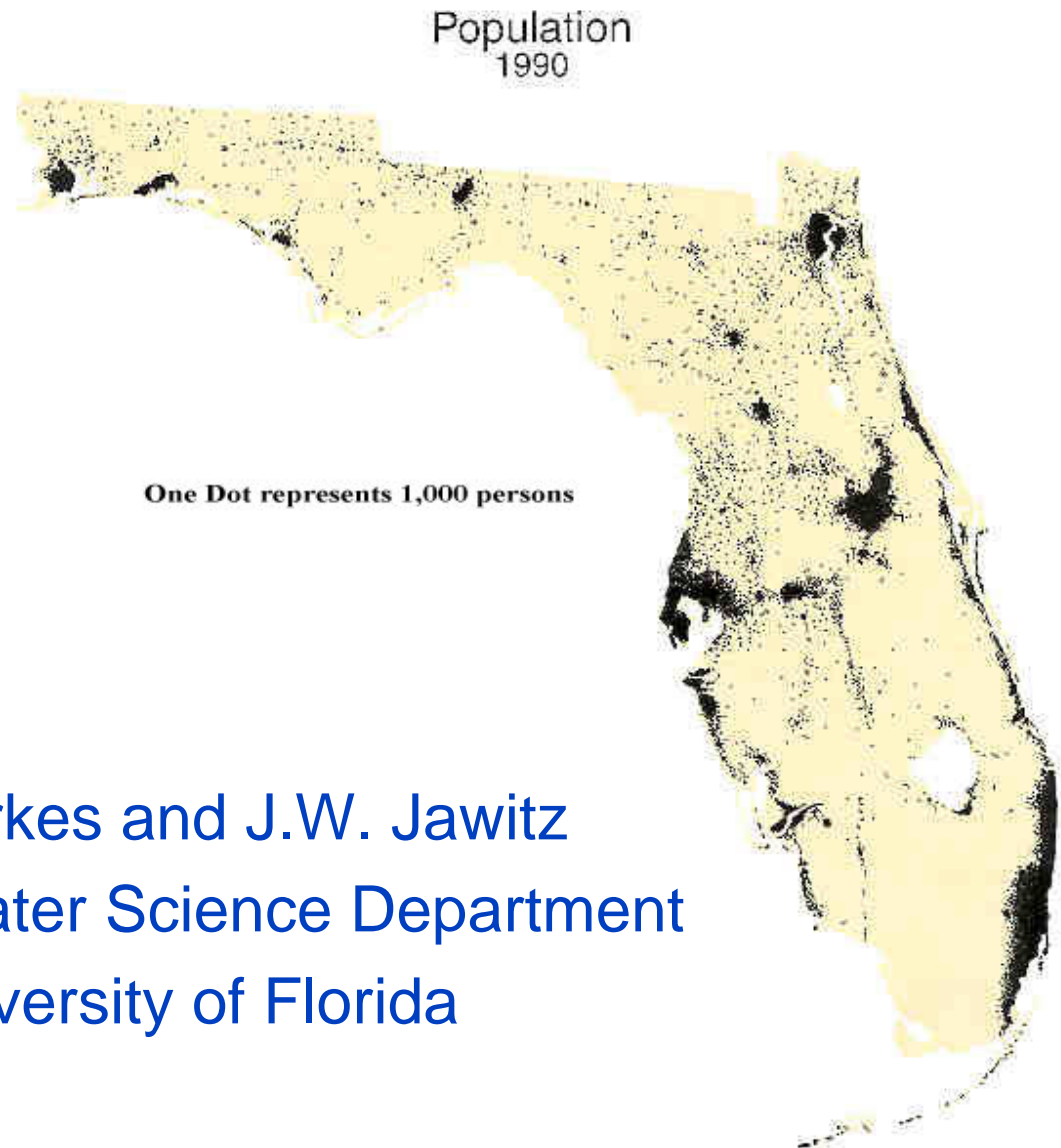


The hydraulic cycle in Florida's metropolitan areas



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Questions and objectives: Water resource sustainability in metropolitan Florida

- From the abstract
 - O1: Examine the hydraulic cycle in the most significant metropolitan statistical areas in Florida
 - O2: Evaluate water resource sustainability for these areas
- Q1: What is the sustainable resource consumption rate?
 - leave “enough” for “future generations”?
 - at or below renewable supply?
 - consistent with the supply available from rainfall—rather than depleting groundwater tables, or importing water?
 - consumption at or below renewable supplies while also leaving enough water for natural ecosystems to function?
 - consumption at or below renewable supplies while also leaving enough water for natural ecosystems to function with the goal of also promoting economic prosperity and social equity?
- Demographic projections and likely water-related impacts on natural resources. Results and implications are discussed in context with other metropolitan areas that rely on both groundwater and surface water resources.



Water for... revealing the mystery of language and awakening the soul

We walked down the path to the well-house, attracted by the fragrance of the honeysuckle with which it was covered. Some one was drawing water and my teacher placed my hand under the spout.

As the cool stream gushed over one hand she spelled into the other the word water, first slowly, then rapidly. I stood still, my whole attention fixed upon the motions of her fingers.

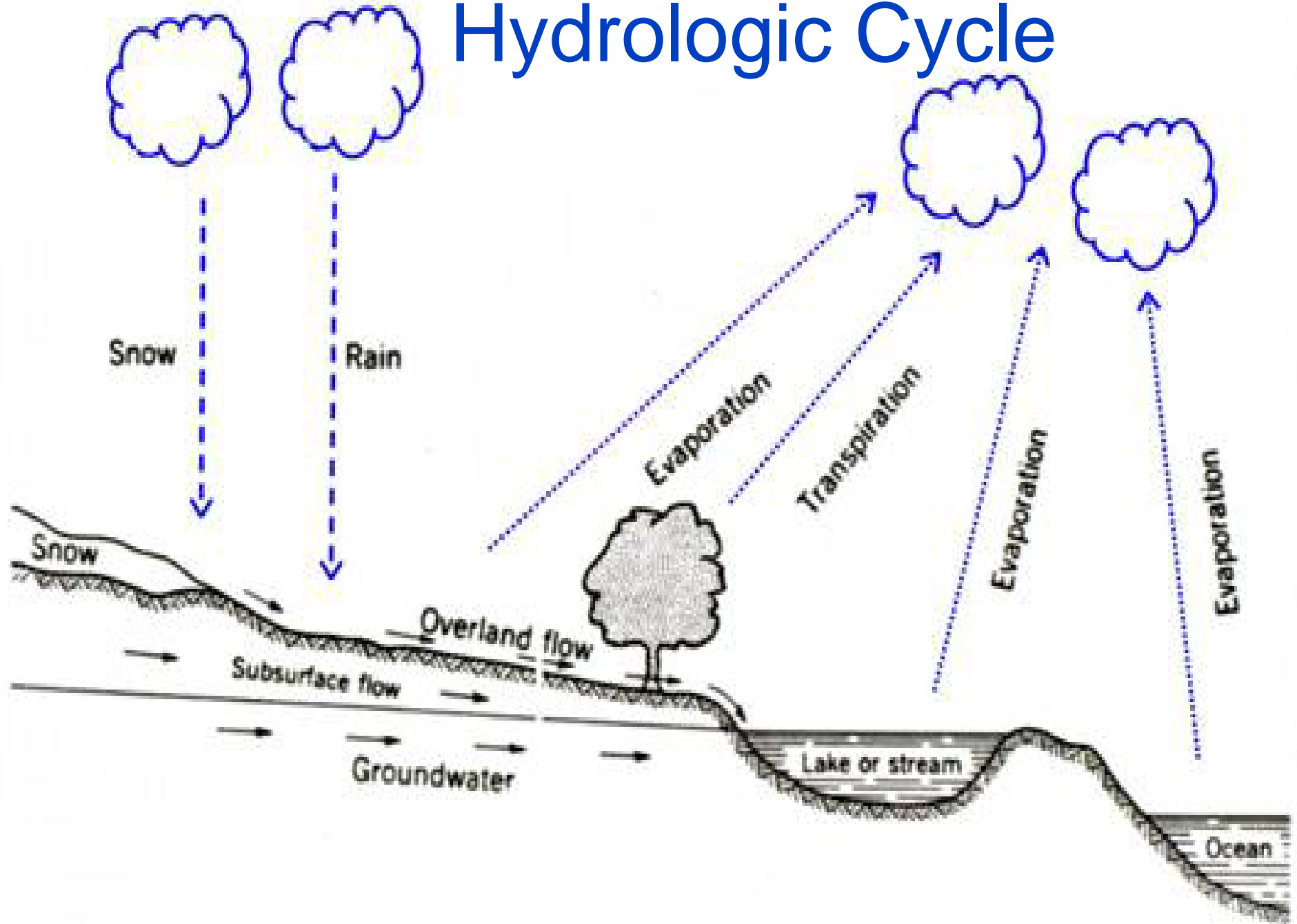
Suddenly I felt a misty consciousness as of something forgotten — a thrill of returning thought; and somehow the mystery of language was revealed to me.

I knew then that "w-a-t-e-r" meant the wonderful cool something that was flowing over my hand. That living word awakened my soul, gave it light, hope, joy, set it free!

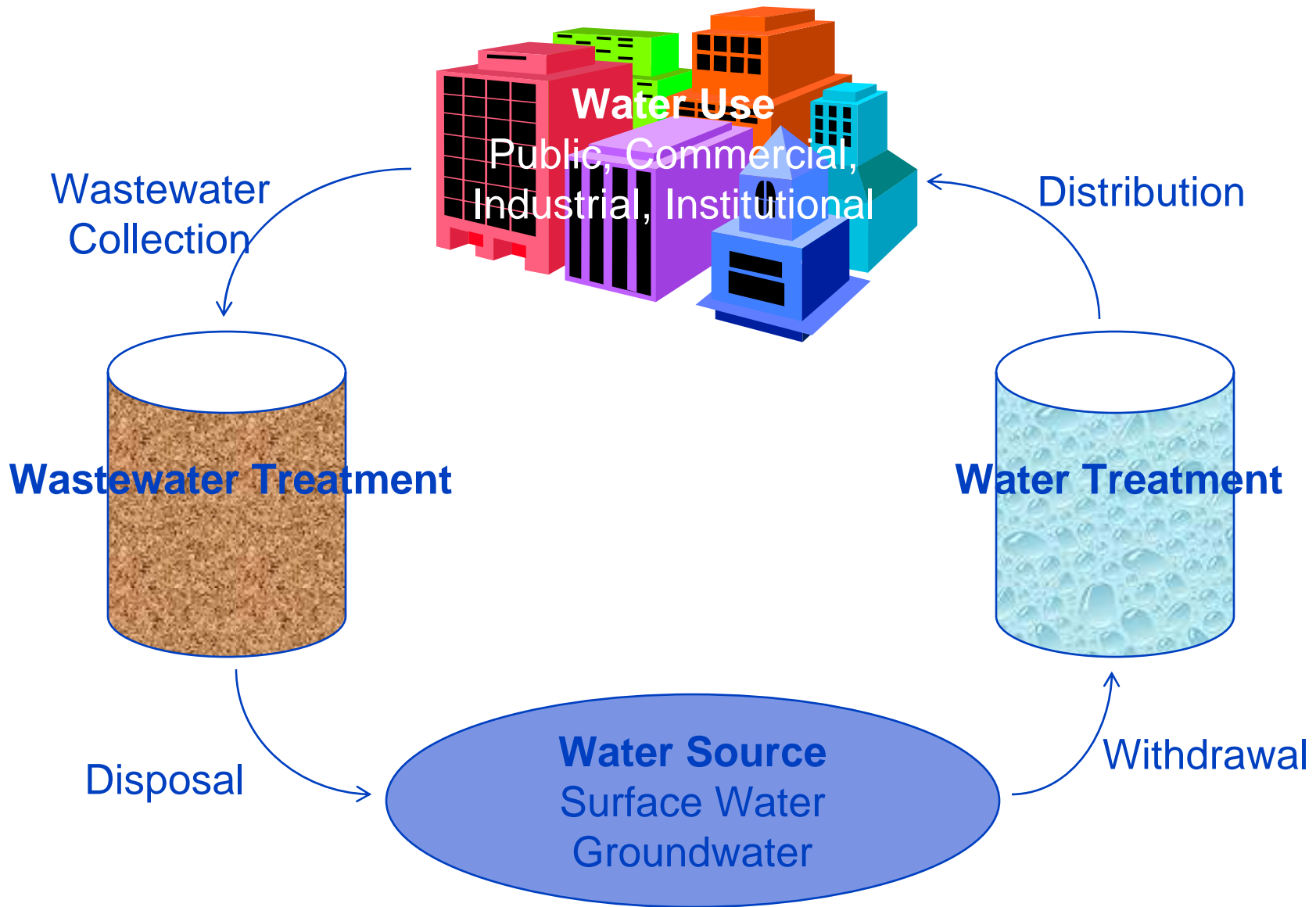
— Helen Keller, *The Story of My Life* (1903)

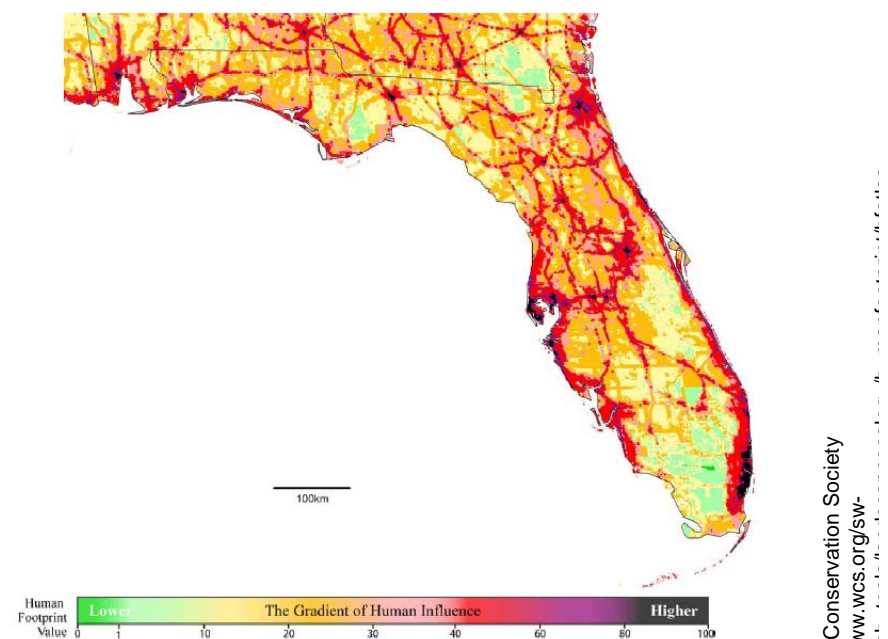
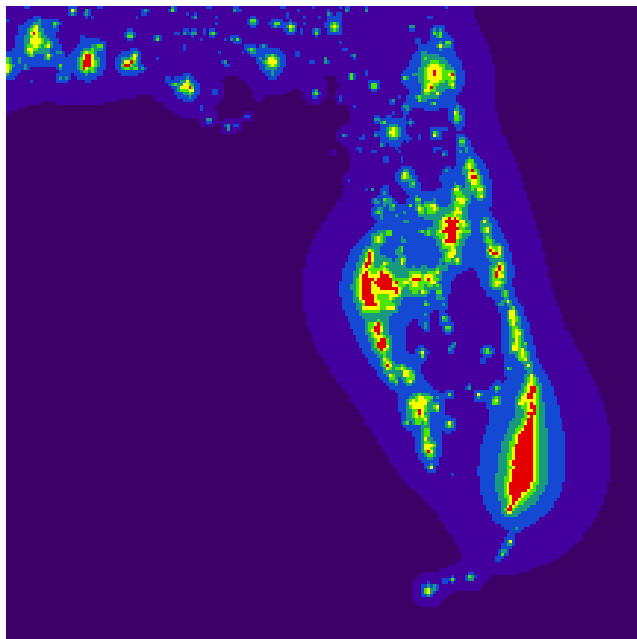
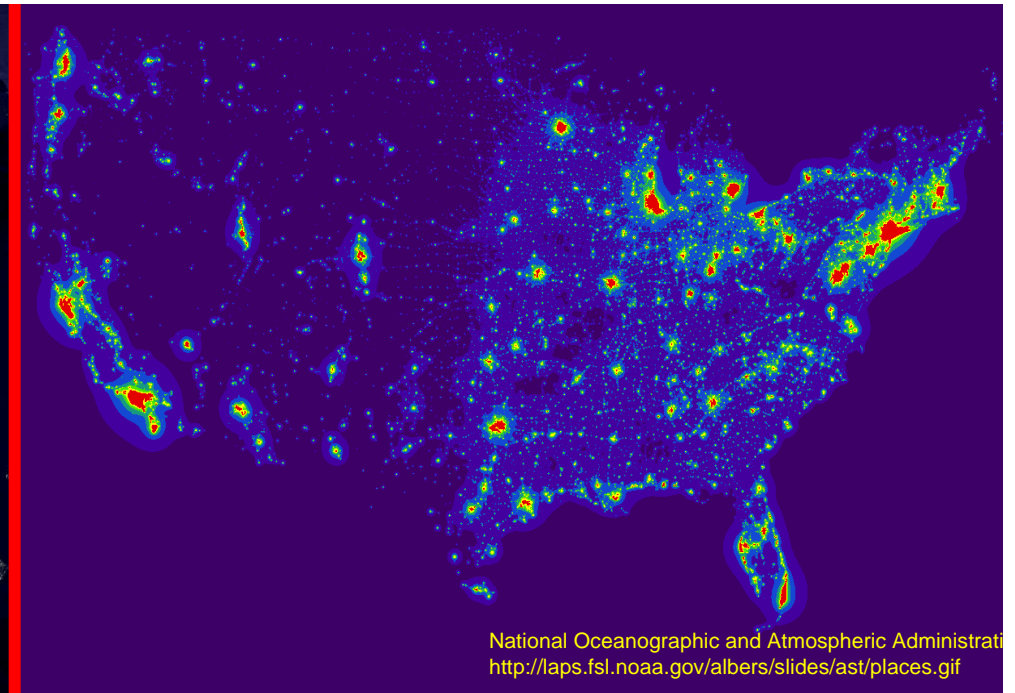
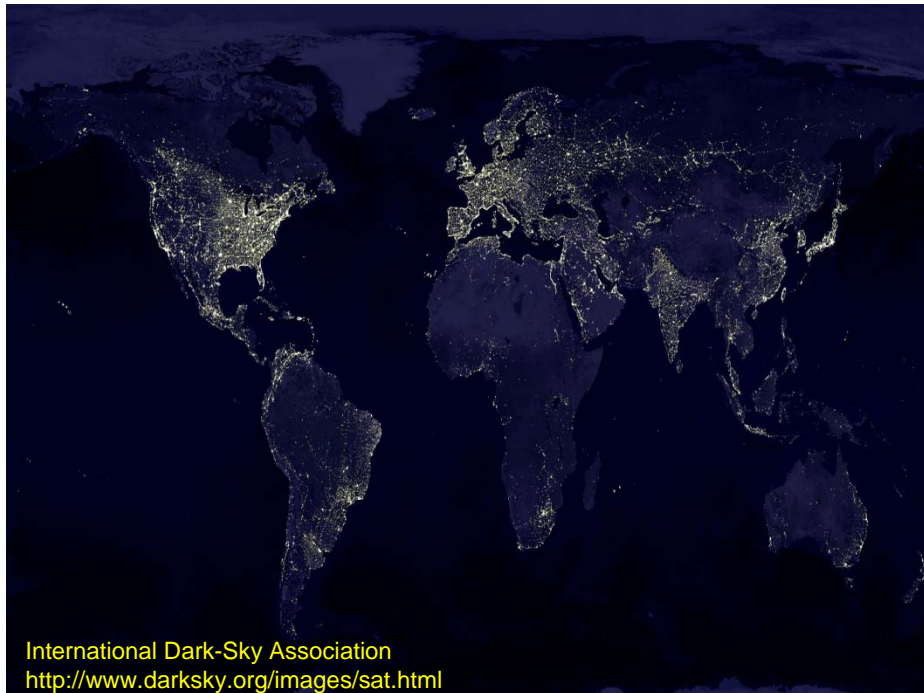


Hydrologic Cycle



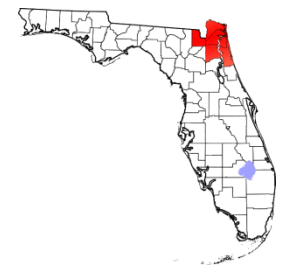
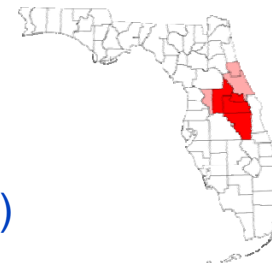
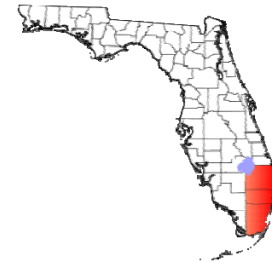
The hydraulic cycle: Corollary to the hydrologic cycle





Five (out of 20) largest US Census Metropolitan Statistical Areas in Florida (2006 population)

1. Miami-Fort Lauderdale-Pompano Beach MSA
5,463,857
 - Miami-Dade (2.4 M), Broward (1.8), Palm Beach (1.3)
 - “South Florida”, 7th largest MSA in US
2. Tampa-St. Petersburg-Clearwater MSA 2,697,731
 - Hillsborough (1.2), Pinellas County (0.9), Pasco (0.5), Hernando (0.2)
 - “Tampa Bay Area”, 19th largest MSA in US
3. Orlando-Kissimmee MSA 1,984,855
 - Orange (1.0), Seminole (0.4), Lake (0.3), Osceola (0.2)
4. Jacksonville, FL MSA 1,277,997
 - Duval (0.8), Clay (0.2), St. Johns (0.2), Nassau (0.07), Baker (0.03)
5. Sarasota-Bradenton-Venice, FL MSA 682,833
 - Sarasota (0.4), Manatee (0.3)



http://en.wikipedia.org/wiki/Florida_census_statistical_areas



Florida population today and tomorrow

- 2006 US Census population estimates
 - Florida 18.3 M
 - Top 5 MSAs 12.0
- 2030 Florida Legislature estimates
 - Florida 26.5 (44% growth)
 - South Florida 7.3 (33%)
 - Tampa Bay 3.7 (37%)
 - Orlando MSA 3.3 (64% !!)
 - Jacksonville MSA 2.0 (49% !)
 - Sarasota MSA 1.0 (46%)
 - Top 5 MSAs 17.3 M

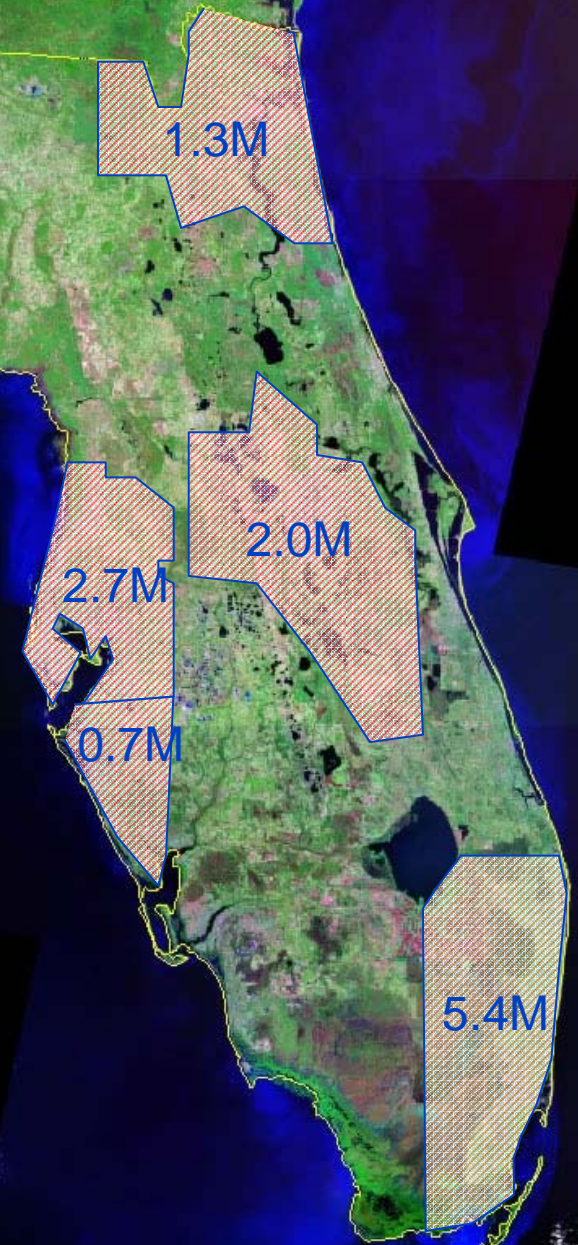


Image - <http://geology.com/state-map/florida.shtml>

Demographic data – Florida Legislature Office of Demographic and Economic Research <http://edr.state.fl.us/population.htm>

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Florida ranks second (CA) in use of groundwater for public supply (2.2 BGD)

> 90% of public supply from groundwater

Table 1. Total water withdrawals in Florida by category, 2000

[Compiled by the U.S. Geological Survey, Tallahassee; all values in million gallons per day]

Florida 2000	Freshwater			Saline Water		
	Ground	Surface	Total	Ground	Surface	Total
Public Supply	2,199.36	237.43	2,436.79	0.00	0.00	0.00
Domestic self-supplied	198.68	0.00	198.68	0.00	0.00	0.00
Commercial-industrial self-supplied	430.70	132.60	563.30	0.00	1.18	1.18
Agricultural self-supplied	1,989.95	1,933.06	3,923.01	0.00	0.00	0.00
Recreational irrigation	230.45	181.28	411.73	0.00	0.00	0.00
Power generation	29.53	628.73	658.26	3.82	11,950.82	11,954.64
TOTALS	5,078.67	3,113.10	8,191.77	3.82	11,952.00	11,955.82

Marella 2004



Percent of public supply from groundwater

• Miami-Dade (2.4 M)	100
• Broward (1.8)	100
• Palm Beach (1.3)	85
• Hillsborough (1.2)	51
• Pinellas (0.9)	100
• Orange (1.0)	100
• Duval (0.8)	100

Marella, R.L., 2004, Water withdrawals, use, discharge, and trends in Florida, 2000: U.S. Geological Survey Scientific Investigations Report 2004-5151, 136 p.



Almost all public supply is from groundwater, and this is the largest demand on groundwater

- Of the total groundwater withdrawals in FL
 - 43% public supply
 - 38% irrigation
 - remainder domestic self-supply, industry, mining
 - globally and nationally, irrigated agriculture accounts for 60 to 70% of total water withdrawals

1995 USGS data
<http://water.usgs.gov/watuse>



Return of potable water to reservoirs?

	Water (MGD)	WW	(% return)	(% to surface)
Miami-Dade (2.4 M)	377	311	(83)	(67)
Broward (1.8)	258	190	(74)	(41)
Palm Beach (1.3)	229	108	(47)	(23)
Hillsborough (1.2)	155	93	(60)	(69)
Pinellas (0.9)	116	106	(91)	(23)
Orange (1.0)	186	73	(39)	
**Orange (1.0)	186	157	(84)	(22)
Duval (0.8)	100	84	(84)	(99)

But not all surface discharges are created equal... some may return to reservoir (Alachua County = 41% to surface but no exports from basin)

Marella, R.L., 2004, Water withdrawals, use, discharge, and trends in Florida, 2000: U.S. Geological Survey Scientific Investigations Report 2004-5151, 136 p.

** wastewater discharges estimated by Adamski, 2004



Which aquifers are used where?

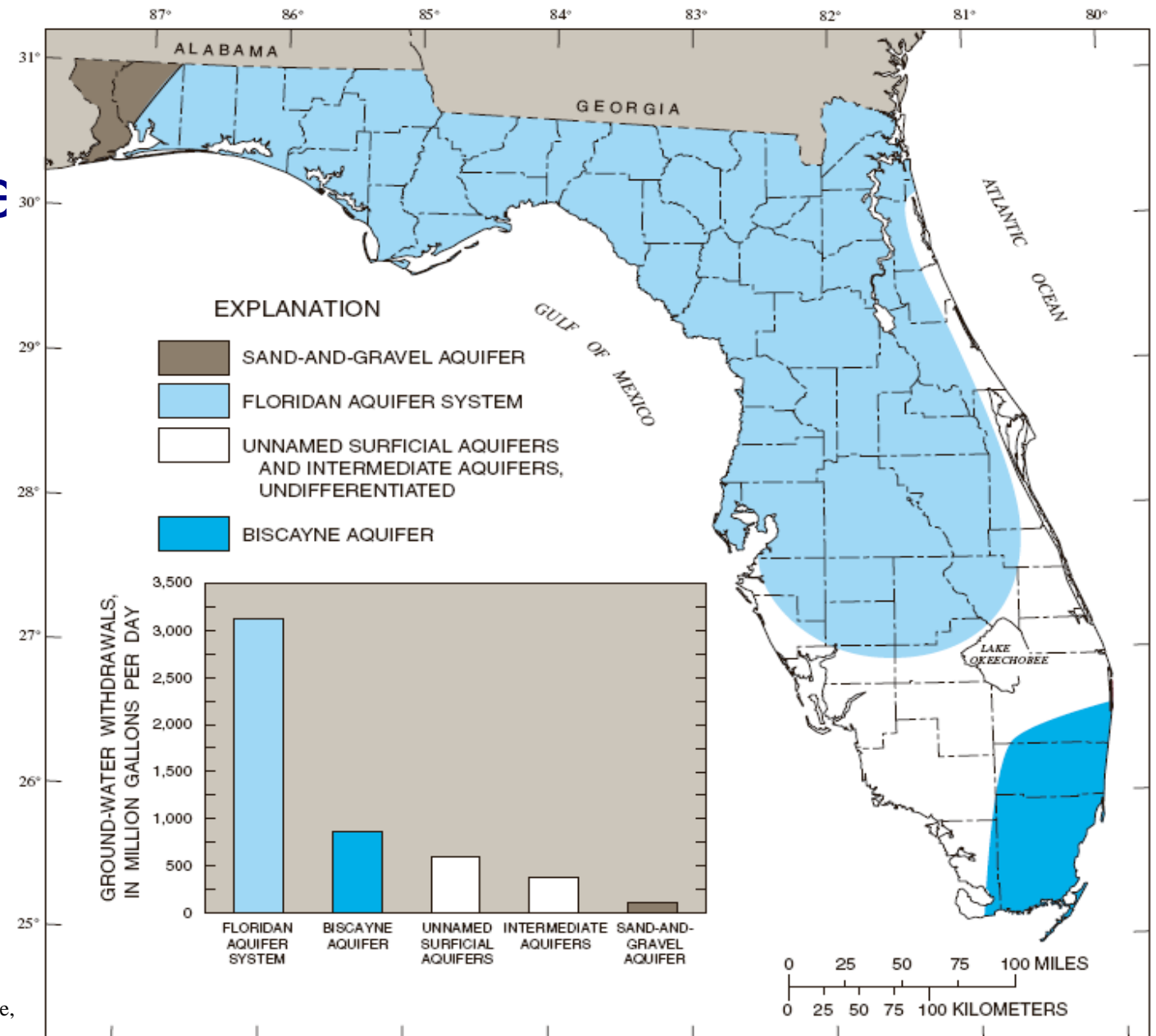


Figure 6. Approximate areal extent throughout which principal aquifers in Florida are the primary source of ground water and quantity of ground-water withdrawals, 2000. (Map modified from Vecchioli and Foote, 1985.)

Marella, R.L., 2004, Water withdrawals, use, discharge, and trends in Florida, 2000: U.S. Geological Survey Scientific Investigations Report 2004-5151, 136 p.



How is the demand distributed (space, time, sector)?

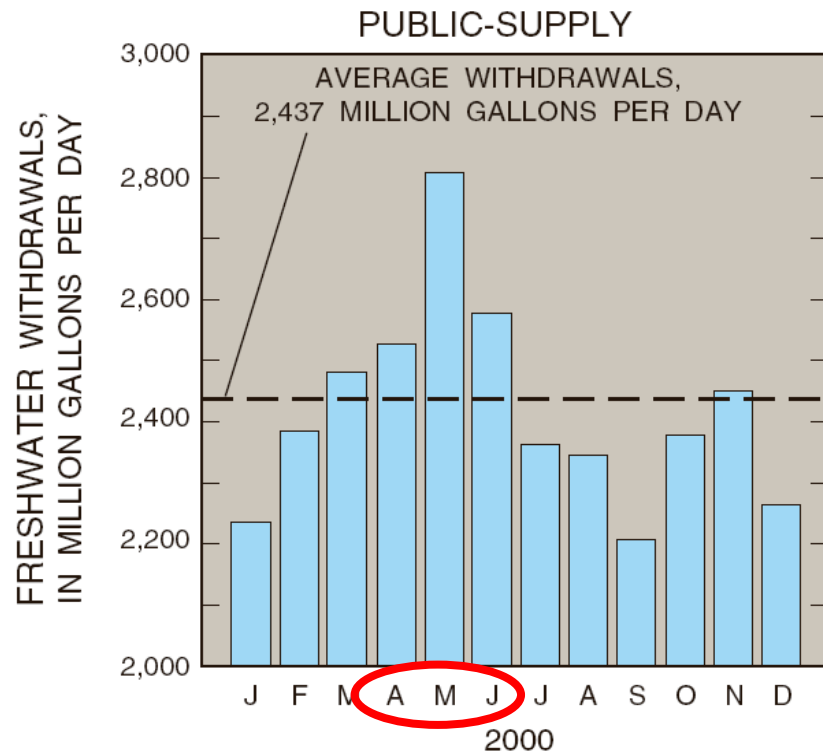
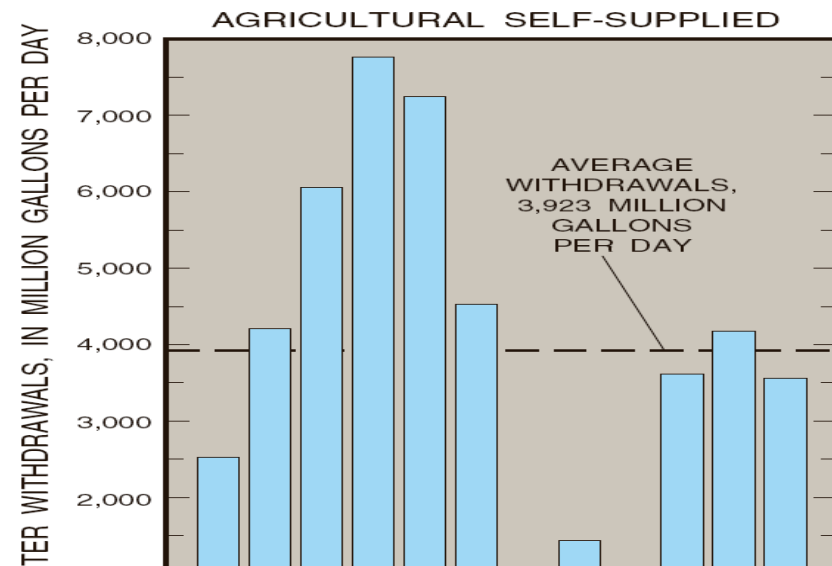
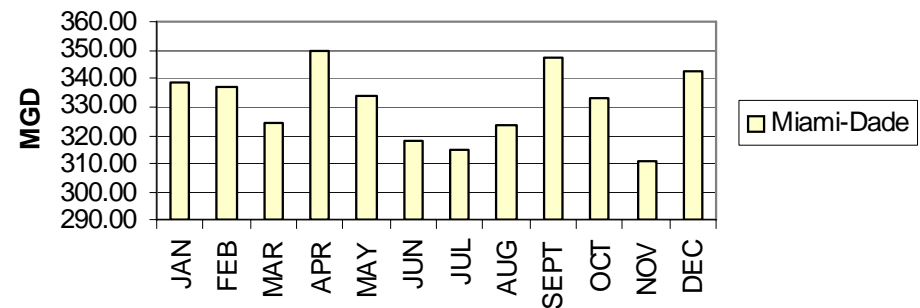


Figure 9. Average daily public-supply freshwater withdrawals by month in Florida, 2000.



2006 Average Daily Water Treatment
Main System Plants (A. Orr, Hialeah, J. Preston)
Miami-Dade Water and Sewer Authority



Marella, R.L., 2004, Water withdrawals, use, discharge, and trends in Florida, 2000: U.S. Geological Survey Scientific Investigations Report 2004-5151, 136 p.



Water demand ... treated groundwater largely used for outdoor home use

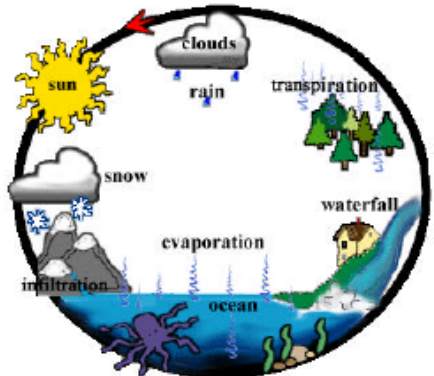
- Irrigation accounted for 64% of residential water use in a 2003-2005 Central Florida study
 - Haley et al., 2007 (J. Irrig.&Drain. Eng.)
- Most public supply comes from Floridan and Biscayne aquifers, and mostly used for residential irrigation (lawns). Combined with agricultural groundwater use, irrigation accounts for about 65% of groundwater withdrawals.
- Indoor water use (low-flow toilets, turning off faucets while brushing teeth, etc) are less significant factors

<http://water.usgs.gov/watuse>



Water conservation outreach

THE EARTH'S WATER



Salt water: 97.2%
Frozen: 2.1%
Ground water: 0.6%
Lakes, rivers, soil, atmosphere: 0.1%

Water is all around us but only .003% is available for human use.

Don't be a Drip

The average Virginian uses 60-80 gallons of water per day.

Water Users	
Flushing toilet:	5 gallons
Brushing teeth - water running:	2 gallons
8 minute shower:	40 gallons
Dishwasher:	15 gallons
Dish washing by hand - water running:	30 gallons
Load of laundry:	40 gallons

(Amounts vary by home)

A leaky faucet can waste 200 gallons a month!

From farm to table, a hamburger, french fries and soda requires 1,500 gallons of water.

Places to save water:


Kitchen	Bathroom	Lawn & Garden	Energy	Laundry
Run a full dishwasher	Take shorter showers or shallow baths	Let grass grow to 3 inches	Conserving water saves energy	Run only full loads or use correct setting
Turn off faucet when rinsing	Flush only when necessary	Water sparingly - once every 5-7 days max	Conserving energy saves water	Wash towels and clothes only when necessary
Repair leaky faucets	Place filled plastic jug in tank	Mulch and use native & drought tolerant plants.	Strive to drive less - it takes 6g of water to produce 1g of gas	Consider a water saving machine
Install faucet aerators				

Save a Drop!


Conserving water protects our natural community and saves money and energy.

Water Savers	
Flushing low-flow toilet:	1.5 gallons
Brushing teeth - water off:	.25 gallons
4 minute shower:	20 gallons
Dishwashing by hand - sink with stopper	10 gallons


Every living thing needs water.



70% water



75% water



50% water



Additional Resources:

DEQ: www.deq.state.va.us/water/waterconservation.html

The James City Service Authority: www.bewatersmart.org

Water Wiser: www.waterwiser.org

Hampton Roads Water Efficiency Team: www.hrwet.org

- GRU: "Time your shower to keep it under five minutes. You can save up to one thousand gallons a month."
 - \$1.47
- Effectiveness varies by strategy, and perhaps demographically
 - A child's connection to "no lawn watering"?

Revisiting the metro areas...

- Orlando
 - Water supply source: Lower Floridan aquifer (1300 to 1500 feet bgs)
 - Waste water receptor:
 - stormwater and reclaimed water injection into Upper Floridan
 - Treatment wetland discharge to St Johns River
 - Aggressive and advanced aquifer recharge program
- South Florida
 - Water supply source Biscayne aquifer (avg. 80 feet bgs)
 - Lower Floridan aquifer is (more) saline



Orlando, FL



Water Park, Orlando



Rapid Infiltration Basins, Conserv II



In Orlando,
groundwater
use is not
declining, or
even leveling
off

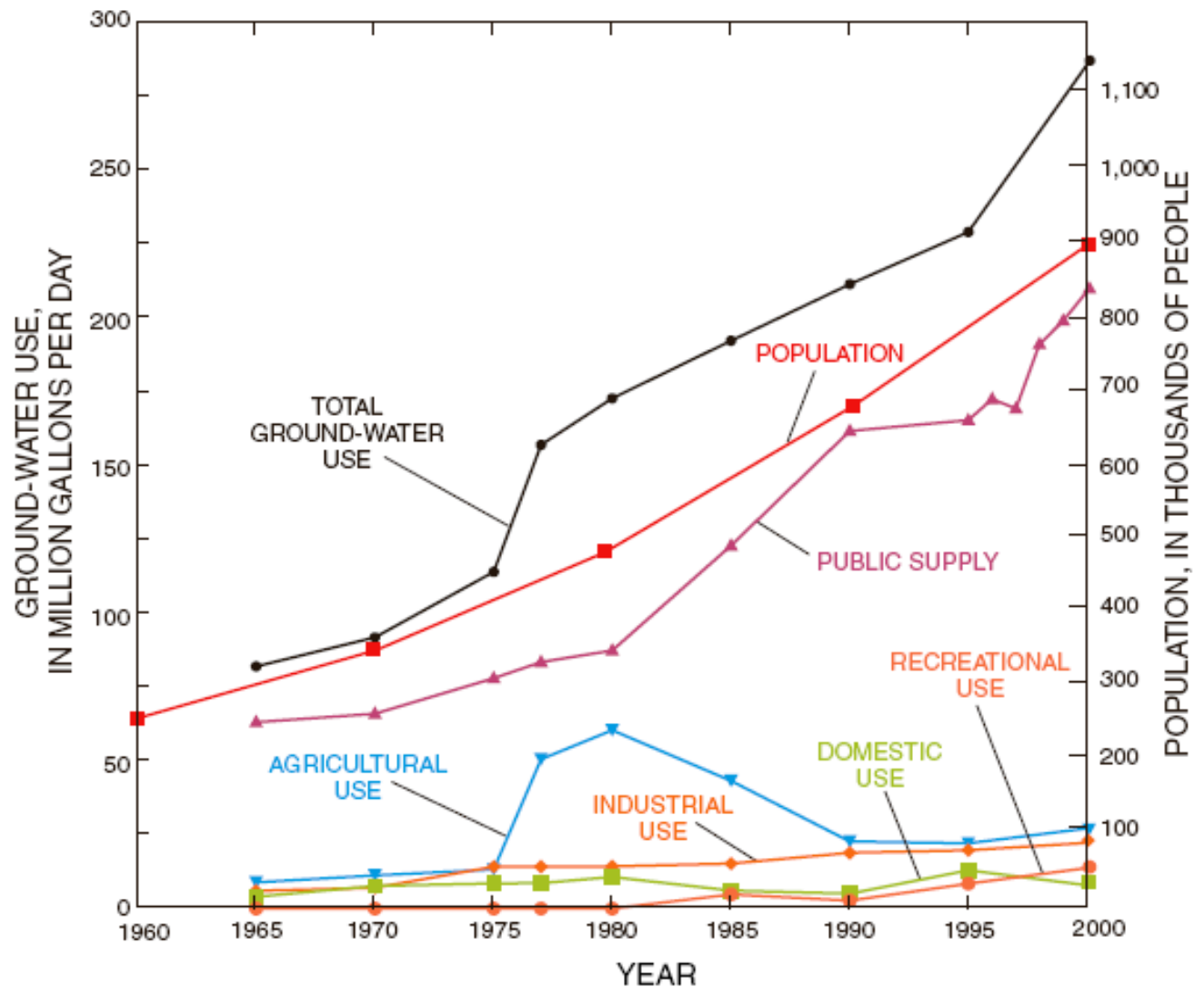
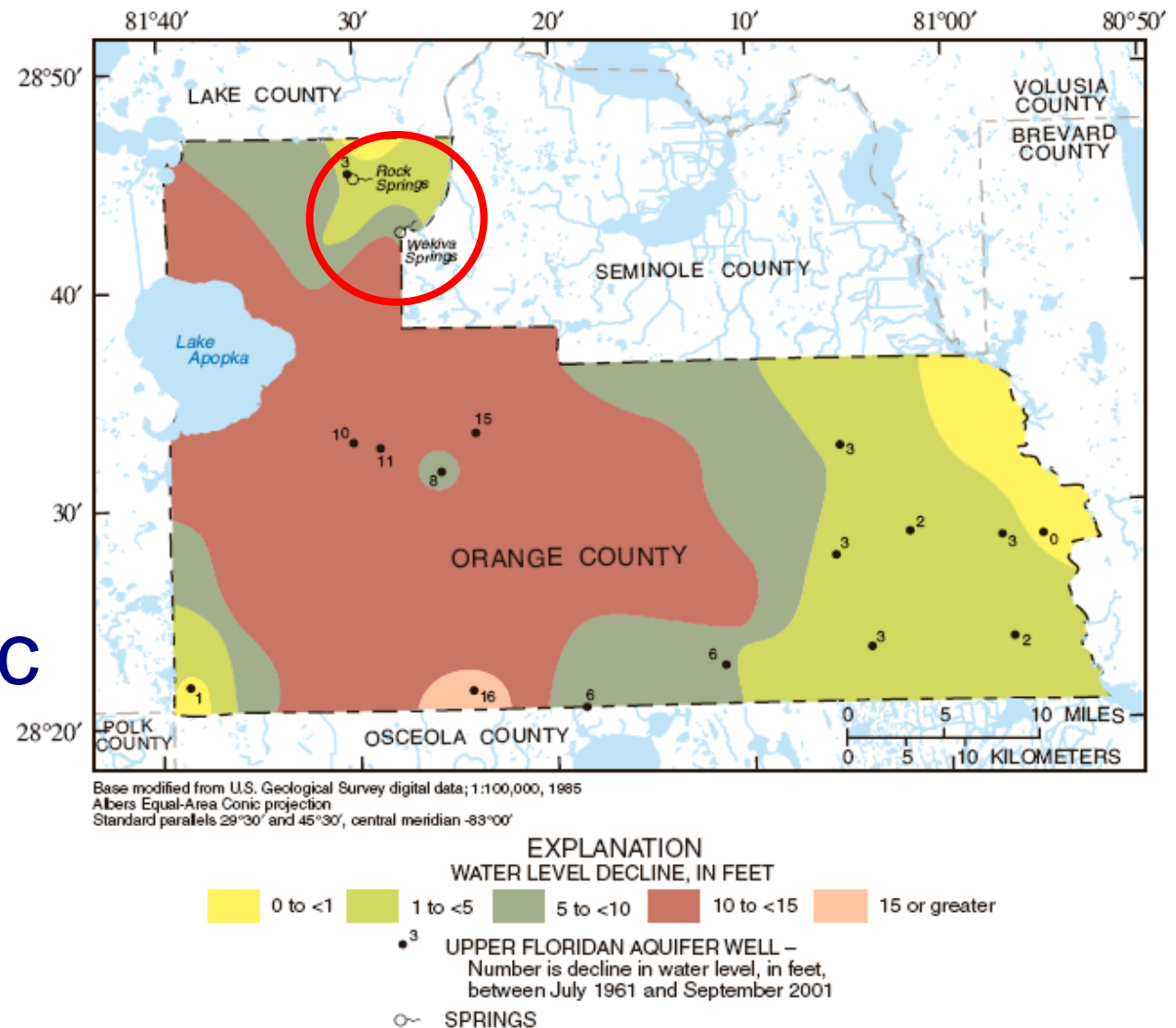


Figure 4. Population (1960-2000; U.S. Census Bureau, 2002) and ground-water use (1965-2000; R.L. Marella, U.S. Geological Survey, written commun., 2002) in Orange County, Florida.

Adamski J.C. and E.R. German, 2004, Hydrogeology and Quality of Ground Water in Orange County, Florida, U.S. Geological Survey, Water-Resources Investigations Report 03-4257



More
groundwater
withdrawal =
lower
potentiometric
surface



Adamski J.C. and E.R. German, 2004, Hydrogeology and Quality of Ground Water in Orange County, Florida, U.S. Geological Survey, Water-Resources Investigations Report 03-4257



Lower potentiometric surface = less discharge

- Water budget components
 - P minus $ET \sim 14$ in/yr
 - Environmental discharges ~ 13 in/yr
 - Exports ~ 1 in/yr
- But some of those exports are quite sensitive to reduced potentiometric surface

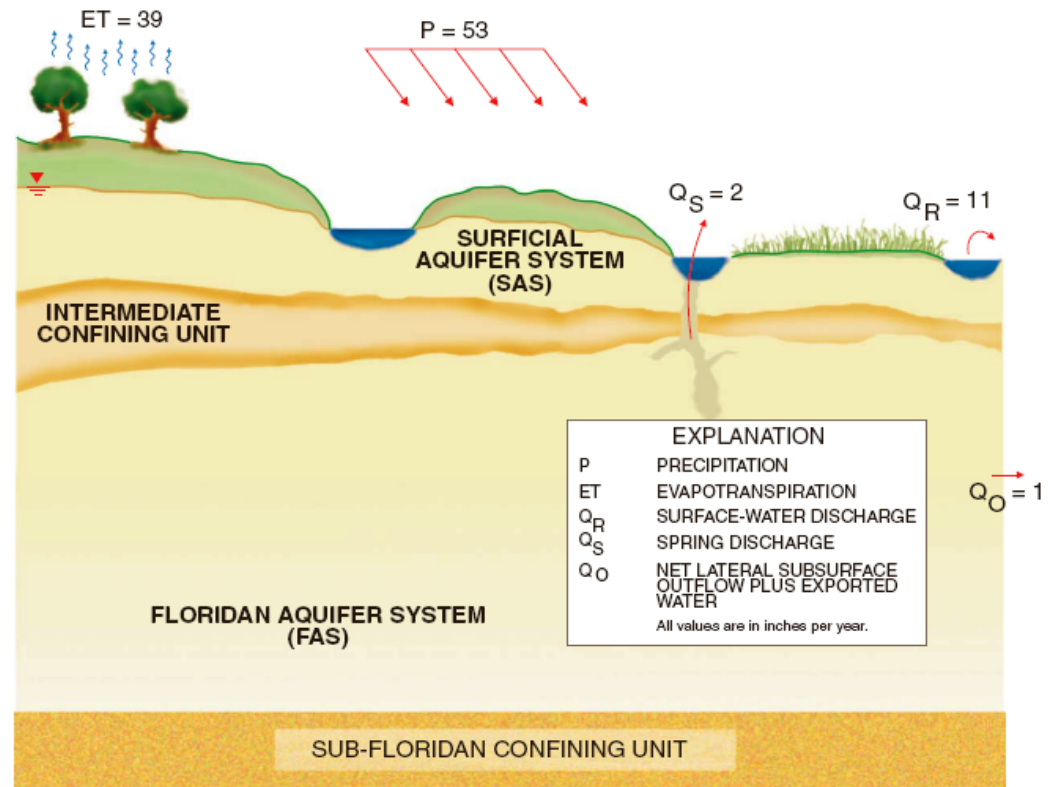


Figure 36. Water budget for Orange County, Florida, 1991-2000.

Adamski J.C. and E.R. German, 2004, Hydrogeology and Quality of Ground Water in Orange County, Florida, U.S. Geological Survey, Water-Resources Investigations Report 03-4257



Lower
potentiometric
surface = less
spring discharge

Reduce flow,
then reduce a bit
more, then a bit
more...

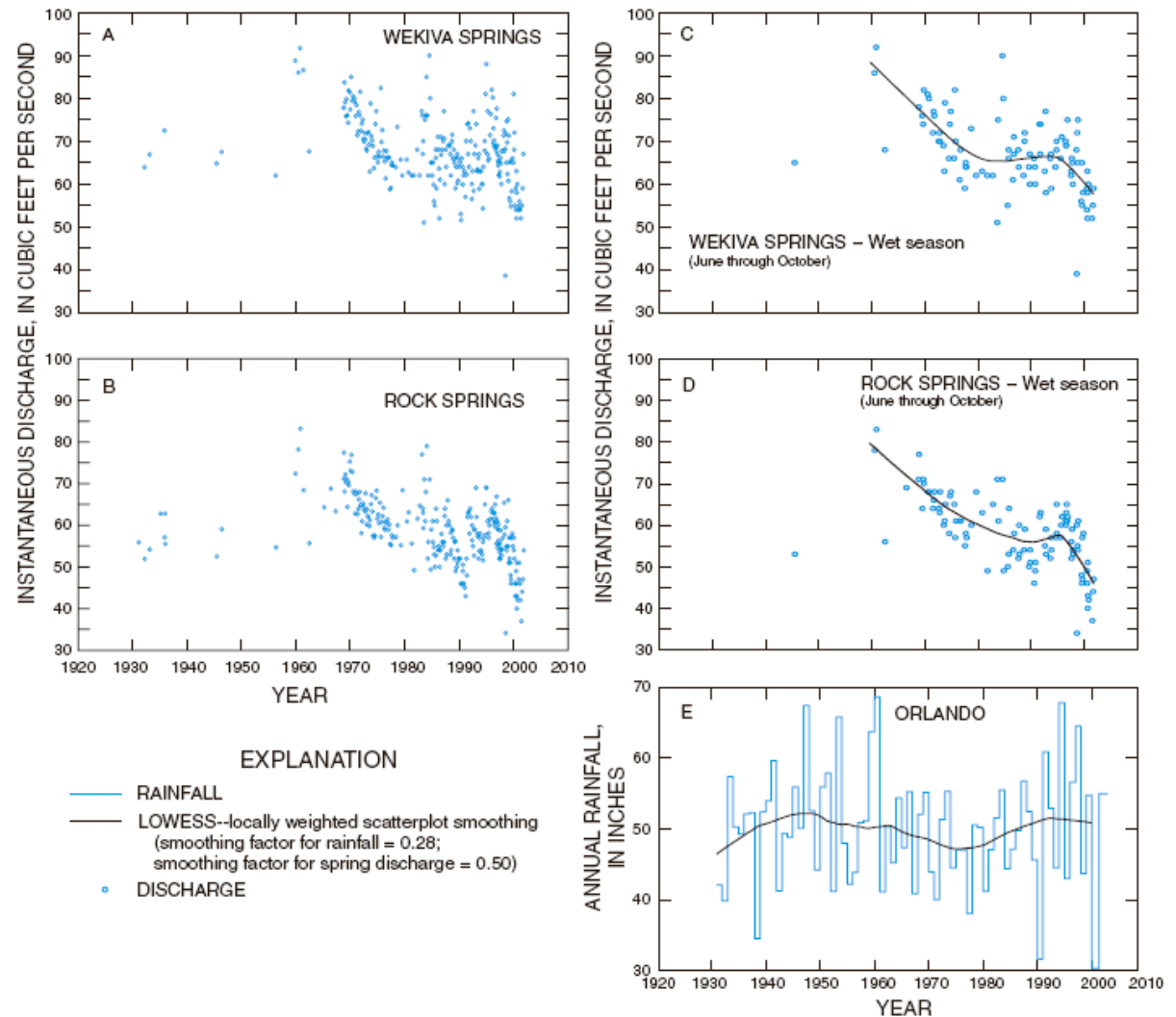


Figure 35. Discharge at Wekiva and Rock Springs for entire period of record (A and B) and for wet season (C and D), and annual rainfall at Orlando, Florida (E). (Spring locations are shown on figure 1.)

Adamski J.C. and E.R. German, 2004, Hydrogeology and Quality of Ground Water in Orange County, Florida, U.S. Geological Survey, Water-Resources Investigations Report 03-4257



Kissengen Spring (Polk County, FL)



1947

2003



Kissengen Spring ceased flowing regularly in February, 1950. Cessation of flow was primarily due to over pumping of the aquifer systems within the springshed which lowered the potentiometric surface such that flow stopped. Prior to that, Kissengen Spring was a popular recreational area known to have been the site of political rallies and gatherings that were attended by thousands of people. Today the spring basin is overgrown with dog fennel and other encroaching plants and its original dimensions are hard to discern.

<http://www.pbase.com/floridageologicalsurvey/image/64778705>

Florida Geological Survey, 2004. Springs of Florida.

<http://www.dep.state.fl.us/geology/geologictopics/springs/bulletin66>

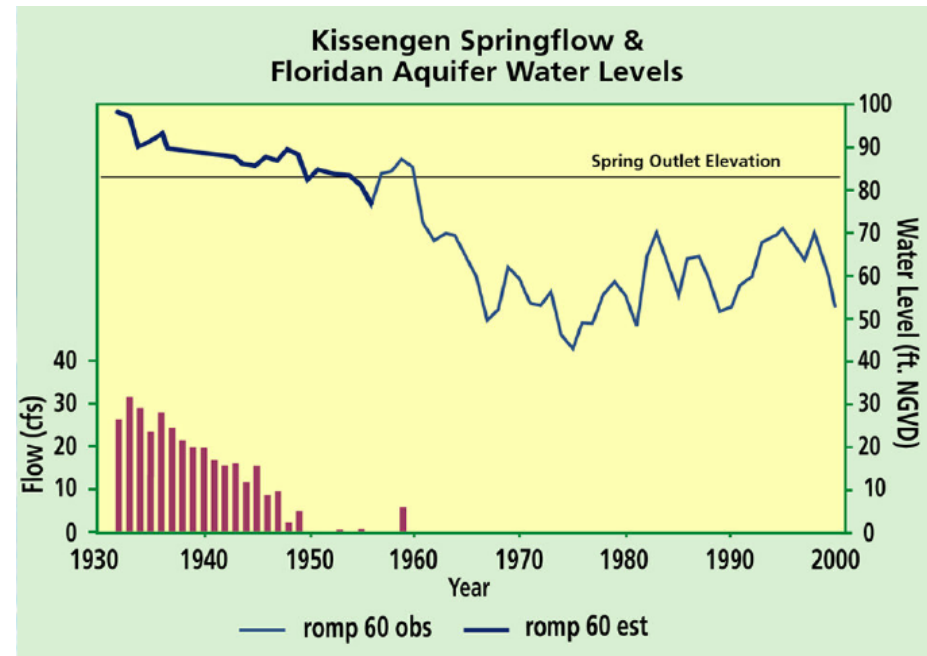
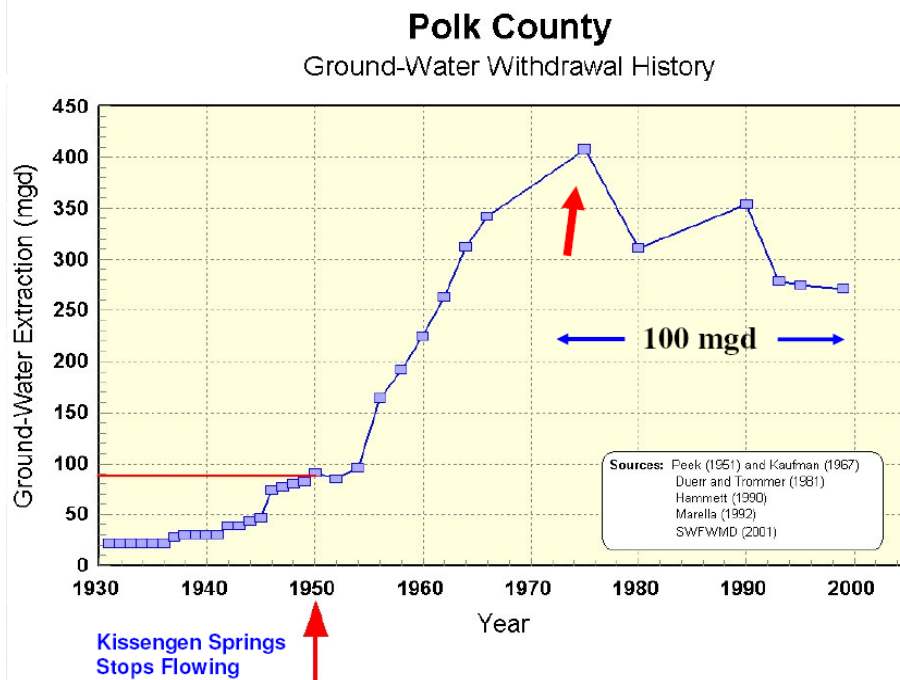
Soil and Water Science Department



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Groundwater pumping effects on springs

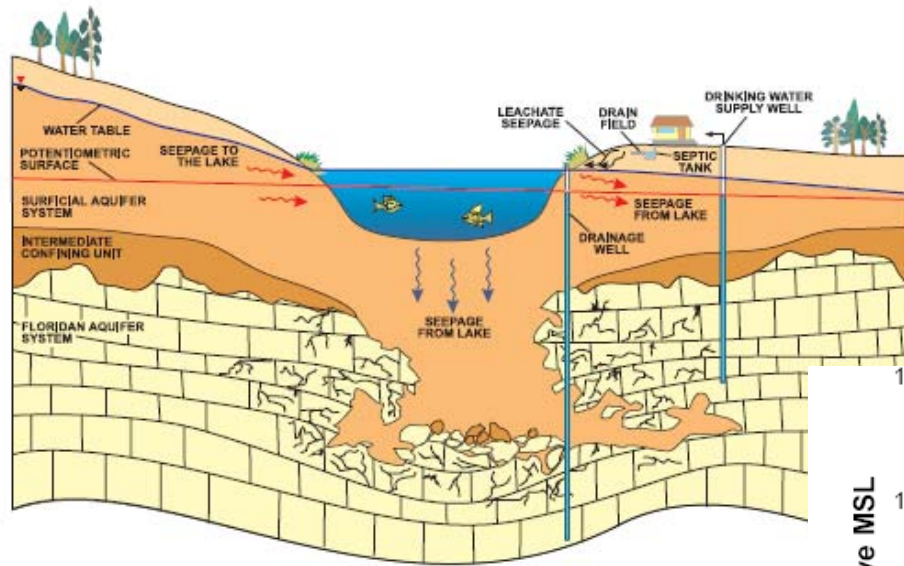
- Kissengen Spring (on Peace River) ceased Flowing in February 1950 due mainly to pumping of aquifer systems. Former discharge averaged 20 million gallons per day



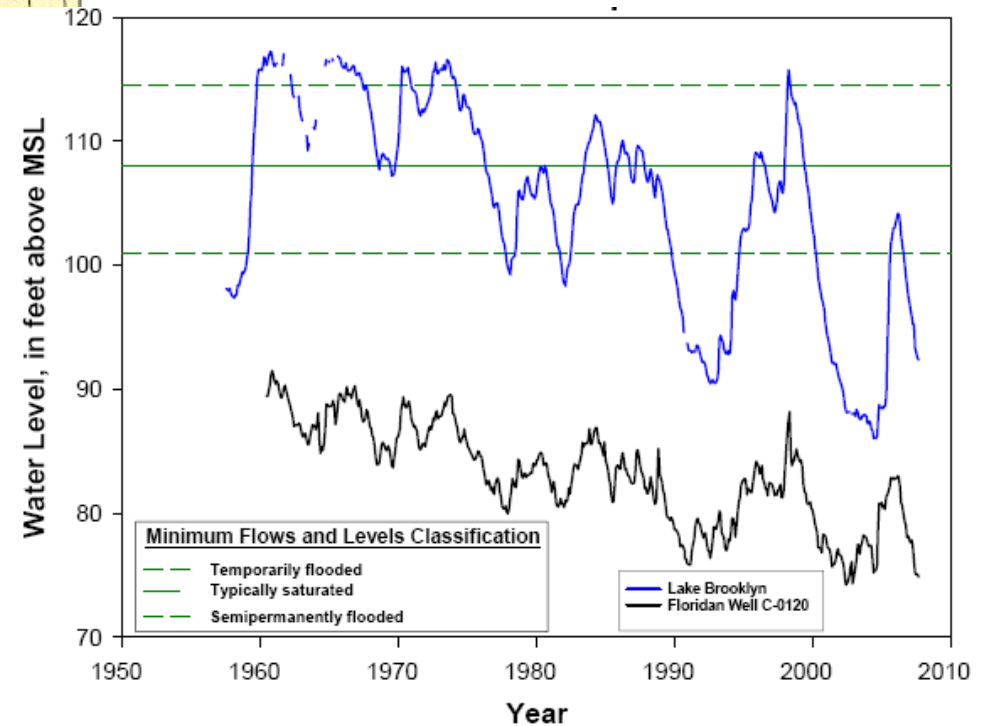
Florida Department of Environmental Protection, Peace River Cumulative Impact Study, May 2006
http://www.dep.state.fl.us/water/mines/pr_cis.htm



Potentiometric surface reflected in the groundwater-surface water continuum – Lake Brooklyn



Sinkhole Lake (Schiffer 1998)



Surface water-groundwater continuum in South Florida... alternate water supply mandate

- During the dry season, the Everglades is relied upon to sustain the Biscayne Aquifer
- 2005 Florida Legislature enacted the Water Protection and Sustainability Program.
 - requires the regional water supply planning function of water management districts to promote alternative water supply projects to both accommodate growth and to reduce the use of traditional ground and surface water supplies
- 2007 South Florida Water Management District authorized the adoption of a rule to limit water supply demands from the Everglades and Loxahatchee River Watershed over levels that existed prior to April 2006
 - unprecedented growth and ongoing delays in federal funding for Everglades restoration, the District is now compelled to impose stricter limitations on the use of Everglades water if it is to protect this natural resource.
- As a result, cities needing additional water supplies will be required to seek sources that are not dependent upon the Everglades for recharge.
 - solutions include recycling water, using reclaimed water to recharge the Biscayne Aquifer, or drawing water from the deeper Floridan Aquifer



Summary

- Metropolitan water issues in Florida are primarily groundwater issues
- S. Florida - Biscayne aquifer future allocations restricted
- Other major metro areas: Floridan aquifer not limiting supply, but ecological impacts are evident through disconnection of surface water/groundwater continuum.
Reduced potentiometric surface =
 - Reduced (eliminated?) spring flows
 - Reduced stage in surface water bodies (lakes, wetlands)
 - Direct effect from surficial aquifers
 - Indirect effect from reduced upward leakage from confined aquifer to overlying units
- Integrated and comprehensive water sustainability analysis for all of Florida's major metro areas still a desirable goal!



Conserv II: Waste Water Treatment Plant (Orlando, McLeod Road)



