Changes to Water Supply Infrastructure and Environmental Impacts with a Hypothetical Low Water Demand

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Purpose

The purpose of this memorandum is to present the changes in the water supply infrastructure and environmental impacts of the water supply alternatives if the City of Waukesha (City) used a hypothetical future low water demand of 8.5 million gallons per day (mgd) average day demand (ADD) and maximum day demand (MDD) of 14 mgd. These ADD and MDD water demand values represent hypothetical future low water demand and are not the recommendation of the water supply planning technical experts. In keeping with good planning practice, the City has based its long-term water supply plan on the mid-range projections of 10.1 mgd ADD and 16.7 mgd MDD.

Infrastructure Changes

The infrastructure for water supply alternatives has been documented in Volume 2 of the Application (Water Supply Service Area Plan [WSSAP]). Infrastructure changes for the hypothetical low water demand are the items in red, summarized in Table 1. In general, reducing the water demand would eliminate some wells and associated pipelines in most groundwater alternatives. The infrastructure in the Lake Michigan alternatives would not appreciably change, but less water would be pumped. In Alternative 6 (Multiple Sources), the two quarries were eliminated with the lower water demand because their use as a drinking water supply source is the least reliable and uncertain because of current active mining operations. In lieu of quarry water, two new shallow wells were included in Alternative 6.

TABLE 1
Facilities for Water Supply Alternatives (8.5 mgd Average Day, 14 mgd Maximum Day)

Alternative	Water Sources	Avg. day demand, mgd	Max. day demand, mgd	Supply Facilities	Treatment Facilities	Transmission Facilities
1. Deep Confined and Shallow Aquifers	Deep confined aquifer	4.5	7.6	8 existing wells	3 new reverse osmosis treatment plants at wells 6, 8, and 10. Existing hydrous manganese oxide treatment at well 3.	About 5 miles of pipeline to Hillcrest Reservoir for blending, then pumped throughout distribution system.
	Shallow aquifer (new wells)	4.9 (3.3)	7.9 (5.2)	12 (8) new wells and about 6 (4) miles of connecting pipeline to the treatment plant.	1 new groundwater treatment plant.	1 new pump station at new water plant and about 10 miles of transmission pipe to Hillcrest Reservoir for blending, then pumped to distribution system with about 4 miles of piping improvements.

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Facilities for Water Supply Alternatives (8.5 mgd Average Day, 14 mgd Maximum Day)

Alternative	Water Sources	Avg. day demand, mgd	Max. day demand, mgd	Supply Facilities	Treatment Facilities	Transmission Facilities
	Shallow aquifer (existing wells)	0.7	1.2	3 existing wells	Existing groundwater treatment plant for wells 11 and 12.	About 1 mile of transmission pipe to Hillcrest Reservoir for blending, then pumped to distribution system.
2. Lake Michigan	Lake Michigan	10.1 (8.5)	16.7 (14)	1 pump station and about 17 miles of transmission pipe (Oak Creek supply) to the southeast side of the Waukesha distribution system.	Surface water treatment by water supplier	About 2 miles of distribution system piping improvements. A return flow pump station and about 20 miles of return flow transmission pipe to the Root River.
3. Shallow Aquifers	Shallow aquifer (existing wells)	0.7	1.2	3 existing wells	Existing groundwater treatment plant for wells 11 and 12.	About 1 mile of transmission pipe in distribution system.
	Fox River Alluvium (Riverbank Inducement)	2.7	4.5	4 new wells and about 1 mile of connecting pipeline to water treatment plant.	1 new groundwater/ surface water treatment plant.	1 new pump station at new water plant and about 6 miles of transmission pipe in distribution system.
	Shallow aquifer (new wells)	6.7 (5.1)	11.0 (8.3)	12 (9) new wells and about 6 (5) miles of connecting pipeline to the treatment plant.	Treated in same ground-water/surface water treatment plant as Fox River alluvium wells.	Pumped through same pump station and pipeline as above.
4. Lake Michigan and Shallow aquifer	Lake Michigan	4.5	7.6	1 pump station and about 19 miles of transmission pipe (Oak Creek supply) to Hillcrest Reservoir for blending.	Surface water treatment by water supplier	Pumped to distribution system with about 4 miles of piping improvements. A return flow pump station and about 20 miles of return flow transmission pipe to the Root River.
	Shallow aquifer (new wells)	4.9 (3.3)	7.9 (5.2)	12 (8) new wells and about 6 (4) miles of connecting pipeline to the treatment plant.	1 new groundwater treatment plant.	1 new pump station at new water plant and about 10 miles of transmission pipe to Hillcrest Reservoir for blending.
	Shallow aquifer (existing wells)	0.7	1.2	3 existing wells	Existing groundwater treatment plant for wells 11 and 12.	About 1 mile of transmission pipe in distribution system.

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Alternative	Water Sources	Avg. day demand, mgd	Max. day demand, mgd	Supply Facilities	Treatment Facilities	Transmission Facilities
5. Unconfined Deep Aquifer		10.1 (8.5)	16.7 (14)	12 (9) new wells and about 9 (7) miles of interconnecting pipeline. 12 miles of raw water transmission pipeline to the water plant.	1 new groundwater treatment plant.	Pump station at treatment plant and about 7 miles of transmission pipe to Hillcrest Reservoir. Water is pumped to distribution system with about 4 miles of transmission pipelines.
6. Multiple Sources	Deep confined aquifer	2.1	3.5	4 existing wells (3, 6, 8, and 10)	3 new reverse osmosis treatment plants at wells 6, 8, and 10. Existing hydrous manganese oxide treatment at well 3.	About 3 miles of transmission pipeline to Hillcrest Reservoir for blending, then pumped to distribution system.
	Fox River Alluvium (Riverbank Inducement)	1.5	2.5	3 new wells and about 1 mile of connecting pipeline to water treatment plant.	1 new groundwater/ surface water treatment plant.	1 new pump station at new water plant and about 10 miles of transmission pipe to Hillcrest Reservoir for blending, then pumped to distribution system.
	Shallow aquifer	0.9 (1.7)	1.5 (2.8)	3 existing wells, 2 new wells, 2 miles of connecting pipeline to water treatment plant.	Existing groundwater treatment plant for wells 11 and 12. Pump new wells to new surface water plant.	About 1 mile of transmission pipe to Hillcrest Reservoir pipeline for blending, then pumped to distribution system.
	Unconfined Deep Aquifer	2.0	3.2	3 new wells and 2 miles of inter-connecting pipeline. 12 miles of raw water transmission pipeline to the water plant.	1 new groundwater treatment plant.	About 5 miles of transmission pipe to Hillcrest Reservoir, then pumped to distribution system.
	Pewaukee Quarry	0.9 (0)	1.5 (0)	2 (0) quarries with 2 (0) intakes, 1 (0) pump station and 2 (0) miles of pipe to a new water plant.	1 (0) new surface water treatment plant near the Hillcrest Reservoir.	1 (0) new pump station at new water plant and about 1 (0) mile of transmission pipe to Hillcrest Reservoir for blending, then pumped to distribution system.
	Lisbon Quarry	1.5 (0)	2.5 (0)	2 (0) quarries with 2 (0) intakes, 1 (0) pump station and 7 (0) miles of pipe to new water plant.	Treated in the same new water treatment plant as the Pewaukee Quarry.	Pumped with the same new pump station above.

TABLE 1
Facilities for Water Supply Alternatives (8.5 mgd Average Day, 14 mgd Maximum Day)

Alternative	Water Sources	Avg. day demand, mgd	Max. day demand, mgd	Supply Facilities	Treatment Facilities	Transmission Facilities
	Silurian Dolomite Aquifer	1.2	2	5 new wells, 8 miles of interconnecting pipeline to a new water plant.	1 new groundwater treatment plant.	1 new pump station at new water plant and about 2 miles of transmission pipe to Hillcrest Reservoir pipeline for blending, then pumped to distribution system.

Note: All treatment facilities have chlorine or chloramine disinfection for the distribution system, consistent with current practice.

Treatment	Processes	Primary Treatment Objectives
Microbial Disinfection		
a Reverse osmosis (RO)	Fine screen filtration, reverse osmosis, degasification, chemicals for membrane antiscaling, membrane cleaning, pH adjustment with sodium hydroxide. Treated water clearwell and pump station. Assumes concentrate brine can be discharged to sewer.	Total dissolved solids removal, radium removal.
b Hydrous manganese oxide (HMO)	Chlorine contact, HMO chemicals, pressure vessel filtration. Backwash residuals are discharged to sewer.	Radium removal.
c Groundwater treatment	Chlorine contact, pressure vessel filtration, granular ferric hydroxide (GFH) contact in pressure vessel. Pressure filter backwash residuals discharged to sewer. GFH replaced when arsenic capacity is reached.	Iron, manganese, arsenic removal.
d Groundwater treatment	Chlorine contact, pressure vessel sand/anthracite filtration. Backwash residuals pumped to sewer or wastewater treatment plant.	Iron, manganese removal.
e Groundwater/surface water treatment	Lime softening, filtration, UV and chlorine disinfection. Lime softening residuals dewatered and land applied. Other residuals pumped to wastewater treatment plant.	Removal of iron, manganese, arsenic, turbidity, hardness, microbials (*Giardia* and virus), total organic carbon, minimization of disinfection byproducts (trihalomethanes and haloacetic acids).
f Lake Michigan water treatment	Rapid mix, flocculation, clarification, filtration. Potential water suppliers use different coagulants (alum, polyaluminum chlorine, or ferric chloride). One water supplier has ozone for disinfection and oxidation. One supplier has membrane filters for additional removal of particles and microbials. All suppliers have chlorine or chloramines for distribution system disinfection.	Removal of turbidity, microbials (*Giardia* and virus), total organic carbon, minimization of disinfection byproducts (trihalomethanes and haloacetic acids).
g Surface water treatment	Rapid mix, flocculation, clarification, filtration, UV and chlorine disinfection. Residuals pumped to wastewater treatment plant.	Removal of turbidity, microbials (*Giardia* and virus), total organic carbon, minimization of disinfection byproducts (trihalomethanes and haloacetic acids).

Environmental Impact Change

The Environmental Report (ER) (Volume 5 of the Application) discussed changes to environmental impacts if water demand was less than planned (Table 1-1 of the ER). The ER states:

"If [water demand] values are less, then the impacts documented in [the ER] will be less but are still suitable for impact comparison purposes. Regardless, a small change in water demand will have either no significant change to impacts or a proportional change to impacts. For example, a reduced water demand and supply

service area would not change the pipeline length or construction corridor, but could proportionally change stream flows and groundwater drawdown. Refer to Table 1-1 [from the ER] for a description of the anticipated changes to environmental impacts based on a reduced water demand."

TABLE 1-1 FROM THE ER
Anticipated Environmental Impact Change due to Possible Reduction in the Water Supply ADD and MDD

Environmental Impact Category	Groundwater Alternatives Expected Change	Lake Michigan Alternatives Expected Change
Groundwater Resources	Proportional impact due to reduced groundwater drawdown	None
Geomorphology and Sediments	None	None
Flooding	None	Proportional impact due to reduced return flow
Aquatic Habitat	Proportional impact due to changes in baseflow from groundwater drawdown	Proportional impact due to changes in baseflow from return flow
Water Quality	None	Minor proportional changes in concentration and annual load with a flow change
Wetlands	Proportional impact due to reduced groundwater drawdown	None
Soils	None	None
Land Use	None	None

Those environmental impact categories in Table 1-1 of the ER that would not change are not described further in this memorandum. Additional information is included below for those environmental impact categories that would have a proportional change in impacts with a change in water demand and which were rated as having a Significant Adverse Impact in Table 6-80 of the ER. For convenience, Table 6-80 of the ER is included here.

TABLE 6-80 OF THE ER

Water Supply and Return Flow Alternative Environmental Impact Comparison Summary

Water Supply Alternative	Groundwater Resources	Geomorphology and Sediments	Flooding	Aquatic Habitat	Water Quality	Wetlands	Soils	Land Use
Deep and Shallow Aquifers	Significant adverse impact	No adverse impact	No adverse impact	Significant adverse impact	Minor adverse impact	Significant adverse impact	Minor adverse impact	No adverse impact
Shallow Aquifer and Fox River Alluvium	Significant adverse impact	No adverse impact	No adverse impact	Significant adverse impact	No adverse impact	Significant adverse impact	Minor adverse impact	No adverse impact
Lake Michigan (City of Milwaukee)	No adverse impact	No adverse impact	No adverse impact	Minor adverse impact	No adverse impact	Minor adverse impact	No adverse impact	No adverse impact
Lake Michigan (City of Oak Creek) Alignment 1	No adverse impact	No adverse impact	No adverse impact	Minor adverse impact	No adverse impact	Minor adverse impact	No adverse impact	No adverse impact
Lake Michigan (City of Oak Creek) Alignment 2	No adverse impact	No adverse impact	No adverse impact	Minor adverse impact	No adverse impact	Minor adverse impact	No adverse impact	No adverse impact
Lake Michigan (City of Racine)	No adverse impact	No adverse impact	No adverse impact	Minor adverse impact	No adverse impact	Moderate adverse impact	No adverse impact	No adverse impact
Return Flow Alternatives for Lake Michigan Water Supplies								
Underwood Creek to Lake Michigan	No adverse impact	No adverse impact	Minor adverse impact	No adverse impact	No adverse impact	Minor adverse impact	No adverse impact	No adverse impact
Root River to Lake Michigan Alignment 1	No adverse impact	No adverse impact	Minor adverse impact	No adverse impact	No adverse impact	Minor adverse impact	No adverse impact	No adverse impact
Root River to Lake Michigan Alignment 2	No adverse impact	No adverse impact	Minor adverse impact	No adverse impact	No adverse impact	Minor adverse impact	No adverse impact	No adverse impact
Direct to Lake Michigan	No adverse impact	Minor adverse impact	No adverse impact	Minor adverse impact	No adverse impact	Minor adverse impact	No adverse impact	No adverse impact

A general description of the environmental impact change from a change in water demand for each environmental impact category with significant adverse impacts is described as follows:

- **Groundwater Resources:** Groundwater supply alternatives have significant adverse impacts to groundwater resources, as documented in the ER. These impacts would be proportionally lower with a change in water demand, but as shown below, the impacts of the ER groundwater alternatives would still be classified as significant adverse impacts. This change to impacts is described further in the following sections. There is no change in impacts for Lake Michigan alternatives with a change in water demand.
- **Aquatic Habitat:** Groundwater supply alternatives have significant adverse impacts to aquatic habitat, as documented in the ER. The impacts would be proportionally lower with a change in water demand, but as shown below, the impacts of the ER groundwater alternatives would still be classified as significant adverse impacts. This is described further in the following sections. For Lake Michigan water supply alternatives, there is no change in aquatic habitat, as the impacts are associated with changes in Fox River flow. For return flow to a Lake Michigan tributary, a lowering of water demand will make the impacts proportionally lower and would remain no adverse impact. For a direct to Lake Michigan return flow, the impacts are not associated with flow and there consequently is no change in aquatic habitat impacts for this alternative. Lake Michigan alternatives are not discussed further.
- **Wetlands:** Groundwater supply alternatives have significant adverse impacts to wetlands, as documented in the ER. The impacts would be proportionally lower with a change in water demand, but as shown below, the impacts of the ER groundwater alternatives would still be classified as significant adverse impacts. This change to impacts is described further in following sections. There is no change in impacts for Lake Michigan alternatives with a change in water demand and they are not discussed further.

Environmental Impact Comparisons with a Change in Water Demand

The resource impacts for groundwater supply alternatives are summarized in the Table 2. The relative impacts of a reduced water demand are summarized in red side by side to the original water demand impacts.

TABLE 2

Resource Impact Comparisons for a Lower Water Demand (8.5 mgd ADD)

Water Supply Alternative	ADD Scenario	Water Source Contribution	Groundwater Resources Impacts	Aquatic Habitat Impacts	Wetland Impacts
As documented in the WSSAP and ER					
1. Deep Confined and Shallow Aquifers	10.1 mgd	5.6 mgd (shallow aquifers)	Approximate 50 foot shallow aquifer drawdown. Stream baseflow reduction of up to 85 percent.	Baseflow reduction of up to 85 percent.	Impacts to nearly 1,000 wetland acres for a groundwater drawdown of 5 feet or more.
	8.5 mgd	4.0 mgd (shallow aquifers)	The shallow aquifer pumping for Alternative 6 (2.4 mgd) and Alternative 1 (5.6 mgd) both have significant adverse impacts and, consequently, significant adverse impacts will occur for a demand of 4.0 mgd.	The baseflow reductions of Alternative 6 (2.4 mgd) are up to 53 percent. Consequently, significant adverse impacts will occur for a demand of 4.0 mgd.	Impacts are nearly 1,000 wetland acres for Alternative 1 (5.6 mgd) and 240 acres for Alternative 6 (2.4 mgd). Consequently, significant adverse impacts would also occur at 4.0 mgd.
2. Lake Michigan	10.1 mgd	10.1 mgd	No Change	Only minor adverse impacts	Only minor adverse impacts (for Oak Creek)
	8.5 mgd	8.5 mgd	No Change	No Change	No Change
3. Shallow Aquifers	10.1 mgd	10.1 mgd	Approximate 105-foot shallow aquifer drawdown. Stream baseflow reduction of up to 77 percent.	Baseflow reduction of up to 77 percent.	Impacts to nearly 2,000 wetland acres for a groundwater drawdown of 5 feet or more.
	8.5 mgd	8.5 mgd	The shallow aquifer pumping for Alternative 1 (5.6 mgd) and Alternative 3 (10.2 mgd) both have significant adverse impacts and, consequently, significant adverse impacts will occur for a demand of 8.5 mgd.	The baseflow reductions of Alternative 1 (5.6 mgd) has significant adverse impacts and consequently significant adverse impacts will occur for at 8.5 mgd.	Impacts are nearly 1,000 wetland acres for Alternative 1 (5.6 mgd). Consequently, significant adverse impacts would also occur at 8.5 mgd.
4. Lake Michigan and Shallow Aquifer	10.1 mgd	5.6 mgd (shallow aquifers)	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
	8.5 mgd	4.0 mgd (shallow aquifers)	Same impacts as Alternative 1.	Same impacts as Alternative 1.	Same impacts as Alternative 1.
5. Unconfined Deep Aquifer	10.1 mgd	10.1 mgd	At 10 mgd, approximate 150-foot unconfined deep aquifer drawdown triggering regulations for groundwater management area. At 10 mgd, baseflow reduction of 9 to 27 percent; no return flow.	At 10 mgd, baseflow reduction of 9 to 27 percent, no return flow.	Impacts to nearly 480 wetland acres for groundwater drawdown of 1 foot or more.
	8.5 mgd	8.5 mgd	The groundwater drawdown for Alternative 5 (10 mgd) and Alternative 6 (2.0 mgd) are both expected to total over 150 feet, triggering regulations for groundwater management area. Consequently, a demand of 8.5 mgd would also trigger this requirement.	Baseflow reductions of Alternative 5 (10 mgd) are 9 to 27 percent and no significant adverse baseflow reduction occurs for Alternative 6 (2.0 mgd). Consequently, some baseflow reduction is expected at this demand.	Impacts are 480 wetland acres for Alternative 5 (10 mgd) within a 1 foot drawdown and no wetlands at 2.0 mgd. At 8.5 mgd, wetland impacts are likely.
6. Multiple Sources (shallow aquifer)	10.1 mgd	2.4 mgd (shallow aquifer and Fox River alluvium)	At 2.7 mgd, approximate drawdown of 20 to 30 feet in the shallow aquifer. At 2.7 mgd, baseflow reduction of up to 53 percent.	At 2.7 mgd, baseflow reduction of up to 53 percent.	Impacts to nearly 240 wetland acres for a groundwater drawdown of 5 feet or more.
	8.5 mgd	3.2 mgd (shallow aquifer and Fox River alluvium)	The baseflow reduction for Alternative 6 (2.4 mgd) is up to 53 percent. Consequently, this alternative will have significant adverse impacts for a 3.2 mgd demand.	The baseflow reduction for Alternative 6 (2.4 mgd) is up to 53 percent. Consequently, this alternative will have significant adverse impacts for a 3.2 mgd demand.	Wetland impacts for Alternative 6 (2.4 mgd) are nearly 240 acres. Consequently, this alternative will have significant impacts for a 3.2 mgd demand.
6. Multiple Sources (Continued) (unconfined deep aquifer)	10.1 mgd	2.0 mgd (deep unconfined aquifer)	Drawdown at approximately 150 total feet, which could trigger regulations for a groundwater management area.	No significant adverse baseflow reduction.	Impacts to wetlands is limited to 0.25 foot drawdown.
	8.5 mgd	No change	No change	No change	No change

Conclusion

The physical water supply infrastructure and environmental impacts of individual water supply alternatives are not significantly different for a hypothetical future low water demand ADD of 8.5 mgd or the mid-range ADD of 10.1 mgd forecast that is recommended in the WSSAP. Basing the City's long-range water supply plan on a hypothetical low 8.5 mgd ADD demand or the 10.1 mgd mid-range projected water demand does not result in a revised water supply recommendation nor does it change the conclusion of the water supply alternatives evaluation. Under either ADD demand, the Lake Michigan alternative provides the most net environmental benefits to the waters and water-dependent natural resources of the Lake Michigan and Mississippi River basins, is the most reliable, and is the most protective of public health and the environment.

If it turns out that the design flow is conservatively high, there would be no additional environmental impacts with an expansion of the Lake Michigan water supply. Environmental impacts are limited to minor impacts for a Lake Michigan supply. Minor impacts related to pipeline construction are essentially the same, due to the requirements for pipeline construction corridor width. Minor operational impacts from a Lake Michigan supply due to a flow change would be proportionally less with a lower water demand. Lake Michigan is the only reasonable water supply alternative, even with a hypothetical lower demand.