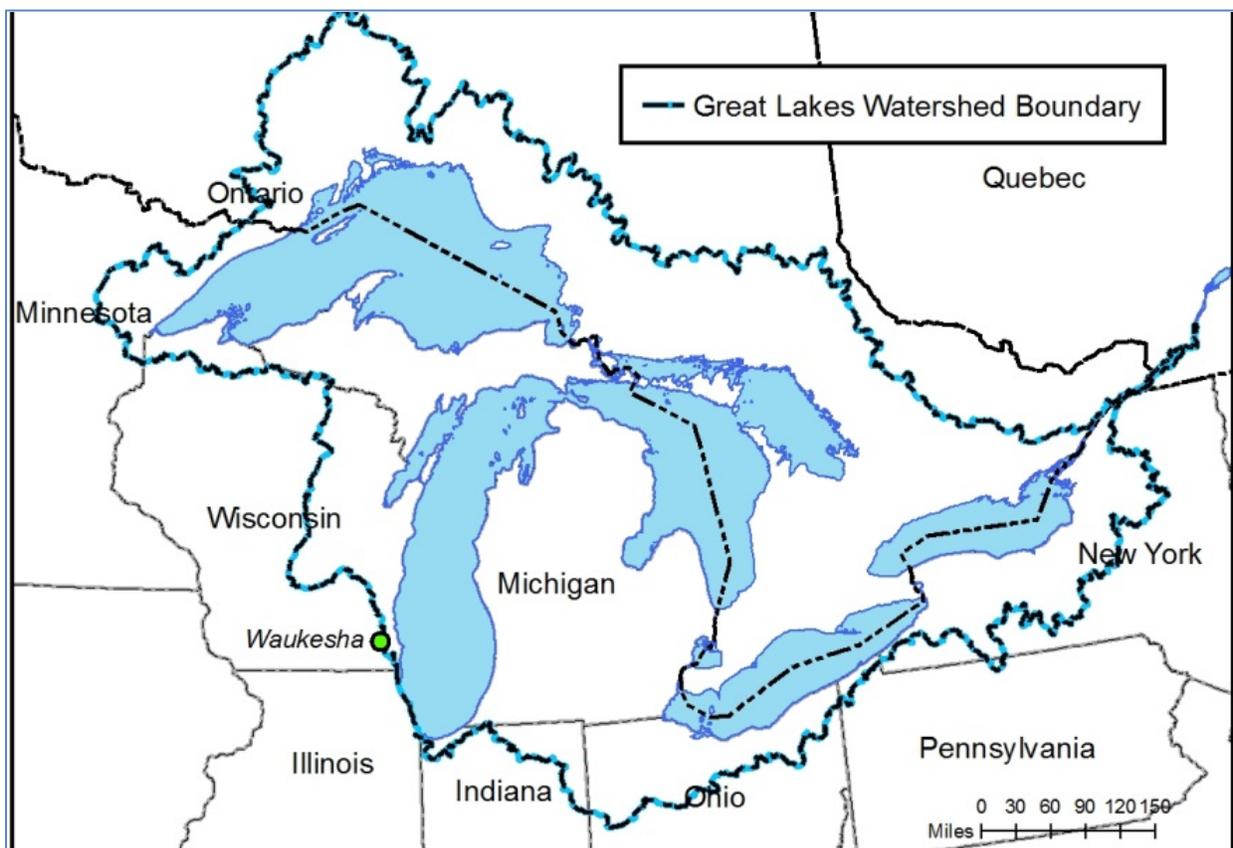


# DRAFT Technical Review



*For the City of Waukesha's Proposed  
Diversion of Great Lakes Water for Public Water  
Supply with Return Flow to Lake Michigan*



June 2015

Prepared by: The Wisconsin Department of Natural Resources

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## **Acronyms and Abbreviations**

Agreement	Great Lakes—St. Lawrence River Basin Sustainable Water Resources Agreement
Applicant	City of Waukesha
Application	<i>City of Waukesha Application for a Lake Michigan Diversion with Return Flow</i>
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
dEIS	Draft Environmental Impact Statement
ELOHA	Ecological Limits of Hydrological Alteration
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
pic/L	picocuries per liter
PRESTO	Pollutant load Ratio Estimation Tool (DNR model)
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
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

## **Executive Summary**

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. 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 Water Resources Compact (Compact). The Applicant seeks to obtain a Lake Michigan water supply as a solution to its current water supply problems.

This draft technical review outlines the department’s analysis of the Application’s compliance with the Great Lakes—St. Lawrence River Basin Water Resources Compact (Compact)<sup>1</sup> and Wisconsin’s Compact implementing legislation<sup>2</sup>. The department’s findings are summarized below.

### *Water supply*

The department finds the Applicant is without adequate supplies of potable water due to the drawdown in the deep sandstone aquifer and the presence of radium in its current groundwater water supply. The Applicant has no reasonable water supply alternative in the Mississippi River basin (MRB), even considering conserving existing water supplies.

The Applicant reviewed six water supply alternatives in detail: four of the reviewed alternatives withdraw water exclusively from the MRB; one alternative withdraws water from a combination of MRB 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.

In addition, the department reviewed the proposed alternatives based on cost, public health protection, and environmental sustainability as required under Wisconsin’s statutory definition of “reasonable water supply alternative.”<sup>3</sup> The water supply alternatives that include the MRB sources are likely to have greater adverse environmental impacts due to projected impacts on wetlands and lakes than the proposed Lake Michigan alternative. The department determined that all the proposed MRB water supply alternatives are similar in cost<sup>4</sup> to the Lake Michigan alternative, yet none is as environmentally sustainable or as protective of public health as the proposed Lake Michigan water source.

Under Wisconsin law, a diversion proposal must be consistent with an approved water supply service area plan that covers the public water supply system. Under the Applicant’s proposal, it would receive treated water from the City of Oak Creek Water Utility, which is located in the Great Lakes basin (GLB) and withdraws surface water from Lake Michigan. The water would be transported to Waukesha via a pipeline and distributed to customers that include all of the City of Waukesha and may also include portions of the City of Pewaukee and the towns of Waukesha,

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<sup>1</sup> Great Lakes-St. Lawrence River Basin Water Resources [Compact](#), sections 4.9.3 & 4.

<sup>2</sup> [Wis. Stat. § 281.346](#)

<sup>3</sup> [Wis. Stat. § 281.346\(1\)\(ps\)](#)

<sup>4</sup> Assuming +/- 25 percent.

Genesee, and Delafield in the future. The department finds the proposed diversion to be consistent with the water supply service area plan<sup>5</sup> covering the public water supply system.

The proposed diversion would be limited to reasonable quantities and used solely for public water supply purposes. The Applicant's requested diversion quantities of an annual average of 10.1 million gallons per day (MGD) at full build-out and a daily maximum of 16.7 MGD are reasonable for the water supply service area. To ensure that the Applicant has implemented its conservation plan and can maintain the ability to serve its entire projected water supply service area, the department would authorize up to 10.1 MGD if the Applicant could demonstrate its need for the increased demand after fully implementing its proposed water conservation plan.

#### *Water conservation*

The department finds that the proposed diversion cannot be reasonably avoided through the efficient use and conservation of existing water supplies. Further, the Applicant has demonstrated a commitment to implementing water conservation and efficiency measures that are environmentally sound and economically feasible. The Applicant forecast 1.0 million gallons per day (MGD) 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.

#### *Wastewater return flow*

The Applicant proposes to return its treated wastewater flow to the Root River, a tributary of Lake Michigan, from a wastewater treatment system within the MRB that would combine water from inside and outside the GLB. The proposal would return all water withdrawn from Lake Michigan, less an allowance for consumptive use, to the Lake Michigan basin. To maximize return of Lake Michigan basin water and minimize MRB water discharge to Lake Michigan, the Applicant proposes a return flow management scheme under which it would return the previous year's average daily withdrawal amount, up to 10.1 MGD. Any additional flow would be discharged to the Applicant's current discharge location on the Fox-Illinois River (MRB).

Under Wisconsin law, the returned water must meet all water quality discharge standards and applicable permit requirements and prevent the introduction of invasive species to the GLB. Prior to issuing any formal diversion approval, the department would issue any necessary permits related to return flow only after the applicant met all permitting requirements under Wisconsin law, ensuring the protection of the physical, chemical and biological integrity of the Root River.

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<sup>5</sup> The approval condition proposed maintains consistency between the Southeastern Wisconsin Regional Planning Commission (SEWRPC) planned sewer service area and the delineated water supply service area as required under Wis. Stat. §§ [281.346\(4\)\(e\)1.em.](#) and [281.348.](#)

### *Impact assessment*

The department finds the proposed diversion would not endanger the integrity of the GLB Ecosystem and would not result in significant individual or cumulative adverse impacts to the quantity or quality of the water and water-dependent natural resources of the GLB.

### *Additional criteria*

The Applicant's current water supply, the deep sandstone aquifer, is derived from groundwater that is hydrologically interconnected to Waters of the 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 Applicant's wells in the deep sandstone aquifer are pumping and distributing water that once flowed towards Lake Michigan and is now flowing towards pumping centers. None of the water currently withdrawn from deep sandstone wells is induced directly from Lake Michigan.

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 decision on any necessary future permits and approvals would not be substantively affected by a diversion approval. The Applicant would be required to comply with all applicable laws and would need to work closely with regulatory authorities throughout any diversion process.

## **Introduction**

### **City of Waukesha's Request**

The City of Waukesha (Applicant) proposes a diversion of Lake Michigan water as a long-term solution to its current water supply problems. The Applicant asserts that it needs a new source of water to address water quality and quantity concerns. The Applicant has long relied on a deep aquifer groundwater supply, but depressed water levels in the deep aquifer have compounded high radium concentration levels, requiring costly treatment. The public water supply is supplemented by water from a shallow aquifer. Waukesha seeks an exception from the prohibition of diversions under the [Great Lakes---St. Lawrence River Basin Water](#)

[Resources Compact](#) (Compact) as a “Community in a Straddling County” ([Figure 1](#) and [Figure 2](#)). The Applicant first applied for a Lake Michigan diversion in May 2010 and submitted a revised [Application](#) for a Lake Michigan Diversion with Return Flow (Application) to the Wisconsin Department of Natural Resources (department) in October 2013.

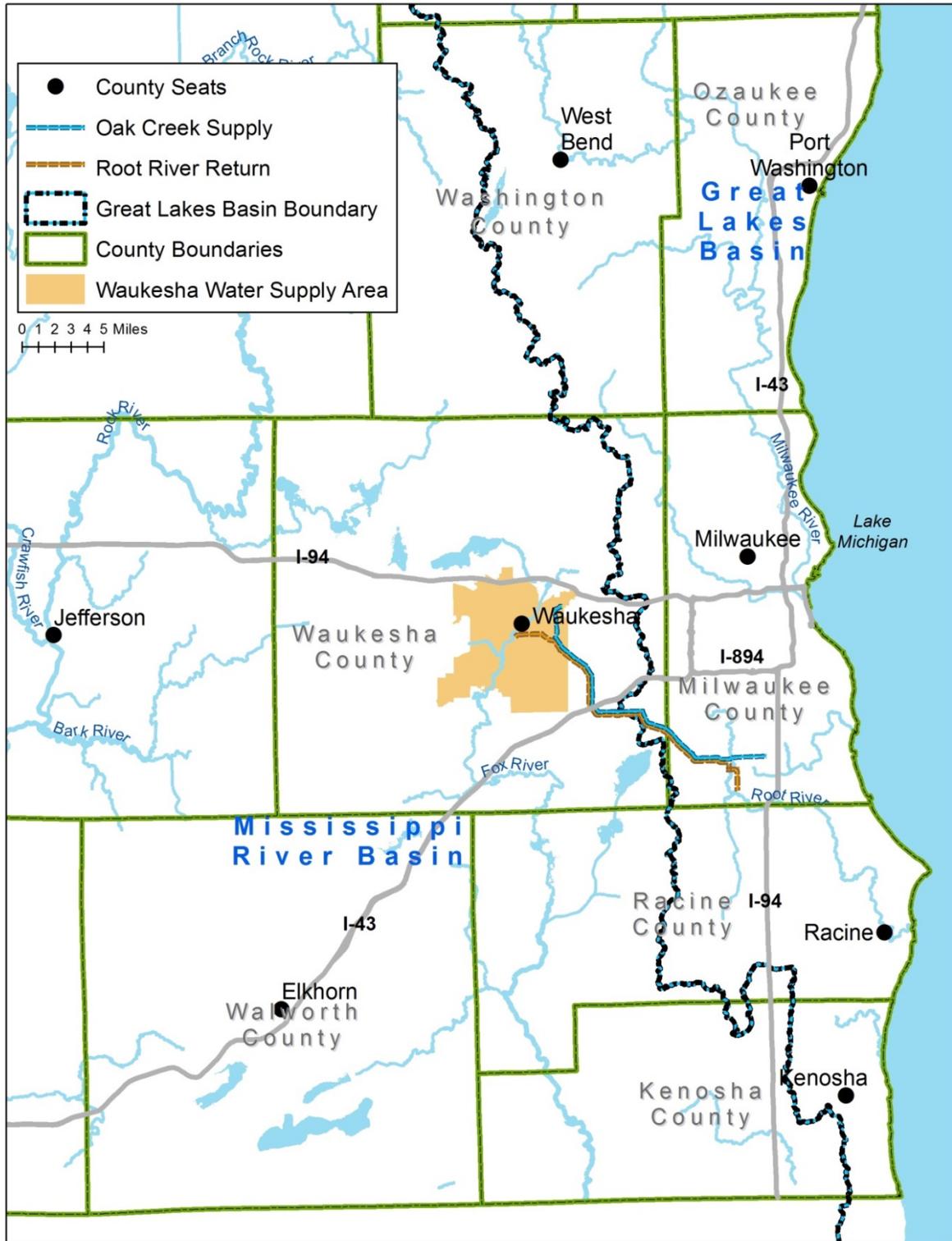
The Applicant proposes to divert an annual average of 10.1 million gallons per day (MGD) and a maximum of 16.7 MGD from Lake Michigan upon final water supply service area build-out (approximately the year 2050).<sup>6</sup> The water is proposed to serve an area that includes all of the City of Waukesha and may also serve portions of the City of Pewaukee and the towns of Waukesha, Genesee, and Delafield. 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 (GLB) and withdraws surface water from Lake Michigan. The water would be transported to Waukesha via a pipeline and distributed to customers. The Applicant proposes that, after consumptive use, remaining water would be treated at the Waukesha wastewater treatment plant before it is piped and discharged to the Root River within the Lake Michigan basin. Under a management scheme suggested by the department and proposed by the Applicant, the previous year's daily average withdrawal would be returned, subject to availability, to the Root River each day and any surplus water would be discharged at the Applicant's current outfall pipe in the Fox River. Supply and return flow pipelines would be approximately 19-20 miles long and share much of the same route.

**Figure 1 . Location of City of Waukesha and Great Lakes Water Basin.**



<sup>6</sup> Waukesha Water Utility currently serves the City of Waukesha and parts of the Town of Waukesha and City of Pewaukee. In addition, the proposed water supply service area includes additional areas of the Town of Waukesha, Delafield, and Genesee, and the City of Pewaukee See section [S3](#) of this technical review for additional information.

Figure 2. Location of water supply and wastewater return flow routes.



The Compact prohibits diversions of Great Lakes water, with limited exceptions. One exception allows a “community within a straddling county” to apply for a diversion of Great Lakes water. A community within a straddling county means “any incorporated city, town or the equivalent thereof, that is located outside the Basin but wholly within a County that lies partly within the basin. . .”<sup>7</sup> Under Wisconsin law, the Applicant’s water supply service area is considered “the equivalent thereof.” The Applicant is also located completely within Waukesha County, which straddles the basin divide and therefore qualifies as a community within a straddling county under the Compact.<sup>8</sup> As such, the Applicant may apply for and receive a diversion provided that it meets a list of criteria provided in the Compact and Wisconsin’s Compact implementing statutes.

Under the provisions of the Compact and Wisconsin’s Compact implementing laws,<sup>9</sup> the department has completed this technical review to “thoroughly analyze the Proposal and provide an evaluation of the Proposal sufficient for a determination of whether the Proposal meets the [criteria].”<sup>10</sup> The department has summarized the Compact/Agreement and Wisconsin state implementation requirements into 15 criteria, which are listed below in [Table 1](#).

**Table 1. Diversion review criteria.**

Criteria	Compact, Agreement and Wisconsin Statutes language
<b>Water Supply Related Criteria are abbreviated S1-S4</b>	
<b>S1</b>	<p><u>Compact/Agreement:</u> The Water shall be used solely for the Public Water Supply Purposes of the Community within a Straddling County that is without adequate supplies of potable water (<a href="#">Compact</a> s. 4.9.3.a.; <a href="#">Agreement</a> art. 201 s. 3.a; <i>see also</i> <a href="#">Wis. Stat. § 281.343(4n)(c)1.a.</a>)</p> <p><u>Wisconsin Statutes:</u> ...the water diverted will be used solely for public water supply purposes in the portion of the community that is within the straddling county and ... the community is without adequate supplies of potable water. (<a href="#">Wis. Stat. § 281.346 (4)(e)1</a>)</p>
<b>S2</b>	<p><u>Compact/Agreement:</u> There is no reasonable water supply alternative within the basin in which the community is located, including conservation of existing water supplies. (<a href="#">Compact</a> s. 4.9.3.d.; <a href="#">Agreement</a> art. 201 s. 3.d; <i>see also</i> <a href="#">Wis. Stat. § 281.343(4n)(c)1.d.</a>)</p> <p><u>Wisconsin Statutes:</u> There is no reasonable water supply alternative within the watershed in which the community is located, including conservation of existing water supplies. (<a href="#">Wis. Stat. § 281.346 (4)(e)1.d.</a>)</p>
<b>S3</b>	<p><u>Compact/Agreement:</u> No equivalent requirement</p> <p><u>Wisconsin Statutes:</u> The proposal is consistent with an approved water supply service area plan under <a href="#">Wis. Stat. § 281.348</a> that covers the public water supply system. (<a href="#">Wis. Stat. § 281.346(4)(e)1.em.</a>)</p>
<b>S4</b>	<p><u>Compact/Agreement:</u> The Exception will be limited to quantities that are considered reasonable for the purposes for which it is proposed. (<a href="#">Compact</a> s. 4.9.4.b.; <a href="#">Agreement</a></p>

<sup>7</sup> [Compact](#) s. 1.2.; [Agreement](#) art. 103, [Wis. Stat. § 281.343 \(1e\)\(d\)](#), and [Wis. Stat. § 281.346 \(1\)\(d\)](#)

<sup>8</sup> See S3 of this technical review.

<sup>9</sup> See [Wis. Stat. § 281](#) and Wis. Admin. Code §§ [NR 852](#) and [NR 856](#)

<sup>10</sup> [Compact](#) s. 4.5.4.b; see also [Agreement](#) art. 505 s. 2. [Wis. Stat. § 281.343 \(4h\)\(d\)2](#), and [Wis. Stat. § 281.346](#).

	<p>art. 201 s. 4.b; <i>see also</i> <a href="#">Wis. Stat. § 281.343(4n)(d)2.</a>)</p> <p><u>Wisconsin Statutes:</u> The diversion is limited to quantities that are reasonable for the purposes for which the diversion is proposed. (<a href="#">Wis. Stat. § 281.346(4)(f)2.</a>)</p>
<b>Water Conservation Related Criteria are abbreviated C1, C2</b>	
<b>C1</b>	<p><u>Compact/Agreement:</u> The need for all or part of the proposed Exception cannot be reasonably avoided through the efficient use and conservation of existing water supplies; (<a href="#">Compact</a> s. 4.9.4.a.; <a href="#">Agreement</a> art. 201 s. 4.a.; <i>see also</i> <a href="#">Wis. Stat. § 281.343(4n)(d)1.</a>)</p> <p><u>Wisconsin Statutes:</u> The need for the proposed diversion cannot reasonably be avoided through the efficient use and conservation of existing water supplies. . . (<a href="#">Wis. Stat. § 281.346(4)(f)1.</a>)</p>
<b>C2</b>	<p><u>Compact/Agreement:</u> The Exception will be implemented so as to incorporate Environmentally Sound and Economically Feasible Water Conservation Measures to minimize Water Withdrawals or Consumptive Use. (<a href="#">Compact</a> s. 4.9.4.e. ; <a href="#">Agreement</a> art. 201 s. 4.e; <i>see also</i> <a href="#">Wis. Stat. § 281.343(4n)(d)5.</a>)</p> <p><u>Wisconsin Statutes:</u> The applicant commits to implementing the applicable water conservation measures under sub. (8)(d) that are environmentally sound and economically feasible for the applicant. (<a href="#">Wis. Stat. § 281.346(4)(f)6.</a>)</p>
<b>Wastewater Return Flow Criteria are abbreviated R1 – R5</b>	
<b>R1</b>	<p><u>Compact/Agreement:</u> The Proposal meets the Exception Standard, maximizing the portion of water returned to the Source Watershed as Basin Water and minimizing the surface water or groundwater from outside the Basin; (<a href="#">Compact</a> s. 4.9.3.b.; <a href="#">Agreement</a> art. 201 s. 3.b.ii.(c); <i>see also</i> <a href="#">Wis. Stat. § 281.343(4n)(c)1.b.</a>)</p> <p><u>Wisconsin Statutes:</u> The proposal maximizes the amount of water withdrawn from the Great Lakes basin that will be returned to the source watershed and minimizes the amount of water from outside the Great Lakes basin that will be returned to the source watershed. (<a href="#">Wis. Stat. § 281.346(4)(e)1.c.</a>)</p>
<b>R2</b>	<p><u>Compact/Agreement:</u> All Water Withdrawn shall be returned, either naturally or after use, to the Source Watershed less an allowance for Consumptive Use. (<a href="#">Compact</a> s. 4.9.4.c.; <a href="#">Agreement</a> art. 201 s. 4.c.; <i>see also</i> <a href="#">Wis. Stat. § 281.343(4n)(d)3.</a>)</p> <p><u>Wisconsin Statutes:</u> An amount of water equal to the amount of water withdrawn from the Great Lakes basin will be returned to the source watershed, less an allowance for consumptive use. (<a href="#">Wis. Stat. § 281.346(4)(f)3.</a>)</p>
<b>R3</b>	<p><u>Compact/Agreement:</u> No equivalent requirement</p> <p><u>Wisconsin Statutes:</u> The place at which the water is returned to the source watershed is as close as practicable to the place at which the water is withdrawn, unless the applicant demonstrates that returning the water at that place is one of the following: not economically feasible; not environmentally sound; not in the interest of public health. (<a href="#">Wis. Stat. § 281.346(4)(f)3m.</a>)</p>
<b>R4</b>	<p><u>Compact/Agreement:</u> No surface water or groundwater from outside the basin may be used to satisfy any portion of this criterion except if it: 1. Is part of a water supply or wastewater treatment system that combines water from inside and outside of the Basin; 2. Is treated to meet applicable water quality discharge standards and to prevent the introduction of invasive species into the Basin; (<a href="#">Compact</a> s. 4.9.4.c.; <a href="#">Agreement</a> art. 201 s. 4.c.; <i>see also</i> <a href="#">Wis. Stat. § 281.343(4n)(d)3.</a>)</p> <p><u>Wisconsin Statutes:</u> No water from outside the Great Lakes basin will be returned to</p>

	the source watershed unless all of the following apply: the returned water is from a water supply or wastewater treatment system that combines water from inside and outside the Great Lakes basin; the returned water will be treated to meet applicable permit requirements under <a href="#">Wis. Stat. § 283.31</a> and to prevent the introduction of invasive species into the Great Lakes basin and the department has approved the permit under <a href="#">Wis. Stat. § 283.31</a> ; if the water is returned through a structure on the bed of a navigable water, the structure is designed and will be operated to meet the applicable permit requirements under <a href="#">Wis. Stat. § 30.12</a> and the department has approved the permit under <a href="#">Wis. Stat. § 30.12</a> . ( <a href="#">Wis. Stat. § 281.346(4)(f)4.</a> )
<b>R5</b>	<u>Compact/Agreement:</u> No equivalent requirement <u>Wisconsin Statutes:</u> If water will be returned to the source watershed through a stream tributary to one of the Great Lakes, the physical, chemical, and biological integrity of the receiving water under subd. <a href="#">3</a> will be protected and sustained as required under <a href="#">Wis. Stat. §§ 30.12, 281.15, and 283.31</a> , considering the state of the receiving water before the proposal is implemented and considering both low and high flow conditions and potential adverse impacts due to changes in temperature and nutrient loadings. ( <a href="#">Wis. Stat. § 281.346(4)(f)4m.</a> )
<b>Impact Assessment Related Criteria are abbreviated IA1, IA2</b>	
<b>IA1</b>	<u>Compact/Agreement:</u> Caution shall be used in determining whether or not the Proposal meets the conditions for this Exception. This Exception should not be authorized unless it can be shown that it will not endanger the integrity of the Basin Ecosystem. ( <a href="#">Compact</a> s. 4.9.3.e.; <a href="#">Agreement</a> art. 201 s. 3.e.; <i>see also</i> <a href="#">Wis. Stat. § 281.343(4n)(c)1.e.</a> ) <u>Wisconsin Statutes:</u> The proposal will not endanger the integrity of the Great Lakes basin ecosystem based upon a determination that the proposal will have no significant adverse impact on the Great Lakes basin ecosystem. ( <a href="#">Wis. Stat. § 281.346(4)(e)1.e.</a> )
<b>IA2</b>	<u>Compact/Agreement:</u> The exception will be implemented so as to ensure that it will result in no significant individual or cumulative adverse impacts to the quantity or quality of the Waters and Water Dependent Natural Resources of the Basin with consideration given to the potential Cumulative Impacts of any precedent-setting consequences associated with the Proposal. ( <a href="#">Compact</a> s. 4.9.4.d.; <a href="#">Agreement</a> art. 201 s. 4.d.; <i>see also</i> <a href="#">Wis. Stat. § 281.343(4n)(d)4.</a> ) <u>Wisconsin Statutes:</u> The diversion will result in no significant adverse individual 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, based upon a determination that the proposed diversion will not have any significant adverse impacts on the sustainable management of the waters of the Great Lakes basin. ( <a href="#">Wis. Stat. § 281.346(4)(f)5.</a> )
<b>Additional Criteria are abbreviated AC1, AC2</b>	
<b>AC1</b>	<u>Compact/Agreement:</u> A Proposal must satisfy all of the conditions listed above. Further, substantive consideration will also be given to whether or not the Proposal can provide sufficient scientifically based evidence that the existing water supply is derived from groundwater that is hydrologically interconnected to Waters of the Basin. ( <a href="#">Compact</a> s. 4.9.3.; <a href="#">Agreement</a> art. 201 s. 3.; <i>see also</i> <a href="#">Wis. Stat. § 281.343(4n)(c)2.</a> )

	<p><u>Wisconsin Statutes:</u> In determining whether to approve a proposal under this paragraph, the department shall give substantive consideration to whether the applicant provides sufficient scientifically based evidence that the existing water supply is derived from groundwater that is hydrologically interconnected to waters of the Great Lakes basin. The department may not use a lack of hydrological connection to the waters of the Great Lakes basin as a reason to disapprove a proposal. (<a href="#">Wis. Stat. § 281.346(4)(e)2.</a>)</p>
<b>AC2</b>	<p><u>Compact/Agreement:</u> The Exception will be implemented so as 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. (<a href="#">Compact</a> s. 4.9.4.f.; <a href="#">Agreement</a> art. 201 s. 4.f.; <i>see also</i> <a href="#">Wis. Stat. § 281.343(4n)(d)6.</a>)</p> <p><u>Wisconsin Statutes:</u> The diversion will be in compliance with all applicable local, state, and federal laws and interstate and international agreements, including the Boundary Waters Treaty of 1909. (<a href="#">Wis. Stat. § 281.346(4)(f)7.</a>)</p>

The purpose of this technical review is to evaluate the proposed diversion for compliance with these criteria. In this technical review, the department presents its findings, methods of analysis, and a summary for each criterion.

### Southeast Wisconsin Region

The City of Waukesha is located in southeastern Wisconsin, where a 7-county area<sup>11</sup> ([Figure 2](#)) (the region) accounts for 5 percent of the total land area of Wisconsin but contains approximately 35 percent of Wisconsin’s population. Southeastern Wisconsin is traversed by a subcontinental divide that runs generally northwest-southeast across the region, separating the Great Lakes—St. Lawrence River basin from the Mississippi River basin (MRB).<sup>12</sup> In southeast Wisconsin, the subcontinental divide is close to the Lake Michigan shoreline – from less than 5 miles inland at the Wisconsin-Illinois border to approximately 30 miles inland at the north end of the region. The City of Waukesha had a 2010 population of 70,718<sup>13</sup> and is located in southeast Wisconsin, about 17 miles west of Lake Michigan. The City’s eastern boundary is approximately 1.5 miles from the Great Lakes surface water divide but is completely outside of the Great Lakes basin. The City is over 100 years old and is home to a growing minority population that accounted for over half of the City’s overall population growth between 2000 and 2010.<sup>14</sup>

### Regional Water Supply

Groundwater in the region is primarily contained in two aquifer systems, a shallow sand, gravel and fractured dolomite aquifer system and a deeper sandstone and dolomite aquifer. Throughout

<sup>11</sup> This region, also known as the Southeastern Wisconsin Regional Planning Commission (SEWRPC) region, includes Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington and Waukesha counties. SEWRPC has state authority (Wis. Admin. Code NR 121.06) to conduct regional planning.

<sup>12</sup> SEWRPC, A Regional Water Supply Plan for Southeastern Wisconsin, Planning Report #52, Volume [1](#), p. 2, p. 64 (12/2010).

<sup>13</sup> U.S. Census Bureau, QuickFacts- Waukesha (city), Wisconsin: <http://quickfacts.census.gov/qfd/states/55/5584250.html>.

<sup>14</sup> U.S. Census Bureau. Censtats, *Profile of General Demographic Characteristics*, Waukesha city, Wisconsin, <http://censtats.census.gov/data/WI/1605584250.pdf> 2000

most of the region, the aquifers are separated by the Maquoketa shale, a relatively impermeable layer that limits recharge from surface infiltration in the deep aquifer.<sup>15</sup>

Groundwater pumping in the region began around 1864 and has gradually altered the groundwater flow structure.<sup>16</sup> Drawdown is most substantial in the deep aquifer where a single cone of depression developed under the entire region and extends under Lake Michigan to the east. Increased pumping rates and new wells from pre-development to 2000 caused the regional cone of depression to deepen and migrate to the west.<sup>17</sup> The cone of depression moved upwards of 10 miles to the west in some parts of the region by 2000.<sup>18</sup> This means that some groundwater that once flowed toward Lake Michigan now flows away from the lake.<sup>19</sup> The maximum drawdown in the area approached 500 feet below pre-development levels in 1997. The southeast Wisconsin cone of depression has converged with a similar cone of depression caused by pumping in northeastern Illinois.<sup>20</sup> Current water levels from U.S. Geological Survey (USGS) monitoring wells in southeast Wisconsin show a rise in groundwater levels from the low in 1997. A USGS monitoring well located in the City of Waukesha currently shows water levels to now be approximately 350 feet below pre-development water levels.<sup>21</sup>

For purposes of groundwater management, Wisconsin has defined groundwater management areas (GMAs) in the state as those areas where the groundwater potentiometric surface is reduced 150 feet or more from the unpumped condition.<sup>22</sup> Southeastern Wisconsin, including Waukesha County has been designated as a GMA.<sup>23</sup>

Pumping from the shallow aquifer causes localized drawdown and impacts surface water features such as streams, wetlands, springs, and lakes. The primary effect is a reduction in groundwater discharge to local surface water features.<sup>24</sup> One modeling study estimated that reduced groundwater levels have resulted in an input loss of 12 percent to area surface waters.<sup>25</sup>

### Regional Water Quality

The groundwater quality of the area is generally good, but with localized water quality problems. The exception to generally good water quality is high radium in some areas of the deep aquifer

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<sup>15</sup> SEWRPC, A Regional Water Supply Plan for Southeastern Wisconsin, Planning Report #52, Volume 1, p. 85 (12/2010).

<sup>16</sup> SEWRPC, A Regional Water Supply Plan for Southeastern Wisconsin, Planning Report #52, Volume 1, p. 105 (12/2010).

<sup>17</sup> USGS, Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin (03/2007), available at [http://wi.water.usgs.gov/glpf/cs\\_pmp\\_wls.html](http://wi.water.usgs.gov/glpf/cs_pmp_wls.html).

<sup>18</sup> SEWRPC, A Regional Water Supply Plan for Southeastern Wisconsin, Planning Report #52, Volume 1, p. 114, Fig. 18. (12/2010).

<sup>19</sup> USGS, Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin (03/2007), available at [http://wi.water.usgs.gov/glpf/cs\\_pmp\\_wls.html](http://wi.water.usgs.gov/glpf/cs_pmp_wls.html).

<sup>20</sup> SEWRPC, A Regional Water Supply Plan for Southeastern Wisconsin, Planning Report #52, Volume 1, p. 2, p. 108 (12/2010).

<sup>21</sup> [USGS Groundwater monitoring network, site number 430052088133501](http://wi.water.usgs.gov/glpf/cs_pmp_wls.html)

<sup>22</sup> [Wis. Stat. § 281.34\(9\)\(a\)](#), [Wis. Admin. Code § NR 820.20](#).

<sup>23</sup> These areas are subject to additional regulation under [Wis. Admin. Code § NR 820](#).

<sup>24</sup> SEWRPC, A Regional Water Supply Plan for Southeastern Wisconsin, Planning Report #52, Volume 1, p. 108 (12/2010).

<sup>25</sup> USGS, Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin (03/2007), available at [http://wi.water.usgs.gov/glpf/cs\\_pmp\\_wls.html](http://wi.water.usgs.gov/glpf/cs_pmp_wls.html).

and high arsenic in isolated areas of the shallow aquifer. Radium in the groundwater is naturally occurring in some types of rock formations in the deep aquifer. A few water supply systems in the region, including the Waukesha Water Utility, have exceeded the federal and state standard for radium, a maximum contaminant level (MCL) of 5 picocuries per liter (pCi/l). Arsenic releases in the groundwater are also naturally occurring. Approximately 5 percent of wells in the region tested for arsenic showed values above the federal and state standards, a MCL of 0.010 milligrams per liter (mg/l). Other types of groundwater quality issues include volatile organic compounds, hardness, leaking septic tanks and groundwater contamination from surface pollution.

Regional Water Use

As of the year 2000, approximately 81 percent of the people (about 1.56 million people) living in southeast Wisconsin were served by public water utilities. Of those served by a public water supply, approximately 77 percent (about 1,197,400 people, 62 percent overall) were served by a utility that uses Lake Michigan surface water while 23 percent (about 364,100 people, 19 percent overall) were served by a public utility that uses groundwater.<sup>26</sup>

**Table 2. Per capita water use from regional public water systems.** Ten largest (population served) southeast Wisconsin water utilities’ water use in 2012 as reported to the Wisconsin public service commission (WPSC). Highest levels are shaded dark grey and lowest levels are shaded light grey (GPCD = gallons per capita per day).

<b>Water Utility</b>	<b>Population served*</b>	<b>Residential GPCD</b>	<b>Commercial GPCD</b>	<b>Industrial GPCD</b>	<b>Public GPCD</b>
Brookfield Municipal Water Utility	28,600	74	37	1	2
Kenosha Water Utility	101,832	49	27	8	3
Village of Menomonee Falls Water Utility	34,609	51	25	12	1
Milwaukee Water Works	862,524	35	25	11	6
Oak Creek Water and Sewer Utility	57,438	24	22	17	1
Racine Water Works Commission	112,564	46	23	48	7
City of Waukesha Water Utility	70,956	41	32	13	4
Wauwatosa Water Utility	46,415	54	31	4	4
West Allis Municipal Water Utility	60,398	45	28	4	6
City of West Bend Water Utility	31,480	48	20	7	5
<b>Regional Average**</b>		43	26	15	5

\* Populations served are imprecise and difficult for utilities to monitor. These numbers are the estimations provided by the water utilities to the (WPSC).

\*\* Average (by population) of all public water utilities in the SEWRPC 7-county region

<sup>26</sup> SEWRPC, A Regional Water Supply Plan for Southeastern Wisconsin, Planning Report #52, Volume 1, p. 43, p. 115, 123, p. 127 (12/2010).

The City currently treats the groundwater from some deep aquifer wells to remove radium or blends it with groundwater from shallow aquifer wells to reduce radium concentration. However, the City does not continuously meet all state and federal radium standards and is required by a state court order to do so by June 30, 2018.<sup>27</sup>

This technical review details the department's review of the Application for accuracy and compliance with the Compact<sup>28</sup> and Wisconsin Compact implementing legislation.<sup>29</sup>

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<sup>27</sup> *State of Wisconsin v. City of Waukesha*, [Case No. 2009-CX 4](#) (Wis. Cir. Ct. Waukesha Cnty. Apr. 9, 2009).

<sup>28</sup> [Compact](#) ss. 4.9.3 & 4.

<sup>29</sup> Wis. Stat. §281.346

## Water Supply Related Criteria

### S1

#### LEGAL REQUIREMENTS

Agreement/Compact: The water shall be used solely for Public Water Supply purposes of the Community within a Straddling County that is without adequate supplies of potable water. ([Compact](#) s. 4.9.3.a.; [Agreement](#) art. 201 s. 3.a.)

Wisconsin Statutes: The water diverted will be used solely for public water supply purposes in a community within a straddling county... ([Wis. Stat. § 281.346\(4\)\(e\)1.](#))

#### FINDINGS

1. The diverted water requested by the Applicant would be used solely for public water supply purposes. The Waukesha Water Utility is a public water supply system owned by the Applicant with operations oversight by the Waukesha Water Utility Commission.
2. The Applicant is without adequate supplies of potable water due to the presence of radium in the groundwater and drawdown in the deep sandstone aquifer.

#### METHOD OF ANALYSIS

The City of Waukesha's Application for a Lake Michigan Diversion with Return Flow (Application) must demonstrate that diverted water would be used solely for public water supply purposes in a community without adequate supplies of potable water. The department evaluated the Application along with technical reports and planning documents relating to the City of Waukesha and Waukesha County.

In determining whether this community has adequate supplies of potable water, the department focused on the quality and quantity of the existing water sources to the community's water supply system. Specifically, the department examined the presence of radium in the groundwater and drawdown in the deep sandstone aquifer. The evaluation for this criterion is based on the Applicant's current water supply system.<sup>30</sup>

The diversion proposal is to supply water to the designated water supply service area—a designation required by [Wis. Stat. § 281.348](#), and discussed in section [S3](#) of this technical review. The water supply service area is designated for planning purposes to ensure orderly development and management of water service.

The department reviewed technical documents, reports, plans and analyses in assessing whether the City met this criterion, including:

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<sup>30</sup> The department's analysis of whether there is a reasonable water supply alternative in the Mississippi River basin can be found in Section [S2](#).

- SEWRPC, *A Regional Water Supply Plan for Southeastern Wisconsin*, Planning Report #52, Volumes [1](#) & [2](#) (12/2010).
- SEWRPC, *A Regional Aquifer Simulation Model for Southeastern Wisconsin*, Technical Report #41 (06/2005).
- Application, [Volume 2](#), sections 3, 4, and 7.4.
- Feinstein, D.T., Hunt, R.J., and H.W. Reeves, *Regional Groundwater-Flow Model of the Lake Michigan Basin in Support of Great Lakes Basin Water Availability and Use Studies*, USGS Scientific Investigations Report 2010-5109 (2010).

## DISCUSSION

### *Background on Applicant Water Supply System*

In 2014, the Applicant withdrew a daily average of 6.6 million gallons (MG) of water. The Applicant withdrew 85 percent of that water from seven deep sandstone aquifer wells and 15 percent from three shallow aquifer wells. From the period 2010 to 2014 the Applicant withdrew a daily average of 6.7 MG, with 80 percent from the deep aquifer and 20 percent from the shallow aquifer. The Applicant’s water supply system includes two deep aquifer wells with radium treatment and a third deep aquifer well which has radium contaminated water but is blended with water from two shallow wells. The remaining four deep aquifer wells that supply water to the water system do not currently have radium treatment.

The Applicant proposes an average water supply demand (see section [S4](#) for more information) of 10.1 million gallons per day (MGD) at full build-out of the water supply service area (see section [S3](#)), around 2050. The Applicant projects the maximum day demand (MDD) at full build-out to be 16.7 MG.

#### *1. Water Supply to be used solely for public water supply purposes in the water supply service area.*

The Applicant, which operates the Waukesha Water Utility, meets the definition of a “public water supply.”<sup>31</sup> Water supplied by the Waukesha Water Utility is largely for residential purposes, but also serves commercial and industrial customers ([Table 3](#)).

**Table 3. Annual water sales for the City of Waukesha Water Utility for 2014 in millions of gallons per year (MGY).**<sup>32</sup>

Year	Annual Water Sales (MGY)				Total Sales (MGY)
	Residential	Commercial	Industrial	Public	
2014	940 45%	790 38%	271 13%	93 5%	2094 100%

<sup>31</sup> “Public water supply” means water distributed to the public through a physically connected system of treatment, storage, and distribution facilities that serve a group of largely residential customers and that may also serve industrial, commercial, and other institutional customers. [Wis. Stat. § 281.346\(1\)\(pm\)](#).

<sup>32</sup> Annual Report of Waukesha Water Utility for Year ended December 31, 2014, WPSC. Pg. W-2. [http://psc.wi.gov/pdf/annlrpts/WEGS/WEGS\\_2014\\_6240.PDF](http://psc.wi.gov/pdf/annlrpts/WEGS/WEGS_2014_6240.PDF)

The Applicant has operated the public water supply system since 1961. The City of Waukesha Water Utility and its operations are regulated by the department under Wis. Stat. §§ [280](#) and [281](#) and Wis. Admin. Code §§ NR [809](#), [810](#), and [811](#), and by the Wisconsin Public Service Commission (WPSC) under Wis. Stat. § [196](#) and Wis. Admin. Code §§ WPSC [184](#) and [185](#).

*2. The community is without adequate supplies of potable water.*

The Application lists the drawdown in the deep sandstone aquifer and the presence of radium, a known carcinogen, at concentrations above the Safe Drinking Water Act (SDWA) standards in the deep sandstone aquifer and the presence of total dissolved solids (TDS) as the rationale for being without adequate supplies of potable water. The department concludes that the presence of radium in the water supply, coupled with treatment challenges and the drawdown in the deep sandstone aquifer, result in the Applicant being without adequate supplies of potable water. However, the department does not agree with the Applicant that TDS concentrations in the water supply are excessive to a point that affects the potable nature of the water supply.

*Radium in the deep sandstone aquifer*

Radium, a known carcinogen, is a naturally occurring element in the deep sandstone aquifer in southeast Wisconsin. Levels of Total Combined Radium (Radium-226 and Radium-228) are currently elevated above the SDWA standard of 5 pCi/L in many of the Applicant's deep aquifer wells. The Applicant operates seven deep wells that are 1,650 feet deep or deeper and three shallow aquifer wells that are between 105 and 150 feet deep. The Applicant obtained approximately 80 percent of its water from the deep sandstone aquifer and approximately 20 percent of its water from the shallow sand and gravel aquifer between 2010 and 2014. The Applicant is under a court order to address the radium problem and comply with all state and federal drinking water radionuclide standards by June 30, 2018.<sup>33</sup> Specifically, to comply with this court order, water at each entry point to the water supply distribution system must be below the SDWA's maximum contaminant level (MCL) standard for radium of 5 pCi/L. In addition, under the court order, until the June 30, 2018 deadline, the Applicant is authorized to meet the federal radium standard as a system—through blending contaminated deep aquifer water with shallow aquifer water and treating some deep aquifer water—rather than meeting the radium standard at each entry point to the distribution system.

The City currently has three deep wells that pump water that is either treated to remove radium or blended with water from the shallow wells to produce water at the entry point to the distribution system that is below the radium MCL. The remaining four deep wells have no treatment and regularly exceed radium standards at its entry point to the water distribution system. The court order allows the Applicant to blend water from all its wells within the distribution system until June 30, 2018 as long as the blended system water meets the radium standard based on a 12-month running annual average. See [Figure 3](#) for radium concentrations at all entry points to the Applicant's water distribution system.

In 2014, the Applicant pumped an average of 6.6 MGD to supply its existing service area. Of this water pumped, 5.1 MGD was treated or blended before entering the water distribution system; the remaining 1.5 MGD was from deep aquifer wells with no treatment before entering the water

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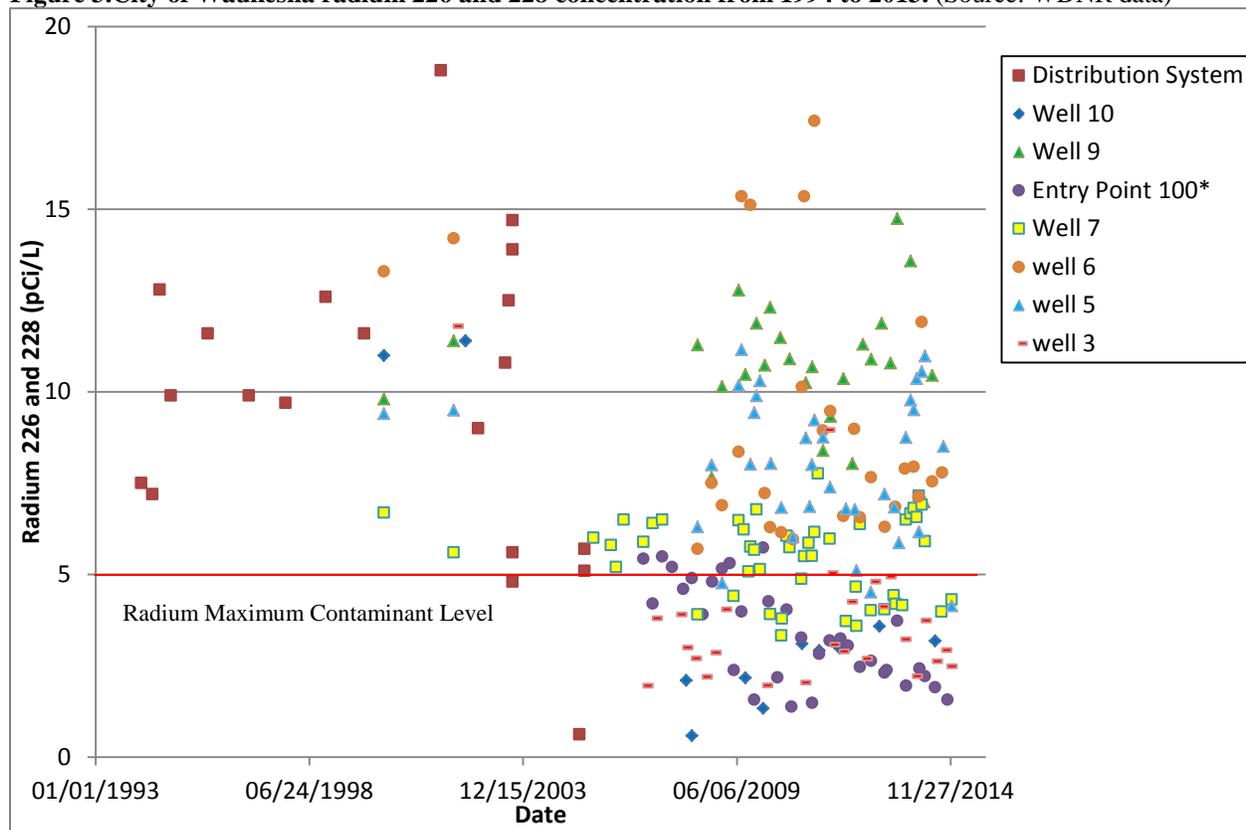
<sup>33</sup> [State of Wisconsin v. City of Waukesha, Case No. 2009-CX-4 \(Wis. Cir. Ct. Waukesha Cnty. Apr. 9, 2009\)](#)

distribution system. With the current well configuration and treatment, the Applicant cannot meet the state drinking water standards for radium as required by June 30, 2018. The Applicant’s projected water supply demand at full build-out is 8.8 to 10.1 MGD – a third more to double what the Applicant was able to pump from treated or blended sources in 2014. Consequently, the department determined that the Applicant is without adequate supplies of potable water to meet current needs.

In addition, the largest well in the Applicant’s system includes radium treatment and has a capacity of more than 3 MGD. However, this well has been out of service on several occasions over the past five years (including a 3-month period in 2011; a 3-month period in 2013; and a 4-month period in 2014)<sup>34</sup>. During these periods, there is less radium-compliant water available to the water supply system to meet the customer demand.

Finally, while water levels in the United States Geological Survey (USGS) monitoring well in the City of Waukesha are rising in the deep aquifer (see discussion in the next section), radium concentrations are still well above the radium 5 pCi/L MCL.

**Figure 3. City of Waukesha radium 226 and 228 concentration from 1994 to 2013.** (Source: WDNR data)



Wells 3 and 10 are deep aquifer wells with radium treatment that began in 2007. Entry Point 100 includes blended water from Well 8, a deep aquifer well, and Wells 11 and 12, shallow aquifer wells. Wells 5,6, and 7 are deep aquifer wells that have no treatment or blending at the entry point. The data represent the radium concentration for

<sup>34</sup> In 2011, well #10 column assembly failed and the pump fell to the bottom of the 2,000 foot well. The pump was not recoverable and required replacement. In 2013, an electrical short in the well required replacement of equipment that caused the well to be out of service from 9/24/2013 – 5/2/2014.

water entering the water distribution system, whether or not it is treated or blended. Distribution system samples are from the distribution system between 1994 and 2005.

### *Drawdown in the deep sandstone aquifer*

The City of Waukesha and Waukesha County are included in one of the two Groundwater Management Areas (GMAs) designated by the State of Wisconsin<sup>35</sup>. A Groundwater Management Area is defined as an area in which the groundwater potentiometric surface has been reduced by 150 feet or more from the level at which the potentiometric surface would be if no groundwater had been pumped.<sup>36</sup>

The USGS and Wisconsin Geological and Natural History Survey (WGNHS), developed a regional groundwater flow model to use as a tool for regional groundwater management. The model covers the seven county area of southeastern Wisconsin and includes both the shallow and deep flow systems in this region.<sup>37</sup> This 2005 model indicates the regional drawdown in year 1997 approaches 500 feet below pre-development water levels.<sup>38</sup> However, subsequent USGS groundwater flow modeling work completed in 2010 for the entire Lake Michigan Basin that includes aquifer drawdown trends in southeastern Wisconsin shows slowed water level declines and possibly some water level recovery by 2005 ([Figure 4](#)). These changes are at least partially attributable to decreases in industrial pumping.<sup>39</sup>

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<sup>35</sup> See [Wis. Admin. Code § NR 820.20 \(1\)](#).

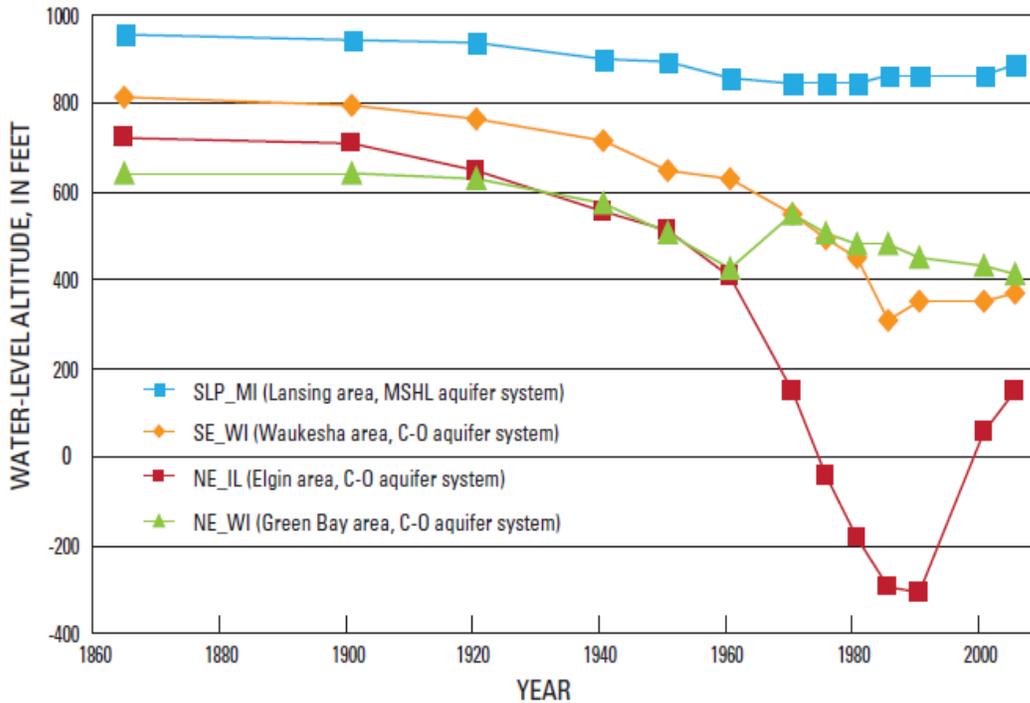
<sup>36</sup> "Groundwater management area" means a multi-jurisdictional area including towns, cities, villages and counties within which the level of the groundwater potentiometric surface in any of its underlying aquifers has been reduced by 150 feet or more from the level at which the potentiometric surface would be if no groundwater withdrawals had occurred." [Wis. Admin. Code § NR 820.12\(8\)](#).

<sup>37</sup> SEWRPC, A Regional Aquifer Simulation Model for Southeastern Wisconsin, [Report 1: Data Collection, Conceptual Model Development, Numerical Model Construction, and Model Calibration](#), Technical Report #41, p. 4 (06/2005).

<sup>38</sup> SEWRPC, Simulation of Regional Groundwater Flow in Southeastern Wisconsin, [Report 2: Model Results and Interpretation](#), Technical Report #41, p. 18 (06/2005).

<sup>39</sup> Feinstein, D.T., Hunt, R.J., and H.W. Reeves, [Regional Groundwater-Flow Model of the Lake Michigan Basin in Support of Great Lakes Basin Water Availability and Use Studies](#), USGS Scientific Investigations Report 2010-5109, p. 163 (2010).

Figure 4. The orange line shows model simulation for groundwater pumping from the Waukesha area between 1860 and 2005.<sup>40</sup>

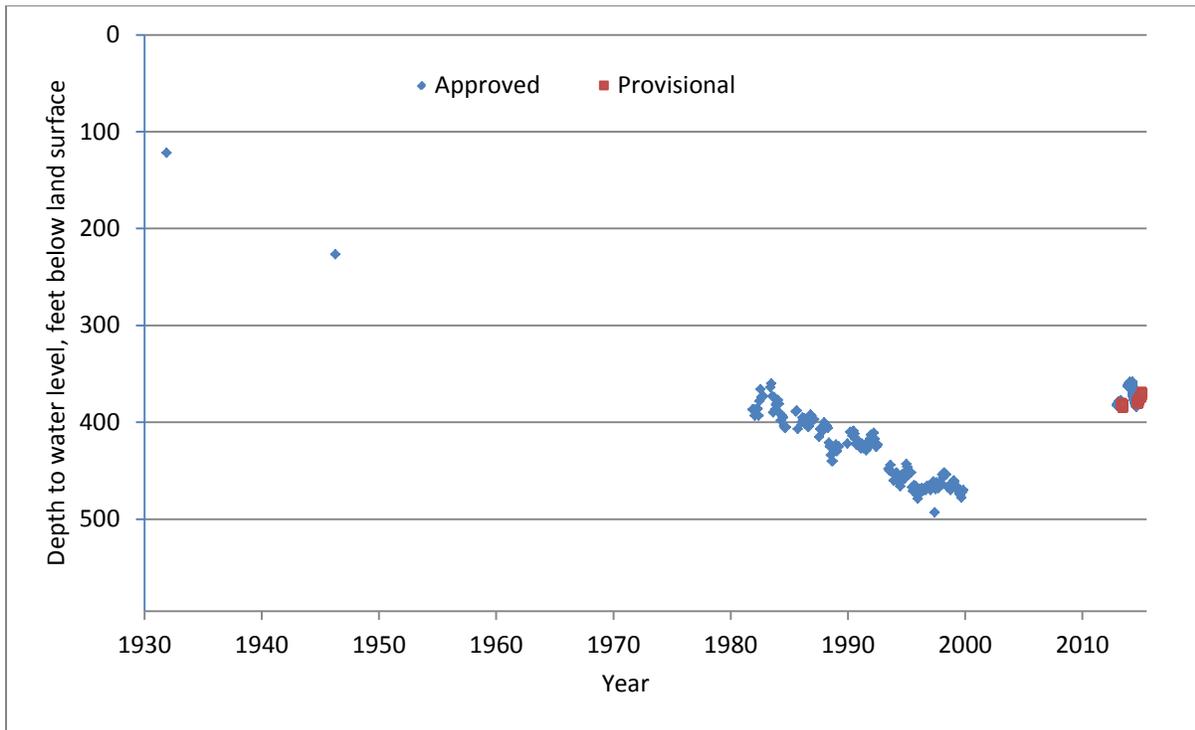


Recent USGS groundwater level monitoring network data from a monitoring well in the City of Waukesha also show that water levels in the deep sandstone aquifer have recovered by approximately 100 feet from a low in 1997.<sup>41</sup> However, these data also show that water levels are still approximately 350 feet below pre-development water levels and 200 feet below the groundwater management area threshold of 150 feet of drawdown (Figure 5).

<sup>40</sup> Figure originally published in Feinstein, D.T., Hunt, R.J., and H.W. Reeves, *Regional Groundwater-Flow Model of the Lake Michigan Basin in Support of Great Lakes Basin Water Availability and Use Studies*, USGS Scientific Investigations Report 2010-5109, p. 165 (2010).

<sup>41</sup> WGNHS, Groundwater watch Site number: 430052088133501 – WK-06/19E/02-0006, retrieved 5/10/2015 from <http://groundwaterwatch.usgs.gov/AWLSites.asp?mt=g&S=430052088133501&ncd=awl>

**Figure 5. Groundwater level data from 1932-2015 in the City of Waukesha deep sandstone aquifer (USGS monitoring site 430052088133501 - WK - 06/19E/02-0006).**

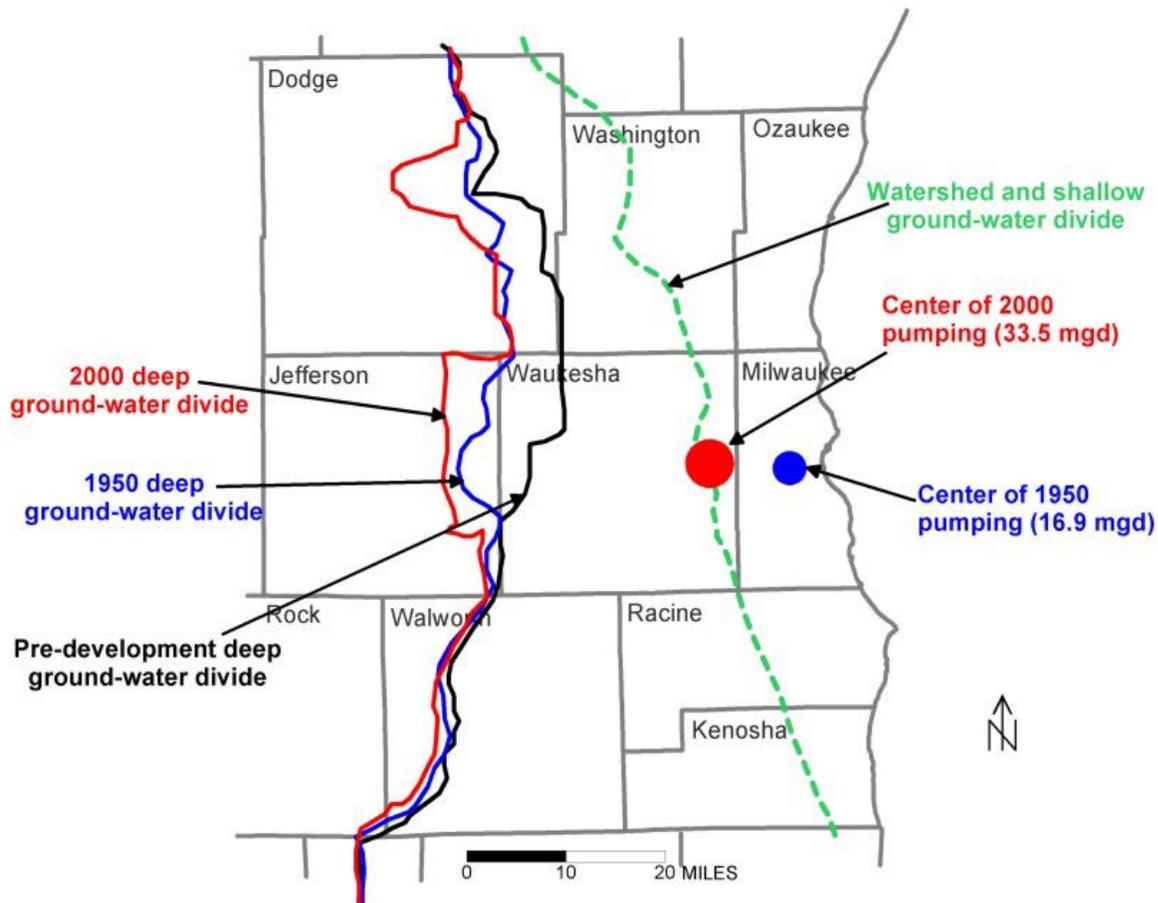


USGS and WGNHS groundwater modeling conducted in 2005 provides the following conclusions:<sup>42</sup>

- The deep aquifer major pumping center in southeastern Wisconsin has moved eight miles to the west from the City of Milwaukee to eastern Waukesha County ([Figure 6](#)).
- Groundwater is the primary source of water to wells; this water would otherwise contribute to inland surface water bodies in southeastern Wisconsin.
- Pumping of the deep aquifer in southeastern Wisconsin has resulted in the reversal of groundwater flow beneath Lake Michigan. An estimated 7 percent of the deep aquifer groundwater that would otherwise flow toward Lake Michigan flows westward and is withdrawn from deep aquifer pumping wells located in southeastern Wisconsin.
- Between 1864 and 2000, groundwater pumping resulted in an 8.5 percent reduction in the rate of direct and indirect discharge of shallow groundwater to Lake Michigan.
- Between 1864 and 2000, the groundwater divide has moved nine miles to the west from Waukesha County to Jefferson County ([Figure 6](#)).

<sup>42</sup> SEWRPC, *Simulation of Regional Groundwater Flow in Southeastern Wisconsin*, [Report 2: Model Results and Interpretation](#), Technical Report #41, pp. 1-2 (06/2005).

**Figure 6. Model results showing the movement of the groundwater divide and pumping centers in southeast Wisconsin for pre-development, 1950, and 2000 conditions.**<sup>43</sup>



The department’s review of the available information concludes that water levels in the deep aquifer are recovering to water levels similar to water levels in the early 1980s. This recovery suggests that the impacts from groundwater pumping identified in the USGS and WGNHS 2005 report are likely still present, but slightly different from the 2000 analysis as rates and locations of pumping from the deep aquifer have changed in the intervening 15 years. Further, the department concludes that groundwater drawdown of approximately 350 feet below pre-development groundwater water levels in the deep sandstone aquifer represents a significant drawdown in the deep aquifer and limits the availability of potable water supply from the deep aquifer.

*Total dissolved solids*

The Applicant indicates that total dissolved solids (TDS) levels in its water supply exceed secondary drinking water standards of 500 milligrams per liter (mg/L). These standards are aesthetic standards and, at the concentrations identified (a maximum of 1000 mg/L), the department did not consider TDS as a factor in determining if the water supply is potable.

<sup>43</sup> Figure originally published in SEWRPC, Simulation of Regional Groundwater Flow in Southeastern Wisconsin, [Report 2: Model Results and Interpretation](#), Technical Report #41, p. 56 (06/2005).

## S2

### LEGAL REQUIREMENTS

Agreement/Compact: There is no reasonable water supply alternative<sup>44</sup> within the basin in which the community is located, including conservation of existing water supplies. ([Compact](#) s. 4.9.3.d.; [Agreement](#) art. 201 s. 3.d.)

Wisconsin Statute: There is no reasonable water supply alternative<sup>45</sup> within the watershed in which the community is located, including conservation of existing water supplies ([Wis. Stat. § 281.346\(4\)\(e\)1.d.](#))

### FINDINGS

1. The City of Waukesha (Applicant) does not have a reasonable water supply alternative within the Mississippi River Basin (MRB) and the analysis of section [C1](#) demonstrates that the Applicant cannot meet water supply needs through conservation of existing supplies.
2. The department reviewed the proposed alternatives on the basis of cost, public health protection, and environmental sustainability as required under the Wisconsin statutory definition of “reasonable water supply alternative” ([Wis. Stat. § 281.346\(1\)\(ps\)](#)).
3. The Applicant reviewed six water supply alternatives in detail: four of the reviewed alternatives withdraw water exclusively from the MRB; one alternative withdraws water from a combination of MRB and Lake Michigan sources; and the final alternative withdraws water from the Lake Michigan Basin.
4. The water supply alternatives that include the MRB sources are all similar in cost to a Lake Michigan water supply assuming a  $\pm 25$  percent range of comparison.
5. Regarding public health protection, the Applicant’s current water supply does not meet the state and federal radium standards. The Applicant is under a court order to comply with the state radium standard by June 30, 2018.<sup>46</sup> The department determined that all the proposed water supply alternatives would be able to meet all state and federal public health standards (including the radium standard). The department also determined that none of the MRB alternatives is as protective of public health as the proposed Lake Michigan water source.
6. The Applicant reviewed six water supply alternatives for environmental impacts to assess whether the alternatives within the MRB are “as environmentally sustainable...and do not have greater adverse environmental impacts than the proposed new...diversion.” Based on public comments, the department reevaluated the analysis for alternatives that included the shallow aquifer using a different groundwater flow model and evaluated additional variations on the Applicant’s proposed alternatives.

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<sup>44</sup> Not defined in Compact.

<sup>45</sup> “Reasonable water supply alternative” means a water supply alternative that is similar in cost to, and as environmentally sustainable and protective of public health as, the proposed new or increased diversion and that does not have greater adverse environmental impacts than the proposed new or increased diversion. [Wis. Stat. §.281.346\(1\)\(ps\)](#)

<sup>46</sup> [State of Wisconsin vs. City of Waukesha, Case No. 2009-CX-4 \(Wis. Cir. Ct. Waukesha Cnty. Apr.9, 2009\).](#)

7. The water supply alternatives that include the MRB sources are not as environmentally sustainable and are likely to have greater adverse environmental impacts than the proposed Lake Michigan alternative due to projected impacts on wetlands and lakes.

## BACKGROUND

The [Agreement/Compact](#) and [Wis. Stat. § 281.346\(4\)\(e\)1.d.](#) require that a diversion applicant demonstrate that there is no reasonable water supply alternative within the watershed in which the community is located, including conservation of existing water supplies. The City of Waukesha (Applicant) includes in its application an initial screening and analysis of 14 water supply alternatives, including 12 within the watershed in which the Applicant’s entire water supply service area is located (the Upper MRB).<sup>47</sup> The Applicant provides further detailed analysis of six of these water supply alternatives—which include a combination of surface water and groundwater sources.

The Applicant submitted [reports](#) documenting its analysis of the water supply alternatives. Additional water supply alternative analysis is provided in technical reports and planning documents prepared by Southeastern Wisconsin Regional Planning Commission (SEWRPC),<sup>48</sup> a state-delegated areawide water quality planning agency overseeing water quality and land use planning in the southeastern portion of the state, including Waukesha County, the straddling county in which the Applicant is located. SEWRPC prepared several documents relating to water supply alternatives with contributions or co-authorship by the United States Geological Survey (USGS), the Wisconsin Geological and Natural History Survey (WGNHS), the University of Wisconsin – Milwaukee, or the University of Wisconsin – Madison.

The department applied the following three evaluation criteria to determine whether any of the proposed water supply alternatives represents a reasonable water supply alternative in the MRB:

- A. Cost** – The department considered a proposed alternative to be “similar in cost to” if the cost was within 25 percent of the Lake Michigan supply alternative. The department chose 25 percent based on documentation<sup>49</sup> that 25 percent is adequate for comparing cost proposals at a conceptual design level that are similar in scope. The department considered costs based on a 50-year present worth analysis that includes both capital costs and long-term operation and maintenance costs for each alternative. As part of the department’s analysis of costs, the department contracted with Boldt Technical Services to review the cost estimates provided by the Applicant and to analyze construction industry standards for evaluating whether construction alternatives are “similar in cost.”
- B. Public Health Protection** – The department reviewed the alternatives to determine if each alternative could meet state and federal water quality requirements. In addition, the department reviewed each alternative for its vulnerability to contamination from microbiological, inorganic, volatile organic compounds, synthetic organic compounds, and radionuclides.

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<sup>47</sup> Application, [Volume 2](#), section 11, pg. 1-7

<sup>48</sup> These reports are cited within this document as they apply to the review.

<sup>48</sup> Application, [Volume 2](#), section 11, pg. 1 -7

<sup>49</sup> Boldt Technical Services, Wisconsin Department of Natural Resources City of Waukesha Lake Michigan Water Supply Application Technical Review of the Cost Estimates (03/2012).

**C. Environmental Impact and Sustainability** –The department considered factors such as sustainability of aquifer yields, groundwater quality preservation, and the effective and efficient use of stored water in aquifers using a 20-year timeframe. The department evaluated each alternative for potentially significant adverse impacts to streams, rivers, wetlands, lakes and springs.

Finally, the analysis of criterion [S4](#) demonstrates that the amount of water requested by the Applicant is reasonable and the analysis of criterion [C1](#) demonstrates that the Applicant cannot meet water supply needs through conservation of existing supplies alone.

### **Water Supply Alternatives**

The Applicant analyzed six primary water supply alternatives in detail: four within the MRB; one that includes both a MRB water supply source and water from the Lake Michigan Basin; and lastly, the alternative preferred by the Applicant, a Lake Michigan water supply.

The six water supply alternatives analyzed in depth include (see [Figure 7](#)):

1. Deep (confined) and shallow aquifers
2. Shallow aquifer (including river bank inducement)
3. Unconfined deep aquifer
4. Multiple source alternative
  - Deep (confined) aquifer;
  - Sand and gravel shallow aquifer
  - Unconfined deep aquifer;
  - Quarries;
  - Silurian dolomite;
5. Lake Michigan and shallow aquifer
6. Lake Michigan

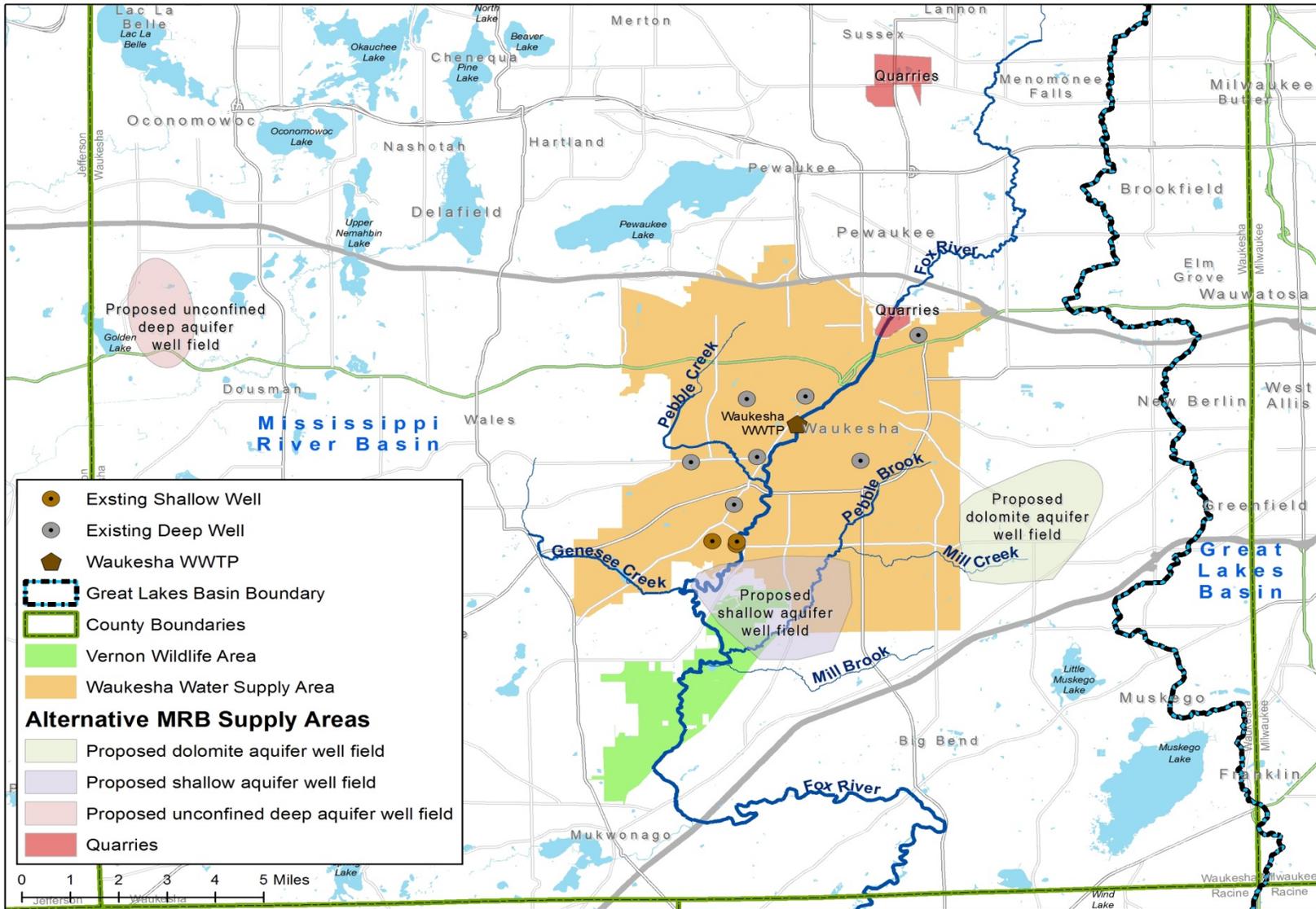
The department analyzed an additional alternative for potential environmental impacts that is a variation on Alternative 1 and is noted as Alternative 1a in the [Environmental Impacts](#) section of S2. Alternative 1a includes a water supply from deep and shallow wells, but the shallow wells are only along the Fox River to minimize impacts to sensitive streams such as Pebble Brook. The department assumed the costs and public health impacts for Alternatives 1 and 1a to be equivalent.<sup>50</sup>

Some alternatives continue to rely on parts or all of the Applicant’s existing water sources with additional wells and new water treatment methods to address water supply and water quality problems, while other alternatives identify completely new sources of water. [Table 4](#) provides a summary of these alternatives, identifying the water sources for each alternative and the planned operation for the alternative.

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<sup>50</sup> See [dEIS](#) Section 4 for additional impacts.

Figure 7. Mississippi River Basin water supply sources for water supply alternatives.



**Table 4. Summary of alternatives evaluated by the Applicant assuming a 10.1 average day demand and 16.7 maximum day demand.** <sup>51</sup>

Water Sources	ADD/MDD (MGD)	Infrastructure	Transmission	Proposed Treatment
<b>1. Deep Confined and Shallow Aquifers</b>				
Deep confined aquifer	4.5/7.6	7 existing wells	5 miles of pipeline to Hillcrest Reservoir.	Radium, total dissolved solids
Shallow aquifer	4.9/7.9	14 new wells	10 miles of pipeline to Hillcrest Reservoir	Iron, manganese, and arsenic
Shallow aquifer	0.7/1.2	3 existing wells	1 mile of pipeline to Hillcrest Reservoir.	Iron, manganese
<b>2. Shallow Aquifers</b>				
Shallow aquifer	0.7/1.2	3 existing wells	1 mile of pipeline to Hillcrest Reservoir.	Iron, manganese
River Bank Inducement	2.7/4.5	4 new wells	6 miles of pipeline to Hillcrest Reservoir.	Iron, manganese, arsenic, microbiological and surface water contaminants
Shallow aquifer	6.7/11.0	14 new wells	Same pump station and pipeline as above.	Iron, manganese, and arsenic
<b>3. Unconfined Deep Aquifer</b>				
Unconfined deep aquifer	10.1/16.7	12 new wells	12 miles of transmission line to treatment plant. 7 miles of pipeline to Hillcrest Reservoir.	Iron, manganese
<b>4. Multiple Sources</b>				
Deep confined aquifer	2.1/3.5	4 existing wells	3 miles of pipeline to Hillcrest Reservoir.	Radium, total dissolved solids
River Bank Inducement	1.5/2.5	3 new wells	10 miles of pipeline to Hillcrest Reservoir.	Iron, manganese, arsenic, microbiological and surface water contaminants
Shallow aquifer	0.9/1.5	3 existing wells	1 mile of pipeline to Hillcrest Reservoir.	Iron, manganese
Unconfined deep aquifer	2.0/3.2	3 new wells	12 miles of transmission pipeline to the water plant. Piped to Hillcrest Reservoir.	Iron, manganese
Pewaukee Quarry	0.9/1.5	2 quarries	2 miles of pipeline to a new water plant and 1 mile of pipeline to Hillcrest Reservoir.	Surface water contaminants
Lisbon Quarry	1.5/2.5	2 quarries	7 miles of pipe to a new water plant and 1 mile of pipeline to Hillcrest Reservoir.	Surface water contaminants
Silurian dolomite aquifer	1.2/2	5 new wells	2 miles of pipeline to a new water plant. Piped to Hillcrest Reservoir for blending.	Iron, manganese
<b>5. Lake Michigan and Shallow aquifer</b>				
Lake Michigan	4.5/7.6		17 miles of pipeline to Hillcrest Reservoir.	Surface water treatment by water supplier.
Shallow aquifer	4.9/7.9	12 new wells	6 miles to Hillcrest Reservoir.	Iron, manganese, and arsenic
Shallow aquifer	0.7/1.2	3 existing wells	1 mile off pipeline to Hillcrest Reservoir.	Iron, manganese
<b>6. Lake Michigan</b>				
Lake Michigan	10.1/16.7		17 miles of pipeline to Hillcrest Reservoir.	Surface water treatment by water supplier.

<sup>51</sup> Application, [Volume 2](#), section 11, p. 9 - 11.  
DRAFT JUNE 2015

## METHOD OF ANALYSIS

### **I. Water Supply Alternatives analysis process conducted by the Applicant.**

In a 2002 water study<sup>52</sup>, the Applicant evaluated 14 possible water supply sources including: deep confined aquifer, deep unconfined aquifer, shallow aquifers, dolomite aquifer, Fox River, Rock River, Lake Michigan, dam on the Fox or Rock Rivers, Waukesha Quarry, Waukesha springs, Pewaukee Lake, Milwaukee River and wastewater reuse. The Applicant narrowed these 14 sources down to four MRB options based on quantity needs, major environmental or regulatory issues, and other factors. A subsequent study completed by SEWRPC in 2010<sup>53</sup> included groundwater and surface water modeling and also screened possible water supply alternatives for the Applicant. The study concluded with a recommendation that the Applicant change from a groundwater supply to a Lake Michigan supply. Based on the evaluations completed in these and other studies, the Applicant developed the six water supply alternatives that are considered in this technical review.<sup>54</sup>

### **II. Analysis for Cost, Environmental Impacts, and Public Health**

#### A. Cost

The Wisconsin Compact implementing statute defines reasonable water supply alternative, in relevant part, as “a water supply alternative that is similar in cost to . . . the proposed new or increased diversion . . .”<sup>55</sup> The Applicant selected the City of Oak Creek as the water supplier and the Root River as the preferred return flow location in its 2013 application. The department evaluated costs for the selected alternative and compared them to the costs for the other proposed alternatives, including both water supply and return flow options for the Lake Michigan water supply alternative.

A report commissioned by the department from the Boldt Company found that the development, format and methodology of the Applicant’s cost estimates is representative of usual costs based on the conceptual stage of the project and the intended use of the cost estimate information. In addition, the Boldt report evaluated the 25 percent contingency factor the Applicant used for cost estimates and found that the alternatives would be “similar in cost to” the preferred alternative if within that 25 percent range. Boldt concluded this was within the range of standard industry practice.<sup>56</sup>

The Applicant provided revised cost estimates to reflect the daily demand of 10.1 MGD and the

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<sup>52</sup> Waukesha Water Utility, *Future Water Supply*, (3/2002).

<sup>53</sup> SEWRPC, A Regional Water Supply Plan for Southeastern Wisconsin. Planning Report #52, Volumes 1 & 2 (12/2010).

<sup>54</sup> Application, Volume 2, section 11, pg.1 –7

<sup>55</sup> Wis. Stat. § 281.346(1)(ps).

<sup>56</sup> Boldt, Wisconsin Department of Natural Resources City of Waukesha Lake Michigan Water Supply Application Technical Review of the Cost Estimates (03/2012). The analysis was based on costs from the 2010 City of Waukesha Application for Great Lakes Water; however, the department finds the conclusions applicable to the 2013 application. The Applicant developed new costs based on the same assumptions that this report evaluated.

maximum day demand of 16.7 MGD.<sup>57</sup> The following tables break down costs associated with the different proposed water supply and wastewater return alternatives. The department reviewed cost data received from the Applicant.<sup>58</sup>

**Table 5. Oak Creek Supply and Root River Return (50-year Present Worth, 6 percent).**

<b>Water Supply Alternative/Return Flow</b>	<b>50-year present worth (\$, 6 percent)</b>
Oak Creek Water Utility/Root River <sup>59</sup>	332,400,000

The costs for the MRB alternatives range from approximately \$276 million to \$407 million in terms of 50-year present worth.

All of the alternatives that include a MRB source are within 25 percent of the cost of the preferred alternative of an Oak Creek water supply and return flow to Root River, and are therefore considered to be “similar in cost”.

**Table 6. Comparison of Water Supply Alternative Costs (50-year Present Worth, 6 percent).**

<b>Alternative</b>	<b>50-year present worth (\$, 6 percent)</b>	<b>Within 25 percent of the preferred alternative cost</b>
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*	√
<b>6 - Preferred Lake Michigan Supply (Oak Creek, Return to Root)</b>	<b>332,400,000</b>	<b>249,300,000 - 415,500,000</b>
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 District)	374,800,000	√
*Does not include home water softening.		

The cost range for the Lake Michigan supply and wastewater return alternatives range from \$332.4 - \$374.8 million in terms of 50-year present worth. The cost range for the MRB alternatives is \$275.6 - \$406.9 million in terms of 50-year present worth. Given that they are within 25 percent of the cost of the Lake Michigan supply alternatives, all of the MRB

<sup>57</sup> Myers, Tony (CH2MHill) [Summary Cost Estimates](#), Message to Shaili Pfeiffer (WDNR), 15 January 2014. Email.

<sup>58</sup> Home water softening costs were removed from the Applicant’s Alternative 1 - Deep and Shallow Aquifer and Alternative 3 - Unconfined Deep Aquifer alternatives because these costs are not incurred by the Applicant. Residential water softening is assumed to be a significant source of chlorides in the City of Waukesha, see Volume 4, Appendix A, Attachment A-4 Compliance Plan to Meet Proposed Chloride Limits. Water softeners are expected to be installed in most homes in the service area – these costs would not be new costs associated with the proposed Alternative.

<sup>59</sup> Costs assume Root River return flow of 16.7 MGD and not 10.1 MGD as recommended by the department. Pipe size is not expected to change, O&M pumping costs may be slightly less.

alternatives are considered to be similar in cost to the Lake Michigan supply alternatives.

## B. Public Health

### *Introduction*

To ensure that citizens are receiving safe drinking water, the department requires that all utilities meet the drinking water quality standards outlined in state and federal law.<sup>60</sup> The Applicant's current water supply is contaminated with radium and gross alpha, two naturally occurring contaminants found in the deep sandstone aquifer in Eastern Wisconsin.<sup>61</sup> The National Academy of Sciences has concluded that long-term exposure to radium may increase the risk for bone cancer.<sup>62</sup> The Applicant must develop a permanent solution to the radium contamination problem by June 30, 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 court judgment.<sup>63</sup> Currently, the Applicant is allowed to use a temporary solution to meet the radium standard that involves treatment of some deep aquifer wells and blending with low radium shallow aquifer water to reduce overall concentration as allowed in the court judgment. However, the Applicant is not meeting the radium MCL at all entry points to the water supply system.

The department reviewed the Applicant's six proposed water supply alternatives to determine if the alternatives as proposed could meet state and federal water quality standards and, specifically, the requirements of the 2009 court judgment. The department finds that each of the alternatives as proposed could meet state and federal water quality standards. To further analyze which alternatives meet the Compact criterion that a Mississippi Basin source be "as . . . protective of public health as the proposed new . . . diversion" the department considered the potential sources of contamination to the water sources used for each alternative.

The following review provides more detail on each of the alternatives, potential public health risks, and how the alternative could meet state and federal drinking water standards.

### *Alternative 1 – Deep confined aquifer and shallow aquifer*

Alternative 1 includes the Applicant's existing well infrastructure, including: 7 existing wells drawing water from the deep confined aquifer and 3 existing wells drawing water from the shallow aquifer. Alternative 1 also adds 14 new shallow wells, water treatment for radium to several of the deep confined aquifer wells, and includes blending of shallow and deep confined aquifer water to meet state and federal radium water quality standards.<sup>64</sup>

Public health concerns for the deep confined aquifer include radium and gross alpha levels exceeding state and federal water quality standards. Alternative 1 proposes to treat the elevated radionuclide levels by using a combination of deep well treatment and blending with shallow groundwater. The Waupun Utilities and Burlington Waterworks currently use similar treatment to meet the radium standard. The Mukwonago Water Utility, Waukesha County, currently uses a

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<sup>60</sup> [Wis. Admin. Code § NR 809.50](#) and [40 C.F.R § 141.66 \(2014\)](#)

<sup>61</sup> [Groundwater Coordinating Council 2011 Report to Legislature – Radionuclides](#)

<sup>62</sup> WDNR, [Radium in Drinking Water](#), DG-008-2002 <http://dnr.wi.gov/org/water/dwg/pubs/radium.pdf>

<sup>63</sup> [State of Wisconsin vs. City of Waukesha, Case No. 2009-CX-4 \(Wis. Cir. Ct. Waukesha Cnty. Apr. 9, 2009\)](#).

<sup>64</sup> Application, [Volume. 2](#), section 11, pp. 9, 14, 20 and 21

blending approach similar to the blending proposed in this alternative.<sup>65</sup> Waukesha Water Utility has previously shut down or abandoned two deep wells due to contamination from industrial or landfill sources.

Public health concerns related to water provided from the shallow aquifer include potential arsenic contamination. The existing shallow groundwater wells do not exceed the state and federal water quality standards for arsenic, however, preliminary testing in the proposed new well field indicates arsenic is present at concentrations that exceed the state and federal water quality standards.<sup>66</sup> Volatile Organic Compound (VOC) contamination sources and Synthetic Organic Compound (SOC) contamination sources are present in the drawdown area of the proposed wells. Shallow aquifers are more readily susceptible to contamination than deep aquifers because they are closer to the surface. Shallow aquifers are commonly used in Wisconsin for water supply. The water supplies for the Pewaukee and Mukwonago Water Utilities (in Waukesha County) currently include shallow sand and gravel aquifer wells.

#### *Alternative 2 – Shallow aquifer and Fox River Alluvium*

Alternative 2 proposes to use three existing shallow wells, adds 14 new shallow wells, and adds 4 new wells along the Fox River constructed to induce flow from the Fox River into the wells. Alternative 2 would comply with the 2009 court order to address radium contamination by eliminating the use of the deep confined aquifer as a water source. Alternative 2 also includes the construction of a new treatment plant to treat all water for iron, manganese, arsenic, and microbiological contaminants associated with surface water (from the Fox River through river bank inducement).<sup>67</sup>

The public health concerns are identical to those identified in the shallow aquifer portion of Alternative 1.

Public health concerns related to drawing water from the Fox River alluvium are similar to those described for the shallow aquifer. The Fox River alluvium is part of the shallow groundwater system, but specifically adjacent to the Fox River. Additional potential contaminants include contaminants derived from the Fox River including microbiological contaminants associated with surface water. River bank inducement wells have been used in Louisville, Dayton, Des Moines, and Cedar Rapids.

#### *Alternative 3 – Unconfined Deep Aquifer*

Alternative 3 proposes 13 new wells constructed approximately 12 miles east of the City of Waukesha in the unconfined deep aquifer. Water would be conveyed to the City of Waukesha via a pipeline and treated for iron and manganese. Alternative 3 would comply with the 2009 court order by eliminating the use of the deep confined aquifer.<sup>68</sup> Radium concentrations in existing municipal wells near the proposed well field are below the radium (226+228) MCL of 5 pCi/L and do not require treatment.<sup>69</sup>

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<sup>65</sup> Note: The blending described for Alternative 1 and Mukwonago occurs before the entry point for the water.

<sup>66</sup> Davy Laboratories, 04/05/2007, See Appendix A of [Supplemental Public Health and Environmental Information on Waukesha Water Supply Alternatives](#).

<sup>67</sup> Application, [Volume. 2](#), section 11, pp. 9, 28, and 33-35

<sup>68</sup> Application, [Volume. 2](#). Section 11, pp.10, 40 and 44

<sup>69</sup> [Supplemental Public Health and Environmental Information on Waukesha Water Supply Alternatives](#), 4/28/2014, CH2MHILL.

VOC and SOC contamination sources are present in the drawdown area of the proposed wells. However, the depth of the aquifer is generally protective of surface induced contamination and the unconfined deep aquifer in western Waukesha County generally has lower concentrations of radium (226+228) than those found in the confined portion of the aquifer.<sup>70</sup>

#### *Alternative 4 – Multiple Sources*

Alternative 4 combines water from 5 different water sources primarily to minimize the environmental impacts. These sources include: 4 of the existing wells in the deep confined aquifer, 3 existing wells in the shallow aquifer, 5 new wells in the Fox River alluvium, 4 quarries north of the City of Waukesha, 5 new wells in the unconfined deep aquifer west of the City of Waukesha, and 4 new wells in the Silurian Dolomite southwest of the City of Waukesha. Water from these various sources would be conveyed to the City of Waukesha via pipelines, treated, and blended. Alternative 4 would comply with the 2009 court order to address radium contamination by removing radium through treatment and blending water from the deep aquifer with other water sources at the Hillcrest Reservoir.

Public health concerns for this alternative are identical to those identified in alternatives 1, 2, and 3 for the deep unconfined aquifer, shallow aquifer, Fox River alluvium, and unconfined deep aquifer. This alternative also includes two quarries. There are no water utilities in Wisconsin that withdraw water directly from a quarry. Surface water can be contaminated by spills, stormwater runoff and bacteria. These issues can be addressed through treatment. Public health concerns for the Silurian dolomite aquifer include fracture flow through horizontal and vertical fractures that can rapidly transmit contaminants that enter the aquifer. The Brookfield Public Water Utility currently uses Silurian dolomite wells as part of its water supply.

#### *Alternative 5 – Lake Michigan and Shallow Aquifer*

Alternative 5 uses a combination of Lake Michigan water supplied through Oak Creek, three existing shallow wells, and adds 14 new shallow wells as described in Alternative 1. Alternative 5 would comply with the 2009 court order by eliminating the use of the deep confined aquifer as a water source. Alternative 5 includes the construction of a new treatment plant to treat all water for iron, manganese and arsenic. A pipeline from the Oak Creek Utility would convey water to the City of Waukesha and water from the shallow aquifer and Lake Michigan would be blended.<sup>71</sup>

The public health concerns and resolutions are identical to those identified in the shallow aquifer portion of Alternative 1.

Microbiological contamination is a major concern for surface water intakes. The 1993 *Cryptosporidium spp.* outbreak in Milwaukee is an example of microbiological contamination associated with surface water.<sup>72</sup> However, since the *Cryptosporidium spp.* outbreak in Milwaukee, water utilities in Wisconsin withdrawing water from surface water have changed

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<sup>70</sup> Grundl, T., Cape, M. 2006. *Geochemical factors controlling radium activity in a sandstone aquifer*. Ground Water 44(4):518-527.

<sup>71</sup> Application, [Volume 2](#), section pp. 9, 36 and 38

<sup>72</sup>In 1993 flooding introduced *Cryptosporidium*, a protozoan parasite, into Milwaukee's drinking water system. The outbreak affected about 400,000, hospitalized 4,000 and killed 111.

treatment practices. Currently, Lake Michigan drinking water is treated to remove 99.99 percent of all microbiological contaminants. The Oak Creek Utility<sup>73</sup> treatment facilities provide water quality that exceeds the state and federal water quality requirements. Waterbodies the size and volume of Lake Michigan are generally a high quality water source because contaminants that can enter the waterbody are diluted. The water intake structures for the Oak Creek Water Utility are located more than a mile offshore at depths greater than 30 feet. Lake Michigan supplies the drinking water for approximately 1.6 million Wisconsin residents.

#### *Alternative 6 – Lake Michigan*

Alternative 6 uses Lake Michigan water supplied by Oak Creek Public Water Utility. Alternative 6 complies with the 2009 court order by eliminating the use of the deep confined aquifer as a water source. Water would be transmitted to the City of Waukesha via a pipeline. The public health concerns and resolutions for a Lake Michigan water supply are identical to those identified for Lake Michigan in Alternative 5.

#### *Summary – Drinking Water Quality*

As proposed, each of the water supply alternatives is planned with appropriate treatment to comply with the 2009 court order and meet all other state and federal water quality requirements.

#### *Review for “as protective of public health”*

[Table 7](#) identifies the potential contaminant sources for each alternative that the department used to evaluate the alternative’s degree of public health protection. At the department’s request, the Applicant identified the potential sources of contamination for each alternative by determining the presence of the contaminant, or a facility that uses the potential contaminant, within a one-foot drawdown contour of the water supply wells, or within 1 mile of a surface water intake. Treatment options are available (and used in Wisconsin) for each of these different types of contamination listed in the table. Noting a source of contamination near a public water supply well or surface water intake only indicates the presence of a potential contaminant, but does not address the likelihood of the well or surface water source being contaminated.

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<sup>73</sup> Milwaukee Water Works and Racine Public Water Utility were also considered as possible water supply alternatives.

**Table 7. Potential contaminant sources to proposed Water Supply Alternatives. Each contaminant type is listed with examples below in parentheses.**<sup>74</sup>

<b>Water Supply Alternative</b>	<b>Micro-biological</b> (pathogenic bacteria)	<b>Inorganic</b> (nitrate, arsenic)	<b>Volatile Organic Compounds</b> (gasoline, solvents)	<b>Synthetic Organic Compounds</b> (herbicides, pesticides)	<b>Radio-nuclides</b> (radium, gross alpha)	<b>Contaminants of Emerging Concern*</b>
1) Deep/ Shallow Aquifers	√	√ (Arsenic)	√	√	√	√
2) Shallow Aquifer	√	√ (Arsenic)	√	√		√
3) Unconfined Deep Aquifer	√		√	√		√
4) Multiple Sources	√	√ (Arsenic)	√	√		√
5) Lake Michigan and Shallow Aquifer	√	√ (Arsenic)	√	√		√
6) Lake Michigan	√					√

\*(e.g. pathogens, pharmaceuticals, personal care products, chromium 6, perchlorate)

As [Table 7](#) indicates, all water supplies are susceptible to microbiological contamination and therefore each of the proposed alternatives includes treatment to address potential microbiological contamination. Alternatives that include a surface water supply have increased levels of microbiological treatment to address the increased potential risk from surface water sources.

[Table 7](#) indicates that proposed alternatives that include the shallow aquifer are vulnerable to the widest variety of contaminants including nitrates, volatile organic compounds, and synthetic organic compounds.

Due to the depth of the unconfined deep aquifer in western Waukesha County, it has fewer potential contaminant sources and types than the shallow aquifers.

Finally, due to the volume of water in Lake Michigan and the water intake pipe's distance offshore, the Lake Michigan alternative is the least vulnerable of the proposed water supply alternatives to contamination. While all of the alternatives can meet state and federal drinking water quality requirements, none of the other alternatives is more protective of public health than the Lake Michigan water supply alternative.

<sup>74</sup> CH2MHILL, [Supplemental Public Health and Environmental Information on Waukesha Water Supply Alternatives](#), 4/28/2014,

## C. Environmental Impacts

### *Introduction*

The department evaluated the water supply alternatives based on information contained in the Application and appendices, supplemental information from the Applicant provided at the department's request, local and regional studies, technical reports, planning documents, and public comments.

The department also used the USGS Upper Fox River Watershed groundwater flow model<sup>75</sup> to evaluate the environmental impacts of the water supply alternatives that propose to use the shallow aquifer south of the City of Waukesha. The department considered impacts to water resources including streams, rivers, wetlands, springs, and lakes for the environmental impacts review. A summary of the department's groundwater flow modeling assessment of environmental impacts is included in [Appendix A](#)<sup>76</sup>

The Applicant used the SEWRPC regional groundwater flow model<sup>77</sup> to evaluate the potential impacts of using the deep unconfined aquifer as presented in Alternative 3 – Deep Unconfined Aquifer and Alternative 5 – Multiple Sources alternative. The department reviewed the following modeling reports in reviewing these alternatives:

- [Report on groundwater flow modeling – RJN Environmental Services, LLC. 08/2013](#)
- [Report on groundwater flow modeling – RJN Environmental Services, LLC. 7/2013](#)
- [Summary of Groundwater Modeling Study – RJN Environmental Services, LLC. 02/2011](#) (see Attachment WS7 – Unconfined Deep Aquifer Water Supply Evaluation to the 2/2011 document)

The department's review of environmental impacts for this criterion followed a three step process.

1) *Review of Application and groundwater flow modeling.*

The department reviewed the information provided by the Applicant. The department also conducted additional groundwater flow modeling for select proposed water supply alternatives. The department then estimated environmental impacts to streams, rivers, wetlands, springs, and lakes from the Applicant's proposed alternatives and the department-constructed modified alternative.

2) *Comparison of impacts of Mississippi River Basin alternatives to the Lake Michigan alternative.*

Wisconsin's definition of a "reasonable water supply alternative"<sup>78</sup> requires the department to consider if a proposed alternative in the MRB is "as environmentally sustainable... as the

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<sup>75</sup> SEWRPC, [A Regional Aquifer Simulation Model for Southeastern Wisconsin](#), Technical Report #41 (06/2005).

<sup>76</sup> Note that this model is actually two models using two different interpretations of the geology with the intent of bounding the uncertainty of the actual geology in the model domain. The results from these model scenarios are presented as a range of predicted environmental impacts.

<sup>77</sup> SEWRPC, [A Regional Aquifer Simulation Model for Southeastern Wisconsin](#), Technical Report #41 (06/2005).

<sup>78</sup> See [Wis. Stat. s. 281.346 \(1\) \(ps\)](#). "[r]easonable water supply alternative means a water supply alternative that is similar in cost to, and as environmentally sustainable and protective of public health as, the proposed new or

proposed new....diversion...” The department compared the potential environmental impacts on the various water resources that would result from the proposed MRB water supply alternatives to the potential environmental impacts from the preferred Lake Michigan water supply alternative (Oak Creek Water Utility).

3) *Analysis for potential adverse environmental impacts for each alternative.*

This analysis provides context for potential adverse environmental impacts of the proposed water supply alternatives. Wetlands and lakes are most affected by the proposed alternatives and are therefore the focus of this part of the analysis. The department also reviewed the alternatives for potential adverse environmental impacts to streams, and the results of this analysis are included in Appendix A.

a) *Wetlands*

The department assessed potential adverse environmental impact to wetlands from groundwater withdrawals by identifying the number of acres of wetlands in each wetland classification in the one-foot drawdown contour<sup>79</sup>. Wisconsin wetlands are classified<sup>80</sup> by wetland plant communities and hydrologic characteristics. Wetlands that are well connected to groundwater whose hydrological regime is characterized by saturated soil and temporary inundation that experience a one-foot or greater drawdown in the water table would be impacted by this change in water level. This drawdown also increases the wetland’s vulnerability to domination by invasive plant species and a poses a moderate-to-high probability that they would become non-wetlands.<sup>81</sup> These wetlands are identified in the Wisconsin Wetland Inventory by a “K” hydrologic modifier. Wetlands well connected to groundwater with saturated soil and prolonged inundation (H, L, or R hydrologic modifier) may be affected to a lesser extent, with a strong possibility for shifts in plant community, but a lower probability that they would become non-wetlands. Shifts in plant community would have concomitant negative impacts on associated fish and aquatic life and wildlife habitat.<sup>82</sup>

Wetlands may be impacted by drawdowns of less than one foot; however, for projects at this scale, the department regularly uses one-foot or greater of drawdown in the water table as a screening criteria for further investigating potential impacts to wetlands.

b) *Lakes*

The department assessed potential adverse environmental impact to lakes from groundwater withdrawals by estimating lake level reductions and decreases to groundwater discharges to the lake. Lake bathymetry, connectivity to wetlands, and lake classification (e.g. seepage, drainage, stratification status) are evaluated as part of the

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increased diversion and that does not have greater adverse environmental impacts than the proposed new or increased diversion.”

<sup>79</sup> Drawdown of the aquifer can occur when water withdrawals from wells lower the water table. The one-foot drawdown contour is the areal extent of the water table that is one foot lower than where the water table would be without the water withdrawal.

<sup>80</sup> WDNR. 1992. [Wisconsin Wetland Classification Guide](#). Publ-WZ-WZ023.

<sup>81</sup> See Wakeley, J.S. 2002 “[Developing a ‘Regionalized’ Version of the Corps of Engineers Wetlands Delineation Manual: Issue and Recommendations](#)” ACOE. And ACOE. 2012 “[Wetlands Regulatory Assistance Program Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region](#)”. Version 2.

<sup>82</sup> WDNR. [WDNR Wetland Rapid Assessment Methodology – User Guidance Document, version 2.0](#) (3/2014)

review. These factors are the primary variables that would impact the lake aquatic biology, fish and wildlife habitat and water quality. Lakes within the cone of depression of the water table are further investigated for potential environmental impacts. Seepage lakes, those without an inlet or outlet, are most likely to be impacted by groundwater depletion. Lakes with extensive shallow areas, vegetated littoral zones that drop off quickly to deep water and connections to wetlands are most susceptible to environmental impacts from decreases in lake level. The department regularly uses the cone of depression and lake classification as screening criteria for further investigation of potential impacts to lakes.

c) *Rivers and Streams*

The department assessed the potential adverse environmental impacts to rivers and streams by determining the modeled baseflow reduction for each river or stream potentially affected by the groundwater withdrawal. The percentage flow reductions were then compared to allowable flow reductions used in the Michigan Water Withdrawal Assessment Tool and generated by the Ecological Limits of Hydrologic Alteration in Wisconsin Streams models which the department has used as screening tools to predict impacts to streams during low flow conditions<sup>83</sup>. Please see [Appendix A](#) for a full description of these models and the stream and river baseflow depletion analysis.<sup>84</sup>

*Water Supply Demand*

For the review of potential adverse environmental impacts associated with the water supply alternatives', the department reviewed the alternatives at a demand rate rounded to 8.5 MGD<sup>85</sup> for modeling purposes—lower than the Application request of 10.1 MGD. This demand is the low end of the range presented by the Applicant ([S4](#)). The department chose this low end of the demand range to be conservative in reviewing for potential adverse environmental impacts. The rationale was that if the water supply alternatives do not prove to be “reasonable” from an environmental impacts perspective at the low end of the demand range, they would not be reasonable at the requested demand of 10.1 MGD.

DISCUSSION

*Overview*

The department focused the analysis on surface water impacts from alternatives that use the shallow aquifer south of the City of Waukesha and the unconfined deep aquifer west of the City of Waukesha. These reviews examined impacts to surface waters including streams, rivers, lakes, wetlands and springs. The review does not provide a detailed analysis for all surface water types for all alternatives. Department staff conducted an initial screening for potential impacts and then conducted a more thorough investigation for water resources that would likely be adversely impacted by implementing the proposed alternative.

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<sup>83</sup> Diebel, M., A. Ruesch, D. Menuz, J. Stewart, and S. Westenbroek.. [Ecological Limits of Hydrologic Alteration in Wisconsin Streams](#). 2014

<sup>84</sup> See [dEIS](#) Section 4 for additional impacts to water quality, flora and fauna.

<sup>85</sup> The low end of the Applicant’s proposed demand range was 8.8 MGD. To make a conservative assumption in the model, the department rounded the demand modeled down to the nearest 0.5 MGD.

The conclusion of the department’s review is that none of the proposed water supply alternatives is “as environmentally sustainable... as the proposed new...diversion...”, and therefore, the proposed water supply alternatives are not reasonable water supply alternatives.

**Table 8. Summary of alternatives and status as a reasonable water supply alternative.**

<b>Sources of Water Supply</b>		
<b>Alternative</b>	<b>Water Supply (MGD)</b>	<b>Reasonable Water Supply Alternative?</b>
1	4 (Shallow Aquifer) 4.5 (Deep Aquifer, confined)	No, based on impacts to wetlands in the shallow aquifer
1a	4 (Shallow Aquifer) 4.5 (Deep Aquifer, confined)	No, based on impacts to wetlands in the shallow aquifer
2	8.5 (Shallow Aquifer)	No, based on impacts to wetlands in the shallow aquifer
3	8.5 (Deep Aquifer, unconfined)	No, based on impacts to lakes near the proposed well field in deep unconfined aquifer
4	3.2 (Deep Aquifer, confined) 2.1 (Shallow Aquifer) 2 (Deep Aquifer, unconfined) 1.2 (Shallow Aquifer, Silurian Dolomite)	No, based on impacts to wetlands in the shallow aquifer
5	4 (Shallow Aquifer) 4.5 (Lake Michigan)	No, based on impacts to wetlands in the shallow aquifer
6	8.5 (Lake Michigan)	Proposed Diversion

The department considered seven water supply alternatives in this analysis. Many of the alternatives include the same sources, but vary the amounts of the total water withdrawal taken from a given source. [Table 9](#) provides a review of the proposed alternatives and the water supply sources used in each alternative when configured for an 8.5 MGD water demand. See [Figure 7](#) for a map of MRB water supply sources.

**Table 9. Proposed alternatives and water supply volume (MGD) from each source.**

<b>Alternative</b>	<b>Shallow Aquifer (Sand and Gravel)</b>	<b>Deep Aquifer (Confined)</b>	<b>Deep Aquifer (Unconfined)</b>	<b>Lake Michigan</b>	<b>Shallow Aquifer (Silurian Dolomite)</b>
1	4*	4.5			
1a	4**	4.5			
2	8.5*				
3			8.5		
4	3.2**	2.1	2		1.2
5	4			4.5	
6				8.5	
*Wells adjacent to the Fox River and Pebble Brook					
**Wells adjacent to the Fox River only					

**Deep Confined Aquifer**

This aquifer is a source in three of the alternatives reviewed (Alternatives 1, 1a, 4), with the amount of water supplied ranging from 2.1 MGD to 4.5 MGD. Historically, this aquifer has been the Applicant’s exclusive water supply source until 2006, when the Applicant began adding

several shallow aquifer wells and blending water from the deep aquifer with shallow aquifer water in its distribution system. The Applicant has cited deep confined aquifer depletion and radium contamination as primary reasons for the diversion application.<sup>86</sup>

The alternatives that include the deep confined aquifer as a source include full treatment for radium and would meet the state and federal drinking water standards as proposed and discussed in the public health section above. The deep confined aquifer has been drawn down significantly over the last 50 years. By 2000, this aquifer was approximately 500 feet below predevelopment water levels. Since 2000, the aquifer has recovered approximately 100 - 150 feet (see [S1](#) for further discussion). However, the drawdown is still hundreds of feet in excess of the 150 foot threshold for designation as a groundwater management area per [Wis. Admin. Code § NR 820](#). The Applicant pumped an average of 5.4 MGD from the deep aquifer between 2010 and 2014. Presumably, water levels would continue to rise at the proposed pumping rates in Alternatives 1, 1a and 4, as they are lower than the current withdrawal rate from the deep confined aquifer, but water levels would not rise as rapidly as they would if this aquifer were not used for the Applicant's water supply. The Applicant reports expected water level recoveries in the deep aquifer of between 100 feet and 270 feet from several studies that include the elimination of deep aquifer pumping by Waukesha and other communities. The deep confined aquifer water supply does not meet the criterion of being "as environmentally sustainable... as the proposed new... diversion ... ." The proposed diversion would result in the Applicant's discontinuation of pumping from the deep confined aquifer that would result in the fastest rate of recovery for this aquifer and therefore would be more environmentally sustainable.

### **Shallow Aquifer System – Sand and Gravel Aquifer**

The shallow aquifer consists of unconsolidated sediments (clay, sand and gravel) overlaying Silurian dolomite. The sand and gravel aquifer is a water supply source in five of the alternatives reviewed (Alternatives 1, 1a, 2, 4, and 5), with the amount of water supplied by the sand and gravel aquifer ranging in volume from 3.2 MGD to 8.5 MGD. Currently the Applicant has three existing wells in the sand and gravel aquifer and has purchased additional land for potential future wells. The five alternatives that use this aquifer are configured in different ways – varying the withdrawal volume and well location to determine whether this aquifer is a potential source while meeting the requirement that it be "as environmentally sustainable ... as the proposed new ... diversion ... ." From its review, however, the department determines that none of the sand and gravel aquifer alternatives meets this requirement and therefore none of these alternatives is a reasonable water supply alternative to the Lake Michigan Water Supply Alternative. Each of the sand and gravel alternatives would adversely impacts hundreds of acres of wetlands, and several of the alternatives also show potential adverse environmental impacts to Pebble Brook and the Fox River.

### **Wetlands**

#### *Vernon Marsh and Fox River Corridor Environmental Impacts from Alternatives 1, 1a, 2, 4, and 5*

Wetlands that are supported by groundwater are expected to experience impacts from long-term reductions of groundwater levels of one foot or greater, and may experience impacts at lower

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<sup>86</sup>Application. [Volume 1](#). P. 2-3

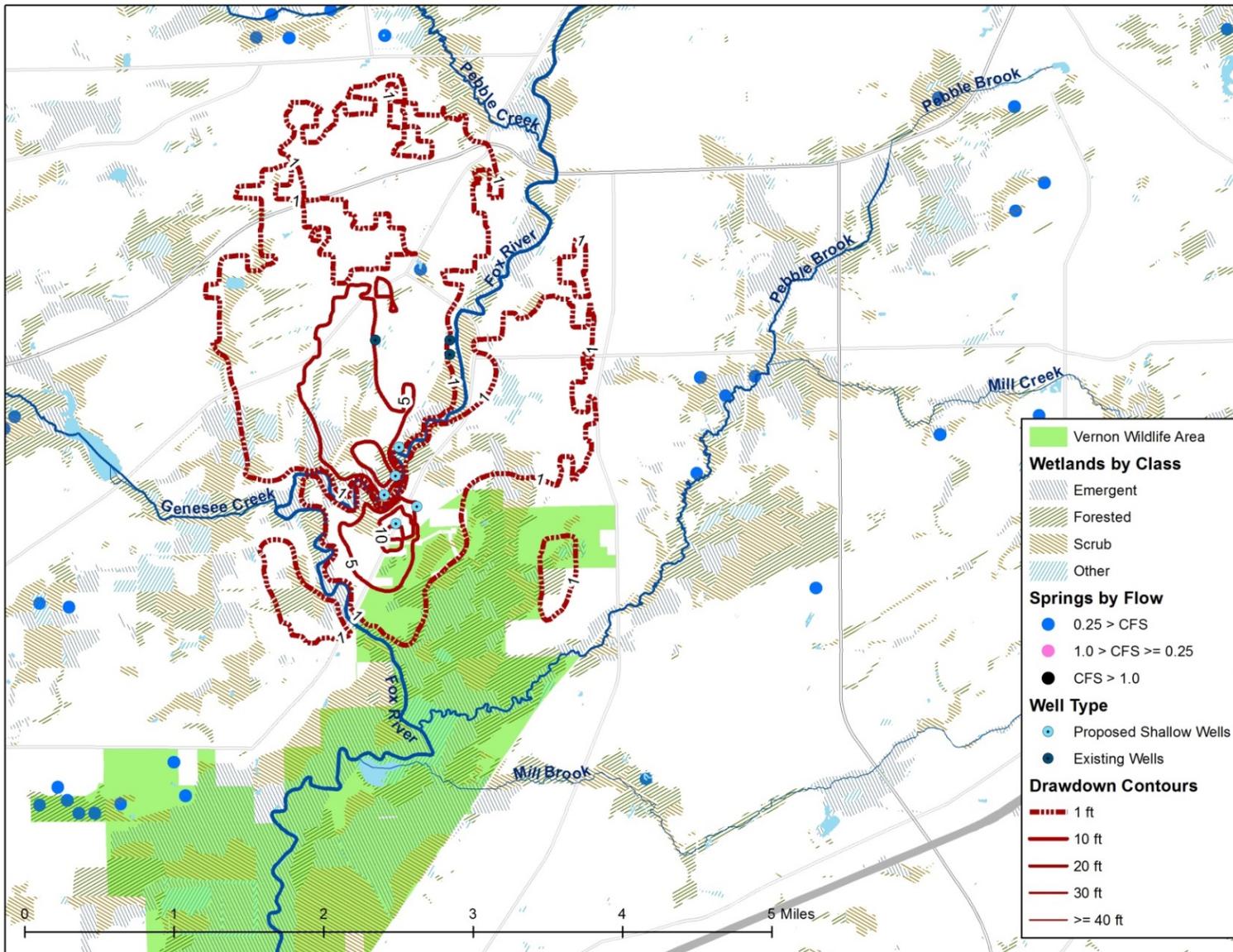
levels of groundwater depletion. The projected impacts would vary by wetland type with expected shifts in plant species composition and community type. Wetland classifications characterized by wet soils with temporary inundation (in contrast to prolonged standing water for much of the growing season) are highly vulnerable to becoming non-wetlands with groundwater drawdowns of greater than one-foot.<sup>87</sup> [Table 10](#) provides a general overview of the estimated acres of wetlands in the one-foot drawdown contour for each of the alternatives with a sand and gravel aquifer water supply component. Alternatives are combined if the well configuration and withdrawal volume are identical. [Figure 8](#) indicates the groundwater drawdown and the locations of impacted wetlands.

**Table 10. Acres of wetlands modeled in the 1-foot drawdown contour.**

<b>Alternative</b>	<b>Wetland acres in the modeled one-foot drawdown contour</b>
1 – Deep and Shallow Aquifers 5 – Lake Michigan and Shallow Aquifers	910 - 1036
1a – Deep and Shallow Aquifers (Fox River wells only)	804 - 1069
2 – Shallow Aquifers	1939 - 2326
4 – Multiple Sources	713 - 893
6 – Lake Michigan*	5
*The Lake Michigan Oak Creek/Root River alternative is provided here for comparison. This alternative does not impact wetlands in the Vernon Marsh, but would result in impacts to wetlands along the pipeline route.	

<sup>87</sup> See discussion in [S1](#).

Figure 8. Water table drawdown map for Alternative 4 - multiple sources alternative using coarse-favor model.



*Review of potential adverse impacts to wetlands from the alternative with the least impact*

The department conducted a more detailed review of the potential adverse environmental impacts to wetlands from the alternative with the fewest acres of wetlands in the one-foot drawdown contour – Alternative 4 – Multiple Sources. The other water supply alternatives would impact wetlands to this degree or greater. [Table 11](#) presents a detailed review of wetland acres impacted by wetland classification for this alternative. The subsequent discussion in this section only addresses Alternative 4, however, the general concepts apply to any of the alternatives that use the sand and gravel aquifer.

**Table 11. Wetland acres in the modeled 1-foot drawdown contour by wetland classification for Alternative 4.**

Wetland Classification	Wetlands (acres)
Open Water	32
Flats/Vegetated - wet soil, shorter duration of standing water	26
Emergent/Wet meadow – prolonged standing water	24
Emergent/Wet meadow – wet soil, shorter duration standing water	126
Scrub/shrub – prolonged standing water	36
Scrub/shrub – wet soil, shorter duration standing water	246
Forested – wet soil, shorter duration standing water	223

Note: Shaded rows indicate wetland classifications that are most likely to become uplands with a one-foot drawdown or greater.

All wetlands that are well connected to groundwater lying within the one-foot drawdown contour would be impacted by the water table lowering and could shift wetland classification to drier wetland plant communities. Generally, the Wisconsin Wetland Inventory uses four hydrologic categories, three of which indicate semi-permanent to permanent standing water or flowing water;<sup>88</sup> and one that indicates saturated soil with no prolonged period of standing water.<sup>89</sup> Wetlands with prolonged standing water are less vulnerable to becoming uplands (i.e. non-wetlands), however they are still vulnerable to shifts in plant communities and wetland classification. Wetlands with saturated soil and temporary inundation may also experience shifts in plant communities and are most vulnerable to becoming uplands. For the alternative presented in [Table 11](#), 621 acres of these wetlands are in classifications that are most vulnerable to becoming uplands with a one-foot or more water table drawdown contour. A review of reports and surveys<sup>90</sup> for the impacted area identified two natural areas of local significance in the one-foot drawdown contour: the Fox River Woods with dry-mesic to wet-mesic woodlands; and the Vernon Mesic Prairie. The wet-mesic areas of the Fox River Woods would be expected to be impacted by a drawdown to the water table, possibly converting to uplands. Similarly, the Vernon Mesic Prairie includes wet-mesic prairie and sedge meadow – both of which would be expected to experience plant community shifts, increased vulnerability to invasive plant species and possible conversion to non-wetland from a one-foot drawdown or less.<sup>91</sup> Shifts in the plant

<sup>88</sup> In the Wisconsin Wetland Inventory these codes are L - standing water, Lake; R - flowing water, River; and H - standing water Palustrine)

<sup>89</sup> In the Wisconsin Wetland Inventory this code is K - wet soil, Palustrine

<sup>90</sup> SEWRPC, Personal communication Jennifer Dietl, CA737-141, CA737-253, and CA783-36. 3/17/2015.

<sup>91</sup> SEWRPC, 1997, [A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeast Wisconsin](#). Planning Report Number 42.

community would have concomitant negative impacts on associated fish and aquatic life and wildlife habitat quality. Additional information on and evaluation of environmental impacts to wetlands in the Vernon Marsh and Fox River is available in the draft environmental impact statement ([dEIS](#)).<sup>92</sup> Based on the determination of the potential for hundreds of acres of wetlands to be impacted by the least impactful alternative using the sand and gravel aquifer, the predicted connection of wetlands to groundwater, the presence of high quality wetlands, and the presence of wetlands impacted by invasive species (exacerbating potential for wetland to upland conversion), the department finds that none of the sand and gravel aquifer alternatives is a reasonable water supply alternative.

### **Impacts to other surface water resources**

The department also analyzed the alternatives that use the sand and gravel aquifer for impacts to other surface water resources. The department calculated baseflow reductions for Pebble Brook, Pebble Creek, Mill Creek, Genesee Creek and the Fox River. For baseflow depletion in Pebble Brook, Alternative 1 – Deep and Shallow Aquifers, Alternative 2 – Shallow Aquifer, and Alternative 5 – Lake Michigan and Shallow Aquifer, modeling results predicted depletions of 18 to 19 percent, 36 to 39 percent, and 18 to 19 percent, respectively.<sup>93</sup> By comparison, groundwater flow modeling predicted the baseflow depletion in Pebble Brook for Alternative 1a – the department-modified Deep and Shallow Aquifers, and Alternative 4 – Multiple Sources, to be 2 to 3 percent.<sup>94</sup> (See [Appendix A](#) for details of the department review of baseflow reductions). There are 1-3 springs with a flow of less than 0.25 cubic feet per second (cfs) identified in the Wisconsin Springs Survey<sup>95</sup> within the one-foot drawdown contour for all of the sand and gravel aquifer alternatives. Further information on potential impacts to springs is available in the [dEIS](#).<sup>96</sup> No lakes are present in the one-foot drawdown contour of the sand and gravel aquifer alternatives.

### **Shallow Aquifer – Silurian Dolomite**

The lower unit of the shallow aquifer is Silurian dolomite. This aquifer is used regionally for domestic, public, and industrial water supply<sup>97</sup>. Alternative 4 uses the Silurian dolomite aquifer for 1.2 MGD of the water supply, siting wells southeast of the City of Waukesha. It is difficult to site productive wells in the Silurian dolomite aquifer because the water supply from this aquifer comes from fractures. Alternative 4 proposes five wells spread over a large area with withdrawal capacity of 0.5 MGD each. Impacts from these wells to the water table would presumably be small based on the relatively small amount of water withdrawn over a large area, however, these impacts were not modeled by the Applicant. The department did not conduct further analysis because it previously determined that Alternative 4 was unreasonable due to the potential adverse environmental impacts from pumping from the sand and gravel portion of the shallow aquifer.

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<sup>92</sup> See the [dEIS](#) Section 4.

<sup>93</sup> Note: These alternatives includes wells directly along Pebble Brook.

<sup>94</sup> Note: These alternatives do not include wells directly along Pebble Brook.

<sup>95</sup> Macholl, J.A. 2007, [Inventory of Wisconsin's Springs](#). WGNHS. WOFR2007-03.

<sup>96</sup> See the [dEIS](#) Section 4.

<sup>97</sup> SEWRPC 2010. [A Regional Water Supply Plan for Southeastern Wisconsin](#). Planning Report Number 52.

### **Deep Unconfined Aquifer – West of City of Waukesha**

Alternatives 3 and 4 use a well field in the deep unconfined aquifer 10-12 miles west of the City of Waukesha near the Cities of Oconomowoc and Delafield and the Village of Dousman. In Alternative 3, the entire water supply would come from the deep unconfined aquifer. In Alternative 4 – Multiple Sources, 2 MGD of the total supply would come from the deep unconfined aquifer. However, Alternative 4 is not discussed further in this section for two reasons: the level of detail in the groundwater flow model is not sufficient to reach conclusions regarding the potential environmental impacts to surface waters at the 2 MGD withdrawal rate; and the results for Alternative 4 suggest that there may or may not be environmental impacts to surface water features, but further investigation and more refined tools would be needed to make this evaluation. The department did not conduct further analysis because it previously determined that Alternative 4 was unreasonable due to the potential adverse environmental impacts from pumping from the sand and gravel portion of the shallow aquifer.

The department reviewed the modeling results<sup>98</sup> provided by the Applicant. For Alternative 3 this modeling was done using a 10.5 MGD water demand<sup>99</sup>, thus an analysis at 8.5 MGD would result in proportionally lower impacts. Alternative 3 was reviewed to determine if this aquifer is a potential source while meeting the requirement to be “as environmentally sustainable ... as the proposed new ... diversion ... .” The department’s review determines that Alternative 3 does not meet the criterion and therefore is not a reasonable water supply alternative to the Lake Michigan Water Supply Alternative. As described below, alternative 3 has potential adverse environmental impacts to lakes.

### **Impacts to Lakes from Alternative 3 - Deep Unconfined Aquifer**

Groundwater withdrawals can impact lakes by lowering the water level and reducing the extent littoral zone<sup>100</sup>, fish and wildlife access to habitat in the nearshore area, and connectivity to other lakes, wetlands or streams. Reductions in water level can also change the water chemistry by reducing groundwater contribution to the lake or reducing or eliminating the stability of lake stratification. Changes in lake level can affect the amount and quality of nearshore aquatic habitat (emergent and submerged vegetation, woody habitat, and rock/cobble substrate). This habitat is important for fish and aquatic life and for preventing shoreline erosion.<sup>101</sup> Changes in water chemistry include changes in pH, hardness, calcium concentrations, or acid-neutralizing capacity.<sup>102</sup> These changes can cause a decrease in the water clarity of the lake, and change the solubility and biological availability of nutrients. In general, seepage lakes—those with no inlet or outlet – are most susceptible to impacts from groundwater pumping, as changes in groundwater inputs can significantly affect lake water chemistry and water budgets. The

<sup>98</sup> This modeling used the USGS Southeastern Regional Groundwater Flow model developed for SEWRPC – reports on the model are included in [Memo August 30, 2013 – RJN Environmental Services, LCC](#)

<sup>99</sup> [RJN Environmental Services](#) ran three versions of this model, with a pumping rate of 10 MGD with 2 and 3 wells and a pumping rate of 10.5 MGD with 7 wells. The results are similar with slight variations – most notably a smaller water table cone of depression and a lower overall groundwater drawdown in the deep aquifer with the alternative with 7 wells. This analysis used the modeling results from the third scenario, 10.5 MGD with 7 wells.

<sup>100</sup> The littoral zone is the region of a lake extending from shoreline outward to the greatest depth capable of supporting rooted aquatic plants, generally less than 20 feet deep.

<sup>101</sup> Gaeta, J.W., G.G. Sass, and S.R. Carpenter. [Drought-driven lake level decline: effect on coarse woody habitat and fishes](#). *Can. J. Fish. Aquat. Sci.* **71**: 315–325 (2014)

<sup>102</sup> Webster, K.E., T.K. Kratz, C.J. Bowser, J.J. Magnuson. The influence of landscape position on lake chemical responses to drought in northern Wisconsin. *Limnol. Oceanogr.*, 41(S), 977-984, (1996)

department reviewed the lakes most susceptible to potential impacts from the proposed well field for impacts related to water level changes and changes in water chemistry ([Table 12](#) and [Figure 9](#)).

**Table 12. Characteristics of potential impacts lakes from western unconfined deep aquifer water supply.**

Lake	Size (acre)	Max./ Mean Depth (feet)	Water Quality	Lake Classification	Notes
<a href="#">Silver Lake</a> <sup>103</sup>	217	44/32	Mesotrophic (2010 – 2014)	Deep Seepage	Groundwater dominated, shallow areas on west and south sides, ecologically sensitive areas, connected wetlands, fish spawning areas, clam beds, diverse macrophyte beds
<a href="#">Upper Genesee</a>	32	27/14	Not available	Deep Headwater*	Groundwater dominated, connected wetland areas
<a href="#">Middle Genesee</a> <sup>104, 105</sup>	109	40/8	Mesotrophic (2011-2014)	Deep Seepage	Groundwater dominated, shallow areas, connected wetlands
<a href="#">Lower Genesee</a>	63	45/18	Oligotrophic (2005-2006)	Two-Story, Deep Seepage	Groundwater dominated, connected wetlands, shallow areas
<a href="#">Golden Lake</a>	250	44/14	Mesotrophic (2010-2014)	Deep Headwater*	Groundwater dominated, connected wetlands, shallow areas
<a href="#">Duck Lake</a>	21	1	Not available	Shallow seepage	Groundwater dominated, wetland area connected to Upper Genesee Lake
<a href="#">Laura Lake</a>	9	11/6	Not available	Small drainage	Muck bottom, part of extensive wetland area

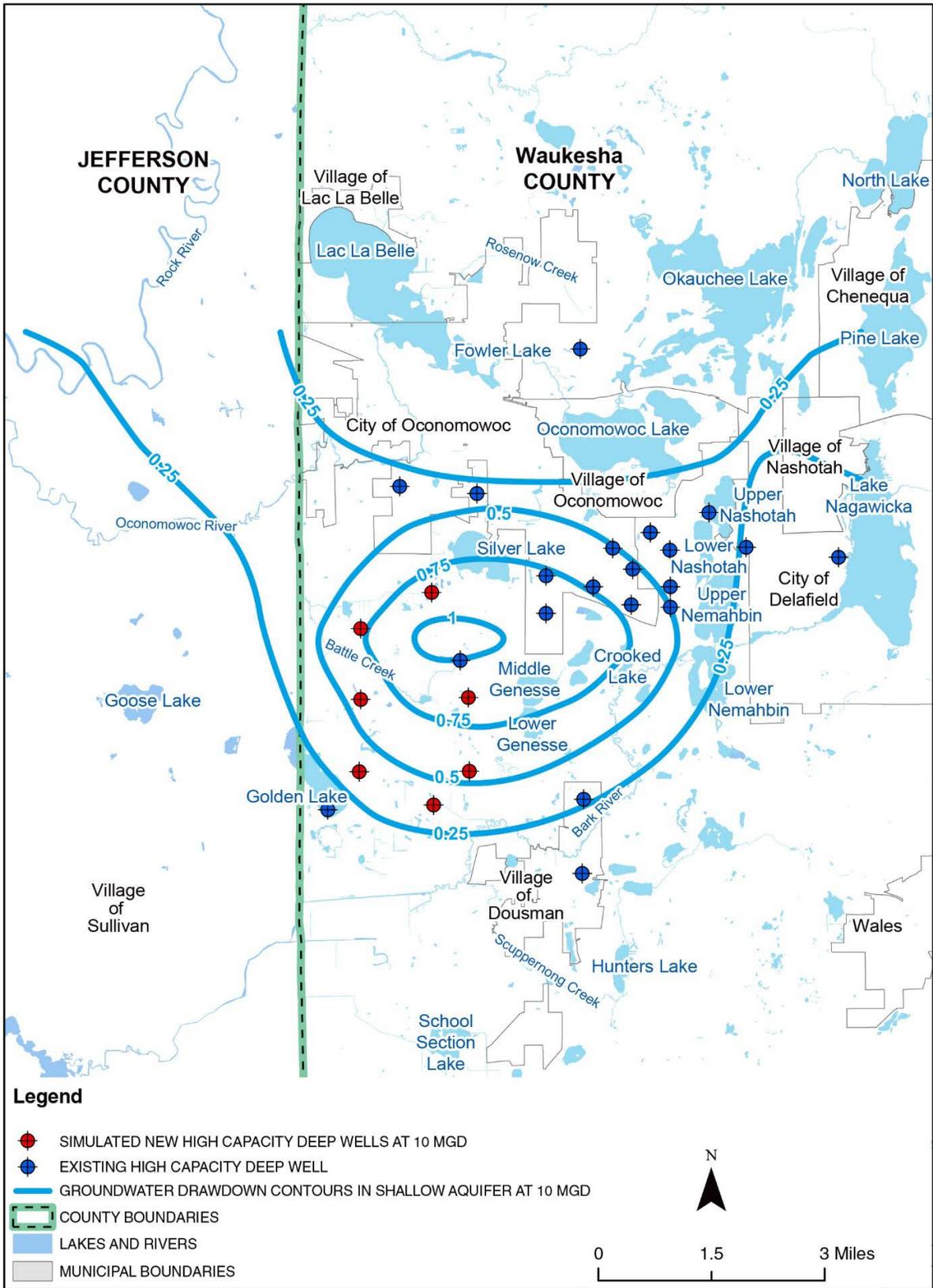
\*Golden Lake and Upper Genesee Lake are classified as deep headwater lakes because they have intermittent outlet streams, but function similarly to deep seepage lakes.

<sup>103</sup> SEWRPC 1993, [A Lake Protection Plan for Silver Lake, Waukesha County, Wisconsin](#). Memorandum Report No. 82.

<sup>104</sup> SEWRPC 2003, [A Lake Protection Plan for Middle Genesee Lake, Waukesha County](#). Memorandum Report No. 148.

<sup>105</sup> Hunt, R.J, et al. 2000. [Simulation of the shallow hydrologic system in the vicinity of Middle Genesee Lake](#), Wisconsin, using analytic elements and parameter estimation. Water-Resources Investigations Report 2000-4136.

Figure 9. Groundwater Drawdown in shallow aquifer at 10.5 mgd. (From Application, vol. 2, exhibit 11-27)



Groundwater modeling found a drawdown of 6-12 inches in five of the lakes reviewed ([Table 13](#) and [Figure 9](#)).

**Table 13. Estimated decrease in water levels (inches) and decrease in baseflow (% decrease) in lakes near proposed unconfined deep aquifer well field based on modeled water table drawdown and modeled groundwater discharge at a 10.5 MGD withdrawal rate.**<sup>106</sup>

Lakes	Lake Level decrease (inches)	Baseflow decrease (%)
Silver Lake	6-12	27%
Upper Genesee and Duck Lakes	6-12	18%
Middle and Lower Genesee Lakes	6-12	16%
Golden Lake	<4	4%

Lake level drawdowns of six to twelve inches and decreases in baseflow of more than 10% for seepage lakes with extensive shallow littoral zones and connected wetlands would be expected to have potential significant adverse impacts on navigation, aquatic vegetation, fish habitat and spawning areas and potentially lake water chemistry.<sup>107</sup> Silver Lake, Upper Genesee and Duck Lakes, and Middle and Lower Genesee Lakes would all be expected to be impacted by groundwater withdrawal rates of 10.5 MGD. Scaling the proposed withdrawals to 8.5 MGD would reduce the magnitude of impacts, but not sufficiently to eliminate the potential adverse environmental impacts. As a result, the department determines that Alternative 3 – Unconfined Deep Aquifer is not a reasonable water supply alternative.

### Impacts to other surface water resources

The department also analyzed Alternative 3 for impacts to rivers, streams, wetlands, and springs; and, using groundwater modeling, calculated baseflow reductions of 14 percent for the Bark River and 57 percent for Battle Creek with the modeled pumping rate of 10.5 MGD.<sup>108</sup> For wetlands, the groundwater flow modeling results include approximately 40 acres of wetlands in the one-foot drawdown contour. However, with an 8.5 MGD withdrawal rate, wetlands may not be impacted. One spring with a flow less than a 0.25 cfs identified in the Wisconsin Springs Survey<sup>109</sup> is in the modeled water table cone of depression. Further analysis would be required to determine what kind of impact the proposed water supply alternatives might have to this spring.

<sup>106</sup> [Report on groundwater flow modeling – RJN Environmental Services, LLC. 08/2013. Figure 9.](#)

<sup>107</sup> Leira, M. and M. Cantonati. Effects of Water-level fluctuations on lakes: an annotated bibliography. *Hydrobiologia* 613:171-184 (2008) and K.M Wantzen, K. Rothhaupt, M. Mortl, M. Contonati, L. Toth, and P. Fischer. Ecological effects of water-level fluctuations in lakes: an urgent issue. *Hydrobiologia* 613:1-4 (2008)

<sup>108</sup> See Appendix A: Assessment of streamflow impacts due to water supply alternatives in the Mississippi River Basin.

<sup>109</sup> Macholl, J.A. 2007, [Inventory of Wisconsin's Springs](#). WGNHS. WOFR2007-03.

## **S3**

### **LEGAL REQUIREMENTS**

Agreement/Compact: No equivalent requirement.

Wisconsin Statutes: The proposal is consistent with an approved water supply service area plan under [Wis. Stat. § 281.348](#) that covers the public water supply system. ([Wis. Stat. § 281.346\(4\)\(e\)1.em.](#))

### **FINDINGS**

1. The Applicant's proposal is consistent with its water supply service area plan that covers the public water supply system.
2. The water supply service area plan is approvable, as conditioned.
3. The proposed approval condition maintains consistency between the Southeastern Wisconsin Regional Planning Commission (SEWRPC) planned sewer service area,<sup>110</sup> and the delineated water supply service area as required under [Wis. Stat. § 281.346\(4\)\(e\)1.em.](#) and [§ 281.348](#).
4. The department retains authority through the water supply service area planning process to approve a withdrawal amount for the 20-year planning period.

### **METHOD OF ANALYSIS**

The department analyzed the technical reports and planning documents listed below to determine whether the proposed water supply service area plan meets [Wis. Stat. § 281.346\(4\)\(e\)1.em.](#), and the associated standards found in [Wis. Stat. § 281.348](#).

The department analyzed the following documents:

- [Application, Volume 2](#), section 2
- [Application, Volume 2](#), section 8
- SEWRPC, *A Regional Water Supply Plan for Southeastern Wisconsin*, Planning Report #52, Volumes [1](#) & [2](#) (12/2010).
- City of Waukesha, [Comprehensive Plan](#) (09/2009).
- Waukesha County Department of Parks and Land Use, Waukesha County University of Wisconsin-Extension and Waukesha County Municipalities, [A Comprehensive Development Plan for Waukesha County, Wisconsin](#) (02/2009).
- Town of Delafield, Waukesha County Department of Parks and Land Use, Waukesha University of Wisconsin-Extension, [Town of Delafield Smart Growth Plan, Waukesha County, Wisconsin](#) (08/2009).
- Town of Waukesha, Waukesha County Department of Parks and Land Use, Waukesha University of Wisconsin-Extension, [Smart Growth Plan](#) (10/2009).

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<sup>110</sup> SEWRPC, Amendment to Community Assistance Planning Report No. 100, Sanitary Sewer Service Area for the City of Waukesha and Environs, Waukesha County, Wisconsin (2 ed.) (Amendment to the Regional Water Quality Management Plan, Village of Wales/City of Waukesha, 12/2007).

- SEWRPC, Amendment to Community Assistance Planning Report No. 100, [Sanitary Sewer Service Area for the City of Waukesha and Environs, Waukesha County, Wisconsin](#) (2 ed.) (Amendment to the Regional Water Quality Management Plan, Village of Wales/City of Waukesha) (12/2007).

## DISCUSSION

The Compact and Wisconsin’s Compact implementing statute define a “community within a straddling county” to mean “any incorporated city, town *or the equivalent thereof*, that is located outside the Basin but wholly within a County that lies partly within the Basin that is not a Straddling Community [emphasis added].”<sup>111</sup> The department considers the delineated water supply service area to be a “community within a straddling county” under the Compact and Wisconsin’s Compact implementing laws and regulations.

For over 30 years, Wisconsin has used a system of local service area planning and boundary delineation to identify how public wastewater services will be developed and managed. To promote sound long-range municipal planning and to maintain compatibility with existing regulatory provisions for public water resources management, the Wisconsin Legislature, through the Compact implementing statutes, directed the department to implement a water supply planning process to mirror the existing sewer service area planning program.

Wisconsin’s water supply service area planning program requires all public water supply systems in the state serving a population of 10,000 or more to have an approved water supply service area in place by December 31, 2025.<sup>112</sup> However, in two instances, public water supply systems must have an approved water supply service area plan prior to December 31, 2025: when a public water supply system in a Great Lakes Basin (GLB) portion of Wisconsin proposes a new or increased withdrawal; and when a community proposes a diversion of Great Lakes water.

[Wis. Admin. Code § NR 121](#) establishes the regional agencies responsible for sewer service area and water supply service area boundary delineation and planning. SEWRPC is the regional planning agency statutorily tasked with delineating the sewer and water supply service areas for the City of Waukesha.

As required by [Wis. Admin. Code § NR 121.05\(1\)\(g\)](#), SEWRPC delineates regional wastewater sewer service areas after determining the most cost-effective option over a 20-year planning period based upon an analysis of alternate configurations. The cost-effectiveness analysis must identify the alternative that would minimize the total resource costs over the planning period. The resource costs include monetary costs as well as environmental and other non-monetary costs.<sup>113</sup> The resulting sewer service area plan is a key element of the areawide water quality management plan.

SEWRPC delineated the Applicant’s water supply service area<sup>114</sup> in accordance with

<sup>111</sup> [Compact](#) s. 1.2; [Agreement](#) art. 103; [Wis. Stat. § 281.343\(1e\)\(d\)](#).

<sup>112</sup> [Wis. Stat. § 281.348\(3\)\(a\)2](#).

<sup>113</sup> [Wis. Admin. Code § NR 121.03\(5\)](#).

<sup>114</sup> SEWRPC 2008, [Water Supply Service Area for the City of Waukesha and Environs](#), 12/2008.

[Wis. Stat. § 281.348\(3\)\(cm\)](#), which states that the water supply service area must be consistent with the areawide water quality management plan. Areawide water quality management plans are designed to provide structure to a community's wastewater collection system to accommodate current and future growth while consolidating wetland, shore land and floodplain protection programs within a community-based plan for sewer development. The plans include sanitary sewer service area maps that show existing sewer areas as well as adjacent land suitable for development. Consistency between sewer service areas and water supply service areas can help produce cost-effective service and environmental protection that enable local water ordinances to more easily achieve their larger water management objectives.

The delineated Waukesha water supply service area is shown in [Figure 10](#). The water supply service area includes parts of the City of Pewaukee, the Town of Delafield, the Town of Genesee, and the Town of Waukesha.<sup>115</sup> Portions of the Towns of Waukesha, Delafield, and the City of Pewaukee were added to the Waukesha water supply service area to meet the requirements of [Wis. Stat. § 281.348\(3\)\(cm\)](#) by maintaining consistency with the Applicant's previously established areawide water quality management plan, including the delineated sanitary sewer service area. Areas of the Town of Genesee currently not in the approved sewer service area were added to the water supply service area upon recommendation by the department for public health reasons. Portions of the Town of Genesee have been designated as a special casing area by the department, which requires more stringent well construction for potable wells, since a survey of wells noted bacterial well contamination in 38 percent of wells sampled. In addition, Wisconsin law generally prohibits the department from limiting a water supply service area based on jurisdictional boundaries.<sup>116</sup>

The Waukesha water supply service area sets the outer boundary of municipal water supply service expansion. Areas included in the water supply service area that are not currently connected to municipal water supply may request water service in the future. Under Wisconsin law, 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).<sup>117</sup> Regardless of its diversion application, Waukesha must have a water supply service area that is consistent with its sewer service area by the end of 2025. As that deadline approaches, water supply service area planning will become a standard process statewide.

The department reviewed the Applicant's proposed water supply service area plan for compliance with the standards in [Wis. Stat. § 281.348](#) and for consistency with SEWRPC planning documents. The water supply service area plan does include: sources and quantities of the current water supplies in the area;<sup>118</sup> forecasted demand for water in the area;<sup>119</sup>

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<sup>115</sup> [Application, Volume 2](#), section 2.1.

<sup>116</sup> [Wis. Stat. § 281.348\(3\)\(e\)](#) states, in part, "The department may not limit water supply service areas based on jurisdictional boundaries, except as necessary to prevent waters of the Great Lakes basin from being transferred from a county that lies completely or partly within the Great Lakes basin into a county that lies entirely outside the Great Lakes basin." The entirety of the proposed water supply service area is within Waukesha County, a county that straddles the Great Lakes basin divide.

<sup>117</sup> See generally [Wis. Stat. § 196 Regulation of Public Utilities](#).

<sup>118</sup> As required by [Wis. Stat. § 281.348\(3\)\(c\)2](#), and discussed in section [S1](#) of this technical review.

<sup>119</sup> As required by [Wis. Stat. § 281.348\(3\)\(c\)3](#), and discussed in section [S4](#) of this technical review.

identification of the existing population and population density and forecasts for growth;<sup>120</sup> identification of cost-effective supply alternatives;<sup>121</sup> assessment of environmental and economic impacts of carrying out the recommendations of the plan;<sup>122</sup> demonstration that the plan will effectively utilize existing storage and distribution facilities and wastewater infrastructure;<sup>123</sup> procedures for implementing and enforcing the plan;<sup>124</sup> and analysis of how the plan is consistent with applicable comprehensive plans.<sup>125</sup>

To ensure that the applicant has available water allocated to meet the water demands of its water supply service area, the department proposes to control the amount of water available resulting from any diversion approval through the water supply service area plan approval process. For example, the department could propose an initial withdrawal amount of up to an average daily withdrawal of 8.5 MGD for the 20-year planning period for the proposed water supply service area. If the applicant wishes to increase the withdrawal amount above a daily average of 8.5 MGD, up to any approved diversion amount during the 20-year planning period, it must seek prior department approval through a revision of its water supply service area plan.

In considering a proposal to amend a water supply service area plan to increase the withdrawal amount (up to the full build-out of 10.1 MGD), the department would review the revised water supply service area plan for the following factors:

- Updated water demand projections, including projected demand for areas within the water supply service area that are currently not served municipal water.
- A plan to meet the projected water demand including evidence that there is adequate water under any diversion approval to meet the demands of the entire water supply service area.
- A review of Conservation and Efficiency Measures (CEMs) to determine if any new CEMs are available or if the cost-effectiveness of any CEMs has changed since the last update of the conservation plan.
- Compliance with NR 852 Tier 3 requirements.

The water supply service area plan as conditioned meets the standards in [Wis. Stat. § 281.348](#), including consistency with the areawide water quality management plan and the sanitary sewer service area.

### *Approval Condition*

Prior to the department approving the Applicant's water supply service area plan, the Applicant must amend its sewer service area plan. The amendment must include those portions of the Town of Genesee currently included in the Applicant's delineated water supply service area that are not included in the delineated sewer service area. This condition is meant to comply with [Wis. Stat. § 281.348\(3\)\(cm\)](#) which requires that the proposed water supply service areas be consistent with the approved areawide water quality management plan, including the sewer service area plan,

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<sup>120</sup> As required by [Wis. Stat. § 281.348\(3\)\(c\)3m](#), and discussed in section [S4](#) of this technical review.

<sup>121</sup> As required by [Wis. Stat. § 281.348\(3\)\(c\)4](#), and discussed in sections [S1](#) and [S2](#) of this technical review.

<sup>122</sup> As required by [Wis. Stat. § 281.348\(3\)\(c\)5](#), and discussed in section [S2](#) of this technical review.

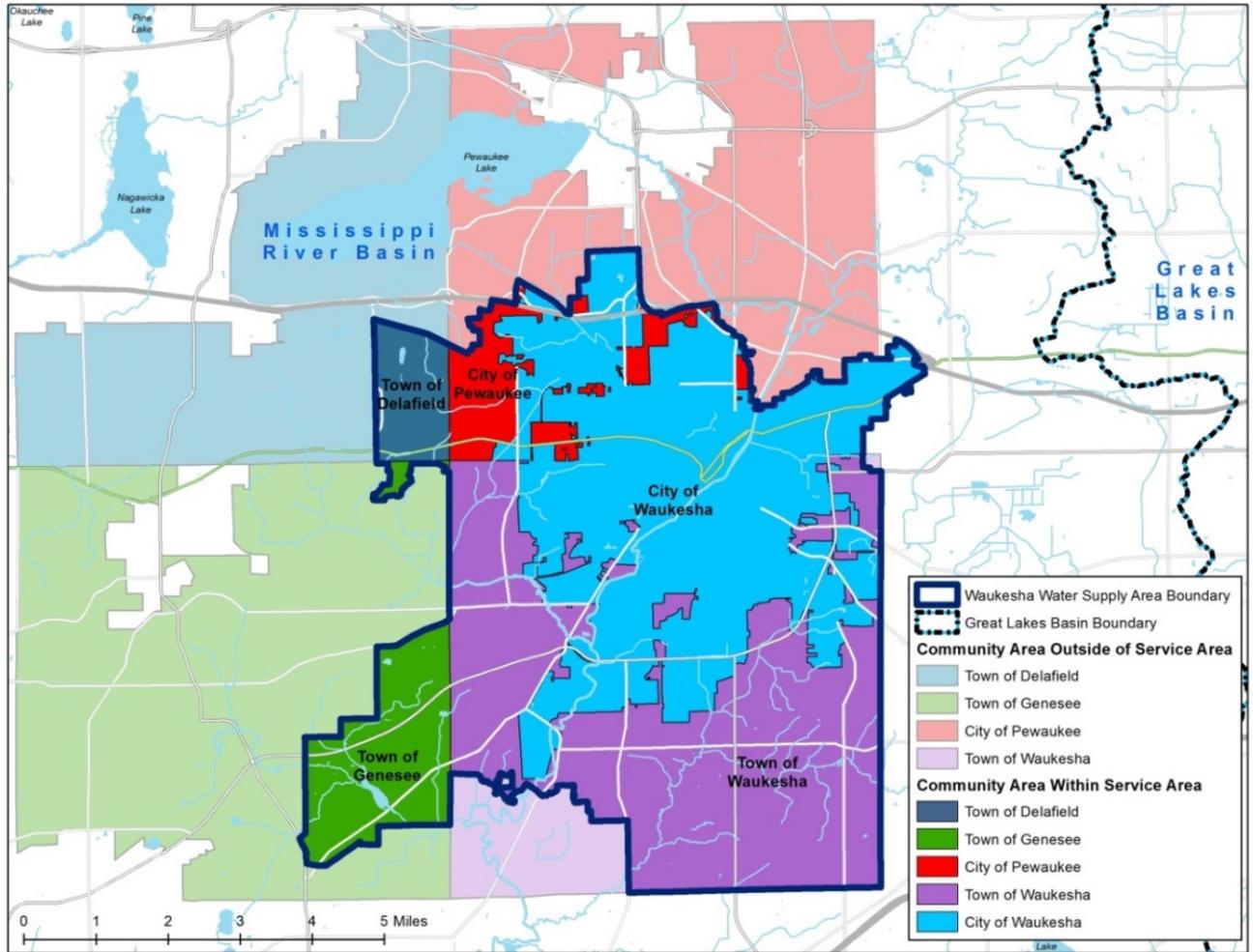
<sup>123</sup> As required by [Wis. Stat. § 281.348\(3\)\(c\)6](#). Great Lakes water would be pumped to the Applicant's Hillcrest Reservoir and be distributed using existing treatment and pumping infrastructure within the City. The Applicant would need to upgrade approximately five miles of pipe to incorporate the necessary distribution system improvements, and the Applicant would utilize its existing wastewater infrastructure.

<sup>124</sup> As required by [Wis. Stat. § 281.348\(3\)\(c\)7](#), and discussed throughout this technical review.

<sup>125</sup> As required by [Wis. Stat. § 281.348\(3\)\(c\)8](#), and discussed supra.

under [Wis. Stat. § 283.83](#); and it also ensures that any Great Lakes water that may eventually be served to those areas is returned to the Great Lakes basin, less an allowance for consumptive use.

Figure 10. The Applicant and SEWRPC's proposed water supply service area.



## S4

### LEGAL REQUIREMENTS

Agreement/Compact: The Exception will be limited to quantities that are considered reasonable for the purposes for which it is proposed ([Compact](#) 4.9.4.b., [Agreement](#) art. 201 s. 4.b.)

Wisconsin Statutes: The diversion is limited to quantities that are reasonable for the purposes for which the diversion is proposed. ([Wis. Stat. § 281.346\(4\)\(f\)2.](#))

### FINDINGS

1. Requested diversion amounts are reasonable: The Applicant's requested diversion of Great Lakes water to a community in a straddling county with up to an annual average of 10.1 million gallons per day (MGD) at full build-out and a daily maximum of 16.7 MGD are reasonable quantities to provide public water services to the water supply service area.

### METHOD OF ANALYSIS

To make its determination under this criterion, the department assessed information included in the Application along with several technical reports, planning documents, and demographic data. These included:

- The 2010 *Application for Lake Michigan Water Supply*, Section 2, Water System Overview and Section 3 Need for New Water Supply
- Southeast Wisconsin Regional Planning Commission (SEWRPC), *A Regional Water Supply Plan for Southeastern Wisconsin*, Planning Report #52, Volumes [1](#) & [2](#), 12/2010
- City of Waukesha, [Comprehensive Plan](#), 09/2009 Waukesha County Department of Parks and Land Use, Waukesha County University of Wisconsin-Extension and Waukesha County Municipalities, [A Comprehensive Development Plan for Waukesha County, Wisconsin](#), 02/2009

In considering the reasonableness of the withdrawal quantity requested, the department evaluated the Applicant's demand forecast against alternate forecasts created by SEWRPC and the department. Considering these forecasts, the department identified a number of demand ranges that could be considered reasonable. The department then recalculated the demand projections to include the expected reductions due to water conservation as identified in section [C1](#) of this technical review.

### DISCUSSION

#### *Applicant's demand projections*

The Applicant presented two scenarios to estimate baseline demand without the effects of future water conservation. The Applicant used population projections for the water supply service

area<sup>126</sup> in calculating commercial, public, and residential demand. For calculating industrial demand, the Applicant used acreage projections. The Applicant used a water loss factor of 8 percent to account for system leaks, losses and water main breaks.<sup>127</sup> To accommodate high demand events and seasonal variation, the Applicant used its historical peaking factor of 1.66 to calculate maximum day demand in each scenario.<sup>128</sup>

The first scenario assumed that baseline customer demand would remain constant at recent levels throughout the 35-year planning period. This “flat-demand” scenario projected an average water demand of 9.8 (MGD) at full build-out in 2050.<sup>129</sup> The Applicant’s second projection was designed to accommodate potential increases in future industrial demand. The Applicant’s “increased demand” projection at full-system build-out in 2050 resulted in an average baseline demand of 11.1 MGD.

The Applicant estimated that conservation savings would save 1.0 MGD upon final build-out. The department subtracted conservation savings from the two demand projections resulting in a “flat demand with conservation” scenario projection of 8.8 MGD and an “increased demand with conservation” scenario projection of 10.1 MGD. The Applicant identified 10.1 MGD as the average day demand (ADD) for which the system infrastructure should be sized to best accommodate a range of uncertainties in water demand projections while including anticipated water conservation savings. As a result, the Applicant requests an annual average diversion amount of 10.1 MGD.

#### *SEWRPC’s demand projections*

To assess the reasonableness of the Applicant’s demand projections, the department compared the Applicant’s projected demand range to several alternative demand estimates. First the department reviewed demand forecast ranges developed for the region by [SEWRPC](#)<sup>130</sup> – which projected average day demand in 2035 for several scenarios with results ranging from approximately 8.4 MGD to 10.7 MGD. All scenarios assumed different degrees of conservation. Since SEWRPC did not calculate demand projections to full build-out, department staff linearly extrapolated the SEWRPC projections to the year 2050. The department calculated the final average daily demand projections for each growth scenario extrapolated to 2050, including SEWRPC conservation alternatives, to be: low (8.8 MGD), intermediate (10.0 MGD), and high (12.1 MGD).

#### *Department demand projections*

Additionally, the department reviewed recent historical pumpage and population estimates<sup>131</sup> and calculated the 10-year average demand rate as 104 gallons per capita per day (GPCD) and the 5-

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<sup>126</sup> The water supply service area was delineated by the Southeastern Wisconsin Regional Planning Commission. A detailed analysis of the water supply service area is located in [S3](#).

<sup>127</sup> The Applicant referred to this as “unaccounted for” water which is synonymous with “Water Loss” as used by the American Water Works Association. “Water loss” is used in this review.

<sup>128</sup> Peaking factor is the ratio of a water supply systems maximum demand to average demand and can vary substantially between different systems. A “rule of thumb” is that this ratio typically ranges between 1.5-3.0 peak to average demand. [U.S. Fire Administration. 2008. Water Supply Systems and Evaluation Methods.](#)

<sup>129</sup> Build-out conditions represent the complete development of the water supply service area. It is assumed that all development would be consistent with applicable approved land use and planning documents.

<sup>130</sup> SEWRPC 2010, A Regional Water Supply Plan for Southeastern Wisconsin. Planning Report No. 52 p. 256, (12/2010)

<sup>131</sup> Application, [Volume 2](#), Appendix C, Attachment C, Tables 1 and 2.

year, 3-year, and 2012 average demand rate as 97 GPCD [Table 14](#). The department calculated these numbers by taking the Applicant’s total water pumpage across all sectors and dividing it by population.

**Table 14. Recent Historical Average GPCD.**

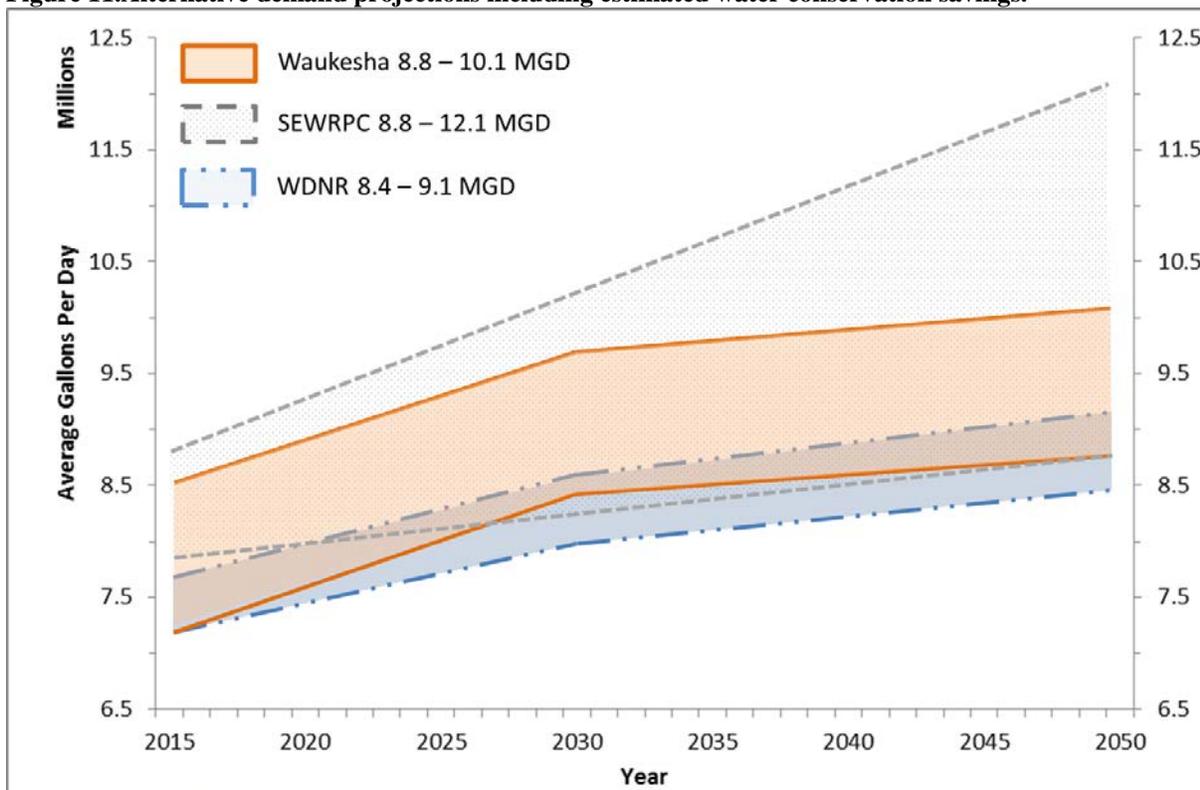
Year Range	Mean GPCD
10-year average (2003-2012)	104
5-year average (2008-2012)	97
3-year average (2010-2012)	97
2012 average	97

The demand rates of 104 and 97 GPCD extrapolated to 2050 with SEWRPC population projections for the water supply service area yield full build-out average demands ranging from 9.4 to 10.1 MGD without water conservation. After subtracting 1.0 MGD for conservation, the department-calculated demand rates at build-out based on GPCD were projected to range between 8.4 and 9.1 MGD average day demand.

*Synthesis of demand projections*

Projections from the Applicant, SEWRPC and the department including anticipated reductions from water conservation cover an average day demand ranging from 8.4 to 12.1 MGD.

**Figure 11. Alternative demand projections including estimated water conservation savings.**



The Applicant's demand range is within the results from alternate projection methods and the department assessed the Applicant's projections based on the following assumptions and parameters:

- The Application includes an estimated population of the service area at full build-out of 97,400.<sup>132</sup> The department determined these projections are reasonable because they were conducted by SEWRPC, the designated regional planning authority for the community. SEWRPC's estimates were based on municipal estimates from the State of Wisconsin Department of Administration and multiple planning factors, including land use, household size, demographic trends, and community development plans.
- The Applicant forecast the amount of water lost in delivery at 8 percent of total pumpage. This rate is equal to the 2008-2012 average amount of water lost in delivery. The department determined that this estimate is reasonable because it is based on historical evidence, and meets the Wisconsin Public Service Commission's<sup>133</sup> standards.
- The Applicant calculated the maximum day demand from a peaking factor of 1.66 times the average day demand. The peaking factor was chosen based on an analysis<sup>134</sup> that reflects a 98 percent confidence level that the actual peak day pumping would be of equal or lesser value. The department determined that this parameter is acceptable since it is based on historical evidence.
- The Applicant's demand estimate included anticipated water conservation savings of 1.0 MGD. The department determined that this calculation of expected conservation savings is reasonable based on the conservation plan evaluated in section [C1](#).
- The Applicant estimated residential, commercial and public customer class demand using the 10-year average (2003-2012) in GPCD. The department determined that this demand estimation is reasonable since it is based on historical evidence and a common demand forecast methodology for municipalities<sup>135</sup>
- The Applicant forecast industrial demand using a gallons-per-acre coefficient at both the year 2000 level and at the 5-year average (2008-2012). The department questioned the use of the year 2000 demand rate in a letter to the Applicant. The Applicant clarified that use of this demand number was intended to represent the upper bound of potential industrial demand to which utility infrastructure would be sized. The department accepts this as reasonable for use in sizing utility infrastructure so that it accounts for demand uncertainties.<sup>136</sup>

The lower bound of the Applicant's average demand projections of 8.8 MGD represents demand continuing at average usage rates over the last decade and full attainment of the Applicant's water conservation goals. The upper bound of the Applicant's demand projections at an average of 10.1 MGD at full build-out reflects uncertainties in community demand and potential variability in attaining the Applicant's conservation goals. The department has determined that this volume is reasonable.

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<sup>132</sup> Application [Volume 2](#), Appendix C, Attachment A

<sup>133</sup> See Wis. Admin. Code § [PSC 185.85\(4\)](#)

<sup>134</sup> Application [Volume 2](#), Appendix C, Attachment C, Table 3

<sup>135</sup> Billings, B., and Jones, C. *Forecasting urban water demand*, 2<sup>nd</sup> Ed., American Waterworks Association, Denver, Co. 2008

<sup>136</sup> See [Letter from Waukesha Water Utility – Re: water demand projections, dated Feb. 20, 2014](#)

## Water Conservation Related Criteria

### C1

#### LEGAL REQUIREMENTS

Agreement/Compact: The need for all or part of the proposed Exception cannot be reasonably avoided through the efficient use and conservation of existing water supplies; ([Compact](#) s. 4.9.4.a.; [Agreement](#) art. 201 s. 4.a.)

Wisconsin Statutes: The need for the proposed diversion cannot reasonably be avoided through the efficient use and conservation of existing water supplies as determined under par.(g) ([Wis. Stat. § 281.346\(4\)\(f\)1.](#))

#### FINDINGS

1. The need for part of the proposed diversion can be reasonably avoided through the efficient use and conservation of existing water supplies.
2. The Applicant forecasts 1.0 million gallons per day (MGD) in water savings due to conservation and efficiency measures by final build-out (approximately the year 2050). This 1.0 MGD represents forecast demand that can be reasonably avoided through conservation and efficiency and the department has taken this into account in calculating projected demand for the water supply service area (as seen in section [S4](#) of this technical review).
3. The need for the entire proposed diversion cannot be reasonably avoided through the efficient use and conservation of existing water supplies.

#### METHOD OF ANALYSIS

The department addressed the following two questions to determine whether efficient use and conservation of existing water supplies could eliminate or reduce the need for a Great Lakes diversion:

1. How much water demand can the Applicant offset through additional conservation?
2. Would this degree of conservation sufficiently reduce water demand to the point that the Applicant's water supply service area may be served by existing supplies?

The Applicant conducted an analysis to determine whether conservation and efficiency measures referenced in Wisconsin's administrative code are environmentally sound and economically feasible, and estimated the corresponding water quantity that it could conserve.<sup>137</sup> The department evaluated whether this could offset the need for a diversion by comparing demand projections (see section [S4](#)) to the identified Mississippi River basin (MRB) water supply alternative capacities identified in technical review section [S2](#).

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<sup>137</sup> See section [C2](#) of this technical review and [Wis. Admin. Code § NR 852.10](#).

In making its determination, the department assessed information included in the City's Application along with several technical reports, planning documents, demographic data and conservation planning tools—including:

- City of Waukesha, *Application for Lake Michigan Water Supply*, [Volume 2](#), Section 2, Water System Overview and Section 3, Need for New Water Supply (2010).
- SEWRPC, *A Regional Water Supply Plan for Southeastern Wisconsin*, Planning Report #52, Volumes [1](#) & [2](#) (12/2010).
- City of Waukesha, [Comprehensive Plan](#) (09/2009).
- Waukesha County Department of Parks and Land Use, Waukesha County University of Wisconsin-Extension and Waukesha County Municipalities, [A Comprehensive Development Plan for Waukesha County, Wisconsin](#) (02/2009).
- Results from the *Alliance for Water Efficiency Conservation Tracking Tool 2.0 Standard Edition*

## DISCUSSION

The department implemented the water conservation and water use efficiency component of its Great Lakes Compact implementing statutes ([Wis. Stat. § 281.346](#)) through [Wis. Admin. Code § NR 852](#) which took effect in December 2010. NR 852 requires mandatory water conservation and efficiency measures for all new or increased withdrawals in the Great Lakes basin (GLB) portion of Wisconsin as well as for any community proposing to divert Great Lakes water. [NR 852](#) prescribes three tiers of conservation and efficiency measures (CEMs) depending on the amount and purpose of the withdrawal. Applicants proposing diversions are held to the most rigorous level of conservation and efficiency, Tier 3. The department considers compliance with [NR 852](#) as evidence that the applicant is reasonably attempting to minimize demand through efficient use and conservation of existing water supplies. As described in section [C2](#), the department determined that the Applicant is in compliance with [Wis. Admin. Code § NR 852](#).

### *Ability to reasonably avoid part of the diversion amount*

Through its conservation planning and analysis, and using the *Alliance for Water Efficiency(AWE) Conservation Tracking Tool*,<sup>138</sup> the Applicant projected that at full system build-out, it would achieve 1.0 MGD in conservation savings. The Applicant estimated that national and state plumbing code changes would yield the largest source of conservation and efficiency savings, predicting that these reductions would come primarily from ongoing installation and replacement of fixtures such as toilets and showerheads. Based on projected population and the factors programmed into *AWE Conservation Tracking Tool*, the Applicant projected plumbing code savings of 0.52 MGD by final build-out.

The Applicant projected it could achieve an additional 0.48 MGD in water conservation and efficiency savings through compliance with [Wis. Admin. Code § NR 852](#). In its conservation plan and in the *AWE Conservation Tracking Tool*, the Applicant identified a number of conservation measures that it has implemented or plans to implement that would result in 0.13

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<sup>138</sup> The AWE Tool was created to estimate changes in future water demand due to implementation of conservation and efficiency standards, practices and programs. The department recommends its use to municipalities for planning and monitoring conservation programs. See section [C2](#) of this technical review for additional discussion.

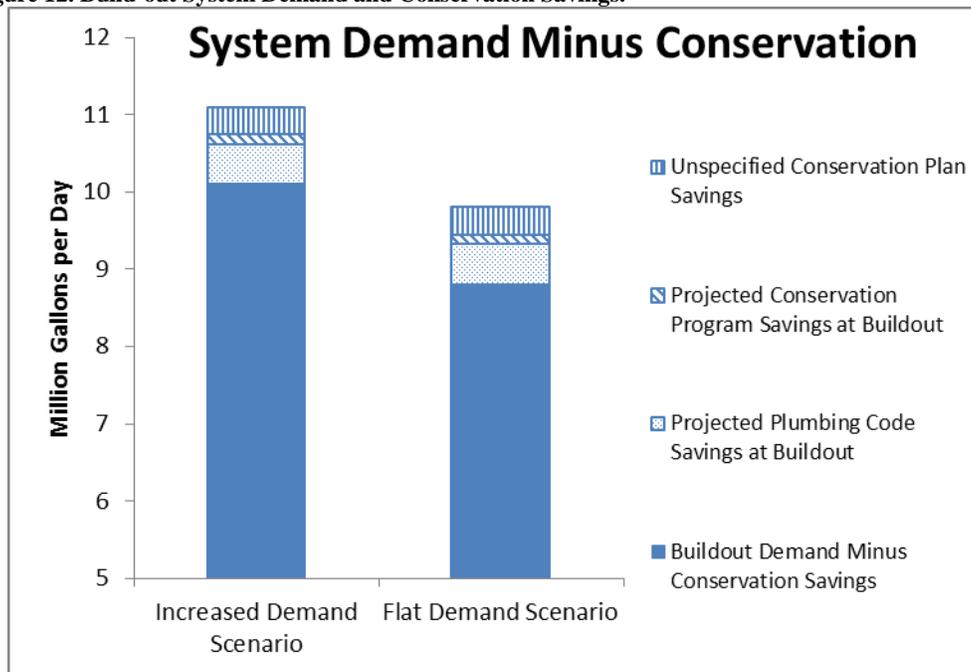
MGD of water savings. These include programs such as high efficiency toilet rebates, conservation outreach and industrial demand management efforts.<sup>139</sup> The Applicant expects the remaining 0.35 MGD of expected conservation savings to accrue through implementing conservation ordinances, conservation pricing structures, or demand management programs designed to fit future needs.

The department would monitor the Applicant’s annual conservation reporting to assess the Applicant’s compliance with its conservation plan and [Wis. Admin. Code § NR 852](#) to verify that the Applicant has implemented all required environmentally sound and economically feasible CEMs.

*Ability to reasonably avoid all of the diversion amount*

The department used the finding that 1.0 MGD could be saved through conservation by final build-out in its demand projections described in section [S4](#) of this technical review.

**Figure 12. Build-out System Demand and Conservation Savings.**



As noted in [Table 15.](#), the finding that the Applicant can expect a 1.0 MGD water savings by final build-out, when combined with the lowest demand scenario (i.e., flat demand) results in an anticipated water use of 8.8 MGD at final build-out. Section [S2](#) concluded that none of the proposed MRB water supply alternatives was reasonable at a modeled demand of 8.5 MGD.<sup>140</sup> Considering the 1.0 MGD potential diversion volume that can be avoided through conservation, the need for all of the proposed diversion of Great Lakes water cannot be reasonably avoided through the efficient use and conservation of existing water supplies.

<sup>139</sup> More details on the Applicant’s conservation programs can be found in section [C2](#) of this technical review.

<sup>140</sup> The final amount was rounded down to 8.5 MGD because the model is not finely tuned to distinguish between 8.8 MGD and 8.5 MGD. In addition, the [S2](#) analysis concluded that 8 MGD was the maximum amount of water reasonably available through its MRB options.

**Table 15. MGD Reduction Expectation.**

Million Gallons per Day	Baseline Demand	Plumbing Code Savings	Conservation Program Savings	Unspecified Conservation Plan Savings	Baseline Demand minus Savings
Increased Demand Scenario	11.1	0.52	0.13	0.35	10.1
Flat Demand Scenario	9.8				8.8

The department finds that 1.0 MGD of the diversion demand may be reduced due to anticipated future water conservation and increased water use efficiency. The department incorporated this into demand calculations in section [S4](#) of this technical review. In addition, modeling referenced in section [S2](#) demonstrates that the entire need for the diversion cannot be reasonably avoided through conservation and efficiency.

## C2

### LEGAL REQUIREMENTS

Agreement/Compact: The Exception will be implemented so as to incorporate Environmentally Sound and Economically Feasible Water Conservation Measures to minimize Water Withdrawals or Consumptive Use. ([Compact](#) s. 4.9.4.e.; [Agreement](#) art. 201 s. 4.e.)

Wisconsin Statutes: The applicant commits to implementing the applicable water conservation measures under [sub. \(8\)\(d\)](#) that are environmentally sound and economically feasible for the Applicant. ([Wis. §Stat. 281.346\(4\)\(f\)6.](#))

### FINDINGS

1. The Applicant has demonstrated a commitment to implementing water conservation and efficiency measures as required by [Wis. Admin. Code § NR 852](#), that are environmentally sound and economically feasible.

### METHOD OF ANALYSIS

Wisconsin implements the Agreement/Compact requirement that a proposed diversion incorporate environmentally sound and economically feasible water conservation measures through [Wis. Stat. § 281.346\(8\)\(d\)](#). This statute directs the department to promulgate rules specifying water conservation and efficiency measures. Under this authority, in December 2010, the department implemented [Wis. Admin. Code § NR 852](#), “to establish a statewide water conservation and efficiency program ... and to specify mandatory water conservation and efficiency measures for withdrawals in the Great Lakes basin.” The department developed NR 852 following extensive stakeholder input, and the rule was drafted to accord with the processes, practices and standards recommended by “The Handbook of Water Use and Conservation” (Vickers, 2001)<sup>141</sup> and “Water Conservation Programs – A Planning Manual” (AWWA, 2006)<sup>142</sup>. The rule requires those proposing a new or increased diversion to conduct an analysis to determine all environmentally sound and economically feasible water conservation measures and to implement those measures<sup>143</sup>. The department evaluated the Applicant’s Water Conservation plan for compliance with [NR 852](#) to determine whether the Applicant meets this criterion.

In determining whether the Applicant met state and Agreement/Compact requirements for water conservation, the department assessed several technical reports, planning documents, demographic data and conservation planning tools, including:

- [Application, Volume 3](#)
- [Application, Volume 2](#)

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<sup>141</sup> Vickers, Amy. 2001. Handbook of Water Use and Water Conservation. Water Plow Press. Amherst, MA. 446p.

<sup>142</sup> American Water Works Association. 2006. Water Conservation Programs – A Planning Manual. AWWA. Denver, CO. 149p.

<sup>143</sup> See Wis. Admin. Code § [NR 852.10](#).

- Results from the *Alliance for Water Efficiency Conservation Tracking Tool 2.0 Standard Edition*
- Letter from Waukesha Water Utility – [Re: Conservation, dated Feb. 11, 2014](#)
- Annual reporting to the Wisconsin Public Service Commission (WPSC)

## DISCUSSION

[NR 852](#) defines three tiers of water conservation and efficiency requirements for applicants applying for a new or increased withdrawal or diversion of Great Lakes basin (GLB) water. Tier 3, the highest level of required conservation and efficiency, applies to “persons applying for a new or increased diversion” ([Wis. Stat. § NR 852.02\(3\)\(a\)](#)) and requires the Applicant to:

1. Implement and document eight water conservation and efficiency measures including a number of specific elements for each measure ([Wis. Admin. Code. § NR 852.08](#)).
2. Document current and historical water use and water conservation ([Wis. Admin. Code. § NR 852.06](#)).
3. Create a water conservation plan including nine requisite elements and water conservation goals ([Wis. Admin. Code. § NR 852.04](#)).
4. Complete an environmental soundness and economic feasibility analysis to evaluate the costs and benefits of additional conservation and efficiency measures (CEMs) ([Wis. Admin. Code. § NR 852.10](#)).

[Wis. Admin. Code § NR 852.05\(3\)](#), offers an applicant the option of developing its own list of CEMs that can be shown to reduce water use or increase water reuse or efficiency by 10 percent from the most recent year or to adopt the pre-defined list of CEMs identified in [Wis. Admin Code § NR 852.05](#). The Applicant chose the latter.<sup>144</sup> The relevant requirements of Wis. Admin. Code § [NR 852](#) represent a practice-based approach to water conservation where implementing CEMs is the standard against which compliance is determined. The following sections assess the Applicant’s implementation of required CEMs.

### *1. Required Conservation and Efficiency Measures (CEMs)*

[NR 852](#) Tables 1 and 2 prescribe eight required CEMs for a Tier 3 practice-based approach. The department finds that the Applicant has satisfactorily complied with each CEM category and each required element. The required CEMs are listed in [Table 16](#) with a brief description of the department’s compliance determination. Details regarding the Applicant’s CEM implementation can be found in Appendix F of the Application, [Volume 3](#), City of Waukesha Water Conservation Plan.

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<sup>144</sup> Letter from Waukesha Water Utility – [Re: Conservation, dated Feb. 11, 2014](#).

**Table 16. Assessment of Required CEMs.**

<b>CEM#</b>	<b>Description</b>	<b>Justification for Compliance Determination</b>
PWS-1	Water Use Audit	In 2006, the Applicant completed a water use audit following WPSC <sup>145</sup> requirements and AWWA M36 <sup>146</sup> standards. As recommended by AWWA, the Applicant has continued to update water use audit measurements and calculations annually. The applicant indicates it will repeat the full audit every 5 years and has met WPSC water audit requirement on a yearly basis. <sup>147 148</sup>
PWS-2	Leak Detection and Repair Program	The Applicant employs leak detection and repair practices as defined by WPSC 185 including: (a) Meter all water uses and sales, where practicable. (b) Maintain and verify the accuracy of customer meters. (c) Maintain and verify the accuracy of station meters. (d) Identify and repair leaks in its distribution system to the extent that it is reasonable for the public utility to do so. (e) Control water usage from hydrants. (f) Maintain a continuing record of system pumpage and metered consumption. (g) Conduct an annual water audit under sub. (3). <sup>149</sup>
PWS-3	Information and Education Outreach	In Appendix F of its conservation plan, the Applicant lists over 30 events and activities it has undertaken since 2005 to promote conservation and efficiency to its employees and customers.
PWS-4	Source Measurement	The Applicant has demonstrated compliance with all WPSC and department rules regarding source measurement (see p 5-3 of the Conservation Plan). These measurements include daily measurement of withdrawals and delivery. These data are submitted to, recorded, and maintained by the department. It is available throughout Volume 2 of the Application.
PWS-R1	Distribution System Pressure Management	Reducing pressure within a distribution system can reduce baseline water use and decrease water main breaks. However, pressure system decreases must be balanced with sufficient pressure to meet fire flow requirements and customer demand. In 2006, the Applicant conducted a distribution system pressure management analysis. Based on recommendations from the analysis, the Applicant implemented pressure zone realignments to optimize required fire flows against its conservation. A 2011

<sup>145</sup> Wisconsin public service commission rule Wis. Admin. Code § [PSC 185.85\(3\)](#) requires all Wisconsin public water utilities to report a number of measures every year by April 1. These include many of the AWWA M36 water audit measures.

<sup>146</sup> American Water Works Association. *Water Audits and Loss Control Programs: Manual of Water Supply Practices M36*. American Water Works Association, Denver CO. 285p. 1999

<sup>147</sup> Application, [Volume 3](#), Appendix F

<sup>148</sup> Annual reporting data can be queried at the Wisconsin Public Service Commission Website here: <http://psc.wi.gov/apps40/WEGS/default.aspx>

<sup>149</sup> Past evidence of these activities can also be found in the Applicant’s annual conservation reporting to PSC. Conservation plan reporting would also be submitted to the department if a diversion is approved.

		memorandum from the consultant AECOM confirms that the Applicant’s average of 7.5 water main breaks per 100 miles of water mains was significantly less than the AWWA M36 goal of 15/100 mile.
PWS-R2	Residential Demand Management Program	The Applicant identifies a number of ongoing activities such as fixture rebate programs, rain barrel incentives, and a sprinkling ordinance that constitute a residential demand management program. The Applicant also created an implementation schedule for additional rebate programs identified in the cost-benefit analysis (see Appendix F of the Conservation Plan). The Applicant has also worked with Wisconsin Focus on Energy to identify opportunities for water and energy savings in public housing and recently began supporting residential meter monitoring services from Meter Hero (formerly H2O Score). Finally, the Applicant has committed to further investigating the costs and benefits of monthly billing and inclining rate structures.
PWS-R3	Commercial and Industrial Demand Management Program	The Applicant documented efforts to contact and assist high volume industrial and commercial water users with water audits, system upgrades and practice changes that would reduce total water use. The Applicant cited specific efforts with customers that saved over 20 million gallons per year. <sup>150</sup> The Applicant has planned ongoing efforts for commercial and industrial demand management through continued outreach and education efforts. Finally, the Applicant committed to further investigating the costs and benefits of inclining rate structures.
PWS-R4	Water Reuse	The Applicant evaluated water reuse opportunities in the operation of its facility. This required CEM applies only to the Water Utility and there are few opportunities for the Utility itself to reuse water beyond recycling filter backwash. At this time, recycling this water is not allowed due to radium contamination in the source water. Consequently, the Applicant did not identify any present opportunities for water reuse. The Applicant committed to reevaluating opportunities for water reuse in future modifications, updates or additions to its water conservation plan.

The activities listed in [Table 16](#) meet the required CEMs in [Wis. Admin. Code § NR 852](#).

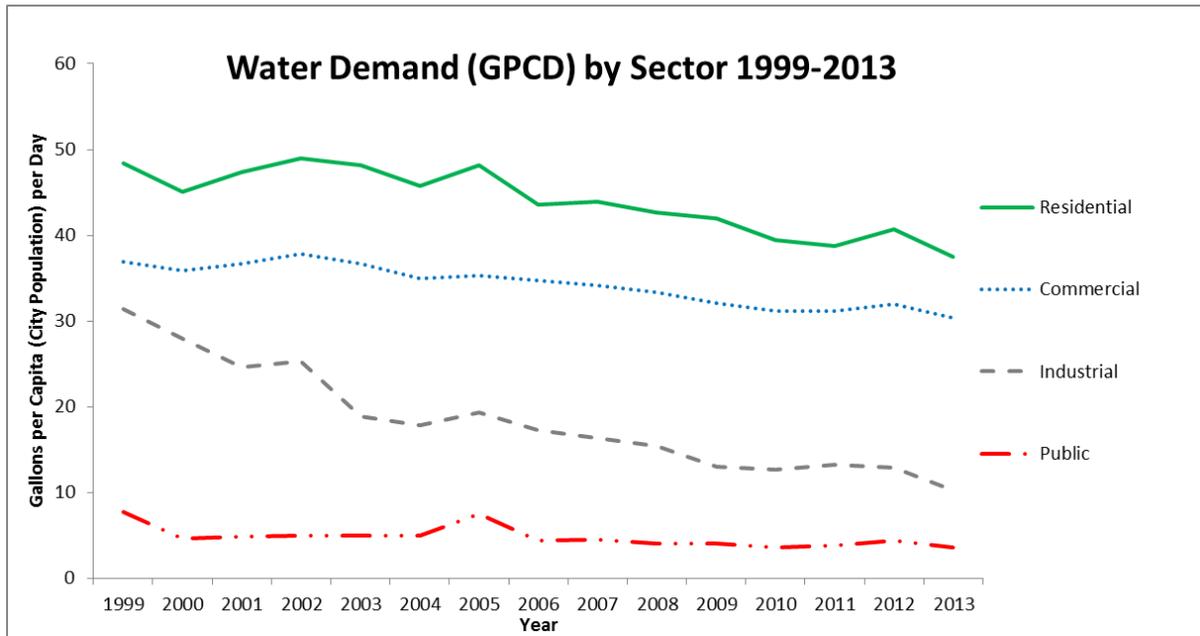
## 2. Documentation of Water Use and Conservation

The Applicant conducted an analysis of historical water use dating back to 1999 and showing regular declines in sales and total pumping.<sup>151</sup> These declines accelerated somewhat since the 2006 adoption of the Applicant’s Water Conservation and Protection plan, most notably in the residential sector ([Figure 13](#)).

<sup>150</sup> See Application, [Volume 3](#), section 5, p. 5; Letter from Waukesha Water Utility [re: Conservation, dated Feb. 11, 2014](#).

<sup>151</sup> Application, [Volume 3](#), section 4

Figure 13. Water Demand (GPCD) by Sector 1999-2013.



Reductions in demand due to conservation are not separable from reductions in demand due to other variables such as weather, economic trends, and shifts in consumer preferences. Therefore, attributing observed demand reductions directly to conservation programs is not possible. However, given the Applicant’s implementation of a plan guided by accepted conservation standards,<sup>152</sup> it is likely that its efforts were responsible, at least in part, for these recent declines. The Applicant documented the efficient use and conservation of existing water supplies over a minimum of the past 5 years as required in [Wis. Admin. Code § NR 852.06\(2\)](#).

### 3. Water Conservation Plan

[NR 852.04](#) requires that the Applicant submit a water conservation plan that meets the nine minimum applicable requirements of [Wis. Admin. Code § NR 852.07](#)—which are listed in [Table 17](#) along with a determination and citation to the element of the Applicant’s water conservation plan.

<sup>152</sup>Vickers, Amy. 2001. Handbook of Water Use and Water Conservation. Water Plow Press. Amherst, MA and American Water Works Association. 2006. Water Conservation Programs – A Planning Manual. AWWA. Denver, CO.

**Table 17. Assessment of Water Conservation Plan Required Elements.**

<b>Required Element</b>	<b>Citation</b>
<a href="#">§ NR 852.07(2)(a)</a> - A description and quantification of current water and reuse as identified by water use audit	Conservation plan section 4.1.1 and Appendix D
<a href="#">§ NR 852.07(2)(b)</a> - A description of water conservation and water use efficiency goals, including quantifiable goals	Conservation plan sections 2.1 and 3.2.1.
<a href="#">§ NR 852.07(2)(c)</a> - Documentation of the implementation of the mandatory CEMs	Conservation plan section 5.
<a href="#">§ NR 852.07(2)(d)</a> - A monitoring plan to assess the impact of implemented CEMs	Conservation plan section 3.2, 7.6.2 and Letter from Waukesha Water Utility – Re: Conservation, dated Feb. 11, 2014
<a href="#">§ NR 852.07(4)(a)</a> - An implementation timeline for implementing required Tier 3 CEMs	Conservation plan section 5 and Appendix F
<a href="#">§ NR 852.07(4)(c)</a> - Results of a CEM analysis for environmental soundness and economic feasibility.	Conservation plan section 6.3-4, Appendix G and results from the Alliance for Water Efficiency Conservation Tracking Tool 2.0 Standard Edition
<a href="#">§ NR 852.07(4)(d)</a> - The results of the analysis to identify additional CEMs	Conservation plan section 6 and 7.
<a href="#">§ NR 852.07(4)(e)</a> - An implementation timeline for additional CEMs	Conservation plan section appendix F
<a href="#">§ NR 852.07(4)(f)</a> - Historical documentation of efficient use and conservation of existing water supplies	Conservation plan section 4.

*4. Environmental soundness and economic feasibility analysis*

As recommended by the department, the Applicant used the *Alliance for Water Efficiency Conservation Tracking Tool*<sup>153</sup> to conduct its environmental soundness and economic feasibility analysis. This tool was developed to project water demand, utility costs, and potential water and monetary savings that would result from implementing pre-defined or user-defined conservation

<sup>153</sup> Results from the tracking tool can be found in the Application, [Volume 3](#), Appendix E. For more information, see <http://www.allianceforwaterefficiency.org/Tracking-Tool.aspx>.

practices. In addition, the tool is designed to project reductions from national, state and local changes to the plumbing code and the regular replacement of older, less-efficient plumbing fixtures and appliances with newer, more efficient ones. The Applicant used this tool to calculate future costs and water savings of potential conservation practices based on projected future population, changes to customer base and service area growth. The Applicant was then able to project future demand reductions that would result from implementing practices identified as cost-effective.

As a result of this analysis, the Applicant identified 19 cost-effective practices that, when implemented, could save an estimated 130,000 gallons per day (GPD) by 2050.<sup>154</sup> These practices comprised rebates, incentives, and customer surveys that would increase the impact of the Residential, Commercial, and Industrial demand management programs already implemented through CEMs PWS-R2 and PWS-R3<sup>155</sup>. Using this tool, the Applicant also identified another 520,000<sup>156</sup> GPD that would be saved by the ongoing replacement of older, less efficient fixtures in existing facilities and the installation of more efficient fixtures in new facilities. Additionally, in section 7 of its Conservation Plan, the Applicant identified a number of less easily-quantifiable programs, policies and regulations that it expects to decrease water use and increased efficiencies totaling another 350,000 GPD.

The Applicant expanded its analysis by soliciting input through a stakeholder committee that evaluated and ranked potential CEMs based on potential savings, costs, and appeal. This stakeholder involvement guided the Applicant in developing its implementation timeline for residential and industrial conservation program elements and also engendered support for current and future conservation efforts. Given these activities, the department concludes that the Applicant has met its obligation to conduct an analysis of the environmental soundness and economic feasibility of potential CEMs, as required by Wis. Admin. Code §§ [NR 852.06](#) and [852.10](#).

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<sup>154</sup> A list of these CEMs and implementation schedules can be found in Application, [Volume 3](#), Section 8.

<sup>155</sup> See [Table 17](#)

<sup>156</sup> Taken together the 650,000 GPD reduction would amount to approximately 5.9 to 6.7 percent of average daily demand. See Technical Review Section [C1](#) for further discussion.

# **Wastewater Return Flow To The Great Lakes Basin Related Criteria**

## **R1**

### **LEGAL REQUIREMENTS**

Agreement/Compact: The proposal meets the Exception Standard<sup>157</sup>, maximizing the portion of water returned to the Source Watershed as Basin Water and minimizing the surface water or groundwater from outside the Basin ([Compact](#) s. 4.9.3.b.; [Agreement](#) art. 201 s. 3.b.)

Wisconsin Statutes: The proposal maximizes the amount of water withdrawn from the Great Lakes basin that will be returned to the source watershed and minimizes the amount of water from outside the Great Lakes basin that will be returned to the source watershed ([Wis. Stat. § 281.346\(4\)\(e\)1.c.](#))

### **FINDINGS**

1. To maximize return of Lake Michigan basin water and minimize Mississippi River basin (MRB) water discharge to Lake Michigan, the department finds approvable the return flow management scenario (Alternative 6) that proposes to return the previous year's average daily withdrawal amount (see revised [Exhibit 3](#)).
2. Alternative 6 proposes a split wastewater discharge, whereby the previous year's average daily withdrawal—up to 10.1 million gallons per day (MGD)—would be returned daily to the Lake Michigan basin, with any additional flow from the Applicant's wastewater treatment plant returned to its current discharge location on the Fox-Illinois River (MRB).

### **METHOD OF ANALYSIS**

The department used the following methods to analyze the proposed return flow management plan alternatives to determine compliance with the legal requirements of [R1](#).

1. Reviewed and analyzed the Applicant's proposed wastewater return flow management plan alternatives.
2. Developed and analyzed other potential return flow scenarios.
3. Reviewed public comments concerning this criterion.
4. Analyzed the sources and quantities of MRB water in the wastewater effluent, including Infiltration and Inflow (I/I).
5. Compared the Applicant's I/I within its Capacity, Management, Operations and Maintenance (CMOM) Plan to other communities in SE Wisconsin.

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<sup>157</sup> The Exception Standard includes many criteria, all of which are included in this technical review. The Exception Standard can be found in the [Compact](#) s. 4.9.4. and in the [Agreement](#) art. 201 s. 4.

## DISCUSSION

The Compact does not explicitly outline requirements for determining the timing and volume of return flow water. The department determined that to meet this criterion, the Applicant should return close to, that is, neither significantly more nor less than, the amount withdrawn. The department's review focused on both maximizing Great Lakes water returned and minimizing MRB water returned in order to preserve the integrity of both basins.

### *Linking the Sanitary Sewer Service Area and Return Flow*

The Application proposes that all water to be returned to the Lake Michigan basin would be treated at the City of Waukesha's wastewater treatment plant (WWTP). The Applicant's entire planned sanitary sewer service area is within the MRB. In addition, the WWTP receives waste from a few holding and septic tanks in the area.<sup>158</sup> Under the Applicant's proposal, wastewater received at Waukesha's WWTP would include both Great Lakes basin (GLB) and MRB water. The Department would ensure that future connections to water supply service within the approved water supply area would be connected simultaneously to sanitary sewer.

### *Infiltration and Inflow*

Excess water that flows into sewer pipes from groundwater and storm water is known as infiltration and inflow (I/I). The City's topography, soil types and aging sewer service infrastructure have contributed to the collection system I/I. The City's I/I<sup>159</sup> (5-year wet weather flow of 2409 gallons per acre per day) is similar to other surrounding communities in Southeastern Wisconsin.<sup>160</sup>

As required in the City's previous Wisconsin Pollutant Discharge Elimination System (WPDES) permit, the City submitted a Capacity, Management, Operations and Maintenance (CMOM) Plan to the department in 2011. The City has submitted annual CMOM self-audits, as part of its previous WPDES permit and as required in its current permit issued on August 1, 2013.

In September 2011, the City started implementing collection system I/I reduction projects identified in its Sanitary Sewer System Master Plan.<sup>161</sup> The City has set aside capital funding for each of the next 10 years for sanitary sewer and manhole rehabilitation projects. The City submits semi-annual progress reports to the department for ongoing collection system I/I reduction project implementation efforts to comply with current WPDES permit requirements. These reports indicate that implementation plans are being followed.<sup>162</sup> For example, aging and leaking force mains are being replaced, discontinued or changed to gravity mains.

It is too early to fully evaluate the success of these improvements in terms of how much I/I or peak flow has been reduced, especially with dry weather conditions in 2012 and 2013. Continuation of the collection system improvement projects will reduce the City's I/I and

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<sup>158</sup> Attached to SEWRPCs approved sanitary sewer service area, designed to accept at least 3000 gallons per day. These storage tanks are not included in the water supply service area.

<sup>159</sup> Personal communication via Timothy Thompson (WDNR) and Steve Sticklen, Donohue and Associates dated Nov. 12, 2013

<sup>160</sup> Comparison of 5-year Wet Weather Flows. Donohue & Associates, [Final Report Inflow and Infiltration Study – Village of Whitefish Bay, Wisconsin](#), p. 18, fig. 4 (2/2012).

<sup>161</sup> Sanitary Sewer System Master Plans Phase I and II, Donahue and Associates, 2011

<sup>162</sup> Reviewed by Timothy Thompson, WDNR Wastewater Engineer, Milwaukee

subsequently would reduce the volume of treated WWTP water that is returned to the Fox-Illinois River.

*Return Flow Volume Alternatives*

The department reviewed all of the Applicant’s return flow management alternatives<sup>163</sup> and developed modifications to the alternatives (e.g., considered monthly and seasonal averaging periods) to determine which alternative would maximize Great Lakes basin water and minimize MRB water in the return flow.

**Table 18. Applicant’s return flow management scenarios.**

Alternative 1	Return all flow from the WWTP to Lake Michigan.
Alternative 2	Return flow from WWTP to Lake Michigan up to 115 percent of average day water demand (10.1 MGD*1.15 = 13 MGD. Divert all WWTP to the Fox River when Lake Michigan receiving tributary exceeds 2-year storm event flow.
Alternative 3	Return flow from WWTP to Lake Michigan up to max day water demand (16.7 MGD). Reduce maximum return flow to average day water demand (10.1 MGD) when Lake Michigan receiving tributary exceeds 2-year storm event flow.*
Alternative 4	Return flow from WWTP equal to previous day water demand (up to 100 percent of WWTP flow).*
Alternative 5	Return flow from WWTP up to the maximum day water demand (16.7 MGD).*
Alternative 6	Return flow from WWTP up to the previous year’s average annual water demand (10.1 MGD) as recommended by the department.*
*For alternatives 3-6, any WWTP water greater than this amount, would be returned to the current discharge location on the Fox River.	

Alternative 1, returning all wastewater from the City’s WWTP to Lake Michigan, does not minimize MRB water to Lake Michigan. The department determined Alternative 2 did not meet Agreement/Compact requirements as this alternative includes periods of no return flow to the Great Lakes basin (GLB), specifically during storm events, and the department determined daily flow to Lake Michigan was necessary to comply with the requirements. Considering historical data (2005-2012), Alternative 3 did not meet the requirement of minimizing MRB water in the return flow.

Alternative 4 includes return flow from the Waukesha WWTP equal to the previous day water demand (up to the daily maximum withdrawal amount of 16.7 MGD). This method does provide a better balance between the Lake Michigan and MRB. However, this option to manage daily flow is operationally intensive and effluent volume would vary considerably on a day-to-day basis to the Root River, so this option would not minimize MRB water to the Lake Michigan basin. Considering this option involved the highest degree of return flow control, the department

<sup>163</sup> Application, Volume 4, Revised [Exhibit 3](#) January 6, 2015.

analyzed variations of this management plan alternative considering monthly, seasonal and annual return flow alternatives.

In 2013, the Application highlighted Alternative 5 as the preferred option, which included returning a daily amount up to 16.7 MGD (the maximum day water demand) of treated effluent to the Lake Michigan basin.<sup>164</sup> Under this management plan, when treated effluent flows exceed 16.7 MGD, any additional volume would be returned to the Fox River via the existing WWTP discharge location on the Fox River.<sup>165</sup> This proposal would return 112 to 152 percent of the water withdrawn. Approximately 18 to 39 percent of the water discharged to the Lake Michigan basin would be MRB water. This wastewater would be added to the wastewater collection system through I/I or other sources of wastewater that are not currently served by Waukesha Water Utility within the MRB.<sup>166</sup>

During the years 2006-2012, the Applicant's water withdrawals averaged approximately 7 MGD while WWTP effluent discharges averaged approximately 10 MGD, and consumptive use averaged approximately 7 percent.<sup>167</sup> If these averages are applied to the Applicant's return flow management plan Alternative 5, approximately 35 percent of the return flow to the GLB would be due to MRB water. Under this management plan, only when volumes from Waukesha's WWTP exceeded 16.7, would the Fox River receive flow. Over this 7-year period, under Alternative 5, the Fox River would receive flow only 3 percent of the days (75 days total). This proposed alternative does not minimize the return of MRB water returned to Lake Michigan basin.

After analyzing all of the Applicant's scenarios, the department suggested that returning the previous year's annual average withdrawal would be a better approach (see comparison in [Table 19](#) below) to maximize Lake Michigan basin water in return flow and minimize the amount of MRB water returned to the GLB. Under this management plan alternative (Alternative 6), the Root River, the Applicant's preferred receiving tributary to Lake Michigan, would receive a relatively consistent volume daily throughout each year.

This additional volume to the Root River provides a steady additional flow of approximately 10.8 cubic feet per second (cfs) up to 15.6 cfs (based on an approximate 7 MGD average daily withdrawal, and up to the maximum average of 10.1 MGD, respectively). During storm events, when flooding is a concern on the Root River, treated effluent flow would never exceed 15.6 cfs (compared to 25.8 cfs under Alternative 5). In addition, this management plan scenario provides flow to the Fox-Illinois River<sup>168</sup> to protect the integrity of both basins.

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<sup>164</sup> Application, Volume 4, Revised [Exhibit 3](#) January 6, 2015.

<sup>165</sup> See Application, [Volume 4](#), p. 6, exhibit 6.

<sup>166</sup> See above: *Linking the Sanitary Sewer Service Area and Return Flow*

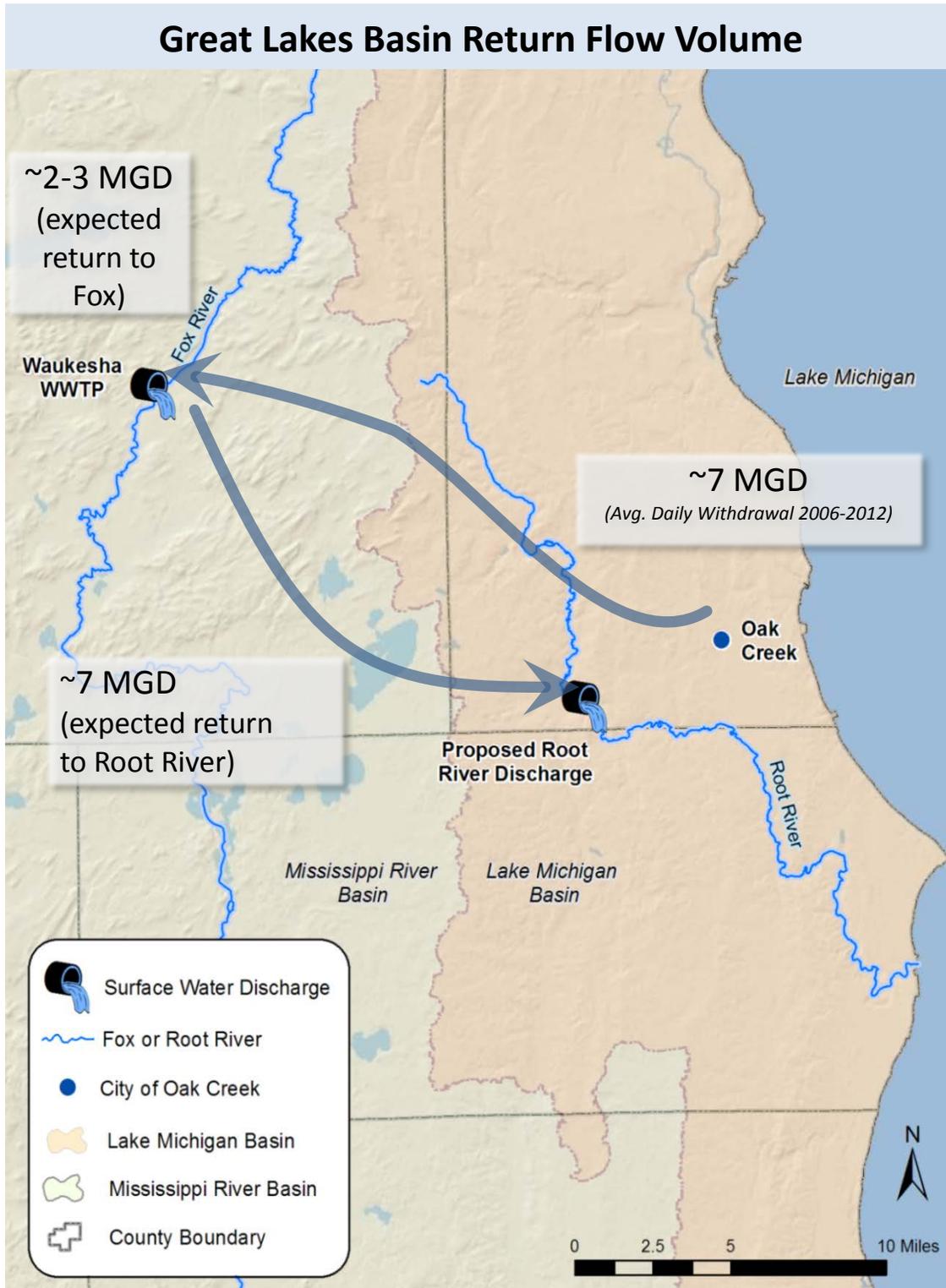
<sup>167</sup> Average consumptive use as calculated by the Applicant from [Volume 2](#), s. 5.4, Exhibit 5-4 and additional data from 2011-2012.

<sup>168</sup> If withdrawals stay at current levels (~7 MGD) and I/I does not change significantly, the Fox River would see continual flow. However, as demand reaches build-out averages of 10.1 MGD and/or I/I improves, flows to the Fox River would also decrease (see [R2](#)).

**Table 19. Comparison of Alternative’s 4 (Previous Day Return), 5 (Return up to 16.7 MGD), and 6 (Previous Year Annual Average Return, based on maximum of 10.1 MGD).**

Year	Previous Year Average Withdrawal (Proposal Return)	Average Daily Return (Actual WWTP data)	Alternative 4 (Number of days, no flow to Fox River)	Alternative 4, % of withdrawn water returned to GLB	Alternative 5 (Number of days, no flow to Fox River)	Alternative 5, % of withdrawn water returned to GLB	Alternative 6 (Number of days, no flow to Fox River)	Alternative 6, % of withdrawn water returned to GLB
2005	7.4	8.7	118	94	365	112	29	95
2006	7.8	10.1	13	100	363	139	2	109
2007	7.2	10.7	20	100	354	148	2	100
2008	7.2	11.7	6	100	337	160	0	104
2009	6.9	10.7	10	100	351	154	0	102
2010	6.8	10.6	3	100	348	154	3	102
2011	6.7	9.7	12	100	359	139	0	96
2012	7	8.5	76	97	366	123	11	101

Figure 14. General depiction of Split Return Flow Based on Historical Withdrawal and Effluent Data (2005-2012).<sup>169</sup>



<sup>169</sup> Full build-out conditions would return a maximum volume of 10.1 MGD to the Root River. Any additional flow would be returned to the Fox River.

## **R2**

### **LEGAL REQUIREMENTS**

Agreement/Compact: All Water Withdrawn shall be returned, either naturally or after use, to the Source Watershed less an allowance for Consumptive Use. ([Compact](#) s. 4.9.4.c.; [Agreement](#) art. 201 s. 4.c.)

Wisconsin Statutes: An amount of water equal to the amount of water withdrawn from the Great Lakes basin will be returned to the source watershed, less an allowance for consumptive use. ([Wis. Stat. § 281.346\(4\)\(f\)3.](#))

### **FINDINGS**

1. All water withdrawn from Lake Michigan, less an allowance for consumptive use, would be returned to the Lake Michigan basin.
2. The Applicant's return flow management alternative (Alternative 6), which returns the previous year's average daily withdrawal amount to maximize return of Lake Michigan basin water and minimize Mississippi River basin (MRB) water return to Lake Michigan, meets this criterion.

### **METHOD OF ANALYSIS**

To determine whether the proposed return flow management alternative returns all water withdrawn to the Lake Michigan basin, less an allowance for consumptive use, the department:

1. Reviewed the department's analysis for technical review criterion [R1](#) to maximize return of Lake Michigan basin water and minimize MRB water return to Lake Michigan.
2. Reviewed the proposed wastewater return flow plan alternatives to the Lake Michigan basin.
3. Reviewed and analyzed the Applicant's consumptive use estimates.

### **DISCUSSION**

The Applicant has a public water supply system that supplies water for residential, commercial and industrial use.<sup>170</sup> The Applicant tracks water use data through sales to each sector. Wisconsin's Compact implementing statute defines "consumptive use" as "a use of water that results in the loss of or failure to return some or all of the water to the basin from which the water is withdrawn due to evaporation, incorporation into products, or other processes".<sup>171</sup> Similarly, the Compact defines "consumptive use" as "that portion of the water withdrawn or withheld from the Basin that is lost or otherwise not returned to the Basin due to evaporation, incorporation into Products, or other processes."<sup>172</sup> The "other processes" referenced in the definition may include water lost from the Applicant's water supply distribution system due to water main leaks or breaks, meter inaccuracies, service leaks or breaks, hydrant leaks, tank

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<sup>170</sup> Application, [Volume 2](#), Section 6.2

<sup>171</sup> [Wis. Admin. Code § 281.346\(1\)\(e\)](#)

<sup>172</sup> [Compact](#) s. 1.2, also see [Wis. Stat. § 281.346\(1\)\(e\)](#)

overflows, and faulty pressure releasing valves (see diagram below). In most municipalities, where the source watershed is in the same basin as the water loss, this would not be a component of consumptive use. However, since the Applicant’s entire water supply service area is located within the MRB, any water lost from the processes above would not be returned to Lake Michigan basin and should be counted toward total consumptive use. The Applicant estimates and reports water loss on an annual basis to the Wisconsin Public Service Commission (WPSC).

Methodologies for calculating consumptive use for public water supply systems vary. The United States Geological Survey (USGS) identifies common approaches for calculating consumptive use such as a water balance equation (withdrawals –return flow = consumptive use) and the application of a consumptive use coefficient (if return flow data is not available).<sup>173</sup> As is true with most communities’ public water utilities, the Applicant’s return flow is frequently greater than its withdrawal due to infiltration and inflow (I/I),<sup>174</sup> and using the water balance equation would underestimate consumptive use.

A third approach, the Winter Base-Rate (WBR) Method can be used to estimate domestic consumptive use. The Applicant calculated average consumptive use using the Winter Base-Rate (WBR) Method as described in a 2009 United States Geological Survey’s (USGS) report.<sup>175</sup> The report explores public water supply withdrawals, return flow and consumptive use in Wisconsin, Ohio and Indiana. The WBR method primarily focuses on outdoor water use (lawn and landscape watering, car washing, pools) and assumes the majority of consumptive use in municipal water supply systems is due to evapotranspiration. Given that the Applicant’s water use peaks in summer months, the department believes this is an acceptable method to calculate domestic consumptive use.<sup>176</sup>

The WBR method calculates consumptive use according to the following equation:

$$\text{Annual Consumptive Coefficient(Percent)} = \frac{\left(\frac{\text{Total Annual Withdrawal}}{12}\right) - \left(\frac{\text{Sum of Winter Withdrawals}}{3}\right)}{\left(\frac{\text{Total Annual Withdrawal}}{12}\right)} \times 100$$

Sum of winter withdrawals or “winter months” refers to December through February.

Based on the WBR, the calculated median annual consumptive use is 8 percent for the Applicant, with summer ranges of 12 to 26 percent.<sup>177</sup> This is consistent with the statewide median annual

<sup>173</sup> Schaffer, K.H., [\*Variations in Withdrawal, Return Flow, and Consumptive Use of Water in Ohio and Indiana, with Selected Data from Wisconsin, 1999-2004\*](#), USGS Scientific Investigations Report No. 2009-5096, p. 32 (2009).

<sup>174</sup> See [R1](#) for more information.

<sup>175</sup> Schaffer, K.H., [\*Variations in Withdrawal, Return Flow, and Consumptive Use of Water in Ohio and Indiana, with Selected Data from Wisconsin, 1999-2004\*](#), USGS Scientific Investigations Report No. 2009-5096 (2009).

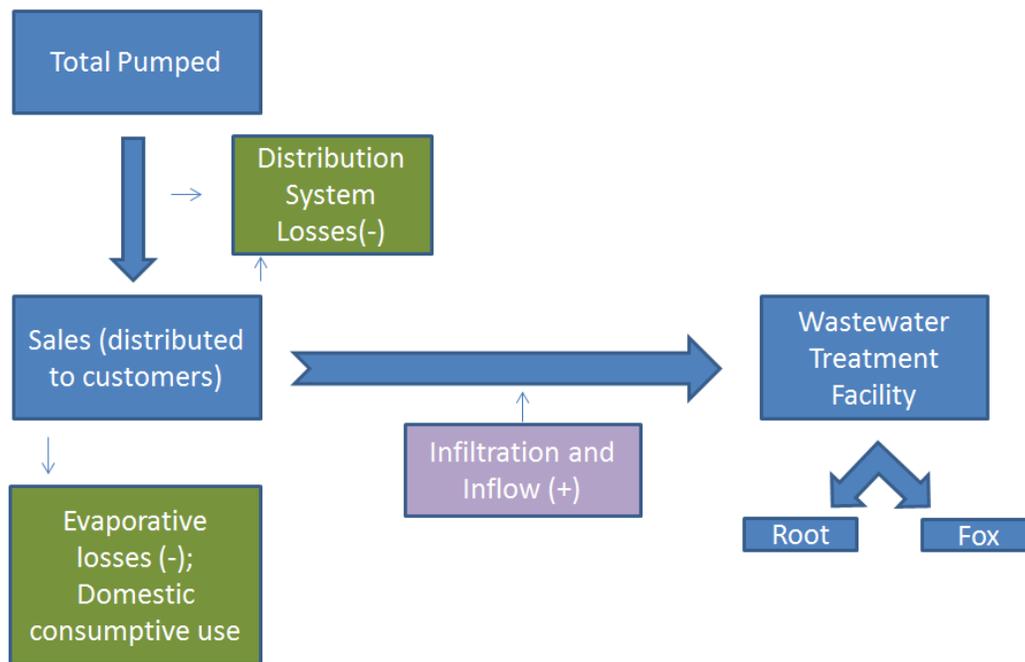
<sup>176</sup> An exception was 2014, when water use in February and March was higher than previous years due to extremely cold temperatures causing water main breaks and trickle orders to prevent pipes from freezing. If peak use is not in summer months, the WBR method will not accurately calculate consumptive use.

<sup>177</sup> Consumptive use averages (1999 to 2010). Application, [Volume 2](#), p. 5-3, Exhibit 5-4.

consumptive use coefficient of 8 percent computed using the WBR method for Wisconsin public water supply systems from 1999-2004.<sup>178</sup>

Failure to return water to the source watershed is driven by two primary components: consumptive use due to evaporative losses (calculated here by the WBR method); and other processes (distribution system losses as reported to WPS). Other processes may include water lost from the Applicant’s water supply distribution system due to water main leaks or breaks, meter inaccuracies, service leaks or breaks, hydrant leaks, tank overflows, and faulty pressure releasing valves (Figure 15). As noted above, the Applicant is required to estimate and annually report water loss to the WPS.<sup>179</sup> The Department considers the Applicant’s total consumptive use to be the combination of the WBR from water sales and distribution system losses (i.e. other processes).

**Figure 15. Water Balance for the City of Waukesha.**



The department used water use and water loss data from the City of Waukesha and the WPS to determine total consumptive use (combining water loss and consumptive use based on the WBR method for years 2010-2013).<sup>180</sup> The department used the following equation to calculate total consumptive use for the City of Waukesha:

$$\text{Annual Consumptive Coefficient}(\%) = \frac{(\text{Water Loss reported to PSC}) + (\text{WBR percent taken off of total water sold})}{(\text{Total Water Withdrawn})} \times 100$$

<sup>178</sup> Schaffer, K.H., *Variations in Withdrawal, Return Flow, and Consumptive Use of Water in Ohio and Indiana, with Selected Data from Wisconsin, 1999-2004*, USGS Scientific Investigations Report No. 2009-5096, p. 32 (2009).

<sup>179</sup> Annual water loss and water audit information is available at <http://psc.wi.gov/>.

<sup>180</sup> The department used winter months (Jan., Feb., Dec.) from the same calendar year to calculate consumptive use.

Using the above equation, the Applicant’s average consumptive use for the years 2010-2013 is approximately 14 percent. To demonstrate compliance with this criterion, the City would be required to return a minimum of 86 percent of the annual average of what is withdrawn from Lake Michigan. However, under the return flow scenario, discussed in section [R1](#) of this technical review, the department determined that 95 to 109 percent of the water withdrawn (using water use data from 2005-2012) would be returned—as depicted in [Table 20](#) below. Though consumptive use can vary from year to year based on factors such as climate, industrial/commercial water use, decreases in outdoor use, etc., the department anticipates that the chosen return flow plan (Alternative 6), would regularly return approximately 100 percent of the volume of water withdrawn.

**Table 20. Hypothetical percentage of water withdrawn that would be returned based on previous year's daily average withdrawal (see [R1](#) for details).**

Alternative 6 <sup>181</sup>	2005	2006	2007	2008	2009	2010	2011	2012
Percent of withdrawn water returned to the Great Lakes basin	95	109	100	104	102	102	96	101

As a condition of any diversion approval, the Applicant would be required to provide the department with annual consumptive use rates based on the WBR and annual water loss numbers.<sup>182</sup>

<sup>181</sup> Application, Volume 4, Revised [Exhibit 3](#) January 6, 2015.

<sup>182</sup> Reported to the Wisconsin Public Service Commission on an annual basis.

## **R3**

### **LEGAL REQUIRMENTS**

Agreement/Compact: No equivalent requirement.

Wisconsin Statutes: The place at which the water is returned to the source watershed is as close as practicable to the place at which the water is withdrawn, unless the Applicant demonstrates that returning the water at that place is one of the following:

1. Not economically feasible.
2. Not environmentally sound.
3. Not in the interest of public health. ([Wis. Stat. § 281.346\(4\)\(f\)3m.](#))

### **FINDINGS**

1. The Applicant proposes to receive Lake Michigan surface water from the City of Oak Creek Water and Sewer Utility. The City's preferred return flow alternative to discharge to the Root River, a Lake Michigan tributary, is as close as practicable to the place at which the water is withdrawn.

### **METHOD OF ANALYSIS**

To determine whether the return flow discharge location is as close as practicable to the place at which the water is withdrawn, the department reviewed the proposed water supply and wastewater return flow plan locations.

### **DISCUSSION**

The department considered the Applicant's preferred return flow option to discharge treated effluent to the Root River, a tributary to Lake Michigan. The proposed discharge location is near the intersection of W. Oakwood Road and S. 60<sup>th</sup> Street, in the City of Franklin, Wisconsin. The Root River flows southeast for approximately 25 miles from the Applicant's proposed discharge location before emptying into Lake Michigan.

For this analysis, the department focused on the phrase "as close as practicable" to the place at which the water is withdrawn.<sup>183</sup> The department calculated the linear distance of the return flow location from the point where the water would reach the source (Lake Michigan) to the City of Oak Creek's water intake pipe location. For example, for the Root River, the distance was calculated from where the water would be returned to Lake Michigan, at the City of Racine, to the City of Oak Creek's intake location.

The proposed Root River discharge location is within 11 miles (north or south) of the City of Oak Creek's intake location (see [Figure 16](#) below). The Applicant paired the water supply and return flow pipelines to share a majority of the same corridor to minimize environmental impacts and costs.<sup>184</sup> The department concludes that the Applicant's preferred Root River discharge

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<sup>183</sup> Practicable is defined as "capable of being effected, done, or put into practice; feasible." American Heritage Dictionary, Fourth Edition.

<sup>184</sup> See the draft Environmental Impact Statement ([dEIS](#)).

location is, for purposes of this criterion, as close as practicable to the place at which the water is withdrawn.

Figure 16. The proposed Root River return flow location in proximity of the City of Oak Creek Water Supply Location.



## **R4**

### **LEGAL REQUIREMENTS**

Agreement/Compact: No surface water or groundwater from outside the Basin may be used to satisfy any portion of this criterion except if it:

1. Is part of a water supply or wastewater treatment system that combines water from inside and outside of the Basin;
2. Is treated to meet applicable water quality discharge standards and to prevent the introduction of invasive species into the Basin; ([Compact](#) s. 4.9. [Agreement](#) art. 201 s. 4.c.)

Wisconsin Statutes: No water from outside the Great Lakes basin will be returned to the source watershed unless all of the following apply:

1. The returned water is from a water supply or wastewater treatment system that combines water from inside and outside the Great Lakes basin.
2. The returned water will be treated to meet applicable permit requirements under [Wis. Stat. § 283.31](#) and to prevent the introduction of invasive species into the Great Lakes basin and the department has approved the permit under [Wis. Stat. § 283.31](#).
3. If the water is returned through a structure on the bed of a navigable water, the structure is designed and will be operated to meet the applicable permit requirements under [Wis. Stat. § 30.12](#) and the department has approved the permit under [Wis. Stat. § 30.12](#). ([Wis. Stat. § 281.346\(4\)\(f4\)](#).)

### **FINDINGS**

1. The water returned to Lake Michigan is from a water supply and wastewater treatment system within the Mississippi River basin (MRB) that combines water from inside and outside the Great Lakes basin (GLB).
2. The returned wastewater would need to meet all applicable permit requirements under [Wis. Stat. § 283.31](#) and the wastewater treatment system would prevent the introduction of invasive species into the GLB.
3. The permits under [Wis. Stat. §§ 283.31](#) and [30.12](#) would be issued prior to receiving any formal diversion approval from the State of Wisconsin only after the applicant meets all permitting requirements under those statutes.

### **METHOD OF ANALYSIS**

To determine the Applicant's compliance with this criterion, the department:

1. Reviewed the proposed wastewater return flow plan for the proposed discharge locations to the Lake Michigan basin.
2. Reviewed and summarized the applicable portions of the analyses for criteria [R1](#) and [R2](#).
3. Reviewed the information provided by the Applicant and calculated draft water quality based effluent limits (WQBELs) to preliminarily determine if permits could be issued to

return water back to Lake Michigan prior to receiving Lake Michigan water for public water supply.

## DISCUSSION

### *Wastewater Treatment System*

The City of Waukesha owns and operates the Waukesha Wastewater Treatment Plant (WWTP) that provides wastewater service and treatment to residents, businesses and industries within the sewered area of City's current sewer service area. If the Applicant were to receive a Great Lakes water supply, water from both the Great Lakes and MRB would be combined in the wastewater system and treated at the Waukesha WWTP (See [R1](#) *Linking the Sanitary Sewer Service Area and Return Flow* for a description of Waukesha's water supply service and sewer service areas).

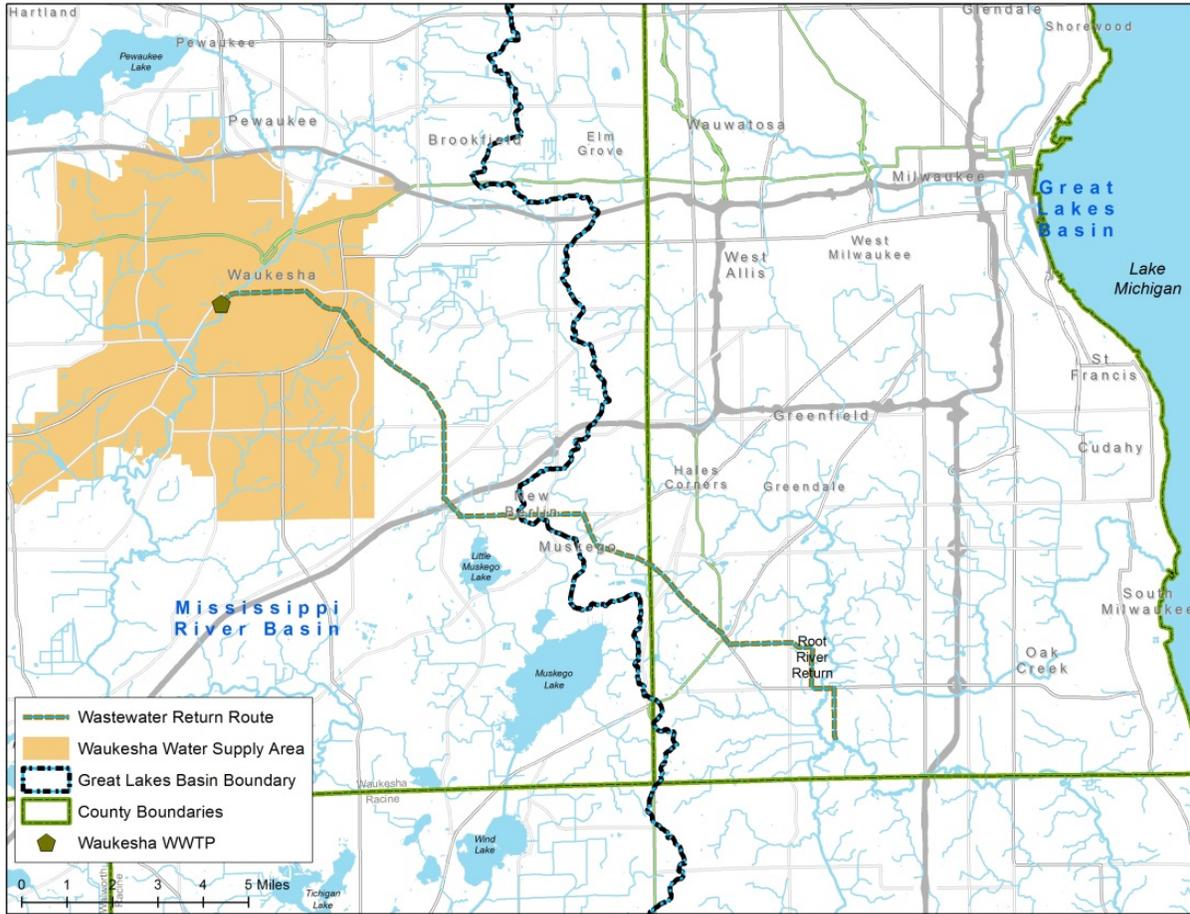
### *Wisconsin's Pollutant Discharge Elimination System Program*

The United States Environmental Protection Agency (EPA) delegates Clean Water Act authority to Wisconsin. Through its Wisconsin Pollutant Discharge Elimination System (WPDES) program, the state has the authority to permit the discharge of treated wastewater effluent from wastewater treatment plants into the waters of the state under [Wis. Stat. § 283.31](#). The Applicant would need to apply for and receive a WPDES permit in order to discharge treated effluent to its preferred discharge site, the Root River. The proposed discharge location for the return flow to the Root River<sup>185</sup> is near the intersection of West Oakwood Road and South 60<sup>th</sup> Street, in the City of Franklin, directly downstream of the confluence of the Root River Canal and the Root River mainstem.

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<sup>185</sup> Waterbody Identification Code (WBIC) 2900

**Figure 17. Proposed Return Flow Route to the Root River.**



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. Adm. Code, to assess whether the Applicant could ‘meet applicable water quality discharge standards’.<sup>186</sup> The United States Geological Survey (USGS) provided the low flow conditions for the Root River (7-Q<sub>10</sub> and 7-Q<sub>2</sub>)<sup>187</sup> to aid in calculating draft WQBELs.<sup>188</sup> USGS used the stream gages on the Root River at Racine (USGS Station #04087240) and Franklin (USGS Station #04087220) as reference sites to determine the low-flow estimates at the proposed discharge location (located near stream mile 25.3):

$$\text{Annual } 7\text{-}Q_{10} = 2.4 \text{ cfs (cubic feet per second)}$$

$$\text{Annual } 7\text{-}Q_2 = 4.2 \text{ cfs}$$

<sup>186</sup> Jackie Fratrack (retired department wastewater engineer) initially calculated Draft Limits for Waukesha Return Water Dec. 13, 2011. This memo was shared with the Applicant on Feb. 5, 2013. The department calculated updated WQBELs in March 2015, using the USGS low flow conditions for the Root River for more accurate limits, for internal review purposes. The updated limits are expressed in this technical review as recommended draft WQBELs.

<sup>187</sup> The 7-Q<sub>10</sub> is the lowest average discharge over a period of one week with a recurrence interval of 10 years, used in calculating discharge limits for streams and rivers

<sup>188</sup> Letter to Dan Duchniak, City of Waukesha from Rob Waschbusch, USGS, 12/19/2014. Monthly low flows are also listed in this document.

In addition, the department reviewed the Applicant's current wastewater effluent quality and planned improvements to the WWTP.

#### *WPDES Requirements for Return Flow to the Root River*

Based on the department's recommended draft WQBELs and the Applicant's current wastewater effluent quality, the department concludes that the following water quality parameters would need further attention in order for a new discharge to the Root River to meet future permit requirements: phosphorus, total suspended solids (TSS), temperature, and chlorides.

#### *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 agricultural, and natural land areas, and failing septic systems), may lead to degraded stream habitat, eutrophic conditions, unbalanced fish populations and excessive algal growth. Excessive algal growth in the stream due to increased phosphorus can decrease water clarity, increase water temperature and reduce light availability for beneficial macrophytes.

The applicable water quality criterion at the point of the proposed discharge for the Root River is 0.075 milligrams per liter (mg/L) total phosphorus (TP) ([Wis. Admin. Code § NR 102.06](#)). The ambient water quality data from the Root River exceed this criterion.<sup>189</sup> As a result, the Root River is listed as impaired under [§303\(d\) of the Clean Water Act](#)<sup>190</sup> for phosphorus, among other parameters.

[Wis. Admin. Code § NR 217.13\(8\)](#), supported by the department's draft phosphorus implementation guidance<sup>191</sup>, states that a new discharge of phosphorus to a phosphorus-impaired water may not be permitted unless: it is allocated in the reserve capacity of an EPA approved Total Maximum Daily Load (TMDL);<sup>192</sup> the discharger will improve the phosphorus water quality; or a trade or other means of offsetting the phosphorus contained in the discharge has been implemented prior to initiating the discharge. The Applicant is considered a new discharge<sup>193</sup> and there is no approved (TMDL) on the Root River. In order to discharge to the Root River, the Applicant must meet a phosphorus effluent limitation set well below the water quality criterion to provide a margin of safety and ensure an improvement in water quality or offset the phosphorus load of the discharge through a water quality trade.<sup>194</sup> The WQBEL may be within the range of 0.039 mg/L to 0.06 mg/L TP. The department calculated the lower end of this draft WQBEL phosphorus range based on a three-part analysis considering: EPA

<sup>189</sup> Technical Review [R5](#) contains more information on phosphorus loading and potential adverse impacts.

<sup>190</sup> [40 CFR § 130.7 \(2013\)](#)

<sup>191</sup> The draft Guidance for Implementing Wisconsin's Phosphorus Water Quality Standards for Point Source Discharges V 2.0 was public noticed in Dec. 2014 and is available at the following link: <http://dnr.wi.gov/news/input/documents/guidance/phosphorusguidance.pdf>

<sup>192</sup> No TMDL is currently planned for the Root River watershed. [Section 303\(d\) of the Clean Water Act](#) requires states to establish priority rankings for impaired waters and develop TMDLs for these waters. A TMDL is a calculation of the maximum amount of a pollutant that waterbody can receive and still meet water quality standards, (<http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/>).

<sup>193</sup> [40 C.F.R. §122.4\(i\) \(2013\)](#) reads "No permit may be issued to a new source or a new discharger, if the discharge from its construction or operation will cause or contribute to the violation of water quality standards..."

<sup>194</sup> See letter from Tinka Hyde, EPA to Russ Rasmussen, DNR dated Sept. 04, 2014 available at: <http://dnr.wi.gov/topic/WaterUse/documents/Waukesha/LetterEPAtoDNR2014-09-04.pdf>

ecoregional background concentrations, environmental phosphorus zones, and a breakpoint analysis used to derive the statewide TP criteria.<sup>195</sup>

The department approved the Applicant's WWTP facilities plan on March 13, 2013 and an amendment to the plan on February 10, 2015 (see [Appendix C](#)). The facilities plan included improvements to the WWTP based on a continued discharge to the Fox River and a new discharge to the Root River. The Applicant expected the current WWTP, with the planned improvements, to meet the effluent limitations and permit requirements required for continued discharge to the Fox River. However, the Applicant's current facilities plan anticipated that the water quality criterion of 0.075 mg/L TP would be required for the Root River and evaluated additional improvements to meet 0.075 mg/L TP. The facilities plan allows for the addition of a reactive filtration system at the wastewater treatment plant, such as *Blue-Pro* or *Actiflo* (ballasted settling with chemical addition) to meet this limit. The total present worth cost to achieve such limits was estimated at \$12.3 million.<sup>196</sup> The Applicant has been able to achieve 0.03 mg/L to 0.05 mg/L TP over a 3-month period with high quality chemical and multi-point chemical addition with flows less than 11 million gallons per day (MGD) based on a recent report to the department.<sup>197</sup>

In order to discharge to the Root River, the Applicant would need to comply with a phosphorus WQBEL well below the water quality criterion that may be between 0.039 mg/L to 0.06 mg/L TP. Further study by the Applicant would be needed to determine the final design of the phosphorus removal facilities to achieve lower limits. The Applicant would be required to prepare a facilities plan and submit plans and specifications for the additional phosphorus removal facilities including capital costs of the phosphorus removal technology and estimated operation and maintenance costs for optimization of the treatment technology to meet limits well below the water quality criterion prior to permit issuance. The draft WQBELS are feasible for the Applicant based on several documented studies that illustrate treatment options to meet low phosphorus concentrations are available.<sup>198</sup>

#### *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

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<sup>195</sup> The draft Guidance for Implementing Wisconsin's Phosphorus Water Quality Standards for Point Source Discharges V 2.0 was public noticed in Dec. 2014 and is available at the following link:

<http://dnr.wi.gov/news/input/documents/guidance/phosphorusguidance.pdf>

<sup>196</sup> Total Present Worth from Wastewater Treatment Plant Facilities Plan, Strand Associates, Inc., July, 2011.

<sup>197</sup> Data from February to April, City of Waukesha WWTP Phosphorus Operational Evaluation Report, Strand and Associates, June 2014.

<sup>198</sup> *Advanced Wastewater Treatment to Achieve Low Concentration of Phosphorus*, EPA 910-R-07-002, April 2007 (Pilot Study at Hayden, ID achieved 0.013 mg/L over 2 months); *Emerging Technologies for Wastewater Treatment and In-Plant Wet Weather Management*, EPA 832-R-011, March 2013 ("levels as low as 0.009 to 0.036 mg/L"); "Phosphorus Removal Achieved with Capital Affordability", Blue PRO Case Study, February, 2012, (Averaged 0.044 mg/L, as low as 0.26 mg/L, target was 0.07 mg/L).

from TSS can also affect fish, reducing its ability to see and catch food. TSS can also abrade and clog fish gills. Increased volumes of TSS can alter habitat for macroinvertebrates and bury fish spawning beds, and can lead to increased water temperatures.

Wisconsin has no numeric water quality criteria for TSS, however excessive sediments are considered “objectionable deposits” under [Wis. Admin. Code § NR 102.04\(1\)\(a\)](#), consequently the narrative water quality criterion applies. The Root River is listed as impaired for TSS/sedimentation under [§303\(d\) of the Clean Water Act](#).<sup>199</sup> In the absence of a wasteload allocation as part of an approved TMDL, the department would set draft recommended TSS limits at the most stringent limits (5 mg/L for summer months; 10 mg/L for winter months). The department recommends that the TSS in the discharge be minimized as much as possible to reduce any potential impacts, as the Root River has long-standing turbidity issues and suspended solids can also bind with other pollutants of concern.<sup>200</sup> The department believes if phosphorus treatment is optimized and installed to meet levels well below 0.075 mg/L TP, this technology should aid the Applicant in meeting draft WQBELs for TSS.

### *Thermal*

Water temperature is an important factor for the health of fish and aquatic communities. Water temperature can affect embryonic development, growth cycles, migration patterns, competition with aquatic invasive species, and risk and severity of disease. Water temperature also affects the concentration of dissolved oxygen, influencing aquatic organism respiration, bacteria activity, and toxic chemical availability in water and sediment.

To protect fish and aquatic life, the department calculates limits for temperature (thermal limits) based on the thermal classification of the receiving water, available dilution in the receiving water, and a statistical evaluation of representative effluent discharge temperature. The department used the highest daily maximum flow rate<sup>201</sup> for each calendar month, based on the thermal classification of the Root River, to calculate the draft acute (daily maximum temperature) WQBEL ([Wis. Admin. Code § NR 106.53\(2\)\(b\)](#)). The department used the highest 7-day rolling average flow rate for each calendar month to calculate the draft sub-lethal (weekly average temperature) WQBEL ([Wis. Admin. Code § NR 106.53\(2\)\(c\)](#)).

[Table 21](#) summarizes the maximum temperatures monitored at the Applicant’s WWTP for the period of January 2011 through December 2014 and the draft WQBELs using allowable dilution from the Root River. The department compared the representative highest effluent temperature to the calculated effluent limits to determine the reasonable potential of exceeding the effluent limits (temperatures listed in red are limits during months that may be difficult to meet based on the Applicant’s current effluent temperatures).

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<sup>199</sup> [40 CFR § 130.7 \(2013\)](#)

<sup>200</sup> [A Restoration Plan for the Root River Watershed Part One](#), Chapters 1-7, Planning Report No. 316, Southeastern Wisconsin Regional Planning Commission, July 2014.

<sup>201</sup> 10.1 MGD, based on the maximum return flow to the Root River under Alternative 6. See Technical Review [R2](#).

**Table 21. Draft Thermal WQBELS for a new Root River discharge.**

Month	Representative Highest Monthly Effluent Temp		DRAFT Calculated Effluent Limits	
	Weekly Ave (°F)	Daily Max (°F)	Weekly Ave Limit (°F)	Daily Max Limit (°F)
JAN	54	55	50	79
FEB	53	54	51	79
MAR	59	60	54	84
APR	59	61	57	88
MAY	64	66	66	86
JUN	71	72	77	86
JUL	74	75	82	86
AUG	73	75	82	85
SEP	73	74	73	83
OCT	68	69	62	82
NOV	61	62	50	80
DEC	59	60	50	80

The department recommends weekly average effluent limitations (October through April) as part of the Applicant’s future WPDES permit based on the calculations outlined in [Table 21](#). At certain times of the year, especially during low flow conditions, the downstream reaches of the Root River would be considered ‘effluent dominated’ from this new discharge. Even if the Applicant can prove 100 percent mixing through modeling and the discharge rate is set at a water demand of 7 MGD (the current average daily withdrawal for the Applicant), a weekly average temperature limit would still be required for October through January.

The Application notes multiple management solutions to meet the draft thermal limits including: heat exchange in the pipeline, surface aerators, multiple discharge locations to disperse return flow to minimize temperature impacts, cooling towers, chillers or some combination of management techniques.<sup>202</sup> In addition, the Applicant may request site specific criteria as part of the detailed WPDES permitting process, because the default ambient temperature included in [Wis. Admin. Code. § NR 102](#), is less than the measured temperature on the Root River. The Applicant would be required to monitor in-stream temperature in 15-minute increments for at least two years at or near the proposed discharge location in order to consider site specific criteria and demonstrate the need for different temperature limits ([Wis. Admin. Code § NR 102.26](#)).

<sup>202</sup> See memorandum “[Summary of the City of Waukesha with Root River Thermal Requirements](#)” CH2MHill, April 2, 2015.

Additionally, a preliminary analysis by the Department has shown that site specific thermal criteria would generally provide a difference of only  $\pm 2-3^\circ$  in the limit. The Applicant would need to submit designs, specifications, and costs to show how the thermal plume would act in the receiving water before the department could issue a permit<sup>203</sup>. The Applicant would be required to meet temperature limits before commencing a new discharge to the Root River.

### *Chlorides*

Chlorides are found in both saltwater and fresh water and are essential life elements. Chlorides in the Root River primarily result from anthropogenic sources (deicing road salt and discharge from water softeners) since geologic formations in the area contains relatively little chloride.<sup>204</sup> 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.

For the Root River wastewater return, the recommended draft WQBEL for chloride is a weekly average of 400 mg/L<sup>205</sup>. The City of Waukesha WWTP currently has an EPA approved chloride variance in its WPDES permit for the discharge to the Fox River, with a final chloride WQBEL of 431 mg/L and an interim weekly average chloride limit of 690 mg/L ([Wis. Stat. § NR 106.83\(2\)](#)). The average chloride concentration in the effluent since the effective date of the current permit is 518 mg/L, with the highest concentration recorded at 587 mg/L.<sup>206</sup> The Applicant would have to make considerable reductions to meet the WQBEL of 400 mg/L for return flow to the Root River, since the current chloride effluent concentrations are significantly 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 (Application, [Volume 4](#), Appendix A, Attachment A-5). The Applicant is required to submit annual chloride progress reports to the department to comply with requirements outlined in its current WPDES permit. The most recent report was submitted on June 30, 2014 and documents the recent steps the Applicant has taken to reduce chlorides (primarily by concentrating on source reduction measures).<sup>207</sup> 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

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<sup>203</sup> Per [Wis. Admin. Code § NR 106.60](#), “The department may require a permittee to provide diffusers or other such devices to ensure rapid mixing of effluent into the water body receiving the discharge or may require a mixing zone analysis to demonstrate that the proposed mixing zone of the new POTW discharge will meet the mixing zone provisions of [Wis. Admin. Code § NR 102.05 \(3\)](#).”

<sup>204</sup> [A Restoration Plan for the Root River Watershed Part One](#), Chapters 1-7, Planning Report No. 316, Southeastern Wisconsin Regional Planning Commission, July 2014

<sup>205</sup> This value is slightly higher than the 395 mg/L WQBEL memorandum previously drafted by Jackie Fratrack (Dec. 13, 2011) due to the draft limit calculations. Note: The upstream segment of the Root River, that ends at the confluence of the Root River is on the 2014 Impaired Waters List ([§303\(d\)](#)) for chlorides.

<sup>206</sup> City of Waukesha Wastewater Treatment Facility Annual Chloride Progress Report, City of Waukesha, 6/30/2014

<sup>207</sup> City of Waukesha Wastewater Treatment Facility Annual Chloride Progress Report, City of Waukesha, 6/30/2014

- d) Hauled Waste
- e) Ferric Chloride
- f) Normal Domestic Wastewater/Background from Groundwater

The Applicant has recently amended the City of Waukesha's sewer use ordinance with respect to water softening and brine reclamation.<sup>208</sup> 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).<sup>209</sup> Groundwater wells supply 'hard' water to customers, consequently many homeowners use water softeners. The current hardness concentration (CaCO<sub>3</sub>) based on an average range of well concentrations is 260-530 mg/L.<sup>210</sup> Recent alkalinity data (hardness CaCO<sub>3</sub>) from the City of Oak Creek Water Utility shows an average of ~111 mg/L, a level that does not require home water softening.<sup>211</sup>

In addition, the Applicant can also expect slight reductions in background chloride concentrations and loading since concentrations of chloride are lower in a Lake Michigan supply (~12 mg/L<sup>212</sup>), versus the current groundwater supply (~31 mg/L<sup>213</sup>). This reduces loading by approximately 1600 lbs/day.<sup>214</sup>

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 draft WQBEL chloride limits prior to discharging to the Root River.

#### *Antidegradation (NR 207 requirements)*

The department determined that the Applicant's proposed outfall to discharge effluent to the Root River would constitute a new discharge<sup>215</sup>, and that the Applicant would be required to submit a full antidegradation analysis with its WPDES application under [Wis. Admin. Code § NR 207](#). The Applicant submitted a draft plan to the department to demonstrate how

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<sup>208</sup> An Ordinance to Amend Certain Provisions of the Sewer Use and Wastewater Treatment Code of the Municipal Code of the City of Waukesha, Wisconsin, Approved April 4, 2104 by the City of Waukesha Common Council

<sup>209</sup> City of Waukesha Wastewater Treatment Facility Annual Chloride Progress Report, City of Waukesha, 6/30/2014

<sup>210</sup> City of Waukesha IOC samples from 1993 to 2012 for wells 10, 11, 12 and 13.

<sup>211</sup> Raw water sample results, Oak Creek, average for April 2015 ~111 mg/L.

<sup>212</sup> 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.

<sup>213</sup> City of Waukesha IOC samples from 1993-2012 for wells 10, 11, 12 and 13.

<sup>214</sup> 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.

<sup>215</sup> [Wis. Admin. Code § NR 207.01 \(2\)](#) reads "This chapter applies to any person proposing to increase an existing discharge or create a new discharge to the surface waters of the state."

antidegradation requirements may be addressed.<sup>216</sup> Both the department and EPA agree<sup>217</sup> that the new discharge could result in a “significant lowering of water quality” [Wis. Admin. Code § NR 207](#) for some of the discharged pollutants. However, the Applicant proposes a new discharge in order to correct a public health problem (i.e. radium in its current drinking water supply).

When applying for a WPDES permit, the Applicant would need to address other primary pollutants of concern, such as ammonia and temperature, as part of its final antidegradation analysis. In addition, according to [Wis. Admin. Code § NR 207.04 \(1\) \(d\)](#), persons proposing a new or increased discharge must provide documentation as to whether there are other feasible and cost effective discharge locations or alternatives. The EPA has provided guidance to the department that when there are feasible alternatives available that would allow an activity to occur with little or no degradation of water quality, those alternatives should be considered.<sup>218</sup>

Given the concerns and additional constraints outlined above, the Applicant would need to meet all WPDES permit requirements in order for the department to allow a new discharge to the Root River and to be in compliance with the antidegradation requirements in Wis. Admin Code § [NR 207](#).

#### *Invasive Species Prevention*

The Applicant’s drinking water treatment would include filters and disinfection procedures to prevent the spread of invasive species during the operation phase. This treatment level would not allow transfer of invasive species through the water supply distribution system. Once the water is distributed in pipelines, the Applicant will maintain an ongoing disinfectant residual to prevent microbial growth within the pipelines.

The Applicant’s wastewater would be collected in the sanitary sewer collection system and the Applicant’s WWTP would provide treatment before discharging the treated water to the Root River and the Fox River. The WWTP is an advanced facility with settling and biological treatment systems, dual media sand filters, and ultraviolet light disinfection designed to meet WPDES program requirements. The treated wastewater would be contained within the WWTP before being discharged as return flow. The Applicant’s proposed wastewater treatment would prevent the introduction of invasive species from the Mississippi Basin to the Root River or Lake Michigan basin.

#### *Chapter 30.12 Requirements for Return Flow to the Root River*

The Applicant has not yet applied for a Chapter 30 permit to place a wastewater outfall structure into navigable water.<sup>219</sup> A Chapter 30 permit applicant must be a riparian owner, and because the Applicant’s land purchase is dependent on approval of its diversion application, it has yet to become a riparian owner.<sup>220</sup> The department would require the Applicant to obtain a Wis. Stat. § 30.12 permit prior to placing any structure (i.e. pipes for water utility crossings, outfall structure)

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<sup>216</sup> Draft Memorandum, [Antidegradation Evaluation](#) for the City of Waukesha Application for a Lake Michigan Water Diversion with Return Flow, CH2MHILL, 05/26/2015

<sup>217</sup> See [EPA letter 09/04/2014](#)

<sup>218</sup> See [dEIS](#) Section 4.

<sup>219</sup> Such a permit is required under [Wis. Stat. § 30.12](#).

<sup>220</sup> Riparian land owners must apply or be a co-applicant for a Chapter 30 permit. The Applicant may also have an easement that allows for the placement and maintenance of the structure.

on the bed of the Root River. The Applicant would be required to meet all general permit or individual permit requirements under [Wis. Stat. § 30.12\(3m\)\(c\)](#), including:

- The structure or deposit will not materially obstruct navigation.
- The structure or deposit will not be detrimental to the public interest.
- The structure or deposit will not materially reduce the flood flow capacity of a stream

## **R5**

### **LEGAL REQUIREMENTS**

Agreement/Compact: No equivalent requirement

Wisconsin Statutes: If water will be returned to the source watershed through a stream tributary to one of the Great Lakes, the physical, chemical, and biological integrity of the receiving water under [subd. 3.](#) will be protected and sustained as required under [§§. 30.12, 281.15,](#) and [283.31,](#) considering the state of the receiving water before the proposal is implemented and considering both low and high flow conditions and potential adverse impacts due to changes in temperature and nutrient loadings ([Wis. Stat. § 281.346 \(4\) \(f\) 4m.](#))

### **FINDINGS**

1. The Applicant is proposing to return treated effluent to the Root River, a tributary of Lake Michigan; therefore, this technical review criterion is applicable.
2. The department finds that if the Applicant can meet all future permit requirements under [Wis. Stat. §§ 30.12, 281.15,](#) and [283.31](#) (outlined in [R4](#)), the physical, chemical and biological integrity of the receiving water would be protected and sustained.

### **METHOD OF ANALYSIS**

1. Reviewed the proposed wastewater return flow plan for return flow to the Root River.
2. Reviewed and summarized the applicable portions of the analysis for [R2](#) and [R4](#), which includes the applicable requirements of [Wis. Stat. §§ 30.12](#) and [283.31.](#)
3. Reviewed stream conditions to identify any potential adverse impacts due to changes in temperature and nutrient loadings.

### **DISCUSSION**

The Applicant is proposing to return a maximum of 10.1 million gallons per day (MGD) of treated effluent to the Root River, a tributary of Lake Michigan.<sup>221</sup> The proposed new discharge location is the Root River near the intersection of West Oakwood Road and South 60<sup>th</sup> Street, in the City of Franklin, directly downstream of the confluence of the Root River Canal and the Root River mainstem ([Figure 18](#)). The following analysis considers current water quality conditions and potential impacts due to this proposed new discharge.

#### *Root River Applicable Water Quality Standards*

The Root River headwaters are located in Waukesha County.<sup>222</sup> The river flows southeast through Milwaukee and Racine counties for about 44 miles before emptying into Lake Michigan at the City of Racine<sup>223</sup>. [Wis. Stat. § 281.15](#) authorizes the department to promulgate rules to

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<sup>221</sup> The return flow would vary from approximately 7 MGD to a maximum of 10.1 MGD depending on the previous year's average annual withdrawal. See [R1](#).

<sup>222</sup> Waterbody Identification Code (WBIC) 2900

<sup>223</sup> See [dEIS](#), Section 3

create water quality standards, including Wis. Admin. Code §§ NR [102](#), NR [104](#), NR [103](#), NR [105](#), NR [106](#), NR [207](#), NR [210](#) and NR [217](#). Water quality standards include creating designated uses of the water, as well as water quality criteria to meet those uses. The designated uses for the Root River include full fish and aquatic life and recreational uses.<sup>224</sup>

To address this technical review criterion, the department focused on the water quality criteria associated with nutrient loading and temperature at a maximum return flow of 10.1 MGD. The nutrient loading analysis focuses on phosphorus, since Wisconsin does not have numeric water quality standards for nitrogen.

Wisconsin adopted its phosphorus water quality standards on December 1, 2010. This process included creating numeric phosphorus water quality standards for surface water and the corresponding procedures for phosphorus implementation ([Wis. Stat. §§ NR 102](#) and [NR 217](#), respectively). The applicable total phosphorus criterion for the Root River is 0.075 mg/L. Any Wisconsin Pollution Discharge Elimination System (WPDES) permit issued after December 2010 is evaluated for phosphorus water quality based standards. The existing phosphorus guidance<sup>225</sup> was used to determine an appropriate water quality based effluent limit for a proposed new discharge to the Root River (see [R4](#)).

Wisconsin revised its Thermal Water Quality Standards, in [Wis. Admin. Code §§ NR 102](#) and [NR 106](#), to protect both fish and aquatic life and human health.<sup>226</sup> [Wis. Admin. Code § NR 102](#), lists the water quality standards for temperature. These standards were established to protect fish and other aquatic life from mortality, immobilization, loss of equilibrium, impaired growth, adverse reproductive effects, and sub-lethal effects. [Wis. Admin. Code § NR 106](#), describes how the water quality criteria are used to establish water quality-based effluent limitations (WQBELs) for point source dischargers under the Wisconsin Pollutant Discharge Elimination System (WPDES). The department used this methodology to calculate draft WQBELs to determine if the Applicant could meet thermal limits for the Root River based on its existing discharge data.

#### *Root River Water Quality – 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), may lead to degraded stream habitat, eutrophic conditions and unbalanced fish populations. Excessive algal growth in the stream due to increased phosphorus can decrease water clarity, increase water temperature, increase the magnitude of oxygen swings, and reduce light availability for beneficial macrophytes and periphyton communities. The entire Root River is listed on Wisconsin's [§303\(d\)](#) list<sup>227</sup> due to excessive phosphorus ([Table 22](#)).

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<sup>224</sup> Fish and Aquatic Life (FAL) uses, see Wis. Admin. Code §§ NR [102](#) and NR [104](#).

<sup>225</sup> The department's implementation guidance for phosphorus is available at: <http://dnr.wi.gov/topic/SurfaceWater/phosphorus.html>.

<sup>226</sup> Thermal water quality standards outlined in Wis. Admin. Code §§ NR [102](#) and [106](#), became effective October 1, 2010.

<sup>227</sup> See [dEIS](#) Section 3 for additional pollutants and impairments on the Root River.

**Table 22. Root River phosphorus s. 303(d) impaired waters listings.**

Root River Mileage	Pollutant	Corresponding Impairment
0 - 5.82	Total Phosphorus	Unknown
5.82 -20.48	Total Phosphorus	Degraded Biological Community
20.48 - 25.80*	Total Phosphorus	Degraded Biological Community, Low Dissolved Oxygen (DO)
25.80 - 43.69	Total Phosphorus	Degraded Biological Community, Low DO

\*The proposed discharge is located at approximately mile 25.3 of the Root River.

There are no approved Total Maximum Daily Loads (TMDLs) for the Root River. The Root River is identified as being adversely affected by high concentrations of phosphorus in the Root River Watershed Restoration Plan<sup>228</sup>. Water quality recommendations in the plan include measures to reduce phosphorus levels in the river. Due to the known impacts of additional nutrient loading to an impaired water, and given that there is no approved TMDL for the Root River, the department determined, and EPA agreed<sup>229</sup>, that a lower water quality effluent limit than the water quality criterion of 0.075 mg/L total phosphorus (TP), would be needed to protect the physical, chemical and biological integrity of the receiving water.

Based on data from 2005-2012, the range of phosphorus concentrations along the Root River mainstem varies from no detection to 0.71 mg/L, with a median concentration of 0.10 mg/L.<sup>230</sup> The Root River Canal empties into the Root River, just north of the Applicant’s proposed discharge location. Total phosphorus concentrations detected at the furthest downstream monitoring station on the Root River Canal range from 0.068 mg/L to 0.892 mg/L<sup>231</sup> ([Figure 18](#)).

The department quantified point and nonpoint source phosphorus loading estimates at seven sites throughout the Root River watershed using available measured discharge and water quality datasets in addition to load estimation tools (see [Appendix D](#)). 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 PRESTO model.<sup>232</sup> Of the 65,877 pounds per year, five existing permitted point sources discharged an average sum of 2,890 pounds of phosphorus (4 percent of the total load) per year between 2010 and 2012. The department assumed 100 percent

<sup>228</sup> [A Restoration Plan for the Root River Watershed Part One, Chapters 1-7](#), Planning Report No. 316, Southeastern Wisconsin Regional Planning Commission, July 2014.

<sup>229</sup> See letter from Tinka Hyde, EPA to Russ Rasmussen, DNR dated Sept. 04, 2014 available at: <http://dnr.wi.gov/topic/WaterUse/documents/Waukesha/LetterEPAtoDNR2014-09-04.pdf>

<sup>230</sup> [A Restoration Plan for the Root River Watershed Part One, Chapters 1-7](#), Planning Report No. 316, Southeastern Wisconsin Regional Planning Commission, July 2014.

<sup>231</sup> From Baseline Assessment of Water Quality in support of the Root River Watershed Restoration Plan, Data Analysis Report, Kinzelman, Koski and Wright, 2011-2013.

<sup>232</sup> Pollutant load Ratio Estimation Tool (PRESTO) model developed by the department.

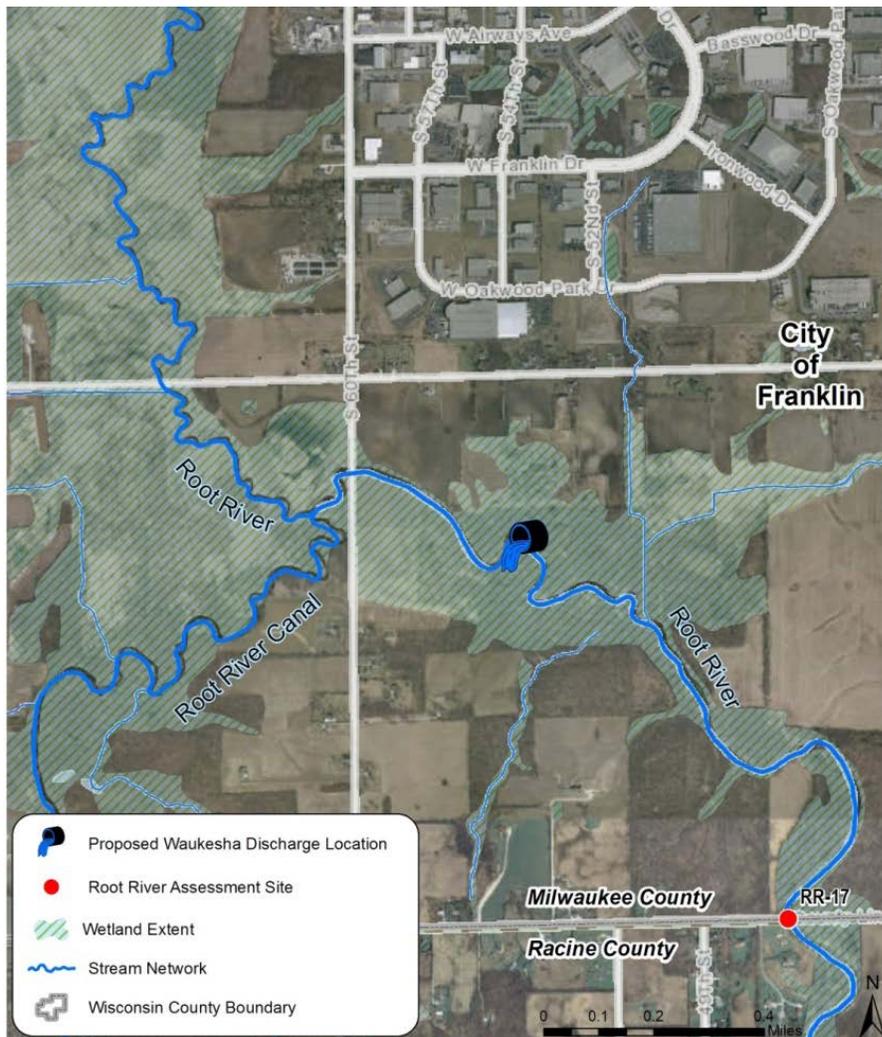
of the phosphorus delivered to the stream network throughout the Root River Watershed reaches Lake Michigan.<sup>233</sup>

The Applicant would be required to meet a limit that is ‘well below’ the Root River’s water quality criterion of 0.075 mg/L TP in order to discharge to an impaired water. This builds in a ‘margin of safety’ (in lieu of no approved TMDL) and ensures an improvement in water quality. AWQBEL may be in the range of 0.039 mg/L to 0.06 mg/L TP to minimize any potential water quality impacts from phosphorus loading. The lower number within this range, 0.039 mg/L at maximum effluent flow conditions, would contribute approximately 1,200 lbs. TP annually to the Root River. Using the PRESTO results listed above, the Applicant’s proposed phosphorus load would contribute less than 2 percent of all of the loading to the entire Root River watershed at its confluence with Lake Michigan. Even with a new point source discharge, nonpoint source loading would still account for the majority (more than 94 percent) of the phosphorus load to the Root River. During high flow conditions, the maximum return flow (15.6 cubic feet per second (cfs)) would be less than one percent (~0.32 percent) of the 100-year river flow (4,820 cfs) near the return flow location. Nonpoint source phosphorus loading that occurs during these large flood events would be more significant than the phosphorus contribution from the Applicant’s waste water treatment plant (WWTP). If the Applicant’s effluent TP concentration were well below the criteria, the effluent should ultimately reduce the concentration of TP in the receiving water at the point of discharge.

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<sup>233</sup> Spatially-referenced Regression on Watershed Attributes (SPARROW) model developed by the United States Geological Survey (USGS)

**Figure 18. Location of Proposed Waukesha Discharge on the Root River.**



The modeled August median flow for the Root River at the proposed outfall location is 23 cfs.<sup>234</sup> The added flow (10.1 MGD, 15.6 cfs) would contribute significant flow during low flow periods. The pre-settlement estimate of August median flow for the Root River is 36 cfs, so the added return flow would restore flow to approximately pre-settlement conditions.

#### *Root River Water Quality – Temperature*

Water temperature is an important factor for the fish health and aquatic communities. Temperature can affect embryonic development, growth cycles, migration patterns, competition with invasive species and risk and severity of disease. Water temperature also affects the dissolved oxygen concentration and can influence the activity of bacteria and alter the availability of toxic chemicals in water and sediment. Wisconsin developed water quality standards for temperature to protect fish and aquatic life communities, especially during critical times of the year for gamete production and spawning.

<sup>234</sup> Diebel, M., A. Ruesch, D. Menuz, J. Stewart, and S. Westenbroek. [Ecological Limits of Hydrologic Alteration in Wisconsin Streams](#), 2014

Acute water quality-based criteria for temperature represent maximum allowable temperatures that protect aquatic organisms from direct lethal effects of thermal loads from effluent. Appropriate temperatures are essential for aquatic ecosystem quality and integrity; aquatic organisms exist within particular temperature ranges, optimums, and tolerances. Additionally, the metabolic limits and acclimation histories of different organisms ultimately determine their thermal tolerances.

Sub-lethal water quality-based temperature criteria represent maximum allowable temperatures that are generally protective of aquatic organisms. In particular, the sub-lethal criteria are based on data from three fish life history activities: gametogenesis, spawning, and growth. These three activities are vital to fish in particular, and in equivalent forms to all aquatic organisms. For this reason it is important to protect these activities through criteria that specifically address them, and to not rely only on acute criteria to attempt to protect sub-lethal life history activities. Since sub-lethal effects generally occur over a much longer time frame than acute effects, the sub-lethal criteria are implemented as weekly averages, rather than daily maximums.

The draft WQBELs ([Table 23](#) below, also see [R4](#)), are designed to meet the Root River water quality criteria (see [Wis. Admin. Code § NR 102](#)). Comparing the representative highest effluent temperature to the calculated effluent limits determines the reasonable potential of exceeding the effluent limits. There does not appear to be reasonable potential to exceed the daily maximum limits based on acute criteria during any months of the year or weekly average limits based on sub-lethal criteria from May through September. From October through April, the current effluent data exceed the calculated limits by anywhere from less than one degree to 11 degrees Fahrenheit, resulting in the need for temperature limits for those months. The Applicant must meet the draft thermal WQBELs during winter, provide evidence for site specific criteria to meet water quality criteria or apply for an alternative effluent limit.<sup>235</sup>

During summer months, the thermal effect of the treated wastewater discharge to the Root River is likely to be minimal since the Applicant's average maximum temperatures are close to the predicted temperature and measured temperatures at the upstream monitoring station, United States Geological Survey (USGS) gage #4087220 ([Table 23](#)). Even if minimal warming occurs, most of the resident species are warmwater species and would most likely benefit more from the increased flow (e.g. deeper water, less stagnant pools) rather than be harmed by the minor temperature change. Based on the information presented above, flow and temperature effects are likely to be neutral or positive to the Root River under the return flow scenario outlined in [R1](#).<sup>236</sup>

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<sup>235</sup> Wis. Admin. Code §§ [NR 102.27](#) and [106.72](#).

<sup>236</sup> Further detail on flow and flooding impacts are in the [dEIS](#), Section 4.

**Table 23. Draft water quality based effluent limits compared to Waukesha's current average monthly temperatures and ambient Root River temperatures. Temperatures are in degrees Fahrenheit.**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Acute Water Quality Criteria – Temp.	76	76	77	79	82	84	85	84	82	80	77	76
Waukesha Daily Max Temp. (2011-2014)	55	54	60	61	66	72	75	75	74	69	62	60
Sub-Lethal Water Quality Criteria for Temp.	49	50	52	55	65	76	81	81	73	61	49	49
<b>DRAFT Sub-Lethal Temp. WQBELs</b>	<b>50</b>	<b>51</b>	<b>54</b>	<b>57</b>	<b>66</b>	<b>77</b>	<b>82</b>	<b>82</b>	<b>73</b>	<b>62</b>	<b>50</b>	<b>50</b>
Waukesha Effluent Monthly Max. Temp. (2011-2014)	52	51	53	55	60	65	70	73	70	65	60	56
Default Ambient Temp. for WI Warm Small Non-Specific Waters*	33	34	38	48	58	66	69	67	60	50	40	35
Upstream USGS Gage Site 4087220 Average Instantaneous Temp. (1972-2014, n=47) <sup>237</sup>	33	33	39	49	59	66	72	72	62	52	41	35

\*Draft WQBELs are based on these temperatures from [Wis. Admin. Code § NR 102.25\(2\)](#). Representative data at the proposed outfall site were not available.

The technology exists to meet the proposed draft WQBELs. If the Applicant can prepare permit materials to show they can meet draft WQBELs and other permitting requirements, there should be no significant impacts to the physical, chemical or biological integrity due to changes in temperature or nutrient loading from the Applicant's proposed new discharge.

<sup>237</sup> Data compiled by SEWRPC and collected by the department, MMSD, City of Racine Health Department and USGS.

## **Impact Assessment Related Criteria**

### **IA1 and IA2**

#### **LEGAL REQUIREMENTS – IA1**

Agreement/Compact: Caution shall be used in determining whether or not the Proposal meets the condition for this Exception. This Exception should not be authorized unless it can be shown that it will not endanger the integrity of the Basin Ecosystem<sup>238</sup> ([Compact](#) s. 4.9.3.e.; [Agreement](#) art. 201 s. 3.e.)

Wisconsin Statutes: The proposal will not endanger the integrity of the Great Lakes basin ecosystem based upon a determination that the proposal will have no significant adverse impact on the Great Lakes basin ecosystem<sup>239</sup> ([Wis. Stat. § 281.346\(4\)\(e\)1.e.](#))

#### **LEGAL REQUIREMENTS – IA2**

Agreement/Compact: The Exception will be implemented so as to ensure that it will result in no significant individual or cumulative adverse impacts to the quantity or quality of the Waters and Water Dependent Natural Resources of the Basin with consideration given to the potential Cumulative Impacts<sup>240</sup> of any precedent-setting consequences associated with the Proposal ([Compact](#) s. 4.9.4.d.; [Agreement](#) art. 201 s. 4.d.)

Wis. Statute: The diversion will result in no significant adverse individual 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, based upon a determination that the proposed diversion will not have any significant adverse impacts on the sustainable management of the waters of the Great Lakes basin ([Wis. Stat. § 281.346\(4\)\(f\)5.](#))

Note: Given the similarity of criteria IA1 and IA2, the department has combined its review of these criteria.

#### **FINDINGS**

1. The Applicant's proposal for a diversion from Lake Michigan would not endanger the integrity of the Great Lakes Basin (GLB) ecosystem.

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<sup>238</sup> "The interacting components of air, land, water, and living organisms, including humankind, within the basin." [Wis. Stat. § 281.343\(1e\)\(m\)](#)

<sup>239</sup> The Compact defines the "Great Lakes—St. Lawrence River Basin Ecosystem" as "the interacting components of air, land, Water and living organisms, including humankind, with the Basin." ([Compact](#) Article 1 Section 1.2)

<sup>240</sup> The Compact defines "Cumulative Impacts" as "the impact on the Basin Ecosystem that results from incremental effects of all aspects of a Withdrawal, Diversion, or Consumptive Use in addition to other past, present, and reasonably foreseeable future Withdrawals, Diversions, and Consumptive Uses regardless of who undertakes the other Withdrawals, Diversions, and Consumptive Uses. Cumulative Impacts can result from individually minor but collectively significant Withdrawals, Diversions, and Consumptive Uses taking place over a period of time." ([Compact](#) Article 1 Section 1.2)

2. The Applicant’s proposal for a diversion from Lake Michigan would result in no significant individual or cumulative adverse impacts to the quantity or quality of the water and water-dependent natural resources of the GLB.

**METHOD OF ANALYSIS**

The department undertook the following analysis:

1. Reviewed the Application, [Volume 5](#) for impacts, including quality and quantity impacts to the Great Lakes basin.
2. Reviewed the department’s Draft Environmental Impact Statement ([dEIS](#)) for the proposed diversion alternatives.
3. Reviewed the findings within the department’s technical review criteria [R4](#) and [R5](#), which include water quality components.

**DISCUSSION**

*Impact on water quantity*

The Applicant proposes to withdraw a maximum daily average of 10.1 million gallons per day (MGD) from Lake Michigan at full build-out (approximately 2050) served by a pipeline from the existing Oak Creek Utility, while returning all water withdrawn less an amount for consumptive use, to the Root River. The daily return flow to the Great Lakes basin (GLB) would equal up to the previous year’s average annual daily withdrawal.<sup>241</sup>

[Table 24](#) illustrates the maximum annual withdrawal as a percentage of the volumes of Lake Michigan and the Great Lakes. 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 GLB. Based on the 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 (see [R1](#)).

**Table 24. Maximum Diversion as Percent of Great Lakes Volume.**

	<b>Total volume (Million Gallons)</b>	<b>Maximum annual withdrawal<sup>242</sup> (MG)</b>	<b>Maximum annual withdrawal (% of total volume)</b>
<b>Lake Michigan</b>	1,299,318,237 <sup>243</sup>	3,686.5	0.000284%
<b>Great Lakes</b>	6,056,144,311 <sup>244</sup>	3,686.5	0.000061%

The department anticipates no significant adverse individual or cumulative water quantity impacts to the GLB given that the withdrawal amount represents such a small percentage of the

<sup>241</sup> The return flow would vary from approximately 7 MGD to a maximum of 10.1 MGD depending on the previous year’s average annual daily withdrawal. See [R1](#).

<sup>242</sup> 10.1 MGD times 365

<sup>243</sup> From NOAA: <http://www.glerl.noaa.gov/pr/ourlakes/lakes.html>

<sup>244</sup> From NOAA: <http://www.glerl.noaa.gov/pr/ourlakes/facts.html>

volume of Lake Michigan and the Great Lakes, and the return flow would regularly return approximately 100 percent of the volume of water withdrawn.

Under any diversion approval, the Applicant would be required to report its annual diversion amount, consumptive use rate, and return flow to the Lake Michigan basin.

#### *Impact on basin water quality*

The Applicant proposes to return up to 10.1 MGD of treated wastewater to the Root River, a tributary to Lake Michigan. 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 a wastewater treatment plant to a water of the state.<sup>245</sup> The Applicant would need to apply for a WPDES permit in order to discharge treated effluent to its preferred discharge site, the Root River.

The department calculated draft water quality-based effluent limits (WQBELs) based on current applicable water quality standards to assess whether the proposed discharge could meet water quality standards for a new discharge to an impaired water (See [R4](#)). These draft limits are set at levels to protect designated uses and the water quality of the Root River and Lake Michigan. The department expects minimal, if any, impacts from the return flow<sup>246</sup> to the water quality of the Root River, estuary, nearshore and deep waters of Lake Michigan.

#### *Integrity of the Basin Ecosystem*

Technical review criterion IA1 requires a determination that the proposal would not endanger the integrity of or have a significant impact on the Great Lakes basin ecosystem. To support this criterion and analyze potential impacts of the project, the department prepared a draft Environmental Impact Statement ([dEIS](#)). The department's [dEIS](#), issued in conjunction with the technical review, provides a detailed analysis of the proposed project and alternatives to determine any potential effects the diversion may have on the GLB.

The [dEIS](#) discusses potential impacts from the proposed diversion, including impacts to: water quality, geomorphology and sediments, local surface water and groundwater resources, and flora and fauna.<sup>247</sup> The [dEIS](#) concludes that the proposed diversion would result in no significant long-term impacts to the GLB ecosystem. Minor impacts to the GLB ecosystem would result from the pipeline construction for the project, which would be temporary assuming proper drilling and pipeline installation procedures are followed. Construction related impacts would be mitigated by the use of best management practices. These practices are described in detail by the applicant in the Application [Volume 5](#).<sup>248</sup>

The integrity of the GLB Ecosystem would not be compromised or significantly impacted by the proposed project. GLB ecosystem water quantity would not be adversely impacted because the Applicant would be required to return to the GLB all water withdrawn less an amount for consumptive use. The proposed discharge would not adversely impact GLB water quality

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<sup>245</sup> See [Wis. Stat. §283.31](#).

<sup>246</sup> See [dEIS](#), Section 4: Root River return flow alternative environmental effects

<sup>247</sup> See [dEIS](#) Section 4.

<sup>248</sup> Application, [Volume 5](#), Appendix 5-2

because the Applicant would be required to meet all current water quality standards for a new discharge, including antidegradation requirements. As described in section [R4](#), the Applicant's proposed wastewater treatment would prevent the introduction of invasive species from the Mississippi Basin to the Root River or Lake Michigan basin.

## Additional Criteria

### AC1

#### LEGAL REQUIREMENTS

Agreement/Compact: Further, substantive consideration will also be given to whether or not the Proposal can provide sufficient scientifically based evidence that the existing water supply is derived from groundwater that is hydrologically interconnected to Waters of the Basin.

([Compact](#) 4.9.3; [Agreement](#) art. 201 s. 3)

Wisconsin Statute: In determining whether to approve a proposal under this paragraph, the department shall give substantive consideration to whether the applicant provides sufficient scientifically based evidence that the existing water supply is derived from groundwater that is hydrologically interconnected to waters of the Great Lakes basin. The department may not use a lack of hydrological connection to the waters of the Great Lakes basin as a reason to disapprove a proposal. ([Wis. Stat. § 281.346\(4\)\(e\)2.](#))

#### FINDINGS

1. Part of the Applicant's current water supply, the deep sandstone aquifer, is derived from groundwater that is hydrologically interconnected to Waters of the Basin.
2. 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.
3. Wells in the deep sandstone aquifer, such as the Applicant's, are pumping and distributing water that once flowed towards Lake Michigan and is now flowing towards pumping centers.
4. Pumping wells in the deep sandstone aquifer induces water that would otherwise have discharged to surface water. Groundwater flow models find that 70 percent of the water is derived from the Mississippi River Basin (MRB) and 30 percent is derived from the Lake Michigan Basin. Of the Lake Michigan Basin water, 4 percent is induced directly from Lake Michigan.
5. None of the water currently withdrawn from deep sandstone wells is water induced directly from Lake Michigan.

#### METHOD OF ANALYSIS

The department evaluated information including the following to determine if the Applicant meets this criterion:

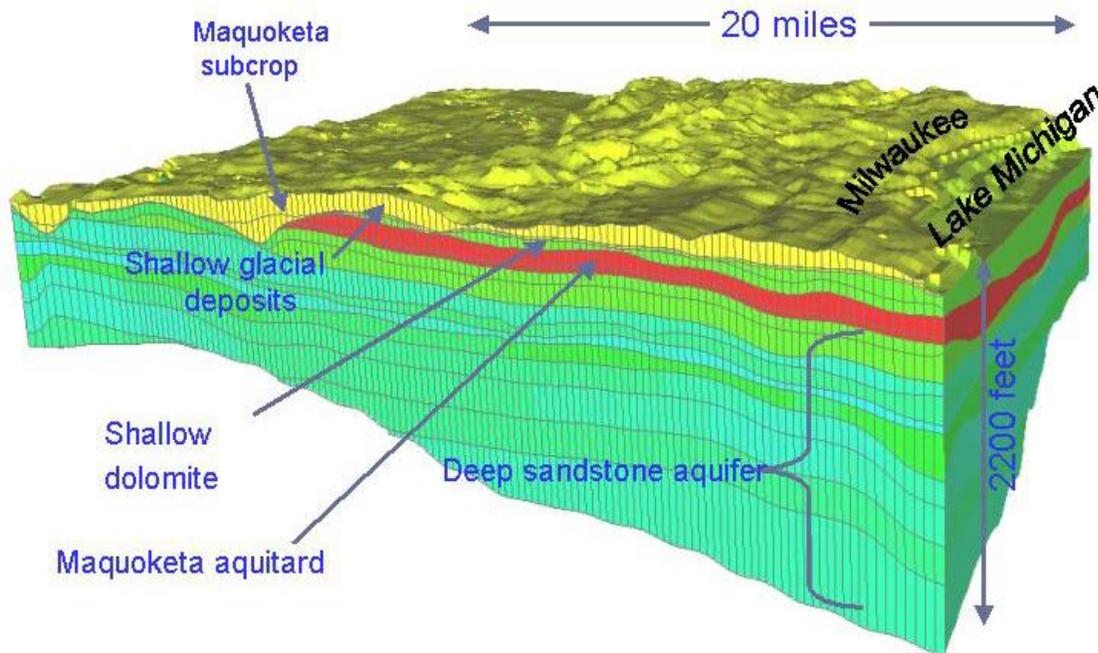
- Application, [Volume 2](#), Section 7.2.1.
- [Groundwater Resources of Southeastern Wisconsin](#), Technical Report No. 37
- A Regional Aquifer Simulation Model for Southeastern Wisconsin, Technical Report No. 41
- [Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin](#)

- [Where do the deep wells in southeastern Wisconsin get their water?](#)

## DISCUSSION

The groundwater system in southeast Wisconsin includes the shallow sand and gravel aquifer, the shallow bedrock aquifer with fractured dolomite, and the deep sandstone aquifer. See Figure 1 below, which also depicts the Maquoketa shale, a regional confining unit that separates the shallow and deep groundwater systems. Near the City of Waukesha the Maquoketa shale is present and the deep sandstone aquifer is a confined aquifer. However, the shale layer thins to the west and is absent in western Waukesha County ([Figure 19](#)).<sup>249</sup>

**Figure 19. General Hydrogeology of southeast Wisconsin.**<sup>250</sup> (K.R. Bradbury, Wisconsin Geological and Natural History Survey).



The Applicant currently withdraws water from the deep sandstone aquifer and the shallow sand and gravel aquifer. For the period 2010 - 2014 the Applicant withdrew a daily average of 6.7 MG, with approximately 80 percent from the deep aquifer and 20 percent from the shallow aquifer.<sup>251</sup>

Groundwater moves very slowly. Even through the most productive units of the deep sandstone aquifer the water moves laterally only at a rate of 2 – 8 feet/day. Water moves vertically through

<sup>249</sup> See [dEIS](#), for a more detailed description of the regional geology and aquifers.

<sup>250</sup> Figure originally published on website: [Groundwater in the Great Lakes Basin: the case of southeastern Wisconsin](#), as 3d block diagram of aquifers and aquitards under southeastern Wisconsin, from K.R. Bradbury, Wisconsin Geological and Natural History Survey (site visited, 5/27/2015).

<sup>251</sup> Based on data submitted to WDNR for 2010 - 2014.

the aquifer at an even slower pace – on the order of 0.04 feet/day.<sup>252</sup> This concept is helpful to keep in mind as the following discussion makes a distinction between the origins of the water pumped out of a well and the impacts of groundwater pumping on the groundwater system as a whole. The United States Geological Survey (USGS) and the Wisconsin Geological and Natural History Survey (WGNHS) collaborated to develop a comprehensive regional groundwater flow model for southeast Wisconsin between 2000 and 2003.<sup>253</sup> The modeling results provide information on the relationship between the shallow and deep aquifer systems and the change in these systems through time as groundwater pumping has changed.

Groundwater pumping in southeast Wisconsin began in 1864 and steadily increased over time. The southeast Wisconsin regional groundwater flow model simulates pumping of an estimated 33 MGD of pumping for the period 2001-2005, the last time period in the model. Prior to groundwater pumping, groundwater in the deep sandstone aquifer flowed east to Lake Michigan ([Figure 20](#)). From 2001- 2005 the Applicant accounted for approximately 25 percent of all pumping from the deep sandstone aquifer in southeast Wisconsin.<sup>254</sup>

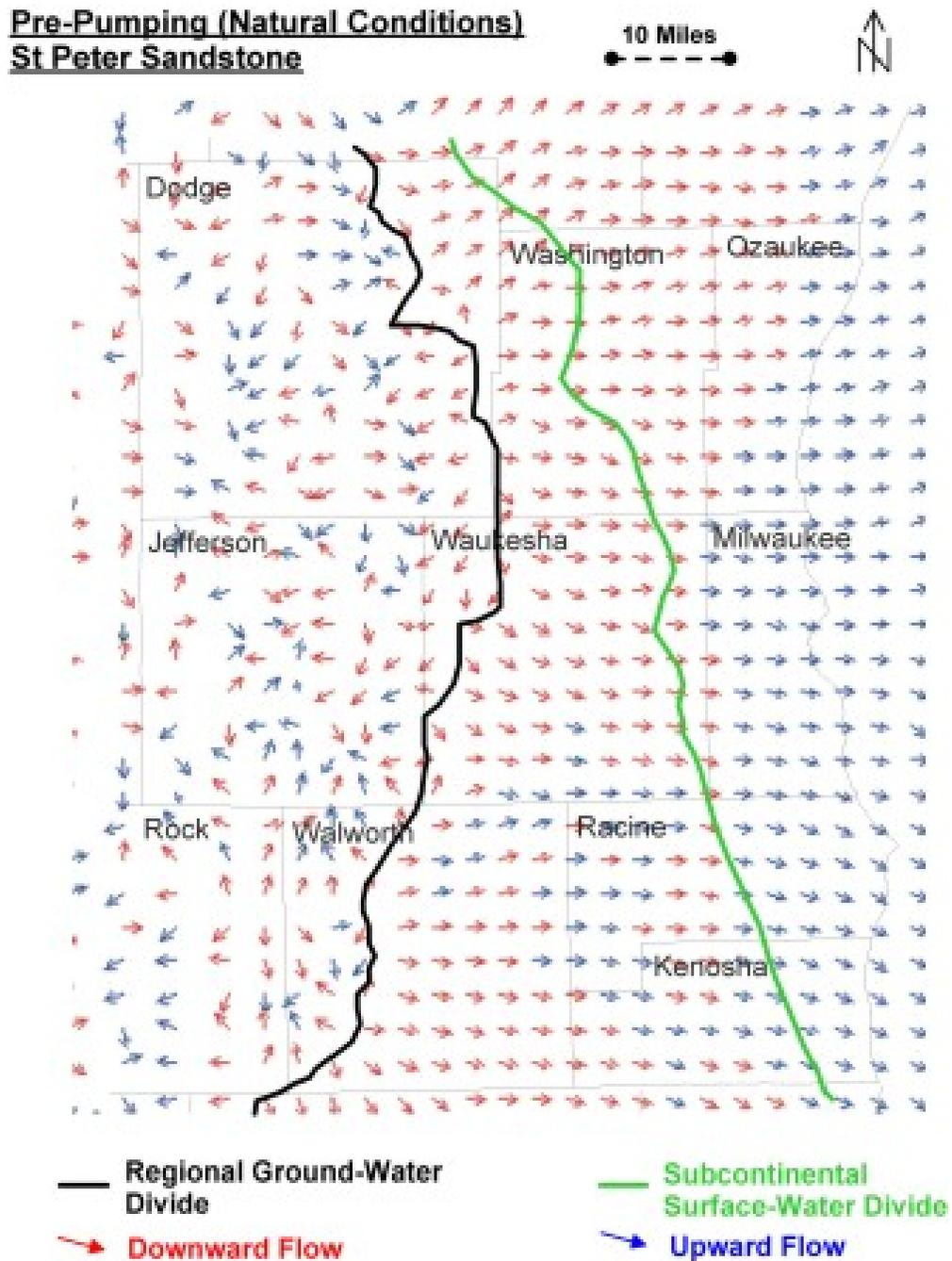
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<sup>252</sup> SEWRPC Simulation of Regional Groundwater Flow in Southeastern Wisconsin, [Report 2: Model Results and Interpretation](#), Technical Report #41, p. 41 (06/2005).

<sup>253</sup> SEWRPC Simulation of Regional Groundwater Flow in Southeastern Wisconsin, [Report 1 and 2](#), Technical Report #41, (06/2005).

<sup>254</sup> The Applicant pumped an average of 7.7 MGD from the deep aquifer for the period 2001 – 2005. Note that this is approximately 2.4 MGD greater than the Applicant pumped from the deep aquifer in the 2010 – 2014 time period.

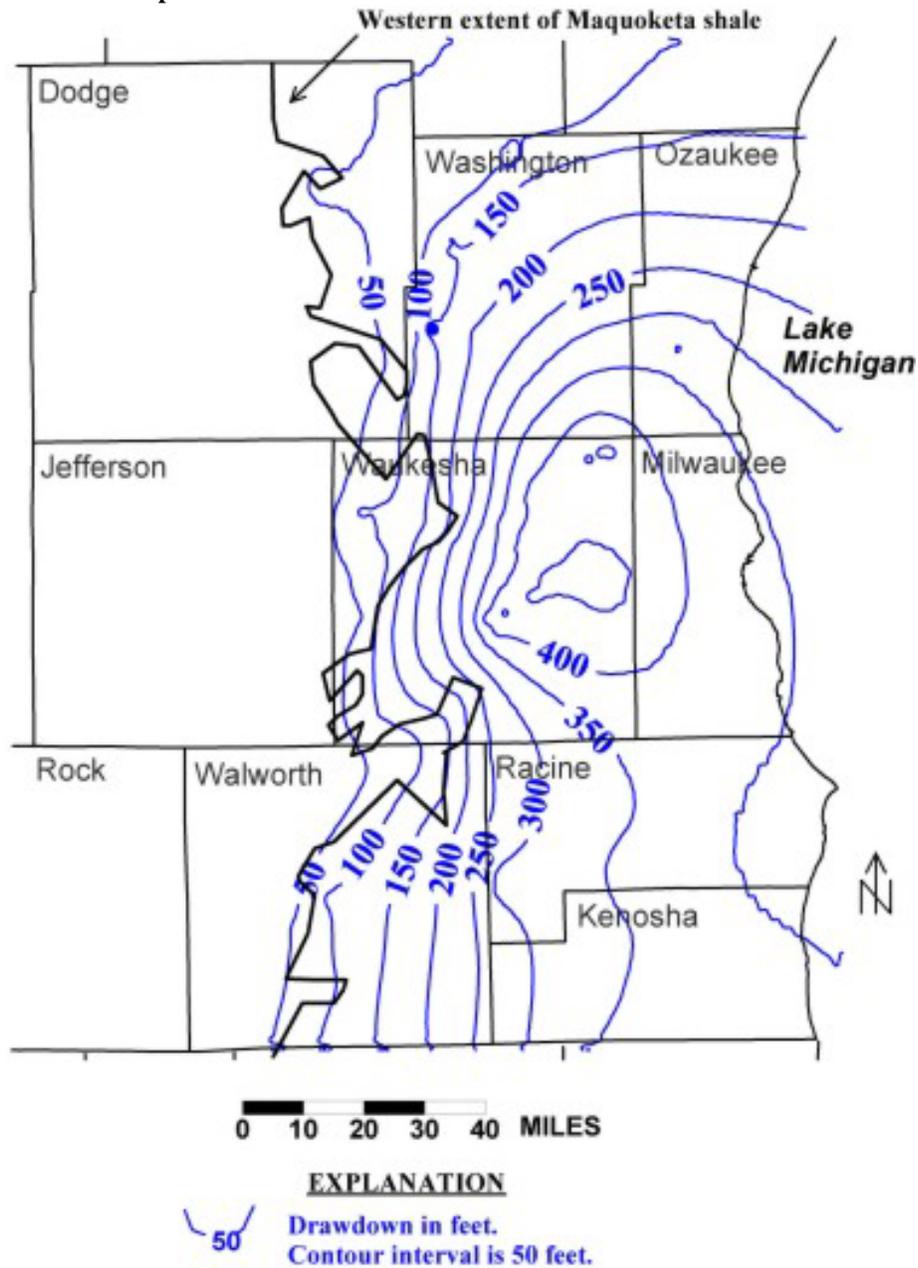
Figure 20: Prior to any pumping of wells, direction of groundwater flow in the deep sandstone aquifer.<sup>255</sup>



Pumping in the deep sandstone aquifer has created a regional cone of depression as shown in [Figure 21](#). In addition, [Figure 21](#) indicates that the regional pumping center is located in eastern Waukesha County (note: recent USGS groundwater monitoring data indicate that the groundwater levels in the deep sandstone aquifer are rising. These changes are discussed in [S1](#)).

<sup>255</sup> Figure originally published in SEWRPC, Simulation of Regional Groundwater Flow in Southeastern Wisconsin, [Report 2: Model Results and Interpretation](#), Technical Report #41, p. 42 (06/2005).

Figure 21: Drawdown in Deep Sandstone from 1864 to 2000.<sup>256</sup>



The southeast Wisconsin regional groundwater flow model results also show that groundwater flow towards the lake has reversed and is now flowing back towards the regional pumping center in Waukesha County ([Figure 22](#)).

<sup>256</sup> Figure originally published in SEWRPC Simulation of Regional Groundwater Flow in Southeastern Wisconsin, [Report 2: Model Results and Interpretation](#), Technical Report #41, p. 21 (06/2005).

**Figure 22: Groundwater flow system in deep sandstone before (Figure A.) and after (Figure B.) well development.**<sup>257</sup>

Figure A.

- **Pre-Development**—Deep bedrock aquifer
- Groundwater divide is west of watershed divide
- Recharge to deep aquifer flows to Lake Michigan
- All groundwater flows to surface water

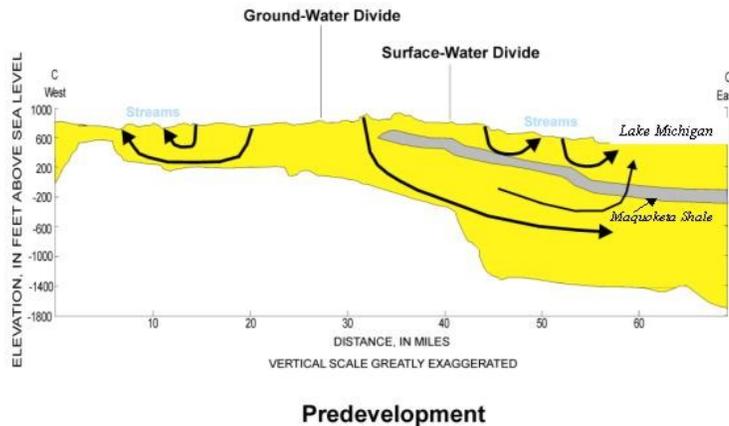
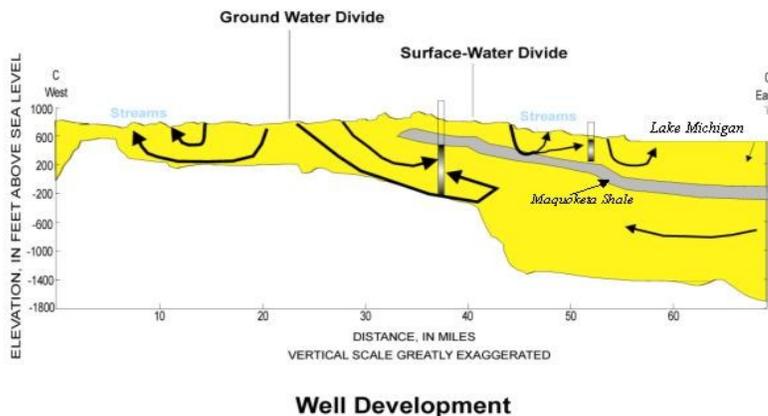


Figure B.

- **Year 2000**—Divide has moved west 10 miles
- Leakage to deep aquifer now captured by **wells**
- Flow under/to Lake Michigan captured by wells—no deep groundwater flows to the Lake anymore
- More of the shallow groundwater west of confining unit is diverted to the deep aquifer



[Figure 22](#) indicates that the water withdrawn from the Applicant’s wells originated from the west, meaning it is water that originally flowed toward Lake Michigan, but now because of pumping in Waukesha County, it has reversed and is now moving toward the west. Water that is

<sup>257</sup> Figure originally published on website: [Groundwater in the Great Lakes Basin: the case of southeastern Wisconsin](#), as Schematic cross sections of ground-water flow system before well development and after well development, from J.T. Krohelski and D.T. Feinstein, Wisconsin Geological and Natural History Survey (site visited, 5/27/2015).

pumped from the Waukesha wells and distributed today originated in Western Waukesha County.

The southeast Wisconsin regional groundwater flow model also shows that 70 percent of water replenishing the deep aquifer as a result of deep aquifer pumping is groundwater diverted from streams in the MRB. A corresponding 30 percent is groundwater and surface water diverted from the Lake Michigan basin (including captured baseflow from streams and water flowing out of Lake Michigan).

Based primarily on the results of the Southeast Wisconsin regional groundwater flow model, the department concludes that the Applicant's wells in the deep sandstone aquifer are hydrologically interconnected to the Lake Michigan basin. The department also concludes that the water currently withdrawn from the Applicant's wells did not originate in Lake Michigan or the Lake Michigan basin. The department also concludes that the Applicant's pumping affects the Lake Michigan basin by inducing groundwater into the deep aquifer that otherwise would have fed surface waters, and inducing a small amount of water out of Lake Michigan into the groundwater system. Finally, the department concludes that if the Applicant were to cease pumping from the deep aquifer, this would contribute to a decrease in groundwater and surface water from the Lake Michigan basin being induced into the deep aquifer system.<sup>258</sup>

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<sup>258</sup> The effect of the Applicant ceasing pumping from the deep sandstone on that aquifer is dependent on the pumping of other withdrawers from the deep sandstone aquifer. Assuming there were no new or increased withdrawals from the deep aquifer, the Applicant ceasing pumping would result in a decrease in induction of surface water from the MRB to the deep aquifer system.

## AC2

### LEGAL REQUIREMENTS

Agreement/Compact: The Exception will be implemented so as 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. ([Compact](#) 4.9.4.f.; [Agreement](#) art. 201 s. 4.f.)

Wisconsin Statute: The diversion will be in compliance with all applicable local, state, and federal laws and interstate and international agreements, including the Boundary Waters Treaty of 1909. ([Wis. Stat. § 281.346\(4\)\(f\)7.](#))

### FINDINGS

1. The proposed diversion is in compliance with the [Boundary Waters Treaty of 1909](#) because any water lost from the basin (due to consumptive use) would not affect the flows or levels of the boundary waters on either side of the border so it is not subject to regulation by the International Joint Commission.
2. The decision on any necessary future permits and approvals would not be substantively affected by a diversion approval. The Applicant would be required to comply with all applicable laws and would need to work closely with regulatory authorities throughout any diversion process.

### METHOD OF ANALYSIS

To determine whether the diversion would be in compliance with applicable local, state, and federal laws and interstate and international agreements, including the Boundary Waters Treaty of 1909, the department used the following methods:

1. Reviewed the [Boundary Waters Treaty of 1909](#) to determine applicability.
2. Reviewed sections of the Application: [Volume 1](#), pp. 5-13 and 5-21, [Volume 2](#), Sec. 12 and [Volume 5](#), Sec. 4.
3. Determined whether incomplete status of permits and approvals is sufficient evidence that the proposed diversion would be in compliance with all applicable laws.

### DISCUSSION

#### *Applicability of the Boundary Waters Treaty of 1909*

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]."<sup>259</sup> The Applicant's proposed diversion would not trigger this section of the treaty because the

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<sup>259</sup> [Boundary Waters Treaty of 1909](#), art. 3.

Applicant would be returning all water withdrawn less an allowance for consumptive use.<sup>260</sup> The diversion would not alter the flows or levels of the Great Lakes.

*Status of Compliance*

The various permits and approvals that would be or may be required for construction, operation and maintenance of the proposed project include, but are not limited to, those presented in [Table 25](#).

**Table 25. Permits Approvals or Evaluations.**

<b>Permit, Approval or Evaluation</b>	<b>Statute or Regulation</b>	<b>Administering and Enforcing Agency</b>
<b>FEDERAL</b>		
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)
Great Lakes—St. Lawrence River Basin Water Resources Compact	Public Law 110-342	Great Lakes---St. Lawrence River Basin Water Resources Council
Environmental Report	40 C.F.R. Parts 1500 to 1508 (National Environmental Policy Act (NEPA))	EPA (delegated to Wisconsin; see “Environmental Report” below)
<b>STATE</b>		
Stream Crossings of Navigable Waters	Wis. Stats. ch. 30, Wis. Adm. Code. chs. NR 199, 102, 103, 155, 117	WDNR
WPDES Stormwater Discharge Permit	Wis. Stats. s. 283.33, Wis. Adm. Code. ch. NR 216	WDNR
Pit/trench Dewatering General Permit	Wis. Stats. ch. 283, Wis. Adm. Code ch. 216	WDNR
Wastewater Facilities Plan Review	Wis. Adm. Code ch. NR 110	WDNR

<sup>260</sup> Note that the amount returned would vary based on the previous year’s average annual withdrawal. A full description of return flow management is provided in [R1](#) and [R2](#) of this technical review. In general, approximately 100 percent of the volume of water would be returned however that number could become slightly lower (to account for consumptive use) as the system approaches full build-out. Section [IA1 and IA2](#) of this technical review find no significant individual or cumulative impact to water quantity of the waters of the basin due to the proposed diversion.

Wisconsin Floodplain Management Program including local floodplain zoning ordinances	Wis. Adm. Code ch. NR 116	WDNR
Environmental Report	Wis. Adm. Code ch. NR 150 (Wisconsin Environmental Policy Act (WEPA))	WDNR
Natural Heritage Inventory	Wis. Stats. s. 23.27 (3)	WDNR
Incidental Take Permit	Wis. Stats. s. 29.604 (6m)	WDNR
Water Quality Anti-degradation evaluation	Wis. Adm. Code ch. NR 207	WDNR
Wisconsin Pollutant Discharge Elimination System Permit	Wis. Adm. Code ch. NR 217, Wis. Stats. ch. 283	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 ch. NR 108	WDNR
Water systems construction plan review	Wis. Adm. Code ch. 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
Control of Particulate Emission - Fugitive Dust	Wis. Adm. Code ss. NR 415.035, .04	WDNR
<b>LOCAL</b>		
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<sup>261</sup> and 20 municipalities<sup>262</sup> 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.

Wisconsin has a well-developed legal system to ensure compliance with its laws. The department enforces state natural resources laws as well as the requirements of the Agreement/Compact. Local laws are enforced at the local level. This is standard and longstanding procedure in the state.

This criterion only requires that the diversion “will be” in compliance with all applicable laws. A diversion approval would not affect the requirements of local, state, and federal laws and interstate and international agreements. The Applicant would still need to work closely with regulatory authorities at various levels to receive the required permits and approvals. The department concludes that any diversion approval would need to comply with all international, federal, state, and local laws in order to be implemented.

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<sup>261</sup> Milwaukee, Racine, and Waukesha counties.

<sup>262</sup> 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, West Allis (City).

## Appendices

### Appendix A: Assessment of streamflow impacts due to water supply alternatives in the Mississippi River Basin

#### Methods

The potential biological impacts of changes in streamflow are characterized using two different models.

- i) The first methodology used was based on the Michigan Water Withdrawal Assessment Tool (MWWAT).<sup>263</sup> This model was developed to review impacts of high capacity wells on streams in Michigan. The approach classifies all streams in Michigan based on water temperature and stream size and divides streams and rivers into eleven different ecological stream classifications. Wisconsin scientists have similarly classified Wisconsin streams and rivers.<sup>264</sup> MWWAT uses a model to predict how fish assemblages typical of each stream classification would change as a result of decreased base flows. MWWAT uses the median August flow as its low-flow metric. The MWWAT establishes as a regulatory standard a streamflow reduction that would result in an adverse resource impact for each ecological stream classification.<sup>265</sup>
- ii) The second approach uses the Wisconsin Ecological Limits of Hydrologic Alteration (ELOHA) models<sup>266</sup> to predict effects of flow alteration on the probability of occurrence of stream fish. In brief, the models simulate how a projected change in median August flow (chosen to parallel Michigan low-flow metrics) and its associated effect on water temperature, will affect each resident fish species. This approach uses fish survey information to confirm representative fish communities and identify the most sensitive fish species to flow alterations in a stream. Based on the most sensitive fish species, the model identifies a stream-specific potential adverse resource impact flow reduction. For this review, a potential significant adverse environmental impact is indicated when the probability of persistence (the likelihood of a fish species being present) of the most sensitive game species has decreased by 5 percent or the probability of persistence of the most sensitive non-game species has decreased by 10 percent.

The two approaches provide alternative methodologies for determining a level of adverse impact and provide context for the potential for an adverse environmental impact to streams from the proposed alternatives.

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<sup>263</sup>Michigan Water Withdrawal Assessment Tool. 2/11/2015 [http://michigan.gov/deq/0,4561,7-135-3313\\_3684\\_45331-201102--,00.html](http://michigan.gov/deq/0,4561,7-135-3313_3684_45331-201102--,00.html)

<sup>264</sup> [Wisconsin Natural Communities](#), DNR

<sup>265</sup> Hamilton, D.A. and P.W. Seelbach. [Michigan's Water Withdrawal Assessment Process and Internet Screening Tool](#). State of Michigan Department of Natural Resources. 2011

<sup>266</sup> Diebel, M., A. Ruesch, D. Menuz, J. Stewart, and S. Westenbroek. [Ecological Limits of Hydrologic Alteration in Wisconsin Streams](#). 2014

## Results

### Shallow Aquifer alternatives

The department staff used groundwater flow modeling to determine the predicted percent baseflow reduction from streams and the Fox River between Vernon Marsh and the City of Waukesha. Baseflow reductions were calculated for Pebble Brook, Pebble Creek, Mill Creek, Genesee Creek and the Fox River. A full summary of this analysis is available in Appendix B. Further details about the streams and Fox River are also presented in the draft Environmental Impact Statement ([dEIS](#)).

#### *Pebble Brook*

Pebble Brook is a cool-warm headwater stream. The MWWAT estimates the allowable flow reduction for this type of stream as 6 to 25 percent for Management zones A-D. The Wisconsin ELOHA model estimates allowable flow reduction at 21percent based on potential impacts to the probability of persistence of fish species found in Pebble Brook during fish surveys from 2013. The difference between the two approaches is due to the Wisconsin ELOHA model taking site specific information from Pebble Brook and generating an allowable flow reduction based on individual species tolerance to the impacts of flow reduction. In contrast, MWWAT specifies a fixed allowable reduction for all streams in a given class based on the average response of fish communities in that class.

**Table 26. Modeled base flow reduction to Pebble Brook from alternatives with a shallow aquifer component.**

<b>Alternative</b>	<b>Modeled Flow Reduction in Pebble Brook</b> <b>MWWAT (6 -25%)</b> <b>WI ELOHA (&lt;21%)</b>
1 – Deep and Shallow Aquifers 5 – Lake Michigan and Shallow Aquifers	18 - 19%
1a – Deep and Shallow Aquifers (Fox River wells only)	2 – 3%
2 – Shallow Aquifers	36 – 39%
4 – Multiple Sources	2 – 3%
6 – Lake Michigan*	0 %
* The Lake Michigan Oak Creek/Root River alternative is provided here for comparison. Eliminating existing shallow well withdrawals does not change the flow in Pebble Brook.	

Alternatives 1, 2 and 5 all include wells along Pebble Brook. [Table 26](#) shows that there are potential impacts to Pebble Brook for these alternatives. Alternatives 1a and 4 (which exclude wells along Pebble Brook) show minimal potential impacts to Pebble Brook from these alternatives.

#### *Fox River*

The Fox River is classified as a warm mainstem river. The MWWAT identifies the allowable flow reduction as 8 to 17 percent for management zones A-D. The Wisconsin ELOHA model identifies allowable flow reduction at 5 percent based on potential impacts to the probability of persistence of fish species found in the Fox River during fish surveys from 2007 and 2014 ([Table 27](#)).

**Table 27. Modeled base flow reduction to Fox River from alternatives with a shallow aquifer component.**

<b>Alternative</b>	<b>Modeled Flow Reduction in Fox River MWWAT (8 - 17%) WI ELOHA (&lt;5%)</b>
1 – Deep and Shallow Aquifers 5 – Lake Michigan and Shallow Aquifers	3%
1a – Deep and Shallow Aquifers (Fox River wells only)	5%
2 – Shallow Aquifers	9%
4 – Multiple Sources	4%
6 – Lake Michigan	15%
* The Lake Michigan Oak Creek/Root River alternative is provided here for comparison. Estimated changes in the flow in the Fox River are not based on the U.S. Geological Survey (USGS) groundwater model, but rather Wastewater Treatment Plant discharge estimates (see <a href="#">R1</a> for more details).	

While Alternatives 1a and 2 show potential for significant impacts under the Wisconsin ELOHA or MWWAT, for alternative 2, the groundwater flow modeling does not take into account flow returned to the Fox River via the wastewater treatment plant upstream of the portion of the Fox River that would see the estimated 4 to 9 percent depletion. This return flow to the Fox would equal or exceed the flow reduction to the Fox River from the shallow aquifer pumping. In contrast, Alternative 6, Lake Michigan supply, baseflow to the Fox River would be expected to decrease by 12 cubic feet per second (cfs), or 15 percent. Under the Lake Michigan alternative, an average of 12 cfs of flow that currently goes to the Fox River would instead be returned to the Great Lakes basin (GLB). See [R1](#) for review of the wastewater return to Lake Michigan and efforts to minimize Mississippi River Basin (MRB) water discharged to the Lake Michigan Basin. While this decrease in flow would potentially have a significant adverse impact to the Fox River, impacts to MRB waters are not part of the Agreement/Compact review criteria. Further discussion of these impacts is also available in the draft Environmental Impact Statement ([dEIS](#)). Note that the Fox River would continue to receive some wastewater discharge under the Lake Michigan diversion alternative to account for infiltration and inflow into the wastewater system from the MRB.

#### *Pebble Creek*

Pebble Creek is a cool-cold mainstem stream. The MWWAT estimates the allowable flow reduction for this type of stream as 2 percent for all management zones. The Wisconsin ELOHA model estimates allowable flow reduction at 2 percent based on potential impacts to the probability of persistence of fish species found in Pebble Creek during fish surveys from 2012 ([Table 28](#)).

**Table 28. Modeled base flow reduction to Pebble Creek from alternatives with a shallow aquifer component.**

<b>Alternative</b>	<b>Modeled Flow Reduction in Pebble Creek MWWAT (&lt;2%) WI ELOHA (&lt;2%)</b>
1 – Deep and Shallow Aquifers 5 – Lake Michigan and Shallow Aquifers	0-1%
1a – Deep and Shallow Aquifers (Fox River wells only)	1%
2 – Shallow Aquifers	1%
4 – Multiple Sources	0-1%
6 – Lake Michigan*	0 %
* The Lake Michigan Oak Creek/Root River alternative is provided here for comparison. Eliminating existing shallow well withdrawals does not change the flow in Pebble Creek.	

All of these alternatives show minimal potential impacts to Pebble Creek.

*Mill Creek*

Mill Creek is a cool-cold headwater stream. The MWWAT estimates the allowable flow reduction for this type of stream as 4 percent for all management zones. The Wisconsin ELOHA model estimates allowable flow reduction at 12 percent based on potential impacts to the probability of persistence of fish species found in Mill Creek during fish surveys from 2008 and 2013 ([Table 29](#)).

**Table 29. Modeled base flow reduction to Mill Creek from alternatives with a shallow aquifer component.**

<b>Alternative</b>	<b>Modeled Flow Reduction in Mill Creek MWWAT (&lt;4%) WI ELOHA (&lt;12%)</b>
1 – Deep and Shallow Aquifers 5 – Lake Michigan and Shallow Aquifers	0-1%
1a – Deep and Shallow Aquifers (Fox River wells only)	0%
2 – Shallow Aquifers	3-5%
4 – Multiple Sources	0%
6 – Lake Michigan*	0 %
* The Lake Michigan Oak Creek/Root River alternative is provided here for comparison. Eliminating existing shallow well withdrawals does not change the flow in Mill Creek.	

Alternatives 1, 1a, 4, and 5 show minimal potential impacts to Mill Creek. Alternative 2 shows potential impacts to Mill Creek under the MWWAT model, but not under the Wisconsin ELOHA model.

*Genesee Creek*

Genesee Creek is a cool-warm mainstem stream. The MWWAT estimates the allowable flow reduction for this type of stream as 15 to 25 percent for management zones A - D. The Wisconsin ELOHA model estimates allowable flow reduction at 8 percent based on potential impacts to the probability of persistence of fish species found in Genesee Creek during fish surveys from 2007 ([Table 30](#)).

**Table 30. Modeled base flow reduction to Genesee Creek from alternatives with a shallow aquifer component.**

<b>Alternative</b>	<b>Modeled Flow Reduction in Genesee Creek MWWAT (15 - 25%) WI ELOHA (&lt;8%)</b>
1 – Deep and Shallow Aquifers 5 – Lake Michigan and Shallow Aquifers	1%
1a – Deep and Shallow Aquifers (Fox River wells only)	1-2%
2 – Shallow Aquifers	3-4%
4 – Multiple Sources	1-2%
6 – Lake Michigan*	0 %
* The Lake Michigan Oak Creek/Root River alternative is provided here for comparison. Eliminating existing shallow well withdrawals does not change the flow in Genesee Creek.	

All of these alternatives show minimal potential impacts to Genesee Creek.

**Results from Deep Unconfined Aquifer – Alternative 3**

*Bark River and Battle Creek*

The model grid size, 2,500 feet on a side, makes it difficult to precisely evaluate baseflow reduction in the Bark River and Battle Creek. Bark River’s estimated depletion of 14 percent is between the MWWAT threshold for management zone A and the WI ELOHA allowable flow reduction threshold. Battle Creek is above both of the MWWAT threshold for management zone A and the threshold for potential significant impacts for the WI ELOHA model ([Table 31](#)).

**Table 31. Results from Deep Unconfined Aquifer - Alternative 3.**

<b>Alternative</b>	<b>Modeled Flow Reduction in Bark River MWWAT (8 - 17%) WI ELOHA Model (&lt;26%)</b>	<b>Modeled Flow Reduction in Battle Creek MWWAT (6 - 25%) WI ELOHA Model (&lt;8%)</b>
Alternative 3 – Unconfined Deep Aquifer (10 MGD)	14%	57%

## **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.<sup>267</sup> 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.<sup>268</sup> 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.<sup>269</sup>

### **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.<sup>270</sup>

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

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<sup>267</sup> A report on the modeling work conducted by the City of Waukesha is provided in the Memo [RJN Environmental Services, LLC, dated August 30, 2013](#). Additional information on the modeling work conducted by the City of Waukesha 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](#).

<sup>268</sup> For the 2013 Application the full build-out demand was revised down to 10.1 MGD.

<sup>269</sup> The department analysis of the Applicant’s water demand, see [S4](#), 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.

<sup>270</sup> 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)

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 32](#) 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.<sup>271</sup> 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<sup>272</sup> and in [S2](#).

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<sup>271</sup> CH2MHill. [Changes to Water Supply Infrastructure and Environmental Impacts](#). Prepared for WDNR. 18 February 2014.

<sup>272</sup> Application, [Volume 2](#), Section 11.

**Table 32. Water supply alternative water sources.**

<b>Scenario / Alternative</b>	<b>Water Supply</b>	<b>Average Day Demand (MGD)</b>	<b>Infrastructure to meet demand (shallow aquifer only)</b>
(1) Deep and Shallow Aquifers <sup>273</sup>	Deep Sandstone Aquifer	4.5	
	Shallow Aquifer	<b>4</b>	
	- 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 <sup>274</sup>	Shallow Aquifer	<b>8.5</b>	
	- 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 <sup>275</sup>	Deep Sandstone Aquifer	2.1	
	Unconfined Deep Aquifer	2.0	
	Silurian Dolomite Aquifer	1.2	
	Shallow Aquifer	<b>3.2</b>	
	- 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 <sup>276</sup>	Deep Sandstone Aquifer	4.5	
	Shallow Aquifer	<b>4</b>	
	- 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)

<sup>273</sup> 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.

<sup>274</sup> Waukesha Water Supply Alternative 3: Shallow Aquifer, Application, Vol. 2. p. 11-28. (2013). [Memo, CH2M Hill, 2 February 2014](#), p. 2.

<sup>275</sup> Waukesha Water Supply Alternative 6: Multiple Sources, Application, Vol. 2. p. 11-45. (2013). [Memo, CH2M Hill, 2/18/2014](#), p. 3.

<sup>276</sup> This alternative is a variation on Waukesha Water Supply Alternative 1 that was not evaluated in the Waukesha Diversion application.

## Model Setup

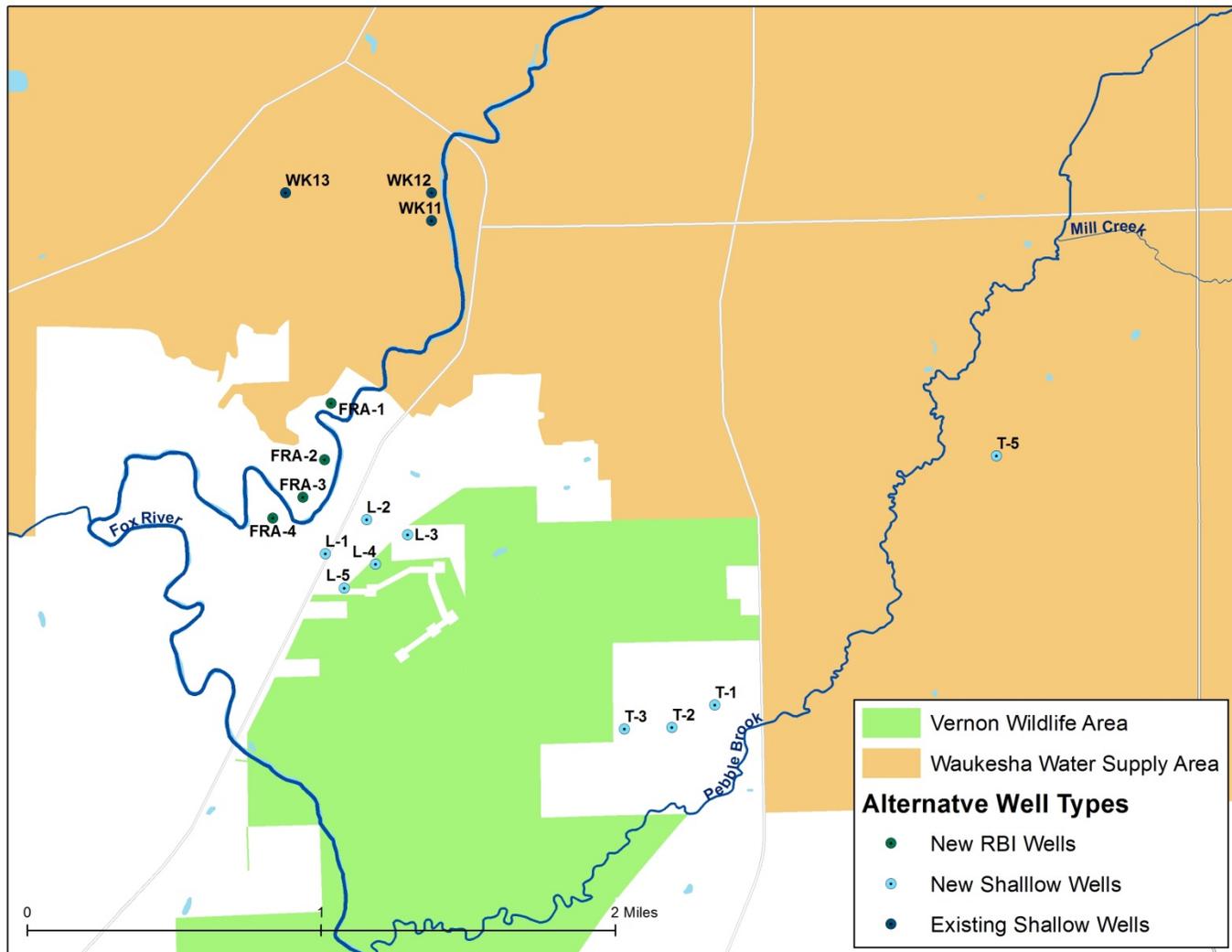
This section describes the inputs used to evaluate the surface water impacts of the various water supply alternatives.

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 23](#) 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 23. 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.<sup>277</sup> 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 33](#) indicates the input pumping rate for each alternative and the modeled pumping rate for each scenario for both the coarse-favored and fine-favored versions of the model. [Table 33](#) 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 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 33. 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 34](#) 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 25 - Figure 32](#) for drawdown maps of each alternative modeled by the department.

**Table 34. Maximum drawdown 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

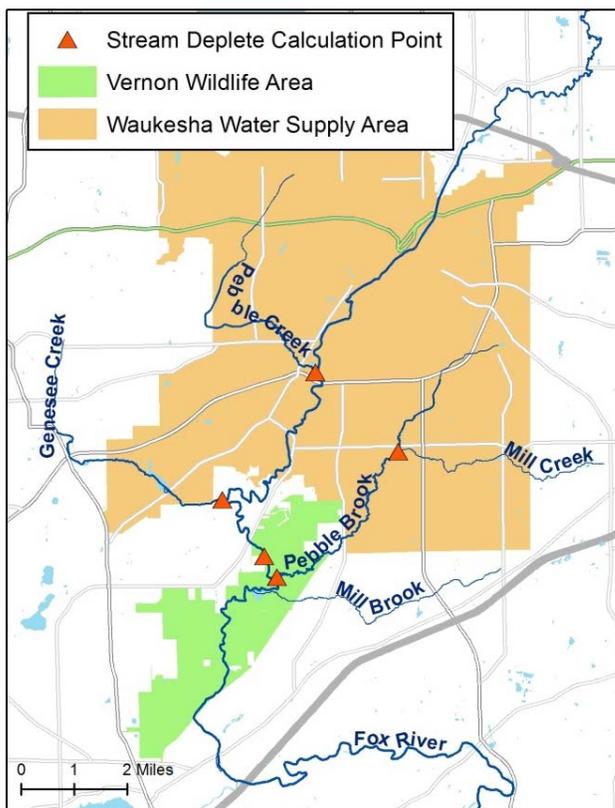
<sup>277</sup> Feinstein, D.T., M.N Fienen, J.L. Kennedy, C.A. Buchwald, and M.M. Greenwood. [Development and Application of a Groundwater/Surface-Water Flow Model using MODFLOW-NWT for the Upper Fox River Basin, Southeastern Wisconsin](#). Scientific Investigations Report 2012-5108. (2012)

## 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 23](#)); 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<sup>278</sup> 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 24. Locations for calculations of streamflow depletion.



The department calculated the percent change in stream baseflow with following equation:

$$B_1 = \text{Cumulative Baseflow (Stress Period 2, Time Step 5)}$$

$$B_2 = \text{Cumulative Baseflow (Stress Period 3, Time Step 20)}$$

$$\text{Percent Change in Stream Baseflow} = \frac{(B_1 - B_2)}{B_1} * 100$$

Note that the percent streamflow reductions do not account for water returned to the Fox River via the wastewater treatment plant. See [Table 35](#) for streamflow depletion calculations.

<sup>278</sup> 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 35. Streamflow depletion – Percent reduction in modeled baseflow due to new shallow wells.**

a) Alternative 1: Deep and Shallow Aquifers

<b>Stream</b>	<b>Coarse-favored model (MGD)</b>	<b>Fine-favored model (MGD)</b>
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

<b>Stream</b>	<b>Coarse-favored model (MGD)</b>	<b>Fine-favored model (MGD)</b>
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

<b>Stream</b>	<b>Coarse-favored model (MGD)</b>	<b>Fine-favored model (MGD)</b>
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.

<b>Stream</b>	<b>Coarse-favored model (MGD)</b>	<b>Fine-favored model (MGD)</b>
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<sup>279</sup> for each alternative (See [Table 36](#)).

<sup>279</sup> WDNR. [Wetland Mapping](#). Web. 4 June 2015.

**Table 36. Wetland acres in the one-foot drawdown contour in model layer 1.**

<b>Alternative</b>	<b>Coarse-favored model (acres)</b>	<b>Fine-favored model (acres)</b>
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 37](#)).<sup>280</sup>

**Table 37. Springs located in the one-foot drawdown contour in model layer 1.**

<b>Alternative</b>	<b>Coarse-favored model (WGNHS Spring #)</b>	<b>Fine-favored model (WGNHS Spring #)</b>
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

<sup>280</sup> 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 25. Alternative 1 - Deep and Shallow Aquifers - Fox River and Pebble Brook Wells - Coarse favored model.

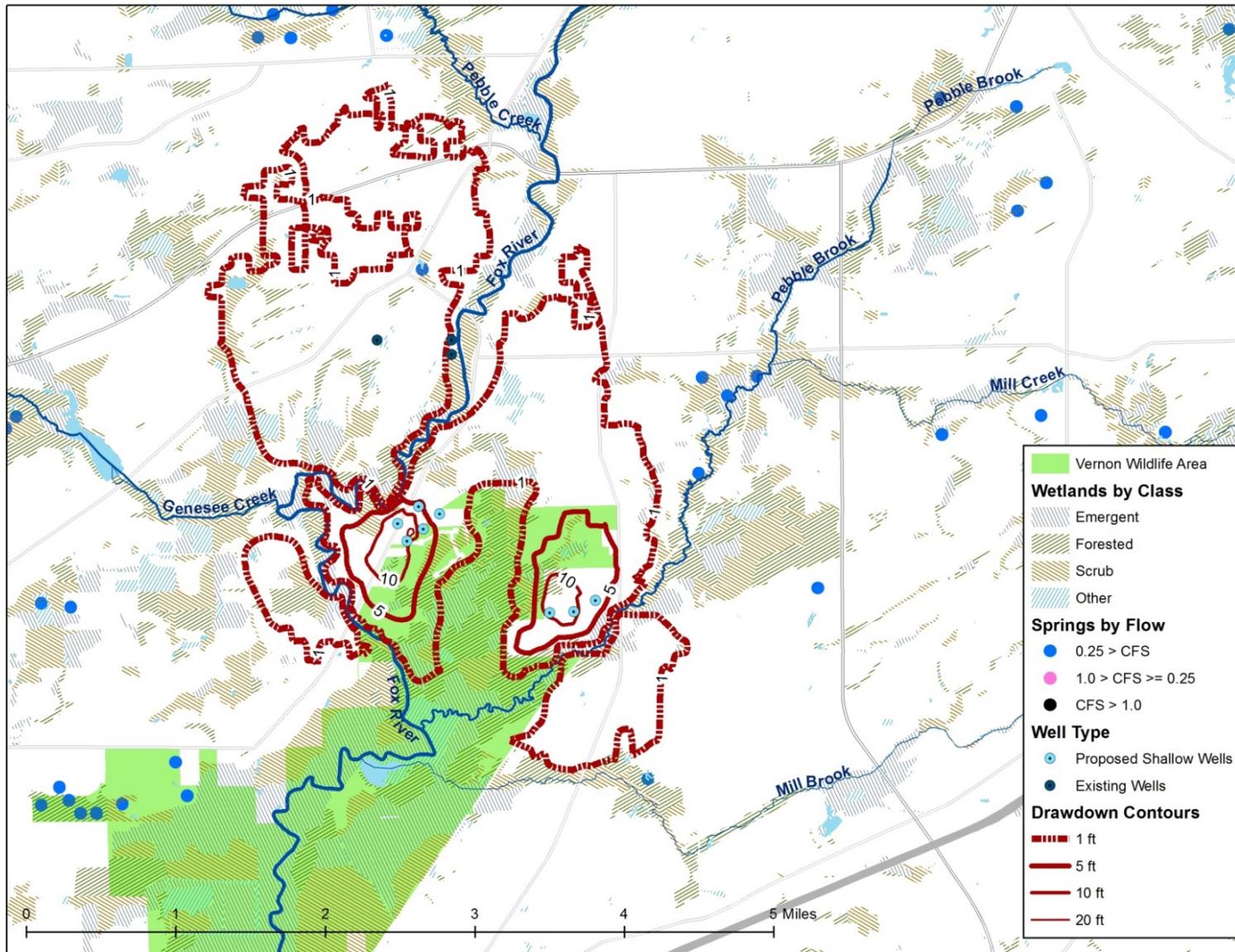


Figure 26. Alternative 1 - Deep and Shallow Aquifers- Fox River and Pebble Brook Wells - Fine-favored model.

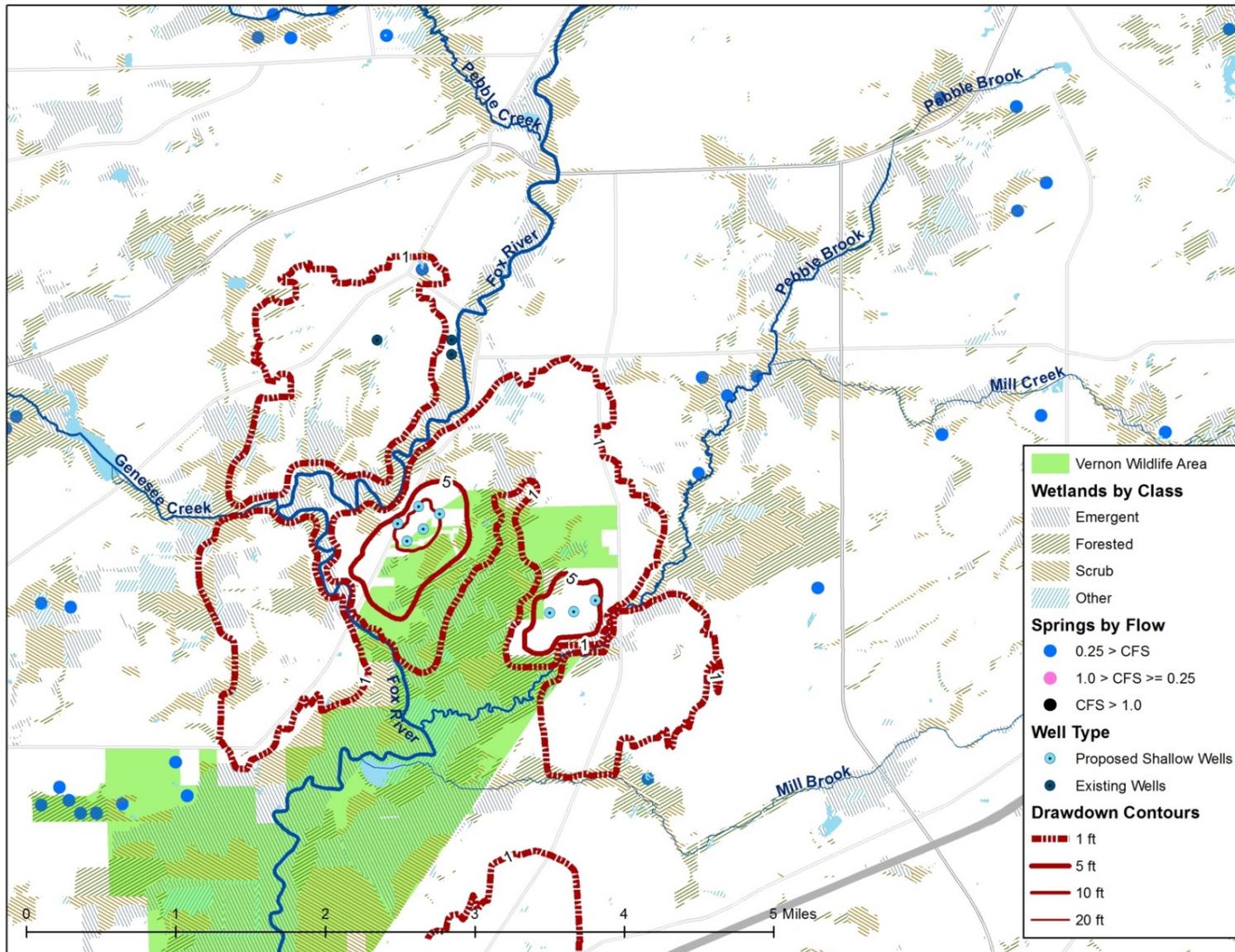


Figure 27. Alternative 2- Shallow Aquifer Only - Coarse-favored model.

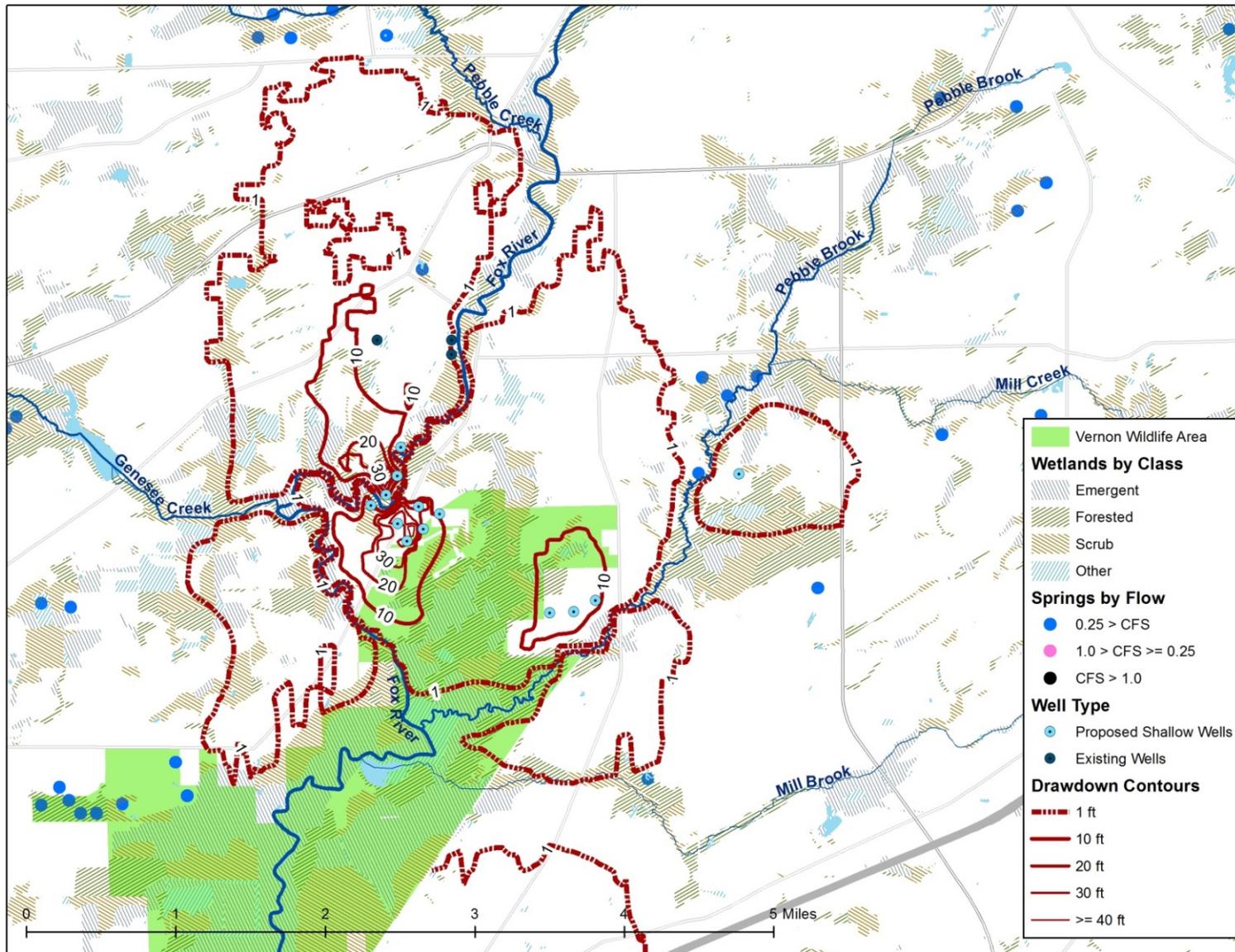


Figure 28. Alternative 2 – Shallow Aquifer Only – Fine-favored model.

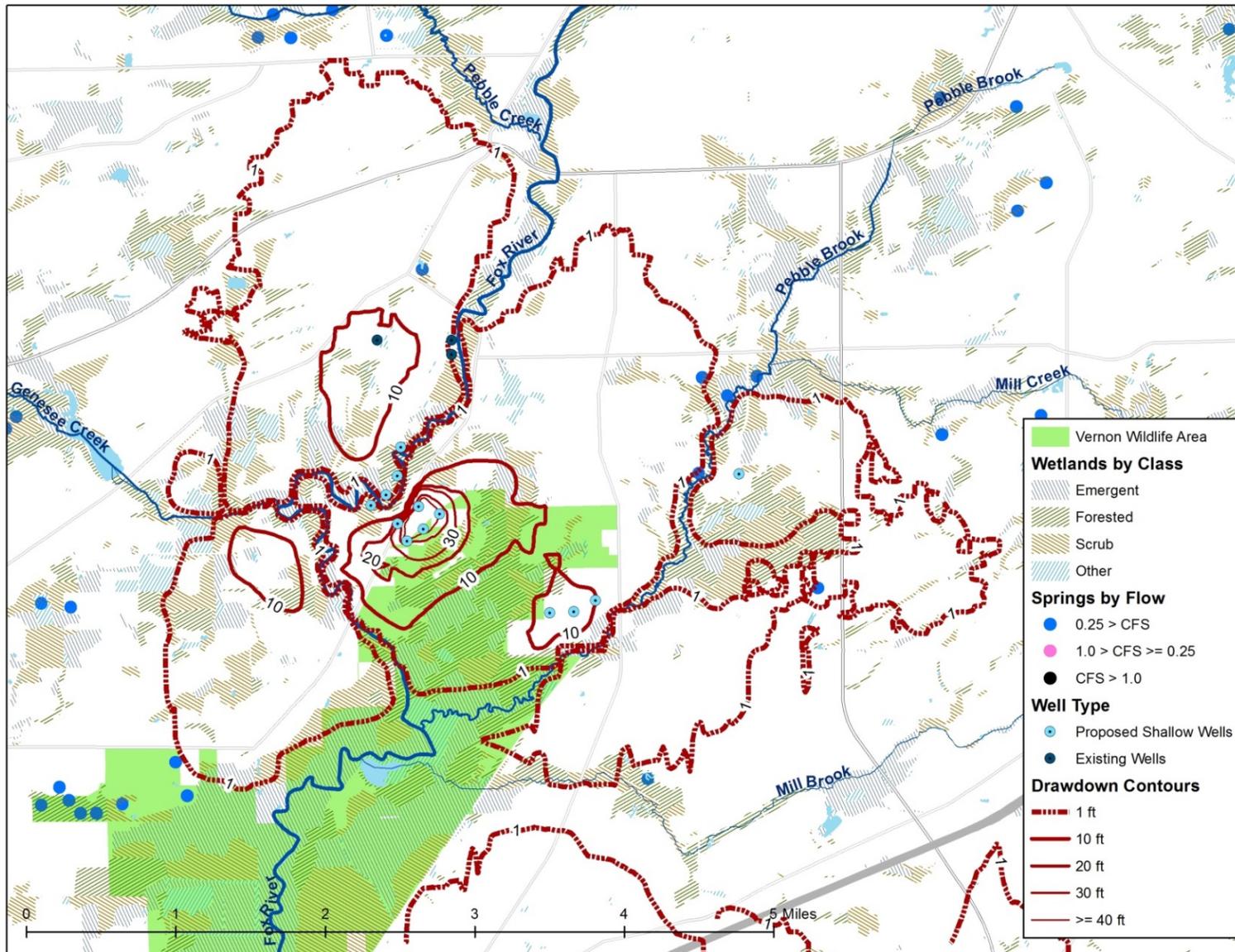


Figure 29. Alternative 3 – Multiple Sources Alternative – Coarse-favored model.

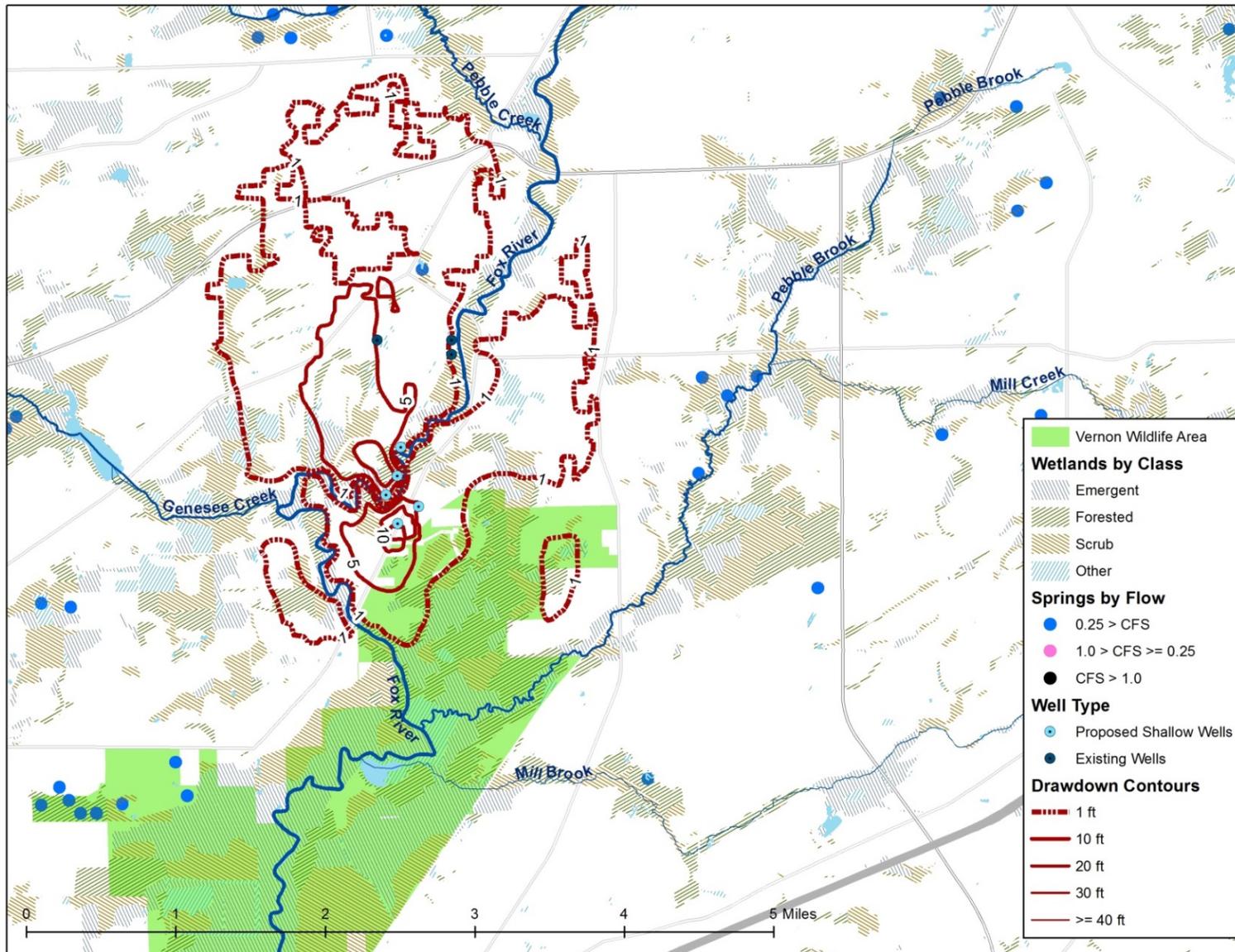


Figure 30. Alternative 3 – Multiple Sources Alternative – Coarse-favored model.

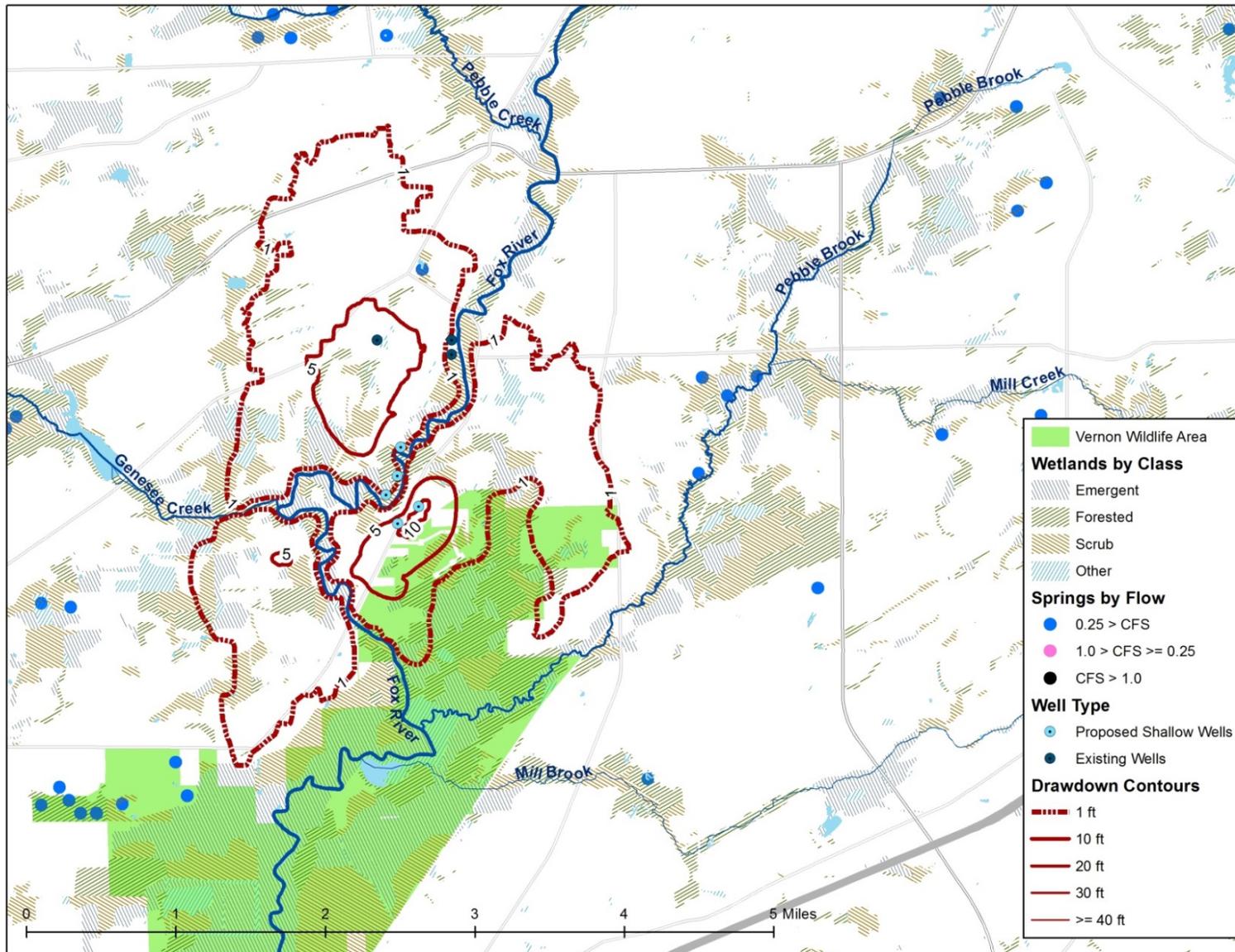


Figure 31. Alternative 4 –DNR-Deep Aquifer and River Bank Inducement – Coarse-favored model.

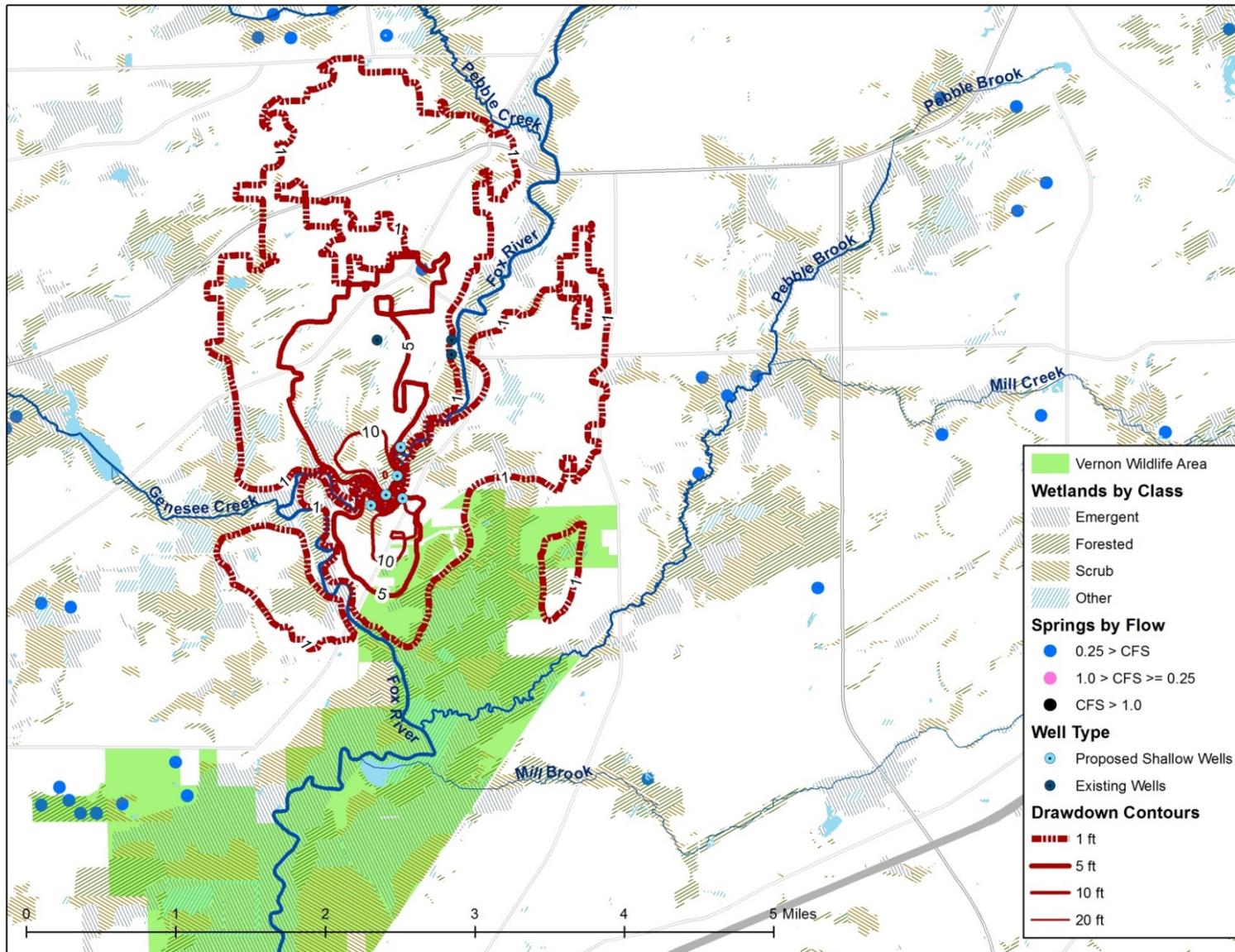
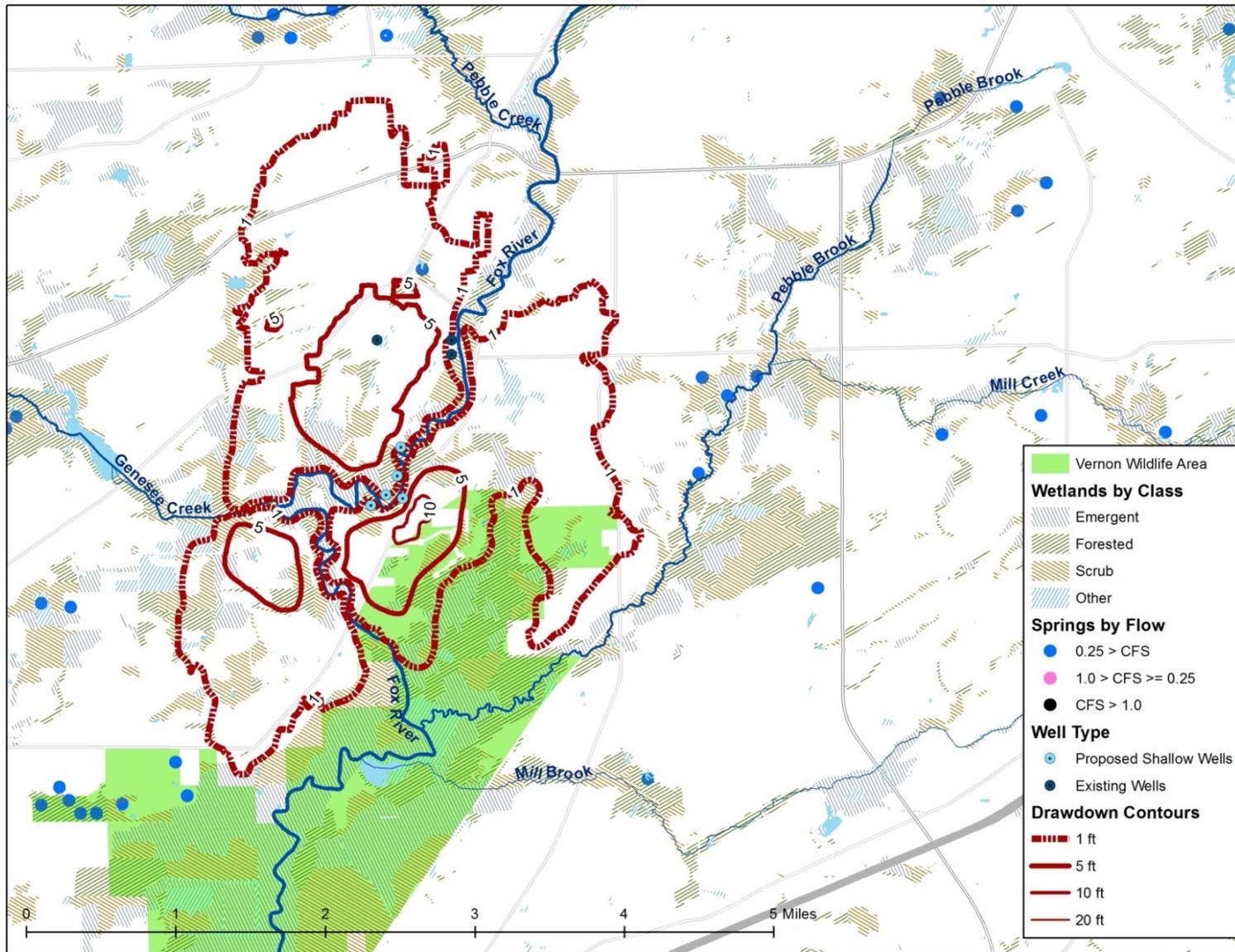


Figure 32. Alternative 4 – DNR-Deep Aquifer and River Bank Inducement – Fine-favored model.



## 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.

### *Alternative 1 – Deep and Shallow Aquifer – Deep Aquifer (4.5MGD), Shallow Aquifer (4 MGD)*

The pumping rate of 0.2 MGD for WK11 was determined from the 2009-2013 average. The remaining 3.8 MGD was divided equally between 10 wells for a pumping rate of 0.38 MGD ([Table 38](#)).

**Table 38. 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
		<b>Total</b>			<b>4</b>

*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 39](#)).

**Table 39. 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
		<b>Total</b>			<b>8.5</b>

*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 40](#)).

**Table 40. 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
					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 41](#)).

**Table 41. 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
		<b>Total</b>			<b>4</b>

## Attachment B – Pumping Rate Reductions

The following tables indicate the pumping rate reduction in each well for each alternative.

**Table 42. Pumping rate reduction to maintain aquifer saturated thickness at 20% of total aquifer saturated thickness.**

**a) Alternative 1.**

<b>Alternative 1 - Shallow/Deep</b>				<b>Coarse-favored Model</b>		<b>Fine-favored Model</b>	
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
				<b>4.00</b>	<b>4.00</b>	<b>4.00</b>	<b>3.84</b>

**b) Alternative 2**

<b>Alternative 2 - Shallow</b>				<b>Coarse-favored Model</b>		<b>Fine-favored Model</b>	
	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
				<b>8.50</b>	<b>8.48</b>	<b>8.50</b>	<b>7.79</b>

c) Alternative 3

<b>Alternative 3 Multi-source</b>				<b>Coarse-favored Model</b>		<b>Fine-favored Model</b>	
	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
				<b>3.20</b>	<b>3.20</b>	<b>3.20</b>	<b>3.20</b>

d) Alternative 4

<b>Alternative 4 DNR RBI</b>				<b>Coarse-favored Model</b>		<b>Fine-favored Model</b>	
	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
				<b>4.00</b>	<b>4.00</b>	<b>4.00</b>	<b>4.00</b>

## **Appendix C: Waukesha Wastewater Treatment Plant**

The design of the Waukesha wastewater treatment plant (WWTP) is based on the flow and loading projections in the following table:

**Table 43. Design of the Waukesha WWTP.**

<b>2030 City of Waukesha WWTP Design Criteria</b>				
<b>Influent Design Flow (MGD)</b>				
<b>Average Annual</b>	<b>Max. Monthly</b>	<b>Max. Week</b>	<b>Max. Day</b>	<b>Max. Hour</b>
14.0	21.44	-	26.21	38.97

Preliminary treatment at the WWTP is provided by two mechanical fine screens and two vortex grit removal tanks. After preliminary treatment, wastewater flow is measured in a 60-inch Parshall flume and discharged into the primary influent pump station. Five primary influent pumps, each with a maximum capacity of 13.5 MGD, convey the wastewater to the primary clarification tanks. Four square 80-foot by 80-foot primary tanks provide settling prior to pumping to the aeration basins. The primary effluent pump station includes five pumps each with maximum capacity of 19 MGD.

Primary effluent is discharged into six 50-foot by 250-foot aeration basins. The aeration basins are followed by four, 120-foot diameter final clarifiers. The clarified wastewater (secondary effluent) flows to four 14-foot by 60-foot coagulation basins where wastewater is mixed with ferric chloride to precipitate phosphorus. Each coagulation basin is followed by an 80-foot by 80-foot settling basin. After coagulation and settling secondary effluent flows to eight dual media deep bed 24-foot by 26-foot filters. Under high flow conditions secondary effluent can be diverted around the filters and discharged directly to the ultraviolet disinfection units. After disinfection treated effluent flows by gravity to the current discharge location on the Fox River.

Waste activated sludge from the final clarifiers is thickened in two dissolved air floatation thickeners, mixed with primary sludge and anaerobically digested in two 90-foot diameter and two 55-foot diameter anaerobic digesters. Biogas from the digesters is used to heat the digester. The digested biosolids are stored in a 140-foot diameter storage tank. Biosolids are dewatered on three 2-meter belt filter presses and further dried to 20 percent solids. The dried solids are stored in a building before being applied to agricultural lands.

The department approved upgrades to the Applicant's WWTP on March 13, 2013 and February 10, 2015. The 2013 approval included improvements to the influent screens and screening washers; grit removal equipment and grit pumping; primary clarifiers; aeration blowers; final clarifiers; biosolids pumping; digestion and gas handling; centrifuge dewatering and dry polymer preparation; an administration building addition and remodeling; maintenance building remodeling; high-voltage electrical power distribution improvements; SCADA system update; HVAC and mechanical system upgrades in multiple buildings; site and site roadway improvements, and miscellaneous mechanical, electrical, and HVAC improvements. The 2015

approval includes improvements to the ultraviolet disinfection and post-aeration facilities. Construction of these improvements is currently on-going.

The City of Waukesha's July 2011 wastewater facilities plan assumed that a reactive filtration system would be constructed to meet the phosphorus effluent limitations for either a continued discharge to the Fox River or the return flow to the Root River.<sup>281</sup> All flow to the wastewater treatment plant would receive the same level of treatment.

In order to return flow to the Root River an effluent pumping station is proposed to be constructed adjacent to the ultraviolet disinfection facility. Because of the infiltration and inflow (I/I) of groundwater and rainfall into the sanitary sewer system during wet weather, the volume of wastewater flow to the treatment plant would at times exceed the volume diverted from Lake Michigan to Waukesha's water supply. The volume of treated wastewater in excess of the required return flow volume would be discharged to the Fox River through the existing outfall structure.

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<sup>281</sup> Wastewater Treatment Plant Facilities Plan, Strand Associates, Inc., July, 2011

## **Appendix D: Root River Watershed Phosphorus Loading Analysis**

The department's Water Use Section completed an analysis of point and nonpoint source phosphorus loading estimates for seven sites throughout the Root River Watershed using available measured discharge and water quality datasets in addition to load estimation tools.

### **Estimated Annual Phosphorus Loads**

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Seven sites were evaluated for phosphorus loading within the 198 square mile Root River Watershed (Figure 1). For each site several methods existed for estimating the annual phosphorus load. The preferred method of calculating phosphorus loads involved coupling site specific water quality and discharge data to create mathematical relationships via software that relies on regression to estimate pollutant concentrations on days when samples are not collected. The unavailability of sufficient measured water quality data at most assessment sites in the watershed limited the availability to calculate loads using site specific measured data and the regression equations. In those instances pollutant loads were estimated from phosphorus loading screen tools such as the Spatially-referenced Regression on Watershed Attributes (SPARROW) model developed by the U.S. Geological Survey (USGS) and the Pollutant load Ratio Estimation Tool (PRESTO) model developed by the WDNR. Both models predict an average annual phosphorus load from point and nonpoint sources within a subwatershed.

The Root River at Highway 100, also referred to as the Root River at Franklin, was assessed by both the Milwaukee Metropolitan Sewer District (MMSD) and the USGS. MMSD collected instantaneous total phosphorus grab-samples and the USGS measured daily mean discharge (USGS Site No. 04087220). The number of total phosphorus samples over a continuous time period in conjunction with the daily flow was sufficient to estimate annual phosphorus loads during a 10-year period (2004 – 2013). To calculate the total phosphorus loads from the measured data the U.S. Army Corps of Engineers (USACE) software FLUX32 was used in conjunction with load methodology developed by the Twin Cities Metropolitan Council.<sup>282</sup> The annual loads from the 48 square mile drainage in the upper Root River watershed varied from a minimum of 2,849 lbs. in 2012 to a maximum of 19,138 lbs. in 2008 with a 10-year average annual phosphorus load of 9,474 lbs. Figure 2 illustrates the variation in loading on the Root River at Highway 100 between 2004 and 2013. The Root River at Franklin site was the only site where all three methods (FLUX32, PRESTO, and SPARROW) could be used to quantify load. The three methods were within 30 percent of each other and the PRESTO and FLUX32 methods were within 14 percent. With increasing watershed size the PRESTO and SPARROW results were more closely matched.

For the remaining six sites (Root River Canal at Franklin, RR-17, RR-18, RR-21, Root River at Racine, and RR-22) the export coefficient method within the WDNR's PRESTO model was used to estimate an average annual phosphorus load. The USGS SPARROW model was not solely

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<sup>282</sup> Jensen, Karen, Environmental Quality Assurance (EQA) Standard Operating Procedure, [http://es.metc.state.mn.us/eims/ExcelLoads/SOPs/SOP\\_Flux32\\_Stream\\_Load\\_Estimates\\_V1.3.pdf](http://es.metc.state.mn.us/eims/ExcelLoads/SOPs/SOP_Flux32_Stream_Load_Estimates_V1.3.pdf), Metropolitan Council Environmental Services, September 2012

used because the SPARROW model’s predefined catchments did not coincide with all seven of the evaluation sites.

At the outlet of the Root River Watershed (Lake Michigan) the average annual phosphorus load is 65,877 pounds per year as defined by the PRESTO model. Of the 65,877 pounds per year, five permitted point sources discharged an average sum of 2,890 pounds of phosphorus (4 percent of the total load) per year between 2010 and 2012 (Table 44). It is assumed, as cited in the USGS SPARROW model, that 100 percent of the phosphorus delivered to the stream network throughout the Root River Watershed reaches Lake Michigan.

**Table 44. Permitted Surface Water Outfalls within the Root River Watershed.**

<b>Facility Name</b>	<b>WDNR Permit No.</b>	<b>Receiving Water</b>	<b>2010-2012 Average Annual Phosphorus Load (lbs.)</b>
Maple Leaf Farms	0001694	West Branch Root River Canal	0
Fonks Home Center, Inc.	0026689	East Branch Root River Canal	103
Yorkville Sewer Utility	0029831	Unnamed Tributary	1,293
Union Grove	0028291	West Branch Root River Canal	1,477
PPG Industries	0029149	Unnamed Tributary	17

Table 2 quantifies the annual phosphorus load for each site with all the available phosphorus estimation methods. When examining the results from the WDNR’s PRESTO model the percentage of point source compared to the total load only varies by 2 percent between the Root River confluence with the Root River Canal and outlet of the Root River at Lake Michigan.

Figure 33. Root River Watershed Phosphorus Loading Assessment Location.

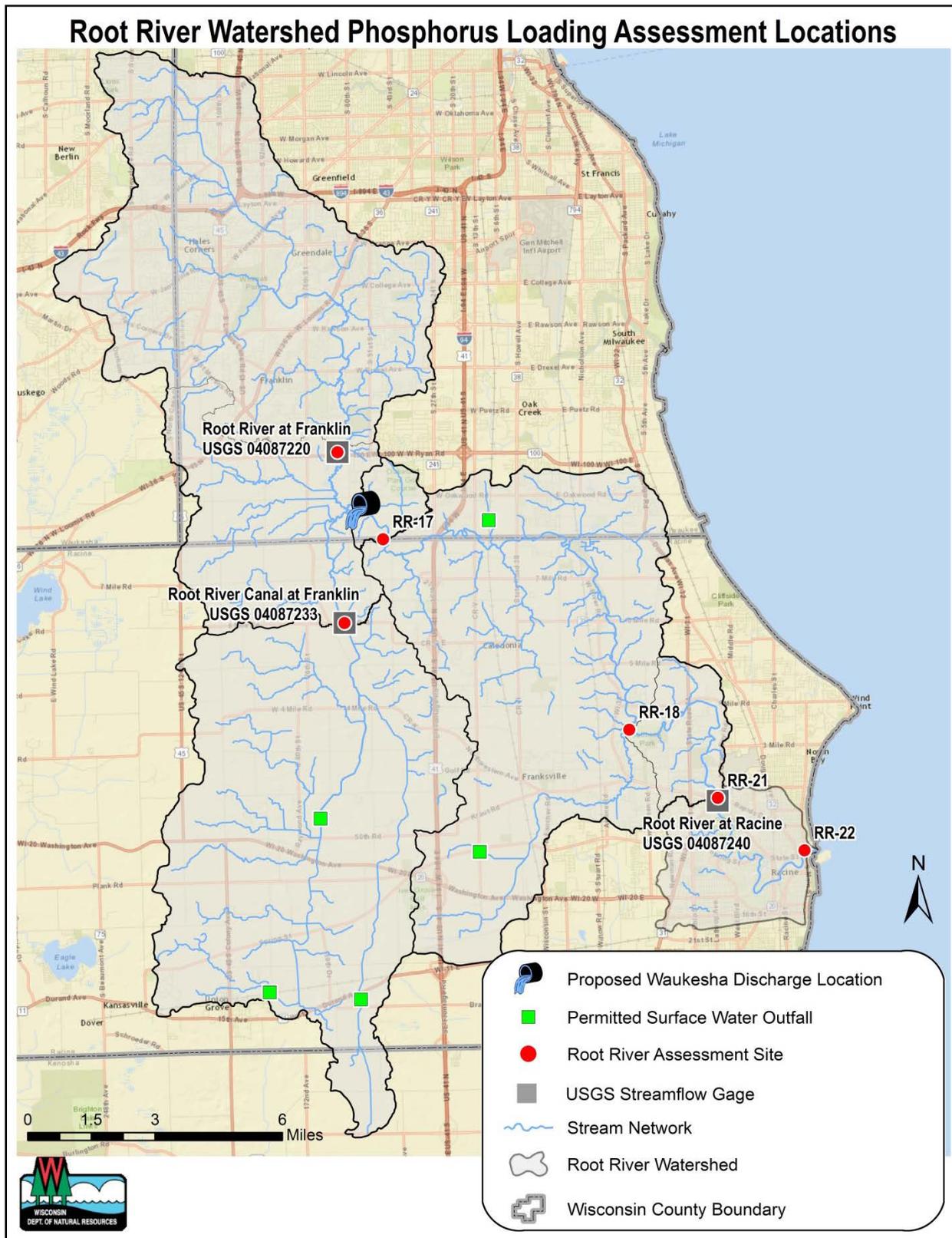
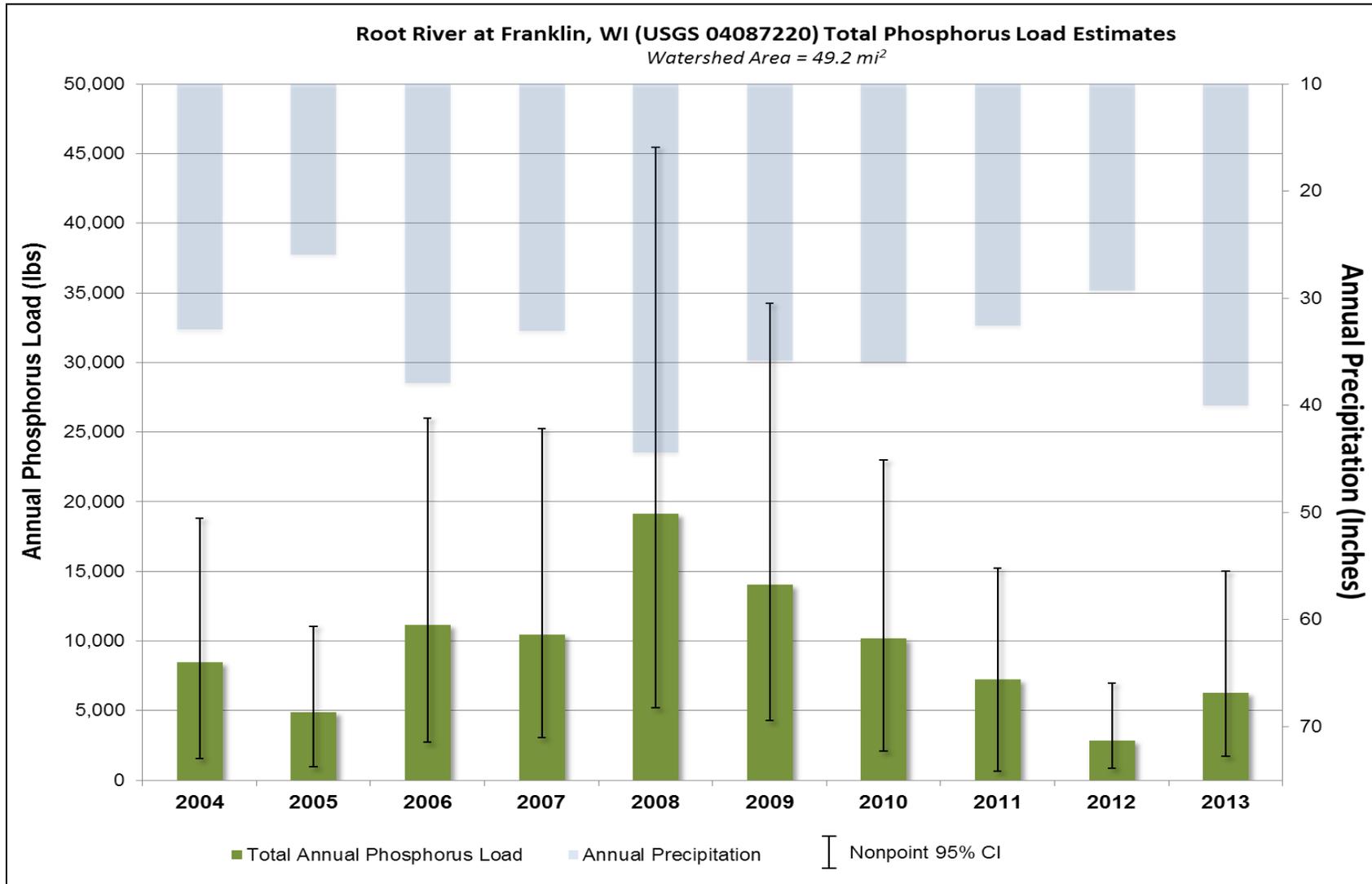


Figure 34. Root River at Franklin, WI (USGS 04087220) Total Phosphorus Load Estimates.



**Table 45. Root River Watershed Characterization and Phosphorus Loading Summary.**

	<a href="#">USGS 04087220</a> Root River at Franklin	<a href="#">USGS 04087233</a> Root River Canal near Franklin	RR-17	RR-18	RR-21	<a href="#">USGS 04087240</a> Root River at Racine	RR-22 (Approx. Watershed Outlet)
Drainage Area (mi <sup>2</sup> )	49	57	130	183	189	190	197
Average Annual (2010-2012) Point Source Phosphorus Load (lbs.)	0	1,580	1,580	2,890	2,890	2,890	2,890
WDNR PRESTO Model <i>Average Annual</i> Total Phosphorus Load (lbs.)	8,106	26,708	40,715	59,430	63,243	63,263	65,877
USGS SPARROW Model <i>Average Annual</i> Total Phosphorus Load (lbs.)	12,253	---	---	59,672	---	60,617	77,408
FLUX32 Estimate Average (2004 - 2013) Annual Load (lbs.)	9,474	---	---	---	---	---	---
WDNR PRESTO Model Point to Nonpoint Phosphorus Load Ratio (%)	0% : 100%	6% : 94%	4% : 96%	5% : 95%	5% : 95%	5% : 95%	4% : 96%
2011 NLCD Landcover							
Open Water (%)	0.5	0.5	0.5	0.4	0.5	0.5	0.5
Urban (%)	51.3	6.6	24.1	21.9	22.1	22.1	24.4
Forest (%)	9.4	7.6	9.5	9.0	9.4	9.4	9.2
Grassland (%)	23.5	4.5	12.2	10.9	11.2	11.2	11.4
Wetland (%)	4.6	1.7	3.8	4.6	4.8	4.8	4.6
Agriculture (%)	9.0	78.3	48.6	52.1	51.1	51.1	49.0
Barren (%)	1.7	0.7	1.2	1.0	1.0	1.0	1.0