## PMTurkeyCOLPEm Resource

| | |
|---|---|
| **From:** | Franzone, Steve <Steve.Franzone@fpl.com> |
| **Sent:** | Wednesday, April 27, 2016 1:50 PM |
| **To:** | Comar, Manny |
| **Cc:** | Orthen, Richard; Jacobs, Paul; Maher, William; TurkeyCOL Resource |
| **Subject:** | [External_Sender] RE: UIC previous presentation |
| **Attachments:** | Turkey Point Units 6 7 Underground Injection Control_NRC_032210.pdf; 2 _Hydrogeology Site Features Turkey Point Units 6 and 7 .pdf |

Rick identified 2 additional earlier presentations which provide additional detail to both the hydrogeology of South Florida and Underground Injection Control program and history.

Thanks
Steve Franzone
NNP Licensing Manager - COLA
"Whatever the dangers of the action we take, the dangers of inaction are far, far greater." ~ Anthony Charles Lynton Blair
561.904.3793 (office)
754.204.5996 (cell)


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**From:** Franzone, Steve
**Sent:** Wednesday, April 27, 2016 9:30 AM
**To:** 'Mr. Manny Comar (manny.comar@nrc.gov)'
**Cc:** TurkeyCOL Resource; Orthen, Richard; Maher, William
**Subject:** UIC previous presentation

I have attached a set of slides from our public meeting held on Feb. 14, 2013. I will continue to look for additional public information on the subject.

Thanks
Steve Franzone
NNP Licensing Manager - COLA
"Whatever the dangers of the action we take, the dangers of inaction are far, far greater." ~ Anthony Charles Lynton Blair
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**Received Date:** 4/27/2016 1:50:40 PM
**From:** Franzone, Steve

**Created By:** Steve.Franzone@fpl.com

**Recipients:**
"Orthen, Richard" <Richard.Orthen@fpl.com>
Tracking Status: None
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"Maher, William" <William.Maher@fpl.com>
Tracking Status: None
"TurkeyCOL Resource" <TurkeyCOL.Resource@nrc.gov>
Tracking Status: None
"Comar, Manny" <Manny.Comar@nrc.gov>
Tracking Status: None

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| MESSAGE | 2254 | 4/27/2016 1:50:40 PM |
| Turkey Point Units 6 7 Underground Injection Control_NRC_032210.pdf | 3704447 | |
| 2_Hydrogeology Site Features Turkey Point Units 6 and 7 .pdf | 1038251 | |

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# Turkey Point Units 6 & 7
# Underground Injection Control


**David McNabb, P.G.**

**McNabb Hydrogeologic Consulting, Inc.**


**March 22, 2010**

# Agenda

**Provide the NRC with an overview of the use and success of Underground Injection Control (UIC) in Florida**

- General UIC Information
- Florida UIC Permitting Process
- UIC Design, Construction and Testing
- Fluid Migration Detection

## History of Underground Injection in Florida

- **1943 – First injection into the Floridan Aquifer took place**
  - Oil Field Brine
- **1959 – First injection of municipal effluent into the Upper Floridan Aquifer**
- **1966 – First injection of non-oil field related industrial wastewater into the Lower Floridan Aquifer (Boulder Zone)**
- **1970s – Injection into Upper Floridan ceases and is replaced by injection into the Boulder Zone**
- **1983 - Florida is granted primacy of the State's UIC Program**
- **Today there are approximately 127 active Class I injection wells in Florida**



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## Class I Wells

- **Class I - industrial and municipal disposal wells which inject fluids beneath the lowermost unit containing an underground source of drinking water (USDW)**
  - Class I Municipal – disposes of treated domestic wastewater
  - Class I Industrial – disposes of non-hazardous industrial wastewater
- **Most dispose of treated municipal effluent**
- **Many dispose of reverse osmosis (RO) concentrate or a combination of treated wastewater and RO concentrate**
- **Power Plant industrial wastewater – primarily cooling tower blowdown**



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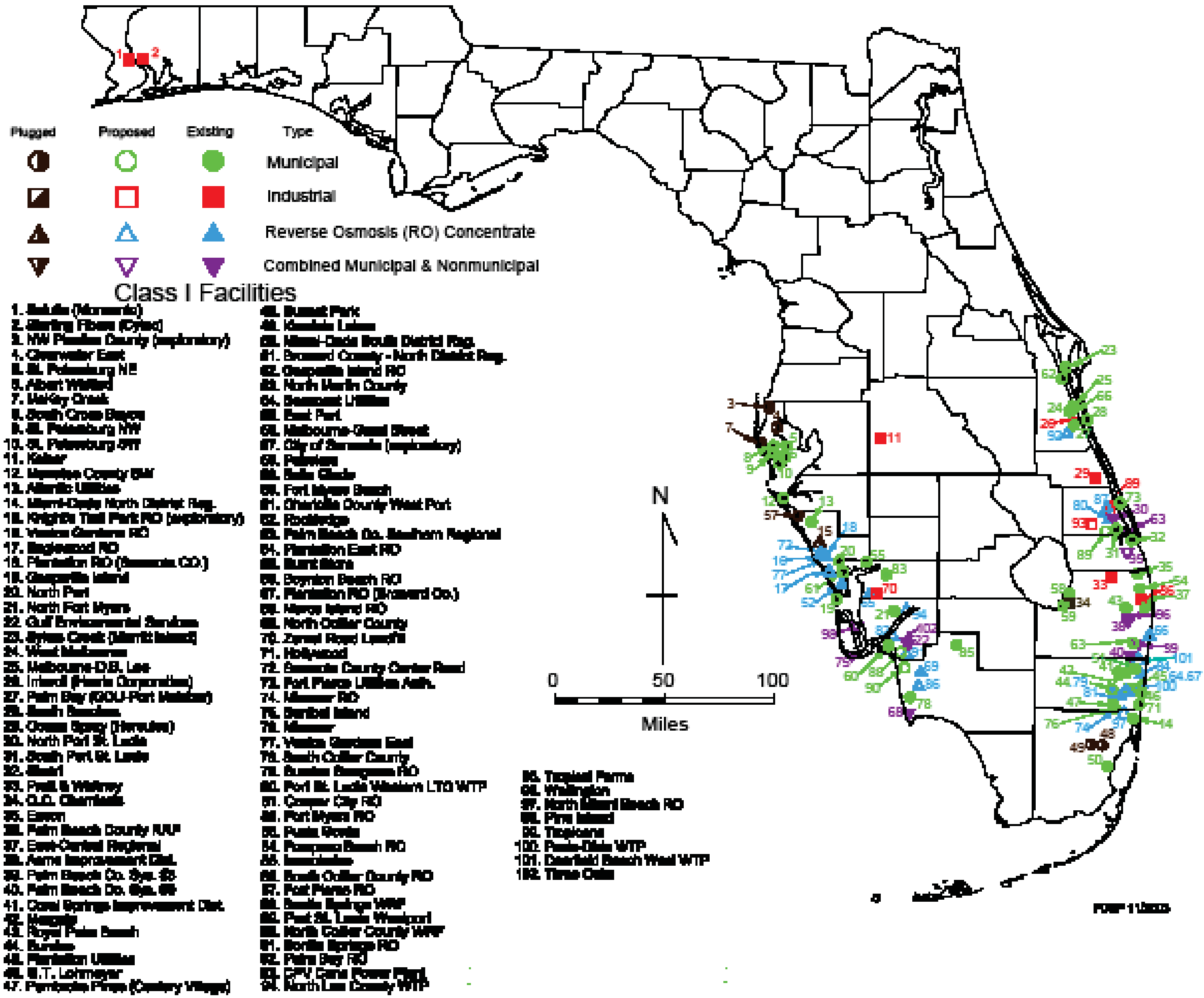
# CLASS I INJECTION FACILITIES



# Class I Injection Technology

- **Inject into the Boulder Zone in the Lower Floridan Aquifer**
- **Thick confining beds separate the Boulder Zone from the Underground Source of Drinking Water (USDW)**
  - USDW = an aquifer or its portion that contains water with a total dissolved solids concentration of less than 10,000 mg/L.
- **Confinement is low permeability limestone and dolomite**
  - Typically 800 – 1,000 feet thick
  - Vertical hydraulic conductivity typically $10^{-4}$ to $10^{-9}$ cm/sec



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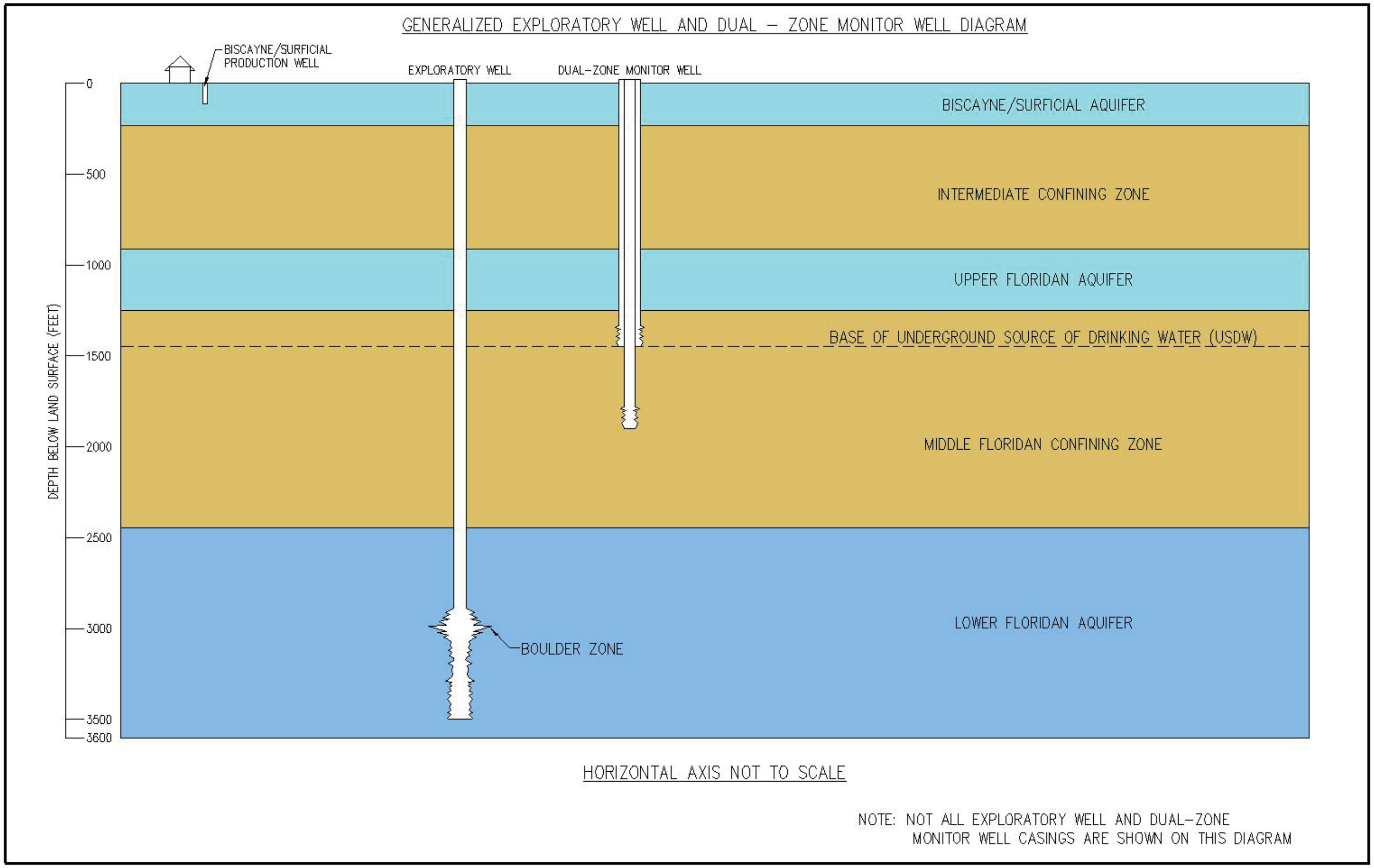
GENERALIZED EXPLORATORY WELL AND DUAL – ZONE MONITOR WELL DIAGRAM
BISCAYNE/SURFICIAL PRODUCTION WELL
EXPLORATORY WELL
DUAL-ZONE MONITOR WELL
DEPTH BELOW LAND SURFACE (FEET)
0
500
1000
1500
2000
2500
3000
3500
3600
BISCAYNE/SURFICIAL AQUIFER
INTERMEDIATE CONFINING ZONE
UPPER FLORIDAN AQUIFER
BASE OF UNDERGROUND SOURCE OF DRINKING WATER (USDW)
MIDDLE FLORIDAN CONFINING ZONE
LOWER FLORIDAN AQUIFER
BOULDER ZONE
HORIZONTAL AXIS NOT TO SCALE
NOTE: NOT ALL EXPLORATORY WELL AND DUAL-ZONE MONITOR WELL CASINGS ARE SHOWN ON THIS DIAGRAM

# Florida's UIC Permitting Process

- **The Florida Department of Environmental Protection (FDEP) administers the UIC Program in Florida**
- **Chapter 62-528, Florida Administrative Code**
- **Technical Advisory Committee (TAC)**
  - District and Tallahassee FDEP offices, USGS, Water Management District, local Health Department, and USEPA



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# Turkey Point Units 6 & 7 – Underground Injection Control

## Florida's UIC Permitting Process – cont.

- **Exploratory Well Construction Permit Application**
  - Evaluation of regional geology
- **Exploratory Well Construction Permit**
  - Detailed evaluation of the site hydrogeology, including extent of confining layer
- **Class I Construction Permit**
  - Conversion of exploratory well to a Class I injection well
  - Short-term injection test
  - Operational testing – 6 to 24 months of test operation with increased monitoring requirements
- **Operating Permit**
  - Allows operation of the Class I injection well system
  - Must be renewed every 5 years



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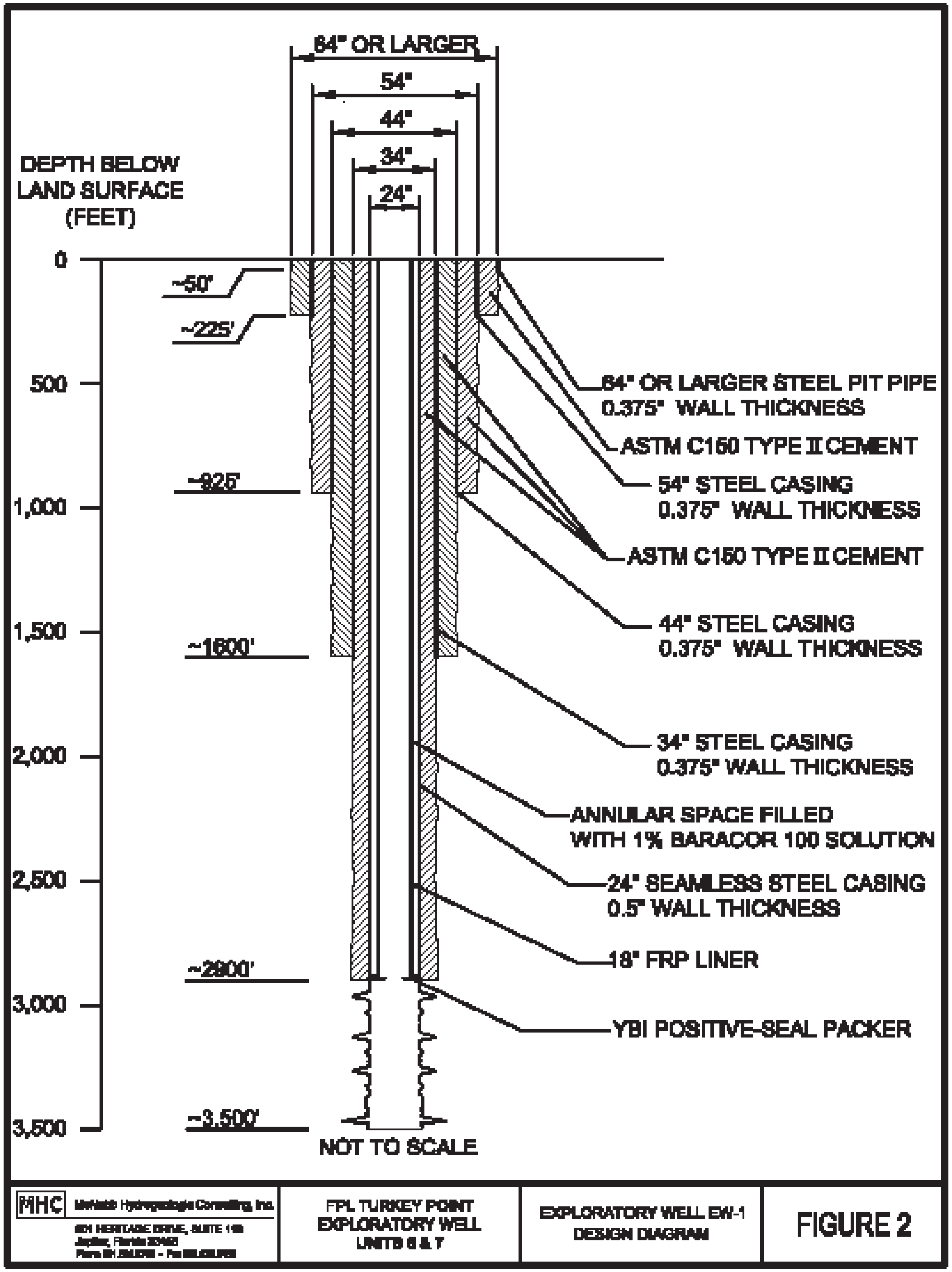
## Injection Well Design

- **Multiple concentric casings**
  - 54-, 44-, 34-, and 24-inch diameter steel fully cemented casings
  - 0.375-inch wall thickness except final casing is seamless 0.5-inch
  - 34-inch and 24-inch diameters casings set below base of USDW
- **Fiberglass Reinforced Pipe (FRP) injection tubing**
  - Protects final casing from corrosion
  - Packer at base of FRP isolates FRP-casing annulus
  - Annulus filled with corrosion inhibitor
- **10-inch overdrill on final casing to allow 5-inch cement thickness around casing**



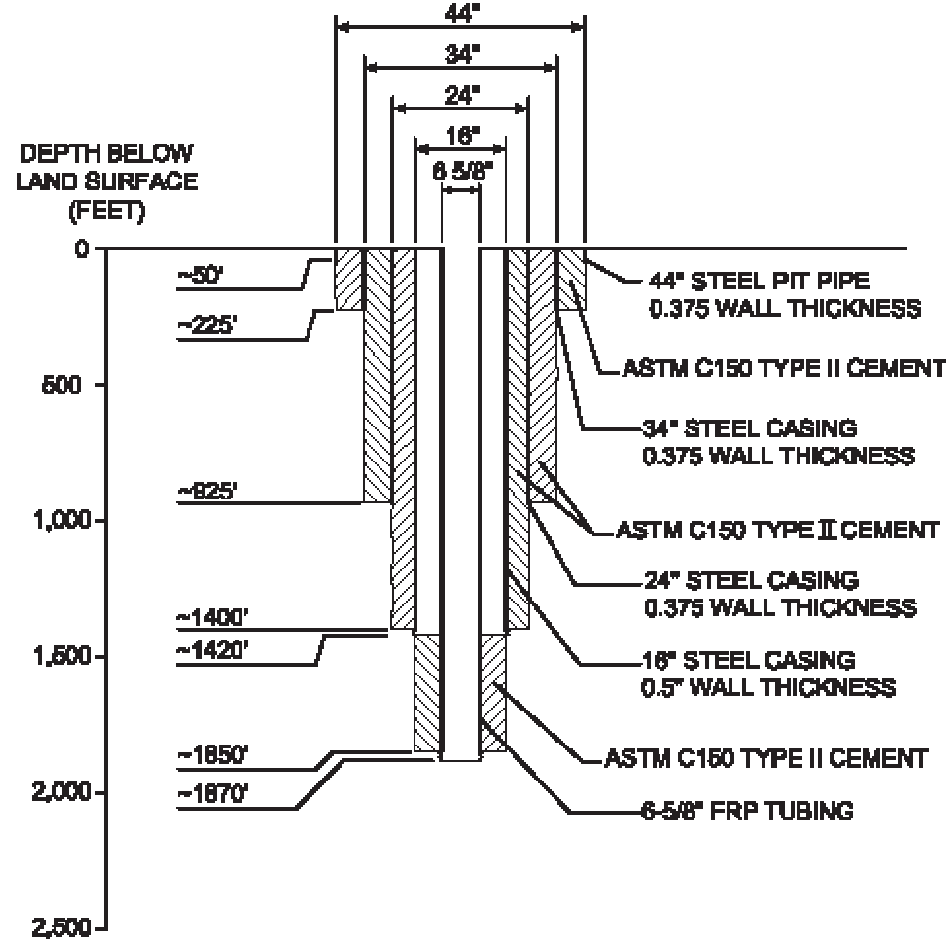
64" OR LARGER
54"
44"
34"
24"
DEPTH BELOW
LAND SURFACE
(FEET)
0
500
1,000
1,500
2,000
2,500
3,000
3,500
~50'
~225'
~925'
~1600'
~2900'
~3,500'
64" OR LARGER STEEL PIT PIPE
0.375" WALL THICKNESS
ASTM C150 TYPE II CEMENT
54" STEEL CASING
0.375" WALL THICKNESS
ASTM C150 TYPE II CEMENT
44" STEEL CASING
0.375" WALL THICKNESS
34" STEEL CASING
0.375" WALL THICKNESS
ANNULAR SPACE FILLED
WITH 1% BARACOR 100 SOLUTION
24" SEAMLESS STEEL CASING
0.5" WALL THICKNESS
16" FRP LINER
YBI POSITIVE-SEAL PACKER
NOT TO SCALE
MHC
FPL TURKEY POINT
EXPLORATORY WELL
UNITS 6 & 7
EXPLORATORY WELL EW-1
DESIGN DIAGRAM
FIGURE 2

# Turkey Point Units 6 & 7 – Underground Injection Control

## Dual-Zone Monitor Well Design

- **Multiple concentric casings**
  - 34-, 24-, 16-, and 6.625-inch diameter casings
  - 16-inch diameter casing is 0.5-inch wall thickness steel, 34- and 24-inch diameter casings are 0.375-inch wall thickness steel
  - 6.625-inch diameter casing is FRP to provide corrosion protection
- **Monitors two separate zones**
  - Upper zone monitors just above or at the base of the USDW
  - Lower zone monitors below base of the USDW and just above the primary confining unit – typically a few hundred feet below the base of the USDW to provide early warning system

## DUAL-ZONE MONITOR WELL




NOT TO SCALE

| | | | |
|---|---|---|---|
| MHC | FPL TURKEY POINT<br>EXPLORATORY WELL<br>UNITS 6 & 7 | DUAL ZONE MONITOR WELL<br>DZMW-1<br>DESIGN DIAGRAM | FIGURE 3 |



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# Turkey Point Units 6 & 7 – Underground Injection Control

## Injection Well Mechanical Integrity Test

- **Mechanical integrity testing (MIT) is required every 5 years**
- **MIT consist of the following**
  - Video survey – visual inspection of injection tubing, packer and open hole interval
  - High-resolution temperature logging – leak detection
  - Annular pressure test – test for leaks in tubing, final casing and packer
  - Radioactive tracer survey – test the integrity of the cement seal at the base of the final casing
  - Interpretation of previous five years of monitoring and operating data
- **Results compiled in report and submitted to FDEP for review and approval**



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# Turkey Point Units 6 & 7 – Underground Injection Control

## Confinement Characterization

- **Geophysical logs**
- **Rock Cores**
  - Laboratory Analysis of core samples
- **Straddle Packer Testing**
  - Hydraulic and water quality data



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## Vertical Fluid Migration Detection

- **Monitor well is located less than 150 feet from injection well**
- **Monitor well sample collection**
  - Weekly during operational testing
  - Monthly thereafter
  - Total dissolved solids, conductivity, chloride, phosphorus, sulfate, sodium, calcium, magnesium, potassium, carbonate, bicarbonate, temperature, pH, gross alpha, radium-226, radium-228
- **Monitor well water level monitoring**
- **Changes in monitor zone water quality and level can indicate vertical migration**

# Turkey Point Units 6 & 7 – Underground Injection Control

## Injection Well Drilling Rig



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# Turkey Point Units 6 & 7 – Underground Injection Control

## 12.25-Inch Diameter Pilot Hole Bit



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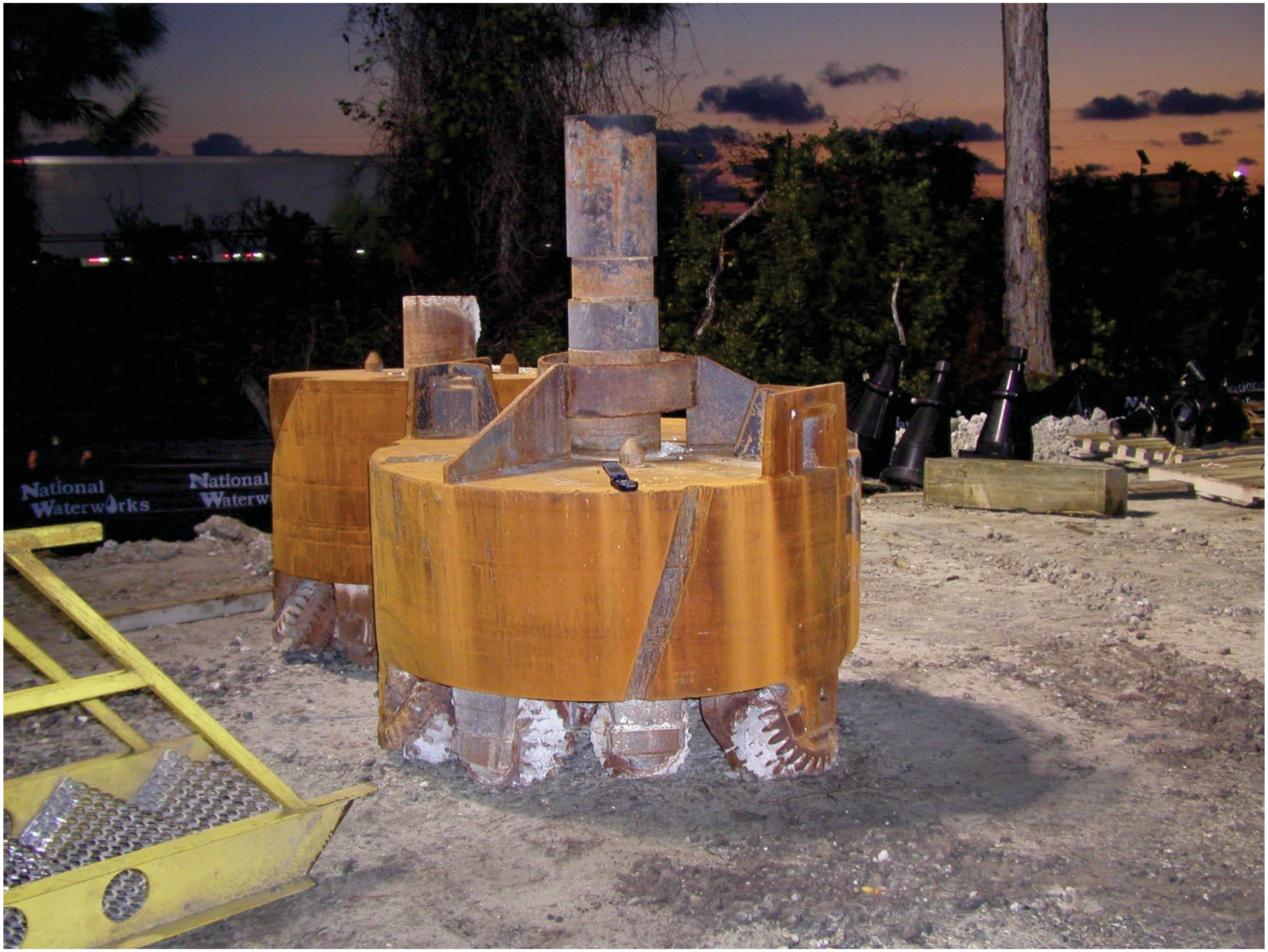
# Turkey Point Units 6 & 7 – Underground Injection Control

## 58-Inch Diameter Reaming Bit



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# Turkey Point Units 6 & 7 – Underground Injection Control

## Casing Installation



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# Turkey Point Units 6 & 7 – Underground Injection Control

## FRP Injection Tubing Installation

# Turkey Point Units 6 & 7 – Underground Injection Control

## Class I Injection Wellhead

# Turkey Point Units 6 & 7 – Underground Injection Control

## Class I Injection Wellhead

# Closing Questions & Comments

# Backup slides



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## Turkey Point Units 6 & 7 – Underground Injection Control

### Well Construction

- 12.25-inch diameter pilot hole is drilled in stages to allow data collection and prevent inter-aquifer fluid migration
- Pilot hole undergoes geophysical logging
- Straddle packer testing takes place in the Floridan Aquifer to assist in identification of the base of the lowermost USDW and determine confining characteristics



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# Turkey Point Units 6 & 7 – Underground Injection Control

## Well Construction

- Core collection takes place during pilot hole drilling through the anticipated confining beds
- Pilot holes in the Floridan Aquifer get backplugged with cement after data collection
- Backplugged pilot hole gets reamed to allow casing installation
- Casing gets cemented from base of casing to land surface with temperature logs between cement stages



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## Well Construction

- Final casing undergoes cement bond logging, pressure testing, video inspection
- FRP injection tubing gets installed to near the base of the final casing
- Packer at the base of the FRP injection tubing seals the annular space between the final casing and the injection tubing
- Injection tubing undergoes video inspection, temperature logging and annular pressure testing



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# Turkey Point Units 6 & 7 – Underground Injection Control

## Well Construction

- Background water sample collection from the injection zone and both monitoring zones
- Perform radioactive tracer survey of the injection well
- Perform short-term injection testing to verify absence of direct conduit fluid migration
- Weekly construction summary reports to the TAC summarize the week's construction and data collection



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# Turkey Point Units 6 & 7 – Underground Injection Control

## Well Construction

- **Construction oversight by a Florida registered Professional Geologist or Professional Engineer**

- **Casing seat recommendations must be approved by FDEP for the 34- and 24-inch casings of the injection well and the upper and lower monitor zones of the monitor well**

- **Final report detailing all construction and testing is signed and sealed by Florida registered Professional Geologist and Professional Engineer**

# Data Collection During Construction

- **Drilling cuttings**
  - Described to develop lithologic log
- **Geophysical logs**
  - Caliper, gamma ray, dual-induction, borehole compensated sonic, borehole televiewer, video, flowmeter, fluid conductivity and temperature
  - Provides rock property (including confining data) information and assists in identification of the base of the USDW
- **Pilot hole water samples**
  - Assist in the identification of the base of the USDW



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# Data Collection During Construction

- **4-inch diameter rock cores**
  - Core descriptions – general rock characteristics
  - Laboratory analysis – vertical and horizontal hydraulic conductivity, porosity, compressive strength
  - Typical vertical hydraulic conductivities range from $1 \times 10^{-4}$ to $1 \times 10^{-9}$ cm/second
- **Straddle packer tests**
  - Hydraulic data collection – determine confining characteristics
  - Water sample collection – assist in locating base of USDW



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## Turkey Point Units 6 & 7 – Underground Injection Control

### Fate of Injected Fluid

- **Fluid gets injected into Boulder Zone at an estimated depth of 2,900 feet**
- **Fluid remains in Boulder Zone due to overlying confining beds**
- **Fluids migrate laterally in a radial manner from the point of injection as injection volume increases until regional hydraulic gradient takes over**



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# Hydrogeological Site Features Turkey Point Units 6 & 7


Stewart Taylor

**Technology Manager, Bechtel Corporation**


**March 26, 2009**

**The information provided in the following presentation is of a preliminary nature and is considered DRAFT**

# Presentation Overview

- **Data Sources**
- **Regional Hydrostratigraphic Units**
- **Floridan Aquifer System**
  - Upper Floridan aquifer
  - Middle confining unit
  - Lower Floridan aquifer (Boulder zone)
- **Boulder Zone**
  - Hydraulic and geochemical properties
  - Deep well injection
- **Regional Groundwater Flow**
- **Fate and Transport of Injectate**



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# Data Sources


Bush, P. and Johnston, R., *Groundwater Hydraulics, Regional Flow and Groundwater Development of the Floridan Aquifer System in Florida and in parts of Georgia, South Carolina and Alabama,* Professional Paper 1403-C, U.S. Geological Survey, 1988.

Maliva, R.G., and Walker, C.W., Hydrogeology of Deep-Well Disposal of Liquid Wastes in Southwestern Florida, USA, *Hydrogeology Journal*, 6: 538-548, 1998.

Maliva, R.G., Guo, W., and Missimer, T., Vertical Migration of Municipal Wastes in Deep Injection Well Systems, South Florida, USA, *Hydrogeology Journal*, 7: 1387-1396, 2007.

Meyer, F., *Hydrogeology, Ground-water Movement, and Subsurface Storage in the Florida Aquifer System in Southern Florida, Regional Aquifer-System Analysis-Floridan Aquifer System*, Professional Paper 1403-G, U.S. Geological Survey, 1989.

Miller, J.A., *Hydrologic Framework of the Floridan Aquifer System in Florida and in Parts of Georgia, Alabama, and South Carolina*, Professional Paper 1403-B, U.S. Geological Survey, 1986.

Miller, J.A., *Ground Water Atlas of the United States, Alabama, Florida, Georgia, and South Carolina*, Hydrologic Atlas 730-G, U.S. Geological Survey, 1990.

Reese, R., *Hydrogeology and the Distribution and Origin of Salinity in the Floridan Aquifer System, Southeastern Florida*, Water-Resources Investigations Report 94-4010, U.S. Geological Survey, 1994.

Reese, R., and Richardson, E., *Synthesis of the Hydrogeologic Framework of the Floridan Aquifer System and Delineation of a Major Avon Park Permeable Zone in Central and Southern Florida*, Scientific Investigations Report 2007-5207, U.S. Geological Survey, 2008.




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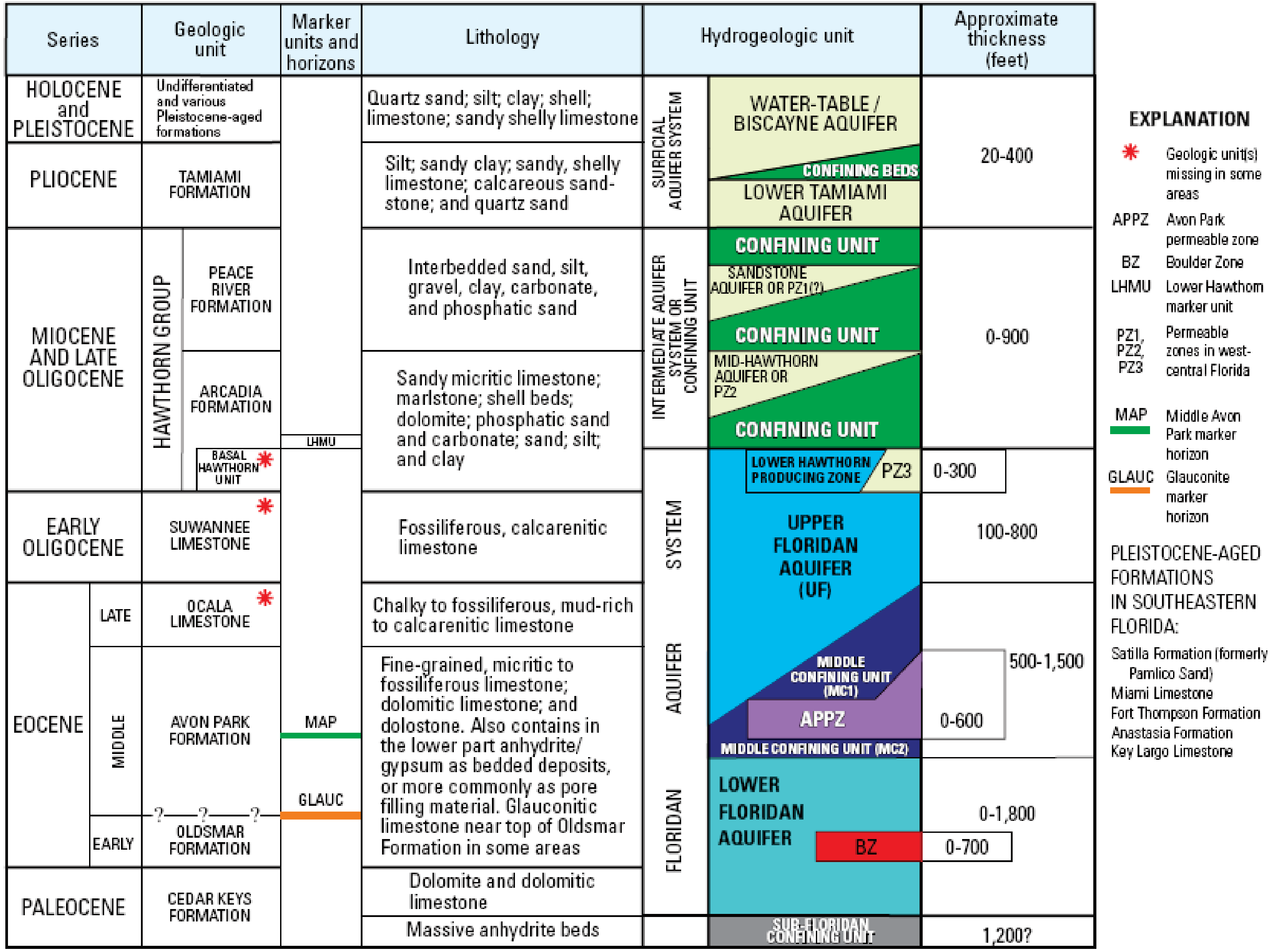
# Regional Hydrostratigraphic Units

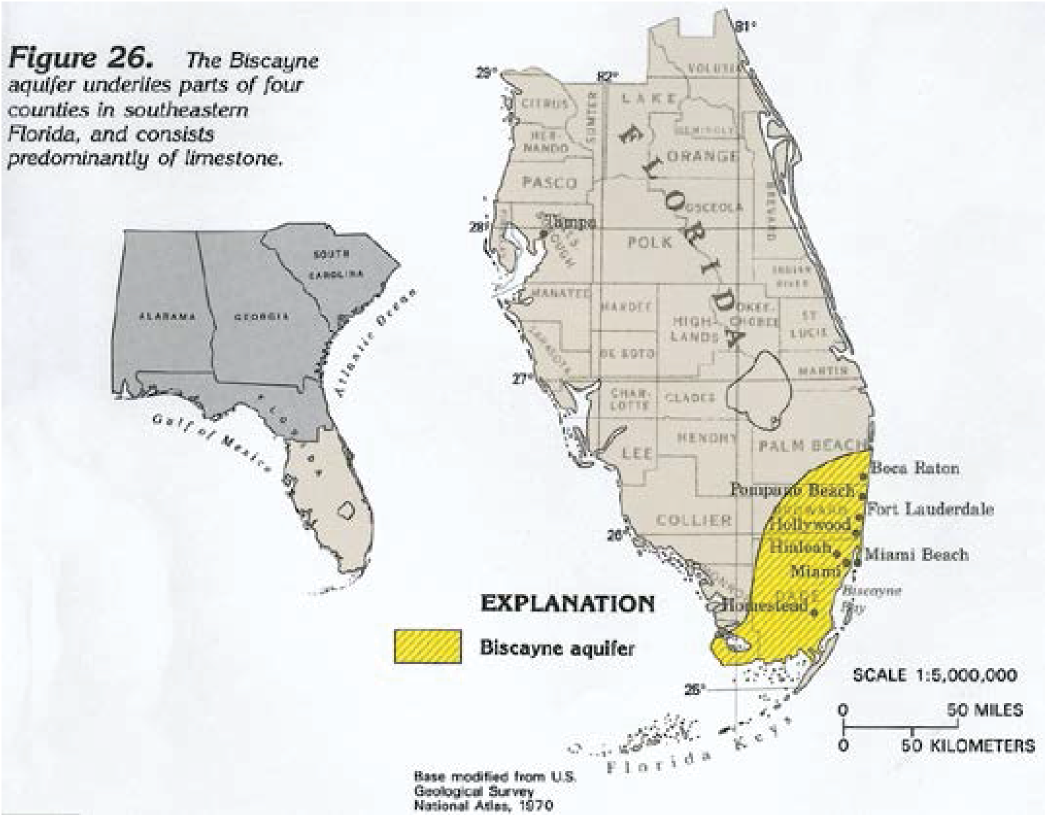



**Source: Reese and Richardson (2008)**

# Regional Hydrostratigraphic Units

## Surficial Aquifer System

- "The permeable hydrogeologic unit contiguous with the land surface that is comprised principally of unconsolidated to poorly indurated, siliciclastic deposits."
- Includes Biscayne aquifer
- 20-400 ft thick




Source: Miller (1990)



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# Regional Hydrostratigraphic Units

## Intermediate Aquifer System / Confining Unit

- **"All rocks that lie between and collectively retard the exchange of water between the overlying surficial aquifer system and the underlying Floridan aquifer system"**
- **Interlayered aquifer/aquitard system comprised of Hawthorn Group sediments**
- **Up to 900 ft thick**
- **Brackish water quality**

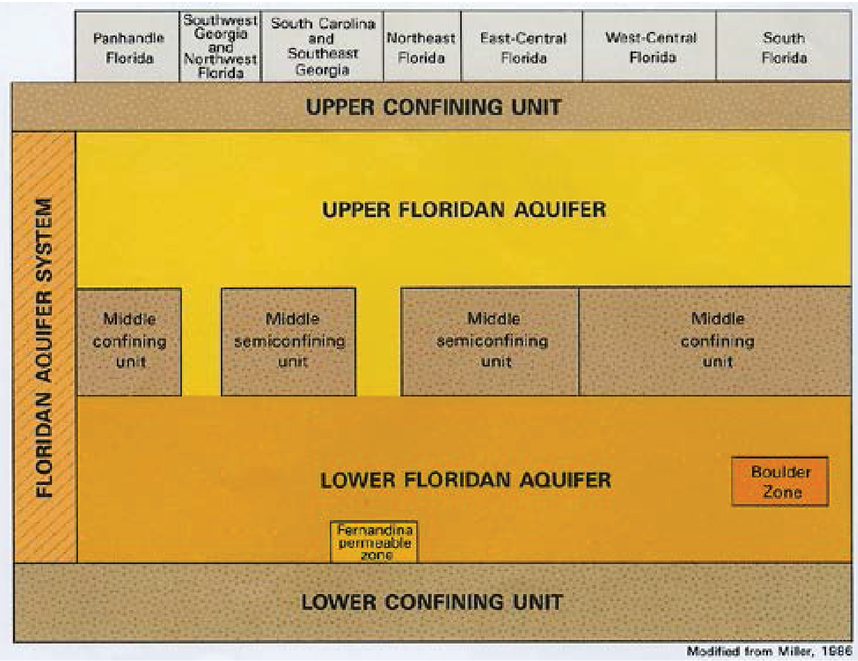


*Figure 50.* The Floridan aquifer system can generally be divided into an Upper Floridan aquifer and a Lower Floridan aquifer, separated by a less-permeable unit in most places and bounded above and below by confining units that are much less permeable. The Lower Floridan aquifer locally contains zones that are extremely permeable.

**Source: Miller (1990)**

# Regional Hydrostratigraphic Units

## Floridan Aquifer System

- **"Vertically continuous sequence of interbedded carbonate rocks of Tertiary age that are hydraulically interconnected by varying degrees and with permeabilities several orders of magnitude greater than the hydrogeologic systems above and below."**
- **Comprised of shallow-water limestone and dolomite beds**
- **2300 to 2400 ft thick in southern Florida**
- **Brackish to marine water quality**

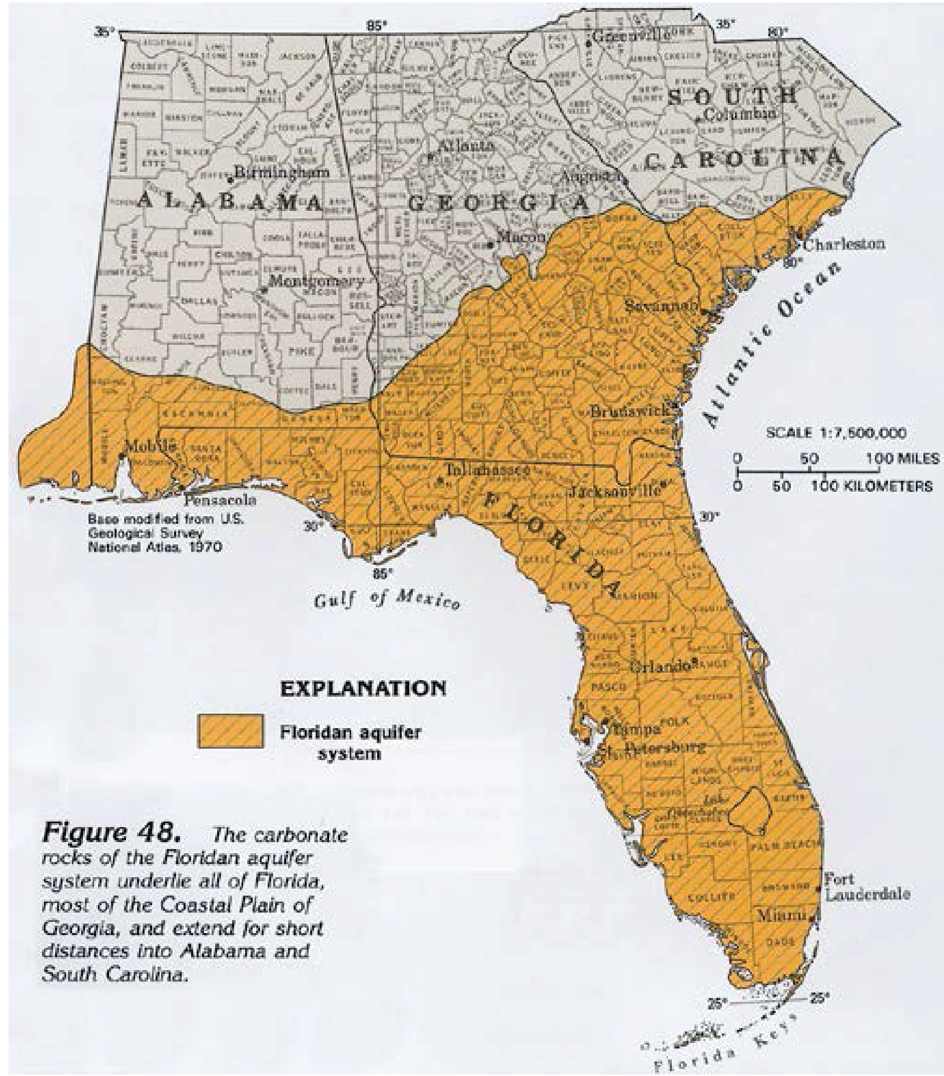


*Figure 48.* The carbonate rocks of the Floridan aquifer system underlie all of Florida, most of the Coastal Plain of Georgia, and extend for short distances into Alabama and South Carolina.

**Source: Miller (1990)**



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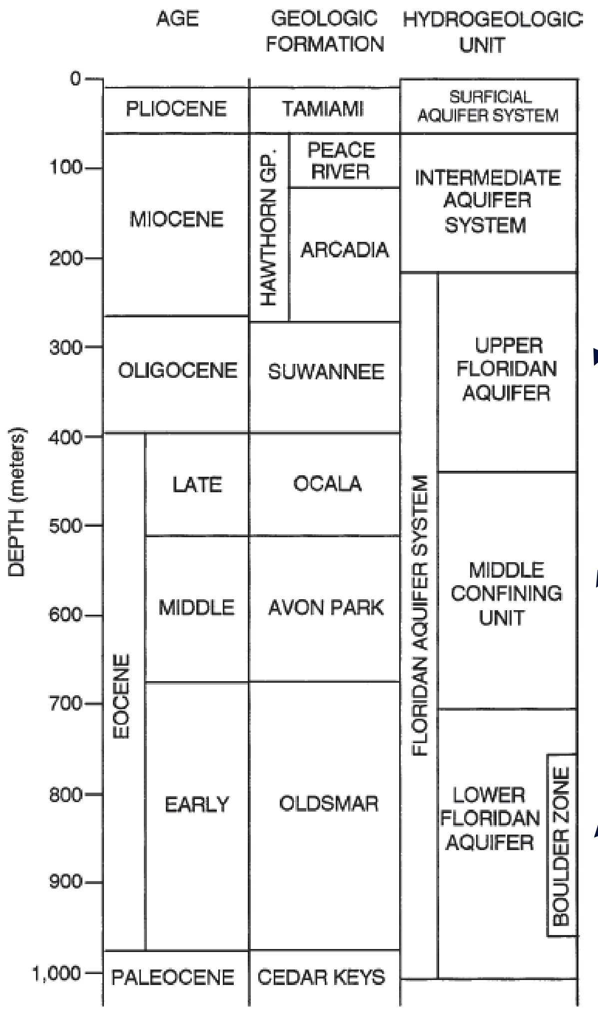
# Floridan Aquifer System




Source: Maliva and Walker (1998)

## Upper Floridan Aquifer

- Porous limestones / dolomites
- 100 to 400 ft in thickness
- Transmissivities of 10,000 to 60,000 $ft^2/d$
- Brackish water quality

## Middle Confining Unit

- Interbedded, low permeability dolomites and limestones
- About 900 ft thick in SE Dade County
- Vertical hydraulic conductivities of $10^{-7}$ to $10^{1}$ ft/d ($10^{-10}$ to $10^{-2}$ cm/s)

## Lower Floridan Aquifer

- Permeable dolostones separated by less permeable limestones
- Up to 2000 ft in thickness
- Lower dolostone termed “Boulder Zone” and highly transmissive
- Marine water quality

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# Boulder Zone

## Geology

- Intervals of cavernous and fractured dolomites in the Early Eocene Oldsmar Formation
- Occurs at a depth of about 2900 ft near site

## Transmissivity

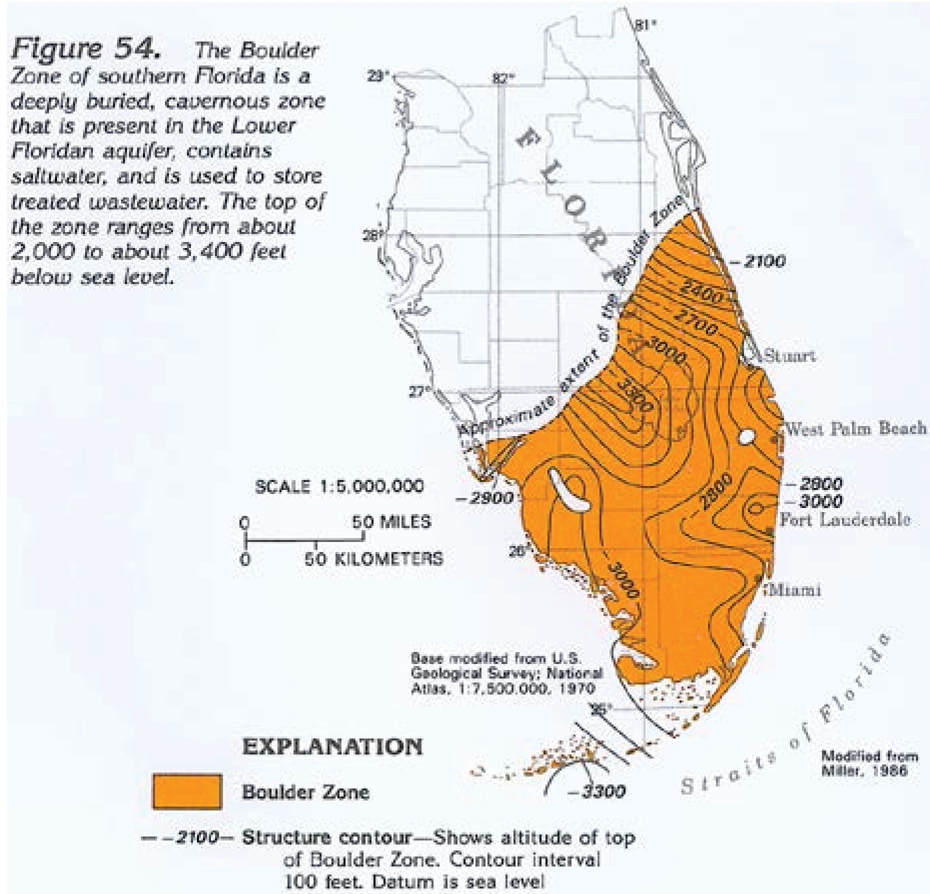
- 3,200,000 to 24,600,000 $ft^2/d$

## Water Quality

- Geochemically similar to modern seawater (35,000 mg/L TDS)
- Anomalous water temperature (nominally 50°F near coast)

## Use

- Wastewater disposal by deep well injection
- Oil field brines, municipal and industrial wastewater




Source: Miller (1990)

# Regional Groundwater Flow

- **"Variations in water quality, hydraulic head, and water temperature within the carbonate rocks that make up the Floridan aquifer system in southern Florida suggest that the flow system is complex." (Meyer, 1989)**
- **Regional flow in Boulder Zone difficult to assess due to:**
  - Limited number of hydraulic head observations
  - Very high transmissivities $\Rightarrow$ very low hydraulic gradients
  - Transitory effects of tides (ocean and atmospheric)
- **USGS (Meyer, 1989) determined regional flow patterns from**
  - Temperature data
  - Water quality data
  - Groundwater age dating
  - Hydraulic head data



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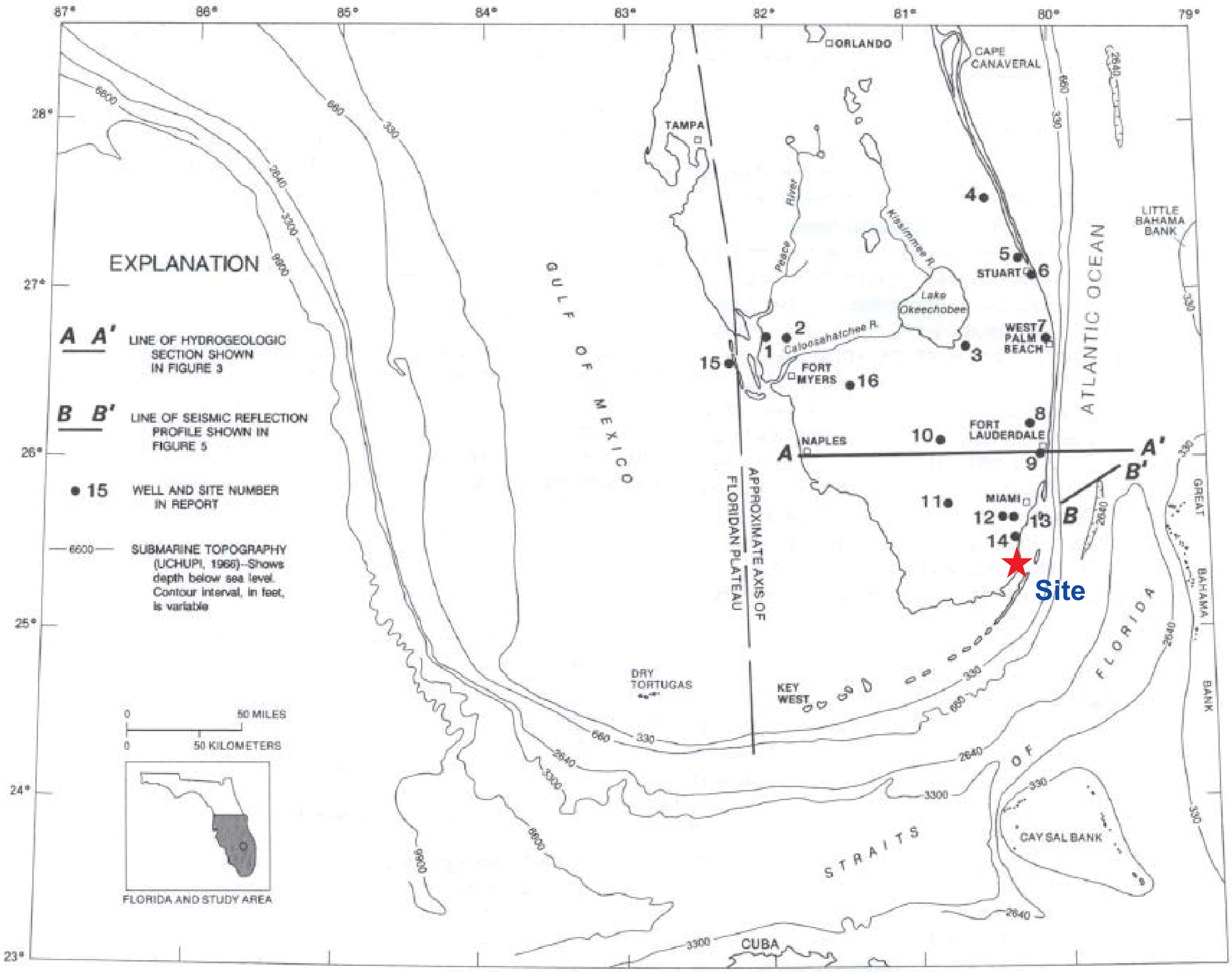
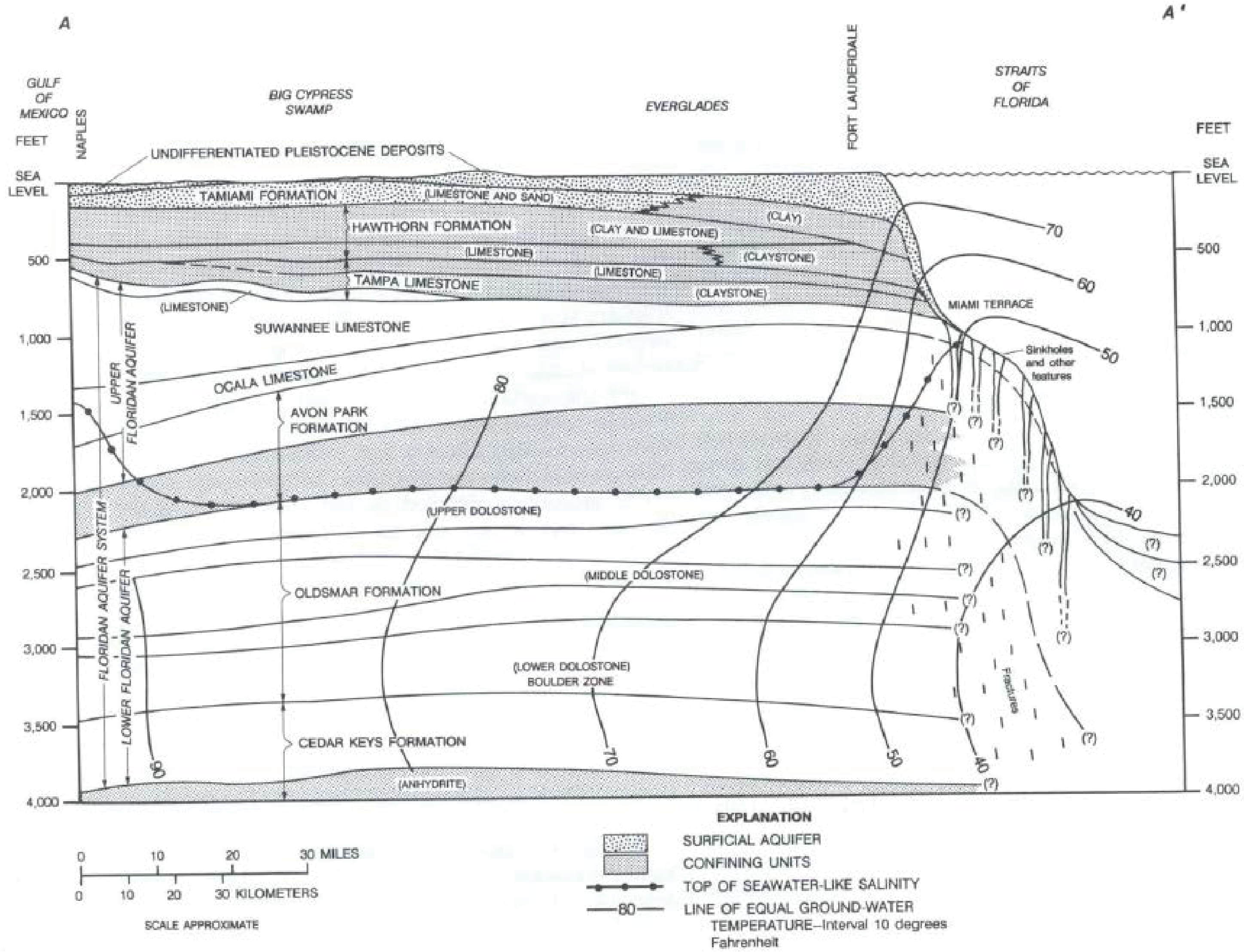
# South Floridan Plateau



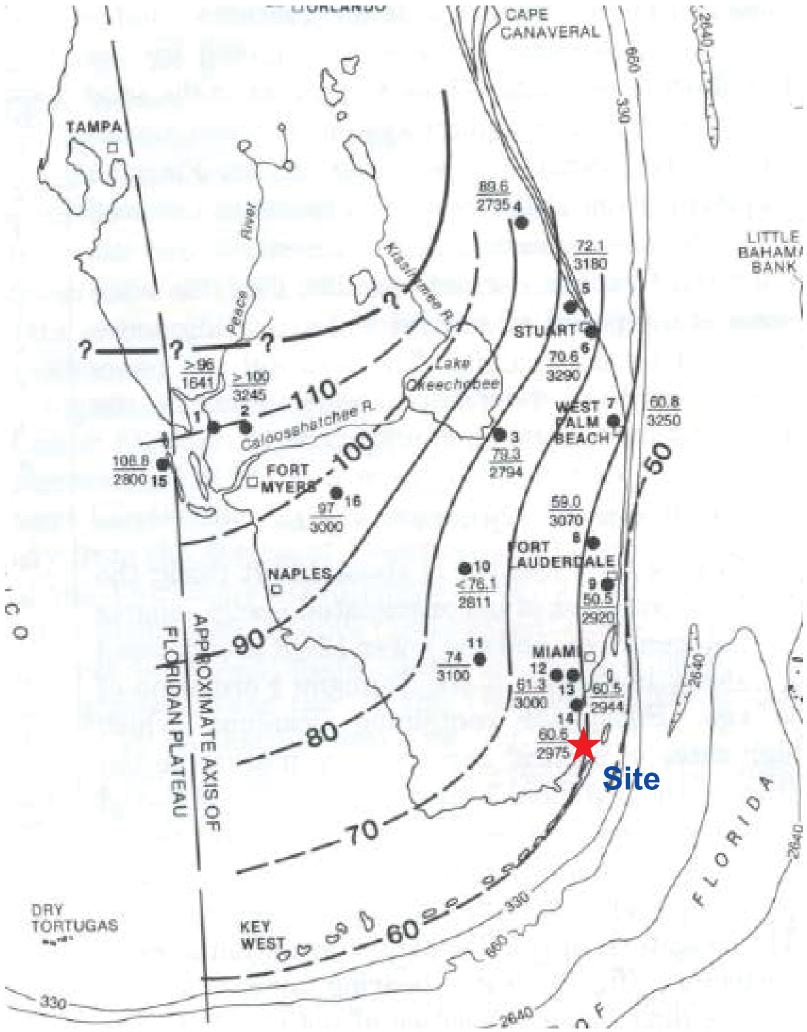

Source: Meyer (1989)

# Generalized Hydrogeologic Section

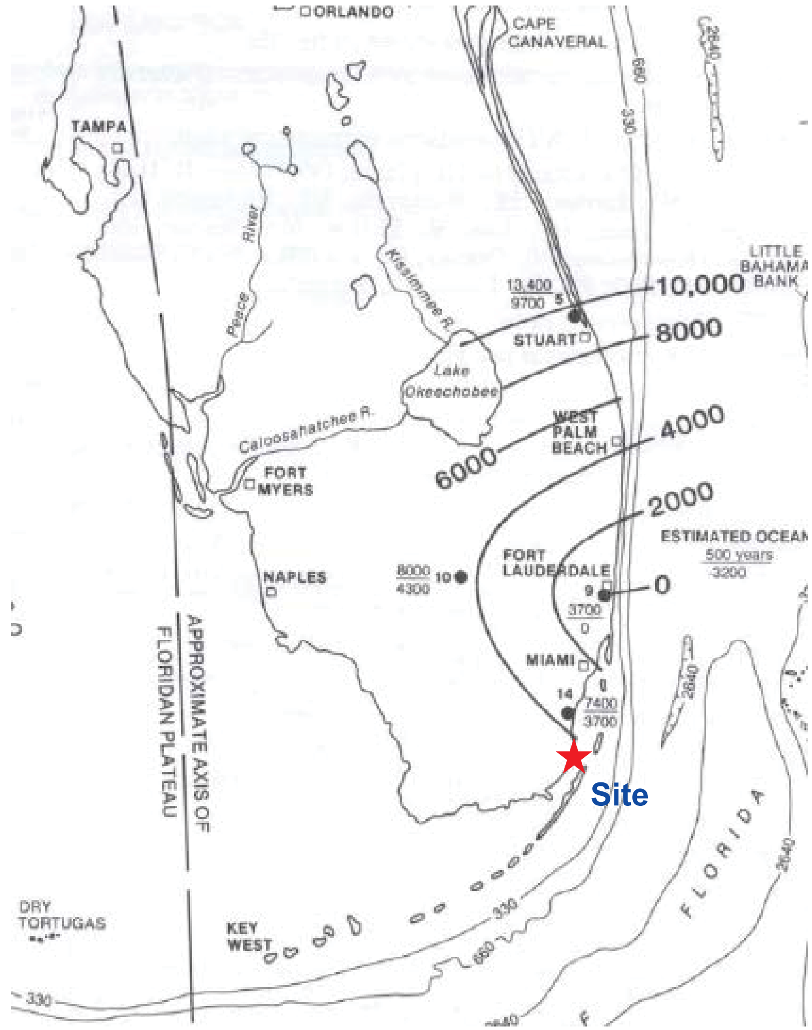



**Source: Meyer (1989)**

## Groundwater Temperature (°F)

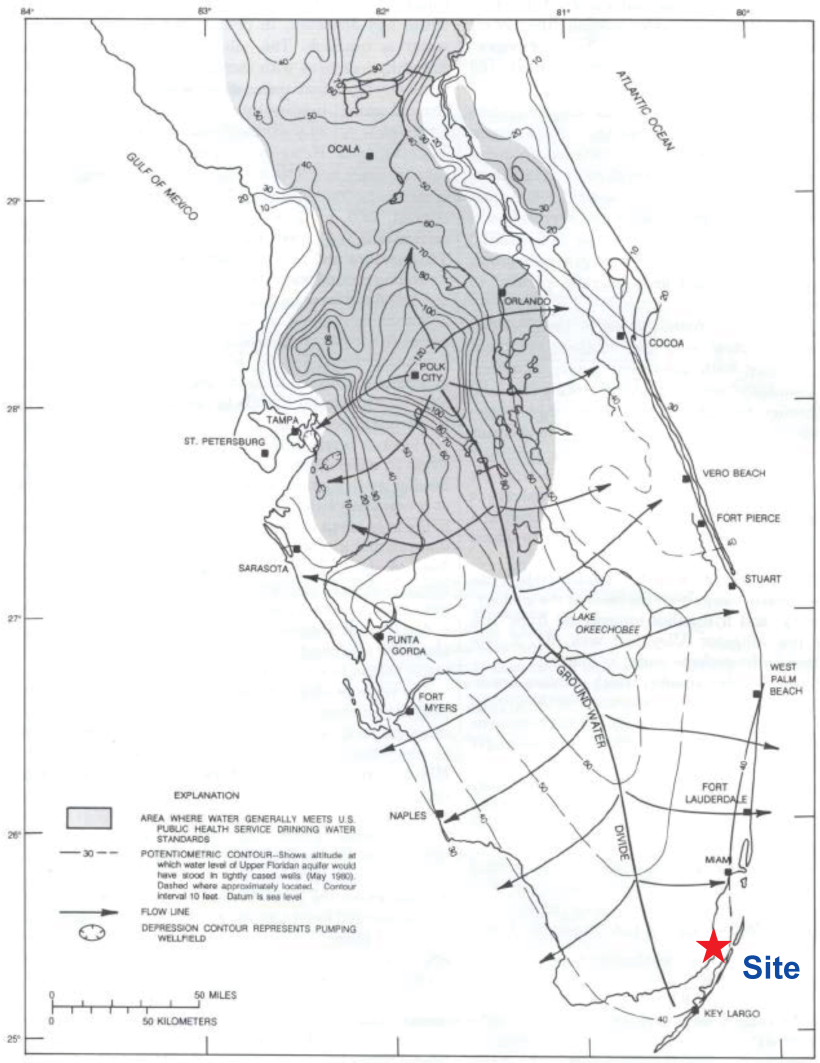



## Relative Age (y) in Boulder Zone



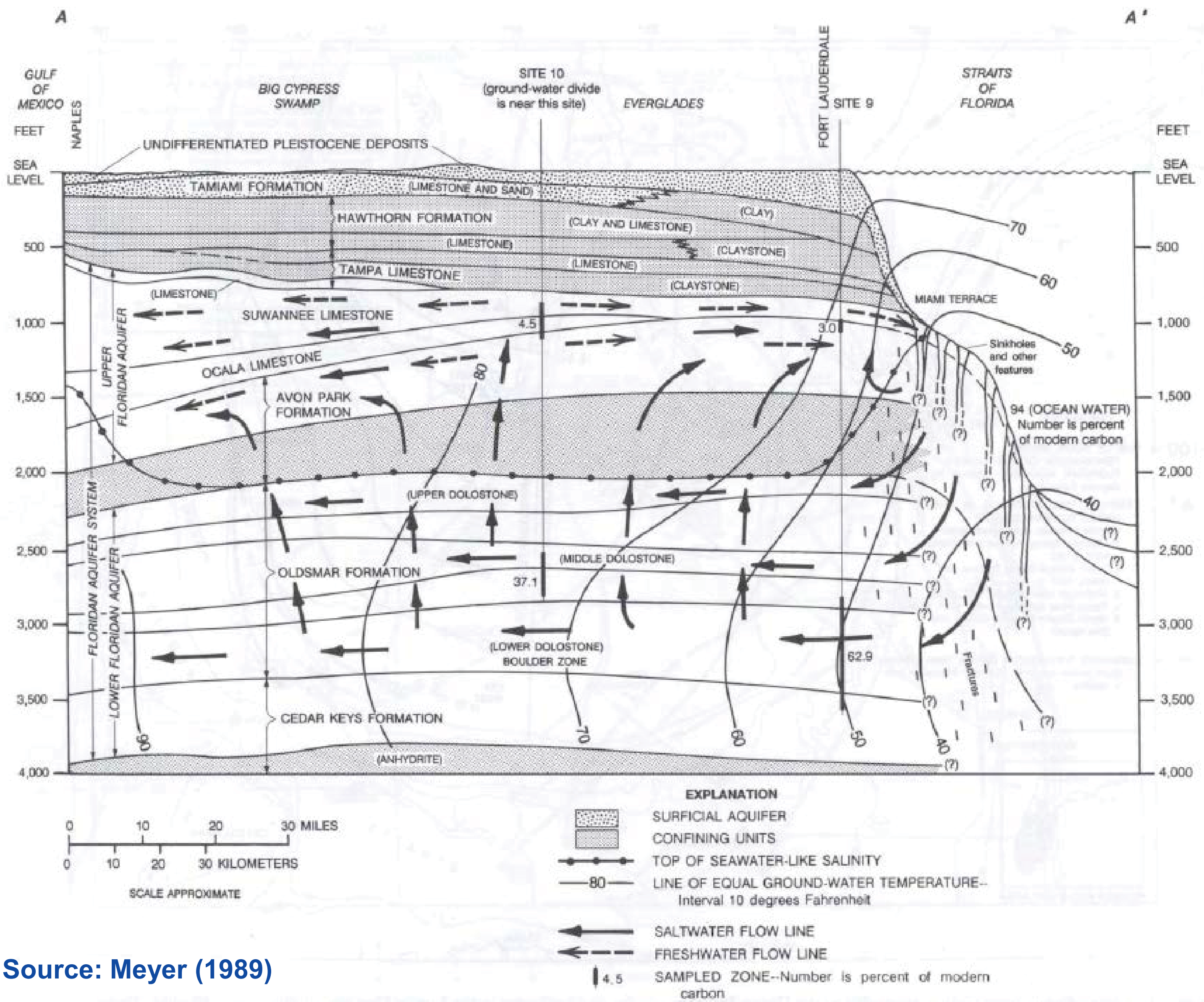

Source: Meyer (1989)

# Potentiometric Surface Upper Floridan Aquifer




Source: Meyer (1989)

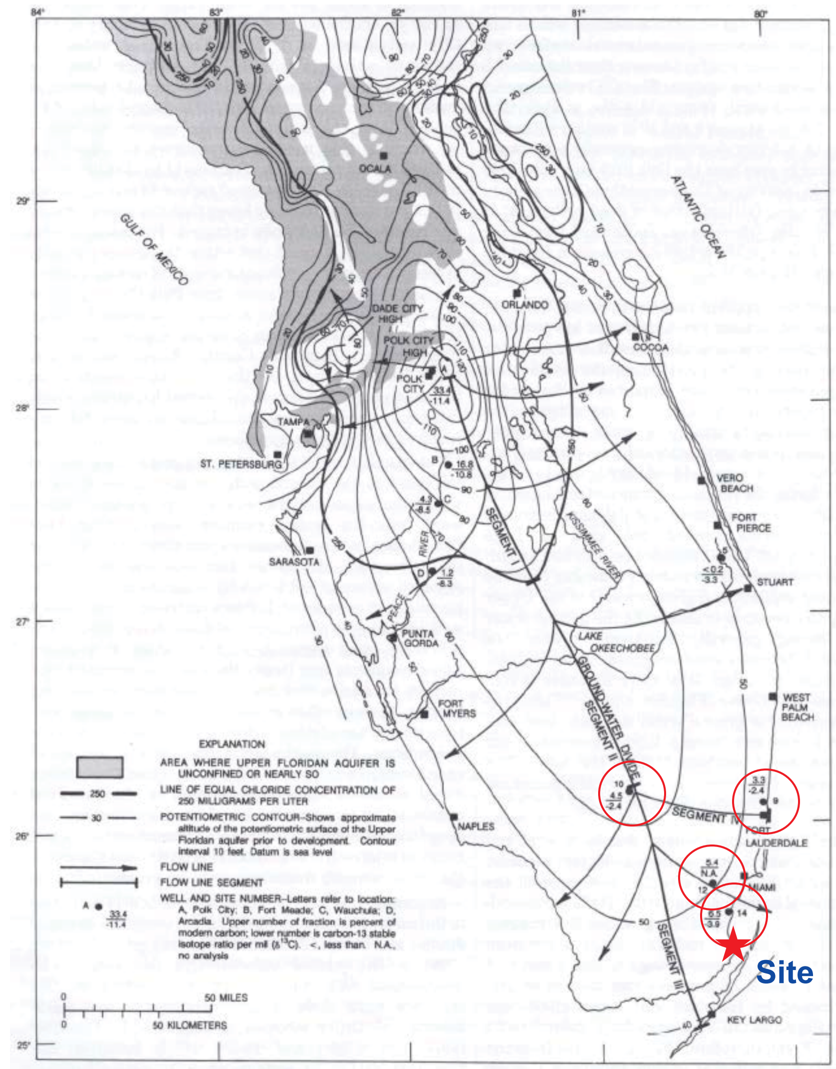
# Regional Groundwater Circulation




**Source: Meyer (1989)**

# Time Scales for Groundwater Circulation

- **Measureable C-14 activity in Upper Floridan aquifer suggests source younger than 40,000 years**
- **Transit times from aquifer recharge areas >> 40,000 years**
- **C-14 attributed to upwelling from Lower Floridan aquifer**
- **Percent Modern Carbon (PMC) in Upper Floridan aquifer**
  - 3.3% ≤ PMC ≤ 6.5%
- **Apparent age (before 1950)**
  - Age = -8033 ln (PMC×10$^{-2}$)
  - 22,000 y ≤ Age ≤ 27,000 y




**Source: Meyer (1989)**



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# Injectate Characteristics

- **Injection Rates**
  - Cooling tower blowdown
    - 12,500 gpm for reclaimed water source (COC = 4)
    - 58,000 gpm for marine water source (COC = 1.5)
  - Normal plant releases
    - 3 gpm
- **Physical Characteristics**
  - Reclaimed water source

    Salinity = 4 x 1,000 mg/l = ~4,000 mg/L TDS

    Temperature = 92°F = 33.2°C

    Density = 997.607 $kg/m^3$
  - Marine water source

    Salinity = 1.5 x 35,000 mg/l = ~52,500 mg/l TDS

    Temperature = 92°F = 33.2°C

    Density = 1033.721 $kg/m^3$



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# Injectate Characteristics

- **Ambient Boulder Zone Water**

  Salinity = 35,000 mg/l TDS

  Temperature = 60°F = 15.6°C

  Density = 1025.866 kg/$m^3$

- **Density Differences**
  - Reclaimed water source
    - Injectate (997.607 kg/$m^3$) < groundwater (1025.866 kg/$m^3$)
    - Positively buoyant
  - Marine water source
    - Injectate (1033.721 kg/$m^3$) > groundwater (1025.866 kg/$m^3$)
    - Negatively buoyant



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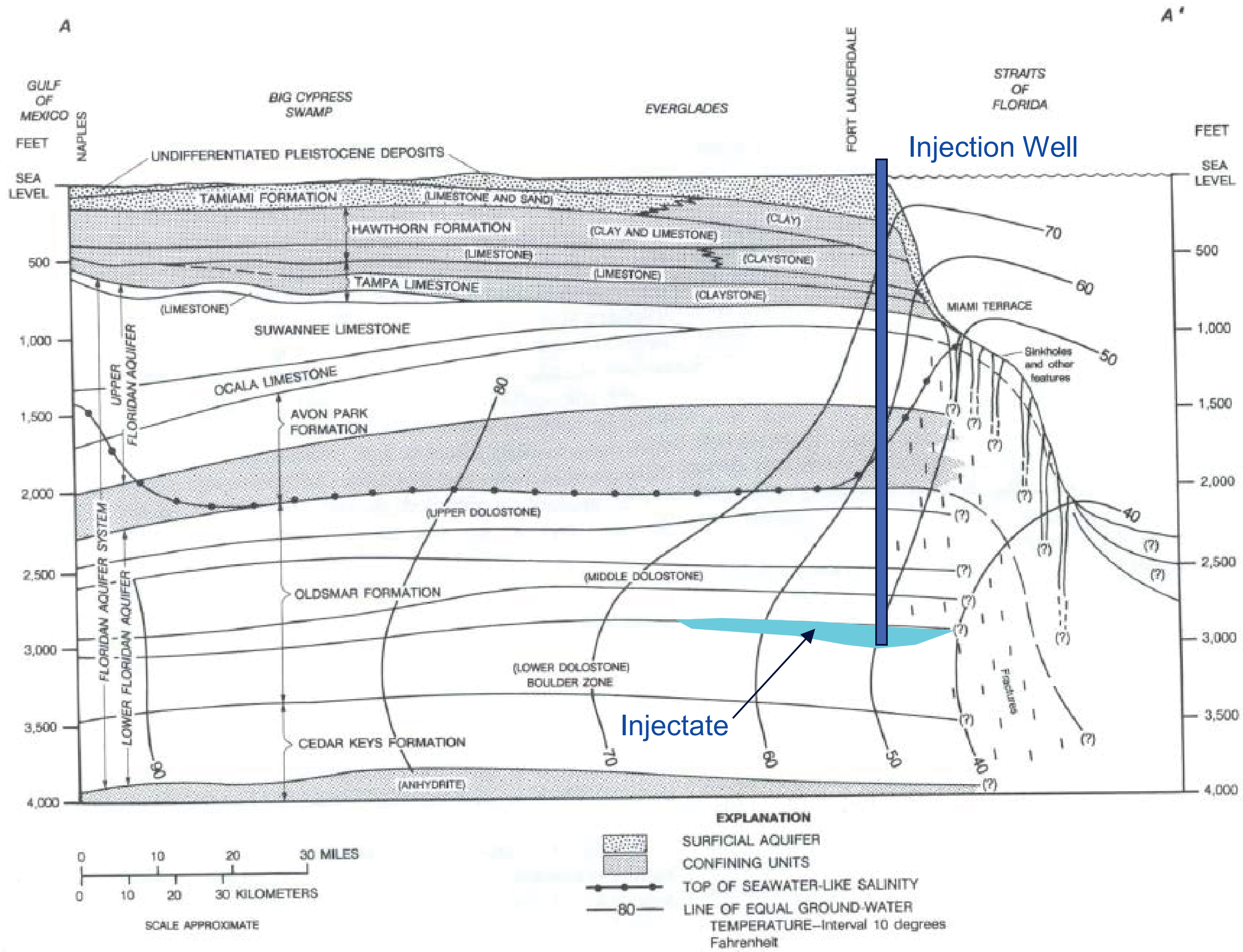
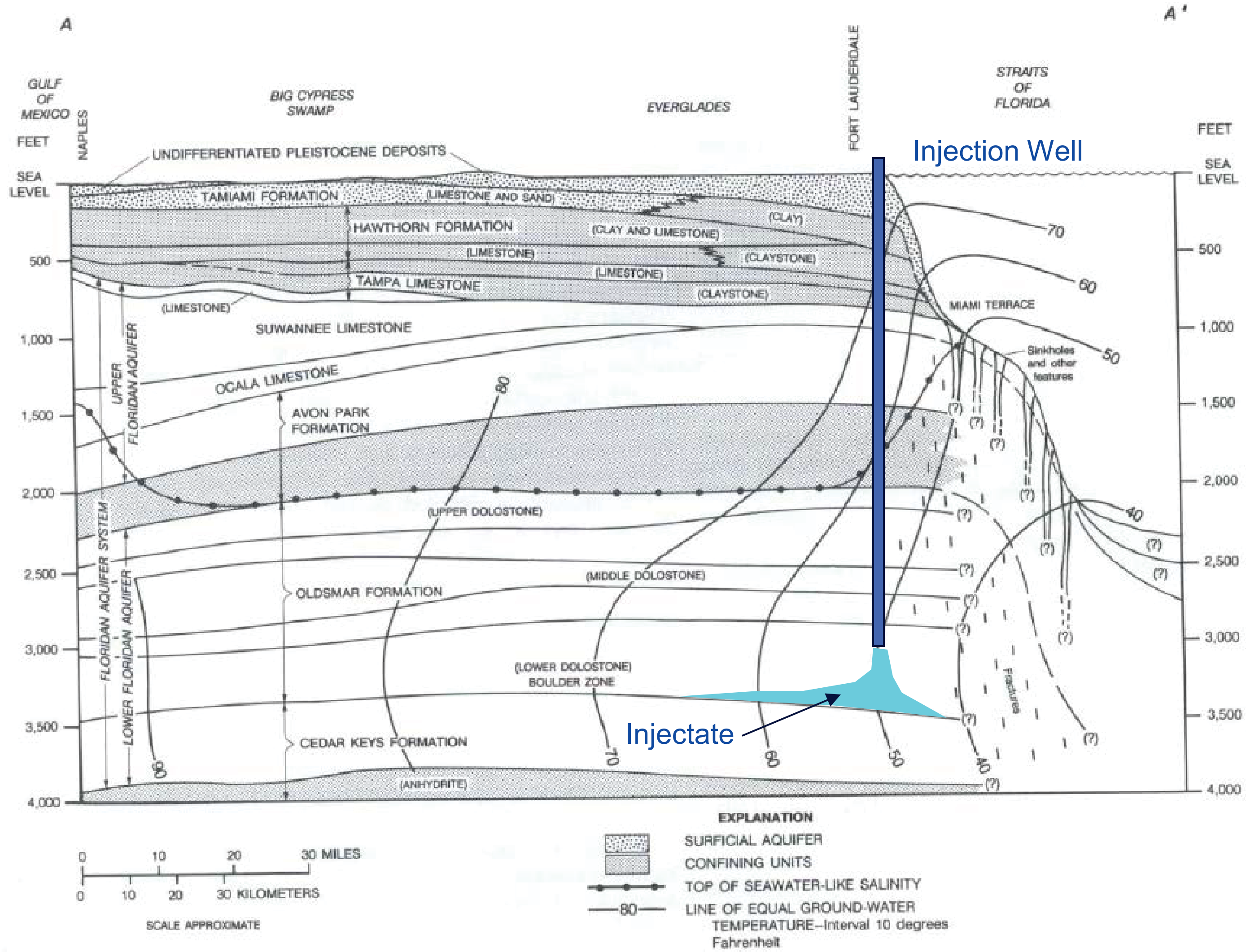
# Injectate Transport – Reclaimed Water Source



# Injectate Transport – Marine Water Source



# Postulated Injectate Fate and Transport

- **Initial spreading of injectate "bubble" governed by buoyancy-driven flow and geologic structure**
- **Dissolution of injectate into ambient groundwater with subsequent advective transport along ambient groundwater pathways and attenuation due to:**
  - Hydrodynamic dispersion
  - Retardation
  - Radioactive decay
- **Plausible groundwater pathways could:**
  - Be confined to the saline, Lower Floridan aquifer
    - No potential exposure
  - Include upwelling to the brackish, Upper Floridan aquifer
    - Travel times > 10,000 y



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