Water Quality Treatment Policies

January 28, 2015

Madison experiences water quality challenges related to aquifer geochemistry as well as historic soil and groundwater contamination. Mineral-rich groundwater pumped from the regional sandstone aquifers is very hard; it has high amounts of calcium and magnesium that require water softening. The deeper Mt. Simon aquifer is also a source of naturally occurring iron, manganese, and radium. At elevated levels, iron and manganese can lead to stains on laundry and plumbing fixtures and possible water discoloration while radium may cause cancer. Normal use, spills, and improper handling of chemicals have caused the contamination of soil and shallow groundwater in some areas of Madison, particularly in former commercial and industrial districts. Environmental releases of volatile organic compounds such as tetrachloroethylene [PCE] and trichloroethylene [TCE] are associated with dry cleaning facilities, automotive repair shops, and manufacturing. Winter de-icing repeatedly introduces road salt [sodium and chloride] onto city streets which later seeps into the drinking water source. Groundwater may remain high in nitrate in areas formerly under agricultural production. Finally, contamination threats to shallow groundwater are not always related to human activity; research suggests aquifer geochemistry supports the release of chromium to the upper bedrock aquifer yet significant amounts of chromium are not found in water drawn from the Mt. Simon aquifer. Future threats to Madison's drinking water supply may emerge as new contaminants are identified or human health impacts of well known pollutants become better understood.

Drinking water contaminants fall into one of three regulatory classifications: (1) ones with a primary Maximum Contaminant Level [MCL] such as tetrachloroethylene [PCE], radium, and nitrate; (2) ones with a non-enforceable, Secondary Maximum Contaminant Level [SMCL] including manganese, iron, and chloride; and (3) ones currently without a federal primary or secondary MCL like sodium, hexavalent chromium, and 1,4-dioxane. Contaminants in this third group may be regulated in Wisconsin under the Groundwater Quality Law (NR 140) by an Enforcement Standard [ES], regulated in another state with an MCL, or have a recommended guideline established by US EPA. Federal and state drinking water regulations, the Safe Drinking Water Act and Wisconsin Administrative Code Chapter NR 809, establish acceptable levels of contaminants in the public water supply; however, the Water Utility Board may establish policies that go beyond these minimum standards.

The Board previously adopted treatment policies for iron and manganese, a policy on testing for pharmaceuticals and endocrine disrupting compounds, and a fluoridation policy. The recommendations below attempt to expand these water quality treatment policies to include contaminants identified on the utility's Water Quality Watch List. Overall, the objective of this report is to establish a strategic framework to identify and respond to an increasing contaminant concentration long before a regulatory threshold might be reached. This approach would establish the contaminant level above which a study would be conducted to evaluate the cause of the increase and potential mitigation efforts – operations change, wellhead treatment, or source replacement – to either reduce the contaminant level or slow further increases.

The general approach proposed is to establish two thresholds: one when a contaminant level consistently exceeds 50% of an established MCL, SMCL, ES, or other numerical guideline or recommendation, and two when it surpasses 80% of these marks. The first threshold would trigger an investigation including an analysis that identifies treatment alternatives, operational changes, or source reductions for mitigating contaminant levels. If a contaminant level rises beyond the second threshold, implementation of wellhead treatment, source replacement, or other mitigation would commence.

A. Volatile and Synthetic Organic Compounds with an MCL or ES

Volatile Organic Compounds [VOCs] are man-made contaminants that volatilize or readily move from water to air. They include compounds such as chlorinated solvents (PCE and TCE, for example) and petroleum chemicals such as toluene, benzene, and xylene. Some are known carcinogens while others may damage the kidney, liver, or other internal organs. Health impacts occur following long-term exposure to high concentrations of the chemical. The Maximum Contaminant Level Goal [MCLG], also called the Public Health Goal, for known or probable carcinogens is set at zero while the MCL is established at a level as close as possible to the MCLG as is technically and economically feasible. For a VOC with non-carcinogenic health impacts, the MCLG is set at a level where there is no known or expected risk to human health with a margin of safety; often the MCL and MCLG are the same. Other VOCs are regulated under NR 140 with enforcement standards for groundwater that are analogous to MCLs. Synthetic Organic Compounds [SOCs] are other man-made contaminants regulated under NR 809 or NR 140. They include pesticides and non-volatile industrial solvents.

Recommendation: As required by NR 809, quarterly monitoring shall occur if any regulated VOC is detected at a level that exceeds 0.0005 mg/L. When four consecutive quarterly samples exceed a concentration equivalent to 50% of the MCL or ES, utility staff shall begin an investigation into feasibility of wellhead treatment, best available technologies [BATs] for VOC reduction, and the source and extent of contamination if not known or previously investigated. At the 80% threshold, staff shall begin a planning process to design and construct a treatment plant to reduce the contaminant level or begin the process to identify a new supply point, free of contamination.

Existing Conditions: Six wells show detections of PCE above the 0.0005 mg/L threshold; four are tested quarterly, the remaining two are tested semi-annually. An air stripper installed at Well #15 successfully reduces the PCE concentration to <0.0005 mg/L. In the last two years, two samples from Well #18 tested above 50% of the MCL for PCE (MCL=0.005 mg/L; max = 0.0035 mg/L); PCE ranged from 0.00085 to 0.0020 mg/L in the other samples. After several years of decline, PCE at Well #9 has gradually increased over the last two years. The current level is 0.0017 mg/L. VOC detections at other wells are either stable or well below the 0.0005 mg/L benchmark.

Implications for the Water Utility: Following the recommendation outlined above would require additional monitoring, most of which the utility already conducts. As a contingency, the utility included a treatment facility at Well #18 as part of its Capital Improvement Plan; construction is projected for 2018 at an estimated cost of $3.3 million. Wellhead treatment at Well #9 might be necessary if the upward trend continues.

B. Inorganics with a Primary MCL or ES

Many regulated inorganic contaminants including trace metals such as chromium, lead, and nickel are found at very low levels in Madison-area ground water. The chemicals are leached from the underlying rock that makes up the aquifer. Their concentrations are well below regulatory and public health goals. Nitrate is one exception. It comes from urban and agricultural fertilizer use in addition to septic tanks and leaky sewer pipes. Madison municipal wells that are open to the upper bedrock aquifer show some signs of nitrate contamination likely reflecting prior land use or aging infrastructure.

Recommendation: Quarterly monitoring shall occur following detections above one half the MCL or ES. When four consecutive quarterly samples exceed this benchmark, an investigation into the contaminant source, causes of the elevated concentration, and alternative strategies for contaminant reductions shall begin. Triggers for an investigation will be based on concentrations at the well rather than in the distribution system. Action shall be taken to reduce the contaminant level if it consistently exceeds 80% of the MCL or ES.

Existing Conditions: Over a dozen inorganic contaminants are detected at some or all Madison municipal wells. Except for nitrate, none of the concentrations are high enough to elicit any additional action. Nitrate is present at fifteen of twenty-two wells with the highest concentrations observed in multi-aquifer wells drawing water from both the upper and lower aquifers. Seven wells exceed 2 mg/L nitrate; the MCL is 10 mg/L. The highest nitrate level (4.4 mg/L) is found at Well #13.

Implications for the Water Utility: None expected.

C. Radionuclides with an MCL

Naturally occurring radioactive elements are found in rock, soil, water, and air. They derive from the creation of our planet and enter our bodies when we drink water, breathe air, and eat foods that contain them. Naturally occurring uranium is found in rock and soil. Over time, it decays to other elements including radium which later decays to radon gas. Data suggest that radium levels are highest at the base of the Mt. Simon aquifer.

Recommendation: Monitor gross alpha, radium, and uranium according to the requirements established by Wisconsin DNR. Detections of any radionuclide above 50 % of the MCL shall trigger quarterly monitoring. If four consecutive quarterly samples exceed this benchmark, staff shall investigate alternatives for contaminant reductions including wellhead treatment, well modifications, and changes to well operations. Source reduction shall be considered if contaminant levels consistently exceed 80% of the MCL.

Existing Conditions: Radium levels are highest at Madison wells that exclusively draw water from the Mt. Simon aquifer. Seven confined aquifer wells exceed 50% of the combined radium MCL and four exceed the 80% benchmark. One sample collected from Well 19 in July 2011 exceeded the radium MCL; however, none of eleven subsequent samples exceeded the legal limit. Best Available Technologies for radium removal include ion exchange, reverse osmosis, and lime softening.

Implications for the Water Utility: The DNR requires radionuclide testing at most Madison wells once every six years. Some wells drawing water exclusively from the Mt. Simon aquifer are monitored more frequently. This policy would mandate quarterly monitoring at seven wells and may ultimately require source reduction at four wells – Well 8, Well 19, Well 27, and Well 28. In addition to the BATs identified above, sealing off a portion of the Mt. Simon aquifer, the source of radium, could be an alternative for reducing radium levels. Estimated costs for increased monitoring are $6000 annually.

D. Inorganics with a Secondary MCL

The US EPA and Wisconsin DNR set non-enforceable secondary MCLs which serve as guidelines for the aesthetic quality of water: taste, odor, and appearance (color). Naturally occurring iron and manganese are present at higher levels in the Mt. Simon aquifer. At elevated levels, these metals can discolor water and stain laundry and plumbing fixtures. Wells open to the upper bedrock aquifer are more susceptible to contamination from road salt (sodium chloride). Increasingly, chloride is becoming problematic at some wells due to long-term application of road salt. Elevated chloride may impart a taste that customers find objectionable.

Policy goals for iron and manganese in new and existing sources were previously established by the Water Utility Board. Existing sources shall meet the secondary MCL while new wells shall supply water with less than 0.1 mg/L of iron and 0.02 mg/L of manganese. The Well #7 facility is currently being re-constructed with the addition of an iron and manganese filter. The 2015 Capital Improvement Plan includes wellhead treatment for iron and manganese removal at Well #8 (2017), Well #19 (2016), and Well #30 (2020). The policy described below would build on policy goals previously developed for iron and manganese and provide further justification for staff recommendations regarding wellhead treatment at Well #19 and Well #30.

Recommendation: Confirmed detections of an inorganic contaminant above one half the SMCL shall trigger an investigation into the contamination source, causes of the elevated concentration, and alternative strategies for reductions. Triggers for an investigation shall be based on concentrations at the well rather than in the distribution system. If the contaminant consistently exceeds 80% of the SMCL, action shall be taken to reduce the contaminant level through wellhead treatment, operations, or source abandonment/new supply.

Existing Conditions: All confined aquifer wells currently produce water that exceeds 50% of the SMCL for iron, manganese, or both nuisance contaminants (see Appendix). Water at Well #19 also exceeds the 80% threshold for iron.

No other contaminant for which an SMCL has been developed measures above 50% of the SMCL. However, the chloride concentration at Well #14 is expected to exceed this level within two years and, if the current trend continues, chloride will surpass the SMCL in 15-20 years. No other well appears at risk of exceeding the SMCL for chloride over the next 30 years; however, four wells could exceed the 50% SMCL benchmark within the next 10-20 year window if current trends continue. Chloride is increasing at a rate of 3-5 mg/L per year at these wells.

Implications for the Water Utility: An investigation into the rising chloride levels and an alternatives analysis would be required for Well #14. Absent a dramatic reduction in chloride, the addition of wellhead treatment, an operational change, source abandonment, or some other alternative likely would be implemented to reduce chloride. An alternatives analysis will be necessary at four other wells if chloride increases continue over the long term.

Expansion of the iron and manganese treatment policy would require wellhead treatment at Well #19, which is already included in the Capital Improvement Plan. An investigation would not be conducted at wells where either iron or manganese exceeds one half the SMCL because the source – the Mt. Simon aquifer – is well known.

E. Unregulated Contaminants

1. Sodium

EPA's *Consumer Acceptability Advice and Health Effects Analysis on Sodium* (2003) recommends reducing sodium levels to between 30 – 60 mg/L based on aesthetic effects including taste. Drinking water within this range is unlikely to be perceived as salty by most individuals. The report identifies a guidance level of 20 mg/L sodium for individuals on a sodium restricted diet; however, it cautions that this level should not be extrapolated to the general population.

Recommendation: Detection of sodium above 30 mg/L at any source shall result in additional monitoring – monthly testing for a period of one year. If the average monthly sodium level is above 30 mg/L, it shall trigger an investigation into the sources and alternative strategies that can reduce the sodium level. If the level exceeds 48 mg/L, staff shall begin the planning process to design and construct a treatment plant, modify the well to seal off the upper aquifer, or identify a new supply point.

Existing Conditions: Sodium currently measures 40 mg/L at Well #14. Five other wells are at or above 19 mg/L; four have seen sodium increase by 40% or more over the last decade. Road salt used for winter de-icing operations is believed to be causing the sodium increase.

Implications for the Water Utility: If the trends continue, sodium levels at Well #14 could exceed the 48 mg/L benchmark in as little as six years and trigger wellhead treatment, well modifications, or source abandonment. An alternatives analysis could be triggered at several sources within ten years if sodium exceeds 30 mg/L. Four wells appear at risk of exceeding the 48 mg/L threshold over the next 20-30 years.

2. Hexavalent Chromium

Drinking water regulations require monitoring for total chromium but they do not require testing for individual forms such as hexavalent chromium. Research now suggests that hexavalent chromium is a probable human carcinogen when ingested. The determination has led to calls for specific regulation of this form of chromium. Further, California recently adopted an enforceable MCL for hexavalent chromium (10 μg/L) which took effect on July 1, 2014.

A collaborative study with the Wisconsin Geological Survey determined that hexavalent chromium naturally occurs in Madison-area groundwater and that aquifer geochemistry is thought to support release of chromium from the upper bedrock aquifer but not the lower Mt. Simon aquifer.

Recommendation: Continue monitoring hexavalent chromium at all wells twice per year through 2015. Then, reduce to annual monitoring at wells where hexavalent chromium exceeds 1 μg/L – a level that corresponds to one tenth the recently adopted California MCL. All wells shall be tested at least once every three years for hexavalent chromium.

Any detection above 5 μg/L shall trigger an investigation into the causes of the elevated concentration and alternative strategies for reductions including operational changes and wellhead treatment. Action may be taken to reduce the contaminant level if it exceeds 8 μg/L.

Existing Conditions: Six wells consistently show hexavalent chromium above 1 µg/L. The highest level, just under 2 µg/L, is found at Well #14.

Implications for the Water Utility: After 2015, annual monitoring for hexavalent chromium will continue at seven wells with triennial testing taking place for the remaining fifteen wells. The estimated annual cost of chromium testing will range from $700 - $2500.

3. Other unregulated or emerging contaminants

   New contaminants of concern are likely to be recognized in the future as a result of health studies conducted by health organizations and government agencies at the state, national, and international level. Improvements in technology to quantify compounds at increasingly minute levels are also expected.

   Recommendation: The utility shall maintain a budget to accommodate the unexpected need to test for new or emerging contaminants. The Technical Advisory Committee shall provide guidance as to the contaminants that should be tested and the frequency of testing.

Appendix

Table 1. Data for wells with highest iron and manganese levels – 2013 results.

	Iron, mg/L	Manganese, µg/L	Notes
50% SMCL	0.15	25	SMCL (Fe) = 0.3 mg/L
80% SMCL	0.24	40	SMCL (Mn) = 50 µg/L
Well #8	***0.62***	***53***	Construction – 2017
Well #19	*0.19*	***45***	Construction – 2016
Well #24	*0.22*	*28*	
Well #28	*0.17*	21	
Well #30	*0.20*	14	Construction – 2020
Well #17	0.11	*30*	Filtration not recommended
Well #23	0.06	*26*	
Well #27	0.14	*31*	

Table 2. Madison wells with above average chloride and sodium levels.

Chloride (mg/L)

Well #	2000	2005	2010	2014
6	26	29	38	59
9	31	31	36	46
11	38	40	52	57
13	6	8	9	40
14	58	70	94	120
15	30	41	49	54
16	18	29	44	57
17	54	56	56	35
23	39	56	60	72
27	19	32	35	38

Sodium (mg/L)

Well #	2000	2005	2010	2014
6	9	10	13	19
9	12	13	15	16
11	12	13	18	19
13	5	5	5	14
14	19	25	34	40
15	11	15	19	20
16	7	11	16	21
17	23	21	23	14
23	13	18	22	25
27	10	18	16	16

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Primary MCL	Contaminant Group	Contaminant	0.5 MCL	0.8 MCL
	Inorganics	Nitrate	Investigation with Alternatives Analysis	Take Action to Reduce Contaminant Level
	Radionuclides	Radium		
	Volatile Organics	Tetrachloroethylene (PCE)		

NR 140 ES	Contaminant Group	Contaminant	0.5 ES	0.8 ES
	Synthetic Organics	1,4 Dioxane	Investigation with Alternatives Analysis	Take Action to Reduce Contaminant Level

Secondary MCL	Contaminant Group	Contaminant	0.5 SMCL	0.8 SMCL
	Inorganics	Chloride	Investigation with Alternatives Analysis	Take Action to Reduce Contaminant Level
		Iron		
		Manganese		

Guideline*	Contaminant Group	Contaminant	0.5 Guideline	0.8 Guideline
	Inorganics	Chromium (VI)	Investigation with Alternatives Analysis	Take Action to Reduce Contaminant Level
		Sodium		

*Source: 0.01 mg/L Hexavalent Chromium (California MCL, 2014); 60 mg/L Sodium from *Consumer Acceptability Advice and Health Effects Analysis on Sodium* (US EPA, 2003)