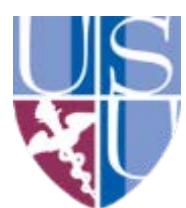


EVALUATING SANITARY SEWERS AS A POTENTIAL SOURCE OF SODIUM AND CHLORIDE IN AN URBAN AQUIFER SYSTEM

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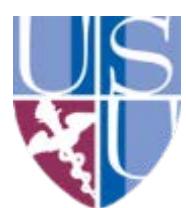
GSA North-Central Section Meeting
19 May 2015



DISCLAIMER

The views expressed are those of the author and do not necessarily reflect the official views of the Uniformed Services University of the Health Sciences, the U.S. Army, or the Department of Defense.



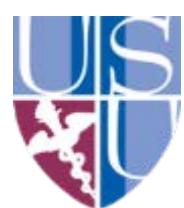


BACKGROUND

Sodium and Chloride

- Detected in all Madison wells
- 2014 Water Quality Report

	MCLG	Median Level	Range	Typical Sources
Chloride (ppm)	250	22	2.4 - 120	Natural Deposits Road Salt
Sodium (ppm)	n/a	9.3	2 - 40	Natural Deposits Road Salt



POTENTIAL SOURCES



Road Salt

- Road de-icing
- Impact on surface water



Home Water Softeners

- Ion Exchange: $\text{Ca}^{2+}, \text{Mg}^{2+}$ for Na^+
- Requires salt to recharge system
- Brine discharge to sewer

SEWER LEAKAGE

U.S. estimates

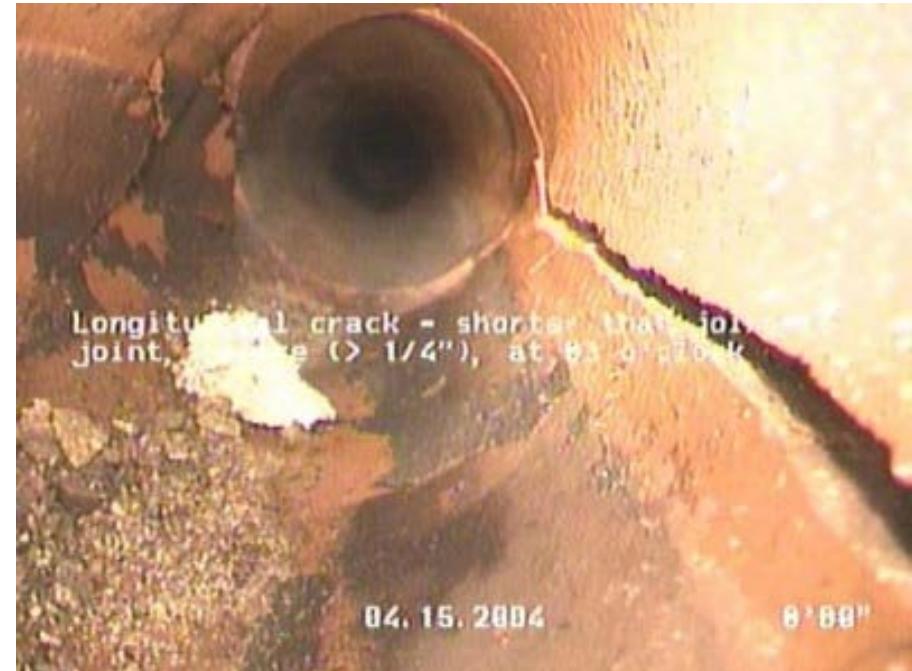
- up to 50% of flow

U.K. estimates

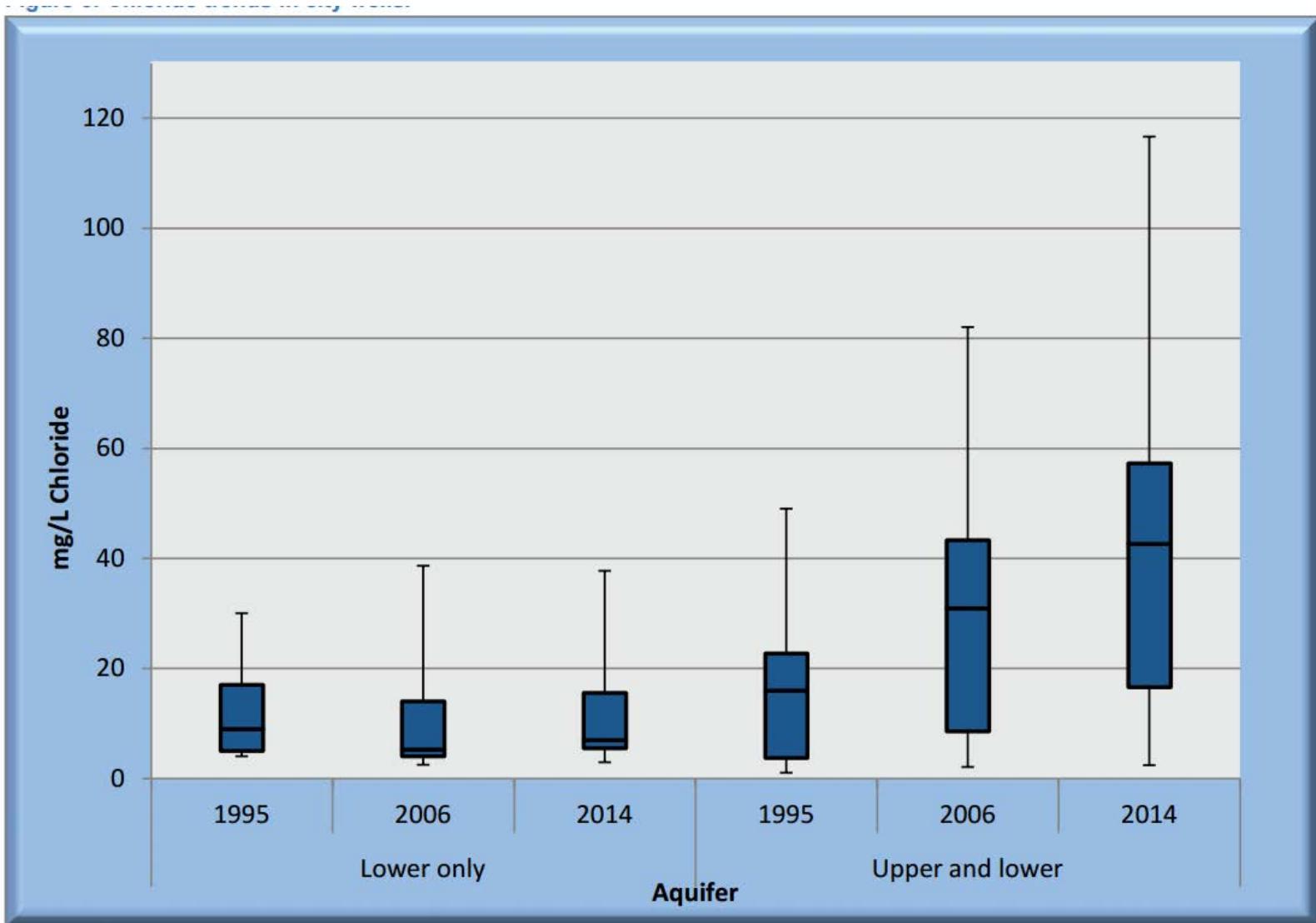
- 10% of flow

Lab experiments

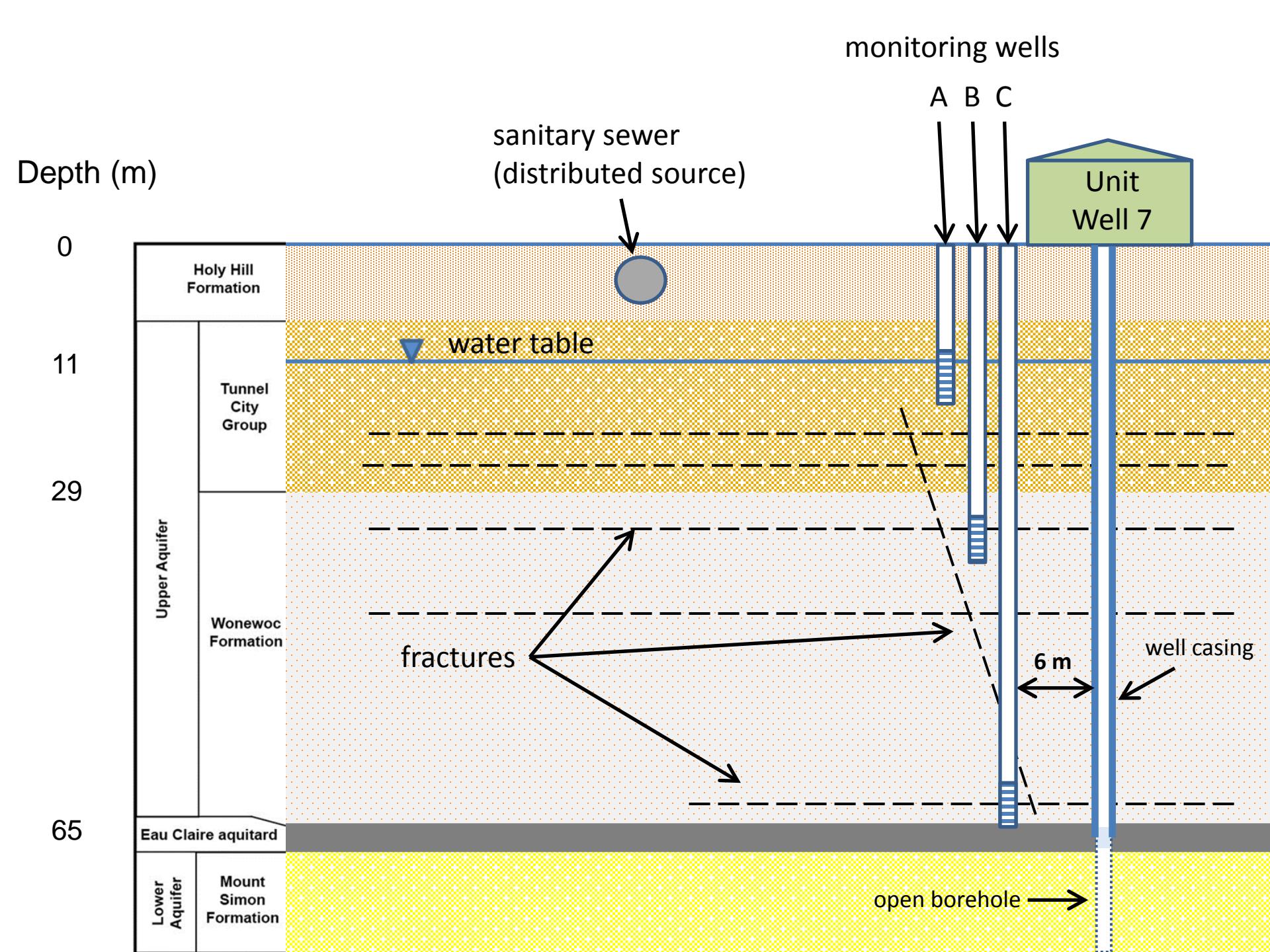
- 0.01 to 0.1 L/sec/km



CHLORIDE IN MADISON WELLS



From Wenta and Sorsa, 2014



GROUNDWATER CHEMISTRY

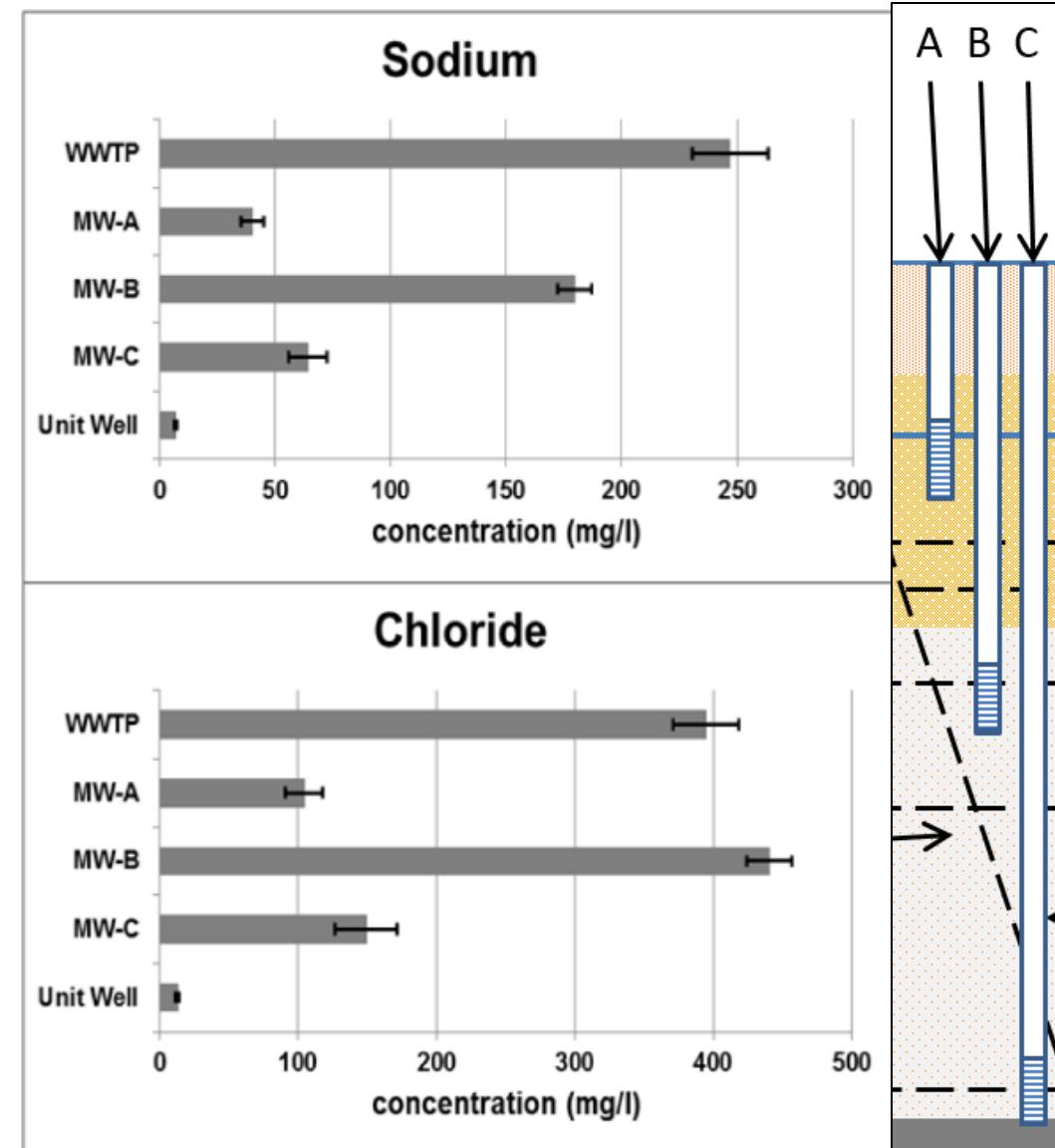
No Seasonal Trend

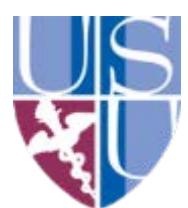
Chloride (mg/l)

- Sewer: 400
- Upper Aquifer: 450
- Lakes: < 100

Electrical Conductivity

Nitrogen

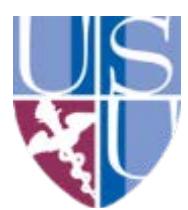




ROAD SALT

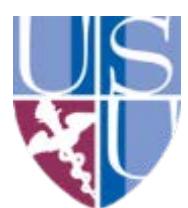
- 10M kg/yr applied to Madison roads
- Seasonal application
- Impervious surfaces
 - Low infiltration rates
 - High surface runoff





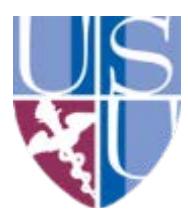
SANITARY SEWERS

- MMSD treats 150M liters/day sewage
- 10% leakage estimate
 - 15M liters/day loading upper aquifer
- 400 mg/l chloride: 2.2M kg/year
- 250 mg/l sodium: 1.4M kg/year



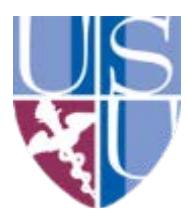
SANITARY SEWERS

- City of Madison: >1,000 km of lines
- Leakage rate: 0.1 L/sec/km
 - 8.6M liters/day loading upper aquifer
- 400 mg/l chloride: 1.3M kg/year
- 250 mg/l sodium: 0.8M kg/year



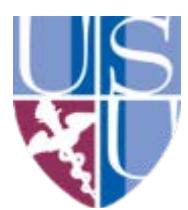
CONCLUSIONS

- Road salt impacts surface water and groundwater
- Sanitary sewers impact groundwater
 - May exceed road salt
 - Infiltration and sewer leakage rates
- Additional impact from storm sewers?



SIGNIFICANCE

- Limiting road salt application may not solve groundwater Na^+ and Cl^- problem
- Effect of sewers must be considered in Na^+ and Cl^- mitigation strategy
- Multi-aquifer wells that intersect fractures with high concentrations Na^+ and Cl^-



ACKNOWLEDGEMENTS

- U.S. Army Research Office STIR grant
- EPA STAR grant (WGNHS)
- RMAG Veterans Memorial Scholarship

- The City of Madison Water and Sewer Utilities
- Madison Metropolitan Sewerage District