

Distribution System Water Quality Monitoring: Well 8 Area  
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## INTRODUCTION

Beginning in late 2005, water quality concerns emerged with regard to manganese, a naturally occurring mineral believed to be the cause of colored water, and stained laundry and plumbing fixtures. The concern originated in the Nakoma area (formerly served by well #10) but later spread to areas of the city served by wells #3, #8, and #29. A comprehensive evaluation of Madison drinking water quality was coordinated between the water utility and the public health department and conducted during 2006. The study revealed that homes with elevated levels of iron and manganese were mostly restricted to areas of the city served by wells with levels of the two minerals that exceed the secondary maximum contaminant level (SMCL) – 50 ug/L or parts per billion for manganese and 0.3 mg/L or parts per million for iron. The study concluded that the problem of elevated manganese and iron was an aesthetic one. However, due to the public concerns about water quality, wells were either (1) permanently removed from service [well #3], (2) used only under emergency conditions [well #10], or (3) designated reserve supply until a filter was installed to remove the nuisance minerals [well #29]. The utility also instituted a more aggressive water main flushing program to scour the water mains and remove the accumulated mineral sediment that contributes to discolored water and elevated iron and manganese observed at the residential tap.

Well #8 continues to operate seasonally from June through October, to meet peak summer water demand, while the water utility investigates the feasibility of installing a filter at the well. The well produces water that exceeds the SMCL for iron and is at the SMCL for manganese. Testing at the well in 2009 showed that manganese ranged from 35-61 ug/L with an average of 50 ug/L and iron ranged from 0.5-1.0 mg/L with an average of 0.6 mg/L. In 2009, 43 million gallons of water was pumped from the well between late July and early September. Average pumpage was about one million gallons per day (mgd), down from nearly 1.2 mgd in 2008 when 114 million gallons were pumped by the well.

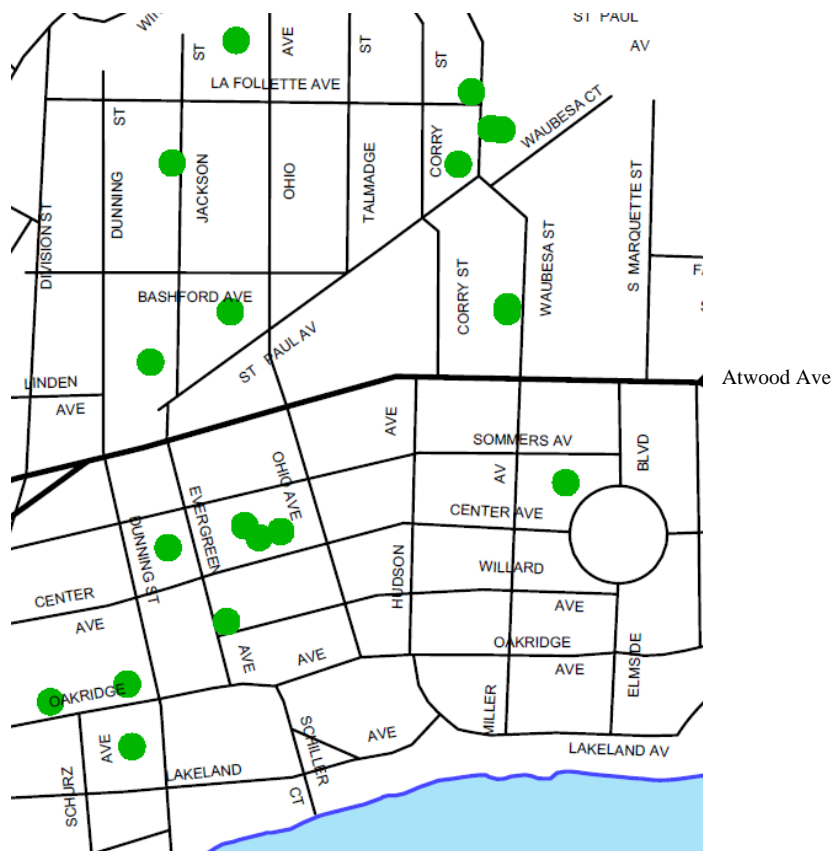
The purpose of the monitoring described in this report was to evaluate distribution system water quality at a subset of homes served by well #8. The study investigated temporal changes in iron and manganese levels at these homes to better understand how the operation of well #8 and water main flushing impact water quality at the residential tap.

## MONITORING METHODOLOGY

Thirty-one homes were identified for long-term monitoring. Locations were selected based on previous water quality problems and customer complaints. Homes were located in three general areas: west (south of Williamson St. between S. Ingersoll St. and S. Baldwin St.), east (between Miller Ave. and Division St.), and north (north of Atwood Ave. between Dunning St. and Waubesa St.). Figure 1 shows the locations of homes selected for monitoring.



(a) “west” monitoring locations



(b) “north” and “east” monitoring locations

Figure 1. Monitoring locations: (a) “west”, (b) “north” and “east” [south of Atwood Avenue].

Attempts were made to collect at least five samples from each location between September 2008 and June 2009. All locations were initially sampled on September 19, 2008. Well #8 was still in service at the time of initial sampling. Later samples were collected at various intervals (table 1) after the flushing of water mains. Flushing occurred between October 1 and November 12, 2008. The locations in each sampling zone (i.e., east, west, and north) were subdivided as shown in the table to increase the number of days in which the distribution system was monitored.

Table 1. Time interval between water main flushing and sample collection.

<b>Zone</b>	<b>Interval 1</b>	<b>Interval 2</b>	<b>Interval 3</b>	<b>Interval 4</b>	<b>Interval 5</b>	<b>Interval 6</b>
<b>East 1</b>	2-3 weeks	6-8 weeks	3 months	6 months	8 months	10 months
<b>East 2</b>	2-3 weeks	6-8 weeks	4.5 months	8 months	10 months	--
<b>North 1</b>	2-3 weeks	6-8 weeks	3 months	6 months	8 months	10 months
<b>North 2</b>	2-3 weeks	6-8 weeks	4.5 months	8 months	10 months	--
<b>West 1</b>	4-5 weeks	3 months	5 months	7 months	--	--
<b>West 2</b>	3-4 weeks	2 months	4 months	7 months	--	--
<b>West 3</b>	2-3 weeks	8 weeks	4 months	7 months	--	--

Samples collected before November 10, 2008 and after April 15, 2009 were collected at outside hose bibbs. For these samples, locations were visited the day prior to sampling to flush the tap for a minimum of three minutes. Remaining samples were collected by homeowners or tenants, generally at the kitchen tap. Customers were asked to collect a first draw sample in the morning before any water was used in the home.

#### Timeline of Water Utility Operations

June 27, 2008	Well #8 began seasonal pumping to the distribution system
September 19, 2008	Initial samples were collected from 31 homes
September 28, 2008	Well #8 was taken off-line for the winter
October 1, 2008	Water main flushing began in the well #8 area
October 13, 2008	Valves were closed at the Yahara River at both Winnebago Street and E. Washington Avenue; this action more or less separated pressure zone 6 into two areas
November 12, 2008	Water main flushing ended in the well #8 area
July 31, 2009	Well #8 began seasonal pumping to the distribution system
September 9, 2009	Well #8 was taken off-line for the winter
October 16, 2009	Final samples were collected

## RESULTS

During the study, a total of 208 water samples were collected; nearly one third of the samples were taken while well #8 was in operation. Table 2 below shows the summary statistics for all

samples, and for periods when the well was on and off. Residential iron and manganese levels were highest during periods when well #8 operated due to higher source water concentrations observed at well #8 compared to well #11. Samples that exceeded the SMCLs for manganese and iron were rare when the well was off-line; however, the frequency of samples testing above the SMCL, especially for iron, was dramatically higher when well #8 was in operation.

Table 2. Summary statistics for iron and manganese levels observed at residential taps during periods when well #8 was on and off.

	Well #8 - Off		Well #8 - On		All Samples	
Samples	134		74		208	
	Iron, mg/L	Mn, ug/L	Iron, mg/L	Mn, ug/L	Iron, mg/L	Mn, ug/L
Minimum	<0.01	<0.2	<0.01	1.8	<0.01	<0.2
Maximum	0.63	151	1.49	101	1.49	151
Mean	0.05	10	0.40	31	0.17	17
Median	0.03	5	0.46	36	0.05	8
Exceed SMCL	2	1	43	11	45	12
% Exceed SMCL	1.5%	0.7%	58%	15%	22%	5.8%

Individual iron and manganese data are plotted as a function of time in Figures 2 and 3. Samples rarely exceeded the SMCL during periods in which well #8 did not operate; two samples tested above these limits, one collected in November 2008 and another in April 2009. No significant trend was observed relative to the time since the water mains were flushed at a given location.

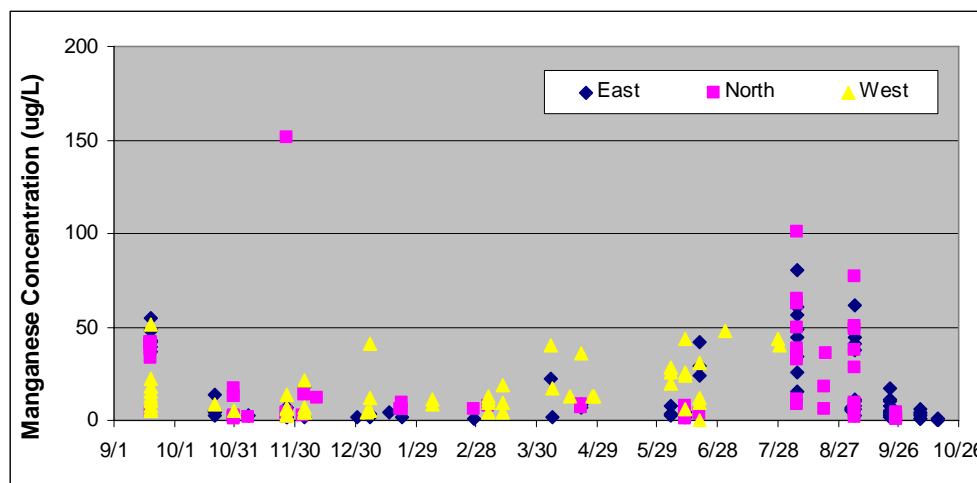


Figure 2. Residential manganese levels (Sept. 2008 – Oct. 2009) in the well #8 area.

Figures 4 and 5 summarize how the range and median values (50<sup>th</sup> percentile) for manganese and iron varied over time. The monthly median manganese level was highest in September 2008 and August 2009, two months in which well #8 was operating. During months in which well #8 was off-line, the monthly median manganese value was below 10 ug/L. Similar trends held for iron; when well #8 was off-line, monthly median levels were less than 0.01 mg/L, and samples above the SMCL were rare – two out of one hundred thirty-four samples total.

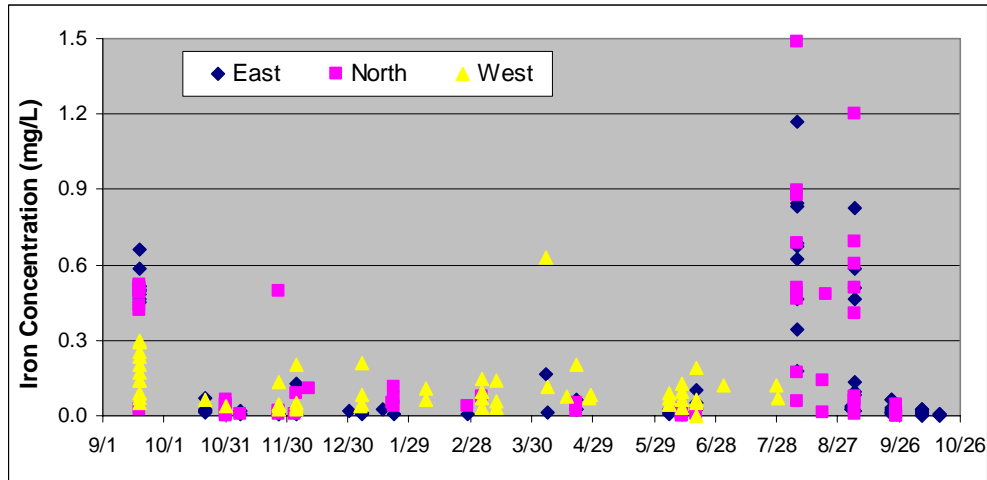


Figure 3. Residential iron levels (Sept. 2008 – Oct. 2009) in the well #8 area.

The small number of total sample sites and locations within each zone prevented comparisons between the three geographic areas that would have statistical meaning. However, the limited data showed, with few exceptions, the west area had higher monthly median manganese levels when compared to the north and east areas. These observations can be explained by the fact that, especially when well #8 was off-line, and after the valves were closed at the Yahara River, the sites located east of the river were most likely receiving water from well #11 while those west of the river were getting water from well #24 and possibly well #7 – two wells that have higher levels of iron and manganese when compared to well #11. Monthly median manganese values for the north area were either similar to or greater than the levels observed in the east area. In general, similar comparisons could be made for the three sampling areas with respect to median monthly iron levels. The most notable exception was in September 2008, when the median iron and manganese levels in the west area were much lower than the levels observed in the east or north sampling areas.

## CONCLUSIONS

Satisfactory levels of iron and manganese were observed at the residential tap in the well #8 area when the well is off-line. Nearly all samples tested well below the SMCL, or aesthetic standard, for both minerals. This observation is significant because the well is typically used for less than three months out of the year, and only to meet peak seasonal water demand. During periods in which the well operated, the iron and manganese levels at the residential tap were comparable to those observed at the well. However, a high degree of variability was observed at the residential tap as reflected in the wide range of observed values particularly in August and September 2009. A significant finding was that no sample had manganese at or near the lifetime health advisory level of 300 ug/L, further supporting the belief that the manganese in Madison’s drinking water system may periodically cause aesthetic problems but not health-related ones. Furthermore, the study showed that iron is more likely to exceed the aesthetic threshold than manganese is. This information confirms the anecdotal observations of field staff who report orange and red colored water when flushing hydrants in the well #8 area.

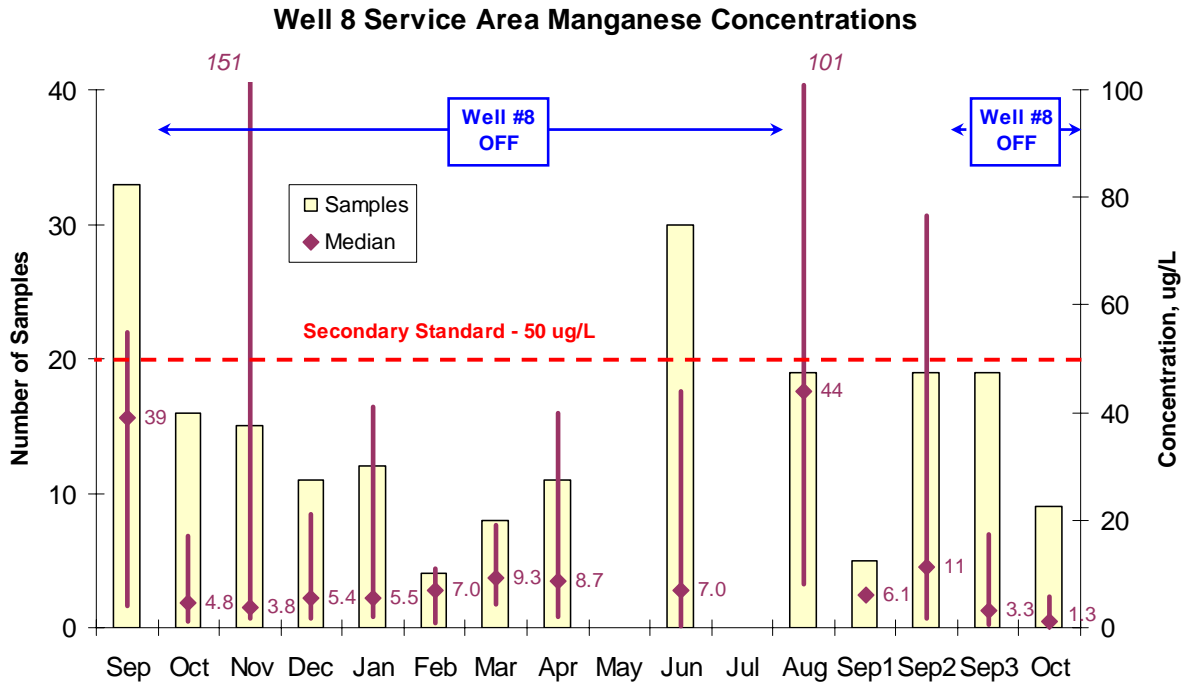


Figure 4. Monthly number of samples, range of residential manganese levels, and median value for samples collected between September 2008 and October 2009.

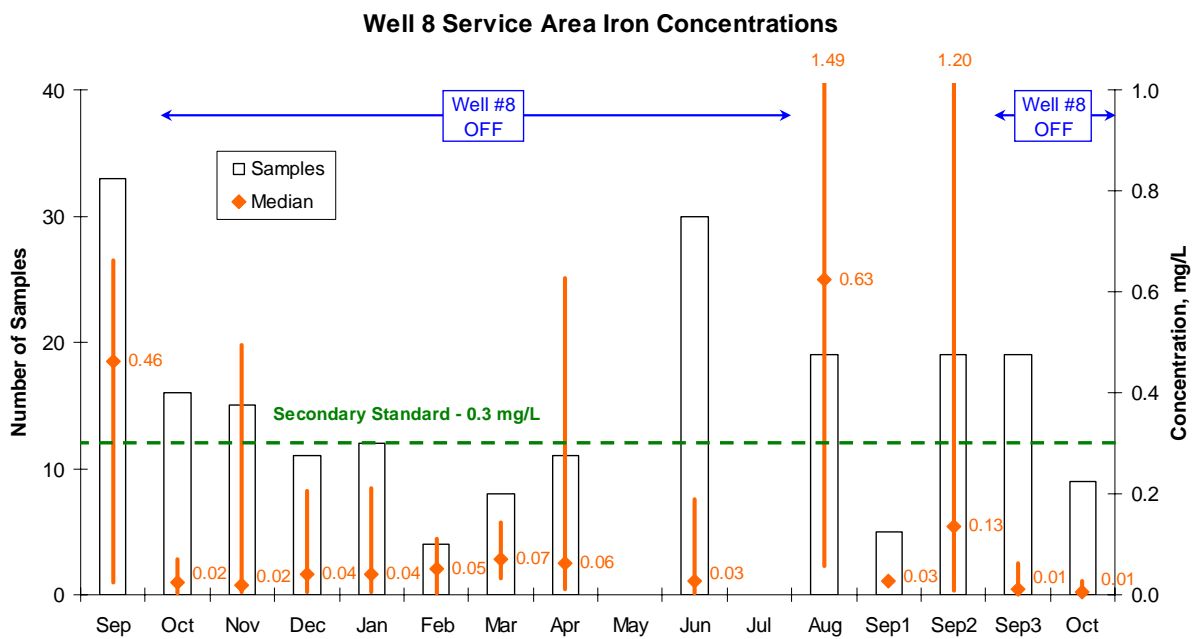


Figure 5. Monthly number of samples, range of residential iron levels, and median value for samples collected between September 2008 and October 2009.