January 2016

City of Waukesha
Proposed Great Lakes Diversion

PRELIMINARY FINAL
ENVIRONMENTAL IMPACT STATEMENT

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

To the Reader

In October 2013, the City of Waukesha (Applicant) submitted a revised *Application for a Lake Michigan Diversion with Return Flow* (Application) to the Wisconsin Department of Natural Resources (department), updating the original version of the Application submitted in May 2010. The Application contained five Volumes (Vol.):

Vol. 1 – Application Summary
Vol. 2 – City of Waukesha Water Supply Service Area Plan
Vol. 3 – City of Waukesha Water Conservation Plan
Vol. 4 – City of Waukesha Return Flow Plan
Vol. 5 – City of Waukesha Environmental Report for Water Supply Alternatives

Because the City of Waukesha lies within a county that straddles the Great Lakes surface water divide, it is eligible to seek an exception from the prohibition of diversions under the Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement (Agreement) and Great Lakes—St. Lawrence River Basin Water Resources Compact (Compact). The Agreement is a good faith agreement between the Great Lake States and Provinces to manage water quantity in the Great Lakes Basin. The Agreement is implemented in the United States through the Compact—a legally binding contract among the eight Great Lakes States. The Applicant seeks to obtain a Lake Michigan water supply as a solution to its current water supply problems that include elevated levels of radium in the drinking water supply above the drinking water standard. The Applicant is currently under a state court order to meet the state and federal radium drinking water standard by 2018.

This document is a preliminary final Environmental Impact Statement (EIS), prepared by the Wisconsin Department of Natural Resources (department) in compliance with ch. NR 150, Wisconsin Administrative Code, and s. 1.11 Wisconsin Statutes. The purpose of an EIS is to inform decision-makers and the public of the anticipated effects on the quality of the human environment of a proposed action or project and alternatives to the proposed action or project. The EIS is an informational tool—it is not a decision document.

The department also prepared a draft version of the EIS. The public was invited to provide comments on the scope of the analysis between February 5, 2010 and August 13, 2011, and three public scoping meetings were held on July 26, 27 and 28 in 2011 at Pewaukee, Wauwatosa and Sturtevant. The department received 102 public scoping comments. The department then prepared the draft EIS and invited the public to comment on it between June 25 to August 28, 2015. The department received 3,634 written comments from individuals and groups. Additionally, comments were received at three public hearings on August 17 and 18, 2015 at Waukesha, Milwaukee and Racine. Of the 404 people who registered at the hearings, 128 provided oral testimony.

This preliminary final EIS explains the Applicant's proposal to use water from Lake Michigan (in order to meet its water supply needs) and return wastewater to the Lake Michigan basin as required by the Agreement and Compact. The preliminary final EIS analyzes potential impacts of alternative water supplies and return flow options, including analysis of an additional alternative, and other analyses not presented in the draft EIS. Also included in this preliminary final EIS is the department's response to public comments on the draft EIS.

In addition, the department has prepared a Technical Review, a requirement of Article 201 of the Agreement, section 4.9 of the Compact, and Wisconsin's Compact implementing legislation (s. 281.346(4)(e)1.f., Wis. Stats.). The Technical Review outlines the department's findings related to the Agreement, Compact and Wisconsin's Compact implementing statutes.

The department will forward the preliminary final EIS, Technical Review and Application to the Great Lakes States, and Quebec and Ontario through the Regional Body and Compact Council for review and decision as required by the Agreement and Compact. The Regional Body is the governing body of the Agreement and includes the Great Lakes premiers and governors. The Compact Council is the governing body of the Compact and includes the Great Lakes governors. Throughout this process, Great Lakes Tribes and First Nations will also be informed of the proposal and provided opportunities to comment.

Once the Compact Council and Regional Body make a determination that the diversion is approved, and before any specific permits are issued, the department will issue a final EIS including any comments and decisions from the Regional Body and a WEPA compliance determination. The Applicant would need to acquire all permits and approvals for the divers from the State of Wisconsin before the department would approve the diversion.

The department maintains a website with information related to the Applicant's diversion application, including the public participation process, communications with the Applicant, and other supporting materials.

Table of Contents

List of Tables

List of Figures

Acronyms and Abbreviations

ADD	average day demand
Agreement	Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement
Applicant	City of Waukesha
Application	*City of Waukesha Application for a Lake Michigan Diversion with Return Flow*
AWE	Alliance for Water Efficiency
AWWA	American Water Works Association
CEM	conservation and efficiency measure
CFS	cubic feet per second
CMOM	Capacity, Management, Operations and Maintenance
Compact	Great Lakes—St. Lawrence River Basin Water Resources Compact
department	Wisconsin Department of Natural Resources
EIS	Environmental Impact Statement
ER	Environmental Report
EPA	United States Environmental Protection Agency
GLB	Great Lakes basin
GMA	Groundwater Management Area
GPCD	gallons per capita per day
GPD	gallons per day
I/I	infiltration and inflow
MCL	maximum contaminant level
MDD	maximum day demand
MG	million gallons
mg/L	milligrams per liter
MGD	million gallons per day
MGY	million gallons per year
MMSD	Milwaukee Metropolitan Sewerage District
MRB	Mississippi River basin
MWWAT	Michigan Water Withdrawal Assessment Tool
PCB	polychlorinated biphenyl
piC/L	picocuries per liter
PRESTO	Pollutant load Ratio Estimation Tool (DNR model)
WPSC	Public Service Commission of Wisconsin
SDWA	Safe Drinking Water Act
SEWRPC	Southeastern Wisconsin Regional Planning Commission
SPARROW	Spatially-referenced Regression on Watershed Attributes (model)
TDS	total dissolved solids
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
ug/L	micrograms per liter
USGS	United States Geological Survey
WBR	Winter Base-Rate

WDNR	Wisconsin Department of Natural Resources
WEPA	Wisconsin Environmental Policy Act
WGNHS	Wisconsin Geological and Natural History Survey
WPDES	Wisconsin Pollutant Discharge Elimination System
WPSC	Wisconsin Public Service Commission
WQBEL	Water quality based effluent limits
WWTP	wastewater treatment plant

Section 1 Introduction and Project Summary

1 Proposed Project

1.1 Process Summary

The City of Waukesha, Wisconsin, located in southeast Wisconsin, 17 miles west of Lake Michigan, seeks an exception from the prohibition of diversions under the Great Lakes—St. Lawrence River Basin Water Resources Compact (Compact) and Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement (Agreement). The Compact prohibits diversions of Great Lakes water, with limited exceptions. One exception allows a "community within a straddling county," such as Waukesha, to apply for a diversion of Great Lakes water.

Figure 1-1 Location of City of Waukesha and Great Lakes Water Basin

The Wisconsin Department of Natural Resources has been reviewing the City of Waukesha's (Applicant) diversion application since the City first applied in May 2010. The City submitted its latest revised *Application for a Lake Michigan Diversion with Return Flow* (Application) to the Wisconsin Department of Natural Resources (department) in October 2013. As part of this process, the Applicant prepared Volume 5 (Vol.5) *City of Waukesha Environmental Report for Water Supply Alternatives*. The department has completed both a draft and a preliminary final Environmental Impact Statement (EIS) under Wisconsin's Environmental Policy Act (s.1.11, Wis. Stats.) and the department procedures for environmental analysis and review (ch. NR 150, Wis. Admin. Code).

This preliminary final EIS evaluates the preferred and proposed alternatives for both water supply and return flow. This EIS contains 6 sections:

- Section 1: Introduction and Project Summary – An overview of the project.
- Section 2: Project Alternatives – A summary of the alternatives reviewed by the department including water supply alternatives and proposed pipeline routes.
- Section 3: Affected Environment – The existing natural resources that are in the region that may be impacted by this project.
- Section 4: Environmental Effects of the Proposed Project – A synopsis of the potential impacts that may result from the project alternatives.
- Section 5: Comparison of Alternatives.
- Section 6: Cumulative Effects and Evaluation.

The Wisconsin Department of Natural Resources maintains a website on the Waukesha diversion application at http://dnr.wi.gov/topic/WaterUse/WaukeshaDiversionApp.html.

1.2 Purpose and need for proposed project

The Applicant asserts that it needs a new source of water to address water quantity and quality concerns. The Applicant has long relied on a deep aquifer groundwater supply, but depressed water levels in the deep aquifer have compounded a problem of high radium concentration (a naturally occurring carcinogen) in the groundwater. The public supply is supplemented by water from the shallow aquifer. In 2014, the Applicant served a population of 70,850 people and used 6.6 million gallons of water per day. The Applicant is under a 2009 Wisconsin court judgment to develop a permanent solution to the radium contamination problem by 2018.

Figure 1-2 Location of water supply and wastewater return flow routes

1.3 Water Supply Service Area

The Applicant had its water supply service area delineated by the Southeastern Wisconsin Regional Plan Commission (SEWRPC) in accordance with Wis. Stat. 281.348. The delineated service area includes the City of Waukesha and portions of the City of Pewaukee, and portions of the Towns of Delafield, Genesee, and Waukesha. Inclusion in the water supply service area is based on several factors including future land use plans, sanitary sewer area plans, and historic private well contamination. The delineated water supply service area sets the outer boundary of municipal water supply service expansion, and is designed to promote the orderly management of growth within a community.

1.4 Water supply for proposed project

The Applicant proposes to divert from the Great Lakes basin up to an annual average of 10.1 million gallons per day and a daily maximum of 16.7 million gallons based upon a final water supply service area build-out for a population of 97,400 (approximately the year 2050).

Under the proposed diversion, the Applicant would receive treated water from the City of Oak Creek Water Utility, which is located in the Great Lakes basin and withdraws surface water from Lake Michigan. The water would be transported to Waukesha through a 19.4 mile pipeline and distributed to customers (see Section 2 of the EIS for details).

1.5 Return flow for proposed project

As required by the Compact, the Applicant proposes that, after consumptive use, remaining water will be treated at the existing Waukesha wastewater treatment plant (WWTP) before it is piped via Root River Alignment 2 and discharged to the Root River, a tributary to Lake Michigan. The pipeline would follow major roads and corridors to minimize environmental impacts. In total, this alternative would require approximately 20.2 miles of 30-inch pipe. The Applicant intends to keep some wells as an emergency back-up supply. Emergency wells are required to meet the requirements of NR 810.22.

1.6 Authorities and approvals for proposed project

Table 1-1 lists the various permits and approvals that will be or may be required for construction, operation and maintenance of the proposed project.

Table 1-1. Permit and Approvals

Permit, Approval or Evaluation	Statute or Regulation	Administering and Enforcing Agency
FEDERAL		
Great Lakes—St. Lawrence River Basin Water Resources Compact	Public Law 110-342	Great Lakes---St. Lawrence River Basin Water Resources Council
Endangered Species Act Section 7 Consultation	16 U.S.C. s. 1531 et. seq. (Endangered Species Act)	U.S. Fish and Wildlife Service (Green Bay ES Field Office)
Clean Water Act Section 404 Dredge and Fill Permit	33 U.S.C. s. 1344 (Clean Water Act)	U.S. Army Corps of Engineers (St. Paul District and Detroit District)
Section 10 Navigable Waters Permit	33 U.S.C. s. 403 (Rivers and Harbors Act of 1899)	U.S. Army Corps of Engineers (St. Paul District)
STATE		
Stream Crossings of Navigable Waters	Wis. Stats. ch. 30, Wis. Adm. Code. NR 102, 320, 329, 341, 345	WDNR
WPDES Stormwater Discharge Permit	Wis. Stats. s. 283.33, Wis. Adm. Code. NR 216	WDNR

Wetland Permit	Wis. Stats s. 281.36, Wis. Adm. Code NR 103	WDNR
Pit/trench Dewatering General Permit	Wis. Stats. ch. 283, Wis. Adm. Code 216	WDNR
Wastewater Facilities Plan Review	Wis. Adm. Code NR 110	WDNR
Control of Particulate Emission - Fugitive Dust	Wis. Adm. Code NR 415.035, 415.04	WDNR
Wisconsin Floodplain Management Program including local floodplain zoning ordinances	Wis. Adm. Code NR 116	WDNR
Incidental Take Permit	Wis. Stats. s. 29.604 (6m)	WDNR
Water Quality Antidegradation evaluation	Wis. Adm. Code NR 207	WDNR
Wisconsin Pollutant Discharge Elimination System Permit	Wis. Stats. ch. 283, Wis. Adm. Code NR 217	WDNR
Water Supply Service Area Plan	Wis. Stats. ss. 281.346 and 281.348	WDNR
Wastewater systems construction plan review	Wis. Stats. s. 281.41, Wis. Adm. Code NR 108	WDNR
Water systems construction plan review	Wis. Adm. Code NR 108	WDNR
Cultural Resources Review	Wis. Stats. ss. 44.40 and 157.70	Wisconsin State Historic Preservation Office
Agricultural Impact Statement	Wis. Stats. s. 32.035	Wisconsin Department of Agriculture, Trade, and Consumer Protection
Certificate of Public Convenience and Necessity	Wis. Stats. s.196.491	Public Service Commission of Wisconsin
LOCAL		
General types include (but are not limited to): construction permits, public utility laws, navigable waters, land use regulations, zoning laws and designations, stormwater management plans, erosion and sediment control, floodplain and wetland ordinances	varies	county/municipality

At least 3 different counties(Milwaukee, Racine and Waukesha) and approximately 20 municipalities (Brookfield (City), Caledonia (Village), Cudahy (City), Franklin (City), Greendale (Village), Greenfield (City), Hales Corners (Village), Milwaukee (City), Mount Pleasant (Village), Muskego (City), New Berlin (City), Norway (Town), Oak Creek (City), Raymond (Town) , St. Francis (City), Waukesha(City and Town), West Allis (City)) could be affected by the construction, operation and maintenance of the proposed diversion project or its alternatives. Each of these counties and municipalities has ordinances that constitute local laws that the Applicant must comply with. These ordinances cover a variety of topics but generally include: construction laws and permits needed (especially in streets and sidewalks), public utility laws, laws governing navigable waters, land use regulations, zoning laws and designations, stormwater management plans, erosion and sediment control, and floodplain and wetland ordinances.

The department has made a determination that the Applicant's proposed diversion is in compliance with the Boundary Waters Treaty of 1909. The treaty states, in relevant part: "[other than as previously stated] no further or other uses or obstructions or diversions… affecting the natural level or flow of boundary waters on the other side of the line shall be made [except with approval of the International Joint Commission]" (Boundary Waters Treaty of 1909; art. 3). The Applicant's proposed diversion will not trigger this section of the treaty because the Applicant will be returning all water withdrawn less an allowance for consumptive use. The diversion will not alter the flows or levels of the Great Lakes.

Section 2 Project Alternatives

2 Project Alternatives

The City of Waukesha (Applicant) first applied for a Lake Michigan diversion in May 2010 and submitted an updated *Application for a Lake Michigan Diversion with Return Flow* (Application) to the Wisconsin Department of Natural Resources (department) in October 2013.

As part of the Application, Volume 5 (Vol. 5), the Applicant prepared an environmental report which considers the preferred alternative (Lake Michigan Supply – City of Oak Creek, with return flow to the Root River) among various alternatives for water supply options in the Mississippi River basin, the Lake Michigan basin and a combination of both basins. Any Lake Michigan Basin alternative under a diversion approval would need to return the water withdrawn, less an amount for consumptive use, back to the Lake Michigan basin.

For purposes of this environmental impact statement (EIS), the department reviewed the following water supply and return flow alternatives after considering analysis completed by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and potentially feasible alternatives identified by the City:

Water supply alternatives:

- Deep and shallow aquifers – Mississippi River basin
- Shallow aquifer – Mississippi River basin
- City of Milwaukee - from Lake Michigan
- City of Oak Creek (alignment 2) – from Lake Michigan
- City of Racine – from Lake Michigan

Return flow alternatives:

- Fox River – Mississippi River basin
- Root River (alignment 2) - to Lake Michigan
- MMSD South Shore Outfall - to Lake Michigan
- Direct to Lake Michigan (near Milwaukee and Oak Creek)

The 'no action' alternative was also included for purposes of comparison. The 'zero demand increase alternative' was also included in response to comments on the draft EIS. The department has analyzed the potential environmental effects of these water supply and return flow alternatives in Section 4 of this EIS. Below is a general description of each alternative.

2.1 No Action Alternative

The Applicant's public water supply system is comprised of groundwater supply (wells), treatment, storage and conveyance assets. The water system consists of ten active wells: seven deep wells and three shallow wells, three water treatment plants for radium and iron/manganese removal, twelve storage tanks, nine booster pump stations, and approximately 326 miles of transmission and distribution water mains.

The 'no action' alternative would continue to use the current public water supply system, with no modifications to the current wells. The deep sandstone aquifer provides approximately 80% of the Applicant's current water supply. The deep wells contain radium, a known carcinogen, at concentrations above the federal and state drinking water standard. Although the Applicant maintains radium treatment to reduce the amount of radium in its drinking water, the water system is not in compliance with state regulations that require less than 5 picocuries per liter (pCi/L) radium 226 and radium 228 at each entry point of the distribution system (see the department's Technical Review S1). The no action alternative assumes 7.3 MGD from the deep aquifer and 1.2 MGD from the shallow aquifer under an 8.5 MGD average day demand. Note that the Applicant's request is for 10.1 MGD average day demand; however, the groundwater flow modeling conducted to review the Mississippi River Basin alternatives used 8.5 MGD average day demand. The no action alternative is not a feasible option, as the Applicant must comply with drinking water quality standards and deep aquifer water supply does not meet radium standards.

The 'no action' alternative is further explained in Section 4.

2.2 Zero demand increase alternative

Multiple comments on the draft EIS supported the alternative put forth by the Compact Implementation Coalition (CIC) – a group of environmental and conservation organizations. The alternative was developed through CIC contracts with GZA GeoEnvironmental Inc., and Mead and Hunt (GZA GeoEnvironmental, Inc. 2015; Mead and Hunt, 2015). The CIC and others expressed the opinion that this alternative demonstrates that the Applicant does not need another water source and therefore does not meet the Agreement/Compact requirements. The following is a description of this alternative, as understood by the department. The potential effects of this alternative are also discussed in section 4.

This alternative assumes that average day demand (ADD) will not increase above 6.7 MGD and an 11.1 MGD maximum day demand (MDD).The alternative was developed by consultants for a group of non-governmental organizations and submitted to the department as part of the comments for the draft EIS. The ADD for this alternative is calculated assuming the full build-out of the existing service area assuming the 2008-2012 average per capita per day demand of 89.1 gallons, 8% unaccounted for water, and 10% demand reduction for water conservation. Details on this alternative can be found in the report "Non-Diversion Alternative Using Existing Water Supply with Treatment City of Waukesha Water Supply, Waukesha Wisconsin." (GZA GeoEnvironmental, Inc. 2015) This ADD does not consider the Applicant's delineated water supply service area for calculating demand projections and uses alternative assumptions for calculating demand than the assumptions used by the Applicant. The department does not consider this alternative viable because it does not meet the Agreement/Compact criteria to meet all applicable state laws. State law requires the Applicant to consider the delineated water supply service area in developing a projected water demand. This alternative only considers the existing service area not the delineated service area (see Technical Review S3 for additional information). In addition, the department determined that the proposed infrastructure does not have the firm capacity to supply the 11.1 MGD projected MDD, as requires under S. NR 811.26 Wis. Adm. Code.

For this alternative, the Applicant would use the existing deep and shallow aquifer wells; add reverse osmosis (RO) treatment to three deep wells; maintain hydrous manganese oxide (HMO) treatment on one deep well; and pump water from all of the wells to the Hillcrest reservoir for blending and then distribution to the system. This alternative would not add any additional wells. Additional infrastructure would be required to pump water from all wells to the Hillcrest Reservoir prior to delivery to the water supply system. See Table 2-1 below for well treatment and capacity summary.

Table 2-1- Applicant well capaccities with proposed zero demand increase alternative. (Duchniak, 2015)

Well	*Aquifer Depth*	*Treatment*	*24-hr Firm Pump Capacity (MGD)*	*24-hr Firm Well Capacity (with Treatment)[1] (MGD)*	*12-hr Firm Well Capacity (with Treatment)[1] (MGD)*	*18-hr Firm Well Capacity (with Treatment)[1] (MGD)*
3	Deep	HMO	1.1	1.1	0.6	0.8
5	Deep	(None)	1.4	1.4	0.7	1.1
6	Deep	Add RO	2.7	2.2	1.1	1.6
7	Deep	(None)	0.9	0.9	0.5	0.7
8	Deep	Add RO	2.4	1.9	1.0	1.4
9	-- Abandon[2] --		0.0	0.0	0.0	0.0
10	Deep	Add RO	3.8	3.0	1.5	2.3
11	Shallow	(None)	0.2	0.2	0.1	0.2
12	Shallow	(None)	0.7	0.7	0.4	0.5
13	Shallow	(None)	0.9	0.9	0.5	0.7
	Firm Capacity[3]:		**10.3**	**9.3**	**4.6**	**7.0**

[1] Reverse Osmosis treatment results in reject water. Reject water is brine that is discharged to the sanitary sewer. A 20% reject water volume is calculated for Reverse Osmosis treatment technology at Wells No. 6, 8 and 10.
[2] Well 9 is proposed to be is abandoned in this review due to poor water quality, and limited well house footprint, preventing addition of treatment facilities. The abandonment of Well 9 was not included in the GZA report.
[3]Firm capacity is the system capacity with the largest well out of service. In the Applicant's system this is Well No. 10.

As discussed for this alternative, treatment would be installed at the three largest deep wells (No. 6, 8, and 10) to reduce total dissolved solids and radium. Since the deep wells are on small lots, adjacent residential property would need to be purchased for the additional treatment facilities. The Applicant has stated that each of these wells would need to have its own treatment facility, and that water from the remaining deep wells and shallow wells would be blended at the Hillcrest reservoir.

Water treatment solids (sludge) generated as part of the treatment process would require a new sludge pipeline from the water treatment plant. This pipeline would parallel the treated water pipeline to minimize construction impacts and costs.

2.3 Water Supply alternatives

2.3.1 Mississippi River basin supply alternatives

There are two Mississippi basin supply alternatives evaluated in this document. The alternatives are: the deep and shallow aquifers supply alternative, and the shallow aquifer supply alternative. If either of these alternatives were chosen, the return flow would be through the City's wastewater treatment plant with discharge to the Fox River.

2.3.1.1 Deep and shallow aquifers supply alternatives

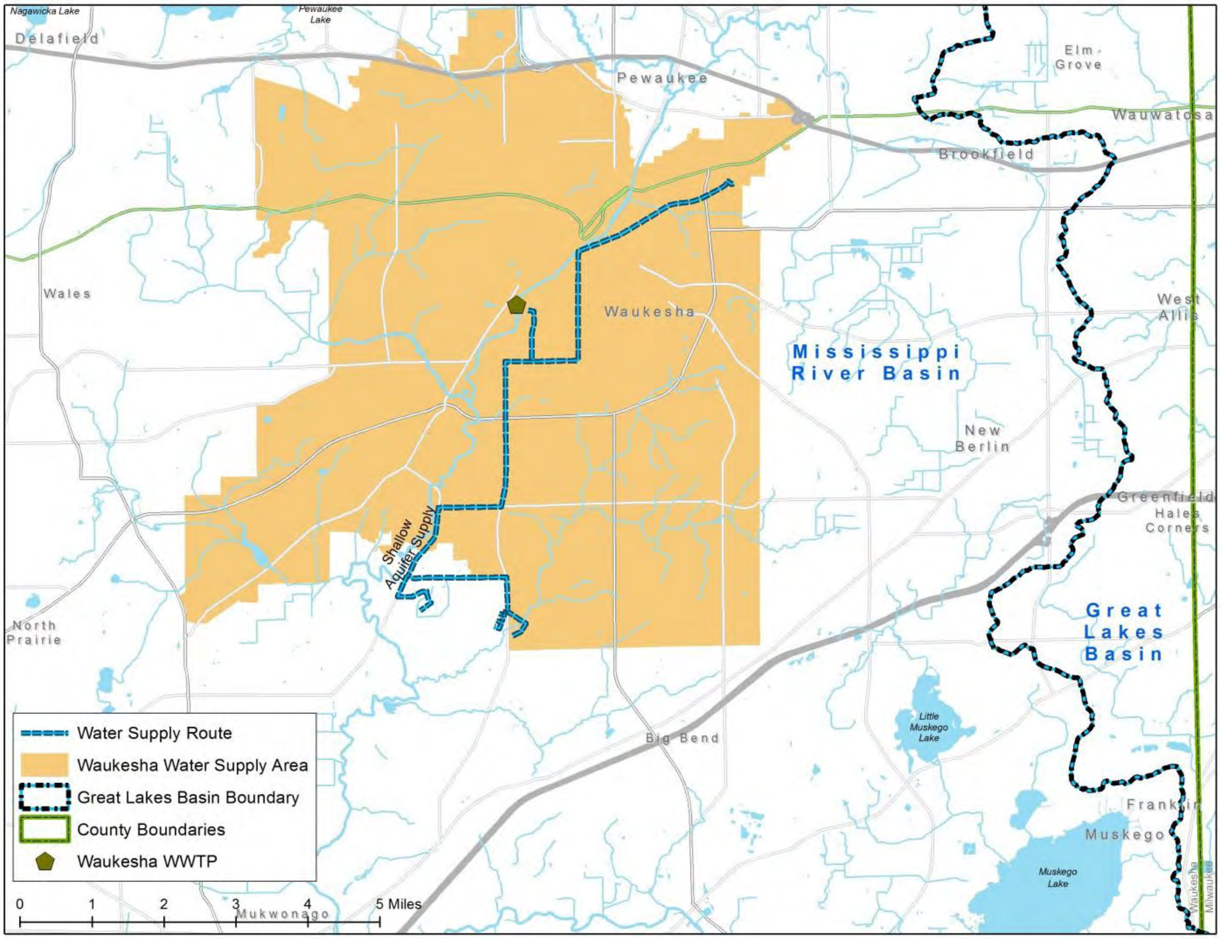
With this alternative the Applicant would continue use of the deep aquifer (St. Peter sandstone) and shallow aquifer south of the City of Waukesha with additional treatment facilities and wells for the deep and shallow aquifer supply alternative (Figure 2-1).

The proposed infrastructure includes 7.6 million gallons per day (MGD) capacity from the existing deep wells and 1.2 MGD from the existing shallow wells. This alternative includes an additional 7.9 MGD capacity from 12 new shallow wells south of Waukesha, near the Vernon Marsh Wildlife Area, in the shallow sand and gravel aquifer (Figure 2-2).

All water in this alternative would require new pipelines to allow water to be blended at the Hillcrest reservoir.

The proposed new shallow aquifer wells would need new pipes to connect the wells with the new water treatment plant needed for this alternative. These pipes would cross the Fox River, Pebble Brook and wetlands adjacent to the Vernon Marsh Wildlife Area between the wells and the water treatment plant. From the water treatment plant, a new pipe would follow existing roads to convey the treated water to the Hillcrest reservoir and Applicant's distribution system.

Figure 2-1 Deep and Shallow aquifer water supply potential pipeline infrastructure



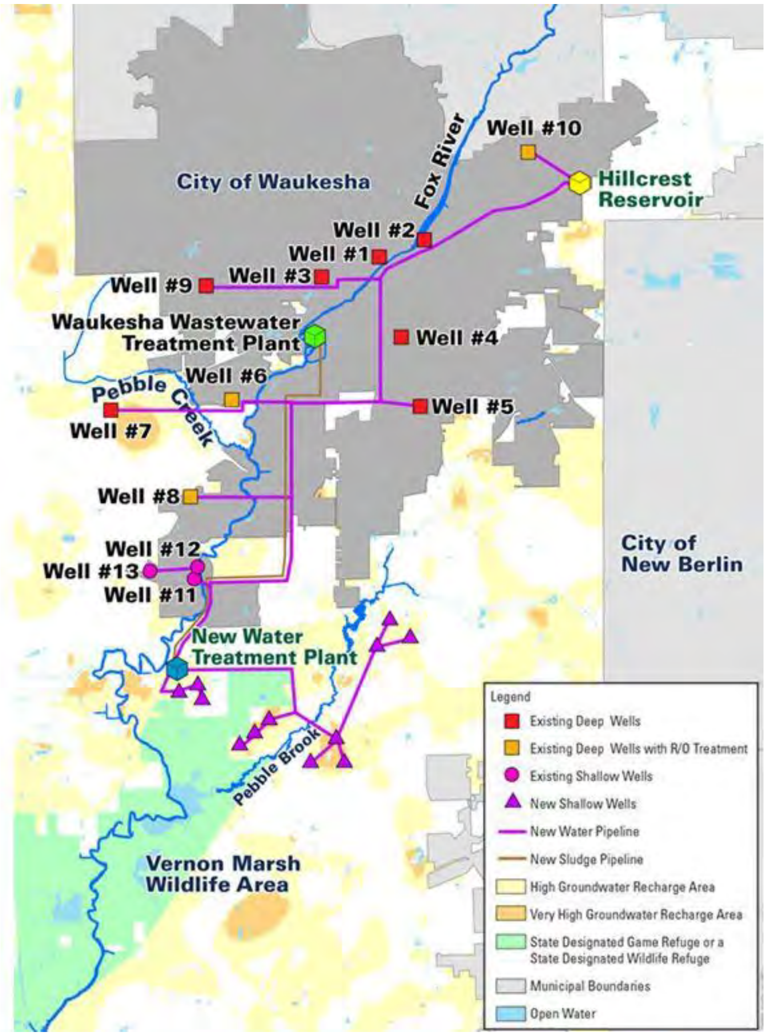
For this alternative, treatment would be installed at the three largest deep wells (No. 6, 8, and 10) to reduce TDS and radium. Since the deep wells are on small lots, adjacent residential property would need to be purchased for the additional treatment facilities. The Applicant assumes wells No. 6, 8, and 10, would each have its own treatment facility, and that water from the remaining deep wells and shallow wells would be blended at the Hillcrest reservoir. Additionally, arsenic treatment may be needed in the shallow wells (test wells identified slightly elevated arsenic levels), as well as iron, manganese and microorganism removal. The shallow well water would be pumped from the wells to a new water treatment plant. A new pump station and 30-inch diameter pipeline would convey treated water to the City of Waukesha and connect with the water distribution system and Hillcrest reservoir.

Water treatment solids (sludge) generated as part of the treatment process would require a new sludge pipeline from the water treatment plant. This pipeline would parallel the treated water pipeline to minimize construction impacts and costs.

In total, this alternative would require approximately 13.9 miles of 8- to 30-inch diameter pipeline.

The department also reviewed a variation on this alternative that would eliminate the shallow wells along Pebble Brook and added River Bank Inducement wells along the Fox River.

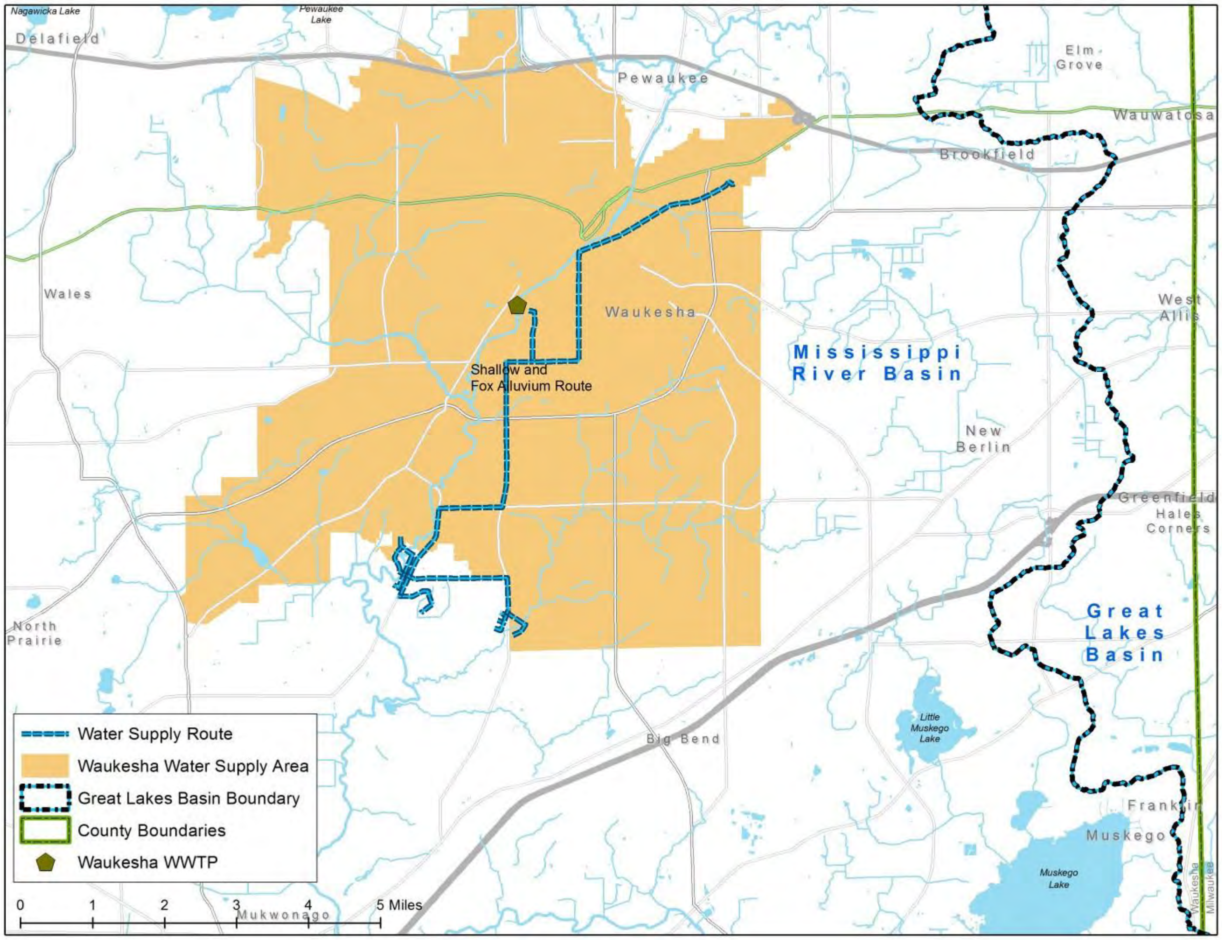
Figure 2-2 Deep and shallow aquifers water supply alternative as proposed by the Applicant (Vol. 1, Exhibit 4-3)



2.3.1.2 Shallow aquifer supply alternatives

In this alternative the Applicant would use the shallow sand and gravel aquifer south of the City of Waukesha (Figure 2-3).

Figure 2-3. Shallow aquifer (Fox River alluvium) water supply potential pipeline infrastructure



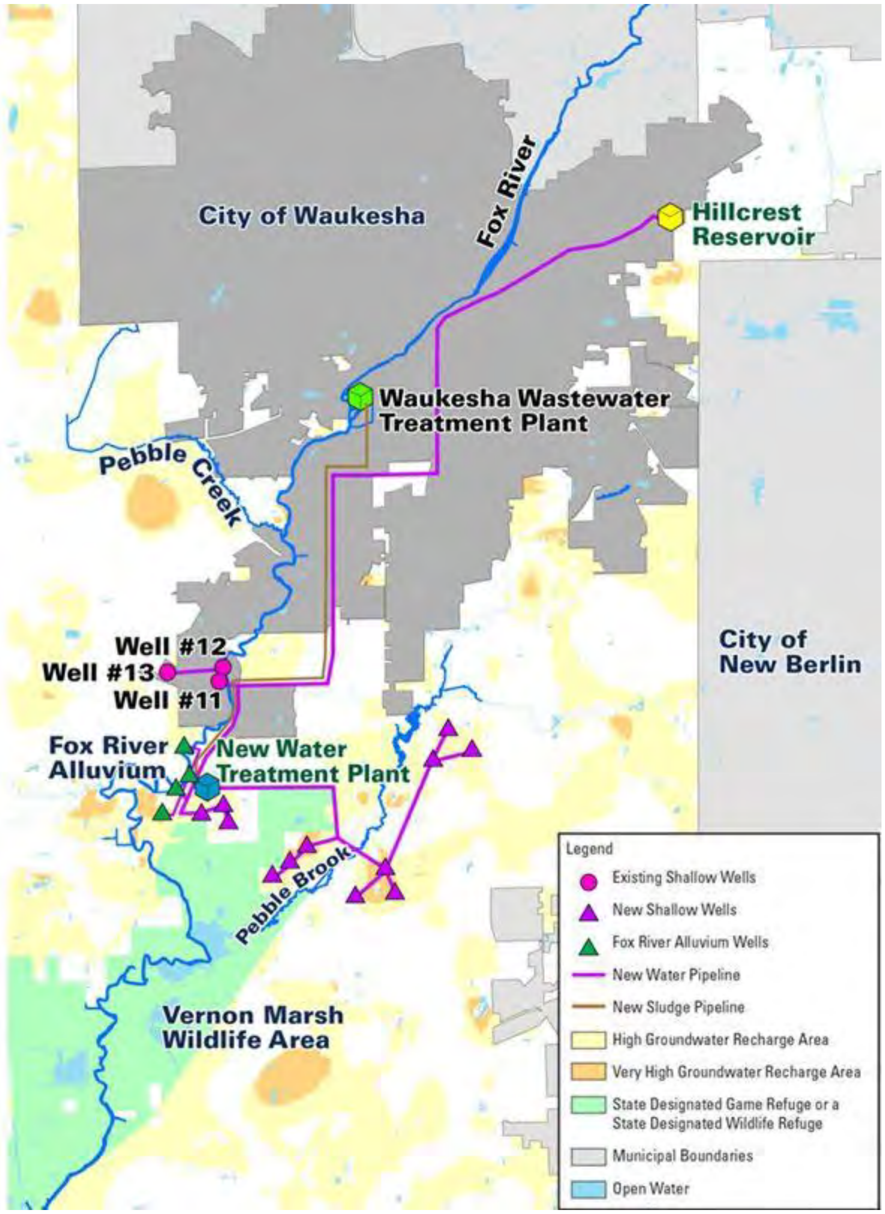
This alternative's proposed infrastructure includes 4.5 MGD capacity through four new wells along the Fox River south of the City of Waukesha, 1.2 MGD from the existing shallow wells, and an additional 11.0 MGD capacity from 12 new shallow wells south of the City of Waukesha near the Vernon Marsh Wildlife Area in the shallow sand and gravel aquifer (Figure 2-4).

For this alternative, the shallow aquifer wells would pump water, through new supply pipes, to a new water treatment plant south of the City of Waukesha. The water would be treated for iron, manganese, microorganism removal and possibly arsenic. The proposed pipes would cross the Fox River, Pebble Brook and wetlands adjacent to the Vernon Marsh Wildlife Area. From the water treatment plant, a new pump station and 30 inch diameter pipeline would follow existing roads to convey the treated water to the Applicant's distribution system and to the Hillcrest reservoir.

Water treatment solids (sludge) generated as part of the treatment process would require a new sludge pipeline from the water treatment plant. This pipeline would parallel the treated water pipeline to minimize construction impacts and costs.

In total, this alternative would require approximately 14.7 miles of 8- to 30-inch diameter pipeline

Figure 2-4. Shallow aquifer water supply alternative as proposed by the Applicant (Vol. 1, Exhibit 4-9)



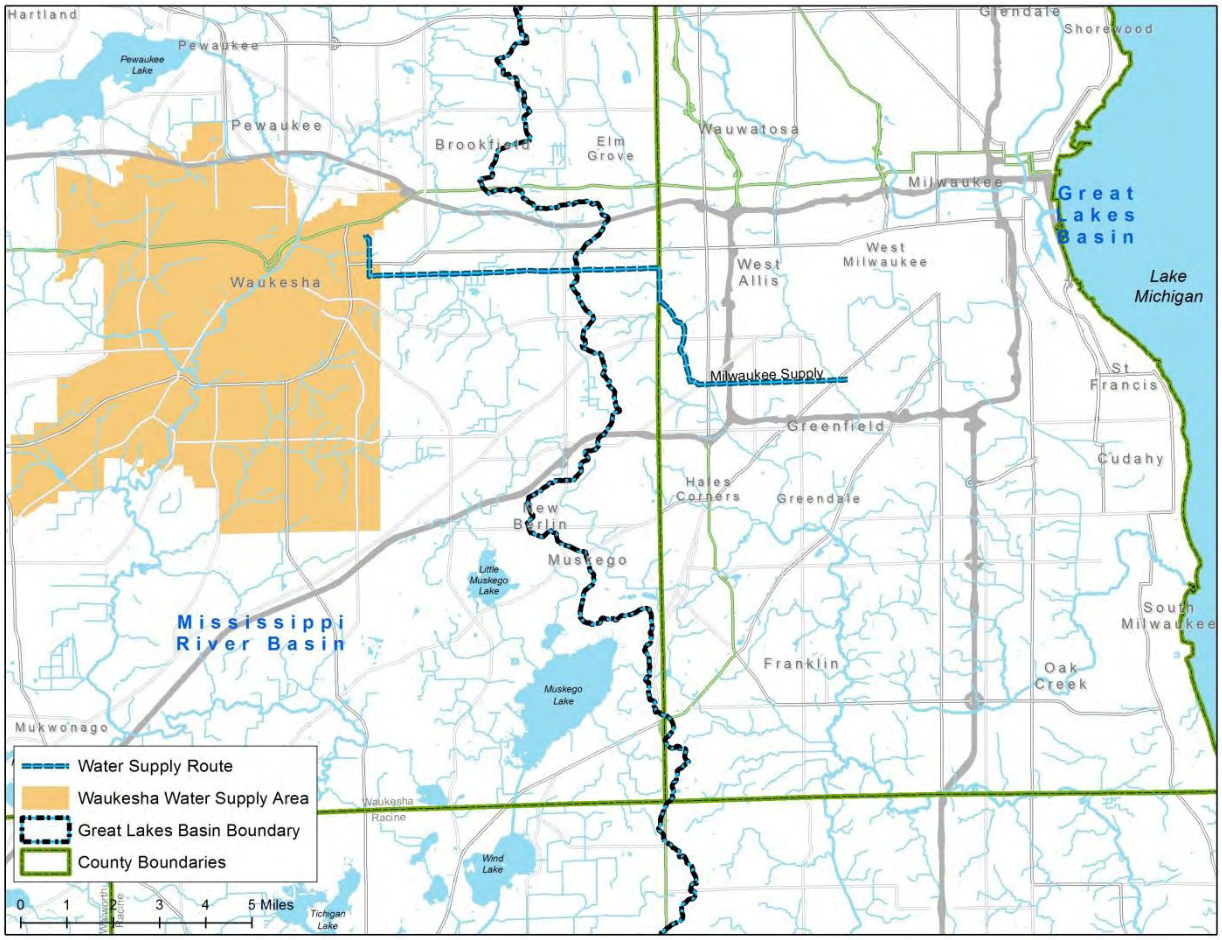
2.3.2 Lake Michigan supply alternatives

There are three Lake Michigan basin supply alternatives evaluated in this EIS. The alternatives are: the City of Milwaukee supply alternative, the City of Oak Creek supply alternative, and the City of Racine supply alternative. If any of these alternatives were chosen, the return flow would be to Lake Michigan

2.3.2.1 Milwaukee supply alternative

Under this alternative, Lake Michigan water would be purchased from the City of Milwaukee, obtained by connecting to the City of Milwaukee's existing distribution system on the west side of Milwaukee. This alternative would utilize treatment from the City of Milwaukee's two existing drinking water treatment plants (Figure 2-5).

Figure 2-5. Lake Michigan - City of Milwaukee water supply potential pipeline infrastructure

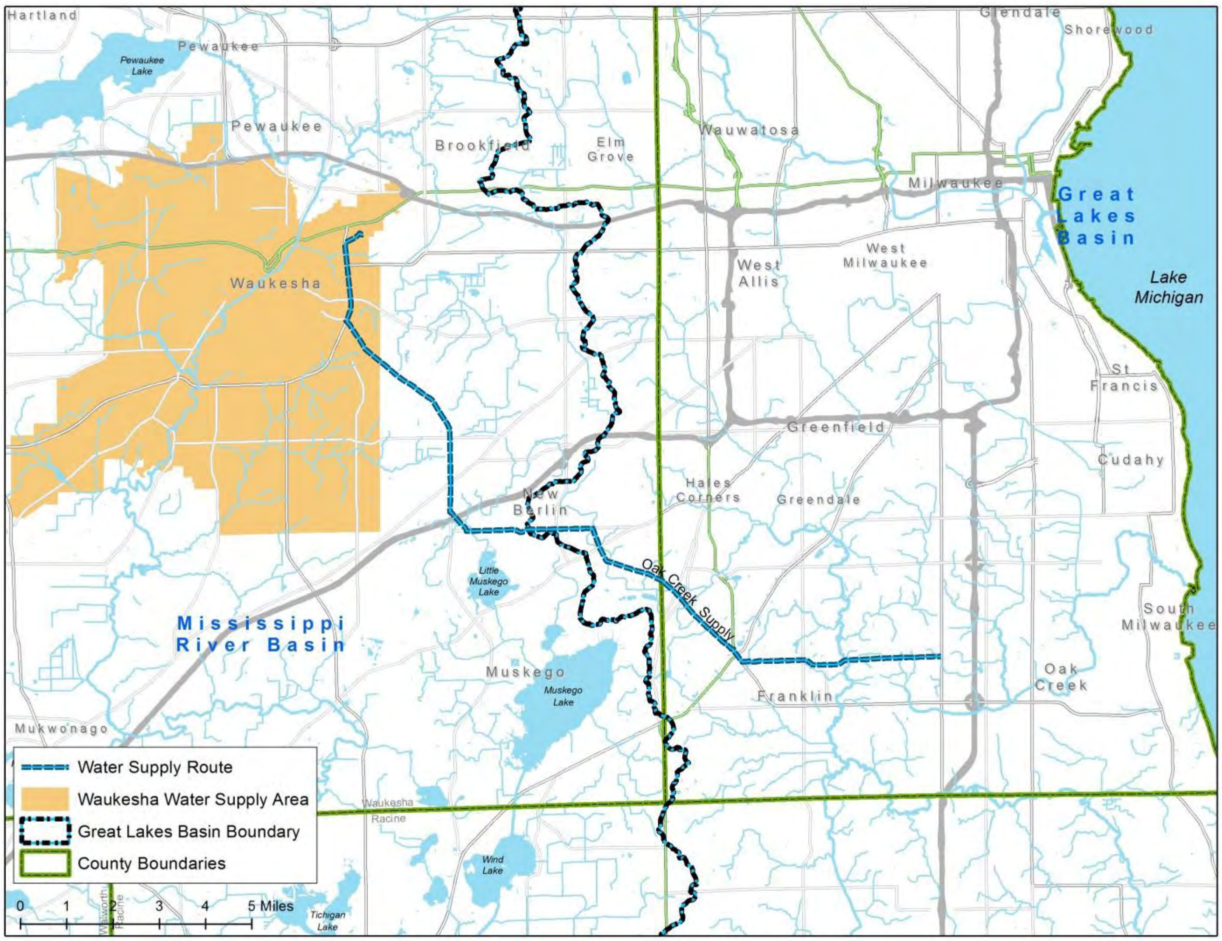


For this alternative, a new pipeline and booster pump station would be constructed. The connection to the City of Milwaukee's distribution system would be near 60th Street and Howard Avenue. The Applicant assumed this location because there is a large transmission main nearby. From this connection, a 30-inch supply pipeline would head west and follow City and Milwaukee County streets for about 6 miles. Along this segment the booster pump station is proposed to be constructed. From the booster pump station, the pipeline would continue west for about 6 miles along a utility corridor. The last segment of pipe (about 1 mile) would continue on City streets and lightly developed areas with a connection at the Hillcrest reservoir. In total, this alternative would require approximately 15 miles of pipeline.

2.3.2.2 Oak Creek supply alternative

The Applicant's preferred water supply alternative would be to obtain Lake Michigan surface water from the Oak Creek Water Utility, utilizing treatment from the City of Oak Creek's existing drinking water treatment plant located in the Great Lakes basin (Oak Creek Alignment 2, Figure 2-6).

Figure 2-6. Lake Michigan - City of Oak Creek water supply potential pipeline infrastructure

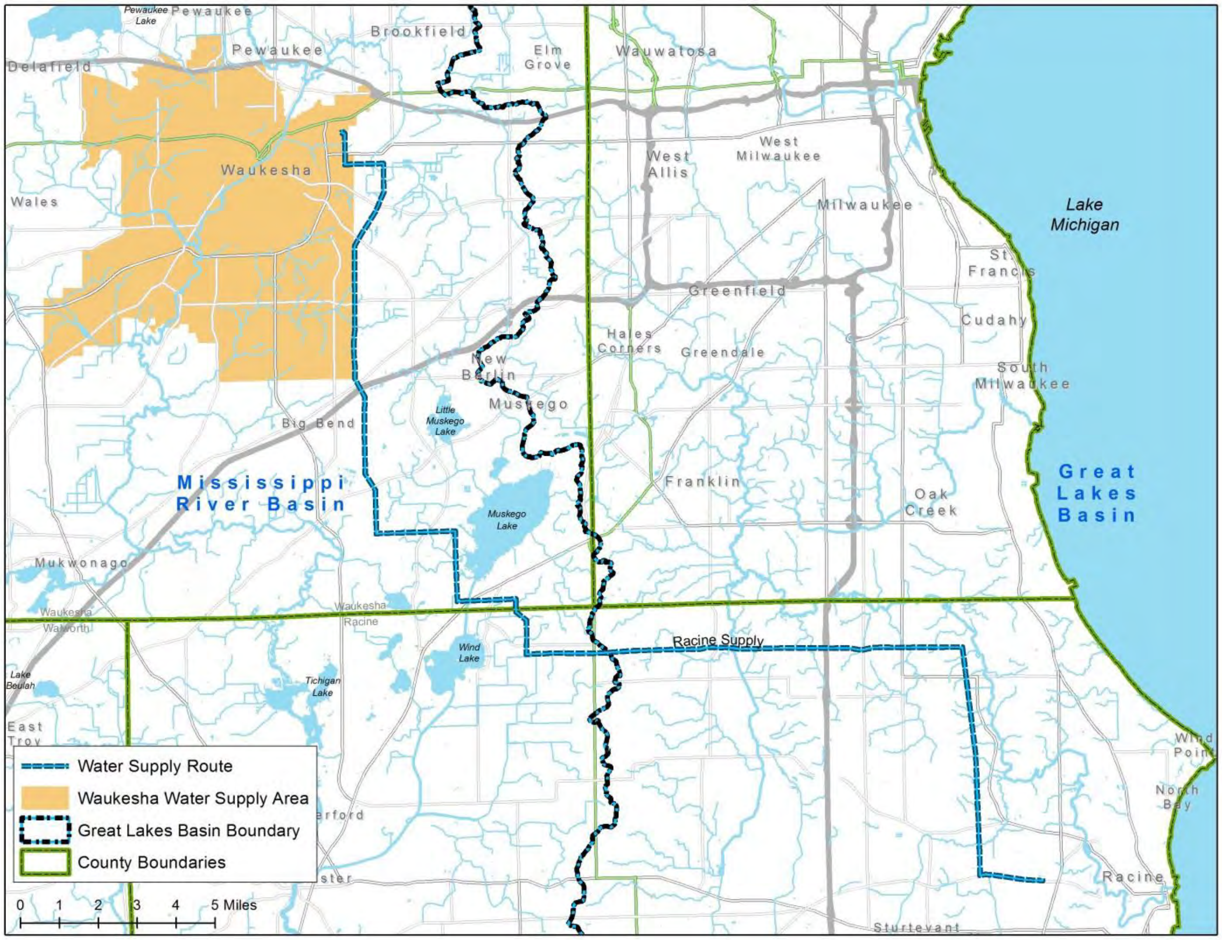


Lake Michigan water would be obtained by connecting to the City of Oak Creek's existing distribution system near 27th Street and Puetz Road. A booster pump station would be required at the point of connection to the existing distribution system. From this station, a 30-inch pipeline would be constructed northwest through the City of Franklin, City of Muskego, City of New Berlin, Town of Waukesha and the City of Waukesha. The approximately 19.4 mile-long pipeline would follow transportation corridors and rights-of-way to minimize environmental impacts. The supply pipeline would terminate at the Hillcrest reservoir in the City of Waukesha.

2.3.2.3 Racine Supply alternative

Under this alternative, Lake Michigan water would be obtained by purchasing water from the City of Racine and connecting to the existing distribution system on the west side of the City of Racine (Figure 2-7).

Figure 2-7. Lake Michigan - City of Racine water supply potential pipeline infrastructure



For this alternative, a new pipeline and booster pump station would be constructed. This alternative would utilize the City of Racine's existing drinking water treatment plant and connect to the City of Racine's distribution system near Highway C and Newman Road. A pump station would be constructed at the connection point to the City of Racine because there is an existing water reservoir nearby. From this connection, a 30-inch pipeline would head west and follow city, state and county roads, and utility corridors for the entire distance. A booster pump station would be constructed along the alignment. The last 2 miles of the alignment are the same as for the Milwaukee and Oak Creek alignments following a utility corridor for about 1 mile and city streets and lightly developed areas for the final mile before its connection at the Hillcrest reservoir. In total, this alternative would require approximately 38 miles of pipeline.

2.4 Return flow Alternatives

2.4.1 Mississippi River basin wastewater discharge alternatives

2.4.1.1 Fox River wastewater discharge alternative

Currently, the Applicant's wastewater treatment plant (WWTP) discharges to the Fox- Illinois River. This alternative considers *all* continued discharge of treated effluent to the Fox-Illinois River for the Mississippi River basin water supply alternatives only.

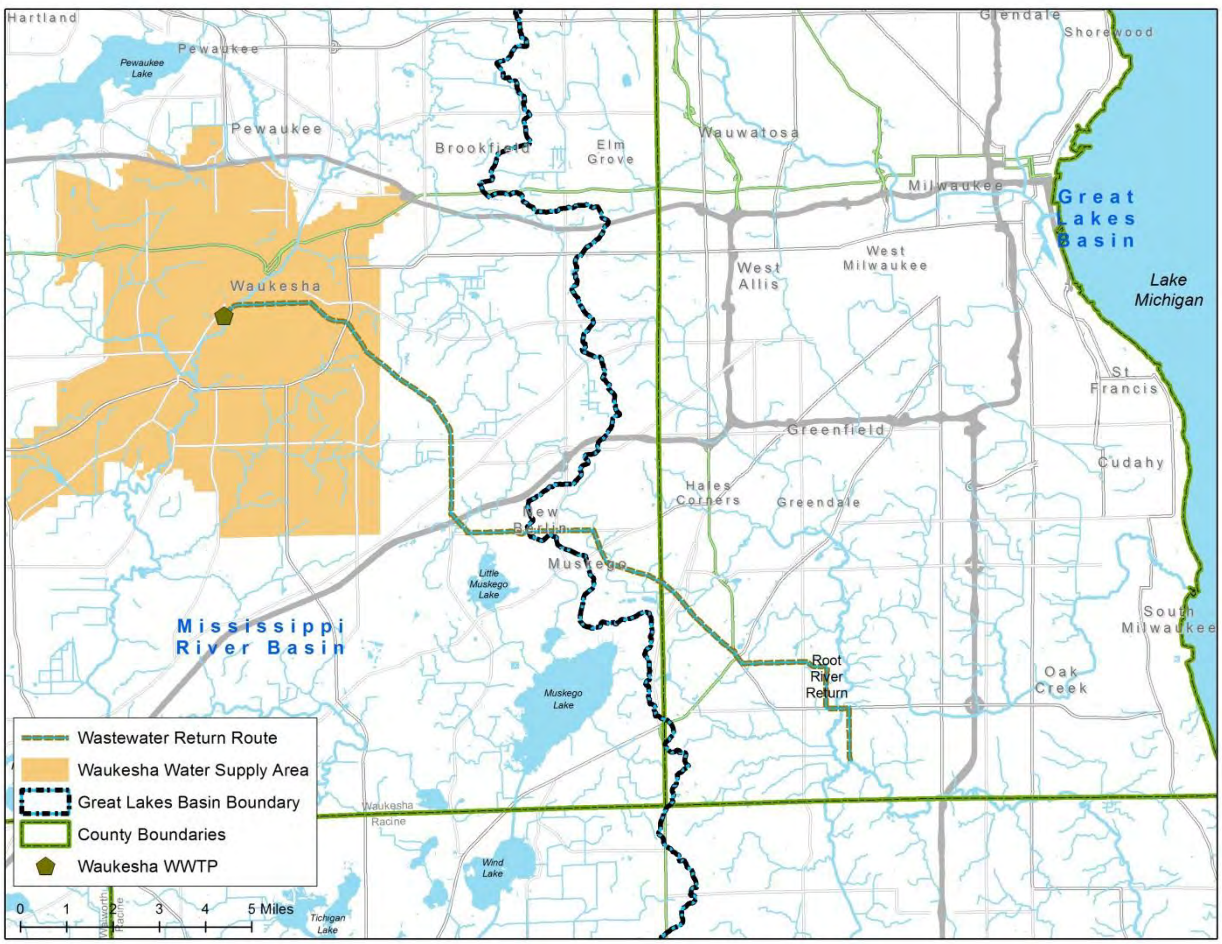
2.4.2 Lake Michigan return flow alternatives

If a Lake Michigan water supply is granted to the Applicant, all water withdrawn, less an amount for consumptive use, would be returned to Lake Michigan. Any additional flow than what is required under the return flow management plan would continue to be discharged to the Fox River. The following options explore the required return flow to the Lake Michigan Basin.

2.4.2.1 Root River return flow alternative

The Applicant's preferred return flow location is the Root River (Root River Alignment 2, Figure 2-8).

Figure 2-8. Root River return flow potential pipeline infrastructure

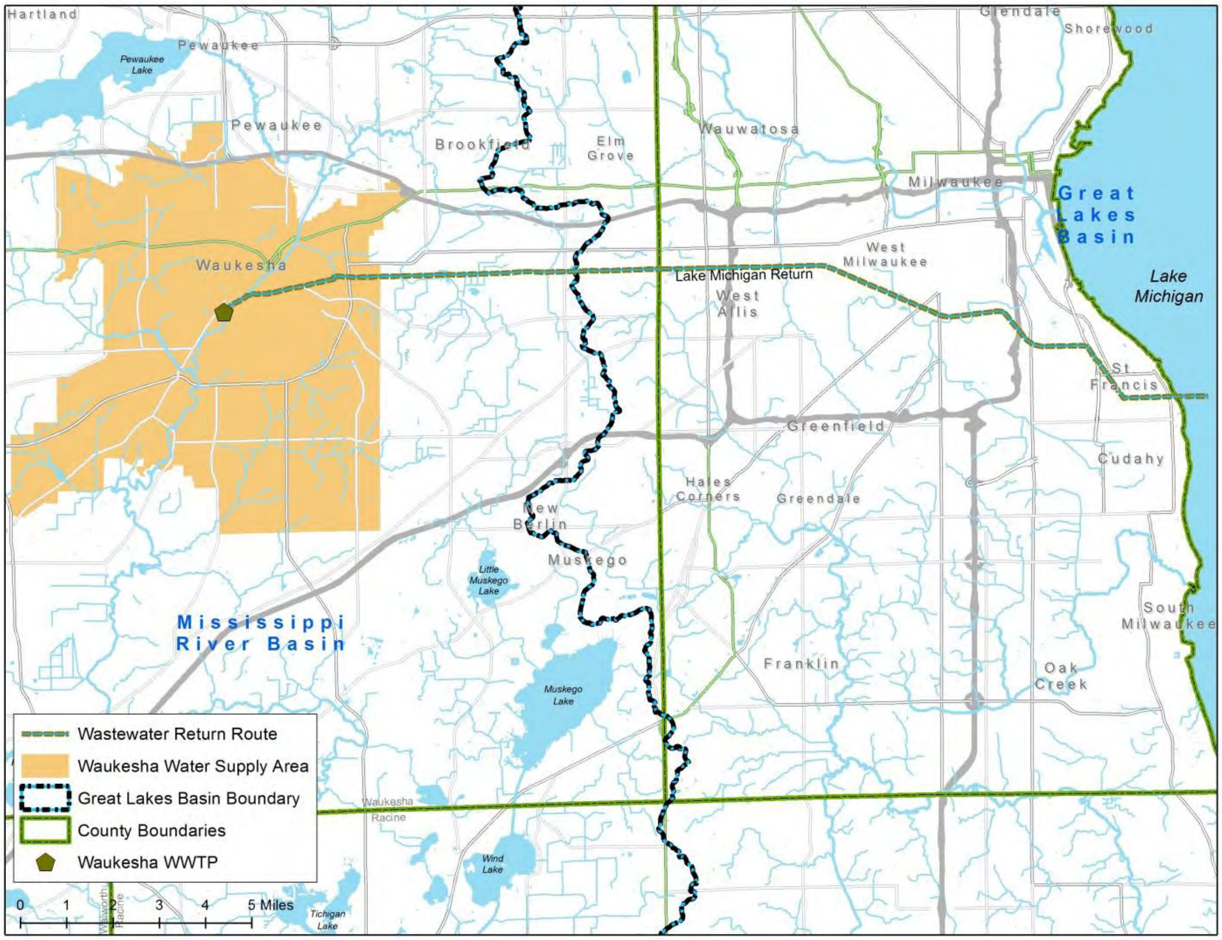


The Applicant proposed a pipeline for return flow to the Root River (Alignment 2, Figure 2-8). Wastewater would be treated at the Applicant's wastewater treatment plant (WWTP). The alignment would begin at the Applicant's WWTP and proceed southeast through the Cities of New Berlin, Muskego and Franklin. The pipeline would follow major roads, listed in Table 2-1 below, to minimize environmental impacts. In total, this alternative would require approximately 20.2 miles of 30- to 36-inch pipe.

2.4.2.2 Direct to Lake Michigan return flow alternative

The Applicant's alternative of returning flow directly to Lake Michigan (near Milwaukee and Oak Creek) would be accomplished by a pipeline constructed from the Applicant's WWTP to Lake Michigan (Figure 2-9).

Figure 2-9. Direct to Lake Michigan return flow potential pipeline infrastructure



This pipeline alignment would parallel the Root River for about 9.6 miles. Where the two pipeline alternatives diverge, the Lake Michigan alignment would continue east for about 11.2 miles parallel to a railroad corridor. As the alignment nears Lake Michigan it would continue east about 1.2 miles along a city street where it would intersect with the lake. The pipeline would extend into Lake Michigan about 0.5 miles to provide an offshore outfall. In total, this alternative would require approximately 22.5 miles of pipeline.

2.4.2.3 MMSD return flow alternatives

The Milwaukee Metropolitan Sewerage District (MMSD) operates regional sewage collection and water reclamation systems for most communities within the Lake Michigan Basin in the Milwaukee metropolitan area. The City included four (MMSD) return flow alternatives in the Application (Vol. 4, Attachment A-2, and CH2MHill Memo, March 10, 2015):

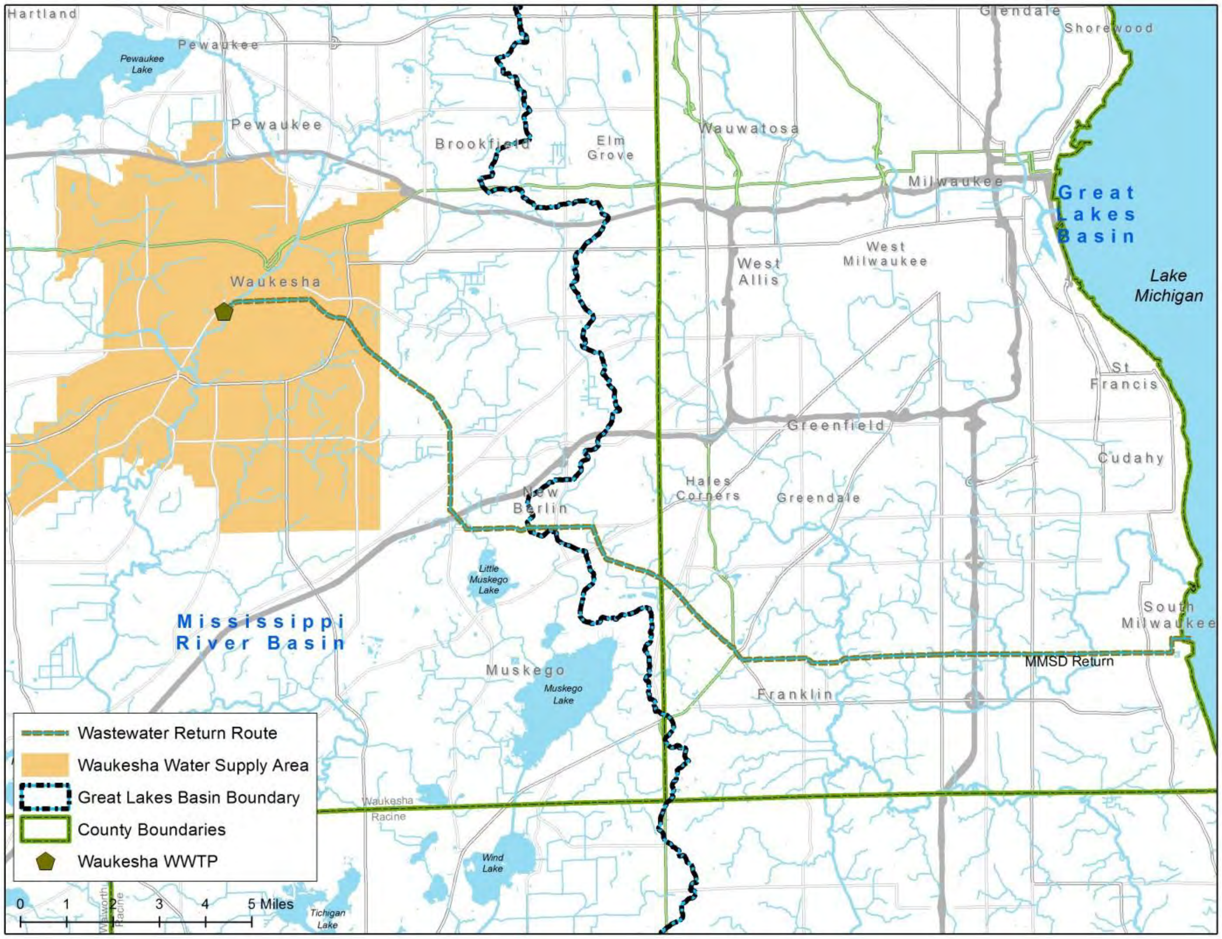
- Alternative 1: Wet Weather Equalization and Pipeline to MMSD South Shore
- Alternative 2: Wet Weather Equalization and Pipeline to MMSD Interceptor near Greenfield Park Pump Station
- Alternative 3: Pipeline to MMSD South Shore and Biological High Rate Treatment Facility at South Shore
- Alternative 4: Pipeline of Treated Wastewater Effluent to MMSD South Shore Outfall

For Alternatives 1-3, the Applicant would decommission its current WWTP. Wastewater from the approved sanitary sewer service area would be conveyed to MMSD for treatment and discharge to Lake Michigan. In these alternatives all the water, including infiltration and inflow from the Mississippi River basin (18 to 45%), would be returned to the Lake Michigan basin (up to 169% of the withdrawal). For these alternatives, improvements to the MMSD collection system and treatment plants would likely be required. The MMSD system is capacity-limited during wet weather, so any flow returned to MMSD would likely require additional conveyance and treatment capacity equivalent to the return flow, or storage to temporarily hold the water until treatment capacity is available.

The SEWRPC regional water supply study included MMSD return flow in its evaluation of return flow alternatives, but did not recommended this option because the cost exceeded that of either return flow directly to Lake Michigan or to a Lake Michigan tributary (SEWRPC, 2010a, Chapter 9, page 631). The MMSD alternative evaluation in the Return Flow Plan (Application, Vol. 4) confirms the high-cost of the MMSD alternative. Consequently, utilizing MMSD infrastructure for conveyance and treatment (MMSD alternatives 1-3) are not evaluated further.

For MMSD Alternative 4, the City would utilize the outfall to Lake Michigan at the MMSD South Shore Water Reclamation Facility (South Shore, Figure 2-10). The Applicant would send treated effluent from its current WWTP and would be required to meet all water quality discharge permit limits. The MMSD Alternative 4, utilizing the existing South Shore outfall, is further evaluated in this document.

Figure 2-10. MMSD return flow alternative 4 potential pipeline infrastructure



The pipeline alignment would be the same as for the Root River alignment (see Figure 2-8 above) for 17.6 miles from the Applicant's WWTP to Puetz Road and 68th Street in Franklin (see Table 2-1). The pipeline would continue east along Puetz Road towards the lake instead of turning southward toward the Root River. At 5th Avenue near Lake Michigan, the alignment would turn north for approximately 0.3 miles to enter MMSD's South Shore Water Reclamation Facility and another 0.5 miles where the return flow would be discharged to Lake Michigan through the MMSD outfall.

2.4.3 Other alternatives not considered in detail

Extensive studies have investigated various water supply alternatives for the Applicant (CH2M HILL and Ruekert & Mielke, 2002, SEWRPC, 2010a, Cherkauer, 2009, CH2M HILL, 2010). The City also looked in detail at alternative pipeline routes and an alternative return flow to Underwood Creek that are not evaluated in detail in this EIS. In March 2002, the Applicant completed a future water supply study. Stakeholders in this study included representatives from the department, the Waukesha Water Utility, the City of Waukesha, Southeastern Wisconsin Regional Planning Commission (SEWRPC), U.S. Geological Survey (USGS), Wisconsin Geological and Natural History Survey, and the University of Wisconsin–Madison. The study looked at the following 14 water supply sources and combinations of them.

- Deep (confined) aquifer near Waukesha
- Deep (unconfined) aquifer west of Waukesha
- Shallow groundwater south of Waukesha (including riverbank inducement along the Fox River)
- Shallow groundwater west of Waukesha
- Shallow aquifer, Silurian dolomite
- Fox River
- Rock River
- Lake Michigan
- Fox or Rock River Dam
- Waukesha quarry
- Waukesha springs
- Pewaukee Lake
- Milwaukee River
- Wastewater reuse

More options for water supply alternatives are reviewed in the department's Technical Review S2 for this project.

The Applicant had also proposed a return flow alternative to Underwood Creek. The department determined that an Underwood Creek return flow is not a viable option at this time due to difficulty in obtaining the required permits. This alternative is not evaluated further in this EIS. A return flow Direct to Lake Michigan near Racine was also not considered for this EIS because it was similar to other direct to Lake Michigan options but had greater costs and impacts due to its larger pipeline.

The Applicant also proposed an alternative water supply pipeline route known as Oak Creek supply alignment 1, and an alternative return flow pipeline route known as Root River return flow alignment 1. There are minimal differences between these alternative routes and the Applicant's preferred routes, so neither is evaluated in this EIS, only the Applicant's preferred options (Oak Creek Alignment 2, Root River Alignment 2) were reviewed.

Table 2-2. Road corridors of potential pipelines for alternatives (Source: Vol. 5, Table 3-4 Supplement)

Alternative	Direction	Length (miles)	Route	City
Deep and Shallow Aquifers	W	1.2	Offroad east to wells	Waukesha
Deep and Shallow Aquifers	W	0.5	Oakdale Road	Waukesha
Deep and Shallow Aquifers	E	2.2	Offroad west to wells	Waukesha
Deep and Shallow Aquifers	NE	1.3	River Drive	Waukesha
Deep and Shallow Aquifers	E	0.9	Lawnsdale Road	Waukesha
Deep and Shallow Aquifers	N	2.0	Oakdale Road	Waukesha
Deep and Shallow Aquifers	N	0.8	Sentry Drive	Waukesha
Deep and Shallow Aquifers	E	1.0	W Sunset Drive	Waukesha
Deep and Shallow Aquifers	N	1.5	S West Avenue	Waukesha
Deep and Shallow Aquifers	NE	2.3	E Main Street	Waukesha
Deep and Shallow Aquifers	SE	0.1	Offroad	Waukesha
Shallow Aquifer	Multi	2.7	Offroad east to wells	Waukesha
Shallow Aquifer	W	0.5	Oakdale Road	Waukesha
Shallow Aquifer	E	2.2	Offroad west to wells	Waukesha
Shallow Aquifer	NE	1.3	River Drive	Waukesha
Shallow Aquifer	E	0.9	Lawnsdale Road	Waukesha
Shallow Aquifer	N	2.0	Oakdale Road	Waukesha
Shallow Aquifer	N	0.8	Sentry Drive	Waukesha
Shallow Aquifer	E	1.0	W Sunset Drive	Waukesha
Shallow Aquifer	N	1.5	S West Avenue	Waukesha
Shallow Aquifer	NE	2.3	E Main Street	Waukesha
Shallow Aquifer	SE	0.1	Offroad	Waukesha
Lake Michigan Supply - Milwaukee	W	3.1	W Howard Avenue	Greenfield/Milwaukee
Lake Michigan Supply - Milwaukee	W	0.2	Offroad	Greenfield
Lake Michigan Supply - Milwaukee	NW	2.2	S Root River Parkway	West Allis/Greenfield
Lake Michigan Supply - Milwaukee	N	0.7	124th Street	Waukesha/West Allis
Lake Michigan Supply - Milwaukee	W	6.3	New Berlin Recreation Trail/Utility Corridor	Waukesha/New Berlin
Lake Michigan Supply - Milwaukee	N	1.0	Offroad	Waukesha
Lake Michigan Supply - Oak Creek	W	4.4	W Puetz Road	Franklin
Lake Michigan Supply - Oak Creek	NW	2.5	W Martins Road	Franklin
Lake Michigan Supply - Oak Creek	NW	2.0	Tess Corners Drive	Muskego
Lake Michigan Supply - Oak Creek	W	2.7	W College Avenue	New Berlin/Muskego
Lake Michigan Supply - Oak Creek	NW	0.5	Minor Roads	New Berlin
Lake Michigan Supply - Oak Creek	NW	5.0	S Racine Avenue	Waukesha/New Berlin
Lake Michigan Supply - Oak Creek	NE	1.7	W 164 Street	Waukesha
Lake Michigan Supply - Oak Creek	NE	0.4	E Main Street	Waukesha
Lake Michigan Supply - Oak Creek	SE	0.1	Offroad	Waukesha

Lake Michigan Supply - Racine	W	1.7	Spring Street	Mount Pleasant
Lake Michigan Supply - Racine	N	5.9	Offroad/Utility Corridor	Caledonia/Mount Pleasant
Lake Michigan Supply - Racine	W	11.3	Offroad/Utility Corridor	Norway/Raymond/Caledonia
Lake Michigan Supply - Racine	NW	1.6	Offroad/Utility Corridor	Norway/Muskego
Lake Michigan Supply - Racine	W	1.5	Offroad/Utility Corridor	Muskego
Lake Michigan Supply - Racine	N	1.8	Offroad/Utility Corridor	Muskego
Lake Michigan Supply - Racine	W	2.0	Offroad/Utility Corridor	Muskego
Lake Michigan Supply - Racine	N	7.6	Offroad/Utility Corridor	New Berlin/Muskego
Lake Michigan Supply - Racine	NE	2.3	Offroad/Utility Corridor	New Berlin
Lake Michigan Supply - Racine	W	1.0	Offroad/Utility Corridor	New Berlin/Waukesha
Lake Michigan Supply - Racine	NW	1.0	Offroad	Waukesha/Brookfield
Root River Return Flow	NE	0.4	Offroad	Waukesha
Root River Return Flow	E	1.6	College Avenue	Waukesha
Root River Return Flow	SE	6.0	Racine Avenue	Waukesha/New Berlin
Root River Return Flow	SE	0.5	Minor Roads	New Berlin
Root River Return Flow	E	2.7	W College Avenue	New Berlin/Muskego
Root River Return Flow	SE	2.0	Tess Corners Drive	Muskego
Root River Return Flow	SE	2.5	Martins Road	Franklin
Root River Return Flow	E	1.9	Puetz Road	Franklin
Root River Return Flow	S	0.9	S 68th Street	Franklin
Root River Return Flow	E	0.5	W Ryan Road	Franklin
Root River Return Flow	S	1.2	S 60th Street	Franklin
Direct to Lake Michigan	NE	2.6	Offroad	Waukesha
Direct to Lake Michigan	E	7.1	New Berlin Recreation Trail/Utility Corridor	Waukesha/New Berlin
Direct to Lake Michigan	E	3.5	Offroad/Railroad Corridor	West Allis
Direct to Lake Michigan	SE	7.7	Offroad/Railroad Corridor	West Allis/Milwaukee/St Francis
Direct to Lake Michigan	E	1.0	E Lunham Avenue	St Francis/Cudahy
Direct to Lake Michigan	E	0.8	Offroad/Lake Michigan	St Francis/Cudahy
MMSD Alternative 4	NE	0.4	Off Road	Waukesha
MMSD Alternative 4	E	1.6	College Avenue	Waukesha
MMSD Alternative 4	SE	6	Racine Avenue	Waukesha/New Berlin
MMSD Alternative 4	SE	0.5	Minor Roads	New Berlin
MMSD Alternative 4	E	2.7	W. College Avenue	New Berlin/Muskego
MMSD Alternative 4	SE	2	Tess Corners Drive	Muskego
MMSD Alternative 4	SE	2.5	Martins Road	Franklin
MMSD Alternative 4	E	1.9	W. Puetz Road/68th Street	Franklin
MMSD Alternative 4	E	7.5	Puetz Road	Franklin/Oak Creek
MMSD Alternative 4	N	0.3	5th Avenue	Oak Creek
MMSD Alternative 4	E	0.5	Off Road	Oak Creek

Section 3 Affected Environment

3 Affected Environment

3.1 Geology and Soils

3.1.1 Surficial and bedrock geology

The bedrock geology of Southeastern Wisconsin consists of Paleozoic sedimentary units, generally thickening to the east. In most places, Pleistocene deposits of till, sand and gravel, cover the bedrock units making bedrock outcrops rare. The basic geology framework of the region is in Table 3.1 below (maps available in CH2MHill, 2013, Vol. 5, Appendix 6-8).

SURFICIAL GEOLOGY

The Pleistocene deposits in the Region consist of a complex sequence of deposits differing in origin, age, lithology, thickness, and areal extent. Mickelson and others (1984) recognized five lithostratigraphic units in Southeastern Wisconsin: Kewaunee, Horicon, Oak Creek, New Berlin, and Zenda Formations.

The inland portion of Waukesha county is covered with glacial deposits of the Green Bay Lobe (Horicon Formation) and early advances of the Lake Michigan Lobe (New Berlin and Zenda Formations) that occurred about 15,000 to 35,000 years ago (Clayton et al., 2001; Mickelson and Syverson, 1997). These earlier ice advances till units tend to be more sandy and more permeable than the younger tills to the east. The till of the Zenda Formation is older, pink, and medium-grained, and only rarely occurs at the surface. The younger Horicon and New Berlin Formations contain yellowish-brown and coarse-grained tills; the New Berlin Formation usually overlies the Zenda Formation (Mickelson and others, 1984). The Kettle Moraine, formed along the junction of these two ice lobes, is a hummocky upland consisting mainly of outwash sediment that collapsed when underlying or adjacent ice melted.

The lakeshore counties of Milwaukee and Racine also contain sandy till units (Horicon and New Berlin Formations) left by earlier advances, but these are mostly buried by younger silty deposits (Kewaunee and Oak Creek Formations) from later advances of the Lake Michigan Lobe.

There are three known major advances of the Lake Michigan Lobe, each of which laid down a distinctive type of till. The first advance of the Lake Michigan Lobe occurred about 15,000 to 35,000 years ago and deposited the sandy tills of the Zenda and New Berlin Formations. During the second major advance of the Lake Michigan Lobe about 13,000 to 14,500 years ago, a gray silty till of the Oak Creek Formation (Mickelson and others, 1984) was deposited, in three major morainic belts: the Valparaiso, Tinley and Lake Border systems, formed roughly parallel to the shoreline (Brown, 1990, Schneider, 1983; Simpkins, 1989). This silty, clayey till has a very low permeability, but contains lenses of gravelly outwash and sandy lake deposits. The third major advance of the Lake Michigan Lobe occurred from about 13,000 to 11,000 years ago, and deposited a reddish silty till (of the Kewaunee Formation) in a narrow band along the lakeshore north of Milwaukee and into Ozaukee County (Mickelson and others, 1984; Mickelson and Syverson, 1997). This till overlies the earlier gray clayey till and is also of very low permeability (Table 3.1).

Table 3-1. Geologic column for bedrock and glacial deposits in southeastern Wisconsin (University of Wisconsin - Extension, Wisconsin Geological Natural History Survey)

Geologic Time	Rock		Lithologic
QUATERNARY			
Recent	Undifferentiated		Soil, muck, peat, alluvium, colluvium, beach sediment
Pleistocene *(all units include lake and stream sediment in addition to*	Kewaunee Formation		Brown to reddish-brown, silty and clayey till
	Horicon Formation		Coarser, brown, sandy till with associated sand and gravel
	Oak Creek Formation		Fine-textured, gray clayey till; lacustrine clay, silt, and sand
	New Berlin Formation		Upper: medium-textured. gravelly sandy till; Lower: outwash sand
	Zenda Formation		Medium-textured, pink, sandy till; limited distribution
PALEOZOIC			
Devonian	Antrim Formation		Gray, silty shale; thin; limited distribution
	Milwaukee Formation		Shaly dolomite and dolomitic siltstone
	Thiensville Formation		Dolomite and shaly dolomite
Upper Silurian	Waubakee Formation		Dense, thin-bedded, gray, slightly shaly dolomite
	Racine Formation		Finely crystalline dolomite; locally shaly beds and dolomite reefs
	Waukesha Formation		Cherty, white to buff, medium bedded, shaly dolomite
	Brandon Bridge beds		Pink to green shaly dolomite with shaly beds
	Lower Silurian beds (undifferentiated)		Dolomite and shaly dolomite
Ordovician	Neda Formation		Brown hematitic shale and oolite; occurs sporadically
	Maquoketa Formation		Green to gray dolomitic shale; locally layers of dolomite,
	Sinnipee Group	Galena Formation	Cherty dolomite with shaly dolomite at the base
		Decorah Formation	Shaly dolomite with fossils; thin or absent
		Platteville Formation	Dolomite and shaly dolomite
	Ancell Group	Glenwood Formation	Blue to green shale or sandy dolomite; thin or absent
		St. Peter Formation	Predominantly medium-grained quartz sandstone
	Prairie du Chien Group	Shakopee Formation	Light gray to tan dolomite or dolomitic sandstone; locally absent
		Oneota Formation	Massive, light gray to tan, cherty, sandy dolomite; locally absent
Cambrian	Trempealeau Group	Jordan Formation	Fine- to medium-grained quartz sandstone; locally absent
		St. Lawrence Formation	Tan to pink silty dolomite; locally absent
	Tunnel City Group		Fine- to medium-grained sandstone and dolomitic sandstone; locally
	Elk Mound Group	Wonewoc Formation	Medium- to coarse-grained, tan to white, quartz sandstone
		Eau Claire Formation	Fine- to medium-grained sandstone; local beds of green shale
		Mt. Simon Formation	Coarse- to medium-grained sandstone; lower beds very coarse and
PRECAMBRIAN	Undifferentiated		Granite or quartzite

BEDROCK GEOLOGY

The bedrock of Southeastern Wisconsin is separated into two major divisions: 1) younger, relatively flat-lying sedimentary rocks of the Paleozoic Era (younger than 570 million years), and 2) older Precambrian predominantly crystalline rocks.

The Paleozoic rocks form the major aquifers of Waukesha, Milwaukee and Racine counties and consist of sedimentary rocks—dolomite, shale, and sandstone—that range from Cambrian to Devonian in age. The Paleozoic rocks are nearly flat-lying, but dip gently to the east from the

Wisconsin Arch into the Michigan Basin, and thicken significantly from west to east (Figure 3.1). An older crystalline basement of Precambrian crystalline rock, primarily granite and quartzite, underlies the Paleozoic sedimentary sequence.

Devonian strata, the youngest Paleozoic rock in Wisconsin, are present only along a narrow band parallel to the Lake Michigan shoreline from Milwaukee to the north. They constitute the westernmost occurrence of Devonian strata in the Michigan Basin. The Silurian dolomites are at the bedrock surface throughout most of the Region. The Ordovician-age Maquoketa Formation (shale) and Sinnipee Group (dolomite) underlie the western edge of the Region. The remaining Ordovician rock units, the St. Peter formation and the Prairie du Chien Group, and the Cambrian sandstone sequence are not exposed at the bedrock surface, but are encountered in deep wells throughout the Region.

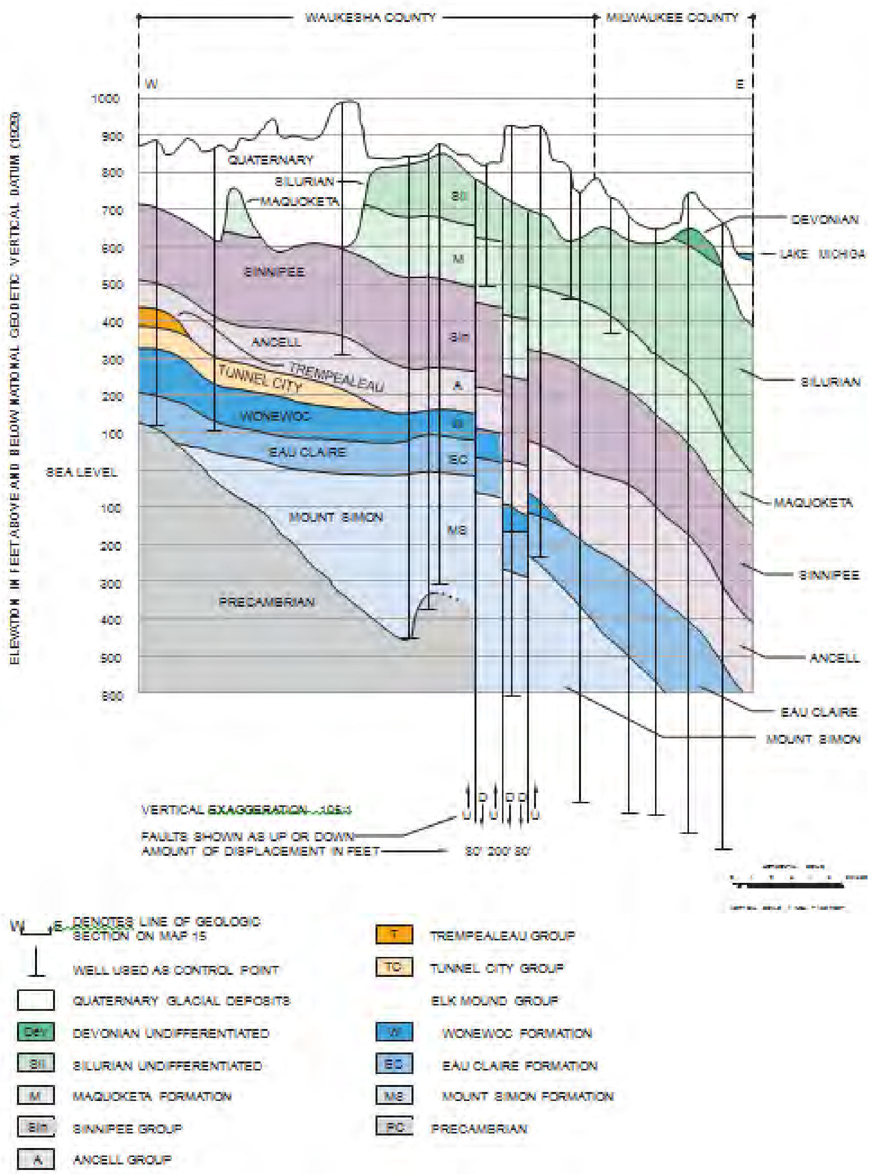
The youngest rocks in the three county area discussed are the Devonian limestone, dolomite, and shale. Because of the eastward regional dip of the beds, Devonian rocks are exposed only in a small area in eastern Milwaukee County. The Devonian consists, from the top, of the Antrim Shale, the Milwaukee Formation, and the Thiensville Formation. The Thiensville Formation ranges from 55 to 75 feet in thickness and grades from shaly dolomite at the base to clean dolomite at the top. The Milwaukee Formation consists of about 60 feet of shaly dolomite and dolomitic siltstone, and locally in eastern Milwaukee County it is overlain by up to 13 feet of a gray, silty mudstone of the Antrim Formation (formerly Kenwood Shale).

The Silurian section of Waukesha, Racine and Milwaukee counties consists of up to 600 feet of dolomite, subdivided into five formations. These are, from the top, the Waubakee Formation, the Racine Formation, the Waukesha Formation, the Brandon Bridge beds, and the undifferentiated “lower Silurian beds” (Table 3.1). The Waubakee Formation consists of dense, laminated to thin-bedded, slightly shaly, gray dolomite and is present only in Ozaukee and eastern Milwaukee County. It varies from 60 to 100 feet in thickness, and is unconformably overlain by the Devonian Thiensville Formation. Locally, reefs developed in the underlying Racine Formation project through the Waubakee Formation and are overlain directly by the Thiensville Formation.

The Racine formation is on average about 170 feet thick in the Milwaukee area, but can reach as much as 290 feet where reefs are developed. The nonreef facies of the Racine Formation is well-bedded, finely crystalline, light olive-gray dolomite, with some shaly beds. Reefs occur locally within the Racine Formation, and consist of massive, coarsely crystalline, porous, fossiliferous, mottled gray to brownish-gray dolomite (Mikulic and Kluessendorf, 1988). The reefs are up to 100 feet thick and over 990 feet in diameter, and grade laterally into typical nonreef Racine dolomite. The contact between the non-reef Racine facies and the overlying Waubakee Formation is gradational.

The Waukesha Formation consists of locally cherty, white to buff-colored, medium-bedded, shaly dolomite. In the southern part of the Region, at Racine and Burlington, the Brandon Bridge beds consist of light pink to green shaly dolomite interbedded with maroon shaly beds in the lower half. The Brandon Bridge beds thin to the north and are not present north of Waukesha (Mikulic, 1977). In Milwaukee County, the Brandon Bridge beds and the Waukesha Formation combined, range in thickness from 45 to 80 feet. These two units are sometimes called in the literature the Manistique Formation.

Figure 3-1. Geologic cross section of Southeastern Wisconsin, west - east (Source: SEWRPC, 2002)
The lower part of the Silurian section is not exposed in Southeastern Wisconsin and has not been extensively studied because few rock cores exist. The “lower Silurian beds” are approximately 175 feet thick in Milwaukee County. The beds consist of dolomite similar to that of other Silurian formations and are probably equivalent to the Byron and Mayville Formations of northeastern Wisconsin. The upper unit, the Byron Formation, is described as a fine-grained mudstone and the lower unit, the Mayville Formation, as a coarser- textured packstone.



The Ordovician rocks of the three county area discussed consist from, from the top, of the Neda Formation (shale), the Maquoketa Formation (shale and dolomite), the Sinnipee Group (dolomite), the Ancell Group (sandstone), and the Prairie du Chien Group (dolomite). The Ancell and Prairie du Chien Groups are not exposed at the bedrock surface, and are known only from well cuttings and logs.

Neda Formation

The upper Ordovician Neda Formation is a layer of brown hematitic shale and oolite, which occurs sporadically at the Ordovician-Silurian boundary in eastern Wisconsin and is conformable and gradational with the underlying Maquoketa Formation. Where present, the Neda Formation can be up to 50 feet thick.

Maquoketa Formation

The Maquoketa Formation underlies the Silurian dolomite and is exposed at the bedrock surface in the western part of Waukesha County. It consists predominantly of green to gray shale, dolomitic shale, and dolomite. It is approximately 150 feet thick in Racine County and thickens to the north and east. The Fort Atkinson Member is a continuous dolomite unit consisting of coarse, dark brown to brown, shaly dolomite up to 50 feet thick in the middle of the Maquoketa Formation, between the Brainard and Scales Members, which are predominantly shale.

Sinnipee Group

The Sinnipee Group consists of dolomite, shaly dolomite, and minor shale, and is divided into three formations (Table 3.1). The uppermost one, the Galena Formation, consists of cherty dolomite with 15 to 20 feet of shaly dolomite at the base. The middle unit, the Decorah Formation, is thin or locally absent in Southeastern Wisconsin, represented by five or less feet of shaly dolomite in Waukesha County (Choi, 1995). The lower formation of the Sinnipee Group, the Platteville Formation, consists of dolomite and shaly dolomite, and reaches a thickness of 85 feet in Racine County.

Ancell Group

The Ancell Group includes the Glenwood and St. Peter Formations (Table 3.1). The Glenwood Formation consists of 20 feet or less of dolomitic sandstone, blue-green shale, or sandy dolomite. The Glenwood Formation is locally variable in thickness and lithology and is not always present in Southeastern Wisconsin (Mai and Dott, 1985). The St. Peter Formation is present throughout the three counties, and is subdivided into two members. The upper Tonti Member is a pure quartz sandstone, ranging in thickness from less than 50 feet to locally greater than 250 feet. The lower Readstown Member is variable in character, consisting of white to red sandstone, conglomerate (consisting of shale, chert, sandstone, and/or dolomite clasts), red to brown shale, or any combination of these rock types, in a matrix of fine to coarse sand or clay. The Readstown Member is not continuous, and is best developed in areas where maximum erosion of the underlying formations took place prior to Ancell Group deposition.

Prairie du Chien Group

The Prairie du Chien Group is subdivided into two formations (Table 3.1). The upper Shakopee Formation, consists of light gray to tan sandy dolomite (the Willow River Member) and a thin (15 feet or less) discontinuous dolomitic sandstone (the New Richmond Member). The New Richmond Member is not always recognizable in well cuttings, and is not well defined. The lower formation, the Oneota Formation, consists of massive, light gray to tan, commonly cherty dolomite. The base of the Oneota Formation becomes sandy and is gradational with the underlying Coon Valley Member of the Cambrian Jordan Formation. The Prairie du Chien Group is not exposed at the bedrock surface in Southeastern Wisconsin, and is known in the subsurface in parts of Racine County, having been removed by pre- St. Peter erosion to the north. Where present, the Prairie du Chien Group is generally less than 70 feet thick (Mai and Dott, 1985).

The Cambrian rocks of the three county area discussed, are primarily sandstone, with some dolomite and shale. These rocks have not been adequately studied due to the scarcity of good samples. Their stratigraphy is not known in detail. The Cambrian is subdivided into three major divisions, the Trempealeau Group, the Tunnel City Group, and the Elk Mound Group (Table 3.1). The Cambrian section thickens from northwest to southeast, ranging in thickness from around 700 feet in western Waukesha County to around 2,400 feet near Zion, Illinois, south of Kenosha.

Trempealeau Group

The Trempealeau Group consists of the Jordan and St. Lawrence Formations. The Trempealeau Group is eroded by the pre-St. Peter unconformity in much of Southeastern Wisconsin. Where not eroded, the Trempealeau Group varies from 70 to 150 feet in total thickness. In its outcrop area of western Wisconsin, the Jordan Formation can be subdivided into five members on the basis of grain size and composition. These members are not easily recognized in the subsurface. The Jordan Formation is predominantly fine- to medium-grained quartz sandstone, commonly with some dolomitic cement. The Coon Valley Member at the top of the Jordan Formation is a sandy dolomite that grades into the overlying Oneota Formation. The St. Lawrence Formation is tan to pink sandy or silty dolomite, becoming more dolomitic to the south, where it is known as the Potosi Dolomite in Illinois (Buschbach, 1964).

Tunnel City Group

The Tunnel City Group consists of fine- to medium-grained sandstone and dolomitic sandstone, which varies in color from light brown to green, depending on glauconite content. In its outcrop area of western Wisconsin, the Tunnel City group is divided into the Lone Rock and Mazomanie Formations. In Southeastern Wisconsin these formations are not easily recognized in well cuttings, and the Tunnel City Group is treated as a single unit varying from 50 to 80 feet in thickness. It is equivalent to the Franconia Formation of northern Illinois (Buschbach, 1964). The Tunnel City Group is not present in Milwaukee County due to erosion.

Elk Mound Group

The Elk Mound Group is the lowermost division of the Paleozoic sedimentary section. It is divided into the Wonewoc, Eau Claire, and Mount Simon Formations (Table 3.1). The lowest one, the Mount Simon sandstone, directly overlies the Precambrian crystalline rock basement.

Wonewoc Formation

The formation is a medium- to coarse-grained, tan to white quartz sandstone. It is generally poorly cemented, but may be locally cemented by dolomite or silica. Where present, the Wonewoc Formation is easily distinguished from the overlying Tunnel City Group and the underlying Eau Claire Formation by coarser grain size, color, and absence of glauconite. The lower contact of the Wonewoc Formation is an erosional surface that locally cuts into the underlying Eau Claire Formation. Total thickness of the Wonewoc and Eau Claire Formations together varies from 160 to 200 feet from north to south across the Region.

Eau Claire Formation

This formation consists of fine- to medium-grained sandstone with local beds of green to black shale and dolomite. Dolomite cement, pyrite, and fossils are commonly present. The Eau Claire Formation thickens to the south into northern Illinois, and shale and dolomite content increases to the south as well (Buschbach, 1964). It is easily distinguished from the overlying Wonewoc and underlying Mount Simon Formations by finer grain size and glauconite content.

Mount Simon Formation

The Mount Simon Formation consists predominantly of coarse- to medium-grained sandstone, with coarser layers commonly containing pebbles. It is generally poorly cemented, but locally may be cemented by dolomite or silica. In Milwaukee and Racine Counties red, black or green shale beds can be present within the Mount Simon Formation. The lower beds are commonly very coarse and pebbly, locally becoming conglomerate near the Precambrian contact. The Mount Simon Formation thickens to the south and east. The maximum complete section penetrated in Southeastern Wisconsin is 1,306 feet in Waukesha County.

The Precambrian crystalline basement of the three counties discussed is poorly known. Limited wells have reached the Precambrian and recovered identifiable samples. The most common recovered rock types, presumably 1,760 million years old or younger, are granitic and quartzite resembling the Waterloo and Baraboo quartzites exposed to the west (Smith, 1978). The Precambrian is encountered at a depth of 77 feet in western Waukesha County, and dips to the south and east (Figure 3.a), reaching a depth of 3,460 feet in the Zion, Illinois well. The Precambrian basement forms the lower boundary of the lower Paleozoic sandstone aquifer.

STRUCTURAL GEOLOGY

The three county area of Southeastern Wisconsin has largely remained tectonically inactive for approximately one billion years and the structural deformations are minimal there. The cross-section in Figure 3.1 shows diagrammatically the stratigraphic formations and their dip, and the dip of the Precambrian surface across Waukesha County and Milwaukee County. Faults shown on the cross-sections are inferred from the differences in elevation of formation boundaries, both in wells shown on the sections and by comparison with wells located within the several miles of the sections. There are no wells shown on the sections that actually cross a fault trace. Because most large faults in Southeastern Wisconsin are nearly vertical, it is rare that a well will cross a fault trace. There is only one well (in the City of Waukesha) supported by drill cuttings that is known to be drilled through a fault trace.

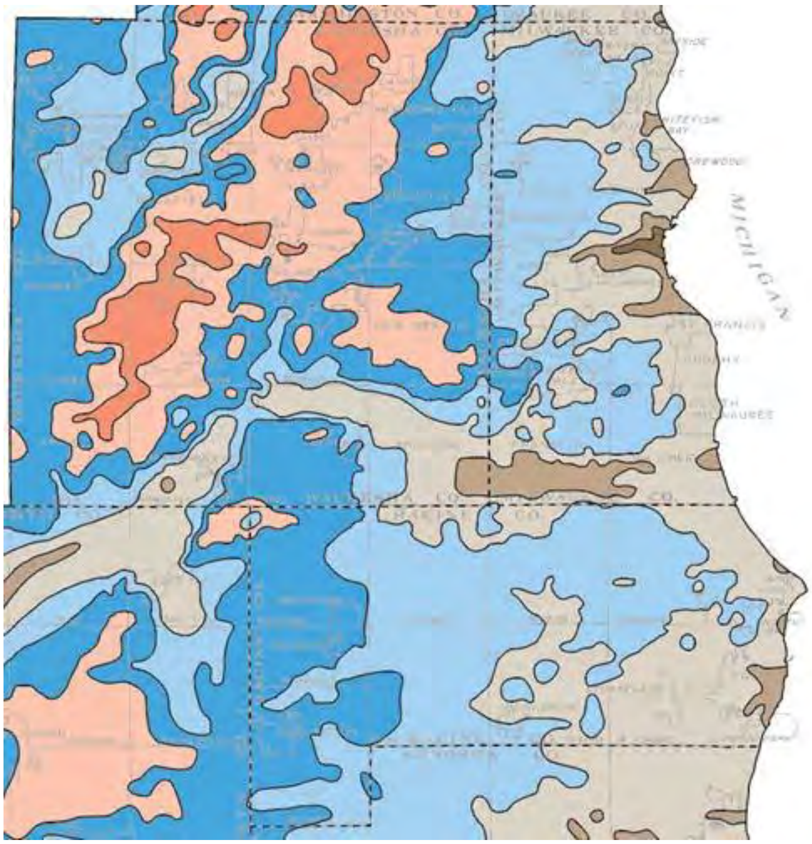
The west-east section (Figure 3.1) crosses a major fault zone, the Waukesha Fault, which passes through Waukesha County and trends northeastward into Lake Michigan. The Waukesha Fault is a potentially important hydrologic feature because it offsets major formation and aquifer boundaries, and may significantly influence deep groundwater flow systems. Although the existence of the Waukesha Fault in Southeastern Wisconsin has been recognized for some time (Foley and others, 1953), its location and linear extent have been, until recently, poorly defined due to limited data from bedrock wells and only one significant exposure. Sverdrup and others (1997) used gravity data from geophysical surveys conducted in the early 1980s to trace the Waukesha Fault from the Waukesha-Walworth county line to Port Washington in Ozaukee County.

BEDROCK ELEVATION AND BEDROCK VALLEYS

Figure 3.2 shows the approximate bedrock elevations in Waukesha, Milwaukee and Racine counties, which broadly resembles depth to bedrock in these counties. Areas located over the deep bedrock valleys are where the bedrock is farthest from the land surface. The northern valley extends from northeastern Washington County southwest through northwestern Waukesha County to southern Jefferson County. In the southern half of the Region, a long valley curves from southern Milwaukee and Waukesha Counties south through Walworth County into Illinois. Thicknesses of glacial materials in these buried valleys range from 250 feet to more than 450 feet.

The areas where bedrock is closest to the land surface trend from northeast to southwest, from southeastern Washington County through northeastern Waukesha, bedrock generally is found there at depths less than 25 feet. Numerous outcrops and large quarries are found in the Silurian dolomite, which is the uppermost bedrock formation. Elsewhere along the same general trend, bedrock lies at depths of less than 50 feet; for example, at the Kettle Moraine in Waukesha County. In most of the rest of Southeastern Wisconsin, depth to bedrock ranges between 50 and 250 feet. This wide range of depth to bedrock is, in large part, caused by end moraines deposited during the last glacial period and the erosion of river valleys since then. For example, there are only a few outcrops or areas where bedrock is less than 50 feet deep in Racine County because of the thickness of glacial deposits. But numerous outcrops are in Milwaukee County, where the Milwaukee, Menomonee, and Root Rivers and their tributaries have formed deep valleys in these same glacial deposits. In some cases, isolated outcrops have been reported in areas where overall bedrock surface is more than 25 feet deep.

Figure 3-2. Bedrock elevation in Milwaukee, Racine and Waukesha Counties (Wisconsin GHNHS)



3.1.2 Soils

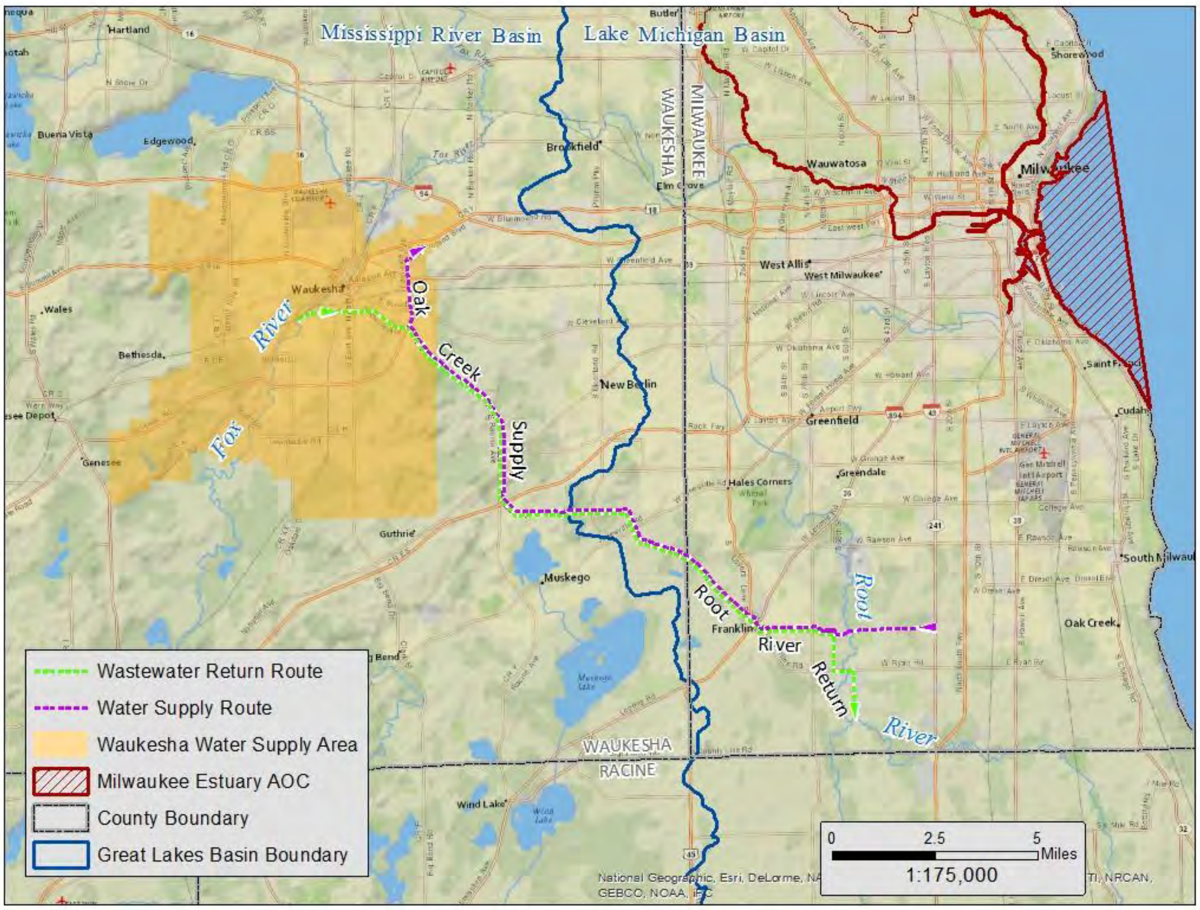
The soils along the near-shore areas of Lake Michigan are within the southern Lake Michigan coastal ecological landscape and are characteristic mainly of glacial lake influence, along with ridge and swale topography, clay bluffs, and lake plains. Ground moraine inland from the lakeshore is the dominant landform, with soils generally consisting of silt-loam surface overlying loamy and clayey tills.

3.2 Lake Michigan

3.2.1 Physical description and floodplain of Lake Michigan

Lake Michigan is bordered by four states and has the second largest volume of any of the Great Lakes. It is the only Great Lake located entirely within the borders of the United States. Lake Michigan is 307 miles long, up to 118 miles wide, and up to 925 feet deep. It has a surface area of 22,300 square miles, an average depth of 279 feet, a volume of 1,180 cubic miles (1,300 trillion gallons) and a retention time of 99 years (USEPA and Environment Canada, 2012).

Figure 3-3. Lake Michigan Shoreline and Area of Concern and Project Area Overview



3.2.2 Water quality of Lake Michigan

Southeastern Wisconsin's Lake Michigan shoreline water quality has been influenced by nonpoint and point source pollution, as well as changes caused by invasive species, most notably zebra mussels (*Dreissena polymorpha)* and quagga mussels (*Dreissena rostriformis bugensis)*. Nonpoint source pollution to the shoreline includes impervious and pervious surface runoff, boating wastes, bacterial transport in shoreline algae accumulation, and direct input from animals, such as seagulls. Point source pollution generally results from combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), or from stormwater outfalls (Kinzelman, 2007).

In recent decades invasive dreissenid mussels which have covered the lake bottom have resulted in clearer water which in turn has led to algae growth, including the spread of *Cladophora* at deeper water levels than prior to mussel colonization. Research at the Great Lakes Water Institute and elsewhere continues on the interaction between invasive mussels, nutrient cycling in Lake Michigan, and the growth of *Cladophora* (Bootsma, 2009).

Milwaukee Harbor Area of Concern

The Milwaukee Harbor estuary is designated a Great Lakes Area of Concern (AOC) because of the presence of legacy contaminants (PCBs, PAHs, heavy metals, etc.) and other impairments. The harbor suffers from urban stresses similar to those experienced in other highly urban areas at the other 42 AOCs throughout the Great Lakes. Priorities for the Milwaukee AOC include remediation of contaminated sediments in tributaries and nearshore waters of Lake Michigan, prevention of eutrophication, nonpoint source pollution control, improvement of beach water quality, enhancement of fish and wildlife populations, and habitat restoration (EPA, 03/2010).

Lake Michigan water quality data – MMSD, UW-Milwaukee, and SEWRPC

SEWRPC and the Milwaukee Metropolitan Sewerage District (MMSD) have been measuring water quality in the Greater Milwaukee area since the 1960s (SEWRPC, 2007, p. 149). Notable water quality improvements have been documented since the MMSD's deep tunnel system came online in 1994 to reduce the number of combined sewer overflows (CSOs). Water quality trends at sampling stations in the Milwaukee outer harbor and nearshore Lake Michigan areas over this historical monitoring period have indicated (SEWRPC, 2007, p. 155):

- Fecal coliform concentration has trended down.
- Biological oxygen demand has trended down.
- Dissolved oxygen concentration has stayed the same or trended down and generally meets standards.
- Total suspended solids concentration trends varied with some stations increasing and others staying the same.

Potential discharge locations for the Applicant's return flow have been identified near the lakeshore cities of Oak Creek (directly to Lake Michigan) and Racine (Root River). A summary of nearshore average water quality data for nearshore samples collected from Lake Michigan near these cities is provided in Vol. 5 (CH2MHill, 2013, see Table 3-1).

Total phosphorus concentration has trended down in the outer harbor and up in the nearshore area. Since 1986, average annual concentrations have been less than 0.1 mg/L, except for 1 year. The phosphorous standard for the near shore and open waters of Lake Michigan is 0.007 mg/L (NR 102.06(5) (b), Wis. Admin. Code), however, an interim effluent limit for discharge to Lake Michigan has been set at 0.6 mg/L (NR 217.13(4), Wis. Admin. Code), for all dischargers until a nearshore model can be developed to determine site specific standards. Nearshore phosphorus water quality data ranged from 0.011to 0.014 mg/L TP (Figure 3.4 below: 1979-2010 data, stations NS-01, NS-02, NS-03 and NS-10).

Data collected closest to the Milwaukee Metropolitan Sewerage District (MMSD) South Shore water reclamation facility measurements are closer to the submerged treatment plant outfall. Nearshore data is expected to be more characteristic of overall Lake Michigan water quality than

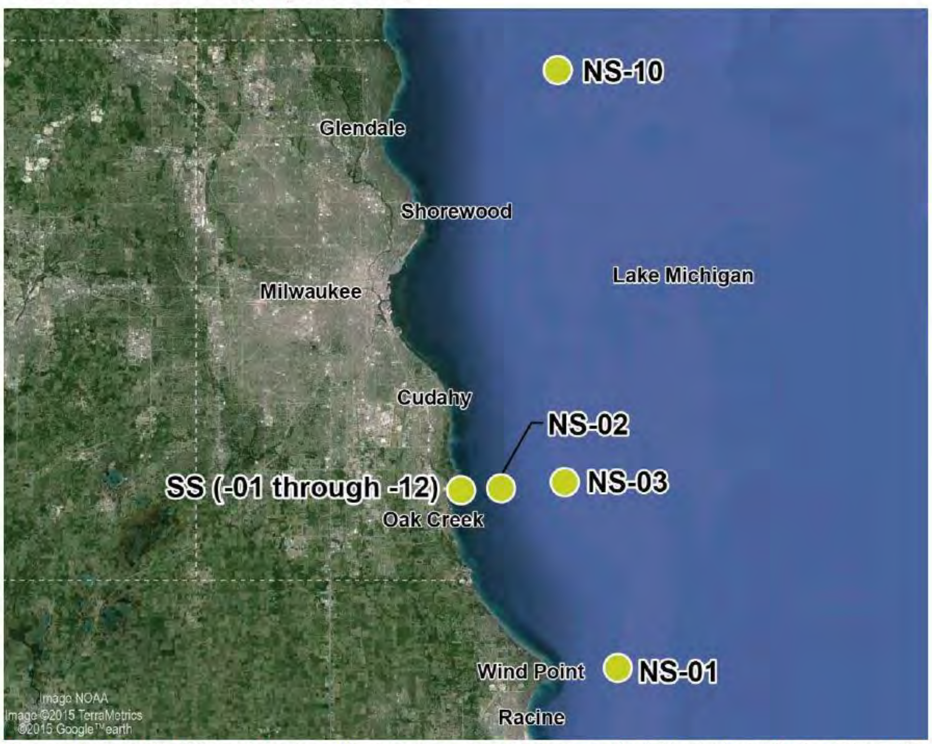
South Shore data because it is further away from a discharge location. South Shore concentrations for TP ranged from 0.015 to 0.111 mg/L (1979-2010 data, stations SS-01 through SS-12).

Figure 3.4 shows the locations of nearshore and South Shore area sampling sites near the cities of Oak Creek and Racine. Nearshore sampling point NS-10 is located north of the Menomonee River. Along the western shoreline of Lake Michigan currents predominantly follow a north-to-south direction (or lake-wide, a counterclockwise rotation). NS-10 is therefore expected to represent water quality without the immediate effects of various discharges to the lake south of the City of Milwaukee. These discharges may include the Kinickinick, Menomonee, Milwaukee, and Root Rivers, the MMSD Jones Island and South Shore water reclamation facilities, the Oak Creek power plant, and various stormwater outfalls and direct runoff.

Figure 3-4. WATERBase Water Quality Data Sampling Locations

Water Quality Data Collection Locations [a]

Locations near Oak Creek, WI, and Racine, WI



[a] Screenshot of WATERBase interface. Nearshore sample locations are individually identified as NS-01, NS-02, NS-03 and NS-10. Clustered samples taken close to the South Shore (SS) Water Reclamation Facility are also indicated.

Lake Michigan water quality data near City of Racine

Racine is a coastal community located on the southwestern shore of Lake Michigan. Over the past decade and a half, research has been conducted at the two primary public beaches, Zoo Beach and North Beach (just north of the mouth of the Root River). Between the years 2000-2004, elevated levels of *Escherichia. coli (E. coli)* caused poor recreational water quality an average of 25 days for North Beach and an average 32 days for Zoo Beach (Kinzelman and McLellan, 2009). The City initiated strategies to determine the sources of pollution, and in turn, mitigation and remediation techniques. Several mitigation measures have been implemented at the two beaches in the past decade such as: beach grooming, slope improvements, specialized infiltration basins and constructed dune systems to reduce stormwater runoff, and planting beach grasses to reduce overland sheet flow. From 2005-2014, the average advisory or closure (per Wisconsin's implementation of the federal BEACH Act) was only 4 days per season, with a range of 1-8 days.

Although beach conditions have improved, algae along the Lake Michigan shoreline can harbor elevated concentration of bacterial indicators. Stranded algal mats are typically found along the water's edge at Lake Michigan beaches, where nearshore recreational activities occur. Stranded mats have higher concentrations of bacterial indicators than submerged mats. Average concentrations of *E. coli* measured in June 2004 ranged from 333 to 25,000 CFU/gram for stranded mats versus 400 to 1,700 CFU/gram for submerged mats (Kinzelman, 2005). The presence of *Cladophora* along the shoreline has been augmented from a variety of environmental factors, including nutrient loading and greater sunlight penetration due to the improved water clarity from the filter feeding by invasive zebra and quagga mussels (Bootsma, 2009)

The Root River itself can be a source of bacteria to the City of Racine beaches and Lake Michigan. Microbiological quality has been studied along the Root River. Between 1975-2004 fecal coliform concentrations commonly exceeded state water quality standards (SEWRPC,2007). Historical fecal coliform data have decreased along the mainstem from upstream to downstream (SEWRPC, 2007). More recently, levels of *E. coli* have been monitored along the Root River in order to compare Root River watershed concentrations to the coastal recreational waters of Lake Michigan (Koski et. al, 2014).

3.2.3 Geomorphology and sediment of Lake Michigan

The geology of Lake Michigan developed during the Pleistocene Epoch as continental glaciers repeatedly advanced across the Great Lakes region and Lake Michigan. Glacial movements deepened and enlarged the basins of the Great Lakes (USEPA and Environment Canada, 2012). Near Milwaukee, the near-shore geomorphology is varied. Example lakebed substrates include: rock, cobble and sand, sand, and clay outcrops (WPSC, 2003).

Groundwater flow into Lake Michigan is a significant component of overall flow. Direct and indirect groundwater inflow contributes 33.8 percent of Lake Michigan water (USGS, 2000).

Sediment quality was reviewed in the vicinity of the Wisconsin Electric Power Company (WEPCO, or We Energies) Oak Creek, Wisconsin power plant. Two sediment quality studies were undertaken to investigate lakebed sediment on behalf of We Energies as a requirement for dredging operations. The first study, conducted in 1998, reported low to undetectable amounts of chlorinated organic compounds, such as polychlorinated biphenyls (PCBs) and pesticides. Metals, which are naturally present at trace levels in Lake Michigan sediment, were also present at or below mean concentrations at other locations on Lake Michigan (WDNR, 2003). The second study, conducted in 2002, detected no PCBs at the selected sample sites, and metals were again detected at or below mean background concentrations. Polycyclic aromatic hydrocarbons (PAHs), which are compounds resulting primarily from industrial oil and coal activities, were detected at three of eleven sample locations at concentrations high enough to negatively affect benthic macroinvertebrates. However, elevated levels were expected based on close proximity to the power plant's coal dock. Locations elsewhere in the lake would be expected to vary in sediment quality.

3.2.4 Flora and fauna (including T/E/SC) of Lake Michigan

Most of the near-shore areas along Lake Michigan are dominated by agriculture and urban development although considerable acreage along Lake Michigan in Milwaukee County is in parkland as well as the Schlitz Audubon Nature Center. Very few forested areas exist, but the remaining stands are dominated by maple and beech trees and also contain oak, hickory, and lowland hardwood species. There are also areas of wet-mesic and wet prairie, but they are limited and occur only in small preserves because of the landscape being heavily disturbed and fragmented. Because of fragmentation and significant disturbance, non-native plants are abundant in those areas. There are no aquatic plant threatened species, endangered species or species of concern within Lake Michigan.

3.2.4.1 Macrophytes of Lake Michigan

The primary aquatic macrophytes found in Lake Michigan include Sago Pondweed (*Stuckenia pectinata*), Coontail (*Ceratophyllum demersum*), Eurasian Watermilfoil (*Myriophyllum spicatum*), Elodea (*Elodea canadensis*), and Curly-leaf Pondweed (*Potamogeton crispus*). These plants are found in harbors and protected areas along the coast.

3.2.4.2 Benthic invertebrates of Lake Michigan

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.*

In recent years, nuisance algae (genus *Cladophora*) growth has been observed along the Lake Michigan shoreline. The algae grow underwater attached to rocks, are dislodged by waves, and then washed up on shore. The decaying algae create nuisance odors. Similar algae growths were observed in the mid-1950s and again during the 1960s and 1970s, before this most recent occurrence. The cause of this latest resurgence in algae growth is uncertain, but it may be due in part to changes in water clarity and phosphorous availability brought on by the prevalence of invasive zebra and quagga mussels.

3.2.4.3 Benthic invertabrates of Lake Michigan

A survey of the Great Lakes in 1998 identified 20 taxa of benthic macroinvertebrates in Lake Michigan with an average of about seven taxa per sampling site (Barbiero et al., 2000). The amphipod *Diporeia* (formerly *Pontoporeia)*, tubificid oligochaetes, and sphaeriid snails dominated the Lake Michigan benthic macroinvertebrate community. However, in near-shore areas, oligochaetes were the dominant taxonomic group. The density of benthic

macroinvertebrates typically ranged from 1,500 to 6,500 organisms per square meter. Surveys performed in 2002 near the Great Lakes Water Institute in Milwaukee revealed that oligochaetes and chironomidae are present, as are freshwater sponges, *Ectoprocta,* mayflies, leeches, isopods, and amphipods.
Since 1988, the southern basin of Lake Michigan has had zebra and quagga mussels and undergone major changes in nutrient cycling. Dreissenid mussel infestations have been confirmed on most suitable habitat (USGS, 2011).

Changes in nutrient cycling due to dreissenid mussels have repartitioned the productivity of the lake and reduced the density of benthic macroinvertebrate fauna, particularly oligochaetes and snails, observed between 1980 and 1987 (Nalepa et al., 1998). A decline in the abundance of an important amphipod (*Diporeia)* also began in 1988. 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). The declining abundance of *Diporeia*, which have been nearly extirpated from Lake Michigan, coincides with the expansion of the dreissenid mussels (Nalepa et al. 2009).

3.2.4.4 Fish of Lake Michigan

Lake Michigan is primarily cold water and relatively infertile. Historically, the fishery consisted mostly of lake trout, burbot, Coregonid fishes, whitefish and sculpins. An introduction of sea lamprey and over-fishing led to declines in the numbers of native piscivorous fish. Alewife populations grew and lake trout, lake herring, lake whitefish, bloater chubs and yellow perch populations declined. Control of invasives, along with a fish stocking program have increased predation and native fish numbers and have assisted in stabilizing alewife numbers. Today, the Lake Michigan fishery consists of nearly 100 species. Table 3.2 below summarizes some of the predominant fish species of the near-shore waters of Lake Michigan (WPSC, 2003). Annual stocking of native lake trout, along with the introduction of Chinook and Coho Salmon, Brown trout and Steelhead has helped develop Lake Michigan into a popular sport fishery.

Both Lake sturgeon and American eel, also nearshore species, are listed as special concern species and skipjack herring is endangered in Wisconsin. The non-native listed in Table 3.2 include: alewife, Chinook salmon, coho salmon, rainbow trout, brown trout, rainbow smelt, gizzard shad, common carp, round goby, three spine stickleback and sea lamprey.

Even though the Milwaukee Harbor estuary has these stresses, the fishery is reported to contain a high abundance and diversity of species, because the fishery is connected to the rest of Lake Michigan and to parts of the Milwaukee, Menomonee, and Kinnickinnic Rivers that achieve full fish and aquatic life standards (SEWRPC, 2007, p. 205).

Table 3-2. Predominant fish species found nearshore in Lake Michigan (WDNR data)

Lake Michigan (nearshore) Fish Species			
Alewife	Emerald shiner	Longnose sucker	Sea Lamprey
Bloater	Fathead minnow	Muskellunge	Slimy sculpin
Bluntnose minnow	Freshwater drum	Nine spine stickleback	Smallmouth bass
Bowfin	Gizzard shad	Northern pike	Spottail shiner
Brook stickleback	Johnny darter	Pumpkinseed	Three spine stickleback
Brook trout	Lake chub	Rainbow smelt	Trout perch
Brown trout	Lake sturgeon	Rainbow trout	Walleye
Burbot	Lake trout	Rock bass	White bass
Chinook salmon	Lake whitefish	Round goby	White sucker
Cisco	Largemouth bass	Round whitefish	Yellow perch
Common carp	Longnose dace	Sand shiner	

3.2.4.5 Herptiles, Birds and Mammals of Lake Michigan

Herptiles of Lake Michigan

The common mudpuppy (*Necturus maculosus*) is a Wisconsin special concern species found near shoals and is a Species of Greatest Conservation Need that is significantly associated with the Lake Michigan natural community per the Wildlife Action Plan (search 'Wildlife Action Plan at dnr.wi.gov).

Birds of Lake Michigan

The Caspian tern (Endangered), common tern (Endangered), Forster's Tern (Endangered), black tern (Endangered) and horned grebe (Special Concern) are all Species of Greatest Conservation Need that are significantly associated with the Lake Michigan natural community per the Wildlife Action Plan.

3.3 Fox River

3.3.1 Physical description of floodplain of the Fox River

The Fox River's headwaters originate near Colgate, Wisconsin and the river flows 202 miles to Ottawa, Illinois, where it empties into the Illinois River. The total watershed area is nearly 2,700 square miles. Eighty four miles of the River are within Wisconsin. The upper part of the Fox River, 35% of the basin, flows through the City of Waukesha and is the current discharge location for treated effluent from the City's wastewater treatment plant (WWTP).

3.3.2 Flow and flooding in the Fox River

The Fox River flow gage (USGS stream gage 05543830) is located in the City of Waukesha and has a contributing drainage area of 124 square miles. The average annual stream flow (flow period 1963 to 2013) is 113 cfs at the Fox River in the City of Waukesha. The gage has been in operation since 1963 and has recorded major flood events in 1965, 1973, 1974 and 1979. Frequencies for these floods were set at once every 5, 20, 6 and 5 years respectively (Waukesha County Flood Insurance Study (FEMA), 2014)

The history of flooding on the streams within the City of Waukesha indicates that flooding may occur during any season of the year. The majority of major floods on the Fox River have occurred in the early spring and are usually the result of spring rains and/or snowmelt. The most recent flooding within the City of Waukesha occurred in March, 1960 and April, 1973. A peak discharge of 2160 CFS was recorded at the USGS gage for the 1973 flood, which would have an expected frequency of once every 25 years. Highwater marks from this flood were used to verify the hydraulic model used in this study (FEMA, 2014).

The Fox River floodplain model was not updated as part of the updated Flood Insurance Study. The current effective profiles and flows for the Fox River are listed in the Waukesha County Flood Insurance Study. Note: A new floodplain study, to be funded by the Federal Emergency Management Agency (FEMA), is in the process of being developed for the Fox River Watershed, which includes new hydrology and hydraulics for the Fox River. The effective date of this study is dependent on the availability of funding.

3.3.3 Water quality of the Fox River

In Wisconsin, the Fox River is designated a Warm Water Sport Fishery with the following uses: fish and aquatic life, recreation, public health and welfare, and fish consumption. Downstream in Illinois, the Fox River is designated as 'general use water,' which includes primary contact uses, and 'public and food water supply standards. The entire Fox River (miles 113.24 – 196.64) is on Wisconsin's §303(d) impaired waters list for PCBs, sediment/TSS and total phosphorus exceedances. Downstream impairments include aquatic toxicity due to PCBs and degraded biological communities due to phosphorus and sediment (Table 3.3).

Table 3-3. Wisconsin's §303 (d) pollutants and impairments for the Fox River - Illinois

Fox River (river miles)	Pollutant	Impairment
113.24 to 196.64	PCBs	Contaminated Fish Tissue
113.24 to 187.16	Total Phosphorus	Degraded Biological Community, Low Dissolved Oxygen, Unknown
171.45 to 187.16	Sediment/Total Suspended Solids	Degraded Habitat, Low Dissolved Oxygen

Water quality information has been gathered by a number of organizations in the Fox River watershed including the WDNR, USGS and SEWRPC. Long-term water quality trend data are gathered by the WDNR about 7 miles downstream of the Waukesha WWTP at County Highway I. Parameters collected include: total suspended solids, alkalinity, dissolved oxygen, pH, total phosphorus, dissolved orthophosphorus, chlorophyll a, nitrogen series and *E. coli*. Several biological indices have been developed for three stream reaches along the Fox River. These indices use benthic macroinvertebrate and fish as indicators of water quality and physical conditions present within the stream (see section on macroinvertebrates below).

The Applicant's WWTP currently discharges to the Fox River (CH2MHill, 2013, Vol. 4, Appendix H for more WWTP information and historical effluent data).

3.3.4 Geomorphology and sediments of the Fox River

Near the City of Waukesha, the Fox River has natural channel reaches with minimal modifications, while other reaches have been significantly altered by development. Within the City center, upstream of the City's WWTP, the Fox River is dammed to create the Barstow Impoundment. River banks in the impoundment consist of sheetpile, concrete, rock reinforcements, and vegetation. Upstream of the dam, large sediment depositions are reported to include pollutants that may cause human and aquatic health concerns.

Further upstream, the Fox River meanders through developed landscapes including residential, golf course, commercial and transportation development. In this segment the river has primarily vegetated banks, with erosion and bank failures common to urban areas. The river generally has a wide floodplain with connected wetlands and some encroachments from development. The river is generally low gradient and primarily consists of pools and glides. The sediments are primarily silts and sands in the pools and sand and gravel in glides.

Downstream of the Barstow Impoundment, the river is confined by development. The river banks are primarily rock riprap and concrete retaining walls. The river is typically narrow and has a higher gradient than upstream reaches. Nearing the WWTP, the river returns to a low gradient meandering stream. Similar to the upstream reaches, the banks are mostly vegetated with some erosion and bank failures (typical in developing watersheds). Continuing downstream, the river has a fairly low gradient, with sediments consisting primarily of silt and sand in pools, and sand in the glides. Occasional areas of gravel are also present. In the downstream reaches, sand point bars have formed due to an increased bedload from agricultural runoff.

3.3.5 Flora and Fauna of the Fox River

The riparian vegetation communities of the Fox River at proposed pipeline intersections are typical of higher-order waterways in the Midwest. The floodplains at County Highway H and State Highway 59 are dominated by reed-canary grass and stinging nettle adjacent to the river; and mature woody trees such as box elder, silver maple, willows, and eastern cottonwood farther from the river. Few other herbaceous or shrub species are present. Four natural communities have been documented adjacent to the river. In addition, six rare plants, including two that are state-listed, are known to occur within the near vicinity of the Fox River.

3.3.5.1 *Macrophytes* of the Fox River

The Fox River does not have complete documentation of aquatic macrophytes. Observations of aquatic invasive species such as Eurasian water milfoil, curly leaf pondweed, reed canary grass and purple loosestrife have been identified in and adjacent to the Fox River.

3.3.5.2 Algae of the Fox River

The Fox River does not have recorded documentation of aquatic periphyton and algal species, however, populations of both have been observed in the Fox River.

3.3.5.3 Benthic invertebrates of the Fox River

Aquatic macroinvertebrates have been collected at multiple locations on the Fox River in 1999, 2000, 2002 and 2007. The MIBI (benthic macroinvertebrate index) was developed for this stream reach of the Fox River and samples ranged from 4.62 to 6.58, generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a good to fair water quality. Sampling in the Fox River resulted in the identification of over 90 macroinvertebrate taxa being identified in these samples. Some taxa were identified at a species level, while others were identified to genus, subfamily, or family levels. Insects were the most identified taxa, including: true flies, beetles, caddisflies, mayflies, true bugs, dragonflies, damselflies, dobsenflies. Other groups found included amphipods, crayfish, isopods, annelid worms, nematode worms and turbellarian worms. The most commonly identified organisms were caddisflies, midges, worms of the family Tricladida.

Surveys for mussels were conducted in the Illinois Fox River watershed and its tributaries from 1997-2001 in Wisconsin and Illinois. 96 main stem and tributary stations were sampled. A total of 27 species were identified of which 23 were live specimens. Three rare mussel species and one caddisfly species are known or have been known to occur within this stretch of the Fox River. An additional 2 introduced bivalve species (zebra mussels and Asian clam) were also found in the Fox River watershed (Schanzle, 2004).

Aquatic invasive species such as zebra mussels, rusty crayfish, banded mystery snails and asian clam have also been identified in segments of the Fox River and its tributaries.

3.3.5.4 Fish of the Fox River

Fox River fisheries data have been collected six miles downstream of the WWTP, between County Highway I and the confluence of Genesee Creek in 1999, 2000, 2003, 2004, and 2006 (Table 3.4). The surveys identified 38 species of fish (Table 3.4). The most abundant species collected were golden redhorse, common carp, bluegill, channel catfish, largemouth bass, white bass, northern pike, rock bass, common shiner, sand shiner, bluntnose minnow, emerald shiner, longnose garb white sucker, and creek chub. Most are considered warm water species, although they may also be found in cool water habitats. Several coldwater species (brook and brown trout) were noted at the confluence of Genesee Creek (a cold water fishery) and the Fox River but were only present in small numbers. The common carp is an invasive species that has also been identified in the Fox River and its tributaries.

A separate fish survey was conducted at the confluence of the Fox River and Pebble Creek, 1.65 miles downstream of the Waukesha WWTP (Waukesha County and SEWRPC, 2008). Many species were the same as those collected in the WDNR surveys, but species not found farther downstream in the Fox River were collected. These were brook stickleback (a cool water species), and the spottail shiner, golden shiner, orange-spotted sunfish, and tadpole madtom, all warm water species. In addition, one endangered, one threatened, and one special concern species were collected. Outside of these surveys, there are two additional rare fish species that may be present in this stretch of the Fox River.

Table 3-4. Fish Species in Fox River found donwstream of Waukesha's Wastewater Treatment Plant

Fox River Species	
Bigmouth shiner	Green Sunfish
Black bullhead	Honeyhead chub
Black crappie	Johnny darter
Blackstripe topminnow	Largemouth bass
Bluegill	Longnose gar
Bluntnose minnow	Mottled sculpin
Bowfin	Northern pike
Brook silverside	Pumpkinseed
Brook trout	Quilback
Brown trout	Rock bass
Central mudminnow	Sand shiner
Central stoneroller	Spotfin shiner
Channel catfish	Stonecat
Common carp	Walleye
Creek chub	White bass
Emerald shiner	White sucker
Golden redhorse	Yellow bass
Grass pickerel	Yellow bullhead
Greater redhorse	Yellow perch

3.3.5.5 Herptiles, Birds and Mammals of the Fox River

Herptiles of the Fox River

One state endangered and two special concern herptile species have been known to use the Fox River and its adjacent wetlands as habitat. However, the endangered herptile is thought to be extirpated from this area.

Birds of the Fox River

One state endangered and three special concern bird species are known to use the Fox River and its adjacent habitat for nesting.

Mammals of the Fox River

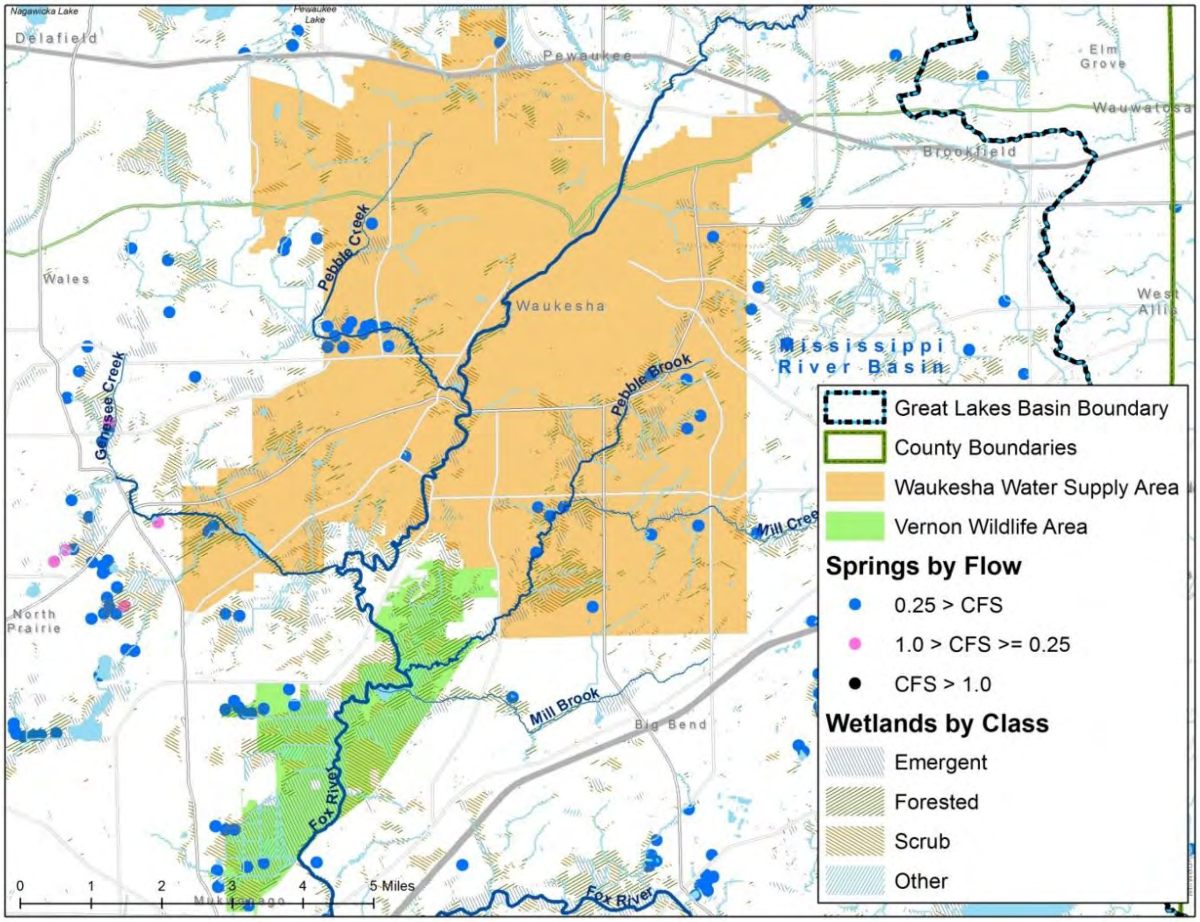
The Fox River also provides habitat for a variety of mammals, mostly furbearers. Muskrats, mink, otter, and beaver thrive in the marsh habitat. Other mammals including opossum, shrews, moles, bats, chipmunk, voles, mice, fox, raccoon, weasels, and skunk are numerous as well. White-tailed deer, eastern gray and fox squirrels, eastern cottontails, and coyotes are popular game species and receive moderate to heavy hunting pressure.

There are two rare mammals, including one that is state threatened, that are known to use the Fox River and/or its adjacent habitats. Fox River Tributaries

3.3.6 Physical description and floodplains of Fox River Tributaries

Pebble Brook, Pebble Creek, Mill Brook, Genesee Creek and Mill Creek all are smaller-order streams that empty into the Fox River in the vicinity of the City of Waukesha (Figure 3.5). All of these waterways are listed as Areas of Special Natural Resource Interest (ASNRI) because they have been designated as trout streams or contain state-listed endangered or threatened species. The riparian vegetation located adjacent to these waterways is often dominated by invasive species due to watershed disturbances (development). Even though the watershed is primarily urban, public parkways often buffer these waterways.

Figure 3-5. Map of Fox-Illinois River and tributary streams and local springs



Pebble Brook description

Pebble Brook is a narrow nine-mile long tributary to the Fox River south of the City of Waukesha. Pebble Brook is classified as a Cool-Warm Mainstem near the convergence with the Fox River and a Cool-Warm Headwater in the upper portions of the watershed.

Pebble Creek description

Pebble Creek is a narrow, six-mile long perennial trout stream in southeastern Waukesha County. It is a tributary to the Fox River south of the City of Waukesha, with a watershed size of 18 square miles. Pebble Creek is classified as a Cool-Cold Headwater stream. Cold water fisheries are surface waters capable of supporting a community of cold water fish and other aquatic life or serving as a spawning area for cold water fish species. Cold water streams often receive much of their flow from groundwater entering the stream which enables their temperature to remain cold. Pebble Creek is listed as a Class II Wisconsin trout stream (Class II is described as having some natural reproduction but not enough to fully utilize available food and space). The main tributary to Pebble Creek is Brandy Brook, a Class I Trout Stream. SEWRPC has created Watershed Protection Plans for Pebble Creek (SEWRPC, 2008).

Mill Creek description

Mill Creek is a four-mile tributary stream that flows west from the City of New Berlin for four miles past two private dams before entering Pebble Brook. The watershed is approximately seven square miles. Mill Creek is classified as a Cool (Warm Transition) Headwater.

Genesee Creek description

Genesee Creek is a five mile long tributary that reaches its mouth at the Fox River about a mile west of Waukesha. From its mouth to three and a half miles upstream Genesee Creek is classified as a Class II Trout water, and the remainder of the creek is a Class I Trout stream and an Exceptional Resource Water. Class I trout streams are high quality trout waters that have sufficient natural reproduction to sustain populations of wild trout, at or near carry capacity

Mill Brook description

Mill Brook is a narrow, five mile long perennial trout stream within an eight square mile watershed in southeastern Waukesha County. It is a tributary to the Fox River south of the City of Waukesha. Mill Brook is classified as a Cool-Warm to Cool–Cold Headwater stream. The headwaters of Mill Brook is listed as a Class I Trout Stream then further downstream as it flows into Vernon Marsh is listed as a Class II Trout Stream.

3.3.7 Flow and flooding in Fox River tributaries

There are no USGS flow gages located on the Fox River tributaries of Pebble Brook, Pebble Creek, Mill Creek, Genesee Creek and Mill Brook. The current effective Flood Insurance Study for these streams is dated November 5, 2014. The floodplain studies for these streams were not updated during this process. The profiles and flows can be found in the Waukesha County Flood Insurance Study. The modeled median low flows for August are: Pebble Brook (5.95 cfs), Pebble Creek (5.56 cfs), Mill Brook (2.34 cfs), Genesee Creek (9.62 cfs) and Mill Creek (2.25 cfs.).

3.3.8 Water quality of Fox River tributaries

Pebble Brook water quality

Water quality data was collected on Pebble Brook in August 2013 for a natural community assessment at WDNR station number 683232. Instantaneous measurements of dissolved oxygen (8.84mg/L, 89.5%), water temperature (15.95^{o}C), specific conductivity (1040 umhos/cm) and pH (7.94) were taken at Pebble Creek for that assessment. A grab sample for total phosphorous was also collected. The result of that grab sample was 0.0604 mg/L which is lower than the phosphorus water quality standard. Pebble Brook is not listed impaired water on Wisconsin's Impaired Waters §303(d) list.

Aquatic macroinvertebrates have been collected at multiple locations on Pebble Brook in 1997, 2000, 2002 and 2013.The MIBI for stream segments of the Pebble Brook samples sites ranged from 4.21-5.57, generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality for samples taken in the Pebble Brook Watershed.

Pebble Creek water quality

Pebble Creek is not listed as impaired on Wisconsin's §303(d) List; however two unnamed tributaries to Pebble Creek are listed. Unnamed - Perennial Stream D (Pb016) and Unnamed - Perennial Stream C (Pb108) are both listed as having impairments of degraded habitat and elevated water temperature due to total suspended solids. Nonpoint source runoff, sedimentation, and beaver dams often result in a loss of habitat, water temperature fluctuations, and water quality impacts in Pebble Creek.

Water quality data was gathered at WDNR station number 683458 on Pebble Creek at Hwy D in August 2011 and at WDNR station number 10037393 downstream of Kame Terrace in August 2012. Instantaneous measurements of dissolved oxygen (9.03 and 6.39 mg/L), water temperature (16.25 and 20.96^{o}C), specific conductivity (893.1 and 1632 umhos/cm) and pH (7.77 and 7.51), respectively, were taken with an MS5 Hydrolab on Pebble Creek. A grab sample for total phosphorous was also collected at each site. The result of that grab sample at Kame Terrace was 0.107 mg/L which exceeds the new phosphorus water quality standard. The sample at Hwy D was 0.034mg/L which is lower than the water quality standard.

Aquatic macroinvertebrate have been collected at multiple locations on Pebble Creek in 1990, 1999, 2004, 2009, 2010, 2011, 2012 and 2013. The MIBI for stream segments of the Pebble Creek and Brandy Brook watershed samples ranged from 2.7-6.1506 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality for samples taken on Pebble Creek and Brandy Brook.

Mill Creek water quality

No water chemistry data is available for Mill Creek. Aquatic macroinvertebrates have been collected at a few locations on Mill Creek in spring and fall of 1980, 1997, 2000, and 2002. The MIBI for stream segments of the Mill Creek samples sites ranged from 3.28-5.89 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality for samples taken on Mill Creek. Mill Creek is not listed as impaired water on Wisconsin's Impaired Waters §303(d) list.

Genesee Creek water quality

Genesee Creek is not listed as impaired on Wisconsin's §303(d) list. Aquatic macroinvertebrates have been collected at multiple locations on Genesee Creek in 1990, 1999, 2004, 2009, 2010, 2011, 2012 and 2013. The MIBI for stream segments of Genesee Creek samples ranged from 4.24-7.36 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a good water quality for samples taken on Genesee Creek. Genesee Creek is also listed as an Exceptional Water Resource with excellent biodiversity and water quality. In 2005 the Genesee Roller Mill Dam was removed, however two dams lower in the watershed remain in place and are having thermal impacts on the lower portions of the watershed.

Mill Brook water quality

No water chemistry data is available for Mill Brook. Aquatic macroinvertebrates have been collected at a few locations on Mill Brook in spring and fall of 1980 and 2004. The MIBI for a stream segment of the Mill Brook ranged from 3.58-4.73 generally indicating that the diversity and abundance of macroinvertebrate species are indicative of fair water quality for samples taken on Mill Brook. Construction erosion, nonpoint source contamination, sedimentation, stream realignment, manmade dams and ponds and beaver dams are all minor stressors in the watershed, that result in the loss of habitat and cause water temperature fluctuations and impacts on water quality in Mill Brook. Mill Brook is not listed as impaired water on Wisconsin's Impaired Waters §303(d) list.

3.3.9 Geomorphology and sediments of Fox River tributaries

Pebble Creek geomorphology

The 18 square mile Pebble Creek watershed contains three main reaches, Brandy Brook and Upper and Lower Pebble Creek. The Brandy Brook and Upper Pebble Creek subwatersheds lie west of the City of Waukesha. The confluence of Upper Pebble Creek and Brandy Brook form Lower Pebble Creek, which then flows into the Fox River within the Fox River Parkway in the southwestern part of the City of Waukesha. Flow data in the watershed is unavailable because it does not have a flow measurement gage. Over half of the reaches within the watershed show evidence of channelization, some of which were widened. Most channelization occurred between the 1940s and 1970s as part of the accepted agricultural practices of the time. Within the Pebble Creek watershed, bank erosion is more common in channelized reaches than in natural reaches. Upper Pebble Creek is the most urbanized and channelized subwatershed and has the most eroding banks (Waukesha County and SEWRPC, 2008, p. 82).

Lower Pebble Creek is a non-channelized stream. Its meandering, highly sinuous pattern is indicative of low gradient (less than one percent) natural streams in the area. Most of the Pebble Creek watershed streams are low gradient sand and gravel systems. High quality riffles occur frequently in Lower Pebble Creek. Brandy Brook's headwaters, which is a moderately sloped (1.4 percent) system, and Upper Pebble Creek's 2.2 percent sloped headwater stream, are exceptions to the low gradient prevalent within the watershed (Waukesha County and SEWRPC, 2008, p. 78). These higher gradient reaches have predominantly gravel, cobble, and boulder substrates.

All streams within the watershed are dominated by pool and riffle habitat. Most of the streams within Pebble Creek watershed have riparian buffers that exceed 75 feet (Waukesha County and SEWRPC, 2008, p. 130). Many reaches are within forested riparian corridors, with a good amount of in-stream cover including large woody debris and undercut banks. Occasionally, the abundant woody debris jams (sometimes with the help from beavers), forming obstructions to flow. Within channelized and incised reaches, these jams exacerbate bank erosion and cause blowouts during storm events.

Pebble Brook and Mill Creek geomorphology

The Pebble Brook and Mill Creek watersheds include residential, some agricultural, commercial, and industrial land uses. They are mostly undeveloped where Pebble and Mill Brook have wide floodplains with large wetland areas bordering the channels. The channels have been straightened in some areas to accommodate road crossings, a railroad, and agricultural developments, but the vast majority of the channel length is natural and highly sinuous with tortuous bends. The channels are low energy systems that include pool-riffle and pool-glide sequences, with few areas of point bar formations. The pools are generally sandy with some silt and organics. The glides and riffles are generally sand and gravel and the point bars are generally gravel.

The channel banks are nearly all earthen with dense vegetation that provides bank stability. Some erosion and bank failures are present that are typical of developing watersheds, but the channel banks are low and the channels have access to their floodplain during high flow events. The banks are undercut in many areas, with exposed root masses and overhanging vegetation. These portions of the channels are still very stable, however, due to the accessible floodplain and because the channels are low energy and the roots provide adequate bank strength.

Mill Brook geomorphology

Mill Brook is approximately 8.5 miles in length with a gradient of 9.4 feet per mile and flows into the Fox River. Construction erosion, nonpoint source contamination, sedimentation, stream realignment, manmade dams and ponds and beaver dams are all minor stressors in the watershed.

Genesee Creek geomorphology

The twenty-four square mile Genesee Creek watershed contains three main reaches, Spring Brook, North Branch of Genesee Creek and Genesee Creek. The North Branch of Genesee Creek, Spring Brook and a majority of Genesee Creek subwatersheds flow southeast through the Town of Genesee and a small section of the Town of Waukesha before converging with the Fox River. Flow data in the watershed is limited because it does not have a flow measurement gage in the watershed.

The headwater portions of Genesee Creek watershed have wide floodplains with large wetland areas bordering the channels. The channels have been straightened in some areas to accommodate road crossings, multiple railroad crossings, and a large area of agricultural development, but a good portion of the channel length is still natural with a high gradient. These higher gradient reaches have predominantly gravel, cobble, and rubble substrate. In 2005, the Roller Mill Dam was removed, however two dams lower in the watershed still remain.

3.3.10 Flora and fauna of Fox River tributaries

Pebble Brook flora and fauna

Pebble Brook has a riparian plant community typical of southeast Wisconsin. At County Highway XX, near where the pipeline crosses Pebble Brook, the surrounding watershed is less-disturbed relative to the other waterways. Tree species such as hackberry, silver maple, box elder, and several willow species are present. Though the herbaceous layer is dominated by weedy species such as reed canary grass and goldenrod, native sedges, rushes, and grasses are also present in some sections. Gray dogwood is a common shrub located in the floodplain; riverbank grape is also widespread.

Four natural communities and two animal concentration sites have been documented adjacent to or within the near vicinity of Pebble Brook. In addition, four rare plants, including two that are state-threatened, are known to occur within the vicinity of this brook.

Pebble Creek flora and fauna

The riparian vegetation along Pebble Creek is similar to the riparian community of Pebble Brook and the Fox River, which Pebble Creek empties into. Willows and maples are dominant woody species. They are located at the outer edge of the creek's floodplain. Closer to the waterway, reed-canary grass and stinging nettles dominate. Large populations of cattail are also present along Pebble Creek near Genesee Road.

Two natural communities have been documented adjacent to the creek. In addition, five rare plants, including three that are state-threatened, are known to occur within the near vicinity of the Pebble Creek.

Mill Brook flora and fauna

Mill Brook empties into the Fox River just south of where Pebble Brook does. Mill Brook riparian vegetation is similar to the other low-order streams in the area. It is dominated by both herbaceous and woody weedy species. Silver maple, green ash, and eastern cottonwood are located frequently along the waterway. Shrubs such as smooth sumac and gray dogwood are also common. Herbaceous species present include common weedy species such as reed-canary grass, goldenrod, stinging nettle, and yarrow.

Two natural communities and one animal concentration site has been documented adjacent to or within the near vicinity of Mill Brook. In addition, four rare plants, including one that is state-threatened, are known to occur within the vicinity of this brook.

Genesee Creek flora and fauna

Genesee Creek has seven natural communities that have been documented nearby. The rare plant diversity is also quite high with ten plant species, six of which are threatened, recorded within the vicinity including a couple that are directly associated with the creek.

Mill Creek flora and fauna

Mill Creek is located south of the City of Waukesha in both rural and residential areas. In the areas of lesser disturbance, a relatively diverse riparian plant community is present, consisting of wet meadows species such as sedges, grasses, and forbs. But stretches of Mill Creek are located adjacent to residential areas where reed-canary grass and mowed turfgrass dominate.

Two natural communities and one animal concentration site have been documented adjacent to or within the near vicinity of Mill Creek. In addition, one special concern plant is known to occur within the vicinity of this creek.

3.3.10.1 Macrophytes of Fox River tributaries

Pebble Brook macrophytes

The department has observed aquatic invasive species such as curly leaf pondweed, reed canary grass and purple loosestrife in or around Pebble Brook.

Pebble Creek macrophytes

SEWRPC's watershed plan lists examples of typical macrophytes observed such as elodea and curly leaf pondweed. The department has observed other aquatic invasive species, such as purple loosestrife and reed canary grass, in or adjacent to Pebble Creek.

Mill Creek macrophytes

The department has observed aquatic invasive species such as Eurasian water milfoil and red canary grass in or around Mill Creek.

Genesee Creek macrophytes

The department has observed macrophytes in or around Genesee Creek such as curly leaf pondweed, reed canary grass and purple loosestrife (all aquatic invasive species). New native species were planted as invasive species management after the removal of the Genesee Roller Mill Dam in 2005. Carroll University staff and students conduct extensive monitoring and projects within the riparian area of Genesee Creek and other information may be available.

Mill Brook macrophytes

The department has observed aquatic invasive species such as Eurasian water milfoil and red canary grass in or around Mill Brook.

3.3.10.2 Algae of Fox River tributaries

The department has observed aquatic periphyton and algal species in all of the Fox River tributaries; however this data is not formally documented.

3.3.10.3 Benthic invertebrates of Fox River tributaries

Pebble Brook invertebrates

Aquatic macroinvertebrates have been collected at multiple locations on Pebble Brook in 1997, 2000, 2002 and 2013. The MIBI for stream segments of the Pebble Brook samples sites ranged from 4.21-5.57 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality for samples taken in the Pebble Brook Watershed. In addition, three rare mussel species and a rare caddisfly are known to be present within Pebble Brook or within connecting waterbodies to Pebble Brook.

Pebble Creek invertebrates

Aquatic macroinvertebrates have been collected at multiple locations on Pebble Creek in the years: 1990, 1999, 2004, 2009, 2010, 2011, 2012 and 2013. The MIBI for stream segments of the Pebble Creek and Brandy Brook watershed samples ranged from 2.7-6.1506 generally indicating that the diversity and abundance of macroinvertebrate species are indicative of a fair to good water quality. In addition, two rare mussel species are known to be present within connecting waterbodies to Pebble Creek.

Mill Creek invertebrates

Aquatic macroinvertebrates have been collected at a few locations on Mill Creek in spring and fall of 1980, 1997, 2000, and 2002. The MIBI for stream segments of the Mill Creek samples sites ranged from 3.28-5.89 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a fair to good water quality. In addition, three rare mussel species are known to be present within connecting waterbodies to Mill Creek.

Genesee Creek invertebrates

Aquatic macroinvertebrates have been collected at multiple locations on Genesee Creek in 1990, 1999, 2004, 2009, 2010, 2011, 2012 and 2013. The MIBI for stream segments of the Genesee Creek samples ranged from 4.24-7.36 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of a good water quality. Two rare mussel species (one is classified as threatened) and a caddisfly species are known to be present within connecting waterbodies to Genesee Creek.

Mill Brook invertebrates

Aquatic macroinvertebrates have been collected at a few locations on Mill Brook in spring and fall in 1980 and 2004. The MIBI for a stream segment of the Mill Brook ranged from 3.58-4.73 generally indicating that the diversity and abundances of macroinvertebrate species are indicative of fair water quality. In addition, two rare mussel species and a caddisfly species are known to be present within connecting waterbodies to Mill Brook.

3.3.10.4 Fix of Fox River tributaries

Pebble Brook fish

Pebble Brook is classified as a Cool-Warm Mainstem near the convergence with the Fox River and a Cool-Warm Headwater in the upper portions of the watershed. Fish Surveys were conducted in 2000, 2002 and 2013. The surveys identified species such as bigmouth shiner, black bullhead, blackside darter, blackstripe topminnow, bluegill, bluntnose minnow, bowfin, central mudminnows, creek chub, common carp, common shiner, green sunfish, johnny darter, largemouth bass, northern pike, rock bass, white sucker and yellow bullhead. Most of these species are considered warm water species but several can be found in cool water habitats. Outside of these surveys, four other rare fish species are known to be present within Pebble Brook or within connecting waterbodies to Pebble Brook.

Pebble Creek fish

Brandy Brook and Pebble Creek upstream of County Trunk Highway (CTH) D supports a cold water fish community. Pebble Creek downstream of CTH D is designated a warm water sport fishery. SEWRPC's report, Community Assistance Planning Report No. 284, Pebble Creek Watershed Protection Plan (2008) documents the presence of a state threatened species and the cold water brown trout (*Salmo trutta*) and mottled sculpin (*Cottus bairdi)*) in 1999–2005 surveys in Pebble Creek. In addition, a special concern species was found in Pebble Creek, at the confluence with the Fox River.

Fish surveys were conducted on Pebble Creek and/or at the confluence with the Fox River 1990, 1995, 1999 and extensive surveying completed in 2004-2005. The fish species found during these surveys included brown trout (cold water species), mottled sculpin (cold water species), blacknose dace, brook stickleback, central mudminnow, fathead minnow, johnny darter, northern pike, rock bass, spottail shiner, white sucker, black bullhead, black crappie, blacknose shiner, blackside darter, blackstripe topminnow, bluegill, bluntnose minnow, bowfin, brook silverside, common carp, central stoneroller, channel catfish, common shiner, grass pickerel, green sunfish, hornyhead chub, largemouth bass, largescale stoneroller, longnose dace, mimic shiner, pumpkinseed, orangespotted sunfish, sand shiner, spotfin shiner, smallmouth bass, one threatened species and one special concern species. Additional species were found during WDNR fisheries surveys in 2005-2014 including creek chub, emerald shiner, golden shiner, rainbow darter and yellow perch. Most of these species are considered warm water species but several can be found in cool water habitats. Outside of these surveys, two other rare fish species are known to be present within connecting waters to Pebble Creek.

Mill Creek fish

Mill Creek is four mile tributary stream that flows west from the town of New Berlin past two private dams before entering Pebble Brook. Mill Creek is classified as a Cool (Warm Transition) Headwater.

Fish surveys were conducted on Mill Creek in 1997, 2000, 2002, 2008 and 2013. The fish species found during surveys included banded darter, black bullhead, black crappie, blackside darter, bluegill, bluntnose minnow, bowfin, brook stickleback, central mudminnow, central stoneroller, common shiner, creek chub, fathead minnow, golden shiner, green sunfish, hornyhead chub, johnny darter, largemouth bass, longnose dace, mottled sculpin (cold water species), pumpkinseed X bluegill, rainbow darter, rock bass, western blacknose dace, white sucker and yellow bullhead. Outside of these surveys, three rare fish species have also been documented within Mill Creek or nearby in connecting waterbodies.

Genesee Creek fish

Genesee Creek is a 5 mile tributary stream to the Fox River that flows east with a dam at Saylesville Millpond. Genesee Creek is listed as a partially Class I and Class II trout stream (Class I waters are high quality and support natural reproduction of wild trout, at or near carrying capacity. Class II waters have some natural reproduction, but not enough to fully utilize available food and space). The upper portion of Genesee Creek is also an Exceptional Resource Water (ERW). Genesee Creek is a Cool-Cold Headwater upstream of the confluence with Spring Brook and a Cool-Warm Mainstem downstream. Fish surveys from 2007 and 2014 found shorthead redhorse, walleye, golden redhorse, rainbow darter, banded darter, stonecat, rock bass, logperch, common shiner, johnny darter, white sucker, bluegill largemouth bass, northern pike, pumpkinseed, black bullhead, bluntnose minnow, common carp, fathead minnow, green sunfish, potfin shiner, yellow bullhead, black crappie, bowfin, channel catfish, tadpole madtom, blackside darter, blackstripe topminnow, brown trout (coldwater species), central mudminnow, creek chub, fantail darter, grass pickerel, longear sunfish, mottled sculpin (coldwater species), northern redbelly dace, sand shiner, slender madtom, southern redbelly dace, suckermouth minnow, warmouth, western blacknose dace. Outside of these surveys, three rare fish species have also been documented within Genesee Creek or nearby in connecting waterbodies.

Mill Brook fish

Mill Brook is listed in the Wisconsin classified trout streams as a partially Class I and Class II trout stream (Class I waters are high quality and support natural reproduction of wild trout, at or near carrying capacity; Class II waters have some natural reproduction, but not enough to fully

utilize available food and space). Mill Brook is also considered a Cool-Warm to Cool-Cold Headwater stream.
Fish surveys were conducted on Mill Brook in 2004 and 2009. The fish species found during those surveys included mottled sculpin (cold water species), brook stickleback, black bullhead, bluegill, central mudminnow, creek chub, largemouth bass, pumpkinseed, green sunfish, grass pickerel, johnny darter and white sucker. Outside of these surveys, three other rare fish species are known to be present within connecting waterbodies to Mill Brook.

3.3.10.5 Herptiles, Birds and Mammals of Fox River tributaries

Herptiles of Fox River Tributaries

One state endangered and two special concern herptile species are known or have been known to use the Fox River tributaries and their adjacent wetlands as habitat. Unfortunately, the state endangered herptile is considered extirpated in this area of Wisconsin.

Birds of Fox River Tributaries

Four rare bird species, including one that is state-endangered, are known to nest within the vicinity of the Fox River tributaries.

Mammals of Fox River Tributaries

These tributaries provide habitat for several species of mammals, mostly furbearers. Muskrats, mink, otter, and beaver thrive in the marsh habitat. Other mammals including opossum, shrews, moles, bats, chipmunk, voles, mice, fox, raccoon, weasels, and skunk are numerous as well. White-tailed deer, eastern gray and fox squirrels, eastern cottontails, and coyotes are popular game species and receive moderate to heavy hunting pressure. There are two state-threatened and one special concern mammal that are known to use the Fox River tributaries and their adjacent habitats.

3.4 Root River

3.4.1 Physical description and floodplains of the Root River

The Root River watershed covers 126,484 acres (about 198 square miles) in Waukesha, Milwaukee, Kenosha and Racine counties. The Root River flows 44 miles south and east from the City of New Berlin (Waukesha County) and empties into Lake Michigan at Racine (Racine County, Figure 3.6). The Root River watershed is within the Lake Michigan Basin.

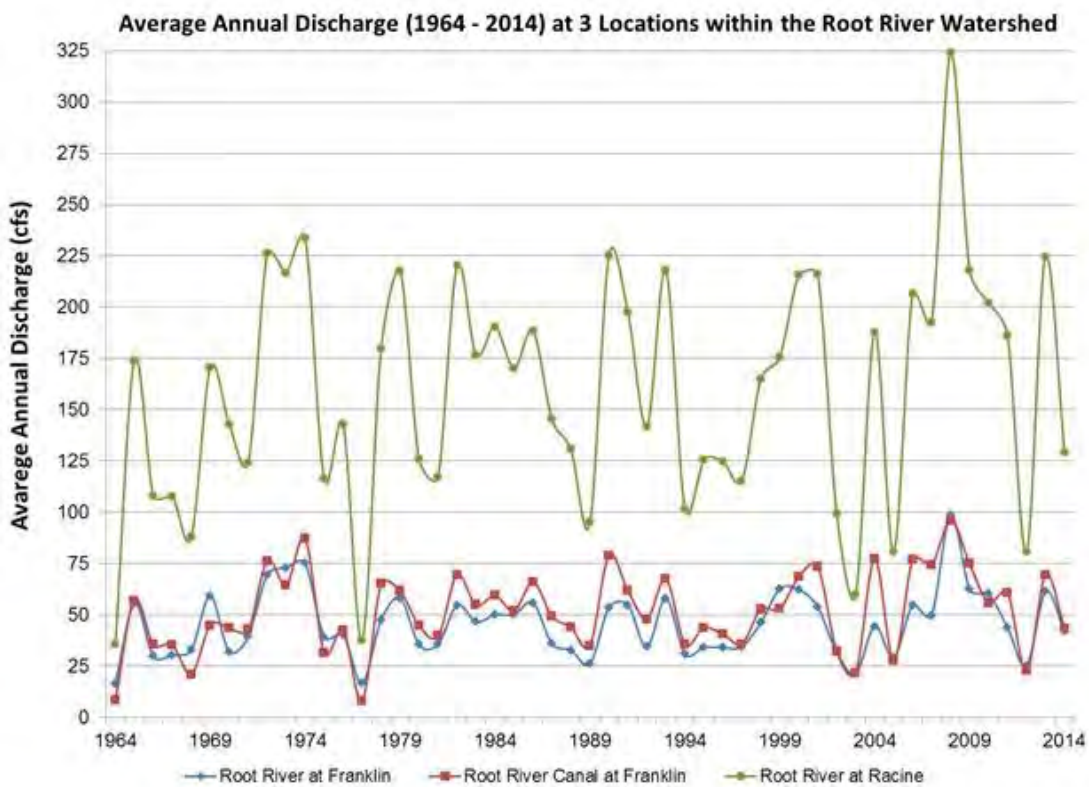
The headwaters of the Root River are heavily urbanized, the middle reaches are primarily agricultural and lower density development, and the lower parts of the watershed near Lake Michigan are heavily urbanized. The river has primarily natural bottom substrate and vegetated river banks and land uses are mixed between its headwaters and Lake Michigan. The principal tributary, near the Milwaukee/Racine County line, is the Root River Canal, coming from the south and joining up with the Root River southwest of Oakwood Road and 60^{th} Street. The Horlick dam, constructed in 1834, is located in the City of Racine just upstream of the STH 38 crossing of the Root River (Figure 3.6). The dam is 19 feet high and impounds a surface area of about 60 acres.

Figure 3-6. Map of Root River Watershed

3.4.2 Flow and flooding in the Root River

At USGS Root River stream gage (04087220) near the City of Franklin, about two miles upstream of the proposed project return flow location, the average annual stream flow is 45.5 cfs (USGS flow data 1964 to 2014). From 1964 to 2014, the minimum daily mean flow recorded was 0.44 cfs, and the maximum daily mean flow was 4340 cfs. The average annual minimum flow is 12.7 cfs and the average annual max. flow is 93.9 cfs. At USGS Root River stream gage (04087240) in the City of Racine, approximately 20 miles downstream of the proposed project return flow location at Horlick Dam, the average annual stream flow is 158.71 cfs (USGS flow data 1964 to 2014, Figure 3.7).

Figure 3-7. Average Annual Discharge at 3 USGS gage sites in the Root River Watershed



3.4.3 Water quality of the Root River

The upper section of the Root River, the Root River Canal and the West Branch of the Root River Canal, are considered impaired because excessive phosphorus and total suspended solids loading that leads to dissolved oxygen levels below what is necessary to support fish and other aquatic organisms. The entire Root River (miles 0 – 43.95) is listed on Wisconsin's Impaired Waters §303(d) list. The harbor is also listed due to unspecified metals. There are no approved Total Maximum Daily Loads (TMDLs) for the Root River. The assessment units and corresponding pollutants and impairments are shown in Table 3.5.

Table 3-5. Root River Mainstem §303 (d) Pollutants and Impairments

Rock River (river miles)	Pollutant	Impairment
0 to 5.82	PCBs, Total Phosphorus	Contaminated Fish Tissues, Unknown
5.82 to 20.48	Total Phosphorus	Degraded Biological Community
20.48 to 25.8	Total Phosphorus, Sediment/TSS	Degraded Biological Community, Low Dissolved Oxygen
25.8 to 43.69	Chlorides, Total Phosphorus, Sediment/TSS	Acute Aquatic Toxicity, Degraded Biological Community, Low Dissolved Oxygen

The department, USGS, MMSD, the City of Racine Health Department, and citizen volunteers have gathered water quality data in the Root River watershed. SEWRPC has done extensive water quality modeling of the watersheds and has finalized the 2014 Root River Watershed

Restoration Plan: (http://www.sewrpc.org/SEWRPCFiles/Publications/CAPR/capr-316-root-river-restoration-plan-part-I.pdf). In support of this plan, additional monitoring was completed between 2011 and 2013 by the City of Racine and the department and is summarized in a comprehensive report (Koski et. al, 2014). Results from this recent monitoring support the impairment status for phosphorus, total suspended solids and fish consumption advisories in the Root River.

Several biological indices have been developed for three stream reaches along the Root River. These indices use benthic macroinvertebrates and fish as indicators of water quality and physical conditions present within the stream. The MIBI (benthic macroinvertebrate index), the HBI (Hilsenhoff Biotic Index, and warm and coolwater fish IBIs (fish indexes) were developed within each of three stream reaches of the Root River. In general the MIBI, HBI, and IBI for the lower reach of the Root River (river miles 0 to 5.82) suggests fair to good water quality and physical habitat condition. The middle reach (river miles 5.82 to 20.48) scores range from poor to good quality, with most of the data suggesting fair conditions. The upper reach (river miles 20.48 to 43.95) also ranges from poor to good quality. Overall, these data suggest some limitations in water quality and physical habitat for the middle and upper reaches. The Root River Watershed Restoration Plan includes a complete map of recent fisheries IBI scores and HBI macroinvertebrate sampling locations and scores (SEWRPC, 2014, p. 270).

3.4.4 Geomorphology of the Root River

The headwaters of the Root River begin near the City of New Berlin, on a glacial ridge. Glaciers shaped the drainage area of the Root River, creating clay bluffs, lake plains, ground moraines and ridge and swales on top of the Niagara Dolomite. The soils are comprised mostly of silt- loams overlying loamy and clay–like tills, which are commonly poorly drained. About 72 percent of the Root River watershed has poorly drained soils with low permeability with moderate to low groundwater recharge potential (SEWRPC, 2014).

MMSD completed a comprehensive study of the portions of the Root River that are within their jurisdiction in 2007 – the data is only available for the portion of the Root River in Milwaukee County and generally consists of data upstream of the proposed return flow location. The purpose of the study was to document existing channel stability in the North Branch of the river and to provide hydrologic, hydraulic and sediment transport predictions on the vertical and lateral stability of the river and tributary channels (MMSD, 2007). The river has a mixture of gradients, with low-gradient reaches dominated by pools and glides with sand, silt, organic and glacial till bottom and bank sediments. Other reaches are higher- gradient with pool and riffle sequences with gravel, cobble and bedrock substrates. The banks of the river are mostly earthen, with vegetation providing bank stability, but there are some areas of erosion and bank failures typical of urbanizing watersheds. The lower reaches of the river in the highly urbanized area of the City of Racine have sheetpile banks.

3.4.5 Flora and fauna of the Root River

The riparian vegetation of the Root River is composed of a variety of woody and herbaceous species. In the agricultural land use portions of the stream, there are often thin strips of non-crop vegetation present. Middle-aged silver maples, eastern cottonwood, and willow trees are scattered along the river. Both forbs and grasses, including reed-canary grass, are also present, with few shrubs intermixed throughout. There are 11 documented natural community types within the near vicinity of the Root River. The most common of these natural communities is the Southern Mesic Forest and Southern Dry-mesic Forest. There are also 18 known rare plant species (four listed as state endangered, four as state threatened, and 10 as special concern) within the near vicinity of the Root River.

3.4.5.1 Macrophytes of the Root River

Aquatic macrophytes found in the Root River include Sago pondweed (*Stuckenia pectinata*), Coontail (*Ceratophyllum demersum*), Eurasian Watermilfoil (*Myriophyllum spicatum*), Elodea (*Elodea canadensis*), Curly-leaf pondweed (*Potamogeton crispus*), and Bur-reed (*Sparganiumsp*).

3.4.5.2 Algae of the Root River

The department does not have formal documentation of algae on the Root River, however, an algae survey was completed by USGS and is summarized in "Biological Water-Quality Assessment of Selected Streams in the Milwaukee Metropolitan Sewerage District Planning Area of Wisconsin, 2007" (USGS, 2010).

3.4.5.3 Benthic invertebrates of the Root River

Macroinvertebrate sampling (2000-2011) within the Root River watershed is summarized in *A Restoration Plan for the Root River Watershed* (SEWRPC, 2014). This report shows water quality improvement over time for some areas of the river and decreases elsewhere. Macroinvertebrate HBIs scores indicate fairly poor to poor water quality near the proposed outfall location. There is positive water quality improvement shown at a site on the mainstem of the river, at Johnson Park near Racine, WI (Fig.41, SEWRPC, 2014).

Sampling in the Root River resulted in the identification of 384 macroinvertebrate taxa. Some taxa were identified at a species level, while others were identified to genus, subfamily, or family levels. Insects were the most identified taxa, including: true flies, beetles, caddisflies, mayflies, true bugs, dragonflies (including a special concern species), and damselflies. Other groups found included amphipods, crayfish (including a special concern species), isopods, annelid worms, nematode worms, turbellarian worms and snails. The most commonly identified organisms were isopods, caddisflies, midges, worms of the family Tubificidae, and caddisflys. Surveys for mussels in 1977 identified three species: giant floater, lilliput, and white heelsplitter. Additional mussel survey work in 2012 found live mussels from seven native species and dead shells from four additional native species. Most common were creeper, fat mucket, giant floater, and white heelsplitter. Fragile papershells, three ridges, and wabash pigtoes were also found. Nonnative zebra mussels were also found. The rusty crayfish has been identified as an invasive invertebrate species in the Root River.There are no known endangered, threatened, or special concern mussel species within the Root River.

3.4.5.4 Fish of the Root River

The Root River is classified for WDNR fish and aquatic life standards and supports a WWSF community. The Root River is a warm-water habitat. There are areas of good quality within parts of the Root River watershed, but also areas of impairment due to agricultural and urban impacts. The Root River watershed has relatively few streambed and bank modifications, with less than one percent of the stream channel being in conduit and none lined with concrete. Fish IBI ratings range from very poor to fair near the outfall location and downstream (Fig.41, SEWRPC, 2014).

Downstream from the Horlick Dam the river supports a stocked trout and salmon fishery. Upstream from the dam, the river supports a poor quality fishery with relatively few species. This section of the stream is dominated by species tolerant of poor water quality, with few top predators (SEWRPC, 2014).

Fishery data for in the Root River watershed shows that 10 new species have been identified, but 10 of 64 recorded species have not been observed since 1986 (SEWRPC, 2007, pp. 100–14). The most recent fishery surveys by USGS conducted in 2004, 2007 and 2010 identified 19 species in the Root River near the proposed return flow location (USGS, 2013). There are five rare fish species (two of which are listed as state threatened) that have at one time been known to be present within the Root River; however, none of these fish species were observed during these surveys. Table 3.6 lists the fish species found at the USGS locations upstream of the proposed return flow location for Alignment 2. Common carp and goldfish have been identified as invasive fish species in the Root River.

Table 3-6. Root River Fish Species at USGS Gage Station (04087214) and (04087220)- 2004,2007,2010

Root River Fish Species (Upstream of Proposed Outfall)	
Black bullhead	Johnny darter
Blacknose dace	Largemouth bass
Blackslide darter	Longnose dace
Bluegill	Northern pike
Bluntnose minnow	Orangespotted sunfish
Brook stickleback	Pumpkinseed
Central mudminnow	Sand shiner
Creek chub	White sucker
Fathead minnow	Yellow perch
Green sunfish	

3.4.5.5 Herptiles, Birds and Mammals of the Root River

Herptiles of the Root River Watershed

Many reptiles and amphibians are known to exist in the Root River watershed. These include mudpuppy and other newts and salamanders, American toad and a variety of frogs (including an endangered species which is thought to be extirpated from this area), turtles (including one special concern species) and a number of snake species (including two special concern and one state-endangered species).

Birds of the Root River Watershed

As many as 283 bird species are known or have been known to exist in the Root River watershed, including: loons, grebes, cormorant, bitterns, herons (including a special concern species), turkey vulture, ducks, eagle, hawks (including a state-threatened species), a state-endangered falcon, grouse, partridge, bobwhite, pheasant, turkey, coot, rail, crane, plovers, woodcock, sandpipers (including a state-threatened species), snipe, terns, gulls, mourning dove, pigeon, cuckoos, owls, nighthawk, woodpeckers, flycatchers, wrens, robin, thrush, vireos, warblers, tanagers, and sparrows. In addition, there is a Migratory Bird Concentration Site that is adjacent to portions of the Root River.

Mammals of the Root River Watershed

A variety of mammals occur in the Root River watershed, including: muskrat, white-tailed deer, gray squirrels, rabbits, opossum, shrews, moles, bats, chipmunk, beaver, voles, mice, coyote, fox, raccoon, weasels otter, and skunk. There are no known endangered, threatened, or special concern mammals within the near vicinity of the Root River.

3.5 Groundwater

3.5.1 Aquifers

The major aquifers in counties of Waukesha and Milwaukee are the Quaternary and Late Tertiary unconsolidated sand and gravel aquifer, the Silurian dolomite aquifer and the Cambrian-Ordovician sandstone aquifer. The unconsolidated sand and gravel aquifer is connected hydrogeologically to the Silurian dolomite aquifer where both are present. The combination of the two is generally considered to be the shallow aquifer in Milwaukee County and the eastern portion of Waukesha County. The shallow aquifer is unconfined in these areas whereas the deep Cambrian-Ordovician sandstone aquifer is confined due to the overlying Maquoketa Shale.

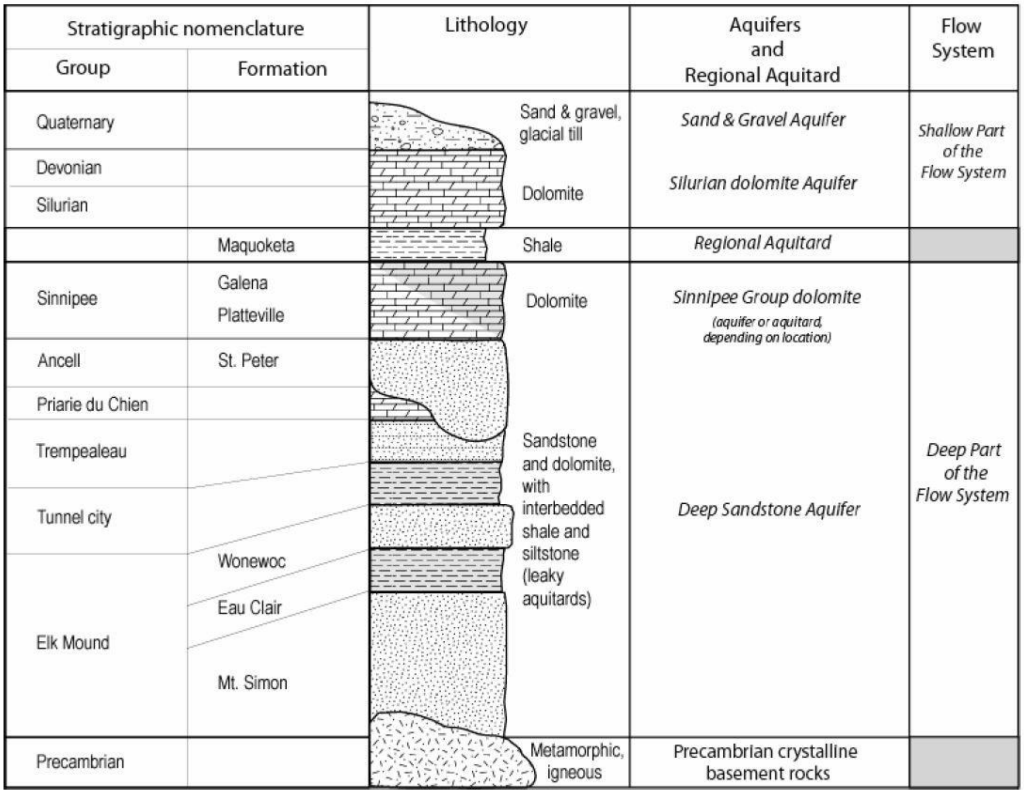
The aquifers extend to great depths, reaching a thickness in excess of 1,500 feet in the eastern parts of Milwaukee and Racine. The aquifers are, in descending order, the Quaternary sand and gravel, Silurian dolomite, Galena-Platteville, upper sandstone, and lower sandstone (see Figure 3.8). The confining beds are the Maquoketa Formation and the Precambrian crystalline rock. The shaly Antrim Formation and siltstone and shaly dolomite of the Milwaukee Formation constitute the uppermost semi- confining bed; and silty dolomite and fine-grained dolomitic sandstone of the St. Lawrence Formation/Tunnel City Group, the lower semi-confining bed in parts of the Region.

Regional Aquifers

The aquifer systems in the counties discussed can be divided into two types: unconfined water table aquifers and semi-confined or confined deep bedrock aquifers. Water-table conditions generally prevail in the Quaternary deposits and Silurian dolomite aquifer above the Maquoketa Formation and in the Galena-Platteville aquifer west of the Maquoketa Formation (Figure Xb). These shallow aquifers provide water for most private domestic wells and some municipal wells.

In the deep sandstone aquifer beneath the Maquoketa Formation, the water can be under artesian pressure. Heavy pumping of deep aquifer high-capacity wells has caused the gradual, steady decline in the artesian pressure and a reversal of the predevelopment, upward flow of groundwater. Flowing wells, common within the Region in the late 1880s, ceased flowing at the beginning of the 1900s, and the potentiometric surface of the sandstone aquifer has been gradually declining and is now lower than the water table throughout most of the Region. On average, water levels in deep observation wells have been declining at the rate of four feet per year in the Milwaukee-Racine area and five feet per year around the City of Waukesha since the beginning of record in the late 1940s (SEWRPC, 2002).

Figure 3-8. Hydrostratigraphic sequence for southeastern Wisconsin lithologic column Stratigraphic nomenclature (after Ostrom, 1962) and lithologic column



Shallow aquifer

The aquifers in the counties discussed are divided into shallow and deep. The shallow aquifer system comprises two or three aquifers, depending on its location relative to the Maquoketa shale (Figure 3.8). Where the Maquoketa formation is present, the shallow aquifer system consists of the Silurian dolomite aquifer and the overlying sand and gravel aquifer. There, the Maquoketa Formation is the lower limit of the shallow aquifer system. In the westernmost parts of Waukesha County where the Maquoketa Formation is not present, the shallow aquifer system consists of the sand and gravel aquifer, Galena-Platteville aquifer, and upper sandstone aquifer, and its lower boundary, the St. Lawrence semi-confining unit.

The sand and gravel aquifer consists primarily of layers or lenses within alluvial and glacial deposits and is extremely variable in thickness. It is not as continuous as the bedrock aquifers. The sand and gravel aquifer occurs as broad outwash deposits, isolated lenses within less permeable deposits, stream terraces, valley fill directly overlying bedrock, and other materials deposited by water or glacier (Kammerer, 1995). Important features are highly productive layers of sand and gravel in segments of buried bedrock valleys in Waukesha County which can yield large amounts of water to wells.

In Waukesha County, shallow groundwater west of the major groundwater divide discharges to large nearby lakes and their outlet the Oconomowoc River, or to the Bark and Scuppernong Rivers. East of the major water table divide, shallow groundwater discharges to Pewaukee Lake and the Fox River; east of the secondary groundwater divide, it discharges to Muskego Lake and flows into Milwaukee County. Locally, large, deep pits and quarries divert groundwater flow from its original direction. For example, a gravel pit just north of the City of Waukesha captures groundwater that would otherwise discharge into the Fox River.

In Milwaukee and Racine counties, the prevalent direction of groundwater flow is to the east, toward Lake Michigan, which is the major regional discharge area. In Milwaukee County, some shallow groundwater locally discharges into Lincoln Creek, Menomonee River, and Root River. In Racine County, the direction of flow depends on the position of the secondary divide running north-south through the counties. West of the secondary groundwater divide, groundwater flows toward the Fox River and its tributaries Honey Creek, New Munster Creek, Peterson Creek, and Basset Creek. East of the secondary divide, groundwater discharges into the Root River Canal in Racine County. In the easternmost tier of townships, the direction of groundwater flow is to the east, towards Lake Michigan (SEWRPC, 2002).

The extent to which the sand and gravel aquifer is used for water supply depends upon the quality and availability of groundwater from underlying or adjacent aquifers. The aquifer is mostly unconfined and its yields vary widely. The sand and gravel aquifer is extensively used in Waukesha County where properly constructed wells finished in this aquifer can produce from 100 to more than 1,000 gallons per minute (gpm).The shallow aquifer is the primary source for domestic wells in the area and is also a source of water supply for the Villages of Mukwonago and East Troy, and the Cities of Waukesha and Muskego.

The aquifer is hydraulically connected to sensitive environmental resources, including the Vernon Wildlife Area, Pebble Brook (a Class II trout stream), Genesee Creek, Mill Brook and Mill Creek and Pebble Creek. The Applicant currently obtains approximately 20 percent of its annual water supply from this aquifer.

Deep sandstone aquifer

The sandstone aquifer consists of alternating sequences of Cambrian and Ordovician age sandstone and dolomite, along with some shale. In the eastern half of Waukesha County the sandstone aquifer underlies a low permeability layer called the Maquoketa shale. Due to the thickness of the sandstone aquifer, large water quantities can be produced from wells within the aquifer.

The deep sandstone aquifer, corresponding to Cambrian-Ordovician units, rests on the Precambrian crystalline basement rocks which transmit little water and form the bottom boundary to the aquifer system. In ascending order, the major water-producing units of the deep part of the flow system are sandstones of the Mt. Simon Formation, the Wonewoc Formation and the St. Peter Formation.

Between the Mt. Simon Formation and the Wonewoc Formation lies the Eau Claire Formation, composed of shale and sandstone. A laterally extensive shaly zone within the Eau Claire Formation forms an important aquitard, the Eau Claire aquitard, over much of southern Wisconsin. Rocks of the Trempealeau and Tunnel City Groups, between the Wonewoc and St. Peter Formations, also form a leaky aquitard made up of interbedded sandstone, shale, siltstone and dolomite. Overlying the St. Peter Formation, dolomite of the Sinnipee Group and shale of the Maquoketa Formation together make up a major regional aquitard between deep and shallow aquifers. The Sinnipee Group dolomite at the top of the deep part of the flow system was of particular interest in our hydrostratigraphic conceptualization because its hydraulic properties depend on whether it is overlain by the Maquoketa shale. Where the Maquoketa is present, the Sinnipee Group dolomite acts as an aquitard that limits flow to the underlying deep sandstone aquifer. Where the Maquoketa is absent, the Sinnipee dolomite, constituting the uppermost bedrock unit, is highly weathered, relatively permeable, and is considered an aquifer.

Groundwater in the lower sandstone aquifer generally moves eastward from the regional potentiometric divide, paralleling the regional eastward dip of the Paleozoic rocks, and is confined under the Maquoketa Formation. Cones of depression on the potentiometric surface, caused by pumping from high-capacity wells in eastern Waukesha and western Milwaukee Counties and in the metropolitan areas of Racine, divert and capture groundwater from great distances and change the original direction of regional groundwater flow (SEWRPC, 2002).

The City's deep aquifer wells are constructed to depths greater than 2,100 feet. Since the nineteenth century (SEWRPC, 2010a, pp. 108–9), the deep aquifer has been drawn down more than 500 feet. More recently, water levels in this aquifer have begun to rise. The USGS groundwater monitoring network well located in the City of Waukesha shows the aquifer is still drawn down, but approximately 100 feet higher than levels observed in a nearby observation well in 1998. The deep aquifer currently supplies approximately 80 percent of annual water supply for the Applicant.

Near Waukesha, recharge to the deep aquifer occurs further west where the Maquoketa shale is not present. Figures 3.9, 3.10 and 3.11 illustrate the constraints limiting recharge of the deep aquifer near the City of Waukesha.

In the western part of Waukesha County, the deep sandstone aquifer is unconfined with permeable sand and gravel deposits in direct contact with the sandstone aquifer and acts as a major recharge source for the deep sandstone aquifer in Waukesha County. As the aquifer is unconfined in this portion of Waukesha County, it has not experienced the same drawdown and water quality issues found in the confined portion. This portion of the aquifer is a water supply source for the cities of Oconomowoc and Delafield, and Village of Dousman.

Precambrian Basement

Precambrian crystalline rock, mostly granite, underlies the Cambrian sedimentary sequence. Its characteristics are poorly known because only a very few wells reach the Precambrian surface in Southeastern Wisconsin. The Precambrian basement is not a source of water supply in the Region. It is assumed to have a very, low permeability and forms the lower boundary of the important lower sandstone aquifer (SEWRPC, 2002).

Groundwater Divides

The major groundwater divide is about 10 to 20 miles west of the subcontinental surface water divide. In Waukesha County, the major groundwater divide follows the trend of the Kettle Moraine topographic high, which corresponds to a secondary surface-water divide between the Fox River and the Rock River. Shallow groundwater east of the major groundwater divide in Waukesha County and west of the subcontinental surface-water divide in Racine County, generally discharges to the Fox River, which in turn eventually empties into the Mississippi River.

In addition to the major water table divide, there are several secondary groundwater divides wherever there are high areas in the water table. For example, secondary groundwater divides are found in southeastern Waukesha County and in western Racine County to the east of the Fox River. Other secondary groundwater divides traverse western Waukesha (SEWRPC, 2002).

The groundwater level in the deep sandstone aquifer increases toward the western edge of Waukesha County. The area just west of Waukesha County has the highest heads in the sandstone aquifer and forms the potentiometric divide (deep aquifer groundwater divide). Historical water-level data collected are not adequate to characterize the exact location of this regional divide, nor whether the divide has moved since pre-development time. Nevertheless, the USGS/WGHNS regional model for southeastern Wisconsin published by SEWRPC uses mathematical and calibration constraints to reproduce the behavior of this divide through time. Simulations using the regional model show that the divide has moved west on the order of 10 miles since pre-development times.[1]

Another west-east regional potentiometric divide exists between the Chicago metropolitan area cone of depression and the Waukesha-Milwaukee cone of depression. The exact location of this divide cannot be confirmed without field measurements of current water levels in wells open to the lower sandstone aquifer. Concentrated pumpage in Waukesha-Milwaukee and Chicago areas has created deep cones of depression, and the Chicago cone of depression probably diverts some groundwater from the north, possibly west-east through the middle of Racine County.

3.5.2 Groundwater quality

Shallow aquifer water quality
Groundwater from the shallow aquifer may require treatment to meet secondary drinking water standards, related to cosmetic or aesthetic quality of drinking water, of 0.3 mg/L for iron, 0.05 mg/L for manganese, and a primary standard of 10 ppb for arsenic. To remove these contaminants from the shallow aquifer supply and meet applicable drinking water standards, conventional groundwater treatment, including coagulation, flocculation, sedimentation, filtration and disinfection is needed (CH2MHill, 2013, Vol. 2).

Deep sandstone aquifer water quality

The Applicant's groundwater supply from the deep aquifer has radium levels up to three times the USEPA's drinking water maximum contaminant level (MCL) of 5 picocuries per liter (piC/L). Radium is a known carcinogen. The naturally occurring radioactive isotopes radium 226 and radium 228 are present in the aquifer because of parent elements in the sandstone. The concentration of radium in the City's groundwater supply is as high as 15 piC/L, one of the highest concentrations of radium in the country for a potable water supply.

The Applicant's deep wells have observed high total dissolved solids (TDS). The secondary drinking water standard is 500 mg/L. One well had TDS concentrations greater than 1,000 mg/L and was rehabilitated by blocking part of the well hole to reduce TDS, but in doing so well capacity was reduced more than 35 percent.

---

[1] See the USGS website http://wi.water.usgs.gov/glpf/ under the Implications section for a map showing the simulated movement of the deep divide.

Groundwater contaminant sites

Areas in Wisconsin where groundwater is most susceptible to contamination are those where most of the groundwater is stored in shallow aquifers (Schmidt, 1987). Milwaukee County has approximately 5,468 environmental repair (ERP) and leaking underground storage tank (LUST) sites, Racine County has approximately 826 ERP and LUST sites, and Waukesha County has approximately 1,717 ERP and LUST sites.

Figure 3-9. Flow of groundwater in the St. Peter Sandstone deep aquifer

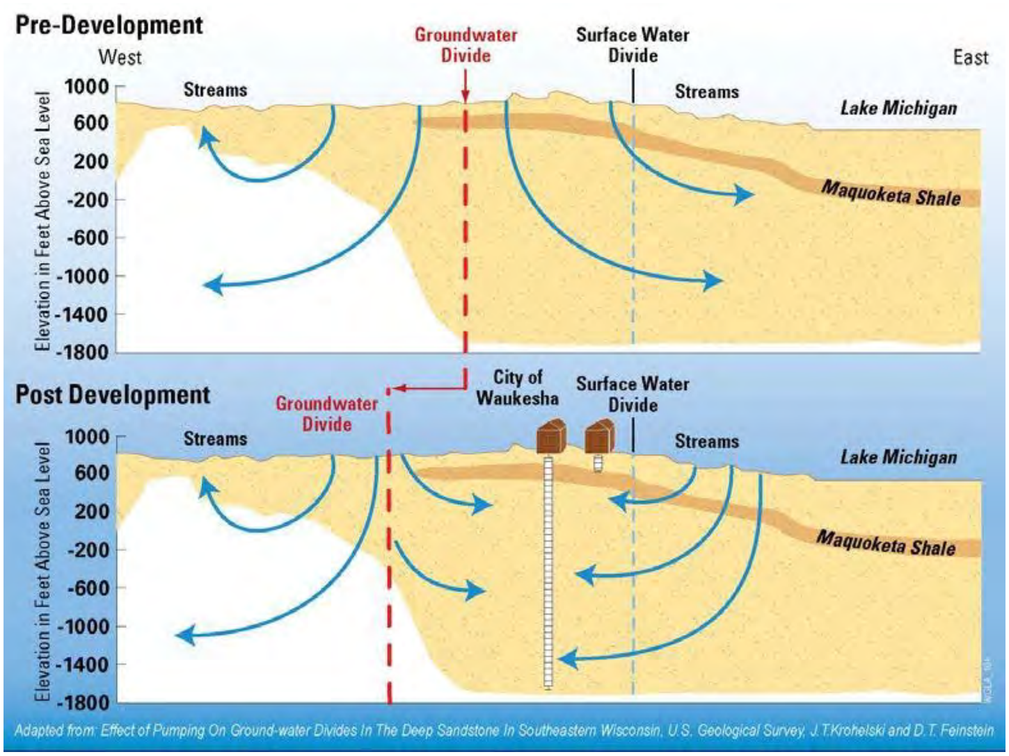
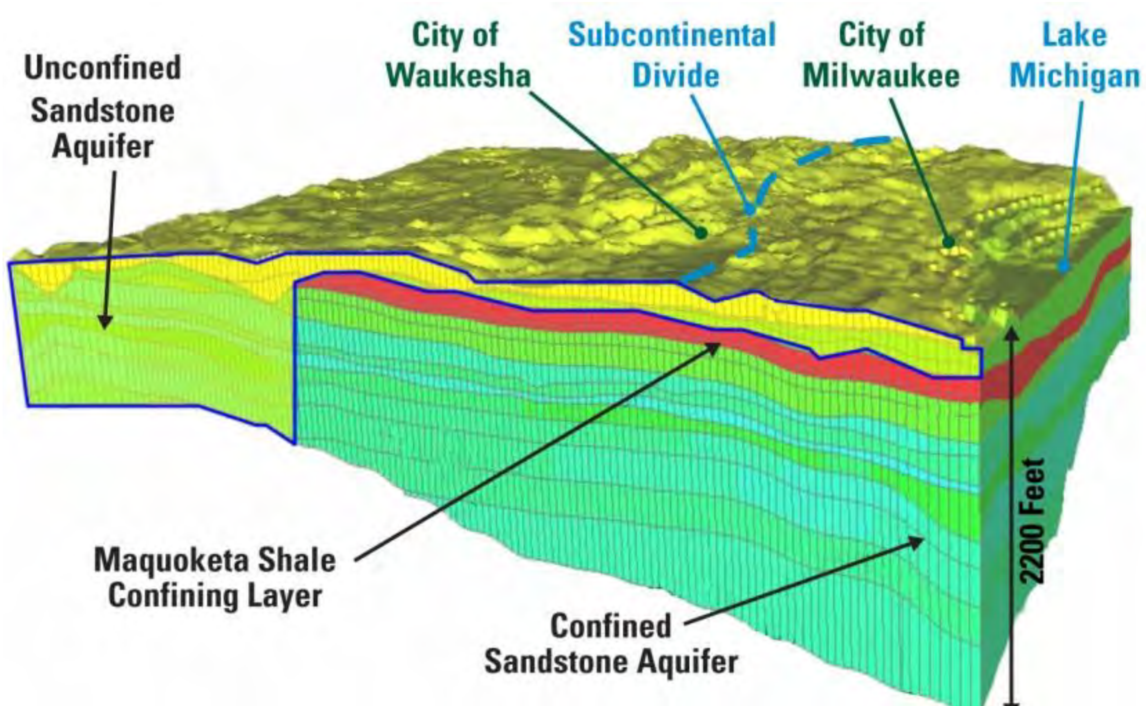
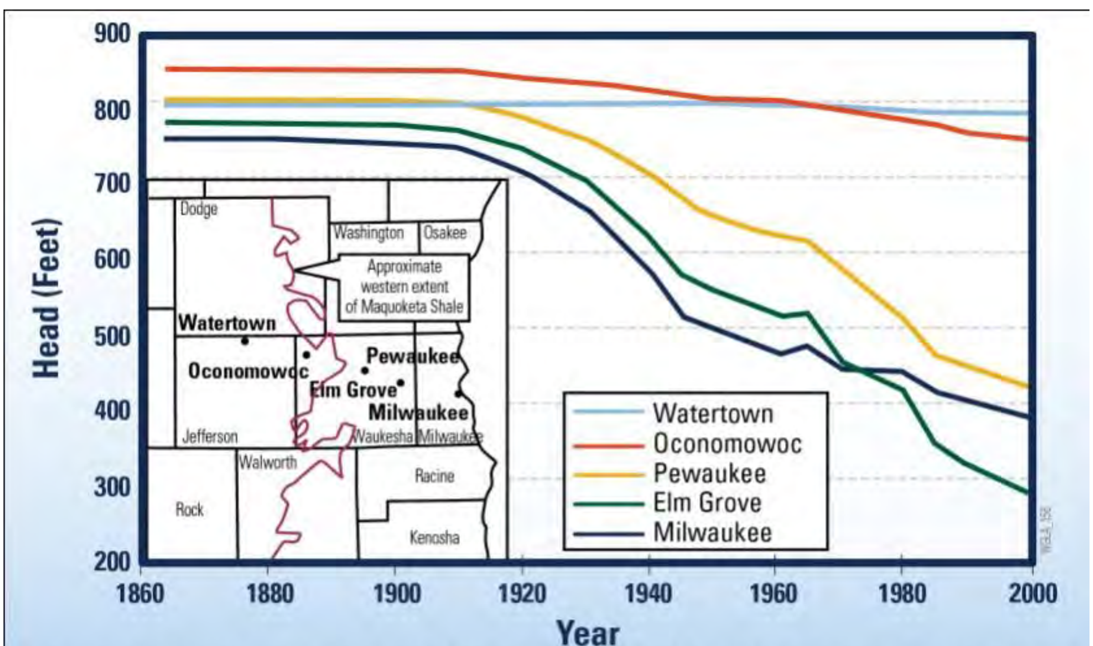


Figure 3-10. Hydrogeology of southeastern Wisconsin



Source: Adapted from Ken Bradbury, Wisconsin Geological and Natural History Survey

Figure 3-11. Deep aquifer groundwater levels in several locations



Water levels in the deep sandstone aquifer at selected locations. Curves represent simulated hydraulic heads (in feet above sea level) near the top of the deep aquifer (St. Peter Formation).
Source: SEWRPC Regional Water Supply Study

3.5.3 Springs

Springs are areas where groundwater discharges from an aquifer to the surface and may occur at the land surface or in a pool, pond, lake, or stream. Springs often provide a positive impact on habitat in surface waters by providing cool, oxygen-rich water. Trout streams, fen-meadows and other wetlands, and numerous sensitive species of plants and animals may be dependent upon spring discharges.

Historically, the Waukesha area had hundreds of springs and was renowned for its many spring spas and resorts in the early 20th century. Since that time, many springs in the area have been lost. Human activities such as dewatering and filling of wetlands, drain tile installation and ditching practices, and high-capacity well pumping may all lower groundwater levels and affect springs (Macholl, 2007). In Waukesha County, much of the land that historically contained springs has been developed for residential or commercial purposes (Swanson, 2007).

The Wisconsin Geological and Natural History Survey maintains an inventory of springs. Multiple springs exist near the groundwater alternatives area (WGNHS, 2010).

3.6 Vernon Marsh

3.6.1 Physical description and floodplain of Vernon Marsh

Vernon Marsh is a 4,655-acre state wildlife area in eastern Waukesha County consisting of wetlands and flowages associated with the Fox River. It is more than five miles long and one mile wide in some sections. Vernon Marsh is primarily located in the floodplain on both sides of the Fox River; the river winds north to south through the marsh. Main tributary streams include Pebble and Mill Brooks, both of which are impounded to form flowages on the property before draining into the Fox River. Vernon Marsh was designated a primary environmental corridor by the Southeastern Wisconsin Regional Planning Commission (SEWRPC, 1997).

Broadly, the marsh is dominated by open wetlands. A variety of open wetland types such as wet meadow, shallow and deep marsh, and open water wetland compose most of the Vernon Marsh floodplain. Less abundant wetland types such as scrub/shrub wetlands, forested wetlands, and calcareous fen (at the southern end of the marsh) are also present. Adjacent uplands are dominated by grassland habitats with interspersed hardwood forest. The property provides significant wildlife habitat, especially for migrating and nesting waterfowl (http://dnr.wi.gov/topic/lands/WildlifeAreas/vernon.html).

3.6.2 Geomorphology and depth of to groundwater of Vernon Marsh

In southeast Wisconsin, after the Wisconsin Glaciation, broad glacial lakes formed behind the glacier's retreat. Over time, these lakes receded. In the remaining low areas of these glacial plains, wetlands formed, including Vernon Marsh. The retreating glaciers left sand and gravel deposits, which hold groundwater in the form of aquifers (SEWRPC, 2002). In southeast Wisconsin, depths to groundwater vary. In wetlands, and specifically Vernon Marsh, groundwater levels are at or near the ground surface for much of the year.

3.6.3 Flora and Fauna (including T/ESC)

Vernon Marsh consists of wetland and upland communities, and flowages associated with the Fox River. The most common wetland communities include wet meadow, shallow marsh, deep marsh, and open water wetland. Less common wetland community types include scrub/shrub wetland, forested wetland and calcareous fen. Adjacent uplands are dominated by grassland habitats with interspersed areas of limited hardwoods. The property provides significant wildlife habitat, especially for migrating and nesting waterfowl. Many state threatened, endangered, and special concern species are present on the property including five plants, two herptiles, three invertebrates, four birds, four fish, and three mussel species.

3.6.3.1 Flora of Vernon Marsh

Vernon Marsh contains a variety of wetland and upland communities. The most common wetland plant communities include wet meadow, shallow marsh, deep marsh, and open water wetlands. Less common wetland plant community types present include scrub/shrub wetland, forested wetland, and calcareous fen.

Open water wetland communities are common throughout the marsh. Five flowages are managed by water control structures and greatly influence vegetation. Herbaceous species present in this open water community include submergent and floating-leaved aquatics such as water lilies, pondweeds, milfoils, coontail, and duckweed. These open water communities differ from deep and shallow marsh because open water complexes rarely have exposed soil, so emergent aquatic vegetation cannot establish.

The next-driest wetland plant community present at Vernon Marsh is marsh. Marsh wetland communities can be divided into deep and shallow marsh, but because vegetation is often similar between the two, they are combined for purposes of this discussion. In general, marsh communities are seasonally inundated; emergent vegetation is able to establish when bare soil is exposed and seeds can germinate. Cattail, composed of up to three very similar species, is ubiquitous in marsh communities at Vernon Marsh. It is also abundant in other nutrient-rich marsh systems throughout the Midwest. Cattail is the most dominant plant species in Vernon Marsh and is considered an invasive species. Other invasive species present in this wetland community in Vernon Marsh include purple loosestrife and giant reed. There are small areas of native marsh community; these contain various species of bulrush, bur reed, and sedges, but the invasive species limit the cover of these native species.

The final dominant wetland community at Vernon Marsh is wet meadow. This wetland community contains saturated soils which are typically only inundated in the spring. At Vernon Marsh, wet meadow primarily consists of monotypic stands of reed canary grass, another invasive species. Similar to cattail, reed canary grass thrives in nutrient-rich environments present in floodplain wetlands like Vernon Marsh. Smaller areas of wet meadow contain native species, including a more diverse assemblages of sedges, rushes, grasses, and forbs. Other common wet meadow species include tall goldenrod, tussock sedge, bluejoint grass, and woolgrass. State-listed species are also present in wet meadows at Vernon Marsh.

Other wetland communities are present, but less frequent. Both scrub/shrub and forested wetland communities exist, both dominated by shrubs and trees. Pockets of scrub/shrub containing several willow species are scattered throughout the marsh. Forested wetlands, composed of box elder, ash, willows, and some tamarack, also occur sporadically throughout.

Finally, though small in size, a calcareous fen is located at the southern end of Vernon Marsh. A fen is fed by mineral-rich groundwater and is composed of peat soils. Fens are the rarest wetland plant community in Wisconsin (Eggers and Reed, 1997). The Vernon Marsh fen is located just uphill from groundwater springs at the base of a moderate slope. This fen is densely vegetated with a sparse shrub layer of glossy buckthorn (an invasive species) and shrubby cinquefoil (native) that gives way to an herbaceous-dominated plant community. Signature fen species here include two species of beak-rush (one is state-listed), several forbs including Joe-pye-weed, and several species of spikerush. Two additional state-listed plants (both threatened) are present in this fen.

Small areas of uplands also occur at Vernon Marsh State Wildlife Area. There are several small dry-mesic forests containing canopy species such as red oaks, white ash, black cherry, and sugar maple. Also scattered throughout the site are old fields containing pasture grasses and occasional prairie plantings.

Vegetation at Vernon Marsh is dominated by reed canary grass, monotypic cattail and lowland brush. Small pockets of high quality sedges remain. Some acreage is forested including northern hardwoods, oak woodlots and lowland hardwoods. Upland prairies consist of warm season grasses such as big bluestem, indiangrass, and switchgrass, cool season grasses such as bromegrass and a variety of forbs but dominated by goldenrods and asters.

3.6.3.2 Herptiles, Birds and Mammals

Herptiles of Vernon Marsh

A robust herptile community composed of reptiles and amphibians including two special concern species consistent with open water and marsh is present at Vernon Marsh. Many other turtles, snakes, and frog species occur here.

Common reptiles and amphibians at Vernon Marsh include painted and snapping turtles, common garter snakes, western fox snakes, eastern milk snakes, brown snakes, northern redbelly and northern water snakes, American toads, spring peepers, Eastern gray tree frogs, Copes gray tree frogs, Northern leopard frogs, wood frogs, green frogs, bullfrogs, eastern tiger salamanders and mudpuppies. Other reptile and amphibian species are likely to be present. Vernon Marsh has the best potential for conserving herptiles of any state wildlife area in Waukesha County.

Birds of Vernon Marsh

Vernon Marsh, including five flowages, is managed for hunting a variety of species, including waterfowl, deer, and upland game birds. The flowages are managed to consist of 50% emergent marsh and 50% open water, specifically for waterfowl. Also, during migration, at least one flowage is drawn down and maintained as mud flats for migrating shorebirds. The large amount of marsh and open water habitat present at Vernon Marsh provides habitat for a variety of shorebirds, wading, birds, and ducks. Dabbling ducks, cranes, pelicans, herons, and egrets all use the marsh. Three state-listed species all nest on-site. Uplands act as hunting areas for turkey and ring-necked pheasant as well.

Common birds at Vernon Marsh include: Canada geese, mallards, wood ducks, blue-winged teal, American coots, belted kingfishers, herring gulls, ring-bill gull, great blue herons and great egrets. Other waterfowl which use the area as a spring or fall migratory stop-over include widgeon, green-winged teal, northern pintail, gadwall, northern shoveler, bufflehead, common goldeneye, and ringnecked duck. Birds found on the surrounding wetlands and uplands include sandhill cranes, woodcock, owls (great horned, screech and barred), hawks (red-tailed, Coopers, sharp-shinned and American kestrel), wild turkeys and a large variety of songbirds and shorebirds. Vernon is one of two wildlife areas in Waukesha County identified as having the best potential for conserving marsh birds, colonial waterbirds and waterfowl.

Mammals of Vernon Marsh

Vernon Marsh provides habitat for several species of mammals. Mammals using the wetlands and riparian areas in Vernon include muskrats, mink, beaver, raccoons, and several bat species. Other mammals on the surrounding uplands include gray and fox squirrels, cottontail rabbits, red and gray fox, coyotes, skunks, opossums, woodchucks, eastern chipmunks, thirteen-lined ground squirrels, white-tailed deer, and various species of shrews, moles, mice, voles and weasels. White-tailed deer, eastern gray and fox squirrels, eastern cottontails, and coyotes are common in the marsh and receive moderate to heavy hunting pressure. There are no known endangered, threatened, or special concern mammals that reside in Vernon Marsh.

3.6.4 Functional values of Vernon Marsh

The Vernon Marsh wetlands (as well as vegetated uplands located adjacent to the marsh), provide many functional values to humans and the environment. Because there are a variety of habitats present, Vernon Marsh provides a wide array of ecosystem functions. The open water and marsh communities are important habitat for waterfowl and furbearers, especially in drought years when more shallow wetlands dry up first. These deeper marsh habitats can also act as spawning grounds for some species of fish. Wildlife heavily use open water and marshes during migration when they feed on submergent vegetation and aquatic invertebrates. The Marsh provides significant opportunities for wetland, bird and herptile conservation.

In addition to wildlife habitat, Vernon Marsh filters runoff and holds flood water. Wetlands in general, and especially riparian wetlands like Vernon Marsh, can trap sediment and take up nutrients, improving water quality. Riparian wetlands can also retain large amounts of floodwater, reducing the risk of flooding to other areas downstream.

Finally, wetlands and open space in general, provide an intrinsic value to humans. Aesthetically, wetlands provide a pleasing environment in addition to their recreational value for hunting, trapping, fishing, and other recreation. Vegetated uplands also add to their aesthetic value and help to buffer the wetlands from runoff and other human-caused impacts.

3.7 Forested and scrub/shrub wetlands

In southeast Wisconsin, forested wetlands are typically dominated by mature deciduous tree species. Forested wetlands are often associated with glacial lake basins or river systems and have seasonally high water tables. Conversely, scrub/shrub wetlands are dominated by woody vegetation less than 20 feet in height. Scrub/shrub wetlands often occur as a transition between open and forested wetlands, both spatially and temporally. They can be located on the landscape spatially in between open and forested wetlands. Scrub/shrub wetlands can also occur in the same location as an open wetland as it transitions to forested wetland over time. This can happen in the absence of disturbance over many years.

Forested wetlands can consist of deciduous or coniferous tree species. Forested wetlands dominated by hardwood species often occur in the floodplains of rivers in southern Wisconsin, but can also occur in ancient lake basins (Eggers and Reed, 1997). Forested wetlands dominated by conifers are more common in the northern part of the state where they grow on organic soils with wide ranges of acidity. Forested wetlands are found in the project area.

Scrub/shrub wetlands typically occur on seasonally-saturated soils that are either organic (pear/muck) or mineral (alluvial) (Eggers and Reed, 1997). They can be located in bands around lakes or ponds, on the margins of floodplains, or more extensively, in glacial lake beds. These communities can persist for very long periods of time if the appropriate hydrologic conditions persist. Scrub/shrub wetlands are less common in southeast Wisconsin, though they are present in the project area.

3.7.1 Flora and fauna (including T/ESC)

3.7.1.1 Flora of forested and scrub/shrub wetlands

Forested wetlands are typically grouped based on the dominant tree species present, either deciduous hardwoods or conifers. Hardwood forested wetlands are typically dominated by black ash, red maple, and yellow birch in northern Wisconsin and silver maple, green ash, and eastern cottonwood, in southern Wisconsin.Coniferous forested wetlands are dominated by different species depending on the pH and water source of the wetland (Eggers and Reed, 1997). Northern white cedars dominate where soils are fertile and have an alkaline to neutral pH. Tamarack and black spruce dominate in nutrient-poor acidic soils, though tamarack can also grow in more basic soils.

A variety of herbaceous species can occur in the understory of all forested wetland types. In the understory of floodplain forests, jewelweed and nettles can be common, though the scouring action of flooding can limit any understory. In coniferous swamps and bogs, sedges, ferns, and forbs dominate. The extent of herbaceous understory also depends on the understory species' tolerance of shade.

Scrub/shrub wetlands are dominated by deciduous shrubs such as red-osier dogwood, gray dogwood, meadowsweet, and several species of willow. Native herbaceous species present in the understory include Canada bluejoint, tussock sedge, joe-pye weed, giant goldenrod, and other species common to sedge meadows. In disturbed scrub/shrub wetlands, reed canary grass can dominate the understory.

3.7.1.2 Herptiles, Birds and Mammals

Herptiles of forested and scrub/shrub wetlands

A variety of herptiles use scrub/shrub wetlands including frogs, snakes, turtles, and salamanders. The woody vegetation that characterizes forested and scrub/shrub wetlands provide needed cover and habitat for some species. Herptiles ranked as Species of Greatest Conservation Need (SGCN) by the Wisconsin DNR associated with forested and scrub/shrub wetlands include the four-toed salamander, and pickerel frog.

Birds of forested and scrub/shrub wetlands

Forested and scrub/shrub wetlands also provide important habitat to many species of birds. Forested wetlands can contain tree species not common elsewhere, providing unique habitat for birds. Further, trees can be stunted due to saturation and soil conditions, providing even more unique habitat. Numerous passerines, shorebirds, waterfowl, and raptors ranked as SGCNs are associated with forested wetlands.

Because scrub/shrub wetlands can act as a transition between open, herbaceous wetlands and forested wetlands, a wide variety of birds also use this community type. SGCNs such as the American woodcock, black-billed cuckoo, golden-winged warbler, veery, and willow flycatcher all rely on scrub/shrub wetlands for habitat.

Mammals of forested and scrub/shrub wetlands

Again, similarly to herptiles and birds, a variety of mammals use these community types because of their increased cover due to being dominated by woody vegetation. Many species of rodents and furbearers inhabit these wetlands types as they can receive additional protection from predators. In the winter, scrub/shrub wetlands can be important habitat for eastern cottontails and white-tailed deer. Scrub/shrub wetlands may also be used by Franklin's Ground Squirrel, a species of special concern.

3.7.2 Functional values of forested and scrub/shrub wetlands

As previously mentioned, scrub/shrub wetlands can act as a transition zone between open wetlands and forested wetlands. Scrub/shrub wetlands can provide additional habitat to species that normally concentrate in either of these other wetland types (forested or open wetlands). Depending on the location and size of the scrub/shrub wetland, it can provide flood attenuation and water quality improvement to the entire watershed. The same is true for forested wetlands. The tree canopy can provide an added layer of wildlife habitat not found in other wetland types and can help reduce runoff and flooding by intercepting and slowing rainfall.

3.8 Open wetlands (including calcareous fens)

Open wetlands are any wetlands dominated by herbaceous plant species. A variety of wetland communities make up open wetlands. They can be differentiated by vegetation, water chemistry, and water level. Open wetland types include open water, emergent marsh, and southern sedge meadow. Less common wetland types include wet prairies and calcareous fens.

Sedge meadows and wet prairies are dominated by grasses and sedges. Fens support grasses, sedges, and a diversity of other herbaceous plants. Emergent marshes occur along the edges of lakes and streams, and are characterized by emergent and submergent vegetation.

3.8.1 Description and locations of open wetlands

Wet meadows are nutrient rich systems dominated by a variety of herbaceous species (wet meadows and sedge meadows are similar, for the department's purposes of this EIS, they are referred to as wet meadows). Calcareous fens are fed by nutrient-rich groundwater while bogs are fed by nutrient poor rainwater. Both are dominated by gramminoids and forbs. Emergent marsh and open water wetlands are wetter, often containing standing water up to six feet with higher level of nutrients. They are dominated by submergent and emergent vegetation. Wet meadows, fens, and open bogs, are often located in depressions with less standing water.

3.8.2 Flora and fauna of open wetlands

3.8.2.1 Flora of open wetlands

The flora of open wetlands can be separated by plant species' nutrient and water level tolerance. Southern sedge meadows are dominated by terrestrial to emergent gramminoids (grasses, sedges, and rushes) and forbs that can tolerate moderate to high nutrient inputs. Tussock sedge, Canada bluejoint grass, and joe-pye weed are all common wet meadow species.

Fens also contain both gramminoids and forbs, typically terrestrial species, but these species must be able to tolerate low nutrients and high mineral levels. This is due to the fen's primary water source being groundwater-fed springs which contain high levels of calcium and magnesium. Because of this uncommon water source, fens are the rarest wetland type in Wisconsin. Typical calciphiles (calcium-tolerant plants) that thrive in fens include sterile sedge, Ohio goldenrod, and lesser fringed gentian.

Bogs receive their water input mostly via rain, which also contains low nutrients, leading to species that again must tolerate low nutrients and alkaline conditions. Sphagnum moss often dominates the saturated surface of bogs. Other representative species include cottongrass, sundew, pitcher plants, and a variety of ericaceous shrubs.

Emergent and open water wetlands contain grasses and forbs, which can tolerate higher water levels. Both submergent species, which live under water, and emergent species, which root in the bed of waterways but can grow out of the water. Common submergent plants include pondweeds, milfoils, coontail. Typical emergent plants include cattail, bulrushes, giant reed, and bur reed.

3.8.2.2 Herptiles, Birds and Mammals of open wetlands

Herptiles of open wetlands

Open wetlands act as habitat for a variety of reptiles and amphibians. Open wetlands, and wetlands in general, act as an interface between drier habitats and open water. These ecotones provide both wetland and upland habitat needs for these species that use both. Many species of frogs, snakes, and salamanders use open wetlands. Species of greatest conservation need (SGCN) with an affinity for a variety of open wetlands include four-toed salamander, pickerel frog, chorus frog, and Blanchard's cricket frog.

Birds of open wetlands

Many species of birds use open wetlands because they include both terrestrial and aquatic habitats. For emergent and open water wetlands, waterfowl, shorebirds, wading birds, and raptors all use these habitats. SGCNs with an affinity for emergent and open water wetlands include great egrets, whooping cranes, trumpeter swans, and bald eagles. In drier open wetlands, many raptors, wading birds, and shorebirds all utilize these systems. SGCNs that use southern sedge meadows include black rail, American bittern, and northern harrier.

Mammals of open wetlands

Similarly to other taxa previously mentioned, many mammal species also utilize open wetlands. Furbearers such as beaver, otter, mink, almost exclusively use open wetlands, while many rodents, ungulates, and larger mammals use wet meadow wetlands, especially in winter.

3.8.3 Functional values of open wetlands

Open wetlands provide a wide range of functions such as wildlife habitat, water quality improvement, flood abatement. Because of the wide-range of water levels contained in open wetlands, their functional values are widespread. Open wetlands adjacent to waterways provide water quality treatment by trapping sediments, nutrients, and toxins, cleaning water as it flows downstream. Similarly, riparian wetlands hold pulses of floodwater, lessening the threat of flooding downstream. Riparian open-water and emergent open wetlands provide wildlife habitat, for many species of birds and mammals. Finally, drier open wetlands, such as wet meadows, fens, and bogs, also provide similar ecosystem functions.

3.9 Upland Forests

3.9.1 Description and locations of upland forests

The project area and greater Southeast Glacial Plains Ecological Landscape is known to support bur oak openings of global significance (Wildlife Action Plan 2005-2015).

Wisconsin's southern forest communities occur south and west of the climatic Tension Zone - the approximate area where vegetative communities change from the prairie, savanna, oak and mixed hardwood forests of the south to the mixed deciduous-coniferous forests of the north. Common upland forest communities south of the Tension Zone and which have been documented in this study area include southern dry forest, southern dry-mesic forest, and southern mesic forest. Less common upland forest communities include oak openings.

Southern Wisconsin's landscapes have changed greatly during the past 150 years. The loss of forested land has been widespread in areas suitable for agriculture and residential development. Another major change occurred as the open landscapes of prairie and savanna succeeded to closed canopy forest following the exclusion of periodic fires. In many areas, canopy composition is now shifting from oak dominance to shade-tolerant mesic hardwoods, primarily due to the absence of fire disturbances. Land use and ownership patterns have resulted in significant forest fragmentation throughout southern Wisconsin, highlighting the ecological significance of the few remaining large forested blocks, particularly those along major river corridors.

Southern Dry Forest

Oaks are the dominant species in this upland forest community of dry sites. White oak and black oak are dominant, often with admixtures of northern red and bur oaks and black cherry. In the well-developed shrub layer, brambles (Rubus spp.), gray dogwood, and American hazelnut are common. The most important sites exist in the Kettle Moraine State Forest and vicinity.

Southern Dry-mesic Forest

Red oak is a common dominant tree of this upland forest community type. White oak, basswood, sugar and red maples, white ash, shagbark hickory, and black cherry are also important. The herbaceous understory flora is diverse and includes many species listed under southern dry forest. Significant patches of the community type exist in the Southern (Walworth, Jefferson, and Waukesha Counties) Unit of the Kettle Moraine State Forest. Examples of this community type are found at Cudahy Woods State Natural Area and Fall Park Woods (Milwaukee County), Bishop's Woods and Muskego Park Hardwoods (Waukesha County), Silver Lake Bog State Natural Area (Kenosha County), and Sander's Park Hardwoods State Natural Area (Racine County). River corridors offer the best opportunities to develop forest connectivity.

Southern Mesic Forest

This upland forest community occurs on rich, well-drained loamy soils, mostly on glacial till plains or loess-capped sites south of the tension zone. The dominant tree species is sugar maple, but basswood, and near Lake Michigan, American beech may be co-dominant. Many other trees are found in these forests, including those of the walnut family, ironwood, red oak, red maple, white ash, and slippery elm. The understory is typically open, or sometimes brushy. Historically, southern mesic forests were quite common throughout southern Wisconsin. This type has been severely reduced from its past extent.

Oak Opening

This is an oak-dominated savanna community in which there is less than 50% tree canopy coverage. Historically, oak openings were very abundant and occurred on wet-mesic to dry sites. Today, very few examples of this type exist. The few extant remnants are mostly on drier sites, with the mesic and wet-mesic oak openings almost totally destroyed by conversion to agricultural or residential uses, and by the encroachment of other woody plants due to fire suppression. The Southern Unit of the Kettle Moraine State Forest offers some of the best management and restoration opportunities in the upper Midwest, including Eagle Oak Opening (Waukesha County). Other good examples occur at Lulu Lake State Natural Area (Walworth County).

3.9.2 Flora and fauna (including T/E/SC) of upland forests

3.9.2.1 Flora of upland forests

Upland forests, much like forested wetlands, are typically grouped based on the dominant tree species present, and in southern Wisconsin are dominated by hardwoods. Upland forests in the study area represent a transition from drier, oak dominated sites to more mesic uplands where more mesophytic tree species (central and northern hardwood types) become more prevalent. Drier sites are typically dominated by bur, white and black oaks with scattered shagbark hickory, northern red oak and black cherry. As sites become more mesic, northern red oak is a common dominant tree species, with white oak, basswood, sugar and red maples, white ash, shagbark hickory and black cherry also important. On the mesic end of the spectrum the dominant tree species shifts to sugar maple, with basswood also important, and near Lake Michigan American beech may also be co-dominant. Other trees common in mesic upland forests include walnuts, ironwood, northern red oak, red maple, white ash and slippery elm.

A variety of herbaceous species can occur in the understory of upland forest types. The understory of oak openings commonly feature grasses, legumes, composites and other forbs that are best adapted to light conditions of high filtered shade. Southern dry forests tend to have a more well-developed shrub layer of *Rubus* spp. and gray dogwood while frequent herbaceous species include wild geranium, false Solomon's-seal and rough-leaved sunflower. As sites become more mesic the understory flora is diverse with a mixture of species found on both drier and more moist sites such as jack-in-the-pulpit, large-flowered bellwort, lady fern and tick-trefoils. Mesic sites support fine spring ephemeral displays of trout-lilies, trilliums, violets, bloodroot, blue cohosh and mayapple.

3.9.2.2 Herptiles, Birds and Mammals of upland forests

Herptiles of Upland Forests

A variety of herptiles use upland forests, including snakes, frogs and salamanders. The woody vegetation that characterizes upland forests provides needed cover and habitat for some species. Herptiles ranked as Species of Greatest Conservation Need (SGCN) by the department associated with upland forest types include the four-toed salamander and pickerel frog.

Birds of Upland Forests

Upland forests also provide important habitat to many bird species. Upland forests contain a wide spectrum of tree species across the moisture and shade gradient, thus providing habitat diversity for birds for both migration and breeding purposes. Numerous passerines ranked as SGCNs are associated with upland forests.

Because of the unique transition of forested uplands across drier to more mesic sites, a wide variety of birds use these community types. SGCNs such as brown thrasher, red-headed woodpecker, whip-poor-will, blue-winged warbler, American woodcock, wood thrush, and Acadian flycatcher all rely on forested uplands for habitat.

Mammals of Upland Forests

A variety of mammals use upland forests because of their varied structure and plant diversity, primarily species of woody vegetation. Mammals may rely on woody browse, mast, or the herbaceous understory for food, while others seek cover from forest structure. Many species, including opossum, shrews, moles, bats, chipmunk, voles, mice, fox, coyote, raccoon, weasels, skunks, white-tailed deer, eastern gray and fox squirrels, and eastern cottontails may use upland forests during all or a portion of their life cycle.

3.10 Upland grasslands

3.10.1 Description and locations of upland grasslands

Grasslands are characterized by a lack of trees and tall shrubs and are dominated by grasses, sedges and forbs. Grasslands occur on a wide variety of topography, soil types and moisture regimes - from water-covered peat to the driest sandy soils. The term grassland often refers collectively to several native vegetation community types known as prairie and bracken grassland.

Prairies are located mostly in the southern and western parts of the state and in addition to playing host to more than 400 species of native vascular plants. Prairies have a diverse and specialized fauna, especially among prairie invertebrates, prairie and grassland herptiles and grassland birds.

Tallgrass prairies are among the most decimated and threatened natural communities in the Midwest and the world. Most native prairies found today in Wisconsin are small remnants that are less than 10 acres in size. Very few exceed 50 acres, too small to support a full complement of species that typically inhabit a native prairie ecosystem. Most of the prairies left today are either of the wet or dry types. Mesic prairie, which was the most common type in pre-settlement days, is almost gone now, with only about 100 acres known to exist today. The greater Southeast Glacial Plains and Southern Lake Michigan Coastal Ecological Landscapes are known to support extensive grassland communities of state significance (Wildlife Action Plan 2005-2015).

3.10.2 Flora and fauna (including T/E/SC) of upland grasslands

3.10.2.1 Flora of upland grasslands

The flora of upland grasslands vary dependent on the soil's moisture gradient, but also by composition of grass versus forbs (herbaceous plants). Dry-mesic prairies, for example, are typically found on drier, sandy or loamy soils and are dominated by taller grass species such as big bluestem and Indian grass. As soils become richer, additional grass species appear including little bluestem, needle grass, prairie dropseed and switch grass. As sites grade into more wetland-type soils, grass species such as Canada bluejoint grass and cordgrass along with sedges begin appearing.

The herbaceous component can be quite diverse throughout the spectrum of grassland community types. On dry-mesic prairie sites there are often species that occur in both dry and mesic prairie, including legumes, rattlesnake-master and flowering spurge. More mesic sites can have a stronger percentage of forbs overall, but with many of the same species represented. Common species found in mesic prairies include prairie dock, lead plant, asters, prairie coreopsis, monarda and spiderwort. A wet-mesic prairie tends to be a much more herbaceous dominated grassland community. Including aster and sunflower species, shooting-star, goldenrod species, and culver's root; this community can occur in large wetland complexes with wet prairie, southern sedge meadow, calcareous fend and emergent marsh (i.e., open wetland) communities.

3.10.2.2 Herptiles, Birds and Mammals of upland grasslands

Upland grasslands act as habitat for a variety of herptiles, particularly where one type grades into another to provide a variety of habitats. Many frog, snake, and turtle species use upland grasslands. Species of greatest conservation need (SGCN) that may occur in upland grasslands include pickerel frog and Butler's gartersnake.

Birds

Over 40 grassland bird species breed in Wisconsin. In the last 30 years this group of birds has declined more than any other in North America (UW-Extension 2000). The shrinking populations of grassland birds can be traced primarily to the loss of grassland habitat as row crop acreage has increased. Additionally, the timing and frequency of hay harvesting can impact nesting efforts, destroying nests before the young birds have fledged.

Passerines, waterfowl, shorebirds, wading birds, and raptors all use upland grassland habitats. SGCNs with an affinity for grassland sites across the spectrum include bobolink, Henslow's sparrow, upland sandpiper, and short-eared owl. Other important grassland bird species include Eastern meadowlark, dickcissel, grasshopper sparrow, vesper sparrow, swamp sparrow, and Northern harrier.

Mammals

A variety of mammals use upland grasslands during all or a portion of their life cycle. Many species, including shrews, moles, thirteen-lined ground squirrels, voles, mice, fox, coyote, skunks, and white-tailed deer may be found in upland grasslands. One species of special concern, Franklin's Ground Squirrel, also uses prairie edges.

3.11 Air Quality

The proposed project area is currently in attainment with all National Ambient Air Quality Standards (ozone, $PM_{2.5}$, PM_{10}, sulfur dioxide, nitrogen dioxide, carbon monoxide and lead).

3.12 Census data

3.12.1 Population of data and trends

Waukesha county population more than doubled between 1960 and 2007. This growth is much greater than that in the seven county SEWRPC planning region as a whole. Whereas Waukesha County accounted for only 10 percent of the regional population in 1960, it now represents almost 20 percent (CH2MHill, 2013, Vol. 5). The City of Waukesha has experienced a similar population growth, increasing from 30,000 in 1960 to more than 64,000 in 2000. The rate of growth in the City is expected to decline over the next 25 years, reaching a projected total of 88,500 in 2035 (36 percent increase). Changes in population are based on three variables: birth and death rates, migration into and out of the community, and the ability of a community/town to annex neighboring lands, which increases the size and population. The birth and death rate, or the balance between births and deaths in a given area, is considered a population's "natural increase." According to SEWRPC, the region experienced a population increase of 120,800 people between 1990 and 2000. It is estimated that, of the 120,800 people, 116,900 were attributed to natural increase (SEWRPC, 2004).

Based on *The Economic State of Milwaukee's Inner City: 2006* (Levine and Williams) and numerous SEWRPC technical reports, the general trend over the past 50 years has been an outward population and job migration from larger cities along the lakeshore to outlying towns and counties (SEWRPC, 2004). The reduction in manufacturing jobs in the historically larger cities and the increased economic development within inland areas has reduced jobs in the large lakeshore cities and increased jobs in inland areas.

It is possible for population growth to be constrained by the unavailability of adjacent land for development. Unless a community has the capability to annex adjacent, developable land, it may experience "build-out" or near build-out conditions. Milwaukee, which is bordered by Lake Michigan, is an example of a community facing build-out conditions. Milwaukee has exhibited a population decline, partially because of the lack of available adjacent developable land. On the contrary, the City of Waukesha has developable land that will support population growth.

3.12.2 Age data

Based on the results of the 2010 census, the median age in Waukesha County is 42 (USCB, 2010a). Table 3.7 summarizes age statistics for the state, Waukesha County, and the City of Waukesha.

Table 3-7. Waukesha and Southeastern Wisconsin regional population age statistics for 2010 (Source: USCB 2010a)

Age Group	State of Wisconsin % of Total	Waukesha County % of Total	City of Waukesha % of Total
Under 5 years	6.3	5.5	7.1
5 to 9 years	6.5	6.7	6.8
10 to 14 years	6.6	7.2	6.1
15 to 19 years	7.0	6.8	6.7
20 to 24 years	6.8	4.7	7.8
25 to 29 years	6.5	5.1	8.6
30 to 34 years	6.1	5.2	8.1
35 to 39 years	6.1	6.0	7.0
40 to 44 years	*6.7*	*7.3*	6.7
45 to 49 years	7.7	8.8	7.0
50 to 54 years	7.7	8.8	6.8
55 to 59 years	6.8	7.5	5.8
60 to 64 years	5.5	6.1	5.1
65 to 69 years	4.0	4.2	3.2
70 to 74 years	3.1	3.1	2.2
75 to 79 years	2.5	2.7	1.9
80 to 84 years	2.1	2.2	1.6
85 and over	2.1	2.0	1.7
Median age	**38.5**	**42.0**	**34.2**

3.12.3 Racial data

The UW-Milwaukee's Center for Economic Development (CED) (Rast and Madison, 2010) made a detailed study of socioeconomic factors for SEWRPC's Regional Water Supply Plan. Current data and trends from that study are summarized here.

Within the Southeast Wisconsin region, the number and proportion of non-white has grown over the past five decades. Census data for 1960 indicates that whites constituted about 95 percent of the regional population. By 2007, racial minority populations increased, from less than five percent to nearly 23 percent in the region.

Table 3-7a shows the change in minority populations in the region between 1960 and 2007. In 1960, nearly 91 percent of racial minorities in the region lived in Milwaukee County. Racine and Kenosha counties had 7.6 percent and 1.4 percent of regional minority populations, respectively, while the other counties in the region totaled less than one percent of Non-White population. The Waukesha County Non-White population is projected to almost double by 2035, to almost 17 percent of the total population.

Table 3-7a: Racial Minority Distribution for Southeastern Wisconsin

County	1960				2007			
	Total Population	Non-White Population			Total Population	Non-White Population		
	Number	Number	Percent	Percent[a]	Number	Number	Percent	Percent[a]
Kenosha	100,615	1,090	1.1	1.4	161,254	22,745	14.1	5.0
Milwaukee	1,036,041	66,777	6.4	90.6	951,026	359,791	37.8	79.3
Ozaukee	38,441	46	0.1	<0.1	85,345	3,503	4.1	0.8
Racine	141,781	5,459	3.9	7.6	194,522	34,664	17.8	7.6
Walworth	52,368	230	0.4	0.2	100,140	6,912	6.9	1.5
Washington	46,119	59	0.1	<0.1	126,636	4,089	3.2	0.9
Waukesha	158,249	290	0.2	0.2	376,978	21,854	5.8	4.8
Region	1,573,614	73,951	4.7	100.0	1,995,901	453,558	22.7	100.0

Source: US Census Bureau and American Community Survey for the Year 2007, as reported by UWM 2010
[a] Percent of Regional Non-White Population

As shown in Table 3-7b, the City of Waukesha is predominately White, but racial diversity has risen since 1960. The percent of Non-Whites increased from 0.5 percent in 1960 to almost nine percent in 2000. More than 5,500 Non-White residents moved into the City over the period. The percent increase in Non-Whites is similar to that in other communities in the southeastern Wisconsin region.

Table 3-7b: Racial Minority Distribution for Southeastern Wisconsin in 1960 and 2000 for Selected Communities in Southeastern Wisconsin

Community	1960				2000			
	Total Population	Non-White Population			Total Population	Non-White Population		
	Number	Number	Percent	Percent	Number	Number	Percent	Percent
Kenosha	67,899	1,015	1.5	1.4	90,352	14,786	16.4	3.7
Milwaukee	741,324	65,752	8.9	88.9	596,974	298,595	50.0	74.9
Oak Creek	2,549	7	0.3	0.0	28,456	2,287	8.0	0.6
Port Washington	5,984	8	0.1	0.0	10,467	317	3.0	0.1
Racine	89,144	4,812	5.4	6.5	81,855	25,447	31.1	6.4
Brookfield	19,812	18	0.1	<0.1	38,649	2,242	5.8	0.6
Cedarburg	5,191	2	<0.1	<0.1	10,908	200	1.8	0.1
Elm Grove	4,994	4	0.1	<0.1	6,249	179	2.9	0.0
Germantown	622	0	0	0	18,260	762	4.2	0.2
Grafton	3,748	3	0.1	<0.1	10,312	235	2.3	0.1
Muskego[a]	--	--	--	--	21,397	405	1.9	0.1
New Berlin	15,788	14	0.1	<0.1	38,220	1,589	4.2	0.4
Saukville	1,038	0	0	0	4,068	105	2.6	0.0
Waukesha	30,004	141	0.5	0.2	64,825	5,692	8.8	1.4

Source: US Census Bureau, as reported by UWM 2010
[a]The Village of Muskego was incorporated in 1964.

The City of Milwaukee‘s White population declined by about 56 percent between 1960 and 2000 largely because of Whites moving to suburban communities. The City of Racine likewise experienced a 33 percent decline in its White population. Racine, Milwaukee and Kenosha had the most significant increases in minority populations during this time period. Table 3-7c shows the difference and percent change in racial distributions between 1960 and 2000 for selected communities in the region. Little of the growth in minority populations in suburban areas has been by growth in African-American populations.

Table 3-7c: Difference and Percent Change in Racial Distribution between 1960 to 2000 for Selected Communities in Southeastern Wisconsin

County	Total		White		Black or African American		Other Non-White	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Kenosha	22,769	100	9,075	39.9	5,770	25.3	7,924	34.8
Milwaukee	-144,368	100	-375,387	-260.0	158,312	109.7	72,707	50.4
Oak Creek	19,084	100	16,826	88.2	651	3.4	1,607	8.4
Port Washington	4,380	100	4,027	91.9	46	1.1	307	7.0
Racine	-7,317	100	-27,833	-380.4	11,627	158.9	8,889	121.5
Brookfield	18,995	100	16,927	89.1	258	1.4	1,810	9.5
Cedarburg	5,584	100	5,451	97.6	20	0.4	113	2.0
Elm Grove	1,282	100	1,158	90.3	9	0.7	115	9.0
Germantown	17,638	100	16,876	95.7	247	1.4	515	2.9
Grafton	6,571	100	6,329	96.3	15	0.2	226	3.4
Muskego[a]	--	--	--	--	--	--	--	--
New Berlin	22,574	100	20,930	92.7	189	0.8	1,455	6.5
Saukville	3,116	100	2,940	94.4	50	1.6	124	4.0
Waukesha	34,368	100	29,180	84.9	639	1.9	4,549	13.2

Source: US Census Bureau as reported by UWM 2010
[a] The Village of Muskego was incorporated in 1964.

CED projects that between 2000 and 2035, the regional population will continue to grow by about 18.5 percent (see Table 3-7d). All counties in the region are expected to increase in population and proportions of minority populations are also expected to continue to increase. By 2035, CED estimates that the minority population in the region will increase from 23.5 to about 36.8 percent of the total population due to mostly by increases in the Hispanic population.

Table 3-7d: Year 2035 Population Projections by Race and Ethnicity Within the Region

County	Total Population	Non-Hispanic Population								Hispanic Population[b]	
		White Alone		Black Alone		Asian Alone		Other[a]			
	Number	Number	%	Number	%	Number	%	Number	%	Number	%
Kenosha	213,886	146,646	68.6	18,611	8.7	5,374	2.5	4,351	2.0	38,904	18.2
Milwaukee	1,012,538	442,183	43.7	268,916	26.6	47,201	4.7	32,534	3.2	221,703	21.9
Ozaukee	98,922	86,238	87.2	2,543	2.6	2,958	3.0	2,374	2.4	4,809	4.9
Racine	234,467	159,866	68.2	21,289	9.1	3,152	1.3	6,668	2.8	43,492	18.5
Walworth	122,275	97,398	79.7	1,110	0.9	2,063	1.7	2,900	2.4	18,805	15.4
Washington	162,462	145,711	89.7	3,019	1.9	2,551	1.6	3,547	2.2	7,634	4.7
Waukesha	445,569	370,199	83.1	14,465	3.2	19,727	4.4	7,440	1.7	33,737	7.6
Region	2,290,118	1,448,240	63.2	329,954	14.4	83,026	3.6	59,814	2.6	369,084	16.1

Source: US Census Bureau and CED
[a] "Other" represents the aggregated Census data from the following populations; American Indian or Alaska Native Alone, Native Hawaiian and Pacific Islander, Some Other Race Alone, Two or More Races.
[b] Hispanics may be of any race.

CED projects that by 2035 Waukesha County will have the largest total population gain in the region and increase of 23.5 percent over the 2000 level. Racial and Hispanic population growth will amount to 64.3 percent of this projected growth. The total minority population of Waukesha County is expected to increase to 16.9 percent of population in 2035. The population of Milwaukee County is anticipated to net the second greatest population gain, an increase of

72,374 people, or about 7.7 percent. CED's analysis is that the White Alone, Non-Hispanic population in Milwaukee County will decline by 24 percent. This is the only projected net loss in any racial or ethnic population group within the region.

Selected communities within southeastern Wisconsin were analyzed by CED, and most are expected to increase in population between 2000 and 2035. CED's projection indicates that the population of Non-White Alone racial and ethnic minorities will increase in each of the selected communities. They further predict that the percent of each minority population will continue to increase relative to the White Alone populations over the 35-year period. Hispanic populations are expected to have the most significant increases in each of the selected communities.

As shown in Table 3-7e, CED's model projects that the total population of the City of Waukesha will increase by a little over 25 percent between 2000 and 2035, from 64,825 to about 81,186 people. The greatest portion of this increase is anticipated to be the Hispanic population. The White Alone, Non-Hispanic population is projected to continue to decline, which would be a new pattern since this group has not experienced a decline over the past 50 years.

The combined minority population is projected by CED to account for all of the population growth in Waukesha. Non-White, Non-Hispanic racial minorities are expected to increase from 1.2 to 5.7 percent of the City's population, the Asian population increasing from 2.1 to 7.5 percent, and the aggregated "Other"‖ population increasing from 1.4 to 2.8 percent. The greatest increase will be in the Hispanic population with an increase, from 8.6 to 26.6 percent of the population.

Table 3-7e: Population by Race and Ethnicity for the City of Waukesha

Population by Race and Ethnicity	2000		Projected 2035		Change		Percent of Change
	Number	Percent	Number	Percent	Number	Percent	
Total Population	64,825	100.0	81,186	100.0	16,361	25.2	100.0
Non-Hispanic Population	59,262	91.4	59,618	73.4	356	0.6	2.2
White Alone	56,191	86.7	46,539	57.3	-9,652	-17.2	-59.0
Black Alone	797	1.2	4,644	5.7	3,847	482.7	23.5
Asian Alone	1,389	2.1	6,127	7.5	4,738	341.1	29.0
Other[a]	885	1.4	2,308	2.8	1,423	160.7	8.7
Hispanic Population[b]	5,563	8.6	21,568	26.6	16,005	287.7	97.8

Source: US Census Bureau and CED
[a] "Other" represents the aggregated Census data from the following populations; American Indian or Alaska Native Alone, Native Hawaiian and Pacific Islander, Some Other Race Alone, Two or More Races.
[b] Hispanics may be of any race.

3.12.4 Health and disabilities

In 2000 the national average of persons reporting one or more disabilities was 19.3 percent (UWM, 2010). Wisconsin reported a lower percentage at 14.7 percent of the state's population. Waukesha County provided an even lower percentage than the national and state average, with only 10.8 percent of the population reporting one or more disabilities. The City of Waukesha was slightly higher than the state average, with 14.9 percent of the population reporting one or more disabilities.

3.13 Economy

There has been a historic trend toward decentralization of jobs from the urban centers to the outlying counties in the region between 1960 and 2000. Tables 3-7f and 3-7g show job growth patterns for southeastern Wisconsin counties.

Table 3-7f: Job Distribution for Southeastern Wisconsin

County	1960		1970		1980		1990		2000	
	Jobs	%	Jobs	%	Jobs	%	Jobs	%	Jobs	%
Kenosha	42,200	6.3	42,100	5.4	54,100	5.7	52,200	4.6	68,700	5.6
Milwaukee	503,300	74.8	525,200	66.9	583,200	61.5	609,800	53.3	624,600	51.1
Ozaukee	10,200	1.5	21,300	2.7	28,200	3.0	35,300	3.1	50,800	4.2
Racine	49,900	7.4	64,600	8.2	81,200	8.6	89,600	7.8	94,400	7.7
Walworth	19,600	2.9	26,400	3.4	33,500	3.5	39,900	3.5	51,800	4.2
Washington	15,200	2.3	24,300	3.1	35,200	3.7	46,100	4.0	61,700	5.0
Waukesha	32,600	4.8	81,000	10.3	132,800	14.0	189,700	16.6	270,800	22.1
Region	673,000	100.0	784,900	100.0	948,200	100.0	1,143,700	100.0	1,222,800	100.0

Source: Bureau of Labor Statistics and the US Census Bureau as reported by UWM, 2010

Table 3-7g: Job Growth in Southeastern Wisconsin

County	1960	2000	1960 to 2000		
			Change	Percent	Compound Annual Growth Rate
Kenosha	42,200	68,700	26,500	62.8	1.23
Milwaukee	503,300	624,600	121,300	24.1	0.54
Ozaukee	10,200	50,800	40,600	398.0	4.10
Racine	49,900	94,400	44,500	89.2	1.61
Walworth	19,600	51,800	32,200	164.3	2.46
Washington	15,200	61,700	46,500	305.9	3.56
Waukesha	32,600	270,800	238,200	730.7	5.44
Region	673,000	1,222,800	549,800	81.7	1.50

Source: Bureau of Labor Statistics and the US Census Bureau

The economy in Waukesha County also has grown over the last 20 years. Economic growth in the City of Waukesha has been much greater than the overall southeastern Wisconsin region, increasing from nearly five percent of the total in 1960 to more than 22 percent in 2000 (Table 3.8). This is consistent with the regional trend of employment migration from the urban areas to the more suburban areas and the shift from manufacturing to service sector jobs in the southeastern Wisconsin region.

Table 3-8. Waukesha and regional economy (Source: Bureau of Labor Statistics and the US Census Bureau as reported in UWM 2010)

	1960		1970		1980		1990		2000	
	Jobs	%	Jobs	%	Jobs	%	Jobs	%	Jobs	%
Waukesha	32,600	4.8	81,000	10.3	132,800	14	189,700	16.6	270,800	22.1
SE Wisconsin	673,000	100	784,900	100	948,200	100	1,143,700	100	1,222,800	100

SEWRPC has developed long-term economic and jobs projections for southeastern Wisconsin. The most recent projections are in Planning Report No. 48 *A Regional Land Use Plan for Southeastern Wisconsin: 2035* (SEWRPC, 2006). The most recent projections were developed for the planning year 2035 (see Table 3-8a).

Table 3-8a: Projected Jobs Distribution for Southeastern Wisconsin

County	2003		Projected Jobs			
	Jobs	Percent of Regional Jobs	2035	Change (2000 – 2035)	Percent Change	Percent of Regional Jobs
Kenosha	69,500	5.9	88,500	19,000	27.3	6.5
Milwaukee	589,800	50.0	628,900	39,100	6.6	46.0
Ozaukee	49,200	4.2	62,300	13,100	26.6	4.6
Racine	90,000	7.6	106,600	16,600	18.4	7.8
Walworth	52,300	4.4	69,400	17,100	32.7	5.1
Washington	61,800	5.2	78,900	17,100	27.7	5.8
Waukesha	266,400	22.6	333,700	67,300	25.3	24.4
Region	1,179,000	100.0	1,368,300	189,300	16.1	100.0

Source: SEWRPC and US Bureau of Economic Analysis

The economy in Waukesha County is projected to increase by 67,000 jobs, or 25 percent, by 2035. This is considerably higher than for Milwaukee County (seven percent increase) but similar to the surrounding counties.

Much of the industry in the southeastern Wisconsin region is considered to be water-intensive, but many large industrial water users rely on private high-capacity groundwater wells rather than municipal water. A review of the large businesses in Waukesha County indicates there are no known major water-intensive businesses or industries using municipal supplies (UWM, 2010, p.15).

SEWRPC also developed job projections for each urbanized service area under the Regional Water Supply Plan. Table 3-8b shows population and job predictions for each selected water utility service area for 2000 and 2035. Each utility service, except Milwaukee Water Works is expected to have some job growth. The Milwaukee Water Works service area is not anticipated to expand over this period.

Table 3-8b: Existing and Forecast Population for Selected Water Service Areas

Community	2000			2035		
	Population	Jobs	Jobs Per 100 Persons	Population	Jobs	Jobs Per 100 Persons
Kenosha Water Utility	98,700	45,269	45.9	105,100	48,693	46.3
Milwaukee Water Works	650,750	410,929	63.1	664,550	404,650	60.9
City of Oak Creek Water and Sewer Utility	26,000	19,916	76.6	50,850	28,349	55.8
City of Port Washington Water Utility	10,600	7,092	66.9	15,000	8,933	59.6
City of Racine Water and Wastewater Utility	103,800	58,601	56.5	113,500	59,644	52.5
City of Brookfield Municipal Water Utility and Village of Elm Grove[a]	30,249	34,772	115.0	51,600	50,711	98.3
City of Cedarburg Light and Water Commission	11,250	8,120	72.2	14,900	8,754	58.8
Village of Germantown Water Utility	15,050	10,545	70.1	23,450	18,071	77.1
Village of Grafton Water and Wastewater Commission	10,500	8,473	80.7	16,450	12,662	77.0
City of Muskego Public Water Utility	7,800	4,344	55.7	28,650	8,068	28.2
City of New Berlin Water Utility	30,100	24,237	80.5	41,300	33,058	80.0
Village of Saukville Municipal Water Utility	4,150	3,306	79.7	5,650	5,245	92.8
City of Waukesha Water Utility	65,000	51,792	79.7	88,500	58,196	65.8

Source: SEWRPC and CED

[a] Based on the analysis methodology, SEWRPC combines forecast jobs data for the Village of Elm Grove with the City of Brookfield Municipal Water Utility. Job estimates are based on both the City of Brookfield Municipal Water Utility and the Village of Elm Grove sewer service area. The year 2000 population projections include the estimate of 24,000 people served by the City of Brookfield Municipal Water Utility and the estimated population of the Village of Elm Grove served by municipal sewer, or 6,249 people.

There has been a widening gap in median household income between the counties over the past 50 years. In 1960, the median income in five of the seven counties was relatively similar, but by 2008 this gap had grown to 40 percent. Table 3-8c shows this increase. Waukesha County had the highest median household income in the region in 2008.

Table 3-8c: Historic Median Household Income for Southeastern Wisconsin (Median Income Adjusted to Reflect 2008 Dollars)

County	1960	1970	1980	1990	2000	2008
Kenosha	50,305	57,599	52,477	50,470	60,701	54,464
Milwaukee	50,691	60,929	47,351	45,906	49,238	45,091
Ozaukee	52,022	70,029	66,770	70,332	81,088	73,186
Racine	48,894	60,862	54,725	53,951	54,354	54,241
Walworth	41,402	53,754	45,613	49,988	59,802	55,988
Washington	45,163	62,566	57,455	63,308	73,706	65,061
Waukesha	52,298	71,000	67,483	73,412	81,209	74,688

Note:Data from Table 4-I. Dollars are adjusted to 2008 dollars based on the Consumer Price Index.
Source: US Census Bureau and American Community Survey as reported by UWM 2010

An estimate of the ranges in household incomes provides information about the distribution of household incomes and provides an assessment of low-income households in each county. This data is shown in Table 3-8d. In 2008, Ozaukee, Washington, and Waukesha Counties had the lowest percentages of households with annual incomes under $10,000.

Table 3-8d: 2000 Annual Household Income Ranges for Southeastern Wisconsin

County	Numbers of Households						
	Less than $10,000	$10,000 to $14,999	$15,000 to $24,999	$25,000 to $34,999	$35,000 to $49,999	$50,000 to $74,999	Over $75,000
Kenosha	3,554	2,926	6,896	6,957	9,300	12,959	13,501
Milwaukee	40,098	25,500	54,013	53,352	66,510	72,565	65,945
Ozaukee	837	881	2,453	2,850	4,360	7,324	12,182
Racine	4,423	3,643	8,428	8,453	11,812	17,196	16,841
Walworth	2,106	2,024	3,913	4,459	6,256	8,307	7,450
Washington	1,479	1,414	3,494	4,642	7,298	12,255	13,328
Waukesha	3,698	4,416	9,696	12,097	19,686	33,478	52,379
Region	56,195	40,804	88,893	92,810	125,222	164,084	181,626

County	Percent of Households						
	Less than $10,000	$10,000 to $14,999	$15,000 to $24,999	$25,000 to $34,999	$35,000 to $49,999	$50,000 to $74,999	Over $75,000
Kenosha	6.3	5.2	12.3	12.4	16.6	23.1	24.1
Milwaukee	10.6	6.7	14.3	14.1	17.6	19.2	17.4
Ozaukee	2.7	2.9	7.9	9.2	14.1	23.7	39.4
Racine	6.2	5.1	11.9	11.9	16.7	24.3	23.8
Walworth	6.1	5.9	11.3	12.9	18.1	24.1	21.6
Washington	3.4	3.2	8.0	10.6	16.6	27.9	30.4
Waukesha	2.7	3.3	7.2	8.9	14.5	24.7	38.7
Region	7.5	5.4	11.9	12.4	16.7	21.9	24.2

Source: US Census Bureau as reported by UWM 2010

Table 3-8e shows, among selected communities in the region, that there has been a widening gap in median incomes over the past 50 years. Other than Brookfield and New Berlin, in 1960 median income in most of the communities was similar. By 2008, four of the smaller suburban communities for which data are available had higher incomes than Kenosha, Milwaukee, Racine, and Waukesha.

Table 3-8e: Historic Median Household Income for Selected Communities in Southeastern Wisconsin (Reported Median Income)

Community	1960	1970	1980	1990	2000	2008
Kenosha	7,035	10,191	18,927	27,770	41,902	46,356
Milwaukee	6,664	10,262	16,028	23,627	32,216	37,022
Oak Creek	6,984	11,715	23,413	39,995	53,779	69,304
Port Washington	6,801	11,465	21,914	36,515	53,827	NA
Racine	6,758	10,526	18,437	26,540	37,164	40,976
Brookfield	8,909	16,052	32,159	57,132	76,225	89,361
Cedarburg	6,729	12,521	22,716	38,322	56,431	NA
Elm Grove	NA	21,969	38,922	66,852	86,212	NA
Germantown	NA	13,128	25,314	43,486	60,742	NA
Grafton	6,980	12,669	23,647	40,596	53,918	NA
Muskego	NA	12,581	25,648	46,119	64,247	82,327
New Berlin	7,503	13,185	28,547	49,394	67,576	77,299
Saukville	NA	NA	22,264	34,461	53,159	NA
Waukesha	6,779	11,547	21,175	36,192	50,084	55,157

Note: 1960 and 1970 Census reports Median Family Income not Median Household Income. 2008 ACS estimates are not available for communities under 25,000 people (Cedarburg, Elm Grove, Germantown, Grafton, Port Washington,

and Saukville).
Source: US Census Bureau and American Community Survey s reported by UWM 2010

Between 1970 and 2000, poverty levels in southeastern Wisconsin counties have fluctuated (see Table 3-8f).

Table 3-8f: Population With Incomes At or Below the Poverty Level in Southeastern Wisconsin

County	1970		1980		1990		2000	
	Persons	Percent of Population	Persons	Percent of Population	Persons	Percent of Population	Persons	Percent of Population
Kenosha	8,844	7.5	12,437	10.1	14,613	11.4	11,218	7.5
Milwaukee	95,920	9.1	135,098	14.0	181,303	18.9	143,845	15.3
Ozaukee	2,449	4.5	3,081	4.6	1,602	2.2	2,140	2.6
Racine	12,471	7.3	16,621	9.6	19,779	11.3	15,862	8.4
Walworth	6,535	10.3	8,581	12.0	8,025	10.7	7,876	8.4
Washington	3,383	5.3	6,194	7.3	3,146	3.3	4,230	3.6
Waukesha	9,255	4.0	12,609	4.5	9,751	3.2	9,741	2.7
Region	138,856	7.9	194,621	11.0	238,218	13.2	194,912	10.1

Source: US Census Bureau as reported by UWM 2010

Table 3-8g shows the historic percentage of population living at or below the poverty threshold by county in in the region. The data indicates that all counties share declined somewhat, except that there was an increase in Milwaukee County's share.

Table 3-8g: Percent of Regional Population With Incomes At or Below the Poverty Level in Southeastern Wisconsin

County	1970	1980	1990	2000
Kenosha	6.4	6.4	6.1	5.8
Milwaukee	69.1	69.4	76.1	73.8
Ozaukee	1.8	1.6	0.7	1.1
Racine	9.0	8.5	8.3	8.1
Walworth	4.7	4.4	3.4	4.0
Washington	2.4	3.2	1.3	2.2
Waukesha	6.7	6.5	4.1	5.0
Region	100	100	100	100

Source: US Census Bureau as reported by UWM 2010

3.13.1 Industries

As shown in Table 3.9, the leading industry in Wisconsin shifted from manufacturing in 2000 to educational services by 2010. In Waukesha County, educational services remained the leading industry from 2000 to 2010. Similar to the Wisconsin trend, the City of Waukesha experienced a shift in leading industries, from manufacturing in 2000 to educational services in 2010 (USCB, 2000 and 2010b).

Table 3-9. Employment percentage in leading industries in 2000 and 2010 (Source: 2010 Census (USCB, 2010b), 2000 American Community Survey (USB, 2000))

	Industries										In Labor Force (population 16 yrs & older)	
	Manufacturing		Educational Services		Retail Trade		Recreation & Entertainment		Professional, Scientific & Management			
Geography	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**
Wisconsin	22.2	17.9	20.0	23.0	11.6	11.6	7.3	9.1	6.6	7.9	69.1	68.3
Milwaukee County	18.5	14.3	22.4	27.1	10.4	10.4	7.7	9.6	9.3	10.7	65.4	66.8
City of Milwaukee	18.5	13.6	23.4	27.7	9.9	11.0	8.6	10.4	8.9	11.2	63.9	66.0
Waukesha County	14.1	16.5	19.9	23.3	11.7	12.1	7.9	7.1	9.3	10.6	63.9	70.3
City of Waukesha	22.0	16.6	20.5	22.3	12.0	14.2	6.8	10.7	9.2	9.6	73.2	74.8

As reported by the CED (Rast and Madison, 2010), all commercial and industrial businesses and industries use water but most would not be considered water-intensive users. The most water-intensive industries in southeastern Wisconsin include brewing and bottling manufacturers, mining, thermoelectric power generators, and agriculture. There are also some large food processors and manufacturers in the region that likely rely on large quantities of water.

Many of the largest water users do not rely on the use of municipal water, instead relying on private high-capacity wells. The most intensive water-using industries are those that generate thermoelectric power, and most are located within the Lake Michigan watershed using Lake Michigan water. There are currently no known major water-intensive businesses or industries located within the regional communities that rely on municipal groundwater. All but one of the bottling and brewing/beverage manufacturers in southeastern Wisconsin are in the Lake Michigan basin.

3.13.2 Unemployment

Unemployment throughout the Milwaukee-Waukesha-West Allis Metropolitan Statistical Area has increased over the past decade. In 2005 the annual average unemployment rate was 5.0 percent. For 2010 the annual average unemployment rate had risen to 8.9 percent, before falling to an annual average 6.0 percent for the 2014 the Bureau of Labor Statistics (BLS, 2015).

Waukesha County and the City of Waukesha reported similar unemployment trends over the past decade. The County's annual average unemployment rate in 2005 was 3.8 percent, it had risen to an annual average of 7.3 percent for 2010, and fallen to an annual average of 4.5 percent for 2014 (BLS, 2015). The City of Waukesha's average annual unemployment rate was 4.8 percent for 2005. It had risen to an annual average of 9.2 percent for 2010; and had fallen to an annual average of 4.8 percent for 2014 (BLS, 2015).

A study by CED (Levine, 2002) looked at the impact of this shift on inner city populations in Milwaukee. Unemployment in the inner city was about four times higher than the average for metropolitan Milwaukee. From 1970 to 2000, the inner city population dropped by 45 percent.

3.13.3 Trends

As described in the report *A Socio-Economic Impact Analysis of the Regional Water Supply Plan for Southeastern Wisconsin* (UWM, 2010), Waukesha County experienced an annual increase in jobs from 1960 to 2000 by approximately 5.4 percent. Before 1960, less than five percent of the regional distribution of jobs was from Waukesha County. By 2000, Waukesha County provided 22 percent of the jobs in southeastern Wisconsin. Percent increases and decreases in the number of jobs in a specific area is considered separately from changes in employment and unemployment rates, which are based on the total number of employable persons in an area.

A similar increase was reflected in the historical labor force pattern. Before 1960, most of the regional labor force, about 68 percent, resided in Milwaukee County. Although Milwaukee County's labor force continued to grow through 1990, its share of the regional labor force decreased to 46.5 percent by 2000. Meanwhile, Waukesha County's share of the regional labor force grew from 9.1 percent in 1960 to 19.9 percent in 2000. Waukesha County experienced an average annual growth rate of 3.15 percent from 1960 to 2000, whereas Milwaukee County experienced an annual growth rate of only 0.21 percent.

3.13.4 Tax base

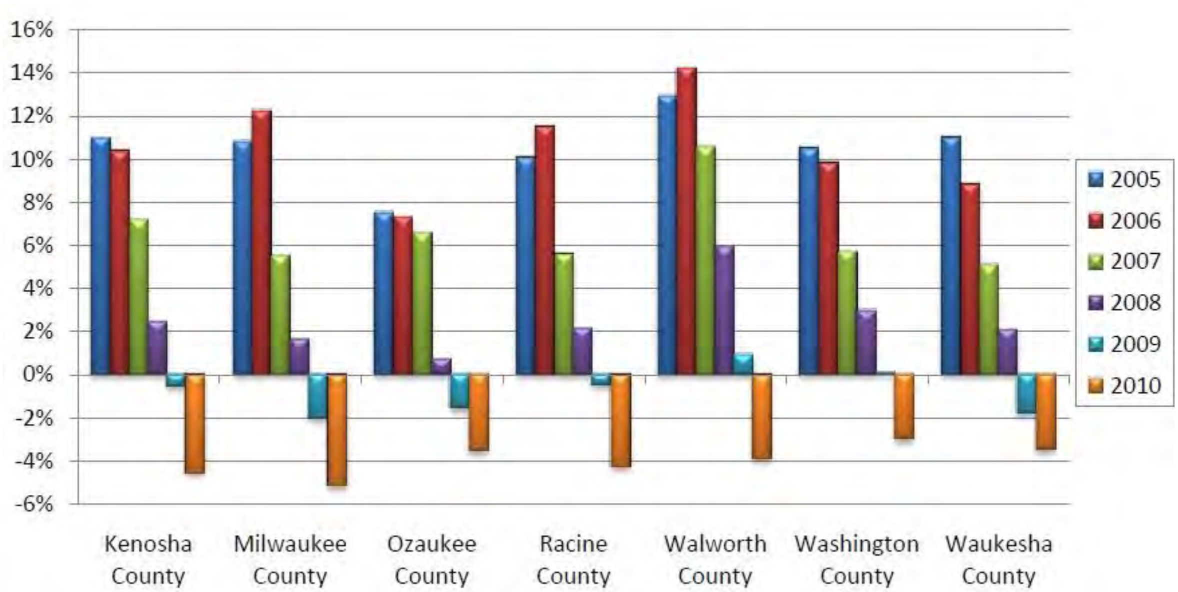
Municipal tax rates (tax base) are based on the total value of all taxable property in a particular municipality. To compare tax bases accurately across multiple municipalities, the State of Wisconsin equalizes assessed values by using tools such as market sales analysis, random appraisals, and local assessors' reports to bring values to a uniform level. Tax base analysis uses equalized values determined by the Wisconsin Department of Revenue. An overview of relevant equalized values for 2010 (Table 3.10) within the seven county region of southeastern Wisconsin, Waukesha County is 28 percent of the tax base (Public Policy Forum, 2011).

Table 3-10. Total equalized value in southeastern Wisconsin 2010 (Source: Public Policy Forum, 2011)

Geography	2010 Total Equalized Value ($)	1 Year % Change in Property Value
Milwaukee County	63,403,508,200	-4.9
City of Milwaukee	29,500,535,100	-5.6
Waukesha County	50,270,294,500	-2.9
City of Waukesha	5,904,933,100	-3.2
SE Wisconsin (7counties)	182,621,628,700	-4.2

In recent years, property values in southeastern Wisconsin have declined by at least three percent in each of the seven counties (Public Policy Forum, 2011). Figure 3.12 provides a visual representation of property value trends in southeast Wisconsin from 2005 to 2010.

Figure 3-12. County aggregate changes in property values: 2005-2010 (Source: Public Policy Forum, 2011)



The Public Policy Forum (2011) reported that the major factors contributing to the decline in property values in southeastern Wisconsin were the economic change in real estate values and the slowed growth of new construction in the region (Table 3.11). The noticeable decline of five percent is believed to be a result of declining property values. New construction is an important criterion in measuring real estate values, as "new construction drives total value growth because as parcels are used more intensively, they generate a higher land utility and thus a higher value" (Public Policy Forum, 2011).

Table 3-11. Changes in aggregate real estate values: 2009-2010 (Source: Public Policy Forum, 2011)

County	2009 Real Estate Value ($USD)	Economic Change ($USD)	New Construction ($USD)	Other Change ($USD)	2010 Real Estate Value ($USD)
Kenosha	14,641,117,700	(885,124,100)	237,637,200	(56,119,800)	13,937,511,000
Milwaukee	64,849,423,300	(3,611,491,400)	398,632,100	(213,156,700)	61,423,407,300
Ozaukee	11,053,112,400	(459,394,700)	89,167,800	(40,538,800)	10,642,346,700
Racine	15,584,722,400	(713,582,400)	69,673,000	(39,075,600)	14,901,737,400
Walworth	15,450,442,800	738,054,200)	134,579,100	1,621,600	14,848,589,300
Washington	13,857,974,100	(512,119,500)	120,946,200	(26,570,000)	13,440,230,800
Waukesha	51,011,477,100	(2,182,165,900)	394,097,100	(37,613,800)	49,185,794,500
SE Wisconsin	**186,448,269,800**	**(9,101,932,200)**	**1,444,732,500**	**(411,453,100)**	**178,379,617,000**
Wisconsin	**499,856,206,900**	**(19,377,213,300)**	**4,575,602,300**	**(1,087,907,700)**	**483,966,688,200**

Table 3-11a shows data from the year 2000 for median housing values and median gross rents selected communities in the region.

Table 3-11a Year 2000 Median Housing Values and Median Gross Rents within the Selected Communities

Community	Median Housing Value	Median Gross Rent
Kenosha	$108,000	$571
Milwaukee	80,400	527
Oak Creek	139,100	704
Port Washington	136,200	624
Racine	83,600	520
Brookfield	189,100	1,014
Cedarburg	179,900	670
Elm Grove	263,900	673
Germantown	169,900	709
Grafton	145,800	625
Muskego	166,700	785
New Berlin	162,100	830
Saukville	135,700	589
Waukesha	139,900	675

Source: US Census Bureau as reported by UWM 2010

3.14 Land use, zoning and transportation

In 2000, there were about 761 square miles of urban land uses in southeast Wisconsin, or 28 percent of the total area of the region. Areas considered “urban” include residential, commercial, industrial, transportation-communication-utility, governmental-institutional, and intensive recreational lands. The largest category of urban land was residential land comprising about 362 square miles, or about 48 percent of all urban land and about 14 percent of the overall area of the region. Sixty three square miles were commercial and industrial lands, or about eight percent of all urban land and about two percent of the region overall. Land used for governmental and institutional purposes covered 34 square miles, or four percent of all urban land and one percent of the region overall. Intensive recreational use lands encompassed about 50 square miles, or seven percent of all urban land and two percent of the region. A total of 201 square miles was used for transportation, communication, and utilities. This included areas used for streets and highways, railways, airports, and utility and communication facilities and covered 26 percent of all urban land and eight percent of the region overall. Unused urban lands encompassed 51 square miles, which was seven percent of all urban land and two percent of the overall area of the region. Land use in the region is shown in Figure 3.13, and is listed in Table 3.12.

Figure 3-13. Land use in the southeast Wisconsin region in 2000 (Source: SEWRPC, 2006)

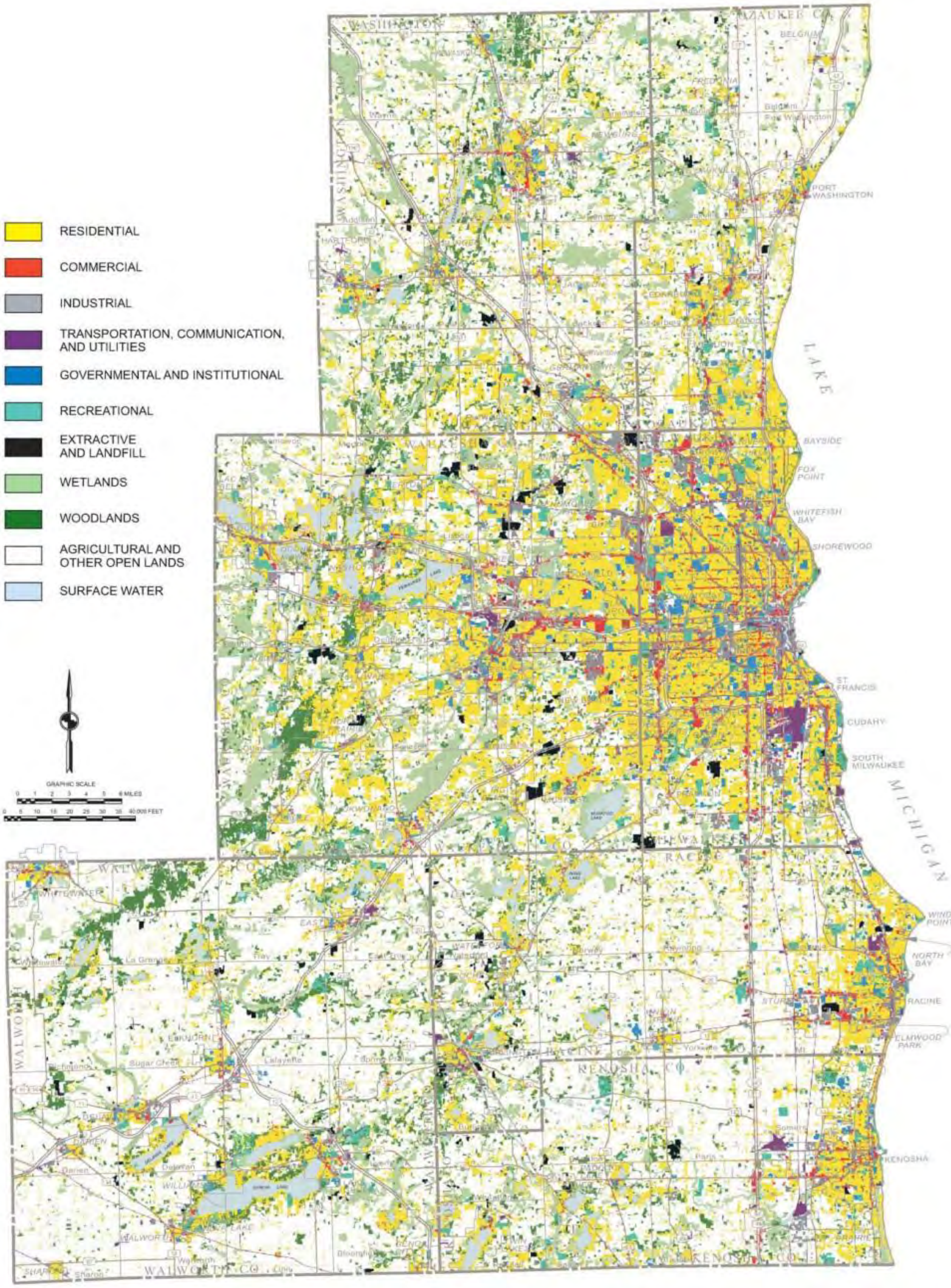


Table 3-12. Land use area in SE Wisconsin region and Waukesha County in 1963 and 2000 (Source: SEWRPC, 2006)

Land Use Category	Region				Waukesha County			
	1963		2000		1963		2000	
	Ac	%	Ac	%	Ac	%	Ac	%
Urban								
Residential	115,170	6.7	231,737	13.5	28,148	7.6	75,221	20.2
Commercial	7,390	0.4	19,397	1.1	1,197	0.3	5,351	1.4
Industrial	8,651	0.5	21,053	1.2	924	0.2	5,525	1.5
Transportation, communication, & utilities	86,366	5.0	128,570	7.5	16,079	4.3	30,001	8.1
Governmental & institutional	13,980	0.8	21,543	1.3	2,550	0.7	4,887	1.3
Recreational	16,669	1.0	32,245	1.9	3,311	0.9	8,253	2.2
Unused urban land	34,895	2.0	32,566	1.9	8,509	2.3	7,806	2.1
Subtotal urban	**283,123**	**16.4**	**487,111**	**28.4**	**60,717**	**16.3**	**137,045**	**36.8**
Non-urban								
Natural areas								
Surface waters	45,794	2.7	49,566	2.9	16,076	4.3	16,892	4.5
Wetlands	175,564	10.2	176,450	10.2	52,588	14.2	52,661	14.2
Woodlands	119,583	6.9	116,905	6.8	31,181	8.4	28,932	7.8
Subtotal natural areas	**340,941**	**19.8**	**342,921**	**19.9**	**99,846**	**26.9**	**98,484**	**26.5**
Agricultural	1,047,740	60.9	806,011	46.8	200,242	53.9	112,611	30.4
Unused rural & other open land	49,378	2.9	85,413	4.9	10,786	2.9	23,397	6.3
Subtotal non-urban	**1,438,059**	**83.6**	**1,234,345**	**71.6**	**310,873**	**83.7**	**234,492**	**63.2**
Totals	**1,721,182**	**100.0**	**1,721,456**	**100.0**	**371,591**	**100.0**	**371,537**	**100.0**

The occupancy and tenure (owner- or renter-occupied) housing stock for the year 2000 is shown in Table 3-12a for selected communities. Several communities in the region have housing policies in place. The Applicant's policy calls for a desirable mix of housing types; 65% single family units and 35% multi-family units.

Table 3-12a Year 2000 Occupancy and Tenure for Households in Selected Communities

Community	Total Housing Units	Occupied Housing Units					Vacant Units	
		Total Occupied Housing Units	Owner Occupied Units		Renter Occupied Units			
			Number	Percent	Number	Percent	Number	Percent
Kenosha	36,162	34,546	21,488	59.4	13,058	36.1	1,616	4.5
Milwaukee	249,215	232,178	105,186	42.2	126,992	51.0	17,037	6.8
Oak Creek	11,897	11,239	6,907	58.1	4,332	36.4	658	5.5
Port Washington	4,225	4,050	2,554	60.4	1,496	35.4	175	4.1
Racine	33,458	31,498	18,977	56.7	12,521	37.4	1,960	5.9
Brookfield	14,246	13,947	12,555	88.1	1,392	9.8	299	2.1
Cedarburg	4,534	4,408	2,831	62.4	1,577	34.8	126	2.8
Elm Grove	2,557	2,444	2,202	86.1	242	9.5	113	4.4
Germantown	7,068	6,898	5,380	76.2	1,518	21.5	170	2.4
Grafton	4,211	4,075	2,870	68.2	1,205	28.6	136	3.2
Muskego	7,694	7,530	6,229	81.0	1,301	16.9	164	2.1
New Berlin	14,939	14,505	11,787	78.9	2,718	18.2	434	2.9
Saukville	1,644	1,585	950	57.8	635	38.6	59	3.6
Waukesha	26,858	25,665	14,480	53.9	11,185	41.6	1,193	4.4

Source: US Census Bureau as reported by UWM, 2010

SEWRPC is the statutorily designated regional planning agency for the southeastern Wisconsin region, and is responsible for making and adopting a master plan for the physical development of the region, including land use, transportation, communications, sewer infrastructure, and this first generation Regional Water Supply Plan. The regional plans that SEWRPC develops are advisory by nature and implementation is based on local or county actions or initiatives.

3.15 Recreation and aesthetic resources

Southeastern Wisconsin Regional Planning Commission Planning Report No. 48, A Regional Land Use Plan for Southeastern Wisconsin: 2035, provides an overview of recreational lands and aesthetic resources in the project area (2006). Land devoted to intensive recreational uses encompassed about 50 square miles, or 7 percent of all urban land and 2 percent of the Region overall. The most important elements of the natural resource base, and features closely related to that base - including wetlands, woodlands, prairies, wildlife habitat, major lakes and streams and associated shorelands and floodlands, and historic, scenic, and recreational sites – when combined result in essentially elongated patterns referred to as "environmental corridors."

"Primary" environmental corridors, which are the longest and widest type of environmental corridor, are generally located along major stream valleys, around major lakes, and along the Kettle Moraine; they encompassed 462 square miles, or 17 percent of the total area of the Region, in 2000.

"Secondary" environmental corridors are generally located along small perennial and intermittent streams; they encompassed 75 square miles, or 3 percent of the Region, in 2000. In addition to the environmental corridors, "isolated natural resource areas," consisting of small pockets of natural resource base elements separated physically from the environmental corridor network, have been identified. Widely scattered throughout the Region, isolated natural resource areas encompassed about 63 square miles, or 2 percent of the Region, in 2000.

Vernon Wildlife Area is a 4,655 acre property (4,154 acres owned and 501 acres leased) located just north of Mukwonago in eastern Waukesha County. The wildlife area provides opportunities for public hunting, fishing, trapping and other outdoor recreation while protecting the qualities of the unique native communities and associated species found on the property. The Vernon Wildlife Area offers many recreational opportunities: birding, boating, canoeing, cross country skiing, dog trial grounds, fishing, hiking, hunting - especially noted for pheasant, snowmobiling, trapping, wild edibles/gathering, and wildlife viewing.

3.16 Archaeological and historical resources

Sites and structures representing all of the recognized prehistoric culture periods are found throughout the area, from Paleo-Indian (ca. 10,000-8000 BC), through Archaic (ca. 8000-500 BC), Woodland (ca. 500 BC-1000 AD), and Oneota (ca. 900-1650 AD). Associated sites include Native American camps, villages, burial and effigy mounds, and more. Historic period sites (ca. 1650-present) include farmsteads, dams, mills, cemeteries, and others. The region's towns and rural roads are dotted with numerous historic homes, businesses, bridges, and other early structures, many used continuously to this day. Whether populated by ancient Indian peoples or more recent arrivals, the area's numerous archaeological sites and historic structures reflect a lengthy record of settlement, as well as intensive utilization of the diverse water, mineral, plant, animal, and other resources characteristic of the region.

3.17 Regional public water supplies and uses

3.17.1 City of Waukesha public water supplies and uses

The Applicant currently obtains approximately 80 percent of its water supply from the confined deep sandstone aquifer. Just east of the City the aquifer is confined by a geological feature—the Maquoketa shale layer—that limits natural recharge of the aquifer. Continued use of the aquifer by the City and surrounding communities since the 19th century and the presence of the Maquoketa shale have led to the decline of 500 feet in aquifer water levels (SEWRPC, 2010, pp. 108, 113). Reductions in groundwater pumping over the last 15 years have resulted in a gradual rebound of the deep confined aquifer by approximately 100 feet. Reduced groundwater levels in southeastern Wisconsin have in turn affected regional surface waters. According to the regional model for southeastern Wisconsin, the volume of deep pumping in 2000 is equivalent to four percent of overall groundwater recharge and has caused a reduction of 6.7% of predevelopment inland baseflow over the 7-county area (Feinstein, et al. 2005). As aquifer water levels rise, the groundwater contribution to surface water will also increase. Significant water quality issues occur with declining water levels in the deep aquifer, including increased levels of salts and radium (a naturally occurring element in the deep aquifer that can cause cancer). As the aquifer water level has risen, radium concentrations have continued to be a problem.

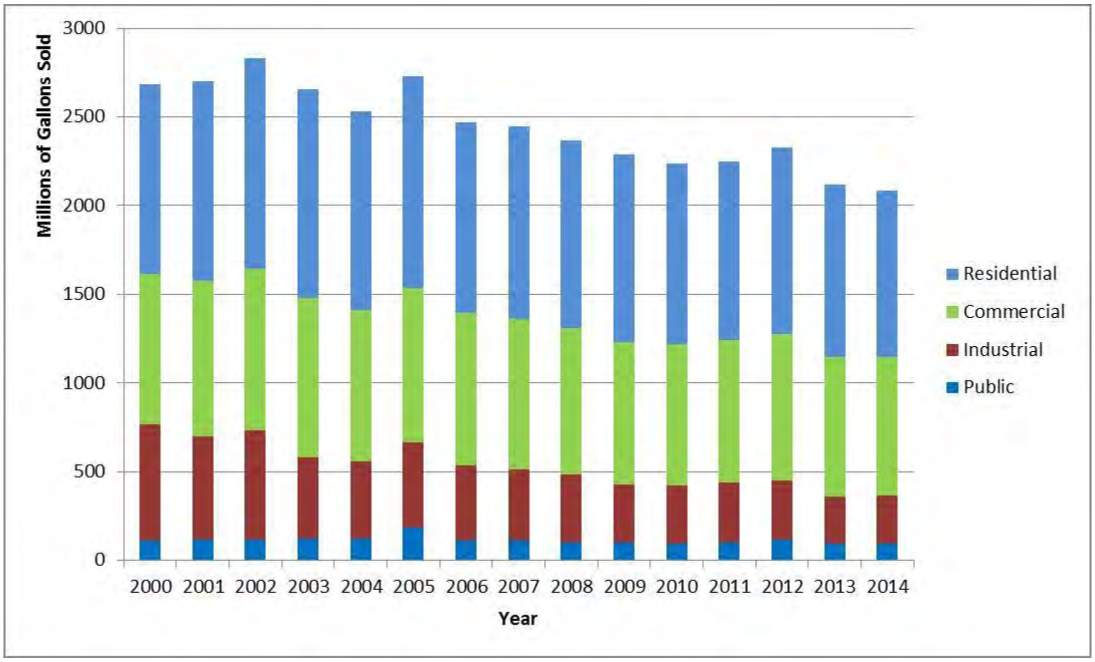
To provide drinking water with low levels of radium, the City treats some deep aquifer water to remove radium and mixes it with radium-free water from the shallow Troy Bedrock aquifer. The City obtains approximately 20 percent of its water supply from the shallow aquifer. Increased pumping of the shallow aquifer will stress surface water resources by reducing baseflows to local streams and wetlands (SEWRPC, 2010).

3.17.1.1 Water use in the City of Waukesha

3.17.1.1.1 Historic water use in Waukesha

Figure 3.14 summarizes water use by customer class and historic water consumption for the period 2000 to 2014. Over this period, total water pumping decreased 20.3 percent.

Figure 3-14. Water Sales by Sector (Source: WPSC)



After the Applicant adopted its 2006 Water Conservation and Protection Plan, additional focus was provided on water use efficiency. While some water use reduction may be attributed to weak economic conditions and seasonal rainfall over the same period, much of the decline can be attributed to decreased water demand resulting from more efficient water use, conservation education, regulation, and incentives. Additional details of historic water use and conservation are included in the Water Supply Service Area Plan (CH2MHill, 2013, Vol. 2).

3.17.1.1.2 Current water use in Waukesha

The Applicant actively tracks water use by customer class for the following:

- *Residential*. Residential water demand typically includes indoor water-using activities, such as those for bathroom, kitchen, and laundry, and outdoor water use, such as lawn irrigation, swimming pools, and car washing. Waukesha's four categories of residential customers were analyzed:

  - Single-family Residential
  - Two-family Residential
  - Three-family Residential
  - Multi-family Residential (multi-family is tracked separately as outlined below)

  For summary purposes, residential water use is measured in accordance with requirements set forth by the Public Service Commission of Wisconsin.

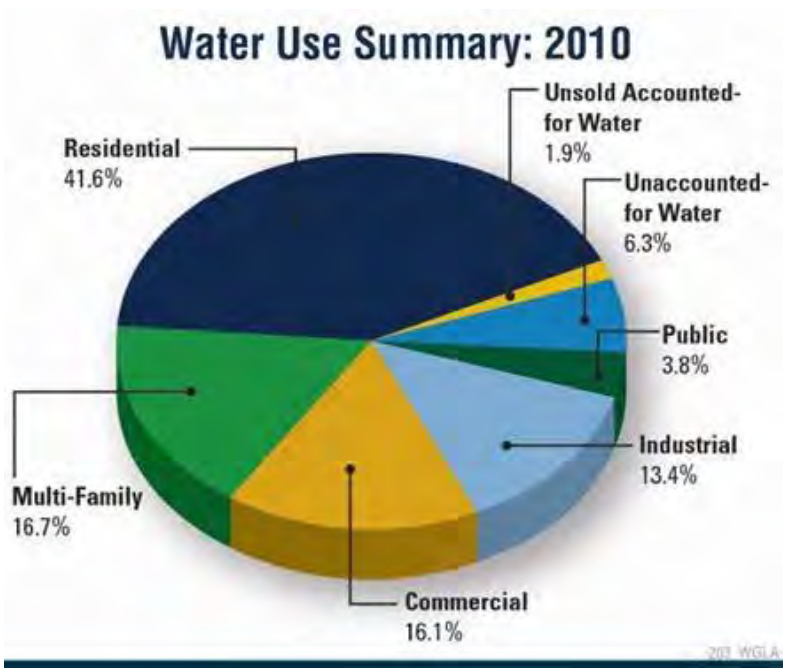
- *Industrial.* Manufacturing, processing, warehouses, foundries, and dairies.
- *Commercial.* Commercial water use is presented by customers such as retail, restaurants, office buildings, medical facilities, and private schools.
- *Public.* Public water use includes water demands for municipal buildings, public facilities, parks, public schools and institutions

- *Unbilled authorized consumption.* Water uses that are measured (or estimated) but not included in sales. Examples of this water use include water used in annual water main flushing to maintain water quality and water used in firefighting exercises.
- *Unaccounted for Water.* From 2000 to 2010 PSC used unaccounted for water to calculate water loss. Unaccounted for water is the difference between total pumpage and total authorized water use.
- *Water loss.* From 2011 on PSC discontinued the use and reporting of 'unaccounted for water' and instead used 'water loss.' PSC defines water loss as water placed into the distribution system that does not find its way to billed customers or unbilled authorized users.

Water use categories aid the utility in effectively managing water, planning for future water demand, and in developing a strategic water conservation plan (CH2MHill, 2012, Vol. 3).

Water use by sector for 2010 is shown in Figure 3.15. Single family and multi-family residential water use accounts for nearly 60 percent of all water use by the Applicant.

Figure 3-15. Water use by customer class for the Waukesha Water Utility



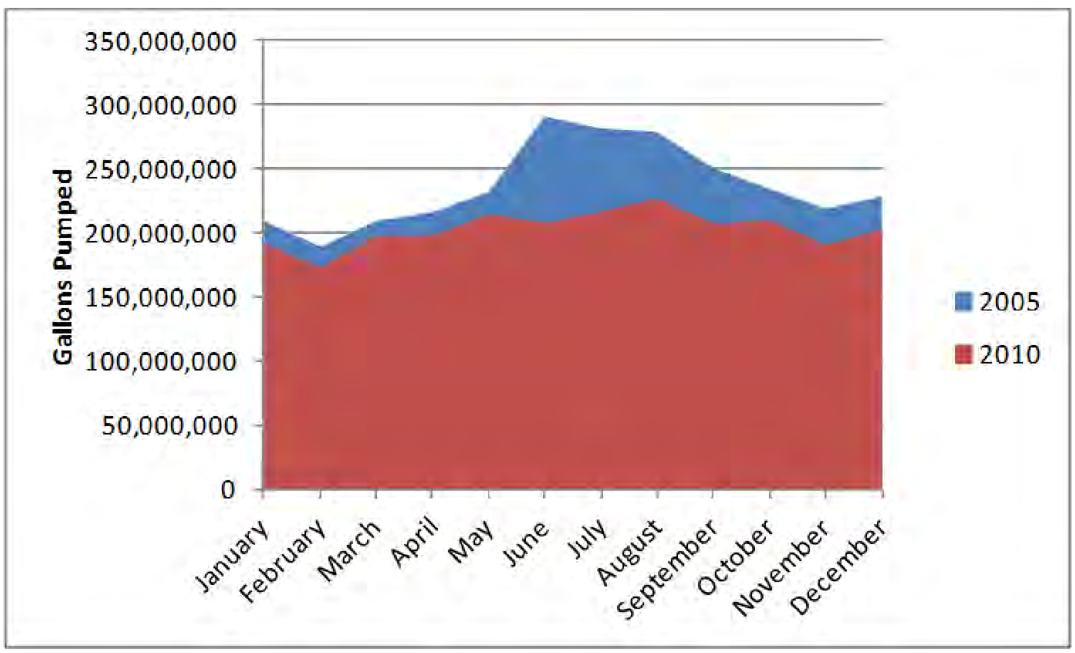
3.17.1.1.2.1 Variations in customer demand

Water demand varies and is typically influenced by several factors including precipitation, temperature, personal income, and community conservation goals. While reductions in water use in wet and cool years or increases in water use associated with higher personal income may be observed, correlating how the factors affect one another is not a straightforward process. Quantification and disaggregation of the effect of variables such as weather (especially temperature and rainfall), and public awareness on water use require extensive data collection and analysis. Results of the City's review of available water use-related data indicating trends that provide insights into long-range water demand forecasts are described below.

3.17.1.1.2.2 Seasonal variation in water use in Waukesha

Seasonal water use patterns provide helpful information regarding the water use in the City's service area. Figure 3.16 presents monthly water use in 2005 (before the 2006 Water Conservation and Protection Plan) and in 2010. In 2006, the City adopted a municipal ordinance restricting lawn and landscape irrigation to no more than 2 days per week between May 1 and October 1. Since Waukesha's water conservation ordinance has been in effect, seasonal peak water demands have declined significantly. The City must plan for a peak pumping season from May through September, but its water demand forecasts for the future assume the City will continue to restrict peak season outdoor water use. Additional information on water conservation can be found in the City of Waukesha Water Conservation Plan (CH2MHill, 2012, Vol. 3).

Figure 3-16. City of Waukesha seasonal water use in 2005 and 2010 (Source: WPSC)

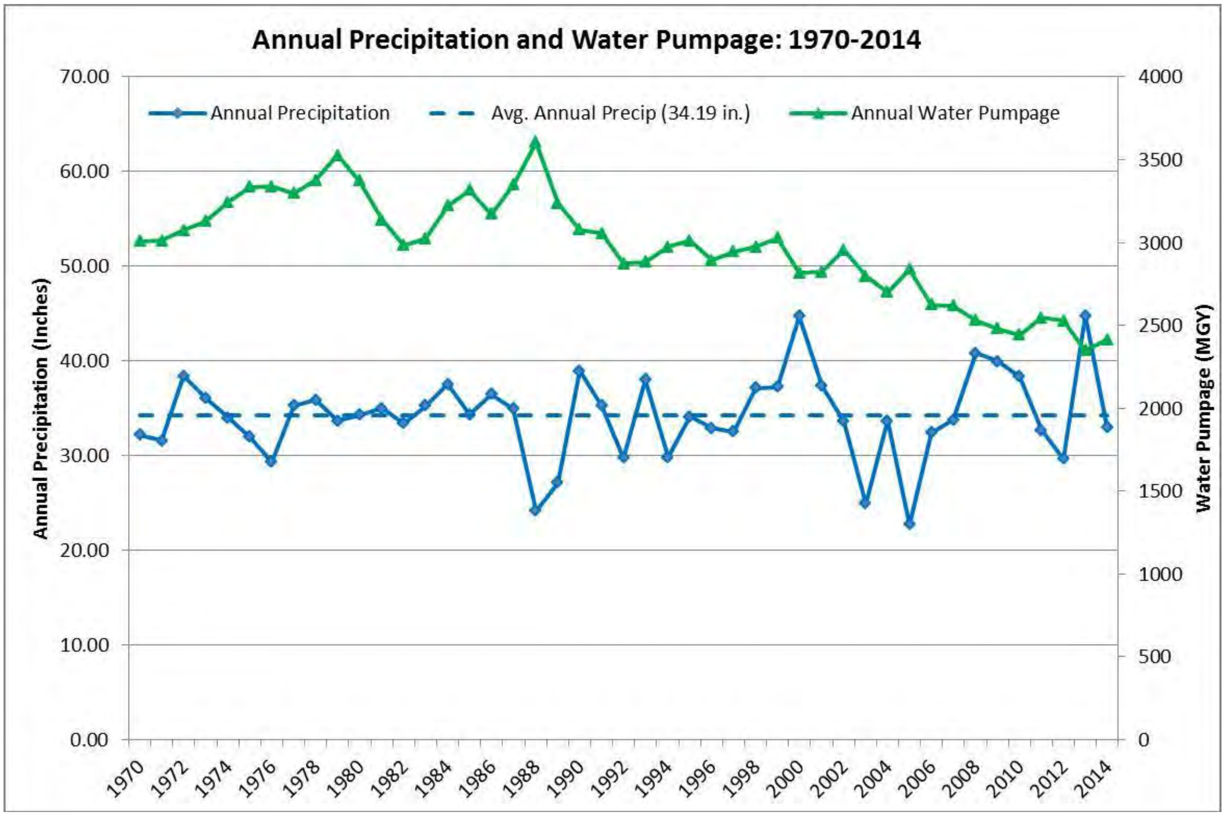


3.17.1.1.2.3 Variation of water use in Waukesha with precipitation

Local climate conditions (such as temperature and wind) and precipitation events (duration, number, and intensity of rainfall and snow) vary widely throughout the year and from year-to year. To some extent, their effect on water use can be observed. In Waukesha, for example, some years that experienced high precipitation correlate with reduced demands, such as 2008 through 2013, as shown in Figure 3-16, while in other years they do not. Figure 3-17 shows a declining trend in the volume of water pumped. The data also illustrate that water demand in the City increases in years of below-average rainfall.

Even though the City receives an average of 34.2 inches of precipitation annually and has implemented a conservation program, it must plan for periods of abnormally dry to moderate drought conditions or high temperatures when water demands may increase or supplies may be constrained. Sound engineering practice and Wisconsin law requires planning for potential droughts to ensure adequate water supply availability to meet essential water needs, such as those for residential sanitation, firefighting, economic stability, system maintenance, and other similar requirements.

Figure 3-17. City of Waukesha Annual Pumping and Precipitation (source: City of Waukesha, WPSC, and National Weather Service)



3.17.1.1.2.4 Variation in daily water use in Waukesha

Table 3.13 summarizes historical variation in average day and maximum day demand over the past 10 years, with the ratio of the annual maximum day to average day water pumpage ranging from a low of 1.29 to 1.66.

Table 3-13. City of Waukesha Maximum and Average Daily Flow, 1999-2010

Year	Average Day Pumpage (MGD)	Max. Day Pumpage (MGD)	Max. Pumpage Date	Ratio of Max. to Ave. Day
2010	6.69	8.65	28-Aug	1.29
2009	6.79	9.35	04-Aug	1.38
2008	6.91	9.93	19-Aug	1.43
2007	7.17	9.79	24-Jul	1.36
2006	7.18	10.23	18-Jul	1.42
2005	7.76	12.87	23-Jun	1.66
2004	7.39	10.48	13-Sep	1.42
2003	7.66	11.67	22-Aug	1.52
2002	8.09	12.78	17-Jul	1.58
2001	7.73	12.53	09-Jul	1.62
2000	7.72	10.15	27-Jun	1.31
1999	8.3	11.59	07-Jul	1.4

Based on the analysis of the City's pumpage data, including review of recent water conservation impacts upon water demand, the maximum day to average day pumping factor used for water system facility design is 1.66. This reflects that, with a 98 percent confidence level, in recent years the actual peak day pumping will be of equal or lesser value (CH2MHill, 2013, Vol. 2). The average to peak ratio appears to be trending downward since 2005, but it is unknown how much of the decrease is due to reliable long-term water use efficiency and how much is due to other factors.

3.17.1.2 Water conservation in the City of Waukesha

Proposed diversions are held to Tier 3 water conservation and efficiency standards of Wis. Admin Code ch. NR 852. These standards require the Applicant to implement all mandatory Conservation and Efficiency Measures (CEM), create a water conservation plan, undertake a CEM analysis prior to applying for a diversion, and provide annual water conservation reporting to the department.

Within its water conservation plan the Applicant identified a number of conservation measures that it has implemented or plans to implement that would result in water savings. These include:

- High efficiency toilet rebates. Customers who replace a pre-1994 high volume (3.5 gallon or more) toilet with a WaterSense High-Efficiency toilet (1.28 gallons/flush) will receive up to a $100 rebate.
- A Lawn sprinkling ordinance which limits lawn watering to twice a week, and limits times to before 9 am or after 5 pm.
- Targeted reductions at municipally owned buildings and school facilities.
- Promoted discounted replacement of spray rinse valves for commercial customers.
- Facilitated major water use reductions with several industrial customers.

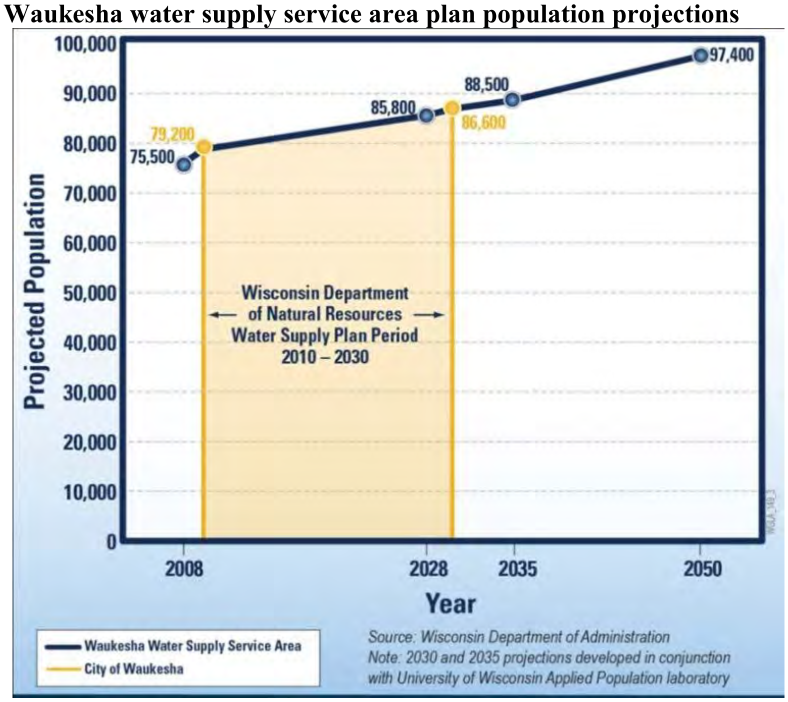
To date, the applicant's conservation plan implementation has directly resulted in an estimated water savings of nearly 90,000 gallons per day. These quantifiable plan savings are in addition to an estimated 170,000 gallons per day passive savings stemming from conservation education, outreach and ongoing replacement of inefficient fixtures and appliances.

Under current water service rules promulgated by the Wisconsin Public Service Commission (PSC), all customers are subject to the City's conservation measures. If water service is extended to areas outside the City, customers will be required to adhere to the City's conservation program as established in the service rules as well as in future service contracts. The City will provide water conservation public education to new customers and make available information, services and incentives to help its customers use water wisely.

3.17.1.3 Water demand forecast for the City of Waukesha

Water demand forecasts for the Applicant were developed on the basis of the delineated water supply service area, population projections for the service area, historical water use by customer class, and the expansion of the City's water conservation program. SEWRPC prepared population projections for the water supply service area including 85,800 people in 2028, 88,500 people in 2035, and an ultimate build-out population of 97,400 people (Figure 3.18). The projections are based on municipal estimates from the State of Wisconsin Department of Administration and multiple planning factors, including but not limited to land use, household size, demographic trends, and community development plans. Additional details of the water supply service area are included in the Water Supply Service Area Plan (CH2MHill, 2013, Vol. 2).

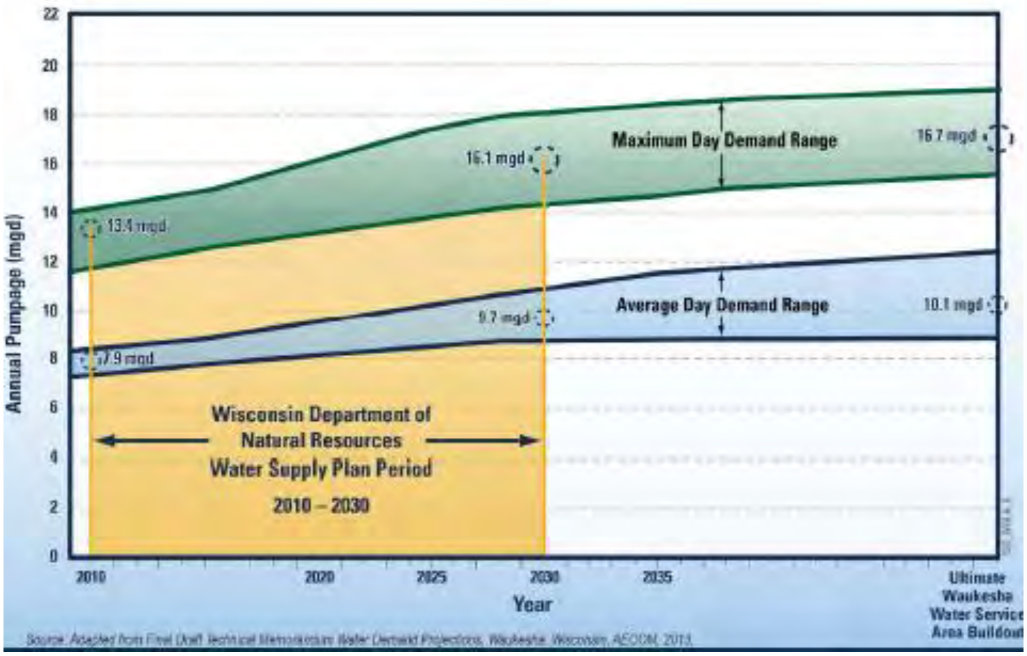
Figure 3-18. City of Waukesha water supply service area plan population projections



As part of its 2006 water system master plan, Applicant prepared water demand forecasts. These were updated in 2013 to reflect updated water service area population projections and water use after implementation of conservation measures (Figure 3.19). The Water Demand

Projections memorandum attachment to the Water Supply Service Area Plan (CH2MHill, 2013, Vol. 2) contains the analysis of future water demands used during the planning process.

Figure 3-19. City of Waukesha water supply service area water demand forecasts



The future water demand forecasts are based on the following assumptions:

- The City's water conservation program is maintained and expanded to meet long-term conservation goals and customer needs.
- The water conservation measures will continue to be implemented, monitored, and adopted as needed to cost-effectively meet the City's water savings goal of 0.5 MGD by 2030 and 1.0 MGD at ultimate build-out. The water conservation plan has been included in the average day demand and maximum day demand projections.
- The 1.0 MGD average day conservation reduction (approximately 10 percent) by 2050 complies with *A Regional Water Supply Plan for Southeastern Wisconsin* (SEWRPC, 2010), which evaluated several levels of water conservation ranging from four to ten percent reductions of average daily demand.
- The ranges of future water forecasts shown in Figure 3.18 were determined by applying water use intensity factors, water savings from conservation, and some contingency to address uncertainty associated in long-term water supply planning for the project population. The uncertainties considered include drought, changes in customer class (particularly the number and type of commercial and industrial users).

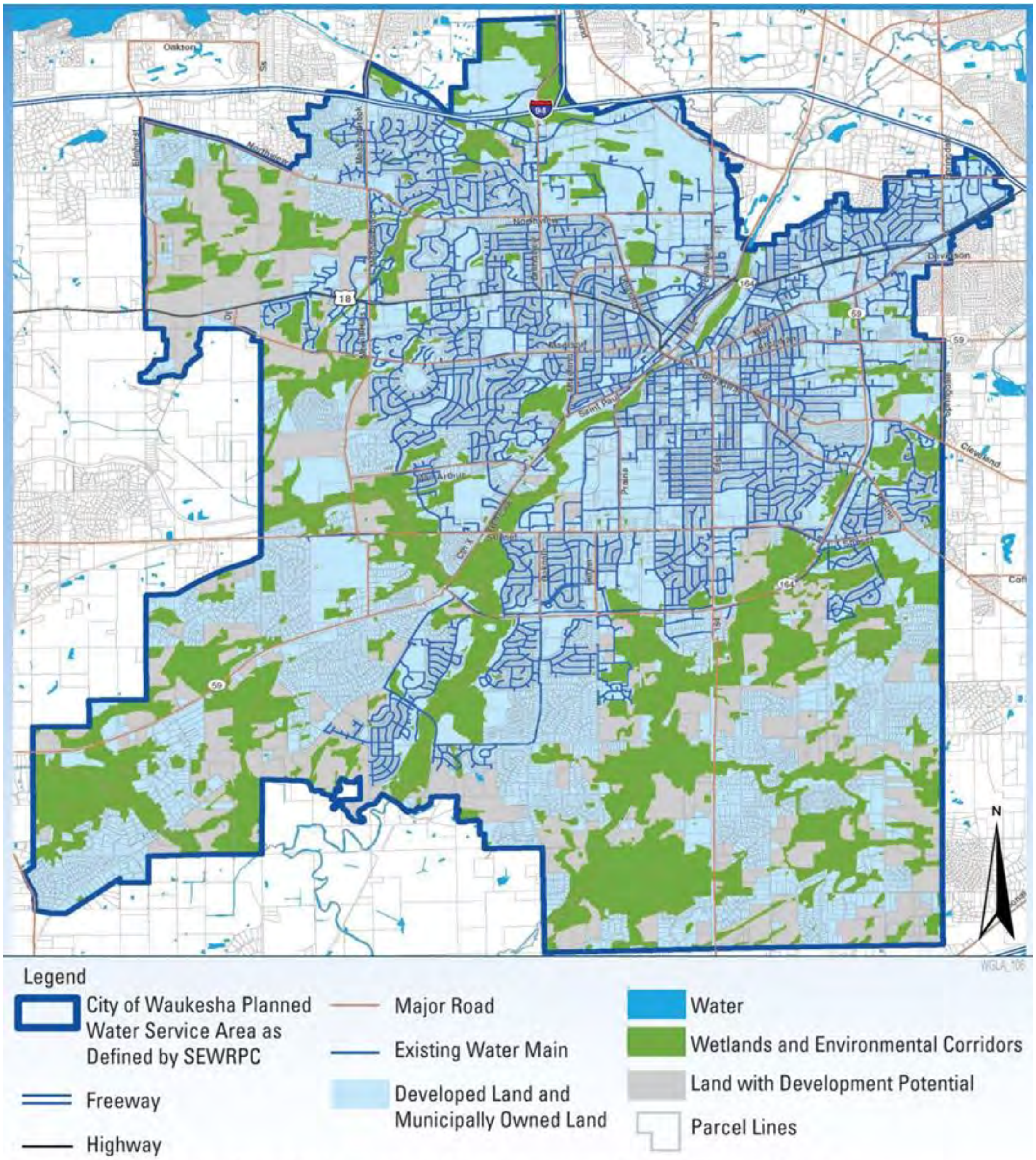
3.17.1.4 Water supply service area for the City of Waukesha

The Applicant presently provides water service to the City of Waukesha and limited areas located outside the city limits. In accordance with Wisconsin's statutory water supply service area planning requirements (Wis. Stat. §281.348), SEWRPC delineated the Applicant's water supply service area to align with its existing sewer service area, include portions of neighboring communities. Service area planning is designed to promote the orderly management of growth. As such, the delineated service area includes portions of neighboring communities currently served by private wells and septic, where future land use plans, sanitary sewer area plans, or historic private well contamination indicate municipal service may be needed. The delineated water supply service area sets the outer boundary of where Waukesha's municipal water supply service can expand.

Wisconsin law generally prohibits the department from limiting a water supply service area based on jurisdictional boundaries (Wis. Stat. § 281.348(3)(e)) . Whether public water service is extended within the delineated service area, and the pace at which public water service is extended within the service area, is primarily up to the jurisdictions within the service area and the Wisconsin Public Service Commission (WPSC) (See generally Wis. Stat. § 196 Regulation of Public Utilities).

The water supply service area includes 3.7 percent of the City of Pewaukee, 9 percent of the Town of Delafield, 14.9 percent of the Town of Genesee, and 83.6 percent of the Town of Waukesha. Within the delineated water supply service area 70 percent of the land is already developed, 15 percent is designated as environmentally protected and 15 percent is currently undeveloped. The Applicant's water supply service area is shown in Figure 3.20. It represents the full development land use envisioned in the Waukesha County Comprehensive Plan at full build-out, projected to occur around 2050, based on historical state population trends.

Figure 3-20. City of Waukesha Proposed Water Supply Service Area



Source: Adapted from Water Supply Service Area for the City of Waukesha and Environs, Waukesha County, Wisconsin, SEWRPC, December 2008

Section 4 Environmental Effects

4 Environmental effects

Section 4 describes the potential impacts on the human environment for the no action alternative (section 4.1), the water supply alternatives (section 4.2) and the return flow alternatives (section 4.3). Section 4.4 provides general information on typical pipeline construction techniques used in pipeline construction.

4.1 No action alternative environmental effects

The "no action" alternative could potentially have an adverse effect upon the health of City of Waukesha (the Applicant) residents because the current water supply source is non-compliant for radium, a cancer causing contaminant naturally occurring in the deep aquifer. The Applicant's existing deep aquifer wells do not provide sufficient quality and quantity of water to meet the projected water supply needs of the Applicant. The Applicant must develop a permanent solution to the radium contamination problem by 2018 and meet the drinking water standard for radium, including meeting the radium maximum contaminant level (MCL) at each entry point to the distribution system as required under a 2009 Wisconsin circuit court judgment (State of Wisconsin vs. City of Waukesha, Case No. 2009-CX, April 8, 2009. Stipulation and Order for Judgment). Currently, the Applicant is allowed to use a temporary solution to meet the federal radium standard that involves treatment of some deep aquifer wells and blending with low radium shallow aquifer water to reduce the overall concentration as allowed in the court judgment. However, the Applicant is having difficulty meeting the radium MCL at all entry points to the water supply system.

The no action alternative would continue use of the deep aquifer and shallow aquifer. Currently approximately 80 percent of the Applicant's water supply comes from the deep aquifer and 20 percent comes from the shallow aquifer. As the Applicant's water demand increases, the no action alternative would result in increased use of the deep aquifer as the shallow aquifer wells are currently pumped to maximum capacity (CH2MHill, 2013, Vol. 2). The no action alternative assumes 7.3 MGD from the deep aquifer and 1.2 MGD from the shallow aquifer under an 8.5 MGD average day demand. Note that the Applicant's request is for 10.1 MGD average day demand; however, the groundwater flow modeling conducted to review the Mississippi River Basin alternatives used 8.5 MGD average day demand, actual impacts of a 10.1 average day demand would be proportionally greater. The increase in long-term water withdrawal from the deep aquifer would contribute to increased deep aquifer drawdown, enlarging the deep aquifer cone of depression and widening the deep aquifer zone of influence, causing deep aquifer groundwater to flow westward toward Waukesha County, away from Lake Michigan. This increased withdrawal would also likely increase the concentrations of contaminants (including radium, gross alpha and TDS) in the water supply, as groundwater withdrawn from lower elevations has higher occurrences of these contaminants.

Flow in the Fox River would be expected to increase by 4 percent from current modeled base flows due to increase use of the deep aquifer (see EIS, Appendix A). Under the no action alternative, additional water to meet a demand increase from a current withdrawal is withdrawn from the deep aquifer. With the additional withdrawal, there is an assumed corresponding increase in discharge from the Wastewater Treatment Plant to the Fox River. Under this alternative, as the shallow aquifer pumping remains the same as current withdrawals, no additional baseflow is diverted from Fox River.

The no action alternative would continue use of the shallow aquifer at the same rate as used between 2010 and 2014. See section 4.2.3 for a description of the expected impacts from continuing to use the existing shallow wells.

The "no action" alternative is not feasible. The Applicant must comply with drinking water quality standards and the deep aquifer water supply does not meet radium standards.

4.2 Zero demand increase alternative

The zero demand increase alternative is similar to the deep and shallow aquifer alternative, in that it would continue using existing deep aquifer and shallow aquifer wells, however with no additional new wells. Upon implementation, this alternative includes radium treatment for four deep aquifer wells with blending of all well water at the Hillcrest Reservoir. However, the zero demand increase alternative does not have sufficient firm capacity[2] to meet the projected 11.1 Maximum Day Demand (MDD) identified in the proposed alternative. The reduced insufficient firm well capacity is a result of the removal of existing Well No. 9 due to water quality problems, reduced capacities in two of the existing shallow wells, and reduced capacities from the existing deep wells that would add radium treatment (Duchniak, 2015).

This alternative assumes an average day demand (ADD) of 6.7 MGD and a MDD of 11.1 MGD. The Applicant calculated full build-out demand for the existing service area as 8.2 MGD ADD and for the delineated water supply service area as 8.8 - 10.1 MGD ADD including water conservation. This ADD does not consider the SEWRPC delineated water supply service area for calculating demand projections and uses alternative assumptions for calculating demand than those used by the Applicant. The department does not consider this alternative viable because it does not meet the Agreement/Compact criteria to meet all applicable state laws. State law requires the Applicant to consider the delineated water supply service area in developing a projected water demand. This alternative only considers the existing service area not the delineated service area (see Technical Review S3 for additional information).

4.2.1 Proposed Water Supply System Demand Analysis

The department analyzed the proposed system capacity in the zero demand increase alternative to determine if the proposed system could meet the 6.7 MGD ADD and 11.1 MGD MDD previously discussed.

Section NR 811.26 Wis. Adm. Code, provides that the total number of [pumping] units shall have sufficient capacity so that if any one pump is taken out of service, the remaining pumps are capable of supplying the peak demand. "Peak demand" is defined as the "maximum water demand in gallons per minute at any given time. Section NR 811.02(47), Wis. Adm. Code, defines peak demand is sometimes estimated to be 2.0 times the total maximum day water use in

[2] Firm capacity is the system capacity with the largest well out of service. In the Applicant's system this is Well No. 10.

gallons averaged over [a day], or the peak hour demand in gallons per minute on the maximum day of use." Under the Great Lakes-Upper Mississippi River Board (GLUMRB) Policy for the Review and Approval of Public Water Supplies, recommends that the "groundwater source capacity, unless otherwise specified by the [Wisconsin Department of Natural Resources], shall equal or exceed the design maximum day demand (MDD) with the largest producing well out of service."

When determining the source capacity of a system, less than a 24 hour time period of calculated firm well capacity is used for a variety of reasons. Causes of well failures can be attributed to overpumping, lowering of the water table, clogging of the aquifer, screen failure, casing failure, or worn pump. To allow recovery of the aquifer and/or maintenance of pumping equipment, the industry standard (Al-Layla, 1977; AWWA, 2001) is to base an average day capacity on a 12 hour well run time and a maximum day capacity on an 18-22 hour run time. Using these criteria, the source (well) capacities of this alternative are provided in Table 4-1 below.

Table 4-1 Applicant well capacities assuming RO treatment for zero demand increase alternative (Duchniak, 2015)

Well	*24-hr Firm Well Capacity (MGD)*	*12-hr Firm Well Capacity (MGD)*	*18-hr Firm Well Capacity (MGD)*	*22-hr Firm Well Capacity (MGD)*
3	1.1	0.6	0.8	1.0
5	1.4	0.7	1.1	1.3
6[1]	2.2	1.1	1.6	2.0
7	0.9	0.5	0.7	0.8
8[1]	1.9	1.0	1.4	1.8
9	0.0	0.0	0.0	0.0
10[1]	3.0	1.5	2.3	2.8
11	0.2	0.1	0.2	0.2
12	0.7	0.4	0.5	0.6
13	0.9	0.5	0.7	0.8
Firm Capacity[2]:	**9.3**	**4.6**	**7.0**	**8.5**

[1] Reverse Osmosis treatment results in reject water. Reject water is brine that is discharged to the sanitary sewer. A 20% reject water volume is calculated for Reverse Osmosis treatment technology at Wells No. 6, 8 and 10.
[2]As described above, firm capacity is the system capacity with the largest well out of service. In the Applicant's system this is Well 10.

As shown, the ADD of 6.7 MGD is greater than the 12-hr firm well capacity of the zero demand increase alternative, reflected as 4.6 MGD in Table 4-1. In this scenario, it would take nearly 18 hours to meet the ADD of 6.7 MGD, which is higher than the industry standard for meeting ADD. Further, the 24-hr firm well capacity cannot meet the 11.1 MGD MDD, which also exceeds the industry standard for meeting the MDD, and does not provide any recovery time for the wells.

If the zero demand increase alternative was implemented with an alternate radium treatment method to RO, the firm capacity of the proposed water supply system would be greater as a result of increased well capacity at Wells No. 6 and 8 due to elimination of RO reject water (note

Well 10 is not included in the calculation of firm capacity). Table 4-2 reflects the system's firm source capacity with an alternate radium treatment technology.

Table 4-2 Applicant well capacities assuming alternate radium treatment for zero demand increase alternative.

Well	*24-hr Well Capacity (MGD)*	*12-hr Well Capacity (MGD)*	*18-hr Well Capacity (MGD)*	*22-hr Well Capacity (MGD)*
3	1.1	0.6	0.8	1.0
5	1.4	0.7	1.1	1.3
6	2.7	1.4	2.0	2.5
7	0.9	0.5	0.7	0.8
8	2.4	1.2	1.8	2.2
9	0.0	0.0	0.0	0.0
10	3.8	1.9	2.9	3.5
11	0.2	0.1	0.2	0.2
12	0.7	0.4	0.5	0.6
13	0.9	0.5	0.7	0.8
Firm Capacity[1]:	**10.3**	**5.2**	**7.7**	**9.4**

[1] Firm capacity is the system capacity with the largest well out of service. In the Applicant's system this is Well 10.

As shown above in Table 4-2, with an alternate radium treatment method to RO the proposed water supply system could provide 5.2 MGD for an ADD with 12 hour pump run times and 7.7-9.4 MGD for a MDD. However, both of these capacities are still below the proposed demands for this alternative.

4.2.2 Water Treatment Options for Deep Aquifer Wells

The zero demand increase alternative follows the same configuration for radium treatment as the Applicant's deep and shallow aquifers alternative. In these alternatives, reverse osmosis (RO) is identified as the preferred treatment alternative for three of the existing deep wells and hydrous manganese oxide (HMO) treatment for one of the existing deep wells. There are five treatment alternatives commonly considered for treating water to remove radium: RO, HMO, radium selective absorptive media, lime softening and cation exchange. The USEPA (2000) report "Update of: Technologies and Cost for the removal of Radionuclides from Potable Water Supplies" provides additional information on radium water treatment technologies.

4.2.2.1 RO treatment

RO treatment removes inorganic and organic compounds from the water supply including radium, total dissolved solids (TDS) and hardness. The treatment process results in a 10-20% loss of water as reject water. The reject water is brine that is typically discharged to the sanitary sewer system and treated through the wastewater treatment plant.

There are two water utilities in Wisconsin that have RO treatment systems, Waupun Water Utility and Stanley Water Utility. The Waupun Water Utility installed RO treatment to replace a lime softening treatment system that was used to remove radium and to reduce the hardness of the water delivered to utility customers. In a cost analysis, the Waupun Water Utility determined it was less expensive to convert to an RO treatment system than to replace the existing lime softening system. The Waupun Water Utility had an average day demand of 0.9 MGD in 2014. The Waupun wastewater treatment plant treats the reject water from the RO treatment plant.

The Stanley Water Utility has two water treatment plants, one uses cation exchange softening and the other uses an RO treatment plant for water softening. The Stanley Water Utility had an average day demand of 0.8 MGD in 2014. The Stanley wastewater treatment plant treats the reject water from the RO treatment plant.

RO treatment is used by public water systems in other nearby states to treat for radium, including approximately a dozen in Illinois, two in Indiana, thirteen in Ohio, and several in Minnesota. The size of these systems varies from much smaller to larger than the Applicant's system. Systems of a similar size to the Applicant typically discharge reject water to the sanitary sewer system. There are some public water systems that have investigated use of RO treatment and not selected the alternative due to problems with disposal of the waste (CH2M, 2015c). Reject water from RO treatment systems is addressed as part of the WPDES permit. The WPDES permit review considers the following: the volume of RO reject water, the quality of the reject water including TDS concentration, and the volume of radium in the sludge, to be disposed.

Under the proposed water supply alternatives that addition of radium treatment, the volume of deep aquifer water pumped is not proposed to increase. Thus the quantities of radium that are currently in the wastewater sludge already are approved under the Waukesha wastewater treatment plant WPDES permit should be approximately the same in the wastewater sludge under the RO treatment. Similarly, the volume of inorganics that pass through the wastewater treatment plant from the deep aquifer water would remain the same. If concentrations of radium or TDS increase, then these would result in greater concentrations in the reject water and may affect the Applicant's WPDES permit.

When evaluating costs for adding RO treatment to implement the zero demand increase alternative, the department estimates capital costs[3] to be $13.8 million for an 18-hr MDD well capacity (5.3 MGD), with an operation and maintenance (O&M) cost of $0.43/thousand gallons for treatment.

4.2.2.2 HMO treatment

HMO treatment removes radium, barium, iron and manganese, but does not remove hardness or TDS. The radium (or other contaminants) adsorb on to the HMO chemical and are then filtered out. These filters are periodically backwashed and the wastewater is discharged to the sanitary sewer system and treated at the wastewater treatment plant. Approximately 3-5% of water pumped is lost to the system for filter backwashing. Approximately ten Wisconsin water utilities use HMO treatment to remove radium, including the Applicant. In the deep and shallow aquifer alternative, one of the deep aquifer wells would continue to use HMO treatment. Fond du Lac Water Utility, with an average day demand in 2014 of 4.8 MGD, uses HMO treatment and is the most similar in treatment volume to the Applicant.

[3] Capital costs were obtained from the U.S. EPA 2007 Drinking Water Infrastructure Needs Survey and Assessment Cost Models adjusted to 2013 dollars for the Milwaukee, WI, region, and include materials, overhead and profit, bonds and insurance, engineering design and construction services, legal, permits, and construction contingency.

When evaluating costs for adding HMO treatment to implement the zero demand increase alternative, the department estimates capital costs[4] to be $13.8M for an 18-hr MDD well capacity (5.34MGD), with an operation and maintenance (O&M) cost of $0.43/ thousand gallons for treatment.

4.2.2.3 Lime softening

Lime softening treatment removes iron, manganese, hardness and radium. The treatment process is a chemical process that results in the formation of a waste sludge. The volume of sludge can be an issue for waste disposal. Lime softening is used by the City of Beaver Dam for radium removal.

When evaluating costs for adding lime softening treatment to implement the zero demand increase alternative, the department estimates capital costs[5] to be $23.7M for an 18-hr MDD well capacity (5.34MGD), with an O&M cost of $1.30/ thousand gallons for treatment.

4.2.2.4 Cation exchange

Cation Exchange treatment removes radium and hardness. With cation exchange, radium is adsorbed on to the resin and is then removed through regeneration with salt (the same as a home water softener removes hardness). The regeneration wastewater is a brine that includes elevated concentrations of chloride and concentrated into a brine that is discharged to the sanitary sewer and treated at the wastewater treatment plant. The chloride waste can be problematic for wastewater treatment plants and the receiving water bodies of the treated effluent. The Waukesha WWTP WPDES permit already has a variance for chloride discharge to the Fox River. Cation exchange treatment should eliminate the need for home water softeners.

When evaluating costs for adding cation exchange treatment to implement the zero demand increase alternative, the department estimates capital costs[6] to be $17.5M for an 18-hr MDD well capacity (5.34MGD), with an O&M cost of $0.55/thousand gallons for treatment.

4.2.2.1 Radium selective adsorptive media

Radium selective adsorptive media removes radium, but does not remove hardness or TDS. The adsorptive media is infrequently backwashed and so a minimal amount of wastewater is discharged to the sanitary sewer. Instead the adsorptive media is replaced when no longer able to remove radium. This media becomes a low level radioactive waste and must be disposed of at a federally licensed radioactive waste site. Radium selective adsorptive media is used by Brookfield and Pewaukee Water Utilities to treat for radium. These water utilities treated 0.7 MGD and 0.02 MGD, respectively, using radium selective adsorptive media in 2014. Fond du Lac Water Utility originally treated for radium using an adsorptive media, but switched to HMO after problems with filters installed before the media required frequent replacement.

---

[4] See footnote 6.
[5] See footnote 6
[6] See footnote 6

Due to the scarcity of information available for the construction and O&M costs for using radium selective adsorptive media treatment technology, these costs were not calculated for implementation of the zero demand increase alternative.

4.2.3 Impacts to surfaces waters from Existing Shallow Wells

The Applicant has three existing shallow wells. Two of these wells were installed in 2006 and the third in 2009. The shallow wells pumped 1.2 MGD and accounted for 20% of the Applicant's pumping from 2010-2014. Two of the wells are less than 250 feet from the Fox River, the third is approximately a half mile from the Fox River. Other surface water features in the area include wetlands, Genesee Creek, and Pebble Creek. The wells are located approximately 1.5 miles from each of the creeks (See section 3.4 for a description of these water bodies.)

The department calculated impacts to surface water features using the USGS Upper Fox Model projected 20 years out (See Appendix B and C for more details on the groundwater flow modeling and results). Maximum drawdown from these three wells pumping at a combined rate of 1.2 MGD is estimated to be 24 – 28 feet. Streamflow depletion in Pebble Brook, Pebble Creek, Mill Creek and Genesee Creek are estimated to be 0 – 1%. The wastewater outfall is upstream of the withdrawal wells, so the net streamflow depletion from the Fox River would be zero. 305 – 467 acres of wetlands are in the one-foot drawdown contour after a 5 year pumping period. After an additional 20 years of pumping the total of wetlands in the one-foot drawdown contour is 430 – 484 acres.

4.3 Water supply alternatives environmental effects

Section 4.2 is broken down into several subsections to evaluate the potential impacts of each of the water supply alternatives considering effects to each of the following: Lake Michigan; Fox River; Fox River tributaries; unnamed and intermittent streams; groundwater; wetlands; upland forests and grasslands; geomorphology and soils; air emissions; population; economics; land use; recreation and aesthetic resources; archeological and historic resources; public water supply and use in the City of Waukesha; and cost and energy use.

4.3.1 Deep and shallow aquifers alternative environmental effects

Note that the impacts of wastewater discharge are discussed separately in section 4.4.

4.3.1.1 Lake Michigan effects from the deep shallow aquifers supply alternative

The deep and shallow aquifer supply alternative would continue to withdraw water from the deep aquifer. The United States Geological Survey (USGS) and Wisconsin Geological and Natural History Survey (WGNHS) jointly constructed a groundwater flow model for southeast Wisconsin to understand the effects of groundwater pumping on the groundwater flow system in southeast Wisconsin. The results of this model found that deep aquifer pumping by the Applicant, along with all the other regional pumping of the deep aquifer, has changed the groundwater flow system in southeast Wisconsin. Prior to pumping of the deep aquifer the groundwater divide was in western Waukesha County and groundwater flowed toward Lake Michigan through the deep sandstone. Based on the modeling results for withdrawals similar to 2000 withdrawal rates, groundwater no longer flows towards Lake Michigan, but rather flows towards pumping centers, such as the pumping center in Waukesha County. In addition, the groundwater pumped is replenished to the deep aquifer by water that would have flowed to streams or other surface waters.

Modeling results show that 70 percent of this replenishing water comes from Mississippi River Basin surface water and 30 percent comes from Lake Michigan Basin surface waters. Lake Michigan itself accounts for approximately 4 percent of the replenishing water (Feinstein, et al.

2005, USGS, 2006) These impacts would continue under this alternative. Withdrawals from the deep aquifer with this alternative would be 4.5 MGD. This would be slightly less (16.7 percent less) than the current 5.4 MGD (2010 – 2014 average) pumping rate from the deep aquifer by the Applicant.

4.3.1.2 Fox Fiver effects from the deep and shallow aquifers supply alternative

Pebble Brook would be crossed by the estimated 75-foot-wide pipeline construction corridor proposed in this alternative. The stream crossing would be approximately 46.5 feet in length and approximately 0.08 acres in area (CH2MHill, 2013, Vol. 5, Table 6-13). The crossing would likely be accomplished by the horizontal directional drilling (HDD) or another proper construction method for stream crossings to avoid or minimize construction impacts (Section 4.4).

4.3.1.2.1 Flow and flooding effects in the Fox Fiver from the deep and shallow aquifers supply alternative

Flow

Groundwater modeling results predict a slight decrease in baseflow from current baseflow in the Fox River for this alternative. The change is due to the decrease in use of the deep aquifer (from 5.4 MGD to 4.5 MGD) and an increase in the use of the shallow aquifer (from 1.2 MGD to 4 MGD). Note that the source of water to the shallow aquifer is diverted baseflow from the Fox River and nearby tributaries to the Fox River. This water, pumped from the shallow aquifer, returns to the Fox River system via the wastewater treatment plant. However, water that is pumped from the deep aquifer does not induce water from the Fox River, and thus just augments baseflow in the Fox River. Baseflow decreases because of a decrease in the augmentation of Fox River from the deep aquifer.

In this alternative, the water supply comes from two sources. The first source is the deep aquifer. Currently, the Applicant pumps 5.4 MGD (2010-2014 average) from the deep aquifer. Under this alternative this would decrease to 4.5 MGD. All of this water is, and would continue to be, discharged to the Fox River from the WWTP. The reduction in deep aquifer pumping would result in a 0.9 MGD average annual decrease in flow to the Fox River.

The second source of water is the shallow aquifer. Water pumped from the shallow aquifer is water diverted from surface water features such as wetlands, rivers and streams. Groundwater flow models also show that 70 percent of the water pumped from the deep aquifer comes from shallow groundwater diverted from streams and rivers in the Mississippi Basin. Currently the Applicant pumps 1.3 MGD (2010-2014 average) from the shallow aquifer. With this alternative, the shallow aquifer pumping would increase to 4 MGD.

Depending on the location of additional shallow wells, groundwater modeling results predict that baseflow to the Fox River would decrease by one to two percent with this alternative (Appendix A). This reduction in baseflow is due to a decrease in the use of the deep aquifer and an increase in use of the shallow aquifer.

Flooding

This alternative would not affect flooding on the Fox River because flows would be slightly reduced. In addition, no regulatory floodplain changes are anticipated as floodplain studies look at the watershed infiltration capabilities and surface water runoff as a system. Flow changes due to point sources such as wells are not considered in the calculations. The aboveground structures associated with this alternative would be located outside the regulatory floodplain.

4.3.1.2.2 Water quality effects in the Fox River from the deep and shallow aquifers supply alternative

Supply and pipeline effects

This alternative would include new water supply treatment plants and pump stations that could impact over 30 acres and could produce stormwater runoff from previously undeveloped land. The increased runoff could affect water quality in the Fox River. However, the runoff would be managed to meet the Wisconsin Department of Natural Resources' (the department) stormwater quality requirements for new development, as provided in ch.NR 151, Wis. Adm. Code, as well as local stormwater management requirements. By doing so, runoff impacts to the Fox River are anticipated to be negligible.

The Applicant would be expected to use the approved stream crossing procedures (HDD or jack and bore) and follow proper procedures through construction. These methods avoid most of the potential impacts that are a concern with pipeline crossings of waterways, as the pipeline is installed beneath the bed of the waterway (Section 4.4).

The potential for reductions to the water table in adjacent corridors of the Fox River and indirect impacts to riparian vegetation could increase the potential for runoff from unvegetated or unstable bank conditions. Increasing the sedimentation could be anticipated if bank stability and riparian vegetation are not maintained.

4.3.1.2.3 Geomorphology and sediments effects in Fox River from the deep and shallow aquifers supply alternative

Supply effects

Groundwater modeling results predict one to two percent baseflow reduction from current baseflow in the Fox River from this alternative (Appendix A). This reduction would likely not affect Fox River geomorphology and sediments.

Pipeline effects

The HDD pipeline crossing of the Fox River, following proper drilling procedures, would likely not result in impacts to Fox River geomorphology and sediments. Use of other crossing methods would result in temporary disruption and require restoration and stabilization of stream bed and banks. Construction trenches through streams are filled with clean, stabile materials like rock while banks have topsoil replaced.

4.3.1.2.4 Flora and fauna (including T/E/SC) effects in the Fox River from the deep and shallow aquifers supply alternative

Supply effects

The slight flow reduction in the Fox River could have a minimal impact on the flora and fauna of the River. This reduction in flow could stress the biological community of the Fox River by reducing habitat, impacting water quality and increasing water temperature. If tributary streams (Pebble Brook, Pebble Creek, Mill Creek, Mill Brook and Genesee Creek) experience flow reductions, flow reduction in the Fox River could be cumulative, as these waterways are largely influenced by groundwater. Increased water temperature could occur because less cold groundwater would seep into the tributaries because of the proposed shallow aquifer pumping. The temperature in the lower flow remaining in the tributaries then further increases from solar radiation. Effects would especially be felt during low flow periods when groundwater baseflow accounts for most of the flow to these tributaries.Lower flow conditions could also increase stresses to macroinvertebrate populations including mussels. Reduced baseflow could alter the environment that the macroinvertebrate community depends upon (increasing competition, predation, etc.).

Baseflow reduction would likely impact semi-aquatic mammal species including beavers, muskrats, otters, and mink. Increased depth to groundwater would cause a change in wetland type, therefore impacting mammal species that rely on a variety of wetland types that have surface water throughout the year. The slight flow reduction in the Fox River would not likely affect any mammal species in the Fox River or its associated habitats.

Pipeline effects

The HDD pipeline crossing of the Fox River, following proper drilling procedures, would likely not result in impacts to Fox River flora and fauna. However, use of other crossing methods would temporarily restrict aquatic organism movements, would present some stress to organisms due to suspended sediments, and possibly result in an Incidental Take Permit (ITP) if take cannot be avoided. Short term impacts from a proposed open cut crossing could decrease or shift macroinvertebrate populations; however, they could quickly reestablish populations (macroinvertebrate drift) within the restored stream bed if crossings were completed successfully. Fish would temporarily move out of the construction zone, while the less mobile organisms like mussels and fish eggs would be destroyed in the immediate construction zone. Options such as mussel relocation and timing of the project may prevent these impacts and the need for an ITP. Recolonization of the construction zone may occur as the stream bed returns to a more natural condition through normal sedimentation over time. Recently disturbed areas in the riparian corridor would be more susceptible to the invasive species and should be managed accordingly. There are other special concern species that may be present at this crossing and avoidance/minimization measures would be recommended.

4.3.1.3 Fox River tributaries environmental effects from the deep and shallow aquifers supply alternative

Proposed Pipeline

Pebble Brook would be crossed by the estimated 75-foot-wide pipeline construction corridor proposed in this alternative. The stream crossing would be approximately 46.5 feet in length and approximately 0.08 acres in area (CH2MHill, 2013, Vol. 5, Table 6-13). The crossing would likely be accomplished by the horizontal directional drilling (HDD) or another proper construction method for stream crossings to avoid or minimize construction impacts (Section 4.4).

4.3.1.3.1 Flow and flooding effects in Fox River tributaries from the deep and shallow aquifers supply alternative

Flow

Shallow groundwater pumping would draw down the aquifer, lowering the water table and decreasing groundwater discharge to Pebble Brook, Pebble Creek, Genesee Creek and Mill Creek. Detailed groundwater modeling assessed the potential adverse environmental impacts to these creeks (Table 4-3).

Flooding

Shallow groundwater pumping from this alternative would not affect flooding on the cold water streams, because flows in these inland waterways would not increase. No regulatory floodplain changes are anticipated as floodplain studies look at the watershed infiltration capabilities and surface water runoff as a system. Flow changes due to point sources such as wells are not considered in the calculations.

Table 4-3. Modeled baseflow reductions from shallow wells near Pebble Brook and the Fox River. See Appendix B for groundwater flow modeling summary. Mill Brook is not listed in this table as it is outside of the model domain.

	Flow Reduction	
Stream	Wells near Pebble Brook	Wells near Fox River
Pebble Brook	18-19%	2-3%
Pebble Creek	0-1%	1%
Mill Creek	0-1%	0%
Genesee Creek	1%	1-2%

4.3.1.3.2 Water quality effects in Fox River tributaries from the deep and shallow aquifers supply alternative

Supply effects

Lower baseflows in these cold water streams could lead to warmer temperatures and potential temperature impairment in Pebble Brook, Pebble Creek, Mill Brook, Genesee Creek and Mill

Creek with this alternative. More effects due to increased temperature are discussed in the flora and fauna section below.

Pipeline effects

The Applicant would be expected to use the approved stream crossing procedures (HDD or jack and bore) and follow proper procedures through construction. These methods avoid most of the potential impacts that are a concern with waterway pipeline crossings, as the pipeline is installed beneath the bed of the waterway (Section 4.4).

4.3.1.3.3 Geomorphology and sediments effects in Fox River tributaries from the deep and shallow aquifers supply alternative

Supply Effects

Reduced baseflows in Pebble Brook, Pebble Creek, Mill Brook and Mill Creek and Genesee Creek could result in smaller channel dimensions over time with this alternative, but are not expected to do so because channel morphometric stability is associated primarily with larger channel-forming flows, generally those flow and flood events having a recurrence interval of one to two years.

Pipeline effects

The HDD pipeline crossing, using proper drilling methods, would likely not result in impacts to the geomorphology and sediments of these tributaries. Use of other crossing methods would result in temporary disruption and require restoration and stabilization of stream bed and banks. Construction trenches through streams are often filled with clean, stabile materials like rock while banks have topsoil replaced (Section 4.4).

4.3.1.3.4 Flora and fauna effects in Fox River tributaries from the deep and shallow aquifers supply alternative

Supply effects

Reductions in baseflow to Pebble Brook, Pebble Creek, Mill Creek, Mill Brook and Genesee Creek could reduce habitat, impact water quality and increase temperature, stressing the cold water species present in these streams. Increased water temperature could occur because less cold groundwater would be available as groundwater discharge decreases from the proposed shallow aquifer pumping. Groundwater discharge provides cool-water environments that protect fish from excessively warm stream temperatures during the summer, and conversely, relatively warm groundwater discharge can protect against freezing of the water during the winter. The temperature in the lower flow remaining in the waterway then further increases from solar radiation. The coldwater species brown trout, mottled sculpin as well as one state threatened fish species would be affected by reduced flows and increased water temperature. Coolwater species including northern pike and walleye would also be negatively affected as a result of reduced baseflow of the coldwater tributaries which provide seasonal cool water refuge and nursery habitat. Effects would especially be felt during low flow periods when groundwater baseflow accounts for most of the flow (Diebel et al., 2014).

Low flow conditions can also increase stresses to macroinvertebrate populations including mussels. Reduced baseflow could alter the environment that the macroinvertebrate community depends upon (changing competition, predation, organic decomposition, etc.). Recently disturbed areas in the riparian corridor would be more susceptible to the invasive species and should be managed accordingly.

Baseflow reduction would also likely impact semi-aquatic mammal species including beavers, muskrats, otters, and mink. Increased depth to groundwater would cause a change in wetland type, therefore impacting mammal species that rely on a variety of wetland types that have surface water throughout the year.

Pipeline effects

The HDD pipeline crossing of Pebble Brook, following proper drilling procedures, would likely not result in impacts to Pebble Brook flora and fauna. However, use of other crossing methods would temporarily restrict aquatic organism movement, would present some stress to organisms due to suspended sediments, and possibly result in an Incidental Take Permit (ITP) if take cannot be avoided. Mobile organisms like fish would temporarily move out of the construction zone, while the less mobile organisms like mussels or fish eggs would be destroyed in the immediate construction zone. Options such as mussel relocation and timing of the project may prevent these impacts and the need for an ITP. Recolonization of the construction zone may occur as the stream bed returns to a more natural condition through normal sedimentation over time. There are other special concern species that may be present at this crossing and avoidance/minimization measures would be recommended.

4.3.1.4 Unnamed and intermittent streams environmental effects from the deep and shallow aquifers supply alternative

Shallow groundwater pumping would minimally affect area unnamed and intermittent streams, ditches and canals by lowering of the water table, decreases in groundwater availability to discharge to these resources and increase in outflow from these resources to the ground. Two intermittent streams (WBIC 5037071, WBIC 771200) would be crossed by the estimated 75-foot-wide pipeline construction corridor proposed in this alternative. One intermittent stream (WBIC 5037071) would have a pipeline crossing length of approximately 17.4 feet, and an approximate area of 0.03 acres. The other stream (WBIC 771200) would have an approximate pipeline crossing length of 11.6 feet and an approximate area of 0.02 acres (CH2MHill, 2013, Vol. 5, Table 6-13). These crossings may be accomplished by the open cut method if the crossings can be completed under no-flow conditions. Crossing these streams under no flow conditions would likely result in impacts only during construction and restoration. Bed and banks would be required to be restored to preconstruction profiles, and the construction zone topsoil replaced, stabilized and revegetated. If crossed under flowing conditions, some temporary sediment suspension and downstream sedimentation is expected until the bed and banks are restored, stabilized and revegetated.

Other crossing methods would be used if the streams must be crossed while flowing (Section 4.4). These two tributaries could be susceptible to short term impacts from a proposed open cut crossing, which would cause short term impacts that range from a decrease in macroinvertebrate populations. However, they could quickly reestablish populations (macroinvertebrate drift) within the restored stream bed if crossings were completed successfully. Mussel populations would most likely be the most affected by open channel crossings as they are unable to relocate quickly. Relocation of existing mussel populations could help reduce effects of the stream crossing construction on the species. Resident fish population would relocate in the short term during construction and almost immediately return upon completion of the project.

Recently disturbed areas in the riparian corridor would be more susceptible to the invasive species and should be managed accordingly.

4.3.1.5 Groundwater effects from the deep and shallow aquifers supply alternative

The aquifers that would be used for this water supply alternative include the unconsolidated sand and gravel aquifer (shallow aquifer) and the Cambrian-Ordovician sandstone aquifer (deep aquifer).

Construction impacts to shallow aquifers resulting from construction and placement of a 30-inch water main from new water treatment plants to the City and of 8-inch to 20-inch pipelines generally less than 10 feet deep from the well field to the water treatment plants are expected to be minor. Temporary impacts may include short-duration trench dewatering efforts. It is anticipated that the shallow aquifers would return to preconstruction conditions following construction. Long term impacts could occur if pipe trenching allows the redirection of subsurface flows, especially in wetlands and at stream crossings.

4.3.1.5.1 Groundwater quantity effects from the deep and shallow aquifers supply alternative

Long-term water withdrawal from the deep and shallow aquifers would result in a slower recovery rate for the deep aquifer and a decrease in shallow aquifer water levels.

Groundwater modeling results predicted a maximum drawdown of 14 to 22 feet in the shallow aquifer (Appendix B). Deep aquifer modeling was not conducted because the Applicant currently uses the aquifer and the performance is well known. Impacts of groundwater withdrawals on surface waters and other natural resources are described later in this section.

Water withdrawals from the deep aquifer in this alternative are predicted to be 0.9 MGD less than the current average annual withdrawals. Water levels in the deep aquifer have been recovering from the lows observed in the late 1990s. A further decrease in the pumping rates from the deep aquifer should continue this trend. However, the deep aquifer water levels are dependent on the regional pumping from this aquifer, not only the pumping from the Applicant.

4.3.1.5.2 Groundwater quality effects from the deep and shallow aquifers supply alternative

Deep aquifer water quality is expected to continue to have concentrations of radium and gross alpha above the state and federal drinking water standards under this alternative. This water would need to be treated or blended to meet both state and federal drinking water standards. There are no other known water quality changes that would occur in the shallow aquifer if it continues to be used as a water supply source.

4.3.1.5.3 Springs effects from the deep and shallow aquifers supply alternative

Springs represent points on the landscape where groundwater discharges to the land surface or to a surface water body. One spring exists within the one-foot groundwater drawdown contour. Maps depicting the Wisconsin Geological and Natural History Service spring inventory were reviewed and compared to the groundwater drawdown to see which springs may be affected

(WGNHS, 2010, and CH2MHill, 2013, Vol. 5, Appendix 6-3). One spring with a recorded flow rate of 0.09 cfs is located within the one foot drawdown contour and may be impacted by this alternative. Pumping from the shallow aquifer may lead to reductions in spring flow, a change in springflow from perennial to ephemeral, or elimination of springs altogether. Pumping from the shallow aquifer may also affect the amount of flow from different sources, thus affecting the chemical composition of the spring water.

4.3.1.6 Wetland effects from the deep and shallow aquifers supply alternative

Wetlands are sensitive to the effects of groundwater pumping. Groundwater pumping can affect wetlands not only as a direct result of progressive lowering of the water table, but also indirectly by increased seasonal changes in the altitude of the water table. The effects on the wetland environment from changes to the hydroperiod may depend greatly on the time of year at which the effects occur. For example, lower than usual water levels during the non-growing season might be expected to have less effect on the vegetation than similar water-level changes during the growing season. The effects of pumping on seasonal fluctuations in groundwater levels near wetlands add a new dimension to the usual concerns about sustainable development that typically focus on annual withdrawals (Bacchus, 1998). The department's groundwater modeling results estimate from 910 to 1036 acres of wetlands with a projected drawdown of one foot or more with a well configuration that includes shallow wells adjacent to Pebble Brook. When this alternative is configured with shallow wells only adjacent to the Fox River, the groundwater modeling results estimate 804 to 1069 acres of wetland with a projected drawdown of one foot or more (Appendix B). The degree of impact on wetlands from groundwater drawdown and lowering of the water table would vary depending on the wetland type, proximity to the zone of drawdown, severity of drawdown, frequency and amount of rainfall. The impacts could vary from total loss of all wetland functions to a shift from one wetland type to another. The degree of impact is dependent on a variety of factors including the hydrologic category of the wetland. Wetlands with saturated soils with no prolonged period of inundation are most vulnerable to conversion to uplands. Of these wetland types the depth of the capillary fringe, determined by the soil type, will also affect the susceptibility of the wetland to conversion to upland. The capillary fringe is typically one foot or less for all soil types. For wetlands with no prolonged period of inundation, it is reasonable to assume that these wetlands will convert to uplands (Table 4-4).

Table 4-4.Ground water drawdown in wetlands of one foot or greater from the deep and shallow aquifers supply alternatives (Source: DNR data, Total acreage is in Appendix B)

	Drawdown of 1 ft. or more in wetlands (ac)					
Alternative	**Emergent/wet meadow**	**Scrub/shrub**	**Forested**	**Open water**	**Flats**	**Total**
Wells adjacent to Pebble Creek	229-276	294-382	321-304	35-37	29-35	**910-1036**
Wells adjacent to Fox River only	177-252	330-450	128-235	35-46	26-191	**804-1069**

Table 4-5 lists wetland crossing acreages from the pipeline associated with this alternative.

Table 4-5. Wetland crossing acreages from the pipeline associated with this alternative (Source: WWI-layer, CH2MHill, 2013, Vol. 5, Table 6-42)

No.	Type	Width*	Acre
7963	Emergent/wet meadow	556.9	1.6
7982	Emergent/wet meadow	597.2	1.83
8111	Flats/unvegetated wet soil	-	0.01
8122	Scrub/shrub	-	0.13
8129	Scrub/shrub	474.7	1.34
8146	Scrub/shrub	872.4	1.5
8178	Scrub/shrub	480.3	0.83
8197	Scrub/shrub	526.8	0.71
8246	Scrub/shrub	-	0.07
8263	Scrub/shrub	283.3	0.58
8315	Forested	-	0.02
8325	Forested	-	0.02
8392	Forested	-	0.84
8395	Forested	235.7	0.4
8399	Forested	611.9	0.95
8401	Forested	-	0.01
	Totals	**4639.2**	**10.84**

*Where a crossing length is not included, the pipeline centerline would not intersect wetland; only the edge of the ROW would be located in the wetland. Because of this, it is anticipated that construction techniques could be adjusted to avoid most, if not all, wetland impacts.

Two palustrine emergent (PEM) wetlands, seven palustrine scrub-shrub (PSS) wetlands, six palustrine forested (PFO) wetlands, and one flat/unvegetated wetland would be affected by the pipeline construction or aboveground structures proposed as part of this alternative. A total of 10.84 acres of wetland would be affected. Above ground structures would affect four acres of wetland.

The temporary removal of wetland vegetation is a primary impact of pipeline construction. Wetland crossings would be required to be restored to original contours, topsoil replaced and revegetated. Construction also would temporarily diminish the recreational and aesthetic value of the wetlands crossed. These effects would be greatest during and immediately following construction. However, wetland invasive species may become more dominant in wetlands that become disturbed as a result of reduced ground water influence.

In wet meadow/emergent wetlands, the impact of construction would be relatively brief, since herbaceous vegetation typically regenerates within one or two seasons. In forested and shrub-dominated wetlands, the impact would last longer due to the longer recovery period of these vegetation types. Long term vegetation management over the pipeline to allow access and inspection would prevent regeneration of tree and shrub cover.

The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way. There would be less than 0.1 acre of wetland type change from forested to emergent associated with this alternative.

The Applicant would need to meet requirements under NR 103, Wis. Admin. Code. Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

4.3.1.6.1 Vernon Marsh effects from the deep and shallow aquifers supply alternative

Supply effects

A related effect of surface groundwater pumping is the lowering of groundwater levels below the depth that streamside or wetland vegetation needs to survive. The overall effect is a loss of riparian and/or wetland vegetation and associated wildlife habitat. Wetland acres affected by shallow aquifer withdrawals in the Vernon Marsh are included in the wetland totals above. Wetland invasive species may become more dominant in wetlands that become disturbed as a result of reduced ground water influence. Construction of facilities for the deep and shallow aquifers supply alternative would directly affect 1.25 acres of the Vernon Marsh Wildlife areas if constructed as proposed by the Applicant (CH2MHill, 2013, Vol. 5, Table 6-56).

Pipeline effects

The temporary removal of wetland vegetation is a primary impact of pipeline construction and right-of-way maintenance activities. Construction also would temporarily diminish the recreational and aesthetic value of the wetlands crossed. These effects would be greatest during and immediately following construction. In wet meadow/emergent wetlands, the impact of construction would be relatively brief, since herbaceous vegetation regenerates within one or two seasons. In forested and shrub-dominated wetlands, the impact would last longer due to the longer recovery period of these vegetation types. Long-term vegetation management over the pipeline to allow access and inspection would prevent regeneration of tree and shrub cover. Plant diversity and other wetland functional values may decrease if invasive wetland plants become established as a result of lowered ground water levels.

4.3.1.6.1.1 Flora and fauna effects on Vernon Marsh from the deep and shallow aquifers supply alternative

This level of groundwater drawdown would likely result in wetland habitat type changes. Species changes, habitat changes or destruction could occur when groundwater levels are lowered below that needed for wetland plant species. Vernal pool habitat is also very susceptible to changes in water depth, and lowered groundwater levels could reduce the occurrence or duration of this seasonal habitat where it exists within the groundwater drawdown zone. Because of this, significant adverse impacts could occur to the rare species that are known to use Vernon Marsh's wetland and waterway habitats. While it does not appear that protected species would be impacted with the pipeline installation, recommended avoidance and minimizations measures could be made for the non-protected rare species.

Calcareous fen occurs in the southern end of the Vernon Marsh Wildlife Area, but is not within the predicted area of groundwater drawdown. Consequently, no known calcareous fens would be impacted by the anticipated drawdown.

Wetland invasive species may become more dominant in wetlands that become disturbed as a result of reduced ground water influence. See also the discussions of effects on forested and open wetlands below.

4.3.1.6.1.2 Forested and scrub/shrub wetlands (other than Vernon Marsh) effects from the deep and shallow aquifers supply alternative

Wetland trees have a morphological adaptation to survive in wet soil conditions. When wet soils are exposed to air for several years, the tree subcanopy and canopy would show signs of stress, the soil can subside, and trees topple as a result of reduced soil strength. With the loss of trees, the habitat would be less suitable for nesting and denning. Animal food source changes (different plant seeds/berries) may also occur, which may affect mammals, birds, or reptiles.

A pipeline crossing a forested or scrub/shrub wetland would have a permanent wetland type change across the pipeline maintenance width because maintenance would include managing woody vegetation. Consequently, pipeline maintenance would cause a shift from forested or scrub/shrub wetland to emergent marsh or wet meadow wetland type.

4.3.1.6.1.3 Open wetlands (other than Vernon Marsh) effects from the deep and shallow aquifers supply alternative

A prolonged or permanent decrease in groundwater levels of one foot or greater could lower the surface water level and soil saturation within such wetlands to such a degree that detrimental impacts to wildlife, endangered resources, and vegetative cover may occur. Impacts might include loss of habitat for invertebrates, fish, amphibians, or wading birds. Other impacts might be seen as a change in wildlife species that use the wetland, that is, with fewer wetland-dependent species present, more terrestrial species move in. Changes in herbaceous groundcover species would be observed first, followed by growth of a shrub layer. Wetland invasive species may become more dominant in wetlands that become disturbed as a result of reduced ground water influence.

Changes in groundcover could include a shift toward upland species, and upland shrubs could invade, resulting in a shift from herbaceous wetland to herbaceous/shrubby upland. In many stressed wetlands, invasive plants become established and out-compete native vegetation. Invasive exotics can include reed canary grass (*Phalaris arundinacea*), giant reed (*Phragmites communis*), and purple loosestrife (*Lythrum salicaria*).

A permanent loss of surface water would most certainly preclude fish habitat and amphibian habitat, which likely would degrade the potential for the wetland to support other wildlife that feed on fish or amphibians.

Open water and aquatic bed wetland systems, which have much deeper water and are typically a permanent year-round flooded wetland type, can retain many of the functions associated with wetlands depending on the severity with which the hydrology has been affected. Some wetland plants along open-water areas may adapt to lowered water levels by extending runners and rhizomes farther into the deeper water zones as they drain. A change in vegetation composition may also occur, in which more drought-tolerant plants become established. Within the predicted one to five foot drawdown range, the deeper systems might lose some deep-water wetland characteristics, such as waterfowl habitat, but may transition to wet meadow or marsh habitat.

Previously impacted (drained or filled) wetlands are likely to have diminished wetland functions and characteristics. Further and prolonged reductions in surface hydrology would in most situations result in complete loss of remaining functions.

The temporary removal of wetland vegetation is a primary impact of pipeline construction and right-of-way maintenance activities. Construction also would temporarily diminish the recreational and aesthetic value of the wetlands crossed. These effects would be greatest during and immediately following construction. In wet meadow/emergent wetlands, the impact of construction would be relatively brief, since herbaceous vegetation regenerates within one or two seasons. In forested and shrub-dominated wetlands, the impact would last longer due to the longer recovery period of these vegetation types. Long term vegetation management over the pipeline to allow access and inspection would prevent regeneration of tree and shrub cover.

4.3.1.7 Upland forest and grassland effects from the deep and shallow aquifers supply alternative

No woodlands would be affected by this alternative. This alternative would affect 6.31 acres of open lands/grasslands (CH2MHill, 2013, Vol. 5, Table 6-52).

4.3.1.8 Geomorophology and soils effects from the deep and shallow aquifers supply alternative

Proposed installation of water mains would require trenching to shallow depths of less than 10 feet. As a result, this alternative is not expected to encounter significant bedrock and would have negligible impacts to surficial geology during construction. Above ground structures associated with this alternative likely would not involve construction or excavation deeper than 10 feet. Parts of the foundations for the water treatment plants may be deeper than 10 feet below ground, but the water treatment plants are limited, nonlinear elements that would affect only a minor amount of surface area (33.2 acres for this alternative), and therefore would have only minor impacts on surficial geology.

The operational and maintenance impacts to soils are those that would occur from the proposed facilities permanently altering the land use, such as the WTP, wells, and service roads. The WTP proposed for this alternative would affect 33.20 acres, all prime farmland soils. The 11 proposed well houses would affect 38.41 acres, of which 30.96 acres, or 80.6 percent, are prime farmland. Impacts to land in active agriculture use would be much lower, however, since land uses other than agricultural occur on most of the remaining affected prime farmland soils.

4.3.1.9 Air emissions (construction and operation) effects from the deep and shallow aquifers supply alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the deep and shallow aquifers supply alternative would release an estimated 24,600 tons/yr (CO2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.3.1.10 Population effects from the deep and shallow aquifers supply alternative

All of the water supply alternatives considered population projections discussed in Section 3 of this EIS and all alternatives can meet the projected water demand. Thus, meeting the demand using any alternative source would not have any constraints on population in the City of Waukesha. No residents would be displaced by the construction or operation of the proposed project alternatives. Economic development projections are consistent under all the water supply alternatives. No low income or minority populations would be displaced in the water supply service area by the project or any of the alternatives.

4.3.1.11 Economic effects from the deep and shallow aquifers supply alternative

Projections of water demand take into account the Applicant's economy and associated water demand as it relates to the water supply service area (CH2MHill, 2013, Vol. 2). By serving the projected demand, water supply would not constrain or otherwise affect economic growth and thus be consistent with all land use planning in the water supply service area. 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 local economy.

The Center of Economic Development (CED) at the University of Wisconsin-Milwaukee (UWM) found that the source of water is not a differentiating factor on development within a municipal service area (UWM, 2010, p. 19).

Construction of the infrastructure for the deep and shallow aquifers supply alternative is expected to provide economic benefits to the well and pipeline construction industries. Operational costs to the Applicant would increase incrementally as wastewater volume use increases with increasing population and economic activity in the City. Construction and operation costs would be borne by the City's residents.

4.3.1.12 Land use effects from the deep and shallow aquifers supply alternative

The deep and shallow aquifers supply would affect a total of 152.6 acres of land. Pipeline construction would impact 121.11 acres. Construction and operation of above ground facilities and access roads would affect 31.49 acres (CH2MHill, 2013, Vol. 5, Table 6-51). A total of 13.75 acres would be affected by 11 well houses, and an additional 14.74 acres would be affected by a new water treatment plant (CH2MHill, 2013, Vol. 5, Table 6-55).

The land use construction and operation acreage impacts of this alternative are listed in Table 4-6 (CH2MHill, 2013, Vol. 5, Table 6-52). Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction.

Land use changes resulting from the operational phase of the deep and shallow aquifers supply alternative would occur because of the need for a new water treatment plant, new driveways/access roads, and aboveground structures. Land affected by pipeline construction would be restored, or allowed to revert to, its previous use. This alternative would affect no private residences.

Table 4-6. Deep and shallow aquifers supply alternative land use impacts (Source: SEWRPC, 2000)

Land Use	Acres	Percent
Residential	10.84	7.1
Commercial & Industrial	2.18	1.43
Transportation & Communication/Utilities	77.57	50.83
Government. & Institutional	0.82	0.54
Recreational Areas	0.66	0.43
Agricultural Lands	46.53	30.49
Open Lands	6.31	4.13
Woodlands	0	0
Surface Water	0.24	0.16
Wetlands	7.46	4.89
Totals	**152.61**	**100**

*Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory. Wetland acreage differs from WWI data.

Transportation

Eight percent of the pipelines for the deep and shallow aquifers supply alternative would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The only new access roads proposed would be under the deep and shallow aquifers and shallow aquifer and Fox River alluvium supply alternatives in Waukesha County. The new gravel access roads would be used for access to the well houses, during construction and operation. Access roads would be 15 feet wide, constructed only between well houses, and would not involve water body crossings. The deep and shallow aquifers supply alternative 1 would include construction of two new access roads covering three acres (CH2MHill, 2013, Vol. 5, Table 6-54). Other access would be from existing municipal roadways and trails.

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.3.1.13 Recreation and aesthetic resources effects from the deep and shallow aquifers supply alternative

Table 4-7 below summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this supply alternative (CH2MHill, 2013, Vol. 5, Table 6-56).

Table 4-7. Public or conservation lands within or adjacent to the deep and shallow aquifers supply alternative (Source: Google Earth (2009), SEWRPC (2005))

Name of Resource	Acres
Vernon Marsh Wildlife Area	1.25
American Legion Memorial Park	0.10
Fox River Park	1.40
Hillcrest Park	0.06
Spring City Soccer Club Athletic Fields	0.72
Total	**3.53**

Above ground construction-related impacts may also occur to state and local public or conservation land and natural, recreational, or scenic areas depending on the final project designs. No permanent aboveground structures are envisioned within such areas. The deep and shallow aquifers supply alternative and its associated aboveground structures (well houses and WTP) would be entirely within Waukesha County and, therefore would not impact a Coastal Zone Management Area. The well houses and water treatment plant for the deep and shallow aquifers supply alternative would be located within primarily agricultural areas, with a small amount of wetland and very limited residential areas (about 1.0 acre) impacted. If required, designs for these above-ground structures would be coordinated with local architectural requirements.

Visual impacts from the proposed supply alternatives are expected to be minor. In agricultural areas, previously disturbed easements, roadway corridors and residential properties, visual disturbance would likely be difficult to detect by the first growing season following completion of construction and surface restoration efforts. Visual impacts could result from a drawdown of the groundwater table with the deep and shallow aquifers supply alternative. Groundwater drawdown may affect areas as described above in Section 4.2.1.7, Wetlands.

4.3.1.14 Archeological and historical resources effects from the deep and shallow aquifers supply alternative

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 construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor. The deep and shallow aquifers supply alternative may affect nine cultural sites and two previous cultural resource surveys (CH2MHill, 2013, Vol. 5, Appendix 5-3). In addition, there are 25 National Register of Historic Places (NRHP) sites within 0.1 mile of facilities proposed for the deep and shallow aquifers supply alternative in Waukesha County (NHRP, 2010). The City intends to meet all regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.3.1.15 Public water supply and use in the City of Waukesha effects from the deep and shallow aquifers supply alternative

No changes in water use sectors are expected with a change in water supply source. Water use by residential, commercial, and industrial sectors is not dependent upon water source. Instead, water use will change over time due to varying factors such regional economic conditions, impacts from water conservation, and climatic conditions.

4.3.1.16 Costs and energy (construction and operation) effects from the deep and shallow aquifers supply alternative

The department considered costs based on a 50-year present worth analysis that includes both capital costs, long-term operation and maintenance, and assumes a six percent interest rate (Technical Review S2). The total costs associated with the deep and shallow aquifer water supply alternative (includes return flow) are estimated as $275,560,000 (Cost estimates by the applicant included operational and maintenance costs for home water softening, but the department did not consider these costs). Capital costs are estimated at $210,560,000.Capital costs were estimate in June 2013 dollars and operation and maintenance costs were estimated as $4,100,000. Operation and maintenance costs were calculated assuming a maximum 16.7 MGD water supply capacity, 10.1 MGD average capacity, and an average return flow of 11.7 MGD).

Operation of the deep and shallow aquifers water supply alternative would be anticipated to use 23,700 megawatt-hours (MWh) of electricity annually. This estimate assumes future average daydemand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

The energy used in the deep and shallow aquifer water supply alternative would release an estimated 24,600 tons (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

4.3.2 Shallow aquifer supply alternative environmental effects

4.3.2.1 Note that the impacts of wastewater discharge are discussed separately in section 4.4.Lake Michigan effects from the shallow aquifer supply alternative

Under this water supply alternative, pumping of the deep aquifer wells for the Applicant would cease, eliminating 5.4 MGD (2010 – 2014 average) of pumping from the deep aquifer. SEWRPC and consultants estimated projected rebound to the deep aquifer using the Southern Wisconsin Regional Groundwater Model. SEWRPC projects a rebound of 270 feet if deep aquifer pumping ceased from several communities including Waukesha (SEWRPC, 2010). Consultants projected a rebound of 100 feet assuming Waukesha ceased pumping from the deep aquifer (CH2MHILL and Ruekert-Mielke, 2003). Prior to pumping of the deep aquifer the groundwater divide was in western Waukesha County and groundwater flowed toward Lake Michigan through the deep sandstone. Based on the modeling results for withdrawals similar to 2000 withdrawal rates, groundwater no longer flows towards Lake Michigan, but rather flows towards pumping centers, such as the pumping center in Waukesha County. In addition, the groundwater pumped is replenished to the deep aquifer by water that would have flowed to streams or other surface waters. Modeling results show that 70 percent of this replenishing water comes from Mississippi River Basin surface water and 30 percent comes from Lake Michigan Basin surface waters. Lake Michigan itself accounts for approximately 4 percent of the replenishing water (Feinstein, et al. 2005, USGS, 2006). Ceasing the Applicant's pumping from the deep aquifer would result in a decrease in the volume of water induced from surface waters to replenish the deep aquifer. Consequently, less groundwater flow away from Lake Michigan and Lake Michigan tributaries could occur and may result in a benefit to the Lake Michigan basin. There would be no adverse impact on the water quality, geomorphology, sediments, or flora and fauna of Lake Michigan with this alternative.

4.3.2.2 Fox River effects from the shallow aquifer supply alternative

The Fox River would be crossed by the estimated 75-foot-wide pipeline construction corridor proposed in this alternative (CH2MHill, 2013, Vol. 5, Table 6-13). The stream crossing would be approximately 342.7 feet in length and approximately 0.59 acres in area. The crossing would likely be accomplished by the horizontal directional drilling (HDD) or another proper construction method for stream crossings to avoid or minimize construction impacts (Section 4.4).

4.3.2.2.1 Flow and flooding effects in the Fox River from the shallow aquifer supply alternative

Groundwater modeling results predict a nine percent decrease in Fox River baseflow from current baseflow with this alternative (See Appendix A). The change is due to the decrease in the use of the deep aquifer (from 5.4 MGD to 0 MGD) and an increase in the use of the shallow aquifer (from 1.2 MGD to 8.5 MGD). Currently the use of the deep aquifer results in a net addition of water to the Fox River. The source of water to the deep aquifer is western Waukesha County outside of the Fox River basin where the Maquoketa Shale is not present below the ground surface. For this alternative, the sources of water to the shallow aquifer wells would be from intercepting baseflow to the Fox River and its tributaries, wetlands, lakes, and quarries, and from flow across the Fox River basin boundary. Water pumped to the shallow aquifer returns to the Fox River system via the wastewater treatment plant. However, water that is pumped from the deep aquifer does not induce water from the Fox River, and thus augments baseflow in the Fox River. Baseflow to the Fox River decreases because augmentation of the Fox River from the deep aquifer ceases. This alternative would not affect flooding on the Fox River because there would be no floodplain changes. No regulatory floodplain changes are anticipated as floodplain studies look at the watershed infiltration capabilities and surface water runoff as a system. Flow changes due to point sources such as wells are not considered in the calculations. The aboveground structures associated with this alternative would be located outside the regulatory floodplain.

4.3.2.2.2 Water quality effects in the Fox River from the shallow aquifer supply alternative

This alternative would include new aboveground structures that could impact over 50 acres and could produce stormwater runoff from previously undeveloped land (CH2MHill, 2013, Vol. 5, Table 6-51). The increased runoff may affect water quality in the Fox River. The runoff would be managed to meet the department's stormwater quality management requirements for new development in Chapter NR 151, Wis. Admin. Code*,* as well as local stormwater management requirements. By doing so, runoff impacts to the Fox River are anticipated to be negligible.

The potential for water table reductions in adjacent corridors of the Fox River and indirect impacts to riparian vegetation could increase the potential for runoff from unvegetated or unstable bank conditions. Increasing the sedimentation and water quality would be anticipated if bank stability and riparian vegetation is not maintained.

4.3.2.2.3 Geomorphology and sediments effects from the shallow aquifer supply alternative

Supply effects

Groundwater modeling results predict a nine percent baseflow reduction in the Fox River from this alternative. (See Appendix B). This reduction would likely not affect Fox River geomorphology and sediments.

Pipeline effects

The HDD pipeline crossing of the Fox River, following proper drilling procedures, would likely not result in impacts to Fox River geomorphology and sediments (Section 4.4). Use of other crossing methods would result in temporary disruption and require restoration and stabilization of stream bed and banks. Construction trenches through streams are filled with clean, stabile materials like rock while banks have topsoil replaced.

4.3.2.2.4 Flora and fauna (including TE/SC) effects in the Fox River from the shallow aquifer supply alternative

Supply effects

The flow reduction in the Fox River could have a minimal impact to the flora and fauna of the River. A baseflow reduction could reduce habitat, impact water quality and increase temperature, stressing the biological community of the Fox River in this scenario. Baseflow reduction would also be cumulative due to the baseflow reductions in Pebble Brook, Pebble Creek, Mill Creek, Mill Brook and Genesee Creek with this alternative. As these waterways are largely influenced by groundwater it would further impact the Fox River. Increased water temperature occurs because less cold groundwater would seep into the tributaries because of the proposed shallow aquifer pumping. The temperature in the lower flow remaining in the tributaries then further increases from solar radiation. Effects would especially be felt during low flow periods when groundwater baseflow accounts for most of the flow to these tributaries, thus causing increased temperature impacts and stresses to the biological community of the Fox River.

Coolwater species including walleye may also be negatively affected as a result of the cumulative reduced baseflow of the Fox River. Adult and juvenile coolwater species of the Fox River including walleye and northern pike depend upon connectivity to cold water tributaries which provide refuge during hot summer months as well as critical nursery habitat throughout the year. These lower flow conditions can also increase stresses to macroinvertebrate populations including mussels. Reduced baseflow may alter the stream environment changing the competition, predation and organic decomposition that the macroinvertebrate community depends upon.

The flow reduction in the Fox River would not likely affect any mammal species in the Fox River or its associated habitats. However, baseflow reduction would likely impact semi-aquatic mammal species including beavers, muskrats, otters, and mink. Increased depth to groundwater would cause a change in wetland type, therefore impacting mammal species that rely on a variety of wetland types that have surface water throughout the year.

Pipeline effects

Short term impacts from a proposed open cut crossing could include a decrease in most macroinvertebrate populations, however those populations could quickly reestablish (macroinvertebrate drift) within the restored stream bed if crossings were completed successfully. Mussel populations would most likely be the most affected by open channel crossings as they are unable to relocate quickly. Relocation of existing mussel populations could help reduce effects of the stream crossing construction on the species. Resident fish population would relocate in the short term during construction and almost immediately return upon completion of the project.

There are other special concern species that may be present on land at this crossing and avoidance/minimization measures would be recommended.

Recently disturbed areas in the riparian corridor would be more susceptible to invasive species and should be managed accordingly.

4.3.2.3 Fox River tributaries environmental effects from the shallow aquifer supply alternative

Pebble Brook would be crossed by the estimated 75-foot-wide pipeline construction corridor proposed in this alternative. The stream crossing would be approximately 46.5 feet in length and approximately 0.08 acres in area (CH2MHill, 2013, Vol. 5, Table 6-13). Under the Applicant's proposal, an unnamed intermittent stream would also be crossed by the pipeline for this alternative. The crossing would be about 11.6 feet long and cover about 0.02 acres. These crossings would be accomplished by one of the drilling methods outlined in Section 4.4. Shallow groundwater pumping that would occur with this alternative would affect groundwater flow to these streams.

All of these locations would be susceptible to short term impacts from a proposed open cut crossing, ranging from decreases in most macroinvertebrate populations; however, those populations could quickly reestablish (macroinvertebrate drift) within a restored stream bed if crossings were completed successfully. Mussel populations would most likely be the most affected by open channel crossings as they are unable to relocate quickly. Relocation of existing mussel populations could help reduce effects of the stream crossing construction on the species. Resident fish population would relocate in the short term during construction and almost immediately return upon completion of the project.

Recently disturbed areas in the riparian corridor would be more susceptible to invasive species and should be managed accordingly.

4.3.2.3.1 Flow and flooding effects in the Fox River tributaries from the shallow aquifer supply alternative

Flow

Shallow groundwater pumping would draw down the aquifer, lowering the water table and decreasing groundwater discharge to Pebble Brook, Pebble Creek, Genesee Creek and Mill Creek. Mill Creek is a tributary to Pebble Brook. For purposes of this EIS, impacts to Mill Creek are included in the broader watershed context of Pebble Brook. Detailed groundwater modeling describes the potential environmental impacts to these creeks (Table 4-6, Technical Review S2 Appendix, 2015).

Table 4-8. Modeled baseflow reduction from shallow wells near Pebble Brook. See Appendix B for the groundwater flow modeling summary. Mill Brook is not listed in this table as it is outside of the model domain.

Stream	Flow reductions (percent) Wells near Pebble Creek
Pebble Brook	36-39 percent
Pebble Creek	1 percent
Mill Creek	3-5 percent
Genesee Creek	3-4 percent

Flooding

Shallow groundwater pumping from this alternative would not affect flooding on the cold water streams, because flows in these inland waterways would not increase. No regulatory floodplain changes are anticipated as floodplain studies look at the watershed infiltration capabilities and surface water runoff as a system. Flow changes due to point sources such as wells are not considered in the calculations.

4.3.2.3.2 Water quality effects in Fox River Tributaries from the shallow aquifer supply alternative

Lower baseflows in these cold water streams could lead to warmer temperatures and potential temperature impairment in Pebble Brook, Pebble Creek, Mill Brook, Genesee Creek, and Mill Creek with this alternative. Pebble Creek is listed as Impaired on Wisconsin's §303d list for temperature and this could get worse.

Pipeline effects

The Applicant would be expected to use the approved stream crossing procedures (HDD or jack and bore) and follow proper procedures through construction. These methods avoid most of the potential impacts that are a concern with pipeline crossings of waterways, as the pipeline is installed beneath the bed of the waterway (Section 4.4).

The Applicant would be expected to use the approved stream crossing procedures (HDD or jack and bore) and follow proper procedures through construction. These methods avoid most of the potential impacts that are a concern with pipeline crossings of waterways, as the pipeline is installed beneath the bed of the waterway (Section 4.4).

4.3.2.3.3 Geomorphology and sediments effects in Fox River tributaries from the shallow aquifer supply alternative

Supply effects

Reduced baseflows could result in smaller channel dimensions over time in Pebble Brook, Pebble Creek, Mill Brook, Mill Creek and Genesee Creek with this alternative, but are not expected to do so because channel morphometric stability is associated primarily with larger channel-forming flows, generally those flow and flood events having a recurrence interval of one to two years.

Pipeline effects

The HDD pipeline crossing, using proper drilling methods, would likely not result in impacts to the geomorphology and sediments of these tributaries. Use of other crossing methods would result in temporary disruption and require restoration and stabilization of stream bed and banks. Construction trenches through streams are filled with clean, stabile materials like rock while banks have topsoil replaced (Section 4.4).

4.3.2.3.4 Flora and Fauna effects in Fox River Tributaries from the shallow aquifer supply alternative

Supply effects

Baseflow reduction reduces habitat, impacts water quality, increases temperature, and stresses cold water species. Baseflow reduction would consequently adversely affect the fishery in Pebble Brook, Pebble Creek, Mill Creek, Mill Brook and Genesee Creek with this alternative. Increased water temperature occurs because less cold groundwater would seep into the waterways because of the proposed shallow aquifer pumping. Because groundwater-temperature fluctuations are relatively small compared to daily and seasonal streamflow- temperature fluctuations, groundwater discharge at a nearly constant temperature provides a stable- temperature environment for fish and other aquatic organisms. Groundwater discharge provides cool-water environments that protect fish from excessively warm stream temperatures during the summer, and conversely, relatively warm groundwater discharge can protect against freezing of the water during the winter. The temperature in the lower flow remaining in the waterway then further increases from solar radiation. The coldwater species brown trout, mottled sculpin as well as one state threatened fish species would be affected by reduced flows and increased water temperature. Coolwater species including northern pike and walleye would also be negatively affected as a result of reduced baseflow of the coldwater tributaries which provide seasonal coolwater refuge and nursery habitat. Effects would especially be felt during low flow periods when groundwater baseflow accounts for most of the flow (Diebel, 2014).

Low flow conditions can also increase stresses to macroinvertebrate populations including mussels. Reduced baseflow and constriction of these stream changes the competition, predation and organic decomposition can all alter the environment that the macroinvertebrate community depends upon.

The flow reduction in Fox River tributaries would not likely affect any mammal species in the Fox River or its associated habitats. However, baseflow reduction would likely impact semi-aquatic mammal species including beavers, muskrats, otters, and mink. Increased depth to groundwater would cause a change in wetland type, therefore impacting mammal species that rely on a variety of wetland types that have surface water throughout the year.

Pipeline effects

The HDD pipeline crossing the Fox River tributary streams could be susceptible to short term impacts from a proposed open cut crossing would cause short term impacts such as a decrease in most macroinvertebrate populations. However, those populations could quickly reestablish (macroinvertebrate drift) within a restored stream bed if crossings were completed successfully. Mussel populations would most likely be the most affected by open channel crossings as they are unable to relocate quickly. Relocation of existing mussel populations could help reduce effects of the stream crossing construction on the species. Resident fish populations would relocate in the short term during construction and almost immediately return upon completion of the project. Recently disturbed areas in the riparian corridor would be more susceptible to invasive species and should be managed accordingly.

4.3.2.4 Unnamed and intermittent streams environmental effects from the shallow aquifer supply alternative

Shallow groundwater pumping would minimally impact area unnamed and intermittent streams, ditches and canals by lowering the water table, decreasing groundwater availability to discharge to these resources and increasing outflow from these resources to the ground.

Two intermittent streams (WBIC 5037071, WBIC 771200) would be crossed by the estimated 75-foot-wide pipeline construction corridor proposed in this alternative. One intermittent stream (WBIC 5037071) would have a pipeline crossing length of approximately 17.4 feet, and an approximate area of 0.03 acres. The other stream (WBIC 771200) would have an approximate pipeline crossing length of 11.6 feet and an approximate area of 0.02 acres (CH2MHill, 2013, Vol. 5, Table 6-13). These crossings may be accomplished by the open cut method if the crossings can be completed under no-flow conditions. Crossing these streams under no flow conditions would likely result in impacts only during construction and restoration. Bed and banks would be required to be restored to preconstruction profiles, and the construction zone topsoil replaced, stabilized and revegetated. If crossed under flowing conditions, some temporary sediment suspension and downstream sedimentation is expected until the bed and banks are restored, stabilized and revegetated.

Other crossing methods would be used if the streams must be crossed while flowing (see Section 4.4). These two tributaries could be susceptible to short term impacts from a proposed open cut crossing such as a decrease in macroinvertebrate populations. However, those populations could quickly reestablish (macroinvertebrate drift) within a restored stream bed if crossings were completed successfully. Mussel populations would most likely be the most affected by open channel crossings as they are unable to relocate quickly. Relocation of existing mussel populations could help reduce effects of the stream crossing construction on the species.

Resident fish population would relocate in the short term during construction and almost immediately return upon completion of the project.

Recently disturbed areas in the riparian corridor would be more susceptible to invasive species and should be managed accordingly.

4.3.2.5 Groundwater effects from the shallow aquifer supply alternative

Effects of the shallow aquifer supply alternative on groundwater resources would be entirely within Waukesha County in the sand and gravel aquifer (shallow aquifer). Construction impacts to shallow aquifers resulting from construction and placement of a 30-inch water main from new water treatment plants to the City and of eight to 20 inch pipelines generally less than 10 feet deep from the well field to the water treatment plants are expected to be minor. Temporary impacts may include short-duration trench-dewatering efforts. It is anticipated that the shallow aquifers would return to preconstruction conditions following construction. Long term impacts could occur if pipe trenching allows redirection of subsurface flows, especially in wetlands and at stream crossings (Section 4.4).

4.3.2.5.1 Ground water quantity effects from the shallow aquifer supply alternative

Groundwater modeling results for the shallow aquifer supply alternative found a maximum drawdown of 54 to 77 feet in the shallow aquifer (Appendix B). Impacts of groundwater withdrawals on surface waters and other natural resources are described in other parts of this section. The extent of shallow aquifer groundwater drawdown is shown in the maps in the EIS, Appendix B.

Water withdrawals from the deep aquifer would stop with this alternative resulting in a 5.4 MGD decrease in withdrawal from the current withdrawal amount. Water levels in the deep aquifer have been recovering from the lows observed in the late 1990s. Cessation of pumping from the deep aquifer by the Applicant should continue the trend of aquifer recovery and possibly accelerate the recovery. However, the deep aquifer water levels are dependent on the regional pumping from this aquifer, not only the pumping from the Applicant.

4.3.2.5.2 Groundwater quality effects from the shallow aquifer supply alternative

There are no known groundwater quality changes that would occur in the shallow aquifer if they were used as a water supply source.

4.3.2.5.3 Spring effects from the shallow aquifer supply alternative

Springs represent points on the landscape where groundwater discharges to the land surface or to a surface water body. One to three springs exist within the modeled one-foot groundwater drawdown contour (See Appendix B). The springs possibly affected include WGNHS spring numbers 680253 (0.0891 cfs), 680257 (0.0668 cfs), and 680240 (0.0446 cfs) (Macholl, 2007). These springs may be impacted by this alternative (CH2MHill, 2013, Vol. 5, Appendix 6-3 for map of springs). Pumping from the shallow aquifer may lead to reductions in spring flow, a change in springflow from perennial to ephemeral, or elimination of springs altogether. Pumping from the shallow aquifer may also affect the amount of flow from different sources, thus affecting the chemical composition of the spring water.

4.3.2.6 Wetland effects from the shallow aquifer supply alternative

Wetlands are sensitive to the effects of groundwater pumping. Groundwater pumping can affect wetlands not only as a direct result of progressive lowering of the water table, but also indirectly by increased seasonal changes in the altitude of the water table. The effects on the wetland environment from changes to the hydroperiod may depend greatly on the time of year at which the effects occur. For example, lower than usual water levels during the non-growing season might be expected to have less effect on the vegetation than similar water-level changes during the growing season. The effects of pumping on seasonal fluctuations in ground-water levels near wetlands add a new dimension to the usual concerns about sustainable development that typically focus on annual withdrawals (Bacchus, 1998). Groundwater modeling results estimate 1939 to 2326 acres of wetlands within a projected drawdown of one foot or more for the shallow aquifer water supply alternative (Appendix B). The degree of impact on wetlands from groundwater drawdown and the lowering of the water table would vary depending on the wetland type, proximity to the zone of drawdown, severity of drawdown, frequency and amount of rainfall. The impacts could vary from total loss of all wetland functions to a shift from one wetland type to another. The degree of impact is dependent on a variety of factors including the hydrologic category of the wetland. Wetlands with saturated soils with no prolonged period of inundation are most vulnerable to conversion to uplands. Of these wetland types the depth of the capillary fringe, determined by the soil type, will also affect the susceptibility of the wetland to conversion to upland. The capillary fringe is typically one foot or less for all soil types. For wetlands with no prolonged period of inundation, it is reasonable to assume that these wetlands will convert to uplands. See Table 4-9.

Table 4-9. Groundwater drawdown in wetlands of one foot or greater from the shallow aquifer supply alternative (WDNR data)

Drawdown of 1 ft. or more in wetlands (ac)					
Emergent/wet meadow	**Scrub/shrub**	**Forested**	**Open water**	**Flats**	**Totals**
473 - 526	731 - 921	643 - 768	47 - 56	44-55	**1939 - 2326**

Table 4-10 lists the wetland crossing acreages associated the pipeline of this alternative.

Table 4-10. Wetland crossings of the shallow aquifer supply alternative (Source: WWI layer, CH2MHill, 2013, Vol. 5, Table 6-42)

No.	Type	Width (ft)	Area (ac)
7963	Emergent/wet meadow	556.9	1.6
7982	Emergent/wet meadow	597.2	1.83
8044	Emergent/wet meadow	—	0.52
8089	Emergent/wet meadow	58.6	0.28
8111	Flats/unvegetated wet soil	—	0.01
8122	Scrub/shrub	—	0.13
8129	Scrub/shrub	474.7	1.34
8146	Scrub/shrub	872.4	1.5
8178	Scrub/shrub	480.3	0.83
8179	Scrub/shrub	45.8	0.31
8184	Scrub/shrub	220.8	1.09
8197	Scrub/shrub	526.8	0.71
8246	Scrub/shrub	—	0.07
8249	Scrub/shrub	—	0.11
8263	Scrub/shrub	283.3	0.58
8266	Scrub/shrub	—	0.15
8303	Forested	782.9	1.34
8315	Forested	—	0.02
8324	Forested	—	1.23
8325	Forested	902.8	2.06
8392	Forested	—	0.84
8395	Forested	235.7	0.4
8399	Forested	611.9	0.95
8401	Forested	248.5	1.59
8402	Forested	213.5	2.42
Totals		**7112.1**	**21.91**

Where a crossing length is not included, the pipeline centerline would not intersect wetland; only the edge of the ROW would be located in the wetland. Because of this, it is anticipated that construction techniques could be adjusted to avoid most, if not all, wetland impacts

Four palustrine emergent (PEM) wetlands, 11 palustrine scrub-shrub (PSS) wetlands, nine palustrine forested (PFO) wetlands, and one flat/unvegetated wetland would be affected by the proposed pipeline and aboveground structures. A total of 21.91 acres of wetland would be affected.

The Applicant would need to meet requirements under NR 103, Wis. Adm. Code. Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

4.3.2.6.1 Vernon Marsh effects from the shallow aquifer supply alternative

Construction of the shallow aquifer and Fox River alluvium supply alternative would affect 1.25 acres of the Vernon Wildlife Area if it were constructed as proposed (CH2MHill, 2013, Vol. 5, Table 6-56). Groundwater modeling shows groundwater level drawdown associated with this alternative (RJN Environmental Services, 2010, 2013). Drawdown relative to the VWA is shown in the maps in Vol. 5, Appendix 6-3 (CH2MHill, 2013). This level of groundwater drawdown could result in wetland habitat type changes.

4.3.2.6.2 Flora and fauna (including T/E/SC) effects on Vernon Marsh from the shallow aquifer supply alternative

This level of groundwater drawdown would likely result in wetland habitat type changes. Species changes, habitat changes or destruction could occur when groundwater levels are lowered below that needed for wetland plant species. Vernal pool habitat is also very susceptible to changes in water depth, and lowered groundwater levels could reduce the occurrence or duration of this seasonal habitat where it exists within the groundwater drawdown zone. Because of this, significant adverse impacts could occur to the rare species that are known to use Vernon Marsh's wetland and waterway habitats. While it does not appear that protected species would be impacted with the pipeline installation, recommended avoidance and minimization measures could be made for the non-protected rare species.

Calcareous fen occurs in the southern end of the Vernon Marsh Wildlife Area, in an area not predicted to be within the area of groundwater drawdown. Consequently, no known calcareous fens would be impacted by the anticipated drawdown.

See also the discussions of effects on forested and open wetlands below.

4.3.2.6.3 Forested and scrub/shrub wetland (other than Vernon Marsh) effects from the shallow aquifer supply alternative

Wetland trees have a morphological adaptation to survive in wet soil conditions. When wet soils are exposed to air for several years, the tree subcanopy and canopy would show signs of stress, the soil can subside, and trees topple as a result of reduced soil strength. With the loss of trees, the habitat would be less suitable for nesting and denning. Animal food source changes (different plant seeds/berries) may also occur, which may affect mammals, birds, or reptiles.

A pipeline crossing a forested or scrub/shrub wetland would have a permanent wetland type change across the pipeline maintenance width because maintenance would include managing woody vegetation. Consequently, pipeline maintenance would cause a shift from forested or scrub/shrub wetland to emergent marsh or wet meadow wetland type (CH2MHill, 2013, Vol.5, Table 6-43).

4.3.2.6.4 Open wetlands (other than Vernon Marsh) effects from the shallow aquifer supply alternative

A prolonged or permanent decrease in groundwater levels of one foot or greater could lower the surface water level and soil saturation within such wetlands to such a degree that detrimental impacts to wildlife, endangered resources, and vegetative cover may occur. Impacts might include loss of habitat for invertebrates, fish, amphibians, or wading birds. Other impacts might be seen as a change in wildlife species that use the wetland, that is, with fewer wetland-dependent species present, more terrestrial species move in. Changes in herbaceous groundcover species would be observed first, followed by growth of a shrub layer.

Changes in groundcover could include a shift toward upland species, and upland shrubs could invade, resulting in a shift from herbaceous wetland to herbaceous/shrubby upland. In many stressed wetlands, invasive plants become established and out-compete native vegetation. Invasive exotics can include reed canary grass (*Phalaris arundinacea*), giant reed (*Phragmites communis*), and purple loosestrife (*Lythrum salicaria*).

A permanent loss of surface water would most certainly preclude fish habitat and amphibian habitat, which likely would degrade the potential for the wetland to support other wildlife that feed on fish or amphibians.

Open water and aquatic bed wetland systems, which have much deeper water and are typically a permanent year-round flooded wetland type, can retain many of the functions associated with wetlands depending on the severity with which the hydrology has been affected. Some wetland plants along open-water areas may adapt to lowered water levels by extending runners and rhizomes farther into the deeper water zones as they drain. A change in vegetation composition may also occur, in which more drought-tolerant plants become established. Within the predicted one to five foot drawdown range, the deeper systems might lose some deep-water wetland characteristics, such as waterfowl habitat, but may transition to wet meadow or marsh habitat. Previously impacted (drained or filled) wetlands are likely to have diminished wetland functions and characteristics. Further and prolonged reductions in surface hydrology would in most situations result in complete loss of remaining functions.

4.3.2.7 Upland forest and grassland effects from the shallow aquifer supply alternative

No woodlands would be affected by this alternative. This alternative would affect 6.31 acres of open lands/grasslands (CH2MHill, 2013, Vol. 5, Table 6-52).

4.3.2.8 Geomorophology and soils effects from the shallow aquifer supply alternative

Proposed installation of water mains would require trenching to shallow depths of less than 10 feet. As a result, the proposed supply and return flow alternative structures are not expected to encounter significant bedrock and would have negligible impacts to surficial geology during construction. Aboveground structures associated with the proposed alternatives likely would not involve construction or excavation deeper than 10 feet. Parts of the foundations for the WTPs may be deeper than 10 feet below ground, but the WTPs are limited, nonlinear elements that would affect only a minor amount of surface area (up to 33.2 acres), and therefore would have only minor impacts on surficial geology.

The proposed WTP would affect 14.74 acres, all prime farmland. The 15 well houses proposed for the shallow aquifer and Fox River alluvium alternative would affect 51.26 acres, of which 50.62 acres, or 99 percent, are as prime farmland. Impacts to land in active agriculture use would be much lower, however, since land uses other than agricultural occur on most of the remaining affected prime farmland soils.

4.3.2.9 Air emissions (constructions and operation) effects from the shallow aquifer supply alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the deep and shallow aquifers supply alternative would release an estimated 22,400 tons/yr (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.3.2.10 Population effects from the shallow aquifer supply alternative

All of the water supply alternatives considered population projections and can meet the projected water demand. Thus, meeting the demand using any alternative source would not have any constraints on population in the City of Waukesha. No residents would be displaced by the construction or operation of the proposed project alternatives. Economic development projections are consistent under all the water supply alternatives. No low income or minority populations would be displaced in the water supply service area by the project or any of the alternatives.

4.3.2.11 Economic effects from the shallow aquifer supply alternative

Projections of water demand take into account the Applicant's economy and associated water demand as it relates to the City's water supply service area (Vol. 2, Water Supply Service Area Plan). 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.

The Center of Economic Development (CED) at the University of Wisconsin-Milwaukee (UWM) found that the source of water is not a differentiating factor on development within a municipal service area (UWM, 2010, p. 19).

Construction of the infrastructure for the shallow aquifer and Fox River alluvium supply alternative is expected to provide economic benefits to the well and pipeline construction industries. Operational costs to the Applicant would increase incrementally as wastewater volume use increases with increasing population and economic activity in the City. Construction and operation costs would be borne by the City's residents.

4.3.2.12 Land use effects from the shallow aquifer supply alternative

The shallow aquifer and Fox River alluvium supply alternative would affect a total of 190.7 acres of land. Pipeline construction would impact 134.51 acres. Construction and operation of above ground facilities and access roads would affect 56.19 acres (CH2MHill, 2013, Vol. 5, Table 6-51). A total of 17.99 acres would be affected by 15 well houses, and an additional 33.20 acres would be affected by a new water treatment plant (CH2MHill, 2013, Vol. 5, Table 6-55). A larger water treatment plant is needed for this alternative for treatment of groundwater under the influence of surface water.

The land use construction and operation acreage impacts of this alternative are listed in Table 4-9 (SEWRPC). Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction.

Table 4-11. Shallow aquifer supply alternative land use impacts (Source for base land use data: SEWRPC, 2000, analysis by CH2MHill, 2013, Vol. 5)

Land Use	Acres[a]	Percent
Residential	10.70	5.61
Commercial & Industrial	2.18	1.14
Transportation & Communication/Utilities	77.70	40.74
Government. & Institutional	0.82	1.43
Recreational Areas	0.66	0.35
Agricultural Lands	73.72	38.65
Open Lands	6.31	3.31
Woodlands	0.00	0.00
Surface Water	0.55	0.29
Wetlands	18.10	9.49
Totals	**190.74**	**101.01[b]**

[a] Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory. Wetland acreage differs from WWI data.
[b] Includes rounding errors.

Land use changes resulting from the operational phase of the shallow aquifer and Fox River alluvium supply alternative would occur because of the need for a new water treatment plant, new driveways/access roads, and aboveground structures. Land affected by pipeline construction would be restored, or allowed to revert to, its previous use.

This alternative would affect no private residences.

Transportation

Seven percent of the shallow aquifer supply alternative pipelines would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The only new access roads proposed would be under the deep and shallow aquifers and shallow aquifer supply alternatives in Waukesha County. The new gravel access roads would be used for access to the well houses, during construction and operation. Access roads would be 15 feet wide, constructed only between well houses, and would not involve water body crossings. The shallow aquifer supply alternative would include construction of three new access roads covering five acres (CH2MHill, 2013, Vol. 5, Table 6-54). Other access would be from existing municipal roadways and trails.

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.3.2.13 Recreation and aesthetic resources effects from the shallow aquifer supply alternative

Table 4-12 summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this supply alternative (CH2MHill, 2013, Vol. 5, Table 6-56).

Table 4-12. Public or conservation lands within or adjacent to the shallow aquifer supply alternative (Source: Google Earth (2009); SEWRPC (2005))

Name of Resource	Acres
Vernon Marsh Wildlife Area	1.25
American Legion Memorial Park	0.10
Fox River Park	1.41
Hillcrest Park	0.06
Spring City Soccer Club Athletic Fields	0.72
Total	**3.54**

Above ground construction-related impacts may also occur to state and local public or conservation land and natural, recreational, or scenic areas depending on the final project designs. No permanent aboveground structures are envisioned within such areas. The shallow aquifer supply alternative and its associated aboveground structures (well houses and water treatment plants) would be entirely within Waukesha County and, therefore would not impact a Coastal Zone Management Area.

The well houses and water treatment plant for the shallow aquifer supply alternative would be located within primarily agricultural areas, with a small amount of wetland and very limited residential areas (about 1.0 acre) impacted. If required, designs for these above-ground structures would be coordinated with local architectural requirements.

Visual impacts from the proposed supply alternatives are expected to be minor. In agricultural areas, previously disturbed easements, roadway corridors and residential properties, visual disturbance would likely be difficult to detect by the first growing season following completion of construction and surface restoration efforts.

Visual impacts could result from a drawdown of the groundwater table with the shallow aquifer supply alternative. Vernon Wildlife Area may be impacted and is described in the open wetlands section above.

4.3.2.14 Archaeological and historical resources effects from the shallow aquifer alternative

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 construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor. The shallow aquifer supply alternative may affect 10 cultural sites (CH2MHill, 2013, Vol. 5, Appendix 5-3). There are 25 National Register of Historic Places (NRHP) sites within 0.1 mile of facilities proposed for the shallow aquifer supply alternative in Waukesha County (NHRP, 2012). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.3.2.15 Public water supply and use in the City of Waukesha from the shallow aquifer supply alternative

No changes in water use sectors are expected with a change in water supply source. Water use by residential, commercial, and industrial sectors is not dependent upon water source. Instead, water use will change over time due to varying factors such regional economic conditions, impacts from water conservation, and climatic conditions.

4.3.2.16 Costs and energy (construction and operation) effects from the shallow aquifer supply alternative

The department considered costs based on a 50-year present worth analysis that includes both capital costs, long-term operation and maintenance, and a six percent interest rate (Technical Review S2, 2015). The total costs associated with the shallow aquifer water supply alternative are estimated as $350,560,000 (cost estimates by the applicant include lime softening at the water treatment plant in operational and maintenance costs; 50-year present worth). Capital costs are estimated at $210,560,000. Capital costs were estimated in June 2013 dollars, while operation and maintenance costs are estimated as $8,900,000. Operation and maintenance costs were calculated assuming a maximum 16.7 MGD water supply capacity, 10.1 MGD average capacity, and an average return flow of 11.7 MGD.

Operation of the shallow aquifers water supply alternative would be anticipated to use 21,200 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

The energy used in the shallow aquifers water supply alternative would release emissions estimated at 22,400 tons (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

4.3.3 Lake Michigan supply alternatives environmental effects

Note that the impacts of wastewater discharge are discussed separately in section 4.4.

4.3.3.1 Common environmental effects of the Lake Michigan supply alternative

Pipeline effects

A Lake Michigan supply, regardless of the water source location would include construction of supply pipelines and a pump station.

The primary construction-related impact to Lake Michigan water quality would be elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed. Impact severity would be a function of sediment load, particle size, and duration of construction activities. Impacts would tend to be minimized by adhering to environmental permit conditions and BMPs designed to reduce the turbidity and erosion (see CH2MHill, 2013, Vol. 5, Appendix 5-2).

4.3.3.1.1 Lake Michigan volume effects from the Lake Michigan supply alternatives

Withdrawal from Lake Michigan with associated return flow is not anticipated to result in a significant change in Lake Michigan water levels. The proposed annual diversion represents 0.00028 percent of the volume of Lake Michigan and 0.000061 percent of the volume of the Great Lakes. These percentages exclude treated wastewater return flow to the GLB. Based on the preferred return flow alternative, 95-100 percent of the water withdrawn (using water use data from 2005-2012) would have been returned to the basin had the return flow plan been in place over that time period

4.3.3.1.2 Lake Michigan geomorphology and sediments effects from the Lake Michigan supply alternatives

The geomorphology and sediments of Lake Michigan would not be adversely affected by any Lake Michigan water supply alternative, because the supply would use existing treatment plant intakes in the lake, and no construction would occur within the lake for a water supply.

4.3.3.1.3 Lake Michigan flora and fauna effects from the Lake Michigan supply alternatives

A Lake Michigan water supply would have negligible effects on the lake's aquatic habitat. No new infrastructure is needed in Lake Michigan to provide water to Waukesha, so no construction impacts to aquatic habitat in the lake would occur. Increased pumping of water through the existing Lake Michigan communities' intake pipes would not affect aquatic organism entrainment and entrapment.

4.3.3.1.4 Fox River, Pebble Brook, Pebble Creek and Mill Brook, Vernon Marsh Flora and fauna effects from the Lake Michigan supply alternatives

Fox River baseflow at the confluence of the Fox River and Pebble Brook would be expected to decrease by approximately 11 percent with a switch to Lake Michigan supply (Appendix A). The percent decrease in baseflow decreases downstream of the Fox River and Pebble Brook confluence as additional flow enters the river system from tributaries. At the Waterford dam, the percent reduction in baseflow is reduced to 5-8% of the total baseflow (See Appendix A for a discussion of the estimated decrease in baseflow downstream of the City of Waukesha). This baseflow reduction could reduce habitat, impact water quality and increase temperature and related stresses in the biological community of the Fox River watershed. Lower flow conditions can also increase stresses on macroinvertebrate populations including mussels. Reduced baseflow of these streams can alter the environment resulting in changes of competition, predation and organic decomposition that the biological community depends upon.

This decrease would be due to the decrease in water discharged at the wastewater treatment plant that is currently discharged by the WWTP to the Fox River. With the change in water supply to Lake Michigan, the average annual water withdrawal would be returned to the Great Lakes basin. Some wastewater discharge would continue to the Fox River – approximately equivalent to the wastewater flow that enters the wastewater system from infiltration and inflow.

There would be no groundwater pumping under a Lake Michigan water supply alternative. Consequently, groundwater flows to Pebble Brook, Pebble Creek, Mill Brook, Mill Creek, Genesee Creek and Vernon Marsh would not be negatively affected. Under this alternative the Applicant would cease shallow groundwater pumping from existing shallow aquifer wells along the Fox River between Pebble Creek and Genesee Creek. These streams may see up a 2% increase in baseflow (see Appendix C) that would be beneficial to these streams.

A Lake Michigan supply, regardless of the water source, would include new aboveground pump stations. Since these structures would involve less than a quarter acre of land disturbance, operational stormwater quality impacts to the Fox River are not anticipated.

With a Lake Michigan supply, the Fox River would still receive some treated effluent from the City's wastewater treatment plant (approximately an annual average of 2-3 MGD, see Technical Review R1, 2015). Some water quality based limits for Lake Michigan return flow scenarios may be more stringent than the Fox River, and effluent added to the Fox may be of higher quality than it is currently.

4.3.3.1.5 Deep confined aquifer effects from the Lake Michigan supply alternatives

This alternative would not involve groundwater withdrawals, except for the emergency purposes (CH2MHill, 2013, Vol. 2). The proposed Lake Michigan water supply would eliminate the need for pumping the deep aquifer, which would continue to rebound in southeast Wisconsin. Withdrawal from Lake Michigan with return flow is not anticipated to result in a change in lake water levels, and thus is not expected to result in adverse effects to regional aquifer supplies influenced by Lake Michigan.

4.3.3.1.6 Geomorphology and soils effects from the Lake Michigan supply alternatives

The geomorphology and sediments of Lake Michigan would not be adversely affected by any Lake Michigan water supply alternative, because the supply would use existing treatment plant intakes in the lake, and no construction would occur within the lake for a water supply.

Proposed installation of water mains would require trenching to shallow depths of less than 10 feet. As a result, the proposed supply alternative structures are not expected to encounter significant bedrock and would have negligible impacts to surficial geology during construction. Aboveground structures associated with the proposed alternatives likely would not involve construction or excavation deeper than 10 feet. Parts of the foundations for the WTPs may be deeper than 10 feet below ground, but the WTPs are limited, nonlinear elements that would affect only a minor amount of surface area (up to 33.2 acres), and therefore would have only minor impacts on surficial geology.

4.3.3.1.7 Population effects from the Lake Michigan supply alternatives

All of the water supply alternatives considered population projections and can meet the projected water demand. Thus, meeting the demand using any alternative source would not have any constraints on population in the City of Waukesha. No residents would be displaced by the construction or operation of the proposed project alternatives. Economic development projections are consistent under all the water supply alternatives. No low income or minority populations would be displaced in the water supply service area by the project or any of the alternatives. See also section 4.6.

4.3.3.1.8 Public water supply and use effects from the Lake Michigan supply alternatives – City of Waukesha

No changes in water use sectors are expected with a change in water supply source. Water use by residential, commercial, and industrial sectors is not dependent upon water source. Instead, water use will change over time due to varying factors such regional economic conditions, impacts from water conservation, and climatic conditions.

4.3.3.2 Milwaukee supply alternative environmental effects

4.3.3.2.1 Stream crossings effects of the Milwaukee supply alternative

The water bodies that would be crossed by the estimated 75-foot-wide pipeline construction corridor for this alternative are listed in below in Table 4-11 (CH2MHill, 2013, Vol. 5, Table 6-13). All inland waterway crossings would result in construction-related impacts. Once construction is complete, the surface water crossings would be restored.

Table 4-13. Waterbody crossings of the Milwaukee supply alternative

No.	Name	Type	Width[a] (ft)	Area (ac)	Fisheries Classification[b]
1845	Poplar Creek	Perennial	16.8	0.030	Unknown
3294	Unnamed	Intermittent/ephemeral	—	0.002	—
3305	Unnamed	Intermittent/ephemeral	—	0.005	—
3315	Deer Creek	Perennial	—	0.020	WWSF
4310	Honey Creek	Perennial	—	0.002	—
22799	North Branch Root River	Perennial	—	0.170	WWSF
22800	North Branch Root River	Perennial	19.8	0.040	WWSF
Totals			**36.6**	**0.269**	

[a] Where no crossing width is included, the pipeline construction either infringes upon the adjacent surface water, based on aerial confirmation of the GIS data, or there was no surface water width information available in GIS format.

4.3.3.2.1.1 Stream water quality effects of stream crossings of the Milwaukee supply alternative

The primary construction-related impact to the water quality of affected streams would be elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed (see Section 4.4 for crossing methods). Clearing of streambanks of large trees could also lead to increased water temperatures due to lack of shady cover. Impact severity would be a function of sediment load, particle size, and duration of construction activities.

Impacts would tend to be minimized by adhering to environmental permit conditions and best management practices designed to reduce the turbidity and erosion (CH2MHill, 2013, Vol.5, Appendix 5-2).

4.3.3.2.1.2 Flora and fauna stream crossing effects of the Milwaukee supply alternative

The pipeline stream crossings of the Milwaukee supply alternative would not likely result in significant impacts on the flora and fauna assuming all stream crossing methodology procedures are properly followed. Streambank habitat could be altered and have a negative impact on aquatic or semi-aquatic organisms (for example, trees being removed, increasing stream temperature and negatively affecting fish populations). There are other special concern species that may be present on land at these crossings and avoidance/minimization measures would be recommended.

4.3.3.2.2 Wetland effects of the Milwaukee supply alternative

Table 4-14 lists the wetland crossing acreages associated with this alternative.

Table 4-14. Wetland crossings of the Milwaukee supply alternative (Source: WWI layer, CH2Hill, 2013, Vol. 5 Table 6-42)

No.	Type	Width[a] (ft)	Area (ac)
4965	Scrub/shrub	216.7	0.380
7962	Emergent/wet meadow	-	0.370
8145	Scrub/shrub	-	0.160
8239	Scrub/shrub	-	0.130
8290	Scrub/shrub	-	0.490
8465	Forested	-	0.120
8723	Emergent/wet meadow	-	0.080
8909	Scrub/shrub	-	0.300
8911	Scrub/shrub	-	0.170
8915	Scrub/shrub	-	0.001
8920	Scrub/shrub	-	0.110
8921	Scrub/shrub	-	0.140
8923	Scrub/shrub	-	0.070
9184	Forested	-	0.010
9306	Open water	-	0.010
10454	Emergent/wet meadow	-	0.020
11047	Emergent/wet meadow	313.4	0.500
11672	Scrub/shrub	-	0.020
11796	Forested	637.4	1.080
11799	Forested	1286.9	2.503
11973	Forested	-	0.002
12645	Forested	-	0.020
12650	Forested	-	0.150
12660	Forested	-	0.010
Totals		**2454.4**	**6.846**

[a] Where a crossing length is not included, the pipeline centerline would not intersect wetland; only the edge of the ROW would be located in the wetland because of this, it is anticipated that construction techniques could be adjusted to avoid most, if not all, wetland impacts

Four palustrine emergent (PEM) wetlands, 11 palustrine scrub-shrub (PSS) wetlands, eight palustrine forested (PFO) wetlands, and one open water wetland would be affected by pipeline construction. A total of 6.846 acres of wetland would be affected by pipeline construction for this alternative (CH2MHill, 2013, Vol. 5, Table 6-42). The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way. There would be approximately 5.866 acres of wetland type change from forested to emergent associated with this alternative.

There are two special concern herptile species, one crustacean, and three plant species that may be impacted that occur in wetlands. The herptiles also occur in associated uplands/grasslands. Recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

The Applicant would need to meet requirements under NR 103, Wis. Admin. Code (water quality standards for wetlands). Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

4.3.3.2.3 Upland forests and grasslands effects of the Milwaukee supply alternative

The pipeline crossings for this alternative would affect 0.45 acres of woodlands. The pipeline crossings for this alternative would affect 7.97 acres of open lands/grasslands (CH2MHill, 2013, Vol. 5, Table 6-52).

4.3.3.2.4 Air emissions (construction and operation) effects of the Milwaukee supply alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the City of Milwaukee water supply alternative would release an estimated 13,200 tons/yr (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.3.3.2.5 Economic effects from the Milwaukee supply alternative

Projections of water demand take into account the Applicant's economy and associated water demand as it relates to the City's water supply service area (CH2MHill, 2013, Vol. 2). 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.

The CED study found that the source of water is not a differentiating factor on development within a municipal service area (UWM, 2010, p. 19).

Construction of the infrastructure for the Milwaukee supply alternative is expected to provide economic benefits to the pipeline construction industry. Operational costs to the Applicant, and payments to the City of Milwaukee, would increase incrementally as water volume use increases with increasing population and economic activity in Waukesha. Construction and operation costs would be borne by Waukesha residents.

4.3.3.2.6 Land use effects from the Milwaukee supply alternative

The Milwaukee supply alternative would affect a total of 122.4 acres of land for pipeline construction. A pump station may be required, and if so is expected to impact approximately 0.25 acres (CH2MHill, 2013, Vol.5, Table 6-51).

The land use construction and operation acreage impacts of this alternative are listed in Table 4-13. Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction.

Table 4-15. Milwaukee water supply alternative land use impacts (Source for base land use data: SEWRPC, 2000; analysis by CH2MHill, 2013, Vol. 5)

Land Use	Acres[a]	Percent
Residential	3.03	2.48
Commercial & Industrial	3.29	2.69
Transportation & Communication/Utilities	97.86	80.08
Government & Institutional	0.04	0.03
Recreational Areas	2.35	1.92
Agricultural Lands	0.00	0.00
Open Lands	7.97	6.52
Woodlands	0.45	0.37
Surface Water	0.00	0.00
Wetlands	7.21	5.90
Totals [b]	**122.20**	**99.99** [c]

[a] Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory (Note: Wetland acreage differs from WWI data)
[b] Lake Michigan supply and return flow options share the same workspace for about six miles. Actual land use totals would be less than reported if a Lake Michigan supply and return flow option was selected.
[c] Includes rounding errors.

No new access roads would be required for the Lake Michigan supply alternatives. Access is anticipated to be from existing municipal roadways and trails. The residential land within the assumed 75-foot construction corridor borders roads. The majority of residential land that could be affected by the proposed alignments is described as single family low density. The construction corridor may be further minimized to avoid private property, or temporary construction easements would be obtained by the City. This alternative would affect no private residences. A single private building in Waukesha County is located within the proposed 75-foot-wide construction corridor at the terminus of the Lake Michigan supply alternatives. Based on a review of aerial photography, it appears to be used as a storage structure. The City would coordinate with the owner of the building if a Lake Michigan supply was approved and would avoid this building or minimize the construction-related impacts.

The Milwaukee supply alternative pipelines would not affect active agricultural lands. Land affected by pipeline construction would be restored, or allowed to revert to, its previous use. No changes to zoning would be required for construction and operation of the Milwaukee supply alternative.

Transportation

Eighty percent of the Milwaukee supply alternative pipelines would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An

increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.
The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

Safety
Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.3.3.2.7 Recreation and aesthetic resources effects of the Milwaukee supply alternative

Table 4-16 (CH2MHill, 2013, Vol. 5, Table 6-56) summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this supply alternative.

Table 4-16. Public or conservation lands within or adjacent to the Milwaukee supply alternative (Source: Google Earth, 2009, SEWRPC, 2005)

Name of Resource	Acres
Greenfield Park	0.17
Hillcrest Park	1.16
New Berlin Golf Course	1.51
Root River Parkway	21.28
Total	**24.12**

Above ground construction-related impacts may also occur to state and local public or conservation land and natural, recreational, or scenic areas depending on the final project designs. No permanent aboveground structures are envisioned within such areas. Depending upon the final booster pump station location, however, Greenfield Park could be affected. If so, impacts would be limited to approximately 0.25 acres and would be coordinated with local public officials and the public. The Milwaukee supply alternative would not impact a Coastal Zone Management Area. Visual impacts from the proposed supply flow alternatives are expected to be minor.

4.3.3.2.8 Archeological and historical resources effects of the Milwaukee supply alternative

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 construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor. The Milwaukee supply alternative may affect five cultural sites (CH2MHill, 2013, Vol. 5, Appendix 5-3). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.3.3.2.9 Costs and energy (construction and operation)effects of the Milwaukee supply alternative

Specific cost estimates for an alternative of obtaining Lake Michigan water by connecting to the City of Milwaukee's existing distribution system were not supplied as part of the Applicant's Environmental Report or Application. The Applicant and City of Oak Creek have entered in agreement for public water supply under a 'letter of intent' for Oak Creek to supply potable water to the Waukesha Water Utility.

Operation of the Lake Michigan water supply via Milwaukee would be anticipated to use 11,500 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

4.3.3.3 Oak Creek supply alternative environmental effects

4.3.3.3.1 Stream crossings effects of Oak Creek supply alternative

The water bodies that would be crossed by the estimated 75-foot-wide pipeline construction corridor for this alternative are listed in Table 4-17 (CH2MHill, 2013, Vol. 5, Table 6-13).

Table 4-17. Water body crossings of the Oak Creek supply alternative

No.	Name	Type	Width (ft)	Area (ac)	Fisheries Classification[a]
3732	Unnamed	Intermittent/ephemeral	14.3	0.02	Unknown
3932	North Branch Root River	Perennial	49.7	0.09	WWSF
5109	Unnamed	Intermittent/ephemeral	18.9	0.04	Unknown
Totals			**82.9**	**0.15**	

4.3.3.3.1.1 Water quality stream crossings effects of the Oak Creek supply alternative

The primary construction-related impact to the water quality of affected streams could be possible elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed. Increase in water temperatures due to bank clearing of large trees could also occur. Impact severity would be a function of sediment load, particle size, and duration of construction activities. Impacts would tend to be minimized by adhering to environmental permit conditions and best management practices to reduce the turbidity and erosion (CH2MHill, 2013, Vol. 5, Appendix 5-2).

4.3.3.3.1.2 Flora and fauna stream crossings effects of the Oak Creek supply alternative

The pipeline stream crossings of the Oak Creek supply alternative would not likely result in impacts on the flora and fauna assuming proper stream crossing methods are used (Section 4.4). There are other special concern species that may be present on land at these crossings and avoidance/minimization measures would be recommended.

4.3.3.3.2 Wetland effects of the Oak Creek Supply alternative

Table 4-18 lists the wetland crossing acreages associated with this alternative.

Table 4-18. Wetland crossings of the Oak Creek supply alternative (Source: WWI layer, CH2MHill, 2013, Vol.5, Table 6-42)

No.	Type	Width[a] (ft)	Area (ac)
8714	Emergent/wet meadow	—	0.07
9020	Forested	—	0.02
9026	Forested	—	0.07
9028	Forested	—	0.01
10401	Emergent/wet meadow	—	<0.01
10573	Emergent/wet meadow	—	<0.01
11286	Scrub/shrub	—	0.01
11290	Scrub/shrub	—	0.02
11369	Scrub/shrub	—	0.02
11376	Scrub/shrub	—	0.05
11539	Scrub/shrub	—	<0.01
11896	Forested	—	0.07
11900	Forested	—	0.13
11906	Forested	—	0.03
11914	Forested	—	<0.01
12293	Forested	—	0.01
12301	Forested	—	0.01
12314	Forested	—	<0.01
12392	Forested	—	0.01
12399	Forested	—	<0.01
Totals		**—**	**0.5[b]**

[a] Where a crossing length is not included, the pipeline centerline would not intersect wetland; only the edge of the ROW would be located in the wetland. Because of this, it is anticipated that construction techniques could be adjusted to avoid most, if not all, wetland impacts.
[b] Total acreage is an estimated maximum.

Three palustrine emergent (PEM) wetlands, five palustrine scrub-shrub (PSS) wetlands, and 13 palustrine forested (PFO) wetlands would be affected by pipeline construction. A total of up to 0.5 acres of wetland would be affected by pipeline construction for this alternative (CH2MHill, 2013, Vol. 5, Table 6-42).

The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way. There would be less than 0.1 acre of wetland type change from forested to emergent associated with this alternative.

There are two special concern herptile species and one crustacean that occur in wetlands and may be impacted. The herptiles also occur in associated uplands/grasslands. Recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

4.3.3.3.3 Upland forest and grassland effects of the Oak Creek supply alternative

This alternative would affect 0.48 acres of woodlands (CH2MHill, 2013, Vol. 5, Table 6-52). There are four rare plants that occur in dry-mesic to mesic woodlands and recommended measures may be suggested in order to avoid and/or minimize impacts to this species. In addition, there is a forested natural community that runs adjacent to a portion of this route and buffers would be recommended to avoid impacts. This alternative would affect 1.18 acres of open lands/grasslands (CH2MHill, 2013, Vol. 5, Table 6-52).

4.3.3.3.4 Air emissions (construction and operation) effects of the Oak Creek supply alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the Oak Creek water supply alternative would release an estimated 15,700 tons/yr (CO2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.3.3.3.5 Economic effects of the Oak Creek supply alternative

Projections of water demand take into account the Applicant's economy and associated water demand as it relates to the City's water supply service area (Vol. 2, Water Supply Service Area Plan). 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.

The CED study found that the source of water is not a differentiating factor on development within a municipal service area (UWM, 2010, p. 19).

Construction of the infrastructure for the Oak Creek supply alternative is expected to provide economic benefits to the pipeline construction industry. Operational costs to the Applicant, and payments to the City of Oak Creek, would increase incrementally as water volume use increases with increasing population and economic activity in Waukesha. Construction and operation costs would be borne by Waukesha residents.

4.3.3.3.6 Land use effects of the Oak Creek supply alternative

The Oak Creek supply alternative would affect a total of 176.8 acres of land for pipeline construction. A pump station may be required, and if so is expected to impact approximately 0.25 acres (CH2MHill, 2013, Vol. 5, Table 6-51).

The land use construction and operation acreage impacts of this alternative are listed in Table 4-19. Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction.

Table 4-19. Oak Creek water supply alternative land use impacts (Source for base land use: SEWRPC, 2000; analysis by CH2MHill, 2013, Vol. 5)

Land Use	Acres[a]	Percent
Residential	5.60	3.17
Commercial & Industrial	0.25	0.14
Transportation & Communication/Utilities	165.57	93.65
Government. & Institutional	0.36	0.2
Recreational Areas	0.25	0.14
Agricultural Lands	2.62	1.48
Open Lands	1.18	0.67
Woodlands	0.48	0.27
Surface Water	0.00	0
Wetlands	0.49	0.28
Totals[b]	**176.8**	**100**

[a] Represents the total land along each alternative that had a specific land use designation within the SEWRPC Digital Land Use Inventory. Wetland data differs from WWI data.
[b] Lake Michigan supply and return flow options share the same workspace for about six miles. Actual land use totals would be less than reported if a Lake Michigan supply and return flow option was selected.

The Lake Michigan City of Oak Creek supply and Root River return flow share the same workspace for about 15 miles. Actual land use totals would be less than reported if this combination of Lake Michigan supply and return flow options were selected. No new access roads would be required for the Lake Michigan supply alternatives. Access is anticipated to be from existing municipal roadways and trails.

The Oak Creek supply alternative pipelines would not affect active agricultural lands.

For this alternative, four single private buildings in the City of Franklin, Milwaukee County, are partially located within the estimated 75-foot-wide construction corridor of the proposed supply project. The pipeline corridor is planned to be within existing street rights-of-way. Impacts should be able to be minimized by adjusting the construction technique at these locations. Based on a review of aerial photography, the structures appear to be two garages, one apartment complex and one storage shed. Impacts to these structures should be avoidable. The City would coordinate with the owners of each structure, if the proposed project was approved, and would avoid these buildings or construction-related impacts. Appropriate mitigation measures would be taken to restore properties disturbed during construction. Land affected by pipeline construction would be restored, or allowed to revert to, its previous use. No changes to zoning would be required for construction and operation of the Oak Creek supply alternative.

Transportation

Ninety four percent of the Oak Creek supply alternative pipelines would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

4.3.3.3.7 Recreation and aesthetic resources effects of the Oak Creek supply alternative

Table 4-20 summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this supply alternative.

Table 4-20. Public or conservation lands within or adjacent to the Oak Creek supply alternative (Source: Google Earth, 2009, SEWRPC, 2005)

Name of Resource	Acres
Franklin Woods Nature Center	0.65
Hidden Lakes Park	0.38
Hillcrest Park	0.04
Park Arthur	0.48
Prospect Hill School	0.62
Total	**2.17**

Above ground construction-related impacts may also occur to state and local public or conservation land and natural, recreational, or scenic areas depending on the final project designs. No permanent aboveground structures are envisioned within such areas. The Oak Creek supply alternative would not impact a Coastal Zone Management Area. Visual impacts from the proposed supply and corresponding return flow alternative are expected to be minor.

4.3.3.3.8 Archeological and historical resources effects of the Oak Creek supply alternative

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 construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor. The Oak Creek supply alternative may affect seven cultural sites (CH2MHill, 2013, Vol. 5, Appendix 5-3). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.3.3.3.9 Costs and energy (construction and operation) effects of the Oak Creek supply alternative

The department considered costs based on a 50-year present worth analysis that includes both capital costs, long-term operation and maintenance, and assumes a six percent interest rate (Technical Review S2, 2015). The total costs of a Lake Michigan water supply from Oak Creek and return flow to the Lake Michigan basin are estimated at $332,400,000 (50 year present worth). Capital costs are estimated at $206,400,000[7] while operation and maintenance costs are estimated as $8,000,000[8].

Operation of the Lake Michigan water supply from Oak Creek alternative would be anticipated to use 14,200 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). The energy used in the Oak Creek water supply

[7] Capital costs were estimate in June 2013 dollars, and assume a 2013 construction start.

[8] Operation and maintenance costs were calculated assuming a maximum 16.7 MGD water supply capacity, 10.1 MGD average capacity, and an average return flow of 11.7 MGD.

alternative (not including return flow) would release an estimated 15,700 tons (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

4.3.3.4 Racine supply alternative environmental effects

4.3.3.4.1 Stream Crossings water quality effects

The primary construction-related impact to the water quality of affected streams would be elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed. Impact severity would be a function of sediment load, particle size, and duration of construction activities. Impacts would tend to be minimized by adhering to environmental permit conditions and best management practices designed to reduce the turbidity and erosion (CH2MHill, 2013, Vol. 5, Appendix 5-2).

The water bodies that would be crossed by the estimated 75-foot-wide pipeline construction corridor for this alternative are listed in Table 4-21 (CH2MHill, 2013, Vol. 5, Table 6-13).

Table 4-21. Water body crossings of the Racine supply alternative

No.	Name	Type	Width[a] (ft)	Area (ac)	Fisheries Classification
1845	Poplar Creek	Perennial		0.03	Unknown
3280	Poplar Creek	Perennial	—	1.09	Unknown
3333	Unnamed	Intermittent/ephemeral	—	0.07	—
3335	Unnamed	Intermittent/ephemeral	—	0.05	—
3408	Unnamed	Intermittent/ephemeral	—	0.02	—
3413	Unnamed	Intermittent/ephemeral	—	0.08	—
3432	Muskego Drainage Canal	Perennial	—	0.51	Unknown
3459	Unnamed	Intermittent/ephemeral	—	0.2	—
3484	Unnamed	Intermittent/ephemeral	—	0.02	—
3486	Unnamed	Intermittent/ephemeral	—	0.06	—
8339	Unnamed	Intermittent/ephemeral	—	0.24	—
210	Husher Creek	Perennial	2.5	0.01	—
668	Hoods Creek	Perennial	11.5	0.02	—
1827	Goose Lake Branch Canal[b]	Perennial	3.9	2.23	—
2282	Root River Canal	Perennial	35.4	0.07	—
20172	Mill Creek	Perennial	4.2	0.01	
Totals			**57.5**	**4.71**	

[a] Where no crossing width is included, the pipeline construction either infringes upon the adjacent surface water, based on aerial confirmation of the GIS data, or there was no surface water width information available in GIS format.

[b] The current theoretical project alignment for Lake Michigan–Racine Supply is parallel to the Goose Lake Branch Canal, but the actual construction corridor would be narrowed to avoid impacts to the water body.

4.3.3.4.1.1 Flora and fauna stream crossings effects

The pipeline stream crossings of the Racine supply alternative would not likely result in impacts on the flora and fauna assuming proper HDD procedures are followed. There are other special concern species that may be present on land at these crossings and avoidance/minimization measures would be recommended.

4.3.3.4.2 Wetland effects of the Racine supply alternative

A total of 56.382 acres of wetland would be affected by pipeline construction for this alternative. Twenty-nine palustrine emergent (PEM) wetlands, 29 palustrine scrub-shrub (PSS) wetlands, 15 palustrine forested (PFO) wetlands, four filled/drained, eight flats/unvegetated soil, and six open-water wetlands would be affected by pipeline construction.

Table 4-22 lists wetland crossing acreages associated with this alternative.

Table 4-22. Wetland crossings of the Racine water supply alternative (Source: WWI, CH2MHill, 2013, Vol. 5, Table 6-42)

No.	Type	Area (ac)
3	Emergent/wet meadow	0.610
4965	Scrub/shrub	0.380
7512	Scrub/shrub	0.020
7895	Open water	0.390
7962	Emergent/wet meadow	0.370
8050	Emergent/wet meadow	1.940
8126	Scrub/shrub	0.510
8139	Scrub/shrub	0.090
8145	Scrub/shrub	0.160
8168	Scrub/shrub	0.430
8183	Scrub/shrub	0.960
8188	Scrub/shrub	0.540
8192	Scrub/shrub	0.700
8239	Scrub/shrub	0.130
8290	Scrub/shrub	0.490
8338	Forested	1.140
8382	Forested	0.030
8383	Forested	0.050
8436	Forested	0.200
8465	Forested	0.120
8625	Filled/drained wetland	0.170
8632	Filled/drained wetland	0.370
8766	Emergent/wet meadow	3.230
8872	Scrub/shrub	3.460
8873	Scrub/shrub	2.720
8901	Scrub/shrub	0.470
9139	Forested	0.060
9184	Forested	0.010
9309	Scrub/shrub	2.250
9336	Emergent/wet meadow	0.220
9337	Emergent/wet meadow	0.360
9345	Emergent/wet meadow	0.400
9353	Emergent/wet meadow	0.810
9358	Emergent/wet meadow	0.001
9366	Emergent/wet meadow	0.430
9378	Emergent/wet meadow	1.850
9381	Emergent/wet meadow	0.120
9382	Emergent/wet meadow	0.100
9395	Emergent/wet meadow	0.260
9396	Emergent/wet meadow	0.550
9406	Emergent/wet meadow	0.450
9408	Emergent/wet meadow	0.150
9423	Flats/unvegetated wet soil	0.210
9432	Flats/unvegetated wet soil	0.610
9434	Flats/unvegetated wet soil	0.440
9450	Flats/unvegetated wet soil	1.840
9451	Flats/unvegetated wet soil	0.630
9457	Scrub/shrub	1.260
9459	Scrub/shrub	0.540

No.	Type	Area (ac)
9461	Scrub/shrub	0.420
9464	Scrub/shrub	1.220
9477	Scrub/shrub	0.750
9503	Forested	0.510
9531	Forested	0.030
9552	Open water	0.200
9556	Open water	0.500
9559	Open water	0.220
9561	Open water	0.050
9592	Emergent/wet meadow	0.460
9597	Emergent/wet meadow	0.260
10058	Emergent/wet meadow	0.720
10090	Emergent/wet meadow	0.260
10164	Scrub/shrub	0.020
10195	Forested	1.310
13701	Filled/drained wetland	0.050
13719	Filled/drained wetland	0.070
14241	Emergent/wet meadow	0.020
14301	Emergent/wet meadow	0.230
14655	Flats/unvegetated wet soil	0.120
15492	Emergent/wet meadow	0.210
15519	Emergent/wet meadow	0.320
15593	Emergent/wet meadow	0.120
15606	Emergent/wet meadow	0.260
15748	Emergent/wet meadow	0.360
15821	Emergent/wet meadow	0.730
16339	Flats/unvegetated wet soil	0.050
16468	Flats/unvegetated wet soil	0.660
16601	Scrub/shrub	2.030
16870	Scrub/shrub	0.680
16945	Scrub/shrub	0.860
16956	Scrub/shrub	0.001
16957	Scrub/shrub	0.260
16973	Scrub/shrub	0.140
17124	Scrub/shrub	0.720
17253	Scrub/shrub	0.180
17860	Forested	0.850
18252	Forested	0.300
18661	Forested	0.020
18669	Forested	0.750
18679	Forested	1.470
20167	Open water	0.260
Totals		**56.382**

The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way. There would be approximately 19.182 acres of wetland type change from forested to emergent associated with this alternative. A state endangered bird occurs within the vicinity of this project and suitable habitat may be impacted. Required measures in order to avoid take of this species could be surveys and/or time of year restrictions. There are four other special concern wetland-dependent birds, including the bald eagle, that occur within the vicinity of the project and recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

There is an endangered herptile species that occurs within the vicinity of supply line; however, there is no suitable habitat within the 2-mile buffer of that occurrence. There are two special concern herptile species and five plant species that occur in wetlands and may be impacted. The herptiles also occur in associated uplands/grasslands. Recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

The Applicant would need to meet requirements under NR 103, Wis. Admin. Code (water quality standards for wetlands). Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

4.3.3.4.3 *Upland forest and gr*asslands effects of the Racine supply alternative

This alternative would affect 7.74 acres of woodlands (CH2MHill, 2013, Vol. 5, Table 6-52). There are five rare plants that occur in dry-mesic to mesic woodlands and recommended measures may be suggested in order to avoid and/or minimize impacts to this species. In addition, there are two forested natural communities that run adjacent to portions of this route and buffers would be recommended to avoid impacts.

This alternative would affect 30.70 acres of open lands/grasslands (CH2MHill, 2013, Vol. 5, Table 6-52). A state endangered grassland bird occurs within the vicinity of this project and suitable habitat may be impacted. There are also two rare plants that occur in a variety of prairies and oak barrens and recommended measures may be suggested in order to avoid and/or minimize impacts to this species.

4.3.3.4.4 Air emissions (construction and operation) effects of the Racine supply alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the Racine supply alternative would release an estimated 17,500 tons/yr (CO2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.3.3.4.5 Economic effects of the Racine supply alternative

Projections of water demand take into account the Applicant's economy and associated water demand as it relates to the City's water supply service area (CH2MHill, 2013, Vol. 2). Serving the projected demand 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.

The CED study found that the source of water is not a differentiating factor on development within a municipal service area (UWM, 2010, p. 19).

Construction of the infrastructure for the Racine supply alternative is expected to provide economic benefits to the pipeline construction industry. Operational costs to the Applicant, and payments to the City of Racine, would increase incrementally as wastewater volume use increases with increasing population and economic activity in Waukesha. Construction and operation costs would be borne by Waukesha residents.

4.3.3.4.6 Land use effects of the Racine supply alternative

The Racine supply alternative would affect a total of 341.6 acres of land for pipeline construction. A pump station may be required, and if so is expected to impact approximately 0.25 acres (CH2MHill, 2013, Vol. 5, Table 6-51).

The land use construction and operation acreage impacts of this alternative are listed in Table 4-22. Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction. Note that Table 4-23 uses SEWRPC land use data.

Table 4-23. Racine water supply alternative land use impacts (Source for base land use data: SEWRPC, 2000; analysis by CH2MHill, 2013, Vol. 5)

Land Use	**Acres**[a]	**Percent**
Residential	9.31	2.73
Commercial & Industrial	4.24	1.24
Transportation & Communication/Utilities	33.85	9.91
Government. & Institutional	0.04	0.01
Recreational Areas	3.75	1.10
Agricultural Lands	213.05	62.37
Open Lands	30.70	8.99
Woodlands	7.74	2.27
Surface Water	0.26	0.08
Wetlands	38.67	11.32
Totals[b]	**341.61**	**100.02**[c]

[a] Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory.
[b] Lake Michigan supply and return flow options share the same workspace for about six miles. Actual land use totals would be less than reported if a Lake Michigan supply and return flow option was selected.
[c] Includes rounding errors.

No new access roads would be required for the Lake Michigan supply alternatives. Access is anticipated to be from existing municipal roadways and trails.

The residential land within the assumed 75-foot construction corridor borders roads. The majority of residential land that could be affected by the proposed alignments is described as single family low density. The construction corridor may be further minimized to avoid private property, or temporary construction easements would be obtained by the City. This alternative would affect no private residences.

A single private building in Waukesha County is located within the proposed 75-foot-wide construction corridor at the terminus of the Lake Michigan supply alternatives. Based on a review of aerial photography, it appears to be used as a storage structure. The City would coordinate with the owner of the building if a Lake Michigan supply was approved and would avoid this building or minimize the construction-related impacts. Land affected by pipeline construction would be restored, or allowed to revert to, its previous use. No changes to zoning would be required for construction and operation of the Racine supply alternative.

Transportation

Sixty nine percent of the Racine supply alternative pipeline would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.3.3.4.7 Recreation and aesthetic resources effects of the Racine supply alternative

Table 4-24, (CH2MHill, 2013, Vol. 5, Table 6-56) summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this supply alternative.

Table 4-24. Public or conservation lands within or adjacent to the Racine supply alternative (Source: Google Earth, 2009; SEWRPC 2005)

Name of Resource	Acres
Big Muskego Lake Wildlife Area (WDNR)	2.64
Cheska Farms Riding Stables (WDNR site)	2.29
WDNR designated area	5.66
Hillcrest Park	1.16
Minooka Park	8.64
Total	**20.39**

Above ground construction-related impacts may also occur to state and local public or conservation land and natural, recreational, or scenic areas depending on the final project designs. No permanent aboveground structures are envisioned within such areas. The Racine supply alternative would not impact a Coastal Zone Management Area. Visual impacts from the proposed supply alternatives are expected to be minor.

4.3.3.4.8 Archeological and historical resources effects of the Racine supply alternative

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 construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor. The Racine supply alternative may affect two cultural sites (CH2MHill, 2013, Vol. 5, Appendix 5-3). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.3.3.4.9 Costs and energy (construction and operation) effects of the Racine supply alternative

The Applicant did not provide cost estimates for an alternative of obtaining Lake Michigan water by connecting to the City of Racine's existing water supply system. Operation of a Lake Michigan water supply from Racine would be anticipated to use 16,100 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb,2015).

4.4 Return flow alternatives environmental effects

4.4.1 Fox River discharge alternative environmental effects

Any of the Mississippi River basin (deep and shallow aquifer, shallow aquifer) water supply alternatives would continue to discharge all of the Applicant's treated wastewater to the Fox River. The Fox River effluent discharge would not affect upland resources or surface water resources within the Lake Michigan basin, including Lake Michigan.

Returning all flow to the Fox River cannot be considered with the Lake Michigan water supply alternatives because the Compact requires that all water withdrawn from Lake Michigan, less an amount for consumptive use, be returned to the Lake Michigan basin. Some treated effluent (approximately 2-3 MGD) will be discharged to the Fox River under the Lake Michigan supply alternatives and that is addressed in later sections of this EIS.

The Fox River discharge alternative only addresses effects on the Fox River under the Mississippi River Basin 'only' water supply alternatives.

4.4.1.1 Flow and flooding effects on the Fox River and Fox River Tributaries from the Fox River discharge alternative

Fox River

The Applicant's wastewater treatment plant (WWTP) currently discharges to the Fox River and would continue to do so under the Mississippi River Basin water supply alternatives. Baseflow at the USGS Waukesha flow gage (05543830) is 49.6 cfs (Feinstein et al., 2012). The average annual discharge from the WWTP from 2008 to 2012 was 15.8 cfs, accounting for approximately 32 percent of the Fox River flow at the WWTP outfall (based on USGS gage station flows approximately 3100 feet upstream from the WWTP).

During high flow and flooding events, the WWTP contributes a small percent of the overall flow in the Fox River. The peak flow recorded at the USGS Waukesha gage flow on the Fox River, June 9, 2008 was 2,390 cfs and downstream, the peak discharge from the City's WWTP was 53 cfs (approximately 34 MGD), contributing about 2 percent of the flow to the Fox River on this date.

Pebble Brook, Pebble Creek, Mill Brook, Mill Creek, and Genesee Creek

Continued discharge of all of the WWTP's treated wastewater to the Fox River would not affect flow or flooding in Pebble Brook, Pebble Creek, Mill Brook, Mill Creek and Genesee Creek.

4.4.1.2 Water quality effects on the Fox River and Fox River Tributaries from the Fox River discharge alternative

Fox River

The Applicant's WWTP currently meets Wisconsin's Pollutant Discharge Elimination System (WPDES) permit requirements to discharge to the Fox River. No change in the plant permit limits would be expected due to a switch in Mississippi River basin water supply sources (CH2MHill, 2013, Vol. 4). The Applicant's current WPDES permit (issued 2013) for the Fox River discharge has a chloride variance that includes a compliance schedule, interim limits and specific requirements for chloride reductions. Continued private water softening would still be expected with any of the Mississippi River basin alternatives. The City continues to implement a chloride reduction scenario to meet interim limits in its 2013 WPDES permit (Technical Review R4, 2015). The Applicant's 2013 Approved Facilities Plan includes plans to meet the phosphorus water quality criterion of the Fox River (0.075 mg/L TP) and upgrades to the WWTP's UV disinfection system (Strand Associates, 2011).

Pebble Brook, Pebble Creek, Mill Brook, Genesee Creek and Mill Creek

Continued discharge of the City's treated wastewater to the Fox River would not affect water quality in any of the Fox River tributaries.

4.4.1.3 Geomorphology and sediments effects on the Fox River and Fox River Tributaries form the Fox River discharge alternative

Continued discharge of the City's treated wastewater to the Fox River would not create any change in geomorphology to the Fox River. Continued discharge of the City's treated wastewater to the Fox River would not affect the geomorphology or sediments in Pebble Brook, Pebble Creek, Mill Brook, Genesee Creek and Mill Creek.

4.4.1.4 Wetlands and Vernon Marsh effects from the Fox River discharge alternative

Continued discharge of the City's treated wastewater to the Fox River would not affect Vernon Marsh or other wetlands.

4.4.1.5 Flora and fauna effects on the Fox River and its tributaries from the Fox River discharge alternative

Continued discharge of the City's treated wastewater to the Fox River is not likely to have a net negative effect on the flora and fauna in the Fox River or its associated habitats. In addition, continued wastewater discharge to the Fox River would not affect the flora and fauna in Pebble Brook, Pebble Creek, Mill Brook, Mill Creek, and Genesee Creek.

4.4.1.6 Upland forest and grassland effects of the Fox River discharge alternative

Continued discharge of the City's treated wastewater to the Fox River would not affect area forests and open lands/grasslands.

4.4.1.7 Air emissions (construction and operations) effects of the Fox River discharge alternative

During operation, energy use and associated air emissions, to pump and discharge treated wastewater effluent would increase only incrementally as the volume of water use increases with increasing population and economic activity in the City of Waukesha. No immediate change from current air emissions is expected with this alternative.

4.4.1.8 Population effects of the Fox River discharge alternative

The Fox River discharge alternative is not anticipated to affect the populations of Waukesha, or other communities in the southeast Wisconsin region. No residents would be displaced by the construction or operation of this alternative. No low income or minority populations would be displaced by this alternative, and the project operation is not expected to cause any adverse impacts to low income or minority populations.

4.4.1.9 Economic effects of the Fox River discharge alternative

Construction of the infrastructure for the Fox River discharge alternative is expected to provide economic benefits to the pipeline construction industry. Operational costs to the Applicant would increase incrementally as wastewater effluent flows increase with increasing population and economic activity. Construction and operation costs would be borne by the residents of the approved water supply service area.

4.4.1.10 Land use effects of the Fox River discharge alternative

No land use changes are anticipated with this alternative.

4.4.1.11 Recreation and aesthetic resources effects of the Fox River discharge alternative

Continued discharge of the Applicant's treated wastewater to the Fox River would not affect area recreation and aesthetic resources.

4.4.1.12 Archeological and historical resources effects of the Fox River discharge alternative

Continued discharge of the Applicant's treated wastewater to the Fox River would not affect area archeological and historical resources.

4.4.1.13 Public water supply and uses in the City of Waukesha from the Fox River discharge alternative

Continued discharge of the Applicant's treated wastewater to the Fox River would not affect public water supply and use in Waukesha or other south east Wisconsin communities.

4.4.1.14 Costs and energy (construction and operation) effects of the Fox River discharge alternative

Continued discharge of the City's treated wastewater to the Fox River would result in incremental increases in wastewater treatment costs and energy use as Waukesha water use increases with increasing population and economic activity. As mentioned above, additional upgrades are outlined in the Applicant's 2013 Approved Facilities Plan related to meeting future phosphorus limits and adding UV disinfection upgrades (Strand Associates, 2011).

4.4.2 Lake Michigan return flow alternatives

4.4.2.1 Common effects from the Lake Michigan Return flow alternatives

4.4.2.1.1 Fox River effects from the Lake Michigan return flow alternatives

The Return Flow Management Alternative 6 (returning the previous year's average daily withdrawal to the Great Lakes basin) was proposed to minimize Mississippi River basin water in return flow and to reduce impacts to both receiving watersheds (Technical Review R 1). Fox River baseflow at the confluence of the Fox River and Pebble Brook is expected to decrease by approximately 11 percent with a switch to Lake Michigan supply (Appendix A) under the proposed management scheme. The percent decrease in baseflow decreases downstream of the Fox River and Pebble Brook confluence as additional flow enters the river system from tributaries. At the Waterford dam, the percent reduction in baseflow is reduced to 5-8% of the total baseflow (See Appendix A for a discussion of the estimated decrease in baseflow downstream of the City of Waukesha). The decrease in baseflow is due to a reduction in the discharge to Fox River from the wastewater treatment plant.

4.4.2.1.1.1 Flow flooding effects on the Fox River from the Lake Michigan return flow alternatives

A Lake Michigan supply would include a portion of wastewater flow continuing to be discharged to the Fox River. The department used historical data to project what may occur in the future under a diversion scenario. Based on the City's previous year's water withdrawals and WWTP effluent data (2005-2012), the Fox River would receive on average, 2-3 MGD or approximately 3-5 cfs. During dry years the average flow to the Fox would be less under a Lake Michigan supply, due to limited I/I, and during wet years, this average could increase.

No regulatory floodplain changes are anticipated as floodplain studies look at the watershed infiltration capabilities and surface water runoff as a system. Flow changes due to point sources such as wells are not considered in the calculations.

4.4.2.1.1.2 Water quality effects on the Fox River from the Lake Michigan return flow alternatives

The portion of effluent at the WWTP that would continue to be discharged into the Fox River would meet permit limits. Some water quality based limits for a Lake Michigan return flow scenarios may be more stringent than the Fox River, and therefore, effluent added to the Fox may be of higher quality than it is currently. Consequently, water quality impacts to the Fox River are not anticipated with return flow to the Lake Michigan watershed.

4.4.2.1.1.3 Geomorphology and sediments effects on the Fox River from the Lake Michigan return flow alternatives

While some additional sediments may be more frequently exposed, no significant change in geomorphology or sediments is expected on the Fox River from the Lake Michigan return flow alternatives.

4.4.2.1.1.4 Flora and fauna effects on the Fox River from the Lake Michigan return flow alternatives

A reduction in flow in the Fox River (due to the removal of the current levels of wastewater discharge) could have a minimal impact to the flora and fauna of the River by reducing habitat - possibly increasing temperature, which can stress the biological community.

Coolwater species including walleye may be negatively affected as a result of the removal of the City's wastewater discharge to the Fox River. Adult and juvenile coolwater species of the Fox River including walleye and northern pike depend upon connectivity to cold water tributaries which provide refuge during hot summer months as well as critical nursery habitat throughout the year. Lower baseflow conditions can stress macroinvertebrate populations including mussels. Reduced baseflow can alter the environment and change the competition, predation and organic decomposition that the macroinvertebrate community depends upon.

The reduction of flow in the Fox River due to the removal of the City's wastewater effluent would not likely affect any mammal species in the Fox River or its associated habitats. Baseflow reduction would likely impact semi-aquatic mammal species including beavers, muskrats, otters, and mink. Increased depth to groundwater would cause a change in wetland type, therefore impacting mammal species that rely on a variety of wetland types that have surface water throughout the year. The slight flow reduction in the Fox River would not likely affect any mammal species in the Fox River or its associated habitats.

Invasives

During the operation phase, multiple barriers would prevent the spread of invasive species. Drinking water treatment includes filters and disinfection procedures to remove and inactivate viruses. This level of treatment would not allow transfer of invasive species through the water distribution system. Once the water is distributed in pipelines, an ongoing disinfectant residual would be maintained, as required, to prevent microbial growth within the pipelines.

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

4.4.2.1.2 Effects on Pebble Brook, Pebble Creek, Mill Brook and Vernon Marsh from the Lake Michigan return flow alternatives

Under this alternative the Applicant would cease shallow groundwater pumping from existing shallow aquifer wells along the Fox River between Pebble Creek and Genesee Creek. Groundwater flow modeling found a 0 – 2% increase in baseflow with ceasing existing shallow groundwater pumping that may be beneficial to these streams.

4.4.2.1.3 Lake Michigan volume effects from the Lake Michigan return flow alternatives

Return flow to the Lake Michigan basin is not anticipated to result in a change in Lake Michigan water levels.

4.4.2.1.4 Groundwater effects from the Lake Michigan return flow alternatives

Because of the small water depth change anticipated in Lake Michigan tributaries under the Lake Michigan return flow alternatives, no impacts to regional aquifers or groundwater quality are anticipated. The Lake Michigan return flow alternatives are also not anticipated to result in impacts to springs.

If the pipeline for the Lake Michigan return flow alternatives crosses a property with groundwater contamination, there is the potential for the groundwater contamination to migrate along the assumed permeable backfill around the pipeline. If the pipeline leaks in the area of a contaminated property with soil and/or groundwater contamination, it is possible that the influx of water due to the leak could, under unique conditions (strong downward vertical gradient, contaminant with a high solubility or specific gravity greater than water, etc.), cause the contamination to migrate to the shallow aquifer or to a spring if the leak is not repaired. Proper permitting process would mitigate these risks should any of the Lake Michigan flow alternatives be selected.

4.4.2.1.5 Geomorphology and soils effects from the Lake Michigan return flow alternatives

Proposed return flow pipeline installations would require trenching to shallow depths of less than 10 feet. The proposed return flow alternative structures are not expected to encounter significant bedrock and would have negligible impacts to surficial geology during construction. Adverse impacts to the local geology are not expected under any of the Lake Michigan return flow alternatives.

4.4.2.1.6 Population effects from the Lake Michigan return flow alternatives

The Lake Michigan return flow alternatives are not anticipated to affect the populations of Waukesha, or other communities in the southeast Wisconsin region.

No residents would be displaced by the construction or operation of the proposed project or alternatives. No low income or minority populations would be displaced by the project or any of the alternatives, and the project operation is not expected to cause any adverse impacts to low income or minority populations.

4.4.2.1.7 Public water supply and use effects from the Lake Michigan return flow alternatives- City of Waukesha

The Lake Michigan return flow alternatives are not anticipated to affect water supply and use in Waukesha.

4.4.2.2 MMSD return flow alternative environmental effects

After review of the Applicant's Technical Memorandum entitled *Evaluation of treated return flow to Lake Michigan through the MMSD* (CH2MHill, 2015a), the department determined more information would be needed to determine if the South Shore Water Reclamation Facility (South Shore) could accommodate pretreated effluent from the Applicant's WWTP. The Applicant would need to work with the MMSD to evaluate pumping capacity at South Shore and pumping stations along the pipeline corridor to ensure that the MMSD would not result in additional combined system overflows during wet weather events. The impacts evaluated below are based on an assumption that the South Shore Facility would have future capacity (greater than the current peak hour capacity of 300 MGD) to handle the additional 10.1 MGD from the Applicant's WWTP under all flow conditions, especially during wet weather events.

4.4.2.2.1 Discharge effects on Lake Michigan from the MMSD return flow alternative

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

All water returned to the Lake Michigan watershed would be required to meet all of the department's water quality permit (WPDES) requirements.

Waukesha's historical discharge quality is equal to or better than the performance MMSD is required to achieve to protect Lake Michigan water quality. 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 (CH2MHill, 2013, Vol. 4). 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. Home water softening could be eliminated with a Lake Michigan water supply source. Consequently, a reduction in chloride concentration in return flow over time is expected. Based on these historical operations and MMSD permit requirements, water quality concentrations would not negatively affect Lake Michigan.

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

The Applicant would work with the MMSD South Shore facility to use the existing outfall pipe, so no construction-related impacts to geomorphology or sediments to Lake Michigan would be expected.

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

With the Waukesha return flow quality better than or equal to the MMSD South Shore WRF effluent quality, no adverse impacts to Lake Michigan flora and fauna are expected with this alternative.

4.4.2.2.2 Stream crossings effects of the MMSD return flow alternative

The streams that would be crossed by the estimated 75-foot-wide pipeline construction corridor for this alternative are listed in Table 4-25 (CH2MHill, 2015a). The crossing would likely be accomplished by the horizontal directional drilling (HDD) or another proper construction method for stream crossings to avoid or minimize construction impacts (Section 4.4).

Table 4-25. Water body crossings of the MMSD return flow alternative

No.	Name	Type	Width (ft)	Area (ac)	Fisheries Classification
3732	Unnamed	Intermittent/ephemeral	14.3	0.02	—
3932	North Branch Root River	Perennial	49.7	0.09	WWSF
4264	Root River	Perennial	52.2	0.01	WWSF
Totals			**116.2**	**0.12**	

4.4.2.2.2.1 Flora and fauna stream crossing effects of the MMSD return flow alternative

The pipeline stream crossings of the MMSD return flow alternative would not likely result in impacts on the flora and fauna assuming the proper drilling procedures would be followed (Section 4.4). There are other special concern species that may be present on land at these crossings and avoidance and/or minimization measures would be recommended.

Invasives

During the construction phase of the water supply and return flow pipelines, best management practices would be used to reduce the potential introduction or spread of invasive species. Example practices that would 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. Post construction restoration methods would only use native species and the City would consider methods to encourage existing native species to thrive to reduce the potential of the invasive species establishing a foothold. Using these approaches would reduce the potential for spreading invasive species during construction.

4.4.2.2.2.2 Wetlands effects of the MMSD return flow alternative

Table 4-24 lists wetland crossing acreages associated with this alternative (CH2MHill, 2015a). Five palustrine emergent (PEM) wetlands, six palustrine scrub-shrub (PSS) wetlands, and 15 palustrine forested (PFO) wetlands would be affected by pipeline construction. A total of 1.06 acres of wetland would be affected by pipeline construction for this alternative.

The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way. There would be approximately 0.79 acres of wetland type change from forested to emergent associated with this alternative.

Table 4-26. Wetland crossings of the MMSD return flow alternative (Source: WWI)

No.	Type	Width[a] (ft)	Area (ac)
8714	Emergent/wet meadow	—	0.07
9020	Forested	—	0.02
9026	Forested	—	0.07
9028	Forested	—	0.01
10401	Emergent/wet meadow	—	<0.01
10573	Emergent/wet meadow	—	< 0.01
10801	Emergent/wet meadow	—	0.02
10810	Emergent/wet meadow	—	0.16
11286	Scrub/shrub	—	0.01
11290	Scrub/shrub	—	0.02
11368	Scrub/shrub	—	0.08
11369	Scrub/shrub	—	0.02
11376	Scrub/shrub	—	0.05
11381	Scrub/shrub	—	0.01
11896	Forested	—	0.07
11897	Forested	—	<0.01
11900	Forested	—	0.13
11902	Forested	—	0.19
11906	Forested	—	0.03
11914	Forested	—	< 0.01
12293	Forested	—	0.01
12301	Forested	—	0.01
12314	Forested	—	< 0.01
12363	Forested	—	< 0.01
12392	Forested	—	0.01
12399	Forested	—	< 0.01
Totals		**—**	**1.06[b]**

[a] Where a crossing length is not included, the pipeline centerline would not intersect wetland; only the edge of the ROW would be located in the wetland. Because of this, it is anticipated that construction techniques could be adjusted to avoid most, if not all, wetland impacts.
[b] Total acreage is an estimated maximum.

There are two special concern herptile species, one crustacean, and two plant species that occur in wetlands and could be impacted. The herptiles also occur in associated uplands/grasslands. Recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

The Applicant would need to meet requirements under NR 103, Wis. Adm. Code (Water Quality Standards for Wetlands). Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

4.4.2.2.2.3 Upland forests and grasslands effects of the MMSD return flow alternative

Upland Forests

This alternative would affect less than 0.5 acres of woodlands (CH2MHill 2015a). The return flow pipeline follows transportation corridors so that the construction corridor would only intersect edges of forested areas. Wooded areas that would be affected by the project generally consist of deciduous upland forests. To facilitate construction trees within the construction corridor would be removed and stumps would be flush-cut with the ground surface. In cleared areas wooded habitat removed by construction would initially be replaced by non-woody vegetation, which may provide food, shelter, and breeding space for small mammals and birds. The pipeline right-of-way would be maintained in non-woody vegetation, but trees would be allowed to grow back on cleared workspace beyond the maintained maintenance corridor.

There are four rare plants that occur in dry-mesic to mesic woodlands and recommended measures may be suggested in order to avoid and/or minimize impacts to this species. In addition, there is one forested natural community that runs adjacent to a portion of this route and buffers would be recommended to avoid impacts.

The Applicant would need to meet requirements under NR 103, Wis. Admin. Code. Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

Open lands/Grasslands

The return flow pipeline would follow transportation corridors so that the construction corridor would only intersect edges of grassland areas. Open areas that would 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.

Construction would 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 would be coordinated with state and federal agencies. Construction would cause only the temporary displacement of more mobile wildlife from workspaces and adjacent areas. Surface restoration would include coordination with regulatory agencies to provide preferred habitat vegetation applicable to adjacent land use and operational considerations. Thus impacts in grasslands would only be temporary and generally one growing season or less. After construction, wildlife is expected to return and recolonize.

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

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the MMSD return alternative would release an estimated 7,500 tons/yr (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.4.2.2.2.5 Economic effects of the MMSD return flow alternative

Construction of the infrastructure for the MMSD return alternative is expected to provide economic benefits to the well and pipeline construction industries. Operational costs to the Applicant and to MMSD would increase incrementally as wastewater effluent flows increase with increasing population and economic activity in Waukesha.

4.4.2.2.2.6 Land use effects of the MMSD return flow alternative

The MMSD return flow alternative would affect a total of 235.1 acres of land for pipeline construction (CH2MHill, 2015a). An additional pump station may be required, and if so is expected to impact approximately 0.25 acres.

The land use construction and operation acreage impacts of this alternative are listed in Table 4-25. Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction. Note that Table 4-27 uses SEWRPC land use data (CH2MHill, 2015a).

Table 4-27. MMSD return flow alternative land use impacts (Source for base land use data: SEWRPC, 2000; analysis by CH2MHill, 2013, Vol. 5)

Land Use	Acres[a]	Percent
Residential	7.52	3.2
Commercial & Industrial	0.55	0.2
Transportation & Communication/Utilities	217.35	92.5
Government. & Institutional	1.08	0.5
Recreational Areas	0.34	0.1
Agricultural Lands	2.97	1.3
Open Lands	4.14	1.8
Woodlands	0.48	0.2
Surface Water	0	0.0
Wetlands	0.61	0.3
Totals[b]	**235.04**	**100.1[c]**

[a] Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory. Wetland acreage differs from WWI data.
[b] Lake Michigan supply and return flow options share the same workspace for about six miles. Actual land use totals would be less than reported if a Lake Michigan supply and return flow option was selected.
[c] Includes rounding errors.

No new access roads would be required for the MMSD return flow alternative. Access is anticipated to be from existing municipal roadways and trails. The residential land within the assumed 75-foot construction corridor borders roads. The majority of residential land that could be affected by the proposed alignments is described as single family low density. The construction corridor may be further minimized to avoid private property, or temporary construction easements would be obtained by the City. This alternative would affect no private residences. Land affected by pipeline construction would be restored, or allowed to revert to, its previous use. No changes to zoning would be required for construction and operation of the MMSD return flow alternative.

Transportation

Over 92 percent of the MMSD return flow alternative pipeline would follow existing utility and transportation corridors. Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.4.2.2.2.7 Recreation and aesthetic resources effects of the MMSD return flow alternative

Table 4-28 summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this return flow alternative. The MMSD return flow alternative would not impact a Coastal Zone Management Area. Visual impacts from the proposed return flow alternatives are expected to be minor.

Table 4-28. Public or conservation lands within or adjacent to the MMSD return flow alternative (Source: Google Earth, 2009; SEWRPC, 2005)

Name of Resource	Acres
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
Total	

4.4.2.2.2.8 Archeological and historical resources effects of the MMSD return flow alternative

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 construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor.

The MMSD return flow alternative may affect 12 known cultural sites (CH2MHill, 2015a). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.4.2.2.2.9 Public water supply and use effects from the MMSD return flow alternative

The MMSD return flow alternative would connect directly to the MMSD South Shore WRF discharge pipe and would have no impact on MMSD's treatment processes. Coordination with MMSD and the department on the WPDES permitting would be expected.

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

The department considered costs for return flow alternatives based on their 50-year present worth. The 50-year present worth assumes a six percent interest rate (Technical Review S2). The 50-year present worth of the MMSD South Shore return flow alternative is $145,408,000. Capital costs are estimated at $135,408,000[9] while operation and maintenance costs are estimated as $855,000[10].
Operation of returning the water to MMSD South Shore is anticipated to use 8,100 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

The energy used in this return flow alternative (not including water supply) would release an estimated 7,500 tons (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

Operation of the MMSD return flow alternative is anticipated to use 8,100 megawatt-hours (MWh) of electricity annually (CH2MHill, 2015a).

4.4.2.3 Root River flow alternative environmental effects

4.4.2.3.1 Discharge effects from the Root River return flow alternative

The United States Environmental Protection Agency (EPA) delegates Clean Water Act authority to Wisconsin. Wisconsin's Pollutant Discharge Elimination System (WPDES) program has the authority to permit the discharge of treated wastewater effluent from wastewater treatment plants into the waters of the state under Wis. Stats. s. 283.31. The Applicant would need to apply for a WPDES permit in order to discharge treated effluent to its preferred return flow location, the Root River. The proposed discharge location to the Root River is near the intersection of West Oakwood Road and South 60th Street, in the City of Franklin, directly downstream of the confluence of the Root River Canal and the Root River mainstem (WBIC 2900).

4.4.2.3.1.1 Discharge effects on Lake Michigan water quality from the Root River return flow alternative

Water quality impacts to Lake Michigan are considered for two different areas, as there is no immediate and sudden transition from the Root River to Lake Michigan proper. The first potentially impacted area is Lake Michigan proper, the area beyond the Racine Harbor breakwater mouth. Due to shore currents, impacts are considered within the near shore and deep water areas. The second potentially impacted area is the Root River estuary. This area begins at the point where the Root River flows into the City of Racine and is influenced from Lake Michigan backwater augmenting river volumes. The water volume of the Root River is influenced by two factors:

---

[9] Capital costs were estimate in June 2013 dollars, and assume a 2013 construction start.
[10] Operation and maintenance costs were calculated assuming a maximum 16.7 MGD water supply capacity, 10.1 MGD average capacity, and an average return flow of 11.7 MGD

- the river reaching grade with Lake Michigan surface elevations due to dredging the stream bed from the harbor back up the river and
- the seiche effect - where windblown Lake Michigan water ‘stacks up’ at the river mouth and occasionally reverses or slows river flows for a brief time.

The Root River then transitions to the Racine Harbor. The Harbor is semi-isolated from Lake Michigan by the north and south breakwaters. The estuary can be considered the wetted area back from the breakwater mouth to that portion of the river where Lake Michigan backwater elevations can reach.

No impacts to minimal impacts to the water quality of the deep waters of Lake Michigan are expected from the Root River return flow alternative. In the very long term, nutrient loadings from *the entire Root River watershed* to Lake Michigan could contribute towards a more eutrophic condition, however, the wastewater discharge is less than two percent of the overall loading to the Root River watershed, so this project will have minimal impacts. Near the shore of Lake Michigan, at the mouth of Racine Harbor and south along the breakwater, minimal impacts may result from elevated levels of chlorides and increased turbidity associated with phosphorus fueled planktonic algae growth coming from the estuary and the Root River.

The department reviewed available data collected by several agencies, primarily the department, the MMSD, SEWRPC, and the City of Racine Health Department. At the outlet of the Root River Watershed (Lake Michigan), the average annual phosphorus load is approximately 65,877 pounds per year as determined by the department’s Pollutant load Ratio Estimation Tool (PRESTO) model. The department assumed 100 percent of the phosphorus delivered to the stream network throughout the Root River Watershed reaches Lake Michigan.[11][12] The Root River return flow alternative would contribute approximately 1200 pounds TP/yr, less than 2 percent of the overall phosphorus loading to Lake Michigan (Technical Review, R5). The Applicant would be required to meet all discharge requirements to minimize any short or long-term impacts to Lake Michigan from the proposed Root River discharge.

4.4.2.3.1.2 Discharge effects on Lake Michigan geomorphology and sediments from the Root River return flow alternative

No impacts to Lake Michigan deep water and near-shore geomorphology, and Lake Michigan deep water sediments are expected. No impacts to Root River estuary geomorphology and inorganic sediments are expected. However, increased loading of phosphorus from the entire Root River watershed, of which the return flow would be a small portion, may result in increased aquatic plant and algae growth within the estuary, and to a much lesser degree, along the near-shore Lake Michigan area beyond the Harbor breakwater and south. The death and subsequent decomposition of these plants and algae may result in increased organic sedimentation.

---

[11] Spatially-referenced Regression on Watershed Attributes (SPARROW) model developed by the USGS.

4.4.2.3.1.3 Discharge effects on Lake Michigan flora and fauna from the Root River return flow alternative

No long-term pollutant loading effects are expected on deep-water Lake Michigan invertebrates, plants, or fish.

This discharge will not have an immediate impact within the estuary or along the near-shore Lake Michigan area beyond the Harbor breakwater and south. However, phosphorus is a conservative pollutant and since the Root River Harbor is a semi-confined area, the eventual effects of cumulative nutrient loading from the entire Root River watershed, with a small contribution from the proposed discharge, may result in increased aquatic plant and algae growth. Increased plant growth within the estuary could alter fish spawning and available resident habitat, both positively and negatively. Fish and aquatic macroinvertebrate communities within the estuary may shift in density and species. Racine Harbor may require an increase in aquatic plant management, such as expanded herbicide treatments or mechanical plant harvesting. These activities require permits under chapters NR 107 and 109, Wis. Admin Code.

Increased concentrations of chlorides within the Root River from Waukesha flow may present a slight increase in risk to fish and aquatic invertebrates within the Root River estuary.

In addition, some pharmaceuticals are known to pass through wastewater treatment plants. Pharmaceuticals can lead to surface water contamination and toxicity to fish and wildlife. While no studies to date have definitively demonstrated harmful effects on human health from long-term exposure to trace amounts of active pharmaceutical ingredients - such as through drinking water - studies have found pharmaceuticals present in some ecosystems at levels likely to harm entire populations of aquatic organisms. Accordingly, there is a slight risk of pharmaceuticals exposure to resident fish and aquatic macroinvertebrates within the estuary. Pharmaceutical exposures in treated effluent have been shown to alter sex ratios in some fish species (Woodling et. al, 2006). The department recognizes that pharmaceuticals are a growing concern. However, the department does not have current regulatory authority to mandate the monitoring of pharmaceuticals or require limits in wastewater effluent. If these limits were established in the future, the Applicant would be required to comply with them under their WPDES discharge permit.

No direct impacts to Lake Michigan birds or mammals are expected from the Root River return flow alternative.

4.4.2.3.1.4 Flow and flooding effects on the Root River from the Root River return flow alternative

The proposed return flow to the Root River would increase the flow in the river downstream of the return flow location. To minimize the discharge of Mississippi River basin water to the Lake Michigan basin, the maximum average annual flow from the WWTP to the Root River under return flow Alternative 6 would be 10.1 MGD (15.6 cfs).

The influence of the Applicant's proposed return flow, 10.1 million gallons per day (15.6 cfs), is dependent on the existing flow regime of the Root River. To calculate the change the additional return flow would have on the Root River the department modeled Root River flow regimes (high, base, and low flow[12]), at the discharge location and further downstream in Racine. The proposed return flow was added to the modeled flow allowing the calculation of the percent contribution from the proposed return flow. Table 4-29 summarizes the flow regimes and Table 4-30 the percent contribution of flow that the proposed discharge would be responsible for.

Table 4-29 Root River Flow Regime

Flow Regime	Proposed Waukesha Discharge Site	Root River at Racine USGS #04087240
High Flow (Q10 – Q5)	230 – 392 cfs	358 – 607 cfs
Baseflow	35.9 cfs	62.6 cfs
Low (Q90 - Aug Q50)	7.92 – 16.7 cfs	11.2 – 26.1 cfs

Table 4-30 Percent Contribution of Proposed Return Flow on Root River

Site	Maximum Waukesha Return Flow (cfs)	Return Flow Contribution During High Flow (%)	Return Flow Contribution During Baseflow Flow (%)	Return Flow Contribution During Low Flow (%)
Proposed Waukesha Root River Return Flow	15.6	3.8 - 6.4 %	30.3%	48.3 – 66.3%
Root River at Racine		2.5 - 4.2%	19.9%	37.4 – 58.2%

The department reviewed the Root River return flow rates at the discharge location for the 2-year through 100-year profiles that the Applicant provided (CH2MHill, 2015b). The proposed discharge location is slightly downstream of the Franklin gage and downstream of the confluence with the Root River Canal. The watershed area at the Franklin gage location is about 49.2 square miles. The watershed area at the discharge location is 126.2 square miles. The discharge location was used as a conservative estimate for low flow impacts from the return flow because it has a significantly smaller watershed area. The maximum return flow (10.1 MGD, 15.6 cfs) would be less than two percent of the river flow during a two year frequency storm, and would be an even smaller fraction of the flow during a 100 year flood. The maximum return flow rate would be less than one percent of the 100 year river flow (4,820 cfs) near the return flow discharge location (MMSD, 2007). The maximum return flow rate would have an even smaller impact on the Root River Steelhead Facility downstream. The 100 year river flow at the Root River Steelhead Facility is 5,916 cfs. For example, this equates to a water depth change of 0.02 feet near the return flow discharge location and 0.01 feet at Root River Steelhead Facility for the 100

[12] Flow conditions were tied to specific flow statistic (Q5 and Q10 represent high flow, hydrograph separation for baseflow, and Q90 and Aug Q50 represent low flow).

year return period flood. Additionally, discharging the maximum return flow rate is expected to occur infrequently.

The flows calculated for the Flood Insurance Study (FIS) are not expected to be affected by the addition of the return flow. The Flood Insurance Rate Map (FIRM) would not be required to be revised for the area along the Root River. Typically, when calculating floodplain hydrology, Waste Water Treatment Plant (WWTP) discharge is not added to the flow calculations because a conservative approach is used when calculating flows that accounts for standard error.
For the Federal Emergency Management Agency (FEMA) to incorporate revised hydrology into the Flood Insurance Study (FIS) it would require an increase of approximately 10 percent to the 100 year flow. For example, the maximum return flow would need to be approximately 482 cfs before a Letter of Map Revision (LOMR) would be required for significant changes in hydrology.

4.4.2.3.1.5 Discharge effects on Root River water quality from the Root River return flow alternative

The department calculated draft water quality-based effluent limits (WQBELs) based on current applicable water quality standards under Chapters NR 102, 103, 104, 105, 106, 207, 210 and 217, Wis. Admin. Code, to assess whether the Applicant could meet applicable water quality discharge standards. WQBELs are set at or below water quality criteria, designed to protect fish and aquatic life and in some cases public health and recreational uses. To determine discharge effects on the Root River from return flow, the department focused on the primary pollutants of concern below.

Phosphorus

Phosphorus is a vital nutrient in aquatic ecosystems. However, excessive phosphorus in the Root River, from existing point sources (urban stormwater runoff, wastewater treatment plants) and nonpoint sources (runoff from agriculture and natural land areas, and failing septic systems), have contributed to degraded stream habitat, increased eutrophic conditions, and unbalanced resident fish and macroinvertebrate populations. As a result, the Root River is listed on Wisconsin’s 303(d) Impaired Waters List for excessive phosphorus.

The Applicant may be subject to Water Quality Based Effluent Limits for phosphorus significantly below the current Wisconsin water quality criterion for phosphorus of 0.075 mg/L in order to discharge to the Root River. Regardless, phosphorus is a conservative pollutant. The addition of phosphorus loading to the Root River from the return flow may increase the planktonic algal, periphyton, and aquatic plant communities in the river and estuary. An increase in these communities could increase the range of diurnal dissolved oxygen swings within portions of the Root River where the biological community is utilizing the increased phosphorus. Turbidity increases due to planktonic algae growth may also occur.

When the Root River is experiencing low flow conditions, phosphorus concentrations in the river may actually decrease due to dilution from the proposed effluent. Biological community effects may be seen further downstream in the Root River and in the Root River estuary from cumulative loading impacts, but are expected to be minimal as a result of return flow from the Applicant’s proposed discharge (see Technical Review Appendix D) .

Total Suspended Solids

Total Suspended solids (TSS) consist of a wide variety of materials including: silt, sand and clay particles, decaying plant and animal matter, sewage, and industrial waste. High volumes of TSS can increase turbidity, blocking light from reaching beneficial aquatic vegetation and algae. Decreased light penetration can reduce photosynthesis, leading to decreased dissolved oxygen levels in the water column. Macrophytes, algae, and periphyton communities may die, increasing bacterial decay processes and using up more of the oxygen in the water. Decreased water clarity from TSS can also affect fish, reducing their ability to see and catch food. TSS can also abrade and clog fish gills. Increased loading of TSS can alter suitable habitat for macroinvertebrates and bury fish spawning beds, and can lead to increased water temperatures.

The proposed Root River return flow would be subject to WQBELs for TSS. TSS levels under the permit would likely be very low, therefore the Root River should experience little to no impacts from this return flow.

Chlorides

Chlorides are found in both salt and fresh water and are essential elements of life. Chlorides in the Root River primarily result from anthropogenic sources (e.g. deicing road salt and discharge from water softeners) - since the background geology in the area contains relatively little chloride (SEWRPC, 2014). High chloride concentrations in freshwater can be harmful to aquatic organisms, hindering reproduction, growth and survival. The department sets chronic and acute toxicity water quality limits for chlorides to prevent long-term and immediate exposure effects to aquatic organisms.

The City would have to significantly reduce chloride sources to meet the proposed water quality based effluent limit of 400 mg/L for return flow to the Root River, since the current chloride effluent concentrations are higher than the proposed WQBEL for the Root River.

The Applicant drafted a compliance plan to demonstrate how future chloride effluent limits may be met (CH2MHill, Volume 4, Appendix A, Attachment A-5). Currently, the Applicant is required to submit annual chloride progress reports to the department to comply with requirements outlined in its current WPDES permit to discharge to the Fox River. The Applicant submitted its Annual Chloride Progress Report to the department on June 30, 2014 documents steps the Applicant has taken to reduce chlorides in its WWTP discharge (primarily by concentrating on source reduction measures). The department understands quantifying potential sources of chloride within the sewer service area is difficult. In the most recent report, the Applicant examined 6 main sources of chlorides:

a) Residential softening (includes industrial and commercial)
b) Road Salt (through infiltration and inflow)
c) Brine
d) Hauled Waste
e) Ferric Chloride
f) Normal Domestic Wastewater/Background from Groundwater

As an additional chloride strategy, the City of Waukesha approved on April 4th 2014, Waukesha, Wis. Code § Ord 29.036 (2014) an amendment to their sewer use ordinance with respect to water softening and brine reclamation. The ordinance requires that all residential, commercial and industrial users installing new or replacement water softeners must install high efficiency, demand initiated regeneration softeners equipped with a water meter or sensor. In addition, the City encourages brine reclamation systems for all significant industrial users where feasible.

A change from a groundwater water supply to a Lake Michigan surface water supply would significantly reduce the need for home water softening. Currently, salt residue from residential home softening is the largest source of chlorides to the Applicant's WWTP (estimated at ~22,000 lbs/day in the Applicant's annual chloride progress report). Groundwater wells supply 'hard' water to customers, consequently many homeowners use water softeners. The current hardness concentration ($CaCO_3$) based on an average range of well concentrations is 260-530 mg/L.[13] Recent alkalinity data (hardness $CaCO_3$) from the City of Oak Creek Water Utility shows an average of ~111 mg/L, a level that does not require home water softening.[14]

In addition, the City can also expect reductions in background chloride concentrations and loading since concentrations of chloride are lower in a Lake Michigan supply (~12 mg/L[15]), versus the current groundwater supply (~31 mg/L[16]). This reduces loading by approximately 1600 lbs/day.[17]

The Applicant is already taking additional steps to reduce infiltration and inflow (therefore reducing infiltration of chlorides from road salt) and brine from Waukesha County Highway salt storage facilities. The Applicant would need to fully implement all efforts outlined in the current annual chloride progress report as well as additional efforts, including education and outreach, to meet the proposed draft water quality based effluent limits.

There could be potential impacts to the Root River with the proposed return flow due to an increased toxicity risk to the biota resulting from the current elevated chloride levels in the Root River combined with the additional chloride loading from the Applicant's return flow effluent.

Dissolved Oxygen

Dissolved oxygen (DO) contained within the water column is essential to aquatic life. Air pressure and temperature, water temperature, photosynthesis, organic and chemical demand, and turbulence all contribute to oxygen levels. The Root River mainstem at and downstream of the proposed outfall has typically met state water quality criteria of 5 mg/l for maintaining fish and aquatic life.

The proposed return flow may have both a local effect on DO concentrations in the Root River at the discharge location as well as minimal effects downstream.

Locally, especially during low-flow periods where the return flow would make up approximately

---

[13] City of Waukesha IOC samples from 1993 to 2012 for wells 10, 11, 12 and 13.
[14] Raw water sample results, Oak Creek, average for April 2015 ~111 mg/L.
[15] Result from Oak Creek Water from intake EP 1 4/13/04. 12 mg/L is consistent with Milwaukee Water Works. 2011 Raw Water Annual Water Quality Report.
[16] City of Waukesha IOC samples from 1993-2012 for wells 10, 11, 12 and 13.
[17] This estimate is lower than Application, Volume 4, Appendix A, A-4, page 5. Exhibit 2. The Applicant's estimates were based on an average flow of 10.9 MGD, not a maximum flow of 10.1 MGD.

80-90 percent of the river flow, the return water emerging from the outfall pipe may contain low oxygen levels (depending on the method chosen by the Applicant to aerate the discharge via cascades or other techniques). The water emerging from the return flow outfall would have been underground for 20 miles, increasing the possibility of the discharge water containing low DO levels. Permit limits for DO would need to be met at the outfall to ensure oxygen concentrations are at levels protective of fish and aquatic life.

Downstream, DO levels of the Root River may be affected due to possible increased periphyton, suspended algae, and aquatic plant growth fueled by additional phosphorus loading. Oxygen levels would rise and fall throughout the 24-hour photosynthetic growth period, where at times oxygen is released into the water, and at other times absorbed. These diurnal swings, where excessive plant and algae growth is present, can result in periods of very low dissolved oxygen levels – typically in the early morning hours.

Biological Oxygen Demand

Biological oxygen demand (BOD) is the measured amount of oxygen utilized by microorganisms during aerobic breakdown of organic material. Treatment plants release a certain amount of organic matter in effluent, and BOD WQBELs are put in place to ensure this organic loading is low.

The proposed return flow would have permit limits in place on the release of organic material. The Root River downstream of the proposed outfall may face a slight risk from elevated levels of organic material and the associated drop in dissolved oxygen levels due to microbial facilitated decomposition of this material. Additionally, the Root River in the vicinity of the outfall may see a slight risk of attached microbial/algae growth associated with organic materials and sulfur.

Temperature

Water temperature is an important factor for the health and success of fish and aquatic communities. Temperature can affect embryonic development, growth cycles, migration patterns, competition with aquatic invasive species, and risk and disease severity. The water temperature also affects the DO concentration and can influence respiration of aquatic communities, and the activity of bacteria and other toxic chemicals in water.

The proposed return flow would be subject to temperature limits under a discharge permit. The effect on the Root River downstream of the return flow outfall would depend on the time of year, temperature of the discharge water, and temperature and amount of flow in the Root River. During low-flow summer months, effluent temperatures may be cooler than current river temperatures. During fall and winter months, the discharge water temperature would likely be higher than current temperatures. If temperature limits can be met, no impacts are expected to the Root River due to temperature from the effluent.

Bacteria (Pathogens)

Bacteria are single-celled organisms, live in various environments and provide functions that can be beneficial or harmful. Bacteria that can cause diseases are referred to as pathogens. Coliform bacteria present in surface water can originate naturally from soil, however, bacteria from the intestinal tracks of human and other animals, such as pets, livestock and wildlife are known as fecal coliform bacteria. Human sources of fecal coliform bacteria include wastewater treatment plants, leaking sewer lines, illicit discharges to streams and urban stormwater runoff. *E.coli* are a subgroup of fecal coliform bacteria, often monitored as indicator organisms, assessing the likelihood that other risks to human health may be present in the environment.

The proposed return flow would be subject to fecal coliform bacteria limits under a WPDES permit. Planned upgrades to the Applicant's WWTP UV disinfection system, as well as historical operations having less than 100 CFU/100 mL during the recreational season, would meet draft WQBELs for fecal coliform bacteria to the Root River. Treated wastewater can contain residual pathogens, so there is a risk to human health from this added return flow. However, current concentrations of pathogens in wastewater are unknown and not regulated by the department at this time.

Pharmaceuticals and endocrine disruptors are known to pass through wastewater treatment plants. Endocrine disruptors are a diverse class of chemicals that are known to disrupt or act like hormones that can disrupt the endocrine systems of fish, wildlife, and possibly humans. Pharmaceuticals may lead to surface water contamination and toxicity to fish and wildlife. While no studies to date have definitively demonstrated harmful effects on human health from long-term exposure to trace amounts of active pharmaceutical ingredients - such as through drinking water - studies have found pharmaceuticals present in some ecosystems at levels likely to harm entire populations of aquatic organisms.

Accordingly, there is a slight risk of pharmaceuticals exposure to resident fish and aquatic macroinvertebrates within the estuary. Pharmaceutical exposures in treated effluent have been shown to alter sex ratios in some fish species (Woodling et. al, 2006). The department recognizes that pharmaceuticals and endocrine disruptors are a growing concern. However, the department does not have current regulatory authority to mandate the monitoring of pharmaceuticals and endocrine disruptors or require limits in wastewater effluent. If these limits were established in the future, the Applicant would be required to comply with them under their WPDES discharge permit.

In conclusion, all water returned to the Root River would be required to meet all of the department's water quality related permit requirements (e.g. WPDES and Chapter 30) under Wisconsin Statutes and Administrative Codes.

4.4.2.3.1.6 Discharge effects on Root River geomorphology and sediments from the Root River return flow alternative

The Wastewater Treatment Plant Facility Plan Amendment which is an attachment to the Return Flow Plan (Strand, 2011) discusses potential outfall structure designs. The outfall structure would be designed to blend in with the streambanks along the Root River and be required to not adversely affect regional flood elevations. A recent Root River sediment transport study concluded that the river stability in the location of the proposed outfall is relatively insensitive to changes in flow because of the erosion resistance of the channel boundary materials, the relatively flat channel gradient, and the presence of a functional floodplain (MMSD, 2007). For these reasons, and because the proposed return flow is a small fraction of higher flow events where the majority of fluvial processes occur, the return flow should not adversely affect the geomorphic conditions in the river.

4.4.2.3.1.7 Discharge effects on Root River flora and fauna from the Root River return flow alternative

Flora

The algal community in the Root River, represented by attached and suspended species, as well as those contained within periphyton complexes, would likely see an increase in total biomass. During low-flow periods, there would be more stream bottom substrate and water column available for colonization and growth. The added nutrient load may also fuel growth. Similarly, the aquatic macrophyte community of the Root River and estuary may see an increase in biomass.

Impacts of increased biomass downstream of the outfall could be both positive and negative. Positive impacts of increased biomass would provide expanded direct and secondary grazing opportunities for benthic invertebrates and fish, as well as expanded refuge habitat. The potential negative impact would be the risk of an expanded lower range of the diurnal oxygen cycle (low DO).

Benthic invertebrates

The proposed Root River return flow would increase available habitat for aquatic invertebrates during low-flow periods due to the increased dimensional wetted area of the stream bottom. Riffle and pool depths may increase. Aquatic macroinvertebrates would be able to utilize or benefit from these areas. If algal and periphyton amounts increase due to phosphorus loading, aquatic macroinvertebrate communities may see a shift in species composition and an increase in numbers.

In addition, some viruses and pharmaceuticals are known to pass through wastewater treatment plants. Pharmaceuticals can lead to surface water contamination and toxicity to fish and wildlife. Studies have found pharmaceuticals present in some ecosystems at levels likely to harm entire populations of aquatic organisms. Accordingly, there is a slight risk of pharmaceuticals exposure to resident fish and aquatic macroinvertebrates within the estuary. Pharmaceutical exposures in treated effluent have been shown to alter sex ratios in some fish species (Woodling et. al, 2006). The department recognizes that viruses and pharmaceuticals are a growing concern. However, the department does not have current regulatory authority to mandate the monitoring of pharmaceuticals or require limits in wastewater effluent. If these limits were established in the future, the Applicant would be required to comply with them under their WPDES discharge permit.

Fish

The proposed Root River return flow has the potential to both positively and negatively affect the fishery of the Root River. Positive effects could result from the addition of flow during low-flow periods (middle to late summer), while both potential positive and negative effects could be evidenced from added phosphorus. Temperature effects would likely have a slightly positive effect. And lastly, the addition of chlorides, and possibly pharmaceuticals, could have a negative effect on the Root River fishery and estuary (see sections above).

The addition of a maximum of 15.6 cfs (where previously a low-flow of three cfs could be expected) to the Root River would greatly compound the availability of wetted fish spawning and resident habitat during the lower flow periods, increase the ability of fish to mobilize between shallow river segments, and enhance forage opportunities. This would all have a positive effect on the numbers, and possibly diversity, of the Root River fishery. During periods of higher flow, there would be no positive or negative impact to the Root River fishery from the flow addition.

Additionally, during low-flow periods, the proposed Waukesha return flow could benefit the department's Root River Steelhead Facility. The Root River Steelhead Facility is Wisconsin's main source of rainbow trout (steelhead) eggs and brood (parent) stock and is the back-up facility for the collection of eggs of other trout and salmon species. During some years when flow on the Root River is low, the department has not met fish egg collection quotas. The department has evaluated flow augmentation of the Root River to improve fish migration for egg collection. The proposed return flow would provide the flow augmentation (during low-flow periods) considered by the department to allow more fish to reach the Steelhead Facility, meet egg collection quotas, and fish stocking goals.

Nutrients, principally phosphorus, contained in the Waukesha return flow may increase algal, periphyton, and aquatic plant communities in the Root River and the estuary. This growth may increase the forage base for fish that consume algae or the macroinvertebrates that reside on aquatic plants. Alternately, there could be a corresponding decrease in some sight feeders in the Root River, should excessive suspended algae growth occur. In general, an overall shift towards higher productivity across all trophic levels in the Root River could be an outcome of the additional nutrients.

The Root River at the proposed outfall location downstream to the Horlick Dam is classified in the SEWRPC 2014 Root River Watershed Restoration Plan as a Warm Mainstem fishery. The department has made recent refinements to the classification methodology, confirmed by biological community, and the results show that this segment of the Root River should be classified as Cool-Warm Mainstem. The Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM) document describes a Cool-Warm Mainstem fish community as, "moderate to large but still wadeable perennial streams with cool to warm summer temperatures. Coldwater fish range from absent to common, transitional fish from common to dominant, and warmwater fish from absent to abundant. Small-stream fish range from absent to very common, medium-stream fish from very common to dominant, and large-river fish from absent to very common." The additive flow from the proposed Waukesha outfall would likely not alter this classification and the fish community associated with this temperature range, assuming that current effluent temperatures reflect future output. Thermal WQBELs, in addition, would likely be applied to the discharge.

Chlorides contained in the proposed discharge could have a negative effect on the fish community of the Root River. Current chloride levels in the Root River exceed both chronic and acute toxicity. Adding effluent flow from Waukesha could exacerbate chloride issues in the Root River, resulting in a negative effect on the fish community. The Root River estuary fish community could be exposed to the increased levels of chlorides from the Root River/Waukesha effluent. However, there is greater dilution afforded by water movement from Lake Michigan into the estuary. Measures will need to be taken by the City to reduce sources of chlorides to meet the proposed water quality based effluent limit (see *Chlorides* subsection in Section 4.4.2.3.1.5 above).

In addition, some pharmaceuticals are known to pass through wastewater treatment plants. Pharmaceuticals can lead to surface water contamination and toxicity to fish and wildlife. While no studies to date have definitively demonstrated harmful effects on human health from long-term exposure to trace amounts of active pharmaceutical ingredients - such as through drinking water - studies have found pharmaceuticals present in some ecosystems at levels likely to harm entire populations of aquatic organisms. Accordingly, there is a risk of pharmaceuticals exposure to resident fish within the Root River. Pharmaceutical exposures from treated effluent have been shown to alter sex ratios in some fish species (Woodling, et al., 2006).

In summary; the proposed additional flow to the Root River during low-flow periods may positively impact the Root River fish community, phosphorus may both negatively and positively impact the fish community of the Root River and estuary, temperature impacts to the Root River should likely be minimal, and the addition of chlorides, and possibly pharmaceuticals, would likely negatively affect the fish of the Root River and possibly have a slightly negative effect on the fish community in the Root River estuary.

Mammals

Nutrient loading may have negative health impacts on semi-aquatic mammals, resulting in population declines. However, due to the minimal nutrient loading expected from the proposed discharge to the Root River (less than two percent of the overall watershed load), no significant negative impacts on semi-aquatic mammals are expected. It is more likely the increased flow to the Root River from the proposed discharge could create more riparian habitat for semi-aquatic mammals, thus positively impacting local mammal populations.

See above section regarding water quality impacts for potential public health impacts associated with the proposed discharged.

4.4.2.3.2 Stream crossing effects of the Root River return flow alternative

The primary construction-related impact to the water quality of affected streams could be potential elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed. Impact severity would be a function of sediment load, particle size, and duration of construction activities. Impacts would be minimized by adhering to environmental permit conditions and best management practices (BMPs) designed to reduce the turbidity and erosion (CH2MHill, 2013, Vol. 5, Appendix 5-2). All inland waterway crossings would result in construction-related impacts. Once construction is complete, the surface water crossings would be restored.

Table 4-31 lists the waterbodies that would be crossed by the estimated 75-foot-wide pipeline construction corridor for the proposed Root River return flow alternative (CH2MHill, 2013, Vol.5, Table 6-13).

Table 4-31. Water body crossings of the Root River return flow alternative

No.	Name	Type	Width (ft)	Area (ac)	Fisheries Classification
3732	Unnamed	Intermittent/ephemeral	14.3	0.02	—
4264	North Branch Root River	Perennial	38.7	0.07	WWSF
4325	North Branch Root River	Perennial	6.6	0.17	WWSF
5109	Unnamed	Intermittent/ephemeral	18.9	0.04	—
Totals			**78.5**	**0.3**	

4.4.2.3.2.1 Flora and fauna stream crossing effects of the Root River return flow alternative

The pipeline stream crossings of the Root River return flow alternative would not likely result in impacts on the flora and fauna assuming proper drilling procedures are followed (Section 4.4). There are other special concern species that may be present on land at these crossings and avoidance/minimization measures would be recommended.

4.4.2.3.2.2 Wetland effects of the Root River return flow alternative

The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way. There would be less than 0.1 acre of wetland type change from forested to emergent associated with this alternative. A total of up to 0.62 acre of wetland would be affected by pipeline construction for this alternative.

Two palustrine emergent (PEM) wetlands, four palustrine scrub-shrub (PSS) wetlands, 11 palustrine forested (PFO) wetlands, and one flat/unvegetated wetland would be affected by pipeline construction.

There are two special concern herptile species and one crustacean species that occur in wetlands and may be impacted. The herptiles also occur in associated uplands/grasslands. Recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

The Applicant would need to meet requirements under NR 103, Wis. Admin. Code. Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

Table 4-32 lists wetland crossing acreages associated with the pipeline of this alternative.

Table 4-32. Wetland crossings of the Root River return flow alternative (Source: WWI, CH2MHill, 2013, Vol. 5, Table 6-42)

No.	Type	Width[a] (ft)	Area (ac)
8714	Emergent/wet meadow	—	0.07
9020	Forested	—	0.02
9026	Forested	—	0.07
9028	Forested	—	0.01
10573	Emergent/wet meadow	—	< 0.01
11209	Flats/unvegetated wet[a] soil	12.96	0.04
11286	Scrub/shrub	—	0.01
11290	Scrub/shrub	—	0.02
11369	Scrub/shrub	—	0.02
11376	Scrub/shrub	—	0.05
11777	Forested	37.48	0.07
11890	Forested	—	0.01
11896	Forested	—	0.07
11914	Forested	—	< 0.01
12263	Forested	—	0.11
12314	Forested	—	< 0.01
12392	Forested	—	0.01
12399	Forested	—	< 0.01
Totals		**50.44**	**0.62[b]**

[a] Where a crossing length is not included, the pipeline centerline would not intersect wetland; only the edge of the ROW would be located in the wetland. Because of this, it is anticipated that construction techniques could be adjusted to avoid most, if not all, wetland impacts.

[b] Total acreage is an estimated maximum

4.4.2.3.2.3 Upland forests and grasslands effects of the Root River return flow alternative

This alternative would affect 0.09 acres of woodlands (CH2MHill, 2013, Vol. 5, Table 6-52). There are four rare plant species that occur in dry-mesic to mesic woodlands and recommended measures may be suggested in order to avoid and/or minimize impacts to this species

this alternative would affect 3.51 acres of open lands. There is one rare plant species that occurs in upland grasslands and prairies and recommended measures may be suggested in order to avoid and/or minimize impacts to this species (CH2MHill, 2013, Vol. 5, Table 6-52).

4.4.2.3.2.4 Air emissions (construction and operation) effects of the Root River return flow alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the deep and shallow aquifers supply alternative would release an estimated 6,800 tons/yr (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

Odor associated with the return wastewater, which can carry a characteristic treatment plant smell, may persist for an unknown distance downstream of the proposed Root River outfall. Treatment plant odors on the Fox River can occasionally be discerned 8.4 miles downstream of the current Waukesha outfall as observed by department staff while collecting water quality data on the Fox River at the County Highway I location.

4.4.2.3.2.5 Economic effects of the Root River return flow alternative

Construction of the infrastructure for the Root River return flow alternative is expected to provide economic benefits to the pipeline construction industry. Operational costs to the Applicant would increase incrementally as wastewater effluent flows increase with increasing population and economic activity in the City. Construction, operation and maintenance costs would be borne by the residents of Waukesha.

4.4.2.3.2.6 Land use effects of the Root River return flow alternative

The Root River return flow alternative would affect a total of 183.7 acres of land for pipeline construction (CH2MHill, 2013, Vol. 5, Table 6-51).The land use construction and operation acreage impacts of this alternative are listed in Table 4-33. Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction.

Table 4-33. Root River return flow alternative land use impacts (Source for base land use data: SEWRPC, 2000; analysis by CH2MHill, 2013, Vol. 5)

Land Use	Acres[a]	Percent
Residential	6.39	3.48
Commercial & Industrial	0.43	0.23
Transportation & Communication/Utilities	167.62	91.24
Government. & Institutional	1.13	0.62
Recreational Areas	0.22	0.12
Agricultural Lands	3.92	2.13
Open Lands	3.51	1.91
Woodlands	0.09	0.05
Surface Water	0.05	0.03
Wetlands	0.36	0.20
Totals[b]	**183.72**	**100.01[c]**

[a] Represents the total that had a specific land use designation within the SEWRPC Digital Land Use Inventory. Wetland acreage differs from WWI data.
[b] Lake Michigan supply and return flow options share the same corridor for about 6 miles. Land use totals would be less than reported if a Lake Michigan supply and return option are approved.
[c] Includes rounding errors.

No new access roads would be required for this Lake Michigan return flow alternative. Access is anticipated to be from existing municipal roadways and trails.

The residential land within the assumed 75-foot construction corridor borders roads. The majority of residential land that could be affected by the proposed alignments is described as single family low density. The construction corridor may be further minimized to avoid private property, or temporary construction easements would be obtained by the City. This alternative would affect no private residences.

A single private building in Waukesha County is located within the proposed 75-foot-wide construction corridor at the terminus of this Lake Michigan return flow alternative. Based on a review of aerial photography, it appears to be used as a storage structure. The City would coordinate with the owner of the building if a Lake Michigan supply was approved and would avoid this building or minimize the construction-related impacts.

Land affected by pipeline construction would be restored, or allowed to revert to, its previous use.

No changes to zoning would be required for construction and operation of the Root River return flow alternative.

Transportation

Ninety five percent of the Root River return flow alternative pipeline would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.4.2.3.2.7 Recreation and aesthetic resources effects of the Root River return flow alternative

Table 4-34 summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this return flow alternative.

Table 4-34. Public or conservation lands within or adjacent to the Root River return flow alternative (Source: Google Earth, 2009, SEWRPC, 2005)

Name of Resource	Acres
Buchner Park	0.09
Carroll College athletic fields	0.05
Catholic Memorial High School	0.15
Fox River Sanctuary	<.01
Hidden Lakes Park	0.38
Park Arthur	0.48
Prospect Hill School	0.62
Randall School	0.18
Root River Parkway	0.2
Total	**2.16**

No permanent aboveground structures are envisioned within conservation land and natural, recreational, or scenic areas. The booster pump needed for this alternative would be constructed within the Waukesha WWTP site, in a previously disturbed area. The Root River return flow alternative would not impact a Coastal Zone Management Area.

Visual impacts from the proposed return flow alternatives are expected to be minor.

4.4.2.3.2.8 Archeological and historical resources effects of the Root River return flow alternative

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 construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative's corridor. The Root River return flow alternative may affect 10 cultural sites (CH2MHill, 2013, Vol. 5, Appendix 5-3). Eight National Register of Historic Places (NRHP) sites were identified within 0.1 mile of the proposed Root River return flow alternative, all within Waukesha County (NRHP, 2012). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.4.2.3.2.9 Costs and energy (construction and operation) effects of the Root River return flow alternative

The department considered costs for return flow alternatives based on their 50-year present worth. The 50-year present worth assumes a six percent interest rate (Technical Review S2, 2015). The 50-year present worth of the Root River return flow alternative is $106,038,000.

Capital costs are estimated at $98,038,000[18] while annual operation and maintenance costs are estimated as $618,000[19].

Operation of the Root River return flow alternative would be anticipated to use 14,200 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

The energy used in the Root River return flow alternative (not including water supply) would release emissions estimated at 15,700 annual greenhouse gas emissions (tons CO_2) (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

4.4.2.4 Direct to Lake Michigan return flow alternative environmental effects

4.4.2.4.1 Discharge effects on Lake Michigan water quality from the direct to Lake Michigan return flow alternative

All water returned to the Lake Michigan watershed would be required to meet all of the department's water quality (WPDES) permit requirements.

4.4.2.4.2 Lake Michigan geomorphology and sediments effects of the direct to Lake Michigan return flow alternative

The geomorphology and sediments of Lake Michigan may be affected by this alternative. This alternative could require a pipeline and discharge structure on the bottom of the Lake to provide an offshore discharge. The proposed offshore pipeline trenching activities and erosion of cleared banks could increase loads of suspended sediments to Lake Michigan. The Lake Michigan substrate composition along the pipe alignment could change as well. Impact severity would be a function of sediment load, particle size and duration of construction activities. The construction near Lake Michigan would require various environmental permits and BMPs would be used to minimize impacts from suspended solids, turbidity and erosion.

4.4.2.4.3 Discharge effects on Lake Michigan flora and fauna from the direct to Lake Michigan return flow alternative

Flora

The outfall is expected to be in a water depth greater than the maximum rooting depth of macrophytes (Eurasian water milfoil, coontail, *Elodea*) commonly found in Lake Michigan (WPSC, 2003). Areas along the outfall pipe that might be shallow enough to be within the range of water depths supportive of macrophyte growth are subject to long-shore drift and high-energy wave action.

---

[18]Capital costs were estimated in June 2013 dollars, and assume a 2013 construction start.

[19]Operation and maintenance costs were calculated assuming a maximum 16.7 MGD water supply capacity, 10.1 MGD average capacity, and an average return flow of 11.7 MGD.

Benthic invertebrates

Benthic invertebrates would not be impacted as a result of an increased discharge to Lake Michigan.

Fish

There are many examples of outfalls (e.g. municipal wastewater, power plants) discharging directly into Lake Michigan. This outfall would be designed and placed similar to those outfalls and would be required to meet all of the necessary state and federal approvals and/or permit requirements. This proposed discharge would also be required to meet all water quality effluent limits under the WPDES program, which are designed to protect fish and aquatic life. The proposed discharge to Lake Michigan is not expected to have any positive or negative impacts to the Lake Michigan fish community

Birds

Birds would not be impacted as a result of an increased discharge to Lake Michigan.

Mammals

Mammals would not be impacted as a result of an increased discharge to Lake Michigan.

Invasives

During the construction phase of the water supply and return flow pipelines, best management practices would be used to reduce the potential introduction or spread of invasive species. Example practices that would 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. Post construction restoration methods would only use native species and the City would consider methods to encourage existing native species to thrive to reduce the potential of the invasive species establishing a foothold. Using these approaches would reduce the potential for spreading invasive species during construction.

4.4.2.4.4 Stream crossings effects of the direct to Lake Michigan return flow alternative

Table 4-35 lists the waterbodies that would be crossed by the estimated 75-foot-wide pipeline construction corridor for this alternative (CH2MHill, 2013, Vol. 5, Table 6-13).

Table 4-35. Water body crossings of the direct to Lake Michigan return flow alternative

No.	Name	Type	Width (ft)	Area (ac)	Fisheries Classification
1845	Poplar Creek	Perennial	—	0.03	Unkown
3052	Unnamed	Intermittent/ephemeral	—	0.01	—
3054	Unnamed	Intermittent/ephemeral	—	0.08	—
3055	Unnamed	Intermittent/ephemeral	—	0.001	—
3294	Unnamed	Intermittent/ephemeral	—	0.003	—
3305	Unnamed	Intermittent/ephemeral	—	0.005	—
3315	Deer Creek	Perennial	—	0.02	WWSF
5428	Lake Michigan	Lake	—	6.24	—
6566	Kinnickinnic River	Perennial	74.5	0.07	—
Totals			**74.5**	**6.459**	

[a] Where no crossing width is included, the pipeline construction either infringes upon the adjacent surface water, based on aerial confirmation of the GIS data, or there was no surface water width information available in GIS format.

4.4.2.4.4.1 Bed and banks of stream crossing effects of the direct to Lake Michigan return flow alternative

All inland waterway crossings would have result in construction-related impacts. Once construction is complete, the surface water crossings would be restored.

4.4.2.4.4.2 Water quality stream crossings effects of the direct to Lake Michigan return flow alternative

The primary construction-related impact to the water quality of affected streams could be potential elevated loads of suspended sediment resulting from trenching activities and erosion of cleared banks and rights-of-way in Lake Michigan tributary streams that are crossed. Impact severity would be a function of sediment load, particle size, and duration of construction activities. Impacts would be minimized by adhering to environmental permit conditions and best management practices designed to reduce the turbidity and erosion (CH2MHill, 2013, Vol. 5, Appendix 5-2).

4.4.2.4.4.3 Flora and fauna stream crossings effects of the direct to Lake Michigan return flow alternative

The pipeline stream crossings of the Lake Michigan return flow alternative would not likely result in impacts on the flora and fauna assuming proper HDD procedures are utilized. There are other special concern species that may be present on land at these crossings and avoidance/minimization measures would be recommended.

4.4.2.4.4.4 Wetland effects of the direct to Lake Michigan return flow alternative

The pipeline crossings of forested or scrub/shrub wetlands would result in a permanent wetland type change across the pipeline maintenance width due to the need to control woody vegetation within the right-of-way.

There would be approximately one acre of wetland type change from forested to emergent associated with this alternative. A total of 3.9 acres of wetland would be affected by pipeline construction for this alternative. Seven palustrine emergent (PEM) wetlands, 11 palustrine scrub-shrub (PSS) wetlands, six palustrine forested (PFO) wetlands, one open-water, and one filled/drained wetland would be affected by pipeline construction.

There are two special concern herptile species, one special concern crustacean species, and three rare plant species that occur in wetlands and may be impacted. The herptiles also occur in associated uplands/grasslands. Recommended measures would be suggested in order to avoid and/or minimize impacts to these species.

The Applicant would need to meet requirements under NR 103, Wis. Admin. Code. Pipeline routes and/or construction methods would be analyzed as part of this process to minimize any wetland impacts.

Table 4-36 lists wetland crossing acreages associated with this alternative.

Table 4-36. Wetland crossings of the direct to Lake Michigan return flow alternative (Source: WWI, CH2MHill, 2013, Vol.5, Table 6-42)

No.	Type	Width[a] (ft)	Area (ac)
7962	Emergent/wet meadow	-	1.38
7970	Emergent/wet meadow	-	0
8015	Emergent/wet meadow	-	0.17
8125	Scrub/shrub	-	0.75
8145	Scrub/shrub	-	0.16
8239	Scrub/shrub	-	0.13
8290	Scrub/shrub	-	0.49
8463	Forested	-	0.11
8723	Emergent/wet meadow	-	0.08
8909	Scrub/shrub	-	0.3
8911	Scrub/shrub	-	0.17
8915	Scrub/shrub	-	0
8920	Scrub/shrub	-	0.11
8921	Scrub/shrub	-	0.14
8923	Scrub/shrub	-	0.07
9184	Forested	-	0.01
9306	Open water	-	0.01
10321	Filled/drained wetland	121.6	0.13
11046	Emergent/wet meadow	270.9	0.45
11053	Emergent/wet meadow	-	0.19
11054	Emergent/wet meadow	-	0.1
11676	Scrub/shrub	-	0.01
12613	Forested	-	0.08
12627	Forested	-	0.08
12628	Forested	-	0.01
12643	Forested	193.6	0.32
Totals		586.1	3.9

Where a crossing length is not included the pipeline centerline would not intersect wetland only the edge of the ROW would be located in the wetland. Because of this it is anticipated that construction techniques could be adjusted to avoid most, if not all wetland impacts.

4.4.2.4.4.5 Upland forests and grassland effects of the direct to Lake Michigan return flow alternative

This alternative would affect 0.08 acres of woodlands (CH2MHill, 2013, Vol. 5, Table 6-52). There are four rare plant species that occur in dry-mesic to mesic woodlands and recommended measures may be suggested in order to avoid and/or minimize impacts to this species.

This alternative would affect 11.33 acres of open lands (CH2MHill, 2013, Vol. 5, Table 6-52). There is one rare plant species that occurs in beach dunes and recommended measures may be suggested in order to avoid and/or minimize impacts to this species if suitable habitat is present onsite.

4.4.2.4.4.6 Air emissions (construction and operation) effects of the direct to Lake Michigan return flow alternative

Particulate air emissions (fugitive dust) are expected to be generated by construction associated with this alternative. Diesel emissions from construction equipment are also expected. The fugitive particulate emissions and diesel emissions would be temporary emissions during the construction period. Emissions would be highly localized and limited to areas where restoration of the construction corridor had not yet been completed. Fugitive dust would be minimized by requiring restoration as construction proceeds. The Applicant would take reasonable precautions to prevent fugitive dust from construction work becoming airborne, such as by applying water as appropriate. Construction-related impacts on air quality are expected to be minimal. Temporary emissions from construction equipment would fall within federal and state air quality standards, including those established to protect sensitive populations such as children.

Emissions from the activities related to the operation of the project would be associated with electricity supplied from regional electrical utilities. The electricity supplied for this project would be within the existing permitted capacity of the utility. The emissions associated with this project would be very low and would not adversely affect the elderly or other sensitive populations. Additionally, public exposure to hazardous conditions is extremely unlikely.

The energy used in the Lake Michigan return flow alternative would release an estimated 4,300 tons/yr (CO_2) of annual greenhouse gas emissions (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015). These emissions are from the existing permitted capacity of the local electric utility.

4.4.2.4.4.7 Economic effects of the direct to Lake Michigan return flow alternative

Construction of the infrastructure for the direct to Lake Michigan return flow alternative is expected to provide economic benefits to the pipeline construction industry. Operational costs to the Applicant would increase incrementally as wastewater effluent flows increase with increasing population and economic activity in the City. Construction and operation costs would be borne by the residents of Waukesha. See also sections 3.14 and 4.6.

4.4.2.4.4.8 Land use effects of the direct to Lake Michigan return flow alternative

The direct to Lake Michigan return flow alternative would affect a total of 206 acres of land for pipeline construction (CH2MHill, 2013, Vol. 5, Table 6-51).

The land use construction and operation acreage impacts of this alternative are listed in Table 4-37. Most of the land affected by any alternative is categorized as transportation and communication utilities and is made up of roadways affected by the proposed pipeline routes. Impacts were evaluated assuming a 75-foot right-of-way for construction.

Table 4-37. Lake Michigan return flow alternative land use impacts (Source for base land use data: SEWRPC, 2000; analysis by CH2MHill, 2013, Vol. 5)

Land Use	Acres[a]	Percent
Residential	4.8	2.40
Commercial & Industrial	9.81	4.91
Transportation & Communication/Utilities	154.77	77.47
Government & Institutional	4.29	2.15
Recreational Areas	4.51	2.26
Agricultural Lands	0.00	0.00
Open Lands	11.33	5.67
Woodlands	0.08	0.04
Surface Water	0.17	0.09
Wetlands	10.03	5.02
Totals [b-c]	**199.79**	**100.01 [d]**

[a] Represents the total land that had a specific land use designation within the SEWRPC Digital Land Use Inventory. Wetland acreage differs from WWI data.
[b] Lake Michigan supply and return flow options share the same workspace for about six miles. Actual land use totals would be less than reported if a Lake Michigan supply and return flow option was selected.
[c] Total does not include 6.2 acres of surface waters within Lake Michigan (not included in the SEWRPC Digital Land Use Inventory)
[d] Includes rounding errors.

No new access roads would be required for this Lake Michigan return flow alternative. Access is anticipated to be from existing municipal roadways and trails.

The residential land within the assumed 75-foot construction corridor borders roads. The majority of residential land that could be affected by the proposed alignments is described as single family low density. The construction corridor may be further minimized to avoid private property, or temporary construction easements would be obtained by the City. This alternative would affect no private residences.

Land affected by pipeline construction would be restored, or allowed to revert to, its previous use.

No changes to zoning would be required for construction and operation of the direct to Lake Michigan return flow alternative.

Transportation

Seventy nine percent of the direct to Lake Michigan return flow alternative pipeline would follow existing utility and transportation corridors (CH2MHill, 2013, Vol. 5, Table 6-53).

The regional transportation system would be minimally affected by construction and by the travel of construction workers and equipment. Since construction would move sequentially along the pipeline routes, any transportation impacts on any given roadway would be temporary. An increased number of vehicles would be encountered during morning and evening peak times, corresponding to normal workday hours.

The proposed pipelines would be installed by boring major paved roadway crossings wherever possible. Crossing of roadways with less traffic would likely be performed by open trenching, which may cause disruptions in local traffic patterns. Where construction follows a road, work schedules would be communicated with local residents and local authorities to minimize impacts. Access across these roadways would be maintained for emergency vehicles and passenger vehicles through the use of metal plates and other measures. If roads are temporarily closed to through traffic, information would be shared with local first responders regarding roadway conditions. Appropriate control measures would be used during construction, such as detouring of traffic where possible, and by the use of flagmen, signage, and warning lights. Roadways would be repaired to their preconstruction condition.

Traffic from commuter (worker) traffic and from the transportation of equipment and materials for the project is expected to increase during the proposed construction. The initial staging, which would involve transporting the bulk of the construction equipment and materials and the daily transportation of additional equipment and materials, may temporarily affect local transportation systems. To minimize the effect, delivery routes would be required to minimize traffic disruption. As construction progresses, much of the equipment movement would occur along the construction right-of-way. When it is necessary for construction equipment and material to cross roadways, traffic flow may be interrupted. The impact of transportation of equipment and materials would be minimized through planning and coordination with local road jurisdictions. For example, the scheduling of heavy loads and delivery of materials would be coordinated so that it would not conflict with commuting hours.

Temporary disruptions of traffic flow and pattern are expected to result from construction of project alternatives.

Safety

Access to proposed construction sites would be restricted to construction workers or contractors unless special circumstances warranted entry by others, which would require pre-approval from the Construction Contractor. Signage, temporary fencing, or other means as appropriate to the location would be put in place to prevent trespassing. Appropriate safety procedures would be implemented to protect workers and the public. Traffic warning signs, detour signs and other traffic control devices would be used as required by federal, state, and local transportation departments and other authorities. Road crossings would be completed in accordance with the requirements of road crossing permits.

4.4.2.4.4.9 Recreation and aesthetic resources effects of the direct to Lake Michigan return flow alternative

Table 4-38 summarizes the public or conservation land and natural, recreational, or scenic areas within or adjacent to the proposed 75-foot-wide pipeline construction corridor workspaces for this return flow alternative.

Table 4-38. Public or conservation lands within or adjacent to the direct to Lake Michigan return flow alternative (Source: Google Earth, 2009; SEWRPC, 2005)

Name of Resource	Acres
Bethesda Springs Park	0.30
Carroll College athletic fields	0.28
Fox River Sanctuary	2.48
Greene Park	0.61
Greenfield Park	0.64
Kinnickinnic River Parkway	0.35
Sheridan Park	0.60
Saint Francis High School	0.49
Saint Francis Property	0.30
Total	**6.05**

No permanent aboveground structures are envisioned within conservation land and natural, recreational, or scenic areas. The booster pump needed for this alternative would be constructed within the Waukesha WWTP site, in a previously disturbed area.

The Direct to Lake Michigan return flow alternative would be within the designated Wisconsin Coastal Zone. If this alternative was utilized, the City would coordinate with the department, United States Army Corps of Engineers, and applicable agencies to avoid and/or minimize impacts to the Wisconsin Coastal Zone.

Visual impacts from the proposed return flow alternatives are expected to be minor.

4.4.2.4.4.10 Archeological and historical resources effects of the direct to Lake Michigan return flow alternative

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 construction corridors for the proposed supply and return flow alternatives. The investigations included a review of the known archaeological sites and previous cultural resource surveys within 100 meters of each alternative’s corridor.

The direct to Lake Michigan return flow alternative may affect 17 cultural sites (CH2MHill, 2013, Vol. 5, Appendix 5-3). There are 10 National Register of Historic Places (NRHP) sites within 0.10 mile of the proposed Direct to Lake Michigan return flow alternative within Waukesha County, and two NRHP sites within Milwaukee County (NHRP, 2012). The City intends to meet regulatory requirements regarding archeological resources during the design and construction phases to prevent or mitigate impacts to known or potential sites.

4.4.2.4.4.11 Costs and energy (construction and operation) effects of the direct to Lake Michigan return flow alternative

The department considered costs for return flow alternatives based on their 50-year present worth. This calculation assumes a six percent interest rate (Technical Review S2). The 50-year present worth of the Lake Michigan return flow near Oak Creek return flow alternative is $124,247,000. Capital costs are estimated at $117,247,000[20] while operation and maintenance costs are estimated as $423,000[21].

Operation of discharging return flow to Lake Michigan near Oak Creek would be anticipated to use 4,600 megawatt-hours (MWh) of electricity annually. This estimate assumes future average day demand of 10.1 MGD and includes alternative-specific treatment (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

The energy used to return flow to Lake Michigan near Oak Creek (not including pumping water supply from Oak Creek) would release emissions estimated at 4,300 annual greenhouse gas emissions (tons CO_2) (CH2MHill, 2013, Vol. 5, Table 6-71, Revised Feb, 2015).

4.5 General pipeline construction effects

4.5.1 Process overview

Regardless of which project alternative is used, similar impacts will occur as a result of pipeline construction through waterways and wetlands. There are a variety of methods to install a pipeline across a waterway or wetland. The Wisconsin Department of Natural Resources (WDNR) has authorization under Chapter 30, Wis. Stats., to permit and dictate the construction method authorized at each waterway.

To allow the passage of construction equipment and materials along the right of way (ROW), temporary bridges may be installed across waterways. Equipment crossings of waterways will be restricted to bridges that are authorized under the WDNR's Chapter 30 permit.

Waterway crossings for the proposed may be accomplished using five distinct construction methods:

- open trench
- dam and pump
- flume
- horizontal direction drill (HDD), and
- jack and bore.

These crossing methods have common procedures and unique components, which are discussed below.

---

[20] Capital costs were estimated in June 2013 dollars, and assume a 2013 construction start.
[21] Operation and maintenance costs were calculated assuming a maximum 16.7 MGD water supply capacity, 10.1 MGD average capacity, and an average return flow of 11.7 MGD.

Standard crossing methods normally require a gradual and uniform approach to the waterbody to prepare a suitable work area for construction equipment and place the pipeline. This usually requires removing bank vegetation and grading the banks away from the waterbody. This process could temporarily increase the potential for soil erosion until construction is complete and the right of way is stabilized and reseeded.

Erosion control measures would be required to be installed before construction. Temporary erosion controls include storing all excavated spoil in containment areas that prevent the spoil from entering the stream, and installation of silt fence and/or straw bales to prevent runoff from upland areas from entering the stream. Additional temporary workspaces on each side of the waterbody are generally required for staging the crossing. These are typically 50 feet wide by 150 feet long. There will be an undisturbed buffer between the additional temporary workspace and the waterway.

Following installation of the pipeline across the waterway, the ROW on either bank would be re-graded to its approximate preconstruction contours. Disturbed stream and river banks would be stabilized with biodegradable geotextile fabric, jute thatching, or bonded fiber blankets. Disturbed soils would be fertilized, seeded, and mulch would be applied as needed. Temporary bridges would be removed after seeding and mulching are complete. Temporary erosion control measures would be removed after permanent erosion control measures are installed and vegetation is re-established. Construction equipment would be required to be decontaminated to prevent the spread of invasive species which may be attached from previous construction sites.

4.5.2 Open trench crossing method

For an open trench crossing, a trench would be excavated through the stream using draglines or backhoes operating from one or both banks. The potential impacts to a waterway and its biota from open trench construction are quite different if the trenching is done when the waterway has flowing water rather than when the stream is dry. The WDNR typically limits open trench installation of the proposed pipelines to intermittent waterways with no flowing water at the time of construction. If there is flowing water, one of the other crossing methods would have to be used. This EIS assumes that open trench construction would be allowed only during times of no stream flow.

Restricting open trenching to times of no flow eliminates the direct construction impacts to the stream's water column, avoiding the associated sedimentation of habitat for fish and aquatic invertebrates, water quality degradation, and reduced light for aquatic plants and algae.

No long term impacts to streams would be expected if the contours of the streambed are restored to their pre-construction condition, required by Chapter 30 permitting.

4.5.3 Dam and pump crossing method

The dam and pump stream crossing method is slower and more expensive than the open trench method, however it generally reduces the water quality impacts caused by open trenching. It is also preferred for small streams that are sensitive to sediment loading.

This method involves damming the stream on either side of the construction area before trench excavation, using sand bags or other methods that greatly minimize the addition of sediment to the stream. Before the dams are installed, one or more water pumps would be placed on the upstream side of the proposed trench so water can be pumped around to the downstream side of the construction area.

The placement and removal of the pumps and damming material would cause minor sediment suspension. Where the pump hose discharges downstream of the crossing, energy dissipation devices would be used as necessary to prevent scouring of the stream bed. Trenching, installation of the pipeline, and restoration of the banks and ROW would be completed in the same manner as described for the open trench method. However, because the stream flow is pumped around the construction area instead of through it, only minimal sediments would be displaced by construction.

The use of the bypass pumping to redirect stream water flow around the construction area would temporarily block movements of fish and other aquatic organisms through the area.

4.5.4 Flume crossing method

The flume method is suitable for small to intermediate streams with straight channels at the crossing area, and that are sensitive to sediment loading.

Flumes made of large pipe sections would be aligned in the stream parallel to the water flow. The stream would then be dammed with a diversion bulkhead to direct stream flow through the flumes. A similar bulkhead would be installed at the downstream end of the flumes to prevent backwash from entering the construction area. Energy dissipation devices would be installed as needed to prevent scouring at the discharge location.

A trench would then be excavated underneath the flumes in the exposed section of stream bed. A section of pipeline long enough to span the stream would be welded together and pulled beneath the flume. The flumes would be removed after the installation of the pipeline. Backfilling and bank restoration would be completed as described for the open trench method.

Fluming, like the dam and pump method, isolates stream flow from the construction area and allows installation of the pipeline without significant displacement of sediments. The use of the flume to redirect stream water flow through the construction area would also temporarily prevent movement of fish and other aquatic organisms.

4.5.5 Horizontal directional drilling crossing method

Directional drilling minimizes the environmental effects of pipeline construction on a waterbody or waterway by going beneath its bed and avoiding direct disturbance of the bed and banks. This technique is especially useful for wide crossings, where navigation traffic is high, areas where bottom sediments are contaminated, or where there are sensitive habitats or cultural resources near the banks.

The HDD method involves using a special drill rig to drill a gently curved borehole below the surface of the ground and the bed of the waterway. After it exits on the opposite side of the stream, the drilling machine pulls a long, pre-welded pipeline section back through the drilled hole.

Temporary workspaces would be cleared for drilling equipment, measuring approximately 250 feet long by 50 feet wide on the entry side of the crossing. A slant drill unit would be placed on one bank and a small-diameter pilot hole would be drilled under the stream. After the pilot hole has been completed, it would be enlarged to accept the pipeline by pulling a barrel reamer back and forth through the bore hole. Drilling mud would be continuously pumped into the hole to remove cuttings and maintain the integrity of the enlarged hole. After the hole has been reamed, a prefabricated pipeline section long enough for the crossing would be pulled through the hole by the drilling rig.

An HDD crossing avoids most of the potential impacts that are a concern with pipeline crossings of waterways, as the pipeline is installed beneath the bed of the waterway. There is no disturbance or change to either the bed or water column. Many of the potential concerns described for other methods of crossing waterways, including sedimentation and turbidity, habitat alteration, disrupting breeding and movement patterns, and the introduction of pollutants into the water column, do not occur when the HDD method is properly used.

HDD construction uses a drill “mud” under pressure to lubricate the drill pipe, remove drill cuttings and maintain the integrity of the drill hole. The drilling mud is usually a water-based slurry of bentonite clay which may have an emulsifier added. Drilling mud and cuttings would also require disposal.

Pressurized drilling mud may leak to the surface, or “frac-out.” Such failures are not easily predicted; however, the impacts from failure can be reduced by monitoring mud pressure and drilling head location, inspecting the surface during the drill process, and by increasing the depth of the drill path below the bed of the river. In most cases the volume of sediment resulting from seepage of drilling mud would be far less than the amount produced by a conventional open-cut crossing.

During the crossing, drilling mud is stored away from the river in an earthen berm containment structure or fabricated containment tanks sized to accommodate the volume of mud necessary for the drill. Following completion of directional drilling, mud is disposed of in accordance with applicable state and local requirements. Where landowner permission is available, mud is typically land-spread in upland, agricultural fields. If landowner permission is not available or land-spreading is not appropriate for some other reason, drilling mud would be disposed of in a landfill or other authorized disposal site.

If an unanticipated frac-out were to occur in an upland location, the drilling mud would be contained to the extent possible with standard erosion control measures such as silt fences and/or hay bales, then disposed of properly by removing and spreading over an upland area or hauled off-site to an approved location.

A frac-out can occur in the bed of a waterbody or an adjacent wetland. If an in-stream frac-out occurred, the drilling would stop to develop an appropriate response. If proceeding with the

HDD crossing would cause significant adverse impacts to waterbodies and fisheries resources, the HDD would stop, and an alternative crossing method would be used. For a wetland frac-out, the slurry at the surface would be isolated using silt fence and/or hay bales, then removed by vacuum truck, machinery, or by hand, and disposed of in an acceptable upland location.

4.5.6 Jack and bore crossing method

This method is used primarily to install pipe under a surface, or shallow obstructions such as roads, railroads and other existing utilities. In some instances it may be used to install a pipeline under waterways. This method is also called auger boring or pipe jacking.

With this method, two construction pits are dug, a jacking pit and a receiving pit. The pits are typically about 15 feet wide and 35 feet long. A rotating boring machine is used to create a hole, starting from the jacking pit and ending in the receiving pit. A casing pipe, larger in diameter than the water pipe, is pushed into the hole following the boring machine. After the casing pipe has been installed between the jacking and receiving pits, the water pipe is slid into the casing pipe. The void area between the casing pipe and the bored soils is filled with grout and the area between the casing pipe and the water pipe is filled with pea gravel or sand.

There is little potential for a frac-out condition occurring during jack and bore installation, unlike that for a HDD installation, because the bentonite drilling slurry is not pressurized. The unpressurized drilling slurry would not have a force mechanism to push it far enough out of the drill hole to result in a frac-out release.

The use of this method to install a pipeline avoids most of the potential impacts that are a concern with pipeline crossings of waterways that place the pipe beneath the bed of the waterway. There is no disturbance or change to either the waterway's bed or water column.

Many of the potential impacts of some other methods of crossing waterways, including sedimentation and turbidity, habitat alteration, disrupting breeding and movement patterns, and the introduction of pollutants into the water column, do not occur when this method is used.

4.5.7 Operation and maintenance related impacts

Other than inspections from vehicles and routine removal of brush and trees, there should be little long-term disturbance of the corridor, and associated long-term effects on water quality due to operating and maintaining the proposed pipelines.

4.5.8 Waterway summary

For intermittent waterways, open trench crossings of these waterways would only be allowed at times of no flow. With this restriction, open cut trenching would not alter the streams' water quality or have any direct effect on aquatic life. With simple restoration efforts, using this method would also not substantially change either streambed configuration or flow characteristics.

For perennial waterways that would be crossed, the potential environmental consequences using HDD or jack and bore pipeline construction methods would be minimal, because those pipeline installation methods do not directly disturb the bed or water column of the waterway. The potential impacts to the perennial waterways crossed using a dam and pump or flume method, are also expected to be minor, with impacts primarily of temporarily inhibiting movements of fish and other aquatic organisms through the construction zone.

4.5.9 Pipeline Construction Impacts on Wetlands

The temporary removal of wetland vegetation is a primary impact of pipeline construction and right-of-way maintenance activities. Construction also would temporarily diminish the recreational and aesthetic value of the wetlands crossed. These effects would be greatest during and immediately following construction. In wet meadow/emergent wetlands, the impact of construction would be relatively brief, since herbaceous vegetation regenerates within one or two seasons. In forested and shrub-dominated wetlands, the impact would last longer due to the longer recovery period of these vegetation types. Long-term vegetation management over the pipeline to allow access and inspection would prevent regeneration of tree and shrub cover.

Clearing of wetland vegetation would also temporarily, or in some cases, permanently, remove or alter wetland wildlife habitat.

Trench excavation is a major disturbance of a wetland, but construction activities would also impact wetlands outside of the trench area. Compaction and rutting of wetland soils could result from the temporary stockpiling of soil and the movement of heavy machinery. Surface drainage patterns and hydrology could be temporarily altered, and there would be increased potential for the trench to act as a drainage channel. Trench breakers would be placed in the trench to prevent the flow of groundwater in the backfilled trench. Increased siltation in adjacent wetland areas may result from trenching activities. Disturbance of wetlands also could temporarily affect the wetland’s capacity to reduce/moderate erosion and floods.

Construction through wetlands would comply, at a minimum, with conditions set in the state and federal permitting. The evaluation of potential impacts from crossing wetlands is based on WDNR waterway and wetland permitting which requires the use of appropriate erosion control practices along with the restoration of the wetland contours to preconstruction conditions.

The following discussion summarizes the major components of proposed construction methods. Staging areas and extra workspace would be needed on both sides of larger wetlands. These areas would be located at least 50 feet away from the wetland boundaries, where topographic conditions permit, and would be limited to the minimum area needed for assembling the pipeline. Storage of hazardous materials, chemicals, fuels, and lubricating oils would generally be prohibited within 100 feet of wetland boundaries.

Temporary erosion control devices would be installed at the base of cleared slopes leading to wetlands. If there is no slope, erosion control devices would be installed as necessary to prevent exposed soils from flowing off the ROW into the wetland or to prevent sediment from flowing from adjacent uplands into the wetlands.

During clearing, woody wetland vegetation would be cut at ground level and removed from the wetland, leaving the root systems intact. In most areas, removal of stumps and roots would be limited to the area directly over the trench. Stumps from areas outside of the trench line would be removed, as necessary, to provide a safe work surface.

To facilitate revegetation of wetlands, topsoil would be stripped over the trench, except in areas where standing water or saturated soils make it impracticable, where no topsoil layer is evident, or where the topsoil layer exceeds the depth of the trench.

The use of either low ground-pressure equipment or standard construction equipment operating from timber pads would reduce disturbance of wetlands with saturated soils or standing water.

Imported rock, stumps, brush, or offsite soil would not be used as temporary or permanent fill in wetlands. Following construction, materials used in wetlands to provide stability for equipment access would be removed.

If the standard crossing method is not practical because of saturation or standing water, either a push/pull method or winter construction might be used. Use of the push/pull method is generally limited to large wetlands with standing water and/or saturated soils that have adequate access for pipeline assembly and equipment operation on either side of the wetland. If this method is used, a long section of pipeline would be assembled on an upland area of the ROW adjacent to the wetland. Usually this requires use of extra temporary workspace adjacent to the ROW. The trench would be dug by a backhoe supported on timber mats. The prefabricated section of pipeline would then be floated across the wetland. When the pipeline is in position, the floats would be removed and the pipeline would sink into position. The trench would then be backfilled and the original contours would be restored by a backhoe working from construction mats.

Under frozen conditions, the pipe would be installed in wetlands similar to conventional upland construction. Because equipment is supported by frozen soil and ice, temporary mats would not be required. The success of winter construction depends on prolonged periods of subfreezing temperatures, which produce sufficient frost depth. Because these conditions are not always predictable, the ability to use the winter construction method is generally not assured.

Ice roads may also be used to decrease impacts. Ice roads are created by plowing the snow off of the wetland surface, and driving sequentially heavier pieces of equipment across the wetland surface to facilitate the penetration of the frost deeper in the ground, creating a stable working surface.

Following restoration of contours, wetlands would typically be seeded with annual ryegrass as a cover crop. Other measures such as replacement of the original surface soil, with its stock of roots and tubers can facilitate restoration. The wetland would either be seeded with an appropriate native wetland seed mix or allowed to re-vegetate naturally to preconstruction vegetative covers. No lime or fertilizer would be added to disturbed wetland areas, unless required in writing by the appropriate permitting agency. After a period of monitoring, wetlands that do not appear to be regenerating by this process may need to be seeded with an approved native seed mix.

Most of the wet meadow wetlands have, or are dominated by, reed canary grass, which is a very aggressive invasive plant. In wetlands that contain the grass, it is likely that, following construction, the ROW and workspace area would become dominated by the grass because of the disturbance and spreading of the plant rhizomes, which facilitate spread. A wetland free of reed canary grass should be protected from its introduction by construction mitigation techniques.

Operation of the pipelines would not require alteration of wetlands other than periodic brush and tree control in the pipeline's permanent ROW. No permanent filling, dredging or other long term wetland disturbance is anticipated.

4.6 Socioeconomic effects

The UW-Milwaukee's Center for Economic Development (CED) made a detailed study of socioeconomic factors for SEWRPC's Regional Water Supply Plan. The conclusions from that study are summarized here (Rast, 2010).

CED's evaluation of the Regional Water Supply Plan (RWSP) considered SEWRPC's Regional Land Use Plan (RLUP), and relevant local and countywide comprehensive plans, including the planned land use components. Plans were evaluated in order to understand how the recommendations set forth in the RWSP would impact development and land use. Existing and planned land uses for specific communities were examined in order to determine whether and use patterns in areas proposed for expansion or conversion under the RWSP could have an impact on environmental justice.

Over the past 50 years, there has been an outward migration of population and jobs from the large lakeshore manufacturing cities to the outlying counties and suburbs. The loss of an economy based on manufacturing and the movement of economic and development activity inland negatively impacted jobs and income in the central city areas. A substantial increase in the number and percent of people living at or below the poverty level has occurred in the Kenosha, Milwaukee, and Racine while it has declined in many suburban communities. Racial and ethnic minority and low-income populations have been disproportionately affected. These populations have become increasingly concentrated in Kenosha, Milwaukee, and Racine.

Job projections and population projections by race, ethnicity, and disability for the year 2035 were also evaluated.

If trends continue, migration of the White Alone, Non-Hispanic populations from Milwaukee and Racine will continue to contribute to growth in suburban areas. White Alone populations in Kenosha and Waukesha are expected to decline in number and proportion while being offset by increases in minority populations that will result in the population growth of those cities.

USGS and SEWRPC studies indicate that groundwater issues are not currently a constraint on development in the region, and that the source of water would not have an impact on development.

CED's land use analysis found that the delineations of the existing and proposed utility service areas in the RLUP include lands that are mostly either currently developed or undevelopable. The land use analysis also found that most of the undeveloped land within the projected service areas is primarily infill development. Growth is limited under the RWSP to the existing development and infill developable areas within the proposed expanded water utility service areas. Therefore it is not anticipated that projected population growth or the distribution of ethnic and racial minorities will be caused by implementation of the recommendation to change sources of water supply.

Based on the land use findings, CED concluded that it is unlikely that recommended water source changes from groundwater to Lake Michigan water would yield any significant socio-economic imbalances through 2035 (Rast, 2010).

Section 5 Comparison of Alternatives

5 Comparison of Alternatives

5.1 Introduction

This section provides a brief summary and comparison of the various water supply and return flow alternatives.

Under WEPA, an EIS must consider alternatives to the proposed action (Wis. Stat. 1.11(2)(c)3.). Section 2 describes the proposed alternatives and pipeline corridors, Section 3 describes the existing environment, and Section 4 identifies the potential impacts of the various water supply source alternatives, and return flow discharge alternatives. Section 4 also evaluates the "no action" alternative. Potential cumulative effects are summarized in Section 6 along with a general evaluation of the proposal.

5.2 Comparison of water supply source alternatives

Section 4 describes in detail the potential impacts of the water supply alternatives (section 4.2).

The Applicant reviewed six water supply alternatives in detail: four of the reviewed alternatives withdraw water exclusively from the Mississippi River Basin; one alternative withdraws water from a combination of Mississippi River Basin and Lake Michigan sources; and the final alternative withdraws water from the Lake Michigan Basin. Based on public comments, the department also modeled and reviewed an alternative scenario that included variations on well placement meant to minimize adverse environmental impacts.

Approximately 1.0 million gallons per day (MGD) is forecasted in water savings due to conservation and efficiency measures by final build-out (approximately the year 2050), and the department has taken this into account in calculating projected demand for the water supply service area. The proposed diversion cannot be reasonably avoided through the efficient use and conservation of existing water supplies.

The EIS analyzes the proposed water supply alternatives based on cost and potential impacts to the human environment. Table 5.1 indicates that all of the proposed Mississippi River basin water supply alternatives are similar in cost to the Lake Michigan alternative.

Table 5-1. Comparison of Water Supply Alternative Costs (50- year Present Worth 6 percent)

Alternative	50-year present worth ($, 6 percent)	Within 25 percent of the preferred alternative cost
1 - Deep and Shallow Aquifers	275,560,000*	√
2 - Fox Alluvium and Shallow Aquifer	350,560,000	√
3 - Unconfined Deep Aquifer	288,670,000*	√
4 - Multiple Sources	391,460,000*	√
5 - Lake Michigan and Shallow Wells	406,890,000*	√
6 - Preferred Lake Michigan Supply (Oak Creek, Return to Root)	**332,400,000**	**249,300,000 - 415,500,000**
6a – Lake Michigan Supply (Oak Creek, Return Direct to Lk. Michigan)	350,600,000	√
6b – Lake Michigan Supply (Oak Creek, Return to Mil. Met. Sewage	374,800,000	√
*Does not include home water softening.		

As described in Section 4, the water supply alternatives that include the Mississippi River Basin sources are likely to have greater overall adverse environmental impacts primarily due to projected impacts on wetlands and lakes than the proposed Lake Michigan alternative. The deep and shallow wells alternative has the potential to impact 809 to1069 acres of wetlands and the shallow wells alternative has the potential to impact 1939 to 2326 acres of wetlands due to groundwater drawdown from pumping. Wetland impacts to Vernon Marsh could be significant from the increased well pumping.

The proposed diversion would not result in significant adverse direct impacts or cumulative impacts to the quantity or quality of the waters of the Great Lakes basin or to water dependent natural resources, including cumulative impacts that might result due to any precedent-setting aspects of the proposed diversion. The proposed annual diversion represents 0.00028 percent of the volume of Lake Michigan and 0.000061 percent of the volume of the Great Lakes. These totals do not take into account any treated wastewater returned to the Lake Michigan basin. Based on the Applicant's preferred return flow alternative, the department determined that 95-109 percent of the water withdrawn (using water use data from 2005-2012) would have been returned to the basin had the return flow plan been in place over that time period.

5.3 Comparison of water supply pipeline alternatives

Sections 4.2.3.2 to 4.2.3.4 describe potential impacts from the various water supply pipeline alternatives on several aspects of the human environment. Table 5.2 summarizes the comparison of potential impacts of the route alternatives. The Milwaukee and Oak Creek alternatives would follow existing transportation or utility corridors for much of the route, while the Racine alternative would cross primarily agricultural and open lands. Natural resource features along any route will be affected during construction. Use of best management practices for protecting wetland and waterways and site restoration would be required to minimize the temporary impacts of the pipeline construction. Permanent changes to wooded areas, especially forested wetland conversion to emergent wetlands, is less for the Oak Creek alternative. The fewest overall impacts to natural resources features would occur for the Oak Creek pipeline alternative.

Table 5-2. Comparison of Water Supply Pipeline Alternatives

	Milwaukee	Oak Creek	Racine
Pipeline length in miles	15	19.4	38
Percent in transportation or utility corridor	80	94	9.9
Number waterways crossed	7	3	16
Acres of wetlands affected	6.8	0.5	56.4
Acres of forested wetlands converted to emergent	5.9	0.1	19.2
Acres of woodland affected	0.45	0.48	7.74
Acres of open or grassland	8.0	1.2	30.7
Acres recreation land near pipeline	24	2.2	20.4
Annual energy use in MWh	11,500	14,200	16,100
Number cultural sites near pipeline	5	7	2

5.4 Comparison of return flow discharge alternatives

Section 4.3.2 describes potential impacts from the various return flow discharge options for the Lake Michigan supply option. For any scenario that involves the Lake Michigan supply option, there could be an estimated 11% decrease in baseflow to the Fox-Illinois River due to decreased discharge from the City's existing WWTP (see Appendix A of the EIS for Fox River impacts). This decrease would likely have minimal impacts to the water quality and flora and fauna using the Fox River. Eliminating the current shallow aquifer well pumping near the Fox River would increase the baseflow of tributaries to the Fox River.

None of the return flow discharge alternatives would involve significant adverse impacts to Lake Michigan water quality, quantity and biota. The MMSD and Root River alternatives would not involve any construction activities in Lake Michigan.

The proposed additional flow to the Root River during low-flow periods may positively impact the Root River fish community. Phosphorus may both negatively and positively impact the fish community of the Root River and estuary. Temperature impacts to the Root River would likely be minimal, and the addition of chlorides, and possibly pharmaceuticals, would likely negatively affect the fish of the Root River and possibly have a slightly negative effect on the fish community in the Root River estuary and possibly the near shore areas of Lake Michigan.

5.5 Comparison of return flow pipeline route alternatives

Sections 4.3.2.2 to 4.3.2.4 describe potential impacts from the various return flow pipeline alternatives on several aspects of the human environment. Table 5.3 summarizes the comparison of potential impacts of the route alternatives. All of the return flow options have similar potential for impacts to natural resources features. All routes would follow existing transportation or utility corridors for much of the route, with the MMSD and Root River alternatives having over 90% of the route in that land use. Natural resource features along any route will be affected during construction. Use of best management practices for protecting wetland and waterways and site restoration will be required to minimize the temporary impacts of the pipeline construction. Permanent changes to wooded areas, especially a conversion from forested wetland to emergent wetlands, are less for the Root River alternative. Energy usage is proposed to be lowest for the direct discharge to Lake Michigan alternative.

Table 5-3. Comparison of Return Flow Pipeline Alternatives

	MMSD	Root River	Lake Michigan
Pipeline length in miles	17.6	20.2	22.5
% in transportation or utility corridor	92.5	91.2	77.5
# waterways crossed	3	4	9
acres of wetlands affected	1.06	0.62	3.90
acres of forested wetlands converted to emergent	0.79	0.1	1.0
acres of woodland affected	0.5	0.09	0.08
acres of open or grassland	5.0	3.5	11.3
acres recreation land near pipeline	2.3	2.2	6.0
annual energy use in MWh	8,100	14,200	4,600
# cultural sites near pipeline	12	10	17

Cumulative Effects and Evaluation

6 Cumulative Effects

The Applicant is without adequate supplies of potable water due to the presence of radium in its current groundwater water supply. The Applicant's current water supply, the deep sandstone aquifer, is derived from groundwater that is hydrologically interconnected to waters of the Lake Michigan basin. Groundwater pumping from the deep sandstone aquifer in southeast Wisconsin has changed the predevelopment groundwater flow direction from flowing towards Lake Michigan to flowing towards pumping centers. Currently the largest pumping center from the deep sandstone aquifer in southeast Wisconsin is in Waukesha County.

The proposed diversion would not result in significant adverse direct impacts or cumulative impacts to the quantity or quality of the waters of the Great Lakes basin or to water dependent natural resources, including cumulative impacts that might result due to any precedent-setting aspects of the proposed diversion. The proposed annual diversion represents 0.00028 percent of the volume of Lake Michigan and 0.000061 percent of the volume of the Great Lakes. These totals do not take into account any treated wastewater returned to the Lake Michigan basin. Based on the Applicant's preferred return flow alternative, the department determined approximately 100 percent of the water withdrawn (using water use data from 2005-2012) would have been returned to the basin had the return flow plan been in place over that time period.

The proposed Oak Creek water supply pipeline route right-of-way would require the permanent conversion of 19.62 acres of forested wetland to emergent wetland, and 7.74 acres of woodland to grassland. The proposed Root River return flow pipeline right-of-way would require that one acre of forested wetland be permanently converted to emergent wetland, and that 0.08 acres of woodland be permanently converted to grassland. Use of best management practices for protecting wetland and waterways and site restoration will be required to minimize the temporary impacts of the pipeline construction.

For the Lake Michigan supply there could be an estimated 11% decrease in baseflow to the Fox-Illinois River due to decreased discharge from the City's existing WWTP. This decrease would likely have minimal impacts to the water quality and flora and fauna using the Fox River. Eliminating the current shallow aquifer well pumping near the Fox River would minimally increase the baseflow of tributaries to the Fox River and to associated wetlands.

The return flow discharge would not involve significant adverse impacts to Lake Michigan water quality, quantity and biota. The proposed Root River return flow would not involve any construction activities in Lake Michigan. The proposed additional flow to the Root River during low-flow periods may positively impact the Root River fish community. Phosphorus may both negatively and positively impact the fish community of the Root River and estuary. Temperature impacts to the Root River would likely be minimal, and the addition of chlorides, and possibly pharmaceuticals, would likely negatively affect the fish of the Root River and possibly have a slightly negative effect on the fish community in the Root River estuary and possibly the near shore areas of Lake Michigan.

6.1 Effects on scarce resources

Other than the permanent conversion of forested wetlands to emergent wetlands within proposed pipeline rights-of-way, effects on scarce resources, such as listed species and archeological/historic resources, are not anticipated.

6.2 Unavoidable adverse effects

Proposed project pipelines are expected to result in a total permanent conversion of 20.62 acres of forested wetland to emergent wetland, and a total permanent conversion of 7.82 acres of woodland to grassland. Additional permitted pollutant loading to the Root River is expected. Fox River baseflows are estimated to decrease by 11%.

6.3 Consistency with plans

The proposed project is consistent with public plans and policies. The department's Technical Review finds that the proposed diversion meets all Agreement/Compact and statutory requirements for a community within a straddling county. The proposed diversion would be implemented to ensure that it is in compliance with all applicable municipal, state and federal laws as well as regional interstate and international agreements, including the Boundary Waters Treaty of 1909. The Applicant would be required to comply with all applicable laws and would need to work closely with regulatory authorities throughout any diversion process.

6.4 Short-term and long-term effects

Construction-related resource effects are anticipated to be short-term. Conversion of wooded to non-wooded areas would be a long-term effect as long as pipeline rights-of-way are maintained. Discharges to the Root River and reduced discharge to the Fox River will continue for the long-term. Energy and materials for construction and operation will be committed for the long-term. Long-term effects on Lake Michigan are not anticipated. A safe and sustainable public water supply for the Applicant is expected for the long-term.

6.5 Precedence

The department determined in the Technical Review that the proposed diversion is approvable under the Agreement/Compact and plans to forward the application to the Regional Body and Compact Council for review. The Agreement/Compact bans diversions, but provides limited exceptions for a public water system in a "straddling community" or a "community within a straddling county" to apply subject to Agreement/Compact requirements. There are no Agreement/Compact provisions that allow for areas outside of a straddling county to apply or become eligible for a diversion. Other diversions of Great Lakes water currently exist; therefore the department sees no precedent related to federal law for the proposed diversion.

Denying the proposed diversion is unlikely to set a precedent for denying all other diversion requests from communities in straddling counties. The specifics of each diversion proposal are likely to be a unique set of facts that have limited applicability to any other diversion approval. The decision on any necessary future permits and approvals would not be substantively affected by a diversion approval.

6.6 Risk

There is little degree of risk or uncertainty in predicting environmental effects or effectively controlling potential deleterious environmental impacts, including those relating to public health or safety. The proposed project would utilize well-known technologies for water supply, treatment and return. Water returned to the Root River would be required to meet permit requirements.

6.7 Controversy

This first-of-its-kind project has generated considerable public interest and controversy. The department received many public comments throughout the review process and has responded to those comments in the Public Comments and Responses document attached to this EIS.

Appendices

7 Appendix A: Impacts to the Fox Flow under different alternatives

DNR staff analyzed the anticipated change in flow to the Fox River from the current flow with current water supply based on the alternatives considered in the EIS. The results of this analysis ranged from 11% decrease in baseflow to a 4% increase in baseflow on the Fox River just downstream of the confluence of Pebble Brook.

Currently the Applicant relies on the deep and shallow aquifers for water supply: 80% of the water supply is from the deep aquifer and 20% from the shallow aquifer. The shallow aquifer wells are located adjacent to the Fox River downstream of the City's Wastewater Treatment Plant. As a result water captured by the wells drawing from the shallow aquifer that would have discharged to the Fox River is still discharged to the Fox River after use through the WWTP. In addition to the water withdrawn for water supply, additional water known as Infiltration and Inflow collects in sewer pipes, is treated at the WWTP and discharges to the Fox River. The City's 2010 – 2014 average annual water withdrawal was 6.7 MGD. The City's 2008 – 2012 average annual wastewater discharge was 10.2 MGD. Assuming a 10% consumptive use coefficient, I/I is assumed to be 4.3 MGD.

DNR staff took a simplified approach to the Fox River water budget for the analysis of flow in the Fox under different water supply alternatives. For all of the alternatives that include baseflow reductions to the Fox River from shallow aquifer withdrawals the water is returned to the Fox River Basin. However, the variable in the different Mississippi River Basin alternatives is the amount of deep aquifer water used for the water supply. Deep aquifer water comes from water recharge in western Waukesha County outside of the Fox River Basin – use of the deep aquifer essentially augments the flow in the Fox River.

The following table shows relative impacts to the Fox River flow from the different proposed water supply alternatives.

Table 7-1. Percent change in baseflow to the Fox River from current baseflow to the baseflow under water supply alternatives

Alternative	Deep Aquifer	Shallow aquifer Fox River Baseflow[a]	Shallow aquifer other streams baseflow[a]	Shallow aquifer other sources[b]	I/I[c]	Consumptive Use 10%	Lake Michigan	WWTP Fox River Discharge[d]	Additional Flow to the Fox River[e]	% Change from Current
Current[f]	5.4	0.9	0	0.3	4.3	0.53	0	10.2	5.1	0%
No Action[f]	7.3	0.9	0	0.3	4.3	0.68	0	12.1	6.8	4%
Deep/Shallow 1	4.5	2.3	1.1	0.6	4.3	0.68	0	12.1	4.6	-1%
Deep/Shallow 1a	4.5	3.5	0.2	0.3	4.3	0.68	0	12.1	4.3	-2%
Shallow	0	5.4	2.2	0.9	4.3	0.68	0	12.1	0.8	-9%
Lake Michigan	0	0	0	0	4.3	0.68	8.5	3.6	0	-11%

a – baseflow calculations from groundwater flow modeling with USGS Upper Fox River Basin Model, see Appendix B for further information. Baseflow from other streams are tributary to the Fox River and considered as Fox River flow.

b – other sources of water are the remaining volume of water not captured from Fox River or tributary to the Fox River. This water is from aquifer storage or captured from baseflow not tributary to the Fox River. Baseflow comparisons are based on modeled Fox River baseflow just downstream of Pebble Brook confluence with the Fox River. Current baseflow was modeled at 74.9 cfs.

c - I/I, infiltration and inflow, is calculated as the remaining flow greater than the average annual withdrawal discharged from the wastewater treatment plant. I/I was calculated for the current scenario and then held constant in the other scenarios. I/I = WWTP Discharge – (Total Water withdrawal*Consumptive Use coefficient).

d – WWTP Fox River Discharge for the Current alternative is the average from 2008 – 2012. All others the WWTP discharge are sums of sources and I/I.

e – Additional flow to the Fox River is flow that would not have naturally discharge to the Fox River – this includes flow from the deep aquifer and from other shallow aquifer sources minus consumptive use.

f –The department used the model results at the end of stress period 2 for alternative 4 as described in Appendix B for estimating impacts of the Current and No Action alternatives.

Description of Alternatives

Current– Withdrawals based on 2010-2014 average annual withdrawals

No Action – Assumes 2010-2014 average annual withdrawal from shallow aquifer and remainder from deep aquifer

Deep/Shallow 1 – Assumes Applicant configured alternative using the deep and shallow aquifers, with shallow wells along the Fox River and Pebble Brook

Deep/Shallow 1a – Assumes DNR configured alternative using the deep and shallow aquifers, with shallow wells along Pebble Brook

Shallow – Assumes Applicant configured alternative using shallow wells along the Fox River and Pebble

Lake Michigan – Assumes Lake Michigan supply and DNR proposed return flow management plan of average annual withdrawal returned to Lake Michigan basin.

The department also calculated the impact of the decrease in flow from the Waukesha WTTP to the Fox River with a switch to Lake Michigan water supply on flows at different points downstream of the City of Waukesha. Under the Lake Michigan water supply alternative the wastewater discharge to the Fox River would decrease by 8.1 cfs from the current discharge. For this analysis the department used modeled August Q50 and Annual Q90 flows from the Wisconsin Natural Communities Model (Diebel, 2014). Note that at the Fox River downstream of the confluence of Pebble Brook the August Q50 and Annual Q90 are 88.1 cfs and 57.2 cfs, respectively. The modeled baseflow from the USGS Upper Fox River Basin Groundwater Flow model at this same location (and used in the previous analysis) is 74.9 cfs. (See table 7-2)

Table 7-2 Estimated percent decrease in Fox-River streamflow with Lake Michigan water supply

Location on Fox River	August Q50	% decrease	Annual Q90	% decrease
Fox River @ Pebble Brook	88.1	9%	57.2	14%
Fox River @ Waterford Dam	160	5%	99.0	8%
Fox River @ Racine Co. Line	327	2%	224	4%
Fox River @ Kenosha County Line*	352	2%	225	4%

*Calculated to address discrepancies in the model.

The daily reduction in flow is expected to minimally impact the fishery of the Fox River. The individual fish habitat requirements for dominant species (Table 6-2) and threatened and endangered species generally would still be met (Table 6-2).

Table 7-3.Potential Changes to Fish Species habitat due to flow changes in the Fox River

Dominant Fish Species	Preferred Current Velocity Range	Stream Gradient	General Habitat Characteristics	Dominant Substrate Preference	Potential Changes to Habitat (with changes in flow to the Fox River)
Channel catfish	Wide range	Not documented in reviewed literature	Wide range	Mud, sand, clay, gravel	With the wide range of preferred velocities, habitat characteristics, and substrate preference, no to minimal impacts are expected.
Creek chub	< 0.98 ft/sec	3-23 m/km	Pools	Sand, gravel	Slightly less pool depth, but because pools are by definition deeper areas no significant changes expected. No to minimal impacts are expected to preferred substrate.
White sucker	1.31 ft/sec	Wide Range	Wide range	Gravel, sand	With the wide range of preferred habitat characteristics and substrate preference, minimal impacts are expected.
Golden redhorse	Not documented in reviewed literature	Not documented in reviewed literature	Pools in river bends	Sand, gravel	Slightly less pool depth, but because pools are by definition deeper areas no to minimal impacts are expected. No to minimal impacts are expected to preferred substrate.
Bluntnose minnow	Not documented in reviewed literature	Not documented in reviewed literature	Wide range	Gravel, sand	With the wide range of preferred habitat characteristics and substrate preference, no to minimal impacts are expected.
Common carp	Not documented in reviewed literature	Not documented in reviewed literature	Wide range	Sand, gravel, clay	With the wide range of preferred habitat characteristics and substrate preference, no to minimal impacts are expected.
White bass	Moderate currents	Not documented in reviewed literature	Generally occurs in waters 6m in depth or less	Sand, mud, rubble, gravel	With the wide range of preferred habitat characteristics and variety of substrate preference, no to minimal impacts are expected.
Common shiner	Not documented in reviewed literature	Not documented in reviewed literature	Rocky pools near riffles	Hard bottom, gravel, sand, rubble	Slightly less pool depth, but because pools are by definition deeper areas no impacts are expected. No to minimal impacts are expected to preferred substrate.

Northern pike	Not documented in reviewed literature	Not documented in reviewed literature	Shallow vegetated areas	Vegetated areas	No to minimal impacts are expected.
Largemouth bass	> 0.33 ft/sec	Not documented in reviewed literature	Not documented in reviewed literature	Vegetated areas, sand, gravel, mud	With the wide range of preferred substrate preference, no to minimal impacts are expected.
Rock bass	Not documented in reviewed literature	Not documented in reviewed literature	Preference for clear cool to warm water	Sand, gravel	No expected to general habitat characteristics or preferred substrate.
Emerald shiner	Not documented in reviewed literature	Not documented in reviewed literature	Wide range	Sand, gravel	With the wide range of preferred habitat characteristics and substrate preference, no to minimal impacts are expected.
Bluegill	< 0.33 ft/sec	≤ 0.5 m/km	60 percent pool areas	Submerged vegetation/ logs, brush	Slightly less pool depth, but because pools are by definition deeper areas no to minimal impacts are expected. No to minimal impacts are expected to preferred substrate.
Longnose gar	Not documented in reviewed literature	Not documented in reviewed literature	Backwaters, quiet currents	Gravel, sand	No to minimal impacts are expected to general habitat characteristics or preferred substrate.

Table 7-4. Potential impacts to state threatened, endangered, species of concern, and cold water species recorded since 1999 in the Fox River due to changes in Fox River flow

Fish Species	Preferred Current Velocity Range	Stream Gradient	General Habitat Characteristics	Dominant Substrate Preference	Potential Changes to Habitat (with changes in flow to the Fox River)
Greater Redhorse (special concern)	Not documented in reviewed literature	Not documented in reviewed literature	Pools and runs of medium to large rivers	Sandy to rocky pools	Slightly less pool depth, but because pools are by definition deeper areas no to minimal impacts are expected. No significant changes expected to preferred substrate.
Longear sunfish (threatened)	Not documented in reviewed literature	Not documented in reviewed literature	Slow moving rivers and streams	Shallow dense vegetation	Shallow areas would become shallower on average, but less than 2 inches water depth change would occur. Consequently, no to minimal impacts are expected.
Banded killifish (special concern)	Not documented in reviewed literature	Not documented in reviewed literature	Shallow sluggish streams	Sand/mud/near vegetation	Shallow areas would become shallower on average, but less than 2 inches water depth change would occur. No impacts are expected to the preferred substrate. Consequently, none are expected.
Starhead topminnow (endangered)	Not documented in reviewed literature	Not documented in reviewed literature	Quit pools and backwaters	Vegetated areas	Slightly less pool depth, but because pools are by definition deeper areas no to minimal impacts are expected. No to minimial impacts are expected to preferred substrate.
Brook trout (cold water species)	Not documented in reviewed literature	Not documented in reviewed literature	Clear, cool, well wxygenated streams	Sand/gravel/rubble	Lower flow in the Fox River could extend cool water influence from Genesee Creek. No to minimal impacts are expected to the preferred substrate. Consequently, no to minimal impacts are expected.
Brown trout (cold water species)	Not documented in reviewed literature	Not documented in reviewed literature	Cold, well oxygenated waters	Submerged rocks, undercut banks, overhanging vegetation	Lower flow in the Fox River could extend cool water influence from Genesee Creek. No to minimal impacts are expected to the preferred substrate. Consequently, no to minimal impacts are expected.

8 Appendix B: Shallow Aquifer Water Supply Alternatives for the Waukesha Water Utility – Evaluated with the USGS Upper Fox River Basin Model

Objective
The objective of this study is to identify the potential impacts to surface waters - including wetlands, rivers, streams, lakes and springs – using the latest tools, from several configurations of water supply alternatives that would use the shallow aquifer south of the City of Waukesha.

Background
The 2013 Waukesha Diversion Application (Application) reported modeled impacts to the shallow aquifer and connected surface waters for three water supply alternatives using the Troy Valley Bedrock Aquifer model.[22] The analysis provided in the Application assumed a total water demand of 10.9 million gallons per day (MGD), the anticipated build-out demand assumed in the 2010 Waukesha Diversion Application.[23] Following comments from several reviewers provided during the Fall 2013 Department of Natural Resources (department) comment period, the department conducted additional analysis. These comments questioned the results of the Applicant's modeling, recommended review of an alternative that focused water supply wells (and impacts) along the Fox River, questioned the Applicant's projected demand at build-out, and recommended using a groundwater flow model completed in 2012 specifically developed to assess surface water impacts from pumping in the shallow aquifer in the Upper Fox River Basin. In response, the department used the U.S. Geological Survey (USGS) Upper Fox River Basin Model to simulate the shallow aquifer impacts for the three alternatives considered in the Application, and for one additional scenario, River Bank Inducement (RBI). For each alternative, the department assumed an average daily maximum water supply need of 8.5 million gallons per day (MGD), similar to the low end of the department projected demand range. [24]

Upper Fox River Basin Model
The USGS developed the Upper Fox River Basin Model as a tool to evaluate water supply options for communities in Waukesha County, specifically the shallow aquifer system of the Upper Fox River Basin. The USGS modeling report provides a full description of the Upper Fox River Basin conceptual model, model construction, and calibration.[25]

---

[22] A report on the modeling work conducted by the Applicant is provided in the Memo RJN Environmental Services, LLC, dated August 30, 2013. Additional information on the modeling work conducted by the Applicant is provided in Appendix 0 of the 2010 application "Results of Groundwater Modeling Study, Shallow Groundwater Source, Fox River and Vernon Marsh Area, Waukesha Water Utility". The report on the Troy Valley Bedrock Aquifer model is SEWRPC Memorandum Report No. 188.

[23] For the 2013 Application the full build-out demand was revised down to 10.1 MGD.

[24] The department analysis of the Applicant's water demand, see section S4 of the Technical Review, found a demand range of 8.4 – 12.1 MGD. For this analysis the department rounded the demand to 8.5 MGD and selected a conservative demand from the low end of the range.

[25] Feinstein, D.T., M.N Fienen, J.L. Kennedy, C.A. Buchwald, and M.M. Greenwood. *Development and Application of a Groundwater/Surface-Water Flow Model using MODFLOW-NWT for the Upper Fox River Basin, Southeastern Wisconsin*. Scientific Investigations Report 2012-5108. (2012)

In southeast Wisconsin, the shallow aquifer includes primarily unconsolidated glacial sediment overlying Silurian dolomite. The glacial sediments in the area of interest exhibit a high degree of heterogeneity resulting from a complicated history of glacial advances. This geologic history includes phases of erosion and deposition of till, including fine-grained material and coarser-grained material that result in interrupted clay layers and sandy layers. The Upper Fox model is a MODFLOW grid constructed with cell dimensions of 125 feet per side and thin layers. The model consists of seven layers; layers 1 - 5 represent unconsolidated material and layers 6 and 7 represent the Silurian dolomite. Within the Upper Fox model, there are two model versions with different sets of hydraulic parameters intended to bracket the possible variations in hydraulic conductivity. One version favors the continuity of fine-grained deposits; the other favors the continuity of coarse-grained deposits. In order to represent the range of possible geology, the pumping impacts reported in this document include the results from the fine-favored and the coarse-favored versions of the Upper Fox model.

Water Supply Alternatives

The department modeled the shallow aquifer impacts for four different potential water supply alternatives, including: (1) the Deep Sandstone and Shallow Aquifers, (2) the Shallow Aquifer only, (3) Multi-Source – Confined and Unconfined Deep Sandstone, Silurian Dolomite, and Shallow Aquifer, and (4) the Deep Sandstone Aquifer with Riverbank Inducement (RBI). Each alternative assumed a total water demand of 8.5 MGD, with between 3.2 MGD and 8.5 MGD being drawn from the shallow aquifer. The department replicated the Applicant's constructed alternatives for Alternatives 1 – 3 and created an additional alternative 4. See Table 1 for a full description of the water sources for each water supply alternative.

Wells modeled in the shallow aquifer include three existing Waukesha wells (11, 12, and 13), along with new wells and RBI wells. RBI wells are located directly adjacent to the Fox River and are expected to partially draw water directly from the river. New wells include wells in the Town of Waukesha not directly adjacent to the Fox River. The number and location of wells modeled in each alternative was based on an estimate of infrastructure needs provided by the Applicant.[26] For alternatives 1, 3, and 4, the remaining water supply demand not sourced from the shallow aquifer would be met from a combination of other sources, such as the deep sandstone aquifer, the Silurian dolomite aquifer, or the unconfined deep sandstone aquifer in western Waukesha County. The department's modeling considers only impacts related to shallow aquifer withdrawals. An analysis of impacts related to the water supply sources other than the shallow aquifer is available in the Application[27] and the Technical Review.

---

[26] CH2MHill. *Changes to Water Supply Infrastructure and Environmental Impacts*. Prepared for WDNR. 18 February 2014.

[27] Application, Volume 2, Section 11.

Table 8-1 Water supply alternative water sources.

Scenario / Alternative	Water Supply	Average Day Demand (MGD)	Infrastructure to meet demand (shallow aquifer only)
(1) Deep and Shallow Aquifers[28]	Deep Sandstone Aquifer	4.5	
	Shallow Aquifer	**4**	
	- Existing wells	0.96	Waukesha wells 11, 12, 13;
	- New wells	3.04	5 wells on the Lathers property; 3 wells near Pebble Brook
(2) Shallow Aquifer Only[29]	Shallow Aquifer	**8.5**	
	- Existing wells	1.21	Waukesha wells 11, 12, 13
	- New wells	4.59	5 wells on the Lathers property; 4 wells near Pebble Brook
	- RBI wells	2.7	4 wells near Fox River
(3) Multi-source[30]	Deep Sandstone Aquifer	2.1	
	Unconfined Deep Aquifer	2.0	
	Silurian Dolomite Aquifer	1.2	
	Shallow Aquifer	**3.2**	
	- Existing wells	0.95	Waukesha wells 11, 12, 13
	- New wells	0.75	2 wells on Lathers property
	- RBI wells	1.5	3 wells near Fox River
(4) DNR - Deep Aquifer and RBI[31]	Deep Sandstone Aquifer	4.5	
	Shallow Aquifer	**4**	
	- Existing wells	1.2	Waukesha wells 11, 12, 13
	- RBI wells	2.8	5 wells near Fox River (4 wells as Alternative 2 and 1 additional)

28 Waukesha Water Supply Alternative 1: Deep Confined and Shallow Aquifer, Application, Volume. 2. Section 11, p 14. (2013). CH2MHill. Memo. 2 February 2014. p.1.
29 Waukesha Water Supply Alternative 3: Shallow Aquifer, Application, Vol. 2. p. 11-28. (2013). Memo, CH2M Hill, 2 February 2014, p. 2.
30 Waukesha Water Supply Alternative 6: Multiple Sources, Application, Vol. 2. p. 11-45. (2013). Memo, CH2M Hill, 2/18/2014, p. 3.
31 This alternative is a variation on Waukesha Water Supply Alternative 1 that was not evaluated in the Waukesha Diversion application.

Model Setup
This section describes the inputs used to evaluate the surface water impacts of the various water supply alternatives.

The modeling runs for each alternative included three stress periods:

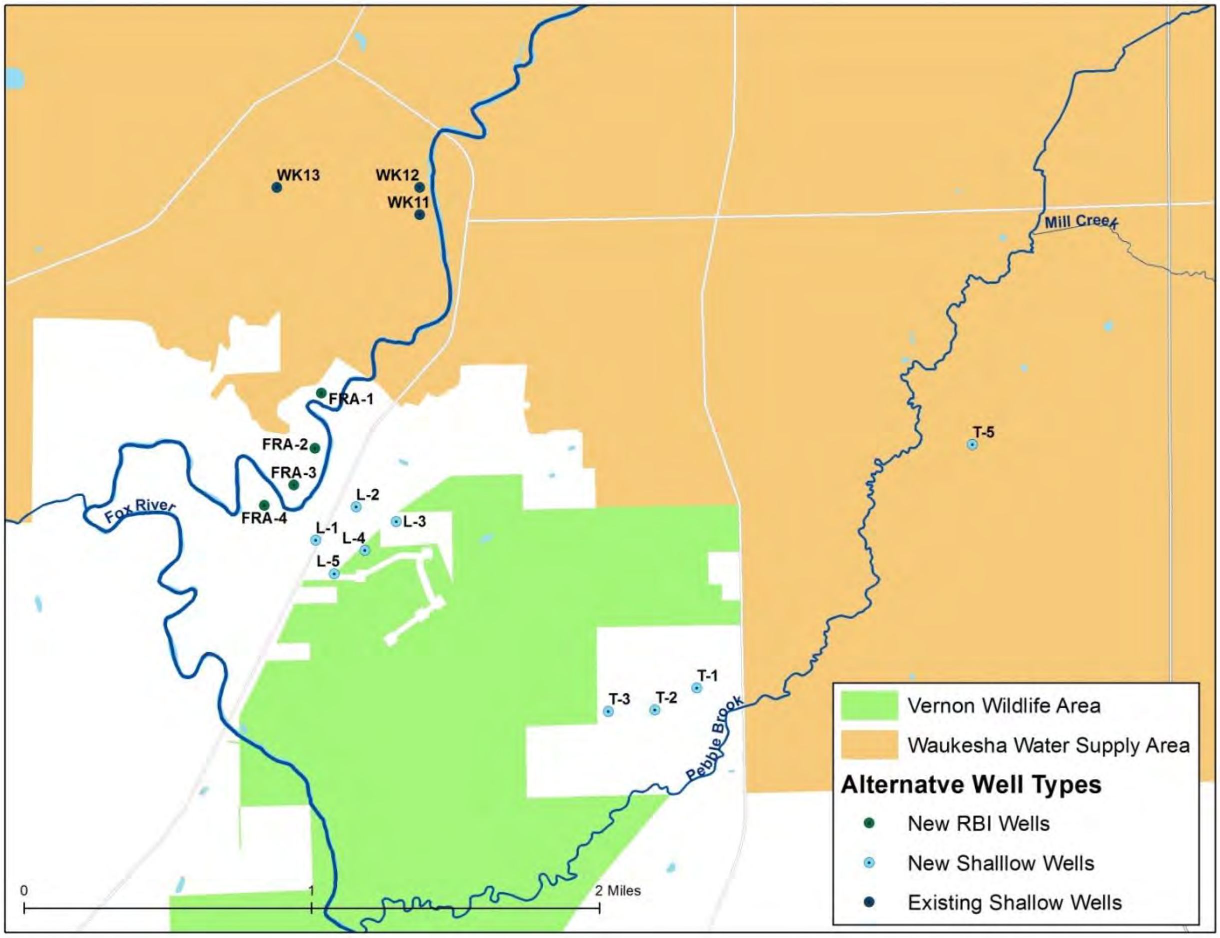
- Stress Period 1 – Model run in steady state mode without Waukesha's shallow wells 11, 12, and 13 pumping.

- Stress Period 2 – Model run in transient mode for 5 years with Waukesha's wells 11, 12, and 13 pumping at the same rate as these wells pump in stress period 2. The pumping for these wells was held constant between stress period 2 and 3 to avoid rebound scenarios in the aquifer. Wells 11 and 12 came online in 2006, Well 13 came online in 2009. The department chose a 5-year period to represent a period in which all three of these wells were in operation, prior to adding additional wells.

- Stress Period 3 – Models run in transient mode for 20 years. Waukesha's wells 11, 12, and 13 pump at the same rate as in stress period 2. Additional shallow wells pump at the average day demand rate anticipated for each water supply alternative. Attachment A provides a list of wells and pumping rates modeled and a map of well locations for each alternative.

Well Locations – See Figure 7-1 for well locations. Attachment B provides details on wells used in each alternative and pumping rates. Well locations were chosen to match the approximate locations used in the Applicant's groundwater flow model. The locations were checked to ensure that they were in model cells with appropriately high hydraulic conductivity values (e.g., a well would not be sited in a low conductivity area). Wells pump from layers 3 and 4 in the Upper Fox model described above.

Figure 8-1. Well locations for shallow aquifer wells used in water supply alternatives



Results

The USGS Upper Fox Model uses the MODFLOW-NWT version of MODFLOW. A full discussion of this solver is available in the model report.[32] One characteristic to note is that if a well pumping rate designated for a given well reduces the saturated thickness of the aquifer to less than 20 percent of the total saturated thickness, the pumping rate is reduced from the input pumping rate. Table 2 indicates the input pumping rate for each alterative and the modeled pumping rate for each scenario for both the coarse-favored and fine-favored versions of the model. Table 7-2 shows some reductions in pumping – particularly for the fine-favored version of the model with 8.5 MGD of desired pumping. The small reductions in the fine-favored version of the deep/shallow scenario and the coarse-favored version of the shallow scenario could easily be made up for by shifting pumping to other wells or moving wells to higher hydraulic conductivity locations. For the fine-favored version of the shallow scenario - where 8.5 MGD

[32] Feinstein, D.T., M.N Fienen, J.L. Kennedy, C.A. Buchwald, and M.M. Greenwood. *Development and Application of a Groundwater/Surface-Water Flow Model using MODFLOW-NWT for the Upper Fox River Basin, Southeastern Wisconsin*. Scientific Investigations Report 2012-5108. (2012)

comes from the shallow aquifer – adjusted pumping rates and likely additional wells would be needed to make up the lost 0.71 MGD. In the interest of time, the department did model these slight adjustments. Modeling results are assumed to be representative of impacts for pumping at the proposed rates. Attachment B includes well-by-well information for the reductions in each scenario.

Table 8-2. Comparison of well pumping input to model and sustained pumping for each alternative in the shallow aquifer

Alternative	Well Pumping Input to Model (MGD)	Actual Pumping – Coarse favored (MGD)	Actual Pumping – Fine favored (MGD)
Deep/Shallow Aquifer	4.00	4.00	3.84
Shallow Aquifer	8.50	8.48	7.79
Multiple Sources	3.20	3.20	3.20
Deep Aquifer/RBI	4.00	4.00	4.00

Results – Maximum Drawdown

Table 7-3 presents the maximum drawdown of the aquifer in model layer 1 (representing the water table). Results are provided for both the fine-favored and coarse-favored versions of the model. See Figure 7-3 – 7-10 for drawdown maps of each alternative modeled by the department.

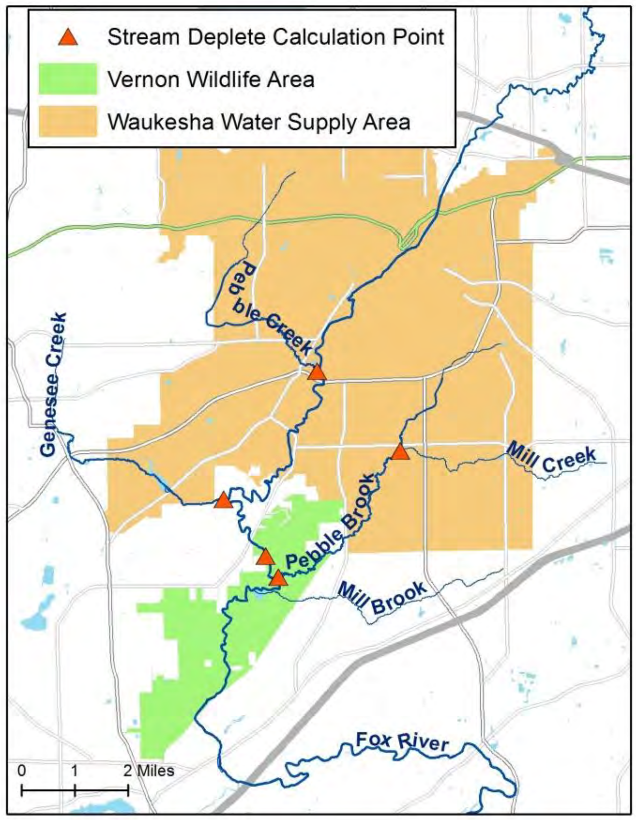
Table 8-3. Maximum draw down in model layer 1 for each alternative

Alternative	Maximum Drawdown – Coarse- favored (feet)	Maximum Drawdown – Fine-favored (feet)
Deep/Shallow Aquifer	22	15
Shallow Aquifer	54	77
Multiple Sources	16	12
Deep Aquifer/RBI	21	14

Results - Streamflow Depletion

The department determined streamflow depletion at the outlet of five streams: Pebble Brook, Pebble Creek, Fox River, Genesee Creek, and Mill Creek (see figure 8-2); and calculated depletion as the difference between modeled flow at the end of the second stress period (after five years of pumping of existing Waukesha wells) and at the end of the third stress period (after 20 years of pumping of additional shallow wells) from the baseflow simulated within the USGS model's streamflow routing package (SFR). The model was calibrated to baseflow estimates from a method developed by Gebert and others[33] in terms of the basin area and 90 percent flow duration value. These depletions represent the impact of additional wells in the shallow aquifer on the nearby streams and rivers after 20 years of pumping, not including the impacts of Waukesha's existing shallow wells 11, 12, and 13 after pumping for 5 years. Existing shallow well impacts are not included in this analysis to limit assessed impacts strictly to additional proposed wells. The department chose this approach to simplify the analysis and to provide a conservative estimate of impacts.

Figure 8-2. Locations for calculations of streamflow



The department calculated the percent change in stream baseflow with following equation:

$$B_1 = Cumulative\ Baseflow\ (Stress\ Period\ 2, Time\ Step\ 5)$$
$$B_2 = Cumulative\ Baseflow\ (Stress\ Period\ 3, Time\ Step\ 20)$$
$$Percent\ Change\ in\ Stream\ Baseflow = \frac{(B_1 - B_2)}{B_1} * 100$$

Note that the percent streamflow reductions do not account for water returned to the Fox River via the wastewater treatment plant. See Table 8-4 for streamflow depletion calculations.

[33] Gebert, W.A., Radloff, M.J., Considine, E.J., and Kennedy, J.L., Use of streamflow data to estimate base flow/ground-water recharge for Wisconsin. Journal of the American Water Resources Association, 43(2007): 220-236.

Table 8-4. Streamflow depletion - percent reduction in modeled baseflow due to new shallow wells

a) Alternative 1: Deep and Shallow Aquifers

Stream	Coarse-favored model (MGD)	Fine-favored model (MGD)
Pebble Brook	19 % (0.99)	18 % (0.86)
Fox River	3 % (1.55)	3 % (1.34)
Pebble Creek	1 % (0.02)	0 % (0.01)
Mill Creek	0 % (0.01)	1 % (0.01)
Genesee Creek	1 % (0.02)	1 % (0.03)

b) Alternative 2: Shallow Aquifer Only

Stream	Coarse-favored model (MGD)	Fine-favored model (MGD)
Pebble Brook	39 % (1.97)	36 % (1.74)
Fox River	9 % (4.56)	8 % (3.86)
Pebble Creek	1 % (0.03)	1 % (0.02)
Mill Creek	3 % (0.04)	5 % (0.06)
Genesee Creek	3 % (0.11)	4 % (0.19)

c) Alternative 3: Multi-source

Stream	Coarse-favored model (MGD)	Fine-favored model (MGD)
Pebble Brook	2 % (0.10)	3 % (0.12)
Fox River	4 % (2.00)	4 % (1.74)
Pebble Creek	1 % (0.03)	0 % (0.01)
Mill Creek	0 % (0.00)	0 % (0.00)
Genesee Creek	1 % (0.03)	2 % (0.08)

d) Alternative 4: DNR – Deep Aquifer and RBI.

Stream	Coarse-favored model (MGD)	Fine-favored model (MGD)
Pebble Brook	2 % (0.11)	3 % (0.14)
Fox River	5 % (2.58)	5 % (2.23)
Pebble Creek	1 % (0.03)	1 % (0.01)
Mill Creek	0 % (0.00)	0 % (0.00)
Genesee Creek	1 % (0.05)	2 % (0.11)

Results – Wetland Impacts

Wetland acres with greater than one-foot of drawdown were calculated by intersecting the one-foot drawdown contour area in model layer 1 with the Wisconsin wetlands GIS layer[34] for each alternative (See Table 8-5).

Table 8-5. Wetland acres in the one foot drawdown contour in model layer 1

Alternative	Coarse-favored model (acres)	Fine-favored model (acres)
Alternative 1 – Deep and Shallow Aquifers	910	1036
Alternative 2 – Shallow Aquifer	1939	2326
Alternative 3 – Multi-source	713	893
Alternative 4 – DNR-Deep Aquifer and RBI	804	1069

Results – Springs Impacts

The one-foot drawdown contour in model layer 1 was compared to a GIS layer of Wisconsin springs (See Table 8-6).[35]

Table 8-6. Springs located in the one foot drawdown contour in model layer 1

Alternative	Coarse-favored model (WGNHS Spring #)	Fine-favored model (WGNHS Spring #)
Alternative 1 – Deep and Shallow Aquifers	680253	680253
Alternative 2 – Shallow Aquifer	680253	680253, 680257, 680240
Alternative 3 – Multi-source	680253	680253
Alternative 4 – DNR-Deep Aquifer and RBI	680253	680253

[34] WDNR. Wetland Mapping. Web. 4 June 2015.
[35] Macholl, J. A. *Inventory of Wisconsin's Springs*. Rep. no. WOFR2007-03. Madison: U of Wisconsin Extension Wisconsin Geological and Natural History Survey, (2007).

Figure 8-3. Alternative 1- Deep and Shallow Aquifers - Fox River and Pebble Brook Wells - Course favored model

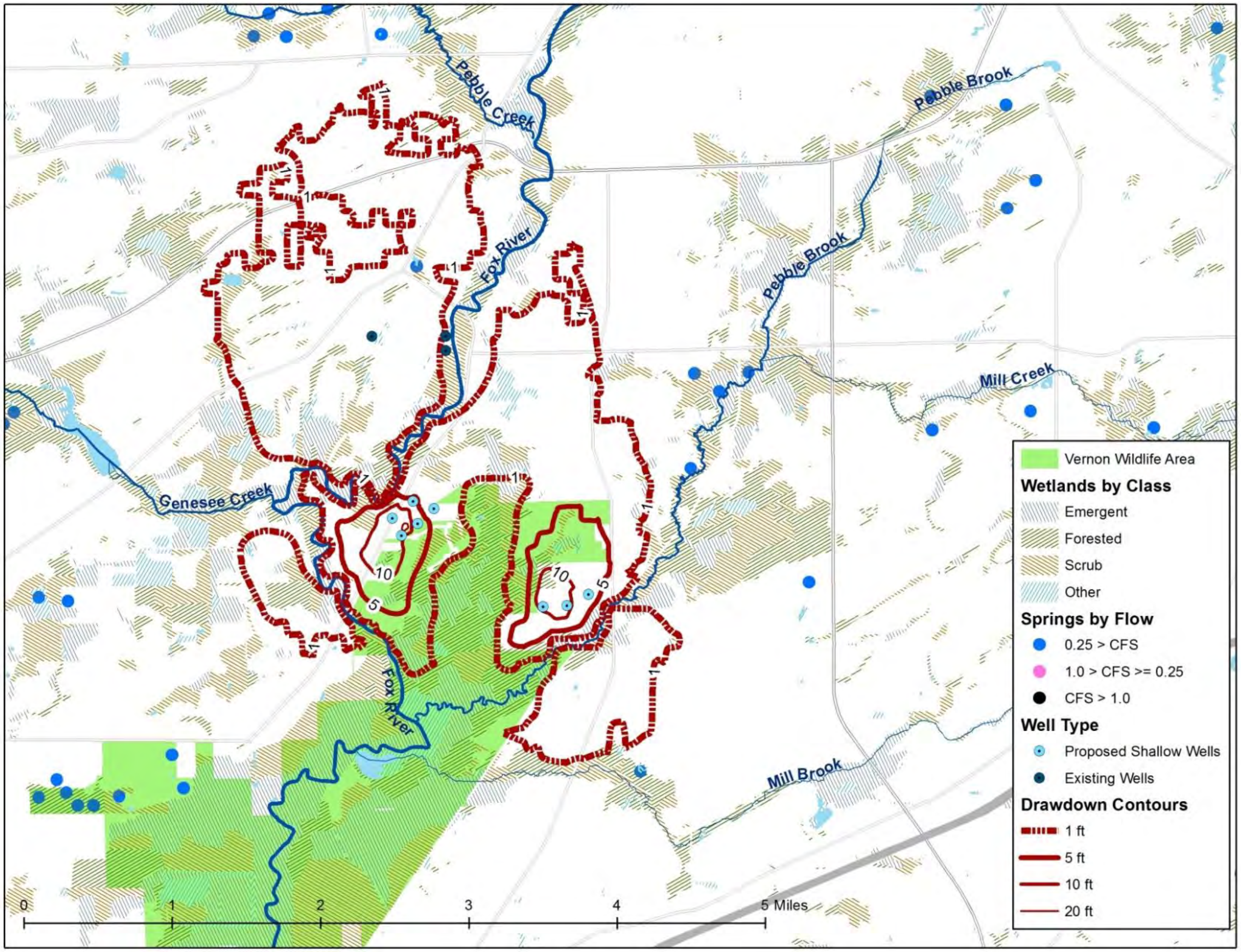


Figure 8-4. Alternative 1 - Deep and Shallow Aquifers - Fox River and Pebble Brook Wells - Fine favored model

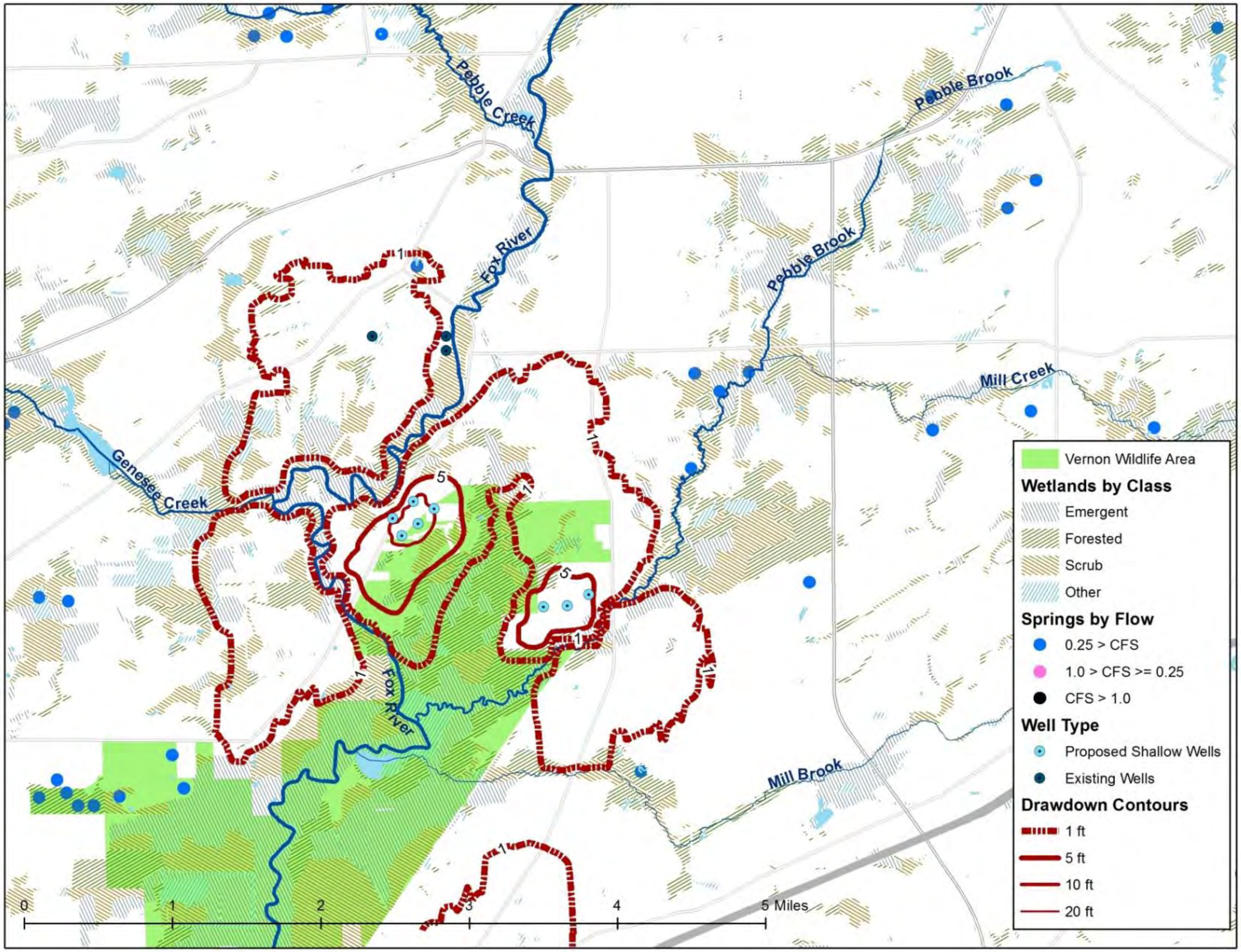


Figure 8-5. Alternative 2 - Shallow Aquifer Only - Course favored model

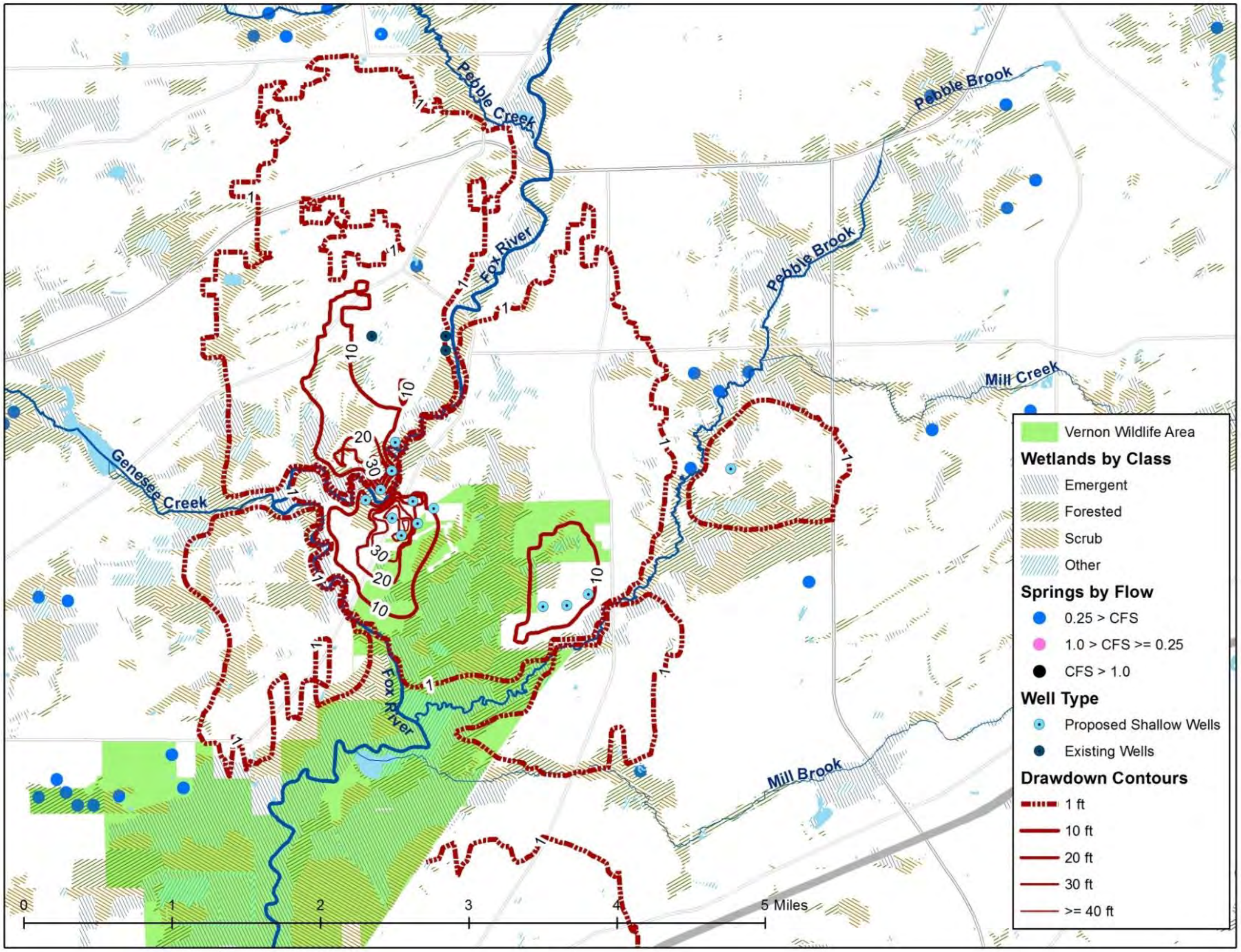


Figure 8-6. Alternative 2 - Shallow Aquifer Only - Fine favored model

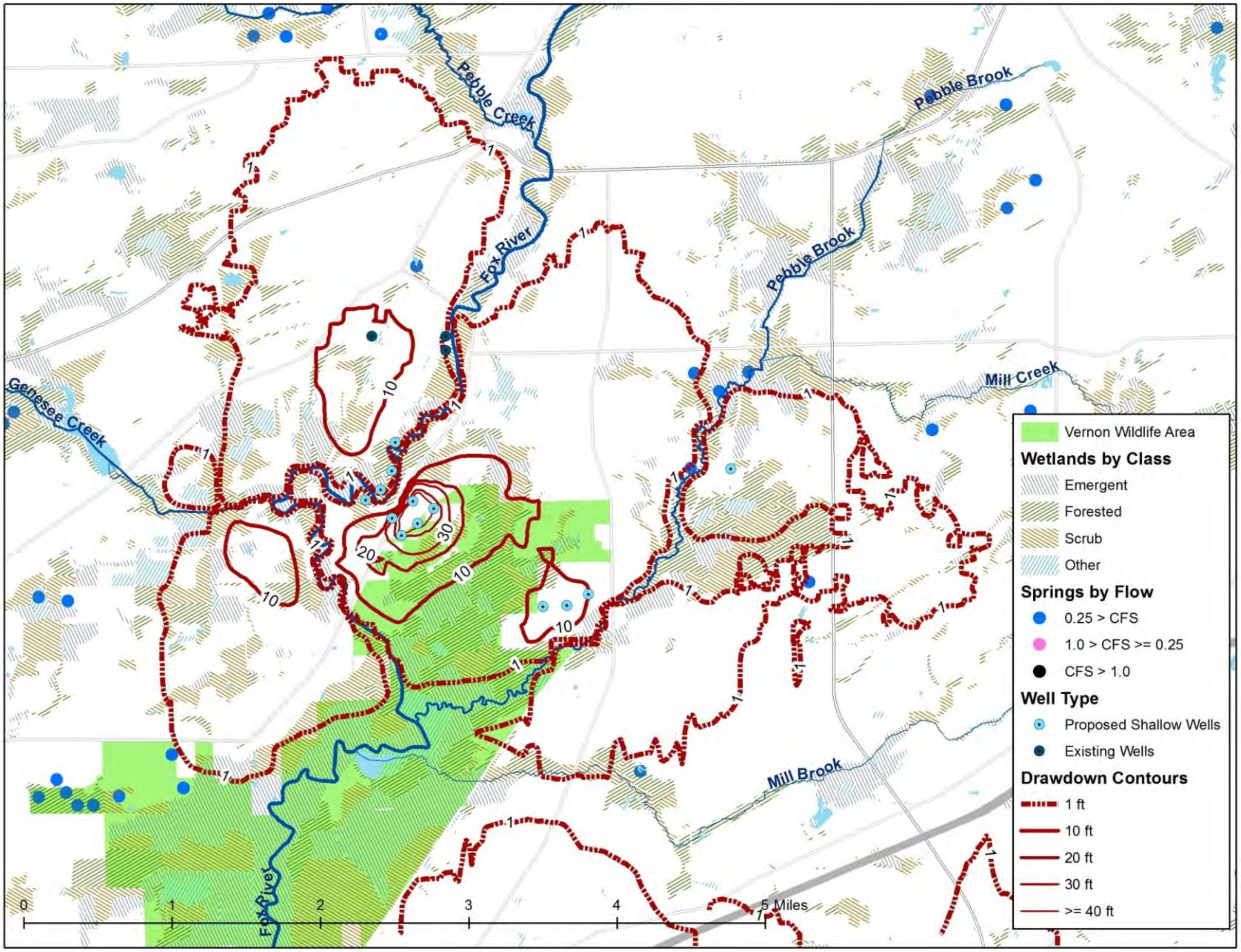


Figure 8-7. Alternative 3 - Multiple Sources Alternative - Course favored model

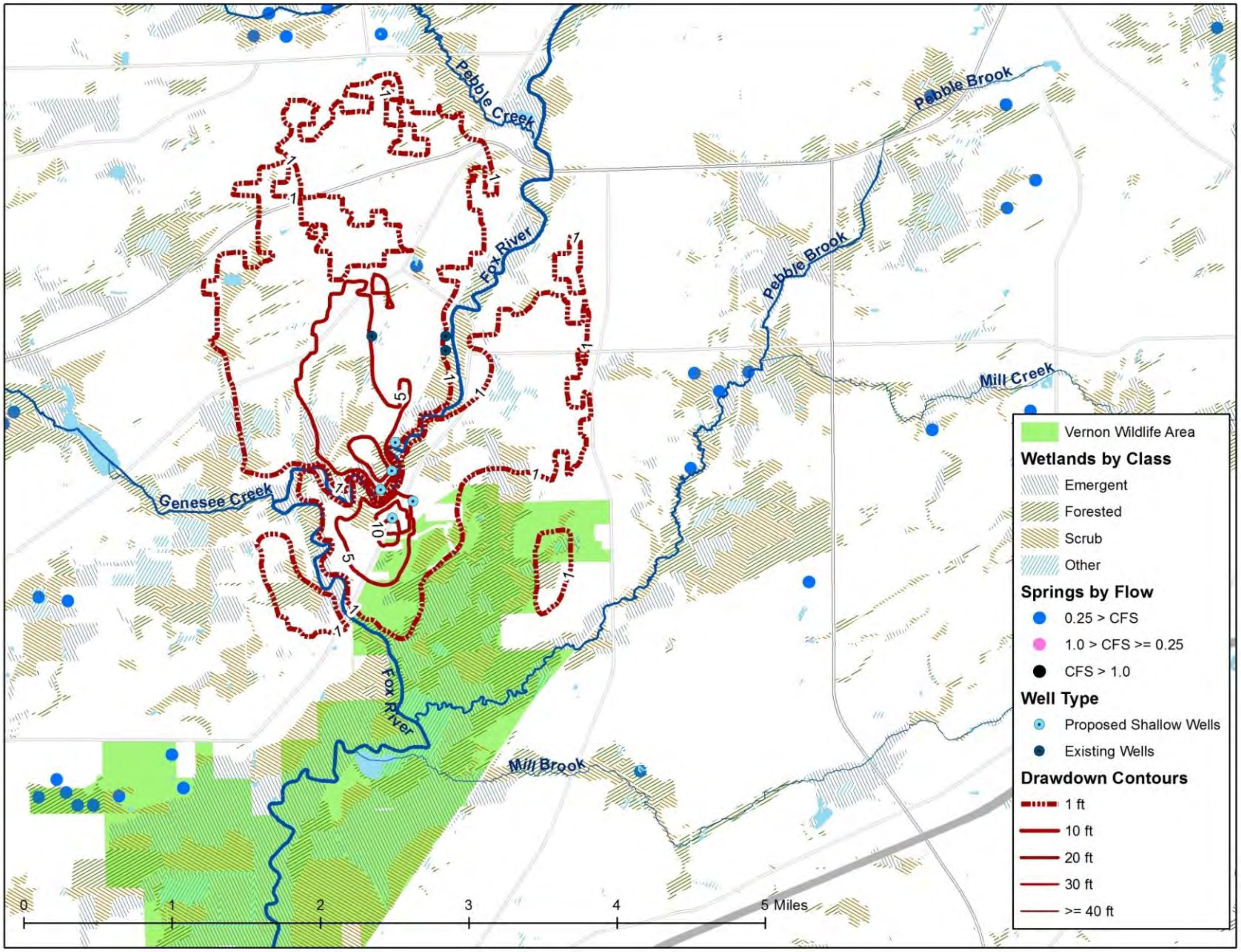


Figure 8-8. Alternative 3 - Multiple Sources Alternative - Course favored model

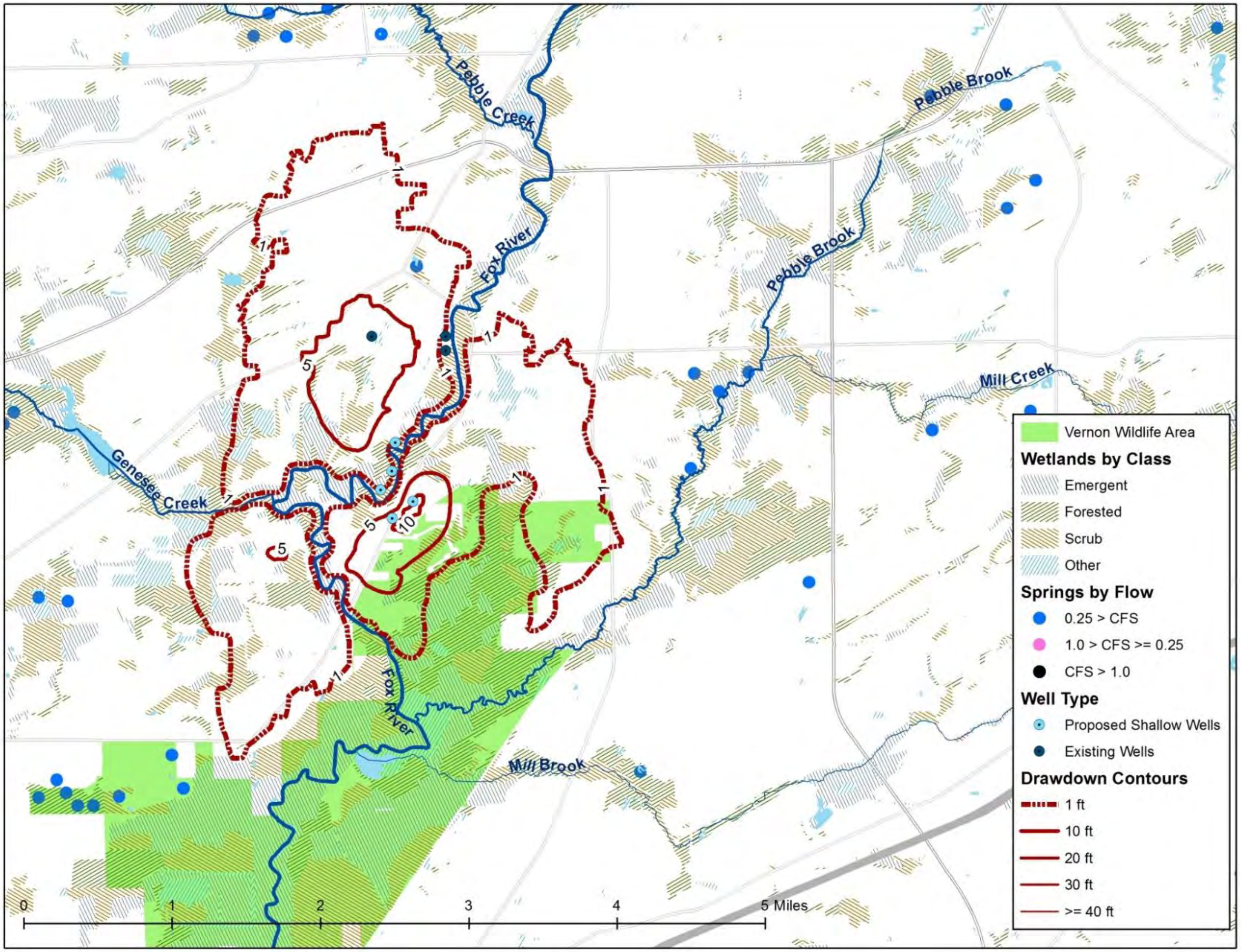


Figure 8-9. Alternative 4 - DNR Deep Aquifer and River Bank Inducement - Course favored model

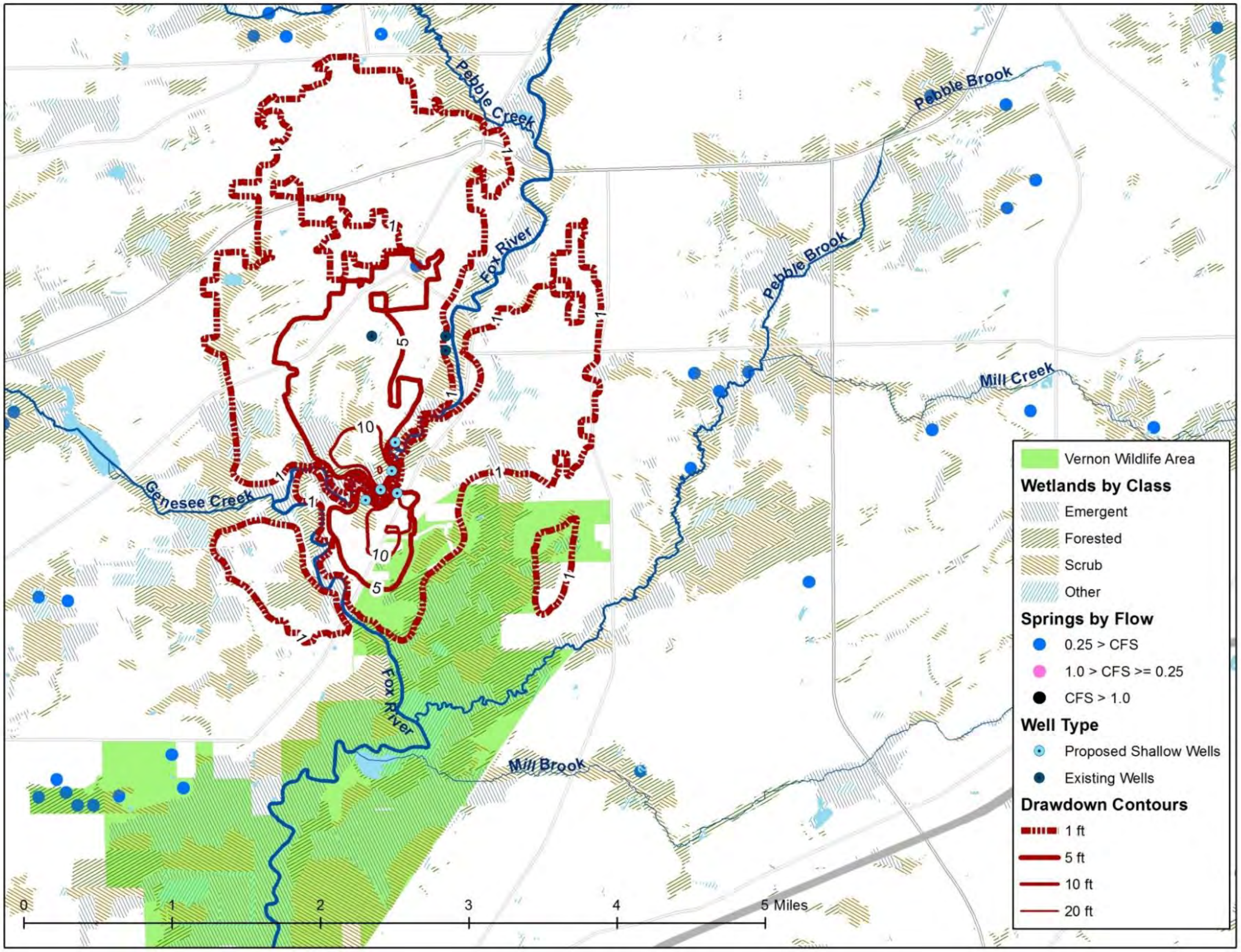
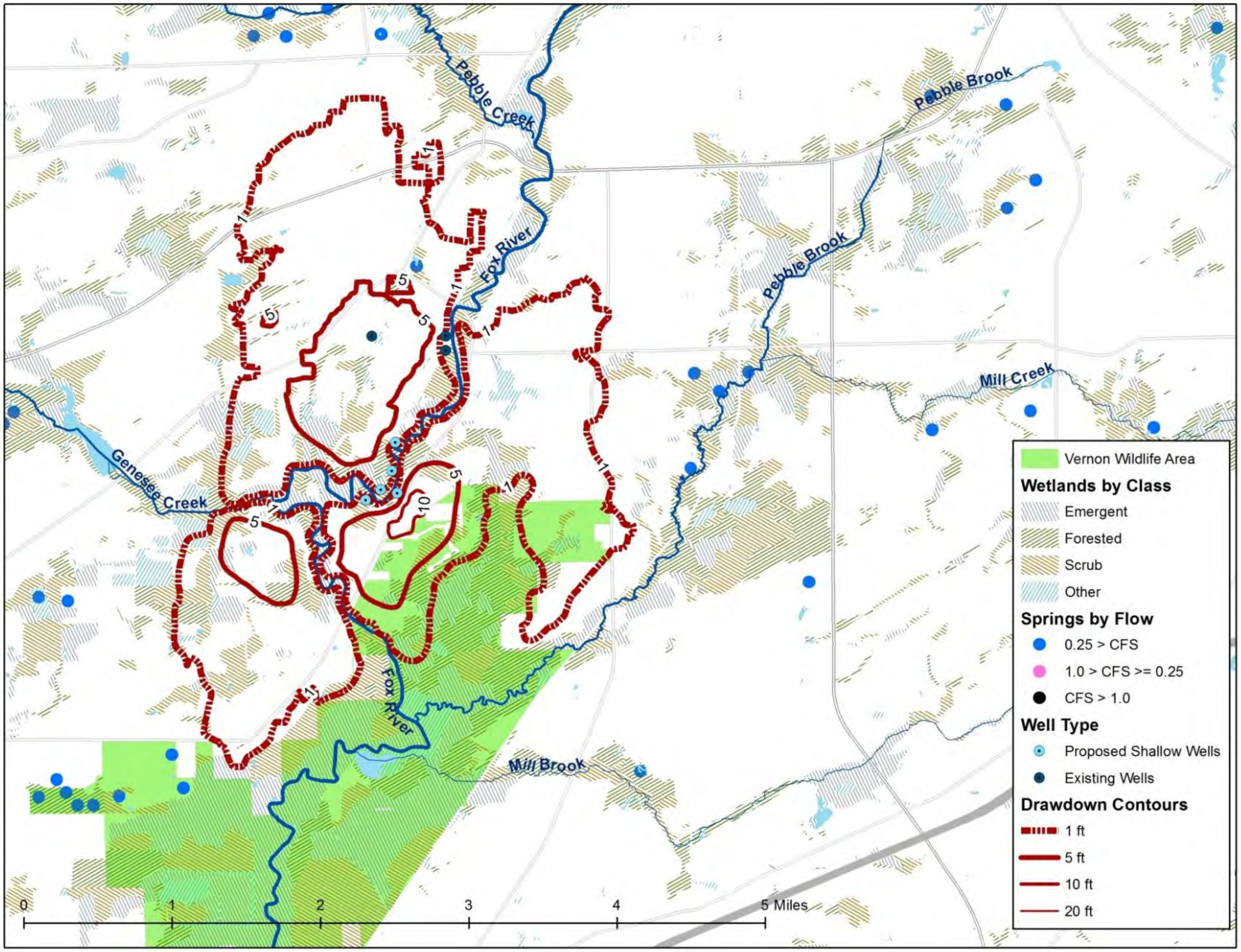


Figure 8-10. Alternative 4 - DNR Deep Aquifer and River Bank Inducement - Fine favored model



Attachment A – Well Pumping Rates and Locations

The following tables provide the pumping rates used in each scenario for each well and a brief description of how these pumping rates were selected. The model uses pumping rates up to the 2009-2013 average pumping rate for Waukesha wells 11, 12 and 13 for each of these scenarios. For example, in Alternative 1 the models use the baseline pumping rate (0.2 MGD) for Well 11 because 0.2 is less than 0.37 (4 MGD divided by 11 wells); however for well 12 the pumping rate of 0.38 MGD (3.8 MGD divided 10 wells) was used because the well 12 baseline pumping rate of 0.5 MGD is greater than 0.38 MGD. The coordinate system is NAD 1983 Transverse Mercator. Waukesha wells in the tables are noted as WK11, WK12, and WK13. New Shallow wells are noted as L-1 through L-5, indicating wells on the Lathers property and as T-1 through T-3 for wells along Pebble Brook. RBI wells are noted as FRA -1 through FRA – 4 and RBI – 1. (See Alternative 1 – Deep and Shallow Aquifer – Deep Aquifer (4.5MGD), Shallow Aquifer (4 MGD) WK11 pumping rate of 0.2 MGD determined from 2009-2013 average. The remaining 3.8 MGD was divided equally between 10 wells for a pumping rate of 0.38 MGD (Table 8-7).

Table 8-7. Alternative 1 wells and pumping rates

Well	X	Y	Stress Period 1 (MGD)	Stress Period 2 (MGD)	Stress Period 3 (MGD)
WK11	2166453.35	911303.03	0	0.2	0.2
WK12	2166453.35	911803.03	0	0.38	0.38
WK13	2163828.00	911803.00	0	0.38	0.38
L-1	2164540.61	905323.92	0		0.38
L-2	2165283.78	905934.34	0		0.38
L-3	2166022.19	905668.49	0		0.38
L-4	2165445.57	905138.00	0		0.38
L-5	2164880.49	904711.31	0		0.38
T-1	2171539.90	902609.33	0		0.38
T-2	2170772.95	902209.83	0		0.38
T-3	2169917.55	902179.23	0		0.38
		Total			**4**

Alternative 2 – Shallow Aquifer – Shallow Aquifer (5.8 MGD), River Bank Inducement (2.7 MGD) – Total average day demand from shallow aquifer of 8.5 MGD

The department used pumping rates of 0.2 and 0.5 MGD for WK11 and WK12, respectively, determined from the 2009-2013 average pumping rates. The department assumed pumping rates for WK13, L1 – 5 and T1, 2, 3, and 5 set at 0.51 MGD dividing 5.1 MGD equally between 10 wells. The department determined pumping rates for the RBI wells (FRA-1-4) by equally dividing 2.7 MGD between 4 wells for a rate of 0.675 MGD. The department used these rates to most closely match the proposed pumping volumes from the Application (Table 8-8).

Table 8-8. Alternative 2 wells and pumping rates

Well	X	Y	Stress Period 1 (MGD)	Stress Period 2 (MGD)	Stress Period 3 (MGD)
WK11	2166453.35	911303.03	0	0.2	0.2
WK12	2166453.35	911803.03	0	0.5	0.5
WK13	2163828.00	911803.00	0	0.51	0.51
L-1	2164540.61	905323.92	0	0	0.51
L-2	2165283.78	905934.34	0	0	0.51
L-3	2166022.19	905668.49	0	0	0.51
L-4	2165445.57	905138.00	0	0	0.51
L-5	2164880.49	904711.31	0	0	0.51
T-1	2171539.90	902609.33	0	0	0.51
T-2	2170772.95	902209.83	0	0	0.51
T-3	2169917.55	902179.23	0	0	0.51
T-5	2176600.68	907078.47	0	0	0.51
FRA-1	2164651.20	908028.10	0	0	0.675
FRA-2	2164532.02	907010.00	0	0	0.675
FRA-3	2164141.77	906341.06	0	0	0.675
FRA-4	2163601.27	905963.18	0	0	0.675
		Total			**8.5**

Alternative 3 – Multi-source – Shallow Aquifer (1.7 MGD), River Bank Inducement (1.5 MGD), Bedrock Sources (5.3) – Total Average day demand from Shallow Aquifer 3.2 MGD

The department used a pumping rate of 0.2 MGD for WK11 from the 2009-2013 average pumping rate. The department determined pumping rates for WK12, 13 and L1, L2 by equally dividing 1.5 MGD between 4 wells for a pumping rate of 0.375 MGD. The department determined pumping rates for RBI wells FRA-1-3 by equally dividing 1.5 MGD by 3 wells for a pumping rate of 0.5 MGD (Table 8-9).

Table 8-9. Alternative 3 wells and pumping rates

Well	X	Y	Stress Period 1 (ft3/day)	Stress Period 2 (ft3/day)	Stress Period 3 (MGD)
WK11	2166453.35	911303.03	0	0.2	0.2
WK12	2166453.35	911803.03	0	0.375	0.375
WK13	2163828.00	911803.00	0	0.375	0.375
L-1	2164540.61	905323.92	0	0	0.375
L-2	2165283.78	905934.34	0	0	0.375
FRA-1	2164651.20	908028.10	0	0	0.5
FRA-2	2164532.02	907010.00	0	0	0.5
FRA-3	2164141.77	906341.06	0	0	0.5
		Total			**3.2**

Alternative 4 – DNR-Deep Aquifer and RBI – Deep Aquifer (4.5 MGD), Shallow aquifer – River Bank Inducement wells (4 MGD)

The department used pumping rates of 0.2 MGD and 0.5 MGD for WK11 and WK12, respectively, determined from 2009-2013 average pumping rates. Pumping rate for WK13 is 0.5 MGD. The department used a pumping rate of 0.56 MGD for each of the 5 RBI wells (Table 8-10).

Table 8-10. Alternative 4 wells and pumping rates

Well	X	Y	Stress Period 1 (MGD)	Stress Period 2 (MGD)	Stress Period 3 (MGD)
WK11	2166453.35	911303.03	0	0.2	0.2
WK12	2166453.35	911803.03	0	0.5	0.5
WK13	2163828.00	911803.00	0	0.5	0.5
RBI - 1	2164724.00	906217.00	0	0	0.56
FRA-1	2164651.20	908028.10	0	0	0.56
FRA-2	2164532.02	907010.00	0	0	0.56
FRA-3	2164141.77	906341.06	0	0	0.56
FRA-4	2163601.27	905963.18	0	0	0.56
		Total			**4**

Attachment B – Pumping Rate Reductions

The following tables indicate the pumping rate reduction in each well for each alternative.

Table 8-11. Pumping rate reduction to maintain aquifer saturated thickness at 20 % of total aquifer saturated thickness. A) Alternative 1

Alternative 1 - Shallow/Deep				Coarse-favored Model		Fine-favored Model	
Name	Well	Row	Col	Qin(mgd)	Qot(mgd)	Qin(mgd)	Qot(mgd)
WK13	1	421	147	0.38	0.38	0.38	0.38
WK12	2	421	168	0.38	0.38	0.38	0.38
WK11	3	425	168	0.20	0.20	0.20	0.20
L-1	4	473	152	0.38	0.38	0.38	0.38
L-2	5	468	158	0.38	0.38	0.38	0.38
L-5	6	478	155	0.38	0.38	0.38	0.38
L-4	7	475	160	0.38	0.38	0.38	0.38
L-3	8	471	164	0.38	0.38	0.38	0.38
T-1	9	495	208	0.38	0.38	0.38	0.22
T-2	10	498	202	0.38	0.38	0.38	0.38
T-3	11	498	195	0.38	0.38	0.38	0.38
				4.00	**4.00**	**4.00**	**3.84**

b) Alternative 2

Alternative 2 - Shallow				Coarse-favored Model		Fine-favored Model	
	Well	Row	Col	Qin(mgd)	Qot(mgd)	Qin(mgd)	Qot(mgd)
WK13	1	421	147	0.51	0.50	0.51	0.50
WK12	2	421	168	0.50	0.50	0.50	0.50
WK11	3	425	168	0.20	0.20	0.20	0.20
L-1	4	473	152	0.51	0.51	0.51	0.51
L-2	5	468	158	0.51	0.50	0.51	0.37
L-5	6	478	155	0.51	0.51	0.51	0.51
L-4	7	475	160	0.51	0.51	0.51	0.49
L-3	8	471	164	0.51	0.51	0.51	0.51
T-1	9	495	208	0.51	0.51	0.51	0.21
T-2	10	498	202	0.51	0.51	0.51	0.51
T-3	11	498	195	0.51	0.51	0.51	0.51
FRA-4	12	468	145	0.68	0.68	0.68	0.68
T-5	13	459	249	0.51	0.51	0.51	0.51
FRA-3	14	465	149	0.68	0.68	0.68	0.59
FRA-1	15	452	153	0.68	0.68	0.68	0.66
FRA-2	16	460	152	0.68	0.68	0.68	0.54
				8.50	**8.48**	**8.50**	**7.79**

c) Alternative 3

Alternative 3 Multi-source				Coarse-favored Model		Fine-favored Model	
	Well	Row	Col	Qin(mgd)	Qot(mgd)	Qin(mgd)	Qot(mgd)
WK13	1	421	147	0.38	0.38	0.38	0.38
WK12	2	421	168	0.38	0.38	0.38	0.38
WK11	3	425	168	0.20	0.20	0.20	0.20
L-1	4	473	152	0.38	0.38	0.38	0.38
L-2	5	468	158	0.38	0.38	0.38	0.38
FRA-3	6	465	149	0.50	0.50	0.50	0.50
FRA-1	7	452	153	0.50	0.50	0.50	0.50
FRA-2	8	460	152	0.50	0.50	0.50	0.50
				3.20	**3.20**	**3.20**	**3.20**

d) Alternative 4

Alternative 4 DNR RBI				Coarse-favored Model		Fine-favored Model	
	Well	Row	Col	Qin(mgd)	Qot(mgd)	Qin(mgd)	Qot(mgd)
WK13	1	421	147	0.50	0.50	0.50	0.50
WK12	2	421	168	0.50	0.50	0.50	0.50
WK11	3	425	168	0.20	0.20	0.20	0.20
RBI 1	4	466	154	0.56	0.56	0.56	0.56
FRA-4	5	468	145	0.56	0.56	0.56	0.56
FRA-3	6	465	149	0.56	0.56	0.56	0.56
FRA-1	7	452	153	0.56	0.56	0.56	0.56
FRA-2	8	460	152	0.56	0.56	0.56	0.56
				4.00	**4.00**	**4.00**	**4.00**

9 Appendix C: Environmental Impacts from Existing Shallow Aquifer Wells

Impacts from Existing Shallow Wells

The department conducted additional groundwater flow modeling to evaluate the impacts to surface water from the existing shallow aquifer wells. See Appendix B for background on the groundwater modeling.

The department modeled the shallow aquifer impacts for the existing shallow aquifer pumping. Shallow aquifer pumping averaged 1.25 MGD for 2010 – 2014. This pumping rate was used in this alternative (Table 9-1).

Table 9-1 Existing water supply system.

Scenario / Alternative	Water Supply	Average Day Demand (MGD)	Infrastructure to meet demand (shallow aquifer only)
(5) Existing Water Supply System	Deep Sandstone Aquifer	5.4	
	Shallow Aquifer	**1.25**	
	- Existing wells	1.25	Waukesha wells 11, 12, 13;
	- New wells	0	

Model Setup

See Appendix B.

Stress Period 1 – Model run in steady state mode without Waukesha's shallow wells 11, 12, and 13 pumping.
Stress Period 2 – Model run in transient mode for 5 years with Waukesha's wells 11, 12, and 13 pumping at the same rate as these wells pump in stress period 3. The pumping for these wells was held constant between stress period 2 and 3 to avoid rebound scenarios in the aquifer. Wells 11 and 12 came online in 2006, Well 13 came online in 2009. The department chose a 5-year period to represent a period in which all three of these wells were in operation, prior to adding additional wells.

Stress Period 3 – Models run in transient mode for 20 years. Waukesha's wells 11, 12, and 13 pump at the same rate as in stress period 2.

Figure 23 in Appendix B indicates well locations.

Results – Maximum Drawdown

Table 9-2 Maximum drawdown with existing three shallow wells pumping.

Time Period	Maximum Drawdown – Coarse- favored (feet)	Maximum Drawdown – Fine-favored (feet)
After Stress Period 2	19 feet	23 feet
After Stress Period 3	Additional 9 feet	Additional <1 foot

Results – Streamflow depletion

Table 9-3 Impacts from existing pumping - results between stress period 1 and stress period 3

Stream	Coarse-favored model (MGD)	Fine-favored model (MGD)
Pebble Brook	0% (0.01)	0% (0.02)
Fox River	2% (1.04)	2% (1.01)
Pebble Creek	1% (0.04)	1% (0.02)
Mill Creek	0% (0.00)	0% (0.00)
Genesee Creek	0% (0.01)	0% (0.00)

Results – Wetland Impacts

Wetland acres with greater than one-foot of drawdown were calculated by intersecting the one-foot drawdown contour area in model layer 1 with the Wisconsin wetlands GIS layer[36].

Table 9-4 Wetlands in the one foot drawdown contour

Time Period	Coarse-favored model (acres)	Fine-favored model (acres)
After Stress Period 2	305	467
After Stress Period 3	Additional 135 acres	Additional 17 acres

Results – Springs

Spring ID number 680253is located in the 10 foot drawdown contour. The spring flow is recorded as 0.09 cfs in the WGNHS springs database.

[36] WDNR. Wetland Mapping. Web. 4 June 2015.

References

Al-Layla, M.A., S. Ahmad & E.J. Middlebrooks, 2001. *Water Supply Engineering Design*. Ann Arbor Science, Ann Arbor, MI

AWWA (American Water Works Association. 2001. Manual of Water Supply Practices M50: Water Resources Planning (1st ed.).

Barbiero, R. P., Carrick H. J., Volerman J. B., and. Tuchman M. L. *Factors affecting temporal and spatial distribution of diatoms in Lake Michigan*. Verhandlungen Internationale Vereinigung für Limnologie. Volume 27: 1788–94, 2000.

Bootsma, H.A. and Auer, M.T. "Cladophora *in the Great Lakes: Guidance for water quality managers"* in *Nearshore Areas of the Great Lakes*, 2009.

Brown, S.E., 1990, Glacial stratigraphy and history of Racine and Kenosha Counties, Wisconsin. M.S. Thesis–Geology, University of Wisconsin-Madison, 173 p.

Bureau of Labor Statistics (BLS). *Local Area Unemployment Statistics.* http://www.bls.gov/lau/#data 06/18/2015.

Buschbach, T.C., 1964, Cambrian and Ordovician strata of northeastern Illinois. Illinois State Geological Survey Report of Investigations 218, 90 p.

City of Waukesha Common Council, An Ordinance to Amend Certain Provisions of the Sewer Use and Wastewater Treatment Code of the City of Waukesha, Approved April 4th 2014.

City of Waukesha, City of Waukesha Wastewater Treatment Facility Annual Chloride Progress Report, June 30th 2014.

Choi, Y.S., 1995, Stratigraphy and sedimentology of the Middle Ordovician Sinnipee Group, eastern Wisconsin. M.S. Thesis-Geology, University of Wisconsin-Madison, 229 p.

CH2MHill, Application Summary, City of Waukesha Application for a Lake Michigan Diversion with Return Flow, October 2013, Vol.1 of 5.

CH2MHill, City of Waukesha Water Supply Service Area Plan, October 2013, Vol. 2 of 5.

CH2MHill, Water Conservation Plan, May 2012, Vol. 3 of 5.

CH2MHill, City of Waukesha Return Flow Plan, October 2013, Vol. 4 of 5.

CH2MHill, City of Waukesha Environmental Report for Water Supply Alternatives, October 2013, Vol. 5 of 5.

CH2MHill, 2015a. City of Waukesha Evaluation of Treated Return Flow to Lake Michigan through the Milwaukee Metropolitan Sewerage District. 03/11/2015.

CH2MHill, 2015b. Updated Root River Return Flow Hydraulic Conditions for Maximum 10.1 MGD Return Flow Rate. 03/23/2015.

CH2M. 2015c. Reverse Osmosis Concentrate Disposal Issues. 10/28/2015.

CH2MHill and Ruekert-Mielke. *Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply*, 2003.

City of Waukesha Wastewater Treatment Facility Annual Chloride Progress Report, City of Waukesha, provided to the Wisconsin Department of Natural Resources 6/30/2014

Clayton, L. 2001. *Pleistocene Geology of Waukesha County, Wisconsin*. Wisconsin Geological and Natural History Survey Bulletin 99, 33 p.

Diebel, M., A. Ruesch, D. Menuz, J. Stewart, and S. Westenbroek,. *Ecological Limits of Hydrologic Alteration in Wisconsin Streams,* 2014.

Duchniak, D. personal communication. Water Supply System – Well Capacities. 11/12/2015

Eggers, Steve, and Reed, Donald, *Wetland Plants and Plant Communities of Minnesota and Wisconsin,* U.S. Army Corps of Engineers, Second Edition, 1997.

EPA, Milwaukee Estuary Area of Concern Information, http://www.epa.gov/glnpo/aoc/ or http://dnr.wi.gov/topic/greatlakes/milwaukee.html, 3/3/2010.

Feinstein, D., Eaton, T., Hart, D., Krohelski, J., and Bradbury, K., 2005. Numerical simulation of shallow and deep groundwater flow in southeastern Wisconsin; Report 2: Model results and interpretation. Southeastern Wisconsin Regional Planning Commission, Technical Report 41, 63 p.

Feinstein, D. and others, 2003. Groundwater in the Great Lakes Basin: the case of Southeastern Wisconsin. U.S. Geological Survey, http://wi.water.usgs.gov/glpf/

Feinstein, D.T., M.N Fienen, J.L. Kennedy, C.A. Buchwald, and M.M. Greenwood. *Development and Application of a Groundwater/Surface-Water Flow Model using MODFLOW-NWT for the Upper Fox River Basin, Southeastern Wisconsin*. Scientific Investigations Report 2012-5108. 2012.

Feinstein, D.T. and others, *Regional aquifer model for southeastern Wisconsin – Report 2: Model results and interpretation* in Technical Report 41, Southeastern Wisconsin Regional Planning Commission, 2005.

Federal Emergency Management Agency (FEMA) Waukesha County Flood Insurance Study, Vol. 1-3, Revised 2014.

Foley and others, 1953. *Ground-Water Conditions in the Milwaukee-Waukesha Area, Wisconsin*. U.S. Geological Survey Water-Supply Paper 1229. 96 p.

Great Lakes – Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. *Recommended Standards for Waterworks*, 2012 Edition.

GZA GeoEnvironmental, Inc. 2015. *Non-Diversion Alternative Using Existing Water Supply With Treatment City of Waukesha Water Supply, Report to Clean Wisconsin and Milwaukee Riverkeeper, Report to Clean Wisconsin and Milwaukee Riverkeepers*. 7/9/2015.

Kammerer, P.A., Jr., 1995, Ground-water flow and quality in Wisconsin's shallow aquifer system. U.S.Geological Survey Water-Resources Investigations Report 90-4171, 42 p.

Kinzelman, J. and McLellan, S. *Success of science-based management practices in reducing swimming bans — a case study from Racine, WI. USA*. Aquat. Ecosyst. Health & Manage. 12 (2). 2009. pp. 187–196.

Kinzelman, Julie. *Using spatial distribution studies and source tracking to target beach remediation – the Racine, WI approach* (oral presentation). Presque Isle Beach Sanitary Workshop. Erie, PA. 2007.

Kinzelman, Julie, *Investigating bathing water quality failures and initiating remediation for the protection of public health.* Ph.D. Thesis, 2005.

Koski, A., Wright, S., and Kinzelman, J. Baseline Assessment of Water Quality in support of the Root River Restoration Plan, Data Analysis Report 2011-2013, 2014.

Levine, Marc, *The Economic State of Milwaukee's Inner City: 1970-2000.* December 2002. Accessible at www4.uwm.edu/ced/publications/innercity2002.pdf.

Levine, Marc, and Lisa Heuler Williams. *The Economic State of Milwaukee's Inner City*. 05/2006.
Macholl, J.A. Inventory of Wisconsin's springs, WGNHS Open File Report 2007-03. 2007.

Mead and Hunt. 2015. *City of Waukesha's application for diversion of Lake Michigan Water, Report to Clean Wisconsin, et al.* (April 6, 2015)

Mickelson, D.M., Clayton, L., Baker, R.W., Mode W.N., and Schneider, A.F., 1984, Pleistocene stratigraphic units of Wisconsin. Wisconsin Geological and Natural History Survey Miscellaneous Paper 84-1, 15 p. +appendices.

Mickelson, D.M. & Syverson, K.M. Quaternary geology of Ozaukee and Washington Counties, Wisconsin. Wisconsin Geological and Natural History Survey Bulletin, 91. 1997. 56 pp. Mikulic, D.G., Mikulic, J.L., History of geologic work in the Silurian and Devonian of southeastern Wisconsin: Guidebook 41st annual tri-state field conference, A19-A27, 1977.

Mai, H. and Dott, R.H., Jr., 1985, A subsurface study of the St. Peter Sandstone in southern and eastern Wisconsin. Wisconsin Geological and Natural History Survey Information Circular 47, 24 p.

MMSD, Milwaukee Metropolitan Sewerage District (MMSD). 09/2007. Root River Sediment Transport Planning Study. Hydrology Technical Memorandum 6. 2007.

Nalepa, T. F., Hartson, D. J., Fanslow, D. L., Lang, G. A., and Lozano, *S. J. Declines in benthic macroinvertebrate populations in southern Lake Michigan*, 1980–1993. Canadian Journal of Fisheries and Aquatic Science, Volume 55:2402–13. 1998.

NRHP, 2012 NRHP. 12/2012. National Parks Service, National Register of Historic Places database, Google Earth layers. Available at http://www.nps.gov/nr/research/index.htm. Accessed December 2012.

Public Policy Forum, *Property Values and Taxes in Southeast Wisconsin*. Sponsored by Baird August, 2011.

RJN Environmental Services, LLC. Results of Groundwater Modeling Study Shallow Groundwater Source, Fox River & Vernon Marsh Area. 04/2010

RJN Environmental Services, LLC. Groundwater Drawdown Analysis, 08/2013. Schmidt, R. *Wisconsin's Ground Water Management Plan Report No. 5; Groundwater Contamination Susceptibility in Wisconsin.* Wisconsin Department of Natural Resources. Madison, Wisconsin, 1987.

Rast, J. and Madison, C., A Socio-Economic Impact Analysis of the Regional Water Supply Plan for Southeastern Wisconsin, University of Wisconsin-Milwaukee Center for Economic Development, July 2010.

Schanzle, R.W., Kruse, G.W., Kath, J.A., Klocek, R.A., and Cummings, K.S. 2004 *The Freshwater Mussels (Bivalvia: Unionidae) of the Fox River Basin, Illinois and Wisconsin*. Illinois Natural History Survey, Biological Notes 141, November, 2004.

Schneider, A.F., 1983, Wisconsinan stratigraphy and glacial sequence in southeastern Wisconsin. In Late Pleistocene history of southeastern Wisconsin, D.M. Mickelson and L. Clayton, eds., Wisconsin Geological and Natural History Survey, Geoscience Wisconsin, Vol. 7, p. 59-83.

SEWRPC, 2002. Groundwater resources of Southeastern Wisconsin. Technical Report No. 37.p 60, Figure 9, 2002.

SEWRPC, 2002. Groundwater resources of Southeastern Wisconsin. Technical Report No. 37. 2002. 203 p.

SEWRPC, 2004. Technical Report No. 10 *The Economy of Southeastern Wisconsin* and Technical Report No. 11 *The Population of Southeastern Wisconsin (*07/2004).

SEWRPC, 2005. Land Use Division and GIS Division, Park and Open Space Sites data. Stuber et al. 1982a, 1982b, 2005.

SEWRPC, 2006. A Regional Land Use Plan for Southeastern Wisconsin: 2035. Planning Report No. 48, 06/2006.

SEWRPC, 2007. A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds. Planning Report No. 50. 2007.

SEWRPC 2008. Community Assistance Planning Report No. 284, Pebble Creek Watershed Protection Plan. 2008.

SEWRPC, 2010. A Regional Water Supply Plan for Southeast Wisconsin. Planning Report No. 48. 2010. pp. 108-9

SEWRPC, 2014 , A Restoration Plan for the Root River Watershed, Community Assistance Planning Report No. 316, Part 1 (Chapters 1-7). 07/2014.

Simpkins, W.W. 1989. *Genesis and spatial distribution of variability in the lithostratigraphic, geotechnical, hydrogeological and geochemical properties of the Oak Creek Formation in southeastern Wisconsin*. Unpublished Ph.D. dissertation (Geology and Geophysics), University of Wisconsin-Madison. 394 p.

Smith, E.I., 1978, Introduction to Precambrian rocks of south-central Wisconsin. Wisconsin Geological and Natural History Survey, Geoscience Wisconsin, Vol. 2, p. 1-17.

Strand Associates, Inc. Wastewater Treatment Facilities Plan for the City of Waukesha, 07/2011.
Swanson, S.K. Assessing the Ecological Status and Vulnerability of Springs in Wisconsin. Project No.WR05R004.
http://wri.wisc.edu/Default.aspx?tabid=73&ctl=Details&mid=423&ProjectID=9856
2266). 2007

Sverdrup, K.A., Kean, W.F., Herb, Sharon, Brukardt, S.A., and Friedel, R.J., Gravity signature of the Waukesha Fault, Southeastern Wisconsin: Geoscience Wisconsin, v. 16, 1997.

United States Environmental Protection Agency (USEPA) and Environment Canada. *The Great Lakes: An Environmental Atlas and Resource Book.* ISBN 0-662-23441-3. http://www.epa.gov/greatlakes/atlas/ January 16, 2012.

USCB. 2010a. *Profile of General Population and Housing Characteristics: 2010.* Accessed on December 27, 2011, at http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk.

USCB 2000 and 2010b (United States Census Bureau (USCB). 2000. U.S. Census 2000 Population, Demographic, and Housing Information. Available at http://quickfacts.census.gov/qfd/states/55000.html.)

USEPA. 2000. *Update of: Technologies and Cost for the removal of Radionuclides from Potable Water Supplies*. EPA-HQ-OW-2004-004-0031

USFWS 2013 Correspondence from Peter Fasbender/USFWS to Anjulie Cheema/ CH2M HILL. February 22, 2013.

USGS: Ellefson, B. R., Mueller, C. A. & Buchwald, C. A., Water Use in Wisconsin, Open-file Report 02-356, 2000. Available at http://wi.water.usgs.gov/pubs/ofr-02-356/ofr-02-356.pdf. Accessed February 2010.

USGS, *Where do deep wells in southern Wisconsin get there water from?* 10/2006 http://wi.water.usgs.gov/glpf, 6/18/2015

USGS, 2007. *Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin*. http://wi.water.usgs.gov/glpf/index.html, 2007.

USGS, 2011. USGS Nonindigenous Aquatic Species website (accessed 02/2011): nas.er.usgs.gov

University of Wisconsin-Extension. *Grassland birds: Fostering habitats using rotational grazing*, http://learningstore.uwex.edu/assets/pdfs/a3715.pdf 2001.

University of Wisconsin – Milwaukee (UWM), *A Socio-Economic Impact Analysis of the Regional Water Supply Plan for Southeastern Wisconsin,* University of Wisconsin–Milwaukee, Center for Economic Development (UW Milwaukee). 07/2010.

Waukesha County Department of Parks and Land Use and Southeastern Wisconsin Regional Planning Commission (Waukesha County and SEWRPC). Community Assistance Planning Report No. 284, Pebble Creek Watershed Protection Plan. Waukesha County, Wisconsin. Part One. 2008.

Wisconsin Geological and Natural History Survey (WGNHS). Spring Inventory provided March 9, 2010.

Woodling, J.D, EM Lopex, TA Maldonado, DO Norris and AM Vajda 2006 Woodling, J. D, EM Lopez, TA Maldonado, DO Norris and AM Vajda. *Intersex and other reproductive disruption of fish in wastewater effluent dominated Colorado streams*, Comp. Biochem. Physiol. Part C 144. 2006. pp. 10 – 15.

WPSC, 2003 Wisconsin Public Service Commission (WPSC). Final Environmental Impact Statement, Elm Road Generating Station—Vol. 1. 2003.