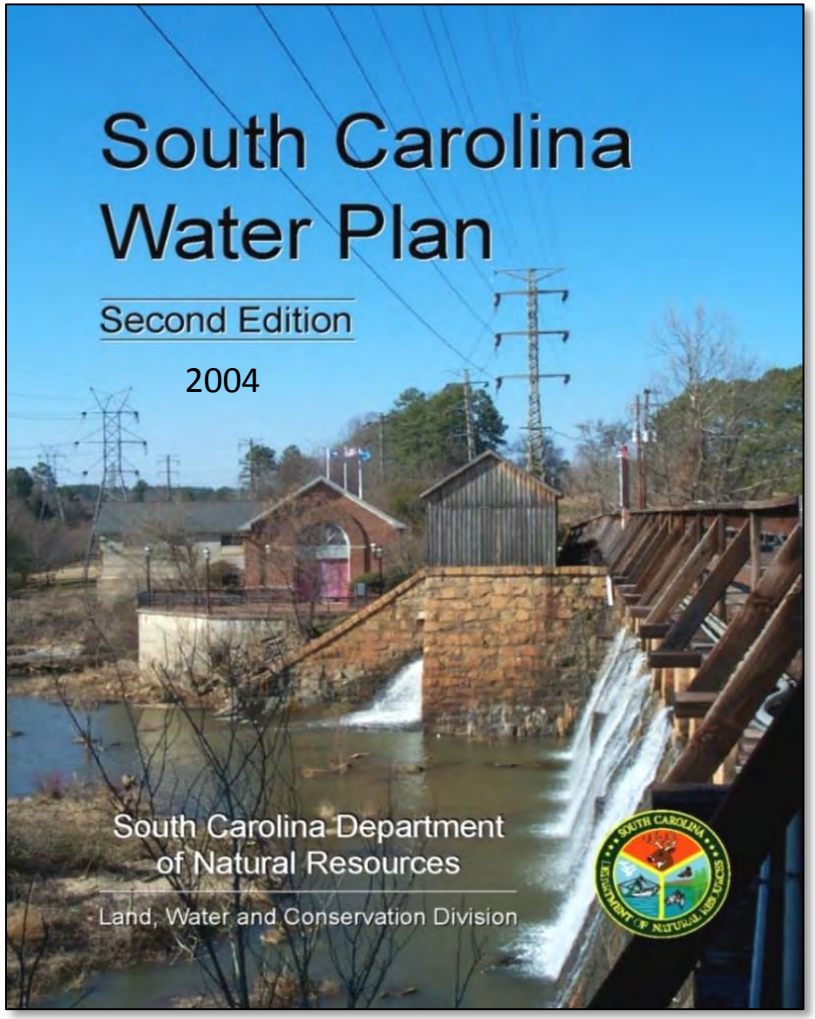
The Hydrogeologic Framework Developed for the South Carolina Coastal Plain Groundwater Flow Model

Groundwater TAC Meeting
Columbia, S.C.
May 17, 2018

Joe Gellici - Hydrologist
Land, Water and Conservation Division
S.C. Department of Natural Resources

Overview of the Water Planning Process

A Brief History…



- In 2004, DNR published the second edition of the South Carolina Water Plan incorporating lessons learned from the drought of 1998-2002.
- One recommendation was for the development of regional water plans for each major river basin in the State.
- 10 years later – SCDNR and SCDHEC initiated the first step towards these regional water plans

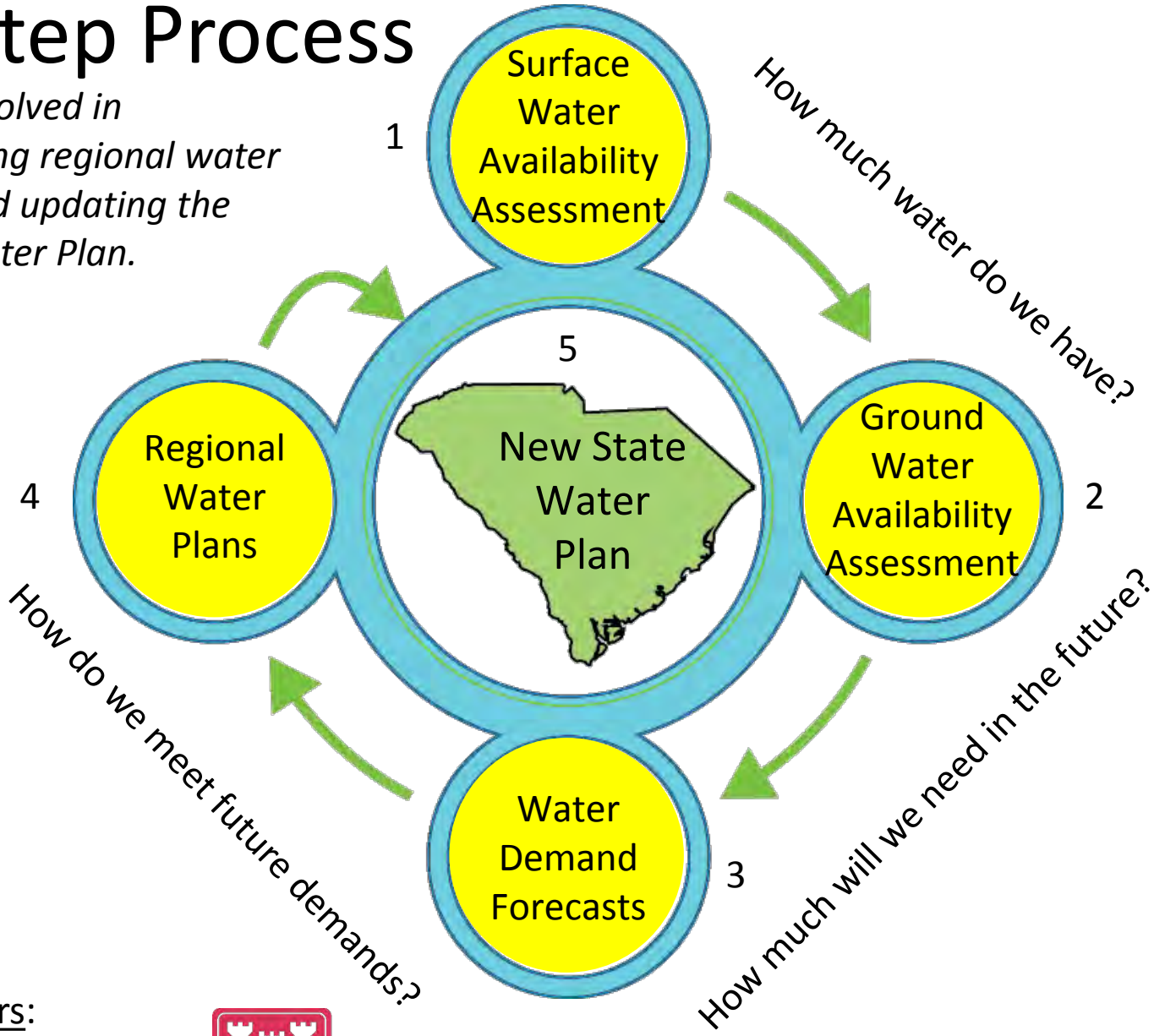
South Carolina's Major River Basins

The goal of water planning is to develop a water-resources management plan that ensures that an adequate and reliable supply of clean water will be available to sustain all future uses.

Water plans will be developed for each of these basins, the same basins used by DHEC for water-quality assessments and for managing interbasin transfers of water.

Five Step Process

Steps involved in developing regional water plans and updating the State Water Plan.



Cooperators:

dhec Healthy People. Healthy Communities.

US Army Corps of Engineers

CDM Smith

USGS science for a changing world

CLEMSON UNIVERSITY

STEP 1
Surface-Water Availability Assessment

Purpose: Develop surface-water quantity models for each basin.

- In August 2014, CDM Smith, Inc. was awarded a contract to develop surface-water quantity models for each basin using its *Simplified Water Allocation Model* (SWAM) modeling tool.
- Models inform us of how much surface water is available for future use and to test water-management strategies.
- Stakeholder meetings were facilitated by Clemson University with support from CDM Smith, DNR, and DHEC.

CDM Smith

John Boyer (lead)
Kirk Westphal
Tim Cox
Nina Caraway

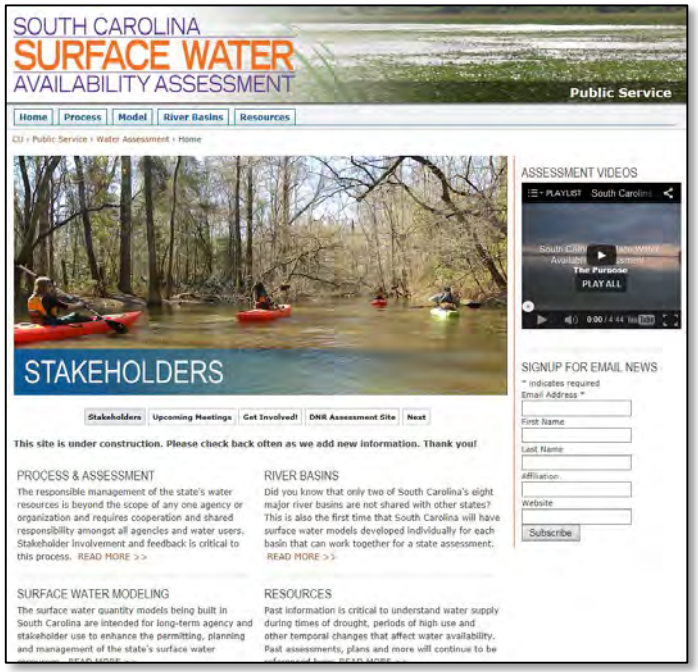
CLEMSON UNIVERSITY

Jeff Allen (lead)
Lori Dickes
Katie Callahan
Tom Walker

Surface-Water Availability Assessment

Stakeholder Meetings

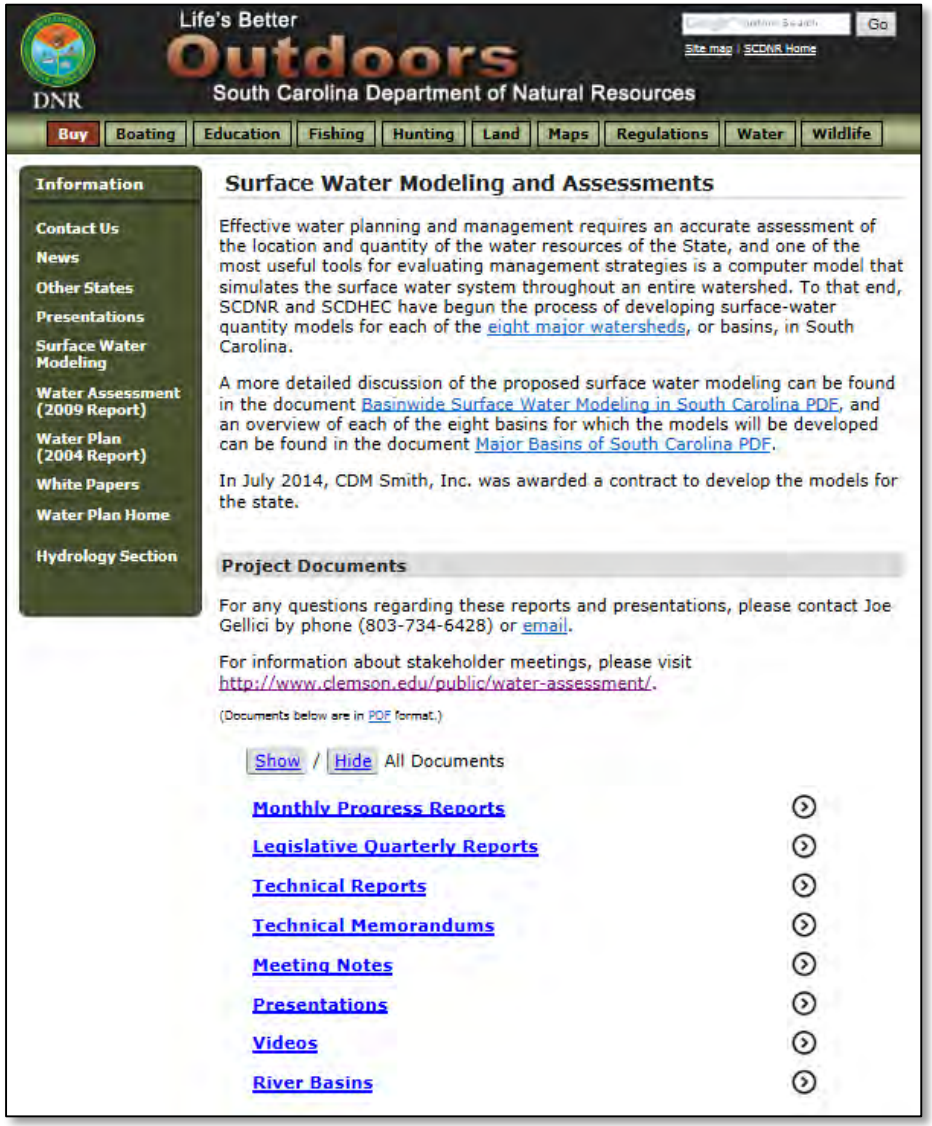
Saluda	#1	Greenville	Apr. 2015
	#2	Greenville	Dec. 2015
Edisto	#1	Blackville	June 2015
	#2	Blackville	Dec. 2015
Broad	#1	Spartanburg	Aug. 2015
	#2	Spartanburg	May 2016
Pee Dee	#1	Florence	Nov. 2015
	#2	Florence	May 2016
Catawba	#1	Rock Hill	Nov. 2015
	#2	Rock Hill	Nov. 2016
Santee	#1	Moncks Corner	Mar. 2016
	#2	Moncks Corner	Dec. 2016
Salkehatchie	#1-2	Walterboro	Aug. 2016
Savannah	#1	North Augusta	Aug. 2016
	#2	North Augusta	Feb. 2017



www.scwatermodels.com

Surface-Water Availability Assessment

DNR Webpage



[Monthly Progress Reports]

[Legislative Quarterly Reports]

[Technical Reports]

[Technical Memorandums]

[Meeting Notes]

[Presentations]

[Videos]

[River Basins]

- Broad
- Catawba
- Edisto
- Pee Dee
- Salkehatchie
- Saluda
- Santee
- Savannah

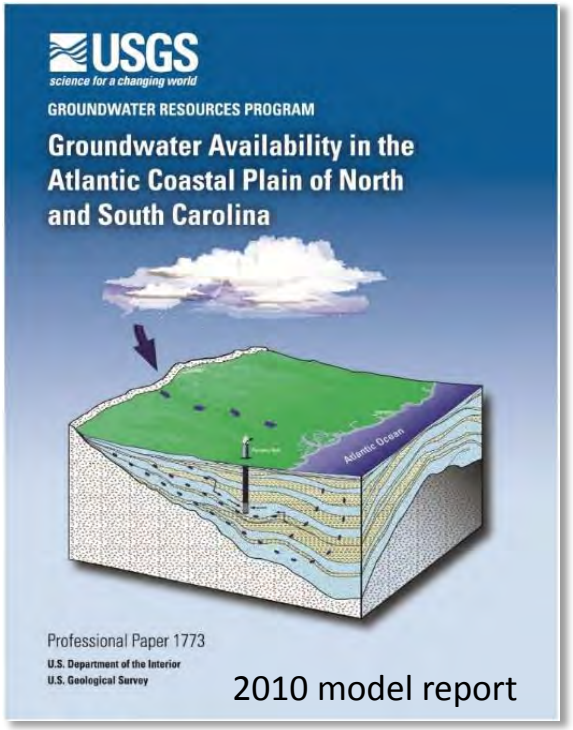
http://www.dnr.sc.gov/water/waterplan/surfacewater.html

STEP 2

Groundwater Availability Assessment

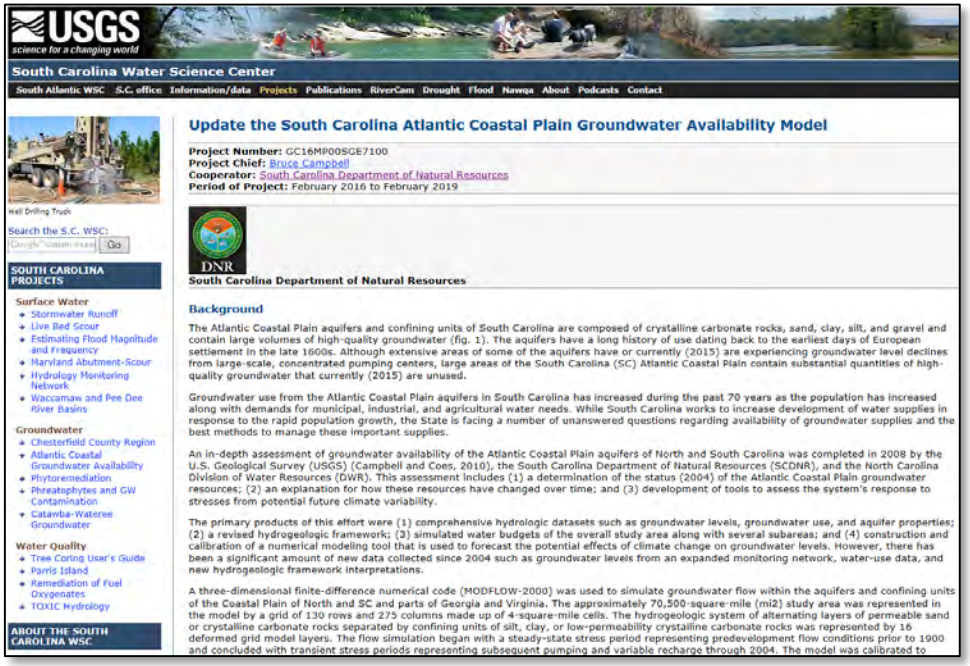
Purpose: Update the 2010 groundwater flow model of the Coastal Plain.

https://pubs.usgs.gov/pp/1773/



2010 model report

USGS webpage for the project:
https://www.usgs.gov/centers/sa-water/science/update-south-carolina-atlantic-coastal-plain-groundwater-availability-0?qt-science_center_objects=0#qt-science_center_objects



Model update is scheduled to be completed by February 2019.

USGS science for a changing world

DNR

STEP 3
Water-Demand Forecasts

Purpose: Develop water-demand forecasts for each of the 8 basins.

SCDNR is working with the USACE (Charleston) and Clemson to develop water-demand forecasts for each basin.

Forecasts from 2015-2065 in 5- and 10-year intervals for:

1. Public supply
2. Domestic supply
3. Agriculture
4. Industry
5. Power
6. Golf Course

Have recently met with these groups:

- Water Works Association, Utility Council
- Chamber of Commerce, Environmental Committee
- Farm Bureau, Water Committee
- Water Quality Association

US Army Corps of Engineers

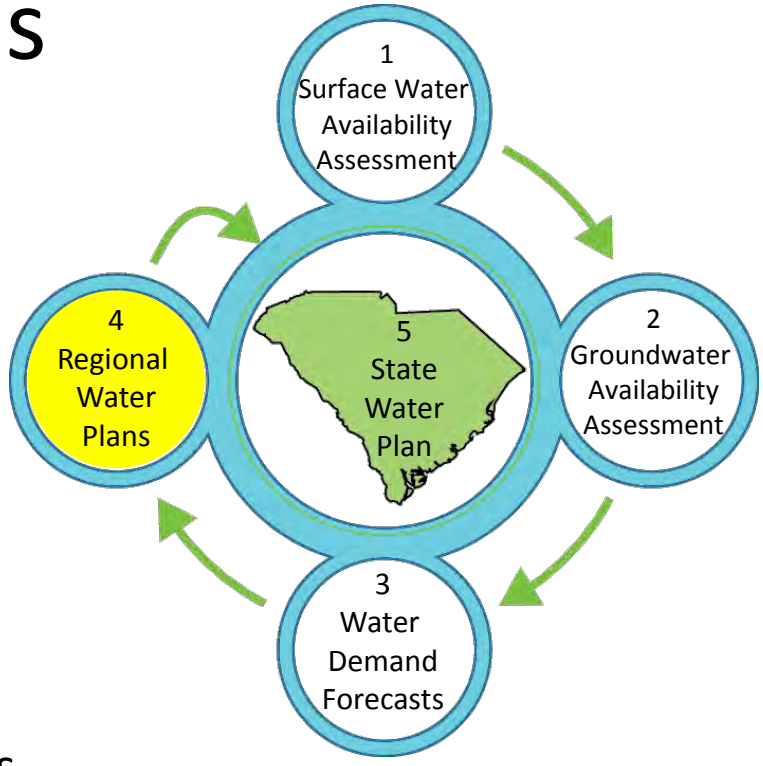
DNR

CLEMSON UNIVERSITY

STEP 4

Regional Water Plans

Using the models and forecasts, and with oversight from State agencies, stakeholders will begin the process of developing regional water plans for each basin.

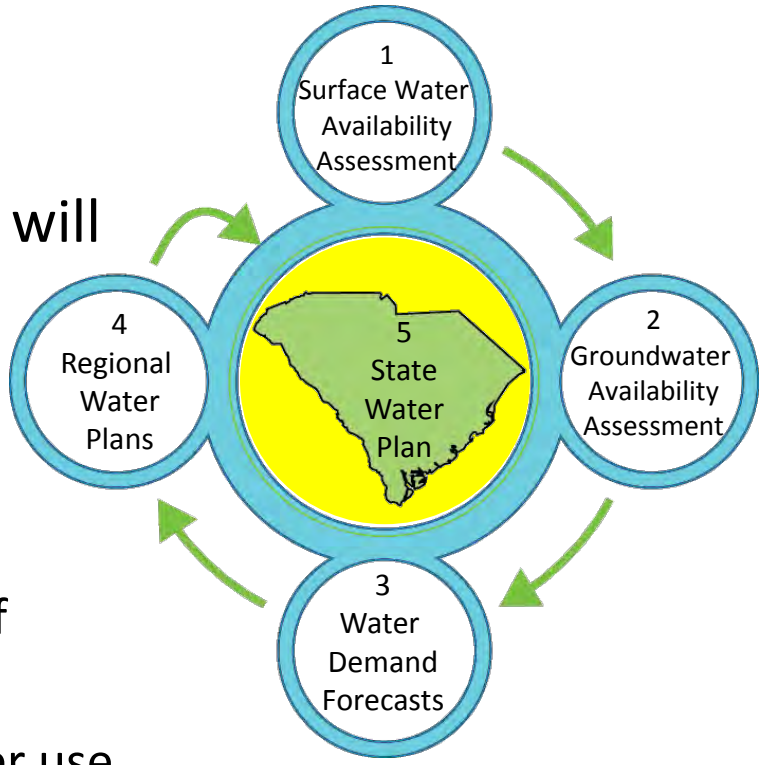


This step includes:

- The formation of basin advisory councils
- An analysis to determine if any water deficits will occur
- An assessment of management strategies to meet the future demands
- Water conservation and drought management recommendations

STEP 5
State Water Plan

Upon completion of the regional water plans, the State water plan will be updated by DNR.

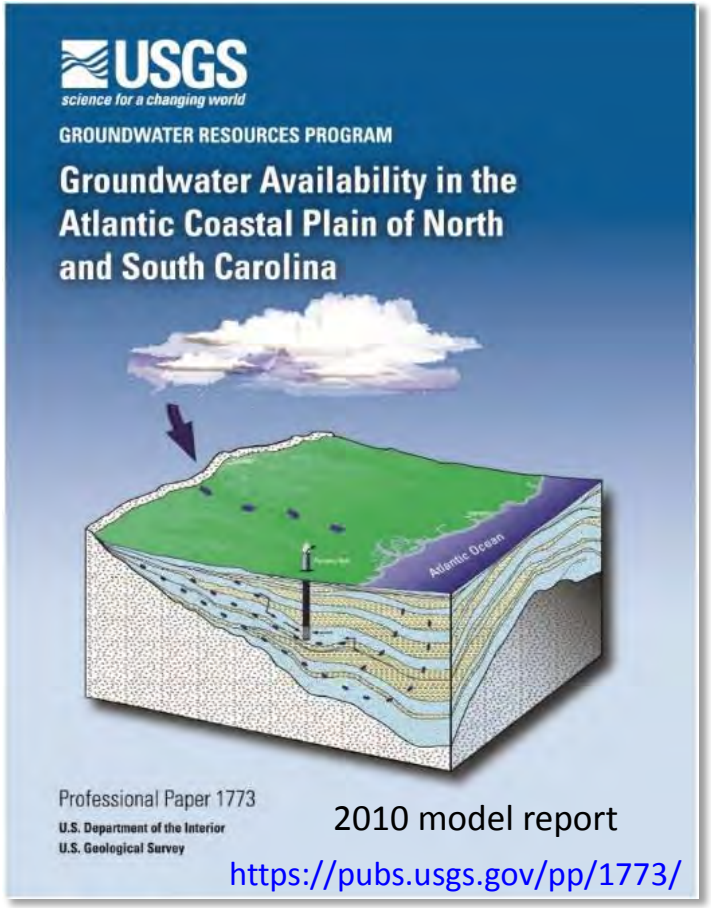


This step includes:

- Assessment of the overall condition of water resources in the State
- Evaluation of statewide trends in water use and availability
- Offering water-resource policy and program recommendations
- Introducing innovative practices

Step 2. Groundwater Availability Assessment

Purpose: To update the 2010 groundwater flow model of the Coastal Plain.



2010 model report

https://pubs.usgs.gov/pp/1773/

Hydrogeologic Framework
Joe Gellici, DNR

Groundwater Recharge Model
Alex Butler, DHEC

Groundwater Flow Model
Bruce Campbell, USGS

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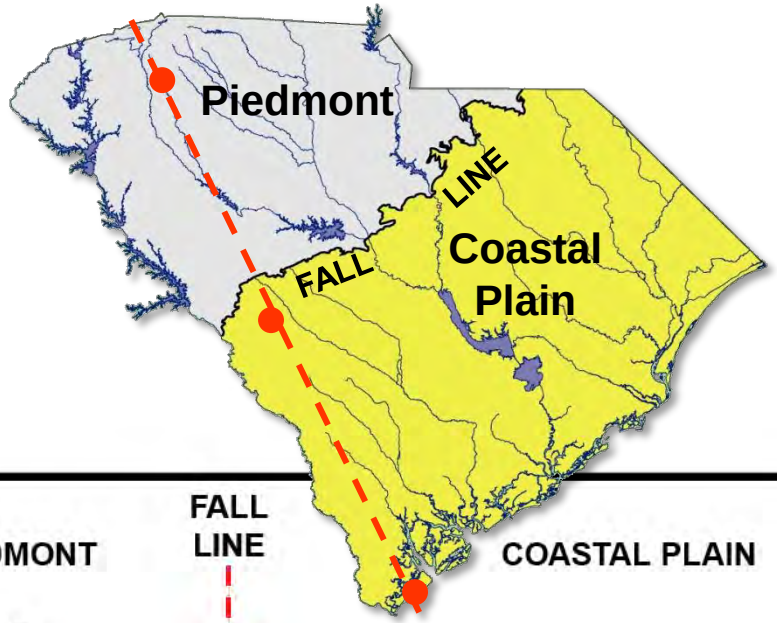
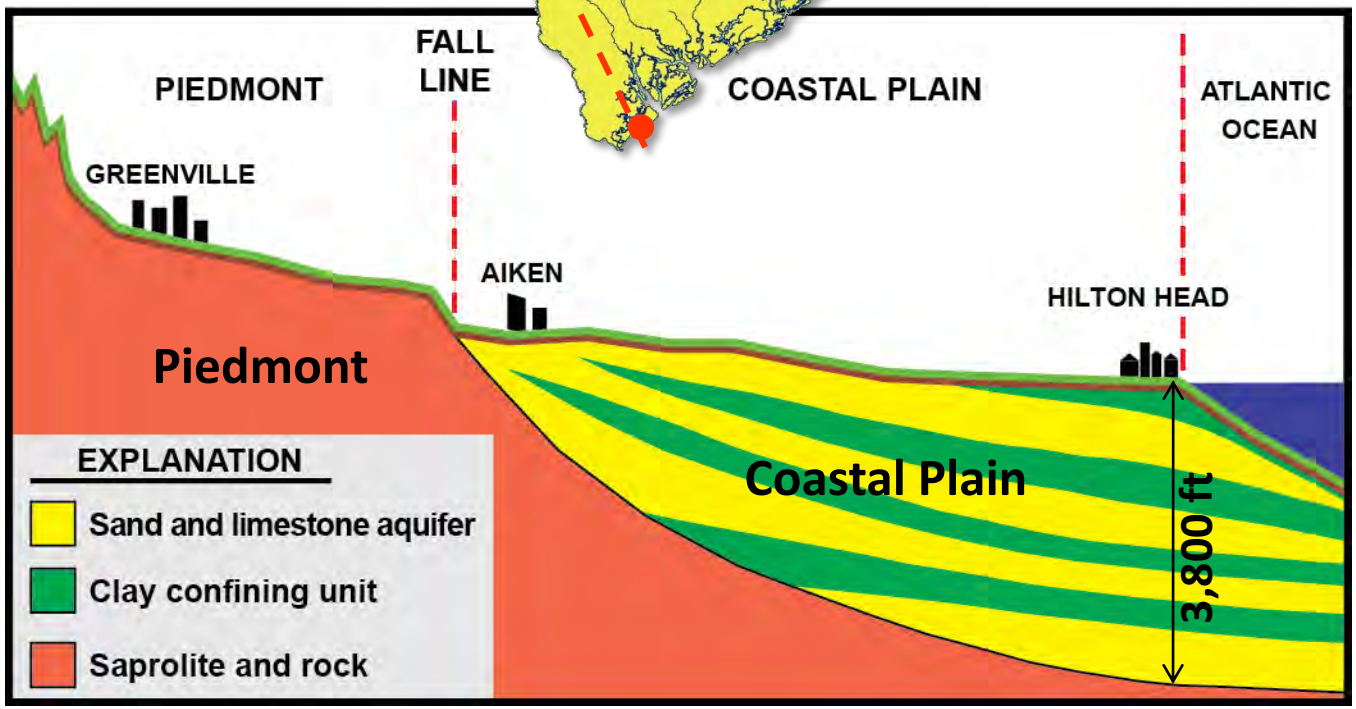
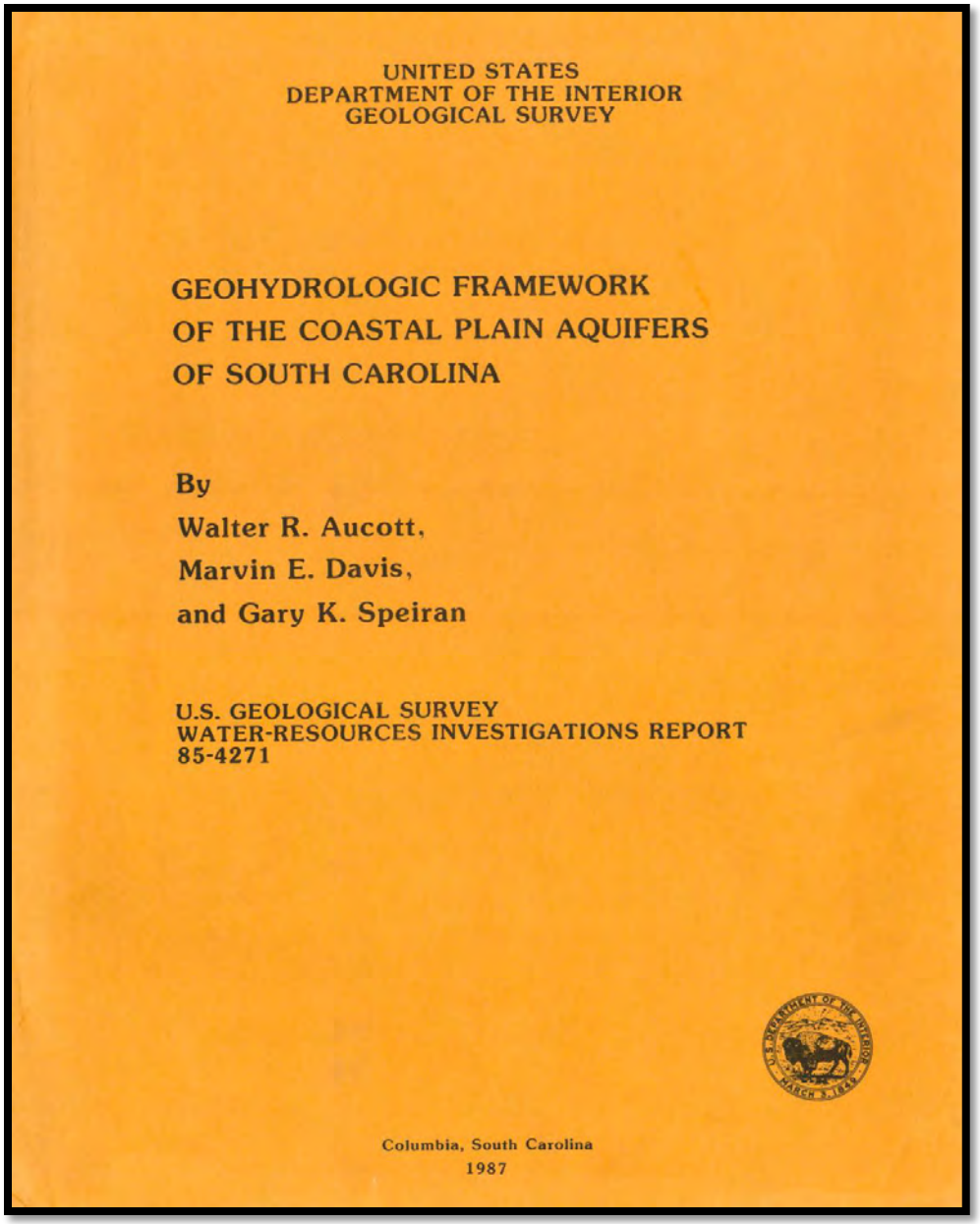
US Army Corps of Engineers

Hydrogeologic Framework



A hydrogeologic framework describes the spatial distribution of the aquifers and confining units that control the occurrence and availability of groundwater in the Coastal Plain.

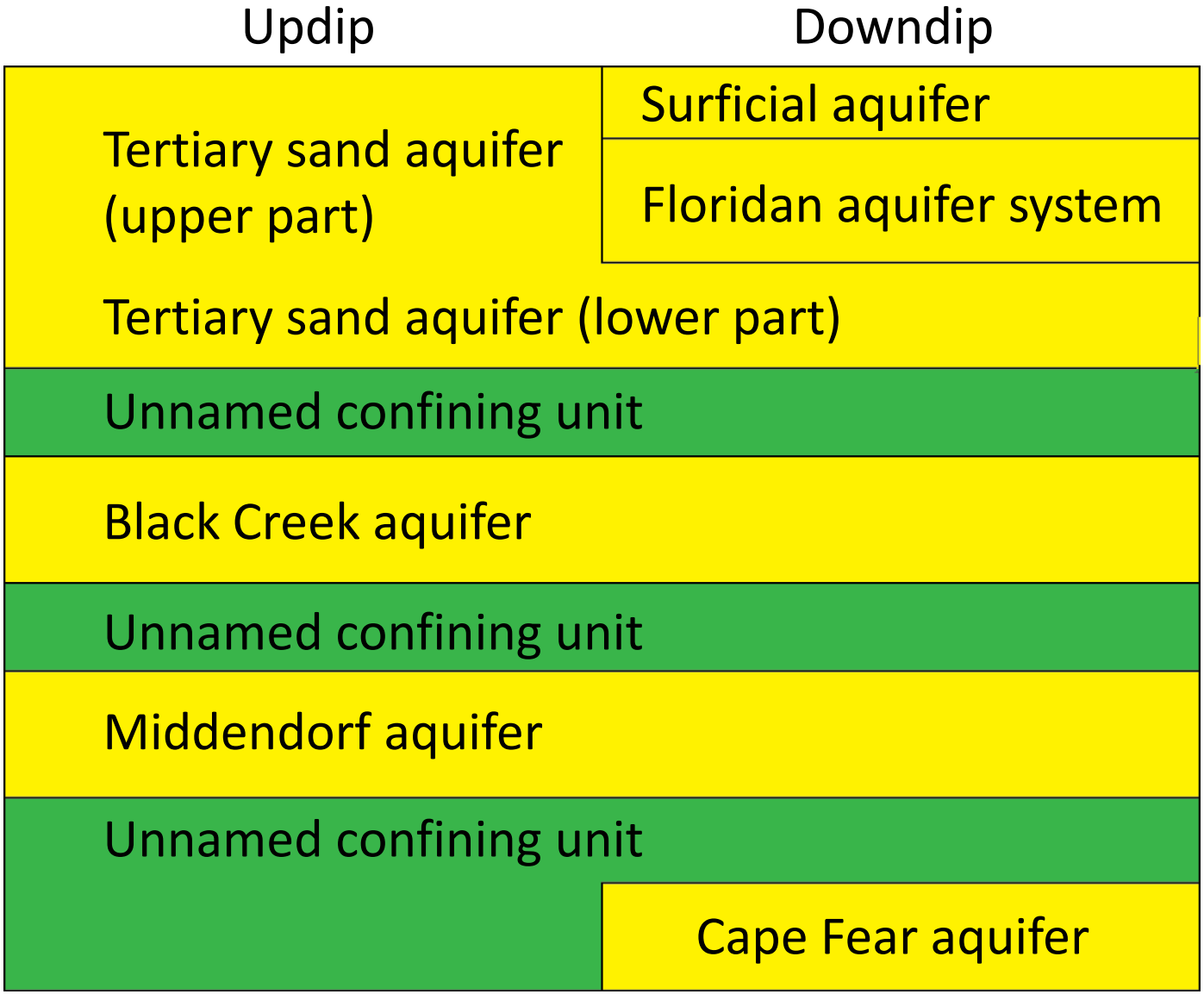




Geohydrologic Framework of the Coastal Plain Aquifers of South Carolina

W. R. Aucott, M. E. Davis, and G. K. Speiran, 1987

Aucott, Davis, and Speiran (1987)

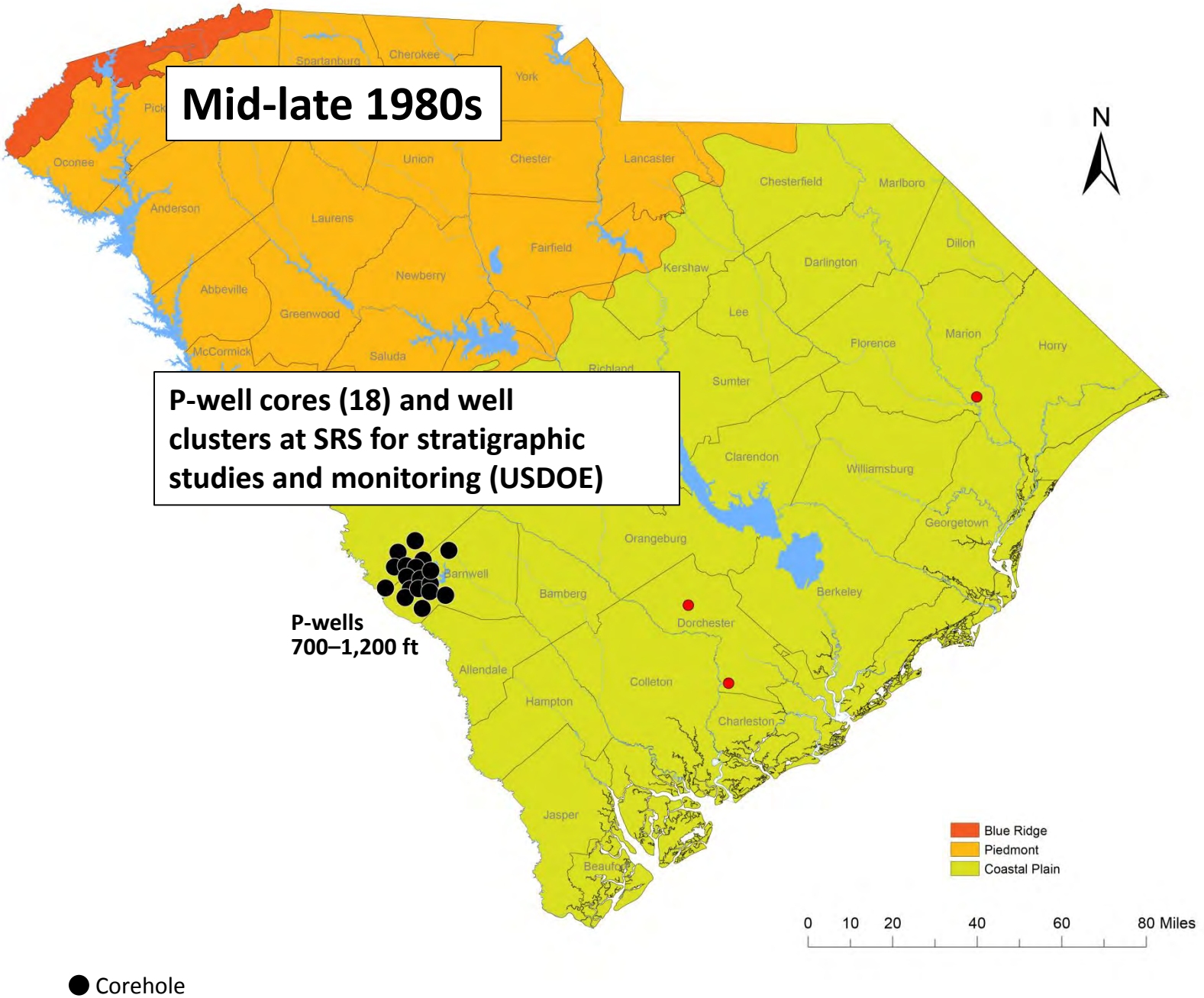


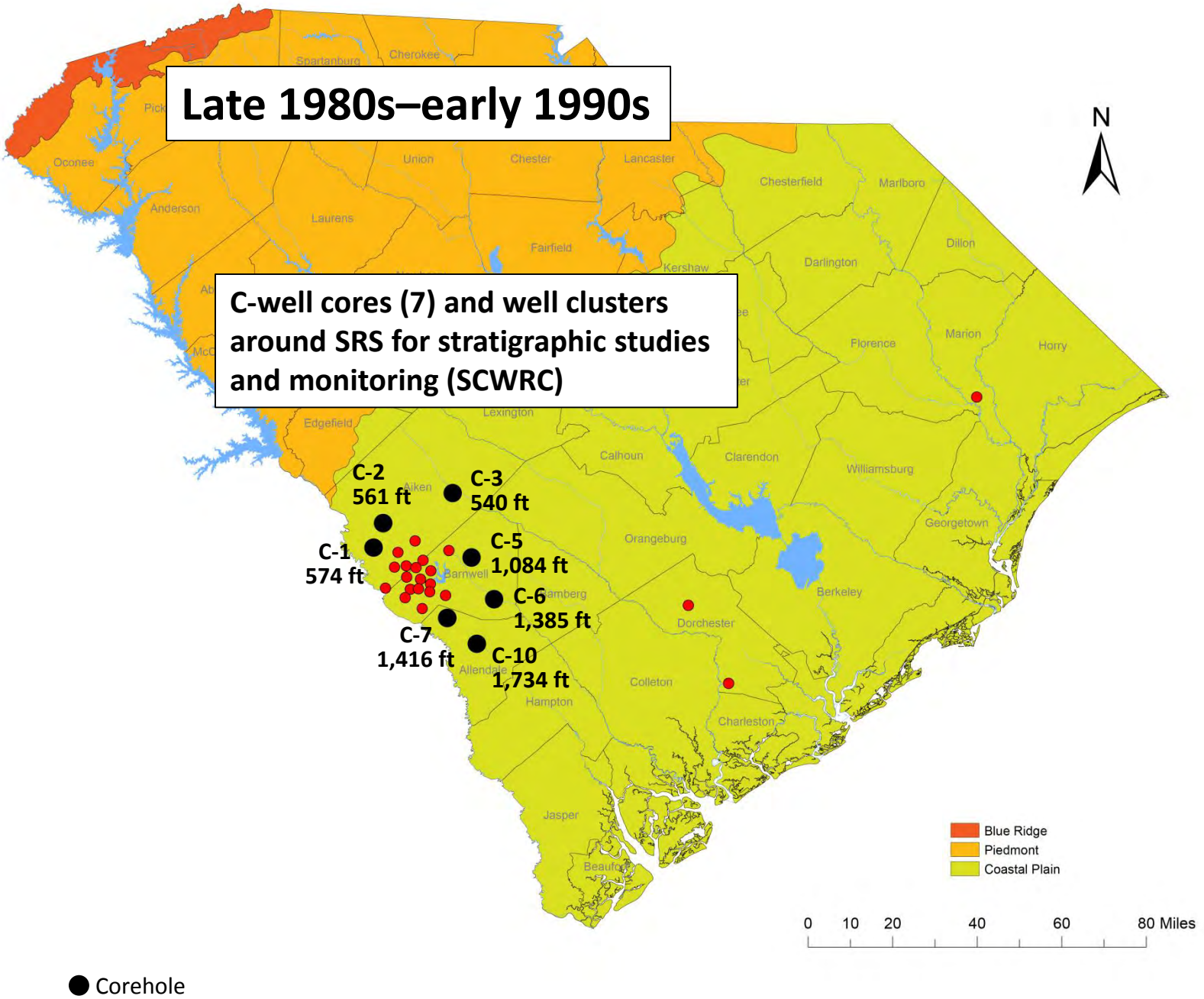
South Carolina Committee on Stratigraphic and Hydrologic Nomenclature

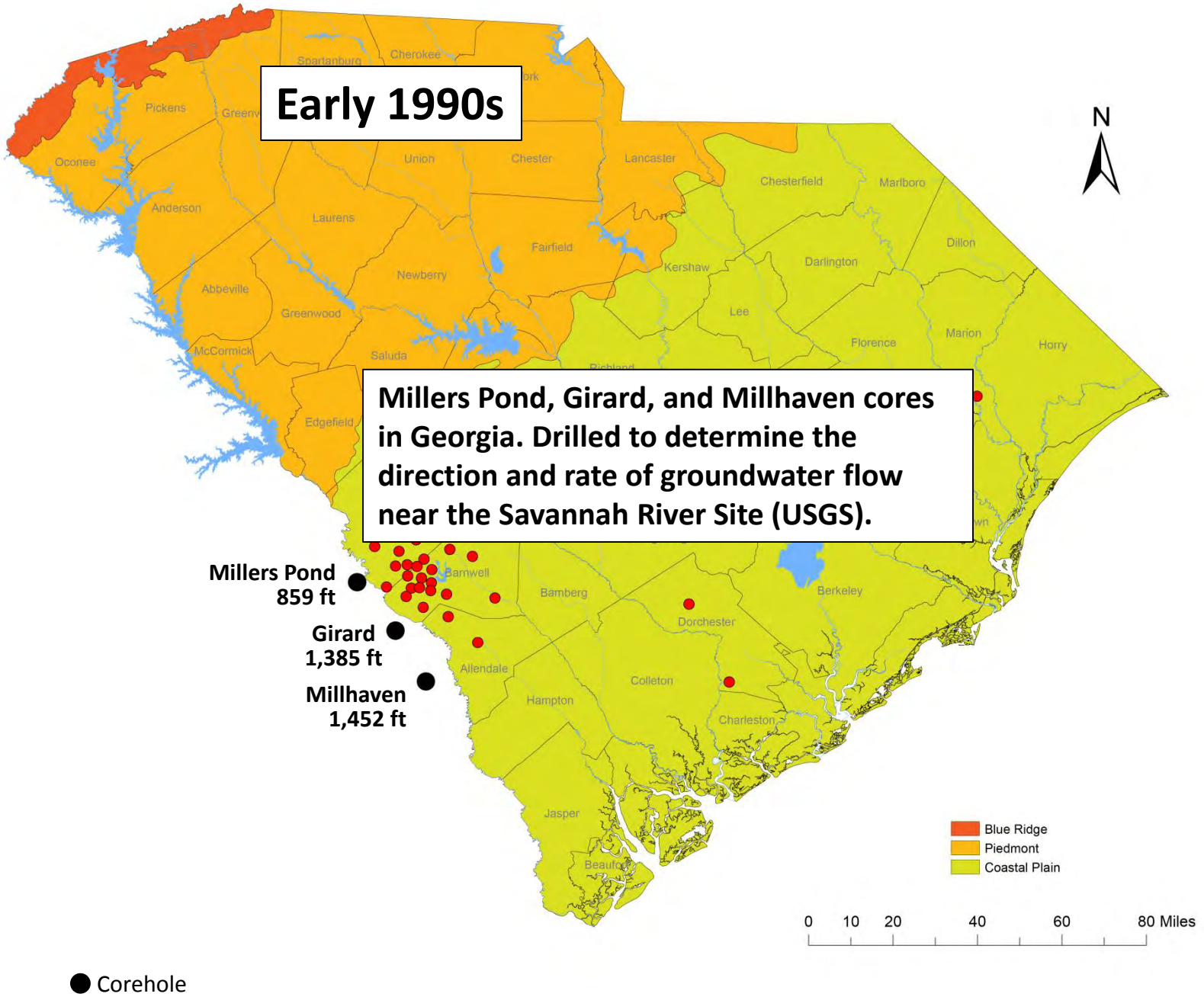
- Formed in the late 1980s to standardize the geologic and hydrologic nomenclature in the State.
- Composed of geologists and hydrologists from government, private industry, and academia.
- Divided into two subcommittees: Stratigraphic and Hydrostratigraphic.

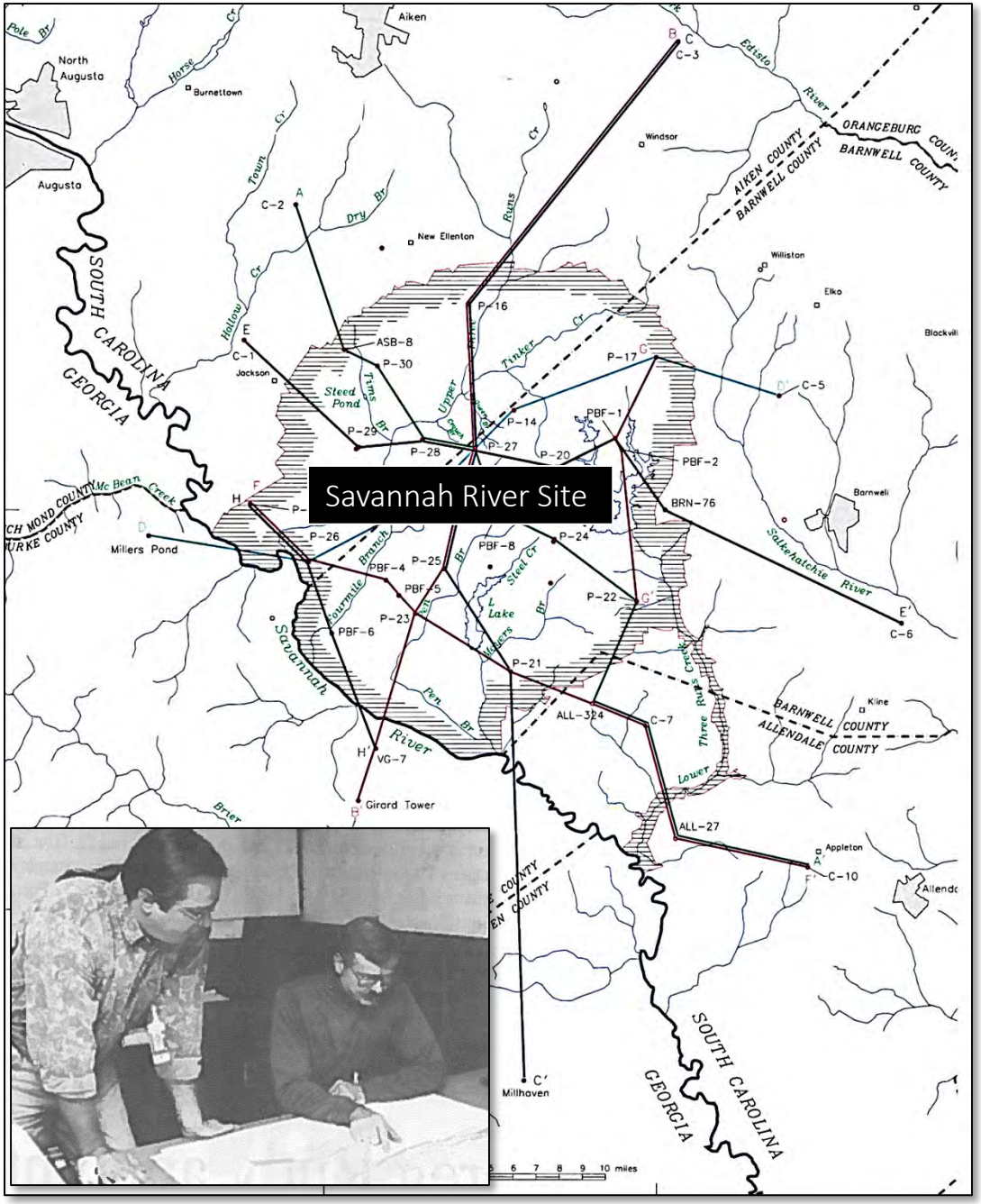
Hydrostratigraphic Subcommittee

- Aquifers be named independently of geologic formations.
- Aquifers be named after geographic or cultural features where the aquifer is well-defined and utilized.
- Confining units be named after the aquifer they confine.
- Wells that penetrate sediments representative of the aquifer be established as type wells.
- To be formally named, aquifers must have a minimal areal extent of 400 square miles.


Mid-late 1980s
P-well cores (18) and well clusters at SRS for stratigraphic studies and monitoring (USDOE)
P-wells
700–1,200 ft
Spartanburg
Cherokee
York
Oconee
Union
Chester
Lancaster
Anderson
Laurens
Fairfield
Newberry
Abbeville
Greenwood
McCormick
Saluda
Chesterfield
Marlboro
Dillon
Darlington
Kershaw
Lee
Florence
Marion
Horry
Sumter
Clarendon
Williamsburg
Georgetown
Orangeburg
Barnwell
Bamberg
Berkeley
Dorchester
Allendale
Colleton
Hampton
Charleston
Jasper
Beaufort
N
Blue Ridge
Piedmont
Coastal Plain
0 10 20 40 60 80 Miles
Corehole

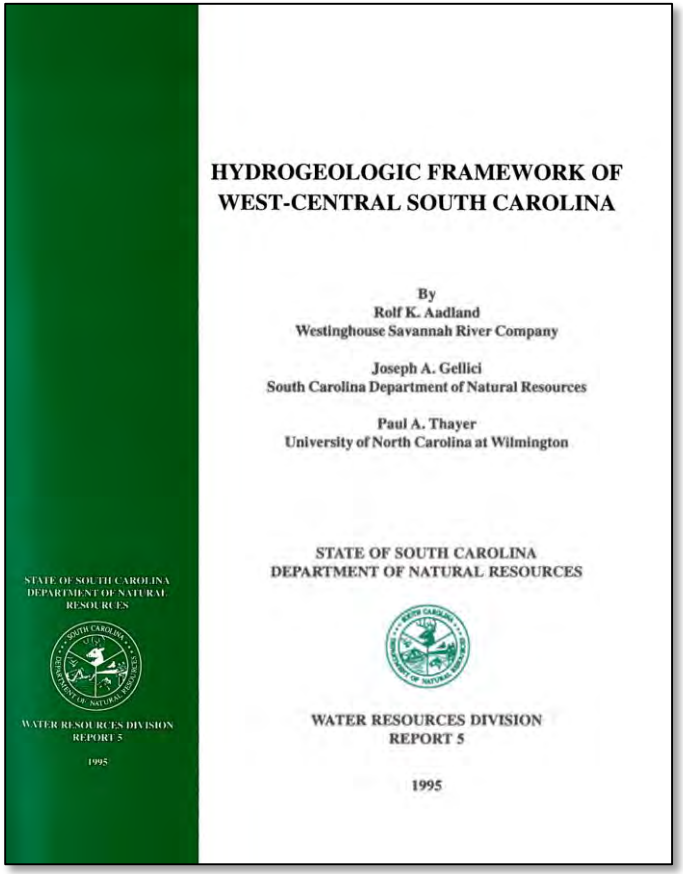

Late 1980s–early 1990s
C-well cores (7) and well clusters around SRS for stratigraphic studies and monitoring (SCWRC)
C-2
561 ft
C-3
540 ft
C-1
574 ft
C-5
1,084 ft
C-6
1,385 ft
C-7
1,416 ft
C-10
1,734 ft
N
Blue Ridge
Piedmont
Coastal Plain
0 10 20 40 60 80 Miles
Corehole


Early 1990s
Millers Pond, Girard, and Millhaven cores in Georgia. Drilled to determine the direction and rate of groundwater flow near the Savannah River Site (USGS).
Millers Pond
859 ft
Girard
1,385 ft
Millhaven
1,452 ft
N
Spartanburg
Cherokee
Pickens
Greenv
Oconee
Union
Chester
Lancaster
Anderson
Laurens
Fairfield
Chesterfield
Marlboro
Dillon
Darlington
Kershaw
Newberry
Abbeville
Greenwood
Lee
Florence
Marion
Horry
McCormick
Saluda
Edgefield
Barnwell
Bamberg
Berkeley
Dorchester
Allendale
Colleton
Hampton
Charleston
Jasper
Beaufo
Blue Ridge
Piedmont
Coastal Plain
0 10 20 40 60 80 Miles
Corehole

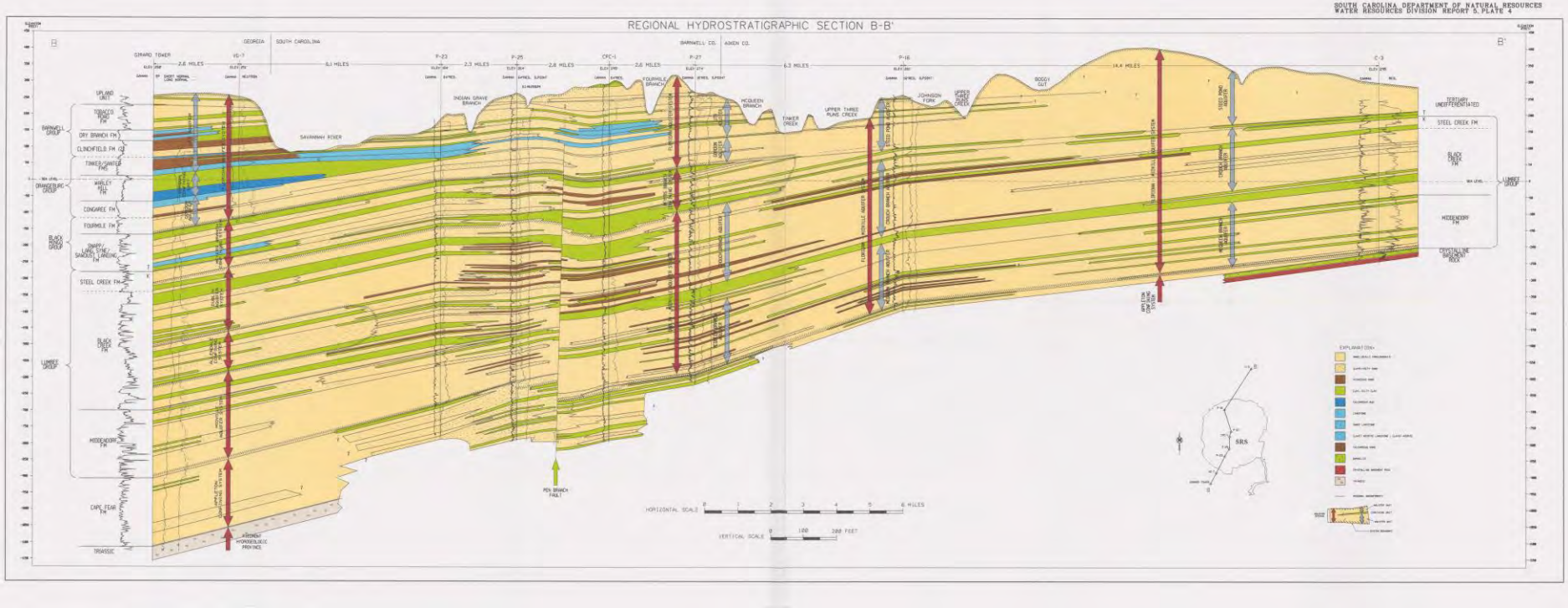


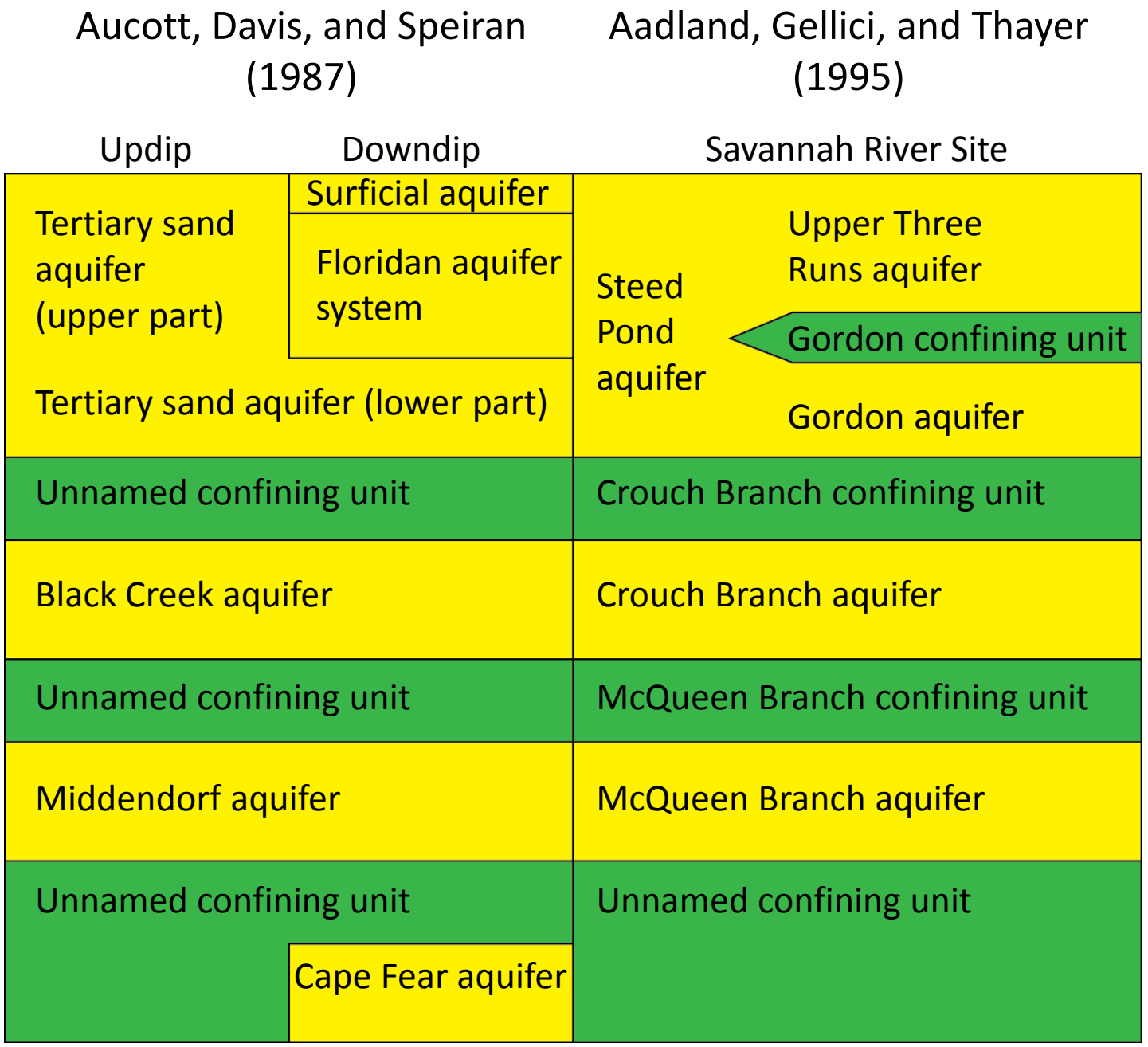
Eight hydrogeologic sections were drawn transecting the Savannah River Site and extending out to the C-well and Georgia coreholes.

A new hydrostratigraphic nomenclature and classification scheme was introduced.



REGIONAL HYDROSTRATIGRAPHIC SECTION B-B'




Aucott, Davis, and Speiran (1987)
Aadland, Gellici, and Thayer (1995)
Updip
Downdip
Savannah River Site
Surficial aquifer
Tertiary sand aquifer (upper part)
Floridan aquifer system
Tertiary sand aquifer (lower part)
Steed Pond aquifer
Upper Three Runs aquifer
Gordon confining unit
Gordon aquifer
Unnamed confining unit
Crouch Branch confining unit
Black Creek aquifer
Crouch Branch aquifer
Unnamed confining unit
McQueen Branch confining unit
Middendorf aquifer
McQueen Branch aquifer
Unnamed confining unit
Cape Fear aquifer
Unnamed confining unit

Southeastern Coastal Plain Project (USGS/DNR - 1995)

Subsurface Geology, Paleontology, and Geologic Mapping in the Carolinas and Georgia Coastal Plains

Biostratigraphy

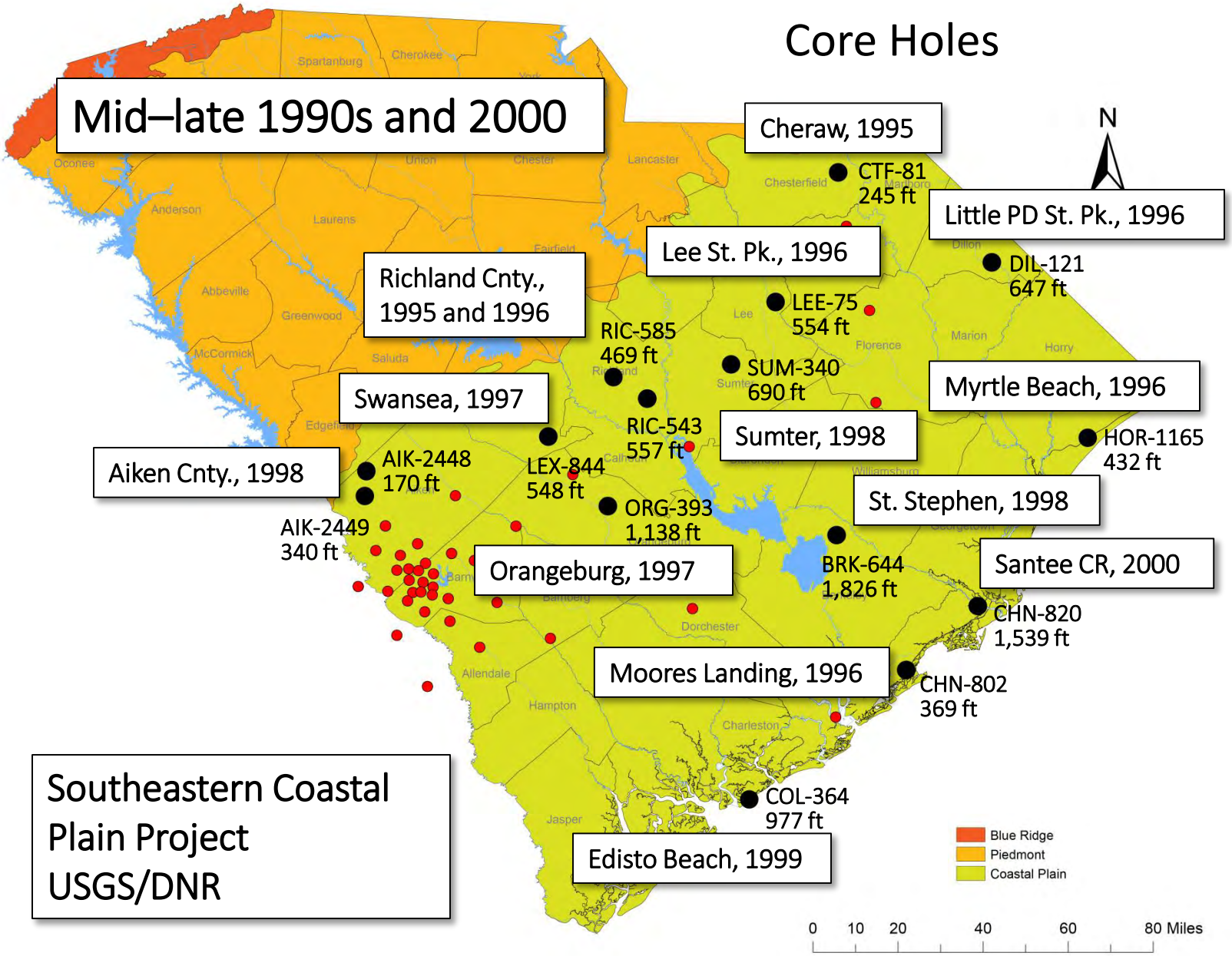
- Raymond A. Christopher (Clemson University, retired) Cretaceous palynomorphs
- Laurel M. Bybell (USGS, retired) Tertiary calcareous nannofossils
- Norman O. Frederiksen (USGS, retired) Tertiary palynomorphs
- Lucy E. Edwards (USGS) Tertiary palynomorphs
- Jean M. Self-Trail (USGS) Cretaceous calcareous nannofossils

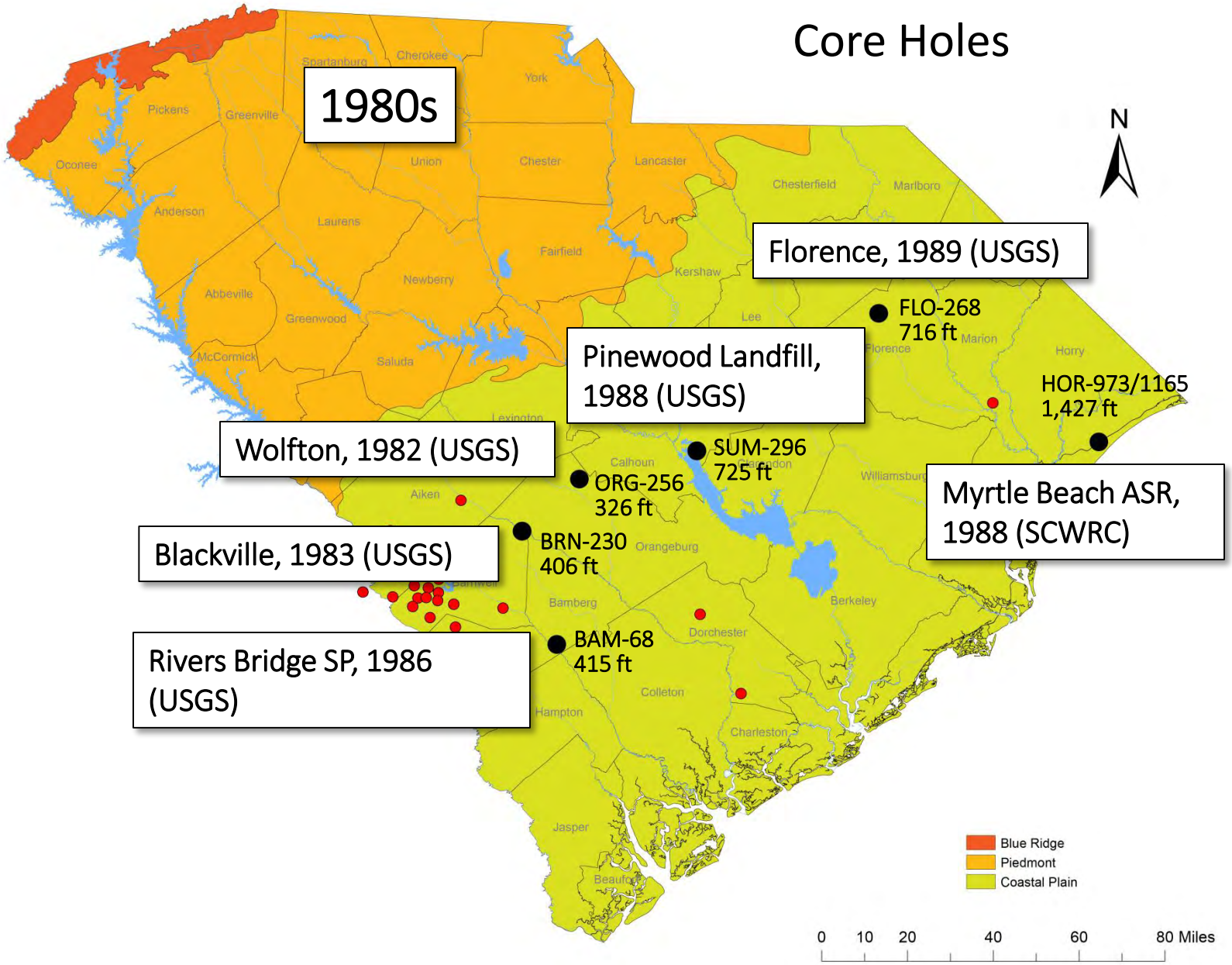
Allostratigraphy

- David C. Prowell (USGS, retired)
- Gregory S. Gohn (USGS, retired)

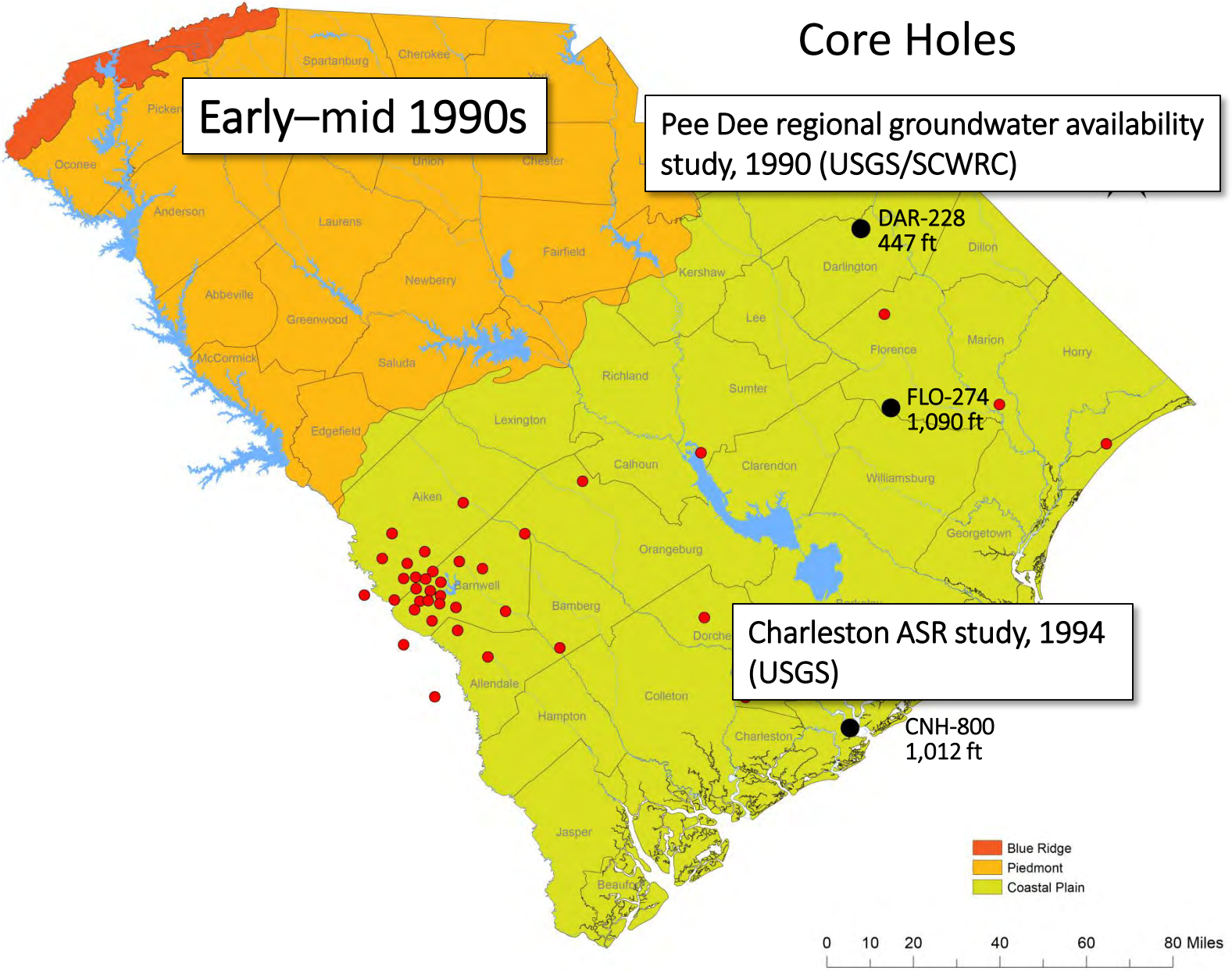
Hydrostratigraphy

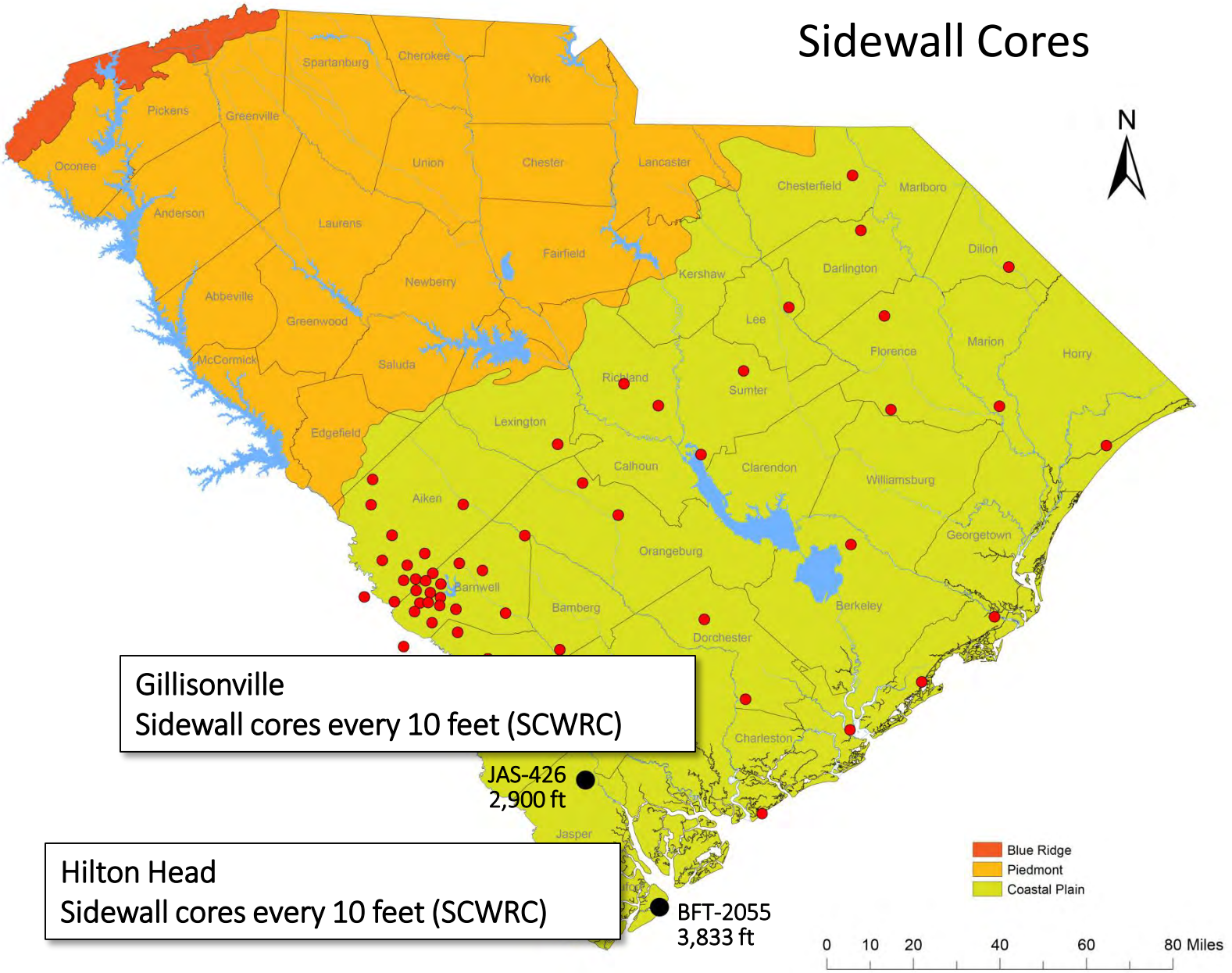
- Joseph A. Gellici (SCDNR)
- Karen E. Agerton (SCDNR)

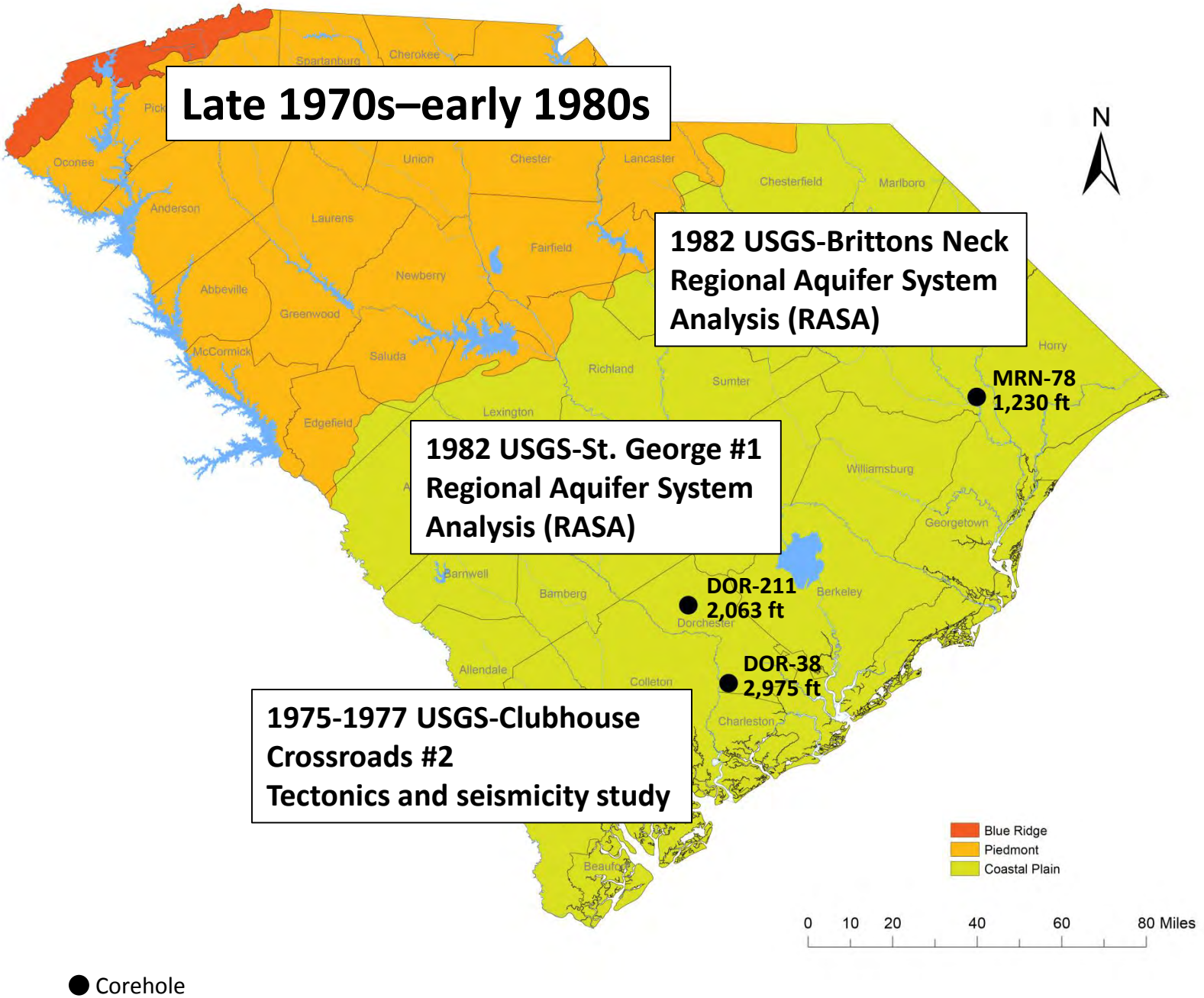

Core Holes
Mid–late 1990s and 2000
Cheraw, 1995
CTF-81
245 ft
Little PD St. Pk., 1996
Lee St. Pk., 1996
DIL-121
647 ft
Richland Cnty.,
1995 and 1996
LEE-75
554 ft
RIC-585
469 ft
SUM-340
690 ft
Myrtle Beach, 1996
Swansea, 1997
RIC-543
557 ft
Sumter, 1998
HOR-1165
432 ft
Aiken Cnty., 1998
AIK-2448
170 ft
LEX-844
548 ft
St. Stephen, 1998
ORG-393
1,138 ft
AIK-2449
340 ft
Orangeburg, 1997
BRK-644
1,826 ft
Santee CR, 2000
CHN-820
1,539 ft
Moores Landing, 1996
CHN-802
369 ft
COL-364
977 ft
Edisto Beach, 1999
Southeastern Coastal
Plain Project
USGS/DNR
N
Blue Ridge
Piedmont
Coastal Plain
0 10 20 40 60 80 Miles


Core Holes
1980s
Florence, 1989 (USGS)
FLO-268
716 ft
Pinewood Landfill,
1988 (USGS)
HOR-973/1165
1,427 ft
Wolfton, 1982 (USGS)
SUM-296
725 ft
ORG-256
326 ft
Myrtle Beach ASR,
1988 (SCWRC)
Blackville, 1983 (USGS)
BRN-230
406 ft
BAM-68
415 ft
Rivers Bridge SP, 1986
(USGS)
N
Blue Ridge
Piedmont
Coastal Plain
0 10 20 40 60 80 Miles
Spartanburg
Cherokee
York
Pickens
Greenville
Oconee
Union
Chester
Lancaster
Chesterfield
Marlboro
Anderson
Laurens
Fairfield
Kershaw
Newberry
Abbeville
Greenwood
Lee
Marion
Florence
Horry
McCormick
Saluda
Lexington
Calhoun
Williamsburg
Aiken
Orangeburg
Bamberg
Berkeley
Dorchester
Colleton
Hampton
Charleston
Jasper
Beaufort

Core Holes


Early–mid 1990s
Pee Dee regional groundwater availability study, 1990 (USGS/SCWRC)
DAR-228
447 ft
FLO-274
1,090 ft
Charleston ASR study, 1994 (USGS)
CNH-800
1,012 ft
Spartanburg
Cherokee
Oconee
Anderson
Laurens
Union
Chester
Fairfield
Newberry
Abbeville
Greenwood
McCormick
Saluda
Edgefield
Lexington
Richland
Kershaw
Lee
Sumter
Darlington
Dillon
Florence
Marion
Horry
Williamsburg
Georgetown
Clarendon
Calhoun
Orangeburg
Aiken
Barnwell
Bamberg
Allendale
Hampton
Colleton
Charleston
Jasper
Blue Ridge
Piedmont
Coastal Plain
0 10 20 40 60 80 Miles


Sidewall Cores
N
Spartanburg
Cherokee
York
Pickens
Greenville
Oconee
Union
Chester
Lancaster
Anderson
Laurens
Fairfield
Newberry
Abbeville
Greenwood
McCormick
Saluda
Edgefield
Lexington
Aiken
Barnwell
Bamberg
Orangeburg
Calhoun
Clarendon
Sumter
Richland
Kershaw
Lee
Chesterfield
Marlboro
Darlington
Dillon
Florence
Marion
Horry
Williamsburg
Georgetown
Berkeley
Dorchester
Charleston
Jasper
Gillisonville
Sidewall cores every 10 feet (SCWRC)
JAS-426
2,900 ft
Hilton Head
Sidewall cores every 10 feet (SCWRC)
BFT-2055
3,833 ft
Blue Ridge
Piedmont
Coastal Plain
0 10 20 40 60 80 Miles


Late 1970s–early 1980s
1982 USGS-Brittons Neck Regional Aquifer System Analysis (RASA)
1982 USGS-St. George #1 Regional Aquifer System Analysis (RASA)
1975-1977 USGS-Clubhouse Crossroads #2 Tectonics and seismicity study
MRN-78 1,230 ft
DOR-211 2,063 ft
DOR-38 2,975 ft
N
Blue Ridge
Piedmont
Coastal Plain
0 10 20 40 60 80 Miles
Corehole
Spartanburg
Cherokee
Oconee
Union
Chester
Lancaster
Chesterfield
Marlboro
Anderson
Laurens
Fairfield
Newberry
Abbeville
Greenwood
McCormick
Saluda
Edgefield
Lexington
Richland
Sumter
Horry
Williamsburg
Georgetown
Barnwell
Bamberg
Berkeley
Dorchester
Allendale
Colleton
Charleston
Beaufort

Rock/sediment repository at the S.C. Geological Survey

Photograph courtesy of Michael Foster, S.C. Wildlife Magazine

Aquifer Delineation

Mapping the aquifers and confining units of the Coastal Plain.

Core holes (43)

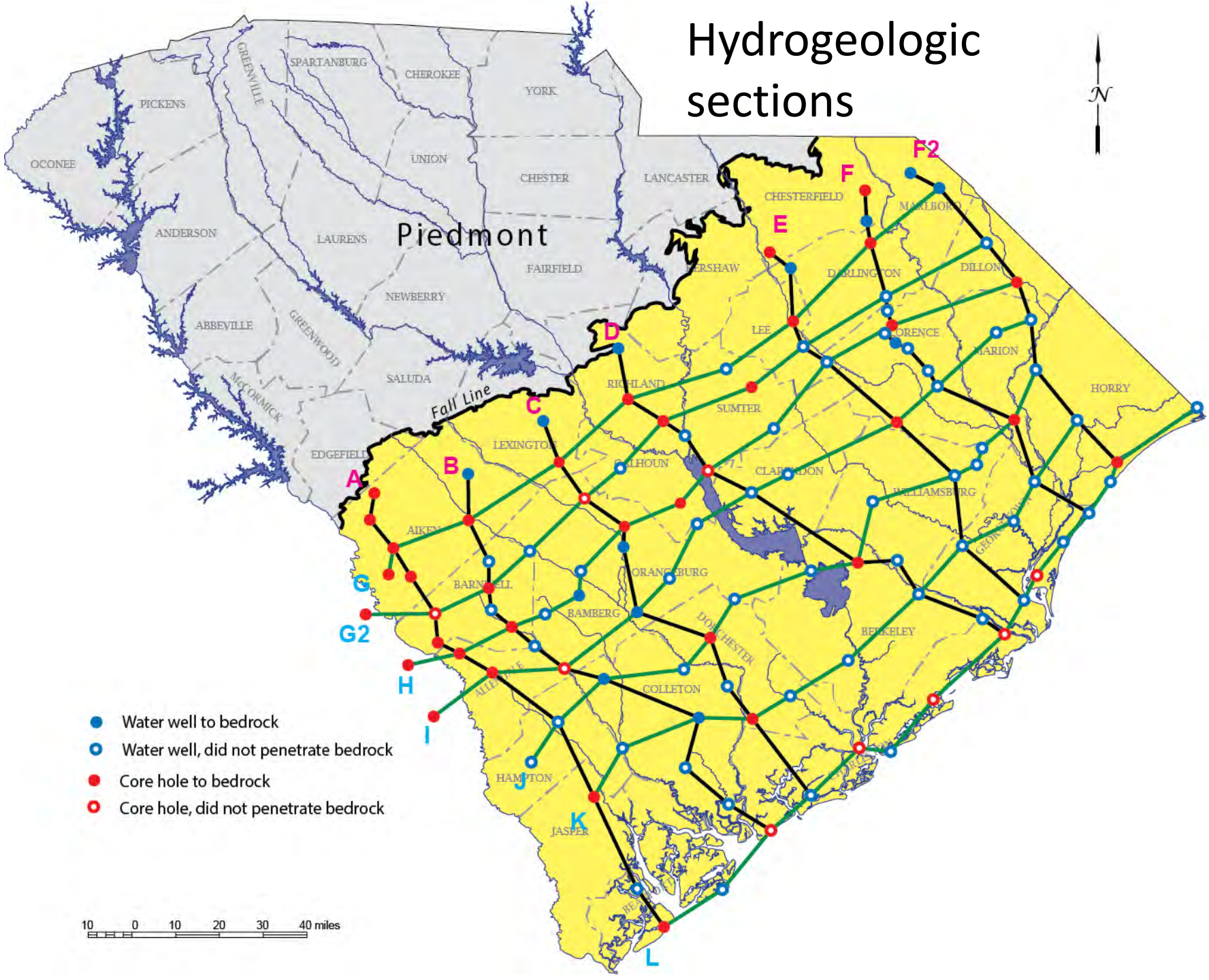
- Geophysical logs
- Geologist's logs
- Paleontology

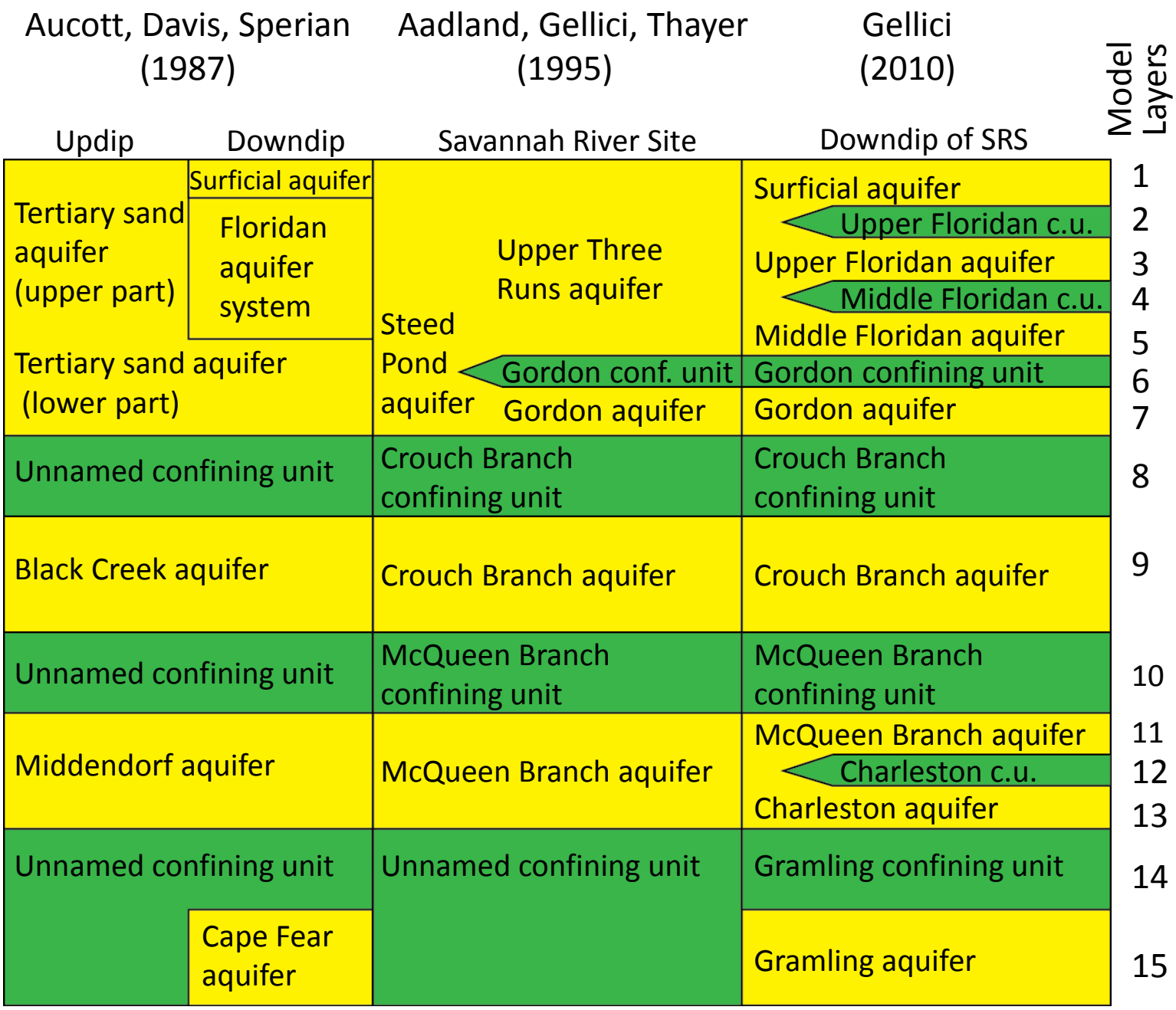
Water wells (96)

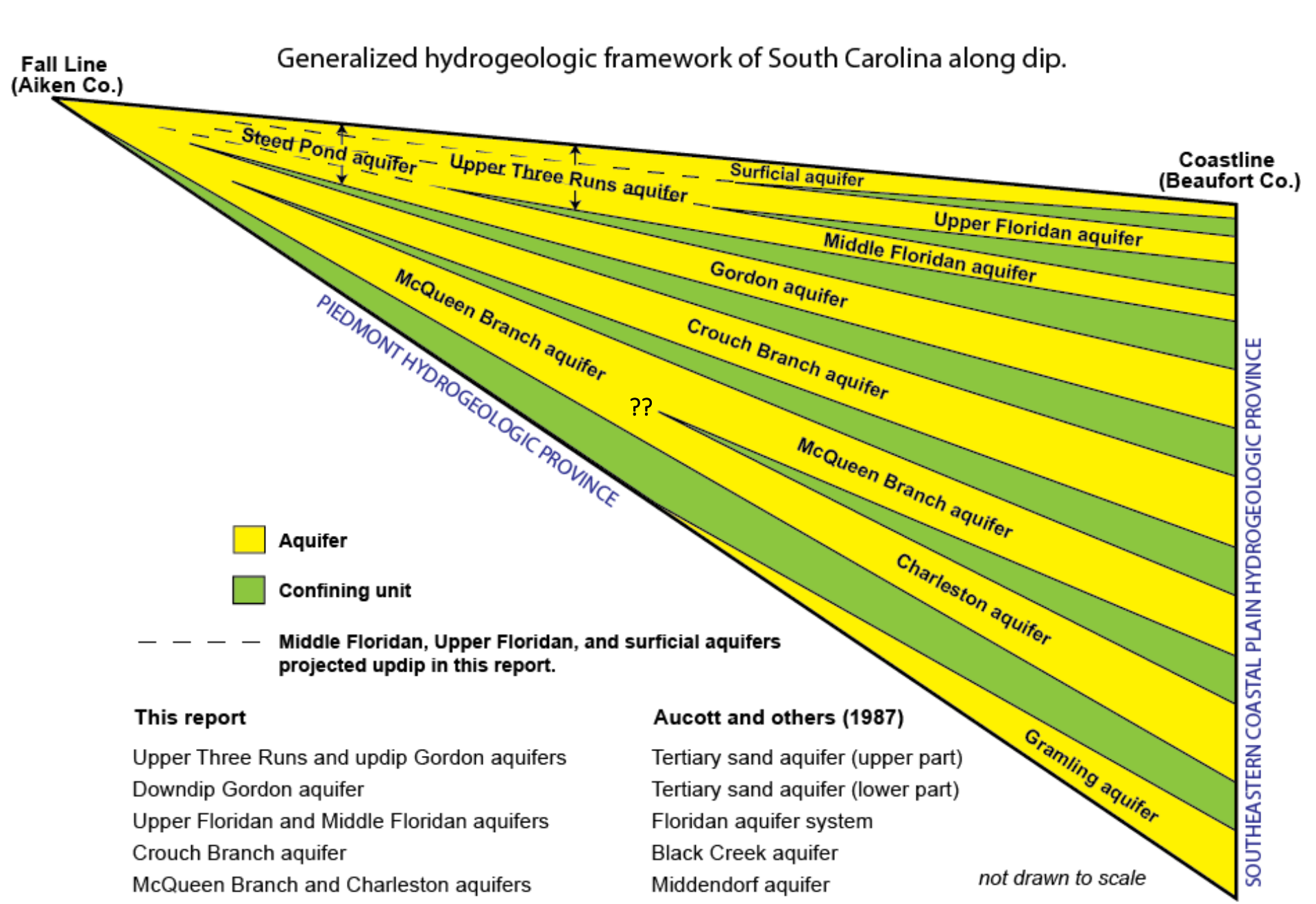
- Geophysical logs
- Driller's logs

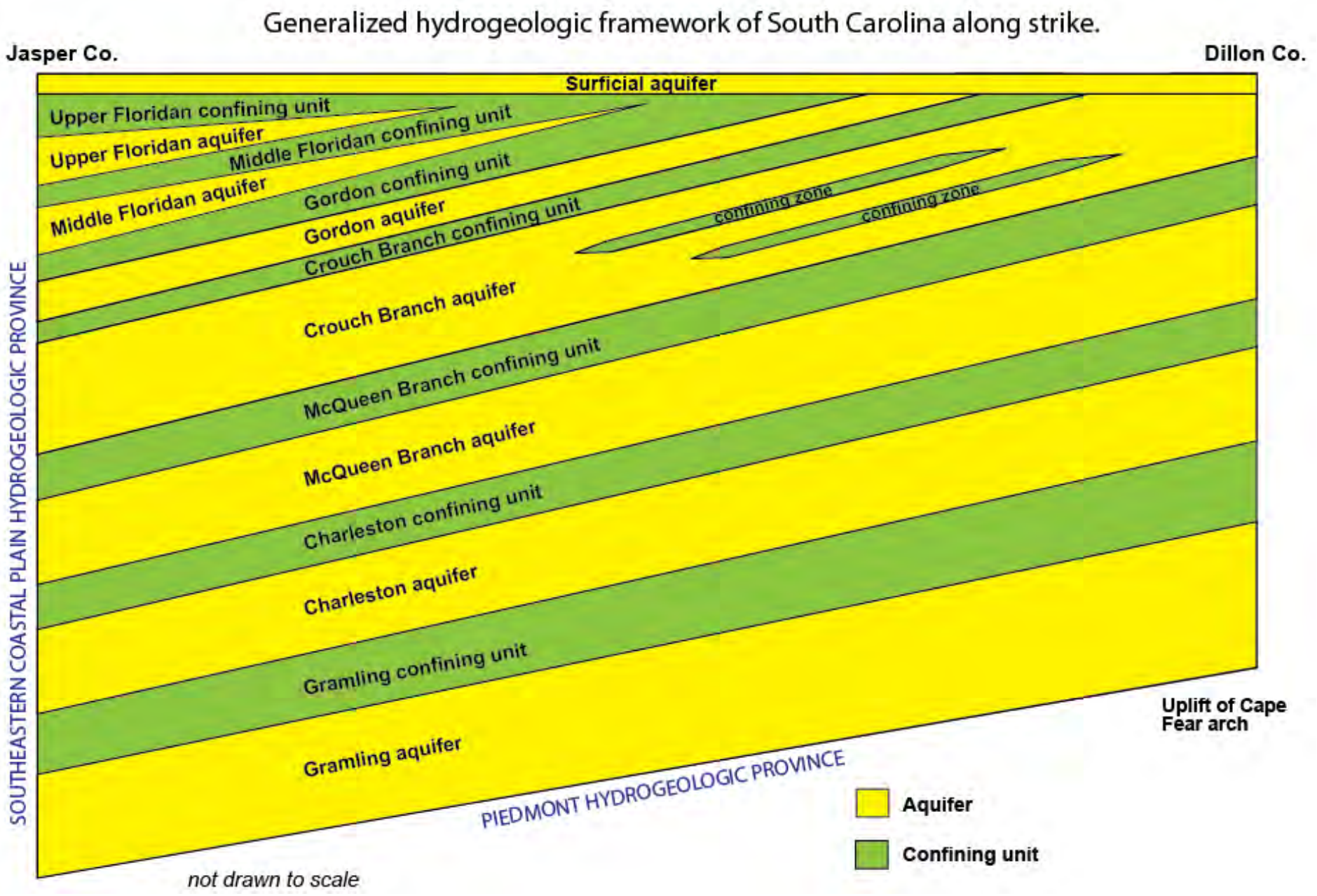
Well-cluster sites (27)

- Hydraulic-head data

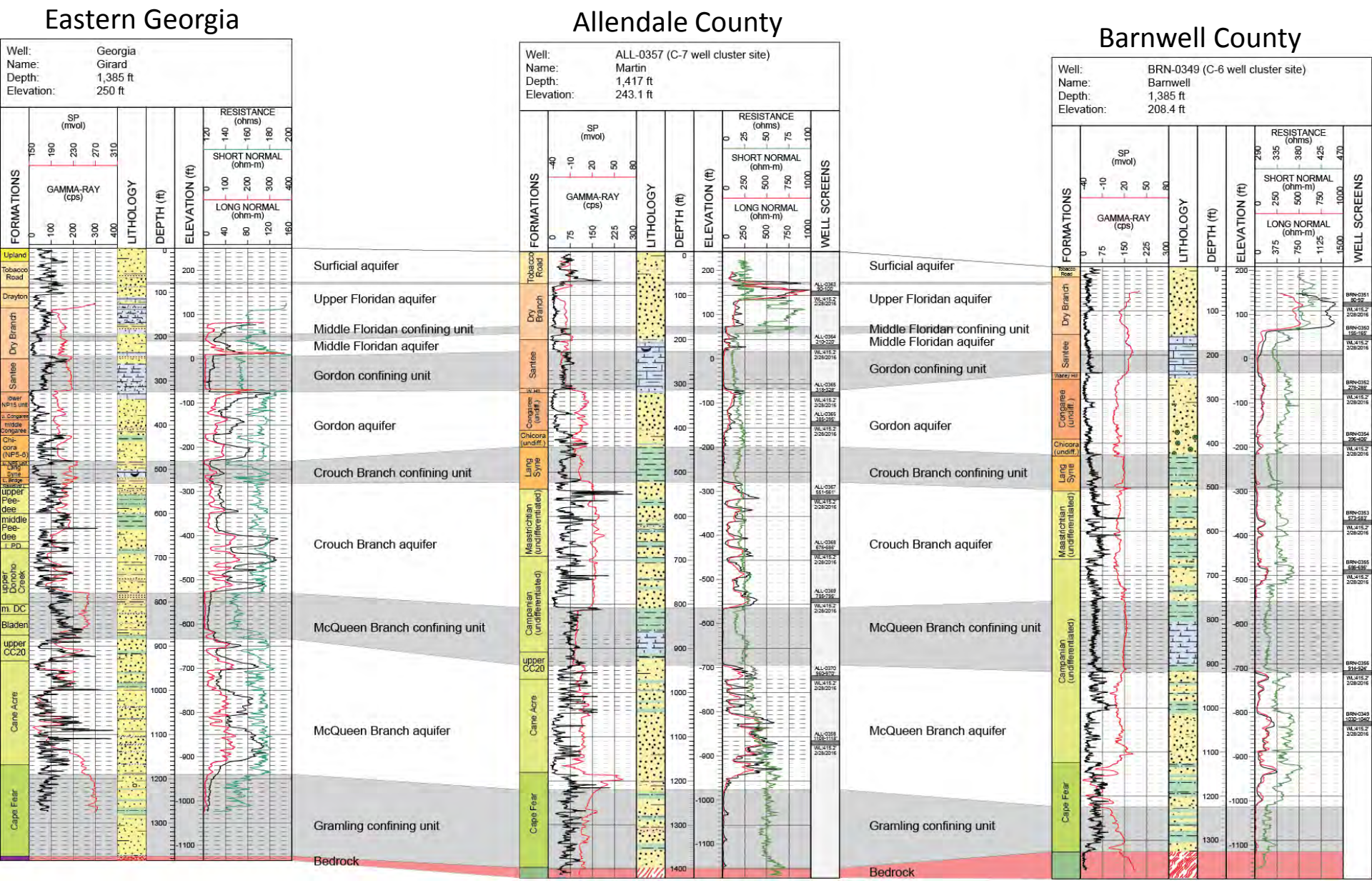

Hydrogeologic sections
N
Piedmont
Fall Line
SPARTANBURG
CHEROKEE
YORK
PICKENS
GREENVILLE
OCONEE
UNION
CHESTER
LANCASTER
ANDERSON
LAURENS
FAIRFIELD
NEWBERRY
ABBEVILLE
GREENWOOD
SALUDA
MCCORMICK
EDGEFIELD
CHESTERFIELD
MARLBORO
DARLINGTON
DILLON
LEE
FLORENCE
MARION
HORRY
RICHLAND
SUMTER
LEXINGTON
CALHOUN
CLARENDON
WILLIAMSBURG
AIKEN
BARNWELL
ORANGEBURG
BAMBERG
DORCHESTER
BERKELEY
COLLETON
ALLENDALE
HAMPTON
JASPER
BEAUFORT
A
B
C
D
E
F
F2
G
G2
H
I
J
K
L
Water well to bedrock
Water well, did not penetrate bedrock
Core hole to bedrock
Core hole, did not penetrate bedrock
10 0 10 20 30 40 miles

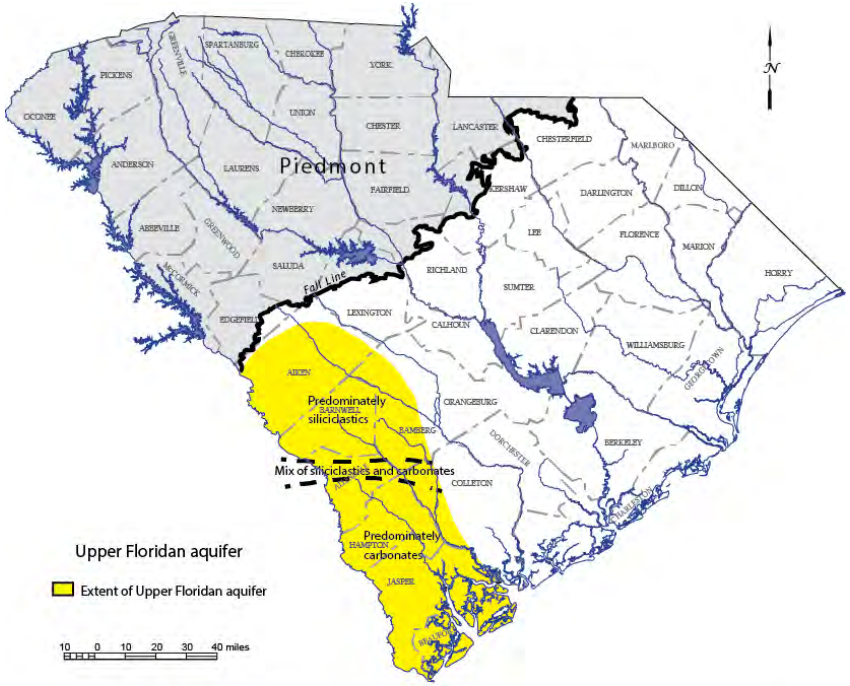

Aucott, Davis, Sperian (1987)
Aadland, Gellici, Thayer (1995)
Gellici (2010)
Model Layers
Updip
Downdip
Savannah River Site
Downdip of SRS
Surficial aquifer
Tertiary sand aquifer (upper part)
Floridan aquifer system
Tertiary sand aquifer (lower part)
Upper Three Runs aquifer
Steed Pond aquifer
Gordon conf. unit
Gordon aquifer
Surficial aquifer
Upper Floridan c.u.
Upper Floridan aquifer
Middle Floridan c.u.
Middle Floridan aquifer
Gordon confining unit
Gordon aquifer
1
2
3
4
5
6
7
Unnamed confining unit
Crouch Branch confining unit
Crouch Branch confining unit
8
Black Creek aquifer
Crouch Branch aquifer
Crouch Branch aquifer
9
Unnamed confining unit
McQueen Branch confining unit
McQueen Branch confining unit
10
Middendorf aquifer
McQueen Branch aquifer
McQueen Branch aquifer
Charleston c.u.
Charleston aquifer
11
12
13
Unnamed confining unit
Unnamed confining unit
Gramling confining unit
14
Cape Fear aquifer
Gramling aquifer
15


Generalized hydrogeologic framework of South Carolina along dip.
Fall Line
(Aiken Co.)
Coastline
(Beaufort Co.)
Steed Pond aquifer
Upper Three Runs aquifer
Surficial aquifer
Upper Floridan aquifer
Middle Floridan aquifer
Gordon aquifer
Crouch Branch aquifer
McQueen Branch aquifer
??
McQueen Branch aquifer
Charleston aquifer
Gramling aquifer
PIEDMONT HYDROGEOLOGIC PROVINCE
SOUTHEASTERN COASTAL PLAIN HYDROGEOLOGIC PROVINCE
Aquifer
Confining unit
Middle Floridan, Upper Floridan, and surficial aquifers projected updip in this report.
This report
Upper Three Runs and updip Gordon aquifers
Downdip Gordon aquifer
Upper Floridan and Middle Floridan aquifers
Crouch Branch aquifer
McQueen Branch and Charleston aquifers
Gramling aquifer
Aucott and others (1987)
Tertiary sand aquifer (upper part)
Tertiary sand aquifer (lower part)
Floridan aquifer system
Black Creek aquifer
Middendorf aquifer
Cape Fear aquifer
not drawn to scale


Generalized hydrogeologic framework of South Carolina along strike.
Jasper Co.
Dillon Co.
Surficial aquifer
Upper Floridan confining unit
Upper Floridan aquifer
Middle Floridan confining unit
Middle Floridan aquifer
Gordon confining unit
Gordon aquifer
Crouch Branch confining unit
confining zone
confining zone
Crouch Branch aquifer
McQueen Branch confining unit
McQueen Branch aquifer
Charleston confining unit
Charleston aquifer
Gramling confining unit
Gramling aquifer
SOUTHEASTERN COASTAL PLAIN HYDROGEOLOGIC PROVINCE
PIEDMONT HYDROGEOLOGIC PROVINCE
Uplift of Cape Fear arch
Aquifer
Confining unit
not drawn to scale

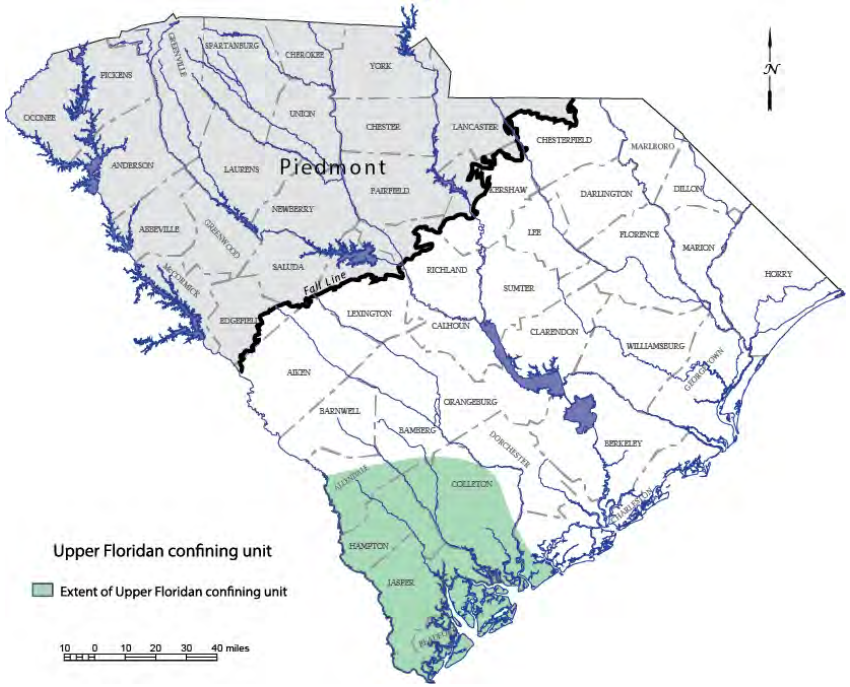
Partial hydrogeologic section from eastern Georgia to Barnwell County





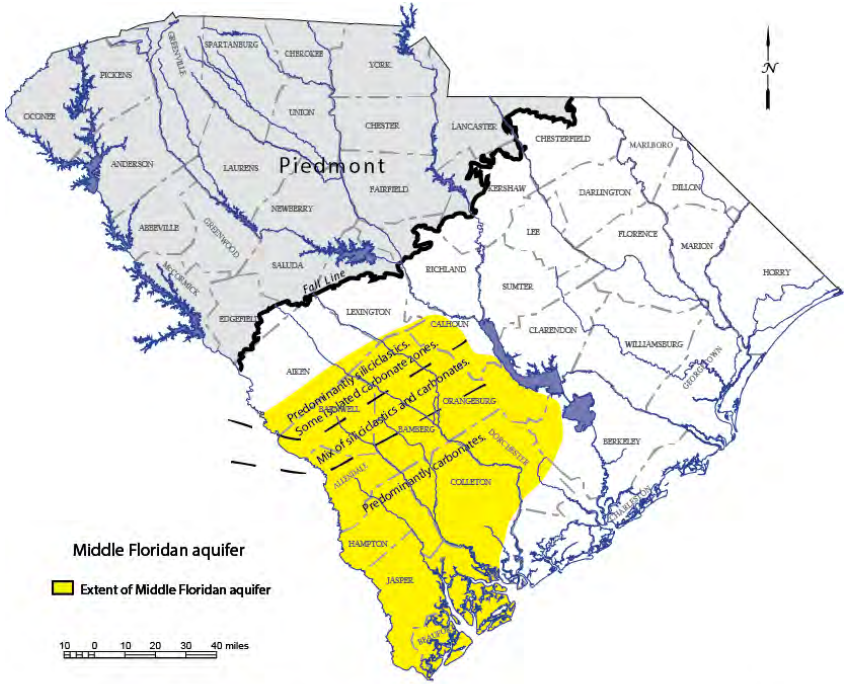
UPPER FLORIDAN AQUIFER

- 0 to 170 ft thick.
- 0 to 170 ft deep.
- Updip, interbedded sand and clay aquifer.
- In Allendale County, transitions to a mix of clastic and carbonate sediments.
- Downdip, consists of limestone.
- Low to very high yields. Transmissivity values range from less than 3,700 gpd/ft at Port Royal Island to 525,000 gpd/ft at Hilton Head Island.



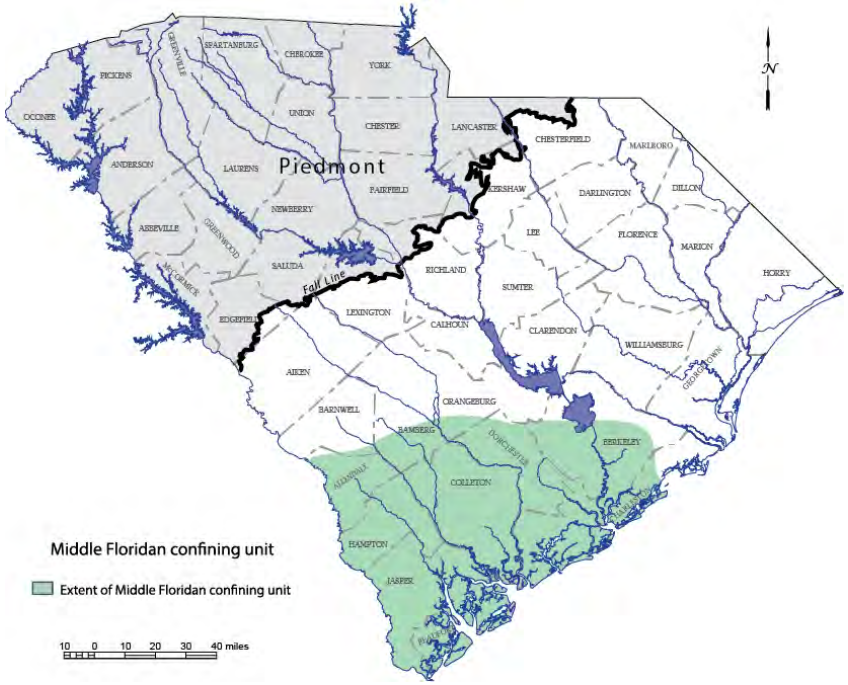
UPPER FLORIDAN CONFINING UNIT

- 0 to 100 ft thick.
- 10 to 100 ft deep.
- Consists of phosphatic sandy clay, clayey sand, and calcareous clayey sand.
- A hard phosphatic limestone occasionally occurs at the base of the confining unit that is referred to as “cap rock.”



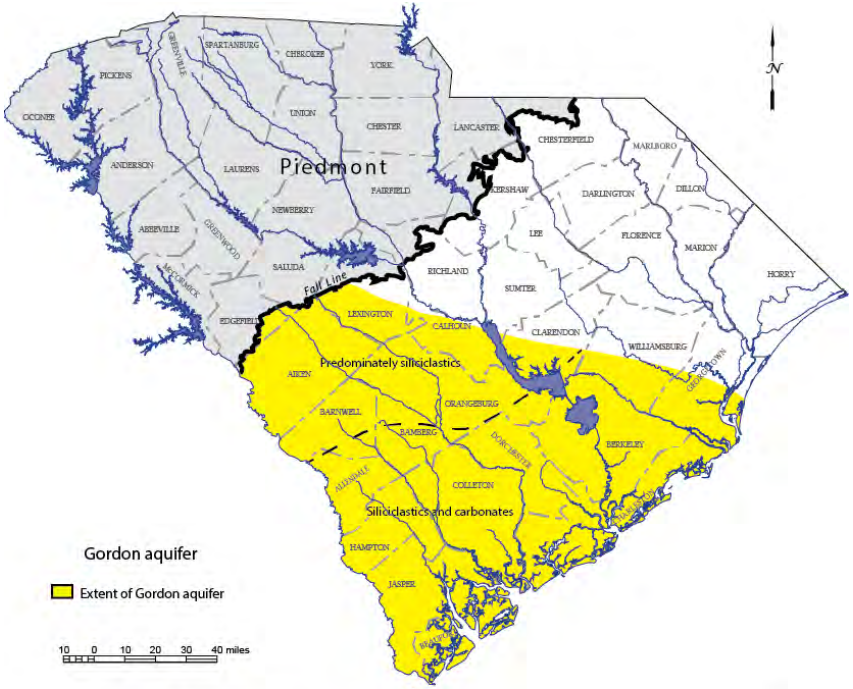
MIDDLE FLORIDAN AQUIFER

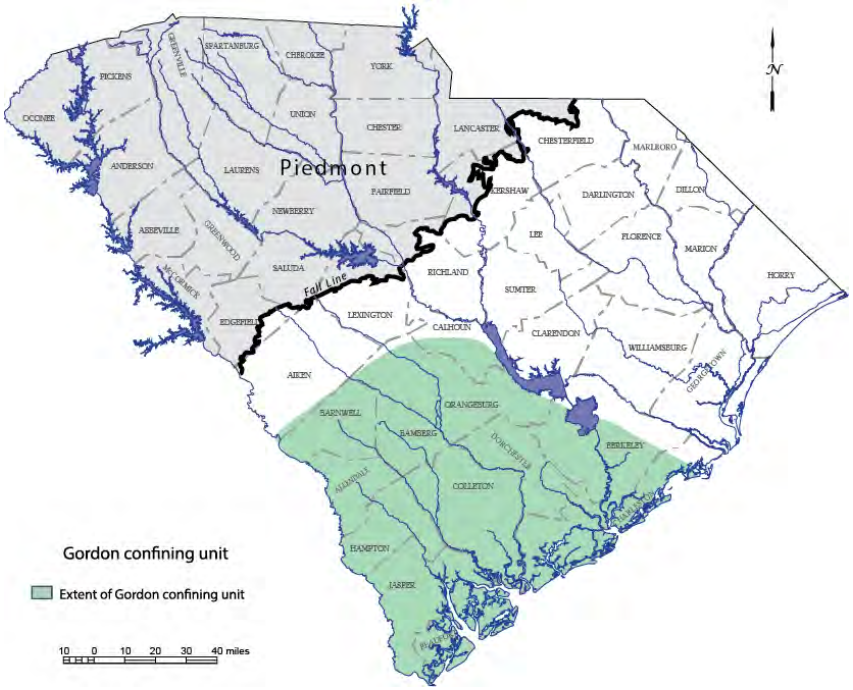
- 0 to 100 ft thick.
- 10 to 600 ft deep
- Updip, consists of sand and clay.
- Downdip, consists of limestone.
- Low to high yields. Transmissivity values from six pumping tests at Hilton Head Island range from 17,000 to 200,000 gpd/ft and average about 80,000 gpd/ft.
- Transmissivity values from four tests in Allendale County average 33,000 gpd/ft.
- A test conducted at Lake Warren State Park in Hampton County yielded no water.



MIDDLE FLORIDAN CONFINING UNIT

- 0 to 320 ft thick.
- 10 to 250 ft deep.
- Consists of fine-grained carbonates containing minor amounts of quartz sand and clay.



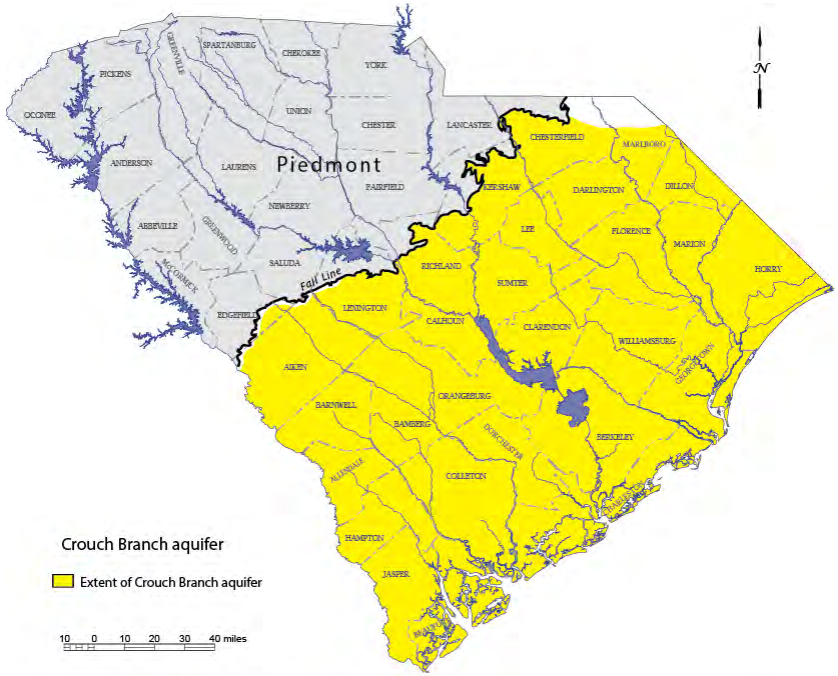


GORDON AQUIFER

- 0 to 360 ft thick.
- 0 to 1,230 ft deep.
- Interbedded sand and clay aquifer in updip areas. Downdip, consists of quartz-bearing limestone and calcarenites.
- Low to moderate yields. Transmissivity calculated from 15 pumping tests in the central part of SRS average 15,000 gpd/ft.
- In central Barnwell County, transmissivity averages 37,000 gpd/ft.
- Two pumping tests in southern Charleston County have transmissivity values of 5,600 and 6,700 gpd/ft.

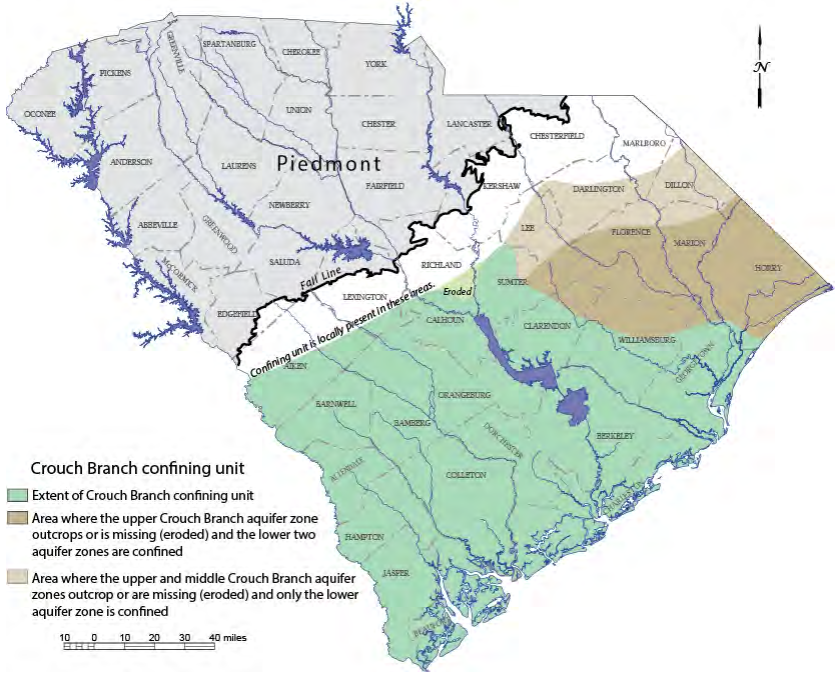
GORDON CONFINING UNIT

- 0 to 630 ft thick.
- 40 to 600 ft deep.
- Updip, consists of fine-grained glauconitic clayey sand and clay.
- Downdip, consists of marl.



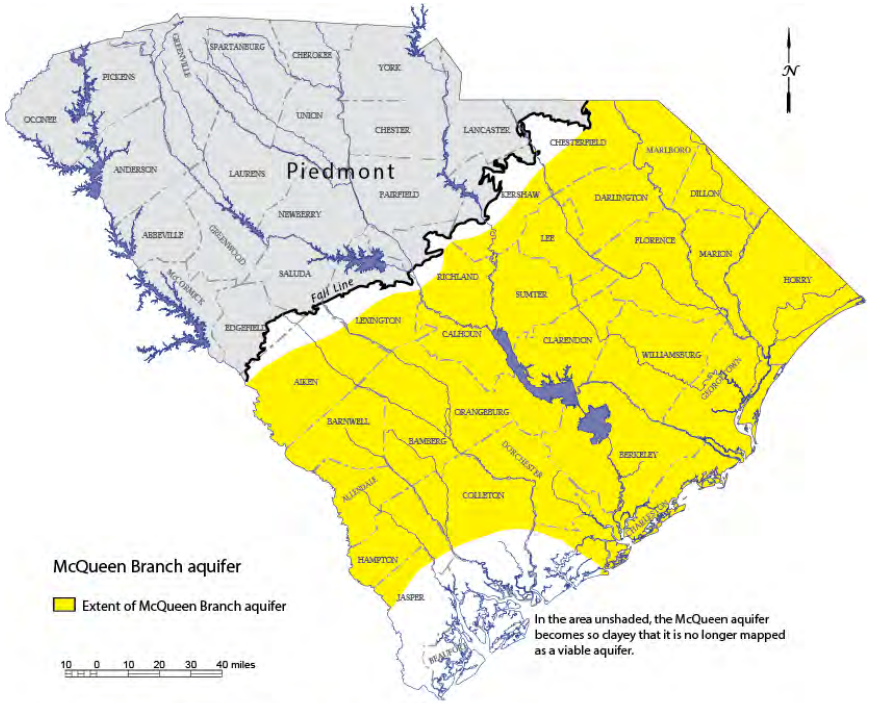
CROUCH BRANCH AQUIFER

- 0 to 550 ft thick.
- 0 to 1,700 ft deep.
- Interbedded sand and clay aquifer.
- Low to high yields. Becomes fine-grained and less productive downdip.
- Transmissivity values of ten pumping tests at SRS average 80,000 gpd/ft.
- Transmissivity from a 7-day pumping test at Cope in western Orangeburg County is 82,000 gpd/ft.



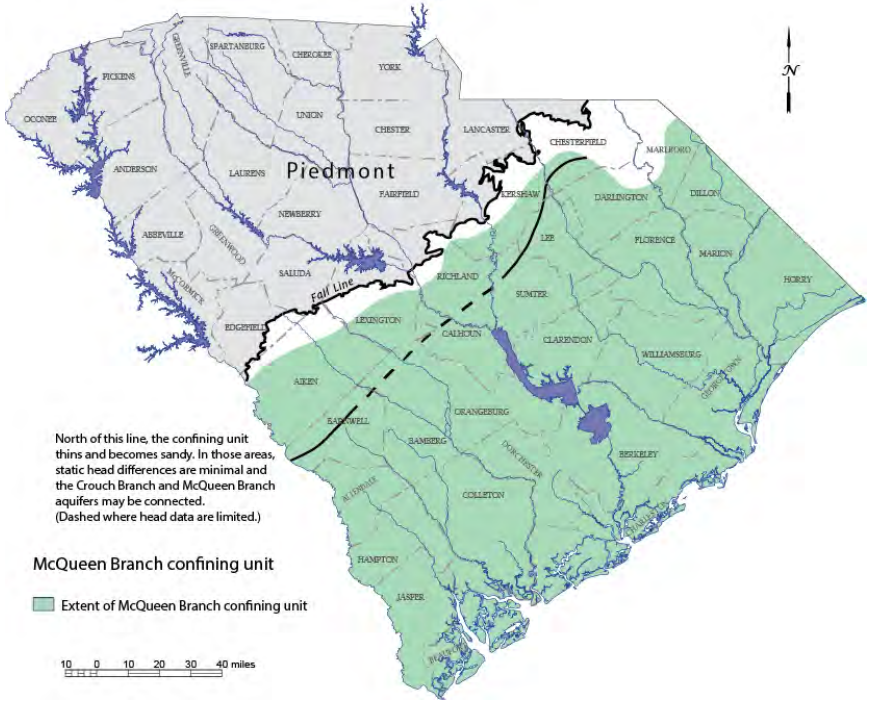
CROUCH BRANCH CONFINING UNIT

- 0 to 360 ft thick.
- 0 to 1,500 ft deep.
- Silty-clay that is thinly laminated with very fine quartz sand and silt.



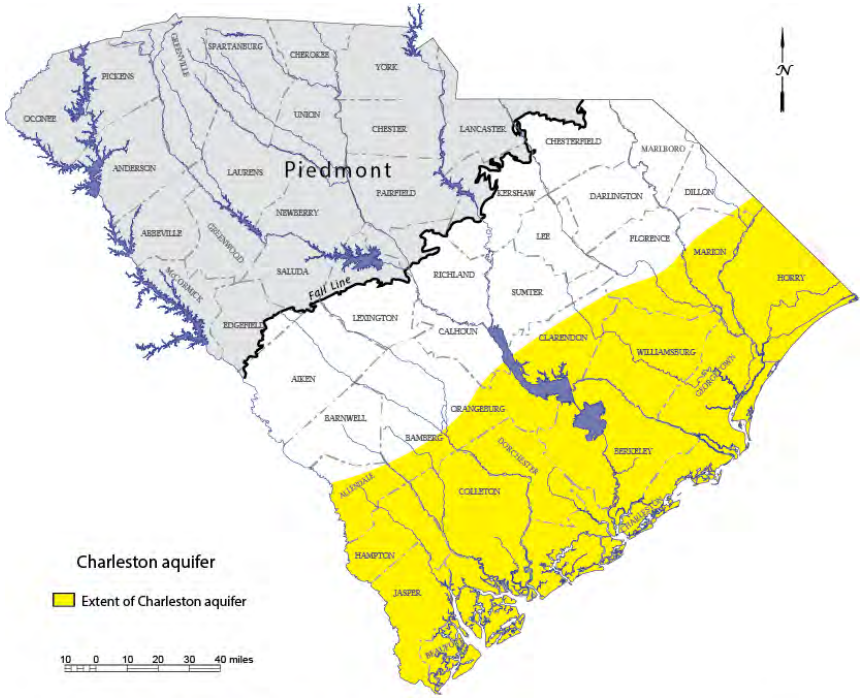
MCQUEEN BRANCH AQUIFER

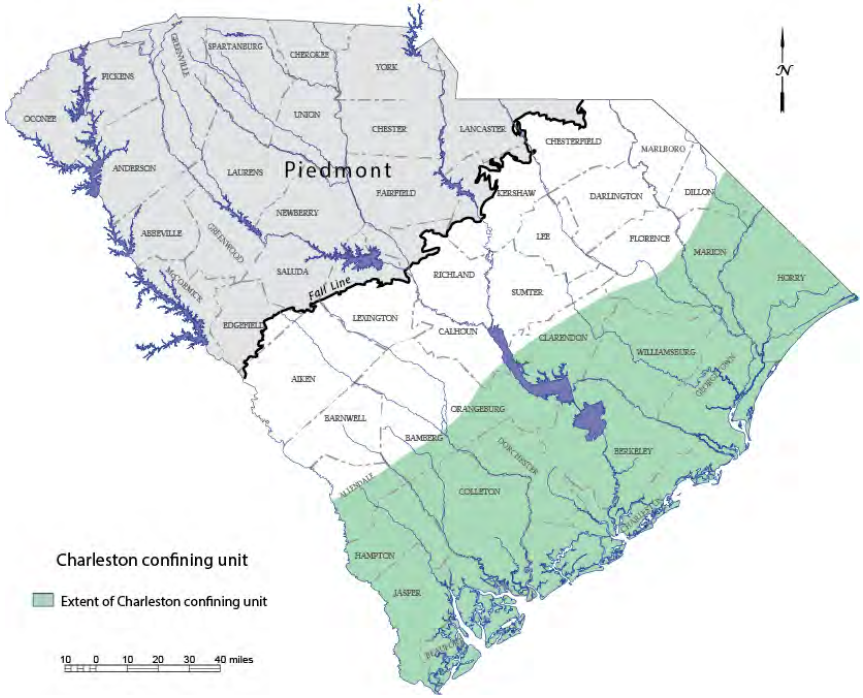
- 0 to 360 ft thick.
- 40 to 1,500 ft deep.
- Interbedded sand and clay aquifer.
- Low to very high yields. One of the most productive in the State, especially in the west-central and updip parts of the Coastal Plain. Becomes fine-grained and less productive downdip.
- Transmissivity values of eight pumping tests at SRS average 215,000 gpd/ft.



MCQUEEN BRANCH CONFINING UNIT

- 0 to 360 ft thick.
- 50 to 2,000 ft deep.
- Calcareous sand, silt and clay.



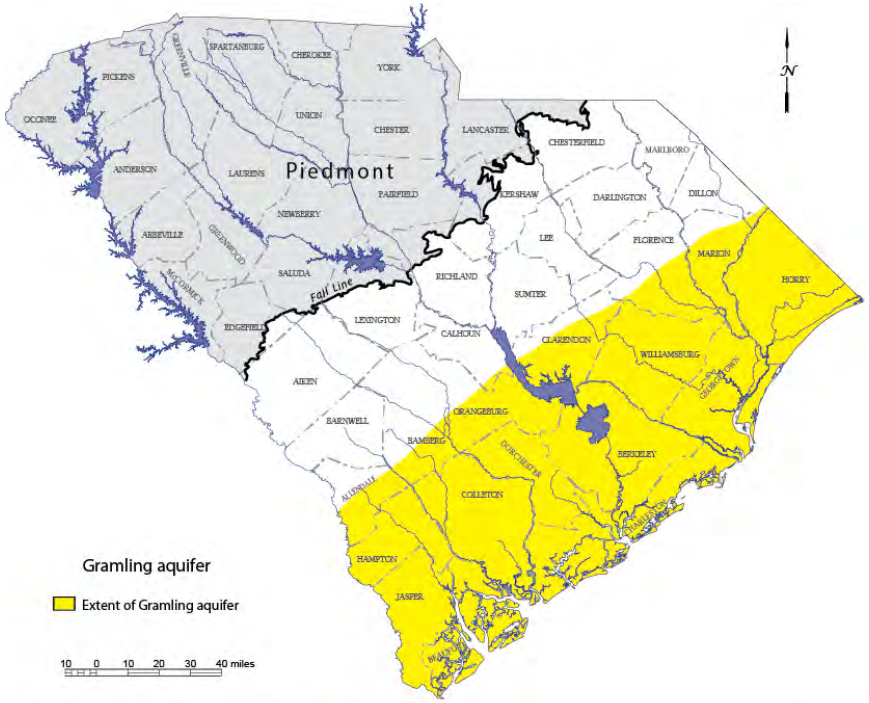


CHARLESTON AQUIFER

- 0 to 350 ft thick.
- 450 to 2,600 ft deep.
- Interbedded sand and clay aquifer.
- Low to moderate yields.
- Transmissivity values from St. Stephen and Mount Holly in Berkeley County are 23,000 and 31,000 gpd/ft, respectively.
- Transmissivity values of six tests at Mount Pleasant in Charleston County range from 11,000 to 18,000 gpd/ft and average 13,500 gpd/ft.

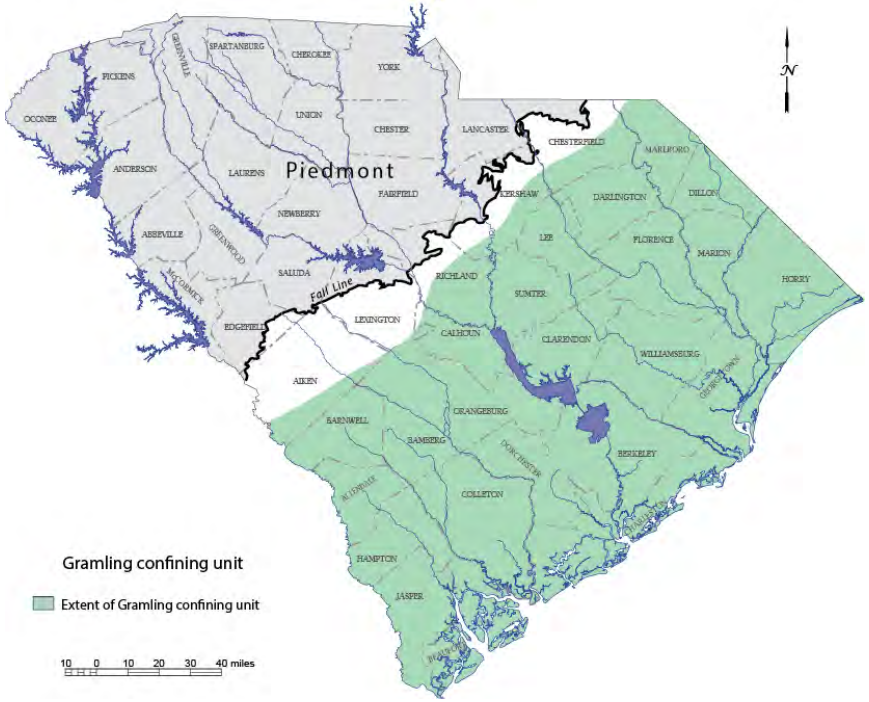
CHARLESTON CONFINING UNIT

- 0 to 460 ft thick.
- 430 to 2,230 ft deep
- Slightly calcareous, clay, silt, and sand.
- Often laminated with very fine to fine-grained sand.
- Some parts of the confining unit consist of indurated clay that is described in cores as “hard and dry”.



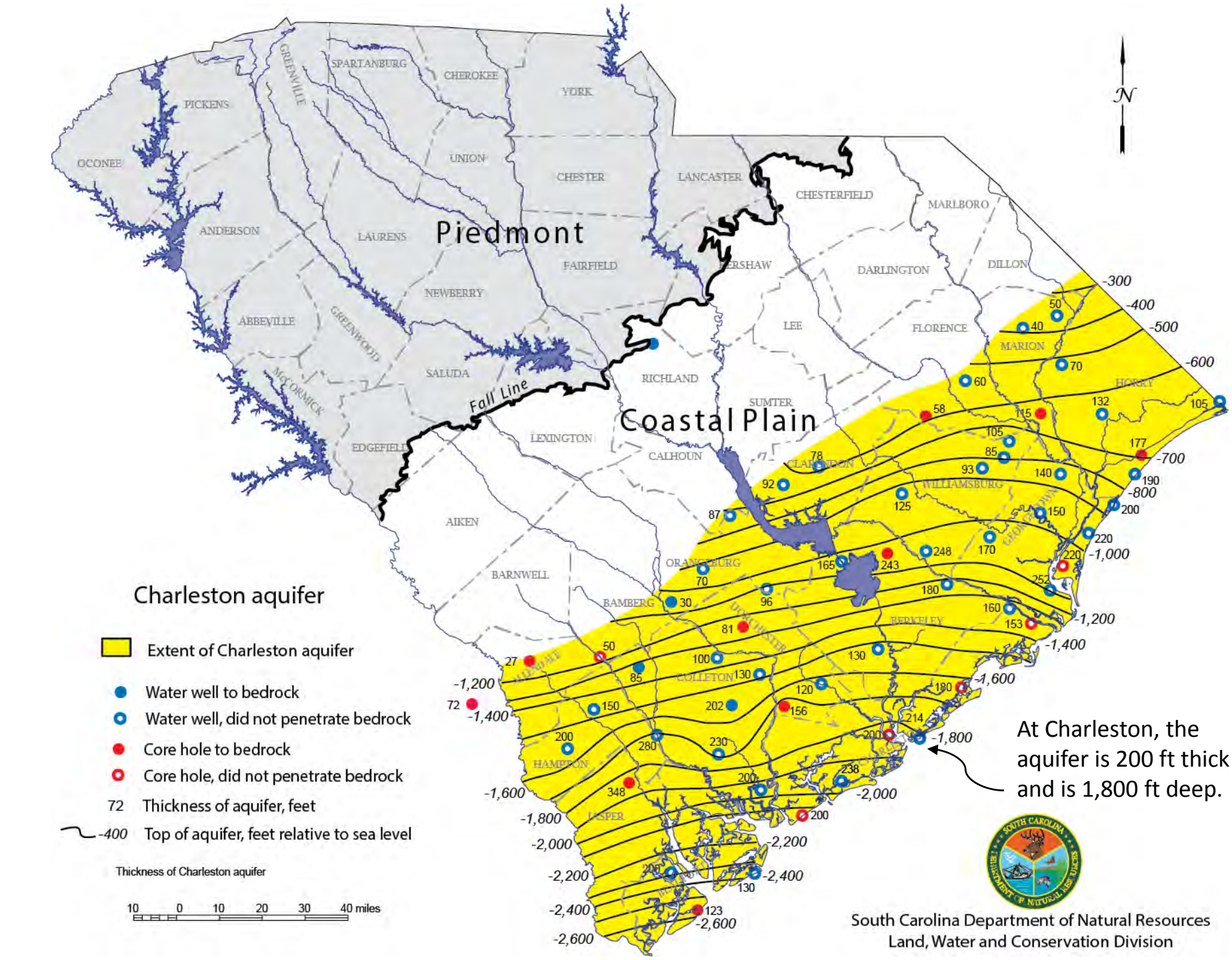
GRAMLING AQUIFER

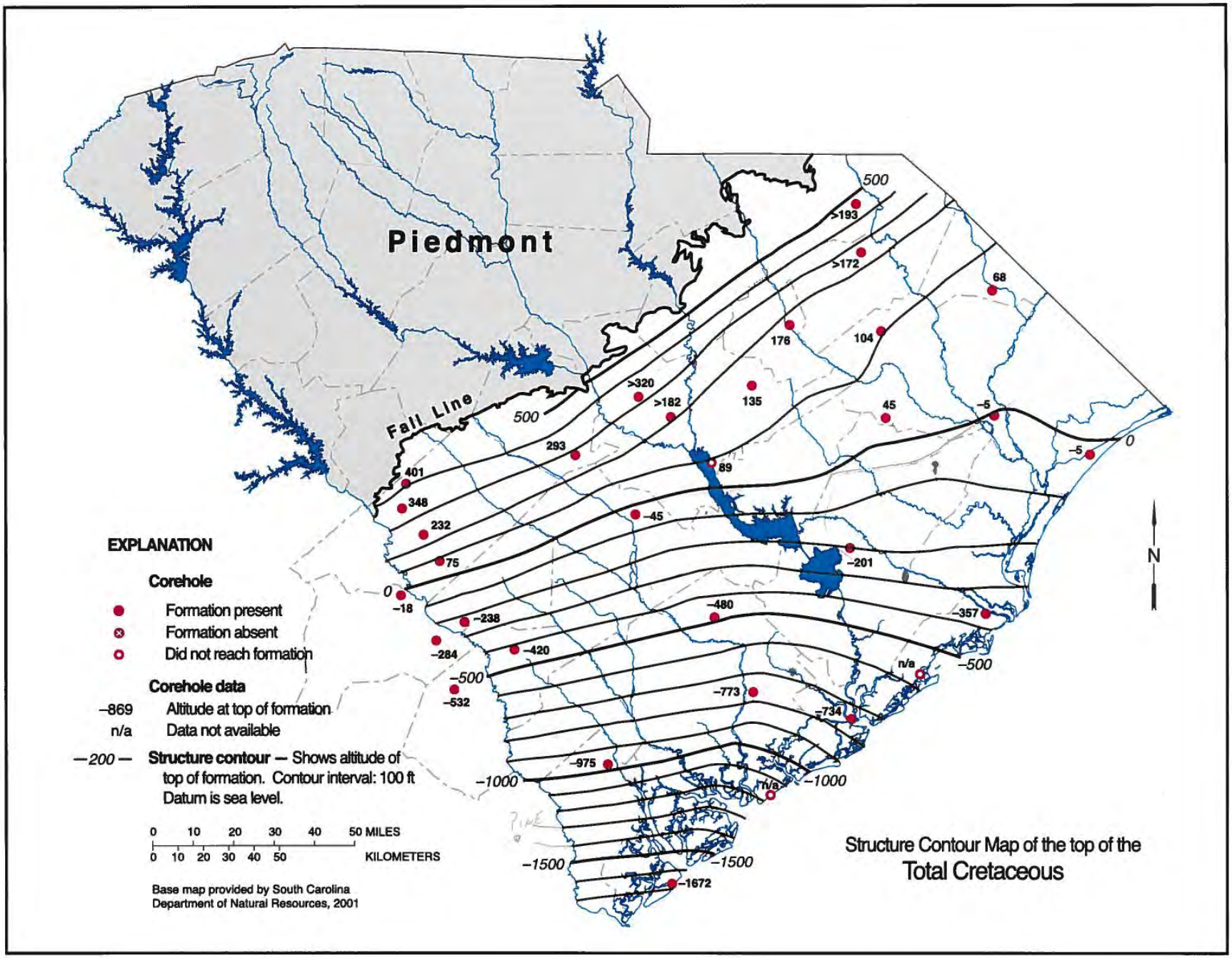
- 0 to 1,000 ft thick.
- 650 to 2,800 ft deep.
- Interbedded sand and clay aquifer.
- Few hydrologic data are available for the aquifer.
- Low yields.
- Transmissivity calculated from a pumping test at Hilton Head is 9,000 gpd/ft (low).

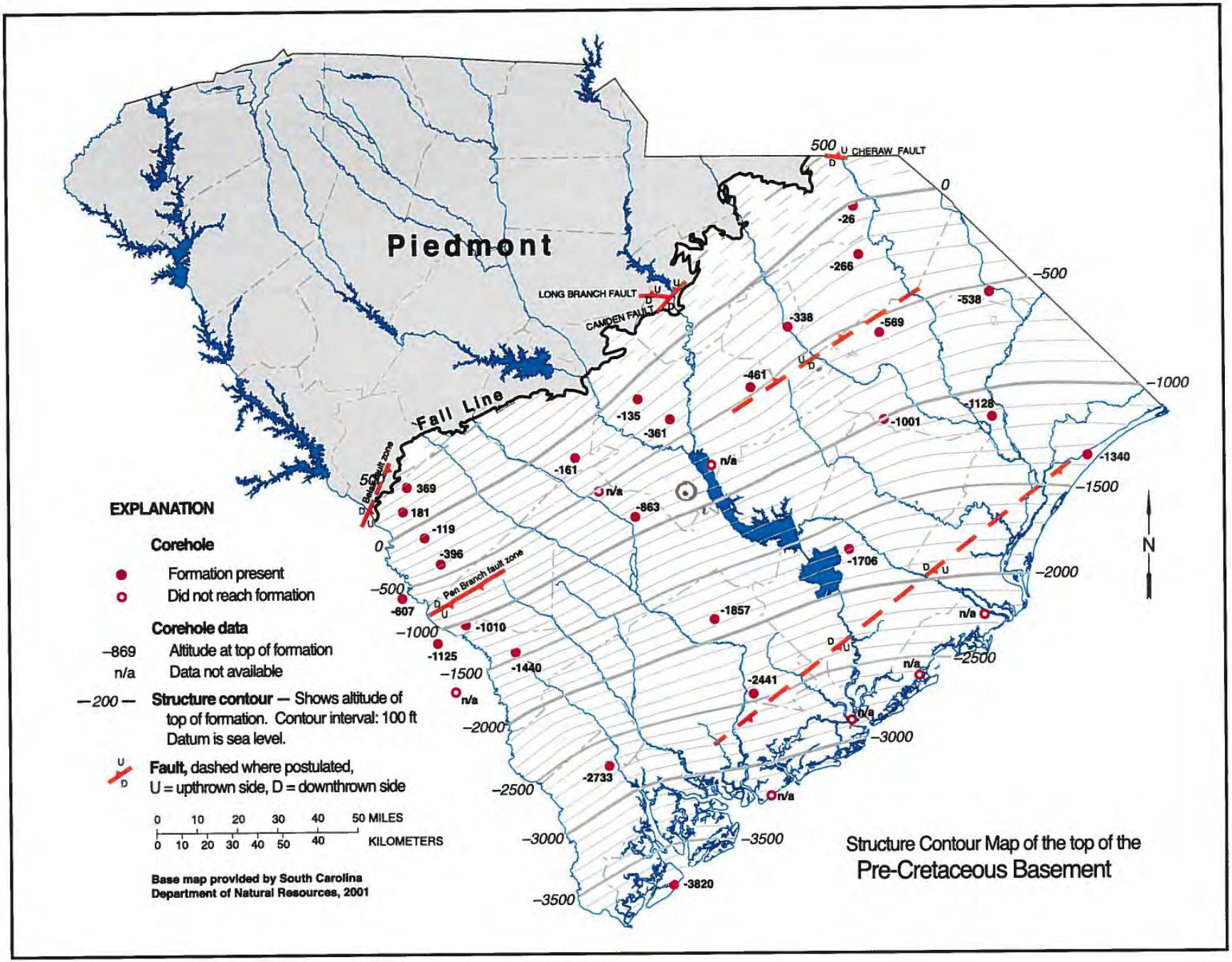


GRAMLING CONFINING UNIT

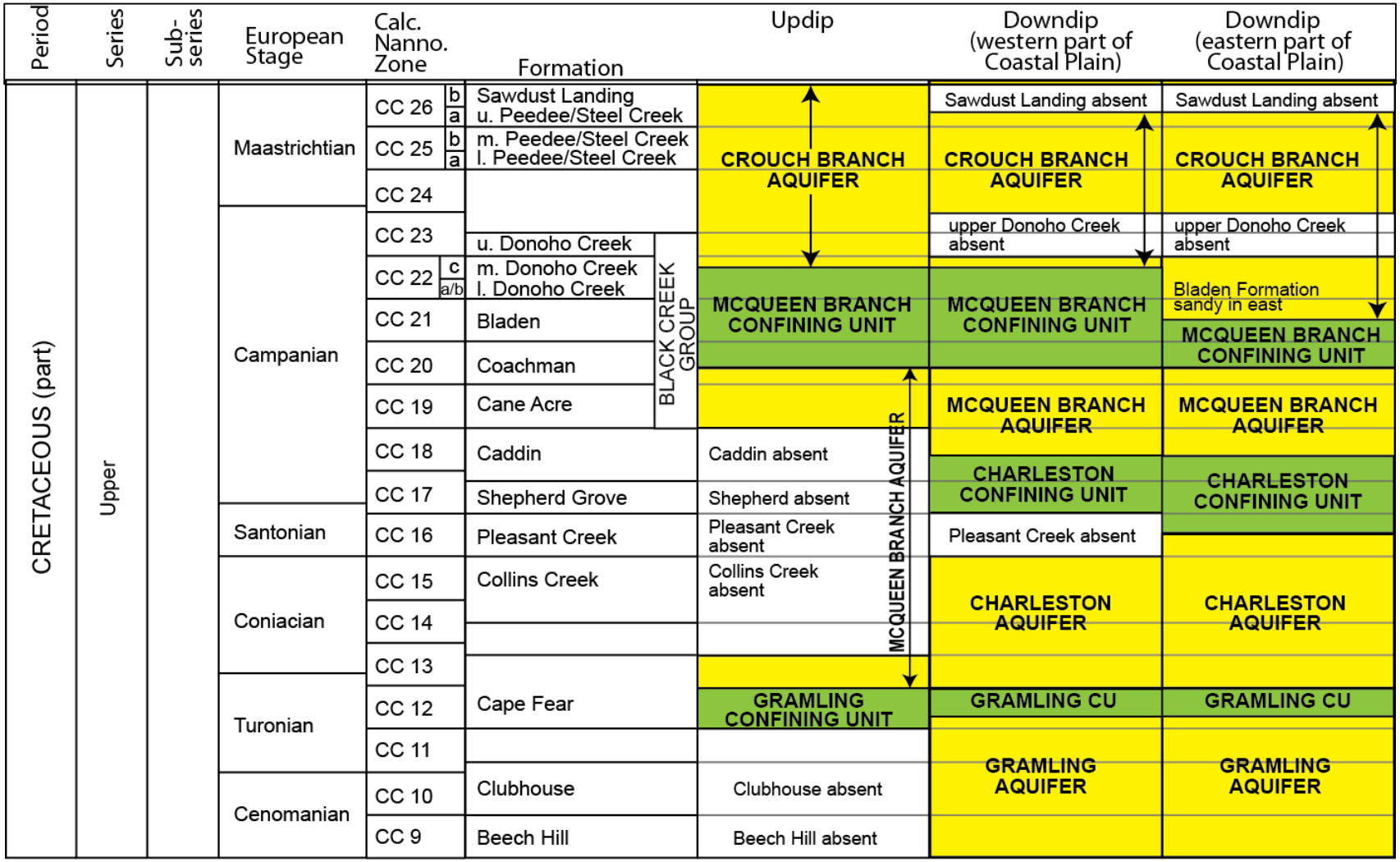
- 0 to 300 ft thick.
- 190 to 2,700 ft deep.
- Clayey sand, and clay.
- Much of the confining unit is consolidated in varying degrees by silica cement.
- Florence has wells screened in sand beds in the confining unit.


Piedmont
Coastal Plain
Fall Line
PICKENS
OCONEE
ANDERSON
GREENVILLE
SPARTANBURG
CHEROKEE
YORK
UNION
CHESTER
LANCASTER
LAURENS
FAIRFIELD
NEWBERRY
ABBEVILLE
GREENWOOD
MCCORMICK
SALUDA
EDGEFIELD
LEXINGTON
RICHLAND
CALHOUN
SUMTER
LEE
CHESTERFIELD
MARLBORO
DARLINGTON
DILLON
FLORENCE
MARION
HORRY
WILLIAMSBURG
GEORGETOWN
BERKELEY
CHARLESTON
DORCHESTER
COLLETON
BARNWELL
AIKEN
ORANGEBURG
BAMBERG
ALLENDALE
HAMPTON
JASPER
-300
-400
-500
-600
-700
-800
-1,000
-1,200
-1,400
-1,600
-1,800
-2,000
-2,200
-2,400
-2,600
Charleston aquifer
Extent of Charleston aquifer
Water well to bedrock
Water well, did not penetrate bedrock
Core hole to bedrock
Core hole, did not penetrate bedrock
72 Thickness of aquifer, feet
-400 Top of aquifer, feet relative to sea level
Thickness of Charleston aquifer
10 0 10 20 30 40 miles
N
At Charleston, the aquifer is 200 ft thick and is 1,800 ft deep.
South Carolina Department of Natural Resources
Land, Water and Conservation Division


Piedmont
Fall Line
500
>193
>172
68
176
104
>320
>182
135
45
-5
0
293
89
401
348
232
75
-45
-201
-18
-238
-480
-357
-284
-420
-500
-532
-773
-734
-975
-1000
-1500
-1672
n/a
EXPLANATION
Corehole
Formation present
Formation absent
Did not reach formation
Corehole data
-869 Altitude at top of formation
n/a Data not available
—200— Structure contour — Shows altitude of top of formation. Contour interval: 100 ft Datum is sea level.
0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETERS
Base map provided by South Carolina Department of Natural Resources, 2001
N
Structure Contour Map of the top of the
Total Cretaceous


Piedmont
Fall Line
CHERAW FAULT
LONG BRANCH FAULT
CAMDEN FAULT
Pen Branch fault zone
Belair fault zone
EXPLANATION
Corehole
Formation present
Did not reach formation
Corehole data
–869 Altitude at top of formation
n/a Data not available
—200— Structure contour — Shows altitude of top of formation. Contour interval: 100 ft Datum is sea level.
Fault, dashed where postulated, U = upthrown side, D = downthrown side
0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETERS
Base map provided by South Carolina Department of Natural Resources, 2001
N
Structure Contour Map of the top of the Pre-Cretaceous Basement

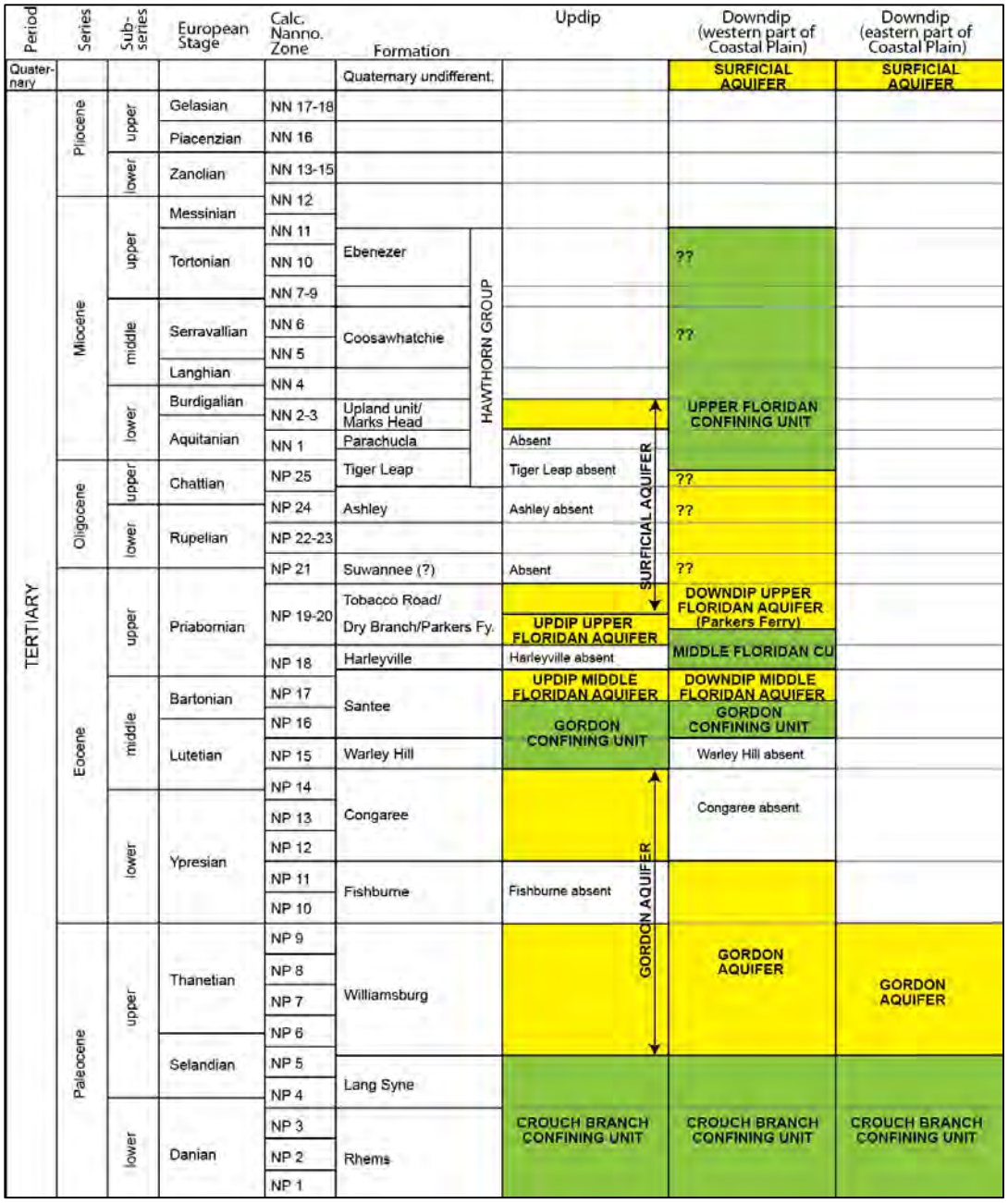
Cretaceous



Christopher, R.A., and Prowell, D.C., 2002, A palynological biozonation for the Maastrichtian Stage (Upper Cretaceous) of South Carolina, USA: Cretaceous Research, v. 23, 31 p.

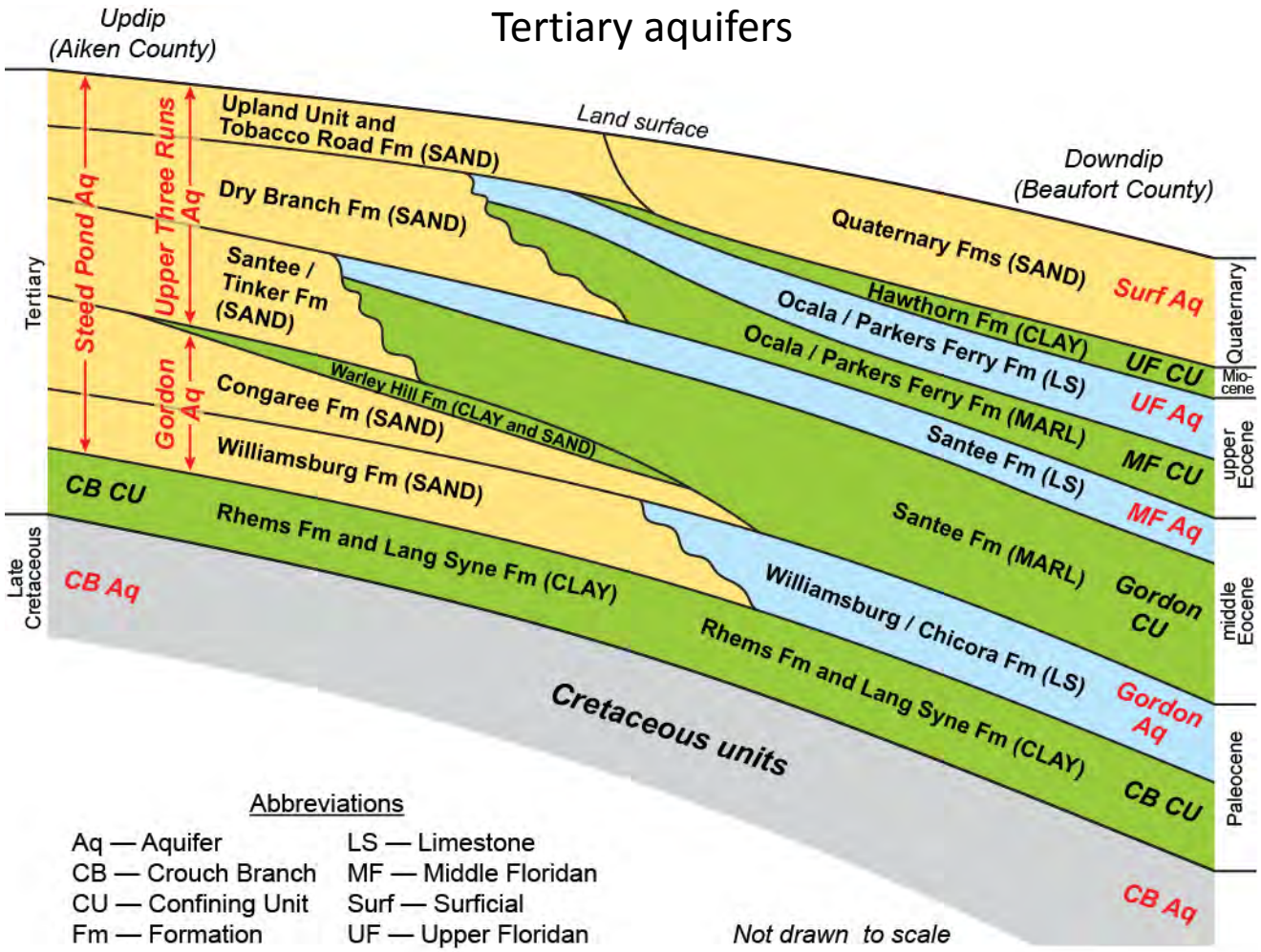
Prowell, D.C., Christopher, R.A., Waters, K.E., and Nix, S.K., 2003, The chrono- and lithostratigraphic significance of the type section of the Middendorf Formation, Chesterfield County, South Carolina: Southeastern Geology, v. 42, no. 1, 20 p.

Christopher, R.A., and Prowell, D.C., 2010, A palynological biozonation for the uppermost Santonian and Campanian Stages (Upper Cretaceous) of South Carolina, USA Cretaceous Research v. 31, no. 2, pp. 101-129

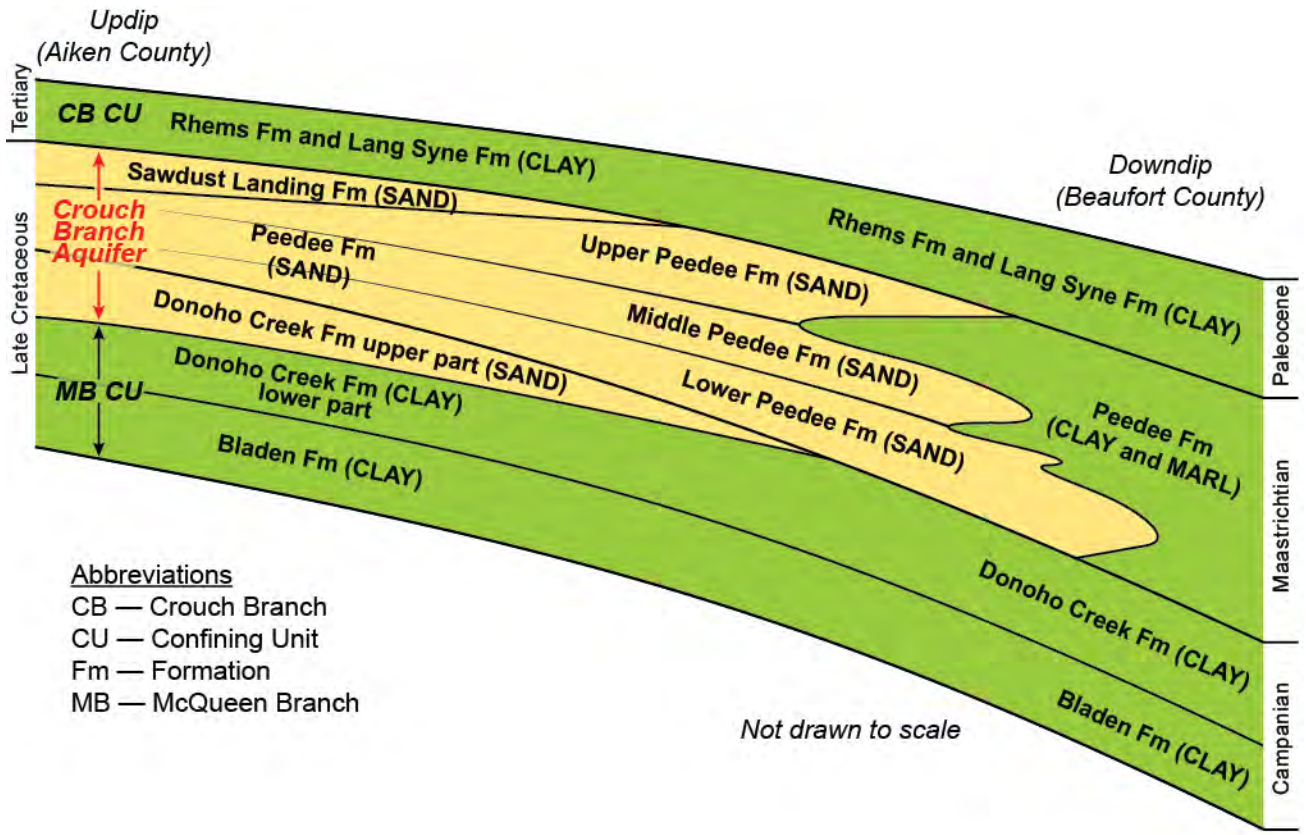


Tertiary and Quaternary

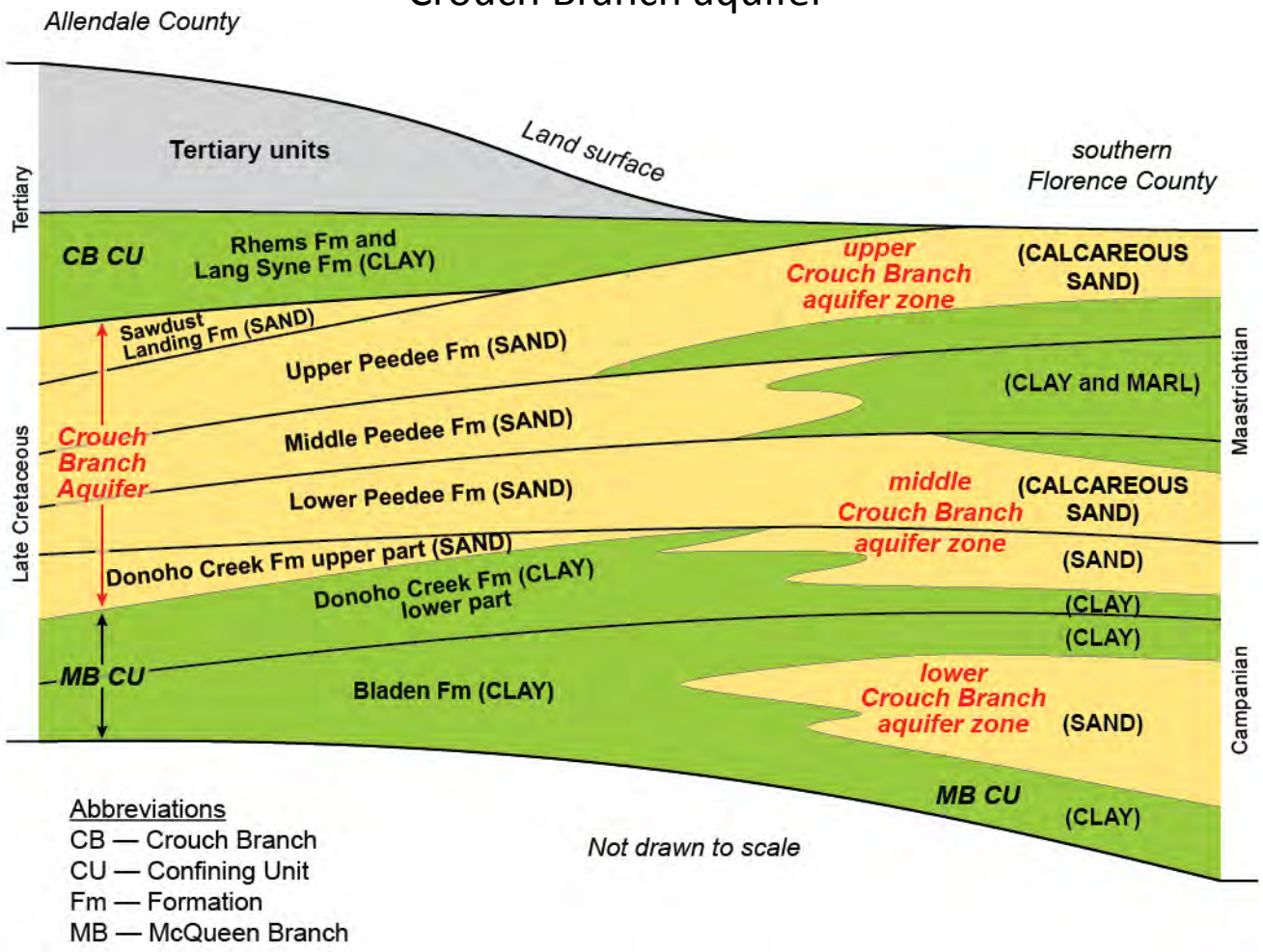
Tertiary aquifers



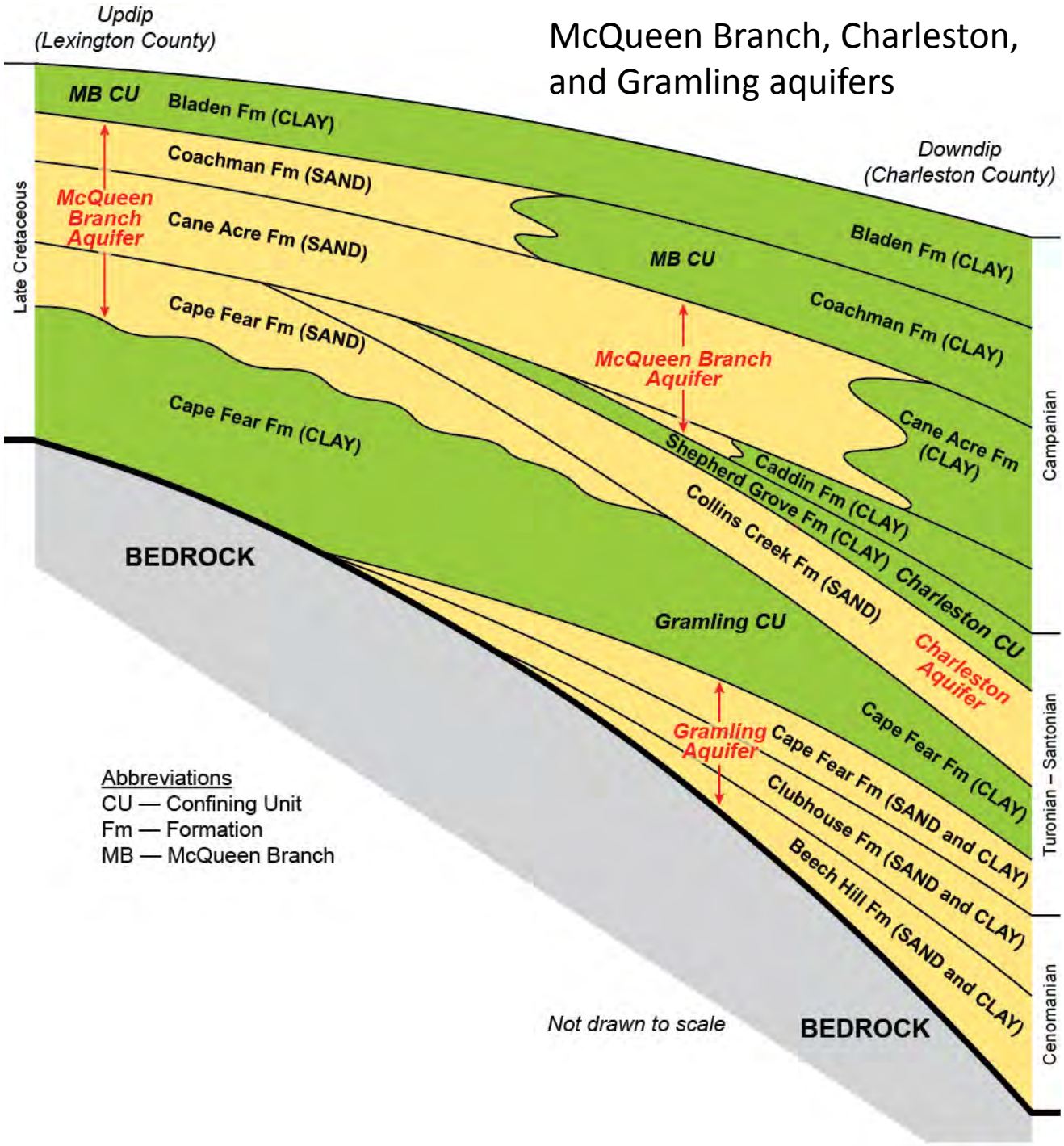
Crouch Branch aquifer



Crouch Branch aquifer

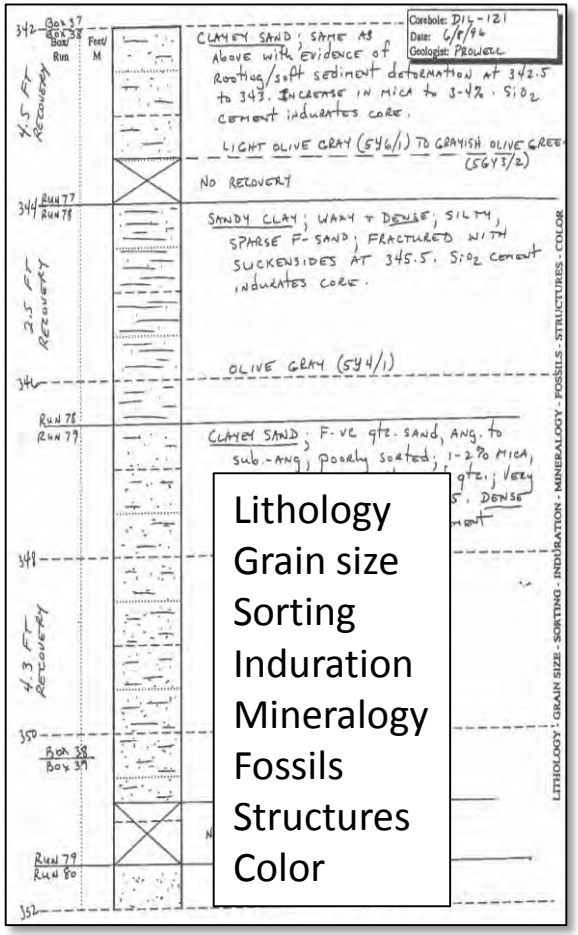


McQueen Branch, Charleston, and Gramling aquifers



Geologist Log

Field sheet



- Lithology
- Grain size
- Sorting
- Induration
- Mineralogy
- Fossils
- Structures
- Color

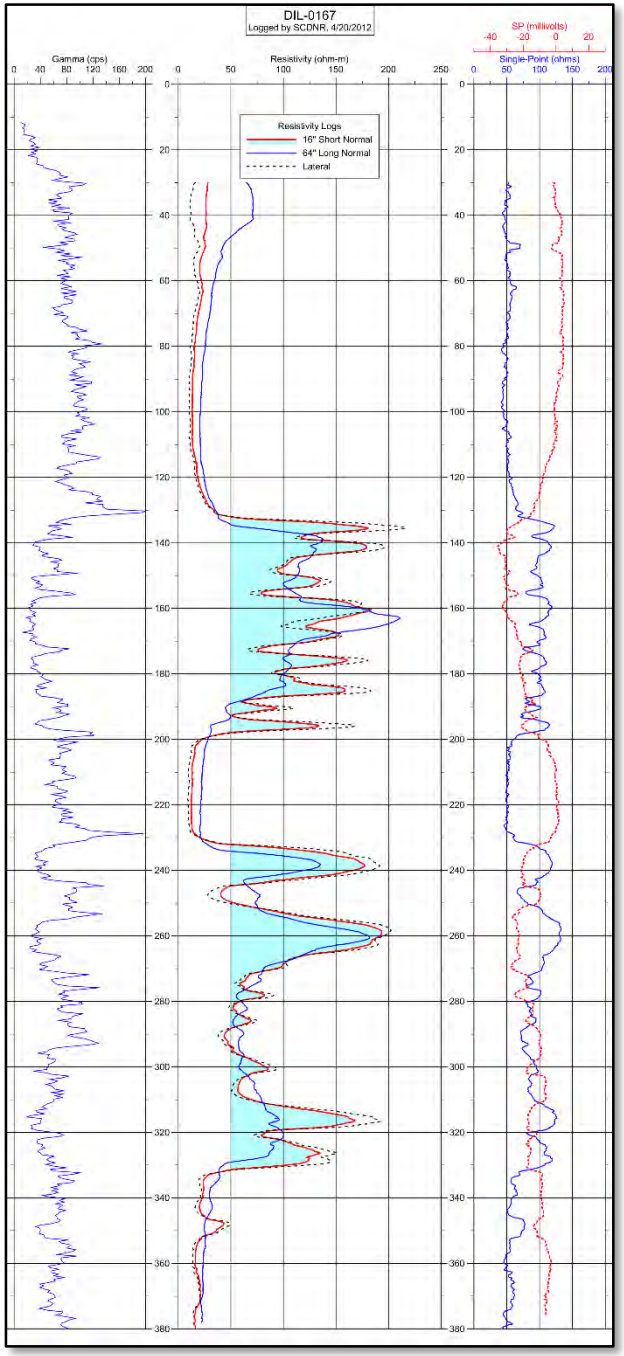
Geophysical Logs

Geophysical logs measure:

- Electrical properties of sediments
- Naturally occurring radiation
- Temperature
- Diameter of borehole or completed well
- Flow rates in pumping wells

Geophysical logs are used to:

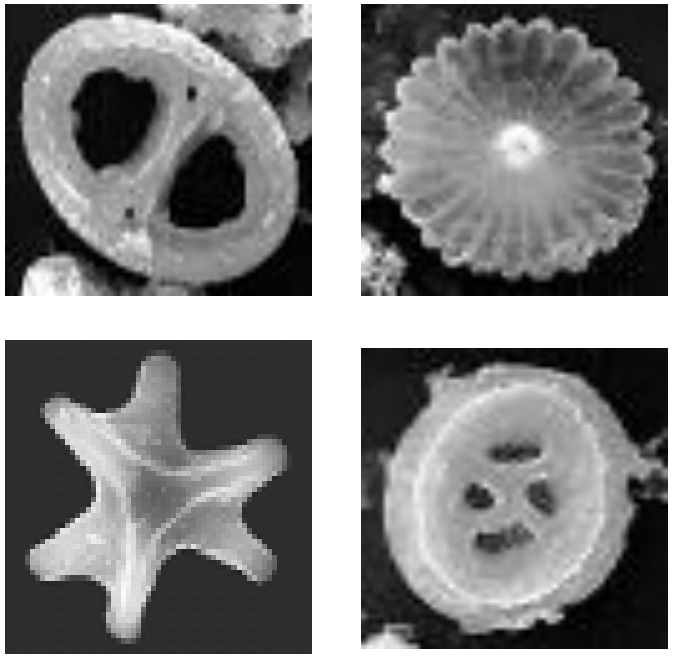
- Identify the depth and thickness of water-bearing zones (aquifers)
- Identify sediment types and locate the depths at which those sediments occur
- Locate the freshwater/saltwater contact in some coastal wells
- Provide information about the construction and condition of existing wells



Paleontology

Aids in the identification and correlation of aquifers and confining units.

- Dr. Raymond A. Christopher (Clemson University, retired) Cretaceous palynomorphs (pollen, spores, dinoflagellate cysts)
- Norman O. Frederiksen (USGS, retired) Tertiary palynomorphs
- Lucy E. Edwards (USGS) Tertiary palynomorphs
- Dr. Jean M. Self-Trail (USGS) Cretaceous calcareous nannofossils (tiny fossils of calcareous, unicellular algae)
- Laurel M. Bybell (USGS, retired) Tertiary calcareous nannofossils



calcareous nannofossils
(magnified thousands of times)

Paleontology

Cenozoic calcareous nannofossil datums

Calcareous nannofossil zone NP 10 is early Eocene
Calcareous nannofossil zone NP 9 is late Paleocene

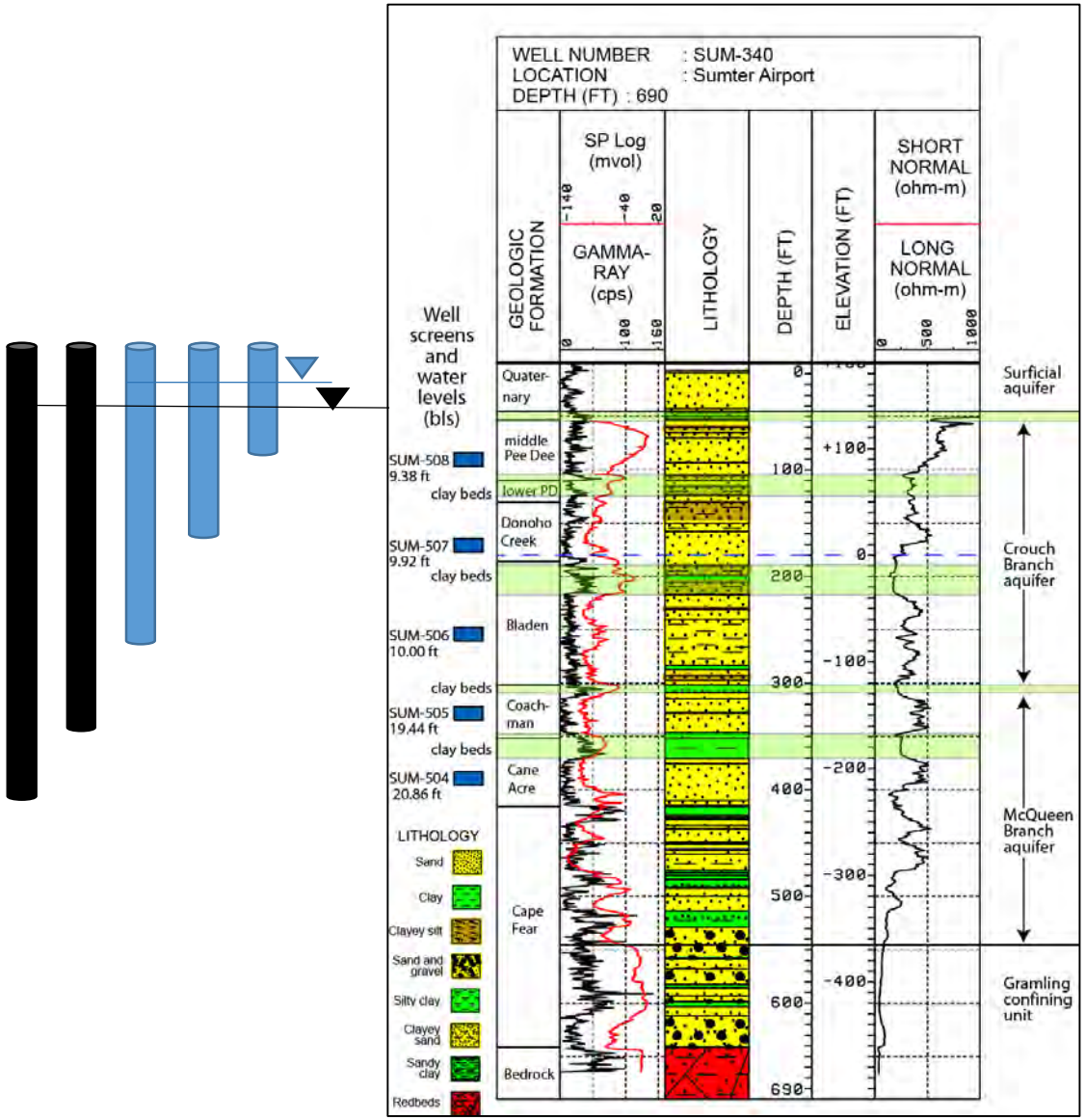
LAD *Hornibrookina* spp. - lower Zone NP 10
FAD **Rhomboaster bramlettei* - base of Zone NP 10 (early Eocene)

---Paleocene/Eocene boundary---

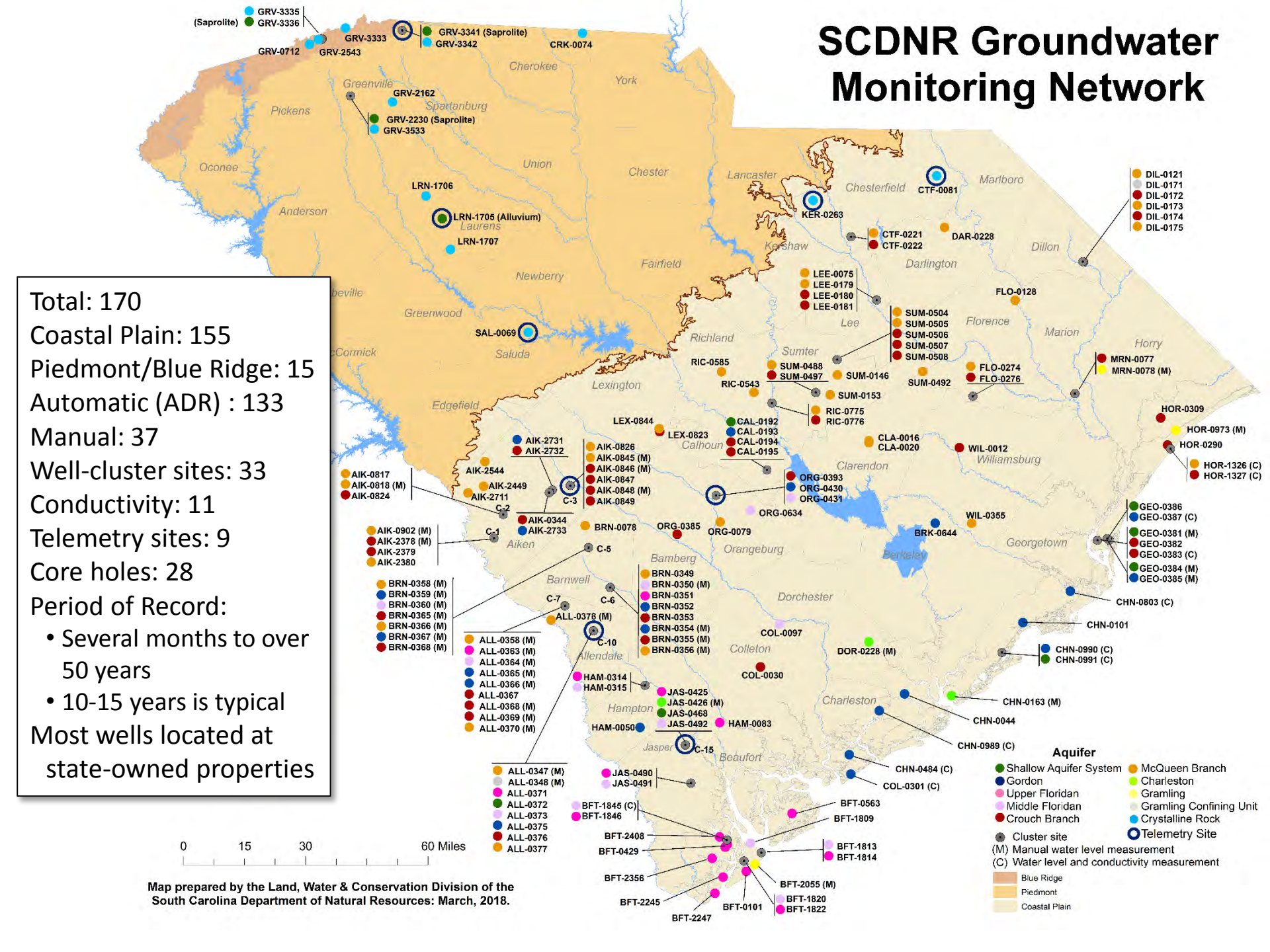
FAD *Toweius occultatus* - within upper Zone NP 9
FAD *Toweius callosus* – within Zone NP 9
FAD *Discoaster lenticularis* - near base of Zone NP 9 (late Paleocene)

FAD indicates a first appearance datum.
LAD indicates a last appearance datum.

Hydraulic Head Data



SCDNR Groundwater Monitoring Network

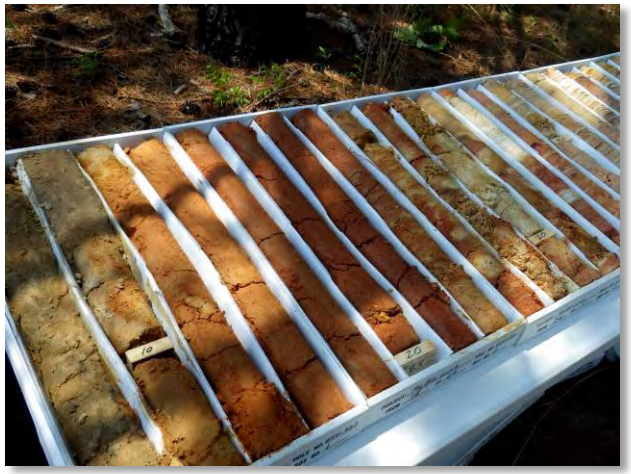


Purpose of Groundwater Monitoring Network

Data are used to…

- Assess drought conditions and long-term trends in storage
- Monitor groundwater availability and the effects of groundwater development
- Study interactions between groundwater and surface water
- Calibrate groundwater flow models
- Note changes in horizontal and vertical flow directions

McBee, Chesterfield County
400 feet



Hobcaw Barony Wildlife Refuge,
Georgetown County
830 feet

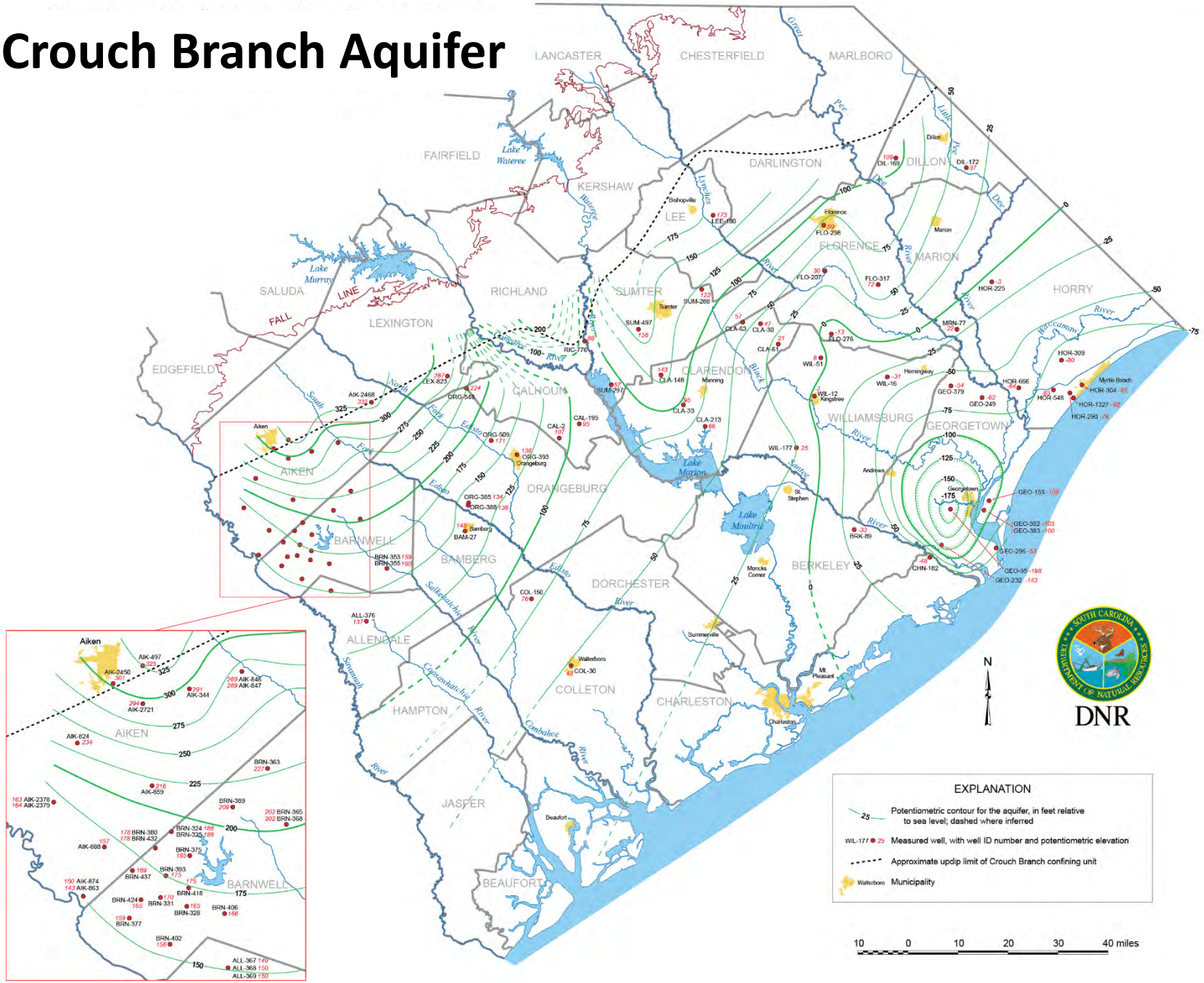
Creston, Calhoun County
1,058 feet

Little Pee Dee State Park
5 wells

Sumter County, near airport
5 wells

Lee State Park
3 wells

Crouch Branch Aquifer



RESULTS OF PUMPING TESTS IN THE COASTAL PLAIN OF SOUTH CAROLINA

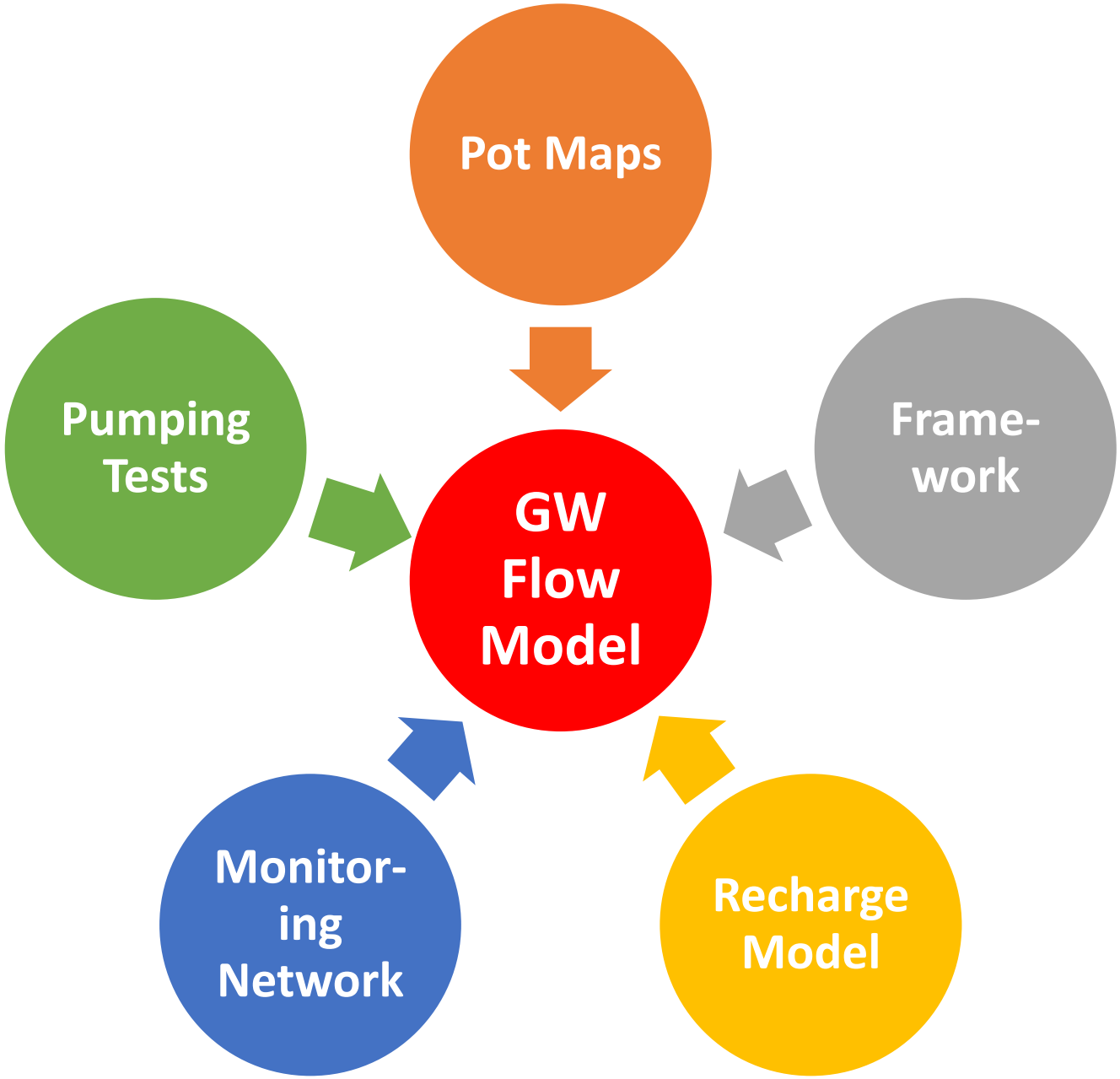
Compiled by Roy Newcome, Jr.

Second supplement to table included in South Carolina Water Resources Commission Report 174, published in 1993 and supplemented in 2000. This supplement includes the findings of 81 additional pumping tests that have become available since 2000.

STATE OF SOUTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES

LAND, WATER AND CONSERVATION DIVISION
WATER RESOURCES OPEN-FILE REPORT 10

2005


Pot Maps
Pumping Tests
Frame-work
GW Flow Model
Monitor-ing Network
Recharge Model