, which should be in a manner that does not displace or remove existing forest litter or decrease bluff stability, and identify replacement vegetation to be planted in place of the vegetation proposed to be removed, including the rational use in selecting the proposed replacement vegetation.⁶⁵
- Landscape management proposals related to viewshed management within the Lake Michigan Coastline Management Zone should account for the need to retain and maintain bluff vegetation in a variety of heights to promote bluff stability.⁶⁶ Soil types and vegetation establishment periods shall be prioritized. Appropriate native vegetation for bluff stabilization that takes into account height at maturity, soil type and moisture, sun/shade tolerance, and other characteristics is presented in Appendix D.⁶⁷

Guidelines for Proposed Shore Protection Modifications and Structures⁶⁸

- Prioritize non-structural shore protection measures⁶⁹ for existing assets within the Lake Michigan Coastline Management Zone that are vulnerable to damage from coastal hazards.⁷⁰
- Enhance, restore, and create coastline wetlands and other appropriate aquatic ecosystem resources where feasible.
- Limit the construction of shore protection structures within the Lake Michigan Coastline Management Zone to areas where non-structural shore protection measures would be ineffective at protecting the value of County-owned land and structural assets. Shore protection structure designs should include the following:
 1. A site investigation of slope stability, lakeshore erosion, and near-shore bathymetry;
 2. A plan for ensuring adequate quality control of materials used in the designed structure; and
 3. Adequate monitoring and maintenance plans, as determined by Milwaukee County.

⁶⁵ Essential information on appropriate vegetation to promote bluff stability is presented in a reference guide, A Property Owner's Guide to Protecting Your Bluff, which was under development by the Wisconsin Coastal Management Program as this report was being prepared.

⁶⁶ Soil stability can be improved by incorporating a variety of vegetation of different type, heights, and with varying root characteristics. Combinations of trees and shrubs, many of which have deep roots that can serve as vertical anchors, with low-growing herbaceous plants, whose roots tend to prevent lateral shear, can create an interlocked root system to mitigate the impact of both groundwater and surface water runoff. In addition, incorporating evergreen vegetation ensures moisture can be extracted from the soil over longer durations than may be accomplished by strictly deciduous vegetation.

⁶⁷ Vegetation for bluff stabilization is taken from a publication under preparation by the University of Wisconsin Sea Grant Institute and the Southeastern Wisconsin Regional Planning Commission, A Property Owner's Guide to Protecting Your Bluff, as this report was being prepared.

⁶⁸ All shore protection modifications and structures are regulated by the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (ACOE).

⁶⁹ Examples of which include bluff top stormwater and wastewater management, maintaining and enhancing vegetation along shoreline and on bluff slopes, and beach enhancement.

⁷⁰ Coastal hazards may include bluff toe erosion, bluff slumping or sliding, or damage related to groundwater seepage or lakebed erosion.

Submittal Requirements for Proposed Projects Within the Lake Michigan Coastline Management Zone⁷¹

- A proposal for a scope of work for any bluff or shoreline modification⁷² within the Lake Michigan Coastline Management Zone should be submitted for review by and approval of the Milwaukee County Park Planning & Development and Environmental Services Divisions prior to work being performed. The proposed work should be performed under the supervision of a Professional Engineer (P.E.) with a minimum of 10 years of experience involving geotechnical investigation and/or engineering and shoreline slope stability evaluation. A proposal for a scope of work should include the following:
 1. A slope stability analysis⁷³ that meets the following requirements:
 - » Calculations are based upon the highest groundwater conditions that can occur at the site—not the elevation of the groundwater on the day of the analysis;
 - » An appropriate safety factor⁷⁴ should be used to account for the intensity of the planned use (see Table 3.1);
 - » The analysis shall evaluate existing surface and subsurface conditions. Collection of soil data is the responsibility of the applicant, and all work must be permitted through a Parks right-of-entry permit from Milwaukee County.
 2. A no adverse impacts (NAI)⁷⁵ analysis stamped by a Professional Engineer (P.E.) with a minimum of 10 years of experience involving geotechnical investigation and/or engineering and shoreline slope stability evaluation that meets the following requirements:
 - » Accounts for the stability of surrounding bluffs and structures;
 - » Accounts for the conditions of the surrounding shoreline;
 - » Accounts for the stormwater managed and produced on-site and for the site's natural drainage system;
 3. A landscape management plan describing the practices and materials, including replacement vegetation, that would be used to implement the plan and maintain the landscape;
 4. Adequate monitoring and maintenance plans as determined by Milwaukee County; and
 5. A statement from the P.E. establishing that the proposed scope of work will not decrease the stability of the bluff area.
- Milwaukee County will determine the veracity and appropriateness of the proposal.

⁷¹ Proposals for a scope of work are required for all land-disturbing activities within the Lake Michigan Coastline Management Zone.

⁷² Bluff or shoreline modifications may include—but are not limited to—the construction of shoreline protection structures, such as beach nourishment; the installation of bulkhead, groin, jetty, revetment, or rip rap, or the establishment of wetlands; and development or landscape management within the Coastline Management Zone.

⁷³ Detailed components of the required slope stability analysis are described in Section 4 of this report.

⁷⁴ An engineer's assessment utilizing a safety factor of 1.0 would identify the point at which a bluff would fail; the P.E. should use a safety factor greater than 1.0 to account for the intensity of the planned use, which would result in development being subjected to a greater setback from the existing bluff toe.

⁷⁵ Established by the Association of State Floodplain Managers (ASFPM), NAI is a managing principle under which the actions of a property owner to manage water on that property are not allowed to adversely affect the rights of other property owners.

Table 3.1
Minimum Design Safety Factors for Coastline Slope Stability Analyses by Intensity of Use

Intensity of Use	Applicable Activities/Facilities	Minimum Design Safety Factor ^a
Low (Passive) ^b	Agricultural or open space use; primary and secondary environmental corridors; and woodlands	1.1
Light/Moderate ^c	Park and recreational uses; ^d barn/garage/shed; small buried utilities; and tile beds	1.1-1.2
Heavy/Active	Infrastructure; ^e occupiable buildings and structures; retaining walls; and storage	1.3-1.5

^a These minimum design safety factors exemplify those that engineers may use to find the bluff edge setback appropriate to the associated land use intensity.

^b No buildings.

^c No occupiable buildings.

^d Including golf courses and swimming pools.

^e Including bridges and high-risk utilities.

Source: Ontario Ministry of Natural Resources and SEWRPC

Application of the Coastline Management Guidelines

When considering the County's Coastline Management Guidelines, Milwaukee County will recognize and protect Milwaukee County's broad public interest via the following:

- Solicit input from individuals and groups representative of local public interests.
- Consider the County's duty to preserve natural resources, provide recreational opportunities, maintain public infrastructure, and address coastline impacts/bluff stability risks, in a balanced and sustainable fashion.
- Take into account the policies, programs, and recommendations of municipalities within the County.
- Solicit information and recommendations from individuals with expertise in technical areas pertinent to the proposed project, such as ecology, geology, hydrology, limnology, aquaculture and other scientific fields pertinent to shoreline management.
- Consider more up-to-date information from pertinent State and Federal coastline management guidelines, policies, and best management practices.
- Adhere to local regulations and approval processes.

Determinations regarding project proposals shall be made by licensed Professional Engineers and Landscape Architects working for Milwaukee County, or consultants working on their behalf.



Credit: Milwaukee County

4.1 ADOPTION OF GUIDELINES

An important step in implementing the coastline management guidelines for Milwaukee County is their formal adoption by the County. Upon formal adoption, the guidelines become an important guide to administering projects along and related management decisions involving lands adjacent to the County's Lake Michigan coastline. Such adoption serves to signify agreement with and official support of the recommendations set forth in this report and enables government officials and staff to begin integrating this report's recommendations into other ongoing County and municipal programs, such as parks and public works development planning and programming.

An informational report on the working draft of this report was provided to the Milwaukee County Parks, Energy, and Environment Committee (PEEC) and County Board of Supervisors in December 2020. In advance of the final review of this report by the PEEC in January 2021, notification through email was shared with leaders of municipalities within and directly adjacent to the Coastline Management Zone who were part of initial project outreach efforts. On February 4, 2021, the Milwaukee County Board of Supervisors authorized adoption of the coastline management guidelines for implementation by the Parks Department for all pertinent land use actions, both County-initiated as well as third party projects.

Establishing an education plan is an important component to implementing these guidelines. In order to ensure that all interested and affected parties are aware of the requirements established in these coastline management guidelines and what actions the guidelines apply to, the County will conduct internal trainings for County staff. External education efforts will also be conducted and will include provision of this information to the general public and to other communities within the County. The guidelines will also be placed on the Milwaukee County Parks' website, in conjunction with information on the Park Improvement Project (PIP) review process through which proposals should be submitted.

Realization of the goals in this report will require a long-term commitment to these guidelines, as well as coordination and cooperation among County officials and staff and various County and municipal departments. Success will also require coordination with any and all parties interested in conducting a PIP and the participation of other affected and interested parties, including Friends Groups of Milwaukee

County Parks, other concerned units and agencies of government and their respective officials and staffs, and concerned private citizens, in undertaking the substantial investments and series of actions needed to implement the plan.

4.2 PROJECT REVIEW PROCESS

As noted in Section 3 of this report, a proposal for a scope of work for any bluff or shoreline modification⁷⁶ within the Lake Michigan Coastline Management Zone should be submitted for review by and approval of the Milwaukee County Parks Planning & Development and Environmental Services Divisions prior to work being performed. The first step that any and all parties interested in a PIP should undertake to initiate such a proposal is to complete an online Parks Improvement Project form via a link in the Milwaukee County Parks *Community Project Request Guide*,⁷⁷ which contains valuable information for completing a PIP form and the PIP review process. The guide sets forth various factors that should be incorporated into PIPs, including, but not limited to, the following:

- Serve the general public
- Reflect the character of and enhance the park and/or park system
- Address the park system's need for ongoing improvement
- Be compatible with surrounding uses (within and adjacent to the park site)
- Be implemented by Milwaukee County Park standards
- Align with Milwaukee County Parks planning efforts
- Comply with zoning, land use and building requirements

A PIP form should also incorporate considerations for funding any PIP. As outlined in the *Community Project Request Guide*, resource constraints limit the number of parks capital projects⁷⁸ that the County is able to fund each year. Identifying alternative funding sources like grants and sponsorships enhance the viability of a PIP and are taken into consideration during the PIP review process. Thus, a PIP should have identified funding sources that address the initial implementation and long-term maintenance of a PIP and should maximize resources by identifying leveraging opportunities and supporting partners. A PIP should ultimately help to mitigate Parks fiscal challenges while addressing the need for improvements in County-owned parks.

As noted in the *Community Project Request Guide*, PIPs may be submitted year-round but are typically reviewed on a biannual basis⁷⁹ by a team of Milwaukee County Parks staff using objective, predetermined scoring criteria. Parks staff responds to proposals as soon as possible but response time varies with the complexity of a PIP. As County Parks staff may be unable to expedite projects due to the legislative process and established monthly meeting cycle of the Milwaukee County Board of Supervisors, proposed project timelines are subject to change. The review process ascertains the need, relevance, and priority of proposed PIPs. General review criteria, which align with the aforementioned factors, are laid out in the *Community Project Request Guide* and include, but are not limited to, the following:

⁷⁶ Bluff or shoreline modifications may include—but are not limited to—the construction of shoreline protection structures, such as beach nourishment; the installation of bulkhead, groin, jetty, revetment, or rip rap, or the establishment of wetlands; and development or landscape management within the Coastline Management Zone.

⁷⁷ The Community Project Request Guide is accessible via the Milwaukee County Parks website. Individuals may email Parks staff regarding the PIP form (and other project request forms) at parkprojects@milwaukeecountywi.gov.

⁷⁸ Capital parks projects, which include projects under \$100,000 in value, may be financed with major maintenance funding on a very limited basis.

⁷⁹ Milwaukee County Parks will not be reviewing project proposals in 2021.

- Supports or improves public health and safety
- Reduces deferred maintenance
- Promotes operational efficiency, innovation or best management practices
- Considers life cycle costs
- Positively impacts the environment or preserves natural resources
- Integrates quality design and aesthetics
- Leverages non-County resources
- Supports an area of need

If approved, Milwaukee County Parks staff will work with the point of contact for a PIP to refine the project scope and develop final terms and agreements during the project development phase. If a PIP is not approved, or if Milwaukee County Parks and the PIP point of contact do not agree to final terms, Parks staff will inform the PIP point of contact of the project's denied status, including relevant information on the review of the PIP. Depending on the scale and complexity of an approved project, the project may be shared with other County departments and leaders, including the County Facility Plan Steering Committee, the County Executive, and the Board of Supervisors, for final approval after the project development phase.⁸⁰

4.3 GUIDELINE UPDATE PROCESS

As noted in Section 3 of this report, the County may adjust or update the coastline management guidelines set forth in this report in order to recognize and protect Milwaukee County's broad public interest. Such adjustments or updates could be made after soliciting input from individuals and groups representative of local public interests and would take into account the policies, programs, and recommendations of municipalities within the County. In addition, the County could solicit information and recommendations from individuals with expertise in technical areas pertinent to coastline management, such as ecology, geology, hydrology, limnology, aquaculture and other scientific fields pertinent to shoreline management.

The guidelines review and update process would be similar to the process undertaken to adopt this report, whereas an updated draft report would be provided to the Milwaukee County PEEC and County Board of Supervisors and shared with the appropriate municipalities prior to a final review of the updated report by the PEEC and adoption by the County Board.

4.4 ORDINANCES RELATED TO COASTLINE MANAGEMENT

The County should evaluate existing Milwaukee County ordinances related to coastline management to address any potential conflicts that may arise as these guidelines are implemented. Such existing ordinances may include those that involve or relate to coastline beaches and bluffs, development setbacks, maintenance of County-owned parks and/or vegetation, and stormwater infrastructure and management. As noted in Section 3 of this report, the Southeastern Wisconsin Regional Planning Commission drafted model regulations for Lake Michigan bluff setbacks based on bluff setback recommendations developed by Wisconsin Sea Grant (see Appendix E of this report). The model ordinance is intended to help protect structures and properties from bluff erosion and failure without reliance on shore protection measures through incorporation as a section in an existing zoning ordinance. The regulations can be used to calculate a setback for development along Lake Michigan that features a stable bluff slope based on the recession rate and distance providing for uncertainties related to future stable slope angles, recession rates, the effect from nearby shore protection structures, and other factors. The County may utilize the model ordinance as a reference while implementing and administering the coastline management guidelines set forth in this report.

⁸⁰ *As County departments and leaders meet on a regular cycle, communication regarding a project is integrated into meeting schedules as appropriate.*

APPENDICES

COASTLINE MANAGEMENT TERMINOLOGY

APPENDIX A

Term	Definition
Accretion	The gradual growth of a beach or shoreline as sediment is deposited by lake currents
Beach	An area of unconsolidated material, usually sand or pebbles, that is located along the edge of a body of water, extending lakeward from the bluff to the body of water's mean low water line
Bluff	A high steep bank facing an adjacent body of water
Bluff crest	The point of abrupt topographical change at the top of the bluff where the relatively flatter upland area meets the steeper bluff slope
Bluff face	Lakeward-facing portion of the bluff, inclined from the relatively flatter coastline area to the bluff top; bluff slope
Bluff recession	The landward retreat of the bluff, bluff crest, or bluff toe from the adjacent body of water as material within the bluff is lost due to coastline impacts
Bluff toe	The point of abrupt topographical change at the bottom of the bluff where the steeper bluff slope meets the relatively flatter coastline area
Bluff slope	Lakeward-facing portion of the bluff land, inclined from the relatively flatter coastline area to the bluff top; bluff face
Breakwater	A structure, usually parallel to the shore in the nearshore zone, built to protect a shore area by reducing wave activity
Bulkhead	A vertical structure separating land and water areas designed to retain soil
Creeping	The imperceptibly gradual downslope movement of unconsolidated material
Coastline	The boundary between a water body and adjacent land; shoreline
Groin (groyne)	A shore protection structure typically built perpendicular to the shoreline for the purpose of constraining littoral drift, trapping sediment, or preventing shoreline erosion
Jetty	A shore protection structure extending into a water body from adjacent lands designed to manage water currents
Littoral current	Nearshore water current
Littoral drift	The movement of nearshore sand and sediment via littoral currents
Moveable structure	A permanent structure designed for relocation
Nearshore	Relating to the area near the shoreline
Nourishment	A shore protection measure entailing adding sand/gravel to restore a beach or shoreline
Permanent structure	An unmovable structure or occupiable building for residential, commercial, industrial, or institutional use, including accessory and related buildings, and other unmovable structures or infrastructure
Revetment	A shore protection measure constructed of piled stone, concrete, or other similar impermeable materials placed along the shoreline to protect the shoreline from erosion; rip rap
Riprap	A shore protection measure constructed of piled stone, concrete, or other similar impermeable materials placed along the shoreline to protect the shoreline from erosion; revetment
Seawall	A vertical concrete structure separating land and water areas designed to retain soil and absorb wave energy
Seiche	Periodic brief lake level fluctuations typically caused by changes in atmospheric pressure
Shoal	A naturally occurring nearshore mound of sand or other unconsolidated material that rises from the lakebed to near the lake surface
Shoreland	Land between the toe of a lake bluff or first major change in terrain and a lake
Shoreline	The boundary between a water body and adjacent land; coastline
Slide/sliding	A type of bluff slope failure involving the downslope movement of unconsolidated bluff material
Solifluction	The slow downward movement of material on a slope, often occurring when frozen subsoil or near-surface bedrock prevents water in the soil from percolating into the slope
Sloughing	The shedding of the uppermost layer or layers of soil or other unconsolidated material from the toe of a bluff
Storm surge	The temporary downwind rise in water levels attributable to strong winds during a storm or extreme weather event

Note: Adapted from information gathered from resources identified in Appendix B of this report.

Source: U.S. Army Corps of Engineers (USACE) and SEWRPC

RESOURCE LIST

APPENDIX B

Community Assistance Planning Report No. 155, *A Lake Michigan Shoreline Erosion Management Plan for Northern Milwaukee County, Wisconsin*, Southeastern Wisconsin Regional Planning Commission, 1988.

Community Assistance Planning Report No. 163, *A Lake Michigan Shoreline Erosion Management Plan for Milwaukee County, Wisconsin*, Southeastern Wisconsin Regional Planning Commission, 1989.

Flora of Wisconsin, Consortium of Wisconsin Herbaria. www.wisflora.herbarium.wisc.edu/index.php (2020).

Levels Reference Study Great Lakes-St. Lawrence River Basin, Levels Reference Study Board, International Joint Commission, 1993.

Levels Reference Study Great Lakes-St. Lawrence River Basin - Annex 2: Land Use and Management, Levels Reference Study Board, International Joint Commission, 1993.

Living on the Coast, Philip Keillor, University of Wisconsin Sea Grant Institute, 2003.

Living with the Lakes, Roger Gauthier, U.S. Army Corps of Engineers, 1999.

Managing Coastal Erosion, National Academy of Sciences, National Academy Press, 1990.

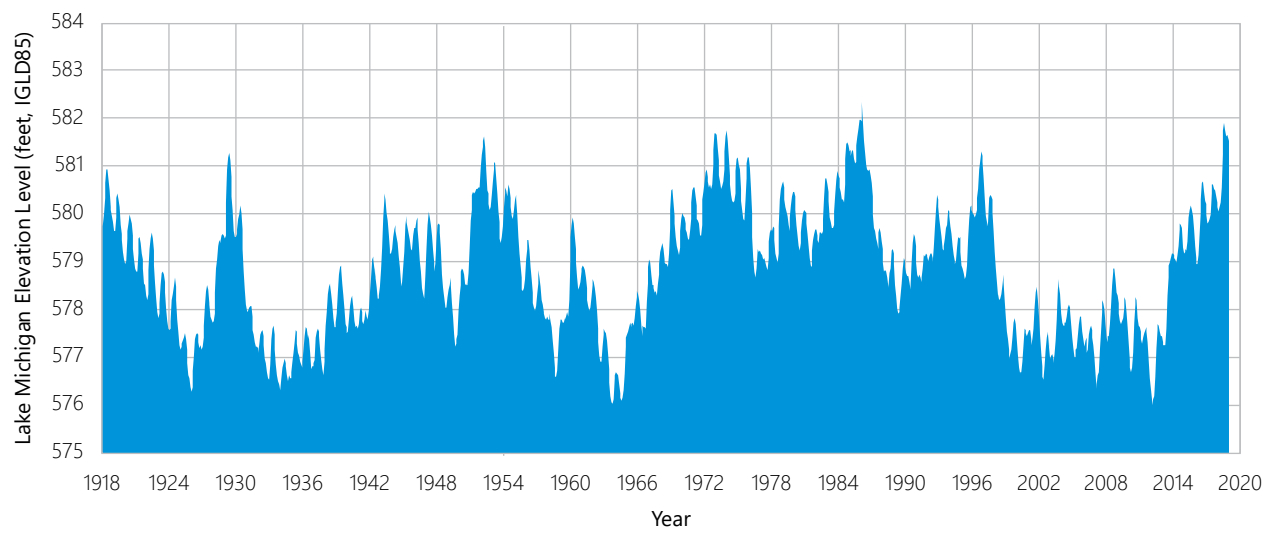
Managing Coastal Hazard Risks on Wisconsin's Dynamic Great Lakes Shoreline, Alan Lulloff and Philip Keillor, Wisconsin Coastal Management Program, 2016.

Protecting the Coastal Zone Through Growth Management: The Experience of Five Coastal States, Kari Dolan and Heidi Bly, Hendrickson National Network for Environmental Management Studies, United States Environmental Protection Agency, 1989.

Shrubs and Woody Vines of Indiana and the Midwest, Sally Weeks and Harmon Weeks Jr., Purdue University, 2012.

LAKE MICHIGAN MEAN MONTHLY WATER LEVELS: 1918-2019

APPENDIX C



Source: U.S. Army Corps of Engineers-Detroit District and SEWRPC

⁸¹ As identified in A Property Owner's Guide to Protecting Your Bluff, a publication under preparation by the University of Wisconsin Sea Grant Institute and the Southeastern Wisconsin Regional Planning Commission as this report was being prepared, and adapted to suitability for local conditions.

VEGETATION FOR BLUFF STABILIZATION⁸¹

APPENDIX D

Common Name(s)	Scientific Name(s)	Typical Mature Height	Soil Type	Moisture	Sun/Shade Tolerance	Root Type	Usage Area
Herbaceous Plants							
Asters	<i>Symphyotrichum eurybia</i>	1-4'	Any	Wet to dry, depending on species	Full sun to shade, depending on species	Fibrous, some species spreading by rhizomes	Table, ravine, bluff face, toe
Bergamot	<i>Monarda fistulosa</i>	3-4'	Any	Moist to somewhat dry	Full sun to partial shade	Deep branched roots and shallow rhizomes	Table, face, toe
Blue Vervain	<i>Verbena hastata</i>	3-5'	Any	Wet to moist	Full sun	Fibrous	Table, toe
Common Milkweed	<i>Asclepias syriaca</i>	2-6'	Any	Moist to dry	Full sun to partial shade	Fibrous, spreading rhizomes	Table, bluff face, toe
Goldenrods	<i>Solidago</i> spp. and <i>Euthamia</i> spp.	2-6'	Any	Wet to dry, depending on species	Full sun to shade, depending on species	Fibrous, some species spreading by rhizomes	Table, ravine, bluff face, toe
Great Blue Lobelia	<i>Lobelia siphilitica</i>	2-4'	Any	Moist to medium	Full sun to light shade	Fibrous, shallow	Table, ravine, toe
Mountain Mint	<i>Pycnanthemum virginianum</i>	2-3'	Any	Moist to medium	Full sun to partial shade	Fibrous with shallow rhizomes	Table, face, toe
Sedges	<i>Carex</i> spp. and <i>Scirpus</i> spp.	0.5-3'	Any	Wet to dry, depending on species	Full sun to shade, depending on species	Fibrous, some species spreading by rhizomes	Table, face, ravine, toe
Tall Boneset	<i>Eupatorium altissimum</i>	3-4'	Any	Medium to dry	Full sun to partial shade	Fibrous	Table, face, toe
Warm-season grasses (Switchgrass, Big Bluestem, Little Bluestem, Indiangrass, etc.)	<i>Panicum virgatum</i> , <i>Andropogon gerardii</i> , <i>Schizachyrium scoparium</i> , <i>Sorghastrum nutans</i> , etc.	2-8'	Any	Moist to dry, depending on species	Full Sun	Fibrous, deeply penetrating root systems, some species spreading by rhizomes (esp. switchgrass)	Table, face, toe
White Snakeroot	<i>Ageratina altissima</i>	1-3'	Any	Moist to somewhat dry	Shade	Fibrous with shallow rhizomes	Table, ravine, toe
Wild Ryes	<i>Elymus</i> spp.	3-5'	Any	Moist to dry, depending on species	Full sun to shade, depending on species	Fibrous	Table, face, ravine, toe
Yellow Coneflower	<i>Ratibida pinnata</i>	3-5'	Any	Medium to dry	Full sun	Fibrous	Table, face, toe
Shrubs							
American Hazelnut	<i>Corylus americana</i>	10-12'	Any	Wet to dry	Full sun to light shade	Spreading	Bluff face
American Highbush Cranberry Viburnum	<i>Viburnum trilobum</i>	8-15'	Any	Moist	Full sun to light shade	Spreading, suckering	Table, ravine, toe

Table continued on next page.

Common Name(s)	Scientific Name(s)	Typical Mature Height	Soil Type	Moisture	Sun/Shade Tolerance	Root Type	Usage Area
Shrubs (continued)							
Arrowwood Viburnum	<i>Viburnum rafinesquianum</i>	6'	Any	Moist to dry	Shade to partial shade	Spreading, suckering	Ravine
Blackhaw Viburnum	<i>Viburnum prunifolium</i>	10-15'	Any	Somewhat moist to somewhat dry	Shade	Branching, woody, suckering	Table, ravine
Bladdernut	<i>Staphylea trifolia</i>	10-13'	Any	Moist, rich soils	Shade to full sun	Spreading, suckering	Ravine
Bush Honeysuckle	<i>Diervilla lonicera</i>	2-3'	Sandy to rocky	Dry	Shade to partial shade	Suckering	Bluff face
Common Ninebark	<i>Physocarpus opulifolius</i>	5-10'	Any	Moist to somewhat dry	Full sun to partial shade	Spreading, fibrous, extensive, suckering	Table, ravine, face, toe
Common Juniper	<i>Juniperus communis</i>	1-4'	Any	Wet to dry	Full sun	Spreading	Bluff face
Common Snowberry	<i>Symphoricarpos albus</i>	2-5'	Any	Moist to dry	Shade	Spreading, suckering	Table, ravine
Hop Tree	<i>Ptelea trifoliata</i>	10-20'	Any	Medium to dry	Full sun to partial shade	Extensive, but does not sucker from roots or rhizomes	Table, bluff face, toe
Leatherwood	<i>Dirca palustris</i>	5-7'	Any	Moist, rich soil	Shade to partial shade	Variable	Ravine
Maple-Leaf Viburnum	<i>Viburnum acerifolium</i>	4-6'	Any	Moist to dry	Shade to partial shade	Shallow	Ravine
Meadow Sweet	<i>Spiraea alba</i>	3-6'	Silt, clay, organic	Moist	Full sun	Suckering	Bluff face
Nannyberry Viburnum	<i>Viburnum lentago</i>	14-25'	Any	Moist to medium	Full sun to light shade	Spreading, fibrous, suckering	Table, ravine, toe
New Jersey Tea	<i>Ceanothus americanus</i>	1-3'	Sandy to silt	Dry	Full sun to partial shade	Extensive, fibrous, suckering	Bluff face
Pussy Willow, Missouri River Willow, and Bebb's Willow	<i>Salix discolor, Salix eriocephala, Salix bebbiana</i>	6-20'	Any	Wet to moist	Full sun to partial shade	Extensive, Fibrous, suckering	Table, ravine, face, toe
Red Elderberry	<i>Sambucus racemosa</i>	8-14'	Any	Moist to medium	Partial shade to light shade	Spreading, suckering	Table, ravine
Red-Osier Dogwood, Gray Dogwood, and Silky Dogwood	<i>Cornus sericea, Cornus racemosa, and Cornus amomum</i>	6-15'	Any	Wet to medium, depending on the species	Full sun to partial shade	Deep, extensive, suckering	Table, ravine, face, toe
Round-Leaved Dogwood	<i>Cornus rugosa</i>	10-15'	Any	Medium to somewhat dry	Partial sun to light shade	Deep, extensive, suckering	Table, ravine, toe

Table continued on next page.

Common Name(s)	Scientific Name(s)	Typical Mature Height	Soil Type	Moisture	Sun/Shade Tolerance	Root Type	Usage Area
Shrubs (continued)							
Sandbar Willow	<i>Salix interior</i>	8-20'	Sands and loams	Wet to moist	Full sun to partial shade	Extensive, Fibrous, suckering to form large colonies	Table, ravine, face, toe
Soapberry	<i>Shepherdia canadensis</i>	3-9'	Neutral to Alkaline	Moist to dry	Full sun to partial shade	Spreading, suckering	Bluff face, toe (naturally occurs most often on exposed bluff headlands)
Sweet Fern	<i>Comptonia peregrina</i>	1-3'	Sandy	Dry	Full sun	Suckering, nitrogen fixing	Bluff face
Winter Berry	<i>Ilex verticillata</i>	10-15'	Silt, clay, organic, prefers acidic	Wet to moist	Full sun to light shade	Spreading	Bluff face
Witch Hazel	<i>Hamamelis virginiana</i>	15-20'	Any	Moist to dry	Shade to partial shade	Variable	Ravine
Trees							
Alternate-leaved Dogwood	<i>Cornus alternifolia</i>	15-25'	Loamy	Well drained, moist to medium	Full shade (understory tree)	Shallow, spreading root system benefits from leaf litter	Table, ravine
Balsam Poplar	<i>Populus balsamifera</i>	75-100'	Loamy	Well drained, moist to medium	Full sun	Shallow, spreading	Bluff face, ravine, toe
Basswood	<i>Tilia americana</i>	50-100'	Any	Moist to somewhat dry	Full sun to partial shade	Mostly lateral roots, can form adventitious roots when base is buried	Table, ravine
Black Cherry	<i>Prunus serotina</i>	45-80'	Any	Medium to dry	Full sun to partial shade	Tap root with shallow spreading roots, some roots up to four feet deep	Table, ravine
Bog Birch	<i>Betula pumila</i>	4-13'	Alkaline	Wet	Full sun	Shallow	Bluff face
Eastern Arborvitae	<i>Thuja occidentalis</i>	40-60'	Loams and clays	Moist to medium	Full sun to partial shade	Shallow, spreading root system	Table, ravine, bluff face
Hophornbeam	<i>Ostrya virginiana</i>	25-50'	Any	Well drained, moist to somewhat dry	Full sun to light shade (understory tree)	Variable, shallow in heavy soils	Table, ravine

Table continued on next page.

Common Name(s)	Scientific Name(s)	Typical Mature Height	Soil Type Trees (continued)	Moisture	Sun/Shade Tolerance	Root Type	Usage Area
Oaks (esp. Bur Oak and Chinquapin Oak)	<i>Quercus</i> spp. (esp. <i>Quercus macrocarpa</i> and <i>Quercus muehlenbergii</i>)	40-120'	Any	wet to dry, depending on species	Full sun	Deep and wide-spreading roots, will re-sprout from stump or crown if top-killed	Table, ravine (where relatively stable)
Paper Birch	<i>Betula papyrifera</i>	50-70'	Any	Moist to somewhat dry	Full sun	Shallow, spreading root system, good for stabilization	Table, ravine, bluff face, toe
Peach-Leaved Willow	<i>Salix amygdaloides</i>	35-70'	Any	Wet to moist	Full sun	Dense, shallow roots, forms adventitious roots when base is buried	Table, ravine (especially along waterways), bluff face, toe
Red Maple	<i>Acer rubrum</i>	50-80'	All but the most high pH (> 7.4) soils	Moist to medium	Full sun to partial shade	Shallow roots	Table, ravine
Speckled Alder	<i>Alnus incana</i>	15-30'	Silt, clay, organic	Wet to moist	Full sun	Spreading, suckering, nitrogen fixing	Bluff face
Wild Plum	<i>Prunus americana</i>	15-25'	Any	Medium to dry	Full sun	Spreading, shallow to medium depths.	Table, ravine, bluff face

Source: Milwaukee County, University of Wisconsin Sea Grant Institute, and SEWRPC

SAMPLE MODEL ZONING REGULATIONS FOR LAKE MICHIGAN BLUFF AND RAVINE SETBACKS

APPENDIX E

These model regulations are primarily based on recommendations for bluff and ravine setbacks developed by Wisconsin Sea Grant. The regulations are intended to provide bluff and ravine setbacks along Lake Michigan for new development and, where lot depth is adequate, redevelopment to help protect structures and properties from bluff and ravine erosion and failure without reliance on shore protection measures. In addition to calculating a stable bluff slope, the model recommends including a setback equivalent to a 60-year bluff recession distance (twice the typical home mortgage loan period) and a 100-foot setback from the top of the calculated bluff (including the recession rate and stable slope distance). The additional 100-foot setback is recommended to provide for uncertainties related to future stable slope angles, recession rates, the effect from nearby shore protection structures, and other factors. See Figure 3.1.

These regulations are not intended to be applied in areas of existing urban development, where deep setbacks would be difficult to implement. In such cases, bluff and ravine stabilization, subsurface and surface water control, bluff and ravine toe protection, or other measures may be needed in addition to maintaining existing bluff and ravine setbacks.

Additional recommendations and sources of information about bluff and ravine setbacks and other coastal protection measures are available from county hazard mitigation plans, Wisconsin Sea Grant, and the publication *"Protecting Coastal Investments,"* published by UW-Extension and Wisconsin Sea Grant in 2008 (aqua.wisc.edu/publications/PDFs/ProtectingCoastalInvestments.pdf).

The attached model regulations are intended to be incorporated as a section in an existing county, city, village, or town zoning ordinance, including a county shoreland zoning ordinance. The attached regulations do not include provisions for appeals, variances, severability, nonconforming uses and structures, and similar considerations that would typically be addressed in other sections of a full zoning ordinance.

Please contact SEWRPC at (262) 547-6721 or sewrpc@sewrpc.org if you have any questions or would like a Microsoft Word version of this model section.

EROSION HAZARD SETBACK FROM BLUFFS AND RAVINES

(Include in the "General Provisions" section of the zoning ordinance and number as appropriate.)

- A. Purpose.** Structures and soil absorption fields shall be set back from the top of bluffs and ravines along Lake Michigan in order to reduce erosion hazard and related damages to structures and property. These regulations do not guarantee nor warrant that development in compliance with its terms will be free from all erosion damage over the useful life of a structure.
- B. Setback from Bluffs.** The bluff setback shall be based upon the expected bluff recession distance over a 60-year period, plus the distance that would be needed to establish a stable slope, plus a minimum structure setback from the edge of the computed stable slope, as set forth below (See Figure 3.1):
1. The bluff recession distance for a 60-year period shall be calculated using a minimum recession rate of one foot per year, unless site-specific information justifying a greater distance is provided by the Zoning Administrator. The bluff recession distance shall be measured from the toe of the bluff.
 2. The distance required to achieve a stable slope shall use a ratio of one foot vertical distance to 2.5 feet horizontal distance. The measurement shall be made from the landward edge of the bluff recession distance.
 3. Soil absorption fields and structures, except those listed in paragraph 4 below, shall be set back a minimum of 100 feet from the landward edge of the stable slope distance.
 4. Storage sheds, driveways, walkways, patios, and fences accessory to a principal use may be permitted within the bluff setback area.
- C. Setback from Ravines.** All structures and soil absorption fields shall be set back from the top of a ravine. The ravine setback shall be based upon the distance that would be needed to establish a stable slope plus a minimum structure setback from the edge of the computed stable slope, as set forth below:
1. For ravines having a depth equal to or greater than 10 feet, as measured from the bottom of the ravine to the horizontal level of the land adjacent to the ravine, a distance required to achieve a stable slope using a ratio of one foot vertical distance to 2.5 feet horizontal distance shall be calculated. The measurement shall be made from the center of the deepest part of the ravine.
 2. For ravines having a depth less than 10 feet as measured from the bottom of the ravine to the horizontal level of the land adjacent to the ravine, a distance required to achieve a stable slope using a ratio of one foot vertical distance to three feet horizontal distance shall be calculated. The measurement shall be made from the center of the deepest part of the ravine.
 3. Soil absorption fields and structures, except those listed in paragraph 4 below, shall be set back a minimum of 100 feet from the landward edge of the stable slope distance determined in accordance with paragraphs 1 or 2 above.
 4. Storage sheds, driveways, walkways, patios, and fences accessory to a principal use may be permitted within the ravine setback area.

D. Modifications. The Board of Zoning Appeals/Plan Commission may grant a conditional use permit as provided in Section _____ allowing a modification of the erosion hazard setback from bluffs or ravines upon presentation by the applicant of a detailed report by a registered Professional Engineer with demonstrable geotechnical expertise documenting lower recession rates, more stable slope conditions, plans for structural protection against wave attack, or plans for stabilization of the bluff or shoreline. Engineering studies evaluating slope stability shall use the top of the lake sediments or 0.75 the height of the bluff, whichever is greater, as the groundwater surface. The 100-foot setback from the top of bluffs and ravines required by Sections B.3 and C.3 above shall be provided from the landward edge of the modified stable slope distance.

RELATED DEFINITIONS

(Include in the "Definitions" section of the zoning ordinance.)

Bluff

A hill, ridge, or similar landform significantly elevated above the surrounding landscape, having a broad, steep face or cliff, and adjoining the shoreline or coastal lowlands of Lake Michigan.

Bluff Recession Rate

The rate at which a bluff recedes because of erosion by the waters of Lake Michigan and because of unstable slope conditions.

Ravine

A small, steep sided valley worn by running water that opens onto a bluff located along the Lake Michigan shoreline.

EXHIBIT 8

CONSULTANT PROPOSAL

MILWAUKEE COUNTY
DEPARTMENT OF ADMINISTRATIVE SERVICES
ARCHITECTURE AND ENGINEERING DIVISION

PROJECT: Sheridan Park Bluff Stability (WP0838)

CONSULTANT PROPOSAL

I. **TASK I - BASIC SERVICES** (Include services of all needed subconsultants)

A. "TIME AND MATERIALS COST -NOT TO EXCEED " fee for task 1: \$
(_____)

II. **TASK II - BASIC SERVICES** (Include services of all needed subconsultants)

A. "TIME AND MATERIALS COST -NOT TO EXCEED" fee for task 2: \$
(_____)

IV. **TASK III - BASIC SERVICES** (Include services of all needed subconsultants)

A. "TIME AND MATERIALS COST -NOT TO EXCEED" fee for task 3: \$
(_____)

V. **PRINCIPAL IN CHARGE**

Name of Principal

Engineer's Registration No. in Wisconsin

Flat hourly rate for principal

Participation of Disadvantaged Business Enterprises at the rate of 9.39% will be required.

Firm Name

Authorized Signature

Title

Date