CHARACTERIZATION OF PREFERENTIAL FLOW PATHWAYS IN A SILICICLASTIC AQUIFER SYSTEM USING HUMAN ENTERIC VIRUSES AND GROUNDWATER GEOCHEMISTRY

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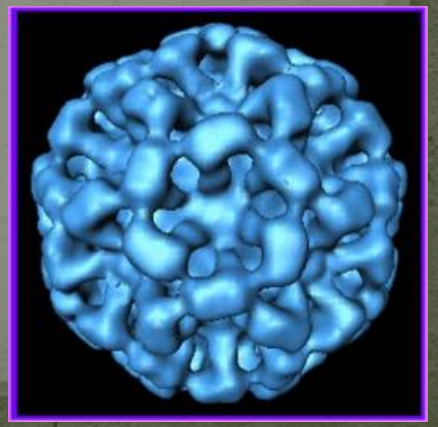
GSA Northeastern Section Meeting
24 March 2014

Background

- Human enteric viruses are a public health threat
  - Only source is human waste
  - Leaking sewers likely source
- Are deep, confined aquifers protected?
  - Viruses infectious for 1-2 years
  - Rapid transport required



Norovirus

Previous Research

- Awareness of viruses in groundwater
  - Madison, WI – virus detection in wells
  - Rural Wisconsin – heath risks

ENVIRONMENTAL Science & Technology

Article

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Source and Transport of Human Enteric Viruses in Deep Municipal Water Supply Wells

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Environmental Health Perspectives, 2012, v. 120, no. 9

Research

Viruses in Nondisinfected Drinking Water from Municipal Wells and Community Incidence of Acute Gastrointestinal Illness

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Research Goals

- Understand mechanisms that control rapid transport in fractured siliciclastic aquifer systems
- Assess vulnerability of public supply wells to near surface contaminants

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DRINKING WATER

Turn on the tap and roll the dice

At least 60 communities in the state don't treat their water despite research on the danger.

from contaminants such as viruses.

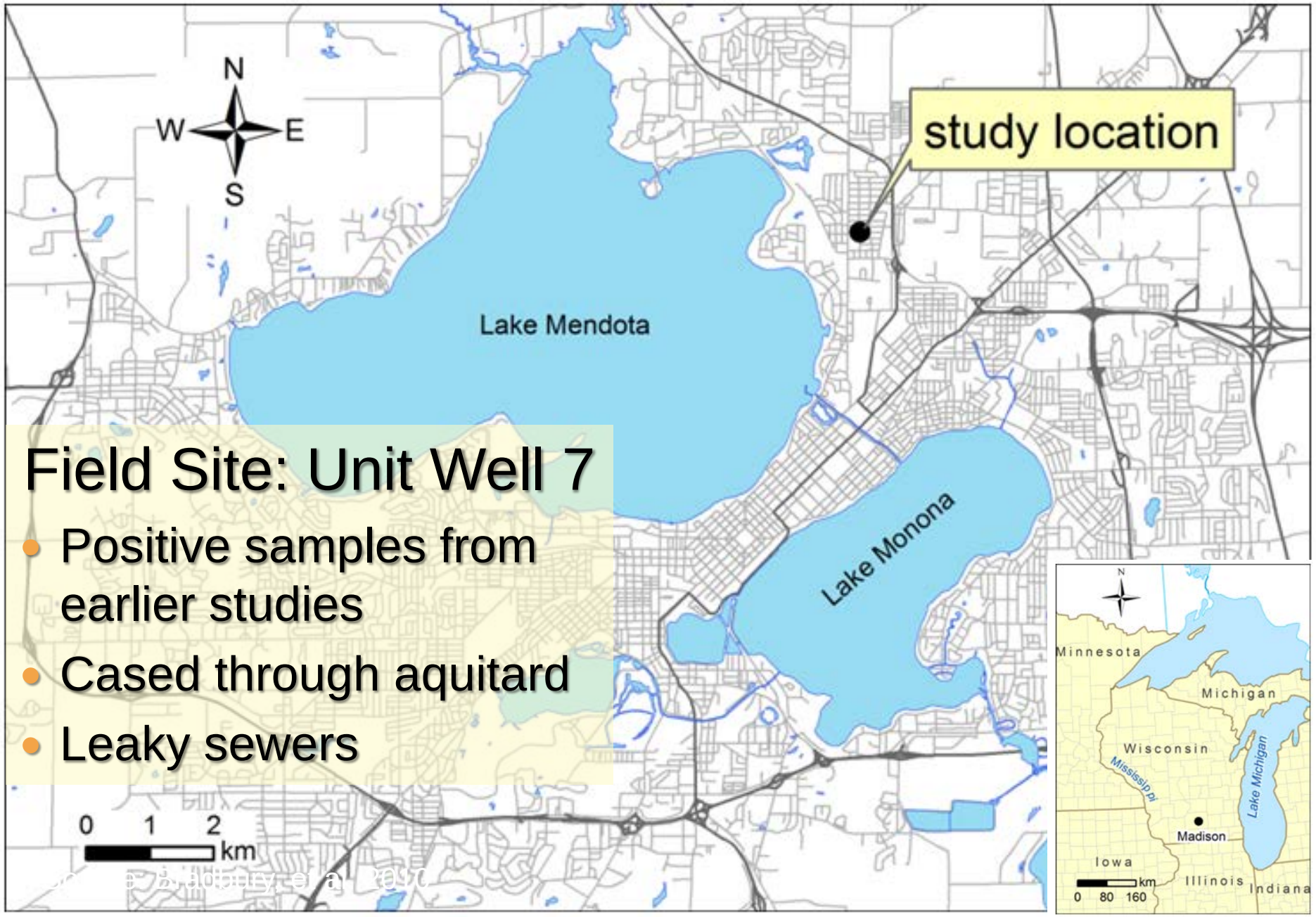
Among the municipalities are Spring Green in Sauk County, with a population of about 1,500, Fall River in Columbia County with almost 2,400 residents, and

recommends communities treat drinking water with either chlorine or ultraviolet light to kill contaminants such as bacteria and viruses.

"We are recommending that all commu-

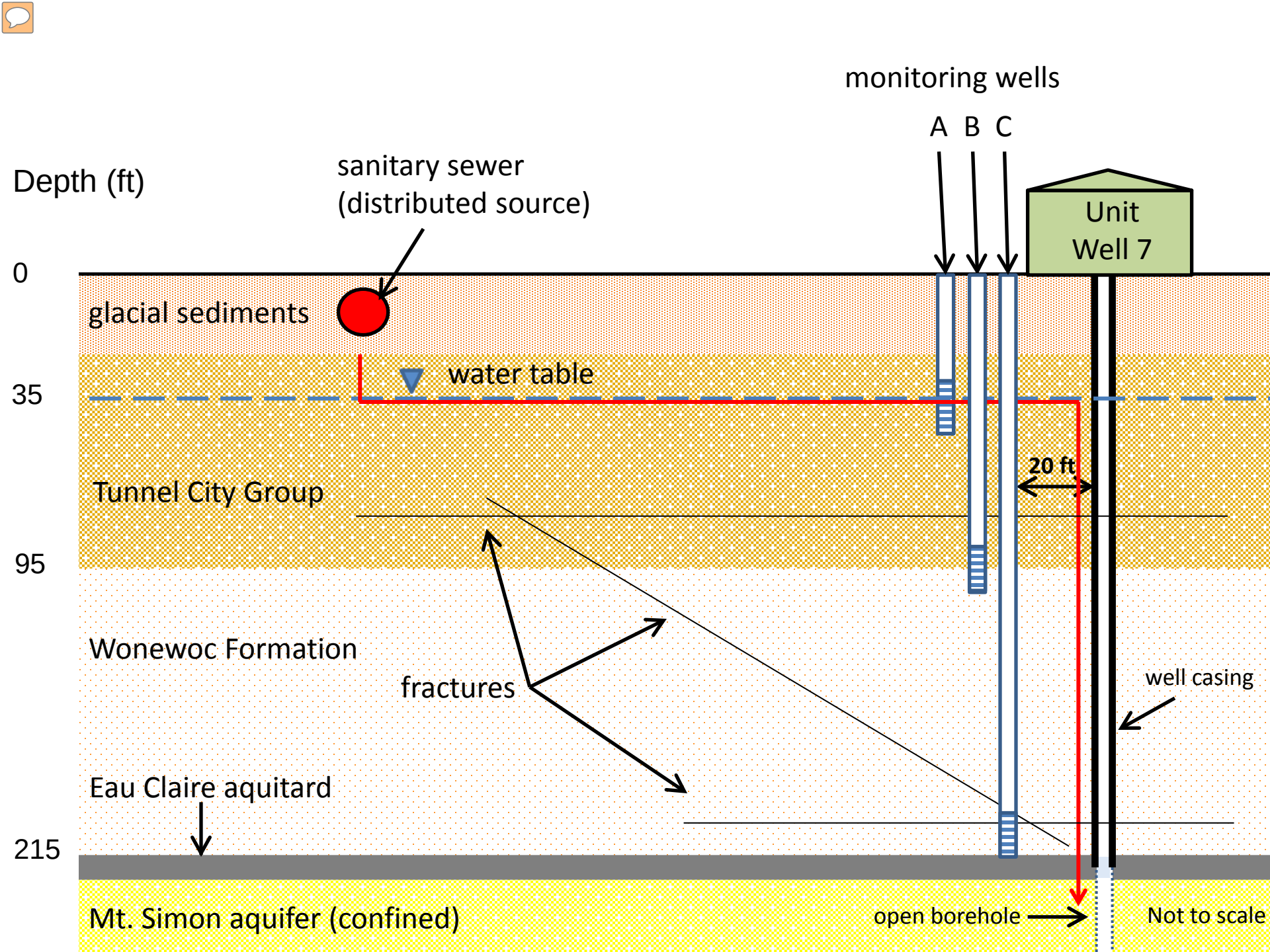
such as Madison, have treated water for some time.

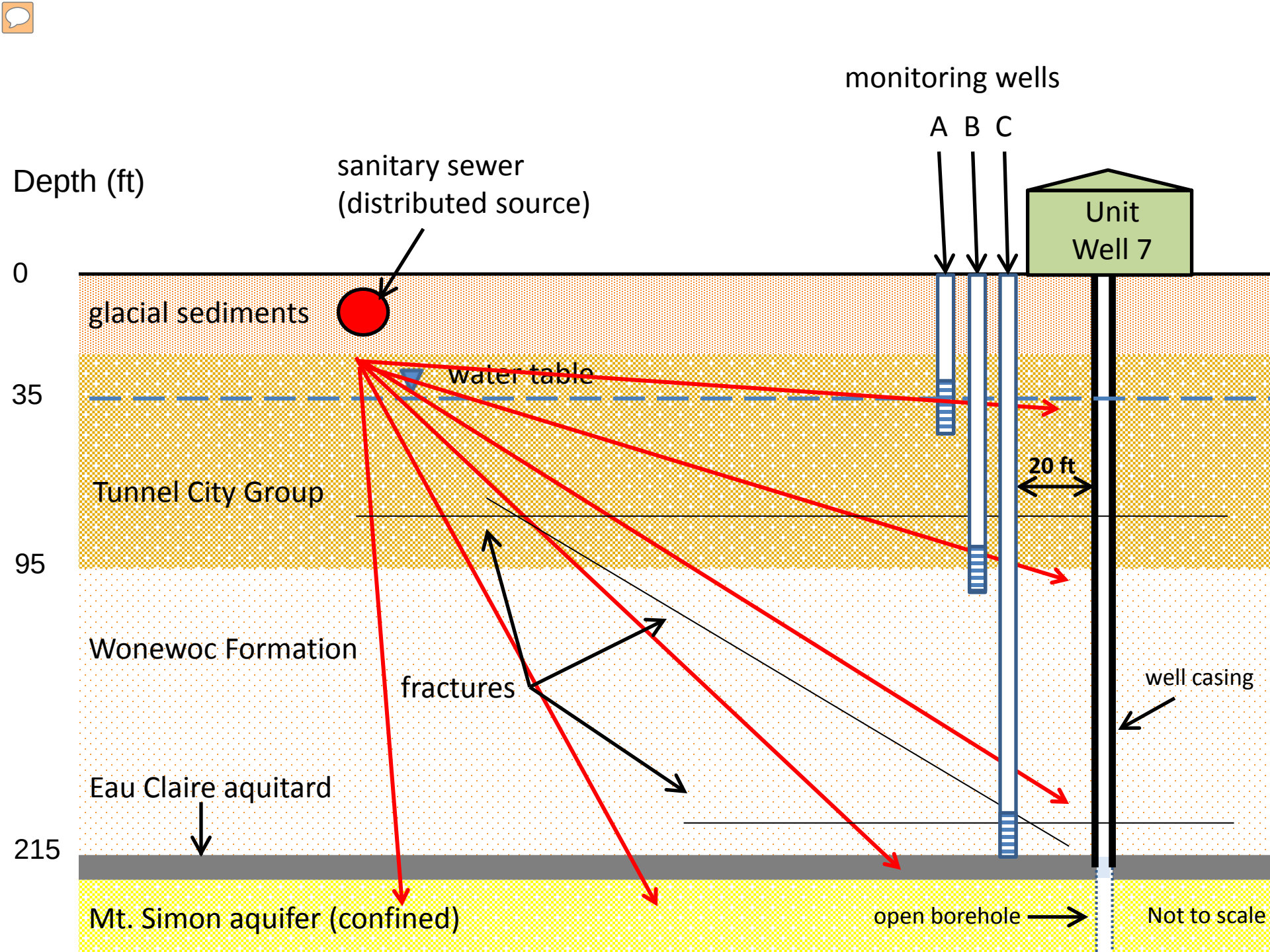
Lee Boushon, who heads the agency's public water supply section, said communities are, in general, more protected



Field Site: Unit Well 7

- Positive samples from earlier studies
- Cased through aquitard
- Leaky sewers


monitoring wells
A B C
Depth (ft)
sanitary sewer
(distributed source)
Unit
Well 7
0
glacial sediments
water table
35
20 ft
Tunnel City Group
95
Wonewoc Formation
fractures
well casing
Eau Claire aquitard
215
Mt. Simon aquifer (confined)
open borehole
Not to scale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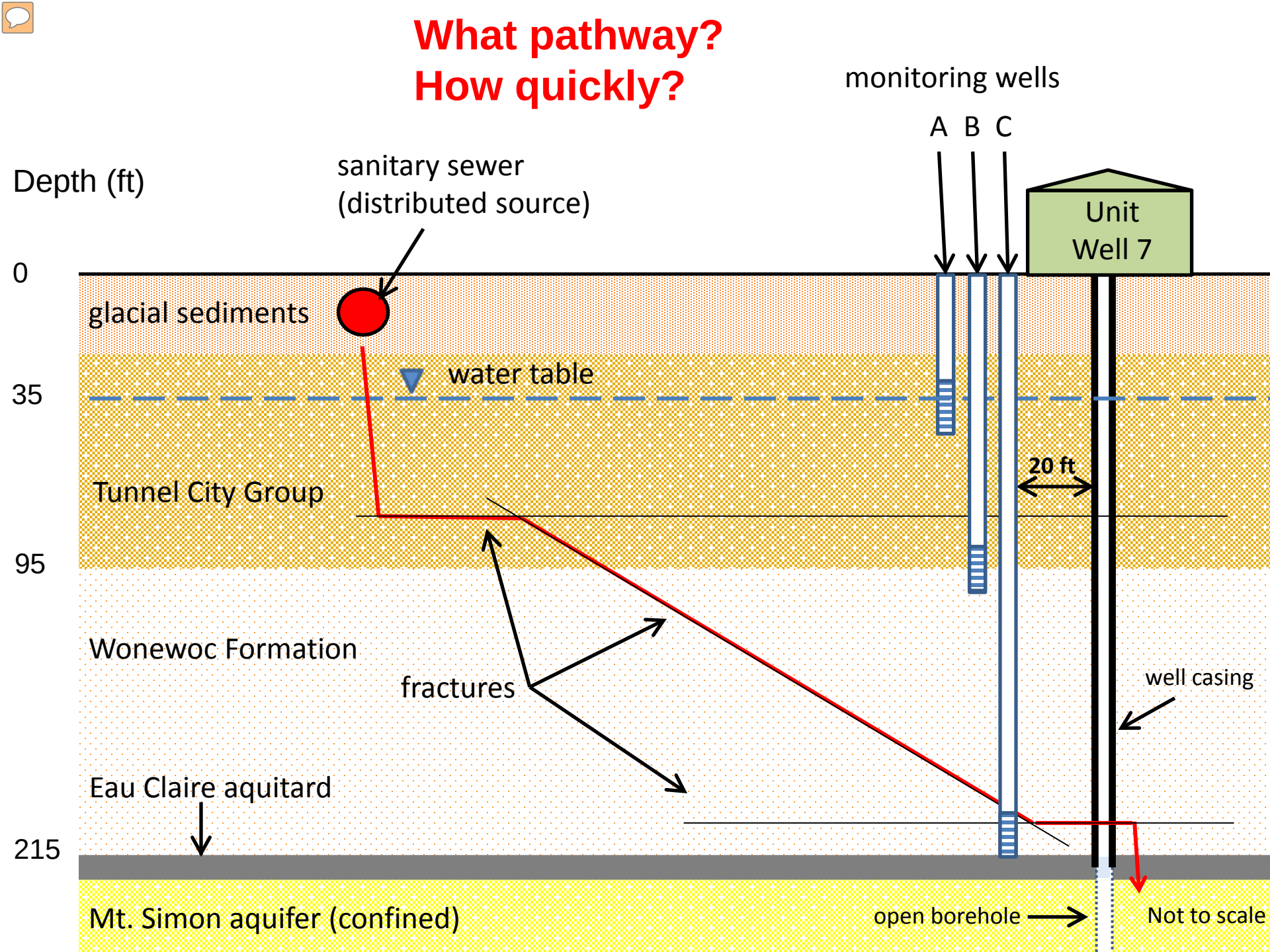
What pathway?
How quickly?
monitoring wells
A B C
Depth (ft)
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(distributed source)
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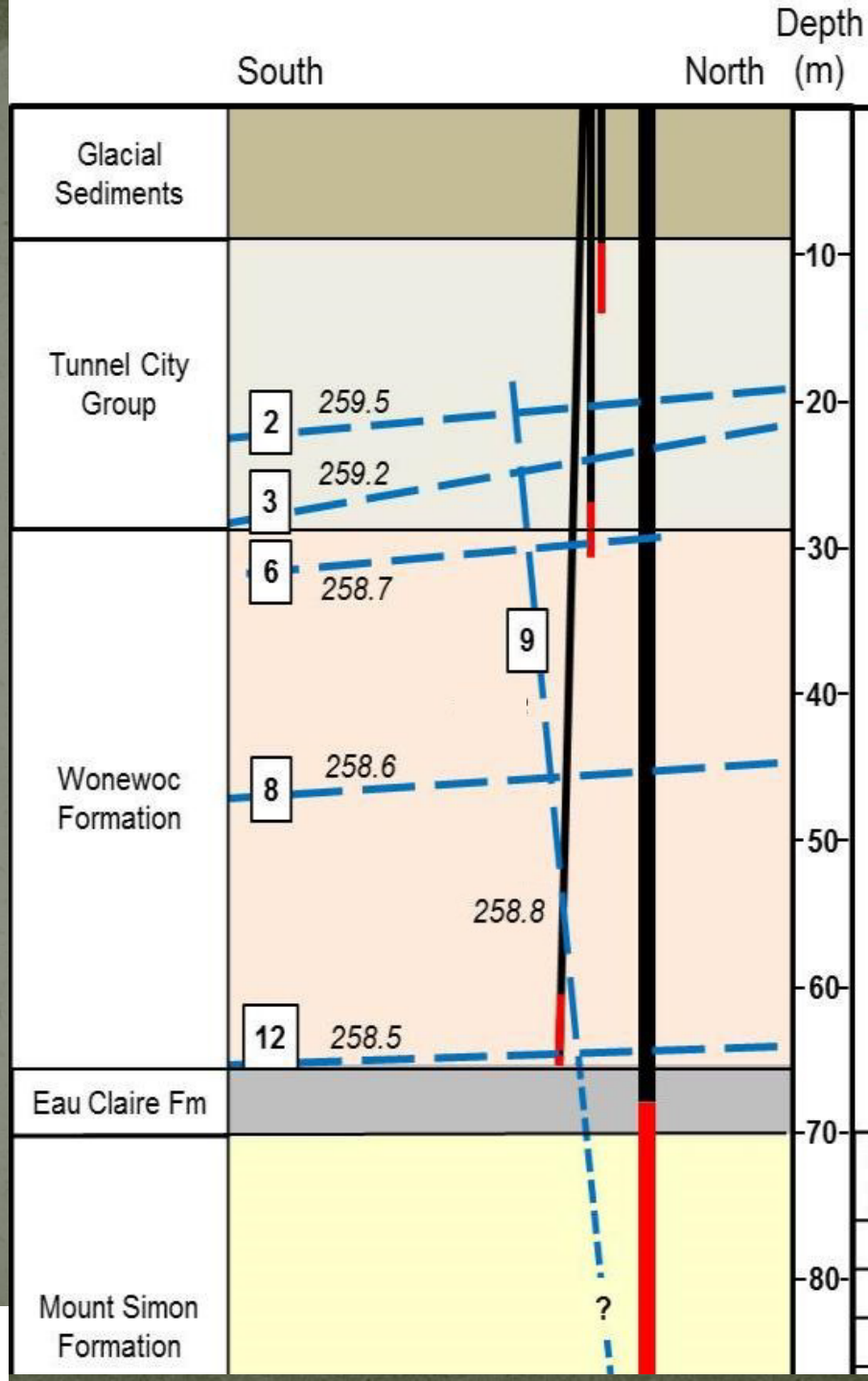
Fracture Characterization

- Borehole Geophysics
  - Identify fractures
- Straddle Packer
  - Slug tests
  - Water chemistry
- Vertical Flow Assessment
  - FLASH program
- Pumping Test

Conceptual Model

- Transient system
- Fracture dominated
  - 60-80% of total flow
  - 3 separate methods
- Fracture Connectivity

Fracture Number	Depth (m)	Transmissivity (cm^2/sec)	Head (m)
2	20.7	0.5	259.5
3	24.1	39.0	259.2
6	29.0	1.2	258.7
8	45.4	0.7	258.6
9	50.0	4.0	258.8
12	64.3	5.2	258.5



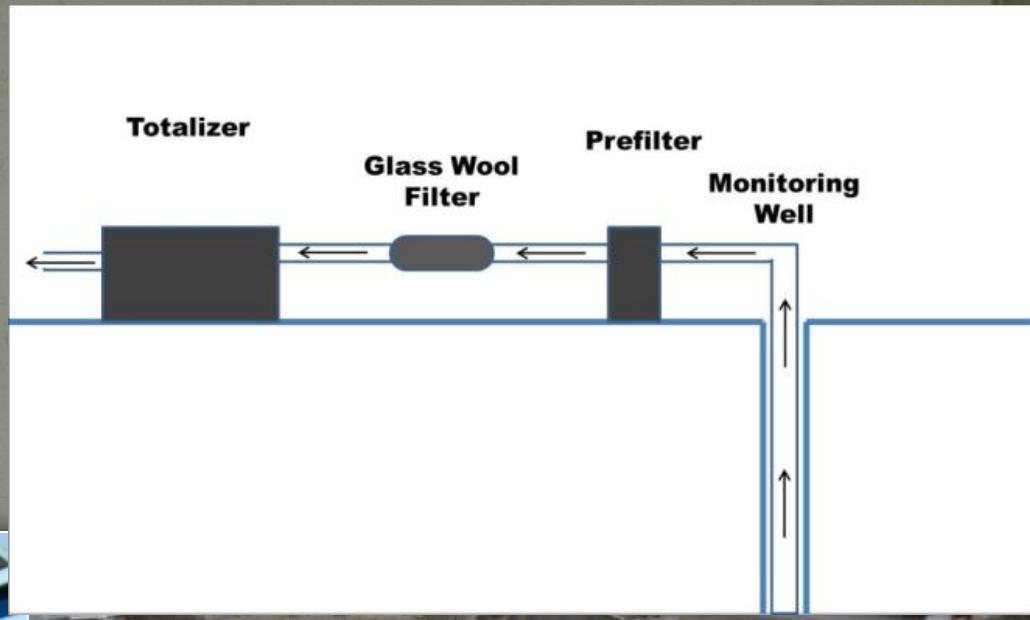
Gellasch, et al., Hydrogeology Journal, 2013

Virus Detection and Water Chemistry

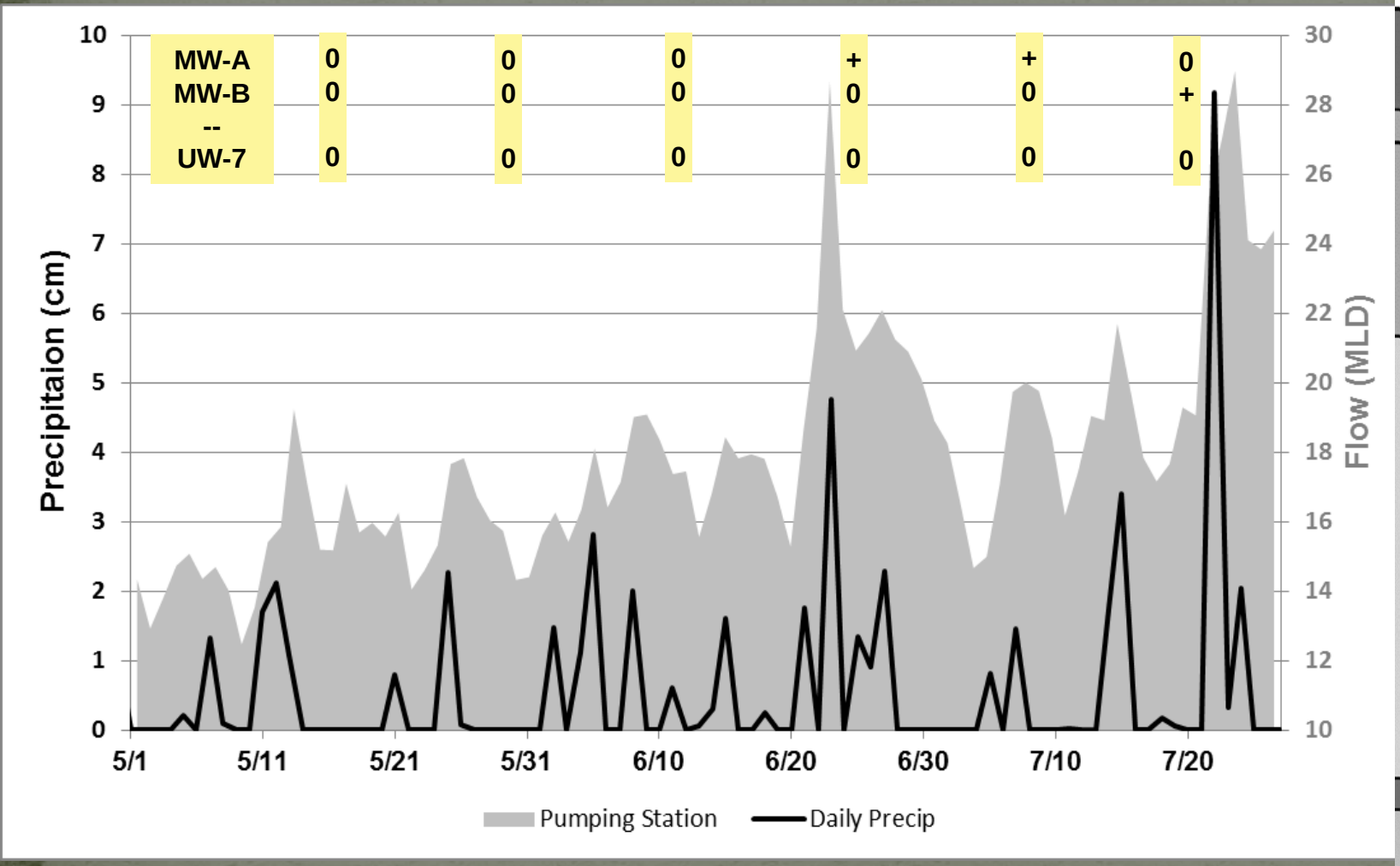
Virus and Chemistry Sampling

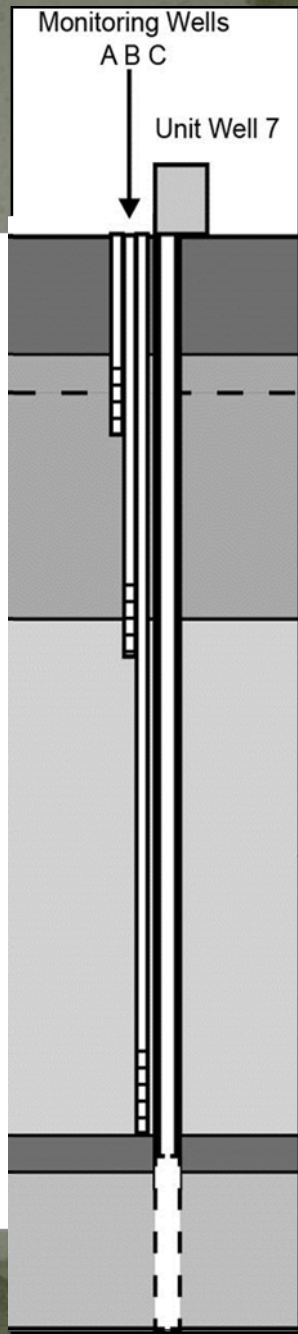
- Two rounds (2010 and 2012)
  - Time sequenced sampling
  - Wastewater, MWs, Unit Well 7
- Viruses
  - Electropositive glass wool filter
  - 800 – 1,000 L per sample
  - Polymerase chain reaction method
- Water chemistry
  - Grab samples: wells and straddle packer
  - Major ions

Virus Sampling Methods

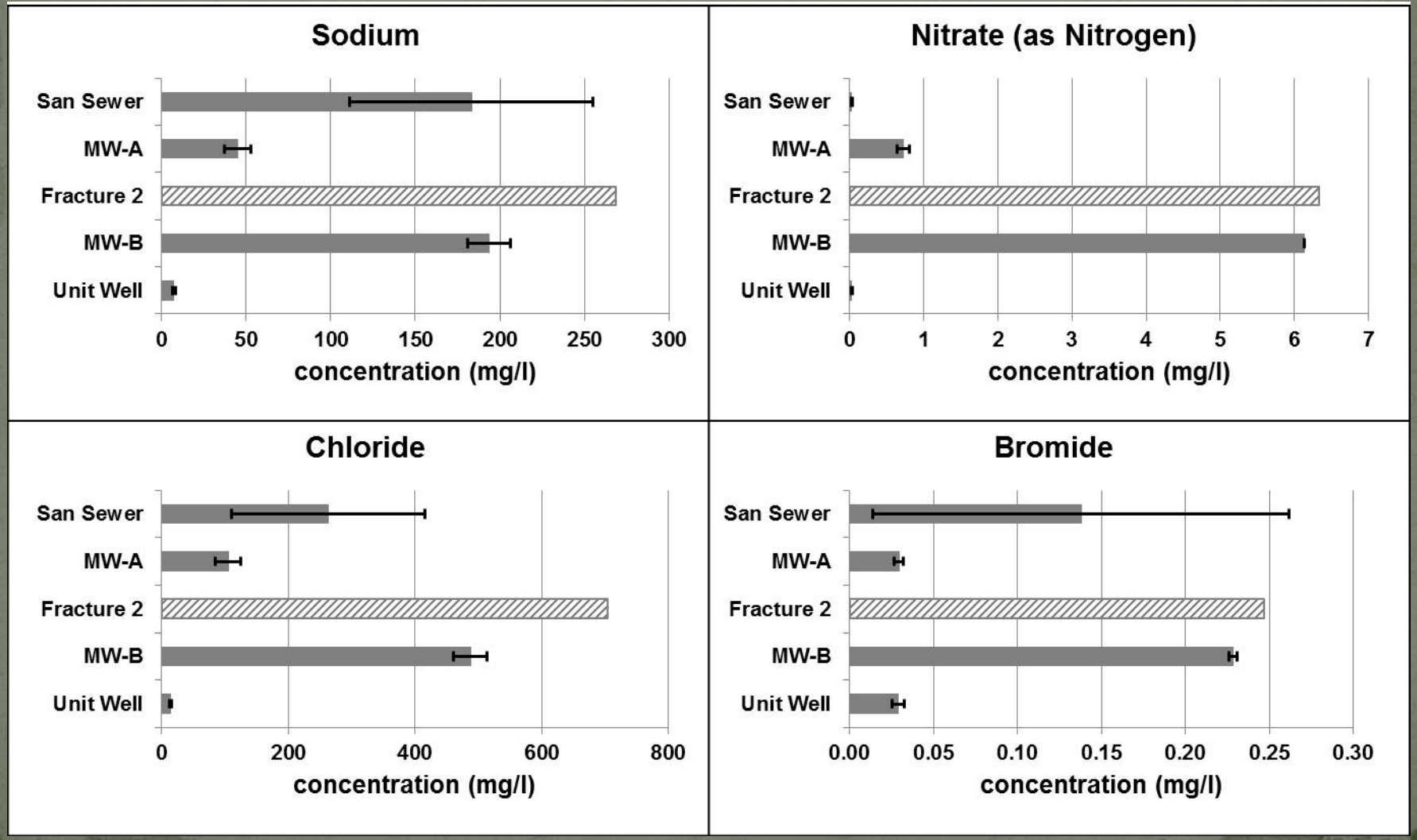


2010 Virus Sampling

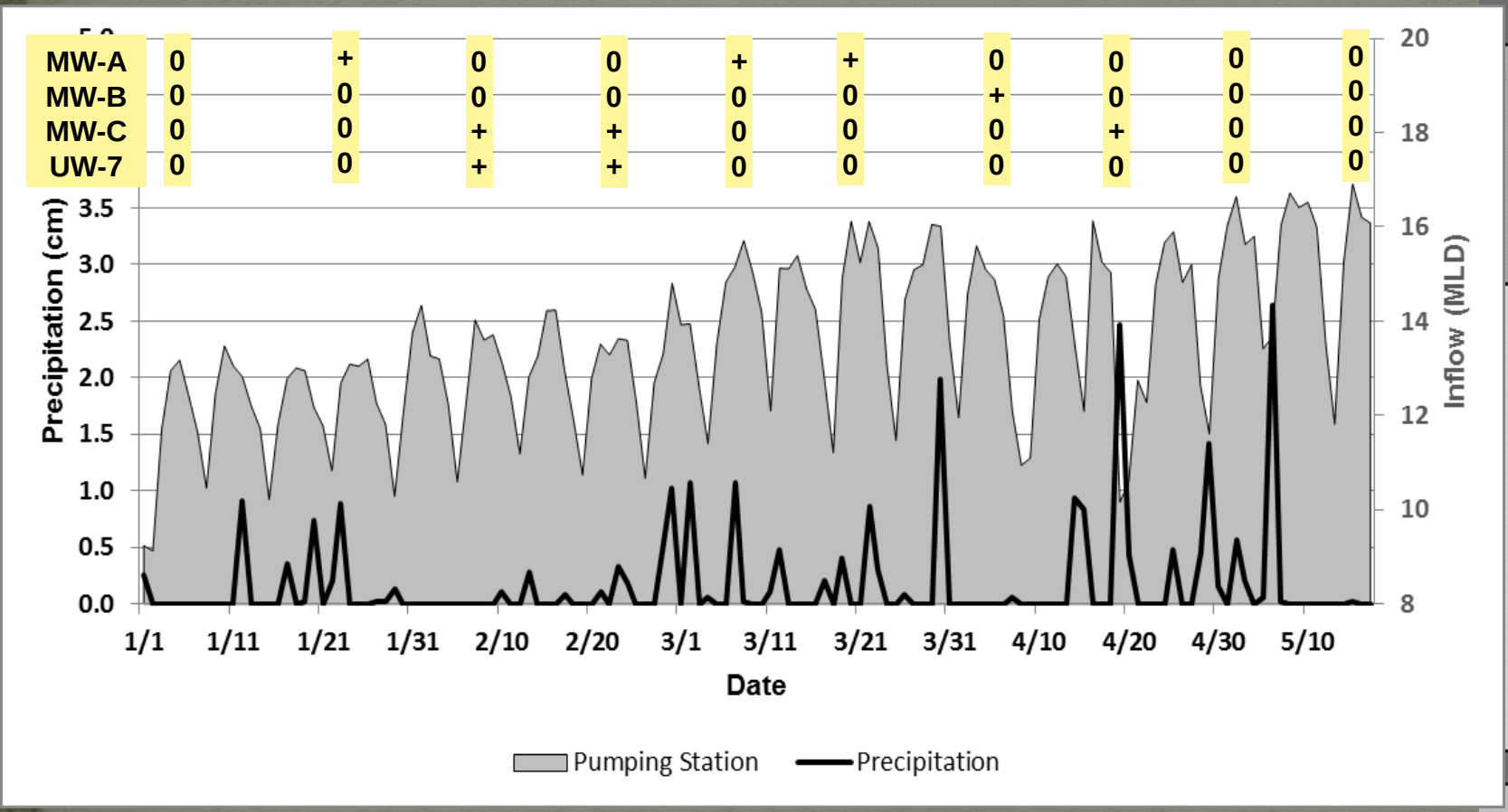


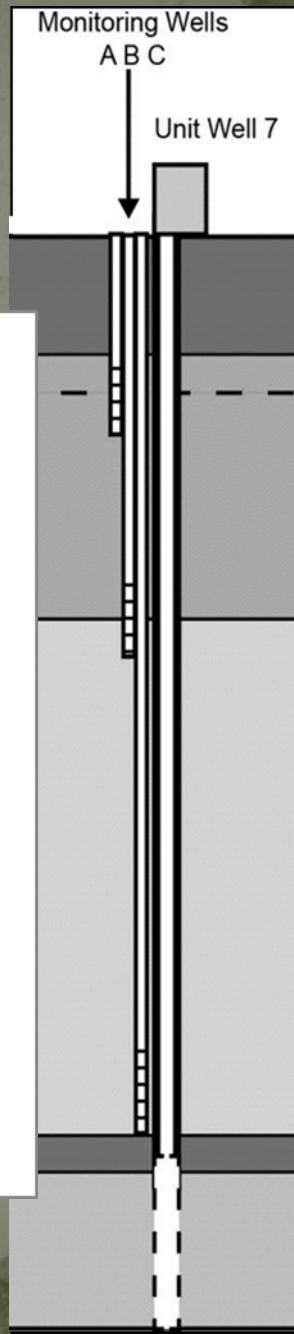


Groundwater Chemistry 2010



2012 Virus Sampling





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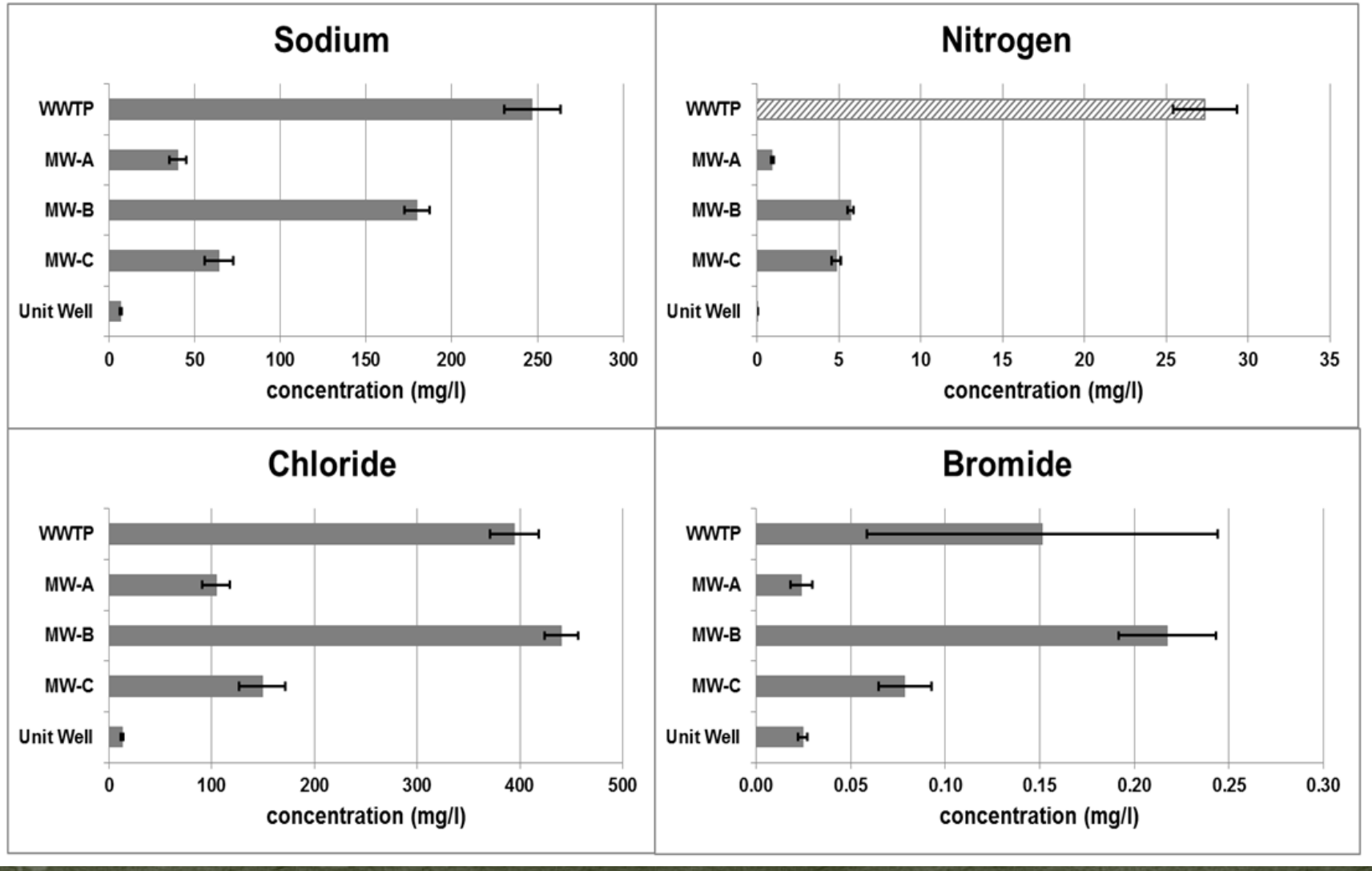
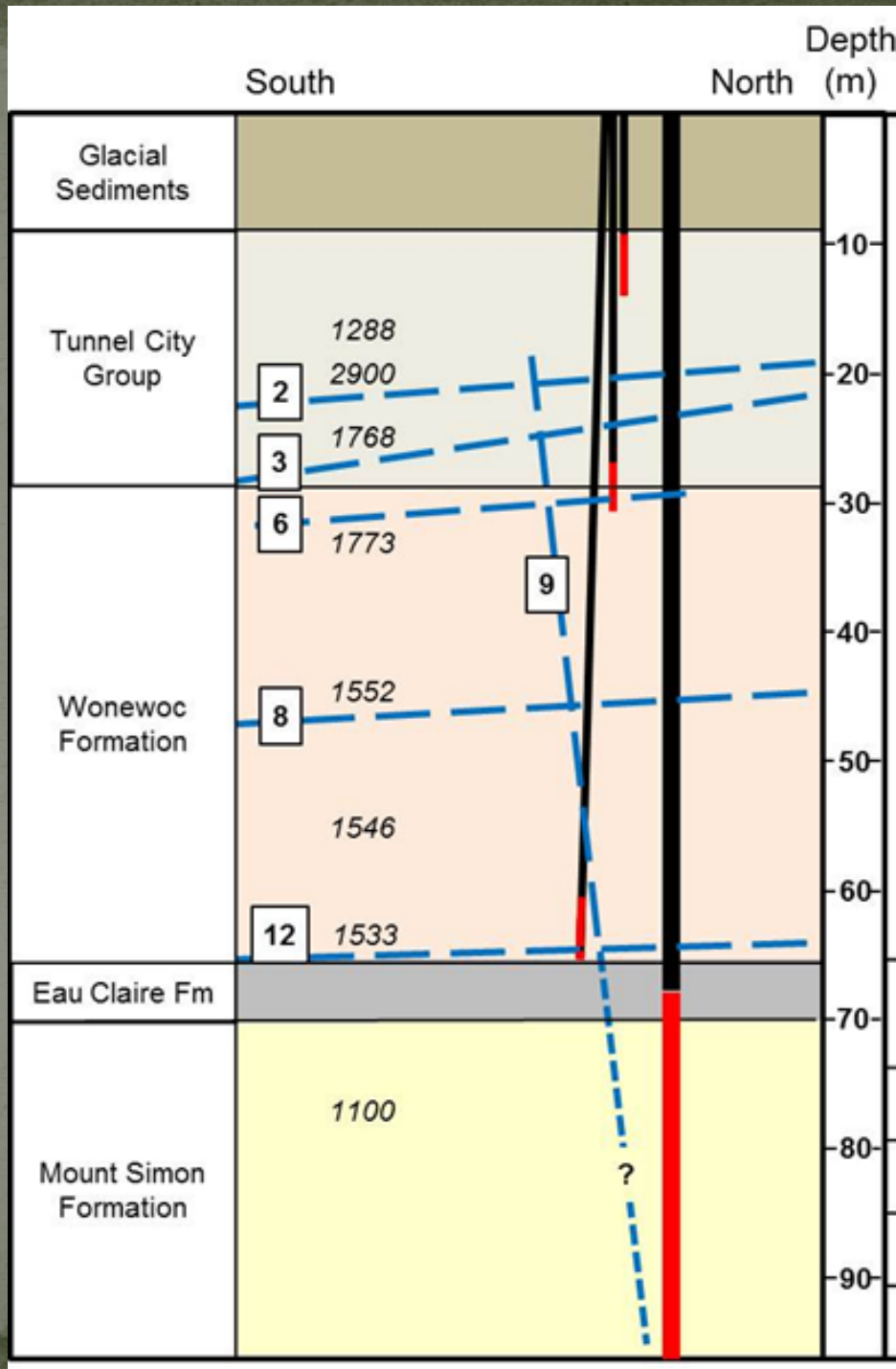


Conceptual Model

- Electrical conductivity
  - General trends
  - MW-B
  - MW-C
- Virus detection

Sample Location	Open Interval (m)	Virus Detects	Virus Groups	Average Conductivity (µS/cm)
MW-A	10.0 – 14.6	5/17 (29%)	4	1080
MW-B	27.5 – 30.5	3/17 (18%)	2	2296
MW-C	62.5 – 65.5	3/10 (30%)	2	1240
UW-7	70 – 202	3/16 (19%)	3	756



Conclusions

- Fractures in upper aquifer appear to significantly control groundwater flow
- Viruses and other wastewater indicators found at discrete depths in upper aquifer
- High Na and Cl levels likely related to water softening salt backwash in sewers
- Inverse relationship between electrical conductivity and virus detection

Acknowledgements

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QUESTIONS?

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