Detailed Project Report

Menomonee River Section 206

Milwaukee, WI

June 2014

DETAILED PROJECT REPORT

MENOMONEE RIVER, ENVIRONMENTAL RESTORATION

CITY OF MILWAUKEE, MILWAUKEE COUNTY, WISCONSIN

SECTION 206 OF THE WATER RESOURCE DEVELOPMENT ACT

June 2014

1.0 EXECUTIVE SUMMARY

This report was prepared as part of an initiative by the U.S. Army Corps of Engineers (USACE) to evaluate the feasibility of ecosystem restoration of approximately 2,400 lineal feet (LF) of the Menomonee River in the City of Milwaukee, Milwaukee County, Wisconsin. The USACE is partnering with the Milwaukee Metropolitan Sewerage District (MMSD) for this project. This study is conducted under the authority of Section 206 of the Water Resources Development Act of 1996, (Public Law 104-303) as amended, Title 33 of the U.S. Code Section 2330 and the report was prepared according to guidelines specified in the USACE's Engineering Regulation 1105-2-100.

Since 1999, MMSD has removed drop structures, a low head dam, and concrete paved segments that restricted upstream fish passage. Immediately upstream of the proposed Menomonee CAP Section 206 project is a concrete segment containing a drop structure. The removal of this upstream concrete segment and drop structure will be completed in 2014. The Menomonee CAP Section 206 project (Figure 1) is 2,400 LF and would remove the last obstacle to upstream fish passage.

The Milwaukee Metropolitan Sewerage District (MMSD) constructed the Milwaukee County Grounds Floodwater Management Facility (MCGFMF), specifically to manage flood events by lowering flood stages to allow for the construction of multiple restoration projects, including the project herein evaluated. Information regarding the construction of the MCGFMF and other related projects are found in the Graef report referenced in section 3.2. Thus, the increase in flood water surface elevation from this project, and other completed projects, was mitigated as part of a larger plan.

The proposed project involves the removal of 8-inch thick concrete channel lining from approximately 2,400 lineal feet of the Menomonee River located in Milwaukee, Wisconsin to create a more natural channel to improve aquatic habitat. The project extends from just downstream of Wisconsin Avenue to just downstream of the I-94 bridge crossing or River Mile 4.03 to 3.55 (See Figure 3). The upstream limit corresponds to the downstream limit of MMSD's drop structure and concrete lining removal project that is scheduled to be completed in 2014. The downstream limit of the project corresponds to the end of the concrete channel lining. This project segment is critical to complete the connection between restored sections of the Menomonee River.

The selection of the preferred alternative involved the utilization of both environmental and economic data and cost-effectiveness (CE) and incremental cost analyses (ICA). The preferred alternative recommends the removal of the concrete channel lining and placement of stone with riffles and pools. This restoration would provide connectivity between previously restored sections of the Menomonee River allowing full use, by the fishery, of the upstream spawning habitat.

The 100 year water surface elevations for Alternatives 1 and 2 exceed the existing conditions water surface elevation (Alternative 3) in several areas, but are lower than or equal to the effective FEMA 100-yr floodplain elevations since the stormwater detention facility built by MMSD [known as the Milwaukee County Grounds Floodwater Management Facility (MCGFMF)] was specifically developed to lower discharge elevations in order to proceed with river restoration projects. The MMSD has submitted a regional CLOMR (Conditional Letter of Map Revision) and LOMR (Letter of Map Revision) to FEMA (Federal Emergency Management Agency) for the existing condition which was incorporated into the modeling used in this analysis. The only measurable increase in inundation area is on the Miller-Coors property located adjacent to our project area, directly west of the river. The difference between existing and proposed conditions measures approximately a third of an acre as circled in blue in Figure 7 of this report. Miller-Coors and the local sponsor, MMSD, are aware of the increase. On the south end of this parking lot, both Alternative 1 and 2 exceed the existing conditions water surface elevation during a 100 year event with no impact for the 50 year or lesser events.

This alternative is supported by the Milwaukee Metropolitan Sewerage District, the non-Federal partner. The proposed plan meets the desired goal of ecosystem restoration.

The comparison of alternatives resulted in a selected plan involving the removal of the concrete channel lining and replacement with a rock lining with riffles and pools. Table 1 presents a summary of the final costs for the selected plan.

Table 1(ES) – Final Cost Apportionment

2014 dollars, FY14 Interest Rate

Remove Concrete w/Riffle/Pool Construction

Category	**Federal**	**Non-Federal**	**Total Cost**
Feasibility Study	$187,500	$87,500	$275,000
Planning, Engineering and Design	$211,250	$113,750	$325,000
Construction Cost	$3,534,700	$1,903,300	$5,438,000
Construction Management	$41,600	$22,400	$64,000
LERRDs[1]	$89,700	$48,300	$138,000
Subtotal	$3,877,250	$2,087,750	$5,827,000
Total First Costs			**$6,240,000**
Operation and Maintenance		$10,000	$10,000
Monitoring and Adaptive Management	$21,450	$11,550	$33,000

[1] Land, Easements, Right-of-Ways, Relocations and Disposal sites

ECOSYSTEM RESTORATION
(SECTION 206)
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1.0 STUDY PURPOSE AND SCOPE

This study evaluates ecosystem restoration along the Menomonee River beginning approximately 100 feet south of the Wisconsin Avenue Bridge and extending approximately 2,400 lineal feet (LF) in a southerly direction downstream to approximately 100 feet south of Interstate Highway I-94 southwest of W Mt Vernon Avenue and N 42nd St in Milwaukee, Wisconsin (Figure 3).

The existing concrete channel in this reach provides extremely limited habitat value and blocks upstream migration of fish, particularly during spring runoff. The purpose of this study is to determine the best solution to provide connectivity for fish spawning and to return the Menomonee River to a more natural state.

Ecosystem restoration in the Civil Works program uses a systems view in assessing and addressing restoration needs and opportunities. Recognition of the interconnectedness and dynamics of natural systems, along with human activities in the landscape, is integral to the assessment. The philosophy behind ecosystem restoration promotes consideration of the effects of decisions over the long term. The goal is to restore and sustain the health, productivity, and biological diversity of ecosystems and the overall quality of life through a natural resources management approach that is fully integrated with social and economic goals.

2.0 STUDY AUTHORITY

This study is being conducted under the authority of Section 206 of the Water Resources Development Act (WRDA) of 1996, (Public Law 104-303) as amended, Title 33 of the U.S. Code Section 2330. As such, the project is subject to the requirements of the National Environmental Policy Act (NEPA), Section 404 of the Clean Water Act, and Engineer Regulation (ER) 1102-5-100.

3.0 PRIOR STUDIES AND REPORTS

This section presents a list of previously collected data and reports relevant to the restoration of the Menomonee River. Listed projects are not necessarily inclusive of the project region, but at least involve the Menomonee River. They may be representative of similar conditions and/or discussions that may or may not have resulted in information pertinent to this evaluation. Previous studies have been conducted by, or on behalf of, the U.S. Army Corps of Engineers (USACE); and the Milwaukee Metropolitan Sewerage District, WI.

3.1 U.S. Army Corps of Engineers Studies

Reconnaissance Report, Flood Control Study, Menomonee River, Milwaukee County, Wisconsin, dated April 1, 1990, and prepared by the U.S. Army Corps of Engineers, Detroit District. The study area was a 2.54 miles stretch of the river from 45th Street (downstream limit) in Milwaukee to Harwood Avenue (upstream limit) in Wauwatosa. The study evaluated both structural and non-structural flood reduction alternatives and concluded that protection measures were not economically feasible and not warranted based on national economic development. This area is immediately upstream of the stretch of river from the Middle Railroad Bridge (near 45th Street to I-94, which is being evaluated for aquatic ecosystem restoration. This study is included since it involved the Menomonee River upstream from the current evaluation. Data utilized in this 1990 report were not considered current and/or were not available and thus, were not included in this evaluation.

Preliminary Restoration Plan (PRP) for Aquatic Ecosystem Restoration, Section 206, at Menomonee River, Milwaukee, Wisconsin, dated August 4, 1999, prepared by the U.S. Army Corps of Engineers, Detroit District. This report collected existing site data and initiated coordination with local, state, and Federal agencies related to formulating alternatives to solve identified problems at the study site. Federal interest was evaluated and a recommendation was made to continue into the feasibility phase to more completely evaluate the benefits and costs related to removal of the concrete channel lining from a 3,700-foot stretch of the river. This PRP was the document prepared in order to determine Federal interest in proceeding with this study. The PRP was utilized as a starting point for this Detailed Project Report (DPR).

Sampling and Analysis of Sediments, Menomonee River, Milwaukee WI. Final Report August 2001.This report was prepared for USACE, Detroit District by Altech Environmental Services, Inc. This report integrates a field report, describing the collection and handling of concrete and sediment samples and the physical properties of the sediment encountered with an analytical report describing the chemical characteristics of the sediment underlying the concrete. The report detailed 22 physical samples and concluded that there are no chemical barriers to upland disposal of the removed material.

Menomonee River Sediment Transport Modeling System, Final Report, February 28, 2003. Report and modeling effort was completed under the Great Lakes Tributary Modeling Program for the USACE, Detroit District by W.F. Baird & Associates, LTD. As of April 2014, this report is available on-line at:
http://projects.glc.org/tributary/models/documents/MenomoneeSedimentTransportReportFinal_000.pdf.
The purpose of the work was to describe the sediment and flow dynamics of the Menomonee River Watershed and to describe the modeling system that was developed for its analysis. The

DPR utilized the information generated in this report in the initial modeling effort for this analysis.

3.2 Milwaukee Metropolitan Sewerage District (MMSD) Studies

Draft Menomonee River Drop Structure Removal Project, Pre-Design Memorandum, dated January 1998, and prepared by Inter-Fluve, Inc. for the Milwaukee Metropolitan Sewerage District. This study evaluated the impact of removing the drop structure upstream of the North 45th Street Bridge. The report also analyzed and made recommendations for channel improvements to a 1,300 foot reach downstream of the drop structure. The recommended short term alternative including removing the drop structure which offered environmental and recreational benefits and it reduced water surface elevations for the 100-year event between the Upper Railroad Bridge and the Drop Structure, while creating only minor increases to the water surface between the Drop Structure and the Middle Railroad Bridge. The long-term goal recommendations included re-evaluating Alternatives 3-6 and possible long-term solutions for habitat restoration and recreation. Alternatives 3-6 included: Alternative 3 (Natural Channel Bed) which included removal of the drop structure, flattening the grade between the drop structure and the middle railroad bridge, removing concrete from the channel in this reach, and establishing a meandering low flow channel in boulders and cobbles which contains a pool/riffle sequence; Alternative 4 (Natural Channel With North Side Pathway) which has the same components as Alternative 3 but includes a 25 foot easement along the northeast bank. The existing wall is removed at this location and the ground is sloped back to provide a greenbelt with a pathway; Alternative 5 (Natural Channel with South Side Pathway) has the same components at Alternative 3, but includes a south side easement along half the distance where the existing wall is removed and replaced with a pathway. A small parking lot is provided which is accessible via Monarch Place and 43rd Street. Alternative 6 (Floodway Easement) is less specific than earlier alternatives, and could include components from Alternatives 2 through 5. The main distinction of this alternative is that a flood wall and storm drain extension is not required. A flood easement is obtained on the southwest bank for all areas inundated during the 100-year event, which includes a portion of three land parcels. This land could be developed for recreational purpose with parks, pathways, river access, and parking. This 1998 report involved recreational components which are not part of the current evaluation.

Menomonee River Flood Management Plan, Interim Executive Summary, dated September 15, 1999, and prepared by the Milwaukee Metropolitan Sewerage District. The Executive Summary presented the status and preliminary recommendations of the various Menomonee River Watershed projects to enable the District to accelerate the implementation of critical projects. This report indicated that the majority of flood damages on the Menomonee River Mainstem (In-County) occur in the Hart Park and Valley Park neighborhoods. The Valley Park neighborhood is located along the east side of the Menomonee River between Wisconsin Avenue and I-94, which is in the study area of this project. The recommended alternative for Valley Park was 750 feet of 5 feet high floodwall and 750 feet of 7 feet high levee as well as 7 residential acquisitions. MMSD has on-going flood management efforts and continued efforts beyond this 1999 study to include the recent CLOMR and LOMR through FEMA which were utilized in the hydraulic modeling in this DPR study.

Sediment Characterization for Menomonee River Drop Structure Project Near 45th and State Streets, Milwaukee, Wisconsin, dated February 10, 2000, and prepared by K. Singh and Associates and James Cape & Sons for the Milwaukee Metropolitan Sewerage District. This area is immediately upstream of the Wisconsin Avenue to I-94 study area. The site investigation summary indicated that levels of soil contamination at five feet below grade exceeded the Wisconsin Department of Natural Resources generic residual contaminant levels (RCL's) in some of the samples along the river channel. Groundwater contaminant levels in the corresponding water samples were generally below detection limits or applicable prevent action limits (PAL's), except for a few cases where contaminant levels were between the PAL and enforcement standard (ES). The MMSD study was referenced in the DPR's Environmental Assessment, Section 3.1.3, to show the characterization of soil located immediately upstream of the proposed Section 206 project reach.

Channelization study Memorandum, dated February 2001, and prepared by Harza Engineering Company for the Milwaukee Metropolitan Sewerage District. MMSD contracted for this study to evaluate the effect of removal of concrete channel lining. The goal was to determine if concrete removal would significantly improve stream habit. The study demonstrated that vegetated banks provide shade and are a source of food for stream life. Gravel stream bottoms were the most productive, but a variety of bottom types provided living spaces for a variety of types of stream life. Variations in depth provided by the natural flow of stream channels, large stones and woody debris provided a variety of depths and current velocities that supported a variety of aquatic life. Objects large enough to provide shelter from the current and hiding places from predators were especially important for fish and large invertebrates such as crayfish. The study also demonstrated that concrete-lined channels provide little or no cover, and objects that fall in the channel are washed downstream. The determinations made in this 2001 report were utilized in the development of the Corps designs in this DPR.

Final Design Memorandum, Menomonee River Stream Management, Contract No. W20021D01, Milwaukee, Wisconsin, May 2011. This report was prepared for Milwaukee Metropolitan Sewerage District, by Graef. This report and modeling effort provided alternatives to meet the goals of providing for fish passage and fish refuge zones while maintaining or decreasing water surface elevations. The designs developed in this 2011 report were utilized in the development of the Corps designs in this DPR. This report includes information on the other projects completed in the watershed and specifically on the Milwaukee County Grounds Floodwater Management Facility (MCGFMF), which lowered flood stages in anticipation of the planned restoration projects, including this proposed project.

4.0 PLAN FORMULATION

4.1 EXISTING CONDITIONS

Location

The Menomonee River is a tributary of the Milwaukee River and discharges to a Federal navigation channel in the Milwaukee Harbor in Milwaukee, Wisconsin. The Menomonee River watershed encompasses 136 square miles, including portions of Washington, Ozaukee, Waukesha and Milwaukee Counties and flows approximately 32 miles in a southeasterly direction from its headwaters in the Village of Germantown and the City of Mequon, Wisconsin to the Milwaukee and Kinnickinnic Rivers in the Milwaukee Harbor Estuary. The watershed flows primarily through urban areas, with the central and lower portions including mainly residential, commercial and industrial developments. The agricultural land near the upper reach of the Menomonee River is rapidly being developed.

During 1965-66, the Milwaukee Metropolitan Sewerage District (MMSD) lined approximately 1 mile of the Menomonee River with concrete, for flood control purposes. No information is available on the level of flood control provided by the locally constructed concrete lining. The upstream limit of the proposed project area corresponds to the downstream limit of a completed MMSD project which is removing a drop structure at 45th Street and 1,300 feet of concrete channel lining.

This project area is enclosed within WPA (Works Progress Administration) constructed walls (WPA walls) circa late 1930's. The WPA was a New Deal agency which constructed parks, bridges, schools, public buildings and roads and, as in this region, flood control structures. Because of the significance of the WPA walls, a Request for SHPO (State Historic Preservation Office) Comment and Consultation on a Federal Undertaking was filed with the Wisconsin Historical Society. The request was initiated to repair outfalls through the WPA walls. Correspondence regarding this submittal is included with this document in the Correspondence attachment (Attachment 2). Due to the historical significance of the WPA walls, they are a constraint to the project and will be protected. If the soil boring data indicates the WPA walls require protection from a slumping failure, the WPA walls will be stabilized with steel sheet piling (SSP) placed at the waterward edge of the upper most concrete panels. The SSP wall would be placed parallel to the river and these costs would be shared as part of the project. Repair of drain outfalls that pass through the WPA walls may occur during the time of construction of this proposed project. However, outfall repairs would not be part of the Federal project and would be pursued separately by the MMSD at 100% MMSD expense. The Menomonee River and Menomonee River Watershed is in southwestern Wisconsin (**Figure 1**). This 32-mile river is one of the principal tributaries of the Milwaukee River, and is part of a major watershed that drains to Lake Michigan. **Figure 2** depicts the Greater Milwaukee

Watersheds showing Menomonee River Watershed and **Figure 3** provides a close view of the project area.

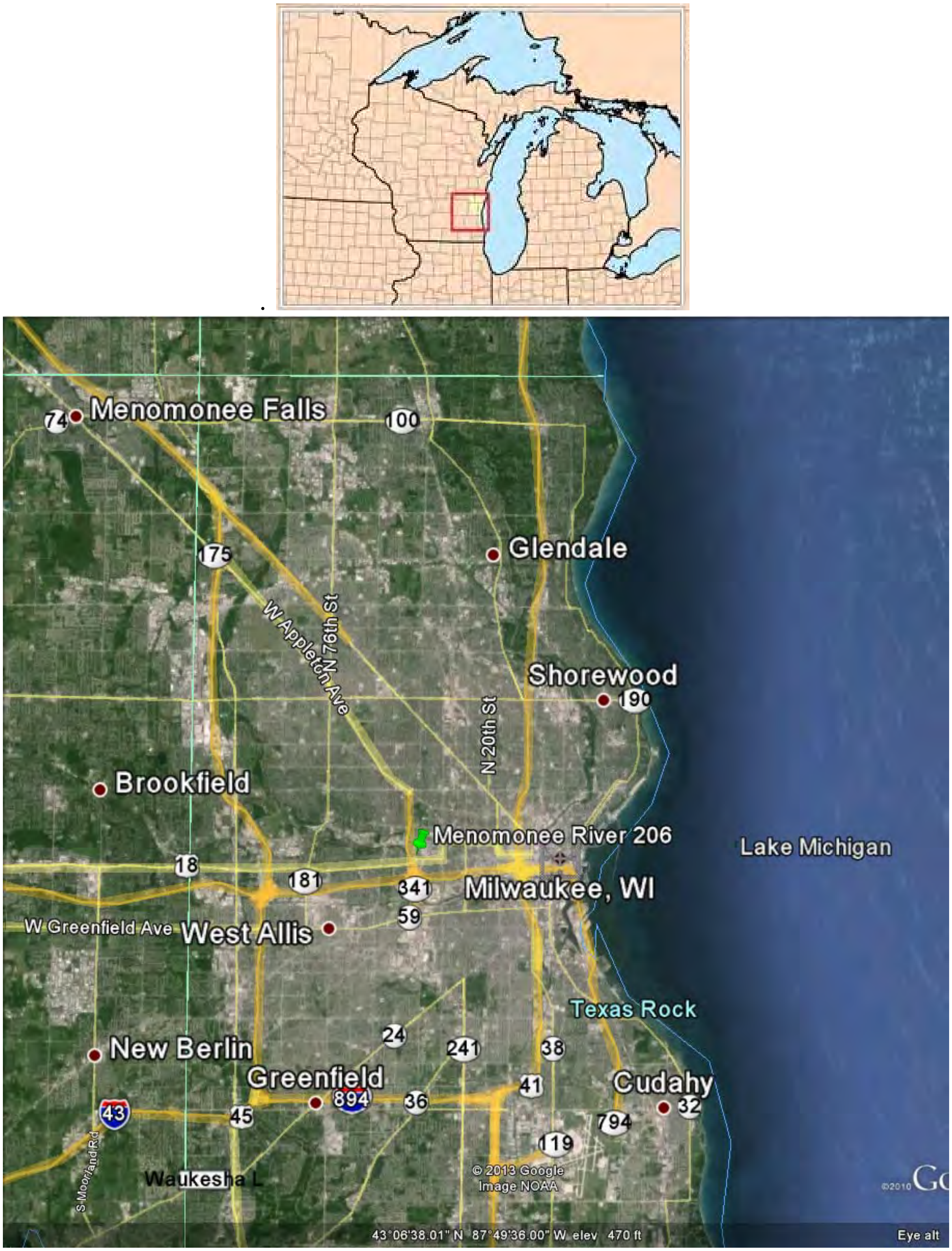
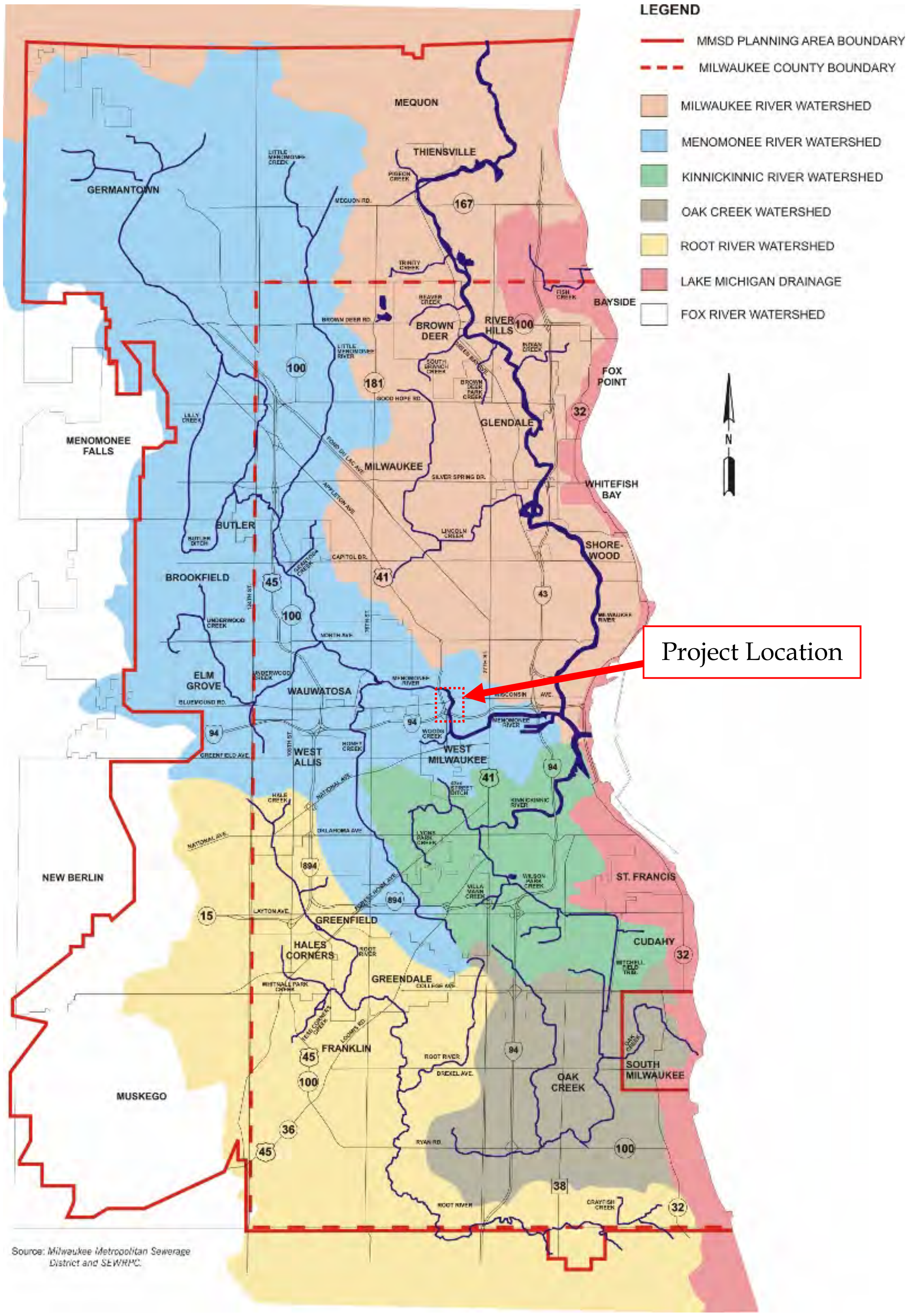


Figure 1. Project Location



Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

Figure 2. Greater Milwaukee Watersheds/Menomonee River Watershed

Figure 3. Location of Proposed Menomonee River Ecosystem Restoration, Milwaukee, WI

Hazardous, Toxic and Radioactive Waste (HTRW) Investigations

The terms "hazardous materials" refers to any item or agent (biological, chemical, radiological or physical) which has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors. When hazardous materials are improperly used, they can threaten the health and well-being of wildlife species, habitats, soil and water systems, and humans.

USACE policy prohibits the use of Civil Works funds to respond to concerns associated with HTRW and requires appropriate investigation to identify potential HTRW concerns early in planning and development of a civil works project. Several actions were conducted to address the existence of, or potential for, HTRW contamination on lands in and adjacent to the proposed project site, including structures and submerged lands, which could impact, or be impacted by project implementation.

Environmental databases and related records were searched and reviewed for information regarding current and former land use indicating storage, disposal or use of Comprehensive Environmental Response, Compensation, Liability Act (CERCLA) regulated substances. No CERCLA sites were revealed in the project vicinity. In 2001 a Phase II ESA was conducted, Twenty-two samples were collected and analyzed to characterize the sediments under the concrete lined channel within the proposed project site. No HTRW materials were detected underneath the concrete located within the proposed project area or in the project reach. All of the soil under the concrete would be classified as a non-regulated material and is suitable for upland placement. MMSD has tested sediments immediately upstream of the proposed CAP Section 206 project reach. No other projects located within the proposed CAP Section 206 project area have contained soil identified as hazardous or have met the requirements for HTRW disposal (MMSD Study, *Sediment Characterization for Menomonee River Drop Structure Project Near 45th and State Streets, Milwaukee, Wisconsin, dated February 10, 2000, and prepared by K. Singh and Associates and James Cape & Sons for the Milwaukee Metropolitan Sewerage District.*).

While implementing the proposed project is not expected to result in the identification or the release of HTRW regulated material, some additional testing is likely to occur prior to or during construction. If the additional testing indicates the presence of CERCLA substances above State of Wisconsin criteria in soils to be excavated and removed from the project, those soils will be transported and disposed of in accordance with applicable Federal, State, and local laws consistent with USACE polices. The non-Federal project sponsor (MMSD) will pay 100% of the costs associated with the removal and disposal of any HTRW regulated waste materials encountered during construction activities. The HTRW regulated materials will be taken to a properly permitted Type II landfill such as the Waste Management Facility located at 2101 W. Morgan Avenue, Milwaukee, Wisconsin. (See EA, Section 3.1.3, Hazardous Material, for further details.)

Excavated non-HTRW regulated material will be disposed of in accordance with applicable Federal, State, and local laws and USACE polices. MMSD has identified the Road and Construction Materials Facility, located approximately 15 miles from the project site at 6401 South Racine Avenue, New Berlin, Wisconsin as the primary disposal site. This site is a disposal for fee site and is compliant with all Federal, State and Local permit requirements to accept this material. As part of the study, the government has screened several sites, including the proposed commercial facility in Racine identified by the Sponsor, and after evaluation of the potential costs, including transportation, permitting, and land, and public and environmental factors, has determined that the Racine commercial site is the most cost effective and reliable option readily available for the disposal of the clean sediment materials. The concrete removed from the site, will be taken to one of several available recycling facilities, location to be determined.

If the construction contractor can find an economically favorable alternative site(s) that is/are suitable for disposal of this material, then the contractor will be required to prove to the government that they have properly obtained all Local, State and Federal permits required for disposal at these alternative sites. The placement of non-HTRW regulated material into an appropriate off site licensed disposal area is considered a project feature and the non-federal project sponsor can obtain Lands, Easements Rights-of-Ways, Relocations, and Disposal (LERRDS) credit. For additional information, see the Real Estate plan located in the DPR, Appendix E - Real Estate.

4.1.1 Water Quality and Fisheries Existing Conditions

The existing concrete lined channel was designed to move water downstream during runoff events at high velocity. Due to high water velocity and length of run necessary to pass the concrete lined channel, these design components prevent the upstream movement of fish to existing spawning habitat. The Menomonee River has been plagued with severe water quality and physical habitat problems in the past. However, recent restoration efforts have resulted in substantial improvements. During this time, MMSD has reduced the annual combined sewer overflow events into the Menomonee River from 60 to 2, resulting in significantly improved water quality. Water quality has also been improved by zebra mussel activity. The concrete portion of the river prevents the passage of fish to valuable spawning areas already restored upstream.

As with other areas of rapid urban development, increases in impervious area contribute to a flashier system with higher peak velocities and shear stresses. Bank erosion and erosion from construction sites also contribute heavily to waterway pollution within the Menomonee River watershed.

Upstream of the concrete lined portion of the channel, the Menomonee River and its tributaries extend into progressively more rural areas. A warm water fish community exists in this portion of the river, supporting significant smallmouth bass populations. Downstream of the concrete section, the river becomes an estuary backwater of Lake Michigan. Northern pike and walleye are the top fish predators in this area, exhibiting significant population increases in response to water quality improvements. The Wisconsin Department of Natural Resources (WDNR) provided a list of some of the fish species lost or severely impaired by the construction, and continued presence of the concrete lined channel, as depicted in **Table 1**.

Table 1 - Impacted Fish Species

	Native Species	
Greater Redhorse Sucker	Smallmouth Bass	Northern Pickerel
White Sucker	Walleye	Johnny Darter
Longnose Sucker	Northern Pike	Creek Chub
Shorthead Sucker	American Eel*	
	Non-Native Species	
Rainbow Trout	Coho Salmon	Atlantic Salmon
Brown Trout	Chinook Salmon	Sockeye Salmon

*SPECIAL CONCERN STATUS: The WDNR has listed the American Eel as a "Species of Concern"; it is considered rare and uncommon in Wisconsin.

Though sea lamprey exists in Lake Michigan, the warm waters of the Milwaukee River tributaries were determined to be unsuitable for sea lamprey production by the USFWS Sea Lamprey Control Unit.

4.1.2 Population, Land Use and Industry

The Menomonee River watershed is populated with 2,367 persons per square mile when compared to the State of Wisconsin with 99 persons per square mile. The population in the watershed is relatively stable with approximately 325,000 individuals in 2010 and has continued to experience increased urbanization with increasing numbers of household units between 1990 and 2010. The watershed spans four counties, nine cities, six villages and four towns.[1]

Figure 4 provides a depiction of land use in the Menomonee Watershed indicating that 52% of the watershed is suburban/urban, 22% is devoted to agriculture with 14% remaining as open water or open space.

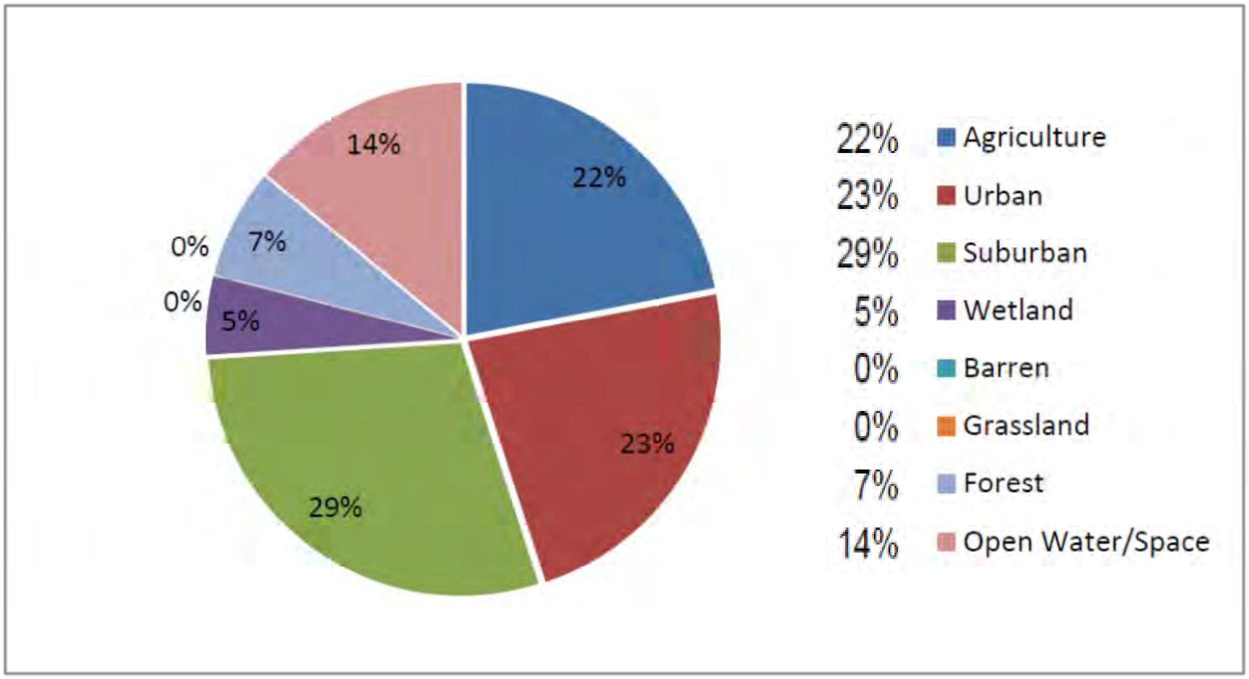


Figure 4. Menomonee Watershed Land Use[1]

The City of Milwaukee is the largest city in the watershed with a 2012 population of nearly 598,000 with a total of over 955,000 in Milwaukee County and over 5,725,000 in Wisconsin. The City of Milwaukee is densely populated with 6,188 persons per square mile compared to 3,926 in the county. The unemployment rate for Milwaukee County exceeded 9% in February of 2013 compared to just over 7% for the state of Wisconsin.

4.2 Future Without-Project Conditions

Water quality conditions on the Menomonee River without this project would be expected to gradually improve over the next 50 years. This projection is based on the assumption that other efforts underway to clean up and restore degraded areas in the river continue. Such efforts include the removal of contaminated sediments, the restoration of wetland areas and other activities. None of these activities are within the proposed project area.

The Milwaukee Estuary Remedial Action Plan (1995), prepared by the Wisconsin Department of Natural Resources lists as a goal, to develop high quality aquatic and wildlife habitats. One of the objectives described in the plan was to evaluate and implement recommendations regarding removal or modification of human-made obstructions along the rivers which restrict navigation and natural fish movement, spawning, feeding, protection, development or winter habitat.

[1] Wisconsin Watersheds, Menomonee Watershed Plan 2010, August 2010, Wisconsin Department of Natural Resources.

Some continuing development along the waterfront is anticipated but it is expected that restoration efforts will exceed development during the period of consideration resulting in stable flows as presented in Table 1, page 3 of the H&H appendix (Appendix B). Overall gains in water quality, sediment quality, and habitat availability are expected to occur as a result of regulation and restoration efforts by governments. Because of the size of the system and the permanence of the development that caused habitat losses, gains will be gradual and small in relation to the losses that have occurred due to development including the placement of a concrete channel lining along the river. If the USACE project is not implemented, the local sponsor, MMSD, could choose to implement the project independently.

The lack of connectivity due to this concrete lined area of the river would continue to prevent fish from accessing valuable spawning areas and thus, would not contribute to the restoration of these species in Lake Michigan and in the Menomonee River.

4.3 Problems, Opportunities, Constraints and Objectives

The problems are described in the Existing Conditions paragraph 4.1.1, Water Quality and Fisheries Existing Conditions. The overall objective is to restore the degraded aquatic structures, functions, and dynamic processes to a less degraded, more natural condition. The identified problems and opportunities are summarized below.

4.3.1 Problems

The fishery within the Milwaukee Harbor is limited due to a lack of access by adult fish to suitable spawning habitat. The concrete lined channel prevents fish access to over 18 river miles comprised of 100 acres of open water, 30 acres of gravel for spawning by game and forage fish species, and access to over 125 acres of shallow water emergent wetlands for spawning use by listed various fish species, and in particular, northern pike.

- Lack of connectivity within the river for fish to reach valuable spawning areas

The concrete channel lining from the Middle Railroad Bridge north of Wisconsin Avenue to I-94 prevents fish from accessing spawning areas upstream due to high velocities during the spawning season.

- Loss of aquatic habitat, natural shoreline and emergent wetlands

The concrete channel lining from the Middle Railroad Bridge north of Wisconsin Avenue to I-94 as well as commercial and industrial development along the Menomonee River has degraded a significant amount of the once available fishery habitat.

- Shortage of deeper water areas sheltered from the main current of the river occurring near to shoreline spawning habitat

The placement of concrete along the Menomonee River channel bottom has resulted in a system with a shortage of deeper water areas sheltered from the main current of the river. The study area of the river lacks any riffle/pool systems, which provide vital habitat to fish and other aquatic organisms. Variations in depth provided by natural stream channels as well as stones and woody debris provide a variety of depths and current velocities that support a variety of aquatic life. This loss of habitat has reduced the quantity and the diversity of fish present in the river and impedes fish passage upstream.

The Milwaukee Estuary Remedial Action Plan cites a goal to develop high quality aquatic and wildlife habitats.

4.3.2 Opportunities

There are several opportunities related to improving fish passage and aquatic habitat in the Menomonee River.

- Improve fishery habitat along the Menomonee River
- Restore indigenous fish species in the river
- Provide increased recreational opportunities along the waterfront
- Restore a diverse and self-sustaining riparian vegetative community along the river's edge
- Restore fish spawning and rearing in the river by providing passage through the affected section
- Decrease peak velocities within the channel
- Improve water quality
- Decrease maintenance expenses
- Improve the overall health of the estuary

Concrete channels provide little or no cover and current velocities often reach speeds unsuitable for fish and other aquatic organisms. The restoration of natural channels and banks provide sources of food for stream life as well as shade and cover for temperature variation in the stream.

Fish access to historical spawning and rearing habitat upstream could be restored, and the composition of benthic communities could be improved.

4.3.3 Planning Constraints

This study was conducted within the constraints depicted in the *Economic and Environmental Principles and Guidelines for Water and Related Land Implementation Studies*, and by applicable USACE regulations and other documents which provide guidance pertaining to the implementation of these principles and guidelines. Plans were developed with due regard to the benefits and costs, both tangible and intangible, as well as associated effects on the ecological, social, and economic well-being of the region. Federal participation in projects seek to ensure that any plan is complete, efficient, economically feasible, environmentally acceptable, and consistent and acceptable in accordance with local, regional, and State plans and policies. To the extent practical, plans are formulated to maximize beneficial effects and minimize adverse impacts and costs.

Planning Constraints identified for the Menomonee River Ecosystem Restoration are:

- Physical constraints along the Menomonee River concrete channel area, including bridges and the WPA walls that must remain in place and the structures on either side of the river, limit the methods and/or designs available for cost effective channel restoration.

- Any implemented alternative should not significantly increase the area of the estimated 100-year flood zone. Project features must safely convey extreme flood flows and protect existing flood risk management measures.

- Bridges near the south end of the project, the I94 Bridge and the Railroad Bridge, require special consideration to evaluate potential impedance to fish passage.

4.3.4 Objectives

The overall goal of the Menomonee River Section 206 project is to restore aquatic ecosystem functions and remove migratory barriers for fish traversing the network of streams and rivers linking them to the estuary. To reach the overall restoration goal, specific objectives were identified through coordination with local and regional agencies, site assessments and review of prior studies and reports. The specific objectives for the proposed restoration within the project area are presented below:

- Provide connectivity upstream to 18 miles of river for spawning for adults and nursery habitat for juvenile fish

SIGNIFICANCE: The reduction of velocity with riffles and pools provides connectivity between Lake Michigan and the upper Menomonee River spawning and rearing habitats and supports the restoration of fish populations.

- Restore more natural riverine habitat for a variety of fish and invertebrates in the channelized portion of the Menomonee River.

- Offset degradation and loss of significant habitat in the study area via improvements in native vegetation, physical habitat and water quality.

SIGNIFICANCE: Vegetation and habitat is currently limited by the concrete lining in the project region.

- Contribute to National Ecosystem Restoration through restoration of degraded ecosystem structure, function, and dynamic processes to a more natural condition of riffles and pools.

5.0 OVERVIEW OF THE PLAN FORMULATION PROCESS

The Planning Guidance Notebook (ER 1105-2-100) calls for the formulation of alternative plans to identify specific ways to achieve the planning objectives within the constraints listed above. An alternative plan consists of a system of measures that address specific needs or concerns of a project. The first phase of the formulation process is identifying potential management measures that could be implemented. The second phase is formulating alternative plans by combining management measures as appropriate.

As plans are formulated, it is crucial that they be developed with the goal of maximizing benefit to the economy, the environment, or the sum of both. As stated in the Planning Guidance, each alternative plan shall consider the four criteria described in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (1983): completeness, efficiency, effectiveness, and acceptability. “Completeness is the extent to which the alternative plans provide and account for all necessary investments or other actions to ensure the realization of the planning objectives, including actions by other Federal and non-Federal entities. Effectiveness is the extent to which the alternative plans contribute to achieve the planning objectives. Efficiency is the extent to which an alternative plan is the most cost effective means of achieving the objectives. Acceptability is the extent to which the alternative plans are acceptable in terms of applicable laws, regulations and public policies.”

6.0 PLAN FORMULATION MANAGEMENT MEASURES AND ALTERNATIVES

Several alternatives were considered and rejected prior to alternative evaluation including some non-structural alternatives that proved to be capital dependent and labor intensive, such as trap and release and stocking. The primary constraint with this project is the river location between the two historic WPA walls. The width of the available corridor for river restoration is set by the WPA walls. The potential is high for slumping or WPA wall failure if excavation is conducted at or below the toe of the WPA structures. The SHPO would not consider removal or modification of the historic WPA walls for project design other than in kind and in place maintenance.

Ideally, a river restoration project would include construction of a two stage channel with meanders and riparian vegetation. The WPA walls prevented the design of such a channel based on available river width. While it is conceivable that a new river corridor alignment could be procured of sufficient width to create a river with meanders, riparian vegetation, riffles and pools, the impacts to existing businesses and residential structures and costs (acquisition and new bridges) made this type of alternative neither feasible nor prudent. The available real estate between the historic walls is insufficient for the creation of a two stage channel with a vegetated floodplain and a natural channel design.

The I94 Bridge and the railroad bridge were specific physical constraints that required special analysis. The challenge was to find alternatives that would achieve desired flow conditions for fish passage while preventing scour near the structures. This concern resulted in a detailed scour analysis to aid in alternative development at these two locations. Again, due to the limitations on the banks with the WPA walls that were required to be left in place, potential measures were extremely limited.

Management measures are the individual means that address specific needs or concerns of the project. Given the constraints, initial plan formulation included evaluation of a limited number of viable measures to improve and restore the degraded aquatic habitat along the Menomonee River.

Evaluated measures included:

- Concrete Removal,
- Stone Placement, and
- Stone Placement with Riffles and Pools.

The project area is highly urbanized, limiting the viability of expanding the restoration beyond the immediate Menomonee River footprint. The water velocity in the concrete channel limits upstream migration of fish and blocks passage. The creation of riffles and pools would allow fish passage to extensive habitat areas. The riffles and pools create an impediment to flow resulting in a slight increase in stage elevation. Several riffle pool variations were considered resulting in either flow velocities that were too high to allow for fish passage or potential flood impacts. Ultimately, the alternatives presented in this report were deemed the only viable solutions, reducing flow velocities from the existing conditions to levels that would allow fish passage without creating flood damage consequences. The MMSD is obtaining necessary flowage easements for the potential flooding in an industrial parking lot and has notified FEMA of the intent to change the 100-year flood plain. The Milwaukee County Grounds Floodwater Management Facility (MCGFMF) was constructed in anticipation of potential increases from individual restoration projects. (NOTE: see Correspondence included with this report). Since the project has no impact for the 50 year event, it is expected that a takings analysis will not be required.

Since 1999, MMSD has removed drop structures, a low head dam, and concrete paved segments that restricted upstream fish passage. Immediately upstream of the proposed Menomonee CAP Section 206 project is a concrete segment containing a drop structure. MMSD has scheduled the removal of this concrete segment and drop structure in 2014. MMSD's project consists of replacing the concrete lined channel with coarse granular bedding stone and rock boulders set in concrete to form riffles and pools, where necessary, for successful fish passage to upstream habitat.

Since the existing 2,400 LF of concrete channel immediately downstream of the MMSD project area provides extremely limited habitat value and blocks the upstream migration of fishes, particularly during spring runoff because of high discharge velocity, the removal of the concrete channel lining was deemed a necessary component to any proposed habitat restoration alternative. Simply removing the concrete channel lining would result in high water velocities and riverbed erosion causing undercutting and compromise of the WPA retaining walls. Given the limitations of the project area to within the existing river width because of the historic WPA walls, the limited measures resulted in only two viable designs which were further evaluated within this DPR. The alternatives evaluated in depth include: 1) removal of the concrete channel lining and replacing it with stone and creating riffle and pool complexes, and 2) removal of the concrete channel lining and replacing it with stone without the creation of any riffle or pool complexes.

The proposed project involves the removal of 8-inch thick concrete channel lining from approximately 2,400 lineal feet of the Menomonee River located in Milwaukee, Wisconsin and replacing it with stone and creating riffle and pool complexes to improve aquatic habitat. The project extends from just downstream of Wisconsin Avenue to just downstream of the I-94 bridge crossing or River Mile 4.027 to 3.55 (See Figure 3). The upstream limit corresponds to the downstream limit of the drop structure and concrete lining removal project to be completed in 2014. The downstream limit of the project corresponds to the end of the concrete channel lining.

All excavated underlying soil material will either be taken to the MMSD identified Road and Construction Materials Facility located approximately 15 miles from the project site at 6401 S. Racine Avenue, New Berlin, Wisconsin. If the construction contractor can find an economically favorable alternative site(s) that is/are suitable for disposal of this material, then the contractor will be required to prove to the government that they have properly obtained all Local, State and Federal permits required for disposal at these alternative sites. All of the concrete removed from this project will be taken to a licensed concrete recycling facility. Any materials determined to be unsuitable for disposal at the Road and Construction Materials Facility site based on further testing will be taken to a Type II landfill with all disposal costs attributed to MMSD.

The alternative plans are compared in this Detailed Project Report using four formulation criteria suggested by the U.S. Water Resources Council: completeness, effectiveness, efficiency, and acceptability as herein defined.

Completeness

Completeness is a determination of whether or not the plan includes all elements necessary to achieve the objectives of the plan. It is an indication of the degree that the outputs of the plan are dependent upon the actions of others.

Effectiveness

Effectiveness is defined as a measure of the extent to which a plan achieves its objectives. Both of the plans provide some contribution to the planning objectives in that both would result in restoration of fish passage to the upstream habitat.

Efficiency

Efficiency is a measure of the cost effectiveness of the plan.

Acceptability

All of the plans must be in accordance with Federal law and policy. In addition, acceptance of the plan to the local sponsor and other stakeholders is important for implementation.

6.1 Alternative 1 – Concrete Removal and Replacement with Stone Riffles and Pools

Alternative 1 includes concrete removal and replacement with stone to restore aquatic habitat along approximately 2,400 LF of the Menomonee River within the City of Milwaukee, Milwaukee County, Wisconsin. The stone placement is designed to remain stationary during 100-year or 1% flood events and will be placed in a riffle and pool configuration to reduce flow velocity and provide resting pools. The riffles and pools will provide access to upstream spawning and nursery habitat for fish that live in the Milwaukee estuary and nearshore waters of Lake Michigan, particularly northern pike, walleye, smallmouth bass, several species of the sucker family and other forage fishes.

This alternative consists of 6 pools and 6 riffles. The riffles range from 40' to 65' with velocities from 1.69 fps to 2.98 fps. Within this design, four riffle/run segments of the project reach have velocities greater than 2 fps, the velocity of concern for passage of northern pike. However, for these riffle segments, the velocity at the edge of the channel is less than 2 ft/s and has over 1 foot depth of flow, therefore, they will still be able to pass fish. The pools range from 45' to 100' with velocities from 1.11 fps to 1.55 fps in spring. The boulders will be set in bedding gravel or crushed concrete unless final design plans reveal that the boulders should be set in concrete at a grade change or at a specific outfall. **Figure 5a** presents a typical riffle cross section and Figure 5b depicts the cross section of a typical pool.

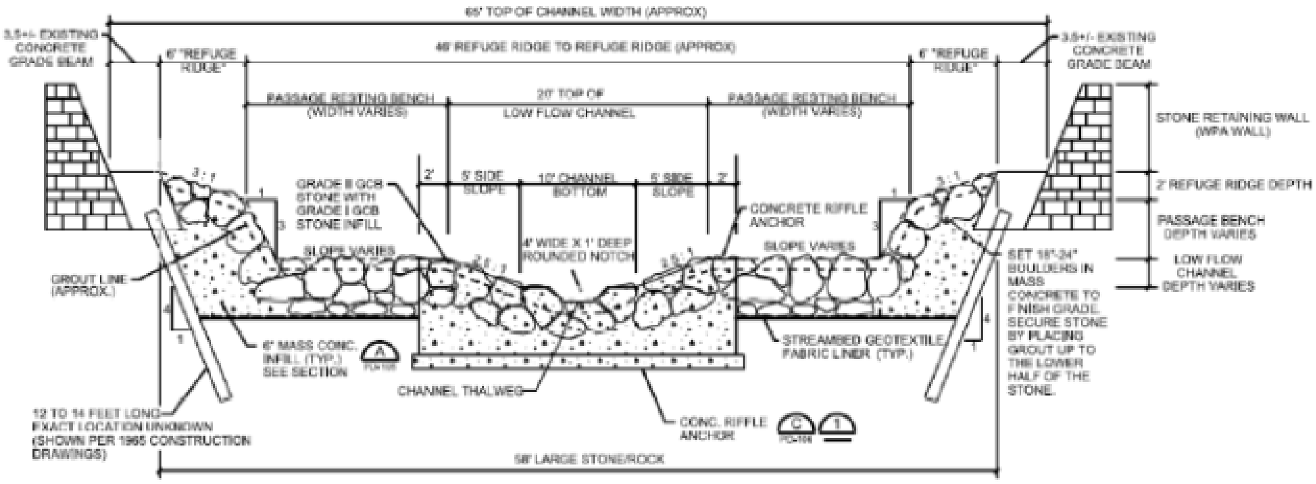


Figure 5a – Typical Riffle Cross Section

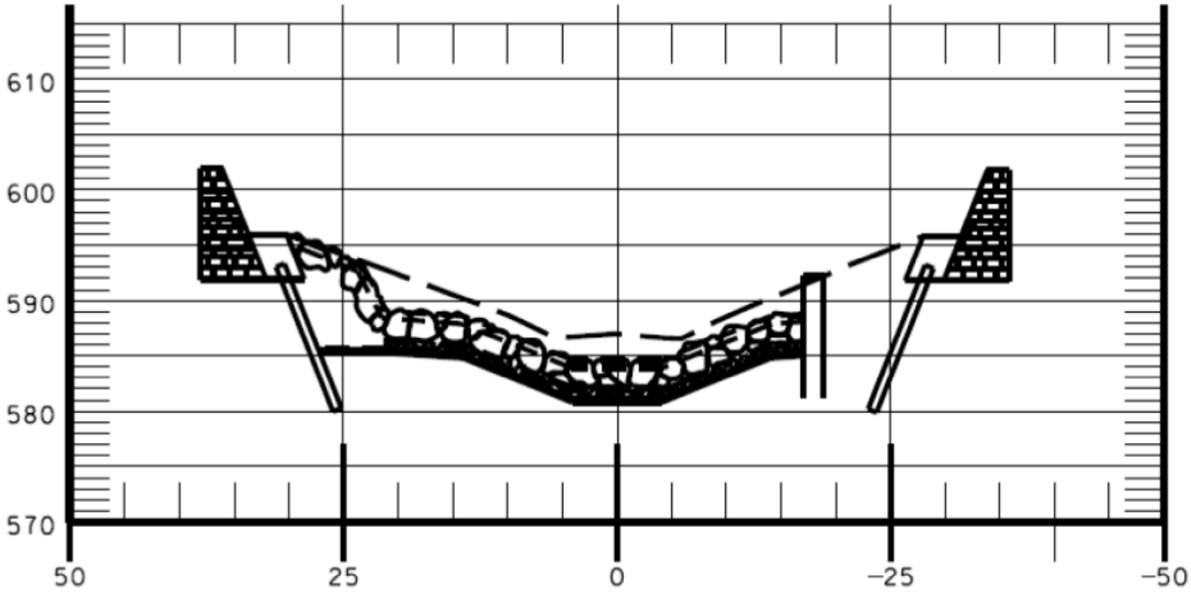


Figure 5b – Typical Pool

6.2 Alternative 2 – Concrete Removal and Replacement with Stone

Alternative 2 involves replacing the removed concrete channel lining with stone without creation of any riffle or pool complexes. Thus, Alternative 2 differs from Alternative 1 in that it does not involve the organization of the stone into designed riffle and pool complexes. Some of the stone would be sized to be mobile enough to allow the river to create its own riffle pool complexes instead of forcing to specific locations on the river. The rock lined channel includes three segments that exceed 2 fps; one at 430' with an average velocity of 2.87 fps, one at 807' with an average velocity of 2.54 fps, and one at 310' with an average velocity of 2.43 fps. All of these segments would restrict northern pike passage and greatly exceed the recommended length of passage at an average velocity of 2.65 fps. Also, the overall average channel velocity of 2.33 fps exceeds the sustained swim speed for northern pike passage as listed in the certified Upper Mississippi River (UMR) model. The mean velocity exceeds sustained swim speeds for the targeted fish species and is unacceptable for upstream connectivity for passage by northern pike and smallmouth bass.

Figure 6 provides a typical cross section for this alternative.

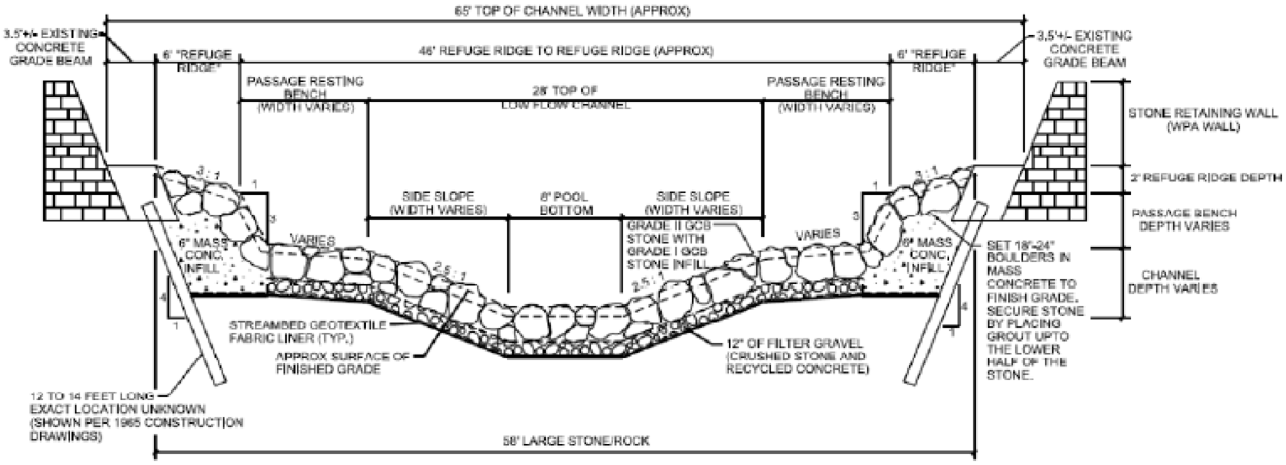


Figure 6 – Typical Cross Section, Alternative 2

6.3 Alternative 3 – No Action

The Corps is required to consider the option of “No Action” as one of the alternatives in order to comply with the requirements of the National Environmental Policy Act (NEPA). No action assumes that no project would be implemented to achieve the planned objectives. No action towards restoration of this habitat would allow the environment to remain in a degraded condition with only gradual improvement expected due to improved water quality, sediment quality, and other restoration efforts ongoing in Milwaukee and other affected areas. In addition, water velocity would remain higher than the sustained swim speed for northern pike, a targeted species in the area.

7.0 EVALUATION OF ALTERNATIVES

The *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (1983) directs Federal agencies to formulate plans that are economically and environmentally sound. Cost-Effectiveness and Incremental Cost Analyses (CE/ICA) are recommended for evaluating ecosystem restoration projects. Using a CE/ICA, the costs and non-monetary environmental outputs of each alternative are weighed against each other to identify the environmental restoration plan. This CE/ICA follows the procedures specified by the U.S. Army Corps of Engineers' *Ecosystem Restoration in the Civil Works Program* (EC 1105-2-210, 1995a) and the Institute for Water Resources (IWR) Report, *Evaluation of Environmental Investment Procedures Manual* (IWR Report #95-R-1, 1995b).

MMSD constructed the Milwaukee County Grounds Floodwater Management Facility (MCGFMF) to lower flood stages to allow for the construction of multiple restoration projects, including the project herein evaluated. The MMSD, FEMA, and the WDNR are aware of the water surface increases involved with the construction of this project and, although these increases result in levels lower than those prior to the construction of the MCGFMF, MMSD is working towards obtaining a CLOMR for this project. The base flows for MMSD's CLOMR were included in the hydraulic model for alternative 1, but is not included in the existing condition model (alternative 3). Miller-Coors is aware of the potential increase in the 100 year water surface elevation on their property and is not concerned, given that this elevation is below the pre-MCGFMF level. The increase in the wetlands area is contained and will not affect surrounding areas. The Valley Park Levee located adjacent to this project area, along the eastern edge of the river, protects the adjoining neighborhood from the 100 year storm event. The 100 year water surface elevations for Alternatives 1 and 2 meet the necessary freeboard requirements for this levee as determined by FEMA.

The 100 year water surface elevations for Alternatives 1 and 2 exceed the existing conditions water surface elevation (Alternative 3) in several areas. The Milwaukee County Grounds Floodwater Management Facility (MCGFMF) came online in 2011 and has reduced flood flows and water surface elevations in the project area below the FEMA base flood elevations (FEMA BFE) to allow the construction of environmental restoration projects, including the herein proposed project. The existing conditions model reflects these new (approved) flows and lower water surface elevation. The effective FEMA BFE is the same or even higher than the proposed WSEL from this project. See the Graef Final Design for the Menomonee River Stream Management (May 2011) for details.

The largest water surface increase over existing conditions (post MCGFMF construction) of 2.5 ft occurs at Section 4.049 which is located at the south end of the Miller-Coors property. Despite this water surface increase, the floodplain is still contained within the banks and the proposed floodplain delineation is nearly identical to the existing FEMA delineation (see Figure 13 in

H&H Appendix). The proposed floodplain delineation and increased inundation area occurs at the south end of the Coors property on their parking lot. Currently, the property owner experiences minor flooding and moves vehicles from the flood prone area prior to high water events. The flood prone portion of the parking lot is used as excess storage. Property damage has not been an issue in the past as the effective FEMA flood hazard inundation area is larger than both the existing and proposed conditions areas. The circled area between the red and green line in Figure 7 below shows this increased inundation area which measures approximately a third of an acre. The minor increased inundation area does not impact any structures and does not pose a threat to property. (In locations where the floodplain leaves its banks, there are slight increased inundation areas including the wetlands area upstream of Wisconsin Avenue.) See Figure 13 in the H&H Appendix B for further detail.

There is a slight change in the floodplain delineation upstream of the project limit. The proposed floodplain delineation upstream of the project area shows minor differences from the existing conditions. This is likely due to better topographic information, better mapping technology, and/or improved modeling.

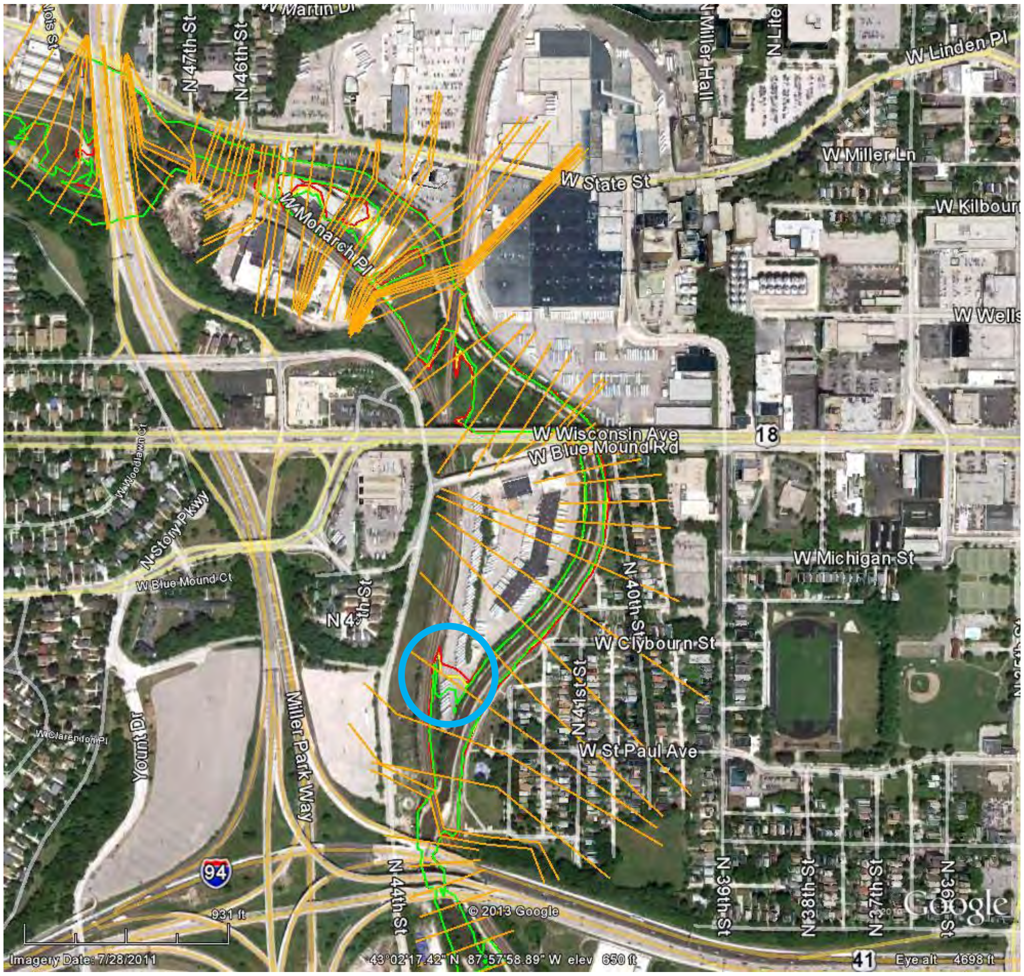


***Figure 7* - Floodplain Map 1 - where green line is Alternative 3 or existing conditions; yellow line is Alternative 2; red line is Alternative 1; and orange lines are existing conditions cross sections. See Appendix B.**

Table 3 of the H&H Appendix (**Appendix B**) contains a detailed summary of the flood increases and provides a larger version of Figure 7.

7.1 Environmental Outputs

The impacted habitat of the Menomonee River was assessed and the environmental outputs associated with each of the alternatives were determined. Both the current status of the Menomonee River and the results of implementing the alternatives were analyzed in terms of habitat connectivity, biodiversity, water quality, and significance. A detailed discussion of the habitat evaluation and the species HSI's are located within **Appendix E.**

7.2 Quantity, Quality and Connectivity

The total acreage for current alternatives is 158 acres (Quantity). Habitat quality was based on the critical components for reproduction using the U.S. Fish and Wildlife Service Habitat

Suitability Index (HSI’s) for selected fish species, northern pike, smallmouth bass, and walleye which are representative of fish species using these two different habitat types for spawning and reproduction. White sucker and common shiner were also reviewed and could be used in place of walleye.

The targeted fish species are smallmouth bass, walleye and northern pike, one of the poorest swimming warm water game fishes. While forage species such as common shiner and suckers would also benefit from the connectivity to upstream habitat, no HSI's were prepared for the forage fishes. Based on the Upper Mississippi River (UMR) model and Step 4 Connectivity from the UMR model, walleye and smallmouth bass can swim upstream during the spawning season under Alternative 1 (riffle pool) as the sustained swim speed of both of these fish exceeds the average velocity in the riffle and pool. Under Alternative 2, of the targeted fish species, only the walleye can swim upstream as the average velocity is greater than the sustained swim speed of the smallmouth bass and northern pike. In the UMR model, the northern pike has a sustained swim speed listed at 1.5 fps. The average stream velocity in the reconstructed riffle pool during springtime is over 1.89 fps. Figure 8 was adapted by others from a report and literature review by Ontario Ministry of Natural Resources (1988) and summarizes passage by free-swimming individuals over standard distance and velocities. The effect of temperature and length of the fish are not provided. The steeper sloping portion of the curve more closely approximates “burst” swimming abilities while the lag or flat side of the curve approximates the “prolonged” swimming abilities. From the Ontario summary, the sustained or “prolonged” swim speed of northern pike (Figure 8) is approximately 2 fps at a distance of 150 feet.

Alternative 1 was designed to allow for northern pike passage based on burst speed. Removal of the concrete lined channel and placement of stone to create riffles and pools will, allow northern pike passage based upon the computed spring flows and decreased flow velocities within the project reach. The Alternative 1 design consists of 6 pools and 6 riffles. The riffles range from 40' to 65' with velocities from 1.69 fps to 2.98 fps. Within this design, four riffle/run segments of the project reach have velocities greater than 2 fps, the velocity of concern for passage of northern pike. However for these riffle segments, the velocity at the edge of the channel is less than 2 fps and has over 1’ depth of flow, therefore the design will still provide for northern pike upstream passage. The pools range from 45' to 100' with velocities from 1.11 fps to 1.55 fps in spring. The average design velocity for Alternative 1 is 1.89 fps, with slower velocities on the riverbanks and river bed. The velocity near the bottom and the sides of the channel will be slower but for conservative computational purposes, 60% northern pike passage is being used in this analysis. Northern pike connectivity (passage) was conservatively estimated at 0.6 based on an assumed average 10% loss of passage at each of the four (4) riffles with velocity > than 2 fps using the Ontario summary, other data and professional judgment.

Alternative 2, rock lined channel, because it does not include any riffles or pools, required special consideration of flow velocity relative to fish passage. For Alternative 2, three segments exceed 2 fps; one at 430' with an average velocity of 2.87 fps, one at 807' with an average velocity of 2.54 fps, and one at 310' with an average velocity of 2.43 fps. All of these segments would restrict northern pike passage and greatly exceed the recommended length of passage at an average velocity of 2.65 fps for 150 feet. Also, the overall average channel velocity of 2.33 fps exceeds the sustained swim speed for northern pike and smallmouth bass as listed in the UMR model. The channel flow velocities within the project reach range from 1.21-3.22 fps for Alternative 2. Since the sustained swim speeds of both the northern pike and smallmouth bass are exceeded in the Alternative 2 armored channel design, professional judgment was used to rate connectivity for smallmouth bass at 0.4 and northern pike at 0.2 based on length of passage and velocity. The WDNR estimates the likelihood of northern pike successfully passing under Alternative 2 as very low, significantly lower than Alternative 1, because of the nature of the velocity in the armored channel and no resting pools. The 2,400 foot passage at the design velocity exceeds any published literature for successful passage. Of significant note is that the summer depths would limit adult fish usage because of lack of depth. During the summer low flow period, water depths in the rock lined channel would range from 1-4 feet and velocity of 1.0-1.5 fps. However, fish are not moving upstream to spawn during this period of lower flow velocity.

Habitat connectivity, or the ability of the selected fish species to swim upstream to access habitat, was based on the Upper Mississippi River (UMR) model for connectivity evaluation, Step 4. The model has been approved as a certified model for use within the Upper Mississippi River region. Certification of the UMR model for use in Great Lakes tributaries has been requested through USACE Headquarters. Since smallmouth bass and walleye can pass upstream under the Alternative 1 design, a value of 1 was entered into Table 2, Column 3 (Connectivity) for these two species which equates to successful fish passage.

Ecosystem output was calculated as the product of all the estimated values [Acres X Quality X Connectivity = HU Output]. The quality of the river habitat within the 18 mile river reach from Lepper Dam downstream to the proposed work site, which is three (3) miles upstream of the confluence with the Milwaukee River, was estimated on a scale of 0 to 1, with 1 being a habitat of the highest value.

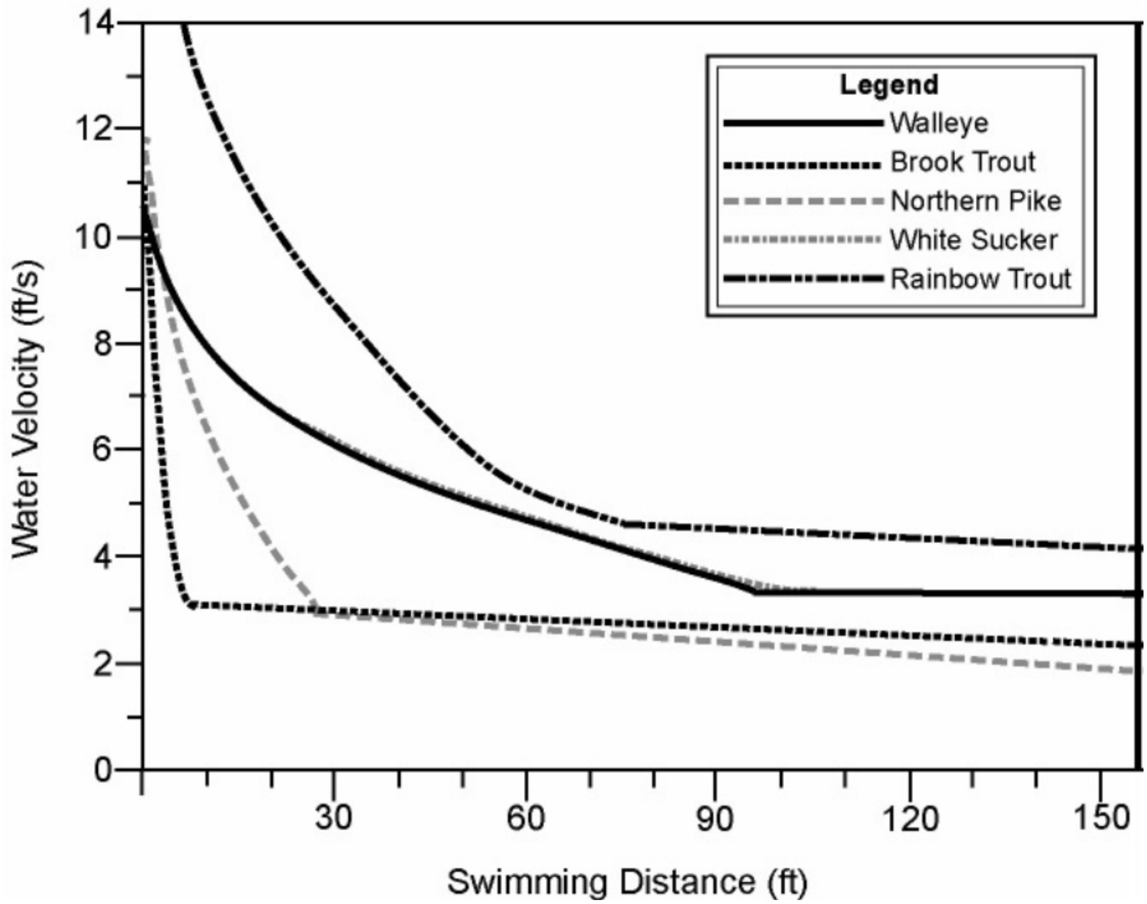


Figure 8 - Swim Speed and Distances, Ontario Ministry of Natural Resources, 1998

7.3 Habitat Units

Table 2 presents the total habitat units determined for each alternative.

Table 2 Notes:
** The quantities on which the subsection was evaluated; the sum of which equals the total quantity of spawning habitat being 30 acres of gravel in the upstream 18 river miles, 125 acres of emergent wetland for use by northern pike and 3 acres of rock riffle/pool (30 + 3 + 125 = 158).*
*** The likelihood fish are able to pass as determined by the Upper Mississippi River Certified Model for Connectivity.*

Table 2 - Menomonee River Habitat Units

	Quantity	Quality	Connectivity	Total Habitat Units		
Alternatives	**(acres)**	**(0-1)**	**(0-1)**		**HU's**	**AAHU**
Alternative 1 - - With-Project—Concrete Removal with Riffle/Pool Construction						
Upstream River Channel	100					
Gravel within 100 acres	30 *					
Smallmouth bass	30	1	1	30		
Walleye	30	1	1	30		
Mean value	30	1		30	30	30
Constructed River Channel Riffle Pool	3*					
Smallmouth bass	3	0.6	1	1.8		
Walleye	3	1	1	3		
Mean value				2.4	2.4	2.4
Riparian Emergent Wetlands for northern pike	125*	0.7	0.6**	52.5	52.5	52.5
TOTAL	158				85	85
Alternative 2 - With-Project —Concrete Removal with Rock Lined Channel						
Upstream River Channel	100					
Gravel within 100 acres	30*					
Smallmouth bass	30	1	0.4	12		
Walleye	30	1	1	30		
Mean value	30	1	0.7	21	21	21
Reconstructed Rock Channel	3*					
Smallmouth bass	3	0.6	0.4**	0.7		
Walleye	3	1	1	3		
Mean value				1.9	1.9	1.9
Riparian Emergent Wetlands for northern pike	125*	0.7	0.2**	17.5	17.5	17.5
TOTAL	158				40	40
Alternative 3 – No Action Alternative						
Upstream River Channel	100					
Gravel within 100 acres	30*					
Smallmouth bass	30	1	0	0		
Walleye	30	1	0	0		
Mean value		1	0	0	0	0
Concrete Lined Channel	3*					
Smallmouth bass	3	0	0	0		
Walleye	3	0	0	0		
Mean value				0		0
Riparian Emergent Wetlands for northern pike	125*	0.7	0	0		0
TOTAL	158			Net 0	0	0

7.4 Project Costs

Table 3 summarizes the preliminary project costs associated with each alternative. Preliminary costs were determined in FY13 and are presented here in FY13 dollars in table 3a and FY14 dollars in table 3b. Costs were updated to FY14 dollars using CWCCIS feature code 06- and FY14 interest rate of 3.5%. The selected alternative was determined, and is evaluated and presented using FY14 dollars. The construction cost estimates are included in Appendix C, Cost Appendix, pages 10 and 11. Feasibility Study costs are considered sunk costs associated with the development of the project to this point and is part of the non-construction costs in Table 3. O&M costs under Section 206 are 100% non-Federal responsibility. Monitoring costs under Section 206 are part of the total project cost and cost shared accordingly.

Table 3a - Preliminary Costs of Alternatives

2013 dollars, FY13 Interest Rate – 3.75%

Item	Alt 1	Alt 2
Construction Cost	Remove Concrete w/Riffle-Pool Construction	Remove Concrete with Rock Lined Channel
Mobilization & Demobilization	$7,300	$7,300
Demolition	$728,300	$728,300
Earthwork	$1,092,300	$750,000
Channel Construction	$2,075,200	$2,002,600
Control of Water	$366,900	$278,500
Access Rd & Parking Area	$39,000	$39,000
Liners, Membranes and Fabrics	$37,400	$37,400
Subtotal	$4,346,400	$3,843,100
Contingency	$651,960	$576,465
SUBTOTAL	$4,998,360	$4,419,565
IDC [1]	$47,104	$34,672
Construction Cost with IDC	**$5,045,464**	**$4,454,237**
Non Construction Costs [2]	**$530,248**	**$495,018**
Total Costs (less sunk)	**$5,575,712**	**$5,949,255**
Life Cycle O&M & Monitoring Costs	$10,227	$9,070
TOTAL PV OF PROJECT COSTS – FY13	**$5,585,939**	**$4,958,325**

Table 3b - Preliminary Costs of Alternatives

2014 dollars, FY14 Interest Rate – 3.5%

SUBTOTAL Construction Costs	$5,083,281	$4,494,652
IDC[3]	$43,949	$32,352
Construction Cost with IDC	**$5,127,230**	**$4,527,004**
Non Construction Costs	**$539,257**	**$503,428**
Total Costs (less sunk)	**$5,666,486**	**$5,030,432**
Life Cycle O&M & Monitoring Costs	$10,401	$9,224
TOTAL PV OF PROJECT COSTS – FY14	**$5,676,887**	**$5,039,656**

Notes for Table 3

[1] FY 13 dollars and 3.75% interest for 6 months construction for Alt 1 and 5 months for Alt 2

[2] Includes Contingency of 15% and excludes sunk feasibility costs

[3] FY14 dollars and 3.5% interest for 6 months construction for Alt 1 and 5 months for Alt 2

7.5 Cost Effectiveness (CE) and Incremental Cost Analysis (ICA)

The CE analysis begins with a comparison of the average costs of each alternative to identify the least-cost alternative for every level of environmental output considered. Alternative 1 has a lower average cost per habitat unit than Alternative 2 as shown in **Table 4.**

Table 4 - Cost Effectiveness Analysis

in 2014 Dollars

Alternative	**Present Value of All Project Costs**	**Total Output (HU)**	**Average Cost (HU)**
3	$0	0.0	-
2	$5,039,656	40.0	$126,000
1	$5,676,887	85.0	$67,000

After the CE analysis, an ICA is conducted to reveal and evaluate incremental changes in costs for increasing levels of environmental outputs. Although ICA does not provide a discrete decision criterion, it allows for the comparison of the changes in costs and HUs on which such decisions are made. Alternative 1 is compared to Alternative 2 in terms of incremental costs, outputs and incremental costs per habitat unit.

Table 5 presents the incremental cost analysis for the evaluated alternatives. Since the No Action Alternative entails making no changes, the incremental values are determined from that basis. Compared with the No Action Alternative, Alternative 2 would provide 40.0 more HUs for an additional cost of $5,039,656, an incremental cost of $126,000 per HU. Alternative 1 would provide an additional 45.0 HUs for an additional $637,231, thus, with an associated incremental cost of $14,000 per HU. Of the two alternatives, Alternative 1 is relatively more cost effective and provides the greatest number of HUs.

Table 5 - Incremental Cost Analysis
in 2014 Dollars

Alternative	Total Cost	Incremental Cost	Total Habitat Units	Incremental Output	Incremental Cost Per HU
3	$0	N/A	0.0	-	-
2	$5,039,656	$5,039,656	40.0	40.0	$126,000
1	$5,676,887	$637,231	85.0	45.0	$14,003

8.0 TRADE-OFF ANALYSIS

The two alternatives are similar in that each was developed to provide access to more than 80% of the main stem habitat in the Menomonee River through elimination of the concrete lining which is currently blocking fish passage from Lake Michigan. The primary trade-off between Alternatives 1 and 2 is that in Alternative 1 the concrete is replaced by a rock structure formed into riffles and pools. This riffle and pool structure slows the flow of water, allowing greater passage and provides shelter for habitat. The flows remain high enough in Alternative 2 to be obstructive to the passage of northern pike in particular (a target species) and does not provide shelter. The no action plan would not increase habitat, or fish diversity and density, in the Menomonee River.

9.0 SELECTION OF THE RECOMMENDED ALTERNATIVE

The rock lined channel alternative resulted in flows with velocities that did not provide for the upstream migration of targeted fish species. The riffle and pool design still had segments that are at the top end of velocity suitable for upstream movement of northern pike. This design did result in expansion of the floodplain but the project would not provide connectivity and low enough velocity for fish passage without the increasing the flood stage relative to existing conditions. The goal of restoration of an urban fishery for social justice was deemed to be of such importance that a minor flood stage increase would be mitigated through the acquisition of one flowage easement in a parking lot. Prior to construction of the MCGFMF, the parking lot was subject to greater flood elevations (100 year elevations as presented in Figure 9 in blue) than those indicated with this alternative (Figure 9 in red). The local sponsor, MMSD, is working directly with FEMA, as shown in the correspondence attachments to this report, for this flowage easement.

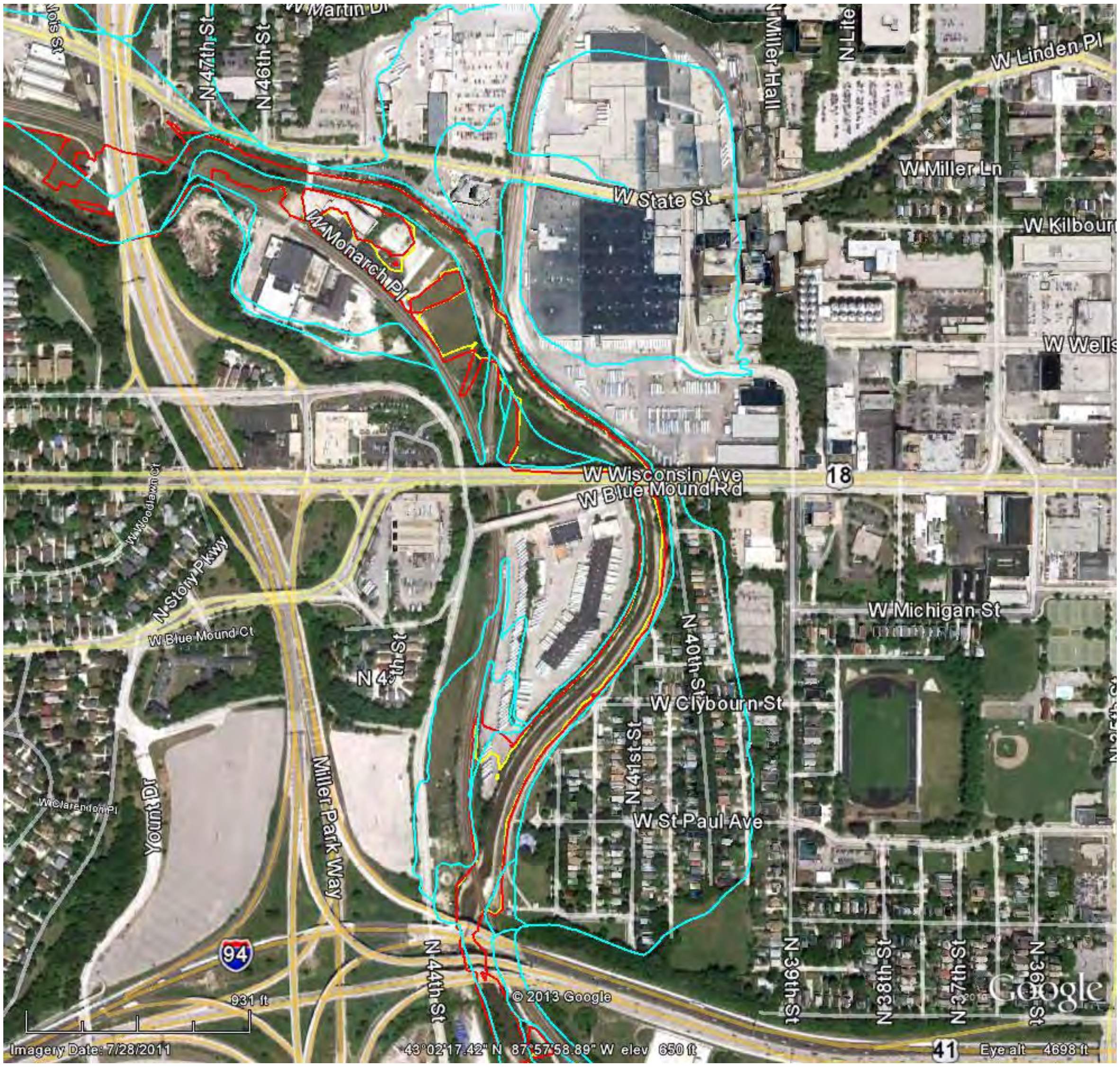


Figure 9 – Floodplain Map 2 - BLUE: FEMA Effective FIS; YELLOW: existing condition, after the construction of the MCGFMF; RED: Current Project

Both Alternative 1 and Alternative 3, the No Federal Action Alternative, are cost effective. Alternative 1 was selected as the recommended alternative because it meets all of the evaluation criteria by being complete, effective, efficient, and acceptable and offers the greatest benefits with a significantly lower cost per habitat unit. Alternative 1 meets the planning objectives of 1) providing connectivity to spawning areas, 2) providing habitat and improved water quality, and 3) providing a more natural river environment.

10.0 ENVIRONMENTAL REQUIREMENTS

National Environmental Policy Act (NEPA) of 1969 requires Federal agencies, including the USACE, to assess the potential environmental impacts of proposed Federal actions. An EA is typically prepared by the USACE to evaluate the effects of a proposed action on the environment. The EA was prepared by the Detroit District and its development was coordinated with appropriate local, State, and Federal agencies.

After the EA is circulated for public and agency review and comment, a determination will be made regarding the need for an Environmental Impact Statement (EIS). If the EA and the public review do not reveal significant adverse impacts on the quality of the natural and human environment, then a Finding of No Significant Impact (FONSI) could be signed and the project implemented. If the EA and public review reveal significant impacts on the quality of the human environment, then an EIS may be required.

This project is subject to the requirements of NEPA and the Clean Water Act. Additionally, the project has been evaluated pursuant to all appropriate statues, executive orders, and memoranda including: Fish and Wildlife Act of 1956; Fish and Wildlife Coordination Act of 1958; National Historic Preservation Act of 1966; Clean Air Act of 1970; Executive Order 11593, Protection and Enhancement of the Cultural Environment, May 1971; Endangered Species Act of 1973; Executive Order 11988, Flood Plain Management, May 1977; and Executive Order 11990, Wetland Protection, May 1977. Project alternatives will be coordinated with the appropriate Federal and State agencies for review under each of the appropriate statutes, executive orders, and memoranda.

Section 2039 of WRDA directs the Secretary of the Army to ensure that when conducting a feasibility study for a project under the USACE ecosystem restoration mission the recommended project include a monitoring plan to measure the success of the ecosystem restoration and to dictate the direction to which adaptive management, if needed, should proceed. Included as a separate appendix to this DPR is a detailed overview of the proposed monitoring and adaptive management plan that will be implemented after the project is completed, Appendix F. This monitoring plan includes a description of the monitoring activities to be carried out, the criteria for ecosystem restoration success, the estimated cost and duration of monitoring.

The Menomonee River Restoration project offers a sustainable solution to the restoration of warm water fishery in the Milwaukee River estuary and near shore waters of Lake Michigan. Environmental and economic data was analyzed to formulate the recommended alternative.

11.0 SUMMARY OF ENGINEERING

The Engineering Appendix (**Appendix A**) provides a narrative for the project design and evaluates the feasibility of implementing the ecosystem restoration project. The appendix includes the development of concrete removal and rock replacement assessments, a conceptual design for river restoration, and a feasibility level design that includes the plan, profile, and pattern of the Menomonee River through the project area. Design plans and detailed calculations regarding the excavation quantities are also included.

Past construction methods involved utilizing a pump to divert the river around the construction area to avoid potential flood impacts and allow for construction in the dry. In addition, all equipment will be removed from the project site during storm events. Further, construction of this project will refer to requirements stipulated in the Section 30 permit from the state of Wisconsin.

The proposed action is the replacement of 2,400 LF of concrete paving with riffles and pools constructed of rock. To implement the proposed project, approximately 15,000 square yards (SYD) of 8 inch thick concrete channel lining will be broken and removed to a recycling facility. Approximately 32,000 cubic yards (CYD) of sediments located on the concrete and up to 3 feet below the existing river bottom from beneath the concrete lined channel will be excavated and taken to a site permitted to accept this material. 2,800 CYD of filter gravel for bedding will be placed and 16,000 CYD of rock/stone will be placed to create a stone lined riffle and pool aquatic habitat. Disposal of materials and/or debris generated in the course of project construction will take place in accordance with applicable Federal, State of Wisconsin, and local laws. Sediment testing will occur before concrete removal. No sediments identified as hazardous material have been identified to date within the existing project limits. All excavated soil material will be recycled for mine land reclamation and taken to the MMSD identified Road and Construction Materials Facility located approximately 15 miles from the project site at 6401 S. Racine Avenue, New Berlin, Wisconsin. This disposal site is a disposal for fee site and is compliant with all Federal, State and Local permit requirements to accept this material. If the construction contractor can find an economically favorable alternative site(s) that is/are suitable for disposal of this material, then the contractor will be required to prove to the government that they have properly obtained all Local, State and Federal permits required for disposal at these alternative sites. Any materials determined to be unsuitable for upland disposal based on further sediment testing, will be taken to a Type II landfill with all disposal costs attributed to MMSD.

12.0 SUMMARY OF COST ANALYSIS

The Cost Analysis Appendix (**Appendix C**) presents the preliminary construction costs for both alternatives and the risk adjusted construction cost for the selected alternative, Alternative 1 – Concrete Removal with Riffles and Pools. The Total Project Cost Summary, pages 8 and 9 of

Appendix C, presents the fully funded, risk adjusted cost for the selected alternative as summarized here in **Tables 6 and 7**.

Table 6 – Final Costs	
2014 dollars, FY14 Interest Rate	
Remove Concrete w/Riffle Pool Construction	
Category	**Alt 1**
Feasibility Study	$275,000
Construction Cost	$5,438,000
LERRDs[1]	$138,000
Planning, Engineering and Design	$325,000
Construction Management	$64,000
Total Project Costs	$6,240,000
PV Monitoring and Adaptive Management[2]	$26,000
Operations & Maintenance	$10,000
Total Project Costs including Monitoring & O&M	$6,276,000

[1] Land, Easements, Right-of-Ways, Relocations and Disposal sites

[2] Present Value (PV) of monitoring & adaptive management costs calculated using 5 year expenditure schedule and FY14 interest rate of 3.5%

Costs were calculated using the FY14 federal discount rate of 3.5 percent and a 50-year period of analysis. All costs are in 2014 dollars. **Table 7** provides the cost apportionment for the selected alternative.

Table 7 - Cost Apportionment			
2014 dollars			
Remove Concrete w/Riffle Pool Construction			
Category	**Federal**	**Non-Federal**	**Total Cost**
Feasibility Study [1]	$187,500	$87,500	$275,000
Planning, Engineering and Design	$211,250	$113,750	$325,000
Construction Cost	$3,534,700	$1,903,300	$5,438,000
Construction Management	$41,600	$22,400	$64,000
Subtotal	$3,787,550	$2,039,450	$5,827,000
LERRDs [2]			$138,000
Total First Costs			**$6,240,000**
Operation & Maintenance		$10,000	$10,000
Monitoring and Adaptive Management	$21,450	$11,550	$33,000

[1] Cost shared 50/50 after the first $100,000.

[2] Land, Easements, Right-of-Ways, Relocations and Disposal sites, including tipping fees, to be credited toward non-Federal share.

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13.0 REAL ESTATE SUMMARY

A detailed report of the real estate plan can be found in the Real Estate Plan Appendix (**Appendix E,)**.

The total land required for the project is approximately 8.35 acres consisting of 4.5 acres of fee ownership that will include the modified river and 3.85 acres of temporary easement for work & storage as well as access to public roads.

The Local Sponsor, Milwaukee Metropolitan Sewerage District (MMSD), will provide all land, easements and rights-of-way, relocations and disposal sites necessary for the construction, operation and maintenance of the project. The Project area is shown in Exhibit B of Appendix E and it is noted that the northern access point is just north of State Highway 18.

A channel improvement easement over the permanent project lands as well as two temporary work and storage areas are required for this project. It is expected that the easements will be easily granted.

MMSD has identified the Road and Construction Materials Facility located at 6401 S. Racine Avenue, New Berlin, Wisconsin as their primary disposal site for any excavated soils that cannot be reused during construction. This site is a disposal for fee site and is compliant with all Federal, State and Local permit requirements to accept this material. All tipping fees at this site will be viewed as a LERR credit towards MMSD's cost share. Prior to construction MMSD will obtain a temporary work easement for disposal at this site. Any materials determined to be unsuitable for disposal at the New Berlin site based on further sediment testing, will be taken to a Type II landfill with all disposal costs attributed to MMSD. If the construction contractor can find an economically favorable alternative site(s) that is/are suitable for disposal of this material, then the contractor will be required to prove to the government that they have properly obtained all Local, State and Federal permits required for disposal at these alternative sites.

As part of the study, the government has screened several sites, including the proposed commercial facility in Racine identified by the Sponsor, and after evaluation of the potential costs, including transportation, permitting, and land, and public and environmental factors, has determined that the Racine commercial site is the most cost effective and reliable option readily available for the disposal of the clean sediment materials. The concrete removed from the site, will be taken to one of several available recycling facilities, location to be determined.

The Corps and MMSD have yet to identify any infrastructure or features that would require relocation on this project and relocations are not anticipated in the future.

14.0 CONCLUSION AND PATH AHEAD

One of Wisconsin's greatest assets is its abundant supply of fresh water and the associated resources. Wisconsin's inland lakes and streams as well as the Great Lakes have experienced the effects of development over the past two centuries. This project will help to restore the natural ecosystem on the Menomonee River. The recommended alternative will connect restored areas to allow full utilization of the river's resources. The USACE has coordinated work on this project with the non-Federal partner (the Milwaukee Metropolitan Sewerage District), U.S. Fish and Wildlife Service, SHPO, and the Wisconsin Department of Natural Resources. The non-Federal partner and the above-mentioned agencies support the preferred alternative.

The NFS signed a Feasibility Cost Share Agreement on 31 Oct 13 to cost share the remaining elements in the DPR at 50/50% Federal to Non Federal costs.

Upon the approval of this DPR, the non-federal sponsor will sign a Project Partnership Agreement (PPA) that commits them to 35% of the total project costs. The NFS must supply all LERRDs, and assume all operation and maintenance expenses associated with this project.

The proposed implementation schedule is as follows:

Table 8 - Implementation Schedule

ACTIVITY	DATE
Sign the Project Partnership Agreement	July 2014
Ready to Advertise	July 2014
Contract Award	September 2014
Notice to Proceed	October 2014
Construction Complete	November 2015

15.0 RECOMMENDATION

I, Lieutenant Colonel Robert J. Ells, Detroit District Commander, have given consideration to all significant aspects in the overall public interest for this project. Those aspects considered include environmental, social, and economic effects; engineering feasibility; and any other elements bearing on this recommendation.

I recommend **Alternative 1 – Concrete Removal with Riffles and Pools** be authorized for implementation as a Federal project, with such modifications thereof as in the discretion of the Commander, USACE may be advisable. Based on 2014 price levels, the estimated project first cost is $5,991,000 which includes a total present value of $6,240,000, and the present value of monitoring and adaptive management costs of $26,000 and excludes the sunk study costs of $275,000. In accordance with the cost share provisions in Section 103(c) of the Water Resources Development Act of 1986, as amended (33 U.S.C. 2213(c)), the Federal share of the project first cost is estimated to be $3,894,000 and the non-Federal share is estimated to be $2,097,000 based on the 65 percent Federal and 35 percent non-Federal cost share provision. The non-Federal costs include the value of lands, easements, rights-of-way, relocations of $138,000.

Table 9 - Project Costs for the Recommended Plan, FY14

Federal Cost	Non-Federal Cost	Total Project Cost
$3,894,000	$2,097,000	$5,991,000

Note: Costs rounded to the nearest thousand. $6,240,000 + $26,000 = $6,266,000 minus sunk costs of $275,000 = $5,991,000

I understand that the non-Federal partner for this project, the Milwaukee Metropolitan Sewerage District, Milwaukee, Wisconsin, shall, prior to implementation, agree to provide the required items of cooperation. This includes providing all lands, easements, rights-of-way, relocations of utilities or interfering infrastructure, and providing disposal areas for excavated material. I also understand that the non-Federal partner agrees to hold the United States and its contractors free of damages and liability as outlined in the Project Partnership Agreement between the Corps and the Milwaukee Metropolitan Sewerage District, to be signed prior to construction.

Robert J. Ells
Lieutenant Colonel, U.S. Army
District Engineer

Menomonee River Restoration, CAP 206

Menomonee, WI

Appendix A

ENGINEERING

Engineering Appendix Components
Menomonee River Restoration, CAP 206
Menomonee, WI

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1. Purpose and Scope

The feasibility study evaluates the potential for Federal interest in existing watershed problems associated with ecosystem and environmental restoration in the Menomonee River. The engineering appendix supports the feasibility study investigations and provides engineering evaluations of implementing an ecosystem restoration project on the Menomonee River, Milwaukee, WI, under Section 206 of the Water Resources Development Act of 1986, as amended.

The scope for this project includes engineering services to develop a feasibility level design that contains a plan and profile of the Menomonee River with several alternatives. The goals of this project are to:

- Remove approximately 2,400-feet of concrete lined channel
- Provide fish passage and resting areas during low-flows and fish refuge zones during higher flows
- Maintain or decrease the water surface elevations

The ecosystem restoration and water surface elevation goals on the Menomonee River can be found in the Environmental and Hydraulic & Hydrology Appendices.

2. Project Background and Study Site Description

The lower Menomonee River currently has a concrete lined channel in the reach between I-94 (approximately river mile 3.65) and just upstream of the Canadian Pacific Railroad Bridge (approximately river mile 4.259). The channel is trapezoidal in shape and is lined with limestone floodwalls, which were constructed by the Works Progress Administration (WPA) is the 1930s. While the system currently serves its functions of conveying flood flows and reducing flow water surface elevations, the concrete is deteriorating as it approaches the end of its design life and high flow velocities and shallow flow depths impede fish migration between Lake Michigan and the upper portions of the watershed.

The Milwaukee Metropolitan Sewerage District (MMSD) has constructed and/or planned multiple projects within this stretch of river to address the issue. In 2000, MMSD rehabilitated part of the Menomonee River with the Drop Structure Removal Project by removing a low-head dam and the concrete lining within the channel. Expected to break ground in 2013, MMSD has planned the removal of the middle segment of the concrete channel.

In a partnership agreement, MMSD has requested the USACE provide engineering assistance in a cost sharing agreement for the lower section of the Menomonee River. The area of focus lies on the downstream portion of the concrete lined channel between the West Bluemound Railroad Bridge and I-94. This reach of the Menomonee River is approximately 2,400-feet and will be the last of the concrete lined channel removed. Concrete removal efforts will need to be coordinated with the upstream project.

3. Past Studies

The project builds upon the Menomonee River Watershed rehabilitation and flood risk reduction projects described below.

3.1 Drop Structure Removal (2001)

MMSD removed a 4-foot drop structure near the North 43rd Street and the Menomonee River and replaced approximately 1,500-feet of concrete channel with rock to imitate a more natural riverbed. This was the first major project on the Lower Menomonee River to improve fish passage and reduce flood levels.

3.2 Valley Park Floodwall Project (2001)

The Valley Park Floodwall was constructed in 2001 to protect the Valley Park neighborhood, near the focus of this study, after two major flooding events in 1997 and 1998. The floodwall was designed with FEMA required freeboard for levee certification. Therefore, the design cannot change the area’s water surface elevations for a 100-year event.

3.3 Milwaukee County Grounds Floodwater Management Facility (2011)

The Floodwater Management Facility was a major flood management project that is capable of diverting up to 4,000-cfs during the 100-year event from Underwood Creek, an upstream tributary of the Menomonee River, into a large detention basin. The project reduced current regulatory flood flows in the Valley Park from 16,600-cfs to 15,000-cfs and a 1.1-foot drop for the 100-year flood event.

3.4 Menomonee River Stream Management Project (Planned 2013)

MMSD has planned to remove approximately 1,100 feet of concrete lined channel in the Menomonee River and place it with a more natural rock bottom. The intent is to provide for fish passage and resting areas as well as reduce the water surface elevations during a 100-year event. The reach stretches from the Canadian Pacific Railroad Bridge (river mile 4.256, a.k.a. the “middle” railroad bridge) to the downstream of the West Bluemound Road Bridge (river mile 4.057), which is also the upper limit of the study focus.

4. Existing Data

4.1 Topography and Survey Data

MMSD provided Menomonee River survey data to USACE on 20NOV12. The survey was collected in November 2012 and includes the Upper Canadian Pacific Railroad Bridge all the way down to the downstream limit of this project. The data provided is more detailed upstream of our project, limiting this projects survey information to the WPA walls and river channel. Detailed topographical maps dated May 2010 were also available for the entire project area. However, the maps did not have accurate elevation data and only provided flat topographical lines. Using both the topographical maps and the survey data USACE was able to create cross-sections and complete all required analysis. The plan view with stationing developed for the site is located in Attachment 1. The vertical datum control for all survey and topographical information was set to National Geodetic Vertical Datum of 1929 (NGVD29). The horizontal datum control was set to the North American Datum of 1927 (NAD27).

4.2 Boring Logs and Lab Data

MMSD kept a good record of historical borings and lab data within the project area and provided them to the USACE. The drilling dates on the borings range from 1953 to 2001 and were collected by a wide range of Contractors. MMSD's historical borings for this project are provided in Attachment 2. Please note that the boring locations shown on the provided location map are not completely accurate and should be checked utilizing the coordinates provided on the boring logs prior to making location assumptions.

Design soil parameters were based on the geotechnical investigation completed by K. Singh & Associates in 2000. The assumed soil parameters shown in Attachment 3 were determined using the available lab data for cohesive soils and blow count correlations for non-cohesive soils. Strategically located soil borings shall be collected during the next project phase to ensure accuracy of the design. The lab data shall provide sufficient information to analyze slope stability, bearing capacity and wall stability.

The following descriptions provide a generalized depiction of the overall soil conditions existing within this project area based off the historical soil borings. The soil borings should be referenced for a more specific and detailed description of an areas soil characteristics. All soil boring elevations are provided in the MMSD Datum (0 MMSD = 580.78 NAVD 1988).

Concrete Channel Section

In conjunction with local partners, the USACE developed a contract with Altech Environmental Services, Inc. in 2001 that collected fourteen borings (Boring No's. MENO106-MENO122) within this project's paved concrete river channel utilizing a 4 and 6 inch diamond drill. The purpose of the contract was "to physically and chemically characterize the sediment underlying the concrete riverbed in order to determine removed material placement options and to evaluate the chemistry of the newly exposed river bottom". A second purpose was to determine the compressive strength of the concrete to provide information related to the concrete removal operations. The thickness of the concrete channel ranged from 6 to 10 inches and steel rebar was present at all boring locations. The compressive strength of the concrete ranged from 5,830-6,340 psi. The soils sampled beneath the concrete liner tended to be more fine grained north of Boring Number MENO110 with more silts than sands. The soils further south tended to be more granular in nature with more sand than silts and clay. The report states that gravel and cobbles were discovered at all locations within the project limits. (Sampling and Analysis 2001)

Outside WPA Walls

The general stratigraphy of the river channel's surrounding soils on the east side of the river remained rather consistent throughout all of the borings collected by K. Singh & Associates, Inc. in 2000. These borings were collected in 1999 during the design of the Valley Park Floodwall project and were drilled along the footprint of the floodwall on the eastside of the river. The first 6-18 ft (Ground Surface Elev. Ranging from +602.13 to +605.78 NAVD 1988) of soil encountered tended to be fill material consisting of poorly grade sand (SP) with gravel and silt. The second layer of soil varied between approximately 5 ft of well graded gravel (GW), 3-12 ft of silty clay, or 8-14 ft of silty sand (SM). The final layer of soil usually consisted of poorly graded sand (SP) extending down to approximately 32-36 ft, in depth. Most borings collected by K. Singh & Associates, Inc. terminated prior to bedrock at approximately 30 ft, in depth. Therefore, the bottom layer of soil for analysis purpose was assumed to extend an additional 2-6 ft down to an assumed bedrock depth of +570.48 NAVD 1988. Based on the results of other historical borings located in the vicinity the depth of bedrock varies between +558.68 and +577.18 NAVD 1988. Water was encountered at approximately +587.28 NAVD 1988.

4.3 Utilities

Wisconsin's Diggers Hotline was able to locate a couple utilities within the limits of the project area. A forcemain sewer siphon structure with an approximate top of structure elevation of 581.0 ft NAVD 1988 was located near station 23+00. The lowest top of concrete apron elevation at station 23+00 was determined to be approximately 584.8 ft NAVD 1988 providing a minimum clearance of approximately 3.8 ft. Extreme caution shall be taken when excavating and traversing with construction equipment above the siphon structure. The design shall provide scour protection near the siphon structure. As-built plans were obtained for the siphon structure and are provided in Attachment 4. Secondly, an inline storage system that provides additional water storage during wet weather events was located at the very downstream limit of the project. The structure is essentially a deep tunnel structure that is located approximately 300 ft below the ground surface. Therefore, this structure will not likely interfere with this project. An aerial map that displays the locations of these two structures was included in Attachment 4.

The Feasibility Report drafted in February of 2004 for this project indicated that an electrical line encased in 3 ft – 4 in diameter conduit piping is located approximately 3 ft below the top of concrete apron at the centerline of the channel. The electrical line is believed to run along St. Paul Street and cross the river at approximately station 15+00. Diggers Hotline was unable to confirm the existence of this electrical conduit without field verification. Extreme caution shall be taken when excavating and traversing with construction equipment above the conduit. The design shall provide scour protection near the conduit.

5. Development of Design

Due to past and current projects on the Menomonee River, MMSD has requested that the design be congruent with upstream designs in order to have seamless transitions between reaches. This section of the report provides documentation of design choices related to all three feasibility level alternatives.

5.1 Stone Sizing

Rock sizes for the channel were calculated using the flows and velocities developed from the HEC-RAS model for a 100-year flood event.

For D_{50}, the results varied from 1.44-ft to 2.85-ft with a median of 2.05-ft for the three calculations (see Attachment 5 for rock sizing results). The United States Geological Survey (USGS) method provided the largest D_{50} value of 2.85 ft. The National Engineering Handbook indicates that the USGS stone sizing method is overly conservative. When researching the upstream projects, a D_{50} of 2.5-ft was used. It appears that the upstream channel experiences a higher shear stress than our reach due to the increased slope upstream. It is also important to note that the rock upstream has remained stable over the past decade, and when combined with our calculations it appears that a D_{50} of 2.5-ft is still appropriate. Therefore, the stone gradation that was specified for the upstream project's Grade II grade control base (shown in Table 1) shall also be used for this project.

Size	**Appox. Stone Weight (lbs)**	**Percent Smaller (by weight)**
48"	925	100
42"	850	90
30"	600	50
24"	475	25
18"	360	15
12"	125	10

Table 1: Grade II GCB Stone Gradation

5.2 Sediment Excavation and Disposal

An Environmental Site Assessment was conducted which no revealed no CERCLA sites in the project vicinity. In addition, sediment sampling and analysis was conducted. No HTRW regulated waste materials were detected underneath the concrete located within the proposed project area. The soil under the concrete is suitable for upland placement. It is anticipated that the excavated material would be taken to the Road and Construction Materials Facility located approximately 15 miles from the project site at 6401 South Racine Avenue, New Berlin, Wisconsin. This disposal site is a disposal for fee site and is compliant with all Federal, State and Local permit requirements to accept this material. Additional sediment sampling will be conducted during the construction phase to confirm the classification of the soils on site. If any soils contain HTRW regulated material, the soil will be disposed of at a type II landfill (such as the Waste Management Facility located at 2101 W. Morgan Avenue, Milwaukee, Wisconsin) with the 100% of the cost of soil removal and disposal attributed to the non-Federal sponsor.

5.3 Slope Stability

The limestone WPA floodwalls constructed in the 1930's extend approximately 4.5 to 11 feet from the top of the concrete lined channel. A 3.5 ft wide by 4 ft deep continuous concrete grade beam was constructed on the interior side of the WPA wall in 1965 to allow for excavation of the channel during the 1965 MMSD project that lowered the river bottom and installed the concrete channel lining. The concrete grade beam has 10 inch battered H-piles embedded into it that extend 14 feet into the soil at a spacing of 5 ft. Due to the unknown condition of the submerged H-piles, they were conservatively neglected for the analyses of the slope stability. Most areas on this project have soil sloping upwards behind the WPA walls causing an unrestrained slope. A deep-seated slope stability analysis was required for this project because material in front of the concrete grade beam will be removed during construction and replaced with riprap. Deep-seated slope instability or global instability consists of a large volume of soil shearing and rotating along a failure surface generally conforming to a circular arc. Near surface stability issues are not likely to occur because the constructed channel slopes are relatively flat and are stabilized with large rip-rap. In addition, during construction the soil behind the WPA walls will not be disturbed.

The deep-seated stability analysis was completed on this project using SLOPE/W Version 7.7 software developed by GEO-SLOPE International Ltd. The analysis was completed for both “during construction” and “post-construction” conditions. The locations selected for analysis were worst-case scenario for stability based off the soil borings, water table and cross-sections created from the survey. The soil profiles were developed utilizing the nearest boring(s). The closest borings with lab data appropriate for slope stability analysis were located approximately 50 to 450 ft away from the station centerline for the cross section being analyzed. The excessive distance between the boring locations and the cross sections being analyzed caused a potential for erroneous soil parameter assumptions. For the Feasibility Stage analysis, it was assumed that similar soil characteristics will exist at the locations being analyzed. It is recommended that soil borings be collected during the Design & Implementation Phase.

Rapid drawdown conditions were assumed to have a minimal effect on the results of the slope stability analysis because the clay layers are primarily located beneath the piezometric line. The soils above the piezometric line that are susceptible to rapid drawdown consist primarily of free draining, sands. Therefore, effective stress parameters were utilized for this analysis.

Factors of safety for slope stability analysis are governed by the uncertainty involved in the parameters such as shear strength and pore water pressures that affect the calculated value of factor of safety and the consequence of failure. The analysis incorporated several conservative measures including modeling the retaining wall as stone without a concrete or grout binder, neglecting the embedded h-piles, and modeling the highest walls and steepest slope locations. On the other hand, there is uncertainty about the accuracy of the soil profile and properties that were utilized in the analysis due to the distance between the boring location and cross section being analyzed. EM1110-2-1902 recommends that a minimum factor of safety of 1.3 be used for end-of-construction conditions (including staged construction). For the purpose of this analysis, a minimum factor of safety of 1.3 and 1.5 was used for during construction and post-construction activities, respectfully. A lower minimum factor of safety was utilized for during construction activities because of the limited exposure time.

The stability at the right bank (looking downstream) at Station 2+00 was the first to be analyzed. The soil behind the WPA is the steepest in this area and the WPA wall stickup height is near the highest. The WPA wall height in this area is approximately 8.5 feet above the top of the concrete grade beam. The slope behind the WPA wall is approximately 2.25H:1V for 41 ft horizontally and then flattens out. The slope is densely populated with large diameter trees. A fence and asphalt parking lot with frequent tractor-trailer loadings are located at the top of the slope. A warehouse structure is located within 40 feet from the top of the slope. Due to the rather steep slope behind the WPA wall, the cross section was first analyzed assuming that only the concrete apron from the channel was to be removed and that no surcharging from the asphalt parking lot, tractor-trailers, trees or warehouse was present. This cross section did not satisfy required factor of safety during and after construction. Therefore, precautions had to be taken to ensure slope stability issues would not occur in this area. The Value Engineering (VE) team was made aware of this issue on 07JAN13 so that they could work to find a solution. The solution that was developed was a permanent solution to stabilize the slope by driving steel sheet pile (SSP) at the joint located halfway up the concrete apron slope, as shown in Figure 1. The proposed solution from the VE team will not be implemented unless the soil information collected during the Design & Implementation Phase indicates that permanent slope stability measures will be required.

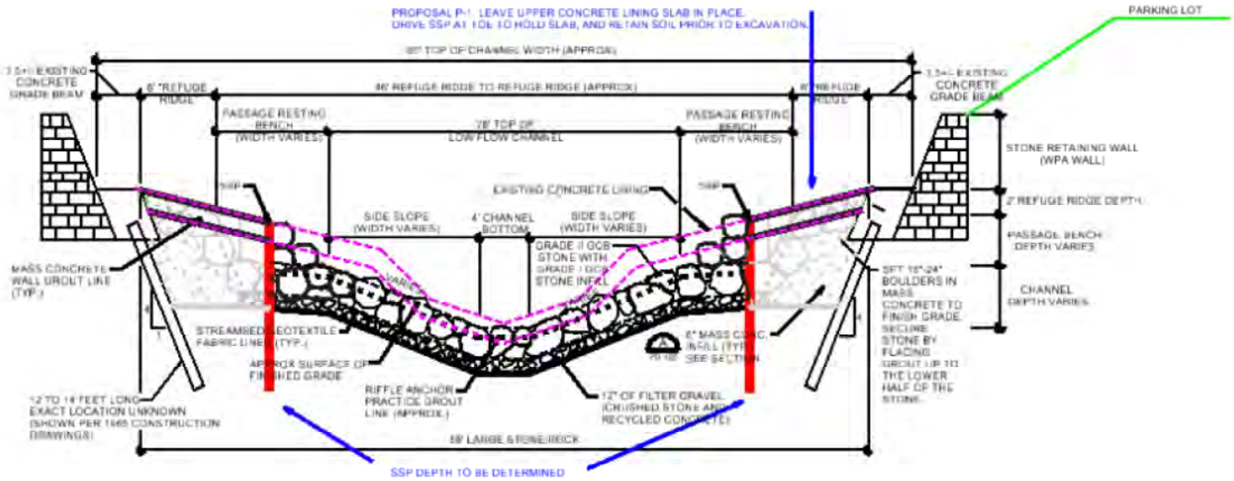


Figure 1: VE Proposal to Stabilize Slope Behind WPA Wall

A summary of the slope stability analysis at various stationing can be found in Table 2. For more detailed information on the stability analysis, see Attachment 6.

Station	Min Req'd F.O.S.	Actual F.O.S.
0+50 LS (During Construction)	1.3	1.360
0+50 LS (Post Construction)	1.5	1.717
2+00 LS (During Construction)	1.3	1.414
2+00 LS (Post Construction)	1.5	1.977
2+00 RS (During Construction)	1.3	**1.180**
2+00 RS (Post Construction)	1.5	**1.477**
8+00 RS (During Construction)	1.3	**1.069**
8+00 RS (Post Construction)	1.5	**1.350**
11+00 RS(During Construction)	1.3	**0.952**
11+00 RS(Post Construction)	1.5	1.516
12+00 RS(During Construction)	1.3	**0.811**
12+00 RS(Post Construction)	1.5	1.612
15+00 RS(During Construction)	1.3	**0.628**
15+00 RS(Post Construction)	1.5	**0.998**

Table 2: Slope Stability Analysis Results

The results of the slope stability analysis indicate that stabilization of the slope during construction will likely be required on the right side (looking downstream) from station 0+00 to 16+00. Extreme caution should be taken to avoid damage to the electrical conduit near station 15+00. Upon installation of the rip-rap, the analysis indicates that the factors of safety will not exceed the post construction factor of safety requirement of 1.5 at stations 2+00 on the right side (looking downstream), 8+00 on the right side (looking downstream), and 15+00 on the right side (looking downstream). However, a very conservative approach was taken by neglecting the support provided by the h-piles and the difference between the calculated and required factor of safety at station 2+00 on the right side (looking downstream) is considered negligible. Therefore, the temporary shoring can be removed upon installation of the riprap given the assumed soil parameters are accurate. The method and means of installation of the temporary shoring will be the responsibility of the Contractor. The Contractor shall not modify the WPA wall during installation of the temporary shoring. Permanent support of the slope shall be provided at station 15+00 on the right side (looking downstream)due to weak soils in the area.

If the actual excavation line will differ from what was assumed, this analysis shall be recomputed to ensure adequacy.   For example, this analysis assumed that no concrete infill would be required at the toe of the concrete grade beam. If the concrete infill was deemed necessary, the excavation line would be lowered which would reduce the factor of safety and potentially cause failure.

5.4 Bearing Capacity

Based on subsurface conditions encountered in the borings within the proposed channel excavation limits as well as expected soil conditions for the area, the net allowable bearing stress of 3,250 psf is used for the design of the channel (see Attachment 7 for calculations). The recommended maximum net allowable bearing stress incorporates a safety factor of 3.0. To verify the existence of suitable subsurface conditions, materials should be observed and tested. All foundation subsoil should be undisturbed native soils, which should exhibit a minimum unconfined compressive strength of 800 psf.

Due to the amount of assumptions being made for the soil parameters and profile, it is recommended that borings be strategically obtained during the Design & Implementation Phase for this project. All bearing capacity calculations shall then be updated to ensure adequacy.

5.5 SSP Wall Analysis

In areas where instability was believed to occur, the slope and WPA wall will likely have to be stabilized by installing either a temporary or permanent SSP wall, as shown in Figure 1. An analysis of the required embedment depth of the SSP was necessary because of the unequal loadings placed on each side of the wall. The support being provided by the WPA wall and embedded h-piles was conservatively neglected for the analyses due to its unknown condition. The SSP was assumed to be positioned at the joint in the concrete apron located halfway up the slope. The analysis was completed by utilizing a computer program called CWALSHT. The right side (looking downstream) of Station 8+00 was the governing cross section. Boring VP-B5 was utilized to develop the soil profile because it was the nearest available boring log. The required embedment depth at Station 8+00 was computed to be approximately 23.78 feet for a wall bottom elevation of 559.72 ft NAVD 1988. Historical borings indicate that top of bedrock elevations vary between 558.7 and 577.2 ft NAVD 1988. There is the potential that bedrock will prohibit the SSP from being driven down to the required embedment depth, in this area.

This design approach is considered conservative because the WPA wall and h-piles are currently supporting the loading from the slope in its existing state. If the soil and concrete between the WPA and SSP wall remain undisturbed the only loading requiring support will be the soil and concrete between the WPA and SSP wall. Therefore, as long as the embedment depth of the SSP wall exceeds 5 feet and the WPA wall and h-piles are adequately supporting the slope, the structure should remain stable.

Station	Req'd Embedment Depth (FT)	Elevation (FT NAVD 1988)
0+50 LS	2.94	582.06
2+00 LS	2.91	582.09
2+00 RS	2.91	582.09
8+00 RS	23.78	559.72
11+00 RS	9.69	573.81
12+00 RS	9.06	574.04
15+00 RS	12.40	570.70

Table 3: SSP Wall Analysis Results

All embedment depth computations shall be recomputed upon receipt of any additional soil information to ensure adequacy. The output files from the CWALSHT analysis can be found in Attachment 8.

5.6 WPA Wall Stability

The WPA walls that were constructed in the 1930's are considered an earth retaining structure. The wall was designed to provide permanent lateral support to a near vertical slope of soil. The structure is considered "historical" and its degraded condition is a clear indication of the structures age. As mentioned previously, the structure was modified in 1965 with the addition of a concrete grade beam with embedded h-piles to provide support during the construction of the concrete apron. To ensure stability, both overturning and sliding of the structure were analyzed for during construction conditions on this project. The embedded h-piles were conservatively neglected for this analyses and will only provide additional support with regard to wall stability.

The sliding analysis factor of safety at station 2+00 was slightly below the required value of 1.5. This area was critical with respect to wall stability because the wall height is highest and the soil sloped behind the wall is steepest. Additionally, the underlying soil consists of poorly graded sand that provides minimal friction resistance to sliding of the structure. An additional analysis was computed which represented the post construction cross section to determine whether the additional passive resistance provided by the riprap being placed in front of the concrete grade beam would be sufficient to eliminate any instability due to sliding. The installed riprap provides enough resistance to raise the factor of safety above the required value of 1.5. Therefore, temporary shoring will be required to eliminate the potential for sliding of the WPA wall near station 2+00 on the right side (looking downstream). All other cross sections analyzed satisfied the minimum factor of safety requirements of 2 and1.5 for overturning and sliding, respectively.

Station	Min Req'd F.O.S.	Actual F.O.S.
0+50 LS	2	7.0
2+00 LS	2	7.3
2+00 RS	2	5.2
8+00 RS	2	7.3
11+00 RS	2	11.1
12+00 RS	2	10.2
15+00 RS	2	12.1

Table 4: WPA Wall Stability - Overturning Results

Station	Min Req'd F.O.S.	Actual F.O.S.
0+50 LS	1.5	1.77
2+00 LS	1.5	1.86
2+00 RS	1.5	**1.31**
2+00 RS Post Construction	1.5	1.82
8+00 RS	1.5	3.34
11+00 RS	1.5	2.33
12+00 RS	1.5	2.12
15+00 RS	1.5	1.59

Table 5: WPA Wall Stability - Sliding Results

All wall stability calculations shall be updated upon receipt of any additional soil information to ensure adequacy. The wall stability calculations can be found in Attachment 9.

5.7 Bridge Crossings

To achieve the project goal of providing fish passage and resting areas during low-flows and fish refuge zones during higher flows, it was determined that the concrete apron underneath the I-94 bridge had to be removed. The Wisconsin Department of Transportation(WisDOT) was contacted to determine if their bridge structure would be impacted if the concrete apron was removed beneath it. WisDOT requested that the HEC-RAS model be submitted to them and that a scour analyses be completed prior to their approval. WisDOT approved the project plan on 25FEB2013.

To promote continuity of the river cross section the Canadian Pacific Railroad Company was also contacted with regard to removal of the concrete apron beneath their bridge structure. Canadian Pacific Railroad Company approved the project plan on 19OCT2012.

Any changes made to the design of the project that impact either bridge crossings shall be communicated with the appropriate stakeholder. The point of contact for the I-94 bridge is Matthew Allie with WisDOT who can be contacted at (608)266-8483 or matthew.allie@dot.wi.gov. The point of contact for the railroad bridge is Derek Harter with Canadian Pacific Rail Company who can be contacted at Derek_Harter@cpr.ca.

The emails containing the bridge owners approval of the project plan can be found in Attachment 10.

5.8 River Restoration Alternatives

For this study, three alternatives were devised. Alternative 1 and 2 include removal of the concrete channel, while Alternative 1 incorporates a riffle-pool design into the reach. Alternative 3 is the "No Action" plan and does not meet the sponsor's criteria.

Alternative 1: Remove Concrete Channel, Add Riffle-Pool Design, and Add Riprap Revetment

Alternative 1 consists of the removal of the concrete channel between the WPA walls and replacing it with a rock-lined channel. However, Alternative 1 will incorporate a riffle-pool design throughout the reach, riffle anchor practices, resting benches, as well as a slight meander. By removing the concrete liner between the WPA walls, this allows the low flow channel to meander back and forth between the walls. With increased roughness from the large boulders and a meandering channel, the flow velocities will be reduced and additional refuge sections of varying widths will exist on both sides of the channel.

The low flow channel is designed to have riffles that are approximately 4-feet wide at the bottom of the channel and approximately 20-feet at the top with 2.5H:1V side slopes (see Figure 1). The anchor functions much like a cross-channel log in a natural channel and helps moderate depth and grade upstream, while also creating small pools downstream (see Figure 2).

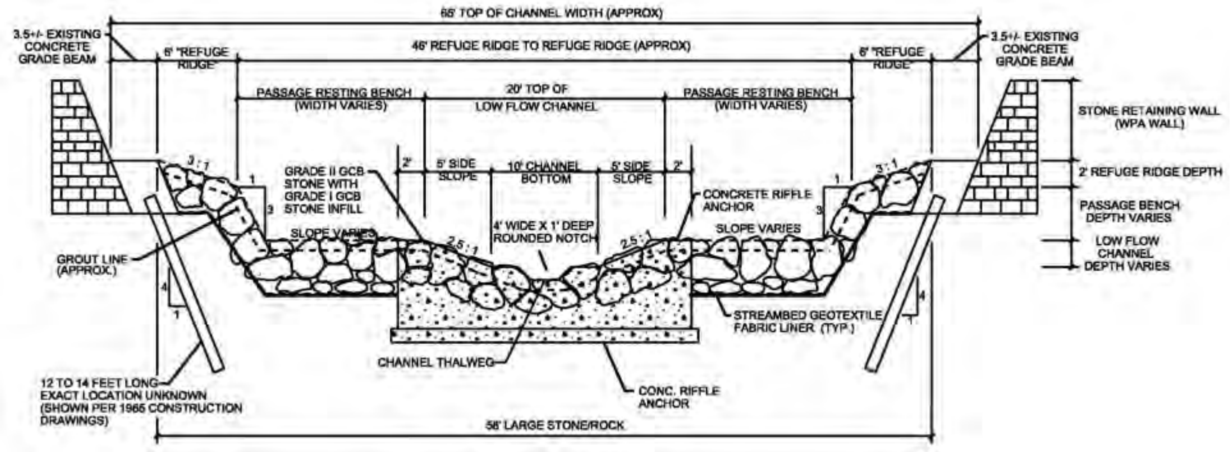


Figure 2: Typical Riffle Cross Section

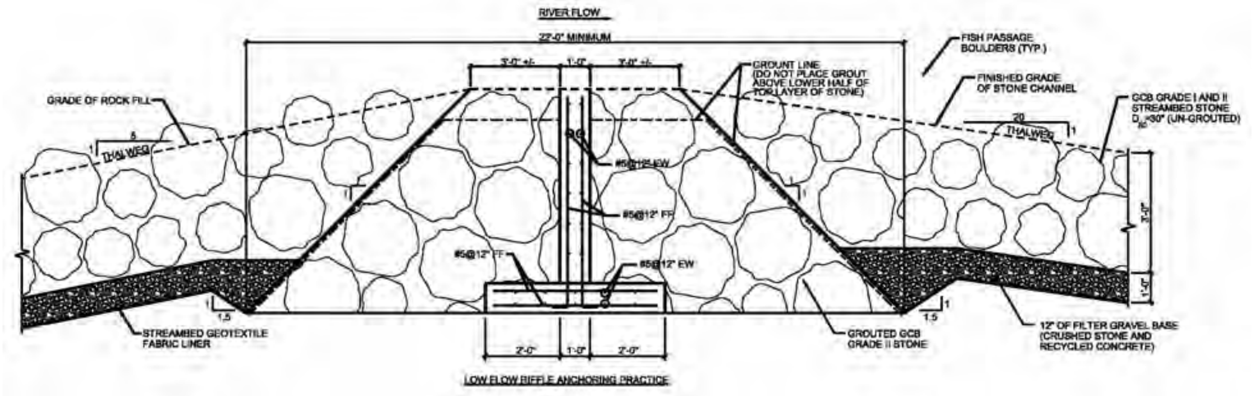


Figure 3: Riffle Anchor Practice Detail

The reach will also contain pools that are wider and deeper when compared to the riffles. Combined with boulders placed within the channel, there will be suitable habitat for northern pike during low flows, while the boulders also provide resting spots during higher flows.

Above the low flow channel will be a stone-lined bench. This rock-lined section of the channel will form an approximate 20-foot bench to one side of the low flow channel; however, the length and slope will vary depending on where there thalwag is placed. Its function is to provide habitat that allows fish to rest and then swim to the next resting structure.

Alternative 2: Remove Concrete Channel and Add Riprap Revetment

The traditional approach to fish passage in urbanized streams is to increase roughness by replacing the concrete channel with large boulders that will not move with shear stresses experienced during large flood events. Thus, Alternative 2 will consist of the removal of the concrete channel between the WPA walls and replacing it with a rock-lined channel. The focus area is a reach that starts downstream of the West Bluemound Road Bridge and extends downstream to the Canadian Pacific Railroad Bridge, approximately 2,400-feet in length. For this alternative, the rock-lined channel will contour with existing grades, which eliminates some excavation when compared to Alternative 1, but also provides less of an ecological benefit. See Figure 4 for the typical cross section.

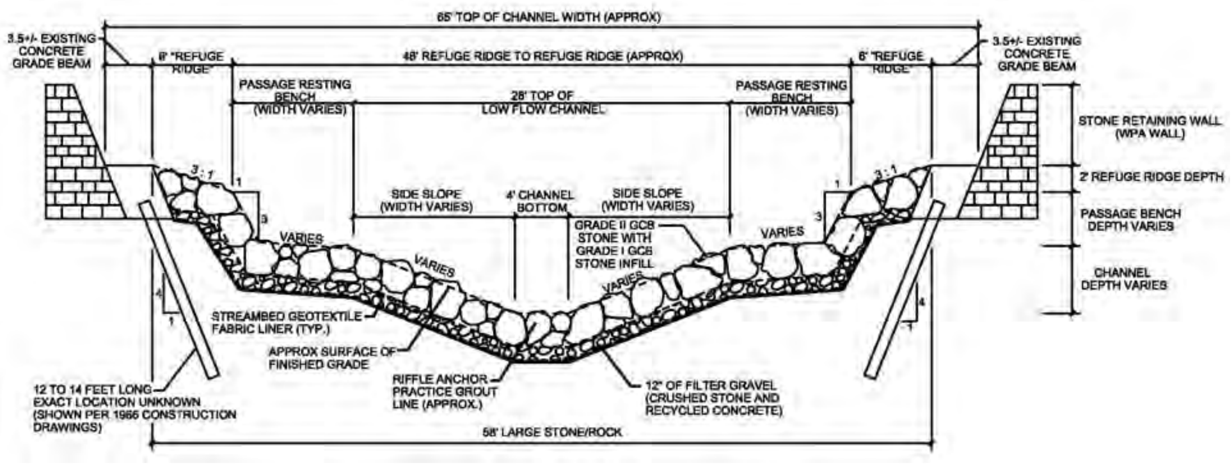


Figure 4: Typical Cross Section

Alternative 3: No Action

Not implementing a stream restoration will have environmental impacts. If the channel remains, the following impacts will occur:

- The river would continue to inhibit fish passage, as the high flow velocities remain unchanged.
- Flood level elevations will remain unchanged.
- Concrete channel will continue to degrade, prolonging maintenance costs.

In essence, the No Action alternative will result in 2,400-feet of the Menomonee River concrete channel degrading causing an economic burden on MMSD with concrete repairs, while also continuing to inhibit fish passage by preventing the upstream migration of fish that cannot handle the high flow velocities.

6. Constructability

6.1 Groundwater Issues

The soil underlying the concrete lined channel appears to be primarily permeable sands on the south side of the project. Since excavation will occur below the groundwater table, dewatering will be required in some areas. Groundwater removal can be accomplished by using centrifugal pumps pumping from shallow sump pits.

6.2 Soil Conditions

All earthwork and foundation subgrades shall be observed and tested by an experienced geotechnical engineer, or technician under a geotechnical engineer's supervision, to determine if the soil and groundwater conditions encountered are consistent with those anticipated in this report. Foundation subsoils should be tested for adequate bearing conditions, and should meet minimum strength requirements discussed previously.

Cohesive soils can become disturbed by repeated passages of heavy construction traffic, especially in the presence of rainwater or groundwater. Traffic and exposure to water should be minimized on clay subgrade soils to the extent possible. Disturbed subgrade soils shall be overexcavated and replaced with engineered fill.

6.3 Working Near WPA Wall

Extreme caution shall be taken when working near the WPA wall due to its deteriorated conditions. Vibrations caused by construction activity including vibratory driving SSP should be limited and monitored to ensure further deterioration of the WPA walls does not occur.

6.4 Placement of Rock

Riprap should be placed in a systematic manner. Rock should typically be placed from the lowest to the highest elevation to allow gravitational forces to minimize void spaces and help lock the rock matrix together. It is important that riprap be placed at full course thickness in one operation to minimize segregation of rock sizes and avoid displacing underlying material. Final grade of the slope should be achieved as the material is placed. Care should be taken not to segregate or group material sizes together during placement. Allowing the stone to be pushed or rolled down slope will cause stone size segregation. See ASTM D6825 for placement of riprap revetments.

Special purpose equipment such as clam shells or orange peels provide the best placement and most compact layers of riprap. Bulldozers and front-end loaders are discouraged for placement of riprap. Bulldozers have the tendency to ruin the integrity of the interlocked rock layer and front-end loaders have poor visibility, which creates placement problems for the operator, since riprap cannot be spread like soils and aggregates.

7. References

Das, Braja M., Fundamentals of Geotechnical Engineering, Third Edition (Thomson Learning, 2008)

EM1110-2-1601 Riprap Protection, United States Army Corps of Engineers, 1994.

EM1110-2-1902 Slope Stability, United States Army Corps of Engineers, 2003.

Final Design Memorandum Menomonee River Stream Management, GRAEF, 2011.

Geotechnical Baseline Report Valley Park Levee/Floodwall and Interior Drainage, K. Singh & Associates, Inc., 2000.

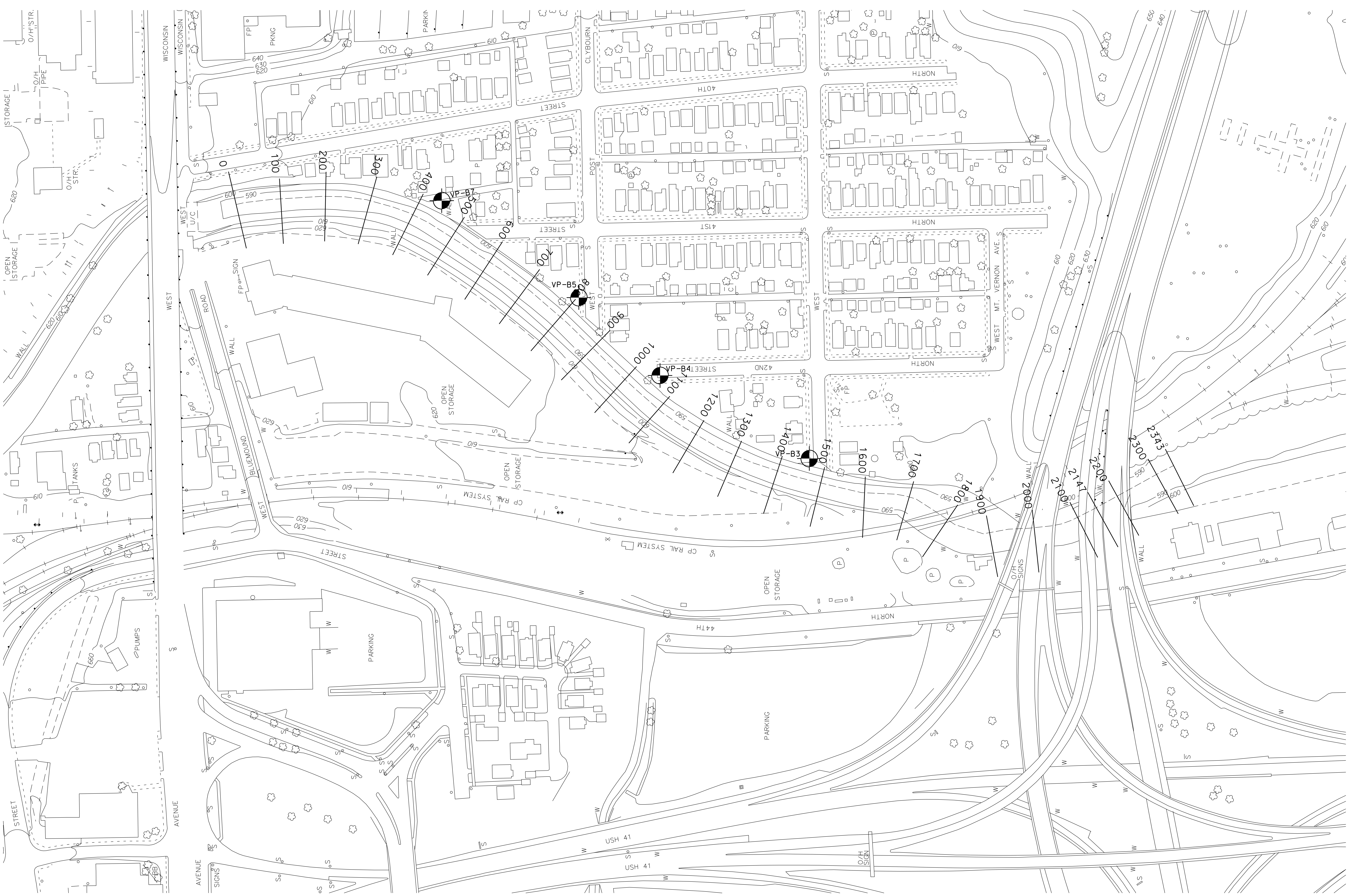
Geotechnical Engineering Report Menomonee River Stream Management Program, Wagner Komurka Geotechnical Group, Inc., 2011.

Sampling and Analysis of Sediments, Menomonee River, Milwaukee, Wisconsin, Altech Environmental Services, Inc., 2001.

Stream Restoration Design (National Engineering Handbook Part 654) – Technical Supplement 14C Stone Sizing Criteria, United States Department of Agriculture Natural Resources Conservation Service, 2007.

ATTACHMENT 1

PROJECT MAP WITH STATIONING



US Army Corps of Engineers
Detroit District

Symbol	Description	Date	Appr.

Symbol	Description	Date	Appr.

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
DETROIT, MICHIGAN

Surveyed by:

Dwn by: E. BURR

Ckd by:

Approval Recommended:

Area Eng. KEW

Reviewed by:

Chief, Eng. Section

Approved by:

District Engineer:

Submitted by:

Chief, SMR Branch

Date: JAN 15 2013

Rev.

Design file name: MNY01A13.DGN

Drawing code:

File name:
Plot date: 1-15-13
Plot scale: 1"=100'

MENOMONEE RIVER
MENOMONEE, WISCONSIN

SECTION 206
CROSS SECTION STATIONING

SHEET REFERENCE NUMBER
4-15
SHEET X OF XX

ATTACHMENT 2

HISTORICAL BORINGS

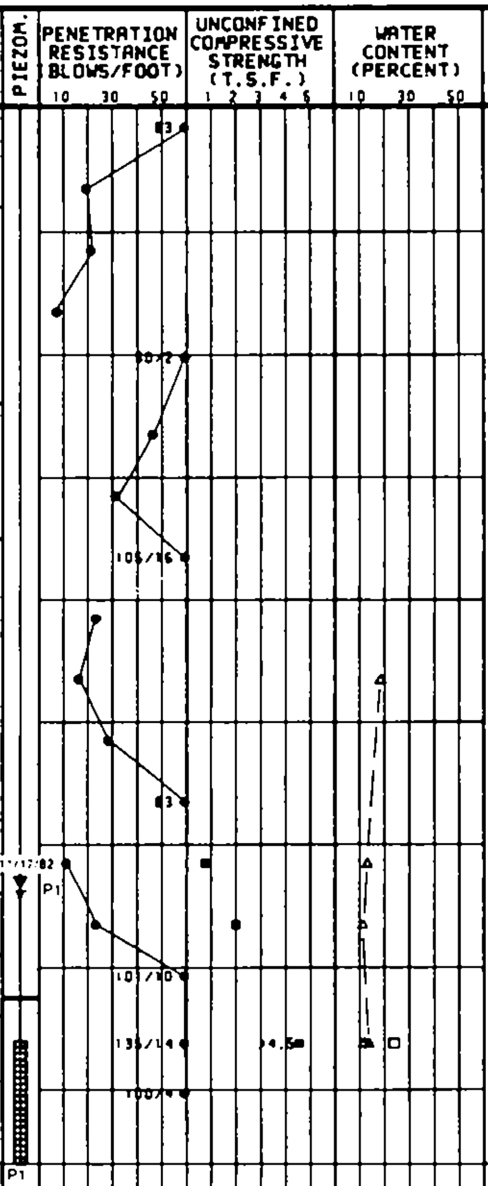

I30-19-CT
W Wisconsin Ave
MEN0106
C10-05-CT3!4
W Bluemound Rd
MEN0107
MEN0108
N 4th St
MEN0109
VP-B7-PZ-4
MEN0110
VP-B6
MEN0111
VP-B12
VP-B5-PZ-3
W Clybourn St
MEN0112
VP-B4
MEN0123
I35-CT-AS-7R-1
I30-CT-AS-07A
TEST-PIT-3
N 40th St
TEST-PIT-4
MEN0114
VP-B3-PZ-2
TEST-PIT-1
N 42nd St
N 41st St
41
FS-50
FS-49
I35-CT-AS-7R-2
VP-B9
FS-48
VP-B2
MEN0116
MEN0115
VP-B8
FS-47
VP-B11
VP-B10
FS-46
B-1
VP-B1-PZ-1
N
MEN0117
Feet
0
200
400
94
Map Request 201200096
Soil Boreholes selected
Image
RGB
Red: Band_1
Green: Band_2
Blue: Band_3

GROUND ELEV.: 39.4
NORTH COORD.: 383925
EAST COORD. : 2543003

PROJECT ID.: I30A11EGC1
FIELD ENG./GEO.: P.S. STEERMAN
DRILLER: D. SINIBALDI

BORING NO.: I30-CT-AS-07A
DATE BEGAN: 11/15/1982
DATE COMPLETED: 11/16/1982

ELEV. (FEET)	DEPTH (FEET)	SAMPLE NUMBER	DESCRIPTION	U.S.C.S	REMARKS
39.4	0	S1 S2	FILL - SANDY GRAVEL. MEDIUM DENSE TO VERY DENSE. BROWN TO BLACK. MOIST. ORGANICS 4.0		
30	5 10	S3 S4 S5	FILL - SAND. LOOSE TO MEDIUM DENSE. BROWN. SATURATED. SOME GRAVEL. ORGANICS. METAL. GLASS PIECES 12.0		FILL PIECE OF METAL AT 10.0'
	15	S6 S7	FILL - SANDY GRAVEL. DENSE. BLACK TO YELLOW. MOIST. ORGANICS AND WOOD PIECES 17.5		17.5
20	20 25	S8 S9 S10 S11 S12	SILTY SAND - MEDIUM DENSE TO VERY DENSE GRAY. MOIST. COARSE TO FINE GRAINED COARSE GRAVEL AT 29.0' DEPTH. CLAY LENS AT 23.0' 29.0	SM	ALLUVIAL DEPOSITS 29.0
10	30	S13	SILTY CLAY - MEDIUM STIFF BROWN. MOIST TRACE SAND 32.0	CL	TILL 2
		S14	CLAYEY SILT - VERY STIFF. BROWN. MOIST. TRACE SAND AND GRAVEL 34.5	CL-ML	34.5
	35	S15	SANDY GRAVEL - VERY DENSE. BROWN TO GRAY. MOIST TRACE SILT 37.0	[illegible]	OUTWASH DEPOSITS 37.0
0	40	S16 S17	CLAYEY SILT - HARD. BROWN MOIST. TRACE FINE GRAVEL 43.0	CL-ML	TILL 2 BOULDER AT 40.5' 43.0
-3.6	43.0		TOP OF ROCK		



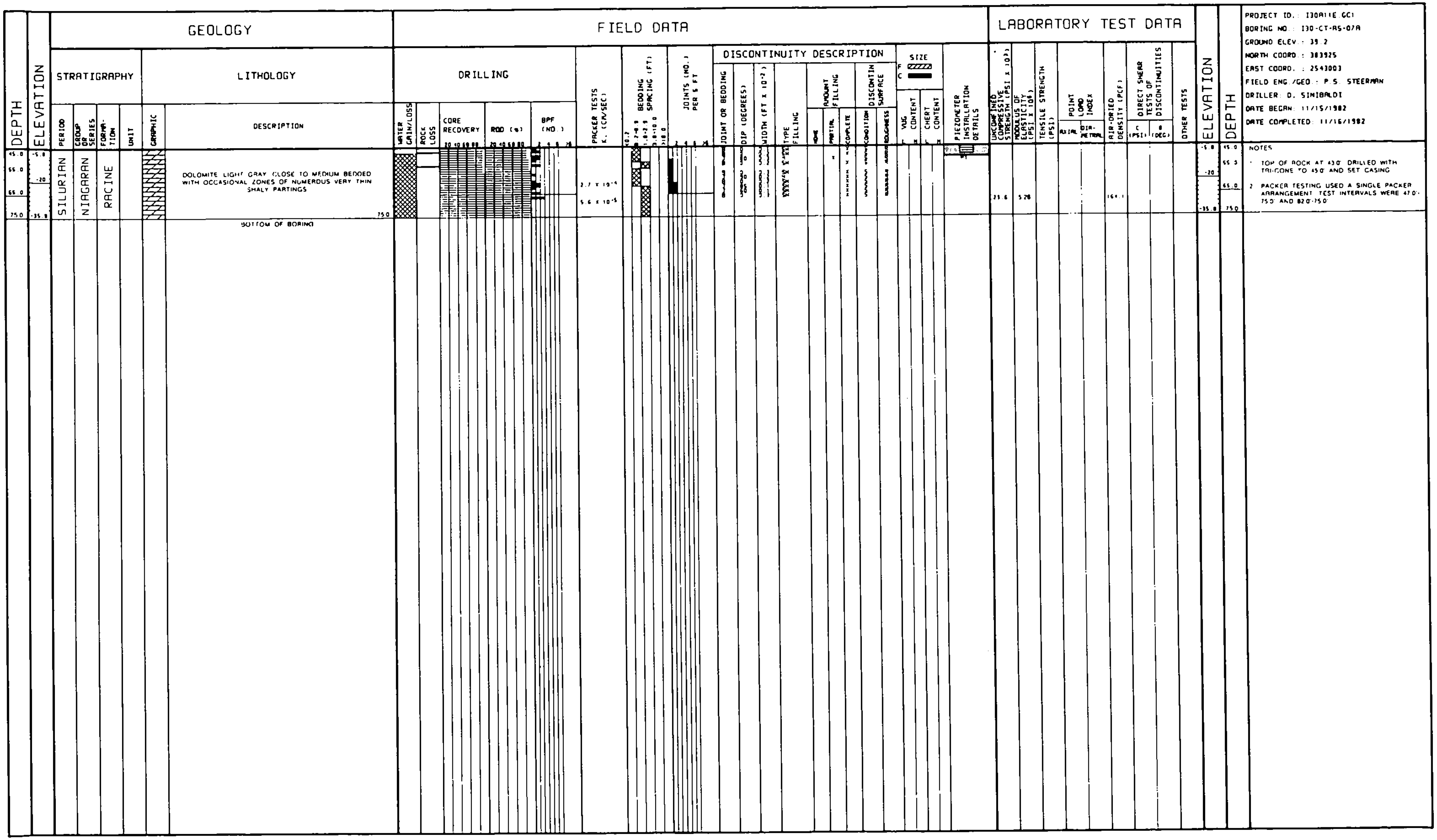
SHEET 1 OF 2

BORING 130-CT-AS-7A

CROSSTOWN INTERCEPTOR

130A11 R0568

PROJECT ID.: 130A11E.GC1
BORING NO.: 130-CT-AS-07A
GROUND ELEV.: 39.2
NORTH COORD.: 383925
EAST COORD.: 2543003
FIELD ENG./GEO.: P.S. STEERMAN
DRILLER: D. SINIBALDI
DATE BEGAN: 11/15/1982
DATE COMPLETED: 11/16/1982



DOLOMITE LIGHT GRAY CLOSE TO MEDIUM BEDDED WITH OCCASIONAL ZONES OF NUMEROUS VERY THIN SHALY PARTINGS 75.0

BOTTOM OF BORING

NOTES

1. TOP OF ROCK AT 43.0' DRILLED WITH TRI-CONE TO 45.0' AND SET CASING
2. PACKER TESTING USED A SINGLE PACKER ARRANGEMENT TEST INTERVALS WERE 47.0'-75.0' AND 82.0'-75.0'

mmsd

SHEET 2 OF 2

BORING 130-CT-AS-7A

CROSSTOWN INTERCEPTOR

130A11.S0099

WKG²
Wagner Komurka
Geotechnical Group, Inc.

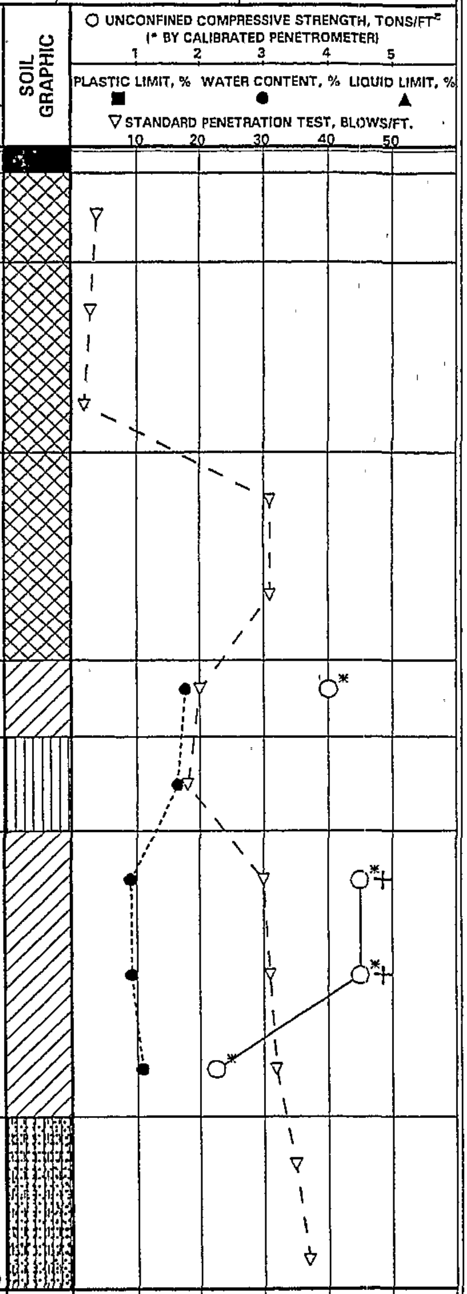
PROJECT NAME	Menomonee Special MIS Improvement
SITE LOCATION	Milwaukee, Wisconsin
BORING NO.	B-1
OWNER	Milwaukee Metropolitan Sewerage District
ARCHITECT/ENGINEER	Metcalf & Eddy
SHEET	1 OF 1

SOIL/ROCK DESCRIPTION

STATION: 75+96 feet OFFSET: 1 feet Right
NORTHING: 383,386 feet EASTING: 2,543,683 feet
SURFACE ELEVATION: +20.0 feet (MMSD Datum)

ELEVATION/ DEPTH, FEET	SOIL/ROCK DESCRIPTION		
20 / 0	PAVEMENT: Asphaltic concrete, 1 inch thick (Driller's observation)	19.9	0.1
	PAVEMENT: Asphaltic concrete, 7 inches thick (Driller's observation)	19.3	0.7
	FILL: Fine to coarse sand, little fine to coarse gravel, trace silt - brown, 10yr5/4 - moist - loose - F (FILL: sp-sm, sw-sm)	17.0	3.0
15 / 5	FILL: Silty fine to medium sand, trace coarse sand & gravel - brown, 10yr4/4 - moist - very loose - F (FILL: sm)	12.0	8.0
10 / 10	FILL: Fine to coarse sand, little fine to coarse gravel, trace silt - brown, 10yr5/4 - moist - dense - F (FILL: sp-sm, sw-sm)	6.5	13.5
5 / 15	Silty clay, with silt seams, with silty sand seams, trace sand, trace gravel - gray, 10yr4/2 - hard - LF (cl)	4.5	15.5
	Silt, trace clay, trace sand - gray, 10yr5/2 - wet - medium dense - LF (ml)	2.0	18.0
0 / 20	Silty to sandy clay, with silty fine sand seams and pockets, trace to little gravel - gray, 10yr 4/2 - very stiff to hard - T (cl)	-5.5	25.5
-5 / 25	Fine sand and silt, with silty clay seams and pockets, and fine to medium sand seams and pockets - gray, 10yr4/2 - wet - dense - LC (sm, ml)	-10.0	30.0
-10 / 30	End of Boring. Boring advanced to 12 feet using 4.25-inch-I.D. hollow- stem auger with center plug; boring advanced from 12 to 28.5 feet using 3.875-inch tri-cone rotary bit and recirculating drilling fluid. Boring grouted, and pavement patched, upon completion.		
-15 / 35			
-20 / 40			

SAMPLE NUMBER	TYPE
1	SS
2	SS
3	SS
4	SS
5	SS
6	SS
7	SS
8	SS
9	SS
10	SS
11	SS
12	SS



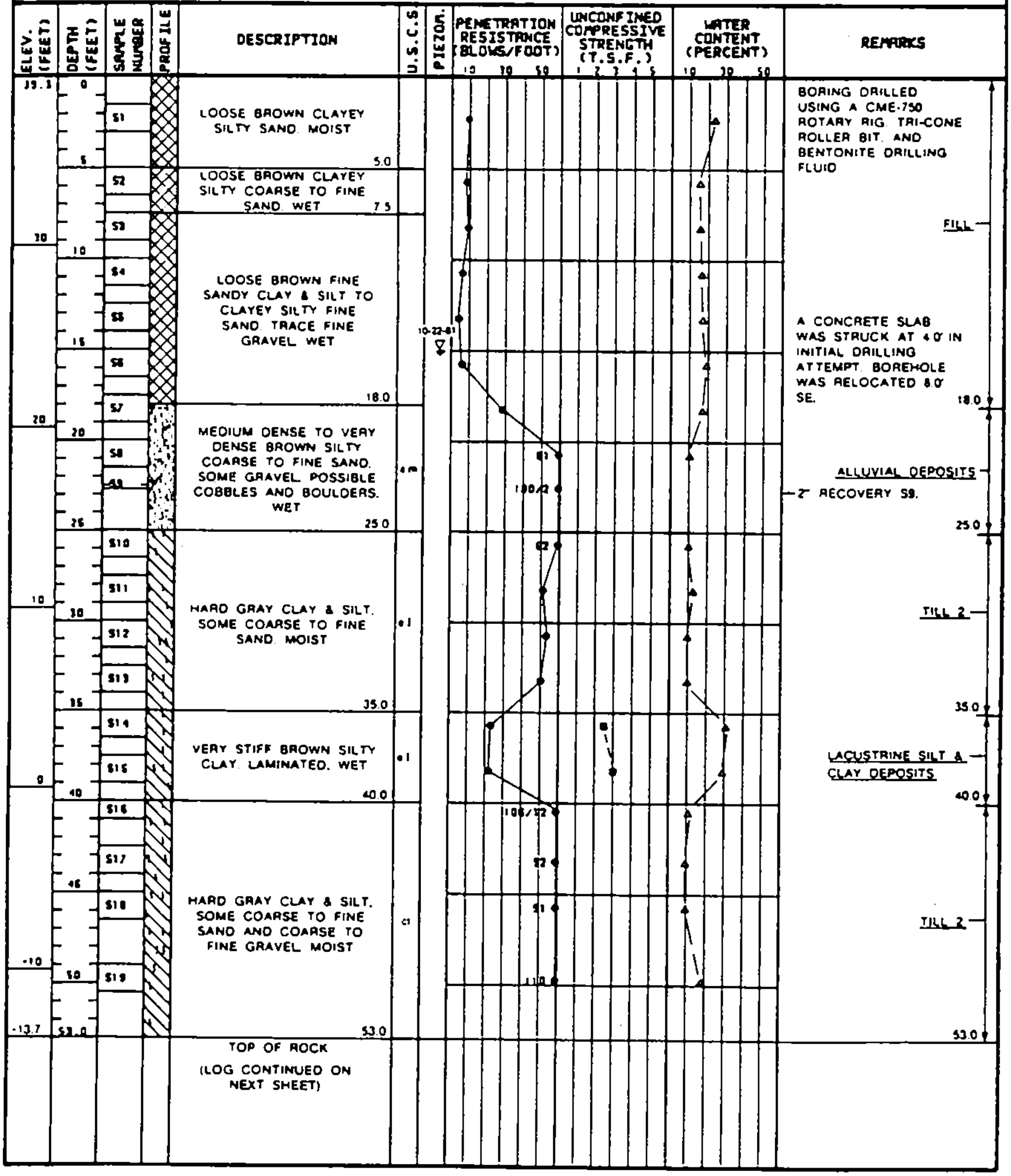
THE STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES; IN-SITU, THE TRANSITIONS MAY BE GRADUAL.

DRILLING COMPANY Badger State Drilling Company, Inc.	RIG/HAMMER D-120/Auto	FOREMAN Dave Cruise	BORING STARTED 05-15-02	BORING COMPLETED 05-15-02
WATER LEVEL(S)		INSPECTOR(S)	APPROVED BY CJW	PROJECT NO. 01023

GROUND ELEV.: 39.3
NORTH COORD.: 385153
EAST COORD. : 2544133

PROJECT ID.: C10A11E.GB1
FIELD ENG./GEO.: K.R. CHANG
DRILLER: R. ST.DENIS

BORING NO.: C10-05-CT3/4
DATE BEGAN: 10/20/1981
DATE COMPLETED: 10/21/1981



SAMPLE NUMBER	DESCRIPTION	U.S.C.S.
S1	LOOSE BROWN CLAYEY SILTY SAND. MOIST 5.0	
S2	LOOSE BROWN CLAYEY SILTY COARSE TO FINE SAND. WET 7.5	
S3 S4 S5 S6	LOOSE BROWN FINE SANDY CLAY & SILT TO CLAYEY SILTY FINE SAND. TRACE FINE GRAVEL. WET 18.0	
S7 S8 S9	MEDIUM DENSE TO VERY DENSE BROWN SILTY COARSE TO FINE SAND. SOME GRAVEL. POSSIBLE COBBLES AND BOULDERS. WET 25.0	SM
S10 S11 S12 S13	HARD GRAY CLAY & SILT. SOME COARSE TO FINE SAND. MOIST 35.0	CL
S14 S15	VERY STIFF BROWN SILTY CLAY. LAMINATED. WET 40.0	CL
S16 S17 S18 S19	HARD GRAY CLAY & SILT. SOME COARSE TO FINE SAND AND COARSE TO FINE GRAVEL. MOIST 53.0	CL
	TOP OF ROCK (LOG CONTINUED ON NEXT SHEET)	

BORING DRILLED USING A CME-750 ROTARY RIG. TRI-CONE ROLLER BIT. AND BENTONITE DRILLING FLUID

FILL

A CONCRETE SLAB WAS STRUCK AT 4.0' IN INITIAL DRILLING ATTEMPT. BOREHOLE WAS RELOCATED 8.0' SE.

18.0

ALLUVIAL DEPOSITS

2" RECOVERY S9.

25.0

TILL 2

35.0

LACUSTRINE SILT & CLAY DEPOSITS

40.0

TILL 2

53.0

FIGURE A-6 SHEET 1 OF 2

BORING LOG C10-5-CT3/4

CT-3/4 COLLECTOR

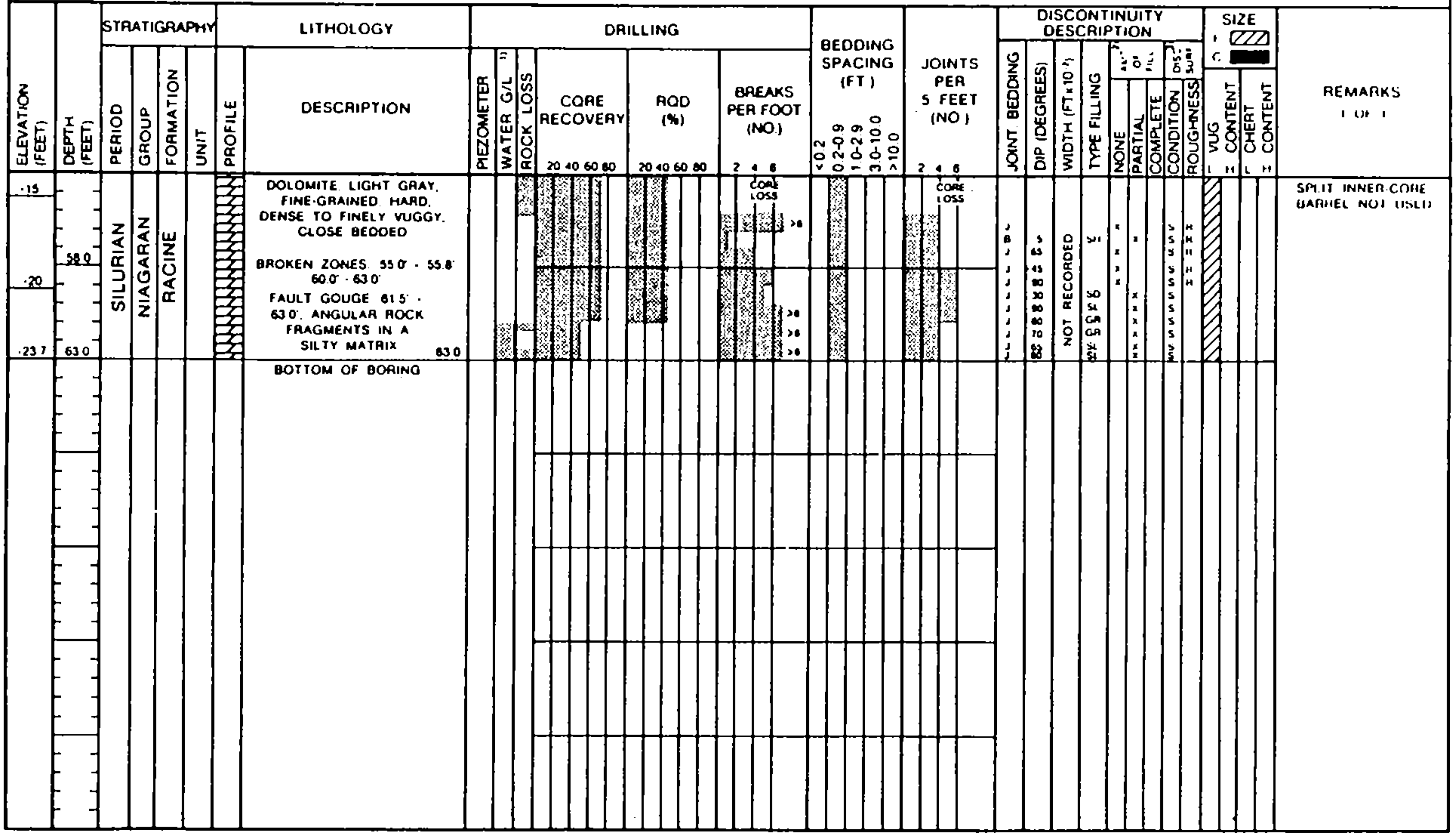
C22J11.R0036

GROUND ELEV.: 39.3 MMSD
NORTH COORD.: 385,153
EAST COORD.: 2,544,133

PROJECT ID.: C10A11E.GB1
FIELD ENG./GEO.: K.R. CHANG
DRILLER: R. ST. DENIS

BORING NO.: C10-5-CT3/4
DATE BEGAN: 10-21-81
DATE COMPLETED: 10-21-81

NOTE:
1) WATER GAIN OR LOSS
2) AMOUNT OF FILLING
3) DISCONTINUITY SURFACE



ELEVATION (FEET)	DEPTH (FEET)	PERIOD	GROUP	FORMATION	UNIT	DESCRIPTION	REMARKS
-15		SILURIAN	NIAGARAN	RACINE		DOLOMITE, LIGHT GRAY, FINE-GRAINED, HARD, DENSE TO FINELY VUGGY, CLOSE BEDDED	SPLIT INNER-CORE BARREL NOT USED
	58.0					BROKEN ZONES: 55.0' - 55.8' 60.0' - 63.0'	
-20						FAULT GOUGE 61.5' - 63.0', ANGULAR ROCK FRAGMENTS IN A SILTY MATRIX	
-23.7	63.0					63.0	
						BOTTOM OF BORING	

REMARKS 1 OF 1

MMSD

FIGURE A-6 SHEET 2 OF 2

BORING LOG C10-5-CT3/4

CT-3/4 COLLECTOR

C22J11.R0037

East-West Expressway Milwaukee

6-4&5-53 Soil Testing Services of Wisconsin, Inc.

F.S. 46 (3'S.) Split Spoon

Northeast Bridge 2 3/8" 2"

19.S 2'

60 378 11

1	1		19.5 to 17.5	0 to 2	Loose Brown Silt - Some Topsoil, Sand & Cla
2	1	5-5-3-5	17.5 to 15.5	2 to 4	" " " Fill - Some Clay, Misc.
3	2	5-12-17-12	15.5 to 13.5	4 to 6	" " " & Medium Gravel - Some Sand Fill
4	3	13-12-11-25	9.5 to 7.5	10 to 12	Medium Dense Yellow Coarse Gravel - Some Sand, Silt
5	3	15-18-15-17	4.5 to 2.5	15 to 17	Dense Yellow Brown Coarse " " " "
6	4	12-16-25	-0.5 to -2	20 to21.5	" Gray Coarse Sand - Some Gravel & Silt
7	5	15-50-60-60	-5.5 to -6.5	25 to 26	Very Tough Gray Loam - Some Gravel
8	6	15-50-60-60	-6.5 to -7.5	26 to 27	Dense Medium Gravel & Some Sand & Silt
9	6	19-25-25-38	-10.5 to -12.5	30 to 32	" Gray Mixed Gravel & Some Sand
10	6	27-29-37-42	-14.5 to -16.5	34 to 36	" " " " " " "

R. F. Horn

East-West Expressway Milwaukee

6-4-53 Soil Testing Services of Wisconsin, Inc.

F.S. 47 (6'W., 2'N.) Split Spoon

Northeast Bridge 2 3/8" 2"

18.5 2'

60 378 1 11

1	1		18.5 to 17.5	0 to 1	Loose Black Cinder Fill
2	2		17.5 to 16.5	1 to 2	" Red Brown Silt, Clay, Sand, Cinder & Misc. Fill
3	3	4-6-4-4	16.5 to 14.5	2 to 4	" Brown Loam
4	4	5-4-4-5	14.5 to 12.5	4 to 6	" " Medium Sand
5	5	16-15-10-9	8.5 to 6.5	10 to 12	Medium Dense Gray Coarse Gravel - Some Sand & Silt
6	5	15-13-13-11	3.5 to 1.5	15 to 17	" " " " " " " " "
*7	6	22-20-40-45	-1.5 to -3.5	20 to 22	Very Tough Gray Loam - Some Gravel
8	6	17-17-27-57Ref.	-6.5 to -8.3	25 to 26.8	" " " " " "
	7	Diamond Bit Core	-11.5 to -24.5	30 to 43	Limestone & Granite Boulder Cores
9	8	Washout	-22.5 to -24.5	41 to 43	Dense Gray Coarse Sand

*Sample taken for State

R. F. Horn

Project No. ______ Road East-West Expressway County Milwaukee

Date of Sounding 6-1-53 Party Soil Testing Services of Wisconsin, Incorporated

---

Hole No. F.S. 48 Sampler, Type Split Spoon

Location Northeast Bridge Diam. - O.D. 2 3/8" I.D. 2"

Orig. Gr. Elev. = 17.5 Length 2'

Roadway Elev. = 60 Hammer - Wt. = 378 , Fall = 11

Sample No.	Layer	Penetration of Sampler Blows per ½ Ft.	Plan Elev.	Depth	Field Classification
1	1		17.5 to 15.5	0 to 2	Loose Sand, Silt, Cinder, & Rock Fill
2	2	4-3-3-3	15.5 to 13.5	2 to 4	Loose Cinder and Ash Fill
3	3	3-2-1-1	13.5 to 11.5	4 to 6	Loose Dry Brown Medium Sand - Some silt & ash
4	4	16-7-6-5	7.5 to 5.5	10 to 12	Medium Dense Rock Fill-Some Sand,Silt(Or
5	5	3-2-3-2	2.5 to 0.5	15 to 17	Loose Coarse Gravel - Some sand, trace cl
6	6	11-7-9-10	-2.5 to -4.5	20 to 22	Medium Dense Coarse Gray Sand - Some gra Trace sil
7	6	12-36-40-37	-7.5 to -9.5	25 to 27	Dense Gray Medium Sand & Gravel-Trace Sil
8	7	Refusal	-12.5 to -12.7	30 to 30.2	Dense Rock Chips - Layer of Gray silt & sand above
9	8	Diamond Bit Core	-12.7 to -14.7	30.2 to 32.2	Limestone Boulder

Remarks:

Signed R. F. Horn

Project No. ______ Road East-West Expressway County Milwaukee

Date of Sounding 6/22/53 ______ Made by Soil Testing Services of Wisconsin, Inc.

Hole No. F.S. 49 Sampler, Type Split Spoon

Location Northeast Bridge (River) Diam. - O.D. 2 3/8" I.D. 2"

Orig. Gr. Elev. = +11.4 Length 2'

Roadway Elev. = 59 Hammer - Wt. = 378 Fall = 11

Sample No.	Layer	Penetration of Sampler Blows per ½ Ft.	Elev.	Depth	Field Classification
1	1	--	11.9 to 9.4	0 - 2	Medium Dense Gravel & Course Sand
2	1	15-22-16-15	9.4 to 7.4	2 - 4	Medium " " " " " - Some Black Organic Peat
		6-8-12-14	3.4 to 1.4	8 - 10	Lost Sample
3	1	Shelby Tube	3.4 to 1.4	8 - 10	Black Organic Silt - Some Medium Dense Sand & Gravel
		14-19-17-18	-3.6 to 5.6	15 - 17	Lost Sample
4	2	Shelby Tube	-3.6 to-5.6	15 - 17	Dense Grey Sand & Gravel - Trace Organic Silt
5	2	4-8-10-11	-7.6 to-9.3	19 - 20.7	" " " " " - Trace Silt
	3	4-8-10-11	-9.3 to -9.6	20.7-21	Tough Grey Silty Clay
			-13.6 to -14.6	25-26	Lost Sample
6	4	Washout	-14.6 to -16.1	26-27.5	Grey Sand & Gravel - Trace Silt
		Observed in Wash	-16.1 to -17.6	27.5-29	" " " " " "
					Boulder or Bedrock at 29'
		End of Boring			

Remarks:

Signed L. R. Schuster

East-West Expressway Milwaukee

6-2&3-53 Soil Testing Services of Wisconsin, Inc.

F.S.50 Split Spoon

Northeast Bridge 2 3/8" 2"

23.0 2'

58 378 11

		[illegible] / Ft.			Field Classification
1	1		22.5 to 21	0.5 to 2	Tough Gray Silty Clay
2	1	9-7-5-4	21 to 19	2 to 4	" Brown " "
3	2	4-3-3-3	19 to 17	4 to 6	Loose Gray Silty Clay
4	3	86-28-29-31	13 to 11	10 to 12	Trace Silt & Cla Dense Yellow Medium Gravel-Some Medium Sa
5	3	21-27-18-21	8 to 6	15 to 17	& Gravel - Trace Silt & C " " Fine Gravel - Some Coarse Sand
6	3	6-18-22-26	3 to 1	20 to 22	Coarse Sand & Silt " " Medium to Coarse Gravel - Some
7	4	91-95-113-89	-2 to -4	25 to 27	Sand & Gravel Very Dense Small Boulders - Some Coarse
8	5	69-25-21-16	-7 to -9	30 to 32	Coarse Gravel Dense Yellow Fine to Medium Gravel - Som
9	6	5-9-16-Ref.	-12 to -14	35 to 37	Hardpan at 36.5 Stiff Silty-Clay Loam Trace Gravel—
10	7	Core Diamond Bit	-16.5to -19	39.5 to 42	Limestone & Granite Boulders
	7	" " "	-19 to -22	42 to 45	" Bedrock or Boulder
	7	" " "	-22 to -24.5	45 to 47.5	" " " "

Remarks:

R. F. Horn

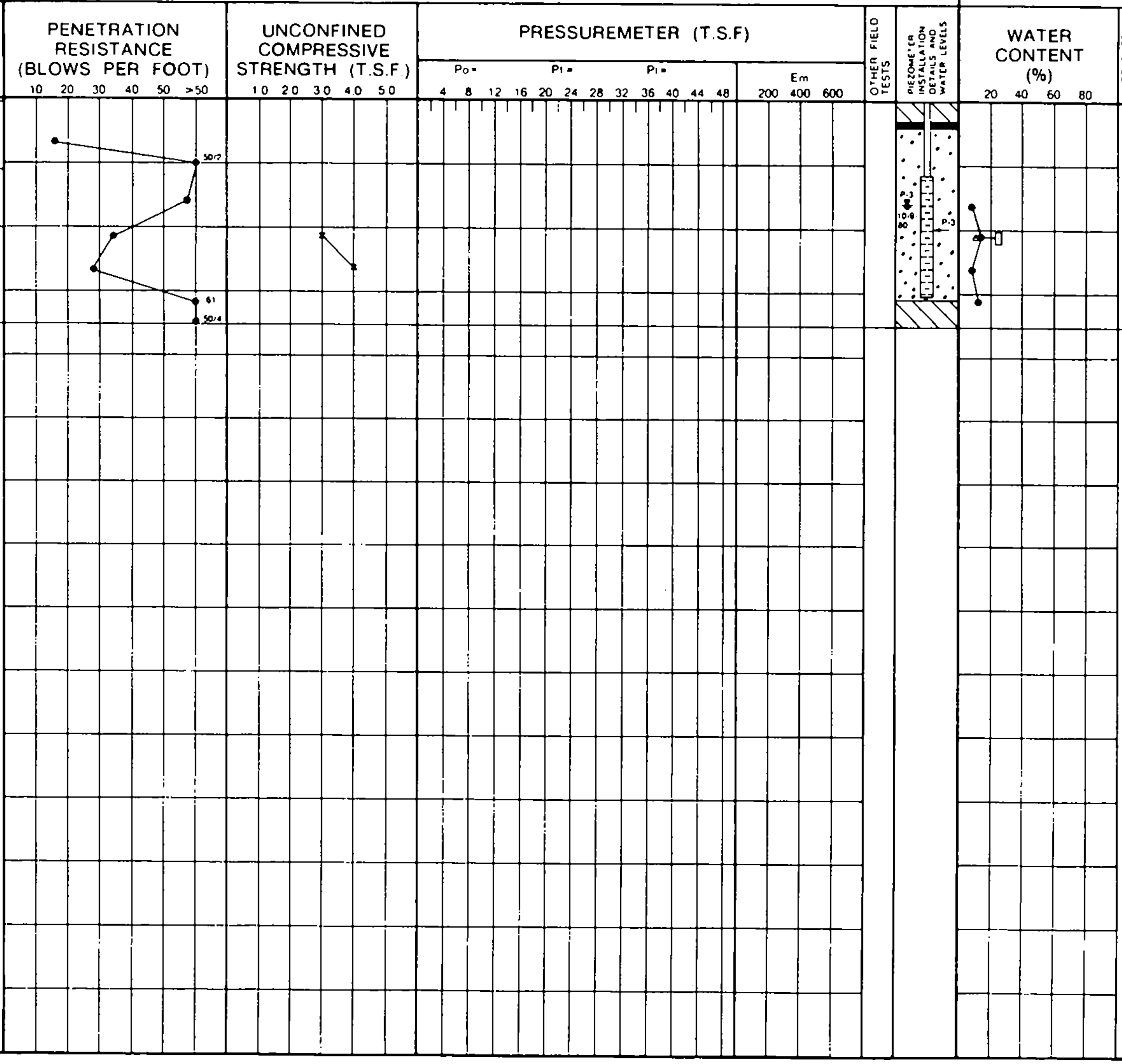
DRILLING

GEOLOGY

DEPTH (FT)	ELEVATION (MCD. FT)	WATER GAIN/LOSS	COMMENTS	SAMPLE NO AND TYPE	GRAPHIC	USCS CLASSIFICATION	DESCRIPTION
							ASPHALT 0.2
				S-1		SP-SM	SILTY SAND - MED DENSE TO VERY DENSE BROWN MOIST. TRACE MED GRAVEL
10	15.7		SOME FLUID LOSS	S-2			11.0
				S-3		ML	CLAYEY SILT - HARD GRAY MOIST
20	5.7						20.0'
				S-4			
				S-5		CL	SILTY CLAY - VERY STIFF TO HARD GRAY MOIST TRACE GRAVEL
30	-4.3			S-6			
35.2'	-9.5		DRILLED WITH TRICONE AND SET CASING TO 37.2	S-7			35.2' TOP OF ROCK AT 35.2'

FIELD DATA

LABORATORY TEST DATA



UNCONFINED COMPRESSIVE STRENGTH (T.S.F.)	WET UNIT WEIGHT (PCF)	OTHER LABORATORY TESTS	DEPTH (FT)
		M S	10
			20
			30
			35.2'

GENERAL NOTES

COORDINATES E 2 543 708 N 385 286 ⚠1
GROUND SURFACE ELEV 25.7 ⚠2
DATE BEGAN 9-27-80
DATE FINISHED 10-4-80
FIELD ENG/GEO T M JOHNSON S B FRADKIN
CONTRACTOR ATEC

NOTES
1 THE BORING LOGS AND RELATED INFORMATION DEPICT SUBSURFACE CONDITIONS ONLY AT THE SPECIFIC LOCATIONS AND DATES INDICATED SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS THE PASSAGE OF TIME MAY ALSO RESULT IN A CHANGE IN THE CONDITIONS AT THESE BORING LOCATIONS
2 REFER TO BORING LOCATION PLAN
3 REFER TO GENERAL NOTES SYMBOLS AND LEGEND

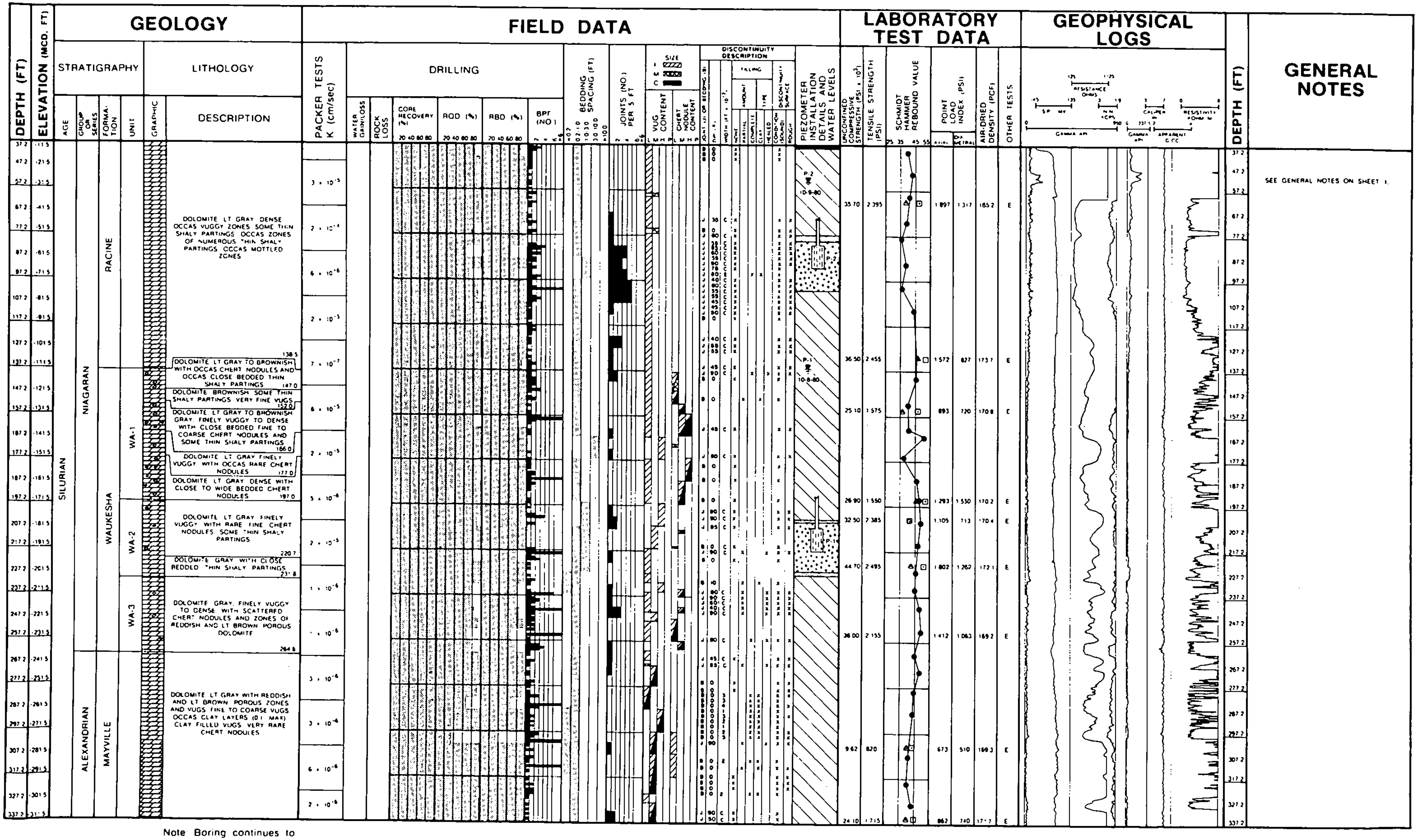
REVISIONS ⚠1 1-31-83 COORDINATES CORRECTED
⚠2 5-4-83 DATUM CHANGED FROM MSL TO MCD

mmsd

FIGURE A-15 SHEET 1 OF 2

BORING LOG 130-19-CT

CT-3/4 COLLECTOR



DOLOMITE LT GRAY DENSE OCCAS VUGGY ZONES SOME THIN SHALY PARTINGS OCCAS ZONES OF NUMEROUS THIN SHALY PARTINGS OCCAS MOTTLED ZONES 138.5

DOLOMITE LT GRAY TO BROWNISH WITH OCCAS CHERT NODULES AND OCCAS CLOSE BEDDED THIN SHALY PARTINGS 147.0

DOLOMITE BROWNISH SOME THIN SHALY PARTINGS VERY FINE VUGS 152.0

DOLOMITE LT GRAY TO BROWNISH GRAY FINELY VUGGY TO DENSE WITH CLOSE BEDDED FINE TO COARSE CHERT NODULES AND SOME THIN SHALY PARTINGS 166.0

DOLOMITE LT GRAY FINELY VUGGY WITH OCCAS RARE CHERT NODULES 177.0

DOLOMITE LT GRAY DENSE WITH CLOSE TO WIDE BEDDED CHERT NODULES 197.0

DOLOMITE LT GRAY FINELY VUGGY WITH RARE FINE CHERT NODULES SOME THIN SHALY PARTINGS 220.7

DOLOMITE GRAY WITH CLOSE BEDDED THIN SHALY PARTINGS 23·.8

DOLOMITE GRAY FINELY VUGGY TO DENSE WITH SCATTERED CHERT NODULES AND ZONES OF REDDISH AND LT BROWN POROUS DOLOMITE 264.6

DOLOMITE LT GRAY WITH REDDISH AND LT BROWN POROUS ZONES AND VUGS FINE TO COARSE VUGS OCCAS CLAY LAYERS (0.1 MAX) CLAY FILLED VUGS VERY RARE CHERT NODULES

Note Boring continues to elev. -520.3'.

FIGURE A-15 SHEET 2 OF 2

BORING LOG 130-19-CT

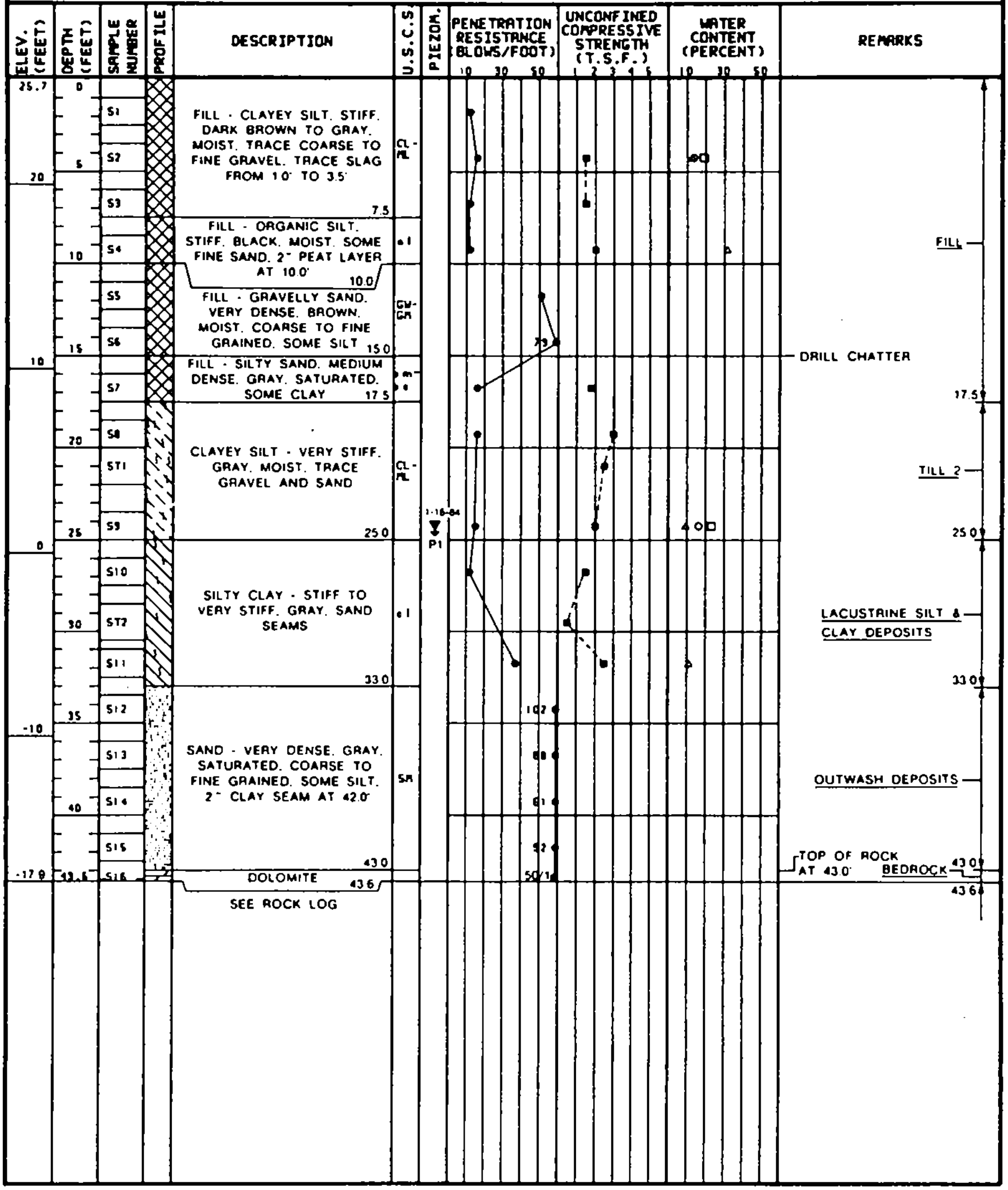
CT-3/4 COLLECTOR

C22J11 S0008

GROUND ELEV.: 25.7
NORTH COORD.: 383938
EAST COORD. : 2543214

PROJECT ID.: I35D11W.GA2
FIELD ENG./GEO.: S NEIMAN
DRILLER: J. JOHNSON

BORING NO.: I35-CTAS7R-1
DATE BEGAN: 7/ 5/1983
DATE COMPLETED: 7/ 6/1983



DESCRIPTION	U.S.C.S.
FILL - CLAYEY SILT, STIFF, DARK BROWN TO GRAY, MOIST, TRACE COARSE TO FINE GRAVEL, TRACE SLAG FROM 1.0' TO 3.5' 7.5	CL-ML
FILL - ORGANIC SILT, STIFF, BLACK, MOIST, SOME FINE SAND, 2" PEAT LAYER AT 10.0' 10.0	OL
FILL - GRAVELLY SAND, VERY DENSE, BROWN, MOIST, COARSE TO FINE GRAINED, SOME SILT 15.0	GW-GM
FILL - SILTY SAND, MEDIUM DENSE, GRAY, SATURATED, SOME CLAY 17.5	SM-SC
CLAYEY SILT - VERY STIFF, GRAY, MOIST, TRACE GRAVEL AND SAND 25.0	CL-ML
SILTY CLAY - STIFF TO VERY STIFF, GRAY, SAND SEAMS 33.0	CL
SAND - VERY DENSE, GRAY, SATURATED, COARSE TO FINE GRAINED, SOME SILT, 2" CLAY SEAM AT 42.0' 43.0	SM
DOLOMITE 43.6	
SEE ROCK LOG	

REMARKS

FILL

DRILL CHATTER

17.5

TILL 2

25.0

LACUSTRINE SILT & CLAY DEPOSITS

33.0

OUTWASH DEPOSITS

TOP OF ROCK AT 43.0'

BEDROCK

43.0

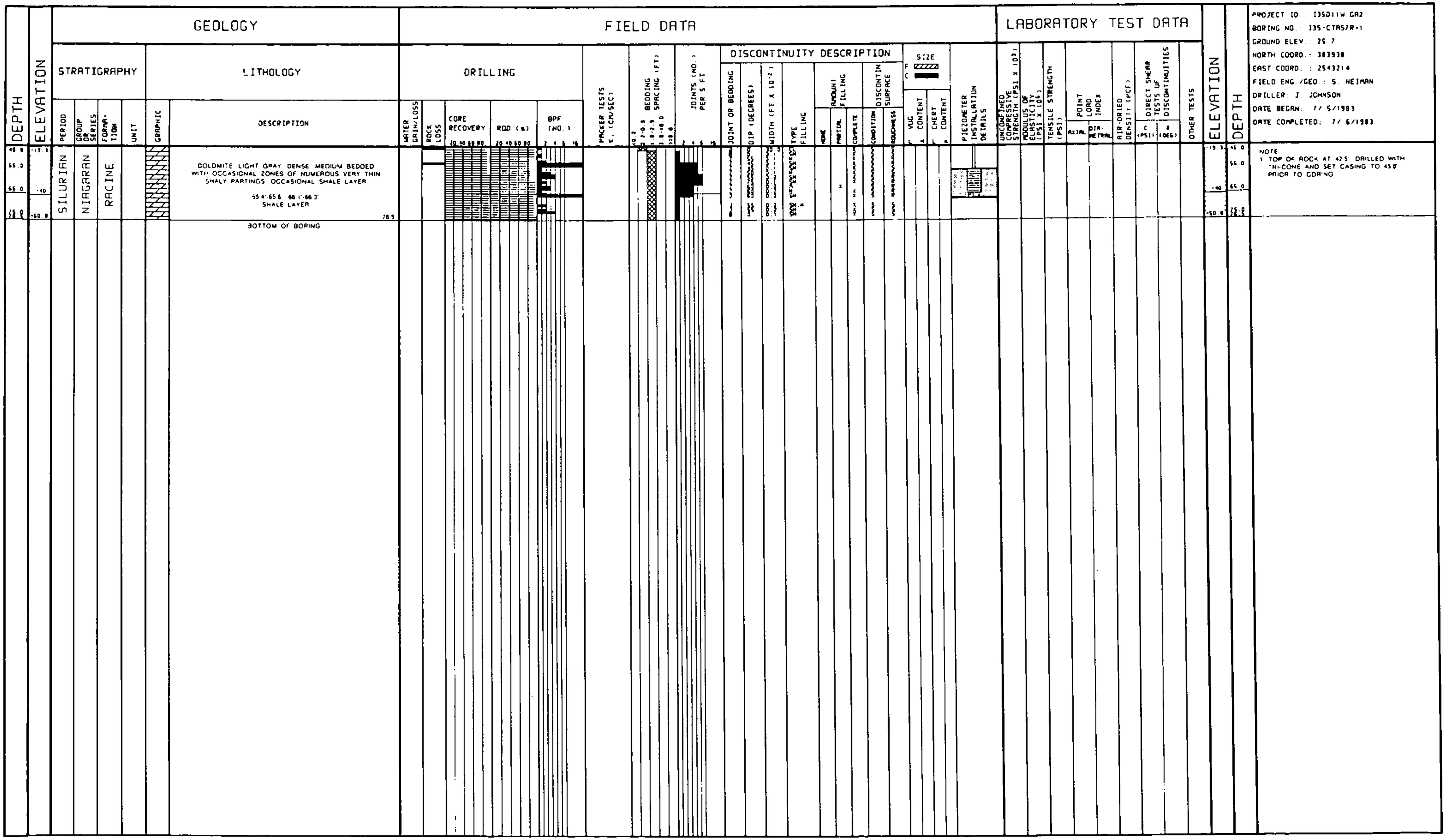
43.6

MMSD

SHEET 1 OF 2

BORING I35-CTAS7R-1

CROSSTOWN INTERCEPTOR SUPPLEMENT 2



PROJECT ID.: I35D11W.GA2
BORING NO.: I35-CTAS7R-1
GROUND ELEV.: 25.7
NORTH COORD.: 383930
EAST COORD. : 2543214
FIELD ENG./GEO.: S. NEIMAN
DRILLER: J. JOHNSON
DATE BEGAN: 7/ 5/1983
DATE COMPLETED: 7/ 6/1983

DOLOMITE LIGHT GRAY DENSE MEDIUM BEDDED WITH OCCASIONAL ZONES OF NUMEROUS VERY THIN SHALY PARTINGS OCCASIONAL SHALE LAYER

65.4'-65.6' 68.1'-68.3'
SHALE LAYER

BOTTOM OF BORING

NOTE
1 TOP OF ROCK AT 42.5' DRILLED WITH TRI-CONE AND SET CASING TO 45.0' PRIOR TO CORING

SHEET 2 OF 2

BORING I35-CTAS7R-1

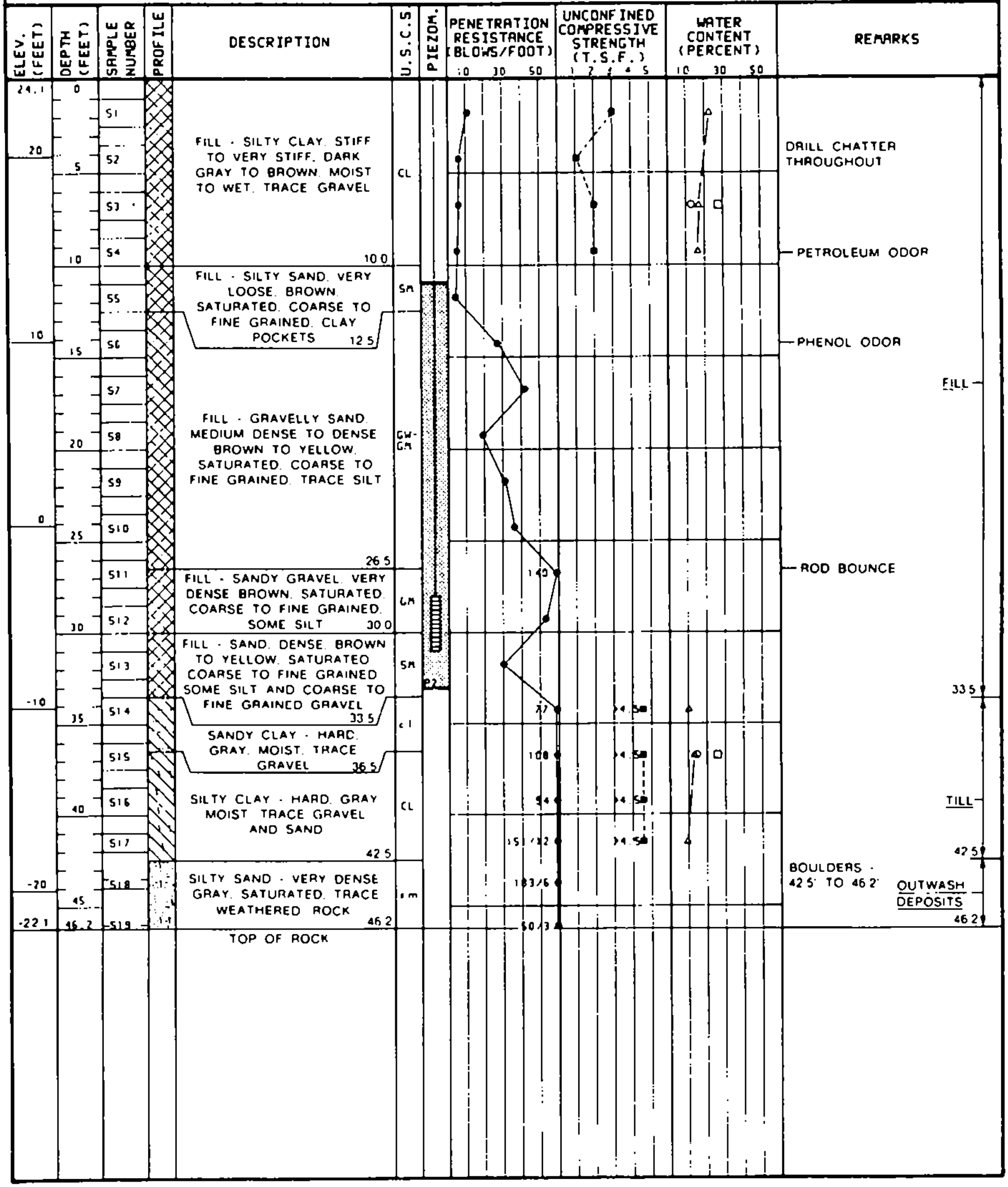
CROSSTOWN INTERCEPTOR SUPPLEMENT 2

I35D11 S0055

GROUND ELEV.: 24.1
NORTH COORD.: 383537
EAST COORD. : 2543253

PROJECT ID.: I35D11W.GA2
FIELD ENG./GEO.: S. NEIMAN
DRILLER: J. JOHNSON

BORING NO.: I35-CTAS7R-2
DATE BEGAN: 7/ 7/1983
DATE COMPLETED: 7/20/1983



DESCRIPTION	U.S.C.S.
FILL - SILTY CLAY, STIFF TO VERY STIFF, DARK GRAY TO BROWN, MOIST TO WET, TRACE GRAVEL 10.0	CL
FILL - SILTY SAND, VERY LOOSE, BROWN, SATURATED, COARSE TO FINE GRAINED, CLAY POCKETS 12.5	SM
FILL - GRAVELLY SAND, MEDIUM DENSE TO DENSE, BROWN TO YELLOW, SATURATED, COARSE TO FINE GRAINED, TRACE SILT 26.5	GW-GM
FILL - SANDY GRAVEL, VERY DENSE, BROWN, SATURATED, COARSE TO FINE GRAINED, SOME SILT 30.0	GM
FILL - SAND, DENSE, BROWN TO YELLOW, SATURATED, COARSE TO FINE GRAINED, SOME SILT AND COARSE TO FINE GRAINED GRAVEL 33.5	SM
SANDY CLAY - HARD, GRAY, MOIST, TRACE GRAVEL 36.5	CL
SILTY CLAY - HARD, GRAY, MOIST, TRACE GRAVEL AND SAND 42.5	CL
SILTY SAND - VERY DENSE, GRAY, SATURATED, TRACE WEATHERED ROCK 46.2	SM
TOP OF ROCK	

REMARKS

DRILL CHATTER THROUGHOUT

PETROLEUM ODOR

PHENOL ODOR

ROD BOUNCE

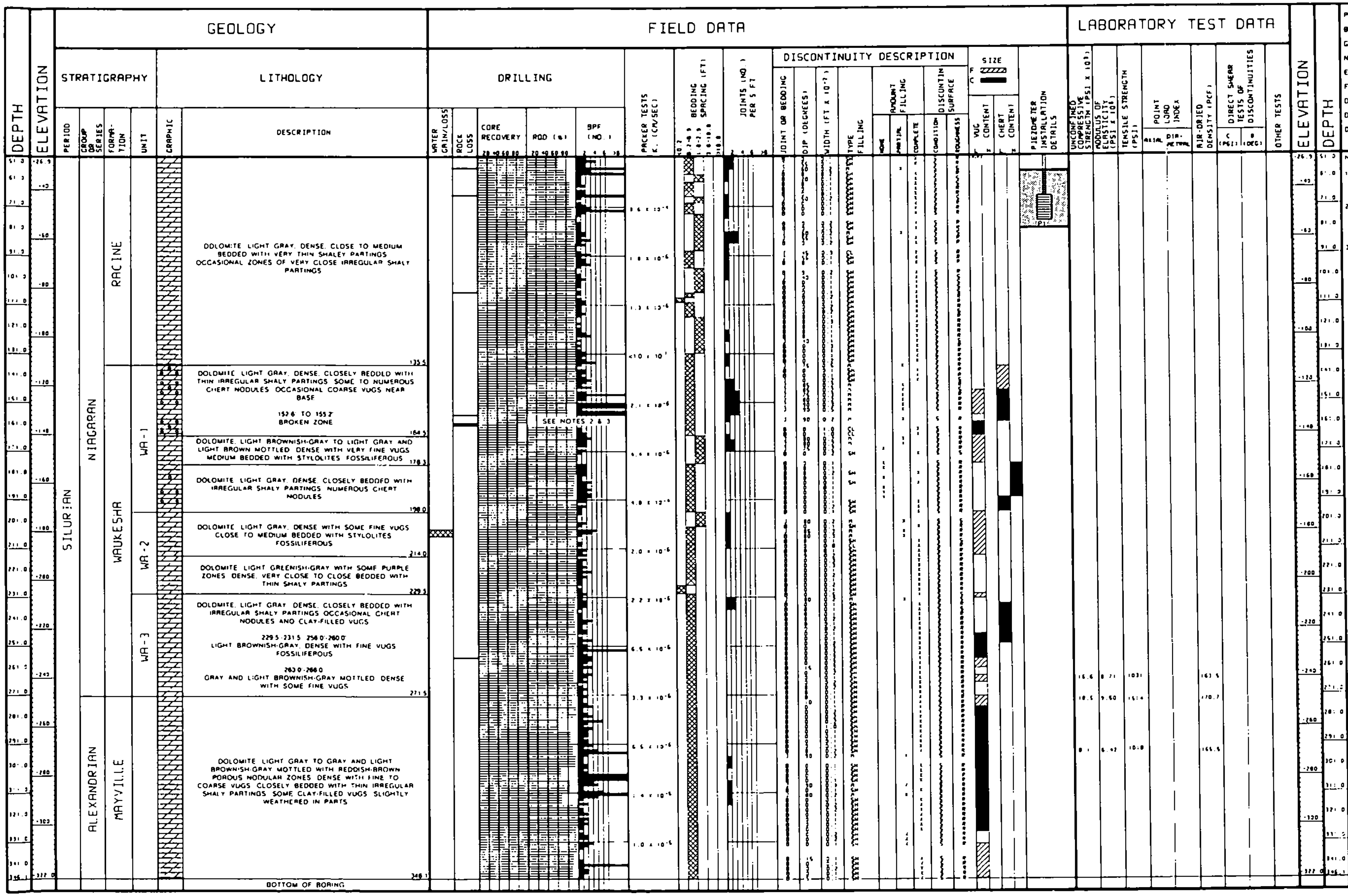
BOULDERS - 42.5' TO 46.2'

SHEET 1 OF 2

BORING I35-CTAS7R-2

CROSSTOWN INTERCEPTOR SUPPLEMENT 1

mmsd



DEPTH (bottom)	DESCRIPTION
135.5	DOLOMITE LIGHT GRAY, DENSE, CLOSE TO MEDIUM BEDDED WITH VERY THIN SHALEY PARTINGS OCCASIONAL ZONES OF VERY CLOSE IRREGULAR SHALY PARTINGS
164.5	DOLOMITE LIGHT GRAY, DENSE, CLOSELY BEDDED WITH THIN IRREGULAR SHALY PARTINGS SOME TO NUMEROUS CHERT NODULES OCCASIONAL COARSE VUGS NEAR BASE 152.6' TO 155.2' BROKEN ZONE
178.3	DOLOMITE, LIGHT BROWNISH-GRAY TO LIGHT GRAY AND LIGHT BROWN MOTTLED DENSE WITH VERY FINE VUGS MEDIUM BEDDED WITH STYLOLITES FOSSILIFEROUS
198.0	DOLOMITE LIGHT GRAY, DENSE, CLOSELY BEDDED WITH IRREGULAR SHALY PARTINGS NUMEROUS CHERT NODULES
214.0	DOLOMITE LIGHT GRAY, DENSE WITH SOME FINE VUGS CLOSE TO MEDIUM BEDDED WITH STYLOLITES FOSSILIFEROUS
229.5	DOLOMITE LIGHT GREENISH-GRAY WITH SOME PURPLE ZONES DENSE, VERY CLOSE TO CLOSE BEDDED WITH THIN SHALY PARTINGS
271.5	DOLOMITE, LIGHT GRAY DENSE, CLOSELY BEDDED WITH IRREGULAR SHALY PARTINGS OCCASIONAL CHERT NODULES AND CLAY-FILLED VUGS 229.5-231.5 256.0-260.0' LIGHT BROWNISH-GRAY, DENSE WITH FINE VUGS FOSSILIFEROUS 263.0-268.0 GRAY AND LIGHT BROWNISH-GRAY MOTTLED DENSE WITH SOME FINE VUGS
346.1	DOLOMITE LIGHT GRAY TO GRAY AND LIGHT BROWNISH-GRAY MOTTLED WITH REDDISH-BROWN POROUS NODULAR ZONES DENSE WITH FINE TO COARSE VUGS CLOSELY BEDDED WITH THIN IRREGULAR SHALY PARTINGS SOME CLAY-FILLED VUGS SLIGHTLY WEATHERED IN PARTS

BOTTOM OF BORING

PACKER TESTS K. (CM/SEC)

3.6 x 10⁻⁵
1.8 x 10⁻⁶
1.3 x 10⁻⁶
<1.0 x 10⁻⁷
2.1 x 10⁻⁶
4.4 x 10⁻⁶
4.8 x 10⁻⁶
2.0 x 10⁻⁶
2.2 x 10⁻⁶
6.5 x 10⁻⁶
3.3 x 10⁻⁶
6.5 x 10⁻⁶
1.4 x 10⁻⁵
1.0 x 10⁻⁵

UNCONFINED COMPRESSIVE STRENGTH (PSI x 10³)	MODULUS OF ELASTICITY (PSI x 10⁶)	TENSILE STRENGTH (PSI)	AIR-DRIED DENSITY (PCF)
16.6	8.71	1031	163.5
18.5	9.50	1514	170.7
8.1	6.42	1018	165.5

PROJECT ID.: I35D11W.GR2
BORING NO.: I35-CTAS7R-2
GROUND ELEV.: 24.1
NORTH COORD.: 383537
EAST COORD.: 2543253
FIELD ENG./GEO.: S. NEIMAN
DRILLER: J. JOHNSON
DATE BEGAN: 7/ 7/1983
DATE COMPLETED: 7/20/1983

NOTES

1. TOP OF ROCK AT 46.0'. DRILLED WITH TRI-CONE TO 51.0 AND SET CASING PRIOR TO CORING
2. RUN 156.2-159.0' EXTENSIVE MECHANICAL BREAKAGE. BPF DATA NOT PRESENTED. RQD NOT PRESENTED FOR 5-FOOT INTERVAL CONTAINING THIS RUN
3. RUN 159.0'-166.0 TOP 1.3' OF RUN APPARENTLY GROUND UP. BPF DATA NOT PRESENTED FOR THAT PART OF RUN. RQD NOT PRESENTED FOR 5-FOOT INTERVAL CONTAINING THAT PART OF RUN

MMSD

SHEET 2 OF 2

BORING I35-CTAS7R-2

CROSSTOWN INTERCEPTOR SUPPLEMENT 1
I35D11 S0018

Hole No. MEN0106

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT: USACE Menomonee River, Milwaukee, Wisconsin
2. LOCATION (Coordinates or Station): 43 02 18.833 N, 87 57 53.955 W (8' 6" W offset)
3. DRILLING AGENCY: Altech Environmental, Coleman Engineering
4. HOLE NO. (As shown on drawing title and file number): MEN0106
5. NAME OF DRILLER: Randy Ochs/Rick Scott
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: > 31"
8. DEPTH DRILLED INTO ROCK: 0
9. TOTAL DEPTH OF HOLE: 31"
10. SIZE AND TYPE OF BIT: 4" Diamond Drill and 2" Bucket Auger
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURES'S DESIGNATION OF DRILL: Hand Auger
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 1 UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: NA
15. ELEVATION GROUND WATER: Unknown
16. DATE HOLE: STARTED 6/20/01 COMPLETED 6/20/01
17. ELEVATION TOP OF HOLE: Unknown
18. TOTAL CORE RECOVERY FOR BORING: NA %
19. SIGNATURE OF INSPECTOR:

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOVERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00–0.83	Concrete			
	0.83	0.83–2.58	GW, Tan-brown gravely-sand, moist, medium to coarse grain, subrounded sand, 30-40% gravel.	N/A	MEN0106A	
	2.58		Refusal, End of boring at 31" Cement Grout Borehole			Concrete cored with 4" diamond drill. Samples collected with 2" hand auger.
	4					
	6					
	8					

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE. (modified by GCA 1/94) PROJECT USACE Menomonee River HOLE NO. MEN0106

Hole No. MEN0107

DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT
USACE Menomonee River, Milwaukee, Wisconsin

2. LOCATION (Coordinates or Station)
43 02 17.001 N, 87 57 53.608 W

3. DRILLING AGENCY
Altech Environmental, Coleman Engineering

4. HOLE NO. (As shown on drawing title and file number) MEN0107

5. NAME OF DRILLER
Randy Ochs/Rick Scott

6. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ________ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN > 31"

8. DEPTH DRILLED INTO ROCK 0

9. TOTAL DEPTH OF HOLE 31"

10. SIZE AND TYPE OF BIT 4" Diamond Drill and 2" Bucket Auger

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURES'S DESIGNATION OF DRILL
Hand Auger

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED 1 UNDISTURBED 0

14. TOTAL NUMBER CORE BOXES NA

15. ELEVATION GROUND WATER Unknown

16. DATE HOLE STARTED 6/20/01 COMPLETED 6/20/01

17. ELEVATION TOP OF HOLE Unknown

18. TOTAL CORE RECOVERY FOR BORING NA %

19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOV-ERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00–0.75	Concrete			
	0.75	0.75–2.58	CL, Reddish-brown silty-clay, low plasticity, damp, 20% silt, 10% fine to medium grain sand, 5% subrounded gravel to 0.5", most gravel 0.25"	N/A	MEN0107A	
	2.58		Refusal, End of boring at 31" Cement Grout Borehole			Concrete cored with 4" diamond drill. Samples collected with 2" hand auger.
	4					
	6					
	8					

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE. (modified by GCA 1/94)

PROJECT USACE Menomonee River

HOLE NO. MEN0107

Hole No. MEN0108

DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT
USACE Menomonee River, Milwaukee, Wisconsin

2. LOCATION (Coordinates or Station)
43 02 16.115 N, 87 57 54.054 W

3. DRILLING AGENCY
Altech Environmental, Coleman Engineering

4. HOLE NO. (As shown on drawing title and file number) MEN0108

5. NAME OF DRILLER
Randy Ochs/Rick Scott

6. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED _______ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN > 1.75'

8. DEPTH DRILLED INTO ROCK 0

9. TOTAL DEPTH OF HOLE 1.75'

10. SIZE AND TYPE OF BIT 4" Diamond Drill and 2" Bucket Auger

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURES'S DESIGNATION OF DRILL
Hand Auger

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 1 — UNDISTURBED 0

14. TOTAL NUMBER CORE BOXES NA

15. ELEVATION GROUND WATER Unknown

16. DATE HOLE — STARTED 6/21/01 — COMPLETED 6/21/01

17. ELEVATION TOP OF HOLE Unknown

18. TOTAL CORE RECOVERY FOR BORING NA %

19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOV-ERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00–0.75	Concrete			
	0.75	0.75–1.75	GM, Gray gravelly-silt, wet, 60% silt, 20% gravel, 15% sand, 5% clay, cobbles.	N/A	MEN0108A	
	1.75		Refusal, End of boring at 1.75' Cement Grout Borehole			Concrete cored with 4" diamond drill. Samples collected with 2" hand auger.
	4					
	6					
	8					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (modified by GCA 1/94)

PROJECT USACE Menomonee River

HOLE NO. MEN0108

Hole No. MEN0109

DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT
USACE Menomonee River, Milwaukee, Wisconsin

2. LOCATION (Coordinates or Station)
43 02 14.361 N, 87 57 54.085 W

3. DRILLING AGENCY
Altech Environmental, Coleman Engineering

4. HOLE NO. (As shown on drawing title and file number) MEN0109

5. NAME OF DRILLER
Randy Ochs/Rick Scott

6. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN > 2.92'

8. DEPTH DRILLED INTO ROCK 0

9. TOTAL DEPTH OF HOLE 2.92'

10. SIZE AND TYPE OF BIT 6" Diamond Drill and 4" Bucket Auger

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURES'S DESIGNATION OF DRILL
Hand Auger

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 1 — UNDISTURBED 0

14. TOTAL NUMBER CORE BOXES NA

15. ELEVATION GROUND WATER Unknown

16. DATE HOLE — STARTED 6/22/01 — COMPLETED 6/22/01

17. ELEVATION TOP OF HOLE Unknown

18. TOTAL CORE RECOVERY FOR BORING NA %

19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOV-ERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00-0.83	Concrete			
	0.83	0.83-2.92	GM, Gray gravelly-silt, wet, 60% silt, 20% gravel, 15% sand, 5% clay, cobbles.	N/A	MEN0109A	
	2.92		Refusal, End of boring at 2.92' Cement Grout Borehole			Concrete cored with 6" diamond drill. Samples collected with 4" hand auger.
	4					
	6					
	8					

ENG FORM 1836 MAR 71 — PREVIOUS EDITIONS ARE OBSOLETE. (modified by GCA 1/94)

PROJECT USACE Menomonee River

HOLE NO. MEN0109

Hole No. MEN0110

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT
USACE Menomonee River, Milwaukee, Wisconsin

2. LOCATION (Coordinates or Station)
43 02 13.556 N, 87 57 55.362 W

3. DRILLING AGENCY
Altech Environmental, Coleman Engineering

4. HOLE NO. (As shown on drawing title and file number) MEN0110

5. NAME OF DRILLER
Randy Ochs/Rick Scott

6. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED _______ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN > 2.67'

8. DEPTH DRILLED INTO ROCK 0

9. TOTAL DEPTH OF HOLE 2.67'

10. SIZE AND TYPE OF BIT 4" Diamond Drill and 2" Bucket Auger

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURES'S DESIGNATION OF DRILL
Hand Auger

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED 1 | UNDISTURBED 0

14. TOTAL NUMBER CORE BOXES NA

15. ELEVATION GROUND WATER Unknown

16. DATE HOLE | STARTED 6/21/01 | COMPLETED 6/21/01

17. ELEVATION TOP OF HOLE Unknown

18. TOTAL CORE RECOVERY FOR BORING NA %

19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOVERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00-0.67	Concrete			
	0.67	0.67-2.67	GM, Gray gravelly-silt, wet, 60% silt, 20% gravel, 15% sand, 5% clay, cobbles.	N/A	MEN0110A	
	2.67		Refusal, End of boring at 2.67' Cement Grout Borehole			Concrete cored with 4" diamond drill. Samples collected with 2" hand auger.
	4					
	6					
	8					

ENG FORM MAR 71	1836	PREVIOUS EDITIONS ARE OBSOLETE. (modified by GCA 1/94)	PROJECT USACE Menomonee River	HOLE NO. MEN0110

Hole No. MEN0111

DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT
USACE Menomonee River, Milwaukee, Wisconsin

2. LOCATION (Coordinates or Station)
43 02 11.641 N, 87 57 57.366 W

3. DRILLING AGENCY
Altech Environmental, Coleman Engineering

4. HOLE NO. (As shown on drawing title and file number) MEN0111

5. NAME OF DRILLER
Randy Ochs/Rick Scott

6. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN > 1.25'

8. DEPTH DRILLED INTO ROCK 0

9. TOTAL DEPTH OF HOLE 1.25'

10. SIZE AND TYPE OF BIT 6" Diamond Drill and 4" Bucket Auger

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURES'S DESIGNATION OF DRILL
Hand Auger

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 1 — UNDISTURBED 0

14. TOTAL NUMBER CORE BOXES NA

15. ELEVATION GROUND WATER Unknown

16. DATE HOLE — STARTED 6/21/01 — COMPLETED 6/21/01

17. ELEVATION TOP OF HOLE Unknown

18. TOTAL CORE RECOVERY FOR BORING NA %

19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOVERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00–0.75	Concrete			
	0.75	0.75–1.25	SM, Tan-brown gravelly-sand, 40% gravel.	N/A	MEN0111A	
	1.25		Refusal, End of boring at 1.25' Cement Grout Borehole			Concrete cored with 6" diamond drill. Samples collected with 4" hand auger.
	4					
	6					
	8					

ENG FORM 1836 MAR 71 — PREVIOUS EDITIONS ARE OBSOLETE. (modified by GCA 1/94)

PROJECT USACE Menomonee River — HOLE NO. MEN0111

Hole No. MEN0112

DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT
USACE Menomonee River, Milwaukee, Wisconsin

2. LOCATION (Coordinates or Station)
43 02 09.812 N, 87 57 59.785 W

3. DRILLING AGENCY
Altech Environmental, Coleman Engineering

4. HOLE NO. (As shown on drawing title and file number) MEN0112

5. NAME OF DRILLER
Randy Ochs/Rick Scott

6. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ________ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN > 1.167'

8. DEPTH DRILLED INTO ROCK 0

9. TOTAL DEPTH OF HOLE 1.167'

10. SIZE AND TYPE OF BIT 6" Diamond Drill and 4" Bucket Auger

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURES'S DESIGNATION OF DRILL
Hand Auger

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 1 — UNDISTURBED 0

14. TOTAL NUMBER CORE BOXES NA

15. ELEVATION GROUND WATER Unknown

16. DATE HOLE — STARTED 6/21/01 — COMPLETED 6/21/01

17. ELEVATION TOP OF HOLE Unknown

18. TOTAL CORE RECOVERY FOR BORING NA %

19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOV-ERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00-0.75	Concrete			
	0.75	0.75-1.167	SM, Tan-brown gravelly-sand, 40% gravel.	N/A	MEN0112A	
	1.167		Refusal, End of boring at 1.167' Cement Grout Borehole			Concrete cored with 6" diamond drill. Samples collected with 4" hand auger.
	4					
	6					
	8					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.
MAR 71 (modified by GCA 1/94)

PROJECT
USACE Menomonee River

HOLE NO.
MEN0112

Hole No. MEN0113

DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT
USACE Menomonee River, Milwaukee, Wisconsin

2. LOCATION (Coordinates or Station)
43 02 07.741 N, 87 58 01.844 W

3. DRILLING AGENCY
Altech Environmental, Coleman Engineering

4. HOLE NO. (As shown on drawing title and file number) MEN0113

5. NAME OF DRILLER
Randy Ochs/Rick Scott

6. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ________ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN > 3'

8. DEPTH DRILLED INTO ROCK 0

9. TOTAL DEPTH OF HOLE 3'

10. SIZE AND TYPE OF BIT 6" Diamond Drill and 4" Bucket Auger

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURES'S DESIGNATION OF DRILL
Hand Auger

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 1 — UNDISTURBED 0

14. TOTAL NUMBER CORE BOXES NA

15. ELEVATION GROUND WATER Unknown

16. DATE HOLE — STARTED 6/26/01 — COMPLETED 6/26/01

17. ELEVATION TOP OF HOLE Unknown

18. TOTAL CORE RECOVERY FOR BORING NA %

19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOV-ERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00-0.75	Concrete			
	0.75	0.75-3	SM, Reddish gray-brown, silty-clay, 30% silt, 10% fine sand, 10% subrounded gravel.	N/A	MEN0113A	
	3		Refusal, End of boring at 3' Cement Grout Borehole			Concrete cored with 6" diamond drill. Samples collected with 4" hand auger.
	4					
	6					
	8					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (modified by GCA 1/94)

PROJECT USACE Menomonee River

HOLE NO. MEN0113

Hole No. MEN0114

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT
USACE Menomonee River, Milwaukee, Wisconsin

2. LOCATION (Coordinates or Station)
43 02 05.606 N, 87 58 02.990 W

3. DRILLING AGENCY
Altech Environmental, Coleman Engineering

4. HOLE NO. (As shown on drawing title and file number) MEN0114

5. NAME OF DRILLER
Randy Ochs/Rick Scott

6. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ________ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN > 10"

8. DEPTH DRILLED INTO ROCK 0

9. TOTAL DEPTH OF HOLE 10"

10. SIZE AND TYPE OF BIT 6" Diamond Drill and 4" Bucket Auger

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURES'S DESIGNATION OF DRILL
Hand Auger

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED 0 UNDISTURBED 0

14. TOTAL NUMBER CORE BOXES NA

15. ELEVATION GROUND WATER Unknown

16. DATE HOLE STARTED 6/26/01 COMPLETED 6/26/01

17. ELEVATION TOP OF HOLE Unknown

18. TOTAL CORE RECOVERY FOR BORING NA %

19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOV-ERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00-0.83	Concrete	N/A	N/A	No sample taken, sediment inaccessible due to gravel at surface. Concrete cored with 6" diamond drill.
	0.83		Refusal, End of boring at 10" Cement Grout Borehole			
	2					
	4					
	6					
	8					

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE. (modified by GCA 1/94)

PROJECT USACE Menomonee River

HOLE NO. MEN0114

Hole No. MEN0115

DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT
USACE Menomonee River, Milwaukee, Wisconsin

2. LOCATION (Coordinates or Station)
43 02 02.561 N, 87 58 03.380 W

3. DRILLING AGENCY
Altech Environmental, Coleman Engineering

4. HOLE NO. (As shown on drawing title and file number) MEN0115

5. NAME OF DRILLER
Randy Ochs/Rick Scott

6. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ________ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN > 6"

8. DEPTH DRILLED INTO ROCK 0

9. TOTAL DEPTH OF HOLE 6"

10. SIZE AND TYPE OF BIT 6" Diamond Drill and 4" Bucket Auger

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURES'S DESIGNATION OF DRILL
Hand Auger

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 0 — UNDISTURBED 0

14. TOTAL NUMBER CORE BOXES NA

15. ELEVATION GROUND WATER Unknown

16. DATE HOLE — STARTED 6/25/01 — COMPLETED 6/25/01

17. ELEVATION TOP OF HOLE Unknown

18. TOTAL CORE RECOVERY FOR BORING NA ✖

19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOV-ERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00-0.5	Concrete	N/A	N/A	No sample taken, sediment inaccessible due to gravel at surface. Concrete cored with 6" diamond drill.
	0.5		Refusal, End of boring at 6" Cement Grout Borehole			
	2					
	4					
	6					
	8					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (modified by GCA 1/94)

PROJECT USACE Menomonee River

HOLE NO. MEN0115

Hole No. MEN0116

DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT
USACE Menomonee River, Milwaukee, Wisconsin

2. LOCATION (Coordinates or Station)
43 02 02.482 N, 87 58 04.622 W

3. DRILLING AGENCY
Altech Environmental, Coleman Engineering

4. HOLE NO. (As shown on drawing title and file number) MEN0116

5. NAME OF DRILLER
Randy Ochs/Rick Scott

6. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ________ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN > 6"

8. DEPTH DRILLED INTO ROCK 0

9. TOTAL DEPTH OF HOLE 6"

10. SIZE AND TYPE OF BIT 6" Diamond Drill and 4" Bucket Auger

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURES'S DESIGNATION OF DRILL
Hand Auger

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED 0 UNDISTURBED 0

14. TOTAL NUMBER CORE BOXES NA

15. ELEVATION GROUND WATER Unknown

16. DATE HOLE STARTED 6/26/01 COMPLETED 6/26/01

17. ELEVATION TOP OF HOLE Unknown

18. TOTAL CORE RECOVERY FOR BORING NA %

19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOV-ERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00-0.5	Concrete	N/A	N/A	No sample taken, sediment inaccessible due to gravel at surface. Concrete cored with 6" diamond drill.
	0.5		Refusal, End of boring at 6" Cement Grout Borehole			
	2					
	4					
	6					
	8					

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE. (modified by GCA 1/94)

PROJECT USACE Menomonee River

HOLE NO. MEN0116

Hole No. MEN0117

DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT
USACE Menomonee River, Milwaukee, Wisconsin

2. LOCATION (Coordinates or Station)
43 01 59.401 N, 87 58 04.444 W

3. DRILLING AGENCY
Altech Environmental, Coleman Engineering

4. HOLE NO. (As shown on drawing title and file number) MEN0117

5. NAME OF DRILLER
Randy Ochs/Rick Scott

6. DIRECTION OF HOLE
☒ VERTICAL ☐ INCLINED ________ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN > 2'

8. DEPTH DRILLED INTO ROCK 0

9. TOTAL DEPTH OF HOLE 2'

10. SIZE AND TYPE OF BIT 6" Diamond Drill and 4" Bucket Auger

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURES'S DESIGNATION OF DRILL
Hand Auger

13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED 1 | UNDISTURBED 0

14. TOTAL NUMBER CORE BOXES NA

15. ELEVATION GROUND WATER Unknown

16. DATE HOLE | STARTED 6/26/01 | COMPLETED 6/26/01

17. ELEVATION TOP OF HOLE Unknown

18. TOTAL CORE RECOVERY FOR BORING NA %

19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOVERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00–0.83	Concrete			
	0.83	0.83–2	GC, Gray-brown, gravelly-clayey sand, 30% subrounded gravel, 20% clay-silt, fine to medium subrounded sand.	N/A	MEN0117A	
	2		Refusal, End of boring at 2' Cement Grout Borehole			Concrete cored with 6" diamond drill. Samples collected with 4" hand auger.
	4					
	6					
	8					

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE. (modified by GCA 1/94)

PROJECT USACE Menomonee River

HOLE NO. MEN0117

Hole No. MEN0122

DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT USACE Menomonee River, Milwaukee, Wisconsin
2. LOCATION (Coordinates or Station) 43 02 07.741 N, 87 58 01.844 W (1' South of MEN0113)
3. DRILLING AGENCY Altech Environmental, Coleman Engineering
4. HOLE NO. (As shown on drawing title and file number) MEN0122
5. NAME OF DRILLER Randy Ochs/Rick Scott
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN > 4.5'
8. DEPTH DRILLED INTO ROCK 0
9. TOTAL DEPTH OF HOLE 4.5'
10. SIZE AND TYPE OF BIT 6" Diamond Drill and 4" Bucket Auger
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURES'S DESIGNATION OF DRILL Hand Auger
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED 1 UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES NA
15. ELEVATION GROUND WATER Unknown
16. DATE HOLE STARTED 6/26/01 COMPLETED 6/26/01
17. ELEVATION TOP OF HOLE Unknown
18. TOTAL CORE RECOVERY FOR BORING NA %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	CORE RECOV-ERY (ft.) e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
	0	0.00-0.75	Concrete			
	0.75	0.75-4.5	Top 6", ML, Reddish-brown slity-clay, 30% silt, 10% subrounded gravel. 6"-18", ML, Gray slity-clay, moist, 10% gravel. 18"-45", SC, Gray clayey-sand, fine grained sand, 10-20% subrounded gravel.	N/A	MEN0113A	
	2					
	4.5		Refusal, End of boring at 4.5' Cement Grout Borehole			Concrete cored with 6" diamond drill. Samples collected with 4" hand auger.
	6					
	8					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (modified by GCA 1/94)

PROJECT USACE Menomonee River

HOLE NO. MEN0122

LOG OF TEST BORING

Project Valley Park Flood Control Plan

Location Northing: 383,677.01 Easting: 2,543,241.59

Soil Testing Firm Underground Power Company, Franksville, WI

Boring No. Test Pit #1

Surface Elevation 20.60

Project No 4378

Sheet 1 of 2

SAMPLE | **SOIL PROPERTIES**

RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type			N	Depth						
1	Grab		M		1	TOPSOIL - brown, moist, roots and other organics, some gravel 1.0'					
2	Grab		M		2	FILL - sand, some gravel, trace cinders, other trash including glass soda and milk bottles, bed frame, corrugated steel trash can, bricks					
3	Gra		M		3	Fill materials are of varying colors					17.2
4	Gra		M		4						
5	Gra		M		5	5.0'					
6	Gra		M		6	FILL- silty sand, some gravel, yellowish brown, some glass 6.0'					
7	Gra		M		7	SILTY SAND (SM) - yellowish brown, moist, some gravel 7.0'					
8	Gra		M		8	SILTY SAND (SM) - dense, light brown, moist, trace clay, trace gravel, layer displays slight cementation 8.0'					
9	Gra		M		9	SANDY GRAVEL (GW) - grayish brown, moist, trace cobbles					

WATER LEVEL OBSERVATIONS

While Drilling 13

Depth to Water

GENERAL NOTES

Start 1/6/00 Complete 1/6/00

Crew Chief Rig

Drilling Method

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location Northing: 383,677.01 Easting: 2,543,241.59
Soil Testing Firm Underground Power Company, Franksville, WI

Boring No. Test Pit #1
Surface Elevation 20.60
Project No 4378
Sheet 2 of 2

SAMPLE							SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type			N	Depth						
10	Grab		M		10	SANDY GRAVEL (GW) - grayish brown, moist, trace cobbles					2.2
11	Grab		M		11						
12	Gra		M		12						
13	Gra		S		13	12.5' SAND (SP) - reddish brown, moist to saturated, trace gravel, trace silt, medium grained, poorly graded					4.2
						End of Test Pit at 13 feet					

WATER LEVEL OBSERVATIONS

While Drilling 13
Depth to Water

GENERAL NOTES

Start 1/6/00 Complete 1/6/00
Crew Chief Rig
Drilling Method

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location 421 N. 42nd Street, Milwaukee, WI
Soil Testing Firm Underground Power Company, Franksville, WI

Boring No. Test Pit #3
Surface Elevation
Project No 4378
Sheet 1 of 2

SAMPLE							SOIL PROPERTIES				
RECOVERY (inches) No	Type	↓	MOISTURE ↓	N	Depth	VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
1	Grab		M		1	TOPSOIL - brown, moist, roots and other organics, some gravel 1.0'					
2	Grab		M		2	FILL - silty sand, some gravel, trace cinders, ash like, other trash including glass bottles, assorted pieces of metal, some ceramics.					
3	Gra		M		3	Fill materials are of varying colors					
4	Gra		M		4						
5	Gra		M		5						
6	Gra		M		6						
7	Gra		M		7						
8	Gra		M		8	8.0'					
9	Gra		M		9	SANDY GRAVEL (GW) - brown, moist, trace cobbles					

WATER LEVEL OBSERVATIONS

While Drilling Not Encountered
Depth to Water

GENERAL NOTES

Start 4/19/00 Complete 4/19/00
Crew Chief Frank Rig Backhoe
Drilling Method Dug Pit

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location 421 N. 42nd Street, Milwaukee, WI
Soil Testing Firm Underground Power Company, Franksville, WI

Boring No. Test Pit #3
Surface Elevation
Project No 4378
Sheet 2 of 2

SAMPLE							SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type	↓	↓	N	Depth						
10	Grab		M		10	SANDY GRAVEL (GW) - brown, moist, trace cobbles					
11	Grab		M		11	11'					
						End of Boring at 11 feet					

WATER LEVEL OBSERVATIONS

While Drilling Not Encountered
Depth to Water

GENERAL NOTES

Start 4/19/00 Complete 4/19/00
Crew Chief Frank Rig Backhoe
Drilling Method

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location 4223 West St. Paul Avenue, Milwaukee, WI
Soil Testing Firm Underground Power Company, Franksville, WI

Boring No. Test Pit #4
Surface Elevation
Project No 4378
Sheet 1 of 2

SAMPLE							SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type	↓	↓	N	Depth						
1	Grab		M		1	TOPSOIL - brown, moist, roots and other organics, some gravel 0.5'					
2	Grab		M		2	FILL - silty sand, some gravel, trace cinders, ash like, other trash including glass bottles, assorted pieces of metal, some bricks.					
3	Gra		M		3	Fill materials are of varying colors					
4	Gra		M		4						
5	Gra		M		5	5.0'					
6	Gra		M		6	SAND (SW) - well graded sand with some gravel, brown, moist					
7	Gra		M		7	7.0'					
8	Gra		M		8	SANDY CLAY (CL) - dark brown, moist, trace gravel					
9	Gra		M		9						

WATER LEVEL OBSERVATIONS

While Drilling Not Encountered
Depth to Water

GENERAL NOTES

Start 4/19/00 Complete 4/19/00
Crew Chief Frank Rig Backhoe
Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan

Location 4223 West St. Paul Avenue, Milwaukee, WI

Soil Testing Firm Underground Power Company, Franksville, WI

Boring No. Test Pit #4

Surface Elevation

Project No 4378

Sheet 2 of 2

SAMPLE **SOIL PROPERTIES**

RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type			N	Depth						
10	Grab		M		10	9.5' SANDY GRAVEL (GW) - yellowish brown, moist, trace cobbles 10'					
						End of Boring at 10 feet					

WATER LEVEL OBSERVATIONS

While Drilling Not Encountered

Depth to Water

GENERAL NOTES

Start 4/19/00 Complete 4/19/00

Crew Chief Frank Rig Backhoe

Drilling Method

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location Northing: 383,428.00 Easting: 2,543,426.20
Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B10
Surface Elevation 20.38
Project No 4378
Sheet 1 of 1

SAMPLE							SOIL PROPERTIES				
No	Type	RECOVERY (inches)	MOISTURE	N	Depth	VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
1	SS	12	M	7	2.5	TOPSOIL - 12" FILL - Silty Clay (CL) - stiff, brown, moist, trace gravel	3.0	21.9			
2	SS	12	M	5	5.0	3.5' FILL - Sand (SP) - dense, brown, moist, poorly graded, coarse to medium grained sand with some gravel		17.1			
3	SS	12	M	15	7.5			7.8			
4	SS	2	M	14	10.0			11.7			
5	SS	8	M	38	12.5	10' GRAVEL (GW) - dense, brown, moist to saturated, well graded gravel with some sand and trace silt		5.1			8.5
6	SS	12	S	24	15.0			8.8			
					17.5						
7	SS	10	S	14	20.0	18.5' SAND (SP) - dense, brown, saturated, poorly graded, coarse grained sand with some gravel		14.0			
						End of Boring at 20' Abandoned in accordance with NR 141.25.					

WATER LEVEL OBSERVATIONS

While Drilling 13'
Depth to Water

GENERAL NOTES

Start 12/22/99 Complete 12/22/99
Crew Chief Kevin Rig Diedrich D120
Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan

Location Northing: 383,430.11 Easting: 2,543,304.20

Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B11

Surface Elevation 19.10

Project No 4378

Sheet 1 of 2

SAMPLE							SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type	↓	↓	N	Depth						
1	SS	12	M	28	2.5	TOPSOIL - 12" FILL - Silty Clay (CL) - medium stiff to stiff, brown, moist, trace gravel	1.0	12.2			
2	SS	6	M	4	5.0		0.5	23.8			
3	SS	10	M	6	7.5	6.0' FILL - Sand (SP) - medium dense to dense, brown, moist to saturated, poorly graded, coarse grained sand with some gravel		7.0			
4	SS	2	M	24	10.0			12.0			
5	SS	0	-	50/6"	12.5	possible cobble					
6	SS	12	S	6	15.0			19.3			
					17.5						
7	SS	18	S	24	20.0	18.5' SILTY CLAY (CL) - hard, brown, saturated, little gravel, trace sand	4.5	10.2	18	10	50.1
					22.5						

WATER LEVEL OBSERVATIONS

While Drilling 13.5'

Depth to Water

GENERAL NOTES

Start 12/27/99 Complete 12/27/99

Crew Chief Ken Rig Diedrich D120

Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location Northing: 383,430.11 Easting: 2,543,304.20
Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B11
Surface Elevation 19.10
Project No 4378
Sheet 2 of 2

SAMPLE							SOIL PROPERTIES				
No	Type	RECOVERY (inches)	MOISTURE	N	Depth	VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
8	SS	16	S	34	25	23.5' SAND (SP) - dense, brown, saturated, poorly graded, coarse grained sand with some gravel		9.0			
					27.5						
9	SS	0	S	50/1"	30	Obstruction, possible boulder, at 29 feet					
						End of Boring at 29 feet Abandoned in accordance with NR 141.25					
						A 140 lb. automatic impact hammer was used to perform the Standard Penetration Test. Qu values are readings recorded by a Pocket Penetrometer.					

WATER LEVEL OBSERVATIONS

While Drilling 13.5'
Depth to Water

GENERAL NOTES

Start 12/27/99 Complete 12/27/99
Crew Chief Ken Rig Diedrich D120
Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan

Location Northing: 384,288.18 Easting: 2,543,304.20

Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B12

Surface Elevation 21.99

Project No 4378

Sheet 1 of 1

SAMPLE **SOIL PROPERTIES**

RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type	↓	↓	N	Depth						
1	SS	12	M	7	2.5	CONCRETE - 4" FILL - mix of sand gravel and clay, brown, moist		17.6			
2	SS	10	M	8	5.0	4.0' FILL - Silty Sand (SM) - medium dense, brown, moist, trace gravel		9.8			
3	SS	12	M	6	7.5			4.6			
4	SS	8	M	28	10.0	9.0 FILL - Gravel (GP) dense, brown, moist, angular gravel with sand		4.0			
5	SS	18	M	21	12.5	11.0 SANDY CLAY (CL) - stiff to very stiff, brown, moist, some silt, trace gravel	1.5	11.1			
6	SS	18	M	29	15.0		3.5	10.9	18	10	52.0
					17.5	Shelby Tube collected 18 to 18.5 feet 18					
7	SS	18	M	24	20.0	CLAYEY SAND (SC) - medium dense, brown, moist 18.5 SANDY CLAY (CL) - very stiff, brown, moist, some silt, trace gravel	3.0	9.4 10.0	23	12	48.7
						End of Boring at 20.0 feet Abandoned in Accordance with NR 141.25 140 lb. Automatic Impact Hammer used for S.P.T. Qu = Pocket Penetrometer Readings					

WATER LEVEL OBSERVATIONS

While Drilling Not Encountered

Depth to Water

GENERAL NOTES

Start 1/26/00 Complete 1/26/00

Crew Chief Kevin Rig Diedrich D120

Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan

Location Northing: 383,378.03 Easting: 2,543,271.64

Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B1 (PZ-1)

Surface Elevation 18.51

Project No 4378

Sheet 1 of 2

SAMPLE **SOIL PROPERTIES**

RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type	↓	↓	N	Depth						
1	SS	14	M	23	2.5	TOPSOIL - 12" FILL - mix of sand and gravel, some silt and clay, brown, moist		9.6			
2	SS	18	M	12	5.0	4.0 SAND (SP) - medium dense, brown, moist to saturated, poorly graded, medium to coarse grained gravel		18.7			
3	SS	2	M	25	7.5			9.8			
4	SS	14	M	22	10.0			4.5			
5	SS	10	S	11	12.5			10.3			
6	SS	6	S	20	15.0	13.5 SILTY SAND (SM) - medium dense, brown, saturated, little gravel		17.6			
					17.5						
7	SS	0	S	27	20.0						
					22.5						

WATER LEVEL OBSERVATIONS

While Drilling 12

Depth to Water

GENERAL NOTES

Start 12/21/99 Complete 12/21/99

Crew Chief Kevin Rig Diedrich D120

Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location Northing: 383,378.03 Easting: 2,543,271.64
Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B1 (PZ-1)
Surface Elevation 18.51
Project No 4378
Sheet 2 of 2

SAMPLE							SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type	↓	↓	N	Depth						
8	SS	18	S	27	25	23.5' SILTY SAND (SM) - medium dense, gray, saturated, little clay, trace gravel		10.8	14	10	37.1
					27.5						
9	SS	14	S	5	30	28.5' SAND (SP) - loose, gray, saturated, poorly graded, coarse grained sand with some gravel					2.4
						End of Boring at 30 feet Converted into a piezometer in accordance with NR 141					
						A 140 lb. automatic impact hammer was used to perform the Standard Penetration Test. Qu values are readings recorded by a Pocket Penetrometer.					

WATER LEVEL OBSERVATIONS

While Drilling 12'
Depth to Water

GENERAL NOTES

Start 12/21/99 Complete 12/21/99
Crew Chief Kevin Rig Diedrich D120
Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan

Location Northing: 383,502.50 Easting: 2,543,230.18

Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B2

Surface Elevation 17.87

Project No 4378

Sheet 1 of 2

SAMPLE | SOIL PROPERTIES

RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type	↓	↓	N	Depth						
1	SS	18	M	13	2.5	TOPSOIL - 12" FILL - mix of sand , gravel and silt. medium dense. black to brown. moist		17.1			
2	SS	8	M	15	5.0			16.8			
3	SS	12	M	7	7.5	6.0' SAND (SP) - medium dense. brown. moist. poorly graded. coarse grained sand with some gravel		18.5			
4	SS	8	M	19	10.0			10.8			
5	SS	6	S	27	12.5	11.0' GRAVEL (GW) - medium dense. gray. saturated. well graded. angular gravel with some sand and silt		14.1			
6	SS	0	S	18	15.0						
					17.5						
7	SS	12	S	7	20.0	18.0' SAND (SP) - loose. brown. saturated. poorly graded. medium grained sand with trace silt		21.0			
					22.5						

WATER LEVEL OBSERVATIONS

While Drilling 11

Depth to Water

GENERAL NOTES

Start 12/22/99 Complete 12/22/99

Crew Chief Kevin Rig Diedrich D120

Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location Northing: 383,502.50 Easting: 2,543,230.18
Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B2
Surface Elevation 17.87
Project No 4378
Sheet 2 of 2

SAMPLE						VISUAL CLASSIFICATION ~~AND REMARKS~~	SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE								
No	Type	↓	↓	N	Depth		qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
8	SS	10	S	4	25	SAND (SP) - loose, brown, saturated, poorly graded, medium grained sand with trace silt		21.7			3.2
						End of Boring at 25 feet					
						Borehole stopped due to excessive blow up of materials into hollow stem auger. Abandoned in accordance with NR 141.25					
						A 140 lb. automatic impact hammer was used to perform the Standard Penetration Test. Qu values are readings recorded by a Pocket Penetrometer.					

WATER LEVEL OBSERVATIONS

While Drilling 11
Depth to Water

GENERAL NOTES

Start 12/21/99 Complete 12/21/99
Crew Chief Kevin Rig Diedrich D120
Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location Northing: 383,776.88 Easting: 2,543,272.07
Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B3 (PZ-2)
Surface Elevation 20.44
Project No 4378
Sheet 1 of 2

SAMPLE							SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type	↓	↓	N	Depth						
1	SS	6	M	2	2.5	CONCRETE SIDEWALK - 4" FILL - mix of sand and gravel, gray to black, moist		11.8			
2	SS	10	M	7	5.0	3.0' FILL - Silt (ML) - brown, loose, moist, some sand, some clay, trace gravel		9.9			
3	SS	10	M	14	7.5	6.0' SAND (SW) - medium dense, brown, moist to saturated, well graded sand with little silt, trace gravel		1.8			
4	SS	9	M	21	10.0			2.0			
5	SS	10	M	16	12.5			6.7			
6	SS	12	S	3	15.0	13.5' SILTY CLAY (CL) - soft, gray, saturated, trace sand, trace gravel	0.5	24.0			
					17.5						
7	ST	24	S	---	20.0	18.0' SAND (SM) - dense, gray, saturated, silty sand with some gravel		8.7 12.3			10.0 18.4
					22.5						

WATER LEVEL OBSERVATIONS

While Drilling 13.5'
Depth to Water

GENERAL NOTES

Start 12/20/99 Complete 12/20/99
Crew Chief Kevin Rig Diedrich D120
Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan

Location Northing: 383,776.88 Easting: 2,543,272.07

Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B3 (PZ-2)

Surface Elevation 20.44

Project No 4378

Sheet 2 of 2

SAMPLE							SOIL PROPERTIES				
No	Type	RECOVERY (inches)	MOISTURE	N	Depth	VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
8	SS	12	S	13	25	1" seam of poorly graded gravel 24' SANDY CLAY (CL) - medium stiff to stiff, gray, saturated, little silt	0.5	16.2			
					27.5						
9	SS	18	S	12	30		1.0	22.7			
						End of Boring at 30 feet Converted into piezometer in accordance with NR 141					
						A 140 lb. automatic impact hammer was used to perform the Standard Penetration Test. Qu values are readings recorded by a Pocket Penetrometer.					

WATER LEVEL OBSERVATIONS

While Drilling 13.5'

Depth to Water

GENERAL NOTES

Start 12/20/99 Complete 12/20/99

Crew Chief Kevin Rig Diedrich D120

Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location Northing: 384,125.64 Easting: 2,543,460.87
Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B4
Surface Elevation 22.05
Project No 4378
Sheet 1 of 2

SAMPLE						VISUAL CLASSIFICATION AND REMARKS	SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE				qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type	↓	↓	N	Depth						
1	SS	9	M	3	2.5	TOPSOIL - 12" FILL - mix of sand and gravel, black, moist		24.0			
2	SS	9	M	4	5.0			17.7			
3	SS	14	M	6	7.5	6.0' FILL - Clayey Sand (SC) - loose to medium dense, brown, moist, trace silt		11.9			
4	SS	12	M	25	10.0			12.9			
5	SS	8	M	17	12.5	11.0' SILTY SAND (SM) - medium dense, brown, moist to saturated, trace gravel		9.8			
6	SS	0	-	-	15.0						
					17.5						
7	SS	8	S	42	20.0	18.5' SAND (SP) - dense, brown, saturated, poorly graded, coarse grained sand with some gravel		18.4			20.2
					22.5						

WATER LEVEL OBSERVATIONS

While Drilling 16
Depth to Water

GENERAL NOTES

Start 12/20/99 Complete 12/20/99
Crew Chief Kevin Rig Diedrich D120
Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan

Location Northing: 384,125.64 Easting: 2,543,460.87

Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B4

Surface Elevation 22.05

Project No 4378

Sheet 2 of 2

SAMPLE						VISUAL CLASSIFICATION AND REMARKS	SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE				qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type	∨	∨	N	Depth						
8	SS	0	S	54	25	SAND (SP) - dense, brown, saturated, poorly graded, coarse grained sand with some gravel					
					27.5						
9	SS	0	S	12	30						
						End of Boring at 30 feet Abandoned in accordance with NR 141.25					
						Boring originally started and stopped at 11 feet where an obstruction, possible boulder, was encountered. The boring was moved 3 feet south and completed.					
						A 140 lb. automatic impact hammer was used to perform the Standard Penetration Test. Qu values are readings recorded by a Pocket Penetrometer.					

WATER LEVEL OBSERVATIONS

While Drilling 16

Depth to Water

GENERAL NOTES

Start 12/20/99 Complete 12/20/99

Crew Chief Kevin Rig Diedrich D120

Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location Northing: 384,286.41 Easting: 2,543,597.24
Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B5 (PZ-3)
Surface Elevation 21.35
Project No 4378
Sheet 1 of 2

SAMPLE							SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type			N	Depth						
1	SS	8	M	26	2.5	TOPSOIL - 12" FILL - mix of sand and gravel, brown, moist, some silt, trace clay					
2	SS	10	M	11	5.0						
3	SS	10	M	29	7.5	6.0' FILL - Sand (SP) - medium dense, brown, moist to saturated, poorly graded sand with some gravel		6.6			
4	SS	10	M	22	10.0			3.7			
5	SS	6	M	11	12.5	11.0' SILTY CLAY (CL) - very stiff, brown, moist to saturated, trace gravel	3.0	26.2			
6	SS	18	S	15	15.0		2.0	17.9	33	14	34.8
					17.5	saturated gravel seam noted at 15'					
7	SS	4	S	23	20.0		3.0	14.8			
					22.5						

WATER LEVEL OBSERVATIONS

While Drilling 15'
Depth to Water

GENERAL NOTES

Start 12/28/99 Complete 12/28/99
Crew Chief Ken Rig Diedrich D120
Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan

Location Northing: 384,286.41 Easting: 2,543,597.24

Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B5 (PZ-3)

Surface Elevation 21.35

Project No 4378

Sheet 2 of 2

SAMPLE							SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type			N	Depth						
8	SS	8	S	18	25	23' SAND (SP) - medium dense, gray, saturated, poorly graded, coarse grained sand with some gravel		20.7			
					27.5						
9	SS	-	S	-	30						
						End of Boring at 30 feet Converted into piezometer PZ-3 in accordance with NR 141					
						A 140 lb. automatic impact hammer was used to perform the Standard Penetration Test. Qu values are readings recorded by a Pocket Penetrometer.					

WATER LEVEL OBSERVATIONS

While Drilling 13

Depth to Water

GENERAL NOTES

Start 12/20/99 Complete 12/20/99

Crew Chief Kevin Rig Diedrich D120

Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan

Location Northing: 384,489.11 Easting: 2,543,758.41

Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B6

Surface Elevation 22.76

Project No 4378

Sheet 1 of 1

SAMPLE **SOIL PROPERTIES**

RECOVERY (inches)		↓	MOISTURE ↓			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type			N	Depth						
1	SS	12	M	51	2.5	TOPSOIL - 12" FILL - mix of sand and gravel, brown, moist, some silt		28.9			
2	SS	10	M	7	5.0			15.7			
3	SS	4	M	3	7.5			21.5			
4	SS	6	M	50/6"	10.0			17.4			22.4
						End of Boring at 10' Boring ended due to obstruction, possible boulders. 3 borings attempted in area. None able to pass beyond 10 feet below grade. Boring abandoned in accordance with NR 141.25					

WATER LEVEL OBSERVATIONS

While Drilling None Encountered

Depth to Water

GENERAL NOTES

Start 12/28/99 Complete 12/28/99

Crew Chief Ken Rig Diedrich D120

Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan

Location Northing: 384,624.46 Easting: 2,543,597.24

Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B7 (PZ-4)

Surface Elevation 24.98

Project No 4378

Sheet 1 of 2

SAMPLE							SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type			N	Depth						
1	SS	6	M	6	2.5	CONCRETE - 12" FILL - Sand (SP) - loose, brown, moist, poorly graded, coarse grained sand with some gravel		9.5			
2	SS	3	M	2	5.0			7.0			
3	SS	3	M	2	7.5			8.8			
4	SS	12	M	29	10.0	8.0 SAND (SP) - medium dense to dense, brown, moist to saturated, poorly graded, coarse grained sand with some gravel		3.0			
5	SS	9	M	60	12.5			5.0			
6	SS	3	S	3	15.0			7.5			
					17.5						
7	SS	10	S	43	20.0	18.5' CLAYEY SAND (SC) - very dense, gray, saturated, trace gravel, trace silt	2.5	8.8	16	9	43.7
					22.5						

WATER LEVEL OBSERVATIONS

While Drilling 15

Depth to Water

GENERAL NOTES

Start 12/27/99 Complete 12/27/99

Crew Chief Ken Rig Diedrich D120

Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan

Location Northing: 384,624.46 Easting: 2,543,597.24

Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B7 (PZ-4)

Surface Elevation 24.98

Project No 4378

Sheet 2 of 2

SAMPLE							SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE			VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type			N	Depth						
8	SS	18	S	34	25	23' SILTY SAND (SM) - dense, gray, satuated, some gravel		10.1			32.2
					27.5	End of boring at 26 feet Boring stopped due to boulder obstruction Converted into piezometer PZ-4 in accordance with NR 141.					
						A 140 lb. automatic impact hammer was used to perform the Standard Penetration Test. Qu values are readings recorded by a Pocket Penetrometer.					

WATER LEVEL OBSERVATIONS

While Drilling 15

Depth to Water

GENERAL NOTES

Start 12/27/99 Complete 12/27/99

Crew Chief Ken Rig Diedrich D120

Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location Northing: 383,493.79 Easting: 2,543,425.60
Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B8
Surface Elevation 21.14
Project No 4378
Sheet 1 of 2

SAMPLE							SOIL PROPERTIES				
No	Type	RECOVERY (inches)	MOISTURE	N	Depth	VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
1	SS	12	M	14	2.5	TOPSOIL - 12" FILL - Sandy Silt (ML) - medium dense, brown, moist, trace gravel		8.6			
2	SS	14	M	8	5.0			20.1			
3	SS	14	M	25	7.5	7.5'		14.8			
4	SS	14	M	36	10.0	GRAVEL (GW) dense, brown, moist to saturated. well graded gravel with some sand and trace silt		2.2			
5	SS	0	S	42	12.5						
6	SS	10	S	45	15.0			9.4			
					17.5						
7	SS	8	S	9	20.0	18' SAND (SP) - dense, brown, saturated, poorly graded. coarse grained sand with some gravel		12.9			
					22.5						

WATER LEVEL OBSERVATIONS

While Drilling 14
Depth to Water

GENERAL NOTES

Start 12/27/99 Complete 12/27/99
Crew Chief Ken Rig Diedrich D120
Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location Northing: 383,493.79 Easting: 2,543,425.60
Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B8
Surface Elevation 21.14
Project No 4378
Sheet 2 of 2

SAMPLE **SOIL PROPERTIES**

RECOVERY (inches) No	Type	↓	MOISTURE ↓	N	Depth	VISUAL CLASSIFICATION AND REMARKS	qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
8	SS	-	S	-	25	SAND (SP) - very dense, brown, saturated, poorly graded, coarse grained sand with some gravel					
					27.5						
9	SS	18	S	64	30	28.5' SILTY SAND (SM) - very dense, brown, saturated, some gravel		8.7			
					32.5						
10	SS	-	S	-	35						
					37.5						
12	SS	18	S	79	40			8.3			21.8
						End of Boring at 40 feet Abandoned in accordance with NR 141.25					
						A 140 lb. automatic impact hammer was used to perform the Standard Penetration Test. Qu values are readings recorded by a Pocket Penetrometer.					

WATER LEVEL OBSERVATIONS

While Drilling 14
Depth to Water

GENERAL NOTES

Start 12/27/99 Complete 12/27/99
Crew Chief Ken Rig Diedrich D120
Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

LOG OF TEST BORING

Project Valley Park Flood Control Plan
Location Northing: 383,502.54 Easting: 2,543,357.29
Soil Testing Firm Briohn Environmental, Pewaukee, WI

Boring No. VP-B9
Surface Elevation 20.63
Project No 4378
Sheet 1 of 1

SAMPLE						VISUAL CLASSIFICATION AND REMARKS	SOIL PROPERTIES				
RECOVERY (inches)			MOISTURE				qu (tsf)	W (%)	LL (%)	PL (%)	P.P. sieve 200
No	Type	↓	↓	N	Depth						
1	SS	16	M	6	2.5	TOPSOIL - 12" FILL - Silty Clay (CL) - soft to medium stiff, brown, moist, little organics. trace sand	0.5	16.3			
2	SS	14	M	7	5.0		1	23.1			
3	SS	16	M	4	7.5		1.5	25.8			
4	SS	18	M	1	10.0	9.5' GRAVEL (GM) - medium dense to dense, brown, moist to saturated. little silt	0.5	29.8			
5	SS	8	M	16	12.5			6.8			
6	SS	8	S	31	15.0			9.3			11.8
					17.5	End of Boring at 17'					
						Boring stopped due to refusal. Possible boulder. Abandoned in accordance with NR 141.25					

WATER LEVEL OBSERVATIONS

While Drilling 13'
Depth to Water

GENERAL NOTES

Start 12/22/99 Complete 12/22/99
Crew Chief Kevin Rig Diedrich D120
Drilling Method HSA, ASTM, D1452 & D1586

K. SINGH & ASSOCIATES, INC.

ATTACHMENT 3

SELECTED SOIL PARAMETERS

Station	Boring Used	Approx. Distance Between Boring and Station Centerline (ft)	Bottom Elevation (ft) (NAVD 1998)	Soil Classification	Unit Weight (pcf)	c (psf)	Φ (°)	Ave. N Value	Ave. W (%)	qu (tsf)	LL	PL	P.P. Sieve 200
0+50	VP-B7	450	597.8	Fill - Sand & Gravel	125	0	30	3.3	8.4				
			587.4	SP	125	0	36	30.7	5.2				
			Bed Rock	SC	125	800	34	38.5	9.5				
2+00	VP-B7	250	597.8	Fill - Sand & Gravel	125	0	30	3.3	8.4				
			587.4	SP	125	0	36	30.7	5.2				
			Bed Rock	SC	125	800	34	38.5	9.5				
8+00	VP-B5	135	591.1	Fill - Sand & Gravel	125	0	35	22.0	5.2				
			579.1	CL w/silts	120	1003	0	16.3	19.6	2.666667	33	14	34.8
			Bed Rock	SP	125	0	33	18.0	20.7				
11+00	VP-B4	175	591.8	Fill - Sand & Gravel	125	0	30	4.3	16.6				
			584.3	SM	120	0	35	17.0	9.8				
			Bed Rock	SP	125	0	30	36.0	18.4				20.2
12+00	VP-B4	180	591.8	Fill - Sand & Gravel	125	0	30	4.3	16.6				
			584.3	SM	120	0	35	17.0	9.8				
			Bed Rock	SP	125	0	30	36.0	18.4				20.2
15+00	VP-B3	50	595.2	Fill - Sand & Gravel	125	0	32	4.5	10.85				
			587.7	SW	125	0	34	17	3.5				
			583.2	CL	125	200	0	3	24				
			577.2	SM	120	0	33		10.5				
			Bedrock	CL	120	750	0	12.5	19.45	0.75			

US Army Corps of Engineers
Detroit District

CAP-206-MENOMONEE, WI

Soil Strength Data

Computed by: TCS **Date:** 6-Dec-12
Checked by: **Date:**

Contents

▨	Water Table
LS	Limestone
TS	Topsoil

Mat'l	%S	γ (psf)
SP-SM		
SP-SM		
SP-SM		
SM		
SP-SM		
GP-GM		

Average Moist Unit Weight: #DIV/0!

DAS pg80 EQN 2.14

$$C_N = \left(\frac{p_a}{\sigma_{vo}}\right)^{0.5}$$

EM1110-1-1905, EQN 3-3b

$$D_r = 100\left(\frac{N_{60}}{60}\right)^{0.5}$$

Pa=

$C_N \geq 2$

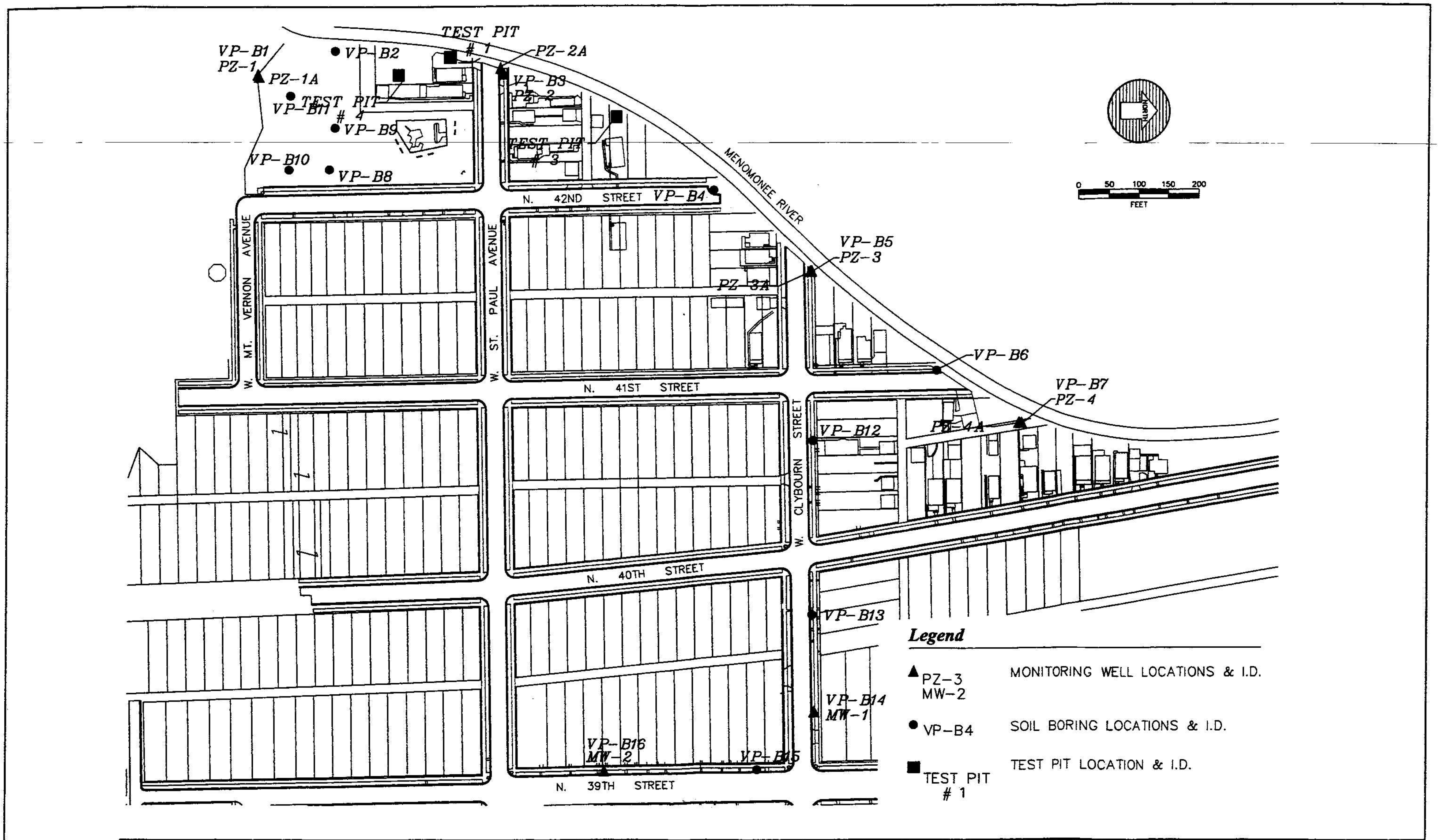
INPUTS																				
Boring	Sample	Class	Depth (ft)	N_{spt} (field)	Thickness of Layer (ft)	C (psf)	Phi (deg)	γ_d (initial) psf	e	w%	S%	γ psf	σ_{vo} (psf) to center of layer	C_N	Corrected Blow Count $N_{60} = C_N N_{spt}$	Relative Density Dr %	ϕ (deg)	γ_{dry} (pcf)	e
VP-B5(PZ-3)	1	FILL (SP)	0-2.5	26	2.5							125.0	156	2.0	52	93	40	126	0.27
VP-B5(PZ-3)	2	FILL (SP)	2.5-5	11	2.5							125.0	469	2.0	22	61	35	114	46.00
VP-B5(PZ-3)	3	FILL (SP)	5-7.5	29	2.5					6.6		125.0	781	1.6	46	88	39	121	0.39
VP-B5(PZ-3)	4	FILL (SP)	7.5-10	22	2.5					3.7		125.0	1094	1.4	30	70	36	117	0.43
VP-B5(PZ-3)	5	CL	10-12.5	11	2.5	3000				26.2		125.0	1406	1.2	13	47	COHESIVE	COHESIVE	COHESIVE
VP-B5(PZ-3)	6	CL	12.5-15	15	2.5	2000				17.9		125.0	1719	1.1	16	52	COHESIVE	COHESIVE	COHESIVE
VP-B5(PZ-3)	7	CL	15-20	23	5	3000				14.8		125.0	2032	1.0	23	62	COHESIVE	COHESIVE	COHESIVE
VP-B5(PZ-3)	8	SP	20-25	18	5					20.7		125.0	2345	0.9	17	53	33.6	112	0.49
VP-B5(PZ-3)	9	SP	25-30		5							125.0	2658	0.9					
VP-B3		FILL (SP)		4.5	6							125.0	750	1.6	7	35	32	109	0.54
VP-B3		SW		17	7.5							125.0	1688	1.1	19	56	34	113	0.48
VP-B3		CL		3	4.5							125.0	1969	1.0	3	22	COHESIVE	COHESIVE	COHESIVE
VP-B3		SM			6							125.0	2345	0.9					
VP-B3		CL		12.5	6							125.0	2720	0.9	11	42	COHESIVE	COHESIVE	COHESIVE
VP-B4	1	FILL (SP)	0-2.5	3	2.5					24		125.0	156	2.0	6	32	30.8	108	0.55
VP-B4	2	FILL (SP)	2.5-5	4	2.5					17.7		125.0	469	2.0	8	37	32	109	0.54
VP-B4	3	FILL (SC)	5-7.5	6	2.5					11.9		125.0	781	1.6	10	40	35	95	106.00
VP-B4	4	FILL (SC)	7.5-10	25	2.5					32.9		125.0	1094	1.4	34	75	35	102	0.63
VP-B4	5	SM	10-12.5	17	2.5					9.8		125.0	1406	1.2	20	58	33	98	0.70
VP-B4	6	SM	12.5-15		2.5							125.0	1719	1.1					
VP-B4	7	SM	15-20	42	5					18.4		125.0	2032	1.0	42	83	36	103	0.61
VP-B4	8	SP	20-25	54	5							125.0	2657						
VP-B4	9	SP	25-30	12	5							125.0	2657						
VP-B7		FILL(SP)		3.3	8							125.0	1000	1.4	5	28	30	106.5	0.57
VP-B7		SP		30.7	10.5							125.0	2313	0.9	29	69	36	115	0.45
VP-B7		SC		38.5	11.5							125.0	3032	0.8	31	72	34	101	0.65

Project: CAP-206-MENOMONEE, WI
Subject:
Prepared By: Tim Smith
Date: 06 Dec 2012
Checked By:
Date:
Status: Feasibility

Correlations of Strength Characteristics for Granular Soils

Ref: NAVFAC Design Manual 7.1, *Soil Mechanics* , Figure 7 (p. 149).

D_r (%)	ML			SM, SC or SC-SM			SM-SP or SP-SM			SP or SW			GP-GM, GP-GC, GC, GM			GP			GW		
	ϕ (deg)	γ_{dry} (pcf)	e	ϕ (deg)	γ_{dry} (pcf)	e	ϕ (deg)	γ_{dry} (pcf)	e	ϕ (deg)	γ_{dry} (pcf)	e	ϕ (deg)	γ_{dry} (pcf)	e	ϕ (deg)	γ_{dry} (pcf)	e	ϕ (deg)	γ_{dry} (pcf)	e
0	26.0	79.0	1.12	26.5	88.0	0.90	27.0	95.0	0.75	27.0	102.0	0.64	27.3	105.8	0.59	27.5	109.5	0.53	28.0	117.0	0.42
5	26.5	80.0	1.08	27.0	88.5	0.89	27.5	96.0	0.74	27.8	103.0	0.62	27.9	106.5	0.57	28.0	110.0	0.52	28.5	118.5	0.41
10	27.0	81.0	1.05	27.5	89.5	0.87	28.0	97.0	0.72	28.4	104.0	0.60	28.7	107.5	0.55	29.0	111.0	0.50	29.5	120.0	0.39
15	27.5	82.0	1.03	28.0	90.0	0.85	28.5	98.0	0.71	29.0	105.0	0.59	29.3	108.5	0.54	29.5	112.0	0.49	30.0	121.0	0.38
20	28.0	83.0	1.01	28.5	91.0	0.83	29.0	99.0	0.69	29.5	106.0	0.58	29.8	109.5	0.53	30.0	113.0	0.48	30.7	122.0	0.37
25	28.5	84.0	0.99	29.0	92.0	0.82	29.5	99.5	0.68	30.0	106.5	0.57	30.4	110.3	0.52	30.8	114.0	0.47	31.3	123.0	0.36
30	29.0	85.0	0.97	29.5	93.0	0.80	30.0	100.5	0.66	30.8	108.0	0.55	31.2	111.5	0.50	31.5	115.0	0.45	32.2	124.0	0.34
35	29.5	86.0	0.95	30.0	94.0	0.78	31.0	102.0	0.64	31.5	109.0	0.54	31.9	112.8	0.49	32.3	116.5	0.43	33.0	126.0	0.33
40	30.0	87.0	0.93	30.5	95.0	0.76	31.5	103.0	0.62	32.3	110.0	0.52	32.7	114.0	0.47	33.0	118.0	0.42	34.0	127.5	0.31
45	30.5	88.0	0.91	31.0	96.0	0.74	32.0	104.0	0.61	33.0	111.0	0.50	33.5	115.0	0.45	34.0	119.0	0.40	35.0	129.0	0.30
50	31.0	88.5	0.89	32.0	97.0	0.72	33.0	105.0	0.59	33.6	112.0	0.49	34.1	116.0	0.44	34.5	120.0	0.39	35.8	130.0	0.28
55	31.5	89.5	0.87	32.5	98.0	0.70	33.5	106.0	0.57	34.4	113.0	0.48	34.9	117.0	0.43	35.3	121.0	0.38	36.8	131.0	0.27
60	32.0	90.0	0.85	33.0	99.0	0.69	34.0	107.0	0.56	35.0	114.0	0.46	35.5	118.3	0.41	36.0	122.5	0.36	37.5	133.0	0.25
65	32.5	91.0	0.83	33.5	100.0	0.67	34.5	108.0	0.55	35.5	115.0	0.45	36.3	119.5	0.40	37.0	124.0	0.35	38.5	134.5	0.24
70	33.0	92.0	0.82	34.0	101.0	0.65	35.0	109.0	0.54	36.2	116.5	0.43	36.9	120.8	0.39	37.5	125.0	0.34	39.0	136.0	0.23
75	33.5	93.0	0.80	34.5	102.0	0.63	36.0	110.0	0.52	37.0	117.5	0.42	37.7	122.0	0.37	38.3	126.5	0.32	40.0	138.0	0.21
80	34.0	94.0	0.77	35.5	103.0	0.61	36.5	111.5	0.50	37.8	119.0	0.40	38.6	123.5	0.35	39.3	128.0	0.30	41.0	140.0	0.20
85	34.5	95.0	0.75	36.0	105.0	0.60	37.0	113.0	0.48	38.5	120.5	0.39	39.3	125.0	0.34	40.0	129.5	0.29	42.0	141.0	0.18
90	35.0	96.0	0.74	36.5	106.0	0.58	38.0	114.0	0.47	39.3	121.5	0.37	40.2	126.3	0.32	41.0	131.0	0.27	43.0	143.0	0.16
95	35.5	97.0	0.72	37.0	107.0	0.56	38.5	115.0	0.45	40.0	123.0	0.36	40.8	127.5	0.31	41.5	132.0	0.26	44.0	145.0	0.15
100	36.0	98.0	0.70	38.0	108.0	0.55	39.0	116.0	0.44	40.7	124.0	0.35	41.6	128.8	0.30	42.5	133.5	0.25	45.0	147.0	0.13



VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 —————— 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

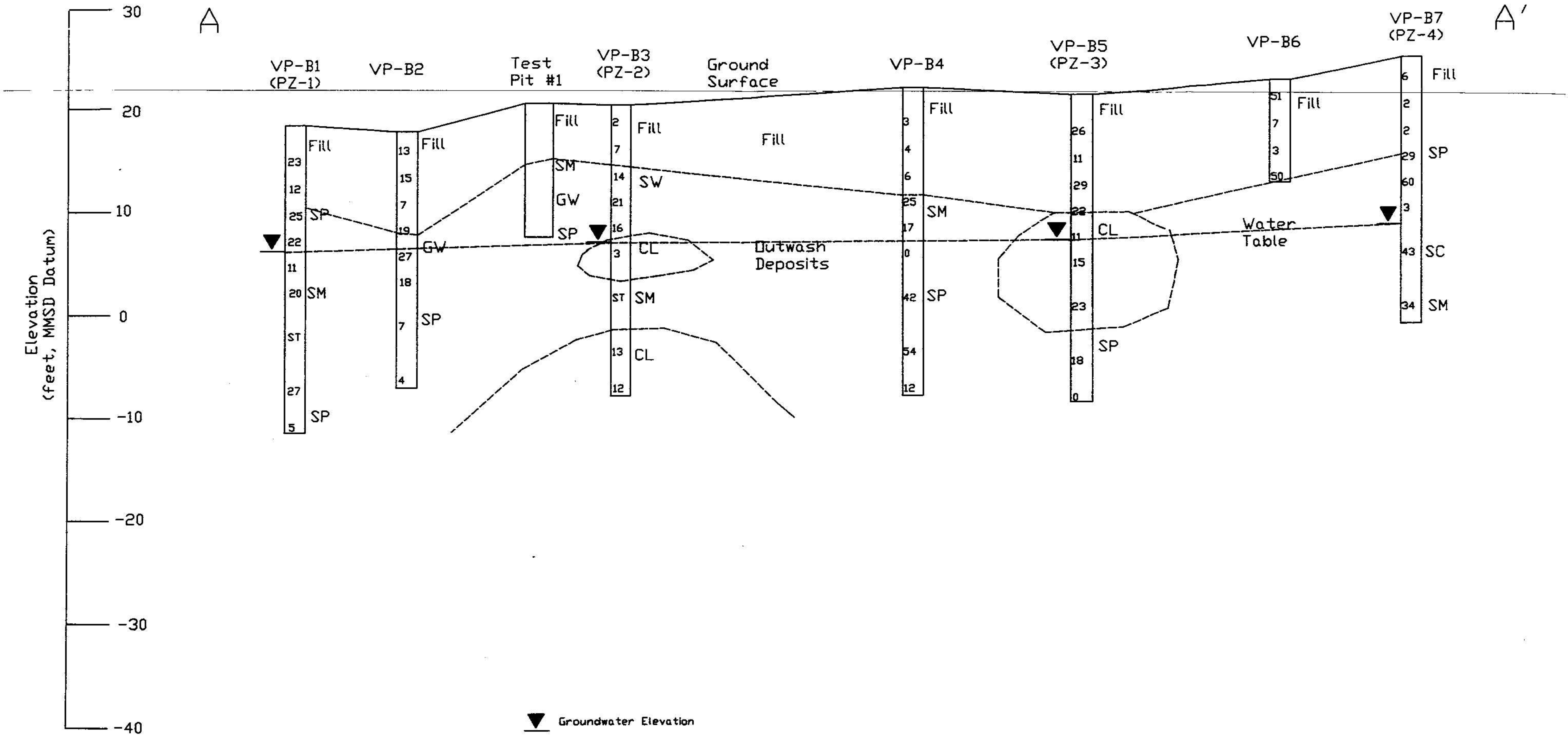
DSGN RTR
DR RTR
CHK DKS
APVD PNS

Hey and Associates, Inc.
KSA
K. SINGH & ASSOCIATES, INC.
Engineers, Scientists and Environmental Management Consultants

NO.	DATE	REVISION	BY	APVD

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT
VALLEY PARK PROJECT
FIGURE 5.2
LOCATIONS OF SOIL BORINGS AND MONITORING WELLS
GEOTECHNICAL BASELINE REPORT

DWG NO. 5.2
SHEET
DATE MARCH, 2000
PROJ W015DE001
FILE



▼ Groundwater Elevation

Numbers in Borehole Profiles represent blow counts.

Horizontal Scale: 1 inch = 150 feet
Vertical Scale: 1 inch = 10 feet

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 —— 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

DSGN	RTR
DR	RTR
CHK	DKS
APVD	PNS

KSA
K. SINGH & ASSOCIATES, INC.
Engineers, Scientists and
Environmental Management Consultants

NO.	DATE	REVISION	BY	APVD

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

VALLEY PARK PROJECT
FIGURE 5.4
SUBSURFACE PROFILE OF LEVEE AND FLOODWALL
GEOTECHNICAL BASELINE REPORT

DWG NO.	5.4
SHEET	
DATE	MARCH, 2000
PROJ	W015DE001
FILE	

Table 7.3 Design Soil Parameters

			Fill Test Values				Outwash Sands and Gravels Test Values				Silts and Clays Test Values			
Soil Parameter	Symbol	Units	Design Value	Min	Max	Avg	Design Value	Min	Max	Avg	Design Value	Min	Max	Avg
Dry Unit Weight	γ_d	pcf	125	--	--	--	125	--	--	--	120	111	129	120
Moisture Content	W	%	15	1.8	33.7	--	15	2.2	29.8	--	17	12	23	17
Saturated Unit Weight	γ_ω	pcf	144	--	--	--	144	--	--	--	140	--	--	--
Consolidation Parameters:														
Cc	--	--	--	--	--	--	--	--	--	--	0.2	--	--	--
Ccr	--	--	--	--	--	--	--	--	--	--	0.02	--	--	--
OCR	--	--	--	--	--	--	--	--	--	--	4	--	--	--
Cv	--	ft2/yr	--	--	--	--	--	--	--	--	174	--	--	--
Cα	--	in/in/log cycle time	--	--	--	--	--	--	--	--	0.004	--	--	--
e_o	--	--	--	--	--	--	--	--	--	--	0.5	--	--	--
Specific Gravity	G	--	--	--	--	--	--	--	--	--	2.76	--	--	--
Unconfined Compressive Strength	qu	tsf	--	--	--	--	--	--	--	--	2	0.5	4.5	3
Internal Friction Angle	ϕ	degrees	30	--	--	--	30	--	--	--	18	--	--	--
Cohesion	C	tsf	0	--	--	--	0	--	--	--	0.4	--	--	--
Effective Internal Friction Angle	$\bar{\phi}$	degrees	30	--	--	--	30	--	--	--	28	--	--	--
Effective Cohesion	$\bar{C}$	tsf	0	--	--	--	0	--	--	--	0.4	--	--	--
Young's Modulus	E	psi	2,000	--	--	--	4,000	--	--	--	1,000	--	--	--
Poisson's Ratio	u	---	0.2	--	--	--	0.3	--	--	--	0.3	--	--	--
Sensitivity	St	--	--	--	--	--	--	--	--	--	2	--	--	--
Coefficient of Earth Press. At Rest	Ko	--	0.5	--	--	--	0.5	--	--	--	0.8	--	--	--
Coefficient of Active Earth Press.	Ka	--	0.33	--	--	--	0.33	--	--	--	0.36	--	--	--
Hydraulic Conductivity	K	cm/sec	1.E-04	--	--	--	1.E-03	--	--	--	6.0E-06	--	--	--
Organic Content	--	%	--	--	--	--	--	--	--	--	--	--	--	--

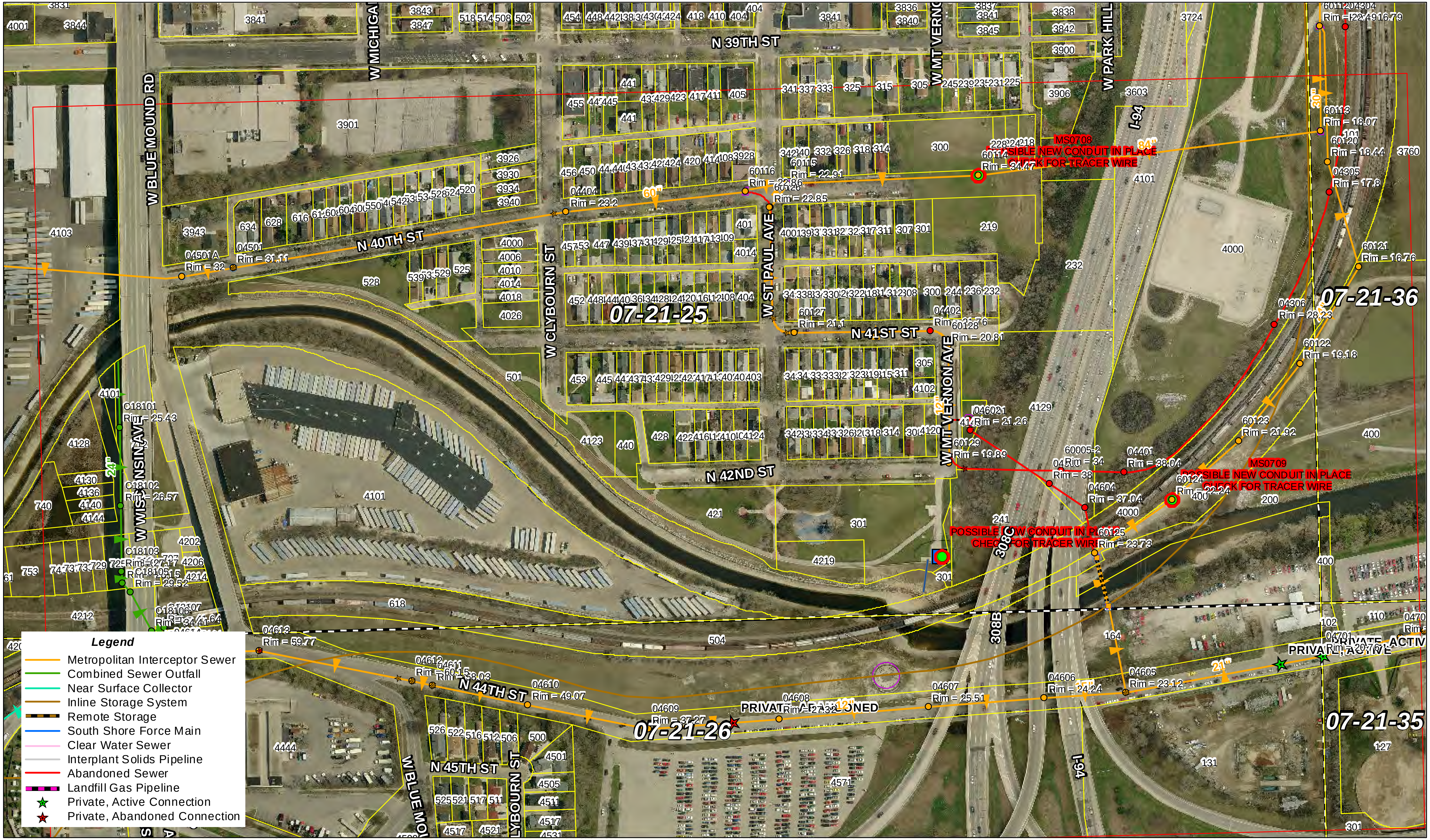
1) Design values based on investigation of K. Singh (2000) and A Study of the Geotechnical Properties of Milwaukee Area Soils (1983) (2).

ATTACHMENT 4

UTILITY MAPS & AS-BUILT DRAWINGS

NUMBER: 20130203891 / PLANNING - PRINTS

STARTDATE: 1/21/2013 10:05:00 AM



Legend

- Metropolitan Interceptor Sewer
- Combined Sewer Outfall
- Near Surface Collector
- Inline Storage System
- Remote Storage
- South Shore Force Main
- Clear Water Sewer
- Interplant Solids Pipeline
- Abandoned Sewer
- Landfill Gas Pipeline
- ★ Private, Active Connection
- ★ Private, Abandoned Connection

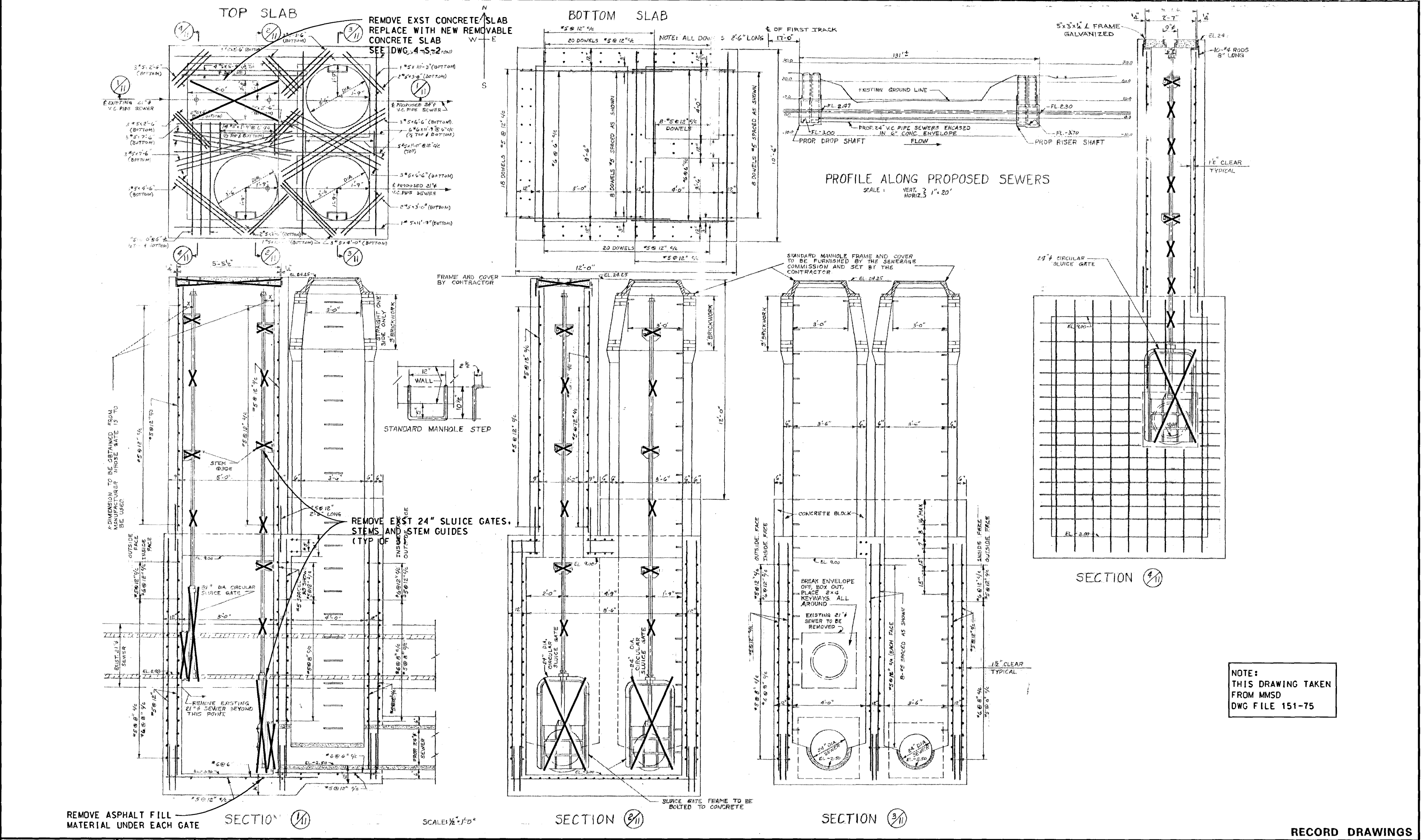
mmsd
Preserving The Environment • Improving Water Quality

NORTH

0 260 520
Feet

DIGGERS HOTLINE
LOCATE REQUEST

PROCESSED ON: 1/11/2013 11:10:53 AM



RECORD DRAWINGS

REUSE OF DOCUMENTS
THIS DOCUMENT AND THE IDEAS AND DESIGNS INCORPORATED HEREIN IS AN INSTRUMENT OF PROFESSIONAL SERVICE AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT.

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

DSGN J.GROSSKREUTZ
DR M.MYASKOVSKY
CHK T.WAGNER
APVD R.KAPUR

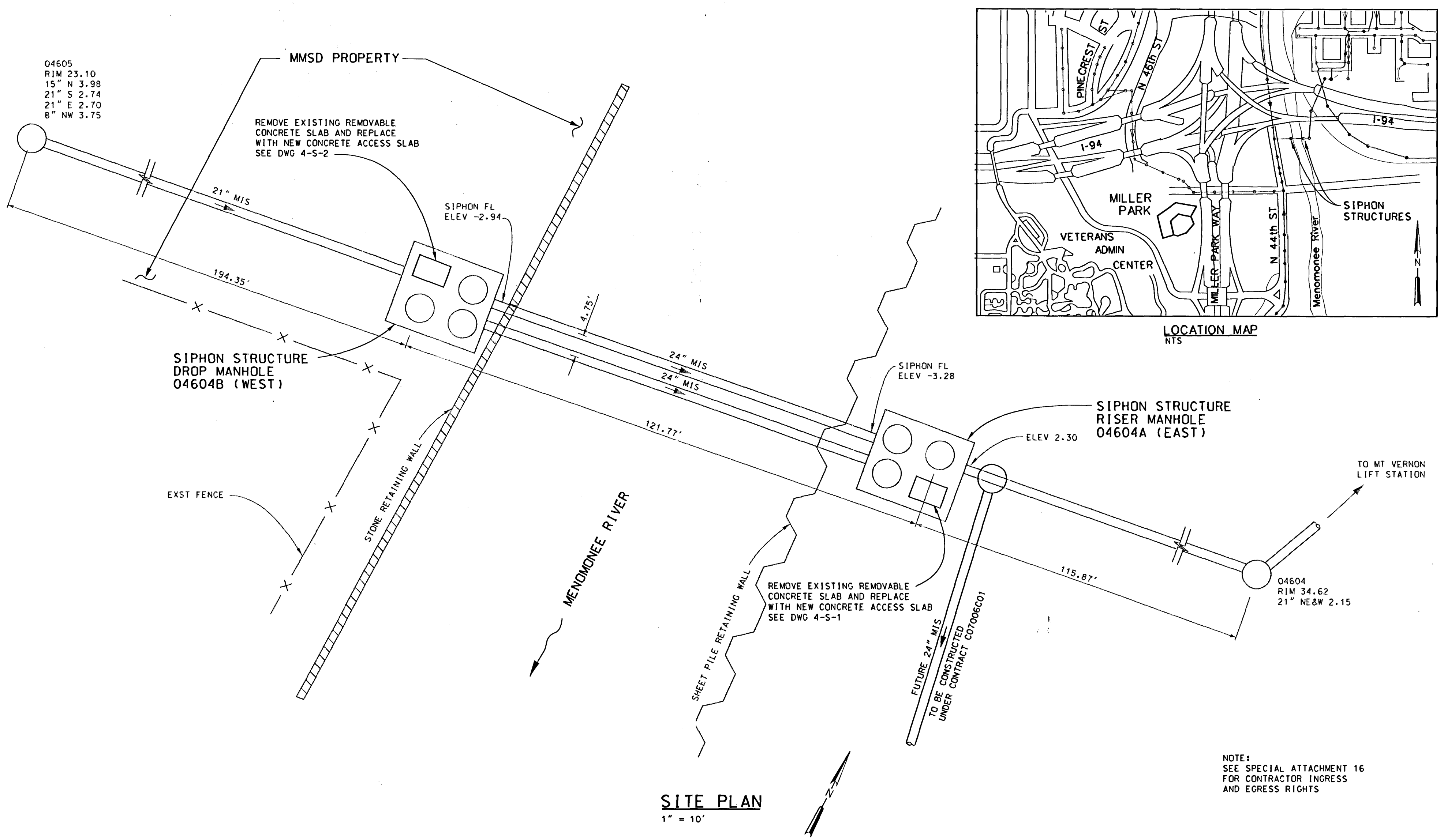
This Design Prepared For MMSD By:
KAPUR & ASSOCIATES, INC.
CONSULTING ENGINEERS
MILWAUKEE, WISCONSIN
414.351.6668
In Association With:
HEARTLAND ENGINEERING, INC.

REV. NO.	DATE	REVISION DESCRIPTION	BY	APVD
1	4/07	RECORD DRAWINGS	TW	JJG

Preserving The Environment • Improving Water Quality

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT MF2007
METROPOLITAN INTERCEPTOR SEWER SYSTEM
DIVERSION STRUCTURE AND SIPHON SLUICE GATE REPLACEMENTS
MILLER PARK SIPHON STRUCTURES
MECHANICAL
REMOVAL PLAN AND SECTION - DROP MH 04604B WEST STRUCTURE

DRAWING NO.: 4-M-2
SHEET: 28
DATE: OCTOBER 2005
CONTRACT: C98040C01
MMSD FILE: 401-462.dgn



LOCATION MAP
NTS

NOTE:
SEE SPECIAL ATTACHMENT 16
FOR CONTRACTOR INGRESS
AND EGRESS RIGHTS

SITE PLAN
1" = 10'

RECORD DRAWINGS

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0" 1"
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KAPUR & ASSOCIATES, INC.
CONSULTING ENGINEERS
MILWAUKEE, WISCONSIN
414.351.6668
In Association With:
HEARTLAND ENGINEERING, INC.

REV. NO.	DATE	REVISION DESCRIPTION	BY	APVD
1	4/07	RECORD DRAWINGS	TW	JJC

mmsd
Preserving The Environment • Improving Water Quality

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT MF2007
METROPOLITAN INTERCEPTOR SEWER SYSTEM
DIVERSION STRUCTURE AND SIPHON SLUICE GATE REPLACEMENTS
MILLER PARK SIPHON STRUCTURES
CIVIL
SITE PLAN

DRAWING NO.: 4-C-1
SHEET: 24
DATE: OCTOBER 2005
CONTRACT: C98040C01
MMSD FILE: 401-458.dgn

ATTACHMENT 5

STONE SIZING CALCULATIONS

Stone Sizing for 100-year Event

Ref: National Engineering Handbook, Part 654, Technical Supplement 14C
National Engineering Handbook, Part 654, Technical Supplement 14N

US Bureau of Reclamation Method

High-energy technique

Avg. Riffle Velocity, V = 10.14 ft/s

$$D_{50} = 0.0122V^{2.06}$$ eq. TS14C-9

D_{50} = 1.441 ft

ARS Rock Chutes

Approach for high-energy applications

Channel Slope, S_f = 0.002 ft/ft

Unit Discharge, q_{design} = 262.6 $ft^3/s/ft$

If S < 0.1. then

$$D_{50} = 12(1.923qS^{1.5})^{0.529}$$ eq. TS14C-16

If 0.1 < S < 0.4, then

$$D_{50} = 12(0.233qS^{0.58})^{0.529}$$ eq. TS14C-17

D_{50} = 2.049 ft

USGS Method

Developed from Western US studies

Avg. Riffle Velocity, V = 10.14 ft/s

eq. TS14C-10

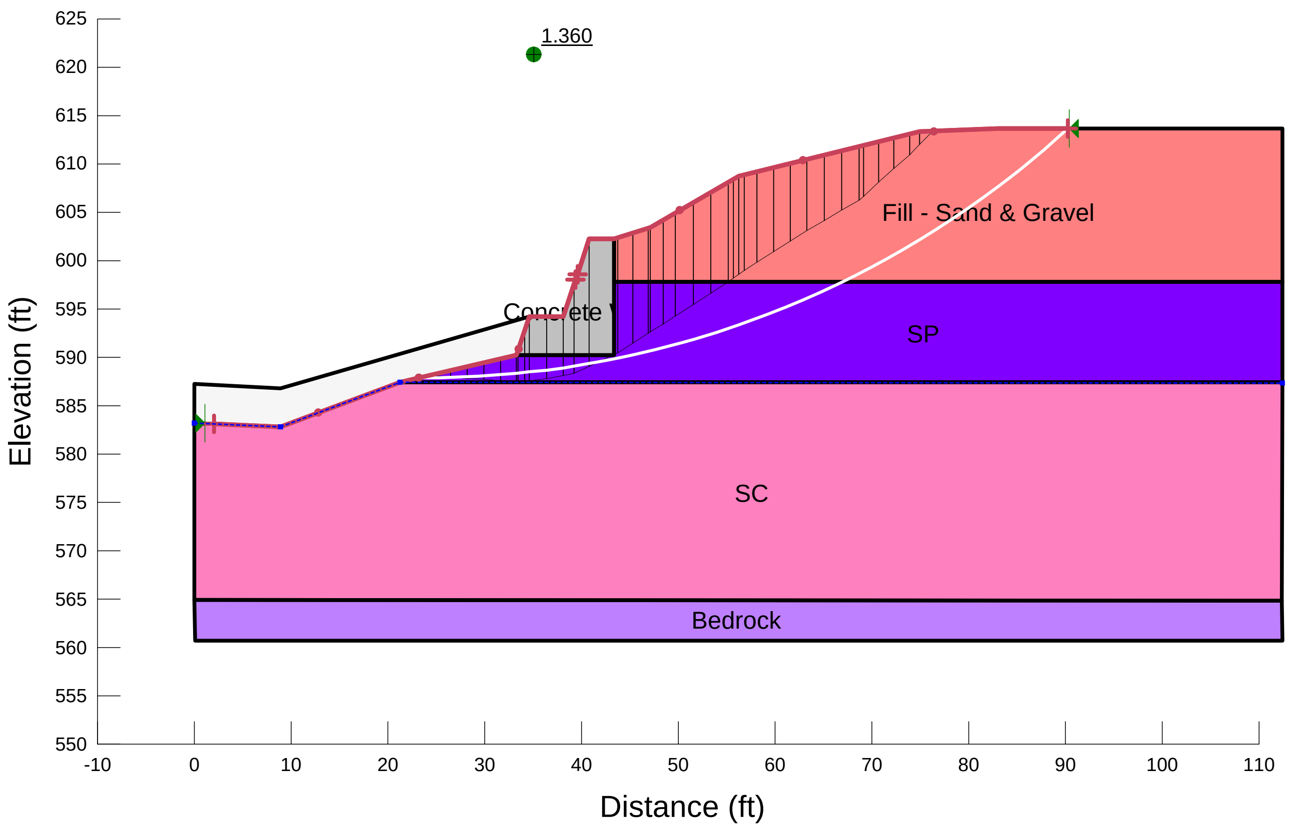
D_{50} = 2.849 ft

ATTACHMENT 6

SLOPE STABILITY RESULTS

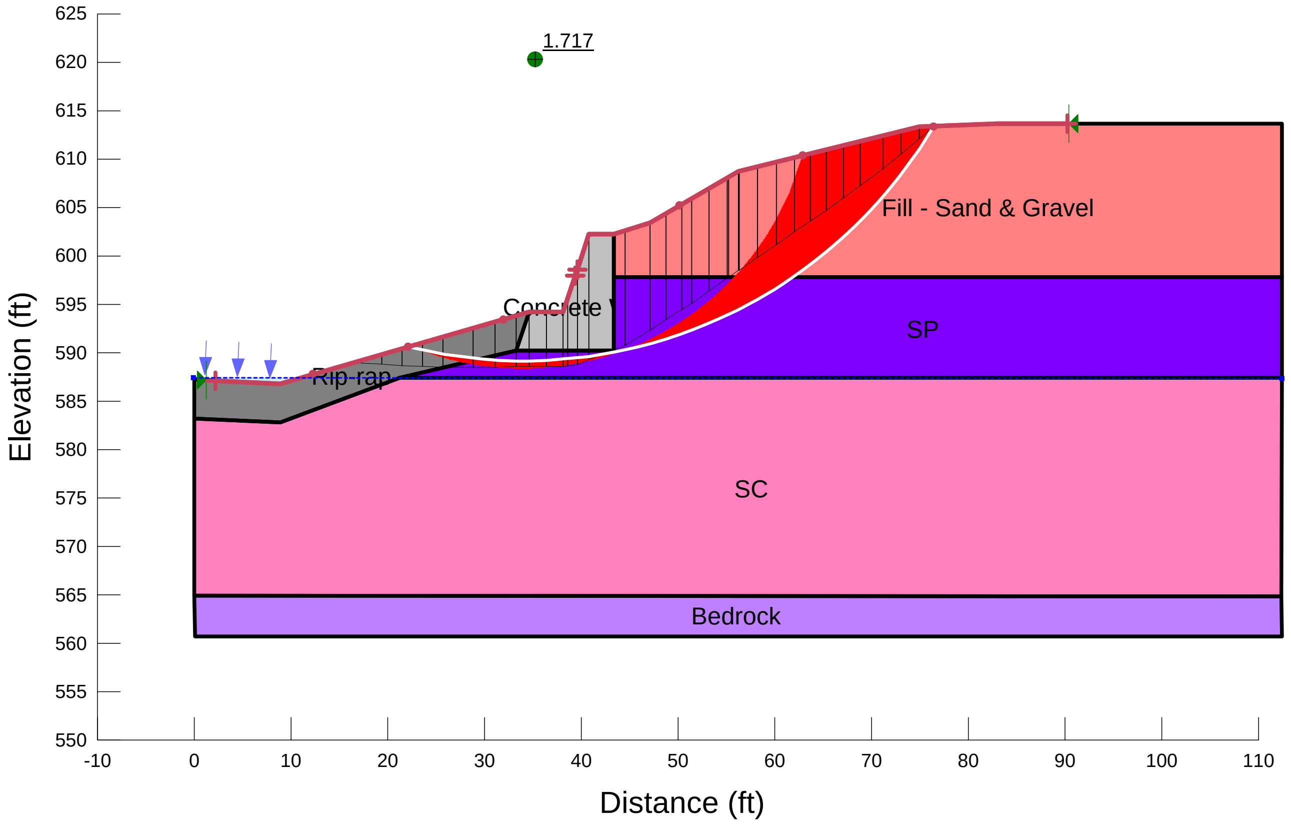
Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis During Construction Sta. 0+50 LS (Boring No. VP-B7)
Method: Spencer

Name: Concrete Wall Unit Weight: 150 pcf Cohesion: 2e+005 psf Phi: 90 °
Name: Fill - Sand & Gravel Unit Weight: 125 pcf Cohesion: 0 psf Phi: 30 °
Name: SP Unit Weight: 125 pcf Cohesion: 0 psf Phi: 36 °
Name: Bedrock
Name: SC Unit Weight: 125 pcf Cohesion: 800 psf Phi: 34 °



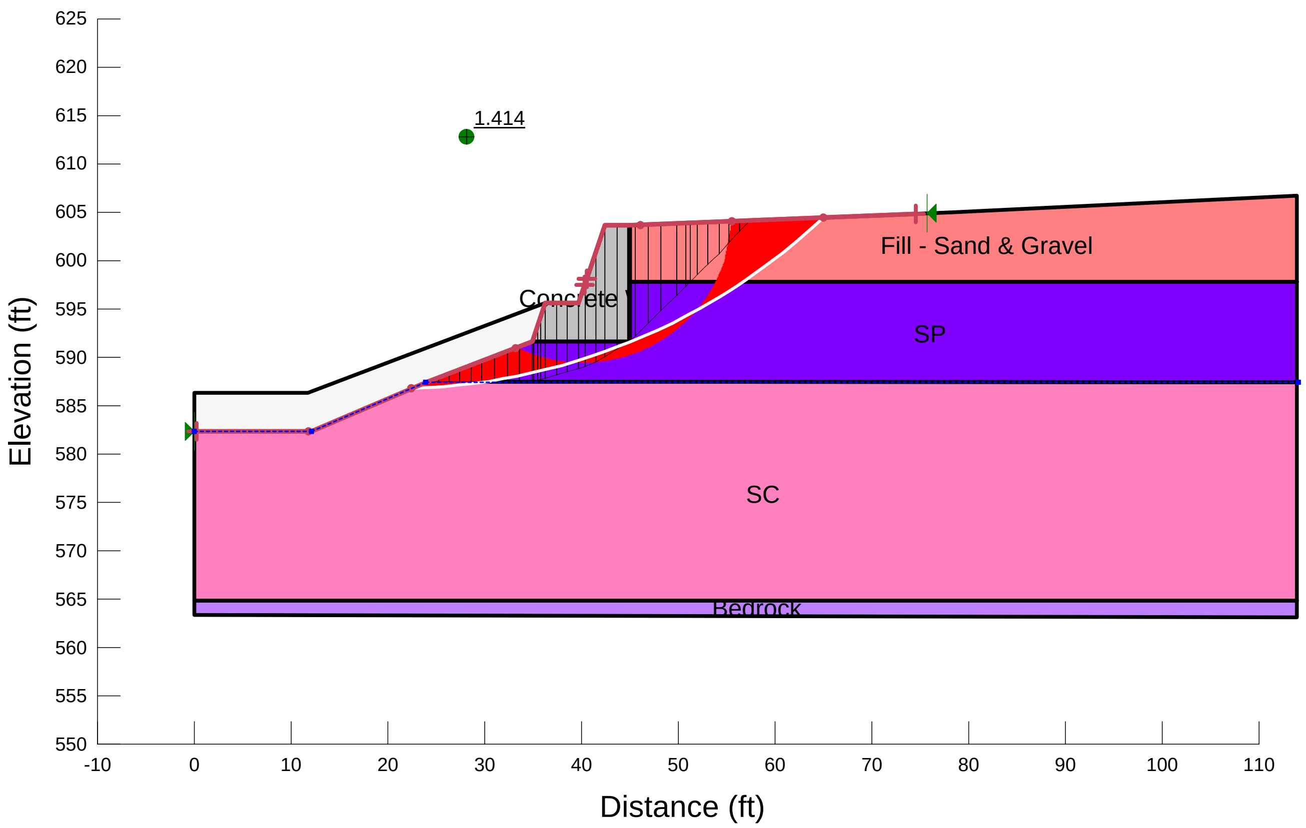
Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis Post Construction Sta. 0+50 LS (Boring No. VP-B7)
Method: Spencer

Name: Concrete Wall Unit Weight: 150 pcf Cohesion: 2e+005 psf Phi: 90 °
Name: Fill - Sand & Gravel Unit Weight: 125 pcf Cohesion: 0 psf Phi: 30 °
Name: SP Unit Weight: 125 pcf Cohesion: 0 psf Phi: 36 °
Name: Rip-rap Unit Weight: 140 pcf Cohesion: 0 psf Phi: 45 °
Name: Bedrock
Name: SC Unit Weight: 125 pcf Cohesion: 800 psf Phi: 34 °



Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis During Construction Sta. 2+00 LS (Boring No. VP-B7)
Method: Spencer

Name: Concrete Wall   Unit Weight: 150 pcf   Cohesion: 2e+005 psf   Phi: 90 °
Name: Fill - Sand & Gravel   Unit Weight: 125 pcf   Cohesion: 0 psf   Phi: 30 °
Name: SP   Unit Weight: 125 pcf   Cohesion: 0 psf   Phi: 36 °
Name: Bedrock
Name: SC   Unit Weight: 125 pcf   Cohesion: 800 psf   Phi: 34 °



Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis Post Construction Sta. 2+00 LS (Boring No. VP-B7)
Method: Spencer

Name: Concrete Wall Unit Weight: 150 pcf Cohesion: 2e+005 psf Phi: 90 °
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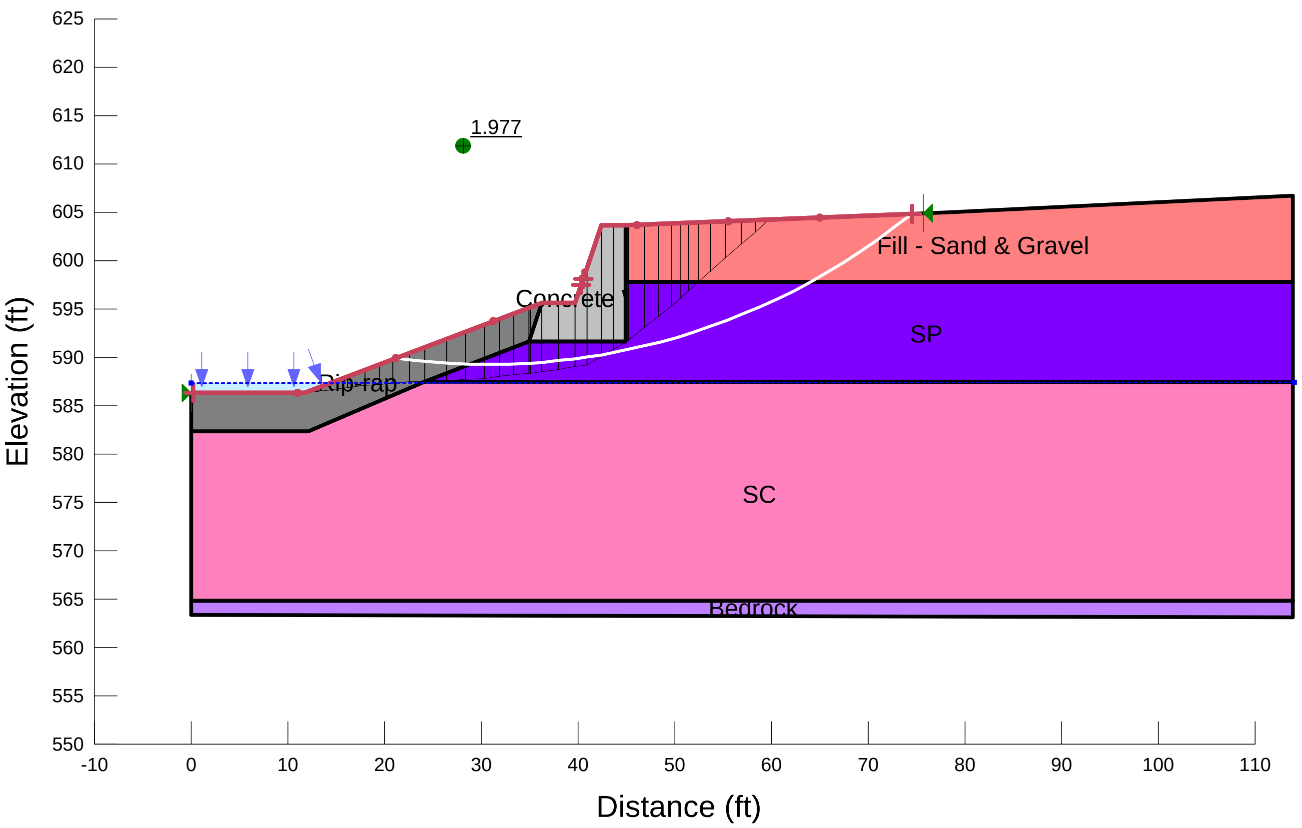
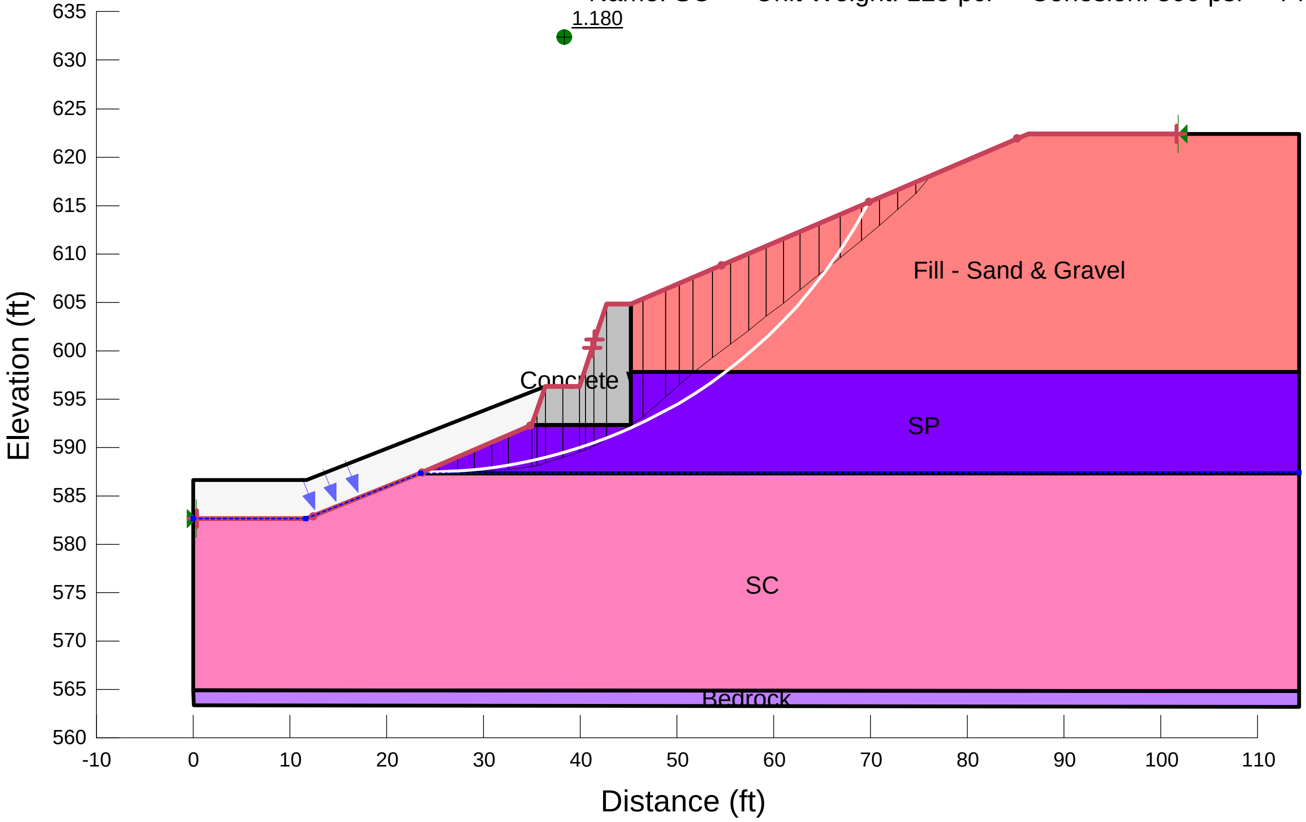
Name: SP Unit Weight: 125 pcf Cohesion: 0 psf Phi: 36 °
Name: Rip-rap Unit Weight: 140 pcf Cohesion: 0 psf Phi: 45 °
Name: Bedrock
Name: SC Unit Weight: 125 pcf Cohesion: 800 psf Phi: 34 °



Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis During Construction Sta. 2+00 RS (Boring No. VP-B7)
Method: Spencer

Name: Concrete Wall   Unit Weight: 150 pcf   Cohesion: 2e+005 psf   Phi: 90 °
Name: Fill - Sand & Gravel   Unit Weight: 125 pcf   Cohesion: 0 psf   Phi: 30 °
Name: SP   Unit Weight: 125 pcf   Cohesion: 0 psf   Phi: 36 °
Name: Bedrock
Name: SC   Unit Weight: 125 pcf   Cohesion: 800 psf   Phi: 34 °



Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis Post Construction Sta. 2+00 RS (Boring No. VP-B7)
Method: Spencer

Name: Concrete Wall Unit Weight: 150 pcf Cohesion: 2e+005 psf Phi: 90 °
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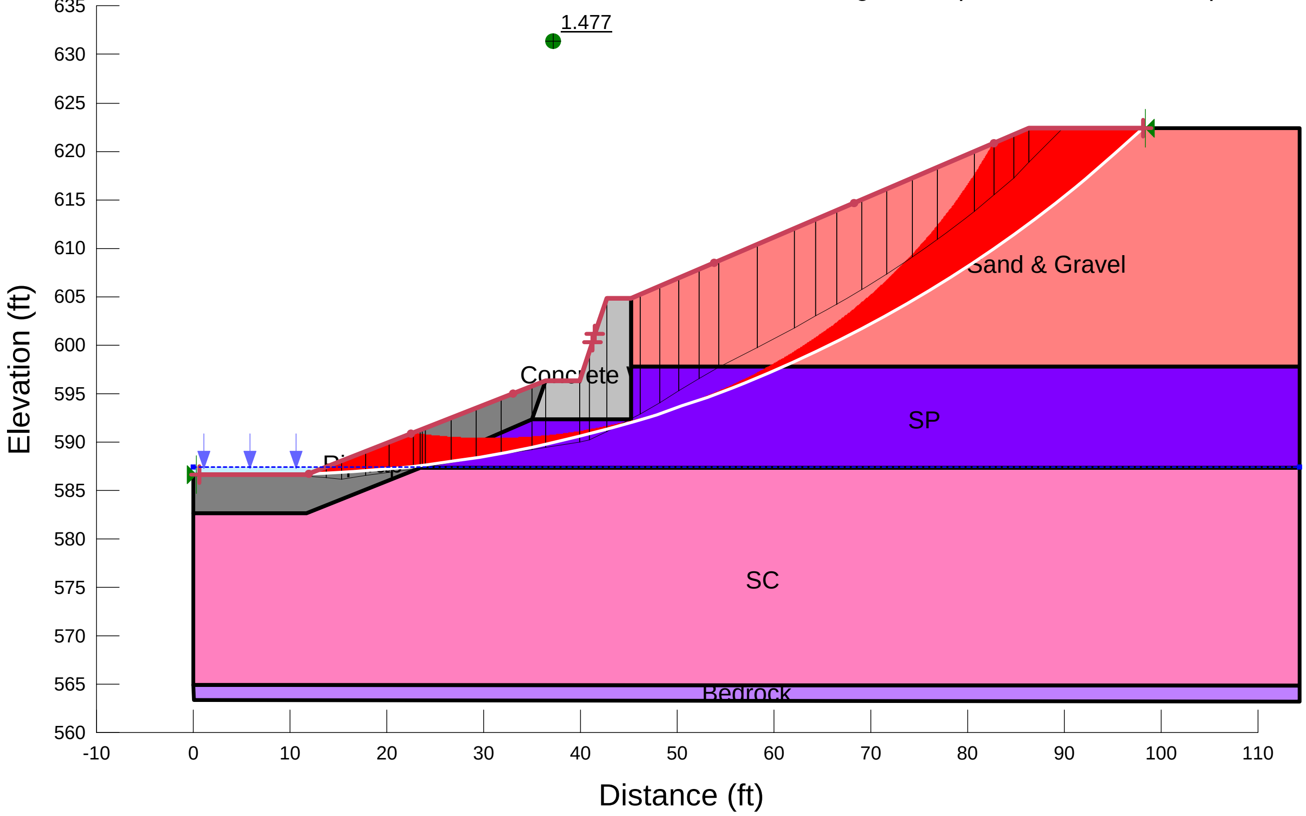
Name: SP Unit Weight: 125 pcf Cohesion: 0 psf Phi: 36 °
Name: Rip-rap Unit Weight: 140 pcf Cohesion: 0 psf Phi: 45 °
Name: Bedrock
Name: SC Unit Weight: 125 pcf Cohesion: 800 psf Phi: 34 °



Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis During Construction Sta.8+00 RS (Boring No. VP-B5)
Method: Spencer

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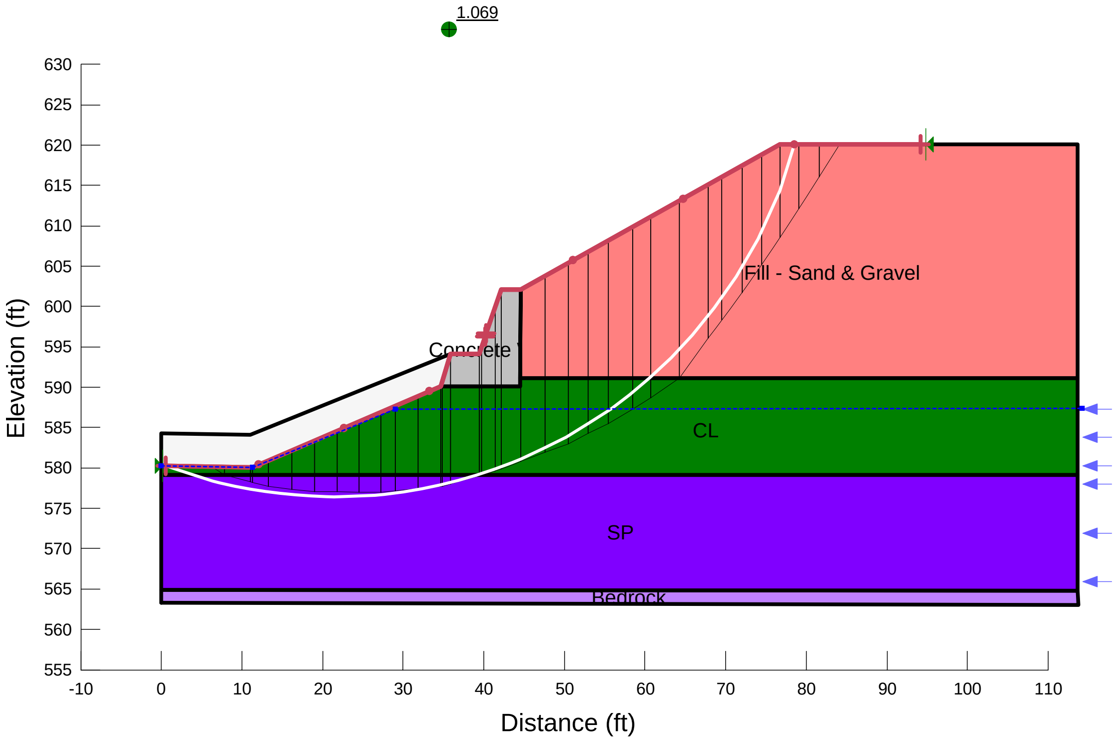
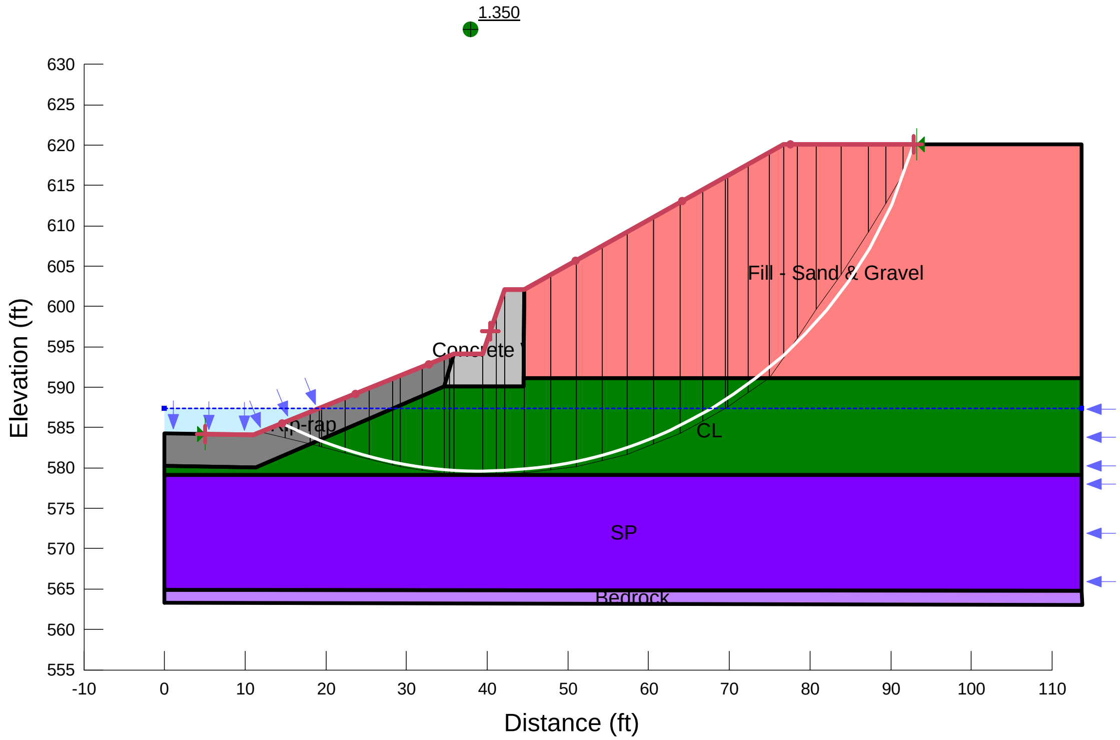
Name: Fill - Sand & Gravel Unit Weight: 125 pcf Cohesion: 0 psf Phi: 35 °
Name: SP Unit Weight: 125 pcf Cohesion: 0 psf Phi: 33 °
Name: CL Unit Weight: 120 pcf Cohesion: 1000 psf Phi: 0 °
Name: Bedrock



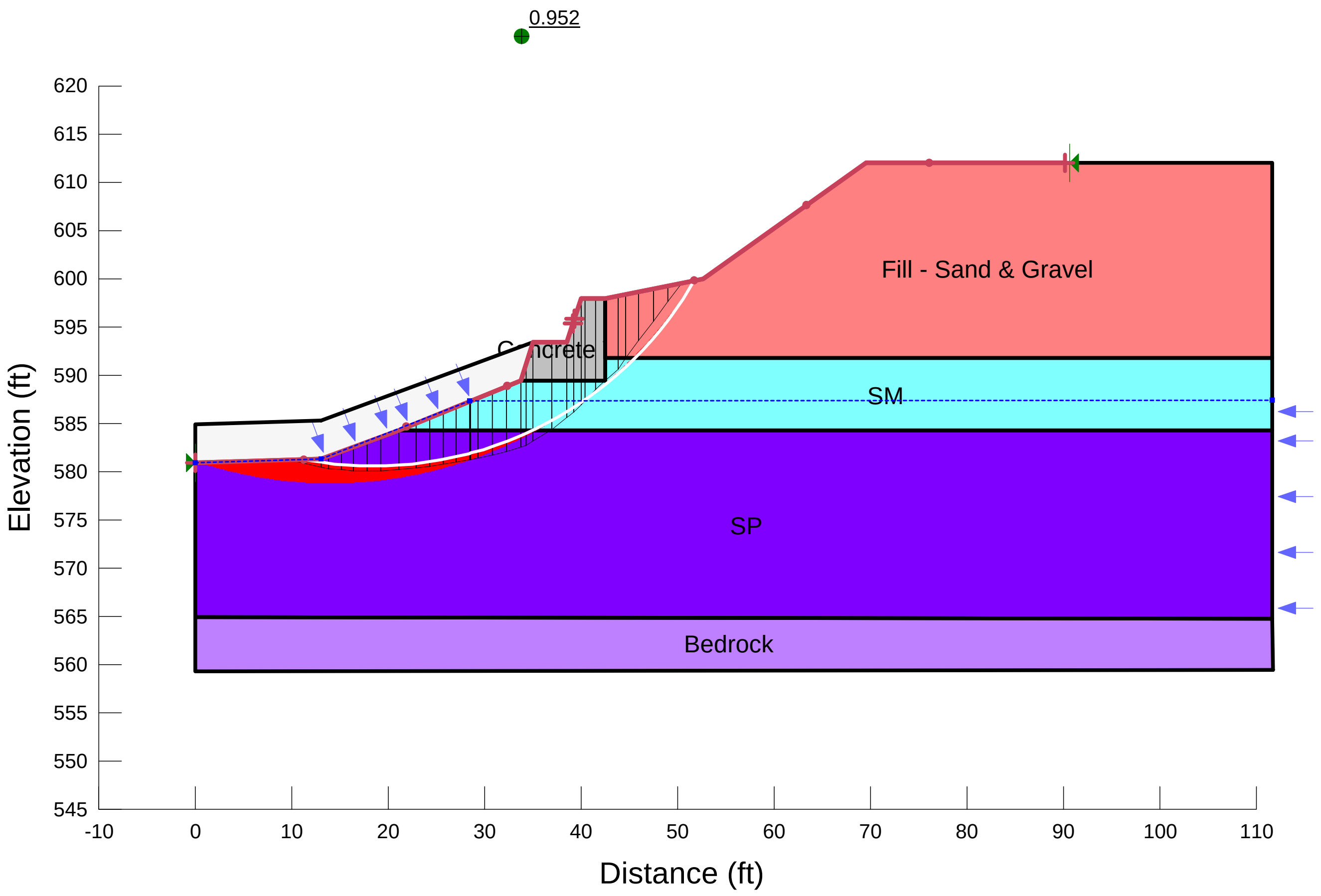
Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis Post Construction Sta 8+00 RS (Boring No. VP-B5)
Method: Spencer

Name: Concrete Wall Unit Weight: 150 pcf Cohesion: 2e+005 psf Phi: 90 °
Name: Fill - Sand & Gravel Unit Weight: 125 pcf Cohesion: 0 psf Phi: 35 °
Name: SP Unit Weight: 125 pcf Cohesion: 0 psf Phi: 33 °
Name: CL Unit Weight: 120 pcf Cohesion: 1000 psf Phi: 0 °
Name: Rip-rap Unit Weight: 140 pcf Cohesion: 0 psf Phi: 45 °
Name: Bedrock



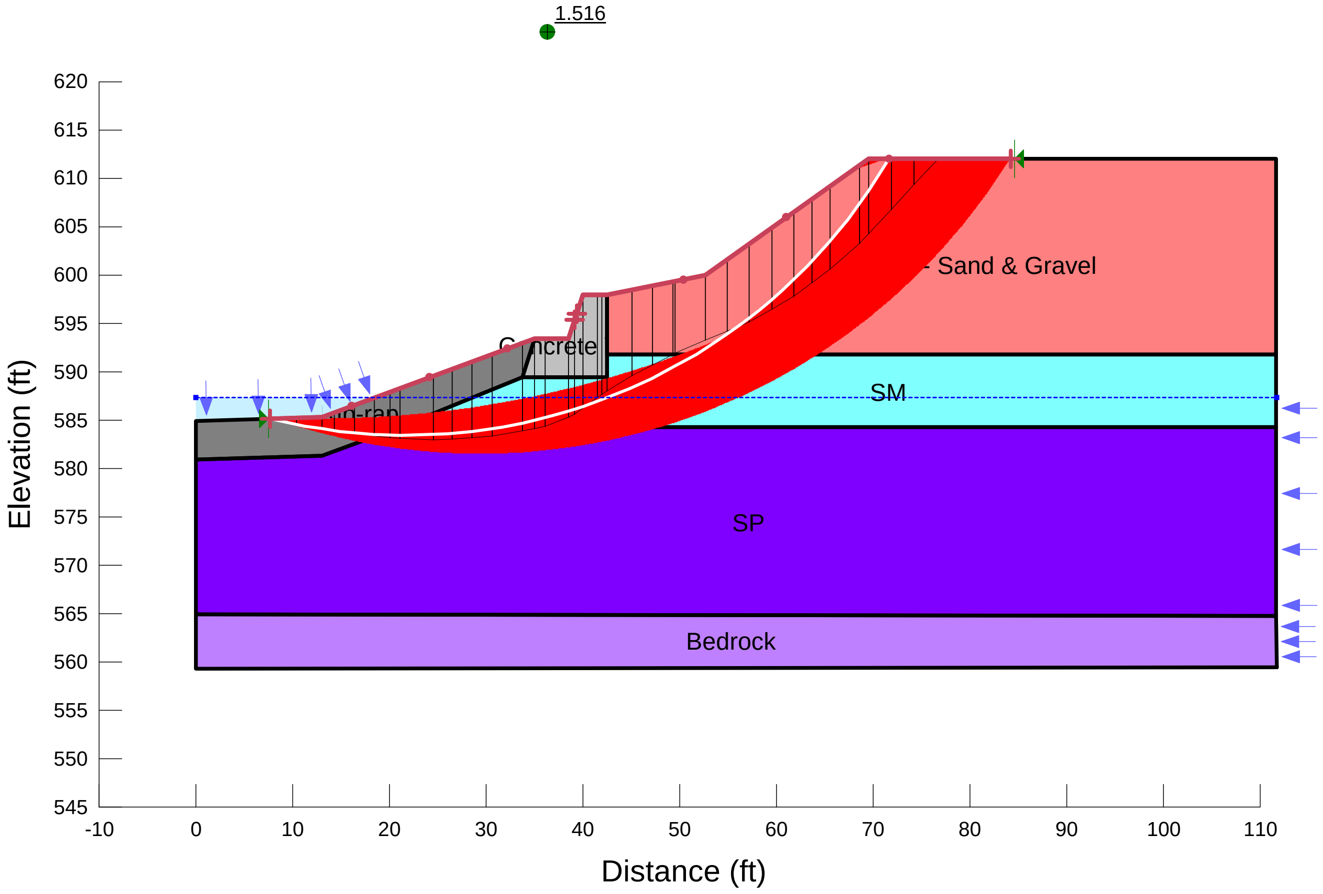
Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis During Construction Sta. 11+00 RS (Boring No. VP-B4)
Method: Spencer

Name: Concrete Wall	Unit Weight: 150 pcf	Cohesion: 2e+005 psf	Phi: 90 °
Name: Fill - Sand & Gravel	Unit Weight: 125 pcf	Cohesion: 0 psf	Phi: 30 °
Name: SP	Unit Weight: 125 pcf	Cohesion: 0 psf	Phi: 30 °
Name: SM	Unit Weight: 125 pcf	Cohesion: 0 psf	Phi: 35 °
Name: Bedrock			



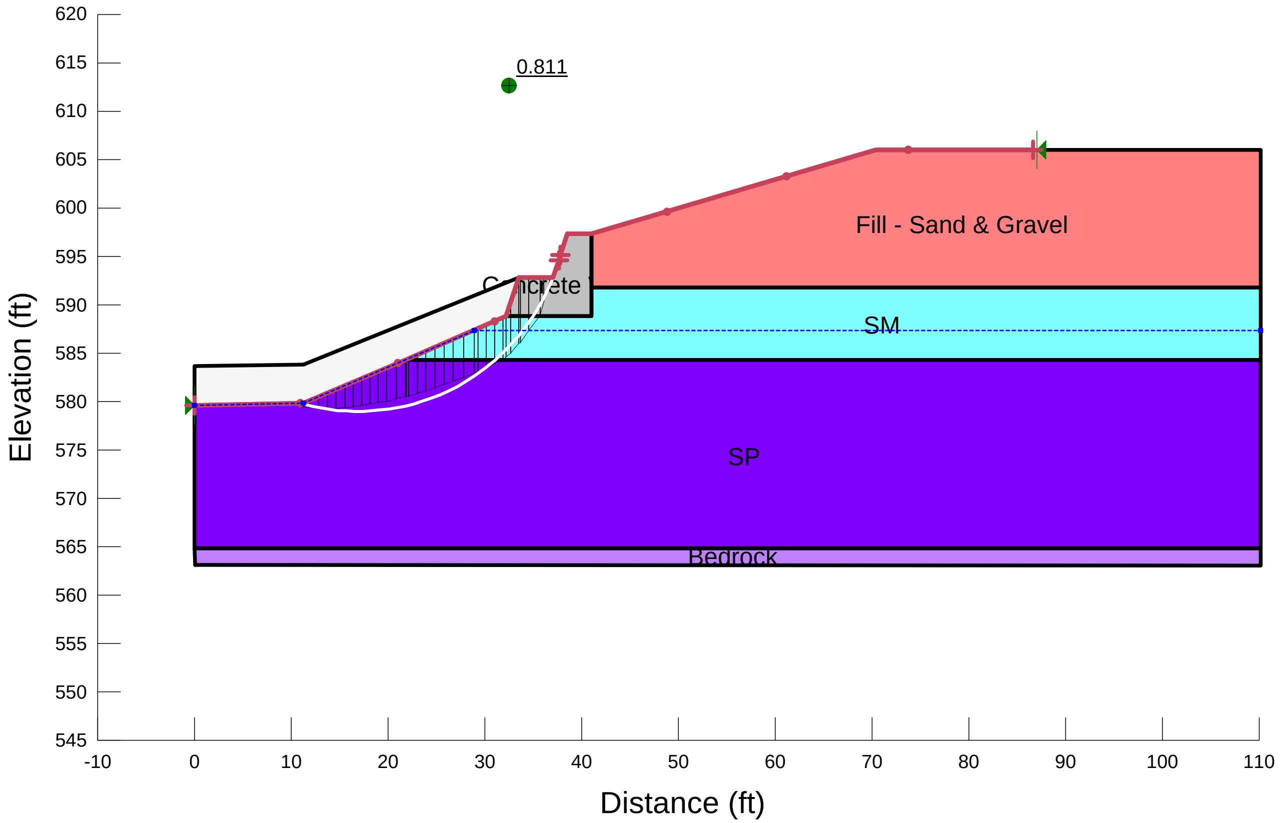
Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis Post Construction Sta. 11+00 RS (Boring No. VP-B4)
Method: Spencer

Name: Concrete Wall Unit Weight: 150 pcf Cohesion: 2e+005 psf Phi: 90 °
Name: Fill - Sand & Gravel Unit Weight: 125 pcf Cohesion: 0 psf Phi: 30 °
Name: SP Unit Weight: 125 pcf Cohesion: 0 psf Phi: 30 °
Name: SM Unit Weight: 125 pcf Cohesion: 0 psf Phi: 35 °
Name: Rip-rap Unit Weight: 140 pcf Cohesion: 0 psf Phi: 45 °
Name: Bedrock



Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis During Construction Sta. 12+00 RS (Boring No. VP-B4)
Method: Spencer

Name: Concrete Wall Unit Weight: 150 pcf Cohesion: 2e+005 psf Phi: 90 °
Name: Fill - Sand & Gravel Unit Weight: 125 pcf Cohesion: 0 psf Phi: 30 °
Name: SP Unit Weight: 125 pcf Cohesion: 0 psf Phi: 30 °
Name: SM Unit Weight: 125 pcf Cohesion: 0 psf Phi: 35 °
Name: Bedrock



Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis Post Construction Sta. 12+00 RS (Boring No. VP-B4)
Method: Spencer

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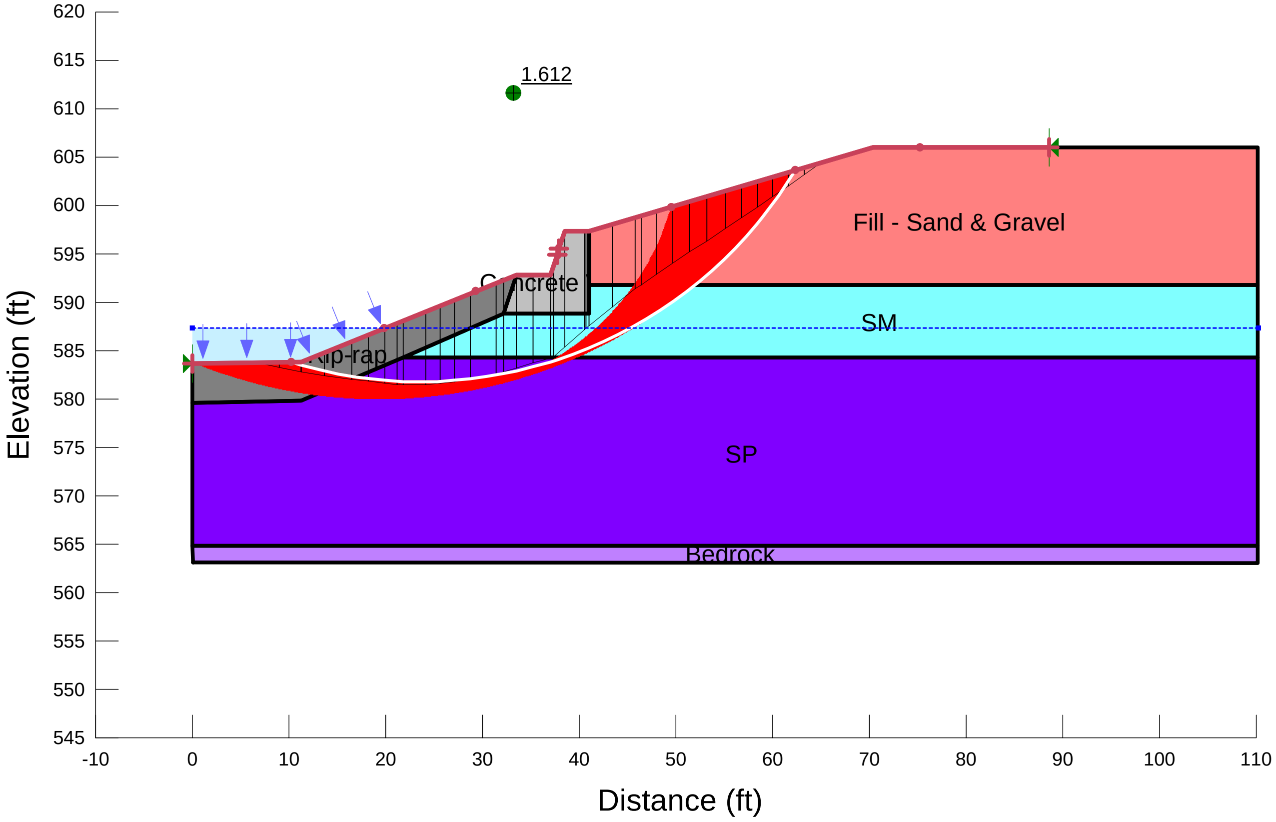
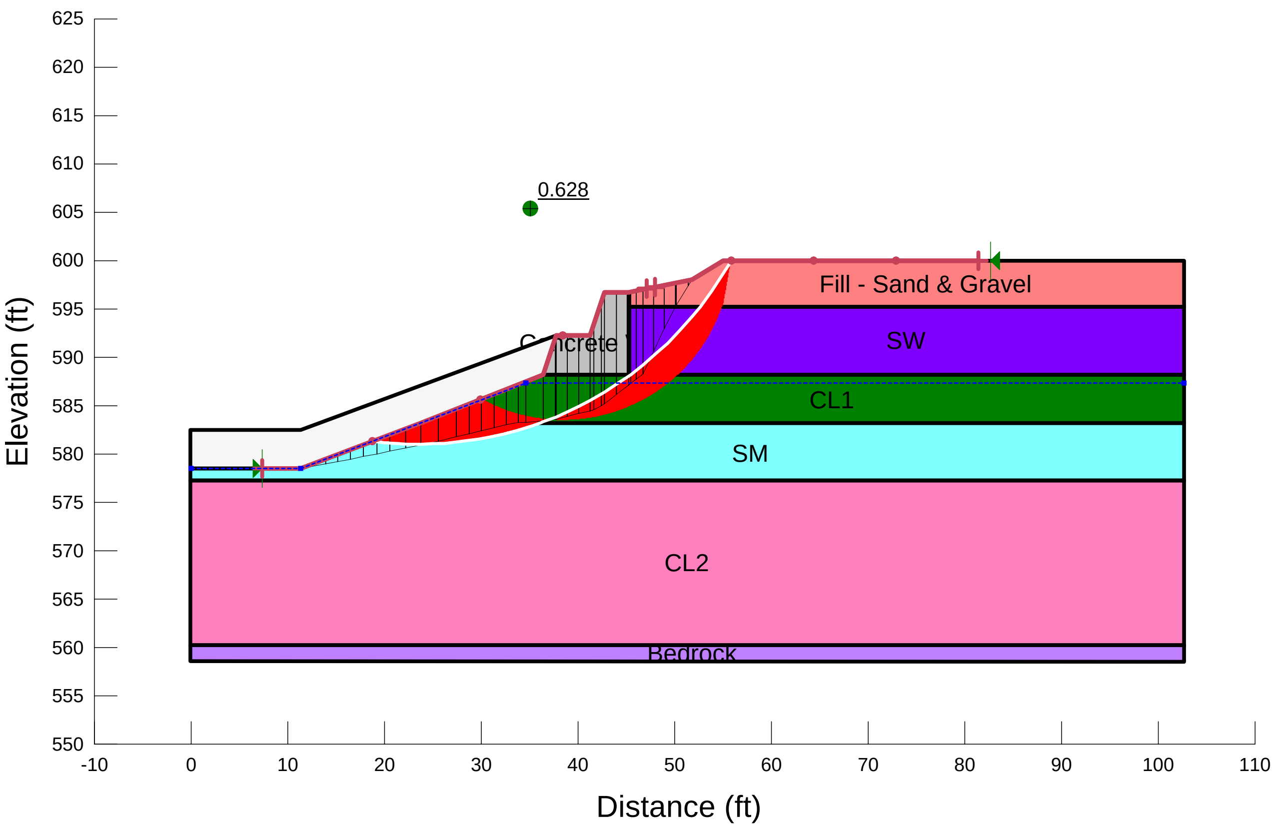
Name: Fill - Sand & Gravel Unit Weight: 125 pcf Cohesion: 0 psf Phi: 30 °
Name: SP Unit Weight: 125 pcf Cohesion: 0 psf Phi: 30 °
Name: SM Unit Weight: 125 pcf Cohesion: 0 psf Phi: 35 °
Name: Rip-rap Unit Weight: 140 pcf Cohesion: 0 psf Phi: 45 °
Name: Bedrock



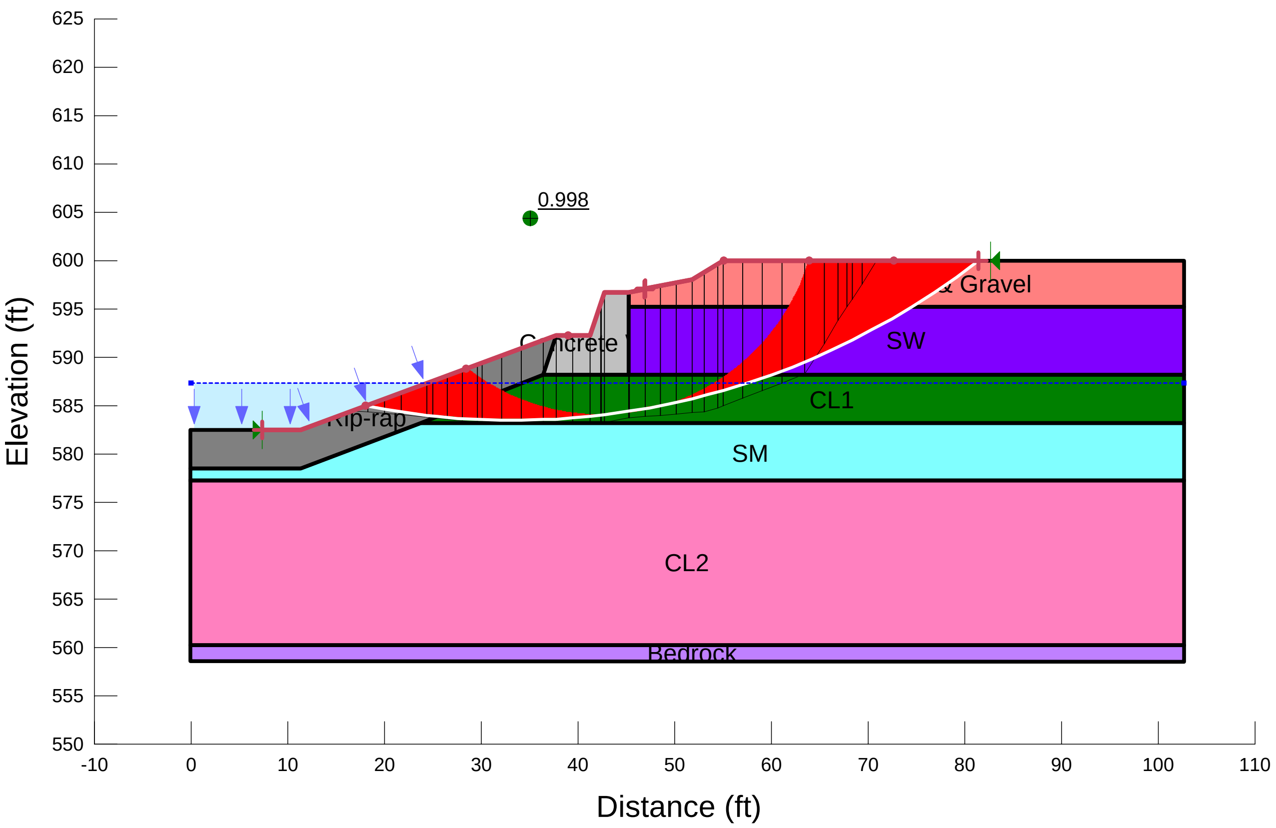
Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis During Construction Sta. 15+00 RS (Boring No. VP-B3)
Method: Spencer

Name: Concrete Wall Unit Weight: 150 pcf Cohesion: 2e+005 psf Phi: 90 °
Name: Fill - Sand & Gravel Unit Weight: 125 pcf Cohesion: 0 psf Phi: 30 °
Name: SW Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
Name: CL1 Unit Weight: 125 pcf Cohesion: 200 psf Phi: 0 °
Name: SM Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 °
Name: Bedrock
Name: CL2 Unit Weight: 120 pcf Cohesion: 750 psf Phi: 0 °



Created By: Smith, Timothy C LRE
Date: 4/1/2013
Name: SLOPE/W Analysis Post Construction Sta. 15+00 RS (Boring No. VP-B3)
Method: Spencer

Name: Concrete Wall Unit Weight: 150 pcf Cohesion: 2e+005 psf Phi: 90 °
Name: Fill - Sand & Gravel Unit Weight: 125 pcf Cohesion: 0 psf Phi: 30 °
Name: SW Unit Weight: 125 pcf Cohesion: 0 psf Phi: 34 °
Name: CL1 Unit Weight: 125 pcf Cohesion: 200 psf Phi: 0 °
Name: SM Unit Weight: 120 pcf Cohesion: 0 psf Phi: 33 °
Name: Rip-rap Unit Weight: 140 pcf Cohesion: 0 psf Phi: 45 °
Name: Bedrock
Name: CL2 Unit Weight: 120 pcf Cohesion: 750 psf Phi: 0 °



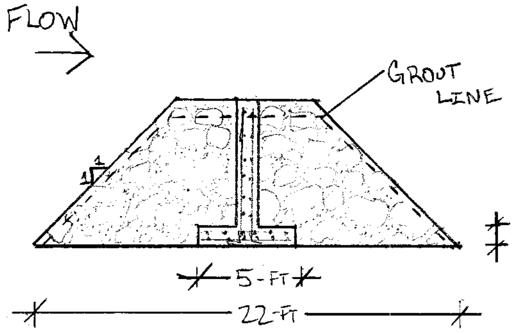
ATTACHMENT 7

BEARING CAPACITY CALCULATIONS

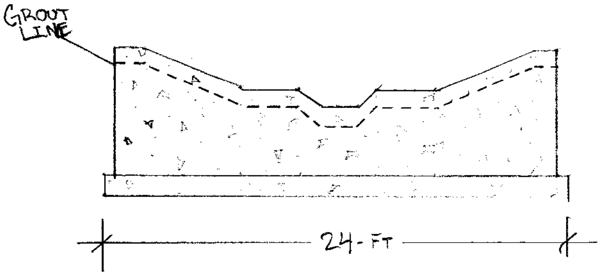
US Army Corps of Engineers
Louisville District®

Subject MENOMONEE BEARING CAPACITY
AT RIFFLE ANCHOR

Page 1 of 1 Pages
Computed By RSF Date 07JAN13
Checked By TCS Date 07JAN13



RIFFLE ANCHOR
DETAIL



RIFFLE ANCHOR
CROSS-SECTION

γ_{STONE} = 110 lb/ft³ (ASSUMING 35% VOIDS) ✓
γ_{FILL} = 132 lb/ft³ (ASSUMING 20% VOIDS) ✓
γ_{GROUT} = 135 lb/ft³ ✓
$\gamma_{CONCRETE}$ = 150 lb/ft³ ✓

V_{STONE} = 2100 FT³ ✓
V_{FILL} = V_{STONE} * 0.35 = 735 FT³ ✓
V_{GROUT} = V_{FILL} * 0.20 = 147 FT³ ✓
$V_{CONCRETE}$ = 240 FT³ ✓

W_{STONE} = 110 lb/ft³ (2100 FT³) = 231,000 lbs ✓
= 115.5 TON ✓
W_{FILL} = 132 lb/ft³ (735 FT³) = 97,000 lbs ✓
= 48.5 TON ✓
W_{GROUT} = 135 lb/ft³ (147 FT³) = 19,800 lbs ✓
= 9.9 TON ✓
$W_{CONCRETE}$ = 150 lb/ft³ (240 FT³) = 36,000 lbs ✓
= 18 TON ✓

W_{TOTAL} = 191.9 TON ✓

ASSUMING THE STRUCTURE BEARS ON A SMALLER FOOT PRINT WILL YIELD A MORE CONSERVATIVE ANSWER. THUS, THE BEARING AREA IS ASSUMED TO BE 7-FT BY 24-FT. ✓

q_{ACTUAL} = 191.9 TON / (7-FT * 24 FT) = 1.14 TSF ✓
= 2285 PSF ✓

US Army Corps of Engineers

Project: Menomonee River
Subject: FY 2012 Section 206
At MEN0112
Tan-Brown Gravelly-Sand

Prepared By: P. Folwer Date: 17 Dec 2012
Checked By: T. Smith Date: 03 Jan 2013
Status: Feasibility

Bearing Capacity of Soil-Supported Shallow Foundations: Terzaghi Model

Ref: EM 1110-1-1905, *Bearing Capacity of Soils*, 30 October 1992.

Foundation Dimensions

Foundation Width, B		24.0	feet
Foundation Length, L		22.0	feet
Reduction Factor, $r_\gamma = 1\text{-}0.25 \cdot \log(B/6)$	(for $B \geq 6$)	0.85	

Soil Parameters for Existing Overburden

Embedment Depth, D	0.0	feet
Wet Unit Weight, $\gamma_{wet,D}$	129.2	pcf
Saturated Unit Weight, $\gamma_{sat,D}$	144.0	pcf

Layer-Weighted Soil Parameters within Effective Shear Depth of Interest

USCS Soil Classification	SM									
Layer Thickness, h (feet)	0.9									
Angle of Internal Friction, ϕ (deg)	30									
Cohesion Intercept, c (psf)	0									
Wet Unit Weight, $\gamma_{wet,H}$ (pcf)	129.2									
Saturated Unit Weight, $\gamma_{sat,H}$ (pcf)	144.0									

Σh (Must Equal H)	0.9	feet
Angle of Internal Friction, ϕ	30	deg
Cohesion Intercept, c	0	psf
Wet Unit Weight, $\gamma_{wet,H}$	129.2	pcf
Saturated Unit Weight, $\gamma_{sat,H}$	144.0	pcf

Effective Shear Depth of Interest

Effective Shear Depth of Interest, $H = 0.5 \cdot B \cdot \tan(45 + \phi/2)$	20.8	feet
$K_{p\gamma} = (0.435\text{-}0.00716 \cdot \phi)^{(-1/0.383)}$	51.77	

(from curve-fit to Bowles' backcalculated $K_{p\gamma}$ values)

Effect of Water Table on Bearing Capacity

Depth to Water Table from Ground Surface, D_{GWT}		0.0	feet
$\gamma_{eff,D} = \gamma_{wet,D} - \gamma_w \cdot (D - D_{GWT})/D$	(for $0 < D_{GWT} \leq D$)	81.6	pcf
$\gamma_{eff,H} = \gamma'_H + \gamma_w \cdot (D - D_{GWT})/H$	(for $D < D_{GWT} \leq D + H$)	81.6	pcf

Bearing Capacity Factors

$N_q = e^{(0.75\pi - \phi/2) \cdot \tan(\phi)} / 2 \cdot \cos^2(45 + \phi/2)$	22.46
$N_c = (N_q - 1) \cdot \cot(\phi)$ (if ϕ=0, N_c=π+2)	37.16
$N_\gamma = \tan(\phi)/2 \cdot (K_{p\gamma}/\cos^2(\phi) - 1)$	19.64

Shape Factors

For:	Strip	Round	Square
s_c	1	1.3	1.3
s_γ	1	0.6	0.8

s_c	1.30
s_γ	0.80

Gross Bearing Pressures

Factor of Safety, FS	3.0	
$q_{ult} = c \cdot N_c \cdot s_c + \gamma_{eff,D} \cdot D \cdot N_q + 0.5 \cdot \gamma_{eff,H} \cdot B \cdot N_\gamma \cdot s_\gamma \cdot r_\gamma$	13,038	psf
Gross Allowable Bearing Capacity, $q_a = q_{ult}$ / FS	4,346	psf

Net Bearing Pressures

Net q_{ult} = Gross q_{ult} - q_D = Gross q_{ult} - $\gamma_{eff,D} \cdot D$	13,038	psf
Net Allowable Bearing Capacity, q_a = Net q_{ult} / FS	4,346	psf
Recommended Maximum Net Allowable Bearing Pressure (based on settlement considerations)	4,000	psf

US Army Corps
of Engineers

Project: Menomonee River
Subject: FY 2012 Section 206
At boring MEN0109
Gray Gravelly-Silt

Prepared By: P. Folwer Date: 17 Dec 2012
Checked By: T. Smith Date: 03 Jan 2013

Status: Feasibility

Bearing Capacity of Soil-Supported Shallow Foundations: Terzaghi Model

Ref: EM 1110-1-1905, *Bearing Capacity of Soils*, 30 October 1992.

Foundation Dimensions

Foundation Width, B		24.0	feet
Foundation Length, L		22.0	feet
Reduction Factor, $r_\gamma = 1\text{-}0.25\cdot\log(B/6)$	(for $B \geq 6$)	0.85	

Soil Parameters for Existing Overburden

Embedment Depth, D	0.0	feet
Wet Unit Weight, $\gamma_{wet,D}$	134.3	pcf
Saturated Unit Weight, $\gamma_{sat,D}$	140.0	pcf

Layer-Weighted Soil Parameters within Effective Shear Depth of Interest

USCS Soil Classification	GM									
Layer Thickness, h (feet)	2.1									
Angle of Internal Friction, ϕ (deg)	18									
Cohesion Intercept, c (psf)	400									
Wet Unit Weight, $\gamma_{wet,H}$ (pcf)	134.3									
Saturated Unit Weight, $\gamma_{sat,H}$ (pcf)	140.0									

Σh (Must Equal H)	2.1	feet
Angle of Internal Friction, ϕ	18	deg
Cohesion Intercept, c	400	psf
Wet Unit Weight, $\gamma_{wet,H}$	134.3	pcf
Saturated Unit Weight, $\gamma_{sat,H}$	140.0	pcf

Effective Shear Depth of Interest

Effective Shear Depth of Interest, $H = 0.5\cdot B\cdot\tan(45 + \phi/2)$	16.5	feet
$K_{p\gamma} = (0.435\text{-}0.00716\cdot\phi)^{(-1/0.383)}$	21.93	

(from curve-fit to Bowles' backcalculated $K_{p\gamma}$ values)

Effect of Water Table on Bearing Capacity

Depth to Water Table from Ground Surface, D_{GWT}		0.0	feet
$\gamma_{eff,D} = \gamma_{wet,D} - \gamma_W\cdot(D - D_{GWT})/D$	(for $0 < D_{GWT} \leq D$)	77.6	pcf
$\gamma_{eff,H} = \gamma'_H + \gamma_W\cdot(D - D_{GWT})/H$	(for $D < D_{GWT} \leq D + H$)	77.6	pcf

Bearing Capacity Factors

$N_q = e^{(0.75\pi - \phi/2)\cdot\tan(\phi)} / 2\cdot\cos^2(45 + \phi/2)$	6.04
$N_c = (N_q - 1)\cdot\cot(\phi)$ (if ϕ=0, N_c=π+2)	15.52
$N_\gamma = \tan(\phi)/2\cdot(K_{p\gamma}/\cos^2(\phi) - 1)$	3.78

Shape Factors

For:	Strip	Round	Square
s_c	1	1.3	1.3
s_γ	1	0.6	0.8

s_c	1.30
s_γ	0.80

Gross Bearing Pressures

Factor of Safety, FS	3.0	
$q_{ult} = c\cdot N_c\cdot s_c + \gamma_{eff,D}\cdot D\cdot N_q + 0.5\cdot\gamma_{eff,H}\cdot B\cdot N_\gamma\cdot s_\gamma\cdot r_\gamma$	10,471	psf
Gross Allowable Bearing Capacity, $q_a = q_{ult}$ / FS	3,490	psf

Net Bearing Pressures

Net q_{ult} = Gross q_{ult} - q_D = Gross q_{ult} - $\gamma_{eff,D}\cdot D$	10,471	psf
Net Allowable Bearing Capacity, q_a = Net q_{ult} / FS	3,490	psf
Recommended Maximum Net Allowable Bearing Pressure (based on settlement considerations)	3,250	psf

ATTACHMENT 8

SSP WALL ANALYSIS RESULTS

```
PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                           BY CLASSICAL METHODS
 DATE: 1-APRIL-2013                                          TIME: 9:45:06

                             ****************
                             *  INPUT DATA  *
                             ****************

       I.--HEADING
      'MENOMONEE SSP WALL ANALYSIS 0+50 LS

      II.--CONTROL
         CANTILEVER WALL DESIGN
         FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
         FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

     III.--WALL DATA
         ELEVATION AT TOP OF WALL    = 592.00 FT.

      IV.--SURFACE POINT DATA

           IV.A.--RIGHTSIDE
              DIST. FROM     ELEVATION
              WALL (FT)         (FT)
                   0.00        591.00
                   5.10        592.26
                  15.60        595.90
                  19.00        596.00
                  21.00        602.30
                  27.80        603.40
                  36.90        608.70
                  55.60        613.30
                  63.70        613.54

           IV.B.--LEFTSIDE
              DIST. FROM     ELEVATION
              WALL (FT)         (FT)
                   0.00        585.00

       V.--SOIL LAYER DATA

          V.A.--RIGHTSIDE
              LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
              LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF         ANGLE OF                        <-SAFETY->
  SAT.   MOIST  INTERNAL  COH-     WALL    ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.  WGHT.   FRICTION  ESION  FRICTION  ESION   ELEV.  SLOPE  ACT. PASS.
 (PCF)   (PCF)    (DEG)   (PSF)    (DEG)   (PSF)   (FT)  (FT/FT)
125.00  125.00    30.00    0.00     0.00    0.00  597.80   0.00   DEF  DEF
125.00  125.00    36.00    0.00     0.00    0.00  587.40   0.00   DEF  DEF
125.00  125.00    34.00  800.00     0.00    0.00                  DEF  DEF

          V.B.--LEFTSIDE
              LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
              LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF         ANGLE OF                        <-SAFETY->
  SAT.   MOIST  INTERNAL  COH-     WALL    ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.  WGHT.   FRICTION  ESION  FRICTION  ESION   ELEV.  SLOPE  ACT. PASS.
 (PCF)   (PCF)    (DEG)   (PSF)    (DEG)   (PSF)   (FT)  (FT/FT)
125.00  125.00    36.00    0.00     0.00    0.00  587.40   0.00   DEF  DEF
125.00  125.00    34.00  800.00     0.00    0.00                  DEF  DEF
```

```
     VI.--WATER DATA
        UNIT WEIGHT         = 62.40 (PCF)
        RIGHTSIDE ELEVATION = 587.30 (FT)
        LEFTSIDE ELEVATION  = 580.00 (FT)
        NO SEEPAGE

    VII.--VERTICAL SURCHARGE LOADS
        NONE

   VIII.--HORIZONTAL LOADS
        NONE








PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                             TIME: 9:45:08

                          **************************
                          *   SOIL PRESSURES FOR   *
                          * CANTILEVER WALL DESIGN *
                          **************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 0+50 LS

   II.--SOIL PRESSURES

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

                                              <------NET------>
         NET    <---LEFTSIDE--->     (SOIL + WATER)     <--RIGHTSIDE--->
ELEV.   WATER   PASSIVE   ACTIVE    ACTIVE   PASSIVE    ACTIVE   PASSIVE
(FT)    (PSF)     (PSF)    (PSF)     (PSF)     (PSF)     (PSF)     (PSF)
597.8     0.0       0.0      0.0       0.0       0.0       0.0       0.0
592.0     0.0       0.0      0.0       0.0       0.0       0.0       0.0
591.0     0.0       0.0      0.0       0.0       0.0       0.0       0.0
590.0     0.0       0.0      0.0     127.0   24158.1     127.0   24158.1
589.0     0.0       0.0      0.0      48.5     250.0      48.5     250.0
588.0     0.0       0.0      0.0     100.2     375.0     100.2     375.0
587.9     0.0       0.0      0.0       0.0     385.8       0.0     385.8
587.4     0.0       0.0      0.0       0.0     450.0       0.0     450.0
587.3     0.0       0.0      0.0       0.0     462.5       0.0     462.5
587.0    18.7       0.0      0.0      18.7    3545.8       0.0    3527.1
586.0    81.1       0.0      0.0      81.1    3877.1       0.0    3796.0
585.0   143.5       0.0      0.0     143.5    4240.2       0.0    4096.7
584.9   152.3     152.3     15.5       0.0    4271.6       0.0    4134.8
584.0   205.9    1081.9    110.3    -876.0    4463.0       0.0    4367.4
583.0   268.3    1400.1    142.8   -1131.8    4793.5       0.0    4667.9
582.0   330.7    1718.3    175.2   -1387.6    5159.4       0.0    5003.9
581.0   393.1    2036.5    207.7   -1643.4    5499.1       0.0    5313.7
580.0   455.5    2354.7    240.1   -1899.1    5939.8       0.0    5724.4
```

```
579.0   455.5    2672.9    272.6   -2217.3    6623.9       0.0    6441.0
578.0   455.5    2991.1    305.0   -2535.5    7595.8       0.0    7445.3
577.0   455.5    3309.3    337.5   -2853.7    7540.4       0.0    7422.4
576.0   455.5    3627.5    370.0   -3171.9    8572.5       0.0    8486.9
575.0   455.5    3945.7    402.4   -3490.1   11384.3       0.0   11331.2
574.0   455.5    4263.9    434.9   -3808.3   10463.1       0.0   10442.4
573.0   455.5    4582.1    467.3   -4126.5   12650.5       0.0   12662.3
572.0   455.5    4900.3    499.8   -4444.7   13237.5       0.0   13281.8
571.0   455.5    5218.5    532.2   -4762.9   12135.6       0.0   12212.3
570.0   455.5    5536.7    564.7   -5081.1   13489.0       0.0   13598.1
569.0   455.5    5854.9    597.1   -5399.3   12531.2       0.0   12672.8
568.0   455.5    6173.1    629.6   -5717.5   13081.7       0.0   13255.7
567.0   455.5    6491.3    662.0   -6035.7   13627.4       0.0   13833.9
566.0   455.5    6809.4    694.5   -6353.9   13944.7       0.0   14183.6
565.0   455.5    7127.6    726.9   -6672.1   13984.1       0.0   14255.5
564.0   455.5    7445.8    759.4   -6990.3   14098.5       0.0   14402.4
563.0   455.5    7764.0    791.8   -7308.5   14342.0       0.0   14678.3
562.0   455.5    8082.2    824.3   -7626.7   14585.5       0.0   14954.3
561.0   455.5    8400.4    856.7   -7944.9   14829.0       0.0   15230.2
560.0   455.5    8718.6    889.2   -8263.1   14176.5       0.0   14610.1
559.0   455.5    9036.8    921.6   -8581.3   14178.7       0.0   14644.8
558.0   455.5    9355.0    954.1   -8899.5   15058.2       0.0   15556.8
557.0   455.5    9673.2    986.5   -9217.7   15226.4       0.0   15757.5
556.0   455.5    9991.4   1019.0   -9535.9   15354.5       0.0   15917.9
555.0   455.5   10309.6   1051.4   -9854.1   15420.2       0.0   16016.1
554.0   455.5   10627.8   1083.9  -10172.3   15267.1       0.0   15895.4
```

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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                          TIME: 9:45:09

                       ****************************
                       *  SUMMARY OF RESULTS FOR  *
                       *  CANTILEVER WALL DESIGN  *
                       ****************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 0+50 LS

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

   WALL BOTTOM ELEV. (FT)     :      582.06
         PENETRATION (FT)     :        2.94

   MAX. BEND. MOMENT (LB-FT)  :  1.4327E+03
         AT ELEVATION (FT)    :      583.97

   MAX. SCALED DEFL. (LB-IN^3):  1.1859E+08
         AT ELEVATION (FT)    :      597.80
```

```
             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                    ELLASTICITY IN PSI TIMES PILE MOMENT
                    OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                    IN INCHES.




PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                         BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                        TIME: 9:45:09

                       ****************************
                       * COMPLETE OF RESULTS FOR  *
                       *  CANTILEVER WALL DESIGN  *
                       ****************************

     I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 0+50 LS

    II.--RESULTS

                   BENDING                          SCALED        NET
    ELEVATION      MOMENT          SHEAR          DEFLECTION    PRESSURE
       (FT)        (LB-FT)          (LB)          (LB-IN^3)      (PSF)
      597.80    0.0000E+00           0.          1.1859E+08       0.00
      592.00    6.7901E-13           0.          6.4773E+07       0.00
      591.00   -1.2733E-11           0.          5.5494E+07       0.00
      590.00    2.1172E+01          64.          4.6218E+07     127.03
      589.00    1.3511E+02         151.          3.6993E+07      48.46
      588.00    3.1922E+02         226.          2.8011E+07     100.19
      587.91    3.3894E+02         230.          2.7257E+07       0.00
      587.40    4.5705E+02         230.          2.2865E+07       0.00
      587.30    4.8004E+02         230.          2.2033E+07       0.00
      587.00    5.4929E+02         233.          1.9588E+07      18.72
      586.00    8.0177E+02         283.          1.2117E+07      81.12
      585.00    1.1354E+03         395.          6.0429E+06     143.52
      584.86    1.1919E+03         405.          5.3310E+06       0.00
      584.00    1.4322E+03          29.          1.9360E+06    -875.96
      583.00    9.8032E+02        -975.          1.8880E+05   -1131.75
      582.72    6.6195E+02       -1302.          5.3308E+04   -1203.38
      582.06    0.0000E+00           0.          0.0000E+00    5138.15

             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                    ELLASTICITY IN PSI TIMES PILE MOMENT
                    OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                    IN INCHES.

   III.--WATER AND SOIL PRESSURES

                          <-------------SOIL PRESSURES-------------->
                WATER     <----LEFTSIDE----->     <---RIGHTSIDE---->
  ELEVATION    PRESSURE   PASSIVE      ACTIVE     ACTIVE     PASSIVE
     (FT)       (PSF)      (PSF)        (PSF)      (PSF)      (PSF)
    597.80         0.         0.           0.         0.         0.
    592.00         0.         0.           0.         0.         0.
    591.00         0.         0.           0.         0.         0.
    590.00         0.         0.           0.       127.     24158.
    589.00         0.         0.           0.        48.       250.
    588.00         0.         0.           0.       100.       375.
    587.91         0.         0.           0.         0.       386.
```

```
   587.40           0.          0.          0.          0.        450.
   587.30           0.          0.          0.          0.        463.
   587.00          19.          0.          0.          0.       3527.
   586.00          81.          0.          0.          0.       3796.
   585.00         144.          0.          0.          0.       4097.
   584.86         152.        152.         16.          0.       4135.
   584.00         206.       1082.        110.          0.       4367.
   583.00         268.       1400.        143.          0.       4668.
   582.72         286.       1489.        152.          0.       4762.
   582.06         327.       1718.        175.          0.       5004.
   581.00         393.       2036.        208.          0.       5314.
```

```
PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                            BY CLASSICAL METHODS
  DATE: 1-APRIL-2013                                            TIME: 9:47:23

                              ****************
                              *  INPUT DATA  *
                              ****************

        I.--HEADING
       'MENOMONEE SSP WALL ANALYSIS 2+00 LS

       II.--CONTROL
          CANTILEVER WALL DESIGN
          FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
          FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

      III.--WALL DATA
          ELEVATION AT TOP OF WALL    = 592.00 FT.

       IV.--SURFACE POINT DATA

            IV.A.--RIGHTSIDE
               DIST. FROM     ELEVATION
               WALL (FT)        (FT)
                    0.00        591.00
                   11.40        595.60
                   14.90        595.70
                   17.70        603.70
                  137.40        608.00
                  237.00        610.00

            IV.B.--LEFTSIDE
               DIST. FROM     ELEVATION
               WALL (FT)        (FT)
                    0.00        585.00

        V.--SOIL LAYER DATA

           V.A.--RIGHTSIDE
               LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
               LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                 ANGLE OF         ANGLE OF                           <-SAFETY->
   SAT.   MOIST  INTERNAL  COH-     WALL    ADH-    <--BOTTOM-->  <-FACTOR->
  WGHT.   WGHT.  FRICTION  ESION  FRICTION  ESION   ELEV.  SLOPE  ACT. PASS.
  (PCF)   (PCF)    (DEG)   (PSF)    (DEG)   (PSF)   (FT)  (FT/FT)
 125.00  125.00    30.00    0.00     0.00    0.00  597.80   0.00   DEF  DEF
 125.00  125.00    36.00    0.00     0.00    0.00  587.40   0.00   DEF  DEF
 125.00  125.00    34.00  800.00     0.00    0.00                  DEF  DEF

           V.B.--LEFTSIDE
               LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
               LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                 ANGLE OF         ANGLE OF                           <-SAFETY->
   SAT.   MOIST  INTERNAL  COH-     WALL    ADH-    <--BOTTOM-->  <-FACTOR->
  WGHT.   WGHT.  FRICTION  ESION  FRICTION  ESION   ELEV.  SLOPE  ACT. PASS.
  (PCF)   (PCF)    (DEG)   (PSF)    (DEG)   (PSF)   (FT)  (FT/FT)
 125.00  125.00    36.00    0.00     0.00    0.00  587.40   0.00   DEF  DEF
 125.00  125.00    34.00  800.00     0.00    0.00                  DEF  DEF

       VI.--WATER DATA
          UNIT WEIGHT         = 62.40 (PCF)
```

```
        RIGHTSIDE ELEVATION = 587.30 (FT)
        LEFTSIDE ELEVATION  = 580.00 (FT)
        NO SEEPAGE

    VII.--VERTICAL SURCHARGE LOADS
        NONE

   VIII.--HORIZONTAL LOADS
        NONE
```

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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                          TIME: 9:47:25

                          **************************
                          *   SOIL PRESSURES FOR   *
                          * CANTILEVER WALL DESIGN *
                          **************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 2+00 LS

   II.--SOIL PRESSURES

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

                                   <------NET------>
         NET    <---LEFTSIDE--->    (SOIL + WATER)     <--RIGHTSIDE--->
ELEV.   WATER   PASSIVE   ACTIVE    ACTIVE   PASSIVE    ACTIVE   PASSIVE
(FT)    (PSF)     (PSF)    (PSF)     (PSF)     (PSF)     (PSF)     (PSF)
597.8     0.0       0.0      0.0       0.0       0.0       0.0       0.0
592.0     0.0       0.0      0.0       0.0       0.0       0.0       0.0
591.0     0.0       0.0      0.0       0.0       0.0       0.0       0.0
590.0     0.0       0.0      0.0     112.2   20919.1     112.2   20919.1
589.0     0.0       0.0      0.0      68.5     250.0      68.5     250.0
588.0     0.0       0.0      0.0     112.4     375.0     112.4     375.0
587.9     0.0       0.0      0.0       0.0     387.1       0.0     387.1
587.4     0.0       0.0      0.0       0.0     450.0       0.0     450.0
587.3     0.0       0.0      0.0       0.0     462.5       0.0     462.5
587.0    18.7       0.0      0.0      18.7    4891.3       0.0    4872.6
586.0    81.1       0.0      0.0      81.1    4810.7       0.0    4729.6
585.0   143.5       0.0      0.0     143.5    5175.6       0.0    5032.1
584.9   152.3     152.3     15.5       0.0    5221.0       0.0    5084.3
584.0   205.9    1081.9    110.3    -876.0    5498.3       0.0    5402.7
583.0   268.3    1400.1    142.8   -1131.8    6159.3       0.0    6033.8
582.0   330.7    1718.3    175.2   -1387.6    7200.8       0.0    7045.3
581.0   393.1    2036.5    207.7   -1643.4    8646.1       0.0    8460.7
580.0   455.5    2354.7    240.1   -1899.1   10584.4       0.0   10369.0
579.0   455.5    2672.9    272.6   -2217.3   10327.1       0.0   10144.2
578.0   455.5    2991.1    305.0   -2535.5    9831.3       0.0    9680.8
577.0   455.5    3309.3    337.5   -2853.7   10348.7       0.0   10230.7
```

```
576.0   455.5    3627.5    370.0   -3171.9    9889.3       0.0    9803.7
575.0   455.5    3945.7    402.4   -3490.1    9688.9       0.0    9635.8
574.0   455.5    4263.9    434.9   -3808.3    9649.3       0.0    9628.6
573.0   455.5    4582.1    467.3   -4126.5    9611.9       0.0    9623.7
572.0   455.5    4900.3    499.8   -4444.7    9544.5       0.0    9588.7
571.0   455.5    5218.5    532.2   -4762.9    9589.9       0.0    9666.6
570.0   455.5    5536.7    564.7   -5081.1    9702.2       0.0    9811.3
569.0   455.5    5854.9    597.1   -5399.3    9754.9       0.0    9896.4
568.0   455.5    6173.1    629.6   -5717.5    9831.2       0.0   10005.2
567.0   455.5    6491.3    662.0   -6035.7    9966.1       0.0   10172.6
566.0   455.5    6809.4    694.5   -6353.9   10101.0       0.0   10340.0
565.0   455.5    7127.6    726.9   -6672.1   10235.9       0.0   10507.3
564.0   455.5    7445.8    759.4   -6990.3   10370.8       0.0   10674.7
563.0   455.5    7764.0    791.8   -7308.5   10505.7       0.0   10842.0
562.0   455.5    8082.2    824.3   -7626.7   10635.1       0.0   11003.9
561.0   455.5    8400.4    856.7   -7944.9   10715.1       0.0   11116.3
560.0   455.5    8718.6    889.2   -8263.1   10800.1       0.0   11233.8
559.0   455.5    9036.8    921.6   -8581.3   10934.0       0.0   11400.1
558.0   455.5    9355.0    954.1   -8899.5   11067.9       0.0   11566.5
557.0   455.5    9673.2    986.5   -9217.7   11201.8       0.0   11732.8
556.0   455.5    9991.4   1019.0   -9535.9   11335.7       0.0   11899.1
555.0   455.5   10309.6   1051.4   -9854.1   11469.6       0.0   12065.5
554.0   455.5   10627.8   1083.9  -10172.3   11603.5       0.0   12231.8







PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                          TIME: 9:47:26

                       ****************************
                       *  SUMMARY OF RESULTS FOR  *
                       *  CANTILEVER WALL DESIGN  *
                       ****************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 2+00 LS

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

   WALL BOTTOM ELEV. (FT)     :      582.09
         PENETRATION (FT)     :        2.91

   MAX. BEND. MOMENT (LB-FT)  :  1.4753E+03
         AT ELEVATION (FT)    :      583.95

   MAX. SCALED DEFL. (LB-IN^3):  1.2186E+08
         AT ELEVATION (FT)    :      597.80

             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                    ELLASTICITY IN PSI TIMES PILE MOMENT
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                OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                IN INCHES.




PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                      BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                          TIME: 9:47:26

                   ****************************
                   * COMPLETE OF RESULTS FOR  *
                   *  CANTILEVER WALL DESIGN  *
                   ****************************

     I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 2+00 LS

    II.--RESULTS

                 BENDING                             SCALED         NET
    ELEVATION     MOMENT           SHEAR           DEFLECTION     PRESSURE
      (FT)       (LB-FT)           (LB)            (LB-IN^3)       (PSF)
      597.80    0.0000E+00            0.           1.2186E+08          0.00
      592.00    1.3891E-12            0.           6.6733E+07          0.00
      591.00    1.4552E-11            0.           5.7229E+07          0.00
      590.00    1.8694E+01           56.           4.7726E+07        112.16
      589.00    1.2358E+02          146.           3.8269E+07         68.54
      588.00    3.1160E+02          237.           2.9037E+07        112.45
      587.90    3.3491E+02          242.           2.8165E+07          0.00
      587.40    4.5685E+02          242.           2.3735E+07          0.00
      587.30    4.8108E+02          242.           2.2876E+07          0.00
      587.00    5.5408E+02          245.           2.0352E+07         18.72
      586.00    8.1902E+02          295.           1.2628E+07         81.12
      585.00    1.1651E+03          407.           6.3304E+06        143.52
      584.86    1.2234E+03          418.           5.5907E+06          0.00
      584.00    1.4743E+03           41.           2.0513E+06       -875.96
      583.00    1.0349E+03         -963.           2.0468E+05      -1131.75
      582.58    5.3185E+02        -1457.           2.3547E+04      -1238.45
      582.09    0.0000E+00            0.           0.0000E+00       7110.54

         NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                ELLASTICITY IN PSI TIMES PILE MOMENT
                OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                IN INCHES.

   III.--WATER AND SOIL PRESSURES

                           <-------------SOIL PRESSURES-------------->
                WATER      <----LEFTSIDE----->      <---RIGHTSIDE---->
  ELEVATION   PRESSURE     PASSIVE      ACTIVE       ACTIVE     PASSIVE
    (FT)        (PSF)       (PSF)        (PSF)        (PSF)      (PSF)
    597.80         0.          0.           0.           0.          0.
    592.00         0.          0.           0.           0.          0.
    591.00         0.          0.           0.           0.          0.
    590.00         0.          0.           0.         112.      20919.
    589.00         0.          0.           0.          69.        250.
    588.00         0.          0.           0.         112.        375.
    587.90         0.          0.           0.           0.        387.
    587.40         0.          0.           0.           0.        450.
    587.30         0.          0.           0.           0.        463.
    587.00        19.          0.           0.           0.       4873.
```

```
 586.00           81.          0.          0.          0.       4730.
 585.00          144.          0.          0.          0.       5032.
 584.86          152.        152.         16.          0.       5084.
 584.00          206.       1082.        110.          0.       5403.
 583.00          268.       1400.        143.          0.       6034.
 582.58          294.       1533.        156.          0.       6456.
 582.09          325.       1718.        175.          0.       7045.
 581.00          393.       2036.        208.          0.       8461.
```

```
PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
  DATE: 1-APRIL-2013                                      TIME: 9:49:18

                              ****************
                              *  INPUT DATA  *
                              ****************

        I.--HEADING
       'MENOMONEE SSP WALL ANALYSIS 02+00 RS

       II.--CONTROL
          CANTILEVER WALL DESIGN
          FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
          FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

      III.--WALL DATA
          ELEVATION AT TOP OF WALL    = 592.00 FT.

       IV.--SURFACE POINT DATA

            IV.A.--RIGHTSIDE
               DIST. FROM     ELEVATION
               WALL (FT)        (FT)
                    0.00        591.00
                   12.00        596.00
                   15.50        596.00
                   18.50        604.85
                   20.50        604.85
                   59.60        622.56
                  100.00        623.18

            IV.B.--LEFTSIDE
               DIST. FROM     ELEVATION
               WALL (FT)        (FT)
                    0.00        585.00

        V.--SOIL LAYER DATA

           V.A.--RIGHTSIDE
               LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
               LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                 ANGLE OF          ANGLE OF                          <-SAFETY->
  SAT.    MOIST  INTERNAL  COH-      WALL    ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.    WGHT.  FRICTION  ESION  FRICTION   ESION   ELEV.  SLOPE  ACT. PASS.
 (PCF)    (PCF)    (DEG)   (PSF)    (DEG)    (PSF)   (FT)  (FT/FT)
125.00  125.00    30.00    0.00     0.00     0.00  597.80   0.00   DEF  DEF
125.00  125.00    36.00    0.00     0.00     0.00  587.40   0.00   DEF  DEF
125.00  125.00    34.00  800.00     0.00     0.00                  DEF  DEF

           V.B.--LEFTSIDE
               LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
               LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                 ANGLE OF          ANGLE OF                          <-SAFETY->
  SAT.    MOIST  INTERNAL  COH-      WALL    ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.    WGHT.  FRICTION  ESION  FRICTION   ESION   ELEV.  SLOPE  ACT. PASS.
 (PCF)    (PCF)    (DEG)   (PSF)    (DEG)    (PSF)   (FT)  (FT/FT)
125.00  125.00    36.00    0.00     0.00     0.00  587.40   0.00   DEF  DEF
125.00  125.00    34.00  800.00     0.00     0.00                  DEF  DEF

       VI.--WATER DATA
```

```
        UNIT WEIGHT         = 62.40 (PCF)
        RIGHTSIDE ELEVATION = 587.30 (FT)
        LEFTSIDE ELEVATION  = 580.00 (FT)
        NO SEEPAGE

    VII.--VERTICAL SURCHARGE LOADS
        NONE

   VIII.--HORIZONTAL LOADS
        NONE
```

```
PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                          TIME: 9:49:23

                          **************************
                          *   SOIL PRESSURES FOR   *
                          * CANTILEVER WALL DESIGN *
                          **************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 02+00 RS

   II.--SOIL PRESSURES

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

                                   <------NET------>
         NET    <---LEFTSIDE--->     (SOIL + WATER)     <--RIGHTSIDE--->
ELEV.   WATER   PASSIVE   ACTIVE    ACTIVE   PASSIVE    ACTIVE   PASSIVE
(FT)    (PSF)     (PSF)    (PSF)     (PSF)     (PSF)     (PSF)     (PSF)
597.8     0.0       0.0      0.0       0.0       0.0       0.0       0.0
592.0     0.0       0.0      0.0       0.0       0.0       0.0       0.0
591.0     0.0       0.0      0.0       0.0       0.0       0.0       0.0
590.0     0.0       0.0      0.0     111.2   20647.7     111.2   20647.7
589.0     0.0       0.0      0.0      69.3     250.0      69.3     250.0
588.0     0.0       0.0      0.0     113.4     375.0     113.4     375.0
587.9     0.0       0.0      0.0       0.0     387.2       0.0     387.2
587.4     0.0       0.0      0.0       0.0     450.0       0.0     450.0
587.3     0.0       0.0      0.0       0.0     462.5       0.0     462.5
587.0    18.7       0.0      0.0      18.7    4923.6       0.0    4904.9
586.0    81.1       0.0      0.0      81.1    4881.1       0.0    4800.0
585.0   143.5       0.0      0.0     143.5    5273.1       0.0    5129.6
584.9   152.3     152.3     15.5       0.0    5317.7       0.0    5180.9
584.0   205.9    1081.9    110.3    -876.0    5590.1       0.0    5494.5
583.0   268.3    1400.1    142.8   -1131.8    6218.0       0.0    6092.5
582.0   330.7    1718.3    175.2   -1387.6    7262.1       0.0    7106.6
581.0   393.1    2036.5    207.7   -1643.4    8715.3       0.0    8529.8
580.0   455.5    2354.7    240.1   -1899.1   10818.6       0.0   10603.2
579.0   455.5    2672.9    272.6   -2217.3   11538.4       0.0   11355.5
578.0   455.5    2991.1    305.0   -2535.5   11446.4       0.0   11295.9
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577.0   455.5    3309.3    337.5   -2853.7   11422.1       0.0   11304.1
576.0   455.5    3627.5    370.0   -3171.9   12002.2       0.0   11916.7
575.0   455.5    3945.7    402.4   -3490.1   13213.7       0.0   13160.6
574.0   455.5    4263.9    434.9   -3808.3   13607.4       0.0   13586.7
573.0   455.5    4582.1    467.3   -4126.5   13886.0       0.0   13897.8
572.0   455.5    4900.3    499.8   -4444.7   14093.0       0.0   14137.2
571.0   455.5    5218.5    532.2   -4762.9   14415.0       0.0   14491.7
570.0   455.5    5536.7    564.7   -5081.1   14808.6       0.0   14917.8
569.0   455.5    5854.9    597.1   -5399.3   15253.7       0.0   15395.3
568.0   455.5    6173.1    629.6   -5717.5   15583.9       0.0   15757.9
567.0   455.5    6491.3    662.0   -6035.7   15817.8       0.0   16024.3
566.0   455.5    6809.4    694.5   -6353.9   16153.6       0.0   16392.6
565.0   455.5    7127.6    726.9   -6672.1   16541.6       0.0   16813.1
564.0   455.5    7445.8    759.4   -6990.3   16947.4       0.0   17251.3
563.0   455.5    7764.0    791.8   -7308.5   17345.2       0.0   17681.5
562.0   455.5    8082.2    824.3   -7626.7   17737.7       0.0   18106.4
561.0   455.5    8400.4    856.7   -7944.9   18130.0       0.0   18531.2
560.0   455.5    8718.6    889.2   -8263.1   18522.3       0.0   18956.0
559.0   455.5    9036.8    921.6   -8581.3   18914.6       0.0   19380.7
558.0   455.5    9355.0    954.1   -8899.5   19306.9       0.0   19805.5
557.0   455.5    9673.2    986.5   -9217.7   19699.3       0.0   20230.3
556.0   455.5    9991.4   1019.0   -9535.9   20091.6       0.0   20655.1
555.0   455.5   10309.6   1051.4   -9854.1   20106.0       0.0   20701.9
554.0   455.5   10627.8   1083.9  -10120.5   19848.7      51.8   20477.1






PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                             TIME: 9:49:24

                       ****************************
                       *  SUMMARY OF RESULTS FOR  *
                       *  CANTILEVER WALL DESIGN  *
                       ****************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 02+00 RS

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

   WALL BOTTOM ELEV. (FT)     :      582.09
         PENETRATION (FT)     :        2.91

   MAX. BEND. MOMENT (LB-FT)  :  1.4764E+03
         AT ELEVATION (FT)    :      583.95

   MAX. SCALED DEFL. (LB-IN^3):  1.2191E+08
         AT ELEVATION (FT)    :      597.80

             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
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                  ELLASTICITY IN PSI TIMES PILE MOMENT
                  OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                  IN INCHES.




PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                        BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                       TIME: 9:49:24

                     ****************************
                     * COMPLETE OF RESULTS FOR  *
                     *  CANTILEVER WALL DESIGN  *
                     ****************************

     I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 02+00 RS

    II.--RESULTS

                   BENDING                          SCALED        NET
    ELEVATION      MOMENT          SHEAR          DEFLECTION    PRESSURE
      (FT)         (LB-FT)          (LB)          (LB-IN^3)       (PSF)
      597.80    0.0000E+00            0.          1.2191E+08       0.00
      592.00    1.3678E-13            0.          6.6772E+07       0.00
      591.00   -1.8190E-12            0.          5.7265E+07       0.00
      590.00    1.8541E+01           56.          4.7760E+07     111.25
      589.00    1.2281E+02          146.          3.8300E+07      69.35
      588.00    3.1075E+02          237.          2.9064E+07     113.43
      587.90    3.3432E+02          243.          2.8183E+07       0.00
      587.40    4.5628E+02          243.          2.3758E+07       0.00
      587.30    4.8057E+02          243.          2.2899E+07       0.00
      587.00    5.5371E+02          246.          2.0373E+07      18.72
      586.00    8.1913E+02          296.          1.2643E+07      81.12
      585.00    1.1657E+03          408.          6.3392E+06     143.52
      584.86    1.2241E+03          418.          5.5986E+06       0.00
      584.00    1.4754E+03           42.          2.0550E+06    -875.96
      583.00    1.0365E+03         -962.          2.0532E+05   -1131.75
      582.58    5.2869E+02        -1461.          2.3043E+04   -1239.32
      582.09    0.0000E+00            0.          0.0000E+00    7171.24

            NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                   ELLASTICITY IN PSI TIMES PILE MOMENT
                   OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                   IN INCHES.

   III.--WATER AND SOIL PRESSURES

                              <-------------SOIL PRESSURES-------------->
                 WATER        <----LEFTSIDE----->       <---RIGHTSIDE---->
  ELEVATION     PRESSURE      PASSIVE      ACTIVE       ACTIVE      PASSIVE
    (FT)         (PSF)         (PSF)        (PSF)        (PSF)       (PSF)
   597.80           0.            0.           0.           0.          0.
   592.00           0.            0.           0.           0.          0.
   591.00           0.            0.           0.           0.          0.
   590.00           0.            0.           0.         111.      20648.
   589.00           0.            0.           0.          69.        250.
   588.00           0.            0.           0.         113.        375.
   587.90           0.            0.           0.           0.        387.
   587.40           0.            0.           0.           0.        450.
   587.30           0.            0.           0.           0.        463.
```

```
     587.00             19.            0.            0.            0.        4905.
     586.00             81.            0.            0.            0.        4800.
     585.00            144.            0.            0.            0.        5130.
     584.86            152.          152.           16.            0.        5181.
     584.00            206.         1082.          110.            0.        5494.
     583.00            268.         1400.          143.            0.        6092.
     582.58            295.         1534.          156.            0.        6519.
     582.09            325.         1718.          175.            0.        7107.
     581.00            393.         2036.          208.            0.        8530.
```

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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                           BY CLASSICAL METHODS
 DATE: 1-APRIL-2013                                          TIME: 9:51:18

                             ****************
                             *  INPUT DATA  *
                             ****************

       I.--HEADING
      'MENOMONEE SSP WALL ANALYSIS 08+00 RS

      II.--CONTROL
         CANTILEVER WALL DESIGN
         FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
         FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

     III.--WALL DATA
         ELEVATION AT TOP OF WALL    = 591.00 FT.

      IV.--SURFACE POINT DATA

           IV.A.--RIGHTSIDE
              DIST. FROM     ELEVATION
              WALL (FT)         (FT)
                   0.00        589.90
                   9.06        590.00
                  18.36        602.10
                  38.76        610.00
                  42.60        612.00
                  44.40        614.00
                  50.70        618.00
                  53.50        620.00
                  91.00        620.90

           IV.B.--LEFTSIDE
              DIST. FROM     ELEVATION
              WALL (FT)         (FT)
                   0.00        583.50

       V.--SOIL LAYER DATA

          V.A.--RIGHTSIDE
              LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
              LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF         ANGLE OF                        <-SAFETY->
  SAT.   MOIST  INTERNAL  COH-     WALL    ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.   WGHT.  FRICTION  ESION  FRICTION  ESION   ELEV.  SLOPE  ACT. PASS.
 (PCF)   (PCF)    (DEG)   (PSF)    (DEG)    (PSF)   (FT)  (FT/FT)
125.00  125.00    35.00    0.00     0.00    0.00  591.10   0.00   DEF  DEF
125.00  120.00    18.00 1003.00     0.00    0.00  579.10   0.00   DEF  DEF
125.00  125.00    33.00    0.00     0.00    0.00                  DEF  DEF

          V.B.--LEFTSIDE
              LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
              LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF         ANGLE OF                        <-SAFETY->
  SAT.   MOIST  INTERNAL  COH-     WALL    ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.   WGHT.  FRICTION  ESION  FRICTION  ESION   ELEV.  SLOPE  ACT. PASS.
 (PCF)   (PCF)    (DEG)   (PSF)    (DEG)    (PSF)   (FT)  (FT/FT)
125.00  120.00    18.00 1003.00     0.00    0.00  579.10   0.00   DEF  DEF
125.00  125.00    30.00    0.00     0.00    0.00                  DEF  DEF
```

```
     VI.--WATER DATA
        UNIT WEIGHT         = 62.40 (PCF)
        RIGHTSIDE ELEVATION = 587.30 (FT)
        LEFTSIDE ELEVATION  = 580.00 (FT)
        NO SEEPAGE

    VII.--VERTICAL SURCHARGE LOADS
        NONE

   VIII.--HORIZONTAL LOADS
        NONE
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                            TIME: 9:51:21

                          **************************
                          *   SOIL PRESSURES FOR   *
                          * CANTILEVER WALL DESIGN *
                          **************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 08+00 RS

   II.--SOIL PRESSURES

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

                                   <------NET------>
         NET    <---LEFTSIDE--->     (SOIL + WATER)     <--RIGHTSIDE--->
ELEV.   WATER   PASSIVE   ACTIVE    ACTIVE   PASSIVE    ACTIVE   PASSIVE
(FT)    (PSF)     (PSF)    (PSF)     (PSF)     (PSF)     (PSF)     (PSF)
591.1     0.0       0.0      0.0       0.0       0.0       0.0       0.0
591.0     0.0       0.0      0.0       0.0       0.0       0.0       0.0
590.0     0.0       0.0      0.0       0.0       0.0       0.0       0.0
589.9     0.0       0.0      0.0       0.0       0.0       0.0       0.0
589.0     0.0       0.0      0.0       0.0    3027.3       0.0    3027.3
588.0     0.0       0.0      0.0       0.0    2002.3       0.0    2002.3
587.3     0.0       0.0      0.0       0.0    2124.1       0.0    2124.1
587.0    18.7       0.0      0.0      18.7    2181.7       0.0    2163.0
586.0    81.1       0.0      0.0      81.1    2343.0       0.0    2261.9
585.0   143.5       0.0      0.0     143.5    2504.3       0.0    2360.8
584.0   205.9       0.0      0.0     205.9    2665.6       0.0    2459.7
583.5+  237.1       0.0      0.0   16315.4    2746.3   16078.3    2509.2
583.5-  237.1    1658.0      0.0   14657.4    2746.3   16078.3    2509.2
583.0   268.3    1750.3      0.0   13271.2    2880.7   14753.1    2612.4
582.6   292.0    1820.4      0.0       0.0    3082.9    1528.3    2805.5
582.6+  294.8    1828.5      0.0   -1533.7    3106.2       0.0    2827.9
582.6-  294.8    1828.5      0.0   -1533.7    3106.2       0.0    2795.1
582.5   299.5    1842.5      0.0   -1543.0    3127.4       0.0    2827.9
```

```
582.0   330.7    1934.7      0.0   -1604.0    3320.1       0.0    2989.4
581.0   393.1    2119.2      0.0   -1726.0    3919.8       0.0    3526.7
580.0   455.5    2303.6      0.0   -1848.1    4518.4       0.0    4062.9
579.1+  455.5    2390.2      0.0   -1244.8    2950.8       0.0    2574.7
579.1-  455.5    1010.4    158.8   -1244.8    2950.8       0.0    2574.7
579.0   455.5    1023.7    160.9    -568.1    2834.7       0.0    2540.0
578.0   455.5    1156.5    181.7    -700.9    4641.6       0.0    4367.8
577.0   455.5    1289.2    202.6    -833.7    5956.2       0.0    5703.2
576.0   455.5    1422.0    223.5    -966.5    8048.0       0.0    7816.0
575.0   455.5    1554.8    244.3   -1099.3   11719.1       0.0   11507.9
574.0   455.5    1687.6    265.2   -1232.1   20288.3       0.0   20098.0
573.0   455.5    1820.4    286.1   -1364.9   18233.7       0.0   18064.3
572.0   455.5    1953.2    306.9   -1497.6   77607.1       0.0   77458.5
571.0   455.5    2085.9    327.8   -1630.4   69625.0       0.0   69497.3
570.0   455.5    2218.7    348.7   -1763.2    1848.7       0.0    1741.8
569.0   455.5    2351.5    369.5   -1896.0    9686.8       0.0    9600.8
568.0   455.5    2484.3    390.4   -2028.8    9819.5       0.0    9754.4
567.0   455.5    2617.1    411.3   -2161.6    9952.3       0.0    9908.0
566.0   455.5    2749.9    432.1   -2294.3    2698.1       0.0    2674.7
565.0   455.5    2882.6    453.0   -2427.1    2741.2       0.0    2738.6
564.0   455.5    3015.4    473.9   -2559.9   10169.7       0.0   10188.0
563.0   455.5    3148.2    494.7   -2692.7   10299.5       0.0   10338.7
562.0   455.5    3281.0    515.6   -2825.5   10429.3       0.0   10489.3
561.0   455.5    3413.8    536.5   -2958.3    3584.6       0.0    3665.5
560.0   455.5    3546.6    557.3   -3091.0    3642.2       0.0    3744.0
559.0   455.5    3679.3    578.2   -3223.8   10673.3       0.0   10796.0
558.0   455.5    3812.1    599.1   -3356.6   10801.0       0.0   10944.6
557.0   455.5    3944.9    619.9   -3489.4   10928.8       0.0   11093.2
556.0   455.5    4077.7    640.8   -3622.2    4518.4       0.0    4703.7
555.0   455.5    4210.5    661.7   -3755.0    4592.4       0.0    4798.6
554.0   455.5    4343.3    682.5   -3887.7   11203.8       0.0   11430.8
553.0   455.5    4476.1    703.4   -4020.5   11330.3       0.0   11578.2
```

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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                          TIME: 9:51:22

                       ****************************
                       *  SUMMARY OF RESULTS FOR  *
                       *  CANTILEVER WALL DESIGN  *
                       ****************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 08+00 RS

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

   WALL BOTTOM ELEV. (FT)     :      559.72
         PENETRATION (FT)     :       23.78
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   MAX. BEND. MOMENT (LB-FT)  :  8.5552E+04
         AT ELEVATION (FT)    :      571.43

   MAX. SCALED DEFL. (LB-IN^3):  4.0668E+10
         AT ELEVATION (FT)    :      591.10

             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                    ELLASTICITY IN PSI TIMES PILE MOMENT
                    OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                    IN INCHES.




PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                            TIME: 9:51:22

                       ****************************
                       * COMPLETE OF RESULTS FOR  *
                       *  CANTILEVER WALL DESIGN  *
                       ****************************

     I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 08+00 RS

    II.--RESULTS

                    BENDING                          SCALED         NET
    ELEVATION       MOMENT           SHEAR          DEFLECTION    PRESSURE
      (FT)          (LB-FT)           (LB)          (LB-IN^3)      (PSF)
      591.10    0.0000E+00              0.         4.0668E+10        0.00
      591.00   -1.9993E-06              0.         4.0453E+10        0.00
      590.00   -3.4312E-05              0.         3.8309E+10        0.00
      589.90   -3.7976E-05              0.         3.8095E+10        0.00
      589.00   -6.1422E-05              0.         3.6165E+10        0.00
      588.00   -8.6577E-05              0.         3.4021E+10        0.00
      587.30   -1.0424E-04              0.         3.2520E+10        0.00
      587.00    2.8069E-01              3.         3.1876E+10       18.72
      586.00    2.2849E+01             53.         2.9732E+10       81.12
      585.00    1.2654E+02            165.         2.7588E+10      143.52
      584.00    3.7374E+02            340.         2.5444E+10      205.92
      583.50+   1.2406E+03           4470.         2.4372E+10    16315.39
      583.50-   1.2406E+03           4470.         2.4372E+10    14657.36
      583.00    5.2501E+03          11452.         2.3301E+10    13271.20
      582.62    1.0241E+04          13974.         2.2489E+10        0.00
      582.58    1.0854E+04          13940.         2.2395E+10    -1533.68
      582.50    1.1910E+04          13823.         2.2233E+10    -1542.97
      582.00    1.8626E+04          13036.         2.1169E+10    -1603.99
      581.00    3.0840E+04          11371.         1.9069E+10    -1726.05
      580.00    4.1328E+04           9584.         1.7022E+10    -1848.10
      579.10    4.9287E+04           8192.         1.5239E+10    -1244.79
      579.00    5.0101E+04           8102.         1.5045E+10     -568.15
      578.00    5.7896E+04           7467.         1.3156E+10     -700.93
      577.00    6.4991E+04           6700.         1.1366E+10     -833.72
      576.00    7.1252E+04           5800.         9.6886E+09     -966.50
      575.00    7.6546E+04           4767.         8.1340E+09    -1099.28
      574.00    8.0741E+04           3601.         6.7116E+09    -1232.07
      573.00    8.3705E+04           2303.         5.4285E+09    -1364.85
      572.00    8.5303E+04            872.         4.2899E+09    -1497.64
      571.00    8.5403E+04           -693.         3.2985E+09    -1630.42
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     570.00    8.3873E+04         -2389.        2.4543E+09      -1763.20
     569.00    8.0580E+04         -4219.        1.7549E+09      -1895.99
     568.00    7.5391E+04         -6181.        1.1945E+09      -2028.77
     567.00    6.8173E+04         -8276.        7.6399E+08      -2161.56
     566.03    5.9080E+04        -10442.        4.5813E+08      -2290.71
     566.00    5.8794E+04        -10504.        4.5102E+08      -2256.55
     565.00    4.7371E+04        -12135.        2.3933E+08      -1004.88
     564.00    3.4942E+04        -12514.        1.0935E+08        246.78
     563.00    2.2760E+04        -11641.        3.9785E+07       1498.44
     562.00    1.2077E+04         -9517.        9.7680E+06       2750.11
     561.00    4.1441E+03         -6141.        1.0165E+06       4001.77
     560.00    2.1280E+02         -1513.        2.3798E+03       5253.43
     559.72    0.0000E+00             0.        0.0000E+00       5602.38

            NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                   ELLASTICITY IN PSI TIMES PILE MOMENT
                   OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                   IN INCHES.

  III.--WATER AND SOIL PRESSURES

                          <-------------SOIL PRESSURES-------------->
               WATER      <----LEFTSIDE----->      <---RIGHTSIDE---->
ELEVATION    PRESSURE     PASSIVE      ACTIVE       ACTIVE      PASSIVE
  (FT)        (PSF)        (PSF)        (PSF)        (PSF)       (PSF)
 591.10            0.          0.          0.           0.          0.
 591.00            0.          0.          0.           0.          0.
 590.00            0.          0.          0.           0.          0.
 589.90            0.          0.          0.           0.          0.
 589.00            0.          0.          0.           0.       3027.
 588.00            0.          0.          0.           0.       2002.
 587.30            0.          0.          0.           0.       2124.
 587.00           19.          0.          0.           0.       2163.
 586.00           81.          0.          0.           0.       2262.
 585.00          144.          0.          0.           0.       2361.
 584.00          206.          0.          0.           0.       2460.
 583.50+         237.          0.          0.       16078.       2509.
 583.50-         237.       1658.          0.       16078.       2509.
 583.00          268.       1750.          0.       14753.       2612.
 582.62          292.       1820.          0.        1528.       2806.
 582.58+         295.       1828.          0.           0.       2828.
 582.58-         295.       1828.          0.           0.       2795.
 582.50          300.       1842.          0.           0.       2828.
 582.00          331.       1935.          0.           0.       2989.
 581.00          393.       2119.          0.           0.       3527.
 580.00          456.       2304.          0.           0.       4063.
 579.10+         456.       2390.          0.           0.       2575.
 579.10-         456.       1010.        159.           0.       2575.
 579.00          456.       1024.        161.           0.       2540.
 578.00          456.       1156.        182.           0.       4368.
 577.00          456.       1289.        203.           0.       5703.
 576.00          456.       1422.        223.           0.       7816.
 575.00          456.       1555.        244.           0.      11508.
 574.00          456.       1688.        265.           0.      20098.
 573.00          456.       1820.        286.           0.      18064.
 572.00          456.       1953.        307.           0.      77459.
 571.00          456.       2086.        328.           0.      69497.
 570.00          456.       2219.        349.           0.       1742.
 569.00          456.       2352.        370.           0.       9601.
 568.00          456.       2484.        390.           0.       9754.
 567.00          456.       2617.        411.           0.       9908.
 566.03          456.       2746.        432.           0.       2872.
 566.00          456.       2750.        432.           0.       2675.
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565.00          456.       2883.        453.          0.       2739.
564.00          456.       3015.        474.          0.      10188.
563.00          456.       3148.        495.          0.      10339.
562.00          456.       3281.        516.          0.      10489.
561.00          456.       3414.        536.          0.       3666.
560.00          456.       3547.        557.          0.       3744.
559.72          456.       3679.        578.          0.      10796.
558.00          456.       3812.        599.          0.      10945.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                        BY CLASSICAL METHODS
  DATE: 1-APRIL-2013                                    TIME: 9:52:23

                            ****************
                            *  INPUT DATA  *
                            ****************

       I.--HEADING
      'MENOMONEE SSP WALL ANALYSIS 11+00 RS

      II.--CONTROL
         CANTILEVER WALL DESIGN
         FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
         FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

     III.--WALL DATA
         ELEVATION AT TOP OF WALL    = 591.00 FT.

      IV.--SURFACE POINT DATA

           IV.A.--RIGHTSIDE
              DIST. FROM     ELEVATION
              WALL (FT)        (FT)
                   0.00        589.90
                   0.83        590.28
                   9.65        593.65
                  14.32        598.03
                  28.03        600.00
                  42.90        610.00
                  44.90        612.00

           IV.B.--LEFTSIDE
              DIST. FROM     ELEVATION
              WALL (FT)        (FT)
                   0.00        583.50

       V.--SOIL LAYER DATA

          V.A.--RIGHTSIDE
              LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
              LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF          ANGLE OF                            <-SAFETY->
  SAT.    MOIST  INTERNAL  COH-      WALL    ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.   WGHT.  FRICTION  ESION   FRICTION  ESION   ELEV.  SLOPE  ACT. PASS.
 (PCF)   (PCF)    (DEG)   (PSF)    (DEG)    (PSF)   (FT)  (FT/FT)
125.00  125.00    30.00    0.00     0.00     0.00  591.80   0.00   DEF  DEF
125.00  120.00    35.00    0.00     0.00     0.00  584.30   0.00   DEF  DEF
125.00  125.00    30.00    0.00     0.00     0.00                  DEF  DEF

          V.B.--LEFTSIDE
              LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
              LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF          ANGLE OF                            <-SAFETY->
  SAT.    MOIST  INTERNAL  COH-      WALL    ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.   WGHT.  FRICTION  ESION   FRICTION  ESION   ELEV.  SLOPE  ACT. PASS.
 (PCF)   (PCF)    (DEG)   (PSF)    (DEG)    (PSF)   (FT)  (FT/FT)
125.00  120.00    35.00    0.00     0.00     0.00  584.30   0.00   DEF  DEF
125.00  125.00    30.00    0.00     0.00     0.00                  DEF  DEF

      VI.--WATER DATA
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        UNIT WEIGHT          = 62.40 (PCF)
        RIGHTSIDE ELEVATION = 587.30 (FT)
        LEFTSIDE ELEVATION  = 580.00 (FT)
        NO SEEPAGE

    VII.--VERTICAL SURCHARGE LOADS
        NONE

   VIII.--HORIZONTAL LOADS
        NONE
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                          TIME: 9:52:25

                          **************************
                          *   SOIL PRESSURES FOR   *
                          * CANTILEVER WALL DESIGN *
                          **************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 11+00 RS

   II.--SOIL PRESSURES

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

                                   <------NET------>
         NET    <---LEFTSIDE--->     (SOIL + WATER)     <--RIGHTSIDE--->
ELEV.   WATER   PASSIVE   ACTIVE    ACTIVE   PASSIVE    ACTIVE   PASSIVE
(FT)    (PSF)     (PSF)    (PSF)     (PSF)     (PSF)     (PSF)     (PSF)
591.8     0.0       0.0      0.0       0.0       0.0       0.0       0.0
591.0     0.0       0.0      0.0       0.0       0.0       0.0       0.0
590.0     0.0       0.0      0.0       0.0       0.0       0.0       0.0
589.9     0.0       0.0      0.0       0.0       0.0       0.0       0.0
589.0     0.0       0.0      0.0      39.4     810.7      39.4     810.7
588.0     0.0       0.0      0.0      81.0     228.0      81.0     228.0
587.3     0.0       0.0      0.0     112.1    1382.9     112.1    1382.9
587.0    18.7       0.0      0.0     142.0    1551.2     123.3    1532.5
586.0    81.1       0.0      0.0     230.5    1989.9     149.4    1908.7
585.0   143.5       0.0      0.0     305.5    2423.1     162.0    2279.6
584.3   187.2       0.0      0.0     399.3    2527.3     212.1    2340.1
584.0   205.9       0.0      0.0     444.0    2562.3     238.0    2356.4
583.5   237.1       0.0      0.0     492.4    2830.1     255.3    2593.0
583.0   268.3     384.7     42.3     156.1    2962.3     272.5    2736.2
582.5   299.5     532.7     58.5      70.4    3246.8     303.6    3005.8
582.0   330.7     680.7     74.8       1.5    3603.5     351.5    3347.6
582.0   331.3     683.3     75.1       0.0    3607.8     352.0    3351.6
581.0   393.1     976.6    107.3    -168.1    4075.6     415.4    3789.8
580.0   455.5    1272.5    139.8    -368.6    4830.6     448.4    4514.9
579.0   455.5    1568.5    172.3    -628.4    5502.1     484.5    5218.9
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578.0   455.5    1864.4    204.9    -895.2    5948.8     513.7    5698.2
577.0   455.5    2160.3    237.4   -1157.1    5966.3     547.7    5748.2
576.0   455.5    2456.3    269.9   -1417.7    5792.7     583.1    5607.1
575.0   455.5    2752.2    302.4   -1686.5    5803.6     610.2    5650.5
574.0   455.5    3048.1    334.9   -1956.3    5846.5     636.3    5726.0
573.0   455.5    3344.1    367.5   -2225.3    5893.7     663.2    5805.7
572.0   455.5    3640.0    400.0   -2487.9    6000.7     696.6    5945.1
571.0   455.5    3936.0    432.5   -2749.6    6107.6     730.8    6084.6
570.0   455.5    4231.9    465.0   -3015.8    6331.3     760.5    6340.8
569.0   455.5    4527.8    497.5   -3281.8    6828.9     790.5    6870.9
568.0   455.5    4823.8    530.1   -3547.8    7061.6     820.5    7136.2
567.0   455.5    5119.7    562.6   -3813.8    7197.4     850.4    7304.4
566.0   455.5    5415.6    595.1   -4079.9    7738.0     880.2    7877.6
565.0   455.5    5711.6    627.6   -4348.0    8358.6     908.0    8530.6
564.0   455.5    6007.5    660.1   -4618.7    8567.0     933.3    8771.6
563.0   455.5    6303.4    692.7   -4760.7    8692.4    1087.2    8929.6
562.0   455.5    6599.4    725.2   -4944.3    9209.9    1199.5    9479.5
561.0   455.5    6895.3    757.7   -5259.9    9790.2    1179.9   10092.3
560.0   455.5    7191.2    790.2   -5536.6   10370.5    1199.1   10705.2
559.0   455.5    7487.2    822.7   -5794.4   10902.0    1237.3   11269.2
558.0   455.5    7783.1    855.2   -6034.8   11055.7    1292.8   11455.4
557.0   455.5    8079.1    887.8   -6293.7   11247.3    1329.9   11679.6
556.0   455.5    8375.0    920.3   -6569.6   11806.0    1349.9   12270.7
555.0   455.5    8670.9    952.8   -6845.6   12364.6    1369.8   12861.9
554.0   455.5    8966.9    985.3   -7121.5   12924.3    1389.8   13454.1
553.0   455.5    9262.8   1017.8   -7397.5   13673.2    1409.8   14235.5
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                             TIME: 9:52:26

                       ****************************
                       *  SUMMARY OF RESULTS FOR  *
                       *  CANTILEVER WALL DESIGN  *
                       ****************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 11+00 RS

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

   WALL BOTTOM ELEV. (FT)     :      573.81
         PENETRATION (FT)     :        9.69

   MAX. BEND. MOMENT (LB-FT)  :  8.3671E+03
         AT ELEVATION (FT)    :      578.15

   MAX. SCALED DEFL. (LB-IN^3):  1.2431E+09
         AT ELEVATION (FT)    :      591.80
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            NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                   ELLASTICITY IN PSI TIMES PILE MOMENT
                   OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                   IN INCHES.




PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                        BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                         TIME: 9:52:26

                        ****************************
                        * COMPLETE OF RESULTS FOR  *
                        *  CANTILEVER WALL DESIGN  *
                        ****************************

     I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 11+00 RS

    II.--RESULTS

                  BENDING                          SCALED         NET
    ELEVATION      MOMENT         SHEAR          DEFLECTION     PRESSURE
       (FT)       (LB-FT)          (LB)           (LB-IN^3)       (PSF)
      591.80    0.0000E+00          0.           1.2431E+09        0.00
      591.00    1.3844E-10          0.           1.1643E+09        0.00
      590.00   -3.0559E-10          0.           1.0659E+09        0.00
      589.90   -5.0414E-08          0.           1.0560E+09        0.00
      589.00    5.3182E+00         18.           9.6738E+08       39.39
      588.00    4.9674E+01         78.           8.6893E+08       80.98
      587.30    1.2660E+02        146.           8.0006E+08      112.14
      587.00    1.7575E+02        184.           7.7057E+08      142.00
      586.00    4.4513E+02        370.           6.7253E+08      230.49
      585.00    9.4274E+02        638.           5.7530E+08      305.47
      584.30    1.4717E+03        885.           5.0816E+08      399.32
      584.00    1.7557E+03       1011.           4.7974E+08      443.96
      583.50    2.3188E+03       1245.           4.3301E+08      492.40
      583.00    2.9889E+03       1407.           3.8728E+08      156.12
      582.50    3.7084E+03       1464.           3.4284E+08       70.42
      582.00    4.4463E+03       1482.           3.0001E+08        1.52
      581.99    4.4596E+03       1482.           2.9926E+08        0.00
      581.00    5.9007E+03       1399.           2.2043E+08     -168.07
      580.00    7.1818E+03       1130.           1.5101E+08     -368.62
      579.00    8.0844E+03        632.           9.3956E+07     -628.40
      578.00    8.3575E+03       -130.           5.0778E+07     -895.22
      577.00    7.7361E+03      -1156.           2.1913E+07    -1157.10
      576.00    5.9579E+03      -2444.           6.2490E+06    -1417.70
      575.39    4.1832E+03      -3363.           1.9312E+06    -1582.45
      575.00    2.8089E+03      -3622.           6.7710E+05      245.91
      574.00    9.7453E+01      -1014.           5.0202E+02     4970.71
      573.81    0.0000E+00          0.           0.0000E+00     5855.37

            NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                   ELLASTICITY IN PSI TIMES PILE MOMENT
                   OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                   IN INCHES.

   III.--WATER AND SOIL PRESSURES

                         <-------------SOIL PRESSURES-------------->
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```
               WATER      <----LEFTSIDE----->      <---RIGHTSIDE---->
ELEVATION    PRESSURE     PASSIVE      ACTIVE      ACTIVE     PASSIVE
   (FT)        (PSF)       (PSF)        (PSF)       (PSF)      (PSF)
 591.80            0.          0.          0.          0.          0.
 591.00            0.          0.          0.          0.          0.
 590.00            0.          0.          0.          0.          0.
 589.90            0.          0.          0.          0.          0.
 589.00            0.          0.          0.         39.        811.
 588.00            0.          0.          0.         81.        228.
 587.30            0.          0.          0.        112.       1383.
 587.00           19.          0.          0.        123.       1532.
 586.00           81.          0.          0.        149.       1909.
 585.00          144.          0.          0.        162.       2280.
 584.30          187.          0.          0.        212.       2340.
 584.00          206.          0.          0.        238.       2356.
 583.50          237.          0.          0.        255.       2593.
 583.00          268.        385.         42.        273.       2736.
 582.50          300.        533.         59.        304.       3006.
 582.00          331.        681.         75.        351.       3348.
 581.99          331.        683.         75.        352.       3352.
 581.00          393.        977.        107.        415.       3790.
 580.00          456.       1273.        140.        448.       4515.
 579.00          456.       1568.        172.        485.       5219.
 578.00          456.       1864.        205.        514.       5698.
 577.00          456.       2160.        237.        548.       5748.
 576.00          456.       2456.        270.        583.       5607.
 575.39          456.       2638.        290.        600.       5634.
 575.00          456.       2752.        302.        610.       5650.
 574.00          456.       3048.        335.        636.       5726.
 573.81          456.       3344.        367.        663.       5806.
 572.00          456.       3640.        400.        697.       5945.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                           BY CLASSICAL METHODS
 DATE: 1-APRIL-2013                                          TIME: 9:53:12

                             ****************
                             *  INPUT DATA  *
                             ****************

       I.--HEADING
      'MENOMONEE SSP WALL ANALYSIS 12+00 RS

      II.--CONTROL
         CANTILEVER WALL DESIGN
         FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
         FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

     III.--WALL DATA
         ELEVATION AT TOP OF WALL    = 590.00 FT.

      IV.--SURFACE POINT DATA

           IV.A.--RIGHTSIDE
              DIST. FROM     ELEVATION
              WALL (FT)         (FT)
                   0.00        589.40
                   2.14        590.20
                  15.60        597.50
                  24.40        600.00
                  30.60        602.00
                  36.30        604.00
                  48.00        606.00

           IV.B.--LEFTSIDE
              DIST. FROM     ELEVATION
              WALL (FT)         (FT)
                   0.00        583.10

       V.--SOIL LAYER DATA

          V.A.--RIGHTSIDE
              LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
              LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF         ANGLE OF                        <-SAFETY->
  SAT.   MOIST  INTERNAL  COH-     WALL    ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.   WGHT.  FRICTION  ESION  FRICTION  ESION    ELEV.  SLOPE  ACT. PASS.
 (PCF)   (PCF)    (DEG)   (PSF)    (DEG)   (PSF)    (FT)  (FT/FT)
125.00  125.00    30.00    0.00     0.00    0.00  591.80   0.00   DEF  DEF
125.00  120.00    35.00    0.00     0.00    0.00  584.30   0.00   DEF  DEF
125.00  125.00    30.00    0.00     0.00    0.00                  DEF  DEF

          V.B.--LEFTSIDE
              LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
              LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF         ANGLE OF                        <-SAFETY->
  SAT.   MOIST  INTERNAL  COH-     WALL    ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.   WGHT.  FRICTION  ESION  FRICTION  ESION    ELEV.  SLOPE  ACT. PASS.
 (PCF)   (PCF)    (DEG)   (PSF)    (DEG)   (PSF)    (FT)  (FT/FT)
125.00  120.00    35.00    0.00     0.00    0.00  584.30   0.00   DEF  DEF
125.00  125.00    30.00    0.00     0.00    0.00                  DEF  DEF

      VI.--WATER DATA
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```
        UNIT WEIGHT         = 62.40 (PCF)
        RIGHTSIDE ELEVATION = 587.30 (FT)
        LEFTSIDE ELEVATION  = 580.00 (FT)
        NO SEEPAGE

    VII.--VERTICAL SURCHARGE LOADS
        NONE

   VIII.--HORIZONTAL LOADS
        NONE
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                          TIME: 9:53:14

                          **************************
                          *   SOIL PRESSURES FOR   *
                          * CANTILEVER WALL DESIGN *
                          **************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 12+00 RS

   II.--SOIL PRESSURES

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

                                   <------NET------>
         NET    <---LEFTSIDE--->     (SOIL + WATER)     <--RIGHTSIDE--->
ELEV.   WATER   PASSIVE   ACTIVE    ACTIVE   PASSIVE    ACTIVE   PASSIVE
(FT)    (PSF)     (PSF)    (PSF)     (PSF)     (PSF)     (PSF)     (PSF)
591.8     0.0       0.0      0.0       0.0       0.0       0.0       0.0
590.0     0.0       0.0      0.0       0.0       0.0       0.0       0.0
589.4     0.0       0.0      0.0       0.0       0.0       0.0       0.0
589.0     0.0       0.0      0.0      37.1   11880.8      37.1   11880.8
588.0     0.0       0.0      0.0      51.2     168.0      51.2     168.0
587.3     0.0       0.0      0.0      79.9     252.0      79.9     252.0
587.0    18.7       0.0      0.0     108.3    1213.0      89.6    1194.3
586.0    81.1       0.0      0.0     207.6    1994.4     126.5    1913.3
585.0   143.5       0.0      0.0     314.3    2644.2     170.8    2500.6
584.3   187.2       0.0      0.0     407.9    2732.5     220.7    2545.3
584.0   205.9       0.0      0.0     448.8    2796.6     242.9    2590.7
583.1   262.1       0.0      0.0     547.5    3200.2     285.5    2938.1
583.0   268.3     384.7     42.3     173.7    3206.7     290.1    2980.6
582.1   324.5     651.1     71.5       4.3    3623.9     330.9    3371.0
582.1   325.9     657.8     72.3       0.0    3634.5     331.9    3380.8
582.0   330.7     680.7     74.8     -14.5    3670.3     335.4    3414.3
581.0   393.1     976.6    107.3    -202.8    4133.9     380.7    3848.1
580.0   455.5    1272.5    139.8    -392.2    4597.5     424.8    4281.8
579.0   455.5    1568.5    172.3    -650.5    4996.1     462.4    4712.9
578.0   455.5    1864.4    204.9    -915.1    5327.7     493.8    5077.1
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577.0   455.5    2160.3    237.4   -1166.3    5468.8     538.5    5250.6
576.0   455.5    2456.3    269.9   -1422.0    5640.6     578.7    5455.0
575.0   455.5    2752.2    302.4   -1691.2    5846.0     605.5    5692.9
574.0   455.5    3048.1    334.9   -1955.2    5987.2     637.4    5866.7
573.0   455.5    3344.1    367.5   -2219.2    6187.9     669.3    6099.8
572.0   455.5    3640.0    400.0   -2483.2    6393.4     701.2    6337.8
571.0   455.5    3936.0    432.5   -2747.3    6610.1     733.2    6587.1
570.0   455.5    4231.9    465.0   -3011.0    6833.2     765.4    6842.7
569.0   455.5    4527.8    497.5   -3273.9    7056.3     798.4    7098.3
568.0   455.5    4823.8    530.1   -3536.4    7279.4     831.8    7354.0
567.0   455.5    5119.7    562.6   -3798.9    7505.9     865.3    7613.0
566.0   455.5    5415.6    595.1   -4061.4    7748.1     898.7    7887.6
565.0   455.5    5711.6    627.6   -4324.4    8004.4     931.7    8176.5
564.0   455.5    6007.5    660.1   -4587.9    8262.7     964.0    8467.3
563.0   455.5    6303.4    692.7   -4851.4    8519.6     996.5    8756.8
562.0   455.5    6599.4    725.2   -5114.6    8742.2    1029.2    9011.9
561.0   455.5    6895.3    757.7   -5377.9    8918.1    1061.9    9220.3
560.0   455.5    7191.2    790.2   -5641.2    9038.6    1094.6    9373.3
559.0   455.5    7487.2    822.7   -5906.6    9104.6    1125.0    9471.8
558.0   455.5    7783.1    855.2   -6175.3    9210.3    1152.3    9610.0
557.0   455.5    8079.1    887.8   -6445.2    9368.2    1178.4    9800.5
556.0   455.5    8375.0    920.3   -6709.5    9525.8    1210.0    9990.5
555.0   455.5    8670.9    952.8   -6969.8    9678.8    1245.6   10176.1
554.0   455.5    8966.9    985.3   -7235.6    9657.5    1275.7   10187.3
553.0   455.5    9262.8   1017.8   -7505.3    9577.6    1302.0   10139.9
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                          TIME: 9:53:15

                       ****************************
                       *  SUMMARY OF RESULTS FOR  *
                       *  CANTILEVER WALL DESIGN  *
                       ****************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 12+00 RS

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

   WALL BOTTOM ELEV. (FT)     :      574.04
         PENETRATION (FT)     :        9.06

   MAX. BEND. MOMENT (LB-FT)  :  7.8367E+03
         AT ELEVATION (FT)    :      578.25

   MAX. SCALED DEFL. (LB-IN^3):  1.1183E+09
         AT ELEVATION (FT)    :      591.80
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             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                    ELLASTICITY IN PSI TIMES PILE MOMENT
                    OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                    IN INCHES.




PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                          TIME: 9:53:15

                       ****************************
                       * COMPLETE OF RESULTS FOR  *
                       *  CANTILEVER WALL DESIGN  *
                       ****************************

     I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 12+00 RS

    II.--RESULTS

                   BENDING                         SCALED         NET
    ELEVATION      MOMENT          SHEAR         DEFLECTION     PRESSURE
       (FT)        (LB-FT)          (LB)          (LB-IN^3)       (PSF)
      591.80    0.0000E+00            0.        1.1183E+09         0.00
      590.00   -9.0992E-11            0.        9.5866E+08         0.00
      589.40   -1.4978E-11            0.        9.0546E+08         0.00
      589.00    9.8959E-01            7.        8.6999E+08        37.11
      588.00    2.9308E+01           52.        7.8133E+08        51.16
      587.30    8.0279E+01           97.        7.1930E+08        79.88
      587.00    1.1353E+02          126.        6.9273E+08       108.32
      586.00    3.0988E+02          284.        6.0434E+08       207.58
      585.00    7.1506E+02          545.        5.1652E+08       314.34
      584.30    1.1809E+03          797.        4.5574E+08       407.86
      584.00    1.4391E+03          926.        4.2997E+08       448.77
      583.10    2.4674E+03         1374.        3.5422E+08       547.54
      583.00    2.6069E+03         1410.        3.4598E+08       173.70
      582.10    3.9236E+03         1490.        2.7421E+08         4.28
      582.08    3.9575E+03         1490.        2.7246E+08         0.00
      582.00    4.0726E+03         1490.        2.6654E+08       -14.54
      581.00    5.5238E+03         1381.        1.9413E+08      -202.79
      580.00    6.7720E+03         1084.        1.3124E+08      -392.16
      579.00    7.6165E+03          562.        7.9988E+07      -650.54
      578.00    7.8095E+03         -221.        4.1808E+07      -915.12
      577.00    7.0895E+03        -1261.        1.6991E+07     -1166.32
      576.00    5.2025E+03        -2555.        4.2559E+06     -1422.04
      575.52    3.7943E+03        -3275.        1.5405E+06     -1552.31
      575.00    2.0141E+03        -3398.        3.0919E+05      1077.18
      574.04    0.0000E+00            0.        0.0000E+00      5981.95

             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                    ELLASTICITY IN PSI TIMES PILE MOMENT
                    OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                    IN INCHES.

   III.--WATER AND SOIL PRESSURES

                           <-------------SOIL PRESSURES-------------->
                WATER      <----LEFTSIDE----->     <---RIGHTSIDE---->
 ELEVATION    PRESSURE     PASSIVE      ACTIVE      ACTIVE     PASSIVE
    (FT)        (PSF)       (PSF)        (PSF)       (PSF)      (PSF)
```

```
591.80            0.          0.          0.          0.          0.
590.00            0.          0.          0.          0.          0.
589.40            0.          0.          0.          0.          0.
589.00            0.          0.          0.         37.      11881.
588.00            0.          0.          0.         51.        168.
587.30            0.          0.          0.         80.        252.
587.00           19.          0.          0.         90.       1194.
586.00           81.          0.          0.        126.       1913.
585.00          144.          0.          0.        171.       2501.
584.30          187.          0.          0.        221.       2545.
584.00          206.          0.          0.        243.       2591.
583.10          262.          0.          0.        285.       2938.
583.00          268.        385.         42.        290.       2981.
582.10          324.        651.         72.        331.       3371.
582.08          326.        658.         72.        332.       3381.
582.00          331.        681.         75.        335.       3414.
581.00          393.        977.        107.        381.       3848.
580.00          456.       1273.        140.        425.       4282.
579.00          456.       1568.        172.        462.       4713.
578.00          456.       1864.        205.        494.       5077.
577.00          456.       2160.        237.        538.       5251.
576.00          456.       2456.        270.        579.       5455.
575.52          456.       2599.        286.        592.       5570.
575.00          456.       2752.        302.        605.       5693.
574.04          456.       3048.        335.        637.       5867.
573.00          456.       3344.        367.        669.       6100.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                            BY CLASSICAL METHODS
  DATE: 1-APRIL-2013                                          TIME: 9:54:17

                              ****************
                              *  INPUT DATA  *
                              ****************

        I.--HEADING
       'MENOMONEE SSP WALL ANALYSIS 15+00 RS

       II.--CONTROL
          CANTILEVER WALL DESIGN
          FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
          FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

      III.--WALL DATA
          ELEVATION AT TOP OF WALL    = 590.00 FT.

       IV.--SURFACE POINT DATA

            IV.A.--RIGHTSIDE
               DIST. FROM     ELEVATION
               WALL (FT)         (FT)
                    0.00        589.20
                   16.70        596.80
                   26.30        598.00
                   29.50        600.00

            IV.B.--LEFTSIDE
               DIST. FROM     ELEVATION
               WALL (FT)         (FT)
                    0.00        583.10

        V.--SOIL LAYER DATA

           V.A.--RIGHTSIDE
               LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
               LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                 ANGLE OF         ANGLE OF                        <-SAFETY->
   SAT.   MOIST  INTERNAL  COH-     WALL    ADH-    <--BOTTOM-->  <-FACTOR->
  WGHT.   WGHT.  FRICTION  ESION  FRICTION  ESION   ELEV.  SLOPE  ACT. PASS.
  (PCF)   (PCF)    (DEG)   (PSF)    (DEG)   (PSF)   (FT)  (FT/FT)
 125.00  125.00    32.00    0.00     0.00    0.00  595.20   0.00   DEF  DEF
 125.00  125.00    34.00    0.00     0.00    0.00  587.70   0.00   DEF  DEF
 125.00  125.00    10.00  200.00     0.00    0.00  583.20   0.00   DEF  DEF
 125.00  120.00    33.00    0.00     0.00    0.00  577.20   0.00   DEF  DEF
 125.00  125.00    18.00  750.00     0.00    0.00                  DEF  DEF

           V.B.--LEFTSIDE
               LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
               LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                 ANGLE OF         ANGLE OF                        <-SAFETY->
   SAT.   MOIST  INTERNAL  COH-     WALL    ADH-    <--BOTTOM-->  <-FACTOR->
  WGHT.   WGHT.  FRICTION  ESION  FRICTION  ESION   ELEV.  SLOPE  ACT. PASS.
  (PCF)   (PCF)    (DEG)   (PSF)    (DEG)   (PSF)   (FT)  (FT/FT)
 125.00  125.00    10.00  200.00     0.00    0.00  583.20   0.00   DEF  DEF
 125.00  120.00    33.00    0.00     0.00    0.00  577.20   0.00   DEF  DEF
 125.00  125.00    18.00  750.00     0.00    0.00                  DEF  DEF

       VI.--WATER DATA
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        UNIT WEIGHT         = 62.40 (PCF)
        RIGHTSIDE ELEVATION = 587.30 (FT)
        LEFTSIDE ELEVATION  = 580.00 (FT)
        NO SEEPAGE

    VII.--VERTICAL SURCHARGE LOADS
        NONE

   VIII.--HORIZONTAL LOADS
        NONE
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                          TIME: 9:54:19

                          **************************
                          *    SOIL PRESSURES FOR   *
                          * CANTILEVER WALL DESIGN *
                          **************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 15+00 RS

   II.--SOIL PRESSURES

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

                                             <------NET------>
         NET    <---LEFTSIDE--->   (SOIL + WATER)     <--RIGHTSIDE--->
ELEV.   WATER   PASSIVE   ACTIVE    ACTIVE   PASSIVE    ACTIVE   PASSIVE
(FT)    (PSF)     (PSF)    (PSF)     (PSF)     (PSF)     (PSF)     (PSF)
595.2     0.0       0.0      0.0       0.0       0.0       0.0       0.0
590.0     0.0       0.0      0.0       0.0       0.0       0.0       0.0
589.2     0.0       0.0      0.0       0.0       0.0       0.0       0.0
589.0     0.0       0.0      0.0     186.7    1141.1     186.7    1141.1
588.0     0.0       0.0      0.0      53.0     391.2      53.0     391.2
587.8+    0.0       0.0      0.0       0.0     657.4       0.0     657.4
587.8-    0.0       0.0      0.0       0.0     550.7       0.0     550.7
587.7     0.0       0.0      0.0       0.0     657.4       0.0     657.4
587.3     0.0       0.0      0.0       0.0     986.6       0.0     986.6
587.0    18.7       0.0      0.0      18.7     992.2       0.0     973.5
586.0    81.1       0.0      0.0      81.1    1244.8       0.0    1163.7
585.0   143.5       0.0      0.0     189.0    1545.0      45.4    1401.5
584.0   205.9       0.0      0.0     369.0    1896.8     163.1    1690.8
583.2   255.8       0.0      0.0     600.9    2799.7     345.0    2543.8
583.1+  262.1       0.0      0.0     624.4    2915.4     362.3    2653.3
583.1-  262.1     299.8      0.0     324.5    2915.4     362.3    2653.3
583.0   268.3     331.5      0.0     302.7    2954.7     365.8    2686.4
582.1   324.5     473.7      0.0     248.6    3258.5     397.8    2934.1
582.0   330.7     489.5      0.0     242.5    3299.4     401.3    2968.6
581.0   393.1     647.5      0.0     175.9    3726.9     430.3    3333.8
```

```
580.0   455.5     805.6       0.0     109.4    4148.0     459.5    3692.5
579.4   455.5     902.6       0.0      28.1    4384.6     475.2    3929.1
579.2   455.5     936.1      18.7       0.0    4447.8     480.6    4011.0
579.0   455.5     963.6      34.0     -23.0    4499.6     485.1    4078.1
578.0   455.5    1121.7     122.0    -161.3    4801.0     504.9    4467.5
577.4+  455.5    1217.9     175.6    -762.3    5199.9       0.0    4981.4
577.4-  455.5    1217.9     175.6    -762.3    5199.9       0.0    4858.4
577.2   455.5    1248.1     192.4    -792.6    5244.5       0.0    4981.4
577.0   455.5    1279.7     210.0    -824.2    5340.9       0.0    5095.4
576.0   455.5    1437.8     298.0    -982.3    5429.2       0.0    5271.7
575.0   455.5    1595.8     386.1   -1140.3    5373.7       0.0    5304.2
574.0   455.5    1753.9     474.1   -1298.3    5282.8       0.0    5301.3
573.0   455.5    1911.9     562.1   -1456.4    5218.6       0.0    5325.1
572.0   455.5    2070.0     650.1   -1614.4    5175.8       0.0    5370.4
571.0   455.5    2228.0     738.1   -1772.5    5168.2       0.0    5450.8
571.0+  455.5    2232.6     740.7   -1777.1    5244.0       0.0    5603.1
571.0-  455.5    2232.6     740.7   -1777.1    5244.0       0.0    5455.2
570.0   455.5    2386.0     826.1   -1881.4    5232.5      49.1    5603.1
569.0   455.5    2544.1     914.1   -1989.8    5438.8      98.7    5897.4
568.0   455.5    2702.1    1002.1   -2100.4    5485.6     146.2    6032.2
567.0   455.5    2860.2    1090.1   -2201.9    5586.5     202.8    6221.2
566.0   455.5    3018.2    1178.1   -2302.7    5868.2     260.0    6590.8
565.0   455.5    3176.3    1266.2   -2422.6    5964.7     298.2    6775.3
564.0   455.5    3334.3    1354.2   -2548.2    5970.3     330.5    6869.0
563.0   455.5    3492.4    1442.2   -2666.3    5915.7     370.6    6902.4
562.0   455.5    3650.4    1530.2   -2780.1    5777.3     414.8    6852.0
561.0   455.5    3808.4    1618.2   -2893.1    5522.7     459.8    6685.4
560.0   455.5    3966.5    1706.2   -3005.0    5235.8     506.0    6486.5
559.0   455.5    4124.5    1794.2   -3116.6    5133.9     552.4    6472.6
558.0   455.5    4282.6    1882.2   -3229.4    5194.2     597.7    6620.9
557.0   455.5    4440.6    1970.2   -3336.2    5285.2     648.9    6799.9
556.0   455.5    4598.7    2058.3   -3434.0    5366.5     709.2    6969.2
555.0   455.5    4756.7    2146.3   -3529.8    5400.2     771.4    7091.0
554.0   455.5    4914.8    2234.3   -3630.3    5396.0     828.9    7174.8
553.0   455.5    5072.8    2322.3   -3751.9    5382.4     865.4    7249.2
```

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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                          TIME: 9:54:20

                        ****************************
                        *  SUMMARY OF RESULTS FOR  *
                        *  CANTILEVER WALL DESIGN  *
                        ****************************

    I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 15+00 RS

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
        AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.
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```
   WALL BOTTOM ELEV. (FT)     :      570.70
         PENETRATION (FT)     :       12.40

   MAX. BEND. MOMENT (LB-FT)  :  1.1857E+04
         AT ELEVATION (FT)    :      575.83

   MAX. SCALED DEFL. (LB-IN^3):  2.8843E+09
         AT ELEVATION (FT)    :      595.20

             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                    ELLASTICITY IN PSI TIMES PILE MOMENT
                    OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                    IN INCHES.




PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 1-APRIL-2013                                            TIME: 9:54:20

                        ****************************
                        * COMPLETE OF RESULTS FOR  *
                        *  CANTILEVER WALL DESIGN  *
                        ****************************

     I.--HEADING
     'MENOMONEE SSP WALL ANALYSIS 15+00 RS

    II.--RESULTS

                    BENDING                          SCALED        NET
    ELEVATION       MOMENT          SHEAR          DEFLECTION    PRESSURE
      (FT)          (LB-FT)          (LB)          (LB-IN^3)      (PSF)
      595.20    0.0000E+00             0.          2.8843E+09        0.00
      590.00   -5.7248E-11             0.          2.0605E+09        0.00
      589.20   -3.0985E-10             0.          1.9337E+09        0.00
      589.00    1.2446E+00            19.          1.9020E+09      186.69
      588.00    9.0973E+01           139.          1.7436E+09       52.98
      587.82    1.1643E+02           143.          1.7151E+09        0.00
      587.70    1.3367E+02           143.          1.6961E+09        0.00
      587.30    1.9097E+02           143.          1.6328E+09        0.00
      587.00    2.3423E+02           146.          1.5853E+09       18.72
      586.00    4.0006E+02           196.          1.4275E+09       81.12
      585.00    6.5459E+02           331.          1.2704E+09      188.96
      584.00    1.1101E+03           610.          1.1144E+09      369.05
      583.20    1.7410E+03           998.          9.9094E+08      600.85
      583.10+   1.8438E+03          1059.          9.7563E+08      624.38
      583.10-   1.8438E+03          1059.          9.7563E+08      324.53
      583.00    1.9513E+03          1091.          9.6035E+08      302.71
      582.10    3.0482E+03          1339.          8.2461E+08      248.57
      582.00    3.1833E+03          1363.          8.0977E+08      242.51
      581.00    4.6567E+03          1572.          6.6472E+08      175.90
      580.00    6.3060E+03          1715.          5.2774E+08      109.38
      579.39    7.3739E+03          1757.          4.4890E+08       28.13
      579.17    7.7476E+03          1760.          4.2269E+08        0.00
      579.00    8.0537E+03          1758.          4.0167E+08      -23.04
      578.00    9.7774E+03          1666.          2.8952E+08     -161.30
      577.39    1.0724E+04          1385.          2.2935E+08     -762.34
      577.20    1.0975E+04          1236.          2.1181E+08     -792.60
      577.00    1.1207E+04          1075.          1.9423E+08     -824.21
```

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     576.00    1.1843E+04          171.        1.1818E+08      -982.25
     575.00    1.1496E+04         -890.        6.2458E+07     -1140.30
     574.00    1.0010E+04        -2109.        2.6437E+07     -1298.34
     573.00    7.2252E+03        -3487.        7.5266E+06     -1456.39
     572.75    6.3254E+03        -3849.        4.9999E+06     -1495.17
     572.00    3.2301E+03        -4044.        9.0351E+05       978.19
     571.00    2.2161E+02        -1427.        2.9474E+03      4255.87
     570.97    1.8197E+02        -1302.        1.9678E+03      4351.11
     570.70    0.0000E+00            0.        0.0000E+00      5240.78

            NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                   ELLASTICITY IN PSI TIMES PILE MOMENT
                   OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                   IN INCHES.

  III.--WATER AND SOIL PRESSURES

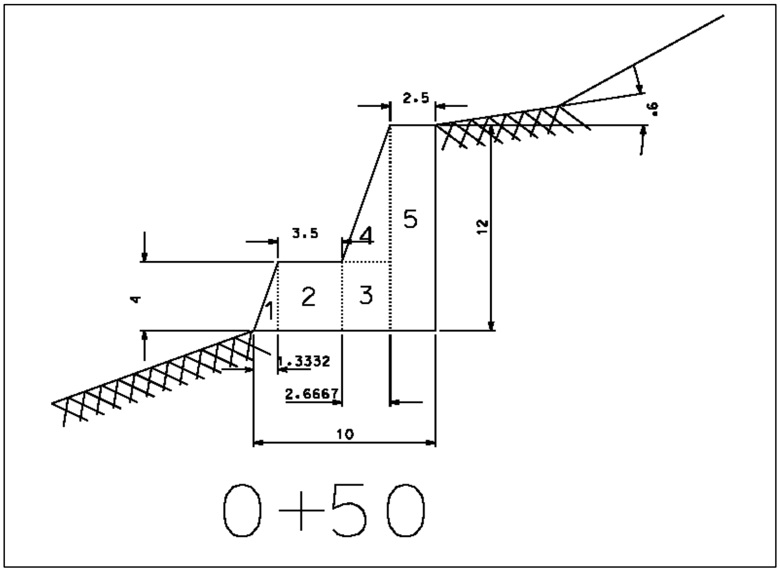
                          <-------------SOIL PRESSURES-------------->
               WATER      <----LEFTSIDE----->     <---RIGHTSIDE---->
ELEVATION    PRESSURE     PASSIVE      ACTIVE      ACTIVE     PASSIVE
   (FT)        (PSF)       (PSF)        (PSF)       (PSF)      (PSF)
 595.20            0.          0.          0.          0.          0.
 590.00            0.          0.          0.          0.          0.
 589.20            0.          0.          0.          0.          0.
 589.00            0.          0.          0.        187.       1141.
 588.00            0.          0.          0.         53.        391.
 587.82+           0.          0.          0.          0.        657.
 587.82-           0.          0.          0.          0.        551.
 587.70            0.          0.          0.          0.        657.
 587.30            0.          0.          0.          0.        987.
 587.00           19.          0.          0.          0.        973.
 586.00           81.          0.          0.          0.       1164.
 585.00          144.          0.          0.         45.       1401.
 584.00          206.          0.          0.        163.       1691.
 583.20          256.          0.          0.        345.       2544.
 583.10+         262.          0.          0.        362.       2653.
 583.10-         262.        300.          0.        362.       2653.
 583.00          268.        331.          0.        366.       2686.
 582.10          324.        474.          0.        398.       2934.
 582.00          331.        490.          0.        401.       2969.
 581.00          393.        648.          0.        430.       3334.
 580.00          456.        806.          0.        459.       3692.
 579.39          456.        903.          0.        475.       3929.
 579.17          456.        936.         19.        481.       4011.
 579.00          456.        964.         34.        485.       4078.
 578.00          456.       1122.        122.        505.       4468.
 577.39+         456.       1218.        176.          0.       4981.
 577.39-         456.       1218.        176.          0.       4858.
 577.20          456.       1248.        192.          0.       4981.
 577.00          456.       1280.        210.          0.       5095.
 576.00          456.       1438.        298.          0.       5272.
 575.00          456.       1596.        386.          0.       5304.
 574.00          456.       1754.        474.          0.       5301.
 573.00          456.       1912.        562.          0.       5325.
 572.75          456.       1951.        584.          0.       5336.
 572.00          456.       2070.        650.          0.       5370.
 571.00          456.       2228.        738.          0.       5451.
 570.97+         456.       2233.        741.          0.       5603.
 570.97-         456.       2233.        741.          0.       5455.
 570.70          456.       2386.        826.         49.       5603.
 569.00          456.       2544.        914.         99.       5897.
```

ATTACHMENT 9

WPA WALL STABILITY CALCULATIONS

US Army Corps of Engineers ® Detroit District	PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
	COMPUTATION TITLE: **WPA Wall Stability Analysis Sta. 0+50 LS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

Assumptions: There will be no soil supporting the passive side of the structure during construction. The battered h-piles embedded into the concrete grade beam were neglected.



OVERTURNING

$$P_a = \frac{1}{2}\gamma_1 H'^2 K_a$$

(Das Eqtn 11.45)

Unit Weight of Soil, γ_1 = 125 LB/FT^3

Height of Wall, H' = 12 FT

$$K_a = \cos\alpha \frac{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}$$

(Das Eqtn 11.44)

α = 9 deg

Φ' = 30 deg

Coefficient of Rankine's Active Earth Pressure, K_a = 0.346288502

Rankine Active Force, P_a = 3116.596519 LB/FT

$P_v = P_a \sin\alpha$ = 1267.634006 LB/FT

$P_h = P_a \cos\alpha$ = 2847.152593 LB/FT

Section No.	Area (ft^2)	Weight/Unit Length (LB/FT) *	Moment Arm (FT)	Moment (LB-FT/FT)
1	2.67	400.50	0.89	355.64
2	14.00	2100.00	3.08	6474.30
3	10.70	1605.00	6.17	9902.85
4	10.67	1600.50	6.61	10583.82
5	30.00	4500.00	8.75	39375.00
P_v		1267.634006	10	12676.34
	ΣV	**11473.63**	ΣM_R	**79367.95**

*Concrete Unit Weight = 150 lb/ft^3

$$\sum M_o = P_h \frac{H'}{3}$$

(Das Eqtn 13.4)

Overturning Moment, ΣM_o = 11388.61037 LB-FT/FT

US Army Corps of Engineers ® Detroit District	PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
	COMPUTATION TITLE: **WPA Wall Stability Analysis Sta. 0+50 LS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

$$FS_{(overturning)} = \frac{\sum M_R}{\sum M_O}$$

(Das Eqtn 13.3)

Factor of Safety for Overturning, $FS_{(overturning)}$ = 7.0 **OKAY, since FS>2**

SLIDING

$$FS_{(sliding)} = \frac{\left(\sum V\right)\tan(k_1\phi'_2) + Bk_2c'_2 + P_p}{P_h}$$

(Das Eqtn 13.13)

Assume $k_1 = k_2$ = 0.66 (Varies between 0.5 - 0.66)

Φ'_1 = 30 deg

Φ'_2 = 36 deg

Width of Wall, B = 10 FT

Cohesion, c'_2 = 0 LB/FT^2

P_p = 0 LB/FT

Factor of Safety for Sliding, $FS_{(sliding)}$ = 1.77 **OKAY, since FS>1.5**

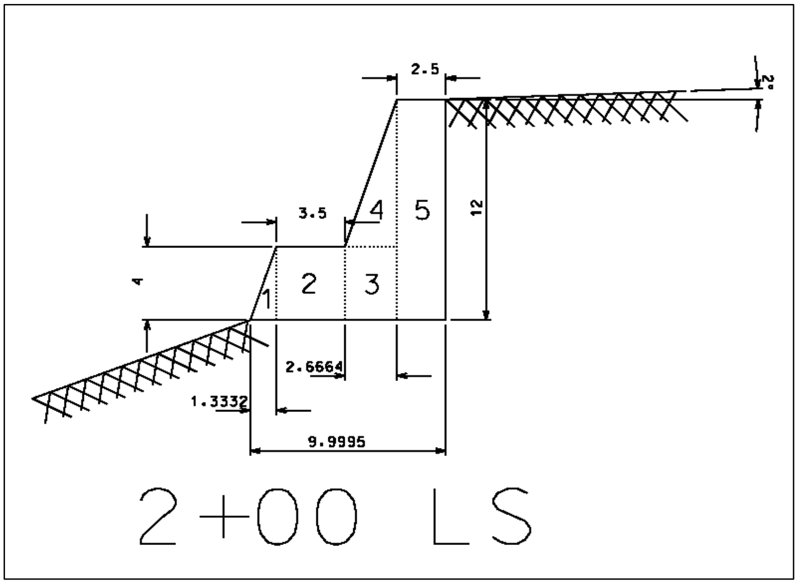
REFERENCES

1. Das, Braja M., (2008). Fundamentals of Geotechnical Engineering, Third Edition. Toronto, ON: Thomson Learning.

US Army Corps of Engineers
Detroit District

PROJECT TITLE:	COMPUTED BY:	DATE:
Menomonee River Aquatic Habitat Restoration	**T. Smith**	**1/28/2013**
COMPUTATION TITLE:	CHECKED BY:	DATE:
WPA Wall Stability Analysis Sta 2+00 LS	**E. Lenhardt**	**3/28/2013**

Assumptions: There will be no soil supporting the passive side of the structure during construction. The battered h-piles embedded into the concrete grade beam were neglected.



OVERTURNING

$$P_a = \frac{1}{2}\gamma_1 H'^2 K_a$$ (Das Eqtn 11.45)

Unit Weight of Soil, γ_1 = 125 LB/FT^3
Height of Wall, H' = 12 FT

$$K_a = \cos\alpha \frac{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}$$ (Das Eqtn 11.44)

α = 2 deg
Φ' = 30 deg
Coefficient of Rankine's Active Earth Pressure, K_a = 0.333943995

Rankine Active Force, P_a = 3005.495954 LB/FT
$P_v = P_a \sin\alpha$ = 1222.445335 LB/FT
$P_h = P_a \cos\alpha$ = 2745.657177 LB/FT

Section No.	Area (ft^2)	Weight/Unit Length (LB/FT) *	Moment Arm (FT)	Moment (LB-FT/FT)
1	2.67	400.05	0.89	355.21
2	14.00	2100.00	3.08	6474.72
3	10.66	1599.00	6.17	9860.07
4	10.66	1599.00	6.59	10542.25
5	31.25	4687.50	8.75	41013.75
P_v		1222.445335	10.00	12223.84
	ΣV	**11608.00**	ΣM_R	**80469.84**

*Concrete Unit Weight = 150 lb/ft^3

$$\sum M_o = P_h \frac{H'}{3}$$ (Das Eqtn 13.4)

Overturning Moment, ΣM_o = 10982.62871 LB-FT/FT

US Army Corps of Engineers ® Detroit District	PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
	COMPUTATION TITLE: **WPA Wall Stability Analysis Sta 2+00 LS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

$$\boxed{FS_{(overturning)} = \frac{\sum M_R}{\sum M_O}}$$

(Das Eqtn 13.3)

Factor of Safety for Overturning, $FS_{(overturning)}$ = 7.3 **OKAY, since FS>2**

SLIDING

$$\boxed{FS_{(sliding)} = \frac{\left(\sum V\right)\tan\left(k_1\phi'_2\right) + Bk_2c'_2 + P_p}{P_h}}$$

(Das Eqtn 13.13)

Assume $k_1 = k_2$ =	0.66		(Varies between 0.5 - 0.66)
Φ'_1 =	30	deg	
Φ'_2 =	36	deg	
Width of Wall, B =	9.9995	FT	
Cohesion, c'_2 =	0	LB/FT^2	
P_p =	0	LB/FT	

Factor of Safety for Sliding, $FS_{(sliding)}$ = 1.86 **OKAY, since FS>1.5**

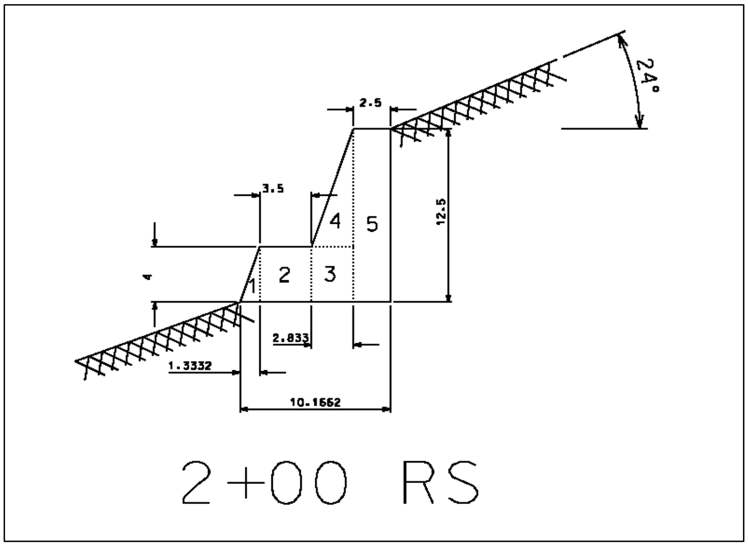
REFERENCES

1. Das, Braja M., (2008). Fundamentals of Geotechnical Engineering, Third Edition. Toronto, ON: Thomson Learning.

US Army Corps of Engineers ®
Detroit District

PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
COMPUTATION TITLE: **WPA Wall Stability Analysis Sta. 2+00 RS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

Assumptions: There will be no soil supporting the passive side of the structure during construction. The battered h-piles embedded into the concrete grade beam were neglected.



OVERTURNING

$$P_a = \frac{1}{2}\gamma_1 H'^2 K_a$$

(Das Eqtn 11.45)

Unit Weight of Soil, γ_1 = 125 LB/FT^3

Height of Wall, H' = 12.5 FT

$$K_a = \cos\alpha \frac{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}$$

(Das Eqtn 11.44)

α = 24 deg

Φ' = 30 deg

Coefficient of Rankine's Active Earth Pressure, K_a = 0.472376676

Rankine Active Force, P_a = 4613.053474 LB/FT

$P_v = P_a \sin\alpha$ = 1876.297885 LB/FT

$P_h = P_a \cos\alpha$ = 4214.234047 LB/FT

Section No.	Area (ft^2)	Weight/Unit Length (LB/FT) *	Moment Arm (FT)	Moment (LB-FT/FT)
1	2.67	400.05	0.89	355.59
2	14.00	2100.00	3.08	6474.30
3	11.33	1699.50	6.25	10621.03
4	12.04	1806.00	6.72	12135.92
5	31.25	4687.50	8.92	41795.16
P_v		1876.297885	10.17	19081.95
	ΣV	**12569.35**	ΣM_R	**90463.94**

*Concrete Unit Weight = 150 lb/ft^3

$$\sum M_o = P_h \frac{H'}{3}$$

(Das Eqtn 13.4)

Overturning Moment, ΣM_o = 17559.30853 LB-FT/FT

US Army Corps of Engineers ® Detroit District	PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
	COMPUTATION TITLE: **WPA Wall Stability Analysis Sta. 2+00 RS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

$$\boxed{FS_{(overturning)} = \frac{\sum M_R}{\sum M_O}}$$

(Das Eqtn 13.3)

Factor of Safety for Overturning, $FS_{(overturning)}$ = 5.2 **OKAY, since FS>2**

SLIDING

$$\boxed{FS_{(sliding)} = \frac{\left(\sum V\right)\tan\left(k_1\phi'_2\right) + Bk_2c'_2 + P_p}{P_h}}$$

(Das Eqtn 13.13)

Assume $k_1 = k_2$ =	0.66	(Varies between 0.5 - 0.66)
Φ'_1 =	30 deg	
Φ'_2 =	36 deg	
Width of Wall, B =	10.17 FT	
Cohesion, c'_2 =	0 LB/FT^2	
P_p =	0 LB/FT	

Factor of Safety for Sliding, $FS_{(sliding)}$ = 1.31 **NO GOOD**

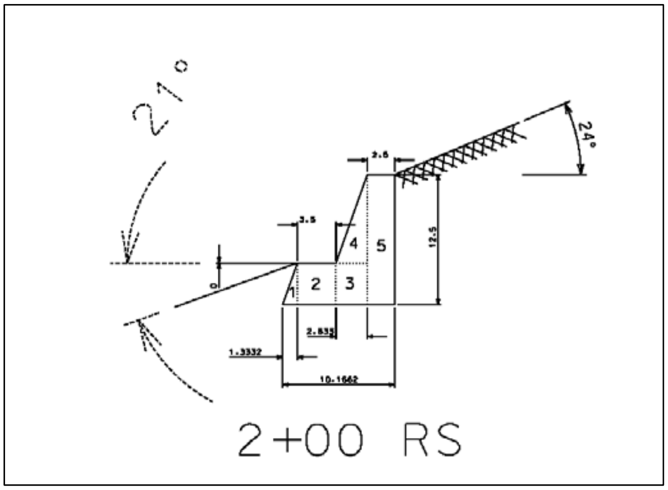
REFERENCES

1. Das, Braja M., (2008). Fundamentals of Geotechnical Engineering, Third Edition. Toronto, ON: Thomson Learning.

US Army Corps of Engineers ®
Detroit District

PROJECT TITLE:	COMPUTED BY:	DATE:
Menomonee River Aquatic Habitat Restoration	**T. Smith**	**1/28/2013**
COMPUTATION TITLE:	CHECKED BY:	DATE:
WPA Wall Stab Anal Sta. 2+00 RS Post Const	**E. Lenhardt**	**3/28/2013**

Assumptions: The battered h-piles embedded into the concrete grade beam were neglected.



SLIDING

$$P_a = \frac{1}{2}\gamma_1 H'^2 K_a$$

(Das Eqtn 11.45)

Unit Weight of Soil, γ_1 = 125 LB/FT^3

Height of Wall, H' = 12.5 FT

$$K_a = \cos\alpha \frac{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}$$

(Das Eqtn 11.44)

α = 24 deg

Φ' = 30 deg

Coefficient of Rankine's Active Earth Pressure, K_a = 0.472376676

Rankine Active Force, P_a = 4613.053474 LB/FT

$P_v = P_a \sin\alpha$ = 1876.297885 LB/FT

$P_h = P_a \cos\alpha$ = 4214.234047 LB/FT

Section No.	Area (ft^2)	Weight/Unit Length (LB/FT) *	Moment Arm (FT)	Moment (LB-FT/FT)
1	2.67	400.05	0.89	355.59
2	14.00	2100.00	3.08	6474.30
3	11.33	1699.50	6.25	10621.03
4	12.04	1806.00	6.72	12135.92
5	31.25	4687.50	8.92	41795.16
P_v		1876.297885	10.17	19081.95
	ΣV	**12569.35**	ΣM_R	**90463.94**

*Concrete Unit Weight = 150 lb/ft^3

$$FS_{(sliding)} = \frac{\left(\sum V\right)\tan\left(k_1\phi'_2\right) + Bk_2c'_2 + P_p}{P_h}$$

(Das Eqtn 13.13)

Assume $k_1 = k_2$ = 0.66 (Varies between 0.5 - 0.66)

Φ'_1 = 30 deg

Φ'_2 = 36 deg

Width of Wall, B = 10.17 FT

Cohesion, c'_2 = 0 LB/FT^2

Unit Weight of Riprap, γ = 130 LB/FT^3

Height of Riprap in Front of Concrete Grade Beam = 4 FT

$$\boxed{K_p = \cos\alpha \frac{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}}}$$

(Das Eqtn 11.47)

α = 21 deg

Φ' = 30 deg

Coefficient of Rankine's Active Earth Pressure, K_a = 2.046622647

$$\boxed{P_p = \frac{1}{2}\gamma_1 H'^2 K_p}$$

(Das Eqtn 11.46)

Rankine Passive Force, P_p = 2128.487553 LB/FT

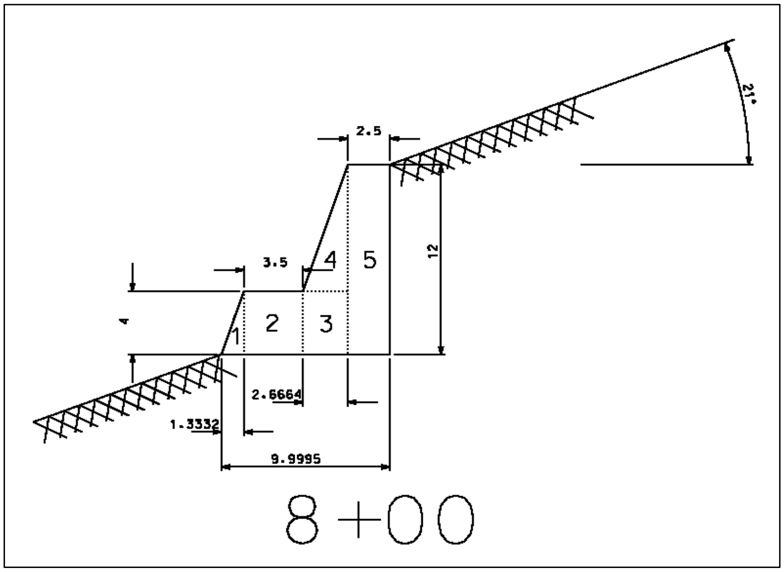
Factor of Safety for Sliding, $FS_{(sliding)}$ = 1.82 **OKAY, since FS>1.5**

REFERENCES

1. Das, Braja M., (2008). Fundamentals of Geotechnical Engineering, Third Edition. Toronto, ON: Thomson Learning.

US Army Corps of Engineers Detroit District	PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
	COMPUTATION TITLE: **WPA Wall Stability Analysis Sta 8+00 RS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

Assumptions: There will be no soil supporting the passive side of the structure during construction. The battered h-piles embedded into the concrete grade beam were neglected.



OVERTURNING

$$P_a = \frac{1}{2}\gamma_1 H'^2 K_a$$ (Das Eqtn 11.45)

Unit Weight of Soil, γ_1 = 125 LB/FT^3

Height of Wall, H' = 12 FT

$$K_a = \cos\alpha \frac{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}$$ (Das Eqtn 11.44)

α = 21 deg

Φ' = 35 deg

Coefficient of Rankine's Active Earth Pressure, K_a = 0.328267474

Rankine Active Force, P_a = 2954.407267 LB/FT

$P_v = P_a \sin\alpha$ = 1201.665694 LB/FT

$P_h = P_a \cos\alpha$ = 2698.985339 LB/FT

Section No.	Area (ft^2)	Weight/Unit Length (LB/FT) *	Moment Arm (FT)	Moment (LB-FT/FT)
1	2.67	400.50	0.89	355.99
2	14.00	2100.00	3.08	6474.30
3	10.66	1599.00	6.17	9859.75
4	10.66	1599.00	6.61	10567.51
5	30.00	4500.00	8.75	39372.30
P_v		1201.665694	10	12016.66
	ΣV	**11400.17**	ΣM_R	**78646.51**

*Concrete Unit Weight = 150 lb/ft^3

$$\sum M_o = P_h \frac{H'}{3}$$ (Das Eqtn 13.4)

Overturning Moment, ΣM_o = 10795.94136 LB-FT/FT

US Army Corps of Engineers ® Detroit District	PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
	COMPUTATION TITLE: **WPA Wall Stability Analysis Sta 8+00 RS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

$$FS_{(overturning)} = \frac{\sum M_R}{\sum M_O}$$

(Das Eqtn 13.3)

Factor of Safety for Overturning, $FS_{(overturning)}$ = 7.3 **OKAY, since FS>2**

SLIDING

$$FS_{(sliding)} = \frac{\left(\sum V\right)\tan\left(k_1\phi'_2\right) + Bk_2c'_2 + P_p}{P_h}$$

(Das Eqtn 13.13)

Assume $k_1 = k_2$ = 0.66 (Varies between 0.5 - 0.66)

Φ'_1 = 35 deg

Φ'_2 = 18 deg

Width of Wall, B = 10 FT

Cohesion, c'_2 = 1003 LB/FT^2

P_p = 0 LB/FT

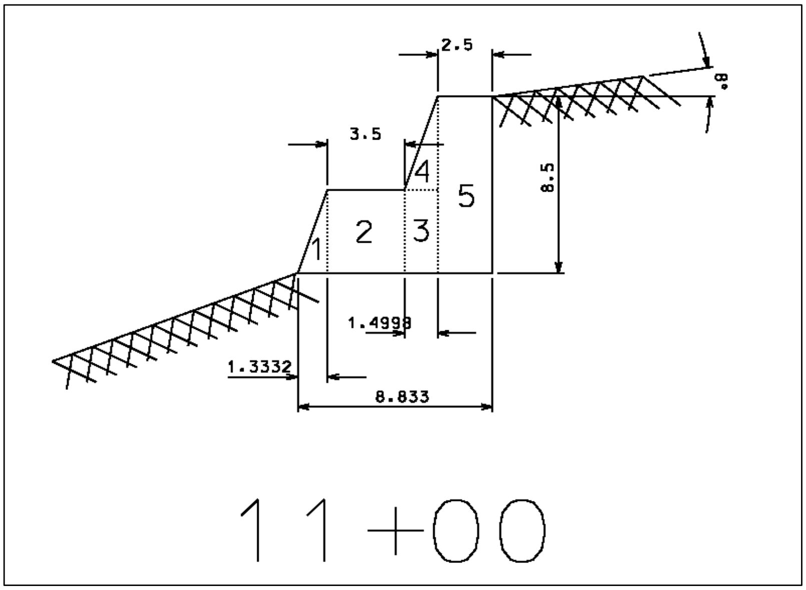
Factor of Safety for Sliding, $FS_{(sliding)}$ = 3.34 **OKAY, since FS>1.5**

REFERENCES

1. Das, Braja M., (2008). Fundamentals of Geotechnical Engineering, Third Edition. Toronto, ON: Thomson Learning.

US Army Corps of Engineers® Detroit District	PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
	COMPUTATION TITLE: **WPA Wall Stability Analysis Sta 11+00 RS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

Assumptions: There will be no soil supporting the passive side of the structure during construction. The battered h-piles embedded into the concrete grade beam were neglected.



OVERTURNING

$$P_a = \frac{1}{2}\gamma_1 H'^2 K_a$$

(Das Eqtn 11.45)

Unit Weight of Soil, γ_1 = 125 LB/FT^3

Height of Wall, H' = 8.5 FT

$$K_a = \cos\alpha \frac{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}$$

(Das Eqtn 11.44)

α = 8 deg

Φ' = 30 deg

Coefficient of Rankine's Active Earth Pressure, K_a = 0.343462222

Rankine Active Force, P_a = 1550.946596 LB/FT

$P_v = P_a\sin\alpha$ = 630.8268119 LB/FT

$P_h = P_a\cos\alpha$ = 1416.860217 LB/FT

Section No.	Area (ft^2)	Weight/Unit Length (LB/FT) *	Moment Arm (FT)	Moment (LB-FT/FT)
1	2.67	400.50	0.89	355.99
2	14.00	2100.00	3.08	6474.30
3	6.00	900.00	5.58	5024.88
4	3.37	505.50	5.83	2948.68
5	21.25	3187.50	7.58	24170.81
P_v		630.8268119	8.833	5572.09
	ΣV	**7724.33**	ΣM_R	**44546.76**

*Concrete Unit Weight = 150 lb/ft^3

$$\sum M_o = P_h \frac{H'}{3}$$

(Das Eqtn 13.4)

Overturning Moment, ΣM_o = 4014.437283 LB-FT/FT

US Army Corps of Engineers ® Detroit District	PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
	COMPUTATION TITLE: **WPA Wall Stability Analysis Sta 11+00 RS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

$$FS_{(overturning)} = \frac{\sum M_R}{\sum M_O}$$

(Das Eqtn 13.3)

Factor of Safety for Overturning, $FS_{(overturning)}$ = 11.1 **OKAY, since FS>2**

SLIDING

$$FS_{(sliding)} = \frac{\left(\sum V\right)\tan\left(k_1\phi'_2\right) + Bk_2c'_2 + P_p}{P_h}$$

(Das Eqtn 13.13)

Assume $k_1 = k_2$ = 0.66 (Varies between 0.5 - 0.66)

Φ'_1 = 30 deg

Φ'_2 = 35 deg

Width of Wall, B = 8.833 FT

Cohesion, c'_2 = 0 LB/FT^2

P_p = 0 LB/FT

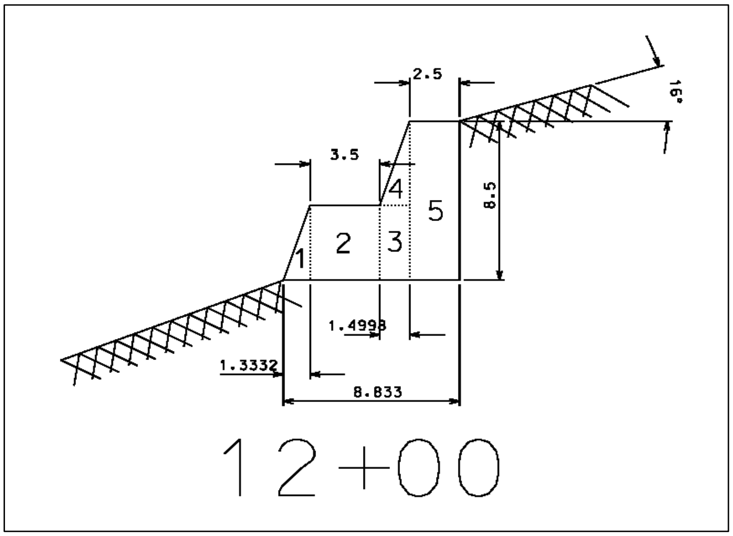
Factor of Safety for Sliding, $FS_{(sliding)}$ = 2.33 **OKAY, since FS>1.5**

REFERENCES

1. Das, Braja M., (2008). Fundamentals of Geotechnical Engineering, Third Edition. Toronto, ON: Thomson Learning.

US Army Corps of Engineers ® Detroit District	PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
	COMPUTATION TITLE: **WPA Wall Stability Analysis Sta 12+00 RS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

Assumptions: There will be no soil supporting the passive side of the structure during construction. The battered h-piles embedded into the concrete grade beam were neglected.



OVERTURNING

$$P_a = \frac{1}{2}\gamma_1 H'^2 K_a$$

(Das Eqtn 11.45)

Unit Weight of Soil, γ_1 = 125 LB/FT^3

Height of Wall, H' = 8.5 FT

$$K_a = \cos\alpha \frac{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}$$

(Das Eqtn 11.44)

α = 16 deg

Φ' = 30 deg

Coefficient of Rankine's Active Earth Pressure, K_a = 0.379435101

Rankine Active Force, P_a = 1713.38663 LB/FT

$P_v = P_a\sin\alpha$ = 696.8971262 LB/FT

$P_h = P_a\cos\alpha$ = 1565.256573 LB/FT

Section No.	Area (ft^2)	Weight/Unit Length (LB/FT) *	Moment Arm (FT)	Moment (LB-FT/FT)
1	2.67	400.50	0.89	355.99
2	14.00	2100.00	3.08	6474.30
3	6.00	900.00	5.58	5024.79
4	3.37	505.50	5.83	2948.62
5	21.25	3187.50	7.58	24170.81
P_v		696.8971262	8.833	6155.69
	ΣV	**7790.40**	ΣM_R	**45130.20**

*Concrete Unit Weight = 150 lb/ft^3

$$\sum M_o = P_h \frac{H'}{3}$$

(Das Eqtn 13.4)

Overturning Moment, ΣM_o = 4434.893624 LB-FT/FT

US Army Corps of Engineers Detroit District	PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
	COMPUTATION TITLE: **WPA Wall Stability Analysis Sta 12+00 RS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

$$\boxed{FS_{(overturning)} = \frac{\sum M_R}{\sum M_O}}$$

(Das Eqtn 13.3)

Factor of Safety for Overturning, $FS_{(overturning)}$ =	10.2	**OKAY, since FS>2**

SLIDING

$$\boxed{FS_{(sliding)} = \frac{\left(\sum V\right)\tan\left(k_1\phi'_2\right) + Bk_2c'_2 + P_p}{P_h}}$$

(Das Eqtn 13.13)

Assume $k_1 = k_2$ =	0.66		(Varies between 0.5 - 0.66)
Φ'_1 =	30	deg	
Φ'_2 =	35	deg	
Width of Wall, B =	8.833	FT	
Cohesion, c'_2 =	0	LB/FT^2	
P_p =	0	LB/FT	

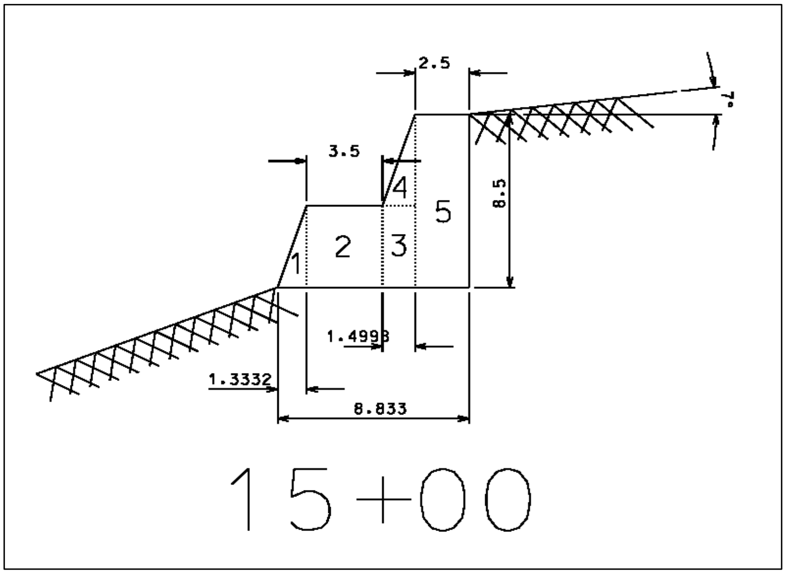
Factor of Safety for Sliding, $FS_{(sliding)}$ =	2.12	**OKAY, since FS>1.5**

REFERENCES

1. Das, Braja M., (2008). Fundamentals of Geotechnical Engineering, Third Edition. Toronto, ON: Thomson Learning.

US Army Corps of Engineers ® Detroit District	PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
	COMPUTATION TITLE: **WPA Wall Stability Analysis Sta 15+00 RS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

Assumptions: There will be no soil supporting the passive side of the structure during construction. The battered h-piles embedded into the concrete grade beam were neglected.



OVERTURNING

$$P_a = \frac{1}{2}\gamma_1 H'^2 K_a$$ (Das Eqtn 11.45)

Unit Weight of Soil, γ_1 = 125 LB/FT^3

Height of Wall, H' = 8.5 FT

$$K_a = \cos\alpha \frac{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi'}}{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi'}}$$ (Das Eqtn 11.44)

α = 7 deg

Φ' = 32 deg

Coefficient of Rankine's Active Earth Pressure, K_a = 0.313789497

Rankine Active Force, P_a = 1416.955698 LB/FT

$P_v = P_a \sin\alpha$ = 576.3278042 LB/FT

$P_h = P_a \cos\alpha$ = 1294.453442 LB/FT

Section No.	Area (ft^2)	Weight/Unit Length (LB/FT) *	Moment Arm (FT)	Moment (LB-FT/FT)
1	2.67	400.50	0.89	355.99
2	14.00	2100.00	3.08	6474.30
3	6.00	900.00	6.08	5474.88
4	3.37	505.50	5.83	2948.62
5	21.25	3187.50	7.58	24170.81
P_v		576.3278042	8.833	5090.70
	ΣV	**7669.83**	ΣM_R	**44515.30**

*Concrete Unit Weight = 150 lb/ft^3

$$\sum M_o = P_h \frac{H'}{3}$$ (Das Eqtn 13.4)

Overturning Moment, ΣM_o = 3667.618086 LB-FT/FT

US Army Corps of Engineers ® Detroit District	PROJECT TITLE: **Menomonee River Aquatic Habitat Restoration**	COMPUTED BY: **T. Smith**	DATE: **1/28/2013**
	COMPUTATION TITLE: **WPA Wall Stability Analysis Sta 15+00 RS**	CHECKED BY: **E. Lenhardt**	DATE: **3/28/2013**

$$\boxed{FS_{(overturning)} = \frac{\sum M_R}{\sum M_O}}$$

(Das Eqtn 13.3)

Factor of Safety for Overturning, $FS_{(overturning)}$ = 12.1 **OKAY, since FS>2**

SLIDING

$$\boxed{FS_{(sliding)} = \frac{\left(\sum V\right)\tan\left(k_1\phi'_2\right) + Bk_2c'_2 + P_p}{P_h}}$$

(Das Eqtn 13.13)

Assume $k_1 = k_2$ = 0.66 (Varies between 0.5 - 0.66)

Φ'_1 = 32 deg

Φ'_2 = 10 deg

Width of Wall, B = 8.833 FT

Cohesion, c'_2 = 200 LB/FT^2

P_p = 0 LB/FT

Factor of Safety for Sliding, $FS_{(sliding)}$ = 1.59 **OKAY, since FS>1.5**

REFERENCES

1. Das, Braja M., (2008). Fundamentals of Geotechnical Engineering, Third Edition. Toronto, ON: Thomson Learning.

ATTACHMENT 10

BRIDGE CROSSING CORRESPONDENCE

From: Allie, Matthew A - DOT [Matthew.Allie@dot.wi.gov]
Sent: Monday, February 25, 2013 4:00 PM
To: Grimmer, Michelle L LRE
Cc: Bolka, John - DOT; Ksontini, Najoua - DOT; Check, Steven G LRE; Smith, Timothy C LRE
Subject: RE: Menomonee River Fish Passage Project (UNCLASSIFIED)

Michelle,

Thanks for sending the HEC-RAS model. I have finished looking over the cross sections near the interstate bridges. I agree with the scour assessment that was done using values from the HEC-RAS output as well as removing the concrete channel and replacing it with riprap. We would like to be kept aware of the progress of the design as the plans and specs are completed.

Thanks,

Matthew Allie
Hydraulic Design Engineer
WisDOT Bureau of Structures
608.266.8483

-----Original Message-----
From: Grimmer, Michelle L LRE [mailto:Michelle.L.Grimmer@usace.army.mil]
Sent: Friday, February 22, 2013 1:09 PM
To: Allie, Matthew A - DOT
Cc: Bolka, John - DOT; Ksontini, Najoua - DOT; Check, Steven G LRE; Smith, Timothy C LRE
Subject: RE: Menomonee River Fish Passage Project (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Matt,

Attached is the USACE HEC-RAS model for the proposed project. It has the existing conditions as well as the proposed project. The cross-sections for the I-94 bridge are 3.692 (westbound) and 3.651 (eastbound). Let me know if you have any questions or problems opening the zip file.

Thanks,

Michelle Grimmer
Watershed Hydrology Branch
USACE - Detroit District
313-226-6753

-----Original Message-----
From: Allie, Matthew A - DOT [mailto:Matthew.Allie@dot.wi.gov]
Sent: Wednesday, February 20, 2013 9:00 AM
To: Smith, Timothy C LRE
Cc: Bolka, John - DOT; Ksontini, Najoua - DOT; Check, Steven G LRE; Grimmer, Michelle L LRE
Subject: RE: Menomonee River Fish Passage Project (UNCLASSIFIED)

Tim,

Thanks for the response. I can wait to take a look at the revised HEC-RAS model until the end of the week or beginning of next week. We wanted to get a better feel for the stream cross sections in this reach since our existing structure plans show little detail in this regard. I wouldn't expect looking through the model to take long.

We wanted to see riprap details to confirm that the material would replace the concrete in a way that doesn't reduce the cross sectional area of the stream. Based on your email it sounds like this is the intention and that it will appear accordingly on the plans. If this is not yet shown in detail then I shouldn't need to see anything else. In addition, the concrete grade beam sounds like it could be a good option to consider to ensure stability of the wall. Once I'm able to look over the HEC-RAS model you should hear back from me shortly.

Thanks,
Matt

Matthew Allie
Hydraulic Design Engineer
WisDOT Bureau of Structures
608.266.8483

-----Original Message-----
From: Smith, Timothy C LRE [mailto:Timothy.C.Smith@usace.army.mil]
Sent: Tuesday, February 19, 2013 2:04 PM
To: Allie, Matthew A - DOT
Cc: Bolka, John - DOT; Check, Steven G LRE; Grimmer, Michelle L LRE
Subject: RE: Menomonee River Fish Passage Project (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Good Afternoon Matt,

Thank you for taking the time to review the scour analysis for the above referenced project.

We have no issue sending the HEC-RAS model over to you. However, our hydraulic engineers are currently revising the model due to some alterations of the cross sections upstream of the I-94 bridge area. They anticipate completing the revisions by the end of this week. It will not likely alter the numbers that we obtained downstream by much. Would you prefer that I send the old model that was used for the scour analysis numbers to you or wait until the revisions are complete?

Secondly, we are currently in the early planning stages for this project and don't anticipate completing the plans and specs until potentially February 2014. With that said, we have currently put together some cross sections for the project to develop some quantities and run some analysis. Furthermore, MMSD has hired an AE Contractor to design the stretch of river just upstream of our section. They have submitted plans up to the 95% level. We are currently planning on continuing their design throughout our work area. At this time, we are not planning to change the elevation of the channel south of station 16+01. South of Station 16+01, the concrete will be removed and restored with rip-rap to the elevation of the existing channel. A concrete grade beam may be installed along the existing WPA wall to ensure that no stability issues arise.

Please let me know your thoughts on these two items and how we can obtain a quick turn-around on this.

Thanks again!

Tim Smith
Geotechnical/Structural Engineer
US Army Corps of Engineers, Detroit District
477 Michigan Avenue, 7th Floor
Detroit, MI 48226
Office: (313) 226-2632
Timothy.C.Smith@usace.army.mil

-----Original Message-----
From: Bolka, John - DOT [mailto:John.Bolka@dot.wi.gov]
Sent: Tuesday, February 19, 2013 11:29 AM
To: Smith, Timothy C LRE
Cc: Allie, Matthew A - DOT
Subject: Menomonee River Fish Passage Project (UNCLASSIFIED)

Tim,

Can you provide Matt with the additional information they are requesting? Please send it directly to him and copy me on the transmittal.

Thanks

John Bolka
SE Bridge Program Manager
john.bolka@dot.wi.gov
262-548-6711

-----Original Message-----
From: Allie, Matthew A - DOT
Sent: Tuesday, February 19, 2013 8:24 AM
To: Ksontini, Najoua - DOT; Bolka, John - DOT
Subject: RE: Menomonee River Fish Passage Project (UNCLASSIFIED)

John,

Najoua and I have reviewed and discussed the Scour Analysis Report provided by the Corps. The scour equation used can be referenced to HEC 23 and the resulting scour depths were calculated correctly. Considering this, the scour assessment made at the site appears to be reasonable. The original (1957) structure plans were consulted to confirm pier locations. Pier 9N (B-40-49-003) is located on or near the existing limestone floodwall. Pier 3 and the north end of Pier 4 are located on top of the concrete (reconstructed) floodwall. These piers would be most vulnerable to scour occurring at the wall, but the plans do show that each of these piers is supported on concrete cast-in-place piles.

Before providing full agreement with the USACE assessment we would like to take a look at the HEC-RAS model for the project. This will provide us a chance to see the stream cross sections in the area of the I-94 bridges (even though the structures aren't modeled) and the hydraulic data that was used to calculate scour. Finally, we would also like to see an elevation and plan view detailing where they propose to place the 2.5 ft D50 riprap.

Matthew Allie

Hydraulic Design Engineer
WisDOT Bureau of Structures
608.266.8483

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

Smith, Timothy C LRE

From: Derek Harter [Derek_Harter@cpr.ca]
Sent: Friday, October 19, 2012 2:03 PM
To: Smith, Timothy C LRE
Cc: Keith Popp
Subject: FW: Menomonee Pics and Plans (UNCLASSIFIED)

Tim:

CP Engineering approves the concrete channel lining and replacing with rip-rap and geotextile fabric. If you have any questions, please let me know.

Derek Harter

-----Original Message-----
From: John Unsworth
Sent: Thursday, October 18, 2012 8:20 AM
To: Derek Harter
Cc: Keith Popp
Subject: RE: Menomonee Pics and Plans (UNCLASSIFIED)

Derek - Provided that there is no interference or disturbance to the existing bridge foundation, there is no objection from a structural perspective..

John F. Unsworth, P.Eng. | Director, Structures | Canadian Pacific

-----Original Message-----
From: Derek Harter
Sent: Wednesday, October 17, 2012 6:25 PM
To: John Unsworth
Cc: Keith Popp
Subject: FW: Menomonee Pics and Plans (UNCLASSIFIED)

John:

The US Army Corp would like to remove the existing concrete channel lining under CP Bridge 87.81 located on the C&M Sub and replace with rip-rap and geotextile fabric under the bridge. This program is funded by the US Federal Government for fish passage and access for spawning habitats.

Attached is a plan from the Army Corp regarding the installation of rip-rap and geotextile fabric for your comments/suggestions.

Derek Harter

-----Original Message-----
From: Smith, Timothy C LRE [mailto:Timothy.C.Smith@usace.army.mil]
Sent: Tuesday, October 16, 2012 9:42 AM
To: Derek Harter
Subject: RE: Menomonee Pics and Plans (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Good Morning Derek,

Please find below some additional information on the project:

PROJECT SOW:
The project consists of the restoration of an aquatic ecosystem by removing an existing concrete channel lining along the Menomonee River in Milwaukee, Wisconsin that was built in the 1960s using non-Federal resources. The concrete channel lining extends for approximately 3,700 feet from just upstream of Wisconsin Avenue to just downstream of Interstate Highway 94. The Menomonee River watershed drains approximately 135 square miles and flows approximately 28 miles from its headwaters in Germantown and Mequon to Lake Michigan. Riffle structures will be placed every 50 to 100 feet with pools in between.

The project will restore fish passage and access to historical spawning habitats including 3,700 acres of wetlands, for Lake Michigan and Milwaukee River Estuary fish stocks; enhance local fish and aquatic life habitat; restore a recreational sport fishery along 17-miles of river and 20-miles of tributary for one of Wisconsin's most populated, urban and demographically diverse watersheds. Restored recreational fishing opportunities will include trout, salmon, small mouth bass, northern pike and walleye.

Normally, removing concrete from the river would increase both flood elevations and the risk of flooding. However, the Milwaukee County Grounds Flood Management Facility that came online in 2011 reduced flood flows and water surface elevations in the project area. This allows for concrete removal without increasing the flood risk to area residents and businesses.

Construction near RR Bridge Pier:
Rip-rap underlain by 12 inches of filter gravel and non-woven geotextile will likely replace the concrete under the bridge and have a mean diameter, D50= 2.5 ft. This same rock sizing was used upstream of the project limits and has remained stable over the past 10 years. Calculations have also been completed indicating that the rock will remain stable. If it is determined that the rocks will not remain stable in this area, grout can be injected between the stones to ensure that they do not move.

Removal of the concrete under the RR Bridge is critical to the success of this project. Without removal of the concrete, USACE anticipates that we will significantly reduce the percent of fish passing successfully in this area because velocities and duration will exceed the capabilities of the target species. I have attached an example cross-section of the design that we would like to proceed with. Please consider that the bridge was constructed long before the concrete lined channel and heavy rip-rap with geotextile will be used.

Let me know if you need further information.

Thanks,

Tim Smith
Geotechnical/Structural Engineer
US Army Corps of Engineers, Detroit District
477 Michigan Avenue, 7th Floor
Detroit, MI 48226
Office: (313) 226-2632
Timothy.C.Smith@usace.army.mil

-----Original Message-----
From: Derek Harter [mailto:Derek_Harter@cpr.ca]
Sent: Thursday, October 11, 2012 5:23 PM
To: Smith, Timothy C LRE
Subject: RE: Menomonee Pics and Plans (UNCLASSIFIED)

No problem Tim, I'll wait for your return.

Derek Harter

-----Original Message-----
From: Smith, Timothy C LRE [mailto:Timothy.C.Smith@usace.army.mil]
Sent: Thursday, October 11, 2012 2:59 PM
To: Derek Harter
Cc: Keith Popp
Subject: RE: Menomonee Pics and Plans (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Thanks Derek!

I have no problem sending you additional project details. Unfortunately, I will be out of the office until Tuesday, October 16th, 2012. I will get the information to you upon my return.

Thanks,

Tim

-----Original Message-----
From: Derek Harter [mailto:Derek_Harter@cpr.ca]
Sent: Thursday, October 11, 2012 10:41 AM
To: Smith, Timothy C LRE
Cc: Keith Popp
Subject: FW: Menomonee Pics and Plans (UNCLASSIFIED)

Tim:

Thank you for working with Keith concerning the Bridge at MP 87.81 C&M Sub near the Monomonee River. I would like to request additional details of the project scope and what the US Army Corps plans to do concerning the addition of rip around the bridge piers. This is the first time this project has been brought to my attention and any information would be greatly appreciated. Once I have more information at hand, I can forward on to our Director of Structures for his comments.

Derek Harter
Division Engineer - Chicago
11306 Franklin Ave
Franklin Park, IL 60131

-----Original Message-----
From: Keith Popp
Sent: Wednesday, October 10, 2012 1:38 PM
To: Derek Harter
Subject: FW: Menomonee Pics and Plans (UNCLASSIFIED)

Derek,

More details on the project at Milwaukee MP 87.81

Keith K. Popp | Manager, Structures |608-513-5757 Canadian Pacific

-----Original Message-----
From: Smith, Timothy C LRE [mailto:Timothy.C.Smith@usace.army.mil]
Sent: Tuesday, October 09, 2012 1:05 PM
To: Keith Popp
Subject: Menomonee Pics and Plans (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Keith,

Please find attached additional information and a picture of the area that we discussed. Please note the large tree that has lodged itself against the piers.

Thanks,

Tim Smith
Geotechnical/Structural Engineer
US Army Corps of Engineers, Detroit District
477 Michigan Avenue, 7th Floor
Detroit, MI 48226
Office: (313) 226-2632
Timothy.C.Smith@usace.army.mil

Classification: UNCLASSIFIED
Caveats: NONE

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Menomonee River
Milwaukee County, Wisconsin
Section 206

Appendix B
Hydraulic & Hydrology

US Army Corps
of Engineers
Detroit District

1.0 Introduction

The purpose of this report is to document the hydrologic and hydraulic analysis of the proposed ecosystem restoration project along the Menomonee River, Milwaukee County, Wisconsin *(Figure1).* The project consists of the restoration of an aquatic ecosystem by removing an existing concrete channel lining along the Menomonee River which was built in the 1960s using non-Federal resources. The concrete removal portion of this project will involve removing the concrete between the existing limestone flood walls (constructed by Works Progress Administration (WPA) in the 1930s) and leaving the walls in place. This is a highly urbanized area with a restricted floodplain. The project area is from the upstream limit located approximately 100 feet south of Wisconsin Avenue extending 2,400 linear feet south to the downstream limit of approximately 100 feet south of Interstate Highway 94 (*Figure 2)*. The project alternatives considered are the following:

1) Alternative 1 consists of removing the concrete channel lining, and placing stone designed to remain stationary during the 1% annual exceedence event. Riffle and pool systems along with vegetated bars will be constructed along the river to create vital habitat for fish and other aquatic organisms during low flow periods as well as provide pools of lower velocity during high flow periods. Boulder runs will also be incorporated to provide areas to rest for migrating fish.

2) Alternative 2 involves the removal of the concrete channel lining and replacing the lining with stone, without creation of any riffle or pool complexes. The stone would be sized to be mobile enough to allow the river to create its own riffle pool complexes instead of forcing the location on the river.

3) Alternative 3 is no action and is required to be one of the alternatives in order to comply with the requirements of the National Environmental Policy Act (NEPA). No action assumes that no project would be implemented by the Federal Government or by local interests to achieve the planned objectives. No action forms the basis from which all other alternative plans are measured.

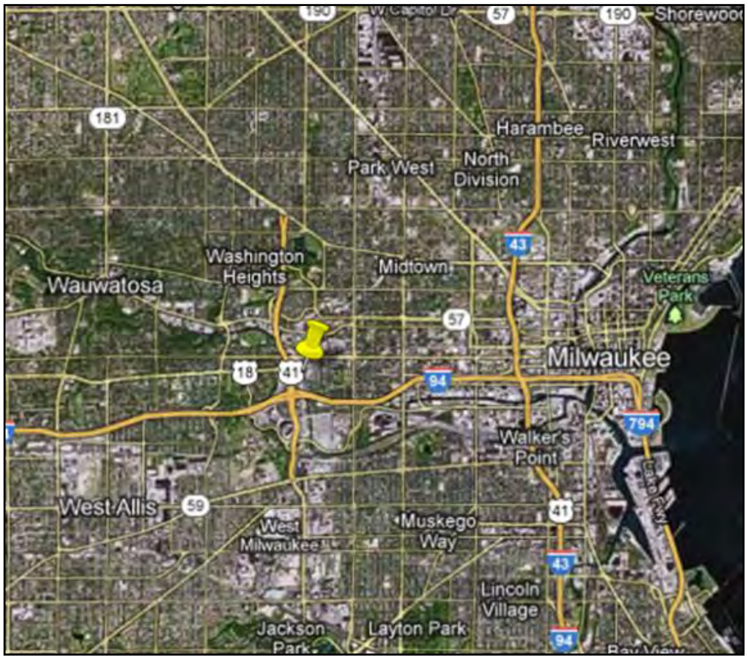


Figure 1: **Project Location indicated by yellow pin**

Figure 2: **Project Area (extends from approximately 100' S of Wisconsin Ave to 100' S of Interstate Highway 94)**

The analysis included gathering and evaluating hydrologic and hydraulic data and creating a hydraulic model with proposed project conditions to determine feasibility of fish passage and potential flooding impacts. Milwaukee Metropolitan Sewerage District (MMSD) provided the existing conditions hydraulic model for this project. This report details the methodology and results of the proposed project hydraulic modeling effort.

2.0 Hydrology

A range of discharge frequencies were used in the hydraulic analysis. Low flows and flows during the fish migration period were analyzed to determine project design efficiency for fish passage. Flood flows were also analyzed to determine potential flooding impacts.

The 10% (10-year), 4% (25-year), 2% (50-year), 1% (100-year), and 0.2% (500-year) discharges used in the analysis were developed by Southeastern Wisconsin Regional Planning Commission (SEWRPC) and provided by MMSD in the existing conditions hydraulic model as shown in *Table 1*. The period of record used to develop the discharge-frequency for these flows was from 1940 to 2004 using various gages with the region.

***Table 1:* Discharge Frequency in Project Area, cubic feet per second**

10% (10-yr)	**4% (25-yr)**	**2% (50-yr)**	**1% (100-yr)**	**0.2% (500-yr)**	**Base Flow**	**Sustained Spring Flow**
8,410	10,600	12,400	14,200	18,600	30	200

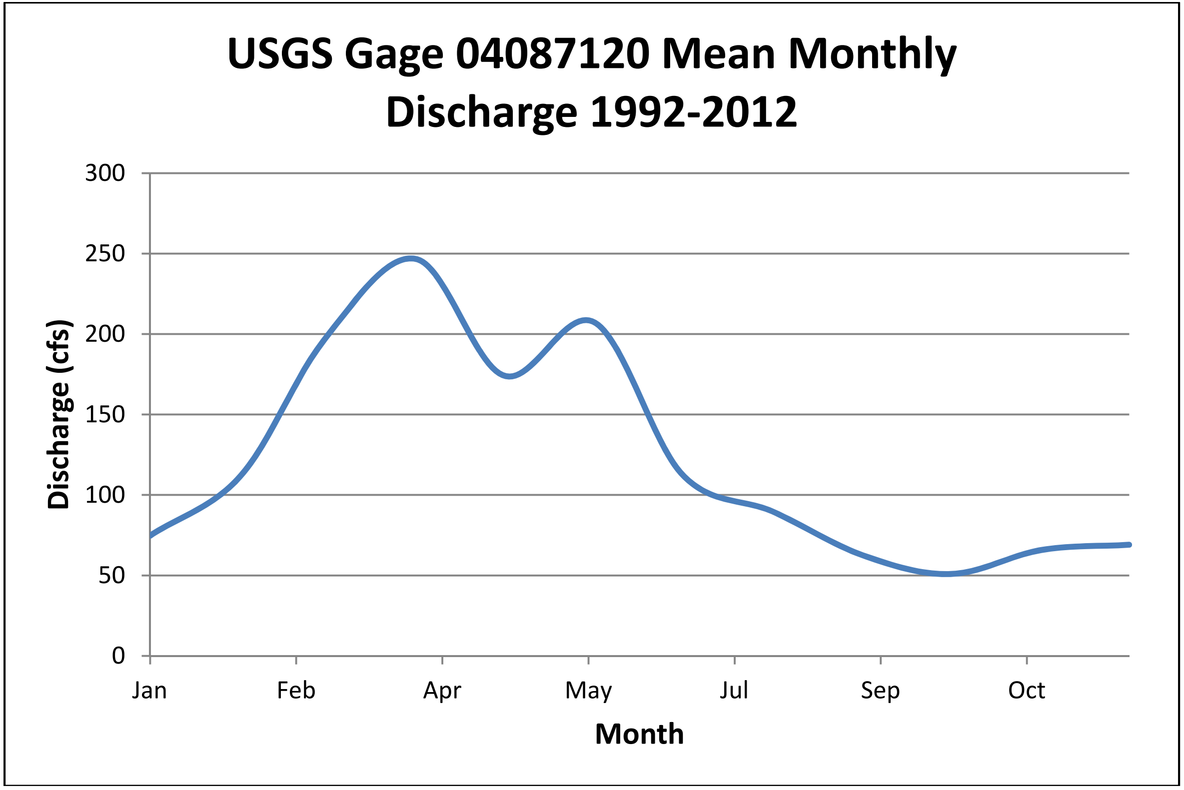
The low flow regimes for fish passage used in this analysis were obtained from the *Final Design Memorandum, Menomonee River Stream Management, May 2011,* prepared by the engineering firm GRaEF for MMSD for an upstream project and are as follows:

- Base flow is flow that occurs during the summer and fall. According to the *Status Report for Watercourse Improvements on the Lower Menomonee River*, by engineering firm HNTB, July 8, 2008 (Status Report), the Menomonee River has flow of less than 100 cubic feet per second (cfs) 75 percent of the time and a flow of less than 40 cfs 50 percent of the time. The typical daily flow is 44 cfs and the average daily flow during the summer and fall is 30 cfs. GRaEF proposed 30 to 50 cfs be used for base flow. For this analysis, 30 cfs was chosen in order to ensure enough water depth is available in the channel during base flow for fish migration.
- Sustained spring flow is flow during spring spawning season. According to the Status Report, the Menomonee River has a sustained spring snow melt flow of 160 cfs. GRaEF proposed 150 to 200 cfs be used for sustained spring flow. For this analysis, 200 cfs was chosen in order to ensure velocity is low enough at the higher range of flow for fish migration.

- Common peak daily spring flow is flow that occurs on the range of 1,200 to 2,000 cfs, twice to once per year, respectively. The project was not designed according to these flows as they occur infrequently.

The U.S. Geological Survey (USGS) has a water gauge located on the Menomonee River in Wauwatosa, WI, which is approximately 2 miles upstream of our project area (USGS Gage 04087120), but located within the boundaries of the hydraulic model. The monthly mean discharge for this gauge was calculated for the past 20 years, and the sustained spring flows and base flows determined by GRaEF are consistent with the flows recorded by USGS (see *Figure 3*).

Figure 3: **Graph of recorded flows along the Menomonee River**



3.0 Hydraulics

The existing conditions hydraulic model was developed by SEWRPC for MMSD in HEC-RAS version 4.1. MMSD provided this existing conditions model to the U.S. Army Corps of Engineers (USACE) for use in modeling this project. SEWRPC calibrated their model using three different USGS gages in the area. The Hydrology for the Regional CLOMR developed by SEWRPC was approved by the WDNR for use as existing conditions. The boundary condition is the known water surface at the mouth of the Menomonee River; the starting water level in the harbor was set at 579.4 ft NGVD20 per NOAA and Corps documentation of long term average water level for Lake Michigan from 1860-2010. All of the calibration, verification and sensitivity tests on this model were completed by SEWRPC.

The HEC-RAS file for this project is entitled, *"Menomonee River Project USACE".* The existing conditions submitted by MMSD is the plan titled "*MnR Planned (Yr2020) L.U. Existing Ch.".* The plan titled *"Existing Conditions – Alt 3"* is a copy of the model submitted by MMSD with geo-referencing inserted for flood mapping and is used for Alternative 3. The existing conditions model reflects several flood management projects that were completed through the MMSD. This includes the Milwaukee County Grounds Floodwater Management Facility (MCGFMF), the Valley Park Levee, Drop Structure Removal, Hawley Road Bridge Removal Project, Hart Park Flood Management Project and Western Milwaukee Phase 1 Flood Management Project. The plan for Alternative 1 is titled *"Riffles/pools proposed – Alt 1"* and the plan for Alternative 2 is titled *"Remove Concrete Proposed – Alt 2"*. Additionally, MMSD provided USACE a model of their proposed project that is located just upstream of the USACE project. This model will be submitted to the Federal Emergency Management Agency (FEMA) for a Conditional Letter of Map Revision (CLOMR). Our project was compared to this CLOMR model for flood mapping purposes. The plan titled *"CLOMR"* is the model submitted by MMSD to FEMA for a CLOMR. The plan titled *"Riffles/pools with CLOMR proposed"* is our project's Alternative 1 combined with the CLOMR model. For all the plans, the project area is in the *"main"* reach and the project area extends from cross-sections 3.651 to 4.061.

Design targets for fish passage were considered in the analysis based on the *Final Design Memorandum, Menomonee River Stream Management, May 2011,* prepared by GRaEF for MMSD, and by data gathered by USACE's Environmental Analysis Branch (EAB).

The following is a list of targets for the project for fish passage during migration:

- Average flow velocity less than 2.5 ft/s during spring flows
- Average flow velocity greater than 2 ft/s does not exceed 150 ft runs during spring flows
- Pool depth between 3 to 5 ft at base flow
- Riffle depth greater than 1 ft at base flow

The existing conditions model given by MMSD was in NGVD 29 and had a limited number of cross sections geo-referenced to North American Datum of 1927. In order to map the floodplain of the project, the stream centerline and cross-sections were geo-referenced in Arc-GIS to NAD 1983 Wisconsin State Plane South FIPS 4803 feet, using a 1/9-Arc Second Digital Evaluation Model (DEM) from Milwaukee County Land Information. This DEM was converted from NAVD 88 to NGVD 29 to be consistent with the HEC-RAS model. A vertical datum adjustment of +0.29 ft was applied to the DEM to convert from NAVD 88 to NGVD 29. The adjustment was determined by reviewing the datasheets of eight National Geodetic Survey (NGS) benchmarks located near the project area, see *Enclosure 1.*

Once the model was geo-referenced, the schematic x and y values from geo-referencing were inserted in the HEC-RAS model for the stream centerline and selected cross-sections. For Alternatives 1 and 2, the cross sections in the hydraulic model in our project area did not have sufficient overbank data for floodplain mapping. Therefore, for these cross-sections overbank data was added to the geometry from the geo-referencing. Additionally, a levee was placed in the geometry for Alternatives 1 and 2 in our project areas on the left bank (looking downstream) to represent the Valley Park Levee. The elevation of the levee was given by MMSD and matched the existing geometry left-most overbank data point *(Figure 4).* Several other cross-sections upstream of the project area had insufficient geometries and did not contain the 1% annual chance exceedence floodplain in the hydraulic model for Alternatives 1 and 2. For these cross-sections, additional overbank data was inserted in the model from the geo-referencing. A list of cross-sections that had overbank data added is found in *Table 2.*

***Figure 4*: Typical addition of overbank data and levee to project area. Green line is the existing conditions geometry, black line to the left and right of the green line is the overbank data and geometry used in Alternatives 1 and 2, pink line and squares is the levee in Alternatives 1 and 2.**

***Table 2:* List of modified cross-sections for Alternatives 1 and 2**

Cross-Sections in Project Area that were modified with additional overbank data and/or levee for Alternatives 1 and 2	3.751, 3.763*, 3.775*, 3.787, 3.797*, 3.807*, 3.817*, 3.827, 3.83675*, 3.8465*, 3.85625*, 3.866, 3.87866, 3.89133, 3.904, 3.916*, 3.928*, 3.94, 3.95333*, 3.96666*, 3.98, 3.988*, 3.996, 4.0045*, 4.013, 4.02200*, 4.031, 4.049

Cross-Sections upstream of Project Area that were modified with additional overbank data for Alternatives 1 and 2 to contain 1% event	4.159, 4.177, 4.322, 4.328, 4.348, 4.352, 4.36, 4.454, 4.462, 4.468, 4.474, 4.481, 4.484, 4.492, 4.495, 4.562, 4.576, 4.582, 4.842, 4.845, 4.873

There are two bridges located within our project area, the Interstate Highway 94 (I-94) Bridge and a Railroad Bridge owned by the Soo Line Rail Company. USACE contacted Wisconsin Department of Transportation (WDOT) for the 1-94 Bridge and Soo Line Rail Company to determine if it would be permissible to remove the concrete lining of the channel under these bridges. The Soo Line Rail Company gave USACE the permission to remove the concrete under the Railroad Bridge. WDOT requested USACE perform a scour analysis under the I-94 Bridge to determine if the concrete lining could be removed, see *Enclosure 2*. After the scour analysis was completed, WDOT gave USACE permission to remove the concrete lining under the I-94 Bridge for this project. Therefore for Alternatives 1 and 2, the manning's n value under the bridges was changed to reflect concrete removal and placement of stone.

The low flow channel under the Railroad Bridge in our project area does an unnatural turn, causing high velocities in that area. Currently the low flow channel goes between the second and third piers from the left (looking downstream). Therefore, for our project, it was proposed for Alternatives 1 and 2 to change the low flow channel to go between the first and second pier from the left (looking downstream) to allow a more natural flow for the river and decrease the velocity for fish passage (*Figure 5).*

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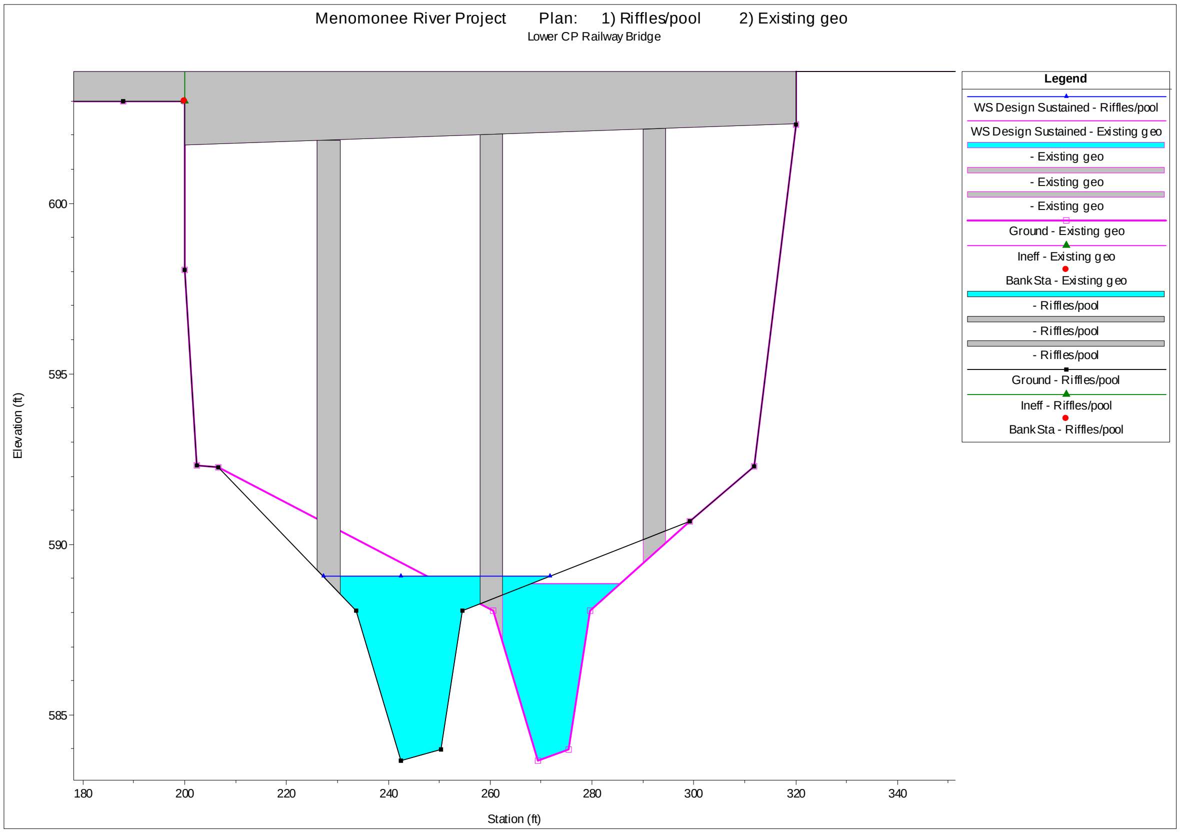

Figure 5: **Cross section of Railroad Bridge in project area. Pink line is the existing conditions geometry; black line is the geometry for Alternatives 1 and 2.**

3.1 Alternative 1: Concrete removal with riffle and pool structures

Alternative 1 consists of removing the concrete channel lining, and placing stone designed to remain stationary during 1% annual exceedence. Riffle and pool systems along with vegetated bars will be constructed along the river to create vital habitat for fish and other aquatic organisms during low flow periods as well as provide pools of lower velocity during high flow periods. Boulder runs will also be incorporated to provide areas to rest for migrating fish. The HEC-RAS geometry for Alternative 1 was built off of the existing conditions geometry provided by MMSD. The design of the riffles and pools was based on meeting the design targets for fish passage outlined in section 3.0 and an upstream project constructed by MMSD for fish passage (*Final Design Memorandum, Menomonee River Stream Management, May 2011,* prepared by the engineering firm GRaEF for MMSD). The design is as

The Alternative 1 geometry included 6 pools with 6 riffle structures (riffles in-between pools and riffle after last downstream pool). *Figure 6* shows the profile of the project area with the riffle and pools compared to the existing conditions profile. Riffles were spaced every 150 to 200' as the project had a relatively flat slope compared to the upstream design by MMSD. Pools were made 1.5' deeper than the existing bed elevation (top of concrete); while riffles were raised approximately 0.5' from the existing conditions bed elevation (top of concrete), based on the upstream design by MMSD. Additionally, a high point downstream of the riffles and pools and upstream of the Railroad Bridge was lowered from existing conditions in order to provide a smoother transition from the riffles and pools to existing ground.

The riffle structures had three design cross sections: a riffle anchor cross section, an upstream of the riffle anchor cross section, and a downstream of the riffle anchor cross section (*Figures 7-9)*. The pools had only one designed cross section (*Figure 10)*. The geometry of the riffle and pool cross sections were changed from the existing conditions cross section to the designed cross section, while all other cross sections in the project area were left as existing conditions geometry.

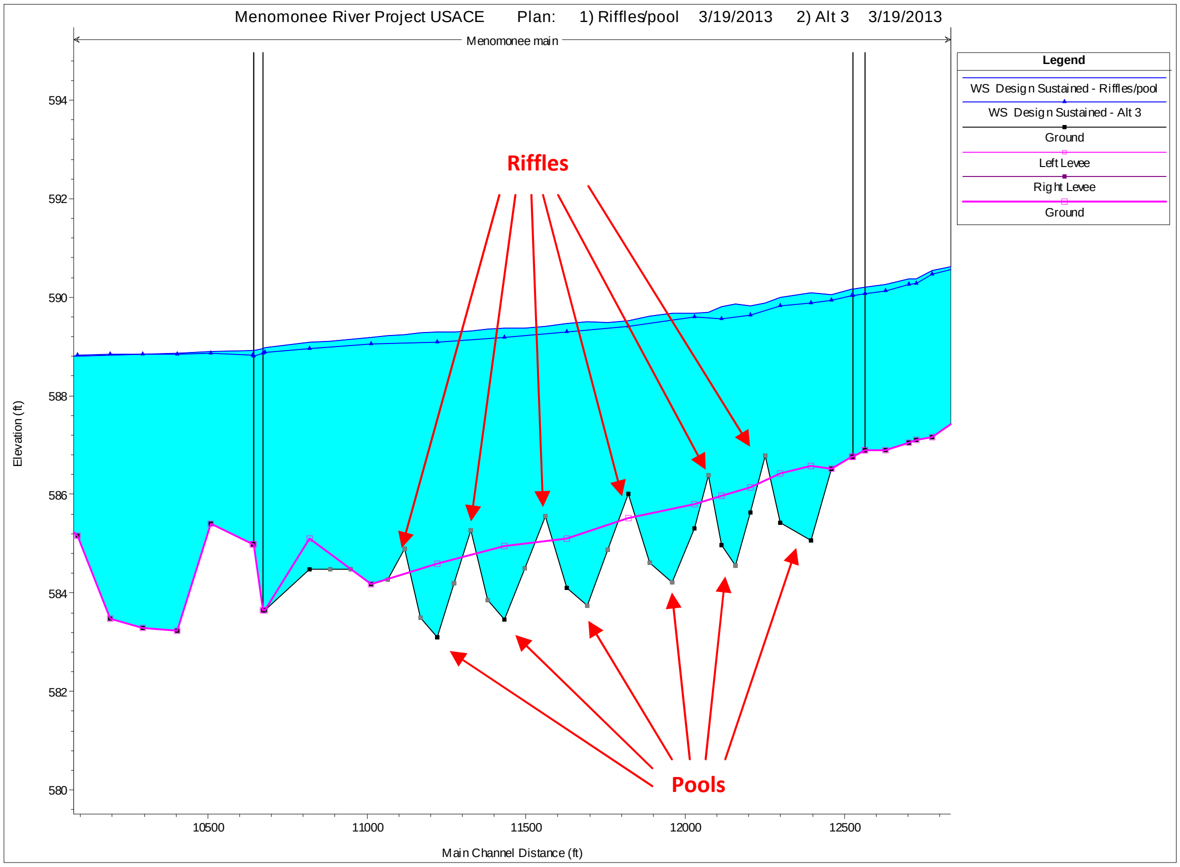

***Figure 6*: Profile of project area in black line, showing 6 pools and 6 riffles. Existing conditions profile in pink line**

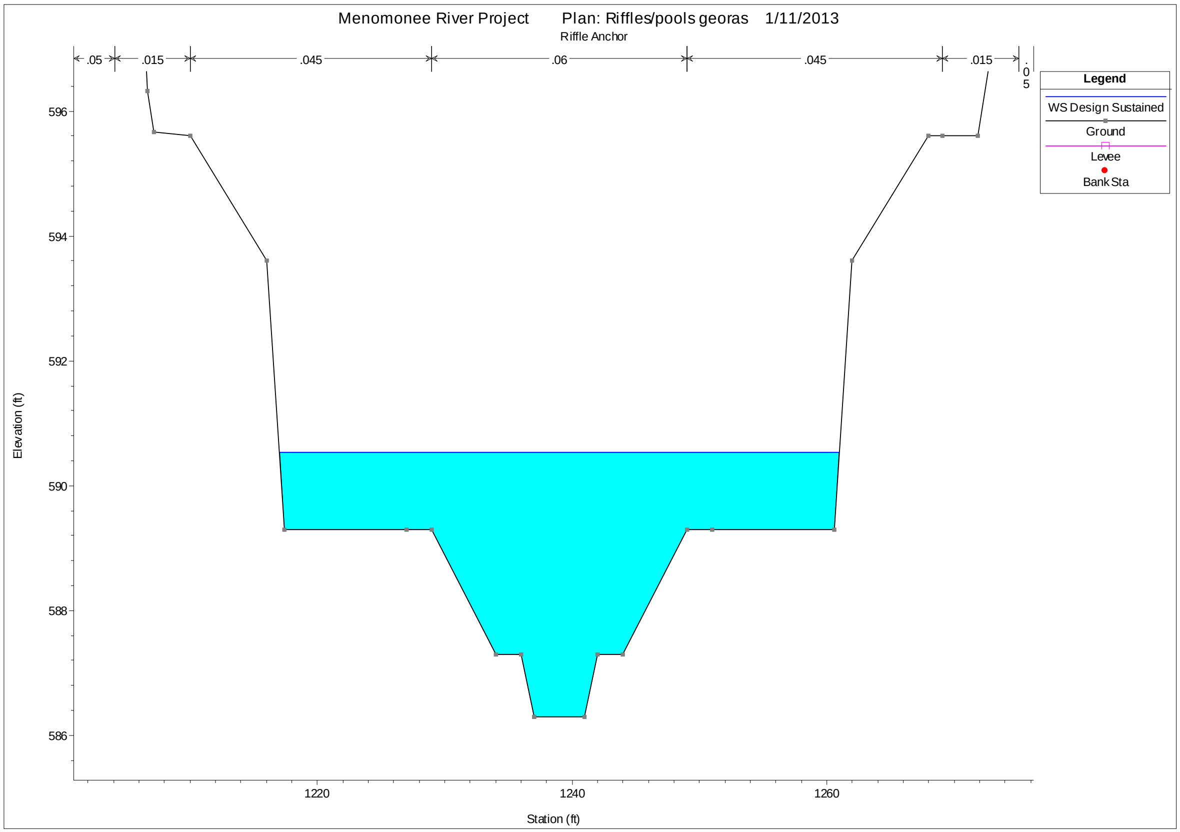

***Figure 7*: Typical cross section of riffle anchor**

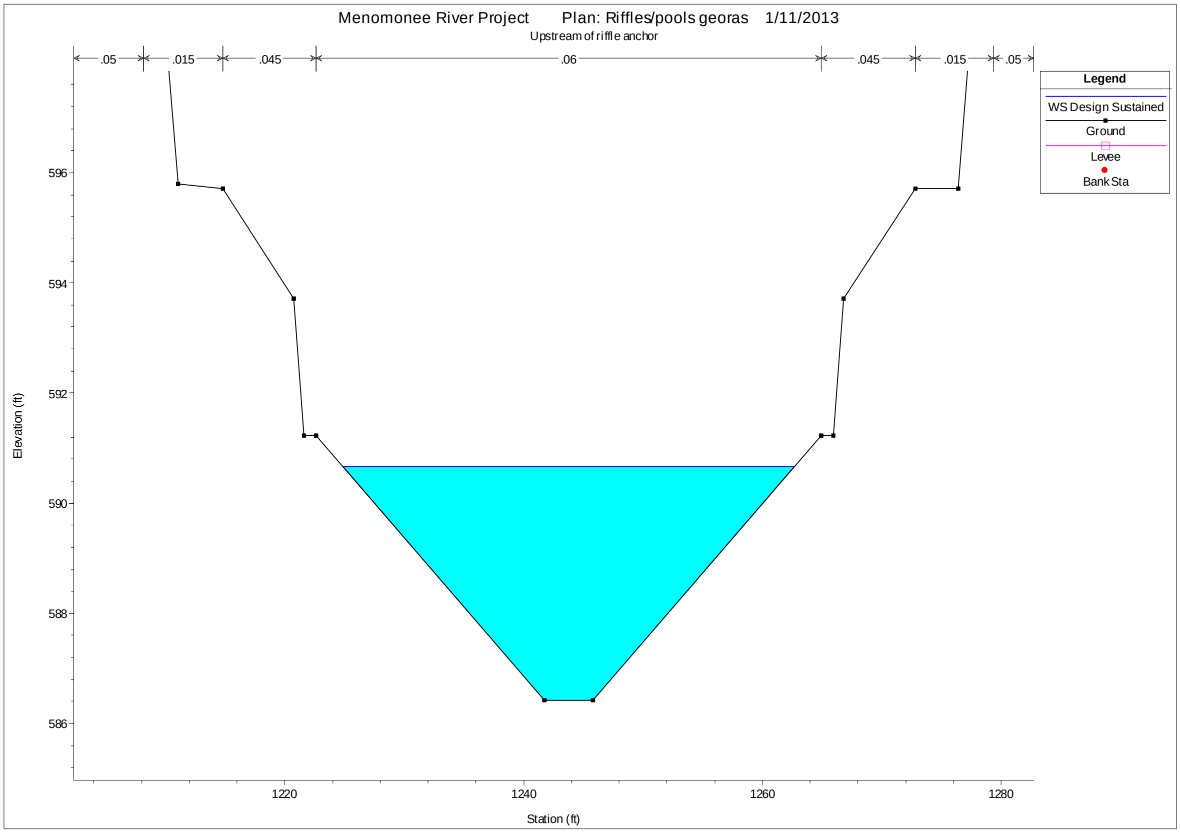

***Figure 8*: Typical cross section upstream of riffle anchor**

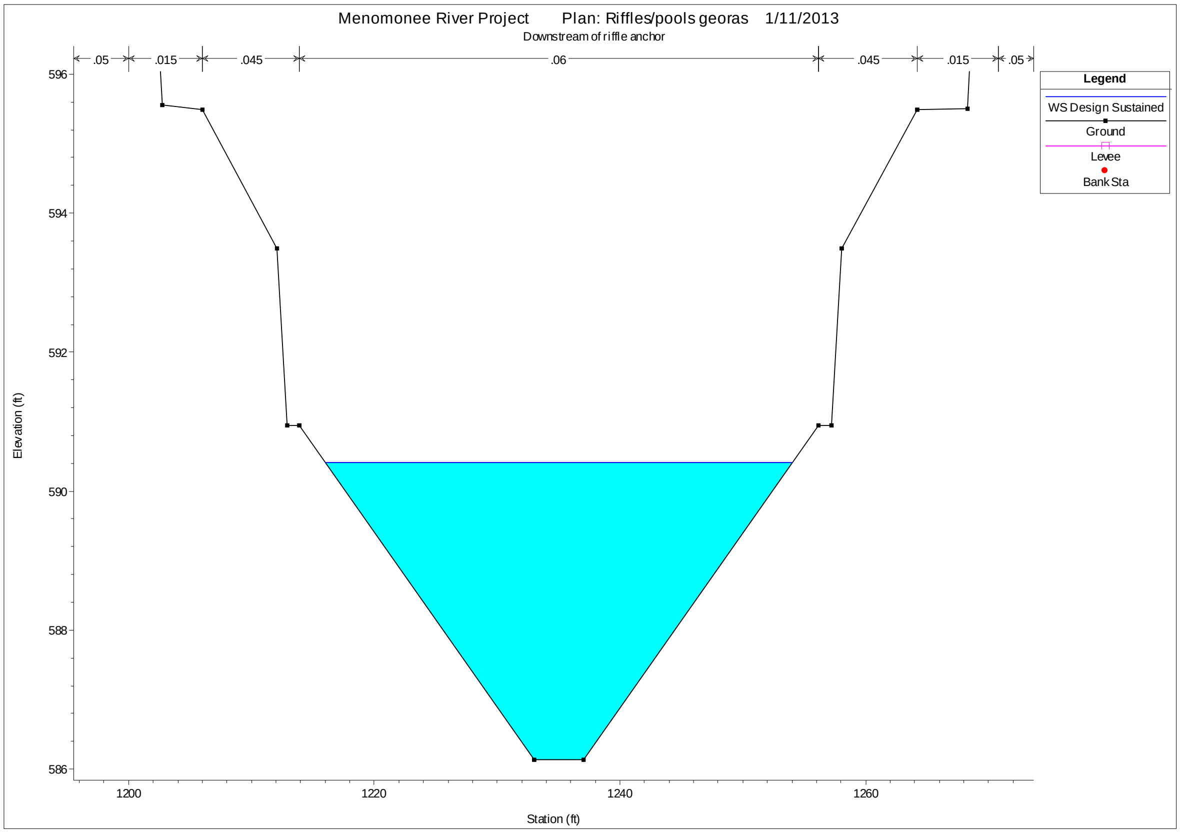

Figure 9: **Typical cross section downstream of riffle anchor**

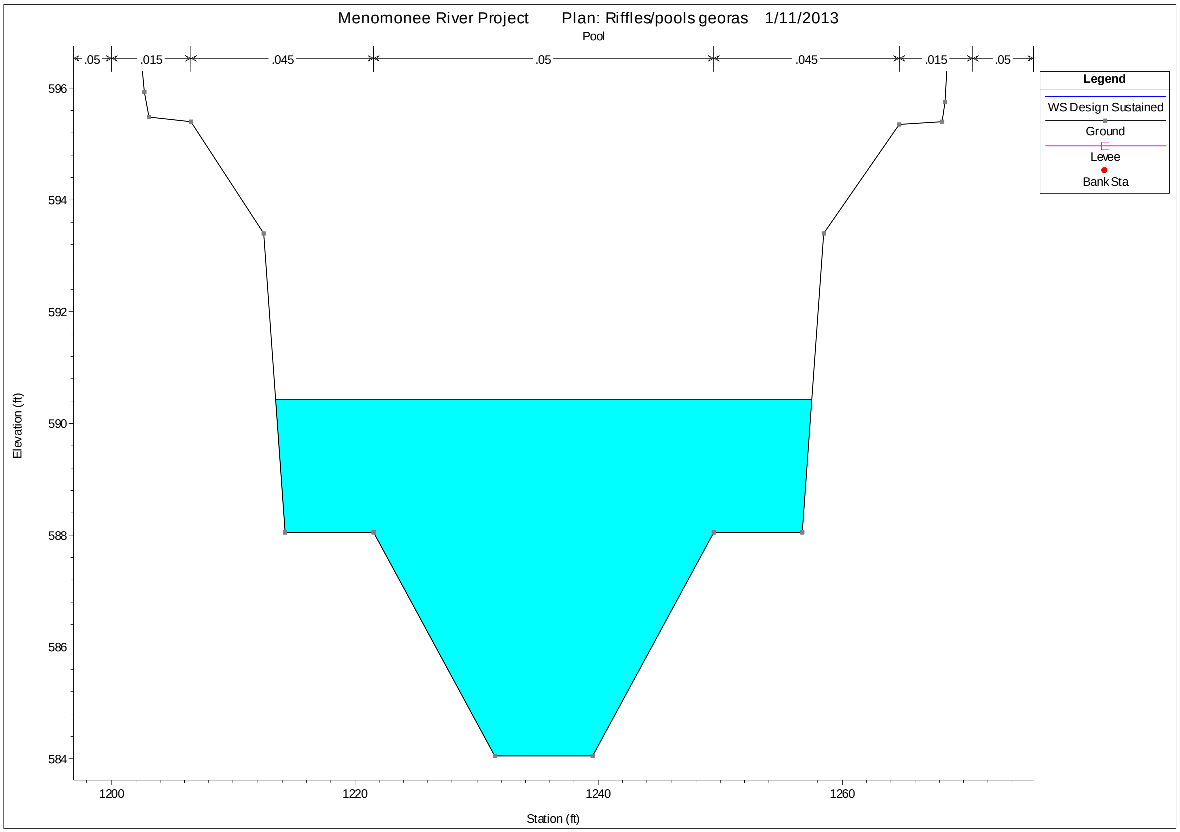

Figure 10: **Typical cross section of pool**

The manning’s n values for Alternative 1 were changed from 0.022 (existing conditions) to 0.033 in the channel for the entire project area. This represents removing the concrete lining and placing angular stone boulder riprap. A manning’s n value of 0.033 correlates to a clean, winding channel with some pools and shoals (*HEC-RAS Reference Manual, Version 4.1, Hydraulic Engineering Center, USACE, January 2010)*. All manning’s n values for overbank areas were kept the same as the existing conditions.

3.2 Alternative 2: Concrete removal and placement of stone

Alternative 2 involves the removal of the concrete channel lining and replacing the lining with stone, without creation of any riffle or pool complexes. The stone would be sized to be mobile enough to allow the river to create its own riffle pool complexes instead of forcing the location on the river.

For Alternative 2, the cross section geometries in the project area were not changed, but left as the existing conditions geometry. The manning’s n values in the channel were changed from 0.022 (existing conditions) to 0.03 for the entire project area to reflect the removal of concrete and placement of riprap. A manning’s n value of 0.03 correlates to a clean, straight channel, with stones and weeds, and no rifts or pools (*HEC-RAS Reference Manual, Version 4.1, Hydraulic Engineering Center, USACE, January 2010)*. All manning’s values for overbank areas were kept the same as the existing conditions.

3.3 Alternative 3: No action, existing conditions

Alternative 3 is no action and is required to be one of the alternatives in order to comply with the requirements of the NEPA. No action assumes that no project would be implemented by the Federal Government or by local interests to achieve the planned objectives. No action forms the basis from which all other alternative plans are measured.

In the analysis of Alternative 3, the existing conditions model provided by MMSD was used and not modified.

3.4 Flood Impacts

The FEMA effective Flood Insurance Study (FIS) designates areas of flooding at the 1% annual exceedence, see *Enclosure 3*. The 1% floodplains for Alternatives 1 and 2 were mapped to determine the extent of flooding beyond the existing conditions 1% floodplain and the 1% floodplain of the effective FIS (*Figure 12)*. The increases in water surface elevation for the 1% floodplain for Alternatives 1 and 2 from existing conditions can be found in *Table 3.*

Additionally, the geometry of Alternative 1 was inserted into the CLOMR model submitted by MMSD for our project area, and the 1% floodplain was mapped to determine the extents of flooding beyond the submitted MMSD CLOMR 1% floodplain (*Figure 13*).

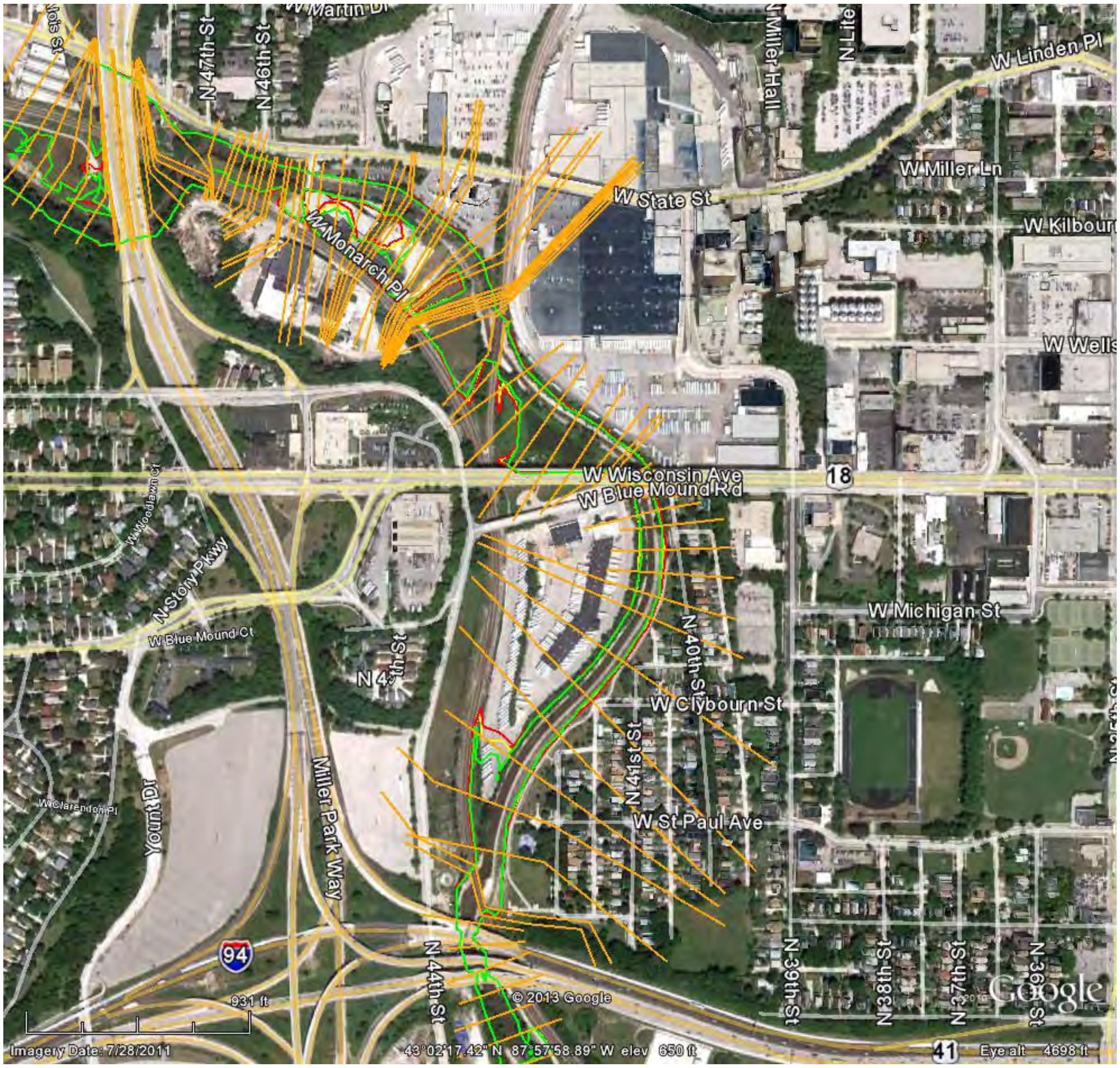

***Figure 12:* Floodplain Map where green line is Alternative 3 or existing conditions; yellow line is Alternative 2; red line is Alternative 1; and orange lines are existing conditions cross sections.**

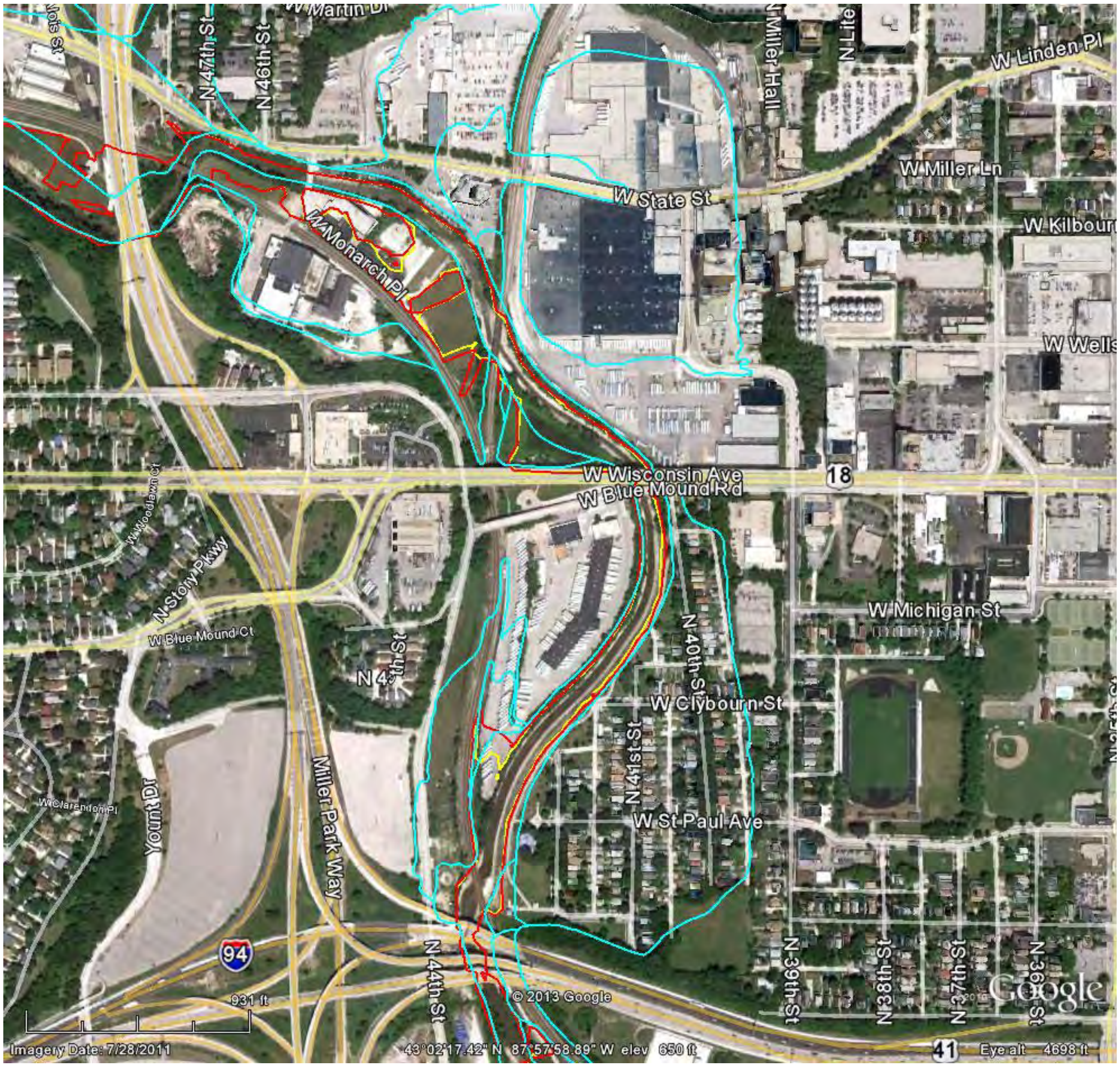

Figure 13: **Floodplain Map where yellow line is CLOMR submitted by MMSD; red line is Alternative 1 with CLOMR; and blue line is FEMA Effective FIS (showing 100 year and 500 year).**

Table 3: **Increases in Water Surface Elevation for 100 year for Alternatives 1 and 2**

		Alternative 1				Alternative 2			Alternative 3 Existing Conditions
Cross Section		100 yr W.S. Elevation	Difference in W.S. Elevation from Existing Conditions	Notes		100 yr W.S. Elevation	Difference in W.S. Elevation from Existing Conditions		100 yr W.S. Elevation
		(ft)	(ft)			(ft)	(ft)		(ft)
4.754		624.9	0.0			624.87	0.0		624.87
4.738		624.99	0.0			624.97	0.0		624.96
4.72		624.64	0.0			624.61	0.0		624.61
4.699		623.8	0.0			623.77	0.0		623.76
4.68		622.96	**0.7**			622.32	0.0		622.31

4.658		622.46	**0.2**			622.31	0.0		622.3
4.657		623.13	**0.1**			622.99	0.0		622.98
4.651									
4.646		622.89	**0.1**			622.77	0.0		622.76
4.643		622.89	**0.1**			622.76	0.0		622.75
4.637									
4.631		622.63	**0.1**			622.48	0.0		622.48
4.623		622.51	**0.1**			622.37	0.0		622.36
4.602		622.66	**0.1**			622.53	0.0		622.53
4.593		622.69	**0.1**			622.57	0.0		622.57
4.582		622.85	**0.2**			622.69	0.0		622.68
4.579									
4.576		620.69	**0.1**			620.6	0.0		620.58
4.562		620.71	**0.0**			620.69	0.0		620.68
4.548		616.96	**0.1**			616.93	0.0		616.9
4.529		616.16	**0.1**			616.12	**0.1**		616.05
4.525		616.33	**0.1**			616.29	**0.1**		616.23
4.518		616.4	**0.1**			616.36	**0.1**		616.29
4.511		616.17	**0.1**			616.12	**0.1**		616.03
4.505		616.06	**0.1**			616.01	**0.1**		615.92
4.502		616.33	**0.1**			616.28	**0.1**		616.2
4.495		615.7	**0.2**			615.62	**0.1**		615.51
4.492		615.6	**0.2**			615.52	**0.1**		615.39
4.484		615.43	**0.2**			615.33	**0.1**		615.2
4.481		615.48	**0.2**			615.38	**0.1**		615.24
4.474		615.6	**0.2**			615.51	**0.1**		615.37
4.468		615.55	**0.2**			615.46	**0.1**		615.33
4.465									
4.462		614.05	**0.5**			613.84	**0.3**		613.55
4.454		614.12	**0.5**			613.9	**0.3**		613.61
4.439		614.34	**0.6**			614.04	**0.3**		613.76
4.42		613.95	**0.4**			613.84	**0.3**		613.52
4.401		613.65	**0.6**			613.48	**0.5**		613
4.396		614.04	**0.5**			613.91	**0.4**		613.5
4.386		613.16	**1.0**			612.89	**0.8**		612.11
4.383		613.07	**1.1**			612.8	**0.8**		611.99
4.366		613.18	**1.4**			612.86	**1.1**		611.8
4.36		613.46	**1.3**			613.15	**1.0**		612.17
4.352		613.48	**1.3**			613.17	**1.0**		612.15
4.348		613.46	**1.4**			613.14	**1.0**		612.11
4.328		613.86	**1.1**			613.59	**0.8**		612.8
4.322		613.83	**1.0**			613.58	**0.8**		612.79
4.312		613.37	**1.1**			613.09	**0.9**		612.24
4.306		613.35	**1.1**			613.07	**0.9**		612.22

4.29		613.56	**1.1**			613.29	**0.8**		612.47
4.289		613.62	**1.1**			613.36	**0.8**		612.56
4.286		613.73	**1.0**			613.48	**0.8**		612.71
4.284		613.5	**1.1**			613.22	**0.9**		612.37
4.283		613.58	**1.1**			613.31	**0.8**		612.49
4.281		613.69	**1.1**			613.43	**0.8**		612.64
4.279		613.69	**1.1**			613.41	**0.8**		612.58
4.272 AP		613.72	**1.1**			613.46	**0.8**		612.64
4.253		614.16	**1.0**			613.92	**0.8**		613.16
4.247 RAILROAD BRIDGE									
4.242		612.86	**0.9**			612.63	**0.7**		611.92
4.216		610.54	**1.7**			610.17	**1.3**		608.84
4.196 AO		610.88	**1.7**			610.51	**1.3**		609.22
4.177		611.3	**1.6**			610.95	**1.2**		609.71
4.159		611.47	**1.6**			611.12	**1.2**		609.89
4.140 AN		611.06	**1.7**			610.68	**1.4**		609.32
4.121		610.39	**1.9**			609.97	**1.5**		608.46
4.112		610.23	**1.9**			609.82	**1.5**		608.3
4.107		610.2	**1.9**			609.79	**1.5**		608.28
4.093		610.09	**2.0**			609.66	**1.5**		608.13
4.082 AM		610.28	**2.0**			609.86	**1.5**		608.32
4.078 BLUEMOUND RD									
4.074		609.5	**2.1**			609.05	**1.6**		607.41
4.061		609	**2.3**	u/s limit of project		608.38	**1.6**		606.73
4.049		608.99	**2.5**	pool		608.11	**1.6**		606.46
4.031 AL		608.69	**2.3**			608	**1.6**		606.42
4.02200*		608.56		riffle					
4.013		608.51	**2.3**			607.79	**1.5**		606.25
4.0045*		608.6		pool					
3.996		608.35	**2.2**			607.66	**1.5**		606.17
3.988*		608.21		riffle					
3.98		608.16	**1.8**			607.73	**1.4**		606.37
3.96666*		608.24		pool					
3.95333*		607.97							
3.94		607.82	**1.9**	riffle		607.3	**1.4**		605.9
3.928*		607.75							
3.916*		607.82		pool					
3.904		607.66	**1.9**			607.08	**1.3**		605.81
3.89133*		607.44		riffle					
3.87866*		607.43							
3.866		607.54	**1.8**	pool		606.99	**1.2**		605.78
3.85625*		607.33							

3.8465*		607.19		riffle					
3.83675*		607.09							
3.827		607.22	**1.6**	pool		606.78	**1.1**		605.66
3.817*		607.05							
3.807*		607.03		riffle					
3.797*		607							
3.787 AK		606.96	**1.2**			606.79	**1.0**		605.78
3.775*		606.7							
3.763*		606.53							
3.751		606.48	**1.0**			606.33	**0.8**		605.52
3.724		607.06	**0.7**			606.98	**0.6**		606.39
3.721 SOO LINE RAILROA									
3.717		604.87	**0.7**			604.76	**0.6**		604.15
3.692		603.37	**0.4**			603.29	**0.3**		602.99
3.672		603.29	**0.3**			603.22	**0.3**		602.96
3.651		602.61	**0.1**	d/s limit of project		602.6	**0.1**		602.5
3.632		602.3	0.0			602.3	0.0		602.25

The Valley Park Levee is located along the eastern edge of the project (*see Enclosure 3*). The freeboard requirements of riverine levees from FEMA are as follows:

- A minimum freeboard of 3' above the 1% annual chance flood elevation
- An additional 0.5' above the 3' minimum at the upstream end of the main levee
- An additional 1' above the 3' minimum within 100' of either side of structures.

Table 4 shows the freeboard of the Valley Park Levee for Alternative 1 for the 1% annual chance exceedence. All cross sections meet the FEMA freeboard requirements for levees.

***Table 4:* Valley Park Levee Freeboard for Alternative 1 for 100 yr**

Cross Section	FEMA Freeboard Requirement	Actual Freeboard
4.049	3.5	3.61
4.031 AL	3	3.21
4.02200*	3	3.23
4.013	3	3.17
4.0045*	3	3.05
3.996	3	3.27
3.988*	3	3.45
3.98	3	3.54
3.96666*	3	3.44
3.95333*	3	3.68
3.94	3	3.81
3.928*	3	3.88
3.916*	3	3.80
3.904	3	3.96
3.89133*	3	4.11
3.87866*	3	4.05
3.866	3	3.87
3.85625*	3	4.13

3.8465*	3	4.33
3.83675*	3	4.48
3.827	3	4.40
3.817*	3	4.48
3.807*	3	4.40
3.797*	3	4.34
3.787 AK	3	4.29
3.775*	3	4.64
3.763*	3	4.91
3.751	4	5.05

3.5 Hydraulic Modeling Results

The targets for fish passage during migration are as follows:

- Average flow velocity less than 2.5 ft/s during spring flows
- Average flow velocity greater than 2 ft/s does not exceed 150 ft runs during spring flows
- Pool depth between 3 to 5 ft at base flow
- Riffle depth greater than 1 ft at base flow

Alternative 1 consists of 6 pools and 6 riffles. The average velocities of the riffles during spring flow range from 1.69 to 2.98 ft/s. For the riffle segments that have average velocities over 2.5 ft/s, the velocity at the edge of the channel is near 2 ft/s and has over 1' depth of flow, therefore they will still be able to pass fish. The average velocities of the pools during spring flow range from 1.11 to 1.55 ft/s. At base flow, pool depths range from 3.25 to 4.63 ft, and riffle depths range from 1.17 to 2.84 ft.

Alternative 2 consists of a rock lined channel which does not include any riffles or pools. It includes three segments that exceed 2 ft/s during spring flows. These segments are: 430' with velocities of 2.65 to 3.22 ft/s, average 2.87 ft/s; 807' at 2.36 to 2.71 ft/s, average 2.354 ft/s; and 310' at 2.27 to 2.54 ft/s, average 2.43 ft/s. At base flow, water depth ranges from 1.54 to 4.46 ft.

Alternative 1 satisfies the requirements necessary for fish passage, while Alternative 2 and Alternative 3 (existing conditions) would cause serious impediments to fish passage. Velocities and water depths for all the alternatives during spring flow and base flow are found in *Table 5.* See *Enclosure 4* for the HEC-RAS results.

***Table 5:* Summary of velocity and water depth for Project Alternatives**

	Alternative 1					Alternative 2				Alternative 3 - Existing Conditions			
	Sustained Spring Flow (200 cfs)		Base Flow (30 cfs)		NOTES	Sustained Spring Flow (200 cfs)		Base Flow (30 cfs)		Sustained Spring Flow (200 cfs)		Base Flow (30 cfs)	
River Sta	Vel Chnl	Water Depth	Vel Chnl	Water Depth		Vel Chnl	Water Depth	Vel Chnl	Water Depth	Vel Chnl	Water Depth	Vel Chnl	Water Depth
	(ft/s)	(ft)	(ft/s)	(ft)		(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
4.078 BLUEMOUND RD													

4.074	2.75	3.39	1.28	1.58		2.42	3.69	1.49	1.43	2.92	3.26	1.79	1.26
4.061	2.97	3.54	1.18	1.8	u/s limit of project	2.72	3.86	1.34	1.63	3.26	3.41	1.54	1.47
4.049	1.55	5.02	0.53	3.25	pool	2.74	3.75	1.37	1.54	3.29	3.31	1.57	1.39
4.031 AL	2.29	4.57	0.77	2.88		2.65	3.81	1.24	1.64	3.13	3.4	1.39	1.5
4.02200*	2.98	3.08	4.46	1.17	Riffle anchor								
4.013	2.48	4.19	1.03	2.34		3.22	3.93	1.72	1.84	3.95	3.5	1.92	1.71
4.0045*	1.42	5.3	0.49	3.43	pool								
3.996	2.08	4.83	0.72	3		3.01	3.99	1.47	1.94	3.61	3.59	1.6	1.84
3.988*	2.81	3.3	3.19	1.4	Riffle anchor								
3.98	2.31	4.36	0.88	2.55		1.87	4.16	0.79	2.09	2.15	3.79	0.85	2
3.96666*	1.35	5.47	0.43	3.65	pool								
3.95333*	1.94	5.01	0.63	3.23									
3.94	2.46	3.53	2.12	1.77	Riffle anchor	2.71	4.26	1.13	2.32	3.16	3.9	1.19	2.25
3.928*	2.09	4.61	0.71	2.91									
3.916*	1.25	5.75	0.35	4.04	pool								
3.904	1.72	5.35	0.51	3.67		2.51	4.51	0.93	2.69	2.86	4.2	0.96	2.64
3.89133*	2.1	3.84	1.31	2.19	Riffle anchor								
3.87866*	1.89	4.87	0.58	3.25									
3.866	1.19	5.93	0.31	4.3	pool	2.58	4.5	0.91	2.81	2.89	4.23	0.93	2.77
3.85625*	1.64	5.49	0.46	3.89									
3.8465*	1.94	4.03	0.88	2.45	Riffle anchor								
3.83675*	1.74	5.1	0.5	3.54									
3.827	1.11	6.2	0.27	4.63	pool	2.36	4.7	0.73	3.13	2.57	4.49	0.74	3.11
3.817*	1.49	5.78	0.39	4.24									
3.807*	1.69	4.35	0.59	2.84	Riffle anchor								
3.797*	1.69	4.94	0.49	3.44									
3.787 AK	1.85	5.02	0.5	3.55		1.83	5.06	0.5	3.55	1.94	4.88	0.5	3.54
3.775*	2.02	4.67	0.58	3.23									
3.763*	1.99	4.63	0.55	3.23									
3.751	1.94	4.6	0.53	3.23		2.27	3.99	0.71	2.6	2.42	3.85	0.71	2.59
3.724	2.21	5.32	0.55	4.05		2.49	5.31	0.64	4.05	2.65	5.22	0.64	4.04
3.721 SOO LINE RAILROAD													
3.717	2.14	3.94	0.6	2.71		2.54	3.91	0.74	2.7	2.77	3.83	0.74	2.7
3.692	1.21	3.5	0.33	2.29		1.21	3.49	0.33	2.29	1.22	3.47	0.33	2.29
3.672	1.42	5.63	0.33	4.46		1.42	5.63	0.33	4.46	1.43	5.62	0.33	4.46
3.651	1.42	5.56	0.32	4.41	d/s limit of project	1.42	5.56	0.32	4.41	1.42	5.56	0.32	4.41
3.632	1.2	5.36	0.28	4.22		1.2	5.36	0.28	4.22	1.2	5.37	0.28	4.22

3.6 Sediment Analysis

A geomorphic analysis was performed by GRaEF for the project reach just upstream of our project and documented in the *Final Design Memorandum, Menomonee River Stream Management, May 2011.* The analysis determined no sediment deposition within the concrete channel in their project area. However, they did note that downstream where the Menomonee River reverts back to a more natural channel (where the concrete channel lining ends and at the downstream limit of our project area), there were deposits composed of sand, gravel, and cobble (up to approximately 8 inches).

For our project area, we observed sediment deposition throughout the entire I-94 Bridge area to the downstream project limit where the concrete lining channel ends. The sediment deposition makes it so one cannot visually determine where the concrete lining channel ends and where the river reverts back to a more natural channel (*Figure 13*). Additionally, the water appeared "murky". No other areas were observed with sediment deposition in our project area.

Figure 13: **Menomonee River, downstream end of concrete lined channel showing sediment build-up**

MMSD published a report in 2001 titled *Sediment Transport Study of the Menomonee River.* The report detailed the overall geomorphic stability of the Menomonee River

Watershed and indicated in reaches where the WPA walls exist or the river has a concrete channel, the vertical bed and lateral bank stability are controlled by these features. For our project, the upstream channel invert elevation matches the existing conditions concrete upstream and the downstream channel invert elevation matches the natural channel downstream of our project area.

For the upstream project being constructed by MMSD, the State of Wisconsin Department of Natural Resources (DNR) issued a permit that requires maintenance of the pools to be removed of sediment at a determined frequency. We expect the DNR to issue a similar permit for this project and will require MMSD to remove any sediment in the pools on a somewhat frequent basis.

4.0 Summary

Alternative 1 is the preferred alternative, as it allows the greatest possibility for fish passage in the project area and does not cause significant flooding impacts. Since there are areas of flooding that exceed the FIS 1% annual exceedence, a CLOMR will need to be submitted to FEMA as this project continues forward.

APPENDIX C
COST APPENDIX FOR DESIGN PROJECT REPORT

for

MENOMONEE RIVER
MILWAUKEE, WISCONSIN

prepared by the

U.S. ARMY CORPS OF ENGINEERS
DETROIT DISTRICT

1. SCOPE OF COST APPENDIX

The scope of this appendix is to present the construction cost of the preferred alternative. This appendix is prepared in accordance with the guidance contained in ER 1110-2-1302, Civil Works Cost Engineering, and ETL 1110-2-573, Construction Cost Estimating Guide for Civil Works. The cost estimate was prepared using MCACES Second Generation MII software and cost estimates are presented in the Civil Works Breakdown Structure (CWBS) to the sub-feature level. This appendix includes a discussion of life cycle cost analysis, Total Project Cost Sheet (TPCS), Abbreviated Cost and Schedule Risk Analysis (ARA), drawings, quantity take offs and construction schedule.

2. GENERAL INFORMATION:

The feasibility study evaluates the potential for Federal interest in existing watershed problems associated with ecosystem and environmental restoration in the Menomonee River. The scope for this project includes engineering services to develop a feasibility level design that contains a plan and profile of the Menomonee River with several alternatives. The goals of this project are to:

- Remove approximately 2,400-feet of concrete lined channel
- Provide fish passage and resting areas during low-flows and fish refuge zones during higher flows
- Maintain or decrease the water surface elevations

3. PROJECT BACKGROUND AND STUDY SITE DESCRIPTION

The lower Menomonee River currently has a concrete lined channel in the reach between I-94 (approximately river mile 3.65) and just upstream of the Canadian Pacific Railroad Bridge (approximately river mile 4.259). The channel is trapezoidal in shape and is lined with limestone floodwalls, which were constructed by the Works Progress Administration (WPA) in the 1930s. While the system currently serves its functions of conveying flood flows and reducing flow water surface elevations, the concrete is deteriorating as it approaches the end of its design life. Also, high flow velocities and shallow flow depths impede fish migration between Lake Michigan and the upper portions of the watershed.

The Milwaukee Metropolitan Sewerage District (MMSD) has constructed and/or planned multiple projects within this stretch of river to address the issue. In 2000, MMSD rehabilitated part of the Menomonee River with the Drop Structure Removal Project by removing a low-head dam and the concrete lining within the channel. Expected to break ground in 2013, MMSD has planned the removal of the middle segment of the concrete channel.

In a partnership agreement, MMSD has requested the USACE provide engineering assistance in a cost sharing agreement for the lower section of the Menomonee River. The area of focus lies on the downstream portion of the concrete lined channel between the West Bluemound Railroad Bridge and I-94. This reach of the Menomonee River is approximately 2,400-feet and will be the last of the concrete lined channel removed. Concrete removal efforts will need to be coordinated with the upstream project.

4. CONSTRUCTION

Construction of both alternatives will be similar to construction of the previous reaches using land based equipment while working in the dry. The dewatering plan includes construction of a stone barrier and use of pumps to pass water downstream of the project. Steel sheet pile will stabilize the WPA walls during construction.

5. ALTERNATIVES

For this study, three alternatives were devised. Alternative 1 and 2 include removal of the concrete channel, while Alternative 1 incorporates a riffle-pool design into the reach. Alternative 3 is the "No Action" plan and does not meet the sponsor's criteria.

Preliminary costs were provided for alternatives 1 and 2 for use in the economics analysis. Preliminary construction costs for alternatives 1 and 2 were $4,998,360 and 4,419,565 respectively and both included 15% contingency. Once alternative 1 was determined preferable based on the preliminary costs provided, cost for this alternative was further refined and is depicted within this appendix.

5.1 Alternative 1 (Preferred) - Remove Concrete Channel, Add Riffle-Pool Design, and Add Riprap Revetment

Alternative 1 consists of the removal of the concrete channel between the WPA walls and replacing it with a rock-lined channel. However, Alternative 1 will incorporate a riffle-pool design throughout the reach, riffle anchor practices, resting benches, as well as a slight meander. By removing the concrete liner between the WPA walls, this allows the low flow channel to meander back and forth between the walls. With increased roughness from the large boulders and a meandering channel, the flow velocities will be reduced and additional refuge sections of varying widths will exist on both sides of the channel.

The low flow channel is designed to have riffles that are approximately 4-feet wide at the bottom of the channel and approximately 20-feet at the top with 2.5H:1V side slopes (see Figure 1). The anchor functions much like a cross-channel log in a natural channel and helps moderate depth and grade upstream, while also creating small pools downstream.

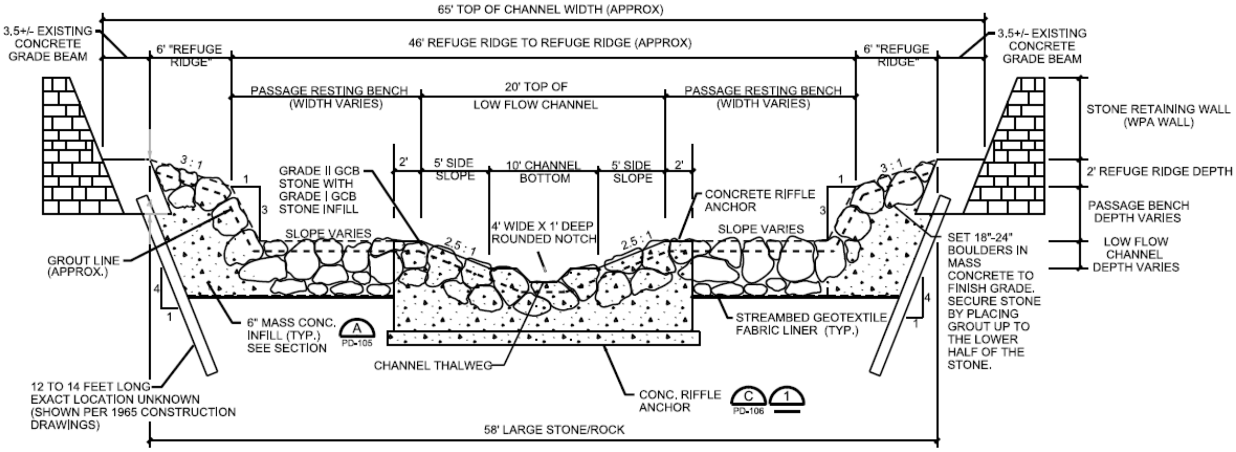

Figure 1: Typical Riffle Cross Section of Alternative 1

The reach will also contain pools that are wider and deeper when compared to the riffles. Combined with boulders placed within the channel, there will be suitable habitat for northern pike during low flows, while the boulders also provide resting spots during higher flows.

Above the low flow channel will be a stone-lined bench. This rock-lined section of the channel will form an approximate 20-foot bench to one side of the low flow channel; however, the length and slope will vary depending on where the thalwag is placed. Its function is to provide habitat that allows fish to rest and then swim to the next resting structure.

Equipment production will be hindered slightly due to the riffles and pools and the construction duration is anticipated to be approximately 6 months from time of project award.

5.2 Alternative 2 - Remove Concrete Channel and Add Riprap Revetment

The traditional approach to fish passage in urbanized streams is to increase roughness by replacing the concrete channel with large boulders that will not move with shear stresses experienced during large flood events. Thus, Alternative 2 will consist of the removal of the concrete channel between the WPA walls and replacing it with a rock-lined channel. The focus area is a reach that starts downstream of the West Bluemound Road Bridge and extends downstream to the Canadian Pacific Railroad Bridge, approximately 2,400-feet in length. For this alternative, the rock-lined channel will contour with existing grades, which eliminates some excavation when compared to Alternative 1, but also provides less of an ecological benefit. See Figure 2 for the typical cross section.

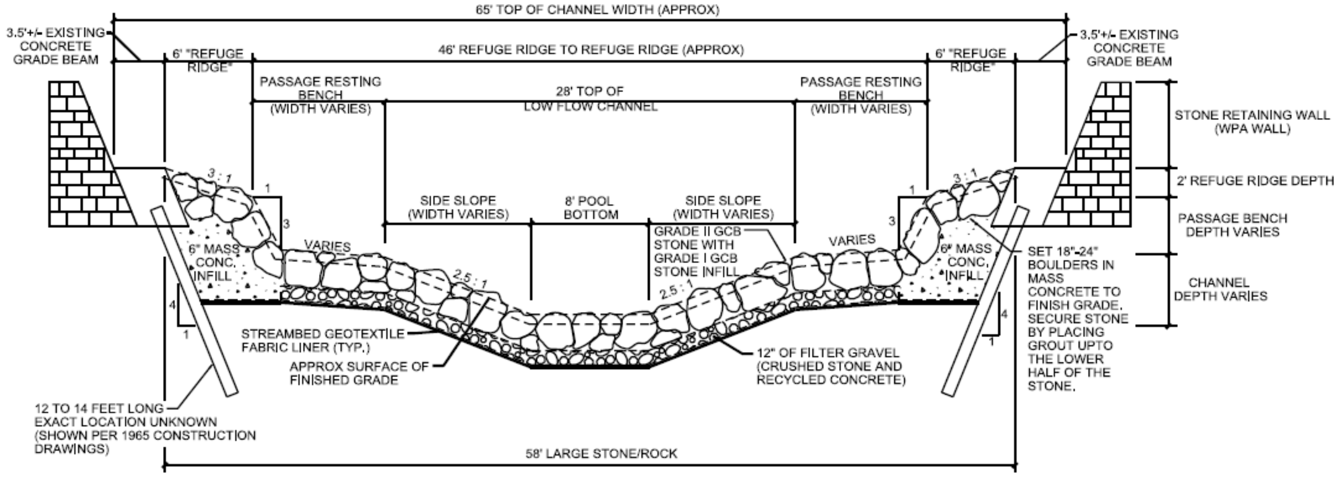

Figure 2: Typical cross section of Alternative 2

Equipment productivity will be unhindered for this alternative and the construction duration will be approximately 5 months from time of project award.

5.3 Alternative 3 - No Action

Not implementing a stream restoration will have environmental impacts. If the channel remains, the following impacts will occur:

- The river would continue to inhibit fish passage, as the high flow velocities remain unchanged.
- Flood level elevations will remain unchanged.
- Concrete channel will continue to degrade, prolonging maintenance costs.

In essence, the No Action alternative will result in 2,400-feet of the Menomonee River concrete channel degrading causing an economic burden on MMSD with concrete repairs, while also continuing to inhibit fish passage by preventing the upstream migration of fish that cannot handle the high flow velocities.

6. COST AND SCHEDULE RISK ANALYSIS

The informal cost and schedule risk analysis was prepared by Detroit District. The analysis was held to determine the contingency placed on the cost estimate of alternative 1. The cost estimate reflects the findings of the risk analysis; construction contingency was determined to be 18.3%. The informal risk register used for this process is attached to this appendix.

6.1 METHODOLOGY/PROCESS

A risk identification meeting was held providing qualitative analysis from the project team to produce a risk register that served as the framework for the risk analysis. The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve any desired level of cost confidence.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required.

6.2 IDENTIFY AND ASSESS THE RISK FACTORS

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

Checklists or historical databases of common risk factors were used to facilitate risk factor identification. However, key risk factors are often unique to a project and not readily derivable from historical information. Therefore, input from the entire PDT is obtained using creative processes such as brainstorming or other facilitated risk assessment meetings. In practice, a combination of professional judgment from the PDT and empirical data from similar projects is desirable and is considered. PDT meetings are held for the purposes of identifying and assessing risk factors. The meetings should include capable and qualified representatives from multiple project team disciplines and functions:

Project/Program managers – Steve Check, Tonya Harrington
Contracting/acquisition – Later coordinated with Tom McKay
Real Estate – Glenn Spence
Environmental – Hal Harrington
Civil and Coastal Design – Michelle Grimmer
Cost and schedule engineer – Julie Udell
Structural & Geotechnical – Tim Smith, Shelby Fowler
Technical Coordinator – Jihad Safa

The initial meeting focused primarily on risk factor identification using brainstorming techniques but also include some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Additionally, conference calls and informal meetings will be conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

On 25 February 2014, the team re-evaluated the risk level for line item PS-3 for Earthwork. Initially, there was concern of possibly excavating small amounts of contaminated soil and the associated tipping fees to dispose of such material. Since this initial assumption, channel construction upstream and adjacent to this project has found no contaminated soil so the risk level for line item PS-3 was reduced to a 1, lowering the overall contingency of the project. The cost estimate was also revised to delete contaminated soil removal line items. Also, the tipping fee for disposal of excavated material was removed from construction cost; this is now an element of the LEERDS cost.

6.3 QUANTIFY RISK FACTOR IMPACTS

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relies more extensively on collaboration between cost engineering, designers, and risk analysis team members with lesser inputs from other functions and disciplines. The following is an example of the PDT quantifying risk factor impacts by using an iterative, consensus-building approach to estimate the elements of each risk factor:

Maximum possible value for the risk factor.
Minimum possible value for the risk factor.
Most likely value (the statistical mode), if applicable.
Nature of the probability density function used to approximate risk factor uncertainty.
Mathematical correlations between risk factors.
Affected cost estimate and schedule elements.

The resulting product from the PDT discussions is captured within a risk register as presented in this appendix for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions are meant to support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

7. TOTAL PROJECT COST

Effective price level of the total project cost is 1 October 2012 and the program year is 2013. Fully funded total project cost was escalated to quarter 4 of 2014. Total project cost includes all estimated construction, lands and damages, planning, engineering, design and construction management costs.

8. LIFE CYCLE COST ANALYSIS

8.1 Life Cycle Cost considers the sum total of the indirect, recurring, nonrecurring, and other related costs incurred or estimated to be incurred in the design, development, production, operation, maintenance, support, and final disposition of a major system over its anticipated useful life span. Where system or project planning anticipates use of existing sites or facilities, restoration, and refurbishment costs are included.

8.2 Estimated annual operation and maintenance cost for Alternatives 1 and 2 is $10,000 and includes possible occasional replacement of stone and/or plantings.

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. 113605

LRE – Menomonee River Stream Restoration Section 206

The Menomonee River Stream Restoration Section 206 project, as presented by the Detroit District, has undergone a successful Cost Agency Technical Review (Cost ATR) of remaining costs, performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the cost products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of March 4, 2014, the Cost MCX certifies the estimated total project cost:

FY2014 First Costs:	$6,354,000
Total Project Costs:	$6,445,000
Estimated Federal Costs:	$4,432,000

Note: Cost ATR was devoted to remaining work. It did not review spent costs, which requires an audit process. It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management throughout the life of the project.

Kim C. Callan, PE, CCE, PM
Chief, Cost Engineering MCX
Walla Walla District

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **PII 113605 Menomonee River Stream Restoration Sec 206**
PROJECT NO: P2 # 113605
LOCATION: Milwaukee, WI
This Estimate reflects the scope and schedule in report; CAP Feasibilty Report

DISTRICT: Detroit District, LRE
PREPARED: ɔdated 25jun201
POC: CHIEF, COST ENGINEERING, William Merte

WBS Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**						**TOTAL PROJECT COST (FULLY FUNDED)**		
									Program Year (Budget EC):	2014				
									Effective Price Level Date:	1 OCT 13				
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%)	COST ($K)	CNTG ($K)	REMAINING COST ($K)	Spent Thru: 10/1/2013 ($K)	**TOTAL FIRST COST** ($K)	COST ($K)	CNTG ($K)	FULL ($K)
09	CHANNELS & CANALS		-			-								
09	Construction	$4,659	$853	18.3%	$5,512	2.1%	$4,755	$870	$5,625		$5,625	$4,819	$882	$5,701
	CONSTRUCTION ESTIMATE TOTALS:	$4,659	$853		$5,512	2.1%	$4,755	$870	$5,625		$5,625	$4,819	$882	$5,701
01	LANDS AND DAMAGES	$6			$6	2.1%	$6		$6		$6	$6		$6
30	PLANNING, ENGINEERING & DESIGN	$283	$31	11%	$314	1.8%	$288	$32	$320		$320	$293	$32	$325
31	CONSTRUCTION MANAGEMENT	$357	$39	11%	$396	1.8%	$363	$40	$403		$403	$373	$41	$64
	PROJECT COST TOTALS:	$5,305	$923	17%	$6,228		$5,412	$941	$6,354		**$6,354**	$5,491	$955	$6,445

Mandatory by Regulation CHIEF, COST ENGINEERING, William Merte

Mandatory by Regulation PROJECT MANAGER, Steve Check

Mandatory by Regulation CHIEF, REAL ESTATE, Vic Kotwicki

CHIEF, PLANNING, Terry Long

CHIEF, ENGINEERING, Phil Ross

CHIEF, OPERATIONS, Dave Wright

CHIEF, CONSTRUCTION, Phil Ross

CHIEF, CONTRACTING, Sandra Kenzie

CHIEF, PM-PB, Jim Galloway

CHIEF, DPM, Scott Thieme

ESTIMATED TOTAL PROJECT COST:		**$6,445**
ESTIMATED FEDERAL COST:	65%	$4,189
ESTIMATED NON-FEDERAL COST:	35%	$2,256
22 - FEASABILITY STUDY (CAP studies):		**$386**
ESTIMATED FEDERAL COST:		$243
ESTIMATED NON-FEDERAL COST:		$143
ESTIMATED FEDERAL COST OF PROJECT		**$4,432**

O&M OUTSIDE OF TOTAL PROJECT COST:

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: PII 113605 Menomonee River
LOCATION: Milwaukee, WI
This Estimate reflects the scope and schedule in report; CAP Feasibilty Report

DISTRICT: Detroit District, LRE
PREPARED: ›dated 25jun201
POC: CHIEF, COST ENGINEERING, William Merte

WBS Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			25-Jun-13	Program Year (Budget EC):			2014					
		Effective Price Level:			1-Oct-12	Effective Price Level Date:			1 OCT 13					
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1 or CONTRACT 1													
09	CHANNELS & CANALS													
09														
09	Construction	$4,659	$853	18.3%	$5,512	2.1%	$4,755	$870	$5,625	2014Q4	1.3%	$4,819	$882	$5,701
	CONSTRUCTION ESTIMATE TOTALS:	$4,659	$853	18.3%	**$5,512**		$4,755	$870	$5,625			$4,819	$882	$5,701
01	LANDS AND DAMAGES	$6			$6	2.1%	$6		$6	2014Q3	0.9%	$6		$6
30	PLANNING, ENGINEERING & DESIGN													
	Project Management	$40	$4	11%	$44	1.8%	$41	$4	$45	2014Q3	1.5%	$41	$5	$46
	Planning & Environmental Compliance	$55	$6	11%	$61	1.8%	$56	$6	$62	2014Q3	1.5%	$57	$6	$63
	Engineering & Design	$130	$14	11%	$144	1.8%	$132	$15	$147	2014Q3	1.5%	$134	$15	$149
	Engineering Tech Review ITR & VE	$25	$3	11%	$28	1.8%	$25	$3	$28	2014Q3	1.5%	$26	$3	$29
	Contracting & Reprographics	$10	$1	11%	$11	1.8%	$10	$1	$11	2014Q3	1.5%	$10	$1	$11
	Engineering During Construction	$23	$3	11%	$26	1.8%	$23	$3	$26	2014Q4	2.6%	$24	$3	$27
	Project Operations													
31	CONSTRUCTION MANAGEMENT													
6.5%	Construction Management	$299	$36	12%	$335	1.8%	$304	$37	$341	2014Q4	2.6%	$312	$37	$350
	Environmental Monitoring	$33			$33	1.8%	$34		$34	2014Q4	2.6%	$34		$34
2.5%	Project Management	$25	$3	12%	$28	1.8%	$25	$3	$28	2014Q4	2.6%	$26	$3	$29
	CONTRACT COST TOTALS:	$5,305	$923		**$6,228**		$5,412	$941	$6,354			$5,491	$955	**$6,445**

Menomonee River, Milwaukee, WI Section 206 Construction Schedule

Preferred Alternative 1	**Nov-13**				**Dec-13**				**Jan-14**				**Feb-14**				**Mar-14**				**Apr-14**				**May-14**				**Jun-14**				**Jul-14**				**Aug-14**				**Sep-14**				**Oct-14**				**Nov-14**			
Activity																																																				
Execute PPA	🟩	🟩	🟩	🟩																																																
Plans & Specs phase					🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩																																				
Ready to advertise																	🟩	🟩	🟩	🟩																																
Contract award																					🟩																															
NTP																						🟩																														
Precon submittals																							🟩	🟩	🟩	🟩																										
Mob/demob & Prep Work																											🟩	🟩																								
Demolition																													🟩	🟩	🟩	🟩	🟩																			
Earthwork																															🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩														
Channel Construction																																	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩								
Control of Water																											🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩								
Access rd & Storage Area																											🟩	🟩																								
Liners, Membranes & Fabrics																																	🟩	🟩	🟩	🟩	🟩	🟩	🟩													

MENOMONEE RIVER CAP SECTION 206
QUANTITY SUMMARY SHEET

JAU received on 20feb2013

Feature(s) of Work :

ALT 1 - Remove and replace concrete apron with natrual streambed and riffle-pool structures.

Prepared by: PSF

Checked by: TCS

Date Checked: 08NOV2012

Item	Description	Quantity	Unit	Unit Rate
	Mobilization and Demobilization			
	Mobilization and Demobilization	1	LS	
	Demolition			
	Concrete Channel Demolition and Disposal	3,752	CY	
	Concrete Cunette Removal and Disposal	100	CY	
	Cunette Rebar Removal and Disposal	1	TON	
	Earthwork			
	Excavaton, Backfill, and Testing	1	LS	
	Excavation	29,096	CY	
				$ 22,585.28
	Channel Construction			
	Filter Gravel (Recycled concrete / crushed stone)	2,802	CY	
	Bed Material (Angular Stone Grade II) (Assume 30% To Be Grouted)	17,830	TON	grade II is 12-48" stone size
	Bed Material Infill (Angular Stone Grade I) (Assume 30% To Be Grouted)	4,755	TON	grade I is 1-10" stone size
	Grout for Grade Control Stone and Boulders	221	CY	
	PZ-22 SSP	18,000	SFT	Vibratory Driven in Channel
	Vegetation Blanket/Articulated Mat	1,350	SY	
	Riffle Anchor Practice Concrete	130	CY	
	Mass Concrete	5,011	CY	
	Reinforcment Steel	167	TON	
	Control of Water			
	Water re-routing	1	LS	
	Access Road and Parking Area			
	Clearing	375	SY	Dense Large Trees Removed on Slope
	Construction Service Road Gravel Prep (1-1/2")	450	tons	
	Storage Area Gravel Prep (1-1/2")	218	tons	
	Restoration of Cleared Area Include tree plantings	375	SY	
	Liners, Membranes, and Fabrics			
	Streambed Liner	11,500	SY	

MENOMONEE RIVER CAP SECTION 206

Item	Total	Unit	Cross Section 1	Cross Section 2	Length
Concrete Channel Demolition and Disposal					
Sta. 77+50 to Sta. 78+80	237.53	CY	49.3	49.3	130.0
Sta. 78+80 to Sta. 80+00	220.74	CY	49.3	50.0	120.0
Sta. 80+00 to Sta. 81+30	242.35	CY	50.0	50.7	130.0
Sta. 81+30 to Sta. 83+20	283.83	CY	50.7	30.0	190.0
B-10 Bridge	100.00	CY	30.0	30.0	90.0
Cunette Rebar	0.90	TONS			
Sta. 84+10 to Sta. 86+18	292.74	CY	30.0	46.0	208.0
Sta. 86+18 to Sta. 100+50	2,475.06	CY	46.0	47.3	1,432.0

The distance in feet of each cross section to the next downstream cross section provided below:

			Grout		Crushed Stone and Recycled Concrete		Bed Material			
									GCB	GCB Infill
River Station	Distance to next X-Sec (ft)	Notes	Avg X-Sec (sq ft)	Volume (cy)	Avg X-Sec (sq ft)	Volume (cy)	Avg X-Sec (sq ft)	Volume (cf)	Wt (ton)	Wt (ton)
									Assume 75% of volume is GCB	Assume 20% of volume is infill
4.074		??	32		42.16		145			
	68.64			81.35111111		107.1800889		9952.8	617.173128	164.5795008
4.061		??	32		42.16		145			
	63.36			75.09333333		98.93546667		9187.2	569.698272	151.9195392
4.049		Pool	32		42.16		145			
	95.04			112.64		148.4032		13780.8	854.547408	227.8793088
4.031		Riffle - US Anchor	32		42.16		145			
	47.52			56.32		37.1008		6534	405.17334	108.046224
4.022		Riffle - Anchor	32	138.4444444	0		130			
	47.52			56.32		37.1008		6534	405.17334	108.046224
4.013		Riffle - DS Anchor	32		42.16		145			
	44.88			53.19111111		70.07928889		6507.6	403.536276	107.6096736
4.0045		Pool	32		42.16		145			
	44.88			53.19111111		70.07928889		6507.6	403.536276	107.6096736
3.996		Riffle - US Anchor	32		42.16		145			
	42.24			50.06222222		32.97848889		5808	360.15408	96.041088
3.988		Riffle - Anchor	32	138.4444444	0		130			
	42.24			25.03111111		32.97848889		5808	360.15408	96.041088
3.98		Riffle - DS Anchor	0		42.16		145			
	70.4352			41.73937778		109.9832604		10213.104	633.314579	168.8838877
3.96666		Pool	32		42.16		145			
	70.3824			83.41617778		109.9008142		10205.448	632.8398305	168.7572881
3.95333		Riffle - US Anchor	32		42.16		145			
	70.3824			83.41617778		54.95040711		9677.58	600.1067358	160.0284629
3.94		Riffle - Anchor	32	138.4444444	0		130			
	63.36			75.09333333		49.46773333		8712	540.23112	144.061632
3.928		Riffle - DS Anchor	32		42.16		145			
	63.36			75.09333333		98.93546667		9187.2	569.698272	151.9195392
3.916		Pool	32		42.16		145			
	63.36			75.09333333		98.93546667		9187.2	569.698272	151.9195392
3.904		Riffle - US Anchor	32		42.16		145			
	66.8976			79.28604444		52.22968178		9198.42	570.3940242	152.1050731
3.89133		Riffle - Anchor	32	138.4444444	0		130			
	66.8976			79.28604444		52.22968178		9198.42	570.3940242	152.1050731
3.87866		Riffle - DS Anchor	32		42.16		145			
	66.8448			79.22346667		104.3769173		9692.496	601.031677	160.2751139
3.866		Pool	32		42.16		145			
	51.48			61.01333333		80.38506667		7464.6	462.879846	123.4346256
3.85625		Riffle - US Anchor	32		42.16		145			
	51.48			61.01333333		40.19253333		7078.5	438.937785	117.050076
3.8465		Riffle - Anchor	32	138.4444444	0		130			
	51.48			61.01333333		40.19253333		7078.5	438.937785	117.050076
3.83675		Riffle - DS Anchor	32		42.16		145			
	51.48			61.01333333		80.38506667		7464.6	462.879846	123.4346256
3.827		Pool	32		42.16		145			
	52.8			62.57777778		82.44622222		7656	474.74856	126.599616
3.817		Riffle - US Anchor	32		42.16		145			
	52.8			62.57777778		41.22311111		7260	450.1926	120.05136
3.807		Riffle - Anchor	32	138.4444444	0		130			
	52.8			62.57777778		41.22311111		7260	450.1926	120.05136
3.797		Riffle - DS Anchor	32		42.16		145			
	52.8			62.57777778		82.44622222		7656	474.74856	126.599616
3.787		??	32		42.16		145			
	63.36			75.09333333		98.93546667		9187.2	569.698272	151.9195392
3.775		??	32		42.16		145			
	63.36			75.09333333		98.93546667		9187.2	569.698272	151.9195392
3.763		??	32		42.16		145			
	63.36			75.09333333		98.93546667		9187.2	569.698272	151.9195392
3.751		??	32		42.16		145			
	142.56			168.96		222.6048		20671.2	1281.821112	341.8189632
3.724		??	32		42.16		145			
	15.84			18.77333333		24.73386667		2296.8	142.424568	37.9798848
3.721		??	32		42.16		145			
	21.12			25.03111111		32.97848889		3062.4	189.899424	50.6398464
3.717		??	32		42.16		145			
	132			156.4444444		206.1155556		19140	1186.8714	316.49904
3.692		??	32		42.16		145			
	105.6			125.1555556		164.8924444		15312	949.49712	253.199232
3.672		??	32		42.16		145			
	110.88			131.4133333		173.1370667		16077.6	996.971976	265.8591936
3.651		??	32		42.16		145			

CULVERT DESIGN #1 MASS DIAGRAM

Station	End Area Cut (sf)	End Area Fill (sf)	Volume of Cut (bcy)	Volume of Fill (ccy)	Adj. Fill for Shrinkage (bcy)	Algebraic Sum (bcy)	Mass Ordinate
-+38.	400	0	0	0	0	0	0
+26.	257.6	0	779.3778	0	0	779.3778	779.3778
1+70.	263.1	0	1388.533	0	0	1388.533	2167.911
2+62.	286.5	0	936.3556	0	0	936.3556	3104.267
3+49.	276.8	0	907.5389	0	0	907.5389	4011.806
4+61.	261.8	0	1117.096	0	0	1117.096	5128.902
6+01.	288.7	0	1427.222	0	0	1427.222	6556.124
7+30.	273.2	0	1342.317	0	0	1342.317	7898.441
8+59.	270.9	0	1299.794	0	0	1299.794	9198.235
9+90.	357.7	0	1524.937	0	0	1524.937	10723.17
10+95.	402.36	0	1477.894	0	0	1477.894	12201.07
12+00.	364.1	0	1490.339	0	0	1490.339	13691.41
13+04.	373.8	0	1421.141	0	0	1421.141	15112.55
14+00.	400	0	1375.644	0	0	1375.644	16488.19
15+37.	400	0	2029.63	0	0	2029.63	18517.82
16+01.	400	0	948.1481	0	0	948.1481	19465.97
17+00.	400	0	1466.667	0	0	1466.667	20932.64
18+00.	400	0	1481.481	0	0	1481.481	22414.12
19+00.	400	0	1481.481	0	0	1481.481	23895.6
20+00.	400	0	1481.481	0	0	1481.481	25377.08
21+00.	400	0	1481.481	0	0	1481.481	26858.56
21+47.	400	0	696.2963	0	0	696.2963	27554.86
22+51.	400	0	1540.741	0	0	1540.741	29095.6

Abbreviated Risk Analysis

Project (less than $40M): **Menomonee River Restoration Section 206**
Project Development Stage: **Feasibility (Recommended Plan)**
Risk Category: **Low Risk: Simple Project-No Life Safety**

Total Construction Contract Cost = **$ 4,443,307**

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	**$ 134,000**		**0.00%**	$ -	$ 134,000.00
1	**09 01 CHANNELS**	**Mob, Demob, Preparatory**	**$ 166,130**		9.07%	$ 15,061	$ 181,190.73
2	**09 01 CHANNELS**	**Demolition**	**$ 749,450**		15.15%	$ 113,516	$ 862,966.46
3	**09 01 CHANNELS**	**Earthwork**	**$ 860,299**		18.65%	$ 160,435	$ 1,020,733.70
4	**09 01 CHANNELS**	**Channel Construction**	**$ 2,098,999**		19.54%	$ 410,214	$ 2,509,213.05
5	**09 01 CHANNELS**	**Control of Water**	**$ 494,721**		21.60%	$ 106,855	$ 601,576.45
6	**09 01 CHANNELS**	**Access Rd & Parking Area**	**$ 40,153**		6.97%	$ 2,800	$ 42,953.41
7	**09 01 CHANNELS**	**Liners, Membranes & Fabrics**	**$ 33,555**		10.70%	$ 3,590	$ 37,144.90
12		**Remaining Construction Items**	**$ -**	*0.0%*	0.00%	$ -	$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	**$ 282,998**		11.09%	$ 31,391	$ 314,388.76
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	**$ 356,968**		11.87%	$ 42,358	$ 399,325.90

Totals				
Real Estate	$ 134,000	0.00%	$ -	$ 134,000.00
Total Construction Estimate	$ 4,443,307	18.29%	$ 812,472	$ 5,255,779
Total Planning, Engineering & Design	$ 282,998	11.09%	$ 31,391	$ 314,389
Total Construction Management	$ 356,968	11.87%	$ 42,358	$ 399,326
Total	$ 5,217,273		$ 886,220	$ 6,103,493

Abbreviated Risk Analysis

Menomonee River Restoration Section 206
Feasibility (Recommended Plan)

Meeting Date: 12/6/2012, updated on 25 February 2014

PDT Members

Note: PDT involvement is commensurate with project size and involvement.

Project Management: Steve Check
Planner: Tonya Harrington
Study Manager: NAME
Contracting: Tom McKay
Real Estate: Glenn Spence
Relocations: NAME
OTHER: Hal Harrington, EAB
Engineering & Design: Tim Smith, Shelby Fowler
Technical Lead: Jihad Safa
Geotech: NAME
Hydrology: Michelle Grimmer
Civil: NAME
Structural: NAME
Mechanical: NAME
Electrical: NAME
Cost Engineering: Julie Udell
Construction: NAME
Operations: NAME
OTHER: NAME
OTHER: NAME
OTHER: NAME
OTHER: NAME
OTHER: NAME
OTHER: NAME
OTHER: NAME
OTHER: NAME

Menomonee River Restoration Section 206
Feasibility (Recommended Plan)
Abbreviated Risk Analysis

Meeting Date: 12/6/2012, updated on 25 February 2014

Risk Level

Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3
	Negligible	Marginal	Significant	Critical	Crisis

Risk Element	Feature of Work	Concerns Pull Down Tab (ENABLE MACROS THRU TRUST CENTER) (Choose ALL that apply)	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Project Scope Growth							
						Max Potential Cost Growth	**40%**
PS-1	Mob, Demob, Preparatory	• Potential for scope growth, added features and quantities?	Yes,	Current assumption is that north access is located approximately 200 ft north into a separate project at the north boundry of this project. We would either have to undo other Contractor's work and replace or have them stop at the access point and we would finish that portion of the project, thus adding linear feet to our scope. Second southerly west side access location needs further investigation, real estate has not secured. There is also good access in the same location on east side of river but real estate has also not secured.	Possible	Marginal	1
PS-2	Demolition	• Potential for scope growth, added features and quantities?	No,	Concrete can be easily recycled/disposed of off site; estimate currently has quote from recycling company to haul away.	Possible	Negligible	0
PS-3	Earthwork	• Potential for scope growth, added features and quantities?	No,	Design could be further refined possibly causing excavation quantities to change.	Unlikely	Significant	1
PS-4	Channel Construction	• Potential for scope growth, added features and quantities?	No,	Stone size analysis is complete; stone size is similar to other finished adjacent reaches. Current estimate includes permanent ssp in areas that may need additional stability. Ongoing getoech investigation/analysis is finding that ssp stability is likely only needed during construction and could be pulled and reused along the reach. Since this analysis remains ongoing, estimate remains unchanged and reflects the over-design/additional cost.	Possible	Marginal	1
PS-5	Control of Water	• Potential for scope growth, added features and quantities?	Yes,	Soil underneath concrete is permeable, water may seep upward causing wet conditions. Also, need to determine which outfalls can get plugged along de-watered area.	Likely	Marginal	2
PS-6	Access Rd & Parking Area	• Potential for scope growth, added features and quantities?	No,	Although urban, there is plenty of open space such as vacant parking lots at this location.	Unlikely	Negligible	0
PS-7	Liners, Membranes & Fabrics	• Potential for scope growth, added features and quantities?	No,	The scope of this shouldn't change unless a reach had to be shortened.	Unlikely	Negligible	0
PS-12	Remaining Construction Items	• Potential for scope growth, added features and quantities?			Unlikely	Negligible	0
PS-13	Planning, Engineering, & Design	• Potential for scope growth, added features and quantities?	Yes,	Still need additional survey data. It's still unknown if concrete can be removed in area under Wi-DOT I-94 bridge which would impact fish passage. It's possible that Wi-DOT would not approve of Corps design, however, other reaches of the creek/river have been completed w/ very simialr designs.	Likely	Marginal	2
PS-14	Construction Management	• Potential for scope growth, added features and quantities?	Yes,	Work is weather and flow dependent, could extend construction management period.	Possible	Marginal	1

Acquisition Strategy

						Max Potential Cost Growth	**30%**
AS-1	Mob, Demob, Preparatory	• Contracting plan firmly established?	Acquisition strategy not well defined.	This project is a likely candidate to advertise for small business. The construction features are fairly typical and would contribute to good competition among contractors. This statement applies to all potential risk areas.	Possible	Marginal	**1**
AS-2	Demolition	• Contracting plan firmly established?	Acquisition strategy not well defined.	This project is a likely candidate to advertise for small business. The construction features are fairly typical and would contribute to good competition among contractors. This statement applies to all potential risk areas.	Possible	Marginal	**1**
AS-3	Earthwork	• Contracting plan firmly established?	Acquisition strategy not well defined.	This project is a likely candidate to advertise for small business. The construction features are fairly typical and would contribute to good competition among contractors. This statement applies to all potential risk areas.	Possible	Marginal	**1**
AS-4	Channel Construction	• Contracting plan firmly established?	Acquisition strategy not well defined.	This project is a likely candidate to advertise for small business. The construction features are fairly typical and would contribute to good competition among contractors. This statement applies to all potential risk areas.	Possible	Marginal	**1**
AS-5	Control of Water	• Contracting plan firmly established?	Acquisition strategy not well defined.	This project is a likely candidate to advertise for small business. The construction features are fairly typical and would contribute to good competition among contractors. This statement applies to all potential risk areas.	Possible	Marginal	**1**
AS-6	Access Rd & Parking Area	• Contracting plan firmly established?	Acquisition strategy not well defined.	This project is a likely candidate to advertise for small business. The construction features are fairly typical and would contribute to good competition among contractors. This statement applies to all potential risk areas.	Possible	Marginal	**1**
AS-7	Liners, Membranes & Fabrics	• Contracting plan firmly established?	Acquisition strategy not well defined.	This project is a likely candidate to advertise for small business. The construction features are fairly typical and would contribute to good competition among contractors. This statement applies to all potential risk areas.	Possible	Marginal	**1**
AS-12	Remaining Construction Items	• Contracting plan firmly established?			Unlikely	Negligible	**0**
AS-13	Planning, Engineering, & Design	• Contracting plan firmly established?	None,	No issues were identified.	Unlikely	Negligible	**0**
AS-14	Construction	• Contracting plan firmly established?	None,	No issues were identified.	Unlikely	Negligible	**0**

Construction Elements

						Max Potential Cost Growth	15%
CE-1	Mob, Demob, Preparatory	• Accelerated schedule or harsh weather schedule?	No,	Relatively small project and storage is widely available.	Unlikely	Negligible	0
CE-2	Demolition	• Accelerated schedule or harsh weather schedule?	Minor concern,	Concrete demolition could possibly damage stability of wpa wall, however, design intends for this area to get sawcut so probablitliy is low that damage will occur. Significant if wall needed repair.	Possible	Significant	2
CE-3	Earthwork	• Accelerated schedule or harsh weather schedule?	Yes,	Wet soils on channel bottom could cause difficulty for equipment and tight equipment clearance for work under railroad bridge.	Likely	Marginal	2
CE-4	Channel Construction	• Accelerated schedule or harsh weather schedule?	No,	construction consists of earth excavation; concrete demo; stone, concrete and ssp placement.	Possible	Marginal	1
CE-5	Control of Water	• Accelerated schedule or harsh weather schedule?	No.	Small low volume channel; higher volume only occurs w/ storm events. Historical info can predict expected high volume flows so proper measures can be taken.	Possible	Marginal	1
CE-6	Access Rd & Parking Area	• Accelerated schedule or harsh weather schedule?	No,	No unusual details required for this construction feature.	Unlikely	Negligible	0
CE-7	Liners, Membranes & Fabrics	• Accelerated schedule or harsh weather schedule?	No,	Laying fabric not a complex task.	Unlikely	Marginal	0
CE-12	Remaining Construction Items	• Accelerated schedule or harsh weather schedule?			Unlikely	Negligible	0
CE-13	Planning, Engineering, & Design	• Accelerated schedule or harsh weather schedule?	Yes,	Unforseen safety concerns due to unaddressed complexities. Possible outfall work to be included, but PM hopes to keep that work with the sponser.	Possible	Marginal	1
CE-14	Construction Management	• Accelerated schedule or harsh weather schedule?	Yes,	Additional construction management will likely be required at bridges and wpa walls.	Likely	Marginal	2

Quantities for Current Scope

						Max Potential Cost Growth	**20%**
Q-1	Mob, Demob, Preparatory	• Level of confidence based on design and assumptions?	No,	Existing AE design has provided quantities, also survey cross sections exist.	Unlikely	Negligible	**0**
Q-2	Demolition	• Level of confidence based on design and assumptions?	No,	The concrete dimensions are known.	Unlikely	Marginal	**0**
Q-3	Earthwork	• Level of confidence based on design and assumptions?	Yes,	These quantities will be revisited to make sure proper amount of material is taken off site.	Likely	Marginal	**2**
Q-4	Channel Construction	• Level of confidence based on design and assumptions?	No,	Quantity of stone is measurable w/ existing survey cross sections; similar design as adjacent reaches that have been constructed. Estimate is based on conservative design; additional investigation is proving that ssp and concrete	Possible	Marginal	**1**
Q-5	Control of Water	• Level of confidence based on design and assumptions?	Possible concern,	We assumed pumps would run for duration of construction in channel bed; the one season construction duration is also an assupmtion.	Likely	Marginal	**2**
Q-6	Access Rd & Parking Area	• Level of confidence based on design and assumptions?	No,	Dimensions known for this material.	Unlikely	Negligible	**0**
Q-7	Liners, Membranes & Fabrics	• Level of confidence based on design and assumptions?	No,	Currently based off of typical cross section.	Unlikely	Marginal	**0**
Q-12	Remaining Construction Items	• Level of confidence based on design and assumptions?			Unlikely	Negligible	**0**
Q-13	Planning, Engineering, & Design	• Level of confidence based on design and assumptions?	Yes, minor concern,	Additional design could affect quantities. Soil analysis could cause additional contaminated soil quantities.	Unlikely	Marginal	**0**
Q-14	Construction Management	• Level of confidence based on design and assumptions?	Yes, minor concern,	Differing conditions could cause additional construction management or quantities.	Unlikely	Marginal	**0**

Specialty Fabrication or Equipment

						Max Potential Cost Growth	50%
FE-1	Mob, Demob, Preparatory	• Unusual parts, material or equipment manufactured or installed?	N/A		Unlikely	Negligible	0
FE-2	Demolition	• Unusual parts, material or equipment manufactured or installed?	N/A		Unlikely	Negligible	0
FE-3	Earthwork	• Unusual parts, material or equipment manufactured or installed?	N/A		Unlikely	Negligible	0
FE-4	Channel Construction	• Unusual parts, material or equipment manufactured or installed?	N/A		Unlikely	Negligible	0
FE-5	Control of Water	• Unusual parts, material or equipment manufactured or installed?	N/A		Unlikely	Negligible	0
FE-6	Access Rd & Parking Area	• Unusual parts, material or equipment manufactured or installed?	N/A		Unlikely	Negligible	0
FE-7	Liners, Membranes & Fabrics	• Unusual parts, material or equipment manufactured or installed?	N/A		Unlikely	Negligible	0
FE-12	Remaining Construction Items	• Unusual parts, material or equipment manufactured or installed?	N/A		Unlikely	Negligible	0
FE-13	Planning, Engineering, & Design	• Unusual parts, material or equipment manufactured or installed?	N/A		Unlikely	Negligible	0
FE-14	Construction Management	• Unusual parts, material or equipment manufactured or installed?	N/A		Unlikely	Negligible	0

Cost Estimate Assumptions

						Max Potential Cost Growth	25%
CT-1	Mob, Demob, Preparatory	• Reliability and number of key quotes?		In general, quantities have been well defined except where noted. RS Means is the primary source of cost data as well as quotes. Negligible because small cost item.	Possible	Negligible	0
CT-2	Demolition	• Reliability and number of key quotes?		In general, quantities have been well defined except where noted. RS Means is the primary source of cost data as well as quotes. Marginal because of cost magnitude of this item.	Possible	Marginal	1
CT-3	Earthwork	• Reliability and number of key quotes?		In general, quantities have been well defined except where noted. RS Means is the primary source of cost data as well as quotes. Negligible because small cost item.	Possible	Negligible	0
CT-4	Channel Construction	• Reliability and number of key quotes?		In general, quantities have been well defined except where noted. RS Means is the primary source of cost data as well as quotes. Significant because this risk area is associated with greater cost.	Possible	Significant	2
CT-5	Control of Water	• Reliability and number of key quotes?		In general, quantities have been well defined except where noted. RS Means is the primary source of cost data as well as quotes. Marginal because of cost magnitude of this item.	Possible	Marginal	1
CT-6	Access Rd & Parking Area	• Reliability and number of key quotes?		In general, quantities have been well defined except where noted. RS Means is the primary source of cost data as well as quotes. Negligible because small cost item.	Possible	Negligible	0
CT-7	Liners, Membranes & Fabrics	• Reliability and number of key quotes?		In general, quantities have been well defined except where noted. RS Means is the primary source of cost data as well as quotes. Marginal because this risk area is associated with less cost.	Possible	Marginal	1
CT-12	Remaining Construction Items	• Reliability and number of key quotes?			Unlikely	Negligible	0
CT-13	Planning, Engineering, & Design	• Reliability and number of key quotes?	No,	Don't anticipate change in cost estimating methods.	Unlikely	Negligible	0
CT-14	Construction Management	• Reliability and number of key quotes?	No,	Don't anticipate change in cost estimating methods.	Unlikely	Negligible	0

External Project Risks

						Max Potential Cost Growth	20%
EX-1	Mob, Demob, Preparatory	• Potential for severe adverse weather?	Yes,	Concern w/ weather related channel conditions and high flow events however, since historic flow volume data exists, dewatering measures should tolerate weather events.	Unlikely	Marginal	0
EX-2	Demolition	• Potential for severe adverse weather?	Yes,	Concern w/ weather related channel conditions and high flow events however, since historic flow volume data exists, dewatering measures should tolerate weather events.	Possible	Significant	2
EX-3	Earthwork	• Potential for severe adverse weather?	Yes,	Concern w/ weather related channel conditions and high flow events. Such events could wash unprotected soil away however, since historic flow volume data exists, dewatering measures should tolerate weather events.	Possible	Significant	2
EX-4	Channel Construction	• Potential for severe adverse weather?	Yes,	Concern w/ weather related channel conditions and high flow events. Small stone could wash away if not all properly in place however, since historic flow volume data exists, dewatering measures should tolerate weather events.	Possible	Significant	2
EX-5	Control of Water	• Potential for severe adverse weather?	Yes,	Concern w/ weather related channel conditions and high flow events however, since historic flow volume data exists, dewatering measures should tolerate weather events. May need additional pumps or pump duration if more water than diversion	Possible	Significant	2
EX-6	Access Rd & Parking Area	• Potential for severe adverse weather?	Yes,	Concern w/ weather related channel conditions and high flow events but this isn't in the channel where flow could occur.	Unlikely	Negligible	0
EX-7	Liners, Membranes & Fabrics	• Potential for severe adverse weather?		Concern w/ weather related channel conditions and high flow events however, since historic flow volume data exists, dewatering measures should tolerate weather events. Can't place fabric if water is flowing through placement area.	Possible	Marginal	1
EX-12	Remaining Construction Items	• Potential for severe adverse weather?			Unlikely	Negligible	0
EX-13	Planning, Engineering, & Design	• Potential for severe adverse weather?	No,	No discussion identified for this risk area in regards to external risk.	Unlikely	Negligible	0
EX-14	Construction Management	• Potential for severe adverse weather?	Yes,	Schedule increase due to weather events.	Possible	Marginal	1

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. 113605

LRE – Menomonee River Stream Restoration
Section 206

The Menomonee River Stream Restoration Section 206 project, as presented by the Detroit District, has undergone a successful Cost Agency Technical Review (Cost ATR) of remaining costs, performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the cost products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of March 4, 2014, the Cost MCX certifies the estimated total project cost:

FY2014 First Costs:	$6,354,000
Total Project Costs:	$6,445,000
Estimated Federal Costs:	$4,432,000

Note: Cost ATR was devoted to remaining work. It did not review spent costs, which requires an audit process. It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management throughout the life of the project.

Kim C. Callan, PE, CCE, PM
Chief, Cost Engineering MCX
Walla Walla District

**** TOTAL PROJECT COST SUMMARY ****

Printed:3/4/2014
Page 1 of 2

PROJECT: **PII 113605 Menomonee River Stream Restoration Sec 206**
PROJECT NO: P2 # 113605
LOCATION: Milwaukee, WI
This Estimate reflects the scope and schedule in report; CAP Feasibilty Report

DISTRICT: Detroit District, LRE
PREPARED: pdated 25jun201
POC: CHIEF, COST ENGINEERING, William Merte

Program Year (Budget EC): 2014
Effective Price Level Date: 1 OCT 13

WBS Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**						**TOTAL PROJECT COST (FULLY FUNDED)**		
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%)	COST ($K)	CNTG ($K)	REMAINING COST ($K)	Spent Thru: 10/1/2013 ($K)	**TOTAL FIRST COST** ($K)	COST ($K)	CNTG ($K)	FULL ($K)
09	CHANNELS & CANALS		-			-								
09	Construction	$4,659	$853	18.3%	$5,512	2.1%	$4,755	$870	$5,625		$5,625	$4,819	$882	$5,701
	CONSTRUCTION ESTIMATE TOTALS:	$4,659	$853		$5,512	2.1%	$4,755	$870	$5,625		$5,625	$4,819	$882	$5,701
01	LANDS AND DAMAGES	$6			$6	2.1%	$6		$6		$6	$6		$6
30	PLANNING, ENGINEERING & DESIGN	$283	$31	11%	$314	1.8%	$288	$32	$320		$320	$293	$32	$325
31	CONSTRUCTION MANAGEMENT	$357	$39	11%	$396	1.8%	$363	$40	$403		$403	$373	$41	$64
	PROJECT COST TOTALS:	$5,305	$923	17%	$6,228		$5,412	$941	$6,354		**$6,354**	$5,491	$955	$6,445

Mandatory by Regulation	CHIEF, COST ENGINEERING, William Merte
Mandatory by Regulation	PROJECT MANAGER, Steve Check
Mandatory by Regulation	CHIEF, REAL ESTATE, Vic Kotwicki
	CHIEF, PLANNING, Terry Long
	CHIEF, ENGINEERING, Phil Ross
	CHIEF, OPERATIONS, Dave Wright
	CHIEF, CONSTRUCTION, Phil Ross
	CHIEF, CONTRACTING, Sandra Kenzie
	CHIEF, PM-PB, Jim Galloway
	CHIEF, DPM, Scott Thieme

ESTIMATED TOTAL PROJECT COST:		**$6,445**
ESTIMATED FEDERAL COST:	65%	$4,189
ESTIMATED NON-FEDERAL COST:	35%	$2,256
22 - FEASABILITY STUDY (CAP studies):		**$386**
ESTIMATED FEDERAL COST:		$243
ESTIMATED NON-FEDERAL COST:		$143
ESTIMATED FEDERAL COST OF PROJECT		**$4,432**
O&M OUTSIDE OF TOTAL PROJECT COST:		

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: PII 113605 Menomonee River
LOCATION: Milwaukee, WI
This Estimate reflects the scope and schedule in report; CAP Feasibilty Report

DISTRICT: Detroit District, LRE
PREPARED: dated 25jun201
POC: CHIEF, COST ENGINEERING, William Merte

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			25-Jun-13	Program Year (Budget EC):			2014					
		Effective Price Level:			1-Oct-12	Effective Price Level Date:			1 OCT 13					
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1 or CONTRACT 1													
09	CHANNELS & CANALS													
09														
09	Construction	$4,659	$853	18.3%	$5,512	2.1%	$4,755	$870	$5,625	2014Q4	1.3%	$4,819	$882	$5,701
	CONSTRUCTION ESTIMATE TOTALS:	$4,659	$853	18.3%	**$5,512**		$4,755	$870	$5,625			$4,819	$882	$5,701
01	LANDS AND DAMAGES	$6			$6	2.1%	$6		$6	2014Q3	0.9%	$6		$6
30	PLANNING, ENGINEERING & DESIGN													
	Project Management	$40	$4	11%	$44	1.8%	$41	$4	$45	2014Q3	1.5%	$41	$5	$46
	Planning & Environmental Compliance	$55	$6	11%	$61	1.8%	$56	$6	$62	2014Q3	1.5%	$57	$6	$63
	Engineering & Design	$130	$14	11%	$144	1.8%	$132	$15	$147	2014Q3	1.5%	$134	$15	$149
	Engineering Tech Review ITR & VE	$25	$3	11%	$28	1.8%	$25	$3	$28	2014Q3	1.5%	$26	$3	$29
	Contracting & Reprographics	$10	$1	11%	$11	1.8%	$10	$1	$11	2014Q3	1.5%	$10	$1	$11
	Engineering During Construction	$23	$3	11%	$26	1.8%	$23	$3	$26	2014Q4	2.6%	$24	$3	$27
	Project Operations													
31	CONSTRUCTION MANAGEMENT													
6.5%	Construction Management	$299	$36	12%	$335	1.8%	$304	$37	$341	2014Q4	2.6%	$312	$37	$350
	Environmental Monitoring	$33			$33	1.8%	$34		$34	2014Q4	2.6%	$34		$34
2.5%	Project Management	$25	$3	12%	$28	1.8%	$25	$3	$28	2014Q4	2.6%	$26	$3	$29
	CONTRACT COST TOTALS:	$5,305	$923		**$6,228**		$5,412	$941	$6,354			$5,491	$955	**$6,445**

Appendix D – Economic Analysis
Menomonee River
Ecosystem Restoration
Section 206
Wisconsin

US Army Corps
of Engineers ®
Detroit District

APPENDIX D – ECONOMIC ANALYSIS
ECOSYSTEM RESTORATION
(SECTION 206)
MENOMONEE RIVER, WISCONSIN

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APPENDIX D – ECONOMIC ANALYSIS
ECOSYSTEM RESTORATION
(SECTION 206)
MENOMONEE RIVER, WISCONSIN

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TABLES

FIGURES

1.0 INTRODUCTION

The Milwaukee Metropolitan Sewerage District of Milwaukee, Wisconsin has requested the assistance of the U.S. Army Corps of Engineers, Detroit District in restoring a 2,400 lf area of the Menomonee River beginning at HWY 18 northwest of the intersection of W Michigan St and N 38th St and continuing southerly direction to I94 southwest of W Mt Vernon Avenue and N 42nd St in Milwaukee, Wisconsin (Figure 1) approximately 100 miles north of Chicago, Illinois.

Figure 1. Project area

This section of the Menomonee River prevents fish from accessing restored sections upstream.

This Section 206 project is intended to provide fish species access to spawning areas upstream and resting and habitat areas within the project sections.

2.0 OVERVIEW AND PROJECT DESCRIPTION

2.1 Existing Conditions

The Menomonee River and Menomonee River Watershed is in southwestern Wisconsin (**Figure 2**). This 32-mile river is one of the principal tributaries of the Milwaukee River, and is part of a major watershed that drains to Lake Michigan. The watershed encompasses 136 square miles, including portions of Washington, Ozaukee, Waukesha and Milwaukee Counties and flows approximately 32 miles in a southeasterly direction from its headwaters in the Village of Germantown and the City of Mequon, Wisconsin to the Milwaukee and Kinnickinnic Rivers in the Milwaukee Harbor. The watershed flows primarily through urban areas, with the central and lower portions including mainly residential, commercial and industrial developments. The agricultural land near the upper reach of the Menomonee River is rapidly being developed.

Figure 2 – Menomonee River Restoration Location map

During 1965-66, the MMSD lined approximately 1 mile of the Menomonee River with concrete for flood control purposes. The proposed project involves the removal of the remaining portion of the concrete channel lining along a 2,400-foot stretch of the Menomonee River, Milwaukee, Wisconsin. The upstream limit of this project corresponds to the downstream limit of a completed MMSD project which removed a drop structure at 45th Street and 1,000 feet of concrete channel lining.

Figure 3 shows the Menomonee River as it appears today.

Figure 3 – Concrete lined Menomonee River Section

The Menomonee River has had severe water quality and physical habitat problems but, recent restoration efforts have resulted in substantial improvements. MMSD has reduced the annual combined sewer overflows into the Menomonee River from 60 to 2, resulting in significantly improved water quality. Water quality has also been improved by zebra mussel activity.

As with other areas of rapid urban development, increases in impervious area contribute to a flashier system with higher peak velocities and shear stresses. Bank erosion and erosion from construction sites also contribute heavily to waterway pollution within the Menomonee River watershed.

Upstream of the concrete lined portion of the channel, the Menomonee River and its tributaries extend into progressively more rural areas. A warm water fish community exists in this portion of the river, supporting significant smallmouth bass populations. Downstream of the concrete section, the river becomes an estuary backwater of Lake Michigan. Northern pike and walleye are the top fish predators in this area, exhibiting significant population increases in response to water quality improvements. The Wisconsin Department of Natural Resources (WDNR) provided a list of fish species lost or severely impaired by the construction, and continued presence of the concrete lined channel, as depicted in **Table 1**. Some of these species were impacted by the drop structure, which was recently removed by the MMSD.

Table 1 - Impacted Fish Species

	Native Species	
Greater Redhorse Sucker	Smallmouth Bass	Northern Pickerel
White Sucker	Walleye	Johnny Darter
Longnose Sucker	Northern Pike	Creek Chub
Shorthead Sucker	American Eel*	
	Non-Native Species	
Rainbow Trout	Coho Salmon	Atlantic Salmon
Brown Trout	Chinook Salmon	Sockeye Salmon

*SPECIAL CONCERN STATUS: The WDNR has listed the American Eel as a "Species of Concern"; it is considered rare and uncommon in Wisconsin.

2.2 Future Without-Project Condition

The Without Project Condition assumes that the MMSD would not remove the concrete section of the Menomonee River beginning at HWY 18 northwest of the intersection of W Michigan St and N 38th St and continuing southerly direction to I94 southwest of W Mt Vernon Avenue and N 42nd St in Milwaukee, Wisconsin. The river would continue to prevent native fish species from accessing critical spawning areas. The spawning reproduction rates for the region would remain unnaturally low with the restored habitat north of the project area remaining inaccessible to spawning fish and the project area itself would continue to produce flows well beyond tolerance for the regions fishery.

Without-project problems:

- Loss of aquatic habitat, natural shoreline and emergent wetlands
- Shortage of deeper water areas sheltered from the main current of the river occurring near to shoreline spawning habitat
- Continuance of a flashier system due to impervious concrete with higher peak velocities and shear stresses resulting in bank erosion contributing to waterway pollution within the Menomonee River watershed.

3.0 SOCIOECONOMIC ANALYSIS[1]

The Menomonee River Watershed covers 136 square miles in portions of Washington, Ozaukee, Waukesha and Milwaukee counties. The river originates in the Village of Germantown and the City of Mequon and flows in a southeasterly direction for about 32

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[1] Wisconsin Watersheds, Menomonee Watershed Plan 2010, August 2010, Wisconsin Department of Natural Resources.

miles before it meets the Milwaukee and Kinnickinnic Rivers in the Milwaukee Harbor Estuary. The watershed contains 96 total stream miles and 4,537 wetland acres.

3.1 Demographics

When compared to the State of Wisconsin with 99 persons per square, the Menomonee River watershed is densely populated with 2,367 persons per square mile. The population is relatively stable, remaining around 322,000 individuals between 1990 and 2000, but the number of household units increased by 3.5% to 129,736 dwellings. Thus, though the number of residents was stable, urban growth was increasing.

3.2 Land Use

The Menomonee watershed contains a mix of land use types (**Figure 4**). From 1970 to 2000, agriculture and related land uses declined by 43%. Most remaining rural land is located in the upper reaches of the watershed in Ozaukee and Washington Counties. As shown in Figure 3, 52% of the watershed is suburban/urban, 22% is devoted to agriculture with 14% remaining as open water or open space.

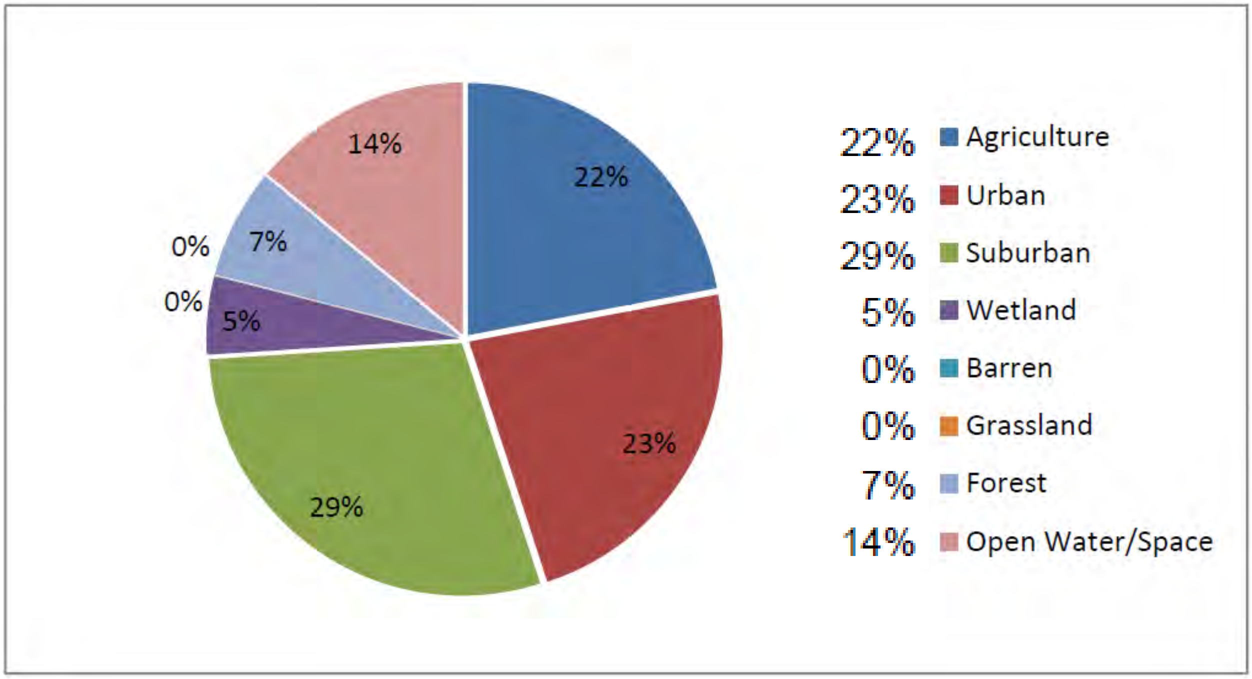

Figure 4. Menomonee Watershed Land Use[2]

The City of Milwaukee is the largest city in the Menomonee watershed and in the state of Wisconsin; it is the 28th most populous city in the United States with a population of nearly 600,000 persons. **Table 2** presents demographic and socioeconomic data for the city. Milwaukee has a lower median home value of $139,000 compared to $165,300 for the

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[2] Information from Source 1

County and $169,700 for the state. Unemployment rates for the city are slightly lower than that for the entire county at 8.4% compared to 9.1%, but higher than the state rate of 7.1%.

Table 2 - Milwaukee Demographic Profile	**City of Milwaukee**	**Milwaukee County**	**Wisconsin**
Population, 2012 (2011 for City of Milwaukee)	597,867	955,205	5,726,398
Number of housing units, 2011 (2010 for City)	255,569	418,935	2,634,781
Population per Square Mile, 2010	6,188.3	3,926	105
Persons under 18 years, percent, 2011 (2010 for City)	27.1%	24.9%	23.2%
Persons 65 years and over, percent, 2011 (2010 for City)	8.9%	11.4%	13.9%
High School Graduate or Higher, 2007-2011 (25 or older)	80.5%	85.2%	89.8%
Bachelor's degree or higher, 2007-2011 (25 or older)	21.3%	27.1%	26.0%
Persons below poverty, percent, 2007-2011	27.0%	19.9%	12.0%
Median household income, 2007-2011	$35,815	$43,397	$52,374
Median value of owner-occupied housing units, 2007-2011	$139,000	$165,300	$169,700
Unemployment Rate for the Milwaukee-Waukesha-West Allis, WI Metropolitan Statistical Area (BLS)-February 2013	8.4%		
Unemployment Rates, February 2013		9.1%*	7.1%
Source: Census Bureau's Quick Facts, U.S. Bureau of Labor Statistics ** January2013*			

4.0 ALTERNATIVES

This project proposes to replace the concrete with a more natural river bed built of stone and containing features found in natural channels such as pools, vegetated bars, and riffles. It is anticipated that this will restore form and function to this impaired waterway. The evaluated alternatives are presented here.

4.1 Alternative 1 – Concrete Removal with Riffle-Pool Construction

Alternative 1 consists of removing the concrete channel lining, and placing stone designed to remain stationary during 100-year or 1% flood events. Riffle and pool systems along with vegetated bars will be constructed along the river to create vital habitat for fish and other aquatic organisms during low flow periods as well as to provide pools of lower velocity during high flow periods. Boulder runs will also be incorporated to provide areas to rest for migrating fish.

This alternative consists of 6 pools and 6 riffles. The riffles range from 40' to 65' with velocities from 1.69 fps to 2.98 fps. Within this design, four riffle/run segments of the project reach have velocities greater than 2 fps, the velocity of concern for passage of northern pike.

However, for these riffle segments, the velocity at the edge of the channel is less than 2 ft/s and has over 1’ depth of flow, therefore, the fish will be able to pass. The pools range from 45' to 100' with velocities from 1.11 fps to 1.55 fps in spring.

4.2 Alternative 2 – Concrete Removal with Rock Lined Channel

Alternative 2 involves the removal of the concrete channel lining and replacing the lining with stone, without creation of any riffle or pool complexes. The stone would be sized to be mobile enough to allow the river to create its own riffle pool complexes instead of forcing to location on the river.

Alternative 2 involves replacing the removed concrete channel lining with stone without creation of any riffle or pool complexes. The stone would be sized to be mobile enough to allow the river to create its own riffle pool complexes instead of forcing to specific locations on the river. It includes three segments that exceed 2 fps; one at 430' with an average velocity of 2.87 fps, one at 807' with an average velocity of 2.54 fps, and one at 310' with an average velocity of 2.43 fps. All of these segments would restrict northern pike passage and greatly exceed the recommended length of passage at an average velocity of 2.65 fps. Also, the overall average channel velocity of 2.33 fps exceeds the sustained swim speed for northern pike passage. The channel flow velocities within the project reach range from 1.21-3.22 fps.

The Alternative 2 design specifications of greater than 2.33 fps and 2,400 LF channel exceeds values found in published literature indicating acceptable velocity and distance for critical or prolonged swim capabilities of northern pike.

4.3 Alternative 3 – No Action

The Corps is required to consider the option of “No Action” as one of the alternatives in order to comply with the requirements of the National Environmental Policy Act (NEPA). No action assumes that no project would be implemented by the Federal Government or by local interests to achieve the planned objectives. No Action, which is synonymous with the Without Project Condition, forms the basis from which all other alternative plans are measured. No action towards restoration of habitat would allow the environment to remain in a degraded condition and only gradual improvement would be expected due to improved water quality, sediment quality, and other restoration efforts ongoing in the Milwaukee and other affected areas.

5.0 ECONOMIC ANALYSIS OF ALTERNATIVES

The *Principles and Guidelines* (March 10, 1983) states that the Federal objective of water and land related resource planning is to contribute to national economic development (NED) consistent with protecting the nation's environment. This guidance directs Federal agencies to formulate plans that are economically and environmentally sound. Generally, the economic effectiveness of plans or alternatives developed for Federal water resource projects are evaluated through the use of a benefit-cost analysis. However, this analysis is impractical when evaluating environmental benefits.

Cost effectiveness and incremental cost analysis are typically recommended when evaluating the effectiveness of environmental restoration projects. When utilizing these tools, the costs and non-monetary outputs of each plan are weighed against each other to aid in the identification of the National Environmental Restoration (NER) plan. Cost effectiveness (CE) is used to screen out those inefficient alternatives that produce fewer environmental benefits at a higher per dollar cost. Once these inefficient alternatives have been eliminated, incremental cost analysis (ICA) is applied to reveal changes in costs as levels of environmental outputs increase. For these two analyses to be useful in decision-making, the non-monetary outputs produced by each plan must be quantified in the same unit of output or measurement (i.e. habitat units, environmental units) to ensure that all plans are comparable and further, the alternatives must be incremental in nature, either by feature or benefits achieved.

The U.S. Army Corps of Engineers Institute for Water Resources (IWR) provides step-by-step guidance on how to conduct cost effectiveness and incremental cost analyses in their *Evaluation of Environmental Investment Procedures Manual* (IWR Report # 95-R-1). In addition, IWR offers IWR Planning Suite that can be used to assist with the formulation and evaluation of environmental restoration plans. Due to the limited nature of the viable alternatives and the lack of incremental units in the alternatives evaluated, this model was not utilized.

5.1. Ecosystem Restoration Outputs

Habitat units (HU) are an assessment tool for examining the environmental impacts or outcomes for each of the proposed alternatives. For this study, the HU is achieved through the evaluation of a combination of importance factors including: Quantity (acres), Connectivity/Interspersion and Quality of the resource. These factors were then utilized to weight the quantity x connectivity x quality factor to achieve the habitat units.

A full description of the HU calculation process is provided in **Appendix E** of this report.

Table 3 summarizes the environmental benefits associated with each of the alternatives. Alternative 3, No Action, indicates zero in benefit units achieved. Of the alternatives evaluated in this study, Alternative 1, Concrete Removal with Riffle-Pool Construction, provides the greatest habitat units with 85.0 Total HU’s.

Table 3 - Menomonee River Habitat Units, Milwaukee, WI

	Quantity	Quality	Connectivity	Total Habitat Units	HU's	AAHU
Alternatives	**(acres)**	**(0-1)**	**(0-1)**			
Alternative 1 - - With-Project—Concrete Removal with Riffle/Pool Construction						
Upstream River Channel	100					
Gravel within 100 acres	30 *					
Smallmouth bass	30	1.0	1.0	30.0		
Walleye	30	1.0	1.0	30.0		
Mean value	30	1.0		30.0	30.0	30.0
Constructed River Channel Riffle Pool	3*					
Smallmouth bass	3	0.6	1.0	1.8		
Walleye	3	1.0	1.0	3.0		
Mean value				2.4	2.4	2.4
Riparian Emergent Wetlands for n. pike	125*	0.7	0.6**	52.5	52.5	52.5
TOTAL	158				85.0	85.0
Alternative 2 - With-Project —Concrete Removal with Rock Lined Channel						
Upstream River Channel	100					
Gravel within 100 acres	30*					
Smallmouth bass	30	1.0	0.4	12.0		
Walleye	30	1.0	1.0	30.0		
Mean value	30	1.0	0.7	21.0	21.0	21.0
Reconstructed Rock Channel	3*					
Smallmouth bass	3	0.6	0.4**	0.7		
Walleye	3	1.0	1.0	3.0		
Mean value				1.9	1.9	1.9
Riparian Emergent Wetlands for n. pike	125*	0.7	0.2**	17.5	17.5	17.5
TOTAL	158				40.0	40.0
Alternative 3 – No Action Alternative						
Upstream River Channel	100					
Gravel within 100 acres	30*					
Smallmouth bass	30	1.0	0.0	0.0		
Walleye	30	1.0	0.0	0.0		
Mean value		1.0	0.0	0.0	0.0	0.0
Concrete Lined Channel	3*					
Smallmouth bass	3	0.0	0.0	0.0		
Walleye	3	0.0	0.0	0.0		
Mean value				0.0		0.0
Riparian Emergent Wetlands for n. pike	125*	0.7	0.0	0.0		0.0
TOTAL	158			Net 0	0.0	0.0

5.2 Project Costs

Table 4 - Preliminary Costs of Alternatives		
2013 dollars, FY13 Interest Rate – 3.75%		
Item	Alt 1	Alt 2
Construction Cost	Remove Concrete w/Riffle-Pool Construction	Remove Concrete with Rock Lined Channel
Mobilization & Demobilization	$7,300	$7,300
Demolition	$728,300	$728,300
Earthwork	$1,092,300	$750,000
Channel Construction	$2,075,200	$2,002,600
Control of Water	$366,900	$278,500
Access Rd & Parking Area	$39,000	$39,000
Liners, Membranes and Fabrics	$37,400	$37,400
Subtotal	$4,346,400	$3,843,100
Contingency	$651,960	$576,465
SUBTOTAL	$4,998,360	$4,419,565
IDC[1]	$47,104	$34,672
Construction Cost with IDC	**$5,045,464**	**$4,454,237**
Non Construction Costs [1]	**$530,248**	**$495,018**
Total Costs (less sunk)	**$5,575,712**	**$5,949,255**
Life Cycle O&M & Monitoring Costs[2]	$10,227	$9,070
TOTAL PV OF PROJECT COSTS – FY13[3]	**$5,585,939**	**$5,958,325**
2014 dollars, FY14 Interest Rate – 3.5%[4]		
SUBTOTAL Construction Costs	$5,083,281	$4,494,652
IDC[1]	$43,949	$32,352
Construction Cost with IDC	**$5,127,230**	**$4,527,004**
Non Construction Costs	**$539,257**	**$503,428**
Total Costs (less sunk)	**$5,666,486**	**$5,030,432**
Life Cycle O&M & Monitoring Costs[2]	$10,401	$9,224
TOTAL PV OF PROJECT COSTS – FY14[3]	**$5,676,887**	**$5,039,656**

[1] Calculation assumes end of month payments with the last payment made when the project goes on-line. Mob & Demob is assumed paid as a lump sum in the first payment. FY14 interest rate of 3.5%. 6 months construction for Alt 1 and 5 months for Alt 2

[2] Assumes annual O&M is 0.2% of construction cost

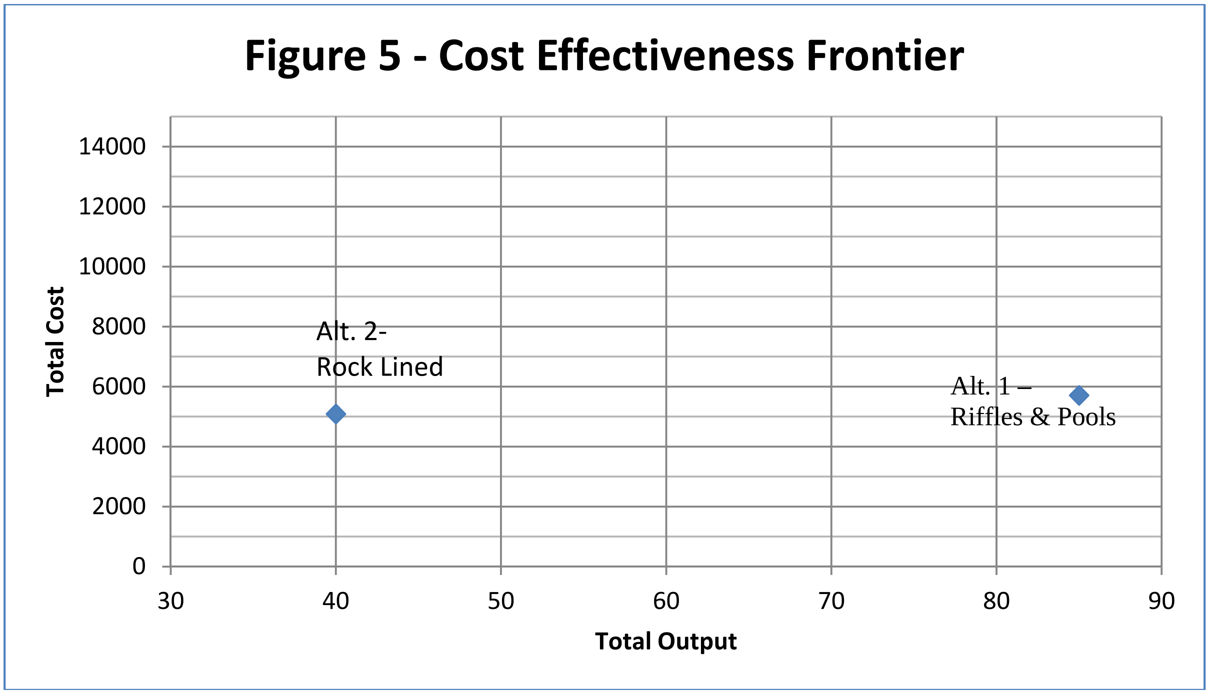
[3] Less sunk feasibility study costs

[4] FY14 costs updated using CWCCIS feature code 06 and FY14 interest rate of 3.5%

The preliminary project cost estimates were provided by Detroit District in 2013 dollars for each of the examined alternatives. Due to the timing of this report, costs were then updated to FY14 dollars using CWCCIS Feature Code 06 and the FY14 interest rate to adjust for changes made through the course of the study. Both FY13 and FY14 costs are presented in **Table 4**. The project costs include construction costs, non-construction costs (i.e. design), environmental monitoring costs and the estimated operations and maintenance costs.

5.3 Cost Effectiveness Analysis

Figure 5 depicts a cost effectiveness frontier of the outputs and costs for the evaluated alternatives. It is designed to compare costs and outcomes of two or more courses of action when monetary quantification of benefits is not practical.



Average Cost

Average cost is calculated by dividing total cost by total output, so the average cost for a particular level of output is the “cost per unit” for that level. For alternative 2, total cost of $5,039,656 divided by total output of 40.0 results in an average cost of $125,991 where alternative 1 has an average cost of $66,787. Average costs facilitate the comparison of production efficiencies across alternatives by placing each alternative plan in the common metric of dollars per unit of output.

Table 5 - Cost Effectiveness Analysis in 2014 Dollars			
Alternative	**Present Value of All Project Costs**	**Total Output (HU)**	**Average Cost (HU)**
3	$0	0.0	-
2	$5,039,656	40.0	$125,991
1	$5,676,887	85.0	$66,787

Preliminary alternative adjusted to FY14 dollars
using CWCCIS Feature Code 06.

Thus, the average cost per habitat unit is lower for alternative 1, Riffles and Pools at $66,787 than for alternative 2, Rock Lined Channel at $125,991.

5.4 Incremental Cost Analysis (ICA)

Incremental cost is the additional cost incurred by choosing one plan rather than another. It is computed by subtracting the cost of the last alternative under consideration from the cost of the alternative currently under consideration resulting in the difference in cost between one alternative and the next. In order to choose a benefit maximizing plan, it would be necessary to provide another alternative. However, given the urban nature of the project area, it is not possible to expand the project beyond the river and options within the riverbed are limited.

Table 6 presents incremental costs, incremental habitat units (outputs) and the incremental costs per unit.

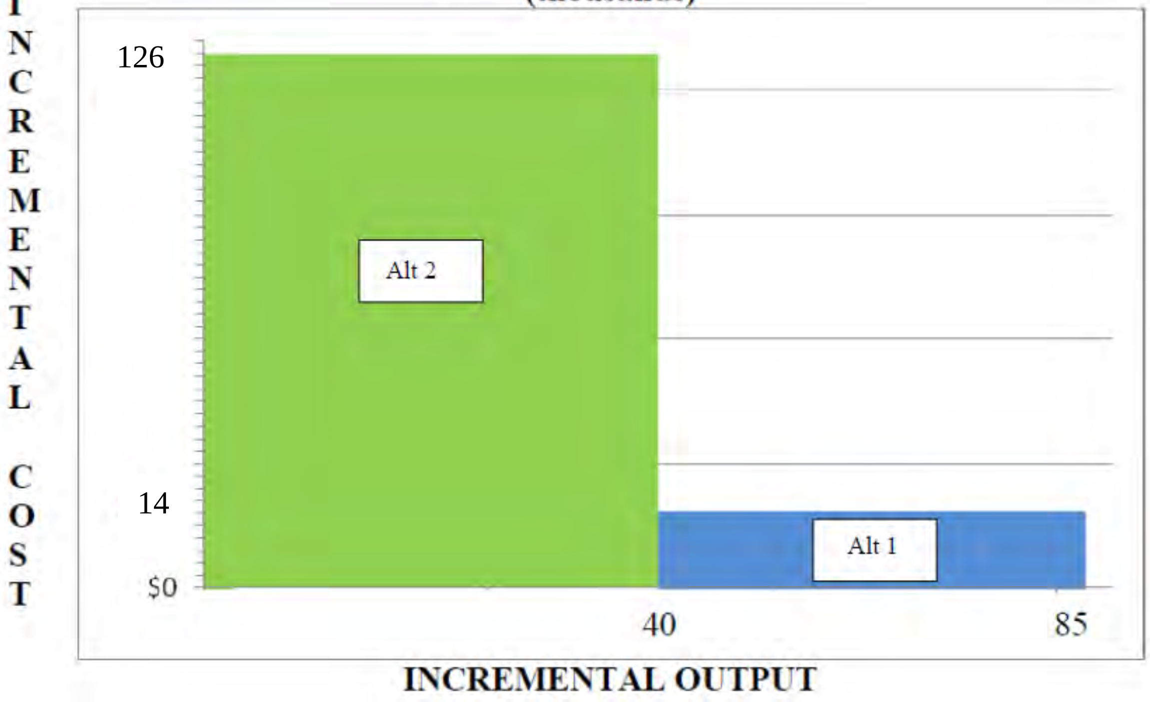
Table 6 - Incremental Cost Analysis in 2013 Dollars					
Alternative	**Total Cost**	**Incremental Cost**	**Total Habitat Units**	**Incremental Output**	**Incremental Cost Per HU**
3	$0	N/A	0.0	-	-
2	$5,039,656	$5,039,656	40.0	40.0	$125,991
1	$5,676,887	$637,231	85.0	45.0	$14,161

Preliminary alternative costs adjusted to FY14 dollars using CWCCIS Feature Code 06.

The table indicates that the incremental cost of deciding to implement Alternative 1 instead of Alternative 2 is $5,676,557-$5,039,656 or $637,231. This incremental cost information simply indicates that Alternative 1 is $637,231 more costly than Alternative 2. The table also indicates that Alternative 2 provides an additional 40.0 in habitat units over the no action plan and Alternative 1 provides 45.0 more than Alternative 2. Thus, for Alternative 1, for an additional $637,231, the alternative provides an additional 45.0 habitat units resulting in a significantly lower incremental cost per habitat unit for Alternative 1 of about $14,000 compared to that of Alternative 2 of nearly $126,000. Thus, we can produce the first 40.0 habitat units at a cost of $126,000/HU. If it is decided that these 40.0 HU's are worth $126,000 each, then the subsequent 45.0 HU's are worth $14,000 each. An incremental cost graph is provided in **Figure 6** showing the significantly lower per unit costs for the implementation of Alternative 1**.**

Thus, we can produce the first 40 habitat units at a cost of $126,000/HU. If it is decided that these 40 HU's are worth $126,000 each, then the subsequent 45 HU's are worth $14,000 each. An incremental cost graph is provided in **Figure 6** showing the significantly lower per unit costs for the implementation of Alternative 1**.**

Figure 6 – Incremental Cost (thousands)



6.0 DETERMINATION

Alternative 1, primarily in providing connectivity of the system, provides significantly greater habitat creation for a minimal increase in cost. Thus, Alternative 1 is the selected plan and was submitted for cost risk assessment.

7.0 REVISED COSTS

The cost risk assessment determined the risk adjusted cost of the selected alternative as shown in **Table 7**.

TABLE 7 – Risk Adjusted Cost, Alternative 1, Riffles and Pools	
RISK BASED - FULLY FUNDED PROJECT ESTIMATE	
2014 DOLLARS	
	TOTAL
CONSTRUCTION	$5,438,000
LANDS AND DAMAGES	$138,000
FEASIBILITY STUDY	$275,000
PLANNING, ENGINEERING & DESIGN	$325,000
CONSTRUCTION MANAGEMENT	$64,000
TOTAL PROJECT COSTS	$6,240,000
TOTAL PROJECT COSTS less sunk feasibility study costs	$5,965,000
PV Monitoring and Adaptive Management	$26,000
Operations & Maintenance	$10,000

Using the fully funded project cost of $6,240,000 less sunk study costs of $275,000 for a total cost of $5,965,000 and a total habitat unit creation of 85.0 units, the result is a cost of $70,200 per unit.

8.0 CONCLUSION/RECOMMENDATION

Alternative 1, Riffles and Pools, provides the most cost effective and economically efficient alternative and is, therefore, the plan recommended for implementation.

MENOMONEE RIVER

MILWAUKEE, WISCONSIN

APPENDIX E

REAL ESTATE PLAN

US Army Corps
of Engineers®

APPENDIX E

REAL ESTATE PLAN
SECTION 206 – AQUATIC ECOSYSTEM RESTORATION PROJECT
MENOMONEE RIVER
MILWAUKEE, WISCONSIN

AUTHORITY

This study is being conducted under the authority of Section 206 of the Water Resources and Development Act (WRDA) of 1996, (P.L. 104-303) as amended; U.S. Code 33 USC 2330. As such, the project is subject to the requirements of NEPA, Section 404(b)(1) of the Clean water Act, Section 401 of the Clean Water Act, as well as U.S. Army Engineers Regulation 1102-5-100.

1. PURPOSE AND DESCRIPTION

The Menomonee River, which is a tributary to the Milwaukee River is in the Milwaukee Estuary Area of Concern (AOC). The Menomonee River originates in Germantown in Washington County, Wisconsin, and flows 28 miles predominately southeast to just north of Blue Mound Road where it enters Milwaukee County and merges with the Milwaukee River. The Menomonee River flows primarily southeast into the City of Milwaukee ending in Milwaukee Bay.

The lower Menomonee River currently has a concrete lined channel in the reach between I-94 (approximately river mile 3.65) and upstream of the W. Wisconsin Avenue Bridge. The channel is trapezoidal in shape and is lined with limestone floodwalls, which were constructed by the Works Progress Administration (WPA) in the 1930s. While the system currently serves its functions of conveying flood flows and reducing flow water surface elevations, the concrete is deteriorating as it approaches the end of its design life and high flow velocities and shallow flow depths impede fish migration between Lake Michigan and the upper portions of the watershed.

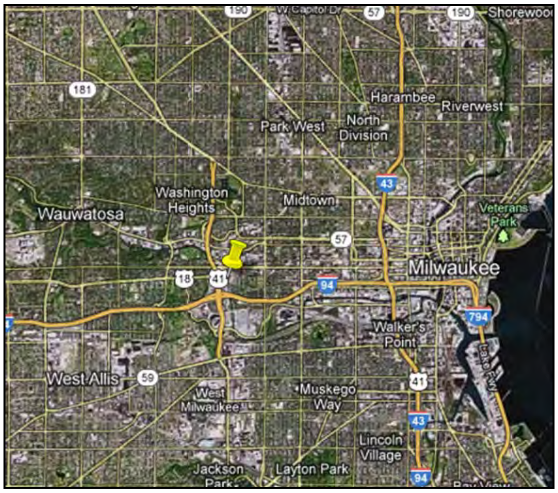


Figure 1: **Project Location indicated by yellow pin**

Project Map

Figure 2: **Project Area (extends from approximately 100' S of Wisconsin Ave to 100' S of Interstate Highway 94)**

DESCRIPTION OF THE WORK:

The specific reach of the Menomonee River being considered in this study is located entirely within the City of Milwaukee and begins on the south side of State Highway 18 (W. Wisconsin Avenue) and extends approximately 2,400 linear feet downstream to a point just south of Interstate 94. The basic components of the project consist of: removing the concrete lining; reconstructing a rock-lined channel with aquatic habitat; and developing a vegetated inset floodplain.

2. LEERD REQUIRED FOR CONSTRUCTION, OPERATION AND MAINTENANCE

The Local Sponsor, Milwaukee Metropolitan Sewerage District (MMSD), will provide all land, easements and rights-of-way necessary for the construction, operation and maintenance of the project. The Project area is shown on Exhibit B and it is noted that the northern access point is just north of State Highway 18.

The total land required for the project is approximately 13.35 acres consisting of 4.5 acres which includes the modified river and 3.85 acres of temporary easement for work & storage at the project location as well as access to public roads.

An additional 5 acres of temporary work area is required for disposal of excavated materials. A facility known as the Road & Construction Materials site at 6401 S. Racine Avenue, New Berlin, Wisconsin has sufficient capacity to handle all excavated material. There are an estimated 30,000 cyds to be taken to the disposal site.

In this project the non-Federal sponsor identified a land reclamation site, known as Road & Construction Materials site at 6401 S. Racine Avenue, New Berlin, Wisconsin. This is the Government's preferred site for disposal of State identified materials suitable for upland disposal for this project. An analysis of other available sponsor owned lands (8 sites) along with the actions needed to make those lands suitable for this type of disposal produced concurrence with use of the land reclamation site as the most cost effective alternative.

A channel improvement easement over the permanent project lands (4.5 acres) is required for this project. The local Sponsor owns the 4.5 acres containing the permanent project lands. Exhibit C depicts the temporary work area easement for disposal quantities.

There is a work and storage area on WDOT property under the State Highway 45 bridge which will require notification by MMSD to WDOT.

The CPR bridge crossing the River near the southern extent of the project is a limiting factor due to its low clearance to the water and results in the need for two work & storage areas designated for the project. The southern work & storage area will accommodate work from the southern extent of the project northwards to the CPR bridge. The northern work & storage area will accommodate activity from the bridge to the northern extent of the project.

No fees for the notification/applications are expected for either CPR or WDOT.

Maintenance access for the project areas will be via public roads.

Following the acquisition activities, the estates covering the project are described as:

Temporary Work Area Easement

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Channel Improvement Easement

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____) for the purposes as authorized by the Act of Congress approved_______________, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate: dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements far public roads and highways, public utilities, railroads and pipelines.

3. LERRDs OWNERSHIP

The land comprising the project area is owned by the Milwaukee County Park Department and the Milwaukee

Metropolitan Sewerage District (MMSD). MMSD has demonstrated the ability to acquire lands and easements on other projects.

MMSD has the full power, authority and capability to operate and maintain the finished Project and also has the legal capability to provide its share of total project costs and comply with the other required assurances. Finally, the MMSD has the capability to complete its portion of the Project within the designated time frames.

MMSD is capable of providing all required LERRD's necessary for the construction, operation and maintenance of the Project. MMSD is a legally constituted public body with the full power, authority, and capability to perform of the terms of the PMP. See Exhibit A, "Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability".

4. LERRDs ACQUIRED FOR, OR WITH THE USE OF FUNDS FROM, ANOTHER FEDERAL PROGRAMS OR PROJECT

No federal funds have been allocated for previous projects at this project site.

5. NON-STANDARD ESTATES

The project does not include the requirement to acquire non-standard estates.

6. EXISTING FEDERAL PROJECTS

No federal funds have been allocated for previous projects at this project site.

7. FEDERAL LAND

There is no federally owned land included within the LERRDs required for the project.

8. NAVIGATION SERVITUDE

Navigational servitude does not apply to the construction of this project.

9. PROJECT MAP

Drawings depicting the project areas are attached (Exhibit B).

10. INDUCED FLOODING

The project causes minimal induced flooding at the 100 year event, but no induced flooding at the 50 year event and below. Thus, the frequency of the induced flooding does not reach the level requiring consideration of acquisition of a real estate interest, such as an occasional flowage easement.

11. BASELINE COST ESTIMATE

The estimated LEERDs for this project (including any contingencies) is..................................$104,000
Based on:
4.5 acres for channel improvement easement areas:...= $ 2,250
8.85 acres for temporary work/storage areas. = $100,000
Total = calculated value, rounded plus contingency:..$104,000

REAL ESTATE COST ESTIMATE

Federal Administrative costs:	$ 12,000
Non-Federal Sponsor costs:	
LERRDs value	$ 104,000
Administrative	$ 8,000
Total Non-Federal Sponsor	$ 122,000
Grand Total (Federal and Non-Federal)	**$ 134,000**

This estimate is only for determining an estimated total project cost for planning purposes. It cannot be used in determining the amount of land, easements, and rights-or-way plus incidental costs for inclusion in the final total project costs. The LERRD's value was based on a study of the City's property site and prior experience. These parklands are subject to inundation and are considered akin to bottomlands which are generally accorded a value of $500/acre. Temporary use is estimated at fee value x 10 percent.

12. RELOCATION ASSISTANCE

The project, as designed, will not require relocation of any residences or business.

13. MINERALS

No extractable minerals are known to exist within the Project lands. There is no standing timber or vegetation on the Project lands.

14. CAPABILITY ASSESSMENT

The sponsor has the full power, authority and capability to operate and maintain the finished project, and has the legal capability to provide its share of total project costs and comply with the other required assurances. In addition, the sponsor has the capability to complete its portion of the project within the designated time frames. This project is one of a few projects that have been and will be performed on this river with this sponsor. We have had no issues previously with the local sponsors capabilities to perform their responsibilities. It is capable of providing all required LERRD's necessary for the construction, operation and maintenance of the project as the sponsor is a legally constituted public body with the full power, authority, and capability to perform of the terms of the PPA. Requirements of PL 91-646, acquisition policies and procedures, LERRD crediting procedures, and the requirements for land acquisition have been discussed with the sponsor as there will be acquisitions occurring for the proposed project. See Exhibit A

15. ZONING

The enactment of zoning ordinances will not be required for this project.

16. SCHEDULE

The Non-Federal Sponsor (NFS) has been given detailed information regarding the requirements for LERRDs necessary for completion of the Project and fully anticipates meeting the current District schedule. The USACE Detroit Real Estate Division will monitor and assist the NFS with all acquisition activities which will assure that the acquisition process complies with Federal and State laws. The schedule for land acquisition will be coordinated with the project PM and the non-federal sponsor, after the project has been authorized, and the PPA signed, the non-federal sponsor will be notified to acquire the LEERDs required for the project. At the conclusion of acquisition, the Non-Federal sponsor will certify in writing to the Government that all LERRDs have been acquired. Potential dates for Real Estate Certification is expected to be reasonable and conformable with project milestones and requirements. Since all of the land is held by the County, it is not expected that there will be any difficulties for the local sponsor to acquire the necessary rights in a timely fashion. The two permits (CPR and WDOT) discussed in Section 2 are expected to be easily granted.

The non-federal sponsor has indicated that they are able to meet the Project's scheduled timeframes.

Tasks and Tentative Dates	
Final Plans and Specs Complete	June, 2014
NFS Real Estate Acquisition	Following signing of PPA – June, 2014
NFS Provides Authorization for Entry to COE	July, 2014
COE Certifies Real Estate Availability	July, 2014
Construction Contract Ready to Advertise	August, 2014

17. FACILITY OR UTILITY RELOCATIONS

The project as designed does not identify any utilities/facilities that will need to be relocated.

18. ENVIRONMENTAL

The Environmental review of the proposed work indicates it would not result in significant adverse short term, cumulative or long term environmental effects. The only potential consideration is outlined as follows:

While it is anticipated that implementing the proposed CAP Section 206 project is not expected to result in the identification and the release of HTRW regulated material during construction, soil collection and analysis will be conducted as the concrete panels are removed. The collected soil will be analyzed for the presence of HTRW regulated waste materials. If the soil analysis reveals that the soils under the concrete panels contain HTRW contaminants at regulated levels, the affected sediment and/or generated debris will be disposed of in accordance with applicable Federal, State, and local laws and USACE polices. The non-Federal project sponsor (MMSD) will pay 100% of the costs associated with the removal and disposal of any HTRW regulated waste materials encountered during construction activities. The HTRW regulated materials will be taken to a Type II landfill. One such Type II landfill site is the Waste Management Facility at 2101 W. Morgan Avenue, Milwaukee, Wisconsin.

The contractor would obtain any permits required for the re-use or sale of materials. Beneficial re-use of materials is encouraged, but not required, to reduce inputs to landfills.

19. PROJECT SUPPORT

The Non-Federal Sponsor is a willing sponsor and fully supportive of this project and there is no opposition on record or anticipated to the project.

20. RISK NOTIFICATION FOR ADVANCE NOTIFICATION

The non-Federal sponsor will be notified in writing about the risks associated with acquiring land before the execution of the PPA. Requirements of PL 91-646, acquisition policies and procedures, LERRDs crediting procedures, and the requirements for land acquisition have been discussed with the sponsor.

21. OTHER RELEVANT REAL ESTATE ISSUES

a. There are no special aquatic sites, impacted by the acquisition though there will be wetlands created as a result of this project.
b. There are no known cemeteries or public facilities within the Project area requiring relocation.
c. Plans and specifications do not identify any relocation of public utilities or roadways.
d. If additional land and/or land rights that are required for construction of this project which the NFS does not have authority to acquire or otherwise provide the USACE will enter into an additional agreement to facilitate the acquisition of the required land and/or land rights. None are expected that the NFS cannot acquire.

Real Estate Division will further assess real estate requirements for the recommended plan, as well as, provide detailed information regarding LERRDs identified as necessary for the Project. In addition, the Real Estate Division will coordinate, monitor, and assist with all acquisition activities undertaken by the Non-Federal Sponsor. This will assure that the acquisition process complies with Federal and State laws specifically the requirements under the Federal Uniform Relocation and Acquisition Act (P.L. 91-646). The Real Estate Division will also attend District team meetings, review and provide input into draft and final reports prepared by the team, and participate in the internal technical review.

EXHIBIT "A"

DETROIT DISTRICT REAL ESTATE ASSESSMENT OF NON-FEDERAL SPONSOR REAL ESTATE ACQUISITION CAPABILITY

PROJECT: Menomonee River, Milwaukee, Wisconsin Section 206 Aquatic Ecosystem Restoration Project, Milwaukee County, Wisconsin.
Tom Chapman, Milwaukee Metropolitan Sewerage District.

I. LEGAL AUTHORITY

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes?

(X) Yes.
( ) No.

Initials GRS Date: 26 November, 2012

b. Does the sponsor have the power of eminent domain for this project?

(X) Yes.
( ) No.

Initials GRS Date: 26 November, 2012

c. Does the sponsor have "quicktake" authority for this project?

(X) Yes.
( ) No.

Initials GRS Date: 26 November, 2012

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary?

( ) Yes.
(X) No.

Initials GRS Date: 26 November, 2012

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn?

( ) Yes.
(X) No.

Initials GRS Date: 26 November, 2012

II. HUMAN RESOURCE REQUIREMENTS

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended?

( ) Yes.
(X) No.

Initials GRS Date: 26 November, 2012

b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training?

( ) Yes.
(X) No.

Initials GRS Date: 26 November, 2012

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? This is a small Village with no experience in matters such as the proposed acquisitions. Their retained legal counsel may or may not have the necessary experience and skill to accomplish the necessary work.

(X) Yes.
( ) No.

Initials GRS Date: 26 November, 2012

d. Is the sponsor's projected in-house staffing level sufficient considering its other workload, if any, and the project schedule?

(X) Yes.
( ) No.

Initials GRS Date: 26 November, 2012

e. Can the sponsor obtain contractor support, if required in a timely fashion?

(X) Yes.
( ) No.

Initials GRS Date: 20 January, 2012

f. Will the sponsor likely request USACE assistance in acquiring real estate?

( ) Yes.
(X) No.

Initials GRS Date: 26 November, 2012

III. OTHER PROJECT VARIABLES

a. Will the sponsor's staff be located within reasonable proximity to the project site?

(X) Yes.
( ) No.

Initials GRS Date: 26 November, 2012

b. Has the sponsor approved the project/real estate schedule/milestones?

(X) Yes.
( ) No.

Initials GRS Date: 26 November, 2012

c. Has the sponsor performed satisfactorily on other USACE projects?

(X) Yes.
( ) No.

Initials GRS Date: 26 November, 2012

d. With regard to this project, the sponsor is anticipated to be: highly capable /moderately capable/marginally capable/insufficiently capable

Initials GRS Date: 26 November, 2012

e. The sponsor has performed successfully on other Corps of Engineers projects and has a full Real Estate Staff performing Real Estate functions.

(X) Yes.
( ) No.

Initials GRS Date: 26 November, 2012

Prepared by:

/s/
____
Glenn Spence
Realty Specialist

Reviewed and approved by:

/s/
____
Victor Kotwicki
Chief, Real Estate Contracting Officer,
Detroit, Buffalo and Chicago Districts

Exhibit B

▩ Temporary Work Area Easement - 3.85 Acres

▨ Channel Improvement Easement - 4.5 Acres

US Army Corps
of Engineers
Detroit District

Symbol	Description	Date	Appr.

Symbol	Description	Date	Appr.

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
DETROIT, MICHIGAN

Surveyed by:		Date: JAN 15 2013	Rev.
Dwn by: E. BURR	Ckd by:	Design file name: MNY01A13.DGN	
Approval Recommended: Area Eng. KEW	Reviewed by: Chief, Eng. Section	Drawing code:	
Approved by: District Engineer:	Submitted by: Chief, SMR Branch	File name: Plot date: 1-15-13 Plot scale: 1"=100'	

MENOMONEE RIVER
MENOMONEE, WISCONSIN

SECTION 206

REALESTATE PLAN

SHEET
REFERENCE
NUMBER

4-15

SHEET X OF XX

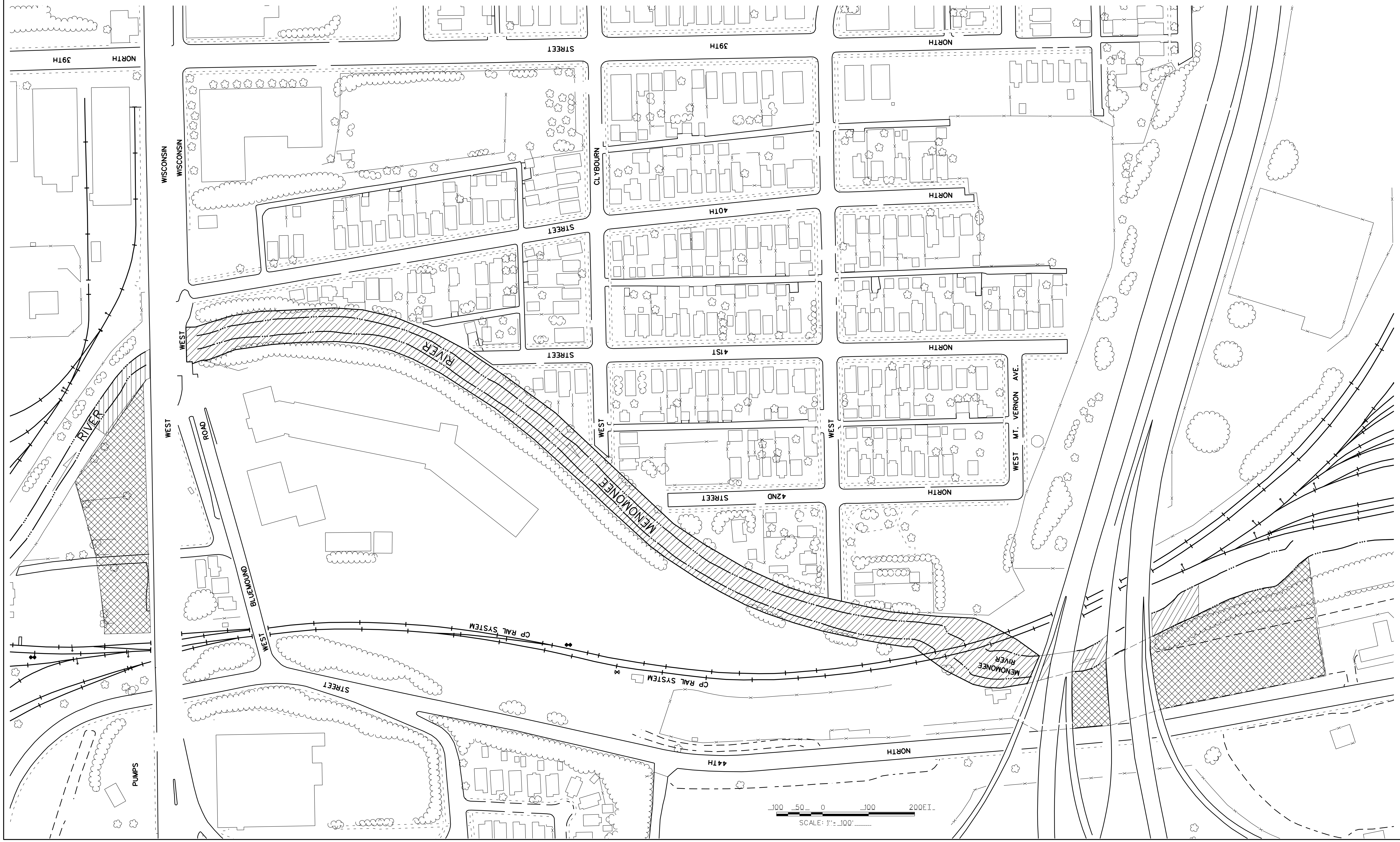


Exhibit C

Road & Construction Materials Site.
6401 S. Racine Avenue
New Berlin, WI 53146

This is an active quarry as well as a land reclamation site. State authorized clean materials are used to fill the non-productive areas of the quarry.

This site will receive the ‘clean’ fill considered suitable for placement at this site.

Menomonee Ecosystem Restoration
Milwaukee, WI

APPENDIX F
MONITORING AND ADAPTIVE MANAGEMENT PLAN

US Army Corps
of Engineers®

INTRODUCTION AND RATIONALE FOR MONITORING

Section 2039 of WRDA 2007 directs the Secretary of the Army to ensure, that when conducting a feasibility study for a project under the U.S. Army Corps of Engineers ecosystem restoration mission, that the recommended project include a monitoring plan to measure the success of the ecosystem restoration and to dictate the direction to which adaptive management, if needed, should proceed. This monitoring plan includes a description of the monitoring activities to be carried out, the criteria for ecosystem restoration success, the estimated cost and duration of the monitoring, and a discussion of adaptive management.

A monitoring plan is an important tool to help establish post-construction success of an ecosystem restoration project. Monitoring provides data to compare pre- and post-project conditions, allowing one to gauge the success of the project, and/or recognize when or if implementation of adaptive management is necessary to achieve the project objectives. This monitoring plan was developed with input from the Wisconsin Department of Natural Resources and MMSD as both have been very active and supportive of restoration of the urban fishery in the Milwaukee estuary. The monitoring plan is designed to verify that river connectivity is restored to the existing upstream Menomonee River habitat. The monitoring plan for the Menomonee River project will be cost shared between the U.S. Army Corps of Engineers, Detroit District (COE) and the Milwaukee Metropolitan Sewerage District (MMSD) for up to 10 years as expressed in the Project Partnership Agreement (PPA) or until the District Commander deems success of the project. A decision point for success of project objective will be made during monitoring year 3 and, if necessary, years 6, 8, and 10. The duration of monitoring may be lengthened if adaptive management becomes necessary to achieve the project objectives. MMSD can continue to monitor beyond the agreed upon period at their own cost.

The purpose of monitoring is to provide actionable information to assess whether the proposed action achieved project objectives. The objectives for this project are:

- Restore connectivity in the Menomonee River
- Provide summer habitat within the constructed riffles/pools.

Achieving these objectives will require removal of the concrete lining and placement of rock for the construction of riffles and pools. This will allow for fish passage (connectivity) and reconnect the upper river habitats with the Milwaukee estuary.

Adaptive management is an iterative process (Figure 1) that integrates results and analysis of long term monitoring with adjustments to project operation to inform environmental protection and operational efficiency decisions. This adaptive management plan (AMP) describes how the restoration of the Menomonee River will be adjusted if long term monitoring finds that connectivity for fish passage upstream has not been achieved. It describes the process for evaluating the results of the monitoring program, membership and responsibilities of the interagency team, "triggers" or action points that would necessitate a restoration corrective action of the project and potential changes that would be implemented to mitigate adverse impacts.

MONITORING OBJECTIVES

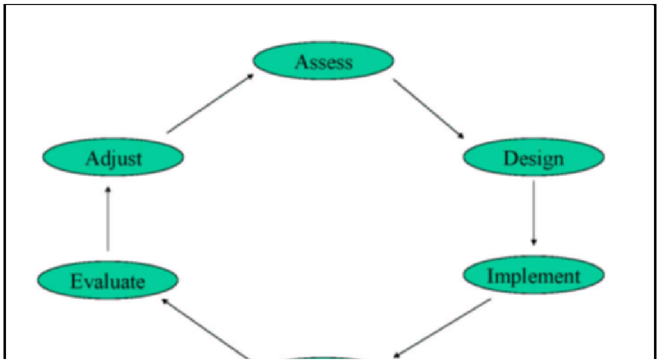


Figure 1. Six steps of adaptive management (from USACE)

Key project specific parameters to be measured were identified based on their relevance to determining whether project objectives were met.

Project Specific Parameters for Monitoring

- Monitoring of channel and habitat structure stability and fish in summer
- Fish sampling upstream on spawning habitat for species identification in the spring for walleye and northern pike

Channel and habitat structures should be inspected regularly. After construction is complete habitat and grade control structures should be inspected for a minimum of three years. The purpose of the inspections will be to identify whether the habitat structures are remaining in place and whether grade control structures and engineered riffles are providing substrate required for spawning. The location of structures should be recorded to sub meter accuracy. Movement or burial of structures should be less than 1 meter. Channel and habitat inspections can occur during monthly maintenance visits or after greater than the 10 year events.

Fish should be collected using a backpack electroshocker or a tote barge with associated electroshockers during low flow conditions in three locations being upstream and downstream of and in the restored stream channel. Fish shocking must always be done in an upstream direction with sampling efforts ensuring that all fish species present are collected in proportion to their occurrence. As a goal, at least 100 individual fish should be examined from each stream reach, which generally requires approximately 30 minutes of electrofishing per station, encompassing 100-300 feet with sufficient sampling to include gravel and pool habitats during the spring spawning season. For the Menominee River, the length of the sampling station should be approximately 300 feet for segments 40 feet wide or about 5-10 channel widths for larger stream segments. If the number of fish collected is no greater than 100 individuals after 45 minutes, discontinue further sampling and calculate metrics based on reduced sample size. All collected fish should be placed immediately in water filled tubs for processing. When sampling has been completed at each station, the following information should be recorded:

1. The location of the sampling stations so that future studies can be repeated at the same station.
2. Record fish by genus and species and common names, lengths, and numbers of each species collected (with a length greater than 4 inches) and determine the total number of fish collected.

   For fish less than 4 inches, if less than 25 fish, identify to species, if more than 25 fish, subsample to identify to genus level.
3. The following externally observable anomalies should be noted as total number of individuals afflicted: bent spine (scoliosis), open lesions, severely eroded fins, fungus patches, growths on skin or fins, tumors, and poor physical condition indicated by severe emaciation, excessive mucus coating, and hemorrhaging.
4. Record the amount of time spent electrofishing at each station including the number of passes through the sampling station and the number of shocking probes used.
5. Record average stream width (wetted stream channel width at time of sampling) and distance of reach electrofished. Catch per unit effort (CPE) will be calculated as the total number of fish collected divided by the number of minutes spent shocking at each station (catch per minute), and as the number of fish per stream area (catch per square meter).

Success can be determined if the fish populations within the downstream sampling locations have similar species and abundances as the sampled upstream reach. Success is also defined as walleye and northern pike being present upstream of the project in the spring spawning season in any of the sampling events. Sampling should be conducted at least twice during the spring spawning season and once in the summer.

If it is decided after year 6 that the riffle/pool portion of the Menomonee River has not developed into suitable habitat, monitoring will continue with the collecting of temperature and dissolved oxygen data in years 7 and 8, and additional fish sampling in year 8. A similar monitoring schedule will be adhered to in years 9 and 10, if the project goals have not been met after year 8.

DISPOSITION AND ANALYSIS OF INFORMATION

The information gathered as part of the monitoring program should be collected in coordination with the WDNR to insure consistency and comparability with previously collected data. Results of the temperature, dissolved oxygen and fish sampling should be recorded and reported annually to the USACE and project stakeholders. The data should be presented in well organized and easy to follow excel spreadsheets that are accompanied by a narrative explaining the results and discussing whether they indicate the project is achieving its objectives. After one year of fisheries monitoring, results should be reviewed and compared to baseline data to determine if evidence exists to determine project success. Upstream fish passage of smallmouth bass, walleye and northern pike for 2 separate seasons is considered the minimum time required to determine success for this type of project. The excel spreadsheet and narrative should be updated annually to assess project success.

COST OF MONITORING

Total cost per year for the first year of monitoring would be approximately $6,000 for year three and year six, and $10,000 for year eight, if required. Refer to "Monitoring Objectives" above for details pertaining to schedule and number of survey events. Anticipated equipment needed for the survey may include: shocking equipment including a backpack electroshocker or tote barge with electroshockers, safety gear, temperature data logger, GPS unit, measuring devices, camera, fish holding pens, work surface and hand held water quality meter. It is expected that a fish survey (including upstream and both downstream sites) could occur within two field days.

It is fully anticipated that the project objectives will be met after year three monitoring. However, the following table details monitoring cost for the potential ten years of monitoring.

Table 1: Monitoring Costs

Year	Parameters to Monitor	Costs
1		
2		
3	Fish	$6,000
4		
5		
6	Fish	$6,000
7		
8	Water Temperature, DO, Fish	$10,000
9		$3,000
10	Water Temperature, DO, Fish	$8,000
Total		$33,000

PARTY RESPONSIBLE FOR MONITORING

The nonfederal sponsor is responsible for performing or having the monitoring performed via a contractor.

ADAPTIVE MANAGEMENT PLAN

Adaptive management is the process of using post action monitoring data to determine whether additional actions are required to meet project objectives. Adaptive management needs to be driven by the information gathered during post action monitoring. It is expected that by the third year sufficient information will be available to determine whether the project was a success.

Adaptive management measures are not expected to be needed as the proposed ecosystem restoration project is well understood and readily predictable. There is a high level of agreement among the resource agencies and other involved parties that the proposed restoration will effectively provide the desired goals within the constraints of the existing ecosystem restoration project. The desired outcome of this restoration is well understood by the parties involved and is easy to predict and measure. The nature of this project and the project design combine to provide a high level of confidence that the project goals will be achieved.

The probability of failure to meet the project goals is very low. The major items of concern for project function are:

1. Habitat and grade control structures move due to the forces of the river and are buried and or displaced, thus preventing upstream fish passage and maintenance of pools.

These are not adaptive management items but are part of construction, operation and maintenance of the project. Item 1 will be addressed in the project Operations and Maintenance manual, which will require annual project inspections, including observations of habitat and grade control structures among other project aspects.

Detailed adaptive management actions need to be devised based on the monitoring data; however, suggestions for mitigating lack of fish diversity are as follows:

- Observe and record the location and condition of engineered structures and inspect the stream bottom for obstructions uncovered during the natural scour and deposition events that occur. If any obstructions are uncovered these should be removed. Structures placed for habitat or grade control should be observed. If they are non-functioning and fish species are not rebounding they should be replaced.

Adaptive management actions need to be tailored to the specific issues encountered and may vary depending on the magnitude of the discrepancy between post construction conditions and desired conditions. Therefore, the specifics of the adaptive management actions should involve a multi-disciplinary group that includes, at a minimum, the WDNR, nonfederal sponsor and USACE.

Menomonee River Habitat Suitability Indices for Selected Species Reproduction

Attachment 1

The primary objective of this project is the upstream passage of fish through river connectivity created through the removal of the 2,400 lineal feet (LF) of concrete in the lower Menomonee River upstream of the confluence with the Milwaukee River (in conjunction with the 1,300 LF MMSD project that is underway and scheduled for completion in 2014). These two projects together provide river connectivity to over 18 river miles of upstream river habitat suitable for use by spawning fish. The specific reproduction requirement that is the controlling component from the US Fish and Wildlife Service Habitat Suitability Indices (HSI's) are depicted for selected species (smallmouth bass, walleye and northern pike). Other fish species would also benefit from the proposed project and would access upstream gravel for spawning. However, no habitat suitability indices were computed for forage species.

Suitable emergent wetland spawning habitat was identified in the Wisconsin DNR northern pike management plan as a critical component in the reestablishment of northern pike within the lower Milwaukee River and estuary. Access to suitable gravel for spawning by smallmouth bass and walleye, as well as other forage species such as suckers and shiners were also identified as necessary to restore the fishery within the Milwaukee estuary and near shore waters of Lake Michigan. These restoration activities are consistent and support the goals of the Milwaukee Estuary Remedial Action Plan (RAP).

The reproduction habitat suitability indices (HSI's) from the US Fish and Wildlife Service were evaluated for selected fish species for reproduction within the gravel for lithophilic and the emergent wetlands for phytophilic spawners. Reproduction was evaluated for three game fish (smallmouth bass, walleye, and northern pike) in the upstream habitats and smallmouth bass and walleye in the reconstructed channel segment. Fish access to suitable habitats for spawning is the primary project objective. As access to suitable spawning habitat was identified as a limiting factor for rebuilding fish stocks within the Milwaukee estuary by the WDNR, only HSI components related to reproduction of selected game fish species were reported in this analysis. The computed HSI values for smallmouth bass, walleye, and northern pike are found in Table 1 at the end of this attachment. The upstream habitat values do not vary but fish access, through connectivity determined the overall habitat units values. The no action alternative does not provide for connectivity and resulted in no HU's either upstream or in the concrete channel.

The water quality in the Menomonee River is rated as acceptable during the spring spawning season. Water quality criteria, such as temperature, pH, suspended solids and total dissolved solids (TDS) meet the HSI's criteria rated for the selected fish species at 0.9-1 and are not individually listed or depicted in the attached USFWS habitat suitability tables except for smallmouth bass which were lower than 0.9-1.0. The smallmouth bass habitat suitability index V_8 (DO) had two stations with readings as low as 3 ppm (0.2) in the summer but fish will move from poorer water quality to better as condition worsen and the upstream and downstream segments had DO > 5 ppm. DO is not a listed component for reproduction and the DO levels during May/June are greater than 6ppm (0.8) and turbidity, V_9 at 0.6 in the HSI's.

The habitat suitability index for northern pike is listed at 0.7 based on water level fluctuations and the requirement for inundation of the emergent vegetation. This rating for pike spawning in the 125 acres of the emergent wetlands could be higher in most years as the emergent wetland spawning habitat is within the ditches and immediately adjacent the waterways which should be suitable for spawning every year. In some years, additional shrub/scrub habitat will be available and usable by northern pike for spawning (estimated at 1 out of 5 years). This conservative reproduction spawning habitat estimate for northern pike realistically addresses access to the emergent wetland sites with suitable water depths for the required 30 days inundation comprised as 7 days for access to spawn and 21-23 days for eggs to hatch based on typical spring water temperature in the Milwaukee area.

The habitat suitability indices for the controlling components for reproduction are listed for the three (3) selected fish species being smallmouth bass, walleye for the upstream gravel and northern pike for the upstream wetlands and for smallmouth bass and walleye in the reconstructed channel with the riffle pool or rock lined alternatives. The primary objective of this project is upstream river connectivity with access to the existing upstream spawning habitat consisting of 30 acres of gravel riffles for spawning by smallmouth bass, walleye and 125 acres of emergent wetlands for use by northern pike. Smallmouth bass and walleye would also use the 3 acres of created riffle/pool complex for spawning and the deep pools would be used by adult smallmouth bass. Under no action, the upstream habitat has no value as no connectivity and the concrete channel has no reproduction value.

SMALLMOUTH BASS* (Reproduction consists of components V_1, V_5, V_8, V_{11}, V_{14} with water quality V_8 (DO) and V_9 turbidity controlling in certain river segments, the other components being rated as 1's.The two tables below depicts the habitat value for 2,400 LF of riffle pool in the concrete removal project area and the 30 acres of gravel with the upstream river connectivity.

Acres Habitat: Rock Riffle and Pool - $([V_{11}]^2 \times V_{14} \times V_1 \times V_5 \times V_8)^{1/6}$ 2,400 LF Concrete Channel						Reproduction Component
Estimated Existing Conditions** (to match HSI formula****)				With Project Proposed Conditions		
Acres	Percent	Substrate		Acres	Percent	Substrate
0	0.0%	boulders/bedrock		3	100.0%	boulders/bedrock
0	0.0%	gravel/rubble 2.5 to 15 cm in diameter***		0	0.0%	gravel/rubble 2.5 to 15 cm in diameter***
0	0.0%	sand***		0	0.0%	sand***
0	0.0%	dense vegetation****		0	0.0%	dense vegetation****
0	0.0%	silt/detritus		0	0.0%	silt/detritus
3	100.0%	concrete		0	0.0%	concrete
3	**100.0%**	**TOTAL**		**3**	**100.0%**	**TOTAL**

Notes:

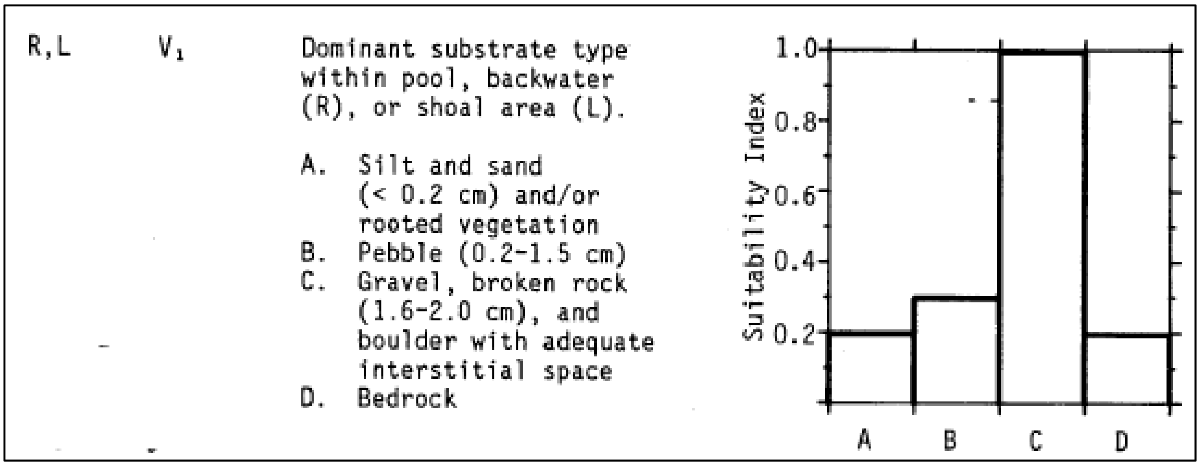
*Smallmouth bass spawn mainly on gravel. Juveniles and adults use rock and the interstitial spaces for feeding.

**The interstitial spaces with the rock/boulders and submergent vegetation are used for cover.

***This proposed “With Project” rock riffle and pool complex is Alternative 1.

Acres Habitat: River Gravel - $([V_{11}]^2 x V_{14} x V_1 x V_5 x V_8)^{1/6}$						Reproduction Component
Estimated Existing Conditions** (to match HSI formula****)				With Project Proposed Conditions		
Acres	Percent	Substrate		Acres	Percent	Substrate
0	0.0%	boulders/bedrock		0	100.0%	boulders/bedrock
30	0.0%	gravel/rubble 2.5 to 15 cm in diameter***		30	0.0%	gravel/rubble 2.5 to 15 cm in diameter***
70	0.0%	sand***		70	0.0%	sand***
0	0.0%	dense vegetation****		0	0.0%	dense vegetation****
0	0.0%	silt/detritus		0	0.0%	silt/detritus
0	100.0%	concrete		0	0.0%	concrete
100	**100.0%**	**TOTAL**		**100**	**100.0%**	**TOTAL**

Notes: The upstream habitat remains the same in both existing conditions and with project conditions. The with-project condition provides connectivity for fish (smallmouth bass) to access the valuable habitat to use for spawning.



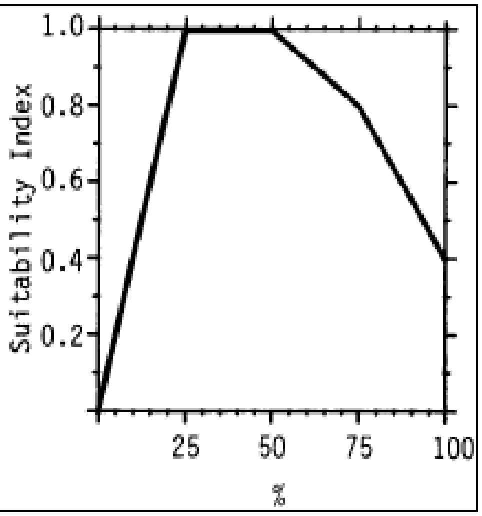
R,L V_1 Dominant substrate type within pool, backwater (R), or shoal area (L).

A. Silt and sand (< 0.2 cm) and/or rooted vegetation
B. Pebble (0.2-1.5 cm)
C. Gravel, broken rock (1.6-2.0 cm), and boulder with adequate interstitial space
D. Bedrock

Smallmouth Bass habitat for spawning

The surface area of the rock in the reconstructed riffle and pool area was computed by the 2,400 lineal foot length, wetted rock perimeter at a 50 foot width (3 acres). The HSI for boulders and rock with interstitial spaces, thus the 0.6 rating, component V_1 "C" is estimated at 0.6 as the rock riffle pool complex does not contain gravel/sand but will contain some gravel as bed load moves downstream into the system. The riffle/pool complex will have some gravel from bed load in the 1.6-2.0 cm size range. The upstream 30 acres of gravel beds are rated as 1.0.

R,L V_5 Percent cover in the form of boulders, stumps, dead trees, and crevices (adults) or vegetation and rocks (fry).



The rock riffle and pool segment has boulders and crevices (20%) suitable for fry and adults. The HSI V_5 component is rated as 0.6. V_{11} and V_{14} are 1.0 Dissolved oxygen (DO), V_8 is a limiting factor at 3 ppm at some times in the late summer (but not during the spawning period of May/June) resulting in a coefficient of 0.2. V_9 maximum monthly turbidity levels provides a suitability index of 0.6. The seventh root of 0.04 is 0.6 which is obtained from the reproduction formula $([V_{11}]^2 \times V_{14} \times V_1 \times V_5 \times V_8 \times V_9)^{1/7}$ = (V_1 0.6, V_5 0.6, V_8 during spawning is 5ppm at 0.6 but has been reported at 3ppm in later summer which is 0.2 and used in this computation, V_9 is 0.6, V_{11} is 1 and V_{14} is 1) =0.6 which is the HSI reproduction component for smallmouth bass with Alternative 1 in the riffle pool complex. The reproduction component for the upstream gravel is rated at 1. These values are entered into Table 1 under Quality in the smallmouth bass row for 30 acres of habitat and 3 acres of habitat. The computed value for Alternative 2 in the channel is 0.5 with (V_1 0.2, V_5 0.6, V_8 is 0.2, V_9 is 0.6, V_{11} is 1 and V_{14} is 1 with the seventh root of 0.0.0144 at 0.54=0.5). The upstream habitat variable values are 1, 1, 0.6, 0.6, 1, 1 and the seventh root of 0.36 is 0.86= 0.9

WALLEYE: Walleye reproduction is listed for both the upstream 30 acres gravel segments accessed by connectivity and the reconstructed 3 acres of gravel riffle/glide/pool as depicted in each of the tables listed below*.

Estimated Existing Conditions** (to match HSI formula****)				Estimated Future Conditions** (to match HSI formula***)		
Acres	Percent	Substrate		Acres	Percent	Substrate
0	0.0%	boulders/bedrock		0	100.0%	boulders/bedrock
30	0.0%	gravel/rubble 2.5 to 15 cm in diameter***		30	30.0%	gravel/rubble 2.5 to 15 cm in diameter***
70	0.0%	sand***		70	70.0%	sand***
0	0.0%	dense vegetation****		0	0.0%	dense vegetation****
0	0.0%	silt/detritus		0	0.0%	silt/detritus
0	0.0%	deep open water		0	0.0%	deep open water
100	**100.0%**	**TOTAL**		**100**	**100.0%**	**TOTAL**

NOTES:*

*Walleye will spawn mainly on gravel in the main branch of the Menomonee River upstream of the project site. Walleye will also spawn in the reconstructed 2,400 LF of riffle pool and in some of the tributaries; however, tributaries are not included in this calculation since the contribution amount of habitat is not significant as compared to the main river branch.

** The estimated Existing and Future habitat conditions of the Menomonee River do not change for this project. This project objective provides connectivity for fish to access the upstream spawning habitat. For computational purposes, the upstream river contains 30 acres of gravel.

*** A gravel substrate is typical in this stretch of the Menomonee River (estimated conservatively at 30% (based on river gradient) which equals 30 acres though WDNR in stream evaluations list the gravel riffle/glide acreage at 48 acres). With an estimated percentage of gravel at 30%, the remainder of the river was classified as sandy substrate being 70 acres within the 100 acres of river. The 70% sand value was the input for the HSI model formula.

**** Dense vegetation would be quite low during the spring spawning season, but would increase by the end of the summer.

Walleye reproduction is the lowest value of V_7, V_{10}, V_{11}, V_{12} or V_{13} being DO, mean water temperature, degree days, spawning habitat index and water level during spawning. All components are rated at 1 for both the upstream river and the reconstructed rock riffle pool or armored channel segment. Therefore, the specific Figures from the Habitat Suitability Index are not displayed except for V_{12}.

Approximate reconstruction area of 3 acres riffle/pool*

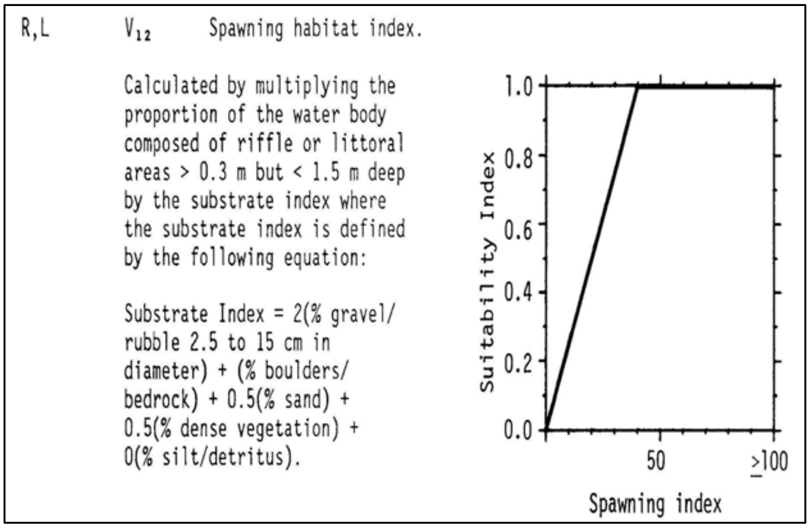
Estimated Existing Conditions** (to match HSI formula****) 2,400 LF Riffle/pool				Estimated Future Conditions** (to match HSI formula***)		
Acres	Percent	Substrate		Acres	Percent	Substrate
0	0.0%	boulders/bedrock		3	100.0%	boulders/bedrock
0	0.0%	gravel/rubble 2.5 to 15 cm in diameter***		0	0.0%	gravel/rubble 2.5 to 15 cm in diameter***
0	0.0%	sand***		0	0.0%	sand***
0	0.0%	dense vegetation****		0	0.0%	dense vegetation****
0	0.0%	silt/detritus		0	0.0%	silt/detritus
3	100.0%	concrete		0	0.0%	concrete
3	**100.0%**	**TOTAL**		**3**	**100.0%**	**TOTAL**

NOTES:

* This section calculates the suitability index for walleye spawning habitat in the project site where the project alternatives would create riffles and pools (preferred walleye spawning habitat).

** Estimated Existing Conditions and conditions with project. Estimated Conditions for riffle/pool complex is 100 % rock and boulder resulting in a habitat suitability of 1.

Spawning Habitat Index: Is calculated by multiplying the proportion of the water body composed of riffle or littoral areas by the substrate index as defined below:



R,L V_{12} Spawning habitat index.

Calculated by multiplying the proportion of the water body composed of riffle or littoral areas > 0.3 m but < 1.5 m deep by the substrate index where the substrate index is defined by the following equation:

Substrate Index = 2(% gravel/rubble 2.5 to 15 cm in diameter) + (% boulders/bedrock) + 0.5(% sand) + 0.5(% dense vegetation) + 0(% silt/detritus).

Image from FWS Habitat Suitability for Walleye (FWS/OBS-82/10.56, April 1984)

V_{12} Substrate Index = 2 (% gravel/rubble 2.5 to 15 cm in diameter) + (% boulders/bedrock) + 0.5 (% sand) + 0.5 (% dense vegetation) + 0 (% silt/detritus) Substrate = 2(30%) + 0.5 (70%)= 0.95 Spawning Habitat Index in the upstream river segment = proportion of water body composed by riffle or littoral areas by the substrate index. Spawning Habitat Index correlates to a Suitability Index of 1 in the reconstructed 3 acres of rock riffle pool and the upstream 30 acres of river gravel.

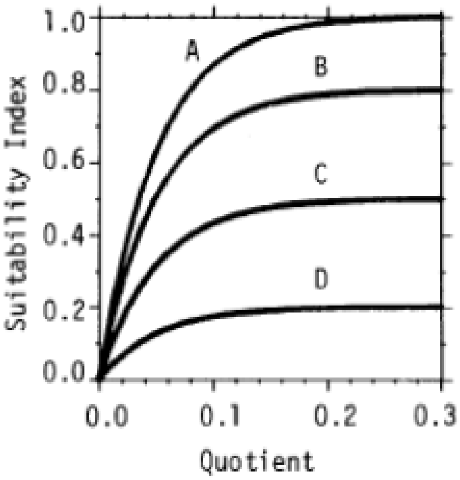
NORTHERN PIKE (Reproduction components consist of component V_1 and V_2)

The overall rating is the lowest of the (7) components, V_1-V_7)

Estimated Existing Conditions** (to match HSI formula****)				Estimated Future Conditions** (to match HSI formula***)		
Acres	Percent	Substrate		Acres	Percent	Substrate
0	0.0%	boulders/bedrock		0	0.0%	boulders/bedrock
0	0.0%	gravel/rubble 2.5 to 15 cm in diameter***		0	0.0%	gravel/rubble 2.5 to 15 cm in diameter***
0	0.0%	sand***		0	0.0%	sand***
125	100.0%	dense vegetation****		125	100.0%	vegetation**** 125 acres emergent
0	0.0%	silt/detritus		0	0.0%	silt/detritus
0	100.0%	deep open water		0	0.0%	deep open water
100	**100.0%**	**TOTAL**		**100**	**100.0%**	**TOTAL**

* Connectivity provides access to the upstream habitats. Habitat remains the same.

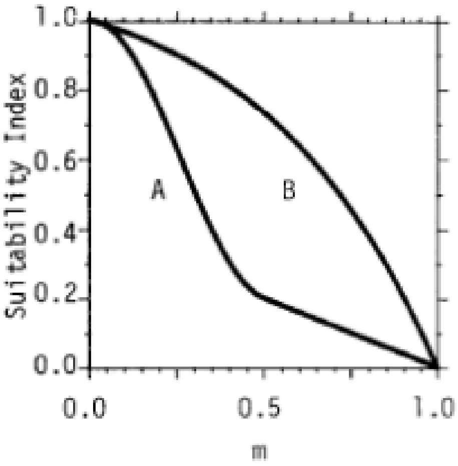
L,R	V_1	Ratio of spawning habitat to summer habitat [area that is less than 1 m deep and vegetated (spring), divided by total midsummer area].



Northern Pike Habitat

The upstream river habitat remains the same under with and without project conditions but the “with project” condition (Alternative 1) provides connectivity for northern pike to access the critical habitat for spawning. The critical spawning component is suitable grass or vegetation remnants located within shallow water that has stable or rising water levels. Within the Menomonee River tributaries, the WDNR has identified emergent wetland areas that would serve as suitable spawning habitat for northern pike. The V_1 ratio 125 acres/100 acres results in a quotient of 0.55. Line B from the HSI V_1 graph is described as "Plant growth less lush than in A but covers much of the substrate and occupies much of the water column directly above the sediments. More than 60% of the bottom is obscured in vertical projection from depth of 15 cm above the bottom. Plant material not compacted when under water." Line B describes the V_1 reproduction component. For the graph of V_1 under a 60% emergent vegetation coverage represented by line B and quotient 0.5, the HSI is 0.8.

L,R	V_2	Drop in water level during embryo and fry stages. A. Embryo and early fry stages (until yolk sac absorbed). B. Fry stage, after yolk sac absorbed. SI for V_2 = A or B, whichever is the lowest.



Water level in the Menomonee River tributaries rise with spring runoff. Using the V_2 graph and water level variation of less than 0.25m, results in an HSI for line A of 0.7. 0.7 is the lower number of either line A or B. The HSI's for the northern pike reproduction is 0.7, the lowest of the nine suitability indices of V_1-V_9.

Table 1 Reproduction Variables Habitat Suitability Indices (USFWS)

Fish Species	Project Location	Reproduction Variables						Habitat Suitability Reproduction Index
		V1	V5	V8	V9	V11	V14	
Smallmouth bass	Alt 1- 3 acres r/p	0.6	0.6	0.2	0.6	1	1	0.6
	Alt 2- channel	0.2	0.6	0.2	0.6	1	1	0.5
	30 acres u/s gravel	1	1	0.6	0.6	1	1	0.9
	Alt 3 -No Action	30 acres u/s -No Connectivity No value 3 acres concrete- no habitat value						0 0
		Reproduction Variables						
Walleye		V7	V10	V11	V12	V13		
	Alt 1- 3 acres r/p	1	1	1	1	1		1
	Alt 2- channel	1	1	1	1	1		1
	30 acres u/s gravel	1	1	1	1	1		1
	Alt 3 No Action	30 acres u/s -No Connectivity No value 3 acres concrete- no habitat value						0 0
		Reproduction Variables						
Northern Pike	125 acres u/s wetlands	V1	V2					
	Alt 1 and 2	0.8	0.7					0.7
	Alt 3-No Action	No Connectivity-no upstream value						**0**

Summary Discussion on Fish Passage Upstream (Connectivity) Based on Channel Action Alternatives 1 and 2

In summary, river connectivity for upstream movement of game and forage fishes to existing spawning habitat is the prime benefit from the project. Alternative 1 provides the most habitat units because of the higher percentage of fish passed upstream (connectivity) and the reconstructed riffle/pool habitat has more value for spawning and adult fish usage. Either alternative results in a vast improvement over the no action alternative but Alternative 1 provides the most habitat units with increased connectivity.

The targeted fish species are smallmouth bass, walleye and northern pike, one of the poorest swimming warm water game fishes,. While forage species such as common shiner and suckers would also benefit from the connectivity to upstream habitat, no HSI's were prepared for the forage fishes. Based on the Upper Mississippi River model and Step 4 Connectivity from the UMR model, walleye and smallmouth bass can swim upstream during the spawning season under Alternative 1 (riffle pool) as the sustained swim speed of both of these fish exceeds the average velocity in the riffle and pool. Under Alternative 2, only the walleye can swim upstream as the average velocity is greater than the sustained swim speed of the smallmouth bass. In the UMR model, the northern pike has a sustained swim speed listed at 1.5 fps. The average stream velocity in the reconstructed riffle pool during springtime is over 1.89 fps. Figure 1 was adapted by others from a report and literature review by Ontario Ministry of Natural Resources (1988) and summarizes passage by free-swimming individuals over standard distance and velocities. The effect of temperature and length of the fish are not provided. The steeper sloping portion of the curve more closely approximates “burst” swimming abilities while the lag or flat side of the curve approximates the “prolonged” swimming abilities. From the Ontario summary, the sustained or “prolonged” swim speed of northern pike (Figure 1) is approximately 2 fps at a distance of 150 feet.

The riffle pool (Alternative 1) was designed to allow for northern pike passage based on burst speed. Removal of the concrete lined channel and placement of stone to create riffles and pools will, using the computed spring flows, decrease flow velocities, within the project reach. The Alternative 1 design consists of 6 pools and 6 riffles. The riffles range from 40' to 65' with velocities from 1.69 fps to 2.98 fps. Within this design, four riffle/run segments of the project reach have velocities greater than 2 fps, the velocity of concern for passage of northern pike. However for these riffle segments, the velocity at the edge of the channel is less than 2 fps and has over 1’ depth of flow, therefore the design will still provide for northern pike upstream passage. The pools range from 45' to 100' with velocities from 1.11 fps to 1.55 fps in spring. The average design velocity for Alternative 1 is 1.89 fps, with slower velocities on the riverbanks and river bed. The velocity near the bottom and the sides of the channel will be slower but for conservative computational purposes, 60% northern pike passage is being used in this analysis. Connectivity at 0.6 is based on 10% loss of passage at each of the riffles with velocity > than 2 fps using the Ontario summary, other data and professional judgment.

Alternative 2, rock lined channel, because it does not include any riffles or pools, required special consideration of flow velocity relative to fish passage: For Alternative 2, three segments exceed 2 fps; one at 430' with an average velocity of 2.87 fps, one at 807' with an average velocity of 2.54 fps, and one at 310' with an average velocity of 2.43 fps. All of these segments would restrict northern pike passage and greatly exceed the recommended length of passage at an average velocity of 2.65 fps for 150 feet as depicted in Figure 1. Also, the overall average channel velocity of 2.33 fps exceeds the sustained swim speed for northern pike and smallmouth bass as listed in the UMR model. The channel flow velocities within the project reach range from 1.21-3.22 fps for Alternative 2. Since the sustained swim speeds of both the northern pike and smallmouth bass are exceeded in the armored channel design, professional judgment was used to rate connectivity for smallmouth bass at 0.4 and northern pike at 0.2 based on length of passage and velocity. The WDNR estimates the reduction of northern pike successfully passing under alternative 2 as very low, much lower than listed in this paragraph because of the nature of the armored channel and no resting pools. The 2,400 foot passage at the design velocity exceeds any published literature for successful passage. Of significant note is that the summer depths would limit adult fish usage because of lack of depth.   During the summer low flow period, water depths in the rock lined channel would range from 1-4 feet and velocity of 1-1.5.

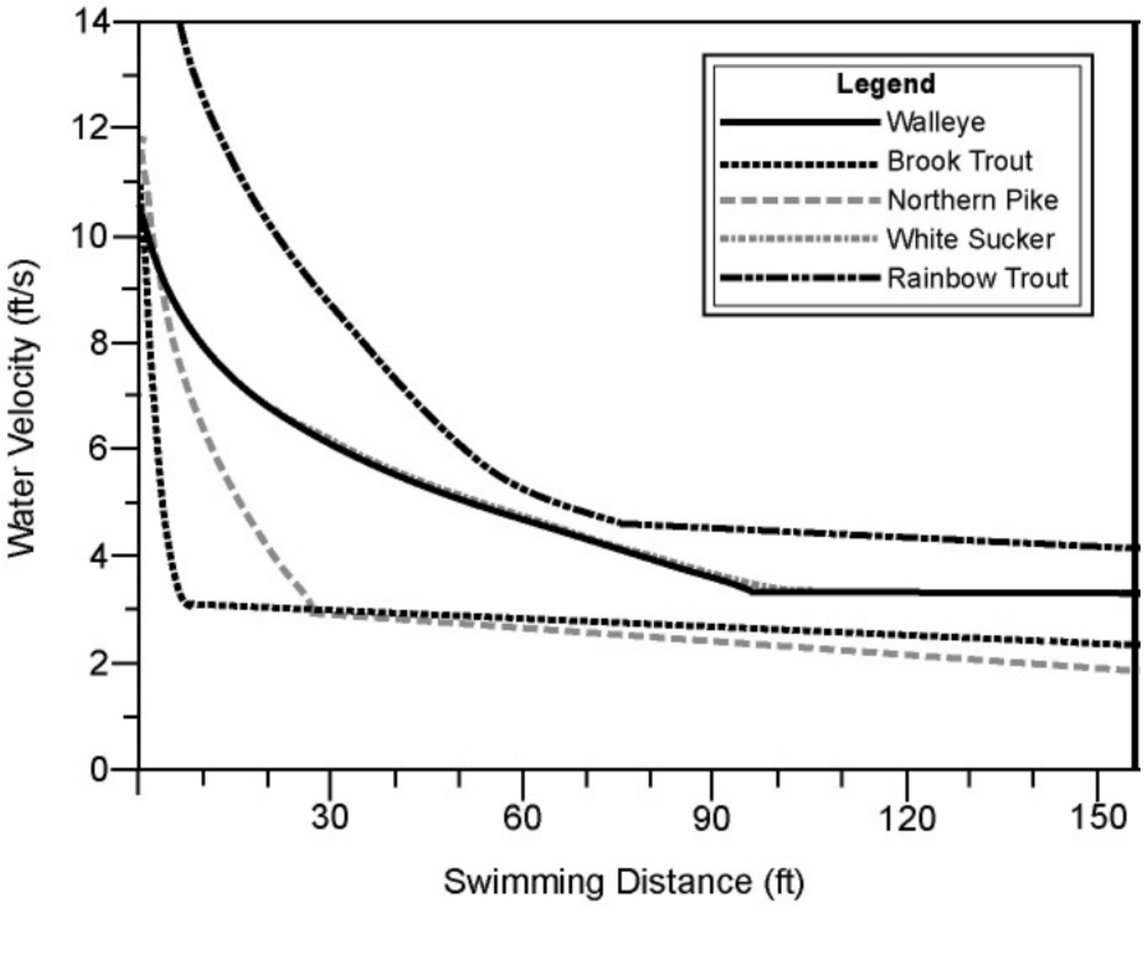


Figure 1 Swim Speed and Distances

DEPARTMENT OF THE ARMY
DETROIT DISTRICT, CORPS OF ENGINEERS
477 Michigan Avenue
DETROIT, MICHIGAN 48226-2550

JUN 5 2014

IN REPLY REFER TO:

Planning Office
Environmental Analysis Branch

TO ALL INTERESTED AGENCIES, PUBLIC GROUPS, AND CITIZENS

A Detailed Project Report (DPR) and an Environmental Assessment (EA), *Menomonee River, Environmental Restoration, City of Milwaukee, Milwaukee County, Wisconsin,* has been prepared to addresses aquatic ecosystem restoration of approximately 2,400 lineal feet of the Menomonee River in the City of Milwaukee, Milwaukee County, Wisconsin. This study is conducted under the authority of Section 206 of the Water Resources Development Act of 1996, (Public Law 104-303) as amended.

Project alternatives considered under this study include: 1) Removal of the concrete channel lining and placing stone riffle and pool complexes; 2) Removal of the concrete channel lining and replacing the lining with stone without the creation of any riffle or pool complexes; and 3) No Action. The recommended project alternative is Alternative 1, which would meet the project's purpose and need of providing fish habitat within the restored river channel and connectivity from the Milwaukee estuary to upstream spawning habitat.

The EA includes a Section 404(b)(1) evaluation, pursuant to the Clean Water Act, for fill placement into the waters of the United States as part of the project. Any person who has an interest that may be affected by the proposed in-water placement of fill material may request a public hearing. The request must be submitted in writing within the comment period of this notice and must set forth the interest and manner the interest may be directly affected by the proposed activity.

A paper copy of the DPR and EA are available for public review at the following locations:

Milwaukee Metropolitan Sewerage District
260 W. Seeboth Street
Milwaukee, WI 53208
Business hours: 7:30 a.m. to 4:30 p.m.
Phone: (414) 272-5100

Washington Park Library
2121 North Sherman Blvd.
Milwaukee, WI 53208
Business hours: Monday - 10 a.m. to 8 p.m.; Tuesday and Wednesday - 12 to 8 p.m.; Thursday and Friday - 10 a.m. to 6 p.m.; and Saturday - 10 a.m. to 5 p.m.
Phone: (414) 286-3000

In addition, the EA can be reviewed online at:
https://lre.usace.afpims.mil/Missions/EnvironmentalServices.aspx

The DPR can be reviewed online at:
https://lre.usace.afpims.mil/Missions/CivilWorks/ProjectManagement/PlanningandStudies.aspx

Any comments you may have concerning the proposed project should be made within thirty (30) days from the date of this letter. If no comments are received by the end of the thirty (30) day review period, it will be assumed that you have no comment. Please direct your comments to:

U.S. Army Engineer District, Detroit
ATTN: CELRE-PL-E (Charles A. Uhlarik)
477 Michigan Avenue
Detroit, Michigan 48226-2550

Following the comment period and a review of the comments received, the Detroit District Engineer will make a final decision regarding the necessity of preparing an Environmental Impact Statement (EIS) for the proposed project. Based on the conclusions of the EA, it appears that preparation of an EIS will not be required.

Jim E. Galloway

Jim E. Galloway
Chief, Planning Office

ENVIRONMENTAL ASSESSMENT

MENOMONEE RIVER ENVIRONMENTAL RESTORATION

CITY OF MILWAUKEE, MILWAUKEE COUNTY, WISCONSIN

SECTION 206 OF THE WATER RESOURCES DEVELOPMENT ACT

US Army Corps
of Engineers®
Detroit District

1.0 Introduction

U.S. Army Corps of Engineers, Detroit District proposes aquatic ecosystem restoration of approximately 2,400 lineal feet (LF) of the Menomonee River in the City of Milwaukee, Milwaukee County, Wisconsin (**Figure 1**). The existing concrete channel in this reach provides extremely limited habitat value and is a blockage to upstream migration of fishes because of discharge velocity, particularly during spring runoff. Removal of the concrete lined channel and replacement with riffles and pools will result in reduced flow velocity during the spring fish spawning periods for upstream fish passage to suitable spawning and rearing habitat. The riffles and pools in the created channel will provide summer habitat for fish and invertebrates.

The City of Milwaukee is located on the western shore of Lake Michigan about 100 miles north of Chicago, Illinois. The Menomonee River is a tributary of the Milwaukee River within the city limits of Milwaukee. The Menomonee River watershed drains approximately 135 square miles and flows approximately 28 miles from its headwaters in Germantown and Mequon to the Milwaukee River and on to Lake Michigan. In 1965 the bottom of the Menomonee River channel in the lower reaches of the river was deepened and lined with concrete to improve flood carrying capacity. The proposed aquatic ecosystem restoration project would remove the concrete lining to restore natural riffle and pool characteristics to the river.

This project and the upstream 1,300 lineal feet of concrete removal project undertaken by the Milwaukee Metropolitan Sewerage District (MMSD) will result in opening the river for upstream fish passage to the next blockage, Lepper Dam, located upstream approximately 18 river miles.

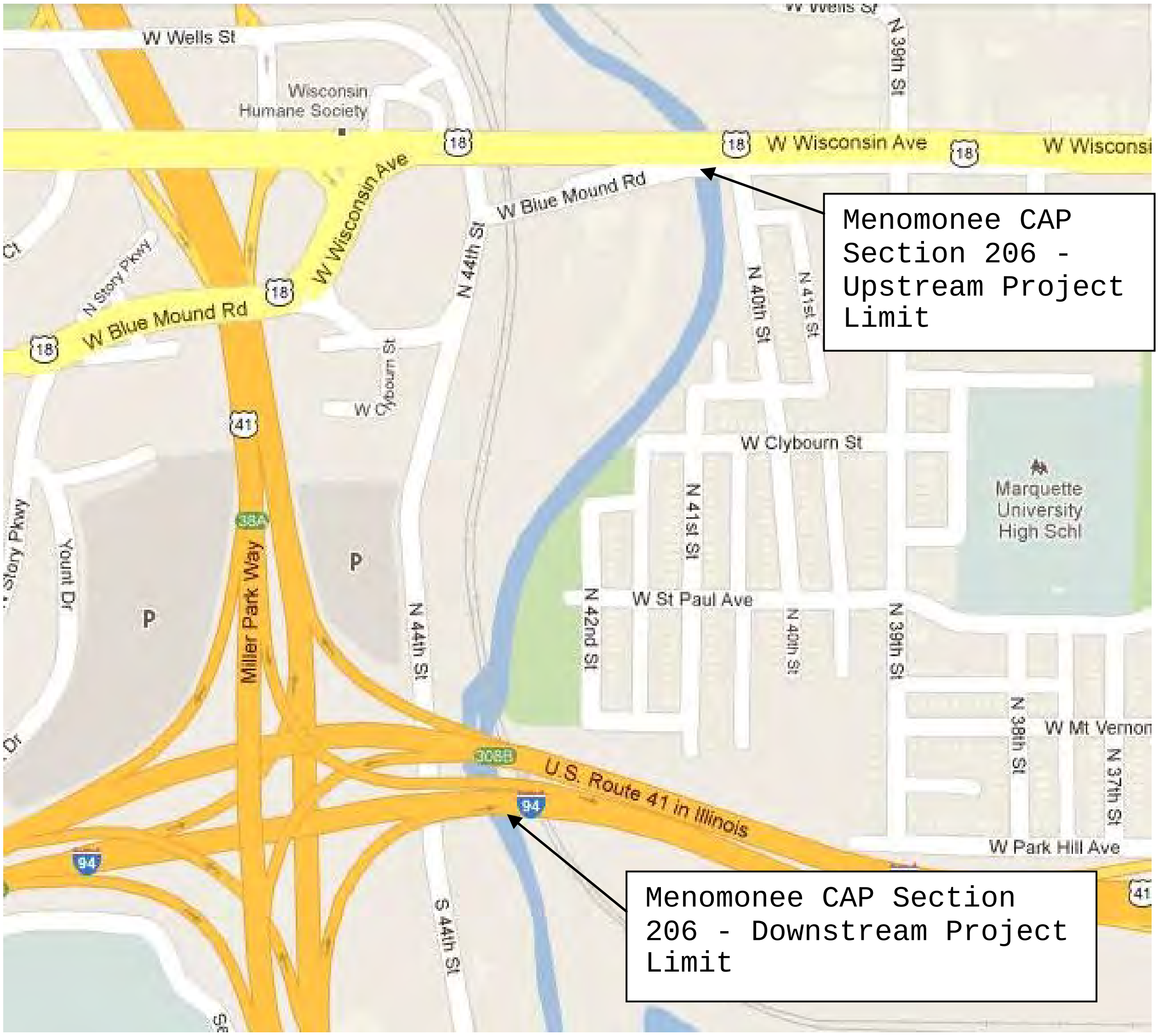
1.1 Study Authority

The proposed project is authorized by Section 206 of the Water Resources Development Act (WRDA) of 1996 (PL104-303), Aquatic Ecosystem Restoration. This act authorizes the Federal government to initiate investigations and studies leading to the implementation of projects for ecosystem restoration and protection.

1.2 Purpose and Need

The primary objective and purpose of the proposed action is to provide river connectivity and fish access to acres of upstream habitat in the Menomonee River that has been blocked by the concrete lined channel, and to restore aquatic habitat in this river reach. Industrialization led to channelizing and lining this section of the river with concrete in the 1960's leading to the loss of important habitat and species that once thrived in the Milwaukee estuary. The project is needed to restore riverine habitat and access to historically significant and valuable upstream spawning and nursery area, thus providing suitable habitat for many species that were once prevalent but now are locally scarce. Restoration of the local fish community within the metropolitan area is the highly desired outcome to re-establishing the urban fishery. Under the US-Canada Great Lakes Water Quality Agreement, the Milwaukee River (and several other harbors/waterfronts) is a listed Area of Concern (AoC). Simply put, an AoC is a location that has experienced environmental degradation. This project assists in the removal of the following Milwaukee River AoC identified Beneficial Use Impairments (BUI):
1) Degradation of fish and wildlife populations, 2) Degradation of benthos, and 3) Loss of fish and wildlife habitat.

Since 1999, MMSD has removed drop structures, a low head dam, and concrete paved segments that restricted upstream fish passage. Immediately upstream of the proposed Menomonee CAP Section 206 project is a concrete segment containing a drop structure. MMSD has scheduled the removal of this concrete segment and drop structure in 2014. The Menomonee CAP Section 206 project (Figure 1) is 2,400 LF and would remove the last obstacle to upstream fish passage. Implementing the project would provide access to extensive fish spawning and rearing habitat which is estimated at more than 30 acres of gravel on the main stem for lithophilic (gravel) spawners and over 125 acres of emergent riparian wetland. Much of the emergent wetland would be suitable for phytophilic (plant) spawning fish such as northern pike. The 100 acres of riverine habitat would also serve as rearing habitat for juvenile fishes. This project is deemed critical by the Wisconsin Department of Natural Resources in restoring the fishery in the Milwaukee estuary and nearshore waters of Lake Michigan. Restoration of the fishery would serve an urban population.



Menomonee CAP Section 206 - Upstream Project Limit

Menomonee CAP Section 206 - Downstream Project Limit

Figure 1. Menomonee CAP Section 206 - Project Work Area 2,400 Lineal Feet (LF)

2.0 Alternatives and the Proposed Action

Alternatives considered under this study include: 1) removal of the concrete channel lining and placing stone designed to create riffle and pool complexes, 2) removal of the concrete channel lining and replacing the lining with stone, without the creation of any riffle or pool complexes, and 3) No Action. The action alternatives (Alternatives 1 and 2) would provide varying levels of restored aquatic habitat in this river reach and upstream fishery access to acres of suitable spawning habitat presently blocked by the concrete lined channel. Alternative 1 would provide the most local habitat improvement and best upstream access for fish.

2.1 Alternative 1: Replacement of 2,400 feet of Concrete with Stone Riffles and Pools

Alternative 1 involves the removal of the concrete lined channel that prevents upstream movement of warm water fish during spring runoff because of flow velocity that is too high for fish passage. MMSD has removed the upstream and downstream drop structures and downstream low head dam that previously prevented upstream fish migration. Removal of this concrete lined segment and replacement with stone to restore riffle and pool habitat along approximately 2,400 LF of the Menomonee River within the City of Milwaukee, Milwaukee County, Wisconsin will restore connectivity to 18 river miles in the main stem upstream that provides excellent gravel spawning and juvenile rearing habitat for the targeted fish species. The northern pike spawning wetlands are primarily on the tributaries, particularly the Little Menomonee River. Construction in the riffle and pool configuration will reduce flow velocity sufficiently and provide resting pools to provide access to upstream spawning and nursery habitat for fish that live in the Milwaukee estuary and nearshore waters of Lake Michigan, particularly smallmouth bass, walleye, northern pike and many other forage species of the sucker and minnow families (**Figures 2a, 2b**). The rock armor stone has been sized for the design flood event, the 1% storm. The armored river channel required to pass the flows within the confines of the historic walls prevented the use of aquatic vegetation and a wider, vegetated floodplain. The armor stone will be set on gravel or crushed concrete bed and filter fabric unless concrete bedding is required at a specific location based on final design plans and specifications.

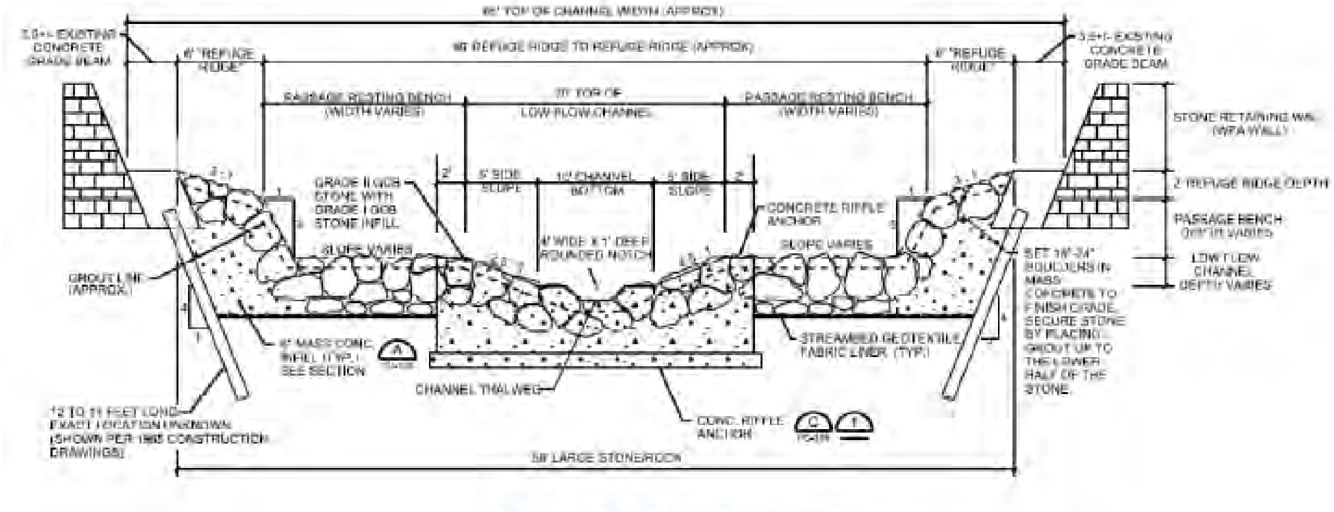


Figure 2a. Typical Riffle Cross Section

The riffle and pool sequence has been designed to reduce flow velocity during the spring run off events when the targeted fish are moving upstream to spawn. The velocity over the riffles is low enough to pass the targeted fish species, particularly northern pike (based on the Upper Mississippi River (UMR) certified model as further discussed in the Monitoring Plan attachment). The pools provide the necessary resting spots for the fish between riffle crossings. The Habitats Units analysis has additional details on design velocity necessary for fish passage.

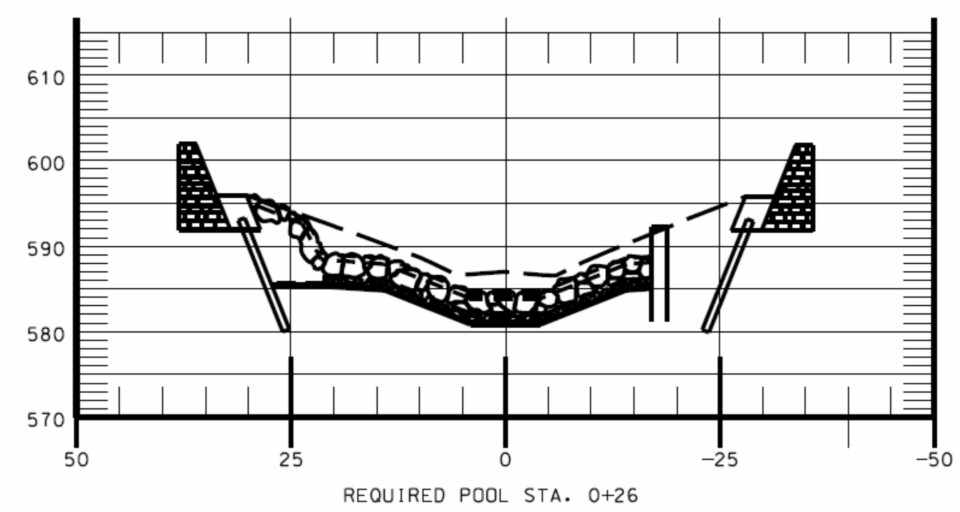


Figure 2b. Typical Pool Cross Section

2.3 Alternative 2: Replacement of 2,400 feet of Concrete with Stone Channel

Alternative 2 involves the removal of the concrete channel lining, excavation of excess sediment and replacing the concrete lining with a rock lined channel with the boulders set on a gravel or crushed concrete bed on fabric without riffles and pools (**Figure 3**). If required in specific segments with grade change, the boulders could be set in concrete. Due to the heavy urbanization and the multiple bridge crossings along the length of the Menomonee River, and the potential flood impacts, the rock must remain in place to prevent unintended impacts to structures and flood discharge. The upstream and downstream drop structures and downstream low head dam have been removed. However, flow velocity through the channel is higher than with Alternative 1 and exceeds the velocity that the targeted fish can pass during spring runoff as depicted in the Upper Mississippi certified model used for fish passage design criteria. This alternative provides less overall habitat units (HU) as fewer fish pass upstream to spawn and the value of the created rock lined channel is less, particularly in the summer months with the lower water depths. Northern pike, one of the targeted fish species cannot pass upstream through the rock lined channel and the value of the habitat is limited in the summer because of depth. A further discussion is found in the Detailed Project Report (DPR), Appendix F - Monitoring Plan and Habitats Units Analysis. The rock armor stone for the channel has been sized for the design flood event, the 1% storm.

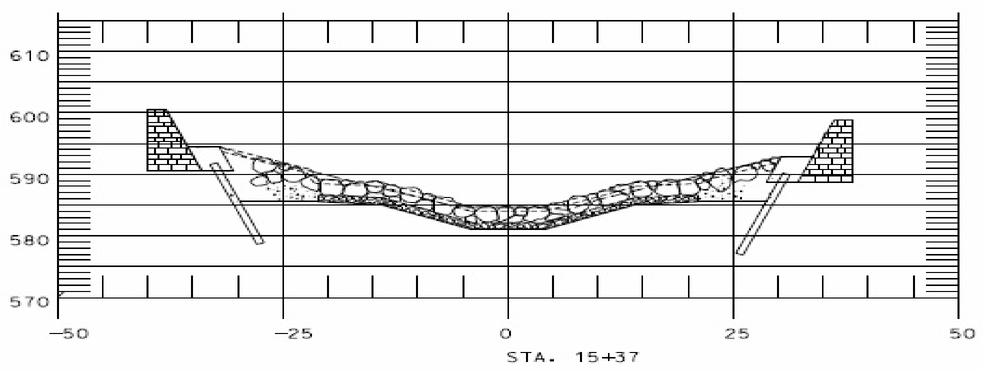


Figure 3. Armored Channel

2.4 Alternative 3: No Action

In the no action alternative, the very low value aquatic habitat ecosystem provided by the concrete channel would remain the same, and the habitat would not be improved and over time, concrete maintenance would be required. The upstream and downstream drop structures and downstream low head dam have been removed. However, flow velocity in the spring through the long, concrete lined channel is higher than the targeted fish species can pass based on the Upper Mississippi River (UMR) certified model. Though flow velocity is reduced during the summer low flow events, the targeted fish species are not moving upstream to spawn during this time period and the shallow, open waters would also minimize any fish passage. The concrete lined channel provides virtually no aquatic habitat. The no action alternative does not meet project objectives of habitat restoration, which includes the primary objective of upstream fish passage to 30 acres of spawning gravel within the upstream 18 main stem river miles (100 surface acres total river area) that will assist in the restoration of fish populations in the Milwaukee AoC. Connectivity also provides access to 125 acres of emergent wetlands suitable for spawning use by northern pike, a targeted warm water fish species. MMSD is scheduled to complete the removal of the upstream concrete segment in 2014 and this proposed Section 206 project is on MMSD's proposed projects list. However, there are no assurances that this segment would be funded in the future by MMSD alone if the proposed habitat restoration project were not implemented.

2.5 Description of the Proposed Action

The proposed action is Alternative 1, replacement of 2,400 LF of concrete with riffles and pools constructed of rock. To implement the proposed project, approximately 15,000 square yards (SYD) of 8 inch thick concrete channel lining will be broken and removed, approximately 32,000 cubic yards (CYD) of sediments located under the concrete and up to 3 feet below the existing river bottom from beneath the concrete lined channel will be dredged, 2,800 CYD of filter gravel for bedding will be placed and 16,000 CYD of rock/stone will be placed to create a stone lined riffle and pool aquatic habitat. In the upstream 1,300 foot section, the boulders will be set in concrete. The boulders in this section will be in bedding gravel or crushed concrete unless a specific section above the OHWM requires that the boulders be set in a concrete base (such as at an outfall through the WPA wall) as determined during planning, engineering and design (PED).

Disposal of materials and/or debris generated in the course of project construction will take place in accordance with applicable Federal, State of Wisconsin, and local laws and regulations. No sediments identified as hazardous material have been identified to date within the proposed project area. The concrete will be broken and transported to a licensed concrete recycling facility. The sediments that are suitable for upland disposal will either be taken to the MMSD provided disposal site identified as the Road and Construction Materials Facility located approximately 15 miles from the project site at 6401 S. Racine Avenue, New Berlin, Wisconsin. This site is a disposal for fee site and is compliant with all Federal, State and local permit requirements to accept this material. If the construction contractor can find an economically favorable alternative site(s) that is/are suitable for disposal of this material, then the contractor will be required to prove to the government that they have properly obtained all Local, State and Federal permits required for disposal at these alternative sites. Any materials determined to be unsuitable for disposal at the New Berlin site, will be taken to a Type II landfill with all disposal costs attributed to MMSD. Beneficial re-use of materials is encouraged to reduce inputs to landfills. The contractor would obtain any permits required for the re-use or sale of materials. See paragraph 3.1.3 Hazardous Material for additional information.

Removal of the concrete lined channel and placement of stone to create riffles and pools will, using the computed spring flows, decrease flow velocities from existing conditions. The design consists of 6 pools and 6 riffles. The riffles range from 40' to 65'-long with velocities ranging from 1.69 fps to 2.98 fps, while the pools range from 45' to 100'-long with springtime average flow velocities ranging from 1.11 fps to 1.55 fps. These design velocities are suitable for upstream fish passage with the resting pools. This riffle/pool design will also provide fishery habitat in this reach during the summer months with water depths over the riffles at 2-3.5 feet and flows at 0.6 to 1.5 fps and pools with depths of 4-6 feet and flows at 0.2 to 0.4 fps. The flows and distances described meet suitable passage criteria for northern pike, the poorest swimming game fish within the harbor.

The spacing and dimensions of the features in the channel have been designed using criteria for fish passage and reference reaches for low flow channels in the Menomonee River. The proposed action consists of removing the concrete channel lining and excavating between 0 to 3 feet of river bottom from beneath the channel lining, and placing stone of about 1.6 to 4 feet in diameter (350 to 5500 pounds) designed to remain stationary during 100 year or 1% flood events that result in a stable channel. Riffle and pool systems will be constructed along the river to create vital habitat for fish and other aquatic organisms during low flow periods (generally summer) as well as to provide pools of lower velocity during high flow periods for use by migrating fish for resting during spring migration upstream.

Historic Works Progress Administration (WPA) masonry walls, built circa 1939, run along both sides of the Menomonee River for most of the project (**Figure 4**). The WPA walls would remain in place. The WPA walls consist of masonry at a 1:4 batter, with a concrete toe and 14-foot driving piles. The height of the WPA walls varies along the length of the project, with a maximum height of approximately 12 feet. Construction access to this project site is available without impacting the WPA walls. An existing canoe ramp adjacent the WPA wall does exist 1,200 feet upstream (north) of Wisconsin Avenue bridge along the west bank. A second canoe ramp will be built at the Wisconsin Avenue Bridge along the west bank as part of the MMSD project. MMSD owns the property adjacent I-94 where no WPA wall exists and access could be created here as well, if required. Some of the stormwater outfalls that discharge through the WPA walls are deteriorated. The deteriorated outfalls are expected to be reconstructed in place by MMSD with materials suitable to the State Historic Preservation Office (SHPO) to maintain the historic nature of the WPA walls. Final repair plans for the WPA walls will be provided to the SHPO for approval consistent with their requirements. It is likely that the outfall repairs will occur in conjunction with the stream restoration project since the construction crews are in the area. If the wall slump stability analysis indicates the WPA wall is in jeopardy for failure, steel sheet piling will be driven along the waterward edge of the upper most concrete panels well above the OHWM to secure the toe of the WPA wall to prevent potential WPA wall failure.

Two major bridge crossings, the Canadian Pacific railroad bridge and the WDOT I-94 highway bridge, are located within this project reach of the Menomonee River. The riffle pool complex will be installed under the bridges with special emphasis in the engineering design analysis for scour protection of the bridge piers.

Construction may take place from the shore or from the channel. During construction, it may be necessary to use cutoff walls and piping to divert the water in the channel to construct in the dry. The contractor will be required to take appropriate measures to prevent erosion and sedimentation, excessive dust, and other undesirable effects. The WDNR has indicated a fishery restriction on work in the river channel 15 March -15 June. Work will be coordinated with the WDNR to protect the fishery resources. No warm water fish can pass upstream of the concrete blockage at this time without the installation of the riffles and pools, as proposed.

Construction activities associated with the proposed CAP Section 206 restoration project may result in fine silts and clays to be transported downstream. The magnitude and duration of soil erosion and sediment transport that is released downstream during construction should be managed appropriately. Therefore, during the next project phase (Design and Implementation) water quality based expectations related to turbidity from soil erosion and sedimentation levels shall be developed with the regulatory agencies and in accordance with USACE policy. The purpose of the plan is to limit erosion and sedimentation within the limits of construction using adequate and efficient control measures during the construction phase. The movement of material downstream may be managed by placing controls such as a low flow diversion, covering the work area with plastic sheeting if rain is imminent and placement of a filter fabric liner over exposed soils during construction. The approach to managing the short and long term impacts of mobilized material will reflect a level of control commensurate with the environmental risk they pose during transport and settlement in the river system.

Minor variations in project design or construction method may occur, depending upon site conditions or as a result of the implementation of cost saving measures. Depending on the method and sequence of construction, temporary staging areas, and associated placement of clean fill material, may be required. These areas would be at USACE approved locations within project boundaries, temporary construction and staging areas or right-of-ways, and would be restored to original condition upon project completion. Any variations that would result in significant changes to either the overall project design or environmental impact would be further evaluated under the National Environmental Policy Act.

Since 2000, several restoration projects on the Menomonee River have been completed by MMSD which include the removal of drop structures, low head dams and concrete panels. There still remains approximately 3,700 LF of concrete channel in the Menomonee River. Concrete removal within this 3,700 LF reach of the Menomonee River consists of two phases: Phase I is being accomplished by MMSD and Phase II is being accomplished by the USACE/MMSD per this Section 206 project. The Phase I project consists of the removal of 1,300 LF of concrete channel and drop structure and the addition of habitat restoration features. The Phase 1 upstream project limit is at Middle Railroad Bridge (RM 4.29) while the downstream project limit is at RM 4.03. The Phase I work is to be completed in 2014. The Phase II project encompasses the removal of 2,400 LF of concrete starting from just downstream of Wisconsin Avenue (RM 4.03) to just downstream of the I-94 bridge crossing (RM 3.55)(**Figure 1**). The downstream limit of this USACE/MMSD Section 206 project corresponds to last remaining concrete channel lining in the Menomonee River. The project eliminates the high flow velocity within these concrete segments and provides lower velocity for fish to migrate upstream to access acres of suitable spawning and juvenile rearing habitat.

The proposed construction sequence for Alternative 1 is as follows: Provide for low flow diversion of the river channel with the following or similar method. The proposed water diversion technique involves driving sheet pile on the upstream end of the work site to create a low flow dam and using a portable pump to move the ponded water thru 18-inch plastic pipe to the downstream end of the project site. This low flow system would be sized to move a maximum capacity of approximately 200 cfs. Daily work is restricted to a maximum 50 foot length that requires securing with plastic liner at the close of each day or if rain is threatening. High flow is allowed to overtop the sheet pile dam and flow over the plastic tarp within the daily work area. This dewatering process will be reviewed and would most probably be incorporated in the Section 401, water quality certification approved by the WDNR as part of the required Wisconsin Chapter 30 permit. Once an area is dewatered, the sequence will continue with the breaking of the concrete and removal of the concrete plates to expose the underlying soil. The work sequence is to excavate one to three feet of soil to proposed project depth, place rock consistent with riffle/pool design and then truck construction materials from and to the work site. As each 50 foot section is completed, move downstream and repeat the process. The river diversion technique will minimize any sediment migration downstream during construction and when river flows are restored.

The work quantities for the project are as follows: remove approximately 15,000 square yards of concrete (4,000 CYD), excavate 32,000 CYD soil (sediment), and place approximately 3,000 CYD bedding gravel and 16,000 CYD rock (24,000 Tons). Construction materials will be moved by dump trucks. A temporary road would be constructed to be accessed at both ends of the work site. The contractor may use the existing concrete bed as the haul road. If not, a temporary road could be built on the side slope of the paved river section. The construction sequence and environmental impacts of implementing either action Alternatives 1 or 2 are virtually the same. The only major difference is in the final elevations of the stream channel and the ability of fish to move upstream upon project completion. Upon completion of the project, the riffle/pools are designed to be self cleaning and pass bed load materials.

Figure 4. Existing WPA Wall in Background with Storm Drain Outfalls

3.0 Affected Environment and Environmental Consequences

3.0.1 Riparian Habitat

The construction area is heavily urbanized and WPA walls line both sides of the Menomonee River through the project reach. The WPA walls are historic, eligible for the National Register of Historic Places, and they will not be removed. The deteriorated stormwater outfalls within the walls will be repaired consistent with the SHPO requirements by MMSD during the construction period. The project is limited to concrete removal from the river channel and riffle pool construction. Implementing the project will have no effect on the WPA walls or on habitat and vegetation outside of the river channel, which is sparse and heavily impacted by adjacent industrial development.

3.0.2 Wetlands

The proposed project would have no impact on wetlands. The river is lined with concrete and the WPA walls. There are no wetlands adjacent to the project reach.

3.0.3 Aquatic Habitat

The proposed project area lined with concrete supports a minimal fish population and a limited invertebrate community residing on the concrete plates. Fish species found in other areas of the Menomonee River and the Milwaukee Harbor estuary include, but are not limited to: greater Redhorse, White Sucker, Longnose sucker, Shorthead Red Horse, Smallmouth Bass, Walleye, Stone Roller, Blunt Nose Minnow, Blacknose Dace, Johnny Darter, Creek Chub, Golden Red Horse, Northern Pike, Rainbow Trout, Brown Trout, Coho Salmon, and Chinook Salmon. The completed project would eliminate the concrete lined channels and provide greater habitat diversity with riffles and pools, thus attracting fish, wildlife, aquatic invertebrates including insects, and benthos that are currently found elsewhere in the watershed tributaries. The most important habitat restoration feature and primary objective of this project is providing river connectivity and fish passage upstream to over 18 river miles of suitable fishery spawning and rearing habitat to assist in the restoration of the fishery within the harbor and near shore waters of Lake Michigan. The low flow river diversion technique will minimize any sediment migration downstream during construction and thus the impacts to the aquatic environment. Upon completion of the project, the riffle/pools are designed to be self cleaning and pass bed load materials downstream.

3.0.4 Wildlife

Milwaukee County supports a wide variety of wildlife resources. Resident terrestrial forms expected to occur in the project area include those generalist and edge species that can co-exist with humans. These include: small rodents, eastern cottontail, squirrels, and many species of birds. With the restoration of the river, fish and other aquatic organisms would return to this stretch of river that they historically occupied. The existence of natural riffle and pool aquatic habitat would provide food and cover for aquatic organisms.

3.0.5 Federally-Listed Species

There are no known federally-listed “endangered” or “threatened” species in the project area. No Federally-listed species are identified within Milwaukee County from the USFWS data base dated March 2012. The USACE has determined that the project will have “no effect” on Federally-listed endangered or threatened species or their critical habitats. The USFWS concurred with the Corps determination in email correspondence dated May 3, 2012. Based on information received from the Wisconsin DNR, three state listed endangered species have been observed in the project area:

- Peregrin falcon (*Falco Peregrines*) - bird, endangered
- Cooper's Milkvetch (*Astragalus Neglectus*) - plant, endangered
- Wafer ash (*Ptelea Trifoliate*) - plant, species of concern

After review of the habitat requirements for the two plant species, the plants are not expected to be found on the concrete panels nor in the project work area. The peregrine falcon is not expected to nest under the I-94 bridge. The project is not expected to impact swallows that may be nesting under the I-94 bridge since work under the bridge would occur after their nesting season.

3.0.6 Recreation, Aesthetic Resources

Portions of the Menomonee River are used for recreational activities such as canoeing, tubing and fishing. Removal of the concrete channel lining and the restoration of the aquatic habitat would benefit these uses. Aesthetically, the project site is highly visible due to its location in downtown Milwaukee. Adverse aesthetic impacts would be minor and temporary during construction activities. The finished habitat restoration will result in long term aesthetic benefits through the restoration of the natural aquatic habitat. MMSD may choose to provide signage detailing the benefits of the restoration work.

3.0.7 Cultural Resources

In compliance with Section 106 of the National Historic Preservation Act of 1966 and Executive Order 11593, the National Register of Historic Places (NRHP) and the State Historic Preservation Office (SHPO) have been consulted. Work within the river channel and removal of the concrete panels will have no effect on historic structures. The Works Progress Administration (WPA) masonry walls, built circa 1939, are eligible for listing on the NRHP. The project will have no adverse effect on the WPA walls as they will not be removed. The MMSD repairs to the stormwater outfalls will be consistent with SHPO requirements as outlined in their letter dated November 9, 2012. The deteriorated outfalls will be reconstructed in place with materials suitable to the SHPO to maintain the historic nature of the WPA walls. The proposed repair plans to the WPA walls will be coordinated for approval by the SHPO prior to construction. The repair plans will be provided to the SHPO for final approval.

The WPA walls, which are located along both sides of the Menomonee River for most of the project reach, would remain in place. The WPA walls consist of masonry at a 1:4 batter, with a concrete toe and 14-foot driving piles. The height of the WPA walls varies along the length of the project, with a maximum height of approximately 12 feet. Due to the age and condition of the WPA walls, vibration during construction must be limited to prevent further damage to the wall. Low vibratory construction equipment and monitoring will be required in the specifications. The WPA walls were analyzed for bearing capacity, sliding, and overturning failure moments as a result of the removal of the concrete channel lining based on existing soil borings in the general area obtained from previous work. The analysis indicated potential risk to the WPA walls in one section. Therefore, soil borings are being collected adjacent the WPA wall work site. The soil borings will be used to analyze wall stability (deep-seated arc slope stability failure). Based on the new soil borings, designs will be revised, if necessary, and incorporated into the work during plans and specifications for WPA wall protection. If the slope stability analysis indicates the western WPA wall may be in jeopardy based on soil data, a steel sheet pile (SSP) wall will be installed along the stream side of the upper most concrete paving panels well above the OHWM stream elevation. The impacts from driving SSP wall above the ordinary high water mark are considered negligible.

Construction access to this project site is available without impacting the WPA walls. An existing canoe ramp does exist 1,200 feet upstream (north) of the Wisconsin Avenue Bridge along the west bank. A second canoe ramp may be built at the Wisconsin Avenue Bridge along the west bank as part of MMSD's project. MMSD owns the property adjacent to I-94 where no WPA wall exists and canoe ramp access could be created here as well, if required.

Adverse impacts to archeological resources are not expected. However, the contract specifications will specify that, if during construction the contractor observes unusual items that might have historical, archeological, or cultural value; the contractor will protect those items and immediately report the find to the Contracting Officer so that the USACE District Archeologist may notify the State Historic Preservation Office (SHPO).

3.0.8 Coastal Zone Management

The coastal zone as defined in the Wisconsin Coastal Program consists of the 15 counties bordering on the Great Lakes. Project implementation would cause minimal temporary turbidity from construction activities due to low flow diversion techniques that would minimize disturbances of the river bottom. Placement of the gravel and rock on filter fabric minimizes re-suspension of sediments when the flows are restored to the river. Sediment underlying the concrete varies from silt, sandy-clay, and clay. The turbidity effects would dissipate over time and distance from the work area and would not have significant long-term effects. Any contaminated sediments located under the concrete lined channel would be disposed in accordance with applicable state and Federal laws.

The contractor will be required to develop a materials management plan, construct low flow diversion and sediment barriers for the active construction area, and limit the total length of active construction area that is covered and secured at the end of each day in case of high flows. No significant adverse water quality effects are expected. Stone will be placed in the river channel that is clean and obtained from commercial sources. Sedimentation control measures or silt fencing will be included around disturbed upland areas to prevent soil runoff into the river. The low river flows will be diverted by means of a plastic pipe to allow for work in the dry or in still water areas to minimize erosion and the movement of suspended sediments. The contractor will locate his equipment staging area in an environmentally non-sensitive area and limit the number of access points without impacting the WPA wall.

Implementing either action alternative would not result in direct impacts to Coastal Zone Management resources within the Project area and are consistent to the extent practicable with the Wisconsin Coastal Management Program.

3.0.9 Air Quality

Construction air quality effects would be short term and minor; all equipment would be required to meet emission standards. If dust generated at the work site is deemed to be a potential problem, water will be used for dust control from demolition, stockpiled materials, and earthwork activities.

Emissions from the proposed construction activity are exempted as de minims and therefore meet the General Conformity Criteria pursuant to Section 107 of the Clean Air Act, as amended. Though Milwaukee County/Milwaukee Racine did not meet air quality standards for 8 hour ozone at least once each year from 2004-2012 nor did they meet particulate matter (PM) from 2009-2012, the proposed work is not expected to affect air quality compliance.

3.1.0 Noise

Implementing the proposed Project would not result in significant adverse noise effects in the Project area. Temporary and minor noise will occur during construction as a result of the mechanized equipment and trucking for the required work. One temporary elevated source of noise associated with the action alternatives would include the use of hydraulic/pneumatic hammers attached to excavators to break up the concrete channel lining. This noise source would be temporary.
A Milwaukee Public High School is located approximately 1,000 feet east of the Project area. The noise related to the hydraulic/pneumatic hammering may be an added disturbance to students, though they are already accustomed to considerable noise from the highway traffic. However, the likely construction period would not significantly overlap with the academic year, and the hydraulic/pneumatic hammering would be temporary. In addition to the high school, other noise sensitive areas include a residential neighborhood to the east adjacent to part of the project reach north of I-94. Noise effects on the residential areas will be limited by having work only during daylight hours or as directed by the on-site contract administration officer to ensure that high noise activities are limited to daylight hours. Implementing either alternative would not result in significant impacts to noise sensitive areas within the Project area given the proximity of the Project area to the elevated I-94/US-41 interchange.

3.1.1 Transportation and Traffic

Operators of trucks and construction equipment used during the proposed project are required to obey all applicable Federal, State of Wisconsin, and local driving laws, construction ordinances, and city-imposed hauling/unloading time restrictions, and are required to obtain the appropriate permit(s).

The area includes several truck marshalling areas located along the northern limits of the Project area. Consequently, truck traffic is common in the area, and the increase of truck traffic due to the project would not noticeably impact the area. Miller Park, a major league baseball stadium, is located near the southern limit of the Project area. The truck traffic will add to the congestion associated with game day events. A Milwaukee Public High School is located in the vicinity of the project; however it is not along any probable trucking routes and the traffic will not interfere with school zone traffic.

Overall, the Project area vicinity is highly urbanized with high capacity surface roads and highways nearby with the capacity to handle the additional truck traffic. Therefore, trucking would not be expected to significantly interfere with local traffic, residential areas, school zones, school buses, or emergency vehicles. Movement of the excavated material to the reclamation site will be along established routes that handle truck traffic. No additional traffic impacts are expected with movement of the sediment to the disposal site.

3.1.2 Utilities and Infrastructure

Area utilities include electric, gas, telephone, sanitary sewer, and domestic water. Because of the nature of the proposed work, it is unlikely service interruptions will be required. Any impacts will be temporary and limited in nature. Implementing either alternative would have limited direct impacts to utilities and infrastructure resources within the project area.

3.1.3 Hazardous Material

The terms "hazardous materials" refers to any item or agent (biological, chemical, radiological or physical) which has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors. Issues associated with hazardous materials typically center around waste streams, underground storage tanks (USTs), above ground storage tanks (ASTs), and the storage, transport, use, and disposal of pesticides, fuels, lubricants, hazardous toxic and radioactive waste (HTRW) and other industrial substances. When such materials are improperly used, they can threaten the health and well-being of wildlife species, habitats, soil and water systems, and humans.

USACE policy prohibits the use of Civil Works funds to respond to concerns associated with HTRW and requires appropriate investigation to identify potential HTRW concerns early in planning and development of a civil works project. Several actions were conducted to address the existence of, or potential for, HTRW contamination on lands in and adjacent to the proposed project site, including structures and submerged lands, which could impact, or be impacted by project implementation.

Environmental databases and related records were searched and reviewed for information regarding current and former land use indicating storage, disposal or use of CERCLA regulated substances. Sanborn Fire Insurance Maps indicated the historic use of the site was residential and railroad, consistent with use today. The EPA CerList that provides information on CERCLA sites revealed no CERCLA sites in the project vicinity. The Wisconsin Bureau for Remediation and Redevelopment Tracking System (BRRTS), a state computerized listing of brownfield sites and clean ups, identified four sites in the project vicinity, all of which have been cleaned up and closed.

Sediment sampling and analysis was conducted in August 2001 to characterize the sediments under the concrete lined channel within the proposed project site (Altech, 2001). Approximate sampling locations are included in **Figure 5**. The following criteria were used to evaluate the sediments:

- EPA Threshold Effect Concentrations (TECs)
- EPA Probable Effect Concentrations (PECs)
- State of Wisconsin Default Background Levels
- Direct Contact Criteria (DCC)[1]

Twenty sample locations in the concreted river bed adjacent to flowing water were cored with a four or six inch diameter diamond drill bit to allow for sediment sampling below the concrete. Samples were collected in the bore hole to project depth. The first 5 feet of collected sediment was composited as over burden material. The five to six foot depth of collected sediment was composited

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[1] Soil Cleanup Levels for Polycyclic Aromatic Hydrocarbons (PAHs) Interim Guidance, April 1997, Publication RR-519-97, Wisconsin Department of Natural Resources.

to represent what sediment characteristics the new river bed would be comprised of upon project completion.

The collected soil samples were analyzed for organic and non-organic compounds. Organic compounds included PCBs, BTEX (Benzene, Toluene, Ethylbenzene, and Xylene (volatile organic compounds)), and PAHs. The non-organic compounds included analysis for trace metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver and zinc). Because the concrete panels were constructed in the 1960's and 1970's and some of the joint compound from that time period contained asbestos, the potential exists that asbestos could be in the concrete joints located within the proposed project reach which was a concern in early coordination with the WDNR. Therefore, the collected soil samples were also analyzed for the presence of asbestos.

The results of the geotechnical sediment analysis indicated that the sediments contained sands and gravels. Analytical testing results indicated that no VOCs were detected and no PCBs were reported in any of the samples collected. In two of the twenty soil samples, PAHs had detectable levels above RCL non-industrial direct contact, yet none of the PAHs were reported at concentrations in excess of the generic residual contaminant levels (RCL) for industrial sites. The levels of metals detected were low or not detected. Arsenic concentrations in the soil samples varied between 2.3 and 4.9 mg/kg exceeding the Wisconsin industrial-residual contaminant level of 1.6 mg/kg but not the USEPA soil screening level (SSL) value of 29 mg/kg (which is the value used for the protection of groundwater). The average arsenic value detected within the soil samples was 3.2 mg/kg which are less than the naturally occurring background levels for soils in southeast Wisconsin. No asbestos was detected in the soil samples. No HTRW regulated waste materials were detected underneath the concrete located within the proposed project area. In summary, all of the soil under the concrete would be classified as a non regulated material and is suitable for upland placement. The sand and gravel may have some use as construction materials, while the removed concrete may have a beneficial reuse. The analytical testing results are contained in the DPR, Appendix F – Phase II ESA.

MMSD has tested sediments immediately upstream of the proposed Section 206 project reach (Bloom Companies, LLC, 2010). Soil samples were collected from beneath the concrete lined channel. The collected sediment was analyzed for VOCs, PAHs, PCBs, and RCRA metals. Testing results indicated that no VOCs were detected. Some of the soil samples contained PAHs that were reported at concentrations in excess of the generic residual contaminant levels (RCL) for non-industrial sites for direct contact. The remaining PAH compounds detected in the soil samples were less than the RCL for non-industrial direct contact levels. No PCBs were reported in any of the samples collected. All samples collected exceeded the industrial RCL for arsenic. Two soil sample locations had arsenic levels above 10 mg/kg (11 mg/kg and 13 mg/kg) yet most of the samples contained arsenic concentrations at levels less than 10 mg/kg which is within common background levels for soils in southeast Wisconsin. No other metals (barium, cadmium, chromium, lead, mercury, selenium, and silver) were reported at concentrations of concern. No HTRW regulated material was detected. MMSD has tested for the presence of asbestos within the concrete joint compounds located at their other concrete removal projects. Their testing results indicate that no asbestos has been found in the concrete joint compound at their project site.

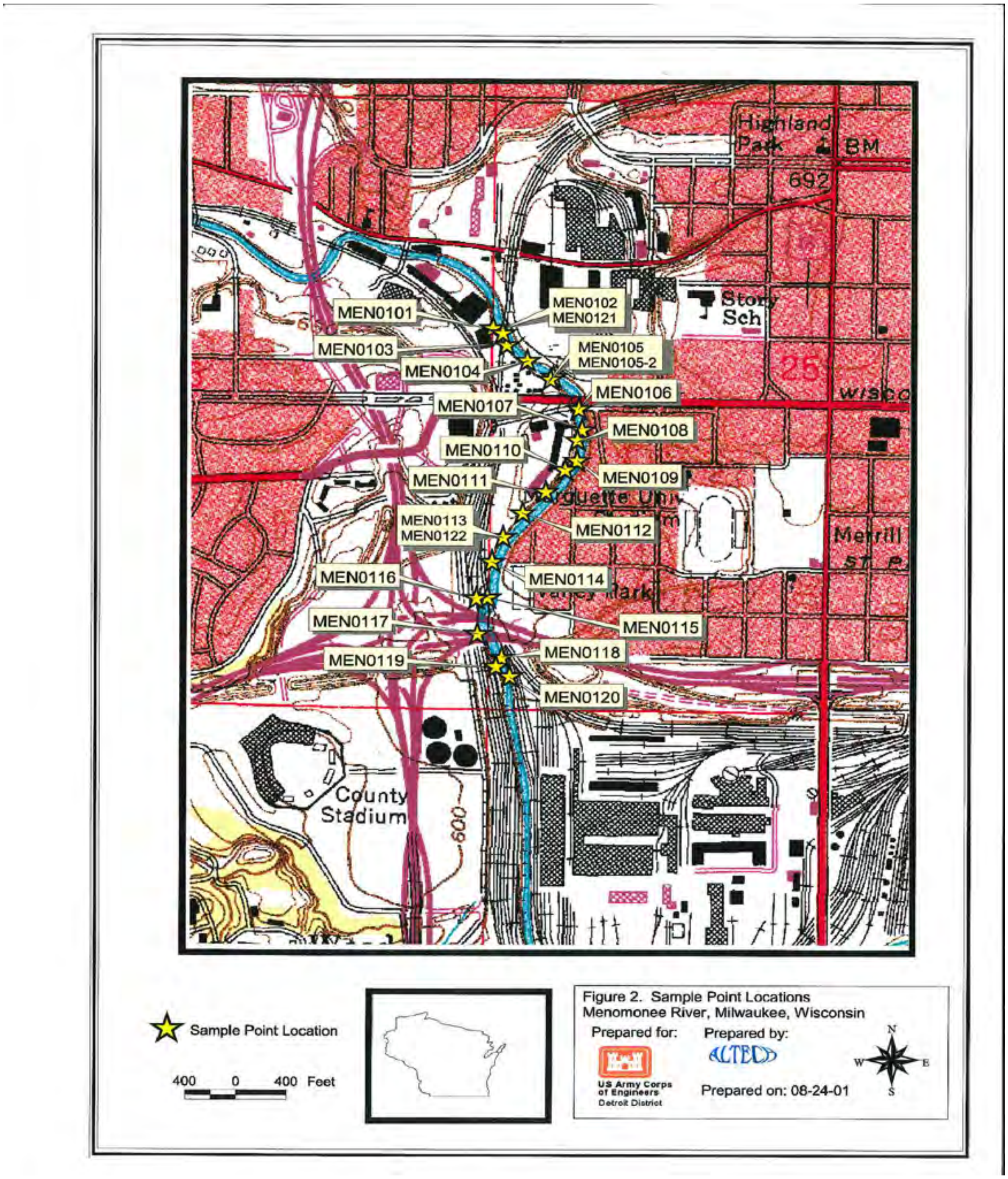

Figure 5 – Menomonee River, Milwaukee, Wisconsin Sample Locations (Altech, 2001)

During MMSD construction activities at their project site located immediately upstream from the proposed Section 206 project site, MMSD put the burden of spoil placement on their contractor. MMSD's contractor took the spoils removed from the construction site to several locations including property that the contractor owned. None of the removed spoils went to a regulated hazardous waste landfill because soil testing deemed the spoils suitable for upland placement. The MMSD contractor was required to obtain all applicable Federal, State, and local permits for the spoil removal and placement activities. The construction activities at this MMSD project site are anticipated to be completed in 2014.

The preliminary sediment management framework for the proposed project assumes that all sediment exists at a contamination level below thresholds requiring special handling and management techniques. This assumption is based on the sediment analysis mentioned above. Sediment within and around the project areas have been analyzed and determined to not contain HTRW regulated material. Based on the testing results, implementing the proposed project is not expected to adversely impact sediment and water quality. The sediments within the proposed construction area do not pose unacceptable exposure risk if removed from the exposed concrete channel and riverbed and spread on floodplain areas.

While implementing the proposed project is not expected to result in the identification or the release of HTRW regulated material, some additional testing is likely to occur prior to or during construction. If the additional testing indicates the presence of CERCLA substances above State of Wisconsin criteria in soils to be excavated and removed from the project, those soils will be transported and disposed of in accordance with applicable Federal, State, and local laws consistent with USACE polices. The non-Federal project sponsor (MMSD) will pay 100% of the costs associated with the removal and disposal of any HTRW regulated waste materials encountered during construction activities. The HTRW regulated materials will be taken to a properly permitted Type II landfill. One such Type II landfill site is the Waste Management Facility at 2101 W. Morgan Avenue, Milwaukee, Wisconsin.

Excavated non-HTRW regulated material will be disposed of in accordance with applicable Federal, State, and local laws and USACE polices. MMSD has identified the Road and Construction Materials Facility, located approximately 15 miles from the project site at 6401 South Racine Avenue, New Berlin, Wisconsin, as a primary disposal site. This site is a disposal for fee site and is compliant with all Federal, State and Local permit requirements to accept this material. If the construction contractor can find an economically favorable alternative site(s) that is/are suitable for disposal of this material, then the contractor will be required to prove to the government that they have properly obtained all Local, State and Federal permits required for disposal at these alternative sites. The placement of non-HTRW regulated material into an appropriate off site licensed disposal area is considered a project feature and the non-federal project sponsor can obtain Lands, Easements Rights-of-Ways, Relocations, and Disposal (LERRDS) credit. For additional information, see the Real Estate plan located in the DPR, Appendix E - Real Estate.

3.1.4 Public Services

Implementing either alternative would not result in direct, indirect, or cumulative impacts to public safety services such as police, fire protection, or local hospitals within the Project area. No major roadways would be closed and any detours or partial road blockage would be minimal.

44CFR 65.12 states: "When a community proposes to permit encroachments upon the floodplain when a regulatory floodway has not been adopted or to permit encroachments upon an adopted regulatory floodway which will cause base flood elevation increases in excess of (0.00ft in floodway) and/or (0.1 in floodplain)…the community shall apply to the Administrator for conditional approval of such actions prior to permitting the encroachments to occur." The implementation of Alternative 1 will not cause an increase in the currently mapped base flood elevation because MMSD has previously implemented projects to mitigate the increases associated with construction of this project. MMSD has/will obtain any required flowage easements, and will work with FEMA and the WDNR to obtain a Letter of Map Revision (LOMR) for documenting the alteration of a flood plain. Any stage increase compared to existing conditions (that occur after MMSD mitigation efforts) will not result in significant enlargement of the flood zone. The proposed project will not result in further development or occupation of the floodplain.

3.1.5 Environmental Justice

The project area is bounded by industrial development to the north, west and south with the major league baseball stadium to the southwest. Residential development is located easterly of the riverfront walkway with the closest homes being approximately 100-150 feet east of the river corridor. Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, was instituted to ensure fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, tribal, and local programs and policies.

Implementing either of the action alternatives would not result in direct impacts to socioeconomic and environmental justice resources within the Project area. The overall socioeconomic impact of the proposed alternatives would be minor because the effects of the construction are temporary and no economic impacts would be felt. Therefore, negative impacts to minority populations and low-income populations would not occur. However, positive impacts through increased fishing and recreation activities are expected with completion of the proposed project.

The 2000 census data for the greater Milwaukee area indicated a population of about 600,000 with 37 percent black but the total population has dropped since then. Over 1,000,000 persons live an hour or less from the downtown Milwaukee estuary and access to an urban fishery supported, in part, by the Menomonee River habitat project.

3.2 Cumulative Effects

The completed aquatic ecosystem restoration would not result in significant cumulative or long-term adverse environmental impacts, nor would it have significant adverse impacts on existing habitat in the Menomonee River. The current degraded condition of the lower Menomonee River and the Milwaukee River estuary is a direct result of industrialization that resulted in the channelization and dredging and filling of estuary wetlands and tributaries. The completed project would provide environmental as well as social benefits as this project provides connectivity to 18 upstream river miles for fish spawning and rearing. This project, in conjunction with other proposed projects on tributaries (Underwood Creek, Kinnickinnic River) to the Milwaukee River will assist in the removal of the Milwaukee River AoC BUI’s and restoration of the Milwaukee Harbor estuary.

3.2.1 Recent, Present, and Reasonably Foreseeable Future Projects

The proposed project is designed to remove the last impediment to fish passage to upstream spawning habitat on the Menomonee River, which is the primary objective of the project. The MSSD has completed several projects within the Milwaukee River tributaries to remove concrete lined channel sections and restore the natural riffle and pool habitat of the rivers. The Menomonee River has had 6 different projects with Federal funding assistance. Sustain Our Great Lakes Program announced on July 29, 2013 a $400,000 grant to MMSD for the removal of five (5) partial concrete blockages that restrict upstream fish passage in the summer. These pipeline/remnant structures do not block passage during spring migration events. Similar projects are proposed on other tributaries within Milwaukee, including work on the Kinnickinnic River and Underwood Creek. These proposed projects do not cause or create significant cumulative adverse effects.

3.2.2 Climate Considerations

The majority of Global Atmospheric Circulation Model runs indicate that, under a continuing global warming trend, air mass differences will become greater in the Great Lakes and upper Midwest regions during the fall and spring (transition) seasons, with stronger resultant atmospheric disturbances. This suggests precipitation events in the project region that will be more frequent and more intense. As such, there is the possibility that river and stream systems in the Great Lakes region could experience more frequent events of intense rain falling during a short period of time which would increase the likelihood of significant stream bank erosion, greater sediment loading into the stream, increased flashiness of the system, and shorter flood warning lead time. These effects would not have a significant cumulative effect in conjunction with the proposed channel restoration.

3.2.3 Effects on Natural and Biological Resources, Invasive Species

This project and similar projects on other tributaries of the Milwaukee River are designed to restore riverine habitat, provide improved habitats for benthos and fish and remove BUI’s as listed in the Milwaukee River AoC. The restoration of tributary rivers with natural channel design using riffles and pools will benefit the aquatic ecosystem without causing adverse effects to the environment. This project, in conjunction with other projects proposed for the Kinnickinnic River, Underwood Creek and the harbor estuary are designed for habitat improvements to beneficially affect the environment. Invasive species, environmental contaminants, and harmful pathogens are not increased or accessed with implementation of the project. Implementation of this project is not expected to create or expand suitable habitat for invasive species. Zebra and quagga live on rocks but the breakwaters and previously restored rock riffle pool areas are not infested with invasive mussels. Some round gobies may move into the reconstructed rock riffle pool segment but the fish already reside in the harbor. Prior to implementation of any of the concrete removal projects, the USFWS sea lamprey control determined that the Menomonee River and tributaries were not suitable for sea lamprey production. No significant detriments caused by invasive species are anticipated with this project and the anticipated gains from river connectivity outweigh the potential adverse effects of expanding river connectivity.

4.0 Findings and Conclusions

Environmental review of the proposed action has indicated that no significant adverse long-term environmental effects would occur, nor would any significant adverse secondary effects occur. The selected alternative, Alternative 1, removing the concrete channel lining and replacing it with rock, in a riffle pool configuration is the most environmentally beneficial alternative.

Minor, temporary effects of increased turbidity and increased air and noise emissions would occur during construction. Post construction effects would be beneficial and meet the primary objective of improved fish access to upstream spawning and nursery areas through river connectivity and riffle pool habitat within the work area.

The proposed action has been reviewed pursuant to the following Acts and Executive Orders, as amended: Fish and Wildlife Act of 1956; Fish and Wildlife Coordination Act of 1958; National Historic Preservation Act of 1966; National Environmental Policy Act of 1969; Clean Air Act of 1970; Executive Order 11593, Protection and Enhancement of the Cultural Environment, May 1971; Coastal Zone Management Act of 1972; Endangered Species Act of 1973; Clean Water Act of 1977; Executive Order 11988, Flood Plain Management, May 1977; and Executive Order 11990, Wetland Protection, May 1977. The proposed project has been found to be in compliance with the above Acts and Executive Orders for this phase of the study.

The USACE, Detroit District and the SHPO have determined pursuant to the National Historic Preservation Act that the project will have no adverse effect on sites listed in the National Register of Historic Places or the potentially eligible WPA walls with the proposed reconstruction of the WPA stormwater outfalls by MMSD consistent with the SHPO recommendations.

The USFWS concurred with the USACE determination that the proposed project would have “no effect” on Federally-threatened or endangered species or the critical habitats of those species.

The aquatic habitat restoration complies with the Federal Executive Order on Flood Plain Management (E.O. 11988) because there is no practicable alternative to construction in the floodplain and the project would not encourage floodplain development. The project is within the coastal zone of Wisconsin and complies to the extent practicable with a Wisconsin’s Coastal Management Program.

Pursuant to the Clean Water Act (CWA), a Section 404(b)(1) Evaluation of the environmental effects of the discharge of fill material, associated with the aquatic habitat restoration, into waters of the U.S. has been prepared (Attachment A to this EA). The Section 404(b)(1) evaluation concludes with the determination that “the proposed action is in compliance with Section 404 of the Clean Water Act.”

This Environmental Assessment has been prepared in accordance with the National Environmental Policy Act (NEPA); the Council on Environmental Quality, Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (40 CFR Parts 1500-1508); and the Corps of Engineers, Policy and Procedure for Implementing NEPA (33 CFR Part 230).

This Environmental Assessment concludes that environmental impacts of the proposed aquatic habitat restoration along the Menomonee River, City of Milwaukee, Milwaukee County, Wisconsin, are minor and local in scope; the benefits of the proposed action outweigh the minor impacts that would result from implementation of the proposed action; and the proposed action does not constitute a major Federal action significantly affecting the quality of the human environment.

Based on the conclusions of this Environmental Assessment, it appears that preparation of an EIS will not be required. Therefore, a Preliminary Finding of No Significant Impact (FONSI) is contained in Attachment B to this EA. If the District Engineer determines that an EIS is not necessary, the Preliminary FONSI would be finalized and the proposed action implemented.

5.0 Agency Coordination

5.1 Early Coordination Comments

Early project coordination did occur with USFWS, USEPA, Wisconsin Historical Society, and the WDNR and concerns/questions/issues raised have been addressed in the EA. Project information was coordinated via written correspondence for the proposed action in May and October 2012. The coordination resulted in early comments which were incorporated into the EA. These entities will receive a copy of the EA for review and comment during the 30-day public review period. Agency early project coordination responses are located in Attachment C to this EA.

The SHPO responded that the reconstruction of the channel will not affect historic structures or property. Reconstruction of the failing stormwater outfalls in the WPA walls needs to essentially be "in place and in kind" as described in their November 9, 2012 letter. MMSD indicates the proposed WPA stormwater outfall reconstruction will comply with the SHPO requirements.

On May 17, 2012, the USEPA responded with several questions regarding specific project details that were not available in the early coordination phase. The information has been addressed within this EA.

On May 3, 2012, the USFWS concurred with the USACE determination that the proposed project would have "no effect" on Federally-threatened or endangered species or the critical habitats of those species. The sea lamprey control unit previously determined the project would not increase sea lamprey access to suitable habitat. The overall Milwaukee restoration plan is acceptable to the agency.

On May 24, 2012, the Wisconsin DNR responded with several questions regarding specific project details that were not available in the early coordination phase. The information has been addressed within this EA and many of the concerns will be incorporated by the WDNR into the Wisconsin Chapter 30 permit.

6.0 References

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ATTACHMENT A

Section 404(b)(1) Evaluation

CLEAN WATER ACT
SECTION 404(b)(1) EVALUATION

Of the Effects of Placing Fill Material into the Waters of the United States
Menomonee River, Environmental Restoration
City of Milwaukee, Milwaukee County, Wisconsin

I. **PROJECT DESCRIPTION**:

a. Project Location, Description, and Authority: The U.S. Army Corps of Engineers (USACE), Detroit District, proposes aquatic habitat restoration of the Menomonee River, Milwaukee, under Section 206 of the Water Resources Development Act (WRDA) of 1996, (P.L. 104-303) as amended; U.S. Code 33 USC 2330. Since 2000, several restoration projects on the Menomonee River have been completed by MMSD which include the removal of drop structures, low head dams and concrete panels. There still remains approximately 3,700 LF of concrete channel in the Menomonee River. Concrete removal within this 3,700 LF reach of the Menomonee River consists of two phases: Phase I is being accomplished by MMSD and Phase II is being accomplished by the USACE/MMSD per this Section 206 project. The Phase I project consists of the removal of 1,300 LF of concrete channel and drop structure and the addition of habitat restoration features. The Phase 1 upstream project limit is at Middle Railroad Bridge (RM 4.29) while the downstream project limit is at RM 4.03. The Phase I work is to be completed in 2014.

The Phase II project (the proposed Section 206 project) encompasses the removal of 2,400 LF of concrete starting from just downstream of Wisconsin Avenue (RM 4.03) to just downstream of the I-94 Bridge crossing (RM 3.55). The downstream limit of this proposed Section 206 project corresponds to last remaining concrete channel lining in the Menomonee River. The project eliminates the high flow velocity within these concrete segments and provides lower velocity for fish to migrate upstream to access acres of suitable spawning and juvenile rearing habitat. The work area encompasses 3 acres (2,400 LF of river x 50-60 feet wide/43,560 ft^2/acre) that are classified as waters of the United States. During construction, the low river flows will be diverted through an 18 inch plastic pipe all the way down stream as work is completed in 50 foot work sections to allow work in the dry or slack water while the concrete is broken and removed, sediments excavated and stone placed to construct riffles and pools in accordance with the described plan.

b. Description of Disposal Methods: The project involves the removal of approximately 15,000 square yards (SYD) of concrete lining in 2,400 LF of river channel, excavation of 32,000 CYD of sediment from under the concrete to shape the river bed and placement of 16,000 cubic yards (CYD) of rock and 3,000 CYD of bedding gravel (or concrete bedding, as required) to create the riffle and pool design. The proposed work will not result in the loss of any waters of the U.S. but result in the creation of a free flowing river segment with riffles and pools in the formerly concrete lined channel, restoring this river segment to a more natural condition. This armored river segment will pass flood flows without causing a significant harmful interference, allow for fish passage upstream and provide aquatic habitat within the work area. All exposed earthwork will include erosion and stormwater controls until the project is complete and bare earth areas are stabilized.

c. Description of Habitat: The existing 2,400 LF of river is concrete lined and in a deteriorated condition requiring removal or replacement. The selected alternative is removal and replacement with stone forming riffles and pools. The river channel habitat is of low quality without wetlands or natural substrate for fish and invertebrates.

II. FACTUAL DETERMINATION

a. Physical Substrate Determinations: No significant adverse effects. Existing concrete will be replaced with stone set in place to create a river with riffles and pools and extensive interstitial space for both invertebrates and fish.

b. Water Circulation, Fluctuation, and Salinity Determinations: No adverse effects. The reconstructed river channel will handle flood flows. The implementation of Alternative 1 will not cause an increase in the currently mapped base flood elevation because MMSD has previously implemented projects to mitigate the increases associated with construction of this project. MMSD has/will obtain any required flowage easements, and will work with FEMA to obtain a CLOMAR and LOMAR, if required. Any stage increase compared to existing conditions (that occur after MMSD mitigation efforts) will not result in significant enlargement of the flood zone. The proposed project will not result in further development or occupation of the floodplain.

c. Suspended Particulate/Turbidity Determinations: No significant adverse effect. Project construction will occur in segments and could cause temporary turbidity if rains occurred prior to placement of the rock. Turbidity effects would dissipate over a short time period and distance from the work area and would not have significant, short term or long term effects. The armor stone would reduce erosion from scour of the underlying sediments from the deteriorated concrete lining and minimize suspended solids discharge to the receiving waters. The project has a plan for minimizing erosion including fluming the waters in the work area, placement of silt fence where required and seeding of exposed areas.

d. Contaminant Determinations: Only suitable bedding aggregate either as gravel or crushed concrete and stone would be placed in the river bed for river reconstruction. The concrete will be broken and transported to a licensed concrete recycling facility. The excavated sediments will be tested and disposed of according to state and Federal regulations. The sediments that are suitable for upland disposal will be taken to the MMSD identified Road and Construction Materials Facility located approximately 15 miles from the project site at 6401 S. Racine Avenue, New Berlin, Wisconsin. This site is a disposal for fee site and is compliant with all Federal, State and Local permit requirements to accept this material. If the construction contractor can find an economically favorable alternative site(s) that is/are suitable for disposal of this material, then the contractor will be required to prove to the government that they have properly obtained all Local, State and Federal permits required for disposal at these alternative sites. Any materials determined to be unsuitable for disposal at the New Berlin site, based on further sediment analysis, will be taken to a Type II landfill with all disposal costs attributed to MMSD. Controls will be in place to prevent sediment movement downstream during construction.

e. Aquatic Ecosystem and Organism Determinations: No significant adverse effects. Construction would destroy any invertebrates living on the concrete. The reconstructed stone river bed with the resulting interstitial spaces will provide additional aquatic habitat for invertebrates and fish. Wildlife would temporarily avoid the area because of the noise and activity. The WDNR has indicated a fishery restriction on work in the river channel 15 March -15 June. Work will be coordinated with the WDNR to protect the fishery resources. No warm water fish can pass upstream of the concrete blockage at this time without the installation of the riffles and pools, as proposed.

f. Federally Listed Species: No Federally listed "threatened" or "endangered" species are known to be present in the work area nor are any species proposed for listing that inhabit the project area. In email correspondence dated May 3, 2012, the U.S. Fish and Wildlife Service (USFWS) concurred that the project will have no effect on Federally listed or proposed threatened or endangered species and concurred with the USACE, Detroit District determination that there will be "no effect" on Federally listed species or their critical habitat.

g. Proposed Disposal Site Determinations: The placement of stone fill material would have no significant adverse impacts on municipal or private water supplies, recreational or commercial fisheries, water related recreation, aesthetics, parks, monuments, wilderness areas, research sites, or similar preserves. The State Historic Preservation Office (SHPO) concurred that the concrete removal project work area, as proposed, will not affect historic properties in a letter dated May 15, 2012. Repairs to the stormwater outfalls through the WPA walls must and will be completed consistent SHPO requirements. MMSD has agreed to complete those repairs consistent with SHPO requirements. If the slope stability analysis indicates the western WPA wall may be in jeopardy based on soil data, a steel sheet pile (SSP) wall will be installed along the stream side of the upper most concrete paving channel well above the OHWM stream elevation. The impacts from driving SSP wall above the ordinary high water mark are considered negligible.

h. Determination of Cumulative and Secondary Effects on the Aquatic Ecosystem: No significant cumulative or secondary impacts are expected to occur from the proposed work and shaping the river bed or banks for placement of rock.

III. **FINDING OF COMPLIANCE:**

No significant adaptations of the Section 404 (b)(1) Evaluation guidelines were made relative to this project. The proposed concrete removal, 32,000 CYD of sediment excavation with testing and appropriate disposal consistent with state and Federal requirements and the placement of approximately 19,000 CYD of stone to reconstruct 2,400 LF of channel in the riffle and pool configuration would meet applicable water quality standards; would not result in significant adverse effects on human health and welfare, aquatic life, or other wildlife dependent on the aquatic ecosystem, nor impact the diversity, productivity, and stability of the aquatic ecosystem. The proposed riffle pool project would maintain bedload discharge and not cause excessive sedimentation during construction. Coordination of the project with the USFWS indicates that no Federally-listed "threatened" or "endangered" species or their critical habitat have been identified that would be affected by the project. Appropriate steps have been taken to minimize adverse effects on the aquatic ecosystem including specific environmental protection clauses in the project contract specifications to ensure protection of natural resources. On the basis of *Section 404 (b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material* (40 CFR part 230), it has been determined that the proposed action is in compliance with Section 404 of the Clean Water Act.

ATTACHMENT B

PRELIMINARY FINDING OF NO SIGNIFICANT IMPACT

PRELIMINARY FINDING OF NO SIGNIFICANT IMPACT

MENOMONEE RIVER, ENVIRONMENTAL RESTORATION
CITY OF MILWAUKEE, MILWAUKEE COUNTY, WISCONSIN
SECTION 206 OF THE WATER RESOURCES DEVELOPMENT ACT

In accordance with the National Environmental Policy Act of 1969, the Detroit District, U.S. Army Corps of Engineers (USACE), prepared an Environmental Assessment (EA) and an evaluation pursuant to Section 404(b)(1) of the Clean Water Act (CWA) for the purpose of conducting a comprehensive evaluation of the existing conditions and environmental consequences of reconstruction of approximately 2,400 lineal feet (LF) of the Menomonee River located in Milwaukee, Wisconsin. The project begins at Middle Railroad Bridge and extends downstream to just south of Interstate Highway I-94 and includes the removal of 2,400 LF of concrete (15,000 square yards, excavation of 32,000 cubic yards (CYD) of material and placement of 19,000 CYD of rock to create riffles and pools within this river segment.

Alternatives considered under this study include: 1) removal of the concrete channel lining and placing stone designed to remain stationary to create riffle and pool complexes; 2) removal of the concrete channel lining and replacing the lining with stone, without the creation of any riffle or pool complexes and 3) No Federal Action. Alternative 1 is the selected alternative as it would restore access to the aquatic ecosystem along the Menomonee River. Alternative 2 would restrict upstream fish passage during spring runoff.

This study is being conducted under the authority of Section 206 of the Water Resources and Development Act (WRDA) of 1996, (P.L. 104-303) as amended; U.S. Code 33 USC 2330. This EA has been prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), Section 102(2)(C); the CEQ, “Regulations for Implementing the Procedural Provisions of NEPA”; 40 Code of Federal Register (CFR) Parts 1500 through 1508; and the USACE, Policy and Procedure for Implementing NEPA (33 CFR Part 230). No wetlands will be destroyed by implementing the proposed project but 3 acres of concrete lined channel will be replaced with rock, creating riffles and pools in a natural channel design

Based on the findings of the EA and 404(b)(1) evaluation (for placement of fill material into 3 acres of waters of the United States), implementation of the selected project alternative would be in compliance with Section 404 of the CWA and would not result in significant short term, long term or cumulative adverse environmental impacts. Adverse effects will be minor, limited primarily to short term noise, air emissions and turbidity from construction activities. The proposed project will provide a long term, environmentally sound solution for aquatic habitat restoration by providing connectivity to 18 miles of river for spawning habitat.

The proposed project complies with Federal Executive Order 11988 on Flood Plain Management as it would not encourage floodplain development. The proposed project would be "consistent to the maximum extent practicable" (as defined in 16 USC 1456, Coastal Zone Management Act, approved 1978) with the Wisconsin Coastal Management Program as it would have no effect on the coastal zone or waterways discharging into Lake Michigan.

Review of the proposed project and the comments received during public review of the EA and 404(b)(1) evaluation indicates that the project does not constitute a major federal action significantly affecting the quality of the human environment; therefore, an Environmental Impact Statement will not be prepared.

________________	________________________
DATE	Robert J. Ells Lieutenant Colonel, U.S. Army District Engineer

ATTACHMENT C

Agency Comments

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

MAY 1 7 2012

REPLY TO THE ATTENTION OF: E-19J

Adam C. Wagner
U.S. Army Corps of Engineers - Detroit District
P.O. Box 1027
Detroit, Michigan 48231

Re: Scoping Request, Menomonee River Ecosystem Restoration, Milwaukee, Wisconsin

Dear Mr. Wagner:

The U.S. Environmental Protection Agency (EPA) reviewed the scoping materials dated May 3, 2012, concerning the above-mentioned project. Our comments in this letter are provided in accordance with our responsibilities under the National Environmental Policy Act (NEPA), the Council on Environmental Quality's NEPA Implementing Regulations (40 CFR 1500-1508), and Section 309 of the Clean Air Act.

The U.S. Army Corps of Engineers (USACE) is proposing aquatic habitat restoration along the Menomonee River in Milwaukee County, Wisconsin. The Menomonee River was degraded by construction of a concrete channel for flood control purposes during the 1960's.

In addition to the no-action alternative, USACE is considering two action alternatives. One alternative, which is designated as the preferred alternative, includes removing the concrete channel lining, replacing it with stone and sand, and constructing pools and riffles. A second action alternative includes removing the concrete channel lining, replacing it with stone and sand, and allowing natural pools and riffles to re-establish naturally.

Based on the information provided, EPA has the following questions and comments:

Project Design:

- We recommend the forthcoming Environmental Assessment (EA) discuss selection of the upstream restoration terminus as indicated in Attachment 2. It appears that the channel continues as a concrete channel upstream of the indicated restoration starting point. Is the upstream concrete portion of the river slated to remain in its present condition? If so, how might the concrete channel affect the proposed restoration, particularly upstream passage for desirable fish species?
- The scoping materials indicate that construction will be done from the channel with water being diverted from those sections under construction. Assuming that the concrete channel invites flashy flood flows and due to the size of the river, EPA recommends that the forthcoming EA discuss how flow will be handled during construction. Is a dam and pump around proposed?
- EPA recommends that the EA discuss how many riffle/pool structures will be installed, and how the structures will be designed.

- In the forthcoming EA, EPA requests information on the size (D50[1]) of and type of rock proposed to be installed to create the new river bed. Due to the desire to naturalize the channel, EPA recommends that natural river rock be utilized in lieu of riprap and recommend that additional evaluation of stream bank bioengineered stabilization methods be utilized as an alternative to rip-rap.

Indirect Impacts:

- Once the river system has re-stabilized, what are the anticipated impacts (if any) to river morphology as a result of converting portions of the river from a concrete river channel to an area with natural substrate (e.g., stream load, turbidity, sediment accumulation, erosion, etc.)?
- How will the re-direction of energy cause downstream changes to the form and function of the river?
- How might this activity impact water quality?

Measures of Success:

- What types of measures of success will be used?
- At what stages of project (i.e., planning, design) are measures determined?
- At what intervals after construction is completed will project performance be measured?

Monitoring/Maintenance:

- Which entity(s) (e.g., USACE, state resource agency, local government, non-governmental organization) will handle monitoring/maintenance activities?
- If an entity other than USACE will be responsible for monitoring/maintenance activities, will USACE be involved in these activities to ensure agreed-upon standards are met?

Public Involvement:

- Given the proposed project's proximity to residential neighborhoods and Marquette University High School, we recommend USACE install signage (covering the different phases of construction, maintenance activities, and anticipated final results, among others) along the restoration site. Signage has the benefit of informing those who may come in contact with the restoration of the proposed project's purpose and anticipated benefits.

Thank you for the opportunity to comment early in the process. Please send us a copy of the draft Environmental Assessment once it is available. If you have any questions, please contact Kathy Kowal of my staff at 312-353-5206 or at kowal.kathleen@epa.gov.

Sincerely,

Kenneth A. Westlake
Chief, NEPA Implementation Section
Office of Enforcement and Compliance Assurance

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[1] D50 = median angular rock size (50% of the sample is finer by weight) in inches

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
101 S. Webster Street
Box 7921
Madison WI 53707-7921

Scott Walker, Governor
Cathy Stepp, Secretary
Telephone 608-266-2621
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WISCONSIN
DEPT. OF NATURAL RESOURCES

May 24, 2012

Adam Wagner
US Army Corp of Engineers
Detroit Division
477 Michigan Ave # 600
Detroit, MI 48226

Subject: Initial Scoping Comments for proposed Aquatic Habitat Restoration Project, Menomonee River, I-94 to Wisconsin Avenue, Milwaukee County

Dear Mr. Wagner:

Thank you for the opportunity to provide comments for the proposed Aquatic Habitat Restoration Project on the Menomonee River from I-94 to Wisconsin Avenue in Milwaukee County. It is understood the project involves the removal of the 8 inch thick concrete channel lining and up to 3 feet of river bottom from a 3,700 foot stretch of the Menomonee River. The removal of the concrete channel lining will improve upstream passage for spawning of lake-run and resident fish species which has been greatly impaired by excessive currents created by the concrete channel. Department initial review and scoping comments are listed below.

Remediation and Redevelopment/Waste and Materials Management

1) Asbestos containing material may have been used as expansion joint material between concrete slabs. An asbestos assessment of the corridor should be completed prior to demolition. If the project includes asbestos removal an abatement plan needs to be defined and a **Notification of Demolition and/or Renovation and Application for Permit Exemption (NR 406, 410, and 447 Wis. Adm. Code)** may be required. Please contact Mark Davis, Asbestos Specialist (414) 263-8674 to request additional information and permit application materials.

2) Hazardous substance releases have been reported in the in the project area. The Department of Solid and Hazardous Waste Information Management provides an on-line database of landfills, waste transporters, hazardous waste generation, and waste processing facilities. The web address is: http://dnr.wi.gov/botw/SetUpBasicSearchForm.do . Please develop a plan to dispose of contaminated waste should it be encountered during construction. Should contamination be encountered within the right-of-way either before or during construction, you must notify the appropriate person in the DNR Solid Waste Section at 1-800-943-0003 prior to continuing operations.

Land Resources

1) Primary Environmental Corridors and Areas of Isolated Resources exist in the project area. The majority of the corridor is along the Menomonee River. Threatened and endangered species habitat may exist in these corridors. See the SEWRPC website for more information on Environmental Corridors at http://www.sewrpc.org/regionallandinfo/regionalmapping/default.shtm.

2) Maps indicate the presence of a trail crossing the project area near 44th Street. The trail has been identified as the Hank Aaron State Trail/Oak Leaf Trail connector. The Department would recommend that trail stays open; however, if this is not possible then detours should be determined and proper signage placed at next entrances. Any construction impacts on the trail shall be replaced

at or above current condition. Contact Melissa Cook, WDNR Trail Coordinator, at 414-263-8559 or Melissa.cook@wisconsin.gov for information.

3) Milwaukee County owned land exists adjacent to the project area. Impacts to this property may have to be mitigated through the 4(f) conversion process. Contact Jim Ritchie, Outreach Team Supervisor, at 414-263-8610 or Jim.ritchie@wisconsin.gov for information.

Water Resources

1) The project area is located in the Menomonee River basin. DNR basin report provides an overview of land and water resource quality is available at http://www.dnr.state.wi.us/org/gmu/rootpike/rootpikefinal.pdf.

2) The Department recommends that all in-water construction activity be avoided from March 15 to June 15 to protect endemic fish population during spawning activities. It is also necessary to maintain an unobstructed passageway through the construction area at these locations at all times to allow for continuous fish movements.

3) Channel stability and fish and wildlife passage should be standard design and construction objectives. A preliminary draft of the Southeastern Wisconsin Regional Planning Commission (SEWRPC) *Planning Report No. 50, Criteria and Guidelines for Stream Crossings to Allow Fish Passage and Maintain Stream Stability Within the Regional Water Quality Management Plan Update Study Area* is attached. The document is also available at http://www.sewrpc.org/SEWRPCFiles/Publications/ppr/pr-050_summary_water_quality_plan_greater_mke_watersheds.pdf. Well designed and installed structures keep channels stable; accommodate fish and wildlife passage, and lower maintenance costs.

4) No wetlands are present in the proposed Project Area.

5) The City of Milwaukee implements shore land and floodplain zoning in the project area. The Federal Emergency Management Agency (FEMA) is implementing a map modernization initiative to upgrade the Floodplain Map development process in which maps are created and distributed in a geographic information systems (GIS) format. The Department's floodplain management program has scanned the existing paper maps and geo-registered them. They are displayed on our web interactive maps http://dnr.wi.gov/topic/floodplains/faddisclaimer.html, and can be overlaid on top of air photos or topographic maps. Contact Tanya Lourigan, WDNR Floodplain Engineer, at 414-263-8641 or Tanya.lourigan@wisconsin.gov for more information.

Endangered Resources

1) There is potential for swallow nesting under bridges. The International Migratory Bird Act protects international migratory birds such as seagulls, swallows, and terns. It is a violation of federal law to disturb nests if eggs or fledgling young are present. Please contact Brian Nelson, United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services at (920) 324-4514 if eggs or fledgling young are present.

2) Endangered resources recently observed within the project area include:

Falco peregrinus Peregrine Falcon – bird, endangered
Astragalus neglectus Cooper's Milkvetch – plant, endangered

Ptelea trifoliata Wafer-ash – plant, species of concern

Construction Impacts

1) Construction erosion and sedimentation must be controlled to the disturbed area. The project must conform to TRANS 207.09 and 207.10. An effective erosion control plan needs to be developed for this project to prevent downstream migration of sediment and other potential pollutants. Erosion control devices shall be specified on the final construction plans. All erosion control BMPs must be in place prior to ground disturbing activity. All disturbed areas shall be adequately protected against erosion within seven days of work completion. Erosion control can be removed entirely after vegetation is established. Contact Jamie Lambert, WDNR Wastewater Specialist, at 414-263-8485 or Jamie.lambert@wisconsin.gov for more information.

2) Department of Natural Resources Waterway approvals are required for removal of concrete channel lining, dredging, sediment removal and by-pass pumping. If sediments need to be altered in the waterway a sediment analysis may be required.

3) If site dewatering is required, sediment-laden water shall be pumped into an adequate sediment basin located in an upland location prior to discharge to the waterway.

4) Excess fill/borrow material or spoils should be stockpiled on upland areas an adequate distance away from wetlands, stormsewer inlets, floodplains, and the waterways. Piles of stockpiled soil shall be protected against erosion and shall not create nuisance dust emissions.

5) Fertilizer (liquid or granular) should not be used on re-vegetated areas that are adjacent to waterways. This minimizes the risk of concentrated nutrients entering into waters of the state that can cause habitat impairments. Temporary cover crops can be used in lieu of fertilizers in these sensitive areas while the seed germinates during the growing season.

6) The proposed project exists within the Emerald Ash Borer Quarantine area. Please include WisDOT Specifications for Clearing and Grubbing within the Quarantine Zone to the contract special provisions.

7) All equipment must be properly cleaned and disinfected to address the spread of invasive species and viruses. Contract special provisions should require contractors to implement the following before and after mobilizing in-water equipment to prevent the spread of viral hemorrhagic septicemia (http://dnr.wi.gov/fish/vhs/) and other invasive species. Disinfect your boat, equipment and gear by either:
   a. Washing with ~212° F water (steam clean), OR
   b. Drying thoroughly for 5 days after cleaning with soap and water and/or high pressure water, OR
   c. Disinfecting with either 200 ppm (0.5 oz per gallon or 1 Tablespoon per gallon) Chlorine for 10-minute contact time or 1:100 solution (38 grams per gallon) of Virkon Aquatic for 20- to 30-minute contact time. This disinfect should be used in conjunction with a hot water (>104° F) application.

Thanks again for the opportunity to provide scoping comments for the proposed Habitat Restoration Project on the Menomonee River from I-94 to Wisconsin Avenue in Milwaukee County. I would be glad to speak or meet with you to discuss the Department's comments and provide additional information.

Sincerely,

Kristina Betzold

Kristina Betzold
Environmental Analysis and Review Specialist
(414) 263-8517
kristina.betzold@wisconsin.gov

HP-05-07 (8/15/03)

For SHPO Use Only. Case # 12-0423/M

REQUEST FOR SHPO COMMENT AND CONSULTATION ON A FEDERAL UNDERTAKING

RECEIVED
MAY 07 2012
DIV HIST PRES

Submit one copy with each undertaking for which our comment is requested. Please print or type. Return to:

Wisconsin Historical Society, Division of Historic Preservation, Office of Preservation Planning, 816 State Street, Madison, WI 53706

Please Check All Boxes and Include All of the Following Information, as Applicable:

I. GENERAL INFORMATION

☑ **This is a new submittal.**
☐ **This is supplemental information relating to Case #:__________ and title:____________________**
☐ **This project is being undertaken pursuant to the terms and conditions of a programmatic or other interagency agreement. The title of the agreement is ____________________**

a. Federal Agency Jurisdiction (Agency providing funds, assistance, license, permit): U.S. Army Corps of Engineers

b. Federal Agency Contact Person: Charles Uhlarik, Chief, Environmental Branch Phone: 313-226-2476

c. Project Contact Person: Karen Krepps, District Archaeologist Phone: 313-226-6238

d. Return Address: 477 Michigan Ave, Detroit, MI Zip Code: 48226-2550

e. Email Address: Karen.L.Krepps@usace.army.mil

f. Project Name: Menomonee Section 206

g. Project Street Address: Menomonee River, Milwaukee, between I-94 and Wisconsin Ave. and East of US-41

h. County: Milwaukee City: Milwaukee Zip Code: 53208

i. Project Location: Township 7 North, Range 21 E, E/W (circle one), Section 25, Quarter Sections SW

j. Project Narrative Description—Attach Information as Necessary. See Attachment 2.

k. Area of Potential Effect (APE). Attach Copy of U.S.G.S. 7.5 Minute Topographic Quadrangle Showing APE. See Attachment 1.

II. IDENTIFICATION OF HISTORIC PROPERTIES

☐ Historic Properties are located within the project APE per 36 CFR 800.4. Attach supporting materials.
☑ Historic Properties are not located within the project APE per 36 CFR 800.4. Attach supporting materials. See Attachment 2.

III. FINDINGS

☑ No historic properties will be affected (i.e., none is present or there are historic properties present but the project will have no effect upon them). Attach necessary documentation, as described at 36 CFR 800.11.
☐ The proposed undertaking will have no adverse effect on one or more historic properties located within the project APE under 36 CFR 800.5. Attach necess documentation, as described at 36 CFR 800.11.
☐ The proposed undertaking will result in an adverse effect to one or more historic properties and the applicant, or other federally authorized representative, wi consult with the SHPO and other consulting parties to resolve the adverse effect per 36 CFR 800.6. Attach necessary documentation, as described at 36 CFR 800.11, with a proposed plan to resolve adverse effect(s).

Authorized Signature: Date: 02 May 12

Type or print name: Charles A. Uhlarik

IV. STATE HISTORIC PRESERVATION OFFICE COMMENTS

☒ Agree with the finding in section III above.
☐ Object to the finding for reasons indicated in attached letter.
☐ Cannot review until information is sent as follows: ____________________

Authorized Signature: Date: 5/15/12

HISTORY
WISCONSIN
HISTORICAL
SOCIETY

November 9, 2012

Ms. Karen L. Krepps
U. S. Army Corps of Engineers
Detroit District
P.O. Box 1027
Detroit, MI 48231

SHSW#: 12-0423/MI
RE: Menomonee River Aquatic Habitat Restoration Project

Dear Ms. Krepps:

We have reviewed your submittal of October 12, 2012 regarding the above referenced project. The proposal does not explain how the project will meet the Secretary of the Interior's Standards. Project plans that are submitted for review and comment need to explain what is meant by "in kind". In the absence of a more complete project plan than what has been provided we offer the following general guidelines.

Existing stones should be reused whenever possible in the reconstruction. When missing new stones of the same material and approximate size as other wall stones shall be used.

It is best to test and match the new mortar to the surrounding historic mortar. The mortar should match in color composition, hardness, and joint profile with hardness being the most significant. The repair mortar should be equal to or softer than the historic mortar not harder than. If testing is not done then nothing harder than a type "N" mortar should be used. To match the color of the original mortar, the mason may need to use white, rather than gray, Portland cement tinted to match the existing.

New work should be laid in the same plane and with the same batter angle as the existing wall however it is acceptable to extend the replaced concrete outfall pipe slightly beyond the wall face enough to create a drip edge and not have the outfall run directly down the wall face.

The use of a poured concrete wall with a stamped stone pattern does not meet the standards and is not approved for use on the repair.

We look forward to reviewing more comprehensive project plans when they become available, at which time we will be able to assess the effects that the proposed project may have on historic properties. If you have any questions concerning these matters please call me at (608) 264-6507.

Sincerely,

Sherman Banker
Wisconsin State Historic Preservation Office

From: Joel_Trick@fws.gov
Sent: Thursday, May 03, 2012 3:05 PM
To: Wagner, Adam C LRE
Cc: Harrington, Hal F LRE
Subject: Re: Early Coordination,

Mr. Wagner:

I have reviewed the documents you attached to your message below, and agree that a determination of no effect to federally listed species is appropriate.

Joel A. Trick
U.S. Fish and Wildlife Service
2661 Scott Tower Drive
New Franken, WI 54229
phone 920-866-1737
fax 920-866-1710
joel_trick@fws.gov
Inactive hide details for "Wagner, Adam C LRE" <Adam.C.Wagner@usace.army.mil>"Wagner, Adam C LRE" <Adam.C.Wagner@usace.army.mil>

"Wagner, Adam C LRE" <Adam.C.Wagner@usace.army.mil>

05/03/2012 07:36 AM

To

"Joel_Trick@fws.gov" <Joel_Trick@fws.gov>

cc

"Harrington, Hal F LRE" <Hal.F.Harrington@usace.army.mil>

Subject

Early Coordination,

The U.S. Army Corps of Engineers, Detroit District, is evaluating a proposed aquatic habitat restoration project along the Menomonee River in downtown Milwaukee, Milwaukee County, Wisconsin. We find that the project will have no effect on Federally recognized T&E species. A brief description of the project and our determination is attached. If you have other recommendations or items that we should discuss in the EA that is being prepared, please let me know.

Your assistance is appreciated.

Adam C. Wagner
U.S. Army Corps of Engineers - Detroit District
Office: 313-226-2138
Email: adam.c.wagner@usace.army.mil

[attachment "TE Summary.docx" deleted by Joel Trick/R3/FWS/DOI] [attachment