Road Salt Contamination in Groundwater and Surface Water in the Maryland Piedmont

Tiffany VanDerwerker
Maryland Geological Survey

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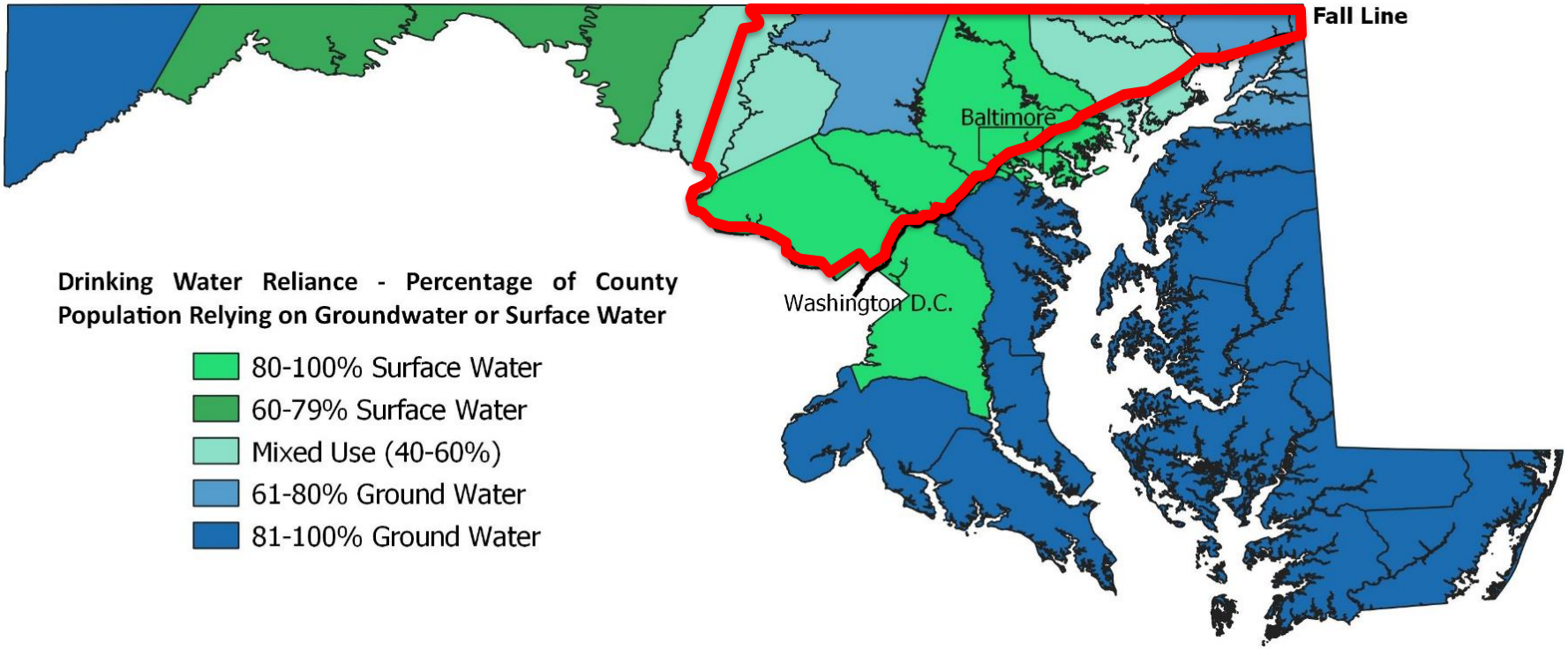
Primary drinking water source varies by county.

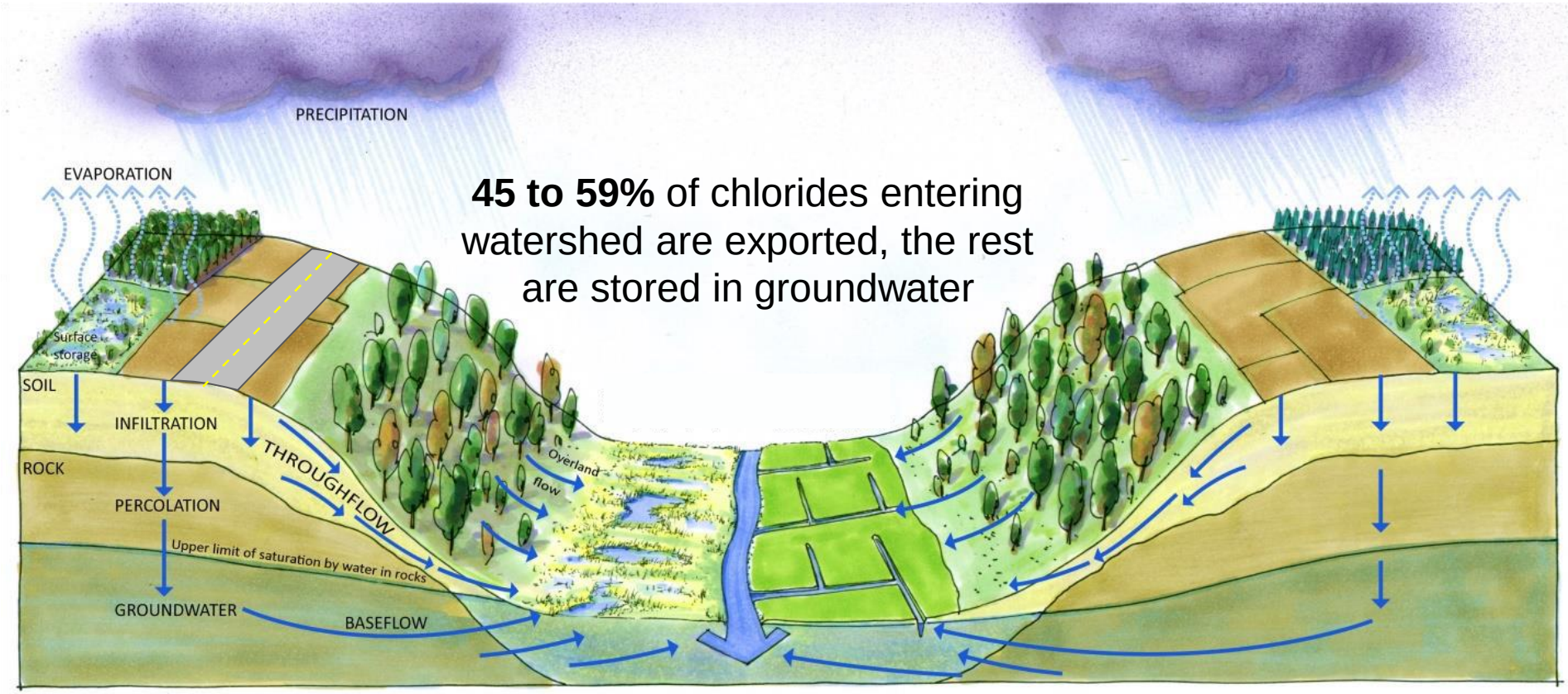


Drinking Water Supply for Marylanders:

13%	Individual Wells (Groundwater)
17%	Groundwater Public Water Supply System
70%	Surface Water Public Water Supply (Baltimore and WSSC = 69%)

Source: Maryland Department of the Environment, Water Supply

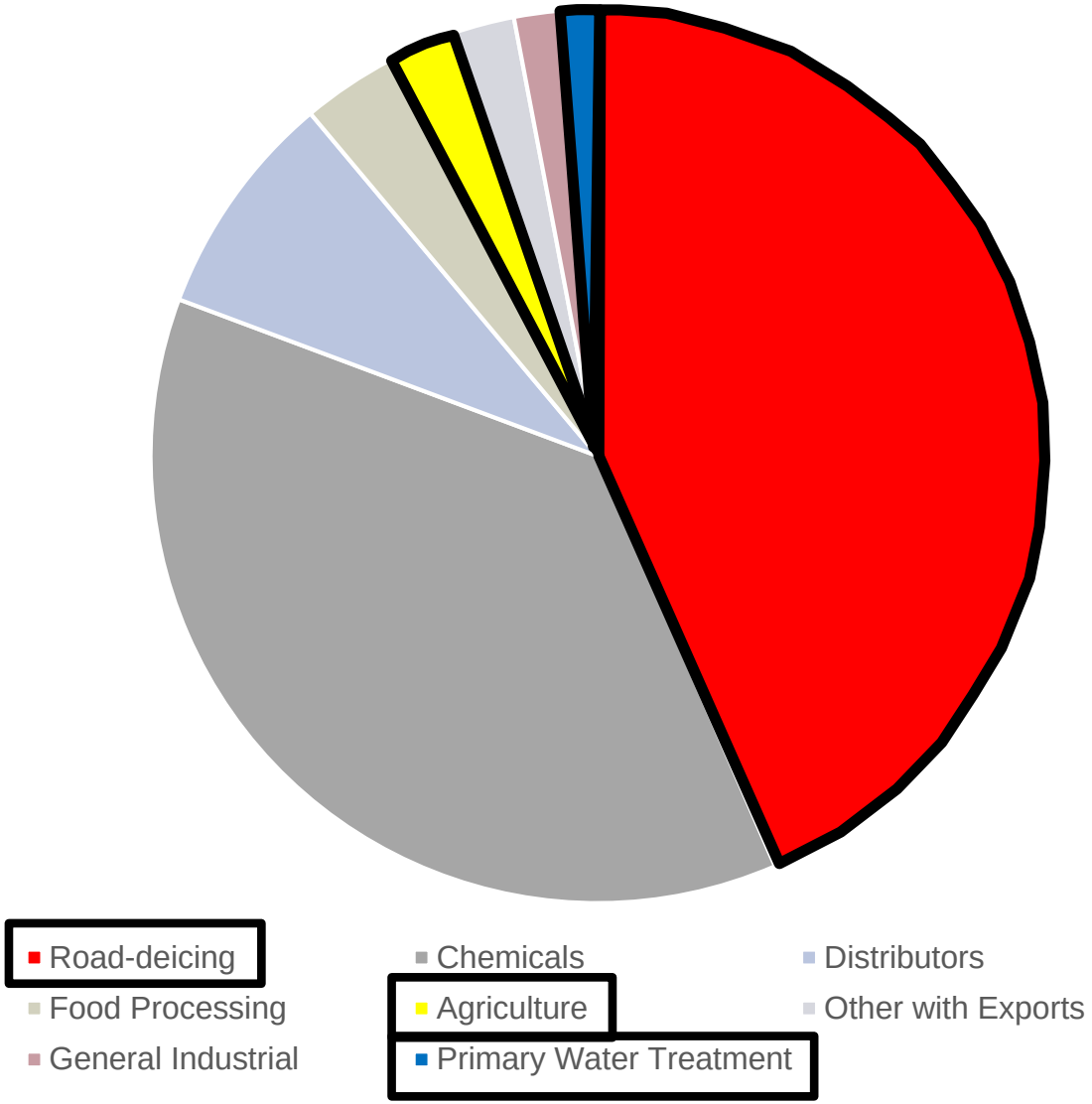
In the Piedmont, **48 to 64%** of streamflow is baseflow.



45 to 59% of chlorides entering watershed are exported, the rest are stored in groundwater

FIGURE: https://europe.wetlands.org/casestudy/restoration-of-marshes-in-rhine-basin/
BASEFLOW: Santhi and others, 2008; Duigon and others, 2000
MASS BALANCE: Howard, 1993; Moore and others, 2017

Total salt use in the US (2015) is largely for road-deicing.



Road-deicing salt – 43.5% of all salts used in US

- Road salt is a dominant source of salinization of fresh water in colder, humid regions of the northeastern United States, and has contributed to long-term, increasing trends in sodium and chloride in surface water and groundwater (Kaushal and others, 2018).
- Chloride concentrations are generally higher near roads (Bolton, 1998; Pieper and others, 2018; Kelly and others, 2018).

https://mde.maryland.gov/programs/Marylander/Pages/roadSalt.aspx; http://bayweekly.com/articles/good-living/article/maryland-roads-reduced-salt-diet

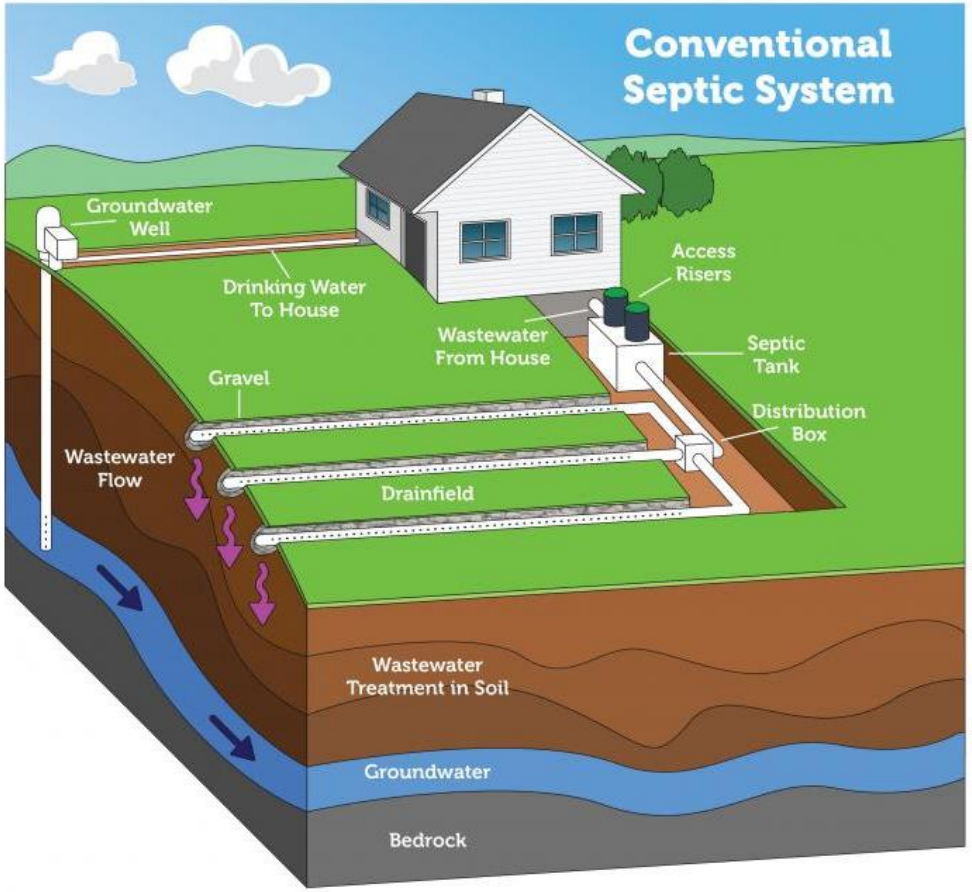
Agricultural – 2.5% of all salts used in US

- Animal feed additives, pesticides, fertilizers
- Potassium chloride is often applied as fertilizer for crops (Zörb and others, 2014), where potassium chloride application can increase chloride concentrations in groundwater (Panno and others, 2006).

https://www.earth.columbia.edu/articles/view/3281

Primary Water Treatment – 1.4% of all salts used in US

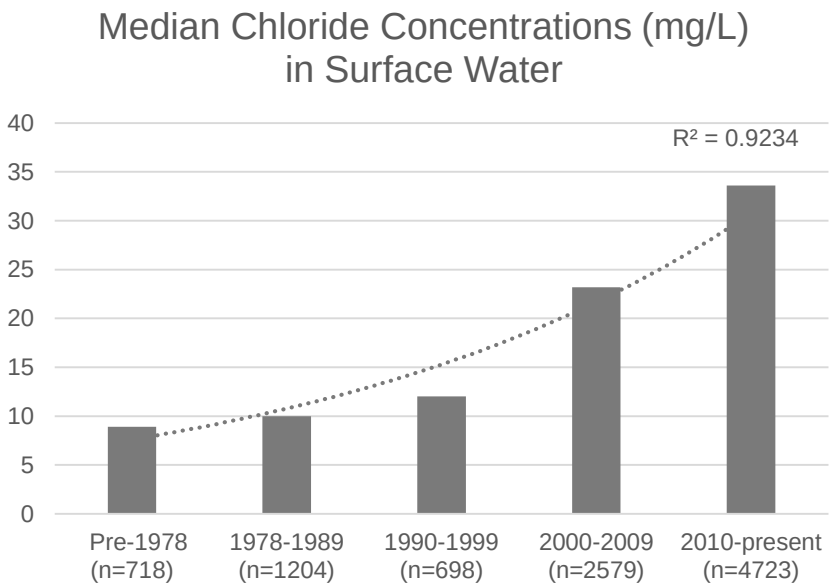
- Water softener effluent is either discharged to septic field, at the ground surface or in a dry well
- Groundwater most affected when houses are close together

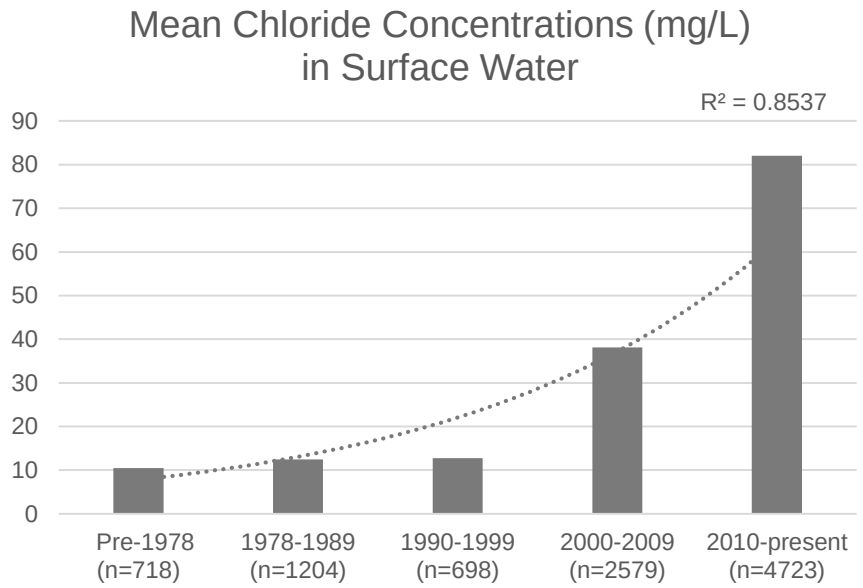


https://www.epa.gov/septic/types-septic-systems

Median and mean chloride concentrations in select streams in the Maryland Piedmont have increased over time.

n= 9,922

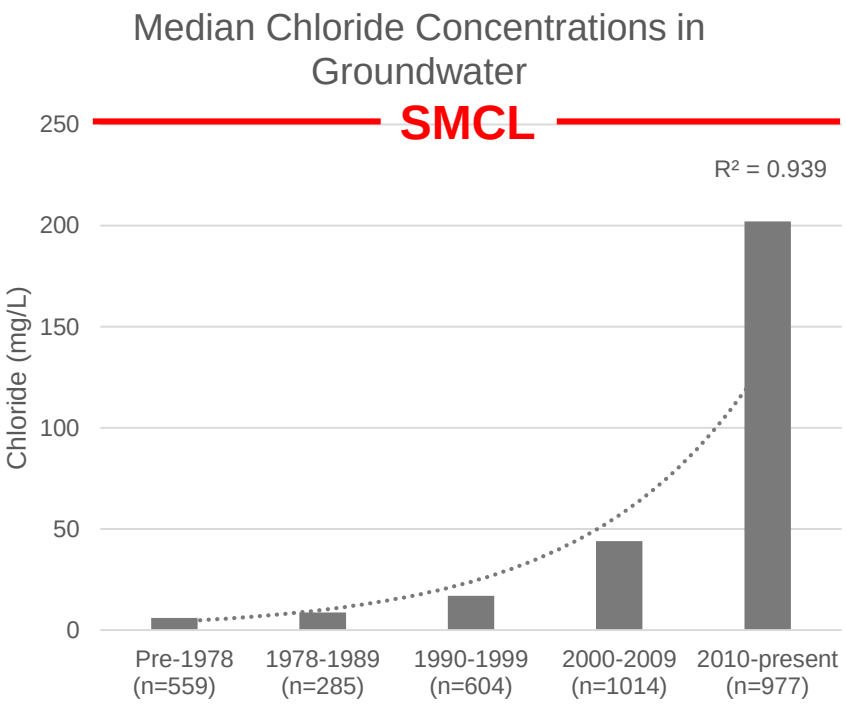


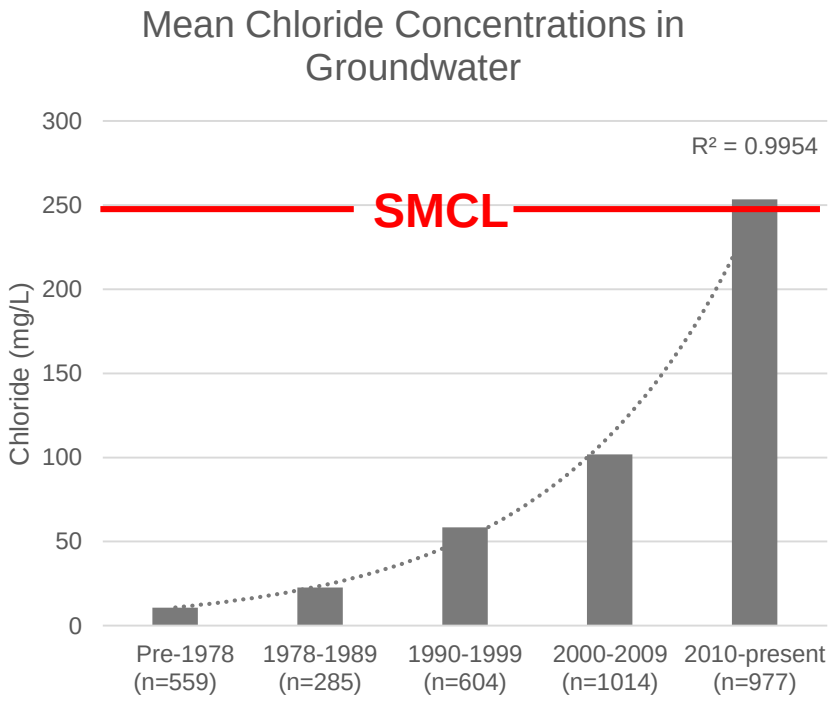


*Data obtained from NURE, NWIS, STORET, MBSS

Median and mean chloride concentrations from wells in the Maryland Piedmont have increased exponentially over time.

n= 3,443

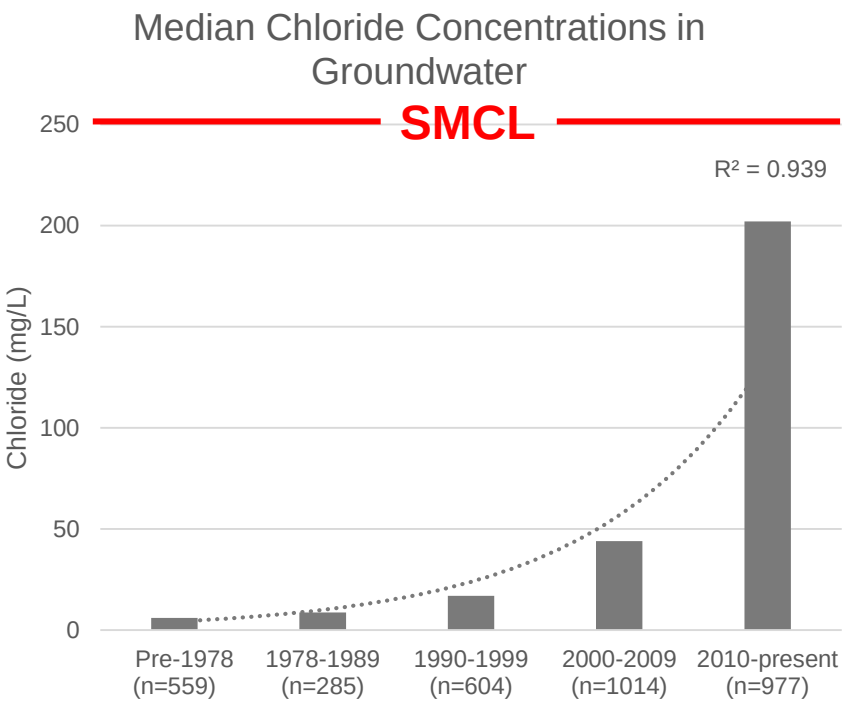


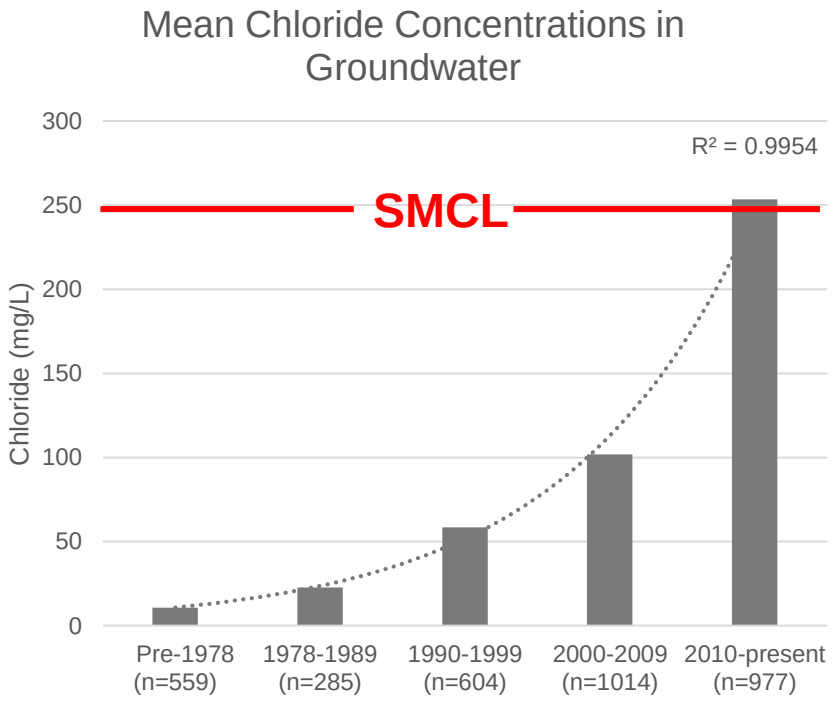


*Data obtained from NURE, NWIS, MDE (transient/non-transient wells), Piedmont Counties

Background concentrations of chloride reflect the lack of geological sources of salt in the Maryland Piedmont.

n= 3,443





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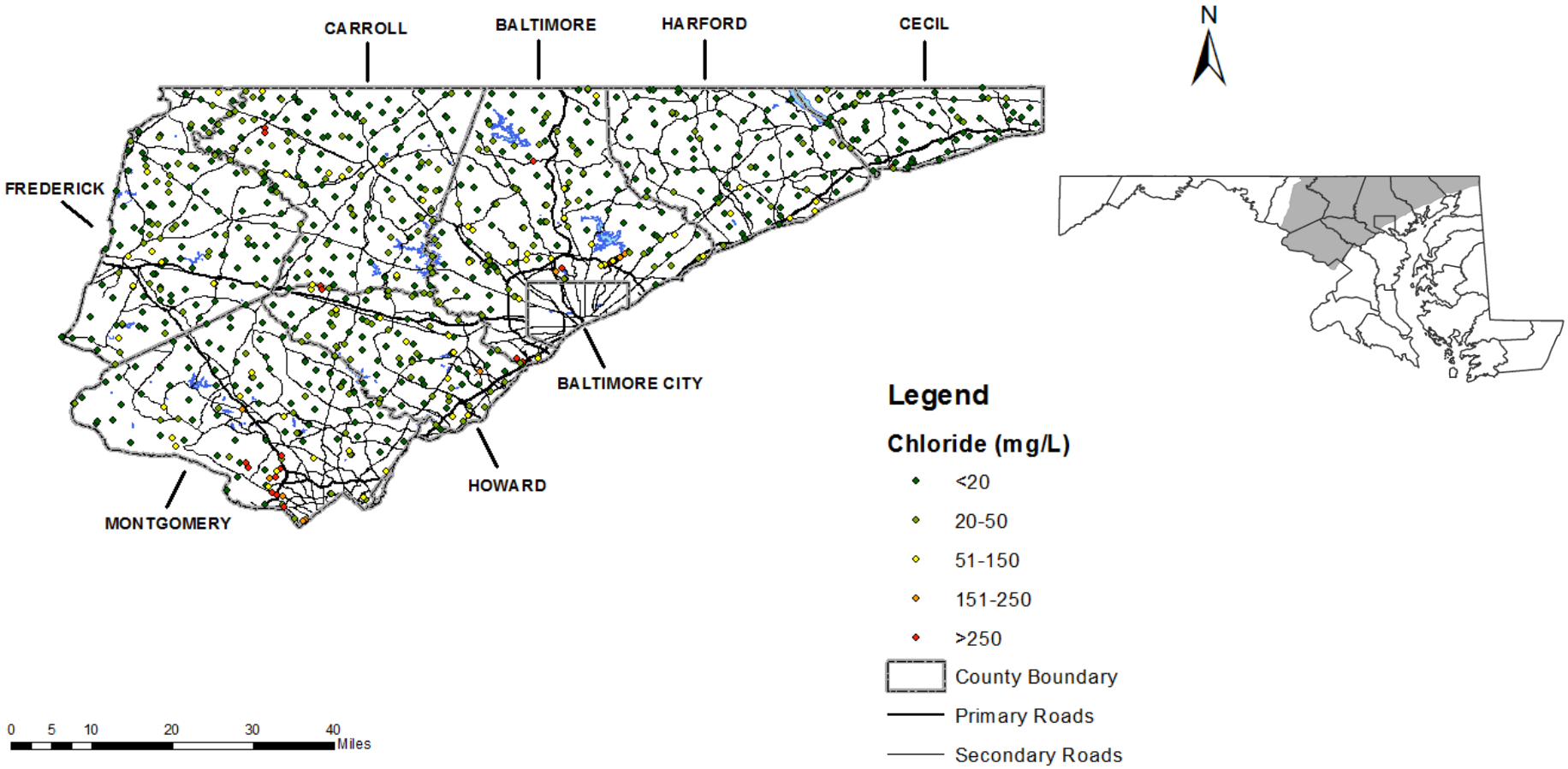
Surface water chloride concentrations in the Piedmont are generally less than 80 mg/L.



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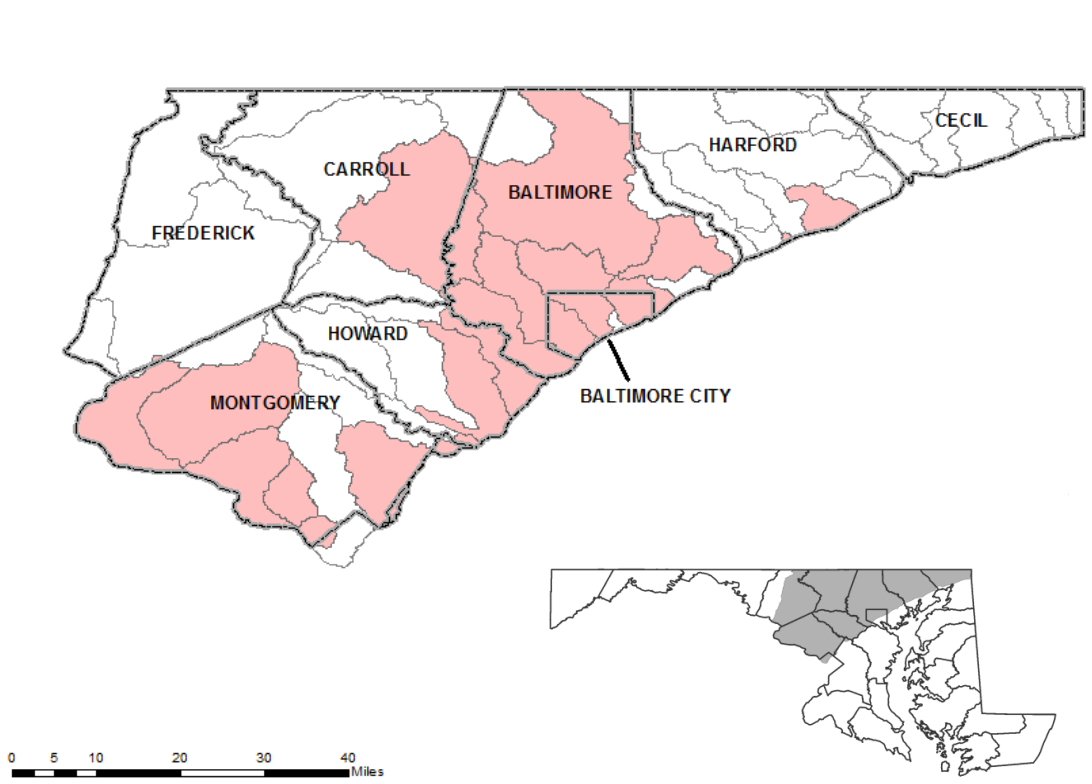
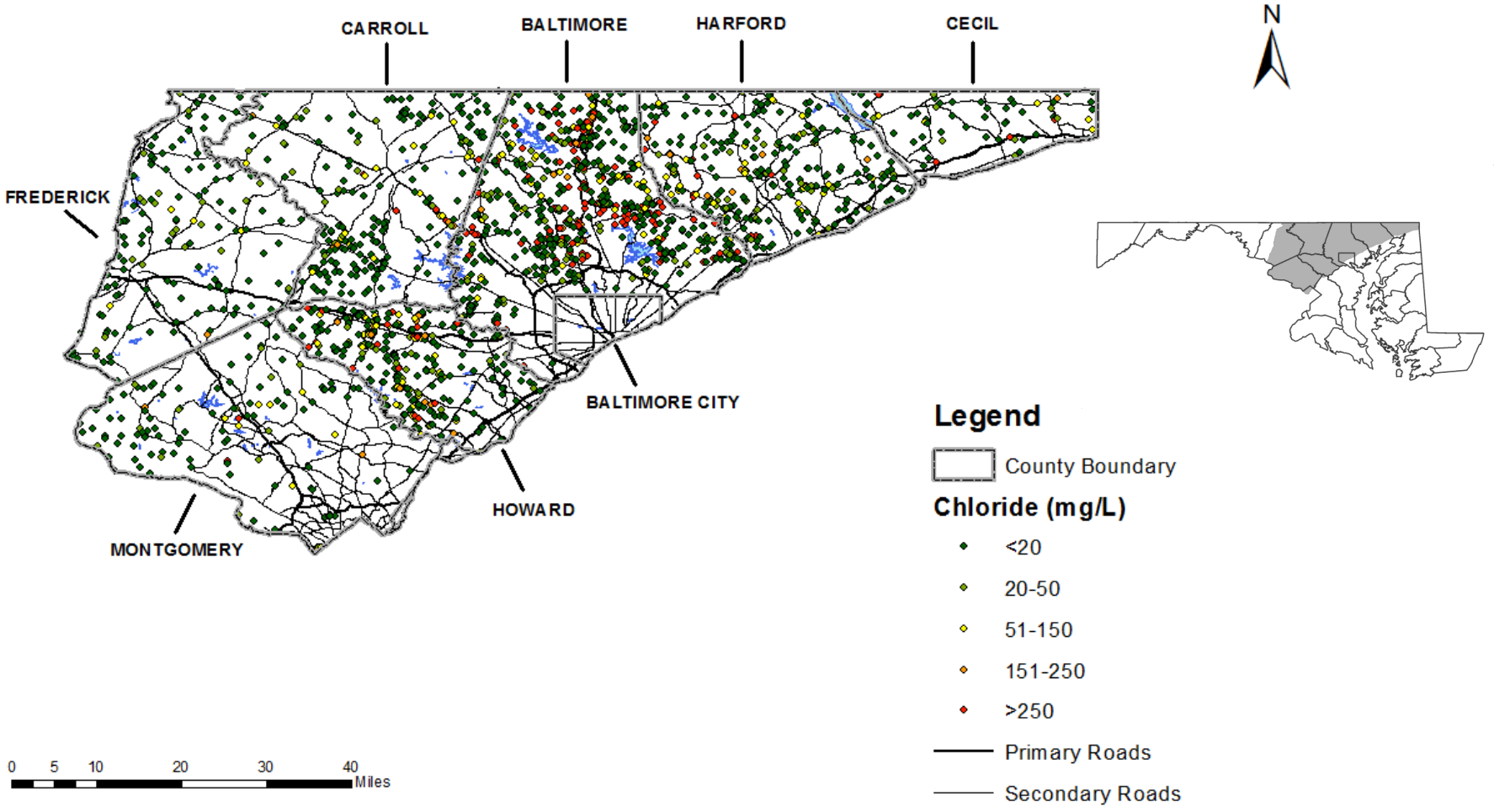
14 watersheds in the Maryland Piedmont are impaired by elevated chloride.



- From 2018 Integrated Report - in Maryland, there are 28 non-tidal watersheds listed as impaired by chloride.
- Elevated chlorides are associated with higher impervious surface cover (Bird and others, 2018).

Groundwater chloride concentrations are higher near major roads.



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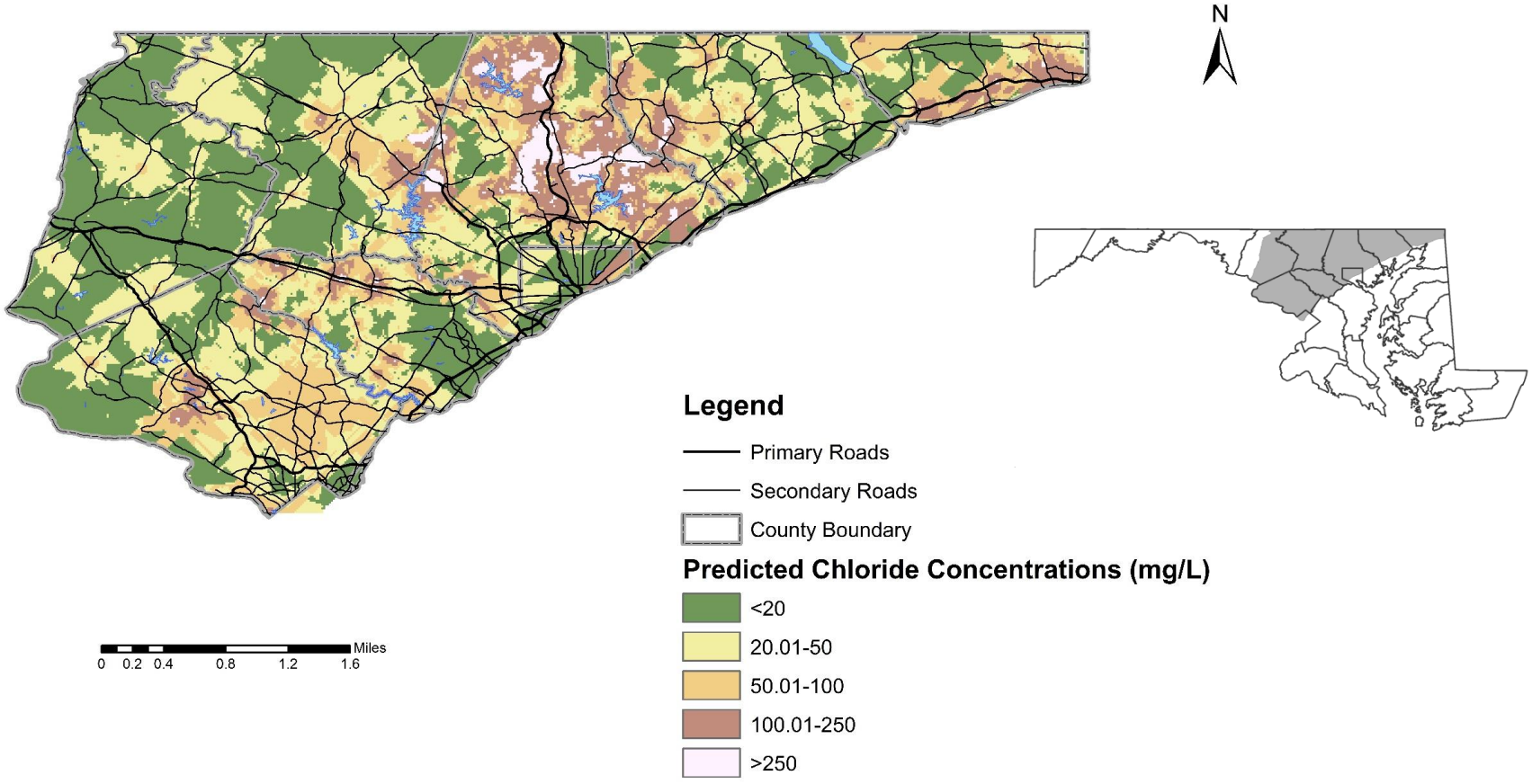
Kriging was used in ArcGIS to create a map of predicted chloride concentrations in groundwater.



*Data obtained from NURE, NWIS, MDE (transient/non-transient wells), Piedmont Counties

There are many adverse impacts to surface water from road-deicing salts.

- Morgan and others, 2012
  - Chloride concentrations between 33 and 108 mg/L affected fish species
- Cooper and others, 2014
  - Green infrastructure investments may be at risk for salinity derived degradation, limiting effectiveness of stream restoration efforts

MD Department of Natural Resources, 2014

There are many adverse impacts to groundwater from road-deicing salts.

- Pieper and others, 2018
  - Increased galvanic corrosion, resulting in metals leaching and pipe wall thinning
- McNaboe and others, 2017
  - Release of radionuclides in groundwater, potential increase of radon degassing from water
- Granato and others, 1995
  - Increased ion exchange, acidification, and mineral weathering from road-deicing salt application

Example: Washing Machine Spindle

New

http://hipolpic.pw/washing-machine-drum-seized.html

Corroded from Salt

Pieper and others, 2018

There are many adverse impacts to groundwater from road-deicing salts.

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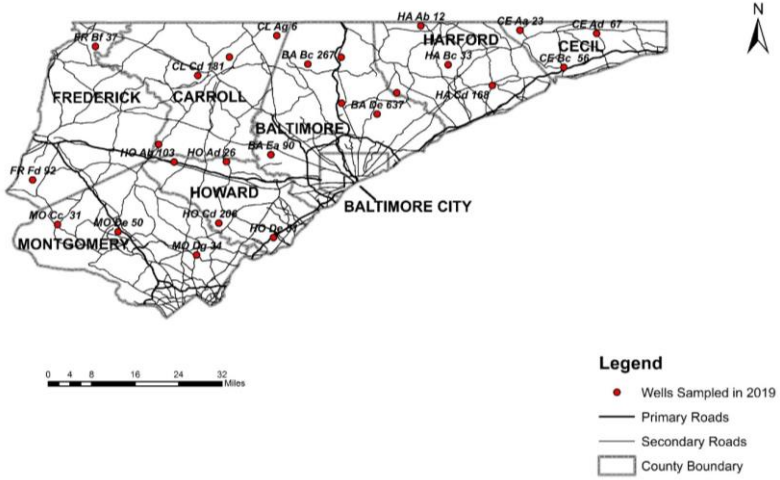
MGS is currently conducting a multi-year study funded by MDE to evaluate road salt in groundwater in the Piedmont.

Year 1

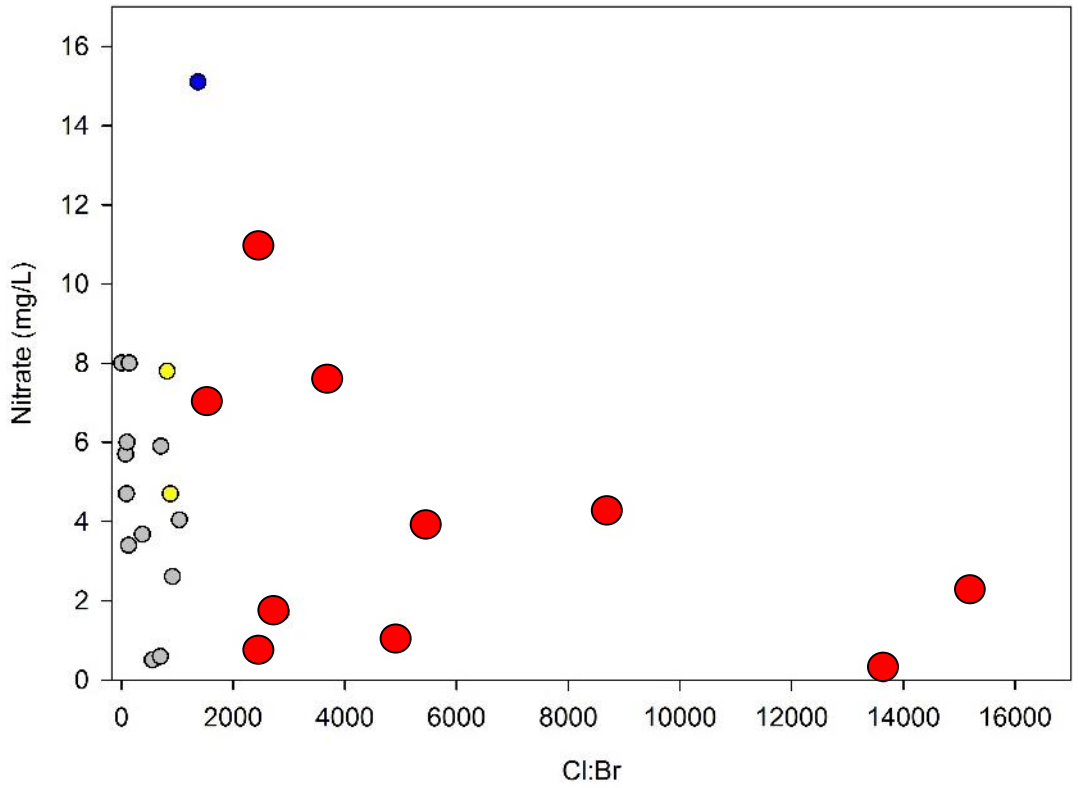
- Sampled 25 wells previously sampled and analyzed for a suite of chemical constituents
- Monitored one well continuously for specific conductance
- Sampled three wells quarterly for major ions and bromide



Year 2

- Sample 25+ wells likely impacted by road salt for a suite of chemical constituents
- Monitor four wells for continuously for specific conductance
- Sample three wells quarterly for major ions and bromide
- Compile chloride data from private labs and local, state, and federal government to create a geodatabase, and perform statistical analyses for correlations between chloride and other parameters

How can we distinguish chloride sources in groundwater?



Cl >60 mg/L

Road-deicing salts (Red)

Cl:Br = 1,000 to 10,000 (can be higher in first flushing events from winter storms)

*Cl:Br ranged from Granato and others, 1996; Davis and others, 1998; Panno and others, 2006

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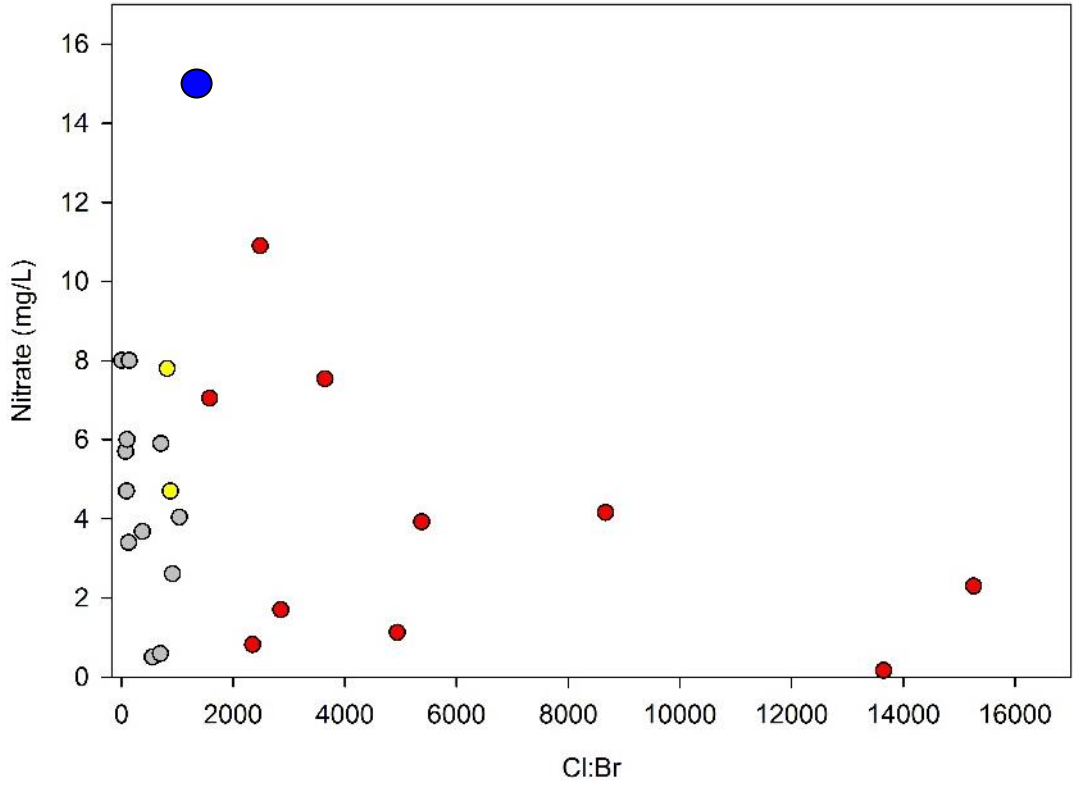


Cl >60 mg/L

Septic Effluent (Blue)

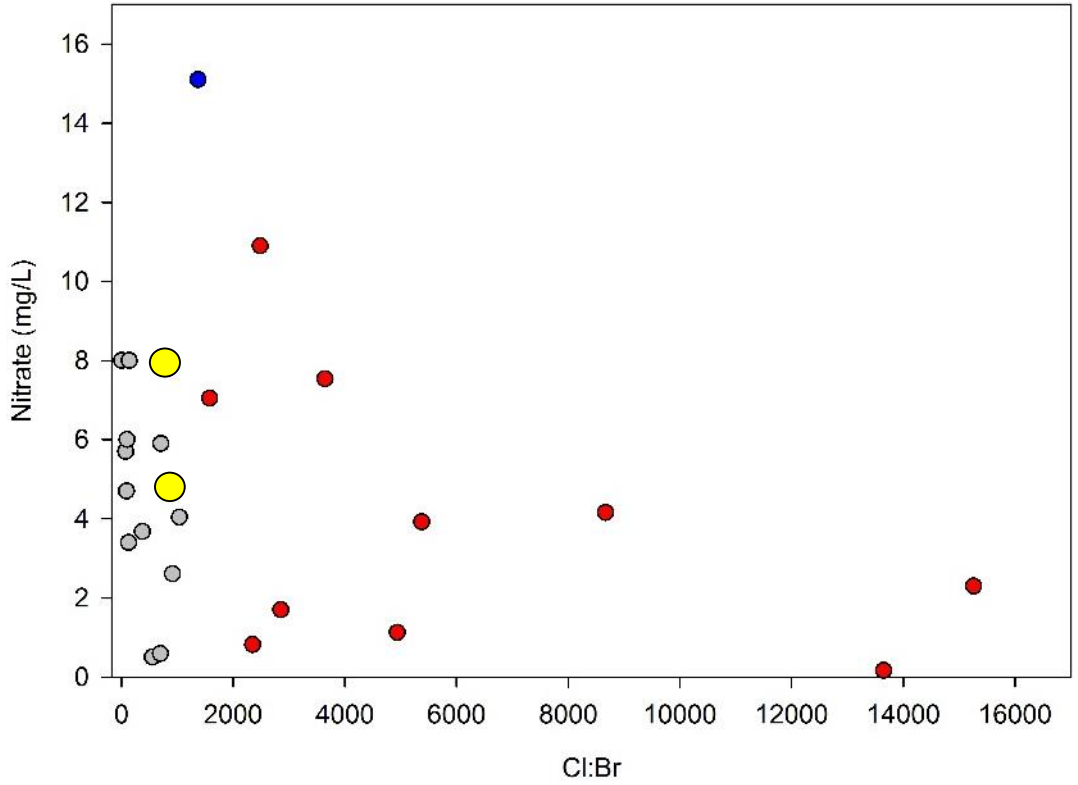
Cl:Br = 300 to 600, with water-softener effluent can mimic road salt

Nitrogen >10 mg/L

Evaluate site conditions

*Cl:Br ranged from Granato and others, 1996; Davis and others, 1998; Panno and others, 2006

How can we distinguish chloride sources in groundwater?



Cl >60 mg/L

Agricultural (Yellow)

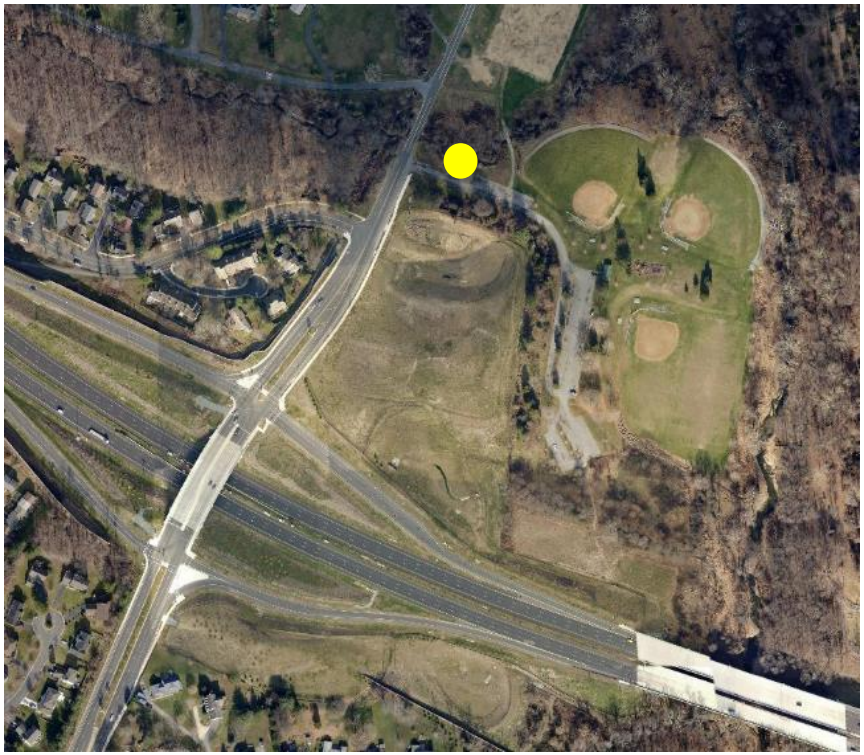
Cl:Br = ~845

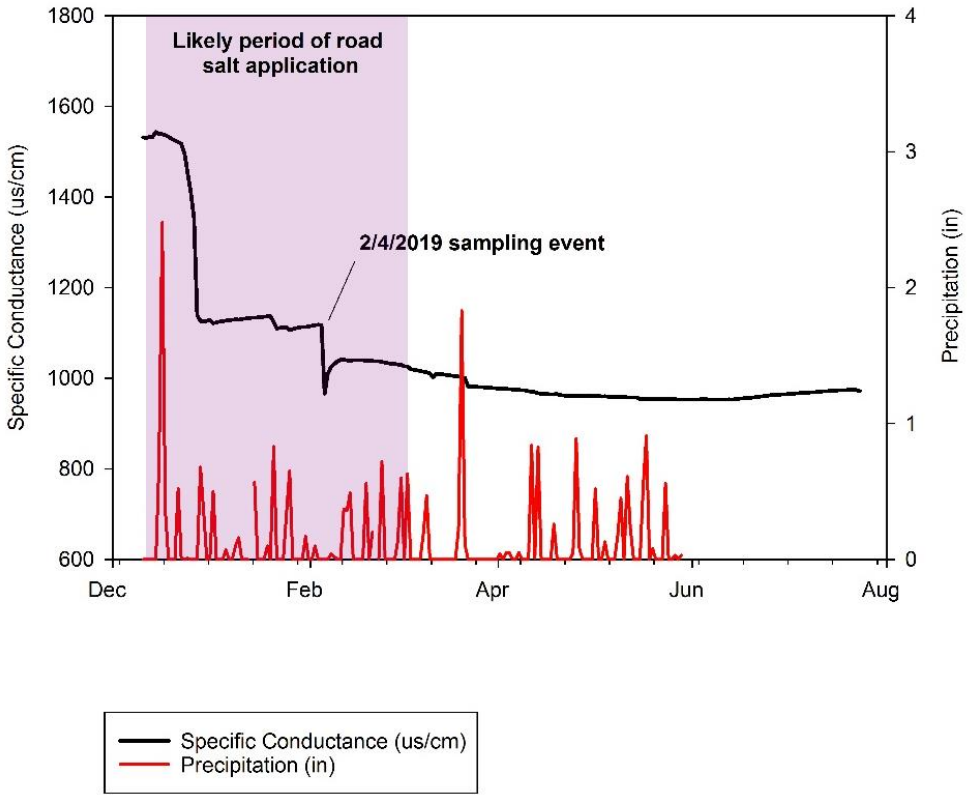
Are there agricultural activities nearby?

*Cl:Br ranged from Granato and others, 1996; Davis and others, 1998; Panno and others, 2006

Land use and road-deicing salt application affect water quality.

Satellite image from 2018





Conclusions

Natural waters are connected

- Groundwater discharge (base flow) accounts for approximately 48 to 64% of streamflow in the Piedmont
- Groundwater can serve as a year-round reservoir for chloride

There are many adverse effects from road-deicing salt

- Fish species adversely affected
- Green infrastructure may become less effective
- Corrosion of plumbing, release of metals
- Radionuclides and trace metals released from geology

Chloride concentrations have increased in natural waters over time

- Median chloride concentrations in groundwater have increased from 6 to 202 mg/L over the past 4+ decades.
- Median chloride concentrations in surface water have increased from 9 to 34 mg/L over the past 4+ decades.