Section 2
System Alternatives

SECTION 2

System Alternatives

The evaluation of water supply alternatives that led to the proposed project introduced in Section 1 considered water supplies in the Mississippi River basin and the Lake Michigan basin. In the case of the Lake Michigan basin water supply alternatives, return flow from the City of Waukesha is required to comply with the Compact and Wisconsin implementation statute requirements. The water supply sources outside of the Lake Michigan basin would have wastewater treatment and discharge at the existing City of Waukesha Wastewater Treatment Plant (WWTP). For water supply alternatives in the Lake Michigan basin, a list of return flow alternatives to satisfy the Compact requirements was developed.

Water supply and return flow alternatives were developed individually, while return flow alternatives were developed considering the Lake Michigan supply source. These individual water supply and return flow alternatives are combined to create a "system alternative". A system alternative adds together the impacts from both water supply and treated wastewater discharge to provide the sum of the impacts with respect to the environment. An example "system alternative" for a Mississippi River basin water supply includes using deep and shallow aquifers for the water supply with wastewater treatment at the existing WWTP. An example "system alternative" for a Lake Michigan basin water supply includes connecting to the City of Milwaukee's Lake Michigan water supply with wastewater treatment at the City of Waukesha WWTP and return flow of treated wastewater to Lake Michigan via Underwood Creek.

The water supply sources and system alternatives in the Mississippi River and Lake Michigan basins are described below.

2.1 Background Information on Water Sources Considered in Prior Studies

Extensive studies have investigated various water supply alternatives for the City of Waukesha[1,2,3,4]. In March 2002, the Waukesha Water Utility completed a future water supply study. Stakeholders in this study included representatives from the Utility, City of Waukesha, Wisconsin Department of Natural Resources (WDNR), Southeastern Wisconsin Regional Planning Commission (SEWRPC), U.S. Geological Survey (USGS), Wisconsin Geological and Natural History Survey, and the University of Wisconsin–Madison. The study looked at the following 14 water supply sources and combinations of them:

- Deep (confined) aquifer near Waukesha

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

2 SEWRPC. 2010. *A Regional Water Supply Plan for Southeastern Wisconsin.* Planning Report No. 52.

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

4 CH2M HILL. 2011. *Response to WDNR Regarding Letter to Waukesha Water Utility on Application for Lake Michigan Water Supply*. Responses to WDNR Comments WS7, WS8 and WS10.

- Deep (unconfined) aquifer west of Waukesha
- Shallow groundwater south of Waukesha (including riverbank inducement through Fox River alluvium)
- 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

The SEWRPC is the official regional planning agency for the seven-county Southeastern Wisconsin Region, including Waukesha County. SEWRPC is charged by law with making and adopting a comprehensive plan for the physical development of the region. In December 2010, SEWRPC released a final report titled, A Regional Water Supply Plan for Southeastern Wisconsin (SEWRPC 2008). This plan is an extensive evaluation of water supply alternatives for the seven-county area, including the City of Waukesha, to the year 2035. Similar to the Future Water Supply Study, the SEWRPC study screened alternative water supplies and ultimately identified similar water supply alternatives. Extensive groundwater and surface water modeling was conducted in the evaluation of these alternatives. The water supply alternatives evaluated for the region included the following:

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

During the development of the City's Application for Lake Michigan Water Supply, additional analysis was completed for the Unconfined Deep Aquifer, the Silurian Dolomite Aquifer, and combinations of source water supplies beyond that evaluated in the 2002 Future Water Supply Study and SEWRPC study.

2.2 System Alternatives Considered

Each of the water supply alternatives is further discussed below where it is also combined with its wastewater discharge location to create a "system alternative." The system alternatives are evaluated below based on their water supply source watershed - Lake Michigan basin or Mississippi River basin.

2.2.1 Lake Mchigan Basin System Alternatives

Within the Lake Michigan basin, surface water and groundwater sources were considered.

2.2.1.1 Surface Water Alternatives in the Lake Mchigan Basin

2.2.1.1.1 Water Supply Alternatives

MIwaukee River

The Milwaukee River is tributary to Lake Michigan in Milwaukee, Wisconsin. The river flows through highly urbanized areas of the City and much of its lower watershed is fully developed with industrial, commercial, and residential land uses. The river was considered as part of the 2002 Future Water Supply Study as one of the 14 potential sources of water, but it was eliminated during initial screening due to public health and water quality concerns of using an urban river as a public water supply, it had limited volume during low-flow periods, and it subsequently would have been more costly than other surface water sources that have better water quality. Because this alternative was screened out during the Future Water Supply Study, a return flow alternative was not developed for a Milwaukee River water supply and this alternative is not considered further in this document.

Lake Mchigan

A Lake Michigan supply was the other surface water alternative considered in the Lake Michigan basin. Water quality in Lake Michigan is very good and the City of Milwaukee, City of Oak Creek, and City of Racine all have existing drinking water treatment plants that could be used to supply water to the City of Waukesha with a connection to their existing distribution systems. Between the City of Waukesha and the Cities of Milwaukee, Oak Creek and Racine, there are wetlands, streams, and other natural resources. Because the City of Milwaukee is the closest to the City of Waukesha, the impacts of a connection between the two cities would be less than a connection with Oak Creek or Racine. The proposed alignments for the pipelines avoid these resources as much as practicable, the majority of impacts are temporary construction impacts because the pipeline corridor will be restored after construction, and they follow previously disturbed routes through existing development, transportation corridors, and utility corridors. All three supplier options are retained for detailed evaluation and are discussed in further in Sections 3, 5, and 6 of this document.

2.2.1.1.2 Return Flow Alternatives

The Compact and Wisconsin implementation statute requires return flow for a Lake Michigan water supply. Five alternatives were considered for return flow to Lake Michigan for a Lake Michigan water supply. The alternatives include return flow to:

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

Underwood Creek Return Flow

Underwood Creek is an urban stream with portions of the creek flowing through parts of Greenfield, Brookfield, Elm Grove, and Wauwatosa before its confluence with the Menomonee River in Wauwatosa. Return flow to Underwood Creek is expected to occur in Waukesha County, near the crossing of Underwood Creek and Bluemound Road. At that location, Underwood Creek is a concrete lined channel that flows about 2.6 river miles to its confluence with the Menomonee River in Wauwatosa before flowing another 10 river miles to Lake Michigan in the City of Milwaukee. Most of Underwood Creek downstream of the return flow location is concrete lined, but a 2,400-foot-long segment of lining was removed and rehabilitated with natural channel design features[5]. The rehabilitated creek provides improved habitat because the bottom substrate is coarse grained sediments (gravel and cobbles); it provides various habitat features such as riffles, runs, pools, and glides; it meanders and includes other habitat features like rock boulders; the vegetation will overhang the channel once it is mature; and the creek is reconnected with its floodplain.

A screening level layout was developed for the return flow pipeline. It begins at the City of Waukesha WWTP, and proceeds north and east through a City park and along an alley and minor streets for about 1.3 miles. The pipeline continues east for another 1.3 miles following an abandoned railroad corridor planned for a future recreational trail, where it joins with an utility corridor and bike trail and runs for another 7 miles. The pipeline continues north 1.9 miles along a street and bike path until it ends near the confluence of the north and south branch of Underwood Creek, near Bluemound Road. A return flow to Underwood Creek is retained for additional analysis in Sections 3, 5, and 6 of this document and it is the proposed return flow alternative for a Lake Michigan water supply from the City of Milwaukee, Oak Creek, or Racine.

Root River Return Flow

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

[5] MMSD. 2008. “Watercourse: Underwood Creek Rehabilitation and Flood Management – Phase 1.” Designed by Short Elliott Hendrickson, Inc. (SEH).

near Lake Michigan are heavily urbanized. Because the return flow pipeline is longer than the alignment to Underwood Creek, a return flow to Root River has greater impacts.

The conceptual pipeline alignment for return flow to the Root River is the same as the pipeline for Underwood Creek for about the first 9.6 miles. Where the Underwood Creek pipeline heads north toward Underwood Creek, the Root River pipeline would continue southeast for 6 miles toward the Root River following streets, a parkway, and a bike trail. This return flow alternative is discussed in more detail in Section 6, but it is not the preferred return flow alternative for a Lake Michigan supply from the City of Milwaukee, Oak Creek or Racine.

Return flow direct to Lake Mchigan near MIwaukee and Oak Creek

Return flow direct to Lake Michigan near Milwaukee and Oak Creek includes a pipeline from the City of Waukesha WWTP to Lake Michigan. The conceptual pipeline alignment is the same as that for Underwood Creek and Root River for about the first 9.6 miles. Where the two pipelines diverge, the Lake Michigan alignment continues east about 11.2 miles parallel to a railroad corridor. As the alignment nears Lake Michigan, it continues east about 1.2 miles along a city street where it intersects with the lake. The alignment extends into Lake Michigan about 0.5 miles to provide an offshore outfall. The alignment is the same as that developed by SEWRPC, except the last segment of pipe is a few city blocks to the north. The city street used for the last segment is larger and the shoreline at Lake Michigan has been previously disturbed but is undeveloped compared to the SEWRPC alignment. This alignment appears to have slightly less constructability challenges and is shorter in distance than the alignment developed by SEWRPC.

Similar to the Underwood Creek and Root River return flow alignments, this alignment follows corridors that are previously disturbed and avoids environmental resources such as wetlands, stream crossings, and other similar land uses as much as possible. Some areas of the alignment will have temporary (short-term) impacts to these resources because of construction activities associated with building the pipeline. This alternative will impact the Lake Michigan bottom where the outfall is constructed within Lake Michigan for an offshore discharge.

As discussed in detail in Return Flow Alternatives Summary (Appendix F of the Application) and in Section 6 of this document, for discharges to Underwood Creek or Root River, the return flow is able to provide a resource benefit by providing additional flow in the creek and river during periods when little or no flow is naturally present. The return flow to these Lake Michigan tributaries could provide habitat benefits by no longer having the streams occasionally dry up. In contrast, return flow directly to Lake Michigan would have no environmental benefit because the return flow would be conveyed in a pipe, instead of through a surface water where the additional flow could benefit the water dependent natural resources. Consequently, return flow directly to Lake Michigan is not a preferred alternative but is evaluated further in Section 6 of this document to carry forward an alternative that includes a return flow piped directly to Lake Michigan.

Return flow direct to Lake Mchigan near Racine

Return flow direct to Lake Michigan near Racine includes a pipeline from the City of Waukesha WWTP to Lake Michigan near Racine. This return flow alternative was originally developed as a return flow alternative for a Lake Michigan water supply from the City of

Racine. Sharing a corridor between the water supply and return flow alignments will minimize cost, construction, and environmental impacts for this alternative. The same as the other return flow pipeline alignments, this corridor follows previously disturbed lands that include agriculture, utility corridors, roads and recreational paths. The first 4.4 miles of the pipeline from the City of Waukesha WWTP follows the same alignment as the Underwood Creek, Root River, and Direct to Lake Michigan near Milwaukee and Oak Creek return flow alternatives. The middle portion of the alignment (about 28 miles) shares the corridor with the Racine water supply alignment. The eastern 4 miles of the shared corridor is where the water supply and return flow alignments diverge, where the proposed water supply continues south to connect with the Racine distribution system and the return flow alignment continues east towards Lake Michigan. The return flow alignment for these 4 miles was chosen because it allowed the discharge location to be near the City of Racine (within about 6.5 miles of the water treatment plant) and the alignment was able to follow an existing utility corridor and previously disturbed open space at the Lake Michigan shoreline.

The environmental impacts associated with the direct to Lake Michigan near Racine return flow alignment will be similar to those for the Racine water supply alignment due to shared corridors for most of the alignment. The same as the other return flow alignments, this alignment follows corridors that are previously disturbed and avoids environmental resources such as wetlands, stream crossings, and other similar land uses as much as possible. Some areas of the alignment will have temporary (short-term) impacts to these resources because of construction activities associated with building the pipeline similar to those impacts with other return flow alignments. The same as the return flow direct to Lake Michigan near Milwaukee and Oak Creek, this alternative will impact the lake bottom where the outfall is constructed within Lake Michigan for an offshore discharge.

The same as return flow directly to Lake Michigan near Milwaukee and Oak Creek, this alternative would not provide an environmental benefit by augmenting flow in a Lake Michigan tributary because it includes a pipeline directly to the Lake. This alternative is also significantly more expensive than all other return flow alternatives (Return Flow Alternatives Summary, Appendix F of the Application), it has the greatest impacts because it has the longest pipeline length, and provides no additional benefit than return flow directly to Lake Michigan near Milwaukee and Oak Creek. This alternative was developed to evaluate a return flow pipeline as close as practicable to Racine, in the event that a Racine water supply was obtained <u>and</u> it was required that a return flow pipeline be constructed directly to Lake Michigan. However, as discussed in Section 5 of the Application and in the Return Flow Alternatives Summary (Appendix F of the Application), a return flow pipeline directly to Lake Michigan is not expected to be required. Consequently, this return flow alternative is not evaluated further in this document. If a Racine water supply is required <u>and</u> a return flow pipeline direct to Lake Michigan is required, the return flow direct to Lake Michigan near Milwaukee and Oak Creek alternative would be pursued (and is evaluated further in this document in Section 6).

Return Flow through the MIlwaukee Metropolitan Sewerage District

Return Flow through the Milwaukee Metropolitan Sewerage District (MMSD) would include a sewer connection between the City of Waukesha and MMSD. The MMSD operates regional sewage collection and water reclamation systems for most communities within the

Lake Michigan Basin in the Milwaukee metropolitan area. Under this return flow alternative, the City of Waukesha sanitary sewer system would collect flow from its sanitary sewer service area and convey return flow to MMSD for treatment and discharge to Lake Michigan. There are two sub-alternatives for return flow to MMSD:

- Sub-alternative 1: Sanitary sewer flow treated at the City of Waukesha WWTP with return flow to MMSD
- Sub-alternative 2: Sanitary sewer flow conveyed to MMSD without treatment at the Waukesha WWTP

For either option a pipeline alignment would be selected to provide return flow while minimizing impacts to environmental resources and other land uses. The City would continue to operate a WWTP, even for sub-alternative 2 where the City would return untreated sanitary sewer flow to the MMSD. Continued City of Waukesha WWTP operation would occur because there are periods when sanitary sewer flow in the City exceeds the water withdrawal. To minimize sending out of basin water to the Lake Michigan basin, (i.e. prevent creating a diversion into Lake Michigan) discharge to the Fox River for the sanitary sewer volume in excess of the water withdrawal volume would continue. This intermittent operation of the WWTP would not be possible without significant modification of the existing WWTP processes.

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

As with returning flow directly to Lake Michigan, returning flow to MMSD does not allow the return flow to be used as a resource because the flow would not be in a Lake Michigan tributary. For sub-alternative 1 with treatment of return flow at the City of Waukesha WWTP and MMSD, the return flow would be inefficiently using resources by providing double-treatment with no significant improvement in return flow water quality.

The SEWRPC regional water supply study included the MMSD return flow alternative in its evaluation of return flow alternatives, but the MMSD alternative was not recommended because the cost exceeded that of return flow directly to Lake Michigan and to a Lake Michigan tributary. Consequently, utilizing MMSD infrastructure for conveyance and treatment is not evaluated further for these reasons, and for those discussed above.

2.2.1.2 Groundwater Alternatives in Lake Mchigan Basin

During the Future Water Supply Study, a wellfield near the Lake Michigan shoreline was initially considered for detailed evaluation because research had shown that there may be permeable sand and gravel and dolomite units that extend under Lake Michigan and connect Lake Michigan to the shallow aquifers in eastern Ozaukee County[6]. Under these conditions, it would be possible to construct a wellfield along the Lake Michigan shoreline and induce recharge from the lake. The wellfield would require at least 15 to 20 miles of pipeline through multiple communities that are nearly built-out and where land is either

[6] Cherkauer, D.S., R.W. Taylor, and M.P. Anderson. *Measurement of the Interaction Between Lake Michigan and the Groundwater of Wisconsin*. 1990.

not available or very unlikely to be dedicated to a municipal wellfield. In addition, the ability to obtain adequate water quantity and quality was not proven. For these reasons, groundwater in the Lake Michigan basin was eliminated from detailed evaluation. Because this alternative was screened out during the Future Water Supply Study, a return flow alternative was not developed and this alternative is not evaluated further in this document.

2.2.1.3 Summary of Lake Michigan Basin System Alternatives

The Lake Michigan basin water supply and return flow alternatives that passed initial screening are shown in Table 2-1. These alternatives are evaluated in detail in this document.

TABLE 2-1
Lake Michigan Basin Water Supply and Return Flow Alternatives Evaluated in Detail

Water Supply Alternatives
Lake Michigan (City of Milwaukee)
Lake Michigan (City of Oak Creek)
Lake Michigan (City of Racine)
Return Flow Alternatives (for Lake Michigan Water Supplies)
Underwood Creek to Lake Michigan
Root River to Lake Michigan
Direct to Lake Michigan near Milwaukee and Oak Creek (hereafter referred to as *Direct to Lake Michigan* in Sections 5 and 6)

The individual water supply and return flow alternatives that passed initial screening are combined into system alternatives for further evaluation in this document. Each of the water supply alternatives is combined with each of the return flow alternatives to formulate nine system alternatives. Table 2-2 is a summary of the nine Lake Michigan basin system alternatives that are retained for further evaluation in Section 6 of this document.

TABLE 2-2
Lake Michigan Basin System Alternatives

	Return Flow Alternative		
Lake Michigan Basin Water Supply	**Underwood Creek to Lake Michigan**	**Root River to Lake Michigan**	**Direct to Lake**
Lake Michigan (City of Milwaukee)	X	X	X
Lake Michigan (City of Oak Creek)	X	X	X
Lake Michigan (City of Racine)	X	X	X

2.2.2 Mississippi River Basin System Alternatives

Within the Mississippi River basin, surface water and groundwater sources were considered.

2.2.2.1 Surface Water Alternatives in Mississippi River Basin

2.2.2.1.1 Fox River

The Fox River was included as an alternative as part of the Future Water Supply Study. The Fox River flows from the northeast to the southwest through the heart of the City of

Waukesha. The watershed is developing with growth in the City of Waukesha, the City and Village of Pewaukee, the Village of Sussex, and portions of the City of Brookfield and Village of Menomonee Falls. Wastewater treatment plants that discharge to the Fox River are located in the Village of Sussex and in the Cities of Brookfield and Waukesha. Sussex and Brookfield are upstream of Waukesha.

The water quality in the Fox River was determined to be of suitable quality as a water supply with adequate treatment. The Fox River is designated as a recreational water, where if it were to be a source of drinking water, its designation would change. This could result in stricter wastewater treatment plant effluent limitations and significant compliance costs for any wastewater plant discharging into these waters. It could also limit or eliminate recreation on the river including the motor boating and water skiing currently practiced on the river in the downtown area of the City of Waukesha.

As part of the Future Water Supply Study, flow records for the Fox River were obtained for a period extending 20 years. The Fox River has significant seasonal variations in flow where summer dry weather flow drops well below seasonal averages. Review of historic data indicates that adequate dry weather flow, including an allowance for base flow, would have been available for only 4 of the past 20 years. A supplemental reservoir such as a dam along the river, a large lake, quarry, or aquifer storage would be required to bridge the dry weather period. Providing a dam on the Fox River was evaluated in the 1970 Fox River Watershed Plan as a method of bridging the summer dry periods by impounding wet weather flows. The concept was not carried forward in the 1979 Regional Water Quality Management Plan, as it would have required significant areas of land purchase and would have posed significant regulatory and environmental challenges not likely to be resolved. A Fox River water supply intake would be located downstream of the City of Brookfield and Village of Sussex wastewater treatment plants, and possibly downstream of the City of Waukesha's wastewater treatment plant. Water treatment technologies exist to treat wastewater for drinking water use, however utilizing the Fox River downstream of at least two wastewater treatment plants would not likely be publically acceptable and may not be permitted by the WDNR (wastewater reuse is discussed further in an alternative below). Consequently, this alternative was eliminated from further evaluation as a reliable source of water in the Future Water Supply Study, and therefore it is not evaluated further in this document.

2221.2 Rock River

The Rock River was included as an alternative as part of the Future Water Supply Study. The Rock River is located west of the City of Waukesha where the closest segment is in Jefferson County about 19 miles northwest of the center of the City of Waukesha. The Rock River watershed is about 7 times the area of the Fox River watershed and is characterized by small rural communities with associated wastewater treatment facilities. Land use is predominantly rural and natural areas including the Horicon Marsh.

The water quality in the Rock River is generally better than the Fox River because it is a less developed watershed. The Rock River was also determined to be of suitable quality as a water supply with adequate treatment. The same as the Fox River, the Rock River is designated as a recreational water, where if it were to be a source of drinking water, its designation would change. This could result in stricter wastewater treatment plant effluent limitations and significant compliance costs for any wastewater plant discharging into these waters.

Flow records for the Rock River were obtained for a period extending 20 years. The Rock River also has significant seasonal flow variations where summer dry weather flows drop well below seasonal averages. Review of historic data indicates that adequate dry weather flow, including an allowance for base flow, would have been available for 16 of the past 20 years. A supplemental reservoir such as a dam along the river, a large lake, quarry, or aquifer storage would be required to bridge the dry weather period. Constructing a dam would have required significant areas of land purchase and would have posed significant regulatory and environmental challenges. Consequently, this alternative was eliminated from further evaluation as a reliable source of water in the Future Water Supply Study, and therefore it is not evaluated further in this document.

2.2.2.1.3 Quarries

Quarries were considered during the Future Water Supply Study and the Water Supply Service Area Plan (Appendix B in the Application) as a potential surface water source and as a storage reservoir for diverted surface water from the Fox River. Four quarries are near the City of Waukesha, but none of them are within the City's boundaries. Two active stone quarries are located north of the City of Waukesha. These quarries are adjacent to the Fox River in the town of Pewaukee. There are also two quarries located in the town of Lisbon. Each of these quarries is active and none are planned for as a drinking water supply. There are no quarries in Wisconsin currently used for drinking water supply.

Quarry water would be obtained through an intake structure in each quarry and conveyed to a treatment plant prior to distribution throughout the City. The Pewaukee quarries pumped about 1 to 3 million gallons per day (mgd) and the Lisbon quarries pumped about 3 to 6 mgd for dewatering purposes based on 2002 to 2010 data from the WDNR. Average day sustainable water supply was assumed to be 2.5 mgd, and about 5 mgd during maximum day demands. Less water would be available from all quarries during a drought since some of the water comes from rainfall and the rest depends on groundwater storage and recharge which is also affected by drought. The quarries alone cannot provide adequate supply for future water demands.

Using an open surface water quarry for water storage and supply increases the potential for contamination from surface water runoff or groundwater. Quarry operations use fuels and solvents that can contaminate groundwater. There are 127 potential contamination sources near the quarries that pose a risk to public health (Water Supply Service Area Plan, Appendix B of the Application) where contamination in groundwater could be carried into the quarry. Urban runoff (stormwater) also could carry contaminants into quarries. Although contaminated water can be treated, the contaminants must be known ahead of time so that the proper treatment technology can be built into the treatment plant to protect public health. If other contaminants that cannot be removed by conventional surface water treatment were discovered, additional treatment would be required. Depending on the contaminant, this could significantly increase capital and operating costs. A WDNR approval for using a quarry as a public water supply would be required and may not be approved because of the public health concern. To develop this water supply source, the permitting process would be extensive because there are no other drinking water quarry supplies in the state.

Supplementing quarry water with water directly from the Fox River may increase the quantity of water available, but the environmental, public health, and regulatory concerns increase. Diverting surface water into direct contact with groundwater will have regulatory impacts and storing water in a quarry would cause stagnation and adverse water quality impacts such as algae growth, lack of oxygen and release of undesirable compounds such as iron, manganese and hydrogen sulfide that can cause “rotten egg” odors in the water. This would increase treatment requirements and reduce public health protection.

For these reasons utilizing quarries as a single water supply source or as part of a multiple source alternative was eliminated from further evaluation in this document.

2.2.2.1.4 Pewaukee Lake

Pewaukee Lake was considered during the Future Water Supply Study. It is located about 5 miles north of the center of the City of Waukesha. It has a surface area of approximately 2,500 acres and it contains about 12 billion gallons of water. The lake watershed is about 18,000 acres, or 28 square miles and the lake includes about 14 miles of shore land that is mostly high-value residential development. The lake is the source water for the Pewaukee River, which flows southeast to the Fox River upstream of the City of Waukesha. The source water for the lake is precipitation to the lake, runoff from the lake watershed, or infiltration/exfiltration to the shallow sand and gravel aquifer. The water surface in the sand and gravel aquifer is reflected by the lake water surface.

Like the river water sources, Pewaukee Lake is also most vulnerable during the dry summer months. It must continue to provide base flow to the Pewaukee River and maintain its level to accommodate the high demand for summer recreational activities. One week of City of Waukesha demand is equal to about 1 inch of lake level. Dry periods can last up to 2 months, resulting in a significant potential draw down. Some replenishment from the sand and gravel aquifer is expected to offset the draw down, but significant impacts on Pewaukee River flows and lake levels during dry weather periods are likely.

The same as the Rock River and Fox River, Pewaukee Lake is a recreational water that if changed to a water supply source, its designation would change. This could limit or eliminate recreation on the lake including the motor boating and water skiing that are very popular with residents and visitors.

For these reasons utilizing Pewaukee Lake as a single source or as part of a multiple source alternative was eliminated from further evaluation in this document.

2.2.2.2 Groundwater Alternatives in Mssissippi River Basin

2.2.2.2.1 Shallow Sand and Gravel Aquifer

The shallow aquifer includes sand and gravel beds in unconsolidated glacial deposits. This water supply source was evaluated in the Future Water Supply Study and by SEWRPC. The extent of this aquifer is generally sporadic in the eastern half of Waukesha County, but it produces a significant portion of the water supply for several communities and many private wells surrounding the City of Waukesha. Several areas near the city have the potential to produce adequate quantities of water from this aquifer to meet the water demand projections of the City of Waukesha. However, most areas are outside of the City’s boundaries.

The sand and gravel aquifer offers some advantages, including faster local recharge, low radionuclide content, and lower costs compared to some other groundwater sources. In spite of the advantages, development of the aquifer has been limited by the distribution of the permeable sand and gravel deposits. In most of southeastern Wisconsin, sand and gravel deposits are absent or too thin to support high-capacity wells. However, several geologic features contain channel deposits of permeable sand and gravel that can support wells producing over 1,000 gallons per minute (gpm). These geologic features include bedrock valleys, outwash deposits, and end moraine deposits. As these features cover a limited area of southeastern Wisconsin, sand and gravel aquifer wells must be sited in these specific areas to produce significant volumes of water.

In the areas where many of the sand and gravel deposits exist near the City of Waukesha, there are also many environmental resources including wetlands, the Vernon Marsh Wildlife Area, cold water trout streams and other connected surface waters like the Fox River, Pebble Brook, Pebble Creek and Mill Brook. Given the permeable nature of the sand and gravel aquifer and its shallow location, there is direct hydraulic connectivity between environmental resources and the ground water. Pumping the shallow sand and gravel aquifer can lower the groundwater levels and result in direct impacts to the surface environmental resources. The effects could include alteration of the vegetation community, flow regimes in the wetlands and streams, and the overall ecological function of the resource.

This water supply alternative is not carried forward as a single source, but is combined with other groundwater alternatives described below. Combinations of groundwater sources are evaluated in detail in Section 6 of this document.

22222 Deep Sandstone Aquifer

The deep sandstone aquifer is a major source of groundwater for municipal supplies in southeastern Wisconsin. It was evaluated in the Future Water Supply Study and by SEWRPC. About 95 percent of the municipal water in Waukesha County comes from wells in the deep sandstone aquifer. Most of the City of Waukesha wells produce water from the deep sandstone aquifer. About 50 communities and 200 industries in southeastern Wisconsin rely on the deep sandstone aquifer for at least part of their water supply.

The sandstone aquifer is comprised of three major sandstone units, separated by lower permeability shale and dolomite units that act as confining layers. In the eastern portion of Waukesha County at the City of Waukesha, the Maquoketa shale is a relatively impervious confining unit that separates the shallow aquifer from the deep sandstone aquifer. Very little water seeps though the shale into the sandstone aquifer. Since the shale is present over most of eastern Waukesha County, the sandstone aquifer is confined and isolated from direct recharge in the area of heaviest demand and in the City of Waukesha. The sandstone aquifer in Waukesha County receives almost all of its recharge from the western portion of the county, where the Maquoketa shale is absent and surface water can infiltrate through the shallow glacial deposits into the deeper sandstone aquifer.

Two areas of the deep sandstone aquifer that were evaluated as part of the Future Water Supply Study, SEWRPC, and subsequent analysis during the Lake Michigan Application process, included the confined aquifer near the City of Waukesha and the unconfined aquifer near the western boundary of Waukesha County.

Deep Confined Sandstone Aquifer

Pumping from the sandstone aquifer has created a large cone of depression centered on eastern Waukesha County. The original groundwater gradient was from west to east but the cone of depression has reversed the regional groundwater gradient in Ozaukee and Milwaukee Counties. This condition has probably existed for about 50 years and is causing water to migrate westward from under Lake Michigan to the pumping center in eastern Waukesha County. Several water quality parameters have changed in the aquifer over the last 10 to 20 years. Most sandstone wells in Waukesha County exceed the maximum contaminant limit (MCL) for radium and gross alpha. Gross alpha levels have risen significantly in most sandstone aquifer wells in Waukesha County. Typically, gross alpha levels have more than doubled over the last 20 years, and are continuing to rise. Many wells contain low levels of arsenic, and in a few wells, arsenic has been detected at levels above the MCL. Total dissolved solids (TDS) levels have increased in many of the deepest wells in the county. Some wells have experienced rising TDS levels that have more than doubled in 10 years and have produced brackish water. The increasing trend complicates efforts to comply with the radionuclide MCLs.

The rise in TDS levels in the aquifer appears to be related to the upward migration of water from deeper portions of the aquifer. This condition is caused by extreme vertical gradient created by the regional cone of depression. The rise in gross alpha levels may be due to related processes or to other geochemical changes in the aquifer caused by the significant decrease in groundwater level.

The groundwater flow path has reversed direction from its predevelopment condition due to heavy pumping of the deep confined sandstone aquifer, and although there is the Maquoketa shale confining unit, wells in the deep confined sandstone aquifer have significant impacts on environmental resources like wetlands and streams. 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.[7]

The deep confined sandstone aquifer does not have capacity, nor sufficient water quality, to support the future regulatory and water supply needs for the City of Waukesha in a cost effective manner. Utilizing this water source as a single source of water for the City of Waukesha was therefore eliminated from evaluation by the Future Water Supply Study and SEWRPC. However, the deep confined sandstone aquifer is carried forward in combination with the shallow sand and gravel aquifer. Although the deep aquifer has water quality and quantity impairments, it is carried forward in combination with the shallow sand and gravel aquifer because the deep aquifer wells are within the City of Waukesha's city limits and the existing wells could have additional treatment added to supplement a new source for peak demands. Because the Future Water Supply Study showed the Fox River alluvium has similar water supply benefits but greater costs than the shallow sand and gravel aquifer, the deep confined sandstone aquifer is evaluated in detail in combination with the shallow sand and gravel aquifer. This alternative is discussed in detail in Section 6 and in the Water Supply Service Area Plan, Appendix B of the Application.

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[7] 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

Deep/Western Unconfined Sandstone Aquifer

In western Waukesha County, about 10 miles west of the City of Waukesha, the Maquoketa shale confining layer ends and the deep sandstone aquifer is unconfined and overlain with a shallow sand and gravel aquifer. Without the confining layer, the deep sandstone aquifer is more easily recharged from shallow aquifers and groundwater levels are higher. The higher groundwater levels result in shallower wells that have better water quality than the deep sandstone aquifer that is confined by the shale under the City of Waukesha. However, the water quality in the unconfined deep sandstone aquifer is still impacted by radium and gross alpha (although the levels are currently below primary drinking water regulations) and the environmental impacts to shallow aquifers, surface waters and wetlands is significant because of the hydraulic connectivity between these and the unconfined deep aquifer.

Pumping from the unconfined deep sandstone aquifer was modeled using the SEWRPC regional groundwater model at flows between 2 mgd and 15 mgd[8]. Modeling results indicated drawdowns in the sandstone aquifer between 46 feet (2 mgd) to 240 ft (15 mgd) near the wells. This corresponded to drawdowns in the shallow aquifer (above the sandstone) of 0.28 foot (2 mgd) to 1.6 feet (15 mgd). The shallow aquifer drawdown impacts surface water sources such as rivers, streams, and lakes. It is estimated that with average day demands of 10 mgd, groundwater pumping will impact 480 acres of wetlands and over 100 acres of surface waters within the 1 foot drawdown contour line (see the groundwater modeling attachment to the Water Supply Service Area Plan in Appendix B of the Application). At maximum day demands the drawdown would be much greater.

Water extracted from the unconfined deep aquifer intercepts natural recharge of the deep confined sandstone aquifer near Waukesha. Removing this water will not eliminate adverse environmental impacts from drawdown in the deep confined aquifer discussed above and still adversely affects the amount of groundwater recharging the Lake Michigan basin.

The most significant impact of this water supply alternative is its implementability. This alternative would require siting and constructing at least 13 wells, interconnecting piping, a pump station, a long transmission pipe to Waukesha, and a treatment plant for removal of iron and manganese and disinfection. Waukesha would need to operate and maintain a remote wellfield and pump station, and a large water treatment plant would be required. Treatment for radium would not likely be initially required because the levels of radium in existing wells is below drinking water standards, but needing radium treatment in the future is possible because existing wells in the unconfined deep aquifer have radium. Each well, pump station and treatment plant would likely require land acquisition, where approximately 10 municipalities, counties, and utility companies are anticipated to require coordination to construct the water supply facilities. Land purchase and easement requirements for the unconfined deep sandstone aquifer supply may be more difficult to implement than, for example, those of the shallow aquifer near the City of Waukesha because of the greater distance from the City of Waukesha.

Pumping water from this deep unconfined sandstone aquifer would create a large area of groundwater drawdown. Over 150 private wells are within the one foot groundwater

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8 RJN Environmental Services, LLC. February, 2011. Summary of Groundwater Modeling . Reviewed by Dr. Kenneth R. Bradbury – Wisconsin Geological and Natural History Survey.

drawdown contour line area, and over 10 high capacity or public drinking water wells are within the 10 foot groundwater drawdown contour line area. In addition, the wellfields in this area are in the Rock River watershed whereas the wastewater discharge from the City of Waukesha would be in the Fox River watershed. Cost estimates of this alternative assumed the water would not have to be returned to the Rock River watershed.

Installing high capacity wells in the deep unconfined sandstone aquifer west of the Maquoketa shale has significant logistical, legal, and environmental resource impacts. Consequently, this alternative is not evaluated further in this document. Additional detail of this alternative is included in the Water Supply Service Area Plan (Appendix B in the Application).

22223 Silurian Dolomite Aquifer

The regional bedrock, the Silurian dolomite, lies below the surficial glacial deposits and sand and gravel aquifer, and serves as an aquifer (commonly called the dolomite aquifer) for much of eastern Wisconsin. This water supply source was considered during the Future Water Supply Study, SEWRPC and in the Water Supply Service Area Plan (Appendix B of the Application). The dolomite itself is relatively dense and incapable of storing or transmitting significant quantities of water. The dolomite aquifer usually produces small quantities of water that are sufficient for private homes only. However, numerous zones of fractured rock exist within the dolomite, which can produce several hundred gpm from the void spaces created by the fractures and related solution cavities. It is only where the dolomite aquifer is fractured that it may produce enough water for municipal needs. The fractures tend to concentrate in regional fracture zones. The fracture zones are nearly vertical and are typically miles long, but only a few tens of feet wide. The dolomite aquifer has become an important water source for municipal wells for much of eastern Wisconsin, especially for the Cities of New Berlin and Brookfield, the Towns of Brookfield and Pewaukee, and the Villages of Germantown and Menomonee Falls (now on standby). The dolomite aquifer is only available in limited areas around the eastern, northern, and southern sides of Waukesha.

Groundwater can rapidly flow through the factures, both horizontally and vertically, without significant filtration. As a result, contamination from the sand and gravel aquifer can be transported for thousands of feet without much attenuation[9]. Locating potential wells away from these contamination sources and screening the sites for suitable thickness and permeability of overlying unconsolidated material is critical. In the neighboring City of Brookfield, siting wells in the dolomite aquifer away from contamination sources with adequate production rates has nearly exhausted new well locations.

Because wells in the dolomite aquifer rely on rock fractures and overlain sand and gravel aquifers for their capacity, effects on wetlands and streams are possible. Three of the possible four well locations were adjacent to Mill Brook and Pebble Creek, and adjacent to the Vernon Marsh Wildlife Area. Groundwater drawdown in these areas could impact the hydraulic regimes in these resources, change vegetation communities, and negatively impact the ecologic function.

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[9] Letter Report to the Waukesha Water Utility on data analysis and modeling of the Silurian dolomite. Ruekert-Mielke. February 28, 2011.

For these reasons, the Silurian dolomite alternative was eliminated from further evaluation in this document.

22224 Fox River Alluvium (Riverbank Inducement)

Locating a wellfield in the permeable alluvial river sands immediately adjacent to a river can intercept the groundwater that would normally discharge to the river. If the wellfield is pumped higher than the natural groundwater flux toward the river, water will be taken initially from storage in the alluvial sand aquifer and ultimately be replenished by recharge from the river as induced by the pumpage. Utilizing the Fox River alluvium as a water supply alternative was evaluated in the Future Water Supply Study and the Water Supply Service Area Plan (Appendix B of the Application).

The fundamental principles of this method involve using the permeable sand and gravel deposits adjacent to and under many rivers as a storage vessel to store water during high river stage flow for use by the wellfield. This method has the advantages of storing large volumes of water without a surface reservoir, and evening out the changes in water quality that occur in the river water.

These types of wellfields are usually called alluvial wellfields, although they are also called river bank filtration or riverbank inducement systems. The volume and timing of the recharge is a function of several factors, including the groundwater flux toward the river, the permeability and extent of the alluvial deposits, the permeability of the river bed, the volume of pumpage from the wellfield, and the proximity of the wells to the river. Alluvial wellfields often consist of a line of shallow wells drilled adjacent to a river that are screened in river alluvium at depth of about 50 to 100 feet. Often, these wells are drilled in the flood plain and have casings that extend above the flood level. In some areas, horizontal collector wells are used to obtain water from under the river bed itself.

In the Waukesha area, there are at least two potential areas for developing an alluvial wellfield. The two most promising areas are the shallow sand and gravel deposits along the Fox River immediately south of the City of Waukesha and the potential shallow alluvial deposits along the Fox River. Of the two areas, the Fox River alluvium appears to be the most logical option for the City of Waukesha. This source was evaluated during the Future Water Supply Study with additional groundwater modeling completed by the University of Wisconsin-Milwaukee (UWM) and the U.S. Geologic Service[10],[11]. A draft report or peer reviewed article of the UWM and USGS groundwater modeling has not been developed.

By its nature, this alternative draws groundwater directly from surface water features. Although the groundwater wells would be primarily directed at drawing Fox River water, the wellfield would also impact other surface waters such as Pebble Creek, Pebble Brook and Mill Brook. The wellfields are also in and adjacent to the Vernon Marsh Wildlife Area and thousands of acres of wetlands. Consequently, this alternative could have significant impacts to the hydrologic regimes of these environmental resources where the wetlands and streams could have significant changes to vegetation and ecosystem communities.

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[10] University of Wisconsin-Milwaukee and USGS. April 1, 2011 presentation to the Wisconsin DNR on the Brico Fund Groundwater Model.

[11] Cost Analysis of a Conceptual Riverbank Inducement System Along the Fox River. Final Report. Black & Veatch for the University of Wisconsin-Milwaukee. April 2011.

This alternative was eliminated from further consideration as a single water source for the City of Waukesha. However, in combination with the shallow aquifer, using the Fox River alluvium as a water supply alternative is evaluated in more detail in Section 6 of this document.

2.2.2.2.5 Waukesha Springs

The City of Waukesha was once famous for its natural springs that were thought to have healing properties. These springs were fed by the confined water of the shallow sand and gravel aquifer. Many of these springs still exist, but deliver only small quantities of water relative to the current and future demand of the City of Waukesha. Therefore, the use of these historic springs as a source of water for the city was eliminated during the Future Water Supply Study.

2.2.2.3 Mississippi River Basin Multiple Source Alternative

In the Water Supply Service Area Plan (Appendix B of the Application), a multiple source alternative was evaluated based on available water resources in the area. The six water supplies in this multiple source alternative include:

- Existing deep confined sandstone aquifer wells in the City of Waukesha
- Existing shallow sand and gravel aquifer wells (that are outside the City of Waukesha limits to the south)
- New wells in the Fox River alluvium (riverbank inducement wells that are outside the City of Waukesha limits to the south)
- Quarries north of the City of Waukesha
- New wells in the unconfined deep sandstone aquifer west of the City of Waukesha
- New wells in the Silurian dolomite aquifer (that are outside the City of Waukesha limits to the Southeast)

Similar to the individual alternatives that make-up this multi source alternative, the environmental impacts, long-term sustainability, public health, and implementability of this alternative had significant adverse impacts. Compared to the five other top ranking alternatives in the Water Supply Service Area Plan, this alternative collectively had the most significant adverse impact ratings. This alternative was also significantly more costly than the five other top ranking alternatives. Consequently, this alternative was eliminated from detailed analysis in this document.

2.2.2.4 Summary of Mississippi River Basin System Alternatives

The Mississippi River basin system alternatives that are retained for further evaluation in Section 6 of this document include:

- Deep confined sandstone aquifer combined with shallow sand and gravel aquifer (Deep and Shallow Aquifers)
- Shallow sand and gravel aquifer combined with Fox River alluvium (Shallow Aquifer and Fox River Alluvium)

2.2.2.5 Other Alternatives

The Future Water Supply Study evaluated using aquifer storage and recovery (ASR) and wastewater reuse as "water supply" alternatives. Although ASR and wastewater reuse are not water supply alternatives per se, they are methods to reduce peak water demand and can be used as part of a water management strategy.

2.2.2.5.1 Aquifer Storage and Recovery

Aquifer Storage and Recovery involves injecting treated municipal drinking water into the aquifer during times of less water use and pumping this water out when demand is high, typically during the summer. ASR was first used in the United States at Wildwood, New Jersey in 1968 as a method to help the area water utility meet summer peak demands, which could be as much as five times the average day demand. ASR allows a utility to take excess capacity, available during low demand periods, and store it in aquifers through wells where it may be later recovered to meet seasonal peak demands. The treated water that is stored underground typically does not require treatment upon recovery and still meets all drinking water standards. Chlorine is typically added to maintain distribution system disinfectant residual when the water is recovered for use.

The cities of Oak Creek and Green Bay sought approval to use ASR wells from the WDNR to address water shortages during peak demand periods. In Green Bay ASR was developed but produced water with significant concentrations of arsenic that mobilized from the aquifer. Similarly, pilot testing of ASR in Oak Creek found increasing concentrations of manganese and iron, and concentrations of mobilized substances eventually exceeded state groundwater quality standards. In 2011 the Oak Creek utility discontinued ASR operations and, instead, expanded its surface water treatment capability[12].

ASR could be used with any of the water supply alternatives, but because of the operational problems experienced in Oak Creek and Green Bay, ASR is not included with the water supply alternatives. It is therefore not evaluated further in this document. Even if ASR is utilized in the future if these operational challenges are overcome, the analysis of other water supply alternatives included in this report will not be impacted because their affects on environmental resources is evaluated based on average day demands during average time periods, whereas ASR affects peak demands during summer months.

2.2.2.5.2 Wastewater Reuse

Treated wastewater can be used for potable water supply either directly or indirectly. Direct potable reuse of wastewater involves treating wastewater plant effluent to drinking water quality. Although technically feasible, this method of wastewater reuse is uncommon because of the multiple treatment barriers required, the higher health risks posed, the high costs involved, and the public perceptions of safety. Several communities have demonstrated direct potable reuse, and tests have indicated that the water meets drinking water standards. However, very few have successfully implemented direct potable reuse for public consumption, even in areas of limited water.

Indirect potable reuse involves discharging treated wastewater to a receiving water body, then using that receiving water body as a source of drinking water supply. Indirect potable

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[12] Wisconsin Groundwater Coordinating Council Fiscal Year 2011 Report to the Legislature. http://dnr.wi.gov/org/water/dwg/gcc/rtl/2011/GwQuantity/AlternativeSources.pdf. Site accessed January 31, 2012.

reuse can be either planned or unplanned. Much of the Great Lakes Basin practices unplanned indirect potable reuse because wastewater treatment plants discharge into the Great Lakes, which is a source of drinking water. The federal government enlisted the National Research Council to develop reuse guidelines[13],[14]. The recent 2012 guidelines are more supportive of reuse than the 1998 guidelines because of advances in technology and treatment plant design, but there are no regulations for potable reuse practices. Since there are other sources of higher quality water for the City of Waukesha, wastewater reuse is not considered further in this document as a source of potable water.

Treated wastewater can also be considered for non-potable reuse. Golf courses and industries that require large volumes of non-potable water are candidates for non-potable reuse. The wastewater would require further treatment, and separate pumps and pipes would be required to deliver the water to potential customers. Non-potable reuse is used to supplement water demands, but is only part of the water supply equation. Non-potable reuse is most commonly practiced in arid regions with limited water supplies. In Waukesha, there would be limited and seasonal demand for non-potable water, and it would be costly to implement because the infrastructure for a separate non-potable water distribution system does not exist. Consequently, non-potable reuse is not evaluated further in this document.

2.2.2.6 Combined Lake Michigan and Mississippi River Basin System Alternatives

Three alternatives were identified that included water sources from both the Lake Michigan and Mississippi River basins. Two alternatives from SEWRPC included artificial recharge of groundwater and one alternative from the Water Supply Service Area Plan (Appendix B of the Application) included combining Mississippi River basin groundwater with Lake Michigan surface water.

2.2.2.6.1 Artificial Recharge

Some of the SEWRPC groundwater alternatives (Shallow aquifer and artificial recharge using rainwater and wastewater treatment plant effluent; and deep aquifer and artificial recharge using treated Lake Michigan water) assume 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 from groundwater pumping 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.[15] Transmission mains from the Waukesha wastewater plant to recharge areas would add another $4 million.

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[13] NRC. 1998. Issues in Potable Reuse: The Viability of Augmenting Water Supplies with Reclaimed Water.

[14] NRC. 2012 In Press. Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater.

[15] SEWRPC. December 2010. *A Regional Water Supply Plan for Southeastern Wisconsin.* Planning Report No. 52. Final Report.

- Large land areas are required for artificial recharge, 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 to implement artificial recharge, even if it relies on the deep aquifer for more than half of its water supply.[16]
- Water which is artificially recharged 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 where 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 groundwater recharge was eliminated from consideration by SEWRPC and is subsequently eliminated from further evaluation in this document.

2.2.2.6.2 Lake Michigan and Shallow Aquifer

The Water Supply Service Area Plan (Appendix B of the Application) included a combined alternative that evaluated utilizing a Lake Michigan water supply with shallow aquifer groundwater in the Mississippi River basin. About 40 percent of the City's required water demand would be obtained from a Lake Michigan water supplier with the remaining 60 percent supplied by the shallow aquifer.

This alternative would include impacts from both the shallow aquifer wellfield development and the construction of the Lake Michigan water supply and return flow pipelines. Similar to the Lake Michigan water supply alternatives, the impacts of the Lake Michigan supply pipelines would include temporary construction related impacts, while the shallow groundwater wellfields would have permanent and significant adverse impacts to wetlands and streams such as the Vernon Marsh Wildlife Area, Pebble Creek, Pebble Brook and Mill Brook. The impacts for this combination alternative would be similar to the groundwater drawdown impacts of the Deep and Shallow Aquifers alternative since the shallow aquifer pumping rate is similar between the two alternatives; and the impacts from constructing a Lake Michigan water supply and return flow pipeline. Consequently, the impacts will be more than either of the sources considered independently.

This alternative has significant implementability challenges because it includes obtaining a Lake Michigan water supply and a shallow groundwater wellfield that are both outside of City of Waukesha's boundary. Utilizing two different water sources (Lake Michigan surface water and shallow groundwater) adds significant operational and maintenance complexity when blending a surface water source with a groundwater source. In addition, this alternative is significantly more costly than other alternatives that have less implementability and environmental impacts.

Because of these reasons, this alternative is not evaluated further in this document.

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16 Ibid.

2.2.3 Water Conservation Alternatives

Water conservation has been implemented by the City of Waukesha for many years. Since the adoption of the 2006 Conservation Plan, the City has successfully advanced various water conservation measures through public information and education, regulations, collaborative partnerships, and incentive programs. Water use in the City has been reduced, in part, because of the measures. Reduced water use is illustrated by the following aggregate metrics:

- Between the base year of 2005 and 2010[17], total water pumped from wells was reduced 14.0 percent.[18]
- Between 2005 and 2010, peak season pumping (May 1 to October 1) was reduced 19.4 percent.[19]
- Since 2005, declining water use reduced the number of days water demand exceeded 10 mgd from 28 to zero. The City has an operational goal to pump 10 mgd or less, to help meet its radium compliance order and stipulation.[20]
- Residential customers who have replaced a toilet in conjunction with the City's rebate program are estimated to be saving an average of over 15,000 gallons per year.[21]
- By regulation, the City annually submits detailed information on the performance and costs of its conservation program to the Public Service Commission (PSC).

Water savings from conservation is an important component of the City's long-range water supply plan. Because water saved from using water efficiently is a source of water supply, one of the City's water conservation goals includes reducing average day demand by 0.5 mgd by year 2030 and by 1.0 mgd by 2050. The water savings represent 5 and 10 percent water savings in average day demand, respectively, of projected baseline (no conservation related) water demands between 2010 and 2050.

Objectives for the planning process used in the development of the updated 2012 Water Conservation Plan[22] included:

- Developing planning analysis and implementation time lines in a manner consistent with NR 852 and the SEWRPC 2035 Regional Water Supply Plan
- Leveraging lessons learned from implementation of existing City conservation and efficiency measures
- Incorporating stakeholder and customer input in the evaluation of conservation and efficiency measures

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17 2010 data represents the most recent complete year of City performance data.

18 Annual Reports of City of Waukesha Water Utility to the Public Service Commission of Wisconsin, 2005–2010.

19 City peak season water pumping data, May through September, 2005–2010.

20 Waukesha Water Utility Report on Water Conservation Programs to the Public Service Commission of Wisconsin, 2010.

21 Ibid.

22 CH2M HILL. 2012. City of Waukesha Water Conservation Plan.

The water conservation measures implemented by the City apply to its customers, whether they are located within city limits or not. Under current water service rules regulated by the Wisconsin PSC, all customers are subject to the City's conservation measures, including the water rate schedule, outdoor water use restrictions, and financial incentives to install water-saving toilets. If water service is extended to areas outside the City, customers will be required to adhere to the City's conservation program as established in the service rules as well as in future service contracts. The City will provide water conservation public education to new customers and make available information, services and incentives to help its customers use water wisely.

Water conservation is a central part of the City's water supply, were water conservation is integral for any future water supply alternative. Although titled as "alternatives", all of the water conservation measures in the Conservation Plan are, or will be, implemented equally for any future water supply alternative. The City cannot meet future water demand through water conservation alone.

2.2.4 No Action Alternative

The City of Waukesha currently obtains water from multiple wells within the deep and shallow aquifers. The "no action" alternative would include the continued use of these aquifers. The No Action alternative, by definition, would continue to use the aquifers without modification. Because the deep and shallow aquifer wells do not have sufficient capacity to meet future demands and because the deep aquifer wells exceed radium water quality requirements, the No Action alternative will not provide for the City's long-term water quantity and quality needs. However, the No Action alternative is carried forward in Section 6 of this document to support an EIS process under NEPA.

2.2.5 Summary of Remaining System Alternatives

Water supply alternatives remaining considering both groundwater and Lake Michigan alternatives are shown together with the return flow alternatives in Table 2-3. The system alternatives combining a Lake Michigan water supply with a return flow alternative are shown in Table 2-4. These system alternatives are evaluated in detail in Sections 3, 5, and 6.

TABLE 2-3
Water Supply and Return Flow Alternatives

Water Supply Alternative
Deep and Shallow Aquifers
Shallow Aquifer and Fox River Alluvium
Lake Michigan (City of Milwaukee)
Lake Michigan (City of Oak Creek)
Lake Michigan (City of Racine)
Return Flow Alternatives (for Lake Michigan Water Supplies)
Underwood Creek to Lake Michigan
Root River to Lake Michigan
Direct to Lake Michigan near Milwaukee and Oak Creek (hereafter referred to as *Direct to Lake Michigan Return Flow* in Sections 5 and 6)

TABLE 2-4
Water Supply and Return Flow System Alternatives

Water Supply Alternative	Lake Michigan Return Flow Alternative
Mississippi River Basin System Alternatives	
Deep and Shallow Aquifers	None – Continued Discharge to Fox River
Shallow Aquifer and Fox River Alluvium	None – Continued Discharge to Fox River
Lake Michigan System Alternatives	
Lake Michigan (City of Milwaukee)	Underwood Creek to Lake Michigan
Lake Michigan (City of Milwaukee)	Root River to Lake Michigan
Lake Michigan (City of Milwaukee)	Direct to Lake Michigan
Lake Michigan (City of Oak Creek)	Underwood Creek to Lake Michigan
Lake Michigan (City of Oak Creek)	Root River to Lake Michigan
Lake Michigan (City of Oak Creek)	Direct to Lake Michigan
Lake Michigan (City of Racine)	Underwood Creek to Lake Michigan
Lake Michigan (City of Racine)	Root River to Lake Michigan
Lake Michigan (City of Racine)	Direct to Lake Michigan