Evaluation of Treated Return Flow to Lake Michigan through the Milwaukee Metropolitan Sewerage District

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Introduction

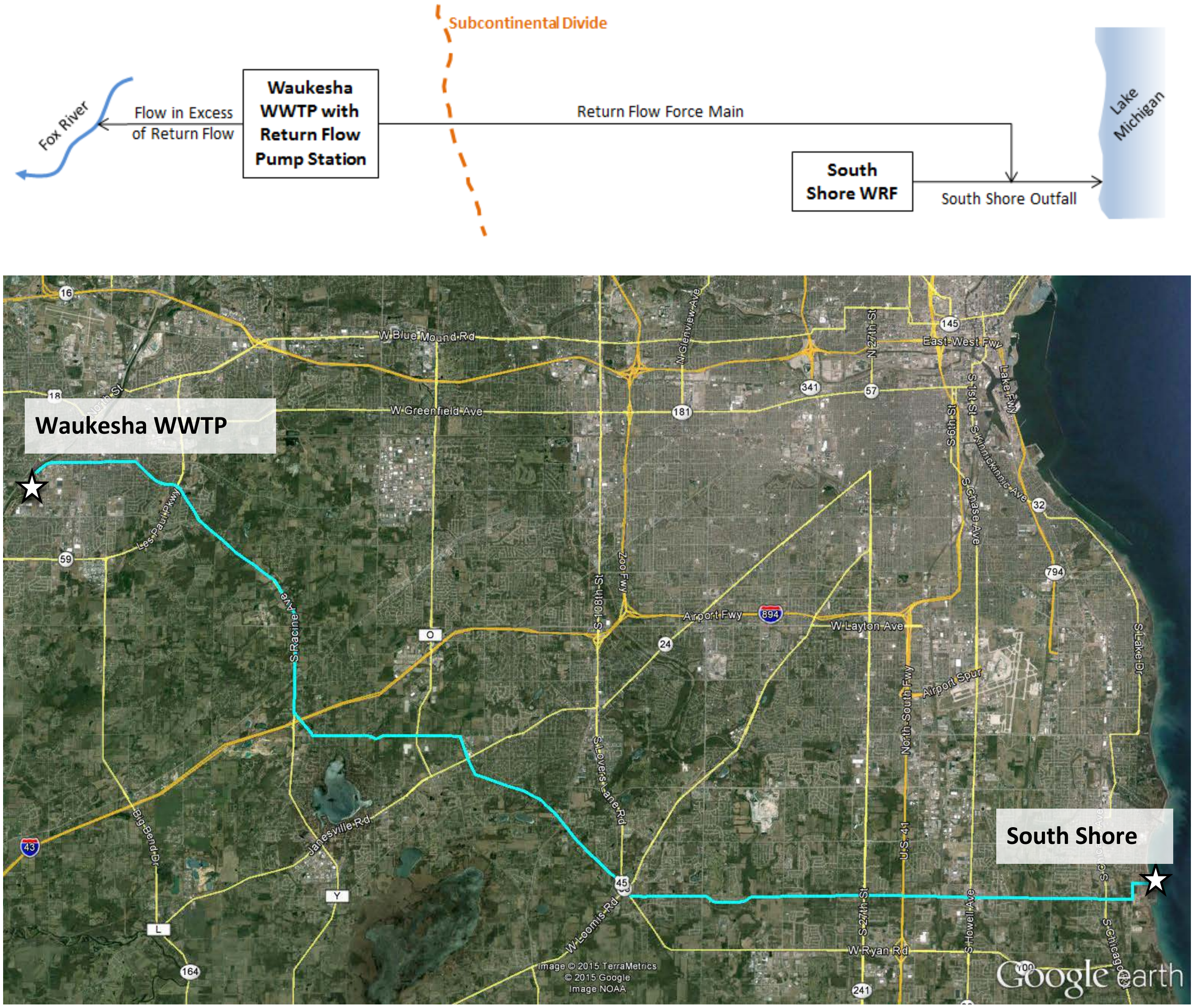
The purpose of this technical memorandum is to present a supplemental evaluation requested by the Wisconsin Department of Natural Resources (WDNR) of a fourth alternative to return flow from a Lake Michigan diversion in the City of Waukesha to the Milwaukee Metropolitan Sewerage District (MMSD). This evaluation is a supplement to three prior alternatives evaluated for return flow to MMSD that are included in the City of Waukesha Application for Lake Michigan Diversion with Return Flow (Application; October 2013) in Volume 4, Appendix A, Attachment A-2.

Background

To supplement the three MMSD return flow alternative evaluations included in the Application, which included decommissioning the City of Waukesha wastewater treatment plant (WWTP) with return of untreated wastewater to MMSD, this evaluation includes maintaining the City of Waukesha WWTP and returning *treated* water to Lake Michigan through MMSD. This evaluation is named Alternative 4 (Figure 1) and utilizes the outfall to Lake Michigan at the MMSD South Shore Water Reclamation Facility (South Shore). Return flow to the South Shore outfall could be considered a direct discharge to Lake Michigan because the return flow would be combined with South Shore flow after all treatment processes at South Shore. No treatment is proposed at South Shore because the return flow would be fully treated through Waukesha's tertiary treatment processes, return flow would meet all permit limits at the City of Waukesha WWTP, and the return flow permit limits at the City of Waukesha WWTP are more restrictive than existing limits at South Shore. As a result, treating return flow again at South Shore would not significantly improve water quality and there would be no additional energy production from the South Shore anaerobic digesters. Conveying treated return flow through the South Shore treatment system may not be allowed because the return flow would be considered clean water that would unnecessarily consume treatment capacity for no significant improvement in water quality.

FIGURE 1

Schematic Drawing and Potential Pipeline Alignment for MMSD Alternative 4: Returning Treated Water from Waukesha WWTP to Lake Michigan through MMSD South Shore Outfall.



Similar to MMSD Alternative 3, MMSD Alternative 4 includes a pipeline from the City of Waukesha WWTP to South Shore. There are however, several differences between the alternatives. Details of MMSD Alternative 4 include the following, which impact cost estimates and environmental impact assessments that are summarized below:

- The return flow alignment is the same as the Root River alternative included in the Application from the WWTP to the intersection of Puetz Road and 68th Street. After 68th Street, the alignment continues east along Puetz Road until South 5th Street where the pipeline continues north 0.3 miles where it enters MMSD South Shore property. This alignment was chosen because it overlays the Oak Creek water supply alignment for about 17 miles. This results in significant cost savings because the pipeline corridors are shared. The total pipeline length is about 26 miles. This alignment differs from MMSD Alternative 3 because at the time of that analysis a City of Milwaukee water supply alignment was under consideration.

- The return flow management plan is the same as the Root River return flow alternative. This includes a maximum return flow rate of 16.7 million gallons per day (mgd) and an average daily return flow of 11.7 mgd. Although the DNR has recently requested (meeting on October 27, 2014) a new management plan that limits the maximum return flow to the previous year's average water withdrawal, this management plan was not used for evaluating MMSD Alternative 4. This is because Root River and other MMSD return flow alternates were evaluated under the return flow management plan included in the Application, and using that management plan allows the return flow alternatives to be more easily compared because the return flow infrastructure is based upon the same return flow conditions. Using the new return flow management plan for the other Alternatives would not materially impact the relative cost differences and the environmental impacts.
- All MMSD return flow alternatives in the Application included decommissioning the existing wastewater treatment plant (WWTP). This resulted in a cost "credit" applied to the MMSD Alternatives 1 to 3 because the City could have *saved* money by not completing budgeted improvements (e.g. expansion of solids handling systems and phosphorus treatment technology). In contrast, MMSD Alternative 4 requires the Waukesha WWTP to continue to also discharge to the Fox River. As a result, the City of Waukesha WWTP cannot be decommissioned in MMSD Alternative 4 and therefore the "credit" given in MMSD Alternatives 1 to 3 does not apply. This is also consistent with other return flow alternatives, such as the proposed Root River return flow.
- MMSD Alternative 4 only utilizes the South Shore outfall to Lake Michigan and the return flow is not *treated* through the entire MMSD system. Consequently, a marginal cost was assumed for utilizing the outfall. This cost was calculated to be 5 percent of the total annual existing treatment costs and was accounted as an annual operation and maintenance cost.
- There are no anticipated costs for site demolition or restoration in MMSD Alternative 4 because the Waukesha WWTP would be maintained.
- The MMSD Alternatives 1 to 3 included a cost markup for pumping raw wastewater. The MMSD Alternative 4 does not include a cost mark up because return flow is treated water. This is consistent with other return flow alternatives that also proposed returning treated water to Lake Michigan.
- A storage tunnel or large wet well is not anticipated in MMSD Alternative 4 (as compared to MMSD Alternative 3) because storage is not needed at the Waukesha WWTP. This allows for a pump station similar to other return flow alternatives such as the Root River.
- MMSD Jones Island Water Reclamation Facility was not evaluated in Alternative 4 because, consistent with the Underwood Creek return flow alternative, an ongoing total maximum daily load (TMDL) study may not provide an allocation for the return flow.
- Where the MMSD Alternative 4 return flow alignment overlays the Oak Creek supply alignment included in the Application, the return flow cost was discounted by 30 percent to estimate the cost sharing for a shared corridor between the pipelines. If the pipelines corridors are not shared, the price would significantly increase. This is also consistent with other return flow alternatives, such as the proposed Root River return flow.
- The MMSD Alternative 4 includes a cost estimate similar to the Root River return flow pump station because the alignments are similar and have similar hydraulic conditions. However the costs were updated for MMSD to account for greater pump horsepower and generator requirements that result from the longer pipeline to South Shore.
- The MMSD Alternative 4 includes a five percent allowance of the total pipeline construction cost for improvements at South Shore for connection with the existing outfall.

Cost Estimates

A conceptual-level cost estimate for the MMSD Alternative 4 is summarized in Table 1. The same contingency, markups, and interest rate factors are used as in all other return flow alternatives. The cost estimates are based on the analysis summarized above and do not include safety factors for sizing equalization storage, treatment or conveyance facilities (e.g. pump station and pipe sizes). If such factors were included, the facility sizes and associated costs would be greater. Additional cost estimating details are included within cost estimate summaries in Attachment A.

TABLE 1
Screening Level Cost Estimates for Return Flow Alternatives to MMSD

Return Flow Alternative	Capital Cost	Annual O&M	20 Year Present Worth
Alternative 1: Wet Weather Equalization and Force Main to South Shore	$ 980,400,000	$ 1,444,000	$ 997,400,000
Alternative 2: Wet Weather Equalization with Return Flow to MMSD Interceptor Near Greenfield Pump Station	$ 869,400,000	$ 1,300,000	$ 884,400,000
Alternative 3: Force Main and Biological HRT at South Shore	$ 262,400,000	$ 1,063,000	$ 274,400,000
Alternative 4: Pump Station and Pipeline to South Shore Outfall to Lake Michigan (includes 30% cost discount where the pipeline corridor is shared with the proposed Oak Creek water supply pipeline)	$ 135,400,000	$ 855,000	$ 145,400,000
Application Proposal: Root River Return Flow	$ 96,038,000	$ 618,000	$ 103,038,000

Cost Estimate with Oak Creek Supply

At the request of the WDNR, the MMSD Alternative 4 return flow cost estimate was combined with Oak Creek water supply alignment proposed in the Application. Summary cost spreadsheets are included in Attachment A.

Environmental Effects

Consistent with the assessment of environmental impacts of the return flow alternatives included in the Application (Environmental Report in Volume 5 of the Application) the MMSD Alternative 4 was also evaluated for its environmental impacts. This is summarized below following a format requested by the WDNR. The MMSD Alternatives 1 to 3 are not included in the below environmental impact review because they were excluded from further consideration as summarized in the Application. The environmental effects are documented on the following pages.

MMSD Return Flow Alternative
Waukesha EIS Information

2. Project alternatives
   2.3. Return flow alternatives
      2.3.2. Lake Michigan return flow alternatives
         2.3.2.4. MMSD return flow alternatives
            2.1.1.1.1. Infrastructure for MMSD return flow alternatives

Identify, describe and map the proposed pipeline route for return flow to MMSD.

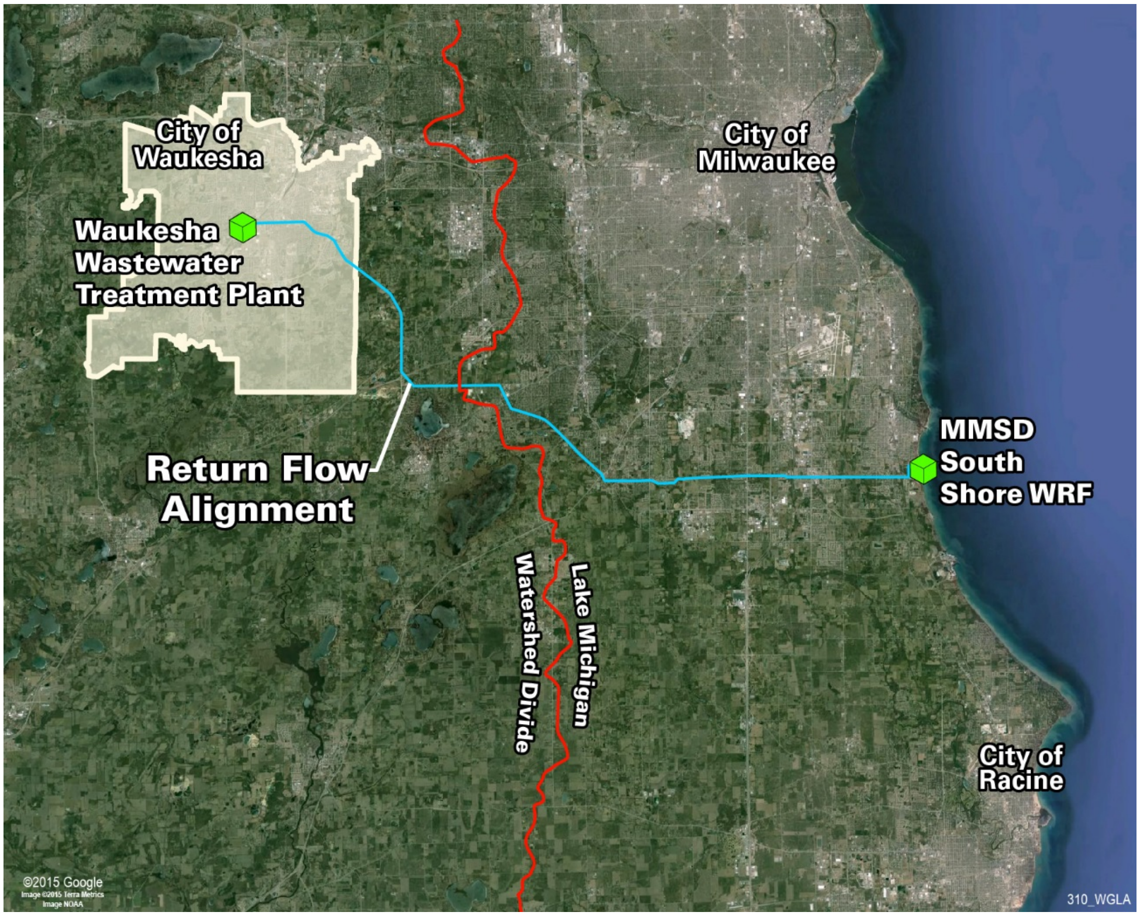
A screening-level alignment for return flow directly to Lake Michigan via MMSD Alternative 4 was developed to evaluate the environmental effects and costs (Figure 2 and Attachment B). The conceptual pipeline alignment is the same as that for Root River Alignment 2 for 17.6 miles from Waukesha to Puetz Road and 68th Street in Franklin. From there, it continues east along Puetz Road towards the Lake instead of going south towards the Root River. At 5th Avenue near Lake Michigan, the alignment turns briefly north for approximately 0.3 miles to enter MMSD's South Shore Water Reclamation Facility (WRF), and another 0.5 miles where the return flow is discharged to Lake Michigan through the MMSD outfall.

The MMSD Alternative 4 alignment path is described in Table 2.

TABLE 2
Roads Parallel to Alternatives

Alternative	Direction	Length (miles)	Road	City
MMSD Alternative 4	North East	0.4	Off Road	Waukesha
MMSD Alternative 4	East	1.6	College Avenue	Waukesha
MMSD Alternative 4	South East	6	Racine Avenue	Waukesha/New Berlin
MMSD Alternative 4	South East	0.5	Minor Roads	New Berlin
MMSD Alternative 4	East	2.7	W. College Avenue	New Berlin/Muskego
MMSD Alternative 4	South East	2	Tess Corners Drive	Muskego
MMSD Alternative 4	South East	2.5	Martins Road	Franklin
MMSD Alternative 4	East	1.9	Puetz Road and 68th Street	Franklin
MMSD Alternative 4	East	7.5	Puetz Road	Franklin/Oak Creek
MMSD Alternative 4	North	0.3	5th Avenue	Oak Creek
MMSD Alternative 4	East	0.5	Off Road	Oak Creek

FIGURE 2
MMSD Alternative 4 Return Flow Alternative



2.1.1.1.2. Cost for MMSD return flow alternatives

Identify the construction and operation costs for return flow to MMSD, including any necessary payments to MMSD.

Construction and operation costs for return flow to MMSD Alternative 4 are included in Table 1. These estimates include funding for the connection to the MMSD outfall and also an estimate of on-going operational payments to MMSD.

4. Environmental effects

4.3. Return flow alternatives environmental effects

4.3.2. Lake Michigan return flow alternatives

4.3.2.2. MMSD return flow alternative environmental effects

4.3.2.2.1. Discharge effects on Lake Michigan from the MMSD return flow alternative

4.3.2.2.1.1. Discharge effects on Lake Michigan water quality from the MMSD return flow alternative

What changes in MMSD effluent discharge quality will occur as a result of the addition of Waukesha's return flow, and how will those changes affect Lake Michigan water quality

All water returned to the Lake Michigan watershed will meet WDNR water quality permit requirements. A summary of proposed discharge limits from the WDNR and a comparison to historical Waukesha WWTP performance are detailed in the Return Flow Plan (Volume 4 of the Application). A comparison of historical WWTP discharge quality to other Lake Michigan dischargers is shown in Table 5-18 in the Inland Waterways section of the Environmental Report.

Waukesha return flow will meet water quality requirements of a return flow and would have no significant adverse impact on Lake Michigan water quality. Waukesha's historical discharge quality is equal to or better than the performance MMSD is required to achieve to project Lake Michigan water quality. Consequently, no significant effect on Lake Michigan water quality would occur. For example, as documented in Table 5-18 of the Environmental Report, Waukesha return flow is likely to have a biological oxygen demand (BOD) requirement of 5.7 to 10 mg/L with historical operations averaging 1.8 mg/L. MMSD has a permit requirement of 30 mg/L BOD monthly average. Waukesha return flow is likely to have a total suspended solids (TSS) requirement of 10 mg/L with historical operations averaging 1.2 mg/L. MMSD has a permit requirement of 30 mg/L monthly average TSS. Waukesha return flow has had historical phosphorus concentration of 0.16 mg/L with MMSD permit requirement of 0.6 mg/L over a 24-month average (WDNR 2015). Based upon these historical operations and MMSD permit requirements, water quality concentrations would not be negatively affected in the MMSD discharge to Lake Michigan.

Water softening no longer would be needed with a Lake Michigan water supply source. Consequently, a reduction in chloride concentration in return flow over time is expected. The City has evaluated chloride concentrations in return flow with a switch to Lake Michigan water and has developed a chloride reduction plan which would further reduce chloride release to the environment.

Water quality loading to Lake Michigan from the watersheds around greater Milwaukee was reviewed and found that the Waukesha return flow would be only 0.18 percent of all fecal coliform loading and only 0.19 percent of all total suspended solids loading under conservative, worst-case conditions. Phosphorus loading was found to be only 0.35 percent of all phosphorous loading under worst-case conditions. Consequently, the water quality impacts to Lake Michigan would be expected to have no adverse impacts.

4.3.2.2.1.2. Discharge effects on Lake Michigan geomorphology and sediments from the MMSD return flow alternative

What change in the volume of MMSD effluent discharge volume will occur as a result of the addition of Waukesha's return flow, and how will that change affect the geomorphology and sediments of Lake Michigan?

The MMSD South Shore WRF has a capacity of 300 mgd with January 2006 through April 2008 having an average discharge of 109 mgd (MMSD, 2011). Return flow would be the same as the Root River return flow alternative. This includes a maximum return flow rate of 16.7 mgd and an average daily return flow of 11.7 mgd. An October 2014 WDNR request for another return flow management plan alternative may lower the ultimate return flow to a maximum of 10.1 mgd. Consequently, the MMSD outfall has extra capacity on average and the Waukesha return flow could range from 5.4 percent to 3.4 percent of the plant rated capacity. It should be noted that the MMSD South Shore WRF capacities for primary treatment, biological treatment, secondary clarifiers, and disinfection would be unaffected by this Waukesha return flow alternative because the Waukesha return flow would be added downstream of all treatment processes. Only connecting into the South Shore WRF discharge pipe would be affected and improvements in capacity made, if required. As a result, no impact to the MMSD treatment capacity would occur.

In addition, Waukesha return flow would represent 5 percent or less of the plant rated discharge capacity, and the return flow would have a lower suspended solids concentration than the existing MMSD effluent. The return flow would use the existing outfall pipe, so that there would be no impacts to geomorphology or sediments. No significant adverse impacts would occur to Lake Michigan geomorphology or sediments.

4.3.2.2.1.3. Discharge effects on Lake Michigan flora and fauna from the MMSD return flow alternative

What Lake Michigan flora and fauna will be affected by the changes in MMSD effluent quality and quantity resulting from the addition of Waukesha's return flow, and how will those flora and fauna be affected?

With the Waukesha return flow quality better than or equal to the MMSD South Shore WRF effluent quality and the return flow volume 5 percent or less of the South Shore WRF capacity, no significant adverse impacts to Lake Michigan flora and fauna would be expected. Additional discussion of the Lake Michigan flora and fauna is described below as documented in the Environmental Report.

Lake Michigan is primarily cold water and relatively infertile. Historically, the fish fauna consisted mostly of lake trout, whitefish, and sculpins. Over the last century, the fisheries of Lake Michigan have experienced dramatic alterations because of fishery exploitation, overharvesting, and nutrient loading changes stimulating algae or plant growth (typically tolerant species). Invasive, or exotic, species, such as the sea lamprey, have caused a significant decline in the population of native species, such as lake herring. The biota is dominated by such introduced or invasive species as the Pacific salmon and trout, alewife, rainbow smelt, ruffe, white perch, goby, zebra mussel (*Dreissena polymorpha*), quagga mussel (*Dreissena bugensis)*, and exotic zooplankton (WDNR, 12/2011a).

A literature review of historical information on biological components of Lake Michigan indicates the following represent typical biological components in the project area.

Benthic Invertebrates

A survey of the Great Lakes in 1998 identified 20 taxa of benthic macroinvertebrates in Lake Michigan with an average of about 7 taxa per sampling site (Barbiero et al., 2000). The amphipod *Diporeia* (formerly *Pontoporeia),* tubificid oligochaetes, and sphaeriid snails dominate the Lake Michigan benthic macroinvertebrate community. However, in near-shore areas, oligochaetes are the dominant taxonomic group. The density of benthic macroinvertebrates typically ranges from 1,500 to 6,500 organisms per square meter. Surveys performed in 2002 near the Great Lakes Water Institute with headquarters in Milwaukee revealed that oligochaetes and chironomidae are present, as are freshwater sponges, *Ectoprocta,* mayflies, leeches, isopods, and amphipods. Dreissenid mussel infestations (zebra and quagga) were confirmed on most suitable habitat (USGS, 2011).

Over the past several decades, the southern basin of Lake Michigan has been invaded by the zebra (*Dreissena polymorpha*) and quagga (*Dreissena bugensis)* mussels and has undergone major shifts in nutrient loading.

Reductions in nutrient loadings have reduced the overall productivity of the lake and produced a decline in the density of benthic macroinvertebrate fauna, particularly oligochaetes and snails, observed between 1980 and 1987 (Nalepa et al., 1998). The year 1988 marked the beginning of colonization of southern Lake Michigan by the zebra mussel and the beginning of a decline in the abundance of *Diporeia.* Filter feeding by zebra mussels in near-shore waters was thought to have decreased the amount of food available to the amphipod (Nalepa et al., 1998).

Plants

Macrophytes

There are no direct impacts to macrophytes with a MMSD Alternative 4 return flow because infrastructure is already in place. Consequently, no construction impacts will occur to Lake Michigan aquatic vegetation.

Algae

Free-floating or planktonic algae are present in Lake Michigan, dominated by the diatoms (represented by *Synedra, Fragilaria, Tabellaria, Asterionella, Melosira, Cyclotella* and *Rhizosolenia)*, among others. Concentrations of free-floating algae fluctuate during the year, subject to the availability of sunlight, water temperatures, and in the cases of diatoms, bioavailability of silicon (WPSC, 2003). Algae typically found attached to substrate are also present in Lake Michigan. These include *Cladophora, Ulothrix, Tetraspora, Stigeoclonium,* and red algae *Asterocytis.*

Fish

Fish species occurring in near-shore waters of Lake Michigan are shown below in Table 3 (Table 5-6 of the Environmental Report) (WPSC, 2003).

Evaluation of Potential Impacts to Invertebrates, Plants, and Fish

Impacts to Lake Michigan aquatic flora and fauna pertain to overall potential aquatic habitat impacts in Lake Michigan. Given the discharge water quality requirements for return flow to Lake Michigan, no significant permanent impacts to the common invertebrates, plants, and fish in the lake are expected. The WDNR informed the City of Waukesha that the City will have to meet future water quality effluent standards at least as stringent as those imposed on discharge to the Fox River (WDNR, 2011a). Given that future Wisconsin Pollution Discharge Elimination System (WPDES) discharge requirements (likely no less stringent than those currently in place) will be designed to protect receiving waters, water quality is not expected to have a significant permanent pollutant loading or other effects upon invertebrates, plants, or fish in Lake Michigan. Based upon revised effluent limits proposed by the WDNR (2011a), these annual estimates are conservative (see an attachment to the Return Flow Plan - Volume 4 of the Application - for additional information). A comparison of historical Waukesha treated effluent quality to MMSD South Shore WRF permit requirements indicates Waukesha quality is equal to or better than MMSD's requirements. As a result, no significant adverse impacts to water quality are expected. The City of Waukesha will work with the WDNR and regulatory community to avoid, minimize, and mitigate potential temporary and permanent impacts.

Potential for Invasive Species

The City of Waukesha will use practices to reduce the potential of introducing or spreading invasive species and viruses (e.g. VHS) through the use of construction best management practices and ongoing operation practices.

During the construction phase of the water supply and return flow pipelines, best management practices will be used to reduce the potential introduction or spread of invasive species. The recently developed NR 40 *Invasive Species Identification, Classification and Control*, will be consulted and followed where applicable to implement best practices to control the spread of invasive species. Example practices that will be considered include washing equipment and timber mats before entering wetlands/water bodies, removing aquatic vegetation from equipment leaving waterways, steam cleaning and disinfecting equipment used in waterways where invasive species may exist, utilizing non-invasive construction techniques, and others. Post construction restoration methods will only use native species and it will consider methods to encourage existing native species to thrive to reduce the potential of the invasive species establishing a foothold. Using these approaches will reduce the potential for spreading invasive species during construction.

During the operation phase of the water supply and return flow pipelines, a Lake Michigan water supply source would have multiple barriers that would prevent the spread of invasive species through water delivered to the City of Waukesha. Drinking water treatment at any of the three potential Lake Michigan suppliers includes filters and disinfection procedures to remove and inactivate viruses. This level of treatment will not allow transfer of invasive species through the water distribution system. Once the water is distributed in pipelines, an on-going disinfectant residual will be maintained, as required, to prevent microbial growth within the pipelines.

Once the drinking water is used and is collected in the sanitary sewer collection system, the City of Waukesha WWTP provides treatment before being discharged to the Fox River or as return flow. The WWTP is an advanced facility with settling and biological treatment systems, dual media sand filters, and ultraviolet light disinfection designed to meet WDNR water quality requirements. The treated wastewater is contained within the WWTP before being discharged as return flow. Consequently, there are no opportunities for invasive species or VHS from the Mississippi Basin to be introduced to the Lake Michigan basin from the return flow discharge.

TABLE 3 (AFTER TABLE 5-6 OF THE ENVIRONMENTAL REPORT)
Fish Species in Near-Shore Waters of Lake Michigan

Common Name	Scientific Name	Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*	Round whitefish	*Prosopium cylindraceum*
Bowfin	*Amia calva*	Bloater	*Coregonus hoyi*
Brook trout	*Salvelinus fontinalis*	Rainbow smelt	*Osmerus mordax*
Brown trout	*Salmo trutta*	Gizzard shad	*Dorosoma cepedianum*
Common carp	*Cyprinus carpio*	Lake chub	*Couesius plumbeus*
Freshwater drum	*Aplodinotus grunniens*	Emerald shiner	*Notropis atherinoides*
Lake sturgeon	*Acipenser fulvescens*	Spottail shiner	*Notropius hudsonius*
Longnose sucker	*Catostomus*	Longnose dace	*Rhinichthys cataractae*
Muskellunge	*Esox masquinongy*	Bluntnose minnow	*Pimephales notatus*
Northern pike	*Esox lucieus*	Sand shiner	*Notropis stramineus*
Pumpkinseed	*Lepomis gibbosus*	Fathead minnow	*Pimephales promelas*
Rainbow trout	*Oncorhynchus mykiss*	Burbot	*Lota*
Rock bass	*Ambloplites rupestris*	Slimy sculpin	*Cottus cognatus*
Smallmouth bass	*Micropterus dolomieui*	Largemouth bass	*Micropterus salmoides*
White bass	*Morone chrysops*	Walleye	*Stizostedion vitreum*
White sucker	*Catostomus commersoni*	Johnny darter	*Etheostoma nigrum*
Yellow perch	*Perca flavascens*	Trout-perch	*Percopsis omiscomaycus*
Lake trout	*Salvelinus namaycush*	Three spine stickleback	*Gasterosteus aculeatus*
Chinook salmon	*Oncorhynchus tshawytscha*	Nine spine stickleback	*Pungitius*

TABLE 3 (AFTER TABLE 5-6 OF THE ENVIRONMENTAL REPORT)
Fish Species in Near-Shore Waters of Lake Michigan

Common Name	Scientific Name	Common Name	Scientific Name
Coho salmon	*Oncorhynchus kisutch*	Brook stickleback	*Culaea inconstans*
Lake whitefish	*Coregonus clupeaformis*	Round goby	*Neogobius melanpostomus*

4.3.2.2.2. Stream crossings effects of the MMSD return flow alternative

Describe all the stream crossings needed for the MMSD return flow pipeline, and include a table of streams crossed, crossing lengths and areas.

Table 4 lists surface waters that are crossed by the MMSD Alternative 4 return flow pipeline and which would have only temporary construction impacts. A water bodies and stream GIS dataset were used to determine the number and acreage of surface water crossings. All water bodies and all streams that intersect the estimated 75-foot-wide construction corridor for impact evaluation purposes are included in Table 4. Crossings of all surface waters contained in the WDNR Surface Water Data Viewer were included.

TABLE 4
Water Body Crossings

Alternative	Water Body/ Stream No.	Water Body Name	Water Body Type	Approximate Crossing Width (feet)	Crossing Area (acres)	Fisheries Classification[a]	Latitude	Longitude	WBIC[b]
Return									
MMSD Alternative 4	3732	Unnamed	Intermittent /ephemeral	14.3	0.02	—	-88.09194113	42.91941533	6200
MMSD Alternative 4	3932	North Branch Root River	Perennial	49.7	0.09	WWSF	-87.99132951	42.8868536	2900
MMSD Alternative 4	4264	Root River	Perennial	52.2	0.01	WWSF	-87.99114969	42.88668099	2900

[a] WDNR (2010d).

[b] Water Body Identification Code from the WDNR Surface Water Data Viewer, Intermittent Streams and Water body Details layers. Water body crossings assigned a WBIC of N/A refers to water bodies not found in the WDNR Surface Water Data Viewer.

4.3.2.2.2.1. Bed and banks stream crossings effects of the MMSD return flow alternative

Describe the intended stream crossing methods for the MMSD return flow pipeline and what effects those crossings will have on the bed and banks of the affected streams.

Techniques that could be used to minimize impacts to stream crossings are discussed in Environmental Report Appendix 5-2, Example Wetland and Waterway Pipeline Construction Crossing Impact Minimization Techniques. Impacts during pipeline construction on in-stream and shoreline vegetative cover may include permanent alteration if woody vegetation must be removed from the pipeline right-of-way or temporary loss at pipeline water crossings within herbaceous emergent wetlands. Submergent and emergent vegetation, in-stream logs and rocks, and undercut banks provide cover for fish and other aquatic biota. Fish and other aquatic life that live in these areas may be displaced during construction. Stream banks and beds will be restored after construction to promote regrowth of riparian vegetation and restoration of habitat features impacted during construction.

Impacts to soils and plant communities of vegetated wetlands that may border water crossings will be minimized and mitigated using environmental construction best management practices (BMPs) such as the use of erosion and sedimentation controls, placement of swamp mats as a working surface for heavy equipment, and the segregation of topsoil containing the wetland seed bank from the subsoils during trench excavation, so that the original soil profile is restored when backfilling the trench. Site hydrology will be preserved by restoring the original contours and elevations within the wetland and removing a volume of trench spoil (sub-soils lacking seed) equal to the volume of pipelines placed within the wetland, so that there is no net placement of fill or loss of flood storage capacity from the wetland and waterbody.

During pipeline design, the City of Waukesha will work with the resource and permitting agencies to determine the appropriate construction techniques for each crossing to minimize and mitigate construction impacts. Regulatory permits will be required for each surface water and wetland crossing and the design will be developed to meet the permit regulatory requirements. Common construction techniques that could be used to minimize construction impacts are discussed in the Environmental Report, Appendix 5-2, Example Wetland and Waterway Pipeline Construction Crossing Impact Minimization Techniques.

In general, construction techniques that range from open cut to horizontal directional drilling could be used for surface water crossings based upon the surface water crossing width, crossing environmental conditions, and site specific geotechnical, construction, and other constraints. Typical construction techniques could be based upon surface water crossing width at the ordinary high water mark.

Optimal crossing methods will be discussed with WDNR to avoid, minimize, and mitigate impacts to all wetlands. Special construction methods also may be needed for crossings of wetlands and waters inhabited by rare, threatened, or endangered (RTE) species of flora or fauna, such as rescue and relocation or replanting of RTE plants or relatively immobile fauna (e.g., turtles). In situations where impacts to aquatic or wetland habitat of RTE species are a major concern, it is expected that WDNR may require seasonal restrictions on construction activity and/or the use of horizontal directional drilling (HDD) methods, to entirely avoid disturbance or permanent alteration of these RTE species and their habitats.

There is no long-term change to inland waterways size, although pipeline stream crossings will cause temporary aquatic habitat impacts. Table 4 lists the surface water crossings. Once construction is complete, the surface water crossing will be restored. Operational and maintenance impacts are expected to be negligible.

Temporary construction impacts on in-stream and shoreline vegetative cover may include alteration or temporary loss at pipeline water crossings. Submergent and emergent vegetation, in-stream logs and rocks, and undercut banks provide cover for fish and other aquatic biota. Fish that live in these areas may be displaced during construction, this habitat alteration will be insignificant because of the small area affected at each crossing location and because the streambanks will be restored to promote regrowth of riparian vegetation. During design, the City of Waukesha will work with the resource agencies to determine the appropriate construction techniques for each crossing to minimize and mitigate temporary impacts. Techniques that could be used are discussed in Appendix 5-2 of the Environmental Report, Example Wetland and Waterway Pipeline Construction Crossing Impact Minimization Techniques.

The Fox River is not impacted by construction, but flow changes will occur in it as a result of redirecting the Waukesha wastewater treatment plant effluent away from the Fox River as return flow back to the Lake Michigan basin. Impacts to the Fox River have been previously described in the Environmental Report and are the same for all return flow alternatives. Consequently, the impacts are not restated here.

Habitat benefits provided through return flow providing increased base flow and habitat on the Root River are not available with the MMSD Alternative 4 return flow alternative.

4.3.2.2.2.2. Water quality stream crossings effects of the MMSD return flow alternative

4.3.2.2.2.2.1. Stream water quality effects of the stream crossings of the MMSD return flow alternative

Describe what effects the construction and operation of the MMSD return flow pipeline will have on the water quality of the affected streams.

Water quality environmental effects could occur during construction in areas where open cut trench construction is necessary. Potential impacts to aquatic resources generally associated with construction can be both direct and indirect. They will depend primarily upon the physical characteristics of the streams, construction methods used, and time of year.

The primary temporary construction impacts to surface waters can be associated with elevated loads of suspended sediment resulting from in-stream trenching activities and erosion of cleared streambanks and rights-of-way from pipeline construction. Impact severity is a function of sediment load, particle size, streambank and streambed composition, flow velocity, turbulence, and duration of construction activities. Temporary construction impacts such as elevated suspended sediment levels can increase turbidity and consequently reduce primary photosynthetic production, flocculate plankton, decrease visibility and food availability, and produce effects that are aesthetically displeasing (USFWS, 1982). Even so, Long (1975) concluded that most fish avoid turbid water and can survive for several days in waters where construction in a stream has caused turbidity. Since the impacts will be temporary, reviewed by the permitting agencies, and BMPs will be designed to reduce the impact, turbidity and erosion created by construction will be minimal.

Construction effects on water quality will be minimized by using BMPs as described in Environmental Report Appendix 5-2, “Example Wetland and Waterway Pipeline Construction Crossing Impact Minimization Techniques.”

After restoration of the pipeline construction crossings, operational and maintenance effects on water quality to inland waterways would not occur with return flow through MMSD Alternative 4 because return flow would go directly to the MMSD South Shore WRF outfall instead of into Root River or Underwood Creek. No significant adverse impacts would occur to water quality in streams.

4.3.2.2.2.2.2. Downstream water quality effects of the stream crossings of the MMSD return flow alternative

Describe what effects the construction and operation of the MMSD return flow pipeline will have on the water quality of downstream reaches of the crossed streams and other downstream waterways.

If there are any water quality impacts to downstream reaches of crossed streams as a result of construction they would be minimal and temporary while using BMPs to minimize impacts and could be absent entirely where horizontal direction drilling (HDD) methods are used that have no surface impacts to stream water quality. After pipeline crossing restoration, there would be no operational water quality impacts to downstream areas.

4.3.2.2.2.2.3. Lake Michigan water quality effects of the stream crossings of the MMSD return flow alternative

Describe what effects the construction and operation of the MMSD return flow pipeline will have on Lake Michigan water quality.

There are no direct construction related impacts to Lake Michigan water quality with an MMSD return flow because infrastructure is already in place. Water quality impacts to Lake Michigan as a result of construction and operation of the MMSD return flow have been previously covered under Section 4.3.2.2.1.1.

4.3.2.2.2.3. Flora and fauna stream crossings effects of the MMSD return flow alternative

Describe what effects the construction and operation of the MMSD return flow pipeline will have on the flora and fauna of the crossed streams and other downstream waterways, including Lake Michigan.

Environmental effects of a MMSD Alternative 4 return flow on the flora and fauna of inland waterways consist of impacts from construction at stream crossings where open trench construction is necessary.

The primary temporary construction impacts can be associated with elevated loads of suspended sediment resulting from in-stream trenching activities and erosion of cleared streambanks and rights-of-way from pipeline construction. The severity of impact would be a function of sediment load, particle size, streambank and streambed composition, flow velocity, turbulence, and duration of construction activities. Turbidity and erosion created by construction would be minimal, because the construction period will be brief and BMPs will be employed to reduce the impact.

Without mitigation by implementing BMPs, temporary construction impacts can also elevate suspended sediment levels that increase turbidity and consequently reduce primary photosynthetic production, flocculate plankton, decrease visibility and food availability, and produce effects that are aesthetically displeasing (USFWS, 1982). However, Long (1975) concluded that most fish avoid turbid water and can survive for several days in waters where construction in a stream has caused turbidity. Since the construction impacts will be temporary and river crossings will use BMPs designed to reduce the impact, turbidity and erosion created by construction will be minimal.

It is not anticipated that a MMSD Alternative 4 return flow would have a significant impact on mammals and birds in the various inland waterways discussed in this document. Mammals and birds that normally live in areas undergoing pipeline construction may be temporarily displaced during construction. However, habitat alteration will be relatively insignificant because of the small area affected and post-construction restoration efforts used to promote habitat recovery.

Downstream waterways and especially Lake Michigan is located significantly downstream of stream crossings and would not have any direct impacts. Turbidity would be minimized through the use of BMPs. Where HDD methods are used, no downstream impacts are expected to flora and fauna.

Because return flow goes directly to the MMSD South Shore WRF, no operational impacts would occur to flora and fauna inhabiting inland waterways crossed by the return flow pipeline or Lake Michigan.

4.3.2.2.2.4. Wetland functional values effects of the MMSD return flow alternative

Identify and describe all wetlands that would be crossed by the MMSD return flow pipeline, and their functional values. Describe the intended wetland crossing methods, and the effects of the crossings on the wetlands' functional values. Include a table of wetlands crossed, crossing lengths and areas.

Pipeline wetland crossings for the MMSD Alternative 4 return flow alternative are included in Table 5. The table includes a listing of all wetlands crossed, crossing lengths, wetland type, and areas. Where a crossing length is not included, the pipeline construction corridor intersected the wetland, but the pipeline itself did not cross the wetland.

Wetland impacts were calculated assuming a 75-foot-width pipeline construction corridor and then comparing the pipeline corridor width to Wisconsin Wetland Inventory wetland mapping using geographic information system (GIS). This same wetland impact assessment approach was conducted for all alternatives to consistently compare potential impacts of one alternative to another. Note that, in many cases during design of the proposed project, wetland resources could be avoided altogether and, where wetlands would be crossed, the construction corridor could be made narrower than 75 feet to minimize, if not avoid, impacts. However, to conservatively estimate wetland impacts for alternative comparison, a consistent construction width was used to assess potential wetland impacts. Crossing lengths are listed in reference to the pipeline centerline. Where no crossing width is included, the pipeline construction infringes upon the adjacent wetland.

TABLE 5
Wetland Crossings

MMSD Return Flow	Wetland No.	Wetland Type	Crossing Width (feet)	Crossing Area (acres)
Return Flow for Lake Michigan Water Supply				
MMSD Alternative 4	8714	Emergent/wet meadow	—	0.07
MMSD Alternative 4	9020	Forested	—	0.02
MMSD Alternative 4	9026	Forested	—	0.07
MMSD Alternative 4	9028	Forested	—	0.01
MMSD Alternative 4	10401	Emergent/wet meadow	—	<0.01
MMSD Alternative 4	10573	Emergent/wet meadow	—	< 0.01
MMSD Alternative 4	10801	Emergent/wet meadow	—	0.02
MMSD Alternative 4	10810	Emergent/wet meadow	—	0.16
MMSD Alternative 4	11286	Scrub/shrub	—	0.01
MMSD Alternative 4	11290	Scrub/shrub	—	0.02
MMSD Alternative 4	11368	Scrub/shrub	—	0.08
MMSD Alternative 4	11369	Scrub/shrub	—	0.02
MMSD Alternative 4	11376	Scrub/shrub	—	0.05
MMSD Alternative 4	11381	Scrub/shrub	—	0.01
MMSD Alternative 4	11896	Forested	—	0.07
MMSD Alternative 4	11897	Forested	—	<0.01
MMSD Alternative 4	11900	Forested	—	0.13
MMSD Alternative 4	11902	Forested	—	0.19
MMSD Alternative 4	11906	Forested	—	0.03
MMSD Alternative 4	11914	Forested	—	< 0.01
MMSD Alternative 4	12293	Forested	—	0.01
MMSD Alternative 4	12301	Forested	—	0.01
MMSD Alternative 4	12314	Forested	—	< 0.01
MMSD Alternative 4	12363	Forested	—	< 0.01
MMSD Alternative 4	12392	Forested	—	0.01
MMSD Alternative 4	12399	Forested	—	< 0.01

Wetland and waterway crossing methods have been previously documented in Appendix 5-2 of the Environmental Report. Additional discussion is provided here.

Where wetlands are unavoidable, temporary impacts will occur. Potential impacts resulting from the construction of the proposed project include vegetation clearing and soil disturbance for construction access and pipeline construction. Trenches would be excavated to install the pipeline. Soil disturbance would be minimized by segregating the topsoil layer from the subsoil layer over the proposed trench line in unsaturated or non-inundated wetlands during excavation. All wetland soils excavated during construction would be segregated from other subsoils. The soil profile would be restored by replacing the layers in reverse order of the initial excavation when backfilling. Following construction, wetland areas would be restored to their pre-existing contours to allow for natural re-vegetation, supplemented with plantings where necessary to achieve full restoration. Excess fill would be removed from the construction corridor, including from floodplain areas. However, many of the impacts can be minimized through the use of best management practices (BMPs) as described in the following subsections, and many wetland functions would only be temporarily impacted until restoration is completed. In most cases, the construction would be completed in a matter of days, or weeks at the most, followed immediately by restoration, re-vegetation, and monitoring to achieve successful re-vegetation and restoration of drainage/hydraulic characteristics.

Wetland Functional Values

The functional value impacts, evaluated using the WDNR Wetland Rapid Assessment Methodology, Version 2.0 (2014), and discussed in the following subsections, are applicable to a MMSD Alternative 4 return flow alternative.

Human Use Values

No adverse permanent impacts to human use functional values of wetlands will occur as a result of the alternative pipeline routes. Temporary restrictions on access to wetlands during construction will be limited to the actual construction window, which is anticipated to be very brief and a return to existing conditions will occur shortly after construction is complete.

Wildlife Habitat Values

Wildlife will leave the palustrine scrub-shrub wetlands (PSS) and palustrine forested wetlands (PFO) habitats adjacent to or within construction areas and, due to the short duration of construction, in most cases will return after pipeline installation and site restoration. For most species they can still occupy/forage in the construction area during periods (e.g. at night) when there would be no human activity.

Trench spoils from within wetlands will be segregated and replaced in the original soil profile to preserve the topsoil seed bank and to facilitate rapid natural regeneration of the original wetland vegetation from root sprouts and the seed bank. Since palustrine emergent wetlands (PEM) wetlands typically recover fully from the seed bank within a single growing season, the temporary disturbance of the plant community would be expected to be minor and ecologically insignificant to the wildlife habitat functions and values of PEM wetlands. Many species of flush-cut wetland shrubs (e.g., alders, dogwoods) and trees (e.g., red maple) can recover from stump sprouts within a few growing seasons and, consequently, disturbances of the woody plant community within PSS wetlands will be temporary and insignificant. Similarly, trees cut within PFO wetlands will recover from existing stumps left in place; however, the timeline for full regrowth will be more significant than for PSS wetland resources. Ultimately, no loss of functional value are anticipated within PFO wetlands within temporary construction workspaces.

Where the permanent maintained right-of-way encroaches on wetland resources, those wetland areas will be operationally maintained as PEM conditions resulting in type class changes. However, the areas are very minor and the original hydrology, soils, and herbaceous component of those PSS and PFO communities will be fully restored such that the temporary disturbance of the non-plant community will be negligible, short-term, and ecologically insignificant to the wildlife habitat functions and values of the original PSS and PFO wetlands.

Fish and Aquatic Life Habitat Values

No adverse impacts will occur from either pipeline to fish and aquatic life habitat values (FA 1 to 4), since none of the wetlands to be disturbed directly provide these functions. The major waterbody crossings along the proposed and alternative pipeline routes occur at bridges or box culverts that cannot be open cut and, therefore, are most likely to be crossed using boring or horizontal directional drilling (HDD) methods. Consequently, any wetlands bordering aquatic habitats at a few locations will not be adversely impacted.

Shoreline Protection Functions

The major waterbody crossings along both pipeline routes occur at bridges or box culverts that cannot be open cut, but are most likely to be crossed using boring, HDD, or other trenchless construction methods; consequently, shoreline protection functions afforded by wetlands bordering aquatic habitats will not be adversely impacted. PEM resources adjacent to waterbodies that are disturbed during construction will be restored such that the existing seed bank can quickly reseed and stabilize the area. If necessary, additional BMPs including erosion control netting and temporary overseeding with an annual rye can be utilized to provide additional short-term shoreline protection. As a result of the implementation of these practices, any impacts to shoreline protection functions will be temporary and insignificant.

PSS and PFO resources adjacent to waterbody crossings that are temporarily disturbed during construction will be restored with the environmental BMPs discussed previously for PEM resources. In addition, shrubs and trees outside of the actual trench line will be flush-cut at the ground surface and the stumps left in place to continue to provide stabilization.

Flood and Stormwater Storage Functions

No adverse impacts will occur to flood and stormwater storage functions (ST 3 & 4), since pipelines will be installed within wetlands using BMPs so that there will be no net fill of wetlands that otherwise would reduce storage capacity. If a pipeline must be placed within a wetland due to utility conflicts within the road bed or shoulder, stumps from the trench line and a volume of trench spoil equal to the pipe volume(s) will be removed for upland disposal, thus resulting in no net filling of the wetland, as required under Section 404 of the Clean Water Act and Wisconsin wetland regulations.

Water Quality Protection Functions

Impacts to water quality functions will temporarily occur within PEM wetlands while construction is occurring due to vegetation removal. However, aside from the pipeline trench itself, construction equipment will operate on swamp mats to protect the roots of emergent herbaceous vegetation. Since emergent wetlands typically recover fully from the existing root systems and seed bank within one growing season, temporary disturbance of the plant community will be negligible and ecologically insignificant to the water quality preservation and renovation functions and values of the PEM wetlands.

For PFO wetlands, the permanent conversion to PEM conditions will not adversely affect the water quality functions of the wetland because the PEM will provide equivalent or superior water quality enhancement functions. Beyond the pipeline trench, there will be little or no disturbance of shrub or tree roots or soils that stabilize and promote soil microbial and fungal communities that help to attenuate pollution, so that there will be no adverse permanent or temporary impacts to water quality functions of disturbed PSS and PFO wetlands. Even if equipment must traverse wetlands during construction any such traffic could occur on swamp mats to protect the flush-cut root systems of shrubs, many of which then should re-sprout and recover fully within a few growing seasons. In some cases, moreover, a dense herbaceous wetland community can be more effective at renovating surface water quality than a more sparsely vegetated PSS or PFO wetland with little or no ground cover of herbaceous vegetation.

Groundwater Processes

Finally, there will be no adverse permanent or temporary impacts to groundwater processes, since the project will not significantly alter the hydrology of the existing wetlands, either during or following construction. Even if there are any PSS and PFO wetlands where trees and shrubs must be removed during construction and a permanent right-of-way within the wetland must be maintained as a PEM free of trees or shrubs, for access and pipeline integrity reasons, the surface and subsurface hydrology of the original PSS or PFO wetland will not be altered.

4.3.2.2.2.5. Upland forests effects of the MMSD return flow alternative

Identify and describe all upland forests and woodlots that would be crossed by the MMSD return flow pipeline. Describe the effects of the crossings on the forests and woodlots. Include a table of forests and woodlots crossed, crossing lengths and areas.

The return flow pipeline follows transportation corridors (See Tables 8 and 9) so that the construction corridor only intersects edges of forested areas. Table 8 estimates less than a half-acre of woodlands could be impacted by this alternative. Wooded areas that will be affected by the project generally consist of deciduous upland forests. Forested areas exhibit a more complex structure than open areas and generally provide a higher-quality wildlife habitat. Large un-fragmented tracts of forested land can provide important habitat for larger, territorial mammals (coyote, deer) and may provide habitat for migratory birds. Food sources from mature trees, as well as berries and other fruits from some understory shrubs and woody vines, are an important wildlife food source. Secondary canopy shrubs and saplings, brush piles, and fallen logs provide cover for various small- to medium-sized mammals. Impacts to forested areas may occur as a result of pipeline installation, but such impacts would be temporary and would be managed by avoidance, minimization, and mitigation measures developed in coordination with the appropriate regulatory agencies. To facilitate construction trees within the construction corridor will be removed and stumps will be flush-cut with the ground surface. In cleared areas wooded habitat removed by construction will be replaced initially by non-woody vegetation, which may provide food, shelter, and breeding space for small mammals and birds. Trees will be allowed to grow back on cleared workspace beyond the maintained maintenance corridor. As a result, temporary impacts to woodland areas do not represent a significant concern.

A summary of land uses crossed by the pipeline, including woodland areas, is included in Table 8 in Section 4.3.2.2.2.9.

4.3.2.2.2.6. Upland grasslands effects of the MMSD return flow alternative

Identify and describe all upland grasslands that would be crossed by the MMSD return flow pipeline. Describe the effects of the crossings on the grasslands. Include a table of grasslands crossed, crossing lengths and areas.

The return flow pipeline follows transportation corridors (See Tables 8 and 9) so that the construction corridor only intersects edges of potential grassland areas. *Open Unforested Areas* that will be affected by the project generally include cropland (fallow and active), undeveloped non-forested areas, and scrub-shrub land. Open lands crossed by the project total less than 5 acres (see Table 8). Farm crops may serve as a food source for certain species, including whitetail deer and Canada goose. Uncultivated grasslands, pasture, scrub-shrub land, and maintained rights-of-way may support herbaceous and low-level woody vegetation, offering protective cover and forage food sources. Open areas may function as travel corridors where adjacent land is wooded or developed. Open, uncultivated areas may sustain abundant populations of small mammals, such as deer mouse and meadow vole, larger herbivorous mammals, such as woodchuck and eastern cottontail rabbit, and predatory omnivores or carnivores, such as opossum, striped skunk, and red fox. Open areas may provide suitable habitat for bird species, including red-winged blackbird, Canada goose, meadowlark, mourning dove, American crow, American robin, European starling, common grackle, and various sparrows. Open areas bordered by woodland habitats or hedgerows are of particular value to birds and other wildlife because of the nesting and refuge opportunities they afford. Reptiles and amphibians that frequent open grassy areas include the eastern garter snake, blue racer, and American toad.

Due to vegetation removal and grading, construction will cause only the temporary displacement of more mobile wildlife from workspaces and adjacent areas. Surface restoration will include coordination with regulatory agencies to provide preferred habitat vegetation applicable to adjacent land use and operational considerations. Thus impacts in grasslands will only be temporary and generally one growing season or less.

After construction, wildlife is expected to return and recolonize. Because there are no planned above ground structures along the pipeline route, and because the pipeline routes follow streets, utility corridors, city and county lands, and other disturbed areas, long-term impacts to wildlife resources are not expected to grasslands. Plans will accommodate general and site-specific protective measures for sensitive wildlife habitats and species identified during the course of detailed design and permitting. Seasonal construction scheduling to accommodate reproductive and migratory patterns will be coordinated with state and federal agencies.

A summary of land uses crossed by the pipeline, including potential grassland areas in opens lands, is included in Table 8 in Section 4.3.2.2.2.9.

4.3.2.2.2.7. Air emissions (construction and operation) effects of the MMSD return flow alternative

Identify the emissions of air pollutants during construction and operation of the MMSD return flow alternative, including CO_2.

The greenhouse gas emissions for the MMSD Alternative 4 return flow alternative was based on two components, 1) emissions associated with the energy usage estimates described below, and 2) emissions associated with the production and transportation of chemicals required for drinking water treatment. Together the emissions for electricity usage and chemical production and transport comprise the total carbon dioxide equivalent (CO_2e) emissions estimate for each alternative. Emissions during construction would be temporary and insignificant.

The energy usage for the MMSD Alternative 4 return flow alternative was based on two components, 1) pumping energy to supply the water from the source, and 2) treatment energy necessary to meet drinking water requirements for that source. The average day demand (ADD) flow, 10.1 million gallons per day (mgd), was used to estimate the energy for each water supply alternative. For return flow, the energy was estimated based on the pumping energy to return average day flow to the Lake Michigan watershed discharge location. An average day demand (ADD) flow of 11.7 million gallons per day was used to estimate the energy for each return flow alternative.

The CO2e emissions for electrical energy usage were calculated using an emission factor of 1,859 pounds CO2e/megawatt-hour (MWh). This is a factor obtained for coal fired power plants. This is considered conservative since the most recently published 2010 eGRID value for the Southeastern Wisconsin regional electricity supply is 1,511 CO2e/MWh[1], which takes into

[1] U.S. EPA eGRID 9th edition Version 1.0 (2010 data: eGRID sub-region RFCW CO_2e total output emission rate). (February, 2014)

account recent data for the regional electricity generation mix from coal, natural gas, renewables, etc.

Quantities of treatment chemicals were calculated based on the treatment required for each alternative using a proprietary software tool, CPES™. The ADD flow and CO_2e emission estimates were made for production and transportation of these chemical quantities.

Table 6 below provides a summary of estimated energy use and greenhouse gas emissions associated with MMSD Alternative 4 is included below.

TABLE 6
Estimated Energy Use and Greenhouse Gas Emissions

Alternative	Estimated Annual Energy Usage (MWh)	Estimated Annual GHG Emissions (tons CO_2)
MMSD Alternative 4 to Lake Michigan	8,100	7,500

Note: the energy use and greenhouse gas emission estimates were based on an ADD of 10.1 mgd for water supply alternatives and average daily flow of 11.7 mgd for return flow alternatives; greenhouse gas emissions will change proportionally with a change in ADD or average daily flow.

4.3.2.2.2.8. Economic effects of the MMSD return flow alternative

Describe how construction and operation of the MMSD return flow alternative will affect the economies of Waukesha, Milwaukee and the southeast Wisconsin region.

Projections of water demand take into account the City of Waukesha's economy and associated water demand as it relates to the City's water supply service area (see the Water Supply Service Area Plan, Volume 2 of the Application). By serving the projected demand, water supply would not constrain or otherwise affect economic growth and thus be consistent with all land use planning. The source of the supply does not affect the quantity; thus, all supply source alternatives are similar with respect to quantity and do not affect the economy.

A University of Wisconsin-Milwaukee Center for Economic Development (CED) study found that the source of water is not a differentiating factor on development within a municipal service area (UWM, 2010, p. 19). The only exception to this view is related to groundwater with radium exceeding allowable levels. The study found some planners and utility managers in the southeastern Wisconsin region understood groundwater quality problems to be associated with radium contamination, when the groundwater was withdrawn from deep aquifer sources. There were no contamination concerns expressed for surface water sources, because contamination, specifically by radium, is associated only with deep aquifer sources.

4.3.2.2.2.9. Land use effects of the MMSD return flow alternative

Identify and describe the land uses that would be crossed by the MMSD return flow pipeline. Include a table of the landuse categories crossed, and the crossing acreages.

Land use data was assembled from the 2000 SEWRPC Digital Land Use Inventory and 2005 SEWRPC Park and Open Space Sites, both produced by SEWRPC's Land Use and GIS Divisions. The following descriptions were used in classifying land use in this section:

- *Residential*. Two-family and multifamily low-rise (up to three stories) and multifamily high-rise (four or more stories) buildings and low-, medium-, and high-density areas.

- *Commercial and Industrial*. Retail sales and service intensive areas; manufacturing, wholesaling and storage areas; and unused lands designated commercial or industrial.
- *Transportation and Communication Utilities.* Freeways, expressways, streets, and truck terminals; off-street parking areas; rail-related rights-of-way; and communication and utility areas/structures.
- *Government and Institutional.* Administrative, safety, or assembly areas, both local and regional; educational areas (local and regional); and cemeteries.
- *Recreational Areas*. Land-related recreational areas, both public and nonpublic.
- *Agricultural Lands.* Cropland, pasture, lowland pasture, farm buildings, and other agricultural areas.
- *Open Lands*. Urban and rural open areas.
- *Woodlands*. Open lands that are forested.
- *Surface Water*. Open lands that are bodies of water.
- *Wetlands*. Wetland areas in designated open land, transportation, and communication/utility areas.
- Table 7 below summarizes the total land impacts expected by the MMSD Alternative 4 return flow alternative.

TABLE 7
Summary of Land Acreage Impacts

Proposed Project	Land Affected (acres)	
	Overall[a]	During Operation[b]
Return Flow for Lake Michigan Water Supply		
MMSD Alternative 4[b]	235.1	0

[a] Includes areas affected by the return flow route.
[b] Aboveground structures may include a pump station, to be constructed within the Waukesha WWTP site in a previously disturbed area.

Table 8 (see next page) provides quantitative data for land use types affected by temporary construction impacts and the operational impacts of the MMSD return flow route. Most of the land affected is categorized as transportation and communication utilities, most of which is made up of the roadways affected by the routes. This emphasizes the fact that the pipelines associated with this project primarily use public rights-of-way or utility corridors. Impacts are evaluated assuming a 75-foot right-of-way for construction. Note that Table 8 uses SEWRPC land use data. The SEWRPC wetland land use data is different from the WWI wetland data. Consequently, wetland acreage is different between Table 8 and Table 5. WWI wetland data was used for wetland analysis while SEWRPC wetland data was used for land use analysis.

The return flow route follows streets, utility corridors, city and county lands, and previously disturbed areas.

TABLE 8
Land Use Impacts in Acres

Route	Residential	Commercial & Industrial	Transportation & Communication/ Utilities	Government. & Institutional	Recreational Areas	Agricultural Lands	Open Lands	Woodlands	Surface Water	Wetlands	Total[a]
MMSD Return Flow											
MMSD Alternative 4	7.52	0.55	217.35	1.08	0.34	2.97	4.14	0.48	0	0.61	235.04

Source: SEWRPC (2000).

[a] Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory.

Table 9 includes the percentage of alignment closely associated with transportation corridors. Land designated for transportation use account for the vast majority of the area potentially affected by the proposed supply and return flow routes. Using previously disturbed areas that are developed or actively maintained minimizes disturbance to land uses and natural resources.

TABLE 9
Use of Existing Transportation Corridors

Return Flow Route	Percent Existing Transportation Corridors
MMSD Alternative 4 to Lake Michigan	92

The second largest land use category that could be affected under the MMSD Alternative 4 return flow route is residential. The residential land within the assumed 75-foot construction corridor borders roads. The majority of residential land that could be affected is described as single family low density. The construction corridor may be further minimized to avoid private property or temporary construction easements will be obtained by the City.

Once the proposed project has been constructed, land with temporary impacts from pipeline construction will be restored to or allowed to revert to its previous use.

4.3.2.2.2.10. Recreation and aesthetic resources effects of the MMSD return flow alternative

Identify and describe the recreational, public and aesthetic resources that would be crossed by the MMSD return flow pipeline. Include a table of the affected public or conservation lands, and the crossing acreages.

The routes were evaluated to identify Public or Conservation Land and Natural, Recreational, or Scenic Areas within the 75-foot-wide construction corridor. Table 10 below summarizes the Public or Conservation Land and Natural, Recreational, or Scenic Areas within or adjacent to proposed workspaces. Public or Conservation Land and Natural, Recreational, or Scenic Areas may include the following:

- Federal or state wild and scenic rivers
- USFWS designated areas, USDA Forest Service areas
- U.S. National Parks
- National Wilderness Areas
- National Trails System
- National Historic Landmarks
- Critical habitat areas of NOAA Fisheries
- State designated natural areas and state managed lands
- State, county, and/or city parks
- Golf courses and athletic fields
- Designated green space corridors
- School properties

TABLE 10
Public or Conservation Lands within or Adjacent to the Proposed Project

Route Name	Name of Resource	Acres within Proposed 75-ft Construction Workspace
Return Flow for Lake Michigan Water Supply		
MMSD Return	Buchner Park	0.09
	Carroll College (Athletic Fields)	0.05
	Fox River Sanctuary	<0.01
	Franklin Woods Nature Center	0.65
	Hidden Lakes Park	0.38
	Oak Creek High School	<0.01
	Oak Creek Library	<0.01
	Park Arthur	0.48
	Prospect Hill School	0.62

Source: Google Earth (2012); SEWRPC (2005).

According to a review of Google Earth and the SEWRPC Land Use Division and GIS Division, Park and Open Spaces Sites data (2005), no federally designated or managed Public or Conservation Land and Natural, Recreational, or Scenic Areas would be affected by the MMSD Alternative 4 return flow alternative. See Table 10 for a list of public (nonfederal) parks, golf courses, and wildlife areas associated with the MMSD Alternative 4 return flow route.

Recreation and Aesthetics Effects

Recreation

Limited temporary construction impacts may occur to state and local public or conservation land and natural, recreational, or scenic areas as a result of construction.

At this time, no permanent aboveground structures are envisioned within areas designated as state or local Public or Conservation Land and Natural, Recreational, or Scenic Areas.

Construction-related impacts to resources can be divided into temporary and permanent impacts. Temporary construction-related impacts will be short in duration and minimized by implementing BMPs designed to reduce impacts to sensitive resources. No permanent aboveground structures are expected to be built within areas designated as state or local public or conservation land and natural, recreational, or scenic areas. As a result, there will be no permanent impacts to recreational resources.

Aesthetics

Construction will not affect any areas subject to federal visual resource management standards, and no designated sensitive viewpoints are known to occur along the route.

The MMSD Alternative 4 return flow route would not require aboveground facilities or would be limited to a pump station and small service building at an existing treatment plant, which would be coordinated with local architectural. None of the proposed aboveground structures is located in any visually sensitive areas.

Visual impacts of the return flow route is expected to be minor and temporary. In agricultural areas, previously disturbed easements, roadway corridors, and residential properties, visual disturbance will be difficult to detect by the first growing season following completion of construction and surface restoration efforts.

Coastal Zone Management Areas

Coastal Zone Management Areas are enforced within Wisconsin counties that border the Great Lakes, including Milwaukee County. The MMSD Alternative 4 return flow route is within Milwaukee County but construction would be limited to work along an existing wastewater treatment plant. As a result, no significant impact to coastal resources is expected.

4.3.2.2.2.11. Archeological and historical resources effects of the MMSD return flow alternative

Identify and describe the archaeological and historic resources that would be crossed by the MMSD return flow pipeline.

Archival investigations were conducted by The Public Service Archaeology & Architecture Program of the University of Illinois at Urbana-Champaign (PSAAP) to identify significant cultural resources within or adjacent to potential construction corridors of the proposed MMSD Alternative 4 return flow alternative (PSAAP, 2015). The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of the new segment of this potential corridor from Puetz Road and 68th Street to the MMSD South Shore WRF. These findings contain archeologically sensitive and confidential information that is made available to necessary agencies for review under separate cover. Detailed information regarding the findings are not included in this memo as they are not intended for public release; however, up to 12 known sites and 27 known previous cultural surveys were identified within and/or adjacent to the MMSD Alternative 4 return flow alternative. A total of 10 sites and 18 previous surveys were associated with the Root River Return Flow Alignment 2 which ties into MMSD Alternative 4 return flow alternative. The MMSD Alternative 4 return flow alternative accounts for an additional 2 sites and 9 surveys. Waukesha would work to avoid and minimize potential impacts to these resources. The general results of the archival investigations are summarized in Table C-1 in Attachment C.

4.3.2.2.2.12. Public water supply and use effects from the MMSD return flow alternative – City of Milwaukee

Describe how operation of the MMSD return flow alternative would affect water supply and use for MMSD.

The Return Flow Plan (Volume 4 of the Application) has been designed to meet the Compact requirements with a maximum return flow rate equivalent to the maximum withdrawal rate that also minimizes out of basin water in return flow. Withdrawal from Lake Michigan with return flow protects lake volume, and therefore withdrawal from the lake would not result in adverse effects to water supply and use for MMSD.

Operationally, the MMSD Alternative 4 return flow would connect directly to the MMSD South Shore WRF discharge pipe and would have no significant impact on MMSD's treatment processes. Coordination with MMSD and the WDNR on the WPDES permitting would be expected and would present administrative items to work through, but this alternative appears technically feasible.

4.3.2.2.2.13. Costs and energy (construction and operation) effects of the MMSD return flow alternative

Identify the construction and operation costs, and energy use of the MMSD return flow alternative.

Table 1 includes the construction and operational costs for MMSD Alternative 4. The energy use for the alternative is included in Table 6.

Summary

Three alternatives for return flow to MMSD were evaluated for the Application that included decommissioning the City of Waukesha WWTP and returning untreated wastewater to MMSD for discharge to Lake Michigan. At the request of the WDNR, a fourth MMSD return flow alternative was evaluated. MMSD Alternative 4 includes maintaining the Waukesha WWTP and returning treated water to MMSD for discharge to Lake Michigan. MMSD Alternative 4 is less expensive than other MMSD Alternatives because it does not contain some of the more expensive infrastructure needed in those alternatives. Maintaining a discharge to the Fox River and to MMSD under Alternative 4 would require treatment at the Waukesha WWTP prior to discharge to the Fox River and prior to the return of treated water to MMSD's South Shore outfall.

Although MMSD Alternative 4 is the least costly MMSD alternative, it is more than 1.4 times the cost of the proposed Root River return flow. This alternative appears to be technically possible, but would require coordinated facilities planning and other administrative policy coordination with MMSD, the WDNR, and others prior to implementation. More detailed engineering could lead to additional costs not included in this analysis. However, this analysis is valid for screening these alternatives.

A return flow discharge to South Shore raises permitting and implementation issues that do not exist with other return flow alternatives and that would require careful consideration by the City of Waukesha, MMSD and the WDNR. Examples of these include:

- MMSD provides service for many contract communities but none of those municipal entities share a WPDES discharge permit for the same flow. It is unclear if the return flow would be governed by two separate entities, what their roles would be regarding regulatory compliance, and whether MMSD permit conditions could apply to the City of Waukesha, such as requirements for green infrastructure or wet weather flow management. This could further increase costs. There is also uncertainty about who would determine whether these requirements apply to the City of Waukesha and what roles MMSD and the City of Waukesha would have during permit renewals for each other's systems.
- A return flow discharge to the South Shore outfall would no longer be a discharge to the waters of the United States and therefore it is unclear whether the City of Waukesha would be the permit holder for its return flow discharge, or if the return flow discharge would be incorporated into a modified South Shore WPDES permit.
- There would need to be clear delineation of responsibility for sewer overflow occurrences from the MMSD system since the City of Waukesha's return flow is downstream of all treatment operations would have no effect on the magnitude or frequency of an overflow event.
- Environmental effects of the MMSD Alternative 4 are most similar to the Direct to Lake Michigan return flow alternative. Like all return flow alternatives, there would be no significant adverse impacts to water quality or flora and fauna in inland waterways or Lake Michigan. Compared to the proposed project which has return flow to the Root River, MMSD return flow does not provide the habitat benefits from increased Root River base flows as documented in the Return Flow Plan and Environmental Report. The MMSD Alternative 4 impact analysis also predicts that the additional pipeline length to MMSD would cause additional wetland impacts compared to the proposed project.

The economic evaluation corroborates the work conducted by the SEWRPC in the Regional Water Supply Plan and the findings that return flow to MMSD is significantly more expensive than other alternatives considered because of the additional infrastructure and facilities required. While additional analyses could further refine these alternatives and cost estimates, the conclusions reached in this alternative screening analysis will not change.

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Attachment A
Return Flow Cost Estimate
for MMSD Alternative 4

Return Flow to MMSD South Shore Outfall

(Costs include corridor sharing with an Oak Creek Water Supply)

Capital Cost

	Quantity	Unit Cost	Total
Pipelines			
25.8 of miles of 30-inch pipe	136,224	$ 387	$ 52,699,000
10% allowance for pipeline valves & appurtenances			$ 5,270,000
5% allowance for improvements at MMSD South Shore outfall			$ 2,635,000
Pipeline Construction Cost			$ 60,604,000
WWTP Effluent Pump Station			
One 16.7 mgd pump station, generators and power supply	1	$ 9,359,000	$ 9,359,000
Subtotal Return Flow Construction Cost			**$ 69,963,000**
3% markup for Bonds & Insurance			$ 2,099,000
5% markup for Mob/Demob			$ 3,499,000
8% markup for Contractors Overhead			$ 6,045,000
4% markup for Contractors profit			$ 3,023,000
25% Contingency			$ 21,158,000
Subtotal Markups and Contingency			**$ 35,824,000**
Total Project Construction Costs			**$ 105,787,000**
8% allowance for pipeline engineering and design			$ 8,463,000
12% allowance for permitting, legal and administration			$ 12,695,000
8% allowance for pipeline engr services during construction			$ 8,463,000
Subtotal Other Project Costs			**$ 29,621,000**

GRAND TOTAL PROJECT COST **$135,408,000**

Operating and Maintenance Cost

	Units	Quantity	Unit Cost	Ext. Cost	Total
Energy	mgd	11.7			$ 485,338
O&M		2% of Capital cost of pump station	2%	$ 9,359,000	$ 187,180
MMSD South Shore Outfall		5% of current contract community sewer service fee	5%	$ 3,658,838	$ 182,942

Alternative Total O&M ($/yr.)	**$ 855,000**
TOTAL PROJECT PRESENT WORTH (6%, 20 yrs)	**$ 145,408,000**
TOTAL PROJECT PRESENT WORTH (6%, 50 yrs)	**$ 148,408,000**

Alternative 2B - Lake Michigan Supply with Return to MMSD South Shore Outfall (MMSD Alternative #4)

Supply from Oak Creek. Return to MMSD South Shore Outfall (MMSD Alternative #4).

Capital Cost

	Quantity	Unit Cost	Total
Lake Michigan Supply Pump Station (27th and Puetz Rd)			
16.7 mgd	1	$ 8,830,125	$ 8,831,000
Lake Michigan Supply Pipeline			
19 miles of 30"	100,320	$ 429	$ 43,084,000
Return Pump Station and Pipeline Direct to Lake Michigan Near Milwaukee and Oak Creek			
16.7 mgd	1	$ 9,359,000	$ 9,359,000
25.8 miles of 30"	136,224	$ 445	$ 60,604,000
Distribution System Improvements			
5 mi of 24" pipes	24,800	$ 206	$ 5,109,000
Subtotal			**$ 126,987,000**
3% markup for Bonds & Insurance			$3,810,000
5% markup for Mob/Demob			$6,350,000
8% markup for Contractors Overhead			$10,972,000
4% markup for Contractors profit			$5,486,000
25% Contingency			$38,402,000
Subtotal Markups and Contingency			**$ 65,020,000**
Total Project Construction Costs			**$ 192,007,000**
8% allowance for engineering and design			$15,361,000
12% allowance for permitting, legal and admin.			$23,041,000
8% allowance for engr services during construction			$15,361,000
Subtotal Other Project Costs			**$53,763,000**
<u>TOTAL PROJECT CAPITAL COST</u>			**$ 245,800,000**

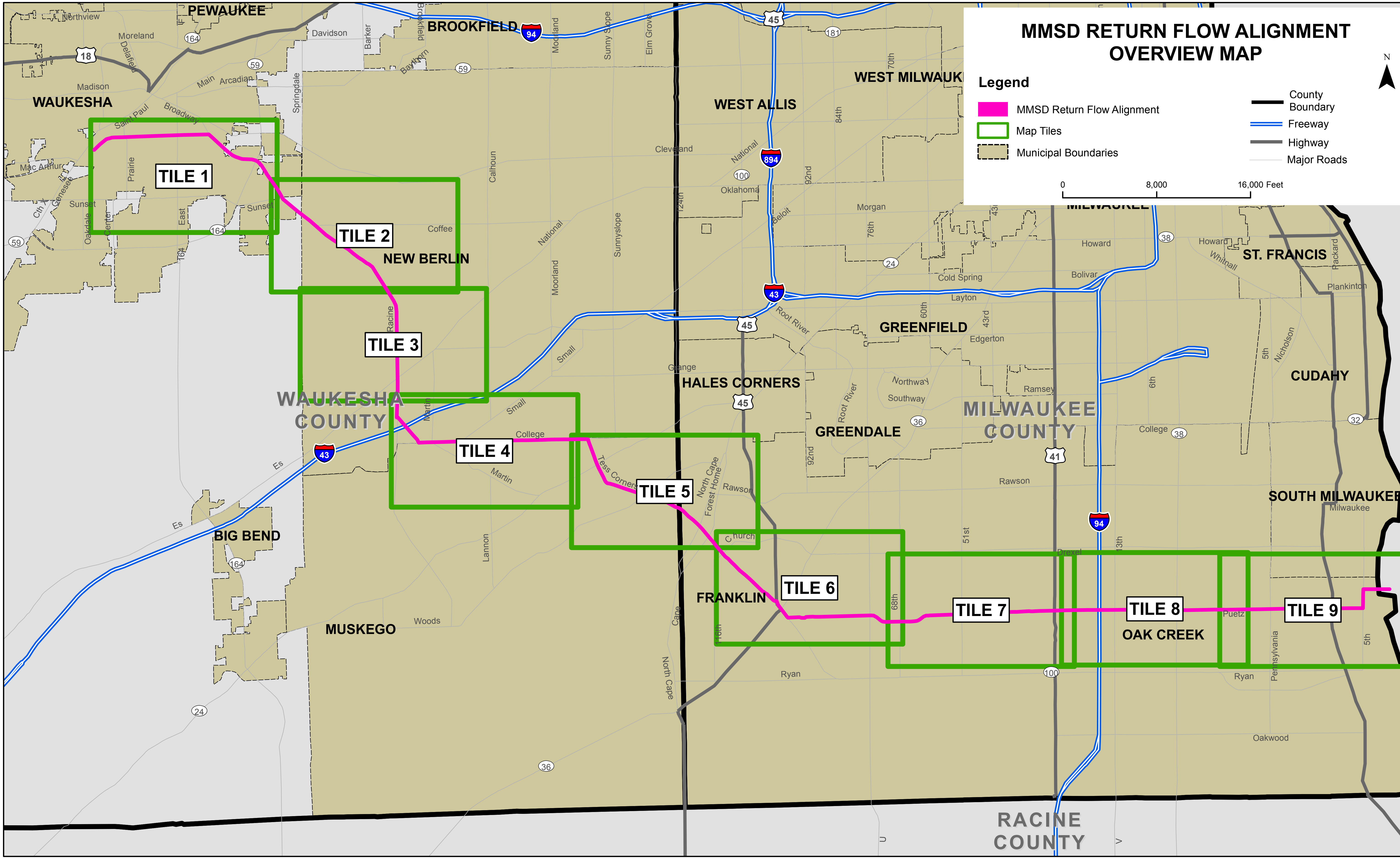
Alternative 2B - Lake Michigan Supply with Return to MMSD South Shore Outfall (MMSD Alternative #4)

Operating and Maintenance Cost

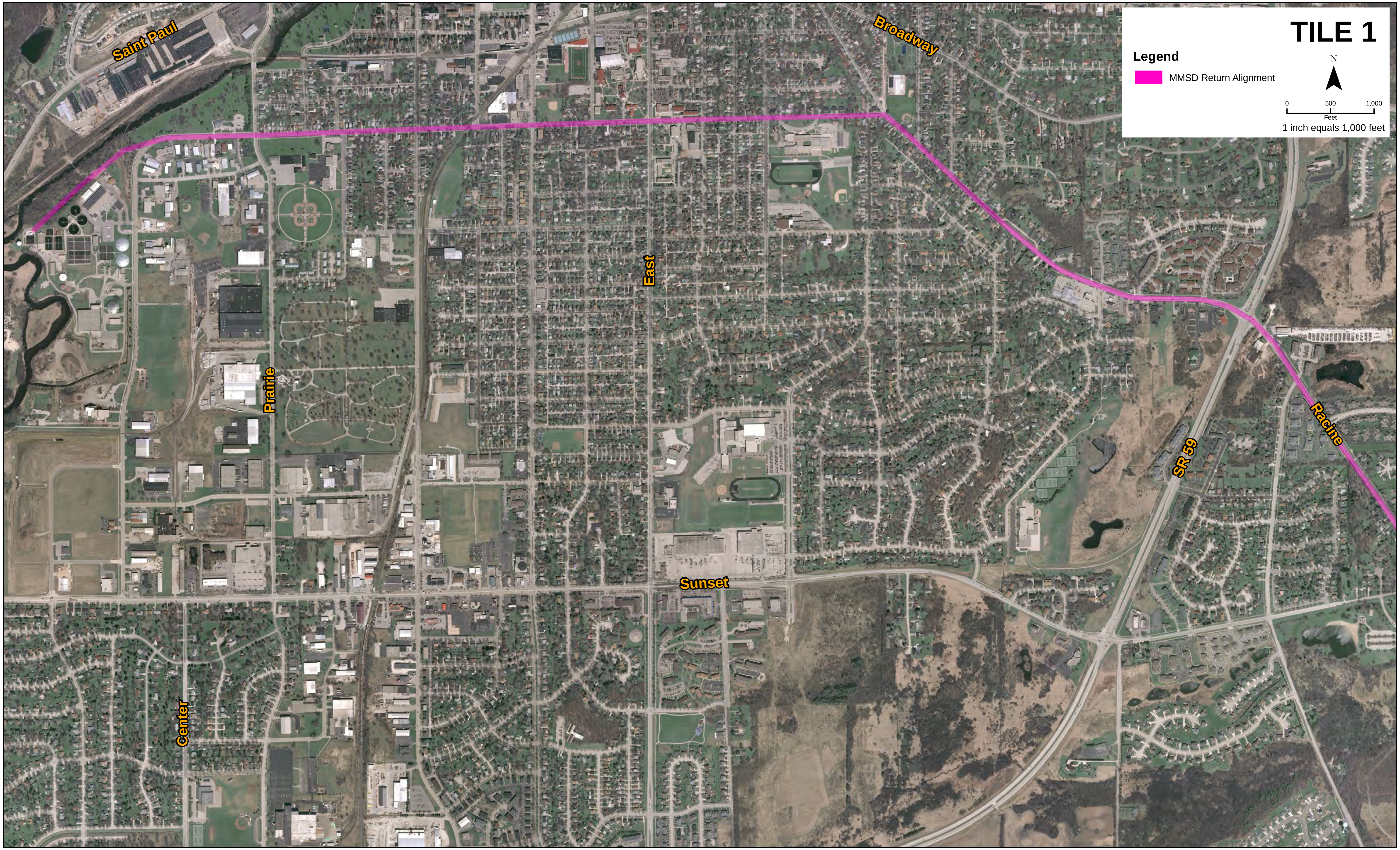
Source of Supply	Units	Quantity	Unit Cost	Ext. Cost	Total
Purchased water	$/1000 gal	3,686,500	$ 1.830	$ 6,746,295	
					$ 6,746,000
Treatment/Pumping					
Lake Michigan Pumping Energy	$/kWh	6,176,619	$ 0.06	$ 370,597	
Lake Michigan Pump Station O&M	%	$ 8,831,000	2%	$ 176,620	
Return Flow Pumping Energy	$/kWh	8,088,971	$ 0.06	$ 485,338	
Return Flow Pump Station O&M	%	$ 9,359,000	2%	$ 187,180	
MMSD Outfall Sewer Fee	%	$ 3,658,838	5%	$ 182,942	
					$ 1,403,000
Transmission					
Operation and Maintenance	$/lf/yr	142,560	$ 0.52	$ 74,131	
					$ 74,131
Total O&M ($/yr.)					**$ 8,200,000**

PRESENT WORTH (6%, 20 yrs)	**$ 94,000,000**
PRESENT WORTH (6%, 50 yrs)	**$ 129,000,000**
Total Present Worth (6%, 20 years)	**$ 339,800,000**
Total Present Worth (6%, 50 years)	**$ 374,800,000**

Attachment B
MMSD Alternative 4 Alignment Maps



MMSD RETURN FLOW ALIGNMENT OVERVIEW MAP
Legend
MMSD Return Flow Alignment
Map Tiles
Municipal Boundaries
County Boundary
Freeway
Highway
Major Roads
0
8,000
16,000 Feet
N
TILE 1
TILE 2
TILE 3
TILE 4
TILE 5
TILE 6
TILE 7
TILE 8
TILE 9
PEWAUKEE
BROOKFIELD
WAUKESHA
WEST ALLIS
WEST MILWAUKEE
NEW BERLIN
GREENFIELD
HALES CORNERS
GREENDALE
ST. FRANCIS
CUDAHY
SOUTH MILWAUKEE
FRANKLIN
OAK CREEK
MUSKEGO
BIG BEND
WAUKESHA COUNTY
MILWAUKEE COUNTY
RACINE COUNTY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Legend
MMSD Return Alignment
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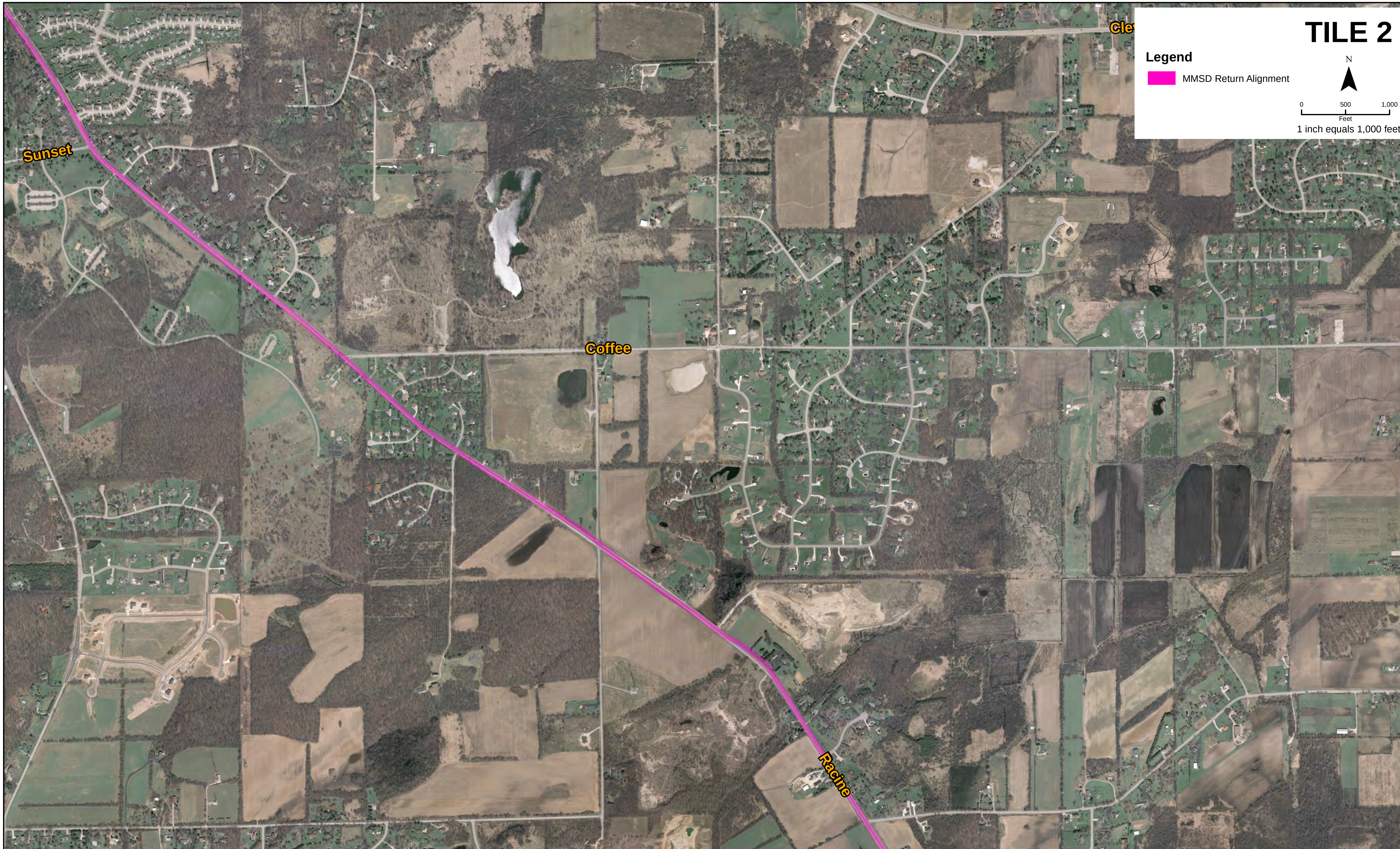
500
1,000
Feet
1 inch equals 1,000 feet
Saint Paul
Broadway
East
Prairie
Racine
SR 59
Sunset
Center


TILE 2
Legend
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500
1,000
Feet
1 inch equals 1,000 feet
Sunset
Coffee
Racine
Clev

TILE 3
Legend
MMSD Return Alignment
N
0
500
1,000
Feet
1 inch equals 1,000 feet
Racine
National
Beloit
Martin
I 43
I 43

TILE 4
Legend
MMSD Return Alignment
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Feet
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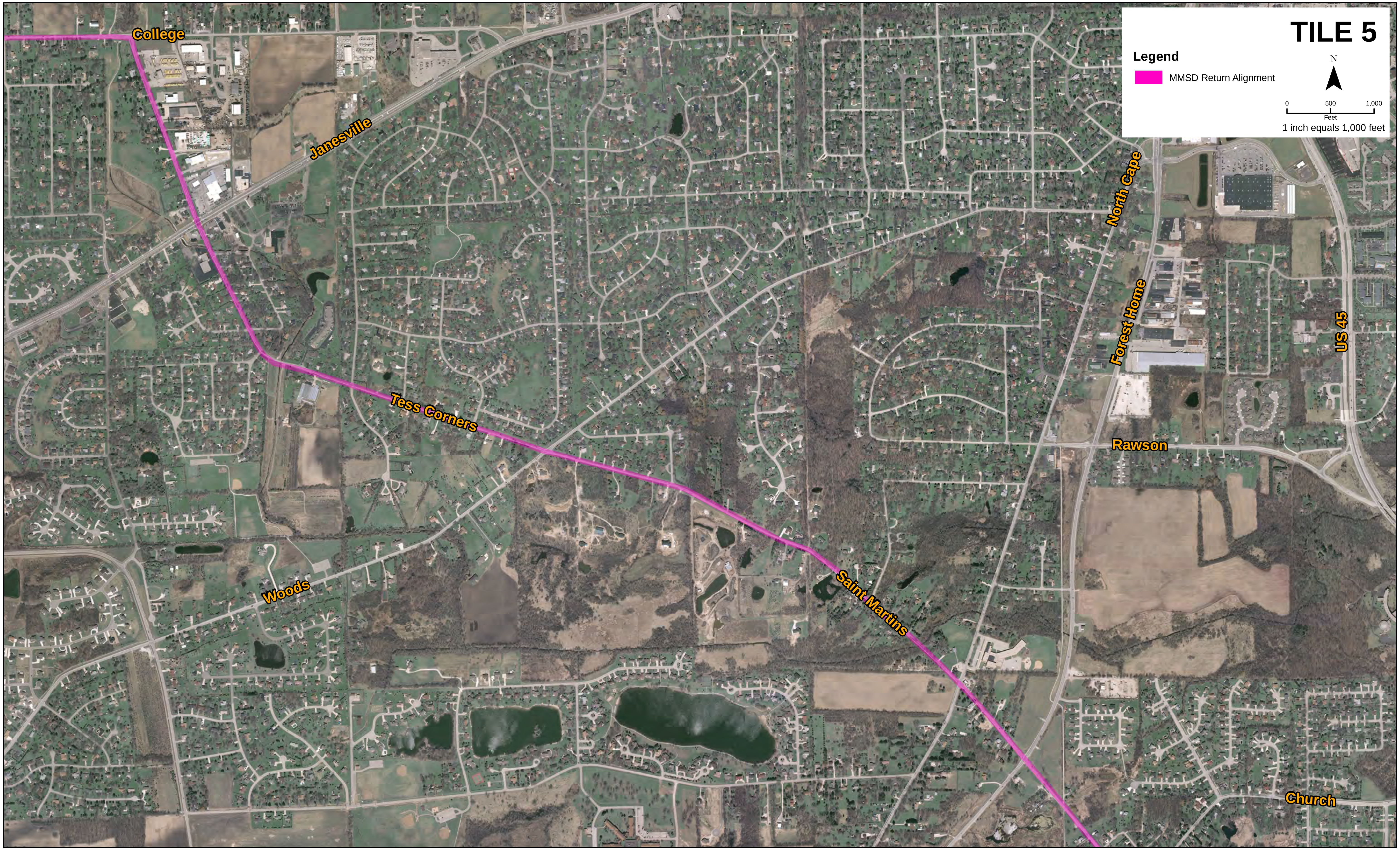
I 43
Martin
Calhoun
Small
College
Martin
Janesville
Racine
Lannon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Feet
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Janesville
North Cape
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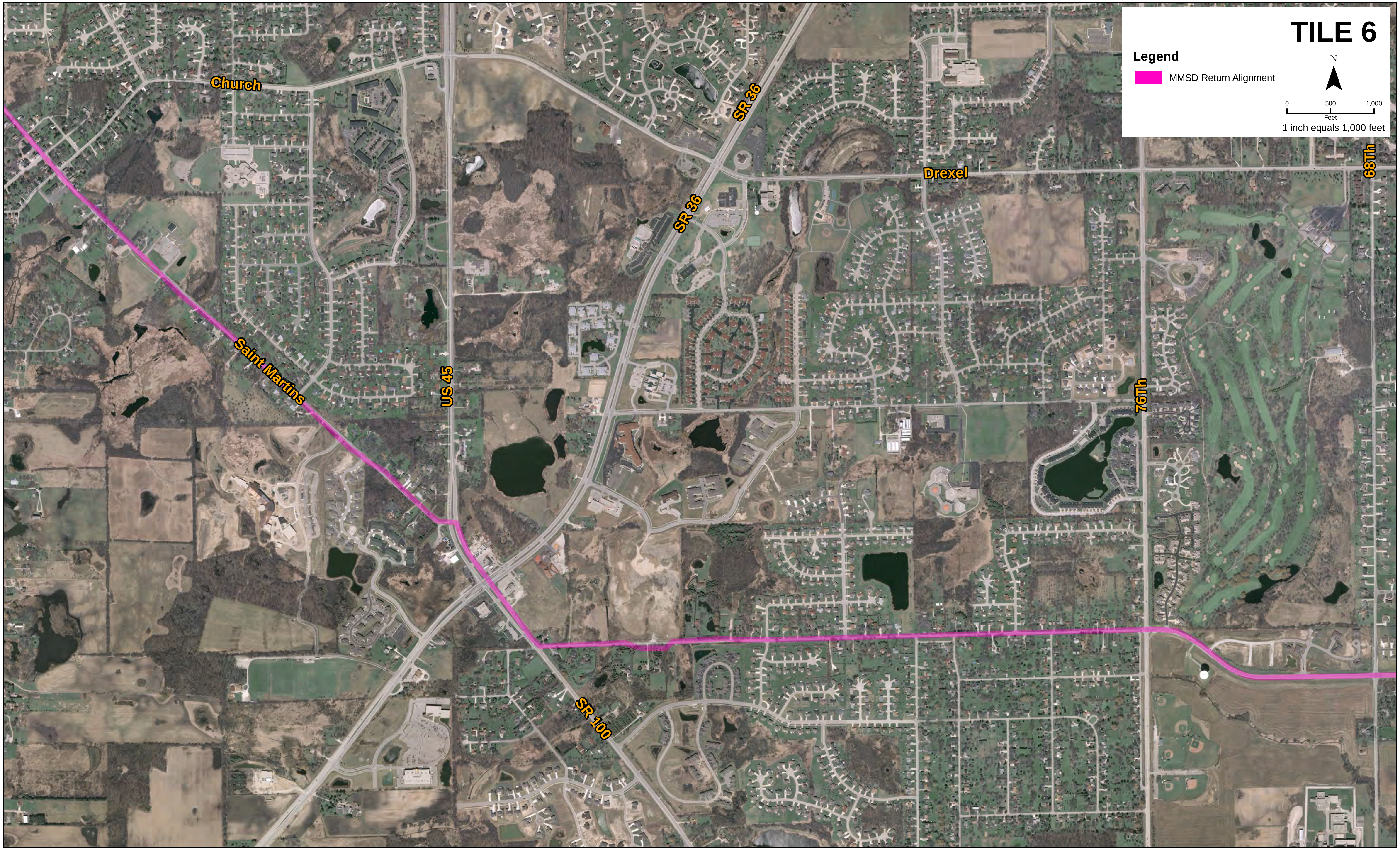
US 45
Tess Corners
Rawson
Saint Martins
Woods
Church



TILE 6
Legend
MMSD Return Alignment
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1,000
Feet
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Church
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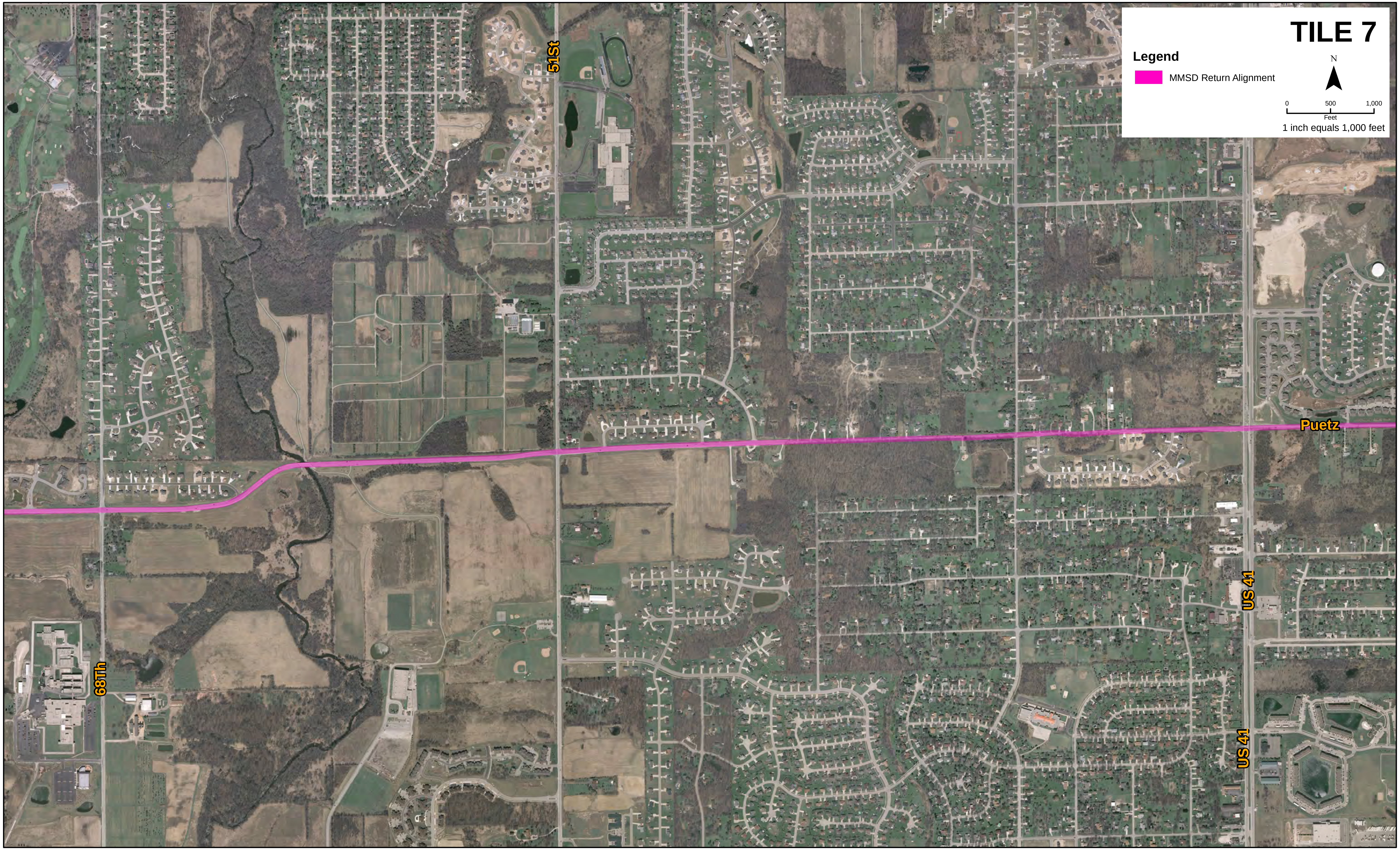
Drexel
68Th
Saint Martins
US 45
76Th
SR 100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500
1,000
Feet
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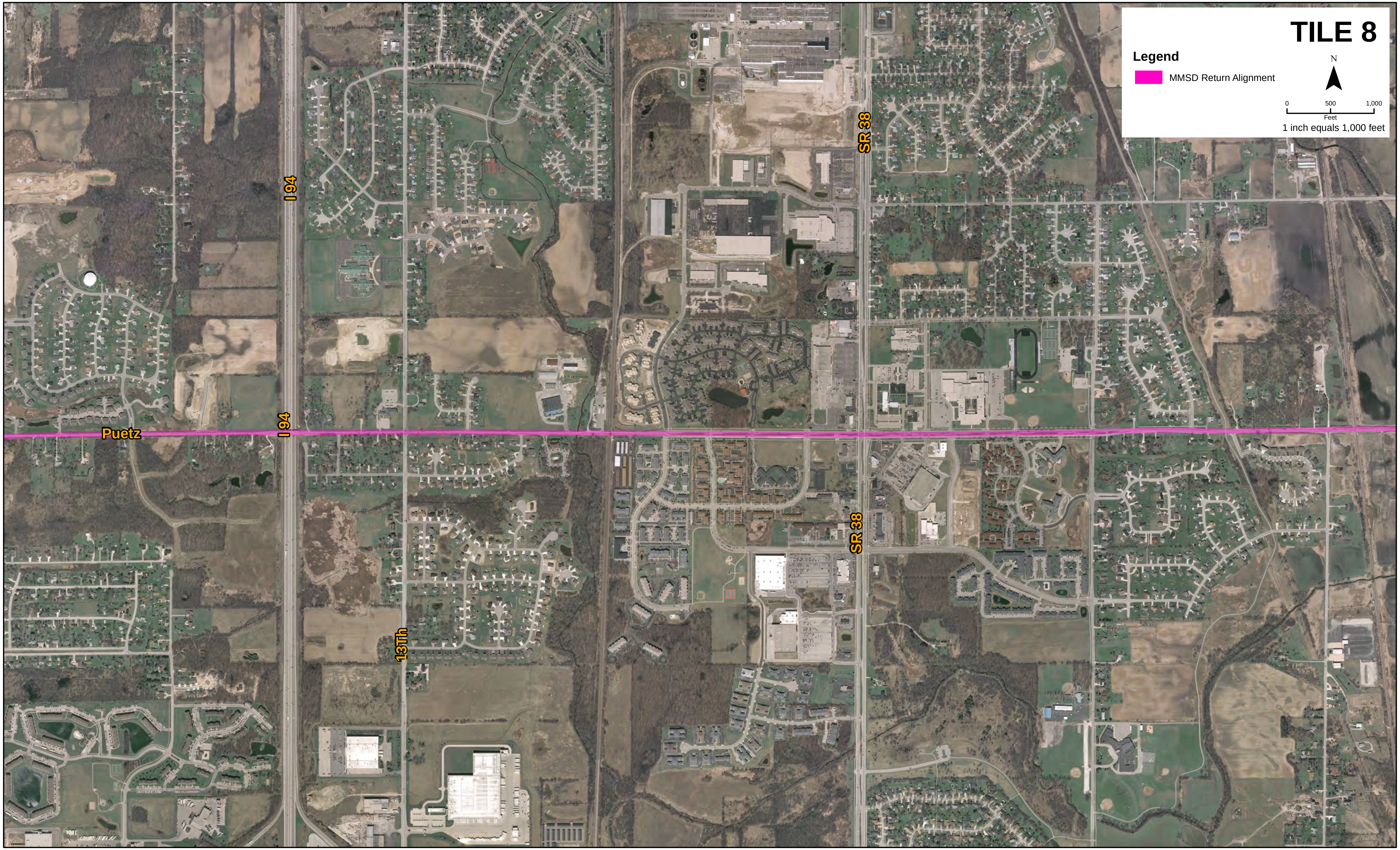
51St
Puetz
68Th
US 41
US 41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500
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Feet
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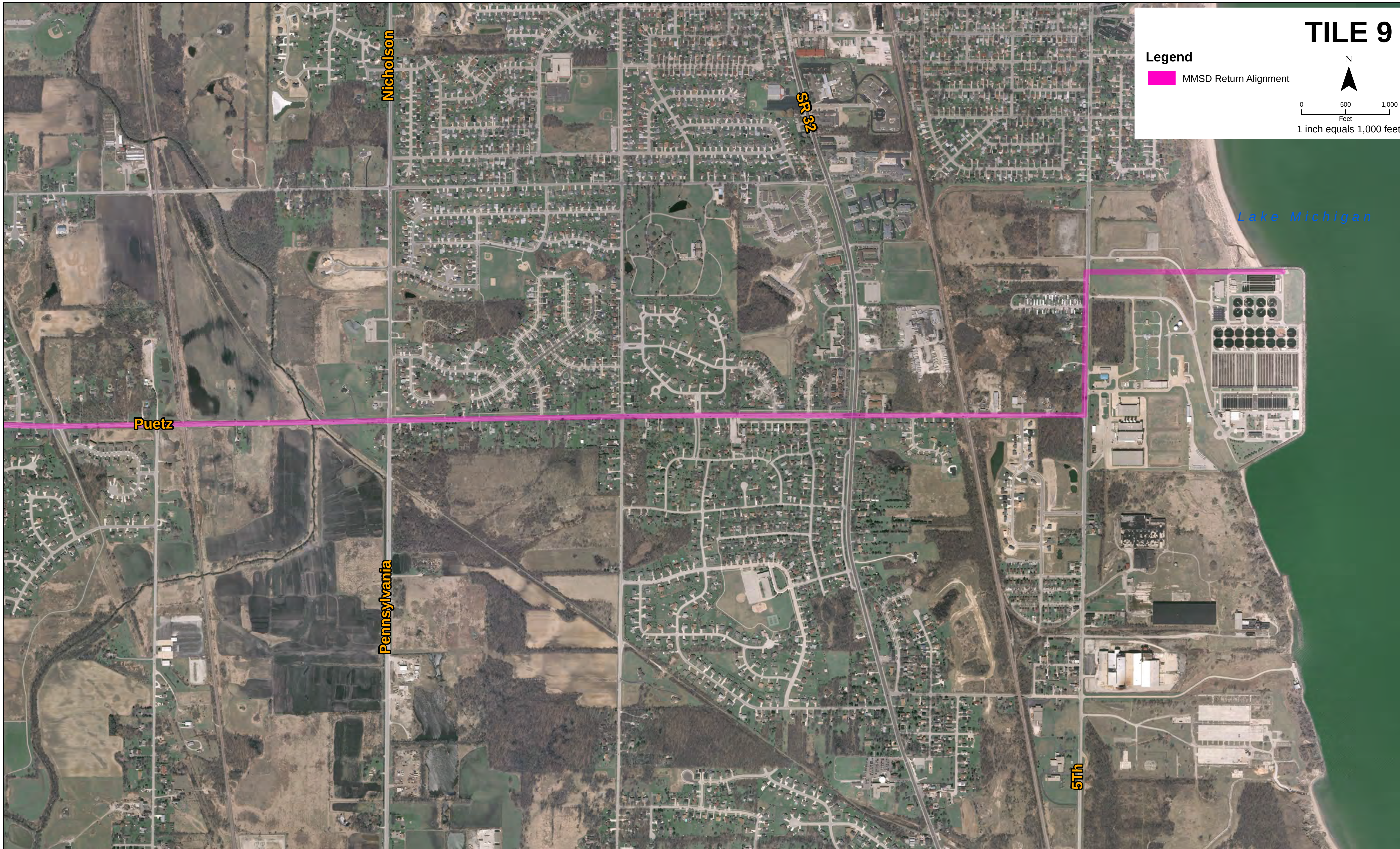
SR 38
I 94
I 94
Puetz
SR 38
13Th


TILE 9
Legend
MMSD Return Alignment
N
0
500
1,000
Feet
1 inch equals 1,000 feet
Lake Michigan
Nicholson
SR 32
Puetz
Pennsylvania
5Th

Attachment C
Cultural Resources

TABLE C-1
Archaeological Sites within 100 Meter of Centerline of the Return Flow to MMSD Alternative 4

Site Name	Township	Range	Description	Consultation Requirements
Return Flow to MMSD Alternative 4[a]				
Unnamed Site #1	5N	21E	Unknown Prehistoric campsite/village.	Current status is unknown and additional investigations may need to be completed. Consultation with WHS is necessary.
Unnamed Site #2	5N	21E	Unknown cornhills/garden beds.	Current status is unknown and additional investigations may need to be completed. Consultation with WHS is necessary.
Unnamed Site #3	5N	21E	Unknown campsite/village.	Current status is unknown and additional investigations may need to be completed. Consultation with WHS is necessary.
Burrwood Cemetery	5N	21E	Historic Euro-American cemetery/burial. Located on the Milwaukee County House of Correction lands. A Milwaukee County Historical Landmark, the Carmen Family Cemetery is located on the grounds.	This Burial Site is catalogued and subject to the provisions of Wis. Stats 157.70. Consultation with WHS is required.
Tess Corners Creek	5N	21E	Unknown Historic/Prehistoric campsite/village.	Current status is unknown and additional investigations may need to be completed. Consultation with Wisconsin Historical Society is necessary.
Unnamed site	5N	R22E	Late-Paleolithic; Early, Middle, and Late Archaic; Late Woodland campsite/village	Current status is unknown and additional investigations may need to be completed. Consultation with Wisconsin Historical Society is necessary.
Unnamed site	5N	R22E	Unknown prehistoric cultural campsite/village.	Current status is unknown and additional investigations may need to be completed. Consultation with Wisconsin Historical Society is necessary.
Sunnyside Cemetery	6N	20E	Historic Euro-American cemetery/burial. The site contains a marked cemetery established in 1887 with at least 360 individuals buried.	This Burial Site is not catalogued, but is protected under Wis. Stats 157.70. Consultation with WHS is required.
Sittle Cemetery	6N	20E	Historic Euro-American cemetery/burial.	This Burial Site is catalogued and subject to the provisions of Wis. Stats 157.70. Consultation with WHS is required.
Evangelical and Reformed Church of New Berlin Cemetery	6N	20E	Historic Euro-American cemetery/burial. Cemetery records are possibly kept in a box at the United Church of Christ-First Evangelical and Reformed Church in Waukesha.	This Burial Site is catalogued and subject to the provisions of Wis. Stats 157.70. Consultation with WHS is required.

TABLE C-1
Archaeological Sites within 100 Meter of Centerline of the Return Flow to MMSD Alternative 4

Site Name	Township	Range	Description	Consultation Requirements
Town Cemetery	6N	20E	Historic Euro-American cemetery/burial. Cemetery was established during the Civil War with the last burial in 1962.	This Burial Site is not catalogued, but is protected under Wis. Stats 157.70. Consultation with WHS is required.
Industrial School Mound	6N	19E	Woodland mounds-conical. Site was investigated by Charles E. Brown in 1923.	This Burial Site is not catalogued, but is protected under Wis. Stats 157.70. Consultation with WHS is required.

[a]To protect cultural resources, section and quarter section locations have been omitted.
WHS, Wisconsin Historical Society.
Sources: Becker (1988); Benchley (1989);Brazeau (1979); Brown (1906b, 1906c, 1923b, 1923d, 1925, 1930a, 1930b); Bruhy (1979a, 1979b); Haas (1998); Harvey (2008); Hendrickson (1995); Holliday (1989); Goldstein (1994); Kolb and Jalbert (2006); Kubicek (2008); Lapham (1836, 1855); Overstreet and Brazeau (1978a, 1978b, 1978c, 1978d, 1979); Phillips (1923); Salkin (1986, 1993, 1999); Van Dyke (1988, 1996, 2008, 2010).