Appendix D

Water Supply Service Area Plan for the City of Waukesha

Report

Water Supply Service Area Plan for the City of Waukesha

Prepared for

City of Waukesha, Wisconsin

April 2010

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Report

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Submitted to

City of Waukesha, Wisconsin

April 2010

CH2MHILL

Contents

*Not on compact disk; available for purchase from SEWRPC

Exhibits

Water Supply Service Area Plan for the City of Waukesha

In compliance with the requirements of the Great Lakes–St. Lawrence River Basin Water Resources Compact and the Wisconsin Compact implementing statute (§281.346, Wis. Stats. and §281.348, Wis. Stats), the City of Waukesha, Wisconsin, is submitting a water supply service area plan for the 20-year planning period from 2010 to 2030. The City is submitting the plan for review by the Wisconsin Department of Natural Resources (WDNR) because the City is applying for a Great Lakes diversion with return flow.

1. Background

1.1 City of Waukesha Water System

The City of Waukesha water system comprises groundwater supply, treatment, storage, and conveyance assets, shown schematically in Exhibit 1. The City's system is a "public water supply"—a means of distributing water to the public through a physically connected system of supply, treatment, storage, and distribution facilities that serve a group of largely residential customers, and that also serves industrial, commercial, and public customers. (§ 281.348(d), Wis. Stat.) The City also maintains a water utility administration building with offices for customer service, billing, supervisory control and data acquisition system control, meter testing, fleet storage, and equipment storage.

1.2 Waukesha Water Conservation and Efficiency

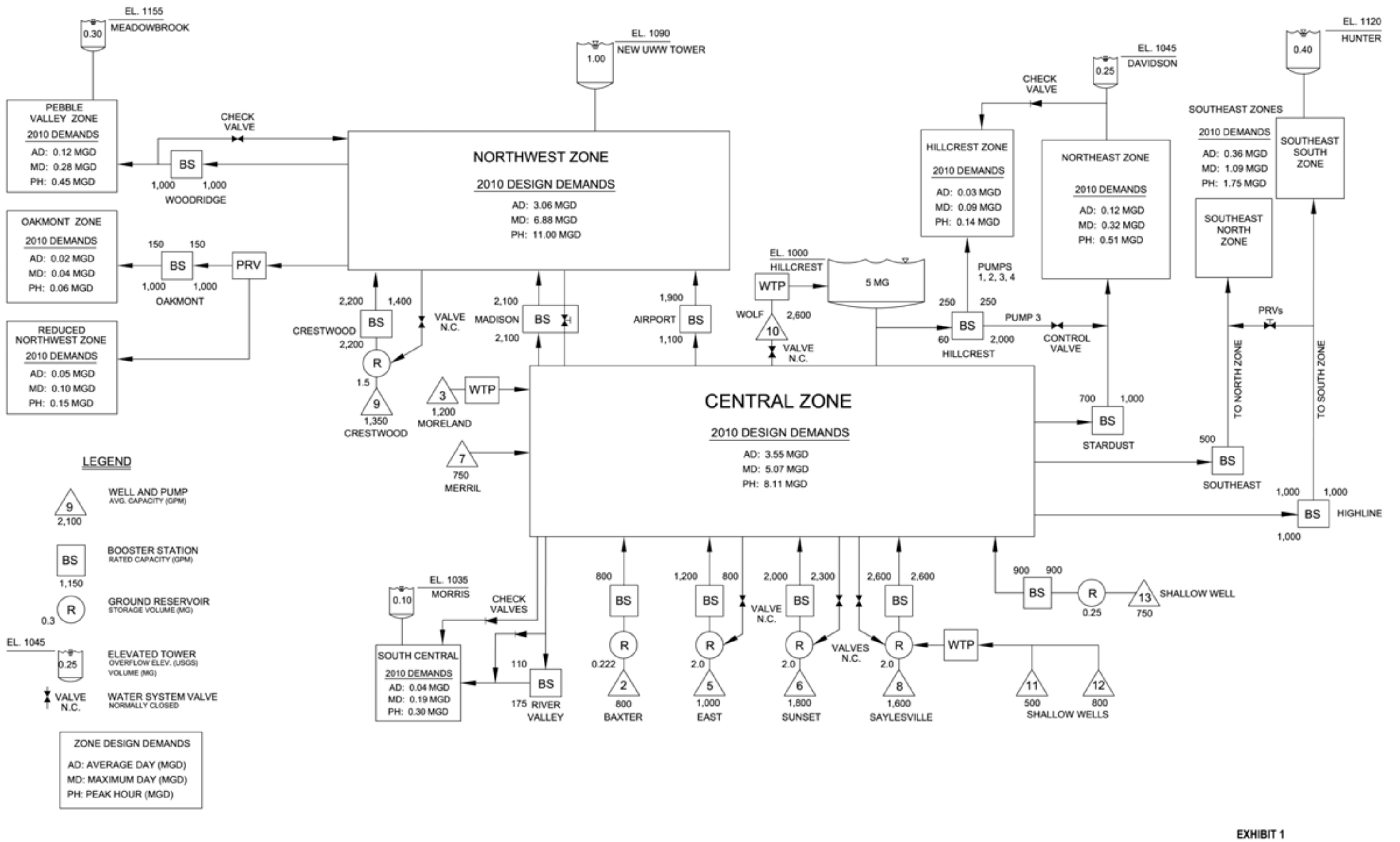
Since 2006, the City has implemented a variety of water conservation measures. These best practices, including implementation of rates that encourage water conservation, were authorized by the Wisconsin Public Service Commission. Further, the City's universal metering, leak detection and repair program, public education and landscape water controls are compliant with draft water conservation and water use efficiency rule (Wis. Admin. Code NR852.04(2)) being developed by the Wisconsin Department of Natural Resources (WDNR).

1.2.1 Accounting for Water

Measuring all water used is essential to ensuring wise water use. The City meters all water customers and monitors water use with accurate automatic flow meters that can be read remotely. Water use is described on customer bills in terms of gallons rather than cubic feet. This small detail helps customers understand how water use relates to behavior. Also, with automatic meters, City staff can easily monitor meter records. If a dramatic change in water use is observed, the City contacts a customer to promptly address potential water waste issues.

All water utilities, including the Waukesha Water Utility, have unavoidable water loss. This water loss, called unaccounted-for water, is used for fighting fires or flushing mains, or is lost through leaks in water pipes. To minimize unaccounted-for water, the City monitors the system for leaks and estimates water used for routine system flushing.

EXHIBIT 1
City of Waukesha Water System Schematic



Source: *Adapted from AECOM Master Plan, 2006*

EXHIBIT 1
Current Water System Schematic
Waukesha Water Utility
Waukesha, Wisconsin

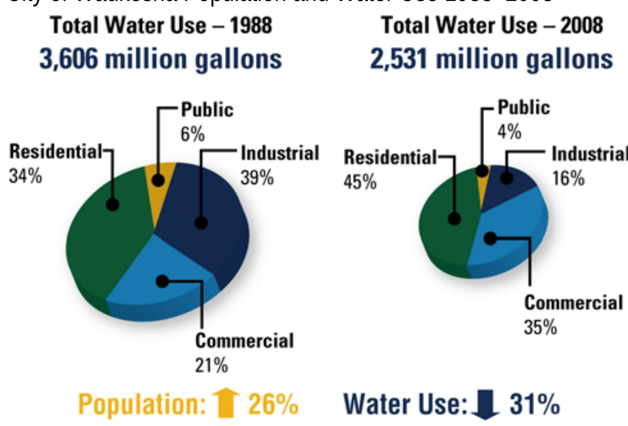
WBG110509184022MKE WGLA_150_Current_WWU_Schematic_v1

Historically, the City averages 4 to 7 percent unaccounted-for water,[2] which is less than the American Water Works Association-recommended benchmark of 10 percent.[3]

1.2.2 Water Conservation Measures

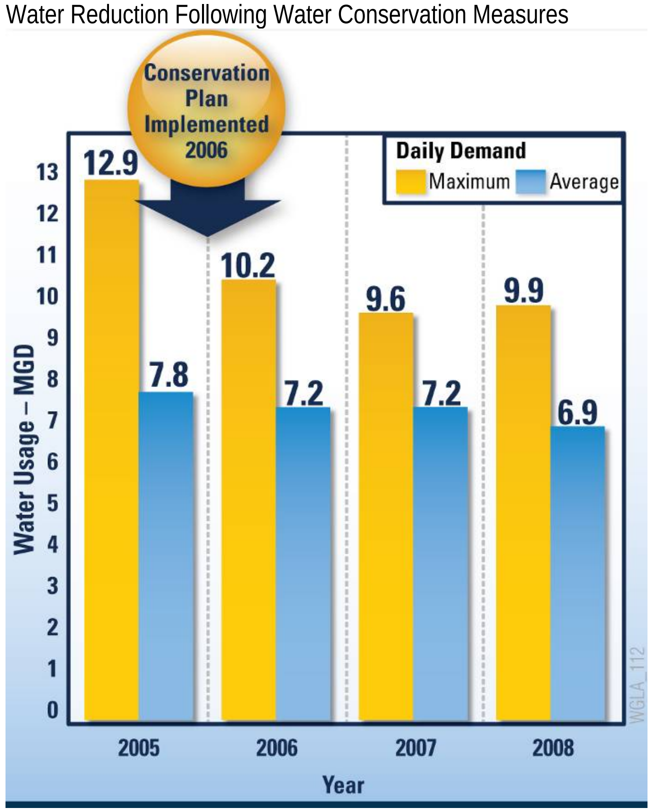
Total water use by City customers has dropped 31 percent from 1988 to 2008, despite a 26 percent population increase (Exhibit 2). Some of the decline in water use is attributed to industry leaving the area and the recent economic recession, but some of the reduction can be attributed to the City's water conservation and protection plan. In 2006, the City implemented a comprehensive water conservation plan to further reduce water use. Water conservation and protection efforts will be continued and monitored to determine which measures are the most effective. Highlights of the City's plan for continued investment in water conservation are presented in Exhibit 3.

EXHIBIT 2
City of Waukesha Population and Water Use 1988–2008



Source: Waukesha Water Utility

EXHIBIT 4
Water Reduction Following Water Conservation Measures



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 demand and reducing overall average day demand.

Water bill inserts, refrigerator magnets, and press releases were used to educate the public regarding the ordinance. In 2007, street signs with sprinkler ordinance information were installed. These actions were successful in reducing the average and maximum day water demand. Comparisons show a 15 percent reduction in summer watering season water use from 2005 to 2008 (Exhibit 4). The baseline year of 2005 was chosen because it is the year before implementation of the conservation plan.

[2] Waukesha Water Utility annual operating data submitted to Wisconsin Public Service Commission.
[3] AWWA Leak Detection and Accountability Committee, 1991.

EXHIBIT 3
City of Waukesha Water Conservation and Protection Plan Goals

Relative Water Savings Benefit Scale: (1 drop) = Minimal (2 drops) = Moderate (3 drops) = 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.	Moderate
Continue Student Water Education – Teach Waukesha students about the water level in the aquifer, the importance of conservation, and practices their families can implement.	Major
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.	Major
Communicate Monetary Benefits of Water Conservation – Place water conservation cost savings information in customer bills.	Moderate
Accelerate Water Main and Lateral Replacement – Continue to replace outdated mains and service laterals, helping to ensure a reduction in leaks.	Major
Promote Water Conservation – Create brochures, magnets, signage, and a public service announcement; attend events to promote conservation.	Moderate
Implement Conservation Water Rates – Develop with the Public Service Commission a water pricing structure that encourages conservation.	Major
Loop Water Mains – Have contractors loop the water mains to reduce hydrant flushing water requirements.	Minimal
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.	Major
Recycle Filtered Backwash Water – Implement a recycling process for Wells 8, 11, and 12.	Minimal
Audit Water Use in City Buildings – Starting with City Hall, audit all city buildings to identify ways to reduce water use.	Moderate
Develop Incentives/Rebates Programs – Continue to work with the Public Service Commission to determine the feasibility and potential success of rebate programs.	Major
Implement Rain Barrel Program – Work with the Coalition to provide rain barrels for landscaping maintenance water supply.	Moderate
Become a Member of WaterSense – Gain current information on tested products to meet performance standards of plumbing fixtures for our rebate programs.	Moderate
Join Alliance for Water Efficiency – Acquire and implement best management practices for water conservation.	Moderate
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.	Moderate

Mid-term Goals

Continue Student Water Education Programs – Update curriculum.	Major
Continue Public Outreach Program – Provide press releases, and update brochures and materials. Update Utility Web site.	Moderate
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.	Major
Implement City Water Audit – Install water-saving fixtures throughout Utility facilities.	Major
Evaluate Indoor Incentives/Rebates Programs – Evaluate rebate programs for targeted water-using appliances and fixtures.	Major
Evaluate Outdoor Incentives/Rebates Programs – Evaluate rebates for outdoor water use equipment (timers, sprayers).	Major
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.	Major
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.	Major
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.	Major
Reduce City Departments and Schools Outdoor Water Use – Identify opportunities for reduced outdoor sprinkling in parks and school fields.	Moderate
Evaluate Sewer Credit Meters – Investigate the phase-out of residential sewer credit meters to further encourage reductions in outdoor water use.	Moderate
Pilot Low-impact Development on City Properties – Add green infrastructure, such as rain gardens and permeable pavement, to City properties.	Moderate
Work with Housing Authority to Update Public Housing Plumbing – Work with Waukesha Housing Authority to update water fixtures in Waukesha public housing.	Moderate
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.	Major
Form Regional Source Water Protection Planning Committee – Work with surrounding utilities to better coordinate source water protection.	Minimal
Communicate Monetary Benefits of Water Conservation – Place individual account water use information on the internet and on water bills.	Moderate
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.	Major

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.	Minimal
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.	Minimal
Audit Commercial and Industrial Sectors Water Use – Work with commercial and industrial customers to identify areas to reduce water use and save customers' money.	Major
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.	Major

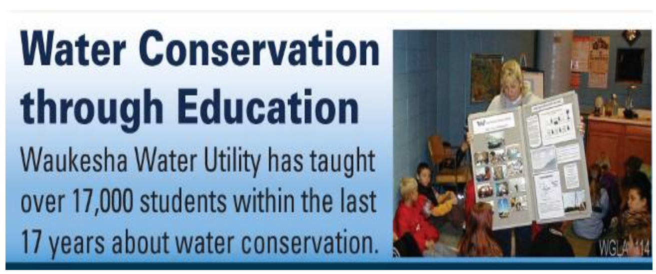
WGLA_125

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 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 5 summarizes the single-family residential rates before and since water conservation rates were implemented. 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,[4] a few key changes with a small number major water users has resulted in significant water savings.

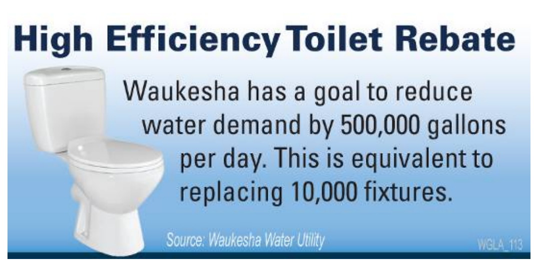
EXHIBIT 5
City of Waukesha Water Conservation Rates

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: over 30,000	3.40
Quarterly Use (gal.)	**2007 Rate ($ / 1,000 gal.)**
Tier 1: 0 to 30,000	1.95
Tier 2: 30,001 to 40,000	2.20
Tier 3: over 40,000	2.70
Quarterly Use (gal.)	**Pre-conservation Rate ($ / 1,000 gal.)**
Tier 1: 0 to 40,000	1.69
Tier 2: 75,000 to 1,425,000	1.14
Tier 3: over 1,425,000	1.02

Water Conservation Education in Public Schools. The hallmark of the City's water conservation public outreach program is its contribution to the environmental education curriculum in the City of Waukesha. Fifth- and ninth-grade students are taught about water conservation by Waukesha Water Utility staff. By visiting water facilities, operating tabletop groundwater models, and collaborating with teachers, the City has introduced water conservation to more than 17,000 students.[5]



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.[6] 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 old high-flow toilets with new high-efficiency toilets. To help meet this goal, the City is providing



4 Waukesha Water Utility annual operating data, 2009.
5 Waukesha Water Utility. 2009. Annual Educational Program Data.
6 Amy Vickers. 2001. *Handbook of Water Use and Conservation*.

rebates for fixture replacement.

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 of business, government, education, and local stakeholder groups, collaborated on countywide messages on water conservation.

Waukesha County Water Conservation Coalition:

- Initiated rain barrel distribution to increase outdoor use of stormwater instead of drinking water
- Created restaurant table tents 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

1.3 Waukesha Water Supply Sources

The City of Waukesha's current source of water supply is groundwater. The City of Waukesha has 11 functional wells, 8 in the deep aquifer and 3 in the shallow aquifer (Exhibit 6). Approximately 87 percent of Waukesha's supply is from the deep St. Peter Sandstone aquifer, which has severely declining water levels and significant water quality issues. About 13 percent of Waukesha's supply is from the shallow Troy Bedrock Valley aquifer, which feeds sensitive surface water resources and also has water quality issues.

EXHIBIT 6
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	Abandoned because of contamination	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 (backup service only)	1.94
10	2,145	3.74
11	127	0.47
12	149	0.90
13	105	1.01

With the passage of the Great Lakes–St. Lawrence River Basin Water Resources Compact, Lake Michigan became a potential source of water supply for the City of Waukesha. Because the City lies wholly within a county that is partially in the Basin, the City may apply to withdraw Lake Michigan water for public water service and return treated water to the Great Lakes Basin.

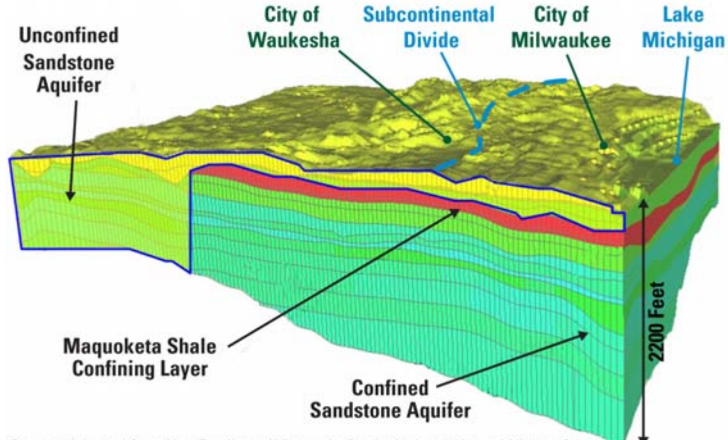
The potential sources of water supply for the City are discussed below and in Section 3 Water Supply Alternatives.

1.3.1 Deep Sandstone Aquifer

The City's deep aquifer wells are constructed to depths of greater than 2,100 feet and withdraw water from 800 to 1,000 feet below ground. Since the 1840s, the aquifer has served as a source of water supply for many communities in Wisconsin and Illinois. Today deep aquifer water supply pumping in southeastern Wisconsin results in additional groundwater level declines of 5 to 9 feet per year.[7]

[7] Waukesha Water Utility operating data.

EXHIBIT 7
Hydrogeology of Southeastern Wisconsin



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

The dramatic drawdown of the aquifer (an estimated 500 to 600 feet in the confined aquifer since the nineteenth century[8]) is in part attributed to the Maquoketa shale confining layer, a geological feature that limits the recharge of the aquifer by rain and snow (Exhibit 7).

Not all of the St. Peter Sandstone aquifer is confined. Parts of the aquifer are unconfined but located outside the jurisdiction of the City. In the unconfined part of the aquifer in southeastern Wisconsin, groundwater levels have declined more than 100 feet. The largest capacity wells in that area supply the City of Oconomowoc and had an average annual flow of 1.8 mgd.[9, 10] In addition to significant draw down and associated environmental impacts, the installation of more wells to meet the City's needs will undoubtedly result in legal challenges because Wisconsin law protects against municipal withdrawal of large amounts of water from a particular area and transporting that water to other locations for its use. Installation of high capacity wells in the unconfined aquifer would interfere with other communities' and land owners' beneficial use of the water and would expose the City to numerous damage claims from other municipalities and homeowner associations.[11]

The deep aquifer is not an adequate source of supply for the City because pumping exceeds the rate at which the aquifer can be renewed. The quantity of available groundwater is decreasing. The deep aquifer is not a reliable, adequate source of supply for the future.

Waukesha's Water Supply Linkage to Great Lakes Basin. The drawdown of the deep sandstone aquifer and continued pumping are also having a measurable impact on the Great Lakes Basin. The U.S. Geological Survey (USGS), the Wisconsin Geological and Natural History Survey (WGNHS), and other leading researchers in Wisconsin and Illinois have conducted extensive modeling and studies of the deep sandstone aquifer. USGS recently determined that most of water withdrawn from southeastern Wisconsin over the last 136 years was not derived from groundwater storage but rather from captured baseflow.[12] Baseflow is groundwater that under natural conditions would discharge to streams and lakes, including Lake Michigan. Because of pumping, groundwater has been diverted to wells instead of supplying water to surface water resources.

Groundwater pumping has also moved the groundwater divide—the boundary that defines the flow of groundwater toward Lake Michigan or to the Mississippi River—farther to the west (Exhibit 8). The natural hydrogeology has been altered so that the deep aquifer, which

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

[9] SEWRPC. 2008. *Draft Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Chapter II, p. 107

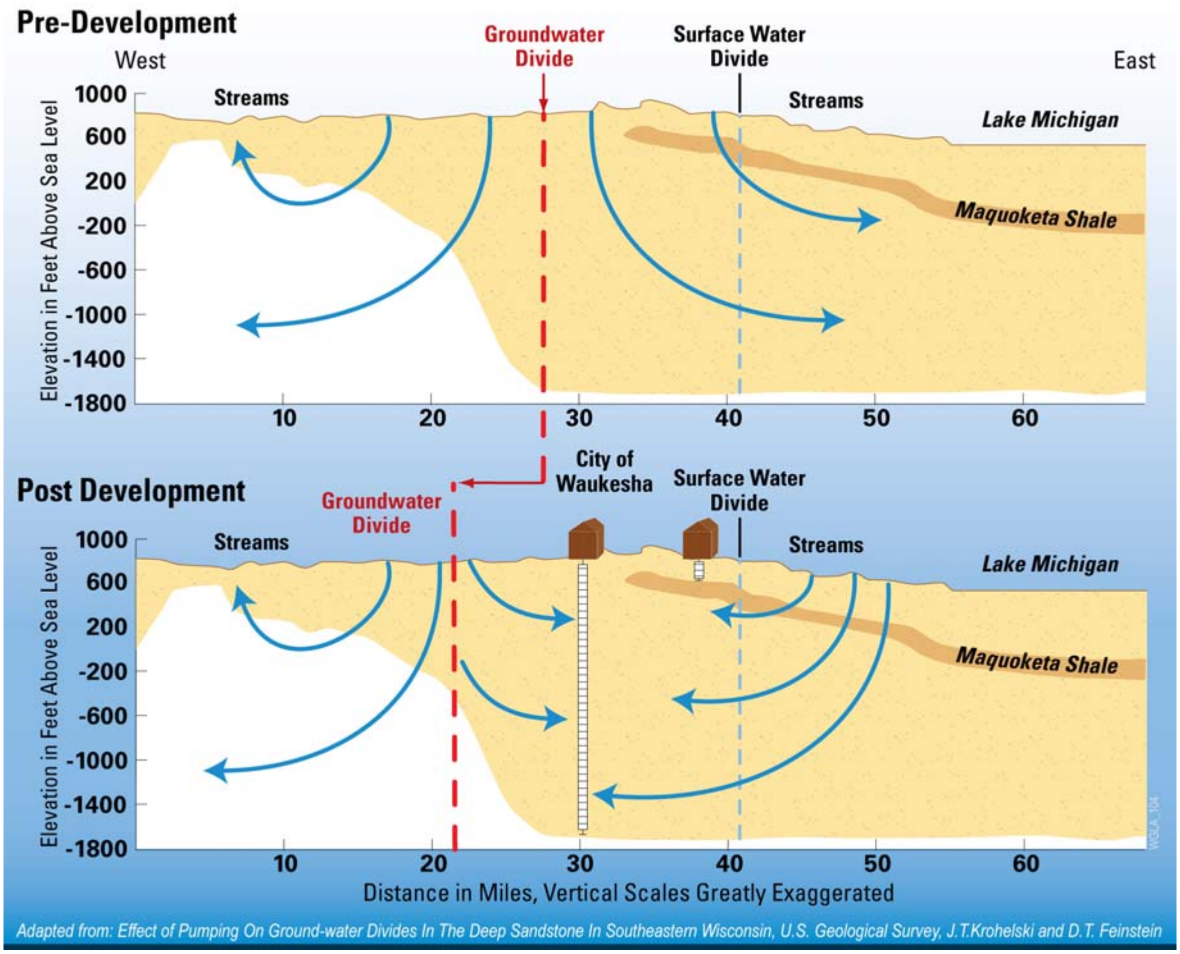
[10] Utility operating data, City of Oconomowoc. 2009.

[11] State v. Michaels Pipeline Construction Inc., 63 Wis.2d 278, 292 (1974).

[12] USGS. March 2007. *Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin.*

historically fed the Lake Michigan Basin with groundwater, now draws water from the Lake Michigan Basin. Even though the City's wells are outside the Great Lakes surface water divide, they withdraw water from both the Mississippi River Basin and the Great Lakes Basin. The USGS estimates that 30 percent of the 33 mgd of water pumped by the deep aquifer wells in southeastern Wisconsin originates from inside the Lake Michigan Basin.[13]

EXHIBIT 8
Flow of Groundwater in the St. Peter Sandstone Aquifer



Reducing or eliminating pumping of the deep sandstone aquifer would have a significant positive effect on groundwater levels. Measurements taken after other communities have replaced deep aquifer groundwater supplies with a Lake Michigan supply indicate recovery of the aquifer. In areas of northeastern Illinois, where groundwater withdrawal has ceased because communities have converted from the deep St. Peter Sandstone aquifer to a Lake Michigan supply, groundwater levels at former pumping centers recovered more than 100 feet.[14] For southeastern Wisconsin, the USGS estimated that if all pumping of the deep

[13] D. T. Feinstein, USGS. October 2006.*Where do the deep wells in southeastern Wisconsin get their water?*

[14] 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 ceased in year 2000, the aquifer would similarly recover over this century. Specifically, USGS estimates that :[15]

- To replace 50 percent of the water drawn out of storage, it would take 13 years for the shallow portion and 9 years for the deep portion of the aquifer to recover.
- To replace 90 percent of the water drawn out of storage, it would take 100 years for the shallow portion and 70 years for the deep portion of the aquifer to recover.

Based upon the available scientific evidence, it has been shown that the City's groundwater supply is derived in part from groundwater that is interconnected hydrologically to the Lake Michigan Basin. Ceasing groundwater pumping of the deep aquifer will reduce amount of groundwater withdrawn from the Lake Michigan Basin. [16]

Deep Aquifer Groundwater Quality. As water is pumped from greater depths, naturally occurring contaminants, primarily radium and total dissolved solids (TDS), are present in progressively high concentrations and require removal to meet drinking water standards. 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). The naturally occurring radioactive isotopes radium-226 and radium-228 are present in the aquifer because of parent elements in the sandstone. The isotopes are known to be carcinogenic. The concentration of radium in the City's groundwater supply is as high as 15 piC/L, which is among the highest levels in the country.

To provide drinking water that is compliant with regulations, the City developed an interim plan with the WDNR that includes 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 2 deep wells with combined capacity of 5 mgd. The City has until 2018 to complete the capital investments needed for full compliance with the 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.

USEPA regulates TDS, hardness, and salts 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. As groundwater levels decline, the concentration of TDS increases. Currently, TDS concentrations in the City's wells range from 300 to 1,000 mg/L. To mitigate high TDS concentration, wells can be partially blocked to avoid high TDS water. Plugging reduces well capacity by as much as 35 percent, as evidenced by modifications to the City's Well No. 9.[17] When TDS concentrations are consistently at 1,000 mg/L greater, it is common practice to treat the water to remove salts. Desalting, or desalination, is a costly and energy-intensive process that would be necessary for the long-term continued use of the deep wells.

[15] USGS. March 2007. *Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin.*
[16] Ibid.
[17] Waukesha Water Utility operating data for Well 9, 2000 and 2006.

Cumulative Impacts of Deep St. Peter Sandstone Aquifer Pumping. The City's deep aquifer pumping contributes to the following cumulative impacts:

- Groundwater level decline on the order of 5 to 9 feet per year
- Baseflow reduction of 12 percent to surface water resources in the region, as water is drawn toward deep wells[18]
- Reversal of the natural flow system that has caused more than 10 times the water that once flowed east toward Lake Michigan through the deep aquifer in southeastern Wisconsin to now converge from all directions on pumping centers19
- Diversion of as much as 30 percent of the water replenishing the deep aquifer from the Waters of the Basin20
- Ultimate discharge of water from the Great Lakes Basin to the Mississippi River Basin

1.3.2 Shallow Troy Bedrock Valley Aquifer

The City draws about 13 percent of its water supply from the shallow aquifer (Troy Bedrock Valley formation) overlying the Maquoketa shale. That formation is a source of water supply for the Village of Mukwonago and the City of Muskego; it is also hydraulically connected to sensitive environmental resources including the Vernon Marsh Wildlife Area, Pebble Brook (a Class II trout stream), and Pebble Creek. Because of quantity and quality concerns with the deep aquifer, the City has considered the shallow aquifer as a greater source of supply.

To estimate the impacts of the City significantly increasing its withdrawal from the shallow aquifer, hydrogeologic modeling was conducted with the Troy Bedrock Valley Aquifer Model.[21] The model predicted groundwater level draw down and the baseflow reduction index if additional City wells are in service. Baseflow is groundwater that discharges to, or feeds, surface water bodies. The groundwater discharge is the inflow that keeps surface waters flowing during dry periods. Estimating the loss of baseflow from groundwater pumping is critical to understanding whether the shallow aquifer is a sustainable water supply. To quantify impacts on baseflow, a baseflow reduction index was used in regional water supply planning studies.[22, 23]

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

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

Although the wells needed to meet the City's demands in the model were spread over an extensive area and located at least 1,300 feet from sensitive water resources, additional shallow aquifer withdrawal resulted in severe drawdown at the wells of up to 50 to 100 feet

18 USGS. Groundwater in the Great Lakes Basin: The Case of Southeastern Wisconsin.

19 D. T. Feinstein, USGS, October 2006. *Where do the deep wells in southeastern Wisconsin get their water?*

20 Ibid.

21 SEWRPC. January 2010. *Southeastern Wisconsin Regional Planning Commission Report No.188.*

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

23 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, p. 11.

and reduction of baseflow to surface waters ranging from 17 to 340 percent.[24] For reference, the historical baseflow reduction index for Waukesha County from 1920 to 2000 is less than 10 percent.[25]

Shallow Aquifer Groundwater Quality. Groundwater from the shallow aquifer requires treatment to meet secondary drinking water standards of 0.3 mg/L for iron, 0.05 mg/L for manganese, and primary standard of 10 ppb for arsenic. Given the results of the Troy Bedrock Valley aquifer modeling, there is also evidence that both the Fox River water and groundwater could be impacted by contaminants from septic waste disposal systems that would be drawn into shallow wells. To address these contaminants, conventional surface water treatment is needed to provide safe drinking water.

Expansion of the Troy Bedrock Valley aquifer supply is not a reasonable water source because withdrawing the quantity of water needed by the City would have a devastating cumulative impacts on state-protected water resources.

Cumulative Impacts of Shallow Troy Bedrock Valley Aquifer Pumping. Additional shallow aquifer pumping by the City would contribute to the following cumulative impacts:

- Significant decline of groundwater levels
- Baseflow reduction indices ranging from 17 to 340 percent for surface waters including the Vernon Marsh Wildlife Area and the Pebble Brook Class II trout stream
- Over 400 existing private wells could be impacted by the City pumping as little at 6.4 mgd from the shallow aquifer to meet the public water system demand26

1.3.3 Water Conservation Practices

Water savings from conservation is another source of water supply. Based on the effectiveness of current water conservation measures and projected water use across various customer classes over the water supply planning period, and beyond, it is estimated that an additional 10 percent water savings may be gained through conservation. This volume, approximately 1 mgd, is not sufficient to offset the future water demands.

1.3.4 Lake Michigan

The purpose of the Compact is to encourage adaptive water management and conservation of Great Lakes Basin (Basin) water resources. The Compact is designed to protect, conserve, restore and improve the Waters and Water Dependent Natural Resources of the Basin. The City of Waukesha may be successful in an application for a Lake Michigan diversion if the following conditions of the Compact are met:

- The diverted water will be used solely for the City's public water supply because the City is without adequate supplies of potable water.
- The portion of diverted water that is returned to the Waters of Basin is maximized and the portion of the returned water that is from the Mississippi River basin is minimized.

[24] *Results of Groundwater Modeling Study Shallow Aquifer Groundwater Source, Fox River & Vernon Marsh Area, Waukesha Water Utility*, RJN Environmental Services, April 2010.
[25] Cherkauer, p. 13.
[26] RJN Environmental Services.

- The City does not have a reasonable water supply alternative within the Mississippi River basin, including conservation of existing groundwater supplies.
- The diversion with return flow does not endanger the integrity of the Basin ecosystem.

In preparation for the passage of the Great Lakes Compact, the City participated in a case study funded by the Great Lakes Protection Fund. The study—*Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply*—arrived at several critical conclusions about a potential diversion for the City. Chief among them was that changing sources from the current groundwater supply to a withdrawal from Lake Michigan would improve the groundwater resources of the Great Lakes Basin through ceasing groundwater pumping. Further, the Lake Michigan withdrawal has no measurable effect on the Basin.[27]

Cumulative Impacts of a Lake Michigan Supply. Switching from a groundwater to a Lake Michigan supply would have the following cumulative impacts:

- Assist in the recovery of both surface water and groundwater resources.
- Assist in the restoration of the natural flow system wherein the deep aquifer feeds the Waters of the Great Lakes.
- Eliminate the diversion of water from the Lake Michigan groundwatershed to the Mississippi River Basin.
- Result in no impact on Lake Michigan water level for the proposed diversion of 10.9 mgd with return flow.
- Prevent radium in wastewater treatment plant sludge from being discharged into the environment

1.3.5 Combined Lake Michigan and Groundwater

To limit the Great Lakes diversion to the smallest reasonable quantity, a combination of Lake Michigan water and shallow aquifer water was evaluated by the City. An alternative with deep aquifer water and Lake Michigan water was not developed. One reason is that Illinois and Wisconsin are both supportive of the goal of eliminating the use of the deep St. Peter Sandstone aquifer. The goal is to enhance recovery of the deep aquifer. Another reason for not combining water sources is related to the practical public water system operating challenges of continuously meeting water quality regulations and system pressure requirements. See Section 4 for additional discussion. Under the shallow aquifer/Lake Michigan supply alternative, return flow to the Great Lakes Basin would consist of both Lake Michigan water and Mississippi River Basin groundwater. It is not evident that this alternative meets the intent of the Compact to protect the Basin ecosystem by minimizing the return of water from outside the Great Lakes Basin.

[27] Great Lakes Protection Fund, *Case Study Report – Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply*, August 2003, p. ES-5.

2. Water Supply Service Area Planning

2.1 Delineated Water Service Area

To prepare a long-term Water Service Area Supply Plan, the City obtained a delineation of a 20-year water supply service area attendant to the Waukesha Water Utility. The delineation was prepared by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) for use in developing a water supply plan in support of an application for a Lake Michigan water source. Under ch. NR 121, Wis. Adm. Code, SEWRPC is granted authority to delineate the proposed water supply service area for the public water supply systems—including the City of Waukesha—in its planning area. (§ 281.348 (3)(c)(9)(cm), Wis. Stat.)

Exhibit 9 shows the proposed delineated service area and other land use plan information. Eighty-five percent of the planned water service area is already developed or designated as natural and environmentally sensitive areas to be preserved in a manner consistent with the regional land use plan.[28] Fifteen percent of the planned water service area would be available for future development.

2.2 Water Service Area Population Projections and Water Demand Forecasts

SEWRPC prepared population projections for the City of Waukesha water supply service area.[29, 30] To account for economic uncertainty, SEWRPC prepared regional population projections assuming low, intermediate, and high growth scenarios. SEWRPC estimated a Waukesha water supply service area population of 88,500 in 2035 under an intermediate growth scenario. The estimated "ultimate population" for the water supply service area is 97,400. The ultimate population projection represents a condition beyond the SEWRPC 2035 planning horizon. It occurs when all land available for development has been developed in a manner consistent with the regional land use plan. For water supply planning purposes, the City assumed the ultimate population will be reached in 2050. Exhibit 10 shows the population projections. The interpolated projections for the 20-year planning period (2010–2030) are also depicted. (§ 281.348 (3)(c)(3m), Wis. Stat.)

SEWRPC prepared future water demand forecasts based on intermediate population projections. The demand forecasts considered water service area demographics, land use plans, and water use data from years 2000, 2004, and 2005.[31] The 2035 water demand forecasts were prepared using multiple factors including implementation of water conservation practices. Water conservation measures were estimated to result in 4 to 10 percent average day demand water savings, depending on the type of water supply.[32] For the Waukesha water service area, a 10 percent average day demand reduction was selected and factored into the water demand forecasts. This reduction represents an increase in water conversation effectiveness over and above the current levels of water conservation. Exhibit 11 summarizes the 2035 water demand forecasts.

[28] SEWRPC. 2008. Preliminary Draft, *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin,* Chapter I, p. 5-6.

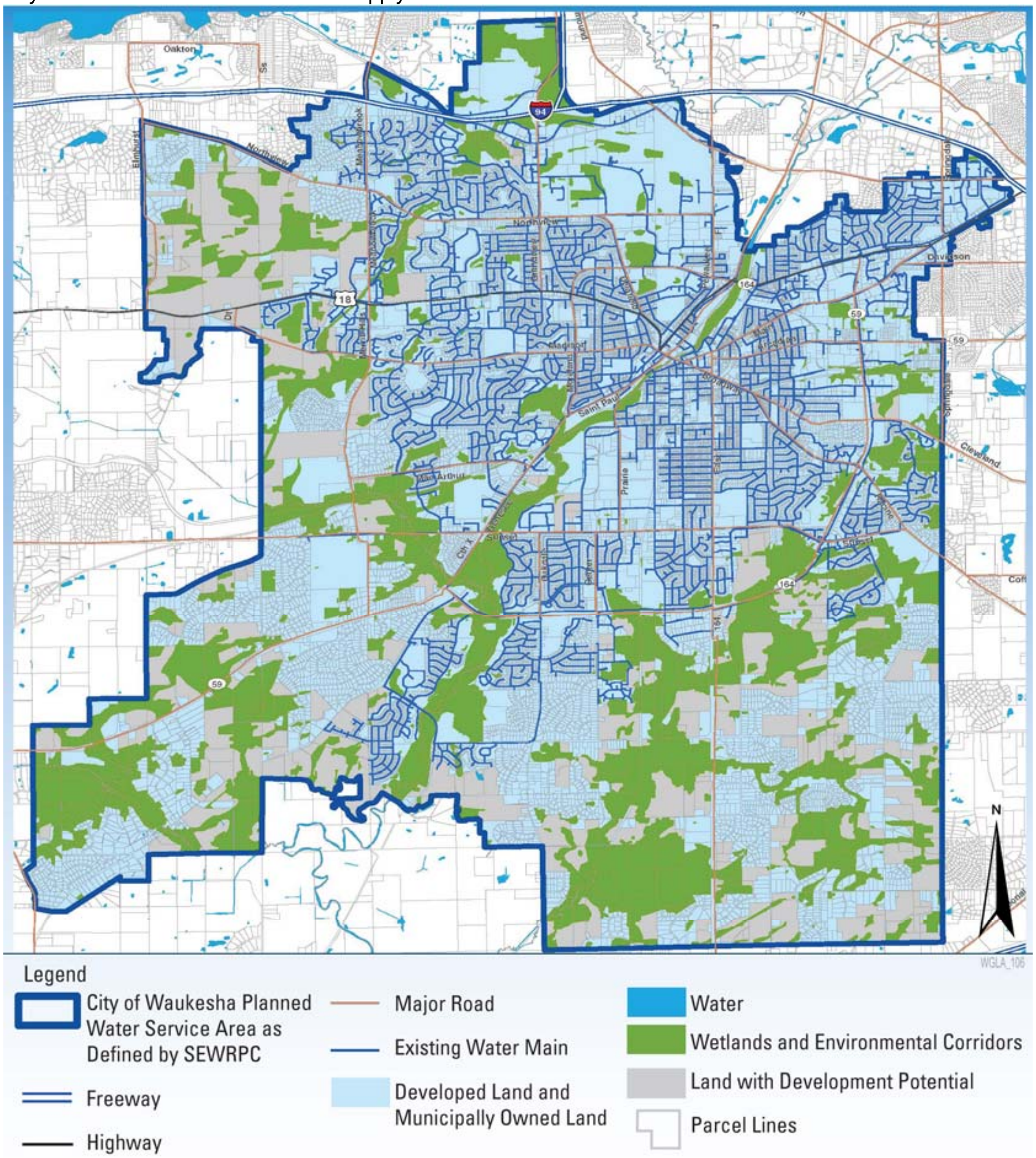
[29] Ibid. Chapter IV, p. 52.

[30] Kenneth R. Yunker, P.E., SEWRPC/Executive Director. March 17, 2009. Letter to Steven Crandall Community Development Director, City of Waukesha.

[31] SEWRPC. 2008. Chapter IV, p.7.

[32] Ibid., Chapter IV, p. 39.

EXHIBIT 9
City of Waukesha Delineated Water Supply Service Area



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

EXHIBIT 10
City of Waukesha Water Supply Service Area Population Projections

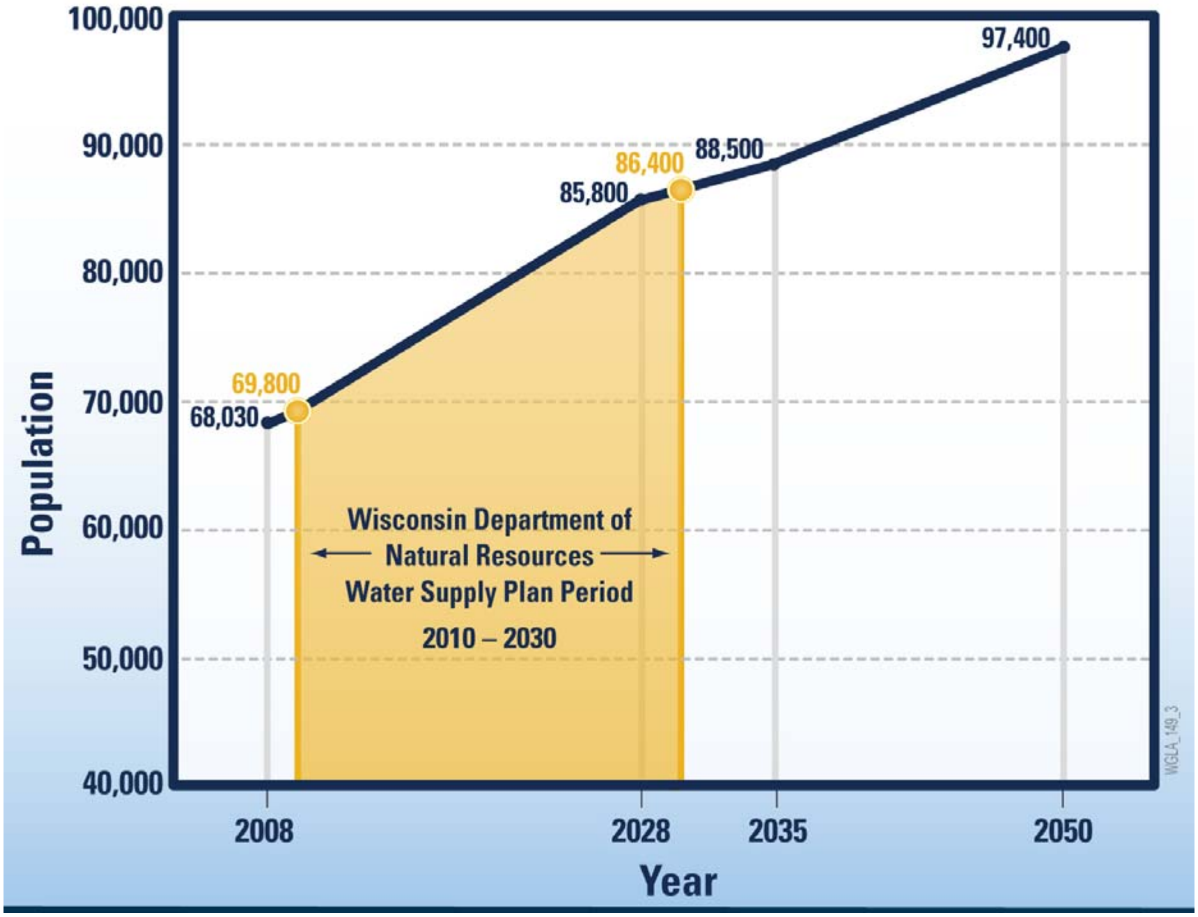


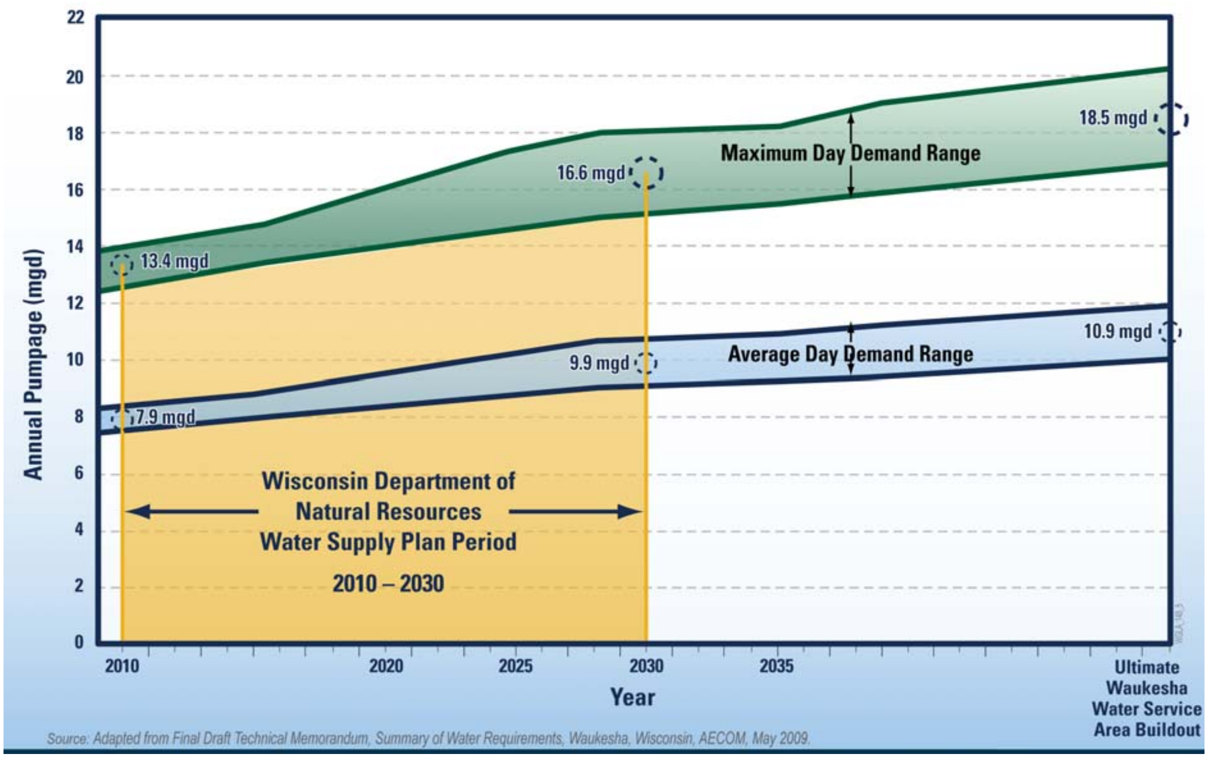
EXHIBIT 11
2035 Water Demand Forecasts

Water Use	Value
2035 Average Daily Pumpage Including 5 percent allowance for firefighting flow and unaccounted for water and 10 percent additional water conservation	9.8 mgd
2035 Average Daily Demand Including 10 percent additional water conservation	9.3 mgd
2035 Average Daily Demand Without water conservation	10.2 mgd
2035 Maximum Day Demand Based on 1.37 peaking factor and including 10 percent additional water conservation	13.7 mgd
2035 Per Capita Water Use Based on 2035 Population of 88,500	111 gallons/capita day

Preliminary Draft *Planning Report on Regional Water Supply Plant for Southeastern Wisconsin*, Chapter IV, pp. 52, 53, 72

The City used the SEWRPC planning projections, 38 years of Waukesha water system operating data, the service area land use plan, and City's water conservation and protection plan to develop water demand forecasts for the ultimate water service area population of 97,400. Ranges of average- and maximum-day demands, developed by considering greater variability in population and water conservation were prepared, as shown in Exhibit 12. The interpolated demand forecasts for the 20-year planning period (2010–2030) are also depicted. (§ 281.348 (3)(c)(3), Wis. Stat.)

EXHIBIT 12
City of Waukesha Water Supply Service Area Demand Projections



Two water demand factors vary between the SEWRPC and City forecasts. First, the City's amount of unaccounted-for water and firefighting flow historically equals 4 to 7 percent of total water pumpage. For long-range planning, the City used a realistic, but conservative value of 7 percent, in lieu of the 5 percent value used by SEWRPC on the basis of Waukesha's performance in 2000, 2004, and 2005.

Second, the City used a more conservative peaking factor to estimate maximum day demand. A peaking factor a 1.68 was used after consideration of several decades of Waukesha system performance and the inherent uncertainty of very long-range water supply plans that need to address potential impacts of climate change, including drought. The peaking factor of 1.37 used by SEWRPC was based on peak flows in 2000, 2004, and 2005. Exhibit 13 tabulates the demand values.

EXHIBIT 13
Ultimate Water Service Supply Area Water Demand Forecasts

Water Use	Value
Ultimate Average Daily Including 7 percent allowance for firefighting flow and unaccounted for water and continued water conservation	10.9 mgd
Ultimate Average Daily Demand Without water conservation	12.0 mgd
Ultimate Maximum Day Demand Based on 1.68 peaking factor and including continued water conservation	18.5 mgd
Ultimate Per Capita Water Use Based on Ultimate Population of 97,400	112 gallons/capita/day

Final Draft Technical Memorandum, Summary of Water Requirements, Waukesha, Wisconsin, AECOM, May 2009

2.3 Waukesha 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. (§ 281.346(1)(e), Wis. Stats.). Public water suppliers can calculate their consumptive use coefficients following the USGS Winter Base-Rate Method.[33] Based on water utility data over the past 10 years, the City of Waukesha annual average consumptive use is 8 percent. 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.[34, 35]

3. Alternative Plans for Water Supply

The City and others have studied extensively the water resources in the Waukesha area.[36, 37, 38] Based on this work the City developed alternative plans to meet the needs of the water supply service area. The alternative plans are consistent with the applicable Regional Water Supply Plan prepared by SEWRPC. (§ 281.348(8), Wis. Stat.) Further, the alternative plans assume the City continues water conservation and efficiency measures. (§ 281.346 (5m) d, Wis. Stat.)

Because a Great Lakes supply is among the alternatives considered, plans were evaluated on the basis of the following criteria (§ 281.348(4), 281.348 (5), Wis. Stat.):

- Environmental impact to the Waters of the Great Lakes Basin
- Protection of public health

[33] USGS, Kimberly H. Shaffer. 2009. Scientific Investigations Report: 2009-5096.

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

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

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

[37] SEWRPC. 2008.

[38] Cherkauer. 2009.

- Long-term sustainability to provide the public with adequate supplies of potable water for generations
- Implementability (infrastructure and land requirements, legal issues, operational complexity and public impact issues)

Costs of the alternatives were also estimated. The cost estimates assume that existing water storage and distribution system infrastructure will be used to the extent practicable. (§ 281.348(6), Wis. Stat.)

3.1 Previous Studies of Water Supply Alternatives

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

3.1.1 Future Water Supply Study

In March 2002, the City of Waukesha Water Utility completed a future water supply study.[39] 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 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 14.[40]

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

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

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

[39] CH2M HILL with Ruekert & Mielke. *Future Water Supply Study*, 2002.
[40] Ibid.

EXHIBIT 14
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.

A brief summary of the results follows.[41]

Continued use of the deep confined aquifer (current water supply for Waukesha) was ranked lowest because:

- It is not sustainable over the long term due to drastically declining water levels and water quality requiring extensive treatment (radium and total dissolved solids removal)
- Negative environmental impacts to the deep aquifer, shallow aquifers, surface water and hydrologically connected waters of the Great Lakes Basin
- Potential negative public health impacts from radium and high dissolved solids in the water
- It also had the highest cost for facilities and long term operations and maintenance

The deep unconfined aquifer alternative, far west of Waukesha, also was ranked low because:

- Negative impacts to the surrounding groundwater and surface water environment due to groundwater table drawdown and water budget depletion
- Negative impacts to other water users currently using this source
- Poor public acceptance and potential lawsuits
- Extensive infrastructure requirements due to the distance from Waukesha
- High costs for facilities and long term operations and maintenance

With the deep aquifer alternatives ranking lowest, the Future Water Supply Study report recommended further evaluation of the highest ranked alternatives:

- Lake Michigan

[41] Ibid.

- Shallow aquifer sources

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, a reasonable water supply.

For the shallow aquifer alternatives, the report recommended evaluating sustainable capacities from the aquifers, environmental impacts of extracting 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.[42]

3.1.2 SEWRPC Regional Water Supply Plan

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, *Planning Report on Regional Water Supply Plan for Southeastern Wisconsin.* This plan is an extensive evaluation of water supply alternatives for the seven-county area, including the City of Waukesha, to 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 treatment plant effluent
- Deep aquifer and artificial recharge using treated Lake Michigan water
- Combinations of these alternatives

[42] SEWRPC. 2008.

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:

- 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.[43] 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.[44]
- 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.

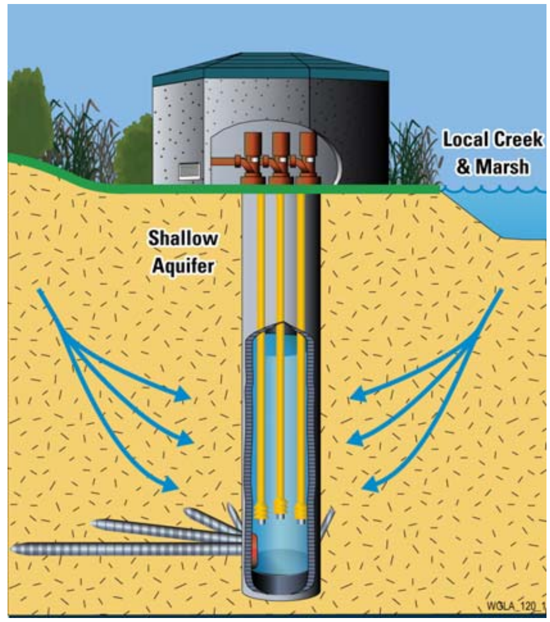
The SEWRPC report did not evaluate a deep unconfined aquifer alternative west of Waukesha, as was done in the Future Water Supply Study. SEWRPC assumed that groundwater supplies will be located within 1 mile of the 2035 water supply service area to minimize public concerns and municipal boundary issues. 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.[45]

Installing high capacity wells in the unconfined aquifer west of the Maquoketa shale presents not only a number of logistical but also definite legal problems. Installation of high capacity wells in an unconfined aquifer would create legal challenges, expose the City to numerous damage claims from lake area homeowners and municipalities, and be a source of continuing controversy in the region. The City, for example, could be liable if withdrawal of water caused unreasonable harm through lowering the water table for residential and municipal wells in the area. The City could be liable if its withdrawal of groundwater has a direct and substantial

[43] Ibid.
[44] Ibid.
[45] Ibid.

effect upon the water of a watercourse or lake (i.e., effects to base flow or lake levels). Damages could include the cost of new wells, deepening existing wells, the cost of water treatment as water quality declines and replacement of well pumps. Additionally, recently proposed groundwater protection legislation (March 8, 2010) requires not only environmental review of proposed high capacity wells, but also expanding review provisions so that they apply to a proposed high capacity well in a groundwater management area before WDNR approves or develops a groundwater management plan for the area.

EXHIBIT 15
A Shallow Aquifer Water Supply Affects Surface Waters and Groundwater



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

- Increased pumping of the deep aquifer would continue to draw down groundwater levels, creating poorer water quality (higher concentrations of radium and TDS), increasing negative impacts on surface waters and hydrologically connected waters of the Great Lakes Basin, and increasing the water budget deficits.
- Increased pumping of the shallow aquifer would reduce baseflows to surface waters, produces water budget deficits, and has negative environmental impacts on sensitive surface water ecosystems, such as Vernon Marsh, Pebble Brook, and Pebble Creek (a high quality trout stream)[46] near Waukesha.
- Shallow aquifer recharge with rainfall or treated wastewater infiltration would increase baseflows, but would create land use concerns and public health concerns due to contamination, and requires overcoming regulatory hurdles along with constructing extensive, costly facilities.
- A Lake Michigan supply to some straddling communities and counties west of the subcontinental divide (with return flow) would reduce the ecological stress on the deep aquifer, shallow aquifer, and associated waters and water dependent natural resources of the Great Lakes Basin compared to the other alternatives.
- The amount of chlorides and sodium discharged into the environment by home water-softening devices would increase greatly under any groundwater alternative. The SEWRPC report estimated that eliminating groundwater softening by providing Lake Michigan water to some communities east and west of the divide (including Waukesha) would eliminate 5.2 million pounds of chlorides discharged to the Cedar Creek, Milwaukee River, and Lake Michigan environments.[47]

[46] WDNR, Wisconsin Trout Streams, PUB-FH-306, 2002.
[47] SEWRPC. 2008.

- 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.

Comparing alternatives under which the City of Waukesha obtains a Lake Michigan water supply with return flow to alternatives using current or new groundwater supplies (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 32 experts in the region concurred.[48]

A 2009 study provided further groundwater/surface water modeling of the SEWRPC alternatives, with projections to 2035.[49] The study evaluated alternatives for the City of Waukesha similar to those in the SEWRPC Regional Water Supply Plan. The analysis showed that a Lake Michigan water supply for the City of Waukesha would improve the deep aquifer water levels and eliminate 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 the Lake Michigan Basin, since they are hydrologically connected.**[50, 51, 52] The study issued cautions against Waukesha's or other similarly situated communities reliance on a future groundwater supply west of the divide, noting that groundwater levels and environmental impacts would worsen.[53]

These studies evaluated alternatives up to 2035, only 25 years from now.[54, 55] This is a relatively limited planning period, given that water supply planning typically looks out 50 years and 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. Developing a short-term water supply puts communities at risk of paying twice for the large capital costs involved.

3.1.3 Unconfined Deep Aquifer

The Future Water Supply Study evaluated a deep unconfined aquifer alternative west of Waukesha, but the SEWRPC did not. 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.[56]

Installing high capacity wells in the unconfined aquifer west of the Maquoketa shale presents not only logistical but also definite legal problems. Installation of high capacity

[48] http://www.sewrpc.org/SEWRPC/DataResources/CommissionAdvisoryCommittees/RegionalWaterSupplyPlanningAdv.htm

[49] Cherkauer. 2009.

[50] USGS. *Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin*, March 2007.

[51] D. T. Feinstein, USGS. October 2006. *Where do the deep wells in southeastern Wisconsin get their water?*

[52] CH2M HILL, Ruekert & Mielke, et al. 2003. *Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply.*

[53] Cherkauer. 2009.

[54] SEWRPC. 2008.

[55] Cherkauer. 2009.

[56] SEWRPC. 2008.

wells in an unconfined aquifer could result in legal challenges and expose the City to numerous damage claims from lake area homeowners and municipalities and would be a source of continuing controversy in the region. Under Wisconsin law, the City could be liable if its withdrawal of water caused unreasonable harm through lowering the water table for residential and municipal wells in the area (State v. Michaels Pipeline Construction, Inc., 63 Wis.2d 278, 217 N.W.2d 339). The City could be liable if its withdrawal of groundwater had a direct and substantial effect upon the water of a watercourse or lake (i.e., effects to base flow or lake levels). Damages could include the cost of new wells, deepening existing wells, the cost of water treatment as water quality declines and replacement of well pumps. Additionally, groundwater protection legislation has been recently introduced (on March 12, 2010), which would require environmental review of proposed high capacity wells located in a groundwater management area, even before WDNR approves or develops a groundwater management plan for the area. For these and other reasons detailed in the Future Water Study, the unconfined deep aquifer west of the Maquoketa shale was screened out as a reasonable water supply.

As discussed previously, two significant reasons that the deep unconfined aquifer was ranked low in the Future Water Supply study is negative impact to the groundwater and surface water environment and negative impacts on other water communities using the same aquifer. Near Oconomowoc, the deep unconfined aquifer has dropped about 100 feet in the last 100 years.[57] This has occurred with the small pumping demands of Oconomowoc of around 1 to 2 mgd. Increasing the water pumped out of that aquifer by a factor of 5 to 10 or more will have significant impacts not only on the aquifer drawdown and surrounding water ecosystems, but on municipal and private wells in the area.

3.2 Water Supply Alternatives Evaluation

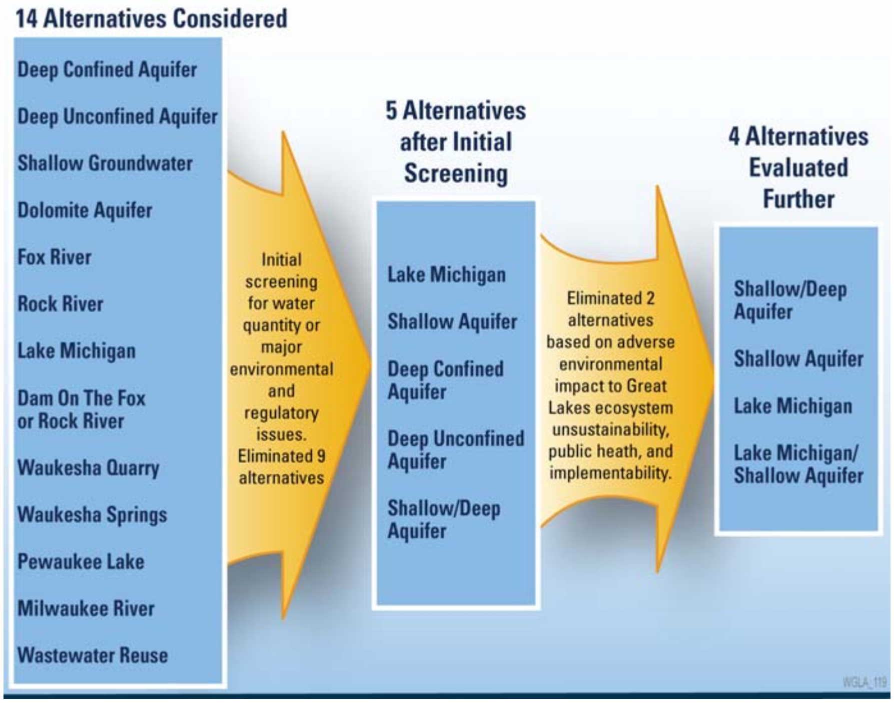
Extensive evaluations of water supply alternatives for the City of Waukesha and the region have previously been conducted. This application requests the use of Lake Michigan water. To be eligible for Lake Michigan water, the City must show that there is no reasonable water supply alternative within the basin the City is located in. For this application, the City compared its Lake Michigan request to the top ranked water supply alternatives. The water supply alternatives were chosen based on the screening done in previous studies.[58] Exhibit 16 summarizes the alternatives screening.

The water supply alternatives include:

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

[57] SEWRPC. 2008, Figure 7.
[58] SEWRPC. 2008; CH2M HILL et al. 2002.

EXHIBIT 16
Water Supply Alternative Screening



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

- **Environmental Impacts**
  - Impact on ground and surface waters of the Great Lakes Basin
  - Impact on ecosystems flora and fauna
  - Greenhouse gas emissions
- **Long-Term Sustainability**
  - Reliability during droughts and infrastructure failures
  - Ability to provide adequate supplies of potable water to the public for generations without negative environmental impacts
- **Public Health**
  - Quality of the water for human consumption
  - Potential for contamination
- **Implementability**
  - Infrastructure requirements
  - Operation and maintenance requirements
  - Land requirements, legal issues, easements, public impact

Each alternative was rated by the following categories:

○ No negative impact
⦿ Minor negative impact
◉ Moderate negative impact
● Significant negative impact

3.2.1 Water Supply Alternative 1: Continued Use of Deep and Shallow Aquifers

Alternative 1 consists of continued use of the deep St. Peter Sandstone aquifer and shallow Troy Bedrock Valley aquifer south of Waukesha. The future average annual water usage would be 10.9 mgd based on water demand projections (Section 2).

To meet a future maximum day demand of 18.5 mgd, infrastructure would be in place for 7.6 mgd firm capacity from the deep wells and 10.9 mgd from the shallow wells. The maximum capacity from the shallow aquifer would be achieved by relying upon the current 1.2 mgd firm capacity from existing wells (No. 11, 12, 13), plus developing an additional 9.7 mgd firm capacity (capacity with the largest well out of operation) by installing 14 new wells south of Waukesha near Vernon Marsh in the Troy Bedrock Valley aquifer.

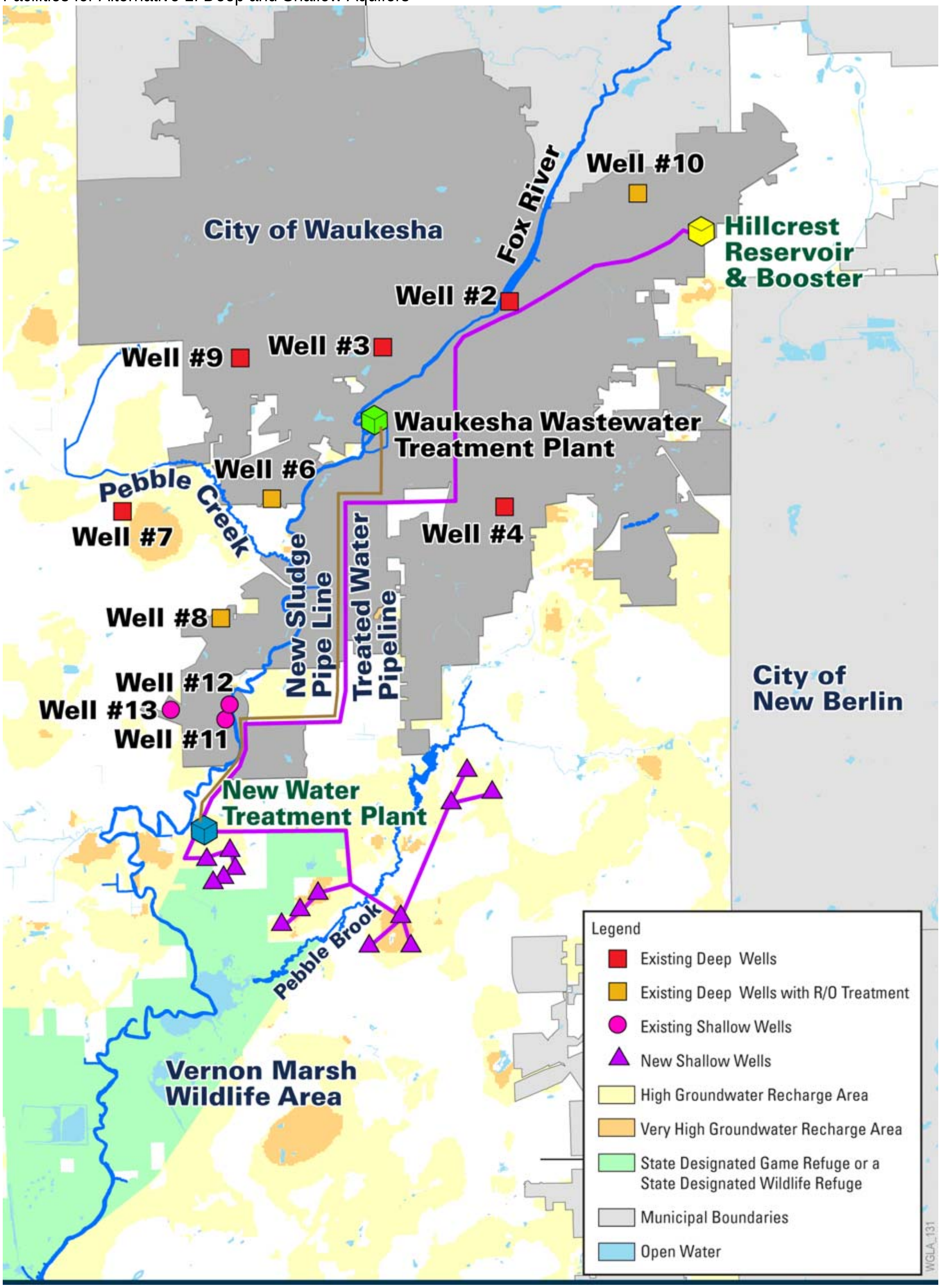
Water from the shallow wells would need to undergo treatment for iron, manganese and microorganism removal. The recent discovery of arsenic in the shallow aquifer at future well sites means arsenic treatment would be required as well. The shallow well water would be pumped from the wells to a new treatment plant. A new pump station would convey 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.

Exhibit 17 shows the facilities for Alternative 1. For the purposes of this alternative, the capacity of the City's deep wells was estimated to decrease 30 percent in the future. 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.[59]

Capacity is also expected to decrease from the deep wells because the groundwater elevation continues to drop. Currently it is over 600 feet below predevelopment levels. This declining water level causes water quality problems (increased TDS, radium, and gross alpha levels). As a result, treatment would be installed at the three largest deep wells (No. 6, 8, 10) to reduce TDS and radium. 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 treatment facility, and that water from the remaining deep wells and shallow wells will be blended at the Hillcrest reservoir. Treatment to remove TDS 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.[60]

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

EXHIBIT 17
Facilities for Alternative 1: Deep and Shallow Aquifers



Environmental Impacts.

Deep Aquifer. Studies have shown that the deep aquifer is hydrologically connected to the waters of the Lake Michigan Basin.[61] Before development, the deep groundwater below southeast Wisconsin flowed toward Lake Michigan. Pumping water from the deep aquifer reduces the amount of water that would flow to the waters of the Lake Michigan Basin, and actually reverses the flow so that it is away from Lake Michigan.[62] The USGS estimates that 30 percent of the 33 mgd of water currently pumped by the deep aquifer wells in Southeast Wisconsin originates from inside the Lake Michigan Basin.[63] The largest pumping center with the highest drawdown is in Waukesha County.[64]

Reducing the amount of water that would have flowed into the Lake Michigan Basin by deep aquifer pumping has negative environmental impacts on the waters of the Lake Michigan Basin. By stopping deep aquifer pumping in Waukesha alone, an improvement in the hydrology and hydrogeology of the waters of the Lake Michigan Basin can be realized.[65]

In addition, water pumped from the deep aquifer removes water that would otherwise be available to local surface water resources. The USGS and WGNHS indicate that 70 percent of water pumped from the deep aquifer would have gone to inland surface waters. The remaining 30 percent originates from inside the Lake Michigan Basin and 4 percent of that is contributed by Lake Michigan.[66] Reducing natural flows to surface waters by pumping the deep aquifer has negative environmental impacts both inside and outside the Lake Michigan Basin.

Adverse environmental impacts are also occurring because of the depletion of the deep aquifer. Recharge is limited for the deep aquifer near Waukesha because of the shale confining layer, causing continued depletion of the aquifer along with increasing TDS and radionuclides. In addition, dropping groundwater levels can expose sulfide minerals to 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.[67] Changing the physical and biological nature of the aquifer creates negative environmental impacts.

Shallow Aquifer. Pumping the shallow aquifer can cause negative environmental impacts on ground and surface water resources. SEWRPC estimates that about 85 percent of water extracted from the shallow aquifer is diverted or extracted from surface waters.[68] This would negatively affect 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 more than 25 percent if the City of Waukesha continues using a combination of deep and shallow groundwater, with artificial recharge.[69] A subsequent study estimated significant baseflow reductions would occur near Waukesha even if only 3.9 mgd of shallow groundwater was pumped and artificial recharge

[61] USGS. March 2007. *Groundwater in the Great Lakes Basin: The Case for Southeastern Wisconsin*; D. T. Feinstein, USGS. October 2006. *Where do the deep wells in southeastern Wisconsin get their water?*; CH2M HILL, Ruekert & Mielke, et al. 2003. *Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply.*

[62] Feinstein. 2006.

[63] Ibid.

[64] Ibid.

[65] CH2M HILL, Ruekert & Mielke, et al. 2003. *Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply.*

[66] Feinstein. 2006.

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

[68] SEWRPC. 2008.

[69] Ibid.

was used.[70] Under Alternative 1, Waukesha would need a maximum of 10.9 mgd of shallow aquifer water without artificial recharge, so the negative impacts to baseflow reduction and groundwater/surface water ecosystems would be much greater.

For this application, the recently completed Troy Bedrock Valley groundwater model[71] was used to simulate shallow aquifer groundwater drawdown and baseflow reduction for Alternative 1. Although a maximum day pumpage of 10.9 mgd may need to be extracted from the shallow aquifer, an annual average well pumpage of 6.4 mgd was the withdrawal amount modeled.

The results on groundwater drawdown are shown in Exhibit 18.[72] The results show significant shallow aquifer drawdown (about 50 feet) near the wells. Water levels would also be lower in a large portion of the Vernon Marsh and near Pebble Brook. A groundwater drawdown of 1 foot is significant in a wetland as it may affect root structures of aquatic plants. In addition, there are many private wells in the drawdown area that could be affected, along with potential contamination from associated septic tanks.

Water extracted from the aquifer reduces the water that would naturally flow to wetlands, lakes and streams (base flow). The model estimated that baseflow would be reduced as shown below with this alternative.[73] This baseflow reduction can have significant negative environmental impacts to the water ecosystems. Not only would groundwater be intercepted and not reach surface waters, under this scenario water also would be drawn from the Fox River.

Resource	Baseflow Reduction (%) from pumping 17 shallow wells for a total of 6.4 mgd
Fox River	142
Pebble Brook	61
Vernon Marsh	7
Mill Brook	29
Pebble Creek	9

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. Additional information on the environmental impacts is included in Supplemental Information.

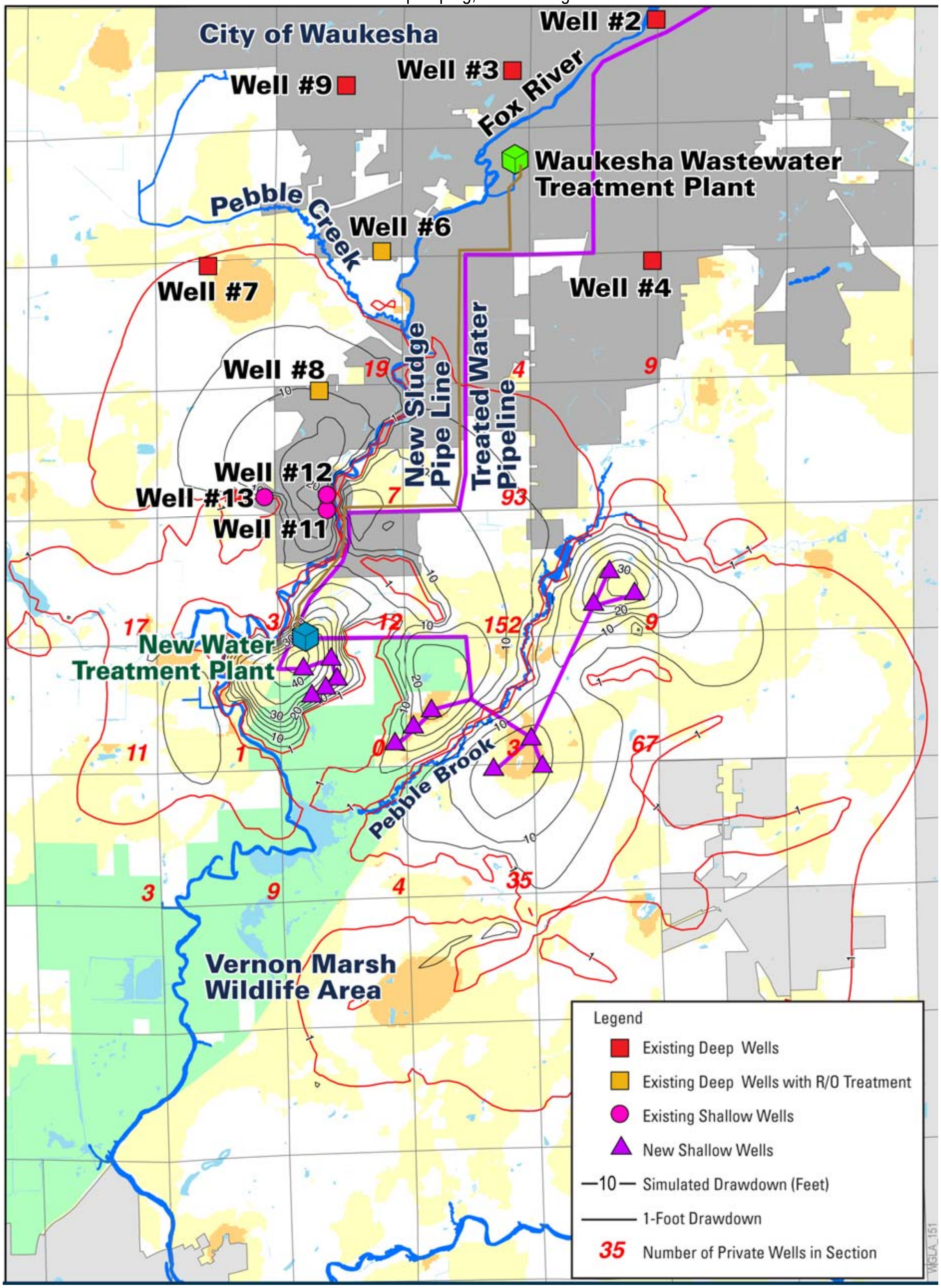
[70] Cherkauer. 2009.

[71] Troy Bedrock Valley Aquifer Model. Memorandum Report Number 188. Prepared by Ruekert & Mielke for SEWRPC. Reviewed by Dr. Kenneth R. Bradbury – Wisconsin Geological and Natural History Survey. January 2010.

[72] RJN Environmental Services, LLC. March 2010. Results of Groundwater Modeling Study Shallow Groundwater Source, Fox River & Vernon Marsh Area. Reviewed by Dr. Kenneth R. Bradbury – Wisconsin Geological and Natural History Survey.

[73] Ibid.

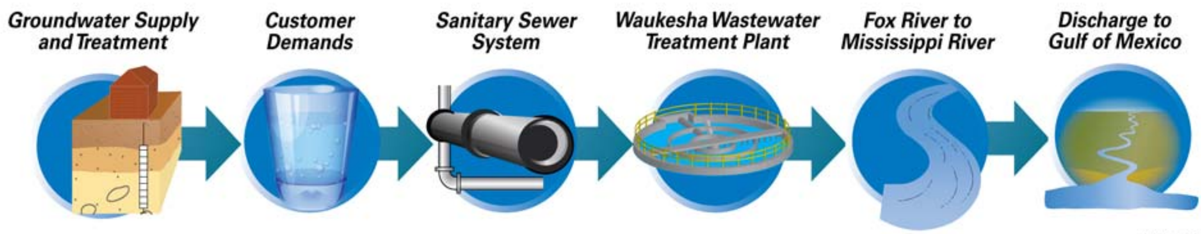
EXHIBIT 18
Groundwater Drawdown – Alternative 1 with 17 wells pumping, total 6.4 mgd



3.2.2 Deep and Shallow Aquifers Combined

Water is not returned to its source when deep or shallow groundwater is pumped and discharged to surface water. Water is transferred out of the Great Lakes and Mississippi river ecosystem and eventually to the ocean (Exhibit 19). This results in less water in the Great Lakes and Mississippi river watersheds and associated negative environmental impacts. One of the decision making standards of the Compact (4.11.1) states "All Water withdrawn shall be returned, either naturally or after use to the Source watershed less allowance for Consumptive Use." Since the deep aquifer and the waters of the Lake Michigan Basin are hydrologically connected, pumping the deep aquifer and discharging the water into the Fox River does not comply with this Compact decision-making standard.

EXHIBIT 19
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. It is estimated that Waukesha discharges 7.4 million pounds of salt into the Fox River each year from home water softeners. 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. TDS removal 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.

Finally, 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. That is equivalent to powering about 3,000 homes for a year.[74]

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

Long-Term Sustainability. The City seeks Lake Michigan water because its current water source is not sustainable.

The deep aquifer water levels are very low and dropping. Water quality is degrading and radium and TDS levels are increasing. Two wells have recently been abandoned due to contamination from outside sources. Capacity in some wells is decreasing due to the ever increasing depth that water needs to be pumped from (over 600 feet from the surface now and dropping 5 to 9 feet per year). In order to continue withdrawing water, the existing pumps may need to be replaced with larger and different type (submersible) pumps to draw water from lower levels. This will increase costs and energy.

74 U.S. Energy Information Administration. http://tonto.eia.doe.gov/ask/electricity_faqs.asp#electricity_use_home

Current deep aquifer pumping could be reduced by using more shallow groundwater. That would slow the drawdown but may not eliminate it. The amount of deep aquifer pumping by other communities (about 75 percent of the total deep aquifer usage in southeastern Wisconsin) would also greatly affect drawdown.

Using the shallow groundwater as a replacement for the deep aquifer pumping would not be sustainable. As described above, pumping for average day water demands result in significant groundwater drawdown and baseflow reduction, causing negative environmental impacts to wetlands, streams, lakes and rivers. This negative impact will increase during drought periods and when water demands are higher. As the shallow aquifer depends on rainwater for recharge, it is less reliable during drought conditions, when water supply is needed most. It is unlikely that the shallow aquifer could provide adequate water for maximum day demands during a drought, and even less likely if it could do so without severe negative impacts to the environment.

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.

It should also be noted that treatment requirements for the deep and shallow aquifers would require more water to be pumped because the treatment process itself uses water. 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 negative impact” was applied.

Public Health. The deep aquifer exceeds the radium and gross alpha regulations. While drinking water regulations can be met with proper treatment, if there is a malfunction in the treatment process or if new contaminants appear, the public may be exposed to these contaminants. One of Waukesha’s deep wells has already been contaminated from outside sources in recent years and shut down, and another deep well has been shut down due to potential contamination from a nearby landfill. Similar contamination may occur in the future requiring abandoning the wells or installing expensive treatment. The deep wells are all located within City limits, so there are numerous sources of contamination present.

In addition, the deep 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. The shallow groundwater is also high in TDS.

Shallow aquifers are more susceptible to contamination than deep confined aquifers and large surface water bodies. Without a confining layer, the porous sand and gravel of shallow aquifers can quickly pass contaminants into the drinking water. Preventing a potential source of contamination (i.e., industry, gas station) from locating near the wellfield is difficult, particularly when the wellfield is located outside of a municipality’s borders. The proposed shallow wellfield here will be located outside of the City limits, and, as a result, the City would have limited zoning control to enforce a wellhead protection ordinance to

protect the well. A wellhead protection program is required by WDNR to protect municipal wells from contamination. Buying large tracts of land or trying to influence land use zoning around the wellfield is possible, but costly and the effectiveness is uncertain.

Arsenic was recently detected in a future shallow aquifer wellfield site near Waukesha. The future shallow wells may exceed arsenic regulations and would require treatment. In addition, City pumping of wells located in the shallow could impact private wells. 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. Exhibit 4-5 shows the number of private wells that may be affected by a shallow wellfield. Private wells are often located near septic systems. These septic systems could be another source of contamination such as pathogenic microorganisms or nitrate, in situations where groundwater pumping pulls the contaminants towards the well.

With the Lake Michigan proposal, the deep aquifer would no longer be used and the potential public exposure to radionuclide and other contaminants would be eliminated. In addition, water resources, 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 1, a rating of “moderate negative impact” was applied.

Implementability. The City’s ability to implement Alternative 1, which requires the installation of 14 new shallow wells, would be difficult for several reasons.

First, Waukesha is part of a groundwater management area, and as a result, more requirements and restrictions could be placed on groundwater development. Additionally, groundwater protection legislation has been recently introduced (on March 12, 2010). The legislation would require environmental review of proposed high capacity wells located in a groundwater management area before WDNR approves or develops a groundwater management plan for the area.

Second, the shallow aquifer wellfield would be installed outside the City’s boundaries. Significant land purchase/lease and controls outside the city limits would be required. Residents near the shallow aquifer wellfield have opposed high-capacity wells because of concerns about adequate water supply and impacts to wetlands, private wells, and other environmental resources.

Installation of wells in the unconfined aquifer may create legal challenges and expose the City to numerous damage claims from lake area homeowners and municipalities and would be a source of continuing controversy in the region. The City, for example, could be liable if its withdrawal of water causes unreasonable harm through lowering the water table for residential and municipal wells in the area. The City could also be liable if its withdrawal of groundwater had a direct and substantial effect upon the water of a watercourse or lake (i.e., effects to base flow or lake levels).

If new wells need to be installed in the future because of declining water levels in existing wells or the need to locate wells farther from surface water resources, wells may need to be

located a greater distance from Waukesha. Locating wells further from Waukesha would increase costs, energy usage, and legal/public concerns. The environmental and legal impacts described above would become more severe.

If the new shallow wells can be built, a new water treatment plant would be required to remove iron, manganese, arsenic and microorganisms. If new contaminants are discovered, additional treatment would need to be constructed. 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 ongoing operation and maintenance.

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

Additional treatment for the water still pumped from the deep aquifer would result in significantly increased operation and maintenance requirements. If TDS is removed with reverse osmosis (RO) treatment, it would consist of pretreatment to condition the water, RO treatment with membranes, 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 would be required to mitigate water quality issues (red water, corrosion) that could lead to customer complaints. However, this requires additional piping in the water distribution system to blend waters from different sources.

Considering the implementability of Alternative 1, a rating of “significant negative impact” was applied. Exhibit 20 summarizes the criteria for Alternative 1.

EXHIBIT 20
Water Supply Evaluation: Alternative 1

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

○ **No negative impact**
⊙ Minor negative impact
◘ Moderate negative impact
● Significant negative impact

3.2.3 Water Supply Alternative 2: Shallow Aquifer and Fox River Alluvium

Alternative 2 uses the shallow aquifer south of Waukesha for Waukesha’s entire water supply. The future average annual water usage would be 10.9 mgd based on water demand projections (Section 2). To meet a future maximum day demand of 18.5 mgd, infrastructure would be built

for 4.5 mgd of firm capacity through 4 new wells along the Fox River south of Waukesha, in what is called the Fox River alluvium. Another 12.8 mgd firm capacity would be obtained through 14 new wells in the Troy Bedrock Valley south of Waukesha and adjacent to Vernon Marsh. The remaining 1.2 mgd firm capacity would be obtained from Waukesha's existing shallow wells 11 through 13.

The wells would pump water to a central treatment plant south of Waukesha. The water would be treated for iron, manganese, arsenic and microorganism removal. A pump station and pipelines would convey treated water to the Hillcrest reservoir in Waukesha and through the distribution system. Exhibit 21 shows the facilities for Alternative 2.

Environmental Impacts. Pumping the shallow aquifer can cause negative environmental impacts on groundwater and surface water resources (see Alternative 1 discussion). Alternative 2 would have greater negative 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). Additional information on environmental impacts is included in Supplemental Information.

For this application, the recently completed Troy Bedrock Valley groundwater model[75] was used to simulate shallow aquifer groundwater drawdown and baseflow reduction for Alternative 2. Although the City may need to extract a maximum day pumpage of 18.5 mgd from the shallow aquifer occasionally, only the annual average well pumpage of 10.9 mgd was modeled to simulate a future average day water demand.

The results on groundwater drawdown are shown in Exhibit 22.[77] The results show significant shallow aquifer drawdown (105 feet) near the wells. Water levels would also be lowered in a large portion of the Vernon Marsh and near Pebble Brook. A groundwater drawdown of 1 foot is significant in a wetland as it may affect root structures of aquatic plants. The model estimated that base flow would be reduced 346 percent to the Fox River and 58 percent to Pebble Brook in this alternative. This would have very significant negative environmental impacts to the water ecosystems and is not sustainable.

Drawdown in the shallow aquifer can be reduced by spreading more wells out over a larger area and reducing the capacity of each well. Exhibit 23 shows the groundwater drawdown if the number of shallow wells increases from 12 to 28 and the wellfield land area is nearly doubled.

[75] Ruekert & Mielke, for SEWRPC. January 2010. Troy Bedrock Valley Aquifer Model. Memorandum Report Number 188. Reviewed by Dr. Kenneth R. Bradbury, Wisconsin Geological and Natural History Survey.

[77] RJN Environmental Services, LLC. March 2010. Results of Groundwater Modeling Study Shallow Groundwater Source, Fox River & Vernon Marsh Area. Reviewed by Dr. Kenneth R. Bradbury, Wisconsin Geological and Natural History Survey.

EXHIBIT 21
Facilities for Alternative 2: Shallow Aquifer and Fox River Alluvium

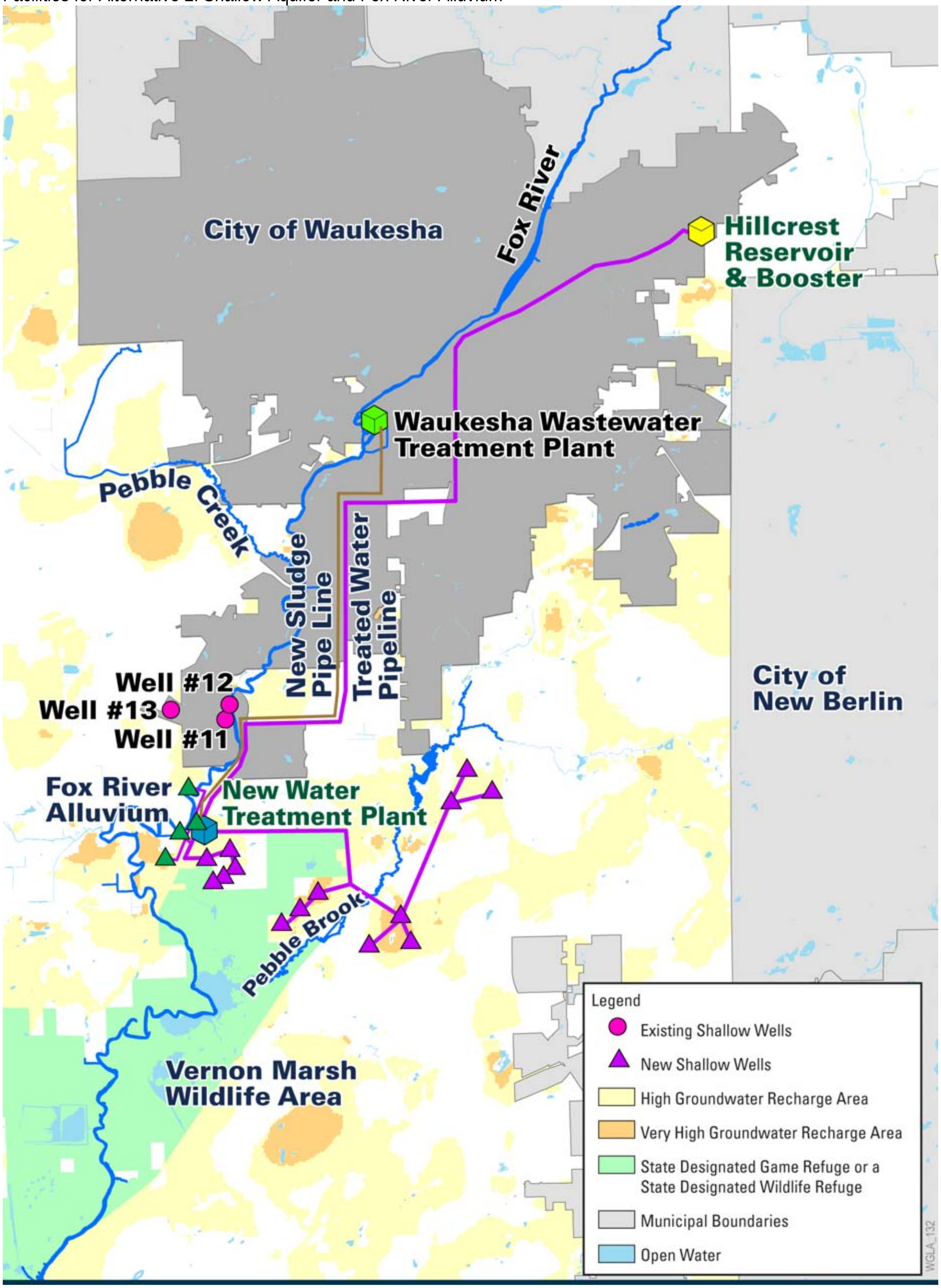


EXHIBIT 22
Groundwater Drawdown—Alternative 2 with 12 Wells Pumping, 10.9 mgd

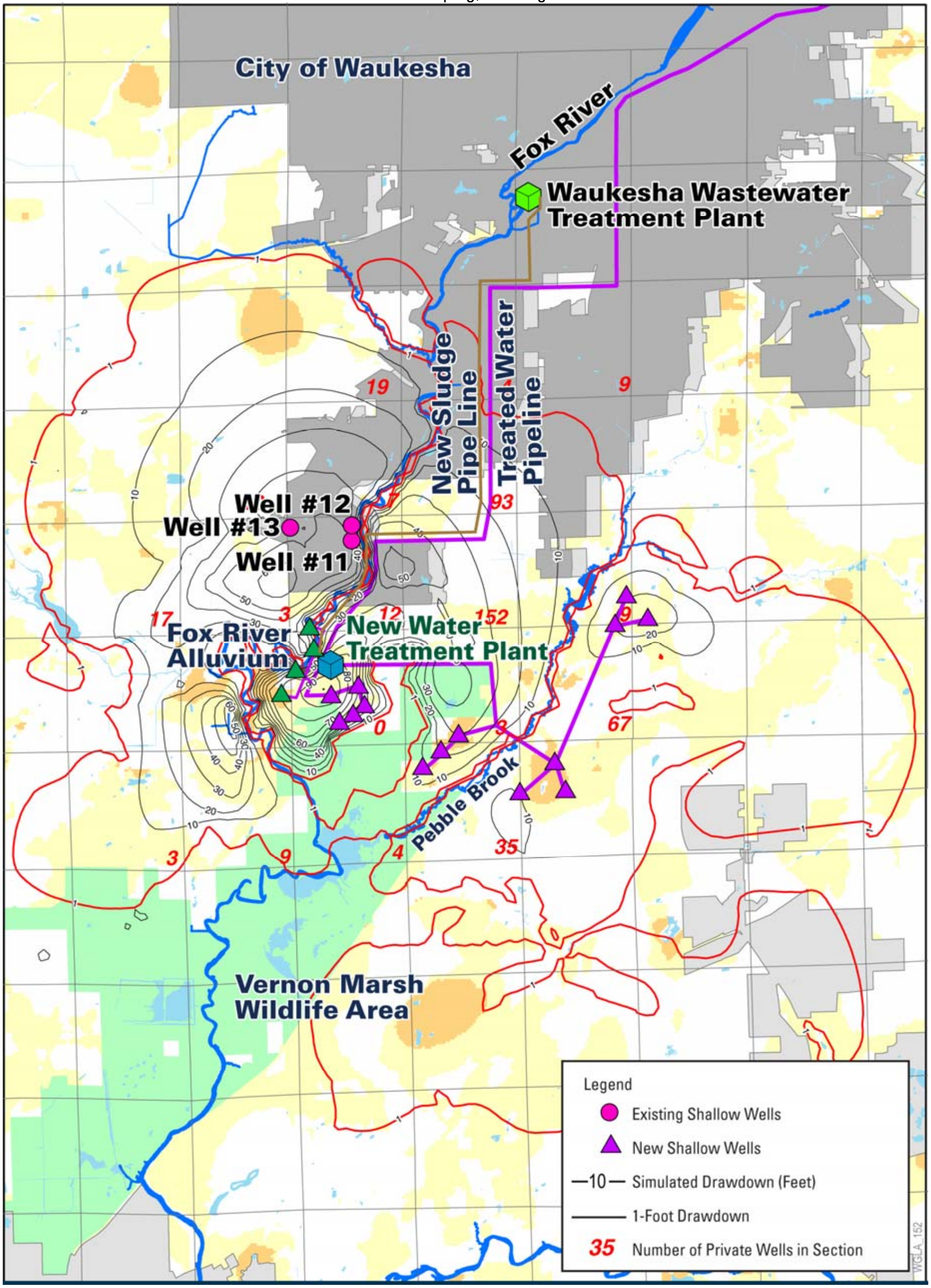
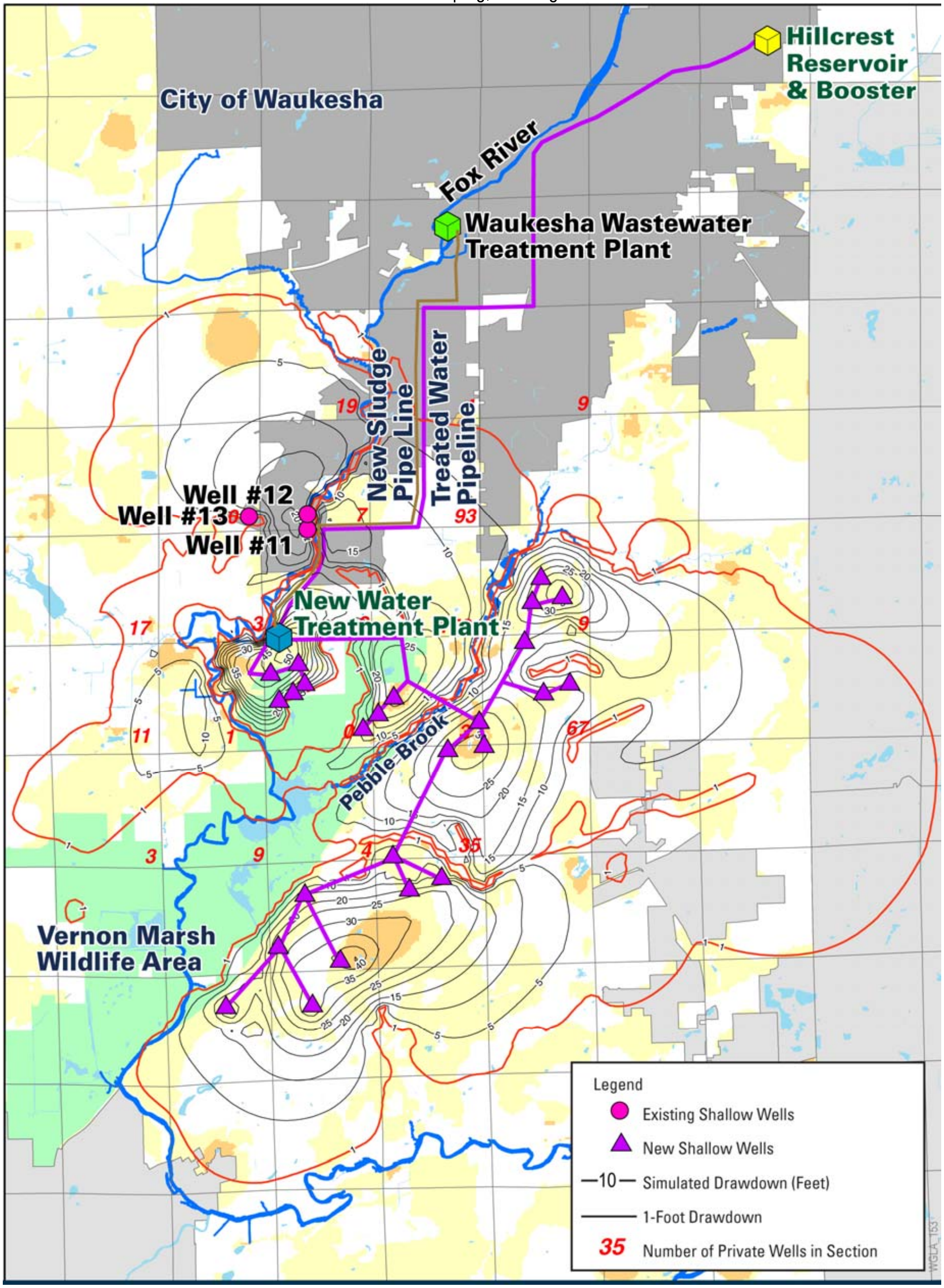


EXHIBIT 23
Groundwater Drawdown—Alternative 2 with 28 Wells Pumping, 10.9 mgd



Although this reduces the drawdown from a maximum of 105 to 55 feet, there is a larger area affected by reduced groundwater levels. Base flow reduction decreases from 346 percent to 156 percent in the Fox River, but increases in the other resources as shown below.[78] Spreading the wells over a larger area and reducing the pumping from each well still would have a very significant negative impact on the baseflow to sensitive wetlands and streams.

Resource	Baseflow Reduction (%) from pumping 28 shallow wells for a total of 10.9 mgd
Fox River	156
Pebble Brook	82
Vernon Marsh	51
Mill Brook	94
Pebble Creek	10

This modeling of the shallow aquifer shows that development of a wellfield for a City the size of Waukesha would be very difficult from an environmental impacts standpoint.

On a much smaller scale, the Village of Mukwonago installed a single shallow groundwater well in the southern area of the Vernon Marsh wildlife area 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.[79, 80] The long-term impacts of pumping this well are being evaluated by WDNR.A benefit of Alternative 2 is that Waukesha's deep aquifer pumpage would be eliminated, and therefore deep aquifer water levels would increase under Waukesha. The amount of the actual increase in 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 would have an environmental benefit.[81, 82, 83]

If shallow groundwater is used as the City's water source, return flow would not remain in the region. Instead, treated wastewater would be discharged to the Fox River and transferred out of the Great Lakes and Mississippi River ecosystem, eventually discharging to the ocean (Exhibit 19). This would result in less water in the Great Lakes and Mississippi River watersheds and associated negative environmental impacts.

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

[78] Ibid.

[79] Letter to City of Waukesha Common Council from Brian Glenzinski, Vernon Marsh Wildlife Area Property Manager, WDNR. July 18, 2006.

[80] Lisa Gaummitz, T. Asplund, and M. R. Matthews. June 2004. "A Growing Thirst of Groundwater." *Wisconsin Natural Resources.*

[81] http://wi.water.usgs.gov/glpf/cs_pmp_src.html.

[82] SEWRPC. 2008.

[83] Cherkauer. 2009.

In order to use the shallow aquifer wellfield, the City would be required to construct water transmission mains from the shallow aquifer wellfield to the treatment plant, and from the treatment plant to Waukesha. Environmental impacts associated with construction of this alternative are included in Supplemental Information.

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 negative impact” was applied.

Long-Term Sustainability. This alternative relies on multiple wells spread out over a large area. All wells would draw from the same aquifer. Relying upon one aquifer is less reliable than relying upon two aquifers as Alternative 1 does.

The shallow aquifer is dependent on rainwater for recharge and is less reliable during drought conditions, when water supply is needed most. Given the modeling of the shallow aquifer conducted at average day conditions, it is unlikely that this shallow aquifer could provide the City’s maximum water demand during a drought. Furthermore, the negative impacts of groundwater drawdown and baseflow reduction at average day water demand conditions as demonstrated by the model would be worse in a drought situation. Pumping the shallow aquifer for the City’s maximum water demand during a drought could result in severe negative impacts to the environment.

Treatment requirements for the shallow aquifers would also reduce the amount of water available to customers because the treatment requirements would require water and produce waste streams. However, the waste streams would only be about 2 to 3 percent of pumped water, much less than the TDS removal treatment in Alternative 1. Treatment of all the water supply in one treatment plant would reduce operation and maintenance efforts and costs compared to the multiple treatment plants in Alternative 1, but reduce reliability because there is only one treatment plant.

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

Public Health. Shallow aquifers are more susceptible to contamination than deep confined aquifers and large surface water bodies. Contaminants may be undetected for some time, exposing the public to health risks. Proper drinking water treatment can meet regulations as long as new contaminants are known before the water treatment plant is designed. If new contaminants are undetected or there is a malfunction in the treatment process, contaminants may be exposed to the public.

In addition, the Fox River alluvium may have exposure to additional contaminants from the Fox River. The Fox River is listed as impaired for PCBs[84] and is known to contain compounds that may be regulated in the future such as endocrine disrupters.

WDNR requires a wellhead protection program to protect municipal wells from contamination. Waukesha would have no zoning control to enforce the wellhead protection

[84] http://dnr.wi.gov/org/water/wm/wqs/303d/303d.html

ordinance because the shallow wellfield is outside the City limits. Preventing a potential source of contamination such as a gas station or industry from locating near the wellfield will be difficult without owning the land. Buying large tracts of land or influencing land use and zoning on surrounding properties is possible, but costly and the effectiveness is uncertain.

Other wells in the influence of the new wellfield may run dry or encounter water quality problems due to additional shallow aquifer pumping. Exhibit 4-10 shows the number of private wells that may be affected by a shallow wellfield. Private wells are associated with septic systems as well. These septic systems under the influence of a wellfield cone of depression could be sources of contamination such as pathogenic microorganisms or nitrate.

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 people have certain health conditions such as heart disease.

Under Alternative 2, the deep aquifer would no longer be used, and potential public exposure to radionuclide and other contaminants would be eliminated.

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

Implementability. For the Troy Bedrock Valley and Fox River alluvium wellfields, significant land purchase/lease and controls outside the city limits would be 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. Installation of wells an unconfined aquifer may create legal challenges and expose the City to damage claims from lake area homeowners and municipalities and would be a source of continuing controversy in the region. The City, for example, could be liable if its withdrawal of water causes unreasonable harm through lowering the water table for residential and municipal wells in the area. The City could also be liable if its withdrawal of groundwater had a direct and substantial effect upon the water of a watercourse or lake (i.e., effects to base flow or lake levels).

Because the Waukesha area is part of a groundwater management area, more requirements and restrictions could be placed on groundwater development. Additionally, groundwater protection legislation has been recently introduced in Wisconsin by the relevant committee chairs (on March 12, 2010). The legislation would require environmental review of proposed high capacity wells in a groundwater management area before WDNR approves or develops a groundwater management plan for the area.

The legal issues with siting new wells and impacting other entities discussed in Alternative 1 would be much greater in Alternative 2 because the City would be installing nearly twice as many wells and they would cover a larger land area. This land is outside the Waukesha municipal boundaries.

A new water treatment plant, pump station, and transmission pipes would be 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.

Treatment of all the water supply in one treatment plant would reduce operation and maintenance efforts and costs compared to the multiple treatment plants in Alternative 1, but reduce reliability because there is only one treatment plant.

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

Considering the implementability of Alternative 2, a rating of "significant negative impact" was applied. Exhibit 24 summarizes the criteria for water supply Alternatives 1 and 2.

EXHIBIT 24
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 negative impact
⊙ Minor negative impact
◉ Moderate negative impact
● Significant negative impact

3.2.4 Water Supply Alternative 3: Proposal to Use Lake Michigan Water

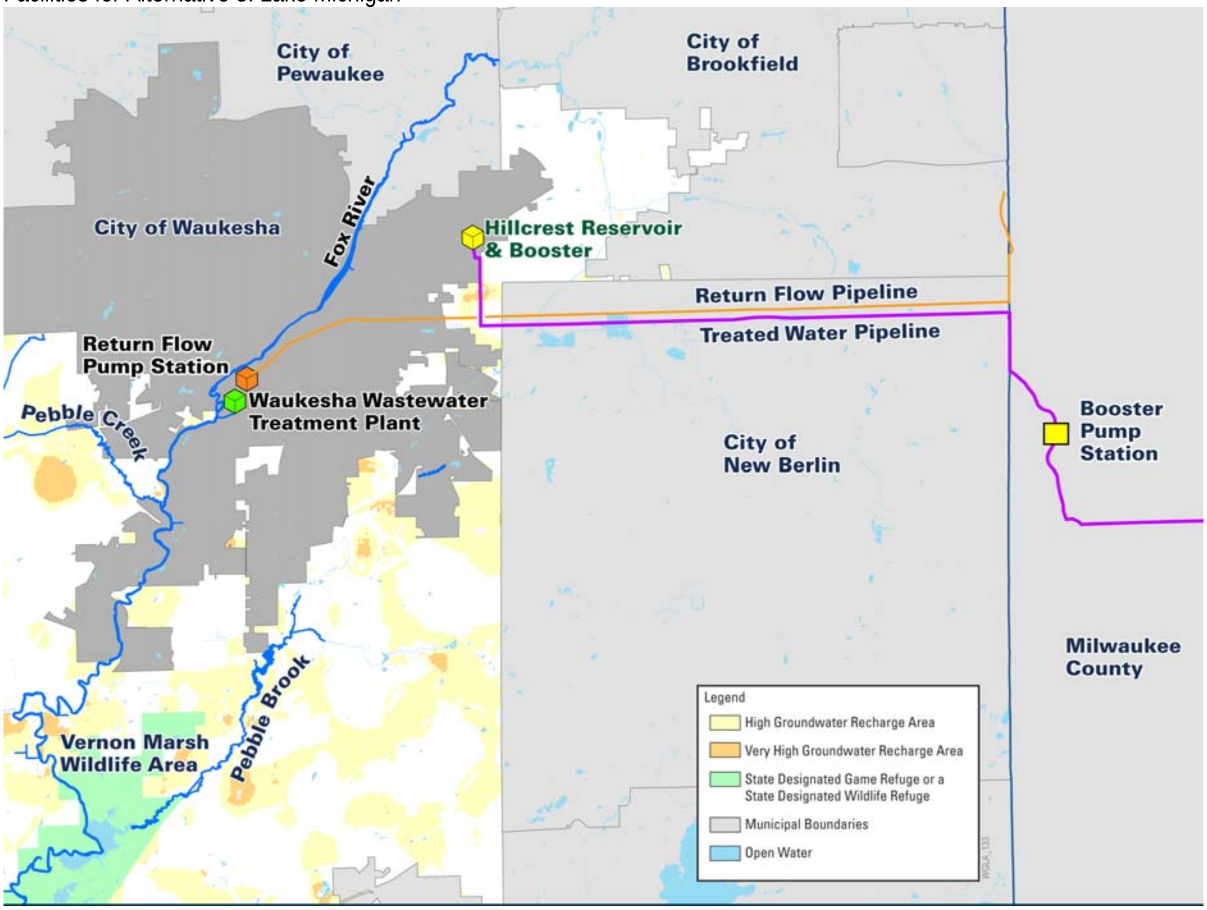
This application seeks authority to obtain water supply from Lake Michigan. The City seeks to obtain treated potable drinking water from a Lake Michigan water utility, and convey it to Waukesha through a transmission pipeline and booster pump station to the Hillcrest reservoir in Waukesha (Exhibit 25). This application seeks to withdraw 10.9 mgd of water on a future average day, and 18.5 mgd on a future maximum day; the same as the other alternatives. Water used by Waukesha would be returned to the Lake Michigan watershed.

To estimate infrastructure requirements and costs, Alternative 3 assumes connection to Milwaukee's water system at a large transmission main near 60th Street and Howard Avenue. Milwaukee is the closest Lake Michigan water utility to Waukesha and has excess capacity to provide water. Other options for a Lake Michigan water supply include the Cities of Oak Creek or Racine. The Lake Michigan water supplier would be determined after negotiations with the various cities.

There are several options for a return flow pipeline, all starting at the Waukesha wastewater treatment plant with 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 is the preferred alternative.

Environmental Impacts. If Lake Michigan water is obtained, the City would cease pumping the deep aquifer and groundwater levels would begin to increase. Using the Southeastern

EXHIBIT 25
Facilities for Alternative 3: Lake Michigan



Wisconsin Regional Groundwater Model and assuming Waukesha stops pumping from the deep aquifer, the deep aquifer cone of depression may recover 100 feet over time.[85] SEWRPC estimates deep aquifer water levels could rise as much as 270 feet if deep aquifer pumping ceased in several communities, including Waukesha.[86] Ceasing deep aquifer pumping in northeastern Illinois allowed water levels to rise 300 feet between 1980 and 2000 at Villa Park and Elmhurst, Illinois.[87] 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.

Increasing deep aquifer water levels would result in an environmental benefit because more water would be provided to the waters and water dependant natural resources of the Lake Michigan Basin.[88] A 2003 study concluded that ceasing groundwater pumping from Waukesha's deep wells would have a beneficial effect on streams and wetlands and help

[85] CH2M HILL, Ruekert & Mielke, et al. 2003. *Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply.*

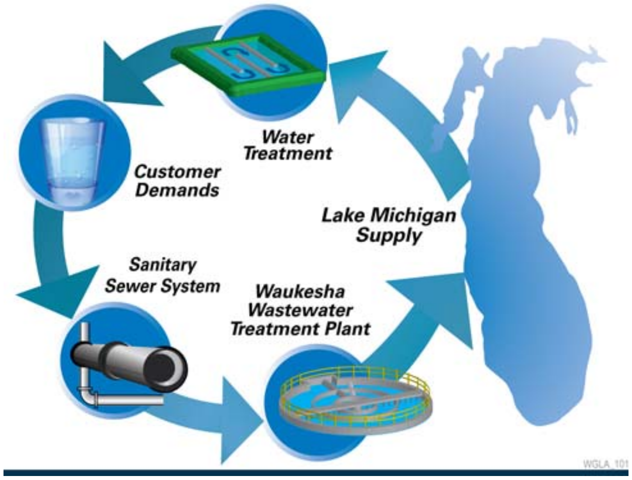
[86] SEWRPC. 2008.

[87] 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.

[88] D.T. Feinstein, USGS. October 2006. *Where do the deep wells in southeastern Wisconsin get their water?* http://wi.water.usgs.gov/glpf/index.html

restore the natural flow regimes toward, rather than away from Lake Michigan.[89] This has a significant benefit to the waters and water dependent natural resources of the Lake Michigan Basin. In addition, water sent to Waukesha is returned to Lake Michigan (Exhibit 26). This preserves the waters and water dependent natural resources of the Lake Michigan Basin and protects the integrity of the Great Lakes ecosystem. There is no measurable impact on Lake Michigan water quantity.[90] In contrast, a groundwater supply alternative diverts water from the region.

EXHIBIT 26
Lake Michigan Water Cycle



Current and future negative environmental impacts of pumping deep and shallow groundwater and reducing baseflows would be eliminated, thus protecting sensitive and valuable environmental areas such as Pebble Brook, Pebble Creek, and Vernon Marsh.

Another benefit of using Lake Michigan water is that it is relatively soft and customers do not need home water softeners. The negative 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 deep and shallow aquifer alternatives (Exhibit 27). Using the Lake Michigan alternative would save enough electricity to power about 1,600 homes for a year compared to the current water supply sources (Alternative 1).[91]

Water transmission mains from a Lake Michigan supplier 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 Supplemental Information). However, existing utility corridors would be used for pipeline routing where possible to minimize environmental impacts.

Overall, the City believes a Lake Michigan water supply results in a net environmental benefit compared to using a groundwater supply. This is consistent with SEWRPC’s conclusion 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.”[92]

89 CH2M HILL, Ruekert & Mielke, et al. 2003. *Making a Decision on Improvement: An Annex 2001 Case Study Demonstration Involving Waukesha Water Supply*.

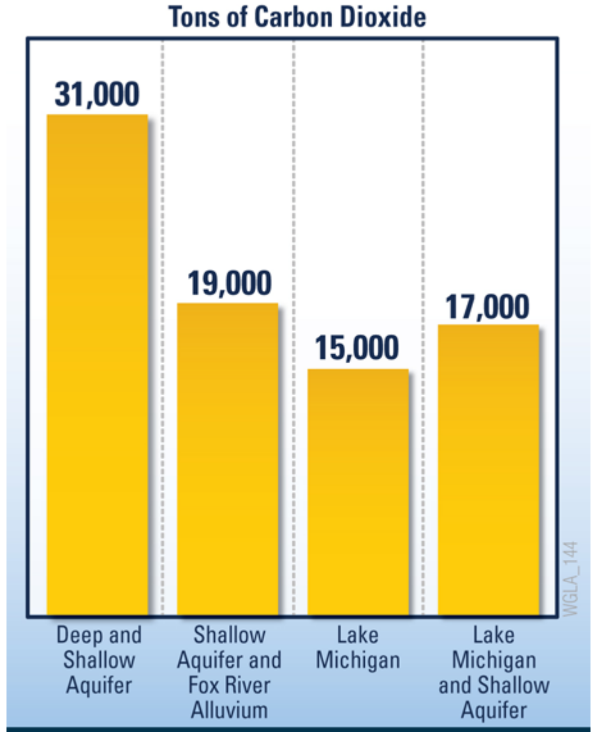
90 Ibid.

91 U.S. Energy Information Administration. http://tonto.eia.doe.gov/ask/electricity_faqs.asp#electricity_use_home

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

Considering the environmental impacts of Alternative 3, a rating of "no negative impact" was applied. There is actually an environmental benefit to the waters and water dependent natural resources of the Lake Michigan Basin because groundwater pumping would be eliminated, and as a result baseflow to surface waters would increase. In addition, there would be less of a need for water softening and salt discharge into the environment would decrease.

EXHIBIT 27
Greenhouse Gas Emissions from Water Supply Alternatives



Long-Term Sustainability. Lake Michigan would provide Waukesha with an adequate quantity of high-quality water. The water source would provide long-term sustainability indefinitely because the water used would be recycled to its source. Lake Michigan is also a reliable water source because it is much more resistant to drought conditions than groundwater.

Using a Lake Michigan water supply also restores the hydrologic conditions and functions of the source watershed by stopping deep aquifer pumping and restoring flow toward, rather than away from Lake Michigan. This improves the long-term reliability and sustainability of the water resources in the region.

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

Waukesha would maintain their shallow wells as an emergency backup to the Lake Michigan supply. This will increase reliability.

Considering the long-term sustainability of Alternative 3, a rating of "no negative 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 and high quality of Lake Michigan water 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 adversely affected if Waukesha obtains a Lake Michigan water supply because Waukesha would no longer be pumping groundwater. 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 negative 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. It would also require approval from the Governors of the Great Lakes States under the terms of the Compact.

Land purchase requirements would be less than a groundwater alternative, because no treatment plant or wellfield are required. Land use issues for wellhead protection, well and treatment plant siting are eliminated. Public concerns over impacts to groundwater levels and long-term wetland impacts are also 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 are no treatment plants or wellfields 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 negative impact" was applied. Exhibit 28 summarizes the criteria for water supply Alternatives 1, 2, and 3.

EXHIBIT 28
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 negative impact
⊙ Minor negative impact
◉ Moderate negative impact
● Significant negative impact

3.2.5 Water Supply Alternative 4: Lake Michigan and Shallow Aquifer

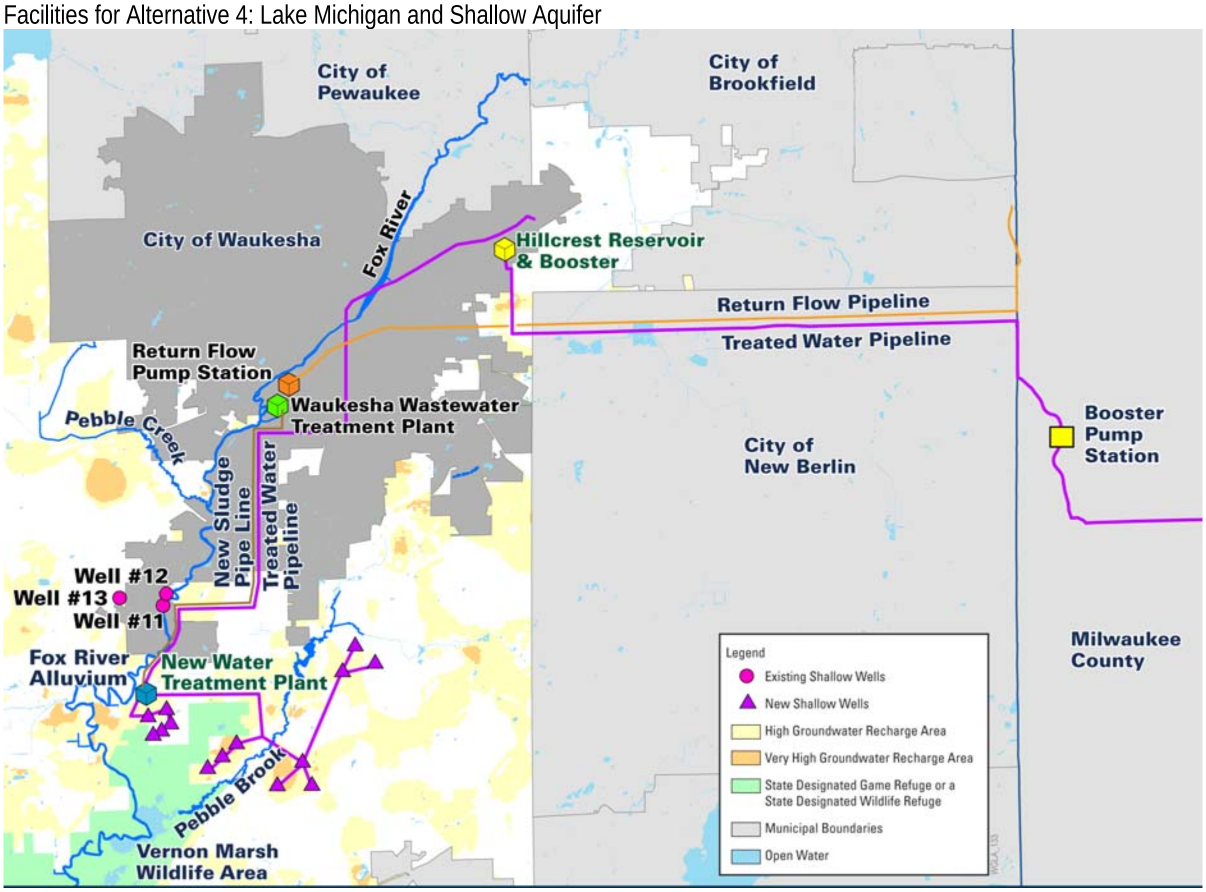
Alternative 4 consists of obtaining about 40 percent the City's required potable water (4.5 mgd average day demand, 7.6 mgd maximum day demand) from a Lake Michigan water utility and the other 60 percent (6.4 mgd average day demand, 10.9 mgd maximum day demand) from the shallow aquifer in the Mississippi River Basin. The shallow aquifer supply quantity is the same as in Alternative 1. This amount of shallow aquifer water caused significant negative environmental impacts on water resources, so using a higher amount of shallow aquifer water and less Lake Michigan water was not deemed reasonable

for the purposes of this alternative. A slightly higher or lower amount of shallow aquifer water would not significantly change the results of this alternative analysis.

The Lake Michigan supply would be conveyed 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. Water used by Waukesha would be returned to the Lake Michigan watershed via Underwood Creek.

The supply from the shallow aquifer would be provided by existing and new wells. Existing shallow wells 11 through 13 would provide firm capacity for 1.2 mgd. The remaining 9.7 mgd would come from 14 wells in the Troy Bedrock Valley south of Waukesha. These wells would be combined into a central water treatment plant and the treated water pumped to the Hillcrest reservoir in Waukesha for blending with Lake Michigan water. The facilities are shown in Exhibit 29.

EXHIBIT 29
Facilities for Alternative 4: Lake Michigan and Shallow Aquifer



Environmental Impacts. Current and future negative environmental impacts of pumping the shallow aquifer would be the same as Alternative 1. Groundwater drawdown would negatively affect sensitive and valuable environmental areas such as Pebble Brook, Pebble Creek, and Vernon Marsh, and the reduction in baseflow to these water resources would negatively impact ecosystems.

Home water softening would continue because although Lake Michigan water is relatively soft the shallow groundwater is hard. Blending the two waters will reduce the hardness, but

hardness will still be relatively high and a significant reduction in home softener use is not anticipated. The negative environmental impacts associated with home water softening (salt discharge to surface waters, additional water and energy use) would remain.

It is estimated that Alternative 4 would discharge 17,000 tons of greenhouse gases per year (carbon dioxide equivalent). Greenhouse gases would be produced by the pumping needed to convey water from and back to Lake Michigan. In addition, pumping from the shallow aquifer, treating the water and pumping the water to Waukesha uses energy and produces greenhouse gases. This alternative produces more greenhouse gases than the Lake Michigan Alternative 3 (see Exhibit 27).

Water transmission mains from a Lake Michigan supplier 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 Supplemental Information). Existing utility corridors would be used for pipeline routing where possible to minimize environmental impacts. Developing the shallow aquifer wellfield, pipelines, treatment plant and pump station would also have environmental impacts during construction.

Considering the environmental impacts of Alternative 4, a rating of "significant negative impact" was applied.

Long-Term Sustainability. Lake Michigan as a drinking water source for Waukesha provides adequate quantity, high-quality, and long-term reliability indefinitely by allowing water to be recycled to its source. Alternative 4 also restores the hydrologic conditions and functions of the source watershed by stopping deep aquifer pumping and restoring flow toward, rather than away from Lake Michigan.

Lake Michigan water is much more resistant to drought conditions than groundwater. During a drought Waukesha could rely more on Lake Michigan and less on the shallow aquifer, increasing reliability. The infrastructure needed to provide Lake Michigan water is similar to Alternative 3, with the main difference being a smaller pipe. In addition, a shallow aquifer wellfield, treatment plant, pump station and pipeline are needed. Waukesha would have to maintain not only the Lake Michigan supply, but also the shallow aquifer supply. Blending the two waters would require attention to water chemistry so customers are receiving consistent water quality and distribution system corrosion is minimized.

Considering the long-term sustainability of Alternative 3, a rating of "moderate negative 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 and high quality 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.

The contamination and wellhead protection issues with the shallow aquifer remain (see Alternative 1). Private wells will be affected by the shallow aquifer pumping and septic systems may contribute contaminants into the water supply. However, if a contamination

issue should occur, Waukesha could rely more on the Lake Michigan water supply. Home softening would still be needed, so the increased sodium and TDS would still be present.

Considering the public health impacts of Alternative 3, a rating of “minor negative impact” was applied.

Implementability. Alternative 4 still requires an agreement with a Lake Michigan water supplier to provide water, and approval from the Governors of the Great Lakes states under the terms of the Compact. Since a large portion of Waukesha’s water supply would come from shallow groundwater and be blended with Lake Michigan water, minimizing out of Basin return water to comply with section 4.9.3(b) of the Compact would not be possible. This would apply even if a much smaller amount of groundwater were used with a Lake Michigan water supply.

A Lake Michigan supply will have the same issues and requirements of pipeline routing studies, easements, land purchase and construction through rural and urban conditions.

Land purchase and easement requirements for the shallow aquifer supply would be similar to Alternative 1. Land use and legal issues for wellhead protection, well and treatment plant siting remain. Public concerns over impacts to groundwater levels and long-term wetland impacts are also still present.

In Alternative 4, Waukesha would operate and maintain the Lake Michigan supply in addition to the shallow aquifer wellfield, treatment plant and pumping/pipelines. This will make operation and maintenance of the water utility more complex than that of a Lake Michigan alternative.

Considering the implementability of Alternative 3, a rating of “significant negative impact” was applied. Exhibit 30 summarizes the criteria for water supply Alternatives 1, 2, 3, and 4.

EXHIBIT 30
Water Supply Evaluation: Alternatives 1, 2, 3, and 4

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

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

Using the deep aquifer with Lake Michigan water instead of the shallow aquifer will have similar results and impacts. However, since the deep aquifer will continue to be pumped, the benefit of increasing water levels and restoration of the natural groundwater flow toward Lake Michigan will not be realized. In addition, the old deep wells are less reliable. The wells are 30 to 75 years old and have some of the largest pumps of their kind which have to be custom built. If a failure occurs with the pumping equipment, it could be many months before repairs can be made. This situation has occurred on Waukesha’s well 10 recently. The deep wells also have more water quality issues than new shallow wells with

treatment. Radium treatment facilities will be over half their expected life when a Lake Michigan supply is finished, and will require replacement in the near future. Additional treatment for TDS removal in the future will be a large expense in both capital and operating costs (See Alternative 1). Other issues with using the deep aquifer for a portion of Waukesha's water supply are explained in the Alternative 1 description. For these reasons, a Lake Michigan and deep aquifer supply alternative was not developed in detail.

3.3 Combinations of Water Supply Sources

In general, water utilities rarely have more than two primary water supply sources. A main principal of public drinking water supply is to obtain the water supply source with the highest quality and most reliability. If this water supply does not have adequate quantity, the next highest quality water supply source is obtained. Using multiple sources of water is possible when necessary, but increases costs along with operational and maintenance complexity. Impacts to the environment can increase if unsustainable sources are tapped, and public health protection can decrease if lower quality water sources are used.

For example, a quarry north of Waukesha was evaluated as a potential water source, but screened out due to inadequate capacity (2 mgd) and contamination concerns.[93] Using this 2 mgd quarry capacity to supplement a deep and shallow aquifer supply instead of obtaining an additional 2 mgd from the shallow aquifer would actually increase the capital cost about $19 million. Under this example, having three sources of water (deep aquifer, shallow aquifer, quarry) instead of two (deep and shallow aquifer) would increase costs and operational complexity, and also increase risk to public health by using a poorer quality water source.

3.4 Summary of Water Supply Alternatives

Major studies previously conducted by the City of Waukesha[94] and others[95, 96] thoroughly evaluated the water supply alternatives for the City of Waukesha. Through these studies, potentially feasible water supply options were identified. This application analyzes four alternatives for Waukesha's water supply:

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

Each alternative was evaluated against four criteria:

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

Exhibit 31 summarizes the water supply alternatives evaluation results. The evaluation results show the Lake Michigan alternative (Alternative 3) has the most environmental

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

94 Ibid.

95 SEWRPC. 2008.

96 Cherkauer. 2009.

benefit for the waters and water dependent natural resources of the Lake Michigan Basin, is the most reliable and sustainable in the long term, provides excellent public health protection, and is implementable. A Lake Michigan water supply also provides higher quality potable water to consumers. Exhibit 32 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.

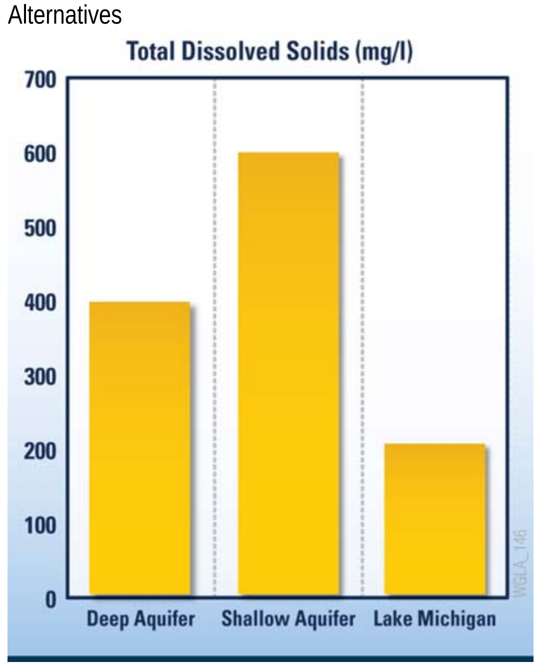
EXHIBIT 31
Water Supply Alternatives Evaluation Summary

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

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

Estimated costs for each alternative are summarized in Exhibit 33. 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.

EXHIBIT 32
Water Quality Comparison between Water Supply Alternatives



The cost comparison of the alternatives shows that the Lake Michigan water supply is the most cost-effective in the long term. There is no cost advantage of a groundwater supply or combination groundwater/Lake Michigan supply over a Lake Michigan supply. See Supplemental Information for detailed capital, operation, and maintenance cost estimates.

The groundwater supply alternatives are not reasonable alternatives under the Wisconsin Compact implementing statute (§281.346(1) (ps), Wis. Stats.). Under Wisconsin law, "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 negative environmental impacts than the proposed new or increased diversion." Compared to a Lake Michigan water supply, the

EXHIBIT 33
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	189	7.2	272	302
Shallow aquifer and Fox River alluvium	184	7.4	269	301
Lake Michigan with return flow to Underwood Creek	164	6.2	235	262
Lake Michigan and shallow aquifer	238	7.5	324	356

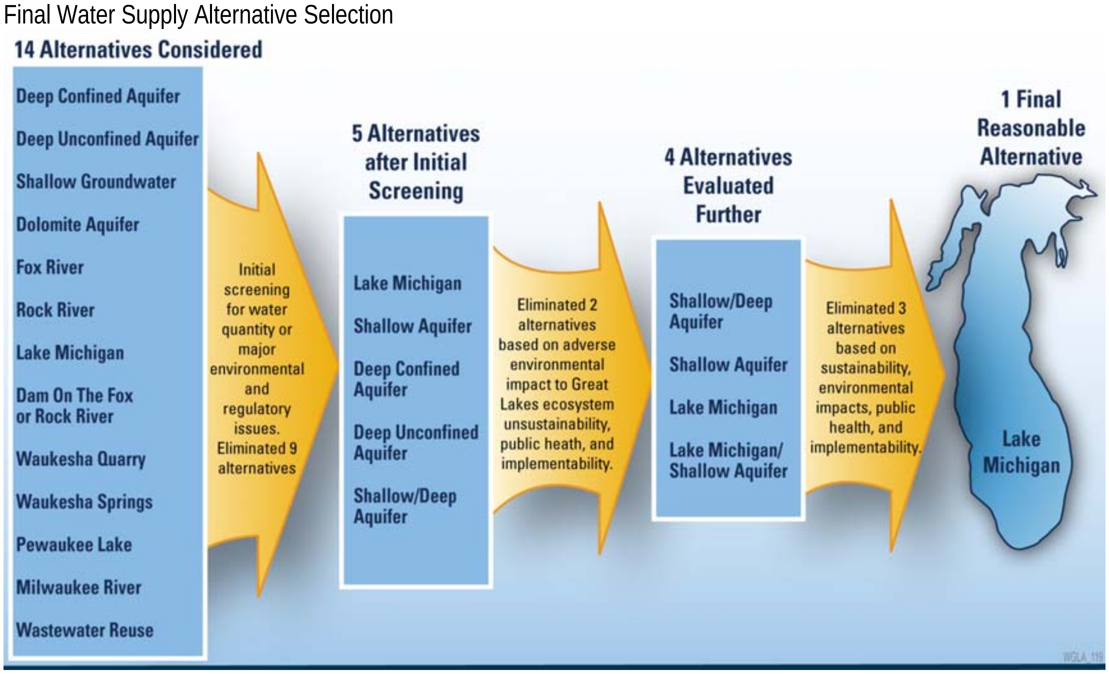
[a]Includes direct construction cost, contractor administrative costs (insurance, bonds, supervision etc), 25% contingency, and costs for permitting, legal, engineering, administrative.

groundwater supply alternatives create greater negative environmental impacts, are less sustainable, less protective of public health and are more expensive.

4. Summary

Analyses of Waukesha's water supply alternatives demonstrate that a Lake Michigan water supply is the only reasonable solution for the City of Waukesha (Exhibit 34). It provides the most reliable, cost-effective, and high quality drinking water for the future. It protects the integrity of the Great Lakes Basin ecosystem. A Lake Michigan water supply will result in termination of deep aquifer pumping which will restore the natural flow regime of the groundwater towards the Lake Michigan Basin instead of away from it. This will eliminate negative environmental impacts of using groundwater and improve the Great Lakes water and water-related ecosystems.

EXHIBIT 34
Final Water Supply Alternative Selection



This analysis also demonstrates that that there is no reasonable water supply alternative to a Lake Michigan supply within the basin in which Waukesha is located. The groundwater water supply options have much greater negative environmental impacts than using Lake Michigan, are not sustainable long-term and are not as protective of public health.