DETAILED PROJECT REPORT

UNDERWOOD CREEK
GREAT LAKES FISHERY AND ECOSYSTEM RESTORATION PROJECT
WAUWATOSA, WISCONSIN

February 2016

US Army Corps of Engineers®
Detroit District

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE), Detroit District, has evaluated a proposed aquatic habitat restoration plan along Underwood Creek in Wauwatosa, Milwaukee County, Wisconsin under the authority of Section 506 of the Water Resources and Development Act (WRDA) of 2000, (P.L. 106-541) as amended. Under this authority, the Secretary of the Army can plan, design and construct projects to support the restoration of the fishery, ecosystem and beneficial uses of the Great Lakes. The purpose of the proposed project is to restore in-stream habitat and connectivity to the downstream end of Underwood Creek.

During the 1960s and 1970s, Underwood Creek was altered for flood management purposes (No Federal involvement). These alterations included: lining the channel with concrete; channel widening and realignment; and the installation of concrete drop structures. While these modifications successfully reduced peak water surface elevations, in-stream habitat was virtually eliminated and aquatic species connectivity to upstream reaches was severed.

In 2011, the sponsor, Milwaukee Metropolitan Sewerage District (MMSD), began pursuing restoration of the creek which included the installation of the Milwaukee County Grounds Floodwater Management Facility (MCGFMF). This facility was constructed to manage flood events by lowering flood stages to allow for the construction of multiple restoration projects, including the project herein evaluated.

This Detailed Project Report (DPR) evaluates two restoration plans designed to address ecosystem restoration. Although complete re-naturalization of the channel is not viable (hydraulically), the proposed alternatives represent naturalized systems in that they provide functions associated with riverine systems. Alternatives 2 and 3 both incorporate: concrete channel bottom removal, the elimination of concrete drop structures, a new limestone channel bottom and the creation of pools and riffles in the stream bed. Although these alternatives have similar design features, they differ with respect to the method used for bank stabilization and the inclusion of meanders. Alternative 2's plan utilizes steel sheet pile for stabilizing a segment of the channel whereas Alternative 3's plan uses a tiered wet-cast retaining wall for bank stabilization. A sequence of meanders is included in a portion of Alternative 3's channel design but meanders are not included as part of Alternative 2's plan. Both of these alternatives are designed to improve in-stream habitat, create stream connectivity and further promote the ongoing watershed restoration efforts.

The 100-year water surface elevations for the two alternatives exceed the existing conditions water surface elevation (Alternative 1) in several areas, but are lower than or equal to the effective FEMA 100-year floodplain elevations since the MCGFMF was specifically developed to lower discharge elevations in order to proceed with river restoration projects. The MMSD has also 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. Alternative 3 was found to have the lowest 100-year water surface water elevation and inundation is limited to the Fisher Parkway. The difference between existing and proposed conditions measures only a few inches and is defined in Figures 17 and 18.

Alternative 3 was identified as the National Environmental Restoration (NER) plan since it is the most efficient and hydraulically feasible plan. This alternative's design includes: concrete removal, channel slope modification, limestone bottom, riffle/pool sequence, low flow channel and channel meanders. Removal of the concrete channel bottom and drop structures would provide connectivity from the Menomonee River to the upstream end of MMSD's recently completed restoration project. The limestone bottom would create a variable substrate that would enhance in-stream habitat and support a diverse macroinvertebrate community. Fish passage and in-stream habitat would be further improved by the pool and riffle sequence which would provide areas for resting and forging for fish. The low-flow channel would allow for suitable depths, needed for certain aquatic species, to be achieved during periods of low flow. The project would also create future connectivity with the restoration planned further upstream by MMSD. Once these barriers are removed, there is an estimated 400 acres of wetland habitat and 140 acres suitable pike spawning habitat that would be accessible.

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GREAT LAKES FISHERY AND ECOSYSTEM RESTORATION
(SECTION 506)
UNDERWOOD CREEK, WAUWATOSA, WI

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APPENDICES

1.0 BACKGROUND

1.1 Study Authority and Sponsor

This study is being conducted under the authority of Section 506 of the Water Resources Development Act of 2000, Public Law 106-541. Under this authority, the Secretary of the Army can *"plan, design and construct projects to support the restoration of the fishery, ecosystem and beneficial uses of the Great Lakes"*. The Federal cost share under the 506 authority is 65 percent with a $10,000,000 Federal expenditure limit per project.

Milwaukee Metropolitan Sewerage District (MMSD) is the non-Federal sponsor for the proposed project. They are a regional government agency that provides water reclamation and flood management services for about 1.1 million customers in 28 communities in Metropolitan Milwaukee. Under the 506 authority, the non-Federal sponsor is required to cost share 35 percent of the total project costs including provision of all lands, easements, rights-of-way, and necessary relocations. Any costs in excess of the Federal expenditure limit, $10,000,000, are the responsibility of the non-Federal sponsor.

1.2 Purpose and Need

This report examines the feasibility of improving riverine habitat, restoring connectivity for native fish species, and increasing species diversity and abundance along the downstream end of Underwood Creek. In the 1960s and 1970s, the creek was structurally modified and altered to improve the efficiency of moving run-off produced by the region's impervious urban surfaces. These changes in the stream's morphology have inhibited fish passage, severed stream connectivity, eliminated riverine habitat, and reduced biodiversity.

The proposed project also would act in concert with several other regional restoration projects that MMSD has completed and/or is currently pursuing. Originally, the MMSD had set out to restore approximately 6,600 linear feet of the concrete channel following the installation of a water retention facility. To date, the MMSD has restored roughly 2,200 feet of the upstream portion of this concrete lined channel. In addition to Underwood Creek, MMSD is also working to restore and remove concrete from other Milwaukee Estuary tributaries. Thus, the proposed project would provide connectivity to MMSD's upstream restoration project and would create synergies with other estuary projects.

1.3 Underwood Creek Project Description and Location

The proposed project reach begins roughly 100 feet upstream from the Canadian Pacific Railroad (CPR) Bridge and extends downstream to end near the confluence of Underwood Creek and the Menomonee River (Figure 1). In total, the proposed reach is approximately 4,400 linear feet in length and is located entirely within the City of Wauwatosa, Wisconsin (Figure 2). Two bridges (U.S. Highway 45 and CPR) bisect the reach at its upstream-most end. The width of the proposed project area is highly constrained with CPR tracks lining the south side of the channel and a mix of residential and commercial properties located immediately to the north.

The Underwood Creek Watershed is highly urbanized consisting of mostly of commercial, residential and industrial developments. Originating in Brookfield, Wisconsin, the creek runs eight miles in a southeasterly direction and empties into the Menomonee River. Dousman Ditch and the South Branch of Underwood Creek are the two tributaries that flow into the main stem of the creek. The stream is responsible for draining approximately 20 square miles of Metropolitan Milwaukee.

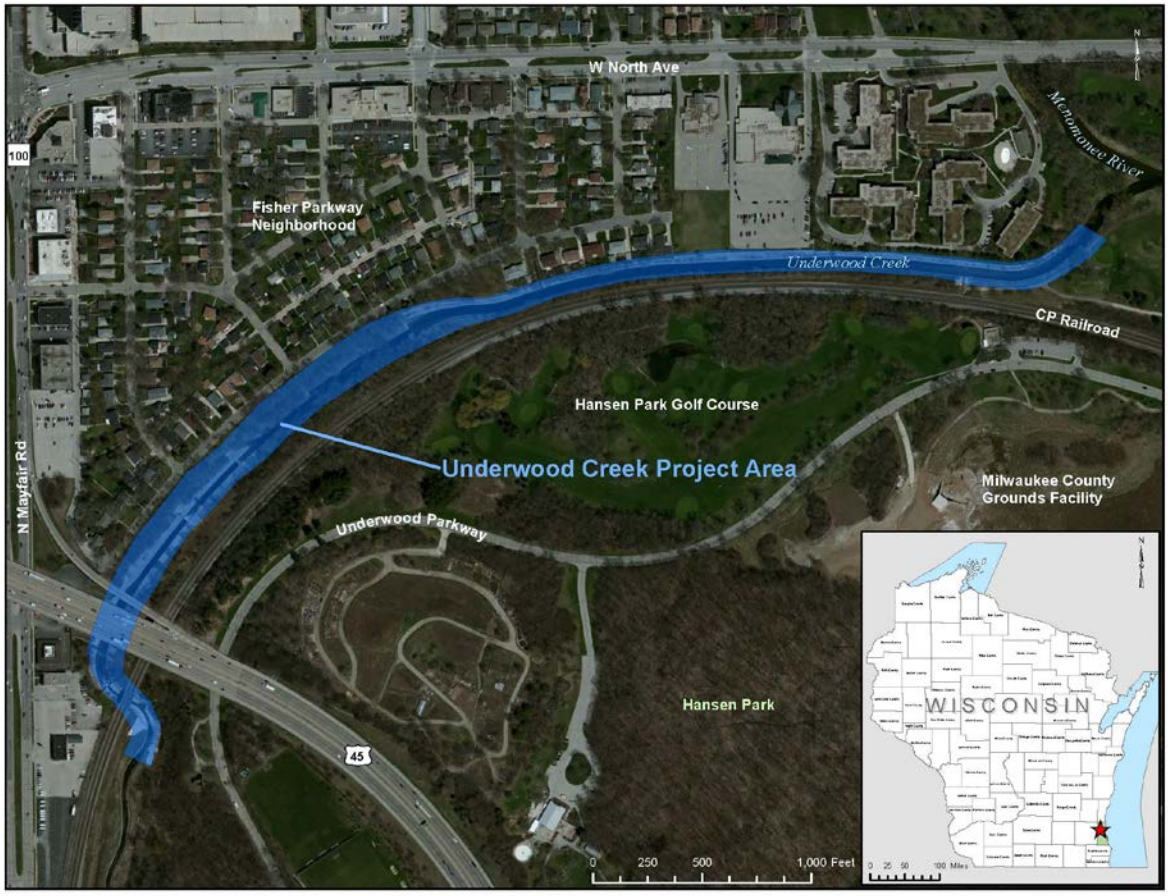
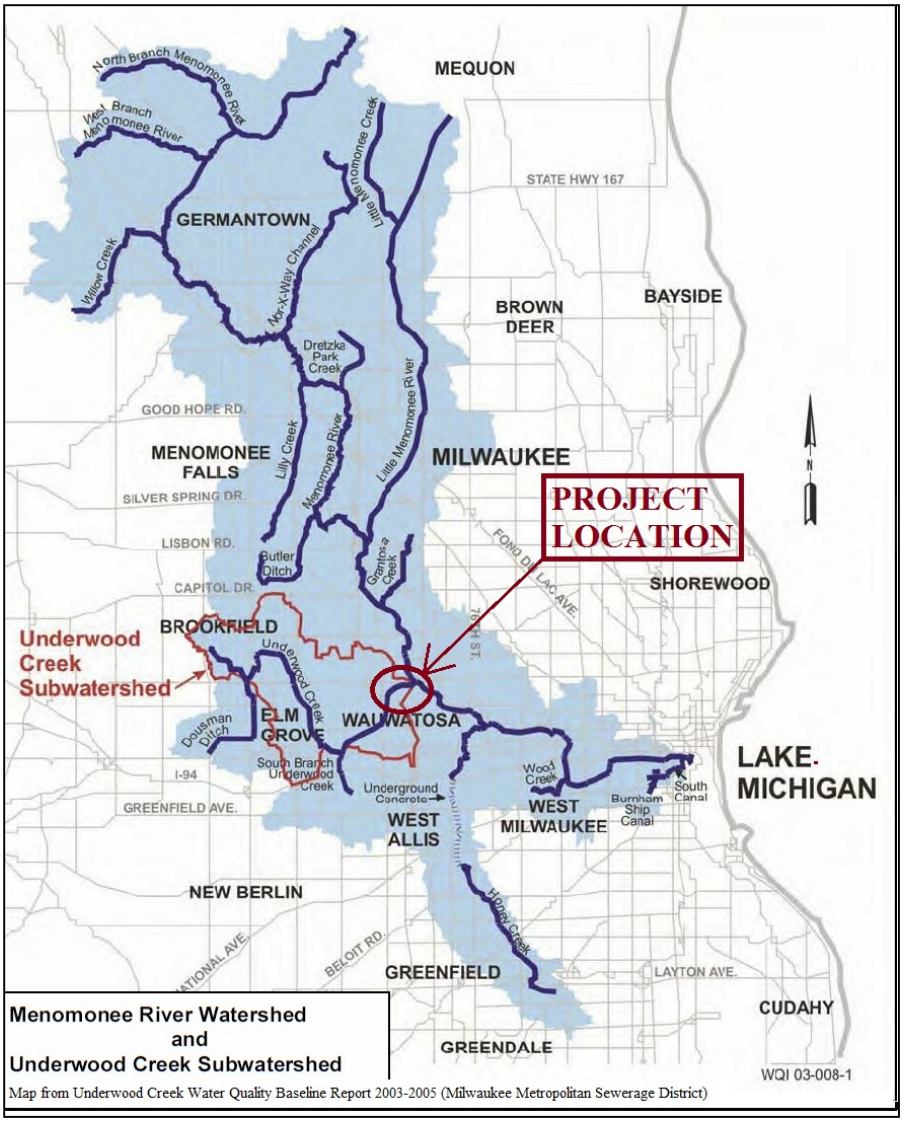


Figure 1 - Project Site

1.4 Underwood Creek and Milwaukee Estuary

Underwood Creek was historically an important regional resource which provided stream and wetland habitat for native fish. The creek is part of a large network of streams, rivers and wetlands linking the creek with the Milwaukee Estuary. This regional collection of waterways once supported the migration of potamodromous fish (migratory fishes whose spawning migrations occur entirely within freshwater) and was the foundation of a former abundant fishery.



Map from Underwood Creek Water Quality Baseline Report 2003-2005 (Milwaukee Metropolitan Sewerage District)

Figure 2 - Project Location

Metropolitan Milwaukee's transformation into an urban industrial center has had significant impacts on the surrounding ecosystem. Sediments contaminated with PCBS, PAHs and heavy metals were left behind in the estuary from twentieth century manufacturing plants. The impervious surfaces created by the development of an urban landscape reduced habitat (terrestrial and aquatic habitat) and also increased the amount of stormwater run-off.

To accommodate the increases in peak discharge, the nearby tributaries were channelized, straightened and lined with concrete. These stream modifications may have reduced area flooding; however, they eliminated in-stream habitat and disconnected estuary migration routes. Further, the estuary was identified as an area of concern (AOC) in 1987 by the International Joint Commission due to its historical modifications and contaminated sediments. Similar to other Milwaukee tributaries, Underwood Creek was straightened, lined with concrete and had several drop structures installed in the 1960s and 1970s in order to improve flood conveyance. While the creek's modifications successfully reduced flood elevations, in-stream habitat was reduced

and aquatic connectivity was severed. It is the regional accumulation of these flood management projects that has contributed to decline in the regional fishery's abundance and diversity.

1.5 MMSD Regional Restoration Initiatives

Although many of the region's streams and tributaries were channelized to reduce flooding, the continued development of the watershed resulted in even more impervious surfaces and run-off. Consequently, the benefits associated with the flood management projects built in the 1960s and 1970s were no longer being realized by the late 1990s. The same channel design for moving water quickly and efficiently was also creating a human safety hazard. As a result, MMSD and other government agencies began working together to address the safety and environmental concerns associated with the region's concrete-lined channels.

During the 1990s, flooding from the creek began to occur on the Fisher Parkway and on the Menomonee River. The region's continued urbanization, coupled with the installation of an efficient drainage system, resulted in Underwood Creek's flashiness and frequent channel overtopping. To address flood management and improve habitat along Underwood Creek, MMSD began working on a comprehensive project which included the development of a retention facility along with the possibility of channel naturalization.

In 2011, the Milwaukee County Grounds Floodwater Management Facility (MCGFMF) was completed and brought online. The facility includes a 3,000-foot-long diversion tunnel and a 315-million gallon floodwater detention basin. Since the facility's installation, floodplain impacts (100-year or 1 percent chance event) have been reduced within the project area between one to two feet. The addition of the MCGFMF has reduced peak discharges along Underwood Creek enough that MMSD was able to remove 2,200 feet of concrete channel. The removal of the concrete channel was incorporated into the MCGFMF project since friction factors, created by the removal of concrete, could be alleviated through the diversion structure. MMSD has been working closely with the Federal Emergency Management Agency (FEMA) during the planning and construction of both the MCGFMF and the creek's channel restoration. In fact, the MMSD has a Conditional Letter of Map Revision (CLOMR) for the region which includes the proposed Section 506 project.

MMSD has been actively restoring and re-naturalizing several of the region's concrete channels. Completed approximately ten years ago, a 1,000-foot-concrete reach on the Kinnickinnic River was removed and re-naturalized. This project reconnected the Kinnickinnic River to Milwaukee Estuary after being severed for roughly 50 years. MMSD is also currently restoring another two miles of concrete channel located along the Kinnickinnic River, just upstream of the 1,000-foot re-naturalized reach. Other MMSD restoration projects that have been completed or are currently being pursued include: the restoration of a two-mile concrete reach of Lincoln Creek; a grant to remove a 1,000-foot concrete migratory blockage located along the Menomonee River; the 2,200-foot upstream naturalization of Upper Underwood Creek; the Corps/MMSD feasibility study to restore aquatic habitat on the Menomonee River and the Kinnickinnic River; and the creation of estuary wetlands at the former site of the Burnham Canal. To date, the MMSD has spent

approximately $30 million dollars removing concrete along tributaries in the Milwaukee Metropolitan area.

1.6 MMSD Restoration of Underwood Creek

As previously mentioned, the rehabilitation of Underwood Creek is part of a larger comprehensive plan which also included the installation of the MCGFMF. The complete restoration of the channel called for removal of 6,600 linear feet of concrete, eliminating drop structures, and reconnecting some of the creek's former floodplain. The completion of this restoration was divided into two phases with Phase 1 being completed by MMSD in concert with the diversion structure. Phase Two, the subject of this feasibility study, includes the remaining 4,400 feet of downstream concrete channel.

Improvements completed by MMSD in the first phase of restoration involved: removal of concrete channel lining; the development of a channel with riffle and pool sequences; and the reactivation (lowering) and re-vegetation of the adjoining floodplain to improve floodplain wetland habitat. The rehabilitated channel bottom was also replaced with a stone substrate designed to provide habitat for fish and other aquatic organisms.

The construction of the MCGFMF required that wetlands be removed during the facilities construction. Consequently, the 404 permit (#2006-10-RMG) issued by the St. Paul District Regulatory Office for the MCGFMF project required that compensatory wetlands be created as mitigation for the unavoidable loss of these wetlands. MMSD has already completed some of this mitigation through their completion of the Phase 1 channel restoration while the remainder of the mitigation will be accomplished within the footprint of this proposed Section 506 channel restoration project. It should be noted that although the sponsor's wetland mitigation is located within the foot print of the Federal Section 506 restoration project, it has not been included as part of the proposed channel restoration project. This mitigation is being accomplished and paid for by MMSD adjacent to the restored channel. No Federal funds will be used to assist the MMSD in completing their mitigation requirement associated with 404 permit (#2006-10-RMG) which includes the MCGFMF project, and no credit will be claimed for the mitigation required by 404 permit (#2006-10-RMG) against the non-Federal share of the Underwood Creek Section 506 restoration project.

1.7 Prior Studies/Reports

The following studies and reports were utilized in the development of this feasibility study:

<u>USACE Reports/Studies</u>

- USACE - Detroit District (2006) *Preliminary Restoration Plan (PRP)*
  This approved PRP was completed in 2006 to determine if there was Federal interest in proceeding with a feasibility study for restoration of this reach, under the authority of Section 206.

- USACE - Detroit District (2006) *Lower Menomonee River Economic Analysis*
  The report summarizes the results of evaluating the benefits and costs of the Menomonee River Watershed project plans and was initiated to add an economic analysis to the existing report base. The report briefly summarizes the existing reports, describes key inputs and assumptions of the economic analysis (including models and methodologies employed), and benefits and costs of the proposed projects.

- USACE - St. Paul District (2006) *Department of the Army Section 404 permit issued to the Milwaukee Metropolitan Sewerage District*
  The USACE 404 permit authorizes "discharge dredged and fill material into 2.67 acres (plus an additional 0.35 acre of temporary fill) of wetlands along and adjacent to Underwood Creek and the Menomonee River."

<u>MMSD Reports/Studies</u>

- HNTB Corporation, (2006) *Final Environmental Assessment: Milwaukee County Grounds Floodwater Management Facility and Underwood Creek Rehabilitation Projects*
  As part of the Chapter 30 permit submittal, this Environmental Assessment was prepared for MMSD and Wisconsin Department of Natural Resources (WDNR) to describe the proposed MCGFMF and Underwood Creek Rehabilitation Projects. The Environmental Assessment provides concept drawings for the projects, details the ecological and cultural resources that would be impacted by the projects, as well as future social and economic impacts in relation to temporary and long term changes.

- Southeastern Wisconsin Regional Planning Commission, (2000) *Memorandum Report No. 141. Analysis of Alternative Plans for the Removal of the Concrete Lining in Underwood Creek in the City of Wauwatosa, Milwaukee County, Wisconsin*
  Prepared for MMSD, the report provides an evaluation of flood flows under existing conditions, with removal of the concrete lining and alternative measures implemented upstream of the Milwaukee/Waukesha County line.

- TetraTech, (2002) *Menomonee River Watercourse Project: Phase 2 Watercourse Management Plan, Volume I of III*
  This report was completed for MMSD to provide an evaluation of the Watercourse Management Plan (WMP) developed for the Menomonee River during the Phase I Menomonee River WMP. Project specific conceptual and preliminary engineering information and floodplain mapping results are provided in the Phase 2 WMP report.

- TetraTech, (2005) *Subsurface Investigation Report, Underwood Creek Rehabilitation and Flood Management Project. Wauwatosa, Wisconsin*
  This report was completed for MMSD as an executive summary of the Phase 2 Site Assessment Report, and the Geotechnical Report. Metals and organic compounds were found in the 15 soil borings performed in the project area. Slopes, greater than 1.5:1, were also identified in this report and would require reinforcement to remain stable.

- Camp Dresser & McKee, (2000) *Menomonee River Phase 1 Watercourse System Management Plan*
  Completed for MMSD in response to flooding events in August 1986, June 1997 and August 1998, this management plan was developed to resolve flooding problems with both immediate and long term results for watercourses within the Menomonee River watershed. The management plan was developed based on five central tasks to ensure the plan provided permanent, reliable, cost-effective, and environmentally responsible flood control.

- TetraTech, (2006) *Underwood Creek Rehabilitation and Flood Management Project: Preliminary Design Report.*
  Completed on behalf MMSD, this report summarizes the preliminary engineering (PE) design and permit ready construction drawings for the Underwood Creek Rehabilitation and Flood Management Project associated with removing concrete channel lining and drop structures along approximately 6,600 linear feet of the watercourse. The purpose of the watercourse rehabilitation is to re-establish aquatic and wetland habitat negatively affected by past creek alterations. The PE design and drawings for the Underwood Creek Rehabilitation and Flood Management Project were also developed to address environmental permit conditions associated with the MCGFMF project.

- HNTB Corporation, (2008) *Final Lower Menomonee River Watercourse Status Report, MMSD Contract No. W20017D04*
  This report was completed for MMSD to provide qualitative analysis of the potential ecological implications (i.e. improving flood management, river stability, and fish habitat) of prospective river improvement projects located within the lower Menomonee River. HNTB also evaluated how to hydraulically and ecologically integrate future watercourse projects in order to support resource objectives.

- Graef, (2011) *Final Design Memorandum, Menomonee River Stream Management, MMSD Contract No. W20021D01*
  This report includes information on several of the MMSD restoration projects completed in the watershed. Specifically, this report examines the Milwaukee County Grounds Floodwater Management Facility (MCGFMF), which lowered flood stages in anticipation of the planned restoration projects.

<u>Other Regional Reports/Studies</u>

- GESTRA Engineering, Inc., (2005) *Geotechnical Data Report: Preliminary Engineering Phase Underwood Creek Rehabilitation and Flood Management Project. Wauwatosa, Wisconsin*
  This study was completed for TetraTech to support the Phase 1 and Phase 2 Environmental Site Assessment performed for the preliminary engineering phase of the Underwood Creek Flood Management Project. Fifteen soil borings were performed (12 within the concrete channel and 3 in the overbank area).

- Wisconsin Department of Natural Resources, (2006) *WDNR Chapter 30 Permit (#IP-SE-2005-410821-827, 857, 882-883) issued to the Milwaukee Metropolitan Sewerage District*
  A copy of the permit issued under Section 30.12(1), 30.123(8), 30.18, 30.20, 281.15, 281.36, 401 CWA, Wisconsin Statutes, to place a structure on the bed of Underwood Creek, to place culverts on the bed of an unnamed tributary to the Menomonee River, a water quality certification for isolated and federal wetlands, and a permit to divert water from Underwood Creek. This permit also includes a second phase of the project that would rehabilitate Underwood Creek and grants a permit to install riprap and other shore protection measures (bioengineering) on the shoreline of Underwood Creek, and to remove materials from the bed of Underwood Creek. All work under this permit would be completed on Underwood Creek, an unnamed tributary to the Menomonee River and wetlands located in the City of Wauwatosa, Milwaukee County, also described as Sections 20 and 21, T7N, R21E.

- Ecological Services of Milwaukee, Inc., (2007) *Site Plan for Underwood Creek Wetland Mitigation Project, Milwaukee County*
  This plan was prepared for Short Elliott Hendrikson to provide monitoring and management guidelines for the Underwood Creek Wetland Mitigation Site to ensure the goals and objectives are met within the required 7-year monitoring period. This mitigation project, proposed in a section of the Underwood Creek floodplain, would compensate for unavoidable impacts to wetlands as a result of the construction of the MCGFMF project.

- United States Geological Survey, (2007) *Biological Water-Quality Assessment of Selected Streams in the Milwaukee Metropolitan Sewerage District Planning Area of Wisconsin, 2007*
  Algal, invertebrate, and fish assemblages were sampled at 14 stream sites in the Milwaukee area. Metrics were calculated from biological assemblage data from each group. The data for algae, invertebrates, and fish were combined to calculate an aggregate bioassessment ranking. Results from Underwood Creek ranked the stream among those with the most degraded water quality.

2.0 EXISTING CONDITIONS

2.1 Cultural Resources

The Milwaukee region was originally inhabited by a number of different Native American tribes including: the Fox, Mascouten, Potawatomi, and Ho-Chunk (Winnebago). French missionaries and traders were the first Europeans to pass through this area in the late 17th and 18th centuries. A fur trading post was established near the Menomonee River in 1795 and eventually moved to the eastern bank of the Milwaukee River in 1825. This post soon attracted settlers from the eastern United States and Europe, particularly Germany. Settlement and development steadily occurred as villages and suburbs became incorporated with Wauwatosa recognized as Milwaukee's first "bedroom suburb". Because of its easy access to Lake Michigan and other

waterways, Milwaukee's Menomonee River Valley has historically been home to manufacturing, stockyards, rendering plants, shipping, and other heavy industry[1].

2.2 Socioeconomic Setting

The reach of Underwood Creek proposed for rehabilitation in this DPR, is located within the City of Wauwatosa, on the west side of Milwaukee County. According to the 2010 Census, the city has an estimated population of 46,400 people living in approximately 20,400 households. In comparison to the rest of the county and state, a greater proportion of Wauwatosa's residents are over the age of 65. The median household annual income is approximately $67,130; approximately 95 percent of Wauwatosa families are above the poverty level. The median household income for Wauwatosa residents was between 20 to 25 percent higher compared to the median household income of other county and state residents.

2.3 Physical Conditions

2.3.1 Physiography

The study area is situated within the Kettle Moraines, a subset of the Southeastern Wisconsin Till Plains Ecoregion. The Southeastern Wisconsin Till Plains ecoregion encompasses most of southeast Wisconsin, beginning just north of Green Bay, extending to Madison and the Illinois border, then extending east and north along the coast of Lake Michigan, but not including the Central Corn Belt Plains region around Kenosha. Representing a transition between the hardwood forests and oak savannas of the ecoregions to the west and the tall-grass prairies of the Central Corn Belt Plains to the south, the Southeastern Wisconsin Till Plains ecoregion supports a myriad of vegetation types. Land use in the Southeastern Wisconsin Till Plains is mostly cropland, historically forage and feed grains to support dairy operations, and has a higher plant hardiness value than ecoregions to the north and west. The Kettle Moraines sub-ecoregion contains a higher concentration of lakes with lower overall biomass weights than in the rest of the ecoregion[2]. Soils of the ecoregion are clayey to the east and sandier to the west. This sub-ecoregion also contains extensive end and ground moraines and pitted outwash with belts of hilly moraines[3].

2.3.2 Climate

As is typical in the Great Lakes Region, Milwaukee is susceptible to rapidly changing weather and experiences a humid continental climate with windy, cold, snowy winters and very humid, warm summers[4]. Milwaukee has the second-coldest average annual temperature of the 50 largest US cities, next to Minneapolis. Average winter lows are in the teens Fahrenheit (F) with average summer highs in the high 70s (F). On average, Milwaukee receives 31.5 inches of precipitation annually at Mitchell Airport. Rainfall is variable throughout the year, although rare

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[1]Milwaukee County Historical Society, http://www.milwaukeehistory.net/ (September 2011)
[2] U.S. Environmental Protection Agency, http://www.epa.gov/wed/pages/ecoregions/wi_eco.htm (September 2011).
[3] USDA Natural Resources Conservation Service, http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm (September 2011).
[4] Wisconsin State Climatology Office, http://www.aos.wisc.edu/~sco/ (September 2011).

during winter months. Long rain events from frontal systems are typically uncommon during summer months as shorter thunderstorms are the main precipitation events from May until September. Snow falls regularly from late November until early March. With an annual average snowfall of 52.4 inches; much of this snow is due to the lake effect produced by Lake Michigan.

2.3.3 Geology

Most of present-day Wisconsin was buried under an ice sheet during the glacial period. Glaciation divided Wisconsin into two distinct geographic provinces: the Driftless Area, which escaped glaciation during the last glacial period and is known for its deeply carved river valleys, and the Glaciated Region. Underwood Creek lies in the Glaciated region in the Eastern Ridges and Lowlands, which is mostly a plain. Dominant features in this plain are more than 1,400 oval drumlins (elongated hills) of glacial till in southeastern Wisconsin. Soils that formed over this glacial till were derived from glacial deposits, decomposed vegetation, and silt.

2.3.4 Soils

According to the current Milwaukee and Waukesha County Soil Survey from the US Department of Agriculture, Natural Resources Conservation Service, the majority of the project site is made up of Loamy land (loamy mine spoil or earthy fill) at 40 percent and Matherton silt loam (loamy glaciofluvial deposits over stratified sandy and gravelly outwash) at 47 percent. Loamy land is predominately located in the lower and middle reaches of Underwood Creek, while Matherton silt loam is focused in the middle to upper reaches. The soil types are generally located along gently sloping areas with the majority of soils on the site consisting of somewhat poorly drained loamy over sandy soil. The parent material of Loamy Land is loamy excavation spoils earthy fill and has a depth to water table of 12-80" with a soil profile of 0-10" of loam. The parent material of Matherton Silt Loam consists of loamy glaciofluvial deposits over stratified sandy and gravelly outwash with a depth to water table of 12-24" and a soil profile of 0-11" silt loam and 11-35" sandy clay loam[5]. Remaining soil types found on site are Casco loam (loamy alluvium over stratified, calcareous sandy and gravelly outwash), Fox silt loam (loess over loamy alluvium over calcareous sandy gravelly outwash), Ozaukee silt loam (loess over calcareous clayey till), and wet alluvial land (alluvium). Soil types immediately adjacent to the project reach include Loamy Land, Ozaukee silt loam, Casco loam, Fox silt loam, and Matherton silt loam.

2.3.5 Channel Morphology

A 1962 plan view of Underwood Creek shows a sinuous stream with the downstream reach located on the south side of the CPR (Figure 3). After the majority of the stream was realigned, channelized, and widened in the 1960s and 1970s, the overall gradient was increased. The current alignment includes a large curve with smaller curves at the upper and lower portion of the project reach. The concrete channel walls are approximately seven inches thick and have slopes 2:1 concrete side slopes.

[5] USDA Natural Resources Conservation Service, http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm (September 2011).

Glide habitat, defined as little to no turbulence and low/moderate velocities, is the primary type of habitat found in the creek since the natural pools/riffles were eliminated through the installation of concrete. Wood debris is not present in the reach since the channel's design is to move water swiftly and efficiently.

Channel Segments

Channel dimensions (width, slide slopes, etc.) vary substantially throughout this 4,400-foot concrete reach. As a result, the channel is broken down into six separate segments (1a through 5) which are defined by their differing floodplains, side slopes and overbank areas. Figure 14, provides a downstream plan view of these segments and includes River Mile (RM) markers.

2.3.5.1 Segment 1a

Segment 1a is the most downstream portion of the proposed project and begins at the confluence of Underwood Creek and the Menomonee River. Notably, this portion of the project reach is naturalized and does not include any of the concrete channel. This segment is roughly 250 feet in length and is the transition area between the concrete channel and the more natural, unlined section of the Creek. Although this portion of the creek is natural, the concrete channel upstream has negatively impacted the hydrologic function of the creek and has left behind a channel bottom with varying gradient. Near the upper end of this stream segment, the channel exhibits some bank erosion and includes a large scour pool associated with hydraulic expansion forces as storm flows exit the concrete-lined reach.

The channel near the downstream end of this segment exhibits an intact wooded floodplain (Figure 4). Channel morphology appears to be highly influenced by the Menomonee River, as this segment of Underwood Creek is within its floodplain. Although there is no drop structure in this reach, it is the first point in the channel where upstream-migrating fish encounter the exposed concrete channel. As such, the beginning of the concrete channel is the first deterrent to fish migration and, therefore, inhibits longitudinal connectivity.

2.3.5.2 Segment 1b

Beginning at the end of Segment 1a, Segment 1b extends upstream approximately 1,945 feet (existing STA 10+49 to 29+94) and is highly constrained on both the north and south sides of the channel. To the north, there is a mix of residential (single and multifamily) and commercial (church) development. The Fisher Parkway also runs along the north side of the channel. Hansen Golf Course and the CPR corridor are located immediately adjacent to the south side of the channel. Figure 5 depicts a typical reach in Segment 1b. The channel dimensions consist of a 30-foot bottom width, 68-foot top width, and 2:1 (horizontal to vertical) side slopes. In addition, there is a 3.5-foot high cracked and failing concrete drop structure located within this segment (Figure 6).

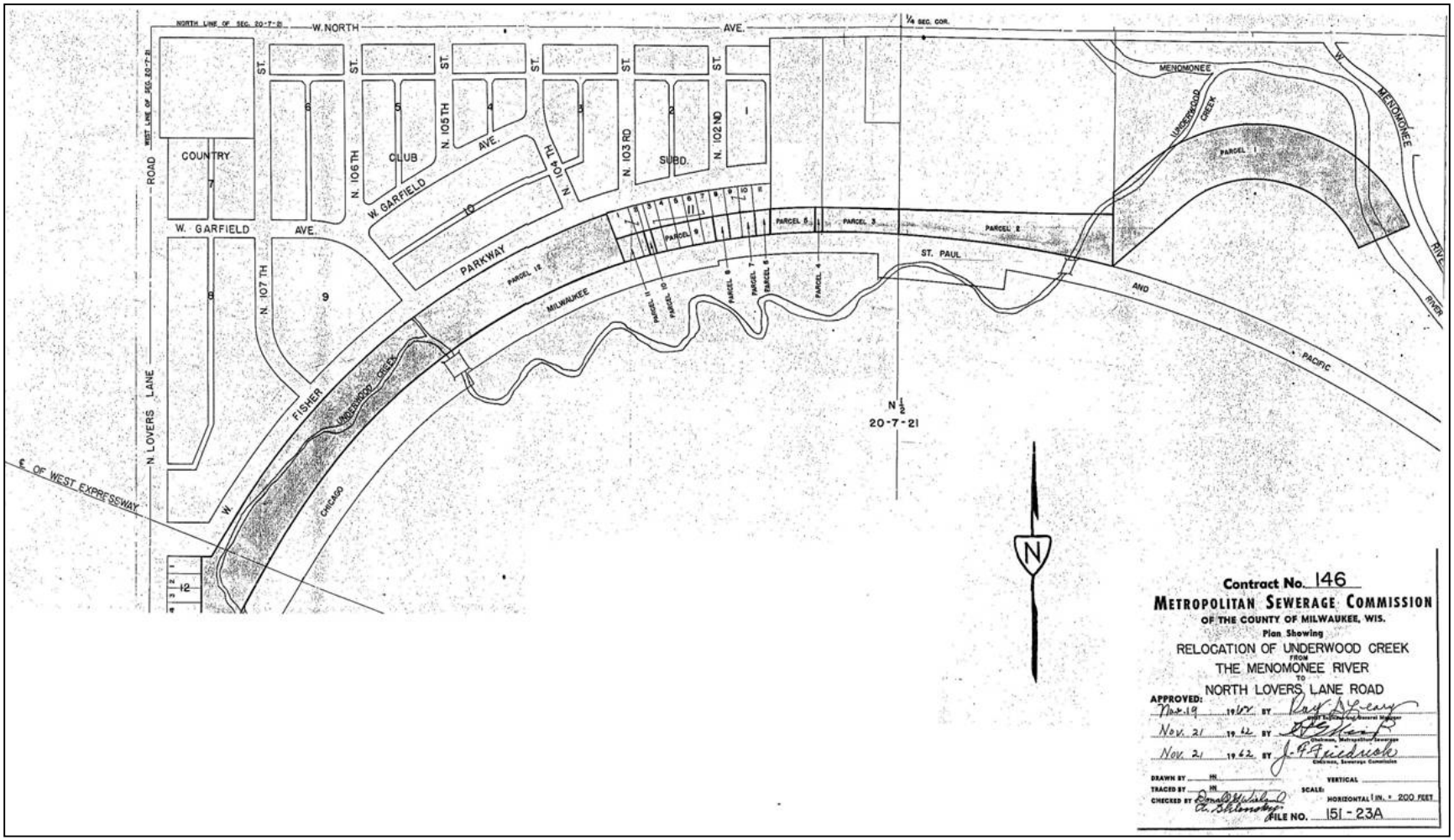

Figure 3 – Underwood Creek Before Concrete Channel Realignment

Figure 4 – Downstream View of Underwood Creek Segment 1a

Figure 5 – Upstream View of Segment 1b

Figure 6 – Segment 1b Drop Structure

2.3.5.3 Segment 2

Compared to the previously discussed segments, Segment 2 is shorter in length and extends upstream approximately 323 feet (STA 29+94 to 33+17). This is a transitional segment that includes a sweeping curvature in the channel. The segment is less constrained than Segment 1b and, thus, the channel banks are wider and flatter (Figure 7). Notably, the channel's width varies substantially throughout this segment.

2.3.5.4 Segment 3

Segment 3 extends upstream 1,320 feet (existing STA 33+17 to 46+37) and ends just downstream from the U.S. Highway 45 Bridge. Located within this segment are three concrete drop structures which are: 0.5 feet (Figure 8) high, 1.9 feet high and 4.0 feet high, respectively (Figure 9). The concrete channel within Segment 3 is a 20-foot wide shallow U-shaped channel, with a six-inch vertical rise on the channel perimeter, which is unique when compared to other concrete-channel cross-sections in the study area (Figure 10).

Adjacent to the channel banks, within Segment 3, is a broad-vegetated floodplain. These areas are extensively eroded due to overtopping of the channel during past storm events. The total channel and floodplain top width in Segment 3 is approximately 150 feet, with the floodplain areas having approximately 6:1 side slopes. Fisher Parkway is located to the north of the project area and the CPR corridor is located to the south.

Figure 7 - Upstream View of Segment 2

Figure 8 - Drop Structure (0.5') in Segment 3

Figure 9 - Segment 3 Drop Structures (1.9-foot foreground, 4-foot background) and HWY 45 Bridge

Figure 10 – Segment 3 Floodplain

2.3.5.5 Segment 4

Segment 4 is 414 feet long (existing STA 46+37 to 50+51) and extends from the downstream face of the U.S. Highway 45 Bridge to the downstream face of the CPR Bridge. Approximately one half of this channel segment is located beneath the U.S. Highway 45 Bridge (Figure 11). This segment also contains a 90 degree right bend, just downstream of the CPR Bridge. Segment 4 includes a 1.9-foot high concrete drop, located approximately 67 feet downstream of the CPR Bridge (Figure 12).

2.3.5.6 Segment 5

Segment 5 is located at the upstream-most end of the project site and is the shortest (149 feet, existing STA 50+51 to 52+00) of the channel segments. The segment starts at the downstream face of the CPR Bridge to end at the downstream end MMSD's restoration project. Thus, this segment of the project reach ties-in with the recently completed MMSD restoration project (Figure 14). The portion of channel located beneath the CPR Bridge is approximately 20-feet wide, has vertical side slopes, and extends to the bridge piers. Located within this segment is a trapezoidal-shaped concrete inset which was installed to allow the MMSD restoration project to properly discharge (downstream) into the existing concrete channel.

Figure 11 –Downstream View of Segment 4 Underneath HWY 45

Figure 12 - Upstream View of Segment 4 and Drop Structure

Figure 13 – Upstream View of Segment 5

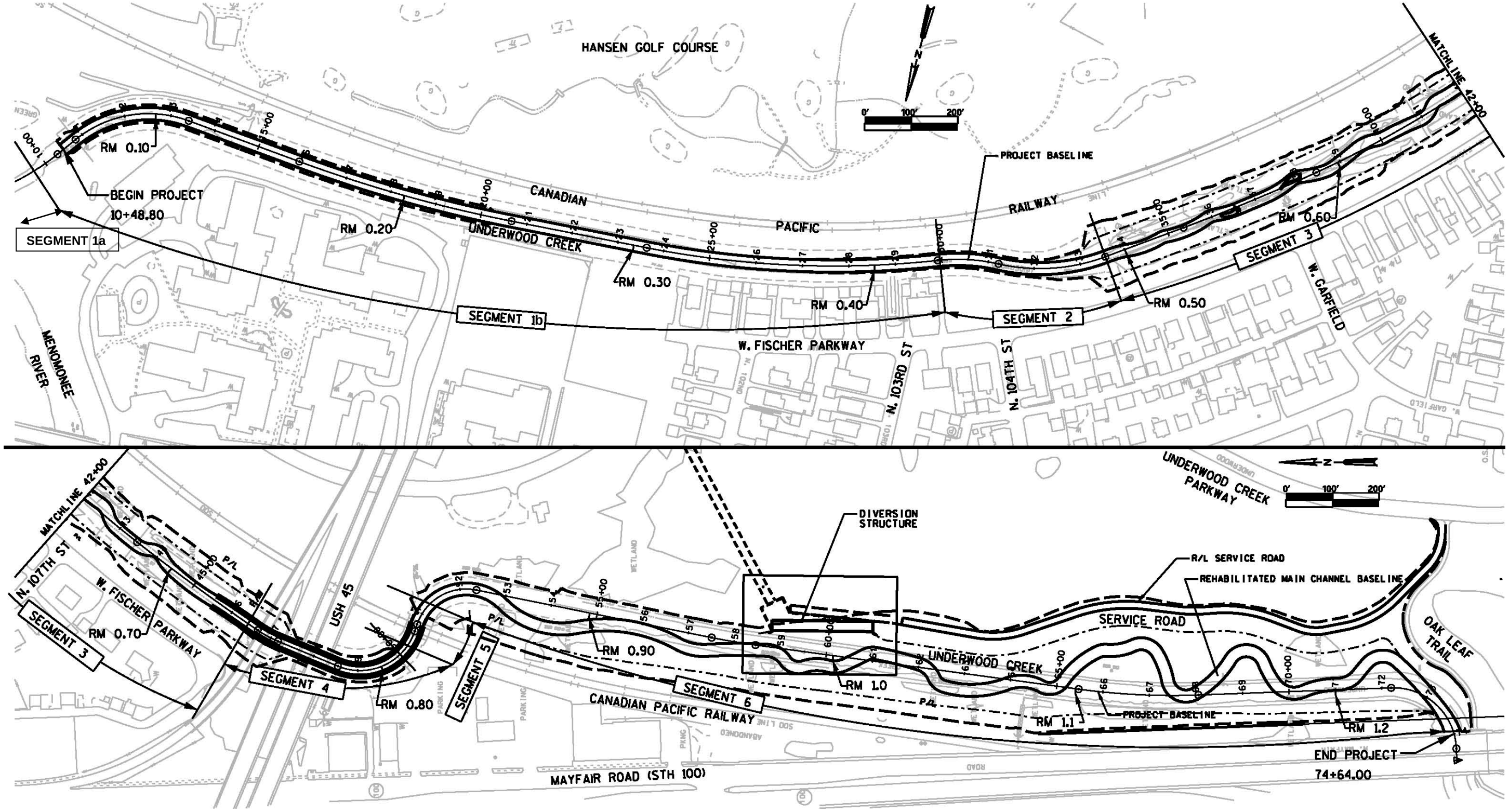

Figure 14 – Downstream View of Underwood Creek Segments 1a through 5

2.3.6 Hydrology & Hydraulics

Hydrology in the Underwood Creek watershed has been substantially altered from pre-development conditions. This watershed is highly urbanized and the installation of efficient drainage systems moves water rapidly through the basin. Based on stream gage data from USGS 04087088, Underwood Creek at Wauwatosa, WI, monthly flows through the project area can range from an average of approximately 10 cubic feet per second (cfs) in the winter to over 20 cfs during spring.

Table 1 - Underwood Creek - Storm Event Discharges

Description	Station	River Mile	Discharges (cfs)			
			50%	10%	2%	1%
Upstream of MCGFMF	60+71	1.011	1,650	3,570	5,800	6,910
Downstream of MCGFMF	58+00	0.960	1,650	2,290	2,860	3,080
Near Upstream Limits of Study Reach	46+40	0.740	1,660	2,680	3,500	3,840
Large Box Culvert at 103rd Street	28+80	0.41	1,770	3,010	4,100	4,570

As previously mentioned, the MCGFMF is located just upstream of the project reach. This structure diverts flows to the detention basin beginning at the 10-percent-annual-chance storm event and has been designed to reduce the 1-percent-annual-chance storm event by over one-half its volume. Prior to the installation of the MCGFMF, Underwood Creek frequently overtopped its banks, flooding the surrounding area (Fisher Parkway and Menomonee River). Consequently, the rehabilitation of Underwood Creek would not have been be possible without the retention facility because the roughness of a restored channel would have added to flooding problems already occurring along the channel.

The MMSD has a regional CLOMR which includes the restoration of this portion of Underwood Creek. In other words, FEMA has already reviewed and commented on the proposed project. Upon the review of the CLOMR, FEMA concluded that the MCGFMF would be required if any channel restoration was pursued on the creek. Additional information pertaining to the existing channel's hydrology and hydraulics is provided in Appendix B – Hydrology and Hydraulics.

2.3.7 Sediment Transport

In 2005, the non-Federal sponsor, MMSD, conducted an evaluation of sediment transport upstream in the reach. This study indicated that primarily gravel (approximate median particle size of 20mm) is being entrained and delivered to the proposed project reach. However, it is important to note that no deposition occurs within the project reach, as particles are easily transported downstream through the concrete channel. The full existing conditions hydraulic and sediment transport analyses are provided in Appendix B.

2.3.8 Water Quality

The MMSD Water Quality Research Department developed a Water Quality Index (WQI), based on established water quality criteria, to evaluate water quality in rivers and creeks. Eleven variables are calculated and values translated into six overall rankings; excellent, good, fair, bad, very bad, and worst water quality. Seven different sites were sampled by MMSD's Water Quality Department between 2003 and 2005. Notably, one of these seven sites is located within the project reach, at 109th Street and the Fisher Parkway. Using their Water Quality Index (WQI), this site received a "fair" reading in both 2003 and 2004 and a "bad" reading in 2005. Most of the other sites fell into the "fair" and "bad" ranges with most of the sites receiving lower scores in 2005 than previous years. The sub-indices typically ranked as "bad" and contributing to degraded water quality were total phosphorus, fecal coliform, and chlorides (MMSD, 2008).

Wisconsin Warm Water Quality Standards require a minimum of 5 mg/l of dissolved oxygen for warm water streams. This is the minimum dissolved oxygen level necessary to support aquatic life in warm water streams. Underwood Creek meets these standards between 50-80 percent of the time (HNTB, 2006 and references therein). In addition, the US Environmental Protection Agency recommends upper nutrient limits for water quality criteria for this ecoregion at 1.59 mg/L for nitrogen and 0.08 mg/L for phosphorus. Underwood creek is meeting the nitrogen requirements at least 85 percent of the time and the phosphorus requirements less than 50 percent of the time.

The existing concrete channel is susceptible to high thermal loading, causing water temperatures to be elevated above natural conditions during the summer months. This situation results from the general lack of shade by riparian trees; the conditions of wide, shallow sheet flow; the heat-absorption capacity of concrete, and the lack of groundwater/surface water (hyporheic) exchange.

2.3.9 Utilities

Utilities in the vicinity of the project site include: an abandoned sanitary sewer and an existing 48-inch Metropolitan Interceptor Sewer (MIS) crossing. The sanitary sewer is no longer in service. The 48-inch MIS pipeline parallels the channel for approximately 500 feet downstream from the Fisher Parkway and then crosses beneath the channel. A buried electric line also runs parallel to the existing concrete channel in Segment 1b.

2.4 Ecological Resources

Due to the confined, narrow, and disturbed nature of the riparian corridor and concrete stream channel, the area is fairly limited in biodiversity. WDNR designated this reach of Underwood Creek for special variance use, meaning that it is unable to support full warm-water fish communities. Fish surveys have shown relatively little fish abundance and diversity with pollution tolerant fish species being the predominant species observed (HNTB, 2006 and references therein). More importantly, the existing concrete channel is ecologically severed from the network of streams and rivers which connect the creek to the estuary and provide important migration routes.

2.4.1 Vegetation

The vegetation on the slopes, beyond the concrete channel, consists of a severely narrow and degraded riparian area. Residential development and flood control activities have resulted in clearing of most riparian habitat at this site, leaving a discontinuous community concentrated along the stream terrace beyond the concrete channel. This community consists of primarily mown turf areas, and narrow riparian wooded banks. Several areas along the stream lack a shrub and canopy layer entirely. Segment 3 is the only stream reach that is somewhat connected to a broad, partially wooded floodplain. The segment contains a mix of young trees and open shrub areas that appear to be in a state of recovery from past disturbance, and/or maintenance. Dominant shrubs in this area are common silky dogwood (*Cornus amomum*) and buckthorn (*Rhamnus cathartica*), while dominant trees are box elder (*Acer negundo*), sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), and American elm (*Ulmus americana*).

The south bank of Underwood Creek is paralleled by railroad tracks and has a riparian buffer width ranging from approximately 30-100 feet. On the north bank of Underwood Creek, the riparian buffer is restricted by development and roads, which reduce its width down to approximately 0-75 feet.

2.4.2 Wetlands

There are two wetlands within Segment 3 of this project reach which are found on the north and south sides of the channel. These wetlands are located within the boundaries of the MMSD mitigation requirement. More specifically, these existing wetlands are slated for removal and would be replaced by MMSD as required by their 404 permit.

2.4.3 Fish and Wildlife

Much of the landscape in the project reach has been considerably disturbed and contains low animal and plant diversity. The project reach contains a mix of wildlife including song birds, waterfowl, pheasant, muskrat, squirrel, and deer.

As with the terrestrial species, the fish community in Underwood Creek is also lacking diversity and indicates continued disturbance. In 1973, the WDNR conducted a fish population inventory on Underwood Creek between U.S. Highway 45 and the confluence with the Menomonee River. Of the four species collected in this study, three are considered pollution tolerant. A more recent fish survey was conducted by staff from the University of Wisconsin-Milwaukee Stream Ecology Laboratory in 2002. A total of 11 species were identified at the confluence with the Menomonee River, while just six species were identified upstream within the concrete reach.

The USGS also evaluated fish communities in lower Underwood Creek and the Menomonee River in 2004 and 2007. They identified 12 species in Underwood Creek. Based on the fish community structure, Index of Biotic Integrity (IBI) scores for Underwood Creek were listed as “very poor” (10) in 2004 and “fair” (37) in 2007. Overall, the concrete-lined channel portions of Underwood Creek tended to have lower fish abundance and diversity compared to more natural channel reaches of the creek. In addition to fish communities, the USGS also evaluated the benthic macroinvertebrate community in Underwood Creek in 2007. Midges and aquatic worms,

which are indicators of poor water and sediment quality, were the dominant groups collected. The creek received a narrative HIBI rating of “fairly poor” (USGS, 2007).

2.4.3.1 Aquatic Migratory Barriers

As noted earlier, MMSD has already or is in the process of removing all the barriers located downstream of the project reach. The most difficult reach along the Menomonee River is within a section of concrete channel beginning immediately downstream from the Interstate I-94 overpass in Milwaukee and extending upstream approximately 3,700 feet. Within this section of channel, a 1,000-foot portion is scheduled for removal in 2013 and the remaining portion of the reach is currently being evaluated as a Corps Section 206 project.

There are three additional concrete drop structures and concrete channel segments located on Underwood Creek, upstream from the project limit, which block access to another 400 acres of floodplain wetland in the upper watershed. The first is located shortly upstream of MMSD’s completed restoration project and the remaining two drop structures are located on the South Branch of Underwood Creek. MMSD plans to establish fish passage by creating a low-flow channel around these stream obstructions or may remove the channel entirely. Recently, the MMSD has requested the assistance of the USACE and a reconnaissance study has been initiated to investigate removal of these upstream obstructions.

3.0 FUTURE WITHOUT-PROJECT CONDITIONS

Without implementing the proposed project, the concrete channel and drop structures on Underwood Creek would remain in place. The watercourse would not provide the beneficial ecosystem services associated with natural channels and migratory fish would remain severed from upstream habitat. MMSD’s rehabilitated reach would remain disconnected from the Menomonee River and would not benefit from the ongoing fish passage and restoration efforts being performed downstream of the project area and new projects planned upstream. Fish and other aquatic creatures would continue to be swept downstream from the project reach during peak flows. The poor aquatic habitat provided by the homogeneous concrete surface would also continue to limit fish and macroinvertebrate communities within the channel.

4.0 PLAN FORMULATION

4.1 Problems

The concrete channel provides minimal beneficial ecosystem services commonly associated with natural channels. Below is a bulleted list of problems identified during this feasibility study:

- Five concrete drop structures within this reach limit the passage of aquatic organisms from the Menomonee River to upstream reaches of Underwood Creek.

- High velocities of water impede upstream migration of certain "slow" swimming species of fish that are unable to overcome the velocity of peak flows.

- The homogeneous concrete channel surface provides no habitat variability and limits colonization by diverse fish and macroinvertebrate communities.

- Sediments and nutrients are rapidly transported through the concrete channel and exported to downstream reaches.

- Often physiochemical parameters, such as dissolved oxygen or phosphorus, do not meet water quality standards.

- Seasonal dryness leads to stagnate water conditions and elevated temperatures.

- Existing concrete channel requires expensive routine maintenance due to its age.

4.2 Opportunities

Ecosystem restoration projects must examine the condition of the existing ecosystems, or portions thereof, and determine the feasibility of restoring degraded ecosystems to a more natural condition. Opportunities have been identified to restore stream connectivity and improve in-stream habitat on Underwood Creek. Below is a list of specific opportunities identified in this study:

- Provide fish passage through the lower portion of Underwood Creek, which would act in concert with the other fish-passage restoration efforts occurring within the watershed.

- Decrease peak velocities within the channel that impact “slow” swimming fish species.

- Re-establish natural riverine functions of sedimentation, erosion, hydraulic forces and hydrologic fluctuations.

- Improve richness and abundance of native fish species and other aquatic creatures.

- Improve water quality (temperature and dissolved oxygen) incidentally through habitat restoration.

- Decrease the maintenance costs associated with maintaining the existing concrete channel.

- Assist with improving the overall health of the estuary and AOC.

4.3 Constraints

Project constraints were identified and evolved during the planning process through discussions with project stakeholders.

- Channel capacity must be maintained up to a one percent chance flood event (or 100-year event).

- Physical constraints along the Underwood Creek watercourse limit the methods and/or designs used for channel restoration.
- The narrow corridor in the downstream end of the channel also presents stability and constructability concerns given that temporary embankment instabilities could develop during the construction of the proposed improvements.
- Channel must be designed to withstand erosion and undermining.

4.4 Objectives

The overall goal of the Underwood Creek 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, the public involvement process, site assessments, review of prior studies and reports. The specific objectives for the proposed restoration within the project area are:

- Improve in-stream habitat for various aquatic species, over the period of analysis (50 years).
- Enhance natural stream substrate within the project reach, which would support a complex habitat for aquatic macroinvertebrate community, within the period of analysis (50 years).
- Provide passage for migratory fish traversing from Lake Michigan up through the network of streams and rivers, within the period of analysis (50 years).
- Provide connectivity between the Lower Menomonee River and the recently restored MMSD reach by 2016.
- Improve stream habitat by providing 40% to 60% pool habitat and riffle to riffle ratios of less than 10, and pool depths of greater than one meter over the period of analysis (50 years).
- Reduce in-stream velocities in order to improve fish passage over the period of analysis (50 years).

4.5 Management Measures

Management measures are the “toolbox” used for the development of each alternative and are designed to address specific planning objectives. They can be a physical feature, an activity, or some combination of the two implemented at a specific geographic site to solve the planning problem. This study considers five specific measures in the formulation of plan alternatives. These measures include:

- Concrete Removal: The majority of the concrete channel bottom and some of the concrete banks would be removed throughout the channel. Due to stability and constructability constraints, specific sections of both the concrete channel bottom and banks would not be removed.

- Channel Slope Modification: The channel's slope must be modified once drop structures are removed. In order to maintain the existing flood management provisions, the slope of the channel must be re-graded so that water moves through the channel at a rate that does not create a backwater effect and/or allows the channel to remain stable.

- Channel Bottom: Once the existing concrete is removed, the channel bottom would be lined with limestone approximately three feet deep which would form the substrate. The addition of the stone would also reinforce the channel bottom and re-establish dynamic channel processes of sediment transport and deposition.

- Riffle and Pool Sequence: Riffles and pools would be constructed within the main channel to improve in-stream habitat and provide resting and forging places for a variety of aquatic species. The riffle/pool sequence would be designed to create velocities within the channel that align with the swimming capabilities of native fish.

- Channel Sinuosity: Meanders slow down water moving through a channel, but also create a back-water effect. Some sinuosity would be added to the channel to promote slower velocities for aquatic organisms.

- Low Flow Channel: A low-flow channel would be incorporated into the channel's bottom to consolidate the volume of water during seasonal dry spells or low flow conditions. By condensing the limited volume of water, the necessary depths needed to support aquatic life for several fish species can be achieved.

4.6 Alternative Plans

MMSD completed an extensive feasibility study during the planning phase for the MCGFMF and 6,600-foot concrete restoration project (restoration Phases 1 and 2). More specifically, the MMSD study examined various alternative designs and their impacts on the existing flood provisions. All of the alternatives evaluated in the MMSD study would have provided habitat improvements and stability; however, only one of the alternatives would have maintained flood conveyance requirements. The design elements from this remaining alternative were utilized in the development of alternatives in this proposed Section 506 study.

The constraints of infrastructure, private properties and urban hydrology preclude the creation of a "natural channel design" within this reach of Underwood Creek. The action oriented alternatives, Alternatives 2 and 3, represent "naturalized" systems in that they provide functions associated with natural channels, yet some engineered characteristics have been maintained. Given the variability in channel dimensions, both action-oriented alternatives are presented on a segment-by-segment basis in an effort to provide clarity to each of the proposed plans.

4.6.1 Alternative 1: No Action

This alternative assumes that no restoration project would be implemented by the Federal Government or the sponsor. With this No Action alternative, the concrete channel and drop structures would remain within this segment of Underwood Creek.

4.6.2 Alternative 2: Naturalized Channel with Floodplain Improvements Upstream

This alternative combines the following measures in its design: concrete removal, channel slope modification, limestone bottom, riffle/pool sequence, and low-flow channel. Alternative 2 is broken down into its respective segments so that details associated with the plan are easier to understand.

Segment 1a

The majority of this segment would not be rehabilitated since it is already naturalized.

Segment 1b

Concrete from the channel bottom and a 3.5-foot drop structure would be removed and replaced with a limestone bottom. The channel's slope would be slightly modified and a riffle and pool sequence would also be incorporated into the channel's design along with an in-set low-flow channel. This low-flow channel would have a top width of 7.5 feet, a bottom width of 3 feet and depth of less than a foot (Table 2). Dimensions of the main channel would consist of: a 30-foot top width, nearly an 18-foot bottom width, and an average channel depth of 2.57 feet (Table 2). In addition, the main channel's design is hydraulically sized so that the actual channel is exceeded on average between 12 and 16 times per year. This overtopping is important for ensuring that any adjacent floodplains remain hydrologically connected.

The concrete side slopes throughout this segment would not be modified. Those concrete slopes that are in good condition would remain in place and any deteriorated slopes would be replaced with new concrete banks/side slopes. To provide channel stability and prevent incision, a SSP wall, 2,100 linear feet in length, would be installed on both sides of the channel. A concrete-block retaining wall would be anchored at the toe of the banks to further ensure slope stability.

Segment 2

Consistent with Segment 1b, this segment would call for: removal of the concrete channel bottom, slight modification in the channel slope, the addition of a main channel riffle/pool sequence, inclusion of an in-set low-flow channel within the main channel, a limestone channel bottom, and new or modified concrete side slopes. Both the main channel and low flow channel dimension would remain fairly consistent with Segment 1b (Table 2).

The SSP and concrete-block wall, installed in Segment 1b, would also continue into Segment 2. The SSP and concrete block wall would be 2,100 feet long, spanning both segments, and would be placed on both sides of the channel.

Segment 3

The concrete channel bottom would also be removed in this segment and would have most of the same design elements incorporated into the rehabilitated main channel as those presented in the previously mentioned segments (1b-2). These design elements include: a limestone channel bottom, a main channel riffle/pool sequence, and an in-set low flow channel. Table 2, provides information pertaining to the rehabilitated channel's dimensions which are consistent with the other two previously mentioned segments. Three concrete drop structures 0.5, 1.7 and 4.0 feet in height, respectively, would also be removed during the concrete channel's demolition.

Segment 3's adjacent floodplain would be increased to a width of 86 feet in order to provide additional flood storage during peak flows. In addition, the channel in the downstream portion of this segment would have a steeper slope compared to the upstream end of the segment (Table 2). Two separate cross sections have been created to accommodate this difference in slope.

Segment 4

As in the other segments, the concrete channel bottom in Segment 4 would be removed but the floodplain would differ along the upstream and downstream sections of the channel. Within the downstream end of the segment, downstream from Highway 45, the floodplain would consist of a relatively flat concrete bench, approximately 30 feet wide. The concrete is necessary to provide stability under a hydraulic jump predicted to occur in this reach during the 50 percent chance (2-year) storm event. The flat concrete bench would be widened to form the transition to Segment 3's floodplain.

In Segment 4, the existing concrete side slopes would be maintained or reconstructed to avoid scour at the Highway 45 bridge pilings. A footing would be required at the base of the concrete slab to support the slab and prevent undermining. The existing piles are not battered, and no adverse impacts are expected if the concrete walls are properly supported.

The 1.9-foot high concrete drop structure would also be taken out during concrete removal. The dimensions of the main channel and low-flow channel would be different in this segment compared to other the segments. More specifically, the main channel in Segment 4 would be wider (26.2 feet) and shallower (1.46 feet) and low-flow channel in this segment would have a narrower (0.5 feet) bottom width (Table 2).

Similar to the other segments, the channel's slope would be modified through Segment 4. The new slope would transition from a fairly flat profile on the upstream end of the segment to a steeper elevation towards the downstream end (Table 2). Segment 4 would have the steepest design reach (1.5 percent) and would require structural grade controls to be installed into the rehabilitated stream bed to provide channel stability. Grade controls maintain the vertical elevation of the stream bed and prevent channel incision. They would be designed as step structures composed of large boulders, rock cross vanes, or a series of boulder cascades.

Segment 5

In Segment 5, the existing channel cross section would be maintained and disturbance under the CPR Bridge would be avoided. Instead, surface roughness and boulders would be added to the existing concrete channel, effectively turning the channel into a riffle section, where water depths and velocities conducive to the passage of migratory fish. The remainder of the reach would be a riffle transition or tie-in to the upstream restoration project (Phase 1, completed by MMSD). Notably, the slope in Segment 5 would not be modified from existing conditions.

Table 2 - Underwood Creek Proposed Channel Parameters

Stations	Slope (ft/ft)	Main Channel[e]				Low Flow Channel[f]		
		Top Width (ft)	Bottom Width (ft)	Max Depth (ft)	Ave Depth (ft)	Top Width (ft)	Bottom Width (ft)	Max Depth (ft)
10+48 to 31+62[a]	0.002280	30	17.8	3.06	2.57	7.5	3.0	0.75
31+62 to 37+43[b]	0.002890	30	18.9	2.78	2.38	7	2.5	0.75
37+43 to 45+87[c]	0.005770	30	21.4	2.15	1.93	6	1.5	0.75
45+87 to 49+92[d]	0.015000	32	26.2	1.46	1.39	5	0.5	0.75

Notes:
[a]Segment 1b & downstream ~162 feet of Segment 2;
[b]Upstream ~188 feet of Segment 2 & downstream ~393 feet of Segment 3;
[c]Upstream ~844 feet of Segment 3;
[d]Segment 4;
[e]2:1 side slopes;
[f]3:1 side slopes

4.6.3 Alternative 3: Expanded Floodplain Upstream with Tiered Walls Downstream

Alternative 3 would have many of the same rehabilitated channel improvements as Alternative 2. The concrete channel bottom would be removed and replaced with limestone throughout all stream segments with exception to Segment 5. As in Alternative 2, boulders would be added to existing channel bottom to create a modified riffle section within Segment 5. The main channel cross section dimensions and proposed channel slopes would remain consistent with Alternative 2 (Table 2). As proposed with Alternative 2, the five concrete drop structures would also be eliminated.

Compared to Alternative 2, this alternative would provide enhanced aquatic habitat and energy dissipation through larger pools (located within the channel bottom) located near stormwater outfalls at North 103rd Street (Segment 2), North 106th Street (Segment 3), and upstream of the Highway 45 Bridge (Segment 4). In-stream habitat would be further enhanced in this alternative compared to Alternative 2 by creating a section of broad meanders throughout Segment 3. To incorporate the broad meanders, the cross section in Alternative 3 would be widened to 120 feet so that it functions hydraulically.

The list of channel segments below presents the physical differences of Alternative 3 in comparison to Alternative 2.

Segment 1a

No change from Alternative 2

Segment 1b

This segment would be consistent with Alternative 2 except with regard to the method chosen for bank stabilization. Once the concrete channel bottom is removed, stabilization would occur on both sides of the channel, near the downstream end of this segment. To stabilize the banks/slope, the edges of the cross section would be composed of tiered wet-cast retaining walls, approximately 2,100 linear feet (on both sides of the channel), which would allow for the development of an expanded stone-lined floodplain bench adjacent to the main channel. (Compared to pre-cast concrete blocks, wet-cast concrete blocks contain higher moisture content; have less entrained air; are more durable to abrasive forces, are larger and heavier.) The bench would accommodate limited low-flow channel sinuosity. Terraces would be created between the walls and would consist primarily of 8-inch-thick geocell layers with a cobble stone backfill. Temporary steel sheet pile shoring, approximately 550 feet in length, would be used during the in the construction of the wall to provide slope stability and prevent channel incision.

Segment 2

This segment would be consistent with Alternative 2 except with regard to the method chosen for bank stabilization. As discussed above, in Segment 1b, the proposed slope stability methods (2,100-foot long retaining wall) would be carried over from Segment 1b into Segment 2.

Segment 3

As mentioned above, this alternative incorporates broad channel meanders into Segment 3. In order to maintain existing flood provisions, the cross section in this segment would be widened to approximately 120 feet to create an expanded area for floodwater storage.

Segment 4

No change from Alternative 2

Segment 5

No change from Alternative 2

5.0 EVALUATION OF HABITAT UNITS

5.1 Habitat Suitability Index Species

Habitat outputs were quantified using the Habitat Suitability Index (HSI), developed by the U.S. Fish and Wildlife Service (USFWS). This assessment tool is used to evaluate the impacts of proposed project plans from a species-habitat approach. First, a representative species is selected to be documented with a HSI index value. This value is quantified using key habitat components necessary for sustaining life for the selected species.

Fish species more adapted to the stream environment of Underwood Creek were used to quantify the in-stream habitat that would be created with each action-oriented alternative. The longnose dace (*Rhinichthys cataractae*) and white sucker (*Catostomus commersoni*) are two fish species commonly found in Underwood Creek and downstream in the Menomonee River.

Longnose dace was chosen as a Habitat Suitability Index (HSI) species to represent fish of smaller plains streams that may have irregular flows, slower velocities, and shallower depths. The species is usually found in riffle areas of streams that have rubble or gravel substrate. Dace benefit from cover and shelter. Riffles are important, as dace will only spawn in riffles with a velocity of 1.5 to 2.0 feet/sec and this criterion is met in the proposed riffle sections. Longnose dace are well-adapted for feeding on the bottom, mainly on larvae of aquatic insects. Young are restricted to areas of shallow water and moderate current. Habitat suitability for dace is determined by stream velocity, depth, substrate type and natural cover and shelter.

The white sucker is a highly adaptable species with preferred spawning habitat that reflects the restored in-stream habitat. White suckers spawn from April to early May when they migrate up tributary streams, usually at night. They typically migrate from lakes or stream pools into riffles to spawn over gravel substrate and swift shallow water less than 11.8 inches of water (Twomey et al. 1984). Spawning migrations are most likely temperature dependent and/or discharge dependent. Both in-stream and shoreline cover are also critical components of white sucker spawning areas. The young hatch and remain in the gravel for one to two weeks before migrating downstream at night. They feed on protozoa, diatoms, and small crustaceans. Adults primarily inhabit pools and are common in areas of slow to moderate velocity.

Habitat suitability for white sucker is determined primarily by cover, water quality and spawning habitat. Food was not considered important in determining habitat suitability as white suckers are opportunistic feeders. The riverine model utilizes the life requisite approach, meaning each identified component is considered essential, and consists of three components: cover, water quality and reproduction.

5.2 Habitat Units and Average Annual Habitat Units

Table 3 summarizes the environmental benefits associated with each of the three alternatives. To derive HUs, each species' HSI is multiplied by the number of acres of habitat available. HUs were calculated for Year 1, Year 5, Year 20, and Year 50 and were then averaged to arrive at the average annual habitat units (AAHUs). (Note: A more detailed table containing acreage, the HSI and HUs can be found in Appendix E, Habitat Units Methodology Results and Analysis). AAHUs for Alternative 1 were estimated to be zero since habitat for white sucker and longnose dace does not currently exist and would not naturally occur given the no action plan. Both of the action-oriented alternatives have similar design elements which results comparable levels of habitat units. However, the broader meanders and larger pools proposed in Alternative 3 result in more acres of habitat (0.2 acres) than the acres of habitat produced by Alternative 2.

Table 3 – Habitat Analysis Table

Model	Alternative 1	Alternative 2	Alternative 3
	AAHUs	AAHUs[1]	AAHUs[1]
Longnose Dace	0	1.7	1.8
White Sucker	0	1.7	1.8
Ecosystem Total	**0**	**1.7**	**1.8**

Note: AAHUs represent the habitat the action oriented alternatives create.

5.3 Future Connectivity Habitat

MMSD is planning to remove several migratory barriers found further upstream on Underwood Creek as funding becomes available. Once these barriers are removed, there is an estimated 400 acres of wetland habitat that would be accessible to pike and other migratory fish. Further, approximately 140 acres of this wetland complex would provide suitable pike spawning habitat. Although MMSD has already completed similar restoration projects and is actively pursuing restoration downstream of this project, an exact start date for removal of these upstream barriers has not yet been determined. Since at this time a completion date for this restoration is undetermined, the habitat assessment quantifies HU created through the future connectivity but does not incorporate this number into the final AAHUs estimated for each alternative.

The future connectivity provided by the proposed project would allow fish traversing upstream from the Menomonee River to find suitable spawning habitat within Underwood Creek. Northern Pike were chosen as an indicator species to evaluate this future connectivity since they would utilize upstream habitat for spawning and are an important species to the watershed. To quantify HUs, the Northern Pike HSI was multiplied by the 140 acres of wetlands found upstream which is classified as "emergent vegetation". As a result, the AAHUs computed for the future connectivity component associated with the proposed project and the MMSD upstream restoration is estimated to be 58.8. Thus, the habitat created through both the proposed project and the future connectivity associated with the MMSD project would have the capability of creating an estimated 60.5 and 60.6 AAHUs for Alternatives 2 and 3, respectively.

6.0 ECONOMIC ANALYSIS SUMMARY

Cost effectiveness (CE) analysis is a form of economic analysis designed to compare costs and outcomes (or effects) of two or more courses of action. The Corps of Engineers utilizes cost effectiveness analysis in environmental restoration projects since benefits (i.e., habitat units) are not measured in monetary terms. More specifically, the analysis is used to evaluate the cost of implementing an alternative's plan to how effective the plan is at producing environmental benefits. Table 4 and the Cost Effectiveness Graph (Figure 15) indicate that Alternative 3 has the lowest implementation cost and produces the most habitat. In addition, this alternative has the lowest average annual cost per average annual habitat unit ($208,000 in 2014 dollars) of the two action-oriented alternatives. Since Alternative 3 is the only cost effective alternative, the incremental cost analysis is not necessary and the NER plan is identified as Alterative 3.

Table 4- Cost Effectiveness Analysis in 2014 Dollars

Alternative	AAC	AAHU	AAC/AAHU
1	N/A	-	-
2	$399,000	1.70	**$235,000**
3	$374,300	1.80	**$208,000**

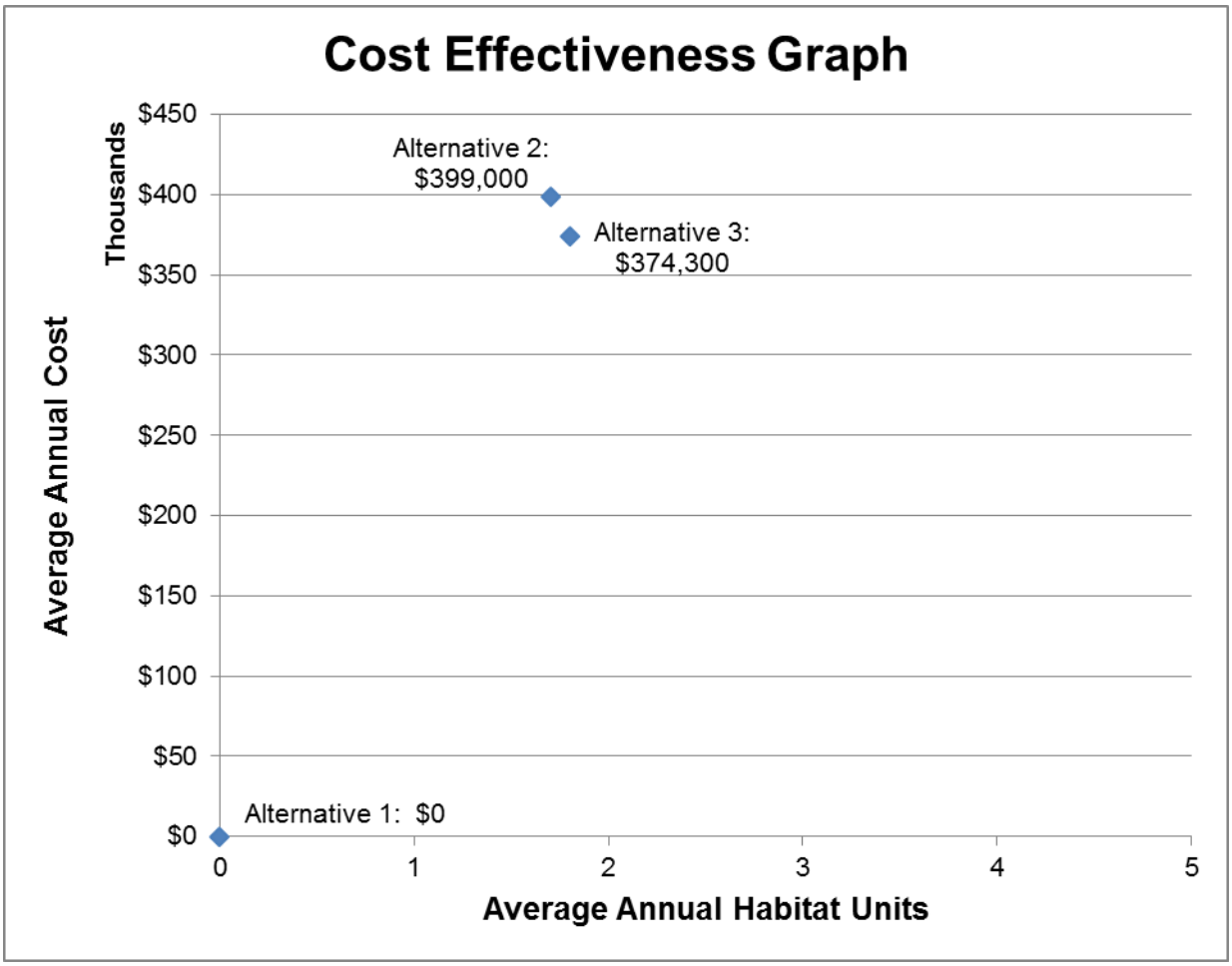

Figure 15 – Cost Effectiveness Graph

7.0 ENGINEERING AND GEOTECHNICAL SUMMARY

The Engineering and Design Analysis Appendix (Appendix A) includes geotechnical data, description of the geotechnical analysis, recommendations for slope stability, constructability, and the ultimate stability of the constructed channel for both Alternatives 2 and 3. The report provides a description of each alternative and preliminary design drawings that display the project vicinity and location, plan view drawings, channel profiles, and typical cross sections for each alternative.

The slope stability analysis performed for Alternatives 2 and 3 indicate slope stability issues post construction for Alternative 2 (if not properly stabilized) and during construction of Alternative 3. Unacceptable factors of safety (below 1.5) were calculated for the bank slopes from approximately STA 10+50, to STA 33+00 (Figure 14). The anticipated failures range from very shallow surfaces from Station 10+50 to 21+00 and deeper failures from Station 21+00 to 33+00. Suggested measures to improve slope stability include a cantilevered steel sheet pile wall with a concrete cap installed at the toe of slope (Alternative 2) and steel sheet pile walls at the outer edge of the channel during construction (Alternative 3). The report also recommended obtaining

additional borings along this area during the design phase to further define the stratigraphy and aid in refining the design. In addition, analysis is required to refine the depth of penetration and section requirements for the sheet pile.

The report also evaluated Metropolitan Interceptor Sewer (MIS) record drawings for potential conflict that could develop related to an existing 48-inch MIS pipeline running along the channel from station 12+50 to 17+50 and crossing beneath Underwood Creek at station 13+30. Review of the drawings indicate that there should be about four feet of cover over the 48-inch MIS pipeline at the bottom of the channel excavation at Station 13+30, which assumes that a pool is not constructed in the rehabilitated channel at this location. Pools should not be included in the rehabilitated channel between stations 12+50 to 17+50 to avoid conflicts with the 48-inch MIS line.

The CPR runs parallel to the south side of the channel from Segments 1a to 4. At the narrowest point, the railroad is 40 feet from the channel and 25 feet from the temporary easement. The slope stability analysis conducted in this feasibility study did not include the railroad loadings since both of the action-oriented alternatives require slope stabilization techniques. However, it is recommended that these loadings be examined further during the planning and design phase.

8.0 HYDROLOGIC AND HYDRAULIC SUMMARY

The Hydrologic and Hydraulic Studies (Appendix B) includes an analysis of how each alternative would perform hydrologically and hydraulically. In addition, this document examines the movements of sediment throughout the creek.

8.1 Hydrology

The term “bankfull” discharge represents a breakpoint between processes of channel formation and floodplain development. The discharge design for the upstream project allows for inundation of the floodplain bench, located within Segment 3, approximately 12 times per year. More specifically, it is channel forming flow that fills the channel to the top of its banks, or when the channel is “bankfull”, and at the point where the water begins to overflow onto the floodplain bench (see Figure 16). This inundation creates connectivity between the stream and adjacent floodplain which helps maintain the stream’s hydrologic connection. Since this design has been successful upstream, the proposed project’s main channel utilizes this same discharge design within Segment 3 and provides continuity between the two projects.

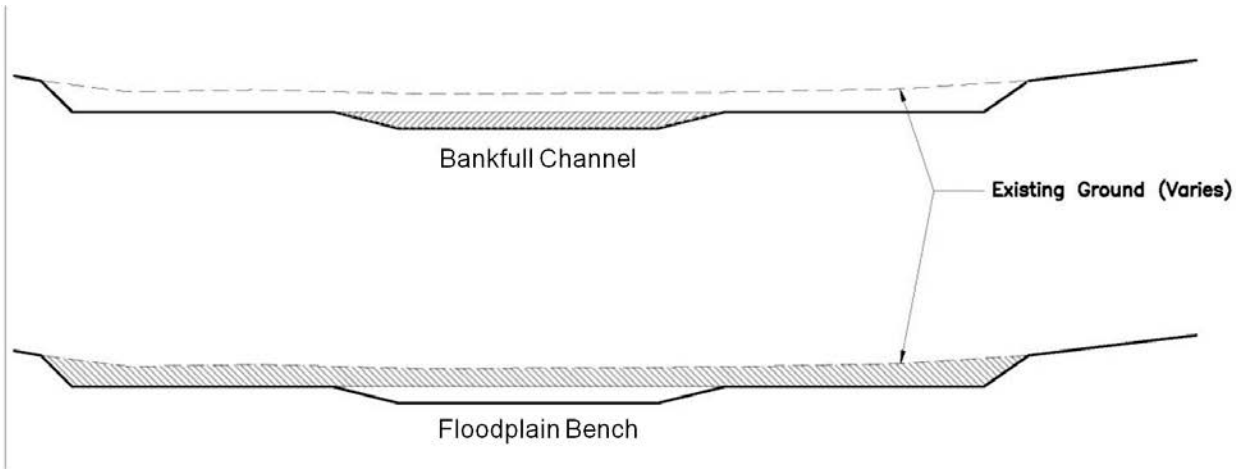

Figure 16 – Illustration of Floodplain Bench

8.2 Hydraulic Comparison of Alternatives

Prior to the installation of the diversion structure in 2011, the Fisher Parkway was subject to between a 17- to 26-inch increase in the one-percent annual-chance water surface elevation. As seen in Figure 17, this inundation would occur on the north side of the channel, in proximity to Segment 2. In addition to the Fisher Parkway, flooding was also prevalent on the downstream end of the creek, near the confluence of the Menomonee River. Once the MCGFMF was completed, this inundation was reduced and water surface elevations in the project area were below the FEMA base flood elevations (FEMA BFE). It should be noted that the existing conditions model reflects these new (approved) flows and lower water surface elevation.

The sponsor constructed the MCGFMF specifically to reduce inundation to allow for the restoration of concrete channels in the area. As previously mentioned, MMSD has already restored 2,200 linear feet of channel located immediately upstream of the proposed project and has planned to have the proposed channel restoration to act in concert with the diversion structure. Thus, channel restoration was predicated on the installation of the MCGFMF since it reduced peak flows on both Underwood Creek and the Menomonee River.

The 100-year water surface elevations for the two alternatives exceed the existing conditions water surface elevation (Alternative 1) in several areas, but are lower than or equal to the effective FEMA 100-yr floodplain elevations since the MCGFMF was specifically developed to lower discharge elevations in order to proceed with river restoration projects. The MMSD has also 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. Alternative 3 was found to have the lowest 100-year water surface elevation and inundation is limited to the Fisher Parkway. The difference between existing and proposed conditions measures only a few inches and is defined in Figures 17 and 18. Additional information pertaining to hydrologic and hydraulic analysis of the alternatives can be found in the Hydrologic and Hydraulic Studies (Appendix B).

The Detroit District's Office of Council issued a Memorandum of Record on January 31, 2013, regarding the impact to the one-percent-annual-chance water surface elevation. This memorandum reports that the District's Office of Council understands that there are some minimal impacts associated with the proposed project, but that these impacts are not significant in comparison to the conditions that existed prior to the installation of the MCGFMF. In addition, the District's Office of Council determined that this inundation did not warrant a takings and would not prevent the customary use of the land nor result in substantial damages (see Real Estate Plan, Appendix F).

8.2.1 Sediment Transport and Rock Sizing

A channel capacity analysis was undertaken to assess the ability of the proposed bankfull channel dimensions to convey the design discharge and associated sediment supply. The analysis was performed using the stable channel design module in the U.S. Army Corps of Engineers Sediment Analysis Model (SAM) Hydraulic Design Package for Channels (SAM in Version 1.0). The results show that for proposed reaches from STA 10+48 – 45+87 (Approximate Segments 1-3), the design slope and channel dimensions are within the range of stable solutions predicted by SAM. In contrast, SAM predicts that the reach from STA 45+87 to 49+92 (Approximate Segment 4) is too steep (1.5 percent) and slightly too deep to maintain stability. The results are the same for proposed Alternatives 2 and 3, which do not have appreciable differences in channel conditions below the bankfull elevations, but differ largely in top of bank and floodplain conditions. The high potential for channel instability in the steeper reach between STA 45+87 and 49+92 predicted by SAM would be a significant concern if the design allowed for the channel to adjust its dimensions alluvially. In this condition, the channel would be expected to incise in an attempt to achieve a lower, stable slope. Due to site constraints, the channel slope proposed in this reach cannot be lowered and the design would include considerable structural grade control measures to prevent channel incision in the steeper reach.

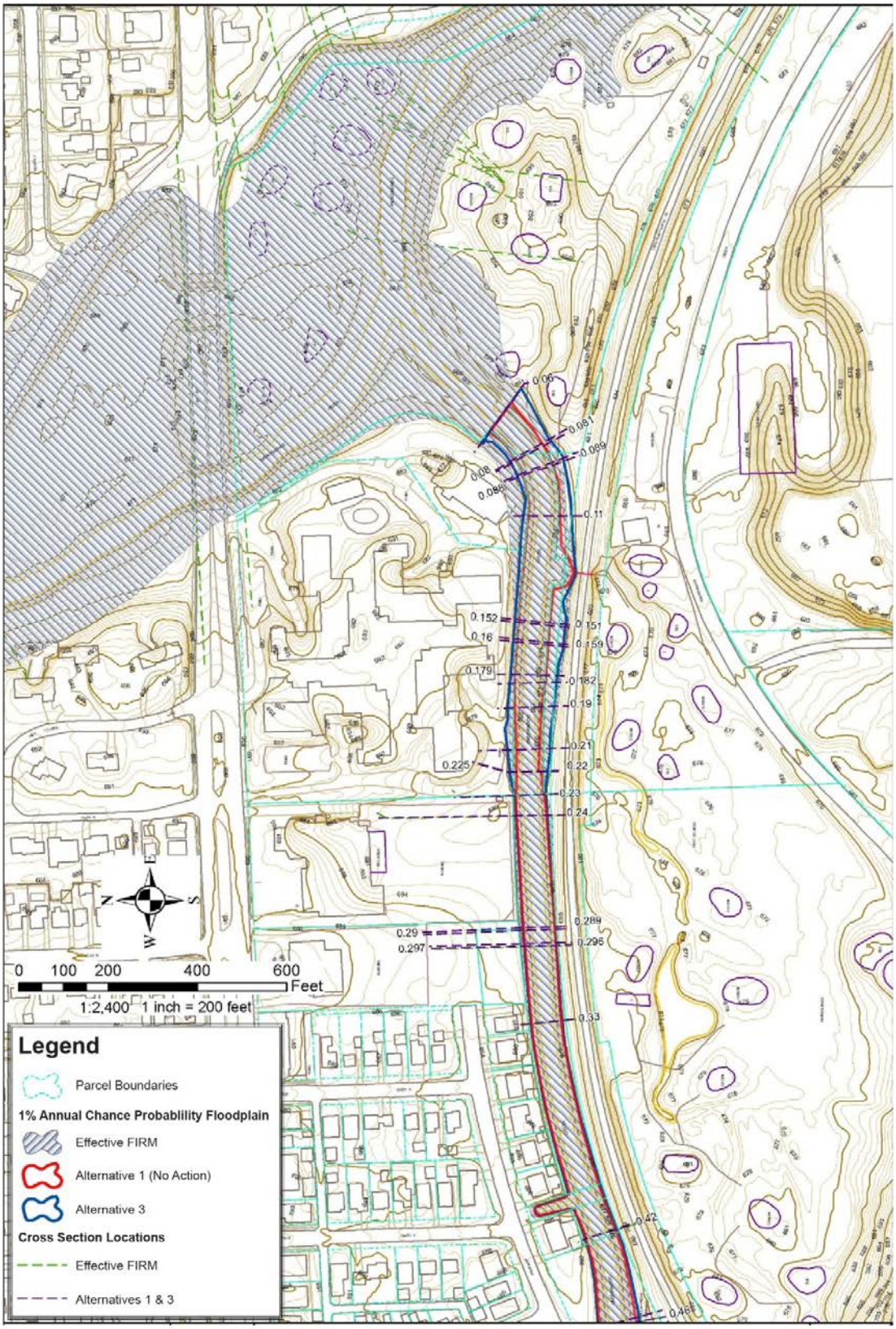

Figure 17 - Flood Comparison Map for Alternatives 1, 3, and Effective FEMA FIRM

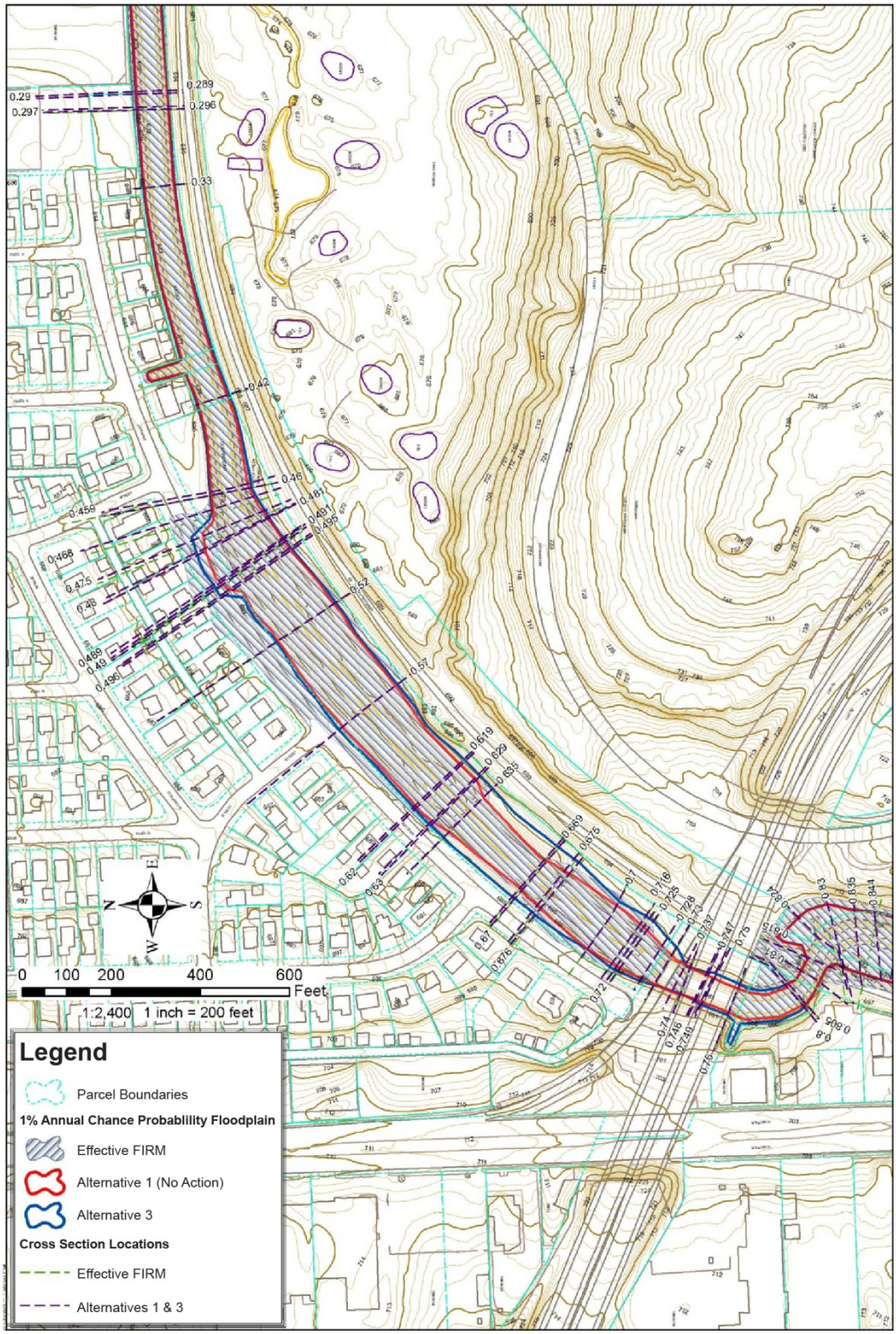

Figure 18 - Flood Comparison Map for Alternatives 1, 3, and Effective FEMA FIRM

Integrated within the SAM package is a riprap sizing procedure based on USACE Engineering Manual (EM) 1110-2-1601 on Riprap Protection. The module was run for the same cross sections used in the channel capacity analysis. In Alternatives 2 and 3, results for reaches from STA 10+48 – 45+87 are the same. SAM predicts a median size of 0.4 feet and maximum size of 0.75 feet. For the steeper reach (STA 45+87 – 49+92) in Alternative 3, where the design slope is an order of magnitude greater, SAM predicts a median and maximum riprap size of 1.3 feet and 2.25 feet, respectively. For the same reach in Alternative 2, which includes less floodplain grading than Alternative 3, larger riprap would be needed to meet stability requirements (median size of 1.8 feet and maximum size of 3.0 feet).

A range of design approaches would continue to be consulted for the final stone sizing. In order to be conservative, it is likely that larger stones would be used to comprise in-stream and bank protection structures along Underwood Creek. However, these SAM results provide a minimum size to guide design.

For use as a guideline in sizing the bed material in the proposed restoration channel, a sediment competency analysis was undertaken using the channel shear stresses computed from the proposed conditions HEC-RAS model for both restoration alternatives. This competency analysis provides a preliminary estimate of the ability of the bankfull channel to move sediment for a given discharge and is embodied by estimating the local threshold grain size. For the 100-year peak discharge in Alternatives 2 and 3, a D_{50} range of approximately 2 to 20 inches is predicted to be stable in the steeper channel from STA 51+00 to 46+84. From STA 46+84 to 10+49, where slopes are milder, the channel is less competent to mobilize bed material and the stable D_{50} predicted does not exceed 2.5 inches. Based on these results, the modeling shows that these proposed sizes should be stable at most locations during the peak discharge events that resemble uniform, steady flow conditions.

8.2.2 Hydraulics and Fish Passage

The stream habitat objectives include providing passage for migrating native potamodromous and resident fish. To ensure that fish passage would be maintained through the restored reach, it was necessary to select the weakest swimming fish that would inhabit Underwood Creek. Northern pike (*Esox lucius*) are prized by sportsman for their size and fighting ability, yet they are recognized by scientists and fisheries biologists as a weak swimming fish. Using their sit-and-wait predatory strategy, they swim in short powerful bursts, but lack stamina for constantly swimming against river and stream currents. Although pike prefer slack water and lakes, they routinely migrate up streams in the spring to reach suitable spawning habitat in shallow wetlands (Inskip, 1982).

Since this species is a weak swimmer, the proposed alternatives were designed to provide less than a three-foot per second velocity through the proposed reach. A combination of literature review for northern pike swimming capabilities, historic flow data from the USGS stream gage station 04087088 (Underwood Creek at Wauwatosa for the spring spawning period), proposed riffle cross sections of each alternative, the Indicators of Hydrologic Modification (IHA) Software developed by the Nature Conservancy, and the proposed conditions from HEC-RAS, were used to evaluate fish passage for Alternatives 2 and 3. Complete description of the

literature review and analyses performed to determine fish passage through the proposed riffle cross sections is provided in Appendix B.

Fish Passage through Riffles

In a stream channel, riffles are a brief change in elevation and slope, where water velocity generally increases and depth decreases. While riffles provide important ecological functions in a channel, they can become barriers to fish passage when velocities become too high, or depths become too shallow for a prolonged period of time. Flow data and HEC-RAS modeling indicate that migratory and resident fish (including northern pike) would be able to move through the rehabilitated channel during approximately 80 percent of spring flow conditions for Alternatives 2 and 3. The velocity results, which are all less than 3 feet/second up to the 90th percentile baseflow (only 10 percent of all spring flows are greater), suggest that the proposed riffle cross sections would be passable at discharges approaching, and possibly beyond, the capacity of the main (bankfull) channel. Riffle depths are also greater than nine inches during most flow conditions. Segments that do not meet the depth criteria are, at most, approximately one inch below the minimum depth. The design proposes the careful placement of boulders and engineered substrate to create pockets in the flow that have depths greater than nine inches.

Although the restored project reach would be able to pass migratory and resident fish, migration beyond MMSD's completed project is limited. Three concrete drop structures remain on Underwood Creek and two additional drop structures exist on the South Branch of Underwood Creek upstream from MMSDs completed project that block access to approximately 400 acres of floodplain wetland. These structures have been targeted for removal by SEWRPC (2000) and MMSD does ultimately plan to remove these structures and rehabilitate the channel if funding becomes available. Approximately 2,700 feet of concrete channel in the Menomonee River is currently under construction. After these migration barriers are removed, fish species would be able to reclaim historic access to upstream sections of the Menomonee River and tributaries including Underwood Creek that have been unavailable for almost 50 years.

Resting and Refuge within Pool Habitat

Pools are a stream feature with low slope and velocity, with greater depth compared to riffles. These were evaluated for their apparent ability to provide refuge habitat during low discharge periods. The proposed pool cross section for Alternatives 2 and 3 has been designed to have a minimum depth of three feet during baseflow conditions. HEC-RAS modeling indicates that the proposed pools would have adequate depth during most flow conditions (Appendix B).

9.0 COST ENGINEERING SUMMARY

9.1 Federal Project

Detailed preliminary costs for Alternatives 2 and 3 were estimated from historical unit price data from similar projects (Table 5). Quantities were derived primarily from direct take-offs of lengths and areas provided by conceptual drawings found in Appendix A. The preliminary estimates were also developed using information (e.g. take-off quantities and unit prices) from

contract documents associated with MMSD's Phase 1 restoration project including its feasibility study.

Table 5 presents the preliminary cost estimates developed for each of the action-oriented alternatives. While both plans share similar design features, Alternative 2 was estimated to be approximately $557,000 more than Alternative 3. This cost differential was derived from the difference in the proposed method of bank stabilization (within Segments 1b and 2). More specifically, Alternative 2's plan requires the use of a temporary SSP wall whereas Alternative 3's plan calls for a wet-cast concrete block wall.

Table 5 - Preliminary Cost Estimates for Alternatives	**Alternative 2**	**Alternative 3**
Move In and Site Preparation	$ 202,400	$ 201,800
Utility Relocation		$ 100,000
Concrete Channel Demolition & Material Disposal	$ 99,820	$ 143,840
Earthwork - Common Excavation, Backfill, Embankment & Material	$ 148,500	$ 311,300
Streambed Granular Fill, Stone & Filter Gravel	$ 1,833,950	$ 1,943,350
Boulder	$ 61,200	$ 63,000
Control of Water/Fabric-Check Dam	$ 163,380	$ 163,380
SubTotal Earthwork/Rehabilitated Channel	***$ 2,509,250***	***$ 2,926,670***
Retaining Wall - Wet Cast Concrete Block	$ 188,600	$ 2,296,000
Steel Sheet Piling	$ 2,675,000	$ 423,750
Concrete Channel Repairs	$ 240,000	$ 48,000
Structural Concrete & Storm Sewer Outfalls	$ 595,400	$ 18,600
Base Aggregate/Subgrade Prepartion	$ 4,210	$ 50,140
SubTotal Embankment Stability	***$ 3,703,210***	***$ 2,836,490***
Construction Costs	**$ 6,212,460**	**$ 5,763,160**
Construction Contingency (12%)	**$ 745,495**	**$ 691,579**
TOTAL CONSTRUCTION COSTS	**$ 6,957,955**	**$ 6,454,739**
Feasibility Study Costs	$ 815,000	$ 815,000
Design & Engineering	$ 785,755	$ 731,839
Environmental Compliance	$ 60,000	$ 60,000
Engineering Technical Review ATR & VE	$ 59,850	$ 59,850
Contracting	$ 28,800	$ 28,800
LERRDS	$ 130,000	$ 130,000
Construction Management Costs	$ 475,000	$ 475,000
Engineering During Construction	$ 30,000	$ 30,000
Project Management	$ 59,850	$ 59,850
TOTAL NON-CONSTRUCTION COSTS	**$ 2,444,255**	**$ 2,390,339**
Environmental Monitoring Costs	$ 28,000	$ 28,000
TOTAL COSTS	**$ 9,430,210**	**$ 8,873,078**

Both of the proposed alternatives are expected to require occasional maintenance to the stone channel lining over the course of the project's life (or 50-years). These costs are considered to be standard operations and maintenance (or lifecycle) costs and were estimated to be

approximately nine percent of the construction costs (minus the contingency). Additional details regarding these costs can be found in the Cost Appendix (Appendix C).

A Value Engineering (VE) study was conducted for three aquatic ecosystem restoration projects, similar in scope, located in the vicinity of Metropolitan Milwaukee. VE is an organized, team-oriented study of project functions for the purpose of meeting project requirements in the most economical life cycle cost manner practicable. The study was held on January 7-10, 2013, and involved the participation of the project delivery team. It should be noted that the VE study did not result in any significant findings for Underwood Creek.

9.2 Risk Assessment

Alternative 3 was identified as the tentatively selective plan during this feasibility study. Consequently, a risk assessment was performed with the Project Delivery Team (PDT) to identify all possible project risks. The qualitative information derived from the risk meeting with the PDT provided the framework for the risk analysis. The risk assessment conducted for this alternative yielded a contingency of approximately 25 percent. Risks identified for this project include:

- Earthwork estimates and site grading.
- Potential for an extended construction period due to managing stream flow during storms in a confined channel and urbanized watershed.
- In some places, soil and sediment materials to be excavated and disposed from the project contain materials regulated by the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) above Wisconsin Department of Natural Resources (WDNR) residual contaminant levels. This potentially could pose risks to human health and the environment, for which both the USACE and the non-Federal sponsor could incur liability for cleanup. The non-Federal sponsor is responsible for the full cost of cleanup and response to CERCLA regulated materials. Additional risk management measures are described in Section 11.2 below.
- Further engineering of design of in-channel stone and structures requiring changes in quantities and cost.
- Planting stock selection and stabilization to mitigate damage and loss from storm flows and velocities.
- Changes in the modeled hydrology, hydraulics, and water quality due to changes in watershed land use, point source discharges, and climate.
- Geotechnical information relating to constructability.
- Prescribed maintenance not followed through and that does not develop along the desired trajectory.
- Currently unknown invasive species that could enter the project area.
- Unidentified, abandoned or improperly located utilities.

In addition to the risk assessment, a detailed cost estimate for the tentatively selected plan was developed through the MII software and summarized in a Total Project Cost Summary (TPCS). The detailed MCACES estimate is prepared in accordance with ER 1110-2-1302 – Civil Works

Cost Engineering, and ETL 1110-2-573 – Construction Cost Estimating Guide for Civil Works. The estimate is organized using the top 2 levels of the Civil Works Work Breakdown Structure (CWWBS) described in the guidance documents. Information regarding the tentatively selected plan's schedule, fully funded cost estimate and cost sharing requirements are presented in Section 14.0, Plan Implementation. The Cost Appendix provides further details regarding cost estimation procedures and information derived during this feasibility study. Attachments to this appendix include: the MII Cost Report for Alternative 3; Project Schedule Breakout; Project Schedule Gantt Chart; and Cost and Schedule Risk Analysis documents.

10.0 SCREENING OF ALTERNATIVES

Planning guidance requires that each plan be formulated with consideration of four criteria: completeness, effectiveness, efficiency and acceptability. Both action-oriented alternatives were evaluated for these four criteria.

10.1 Completeness

Completeness is a determination of whether or not an alternative 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.

All of the with-project alternatives formulated for this study are considered complete since they create in-stream habitat and reconnect the Menomonee River with the recently restored concrete reach. The restoration of Underwood Creek would contribute to major watershed goals of aquatic connectivity from Lake Michigan and the Milwaukee River Estuary through the Menomonee River into Underwood Creek and into upstream areas of Underwood Creek. This connectivity is a major watershed goal for both the sponsor and other watershed stakeholders. Each of these alternatives is a stand-alone plan and can be implemented independent of any other plan.

10.2 Effectiveness

Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specific opportunities. This criterion is the extent to which the action-oriented plans contribute to achieving the planning objectives.

In-stream habitat and fish passage are impaired/impacted by the concrete channel and drop structures. Both of the with-project alternatives would improve in-stream habitat, create connectivity to the recently restored upstream channel, and enhance the natural stream substrate responsible for supporting aquatic macroinvertebrate communities. In addition, all of the alternative plans would also provide future connectivity to the upstream restoration projects that MMSD has planned to pursue.

This restoration project would also indirectly benefit the Milwaukee Estuary Area of Concern (AOC). One of the 14 beneficial uses impairments identified by the International Joint Commission is loss of fish and wildlife habitat. Underwood Creek is a tributary to the estuary and, thus, restoration of this creek would indirectly help address fish and wildlife habitat impairments.

Although both alternatives improve in-stream habitat and fish passage, only Alternative 3 is able to do so within the planning constraints. More specifically, this is the only hydraulically feasible alternative.

10.3 Efficiency

Efficiency is defined as the extent to which an alternative plan is the most cost effective means of achieving the planning objectives. Of the two action-oriented alternatives, only Alternative 3 is cost effective and was subsequently identified as the NER plan or recommended plan.

10.4 Acceptability

Acceptability is the extent to which the alternative plans are acceptable in terms of applicable laws, regulations and public policies. Since only Alternative 3 is hydraulically viable, this plan is the only acceptable plan. This plan is also the locally preferred and is supported by FEMA and the City of Wauwatosa.

11.0 RECOMMENDED PLAN

Alternative 3 was found to be the only cost effective plan since it produces more habitat at a lower cost than the other action-oriented alternative. In addition, this is the most hydraulically feasible plan considered in this study.

11.1 Plan Description

The recommended plan for the proposed Section 506 Underwood Creek restoration project is Alternative 3. This alternative combines the following measures in its design: concrete removal, drop structure removal, channel slope modification, limestone bottom, riffle/pool sequence, broad channel meanders, wet-cast concrete retaining wall and a low-flow channel.

<u>Segment 1a</u>

The majority of this segment would not be rehabilitated since it is already naturalized.

<u>Segment 1b</u>

Concrete from the channel bottom and a 3.5-foot drop structure would be removed and replaced with a limestone bottom. The channel's slope would be slightly modified and a riffle and pool sequence would also be incorporated into the channel's design along with an in-set low flow channel. This low-flow channel would have a top with of 7.5 feet, a bottom width of 3 feet and depth of less than a foot (Table 2). Dimensions of the main channel would consist of: a 30-foot top width, nearly an 18-foot bottom width, and an average channel depth of 2.57 feet (Table 2). In addition, the channel would be sized hydraulically so that the actual channel is exceeded on average between 12 and 16 times per year. This overtopping is important for ensuring that any floodplains in the area are maintained.

Once the concrete channel bottom is removed, stabilization would occur on both sides of the channel, near the downstream end of this segment. To stabilize the banks/slope, the edges of the cross section would be composed of tiered wet-cast concrete retaining walls, approximately 2,100 linear feet (on both sides of the channel), which would allow for the development of an expanded stone-lined floodplain bench adjacent to the main channel. (Compared to pre-cast concrete blocks, wet-cast concrete blocks contain higher moisture content; have less entrained air, are more durable to abrasive forces, are larger and heavier). The bench would accommodate limited low-flow channel sinuosity. Terraces would be created between the walls and would consist primarily of 8-inch-thick geocell layers with a cobble stone backfill. Temporary steel sheet pile shoring, approximately 550 feet in length, would be used during the construction of the wall to provide slope stability and prevent channel incision.

Segment 2

Consistent with Segment 1b, this segment would call for: removal of the concrete channel bottom, slight modification in the channel slope, the addition of a main channel riffle/pool sequence, inclusion of an in-set low flow channel within the main channel, a limestone channel bottom, and new or refurbished concrete side slopes. Both the main channel and low flow channel dimension would remain fairly consistent with Segment 1b (Table 2). The wet-cast concrete retaining wall, discussed above in Segment 1b, would continue into Segment 2.

Segment 3

The concrete channel bottom would also be removed in this segment and would have most of the same design elements incorporated into the rehabilitated main channel as those presented in the previously mentioned segments (1b-2). These design elements include: a channel bottom, a main channel riffle/pool sequence, broad meanders and an in-set low flow channel (Figure 19). Table 2 provides information pertaining to the rehabilitated channel's dimensions which are consistent with the other two previously mentioned segments. Three concrete drop structures 0.5, 1.7, and 4.0 feet in height, respectively, would also be removed during the concrete channel's demolition.

Segment 3's adjacent floodplain would be increased to a width of 120 feet in order to provide additional storage during peak flows. In addition, the channel slope in the upstream portion of this segment would have a slightly steeper slope compared to the downstream end portion of the segment (Table 2). Two separate cross sections have been created to accommodate this difference in slope.

Segment 4

As in the other segments, the concrete channel bottom in Segment 4 would be removed but the floodplain would differ along the upstream and downstream sections of the channel. Within the downstream end of the segment, downstream from Highway 45, the floodplain would consist of a relatively flat concrete bench, approximately 30 feet wide. The concrete is necessary to provide stability under a hydraulic jump predicted to occur in this reach during above the 50

percent chance (2-year) storm event. The flat concrete bench would be widened to help transition to the Segment 3 floodplain.

Segment 4's the existing concrete side slopes would be maintained or reconstructed to avoid scour at the Highway 45 bridge pilings. A footing would be required at the base of the concrete slab to support the slab and prevent undermining. The existing piles are not battered, and no adverse impacts are expected if the concrete walls are properly supported.

The 1.9-foot high concrete drop structure would also be taken out during the concrete channel's removal. The main and low channel dimensions in Segment 4 would be different compared to the segments. Segment 4's main channel would be wider and shallower and the low-flow channel would have a narrower bottom width (Table 2).

Similar to other segments, the channel's slope would be modified through Segment 4. The new slope would transition from a fairly flat profile on the upstream end of the segment to a steeper elevation towards the downstream end (Table 2). Segment 4 would have the steepest design reach (1.5 percent) and would require structural grade controls to be installed into the rehabilitated stream bed to provide channel stability. Grade controls maintain the vertical elevation of the stream bed and prevent channel incision. They would be designed as step structures composed of large boulders, rock cross vanes, or a series of boulder cascades.

<u>Segment 5</u>

In Segment 5, the existing channel cross section would be maintained and disturbance under the CPR Bridge would be avoided. Instead, surface roughness and boulders would be added to the existing concrete channel, effectively turning the channel into a riffle section, where water depths and velocities would be conducive to the passage of migratory fish. The remainder of the reach would be a riffle transition or tie-in to the upstream restoration project (Phase 1, completed by MMSD). Notably, the slope in Segment 5 would not be modified from existing conditions.

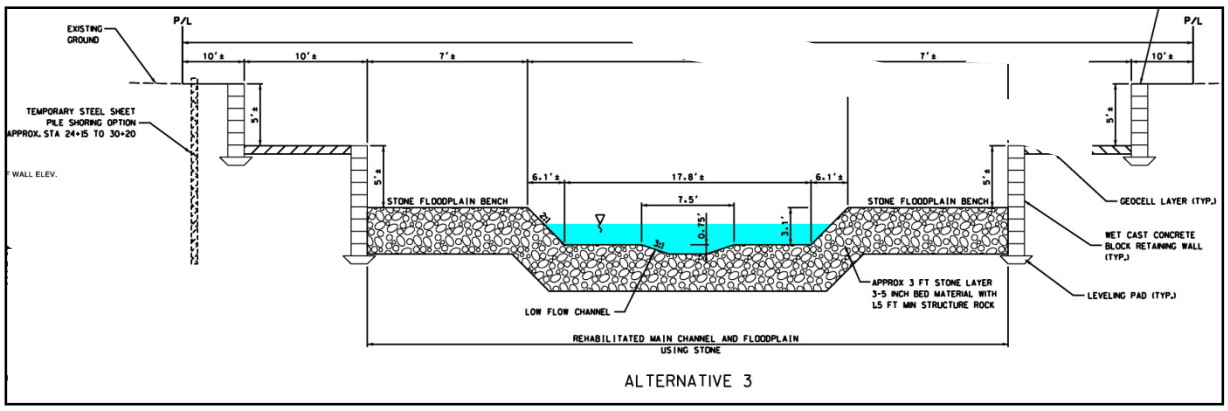

Figure 19 - Segment 1b and 2 Proposed Cross Section

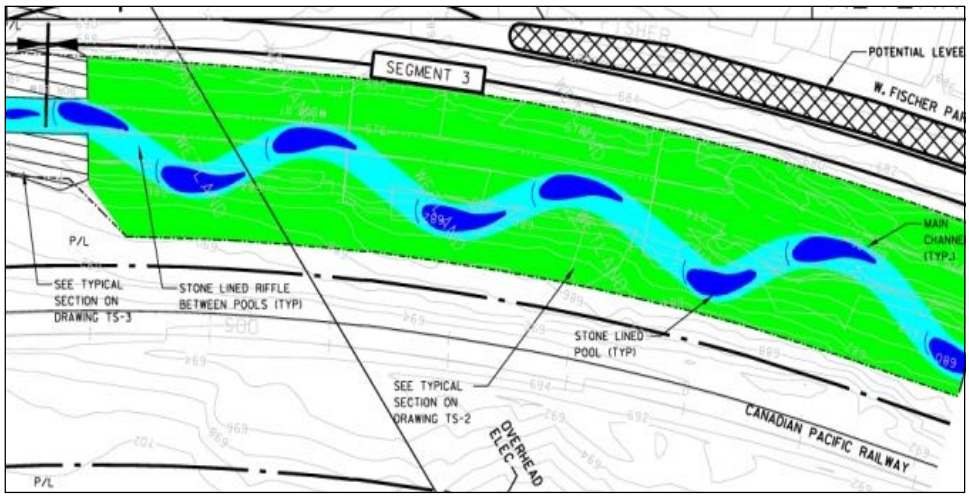

Figure 20 - Segment 3 New Meander Pattern

11.2 Real Estate Requirements & Excavated Material Plans

The total land required for the project is approximately 18.14 acres consisting of 12.0 acres which includes the modified river and 1.04 acres of temporary easement for work & storage and temporary construction access, 0.1 acres of permanent channel improvement easement for future maintenance activities as well as access to public roads.

A land disposal site, Lakefield Sand and Gravel, located at 7003 Good Hope Road, Milwaukee, Wisconsin has sufficient capacity to handle all excavated material that qualifies for a WDNR Low-Hazard exemption.

The project's non-Federal 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 boundary represented in Appendix B may be modified during the design phase as construction engineering requirements and construction procedures are further refined. The lands, easements, rights-of-way, relocations and disposal sites (LERRDS) required to support construction and subsequent operation and maintenance are presented in Appendix F Real Estate Plan.

In preparation for an upstream restoration project (located adjacent to the proposed project and completed several years ago) and the MCGFMF, the MMSD completed Hazardous Materials Assessments and subsurface investigations. The MMSD contracted a Phase I Environmental Site Assessment (ESA) dated April 2005 that included the area of the present project, and a subsequent Phase II ESA dated December 2005, both which investigated the sediments in the subject channel reach for the presence of regulated chemical materials under the concrete lined channel and along the creek bank (GeoTrans, Inc., and Norris & Associates, Inc., 2005). Within the proposed area for this Section 506 ecosystem restoration project, seven soil borings were advanced, composite samples collected and packaged, and transported for chemical laboratory analyses for the presence of: volatile organic compounds (VOCs), diesel range organics (DRO), gasoline range organics (GRO), polycyclic aromatic hydrocarbons (PAHs), and Resource Conservation and Recovery Act (RCRA) metals (arsenic, barium, cadmium, chromium, lead,

mercury, selenium and silver). A map showing the locations of each soil boring can be found in the Environmental Assessment (EA). The results indicated the presence of VOCs, PAHs, and RCRA metals from samples collected within the anticipated construction excavation depth in the Section 506 project reach; however, the measured concentrations were generally low relative to applicable health based standards. Due to the channel's steep embankments, only one soil boring was taken within the downstream portion of the proposed project site (approximately 1,600 linear feet).

Another Phase I ESA was also conducted in the fall of 2014 due to the age of the initial Phase I and II ESA reports. The primary recommendation in the 2014 Phase I ESA was that additional investigation be conducted to determine the nature of potential contamination of the soil materials scheduled for removal from the project. These findings were shared and discussed with the Wisconsin Department of Natural Resources (WNDR) in order to obtain preliminary guidance on acceptable methods of disposal for excavated material.

The WDNR reviewed the results of the Phase II ESA and concluded that additional sampling and analyses would be required to determine the nature and extent of contamination, so disposal options can then be determined. In a March 2015 correspondence to the MMSD, the WDNR suggested that most of the excavated materials, "… could potentially be placed as part of the remedial action plan at a contaminated site, such as the Lakefield Sand and Gravel site, which the MMSD recently proposed for materials excavated from the Menomonee River. For use as part of a remedial action plan, a Low Hazard Exemption would not be required, but approval by the Remediation and Redevelopment Program's Project Manager for the proposed receiving site would be necessary."

It is anticipated that excavated soil from areas in proximity to SB 2 through 5 would qualify as low hazard exempt material based on the available data and the similarity with material excavated from MMSD's upstream restoration of Underwood Creek and other concrete lined channel removal and restoration projects in the area. Based on the data in the 2005 Phase II ESA, the PDT estimated that 1,500 cubic yards of contaminated material may need to be placed in a Type II landfill. While additional sediment sampling could reduce uncertainty regarding the quantity of regulated material, previous attempts to conduct sediment sampling in other concrete-lined channels within the area have proven to be unsafe and are infeasible at this time. As a result, any additional sampling required will be completed in accordance with a Waste Characterization Plan developed during project design, which is consistent with the application requirements to the WDNR for a Low-Hazard exemption and coordinated with the WDNR prior to initiating the sampling. Any additional sampling will also be designed to further characterize soil conditions in and around proposed excavation sites and confirm that the proposed plan includes appropriate placement of excavated materials, and minimizes the risk that soil exposed during excavation would result in the release of CERCLA regulated substances at concentrations that warrant cleanup or response during construction or operation of the project.

The sponsor, MMSD, has secured a nearby site for the placement of soil material that complies with the WDNR Low-Hazard exemption criteria. Specifically, that site is the Lakefield Sand and Gravel site located at 7003 W. Good Hope Road, Milwaukee, Wisconsin, which is referenced in the March 2015 WDNR correspondence. This site has been reviewed for placement of materials and is deemed environmentally compliant (see EA). Any soil/material identified as exceeding

the WDNR Low-Hazard exemption criteria will be placed in a licensed Type II landfill facility. The non-Federal project sponsor (MMSD) will pay 100 percent of the costs associated with the removal and disposal of materials excavated from the project that must go to a licensed Type II facility, which for this project is likely to be the Advanced Disposal Emerald Park landfill located at W124S 10629 S. 124th Street 587, Muskego, Wisconsin.

11.3 Environmental Monitoring & Adaptive Management Plan

In order to evaluate the effectiveness of the project, a basic monitoring plan for fish species would be conducted in the first, second, fourth and seventh year of the project's lifecycle. Fish sampling would be done during the spring spawning season and would involve electro fishing at four sampling stations within the project reach. A successful project would be defined as the presence of white sucker (or members of the sucker family Catostomidae) and longnose dace found within the restored reach, upstream of the restoration reach, and downstream, near the confluence of the Menomonee River.

In addition to the monitoring of fish, the monitoring plan recommends that the non-Federal sponsor inspect the channel after any storm event which exceeds 10 percent annual chance. These inspections would need to be conducted for at least for the first seven years of the project's life to verify that the riffle/pool design remains intact and is suitable for fish passage per the design criteria.

It should be noted that environmental monitoring costs are cost-shared 65/35 between the USACE and the non-Federal sponsor up to the tenth year after implementation. Additional details regarding the project's monitoring plan are included in Appendix G.

If the environmental monitoring indicates that the project does not perform as expected or is not as effective as planned, an adaptive management plan should be implemented. The adaptive management will provide direction to the sponsor as to how the project might be modified. Detailed information for the environmental monitoring plan and adaptive management plan can be found in Appendix G.

11.4 Construction

During the construction of the proposed project, impacts to existing utilities would be avoided. As previously mentioned the abandoned sanitary sewer is no longer in service and is not likely to be encountered. If it is encountered during construction, it would either be demolished in place or removed with appropriate measures taken to ensure no leakage into the remaining abandoned pipe. The 48-inch MIS pipeline parallels the proposed channel for approximately 500 feet downstream from the Fisher Parkway neighborhood, and then crosses beneath the channel. It is estimated that there would be about 4 feet of cover over the pipeline at the bottom of the proposed channel excavation at the typical riffle cross section. In order to ensure maximum cover over this pipeline, the proposed channel in the vicinity of the pipeline would not include any pools.

The proposed alternative does not call for removal of the concrete channel underneath the CPR railroad bridge (within Segment 5). Detailed drawings for this bridge are not available, therefore, this feasibility study found it to be more appropriate to leave the existing concrete in-place and create a riffle section by adding surface roughness and boulders to the channel. Based on a review of the Highway 45 Bridge plans, there are no anticipated impacts associated with the proposed project.

Two other items that should be noted for the construction phase include the accommodation of peak flows and the use of a snake fence. The MCGFMF would be used to control peak flows during the construction of the proposed restoration project. A snake fence would be used during the construction phase to ensure the Butler's garter snake, a state threatened species, is not adversely impacted during the construction phase.

11.5 Sponsor Mitigation

When MMSD planned the Milwaukee County Grounds Floodwater Management Facility (MCGFMF) in the mid-2000s, they sought the required Section 404 permit from the USACE St. Paul District that covered the retention pond (including inflow and outflow channels/culverts) and stream restoration work in Underwood Creek. The stream restoration included an upstream phase which has been completed by MMSD and the currently proposed Section 506 work. MMSD received their 404 permit (#2006-10-RMG) which required mitigation for expected unavoidable adverse wetland impacts associated with the MCGFMF project. Some of that mitigation was slated to occur in the area identified in this Section 506 project as Segment 3. Because of the plans to remove the concrete from Underwood Creek to improve fish passage under the currently proposed Section 506 project, MMSD was forced to delay mitigation work in the floodplain in Segment 3 until the channel work is done and the floodplain is appropriately sized to accommodate a 100 year flood event. During construction of the proposed 506 project the USACE will remove the concrete and drop structures and create an armored channel and floodplain cross section to accommodate flooding. Following that, MSSD will do additional work within the floodplain created by the proposed Section 506 project to meet their remaining 404 mitigation requirements at their cost. MMSD will design their work to assure it does not inhibit flow during flood events. It is anticipated that the MMSD work will involve some additional excavation to establish wetlands at the appropriate elevations and the planting of native vegetation. No Federal funds will be used to assist the MMSD in completing their mitigation requirement associated with 404 permit (#2006-10-RMG) which includes the MCGFMF project, and no credit will be claimed for the mitigation required by 404 permit (#2006-10-RMG) against the non-Federal share of the Underwood Creek Section 506 restoration project.

12.0 ENVIRONMENTAL COMPLIANCE

The National Environmental Policy Act of 1969 (NEPA) requires Federal agencies, including the Corps, to assess the potential environmental impacts of proposed Federal actions. An Environmental Assessment (EA) was prepared to determine whether the Federal action may have significant adverse impacts on the quality of the human environment. Environmental consequences are evaluated for such items as fish and wildlife, endangered species, wetlands,

water quality, floodplains, cultural resources, recreation, noise, aesthetics, air quality, and cumulative impacts. The EA was prepared as a separate document and accompanies this DPR.

The EA indicates that the proposed Section 506 ecosystem restoration project would not result in significant adverse environmental effects nor would it be expected to result in any significant cumulative or long-term adverse environmental effects. Adverse effects would be minor, including, short-term noise and air emissions from equipment operation; temporary turbidity from construction operations; disturbance of low quality vegetation; and temporary displacement of fish and wildlife. In accordance with NEPA, the EA would be made available for public review and comment for approximately 30 days.

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

The non-federal project sponsor, MMSD, has obtained a Clean Water Act (CWA) Section 404 permit from the St. Paul District USACE Regulatory Office (2006-RMG-10) for the channel and floodplain restoration activities. MMSD will apply to the WDNR for a Wisconsin Chapter 30 permit. Issuance of the Chapter 30 permit is certification that the proposed Section 506 project is in compliance with Section 401 of the CWA.

13. VIEWS OF THE NON-FEDERAL SPONSOR AND OTHER AGENCIES

The Milwaukee Metropolitan Sewer District has submitted a letter of intent and agrees to be the non-Federal sponsor for the project.

The U.S. Fish and Wildlife Service indicated in their response that no federally-listed, proposed, or candidate species, or designated critical habitat occurs within the project area and no special coordination would be necessary. They have also indicated that aquatic non-native and invasive species are not a threat to the success of the project.

The WDNR supports the project. In their response to USACE's coordination letters, they indicated that a new Chapter 30 permit would likely be required for the Section 506 project as the existing permit expired on December 31, 2013. They recommend that Alternative 1 not be selected as it would eliminate the potential for an additional stream corridor available for fish passage. The non-federal project sponsor (MMSD) will apply for a Chapter 30 permit for the proposed Section 506 project.
The WDNR also provided correspondence dated March 2015 regarding its evaluation of the 2005 Phase II ESA and its guidance on disposal options for soil that must be removed from the construction project.

The State Historical Preservation Office (SHPO) expressed concerns about the impact this project could have on the Underwood Creek Parkway (determined eligible for the National Register of Historic Places) and requested an opportunity to review the proposed plans and specifications accordingly (correspondence dated November 7, 2011). MMSD provided the Wisconsin SHPO additional project information, which supported a finding of "no historic properties affected" (correspondence dated May 13, 2014). The Wisconsin SHPO responded with a finding of "no historic properties affected" pursuant to 36 CFR 800.4(d)(1) (correspondence dated May 27, 2014). The USACE submitted a letter to the Wisconsin SHPO on June 3, 2014, stating that based on the recent correspondences between the Wisconsin SHPO and MMSD, the USACE has reached a determination under 36 CFR 800.4 that there are no historic properties affected by the proposed Section 506 project. In an electronic mail message of May 8, 2015, the compliance archeologist at the Wisconsin SHPO office noted that, "After having reviewed the contents of our Compliance file, and Chief Uhlarik's June 3, 2014 letter addressed to Sherman Banker at the Wisconsin Historical Society, I concur with the Chief's determination that no historic properties will be affected by the proposed Underwood Creek Aquatic Ecosystem Restoration Project."

One tribe responded that they have no interest in the project area. No comments were received from the other tribes contacted. A copy of the EA would be provided to the tribes for their review.

14.0 PLAN IMPLEMENTATION

14.1 Cost Sharing and Sponsor Responsibilities

The total project cost would be shared between the USACE and MMSD, with 65 percent of the cost from Federal funds and 35 percent non-Federal. Section 506 projects have a federal expenditure limit of $10,000,000. Table 6 presents the fully funded cost estimate for the proposed project which includes the Federal and non-Federal cost shares. The fully funded cost estimate assumes a single construction season in fiscal year 2016 and reflects the estimated costs, or includes inflation, at the time the project is constructed. Feasibility costs include those costs spent to date on the study. It should be noted that the first $100,000 of the project study costs are paid for (100 percent) by the Federal government and not included in the estimated Total Project Cost shown in Table 6.

Table 6 - Federal and non-Federal Cost Share Apportionment Table

Item	**Total Project Costs**
Feasibility Study Costs	**$815,000**
FED Share[1]	$564,750

non-FED Share	$250,250
Design & Implementation Costs	**$10,782,000**
Design Analyses, Plans & Specs	$1,680,000
Construction	$8,943,000
Monitoring[2]	$28,000
LERRDs[4]	$131,000
FED Cost Share	$7,008,300
Non-FED Cost Share	$3,773,700
Non-FED cash/WIK	$3,642,700
Non-FED LERRDs	$131,000
TOTAL PROJECT COST[3]	$11,497,000
FED Cost Share	$7,473,050
Non-FED Cost Share	$4,023,950

Note: Costs are based on Total Project Cost Fully Funded Estimate from TPCS

[1] The first $100,000 of the study costs are paid for (100%) by the Federal government.

[2] Monitoring Costs are incurred after the project is constructed.

[3] Total Project Costs do not include operations and maintenance costs.

[4] LERRDs are a non-Federal responsibility for which the sponsor gets cost sharing credit.

The non-Federal Sponsor, MMSD, would provide all land, easements and rights-of-way necessary (or LERRDs) necessary for the construction, operation and maintenance of the proposed project. There is an estimated 39,000 cubic yards of excavated material that is deemed suitable for placement into the Lakefield Sand and Gravel facility, located at 7003 W. Good Hope Road, Milwaukee, Wisconsin. The Lakefield site is compliant with all Federal, State and Local permit requirements to accept low hazard exempted material. It should be noted that the LERRDs value of $131,000 accounts for the acreage needed for disposal of low hazard exempt material at the designated disposal site.

While it is anticipated that implementing the proposed project is not expected to result in the release of regulated material, soil collection and analysis will be conducted based on coordination and collaboration with the WDNR and the Remediation and Redevelopment Program's Project Manager at the Lakefield Sand and Gravel site before or during the implementation phase. The collected soil will be analyzed for the presence of regulated materials. If the soil analysis reveals contaminants that exceed WDNR Low-Hazard exemption criteria, the disposal of the sediment and/or generated debris will be conducted in accordance with applicable Federal, State, and local laws and USACE policies. USACE policy stipulates that Civil Works funds shall not be used to remediate contamination caused by others, so the non-Federal project sponsor (MMSD) will pay 100% of the costs associated with the removal and disposal of excavated soil material that exceed the WDNR Low-Hazard exemption criteria and must therefore go to a licensed Type II landfill facility.

The Detroit District has estimated that, based on the WDNR's review of the 2005 testing data (correspondence of March 6, 2015), and in consultation with the Buffalo HTRW Design Center,

approximately 1,500 cubic yards of the excavated material may have to be placed at a licensed landfill. To verify the need for landfill placement of this 1,500 cubic yards, sediment samples and analysis will be conducted before or during the implementation phase. All other material (approximately 39,000 cubic yards) should qualify for low hazard exemption based on WDNR evaluation of the 2005 soil borings and will be taken to the Lakefield Sand and Gravel site.

14.2 Schedule

To proceed with the design and implementation of the proposed project, a Project Partnership Agreement (PPA) would need to be signed by USACE and the non-Federal sponsor. This PPA would bind the USACE and sponsor to meet their Federal and non-Federal responsibilities for implementing, operating, and maintaining the project.

Once the PPA is in place, the USACE would begin preparing plans and specifications for the proposed project. Upon completion of plans and specifications, the construction contract would be advertised. The USACE would award, supervise, and administer the construction contracts. After construction, the USACE would transfer the project to the non-Federal sponsor for operation and maintenance, and would provide an operation and maintenance manual. The USACE would continue to participate in the monitoring phase of the project. The estimated schedule for project implementation is provided in Table 7 and would be documented in a Project Management Plan once the project is approved.

Table 7 - Project Implementation Schedule

MILESTONE	DATE or DURATION
Detailed Project Report Approval	January 2016
Plans & Specifications	May 2016
Ready to Advertise	June 2016
Contract Award	August 2016
Initiate Construction	September 2016
Construction Complete	November 2017
OMRR&R Manual	2019
Project Turned Over to the Sponsor	2019
Monitoring	November 2026

14.3 Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R)

Once the project is completed and turned over to the non-Federal sponsor, the routine operation maintenance, repair, replacement and rehabilitation, or OMRR&R, would be the responsibility of the non-Federal sponsor. For the selected alternative, Alternative 3, the annual cost associated with OMRR&R is estimated to be $13,000. OMRR&R activities would include activities such as: debris management and erosion inspection and repair.

15.0 RECOMMENDATIONS

This Detailed Project Report has been prepared to evaluate ecosystem restoration alternatives for the rehabilitation of Underwood Creek in regard to their relative completeness, effectiveness, efficiency and acceptability and potential impact to existing ecological, cultural and socioeconomic resources. Alternative 3 was the only alternative that was hydraulically acceptable. In addition, this alternative was also identified as the NER plan since it is more efficient at producing habitat than compared to the other alterative (Alternative 2). The recommended alternative would improve in-stream habitat and create connectivity from the Menomonee River to upstream areas of Underwood Creek. The former concrete channel lining and drop structures would be removed and a riffle/pool sequence with natural stone bottom would be constructed in its place. Pools and riffles would provide spawning habitat and cover for various fish species. Within Segment 3, broad meanders would be added to the channel's design and this segment's cross section would be widened.

This Detailed Project Report has given consideration to aspects in the overall public interest, including environmental, social, and economic impacts; feasibility; and the ability and interests of the non-Federal sponsor. The sponsor, the Milwaukee Metropolitan Sewer District, will enter a Project Partnership Agreement to perform the required items of cooperation, including provision of all needed real estate interests, provision of cash as needed beyond real estate values to constitute 35 percent of total costs, and post-construction operation and maintenance of the project.

I recommend that the proposed plan for aquatic ecosystem restoration be approved and implemented. This recommendation reflects the information available at this time and current departmental policies.

27 OCT 15
Date Signed

Michael L. Sellers
Lieutenant Colonel, U.S. Army
District Engineer

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