Salinity Network Workgroup

A workgroup of the Florida Water Resources Monitoring Council (FWRMC)

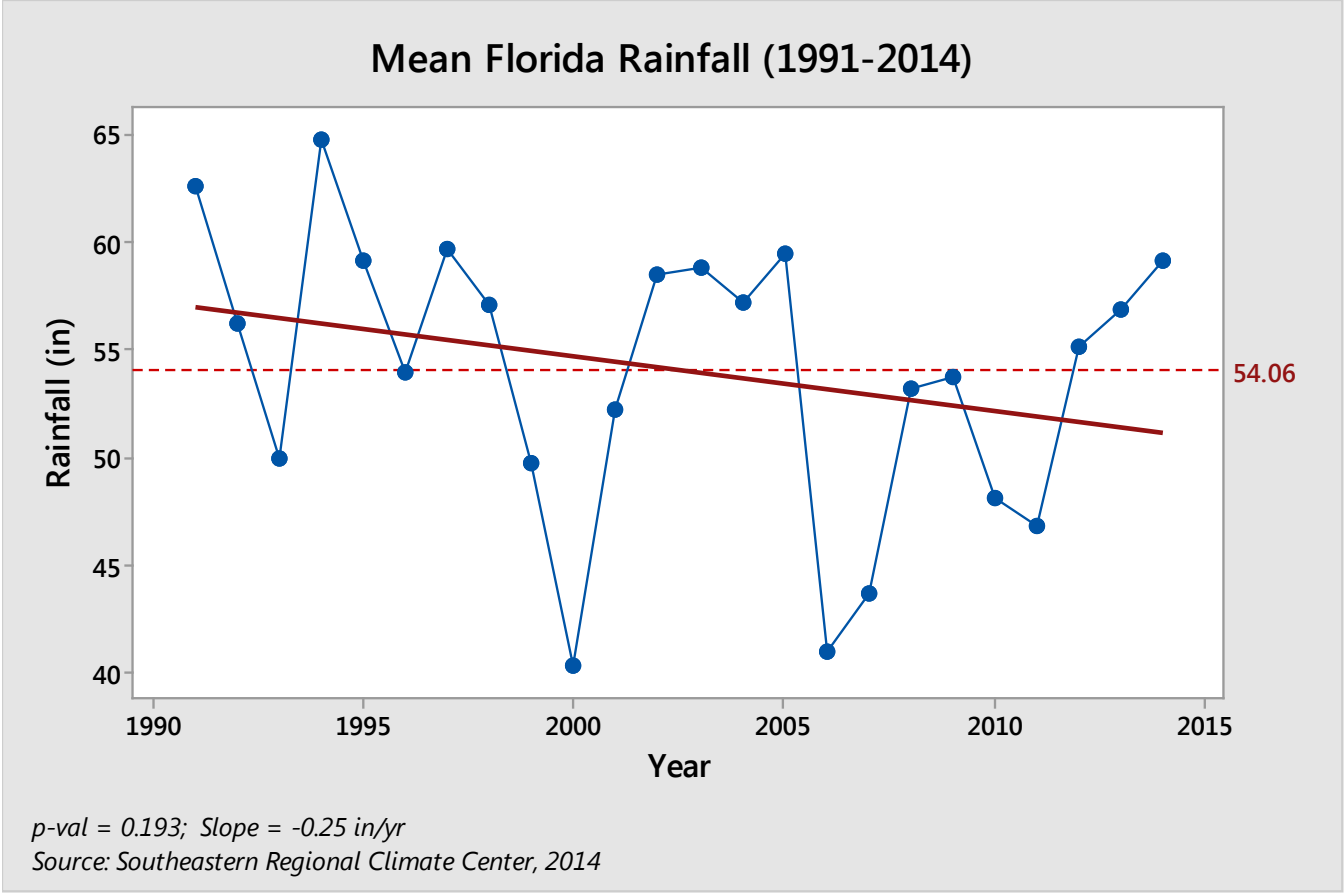
March, 2016

Chair: Rick Copeland (FDEP)

Why Have a Salinity Network?

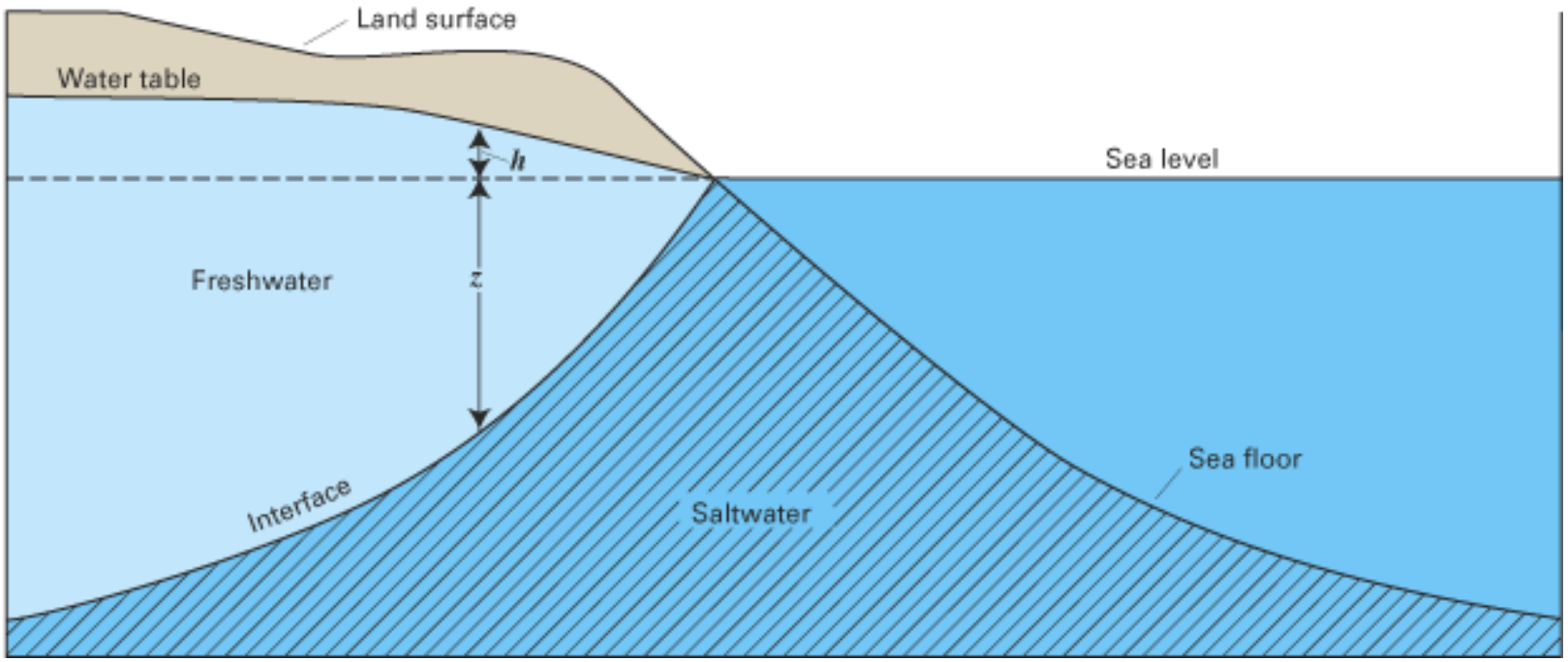
- Since 1990s, Florida has had below normal rainfall and probably less recharge
- Water Levels in FDEP Trend Wells generally decreased; Spring discharge generally decreased
- Salinity indicator concentrations generally increased
  - Na, Cl, TDS, SC, and SO4

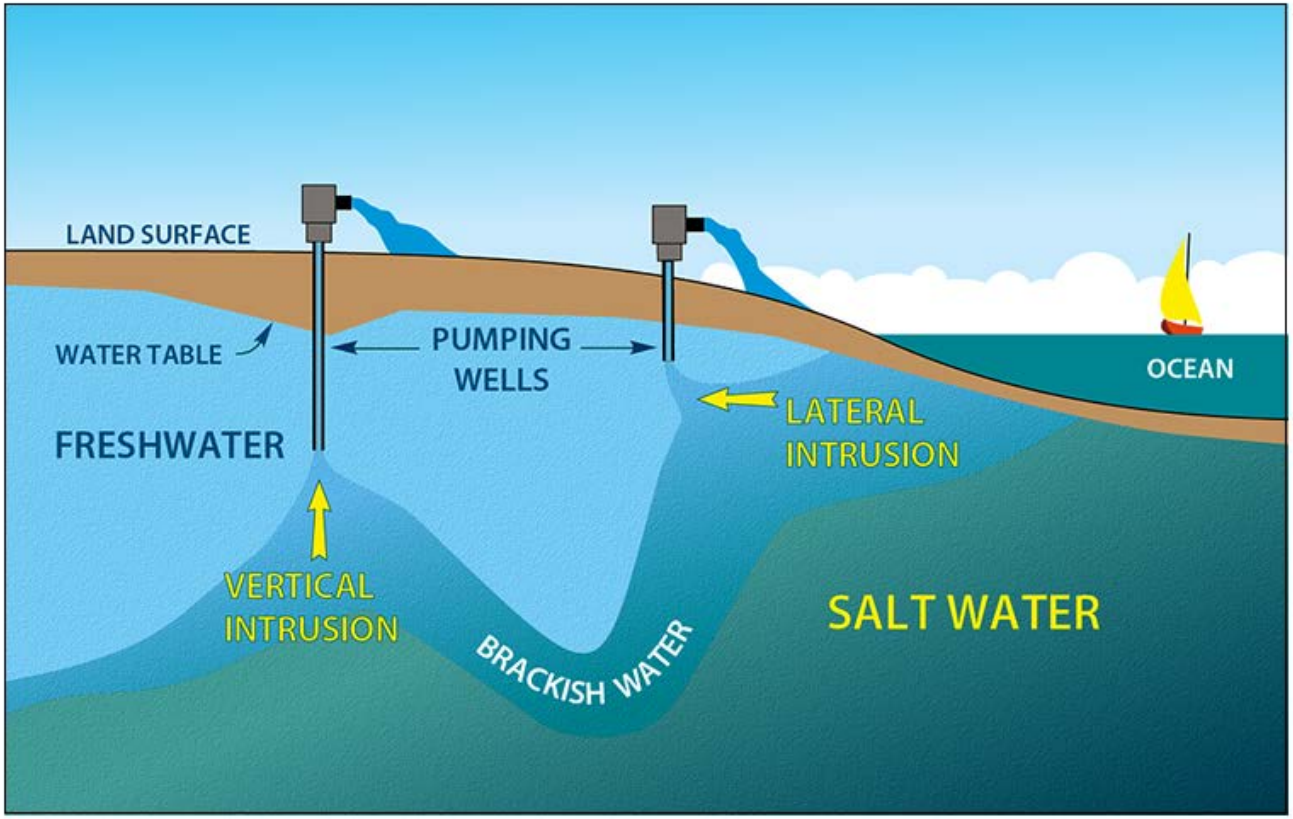
Florida Mean Rainfall
(Driver)



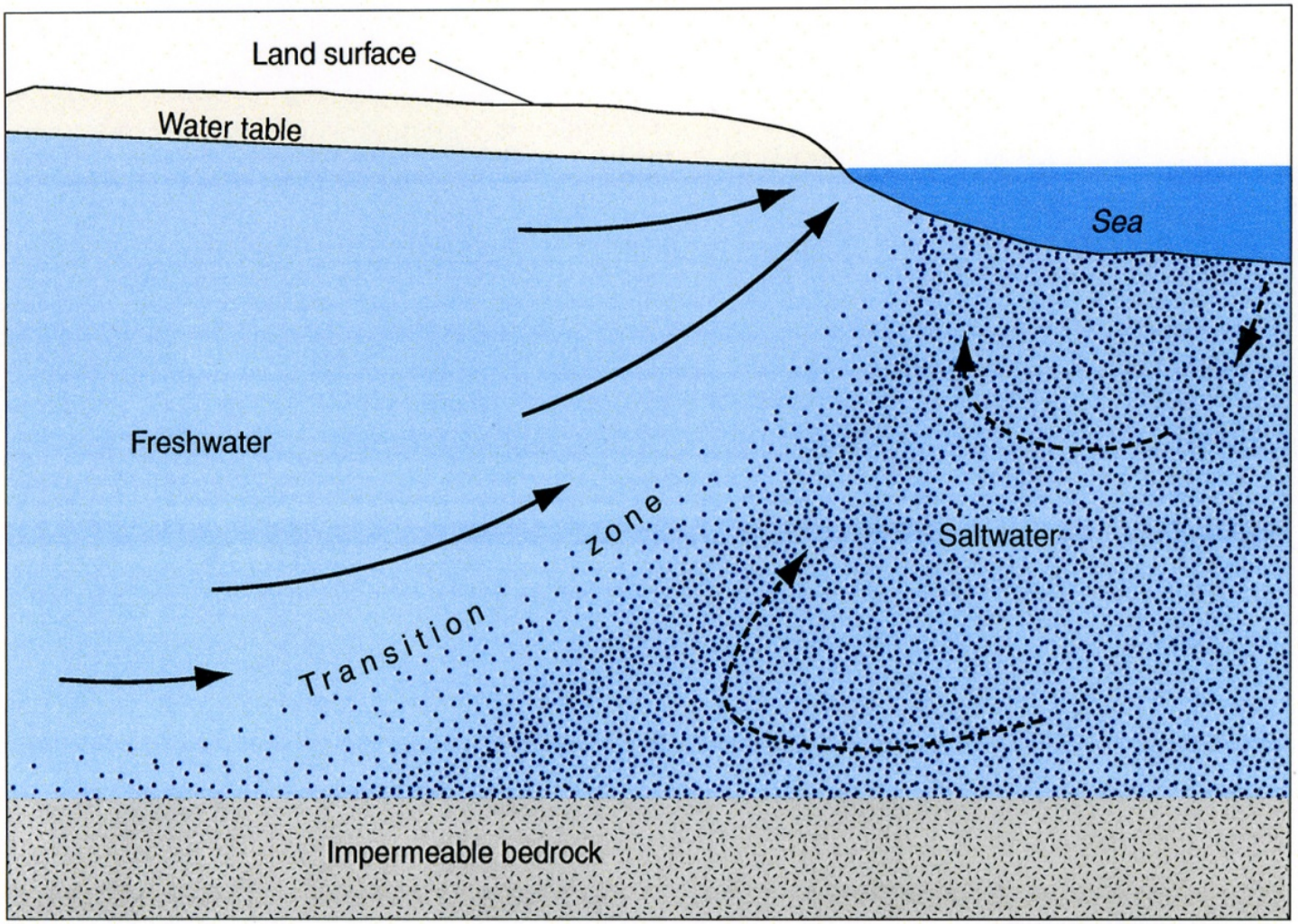
p-val = 0.193; Slope = -0.25 in/yr
Source: Southeastern Regional Climate Center, 2014

Gyben-Herzberg Principle



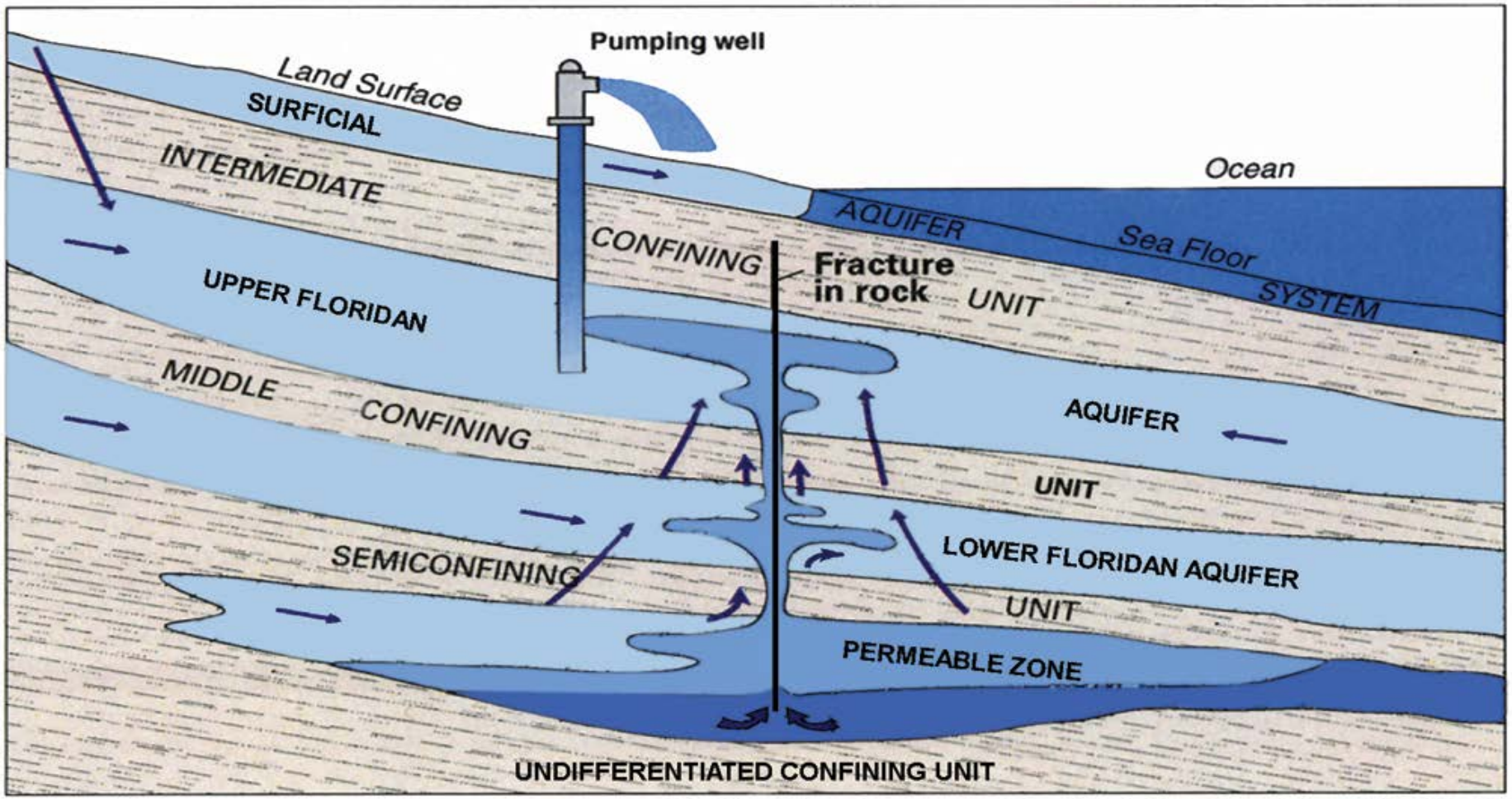


Saint Johns River Water Management District (Date Unknown)



Not to scale

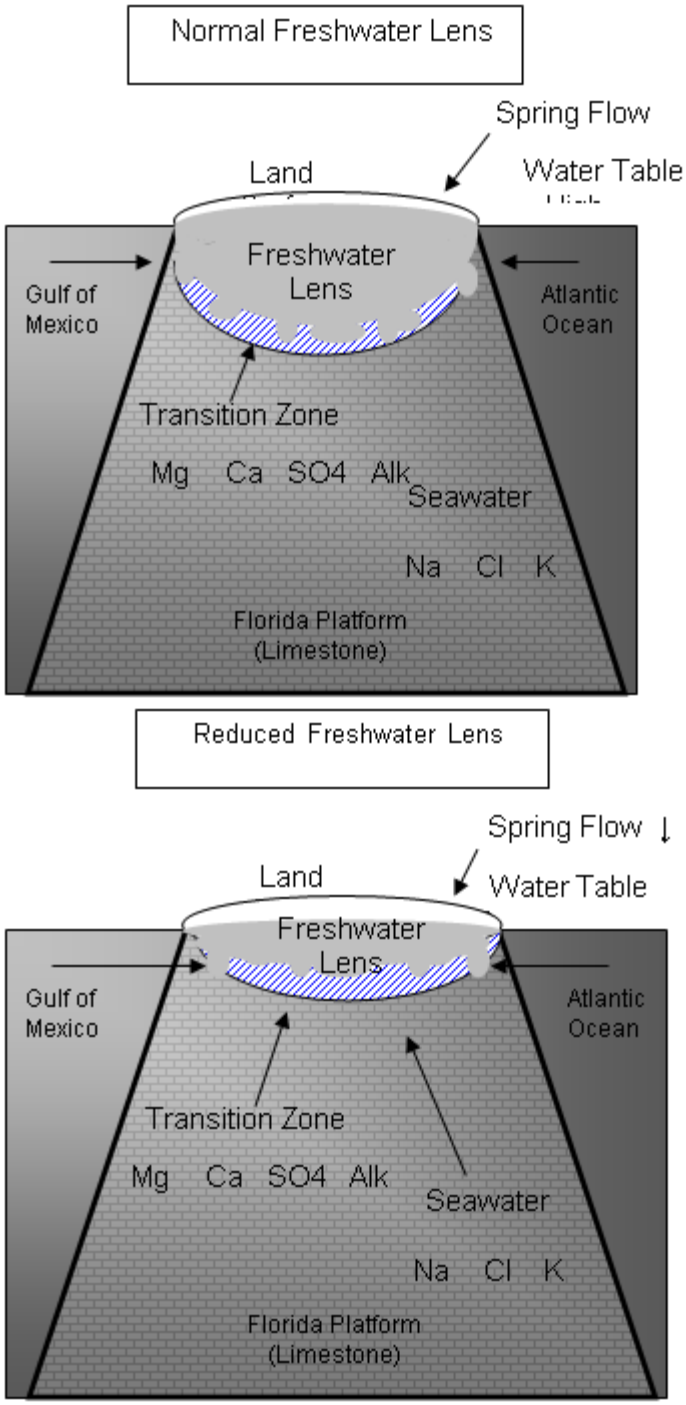
Modified from Cooper (1964)



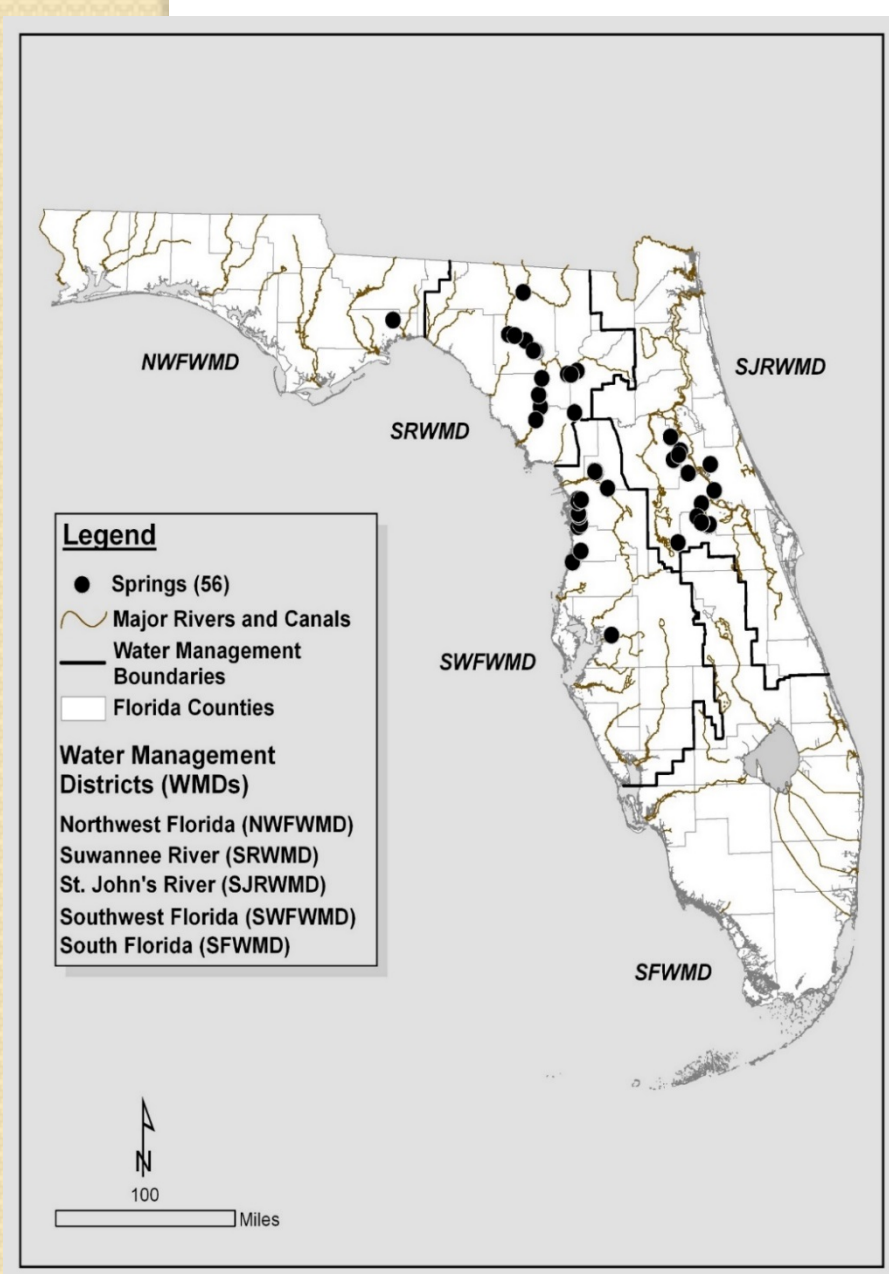
Modified from Krause and Randolph (1989) and Spechler (1994)

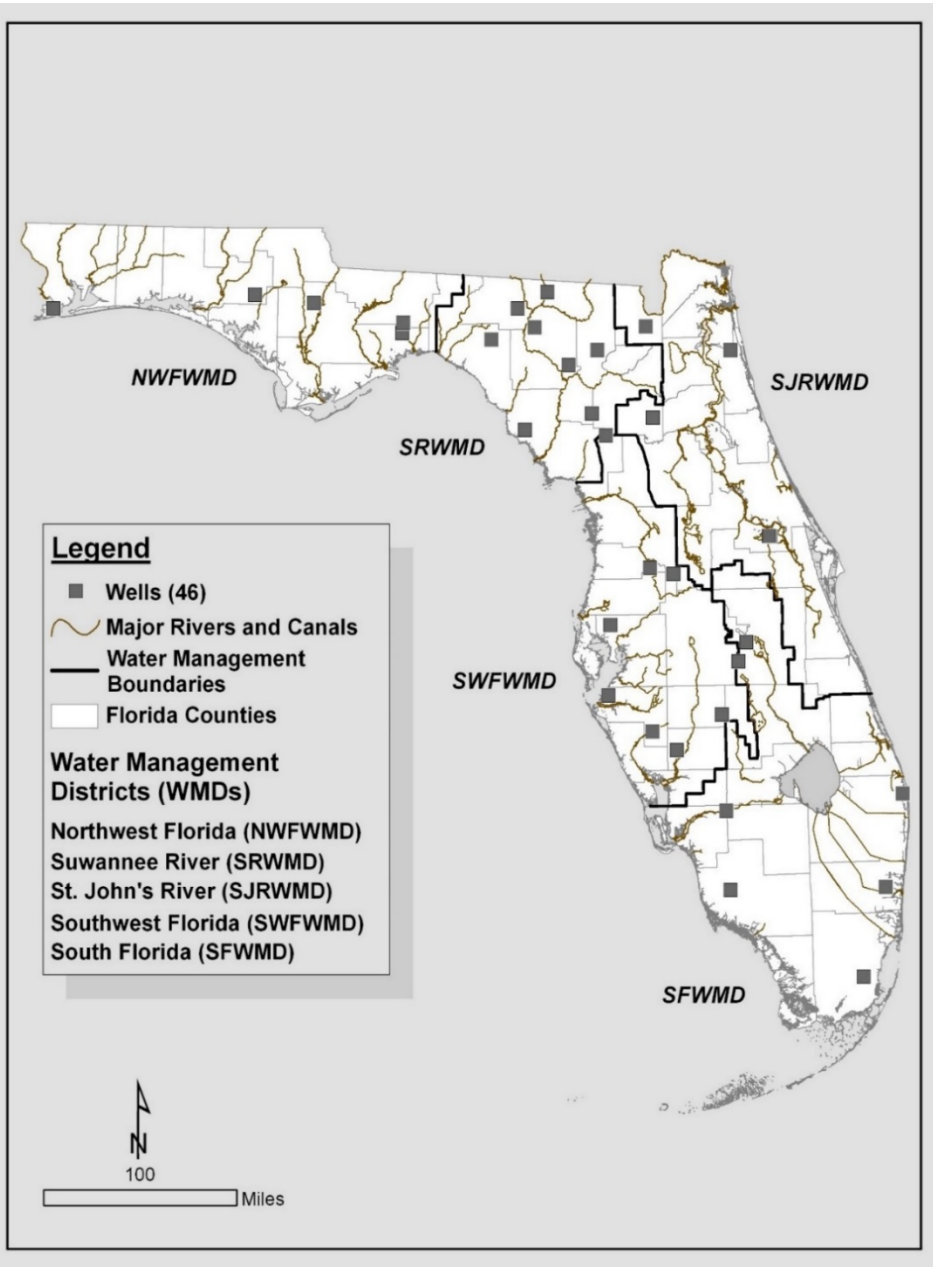
EXPLANATION

- Brackish water
- Saltwater
- Freshwater
- Direction of ground-water flow

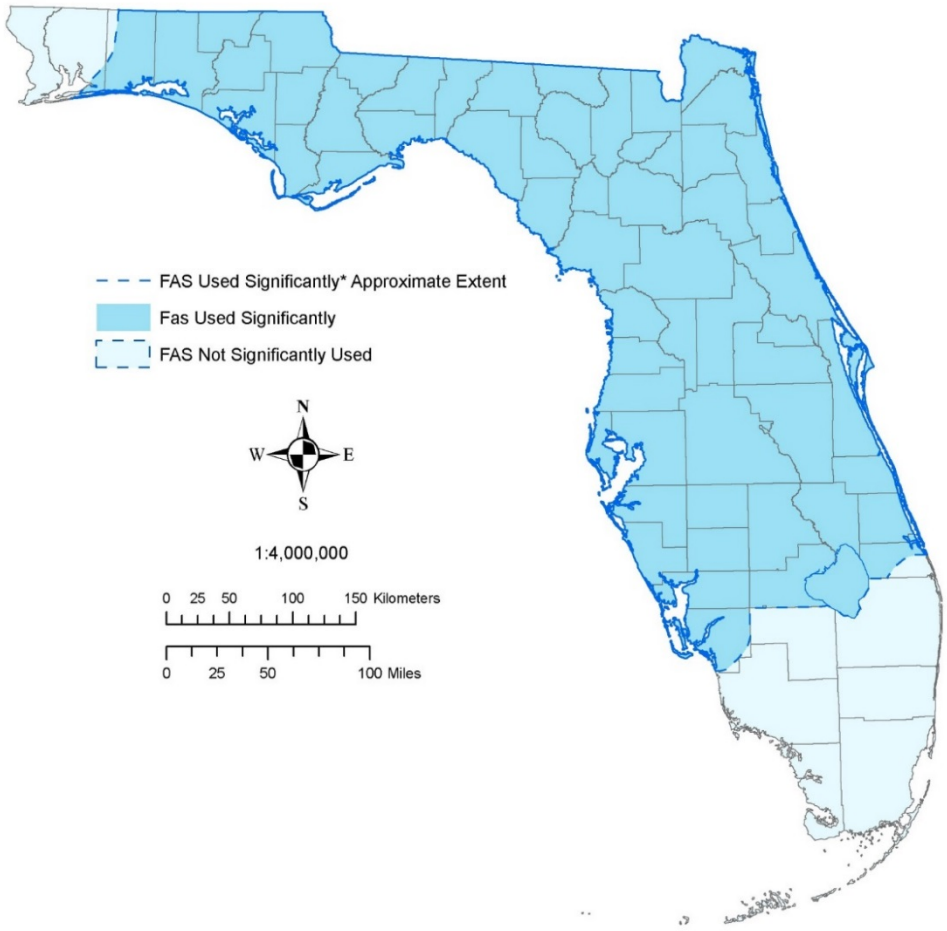

Normal Freshwater Lens
Spring Flow
Land
Water Table
Freshwater Lens
Gulf of Mexico
Atlantic Ocean
Transition Zone
Mg Ca SO4 Alk
Seawater
Na Cl K
Florida Platform (Limestone)
Reduced Freshwater Lens
Spring Flow ↓
Land
Water Table
Freshwater Lens
Gulf of Mexico
Atlantic Ocean
Transition Zone
Mg Ca SO4 Alk
Seawater
Na Cl K
Florida Platform (Limestone)

Location of Springs and Trend Wells



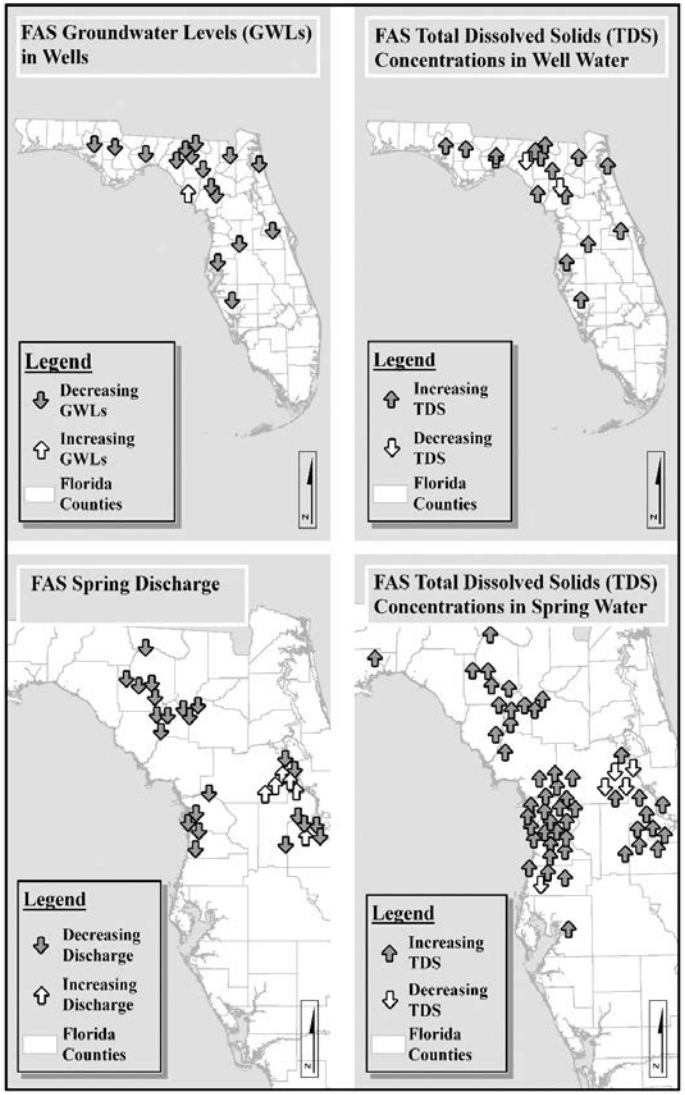


Most change in Floridan Aquifer System (FAS)

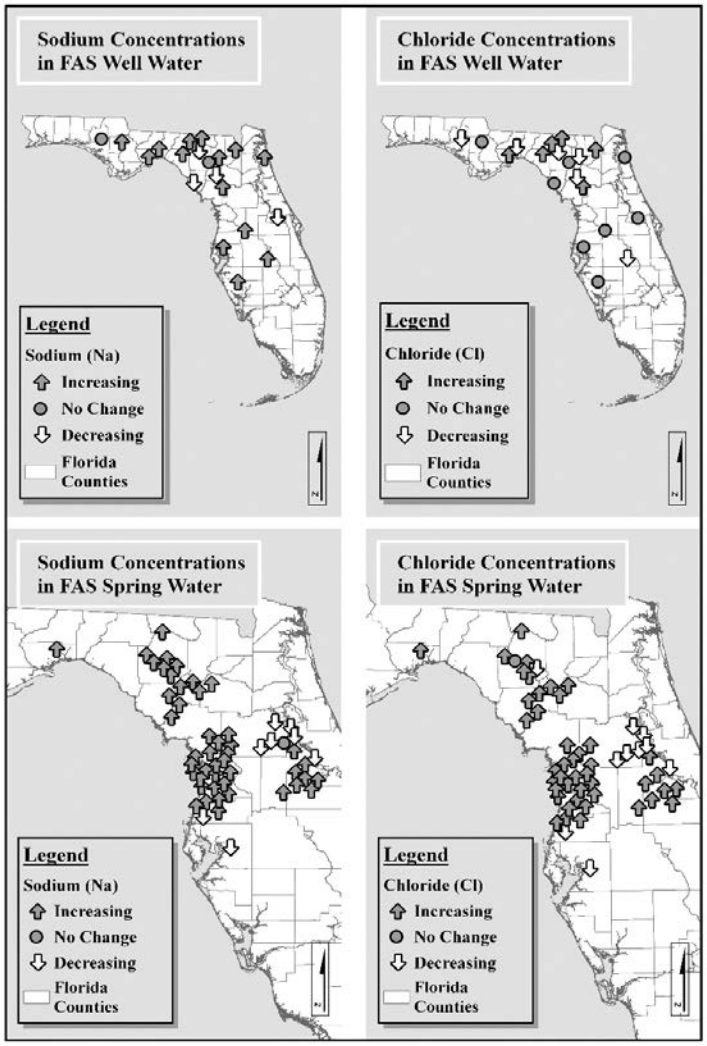


* Significant is greater than 5% of county groundwater use based on 2000 data from Marella and Bendt (2005).

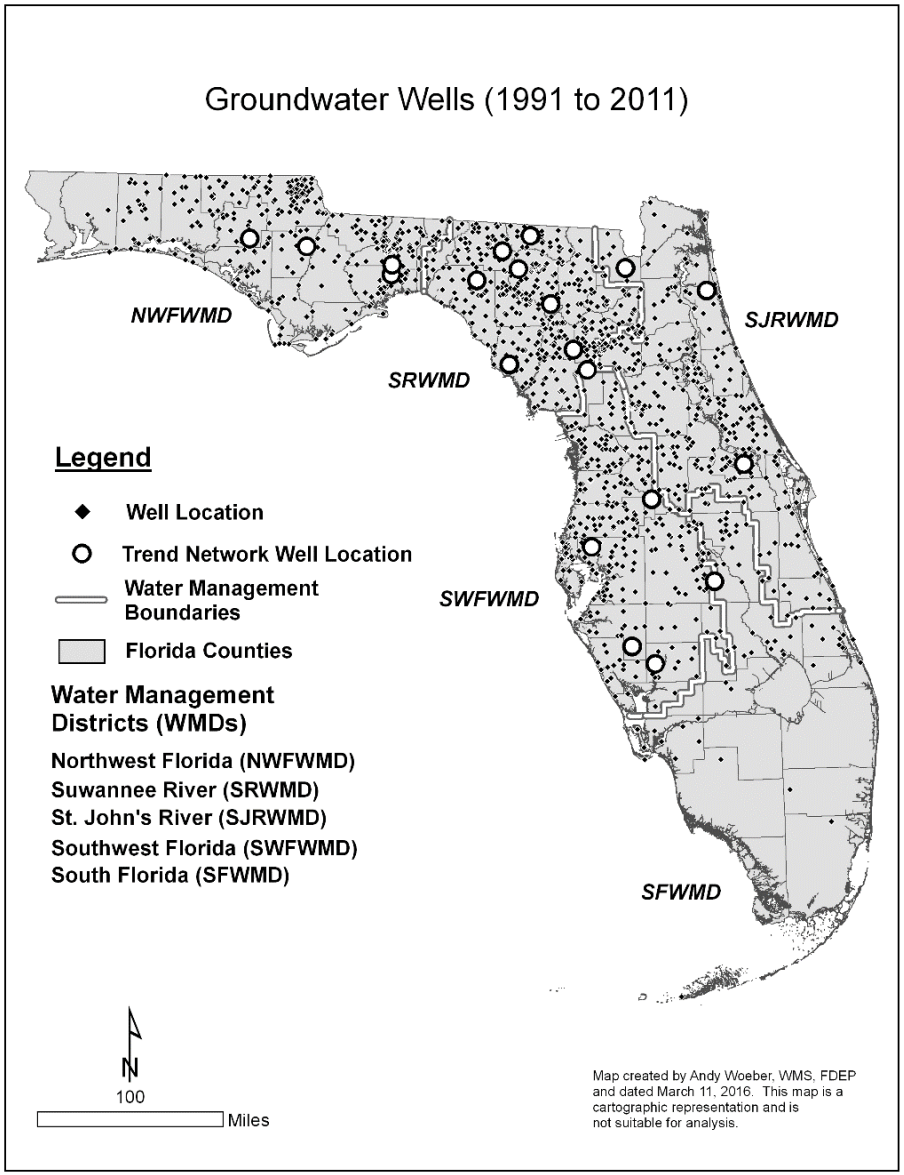
Spring Flow, TDS (1991-2011) (Trend Wells and Springs)



Changes in Na and Cl (1991-2011) (Trend Wells and Springs)



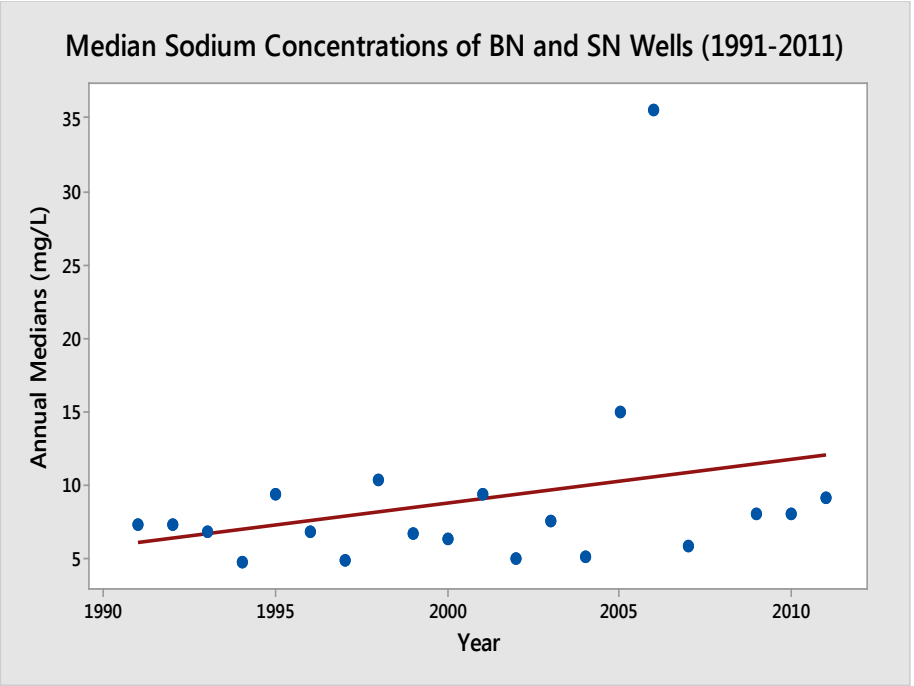
FAS - Wells with Na and Cl data



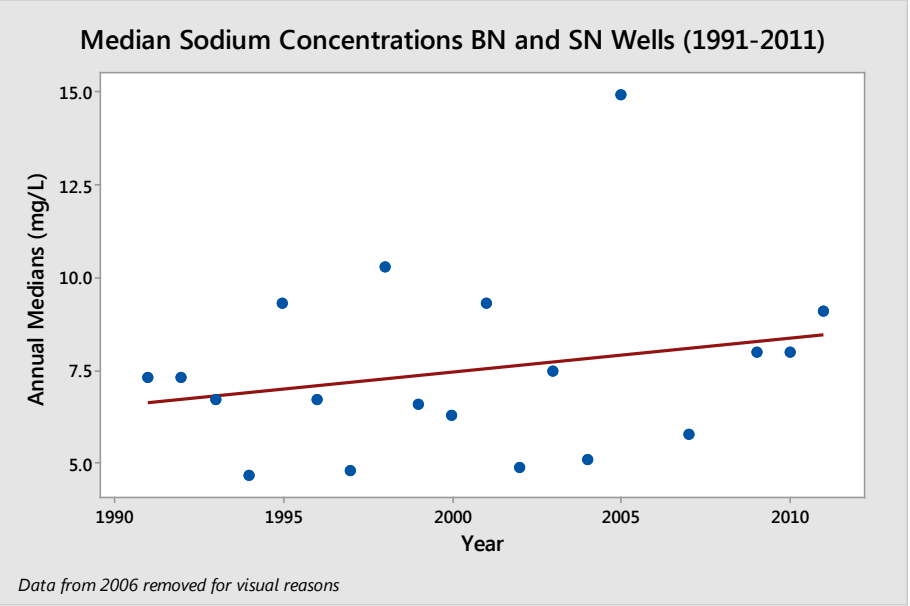
1451 FAS Monitoring Wells

- Sampled 60-366 per year, across FL
- Obtained annual medians
  - Na and Cl
- Plotted medians per year

Annual Medians

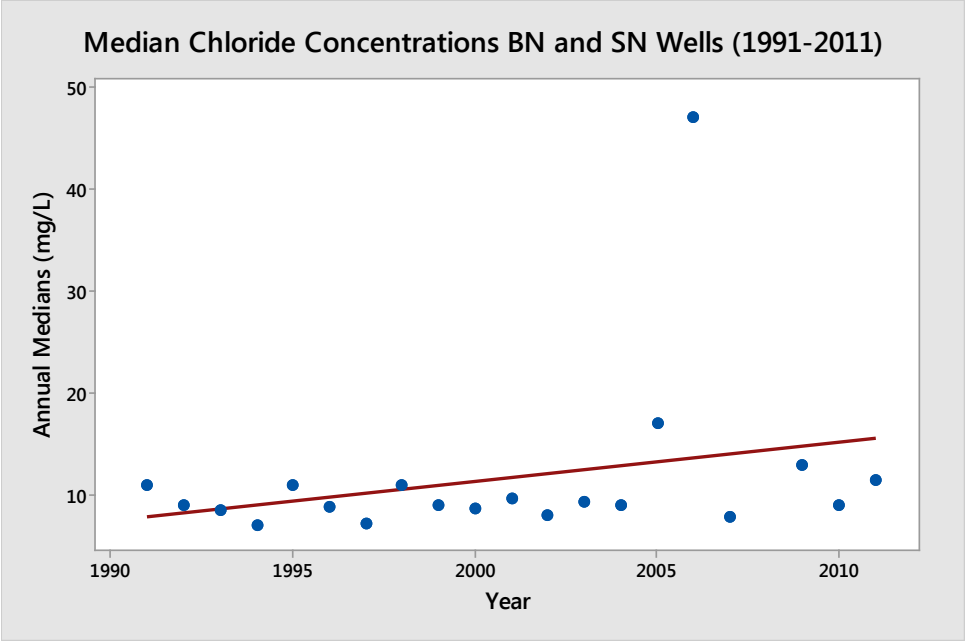


Outlier

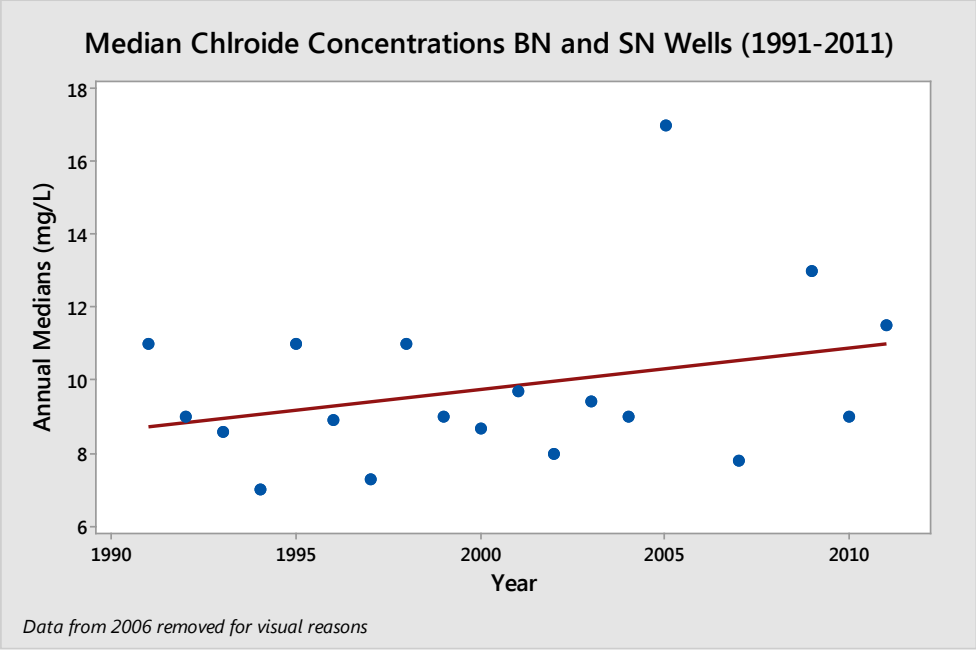


Data from 2006 removed for visual reasons

Annual Medians



Outlier



Data from 2006 removed for visual reasons

Salinity Network Workgroup (SNW)

- Established in 2012
- Under the umbrella of the Florida Water Resource Monitoring Council (FWRMC)
- Audience
  - General Public
  - Policy Makers
  - Scientists
- Network of Existing Networks
- Meet via webinar every six months
- “Success is in our ability to cooperate”

Mission (Abridged)

- …assist in the management, protection, preservation, and restoration of Florida's ground-water and surface-water resources, facilitated by the Council and the monitoring entities of the state…

- Emphasis on the encroachment of saline water into our freshwater resources:
  - GW levels, SW flows, Spring flows, Saline-related analytes

SNW

- Predominantly GW
- But committed to Working Closely with Surface-Water Monitoring Programs. Consider GW/SW interactions if applicable
- Currently made up of > 20 agencies

Major Objectives

- Monitor…Florida's freshwater …as related to saltwater encroachment
- Encourage …monitoring programs …to participate in the FWRMC (Council) activities
- **Encourage the timely reporting of the status and trends (related to saltwater encroachment)**

Objectives (continued)

- **Develop and use indices**…to evaluate the status and trends of encroachment that… are uniform among monitoring entities…relatively easy to understand by the general public, policy makers and the scientific community.

- Evaluate the best GW sampling methodologies for saline water given its physical properties,

- Develop SOPs to these methodologies,

Currently Top Priorities

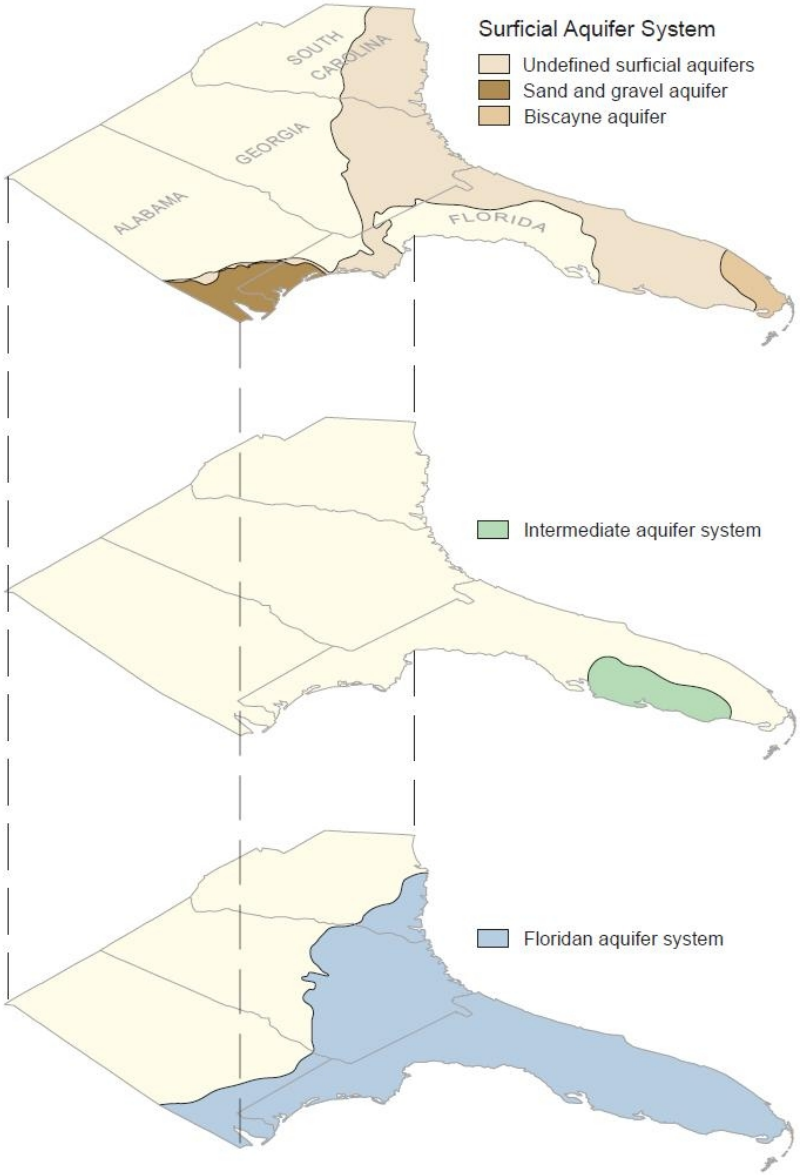
- **Produce GWL Percentile Ranking (PR) Maps**
- **Establish Coastal Salinity Monitoring Network**
  in addition to the Salinity Network

- Next in line
- Develop a salinity GW Quality Index
- Develop Samp Protocols near SW / FW interface

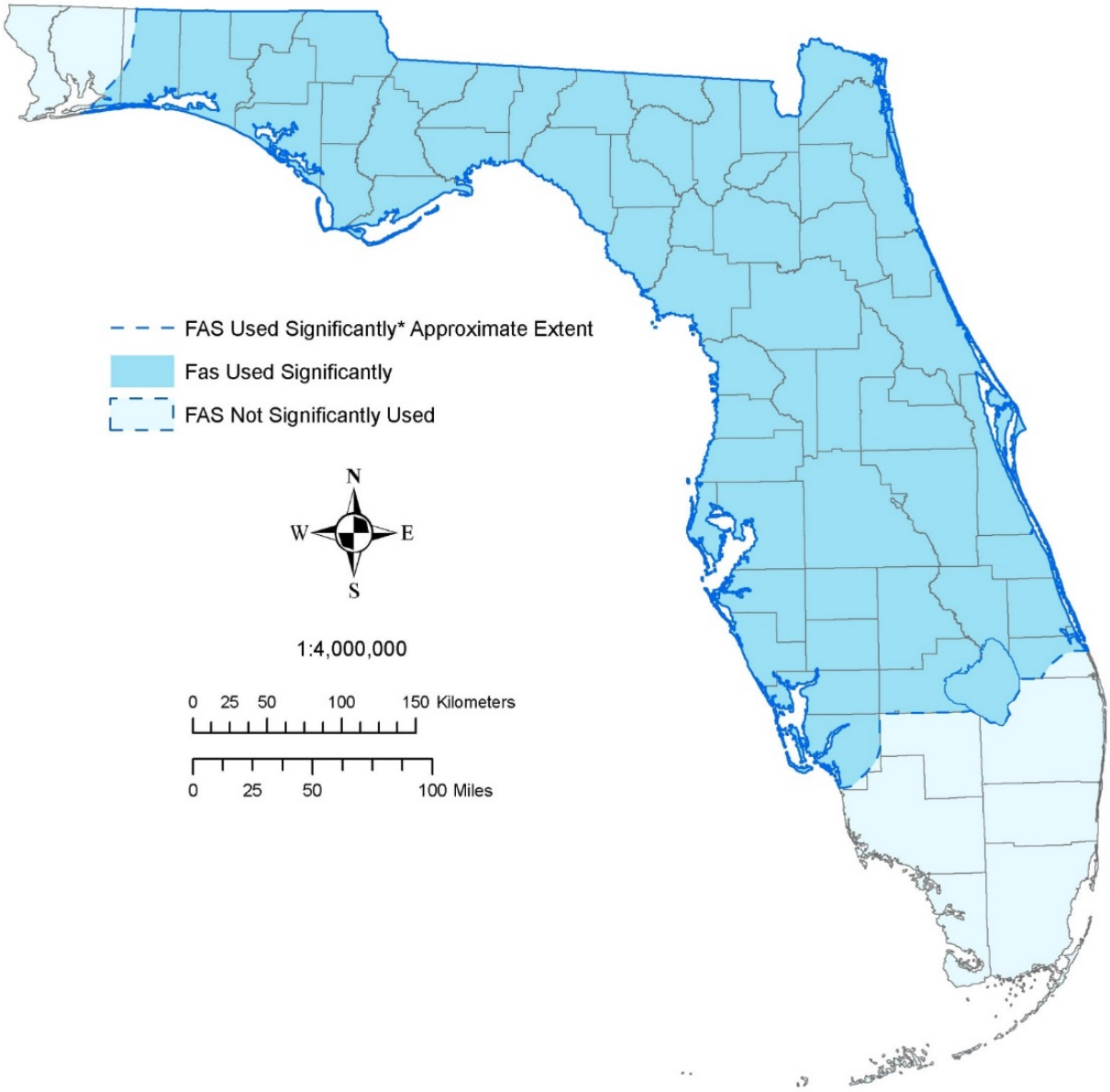
GWL Percentile Ranking Index Pilot Study

- Decided on a Percentile Ranking (PR)
  - Why? ⇩GWL⇧ potential encroachment
  - Spring 2010: Upper Floridan aquifer (UFA)
- **Purpose**
  - To overcome (internal, external) obstacles
  - To reach consensus
  - Note - the GWL PR Index can be used for a variety of aquifers, and at various scales
  - Periodically produce GWL up-to-date maps

Sequence of Aquifers



Water Resources Atlas of Florida, Institute of Science and Public Affairs



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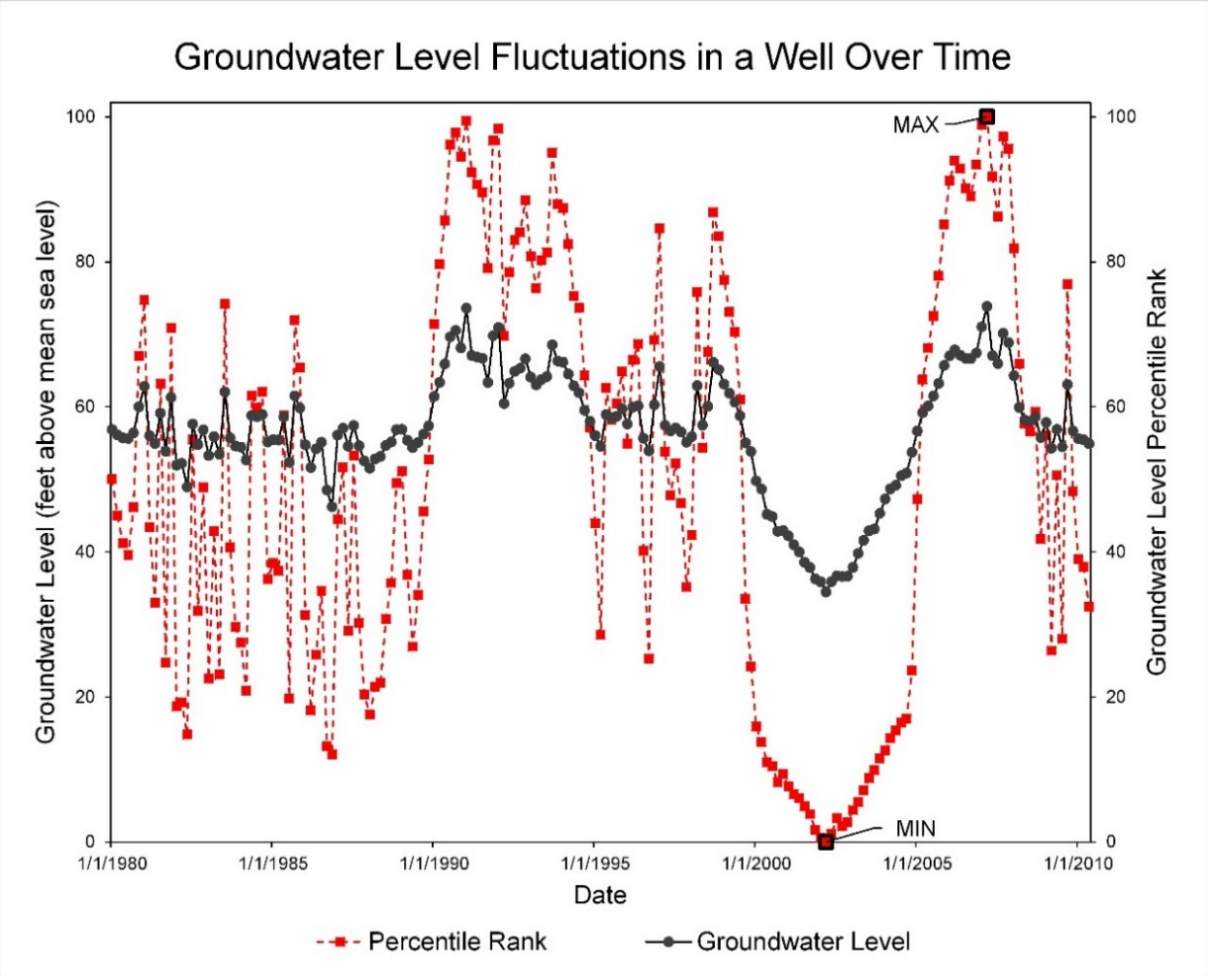
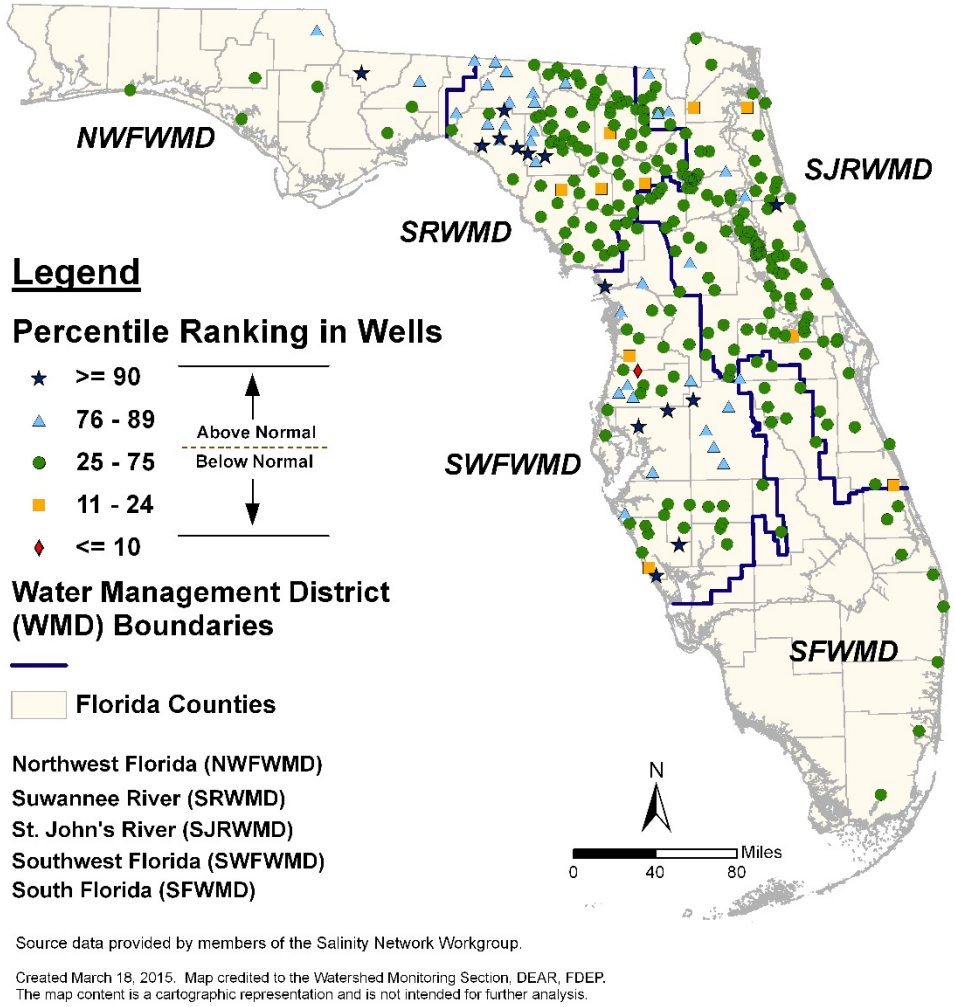
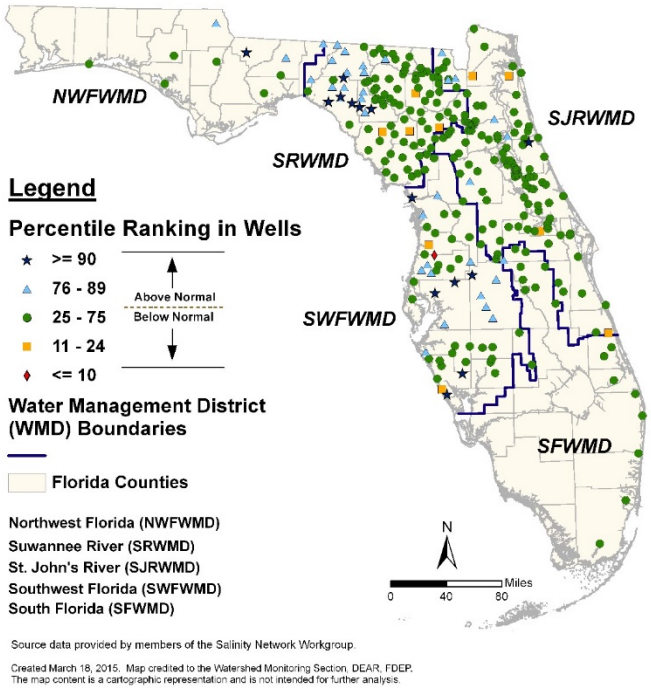
Example of GWLs and Percentile Ranks





Groundwater level conditions in the Upper Floridan aquifer in Florida in percentile ranks, May 2010.

Issues to be addressed

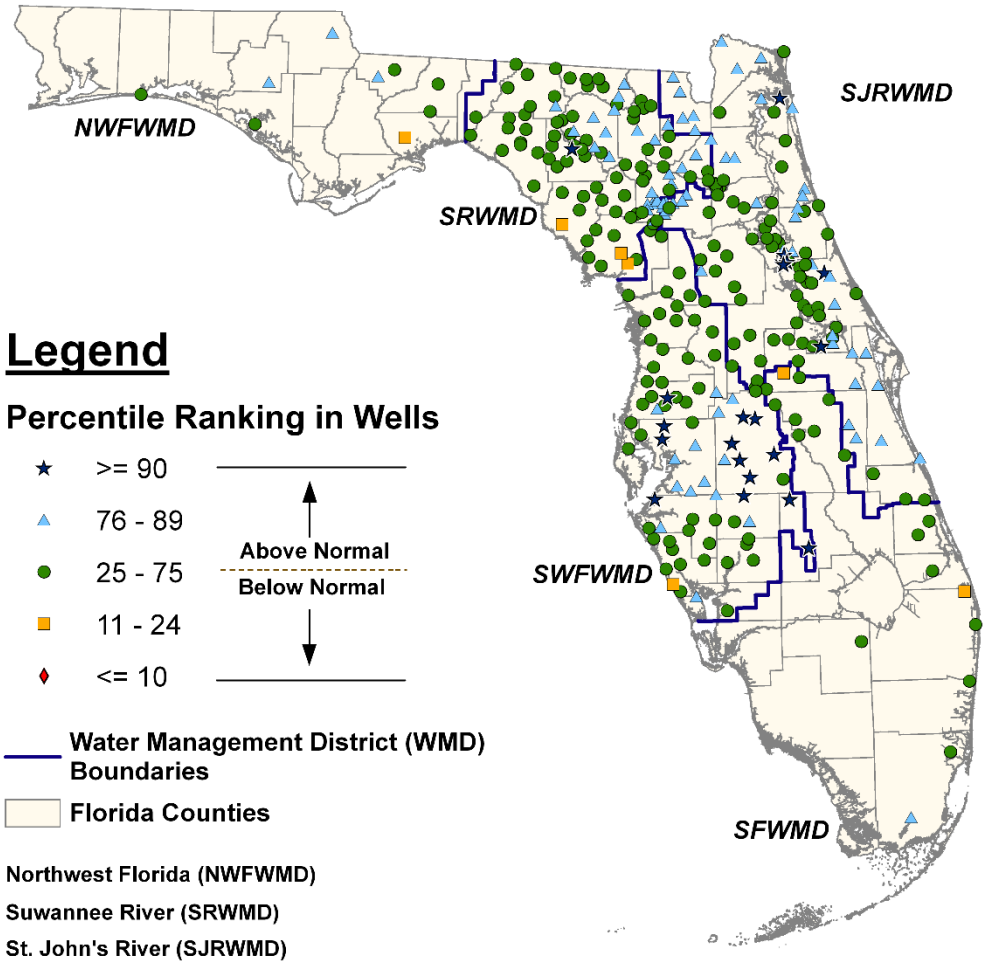


Groundwater level conditions in the Upper Floridan aquifer in Florida in percentile ranks, May 2010.

SR- SRWMD
SJ- SJRWMD
SW- SWFWMD

- PR map is composite
  - Inconsistent POR
  - and methodologies
- For PR map
  - Decrease density of wells in SR, SJ, & SW?
  - Over time PORs may become more consistent
  - Over time, change to one standard meth?

D R A F T
Groundwater Levels, in Percentile Ranks for the Upper Floridan Aquifer (May 2015)



Map and Text

- Each map to be accompanied by an explanation page
- Lag time – Currently working on September, 2015 map.
- When complete, each map/text is uploaded to a link, e.g.
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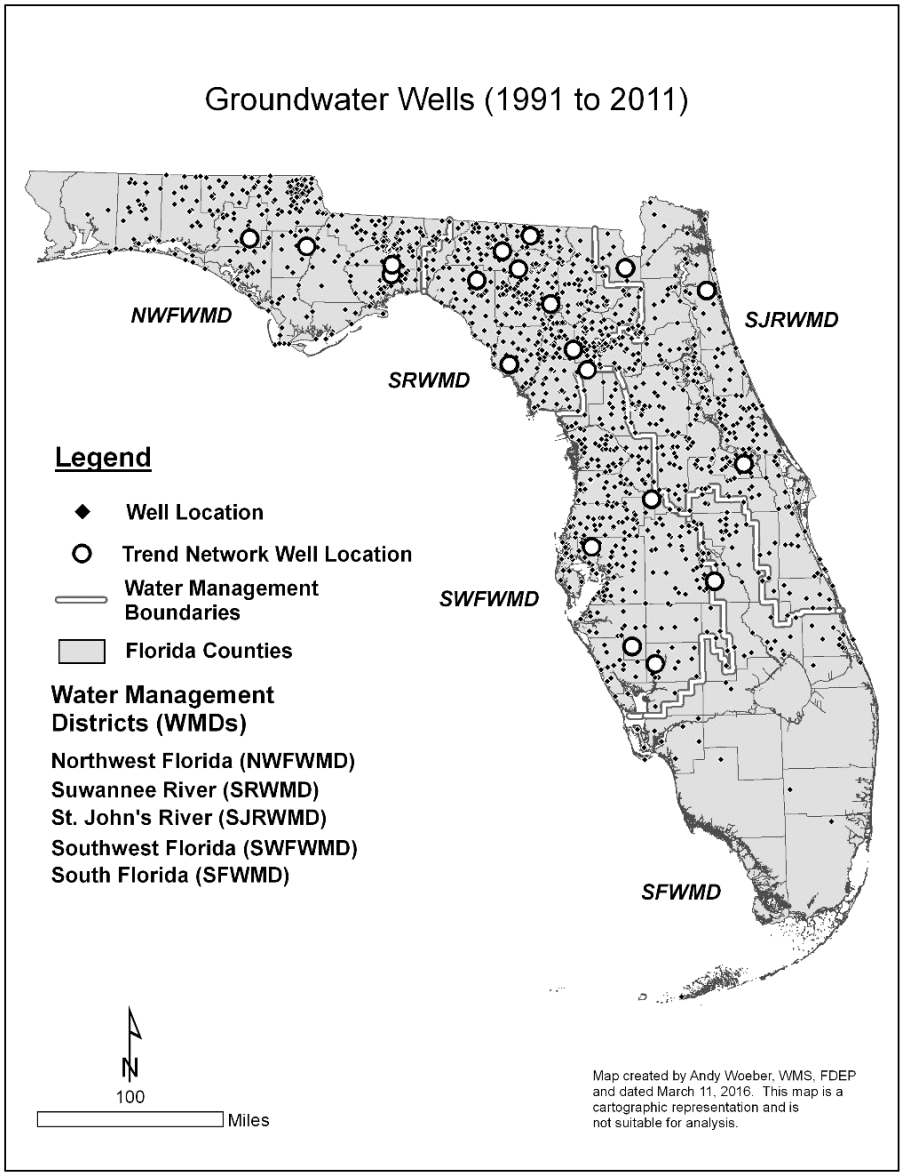
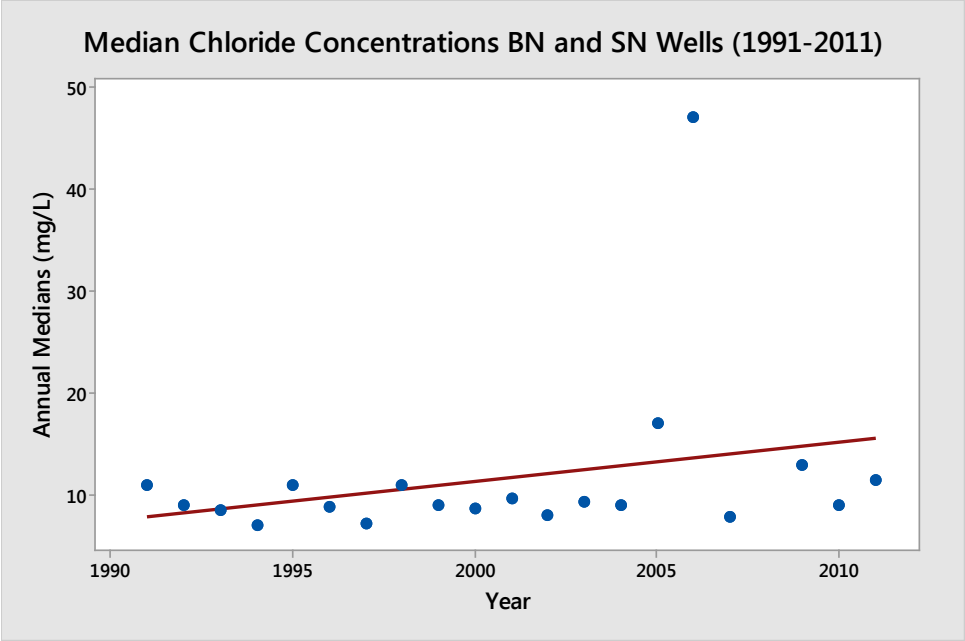
- When complete, each map/text is uploaded to a link, e.g.
  http://www.dep.state.fl.us/water/monitoring/council/docs/salinity/SNWGWLPRIPilotFinal.pdf

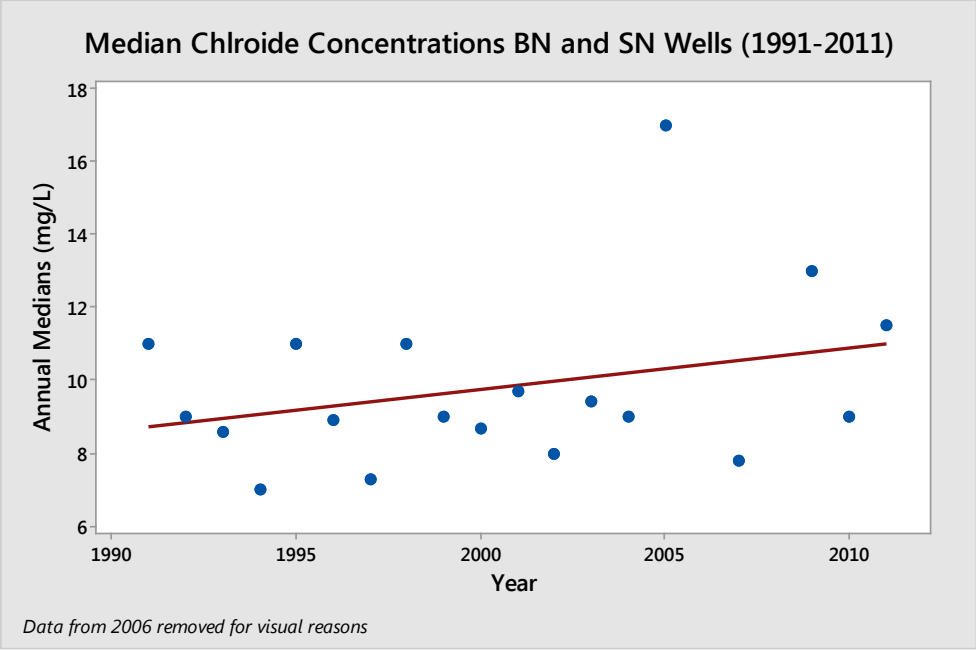
Recall Wells with Na and Cl data



Annual Medians



Outlier



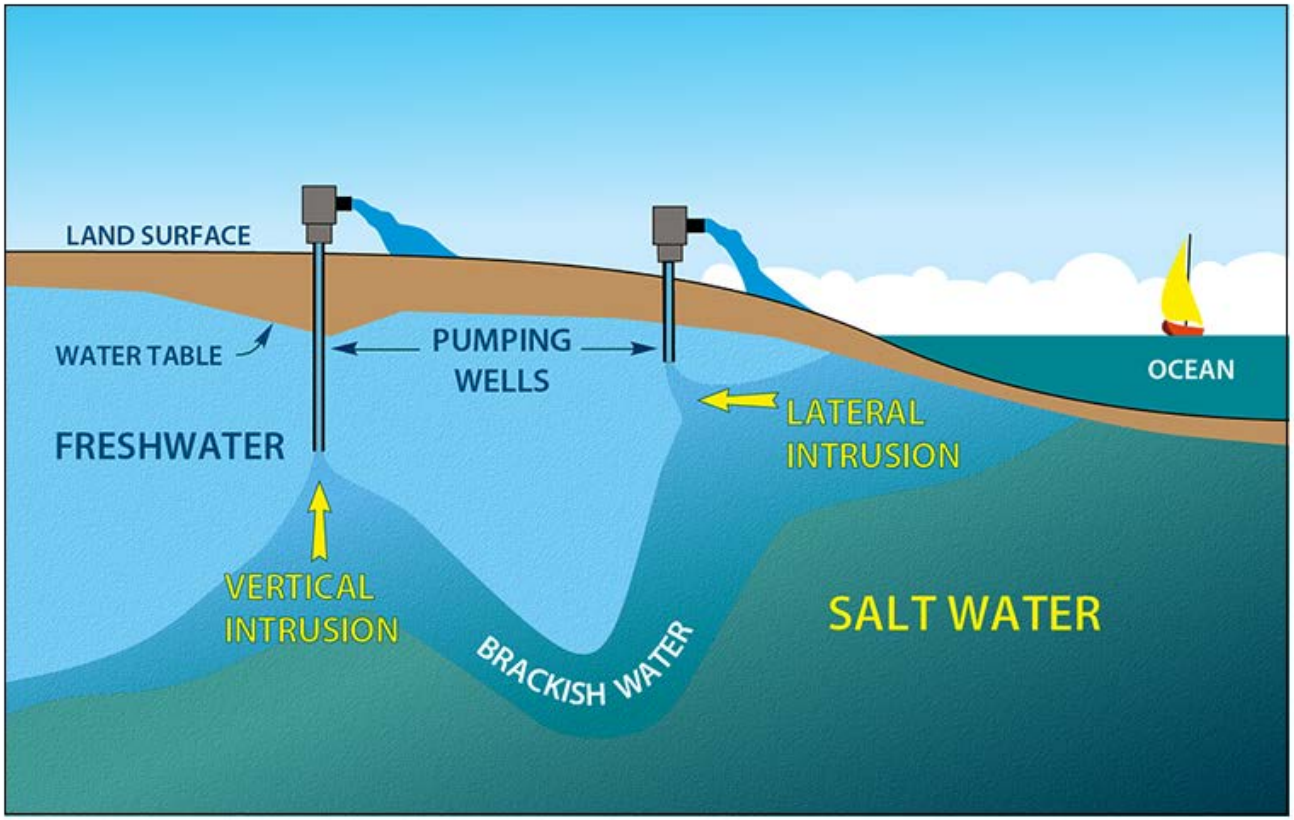
Data from 2006 removed for visual reasons

2. Development of Coastal Salinity Mon. Network

- Not only the Salinity Network, but also a Coastal Salinity Monitoring Network (CSMN)- "Rind around the state"
  - Networks-of-existing networks (**no new $**)
  - Add wells and surface water sites in future

- **Governor's Office Supports CSN**
- Secretary's Office supports CSN
- Office of Water Policy supports CSN
- FDEP Coastal Office supports CSN

Coastal Salinity Network



Saint Johns River Water Management District (Date Unknown)

Development of Coastal SalNet

- "Let data suggest were to build Coastal SalNet"
- SNW to start with GW and then be open to adding SW sites

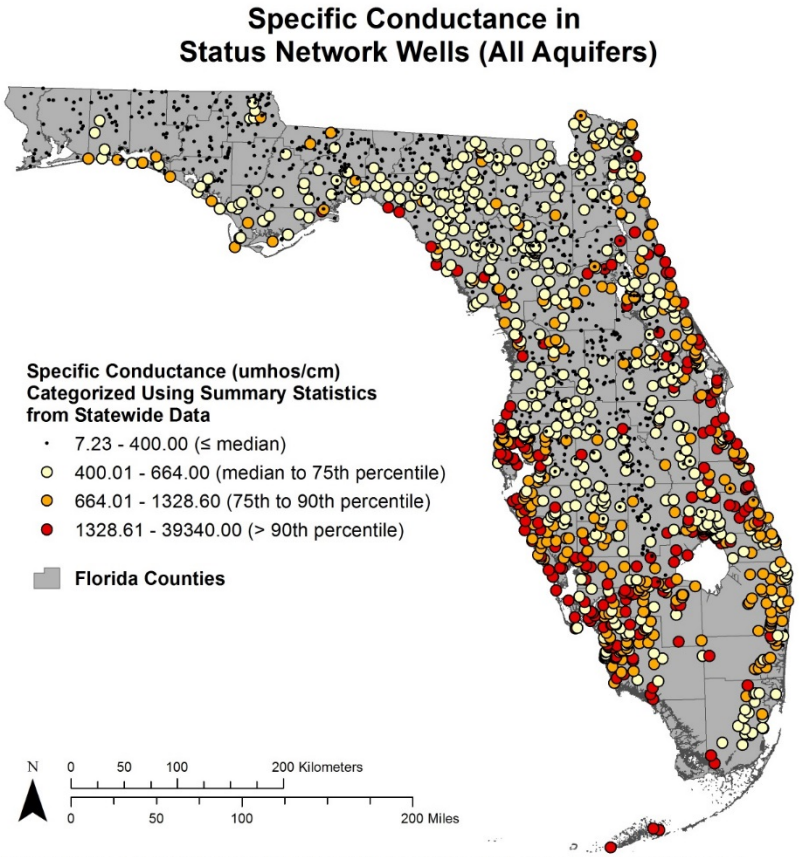
Saline Chemical Concentrations (Major Aquifers)

- Data are from DEP Status Monitoring Network

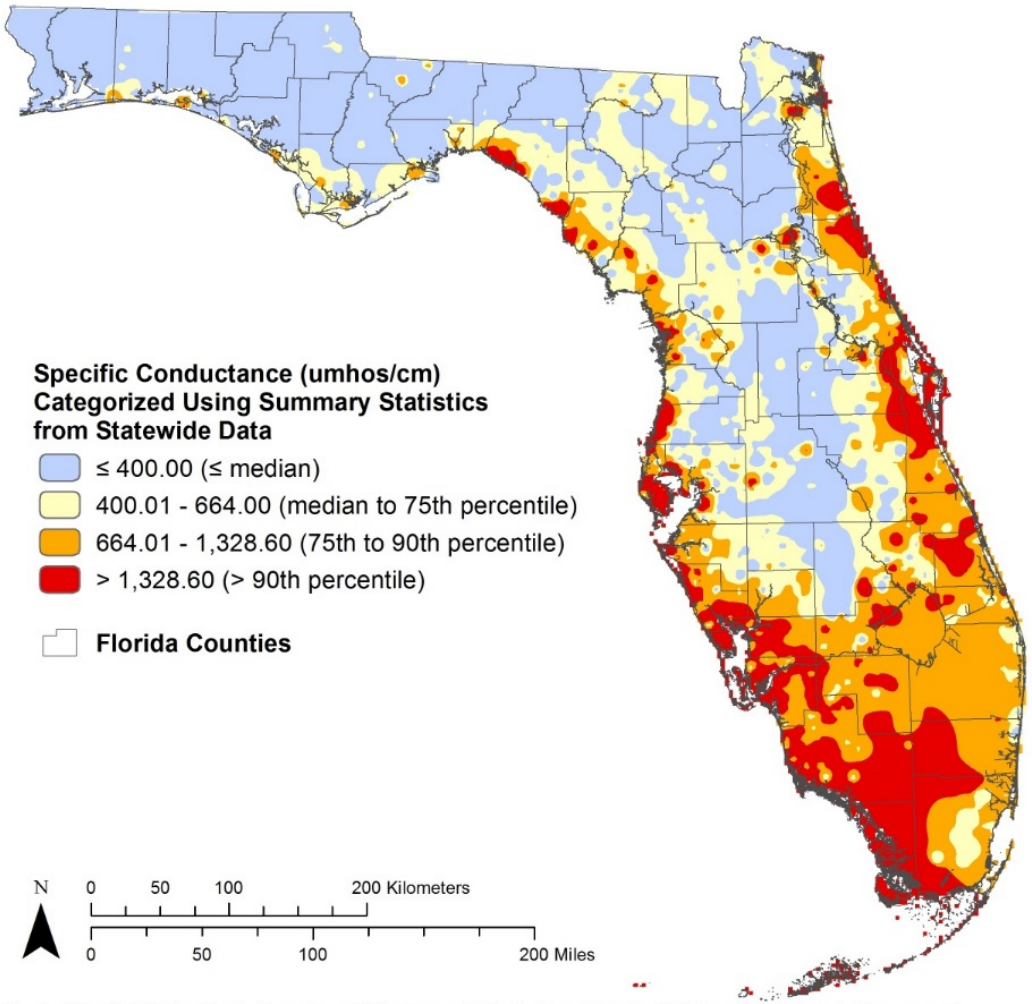
- GW samples between 2000-2014;
- Most wells have only one sample
- If multiple samples at a site, most recent sample with most complete record was used
  - > 2000 Wells

All Aquifers

- Four analytes: TDS, SC, Cl, and SO4
- Determined selected percentiles from all samples across Florida
- Greatest concentration Maps
- Contour Maps
  - Then repeated by aquifer system


Specific Conductance in
Status Network Wells (All Aquifers)
Specific Conductance (umhos/cm)
Categorized Using Summary Statistics
from Statewide Data
7.23 - 400.00 (≤ median)
400.01 - 664.00 (median to 75th percentile)
664.01 - 1328.60 (75th to 90th percentile)
1328.61 - 39340.00 (> 90th percentile)
Florida Counties
N
0 50 100 200 Kilometers
0 50 100 200 Miles
Created May 8, 2015 by Florida Department of Envionmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.

Specific Conductance in Status Network Wells (All Aquifers) Modeled Using Inverse Distance Weighting



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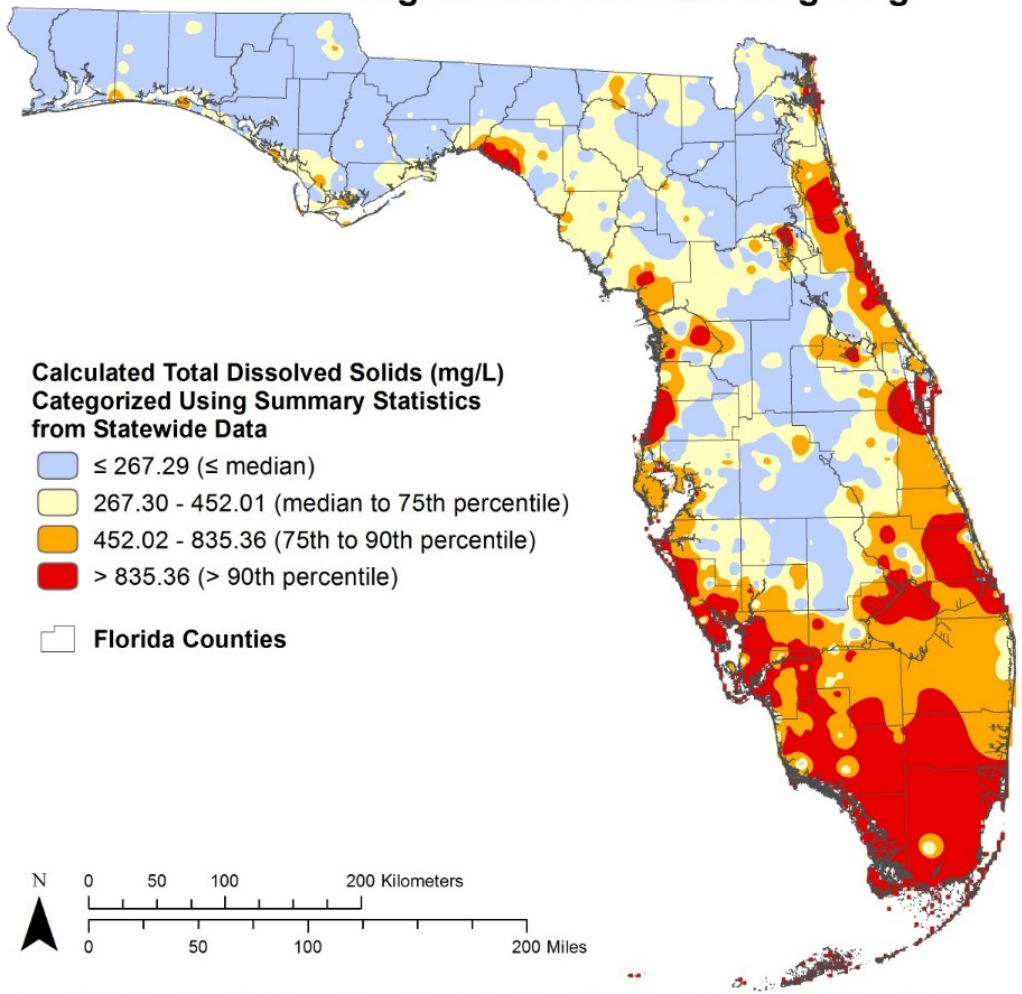
Calculated Total Dissolved Solids (TDS) in Status Network Wells (All Aquifers) Modeled Using Inverse Distance Weighting



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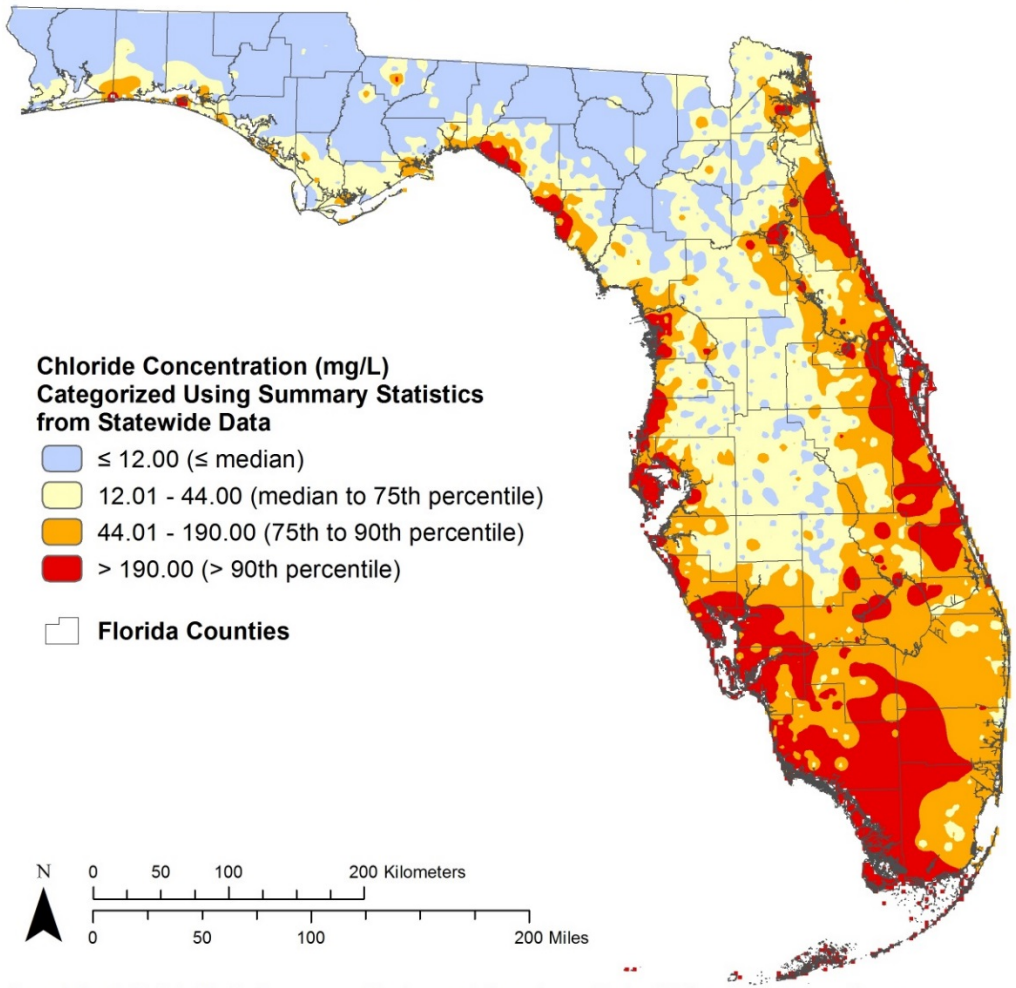
Chloride in Status Network Wells (All Aquifers) Modeled Using Inverse Distance Weighting



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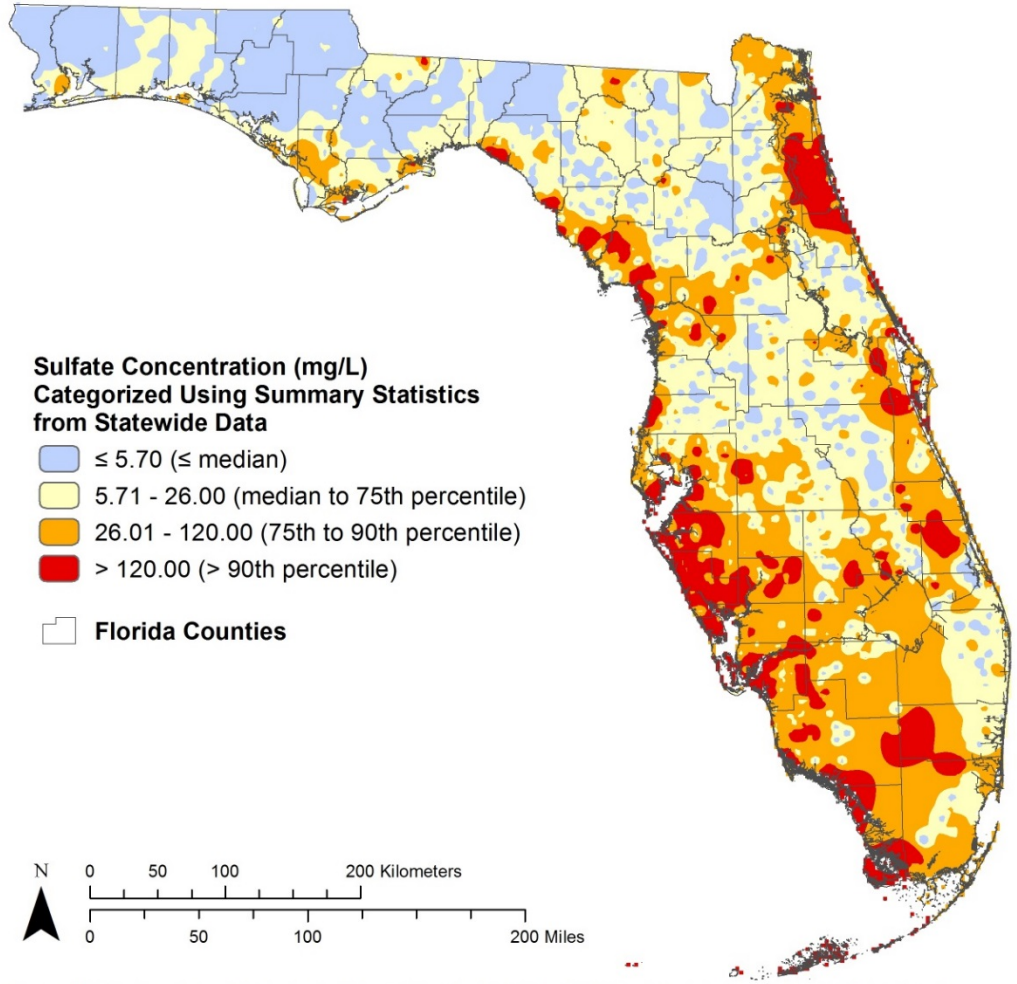
Sulfate in Status Network Wells (All Aquifers) Modeled Using Inverse Distance Weighting



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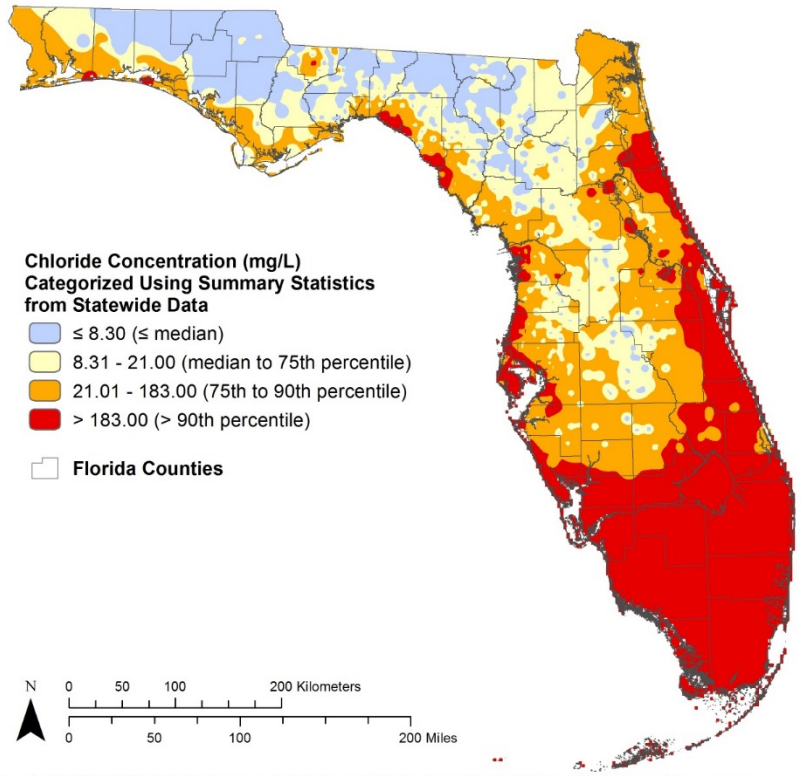
Next, Aquifer/Aquifer System

Chloride in
Status Network Upper Floridan Aquifer Wells
Modeled Using Inverse Distance Weighting



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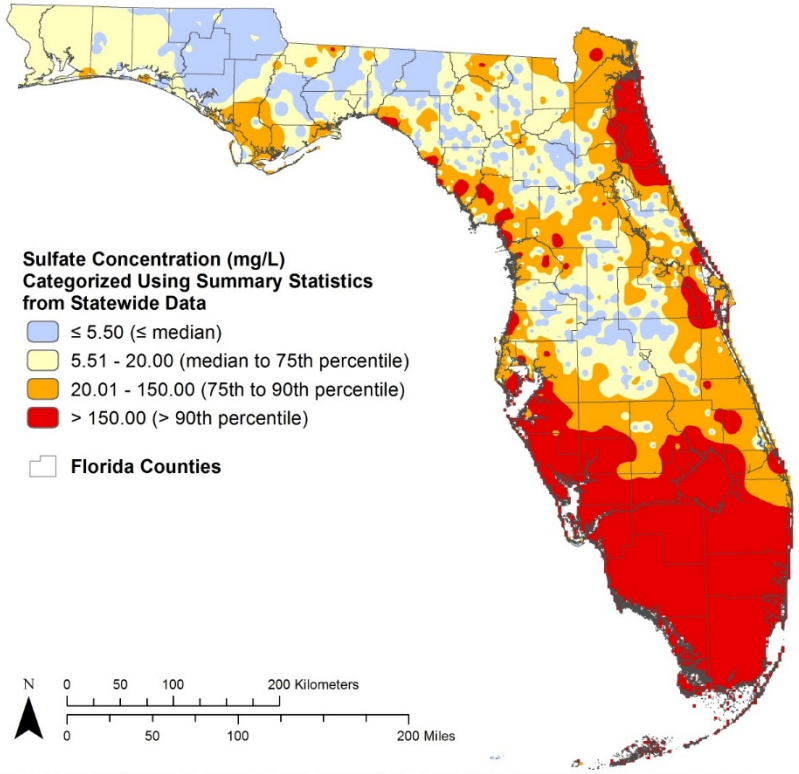
Sulfate in
Status Network Upper Floridan Aquifer Wells
Modeled Using Inverse Distance Weighting



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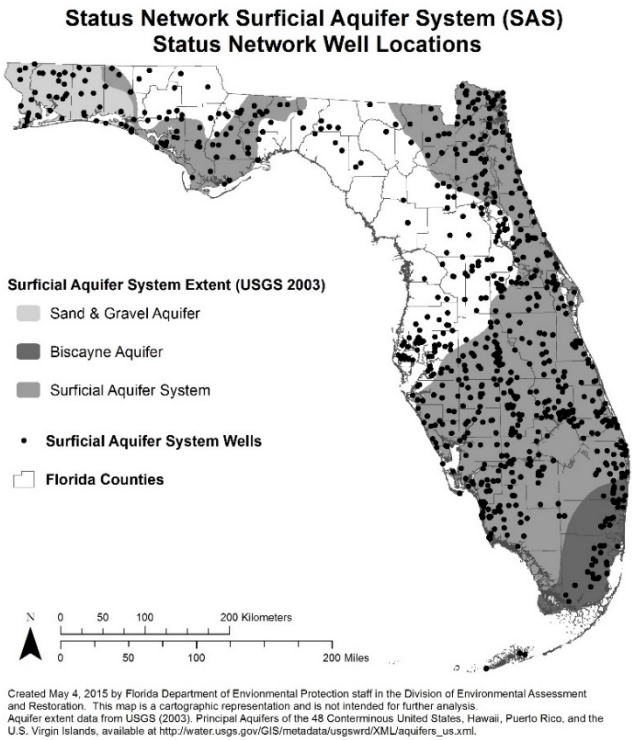
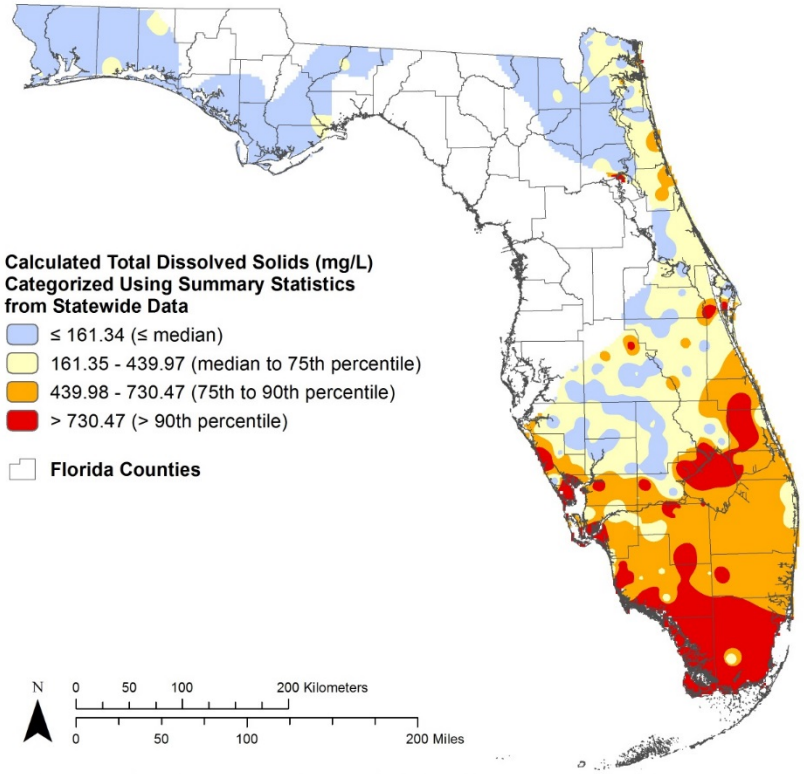
Surficial Aquifer System



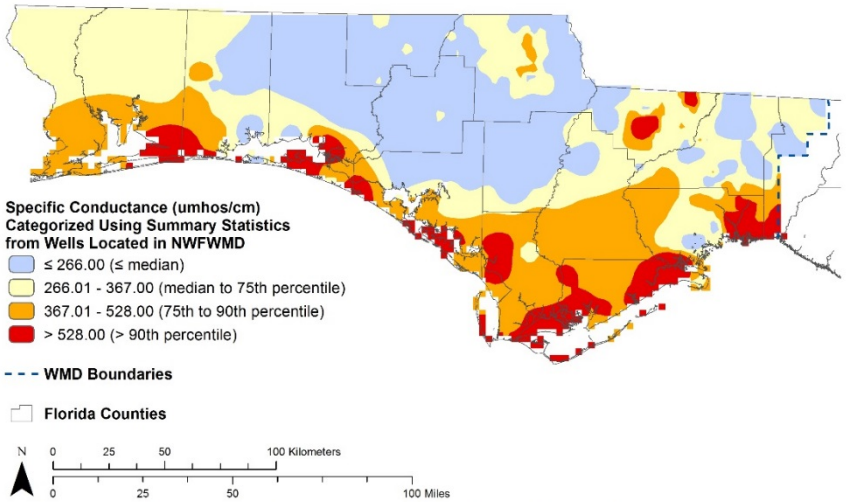
Calculated Total Dissolved Solids (TDS) in Status Network Surficial Aquifer System Wells Modeled Using Inverse Distance Weighting



Created May 4, 2015 by Florida Department of Envionmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.
Aquifer extent data from USGS (2003). Principal Aquifers of the 48 Conterminous United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands, available at http://water.usgs.gov/GIS/metadata/usgswrd/XML/aquifers_us.xml.

NWFWMD

Specific Conductance in
Status Network Upper Floridan Aquifer Wells
Modeled using Inverse Distance Weighting



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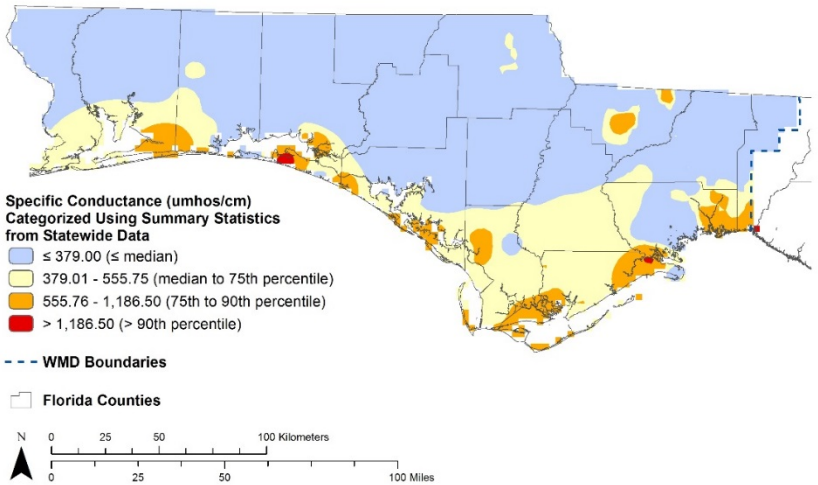
Specific Conductance in
Status Network Upper Floridan Aquifer Wells
Modeled using Inverse Distance Weighting



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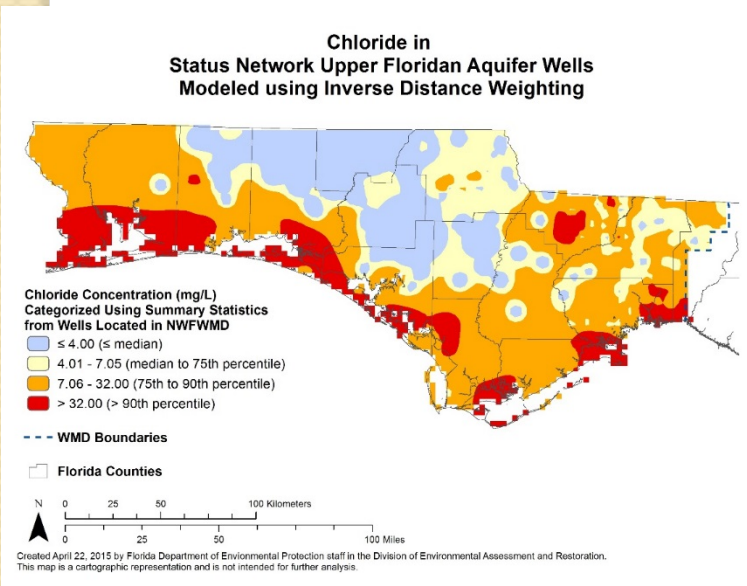
Chloride in
Status Network Upper Floridan Aquifer Wells
Modeled using Inverse Distance Weighting
Chloride Concentration (mg/L)
Categorized Using Summary Statistics
from Wells Located in NWFWMD
≤ 4.00 (≤ median)
4.01 - 7.05 (median to 75th percentile)
7.06 - 32.00 (75th to 90th percentile)
> 32.00 (> 90th percentile)
WMD Boundaries
Florida Counties
N
0 25 50 100 Kilometers
0 25 50 100 Miles
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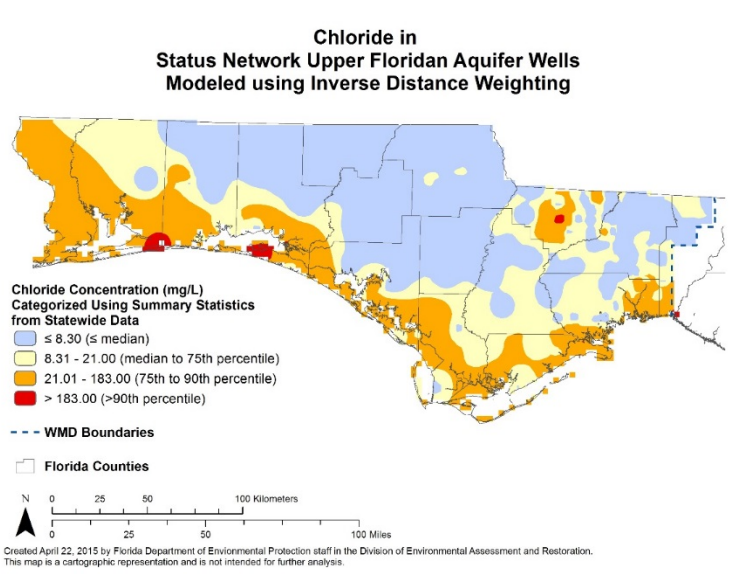
Chloride in
Status Network Upper Floridan Aquifer Wells
Modeled using Inverse Distance Weighting
Chloride Concentration (mg/L)
Categorized Using Summary Statistics
from Statewide Data
≤ 8.30 (≤ median)
8.31 - 21.00 (median to 75th percentile)
21.01 - 183.00 (75th to 90th percentile)
> 183.00 (>90th percentile)
WMD Boundaries
Florida Counties
N
0 25 50 100 Kilometers
0 25 50 100 Miles
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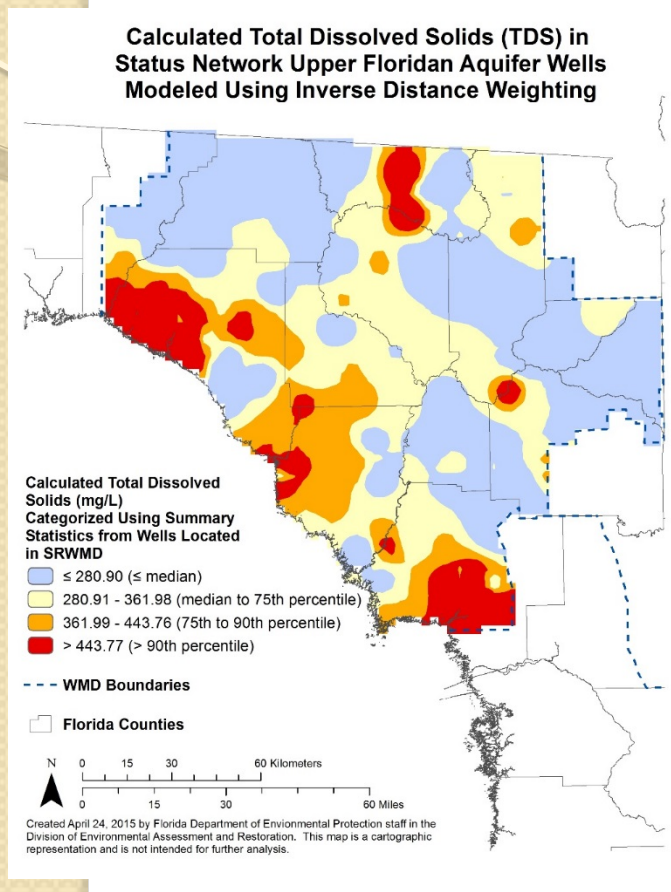
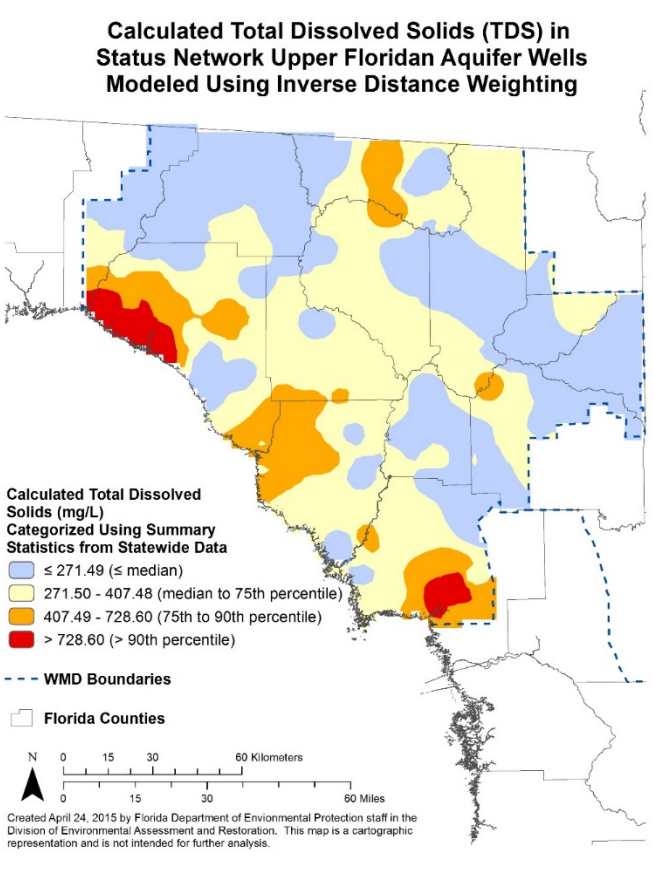
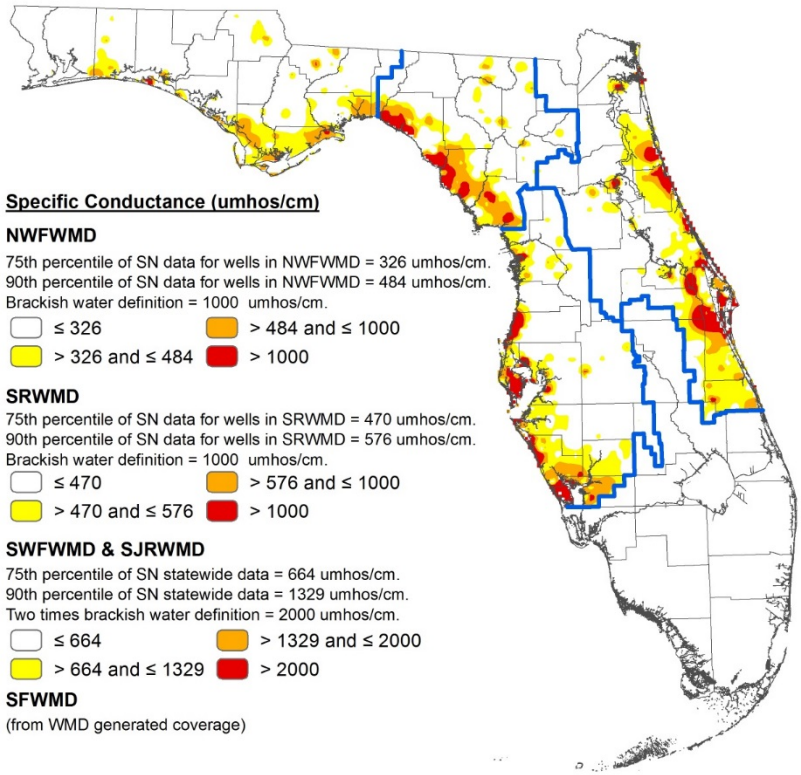
This map is a cartographic representation and is not intended for further analysis.


Calculated Total Dissolved Solids (TDS) in Status Network Upper Floridan Aquifer Wells Modeled Using Inverse Distance Weighting
Calculated Total Dissolved Solids (mg/L) Categorized Using Summary Statistics from Wells Located in SRWMD
≤ 280.90 (≤ median)
280.91 - 361.98 (median to 75th percentile)
361.99 - 443.76 (75th to 90th percentile)
> 443.77 (> 90th percentile)
WMD Boundaries
Florida Counties
N
0 15 30 60 Kilometers
0 15 30 60 Miles
Created April 24, 2015 by Florida Department of Enviornmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.


Calculated Total Dissolved Solids (TDS) in Status Network Upper Floridan Aquifer Wells Modeled Using Inverse Distance Weighting
Calculated Total Dissolved Solids (mg/L) Categorized Using Summary Statistics from Statewide Data
≤ 271.49 (≤ median)
271.50 - 407.48 (median to 75th percentile)
407.49 - 728.60 (75th to 90th percentile)
> 728.60 (> 90th percentile)
WMD Boundaries
Florida Counties
N
0 15 30 60 Kilometers
0 15 30 60 Miles
Created April 24, 2015 by Florida Department of Enviornmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.

Areas for CSMN wells

Specific Conductance in Status Network (SN) Wells (All Aquifers) Modeled Using Inverse Distance Weighting



Specific Conductance (umhos/cm)

NWFWMD

75th percentile of SN data for wells in NWFWMD = 326 umhos/cm.
90th percentile of SN data for wells in NWFWMD = 484 umhos/cm.
Brackish water definition = 1000 umhos/cm.

- ≤ 326
- > 326 and ≤ 484
- > 484 and ≤ 1000
- > 1000

SRWMD

75th percentile of SN data for wells in SRWMD = 470 umhos/cm.
90th percentile of SN data for wells in SRWMD = 576 umhos/cm.
Brackish water definition = 1000 umhos/cm.

- ≤ 470
- > 470 and ≤ 576
- > 576 and ≤ 1000
- > 1000

SWFWMD & SJRWMD

75th percentile of SN statewide data = 664 umhos/cm.
90th percentile of SN statewide data = 1329 umhos/cm.
Two times brackish water definition = 2000 umhos/cm.

- ≤ 664
- > 664 and ≤ 1329
- > 1329 and ≤ 2000
- > 2000

SFWMD

(from WMD generated coverage)

Water Management Districts

Florida Counties

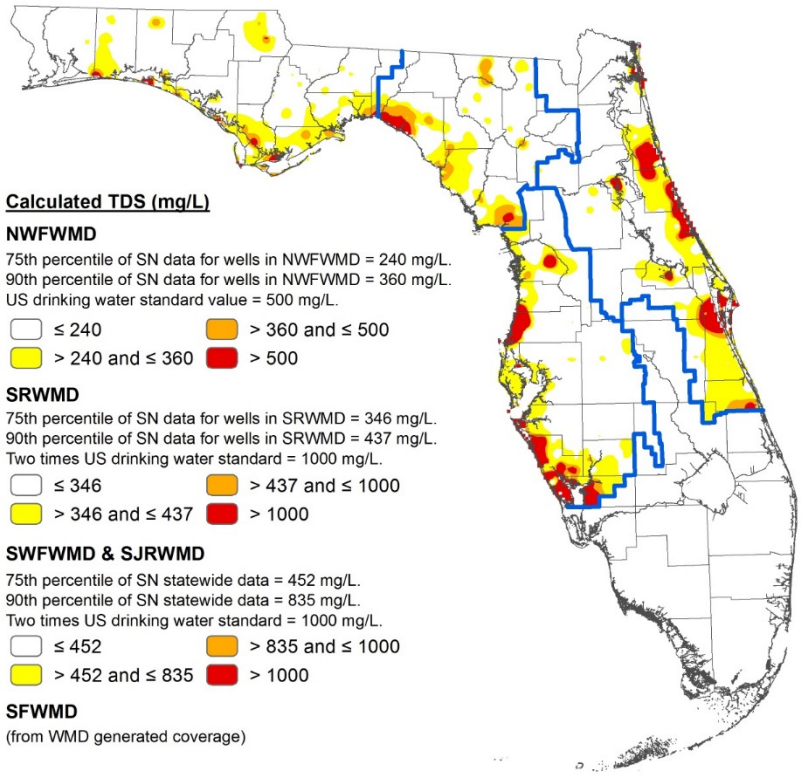
N

0 50 100 200 Kilometers

0 50 100 200 Miles

Created November 3, 2015 by Florida Department of Enviornmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.

Calculated Total Dissolved Solids (TDS) in Status Network (SN) Wells (All Aquifers) Modeled Using Inverse Distance Weighting



Calculated TDS (mg/L)

NWFWMD

75th percentile of SN data for wells in NWFWMD = 240 mg/L.
90th percentile of SN data for wells in NWFWMD = 360 mg/L.
US drinking water standard value = 500 mg/L.

- ≤ 240
- > 240 and ≤ 360
- > 360 and ≤ 500
- > 500

SRWMD

75th percentile of SN data for wells in SRWMD = 346 mg/L.
90th percentile of SN data for wells in SRWMD = 437 mg/L.
Two times US drinking water standard = 1000 mg/L.

- ≤ 346
- > 346 and ≤ 437
- > 437 and ≤ 1000
- > 1000

SWFWMD & SJRWMD

75th percentile of SN statewide data = 452 mg/L.
90th percentile of SN statewide data = 835 mg/L.
Two times US drinking water standard = 1000 mg/L.

- ≤ 452
- > 452 and ≤ 835
- > 835 and ≤ 1000
- > 1000

SFWMD

(from WMD generated coverage)

Water Management Districts

Florida Counties

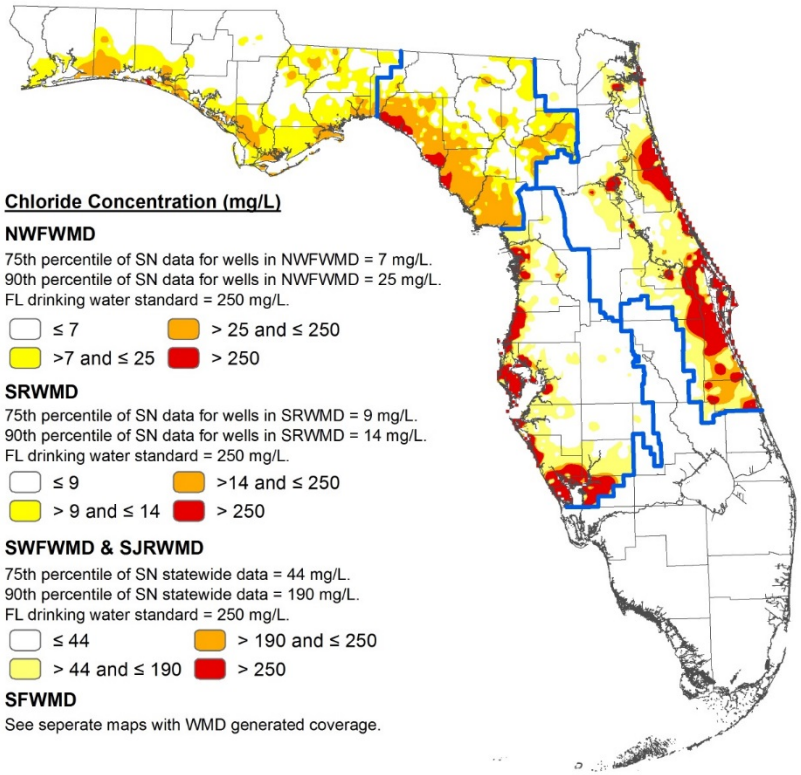
N

0 50 100 200 Kilometers

0 50 100 200 Miles

Created November 3, 2015 by Florida Department of Enviornmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.

Chloride in
Status Network (SN) Wells (All Aquifers)
Modeled Using Inverse Distance Weighting



Chloride Concentration (mg/L)

NWFWMD

75th percentile of SN data for wells in NWFWMD = 7 mg/L.
90th percentile of SN data for wells in NWFWMD = 25 mg/L.
FL drinking water standard = 250 mg/L.

- ≤ 7
- >7 and ≤ 25
- > 25 and ≤ 250
- > 250

SRWMD

75th percentile of SN data for wells in SRWMD = 9 mg/L.
90th percentile of SN data for wells in SRWMD = 14 mg/L.
FL drinking water standard = 250 mg/L.

- ≤ 9
- > 9 and ≤ 14
- >14 and ≤ 250
- > 250

SWFWMD & SJRWMD

75th percentile of SN statewide data = 44 mg/L.
90th percentile of SN statewide data = 190 mg/L.
FL drinking water standard = 250 mg/L.

- ≤ 44
- > 44 and ≤ 190
- > 190 and ≤ 250
- > 250

SFWMD

See seperate maps with WMD generated coverage.

Water Management Districts

Florida Counties

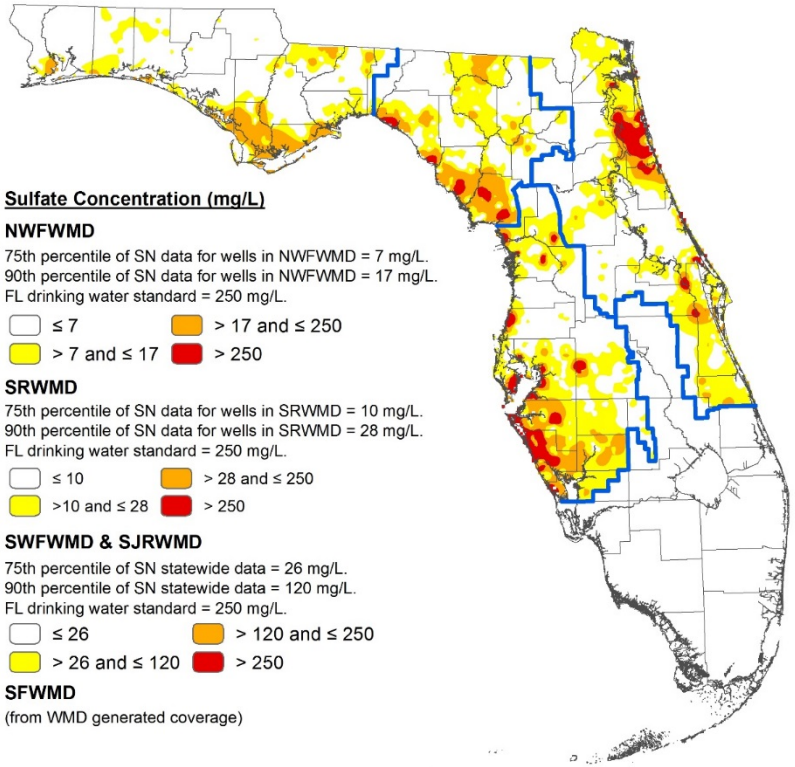
N

0 50 100 200 Kilometers

0 50 100 200 Miles

Created November 3, 2015 by Florida Department of Enviornmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.

Sulfate in Status Network (SN) Wells (All Aquifers) Modeled Using Inverse Distance Weighting



Sulfate Concentration (mg/L)

NWFWMD

75th percentile of SN data for wells in NWFWMD = 7 mg/L.
90th percentile of SN data for wells in NWFWMD = 17 mg/L.
FL drinking water standard = 250 mg/L.

- ≤ 7
- > 7 and ≤ 17
- > 17 and ≤ 250
- > 250

SRWMD

75th percentile of SN data for wells in SRWMD = 10 mg/L.
90th percentile of SN data for wells in SRWMD = 28 mg/L.
FL drinking water standard = 250 mg/L.

- ≤ 10
- >10 and ≤ 28
- > 28 and ≤ 250
- > 250

SWFWMD & SJRWMD

75th percentile of SN statewide data = 26 mg/L.
90th percentile of SN statewide data = 120 mg/L.
FL drinking water standard = 250 mg/L.

- ≤ 26
- > 26 and ≤ 120
- > 120 and ≤ 250
- > 250

SFWMD

(from WMD generated coverage)

Water Management Districts

Florida Counties

N

0 50 100 200 Kilometers

0 50 100 200 Miles

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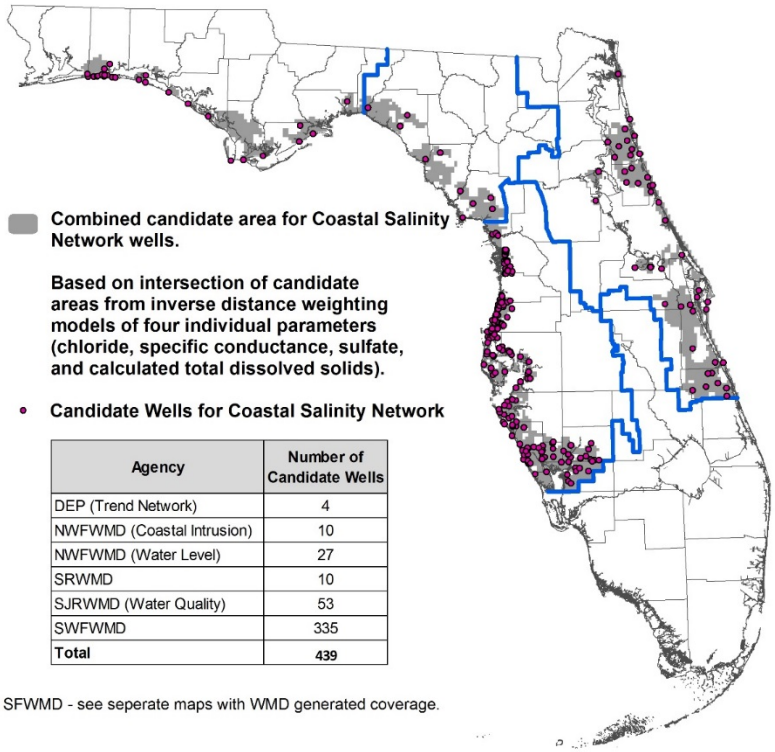
Identify Potential WMD Wells

- Used FDEP wells for water Quality
- Used WMD wells as candidate wells

Candidate Coastal Salinity Network Wells
Based on Combined Modeled Data
(Chloride, Specific Conductance, Sulfate, Calculated TDS)



Combined candidate area for Coastal Salinity Network wells.

Based on intersection of candidate areas from inverse distance weighting models of four individual parameters (chloride, specific conductance, sulfate, and calculated total dissolved solids).

Candidate Wells for Coastal Salinity Network

Agency	Number of Candidate Wells
DEP (Trend Network)	4
NWFWMD (Coastal Intrusion)	10
NWFWMD (Water Level)	27
SRWMD	10
SJRWMD (Water Quality)	53
SWFWMD	335
Total	**439**

SFWMD - see seperate maps with WMD generated coverage.

Water Management Districts

Florida Counties

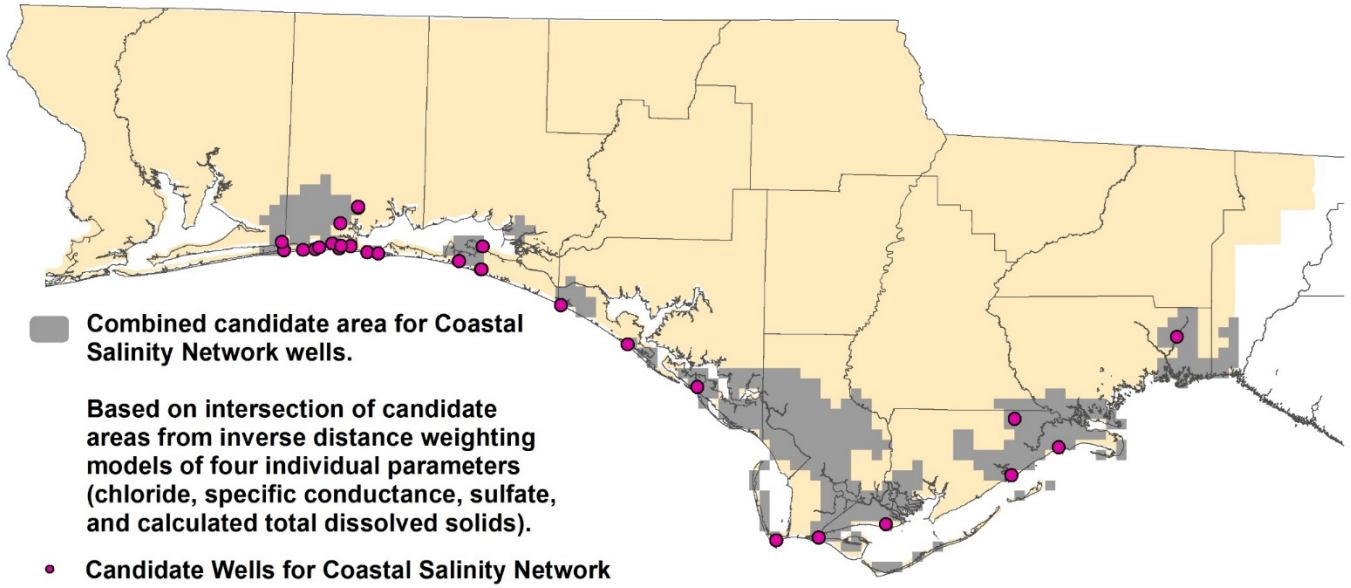
N

0 50 100 200 Kilometers

0 50 100 200 Miles

Created November 3, 2015 by Florida Department of Envionmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.

Candidate Coastal Salinity Network Wells in NWFWMD
Based on Combined Modeled Data
(Chloride, Specific Conductance, Sulfate, Calculated TDS)



Combined candidate area for Coastal Salinity Network wells.

Based on intersection of candidate areas from inverse distance weighting models of four individual parameters (chloride, specific conductance, sulfate, and calculated total dissolved solids).

- **Candidate Wells for Coastal Salinity Network**

Agency	Number of Candidate Wells
NWFWMD (Coastal Intrusion)	10
NWFWMD (Water Level)	27
Total	**37**

NWFWMD

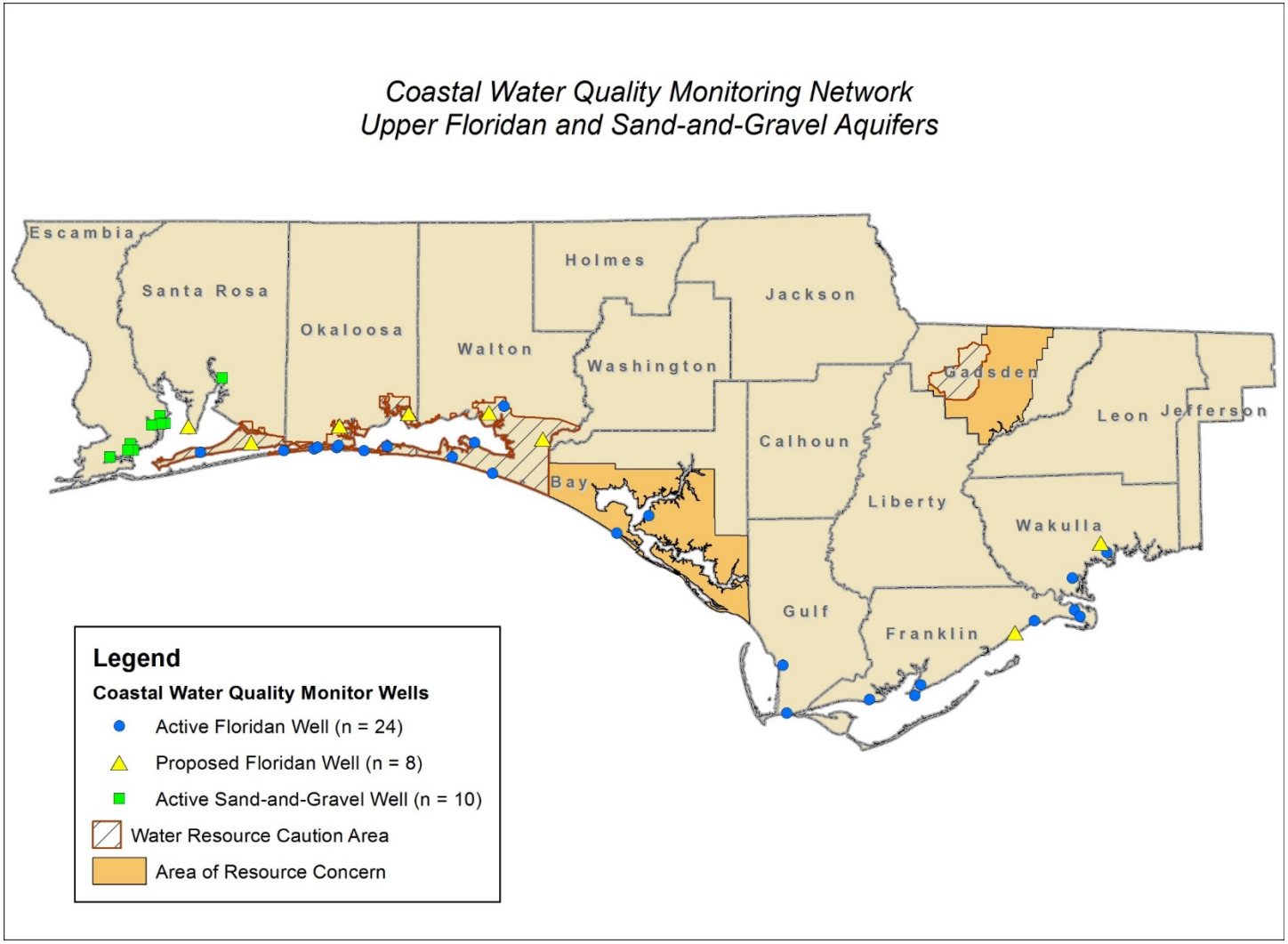
Florida Counties

N

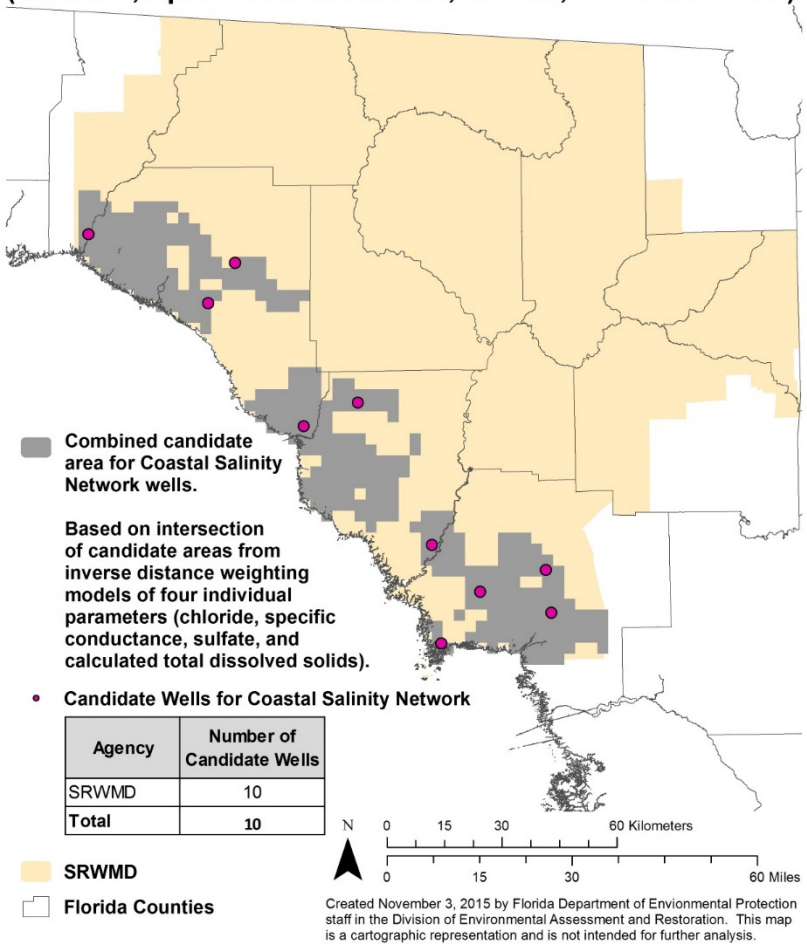
0 25 50 100 Kilometers

0 25 50 100 Miles

Created November 3, 2015 by Florida Department of Envionmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.

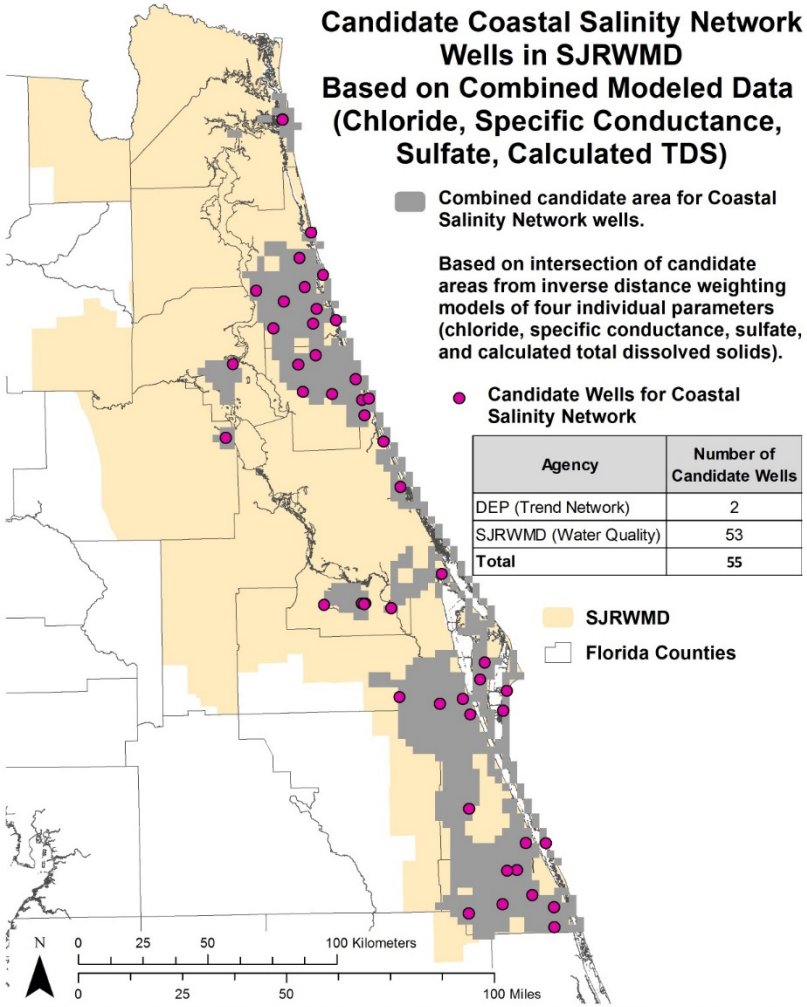

Coastal Water Quality Monitoring Network
Upper Floridan and Sand-and-Gravel Aquifers
Escambia
Santa Rosa
Okaloosa
Walton
Holmes
Washington
Jackson
Calhoun
Gadsden
Leon
Jefferson
Liberty
Wakulla
Bay
Gulf
Franklin
Legend
Coastal Water Quality Monitor Wells
Active Floridan Well (n = 24)
Proposed Floridan Well (n = 8)
Active Sand-and-Gravel Well (n = 10)
Water Resource Caution Area
Area of Resource Concern

Candidate Coastal Salinity Network Wells in SRWMD Based on Combined Modeled Data (Chloride, Specific Conductance, Sulfate, Calculated TDS)



Agency	Number of Candidate Wells
SRWMD	10
Total	**10**

Created November 3, 2015 by Florida Department of Environmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.



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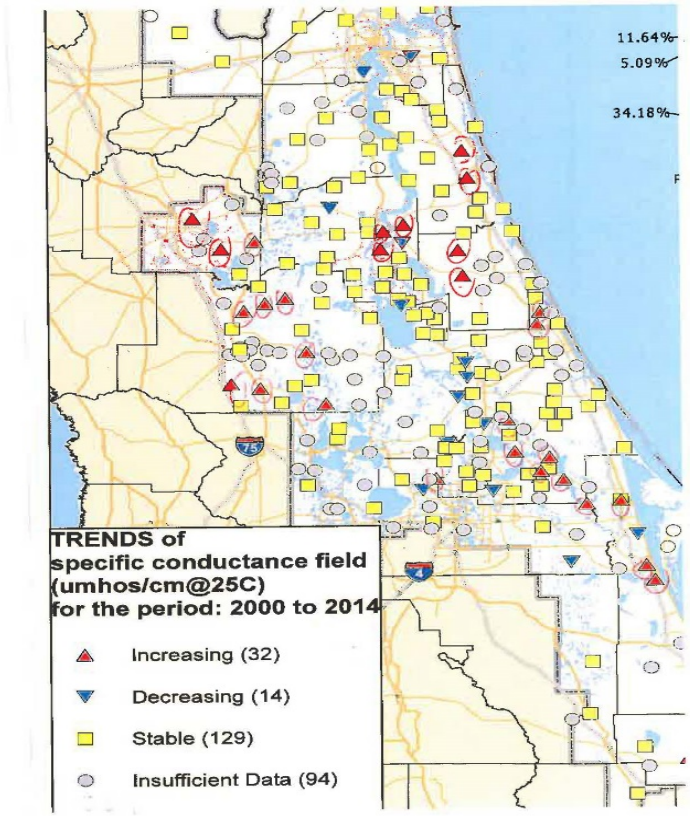
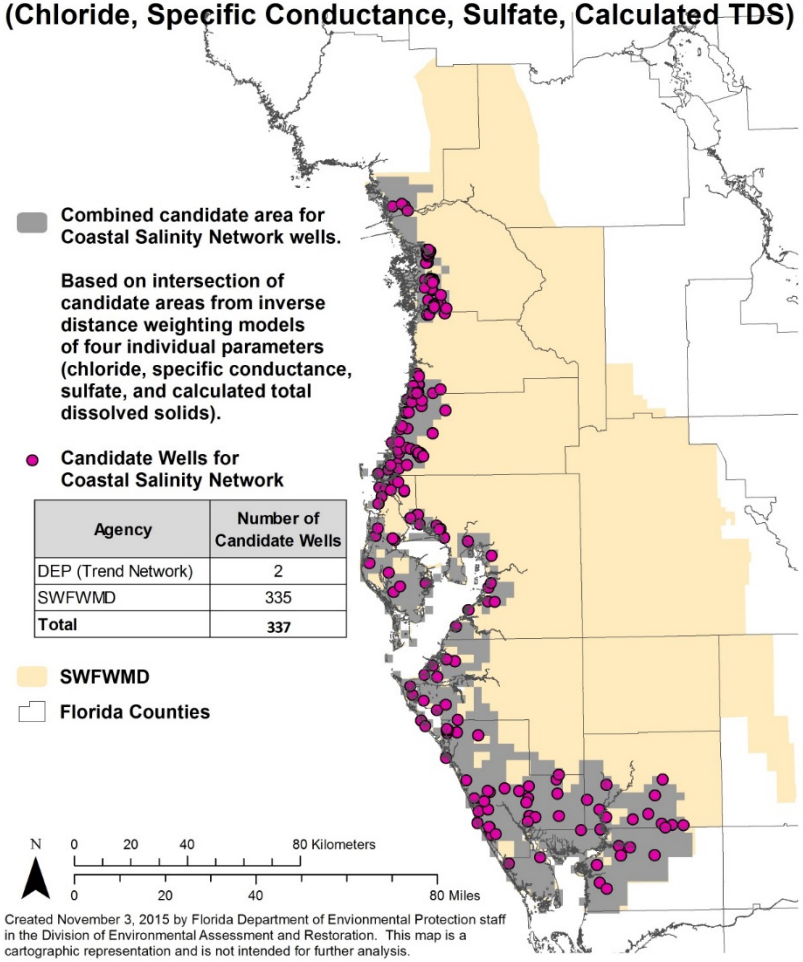

11.64%
5.09%
34.18%
TRENDS of
specific conductance field
(umhos/cm@25C)
for the period: 2000 to 2014
Increasing (32)
Decreasing (14)
Stable (129)
Insufficient Data (94)

Candidate Coastal Salinity Network Wells in SWFWMD Based on Combined Modeled Data (Chloride, Specific Conductance, Sulfate, Calculated TDS)



Agency	Number of Candidate Wells
DEP (Trend Network)	2
SWFWMD	335
Total	**337**

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Distribution of monitoring wells

- 215 wells in the CGWQMN
- 152 wells in the WUPNet

(Southern Water Use Caution Area)

Distribution by aquifer

249 wells, Upper Floridan aquifer

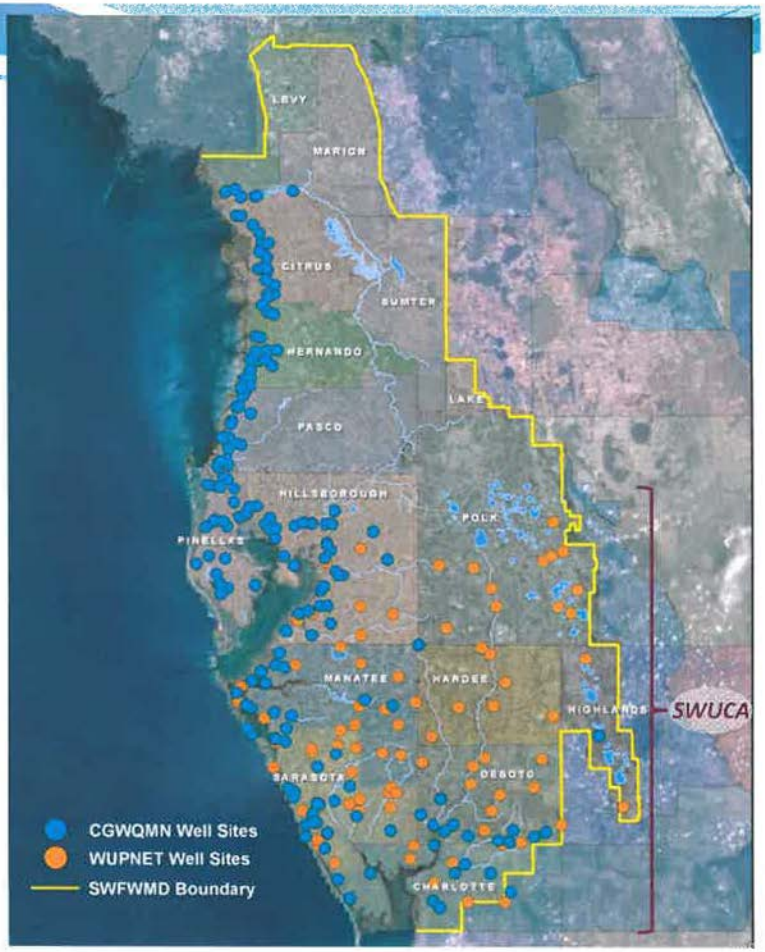
- 139 Tampa/Suwannee wells
- 110 Ocala/Avon Park wells

106 wells, intermediate aquifers

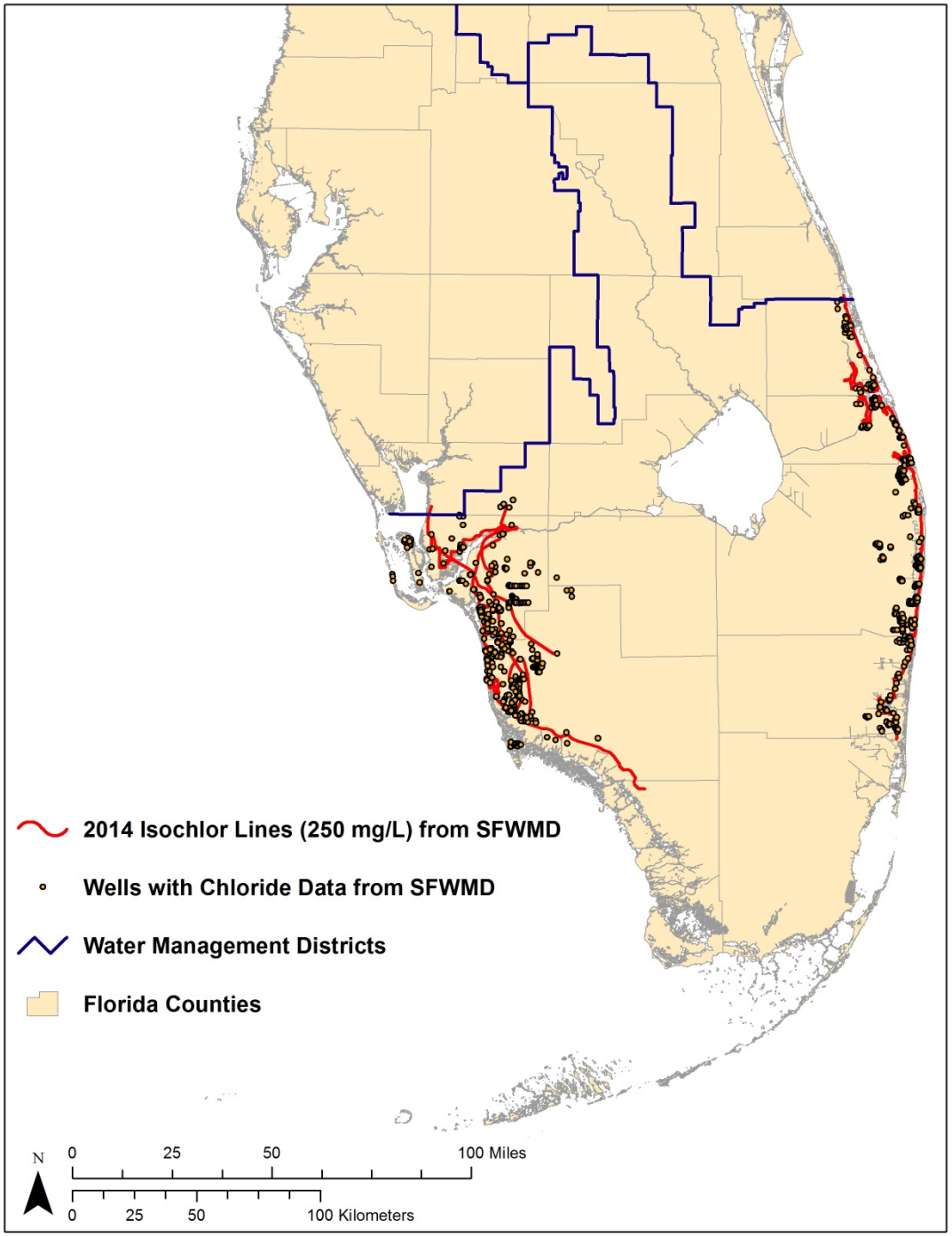
12 surficial aquifer wells *

2 Lower Floridan aquifer wells *

* not included in statistical analysis



SFWMD area


2014 Isochlor Lines (250 mg/L) from SFWMD
Wells with Chloride Data from SFWMD
Water Management Districts
Florida Counties
N
0
25
50
100 Miles
0
25
50
100 Kilometers

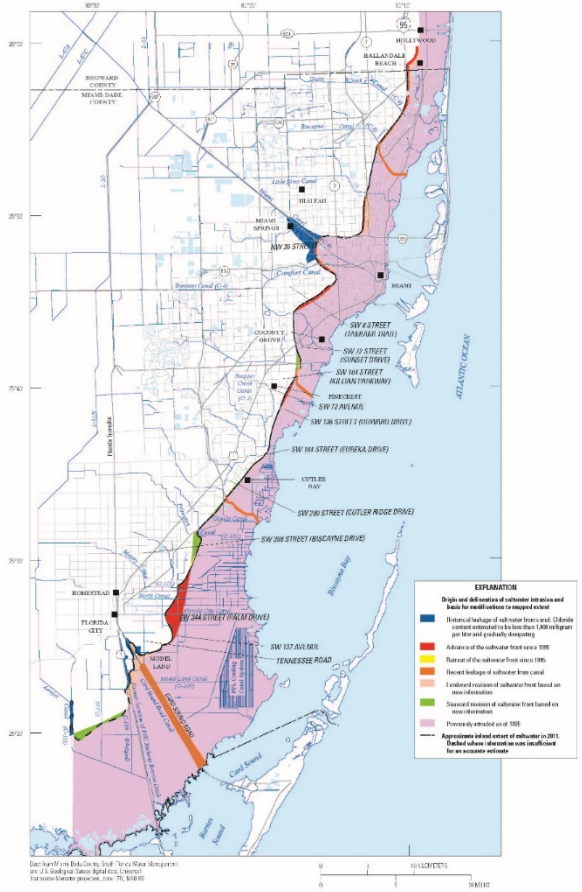


Figure 17. Map showing the origin and delineation of saltwater intrusion in the Biscayne aquifer and the basis for modifications to its mapped extent.

Next Steps

- Select specific wells for CSMN
- Analytes: probably TDS, SC, Cl, and SO4
  - Possibly use SC to estimate other analyte concentrations
- Specific questions:
  - Are concentrations changing over time?
    - If found, what is the scale of the issue?
  - Is the saltwater/fresh water interface moving?
- Commence operations

Questions?

- Rick Copeland
- (850) 245-8503

- rick.copeland@dep.state.fl.us