

**PS Savannah River National Laboratory Core Repository: Core Used in Real World
Fluid and Chemical Transport Assessments***

Mary K. Harris¹, Margaret Millings¹, Laura Bagwell¹, and Gerald C. Blount²

Search and Discovery Article #70184 (2015)**

Posted August 17, 2015

*Adapted from poster presentation given at AAPG 2015 Annual Convention and Exhibition, Denver, Colorado, May 31 – June 3, 2015

**Datapages © 2015 Serial rights given by author. For all other rights contact author directly.

¹Savannah River National Laboratory, Aiken, SC, USA (mary.harris@srnl.doe.gov)

²Savannah River Nuclear Solutions, Aiken, SC, USA

Abstract

The coastline of South Carolina is familiar to geoscientists and petroleum engineers as a field laboratory for observing modern coastal processes as analogs for ancient sedimentary environments. Inland, the southeastern Atlantic Coastal Plain physiographic province extends from the Fall Line to the shoreline and is underlain by mostly unconsolidated sediments deposited along a passive emergent margin during the Mesozoic and Cenozoic eras. The sediments of the southeastern Atlantic Coastal Plain in South Carolina are stratified quartz sand, clay, calcareous sediment, and conglomerates that dip gently seaward and range from late Cretaceous to Holocene. At the United States Department of Energy Savannah River Site (SRS), the site geologic data archive includes more than 12,000 borings, wells and cone penetrometer soundings, more than 300 km (200 mi) of seismic reflection data, many kilometers of seismic refraction data, and regional soil gas chemical surveys. Many of the borings were cored and more than 50 miles of core are archived in the Savannah River National Laboratory (SRNL) repository. The repository provides a unique opportunity to observe fluvial, deltaic, and shallow marine sand, mud and calcareous sediments of the upper Atlantic Coastal Plain along with the underlying Paleozoic bedrock and Dunbarton Triassic Basin sequences. At the SRS, primary uses of the core are to understand sediment heterogeneity and resulting effect on contaminant migration, groundwater availability, drought response and other environmental applications as well as geotechnical facility siting and foundation design. Physical properties (grain size, porosity, permeability, K_d, etc.) are incorporated into radiological performance assessments and groundwater fate and transport models. Cores will be displayed that focus on the fluvial, deltaic, and shallow marine sequences with discussion of depositional facies and environment, fabric and texture, and stratigraphy. A detailed environmental characterization will be featured that illustrates how SRS uses core data in real world applications to assess the environmental “water reservoir quality.”



Savannah River National Laboratory Core Repository: Core used in real world fluid and chemical transport assessments

Mary K Harris¹, Margaret Millings¹, Laura Bagwell¹, and Gerald C Blount²

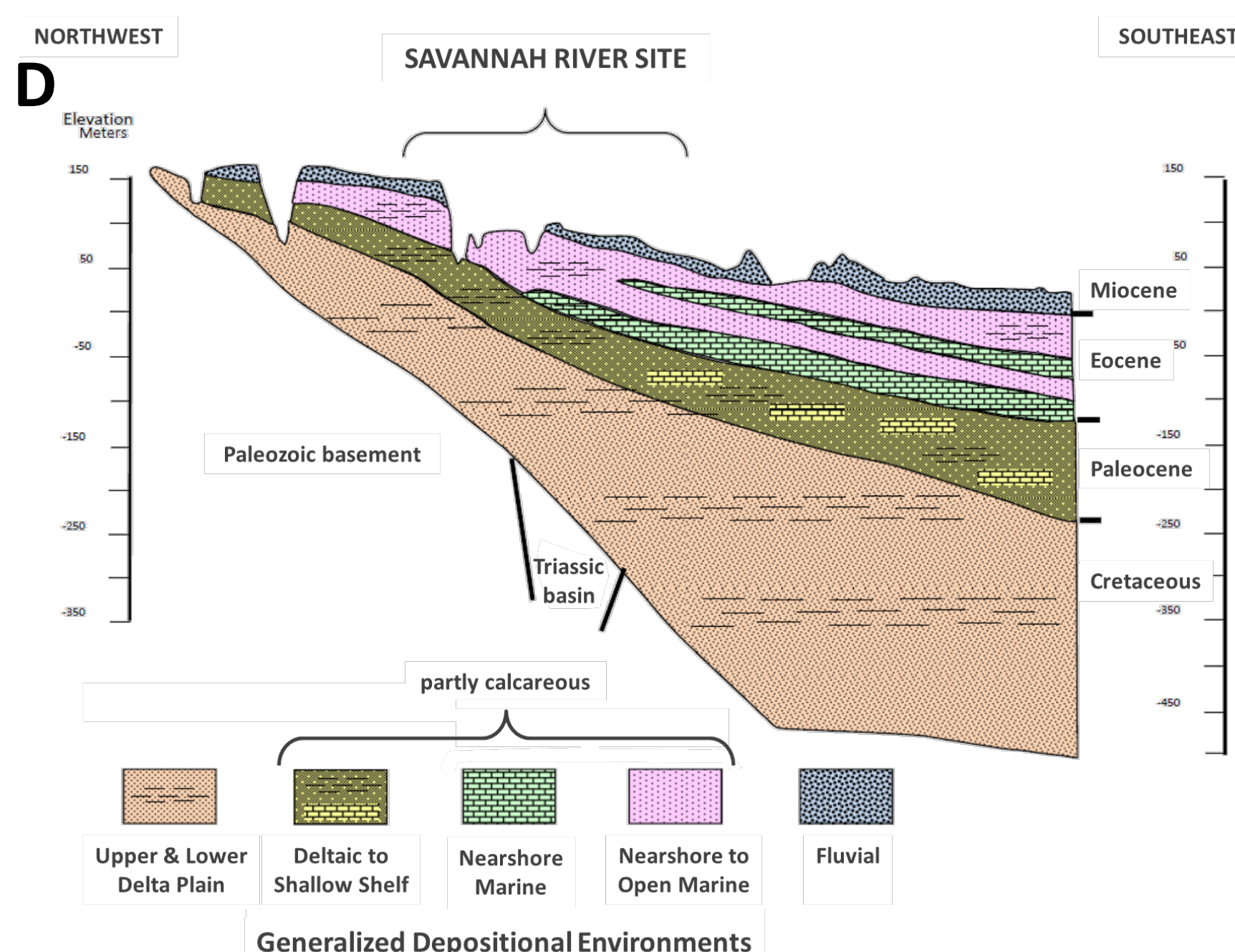
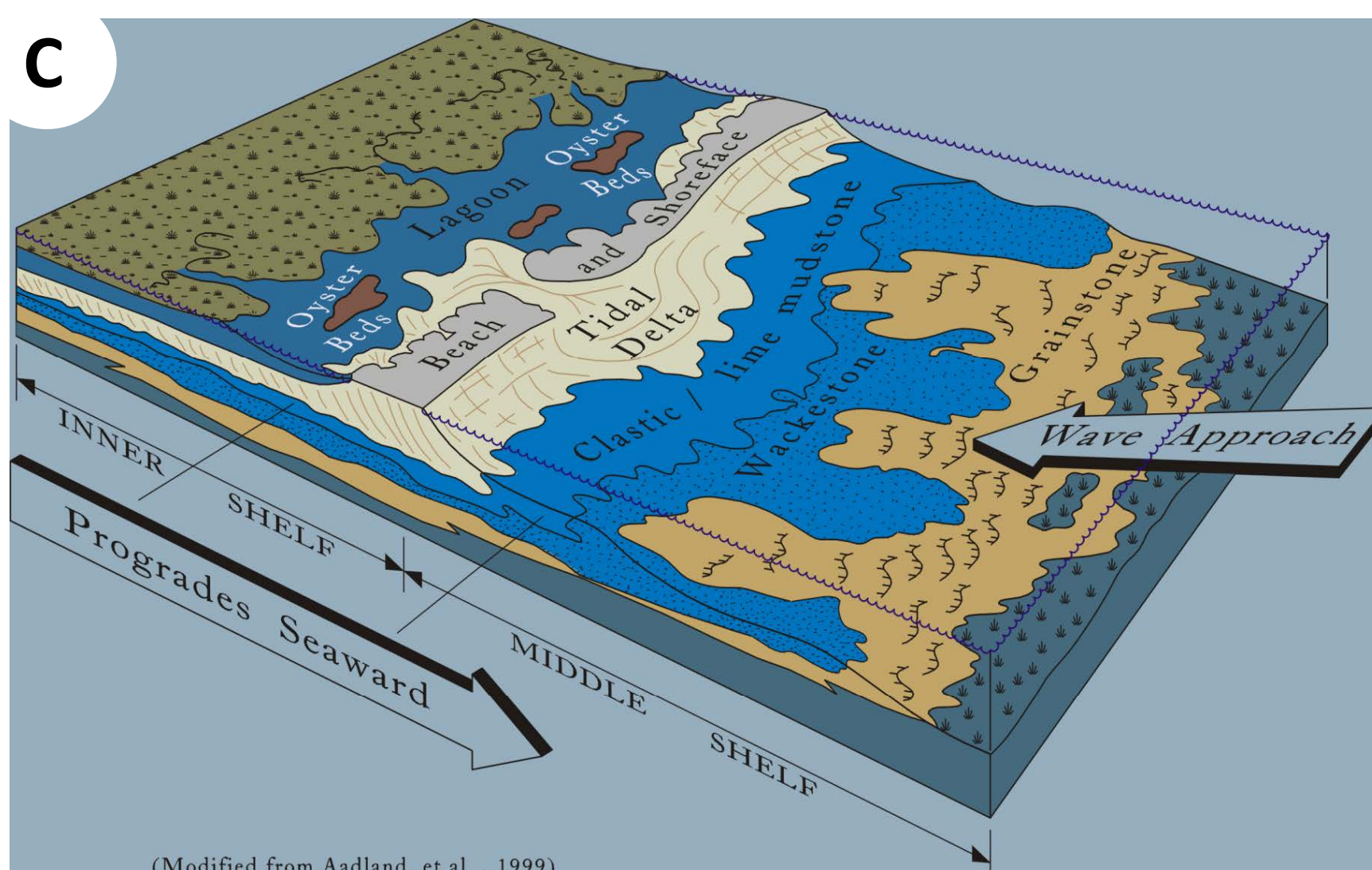
1. Savannah River National Laboratory, Aiken, SC, United States
2. Savannah River Nuclear Solutions, Aiken, SC, United States

The coastline of South Carolina is familiar to geoscientists and petroleum engineers as a field laboratory for observing modern coastal processes as analogs for ancient sedimentary environments. Inland, the southeastern Atlantic Coastal Plain physiographic province extends from the fall line to the shoreline and is underlain by mostly unconsolidated sediments deposited along a passive emergent margin during the Mesozoic and Cenozoic eras. The sediments of the southeastern Atlantic coastal plain in South Carolina are stratified quartz sand, clay, calcareous sediment, and conglomerates that dip gently seaward and range from late Cretaceous to Holocene.

At the United States Department of Energy Savannah River Site (SRS), the site geologic data archive includes more than 12,000 borings, wells, and cone penetrometer soundings, more than 300 km (200 mi) of reflection seismic data, many kilometers of seismic refraction data, and regional soil gas chemical surveys. Many of the borings were cored and more than 50 miles of core are archived in the Savannah River National Laboratory (SRNL) repository. The repository provides a unique opportunity to observe fluvial, deltaic, and shallow marine sand, mud, and calcareous sediments of the upper Atlantic Coastal Plain along with the underlying Paleozoic bedrock and Dunbarton Triassic Basin sequences.

At the SRS, primary uses of the core are to understand sediment heterogeneity and resulting effect on contaminant migration, groundwater availability, drought response, and other environmental applications, along with geotechnical facility siting and foundation design. Physical properties (grain size, porosity, permeability, K_d, etc.) are incorporated into radiological performance assessment and groundwater fate and transport models.

Cores will be displayed that focus on the fluvial, deltaic, and shallow marine sequences, with discussion on depositional facies and environment, fabric and texture, and sequence stratigraphy. A detailed environmental characterization will be featured that illustrates how SRS uses core data in real world applications to assess the environmental “water reservoir quality.”



B. Location of Savannah River Site in the Upper Atlantic Coastal Plain physiographic province

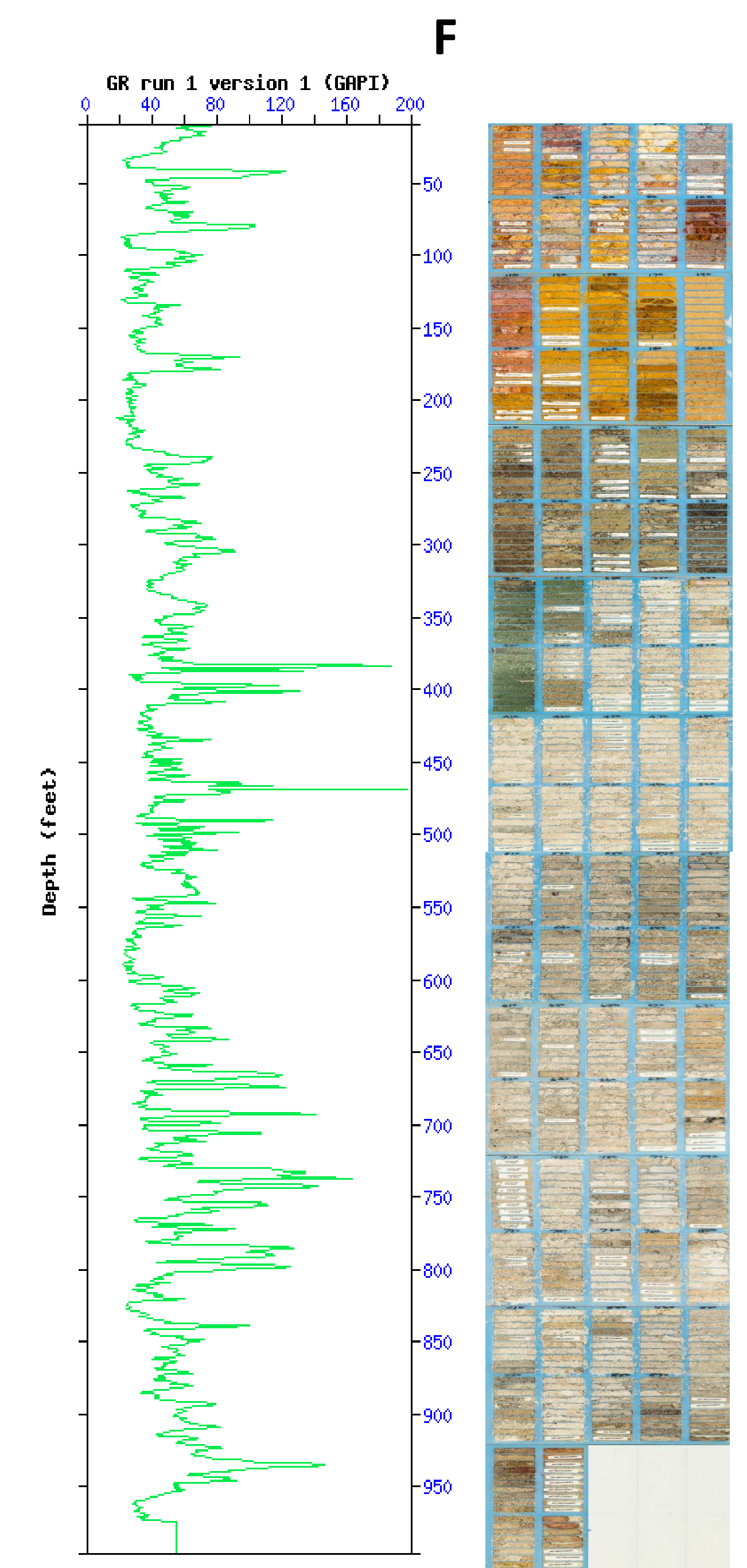
C. Schematic illustration of Cretaceous and Tertiary environments of deposition

D. Schematic cross-section showing Cretaceous and Tertiary sediments overlying Paleozoic crystalline basement rock and Triassic graben sediments.

E. Lithostratigraphic and hydrostratigraphic classification for Cretaceous and Tertiary sediments at SRS

F. Gamma log and photomosaic of Cretaceous and Tertiary sedimentary sequence from borehole GCB-5

Epochs		Lithostratigraphy (modified from Fallaw and Price, 1995)		Hydrostratigraphy (modified from Aadland et al., 1995)											
				Northern SRS		Central-Southern SRS		SRS							
Miocene		Altamaha Formation		Steed Pond Aquifer	M Area Aquifer	Upper Three Runs Aquifer	Upper Zone UTR Aquifer	Tan Clay Confining Zone	Lower Zone UTR Aquifer	Floridan Aquifer System					
Tobacco Road Formation															
Tertiary	Eocene	Dry Branch Formation	Irwinton Sand												
			Twiggs Clay												
		Griffin's Landing Mbr													
		Santee Formation													
	Paleocene	Warley Hill Formation													
		Congaree Formation													
		Fourmile Branch Formation													
		Snapp Formation													
Cretaceous		Lang Syne Formation									Crouch Branch Confining Unit				Meyer's Branch Confining System
		Sawdust Landing Formation									Crouch Branch Aquifer				
		Steel Creek Formation		McQueen Branch Confining Unit											
		Black Creek Formation		McQueen Branch Aquifer											
		Middendorf Formation		undifferentiated											
		Cape Fear Formation													
Triassic Newark Supergroup or Paleozoic Crystalline Basement				Piedmont Hydrogeologic Province											

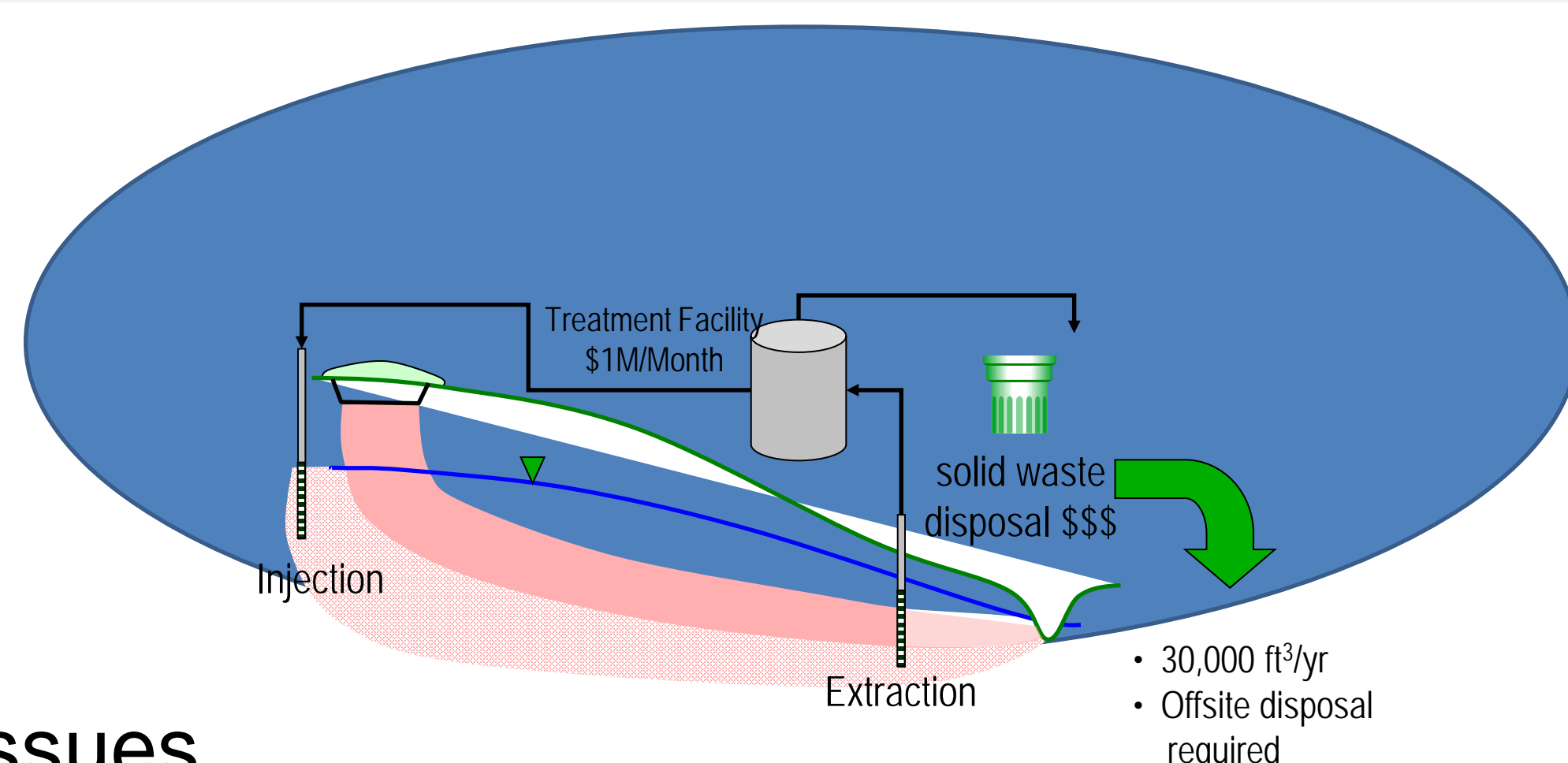
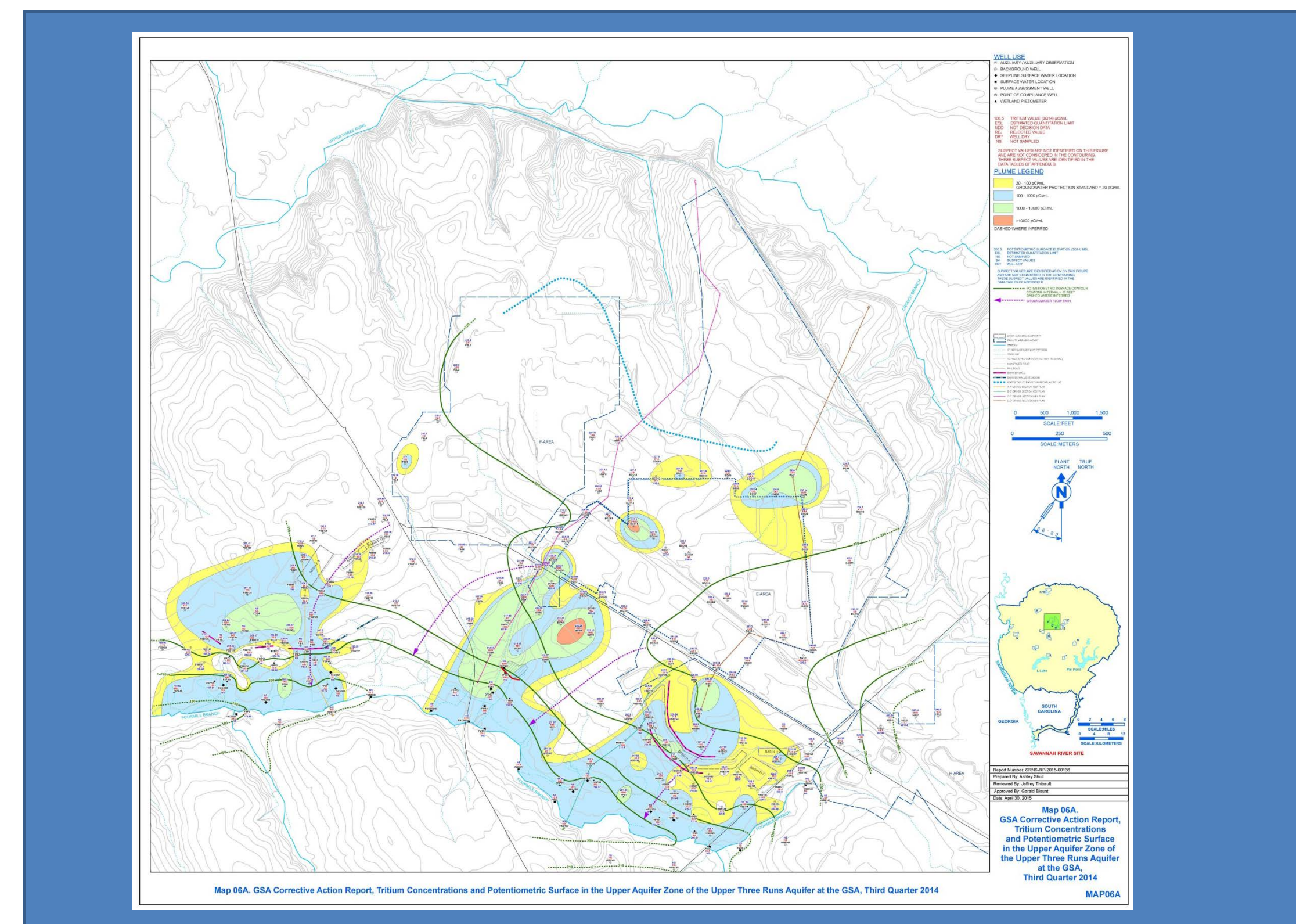


Innovative In-Situ Groundwater Remedial Technologies at the Savannah River Site

Tritium, Metals, and Metallic Radionuclides Example

History and Original Remedial Strategy

- Operated 1954 -1988 - basins received acidic & radioactive process water from F & H separations facilities resulting in a shallow persistent low pH contaminant plume – capped in the early 1990s
- The acid stripped the formation of metals (including natural radionuclides) and minimized the retardation of contaminants
- The plumes discharge into Fourmile Branch
- Treatment system employs extraction and injection wells, to manage tritium and metals releases to surface water
- Hydraulic containment of tritium is ineffective and cost intensive
- Systems would have to operate for 90 years (until tritium decays to standards), over \$10 billion!

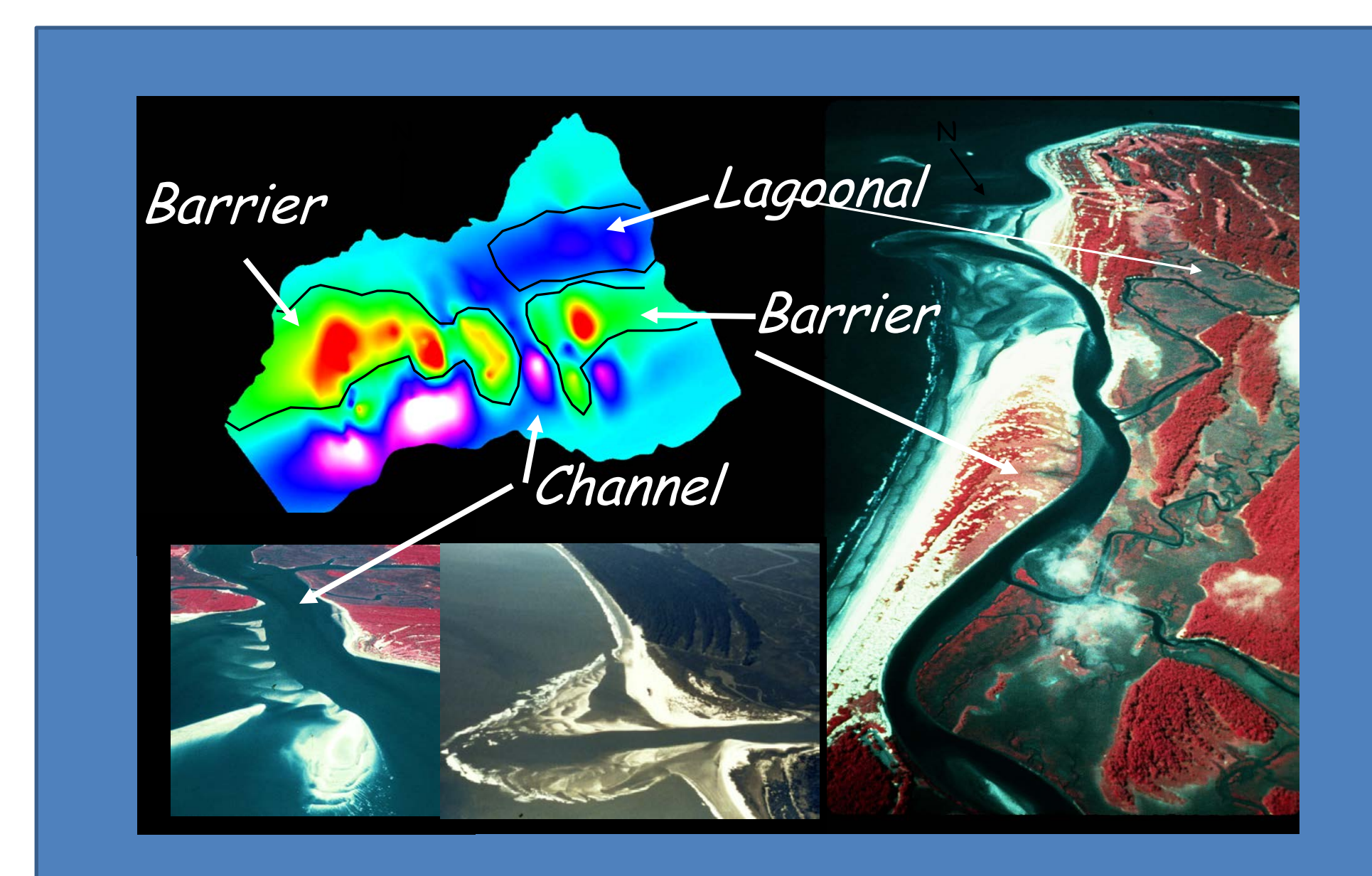
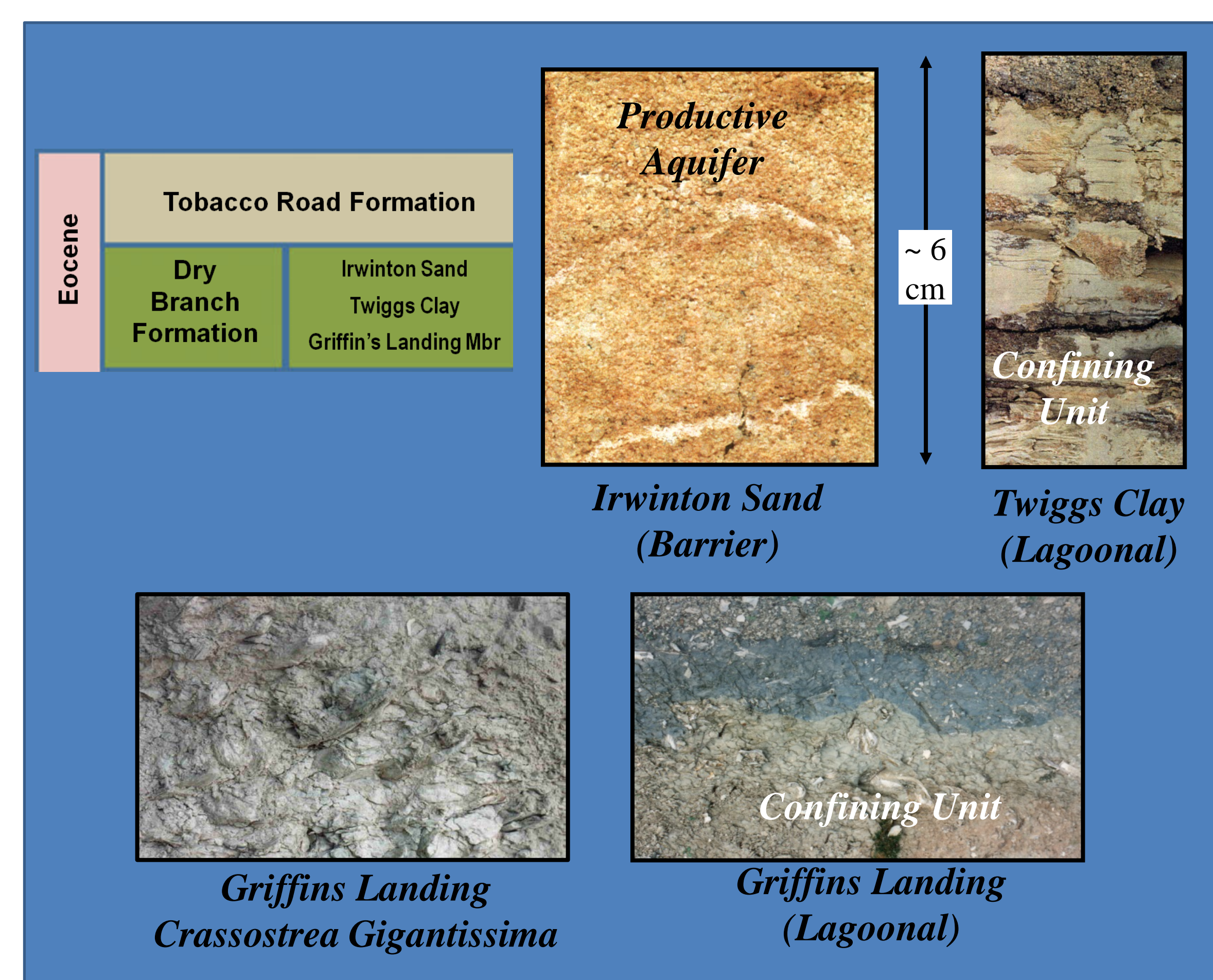


Technical Issues

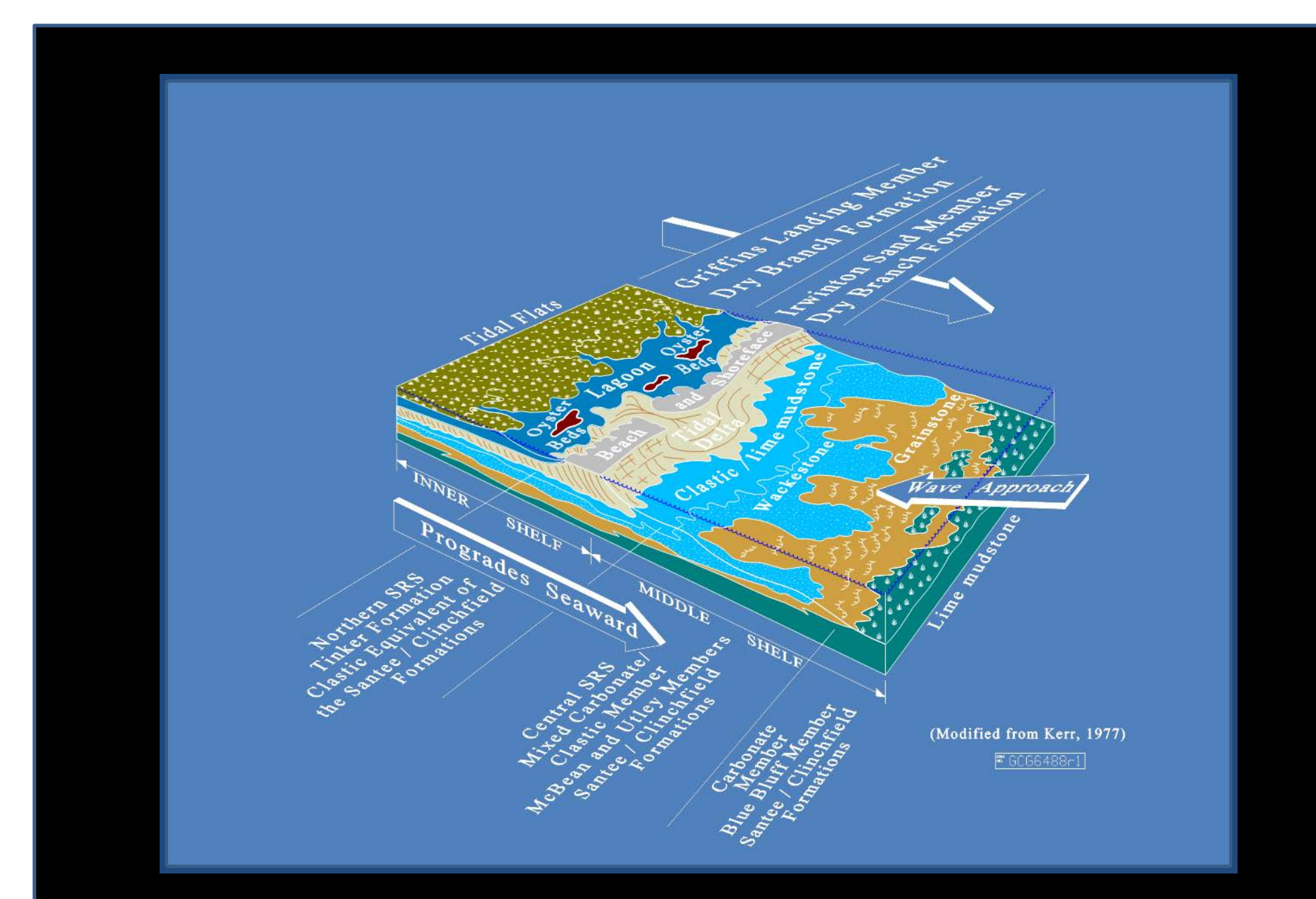
- Pump and Treat System had capture issues
 - Are there hydraulic controls that are not well understood?
 - Additional characterization needed !
- Need an innovative solution for the acid problem
 - 12 billion liters discharged into basins
 - Formation is completely acidified (pH of 3 common)

New Strategy Needs

- Need a remedial strategy that works and is not so expensive
 - Prefer passive
 - No waste generation
 - Regulators insist on a 70% reduction in tritium flux to Fourmile Branch in 5 years (10/2007)
 - Regulators insist on bringing all other contaminants below standards in Fourmile Branch
 - Have to be able to pay for it with the shutdown of the existing system



Modeled depositional facies from detailed core data compared to modern depositional environments in SC



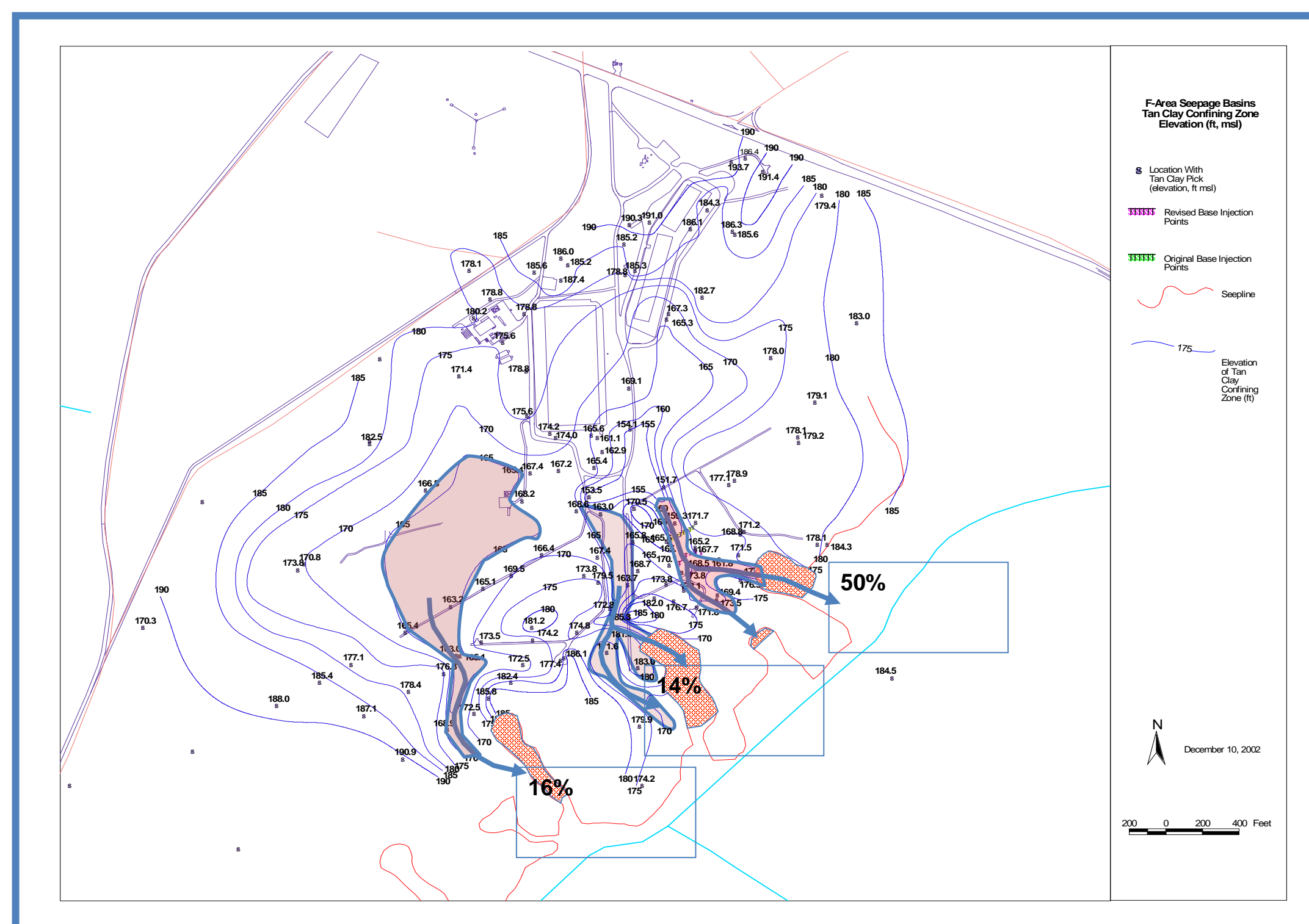
Innovative In-Situ Groundwater Remedial Technologies at the Savannah River Site

Nearshore Marine Facies Controls Hydrology

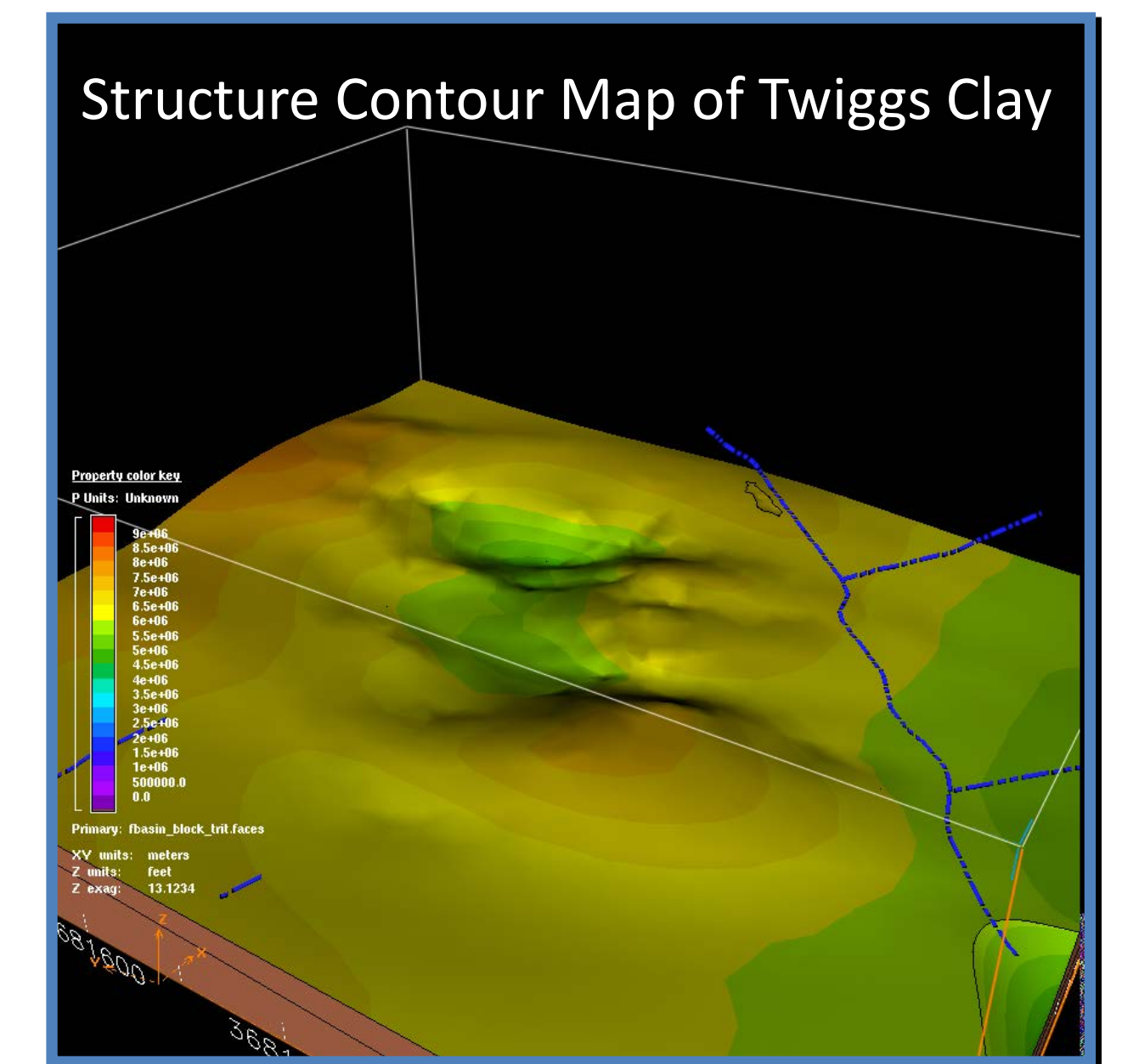
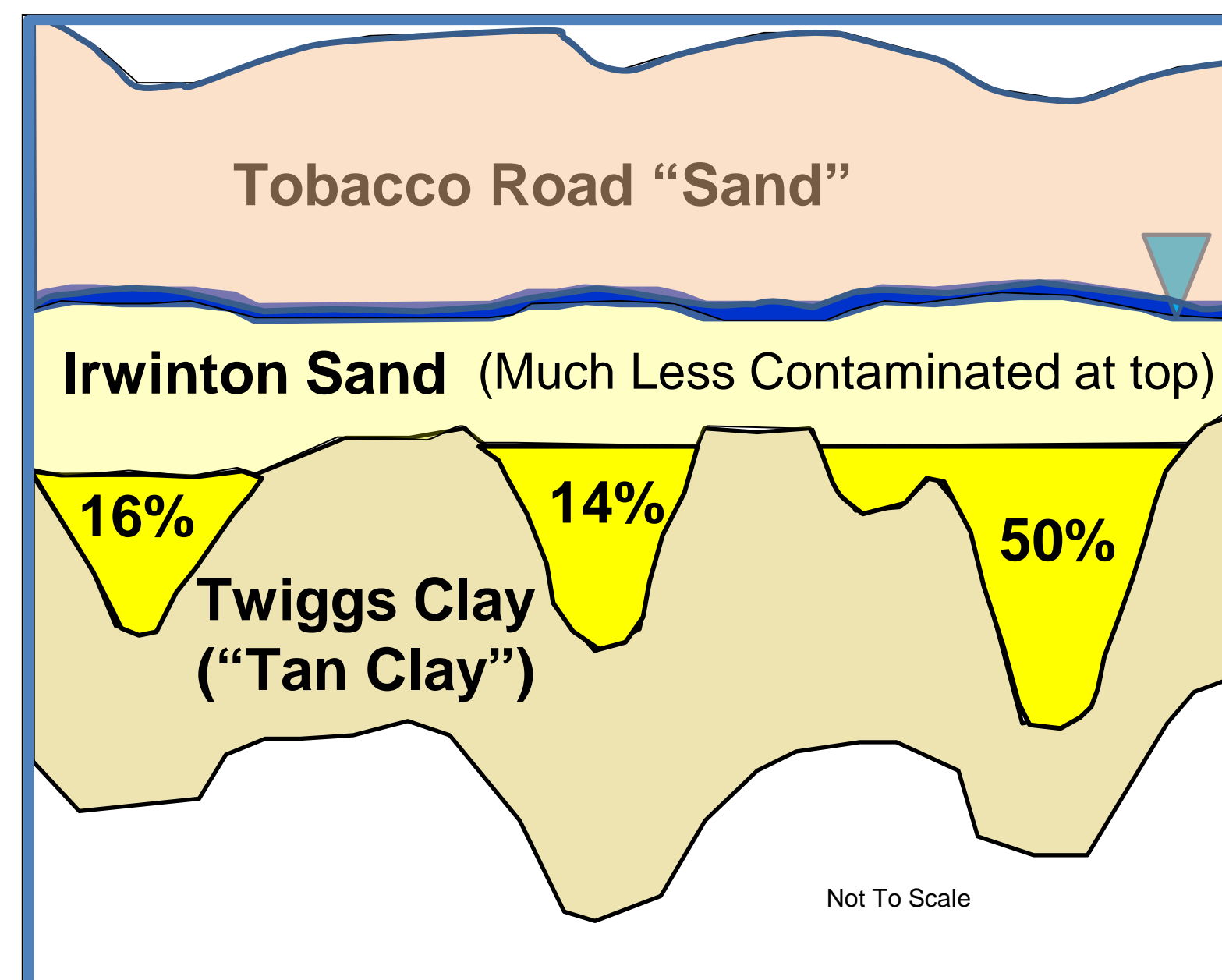
- Structure contour map of the top of the Twiggs/"Tan" Clay indicates channel deposits
- Contaminant flow distribution and path to Fourmile Branch is controlled by channels

Distribution of Contaminant Flow

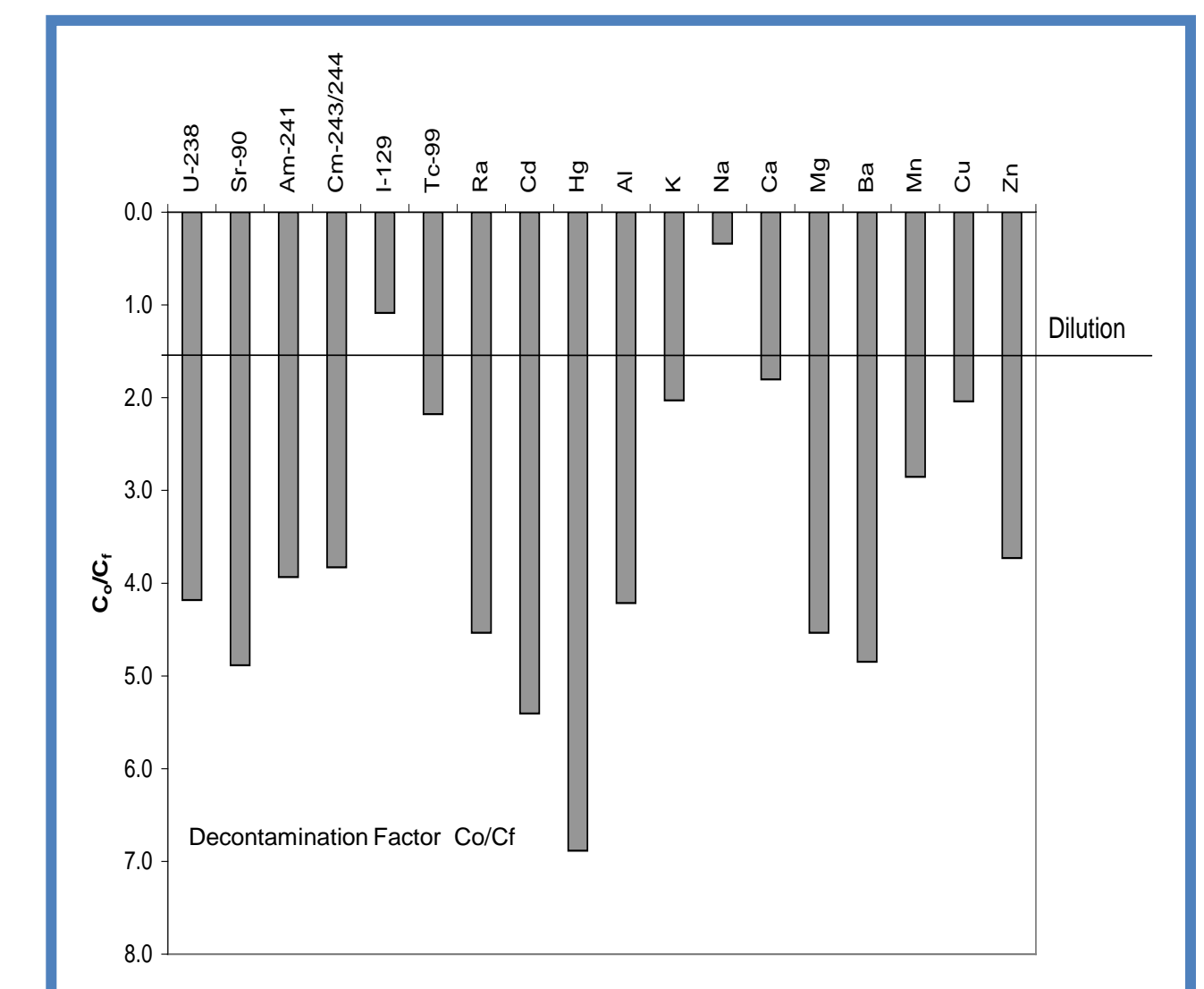
- 3 highly transmissive channels in Irwinton Sand
 - 50%, 14%, and 16% flow
 - Separated by highs in the clay



Hydrogeologic Conceptual Modeling



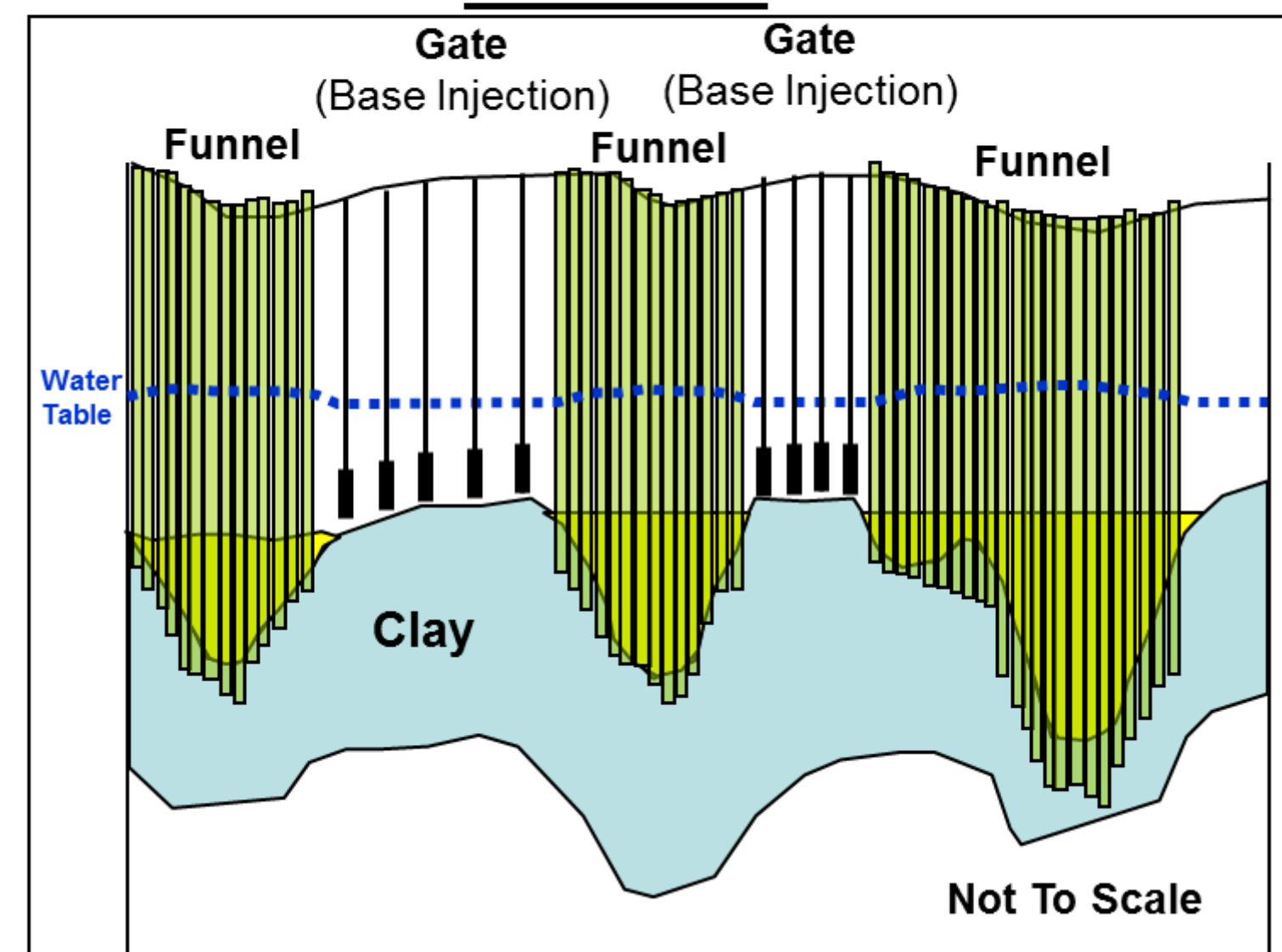
Effective of Base Injection Tests



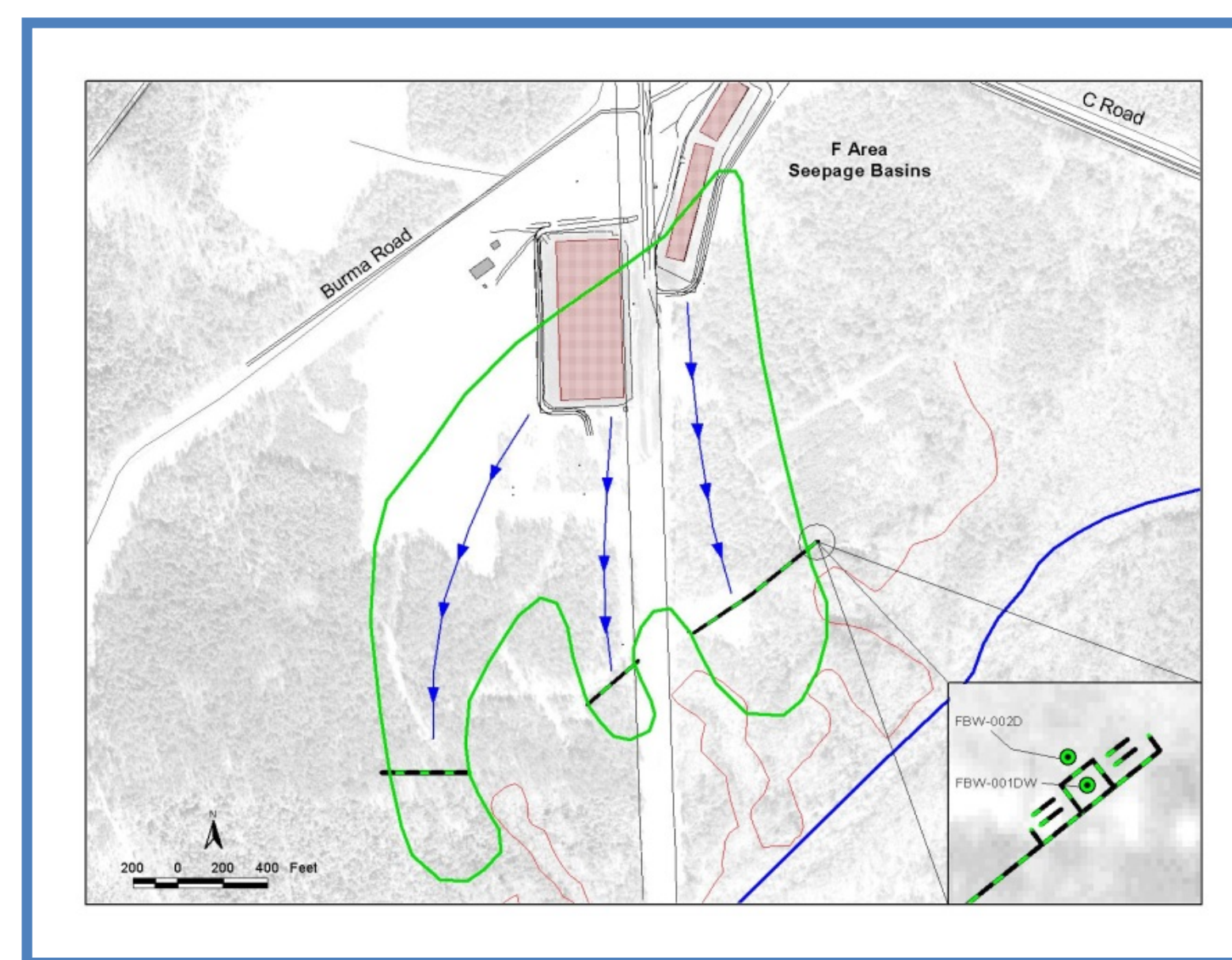
Solving the Acid Problem

- The lower the pH the higher the metal solubility
-
- With H⁺ ion coating the formation materials there is little attachment of metals (sediments typically capture metals)
 - 12 billion liters is a lot of H⁺

Conceptual Design of the Funnel and Gate



Location and Placement Method

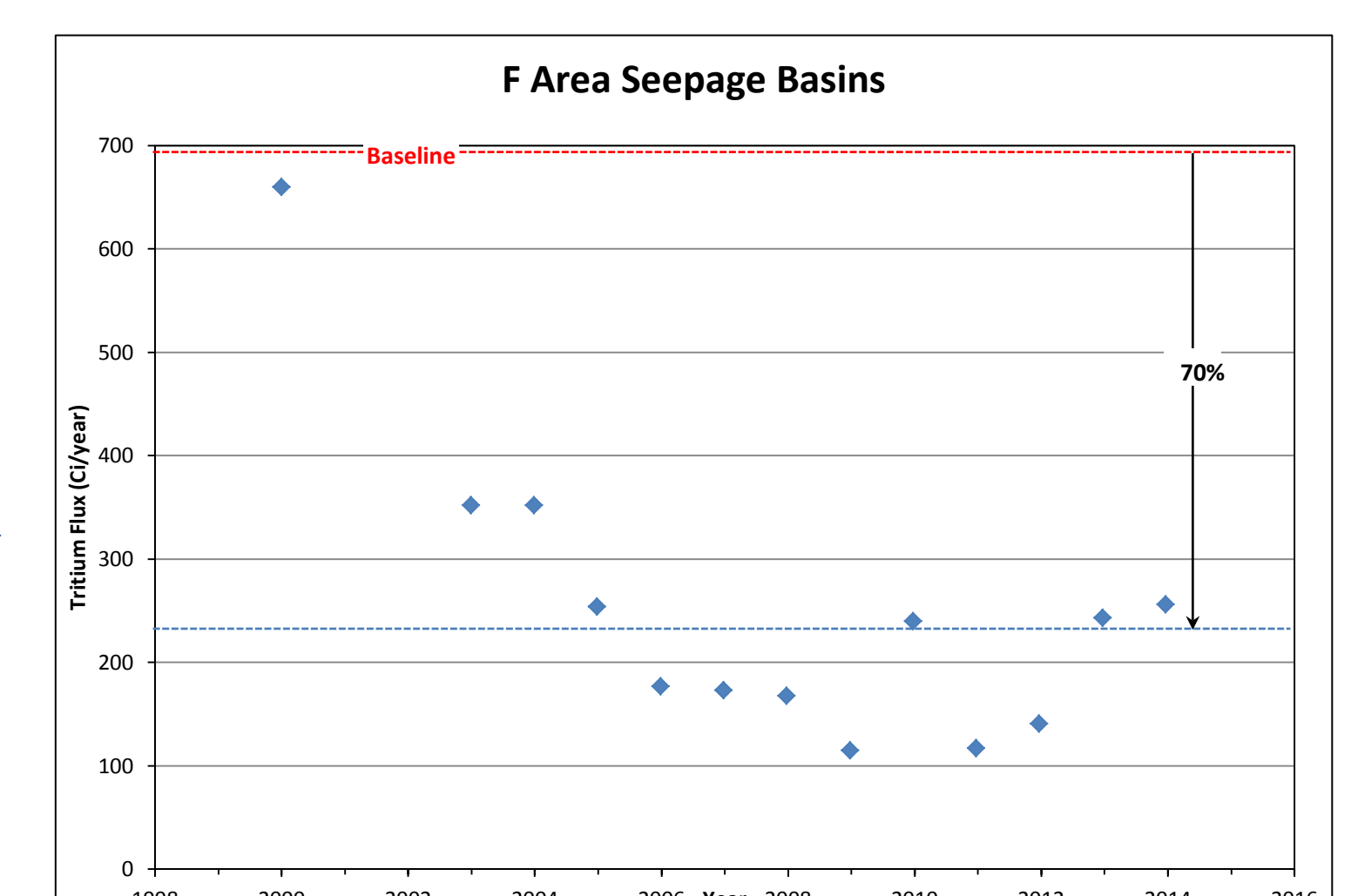


New Strategy

- Interrupt the flow of contamination to Fourmile Branch in the bottom of the aquifer, and decant off the top with a funnel
- Pretreat area with base before placement
 - Base = mixture of sodium hydroxide and bicarbonate of soda
- Treat the water in a gate with base to precipitate metals / metallic radionuclides

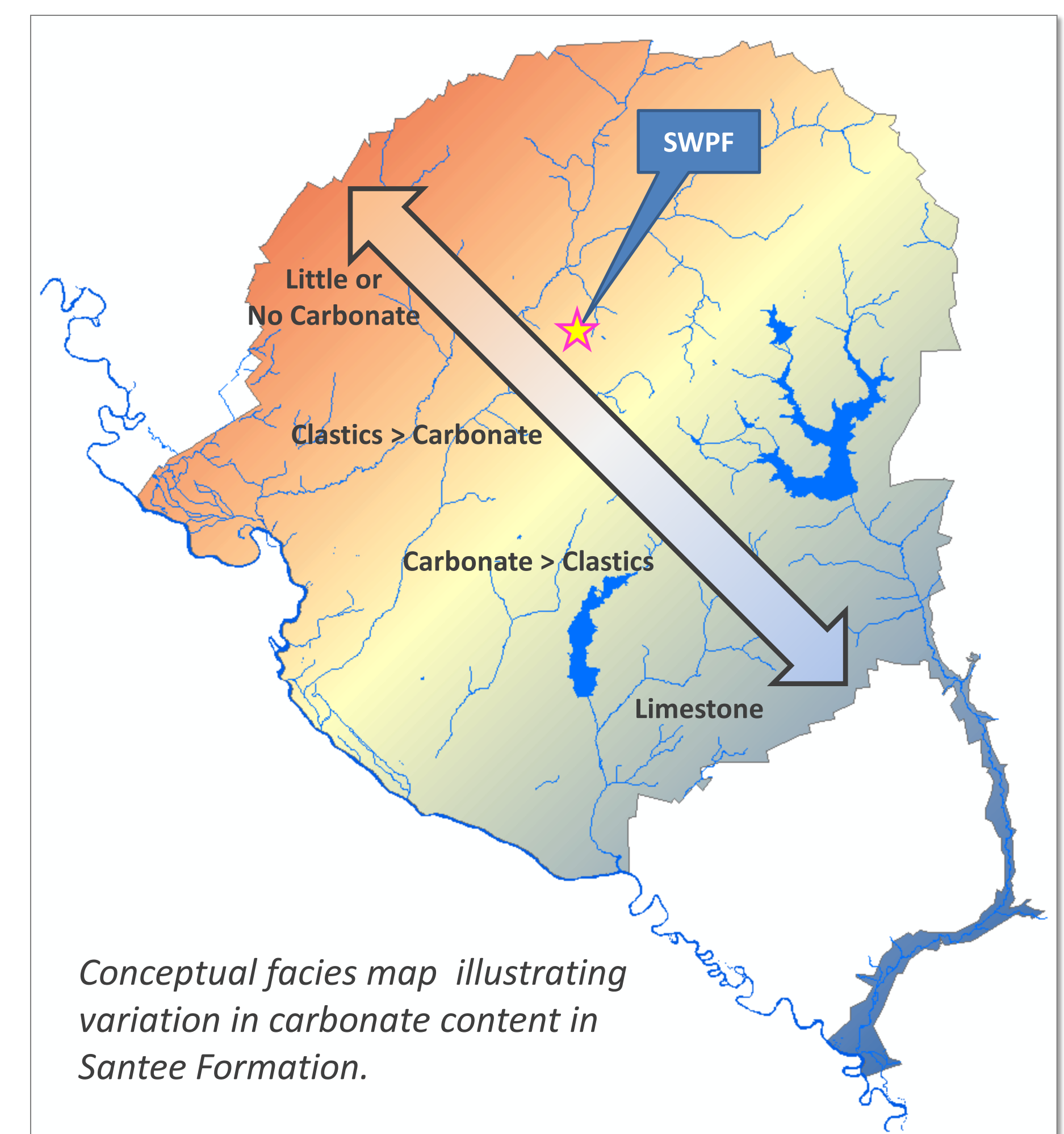
Effects of the System

- 70% reduction in tritium flux to Fourmile Branch
- Reduction in metals and radioactive metals in Fourmile Branch
- Working on in-situ treatment for I-129



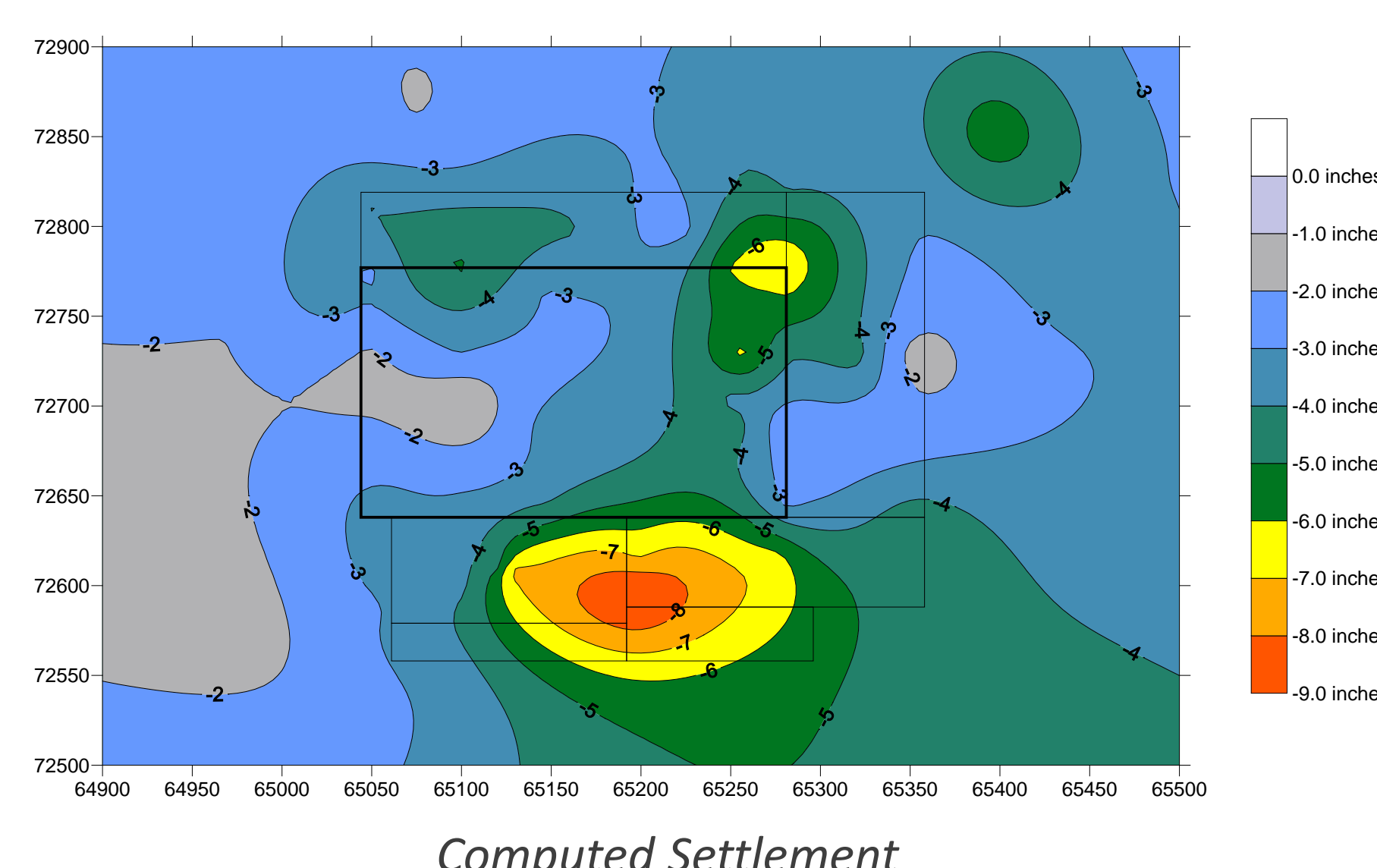
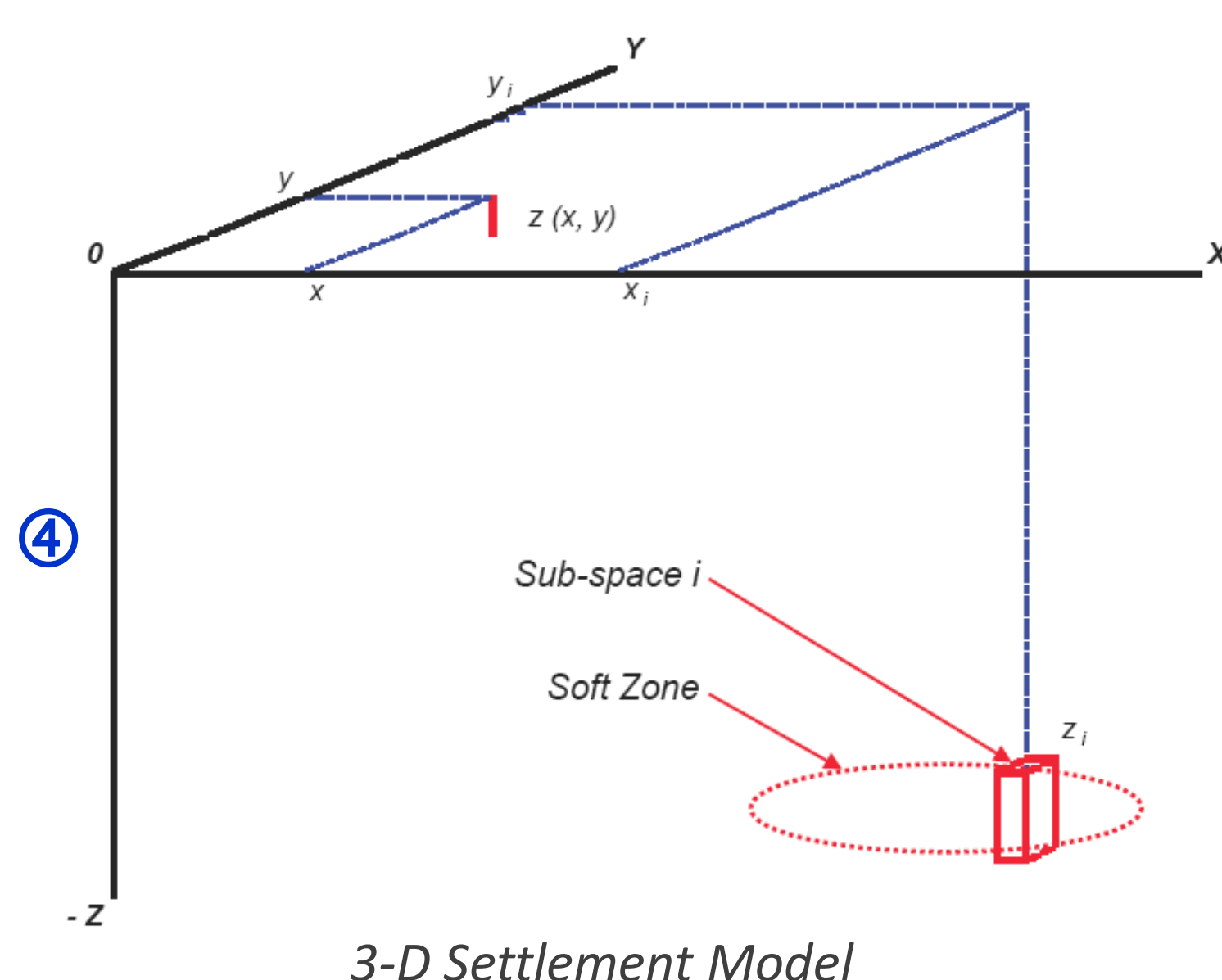
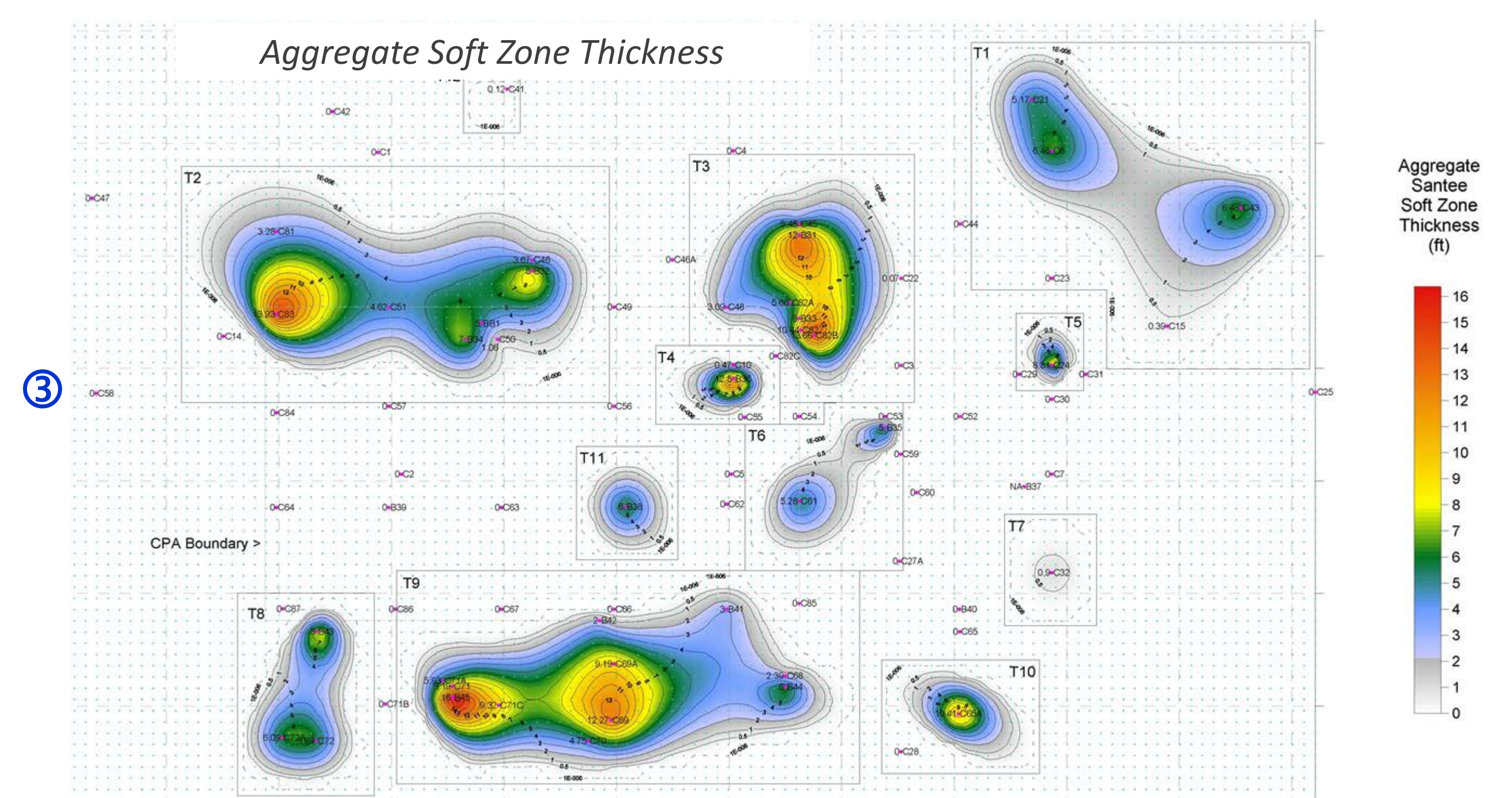
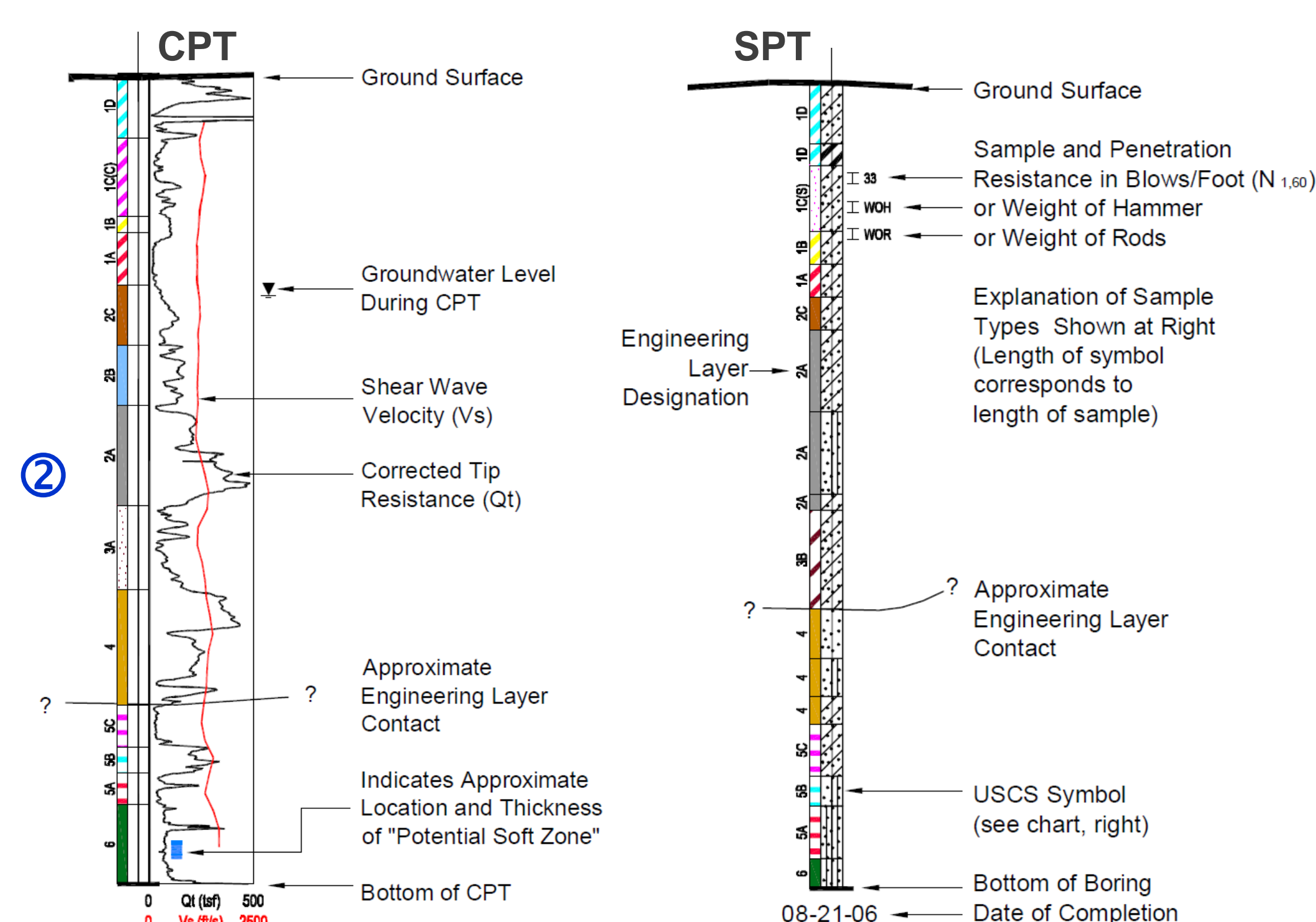
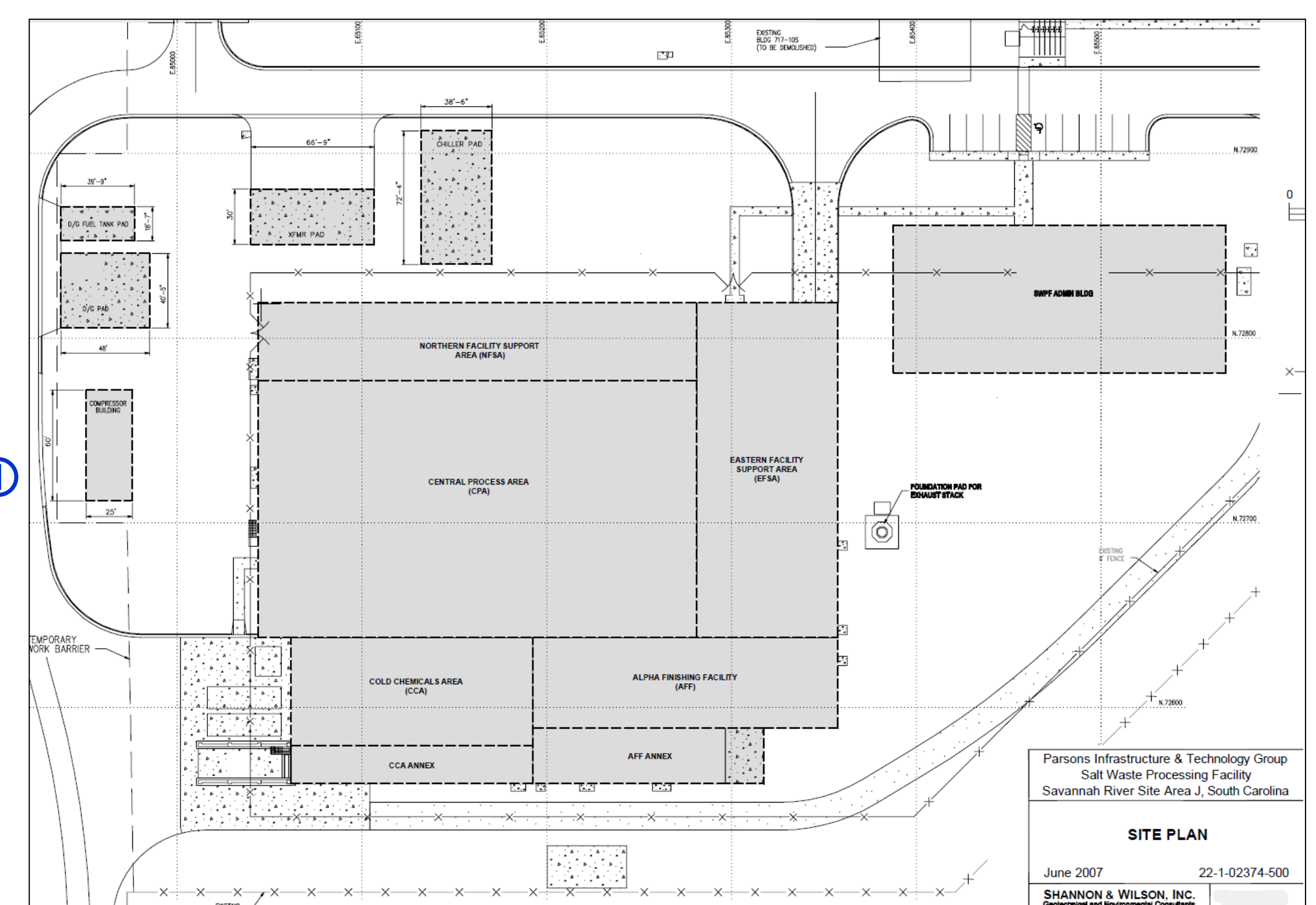
Geotechnical Considerations

Engineering properties of unconsolidated strata are key factors in siting new facilities and predicting facility performance over time. A well characterized soft zone exists in the Santee Formation beneath SRS. The variably under-consolidated behavior of this zone likely results from partial dissolution of the Santee Formation, a mixed carbonate/clastic layer of Eocene age that underlies SRS at depths ranging from about 100 to 200 ft (30 to 60 m). The Santee Formation exhibits significant mineralogical variation resulting primarily from original depositional environment (nearshore to shallow marine) and, to a lesser extent, variations in the degree of post-depositional dissolution. The SRNL Core Repository includes >250 cores that fully penetrate this important formation.



Case Study: SRS Salt Waste Processing Facility

- ① Performance Category 3 nuclear facility
- ② Characterization program included CPTs, soil borings, SPT, and crosshole seismic tests to define the extent and thickness of soft zones
- ③ Integrated multiple datasets to calculate aggregate soft zone thickness beneath proposed facility
- ④ Conservative engineering analysis:
 - assumed soft zones lose strength (static & dynamic)
 - modeled application of full overburden pressures to soft zones
 - calculated compression at depth
 - propagated compression to surface and computed settlement
 - resulted in 8' thick concrete basemat



Pre-Cretaceous Rocks

In addition to samples of the entire upper Atlantic Coastal Plain stratigraphic sequence, the SRNL Core Repository houses core from more than 25 boreholes that penetrate into underlying Triassic sedimentary rock or Paleozoic crystalline rock. Due to the cost and difficulty of drilling through more than 1,000 feet of sedimentary cover, pre-Cretaceous rocks are rarely sampled in this region, making these cores especially significant assets.

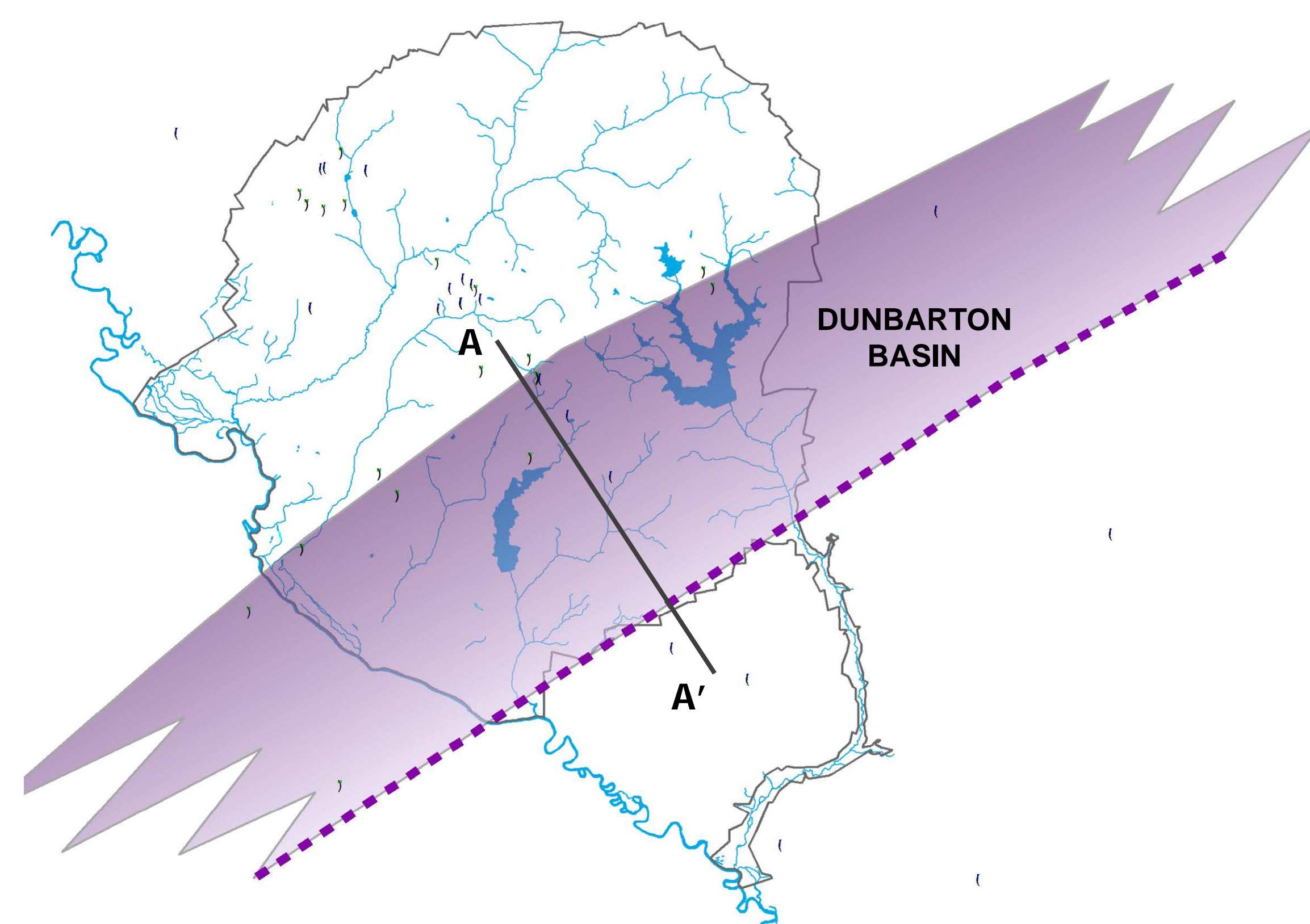
Triassic Sedimentary Rocks

The Dunbarton Basin is a Triassic-age half-graben -- one of numerous extensional basins formed during the breakup of Pangea and the opening of the Atlantic Ocean. Drilling and geophysical studies indicate that the basin is ~30 miles long and 8 miles wide. Core samples indicate that the basin is filled with lithic arkose, litharenite, mudstone, and conglomerate of the Newark Supergroup.

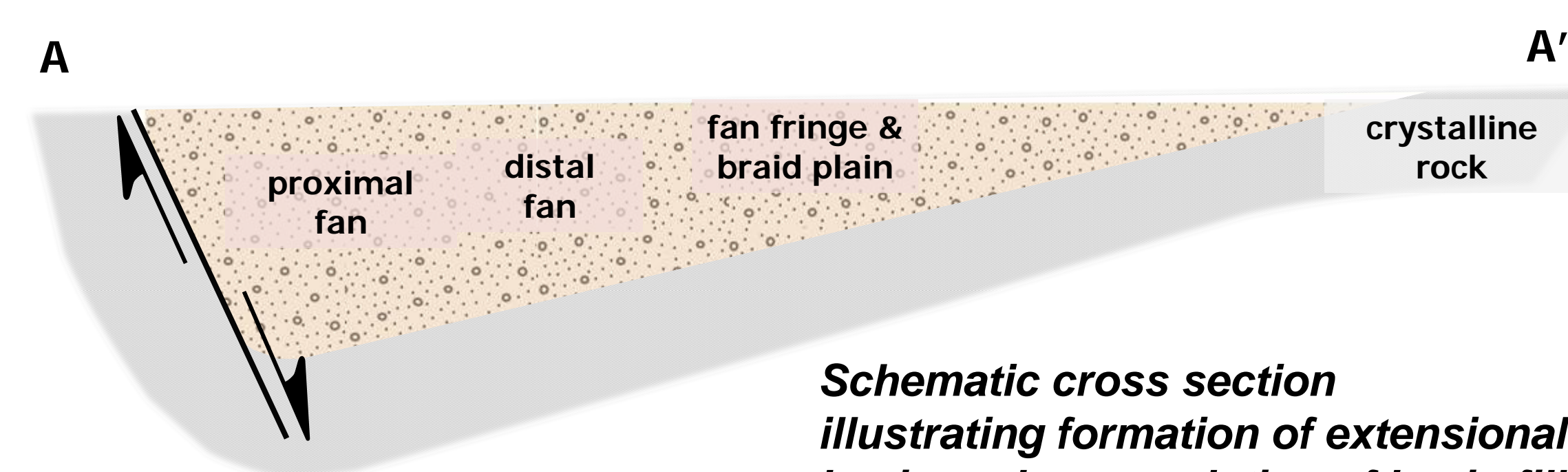
Core samples from the Dunbarton Basin facilitate a more complete understanding of the basin's evolution (age of opening, sediment accumulation rate and provenance, diagenetic history, etc.) and can also provide a proxy for studying similar buried basins. And, of particular interest to industry and regulators, this and other sedimentary basins may hold promise as reservoirs for carbon dioxide sequestration.



Locally metamorphosed sedimentary rocks from the Dunbarton Basin.



Boreholes penetrating Triassic basin sediments (shaded purple) or Paleozoic crystalline basement.



Schematic cross section illustrating formation of extensional basin and accumulation of basin fill sediments during Triassic period.



A. Metaplatonic bedrock showing range of textures and metasomatic alteration.

B. Pseudotachylyte formed from metavolcanic bedrock.

Paleozoic Crystalline Rocks

More than 15,000 feet of basement rock has been recovered from deep boreholes at and near Savannah River Site. Most of this core was collected primarily during 1960s and 1970s drilling campaigns aimed at studying the feasibility of various waste storage/disposal options or during later programs designed to understand the age and capability of local faulting. While no waste was ever emplaced in bedrock, the archived cores are an important resource in understanding the age, lithology, geochemistry, structural behavior, and complex metasomatic history of Appalachian basement rocks.

All rock photos courtesy of Dr. Allen Dennis, University of South Carolina Aiken