Engineering Investigation of Water Quality and Treatment Issues

submitted to the Rustic Acres Homeowners' Association

November, 2014

H2O'C Engineering
877-22-WATER
www.h2oc.com

Background

The Rustic Acres Subdivision operates an iron- and arsenic-removal water treatment plant. At times, the system has experienced challenges with contaminant removal performance, disinfection byproducts formation, high chemical usage rates, and high operational costs.

The purpose of this study is to investigate these issues and help develop a plan to maintain regulatory compliance, high water quality, and cost-effective, trouble-free, long-term operation.

Existing System

Rustic Acres Water Association is water system # IL0735500. Illinois EPA's website currently provides the following water system details:

Water System No. :	IL0735500	**Federal Type :**	C
Water System Name :	RUSTIC ACRES WATER ASSOCIATION	**State Type :**	C
Principal County Served :	HENRY	**Primary Source :**	GW
Status :	A	**Activity Date :**	01-01-1972

Points of Contact

Name	Job Title	Type	Phone	Address	Email
WELVAERT, JEFFERY A.	OPERATOR	DO		3408 14TH STREET, MOLINE, IL-61265	j.welvaert@moline.il.us
WELVAERT, JEFFERY A.	OPERATOR	SA		3408 14TH STREET, MOLINE, IL-61265	j.welvaert@moline.il.us
BARRETT, KAREN	PRESIDENT	AC	309-441-6142	PO BOX 121, 101 LAKEVIEW DR., COLONA, IL-61241	hostas52@hotmail.com
BARRETT, KAREN	PRESIDENT	OW	309-441-6142	PO BOX 121, 101 LAKEVIEW DR., COLONA, IL-61241	hostas52@hotmail.com
BARRETT, KAREN	PRESIDENT	OC	309-441-6142	PO BOX 121, 101 LAKEVIEW DR., COLONA, IL-61241	hostas52@hotmail.com

Annual Operating Periods & Population Served

Start Month	Start Day	End Month	End Day	Population Type	Population Served
1	1	12	31	R	200

Service Connections

Type	Count	Meter Type	Meter Size Measure
RS	85	ME	0

Sources of Water

Name	Type Code	Status
WELL 1 (31783)	WL	A

Service Areas

Code	Name
R	MUTUALLY OWNED
R	RESIDENTIAL AREA

Water System Facilities

Water System No. :	IL0735500	**Federal Type :**	C
Water System Name :	RUSTIC ACRES WATER ASSOCIATION	**State Type :**	C
Principal County Served :	HENRY	**Primary Source :**	GW
Status :	A	**Activity Date :**	01-01-1972

State Asgn ID No.	Facility Name	Type	Activity Status
DISTRIBUTION	RUSTIC ACRES WATER ASSOCIATION	DS	A
GENFIN	GENERIC FINISHED SAMPLING STATION	SS	A
GENRAW	GENERIC RAW SAMPLING STATION	SS	A
D-PRESSURE	DISTRIBUTION PRESSURE STORAGE	ST	A
TP01	TP 01-TREATMENT PLANT	TP	A
WL31783	WELL 1 (31783)	WL	A

Raw Water Quality

Chem/Rad water quality monitoring results from EPA (April 2009), prior to the installation of the new treatment facility for arsenic and iron removal in May 2010. (Note iron:arsenic ratio of 25:1.)

Analyte Code	Analyte Name	Method Code	Less than Indicator	Level Type	Reporting Level	Concentration level
1005	ARSENIC	200.8			0	76 UG/L
1010	BARIUM	200.8			0	390 UG/L
1015	CADMIUM	200.8	Y	MRL	1 UG/L	
1020	CHROMIUM	200.8	Y	MRL	4 UG/L	
1024	CYANIDE	4500CN-C	Y	MRL	.01 MG/L	
1025	FLUORIDE	300.0	Y	MRL	.25 MG/L	
1028	IRON	200.7			0	1900 UG/L
1032	MANGANESE	200.8			0	18 UG/L
1035	MERCURY	200.8	Y	MRL	.2 UG/L	
1036	NICKEL	200.8	Y	MRL	5 UG/L	
1040	NITRATE	300.0	Y	MRL	.02 MG/L	
1045	SELENIUM	200.8	Y	MRL	2 UG/L	
1052	SODIUM	200.8			0	15 MG/L
1055	SULFATE	300.0	Y	MRL	1 MG/L	
1074	ANTIMONY, TOTAL	200.8	Y	MRL	3 UG/L	
1075	BERYLLIUM, TOTAL	200.8	Y	MRL	1 UG/L	
1085	THALLIUM, TOTAL	200.8	Y	MRL	1 UG/L	
1095	ZINC	200.8			0	20 UG/L

Finished Water Quality

The most recent Chem/Rad water quality monitoring results from EPA (June 2012) are below. At that time, the treatment process appeared to be removing most of the arsenic and iron.

Analyte Code	Analyte Name	Method Code	Less than Indicator	Level Type	Reporting Level	Concentration level
1005	ARSENIC	200.8			0	2.4 UG/L
1010	BARIUM	200.8			0	1.4 UG/L
1015	CADMIUM	200.8	Y	MRL	1 UG/L	
1020	CHROMIUM	200.8	Y	MRL	4 UG/L	
1024	CYANIDE	4500CN-C	Y	MRL	.2 MG/L	
1025	FLUORIDE	300.0			0	0.727 MG/L
1028	IRON	200.7			0	0.046 MG/L
1032	MANGANESE	200.8	Y	MRL	1 UG/L	
1035	MERCURY	200.8	Y	MRL	.2 UG/L	
1036	NICKEL	200.8	Y	MRL	5 UG/L	
1040	NITRATE	300.0	Y	MRL	.02 MG/L	
1045	SELENIUM	200.8	Y	MRL	5 UG/L	
1052	SODIUM	200.7			0	230 MG/L
1055	SULFATE	300.0	Y	MRL	1 MG/L	
1074	ANTIMONY, TOTAL	200.8	Y	MRL	3 UG/L	
1075	BERYLLIUM, TOTAL	200.8	Y	MRL	1 UG/L	
1085	THALLIUM, TOTAL	200.8	Y	MRL	2 UG/L	
1095	ZINC	200.8			0	6.6 UG/L

Existing System Removal Mechanism

The existing treatment system was supplied by Adedge. Iron and arsenic are removed by oxidation with chlorine and removal on proprietary media in two separate, sequential high-rate pressure filters (first for iron, second for arsenic). Although effective, the process requires periodic media replacement at a cost of approximately $40,000. Media life was anticipated to be on the order of five to six years, but arsenic breakthrough was seen after slightly more than two years.

Iron Removal Efficacy

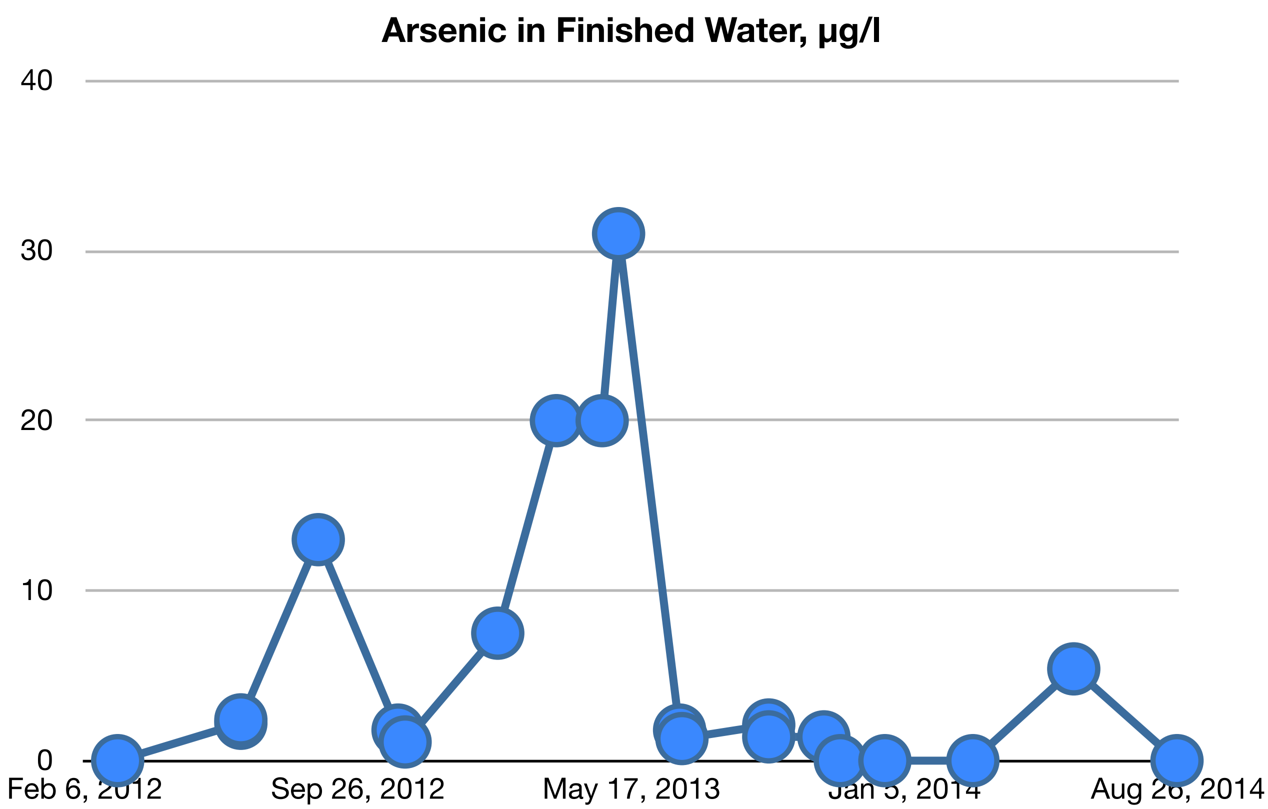
Available data on iron removal indicates that the plant is consistently highly effective.

Iron, mg/l	Raw Water	After Filters
Feb 23, 2012	2.0	0
Mar 1, 2012	1.8	0
Mar 7, 2012	1.7	0
Mar 22, 2012	1.4	0
Apr 5, 2012	1.5	0
Apr 26, 2012	1.6	0
May 12, 2012	1.6	0
Jun 3, 2012	1.5	0
Jul 1, 2012	1.6	0
Jul 23, 2012	1.7	0
Aug 18, 2012	1.6	0
Sep 18, 2012	1.5	0
Oct 28, 2012	1.6	0
Nov 22, 2012	1.6	0
Dec 23, 2012	1.5	0
Feb 19, 2013	1.7	0
Apr 9, 2013	1.8	0
May 3, 2013	1.8	0
May 20, 2013	2.0	0

Arsenic Removal Efficacy

Available data on arsenic in the finished water shows the breakthrough in the spring of 2013, at which time the media was replaced, and effective removal resumed.

Operators report that arsenic was effectively removed at much lower chlorine feeds in 2012.



Disinfection Byproducts

Beginning in 1999, samples have been collected and analyzed every three years for disinfection byproducts (DBP). Every time, this has resulted in very low, nearly non-detectable, DBP levels.

However, DBPs have become an issue with the new treatment facility.

Trihalomethane (TTHM) compliance samples from August 2014 were 96 μg/l, which is above the MCL of 80 μg/l. Haloacetic acid (HAA) compliance samples from August 2014 were 156 μg/l, which is above the MCL of 60 μg/l. DBP monitoring is now performed quarterly.

Separate sampling was done in October, 2014. This confirmed that both THMs and HAAs were over the MCLs in the distribution system, and HAAs were over the MCL upon leaving the treatment plant.

Date	location	Finished Water		Distributed Water	
		TTHM, μg/l	HAA, μg/l	TTHM, μg/l	HAA, μg/l
Aug 21, 2014	House #5			**96**	**156**
Oct 27, 2014	Well House Chem. Room Tap	**64**	**70**		
Oct 27, 2014	142 Rustic Lake Dr.			**118**	**129**
Oct 27, 2014	109 Oakwood Court			**119**	**115**
Average		**64**	**70**	**111**	**133**

Causes of Disinfection Byproduct Formation

Disinfection byproducts are formed when natural organic matter in the source water is in contact with free chlorine over time. No information on the total organic carbon (TOC) content of the source water is available.

At average flows of 20,000 gallons per day, the detention time in the four hydropneumatic tanks is nearly one full day.

The distribution system consists of approximately one mile of 4" PVC pipe, which would contain less than 4,000 gallons of water. Detention time in the distribution system would therefore be expected to be only a few hours.

Under current plant operational protocols, a large amount of chlorine (over 30 mg/l) is fed in order to achieve a free chlorine residual. This is likely the major factor in disinfection byproduct formation.

Chlorination

Water treatment equipment supplier Adedge requires that 0.5 mg/l of free chlorine be present in the output of their arsenic removal unit.

A high chlorine demand in the source water—including naturally-occurring ammonium ion (2.6 mg/l, according to a June 2013 grab sample)—necessitates the feed of over 30 mg/l of chlorine to meet the free chlorine residual criterion.

However, the treatment plant historically has been removing arsenic with a much lower chlorine feed.

Alternative Arsenic Removal Options

High media replacement costs and chemical costs—as well as the disinfection byproduct compliance issues raised by high chlorine feeds—indicate that modifications of the existing treatment protocols should be considered.

In the absence of a compelling reason to use a high-flow rate, proprietary system, the existing equipment could be reconfigured to employ a basic oxidation and filtration approach to combined iron and arsenic removal. This would require re-engineering and testing.

From EPA's "Arsenic Removal from Drinking Water by Iron Removal Plants":

1.1.3 Treatment Technologies for Arsenic Removal

Several common treatment technologies are used for the removal of inorganic contaminants, including arsenic, from drinking water supplies...

Chemical precipitation/filtration commonly is used for removal of iron from source waters. This process, referred to in this document as iron removal, involves two major steps: (1) oxidation of reduced iron, Fe(II), to the relatively insoluble Fe(III) in order to form precipitates; and (2) filtration of the water to remove the precipitated iron hydroxides. The most common oxidants used to precipitate soluble iron are air, chlorine, and potassium permanganate. Iron removal can be used to remove arsenic from drinking water. Two primary removal mechanisms exist: adsorption and coprecipitation (Benefield and Morgan, 1990). During the adsorption process, dissolved arsenic attaches to the surface of a particle or precipitate. And during the coprecipitation process, dissolved arsenic is adsorbed to a particle and entrapped as the particle continues to agglomerate. The following major steps occur when using iron removal for arsenic treatment: (1) the soluble iron and any As(III) are oxidized; (2) As(V) attaches to the iron hydroxides through adsorption and/or coprecipitation; and (3) the particle/precipitate subsequently is filtered from the water.

Recommendations for Near-Term Future Actions

• Valve off three of the four existing hydropneumatic tanks to minimize detention time in the plant.

• Reduce chlorine feed to the point at which the plant effluent is approximately 1 mg/l total chlorine.

Recommendations for Longer-Term Future Actions

• Install a variable-frequency drive controller on the well pump to enable a slower, steadier, controllable flow through the treatment plant. (Additionally, a smaller pump would be desirable.)

• Re-engineer the treatment plant to utilize a basic oxidation/filtration method for iron and arsenic removal on traditional filter media.

• Consider installing air-assisted filter backwash and/or periodic media disinfection if fouling becomes an issue.