GZA
GeoEnvironmental, Inc.

Engineers and Scientists

February 29, 2016
File No. 20.0154335.02

Milwaukee Riverkeeper
1845 North Farwell Avenue, Suite 100
Milwaukee, Wisconsin 53202

Attention: Ms. Jennifer Bolger Breceda
Executive Director

Re: Response to Comments on Non-Diversion Alternative
City of Waukesha Water Supply
Waukesha, Wisconsin

Global Water Center
247 Freshwater Way,
Suite 542
Milwaukee, Wisconsin
53204

414-831-2540

www.gza.com

Dear Ms. Bolger Breceda:

In accordance with our February 5, 2016 conference call, GZA GeoEnvironmental, Inc. (GZA) is pleased to submit this response letter to comments from units and agencies of government on the Non-Diversion Alternative (NDA) report, prepared by GZA, dated July 9, 2015, to Clean Wisconsin and Milwaukee Riverkeeper ("Client").

BACKGROUND

The City of Waukesha ("City") submitted an Application for Lake Michigan Supply to the Wisconsin Department of Natural Resources (WDNR) in May 2010, revised in 2013, proposing to use Lake Michigan water with return flow to meet its long range water supply planning needs. As discussed in the City's revised application Volume 2,[1] the City proposed an average water demand of 10.1 million gallons per day (MGD) and a peak water demand of 16.7 MGD.

WDNR, supporting the City's Application, published its "Draft Technical Review for the City of Waukesha's Proposed Diversion of Great Lakes Water for Public Water Supply with Return Flow to Lake Michigan," dated June 2015 ("Draft Technical Review"), and "Draft Environmental Impact Statement," dated June 2015 ("Draft EIS"), which were open for public comment from June to August 2015. The WDNR responded to the public comments and finalized its review, leading to the submission of the City's Application to the Great Lakes – St. Lawrence River Water Resources Regional Body ("Regional Body") and the Great Lakes – St. Lawrence River Basin Water Resources Regional Council ("Compact Council") for regional review on January 7, 2016.

In WDNR's submission packet, WDNR commented on the NDA in the Preliminary Final Environmental Impact Statement ("Preliminary Final EIS") (WDNR, 2016).[2] After reviewing WDNR's submission packet and other additional information present since July 2015, GZA provides the following responses:

[1] CH2MHill, 2013, City of Waukesha Water Supply Service Area Plan, Volume 2 of 5.
[2] WDNR, January 2016, City of Waukesha Proposed Great Lakes Diversion, Preliminary Final Environmental Impact Statement.

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Comment 1 – Firm Well Capacity

The proposed NDA utilizes the existing deep bedrock wells and shallow aquifer wells. Table 1.1 provides a summary of the proposed NDA (GZA, 2015).[3]

Table 1.1 - Non-Diversion Alternative

Water Source	Demand (MGD)		Supply Wells	Treatment Facilities	Transmission Facilities
	Avg. 6.7 MGD	Max. 11.1 MGD			
Deep Confined Aquifer (Existing Wells)	5.7	9.6	7 Existing Wells (Nos. 3, 5, 6, 7, 8, 9, 10)	3 new reverse osmosis treatment plants at Well Nos. 6, 8 and 10. Existing hydrous manganese oxide treatment at Well No. 3.	Improvement for the 4.3 miles of existing distribution piping system. 7 miles of new piping for blending.
Shallow Aquifer (Existing Wells)	1.0	1.5	3 Existing Wells (Nos. 11, 12, 13)	Existing groundwater treatment plant for iron and manganese removal for Well Nos. 11 and 12.	

WDNR Comment

In Section 4.2.1 – Proposed Water Supply Demand Analysis of the Preliminary Final EIS (page 106), WDNR included a firm well capacity table provided by the City (Duchniak, 2015).[4] The table summarized the 24-hour firm capacities, the 12-hour firm capacities and the 22-hour firm capacities of the existing deep bedrock wells (Well Nos. 3 through 10). According to industrial standard on groundwater water supply system sizing, the total 12-hour firm capacity of the existing deep well network was compared to the NDA average day demand (ADD); the total 22-hour firm capacity of the existing deep well network was compared to the maximum day demand (MDD). With reverse osmosis treatment, 20% of 24-hour firm capacities for Well Nos. 6, 8 and 10 were removed, considering the typical reverse osmosis (RO) reject water percentage. Well No. 10, the largest well, was excluded according to the industrial standard. Most significantly, the capacity of Well No. 9 was counted as zero, as the City is proposing to abandon Well No. 9, citing poor water quality, and limited well house footprint (Preliminary Final EIS, page 8). The total well capacity

[3] GZA GeoEnvironmental, Inc., July 2015, Non-Diversion Alternative Using Existing Water Supply with Treatment, City of Waukesha Water Supply.
[4] Duchniak, D. personal communication. Water Supply System – Well Capacities. November 12, 2015.

with RO or other alternative radium treatment options in WDNR's Preliminary Final EIS is summarized in Table 1.2.

Table 1.2 – WDNR's Existing Well Firm Capacity (WDNR, 2016)

Radium Treatment Alternative	Total 12-hour Firm Capacity of Existing Well System	Total 22-Hour Firm Capacity of Existing Well System
Reverse Osmosis Treatment for Well Nos. 6, 8, 10	4.6 MGD	8.5 MGD
Other Treatment Alternatives	5.2 MGD	9.4 MGD

The WDNR concluded that the existing deep well system capacity would not meet the proposed ADD and MDD in the NDA. Upon further review, it appears that WDNR did not attempt to evaluate potential options and alternatives to address the capacity issue primarily caused by the proposed abandonment of Well No. 9.

Response to WDNR Comment

We believe the shortage in the well capacity can be resolved by installing one or two new deep bedrock wells to replace the to-be-abandoned Well No. 9 and the abandoned Well No. 2. As discussed in "Future Water Supply for Waukesha Water Utility" (CH2MHill and Ruekert-Mielke, 2002, page 4-4),[5] to minimize the risk of encountering high total dissolved solid (TDS) groundwater or accelerating the upward migration of saline water from a deeper portion of the aquifer, "any new sandstone wells should be drilled no deeper than about 1,500 to 1,800 feet and pumped at typical rates of about 1,000 gpm. The wells could be pumped at rates up to about 1,500 gpm for short periods by using a variable speed pump." Each new well is expected to meet an average day demand of approximately 1,000 gallons per minute (GPM), or 1.44 MGD (CH2MHill and Ruekert-Mielke, 2002, page 4-6). Assuming one new well will be installed in the area of the current well field and another on the northwest side of the City, the two new wells are expected to provide an average day capacity of 2.88 MGD. With the new replacement well(s) having a designed 24-hour firm capacity of 5.76 MGD, the 12-hour and 22-hour firm capacities are expected to be as provided in Table 1.3.

Table 1.3 - Improved Well Firm Capacity by Installing Replacement Wells

Radium Treatment Alternative	Total 12-hour Firm Capacity of Existing Well System (Add Replacement Wells), MGD	Total 22-Hour Firm Capacity of Existing Well System (Add Replacement Wells), MGD
Reverse Osmosis Treatment for Well Nos. 6, 8, 10	4.6 + 2.88 (New Wells) = 7.5	8.5 + 5.28 (New Wells) = 13.8
Other Treatment Alternatives	5.2 + 2.88 (New Wells) = 8.1	9.4 + 5.28 (New Wells) = 14.7

The improved 12-hour firm capacities for both treatment options are greater than the NDA proposed ADD of 6.7 MGD; the improved 22-hour firm capacities for both treatment options are greater than the NDA proposed MDD of 11.1 MGD.

[5] CH2MHill and Ruekert-Mielke, March 2002, "Future Water Supply for Waukesha Water Utility."

We understand the installation of the replacement wells will incur additional cost, which will be included in the revised capital cost below but, as presented in a subsequent section of this document, the total NDA project cost would still be significantly less than the Lake Michigan Diversion with Return Flow cost.

Comment 2 - Radium Treatment and Residual Management

The proposed NDA considered utilization of three new RO treatment plants at Deep Well Nos. 6, 8 and 10; existing hydrous manganese oxide (HMO) treatment at Deep Well No. 3 and Shallow Aquifer Wells 11 and 12; and blending water from other wells with the treated water. It is important to note that the NDA used the same treatment technologies as the City's Alternative 1 – Deep Confined and Shallow Aquifers for two reasons: RO and HMO are technically feasible technologies for radium treatment, the unit costs in the City's Application can be utilized, and the estimated cost for NDA is comparable to those Alternatives in the City's Application.

WDNR performed a preliminary review of five commonly used radium treatment alternatives for the NDA water supply option in Section 4.2.2 of the Preliminary Final EIS (page 108). Table 2-1 provides a summary of WDNR's preliminary review.

Table 2.1 - WDNR's Preliminary Review of Radium Treatment Alternatives.

Radium Treatment Alternatives and Estimated Cost for NDA option	Benefit	Limitation	Residual Disposal Option
RO Capital: \$13.8 M O&M: \$0.43/1,000 gallons	Remove inorganic, organic compounds including radium, TDS and hardness.	10-20% loss of water as reject water.	Reject water commonly discharged to a sanitary sewer and treated in a publicly-owned treatment work (POTW). The quantities of radium should be covered under the current approved WPDES[6] permit.
HMO Capital: \$13.8 M O&M: \$0.43/1,000 gallons	Remove radium, barium, iron and manganese. City is currently using HMO.	Does not remove hardness or TDS; 3-5% loss of water for backwashing.	Radium-concentrated sludge treated in Waukesha Wastewater Treatment Plant under the current WPDES permit.
Lime Softening Capital: \$23.7 M O&M: \$1.30/1,000 gallons	Remove iron, manganese, hardness and radium.	Volume of sludge can be an issue for disposal.	Not discussed in WDNR review. Typically, the radium-concentrated sludge is stored in a drying lagoon and then disposed of through land application.

[6] WWTP (wastewater treatment plant); WPDES (Wisconsin Pollutant Discharge Elimination System).

Radium Treatment Alternatives and Estimated Cost for NDA option	Benefit	Limitation	Residual Disposal Option
Cation Exchange Capital: $17.5 M O&M: $0.55/1,000 gallons	Remove radium and hardness. Cation exchange should eliminate the need for home water softeners.	Regeneration wastewater used to remove radium from the adsorptive resin is a brine that contains elevated chloride, which can be problematic for POTW.	Concentrated regeneration water can be treated in Waukesha Wastewater Treatment Plant (WWTP) under current WPDES permit.
Radium Selective Adsorptive Media Cost not available.	Remove radium; Minimal amount of waste is discharged to POTW.	Does not remove hardness or TDS.	Adsorptive media is replaced and disposed of at a federally licensed low level radioactive waste landfill.

Note: WDNR's cost estimate was based on the United States Environmental Protection Agency (USEPA) 2007 Drinking Water Infrastructure Needs Survey and Assessment Cost Models adjusted to 2013 dollars for the Milwaukee, Wisconsin region, and includes materials, overhead and profit, bonds and insurance, engineering design and construction services, legal, permits, and construction contingency.

In addition, while indicating that the quantities of radium in the NDA option are expected to be covered under the Waukesha WWTP WPDES permit, WDNR suggested potential problems with RO residual disposal in the future by citing a memo prepared by CH2M for WDNR (CH2M, 2015),[7] which was included in the submission packet as supplemental material.

Response to WDNR and CH2M's comments on RO Reject Water Disposal Difficulties

Review of CH2M's memo indicates that the primary reason for the concern is the RO reject water would increase chloride concentration in POTW influent and effluent.

> "Waukesha already faces challenges with chlorides in their wastewater plant effluent. Discharging RO concentrate could make the problem worse. Madison Wisconsin MSD recently completed a study on removing chlorides. Future wastewater plant discharge regulations are likely to be more stringent and apply to more water quality constituents." (CH2M, 2015, page 3)

However, CH2M and WDNR failed to point out that RO treatment removes hardness, through membrane, either without pre-treatment or with pre-treatment to control membrane scaling associated with high hardness in feed water. The treated water is blended with other well water and is expected to have a lower level of hardness, thus reducing home softening usage. Home softening is the largest source of chlorides to the City's WWTP, estimated at approximately 22,000 pounds per day (lbs/day), according to WDNR's Preliminary Final EIS (WDNR, January 2016, page 186). Chloride concentrations in the current groundwater supply was estimated to be approximately 31 milligrams per liter (mg/L) according to WDNR's Preliminary Final EIS (page 186). Based on an average flow

[7] CH2M, October 2015, "Reverse Osmosis Concentrated Disposal Issue."

of 6.7 MGD, the chloride loading from groundwater is estimated to be approximately 1,700 lbs/day, including the loading from RO reject water and blending well water, which is significantly less than the chloride loading from home softening uses. While it is difficult to accurately predict the patterns and quantities of home softening uses, it is reasonable to expect that the NDA RO treatment option will provide softer water and reduce home softening usages, thus reducing chloride loading to the City's WWTP.

Response to WDNR's Review on Radium Selective Adsorptive Media Treatment

It is important to note that the treatment used by the City of Brookfield and the City of Pewaukee Water Utilities is known as Water Remediation Technology (WRT) Z-88® process, which removes radium by passing contaminated water through a fluidized bed of WRT's proprietary Z-88® natural adsorptive media in treatment columns - without adding chemicals, generating liquid waste, or wasting water. The City of Fond du Lac Water Utility uses the Dow Radium Selective Complexer media, which is a radium-specific resin that is periodically removed and replaced.[8]

Based on our discussions with WRT, the Brookfield system capacity is approximately 1,150 GPM) (1.656 MGD); the Pewaukee system capacity is approximately 500 GPM (0.72 MGD). In addition, WRT Z-88® full scale systems have been installed and utilized by Ethan Allen School in Wales, Wisconsin, The Arbors Water Trust in Delafield, Wisconsin, six municipal water utilities in Illinois, and another six water utilities in other parts of the Country.[9]

The technology features of WRT's Z-88® systems are summarized below:

- It can be used for individual wells or as a central treatment facility;
- It can handle rates of 7 GPM - 4800 GPM (0.01 to 6.91 MGD);
- No water loss;
- Cation exchange media targeted for radium;
- Technology also has a high affinity for barium, and it can also treat strontium;
- The adsorptive media is typically changed every two to three years, depending on monitoring data;
- WRT transports and disposes off the spent media at USEPA-approved, licensed facilities (USEcology.com) – either at the Washington State Low Level Radioactive Waste Landfill or Grandview Idaho LLRWL, both of which was approved by USEPA for low level radioactive waste disposal;

[8] Strand Associates, Inc., January 2009, "Report for the City of Fond du Lac, Water System Master Plan."
[9] http://www.wateronline.com/doc/z-88-radium-removal-process-0001

- No discharge to POTW; and
- WRT assumes liability for radioactive residuals.

Based on the well capacity and NDA demand analysis, the NDA with WRT Z-88 treatment alternative will consist of seven individual WRT Z-88 systems installed at deep Well Nos. 5, 6, 7, 8, 10 and the two replacement wells (Well Nos. 2R and 9R). The existing HMO treatment systems will remain at Well Nos. 3, 11 and 12.

Table 2.2 - Non-Diversion Alternate with WRT Z-88® Process

Water Source	Demand (MGD)		Supply Wells	Treatment Facilities	Transmission Facilities
	Avg. 6.7 MGD	Max. 11.1 MGD			
Deep Confined Aquifer (Existing Wells)	5.7	9.6	6 existing wells (Well Nos. 3, 5, 6, 7, 8, 10) and two new replacement wells (Wells No. 2R and 9R).	7 new WRT Z-88 treatment plants at Well Nos. 2R, 5, 6, 7, 8, 9R and 10. Existing hydrous manganese oxide treatment at Well No. 3.	Improvement for the 4.3 miles of existing distribution piping system. 7 miles of new piping for blending.
Shallow Aquifer (Existing Wells)	1.0	1.5	3 existing wells (Well Nos. 11, 12, 13)	Existing groundwater treatment plant for iron and manganese removal for Well Nos. 11 and 12.	

Based on our discussions with WRT, the total capital cost for the seven new treatment plants is estimated to be approximately $10.85 M, and the operation and maintenance (O&M) cost, including changing media, trucking and disposal spent media, is estimated to be approximately $0.88 per 1,000 gallons of water.

A review of the above treatment options indicates that the radium can be treated with the above technologies and they have been used effectively in public water systems. While each has its own benefits and limitations, it is anticipated that the limitations can be resolved with engineering solutions. Treatment pilot tests and a detailed engineering cost evaluation are recommended to be performed to identify the most cost-effective radium treatment option.

Revised NDA Alternative Cost Projections

Based on the preliminary review, we will retain the original NDA with three RO systems and the existing HMO system, and revise the cost estimates by including the installation of the replacement wells (No. 2R and 9R). In addition, as requested, an alternate NDA with seven new WRT Z-88 systems is included and the cost estimated. The itemized cost estimates for the NDA alternatives with RO or WRT Z88 are shown in the attached Tables

1 and Table 2, respectively. Table 2.3 provides a summary of the capital costs and O&M costs.

Table 2.3 – Estimated Cost for NDA Alternatives

Water Supply Alternative	Capital Cost ($ mil)	Annual O&M Cost ($ mil)	20-yr. Present Worth Cost ($ mil, 6%)	50-yr. Present Worth Cost ($ mil, 6%)
Proposed Alternative (Ave 6.7 mgd, Max 11.1 mgd) with RO and HMO Treatment	98.0	5.5	161.0	184.0
Proposed Alternative (Ave 6.7 mgd, Max 11.1 mgd) with WRT Z-88 and HMO Treatment	76.4	6.5	151.4	179.4

The cost for the proposed alternatives is significantly less than the $334M Lake Michigan with Return Flow and other alternatives, as evaluated in the City's application.

Comment 3 - Groundwater Sustainability

As discussed in GZA's Non-Diversion Alternative Using Existing Water Supply With Treatment (GZA, 2015),[10] both the Southeastern Wisconsin Regional Planning Commission (SEWRPC) Model (SEWRPC, 2005)[11] and the groundwater elevation data from 2000 to 2012, indicate that the groundwater elevation in the deep sandstone aquifer would be generally stabilized if the 2000 pumping rate were maintained, or raised if the deep aquifer pumping rate were less than the 2000 pumping rate.

GZA obtained the 2010 water use data from the United States Geological Survey (USGS) Water Use website[12] and the 2011 to 2014 State-wide water use data from WDNR.[13] Combining with the water use data from 1979 to 2005, tabulated in SEWRPC's "A Regional Water Supply Plan for Southeast Wisconsin," Volume I (SEWRPC, 2005, Table 29),[14] GZA has summarized the historical total groundwater uses in the seven counties in Table 3.1 and Figure 3.1.

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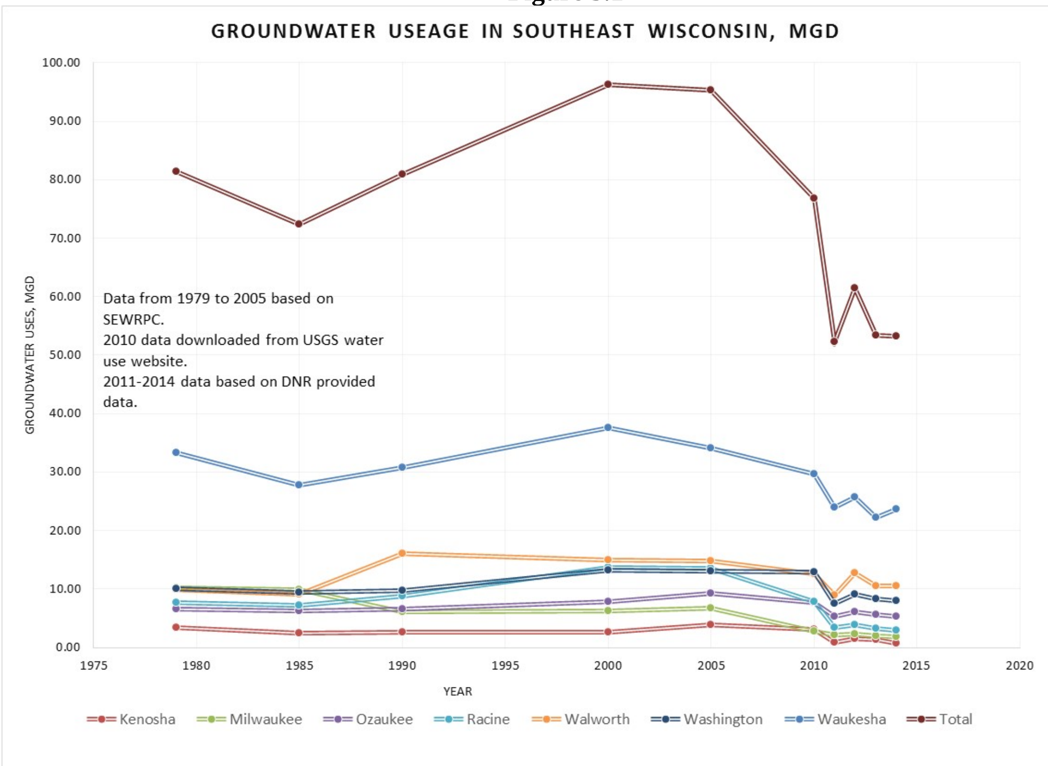
[10] GZA GeoEnvironmental, Inc., July 2015, Non-Diversion Alternative Using Existing Water Supply with Treatment, City of Waukesha Water Supply.
[11] SEWRPC, June 2005, "Simulation of Regional Groundwater Flow in Southeastern Wisconsin, Report 2: Model Results and Interpretation, Technical Report #41.
[12] http://water.usgs.gov/watuse/data/index.html
[13] GZA obtained shapefile data from Mr. Robert Smail at WDNR through data request.
[14] SEWRPC, December 2010, "A Regional Water Supply Plan for Southeastern Wisconsin." Volume I, Table 29.

Table 3.1 - Groundwater Use in Southeast Wisconsin

Groundwater Use, MGD										
Year	**1979**	**1985**	**1990**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**
Kenosha	3.42	2.54	2.56	2.69	3.87	3.14	0.85	1.47	1.33	0.79
Milwaukee	10.18	9.91	6.17	6.32	6.81	2.73	2.17	2.35	2.06	1.88
Ozaukee	6.66	6.33	6.66	7.80	9.27	7.76	5.38	6.07	5.66	5.28
Racine	7.69	7.28	8.85	13.63	13.47	7.92	3.45	3.87	3.19	3.01
Walworth	9.89	9.14	16.07	14.95	14.81	12.65	8.88	12.74	10.54	10.51
Washington	10.11	9.37	9.76	13.30	13.09	12.86	7.58	9.14	8.36	8.07
Waukesha	33.37	27.84	30.78	37.56	34.06	29.73	23.92	25.76	22.26	23.70
Total	81.32	72.41	80.85	96.25	95.38	76.79	52.22	61.40	53.39	53.23

Figure 3.1



The groundwater use data indicate the total groundwater uses decreased from 2000 to 2011, and fluctuated from 2011 to 2014. Total groundwater use in the seven counties generally decreased from 2010 to 2014, even though it bounced back from 2011 to 2012. Groundwater pumping in the deep sandstone aquifer is expected to follow a similar trend.

A recent groundwater modeling effort was performed to predict future groundwater drawdown in the deep sandstone aquifer (LBG, 2015).[15] It used the SEWRPC Model to simulate groundwater levels from 2014 to 2064, assuming three pumping scenarios: low-

[15] Leggette, Brashears & Graham, Inc. (LBG), November 2015, "Predicting Future Water Levels in the Sandstone Aquifer of Southeastern Wisconsin."

level pumping scenario - pumping rates remain flat; mid-level pumping scenario - pumping rates from the sandstone aquifer increasing at annual rates ranging from 4.4% to 10.2 %; and high-level pumping scenario - pumping rates from the sandstone aquifer increasing at annual rates ranging from 5.1% to 11.9%.

As shown on Figure 3.1, the total groundwater use data from 2000 to 2014, does not support the mid-level and high-level pumping rate assumptions. The low-level pumping scenario appears to be relatively reasonable as compared to the total groundwater use decreasing trend. The low-level pumping scenario simulation result indicates that, assuming pumping rates remain the same as 2014 for the next 50 years, water levels in the sandstone aquifer can be expected to decline approximately 20 feet in the eastern portion of the SEWRPC service area and less than 10 feet in the western portion from 2014 to 2064 (LBG, 2015). However, as previously presented, groundwater level data from the USGS observation well located near the City well field has rebounded approximately 100 feet to an elevation of approximately 450 feet MSL (GZA, 2015).[16] The low-level pumping scenario simulation result indicates that the groundwater level at the USGS observation well is expected to be approximately 440 feet MSL, approximately 240 feet higher than the top of the sandstone aquifer. It is important to note that the low-level pumping scenario is conservative in that it does not take into account of the effect of water conservation on future water uses. According to SEWRPC's definition and interpretation for the deep sandstone aquifer,[17] the declining groundwater use data from 2000 to 2014, the rising groundwater elevation data measured in the USGS monitoring well,[18] SEWRPC's modeling effort in 2005 (SEWRPC Model),[19] and the recent low-level pumping scenario simulation results indicate that the deep sandstone aquifer is sustainable under the current (and our projected future) level of water demand.

CLOSING

The supplemental aquifer sustainability and treatment evaluation performed by GZA, as presented herein, confirms that the NDA represents the most cost-effective and technically feasible alternative to meet the existing and future water supply demands for the City. This alternative is protective of both human health and the environment and represents less than 60% of the cost of the diversion alternative, using either RO treatment with the existing HMO treatment, or WRT-Z 88 treatment with the existing HMO treatment, on a 50-year net present worth basis. The supplemental information presented herein confirms the findings of our report dated July 9, 2015.

[16] GZA GeoEnvironmental, Inc., July 2015, Non-Diversion Alternative Using Existing Water Supply with Treatment, City of Waukesha Water Supply.
[17] See GZA, 2015.
[18] See GZA, 2015.
[19] SEWRPC, June 2005, "Simulation of Regional Groundwater Flow in Southeastern Wisconsin, Report 2: Model Results and Interpretation, Technical Report #41.

We appreciate the opportunity to be of service to you. Please feel free to contact the undersigned at (414) 831-2540 with any questions.

Very truly yours,

GZA GeoEnvironmental, Inc.

Jiangeng (Jim) Cai, P.E.
Senior Consultant

James F. Drought, P.H.
Principal Hydrogeologist

John C. Osborne, P.G.
Senior Principal
District Office Manager

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Attachments: Tables 1 and 2

TABLE 1

COST ESTIMATE - NDA WITH REVERSE OSMOSIS AND EXISTING HMO

Deep Well Treatment Plant - Capital Cost (1)	Quantity	Unit Cost	Extended Cost	NOTE
2 New Wells (2R and 9R), each at 1.5 mgd	2	$557,500	$1,115,000	2
Well house and pump	2	$334,500	$669,000	2
Land	2	$334,500	$669,000	2
Roads and Interconnecting Pipe, 12" to 24", ft	15,000	$195	$2,923,500	2
			$5,376,500	2
3 RO plants for Wells 6,8,10 @ 5.35 mgd	5,350,000	$4.57	$24,460,000	1
including land built in 2020				1
4.3 mi of 16", 24", and 30" pipes	22,500	$413	$9,289,000	1
7 mi of 16" pipe for blending	36,960	$323	$11,938,000	1
			$45,687,000	
Subtotal			**$51,063,500**	
3% markup for Bonds & Insurance			$1,532,000	1
5% markup for Mob/Demob			$2,553,000	1
8% markup for Contractors Overhead			$4,085,000	1
4% markup for Contractors profit			$2,043,000	1
Subtotal			**$10,213,000**	
25% Contingency			$15,319,000	1
Subtotal Markups and Contingency			**$25,532,000**	
Total Project Construction Costs			**$76,595,500**	1
8% allowance for engineering and design			$6,128,000	1
12% allowance for permitting, legal and admin.			$9,191,000	1
8% allowance for engr services during construction			$6,128,000	1
Subtotal Other Project Costs			**$21,447,000**	
Total Project Capital Cost			**$98,042,500**	
Operation and Maintenance (1)				
Source of Supply	**Units**	**Quantity**	**Unit Cost**	**$/year**
Deep Well pumping/maintenance	$/1000 gal	2,190,000	$0.35	$728,000
Shallow Well Pumping/Maintenance	$/1000 gal	365,000	$0.14	$51,000
			Total	**$779,000**
Treatment/Pumping				
Deep Wells 6,8,10 starting in 2020	$/1000 gal	1,460,000	$0.61	$891,000
Shallow Wells	$/1000 gal	365,000	$1.09	$398,000
Residuals	$/1000 gal	128,000	$4	$512,000
			Total	**$1,801,000**
Home Softening				
Salt/Equipment/Replacement	$/person/yr	13,683	$209	$2,860,000
			Total	**$2,860,000**
Transmission				
Operation and Maintenance	$/lf/year	$59,460	$1	$31,000
			Total	**$31,000**
Total O&M Per Year				**$5,471,000**

Present Worth of O&M (6%, 20 Yrs)	**$63,000,000**
Present Worth of O&M (6%, 50 Yrs)	**$86,000,000**
Total Present Worth (6%, 20 Yrs)	**$161,042,500**
Total Present Worth (6%, 50 Yrs)	**$184,042,500**

Notes:
(1) Cost estimates were based on Mead & Hunt's "Waukesha 6.7 MGD Water Demand Alternative," dated July 7, 2015.
Mead & Hunt utilized the unit costs in the City of Waukesha's Application, Volume 2, Water Supply Service Area Plan, Appendix E.
(2) Unit costs were based on the unit costs for Alternative 5 - Unconfined Deep Aquifer in the City of Waukesha's Application, Volume 2, Water Supply Service Area Plan, Appendix E.

TABLE 2

COST ESTIMATE - NDA WITH WRT'S Z-88 SYSTEMS AND EXISTING HMO

Deep Well Treatment Plant - Capital Cost (1)	Quantity	Unit Cost	Extended Cost	NOTE
2 New Wells (2R and 9R), each at 1.5 mgd	2	$557,500	$1,115,000	2
Well house and pump	2	$334,500	$669,000	2
Land	2	$334,500	$669,000	2
Roads and Interconnecting Pipe, 12" to 24", ft	15,000	$195	$2,923,500	2
			$5,376,500	
WRT Z-88 Treatment Plant for Well No. 2R at 1.4 MGD	1	$1,000,000	$1,000,000	3
WRT Z-88 Treatment Plant for Well No. 5 at 1.4 MGD	1	$1,000,000	$1,000,000	3
WRT Z-88 Treatment Plant for Well No. 6 at 2.7 MGD	1	$2,000,000	$2,000,000	3
WRT Z-88 Treatment Plant for Well No. 7 at 0.9 MGD	1	$850,000	$850,000	3
WRT Z-88 Treatment Plant for Well No. 8 at 2.4 MGD	1	$2,000,000	$2,000,000	3
WRT Z-88 Treatment Plant for Well No. 9R at 1.4 MGD	1	$1,000,000	$1,000,000	3
WRT Z-88 Treatment Plant for Well No. 10 at 3.8 MGD	1	$3,000,000	$3,000,000	3
Land	7	$334,500	$2,341,500	2
4.3 mi of 16", 24", and 30" pipes	22,500	$413	$9,289,000	1
7 mi of 16" pipe for blending	36,960	$323	$11,938,000	1
			$34,418,500	
Subtotal			**$39,795,000**	
3% markup for Bonds & Insurance			$1,194,000	1
5% markup for Mob/Demob			$1,990,000	1
8% markup for Contractors Overhead			$3,184,000	1
4% markup for Contractors profit			$1,592,000	1
Subtotal			**$7,960,000**	
25% Contingency			$11,939,000	1
Subtotal Markups and Contingency			**$19,899,000**	
Total Project Construction Costs			**$59,694,000**	
8% allowance for engineering and design			$4,776,000	1
12% allowance for permitting, legal and admin.			$7,163,000	1
8% allowance for engr services during construction			$4,776,000	1
Subtotal Other Project Costs			**$16,715,000**	
Total Project Capital Cost			**$76,409,000**	
Operation and Maintenance (1)				
Source of Supply	**Units**	**Quantity**	**Unit Cost**	**$/year**
Deep Well pumping/maintenance	$/1000 gal	2,190,000	$0.35	$728,000
Shallow Well Pumping/Maintenance	$/1000 gal	365,000	$0.14	$51,000
			Total	**$779,000**
Treatment/Pumping				
Deep Wells 2R, 5,6,7,8,9R,10 starting in 2020 (3)	$/1000 gal	2,190,000	$0.88	$1,927,200
Shallow Wells	$/1000 gal	365,000	$1.09	$398,000
Residuals	$/1000 gal	128,000	$4	$512,000
			Total	**$2,837,200**
Home Softening				
Salt/Equipment/Replacement	$/person/yr	13,683	$209	$2,860,000
			Total	**$2,860,000**
Transmission				
Operation and Maintenance	$/lf/year	$59,460	$1	$31,000
			Total	**$31,000**
Total O&M Per Year				**$6,507,200**

Present Worth of O&M (6%, 20 Yrs)	**$75,000,000**
Present Worth of O&M (6%, 50 Yrs)	**$103,000,000**
Total Present Worth (6%, 20 Yrs)	**$151,409,000**
Total Present Worth (6%, 50 Yrs)	**$179,409,000**

Notes:
(1) Cost estimates were based on Mead & Hunt's "Waukesha 6.7 MGD Water Demand Alternative," dated July 7, 2015.
Mead & Hunt utilized the unit costs in the City of Waukesha's Application, Volume 2, Water Supply Service Area Plan, Appendix E.
(2) Unit costs were based on the unit costs for Alternative 5 - Unconfined Deep Aquifer in the City of Waukesha's Application, Volume 2, Water Supply Service Area Plan, Appendix E.
(3) Preliminary cost estimates for the Z-88 systems were provided by Water Remediation Technology (WRT).