Design Study Report

McKinley Park Flushing Channel

Project No. P372-20145

Prepared for:

MILWAUKEE COUNTY
INCORPORATED
1835

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EXECUTIVE SUMMARY

Project: **McKinley Park Flushing Channel**

The Milwaukee County Department of Administrative Services (Milwaukee County) has retained Collins Engineers, Inc. (Collins) to complete an investigation and develop alternate recommendations for rehabilitation of the existing wall system at the Flushing Channel within Milwaukee Bay. The channel was originally used to pump lake water through a tunnel into the Milwaukee River during periods of low flow to flush stagnant water and is now being used by the Milwaukee Yacht Club (Yacht Club) for boat launch and haul out operations. The original plans for the timber Wakefield walls, timber pilings, and concrete cap that comprise the channel walls date back to 1906. As a result of deterioration that can be expected for materials of this age and environmental exposure, the structures have reached the end of their useful service life.

Collins visited the site in June, 2020 to complete a topographic survey and underwater investigation, and Collins’ subcontractor GESTRA Engineering, Inc. (GESTRA) visited the site in July, 2020 to complete a subsurface investigation. The full extents of deterioration along the wall system could not be effectively determined by Collins’ due to the shoaling of sediment along the wall system; however, several sinkholes were observed along the topside of the wall, there appeared to be differential settlement of the concrete cap and wall system. In addition, previous available reports have indicated that the timber piles and Wakefield walls were deteriorated and at the end of their useful service life.

The project has been divided into various sections. Alternatives for rehabilitation or replacement of the existing infrastructure is presented for each section.

It is recommended that rehabilitation of the existing timber channel walls consist of replacement with a new steel sheet pile (SSP) bulkhead on both sides of the channel. This alternate presents a cost-effective, low maintenance, and predictable level of protection during its useful life that effectively repairs the existing infrastructure. This alternate is commonly used for construction and is familiar to many local contractors, resulting in a larger pool of qualified bidders competing for the work. In addition, the construction method of installing a new steel sheet pile wall outboard of the existing wall allows the existing infrastructure to remain in place, limiting demolition efforts, project complexity, and susceptibility to slope erosion and landward subsidence during construction efforts.

For the existing steel sheet pile at the Milwaukee Yacht Club loading and unloading yard, it is recommended that the existing bulkhead be left in place and a new fiber reinforced panel and underwater grout system be installed. The panel and grout system will extend the longevity of the existing steel sheet piling.

Although a final cost estimate will be prepared once the design is complete, the preliminary estimated construction cost of the preferred alternatives is approximately **$3,753,000.**

1.0 DESCRIPTION OF PROJECT

1.1 Introduction

The Milwaukee County Department of Administration Services (Milwaukee County) has retained Collins Engineers, Inc. (Collins) to review existing conditions and provide recommendations and associated costs for the rehabilitation of the existing Flushing Channel walls in Milwaukee, Wisconsin. The information provided herein will aid in the design and development of construction documentation.

1.2 Purpose and Scope

The walls and timber support piles along the perimeter of the Flushing Channel have reached the end of their useful service life. Milwaukee County wishes to complete rehabilitation of the channel walls with a new steel sheet bulkhead or stone revetment, along with topside improvements such as concrete walkways and decorative railings.

The scope of work for the Flushing Channel Rehabilitation project includes the following:

- Land and Bathymetric Surveys
- Geotechnical Sampling and Analysis
- Design Development Report
- Erosion Control Planning and Design
- Structural Analysis and Design
- Preliminary Design
- Draft Final Design
- Final Design and Contract Documents
- Permitting
- Coordination with Stakeholders and Public Information Meeting
- Project Delivery

1.3 Description of Site

The Flushing Channel is located along the Milwaukee Bay between Veterans Park and McKinley Park. The channel was originally constructed circa 1906 and was previously used to pump lake water through a tunnel into the Milwaukee River during periods of low flow to flush stagnant water. The channel extends approximately 488 feet northwest from Milwaukee Bay where it meets the concrete and steel sheet pile intake structure for the tunnel. The channel is currently being used by the Milwaukee Yacht Club (Yacht Club) who leases land from Milwaukee County along the east side for boat launch and haul out operations and mooring small sailboats. The top of the channel wall is outfitted with concrete rails and lighting fixtures with the exception of the land leased by the Yacht Club, which has removable guardrails, chain, and cranes.

An aerial with labels depicting the different sections of Flushing Channel walls is shown in Diagram 1 below.

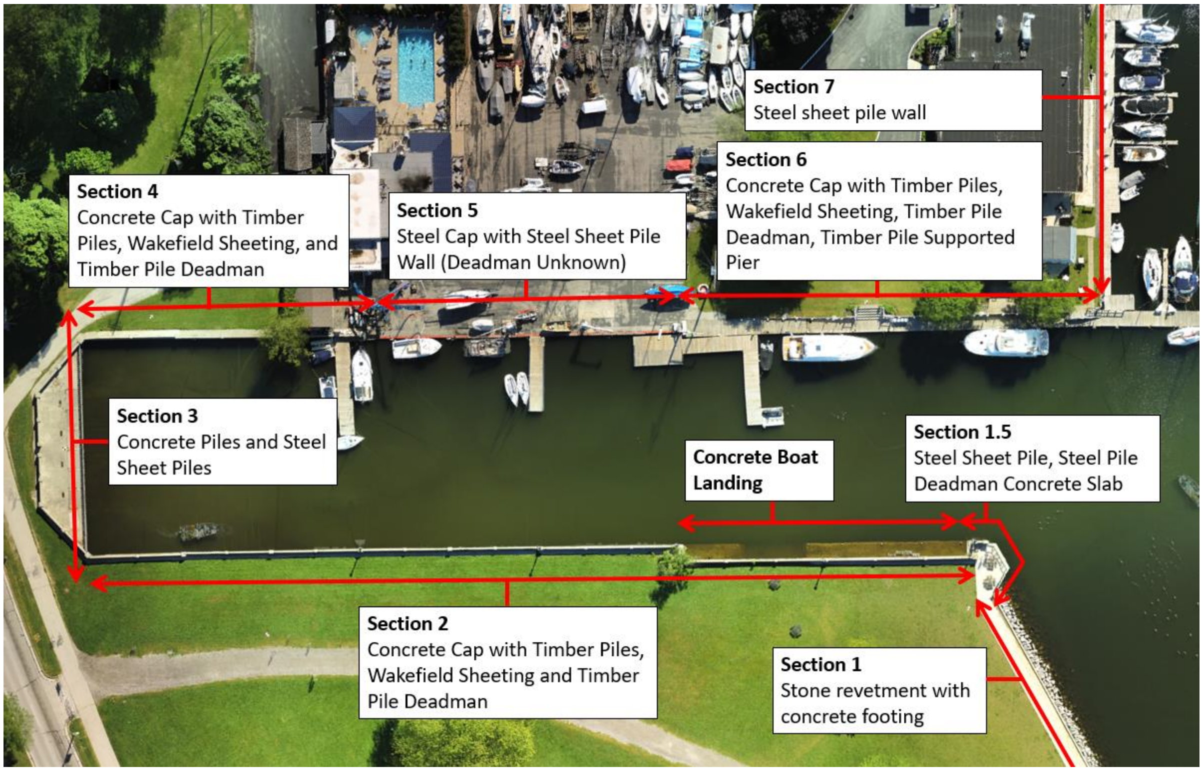


Diagram 1: Site Layout

The west side of the channel, Section 2, consists of approximately 480 feet of timber piles supporting a concrete cap and timber Wakefield wall (tongue-and-groove sheeting with timber king piles). The wall system is tied back through the concrete cap by two (2) steel anchor rods which extend approximately 16 to 20 feet to a timber pile deadman. Approximately 168 feet of the west channel wall includes a concrete boat landing constructed circa 1929 which also consists of timber piles, timber Wakefield walls, and timber deadman piles with steel tiebacks. Access to the boat landing is provided via concrete steps which lead down to a platform approximately 4.25-feet below the topside elevation.

Various repairs to the inlet headwall structure were completed by MMSD in 1996, including installation of concrete-filled steel pipe piles, concrete slab, and concrete rails (Section 3). Records of this construction are available.

The northern 160 feet of the east channel wall (Section 4) is of similar construction to the west channel with timber piles, timber Wakefield walls, concrete cap, and timber pile deadman system.

The central 160 feet of the east channel located in front of the yacht club (Section 5) consists of steel sheet piles with two (2) exterior C-channel wales approximately 10-in tall x 3.75-in wide located at the waterline and 3 feet below the waterline. The record drawings of this portion of the wall were not available during the preparation of this report, as such the age and presence of tieback system for this section of wall is unknown. Several cranes are located on top of the wall which are used by the Yacht Club to lift boats in and out of the channel. Timber fender planks are attached to the front of the steel sheet pile wall along the length. Several timber floating docks are attached for small vessel mooring. The Yacht Club reportedly removes the floating docks in the winter.

The southern 230 feet of the east channel wall (Section 6) is of similar construction to the west channel with timber piles and timber Wakefield walls. It is unknown if there is also a timber deadman system, but it is reasonable to assume that there is since it is of similar construction type as the west wall. There is an 8 foot wide fixed timber pier/boardwalk in front of the Wakefield wall supported by timber piles used by the Yacht Club for mooring and accessing vessels. Yacht Club staff reported that under the timber boardwalk there are derelict timber piles. The location of the timber boardwalk corresponds to the location of the concrete boat landing on the west wall. Behind this section of wall is greenspace and a paved patio area for the Yacht Club.

It is reasonable to assume that the northern and southern portions of the east wall are original timber construction and that the more recent steel sheet pile in the central portion of the east wall was installed outboard of the existing timber wall. The variations in alignment will need to be considered during final design.

The wall that abuts the Flushing Channel to the southwest (Section 1 and 1.5) was recently rehabilitated and consists of a stone revetment and concrete curb wall along the length. There is an outlook area at the southwest corner which consists of steel sheet piling and tiebacks. The wall that abuts the channel to the southeast (Section 7) consists of steel sheet piling, with an anchor rod tieback system with unknown length. These sections are out of the scope of the proposed work; however, the proposed repairs will need to tie into these sections.

1.4 Existing Information

Collins reviewed available existing information and drawings provided by Milwaukee County during the preparation of this report. Documents reviewed include the following:

- Drawing titled “Plan and Details of Concrete Docks and Railings Milwaukee River Flushing Tunnel Intake” by the City of Milwaukee Department of Public Works, dated May 16, 1929 (1 sheet);
- Record Drawings titled “Milwaukee River Flushing Station – Inlet Structure, Contract M002GX010, Volume III of III Plans” by the Milwaukee Metropolitan Sewerage District, dated January 1996 (20 sheets);
- Record Drawings titled “McKinley Marina Seawall Replacement at Former Coast Guard Station, County Project No. P513-03617” by the Milwaukee County Department of Transportation & Public Works, dated January 6, 2009;
- Report titled “Condition Survey of Seawalls at Flushing Channel” from the Milwaukee County Department of Public Works, dated January 18, 2000 (12 sheets);
- Boring logs for project titled “MMSD Flushing Station Inlet Structure, McKinley Marina Boat Slip” by Woodward-Clyde Consultants, dated December 7, 11, 14, and 16, 1992 (10 sheets);

2.0 SITE INVESTIGATION

2.1 Method of Investigation

Collins performed the on-site investigation on June 25, 2020, including a topographic survey, bathymetric/hydrographic survey, and underwater inspection. The inspection team consisted of one Professional Land Surveyor, two Professional Engineer-Divers, and one engineering technician. Photographs of existing conditions observed during inspection and investigations are included in Appendix B.

The topographic survey included utilization of a drone to obtain detailed aerial photography of the project site. The drone was operated by an FAA Part 107 licensed UAV pilot and the photographs processed through a photogrammetry software to obtain a detailed 3-D model of the above water portions of the project site. The bathymetric/hydrographic survey included the entire flushing channel and 50 feet adjacent to the face of the Veterans Seawall. Acoustic imaging was completed utilizing the BlueView BV5000 sonar system. A hydrographic and drone survey map is included in Appendix A.

Collins' subcontractor, GESTRA Engineering, Inc., completed a subsurface investigation from June 26 to July 9, 2020 which consisted of eight (8) SPT soil borings to depths of 45 to 60-feet below the surface using a track mounted Diedrich D50 and/or a truck mounted CME 75 drill rig. Samples were collected at 5-foot intervals, and representative soil samples were taken in general accordance with "Standard Method for Penetration Test and Split-Barrel Sampling of Soils" (ASTM D1586). Detailed findings of the subsurface investigation program are included in Appendix C.

2.2 Underwater Investigation

Collins completed a visual and tactile inspection of the walls along the perimeter of the Flushing Channel. The underwater inspection utilized commercial surface supplied air diving equipment in accordance with OSHA regulations. The inspector cleaned sample areas approximately every 100 feet to remove the 1 inch layer of zebra mussel growth that was typically present below water. Underwater inspection methods were completed in accordance with the ASCE Waterfront Facilities Inspection and Assessment Manual (MOP 130).

In Section 2 of the west wall, differential settlement of the concrete cap and significant deterioration of the exposed timber members comprising the wall indicate that the wall is in poor to serious condition; however, limited inspection of the timber portion was performed as the mudline extends up to approximately 1 foot below the existing concrete cap. In addition, areas of subsidence were noted along the topside of the structure indicating a loss of fill through the deteriorated timber wall.

The northern section of the east wall near the headwall structure (Section 4) consists of Wakefield sheeting and timber piles which was observed to be in serious condition, with up to 100% section loss typical in timber members.

Section 5 of the east wall in front of the Yacht Club loading yard was covered with timber fender planks which prevented a full inspection of the wall. However, several areas of missing timber planks exposed the underlying steel sheet piling, which was observed to have heavy corrosion and pitting up to ¼-in deep. Ultrasonic thickness measurements of the steel could not be obtained due to the extremely rough texture of the pitted steel. The Yacht Club indicated that there have been no known issues or observed deficiencies with the steel sheet pile wall. While there were no visible deficiencies observed during inspection that would indicate advanced deterioration of the wall such as holes in the sheet piles or areas of subsidence along the top of the structure, the condition of the sheet piles could not be confirmed.

Section 6 of the west wall is comprised of a timber Wakefield wall, timber piles, and a timber pile supported pier along the face of the wall. Timber fender planks were typical along the outside face of the timber piles supporting the fixed pier down to approximately 1 to 2 feet above the mudline which limited access to the wall system and piles supporting the pier. Areas of 100% section loss were observed at visible portions of the Wakefield sheeting and timber piles along the wall, indicating the wall system may be in poor to serious condition. Due to limited access, the condition of the timber pile supported pier could not be determined.

Although not included in the scope, the north headwall/intake structure was observed to be in good condition with no significant deficiencies noted. The walls adjacent to the channel to the east and west were also observed to be in good condition with no significant deficiencies noted.

In addition to conditions observed below water, Collins noted several areas of subsidence near the edge of the concrete cap along the topside of the west and east channel walls which indicate a loss of fill through the wall system. There is a large sinkhole near the northern entrance of the west wall boat ramp (Section 2) which has unsupported concrete and exposed reinforcement. It appears that this area has been blocked off with a timber stockade fence. These areas of subsidence present a safety hazard, and the extent of sinkholes beneath the surface is unknown.

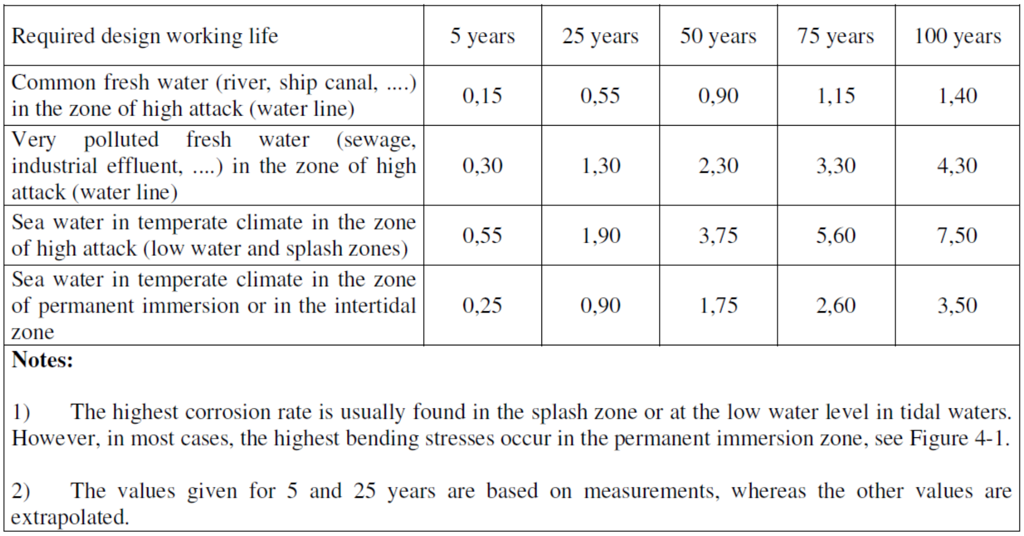
Detailed findings of the underwater investigation are included in Appendix D.

2.3 Evaluation and Assessment

The existing timber piles and Wakefield walls comprising the Flushing Channel were observed to be in poor to severe condition and should be replaced. Although the mudline was shoaled at the existing walls and prohibited a thorough inspection of timber members, the concrete cap exhibited differential settlement and rotation towards the channel, particularly along the west channel wall.

Collins’ findings were similar to the conditions reported in the inspection of the channel walls completed in November 1999. The report indicated that the walls were in very poor condition with up to 100% section loss of timber piles and wales, corrosion spalls on the bottom of the concrete cap, and exposed deteriorated reinforcement. In addition, the timber sheathing was noted to be severely rotted in several locations which allowed backfill material to pass through the wall and create sinkholes on the topside. This condition may have also caused the shoaling within the channel which prevented further inspection of the structure.

The existing steel sheet pile wall in front of the loading yard in Section 5 was observed to be corroded with heavy pitting up to 1/4-in deep. Drawings and construction records of the steel sheet pile wall were not available during the preparation of this report and the age and remaining steel thicknesses could not be confirmed. However, based on the construction type and environmental exposure typical for the area, it is likely that the original thickness of the wall was approximately 3/8 -inch thick. With corrosion section loss observed up to 1/4-inch deep, the steel thickness may be in the range of 50% to 70% section loss. Using published rates of typical corrosion for a steel sheet pile (Table 1) in “very polluted” fresh water, approximately 0.17 in (4.30 mm) of waterside section loss can be expected in 100 years, suggesting that the steel sheet pile is approximately 150-years old based on the level of corrosion observed. However; steel sheet piles were not introduced into the United States until after 1910, indicating that the Flushing Channel site has a more corrosive environment than published values. Accelerated corrosion may be due to several factors, such as higher/stronger currents, microorganisms, and pollution.



Required design working life	5 years	25 years	50 years	75 years	100 years
Common fresh water (river, ship canal, ...) in the zone of high attack (water line)	0,15	0,55	0,90	1,15	1,40
Very polluted fresh water (sewage, industrial effluent, ...) in the zone of high attack (water line)	0,30	1,30	2,30	3,30	4,30
Sea water in temperate climate in the zone of high attack (low water and splash zones)	0,55	1,90	3,75	5,60	7,50
Sea water in temperate climate in the zone of permanent immersion or in the intertidal zone	0,25	0,90	1,75	2,60	3,50

Notes:

1) The highest corrosion rate is usually found in the splash zone or at the low water level in tidal waters. However, in most cases, the highest bending stresses occur in the permanent immersion zone, see Figure 4-1.

2) The values given for 5 and 25 years are based on measurements, whereas the other values are extrapolated.

Table 1: Loss of Thickness Due to Corrosion for Piles in Fresh Water or Sea Water (mm)[1]

Without additional information on the steel sheet pile wall system such as the age of the wall, remaining thickness of the steel, condition, and environmental factors, a site-specific determination on remaining service life cannot accurately be made. However; assuming the wall had an original steel thickness of 3/8 inches and is between 50 to 80-years old, the existing steel sheet pile wall may have between 20 to 30 years of remaining useful life. Based on the 1/4-inch deep pitting observed, it appears that the wall currently has sufficient remaining structural capacity to meet the loading requirements of the Yacht Club (250 psf surcharge) and environmental loading of a storm surge (low tide with 4 feet of differential head). However, further deterioration of the sheet pile and reduction in capacity may result in the need for loading restrictions in the loading yard. It should be noted that these values are assumed based on multiple unknown conditions, and may be significantly more or less based on actual site-specific information.

It is possible that the deterioration will advance to a point where holes develop in the steel sheet pile within its remaining useful service life and the loss of fill material results in potholes within the paved area along the topside of the structure. Unless the holes in the steel sheet pile wall are patched, annual maintenance of potholes would be required until the eventual cost of upkeep or localized failure of the structure would warrant the replacement of this section. Preventative maintenance and/or replacement should be performed as discussed in Section 4.

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[1] Eurocode 3 – Design of Steel Structures, Part 5: Piling, Table 4-1: Recommended value for the loss of thickness [mm] due to corrosion for piles and sheet piles in fresh water or in sea water

3.0 DESIGN CRITERIA AND CONSIDERATIONS

3.1 Design Loads

Design criteria for the bulkhead is based upon geotechnical investigation, site constraints, and loading requirements. It is anticipated that the west channel wall will primarily be supporting pedestrian loading at the park, and the east channel wall will be supporting both pedestrian and vehicular loading. The new channel walls will be designed to resist the lateral active soil loads determined by the geotechnical investigation, live load surcharges, and also the full hydrostatic pressure loads of undrained backfill.

3.2 Geotechnical Design Considerations

Detailed findings of the subsurface investigation program are included in Appendix C.

3.3 Other Design Considerations

Water Levels

Based on information from the U.S. Army Corps of Engineers (ACOE), Lake Michigan has been experiencing record high water levels since May 2019. As of July, 2020, the lake level is over 2 feet above the long-term average water level. During the site inspection and survey, the water level was observed to be approximately 6 inches from the top of wall in areas along the east channel by the Yacht Club.

The design of a construction project presents an opportunity to improve defense against storm surge, waves, and higher water levels which typically includes consideration to raising wall elevations. However, new construction must also consider existing site features such as the existing riprap revetment and promenade, MMSD headwall, Yacht Club loading yard, greenspace, and existing buildings. The greenspace in front of the Yacht Club is approximately 2-feet higher in elevation than the other sections of the east wall, where the additional fill is being retained by the existing timber Wakefield wall. In this location there is an existing timber pier which extends into Milwaukee Bay and serves as a dock for the marina. The Yacht Club has expressed that a similar boardwalk at the same elevation is necessary for their operations. The Yacht Club loading yard also has a fixed elevation where major changes in wall heights will likely impact vessel access if Lake Michigan water levels drop to (or below) normal levels.

Raising the height of any of the sections of the channel has limited benefit in that adjacent features are fixed and would present drainage obstacles and interfere with park users' ability to experience the lakefront.

The high water table will also require design consideration in terms of constructability, as any excavation completed on site will likely require some level of dewatering. Design of the new channel walls should consider construction limitations due to the high water levels, including installation of a tieback system. It should be noted that the estimated construction costs presented herein account for high water levels observed during the time of site investigations. For final design analysis of the new construction, both extreme high water and low water level scenarios will be considered.

Adjacent Facilities

There are several buildings located on the east side of the channel within 50 feet of the existing wall. Collins was able to review original construction blueprints depicting the foundations of the Yacht Clubhouse building. The Yacht Club has several cranes in the loading yard used to load and unload vessels. Discussion about how each of these facilities impact the design alternates is presented in each section.

Existing East Wall Alignment

There are several different wall configurations and jogs in the alignment along the east side of the channel due to previous repairs and replacements. Section 4 of timber Wakefield wall transitions to the existing sheet pile wall in front of the loading yard in Section 5 which appears to be installed approximately 6 to 12 inches outboard from the face of the concrete parapet wall. In the area of the existing timber pile supported pier in front of the Clubhouse in Section 6, it appears the existing timber wall system is approximately 4 feet inboard of the steel sheet pile at the loading yard. In addition, the facilities manager at the Yacht Club indicated that there are various derelict piles beneath the existing timber pier that may have been previously used as mooring or support piles. If the proposed sheet pile alignment were to follow the alignment of the existing timber wall or be in line with the existing steel sheet pile wall, the derelict and existing timber piles supporting the pier may be an obstruction to pile driving operations during construction. For new construction at the timber pier, Collins proposes that the new wall be installed outboard of the existing pier. Further discussion on the proposed sheet pile alignment is discussed herein.

Utilities

There are existing electrical conduits with cable and potable water lines located along the front of the existing wall at the Yacht Club and loading yard. These lines provide shore power to vessels that dock along the timber pile supported pier in front of the Yacht Club and power the existing lighting and cranes in the loading yard. It is assumed that the outlets and electric line may get submerged during large storm events, and that the electrical lines in front of the loading yard may be partially submerged during periods of high water levels. Consideration should be given to disruption to these facilities during any construction work including the potential for relocating the lines and providing waterproof power pedestals for safety.

Hardscape Improvements

As part of the wall replacement, Collins will evaluate landscape and general architecture along the topside of the proposed wall rehabilitation. It is our understanding that the proposed improvements will match the work previously completed by Milwaukee County including the concrete promenade along the west wall that abuts the channel and the handrails within the Marina. It is anticipated that a concrete walkway will extend along the majority of the site; however, Collins will coordinate with Milwaukee County and the Yacht Club regarding improvements in the loading yard, greenspace and patio area of the Yacht Club.

Parapet Walls

Milwaukee County has requested that the final design of the steel sheet pile walls in Section 2 and 4 near the existing MMSD headwall include a concrete parapet that emulates the historic concrete parapet of the Flushing Channel. This would replace the proposed concrete cap and steel railing for the 40 feet closest to the headwall. The final design for the concrete parapet is anticipated to include a moment slab to prevent overturning. The additional dead load and lateral forces acting on the parapet are not anticipated to significantly alter the sheet pile shape or proposed anchoring system.

4.0 REHABILITATION AND REPLACEMENT ALTERNATES AND COST ESTIMATES

The following alternate discussions are broken into the various sections corresponding Diagram 1. Alternates for Sections 2, 4, 5, and 6 are presented. Sections 1, 1.5, 3, and 7 are outside the scope of this project.

- Alternates for Section 2 include a new steel sheet pile bulkhead (A) or a riprap revetment (B).
- Alternates for Section 4 and 6 include a new steel sheet pile bulkhead with deadman tiebacks (A) or grouted anchors (B).
- Alternates for Section 5 include a new steel sheet pile bulkhead with deadman tiebacks (A), a new steel sheet pile bulkhead with grouted anchors (B), rehabilitation with Fiber Reinforced Polymer panels and grout infill (C), or a cathodic protection system (D).

Although not included as an alternate, it should be noted that leaving the walls of the Flushing Channel in their present condition will result in the wall continuing to move and deteriorate until the eventual collapse of the system. Areas of subsidence will continue to develop along the topside, likely in conjunction with major storm events. These areas of subsidence, potential voids beneath the topside, and movement of the wall system present a safety hazard and require continuous repair. Therefore, it is not recommended that the walls be left in its current condition. Initial construction costs are zero; however, maintenance costs will become prohibitively more expensive as the existing walls deteriorate.

4.1 Section 2: West Wall

The alternates for this section involve installing a new steel sheet pile bulkhead outboard of the existing Wakefield wall or replacing the existing wall with a riprap revetment along the west channel wall.

Alternate A – New Steel Sheet Pile with Deadman Tieback

This alternate consists of installing a new steel sheet pile bulkhead approximately 1-foot outboard of the existing west timber wall. It is anticipated that the existing concrete cap and the top portion of the concrete boat platform would be removed; however, the existing timber Wakefield wall and timber piles could remain in place. A new tieback system consisting of a steel or concrete deadman and tie rods would be installed, and the space between the existing timber Wakefield walls and new steel sheet piles would be filled with granular material. The final design phase will determine the exact deadman and tieback configuration and location.

To facilitate installation of the tieback system, excavation would be required behind the bulkhead and, due to the high water level, it is anticipated that some level of dewatering will also be required to make the tieback to deadman connections. A new concrete pile cap with steel handrail will be provided on top of the steel sheet piling along the length of the wall with the exception of the 40-feet adjacent to the headwall at Section 3 where a new concrete parapet will be provided to match the historic structure. The steel tie rod would be cast into the concrete cap, therefore also acting as the wale. The new steel sheet pile bulkhead will tie into the existing steel sheet pile wall at the viewing area in Section 1.5 and connect to the existing intake structure at Section 3.

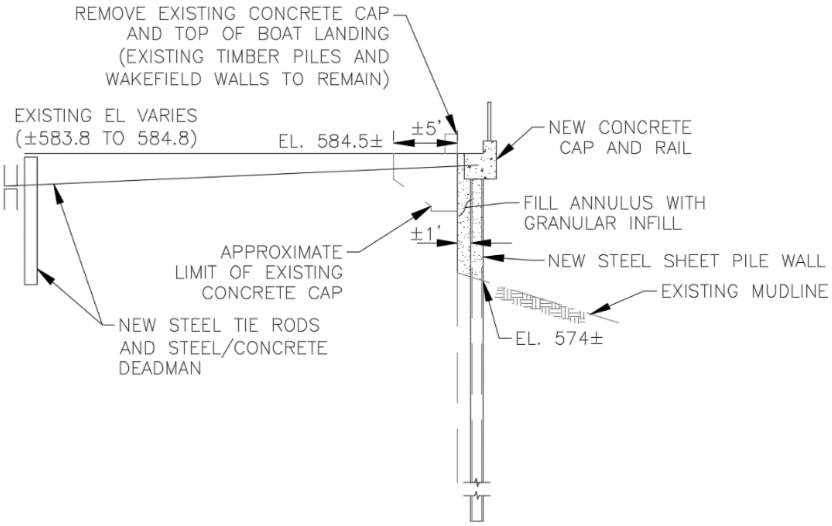

Diagram 2: Steel Sheet Pile with Deadman Tieback

Steel sheeting can also be provided with shop coatings. These marine grade coating systems, such as coal-tar or fusion bonded epoxy can help extend the useful service life of the proposed steel sheet pile. Such coatings are not included in the narrative but additional cost estimates of such systems are provided in Appendix F.

The following lists advantages and disadvantages of the steel sheet pile bulkhead:

Advantages	**Disadvantages**
• Longer service life • Requires less demolition • Maintains landside area in park • Public water access easy to maintain • Less long-term maintenance costs • Similar to existing wall with minimal channel disturbance	• Excavation may require dewatering

The rehabilitation alternates presented herein assume that public water access for small vessels will not be maintained along the west side of the Flushing Channel. However, should Milwaukee County wish to provide public access to the water, Alternate A with steel sheet piling is recommended. Access could be provided via timber piers similar to the area in front of the Yacht Club, or by utilizing a steel gangway and floating dock system to account for fluctuations in water levels. For the purpose of this report, the cost of maintaining public water access was not evaluated but may be included in cost estimates during final design development if required.

The existing Wakefield wall has a tieback system consisting of steel tie rods and timber anchor piles, the condition of which is unknown and has not been investigated. The reuse of the existing tieback system could be considered; however, this would require verifying the adequacy of the existing tieback system via exploratory investigations and analysis, non-destructive material testing, and/or pull tests of the existing tiebacks. Due to the costs of verifying the existing tieback system and the unknown capacity of the existing system as compared to the potential cost benefit related to reuse, Collins does not recommend reuse of the existing tieback system.

The exact design of the proposed deadman system can take many forms including deep driven piling or mass concrete. The optimal configuration was not finalized as part of this report but will be investigated as part of final design.

Alternate B – New Riprap Revetment

This option consists of replacing the existing west channel wall with a new stone revetment and includes full removal of the existing wall system consisting of timber piles, Wakefield wall, concrete pile cap, and concrete boat platform down to the mudline. A new stone revetment would then be installed as a means of shore protection from the mudline up to the topside. To maintain channel width, the revetment would be installed so that the center of the slope is located at the location of the existing wall alignment which will require excavation of material. It is anticipated that the soil excavated to install the revetment will be used to fill and grade the slope, and any excess material may need to remain on site but could be reused to develop a berm nearby. Due to the saturated nature of the soil, it is anticipated that it will need to be temporarily stockpiled on site and dried in order to reuse it as suitable fill material.

Existing drawings for the Coast Guard Seawall Replacement at the southwest corner of the west channel wall indicate that existing tie rods and steel sheet piling at the promenade/outlook area may interfere with the revetment in this area. It is recommended that a new steel sheet pile extension (return wall) be provided for approximately 40 feet in order to transition into the stone revetment. Additionally, a short section of steel sheet pile may be needed at the MMSD headwall structure.

The layout of the revetment would be similar to that of the existing revetment along Section 1, with the top of slope consistent and a concrete curb wall at grade. The sizing of the riprap stone is contingent upon a relatively conservative prediction of wave height and period. As the waves are wind-driven, this requires understanding what the probability of future storm events generating waves of a certain magnitude are. Typically, shoreline structures are designed for the probability of a storm event of a certain magnitude occurring once during any time within a period of one hundred years (a hundred-year storm). However, considering the recent significant impacts to the western and southern shores of the Lake Michigan shoreline, it is likely that this probability may be increased to include a 500-year storm event. These probabilities are based on a statistical evaluation of historical data which includes water depth and seasonal variations, dominant wind direction and velocity, predictions of future water levels based on our current understanding of climate changes, and the associated economics of providing protection at any cost versus accepting some level of damage at some level of acceptable cost.

The Yacht Club indicated that the Flushing Channel was recently dredged to accommodate for the drafts of vessels which utilize the marina and loading yard. Given the configuration of floating docks that are utilized by the Yacht Club on the east side of the channel, the configuration of the revetment, proposed toe location, and vessel fairway dimensions would need to be evaluated and coordinated with the marina.

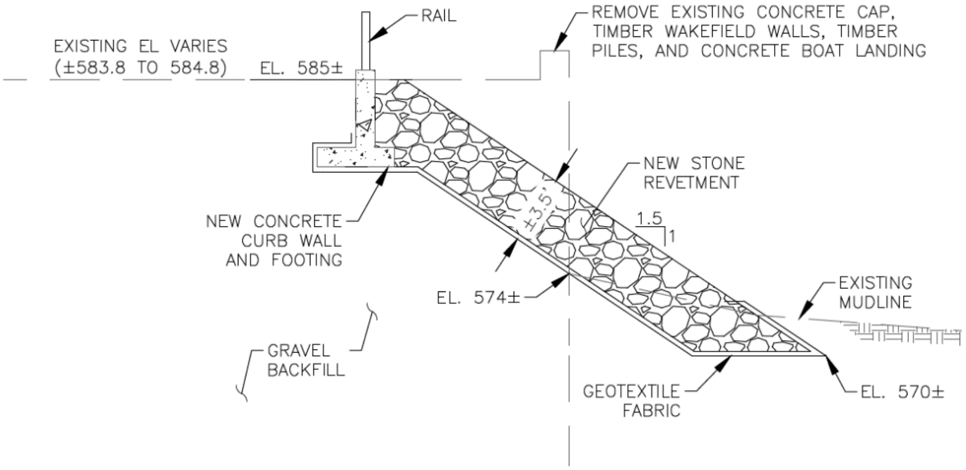

Diagram 3: Riprap Revetment

The following lists advantages and disadvantages of the stone revetment:

Advantages	Disadvantages
• Visually similar to recent project	• Shorter service life • High wave action can cause movement of riprap (maintenance) • Requires demolition of existing wall to mudline • Loss of land along wall • Installation of steel sheet pile still required near pavilion (Section 1.5) and MMSD headwall (Section 3) • Potential limitation to vessels utilizing the channel

Estimated Construction Cost

Estimated construction costs include mobilization, overhead and profit, and contingency. The costs do not include estimated engineering fees (permitting, design and construction services). A breakdown of order of magnitude costs for Section 2 of the west wall is provided in the table below and additional details are provided in Appendix F.

Alternate	Estimate
A – Steel Sheet Pile	$1,867,000
B – Riprap Revetment	$1,655,200

4.2 Section 4 and Section 6: East Wall

The alternates for these sections involve installing a new steel sheet pile bulkhead outboard of the existing Wakefield wall in Section 4 near the existing headwall structure and Section 6 near the Yacht Clubhouse along the east wall. The alternates presented are for the wall anchor system which considers either a deadman tieback system or grouted anchors. A riprap revetment has limited feasibility in Section 4 due to the need to install some steel sheet piling to connect to the MMSD headwall and to provide support to the existing building at the Yacht Club loading yard. In Section 6, a riprap revetment would not allow for Yacht Club access to the waterfront and is not considered a viable alternative.

Due to anticipated constructability issues related to existing derelict timber piles under the timber boardwalk, the alternates for Section 6 involve installing a new steel sheet pile bulkhead outboard of the existing boardwalk. The area between the new steel sheet piles and the existing timber wall would be filled with granular material and capped.

The new steel sheet pile bulkhead will tie into the existing headwall structure at Section 3, connect to the existing or proposed wall in Section 5, and tie into to the existing steel sheet pile bulkhead in Section 7. Steel sheeting can also be provided with shop coatings. These marine grade coating systems, such as coal-tar or fusion bonded epoxy can help extend the useful service life of the proposed steel sheet pile. Such coatings are not included in the narrative, but additional cost estimates of such systems are provided in Appendix F.

Alternate A – New Steel Sheet Pile with Deadman Tieback

This alternate consists of installing a new steel sheet pile bulkhead outboard of the existing east timber wall, including installation of a steel or concrete deadman. The new steel sheet pile will be installed approximately 1-foot outboard of the existing wall at Section 4, and approximately 8-feet outboard of the existing wall and directly outboard of the existing timber pier at Section 6 due to the jog in alignment in front of the Clubhouse. It is anticipated that the existing concrete cap in Section 4 will be partially removed and the existing timber pier in Section 6 would be fully removed, but the existing timber Wakefield wall and timber piles at both sections could remain in place. This includes the section of the timber wall in front of the Clubhouse which is at a higher elevation and retains the fill in the patio area. The space between the existing timber walls and new steel sheet piles would be filled with granular material.

To facilitate installation of the tieback system, excavation would be required behind the bulkhead and, due to the high water level, it is anticipated that some level of dewatering will also be required to make the tieback and deadman connections. There is an existing building within 6 feet of the existing timber wall in Section 4 between the landscaped grass area and the loading yard parking lot. The building is approximately 20-feet wide and is slab-on-grade construction, which would prevent installation of the deadman tieback system unless the building is removed. Additionally, the existing large stationary crane near the south end of Section 4 would prevent the installation of a tieback system along approximately 10 feet of existing wall. In order for the building and crane to remain in place it is anticipated that this section would require a combination-wall system consisting of steel H-section king piles between the proposed steel sheet piles to resist lateral loads. It is anticipated that the contractor could use the same or similar hammer to install both the steel sheet piles and steel H-piles.

Section 4 of the east wall will include approximately 40 feet of concrete parapet along the topside of the wall adjacent to the headwall at Section 3 to match the historic structure. The remainder of the wall at Section 4 will consist of a concrete pile cap and steel rail. Section 6 in front of the Clubhouse is anticipated to include a concrete cap along the topside of the wall. The tieback would be anchored into the concrete cap within Section 4 and 6, therefore the concrete cap would also act as a wale.

In Section 6, the patio area in front of the Clubhouse includes concrete pavers, an awning supported by the building and two steel posts located approximately 17 feet from the existing timber wall, an outdoor bar structure approximately 27 feet from the existing timber wall, and two mature trees directly adjacent to the existing timber wall. Based on the site conditions, subsurface soil, wall orientation, and loading requirements, it is anticipated that the deadman system will be a minimum of 40-feet from the face of the proposed steel sheet pile wall. Given the close proximity of the awning, it is anticipated that the steel posts will need to be temporarily removed and replaced to facilitate construction of the deadman system. The outdoor bar structure is located further away from the wall, so the placement of a deadman system located 35 feet from the proposed steel sheet pile bulkhead could be evaluated during final design; however, it is possible that the structure may need to be removed to facilitate construction of the deadman system. Due to the proximity of the existing Clubhouse to the proposed deadman, Collins proposes a mass concrete deadman for Section 6. This would be to limit vibration damage to the structure related to installing a deep foundation system.

In addition, removal and replacement of the pavers in the patio area would be required and the removal of the trees adjacent to the existing wall may be required. Having trees within the tieback anchorage zone is not recommended as the roots can exert additional lateral pressures.

The following lists advantages and disadvantages of the steel sheet pile bulkhead with deadman tiebacks:

Advantages	**Disadvantages**
• Common construction technique familiar to local contractors	• Requires disruption to land behind the wall including existing asphalt paths, patio and potential tree removal • Requires combination-wall or removal and replacement of building at loading yard • May require alternate construction methods at the outdoor bar or removal and replacement of structure

The existing Wakefield wall has a tieback system in Section 4 consisting of steel tie rods and timber anchor piles, the condition of which is unknown and has not been investigated. Record drawings of the existing timber in Section 6 could not be found, but it is anticipated that it has a similar tieback system. The reuse of the existing tieback system could be considered; however, this would require verifying the adequacy of the existing tieback system via exploratory investigations and analysis, non-destructive material testing, and/or pull tests of the existing tiebacks. Due to the costs of verifying the existing tieback system and the unknown capacity of the existing system as compared to the potential cost benefit related to reuse, Collins does not recommend reuse of the existing tieback system.

Alternate B – New Steel Sheet Pile with Grouted Anchors

This alternate consists of installing a new steel sheet pile bulkhead approximately 1-foot outboard of the existing east timber wall similar to Alternate A; however, the installation of grouted anchors is considered instead of a deadman system.

The grouted anchors would be installed from the front face of the proposed wall, drilled at a downward angle, and filled with grout material after installation. The topside of the wall includes a concrete cap and parapets similar to Alternate A.

While this alternate alleviates the need to remove and replace structures within the patio area of Section 6 and the need for a combination-wall in Section 4, there are additional unknowns regarding the existence of existing infrastructure behind the existing wall system that may result in a significantly higher construction cost in the location of the Clubhouse.

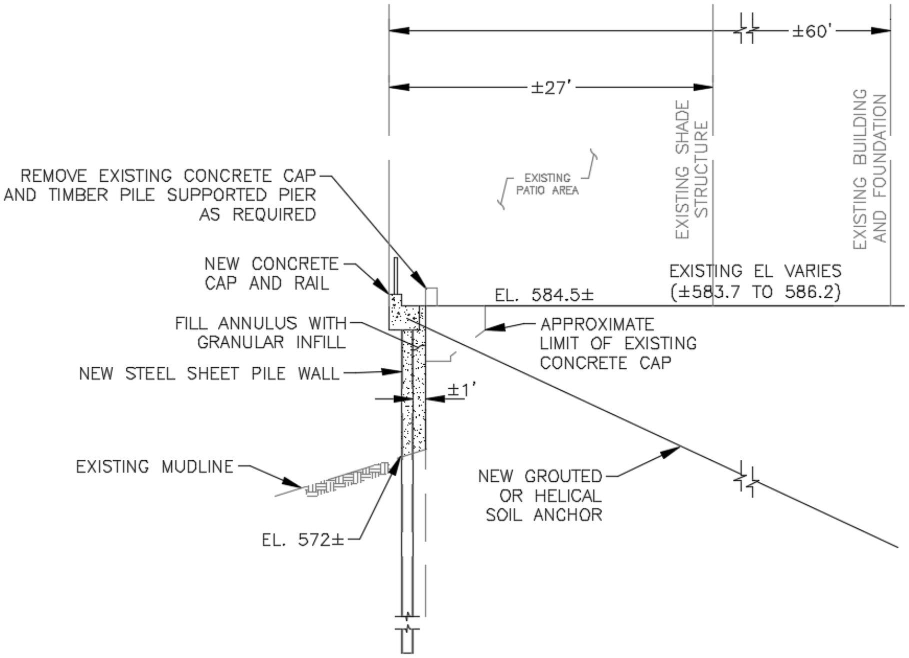

Diagram 4: Steel Sheet Pile with Grouted Anchors (in location of Clubhouse)

The following lists advantages and disadvantages of the steel sheet pile bulkhead with grouted anchors:

Advantages	**Disadvantages**
• Less disruptive to existing structures behind the wall	• Potential additional construction costs due to unknown conditions • Specialty contractor work • Typically more expensive than deadman tiebacks • May have more lateral movement than deadman tiebacks • Requires barge work to drill anchors from front face of wall

Estimated Construction Cost

Estimated construction costs include mobilization, overhead and profit, and contingency. The costs do not include estimated engineering fees (permitting, design and construction services). A breakdown of order of magnitude costs for Sections 4 and 6 of the east wall is provided in the table below and additional details are included in Appendix F.

Alternate	Estimate
A – Deadman Tiebacks	$1,588,000
B – Grouted Anchors	$1,542,000

It should be noted the deadman tiebacks have a higher construction cost due to the combination-wall required in front of the existing building between the landscaped area and loading yard in Section 4. Based on the preliminary design, the installation of a combination wall in this area accounts for approximately $130,000 in additional construction cost. If the existing building was removed to allow for deadman anchor installation and replaced in-kind after construction in this area, the cost would likely be approximately the same as the combination wall. In addition, it is anticipated that the combination wall would be included in the bid documents as a performance specification, and the cost could be increased or decreased from the preliminary estimate provided herein based on the contractor’s means and methods.

It should also be noted that while the grouted anchors appear to be the cheaper alternate for Section 4 and Section 6, the estimated construction cost does not include potential additional costs related to the unknown conditions behind the existing walls. There are no existing plans available for the existing wall at Section 6; therefore the orientation of the existing wall system, tiebacks, presence of historic walls behind the timber wall, and location and length of tiebacks from the sheet pile wall at Section 7 is unknown. It is possible that the unknown conditions could result in significant additional construction costs which cannot accurately be quantified prior to additional investigations. Additional construction costs for the installation of grouted anchors may include, but not be limited to, demolition and removal of historic walls behind the timber wall in Section 6.

The additional cost associated with removal and replacement of the outdoor bar has not been included in the order of magnitude cost and will be further evaluated during final design.

4.3 Section 5: East Wall Yacht Club Loading Yard

Historic drawings of the existing steel sheet pile wall were not available during the preparation of this report. It is anticipated that the steel sheet pile present in the loading yard was installed outboard of an existing timber Wakefield wall; however, the presence of a prior timber wall and associated tiebacks is unknown.

Record drawings of the existing steel cranes and concrete foundation systems at the Yacht Club loading yard were not available during the preparation of this report. The Yacht club has four existing cranes. Three of these are supported by concrete foundations with the third supported on the existing steel sheet piling system. Additionally, the Yacht Club has indicated that the existing crane used to load and unload vessels does not have additional capacity to extend beyond where the existing wall is located. Any alternate that extends the face of the wall toward the channel, would require installing a new foundation and moving the existing crane in order to maintain the Yacht Club’s operations. Two alternatives that install a new steel sheet pile wall are presented. Rehabilitation of the existing wall is provided as an alternative and a potential additional cathodic protection option is also presented that could be used in conjunction with the rehabilitation alternate. A riprap revetment was not considered for the east wall due to loading and vessel access requirements for the Yacht Club.

Steel sheeting can also be provided with shop coatings. These marine grade coating systems, such as coal-tar or fusion bonded epoxy can help extend the useful service life of the proposed steel sheet pile. Such coatings are not included in the narrative but additional cost estimates of such systems are provided in Appendix F.

Alternate A – New Steel Sheet Pile with Deadman Tieback

This alternate consists of installing a new steel sheet pile bulkhead approximately 1-foot outboard of the existing steel sheet pile, including the installation of a steel or concrete deadman similar to that presented for Alternate A of Section 4. It is anticipated that the existing steel cap and timber fender boards would be removed, but the existing steel sheet pile wall, steel wale, and tiebacks could remain in place. The space between the existing timber walls and new steel sheet piles would be filled with granular material.

To facilitate installation of the tieback system, excavation would be required behind the bulkhead and, due to the high water level, it is anticipated that some level of dewatering will also be required to make the tieback and deadman connections. The bituminous pavement in the parking lot would need to be removed and replaced. The additional cost associated with installation of a new fender system along this section of wall has not been included in the cost estimate but can be evaluated during final design.

There are four existing cranes in or near this section of the wall; three smaller cranes located adjacent to the existing wall and a larger 20-ton crane located between the existing wall and a building for the loading yard.

In addition, Collins anticipates that the existing steel sheet pile wall was installed outboard of a historic timber Wakefield wall found in other locations in the Flushing Channel. It is anticipated that the additional cost of demolition of a timber wall for the installation of deadman tiebacks will be minor and not result in a significant additional cost during construction.

The existing steel sheet pile wall has a tieback system consisting of steel wales and tie rods. The condition of all of the existing tieback system could not be determined during the field investigation due to the existing timber fender system. Some individual sections were inspected and found to be in good condition with no appreciable degredation. The reuse of the existing tieback system could be considered based on its acceptable past performance and lack of issues. If reused, a pull test during construction would verifying the adequacy of the existing tieback system. The existing tieback system has two horizontal rows of anchors. Both rows of anchors would need to be incorporated into the new system. During field inspection, the top row of anchors was accessible and just above the Lake water level, but the bottom row was underwater. Extending and reusing the existing anchors would require removing the existing plate and nuts that secures the anchor to the existing whaler, installation of a coupler and additional threaded rod to extend the rod to the front of the new wall. It is possible to perform this work underwater but adds complexity and cost.

The following lists advantages and disadvantages of the steel sheet pile bulkhead with deadman tiebacks:

Advantages	Disadvantages
• Common construction technique familiar to local contractors	• Requires removal and replacement of pavement • Requires removal and relocation of the primary Yacht Club crane • If existing tieback anchors are reused, would require load testing and additional testing

Alternate B – New Steel Sheet Pile with Grouted Anchors

This alternate consists of installing a new steel sheet pile bulkhead approximately 1-foot outboard of the existing steel sheet pile similar to Alternate B at Section 4 and 6 along the east wall.

The grouted anchors would be installed from the front face of the proposed wall, drilled at a downward angle, and filled with grout material after installation. It is anticipated that the existing primary crane would need to be temporarily removed and relocated for this alternate due to capacity limitations.

The grouted anchors would need to pass through the existing steel sheet pile wall and openings in the existing wall would need to be made. It is anticipated that drilling through any existing historic timber Wakefield wall would not be a hinderance an estimate to perform additional test pits / investigation to determine the orientation and presence of an existing wall.

The following lists advantages and disadvantages of the steel sheet pile bulkhead with grouted anchor tiebacks:

Advantages	Disadvantages
• May be less disruptive to Yacht Club operations and area behind the wall	• Requires barge work to drill anchors from front face of wall • Requires removal and relocation of the primary Yacht Club crane • Specialty contractor work • Typically more expensive than deadman tiebacks and rehabilitation alternatives • Requires modification to existing steel sheeting • May have more lateral movement than deadman tiebacks

Alternate C – Rehabilitation of Existing Steel Sheet Pile – Grout Facing

This alternate consists of rehabilitation of the existing sheet pile bulkhead with the installation of Fiber Reinforced Polymer (FRP) panels outboard of the existing wall and filling the space between with an underwater grout. The existing sheets would have to be cleaned through underwater pressure blasting, anchors would be installed on the existing sheets to bond the new grout to the existing steel, formwork would be installed in front of the existing sheets and an underwater grout would be pumped into the space between the formwork and the steel sheets.

The limits of panel and grout installation would be from the existing channel bottom to the bottom of the existing horizontal steel wale to leave the existing tieback exposed for future inspections. It is anticipated that the existing wall infrastructure would remain in place with the exception of the timber fender planks which would be removed. Because the front face of the wall would not move significantly outward, it is anticipated that the existing loading yard crane could remain in place.

The intent of this system is that the FRP panels and grout form a barrier to water and oxygen reaching the existing steel sheet panels. There are two manufacturers of this style of system including Quakewrap and the SPiRe ® product and Simpson Strong-Tie FX Structural Repair and Protection System. These systems use specialty underwater grouts. Marine epoxy grouts are used for small annular spaces and non-shrink underwater grouts are used for annular spaces greater than 2". It is anticipated that the non-shrink underwater grout would be most appropriate for this situation. Although the lifespan of the product is not definitively known, discussions with the manufacturer indicate that the FRP sheets and grout could extend the life of an existing sheet pile wall up to 50 years depending on the environmental conditions. These products were developed for aggressive saltwater marine environments and have been around since the 1970s. .

It is anticipated that the life of the existing steel sheet pile will be dependent on the existing steel wale and tieback system. The Yacht Club has indicated that they have not experienced any movement or settlement behind the existing wall, but because the configuration of the tieback system is unknown the capacity of the wall can not be independently confirmed. If this alternate is selected, Collins recommends periodic inspection and maintenance of the existing tieback system. Additionally, cathodic protection could be applied to the steel above the grout. For more discussion on cathodic protection see Alternate D.

The following lists advantages and disadvantages of the rehabilitation of the existing steel sheet pile bulkhead with grout:

Advantages	**Disadvantages**
• Does not require crane relocation • Lower construction cost than new wall • Low impact to Milwaukee Yacht Club operations.	• Limited case use history • Recommended inspection and maintenance of existing wale and tieback system • Service life may not be the same as a new steel sheet pile wall • Grout installation temperature is limited to 40 degrees F

Alternate D – Cathodic Protection

This alternate consists of leaving the existing steel sheet pile bulkhead in place and the installation of preventative cathodic protection along the wall to extend the remaining service life of the structure. Collins anticipates that this would take the form of a sacrificial anode system, which is passive, rather than an impressed current system, which is active. The steel and anode material form a galvanic cell where the anode oxidizes preferentially to the steel.

> *The primary advantage of sacrificial anode cathodic protection systems over impressed current cathodic protection systems is their simplicity and reliability. There are fewer critical components such as rectifiers in sacrificial anode systems. The critical cable from the anode to the impressed current anodes which is prone to failure is not a factor in sacrificial anode cathodic protection systems. The anode-to-structure cable in sacrificial anode systems is at a negative (protected) potential. Sacrificial anode cathodic protection systems are also in some cases less costly to install and maintain than impressed current cathodic protection systems. This is particularly true for systems with small current requirements (0.5 A or less per 100 lineal feet of structure). There are no power costs or costs associated with furnishing power at a remote site associated with sacrificial anode cathodic protection systems. Another major advantage of sacrificial anode cathodic protection system is the nearly zero probability that interference problems will be experienced when this type of system is used. Sacrificial anode cathodic protection systems are commonly of the distributed anode type. This is usually necessary because of the limited driving potential of the anode materials used.*
>
> *(Unified Facilities Criteria, Department of Defense, Design: Electrical Engineering Cathodic Protection, 2004)*

The cathodic protection would consist of anodes installed along the belly-ins of the steel sheet pile wall. The existing timber fender planks would be removed and replaced in-kind to facilitate installation of the anodes, and also protect the cathodic protection system. The anodes can be designed with a specific lifespan, but for the purpose of this cost estimate it has been assumed that the anodes have a 20 year design life which will significantly reduce or effectively stop further corrosion. Based on the type of cathodic protection system, it is not anticipated that maintenance over the 20 year design life will be required. However, it is recommended that the anodes be routinely monitored to check for damage and that they are functioning correctly.

It should be noted that based on the 1/4-inch deep pitting observed, it appears that the wall currently has sufficient remaining capacity to meet the loading requirements of the Yacht Club (250 psf surcharge) and environmental loading of a storm surge (low tide with 4 feet of differential head). However, further deterioration of the sheet pile and reduction in capacity may result in the need for loading restrictions in the loading yard. If cathodic protection is considered, it is recommended that the existing timber fender planks be removed and a thorough underwater inspection be completed to more accurately determine the remaining service life and anticipated design life of the anodes.

Cathodic protection could also be added to Alternate C, Rehabilitation of the existing steel sheet pile, as a means to protect the existing wale and tieback system. The grout facing on the existing sheeting has the potential to create a galvanic cell and the anodes may be a way to counteract any electrochemical reaction. The anodes for freshwater applications are typically zinc alloys, but there are also aluminum and magnesium forms, and are consumed or sacrificed in the process.

The cathodic protection does not need to be installed immediately and can be added as a separate project if future underwater inspections note additional deterioration to the existing steel sheet pile.

The following lists advantages and disadvantages of the rehabilitation of the existing steel sheet pile bulkhead with a cathodic protection system:

Advantages	Disadvantages
• Does not require crane relocation • Does not require full rehabilitation of the sheet pile wall • Lower construction cost • Does not require maintenance within selected design life and anodes can be replaced • Does not need to be installed during construction and can be added in the future	• Thorough underwater inspection necessary for design • Anodes should be routinely monitored • Anodes require replacement as they are consumed

Estimated Construction Cost

Estimated construction costs include mobilization, overhead and profit, and contingency. The costs do not include estimated engineering fees (permitting, design and construction services). A breakdown of order of magnitude costs for Section 5 of the east wall is provided in the table below and additional details are included in Appendix F.

Alternate	Estimate
A – New SSP with Deadman Tiebacks	$691,000
B – New SSP with Grouted Anchors	$775,000
C – Rehabilitation of existing SSP – Grout Facing	$298,000
D – Cathodic Protection	$109,000

The additional cost associated with recommended dive inspections, inspection and maintenance of tieback systems and cathodic protection is not included in order of magnitude cost.

5.0 RECOMMENDATIONS

For the west wall of the Flushing Channel (Section 2), Collins determined that both Alternates A and B which consider the installation of a new steel sheet pile wall and the installation of a new riprap revetment, respectively, are viable options with similar initial construction cost. However, the most cost-effective, lowest maintenance, long-term solution is Alternate A which includes a new steel sheet pile bulkhead. The steel sheet pile bulkhead provides a longer duration for the expected useful service life. In addition, corrosion protection systems such as cathodic protection and epoxy coating can be added to the steel sheet pile wall to help further extend the service life. Should Milwaukee County wish to consider future improvements to provide public access to the water on the west side of the channel, the steel sheet pile wall alternate more easily facilitates future water access. In addition, steel sheet pile installation is a common construction familiar to many contractors and can result in a suitable pool of qualified bidders for competing for the work.

For the east side of the channel at Section 4 and 6, Collins determined that Alternate A consisting of installation of a new steel sheet pile wall with deadman anchors was the most beneficial option due to initial construction costs. The grouted anchor alternative has added complexity. Although the cost for grouted anchors appears to be slightly less expensive alternate for Section 4 and Section 6, the risks associated with installation due to unknown underground obstructions could lead to significant additional construction costs. Removal and replacement of the existing slab on grade structure could also improve the attractiveness of the deadman anchor alternative that will be considered during final design in coordination with Milwaukee County and the Yacht Club.

For the east wall at Section 5, Collins determined that Alternate A, B, C, and D are all viable options, but the current acceptable condition of the existing steel sheeting combined with the costs associated with relocating the existing crane make Alternates A and B less attractive. Collins recommends Alternate C which includes rehabilitation of the existing wall with FRP panels. This alternate provides an economical option to extend the life of the existing steel sheet pile while reducing the upfront construction cost for this section of the wall. Alternate C has been included in the total estimated construction cost provided herein.

The following table provides a listing of the preferred alternates by section.

Wall Section	Preferred Alternate	Estimated Construction Cost
2	Alternate A – New Steel Sheet Pile with Deadman Tieback	$1,867,000
4	Alternate A – New Steel Sheet Pile with Deadman Tieback	$711,000
5	Alternate C– Rehabilitation of Existing SSP	$298,000
6	Alternate A – New Steel Sheet Pile with Deadman Tieback	$877,000
	Total	**$3,753,000**

The estimated construction costs are presented as rough order of magnitude values to be used for budgeting. Updated anticipated costs estimates will be updated as part of the design process.

Collins appreciates this opportunity to provide our engineering services and we look forward to further discussions regarding this project. Please feel free to contact me at 414-930-4598 or rtranel@collinsengr.com with any questions or comments regarding this design study report.

Respectfully Submitted,

COLLINS ENGINEERS, INC.

Rachel a. Tranel

Rachel Tranel, P.E. LEED AP
Senior Project Manager

Danielle Goudreau, P.E.
Senior Design Engineer

APPENDIX A:

AERIAL TOPOGRAPHIC & HYDROGRAPHIC SURVEY MAP

LEGEND:

▨ EX. BUILDING/STRUCTURE

EX. WALL

—X—X— EX. FENCE

EX. HYDROGRAPHIC MAJOR CONTOUR (BELOW WATER)

EX. HYDROGRAPHIC MINOR CONTOUR (BELOW WATER)

— — — — EX. TOPOGRAPHIC MAJOR CONTOUR

- - - - - - - EX. TOPOGRAPHIC MINOR CONTOUR

590.3
589.1 EX. TOP OF WALL ELEVATION/EX. GROUND ELEVATION AT BACK FACE OF WALL

EX. TREE

NOTES:

1. HYDROGRAPHIC SURVEY:
   - 1.1. COMPLETED ON JUNE 25, 2020 BY COLLINS ENGINEERS, INC.
   - 1.2. SOUNDINGS WERE OBTAINED USING A CONTINUOUSLY RECORDING FATHOMETER OPERATING AT 200KHZ AND LINKED TO A WAAS CAPABLE GPS RECEIVER.
   - 1.3. LAKE MICHIGAN WATER LEVEL AT THE TIME OF THE SURVEY WAS 582.83.
2. AERIAL TOPOGRAPHIC SURVEY:
   - 2.1. TERRESTRIAL DATA WAS OBTAINED VIA AERIAL SURVEY WITH AEROPOINT PPK GROUND CONTROL POINTS AND TRADITIONAL SURVEY METHODS ON JUNE 25, 2020 BY COLLINS ENGINEERS, INC.
   - 2.2. AERIAL IMAGE SHOWN FROM AERIAL SURVEY PERFORMED JUNE 25, 2020 BY COLLINS ENGINEERS, INC.
3. HORIZONTAL DATUM IS REFERENCED TO WISCONSIN STATE PLANE COORDINATES NAD83 SOUTH ZONE.
4. VERTICAL DATUM IS REFERENCED TO NAVD 88.

COLLINS ENGINEERS, INC. ASSUMES NO RESPONSIBILITY FOR DAMAGES, LIABILITY, OR COSTS RESULTING FROM CHANGES OR ALTERATIONS MADE TO THIS PLAN WITHOUT THE EXPRESSED WRITTEN CONSENT OF COLLINS ENGINEERS, INC.

N
1
AERIAL TOPOGRAPHIC AND
HYDROGRAPHIC SURVEY MAP
SCALE: 1" = 80'
0 40' 80'

COLLINS ENGINEERS℠
2033 West Howard Ave.
Milwaukee, WI 53221
Phone: 414-282-6905
Fax: 414-282-6955

MILWAUKEE COUNTY
9480 Watertown Plank Rd
Wauwatosa, WI 53226

FLUSHING CHANNEL SEAWALL
AERIAL TOPOGRAPHIC AND
HYDROGRAPHIC SURVEY MAP
Milwaukee, WI

CEI PROJECT
60-12459.02
DESIGN BY:
———
DRAWN BY:
MSR
CHECKED BY:
RAT
DATE:
07/31/2020
SHEET NO:
1 OF 1

APPENDIX B:

INSPECTION PHOTOGRAPHS

Photo 1 – View of the west channel wall facing south. Note the differential settlement of the concrete pile cap.

Photo 2 – View of the west channel wall facing south.

Photo 3 – Area of subsidence located along the topside of the west wall.

Photo 4 – Deteriorated concrete rail system along west channel wall.

Photo 5 – Area of subsidence with unsupported concrete and exposed rebar near existing boat ramp along west channel wall.

Photo 6 – Existing submerged boat ramp facing south.

Photo 7 – View of the west channel wall facing north.

Photo 8 – View of the recently installed concrete promenade at the southeast corner of the channel.

Photo 9 – View of the intake structure at the end of the Flushing Channel.

Photo 10 – View of the Flushing Channel from the intake structure facing south.

Photo 11 – View of landside near the intake structure and east channel wall.

Photo 12 – View of the most northern portion of the east channel wall with concrete pile cap and rail, facing north.

Photo 13 – View of middle section of east channel wall consisting of steel sheet pile. Note the davits located on the topside of the wall.

Photo 14 – Electrical box located near waterline on east channel wall.

Photo 15 – View of the east channel wall with floating docks and davits, facing northeast.

Photo 16 – View of the east channel wall facing east. Note the high water level compared to the timber pile supported pier and small retaining structure.

Photo 17 – View of the southern most portion of the east channel wall, facing south. Note the timber pile supported boardwalk along the length.

Photo 18 – Electrical outlet located near the water line along the east channel wall.

Photo 19 – View of the southern most portion of the east channel wall, facing south. Note the small retaining structure and patio area.

Photo 20 – View of timber pile supported pier and Yacht Club patio area long east channel wall, facing north.

Photo 21 – Existing steel sheet pile wall that abuts the channel to the east.

Photo 22 – Existing stone revetment that abuts the channel to the west.

APPENDIX C:

SUBSURFACE INVESTIGATION

GEOTECHNICAL DATA REPORT

McKinley-Flushing Channel
Milwaukee, Wisconsin
Milwaukee County Project Number: P372-20145

GESTRA Project No.: 20192-10
July 29, 2020

Prepared For:
Collins Engineers, Inc.
2033 West Howard Avenue
Milwaukee, Wisconsin 53221

GESTRA

Geotechnical Data Report

McKinley-Flushing Channel
Milwaukee, Wisconsin
Milwaukee County Project Number: P372-20145

GESTRA Project No. 20192-10
July 29, 2020

Prepared For:

Collins Engineers, Inc.
2033 West Howard Avenue
Milwaukee, Wisconsin 53221

Prepared By:

GESTRA Engineering, Inc.
191 W. Edgerton Avenue
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4.0 LABORATORY TESTING PROCEDURES **4**

5.0 LIMITATIONS **5**

APPENDIX I SITE LOCATION MAP, BOREHOLE LOCATION MAP, TEST BORING LOGS, GENERAL NOTES AND SOILS CLASSIFICATION

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Geotechnical Data Report
McKinley-Flushing Channel
Milwaukee, Wisconsin
Milwaukee County Project Number: P372-20145

1.0 INTRODUCTION

GESTRA Engineering, Inc. (GESTRA) was authorized by Collins Engineers, Inc. (Collins) to complete a subsurface exploration and geotechnical data report for the McKinley Flushing Channel project located in McKinley Park at 1750 N. Lincoln Memorial Drive in Milwaukee, Wisconsin. This Geotechnical Data Report provides a brief summary of the soil conditions at the boring locations and discussion on drilling methods used. Boring logs have been included with this report.

2.0 PROJECT DESCRIPTION

The project is a planned replacement of seawalls along the flushing channel near McKinley Marina in McKinley Park. The project concept is steel sheet pile seawalls with a concrete promenade and railings similar to the improvements located at the center section of McKinley Marina. Milwaukee Metropolitan Sewerage District (MMSD) reconstructed the west end of the channel several years ago where it joins the flushing tunnel. A potential alternative on the southerly side of the channel is placement of a stone revetment. Excavation of material may be necessary in order to maintain a channel width similar to the existing width.

The flushing channel is abutted by McKinley Park open park land on the southerly side, and Milwaukee Yacht Club on the northerly side. On the northerly side of the channel, the yacht club operations take place right up to the edge of the channel. The flushing channel is currently used by the yacht club for lifting boats in and out of the lake, mooring small sail boats and for additional boat slips.

A capitol project has been approved in the Milwaukee County 2020 Capital Budget for the replacement of the seawalls. GESTRA's scope was limited to completing eight (8) Standard Penetration Test (SPT) soil borings to determine soils conditions on both landsides of the flushing channel. This data report does not provide any recommendations related to the design and construction for repairing/ upgrading the existing seawall.

2.1 SUBSURFACE SOIL PROFILE

Boring B-1 through B-4 were drilled in the landscaped areas on the west side of the channel. The ground covering at B-1 through B-4 consisted of 6 to 9 inches topsoil. Borings B-5 through B-8 were drilled on the east side of the channel. Borings B-5 and B-8 were drilled in landscaped areas. The ground covering consisted of 8 inches of topsoil at both locations. Borings B-6 and B-7 were drilled on pavement within the Yacht Club yard. The pavement structure at the boring locations consisted of 2-1/2 to 3-1/2 inches of asphalt overlying 6 to 8 inches of base course material.

Fill material was encountered in borings B-1, B-3 to B-5, B-7, and B-8. Borings B-2 and B-6 did not encountered fill materials. The fill material typically extended to an elevation of 577 to 581 feet. However, the fill was observed to be deeper in boring B-1 and extended to an approximate elevation of 574 feet. In borings B-1 and B-3, the fill material primarily consisted of clay soil, and in borings B-4, B-5, B-7, and B-8 consisted of granular soils. In boring B-1, wood was encountered with the fill. Moisture contents of the clay fill tested varied between 22% and 27%. The fill material typically had N-values between 2 and 11 blows per foot.

The generalized native soil profile at the boring locations consists of a layer of very loose to medium dense sand/silty sand, overlying stiff to hard clay soil, over very hard clay and very dense silt with various amounts of granular soils. The below paragraphs provide a summary of each soil layer.

Very Loose to Medium Dense Sand/Silty Sand

The very loose to medium dense sand and/or silty sand layer typically extended to an elevation between 568 and 573 feet. The soils within this layer were typically loose soils near the top of the strata which became denser with depth. N-values of this soil strata typically varied between 2 and 17 blows per foot (bpf).

Very Stiff to Hard Clay

The very stiff to hard lean clay soils typically extended to an elevation between 541 and 548 feet. These soils typically had N-values between 5 and 27 bpf. In many of the borings, sand and silt layers were encountered embedded within the clay soils. In boring B-7, the soils in this strata primarily consisted of sand with various amount of fines. Moisture contents of the cohesive soils tested typically varied between 8 to 28%, and hand penetrometer values between 2 to over 4.5 tons per square foot (tsf). In borings B-4 and B-7, weak clay soil layers with hand penetrometer values between 0.5 and 2.0 tsf were observed with this layer.

Very Dense Granular Soils and Very Hard Clay

The very dense granular soils and very hard clay soils were typically observed to extend to the termination depth of the borings. This soil profile typically consisted of very dense granular soils over very hard bluish gray clay. These soils usually had split spoon refusal (N-value greater than 50 bpf). However, these soils were not encountered in boring B-5. Moisture content of the cohesive soil tested typically varied between 6% and 17%.

Results of the field and laboratory tests and observations are depicted on the individual boring logs included in Appendix I. Soils were grouped together based on similar observed properties. The stratification lines were estimated by the reviewing engineer based on available data and experience. The actual in-situ changes between layers may differ slightly and may be more gradual than depicted on the boring logs. Subsurface and groundwater conditions can vary between borehole locations and in areas not explored.

It is important to note that the soil observations, fill depths, topsoil, and pavement thickness estimates were made in small diameter boreholes. Therefore, it should be understood that thicker or thinner deposits of the individual strata are likely to be encountered within other portions of the project. Furthermore, the estimation of strata thickness at a particular location can differ from person to person due to a sometimes indistinct transition between the soils encountered. Additionally, it must be recognized that in the absence of foreign substances and/or debris within the soil samples obtained, it is sometimes difficult to distinguish between natural soils and clean soil fill.

2.2 GROUNDWATER OBSERVATIONS

Groundwater observations were made during and at the completion of drilling operations. Table 3-1 summarizes the observed water level readings at each location. A water level reading was not obtained after drilling operations in some of the borings due to the driller using mud rotary drilling techniques and introducing mudding fluid into the boreholes.

Table 3-1: Summary of Groundwater Observations

Boring	Ground Surface Elevation (feet)	Depth of Water During Drilling (feet)	Elevation of Water During Drilling (feet)	Depth of Water at the Completion of Drilling (feet)	Elevation of Water at the Completion of Drilling (feet)
B-1	586.2	8	578.2	3	583.2
B-2	586.4	4	582.4	4	582.4
B-3	584.8	4	580.8	NMR	--
B-4	584.9	4.5	580.4	NMR	--
B-5	584.0	4	580.0	7	577.0
B-6	584.1	1	583.1	NMR	--
B-7	584.1	2	582.1	NMR	--
B-8	585.6	4.5	581.1	NMR	--

NMR = No Measurement Recorded due to the driller converting to mud rotary drilling techniques prior to encountering water.

Groundwater level fluctuations may occur with time and seasonal changes due to variations in precipitation, evaporation, surface water runoff, local dewatering, and the adjacent lake elevation. Perched water pockets and a higher water table may also be encountered during wet weather periods, particularly in more permeable silt and sand seams or granular fill material overlying less permeable clays. Installation and monitoring of an observation well would be required to assess true groundwater elevation which is anticipated to be near the current Lake Michigan elevation.

3.0 FIELD TESTING PROCEDURES

The location of the borings were selected by Collins and located in the field by GESTRA. Elevation of the boreholes were obtained by GESTRA using a Geomax Zenith 35 GNSS-INS receiver. Elevations shown on the boring logs are referenced to the Wisconsin Carrier Registration System – Milwaukee County (NAVD 88) coordinate system. Coordinates and elevation were not obtained by a licensed surveyor.

Prior to our arrival on site, GESTRA contacted Digger's Hotline to mark all public utilities near the boring locations. A total of eight (8) SPT soils borings were completed by GESTRA between June 26 and July 9, 2020 using either a track mounted Diedrich D50 drill rig or truck mounted CME 75 drill rig. The borings were initiated and drilled by using hollow stem augers. In borings B-3, B-4, B-6, B-7 and B-8, the driller converted to mud rotary drilling at a depth of 16 feet. Spoils produced from the drilling activities were containerized in 55-gallon drums. The drums were disposed of by others. At the completion of drilling, the borehole were abandon per WDNR requirements.

Samples were collected at 5-foot intervals to the assigned termination depth of boring. All representative soil samples were taken in general accordance with the "Standard Method for Penetration Test and Split-Barrel Sampling of Soils" (ASTM D1586). After each sampling, a soil sample was retained and placed in a jar and recorded for type, color, consistency, and moisture, sealed and then transported to the laboratory for further review and testing, if required. The specific drilling method used including the depths, rig type, and crew chief, are included on each of the individual boring logs as it may change for each borehole.

4.0 LABORATORY TESTING PROCEDURES

After completion of drilling operations, all of the retained soil samples were transported to GESTRA's laboratory and classified by a geotechnical engineer using the Unified Soil Classification System (USCS). A chart describing the classification system used is included in Appendix I of this report. The laboratory testing included hand penetrometer and moisture content.

5.0 LIMITATIONS

Our exploration was limited to evaluating subsurface soil and groundwater conditions pertaining to the proposed project. This report is prepared as a data report to provide factual information and does not include recommendations for design or construction procedures. The field and laboratory testing results will be used by others in the evaluation and design of the project. Our report is not valid if used for purposes other than what is described in the report.

GESTRA has presented findings in this report in the form of documentation of field observations and laboratory test results. The observations and testing are based on accepted engineering practices at the time of this report. Other than this, no warranty is implied or intended.

Sincerely,

GESTRA Engineering, Inc.

Report Prepared By:

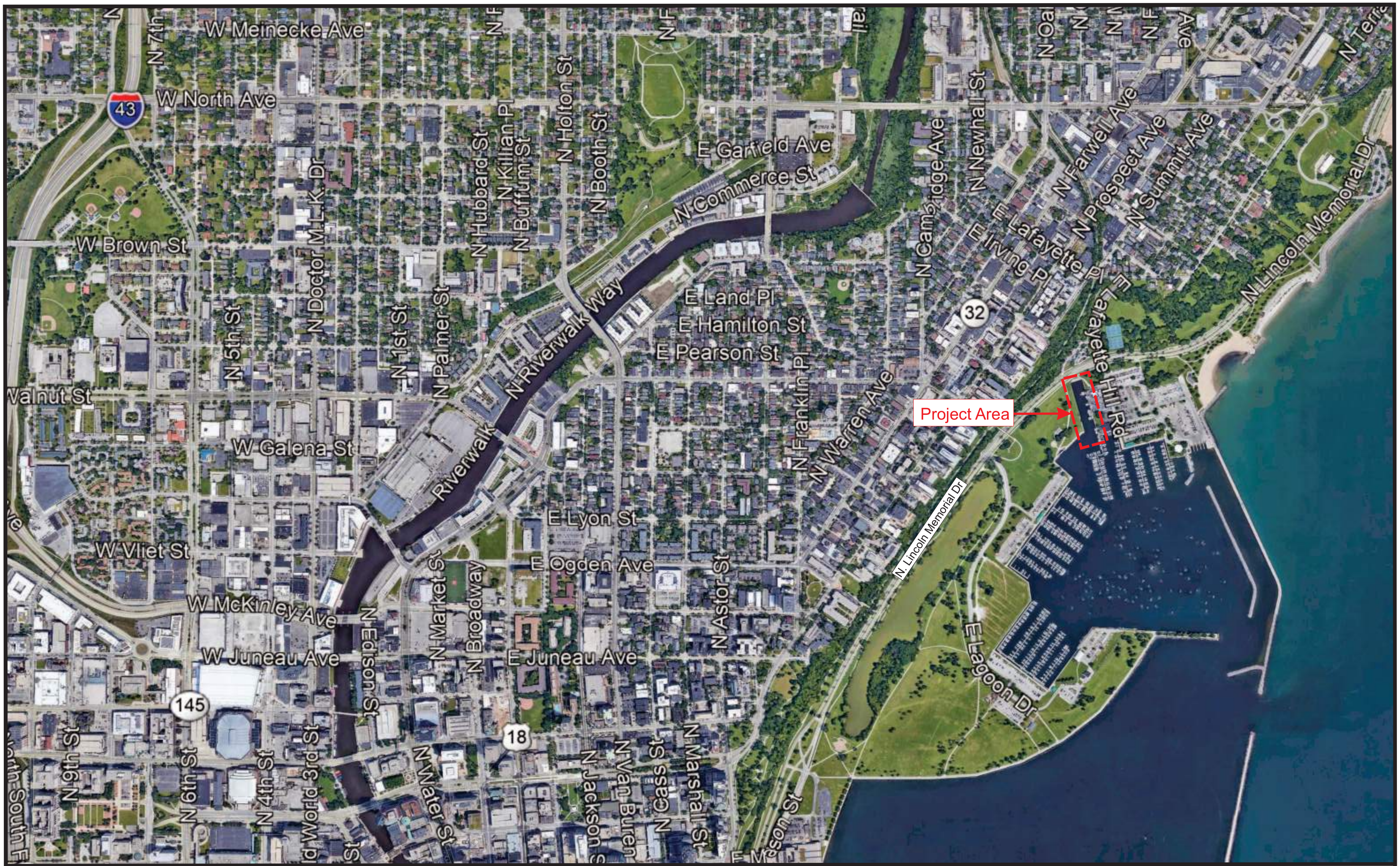
Tri Tran, Ph. D., E. I. T.
Staff Engineer

Report Reviewed By:

Eric Jeske, P.E.
Geotechnical Engineer

APPENDIX I

SITE LOCATION MAP, BOREHOLE LOCATION MAP, TEST BORING LOGS, GENERAL NOTES AND SOILS CLASSIFICATION



N

Base map obtained using aerial topographic map from Google Earth

GESTRA

GESTRA Engineering, Inc.
191 W. Edgerton Avenue
Milwaukee, WI 53207
Phone: (414) 933-7444
Fax: (414) 933-7844

Project Name & Location:
McKinley-Flushing Channel
McKinley Park, 1750 N. Lincoln Memorial Drive
Milwaukee, Wisconsin

Drawing Title:
Site Location Map

Project No.: 20192-10

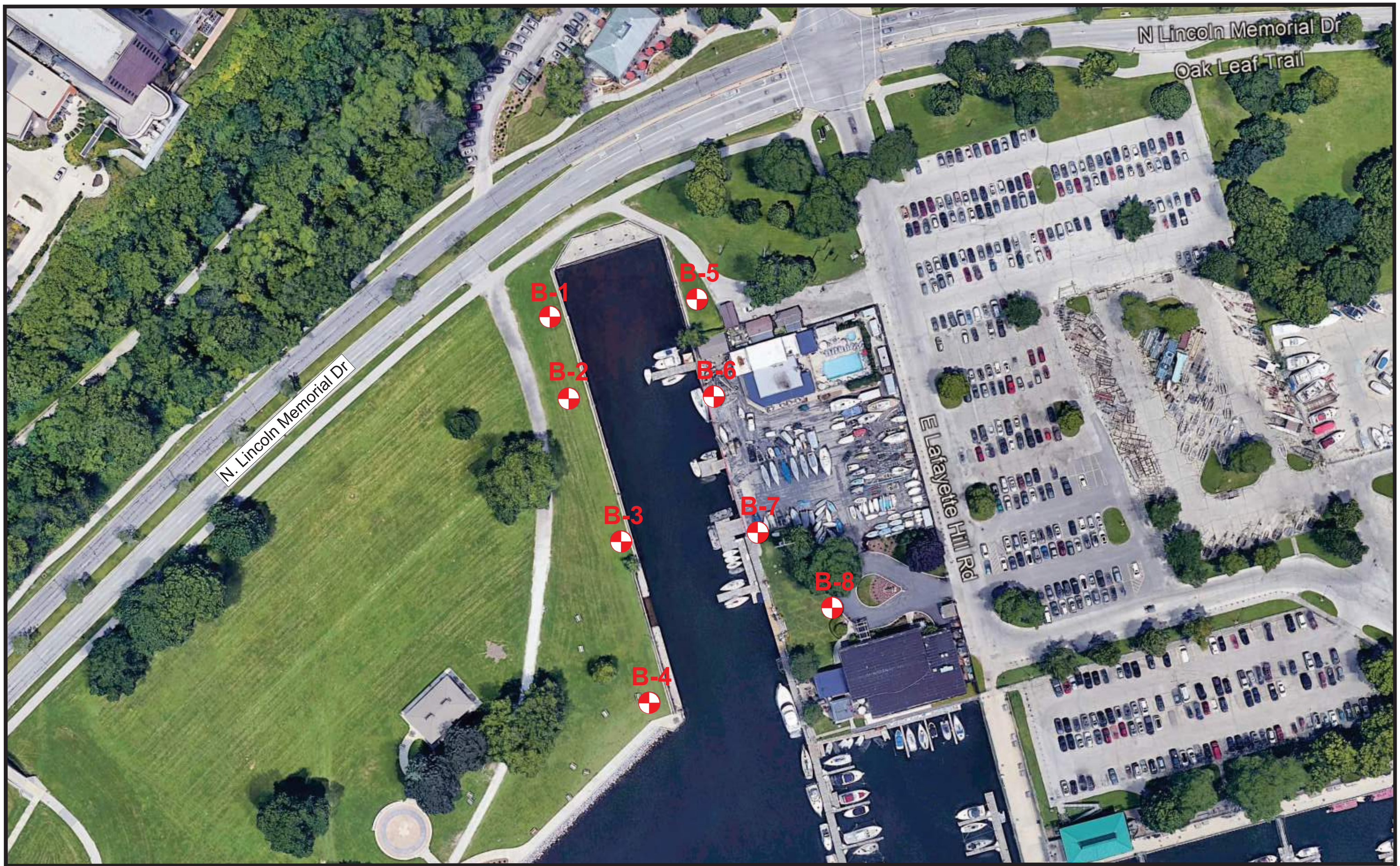
Scale: Not to Scale

Drawing No.: 1 of 2

Prepared by: T. Tran

Checked by: E. Jeske

Date: July 28th, 2020



Base map obtained using aerial topographic map from Google Earth

N

● = Approximate Borehole Location

GESTRA Engineering, Inc.
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Phone: (414) 933-7444
Fax: (414) 933-7844

Project Name & Location:
McKinley-Flushing Channel
McKinley Park, 1750 N. Lincoln Memorial Drive
Milwaukee, Wisconsin

Drawing Title:
Site Location Map

Project No.: 20192-10

Scale: 1 inch = 500 feet
Drawing No.: 2 of 2
Prepared by: T. Tran
Checked by: E. Jeske
Date: July 28th, 2020

SOIL BORING LOG

GESTRA Engineering Inc.
191 W. Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

PAGE NUMBER	1 of 2
PROJECT NAME	McKinley Flushing Channel
DATE DRILLING STARTED	6/26/2020
BORING NUMBER	B-1
PROJECT LOCATION	Milwaukee, WI
DATE DRILLING ENDED	6/26/2020
PROJECT NUMBER	20192-10
DRILLING RIG	Diedrich D50 ATV
BORING DRILLED BY	FIRM: Gestra CREW CHIEF: M. Rhodes
FIELD LOG	B. Sargent
LAB LOG / QC	E. Jeske
NORTHING	304733
EASTING	611952
DRILLING METHOD	3¼" HSA
SURFACE ELEVATION	586.2 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						TOPSOIL (6") 0.5 (585.7)								
					585.0	LEAN CLAY, dark brown, moist, trace sand, with organics, brick and glass, driller observation, (FILL) 2.5 (583.7)								
					▼	LEAN CLAY, red brown, moist, (FILL)								
SS - 1	8	2 2 3	5	5									22.1	
					580.0	7.3 (578.9)								
					▽	WOOD Driller noted water on rods at 8'								
SS - 2	6	16 9 11	20	10										
					575.0	12.3 (573.9)								
						SAND, gray, wet, dense, driller observation	SP							
						14.8 (571.4)								
SS - 3	16	7 13 20	33	15		LEAN CLAY, gray, moist, hard, trace gravel Trace sand seams in sample SS-3B				4.5+			11.9	
					570.0									
SS - 4	17	7 12 17	29	20			CL			4.5+			16.8	
					565.0									
SS - 5	16	10 12 15	27	25						4.50			15.8	

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 8 ft.	▨	CAVE DEPTH AT COMPLETION: NMR WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: 3 ft.		CAVE DEPTH AFTER 0 HOURS: NMR WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR		

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

GESTRA Engineering Inc.
191 W. Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

PROJECT NAME: McKinley Flushing Channel	DATE DRILLING STARTED: 6/26/2020	PAGE NUMBER: 2 of 2	BORING NUMBER: B-1
PROJECT LOCATION: Milwaukee, WI	DATE DRILLING ENDED: 6/26/2020	PROJECT NUMBER: 20192-10	DRILLING RIG: Diedrich D50 ATV
BORING DRILLED BY: FIRM: Gestra CREW CHIEF: M. Rhodes	FIELD LOG: B. Sargent LAB LOG / QC: E. Jeske	NORTHING: 304733 EASTING: 611952	DRILLING METHOD: 3¼" HSA SURFACE ELEVATION: 586.2 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength ($\mathbf{Q_u}$ or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						LEAN CLAY, gray, moist, hard, trace gravel	CL	▨						
SS - 6	17	9 15 22	37	30	555.0			▨		4.5+			17.5	
						32.7 (553.5)								
						LEAN CLAY, gray, moist, hard	CL	▨						
SS - 7	3	50/3"	R	35	550.0			▨		4.5+			15.9	
						37.1 (549.1)								
						SANDY SILT, gray, moist, very dense, trace gravel	ML	░						
SS - 8	4	50/4"	R	40	545.0			░					7.7	
SS - 9	5	50/5"	R	45	540.0			░					9.3	
						47.2 (539)								
						LEAN CLAY, blueish gray, moist, very stiff, trace gravel, with sandy silt seams	CL	▨						
SS - 10		17 19 29	48	50	535.0	51 (535.2)		▨		3.50			16.6	Recovery not recorded on field log
						End of Boring at 51.0 ft.								

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 8 ft.	☒	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: 3 ft.		CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR			

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PAGE NUMBER: 1 of 2

PROJECT NAME: McKinley Flushing Channel
DATE DRILLING STARTED: 6/26/2020
BORING NUMBER: B-2
PROJECT LOCATION: Milwaukee, WI
DATE DRILLING ENDED: 6/26/2020
PROJECT NUMBER: 20192-10
DRILLING RIG: Diedrich D50 ATV
BORING DRILLED BY: FIRM: Gestra
CREW CHIEF: A. Woerpel
FIELD LOG: D. Harris
LAB LOG / QC: E. Jeske
NORTHING: 304648
EASTING: 611972
DRILLING METHOD: 3¼" HSA
SURFACE ELEVATION: 586.4 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						TOPSOIL (6") 0.5 (585.9)								
					585.0	SILTY SAND, brown and gray, wet, very loose to loose, possible fill	SM							
				▽										
SS - 1	16	1 1 1	2	5										
					580.0									
SS - 2	18	1 2 3	5	10										
					575.0									
						12.8 (573.6) SILTY SAND, gray, wet, medium dense, with thin clay seams	SM							
SS - 3	18	4 9 7	16	15										
					570.0									
						17.8 (568.6) LEAN CLAY, gray, moist, very stiff to hard, trace gravel	CL	▨						
SS - 4	18	3 8 12	20	20						4.00			12.8	
					565.0									
SS - 5	18	5 6 8	14	25						3.25			17.3	

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 4 ft.		CAVE DEPTH AT COMPLETION: NMR WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: 4 ft.		CAVE DEPTH AFTER 0 HOURS: NMR WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR		

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

GESTRA Engineering Inc.
191 W. Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

PAGE NUMBER 2 of 2
PROJECT NAME McKinley Flushing Channel
DATE DRILLING STARTED 6/26/2020
BORING NUMBER B-2
PROJECT LOCATION Milwaukee, WI
DATE DRILLING ENDED 6/26/2020
PROJECT NUMBER 20192-10
DRILLING RIG Diedrich D50 ATV
BORING DRILLED BY
FIRM: Gestra
CREW CHIEF: A. Woerpel
FIELD LOG D. Harris
LAB LOG / QC E. Jeske
NORTHING 304648
EASTING 611972
DRILLING METHOD 3¼" HSA
SURFACE ELEVATION 586.4 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
					560.0	LEAN CLAY, gray, moist, very stiff to hard, trace gravel	CL							
SS - 6	15	6 13 10	23	30		Increase in sand content in sample SS-6				4.00			11	
					555.0									
						32.6 (553.8)								
						SANDY LEAN CLAY, gray, moist, hard, trace gravel	CL							
SS - 7	16	10 13 30	43	35						4.5+			11.8	
					550.0									
						37.7 (548.7)								
						SANDY SILT, gray, moist, very dense, trace gravel	ML							
SS - 8	10	28 50/5"	R	40									9.5	
					545.0									
SS - 9	7	43 50/3"	R	45		45.3 (541.1)							6	
						End of Boring at 45.3 ft.								
					540.0									
				50										
					535.0									

WATER & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: 4 ft.
WATER LEVEL AT COMPLETION: 4 ft.
WATER LEVEL AFTER 0 HOURS: NMR
CAVE DEPTH AT COMPLETION: NMR WET ☐ DRY ☐
CAVE DEPTH AFTER 0 HOURS: NMR WET ☐ DRY ☐

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

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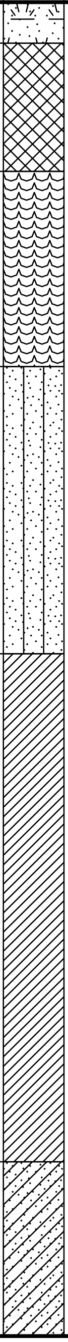
PROJECT NAME: McKinley Flushing Channel	DATE DRILLING STARTED: 7/2/2020	PAGE NUMBER: 1 of 3	BORING NUMBER: B-3
PROJECT LOCATION: Milwaukee, WI	DATE DRILLING ENDED: 7/2/2020	PROJECT NUMBER: 20192-10	DRILLING RIG: CME 75 (International)
BORING DRILLED BY: FIRM: Gestra CREW CHIEF: M. Rohdes	FIELD LOG: D. Harris	NORTHING: 304498	DRILLING METHOD: 3¼" HSA w/ RW
	LAB LOG / QC: E. Jeske	EASTING: 612026	SURFACE ELEVATION: 584.8 ft



Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						TOPSOIL (9") 0.8 (584)								
SS - 1		1 2 2 2	4			SANDY LEAN CLAY, dark brown with brown, moist, (FILL) 3.3 (581.5)							27	Recovery not recorded on field log
				▽		ORGANIC SILTY CLAY WITH SAND, gray, wet, very loose								
				5	580.0									
SS - 2	3	0 0 0	0			7.1 (577.7)	OH						51.3	
						SILTY SAND, gray, wet, loose								
SS - 3	16	1 3 4	7	10	575.0	12.7 (572.1)	SM							
						LEAN CLAY, gray, moist, very stiff to hard								
SS - 4	18	10 7 9	16	15	570.0					4.00			24.3	Driller converted to mud rotary at 16'
							CL							
SS - 5	15	3 3 4	7	20	565.0	Silt seam in sample SS-5 22.6 (562.2)				2.50			19	
						CLAYEY SAND WITH GRAVEL, gray, wet, medium dense	SC							
SS - 6	10	5 7 7	14	25	560.0									

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 4 ft.		CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR		CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR			

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

GESTRA Engineering Inc.
191 W. Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

PROJECT NAME McKinley Flushing Channel	DATE DRILLING STARTED 7/2/2020	PAGE NUMBER 2 of 3	BORING NUMBER B-3
PROJECT LOCATION Milwaukee, WI	DATE DRILLING ENDED 7/2/2020	PROJECT NUMBER 20192-10	DRILLING RIG CME 75 (International)
BORING DRILLED BY FIRM: Gestra CREW CHIEF: M. Rohdes	FIELD LOG D. Harris	NORTHING 304498	DRILLING METHOD 3¼" HSA w/ RW
	LAB LOG / QC E. Jeske	EASTING 612026	SURFACE ELEVATION 584.8 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength ($\mathbf{Q_u}$ or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						CLAYEY SAND WITH GRAVEL, gray, wet, medium dense	SC							
						27.4 (557.4)								
						LEAN CLAY, gray, moist, hard								
SS - 7	18	4 5 6	11	**30**	**555.0**		CL			4.5+			20.5	
						32.8 (552)								
						SANDY LEAN CLAY, gray, moist, hard, trace gravel								
SS - 8	18	14 24 33	57	**35**	**550.0**		CL			4.5+			9.5	
						37.8 (547)								
						LEAN CLAY, gray, moist, hard, with thin silt seams								
SS - 9	18	12 17 33	50	**40**	**545.0**		CL			4.5+			18.8	
						42.8 (542)								
						SANDY LEAN CLAY, gray, moist, very hard, trace gravel								
SS - 10	4	50/4"	R	**45**	**540.0**									
							CL							
SS - 11	2	50/2"	R	**50**	**535.0**								9.3	
						52.1 (532.7)								

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 4 ft.	▨	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR		CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR			

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

GESTRA

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Milwaukee, WI 53207
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SOIL BORING LOG

PAGE NUMBER: 3 of 3

PROJECT NAME: McKinley Flushing Channel

DATE DRILLING STARTED: 7/2/2020

BORING NUMBER: B-3

PROJECT LOCATION: Milwaukee, WI

DATE DRILLING ENDED: 7/2/2020

PROJECT NUMBER: 20192-10

DRILLING RIG: CME 75 (International)

BORING DRILLED BY: FIRM: Gestra
CREW CHIEF: M. Rohdes

FIELD LOG: D. Harris

LAB LOG / QC: E. Jeske

NORTHING: 304498

EASTING: 612026

DRILLING METHOD: 3¼" HSA w/ RW

SURFACE ELEVATION: 584.8 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						LEAN CLAY, bluish gray, moist, very hard	CL	▨						
SS - 12	1	50/2"	R	55	530.0								16.7	
						59.6 (525.2)								
SS - 13	0	50/1"	R	60	525.0	End of Boring at 59.6 ft.								
				65	520.0									
				70	515.0									
				75	510.0									

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 4 ft.

▼ WATER LEVEL AT COMPLETION: NMR

▼ WATER LEVEL AFTER 0 HOURS: NMR

CAVE DEPTH AT COMPLETION: NMR WET ☐ DRY ☐

CAVE DEPTH AFTER 0 HOURS: NMR WET ☐ DRY ☐

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME McKinley Flushing Channel	DATE DRILLING STARTED 7/2/2020	PAGE NUMBER 1 of 3	BORING NUMBER **B-4**
PROJECT LOCATION Milwaukee, WI	DATE DRILLING ENDED 7/2/2020	PROJECT NUMBER 20192-10	DRILLING RIG CME 75 (New)
BORING DRILLED BY FIRM: Gestra CREW CHIEF: A. Woerpel	FIELD LOG M. Rohdes LAB LOG / QC E. Jeske	NORTHING 304330 EASTING 612056	DRILLING METHOD 3¼" HSA w/ RW SURFACE ELEVATION 584.9 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
SS - 1	10	1 2 1 1	3			TOPSOIL (8") 0.7 (584.2) CLAYEY SAND, dark gray, to gray, moist, (FILL)								
						2.7 (582.2) SILTY SAND, gray, wet, with glass pieces, (FILL)								
SS - 2	8	2 1 2	3	5	▽ 580.0									
						7.3 (577.6) SILTY SAND, gray, wet, medium dense, trace gravel								
SS - 3	11	7 7 6	13	10	575.0		SM							
						12.5 (572.4) SAND, gray, wet, medium dense, trace gravel								
SS - 4	18	1 7 10	17	15	570.0		SP							Driller converted to mud rotary at 16'
SS - 5	18	3 5 7	12	20	565.0	20.1 (564.8) LEAN CLAY, gray, moist, medium stiff to stiff With thin sand seams from 20.1' to 21'				1.50			14.1	
							CL							
SS - 6	9	4 3 4	7	25	560.0					<0.5			24.2	

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 4.5 ft.	▨	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR		CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR			

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PAGE NUMBER	2 of 3
PROJECT NAME	McKinley Flushing Channel
DATE DRILLING STARTED	7/2/2020
BORING NUMBER	**B-4**
PROJECT LOCATION	Milwaukee, WI
DATE DRILLING ENDED	7/2/2020
PROJECT NUMBER	20192-10
DRILLING RIG	CME 75 (New)
BORING DRILLED BY	FIRM: Gestra CREW CHIEF: A. Woerpel
FIELD LOG	M. Rohdes
LAB LOG / QC	E. Jeske
NORTHING	304330
EASTING	612056
DRILLING METHOD	3¼" HSA w/ RW
SURFACE ELEVATION	584.9 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						LEAN CLAY, gray, moist, medium stiff to stiff	CL	▨						
						27.4 (557.5)								
						LEAN CLAY WITH SAND, gray, wet, medium stiff to stiff	CL	▨						
SS - 7	18	4 5 6	11	**30**	**555.0**					0.75			11.3	
SS - 8	18	3 4 6	10	**35**	**550.0**					1.00			15.3	
						36.5 (548.4)								
						POSSIBLE BOULDERS AND COBBLES, driller notes boulders from 36.5' to 38' and 39' to 40'		●						
SS - 9	0	50/1"	R	**40**	**545.0**	40 (544.9)								
						LEAN CLAY, bluish gray, moist to very moist, very hard	CL	▨						
SS - 10	2	50/2"	R	**45**	**540.0**	With gravel in sample SS-10								
SS - 11	3	50/4"	R	**50**	**535.0**					4.5+			18.6	

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 4.5 ft.		CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR		CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR			

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PAGE NUMBER	3 of 3
PROJECT NAME	McKinley Flushing Channel
DATE DRILLING STARTED	7/2/2020
BORING NUMBER	**B-4**
PROJECT LOCATION	Milwaukee, WI
DATE DRILLING ENDED	7/2/2020
PROJECT NUMBER	20192-10
DRILLING RIG	CME 75 (New)
BORING DRILLED BY	FIRM: Gestra CREW CHIEF: A. Woerpel
FIELD LOG	M. Rohdes
LAB LOG / QC	E. Jeske
NORTHING	304330
EASTING	612056
DRILLING METHOD	3¼" HSA w/ RW
SURFACE ELEVATION	584.9 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						LEAN CLAY, bluish gray, moist to very moist, very hard	CL	▨						
SS - 12	4	50/5"	R	**55**	**530.0**					4.5+			15.6	
SS - 13	5	50/5"	R	**60**	**525.0**	59.9 (525)				4.5+			17.4	
						End of Boring at 59.9 ft.								
				65	**520.0**									
				70	**515.0**									
				75	**510.0**									

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 4.5 ft.	☒	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR		CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR			

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME: McKinley Flushing Channel
DATE DRILLING STARTED: 7/1/2020
BORING NUMBER: B-5
PROJECT NUMBER: 20192-10
PROJECT LOCATION: Milwaukee, WI
DATE DRILLING ENDED: 7/1/2020
DRILLING RIG: CME 75 (International)
BORING DRILLED BY: FIRM: Gestra
CREW CHIEF: M. Rhodes
FIELD LOG: D. Harris
LAB LOG / QC: E. Jeske
NORTHING: 304751
EASTING: 612106
DRILLING METHOD: 3¼" HSA
SURFACE ELEVATION: 584 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						TOPSOIL (8") 0.5 (583.5)								
SS - 1	16	2 4 4 5	8			SILTY SAND, brown and gray, moist, trace gravel, (FILL) 2.9 (581.1)								
					∇ 580.0	SILTY SAND, gray, wet, medium dense, with clay seams, trace gravel	SM							
SS - 2	14	2 6 7	13	5										
					▼	7.6 (576.4)								
					575.0	SILTY SAND, gray, wet, medium dense	SM							
SS - 3	13	3 6 8	14	10		12.5 (571.5)								
					570.0	LEAN CLAY WITH SAND, gray, moist, hard, trace gravel								
SS - 4	18	9 10 14	24	15						4.5+			14	
					565.0		CL							
SS - 5	15	5 9 15	24	20						4.5+			13.8	
					560.0									
SS - 6	18	7 11 16	27	25						4.5+			12.1	

WATER & CAVE-IN OBSERVATION DATA

∇	WATER ENCOUNTERED DURING DRILLING: 4 ft.		CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: 7 ft.		CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR			

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SOIL BORING LOG

PROJECT NAME McKinley Flushing Channel	DATE DRILLING STARTED 7/1/2020	PAGE NUMBER 2 of 2	BORING NUMBER **B-5**
PROJECT LOCATION Milwaukee, WI	DATE DRILLING ENDED 7/1/2020	PROJECT NUMBER 20192-10	DRILLING RIG CME 75 (International)
BORING DRILLED BY FIRM: Gestra CREW CHIEF: M. Rhodes	FIELD LOG D. Harris	NORTHING 304751	DRILLING METHOD 3¼" HSA
	LAB LOG / QC E. Jeske	EASTING 612106	SURFACE ELEVATION 584 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength ($\mathbf{Q}_u$ or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						LEAN CLAY WITH SAND, gray, moist, hard, trace gravel		▨						
					555.0		CL	▨						
SS - 7	11	9 9 9	18	30				▨					23.7	Sample SS-7 disturbed, unable to get Qp value.
						32.5 (551.5)								
						LEAN CLAY, gray, moist, very stiff, with silt seams		▨						
					550.0			▨						
SS - 8	18	5 5 6	11	35			CL	▨		2.00			19.9	
						37.8 (546.2)								
						SANDY LEAN CLAY, gray, moist, hard, trace gravel		▨						
					545.0			▨						
SS - 9	18	11 14 17	31	40				▨		4.5+			9.8	
					540.0		CL	▨						
SS - 10	14	14 16 21	37	45				▨		4.5+			8.9	
					535.0			▨						
SS - 11	16	10 17 27	44	50				▨		4.5+			9.7	
						51 (533)								
						End of Boring at 51.0 ft.								

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 4 ft.		CAVE DEPTH AT COMPLETION: NMR WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: 7 ft.		CAVE DEPTH AFTER 0 HOURS: NMR WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR		

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME: McKinley Flushing Channel
DATE DRILLING STARTED: 7/9/2020
BORING NUMBER: B-6
PROJECT LOCATION: Milwaukee, WI
DATE DRILLING ENDED: 7/9/2020
PROJECT NUMBER: 20192-10
DRILLING RIG: CME 75 (HT)
BORING DRILLED BY: FIRM: Gestra
CREW CHIEF: A. Woerpel
FIELD LOG: D. Harris
LAB LOG / QC: E. Jeske
NORTHING: 304649
EASTING: 612125
DRILLING METHOD: 3¼" HSA w/ RW
SURFACE ELEVATION: 584.1 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						ASPHALT (2-1/2") 0.3 (583.8)								
						BASE COURSE (6") 0.7 (583.4)								
SS - 1	14	1 1 1	2	▽		SAND, gray, wet, very loose, possible fill	SP							
					580.0									
SS - 2	18	1 2 1	3	5										
					575.0									
SS - 3	16	1 2 3	5	10		10.5 (573.6)								
						SILTY SAND, gray, wet, loose 12.7 (571.4)	SM							
						LEAN CLAY, gray, moist, very stiff	CL							
					570.0									
SS - 4	18	2 5 6	11	15						3.00			16.1	Driller converted to mud rotary at 16'
						17.8 (566.3)								
						SILT, gray, moist, loose	ML							
					565.0									
SS - 5	14	3 4 5	9	20									16.5	
						22.6 (561.5)								
						LEAN CLAY, gray, moist, very stiff	CL							
					560.0									
SS - 6		5 8 11	19	25									13.5	Recovery not recorded on field log

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 1 ft.
▼ WATER LEVEL AT COMPLETION: NMR
▼ WATER LEVEL AFTER 0 HOURS: NMR
CAVE DEPTH AT COMPLETION: NMR WET ☐ DRY ☐
CAVE DEPTH AFTER 0 HOURS: NMR WET ☐ DRY ☐

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PROJECT NAME: McKinley Flushing Channel	DATE DRILLING STARTED: 7/9/2020	PAGE NUMBER: 2 of 2	BORING NUMBER: B-6
PROJECT LOCATION: Milwaukee, WI	DATE DRILLING ENDED: 7/9/2020	PROJECT NUMBER: 20192-10	DRILLING RIG: CME 75 (HT)
BORING DRILLED BY: FIRM: Gestra CREW CHIEF: A. Woerpel	FIELD LOG: D. Harris	NORTHING: 304649	DRILLING METHOD: 3¼" HSA w/ RW
	LAB LOG / QC: E. Jeske	EASTING: 612125	SURFACE ELEVATION: 584.1 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength ($\mathbf{Q_u}$ or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						LEAN CLAY, gray, moist, very stiff	CL	▨						
					555.0									
SS - 7	18	8 7 7	14	30						3.00			15.9	
						32.8 (551.3)								
						SILT, gray, wet, medium dense	ML	▥						
					550.0									
SS - 8	16	7 13 8	21	35										
						37.8 (546.3)								
						SANDY LEAN CLAY, gray, moist, hard, trace gravel	CL	▨						
					545.0									
SS - 9	18	10 17 21	38	40						4.5+			11.4	
					540.0									
SS - 10	15	26 40 48	88	45						4.5+			8.9	
						47.6 (536.5)								
						CLAYEY SAND WITH GRAVEL, gray, moist, very dense	SC	▨						
					535.0									
SS - 11	9	45 50/3"	R	50		50.3 (533.8)							11.5	
						End of Boring at 50.3 ft.								

WATER & CAVE-IN OBSERVATION DATA

∇ WATER ENCOUNTERED DURING DRILLING: 1 ft.
▼ WATER LEVEL AT COMPLETION: NMR
▼ WATER LEVEL AFTER 0 HOURS: NMR

CAVE DEPTH AT COMPLETION: NMR WET ☐ DRY ☐
CAVE DEPTH AFTER 0 HOURS: NMR WET ☐ DRY ☐

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PAGE NUMBER	1 of 3	BORING NUMBER	B-7
PROJECT NAME	McKinley Flushing Channel	DATE DRILLING STARTED	7/9/2020
PROJECT LOCATION	Milwaukee, WI	DATE DRILLING ENDED	7/9/2020
PROJECT NUMBER	20192-10	DRILLING RIG	CME 75 (HT)
BORING DRILLED BY	FIRM: Gestra CREW CHIEF: A. Woerpel	DRILLING METHOD	3¼" HSA w/ RW
FIELD LOG	D. Harris	NORTHING	304507
LAB LOG / QC	E. Jeske	EASTING	612170
SURFACE ELEVATION	584.1 ft		

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength ($\mathbf{Q}_u$ or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						ASPHALT (3-1/2") 0.3 (583.8)								
SS - 1	6	1 1		▽		BASE COURSE (8") 1 (583.1) SANDY SILT, gray, wet, trace grave, (FILL) 3 (581.1)							12.8	
					580.0	SILT, gray, moist, very loose, (possible fill)								
SS - 2	14	0 1 1	2	5			ML						17.4	
						7.6 (576.5)								
					575.0	SAND, gray, wet, loose to medium dense								
SS - 3	18	2 4 6	10	10			SP							
					570.0									
SS - 4	18	2 3 4	7	15		15 (569.1) LEAN CLAY, gray, wet, stiff, with silt seams				1.75			24.4	Driller converted to mud rotary at 16'
					565.0		CL							
SS - 5	18	2 4 4	8	20						1.75			23.2	
						22.8 (561.3) SILTY SAND WITH GRAVEL, gray, wet, medium dense								
					560.0		SM							
SS - 6		6 8 5	13	25										Recovery not recorded on the field log

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 2 ft.		CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR		CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR			

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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SOIL BORING LOG

PAGE NUMBER	2 of 3		
PROJECT NAME	McKinley Flushing Channel	DATE DRILLING STARTED	7/9/2020
BORING NUMBER	B-7	PROJECT NUMBER	20192-10
PROJECT LOCATION	Milwaukee, WI	DATE DRILLING ENDED	7/9/2020
DRILLING RIG	CME 75 (HT)		
BORING DRILLED BY	FIRM: Gestra CREW CHIEF: A. Woerpel	FIELD LOG	D. Harris
LAB LOG / QC	E. Jeske	NORTHING	304507
EASTING	612170	DRILLING METHOD	3¼" HSA w/ RW
SURFACE ELEVATION	584.1 ft		

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						SILTY SAND WITH GRAVEL, gray, wet, medium dense	SM							
						27.8 (556.3)								
						SILTY SAND WITH GRAVEL, gray, wet, dense								
					555.0									
SS - 7	15	9 31 10	41	30			SM							
						32.6 (551.5)								
						GRAVEL WITH SAND, gray, wet, dense								
					550.0									
SS - 8	3	10 15 15	30	35			SP							
						37.1 (547)								
						CLAYEY SAND WITH GRAVEL, gray, moist, very dense								
					545.0									
SS - 9	5	17 27 37	64	40			SC							
						42.2 (541.9)								
						GRAVEL, gray, wet, very dense								
					540.0									
SS - 10	3	37 50/3"	R	45			GP							
						47.1 (537)								
						LEAN CLAY, bluish gray, moist, hard								
					535.0									
SS - 11	18	9 11 18	29	50			CL			4.5+			18.2	

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 2 ft.		CAVE DEPTH AT COMPLETION: NMR WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR		CAVE DEPTH AFTER 0 HOURS: NMR WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR		

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

SOIL BORING LOG

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PAGE NUMBER: 3 of 3

PROJECT NAME: McKinley Flushing Channel

DATE DRILLING STARTED: 7/9/2020

BORING NUMBER: **B-7**

PROJECT NUMBER: 20192-10

PROJECT LOCATION: Milwaukee, WI

DATE DRILLING ENDED: 7/9/2020

DRILLING RIG: CME 75 (HT)

BORING DRILLED BY
FIRM: Gestra
CREW CHIEF: A. Woerpel

FIELD LOG: D. Harris

LAB LOG / QC: E. Jeske

NORTHING: 304507

EASTING: 612170

DRILLING METHOD: 3¼" HSA w/ RW

SURFACE ELEVATION: 584.1 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (**Q_u** or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
						LEAN CLAY, bluish gray, moist, hard		▨						
					530.0			▨						
SS - 12	7	48 50/5"	R	55			CL	▨					14.9	
					525.0			▨						
SS - 13	4	50/5"	R	60		59.9 (524.2)		▨					16.6	
						End of Boring at 59.9 ft.								
					520.0									
				65										
					515.0									
				70										
					510.0									
				75										

WATER & CAVE-IN OBSERVATION DATA

▽	WATER ENCOUNTERED DURING DRILLING: 2 ft.	☒	CAVE DEPTH AT COMPLETION: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AT COMPLETION: NMR		CAVE DEPTH AFTER 0 HOURS: NMR	WET ☐ DRY ☐
▼	WATER LEVEL AFTER 0 HOURS: NMR			

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

GESTRA

GESTRA Engineering Inc.
191 W. Edgerton Avenue
Milwaukee, WI 53207
Phone: 414-933-7444, Fax: 414-933-7844

SOIL BORING LOG

PAGE NUMBER	1 of 2
PROJECT NAME	McKinley Flushing Channel
DATE DRILLING STARTED	7/9/2020
BORING NUMBER	B-8
PROJECT LOCATION	Milwaukee, WI
DATE DRILLING ENDED	7/9/2020
PROJECT NUMBER	20192-10
DRILLING RIG	CME 75 (International)
BORING DRILLED BY	FIRM: Gestra CREW CHIEF: S. Gonyer
FIELD LOG	K. Turner
LAB LOG / QC	E. Jeske
NORTHING	304429
EASTING	612249
DRILLING METHOD	3¼" HSA w/ RW
SURFACE ELEVATION	585.6 ft

Number and Type	Recovery (in)	Blow Counts	N - Value	Depth (ft)	Elevation	Soil Description and Geological Origin for Each Major Unit	USCS Classification	Graphic	Well Diagram	Unconfined Comp. Strength (Q_u or Q_p) (tsf)	Liquid Limit	Plasticity Index	Moisture Content (%)	Comments
					585.0	TOPSOIL (8") 0.7 (584.9)								
SS - 1	16	3 4 7 4	11			SILTY SAND WITH CLAY, brown, moist, (FILL)								
						2.9 (582.7) SILTY SAND, dark brown, wet, (FILL)								
				▽										
SS - 2	5	2 1 1	2	5	580.0									
						7.2 (578.4) SAND WITH SILT, gray, wet, medium dense								
SS - 3	10	2 6 4	10	10	575.0		SP-SM							
						12.4 (573.2) LEAN CLAY, brown to gray, wet, very stiff Driller noted heavy rig chatter from 13' to 14.5'								
SS - 4	16	2 3 5	8	15	570.0					2.75			26.5	
							CL							
SS - 5	18	7 6 7	13	20	565.0					3.25			18.2	
SS - 6	18	5 6 7	13	25	560.0					3.00			22.6	

WATER & CAVE-IN OBSERVATION DATA

▽ WATER ENCOUNTERED DURING DRILLING: 4.5 ft.

▼ WATER LEVEL AT COMPLETION: NMR

▼ WATER LEVEL AFTER 0 HOURS: NMR

CAVE DEPTH AT COMPLETION: NMR WET ☐ DRY ☐

CAVE DEPTH AFTER 0 HOURS: NMR WET ☐ DRY ☐

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

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						LEAN CLAY, brown to gray, wet, very stiff	CL	▨						
SS - 7	9	5 3 6	9	30	555.0					2.00			27.9	
						32.4 (553.2)								
						SANDY SILT, gray, wet, loose, with sand layer (1 to 2 inches thick)	ML	⁙						
SS - 8	18	2 2 3	5	35	550.0								18.3	
						37.8 (547.8)								
						LEAN CLAY, gray, moist, hard	CL	▨						
SS - 9	16	8 15 20	35	40	545.0					4.5+			19.6	
						42.7 (542.9)								
						SILTY SAND WITH GRAVEL, gray, wet, very dense Driller noted heavy rig chatter from 43.5' to 44.5'	SM	⁙						
SS - 10	9	20 50/3"	R	45	540.0									
						48 (537.6)								
						End of Boring at 48.0 ft.								Driller noted slow tri cone advancement at 48'
				50	535.0									

WATER & CAVE-IN OBSERVATION DATA

∇ WATER ENCOUNTERED DURING DRILLING: 4.5 ft.
▼ WATER LEVEL AT COMPLETION: NMR
▼ WATER LEVEL AFTER 0 HOURS: NMR
CAVE DEPTH AT COMPLETION: NMR WET ☐ DRY ☐
CAVE DEPTH AFTER 0 HOURS: NMR WET ☐ DRY ☐

NOTE: Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.

GENERAL NOTES

DRILLING AND SAMPLING SYMBOLS

SYMBOL	DEFINITION
HSA	Hollow Stem Auger
RWB	Rotary Wash Boring (Mud Drilling)
_FA	4”, 6” or 10” Diameter Flight Auger
_HA	2”, 4” or 6” Hand Auger
_DC	2 1/2” , 4” , 5” or 6” Steel Drive Casing
_RC	Size A, B, or N Rotary Casing
PD	Pipe Drill or Cleanout Tube
CS	Continuous Split Spoon Sampling
DM	Drill Mud
JW	Jetting Water
SS	2” O.D. Split Spoon Sample
_L	2 1/2” or 3 1/2” O.D. SB Liner Sample
ST	3” Thin Walled Tube Sample (Shelby Tube)
3TP	3” Thin Walled Tube (Pitcher Sampler)
_TO	2” or 3” Thin Walled Tube (Osterberg Sampler)
W	Wash Sample
B	Bag Sample
P	Test Pit Sample
_Q	BQ, NQ, or PQ Wireline System
_X	AX, BX, or NX Double Tube Barrel
CR	Core Recovery – Percent
NSR	No Sample Recovered, classification based on action of drilling, equipment and/or material noted in drilling fluid or on sampling bit.
NMR	No Measurement Recorded, primarily due to presence of drilling or coring fluid.
▽	Water Level Symbol

TEST SYMBOLS

SYMBOL	DEFINITION
MC	Moisture Content - % of Dry Wt. – ASTM D 2216
OC	Organic Content - % of Dry Wt. – ASTM D 2974
DD	Dry Density – Pounds Per Cubic Foot
LL, PL	Liquid and Plastic Limit – ASTM D 4318

Additional Insertions

Qu	Unconfined Comp. Strength-psf – ASTM D 2166
Qp	Penetrometer Reading – Tons/Square Foot
Ts	Torvane Reading – Tons/Square Foot
G	Specific Gravity – ASTM D 854
SL	Shrinkage Limits – ASTM D 427
OC	Organic Content – Combustion Method
SP	Swell Pressure - Tons/Square Foot
PS	Percent Swell
FS	Free Swell – Percent
pH	Hydrogen Ion Content. Meter Method
SC	Sulfate Content – Parts/ Million, same as mg/L
CC	Chloride Content - Parts/ Million, same as mg/L
C*	One Dimensional Consolidation – ASTM D 2453
Qc*	Triaxial Compression
D.S.*	Direct Shear – ASTM D 3080
K*	Coefficient of Permeability – cm/sec
D*	Dispersion test
DH*	Double Hydrometer – ASTM D 4221
MA*	Particle Size Analysis – ASTM D 422
R	Laboratory Receptivity, in ohm – cm – ASTM G 57
E*	Pressuremeter Deformation Modulus – TSF
PM*	Pressuremeter Test
VS*	Field Vane Shear – ASTM D 2573
IR*	Infiltrometer Test – ASTM D 3385
RQD	Rock Quality Designation – Percent

*See attached data sheet or graph

WATER LEVEL

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In sand, the indicated levels may be considered reliable ground water levels. In clay soil, it may not be possible to determine the ground water level within the normal time required for test borings, except where lenses or layers of more pervious waterbearing soil are present. Even then, an extended period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed texture soils may not indicate the true level of the ground water table. Perched water refers to water above an impervious layer, thus impeded in reaching the water table. The available water level information is given at the bottom of the log sheet.

DESCRIPTIVE TERMINOLOGY

DENSITY TERM	“N” VALUE
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	Over 50

CONSISTENCY TERM	Unconfined Compressive Strength, (tsf)	“N” VALUE
Very Soft	<0.25	0-2
Soft	0.25 - 0.49	2-4
Medium Stiff	0.5 - 0.99	4-8
Stiff	1.0 - 1.99	8-16
Very Stiff	2.0 - 3.99	16-30
Hard	4.0+	Over 30

Standard “N” Penetration: Blows per Foot of a 140 Pound Hammer Falling 30 inches on a 2 inch OD Split Barrel Sampler

Lamination	Up to 1/2” thick stratum
Layer	1/2” to 6” thick stratum
Lens	1/2” to 6” discontinuous stratum
Varved	Alternating laminations
Dry	Powdery, no noticeable water
Moist	Below saturation
Wet	Saturated, above liquid limit
Water bearing	Pervious soil below water

RELATIVE GRAVEL PROPORTIONS

CONDITION	TERM	RANGE
Coarse Grained Soils	trace of gravel	2-14%
	with gravel	15-49%
Fine Grained Soils		
15-29% + No. 200	trace of gravel	2-14%
15-29% + No. 200	with gravel	15-29%
30% + No. 200	trace of gravel	2-14%
30% + No. 200	with gravel	15-24%
30% + No. 200	gravelly	25-49%

RELATIVE SIZES

Boulder	Over 12”
Cobble	3” - 12”
Gravel	
Coarse	3/4” - 3”
Fine	#4 – 3/4”
Sand	
Coarse	#4 - #10
Medium	#10 - #40
Fine	#40- #200
Silt & Clay	- # 200, Based on Plasticity

SOILS CLASSIFICATION FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 - 83

(Based on Unified Soil Classification System)

SOIL ENGINEERING

Criteria for Assigning GroupSymbols and Group Names Using Laboratory Tests [A]				Soil Classification[B]	
				Group Symble	Group Name
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less Less than 5% fines [C]	Cu≥ 4 and 1≤ Cc ≤3[E]	GW	Well graded gravel [F]
			Cu< 4 and/or 1> Cc >3[E]	GP	Poorly graded gravel [F]
		Gravels with Fines more than 12% fines [C]	Fines Classify as ML or MH	GM	Silty gravel [F.G.H.]
			Fines classify as CL or CH	GC	Clayey gravel [F.G.H.]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean sands Less than 5% fines [D]	Cu≥ 6 and 1≤ Cc ≤3[E]	SW	Well graded sand [I]
			Cu< 6 and/or 1> Cc >3[E]	SP	Poorly graded sand [I]
		Sands with Fines more than 12% fines [D]	Fines Classify as ML or MH	SM	Silty sand [G.H.I]
			Fines classify as CL or CH	SC	Clayey sand [G.H.I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid Limit less than 50	inorganic	PI >7 and plots on or above " A" line	CL	Lean clay [K.L.M]
			PI<4 or plots below " A " line	ML	Silt [K.L.M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic clay [K.L.M.N] Organic Silt [K.L.M.O]
	Silts and Clays Liquid Limit 50 or more	inorganic	PI plots on or above " A " line	CH	Fat clay [K.L.M]
			PI plots below " A " line	MH	Elastic silt [K.L.M]
		Organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay [K.L.M.P] Organic Silt [K.L.M.Q]
Highly organic Soils		Primarily organic matter, dark in color, and organic odor		PT	Peat
Fibric Peat > 67% Fibers		Hemic Peat 33 % - 67 % Fibers		sapric	Peat < 33% Fibers

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[A] Based on the material passing the 3-in (75- mm)sieve

[B] If field sample contained cobbles or boulders, or both. add with cobbles or boulders, or both to group name

[C] Gravels with 5 to 12 % fines require dual symbols:

GW - GM well-graded gravel with silt
GW - GC well-graded gravel with clay
GP - GM poorly-graded gravel with Silt
GP - GC poorly-graded gravel with clay

[D] Sands with 5 to 12 % fines require dual symbols:

SW -SM well-graded sand with silt
SW - SC well-graded sand with clay
SP - SM poorly-graded sand with Silt
SP - SC poorly-graded sand with clay

[E] $Cu = \frac{D_{60}}{D_{10}}$ $\qquad C_c = \frac{(D_{30})^2}{D_{10} \text{ x } D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name

[G] If fines classify as CL-ML, use dual symbol GC-GM. or SC-SM

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL_ML silty clay

If soil contains 15 to 29% plus No. 200, add, "with sand" or " with gravel", whichever is predominent

[L] If soil contains ≥ 30% plus No.200, predominantly sand, add "sandy" to the group name

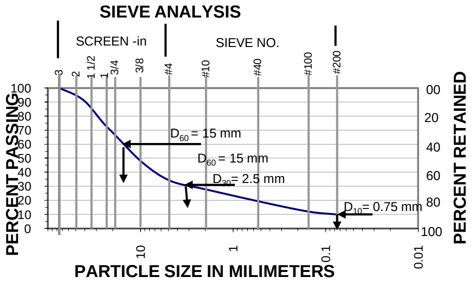
[M] If soil contains ≥ 30% plus No.200, predominantly gravel add "gravelly" to the group name

[N] PI ≥4 and plots on or above "A" Line

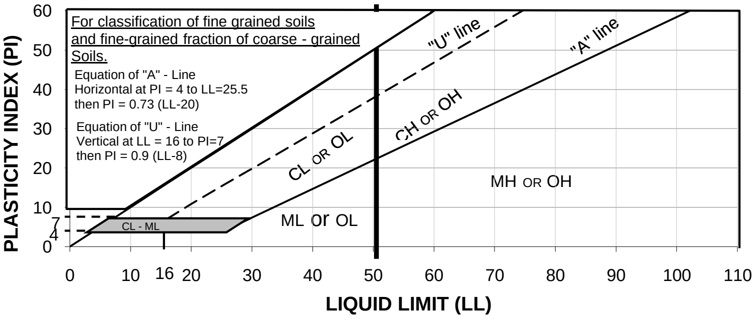
[O] PI < 4 or plots below "A" Line

[P] PI plots on or above "A" Line

[Q] PI plots below "A" Line



$$Cu= \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200 \qquad C_c = \frac{(D_{30})^2}{D_{60}X\ D_{10}} = \frac{(2.5)^2}{15X\ 0.075} = 5.6$$



Geotechnical -Structural- Pavement - Construction Materials

APPENDIX D:

UNDERWATER INSPECTION

COLLINS
ENGINEERS INC.

June 25, 2020
Collins Project No. 12459.02

Subject: Milwaukee County Flushing Channel Seawall

Mr. Karl Stave, PE
DAS – Facilities Management Division
Milwaukee County
633 W Wisconsin Ave.
Suite 1000
Milwaukee, WI 53203

Dear Mr. Stave:

This letter report summarizes the detailed inspection findings of the Milwaukee County Flushing Channel Seawall located at McKinley Marina along the Lake Michigan shore of Milwaukee, WI. The inspection was performed on June 25, 2020.

Photographs after the narrative include overall views of the various sections of dock wall and a location map showing general sections overlaid on an aerial image is also provided.

Method of Investigation

The investigation included a visual and tactile inspection of both the dry and submerged sections of the exterior face of the dock wall. The inspection team consisted of two Professional Engineer-Divers and one technician. The team utilized commercial surface supplied air diving equipment in accordance with OSHA regulations.

For inspection documentation purposes, the wall was broken into 7 segments based on the differing construction types observed. See location map in Appendix B.

To obtain broader observations, the inspector cleaned sample areas approximately every 100 feet to remove the 1 in. thick layer of zebra mussel growth that was typically present below water. Ultrasonic thickness readings were taken on steel sheet piling material above water, at the waterline, and at the mudline at random locations throughout the wall. Additionally, a hydrographic survey was performed to obtain below water channel bottom elevation contours.

Summary of Findings

Channel bottom material within the flushing channel typically consisted of soft silt and shells with over 1 ft of penetration when probed by hand. The area located immediately to the west of the flushing channel had a riprap revetment and the area to the east had riprap armor directly adjacent to the steel sheet piling.

The subject seawall is composed of six separate sections as shown in the inspection map and described below:

1. The wall located west of the flushing channel consisted of a riprap revetment with a concrete wall at the top of the slope. Exposed portions of the concrete cap were in good condition. At the east end of this section, there is approximately 20 ft of wall consisting of Z shaped steel sheeting with a concrete cap. The sheeting and concrete cap are in good condition.

2. The West Channel Wall consisted of timber piles and timber Wakefield sheeting with a concrete cap. The channel topography at this section of wall was configured so approximately 1 ft of timber was vertically exposed below the concrete cap. The minimal exposure of the wood provided limited ability to inspect the timber condition. However, there was signification deterioration of the exposed and visible timber. Differential settlement of the concrete cap was also observed.

3. North Channel Wall – The north channel wall consisted of concrete piers with 12 separate openings. Each of the openings was closed off with stainless steel bars. The concrete piers and grating were in good condition.

4. The northern 160 ft of the east flushing channel wall consisted timber piles and timber Wakefield sheeting with a concrete cap. The channel topography at this section of wall was configured so approximately 1 to 2 ft of timber was vertically exposed below the concrete cap. The minimal exposure of the wood provided limited ability to inspect the timber condition. The timber piles and Wakefield sheeting typically exhibited significant deterioration of the exposed portion with up to 100% loss of section.

5. The central 160 ft section of the east flushing channel wall located in front of the yacht club crane lifts consisted of steel sheet piles with two exterior horizontal C-channel wales (10 in. tall x 3.75 in. wide) located at the waterline and at 3 ft below the waterline. Approximately 6 to 7 ft of the wall was exposed above the channel bottom. The steel sheeting was typically covered with vertical timber planks from the top of wall to approximately 1 ft above the channel bottom. The vertical timber planks obstructed the ability to perform a full inspection. However, random areas of missing vertical timber planking revealed that the steel sheeting typically exhibited heavy corrosion with up to ¼ in. deep pitting. The corrosion was worst near the channel bottom and lighter near the water surface. D-meter thickness analysis of the wall could not be obtained due to the extremely rough texture of the pitted steel.

   The intersection of the steel sheet piles at Wall Section 5 to the concrete cap with Timber piles at Wall Section 6 exhibited a 2 to 3 ft wide gap extending the full height of the wall (the wall sections were not connected). There was loss of backfill from the steel sheeting at this area with approximately 5 ft penetration behind the wall.

6. The southern 230 ft section of the east flushing channel wall consisted of timber piles and assumed Wakefield sheeting. The wall had a fixed timber pier that was founded on timber piles both at the face of the existing timber wall and 8' from the face of the wall. A timber boardwalk was located was supported by these piles. In the area under the fixed timber pier, abandoned deteriorated timber piles were present. The exterior face of the fixed pier was typically covered with vertical timber planks from the top of pier to approximately 1 to 2 ft above the channel bottom. The height of the piles from waterline to channel bottom was between 6 and 7 ft. Additionally, the channel bottom sloped up steeply under the pier, making access under the planks for inspection of the area under the fixed pier difficult. The vertical planks were installed as fender protection for boats. However, the limited available access revealed that the timber piles and Wakefield sheeting composing the wall were in poor condition. The exposed height of wall was estimated at 1 to 2 ft. The timber piles and Wakefield sheeting typically exhibited up to 100% loss of section.

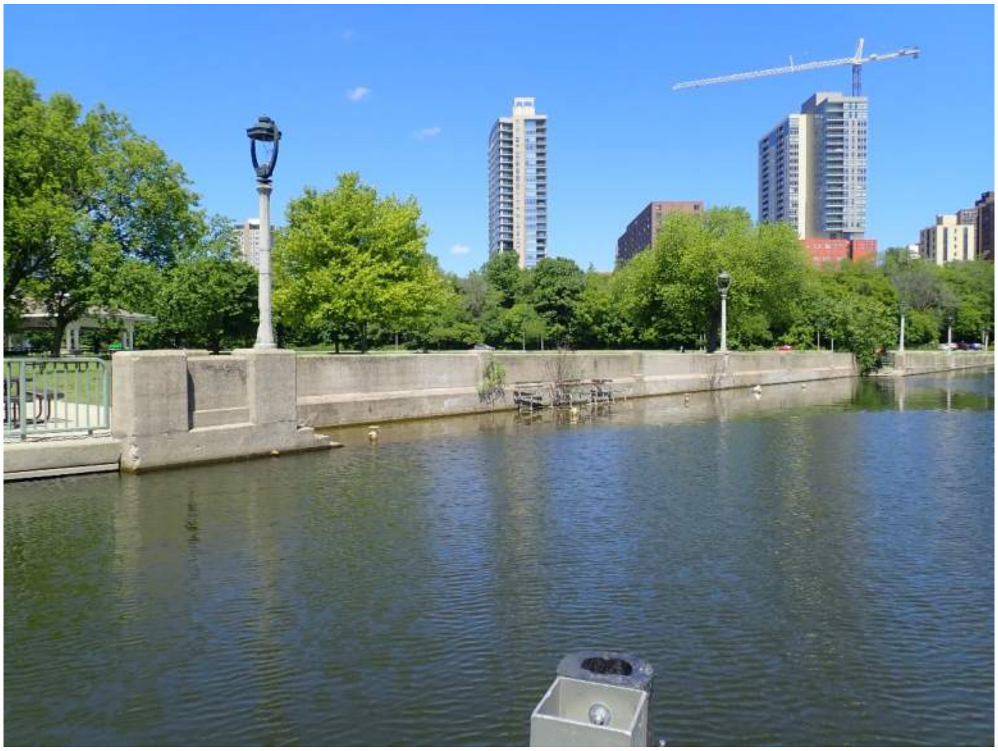
   Limited access and ability to inspect the timber piles below the fixed piers resulted in an inconclusive determination of their condition; however, Yacht Club maintenance staff reported the timber piles to be in "poor" condition with regular maintenance needed.

7. The section of wall located east of the flushing channel consisted of steel sheet piling. The steel sheeting was in good condition with painted coating intact over 90% of the surface area. Ultrasonic thickness analysis of the sheeting revealed the web and flange thickness were both 0.375 in. at all locations measured. Concrete rubble 2 to 3 ft diameter was found in front of the steel sheet piling.

The above report summarizes our inspection findings for the Milwaukee Flushing Channel Seawall inspection. In accordance with ASCE's Underwater Investigation Standard Practice Manual, it is recommended that all in-service docks be inspected underwater at least every 5 years and during or soon after repairs to ensure safety and long-term serviceability.

Photograph 1: Typ. condition riprap revetment with concrete wall, west of Flushing Channel (Wall Section 1), looking west.

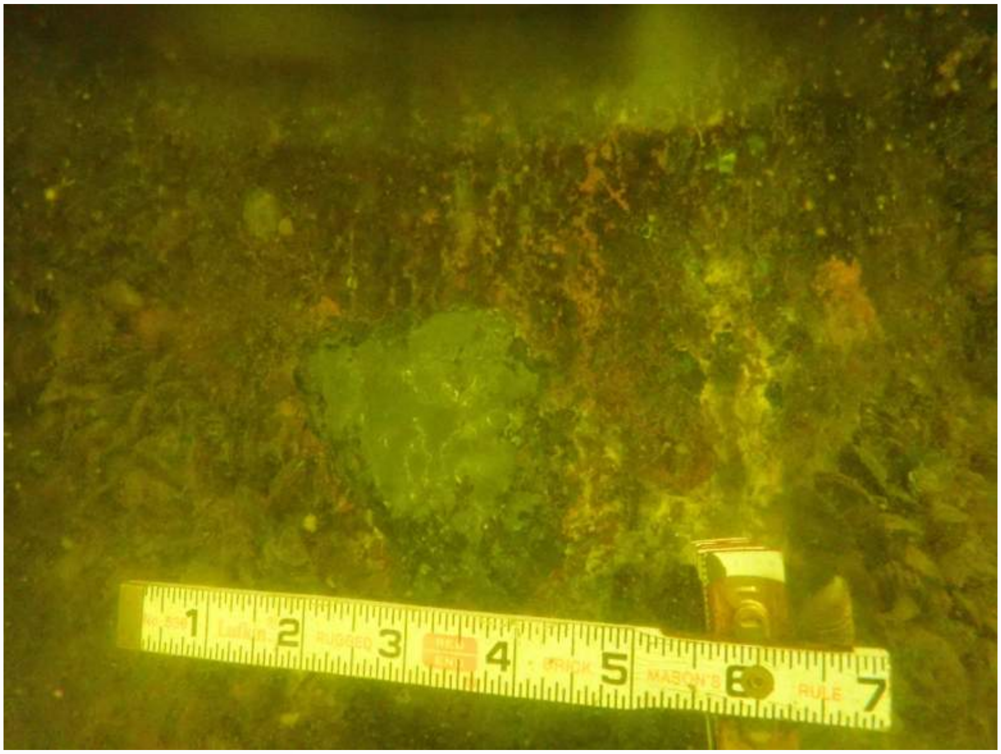
Photograph 2: View of overlook at the southwest corner of Flushing Channel, looking northwest.



Photograph 3: View of west wall of Flushing Channel (Wall Section 2), looking northwest.

Photograph 4: View of North Wall of Flushing Channel (Wall Section 3), looking north.

Photograph 5: View of Northeast Flushing Channel Wall (Wall Section 4), looking east.



Photograph 6: View of typical pitted steel sheet piling below water at Flushing Channel East-Central Wall (Wall Section 5).

Photograph 7: View of East-Central and South-Central Flushing Channel Walls, looking east.

Photograph 8: View of wall located to east of flushing channel (Wall Section 7), looking northeast.

Section 3 - Concrete Piers with Stainless Steel Intake Grates
Condition good

Section 4 - East Channel Wall - Timber Piles/ Wakefield Sheeting with Concrete Cap
Condition deteriorated

Section 5 - East Channel Wall - Steel Sheet Piling with timber facing
Condition deteriorated

Section 2 - West Channel Wall - Timber Piles/ Wakefield Sheeting with Concrete Cap
Condition deteriorated

Section 6 - East Channel Wall - Timber Piles/Wakefield Sheeting with fixed timber pier
Condition deteriorated

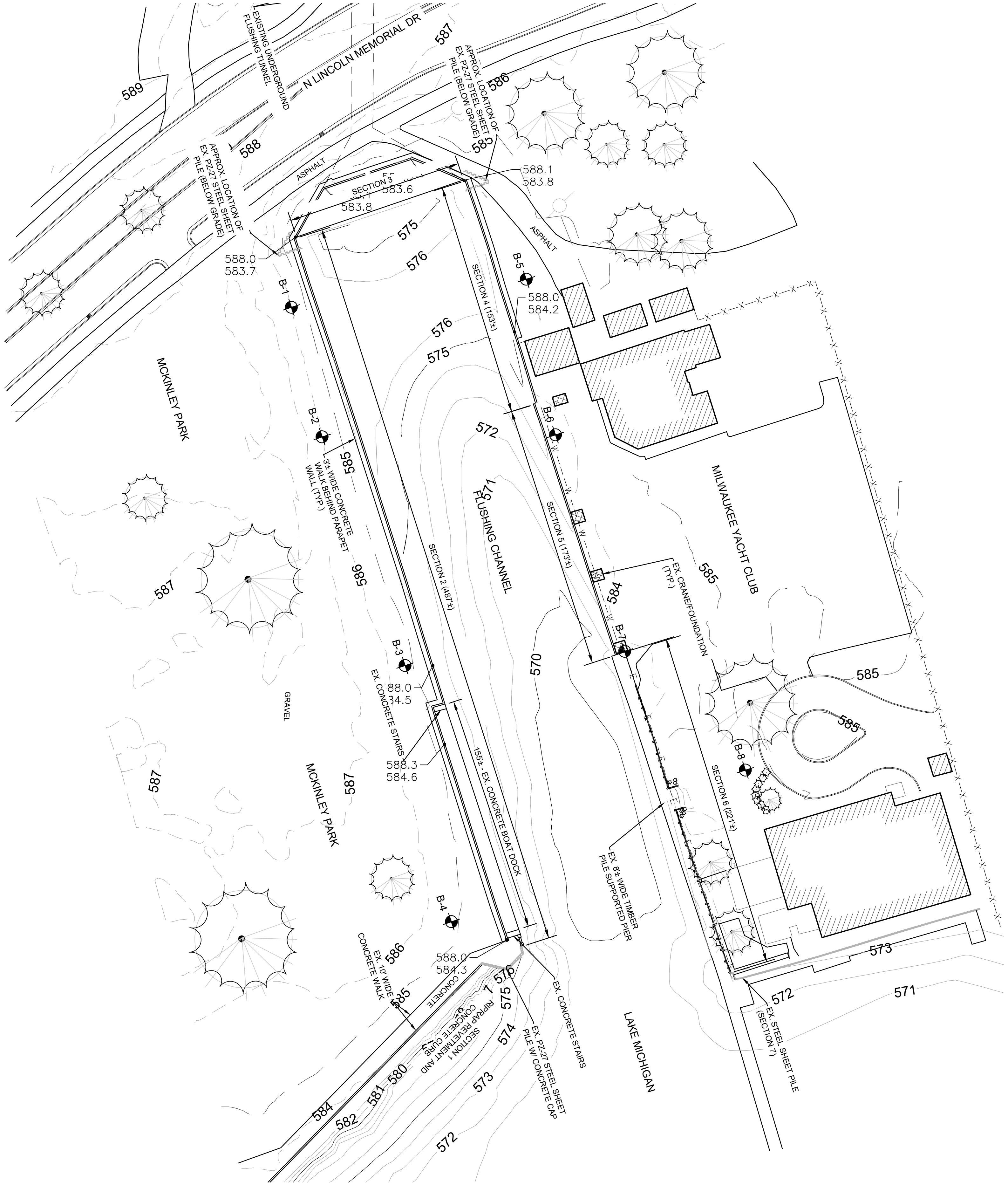
Z-shaped sheeting with concrete cap
Condition good

Section 1 - Riprap revetment with Concrete wall
Condition good

Section 7 - Steel Sheet Piles and riprap armor
Condition good

APPENDIX E:

ALTERNATIVE DRAWINGS



LEGEND:

- Hydrographic Major Contour
- Hydrographic Minor Contour
- Topographic Major Contour
- Topographic Minor Contour

590.3
589.1
- Top of Wall Elevation/Back of Wall Elevation

GENERAL NOTES:

1. The hydrographic survey was completed on June 25, 2020 by Collins Engineers, Inc.
2. Soundings were obtained using a continuously recording fathometer operating at 200kHz and linked to a WAAS capable GPS receiver.
3. Terrestrial data was obtained via aerial survey with PPK ground control points and traditional survey methods on June 25, 2020.
4. Horizontal datum is referenced to Wisconsin State Plane Coordinates NAD83 South Zone.
5. Vertical Datum is referenced to NAVD 88.
6. Lake Michigan water level at the time of the survey was 582.83.

OVERALL SITE TOPOGRAPHY AND HYDROGRAPHY

SCALE: 1" = 80'

0 40' 80'

N

1

COLLINS ENGINEERS INC
2033 W. Howard Ave.
Milwaukee, WI 53221
Phone: 414-282-6905
www.collinsengr.com

Overall Site Topography & Hydrography
Flushing Channel
Milwaukee County Seawall Inspection
Milwaukee, WI

CEI PROJECT
60-12459.02

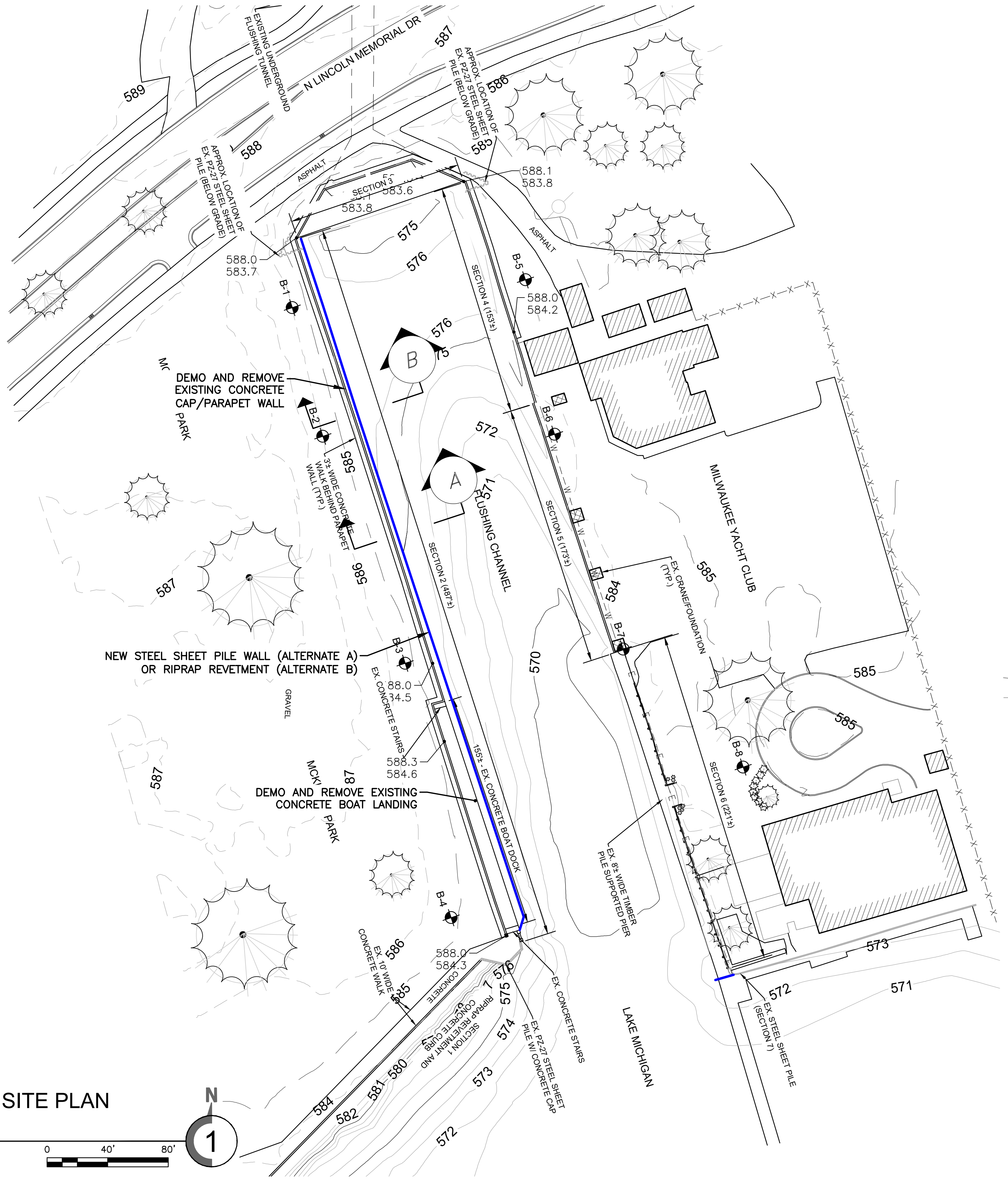
INSPECTED BY:
RAF,MJS,JAC

DRAWN BY:
JCG

CHECKED BY:
RAF

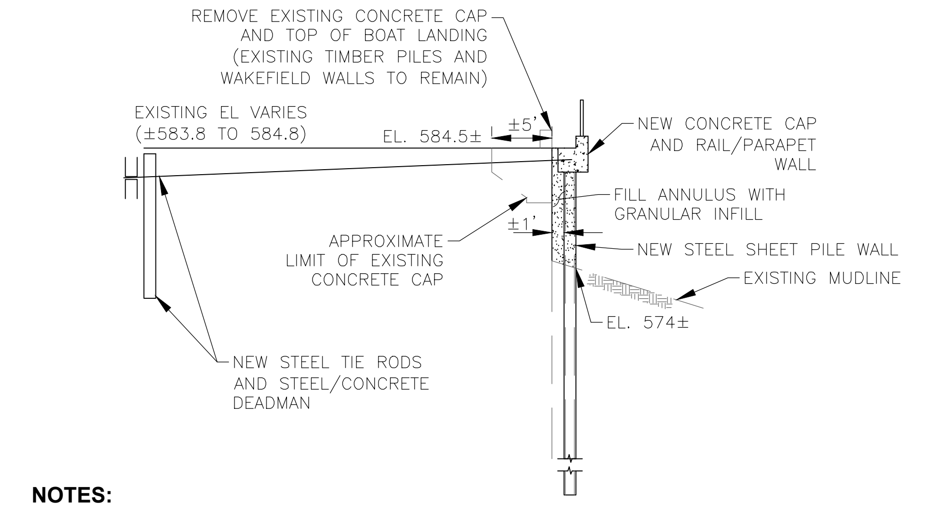
DATE:
6-25-2020

SHEET NO:
1



CONCEPTUAL SITE PLAN
WEST WALL

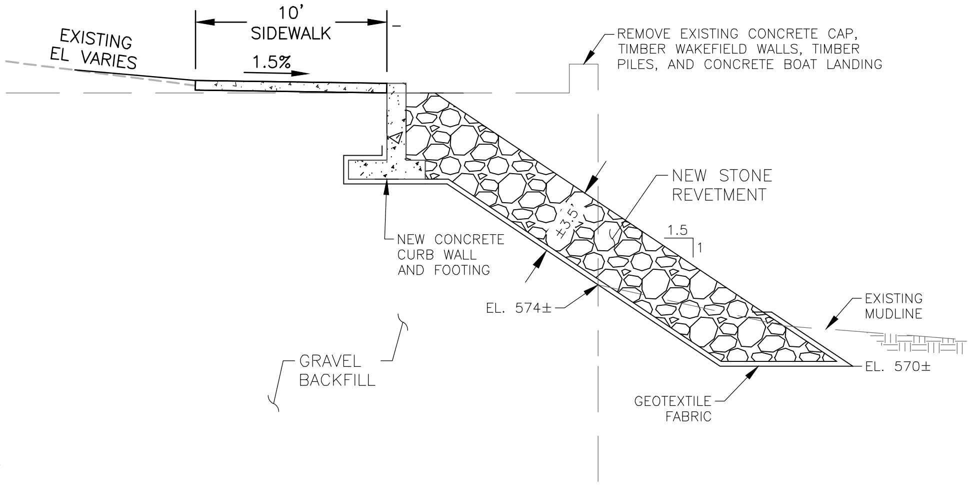
SCALE: 1" = 80'



NOTES:

1. EXISTING TIMBER WAKEFIELD WALLS AND TIMBER PILES TO REMAIN.
2. EXISTING CONCRETE CAP/PARAPET WALL TO BE PARTIALLY REMOVED.
3. EXISTING CONCRETE BOAT LANDING TO BE FULLY REMOVED.
4. ALTERNATE INCLUDES 40 FT OF CONCRETE PARAPET WALL NEAR HEADWALL STRUCTURE (SECTION 3).

A — ALTERNATE A - STEEL SHEET PILE WITH DEADMAN TIEBACK



NOTES:

1. EXISTING TIMBER WAKEFIELD WALLS, TIMBER PILES, CONCRETE CAP/PARAPET WALL, AND CONCRETE BOAT LANDING TO BE FULLY REMOVED.
2. ALTERNATE INCLUDES 50 FT OF CONCRETE PARAPET WALL NEAR HEADWALL STRUCTURE (SECTION 3).

B — ALTERNATE B - RIPRAP REVETMENT

COLLINS ENGINEERS INC
2033 W. Howard Ave.
Milwaukee, WI 53221
Phone: 414-282-6905
www.collinsengr.com

WEST WALL ALTERNATES
Flushing Channel Rehabilitation
Milwaukee County Seawall Inspection
Milwaukee, WI

CEI PROJECT
60-12459.02
DESIGNED BY:
DJG
DRAWN BY:
JCG, MG
CHECKED BY:
RAF
DATE:
DEC 2020
SHEET NO:
2

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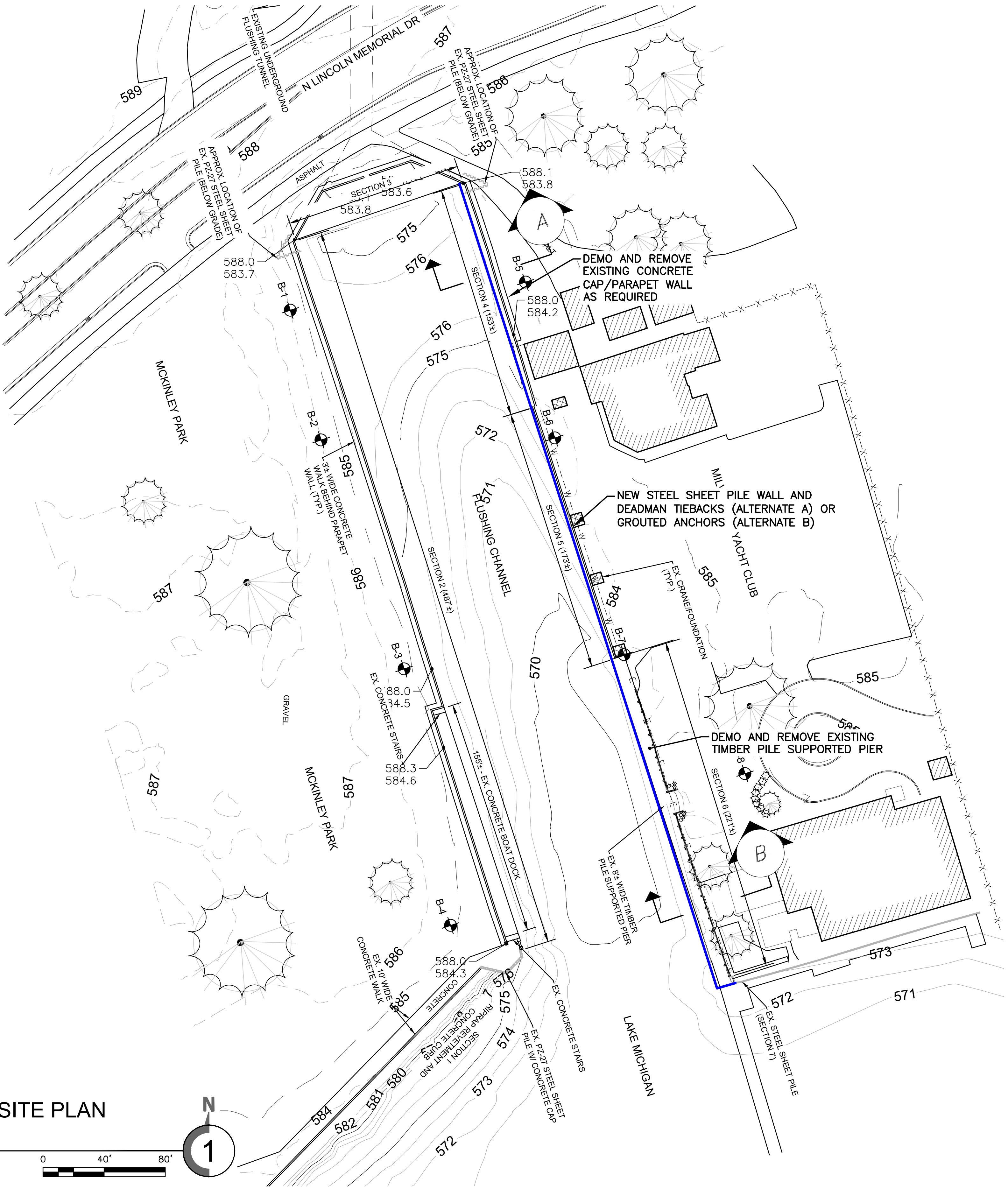
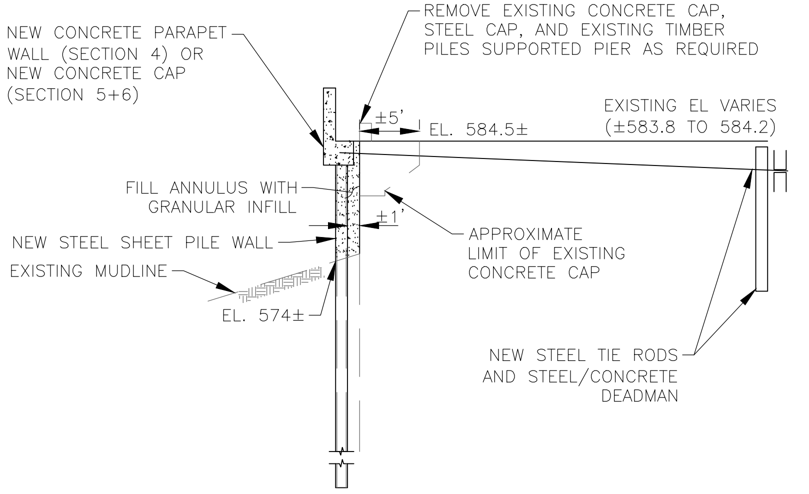


CONCEPTUAL SITE PLAN
EAST WALL

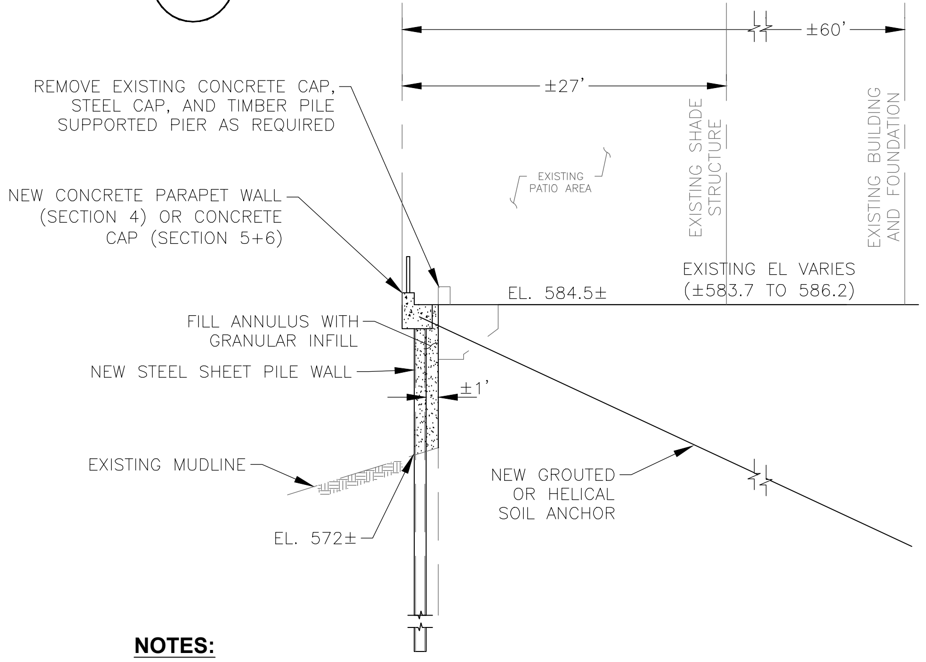
SCALE: 1" = 80'



NOTES:

1. EXISTING TIMBER WAKEFIELD WALLS AND TIMBER PILES TO REMAIN.
2. EXISTING CONCRETE CAP/PARAPET WALL TO BE PARTIALLY REMOVED.
3. EXISTING CONCRETE BOAT LANDING TO BE FULLY REMOVED.
4. PRESENCE OF HISTORIC TIMBER WALL/CONCRETE CAP UNKNOWN AT SECTION 5 AND 6.
5. PROPOSED ALTERNATE AT SECTION 5 CONSISTS OF EXISTING STEEL SHEET PILE WALL AND STEEL CAP.

A ALTERNATE A - STEEL SHEET PILE WITH DEADMAN TIEBACK



NOTES:

1. EXISTING TIMBER WAKEFIELD WALL AND TIMBER PILES TO REMAIN.
2. EXISTING CONCRETE CAP TO BE PARTIALLY REMOVED.
3. PRESENCE OF HISTORIC TIMBER WALL/CONCRETE CAP UNKNOWN AT SECTION 5 AND 6.
4. PROPOSED ALTERNATE AT SECTION 5 CONSISTS OF EXISTING STEEL SHEET PILE WALL AND STEEL CAP.
5. ALTERNATE INCLUDES 40 FT OF CONCRETE PARAPET WALL NEAR HEADWALL STRUCTURE (SECTION 4).

B ALTERNATE B - GROUTED ANCHORS

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MILWAUKEE COUNTY

EAST WALL ALTERNATES
Flushing Channel Rehabilitation
Milwaukee County Seawall Inspection
Milwaukee, WI

CEI PROJECT
60–12459.02
DESIGNED BY:
DJG
DRAWN BY:
JCG, MG
CHECKED BY:
RAF
DATE:
DEC 2020
SHEET NO:
3

APPENDIX F:

COST ESTIMATES

COLLINS ENGINEERS

Client: Milwaukee County
Project: Flushing Channel Rehabilitation
Description: Order of Magnitude Costs
Job No.: 60-12459.02
Prep. By: DJG Date: 12/4/2020
Checked By: RMM 12/7/2020

West Wall - Section 2

Alternate A - Steel Sheet Pile and Deadman Tiebacks

Item	Quantity	Unit	Unit Price	Total Cost*	Notes
Site Prep and Erosion Control	1	LS	$10,000	$10,000	Fencing, barriers, haybales/silt socks, turbidity boom
Demolition and Removal	482	LF	$100	$48,200	Concrete cap and wall; timber boardwalk
Steel Sheet Pile	482	LF	$1,100	$530,200	SKZ20 uncoated, supply and install
Concrete Cap	135	CY	$1,200	$162,000	Reinforced concrete cap / wale along length of wall
Concrete Parapet Wall	50	CY	$1,500	$75,000	Reinforced concrete wall near headwall structure
Steel Tie Rods	73	EA	$600	$43,800	8' o.c. uncoated solid bar
Double Channel Steel Wale	482	LF	$180	$86,760	Uncoated entire length
Steel Sheet Pile Deadman	482	LF	$300	$144,600	12' high continuous SSP, uncoated
Granular Infill	930	CY	$40	$37,200	Between proposed and existing SSP
Steel Pipe Railing	432	LF	$150	$64,800	Pipe and rail bolted to concrete cap
Excavation and Earthwork	1	LS	$140,000	$140,000	Excavation, minor dewatering, backfill, compaction
Concrete Sidewalk	5400	SF	$6	$32,400	10' wide
Concrete Mow Strip	180	SF	$6	$1,080	Adjacent to concrete cap / parapet
Lamp Posts	1	EA	$5,000	$5,000	Near headwall structure
Loam and Seed	2000	SY	$15	$30,000	Restoring existing grass areas
			Contractor Mobilization/Demobilization (15%)	$212,000	
			Contingency (15%)	$244,000	
			Estimate Subtotal:	***$1,867,040***	

Add Alternates

Epoxy Coating on SSP	482	LF	$370	$178,340
			Contingency (15%)	$26,751

Alternate B - Riprap Revetment

Item	Quantity	Unit	Unit Price	Total Cost*	Notes
Site Prep and Erosion Control	1	LS	$10,000	$10,000	Fencing, barriers, haybales/silt socks, turbidity boom
Demolition and Removal	482	LF	$380	$183,160	Concrete cap and wall
Excavation and Earthwork	1	LS	$240,000	$240,000	Cut existing fill to create slope; includes stockpiling
Stone Revetment	500	LF	$800	$400,000	Geotextile, bedding stone, armor stone
Concrete Parapet Wall	50	CY	$1,500	$75,000	Reinforced concrete wall near headwall structure
Concrete Curb Wall	482	LF	$300	$144,600	Reinforced concrete
Steel Sheet Pile Return Wall	50	LF	$1,800	$90,000	SKZ20, solid bar, ssp deadman, uncoated, supply and install
Concrete Sidewalk	5400	SF	$6	$32,400	
Concrete Mow Strip	180	SF	$6	$1,080	Adjacent to concrete cap / parapet
Lamp Posts	1	EA	$5,000	$5,000	
Loam and Seed	2000	SY	$15	$30,000	Restoring existing grassed areas
Berm Contingency	500	CY	$80	$40,000	excavation, backfill, compaction, and loam/seed
			Contractor Mobilization/Demobilization (15%)	$188,000	
			Contingency (15%)	$216,000	
			Estimate Subtotal:	***$1,655,240***	

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COLLINS
ENGINEERS

Client: Milwaukee County
Project: Flushing Channel Rehabilitation
Description: Order of Magnitude Costs
Job No.: 60-12459.02
Prep. By: DJG Date: 12/4/2020
Checked By: RMM 12/7/2020

East Wall - Section 4 + 6 (Near Headwall and Clubhouse)

Option A - Steel Sheet Pile and Deadman Tiebacks

Item	Quantity	Unit	Unit Price	Total Cost*	Notes
Section 4					
Site Prep and Erosion Control	1	LS	$3,000	$3,000	Fencing, barriers, haybales/silt socks, turbidity boom
Demolition and Removal	1	LS	$8,000	$8,000	Concrete cap
Steel Sheet Pile	153	LF	$1,100	$168,300	SKZ20 uncoated, supply and install
Steel Tie Rods	16	EA	$600	$9,600	8' o.c. uncoated, supply and install
Steel Channel Wale (Deadman)	123	LF	$180	$22,140	Uncoated entire length
SSP Deadman	123	LF	$300	$36,900	12' high continuous SSP, uncoated
Combination-Wall	30	LF	$3,850	$115,500	PZ27 / W21x122 uncoated
Concrete Cap	35	CY	$1,200	$42,000	Reinforced concrete cap / wale along length of wall
Parapet Wall	50	CY	$1,500	$75,000	Reinforced concrete wall near headwall structure
Excavation and Earthwork	1	LS	$40,000	$40,000	Excavation, minor dewatering, backfill, compaction
Granular Fill	165	CY	$40	$6,600	Between proposed and existing SSP
Site Restoration	680	SY	$15	$10,200	Restoring existing grass areas
			Contractor Mobilization/Demobilization (15%)	$81,000	
			Contingency (15%)	$93,000	
			Section 4 Subtotal:	**$711,240**	
Section 6					
Site Prep and Erosion Control	1	LS	$3,000	$3,000	Fencing, barriers, haybales/silt socks, turbidity boom
Demolition and Removal	1	LS	$50,000	$50,000	Existing timber pier
Steel Sheet Pile	221	LF	$1,100	$243,100	SKZ20 uncoated, supply and install
Steel Tie Rods	37	EA	$600	$22,200	6' o.c. uncoated, supply and install
Steel Channel Wale (Deadman)	221	LF	$180	$39,780	Uncoated entire length
Mass Concrete Deadman	221	LF	$300	$66,300	
Concrete Cap	68	CY	$1,200	$81,600	Reinforced concrete cap / wale along length of wall
Excavation and Earthwork	1	LS	$75,000	$75,000	Excavation, minor dewatering, backfill, compaction
Granular Fill	1080	CY	$40	$43,200	Between proposed and existing SSP
Site Restoration	1250	SY	$30	$37,500	Restoring existing grass areas
			Contractor Mobilization/Demobilization (15%)	$100,000	
			Contingency (15%)	$115,000	
			Section 6 Subtotal:	**$876,680**	
			Estimate Subtotal:	***$1,587,920***	
Add Alternates					
Epoxy Coating on SSP	153	LF	$370	$56,610	
			Contingency (15%)	$8,492	

Option B - Steel Sheet Pile and Grouted Anchors

Item	Quantity	Unit	Unit Price	Total Cost*	Notes
Section 4					
Site Prep and Erosion Control	1	LS	$8,000	$8,000	Fencing, barriers, haybales/silt socks, boom
Demolition and Removal	1	LS	$8,000	$8,000	Concrete cap
Steel Sheet Pile	153	LF	$1,100	$168,300	SKZ20 uncoated, supply and install
Grouted Anchors	20	EA	$5,000	$100,000	8' o.c. galvanized pre-tensioned rods
Concrete Cap	35	CY	$1,600	$56,000	Reinforced concrete cap / wale along length of wall, embedded connections
Parapet Wall	50	CY	$1,500	$75,000	Reinforced concrete wall near headwall structure
Excavation and Earthwork	1	LS	$18,000	$18,000	Excavation, minor dewatering, backfill, compaction
Granular Fill	165	CY	$40	$6,600	Between proposed and existing SSP
Site Restoration	170	SY	$15	$2,550	Restoring existing grass areas
Concrete Mow Strip	640	SF	$6	$3,840	
Lamp Posts	1	EA	$5,000	$5,000	
			Contractor Mobilization/Demobilization (20%)	$91,000	Includes 5% additional for specialty equipment
			Contingency (15%)	$82,000	
			Section 4 Subtotal:	**$624,290**	
Section 6					
Site Prep and Erosion Control	1	LS	$5,000	$5,000	Fencing, barriers, haybales/silt socks, boom
Demolition and Removal	1	LS	$50,000	$50,000	Existing timber pier
Steel Sheet Pile	221	LF	$1,100	$243,100	SKZ20 uncoated, supply and install
Grouted Anchors	37	EA	$5,000	$185,000	6' o.c. galvanized pre-tensioned rods
Concrete Cap	68	CY	$1,600	$108,800	Reinforced concrete cap / wale along length of wall, embedded connections
Excavation and Earthwork	1	LS	$22,000	$22,000	Excavation, minor dewatering, backfill, compaction
Granular Fill	1080	CY	$40	$43,200	Between proposed and existing SSP
Site Restoration	250	SY	$30	$7,500	Restoring existing grass areas
			Contractor Mobilization/Demobilization (20%)	$133,000	Includes 5% additional for specialty equipment
			Contingency (15%)	$120,000	
			Section 6 Subtotal:	**$917,600**	
			Estimate Subtotal:	***$1,541,890***	
Add Alternates					
Epoxy Coating on SSP	221	LF	$370	$81,770	
			Contingency (15%)	$12,266	

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COLLINS ENGINEERS

Client: Milwaukee County
Project: Flushing Channel Rehabilitation
Description: Order of Magnitude Costs
Job No.: 60-12459.02
Prep. By: DJG Date: 12/4/2020
Checked By: RMM 12/7/2020

East Wall - Section 5 (Loading Yard)

Option A - Steel Sheet Pile and Deadman Tiebacks

Item	Quantity	Unit	Unit Price	Total Cost*	Notes
Site Prep and Erosion Control	1	LS	$6,000	$6,000	Fencing, barriers, haybales/silt socks, boom
Demolition and Removal	1	LS	$8,000	$8,000	Concrete cap
Steel Sheet Pile	173	LF	$1,100	$190,300	SKZ20 uncoated, supply and install
Steel Tie Rods	29	EA	$600	$17,400	8' o.c. uncoated, supply and install
Steel Channel Wale (Deadman)	173	LF	$180	$31,140	Uncoated entire length
SSP Deadman	173	LF	$300	$51,900	12' high continuous SSP, uncoated
Concrete Cap	55	CY	$1,200	$66,000	Reinforced concrete cap / wale along length of wall
Excavation and Earthwork	1	LS	$55,000	$55,000	Excavation, minor dewatering, backfill, compaction
Granular Fill	180	CY	$40	$7,200	Between proposed and existing SSP
Site Restoration	770	SY	$60	$46,200	Bituminous pavement surfacing
Relocate Crane	1	LS	$50,000	$50,000	Temporary removal and relocation of existing large crane
			Contractor Mobilization/Demobilization (15%)	$72,000	
			Contingency (15%)	$90,000	
			Estimate Subtotal:	***$691,140***	

Add Alternates

Item	Quantity	Unit	Unit Price	Total Cost*	Notes
Epoxy Coating on SSP	173	LF	$370	$64,010	
			Contingency (15%)	$9,602	

Option B - Steel Sheet Pile and Grouted Anchors

Item	Quantity	Unit	Unit Price	Total Cost*	Notes
Site Prep and Erosion Control	1	LS	$8,000	$8,000	Fencing, barriers, haybales/silt socks, boom
Additional Exploratory Investigation	1	LS	$60,000	$60,000	Includes test pits and inspection of existing wall
Demolition and Removal	1	LS	$8,000	$8,000	Does not include additional demo identified from test pits
Steel Sheet Pile	173	LF	$1,100	$190,300	SKZ20 uncoated, supply and install
Grouted Anchors	29	EA	$5,000	$145,000	8' o.c. galvanized pre-tensioned rods, includes concrete coring
Concrete Cap	55	CY	$1,600	$88,000	Reinforced concrete cap / wale along length of wall, embedded connections
Excavation and Earthwork	1	LS	$15,000	$15,000	Excavation, minor dewatering, backfill, compaction
Granular Fill	180	CY	$40	$7,200	Between proposed and existing SSP
Site Restoration	770	SY	$60	$46,200	Restoring existing grass areas
			Contractor Mobilization/Demobilization (20%)	$114,000	Includes 5% additional for specialty equipment
			Contingency (15%)	$93,000	
			Estimate Subtotal:	***$774,700***	

Add Alternates

Item	Quantity	Unit	Unit Price	Total Cost*	Notes
Epoxy Coating on SSP	173	LF	$370	$64,010	$749,000
			Contingency (15%)	$9,602	

Option C - FRP Panels and Grout

Item	Quantity	Unit	Unit Price	Total Cost*	Notes
FRP Panels	1	LS	$165,000	$165,000	Fiber Reinforced Polymer Panels (48 total)
Grout	1	LS	$60,000	$60,000	Grout between FRP and existing SSP
			Contractor Mobilization/Demobilization (15%)	$34,000	
			Contingency (15%)	$39,000	
			Estimate Subtotal:	***$298,000***	

Option D - Cathodic Protection

Item	Quantity	Unit	Unit Price	Total Cost*	Notes
Annodes	17	EA	$2,400	$40,800	Magnesium bulk annodes
Timber Lagging	1	LS	$40,000	$40,000	3x10 timber lagging
			Contractor Mobilization/Demobilization (15%)	$13,000	
			Contingency (15%)	$15,000	
			Estimate Subtotal:	***$108,800***	

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