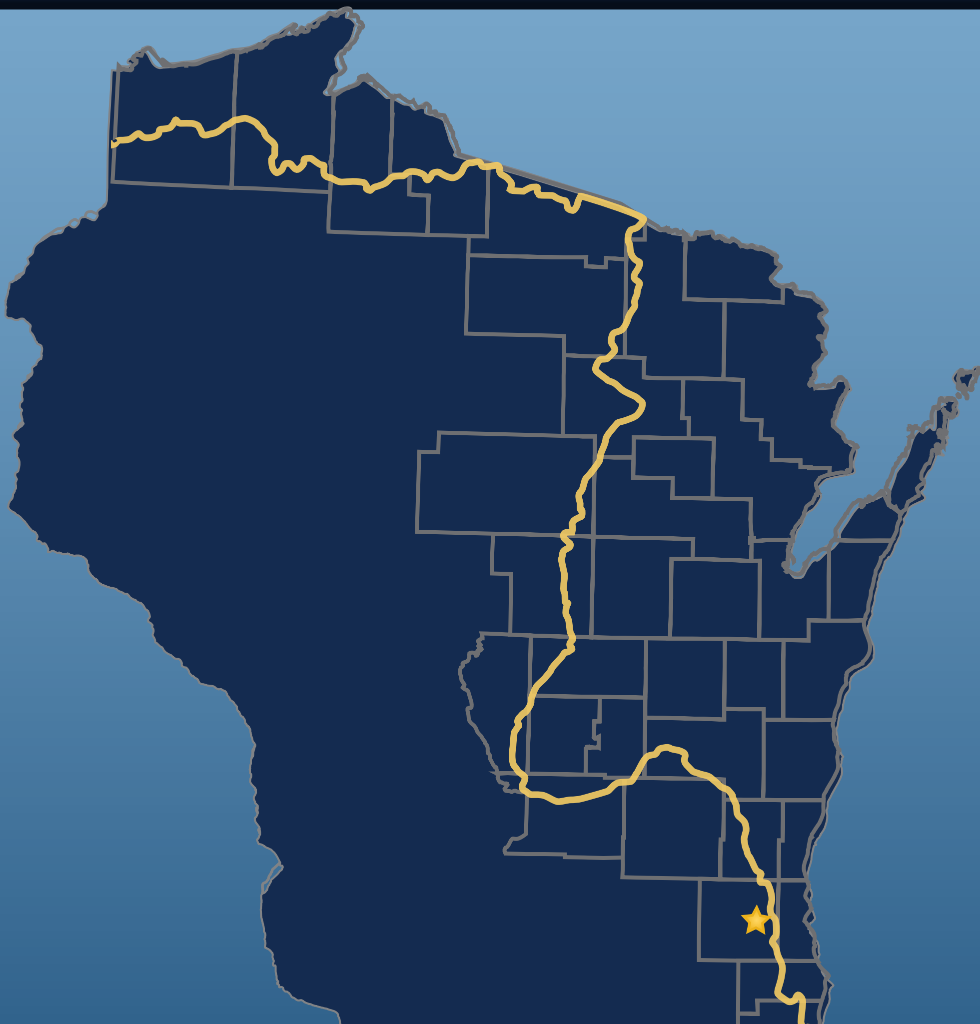
Draft Application for

Lake Michigan Water Supply



Submitted by:

Waukesha Water Utility

January 2010

WBG110509184022MKE

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CH2MHILL

Executive Summary

The City of Waukesha provides water to its customers primarily from deep wells, constructed to depths of 2,100 feet and withdrawing water from 800 to 1,000 feet below ground. The extraction of groundwater from the deep aquifer has decreased the water level 500 to 600 feet in little over a century, and it continues to decrease 5 to 9 feet annually. Existing groundwater levels require that the City use very large well pumps to extract the groundwater. Pumping water from extreme depths is energy-intensive and costly, and increases the carbon footprint of the water utility. Furthermore, as water is pumped from greater and greater depths, the quality of the source water declines. Radium and other dissolved solids are present in increasingly higher concentrations and require removal to meet drinking water standards.

In certain areas of the region, precipitation helps to recharge the deep aquifer, but in the Waukesha area, a hard layer of shale above the aquifer limits groundwater recharge. Also, the water the City uses does not recharge the aquifer. After use and treatment, the water is discharged to the Fox River, ultimately finding its way to the Mississippi River and the Gulf of Mexico. The precious freshwater resource is not returned to its source—the Great Lakes and Mississippi River groundwatersheds. It is sent to the ocean.

The City obtains less than 13 percent of its water supply from shallow wells in the Troy Bedrock Valley aquifer. Increased pumping of the shallow aquifer has adverse environmental impacts on surface water resources, including reduced baseflows (groundwater contributions) to local streams and wetlands.

The City's vision for the future is to provide an adequate supply of healthful water to its citizens for the long term (50 to 100 years), without overburdening the region's water resources. In 2006, the City launched one of the most comprehensive water conservation programs in the Midwest. Between 1988 and 2008, water use decreased 31 percent, despite a corresponding 18 percent increase in population. The City's water conservation goal is to reduce water use by 20 percent per capita between 2005 and 2020. Initial efforts, such as a ban on daytime water sprinkling, rate structures that promote water conservation, a high efficiency toilet rebate program, and public education, have resulted in an 11 percent decrease in use in just 3 years. But a successful water conservation program alone is not a solution to the City's water supply needs. The City is also under a court order to comply with radium standards by June 30, 2018. Continuing the current practice is not an option available to the City.

Continued and increasing withdrawal from the deep and shallow groundwaters to meet present and future demands, at the cost of adverse environmental impacts to water resources and ecosystems, is not a sustainable solution, nor the best way to protect public health. The City of Waukesha needs a new long-term water supply.

The City needs 18.5 million gallons per day (mgd) to meet its future maximum day demand (10.9 mgd average day demand) when the City is fully developed, as determined by the Southeastern Wisconsin Regional Planning Commission, the local planning authority. The 2009 maximum and average day demands were 9.4 mgd and 6.8 mgd, respectively. The City and SEWRPC evaluated numerous water supply alternatives, such as increased withdrawal from the shallow aquifer, local river supplies, local lake supplies, continued use of the deep and shallow aquifers, and wastewater reuse. This application presents a review of the water supply alternatives that have been studied for many years. The three most feasible alternatives are presented in detail:

- Continued use of the deep and shallow aquifer
- Use of shallow aquifer resources alone
- Use of Lake Michigan water, and return of flow to Lake Michigan

The most feasible alternatives have been developed and compared with four evaluation criteria consistent with Wisconsin Department of Natural Resources requirements: environmental impact, long-term sustainability, public health, and implementability. The evaluation is summarized below.

Water Supply Alternatives	Environmental Impact	Long-Term Sustainability	Public Health	Implementability
Deep and shallow aquifers	● Significant	● Significant	Moderate	● Significant
Shallow aquifer	● Significant	● Significant	Moderate	● Significant
Lake Michigan	⊙ Minor	○ None	⊙ Minor	Moderate

- ○ No adverse impact
- ⊙ Minor adverse impact
- Moderate adverse impact
- ● Significant adverse impact

The groundwater in the deep aquifer is severely depleted and not reliable over the long term. The quantity of water in the shallow aquifer is limited, the water is less protected from contamination, and increased withdrawal would have an adverse environmental impact on sensitive streams, brooks, and wetlands. Use of Lake Michigan as a water supply is fully sustainable with sound management of return flow. It has the least environmental impact and provides the greatest protection of public health. All three alternatives have similar costs.

The most reasonable strategy for the City of Waukesha is to use Lake Michigan for its water supply, and to return flow in a manner consistent with the requirements of the Great Lakes–St. Lawrence River Basin Water Resources Compact, an agreement between Wisconsin, Minnesota, Michigan, Illinois, Indiana, Ohio, Pennsylvania, New York, Quebec, and Ontario.

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Abbreviations and Acronyms

AWWA	American Water Works Association
BOD	biological oxygen demand
cfs	cubic feet per second
Compact	Great Lakes–St. Lawrence River Basin Water Resources Compact
EPA	U.S. Environmental Protection Agency
I&I	infiltration and inflow
mg/L	milligrams per liter
mgd	million gallons per day
MMSD	Milwaukee Metropolitan Sewerage District
N/A	not applicable
NR	Natural Resources
NH_3-N	ammonia nitrogen
P	phosphorus
piC/L	picocuries per liter
PSC	Wisconsin Public Service Commission
SCADA	supervisory control and data acquisition
SEWRPC	Southeastern Wisconsin Regional Planning Commission
SWWT	Southeastern Wisconsin Watersheds Trust
TDS	total dissolved solids
TSS	total suspended solids
WDNR	Wisconsin Department of Natural Resources
USGS	United States Geological Survey
Utility	Waukesha Water Utility
WGNHS	Wisconsin Geological and Natural History Survey
WPDES	Wisconsin Pollutant Discharge Elimination System
WWTP	wastewater treatment plant

SECTION 1
Introduction

This draft application is prepared and submitted in accordance with the Great Lakes–St. Lawrence River Basin Water Resources Compact (the Compact) and the Wisconsin Compact implementing statute (§281.346(1) (ps), Wis. Stats. (Wisconsin Act 227) for the purpose of gaining approval of the request for a Great Lakes water diversion with return flow. It provides historic evidence, future water resources planning, and scientific data that support the conclusion that a Lake Michigan water supply with return flow is the most sustainable and environmentally beneficial water supply for the City of Waukesha, Wisconsin. A Lake Michigan supply will end the City's use of the deep aquifer and provide environmental benefits to groundwaters and surface waters throughout the region.

The appendixes contain technical references in support of this application.

City of Waukesha Background

The City of Waukesha is a historic community located in southeastern Wisconsin, 18 miles west of Lake Michigan. It is a leading contributor to the economic vitality of the greater Milwaukee metropolitan area. Major employers include General Electric, ProHealth Care, Carroll University, Waukesha Engine, MetalTek, Cooper Power, and Navistar. Redevelopment has been central to the City's strategic plan for the community. For example, extensive revitalization of Waukesha's historic downtown area has created a thriving commercial and arts district. Investments made in the downtown area have spurred the development of community resources, including local small businesses, galleries, and museums. The City looks forward to a future with well-managed growth that involves more urban redevelopment; increased use of green infrastructure best practices to minimize environmental impacts; and stewardship of water resources to sustain water and the natural environment for future generations.

The City lies within a straddling county that is outside the Great Lakes basin but wholly within a county that lies partly within the Great Lakes basin (see Exhibit 1-1). It is 1.5 miles west of the Great Lakes watershed surface water divide and 17.4 miles east of the Great Lakes groundwater divide, well within the Great Lakes groundwatershed. To qualify for Great Lakes water, the City must practice water conservation, return treated water to the lake, and obtain the permission of the eight Great Lakes governors, with input from the Canadian provinces.

Waukesha is the first community within a county that straddles the surface water divide to apply to the Council of Great Lakes Governors for lake water under the terms in the Compact. Waukesha's application follows the New Berlin, Wisconsin application, which was approved under the straddling community provision of the Compact and Wisconsin Act 227.

EXHIBIT 1-1
Wisconsin Counties Within Great Lakes Basin

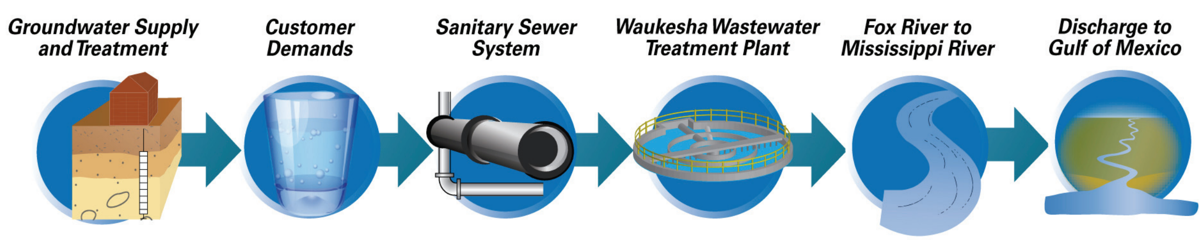
Need for a New Water Supply

The City of Waukesha is applying for Great Lakes water to secure a sustainable, reliable water supply that is protective of public health and provides regional environmental benefits. Despite significant success with an aggressive water conservation program, the City is faced with a declining groundwater supply and worsening water quality conditions. The City's historic groundwater source is not feasible over the long term. Scientific investigation of local groundwater aquifers and comprehensive regional planning have produced no other sustainable option that is as protective of public health and natural water resources as a Great Lakes water supply. The City obtains more than 87 percent of its water supply from the deep St. Peter Sandstone Aquifer. Near and beyond the City of Waukesha, the aquifer is confined by a geological feature—the Maquoketa shale layer—that limits natural recharge of the aquifer. Continued use of the aquifer by the City and surrounding communities since the 19th century, and the presence of the Maquoketa shale have led to the 500- to 600-foot decline in aquifer water levels.[1] Water levels continue to drop 5 to 9 feet per year.[2] Reduced groundwater levels in southeastern Wisconsin have in turn affected regional surface waters, which now receive about 18 percent[3] less in groundwater contribution as water migrates toward the deep aquifer. Significant water quality issues occur with declining water levels in the deep aquifer, including increased levels of salts and radium (a naturally occurring element in the deep aquifer that may cause cancer). To provide drinking water with low levels of radium, the City treats some deep aquifer water to remove radium and blends some deep aquifer water with water from the shallow Troy Bedrock Valley aquifer.

The City obtains less than 13 percent of its water supply from the shallow aquifer. Increased pumping of the shallow aquifer will stress surface water resources by reducing baseflows to local streams and wetlands.[4] Increasing withdrawal from the deep and shallow aquifers to meet consumer demand for water, at the cost of negative impacts to other water and environmental resources, is not a sustainable solution. The City of Waukesha needs a new long-term water supply.

Currently, water used to meet City customer demands, is collected, treated, and discharged to the Fox River, which flows to the Mississippi River and ultimately the Gulf of Mexico (Exhibit 1-2). Under this water management practice, freshwater from both the Great Lakes and Mississippi River groundwatersheds is withdrawn, used, and discharged to the ocean.

EXHIBIT 1-2
Existing Waukesha Water System Overview



1 *Draft Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* SEWRPC, 2008, p.102–103.

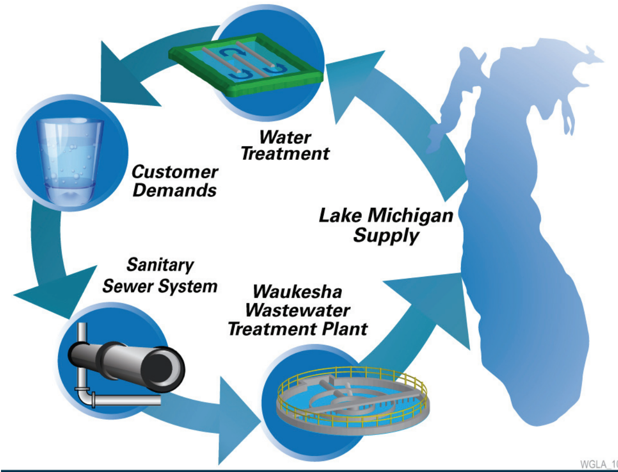
2 Waukesha Water Utility operating data 2009.

3 USGS and WGNHS.

4 *Draft Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* SEWPRC, 2008, p 8–14.

The City seeks a Great Lakes diversion of 18.5 million gallons per day (mgd) to meet maximum day demand of the City's projected water service area as delineated by the local planning authority, the Southeastern Wisconsin Regional Planning Commission (SEWRPC). The City's average day demand for the projected water service area is 10.9 mgd. The City seeks sufficient water to serve customers within its delineated service area. Exhibit 1-3 depicts the proposed new water management system including a Lake Michigan supply with return flow.

EXHIBIT 1-3
Proposed Supply, Treatment, and Discharge System



Before preparing its request, the City evaluated numerous water supply alternatives, including continued use of the deep and shallow aquifer, increased withdrawal from the shallow aquifer, local river supplies, local lake supplies, and wastewater reuse. This application presents a comprehensive review of the three most feasible alternatives: continued used of the deep and shallow aquifer, use of shallow aquifer resources alone, and Great Lakes water.

Long-term water supply and water resource planning studies that weighed water supply alternatives concluded that using Lake Michigan to supply water to the City of Waukesha is a more sustainable practice than withdrawing groundwater from the depleted deep aquifer or the shallow aquifer, and discharging that water to the Mississippi River. Given the findings of the science-based City and regional water supply plans, a new Lake Michigan water supply is the most reasonable alternative for the following reasons:

- It manages water resources so they are available for future generations.
- It ensures a reliable, long-term City of Waukesha water supply.
- It contributes toward recovery of the groundwater aquifer and improvement to stressed surface waters.
- It provides environmental benefits by increasing Underwood Creek flows to restore aquatic and wildlife habitat in the creek watercourse as water is returned to Lake Michigan.
- It reduces energy usage and greenhouse gas emissions associated with the water supply.
- It reduces the release of salt to the environment, since the need to soften the water is eliminated.

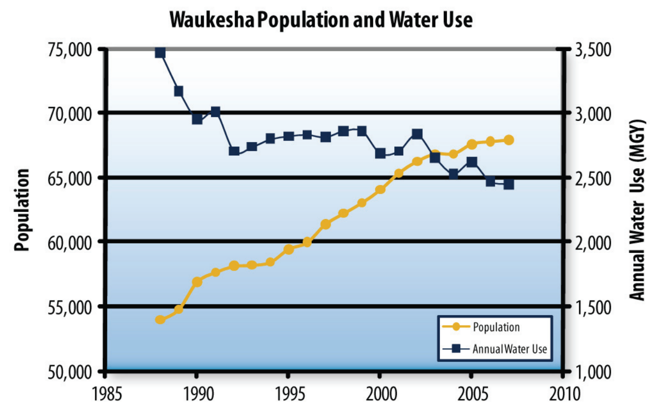
Regional Water Conservation Leadership

In 2006, Waukesha launched, and continues to implement, one of the most aggressive water conservation programs in the Midwest. Between 1988 and 2008, water use decreased 31 percent, despite a corresponding 18 percent increase in population during the period (Exhibit 1-4). The City's water conservation plan sets a goal of a 20 percent reduction in water use per capita between 2005 and 2020. Waukesha is well on its way to that goal, as initial efforts, including a ban on daytime water sprinkling, rate structures that promote water conservation, a high efficiency toilet rebate program, and education, have already resulted in an 11 percent decrease in use in just 3 years. While these measures continue to reduce water use, conservation will not save enough water to meet the City's projected long-term water demand with the overtaxed groundwater sources. Water conservation alone is not a solution to Waukesha's water supply needs.

Regional Environmental Benefits

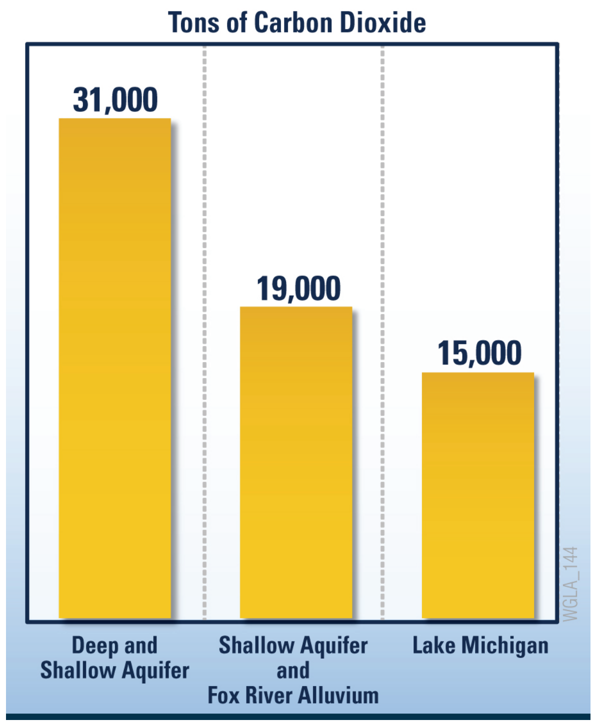
Use and return of Lake Michigan water would contribute to the successful recovery of the deep aquifer and the improvement of local streams, creeks, and marshes that are sensitive to pumping of the shallow aquifer. The proposed return flow strategy would provide additional flows beneficial to habitat restoration in the Underwood Creek and Menomonee River. The increased flows would support environmental goals for the watercourse, particularly during dry months when more water is needed. Use of Lake Michigan water also would reduce the need to soften groundwater to remove its natural hardness. Salts used for water softening pass through conventional wastewater treatment processes and are discharged to the environment in wastewater effluent. Customers of the Waukesha Water Utility can use nearly 5,000 tons of salt annually to soften groundwater. The salt is discharged in treated wastewater into receiving waters.[5] Another significant regional environmental benefit of Lake Michigan water is reduced energy consumption. Energy use and greenhouse gas emissions are less with a Great Lakes water supply than they are for withdrawing and treating groundwater supplies (Exhibit 1-5).

EXHIBIT 1-4
Waukesha Population and Water Use



Source:Waukesha Water Utility, 2009

EXHIBIT 1-5
Annual Greenhouse Gas Emissions

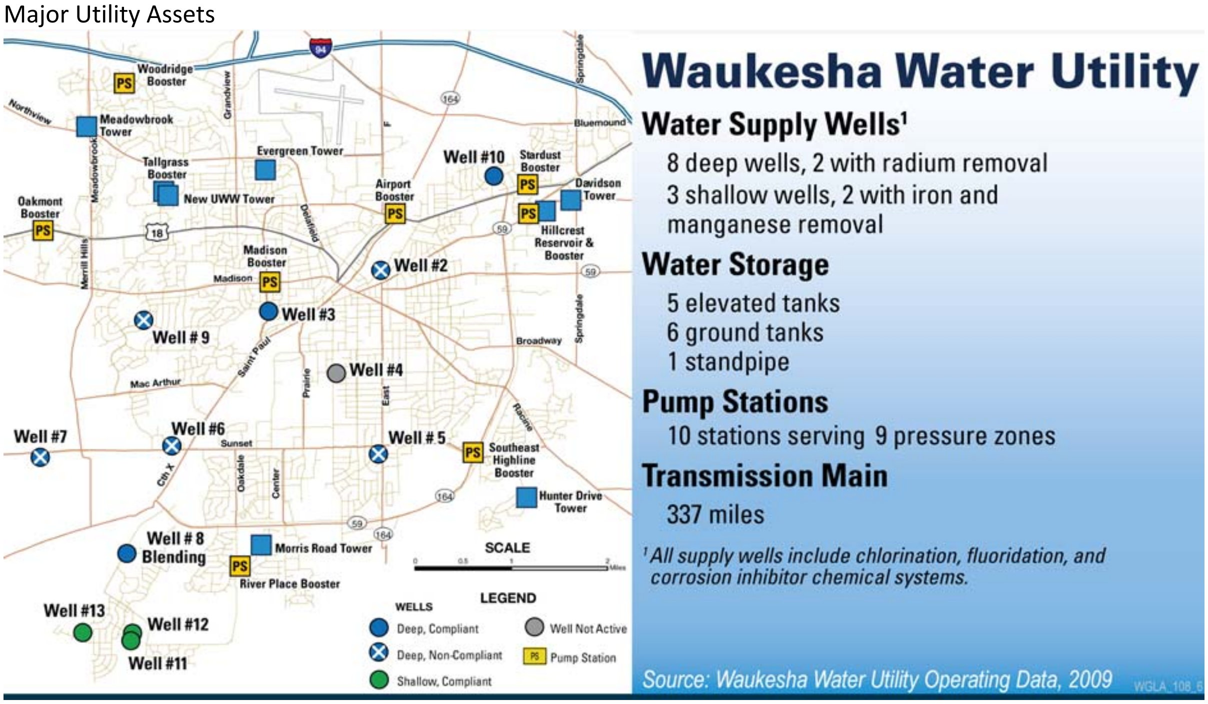


5 *Future Water Supply Report*, 2002, CH2M HILL and Ruekert-Mielke, p. 6-3.

City of Waukesha Water System

The City of Waukesha water system comprises groundwater supply, treatment, storage, and conveyance assets (Exhibit 2-1). The City also maintains a water utility administration building with offices for customer service, billing, supervisory control and data acquisition (SCADA) system control, meter testing, fleet storage, and equipment storage. Appendix D, Water Service Area Plan, contains detailed descriptions of the water utility facilities and the distribution system.

EXHIBIT 2-1
Major Utility Assets

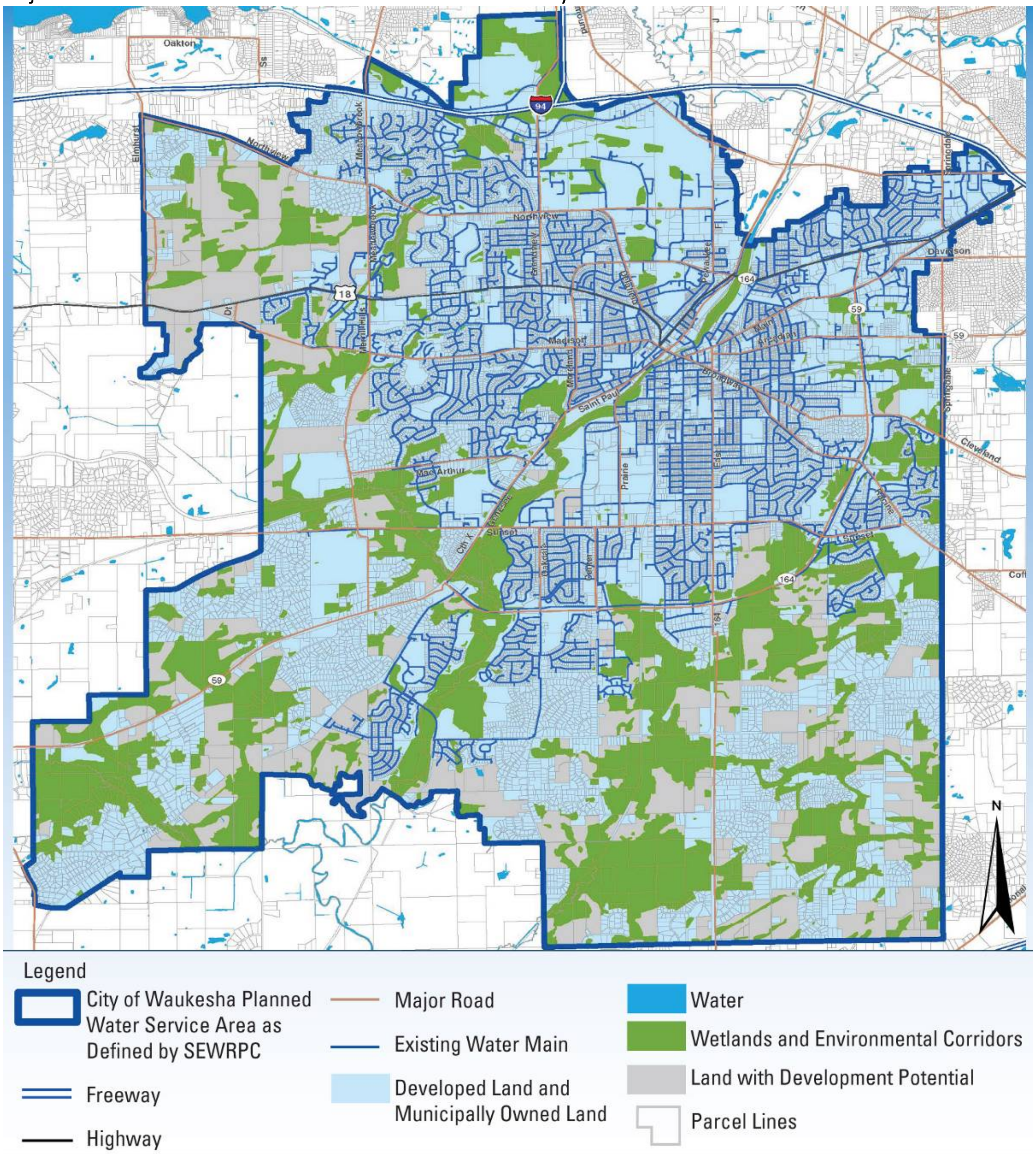


Water System Service Area

To prepare a long-term water supply plan for the future, the City studied historic water utility performance, investigated regional water quality and quantity data, undertook aggressive water conservation practices, and developed water supply projections to match the estimated needs of its water service area. The City's water service area is delineated by SEWRPC, the area-wide water quality planning agency. Granted authority under Chapter NR121 Wis. Admin. Code, SEWRPC delineated the City of Waukesha water service area and prepared population estimates that include a reasonable allowance for economic growth as required by state law. The projected water service area and population projections are shown in Exhibit 2-2 and 2-3, respectively. Although population within the water service area is expected to increase, growth will be limited. Only 15 percent of the service area land is available for new future development. The remainder already is developed or is designated in regional land use plans as natural and environmentally sensitive areas to be preserved.[1]

[1] SEWRPC. 2008. *Regional Water Supply Plan for Southeastern Wisconsin*, p. 88.

EXHIBIT 2-2
Projected Ultimate Buildout Water Service Area for the City of Waukesha



Source: SEWRPC/Philip Evenson, Executive Director. 2008. Letter to Waukesha Water Utility/Daniel S. Duchniak, P.E., General Manager. December 23, attachment.

SEWRPC estimated a planning period population of 88,500 (occurring in 2035) and an ultimate buildout population for the City of Waukesha water supply service area of 97,400. A buildout condition exists when all the land available for development has been developed in a manner consistent with the regional plan. Buildout could be more than 50 years into the future. Projected population values, historical water use (including the impact of continued water conservation), planned land use information, and residential data within the water service area were used to estimate future average- and maximum-day water demand (Exhibit 2-3).

Although there are minor differences between the City of Waukesha water and wastewater service areas, SEWRPC considers the two areas to be essentially the same.[2] The minor differences are quantified in Appendix E, Waukesha Wastewater Facility Plan Amendment, Return Flow.

With a Lake Michigan water supply, the water used in the water service area will be returned in equal measure to Lake Michigan. Current and future City of Waukesha water service area customers will be subject to the City's water conservation provisions and the Compact's return flow requirement.

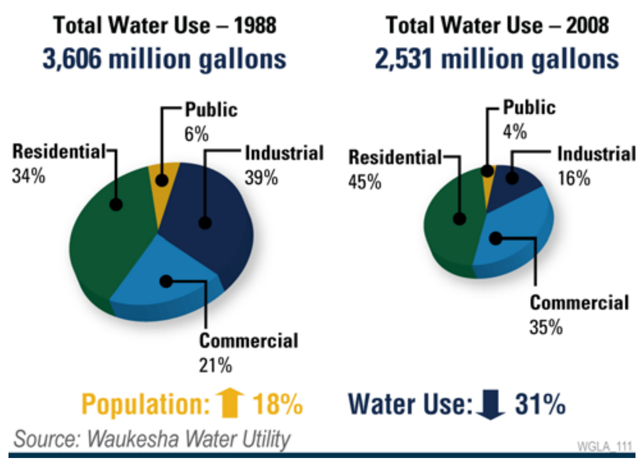
EXHIBIT 2-3
Estimated Population and Water Demand for the City of Waukesha Water Service Area

Year	Population[a]	Average Day Demand (mgd)[b]	Maximum Day Demand (mgd)[b]
2008	68,030	6.9	9.9
2028	85,800	10.7	18.0
2035	88,500	10.9	18.5
Beyond	97,400	12.0	20.2

[a]SEWRPC. 2008. *Regional Water Supply Plan for Southeastern Wisconsin, p. 52.*
[b]AECOM. 2009. *Summary of Water Requirements Technical Memorandum, p. 3.*

Waukesha Water Efficiency Best Practices

Water efficiency is the cornerstone of decision-making and customer service in the City of Waukesha. The City uses drinking water industry best practices to minimize water waste. For example, the City meters its customers to help them better understand how to use water wisely. For efficiency, the City uses automatic flowmeters that can be read remotely. Meters are read monthly or quarterly, depending on size. They are tested and calibrated routinely to maintain accuracy. In addition to universal metering, the City describes water use on customer bills in terms of gallons rather than cubic feet. This small but important detail helps customers understand how their water use relates to their behaviors. Finally, meter-reading records are monitored by City staff. If a dramatic change in water use is observed, the City contacts customers to address potential problems early.



Water use efficiency can also be determined by measuring and minimizing "unaccounted-for water"—water not accounted for as the result of leaks in the water system and other kinds of unavoidable losses. For the past 20 years, the City has had an average of 5 percent unaccounted-for water,[3] surpassing the AWWA-recommended benchmark of 10 percent.[4]

Water Consumptive Use

"Consumptive use" means 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 because of evaporation, incorporation into products, or other processes. (Wisconsin State Statute 281.346(1)(e)). Following

[2] SEWRPC/Philip Evenson, Executive Director. 2008. Letter to Waukesha Water Utility/Daniel S. Duchniak, P.E., General Manager. December 23, attachment, p. 1.

[3]Waukesha Water Utility annual operating data submitted to Wisconsin Public Service Commission.

[4] AWWA Leak Detection and Accountability Committee, 1991.

the recommendations and findings from USGS Scientific Investigations Report: 2009-5096 (Kimberly H. Shaffer), public water suppliers would calculate their consumptive use coefficients following the Winter Base-Rate Method. Based on water utility data over the past 10 years, the City of Waukesha annual average consumptive use is 8 percent (Exhibit 2-4). By comparison, the USGS found consumptive use in the Great Lakes can range as high as 74 percent for the domestic and public sector, with an average between 12 to 15 percent.[5, 6]

EXHIBIT 2-4
Waukesha Water Utility seasonal and Annual Consumptive-Use Coefficients Computed Using the Winter-Base-Rate Method

Year	Spring	Summer	Fall	Annual
1999	8	18	6	9
2000	6	12	2	5
2001	6	22	5	9
2002	6	24	8	10
2003	3	20	7	8
2004	5	16	10	8
2005	5	26	11	12
2006	5	16	3	6
2007	8	19	6	9
2008	5	14	3	6
2009	4	14	3	5
25th percentile	5	15	3	6
Median	6	17	6	8
75th percentile	6	21	7	9
Average (1999–2009)	6	18	6	8

Note: The consumptive-use coefficient is a percentage, rounded to the whole number.

Water Conservation

Total water use by City customers has dropped 31 percent from 1988 to 2008, despite an 18 percent population increase. In 2006, the City implemented a comprehensive water conservation plan to further reduce water use by 20 percent per capita by 2020. A copy of the plan is included in Appendix A, Waukesha Water Utility Water Conservation and Protection Plan Water. Water conservation and protection efforts will be continued and increased. The effectiveness of practices implemented by the City is monitored continuously to determine how best to invest in the program. Exhibit 2-5 summarizes water conservation goals and actions.

[5] USGS, Consumptive Water Use in the Great Lakes Basin, 2008, Fact Sheet 2008-3032, page 3.

[6] USGS Consumptive Water Use Coefficients for the Great Lakes Basin and Climatically Similar Areas, 2007, Scientific Investigations Report 2007-5197, page 25.

EXHIBIT 2-5

City of Waukesha Water Conservation and Protection Plan Goals

Relative Water Savings Benefit Scale: 💧 = Minimal 💧💧 = Moderate 💧💧💧 = Major

Short-term Goals	
Provide Public Education on Web Site – Teach the public why they should conserve water and how they can help, mentioning the resulting time and cost savings. Provide information on rain gardens and rain barrels.	💧💧
Continue Student Water Education – Teach Waukesha students about the water level in the aquifer, the importance of conservation, and practices their families can implement.	💧💧💧
Develop Outdoor Water Use Ordinance – Create and implement an ordinance that sets limits on sprinkling times to reduce peak water use and costs for customers.	💧💧💧
Communicate Monetary Benefits of Water Conservation – Place water conservation cost savings information in customer bills.	💧💧
Accelerate Water Main and Lateral Replacement – Continue to replace outdated mains and service laterals, helping to ensure a reduction in leaks.	💧💧💧
Promote Water Conservation – Create brochures, magnets, signage, and a public service announcement; attend events to promote conservation.	💧💧
Implement Conservation Water Rates – Develop with the Public Service Commission a water pricing structure that encourages conservation.	💧💧💧
Loop Water Mains – Have contractors loop the water mains to reduce hydrant flushing water requirements.	💧
Organize Regional Stakeholder Groups – Create stakeholder groups to promote regional water conservation through residential contests, commercial and industrial customer groups, regional water utility collaboration, and educational events for conservation.	💧💧💧
Recycle Filtered Backwash Water – Implement a recycling process for Wells 8, 11, and 12.	💧
Audit Water Use in City Buildings – Starting with City Hall, audit all city buildings to identify ways to reduce water use.	💧💧
Develop Incentives/Rebates Programs – Continue to work with the Public Service Commission to determine the feasibility and potential success of rebate programs.	💧💧💧
Implement Rain Barrel Program – Work with the Coalition to provide rain barrels for landscaping maintenance water supply.	💧💧
Become a Member of WaterSense – Gain current information on tested products to meet performance standards of plumbing fixtures for our rebate programs.	💧💧
Join Alliance for Water Efficiency – Acquire and implement best management practices for water conservation.	💧💧
Initiate Restaurant Table Tents and Other Water-saving Ideas – Work with the Coalition and Wisconsin Conference for Restaurants to develop "table tents" that explain water conservation at restaurants.	💧💧

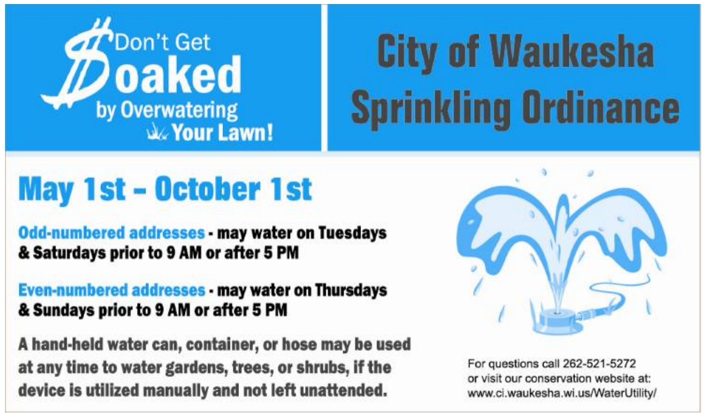
Mid-term Goals	
Continue Student Water Education Programs – Update curriculum.	💧💧💧
Continue Public Outreach Program – Provide press releases, and update brochures and materials. Update Utility Web site.	💧💧
Maintain Water System Leak Detection Program – Update Utility leak detection to identify priority areas in the system to reduce large leaks and reduce unaccounted-for flow.	💧💧💧
Implement City Water Audit – Install water-saving fixtures throughout Utility facilities.	💧💧💧
Evaluate Indoor Incentives/Rebates Programs – Evaluate rebate programs for targeted water-using appliances and fixtures.	💧💧💧
Evaluate Outdoor Incentives/Rebates Programs – Evaluate rebates for outdoor water use equipment (timers, sprayers).	💧💧💧
Evaluate Residential Audit Feasibility – Determine the feasibility of coordinating a residential water audit program with a water meter change-out program that would link to an incentive/rebate program.	💧💧💧
Review Water Use Restriction Ordinances – Review plumbing requirements in ordinances for new construction, remodeling, and retrofits, and study potential for requiring plumbing updates at time of property sale.	💧💧💧
Enhance Outreach to Commercial Sector – Provide commercial businesses (i.e., car washes, laundromats, hair salons) and retailers with information for customers about the benefits of updating indoor fixtures and outdoor watering devices.	💧💧💧
Reduce City Departments and Schools Outdoor Water Use – Identify opportunities for reduced outdoor sprinkling in parks and school fields.	💧💧
Evaluate Sewer Credit Meters – Investigate the phase-out of residential sewer credit meters to further encourage reductions in outdoor water use.	💧💧
Pilot Low-impact Development on City Properties – Add green infrastructure, such as rain gardens and permeable pavement, to City properties.	💧💧
Work with Housing Authority to Update Public Housing Plumbing – Work with Waukesha Housing Authority to update water fixtures in Waukesha public housing.	💧💧
Replace Plumbing Fixtures with Efficient Devices – Work with the Wisconsin Focus on Energy Program to update shower heads at hotels and hand sprayers at restaurants.	💧💧💧
Form Regional Source Water Protection Planning Committee – Work with surrounding utilities to better coordinate source water protection.	💧
Communicate Monetary Benefits of Water Conservation – Place individual account water use information on the internet and on water bills.	💧💧
Fix a Leak Week in March – Get involved with EPA's Fix a Leak Week by including dye tablets and a brochure in all water bills.	💧💧💧

Long-term Goals	
Implement Unidirectional Flushing – Update the flushing program to maximize velocities in the main for flushing, thereby reducing the amount of water needed to clean the water mains.	💧
Implement Smart Growth Land Use Planning and Zoning – Work with other entities (surrounding communities, developers, businesses) to develop Low-impact Development Practices to prevent pollution from entering the Fox River. Consider revision of Comprehensive Plan and zoning ordinances to encourage infiltration of stormwater into the ground.	💧
Audit Commercial and Industrial Sectors Water Use – Work with commercial and industrial customers to identify areas to reduce water use and save customers' money.	💧💧💧
Evaluate Gray Water Systems – Investigate reuse of the City's wastewater after it is returned to the Lake Michigan watershed. Reuse may involve "gray" water separation or redirection of treated wastewater for regional aquifer recharge.	💧💧💧

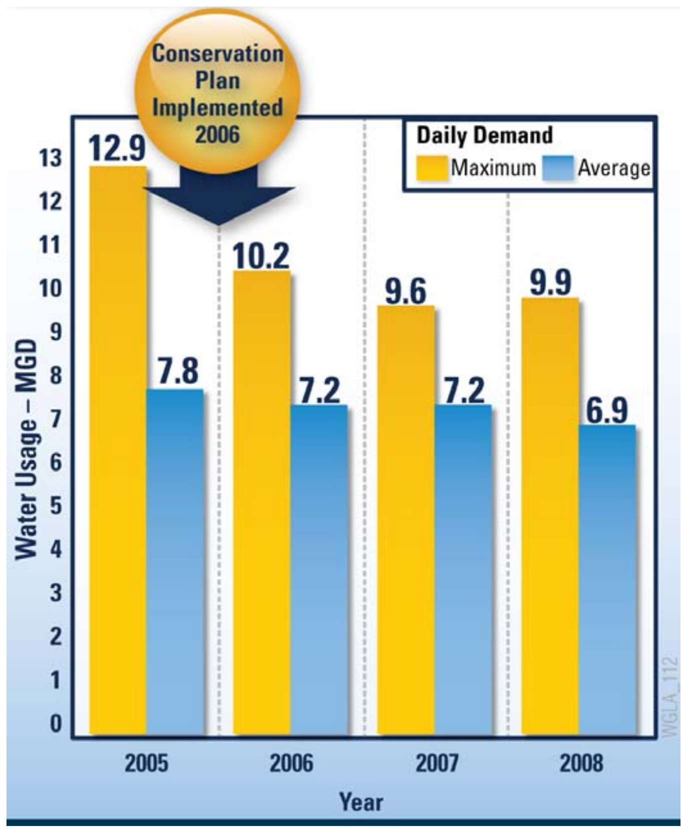
WGLA_125

First in Wisconsin—City Ordinance to Restrict Outdoor Sprinkling

The first conservation initiative implemented in 2006 was adoption of a sprinkling ordinance that affected all customer classes. The ordinance was targeted at reducing peak demands and reducing overall average day demands. Waukesha's ban on daytime sprinkling and limits on evening sprinkling were the first of their kind in Wisconsin.



To educate the public regarding the ordinance, water bill inserts, refrigerator magnets, and press releases were used. In 2007, street signs with sprinkler ordinance information were installed. These actions were extremely successful in reducing the average and maximum day water demand. Comparisons from May 1 to October 1 show a 15.4 percent reduction in summer watering season water use from 2005 to 2008. The baseline year of 2005 was chosen because it is the year before implementation of the conservation plan, and it aligns the planning period used in the analysis of return flow alternatives.



First in Wisconsin—Conservation Water Rates

Waukesha adopted a conservation (inclining) rate structure for residential customers in 2007, becoming the first city in the state to charge customers more per gallon as water use increases. The Wisconsin Public Service Commission has called the rate design a model for other utilities.

The City recently strengthened and expanded the conservation water rate model to include increasing the cost in each rate tier and reducing the amount of water allowed before reaching the next tier. Exhibit 2-6 summarizes the current single-family residential rates.

EXHIBIT 2-6
City of Waukesha Water Conservation Rates

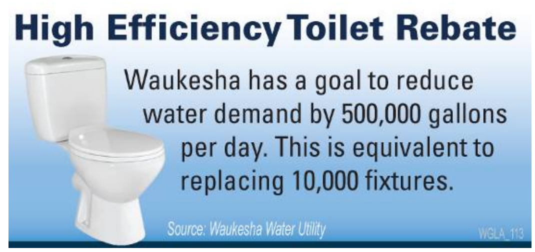
Current Quarterly Use (gal.)	Current Rate ($ / 1,000 gal.)
Tier 1: 0 to 10,000	2.05
Tier 2: 10,001 to 30,000	2.65
Tier 3: 30,001 and above	3.40

The Utility has focused on residential users because they represent the largest customer class with the most significant fluctuations in water use. Water rates for commercial and industrial customers have increased by larger percentages than for residential customers. To date, non-residential customers have realized major water use reductions through individual conservation efforts and collaboration with City officials.

Because 20 percent of the industry and commercial business class uses 80 percent of the water,[7] a few key changes with a few major water users has resulted in significant water savings.

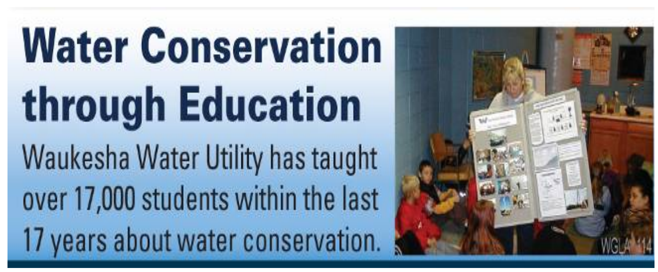
First in Wisconsin—Toilet Rebate Program

After the City's measurable success with outdoor water use reduction, more attention was focused on indoor water use. Toilets are the largest user of residential water, accounting for 26.7 percent of the water used in an average home.[8] Toilet replacement is one the most effective ways to reduce indoor water use. The toilet rebate program was launched in October 2008, with a goal of saving 500,000 gallons per day by replacing older high-flow toilets with new high-efficiency toilets. To help meet this goal, the City is providing rebates for fixture replacement.



First in Wisconsin—Water Conservation in Public School Curriculum

The hallmark of the City's water conservation public outreach program has been its contribution to the environmental education curriculum in the City of Waukesha. Water utility staff teach fifth- and ninth-grade students about the Waukesha water system and water conservation. By visiting water facilities, operating tabletop groundwater models, and collaborating with teachers, the City has introduced water conservation to more than 17,000 students.[9]



First in Wisconsin—Regional Conservation Coalition

In 2006, leaders from the City of Waukesha and Waukesha County created the Waukesha County Water Conservation Coalition. Water supply is a regional issue and cooperation among the area's water users will improve the results of conservation initiatives. The coalition, which includes representatives of business, government, education, and local stakeholder groups, has developed messages for consistent communication across the county. The coali-

Waukesha County Water Conservation Coalition:

- Initiated rain barrel distribution to collect water stormwater for beneficial use and reduce the amount of drinking water used outdoors.
- Initiated program for table tents at local restaurant that say, "Water served upon request. By reducing water waste and washing chemical use, our restaurant is protecting the environment. Thank you for your cooperation and helping us do the right thing."
- Sponsored a residential water conservation contest with prizes going to greatest water use reductions.

[7] Waukesha Water Utility annual operating data, 2009.

[8] *Handbook of Water Use and Conservation*. 2001, Amy Vickers.

[9] Waukesha Water Utility. 2009. Annual Educational Program Data.

tion uses a variety of outreach practices, including public contests, to raise awareness of water conservation and water resource protection. The Waukesha County Water Conservation Coalition has been heralded by the Wisconsin Public Service Commission as a successful model of regional collaboration that could be effective in other parts of the state.

Active Member of Water Conservation Advocacy Organizations

The Utility is a member of leading national advocacy organizations to promote best water management strategies. Associations with the following key partners have enabled the City to bring innovative water conservation best practices to their customers:

WaterSense, a partnership program sponsored by the U.S. Environmental Protection Agency, makes it easy for all Americans to save water and protect the environment. The Utility is a partner of the program that promotes water efficiency and enhances the market for water-efficient products. The WaterSense label denotes quality, water-efficient products, the same way EnergyStar promotes energy-efficient appliances.

Alliance for Water Efficiency serves as a national voice on water efficiency, and the Utility is a sponsor. Headquartered in Chicago, the Alliance for Water Efficiency promotes the efficient and sustainable use of water.

The City of Waukesha has capacity to pump 17.9 mgd of water to its customers using 11 wells (Exhibit 3-1). The deep aquifer on which the City depends has severely declining water levels and significant water quality issues. Use and expansion of the shallow aquifer to meet City demand would have adverse impacts on sensitive surface water resources. Continued withdrawal of depleted groundwater supplies, causing harm to other water resources, is not a feasible, long-term water supply strategy. The City must find a new water supply.

EXHIBIT 3-1
Waukesha Water Utility Supply Wells

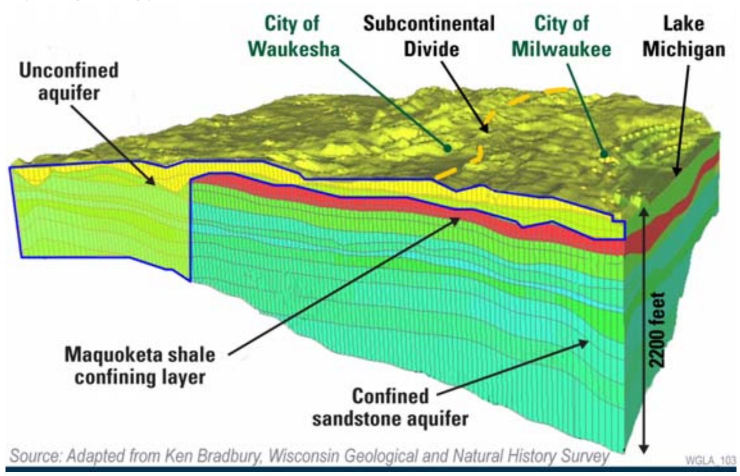
Well No.	Well Depth (ft)	Capacity (mgd)
1	Abandoned because of contamination	N/A
2	1,835	1.15
3	1,995	1.40
4	Out of service	N/A
5	2,120	1.44
6	2,075	2.59
7	1,658	1.08
8	2,024	2.16
9	1,730	1.94
10	2,145	3.74
11	127	0.47
12	149	0.90
13	105	1.01

Water Quantity

Deep Aquifer

The City withdraws about 87 percent of its water supply from the deep St. Peter Sandstone Aquifer. Its wells draw water from depths of 1,600 to 2,100 feet below ground. The aquifer serves as a water source for many communities in Wisconsin and Illinois. It served the City of Milwaukee before it began to use Lake Michigan for its water supply in the 1950s. Today, aquifer drawdown is 5 to 9 feet per year,[1] and water quality issues increase with the declining groundwater levels. The dramatic drawdown of the aquifer (an estimated 500 to 600 feet since the nineteenth century[2]) is in part attributed to the Maquoketa shale confining layer, a geological feature that limits the recharge of the aquifer from rain and snow (Exhibit 3-2). As water is pumped from greater depths, naturally occurring contaminants, primarily radium and total dissolved solids (TDS), are present in high concentrations and require removal to meet drinking water standards. Extensive modeling and studies conducted by the U.S. Geological Survey (USGS), the Wisconsin Geological and Natural History Survey (WGNHS), and leading researchers show that the continued use of the deep aquifer for water supply is unsustainable.

EXHIBIT 3-2
Hydrogeology of Southeastern Wisconsin



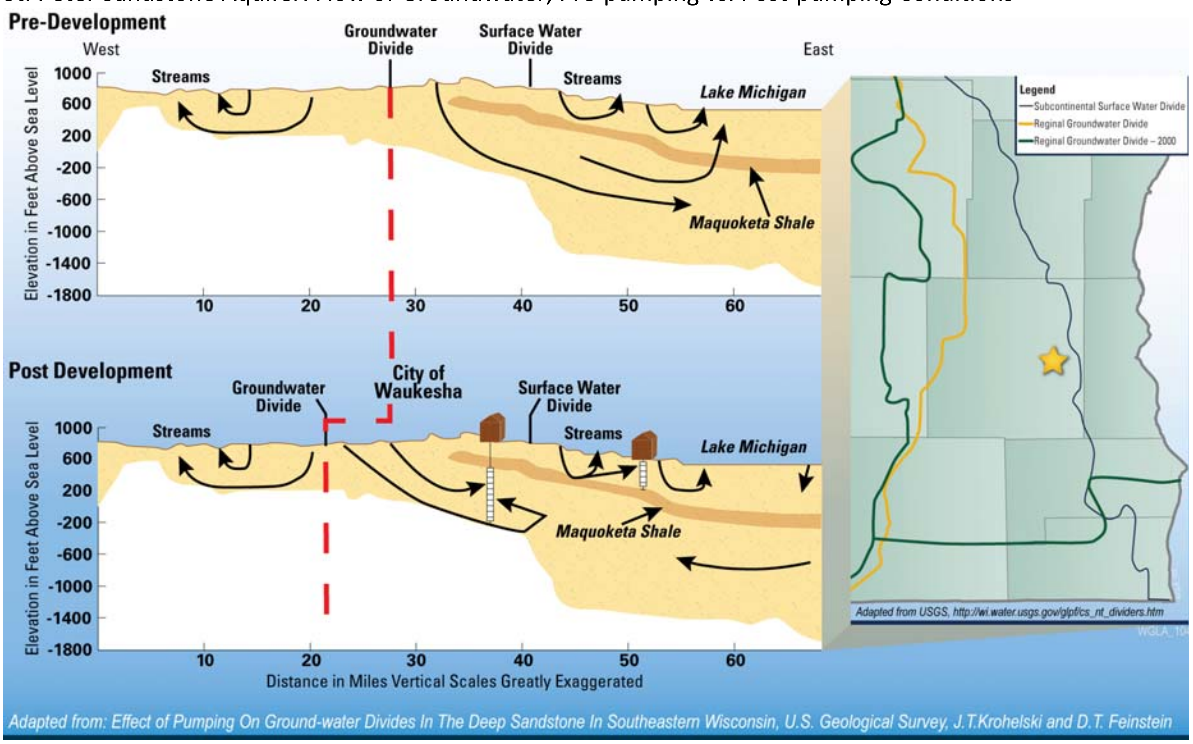
1 Waukesha Water Utility operating data.
2 *Draft Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* SEWRPC, 2008, p.102–103.

Waukesha's Water Supply Linkage to Great Lakes Groundwatershed

Groundwater pumping in southeastern Wisconsin has drawn the water level in the deep aquifer down nearly 600 feet, moving the groundwater divide—the boundary that defines the flow of groundwater toward Lake Michigan or the Mississippi River—farther to the west (Exhibit 3-3). This finding is based on extensive modeling and field measurements. The natural hydrogeology has been altered so that the deep aquifer, which historically fed Lake Michigan with groundwater, now draws water from Lake Michigan. This is a reversal of natural flow to the Great Lakes. The linkage between the City's groundwater supply and Lake Michigan is important, because the Compact provides that "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."[3]

EXHIBIT 3-3

St. Peter Sandstone Aquifer: Flow of Groundwater, Pre-pumping vs. Post-pumping Conditions



Deep Aquifer Recovery

Groundwater level measurements taken after communities have replaced their deep aquifer groundwater supply with a Lake Michigan supply indicate aquifer recovery. Where withdrawal has been reduced sharply at long-term pumping centers, deep aquifer groundwater level recoveries of more than 100 feet over widespread areas were observed.[4] Deep aquifer draw-up will reduce the flow from the Lake Michigan groundwatershed out of the basin.

Shallow Aquifer

The City of Waukesha draws about 13 percent of its water supply from the shallow sandstone

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[3] Great Lakes–St. Lawrence River Basin Water Resources Compact, p. 16.

[4] S. L. Burch. 2002. *A Comparison of Potentiometric Surfaces for the Cambrian-Ordovician Aquifers of Northeastern Illinois, 1995 and 2000.* Illinois State Water Survey Data/Case Study 2002-02.

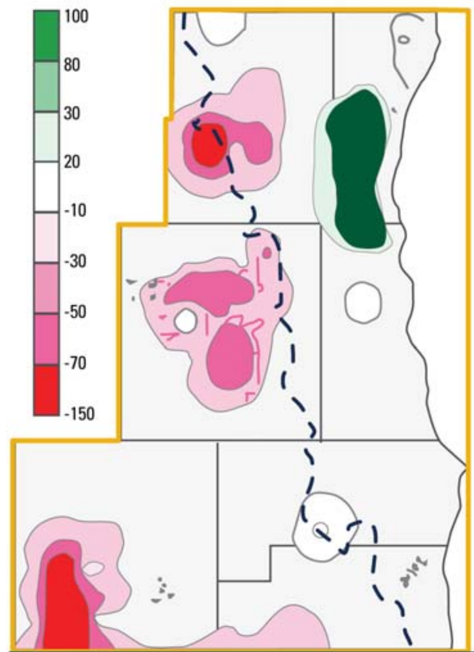
aquifer overlying the Maquoketa shale. The shallow aquifer is not a potential long-term water supply solution because drawing more water from the shallow aquifer would deplete baseflows in local surface water resources, including the Vernon Marsh, Pebble Creek, and Pebble Marsh.[5] Baseflow is groundwater that discharges to surface water bodies. Estimating the loss of baseflow from groundwater pumping is critical to understanding whether the shallow aquifer water supply is sustainable. To quantify impacts on baseflow, a baseflow reduction index was used in regional water supply planning studies (Exhibit 3-4).[6, 7]

$$\text{baseflow reduction index} = [(\text{net baseflow}_{2005} - \text{net baseflow}_{1900})/\text{net baseflow}_{1900}] \times 100$$

where net baseflow is surface water flow_{out} – surface water flow_{in}.

It is estimated that baseflow to local lakes, streams, and wetlands would decrease by 50 percent if the City of Waukesha withdraws an additional 4 mgd from the shallow aquifer[8]. Based on regional modeling of several groundwater and Lake Michigan supply scenarios, increased use of the shallow aquifer to meet the City's water supply needs is a detriment to other local sensitive water resources. In addition to adverse environmental impacts, there is no evidence from groundwater modeling or testing that the shallow aquifer south of the City will yield enough water to meet the City's demand.

EXHIBIT 3-4
Baseflow Reduction Index in Shallow Aquifer for 49% Increase in Pumping Across Seven-County Planning Area



Source: SEWRPC, 2009

Water Quality

Deep Aquifer: Radium

The City's groundwater supply has radium levels up to three times the United States Environmental Protection Agency's (USEPA's) drinking water maximum contaminant level (MCL) of 5 picocuries per liter (piC/L), regulated under the 2003 federal Safe Drinking Water Act's Radionuclide Rule. The naturally occurring radioactive isotopes radium-226 and radium-228 are present in the aquifer because of parent elements in the sandstone. The isotopes have been found to be carcinogenic. In deep wells, the concentration of radium increases with depth because of the geology of the formation. The City's deepest wells withdraw groundwater with radium concentrations of 15 piC/L, among the highest in a public drinking water supply the country.

To comply with the Radionuclide Rule, the City developed an interim plan with the WDNR to meet regulatory requirements and system demands by blending radium-free groundwater from three new shallow wells with water from some deep wells with high radium. The interim plan includes adding radium removal facilities at two deep wells with combined capacity of 5 mgd. The City has until 2018 to complete the capital investments needed for full compliance with the

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5 Douglas S. Cherkauer. *Draft Groundwater Budget Indices and Their Use in Assessing Water Supply Plans for Southeastern Wisconsin, 2009*, p. 27.

6 SEWRPC. *A Regional Water Supply Plan for Southeastern Wisconsin*, pp 38–50.

7 Cherkauer, p. 11.

8 Cherkauer, pp. 45-47.

radium standard, which it proposes to do with Great Lakes water. Even as the City is engaged in the rigorous application process for a Great Lakes diversion with return flow, it is developing a new 4-mgd shallow aquifer wellfield to provide firm capacity of radium-compliant water. The new wells will help the City increase the reliability of its system to meet radium regulations in the short term. In the long term, pumping the shallow aquifer will cause adverse environmental impacts nearby natural resources.

The City's deepest wells withdraw groundwater with radium concentrations of 15 piC/L; these are among the highest in the country for a public drinking water supply.

Deep Aquifer: Total Dissolved Solids

TDS, hardness, and salts are regulated by USEPA as a secondary drinking water standard. The standard for TDS is 500 mg/L. For the City of Waukesha, continued use of the deep aquifer eventually will require treatment to remove salts. Data for the deep wells indicate that as depth to groundwater increases, TDS increases. TDS concentrations in the City's wells ranges from 300 to 1,000 mg/L. To mitigate high TDS concentration, wells can be partially blocked to avoid high TDS water, but such plugging can reduce production capacity by as much as 35 percent.[9] In the drinking water industry, water commonly is treated to remove salts when the TDS concentration approaches 1,000 mg/L. Desalination is a costly and energy-intensive process that would be necessary for the long-term continued use of the wells, and TDS levels in Waukesha's wells have increased with declining groundwater levels.

Shallow Aquifer: Iron, Manganese, and Arsenic

Groundwater withdrawn from the shallow aquifer is treated for iron and manganese removal to USEPA secondary drinking water standards of 0.3 mg/L and 0.05 mg/L, respectively. In addition to iron and manganese, naturally occurring arsenic is present in the shallow aquifer groundwater in the new wellfield under City development. Arsenic is an odorless and tasteless element that enters drinking water supplies from natural deposits in the earth. Arensic has been linked to bladder and lung cancer and a wide variety of other illnesses.[10] The USEPA Safe Drinking Water Act Arsenic Rule established the arsenic MCL of 10 parts per billion to protect consumers served by public water systems. In addition, TDS levels in the water of the shallow aquifer exceed EPA's secondary drinking water standard of 500 µg/L.

Most Reasonable Water System Strategy

The City of Waukesha needs a new water supply, because the groundwater in the deep aquifer is severely depleted and not reliable over the long term. The quantity of shallow aquifer water is limited, and its withdrawal significantly reduces the quantity of water available for local streams, brooks, and wetlands. Furthermore, the water of the shallow aquifer must be treated before potable use. Without an adequate supply of local groundwater, the most reasonable strategy for the City of Waukesha water system is to develop a Lake Michigan supply with return flow in a manner consistent with the requirements of the Compact. A Lake Michigan supply is fully sustainable, provided it is developed with sound management of return flow.

[9] Waukesha Water Utility operating data for Well 9, 2000 and 2006.

[10] USEPA Office of Drinking Water. *Arsenic Reference Guide* EPA 816-F-01-004, 2001.

Introduction

The City and others have studied extensively the water resources in the Waukesha area.[1, 2, 3,] The evaluations and recommendations from these and other studies are summarized in this application.

The Compact states the following condition for a diversion for a community in a straddling county: "There is no reasonable water supply alternative within the basin in which the community is located, including conservation of existing water supplies." Further, Act 227 states:

> A 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.

Environmental impacts of the water supply alternatives have been analyzed, along with sustainability, protection of public health, implementability, and cost.

Previous Studies of Water Supply Alternatives

Extensive studies have investigated various water supply alternatives for the City of Waukesha. The results and conclusions are summarized below.

Future Water Supply Study Report

In March 2002, the City of Waukesha water utility completed a future water supply study.[4] Stakeholders in this study included representatives from the water utility, City of Waukesha, WDNR, SEWRPC, USGS, the WGNHS, and the University of Wisconsin–Madison. The study looked at the following 14 water supply sources and combinations of them:

- Deep aquifer near Waukesha (confined)
- Deep aquifer west of Waukesha (unconfined)
- Shallow groundwater south of Waukesha
- Shallow groundwater west of Waukesha
- Dolomite aquifer
- Fox River
- Rock River
- Lake Michigan
- Dam on the Fox or Rock River
- Waukesha quarry
- Waukesha springs
- Pewaukee Lake
- Milwaukee River
- Wastewater reuse

Nine water supply sources were eliminated for the reasons listed in Exhibit 4-1. Additional detail can be found in the Future Water Supply Study report, Appendix C.[5]

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[1] CH2M HILL and Ruekert & Mielke. 2002. *Future Water Supply Report for the Waukesha Water Utility.*

[2] SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin*, Preliminary Draft.

[3] Douglas S. Cherkauer. 2009. *Groundwater Budget Indices and their Use in Assessing Water Supply Plans for Southeastern Wisconsin*, Technical Report 46, Preliminary Draft. Department of Geosciences, University of Wisconsin—Milwaukee.

[4] CH2M HILL with Ruekert & Mielke. 2002.

[5] Ibid.

The water supply alternatives that passed the initial screening process included:

- Deep confined aquifer
- Deep unconfined aquifer
- Shallow groundwater near Waukesha
- Shallow groundwater and deep confined aquifer
- Lake Michigan

EXHIBIT 4-1
Water Supply Alternatives Eliminated

Potential Water Supply Source	Primary Reason for Not Being a Reasonable Alternative
Dolomite Aquifer	Insufficient water in the aquifer to meet the needs of the City of Waukesha.
Fox River	Inability to provide a reliable supply during dry periods, when public water supply is most needed.
Rock River	Inability to provide a reliable supply during dry periods, when public water supply is most needed.
Dam on the Fox or Rock River	Environmental impacts, regulatory issues, and public/property concerns.
Waukesha Quarry	Inadequate supply, water quality contamination potential, used for other purposes.
Waukesha Springs	Insufficient water in the aquifer to meet the needs of the City of Waukesha.
Pewaukee Lake	Insufficient water to meet the needs of the City of Waukesha, adverse environmental impacts, property owner concerns.
Milwaukee River	Poor quality, environmental impacts.
Wastewater Reuse	Public health and perception, water quality concerns, treatment requirements, limited supply, seasonal demand, regulatory issues.

These remaining alternatives, and combinations of them, were evaluated by a broad group of stakeholders using the following criteria:

- Reliability as a long-term, high-quality water supply
- Regulations, environmental impacts, and land and legal requirements
- Political issues and public acceptance
- Operational and maintenance requirements
- Schedule for implementation
- Infrastructure requirements

The deep confined aquifer alternative was ranked lowest because it had the highest cost and is not sustainable over the long term because of drastically declining water levels, poorer water quality requiring extensive treatment, adverse environmental impacts to the deep and shallow aquifers and public health impacts. The deep unconfined aquifer alternative, far west of Waukesha, also was ranked low because of adverse impacts to the environment and other water users, high costs, poor public acceptance and potential lawsuits, infrastructure requirements, and distance from Waukesha.

The Future Water Supply Study report recommended further evaluation of the Lake Michigan and shallow aquifer alternatives. Key recommendations relating to the Lake Michigan alternative included evaluating diversion permit requirements and identifying a Lake Michigan water provider. The alternatives analysis noted that the Lake Michigan alternative provided the most reliable and highest quality source of water for Waukesha.

For the shallow aquifer alternative, the report recommended evaluating sustainable capacities from the aquifer, environmental impacts of tracting additional shallow groundwater, land issues, and impacts on other shallow aquifer users. Evaluation of these items was not in the scope of the future water supply study. However, subsequent reports addressed these issues.[6]

The Lake Michigan alternative provides the most reliable and highest quality source of water for Waukesha.

SEWRPC Report Further Evaluates Water Supply Alternatives

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) is the official areawide planning agency for the seven-county Southeastern Wisconsin Region. SEWRPC is charged by law with making and adopting a comprehensive plan for the physical development of the region. In 2008, SEWRPC released a draft report titled, *A Regional Water Supply Plan for Southeastern Wisconsin* (Appendix I). This plan is an extensive evaluation of water supply alternatives for the seven-county area, including the City of Waukesha, to the year 2035.

Water supply alternatives were evaluated on the basis of five overall objectives:

1. Support of existing land use patterns
2. Conservation and wise use of the surface water and groundwater supplies
3. Protection of public health, safety, and welfare
4. Economical and efficient systems
5. Responsive and adaptable plans

Each objective had several sub-objectives or standards. Two key standards under Objective 2 were as follows:

- Manage the use of the deep and shallow aquifers so as to minimize ecological impacts on the surface water system of the region.

- Use groundwater and surface water for water supply purposes in a manner that minimizes adverse impacts to the water resources, including lakes, streams, springs, and wetlands.

Similar to the Future Water Supply Study, the SEWRPC study screened alternative water supplies and ultimately identified similar water supply alternatives. The water supply alternatives evaluated for the region included the following:

- Lake Michigan
- Shallow aquifers
- Deep aquifer
- Shallow aquifers and artificial recharge using rainwater and wastewater treatment plant effluent
- Deep aquifer and artificial recharge using treated Lake Michigan water
- Combinations of these alternatives

The Future Water Supply Study did not evaluate artificial aquifer recharge. This alternative assumes that the shallow aquifer will be artificially recharged with rainwater infiltration facilities, or that treated wastewater effluent will be artificially recharged into the shallow aquifer. By artificially increasing the amount of water infiltrating into the shallow aquifer, surface water baseflow reduction can be decreased. However, SEWRPC noted several issues and concerns:

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[6] SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin*, Preliminary Draft.

- WDNR regulations do not allow using treated wastewater effluent to recharge a potable drinking water aquifer. A high level of treatment would be required for this to be considered. Capital and operating costs would be very high. SEWRPC estimates capital costs of advanced wastewater treatment alone would be $12.6 million for 1 mgd.[7] Transmission mains from the Waukesha wastewater plant to recharge areas would add another $4 million.
- Large land areas are required, with significant costs and public concerns. An important issue is who owns and controls the use on these lands. SEWRPC estimated more than 100 acres would be needed for Waukesha, even if it relies on the deep aquifer for more than half of its water supply.[8]
- The water is more vulnerable to contamination, which might increase the cost of treatment and risk to public health.
- The long-term feasibility of artificial recharge is unknown. Long-term soil permeability for effective recharge might be compromised in the long term. Plugging of the aquifer would reduce effectiveness over time. Restoration or decommissioning of facilities would add to costs.
- Rainfall recharge will be subject to drought constraints.

Because of the issues above, artificial recharge was not considered in this application.

The SEWRPC report did not evaluate a deep unconfined aquifer alternative west of Waukesha, as was done in the Future Water Supply Study. SEWRPC assumed that groundwater supplies will be located within 1 mile of the 2035 utility service area to minimize public concerns and municipal boundary issues. Even though a groundwater supply may meet all applicable laws and regulations, property owners may institute a common law nuisance claim against the entity withdrawing groundwater. If there is “unreasonable harm” from withdrawing groundwater, the withdrawer may be responsible for mitigating damages.[9]

Extensive groundwater and surface water modeling was conducted in the evaluation of these alternatives. Major findings include the following:

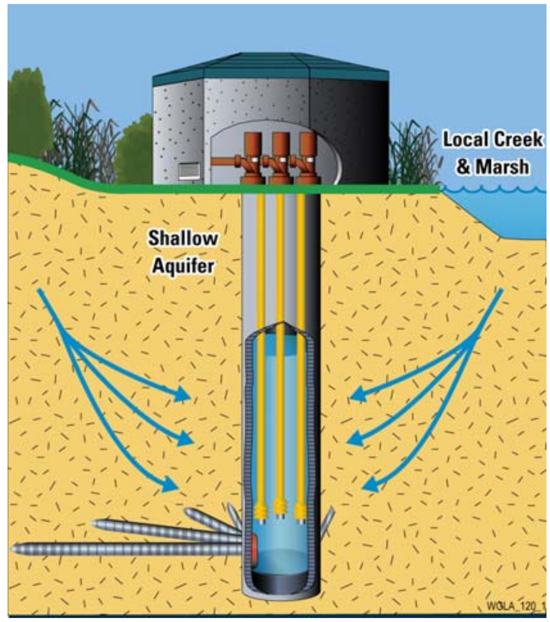
- Continued increased pumping of the deep aquifer continues to draw down groundwater levels, creates poorer water quality (higher concentrations of radium and TDS), increases adverse impacts on surface waters, and increases the water budget deficits.
- Increased pumping of the shallow aquifer reduces baseflows to surface waters, produces water budget deficits, and has adverse environmental impacts on sensitive surface water ecosystems, such as Vernon Marsh, Pebble Brook, and Pebble Creek (a high quality trout stream)[10] near Waukesha.
- Shallow aquifer recharge with rainfall or treated wastewater infiltration increases baseflows, but creates land use concerns and public health concerns due to contamination, and requires overcoming regulatory hurdles along with constructing extensive facilities.
- A Lake Michigan supply to some straddling communities and counties west of the subcontinental divide (with return flow) reduces the ecological stress on the deep aquifer, shal-

[7] Ibid.
[8] Ibid.
[9] Ibid.
[10] Wisconsin Department of Natural Resources, Wisconsin Trout Streams, PUB-FH-306, 2002.

low aquifer, and associated Great Lakes ter resource ecosystems compared to the other alternatives.

- The amount of chlorides and sodium discharged into the environment by home water-softening devices increases greatly under a groundwater alternative. The SEWRPC report estimated that eliminating groundwater tening by providing Lake Michigan water to some communities east and west of the divide would eliminate 5.2 million pounds of chlorides discharged to the Cedar Creek, Milwaukee River, and Lake Michigan environments.[11]
- Shallow groundwater supplies are more susceptible to contamination than a Lake Michigan supply. This could result in an increased risk to public health and the need for advanced water treatment facilities that would increase costs, energy use, and greenhouse gas emissions.

EXHIBIT 4-2
A Shallow Aquifer Water Supply Affects Surface Waters and Groundwaters



Comparing alternatives under which the City of Waukesha obtains a Lake Michigan water supply with return flow to the remaining groundwater alternatives (deep and shallow aquifers), SEWRPC concluded that the Lake Michigan alternative "offers advantages related to a greater improvement in the deep aquifer long-term sustainability, reductions in chloride discharges to the surface waters, and improvement in groundwater-derived baseflow inputs to the surface water system." On that basis, SEWRPC issued a draft recommendation for the City of Waukesha to change to a Lake Michigan water supply. This recommendation was reviewed, and nearly 40 experts in the region concurred.

SEWRPC recommended that the City of Waukesha switch to a Lake Michigan water supply.

A 2009 study provided further groundwater/surface water modeling of the SEWRPC alternatives, with projections to 2035.[12] The study evaluated similar alternatives for the City of Waukesha as did the SEWRPC Regional Water Supply Plan. The analysis showed that a Lake Michigan water supply for the City of Waukesha improved the deep aquifer water levels and eliminated its negative impacts on the shallow aquifer and surface water baseflow reductions in the whole region. A Lake Michigan supply to Waukesha would also increase deep aquifer flows to Lake Michigan. The study issued cautions against reliance on a future groundwater supply west of the divide, noting that groundwater levels and environmental impacts would worsen.[13]

Other studies evaluated alternatives up to 2035, only 25 years from now.[14, 15] This is a relatively limited planning period, given that water supply planning typically looks out 50 years or

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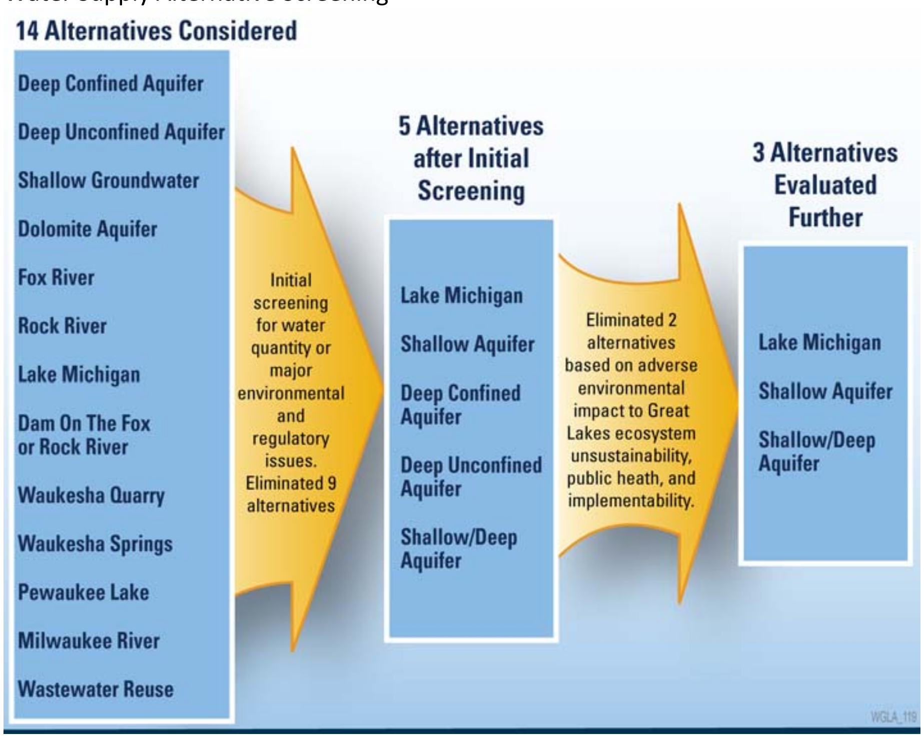
[11] Ibid.
[12] Cherkauer. 2009.
[13] Ibid.
[14] SEWRPC. 2008.
[15] Cherkauer. 2009.

more. A community water supply must be sustainable in the long term, or the capital, operations, and environmental costs of development are too high to make it reasonable.

Water Supply Alternatives Comparison

Various parties have conducted extensive evaluations of water supply alternatives for the City of Waukesha and the region. For this application, an evaluation and comparison of the three top ranked water supply alternatives was prepared. The water supply alternatives were chosen based on the screening done in previous studies.[16] Exhibit 4-3 summarizes the alternatives screening.

EXHIBIT 4-3
Water Supply Alternative Screening



The three water supply alternatives left after initial evaluations include:

- Deep and shallow aquifer
- Shallow aquifer and Fox River alluvium
- Lake Michigan

A general description of each alternative is provided, followed by comparisons to the following evaluation criteria:

- **Environmental Impacts**
  - Impact on groundwater, surface water ecosystems
  - Impact on flora and fauna
  - Greenhouse gas emissions

[16] SEWRPC 2008;CH2M HILL et al. 2002.

- **Long-Term Sustainability**
  - Reliability during droughts and infrastructure failures
  - Ability to provide sufficient water quantity for 50 years or more without adverse environmental impacts
- **Public Health**
  - Quality of the water for human consumption
  - Potential for contamination
- **Implementability**
  - Infrastructure requirements
  - Operation and maintenance requirements
  - Land requirements, easements, public impact

Each alternative was rated by the following criteria:

○ No adverse impact
⊙ Minor adverse impact
◘ Moderate adverse impact
● Significant adverse impact

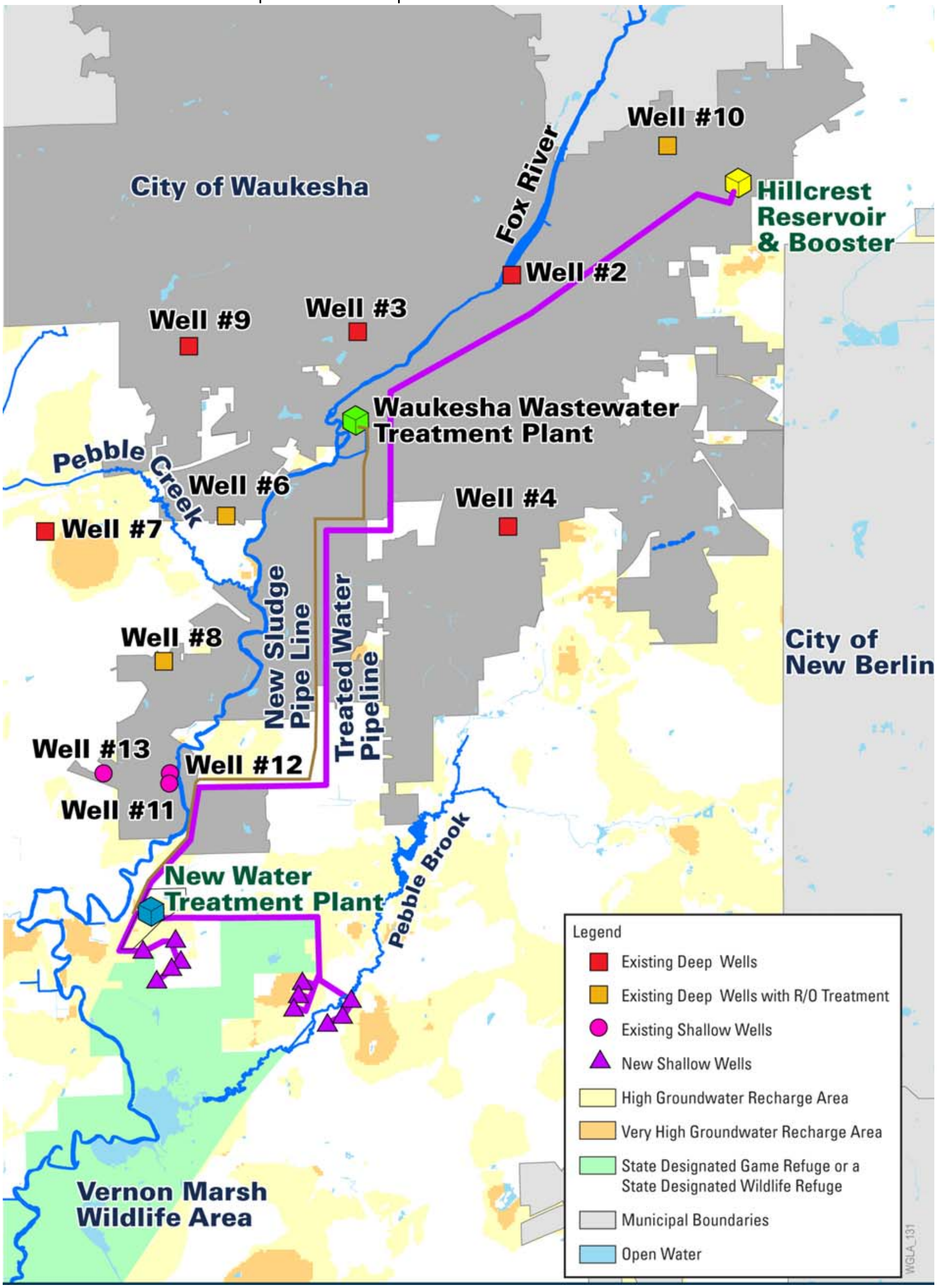
Water Supply Alternative 1: Deep and Shallow Aquifers

Alternative 1 consists of continued use of the deep aquifer (St. Peter sandstone) and shallow aquifer south of Waukesha (Troy Bedrock Valley). To meet a future firm maximum day demand of 18.5 mgd, 7.6 mgd would be provided by the deep wells and 10.9 mgd by shallow wells. The shallow well capacity would consist of the current 2.4 mgd, plus 4 mgd by developing new wells south of Waukesha near Vernon Marsh, and 4.5 mgd by developing new wells in the Troy bedrock valley, also south of Waukesha adjacent to Vernon Marsh. Water from the shallow wells would undergo treatment for iron, manganese, and arsenic removal. Shallow well water would be pumped from the wells to a new treatment plant, then a new pump station would pump treated water to the City of Waukesha and connect with the water distribution system and Hillcrest reservoir, the largest reservoir in Waukesha used as a point to deliver water to the City.

It was assumed that the three largest deep wells (No. 6, 8, 10) will require reverse osmosis (RO) for TDS removal in the future, starting in 2020 (see below). Since the deep wells are on small lots, adjacent residential property would need to be purchased and homes demolished to make room for the additional treatment facilities. It was assumed that the three deep wells will have their own RO treatment facility, and that water from the remaining deep wells and shallow wells will be blended at the Hillcrest reservoir. Exhibit 4-4 shows the facilities for Alternative 1.

Waukesha has 8 wells in the deep aquifer with a total capacity of 15.5 mgd and 3 wells in the shallow aquifer with a total capacity of 2.4 mgd. Total combined capacity is 17.9 mgd, but firm capacity (capacity with the largest well out of service) is 14.1 mgd. WDNR requires that water utilities provide firm capacity for the maximum day demand. Radium removal is provided at two deep wells, and iron/manganese removal is provided for the shallow wells. The recent discovery of arsenic in the shallow wells means they will require arsenic treatment as well.

EXHIBIT 4-4
Facilities for Alternative 1: Deep and Shallow Aquifers



Waukesha's deep wells vary in age from 30 to 75 years. Several wells have been abandoned because of contamination and decreasing capacity. One well had TDS concentrations greater than 1,000 mg/L and was rehabilitated to reduce the TDS (blocking off part of the well hole). In doing so, the well capacity was reduced over 35 percent. The Future Water Supply Study warned that many of the wells were not constructed to current well codes and could experience physical failures such as casing leaks or borehole collapse, which would require extensive rehabilitation or replacement.[17]

In addition to the age and condition of the deep wells, the groundwater elevation continues to drop and is well over 500 feet below predevelopment levels. This causes water quality problems (increased TDS, radium, and gross alpha levels) and physical problems of providing well pumps large enough to withdraw the water. Waukesha already has some of the largest well pumps in the world.

Given the issues with deep wells, it was assumed that the capacity of the deep wells will decrease 30 percent in the future. In addition, given the declining water quality, RO treatment would be installed at three deep wells to reduce TDS and radium. RO treatment would produce a concentrated salt waste stream equal to about 7.5 percent of the water pumped (assuming 25 percent bypass). The lost capacity would be made up with shallow wells. This is consistent with the Future Water Supply Study.[18]

Environmental Impacts

Pumping the shallow aquifer can cause adverse environmental impacts on ground and surface water resources. SEWRPC estimates that about 85 percent of water extracted from the shallow aquifer was diverted or extracted from surface waters.[19] This adversely affects sensitive and valuable environmental areas near Waukesha, such as Pebble Brook, Pebble Creek (a trout stream), and Vernon Marsh. SEWRPC estimated parts of Vernon Marsh and Pebble Creek could see the baseflow decrease greater than 25 percent if the City of Waukesha continues using a combination of deep and shallow groundwater, with artificial recharge (subalternative 1 to the composite plan).[20] A subsequent study estimated significant baseflow reductions near Waukesha when only 3.9 mgd of shallow groundwater was pumped and artificial recharge was used.[21] Under Alternative 1, Waukesha would using a maximum of 10.9 mgd of shallow aquifer water without artificial recharge, so the adverse impacts to baseflow reduction and groundwater/surface water ecosystems would be much greater. Appendix O, Environmental Report, contains additional information on environmental impacts.

Under Alternative 1, pumpage of the deep aquifer would be reduced from current levels because of more reliance on shallow aquifer water. However, unless many other nearby water utilities stop pumping from the deep aquifer, water levels and water quality would continue to drop.[22] Recharge is limited for the deep aquifer near Waukesha because of the shale confining layer, causing continued depletion of the aquifer and environmental harm. TDS and radionuclides in the groundwater are increasing. Dropping groundwater levels can expose sulfide minerals to

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17 CH2M HILL and Ruekert & Mielke. 2002.

18 Ibid.

19 SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Preliminary Draft.

20 Ibid.

21 Cherkauer. 2009.

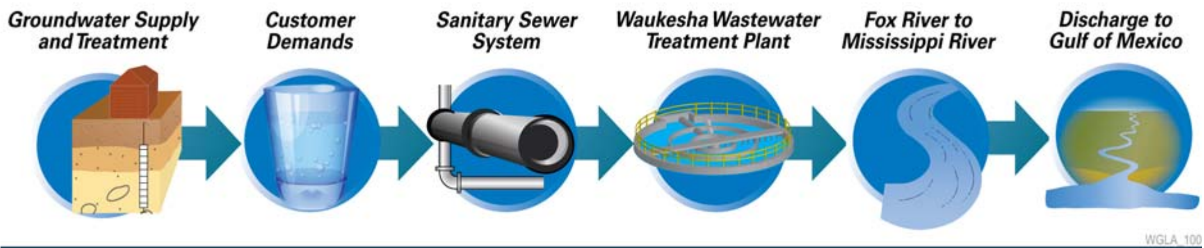
22 http://wi.water.usgs.gov/glpf/cs_pmp_src.html.

oxygen and increase arsenic levels. This oxygen can also provide conditions for growth of pathogenic microorganisms in wells, which as occurred in a number of deep wells.[23]

Water pumped from the deep aquifer is still removed from availability to local surface water resources. The USGS and WGNHS indicate that 59 percent of water pumped from the deep aquifer would have gone to inland surface waters and 8 percent to groundwater flow toward Lake Michigan.[24] This has an adverse environmental impact.

Water is not returned to its source when deep or shallow groundwater is diverted from the region. Water is transferred out of the Great Lakes and Mississippi river ecosystem and eventually to the ocean (Exhibit 4-5). This results in less water in the Great Lakes and Mississippi river watersheds and associated adverse environmental impacts.

EXHIBIT 4-5
Groundwater Supply Water Cycle



Both the deep and shallow groundwaters are hard, requiring use of home water softeners. Continued and expanded use of water softeners increases salt discharge into the environment. SEWRPC estimated that eliminating groundwater softening by providing Lake Michigan water to a number of communities east and west of the divide would eliminate 5.2 million pounds of chlorides discharged to the Cedar Creek, Milwaukee River, and Lake Michigan environments.[25] Water use also increases with the use of home water softeners. It is estimated that each household water softener produces 40 gallons of salty wastewater per regeneration. RO treatment concentrates salts that also are discharged into the environment and increases wastewater volumes. Continued use of hard groundwater would increase water and energy use while degrading conservation efforts.

Water transmission mains extending from the shallow aquifer wellfield to the treatment plant, and from the treatment plant to Waukesha, would have environmental impacts during construction. Appendix O, Environmental Report, contains additional information on environmental impacts.

It is estimated that Alternative 1 would discharge 31,000 tons of greenhouse gases per year (carbon dioxide equivalent) through pumping from aquifers, water treatment, and pumping from the wellfield to Waukesha.

Considering the environmental impacts of Alternative 1, a rating of "significant adverse impact" was applied.

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23 CH2M HILL with Ruekert & Mielke. 2002. *Future Water Supply Report for the Waukesha Water Utility.*

24 http://wi.water.usgs.gov/glpf/cs_pmp_src.html.

25 SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin*, Preliminary Draft.

Long-Term Sustainability

The shallow aquifer depends on rainwater for recharge and is less reliable during drought conditions, when water supply is needed most. In addition, adverse environmental impacts can increase during a drought.

The deep aquifer is not significantly affected by drought, since the shale confining layer above the aquifer limits recharge near Waukesha. Having two sources of water is more reliable than having only one.

The deep aquifer water levels are very low and dropping. This will reduce sustainability as well pumps need to draw water from lower levels and already employ some of the largest pumps in the world to extract the water. Reducing current deep aquifer pumping by using more shallow groundwater would slow the drawdown but may not eliminate it. The amount of deep aquifer pumping by other communities would also affect drawdown.

The deep aquifer wells are very old and likely will require repair or replacement in the future. This will reduce reliability.

Treatment requirements for the deep and shallow aquifers would reduce the amount of water usable by customers because of the waste streams. This would require more water to be pumped out of the ground to meet demand and thus decrease water efficiency. Treatment of all the water supply in multiple treatment plants is required. This would increase operation and maintenance efforts and costs, plus produce a salty liquid waste stream.

Considering the long-term sustainability of Alternative 1, a rating of "significant adverse impact" was applied.

Public Health

Shallow aquifers are more susceptible to contamination than deep confined aquifers and large surface water bodies, potentially requiring advanced treatment. Proper drinking water treatment can meet regulations as long as new contaminants with different treatment characteristics are not introduced. If contaminants are undetected, or there is a malfunction in the treatment process, contaminants may be exposed to the public.

A wellhead protection program is required by WDNR to protect municipal wells from contamination. Waukesha would have no zoning control to enforce the wellhead protection ordinance because the shallow wellfield is outside the City limits. Buying large tracts of land or trying to influence land use zoning around the wellfield are other options.

The deep aquifer exceeds the radium and gross alpha regulations, and the shallow wells may exceed arsenic regulations. Both can meet regulations with proper treatment. If there is a malfunction in the treatment process, these contaminants may be exposed to the public.

Private wells may run dry or encounter water quality problems due to additional shallow aquifer pumping. If this should occur, new wells or deeper wells would be needed.

Groundwater is high in TDS, mainly from calcium, magnesium, carbonates, chlorides and sulfate. Home softening takes out calcium and magnesium, but adds sodium. Sodium has been identified as an item to limit if you have certain health conditions such as heart disease.

Considering the public health impacts of Alternative 1, a rating of "moderate adverse impact" was applied.

Implementability

For the shallow aquifer wellfield, significant land purchase/lease and controls outside the city limits are required. Local residents have opposed high-capacity wells because of concerns about adequate water supply and impacts to wetlands, private wells, and other environmental resources. There is potential for common law nuisance lawsuits to occur. Because the Waukesha area is part of a WDNR groundwater management zone, more requirements and restrictions may be placed on groundwater development.

If well capacity decreases, wells may need to be located a greater distance from Waukesha, which would increase costs, energy, and public concerns. The environmental impacts described above would still be present.

The Waukesha area is part of a WDNR groundwater management zone which may add more requirements and restrictions on groundwater development.

A new water treatment plant would be required to remove iron, manganese, and arsenic. A new pump station and transmission pipes are required to convey the treated water to the Hillcrest reservoir in Waukesha and throughout the City. The water treatment plant would be located outside the City limits and require land purchase or lease. The new wells, water plant, and pump station would require operation and maintenance.

Water transmission mains from the shallow aquifer wellfield to the treatment plant, and from the treatment plant to Waukesha would require easements, and construction through rural and urban conditions.

Additional treatment for the deep aquifer would increase operation and maintenance requirements significantly. RO treatment consists of pretreatment to condition the water, RO treatment, aeration to remove dissolved gases, and chemical addition for corrosion control and disinfection. It is assumed that the concentrated waste brine and chemical cleaning waste solution can be discharged to the sewer. This may cause TDS increases in the wastewater plant influent. In addition, residential housing would need to be bought and demolished to make room for the treatment facilities at the three well sites. This may require legal condemnation procedures.

Some of the deep aquifer water supply would be softened by RO, but the shallow aquifer supply would still be hard. Blending the different waters before distribution should mitigate water quality issues (red water, corrosion) that could lead to customer complaints.

Considering the implementability of Alternative 1, a rating of "significant adverse impact" was applied. Exhibit 4-6 summarizes the criteria for Alternative 1.

EXHIBIT 4-6
Water Supply Evaluation: Alternative 1

Water Supply Alternative	Environmental Impact	Long-term Sustainability	Public Health	Implementability
Deep and shallow aquifers	●	●	Moderate adverse impact	●

○ No adverse impact
⊙ Minor adverse impact
◉ Moderate adverse impact
● Significant adverse impact

Water Supply Alternative 2: Shallow Aquifer and Fox River Alluvium

Alternative 2 uses the shallow aquifer near Waukesha for Waukesha's entire water supply. Ten mgd of firm capacity would be obtained through 4 wells along the Fox River south of Waukesha, in what is called the Fox River alluvium. Another 8.5 mgd would be obtained through 8 wells in the Troy Bedrock Valley south of Waukesha and adjacent to Vernon Marsh. Total firm capacity would be 18.5 mgd. The wells would pump water to a central treatment plant south of Waukesha. The water would be treated to surface water standards because of the influence of the Fox River on the Fox River alluvium wells. Typical treatment processes include coagulation, rapid mixing, flocculation, settling, filtration and disinfection. The treatment processes can remove iron, manganese, arsenic and surface water constituents. A pump station and pipelines would convey treated water to the Hillcrest reservoir in Waukesha and through the distribution system. Exhibit 4-7 shows the facilities for Alternative 2.

Environmental Impacts

Pumping the shallow aquifer can cause adverse environmental impacts on groundwater and surface water resources (see Alternative 1). Alternative 2 would have greater adverse environmental impacts than Alternative 1, since almost twice the amount of shallow groundwater would be pumped. The Troy Bedrock Valley aquifer south of Waukesha has several sensitive environmental areas (Vernon Marsh, Pebble Creek) and pumping a large amount of water would have more adverse environmental impacts than Alternative 1. Appendix O, Environmental Report, contains additional information on environmental impacts.

In the southern area of the Vernon Wildlife Area, the Village of Mukwonago installed a shallow groundwater well and monitored the effects to a nearby marsh and calcareous fen, a rare Wisconsin wetland. According to the WDNR, the well appears to have created a cone of depression that is affecting the fens, along with the endangered plant species that depend on the groundwater supply.[26, 27] The long term impacts of pumping this well are not known.

Under Alternative 2, Waukesha's deep aquifer pumpage would be eliminated, thus reducing the rate of drawdown. Actual water levels in the deep aquifer would depend on how many other communities continue to use it. If enough communities reduce deep aquifer pumping, increasing deep aquifer levels could have an environmental benefit.[28, 29, 30,]

Water would not be returned to its source when using shallow groundwater and is diverted from the region. It is transferred out of the Great Lakes and Mississippi river ecosystem and eventually to the ocean (Exhibit 4-5). This results in less water in the Great Lakes and Mississippi River watersheds and associated adverse environmental impacts.

Shallow groundwater is hard, and customers would continue to use home water softeners. Adverse environmental impacts associated with home water softening (salt discharge to surface waters, additional water and energy use) are similar to those under Alternative 1.

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26 Letter to City of Waukesha Common Council from Brian Glenzinski, Vernon Marsh Wildlife Area Property Manager, Wisconsin Department of Natural Resources. July 18, 2006.

27 Lisa Gaummitz, T. Asplund, and M. R. Matthews. June 2004. "A Growing thirst of groundwater". Wisconsin Natural Resources.

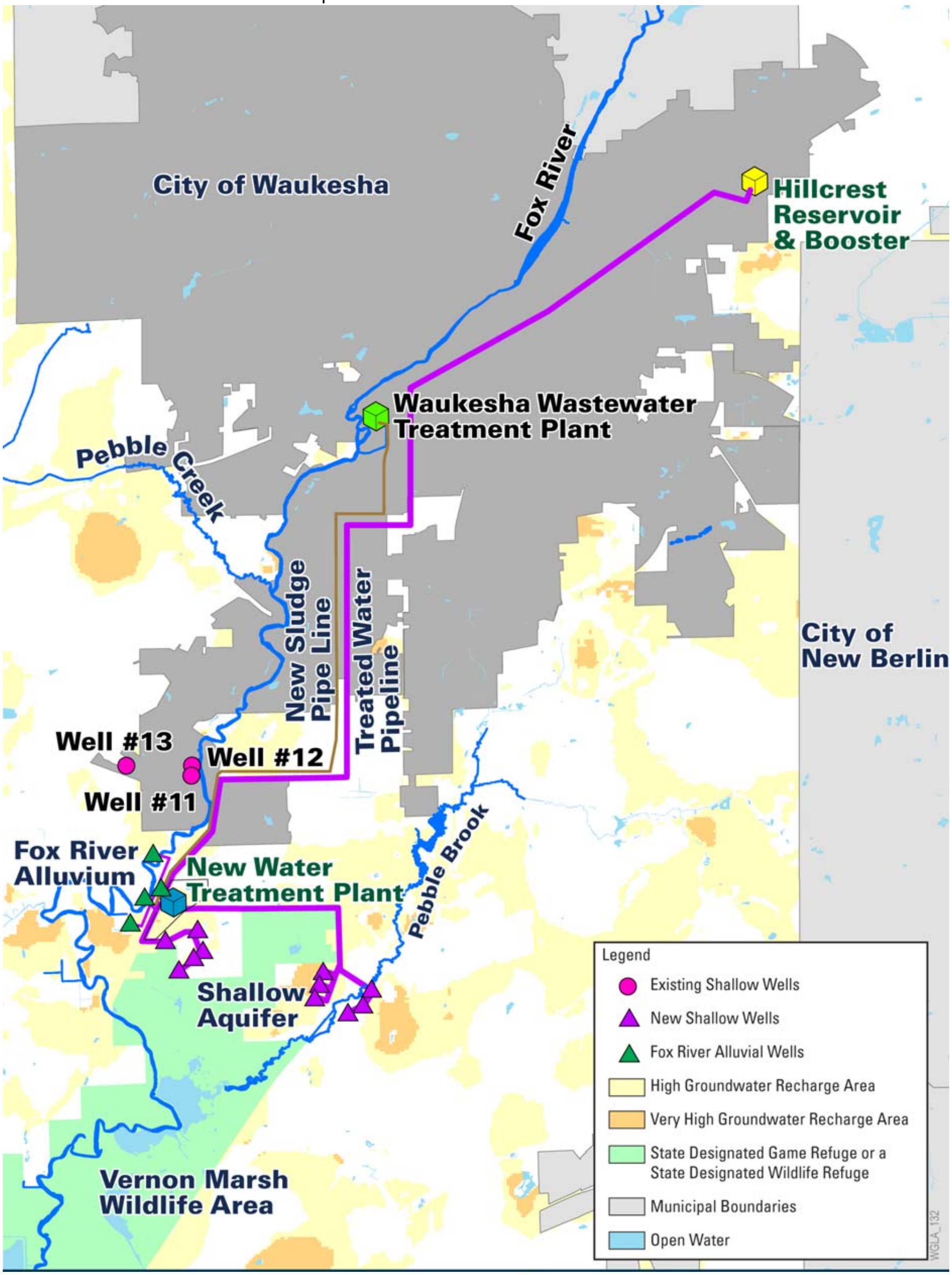
28 http://wi.water.usgs.gov/glpf/cs_pmp_src.html.

29 SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Preliminary Draft.

30 Douglas Cherkauer. 2009. *Groundwater Budget Indices and their Use in Assessing Water Supply Plans for Southeastern Wisconsin,* Technical Report 46, Preliminary Draft. Department of Geosciences, University of Wisconsin—Milwaukee.

EXHIBIT 4-7

Facilities for Alternative 2: Shallow Aquifer and Fox River Alluvium



Water transmission mains from the shallow aquifer wellfield to the treatment plant, and from the treatment plant to Waukesha, would have environmental impacts during construction. These impacts are discussed in Appendix O.

Alternative 2 would discharge 19,000 tons of greenhouse gases (carbon dioxide equivalent) annually through pumping from aquifers, water treatment, and pumping from the wellfield to Waukesha.

Considering the environmental impacts of Alternative 2, a rating of "significant adverse impact" was applied.

Long-Term Sustainability

The shallow aquifer is dependent on rainwater for recharge and is less reliable during drought conditions, when water supply is needed most. In addition, adverse environmental impacts can increase during a drought Having two sources of water is more reliable than having one only, although both sources are close to each other and interconnected.

Treatment requirements for the shallow aquifers would reduce the amount of water usable by customers because of the waste streams, but only by about 2 to 3 percent, much less than the RO treatment in Alternative 1. Treatment of all the water supply in one treatment plant would reduce operation and maintenance efforts and costs compared to Alternative 1, but reduce reliability because there is only one treatment plant.

Considering the long-term sustainability of Alternative 2, a rating of "significant adverse impact" was applied.

Public Health

Shallow aquifers are more susceptible to contamination than deep confined aquifers and large surface water bodies, potentially requiring advanced treatment. Contaminants may be undetected for some time, exposing the public to health risks. In addition, the Fox River alluvium may have exposure to additional contaminants from the Fox River and treated wastewater. The Fox River is listed as impaired for PCBs.[31] Proper drinking water treatment can meet regulations as long as new contaminants with different treatment characteristics are not introduced. If there is a malfunction in the treatment process, contaminants may be exposed to the public.

WDNR requires a wellhead protection program to protect municipal wells from contamination. Waukesha would have no zoning control to enforce the wellhead protection ordinance because the shallow wellfield is outside the City limits. Buying large tracts of land or influencing land use on surrounding properties are other options.

The deep aquifer would no longer be used, and potential public exposure to radionuclide and other contaminants is eliminated. Other wells in the influence of the new wellfield may run dry or encounter water quality problems due to additional shallow aquifer pumping. Groundwater is high in TDS, mainly from calcium, magnesium, carbonates, chlorides and sulfate. Home softening takes out calcium and magnesium, but adds sodium. Sodium has been identified as an item to limit if you have certain health conditions such as heart disease.

Considering the public health impacts of Alternative 2, a rating of "moderate adverse impact" was applied.

31 http://dnr.wi.gov/org/water/wm/wqs/303d/303d.html

Implementability

For the Troy Bedrock Valley and Fox River alluvium wellfields, significant land purchase/lease and controls outside the city limits are required. Local residents have opposed high-capacity wells because of concerns about adequate water supply and impacts to wetlands, private wells, and other environmental resources. There is potential for common law nuisance lawsuits to occur.

A new water treatment plant, pump station, and transmission pipes are required to convey the treated water to the Hillcrest reservoir in Waukesha and through the distribution system. The treatment plant would be located outside the City limits and require land purchase or lease. The new wells, water plant, and pump station would require additional operations and maintenance. Water transmission mains from the shallow aquifer wellfield to the treatment plant, and from the treatment plant to Waukesha would require, easements, and construction through rural and urban conditions.

If well capacity decreases, wells may need to be located a greater distance from Waukesha, which would increase costs, energy, and public concerns.

The Waukesha area is part of a WDNR groundwater management zone which may add more requirements and restrictions on groundwater development.

Considering the implementability of Alternative 2, a rating of "significant adverse impact" was applied. Exhibit 4-8 summarizes the criteria for water supply Alternatives 1 and 2.

EXHIBIT 4-8
Water Supply Evaluation: Alternatives 1 and 2

Water Supply Alternative	Environmental Impact	Long-Term Sustainability	Public Health	Implementability
Deep and shallow aquifers	●	●	◘	●
Shallow aquifer and Fox River alluvium	●	●	◘	●

○ No adverse impact
⊙ Minor adverse impact
◘ Moderate adverse impact
● Significant adverse impact

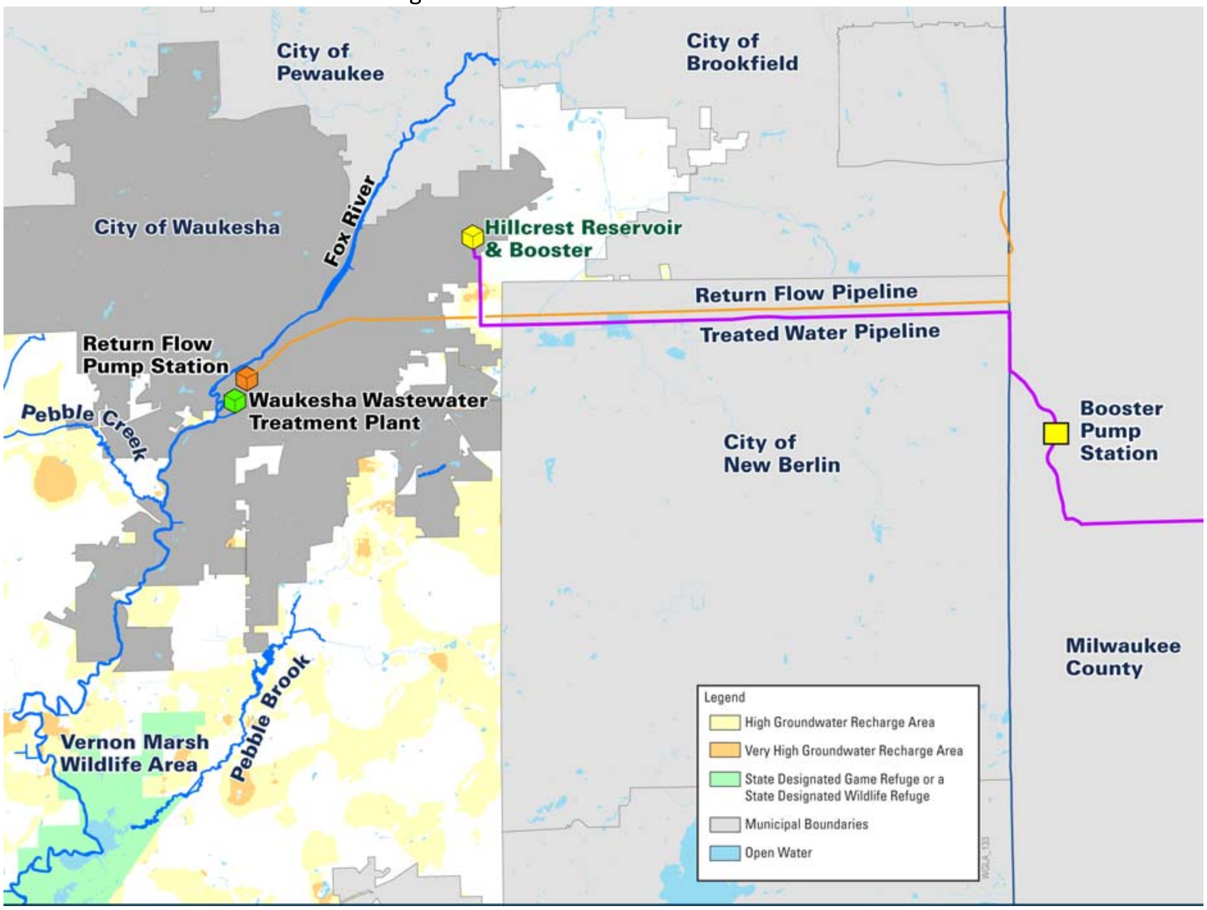
Water Supply Alternative 3: Lake Michigan

Alternative 3 consists of obtaining 18.5 mgd of treated lake water from a Lake Michigan water utility, and conveying it to Waukesha through a transmission pipeline and booster pump station to the Hillcrest reservoir in Waukesha. Additional distribution system piping would convey water through the City (Exhibit 4-9).

Alternative 3 assumes connection to Milwaukee's water system at a large transmission main near 60th street and Howard Avenue. One booster pump station would pump drinking water to the City of Waukesha. Other options for a Lake Michigan water supply include the Cities of Oak Creek and Racine, but Milwaukee is closer and has excess treatment and pumping capacity. The Milwaukee option provides the best use of existing infrastructure. Therefore, Milwaukee is assumed to be the water supplier just for the purpose of comparing water supply alternatives. The Lake Michigan water supplier would be determined after negotiations with the various Cities.

Water used by Waukesha would be returned to the Lake Michigan watershed. There are several options for a return flow pipeline, all starting at the Waukesha wastewater treatment plant with

EXHIBIT 4-9
Facilities for Alternative 3: Lake Michigan



a pump station. Discharge location options include Underwood Creek, Root River, and Lake Michigan through an outfall. The Underwood Creek location has the shortest distance and provides the best use of existing infrastructure. Therefore, Underwood Creek is assumed as the return flow pipeline route for the purpose of comparing water supply alternatives.

Environmental Impacts

Water transmission mains from the City of Milwaukee to Waukesha, the booster pump stations, and return flow pipelines from the Waukesha wastewater plant to Underwood creek would have environmental impacts during construction (see Appendix O, Environmental Report). Existing utility corridors would be used for pipeline routing where possible to minimize environmental impacts.

Under Alternative 3, Waukesha's deep aquifer pumpage would be eliminated, thereby reducing the rate of drawdown. Actual deep aquifer levels would depend on how many other communities continue using the deep aquifer. If enough communities reduce deep aquifer pumping, increasing deep aquifer levels could have an environmental benefit. SEWRPC estimates deep aquifer water levels would rise as much as 270 feet if deep aquifer pumping ceased in several communities, including Waukesha.[32] Ceasing deep aquifer pumping in northeastern Illinois allowed water levels to rise 300 feet between 1980 and 2000 at Villa Park and Elmhurst, Illi-

32 SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Preliminary Draft.

nois.[33] Similar aquifer recovery is becoming evident near Green Bay, Wisconsin, where Brown County water utilities stopped pumping the deep aquifer and started using Lake Michigan water. Rising deep aquifer levels provide more water to the shallow aquifers and surface waters, creating an environmental benefit.[34]

When using a Lake Michigan supply, water is returned to its source (Exhibit 4-10), whereas groundwater is diverted from the region. This preserves the water in the Great Lakes ecosystem. Current and future adverse environmental impacts of pumping shallow groundwater and reducing baseflows would be eliminated, thus protecting sensitive and valuable environmental areas such as Pebble Brook, Pebble Creek, and Vernon Marsh.

Lake Michigan water is relatively soft and customers does not need home water softeners. The adverse environmental impacts associated with home water softening (salt discharge to surface waters, additional water and energy use) would be eliminated under Alternative 3.

It is estimated that Alternative 3 would discharge 15,000 tons of greenhouse gases per year (carbon dioxide equivalent) through pumping from Milwaukee and returning the water to the Great Lakes basin. This is less than the shallow aquifer alternatives (Exhibit 4-11).

Considering the environmental impacts of Alternative 3, a rating of "minor adverse impact" was applied. There is actually an environmental benefit to the water resources of the area, but some environmental impact from the pipelines construction.

EXHIBIT 4-10
Lake Michigan Water Cycle

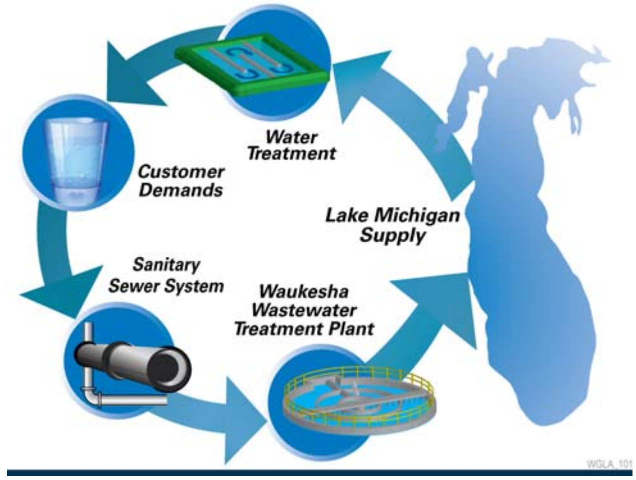
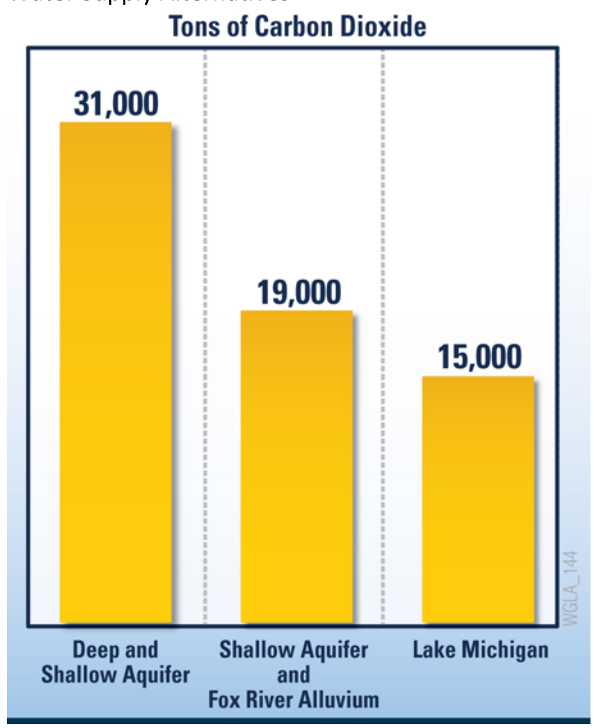


EXHIBIT 4-11
Greenhouse Gas Emissions from Water Supply Alternatives



33 S. L. Burch. 2002. *A Comparison of Potentiometric Surfaces for the Cambrian-Ordovician Aquifers of Northeastern Illinois, 1995 and 2000.* Illinois State Water Survey Data/Case Study 2002-02.

34 http://wi.water.usgs.gov/glpf/cs_pmp_src.html.

Long-Term Sustainability

The Alternative 3 provides a sustainable source of high-quality water indefinitely by allowing water to be recycled to its source. Lake Michigan water is more resistant to drought conditions and the adverse impacts of pumping than groundwater, especially during a drought.

The infrastructure needed to provide Lake Michigan water is less than that for groundwater because no additional treatment or wellfields are needed. Unused treatment and pumping infrastructure from Milwaukee would be used. In addition, long term operation and maintenance of pipelines and pump stations are simpler and less expensive than those of water treatment plants.

Considering the long-term sustainability of Alternative 3, a rating of "no adverse impact" was applied.

Public Health

Treated Lake Michigan water is high quality and safe. Millions of people are provided with drinking water from Lake Michigan. Contamination is possible, as with all supplies, but the large size of Lake Michigan makes this a rare occurrence. Lake Michigan water suppliers have some of the most stringent water quality programs and advanced treatment processes to assure high quality water.

The deep aquifer would no longer be used, and potential public exposure to radionuclide and other contaminants is eliminated. Private wells and municipalities on groundwater near Waukesha would not be affected if Waukesha obtains a Lake Michigan water supply. Home softening would no longer be needed, and the water would contain much less sodium and TDS than a groundwater supply, making it healthier to consume.

Considering the public health impacts of Alternative 3, a rating of "minor adverse impact" was applied.

Implementability

Alternative 3 requires an agreement with a Lake Michigan water supplier to provide water. Waukesha has letters from three Lake Michigan water utilities willing to negotiate a contract.

Land purchase requirements would be less than a groundwater alternative, because no treatment plant or wellfield are required. Land use issues for wellhead protection are eliminated. Public concerns over impacts to groundwater levels and long-term wetland impacts are eliminated.

A new pump station and transmission pipe would be required to convey the treated drinking water to the Hillcrest reservoir in Waukesha. A new pump station and transmission pipe would be required to convey treated wastewater from the wastewater treatment plant to Underwood creek. The drinking water pump station would be located outside the City limits and require land purchase or lease. Water transmission mains to and from Waukesha would require routing studies, easements, and construction through rural and urban conditions. There is no treatment plant for Waukesha to operate with Alternative 3, making operation and maintenance of the water utility much simpler than that of a groundwater alternative.

Considering the implementability of Alternative 3, a rating of "moderate adverse impact" was applied. Exhibit 4-12 summarizes the criteria for water supply Alternatives 1, 2, and 3.

EXHIBIT 4-12
Water Supply Evaluation: Alternatives 1, 2, and 3

Water Supply Alternative	Environmental Impact	Long-Term Sustainability	Public Health	Implementability
Deep and shallow aquifers	●	●	◎	●
Shallow aquifer and Fox River alluvium	●	●	◎	●
Lake Michigan	⊙	○	⊙	◎

○ No adverse impact
⊙ Minor adverse impact
◎ Moderate adverse impact
● Significant adverse impact

Summary of Water Supply Alternatives

Major studies by the City of Waukesha,[35] SEWRPC,[36] and the University of Wisconsin–Milwaukee[37] concluded that groundwater and Lake Michigan water were the main water supply alternatives for the City of Waukesha. After extensive analysis, SEWRPC concluded that a Lake Michigan water supply was the best alternative for Waukesha. This water supply application evaluated three alternatives for Waukesha:

- Deep and shallow aquifer
- Shallow aquifer and Fox river alluvium
- Lake Michigan

Each alternative was evaluated against four criteria:

- Environmental impact
- Long-term sustainability
- Public health
- Implementability

Exhibit 4-13 summarizes the water supply alternatives evaluation results. Compared to the other water supply alternatives, the Lake Michigan alternative has the least environmental impact, is the most sustainable in the long term, provides excellent public health protection, and is implementable.

Estimated costs for each alternative are summarized in Exhibit 4-14. These cost estimates were prepared for guidance in comparing alternatives based on information available at the time of the estimate. Detailed engineering design has not been done. The final cost estimate of any project will depend on market conditions, site conditions, final project scope, schedule, and other variable factors. As a result, final project costs may vary from the estimates presented here.

There is no cost advantage of a groundwater supply over a Lake Michigan supply. The Lake Michigan water supply is the most cost effective in the long term. Capital, operation, and maintenance cost details are in Appendix M, Cost Estimates Update.

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[35] CH2M HILL with Ruekert & Mielke. 2002.

[36] SEWRPC. 2008. *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin*, Preliminary Draft.

[37] Cherkauer. 2009.

EXHIBIT 4-13
Water Supply Alternatives Evaluation Summary

Water Supply Alternative	Environmental Impact	Long-Term Sustainability	Public Health	Implementability
Deep and shallow aquifers	●	●	◉	●
Shallow aquifer and Fox River alluvium	●	●	◉	●
Lake Michigan	⊙	○	⊙	◉

○ No adverse impact
⊙ Minor adverse impact
◉ Moderate adverse impact
● Significant adverse impact

EXHIBIT 4-14
Water Supply Alternative Cost Estimates

Water Supply Alternative	Capital Cost[a] ($ million)	Annual Operation/Maintenance Cost ($ million)	20 yr. Present Worth Cost ($ million, 6%)	50 yr. Present Worth Cost ($ million, 6%)
Deep and shallow aquifers	177	7.1	258	288
Shallow aquifer and Fox River alluvium	174	7.4	258	290
Lake Michigan	164	6.2	235	261

[a]Includes direct construction cost, contractor administrative costs (insurance, bonds, supervision etc), 25% contingency, and costs for permitting, legal, engineering, administrative.

A Lake Michigan water supply provides higher quality water to consumers. Exhibit 4-15 shows the total dissolved solids in each water supply. The much lower total dissolved solids in the Lake Michigan water supply not only eliminates the need for home softening; it also is more healthy for consumers and the environment, and better for many industrial and commercial uses.

Exhibit 4-16 compares the water supply alternatives to Great Lakes Compact criteria. A check mark indicates a positive impact.

A Lake Michigan water supply is the best solution for the Waukesha Water Utility (Exhibit 4-17). It provides the most reliable source of high-quality water for the future, eliminates adverse environmental impacts of using groundwater, and improves the Great Lakes water and water-related ecosystems. It is sustainable over the long term and also cost-effective.

EXHIBIT 4-15
Water Quality Comparison between Water Supply Alternatives

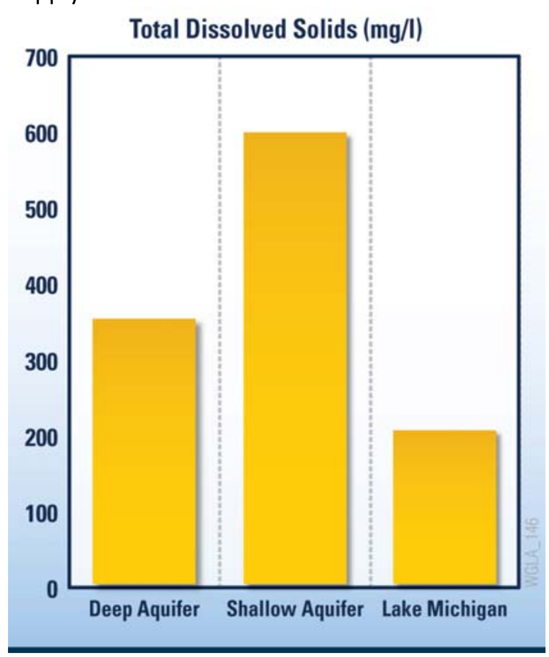


EXHIBIT 4- 16
Great Lakes Compact Requirements and Water Supply Alternatives

	Lake Michigan	Shallow Aquifer	Shallow / Deep Confined Aquifer
Return flow to original source location	✓		
No significant adverse impact to watersheds	✓		
Conservation/efficient use	✓	✓	✓
Restoration of hydrologic conditions	✓		
Cost-effectiveness	✓	✓	✓
Water supply reliability and safe yield	✓		
Legally allowable	✓	✓	✓

A groundwater water supply has greater adverse environmental impact than using Lake Michigan, and it conveys the water out of the Great Lakes Basin. It offers no cost advantage over a Lake Michigan alternative and in the long term is actually more costly. It is not a reasonable alternative according to the Wisconsin Compact implementing statute (§281.346(1) (ps), Wis. Stats.): "a 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."

EXHIBIT 4-17
Final Water Supply Alternative Selection

SECTION 5
Return Flow

The Compact requires return flow to the source watershed equal to the amount of water diverted from the Great Lakes, less the volume of water consumed. It also requires that the return flow protect the chemical, physical, and biological integrity of the Great Lakes. The City of Waukesha has developed a return flow management plan to meet those requirements, with a goal to exceed the requirements of the Compact by returning 100 percent of the withdrawn water over a management period. The return flow management plan will also provide environmental benefits to the source watershed by returning flow to a Lake Michigan tributary that is flow-limited during baseflow and low flow periods.

Return Flow Management Plan

The City of Waukesha's goal is to return 100 percent of the water withdrawn from Lake Michigan.

The City of Waukesha will meet the requirements of the Compact by returning the volume of water withdrawn from Lake Michigan, less consumptive use. The City of Waukesha also has a goal of returning 100 percent of the water supplied from Lake Michigan to ensure that the water balance within Lake Michigan will not be affected by its withdrawal. To accomplish the 100-percent return flow goal, a management plan has been developed using an innovative precedent of using treated wastewater as an environmental resource to balance the return and withdrawal volumes, and for supporting flow restoration and other watershed goals for the Lake Michigan tributary.

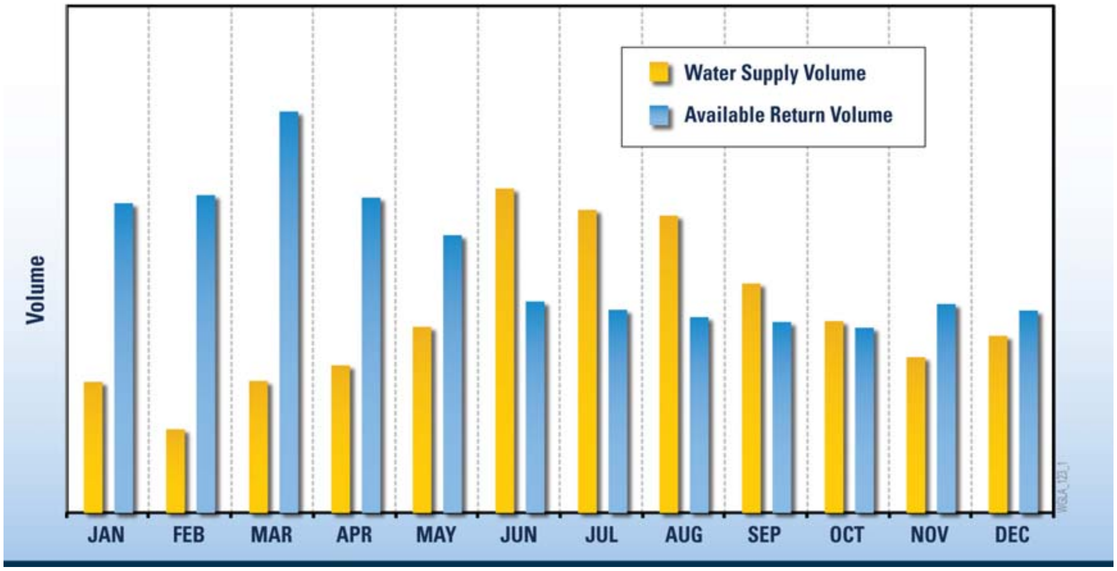
The return flow will come from the City of Waukesha Wastewater Treatment Plant (WWTP). The WWTP is an advanced facility with primary, secondary, tertiary treatment (sand filters), and ultraviolet light disinfection processes. It produces a high quality effluent that is discharged to the Fox River, in the Mississippi watershed. The Fox River has a relatively small watershed area at the City of Waukesha, and the WWTP provides a significant contribution to the flow in the Fox River during periods of low river flow. The WWTP maintains high quality treatment standards to protect the river water quality. The City of Waukesha will continue to use the treatment facility and at least maintain its high-quality treatment standards for future return flow.

Water supply changes throughout the year because of changes in demand, with the greatest water usage generally during hot and dry periods. Return flow from the WWTP varies throughout the year, but it does not always follow the same variation as the water supply. During periods of high water demand (e.g., July and August), return flow from the WWTP often is less than the water supply. For example, water consumption is greater during the summer, when the temperatures are high and precipitation is low, than it is in the winter. Exhibit 5-1 shows how the water supply and an available return flow (flow from the WWTP) would have varied seasonally during 2005, a year when there were several months when supply exceeded available return flow.

Return Flow Rates

To achieve 100 percent return volume and to balance the periods when the water withdrawal exceeds available return flow, the return flow management plan will use a certain period of time to track water withdrawal and return volume. The return flow will at least meet the Compact requirement of returning the withdrawn water, less consumptive use. To account for summer days when water withdrawal exceeds available return flow, slightly more water will be returned during

EXHIBIT 5-1
Variability of Water Supply and Available Return Flow Volume for Example Year 2005



spring, fall, and winter when the available return volume typically is greater than the demand (Exhibit 5-1). This will provide a total water balance of 100 percent return over a management period.

The return flow will meet the Compact requirement of returning the withdrawn water, less consumptive use.

The *minimum* daily return flow rate will be the water withdrawn (less consumptive use), which during some times of the year (summer) is the available flow rate from the WWTP. As discussed in Section 2, the City of Waukesha has an average consumptive use of about 8 percent. The *maximum* daily return flow rate will not exceed 115 percent of the average water withdrawal; that is the maximum daily return flow rate will not be more than 15 percent more than the average withdrawal. With return flow not exceeding 115 percent of the average daily withdrawal, the City of Waukesha will balance the amount of return flow with the amount of water withdrawn, and it will allow the City to provide a return flow rate very close to the withdrawal rate. This approach will provide a uniform return flow rate that will prevent large fluctuations in the return volume and excessive "banking" of volume during the management period.

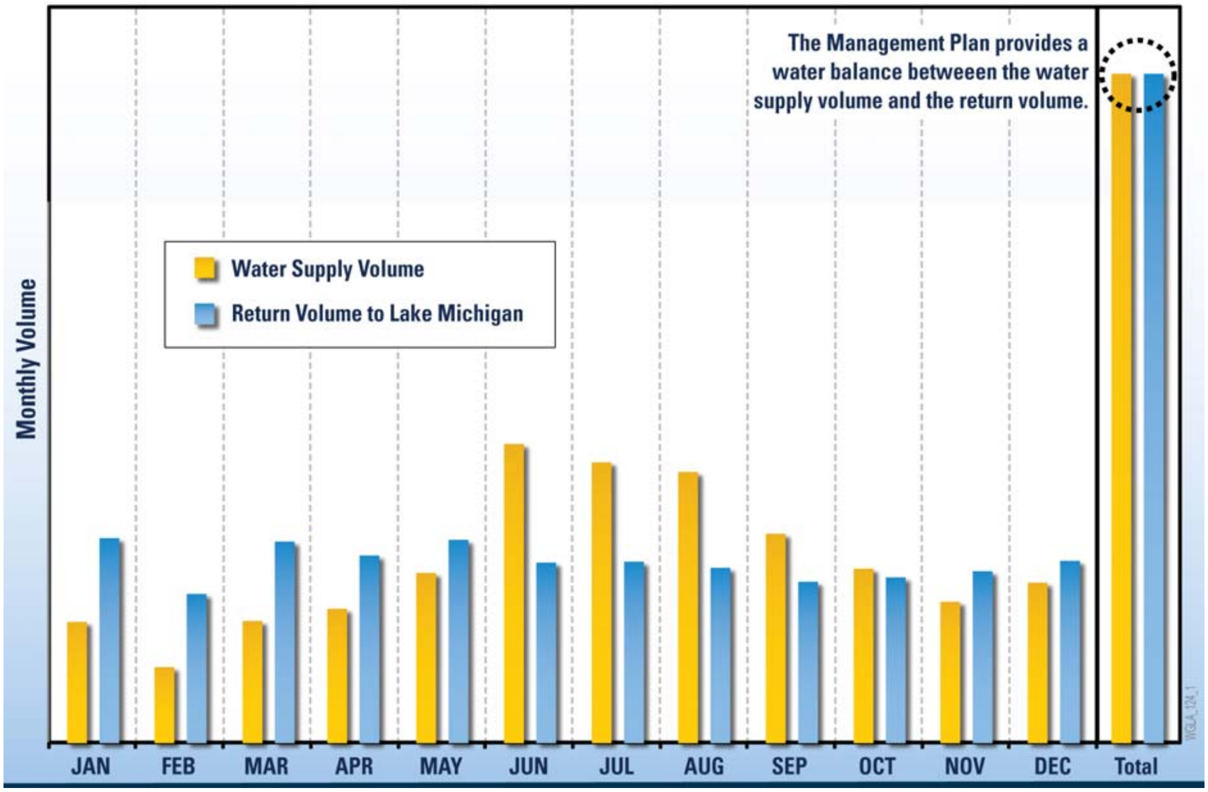
EXHIBIT 5-2
Summary of Return Flow Management Plan

Average Daily Return Flow to Lake Michigan Source Watershed		Receiving Water Body for Return Flow Exceeding the Maximum
Minimum Return Flow	Maximum Return Flow	
Available flow from WWTP (water withdrawal, less consumptive use)	Average daily water withdrawal + 15%	Fox River

When the available return flow (from the WWTP) exceeds the 115 percent of the water withdrawal, the excess flow from the WWTP will be conveyed through the existing outfall to the Fox River. Exhibit 5-2 summarizes the management plan.

To demonstrate how the management plan would provide return flow, the most recent water supply and available return flows (WWTP flows) were modeled for the most recent period of record, between 2002 and 2009. Over this period the management plan provided 100 percent re-

EXHIBIT 5-3
Example of 100 percent Return in 2005



turn of the withdrawn volume each year, including 2005 when there were several months when the water supply was greater than the available return volume (i.e., a year when obtaining 100 percent return flow would be more difficult). As shown in Exhibit 5-3, the monthly return for 2005 demonstrates that the return volume fluctuates throughout the year with the water withdrawal volume, and at the end of the year there is a water balance between the withdrawal and return volumes. The graph also demonstrates that some months will have more return volume than the withdrawal, to make up for months when withdrawal is greater than the available return. However, because the management plan allows the return flow rate to be very close to the withdrawal rate (Exhibit 5-2), the average daily variations between the withdrawal and return flow rates will be limited.

Management Plan Period

The City of Waukesha will monitor the withdrawal and return flow rates on a daily basis to ensure that the minimum requirement of the Compact is met: returning the withdrawn water, less consumptive use. The City also proposes using a 5-year rolling average to track water withdrawal and return flow rates to achieve its goal of 100 percent return flow. The 5-year management period will be used to provide 100 percent return flow, because there could be periods in the future with extended drought, when available return flow from the WWTP is less than the water withdrawal (when only the minimum Compact requirement of returning the withdrawn water, less consumptive use, is achieved). By using the 5-year rolling average, drought periods can be balanced with wet or normal precipitation periods, to provide a 100 percent return flow and a water balance between the withdrawal and the return volumes. As noted, because the average return flow rate is similar to the average withdrawal flow rate, the management plan will minimize daily variations between the two and will prevent "banking" excessive volume to account for days when available return flow is much less than the withdrawal.

Minimizing Out-of-Basin Water in Return Flow

The City of Waukesha has been implementing an aggressive infiltration and inflow (I&I) reduction program to reduce the amount of clear water entering the sanitary sewer collection system. Like all communities with sanitary sewer collection systems, some I&I is observed in the City of Waukesha during wet periods and storms. The I&I flows contribute to the collection system flows during those times, and subsequently receive the same treatment at the WWTP as the sanitary flow. The City's collection system and WWTP have adequate conveyance and treatment capacity to treat the I&I, but the City has continued the I&I reduction program to minimize treatment costs and to minimize the I&I that could be part of the return flow.

Over the past several years, projects that have contributed to reducing I&I include televising, smoke testing, and dye tracing of sewer pipes and structures; replacing sewer laterals, cracked pipes, and manholes; lining and sealing manholes and sewers; and identifying and correcting sump pump and foundation drain connections to the sanitary sewer. The City continues to investigate I&I throughout the collection system to prioritize projects that provide the most efficient I&I reduction.[1] Those efforts include sewer system modeling, in-pipe flow monitoring, sewer televising and smoke testing, and conducting a sewer system evaluation survey.

The return flow management plan will minimize out-of-basin water in the return flow. Because I&I contributes to WWTP flows exceeding the withdrawn water, the maximum return flow rate will not include the WWTP flows where I&I have the greatest contribution. Instead, the return flow rate will not exceed 15 percent more than the average withdrawal (as discussed under "Return Flow Management Plan"). By limiting the return flow rate, I&I contributions above that amount will not contribute to return flow, and the out-of-basin water (I&I) will be minimized. WWTP flows exceeding the return flow will continue to the Fox River, which is within the watershed where the I&I occurs and WWTP flows exceeding the withdrawn water originate.

Return Flow Alternatives

Five alternatives were considered for return flow to the Lake Michigan source watershed. The alternatives include return flow to:

- Underwood Creek, a tributary to the Menomonee River that flows to Lake Michigan
- Root River, a tributary to Lake Michigan
- Direct to Lake Michigan
- The Milwaukee Metropolitan Sewerage District (MMSD) system and water reclamation facility, which would then return flow to Lake Michigan. Two subalternatives were considered for return flow to MMSD.

Each alternative includes a corridor for the return flow pipeline and associated infrastructure along the pipeline alignment (e.g., pump station, service manholes). The pipeline corridors and the return flow discharge locations were selected to protect public health and safety, to provide long-term sustainability, to minimize environmental impacts, to provide feasible implementation (constructability), to use previously disturbed areas and existing utility corridors, to be consistent with the SEWRPC alignments, to allow the return flow to be used as a resource to the Lake Michigan basin, and to minimize cost.

[1] Donohue & Associates. (2010; in press). *Sanitary Sewer Master Plan—Phase I.*

The return flow alignments selected follow previously disturbed areas including streets and alleys, bike paths, active and abandoned railroad corridors, utility corridors, and city and county lands. The alignments are discussed below for each return flow alternative. The alignments were developed to a limited level detail that allows for screening and comparison of alternatives. The concepts do not include the details that will be identified and evaluated in subsequent engineering design phases for the actual project.

Similar infrastructure (a pump station and a pipeline of varying length depending on the alternative) was included for each alternative. Based on the above criteria, return flow to Underwood Creek is the preferred alternative because it protects public health, it has the lowest environmental impact, it occurs exclusively in previously disturbed areas, it is consistent with SEWRPC's recommended alignment, it will allow the return flow to provide a resource benefit within Underwood Creek, and it is the least costly alignment.

Each alternative is discussed below; Appendixes E and O contain additional information. Because Underwood Creek is the preferred return flow location, it is discussed in detail.

Return Flow to Underwood Creek

Return flow to Underwood Creek is expected to occur in Waukesha County, near the crossing of Underwood Creek and Bluemound Road. At that location, Underwood Creek flows about 2.6 river miles to its confluence with the Menomonee River in Wauwatosa before flowing another 10 river miles to Lake Michigan in the City of Milwaukee.

A screening level layout was developed for the return flow pipeline (Exhibit 5-4; see next page). It begins at the City of Waukesha WWTP, and proceeds north and east through a City park and along an alley and minor streets for about 1.3 miles. The pipeline continues east for another 1.3 miles following an abandoned railroad corridor planned for a future recreational trail, where it joins with an utility corridor and bike trail and runs for another 7 miles. The pipeline continues north 1.9 miles along a street, bike path and Underwood Creek Parkway until it ends near the confluence of the north and south branch of Underwood Creek.

Environmental Resources

The return flow pipeline follows corridors that are previously disturbed, and it avoids environmental resources, such as wetlands, stream crossings, and other similar land use categories as much as possible. Some areas of the alignment will have temporary (short-term) impacts to these resources because of construction associated with building the pipeline, and there will be no long-term significant impacts. The impacts to environmental resources (Appendix O) were analyzed for the return flow pipeline corridor, and the Underwood Creek return flow had the least impact of all alternatives. A 75-foot-wide corridor was used along the centerline of the pipeline alignment to assess and compare impacts between alternatives. The impacts are summarized in Exhibit 5-5.

EXHIBIT 5-5
Summary of Potential Environmental Impacts for an Underwood Creek Return Flow

Resource Type	Potential Temporary Impact of Pipeline Corridor
Stream crossings	17
Water body crossings	8
Water body crossing (acres)	0.15
Wetlands (acres)	9.4[a]

[a]For an outfall near Bluemound Road. The impacts are about 5.0 acres for a discharge 0.9 mile upstream.

The estimated total temporary wetland impacts related to construction are 9.4 acres within the pipeline corridor

EXHIBIT 5-4
Return Flow Alignment to Underwood Creek

between the City of Waukesha WWTP and the outfall to Underwood Creek. Most of the impacts occur in the last 0.9 mile of the alignment, where about 5.3 acres of land are classified as wetlands. This area has been disturbed in the past when the creek was lined with concrete and when a pedestrian trail was constructed. The pipeline corridor is located along the pedestrian trail to minimize wetland impacts, but some temporary impacts are estimated for a return flow outfall near Bluemound Road. To reduce these impacts, the outfall could be located upstream of Bluemound Road 0.9 mile. This would reduce the total potential temporary construction impacts from 9.4 acres to about 5.0 acres.

The return flow *discharge* will not affect the environmental resources along the pipeline corridor, but the discharge was analyzed for potential effects on resources within Underwood Creek, Menomonee River, and Lake Michigan. These effects are summarized below.

Flow, Geomorphology, and Habitat

Downstream of the return flow outfall, Underwood Creek is mostly concrete-lined, but in 2009 a 2,400-foot-long segment of lining was removed and rehabilitated with natural channel design features.[2] The rehabilitated creek provides improved habitat because the bottom substrate is

[2] MMSD. 2008. "Watercourse: Underwood Creek Rehabilitation and Flood Management—Phase 1." Designed by Short Elliott Hendrickson, Inc. (SEH).

coarse grained sediments (gravel and cobbles); it provides various habitat features such as riffles, runs, pools, and glides; it meanders and includes other habitat features like rock boulders; the vegetation will overhang the channel once it is mature; and the creek is reconnected with its floodplain. A preliminary design for rehabilitating an additional 4,400-foot section of creek is complete,[3] and is expected to provide similar environmental resource benefits.

The Underwood Creek design engineers conducted a hydraulic and geomorphic analysis for a potential City of Waukesha return flow. A 20-cfs (12.9-mgd) return flow rate, which is slightly more than the future average day water demand, was assumed. The analysis assessed the impacts of return flow to the creek and concluded that the increase in flow will have a negligible effect on the geomorphic stability of the rehabilitated creek.[4] The flow in Underwood Creek fluctuates from no flow during dry periods (winter), to high flows during storms in its predominantly urban watershed. The return flow rate would subsequently fluctuate between providing all the flow in Underwood Creek (e.g., during dry periods) to providing a very small part of flow during storms. For example, a 20-cfs return flow is only 1.5 to 2.0 percent of the 2-year creek flow (for locations in the creek downstream of the potential return flow location) and 0.29 to 0.76 percent of the 100-year flow.[5]

Because the Menomonee River is downstream of Underwood Creek (with a subsequently larger watershed and flow), the return flow is also expected not to affect the geomorphic stability of river. The effect of return flow on the flow in the Menomonee River is also less, where a 20-cfs return flow is only 0.30 to 0.59 percent of the 2-year flow (for locations in the river downstream of the potential return flow location) and 0.11 to 0.21 percent of the 100-year flow.[6]

A habitat assessment was also completed for Underwood Creek and Menomonee River to determine the changes in habitat that could result from return flow to Underwood Creek. The return flow increases the average velocity, cross sectional flow area, shear stress, and the wetted perimeter in the creek and river. The increases are not expected to have a significant effect on the instream habitat, but they are expected have benefit to the habitat within the creek by reducing the potential for fine sediments to fill the coarse sediment substrate (embeddedness), providing deeper pools and riffles for more functional fish passage, and providing more wetted perimeter to support a greater benthic macroinvertebrate community. The return flow is expected to have similar but less significant benefits for the Menomonee River, because the river flow is greater than the creek flow. Appendix L contains additional details of the habitat analysis.

Fisheries

Fisheries data for the Menomonee River watershed show an apparent net gain of fish species within the watershed. For example, 10 new species have been identified since 1986, and the most recent fishery surveys conducted by the USGS in 2004 and 2007 identified that 12 of the 20 species found in the Menomonee River watershed occurred within Underwood Creek.[7] Underwood Creek is predominantly a concrete channel with little habitat for fish, but the creek provides minimal substrate for macroinvertebrates. The part of the concrete channel removed

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[3] SEH. 2009. "Underwood Creek Effluent Return Evaluation". Technical memorandum dated July 23, 2009, page 2.

[4] SEH. 2009. "Underwood Creek Effluent Return Evaluation," pages 2, 5.

[5] Underwood Creek HEC-RAS Model. Underwood Creek Rehabilitation and Flood Management Project. Short Elliott Hendrickson Inc., 2009. Computer Model.

[6] Menomonee River HEC-RAS Model. Phase I Watercourse System Management Project. MMSD, 2001. Computer Model. Modified for newer HEC-RAS model v3.1.3.

[7] SEWRPC. 2007. A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds. Planning Report No. 50. pp. 200–14. Data compilation from MMSD, USGS, and WDNR.

in 2009 and rehabilitated to a meandering stream channel has numerous pools and riffles, and a substrate composed of gravel, sand, and silt.

Underwood Creek, along with most streams in the Menomonee River watershed, is a warm-water habitat, with an imbalance of number and type of species indicative of a poor quality fishery. Although macroinvertebrate communities within the watershed improved substantially since 1993, the USGS macroinvertebrate data collected in 2007 concluded that Underwood Creek and the Menomonee River range from fairly poor to fair to good, in terms of relative quality based on the presence of specific macroinvertebrates.

With the potential presence of two state-listed threatened fish species in the Menomonee River watershed, there appear to be areas of good river quality within limited parts of the watershed. The poor quality of the fish communities in the watershed is caused mostly by habitat loss. The rehabilitated channel of Underwood Creek contains habitat features that fish and macroinvertebrates can use. Although habitat conditions in Underwood Creek are limiting for the fish and benthic communities, those conditions could be improved by providing more or higher quality habitat. Because return flow is expected to improve habitat, the fish and macroinvertebrate communities would also be expected to improve.

One example of improving fisheries with effluent flow from a WWTP is in southeast Michigan, where the Ypsilanti Community Utilities Authority (YCUA) WWTP uses wastewater effluent as an environmental resource. In 1995, the Lower Rouge River near Detroit began receiving flow augmentation from YCUA effluent. Since then, the Lower Rouge River has been able to support an improved fishery, with the potential for up to 29 species and angling opportunities for 7. Baseflow enhancement has dramatically increased the fishery potential of the Lower Rouge, where the YCUA flow augmentation demonstrates that baseflow enhancement to low flow systems may be a particularly useful tool to enhance sport fish populations.[8] Following a similar precedence for the City of Waukesha, return flow could provide similar opportunities to improve public and natural resources, and provide benefits beyond just maintaining a water balance in Lake Michigan. Underwood Creek experiences extended periods of very low flows and periods of no flow (i.e., a dry creek). Flow augmentation with return flow would eliminate dry periods and could enhance the baseflow in Underwood Creek and Menomonee River to support an improved fishery. Return flow to the creek provides natural resource benefits as it flows on the surface towards Lake Michigan. In contrast, when conveyed in a pipe (e.g., discharge direct to Lake Michigan), the flow does not have an opportunity to provide an environmental benefit.

Flooding

Waukesha return flow will be provided in a manner that meets regulatory floodplain management requirements and does not cause additional flood damage. The Underwood Creek and Menomonee River watersheds in the Milwaukee area are highly developed with existing residential and commercial buildings very near, and sometimes within, the 100-year flood plain. During a flood in the watershed, floodwaters rise and then subside quickly. To protect downstream properties, conveying floodwaters to the Milwaukee County Grounds floodwater management facility is estimated to last only 6 hours for the 100-year return period storm.[9]

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8 Michael Wiley, P. Seelbach, S. Bowler. 1998. "Ecological Targets for Rehabilitation of the Rouge River." School of Natural Resources and Environment. University of Michigan. Final Report, April 30. Page 7, 13, and 18.

9 HNTB, Environmental Assessment Milwaukee County Grounds Floodwater Management Facility and Underwood Creek Rehabilitation Projects, 2006.

To protect public and private property, there have been significant and ongoing investment in flood control projects. For example, downstream of the return flow location, the MMSD has invested $48 million in the Hart Park flood control project, completed in 2007,[10] and $99 million in the County Grounds flood control project, to be completed in 2010.[11] Other projects have been completed or are planned elsewhere in the watershed. Each project contributes to providing flood protection to neighboring and downstream residents.

Although return flow is a very small percentage of flow during a flood, if an extreme flood condition threatens personal property or public investments, return flow would be temporarily paused. This will not affect the City of Waukesha's goal of providing 100 percent return flow.

Water Quality

The City will provide return flow with water quality that not only meets but also exceeds the discharge requirement stipulated by the Wisconsin Pollutant Discharge Elimination System (WPDES). The City of Waukesha will also meet future water quality effluent standards at least as stringent as those currently imposed.

The WDNR has provided the City of Waukesha with proposed effluent limits for discharge to a Lake Michigan tributary.[12] Effluent limits for two other in-basin municipal dischargers to Lake Michigan tributaries were obtained for comparison purposes. The WDNR-proposed effluent limits for the City of Waukesha are more stringent than the other Lake Michigan tributary dischargers (Exhibit 5-6). Because the City of Waukesha is committed to maintaining high quality effluent from their WWTP, the return flow will meet WPDES requirements with any alternative return flow location.

EXHIBIT 5-6
Comparison of WDNR-Proposed WPDES Limits to
Historical WWTP Performance and Other Lake Michigan Tributary Dischargers

	City of Waukesha Potential Return Flow			
Water Quality Parameter	WDNR-Proposed Limit for Lake Michigan Tributary Return	Waukesha Historic Average[a]	Lake Michigan Tributary WWTP Discharger #1[b]	Lake Michigan Tributary WWTP Discharger #2[c]
Biological oxygen demand, mg/L	≤ 5.0 to ≤ 10.0	1.8	≤ 10.0 to ≤ 15	≤ 30.0 monthly average
Total suspended solids, mg/L	≤ 5.0 to ≤ 10.0	1.2	≤15.0	≤ 30.0 monthly average
Dissolved oxygen, mg/L	≥ 7.0	9.2	≥ 6.0	≥ 6.0
Phosphorus, mg/L	≤ 1.0	0.16	≤ 1.0	≤ 1.0
Ammonia (NH_3-N), mg/L	Likely lower than current range of 2.0 to 6.0	< 1.0	3.3 to 6.4 monthly avg.	6.3 to 12.0 monthly avg.

[a]October 1, 2002, to August 31, 2009.
[b]WPDES Permit No. WI-0020222-08-0
[c]WPDES Permit No. WI-0020184-08-0

10 MMSD. http://v3.mmsd.com/hartparkproject.aspx. Site accessed January 13, 2010.

11 MMSD. http://v3.mmsd.com/milwaukeecogrounds.aspx. Accessed January 13, 2010.

12 WDNR Letter from Duane Schuettpelz, October 16, 2008.

The City of Waukesha WWTP has water quality limits for several other parameters, including chlorides, which the WDNR has indicated would continue to be regulated.[13] As noted in Section 4, Water Supply Alternatives, a Lake Michigan water supply will eliminate the need for Utility customers to soften water with salt. As a result, the chloride concentration from WWTP-treated return flow is expected to decrease in the future.

The temperature of the WWTP discharge varies seasonally, with the warmest month of August averaging 70°F (21.3°C) and the coolest month of February averaging 53°F (11.5°C). This type of seasonal variation is typical at municipal WWTPs. The current discharge to the Fox River meets temperature requirements and consequently, return flow temperatures will meet temperature requirements.

Underwood Creek and Menomonee River Water Quality

Underwood Creek is classified for WDNR fish and aquatic life standards, but it has a variance in Milwaukee County for dissolved oxygen and fecal coliform.[14] The Menomonee River downstream of Underwood Creek is classified for WDNR fish and aquatic life standards, but it has the same dissolved oxygen and fecal coliform variances from Honey Creek to the mouth of the river (about 5 miles downstream of the proposed return flow location).[15]

A reach of Underwood Creek upstream of the discharge in Waukesha County is proposed to be included on the 2010 303(d) list for fecal coliform as a recreational restriction.[16] The last 2.67 miles of the Menomonee River is proposed to be included on the 2010 303(d) list for fecal coliform as recreational restrictions. The Menomonee River is on the 303(d) list in the same stretch of river for PCBs from contaminated sediment, *E. coli* bacteria for recreational restrictions, total phosphorus for low dissolved oxygen, and unspecified for chronic aquatic toxicity. These listings were all made in 1998.[17] More recently, SEWRPC completed a detailed analysis of water quality in the Menomonee River and found that the dissolved oxygen variance standard was always met for the 11-year period of record analyzed.[18]

Water quality in Underwood Creek and the Menomonee River was extensively studied in SEWRPC's *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds*. Findings for the 11-year period of record under SEWRPC's existing condition scenario are summarized below for three points closest to the proposed return flow location. Additional water quality analysis was completed for the current conditions in Underwood Creek and Menomonee River, and for conditions with return flow (Appendix H).

Fecal Coliform. Underwood Creek and Menomonee River sometimes meet fecal coliform standards during the summer recreational season. The overall compliance for the single sample standard is met 67 to 86 percent of the time. The geometric mean fecal coliform concentration for the summer season ranges from 351 to 496 cells/100 mL.[19]

The historical performance at the City of Waukesha WWTP for the summer recreation season (May through October) had geometric mean fecal coliform concentration ranging from 2 to

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[13] Ibid.

[14] NR 104.06(2) Water Quality Standards for Wisconsin Surface Waters

[15] Ibid.

[16] http://dnr.wi.gov/org/water/wm/wqs/303d/303d.html accessed January 19, 2010.

[17] Ibid.

[18] SEWRPC, Planning Report Number 50, *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds*, Appendix N, 2007.

[19] Ibid.

49 cells/100 mL. Because the return flow fecal coliform concentration is much lower than the existing conditions and water quality standards in Underwood Creek and Menomonee River, the average fecal coliform concentration with return flow will improve.

Dissolved Oxygen. The SEWRPC study predicted that Underwood Creek and Menomonee River comply with the standards of maintaining 5 mg/L of dissolved oxygen (2 mg/L for variance standard). The City of Waukesha WWTP historical performance for average dissolved oxygen concentration ranges from 7.9 to 10.5 mg/L. Because the return flow concentration is greater and has a very low concentration of biological oxygen demand, the average dissolved oxygen concentration in Underwood Creek and the Menomonee River would be expected to continue to meet water quality standards.

Total Phosphorus. Underwood Creek and Menomonee River meet the SEWRPC planning level goal of 0.1 mg/L 66 to 84 percent of the time. The City of Waukesha WWTP historical performance for monthly average phosphorus concentration ranges from 0.10 to 0.24 mg/L. Phosphorus concentration in Underwood Creek and the Menomonee River is expected to increase as a result of return flow, but the effect of the increased concentration is expected to be minimal as described below and in Appendix H.

Total Suspended Solids. The average total suspended solids in Underwood Creek and the Menomonee River are always less than the total suspended solids reference background concentration of 17.2 mg/L used in the SEWRPC modeling. The City of Waukesha WWTP historical performance for total suspended solids concentration ranges from 0.9 to 1.8 mg/L. Because the return flow total suspended solids are much lower than the background concentration, the average total suspended solids concentration is expected to improve in Underwood Creek and the Menomonee River as a result of return flow.

Return Flow Water Quality Modeling

Underwood Creek Water Quality. Water quality modeling was conducted for the Underwood Creek return flow alternative. Modeling included existing conditions in Underwood Creek with expected Waukesha return flow concentration and also a worse case scenario having high flows and higher concentrations in the discharge. Appendix H contains the water quality modeling summary conclusions and also the detailed findings.

The water quality modeling found that average water quality improved or continued to meet water quality standards or background reference concentrations for three of four water quality parameters (fecal coliform, dissolved oxygen, and total suspended solids). For the fourth water quality parameter (phosphorus), concentrations increased and were more frequently higher than the planning level goal used in the SEWRPC modeling (0.1 mg/L). However, the modeling results indicate that with return flow, nuisance algae growth will decrease in Underwood Creek and Menomonee River. The WDNR is developing new phosphorus standards that could further reduce the phosphorus discharge concentration in the return flow.

Lake Michigan Water Quality. The return flow ultimately ends up in Lake Michigan. Consequently, water quality information was reviewed for overall water quality parameter loadings from the greater Milwaukee watersheds tributary to Lake Michigan. SEWRPC compiled total annual water quality parameter loadings for all the greater Milwaukee watersheds.[20] The contribution of the City of Waukesha return flow loadings was calculated using the information

[20]SEWRPC, Planning Report Number 50, A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds, Tables 54–56, 2007.

from the water quality modeling documented in Appendix H and then compared to the SEWRPC annual average load findings. The analysis indicates the following:

- Fecal coliform contribution in the return flow under very conservative worst case conditions is only 0.20 percent of all fecal coliform loading from the greater Milwaukee watersheds.
- Total suspended solids contribution in the return flow under very conservative worst case conditions is only 0.21 percent of all total suspended solids loading from the greater Milwaukee watersheds.
- Phosphorus contribution in the return flow is only 1.23 percent of all phosphorus loading even under worst case conditions and only 0.62 percent of all phosphorus loading when considering the City of Waukesha's WWTP historic performance. These contributions could be even less because the WDNR is considering new phosphorus regulations that could require more stringent phosphorus discharge limitations.

Cost Estimate

Exhibit 5-7 summarizes the screening-level cost estimate, based on return flow to the creek through a pump station at the City of Waukesha WWTP, a pipeline, and an outfall to the creek. Appendixes E and M contain additional information. These cost estimates were prepared for guidance in comparing alternatives based on information available at the time of the estimate. Detailed engineering design has not been completed. The final cost estimate of any project will depend on market conditions, site conditions, final project scope, schedule, and other variable factors. As a result, final project costs may vary from the estimates presented here.

EXHIBIT 5-7
Screening Level Cost Estimate for Return Flow to Underwood Creek

Return Flow Alternative	Capital Cost[a]	Annual Operations and Maintenance	20-Year Present Worth	50-Year Present Worth
Underwood Creek	$56,874,000	$119,000	$58,239,000	$58,750,000

[a]Includes direct construction cost, contractor administrative costs (insurance, bonds, supervision etc), 25% contingency, and costs for permitting, legal, engineering, administrative.

Return Flow to Root River

The Root River flows through parts of Milwaukee and Racine counties, and into Lake Michigan at Racine, Wisconsin. The river has more natural channel (e.g., natural bottom substrate and vegetated river banks) than does Underwood Creek, and it has a mixture of land uses between its headwaters and Lake Michigan. The headwaters of the Root River are heavily urbanized, the middle reaches are primarily agriculture and lower density development, and the lower parts of the watershed near Lake Michigan are heavily urbanized.

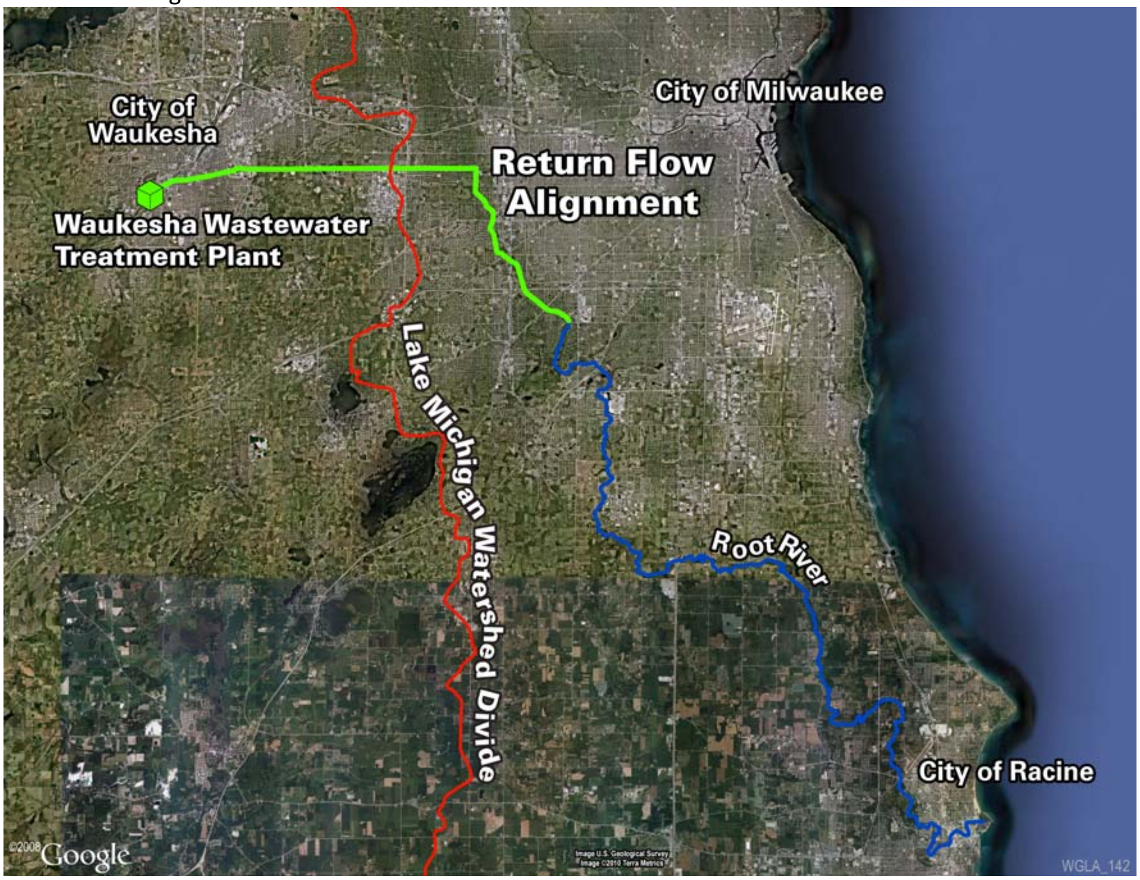
The conceptual pipeline alignment for return flow to the Root River is the same as the pipeline for Underwood Creek for about the first 9.6 miles. Where the Underwood Creek pipeline heads north toward Underwood Creek, the Root River pipeline would head southeast for 6 miles toward the Root River (Exhibit 5-8) following streets, a parkway, and a bike trail.

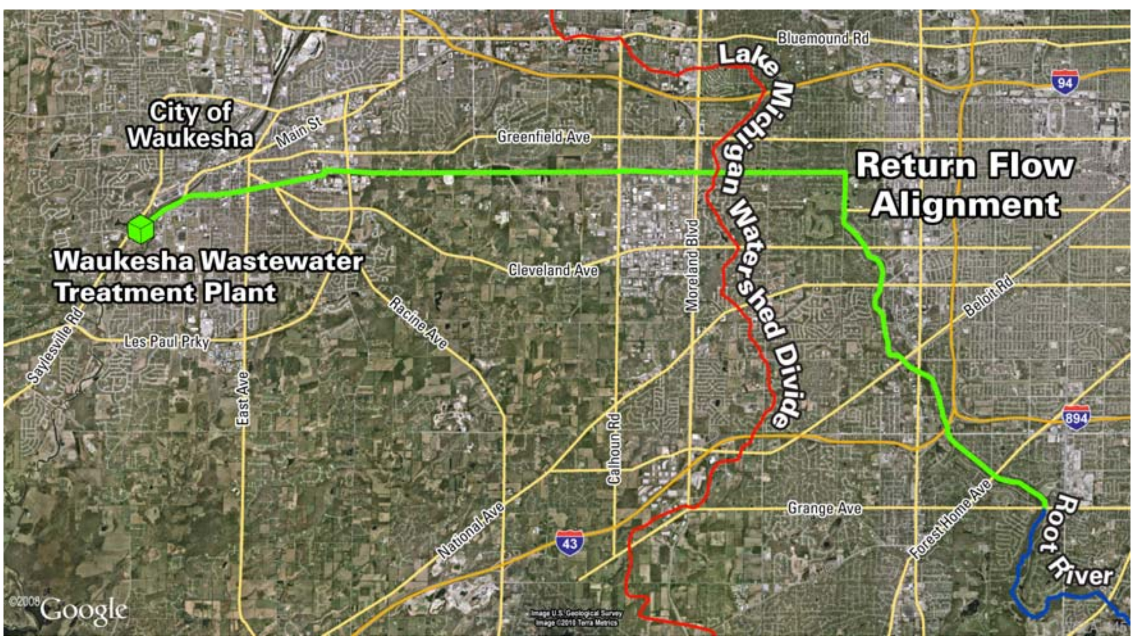
The outfall location is farther downstream than the location considered by SEWRPC.[21] It was chosen for a watershed size and river flow rate similar to that of the Underwood Creek outfall loca-

[21] SEWRPC. 2008. Planning Report No. 52: A Regional Water Supply Plan for Southeastern Wisconsin. Chapter 9, Map IX-8.

tion (i.e., the SEWRPC outfall location was farther upstream on the Root River, where the watershed was smaller). Having similar watershed areas allows the Root River and Underwood Creek return flow locations to be more readily compared for a resulting return flow discharge.

EXHIBIT 5-8
Return Flow Alignment to Root River





Environmental Resources

Similar to the Underwood Creek alignment, the Root River alignment follows corridors that are previously disturbed and avoids such environmental resources as wetlands and stream crossings as much as possible. Some areas of the alignment will have temporary (short-term) impacts to these resources because of construction associated with building the pipeline, and there will be no long-term significant impacts. Impacts to environmental resources were analyzed for the return flow pipeline corridor (Appendix O). The Root River alignment has greater environmental impacts than does the Underwood Creek alignment, primarily because the Root River is a more natural channel than Underwood Creek, and because more environmental resources are near the Root River. A 75-foot-widecorridor was used along the centerline of the pipeline alignment to assess and compare impacts between alternatives. The impacts are summarized in Exhibit 5-9.

EXHIBIT 5-9
Summary of Potential Environmental Impacts for a Root River Return Flow

Resource Type	Potential Temporary Impact of Pipeline Corridor
Stream crossings	24
Water body crossings	9
Water body crossings (acres)	0.34
Wetlands (acres)	12.4

The return flow discharge will not affect the environmental resources along the pipeline corridor. Instead, the discharge was analyzed for its effect on resources within the Root River.

Flow, Geomorphology, and Habitat

The flow, geomorphology, and habitat impacts from a Root River return flow were evaluated for comparison to Underwood Creek. A general comparison can be made because the watersheds border each other and they have similar size, land use, and urbanization at the discharge location.

The Root River has a more natural channel than does Underwood Creek, and it is longer from the discharge location to the confluence with Lake Michigan. With the greater length, there is a greater opportunity for habitat enhancements by augmenting the flow in the Root River with return flow. Similar to Underwood Creek, flow in the Root River sometimes is very low, and the functional habitat in the river is limited by the river flow. Augmentation of the return flow would eliminate the very low flow periods. Because the return flow rate is small compared to the higher flows in the river, return flow is not expected to affect the geomorphic stability of the river. For example, a 20-cfs return flow is about 5 percent of the 2-year river flow in the model reach at the discharge location, and about 2.2 percent at the next reach about 1.3 miles downstream of the return flow outfall location.[22] For a 100-year river flow at the two locations, the return flow is about 0.5 and 0.8 percent. These are similar to the Underwood Creek flow, where a detailed evaluation concluded that the return flow would not affect the geomorphic stability of the rehabilitated parts of the creek. A recent sediment transport study of the Root River concluded that the river stability is relatively insensitive to changes in flows because of the erosion resistance of the channel boundary materials, the relatively flat channel gradient, and the presence of a functional floodplain.[23] Consequently, the return flow is not expected to affect the Root River adversely.

Beneficial habitat effects in the Root River are expected to be similar to those for Underwood Creek and Menomonee River. Because the Root River is longer and has more natural channel

[22] MMSD. *Root River Sediment Transport Planning Study.* May 4, 2007. Hydraulics Technical Memorandum 3. HEC-RAS model from enclosed CD.

[23] MMSD. *Root River Sediment Transport Planning Study.* May 4, 2007. Hydraulics Technical Memorandum 6. Page 1.

(compared to concrete in Underwood Creek) downstream of the return flow location, more habitat benefits are expected. However, because the return flow is a small part of the river flow, the habitat benefits are not expected to be significant, similar to Underwood Creek and the Menomonee River.

Fisheries

Fishery data for in the Root River watershed show that 10 new species have been identified, but 10 of 64 recorded species have not been observed since 1986.[24] The most recent fishery surveys, conducted in 2004 and 2007 by the USGS, identified 17 species in the Root River near the proposed return flow location. Some of the new species were observed in reaches of the Root River between the confluence with Lake Michigan and the first dam, suggesting that Lake Michigan's fish community may be influencing the fish community of the lower reaches of the watershed. The Root River is a warmwater habitat, where the balance of fish species indicates a fair quality fishery overall in the watershed that is higher in quality than that of the Menomonee River watershed. Macroinvertebrate data collected within the Root River watershed suggest that the river is dominated by species tolerant of a low quality habitat. Most species within the fish and macroinvertebrate communities generally indicate fair habitat quality.

With the potential presence of one state-listed endangered and three state-listed threatened fish species, there appear to be areas of good quality within parts of the watershed, but there is also impairment because of the agricultural and urban development. The Root River watershed has relatively few streambed and bank modifications, with less than 1 percent of the stream channel observed being in conduit and none lined with concrete. Although habitat conditions in the Root River are fair to good, habitat could be improved by providing more or higher quality habitat. Because return flow would be expected to improvement habitat somewhat, the fish and macroinvertebrate communities could also be expected to improve.

Flooding

Similar to return flow to Underwood Creek, flow would be returned to the Root River in a manner that meets regulatory floodplain management requirements and without causing additional flood damage.

Water Quality

The Root River is classified for WDNR fish and aquatic life standards. The Root River at the potential discharge location is on the 303(d) list for low dissolved oxygen with reported causes from sediment and phosphorus.[25] In addition, the last roughly 6-mile of the Root River upstream of Lake Michigan is on the 303(d) list for PCBs. These listings were all made in 1998.[26] More recently, SEWRPC modeled water quality in the Root River in great detail and found that dissolved oxygen predictions met the standard between 95 and 100 percent of the time for the 11-year period of record analyzed.[27] The water quality findings for SEWRPC's existing condition scenario are summarized below for three points closest to the proposed return flow location.

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[24] SEWRPC. 2007. *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds.* Planning Report No. 50. pp. 200–14. Data compilation from MMSD, USGS, and WDNR.

[25] http://dnr.wi.gov/org/water/wm/wqs/303d/303d.html accessed January 19, 2010.

[26] Ibid.

[27] SEWRPC, Planning Report Number 50, *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds,* Appendix N, 2007.

Fecal Coliform. The Root River sometimes meets fecal coliform standards during the summer recreational season, where the compliance for the single sample standard is met 58 to 66 percent of the time. The geometric mean fecal coliform concentration for the summer season ranges from 603 to 770 cells/100 ml.[28] The historical performance at the City of Waukesha WWTP for the summer recreation season (May through October) had geometric mean fecal coliform concentration ranges from 2 to 49 cells/100 mL. Because the return flow fecal coliform concentration is much lower than the existing conditions and water quality standards in the Root River, the average fecal coliform concentration with return flow will improve.

Dissolved Oxygen. The SEWRPC study predicted that the Root River would comply with the standards of maintaining 5 mg/L of dissolved oxygen 95 to 100 percent of the time. The City of Waukesha WWTP historical performance for average dissolved oxygen concentration ranges from 7.9 to 10.5 mg/L. Because the return flow concentration is greater and has a very low concentration of biological oxygen demand, the average dissolved oxygen concentration in the Root River could improve compliance with water quality standards.

Total Phosphorus. The Root River meets with the SEWRPC planning level goal of 0.1 mg/L 73 to 84 percent of the time. The City of Waukesha WWTP historical performance for monthly average phosphorus concentration ranges from 0.10 to 0.24 mg/L. Phosphorus concentration in the Root River is expected to increase as a result of return flow. However, the environmental change with an increase in phosphorus could be limited, as described in the Underwood Creek water quality modeling conclusions.

Total Suspended Solids. The average total suspended solids in the Root River ranges from 10.3 to 19.4 mg/L. The historical performance of the City of Waukesha WWTP for total suspended solids concentration ranges from 0.9 to 1.8 mg/L. Because the return flow total suspended solids are much lower than the current concentration, the average total suspended solids concentration is expected to improve in Underwood Creek and the Menomonee River as a result of return flow. Return flow under all alternatives is ultimately to Lake Michigan. The comparison of the return flow water quality loading to that of the greater Milwaukee watersheds is the same as that summarized in the Underwood Creek alternative.

Cost Estimate

Exhibit 5-10 summarizes the screening-level cost estimate for this alternative. The costs were based on return flow to the river through a pump station at the City of Waukesha WWTP, a pipeline, and an outfall to the river. Appendixes E and M contain additional information.

EXHIBIT 5-10
Screening Level Cost Estimate for Return Flow to Root River

Return Flow Alternative	Capital Cost[a]	Annual Operations and Maintenance	20-Year Present Worth	50-Year Present Worth
Root River	$74,415,000	$145,000	$76,079,000	$76,701,000

[a]Includes direct construction cost, contractor administrative costs (insurance, bonds, supervision etc), 25% contingency, and costs for permitting, legal, engineering, administrative.

28 Ibid.

Return Flow Directly to Lake Michigan

A screening-level alignment for return flow directly to Lake Michigan was developed to evaluate the environmental effects and costs (Exhibit 5-11). The conceptual pipeline alignment is the same as that for Underwood Creek and Root River for about the first 9.6 miles. Where the two pipelines diverge, the Lake Michigan alignment continues east about 11.2 miles parallel to a railroad corridor. As the alignment nears Lake Michigan, it continues east about 1.2 miles along a city street where it intersects with the lake. The alignment extends into Lake Michigan about 0.5 mile to provide an offshore outfall.

EXHIBIT 5-11
Return Flow Alignment Direct to Lake Michigan

The alignment is that developed by SEWRPC, but the last segment of is a few blocks to the north. The alignment is shorter, the city street used for the last segment is larger, and the shoreline at Lake Michigan has been previously disturbed and is undeveloped. This alignment appears to have slightly less constructability challenges.

Environmental Resources

Similar to the Underwood Creek and Root River alignments, the alignment follows corridors that are previously disturbed and avoids environmental resources such as wetlands, stream crossings, and other similar land uses as much as possible. Some areas of the alignment will have temporary (short-term) impacts to these resources because of construction associated with building the pipeline. A long-term impact may occur in this alternative where the outfall is constructed within Lake Michigan for an offshore discharge. The impacts to environmental resources were analyzed (Appendix O) for the return flow pipeline corridor. The alignment has greater environmental impacts than the other two alignments, primarily because it is much longer. A 75-foot-wide corridor was used along the centerline of the pipeline alignment to assess and compare impacts between alternatives. Exhibit 5-12 summarizes the environmental impacts.

EXHIBIT 5-12
Summary of Potential Environmental Impacts for Return Flow Direct to Lake Michigan

Resource Type	Potential Impact of Pipeline Corridor
Stream crossings	19
Water body crossings	8
Water body crossings (acres)	6.5
Wetlands (acres)	5.4

The return flow discharge will not affect the environmental resources along the pipeline corridor. Instead, a direct discharge was analyzed for the potential effect on resources in Lake Michigan. Return of flow directly to Lake Michigan does not provide the opportunity to use the flow as a resource.

Flow, Geomorphology and Habitat

Returning the flow directly to Lake Michigan does not have significant long-term impacts. For discharges to Underwood Creek or Root River, the return flow is able to provide a resource benefit by providing additional flow in the creek and river during periods when little or no flow is naturally present. As discussed for the Underwood Creek and Root River return flow alternatives, return flow could provide benefits to the habitat with flow augmentation while not adversely affecting geomorphic stability. In contrast, return flow directly to Lake Michigan would have no environmental benefit beyond returning the water to the Lake Michigan, because the return flow would be conveyed in a pipe, instead of through a surface water.

Fisheries

Return flow directly to Lake Michigan will not adversely affect fisheries in Lake Michigan.

Water Quality

Under all alternatives, flow ultimately is returned to Lake Michigan. The comparison of water quality loading to that of the greater Milwaukee watersheds is the same as that summarized in the Underwood Creek alternative.

Cost Estimate

Exhibit 5-13 summarizes the screening-level cost estimate for this alternative. Costs were based on return flow to Lake Michigan through a pump station at the City of Waukesha WWTP, a pipeline, and an outfall to the lake. Appendixes E and M contain additional information.

EXHIBIT 5-13
Screening Level Cost Estimate for Return Flow Direct to Lake Michigan

Return Flow Alternative	Capital Cost[a]	Annual Operations and Maintenance	20-Year Present Worth	50-Year Present Worth
Direct to Lake Michigan	$117,556,000	$159,000	$119,380,000	$120,063,000

[a]Includes direct construction cost, contractor administrative costs (insurance, bonds, supervision etc), 25% contingency, and costs for permitting, legal, engineering, administrative.

Return Flow through the Milwaukee Metropolitan Sewerage District

The MMSD operates regional sewage collection and water reclamation systems for most communities within the Lake Michigan Basin in the Milwaukee metropolitan area. Under this return flow alternative, the City of Waukesha sanitary sewer system would collect flow from its sanitary sewer service area and convey return flow to MMSD for treatment and discharge to Lake Michigan. There are two subalternatives for return flow to MMSD:

- Sanitary sewer flow treated at the City of Waukesha WWTP with return flow to MMSD
- Sanitary sewer and return flow conveyed to MMSD without treatment at City of Waukesha WWTP

For either option, a new pump station would be located at the WWTP, and a pipeline alignment would be selected to provide return flow while minimizing impacts to environmental resources and other land uses. The City of Waukesha would continue to operate a WWTP, even for the subalternative under which the City would return untreated sanitary sewer flow to the MMSD.

Continued WWTP operation would occur because there are periods when sanitary sewer flow exceeds the water withdrawal. To prevent returning more than 100 percent of the withdrawn water, discharge to the Fox River for the additional sanitary sewer flow would continue. This intermittent operation of the WWTP would not be possible without significant modification of the existing WWTP processes.

For either subalternative, improvements to the MMSD collection system and treatment plants are likely required. The MMSD system is capacity limited during wet weather, so any flow returned to MMSD would likely require additional conveyance and treatment capacity equivalent to the return flow.

As with returning flow directly to Lake Michigan, returning flow to MMSD does not allow the return flow to be used as a resource, because the flow would not be in a Lake Michigan tributary. For the subalternative with treatment of return flow at the City of Waukesha WWTP and MMSD, the return flow would be inefficiently using resources by providing double-treatment with no significant improvement in return flow water quality.

SEWRPC included the MMSD in its evaluation of return flow alternatives, but it was not recommended because the cost exceeded that of return flow directly to Lake Michigan or to a Lake Michigan tributary.[29] Consequently, this alternative was not evaluated further for these reasons, and for those discussed above.

Preferred Return Flow Alternative

The City of Waukesha is committed to providing return flow for the withdrawn water, with a goal of returning 100 percent of it as discussed under "Return Flow Management Plan." Returning flow through Underwood Creek or Root River, or directly to Lake Michigan, can be achieved, but return flow through Underwood Creek is preferred because it has the least environmental impact, it maximizes use of existing utility corridors and previously disturbed areas, and the discharge can be used as an environmental resource by improving the habitat and fisheries in Underwood Creek and the Menomonee River. Exhibit 5-14 summarizes the environmental impacts for the return flow alternatives for a 75-foot-wide corridor along the pipeline alignments.

EXHIBIT 5-14
Summary of Potential Environmental Impacts for Return Flow Alternatives

Return Flow Alternative	Stream Crossings	Water Body Crossings	Water Body Crossings (acres)	Wetlands (acres)
Underwood Creek	17	8	0.15	9.4[a]
Root River	24	9	0.34	12.4
Direct to Lake Michigan	19	8	6.5	5.4

[a]For an outfall near Bluemound Road. The impacts are about 5.0 acres for a discharge 0.9 mile upstream.

Return flow to Underwood Creek also will protect public health by providing return flow with water quality that meets or exceeds the effluent limits proposed by the WDNR. These proposed effluent limits would be a higher standard than that from other Lake Michigan tributary dischargers.

Return flow through Underwood Creek is also the least cost alternative. Because return flow to Underwood Creek and Root River has similar benefits, the additional cost and additional impacts further support Underwood Creek as the preferred alternative. Exhibit 5-15 summarizes the cost

[29] SEWRPC. 2008. Planning Report No. 52: A Regional Water Supply Plan for Southeastern Wisconsin. Chapter 9, Page 37.

estimates for return flow under the three alternatives studied. Flow returned directly to Lake Michigan is least preferred because it does not allow the discharge to provide an environmental resource, and it is the highest cost. A cost estimate for return flow to MMSD was not made, because the alternative is not being considered further.

EXHIBIT 5-15
Cost Comparison for Return Flow Alternatives

Return Flow Alternative	Capital Cost[a]	Annual Operations and Maintenance	20-Year Present Worth	50-Year Present Worth
Underwood Creek	$56,874,000	$119,000	$58,239,000	$58,750,000
Root River	$74,415,000	$145,000	$76,079,000	$76,701,000
Direct to Lake Michigan	$117,556,000	$159,000	$119,380,000	$120,063,000

[a]Includes direct construction cost, contractor administrative costs (insurance, bonds, supervision etc), 25% contingency, and costs for permitting, legal, engineering, administrative.

SECTION 6

Compact Compliance

Compliance with the requirements of the Great Lakes–St. Lawrence River Basin Water Resources Compact and the Wisconsin Compact implementing statute (§281.346(1) (ps), Wis. Stats. are summarized in Exhibit 6-1. Many of the terms and expressions used below are defined in the Compact and included in a glossary at the end of this application.

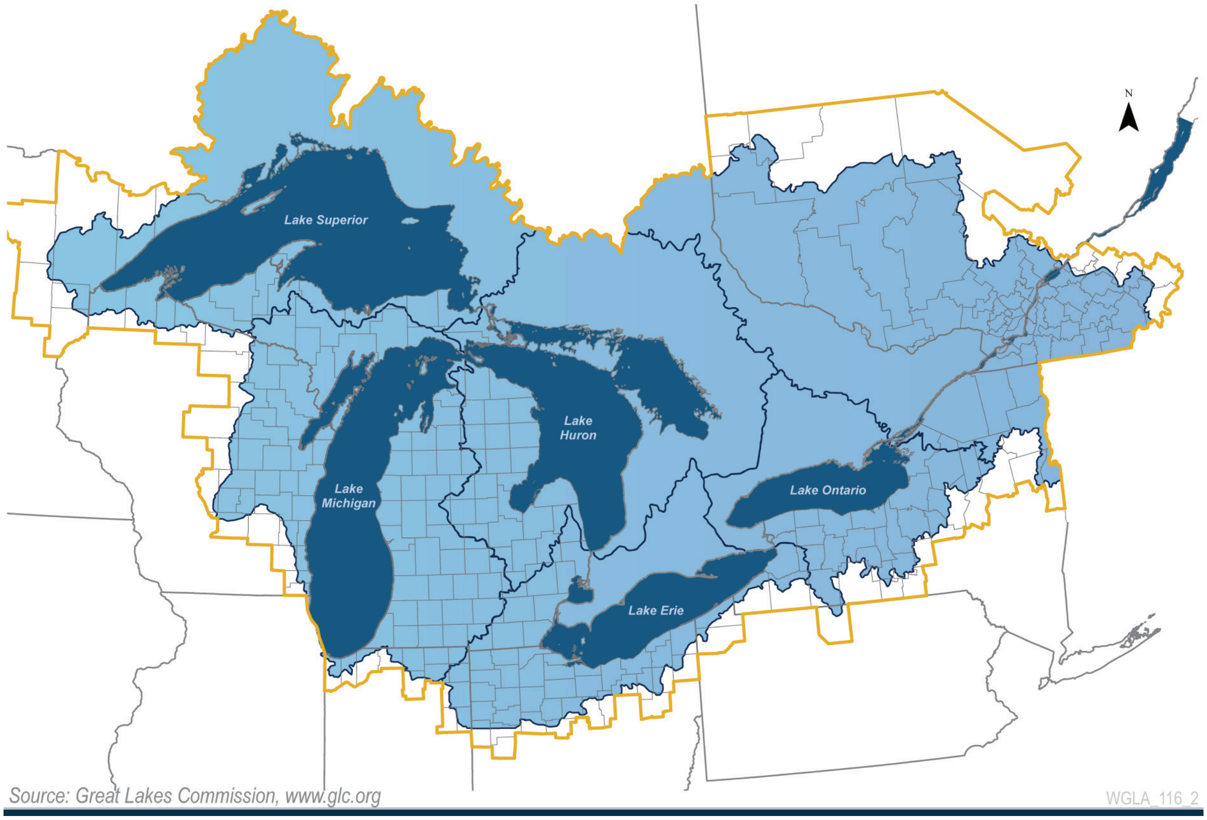

EXHIBIT 6-1

Compact Compliance Summary

Compact Article 4, Section 4.9.3 Exceptions to the Prohibition of Diversion. Straddling Counties. A proposal to transfer Water to a Community within a Straddling County that would be considered a Diversion under this Compact shall be excepted from the prohibition against Diversion, provided that it satisfies all of the following conditions: Section 4.9.3.a. 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 water;	The City of Waukesha is located in a straddling county of Waukesha County, Wisconsin. The City is located 18 miles west of Lake Michigan and 1.5 miles west of the Great Lakes watershed surface water divide. The Waukesha Water Utility is a public water supplier authorized and governed under municipal ordinance Chapter 3, subsection 02, and operates under Chapter 185, Wisconsin Statutes, Standards for Water Public Utility Service. The water utility is regulated by the Wisconsin Department of Natural Resources and the Wisconsin Public Service Commission. The City withdraws about 87 percent of its water supply from the deep St. Peter Sandstone Aquifer. Its wells draw water from depths of 1,600 to 2,100 feet below ground. The aquifer serves as a water source for many communities in Wisconsin and Illinois. It served the City of Milwaukee before that city switched to a Lake Michigan surface-water supply in the 1950s. Today, aquifer drawdown is 5 to 9 feet per year,[1] and water quality issues are increasing with declining groundwater levels. The dramatic drawdown of the aquifer (an estimated 500 to 600 feet since the nineteenth century[2]) is in part attributed to a geological feature called the Maquoketa shale confining layer that limits the recharge of the aquifer from rain and snow. Reduced groundwater levels in southeastern Wisconsin have in turn affected regional surface waters, which now receive about 18 percent[3] less in groundwater contribution as water migrates toward the deep aquifer. Significant water quality issues occur with declining water levels in the deep aquifer, including increased levels of salts and radium (a naturally occurring element in the deep aquifer that can cause cancer). To provide drinking water with low levels of radium, the City treats some deep aquifer water to remove radium and blends some deep aquifer water with water from the shallow, glacial till aquifer. Extensive modeling and studies conducted by the USGS, the WGNHS, and other leading researchers show that the continued use of the deep aquifer for water supply is unsustainable. Increased pumping of the aquifer stresses water resources by reducing baseflows in local streams and wetlands. Increasing water removal from the deep and shallow aquifers to meet demands at the cost of environmental resources is not a reasonable long-term water supply strategy. The City of Waukesha needs an adequate supply of potable water as defined by Wisconsin Act 227 this is economically and environmentally sustainable in the long-term, is protective of public health, and does not have adverse environmental impacts greater than those likely to result from a new diversion. The City needs a new long-term public water supply and requests a Lake Michigan supply with return flow to protect and manage regional water resources so that they are available for future generations.

1 Waukesha Water Utility operating data.

2 *Draft Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* SEWRPC, 2008, p.102–103.

3 USGS and WGNHS.

EXHIBIT 6-1
Compact Compliance Summary

Compact Article 4, Section 4.9.3.b 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;	The City of Waukesha will maximize the amount of water returned to the basin by managing return flow to equal the withdrawn water volume less consumptive use. Consumptive use in the City averages 8 percent of the water supply.[4] By comparison, the USGS found consumptive use in the Great Lakes can range as high as 74 percent for the domestic and public sector, with an average between 12 to 15 percent.[5, 6] The City has a goal to exceed the Compact requirements by returning 100 percent of the withdrawn water over a management period. The City has a sanitary sewer collection system that flows to the City's wastewater treatment plant. There are no combined sewers in the City of Waukesha. Return flow will be conveyed from the City's wastewater treatment plant to the Lake Michigan basin. The City's sanitary sewers have some infiltration and inflow (I&I) during wet weather periods, but the City has been implementing an aggressive I&I reduction program. The City's collection system and WWTP have adequate capacity to provide treatment of the I&I, but the City is working to reduce the I&I that could be part of the return flow. To identify and reduce the sources of I&I, the City has surveyed the collection system with sewer televising, smoke testing and dye tracing; replaced sewer laterals, cracked pipes and manholes; and lined manholes and sewers. The City continues to reduce I&I through more sophisticated monitoring and testing. Its capital improvement program includes additional improvements that will cost-effectively minimize I&I and out-of-basin water in the return flow. Because I&I contributes to WWTP flows in excess of the water withdrawal, the maximum return flow rate will not include the WWTP flows where I&I have the greatest contribution. Instead, the return flow rate will not exceed 15 percent more than the average withdrawal (as discussed in Section 5 of this application). By limiting the return flow rate, I&I contributions above this amount will not contribute to return flow and the out-of-basin water contribution from I&I will be minimized. WWTP flows exceeding the return flow amount will be discharged to the Fox River, which is within the Mississippi River watershed and is the current discharge location for the WWTP. With a Lake Michigan water supply, the City will stop pumping groundwater, which will result in the draw-up of water levels in both the deep and shallow aquifers. Reducing pumping will also increase the groundwater baseflow contributions to the local environmentally sensitive streams, wetlands, and brooks.
Compact Article 4, Section 4.9.3.c The Proposal shall be subject to management and regulation by the Originating Party, regardless of its size;	The WDNR, the Originating Party, will manage and regulate the diversion.

[4] Waukesha Water Utility operating data 1999–2009, using the USGS Winter-Base Method, USGS Report 2009-5096, Kimberly H. Shaffer.

[5] USGS, Consumptive Water Use in the Great Lakes Basin, 2008, Fact Sheet 2008-3032, page 3.

[6] USGS Consumptive Water Use Coefficients for the Great Lakes Basin and Climatically Similar Areas, 2007, Scientific Investigations Report 2007-5197, page 25.

EXHIBIT 6-1

Compact Compliance Summary

Compact Article 4, Section 4.9.3.d There is no reasonable water supply alternative within the basin in which the community is located, including conservation of existing water supplies;	The quality and quantity of the City of Waukesha's current water supply is decreasing. It is projected the groundwater supply will not remain feasible in the future. Continued pumping will result in greater aquifer depletion and negative impacts on local wetlands, streams and brooks. The Lake Michigan supply is the most environmentally sound and economically feasible water supply option for the City. In addition to extensive water supply studies conducted by SEWRPC with the support of the USGS and the WGNHS, the City has completed the following related investigations: *Report on City of Waukesha Crestwood Well No. 9 Water Quality Investigation, City of Waukesha, Waukesha County, Wisconsin,* Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., May 1999. *Report on the Time Domain Electromagnetic Induction Survey for the Waukesha Water Utility, City of Waukesha, Waukesha County, Wisconsin,* Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., March 2000. *Report on the Time Domain Electromagnetic Induction Geophysical Survey for Well 11, City of Waukesha, Waukesha County, Wisconsin,* Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., November 2001. *Report on Geological Reconnaissance for Well 11, Aquifer Science & Technology, City of Waukesha, Waukesha County, Wisconsin,* Division of Ruekert & Mielke, Inc., April 2002. *Future Water Supply Study, City of Waukesha,* CH2M HILL and Ruekert & Mielke, May 2002. *Report on Geophysical Surveys and Recommendation for Continued Well Exploration Activities for Shallow Wells near West High School, City of Waukesha, Waukesha County, Wisconsin,* Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., March 2003. *Report on the Potential of Developing a Municipal Well Field in the unconfined Portion of the Sandstone Aquifer, Waukesha County, Wisconsin,* Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., April 2003. *Report on the Sand and Gravel Test Boring Results at Rivers Crossing Site, City of Waukesha, Waukesha County, Wisconsin,* Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., June 2003. *Well Site Investigation Report Wells No. 11 and No.12, City of Waukesha, Waukesha County, Wisconsin,* Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., July 2003. *Report on the Geophysical Investigation Results and Recommendations for Timm, Illing, and Rivers Crossing Sites, Town of Waukesha, City of Waukesha, Waukesha County, Wisconsin,* Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., January 2004. Followup memo regarding the preliminary geophysical recon at the Green Lane and Hwy 18 sites, Town of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., June 2004.

EXHIBIT 6-1
Compact Compliance Summary

Report on Engler Site Test Boring Results and Recommendations, City of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., September 2004.

Report on Engler Site Contaminant Inventory Review and Geophysical Study Results, City of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., December 2004.

Report on the Geophysical Investigation Results and Recommendations, Highway 18 Site, Town of Delafield, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., June 2005.

Report on the Howell Sites Geologic Reconnaissance Results, City of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., June 2005.

Report on the Engler Site Test Boring Results and Recommendations, City of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., July 2005.

Report on the Lathers Site Geologic Reconnaissance Results, Town of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., September 2005.

Radium Removal Pilot Plant Study, CH2M HILL, 2005.

Report on the Rivers Crossing Site Test Well 14 Results and Recommendations, City of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., January 2006.

Report on the Engler Site Test Well Results and Recommendations, City of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., January 2006.

Report on the Well Site Investigation for Proposed Production Well No. 13, Engler Site, City of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., April 2006.

Report on the Geophysical Investigation and Test Boring Activities, Lathers Site, Town of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., May 2006.

Final Report Water System Master Plan, City of Waukesha, 2006, EathTech.

Report on the Geophysical Investigation Results and Recommendations, Woodland Hills Development, City of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., October 2006.

EXHIBIT 6-1
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Report on the Geologic Reconnaissance Results for Merrill Hills Road School Property, Town of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., October 2006.

Report on the Geophysical Survey Results and Recommendations for the Howell Trust Site, City of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., October 2006.

Report on Phase II Geophysical Investigation and Test Boring Results and Recommendations for Lathers Site, Town of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., June 2007.

Report on the Test Boring Results for Woodland Hills Development, City of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., November 2007.

Report on the Wolf Sand and Gravel Site Geologic Reconnaissance Results, Town of Genesee, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., December 2007.

Report on Test Boring Results and Recommendations, Howell Trust Site, City of Waukesha, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., November 2007.

Report on Empire Oil Geologic Reconnaissance Results, Town of Genesee, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., April 2008.

Report on the Geophysical Survey Results and Recommendations for the Empire Oil Site, Town of Genesee, Waukesha County, Wisconsin, Aquifer Science & Technology, Division of Ruekert & Mielke, Inc., August 2008.

Summary of Water Requirements Technical Memorandum, AECOM, 2009.

In 2006, the City Implemented a Water Conservation and Protection Plan that has accomplished significant water savings through water sprinkling restrictions, conservation water rates, plumbing fixture replacement, public education, regional water conservation collaboration, and strategic alliances with national water conservation agencies. Total water use by City customers has dropped 31% from 1988 to 2008, despite an 18% population increase.[7] While the City's efforts continue to be successful, water conservation measures alone cannot offset the projected need for water supply.[8]

The results of extensive studies and aggressive water conservation efforts indicate that Lake Michigan is the only feasible source for the long-term water supply needs of the community.

7 Waukesha Water Utility operating data, 1988 through 2008.

8 AECOM. 2009. *Summary of Water Requirements Technical Memorandum.*

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Compact Article 4, Section 4.9.4 Exception Standard Proposals subject to management and regulation shall be declared to meet this Exception Standard and may be approved as appropriate only when the following criteria are met: Section 4.9.4.a. The need for all or part of the proposed Exception cannot be reasonably avoided through the efficient use and conservation of existing water supplies;	The proposal is based on continuation and expansion of the City's aggressive water conservation and protection plan, described in Section 3 of the application. Current water conservation measures include sprinkling restrictions, inclining water rates, public education and high efficiency plumbing fixture rebates. The City is well on its way of achieving its 2005 goal of 20 percent reduction in per capita water use by 2020. In addition to water conservation, the City uses several leading drinking water industry best practices for water efficiency. These include metering all customers and investing in main replacement to minimize leaks. The City historically operates with less than 5% unaccounted-for water. As effective as these programs are, they are not sufficient to completely meet water supply needs in and by themselves. The need for the proposed diversion cannot reasonably be avoided through the efficient use and conservation of existing water supplies.
Compact Article 4, Section 4.9.4.b The Exception will be limited to quantities that are considered reasonable for the purposes for which it is proposed;	The proposed quantity of water is limited by the supply needed to serve the projected City of Waukesha water service area population as delineated by SEWRPC in the 2008 regional water supply study. Under Wisconsin Act 227 and Chapter NR 121, Wisconsin Administrative Code, SEWRPC is the area wide water quality planning agency designated by the State to delineate proposed water supply services for all public water supply systems in the southeastern Wisconsin planning area. The SEWRPC regional water supply study evaluated water supply alternatives to balance economic development, social development and environmental protection in southeastern Wisconsin. The findings and recommendations of this study include consideration of the efficient use of water, including water conservation, to minimize water waste. The City of Waukesha developed average day and maximum day water demands solely for their water service area, based on past water system performance and water conservation efforts. The proposed quantities of 10.9 mgd average day and 18.5 mgd maximum day demand were estimated from fact-based plans and actual operating data.
Compact Article 4, Section 4.9.c All Water Withdrawn shall be returned, either naturally or after use, to the Source Watershed less an allowance for Consumptive Use. No surface water or groundwater from the outside the Basin may be used to satisfy any portion of this criterion except if it: Is part of a water supply or wastewater treatment system that combines water from inside and outside the Basin;	While there are minor differences between the City of Waukesha water and wastewater service areas, SEWRPC considers those areas to be essentially the same.[9] These minor differences are quantified in Appendix E, Waukesha Wastewater Facility Plan Amendment, Return Flow. The City of Waukesha has a Consumptive Use of 8% as described in Section 3 of this application. The break down by customer class in the City of Waukesha water service area are residential (45%), commercial (35%), industrial (16%) and public (4%). There are no major industrial or commercial operations in the City of Waukesha that incorporate water into their products.

[9] SEWRPC/Philip Evenson, Executive Director. 2008. Letter to Waukesha Water Utility/Daniel S. Duchniak, P.E., General Manager. December 23. p. 1.

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Is treated to meet applicable water quality discharge standards and to prevent the introduction of invasive species into the Basin;	Return flow will be implemented to ensure that no cumulative adverse impacts result to the quantity and quality of the Waters and Water Dependent Natural Resources. Returning flow through a tributary is projected to have a positive impact on the tributary with the returned water providing necessary flows to allow an increase in aquatic and wildlife habitat. Return flow will also improve the water quality of the Lake Michigan tributaries for some parameters because the high quality treatment provided by the City of Waukesha WWTP provides effluent quality much better than the tributary water quality. For example, improved water quality is expected for fecal coliforms, and total suspended solids. The Lake Michigan water supply, City of Waukesha water use, and City of Waukesha wastewater collection and treatment systems will not be sources of invasive species that could be introduced to the Great Lakes. These systems are primarily closed and not conducive to migration of invasive species. All return flow will be directly from the City of Waukesha WWTP with a direct discharge to the Lake Michigan basin.
Compact Article 4, Section 4.9.4.d 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;	The City proposes to provide 100% return flow to achieve a water balance and prevent measurable impact to the water dependent industries of the Great Lakes such as shipping or hydropower generation. The cumulative impacts of discontinuing the withdrawal of groundwater from the deep aquifer include assisting in the recovery of both surface water and groundwater resources. With current pumping practices, Lake Michigan now flows into the deep aquifer rather than being recharged by the deep aquifer, as was the hydrogeologic condition before pumping started in the 19th century. Switching from the groundwater supply to a Lake Michigan surface water supply would allow the cone of depression to begin recovery and reduce the diversion of water from the Lake Michigan groundwatershed to the Mississippi River watershed.[10] The existing deep cone of depression also induces leakage away from inland surface water down toward the declining groundwater level. The cumulative impacts of discontinuing the withdrawal of groundwater from the shallow aquifer is restoration of the critical baseflows to surface water resources including wetlands, streams, and lakes. The cumulative impacts of return flow to Underwood Creek include increased flow that will benefit aquatic and wildlife habitat by contributing to restoration measures already being implemented along the creek and the Menomonee River. The quality of the City's treated wastewater meets or exceeds the WPDES discharge permit requirements, under the Clean Water Act, for the receiving stream in the Lake Michigan basin. On individual days the amount of return flow may be greater than or less than the amount of the withdrawal, but over the management plan period, the amount of return flow will equal the amount of the withdrawal.

[10] S. L. Burch. 2002. *A Comparison of Potentiometric Surfaces for the Cambrian-Ordovician Aquifers of Northeastern Illinois, 1995 and 2000.* Illinois State Water Survey Data/Case Study 2002-02.

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	The proposed diversion will have no significant adverse impacts on the Great Lakes Basin ecosystem. The cumulative impacts of a Lake Michigan water supply are contributions to the sustainability of groundwater resources, increased baseflows to local surface water resources, enhancement of the Lake Michigan source watershed and effective leadership in water conservation.
Compact Article 4, Section 4.9.4.e. The Exception will be implemented so as to incorporate Environmentally Sound and Economically Feasible Water Conservation Measures to minimize Water Withdrawals or Consumptive Use;	The estimated water supply needed to meet the projected Waukesha water service area assumes that water conservation measures are in place and further reductions in water use are realized. If Waukesha had not implemented a successful water conservation and protection plan, the estimated maximum day demand for the projected water service area would be 20 to 24 mgd. With a commitment to continued water efficiency and conservation, the City proposes a withdrawal of 18.5 mgd. The City's water conservation plan has been referred to by the Wisconsin PSC as a model for conservation planning in the state. It identifies practical near-term, mid-term, and long-term goals and actions to be evaluated and implemented. The effectiveness of the conservation practices being used is measured so that the City can adapt the plan and target investment to maximize water savings.
Compact Article 4, Section 4.9.4.f. The Exception is 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;	The City will meet all applicable municipal, state, and federal laws as well as regional interstate and international agreements. The requirements of the Boundary Waters Treaty of 1909 are not triggered by this proposal.
S. 281.346 (3), Wis. Stats., STATEWIDE REGISTRATION AND REPORTING	The registrant for the diversion is the City of Waukesha located at 115 Delafield Street, Waukesha, Wisconsin 53188-3615
Any person who proposes to begin a withdrawal from the waters of the state . . . shall register the Withdrawal or Diversion with the department . . . and provide all the following information: Name and address of the registrant and date of registration. Locations and sources of the withdrawal or diversion. Daily capacity of the withdrawal or diversion. Estimate of the volume of the withdrawal or diversion in terms of gallons per day average in any 30-day period. Uses made of the water. Places at which the water is used.	The City proposes a single source and single location for a Lake Michigan water supply. The City is discussing the purchase of drinking water from Lake Michigan–supplied public water systems in the City of Milwaukee, the City of Oak Creek, and the City of Racine. For the projected buildout (beyond 2035) City of Waukesha water service area, as delineated by SEWRPC, the maximum day capacity of the proposed supply is 18,500,000 gallons per day; the average 30-day estimated volume of the proposed supply is 10,900,000 gallons per day.[11] For the 20-year planning period (2028) City of Waukesha water service area, the maximum day capacity of the proposed supply is 18,000,000 gallons per day; the average 30-day estimated volume of the proposed supply is 10,700,000 gallons per day.[12] Water will be used solely for public water supply.

11 AECOM. 2009. *Summary of Water Requirements Technical Memorandum.*
12 Ibid.

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Places at which any of the water is discharged Whether the water use is continuous or intermittent Whether the Person holds a permit under S.283.31	Water service is currently provided to the following customer classes: residential (45%), commercial (35%), industrial (16%) and public (4%). There are no major industrial or commercial operations in the City of Waukesha that incorporate water into their products for distribution outside the Basin. Water use and return flow will be continuous. The City of Waukesha does not hold a diversion permit.
Act 227, Section 18. 281.346 (4) DIVERSIONS (f) Exception standard (3m) 3m. 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: a. Not cost−effective. b. Not environmentally sound. c. Not in the interest of public health. 4. No water from outside the Great Lakes basin will be returned to the source watershed unless all of the following apply: a. The returned water is from a water supply or wastewater treatment system that combines water from inside and outside the Great Lakes basin. b. The returned water will be treated to meet applicable permit requirements under s. 283.31 and to prevent the introduction of invasive species into the Great Lakes basin and the department has approved the permit under s. 283.31. c. If the water is returned through a structure on the bed of navigable water, the structure is designed and will be operated to meet the applicable permit requirements under s. 30.12 and the department has approved the permit under s. 30.12.4m. 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 ss. 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.	The Lake Michigan source water will be from a provider in the southeastern Wisconsin regional planning area. Return flow alternatives were considered that discharge directly to Lake Michigan and to lake tributaries in the Greater Milwaukee Watersheds. The preferred return flow location is to Underwood Creek, a lake tributary that will return flow to Lake Michigan through the Menomonee River. Return flow to Underwood Creek is also the most cost effective return flow alternative and is roughly half the cost of returning water directly to Lake Michigan. A return flow to Underwood Creek meets all of the requirements because: a. The City of Waukesha's sanitary sewer system collects wastewater flow in the City and conveys it to the Waukesha WWTP. At the WWTP, wastewater is treated to required standards and returned to the Great Lakes basin. b. Return flow will be treated to meet Wisconsin s. 283.31 (*Water Pollutant Discharge Elimination System; Permits, Terms and Conditions*) requirements. The return flow will prevent the introduction of invasive species by only returning treated wastewater conveyed in a pipe directly from the WWTP to the return flow location. The return flow will have an approved permit under Wisconsin s. 283.31. c. The applicable permits and associated operating requirements for a lake discharge (s. 30.12) or tributary discharge (s. 30.12.4m) will be obtained before the return flow outfall is constructed. The preferred return flow location on Underwood Creek has been analyzed for protecting and sustaining the physical, chemical, and biological integrity under ss. 30.12, 281.15, and 283.31. The physical integrity (geomorphology) of the stream has been shown to be protected (Appendix L), the chemical integrity of the stream has been shown to be protected (Appendix H), and the biological integrity of the stream has been shown to be protected (Appendix L) along with preventing the introduction of invasive species as described above. Temperature of the return flow has been considered (Section 5) and is consistent with other municipal wastewater discharges. Changes in nutrient loadings were evaluated (Appendix H) and found to be less than 1 percent of expected annual loadings to Lake Michigan.

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Glossary

Applicant. A person who is required to submit a proposal that is subject to management and regulation under the Compact.

Aquifer. An underground storage area that holds water in layers of porous rock and sediments

Build-out condition. State that exists when all of the land available for development has been developed in a manner consistent with the regional plan, which could be more than 50 years in the future.

Community within a straddling county. Any city, village, or town that is not a straddling community and tat is located outside the Great Lakes basin but wholly within a county that lies partly with the Great Lakes basin.

Compact. The Great Lakes–St. Lawrence River Basin Water Resources Agreement.

Consumptive use. The portion of the water withdrawn or withheld from the basin that is lost or otherwise not returned to the basin due to evaporation, incorporation in products, or other processes.

Cost-effectiveness analysis. A systematic comparison of alternative means of providing a water supply in order to identify alternatives that will minimize total resources costs and maximize environmental benefits over a planning period.

Cumulative impacts. 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 who undertakes the other withdrawals, diversions, and consumption uses. Cumulative impacts can result from individually minor but collectively significant withdrawals, diversions, or consumptive uses take place over a period of time.

Deep aquifer. Made up of thick sandstone layers that extend 2,000 feet underground.

Diversion. A transfer of water from the Great Lakes basin into a watershed outside the Great Lakes basin into a watershed outside the Great Lakes basin, or from the watershed of one Great Lake to another, by any means of transfer, including a pipeline, canal, tunnel, aqueduct, channel, ship, tanker truck, or rail tanker.

Great Lakes basin. Means the watershed of the Great Lakes and the St. Lawrence River upstream from the Trois-Rivieres, Quebec.

Groundwatershed. An area from which all groundwater flows to the same river, lake, or ocean.

Originating party. The party within whose jurisdiction an Application or registration is made or required.

Proposal. A withdrawal, diversion, or consumptive use.

Public water supply purposes. The water distributed to the public through a physically connected system of treatment, storage and distribution facilities serving a group of largely residential customers that may also serve industrial, commercial, and other institutional operators. Water withdrawn directly from the basin and not through such a system shall not be considered to be sued for public water supply purposes.

Recharge. Water added to an aquifer by rain, snowmelt, or exchange of surface waters.

Reasonable water supply alternative. A water supply alternative that is similar in cost to, an is 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.

Source watershed. The watershed from which a withdrawal originates.

Shallow aquifer. Made up of sand, gravel, and clay. Left behind by glaciers. In some areas, includes and upper layer of rock.

Total resources costs. Monetary costs and direct and indirect environmental as well as other nonmonetary costs.

Water. means the ground and surface waters contained within the basin.

Water dependent natural resources. The interacting components of land, Water and living organisms affected by the waters of the basin.

Watershed . An area from which all surface waters (rives, stream, runoff) flows to the same river, lake, or ocean.

Waukesha. The City of Waukesha.

Withdrawal. The taking of water from surface water or groundwater.

Without adequate supplies of potable water. Without a water supply that is economically and environmentally sustainable in the long term to meet reasonable demands for a water supply in the quantity and quality that complies with applicable drinking water standards, is protective of public health, is available at a reasonable cost, and does not have adverse environmental impacts greater than those likely to result from the proposed new or increased diversion.