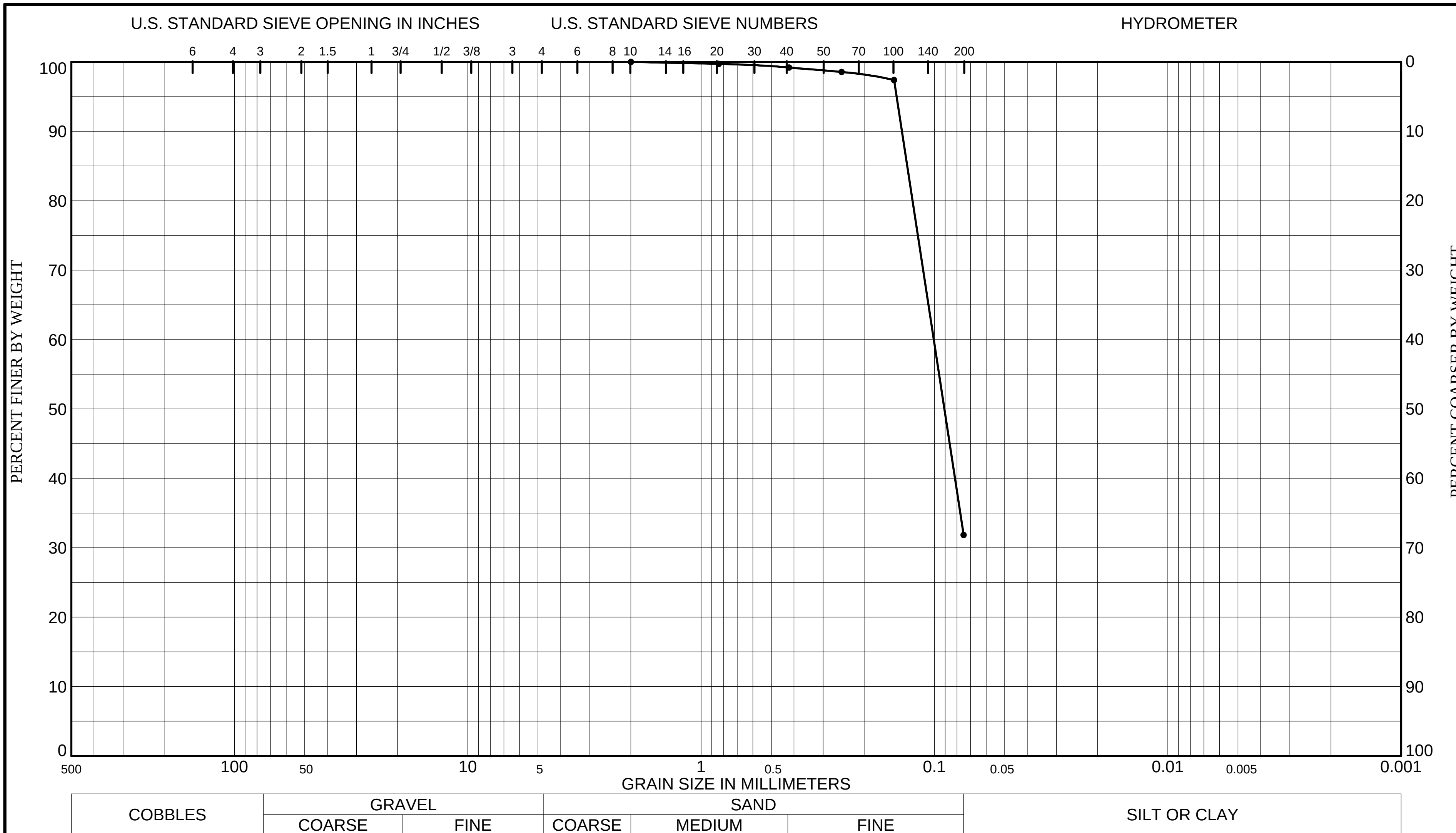
DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-4	99.7 to 100.3	Olive Gray with White sand lenses, (Visual) Clayey Sand (SC).	50.8			

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/262

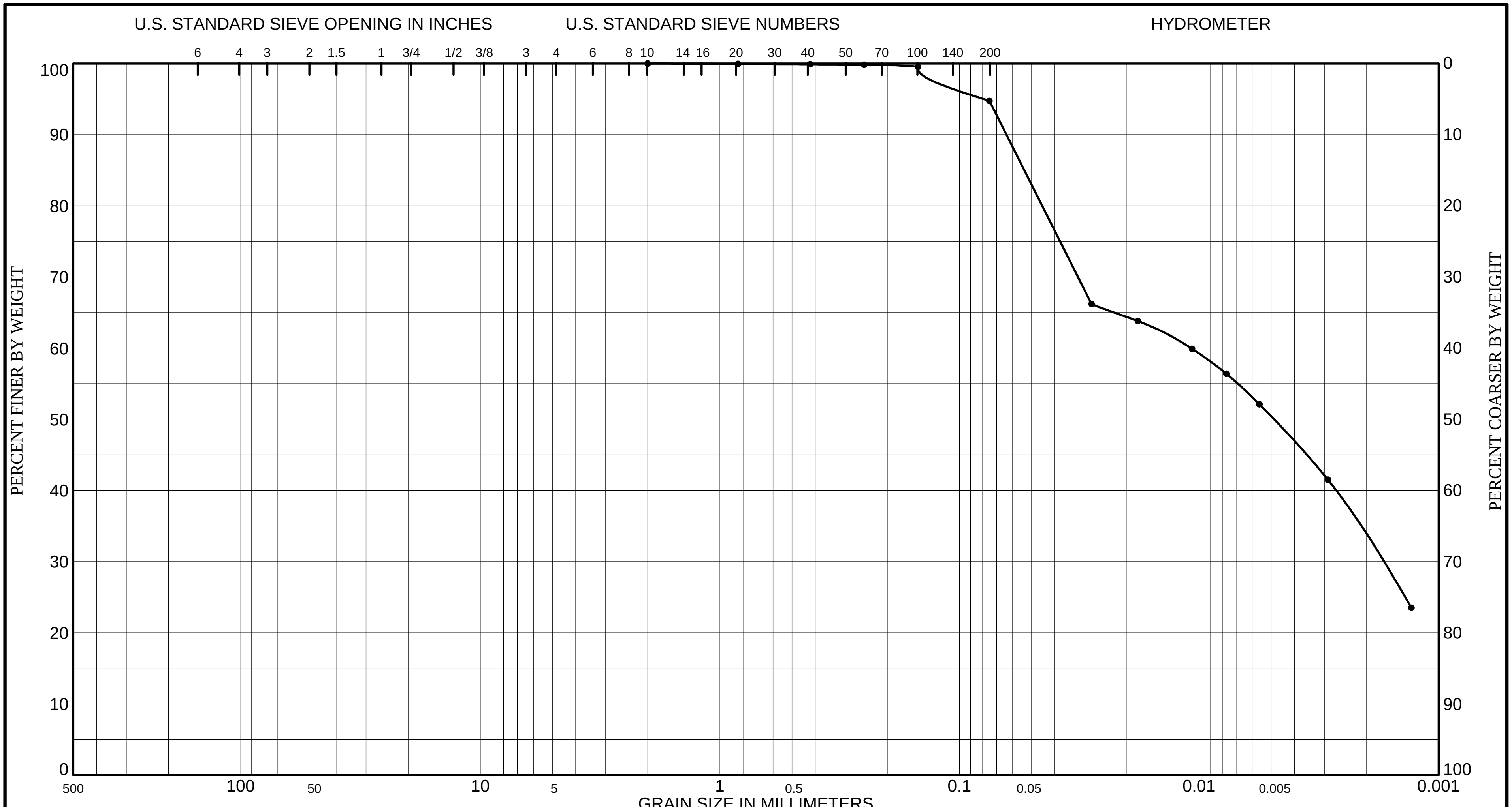
Boring No. SHE-15

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-5	112.0 to 112.6	Olive Gray with White sand lenses, Clayey Organic Silt (OH), with a trace of sand.	74.8	144	59	85
		Oven dried LL was 71% of wet prepared soil.				

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/263

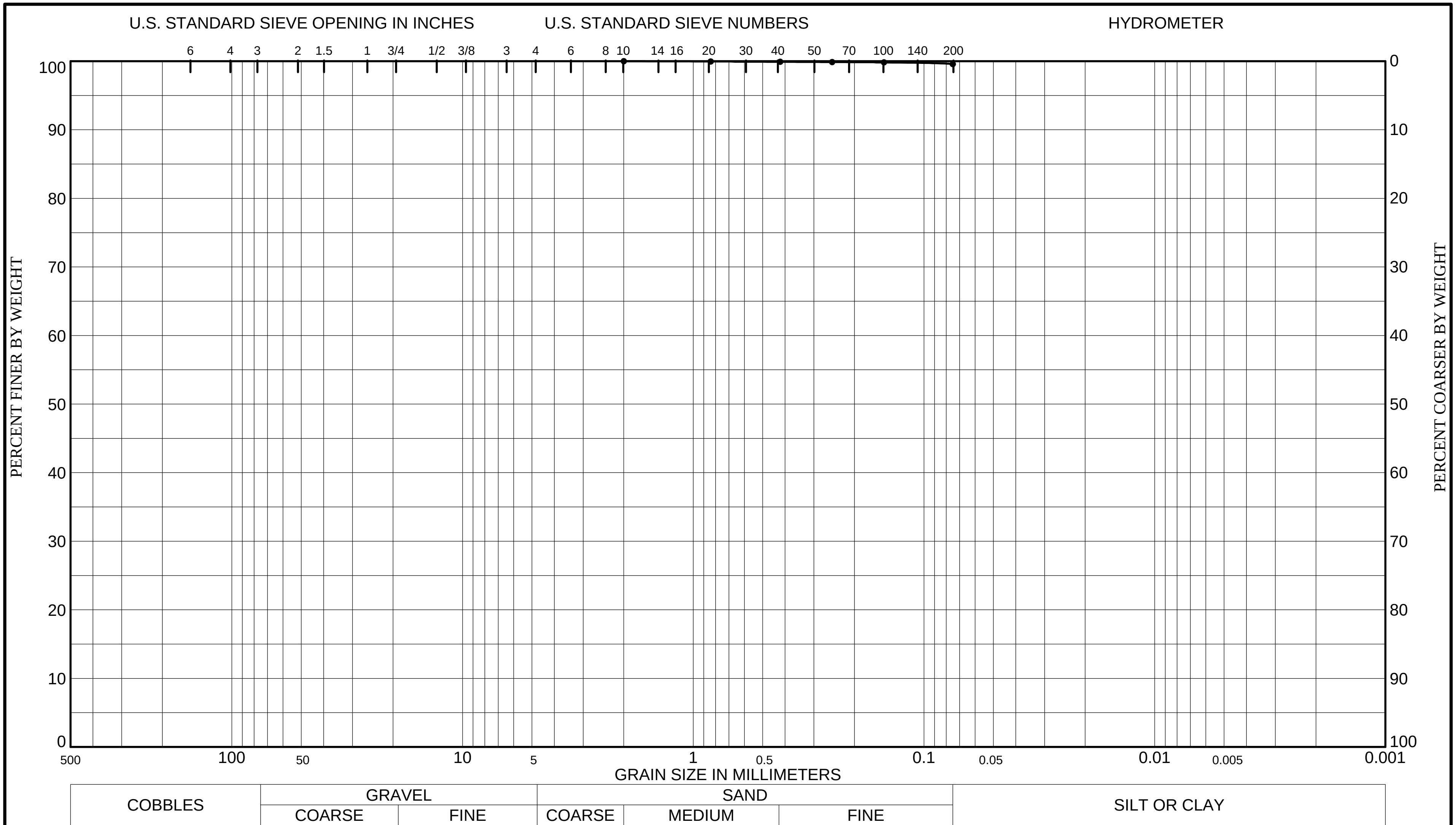
Boring No. SHE-15

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



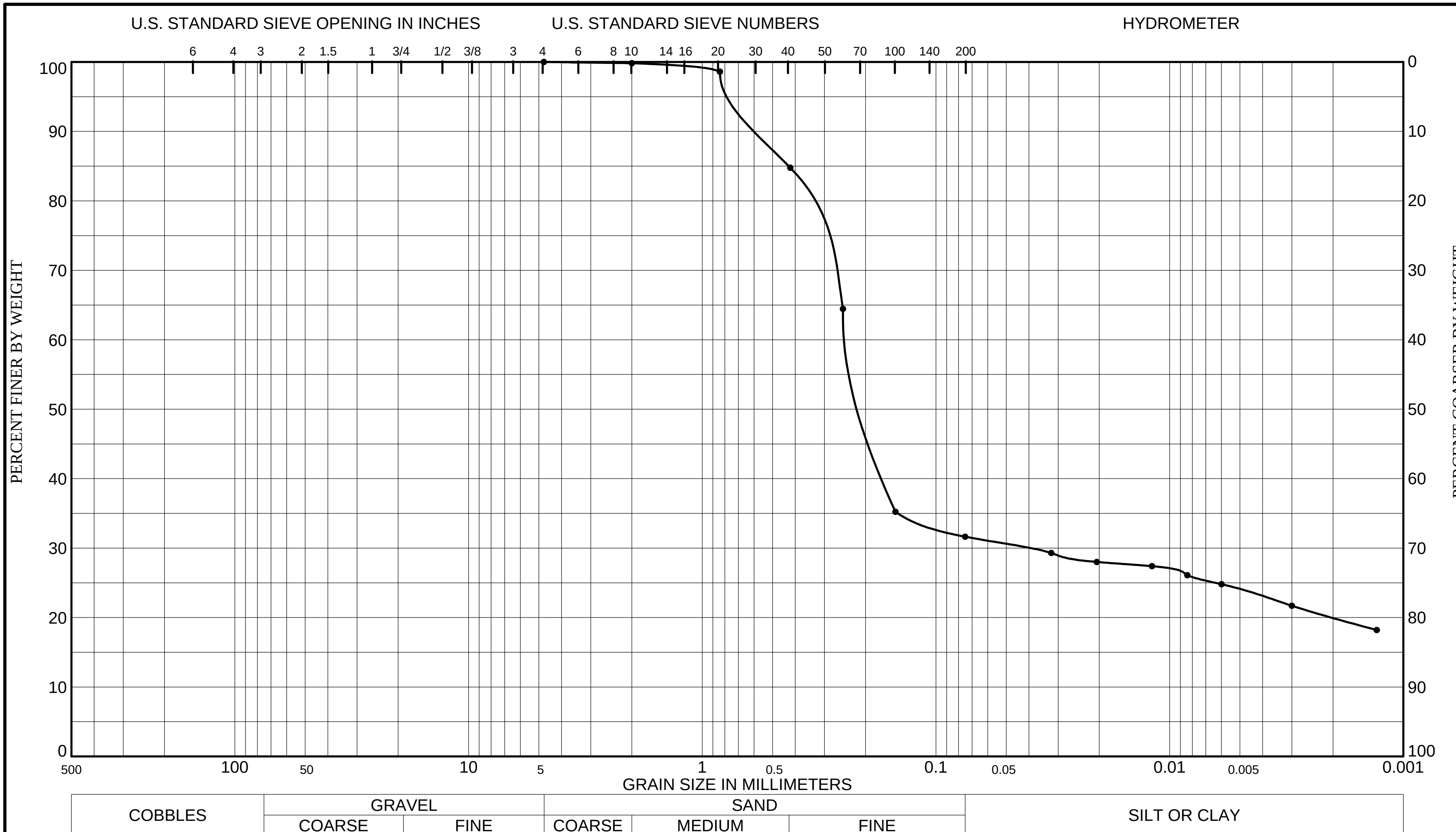
Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-6	129.8 to 130.2	Olive Gray, (Visual) Clayey Organic Silt (OH).	115.5			

Project	Savannah Harbor
	Savannah Harbor Expansion, Savannah, GA
Lab No.	K6/264
Boring No.	SHE-15
Date	2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-7	152.0 to 152.5	Olive Gray, Clayey Sand High LL (SC-H).	42.0	94	35	59

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/265

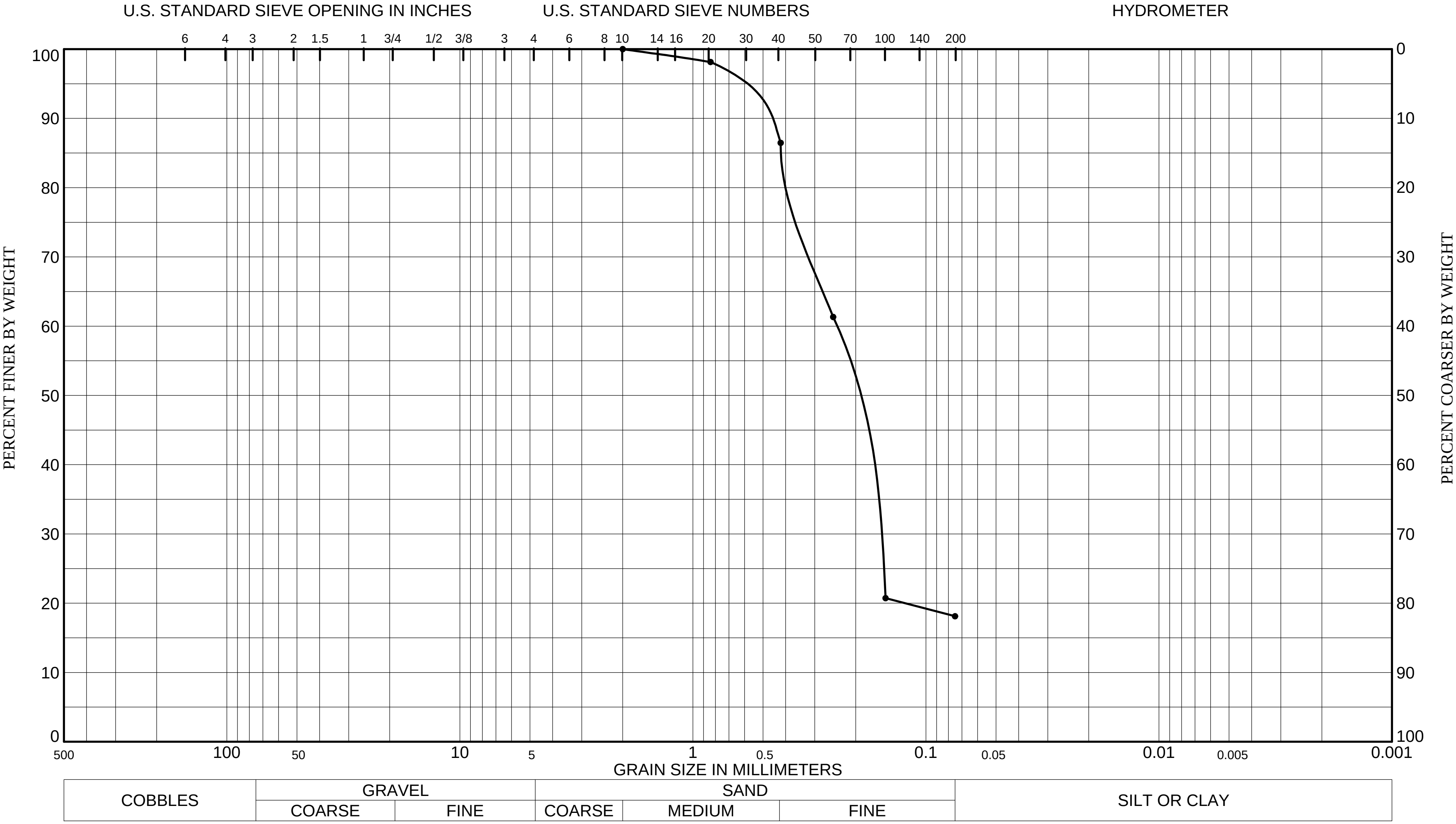
Boring No. SHE-15

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



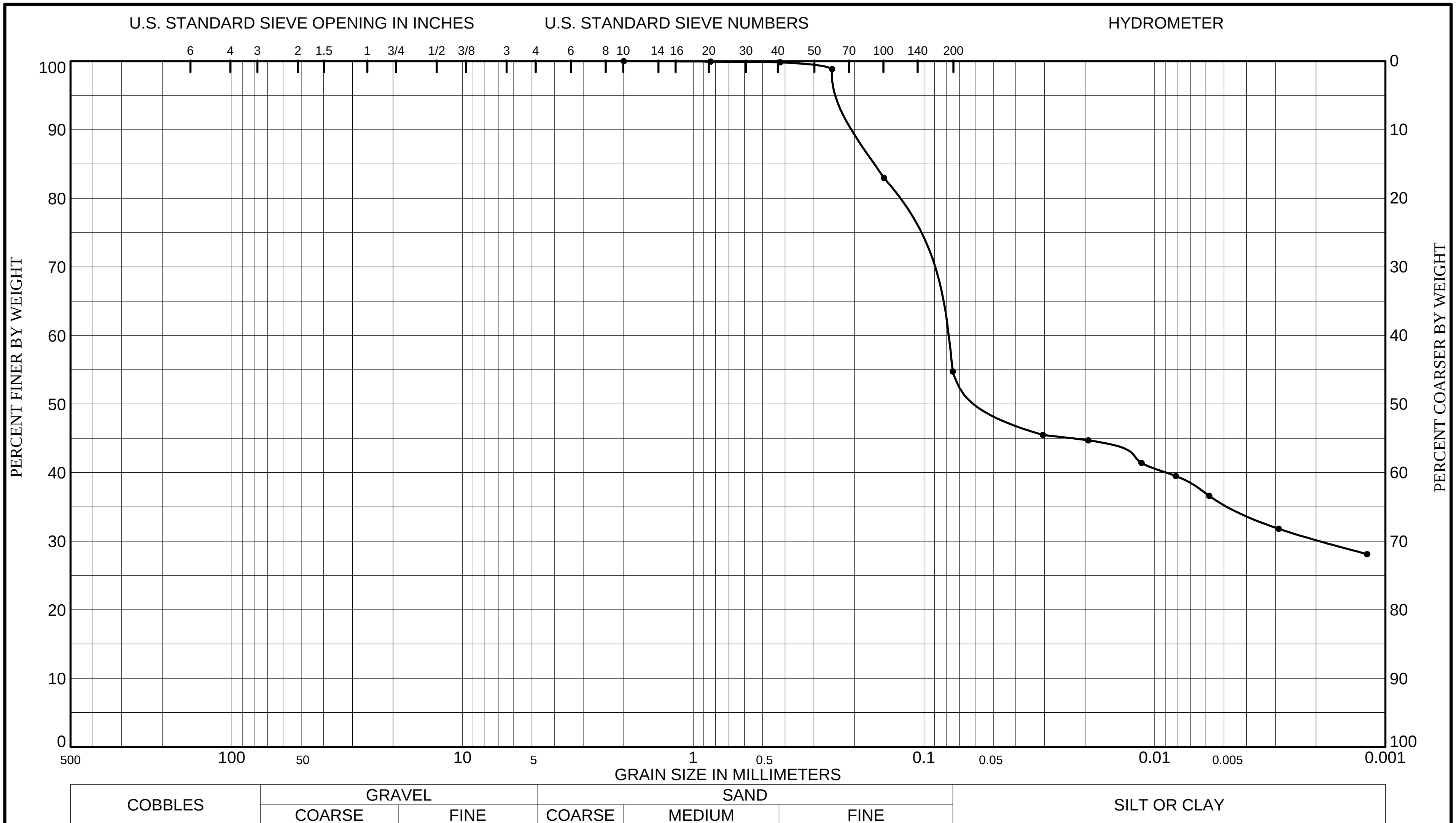
Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-8	161.4 to 161.9	Olive Gray, Silty Sand (SM-H), with High LL plastic fines.	30.6	66	35	31

Project: Savannah Harbor
Savannah Harbor Expansion, Savannah, GA
Lab No.: K6/266
Boring No.: SHE-15
Date: 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-9	172.0 to 172.5	Olive Gray, (Visual) Sandy Inorganic Silt High LL (MH).	60.5			

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/267

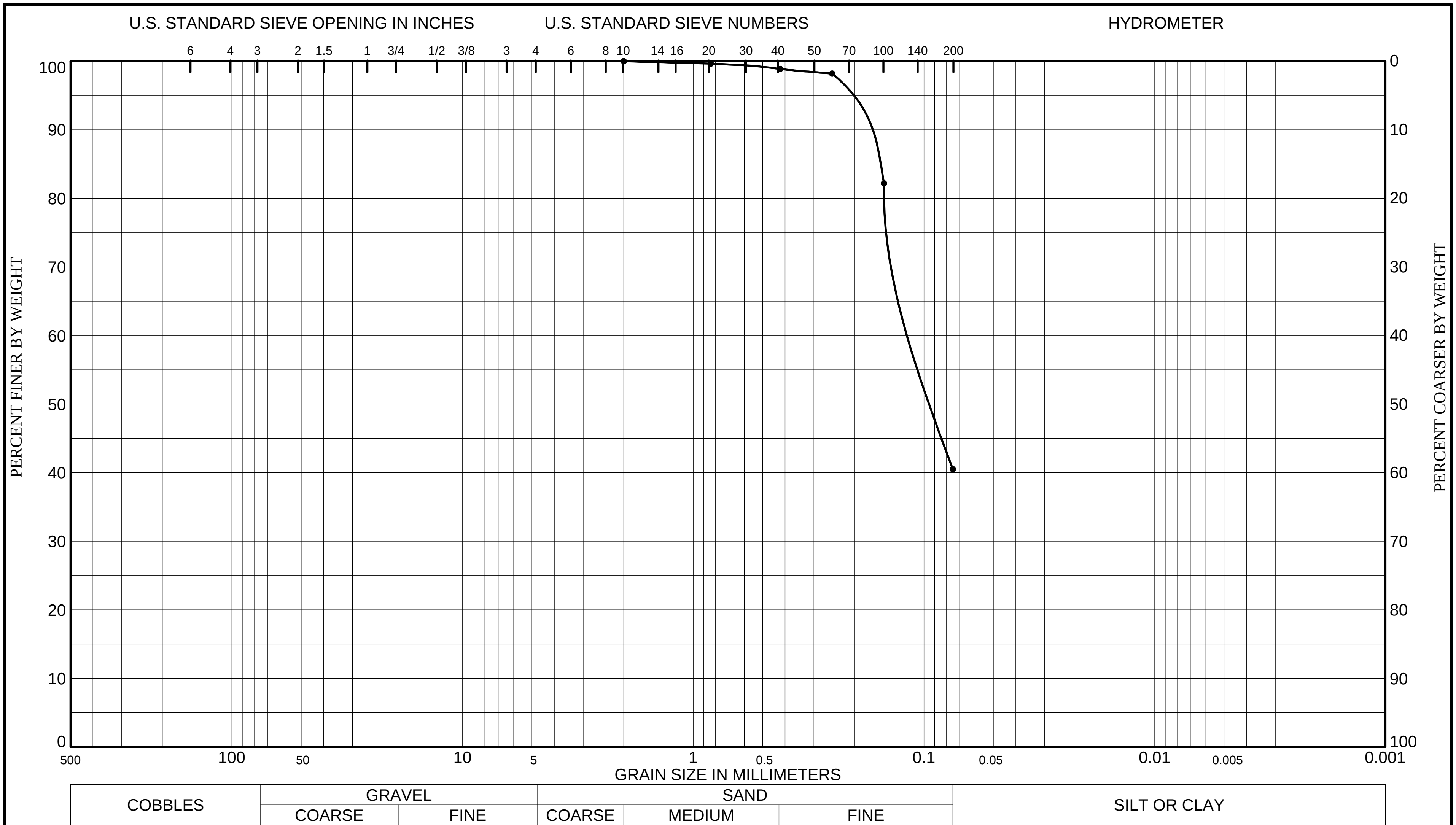
Boring No. SHE-15

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-10	187.7 to 188.2	Olive Gray, Silty Sand (SM-H), with High LL plastic fines.	54.9	137	55	82

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/268

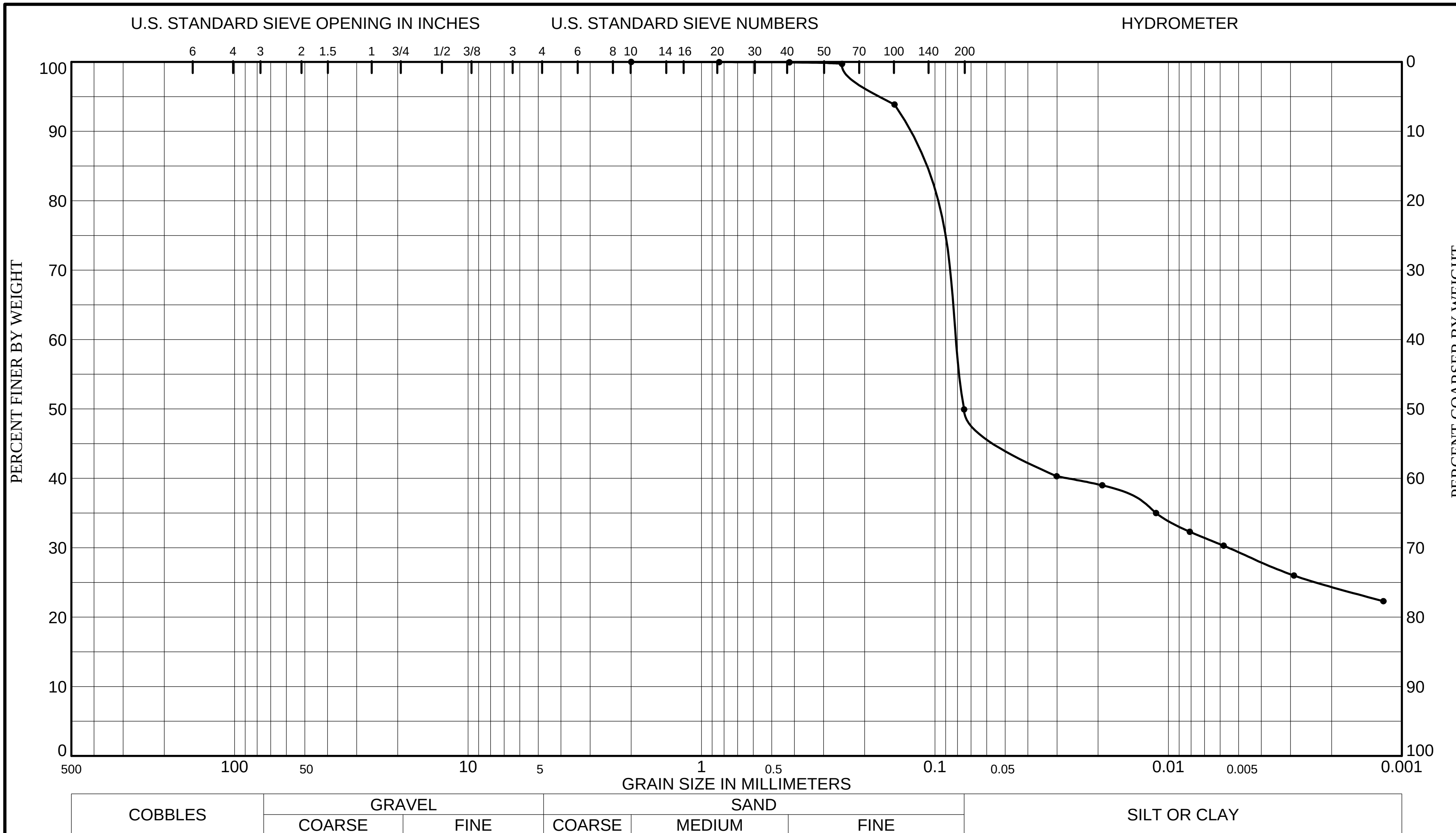
Boring No. SHE-15

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-11	198.0 to 198.5	Olive Gray, (Visual) Silty Sand (SM).	59.6			

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/269

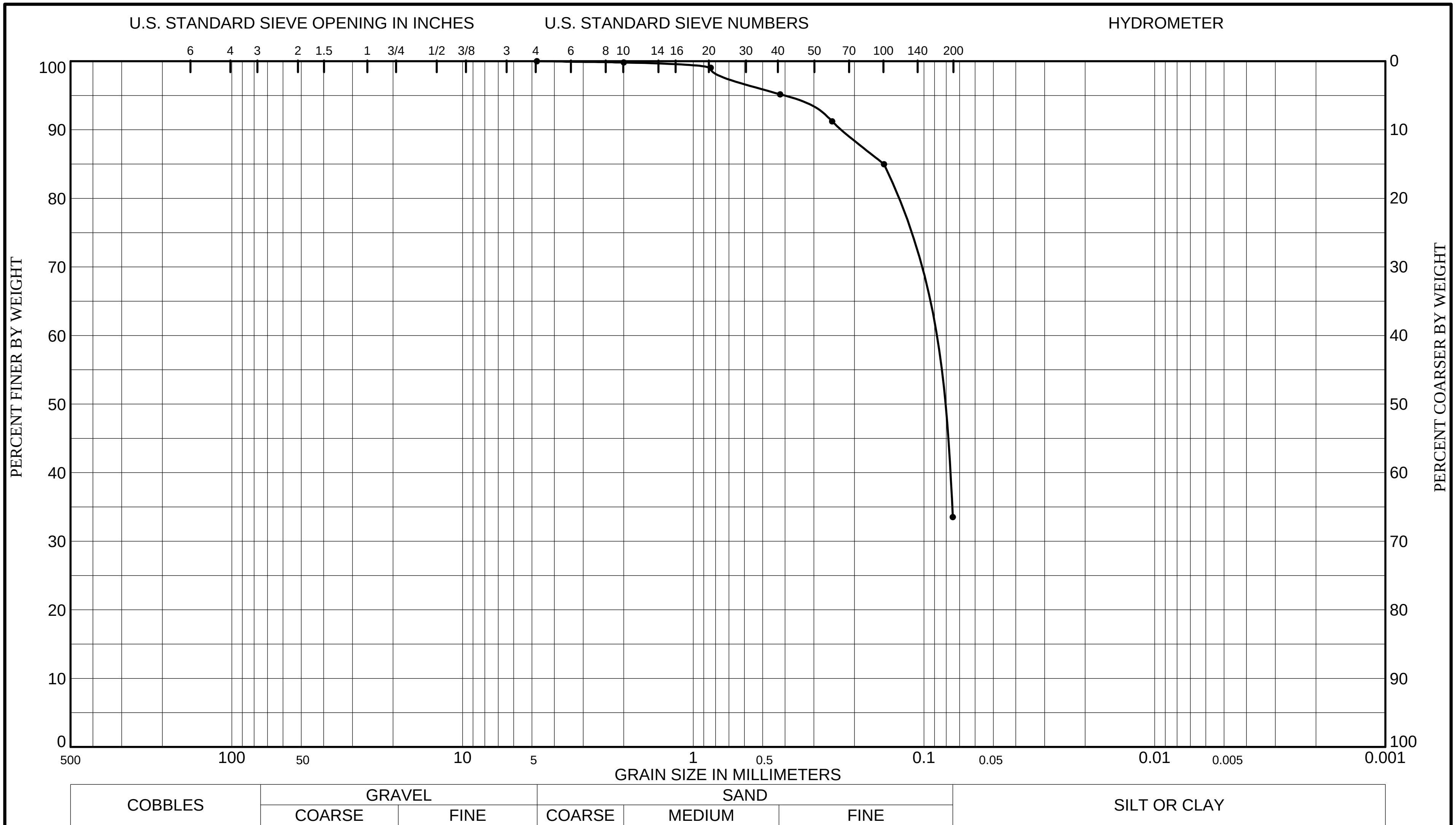
Boring No. SHE-15

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-12	210.6 to 211.1	Olive Gray, Silty Sand (SM-H), with High LL plastic fines.	49.7	122	52	70

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/270

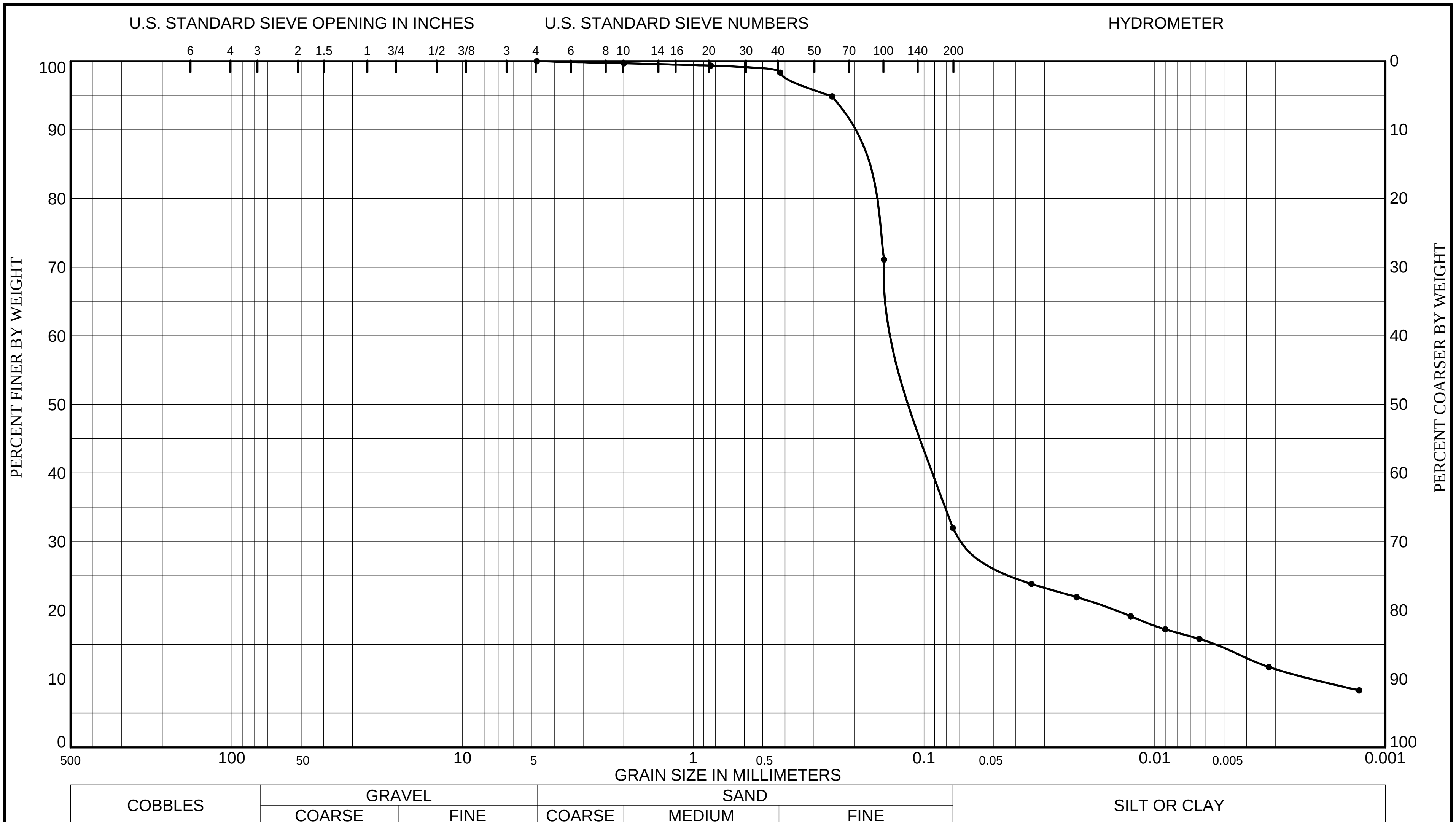
Boring No. SHE-15

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-1	62.0 to 62.6	Olive, Clayey Sand High LL (SC-H).	53.7	60	28	32

Project: Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/271

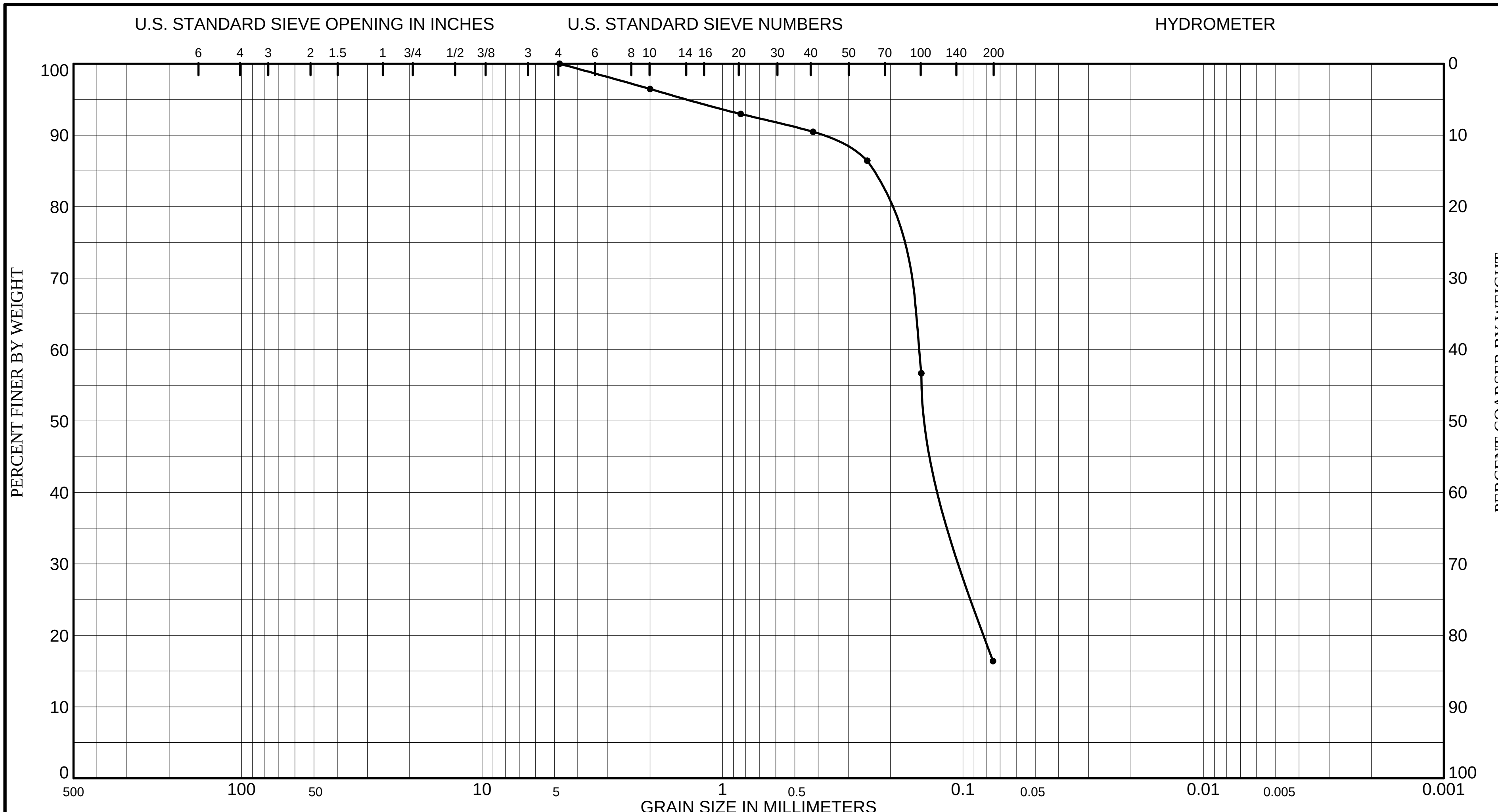
Boring No. SHE-16

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

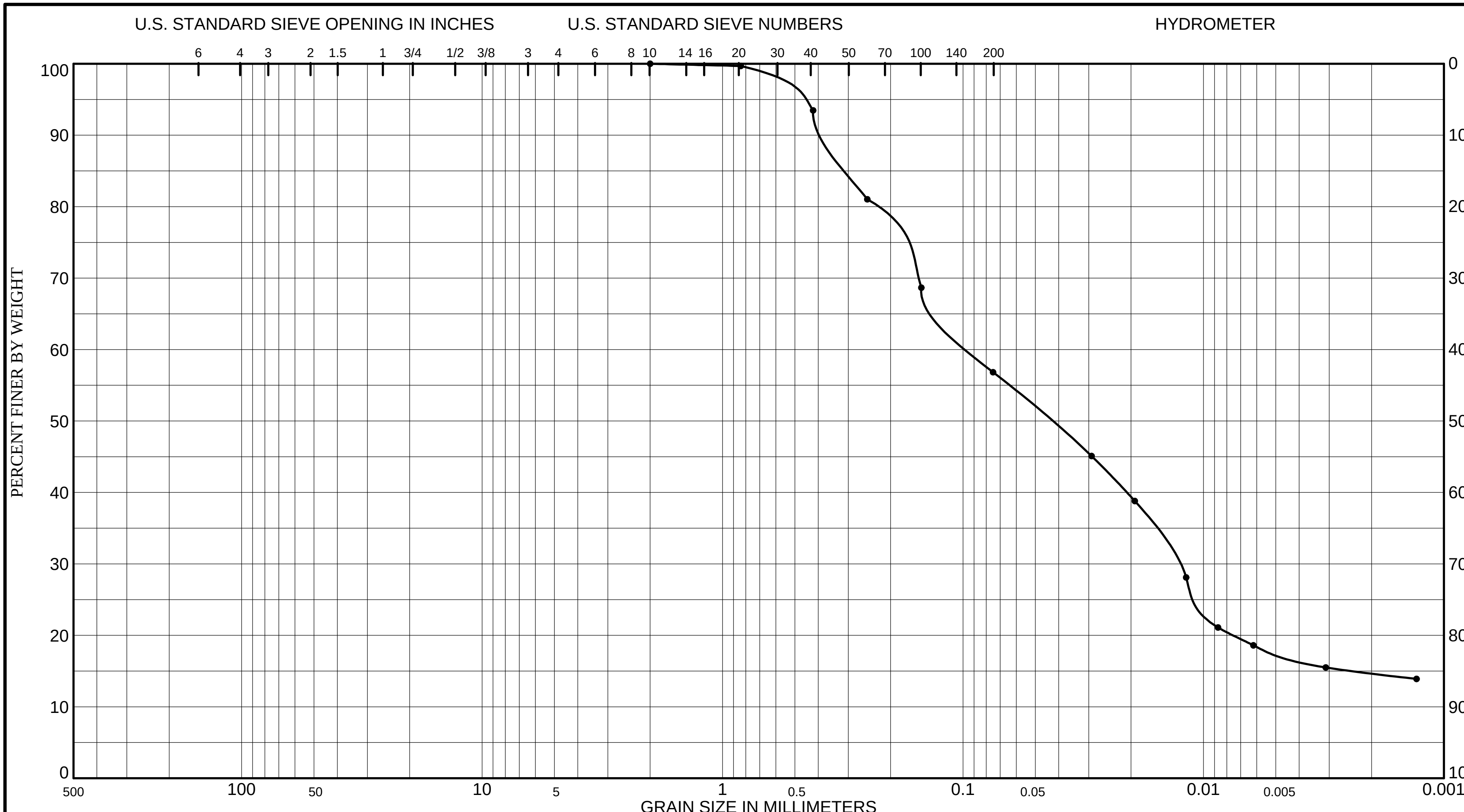
Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-2	73.0 to 73.5	Olive, (Visual) Clayey Sand (SC).	37.5			

Project Savannah Harbor
Savannah Harbor Expansion, Savannah, GA
Lab No. K6/272
Boring No. SHE-16
Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-3	89.3 to 89.8	Olive Gray, (Visual) Sandy Fat Clay (CH).	46.7			

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/273

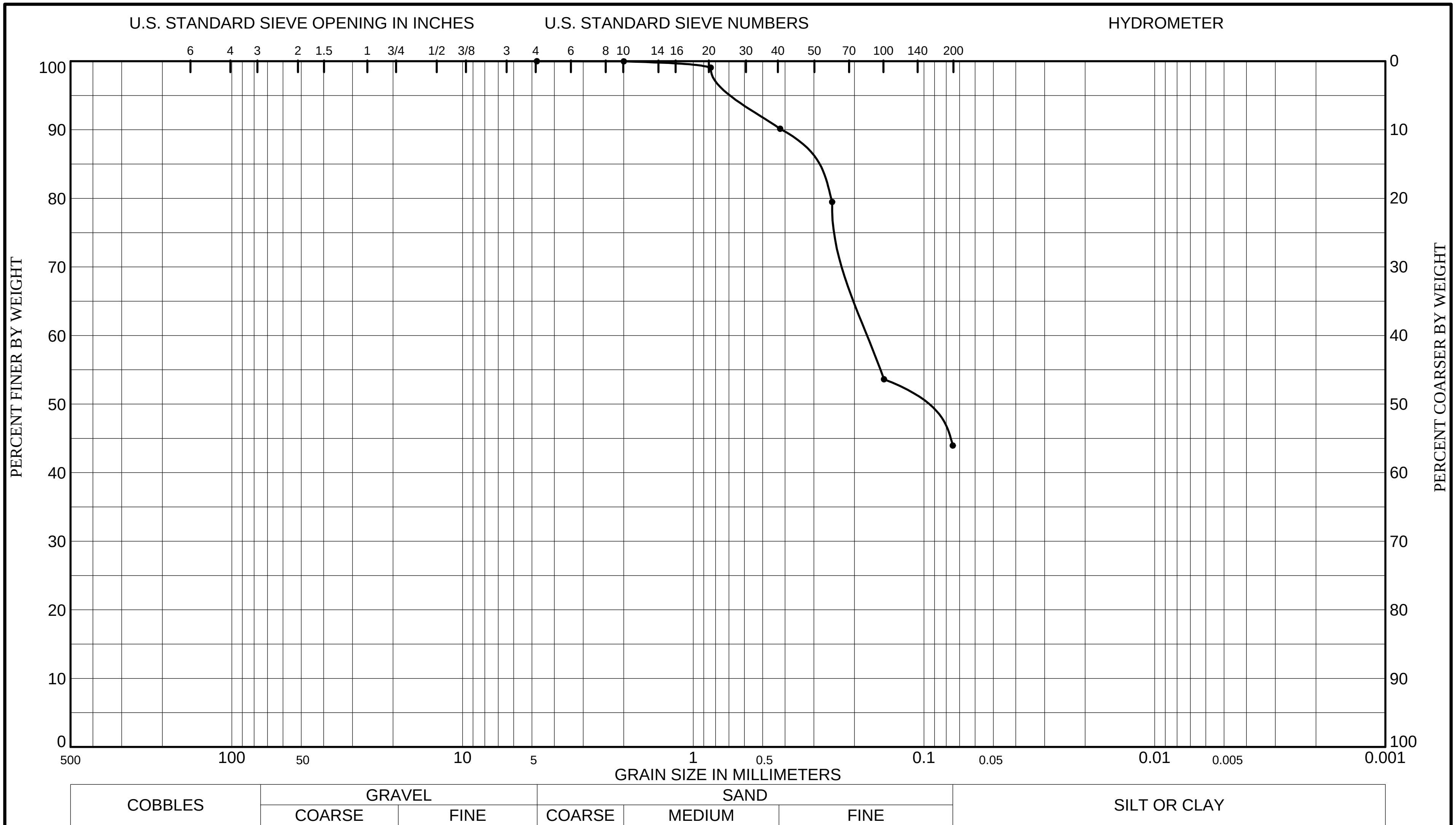
Boring No. SHE-16

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-4	99.3 to 99.8	Olive Gray, Clayey Sand High LL (SC-H).	51.0	110	41	69

Project: Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/274

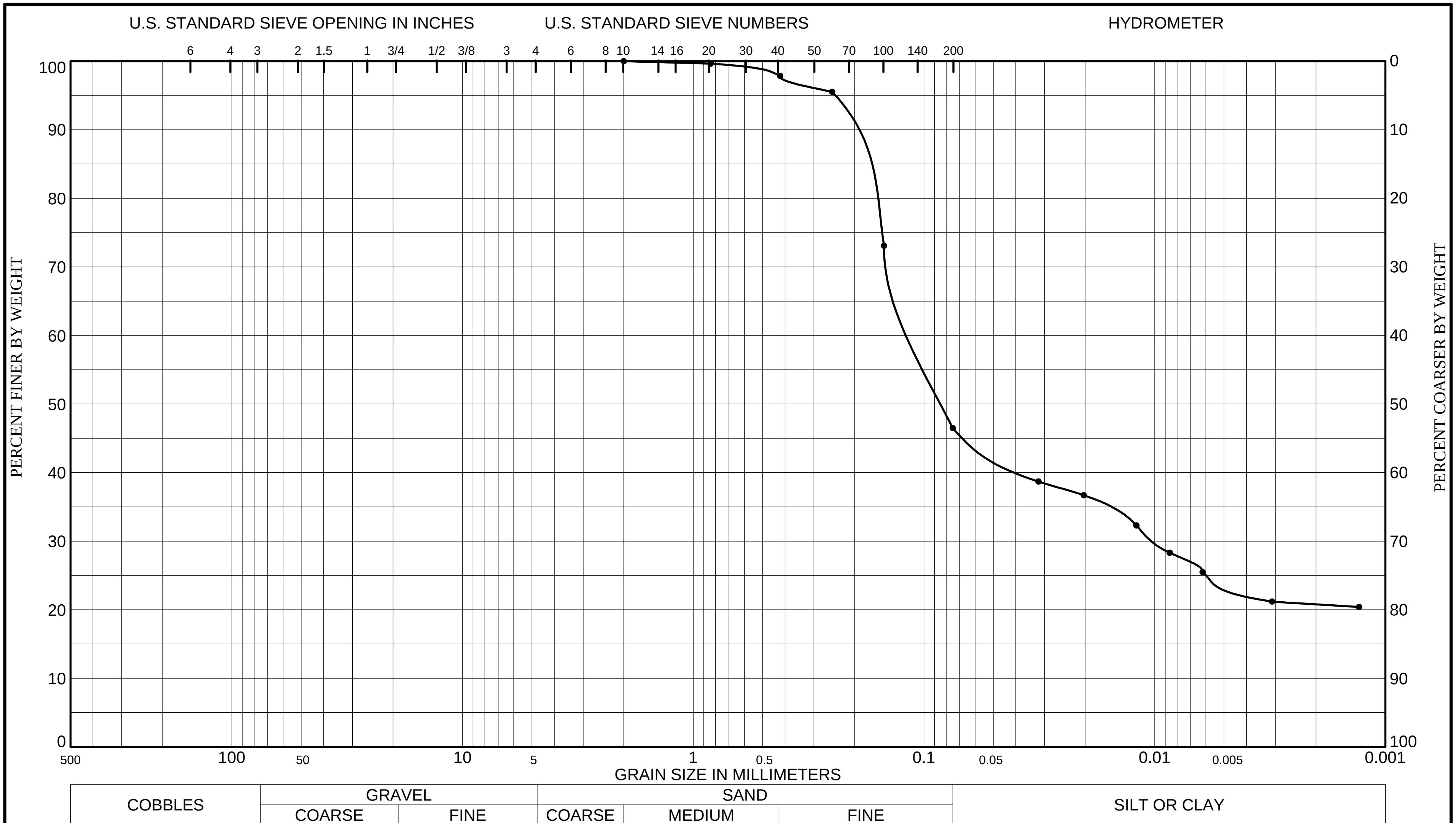
Boring No. SHE-16

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-5	111.0 to 111.5	Dark Olive Gray, Silty Sand (SM-H), with High LL plastic fines.	49.7	99	44	55

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/275

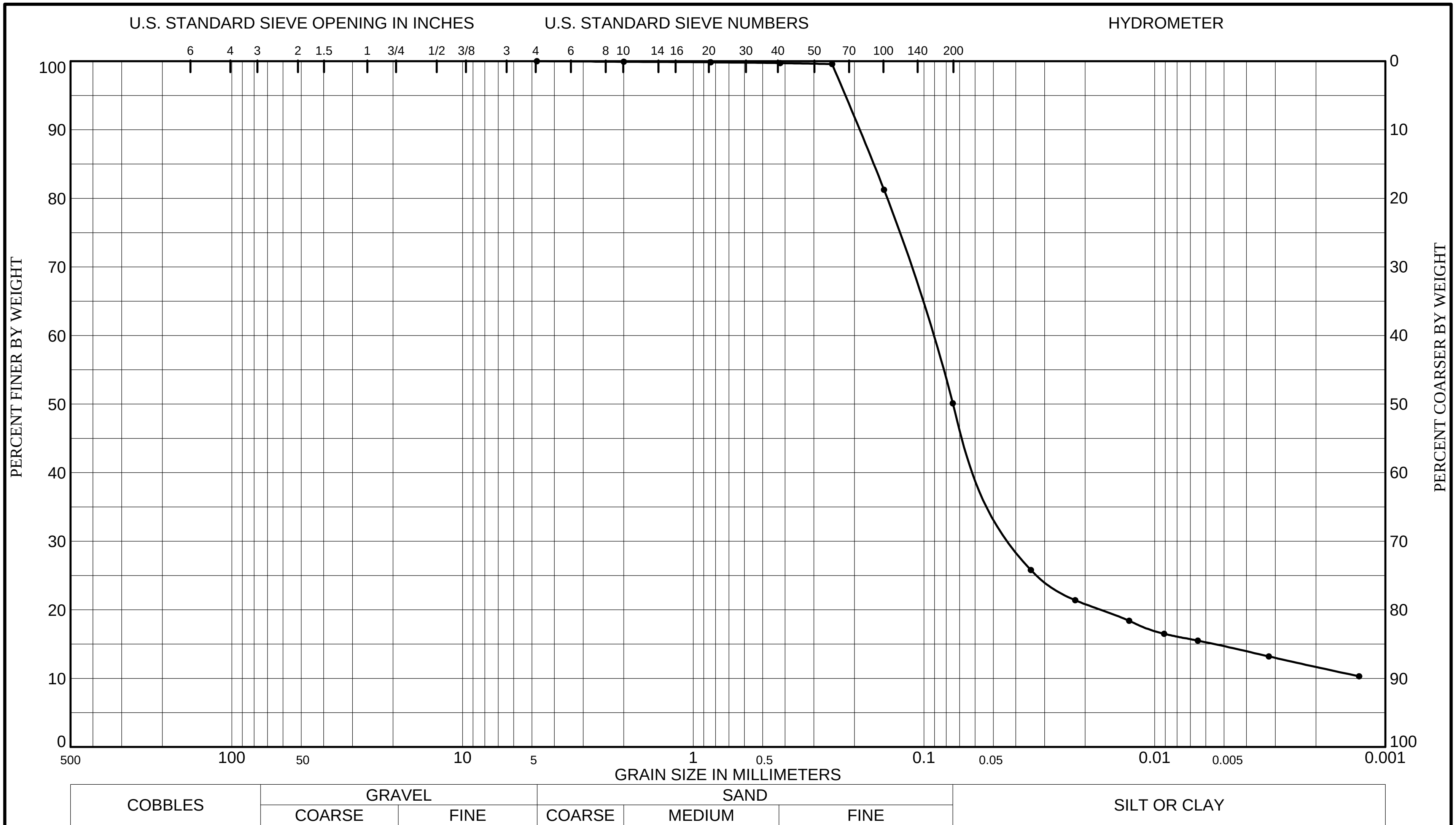
Boring No. SHE-16

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-1	58.1 to 58.6	Olive Gray & Dark Gray, Sandy Lean Clay (CL).	47.1	46	21	25

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/276

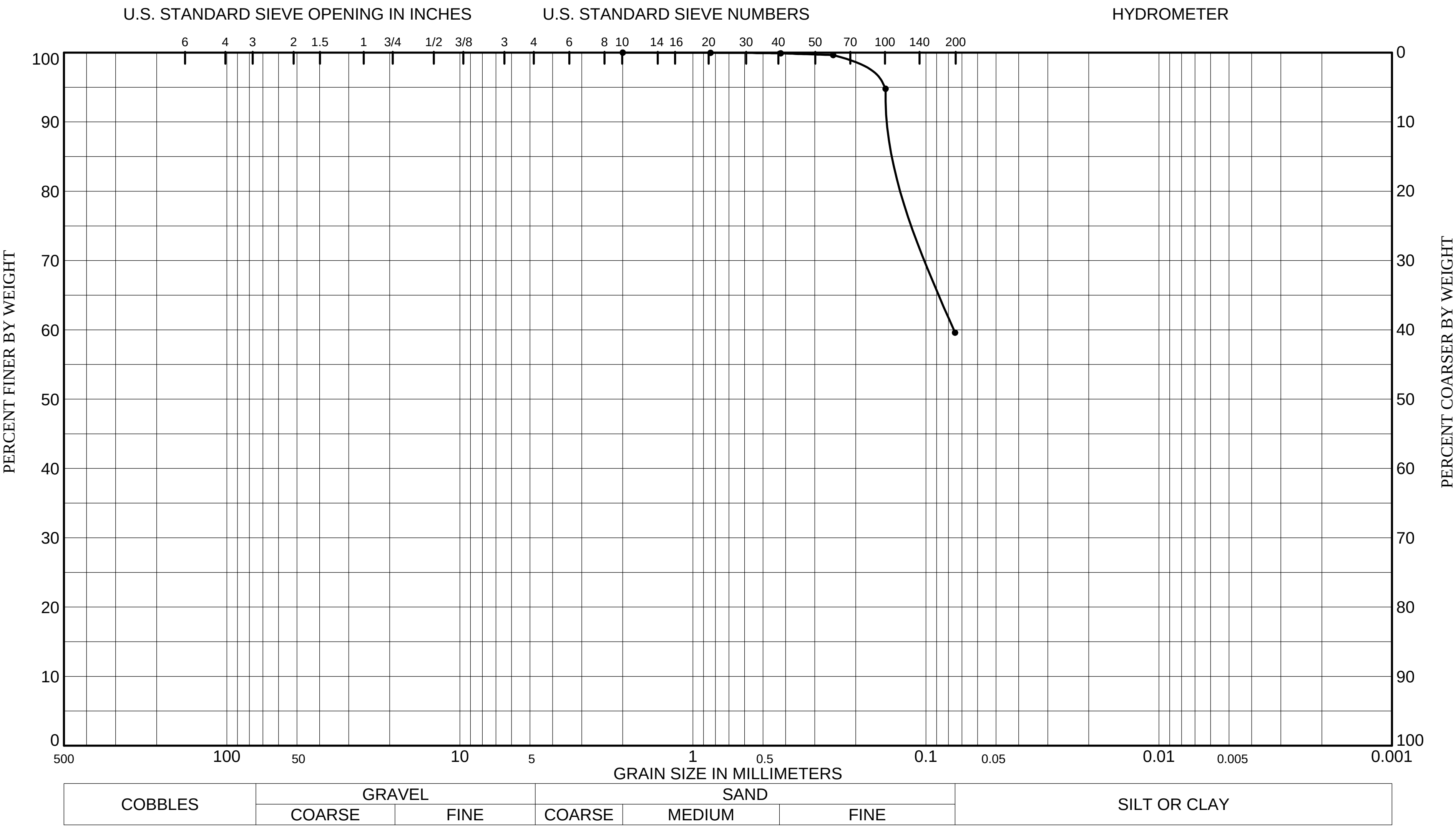
Boring No. SHE-17

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-2	62.8 to 63.4	Olive Gray & Dark Gray, (Visual) Sandy Fat Clay (CH).	44.4			

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/277

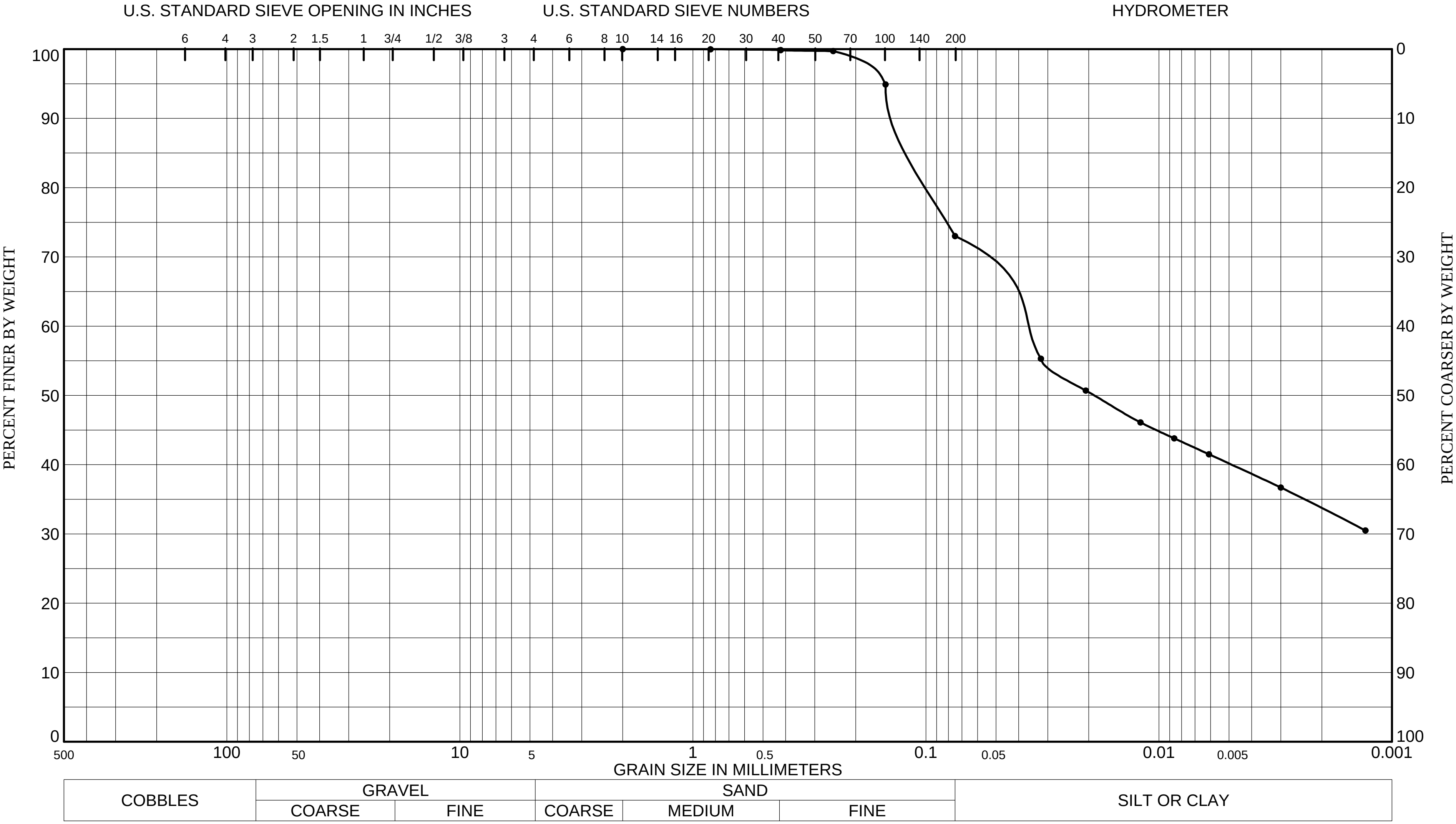
Boring No. SHE-17

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
T-1	69.1 to 70.1	Olive Gray & Dark Gray, Fat Clay (CH), with some sand.	60.5	87	30	57

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/282

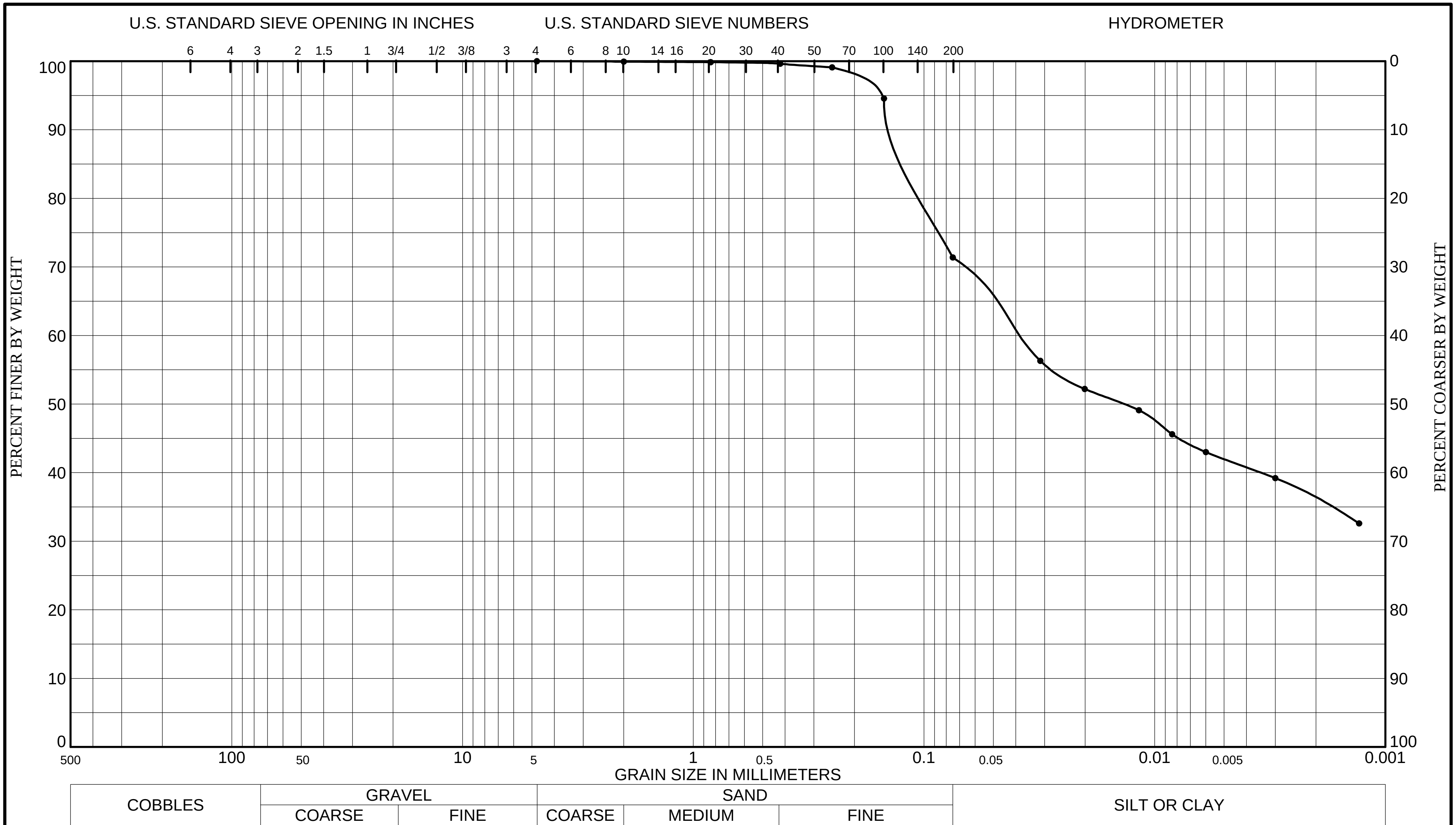
Boring No. SHE-17

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-3	70.4 to 71.0	Olive Gray & Dark Gray, Fat Clay (CH), with some sand.	64.3	82	24	58

Project: Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/278

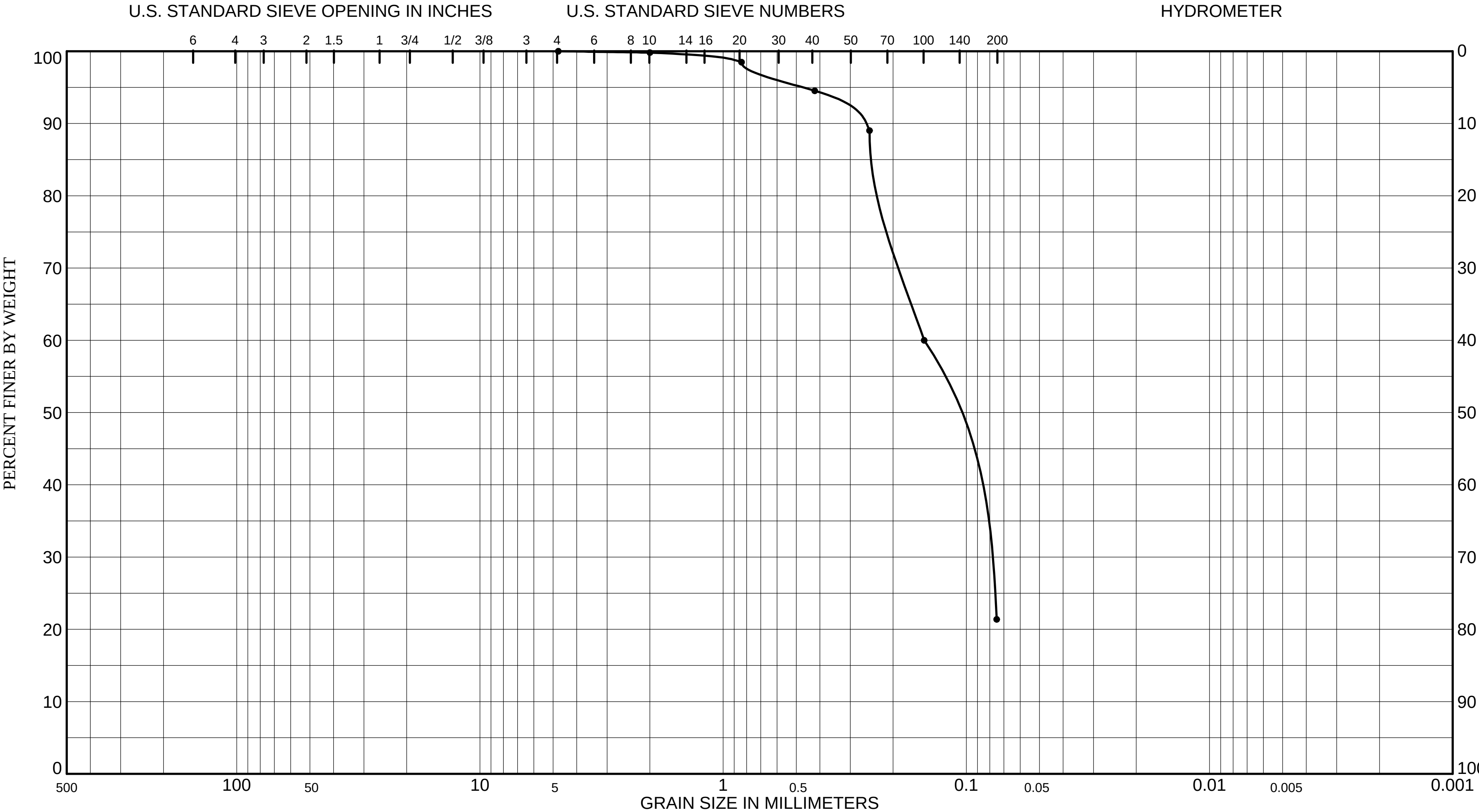
Boring No. SHE-17

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-4	77.3 to 77.9	Dark Olive Gray, Clayey Sand High LL (SC-H).	34.9	64	25	39

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/279

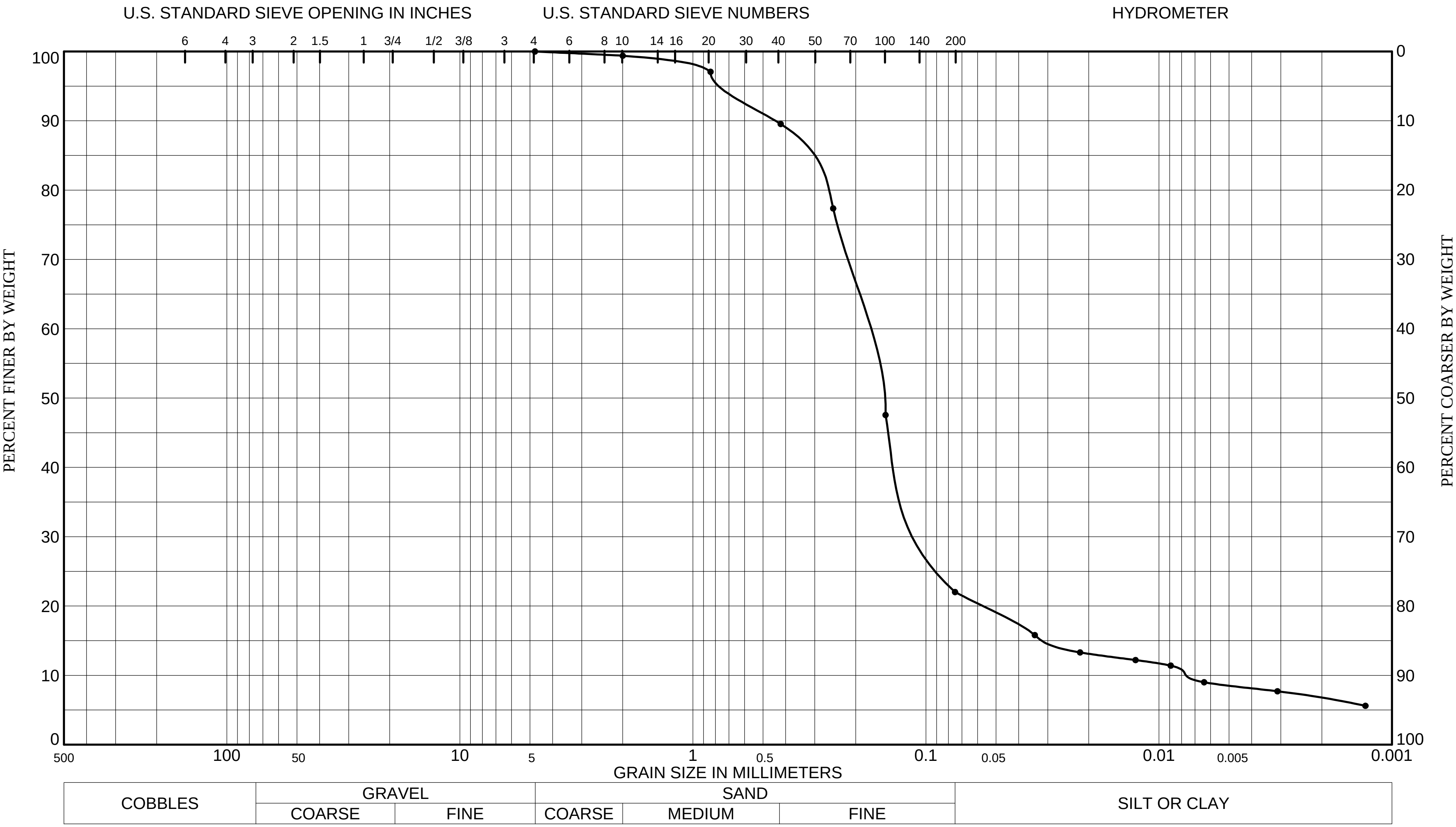
Boring No. SHE-17

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



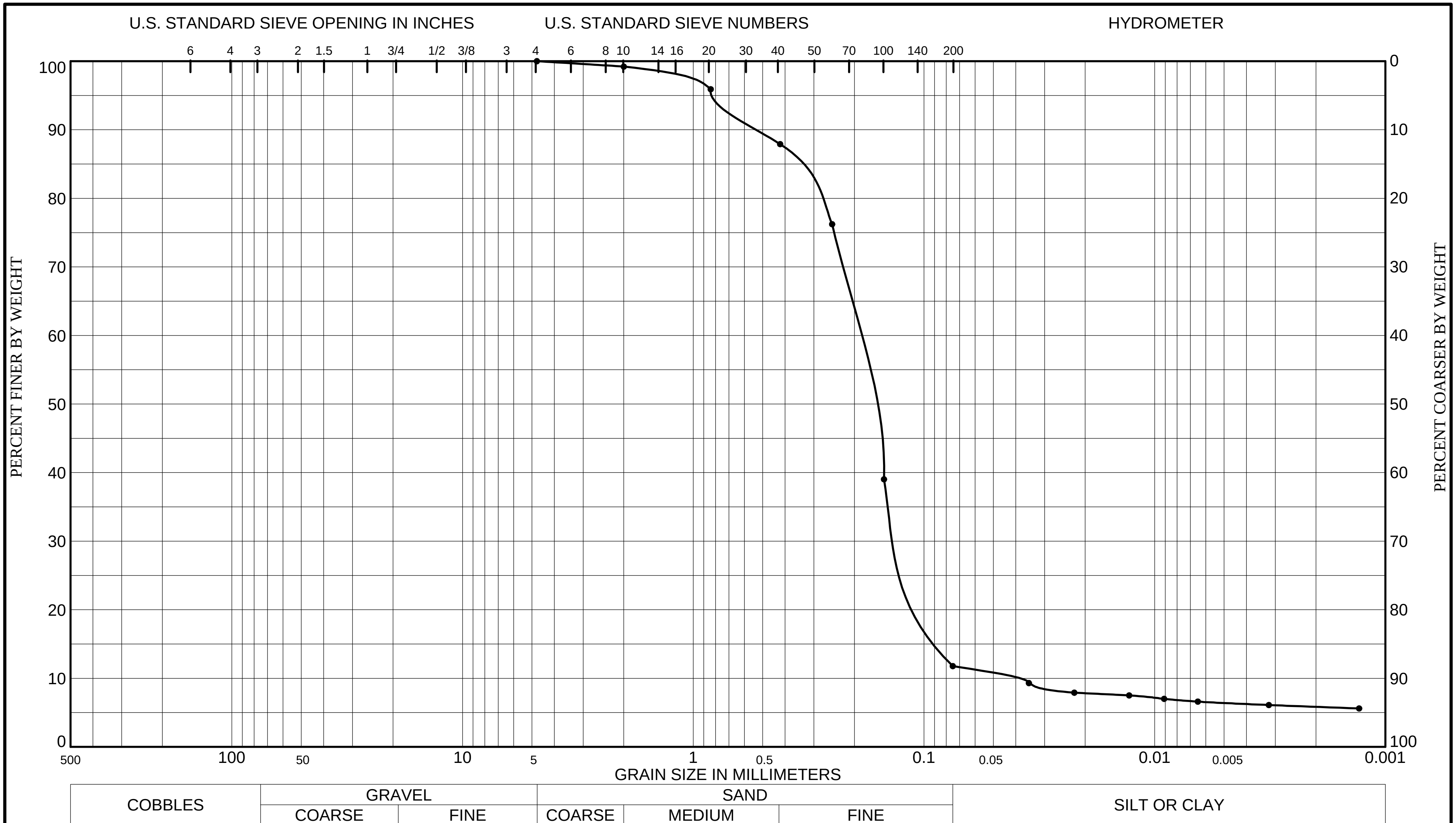
Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
T-2	79.0 to 80.0	Dark Olive Gray, Clayey Sand High LL (SC-H).	36.3	62	23	39

Project Savannah Harbor
Savannah Harbor Expansion, Savannah, GA
Lab No. K6/283
Boring No. SHE-17
Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-5	86.9 to 87.4	Dark Olive Gray, (Visual) Poorly Graded Silty Sand (SP-SM).	33.3			

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/280

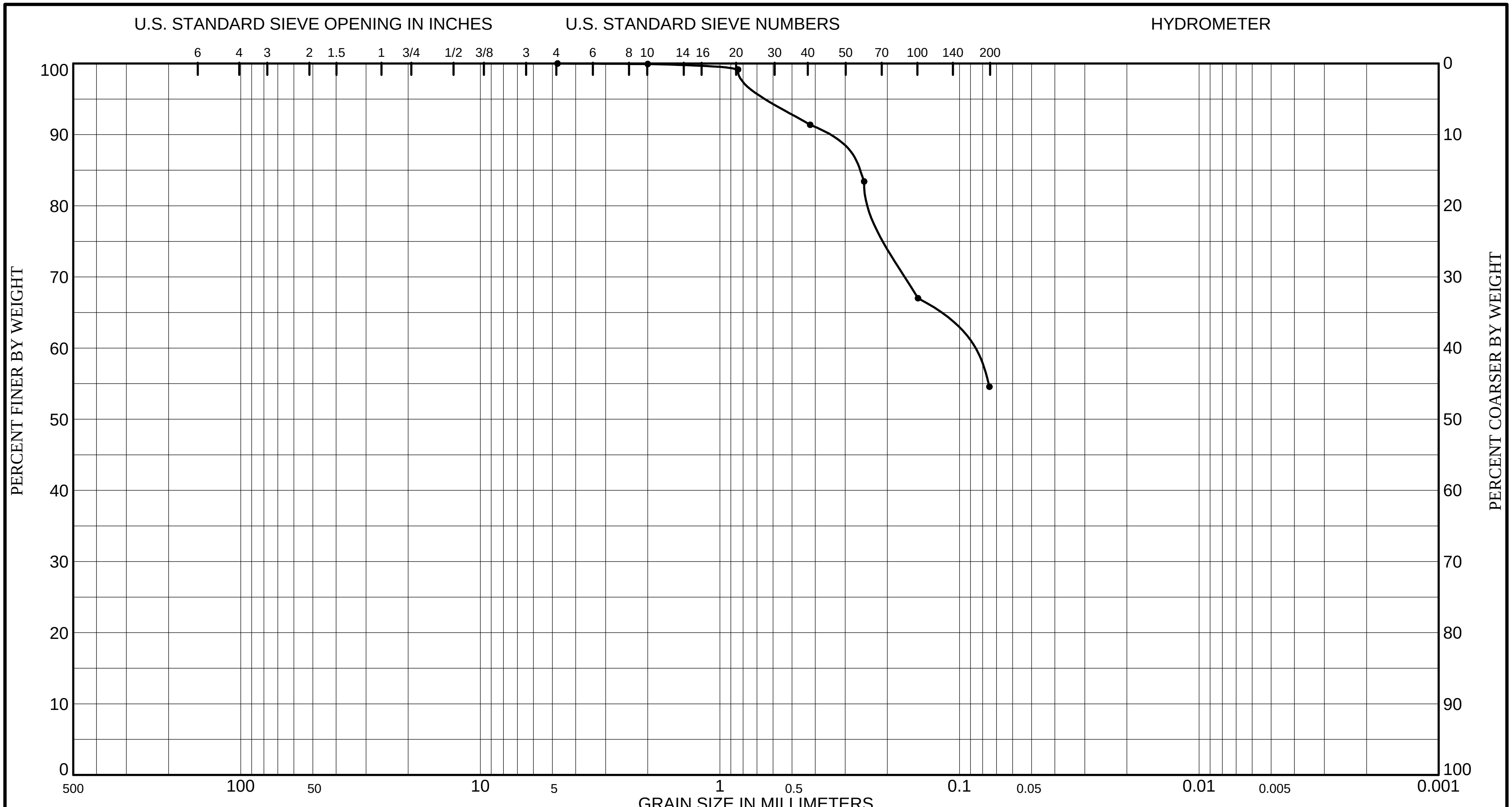
Boring No. SHE-17

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-6	104.8 to 105.2	Olive, Sandy Clayey Inorganic Silt High LL (MH).	42.9	106	46	60

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/281

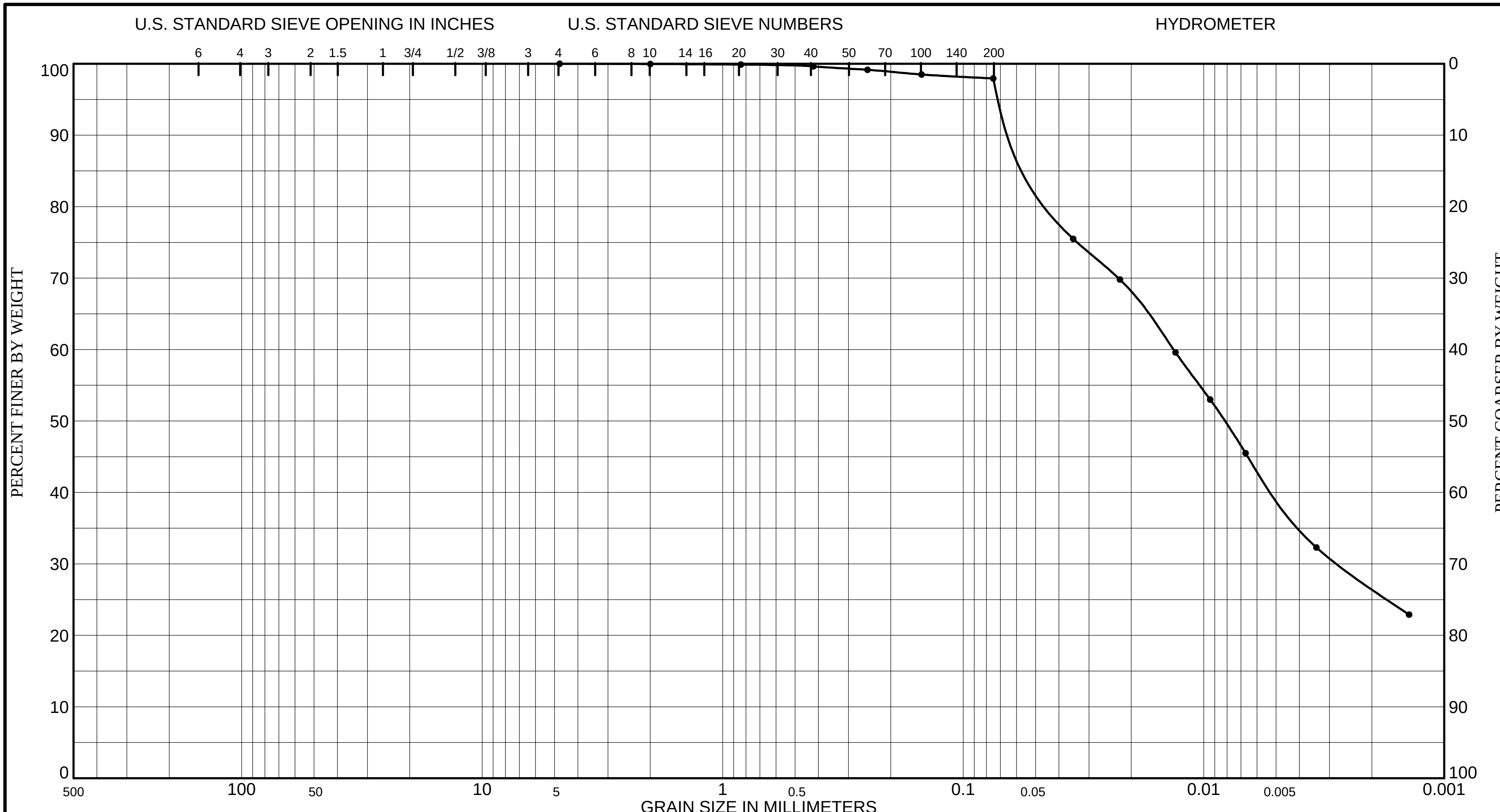
Boring No. SHE-17

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-1	91.5 to 92.2	Dark Olive Gray, Clayey Organic Silt (OH), with a trace of sand.	179.7	328	108	220
		Oven dried LL was 30% of wet prepared soil.				

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/284

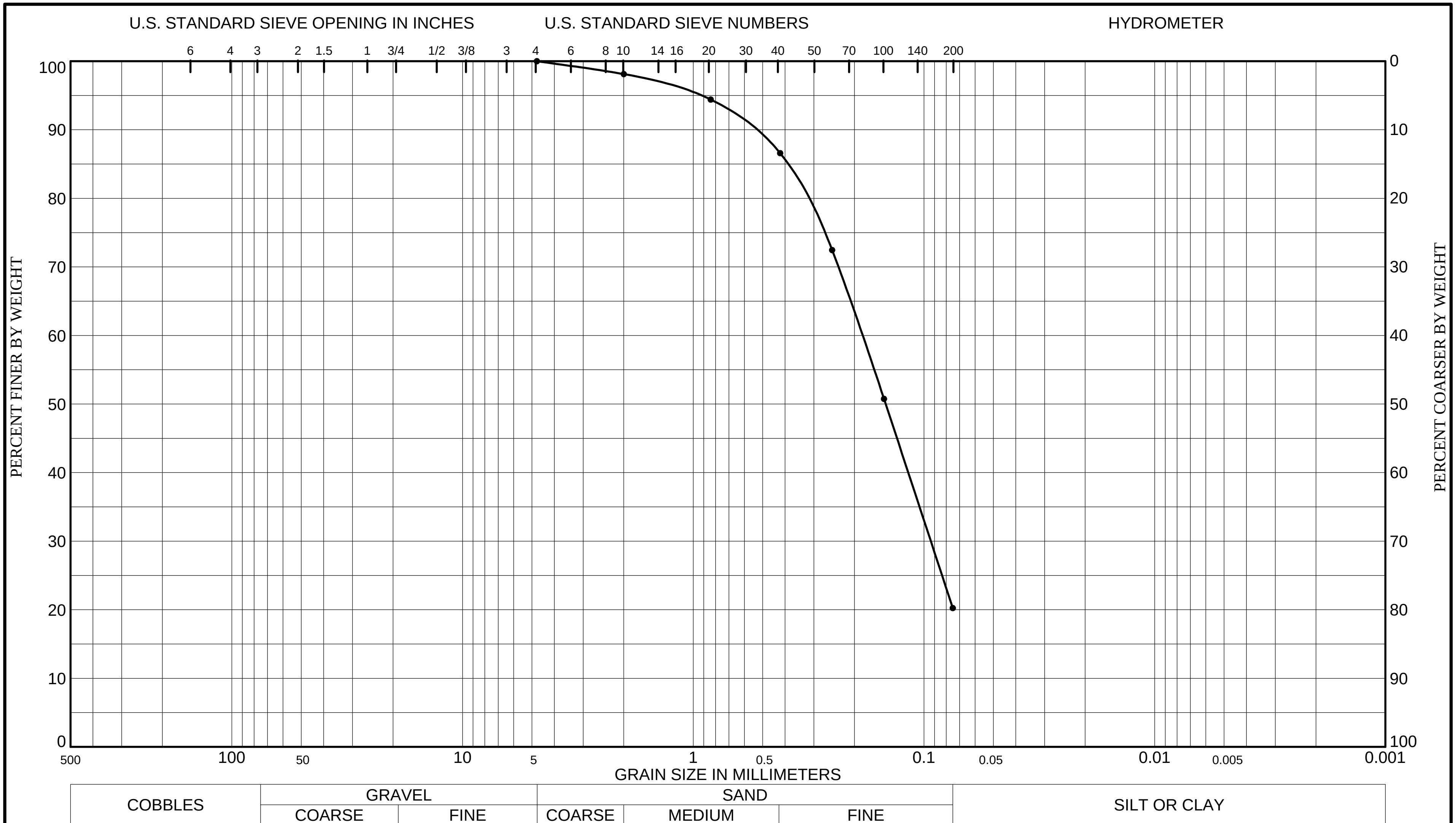
Boring No. SHE-18

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-2	97.2 to 97.9	Dark Olive Gray, (Visual) Silty Sand (SM).	37.3			

Project: Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/285

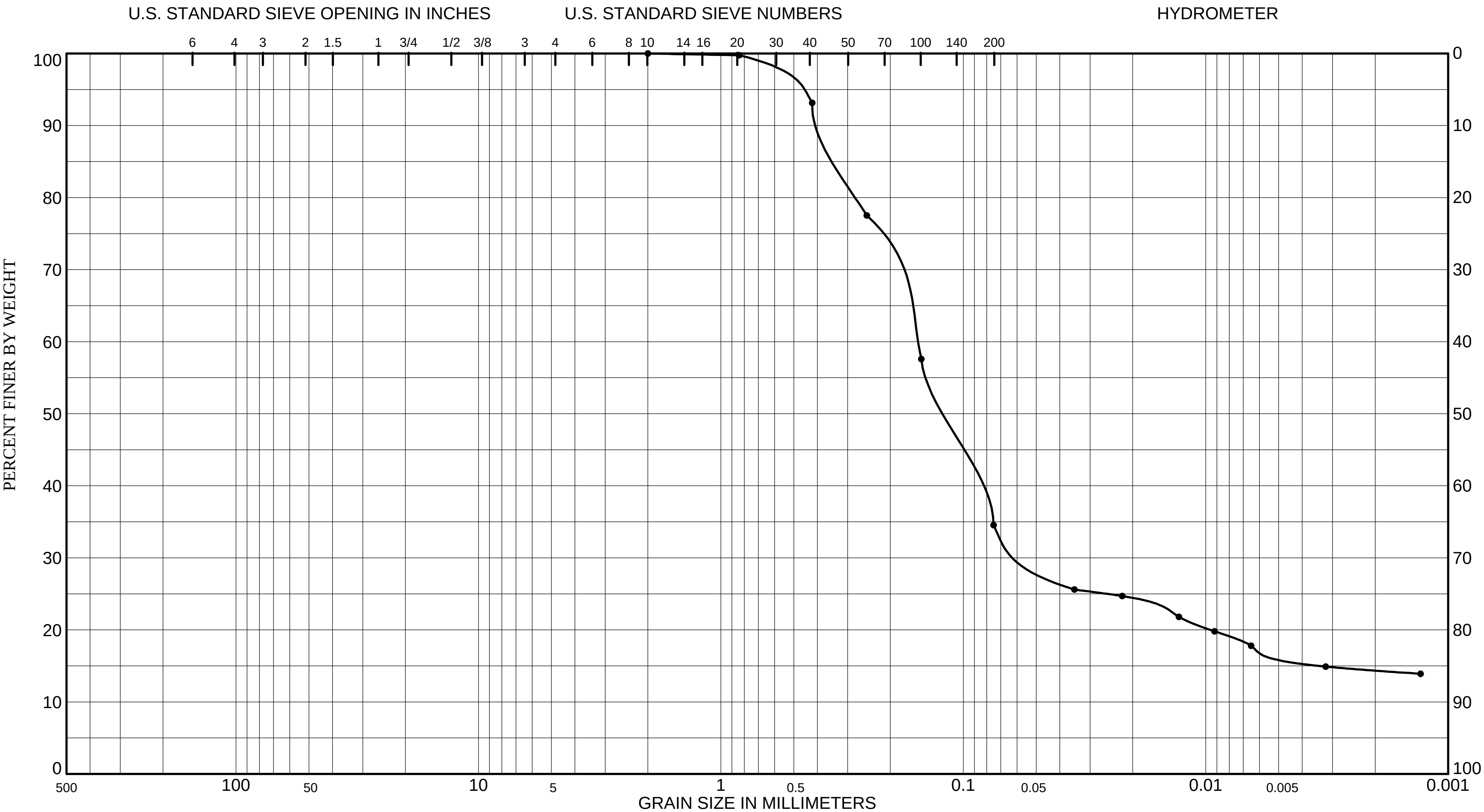
Boring No. SHE-18

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

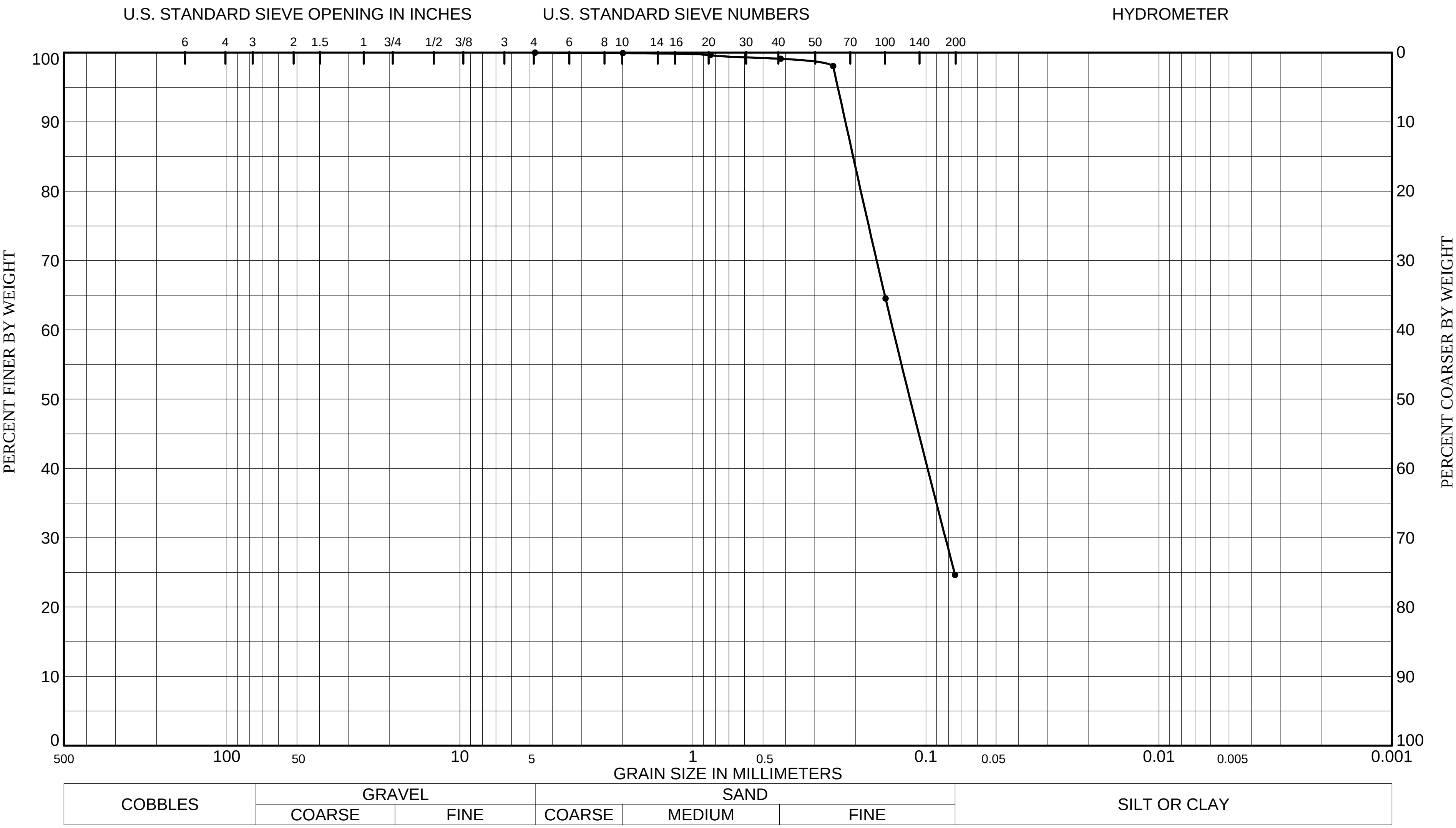
Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-3	120.9 to 121.5	Olive Gray, Silty Sand (SM-H), with High LL plastic fines.	51.1	131	53	78

Project Savannah Harbor
Savannah Harbor Expansion, Savannah, GA
Lab No. K6/286
Boring No. SHE-18
Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-4	133.3 to 134.0	Olive Gray, (Visual) Silty Sand (SM).	43.1			

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/287

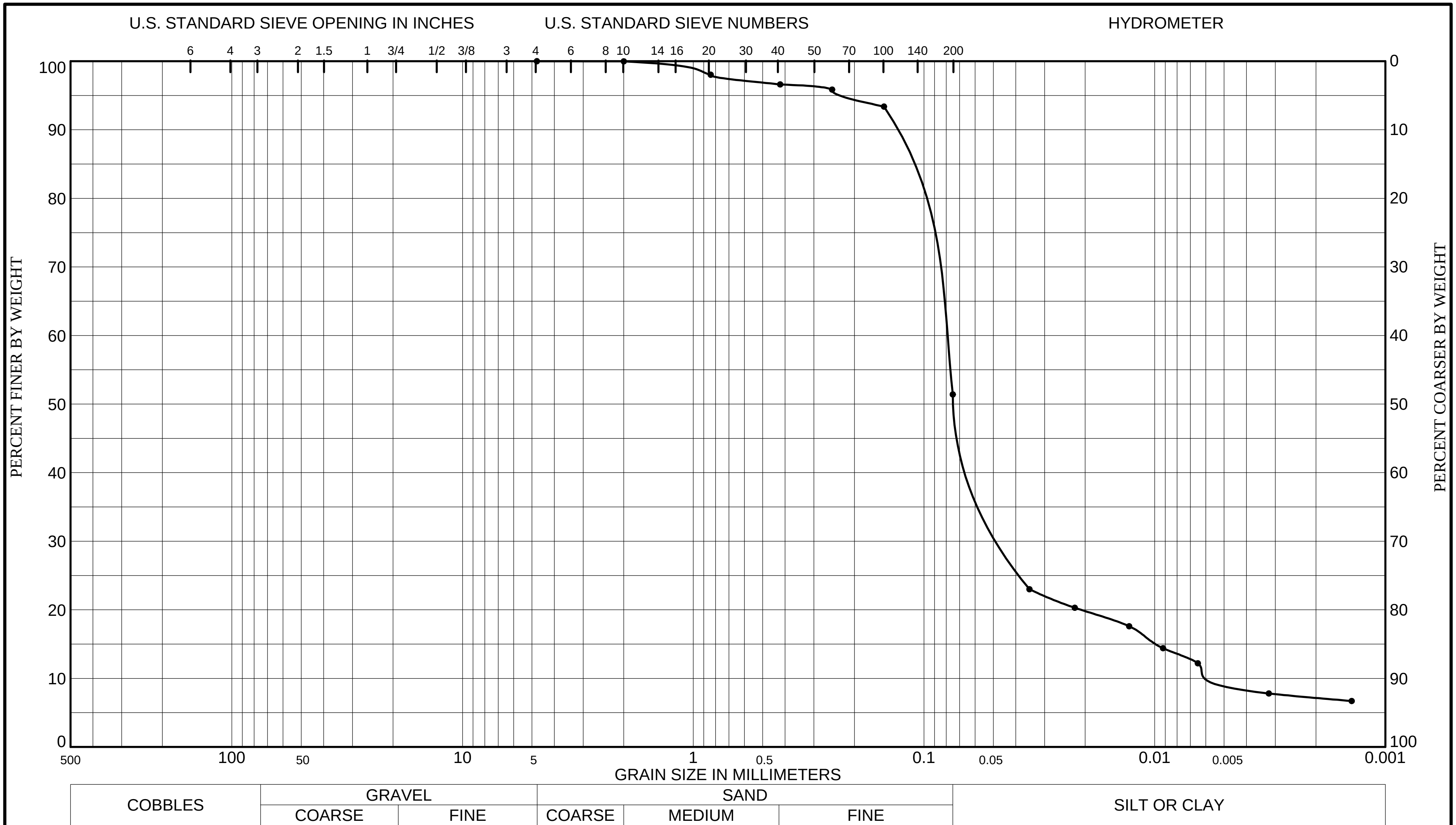
Boring No. SHE-18

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-1	86.2 to 87.0	Olive Gray, Sandy Fat Clay (CH).	43.9	72	31	41

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/288

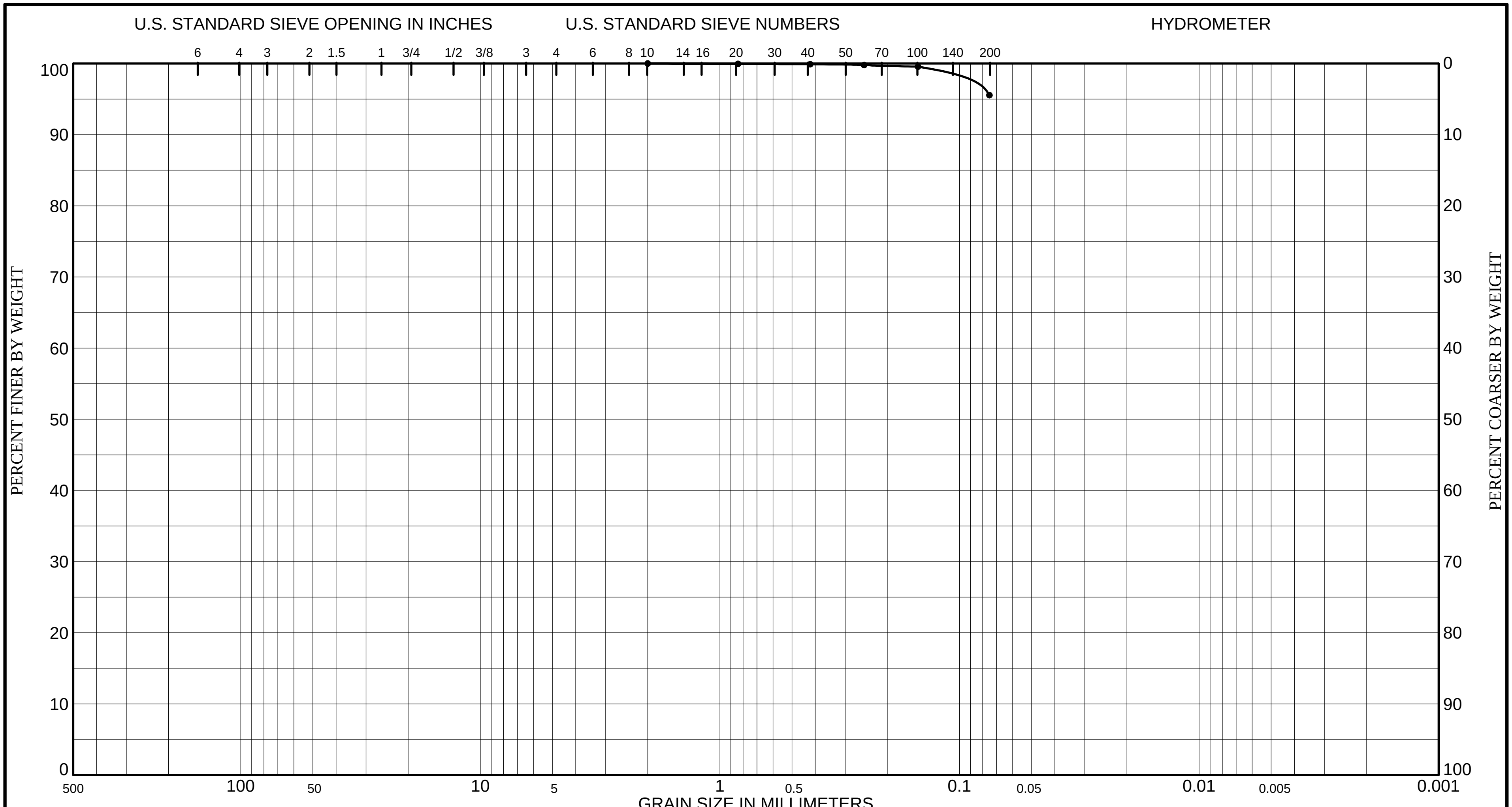
Boring No. SHE-19

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-2	96.7 to 97.5	Olive Gray, Clayey Inorganic Silt High LL (MH), with a trace of sand.	85.1	156	63	93

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/289

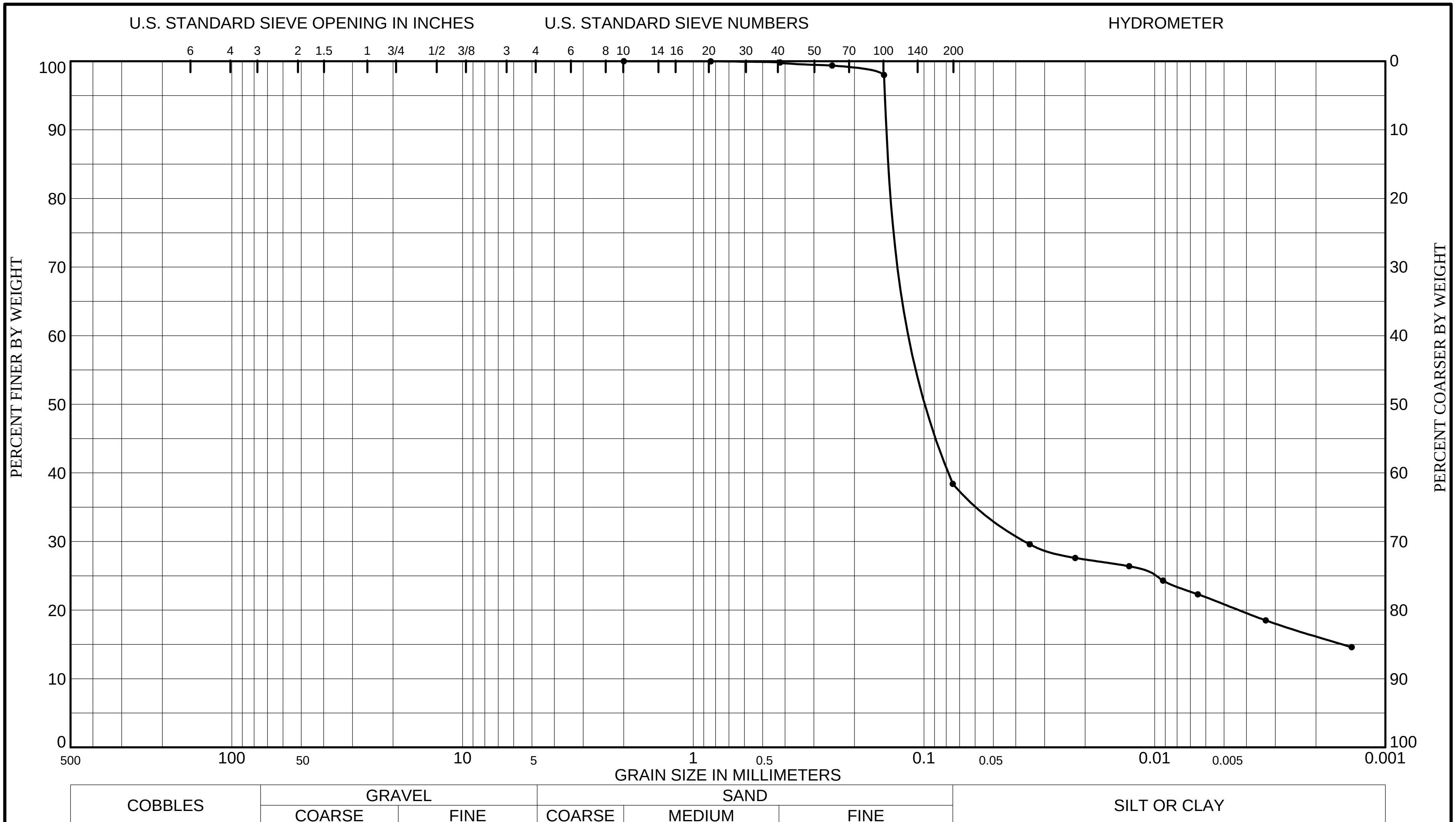
Boring No. SHE-19

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-3	118.5 to 119.3	Olive Gray, Clayey Sand High LL (SC-H).	51.1	84	31	53

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/290

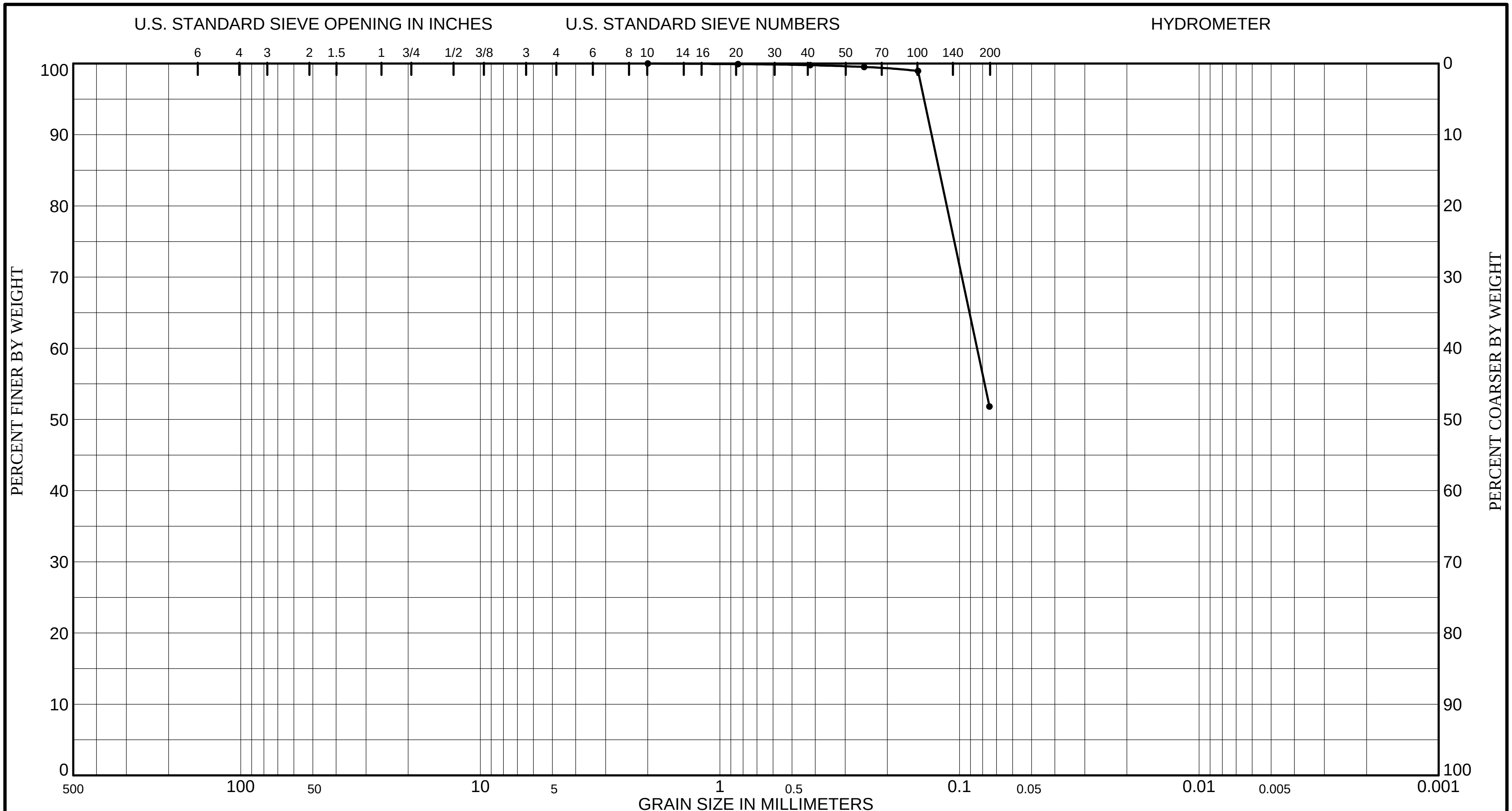
Boring No. SHE-19

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-4	131.8 to 132.4	Olive Gray, (Visual) Sandy Clayey Inorganic Silt High LL (MH).	53.4			

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/291

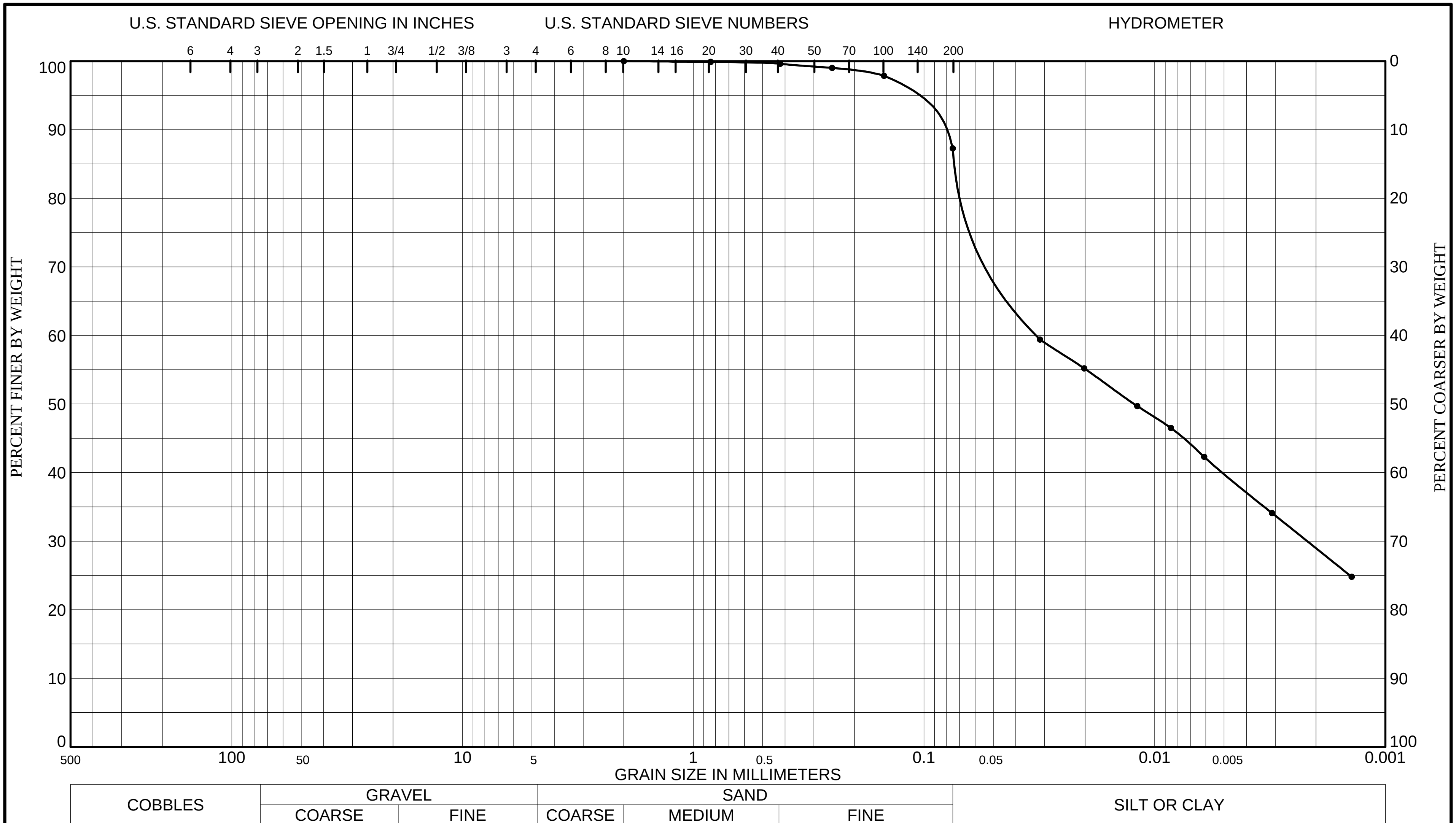
Boring No. SHE-19

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-5	142.0 to 142.6	Olive Gray, Clayey Inorganic Silt High LL (MH), with a little sand.	63.5	135	55	80

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/292

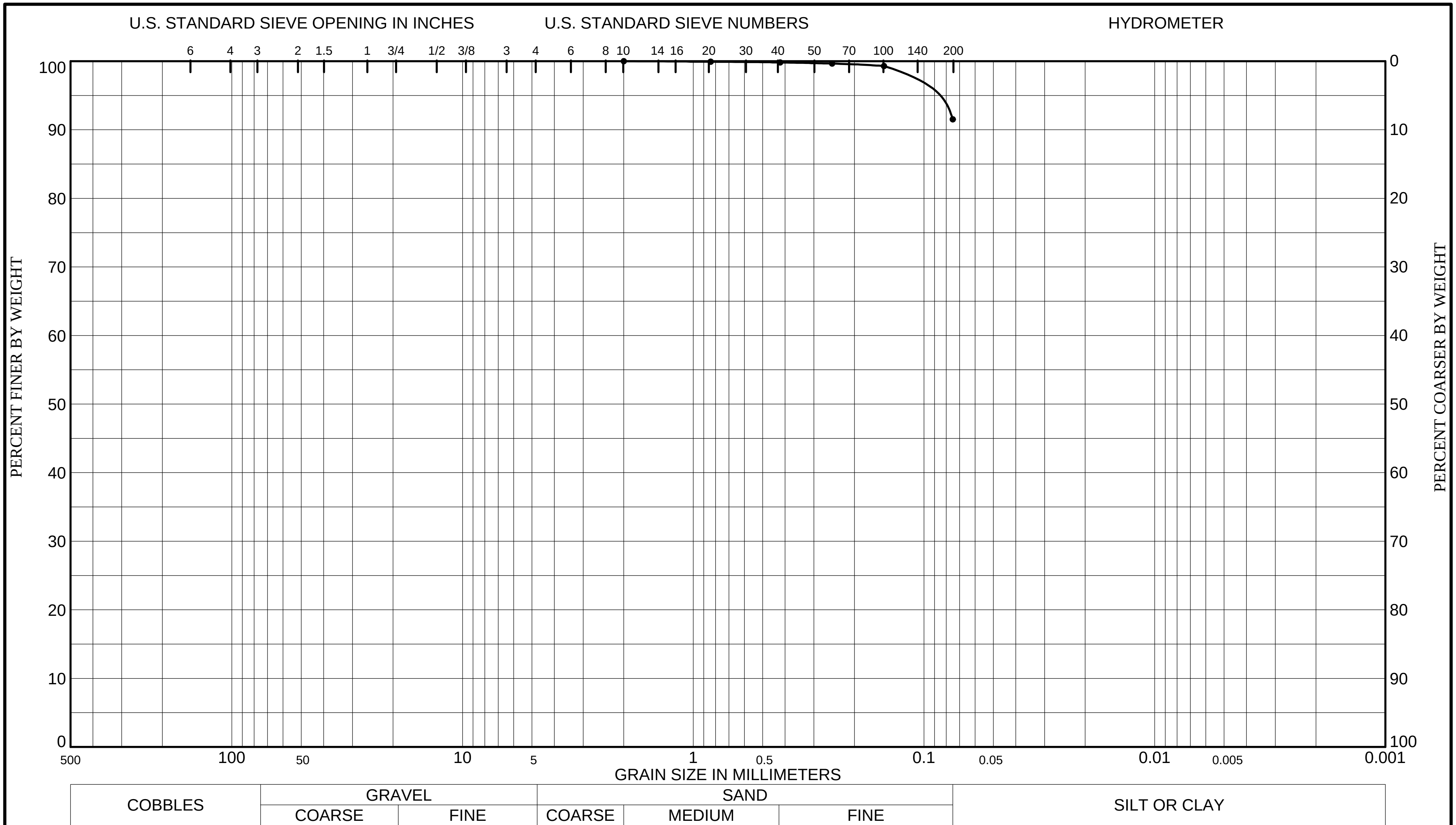
Boring No. SHE-19

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-6	152.5 to 153.1	Olive Gray, (Visual) Clayey Inorganic Silt High LL (MH), with a trace of sand.	81.7			

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/293

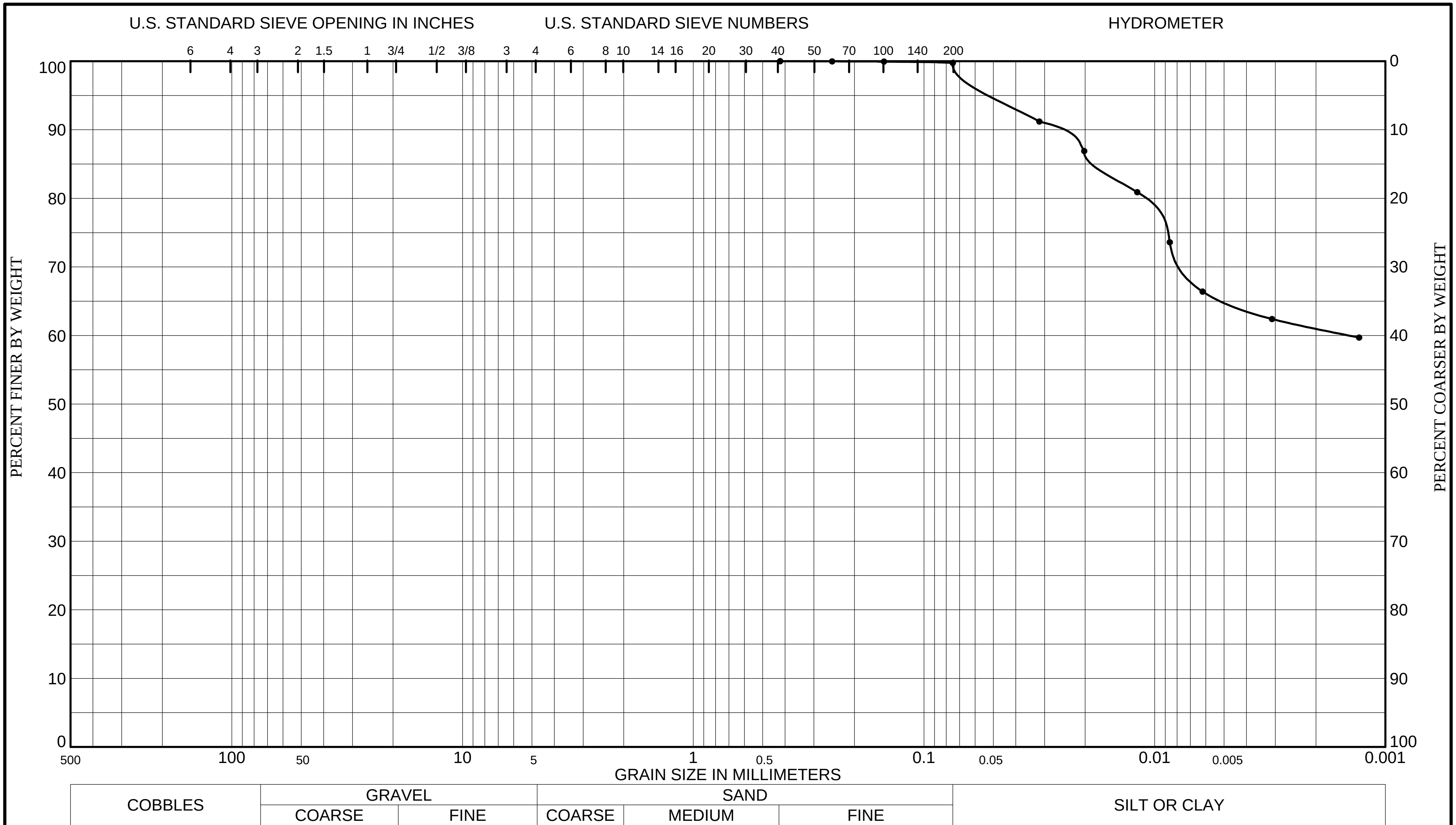
Boring No. SHE-19

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-7	162.3 to 162.9	Olive Gray, Clayey Organic Silt (OH).	124.7	250	83	167
		Oven dried LL was 41% of wet prepared soil.				

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/294

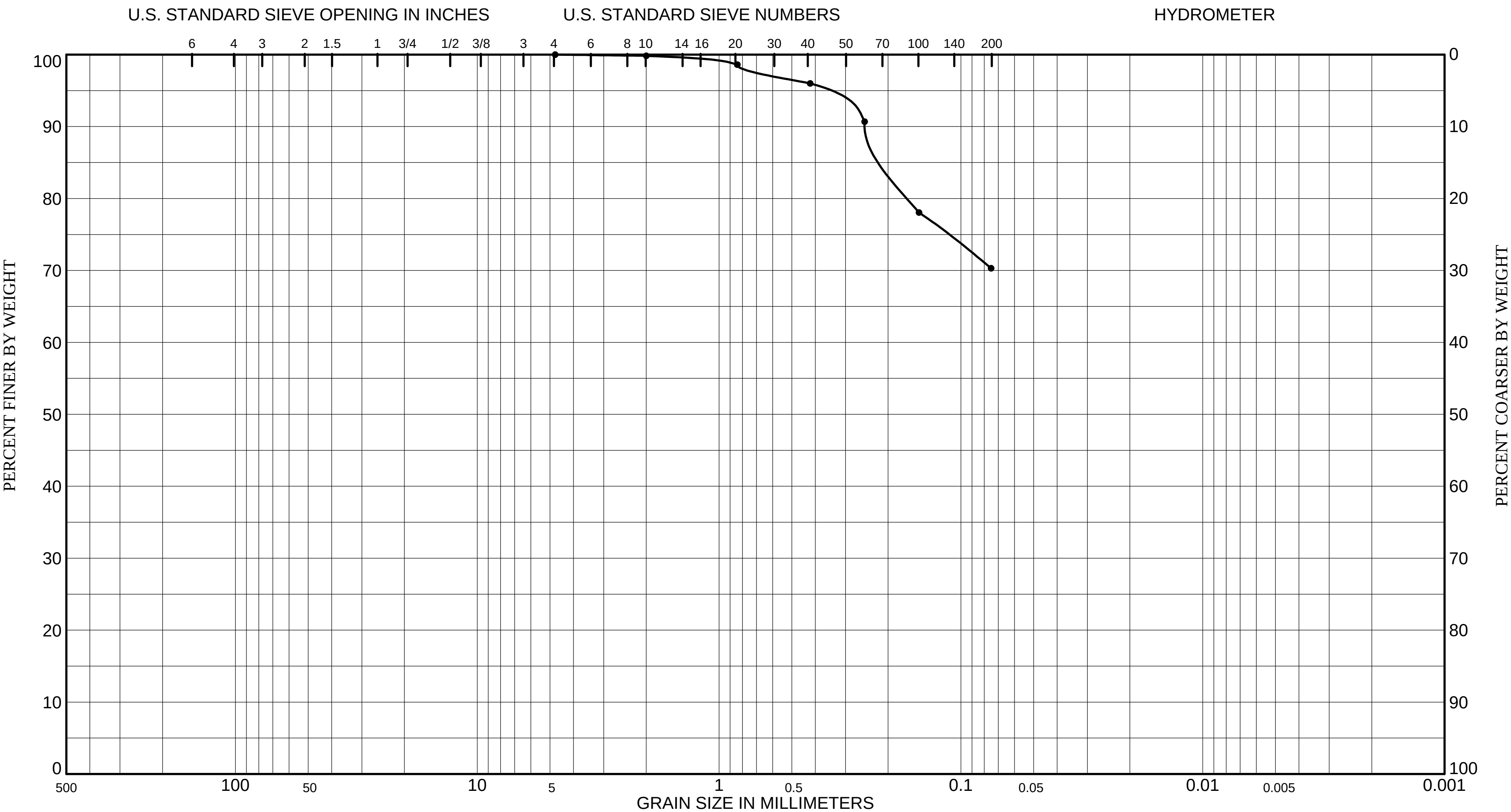
Boring No. SHE-19

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

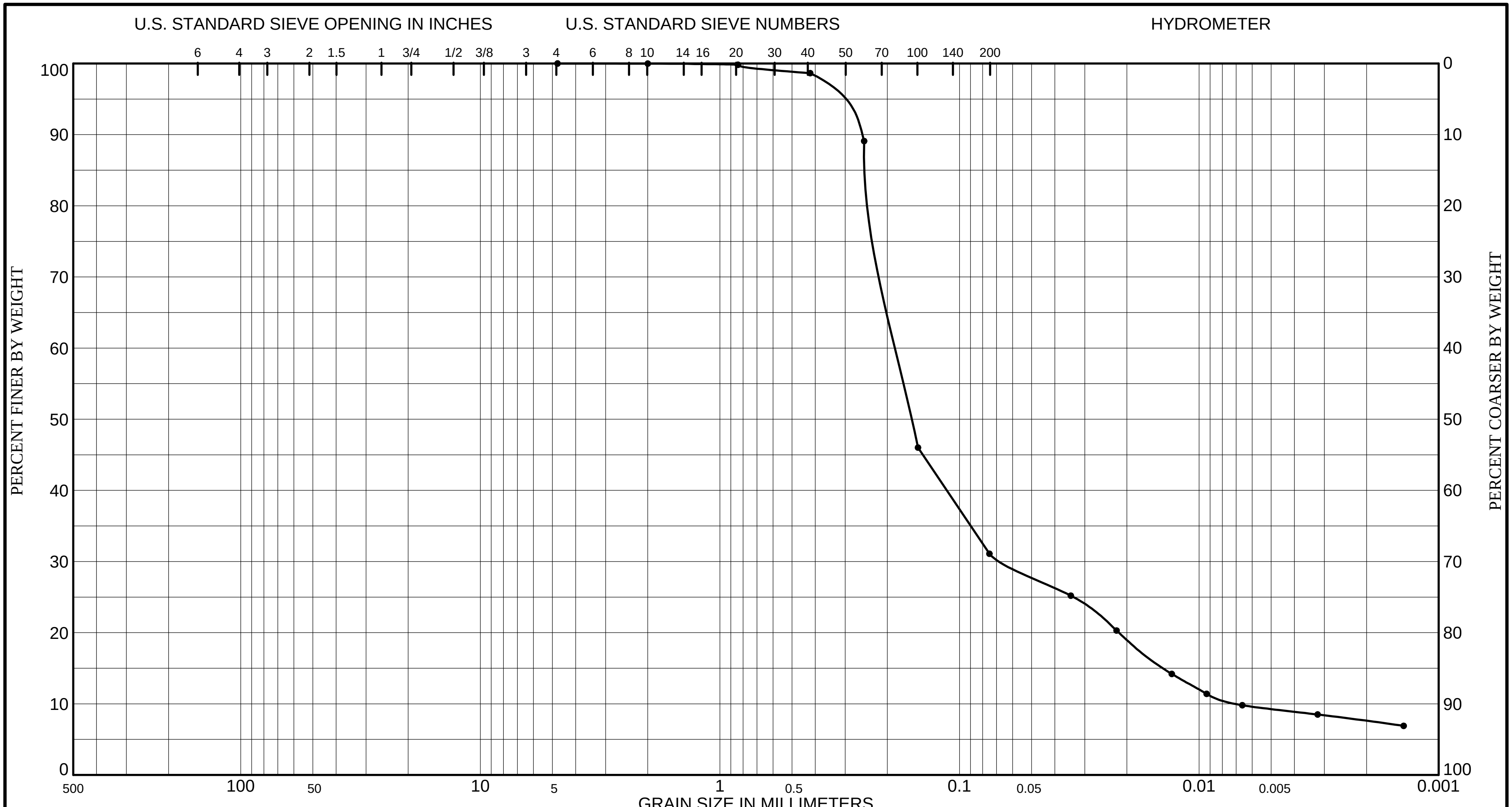
Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-8	167.1 to 167.6	Olive Gray, (Visual) Clayey Organic Silt (OH), with some sand.	155.7			

Project Savannah Harbor
Savannah Harbor Expansion, Savannah, GA
Lab No. K6/295
Boring No. SHE-19
Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-9	188.8 to 189.3	Olive, Silty Sand (SM-H), with High LL plastic fines.	28.5	69	37	32

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/296

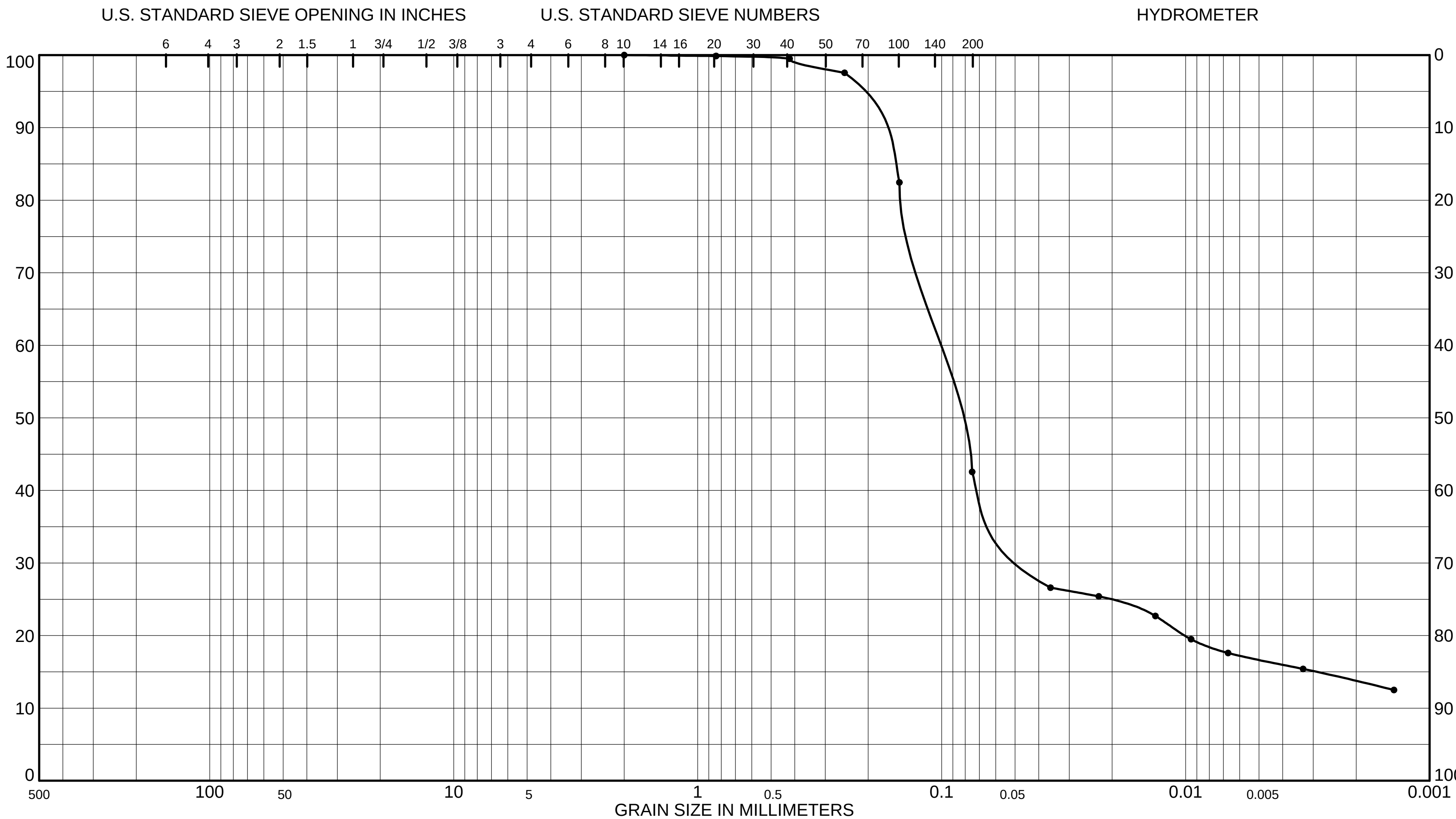
Boring No. SHE-19

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-10	202.1 to 202.6	Olive Gray, Silty Sand (SM-H), with High LL plastic fines.	52.0	132	58	74

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/297

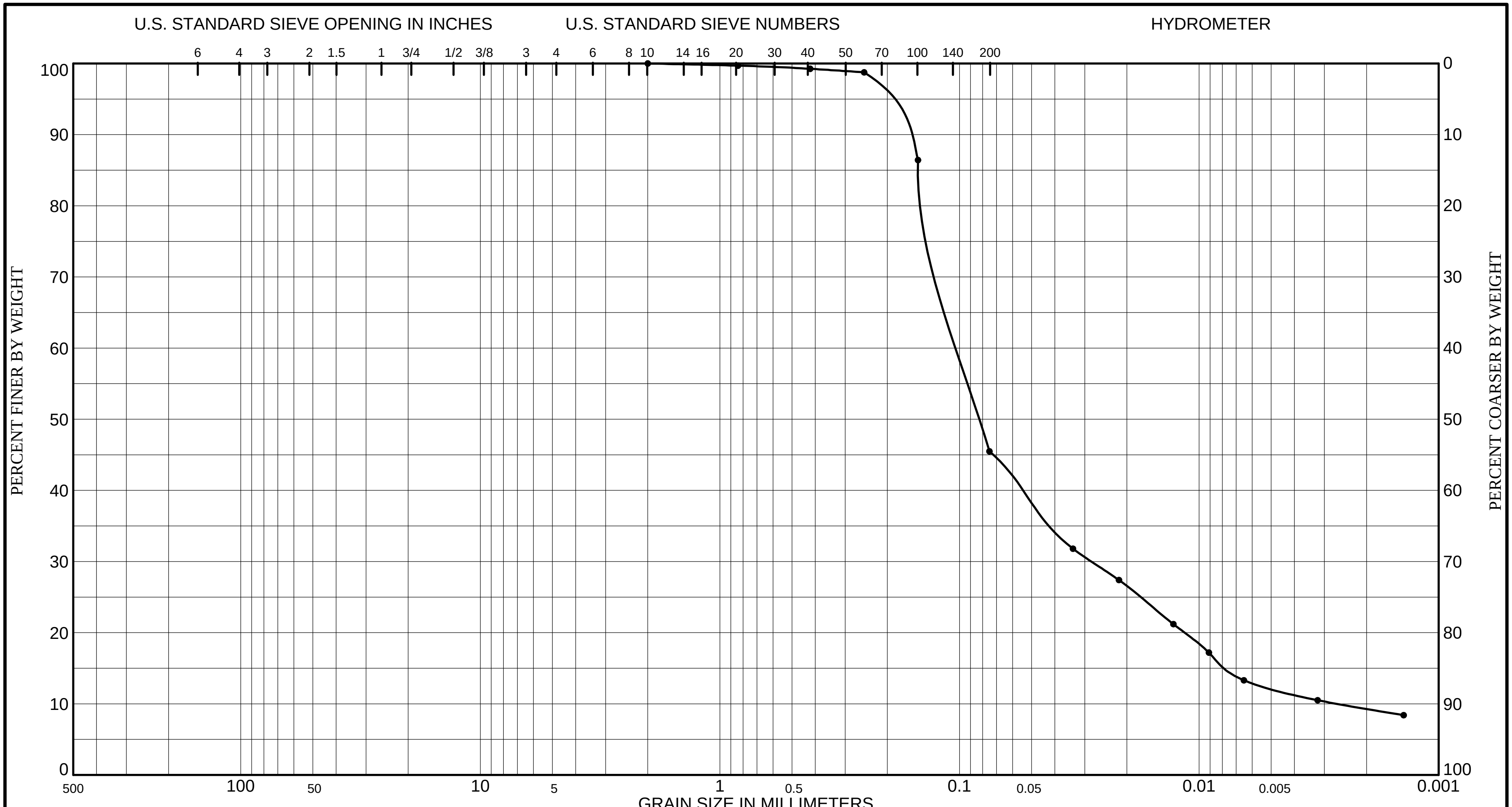
Boring No. SHE-19

Date 2/22/05

GRADATION CURVES

DEPARTMENT OF THE ARMY, SAVANNAH DISTRICT, ENVIRONMENTAL AND MATERIALS UNIT
CORPS OF ENGINEERS, 200 N. COBB PARKWAY, BLDG 400 SUITE 404, MARIETTA, GA. 30062

WORK ORDER: 330e
REQUISITION: W33SJG40168635



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Depth (ft)	Classification	Nat w%	LL	PL	PI
K-11	213.7 to 214.2	Olive, Silty Sand (SM-H), with High LL plastic fines.	38.1	97	47	50

Project Savannah Harbor

Savannah Harbor Expansion, Savannah, GA

Lab No. K6/298

Boring No. SHE-19

Date 2/22/05

GRADATION CURVES

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/205	Olive Gray	Fat Clay (CH), with a little sand, a trace of mica and wood fragments.	2.68	84	24	60	100.0	87.7

Specimen Results

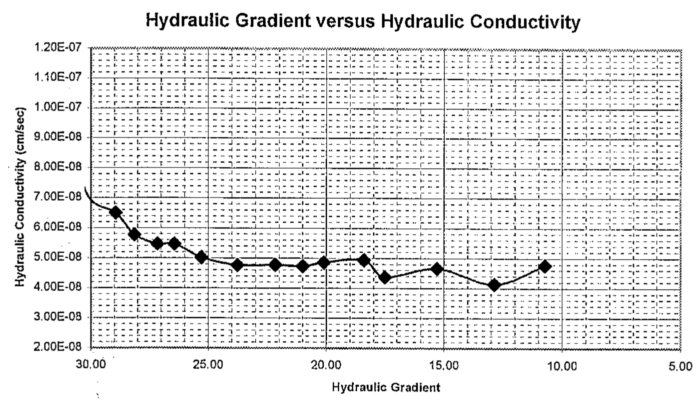
Trial	Diameter, D (cm)	Area, A (cm²)	Length, L (cm)	Volume (cm³)	Moist Mass (gms)
Initial	5.459	23.408	7.461	174.638	265.5
Final	5.487	23.648	7.329	173.307	265.9
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	75.7%	0.823	0.817	2.275	94%
Final	84.1%	0.824	0.817	2.250	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm²)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	64.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	4.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
1/27/2004	~Start~	20.3	16.0	1.2					
1/27/2004	960	20.3	15.1	1.2	14.8	13.9	25.3	23.7	4.77E-08
1/27/2004	1080	20.3	14.2	1.3	13.9	12.9	23.7	22.1	4.79E-08
1/27/2004	840	20.3	13.6	1.3	12.9	12.3	22.1	21.0	4.73E-08
1/27/2004	660	20.3	13.1	1.3	12.3	11.7	21.0	20.1	4.86E-08
					Averages:		22.4		4.79E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-11	Sample No.	K-1
Depth (ft)	48.5 to 49.0	Lab No.	K6/205
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/206	Olive Gray	(Visual) Fat Clay (CH), with a little sand.	2.66				100.0	89.2

Specimen Results

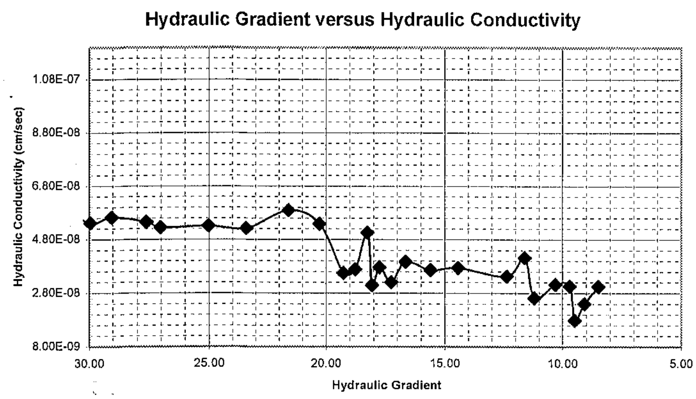
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.472	23.521	6.727	158.228	241.0
Final	5.479	23.579	6.492	153.065	235.9
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	90.3%	0.801	0.794	2.348	100%
Final	84.3%	0.800	0.794	2.239	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time: Date	Time Elapsed (sec)	Temp. (°C)	Permometer Reading Pipet (cm)	Permometer Reading Annulus (cm)	Head Loss Start	Head Loss Final	Hydraulic Gradient Start	Hydraulic Gradient Final	Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
1/27/2004	*~Start~*	20.2	14.2	1.3					
1/27/2004	840	20.2	13.4	1.3	12.9	12.1	25.0	23.4	5.22E-08
1/27/2004	780	19.8	11.9	1.4	11.2	10.5	21.6	20.3	5.33E-08
1/27/2004	480	19.5	11.1	1.4	10.0	9.7	19.3	18.8	3.70E-08
1/27/2004	240	19.5	10.8	1.4	9.4	9.3	18.3	18.1	3.09E-08
					Averages:		20.6		4.33E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-11	Sample No.	K-2
Depth (ft)	76.0 to 76.5	Lab No.	K6/206
Sample Received	16-Dec-03	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/207	Olive Gray	(Visual) Fat Clay (CH), with a trace of sand.	2.70				100.0	95.2

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.461	23.419	6.932	162.332	240.9
Final	5.498	23.743	6.732	159.846	236.9
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	78.4%	0.730	0.725	2.730	89%
Final	98.9%	0.732	0.725	2.672	100%

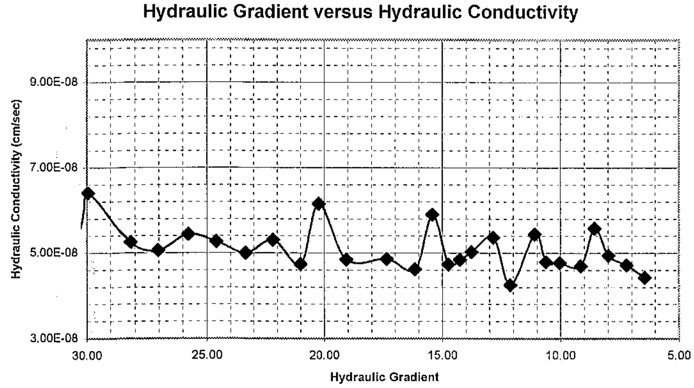
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	75.0	Consolidation Stress (psi)
Back Pressure (psi)	70.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time: Date	Time Elapsed (sec)	Temp. (°C)	Permometer Reading: Pipet (cm)	Annulus (cm)	Head Loss: Start	Final	Hydraulic Gradient: Start	Final	Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
2/2/2004	~Start~	19.9	15.1	1.2					
2/2/2004	600	19.9	14.5	1.3	13.8	13.2	25.8	24.6	5.27E-08
2/2/2004	660	19.9	13.2	1.3	12.5	11.9	23.3	22.2	5.31E-08
2/2/2004	420	19.8	12.2	1.3	11.3	10.9	21.0	20.2	6.15E-08
2/2/2004	1320	19.7	10.7	1.4	10.2	9.3	19.1	17.4	4.86E-08
					Averages:		21.7		5.40E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-11	Sample No.	K-3
Depth (ft)	78.5 to 79.0	Lab No.	K6/207
Sample Received	16-Dec-03	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/208	Dark Olive Gray	Clayey Sand High LL (SC-H).	2.80	67	30	37	100.0	19.3

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	6.613	34.346	7.284	250.177	472.5
Final	6.599	34.201	7.283	249.078	473.2
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	37.5%	1.377	1.372	1.038	100%
Final	36.8%	1.377	1.372	1.030	100%

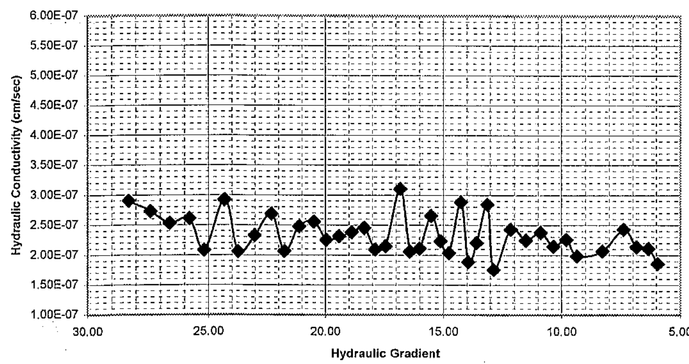
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
1/30/2004	*~Start~*	20.3	15.8	1.2					
1/30/2004	60	20.3	15.3	1.2	14.6	14.1	25.2	24.3	2.92E-07
1/30/2004	60	20.3	14.6	1.2	13.8	13.4	23.7	23.0	2.60E-07
1/30/2004	60	20.3	13.9	1.3	12.9	12.6	22.3	21.8	2.07E-07
1/30/2004	60	20.3	13.2	1.3	12.3	11.9	21.1	20.5	2.55E-07
					Averages:		22.7		2.53E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-11	Sample No.	K-4
Depth (ft)	88.3 to 88.8	Lab No.	K6/208
Sample Received	16-Dec-03	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/209	Pale Olive	Sandy Clayey Inorganic Silt High LL (MH).	2.74	76	39	37	100.0	59.3

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.769	26.141	6.818	178.228	330.5
Final	5.748	25.946	6.806	176.583	331.4
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	38.0%	1.343	1.338	1.049	100%
Final	37.6%	1.343	1.338	1.030	100%

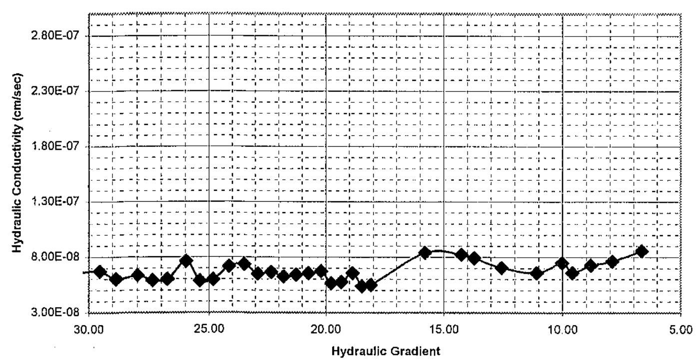
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	64.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	4.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time: Date	Time Elapsed (sec)	Temp. (°C)	Permometer Reading: Pipet (cm)	Annulus (cm)	Head Loss: Start	Final	Hydraulic Gradient: Start	Final	Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
1/30/2004	~Start~	20.3	15.3	1.2					
1/30/2004	240	20.3	15.0	1.2	14.1	13.8	26.0	25.4	5.86E-08
1/30/2004	240	20.3	14.4	1.3	13.5	13.1	24.8	24.1	7.17E-08
1/30/2004	240	20.3	13.7	1.3	12.7	12.4	23.5	22.9	6.49E-08
1/30/2004	240	20.3	13.1	1.3	12.1	11.8	22.3	21.8	6.25E-08
					Averages:		23.8		6.44E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-11	Sample No.	K-5
Depth (ft)	97.8 to 98.3	Lab No.	K6/209
Sample Received	16-Dec-03	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/210	Olive Gray	(Visual) Fat Clay (CH).	2.67				100.0	100.0

Specimen Results

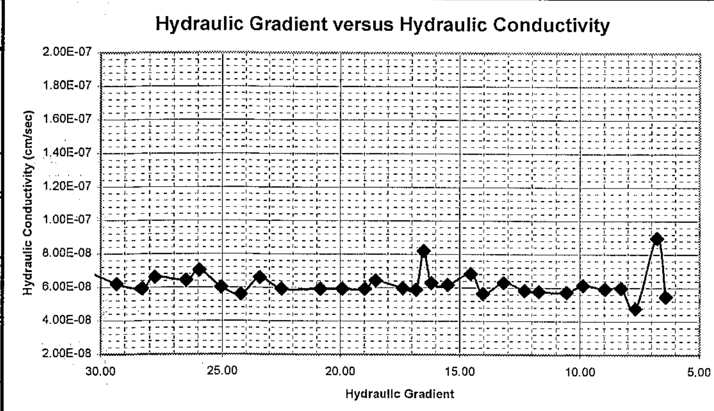
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.299	22.052	7.180	158.335	293.8
Final	5.307	22.119	7.163	158.451	294.9
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	36.8%	1.371	1.366	0.956	100%
Final	35.8%	1.371	1.366	0.957	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
2/2/2004	~Start~	18.4	16.3	1.2					
2/2/2004	240	18.4	16.0	1.2	15.1	14.8	26.5	26.0	7.05E-08
2/2/2004	480	18.6	15.1	1.2	14.3	13.8	25.0	24.2	5.60E-08
2/2/2004	540	18.8	14.1	1.3	13.4	12.8	23.4	22.5	5.91E-08
2/2/2004	600	19.2	12.7	1.3	11.9	11.4	20.8	19.9	5.93E-08
					Averages:		23.5		6.12E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-11	Sample No.	K-6
Depth (ft)	109.3 to 109.8	Lab No.	K6/210
Sample Received	16-Dec-03	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/211	Dark Olive Gray	(Visual) Silty Sand (SM), with plastic fines.	2.65				100.0	20.6

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.445	23.285	7.323	170.525	298.2
Final	5.436	23.205	7.297	169.323	299.2
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	38.2%	1.210	1.205	1.201	89%
Final	44.7%	1.211	1.205	1.186	100%

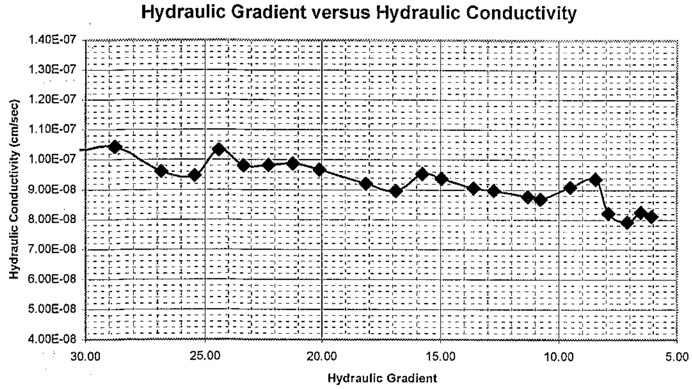
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	64.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	4.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
2/3/2004	~Start~	20.4	16.8	1.2					
2/3/2004	420	20.4	16.0	1.2	15.6	14.8	26.8	25.4	9.48E-08
2/3/2004	360	20.4	14.8	1.2	14.2	13.6	24.4	23.3	9.37E-08
2/3/2004	360	20.3	13.6	1.3	12.9	12.3	22.3	21.2	9.87E-08
2/3/2004	840	20.3	11.9	1.4	11.7	10.5	20.1	18.1	9.21E-08
					Averages:		22.7		9.48E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-11	Sample No.	K-7
Depth (ft)	117.0 to 117.5	Lab No.	K6/211
Sample Received	16-Dec-03	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/212	Dark Olive Gray	Silty Sand (SM-H), with High LL plastic fines.	2.70	64	34	30	99.6	13.6

Specimen Results

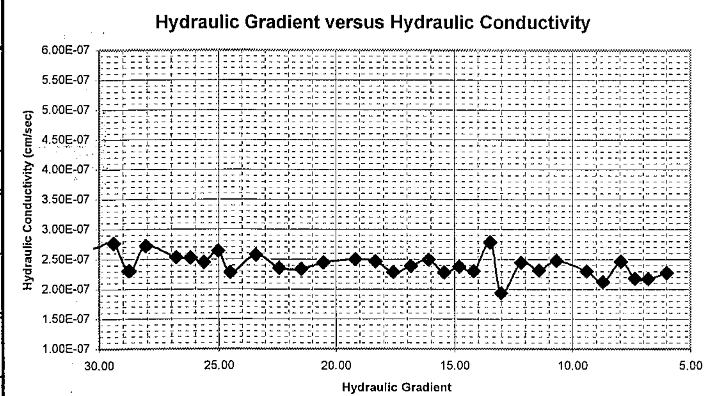
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.634	24.931	7.163	178.594	330.7
Final	5.684	25.375	6.998	177.569	329.6
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	38.9%	1.324	1.319	1.046	100%
Final	38.3%	1.324	1.319	1.034	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	64.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	4.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
2/4/2004	*~Start~*	20.1	15.8	1.2					
2/4/2004	60	20.1	15.5	1.2	14.6	14.3	26.2	25.6	2.38E-07
2/4/2004	60	20.2	14.9	1.2	14.0	13.7	25.0	24.5	2.28E-07
2/4/2004	120	20.2	13.8	1.3	13.0	12.5	23.4	22.4	2.36E-07
2/4/2004	120	20.2	12.8	1.3	12.0	11.5	21.5	20.5	2.45E-07
					Averages:		23.6		2.37E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-11	Sample No.	K-8
Depth (ft)	119.3 to 119.8	Lab No.	K6/212
Sample Received	16-Dec-03	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/213	Dark Olive Gray	Silty Sand (SM-H), with High LL plastic fines.	2.65	144	71	73	100.0	48.1

Specimen Results

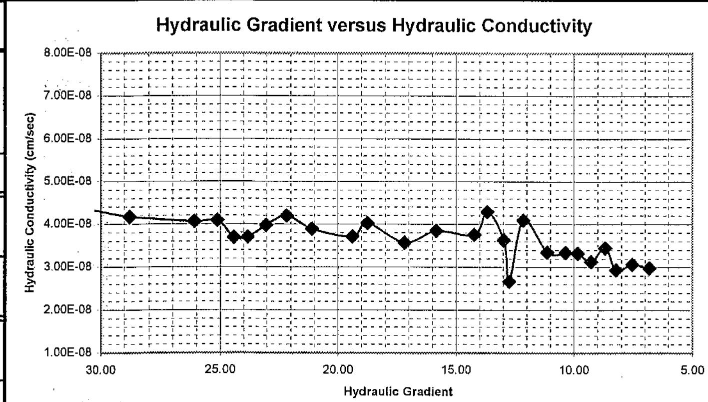
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.523	23.956	7.096	169.993	262.1
Final	5.483	23.615	7.090	167.428	262.8
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	77.1%	0.887	0.880	2.009	100%
Final	74.2%	0.886	0.880	1.963	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	64.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	4.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time: Date	Time Elapsed (sec)	Temp. (°C)	Permometer Reading: Pipet (cm)	Annulus (cm)	Head Loss: Start	Final	Hydraulic Gradient: Start	Final	Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
2/5/2004	~Start~	20.4	15.9	1.2					
2/5/2004	660	20.4	15.4	1.2	14.7	14.2	26.1	25.1	4.09E-08
2/5/2004	480	20.4	14.7	1.2	13.8	13.5	24.4	23.8	3.69E-08
2/5/2004	660	20.4	13.8	1.3	13.0	12.5	23.0	22.2	4.19E-08
2/5/2004	1620	20.4	12.3	1.3	11.9	11.0	21.1	19.4	3.71E-08
					Averages:		23.1		3.92E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-11	Sample No.	K-9
Depth (ft)	125.0 to 125.5	Lab No.	K6/213
Sample Received	16-Dec-03	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/214	Olive Gray	(Visual) Clayey Sand (SC).	2.70				100.0	18.8

Specimen Results

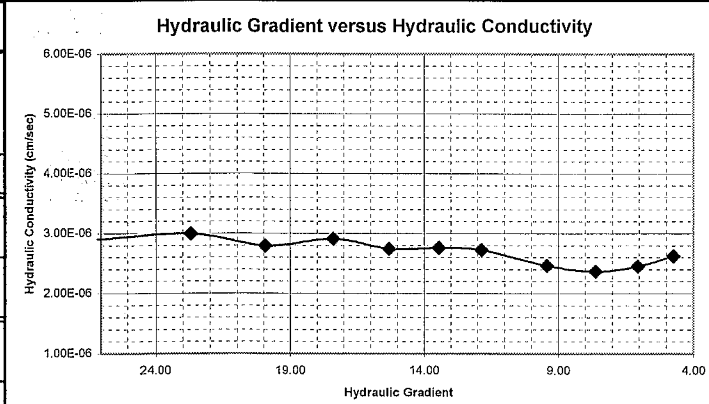
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.634	24.931	7.133	177.834	346.4
Final	5.617	24.782	6.718	166.491	337.5
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	30.4%	1.491	1.486	0.818	100%
Final	26.0%	1.490	1.486	0.702	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
2/6/2004	~Start~	20.6	15.2	1.2					
2/6/2004	30	20.6	13.5	1.3	14.0	12.2	26.1	22.7	2.99E-06
2/6/2004	30	20.6	10.7	1.4	10.7	9.3	19.9	17.4	2.91E-06
2/6/2004	30	20.6	8.7	1.5	8.2	7.2	15.3	13.5	2.76E-06
2/6/2004	60	20.6	6.6	1.6	6.3	5.0	11.8	9.4	2.46E-06
					Averages:		17.0		2.78E-06

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-13	Sample No.	K-1
Depth (ft)	70.0 to 70.5	Lab No.	K6/214
Sample Received	21-Jan-04	Report Date	3-Feb-05

Permeability Test Report **- ASTM D5084 Method C**

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/215	Olive Gray	Sandy Fat Clay (CH).	2.68	67	22	45	100.0	52.6

Specimen Results

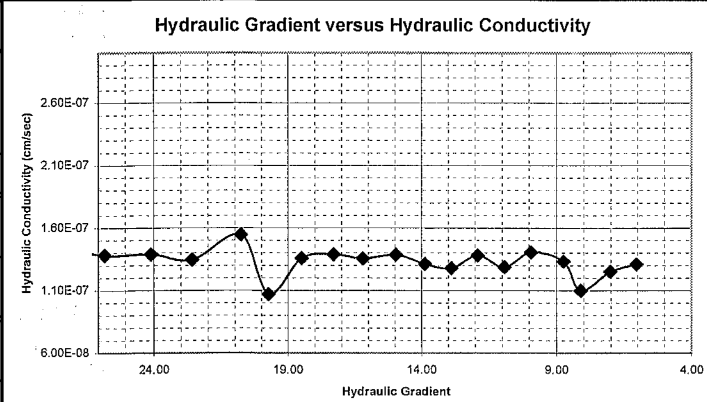
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.597	24.603	6.427	158.118	265.5
Final	5.560	24.284	6.305	153.107	262.8
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	35.0%	0.953	0.949	1.818	67%
Final	64.6%	0.955	0.949	1.728	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time: Date	Time Elapsed (sec)	Temp. (°C)	Permometer Reading Pipet (cm)	Permometer Reading Annulus (cm)	Head Loss Start	Head Loss Final	Hydraulic Gradient Start	Hydraulic Gradient Final	Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
2/7/2004	*~Start~*	19.9	14.2	1.3					
2/7/2004	300	19.9	13.4	1.3	12.9	12.1	25.8	24.1	1.39E-07
2/7/2004	300	19.9	11.8	1.4	11.3	10.4	22.6	20.8	1.75E-07
2/7/2004	300	19.9	10.7	1.4	9.9	9.3	19.7	18.5	1.36E-07
2/7/2004	300	19.9	9.6	1.5	8.7	8.1	17.3	16.2	1.35E-07
					Averages:		20.6		1.46E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-13	Sample No.	K-2
Depth (ft)	75.8 to 76.3	Lab No.	K6/215
Sample Received	21-Jan-04	Report Date	3-Feb-05

Permeability Test Report **- ASTM D5084 Method C**

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/216	Olive Gray	(Visual) Fat Clay (CH), with a trace of sand.	2.63				100.0	96.2

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.513	23.868	6.349	151.529	236.0
Final	5.493	23.696	6.313	149.595	234.9
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	75.8%	0.885	0.879	1.993	100%
Final	74.3%	0.885	0.879	1.955	100%

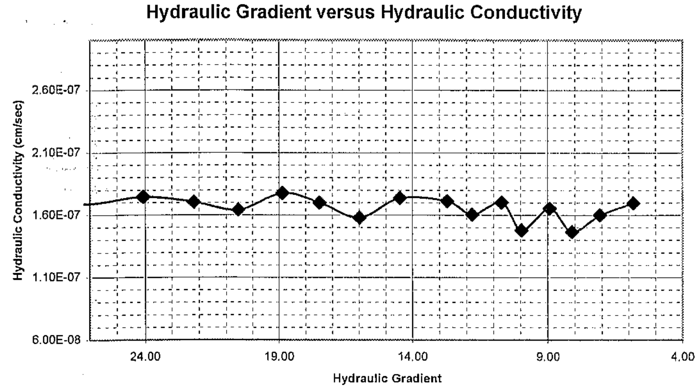
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
2/9/2004	*~Start~*	20.4	15.5	1.2					
2/9/2004	300	20.4	14.4	1.3	14.2	13.1	28.3	26.1	1.69E-07
2/9/2004	300	20.4	12.5	1.3	12.1	11.2	24.1	22.2	1.70E-07
2/9/2004	300	20.4	10.9	1.4	10.3	9.5	20.5	18.9	1.78E-07
2/9/2004	360	20.4	9.5	1.5	8.8	8.0	17.5	16.0	1.58E-07
					Averages:		21.7		1.69E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-13	Sample No.	K-5
Depth (ft)	92.7 to 93.2	Lab No.	K6/216
Sample Received	21-Jan-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/217	Olive Gray	(Visual) Fat Clay (CH), with a trace of sand.	2.70				100.0	98.3

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm²)	Length, L (cm)	Volume (cm³)	Moist Mass (gms)
Initial	5.479	23.575	6.335	149.344	232.3
Final	5.507	23.820	6.240	148.641	230.5
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	82.3%	0.845	0.838	2.221	100%
Final	81.7%	0.845	0.838	2.206	100%

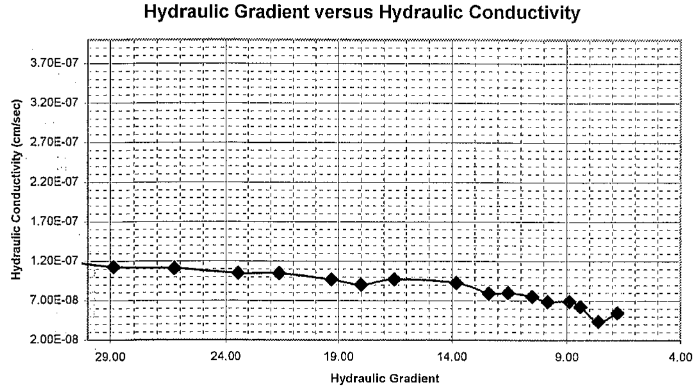
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm²)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
2/10/2004	~Start~	20.8	15.6	1.2					
2/10/2004	540	20.8	14.3	1.3	14.3	13.0	28.8	26.2	1.09E-07
2/10/2004	480	20.8	12.1	1.4	11.7	10.7	23.4	21.6	1.05E-07
2/10/2004	480	20.8	10.4	1.4	9.6	9.0	19.3	18.0	9.04E-08
2/10/2004	1200	20.8	8.4	1.5	8.2	6.9	16.5	13.8	9.27E-08
					Averages:		21.0		9.92E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-13	Sample No.	K-6
Depth (ft)	98.3 to 98.8	Lab No.	K6/217
Sample Received	21-Jan-04	Report Date	3-Feb-05

Permeability Test Report **- ASTM D5084 Method C**

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/218	Olive	Clayey Inorganic Silt High LL (MH), with some sand.	2.71	132	53	79	100.0	77.2

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.506	23.809	7.127	169.678	276.8
Final	5.511	23.853	7.085	169.007	276.4
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	64.1%	0.997	0.991	1.738	100%
Final	63.7%	0.997	0.991	1.727	100%

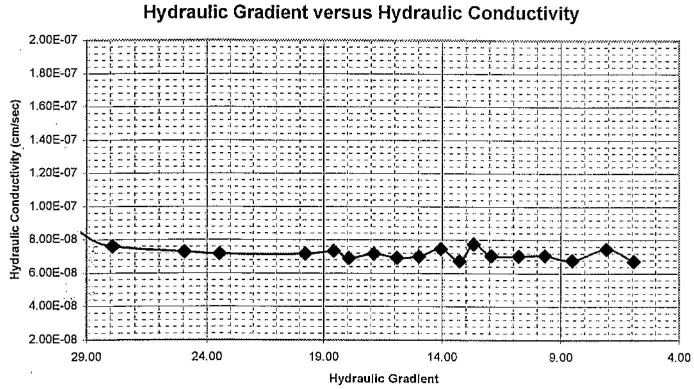
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
2/11/2004	~Start~	20.6	17.5	1.1					
2/11/2004	360	20.6	16.9	1.1	16.4	15.8	29.0	27.9	7.61E-08
2/11/2004	600	20.6	14.5	1.2	14.1	13.3	24.9	23.5	7.16E-08
2/11/2004	600	20.6	11.9	1.4	11.2	10.5	19.8	18.6	7.34E-08
2/11/2004	600	20.6	10.9	1.4	10.1	9.5	17.9	16.9	7.16E-08
					Averages:		22.3		7.32E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-13	Sample No.	K-7
Depth (ft)	102.3 to 102.8	Lab No.	K6/218
Sample Received	21-Jan-04	Report Date	3-Feb-05

Permeability Test Report **- ASTM D5084 Method C**

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/219	Olive Gray	(Visual) Clayey Inorganic Silt High LL (MH), with some sand.	2.68				100.0	65.7

Specimen Results

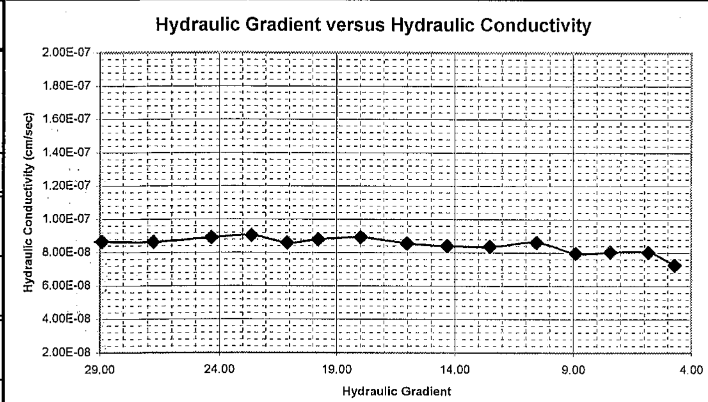
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.527	23.992	6.756	162.088	259.7
Final	5.490	23.674	6.704	158.702	258.9
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	64.5%	0.981	0.974	1.751	99%
Final	63.2%	0.980	0.974	1.693	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
2/12/2004	~Start~	20.6	16.6	1.2					
2/12/2004	600	20.6	15.5	1.2	15.4	14.3	28.9	26.8	8.63E-08
2/12/2004	540	20.6	13.4	1.3	13.0	12.1	24.3	22.6	9.05E-08
2/12/2004	480	20.6	11.9	1.4	11.3	10.6	21.1	19.8	9.01E-08
2/12/2004	900	20.6	10.0	1.4	9.6	8.6	18.0	16.0	8.57E-08
					Averages:		22.2		8.81E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-13	Sample No.	K-8
Depth (ft)	106.5 to 107.0	Lab No.	K6/219
Sample Received	21-Jan-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/220	Olive Gray	Clayey Inorganic Silt High LL (MH), with a little sand.	2.67	158	74	84	100.0	80.8

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.499	23.751	7.129	169.321	261.5
Final	5.539	24.099	6.918	166.726	256.7
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	83.7%	0.833	0.826	2.238	100%
Final	81.9%	0.832	0.826	2.189	100%

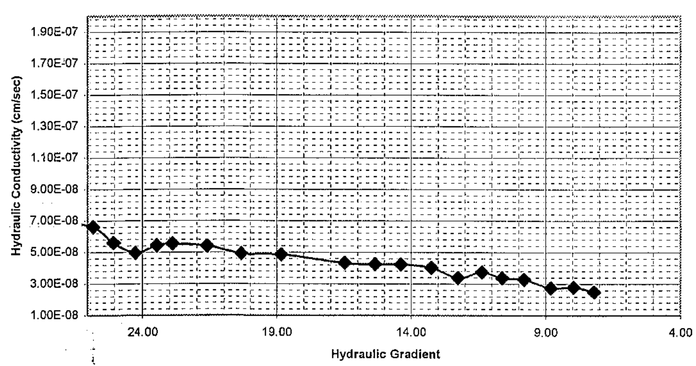
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
2/14/2004	*~Start~*	20.6	16.1	1.2					
2/14/2004	480	20.6	15.4	1.2	14.9	14.2	27.0	25.8	6.35E-08
2/14/2004	420	20.7	14.6	1.2	13.8	13.4	25.0	24.3	4.96E-08
2/14/2004	300	20.7	13.9	1.3	12.9	12.6	23.5	22.9	5.53E-08
2/14/2004	840	20.7	12.6	1.3	11.9	11.2	21.6	20.3	4.91E-08
					Averages:		23.8		5.44E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-13	Sample No.	K-9
Depth (ft)	111.5 to 112.0	Lab No.	K6/220
Sample Received	21-Jan-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/221	Olive Gray	(Visual) Clayey Inorganic Silt High LL (MH), with a little sand.	2.66				100.0	89.0

Specimen Results

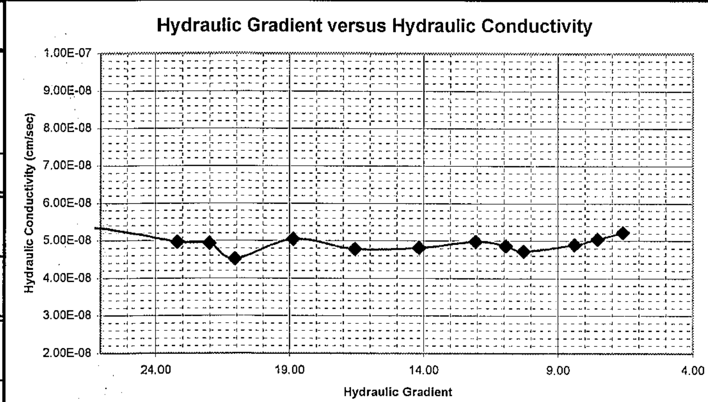
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.579	24.447	7.150	174.796	259.9
Final	5.547	24.166	6.959	168.167	254.4
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	100.0%	0.734	0.727	2.655	100%
Final	94.7%	0.734	0.727	2.516	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time: Date	Time Elapsed (sec)	Temp. (°C)	Permometer Reading Pipet (cm)	Permometer Reading Annulus (cm)	Head Loss Start	Head Loss Final	Hydraulic Gradient Start	Hydraulic Gradient Final	Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
2/16/2004	*~Start~*	20.4	17.2	1.1					
2/16/2004	540	20.4	16.6	1.2	16.1	15.4	29.0	27.8	5.24E-08
2/16/2004	1680	20.4	14.1	1.3	14.5	12.9	26.2	23.2	4.97E-08
2/16/2004	660	20.5	13.0	1.3	12.2	11.7	22.0	21.1	4.52E-08
2/16/2004	1860	20.5	10.6	1.4	10.5	9.2	18.9	16.6	4.78E-08
					Averages:		23.1		4.88E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-13	Sample No.	K-10
Depth (ft)	117.2 to 117.7	Lab No.	K6/221
Sample Received	21-Jan-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/222	Dark Olive Gray	Silty Sand (SM-H), with High LL plastic fines.	2.69	151	67	84	100.0	38.5

Specimen Results

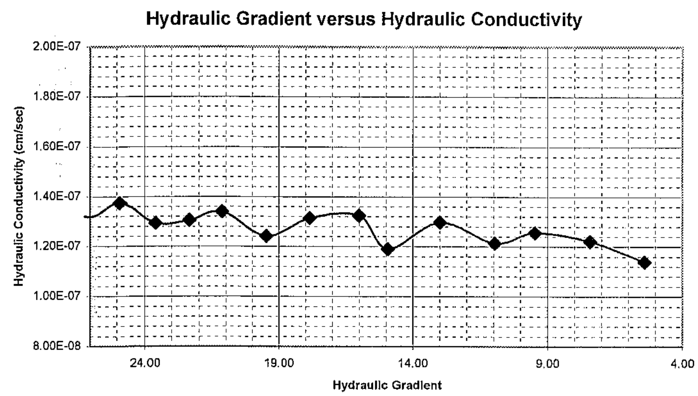
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.420	23.075	7.107	163.994	272.1
Final	5.420	23.068	7.061	162.873	272.1
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	59.2%	1.044	1.037	1.595	100%
Final	58.6%	1.043	1.037	1.577	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
2/17/2004	*~Start~*	20.6	16.8	1.1					
2/17/2004	360	20.6	15.9	1.2	15.7	14.7	27.8	26.1	1.32E-07
2/17/2004	300	20.6	14.5	1.2	14.0	13.3	24.9	23.6	1.29E-07
2/17/2004	300	20.6	13.2	1.3	12.6	11.9	22.3	21.1	1.34E-07
2/17/2004	480	20.6	11.4	1.4	11.0	10.0	19.5	17.9	1.31E-07
					Averages:		22.9		1.32E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-13	Sample No.	K-11
Depth (ft)	124.0 to 124.5	Lab No.	K6/222
Sample Received	21-Jan-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/250	Olive Gray	(Visual) Fat Clay (CH), with a trace of sand.	2.75				100.0	96.8

Specimen Results

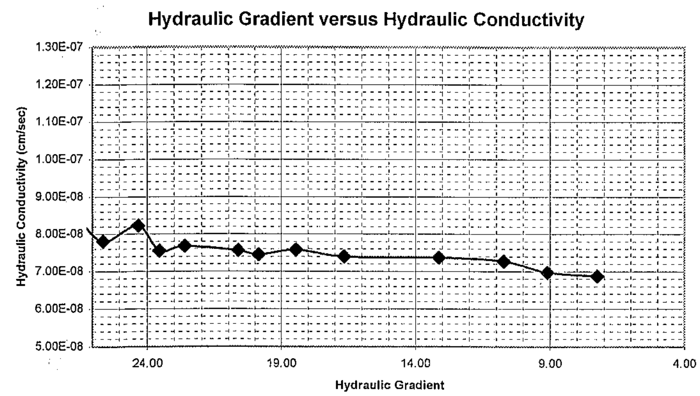
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.595	24.584	7.278	178.932	280.7
Final	5.516	23.893	7.060	168.685	275.4
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	77.8%	0.883	0.876	2.142	100%
Final	71.3%	0.882	0.876	1.962	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
2/21/2004	~Start~	21.2	16.7	1.2					
2/21/2004	300	21.2	16.2	1.2	15.5	15.0	27.6	26.7	8.23E-08
2/21/2004	420	21.2	14.9	1.2	14.4	13.7	25.6	24.3	8.22E-08
2/21/2004	360	21.2	14.0	1.3	13.3	12.7	23.6	22.6	7.68E-08
2/21/2004	360	21.2	12.5	1.3	11.6	11.2	20.6	19.8	7.45E-08
					Averages:		23.9		7.90E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-14	Sample No.	K-1
Depth (ft)	63.6 to 64.1	Lab No.	K6/250
Sample Received	4-Feb-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/251	Olive Gray	Fat Clay (CH), with a little sand.	2.72	130	38	92	100.0	89.2

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.474	23.532	7.087	166.759	276.4
Final	5.550	24.195	6.946	168.050	272.8
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	66.4%	0.976	0.970	1.805	100%
Final	67.2%	0.976	0.970	1.827	100%

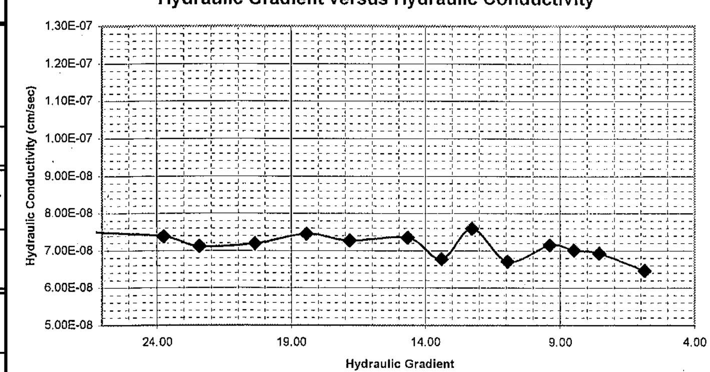
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
2/20/2004	*~Start~*	21.0	17.3	1.1					
2/20/2004	540	21.0	16.4	1.2	16.2	15.2	29.2	27.5	7.66E-08
2/20/2004	960	21.0	14.4	1.3	14.6	13.1	26.4	23.8	7.38E-08
2/20/2004	900	21.0	12.6	1.3	12.4	11.3	22.4	20.4	7.25E-08
2/20/2004	840	21.0	10.7	1.4	10.2	9.3	18.4	16.8	7.28E-08
					Averages:		23.1		7.39E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-14	Sample No.	K-2
Depth (ft)	70.6 to 71.2	Lab No.	K6/251
Sample Received	4-Feb-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/252	Olive Gray	(Visual) Fat Clay (CH), with a trace of sand.	2.77				100.0	97.9

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.539	24.099	7.004	168.792	278.0
Final	5.538	24.092	6.913	166.553	276.3
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	68.6%	0.961	0.955	1.898	100%
Final	67.2%	0.961	0.955	1.859	100%

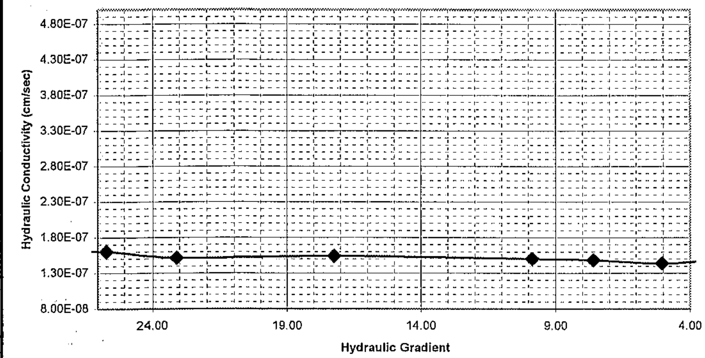
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time: Date	Time Elapsed (sec)	Temp. (°C)	Permometer Reading: Pipet (cm)	Permometer Reading: Annulus (cm)	Head Loss: Start	Head Loss: Final	Hydraulic Gradient: Start	Hydraulic Gradient: Final	Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
4/5/2004	*~Start~*	19.7	18.8	1.1					
4/5/2004	120	19.7	18.3	1.1	17.7	17.2	32.1	31.2	1.73E-07
4/5/2004	540	19.7	15.4	1.2	16.0	14.1	29.1	25.7	1.60E-07
4/5/2004	1320	19.7	10.9	1.4	12.7	9.5	23.1	17.2	1.54E-07
4/5/2004	1260	19.7	5.8	1.6	5.4	4.2	9.9	7.6	1.44E-07
					Averages:		22.0		1.58E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-14	Sample No.	K-3
Depth (ft)	75.0 to 75.5	Lab No.	K6/252
Sample Received	4-Feb-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/253	Dark Olive Gray	Poorly Graded Silty Sand (SP-SM), with plastic fines.	2.73	41	26	15	100.0	5.9

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.395	22.863	7.617	174.159	366.3
Final	5.533	24.048	7.188	172.859	354.2
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	25.2%	1.621	1.617	0.689	100%
Final	24.8%	1.621	1.617	0.677	100%

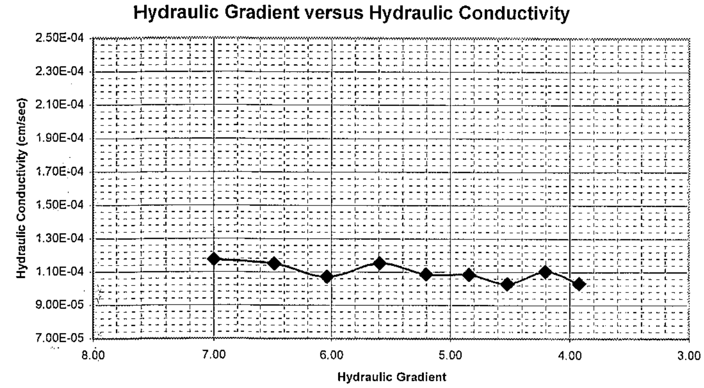
Permeameter Conditions

Permeant Fluid	Permometer Area of Tubes (cm^2) pipet
De-aired tap water	0.3184

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Head (cm)	Tail (cm)	Start	Final	Start	Final	
4/22/2004	~Start~	22.2	57.4	5.1					
4/22/2004	30	22.2	56.4	6.1	52.3	50.3	7.3	7.0	1.17E-04
4/22/2004	120	22.2	48.9	14.1	40.2	34.8	5.6	4.8	1.08E-04
4/22/2004	420	23.1	46.9	15.2	52.5	31.7	7.3	4.4	1.06E-04
4/22/2004	90	22.2	54.5	7.9	52.3	46.6	7.3	6.5	1.16E-04
					Averages:		6.3		1.12E-04

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-14	Sample No.	K-4
Depth (ft)	84.0 to 84.5	Lab No.	K6/253
Sample Received	4-Feb-04	Report Date	3-Feb-05

***Permeability Test Report* - ASTM D5084 Method C**

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/254	Olive	(Visual) Clayey Inorganic Silt High LL (MH), with some sand.	2.75				100.0	77.1

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.645	25.029	7.092	177.497	308.4
Final	5.644	25.018	6.922	173.159	303.7
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	52.9%	1.125	1.120	1.453	100%
Final	50.7%	1.125	1.120	1.393	100%

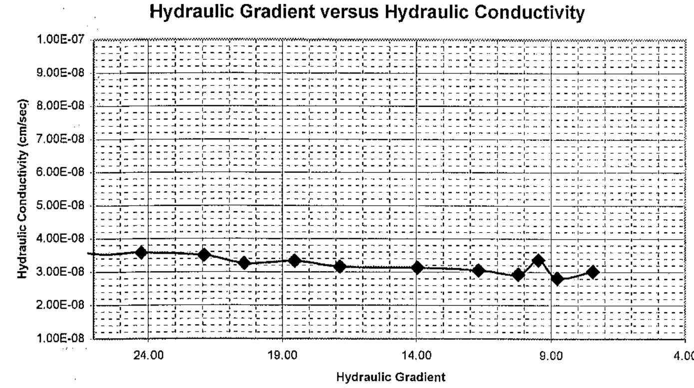
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	64.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	4.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
4/21/2004	~Start~	22.2	16.9	1.1					
4/21/2004	1560	22.2	15.6	1.2	15.8	14.4	28.6	26.2	3.56E-08
4/21/2004	1800	22.2	13.4	1.3	13.4	12.1	24.3	21.9	3.51E-08
4/21/2004	1800	22.2	11.6	1.4	11.3	10.2	20.4	18.5	3.40E-08
4/21/2004	3780	22.2	9.2	1.5	9.3	7.7	16.8	14.0	3.13E-08
					Averages:		21.3		3.40E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-14	Sample No.	K-5
Depth (ft)	90.0 to 90.5	Lab No.	K6/254
Sample Received	4-Feb-04	Report Date	3-Feb-05

Permeability Test Report **- ASTM D5084 Method C**

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/255	Olive	Silty Sand (SM-H), with High LL plastic fines.	2.74	110	48	62	100.0	48.9

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.547	24.166	7.116	171.973	299.1
Final	5.551	24.202	7.026	170.053	296.8
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	53.6%	1.115	1.109	1.469	100%
Final	52.6%	1.115	1.109	1.441	100%

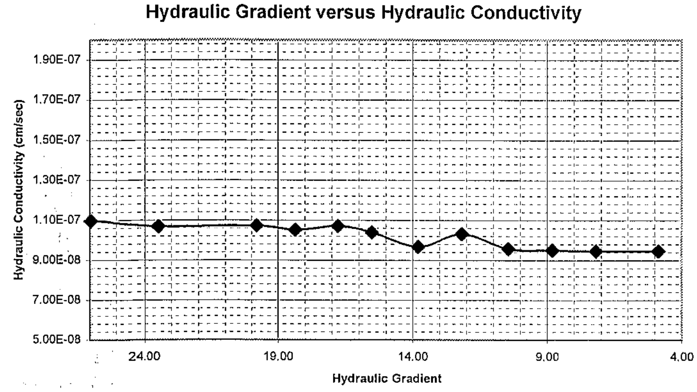
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	64.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	4.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
4/23/2004	~Start~	23.4	17.2	1.1					
4/23/2004	600	23.4	15.7	1.2	16.1	14.5	28.7	25.9	1.10E-07
4/23/2004	1020	23.4	12.4	1.3	13.1	11.1	23.5	19.8	1.07E-07
4/23/2004	540	23.5	10.8	1.4	10.3	9.4	18.4	16.8	1.07E-07
4/23/2004	780	23.6	9.2	1.5	8.7	7.7	15.5	13.8	9.66E-08
					Averages:		20.3		1.05E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-14	Sample No.	K-6
Depth (ft)	95.0 to 95.6	Lab No.	K6/255
Sample Received	4-Feb-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/256	Olive Gray	Sandy Clayey Inorganic Silt High LL (MH).	2.71	156	59	97	100.0	60.0

Specimen Results

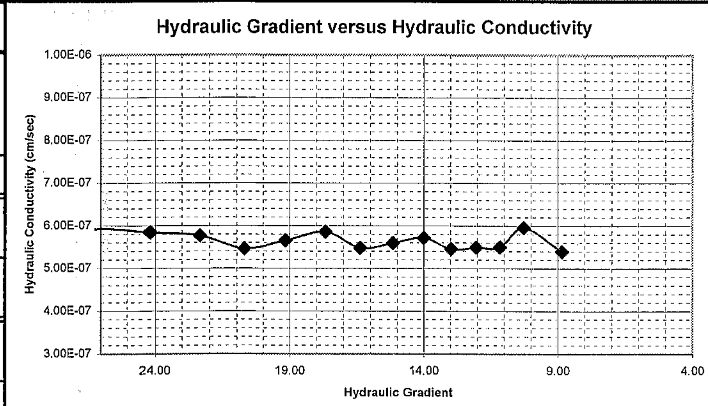
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.534	24.055	4.927	118.518	196.4
Final	5.569	24.361	4.822	117.460	193.1
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	64.7%	0.991	0.984	1.755	100%
Final	63.8%	0.991	0.984	1.731	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
4/26/2004	~Start~	23.9	12.3	1.3					
4/26/2004	60	23.9	11.5	1.4	10.9	10.1	28.4	26.2	5.92E-07
4/26/2004	60	23.9	10.0	1.4	9.3	8.6	24.2	22.3	5.69E-07
4/26/2004	60	23.9	8.9	1.5	8.0	7.4	20.7	19.2	5.66E-07
4/26/2004	60	23.9	7.8	1.5	6.8	6.3	17.7	16.4	5.47E-07
					Averages:		21.9		5.69E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-14	Sample No.	K-7
Depth (ft)	100.0 to 100.5	Lab No.	K6/256
Sample Received	4-Feb-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/257	Olive Gray	(Visual) Silty Sand (SM), with plastic fines.	2.69				100.0	43.1

Specimen Results

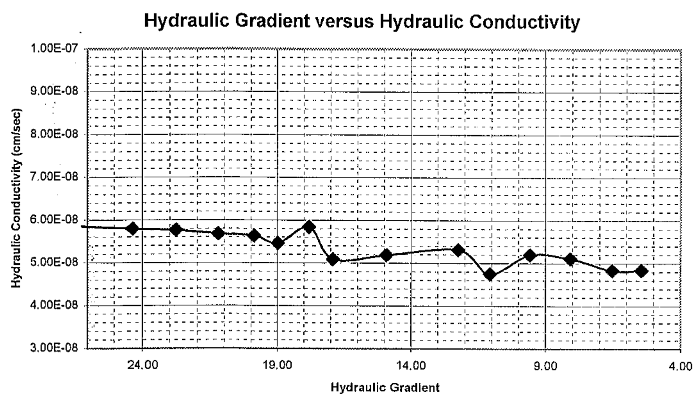
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.458	23.401	7.078	165.624	280.0
Final	5.467	23.473	6.986	163.977	277.8
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	55.1%	1.089	1.083	1.482	100%
Final	54.2%	1.089	1.083	1.457	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
4/28/2004	~Start~	19.9	16.8	1.2					
4/28/2004	780	19.9	15.9	1.2	15.6	14.7	28.1	26.3	5.85E-08
4/28/2004	840	19.9	14.0	1.3	13.6	12.7	24.4	22.8	5.76E-08
4/28/2004	840	19.9	12.4	1.3	11.8	11.1	21.2	19.9	5.64E-08
4/28/2004	780	19.9	11.3	1.4	10.6	9.9	19.0	17.8	5.84E-08
					Averages:		22.4		5.77E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-14	Sample No.	K-8
Depth (ft)	105.5 to 106.0	Lab No.	K6/257
Sample Received	4-Feb-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/258	Dark Olive Gray	(Visual) Silty Sand (SM), with plastic fines.	2.73				100.0	31.9

Specimen Results

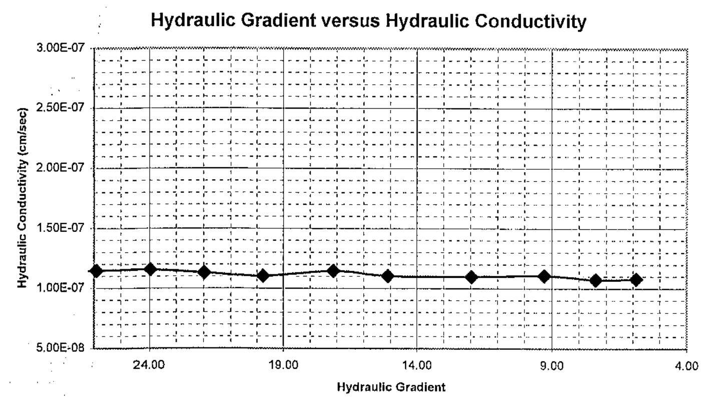
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.444	23.281	6.167	143.578	238.9
Final	5.461	23.426	6.079	142.419	238.7
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	59.7%	1.044	1.037	1.628	100%
Final	58.9%	1.044	1.037	1.607	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
5/3/2004	~Start~	19.9	15.1	1.2					
5/3/2004	540	19.9	13.8	1.3	13.9	12.5	28.6	25.9	1.17E-07
5/3/2004	480	19.9	12.0	1.4	11.6	10.6	24.0	22.0	1.13E-07
5/3/2004	780	19.9	9.8	1.5	9.6	8.3	19.8	17.1	1.15E-07
5/3/2004	1320	19.9	7.4	1.6	7.3	5.8	15.1	12.0	1.10E-07
					Averages:		20.6		1.13E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-14	Sample No.	K-9
Depth (ft)	111.2 to 111.7	Lab No.	K6/258
Sample Received	4-Feb-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/259	Dark Olive Gray	Clayey Inorganic Silt High LL (MH), with a little of sand.	2.64	186	73	113	100.0	80.8

Specimen Results

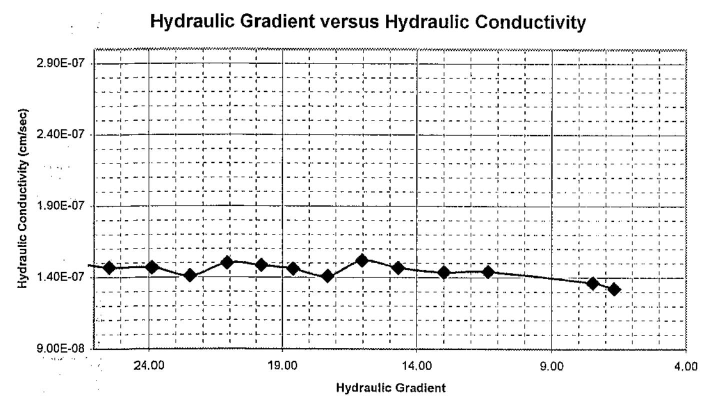
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.209	21.312	7.090	151.109	223.7
Final	5.245	21.604	6.582	142.190	215.3
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	101.6%	0.724	0.717	2.687	100%
Final	93.4%	0.724	0.717	2.469	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time: Date	Time Elapsed (sec)	Temp. (°C)	Permometer Reading: Pipet (cm)	Permometer Reading: Annulus (cm)	Head Loss: Start	Head Loss: Final	Hydraulic Gradient: Start	Hydraulic Gradient: Final	Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
5/20/2004	*~Start~*	21.6	16.3	1.2					
5/20/2004	300	21.6	15.4	1.2	15.1	14.2	28.8	27.1	1.50E-07
5/20/2004	300	21.6	13.8	1.3	13.3	12.5	25.4	23.9	1.47E-07
5/20/2004	300	21.6	12.4	1.3	11.8	11.1	22.5	21.1	1.50E-07
5/20/2004	300	21.6	11.2	1.4	10.4	9.8	19.8	18.6	1.46E-07
					Averages:		23.4		1.48E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-15	Sample No.	K-1
Depth (ft)	71.7 to 72.3	Lab No.	K6/259
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report **- ASTM D5084 Method C**

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/260	Dark Olive Gray	(Visual) Clayey Inorganic Silt High LL (MH), with some sand.	2.66				100.0	72.2

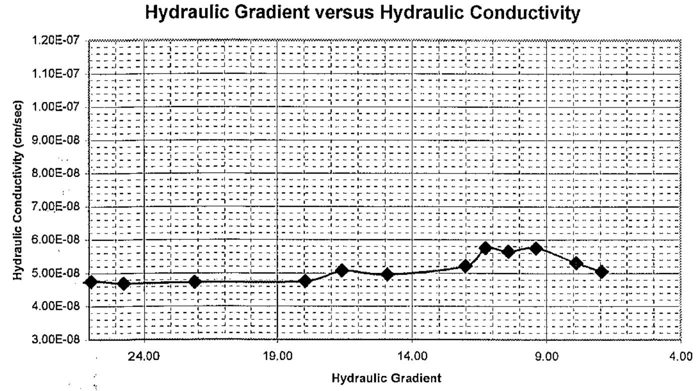
Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.415	23.032	7.010	161.464	260.8
Final	5.414	23.018	6.984	160.749	260.6
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	66.1%	0.970	0.964	1.757	100%
Final	65.6%	0.970	0.964	1.745	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0
Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20^\circ C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
5/24/2004	~Start~	21.3	18.2	1.1					
5/24/2004	1080	21.3	17.1	1.1	17.1	16.0	30.7	28.7	4.54E-08
5/24/2004	720	21.5	15.0	1.2	14.4	13.7	25.9	24.7	4.70E-08
5/24/2004	3060	21.7	11.4	1.4	12.3	10.0	22.1	18.0	4.77E-08
5/24/2004	1500	21.9	9.8	1.5	9.2	8.3	16.6	14.9	4.97E-08
					Averages:		22.7		4.74E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-15	Sample No.	K-2
Depth (ft)	80.0 to 80.5	Lab No.	K6/260
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/261	Dark Olive Gray	Fat Clay (CH), with some sand.	2.71	108	34	74	100.0	72.6

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.497	23.736	7.114	168.855	263.0
Final	5.504	23.791	7.104	169.003	263.5
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	75.0%	0.896	0.890	2.040	100%
Final	75.4%	0.897	0.890	2.043	100%

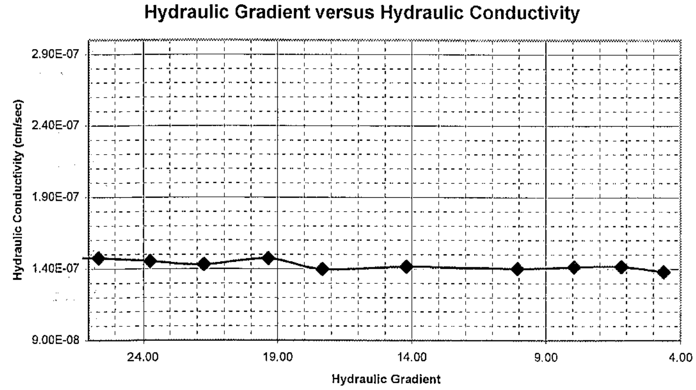
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
5/21/2004	~Start~	22.0	17.6	1.1					
5/21/2004	240	22.0	16.8	1.1	16.5	15.7	29.2	27.7	1.48E-07
5/21/2004	360	22.0	14.7	1.2	14.5	13.4	25.6	23.7	1.45E-07
5/21/2004	540	22.1	12.3	1.3	12.3	11.0	21.8	19.4	1.47E-07
5/21/2004	960	22.1	9.5	1.5	9.8	8.0	17.3	14.2	1.42E-07
					Averages:		22.4		1.46E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-15	Sample No.	K-3
Depth (ft)	89.0 to 89.6	Lab No.	K6/261
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/262	Olive Gray	(Visual) Clay Sand (SC).	2.71				100.0	31.8

Specimen Results

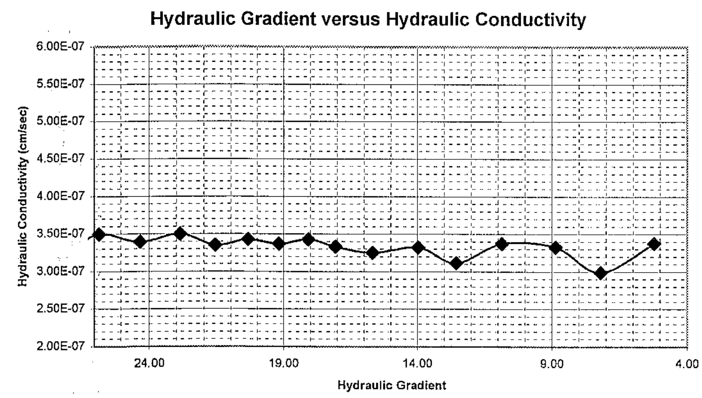
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.444	23.278	7.104	165.372	287.3
Final	5.451	23.339	7.102	165.765	286.6
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	49.1%	1.168	1.162	1.328	100%
Final	49.1%	1.168	1.162	1.334	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
5/26/2004	*~Start~*	22.2	17.1	1.1					
5/26/2004	60	22.2	16.7	1.2	16.0	15.5	28.2	27.4	3.25E-07
5/26/2004	120	22.2	15.0	1.2	14.6	13.8	25.8	24.3	3.40E-07
5/26/2004	120	22.2	13.5	1.3	12.9	12.2	22.9	21.6	3.35E-07
5/26/2004	120	22.2	12.2	1.3	11.5	10.9	20.3	19.2	3.37E-07
					Averages:		23.7		3.34E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-15	Sample No.	K-4
Depth (ft)	99.7 to 100.3	Lab No.	K6/262
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	**Color**	**USCS Classification**	**SpGr**	**LL**	**PL**	**PI**	**%Pass No. 4**	**%Pass No. 200**
K6/263	Olive Gray	Clayey Organic Silt (OH), with a trace of sand.	2.58	144	59	85	100.0	94.7

Specimen Results

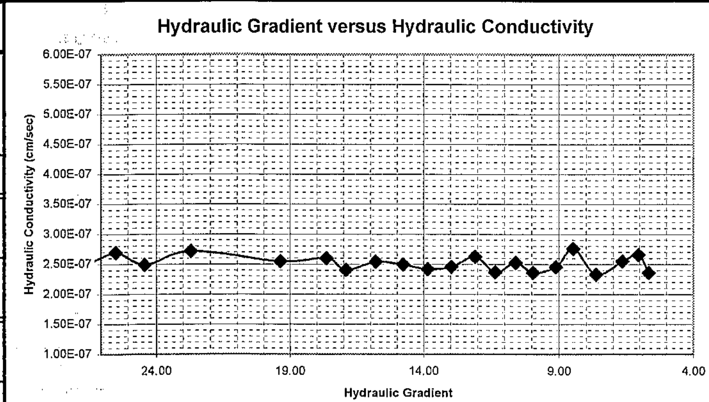
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.525	23.970	7.083	169.778	264.8
Final	5.525	23.970	7.050	169.001	264.5
	Water Content, %	**Wet Density (g/cc)**	**Dry Density (g/cc)**	**Void Ratio**	**Saturation, %**
Initial	71.6%	0.913	0.906	1.849	100%
Final	71.1%	0.913	0.906	1.836	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	**annulus**
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	**Consolidation Stress (psi)**
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	**Time Elapsed (sec)**	**Temp. (°C)**	**Pipet (cm)**	**Annulus (cm)**	**Start**	**Final**	**Start**	**Final**	
5/26/2004	*~Start~*	22.1	16.5	1.2					
5/26/2004	60	22.1	16.2	1.2	15.3	15.0	27.3	26.7	2.50E-07
5/26/2004	120	22.1	15.0	1.2	14.3	13.7	25.4	24.4	2.29E-07
5/26/2004	420	22.1	12.2	1.3	12.8	10.9	22.7	19.4	2.54E-07
5/26/2004	120	22.1	10.9	1.4	9.9	9.5	17.6	16.9	2.40E-07
					Averages:		22.6		2.44E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	**Work Order No.**	330e
Hole No.	SHE-15	**Sample No.**	K-5
Depth (ft)	112.0 to 112.6	**Lab No.**	K6/263
Sample Received	5-May-04	**Report Date**	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/264	Olive Gray	(Visual) Clayey Organic Silt (OH).	2.57				100.0	99.6

Specimen Results

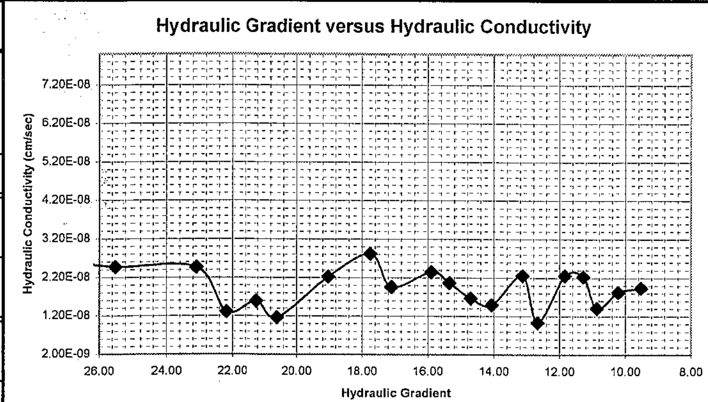
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.488	23.652	7.095	167.822	236.4
Final	5.491	23.685	7.085	167.799	236.6
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	113.6%	0.663	0.656	2.913	100%
Final	113.5%	0.663	0.656	2.912	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
6/1/2004	~Start~	22.3	16.0	1.2					
6/1/2004	1920	22.3	15.3	1.2	14.8	14.0	26.2	24.9	1.92E-08
6/1/2004	2100	22.5	13.9	1.3	13.0	12.6	23.1	22.4	1.05E-08
6/1/2004	1800	22.6	13.0	1.3	12.0	11.6	21.3	20.6	1.16E-08
6/1/2004	1740	21.9	11.5	1.4	11.0	10.1	19.4	17.9	3.22E-08
					Averages:		22.0		1.84E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-15	Sample No.	K-6
Depth (ft)	129.8 to 130.2	Lab No.	K6/264
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/265	Olive Gray	Clayey Sand High LL (SC-H).	2.66	94	35	59	100.0	31.6

Specimen Results

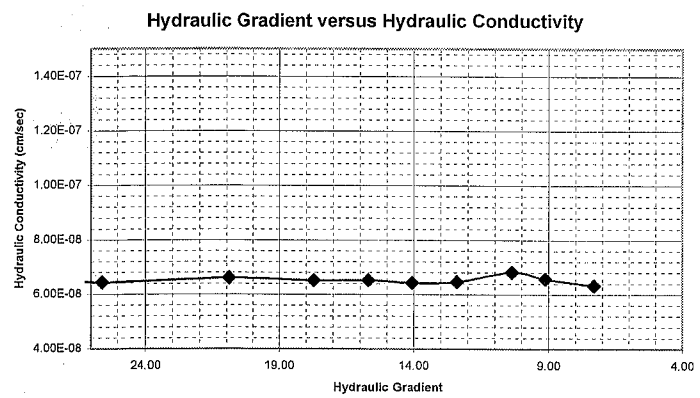
Trial	Diameter, D (cm)	Area, A (cm²)	Length, L (cm)	Volume (cm³)	Moist Mass (gms)
Initial	5.442	23.256	7.097	165.041	299.7
Final	5.453	23.354	7.079	165.320	301.0
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	39.2%	1.306	1.301	1.041	100%
Final	39.3%	1.306	1.301	1.045	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm²)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
6/2/2004	*~Start~*	21.1	17.5	1.1					
6/2/2004	780	21.1	16.4	1.2	16.4	15.2	29.0	27.0	6.60E-08
6/2/2004	2160	21.1	13.1	1.3	14.4	11.8	25.6	20.9	6.61E-08
6/2/2004	1320	21.1	10.3	1.4	10.0	8.8	17.7	15.7	6.54E-08
6/2/2004	1380	21.1	8.5	1.5	7.9	7.0	14.1	12.4	6.46E-08
					Averages:		20.3		6.55E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-15	Sample No.	K-7
Depth (ft)	152.0 to 152.5	Lab No.	K6/265
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/266	Olive Gray	Silty Sand (SM-H), with High LL plastic fines.	2.66	66	35	31	100.0	18.1

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.436	23.212	7.117	165.205	320.7
Final	5.428	23.137	7.115	164.621	322.1
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	29.0%	1.504	1.500	0.771	100%
Final	28.8%	1.504	1.500	0.764	100%

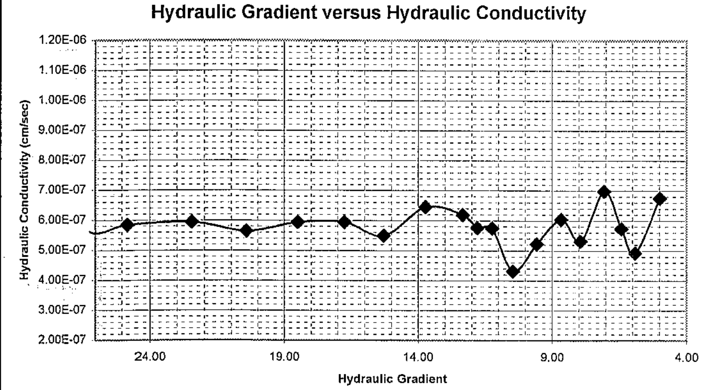
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
6/3/2004	~Start~	21.2	16.6	1.2					
6/3/2004	60	21.2	16.0	1.2	15.5	14.8	27.3	26.0	5.57E-07
6/3/2004	120	21.2	14.0	1.3	14.1	12.7	24.8	22.5	5.94E-07
6/3/2004	120	21.2	11.9	1.4	11.6	10.5	20.4	18.5	5.94E-07
6/3/2004	120	21.2	10.1	1.4	9.5	8.7	16.8	15.3	5.50E-07
					Averages:		21.4		5.74E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-15	Sample No.	K-8
Depth (ft)	161.4 to 161.9	Lab No.	K6/266
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/267	Olive Gray	(Visual) Sandy Inorganic Silt High LL (MH).	2.64				100.0	54.7

Specimen Results

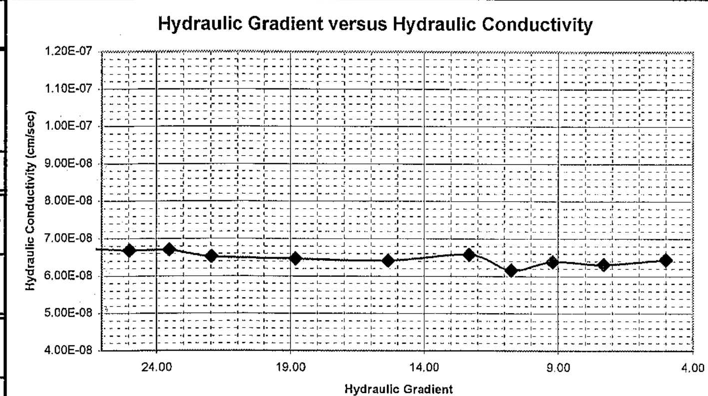
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.531	24.029	7.115	170.957	281.4
Final	5.531	24.026	7.080	170.107	282.4
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	58.9%	1.039	1.033	1.555	100%
Final	58.5%	1.039	1.033	1.543	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
6/4/2004	~Start~	21.4	18.5	1.1					
6/4/2004	540	21.4	17.6	1.1	17.4	16.5	30.9	29.3	6.81E-08
6/4/2004	600	21.6	14.5	1.2	14.1	13.3	25.0	23.5	6.71E-08
6/4/2004	1620	21.7	12.0	1.4	12.4	10.6	22.0	18.8	6.47E-08
6/4/2004	2280	21.8	8.5	1.5	8.7	6.9	15.4	12.3	6.58E-08
					Averages:		22.1		6.64E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-15	Sample No.	K-9
Depth (ft)	172.0 to 172.5	Lab No.	K6/267
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/268	Olive Gray	Silty Sand (SM-H), with High LL plastic fines.	2.69	137	55	82	100.0	40.5

Specimen Results

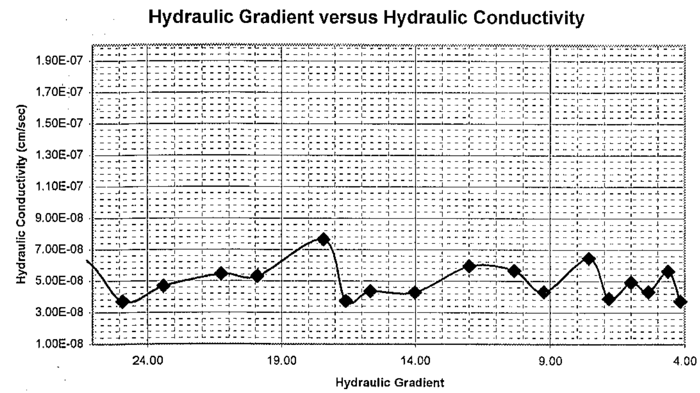
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.518	23.915	7.130	170.526	289.7
Final	5.522	23.945	7.103	170.082	290.3
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	52.7%	1.118	1.112	1.420	100%
Final	52.5%	1.118	1.112	1.414	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
6/7/2004	*~Start~*	21.4	17.9	1.1					
6/7/2004	1140	21.4	16.2	1.2	16.7	15.0	29.6	26.5	6.56E-08
6/7/2004	900	21.4	14.5	1.2	14.2	13.3	25.1	23.4	5.24E-08
6/7/2004	900	21.4	12.6	1.3	12.1	11.3	21.3	19.9	5.13E-08
6/7/2004	900	21.5	10.8	1.4	9.8	9.4	17.2	16.6	2.91E-08
					Averages:		22.5		4.96E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-15	Sample No.	K-10
Depth (ft)	187.7 to 188.2	Lab No.	K6/268
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/269	Olive Gray	(Visual) Silty Sand (SM).	2.70				100.0	49.9

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.582	24.476	7.116	174.185	287.1
Final	5.544	24.140	7.086	171.053	288.4
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	60.0%	1.036	1.030	1.618	100%
Final	58.2%	1.036	1.030	1.571	100%

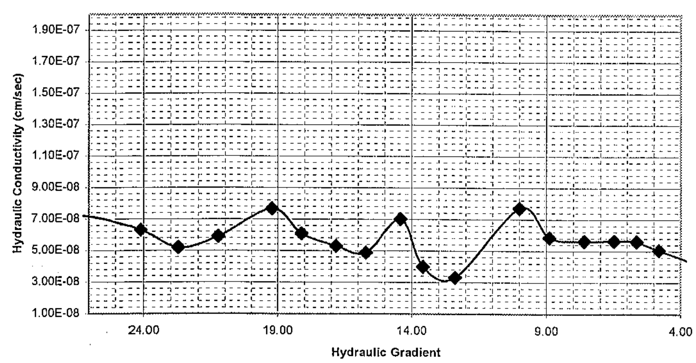
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
6/8/2004	~Start~	21.1	17.1	1.1					
6/8/2004	780	21.1	15.9	1.2	16.0	14.7	28.3	26.1	7.18E-08
6/8/2004	780	21.1	14.1	1.3	13.6	12.8	24.1	22.7	5.20E-08
6/8/2004	900	21.1	12.2	1.3	12.0	10.9	21.3	19.2	7.66E-08
6/8/2004	960	21.1	10.9	1.4	10.2	9.5	18.1	16.8	5.29E-08
					Averages:		22.1		6.33E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-15	Sample No.	K-11
Depth (ft)	198.0 to 198.5	Lab No.	K6/269
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report **- ASTM D5084 Method C**

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/270	Olive Gray	Silty Sand (SM-H), with High LL plastic fines.	2.73	122	52	70	100.0	33.5

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.546	24.154	7.083	171.096	298.7
Final	5.540	24.103	6.954	167.609	296.4
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	49.7%	1.163	1.157	1.356	100%
Final	48.0%	1.163	1.157	1.308	100%

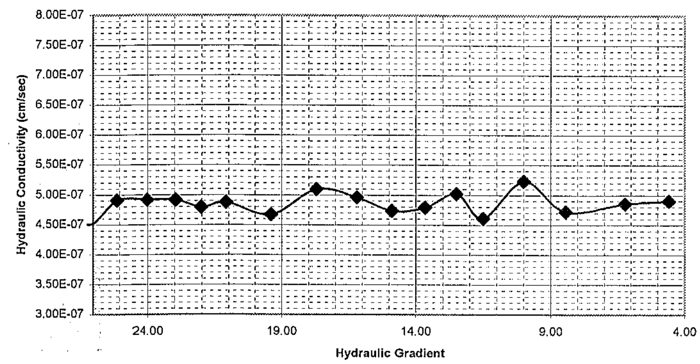
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
6/9/2004	~Start~	21.4	15.7	1.2					
6/9/2004	60	21.4	15.1	1.2	14.5	13.9	26.2	25.1	4.91E-07
6/9/2004	60	21.4	14.0	1.3	13.3	12.7	24.0	23.0	4.92E-07
6/9/2004	60	21.4	13.0	1.3	12.2	11.7	22.0	21.1	4.87E-07
6/9/2004	120	21.4	11.2	1.4	10.7	9.8	19.4	17.7	5.10E-07
					Averages:		22.3		4.95E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-15	Sample No.	K-12
Depth (ft)	210.6 to 211.1	Lab No.	K6/270
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/271	Olive	Clayey Sand High LL (SC-H).	2.68	60	28	32	100.0	32.0

Specimen Results

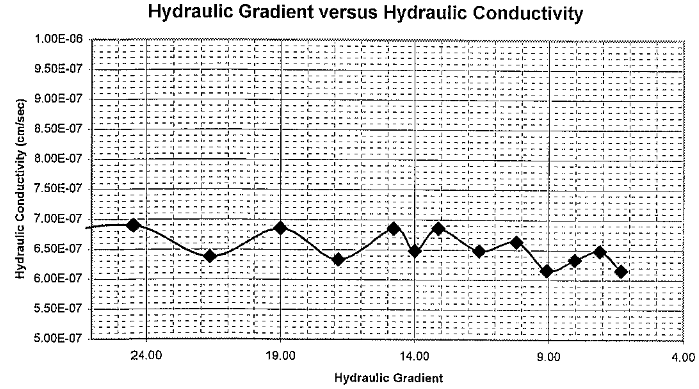
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.664	25.198	6.817	171.784	308.8
Final	5.544	24.143	6.649	160.532	290.7
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	47.6%	1.183	1.178	1.272	100%
Final	42.0%	1.183	1.178	1.124	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
9/2/2004	~Start~	22.1	17.9	1.1					
9/2/2004	120	22.1	16.0	1.2	16.8	14.8	31.7	27.9	6.67E-07
9/2/2004	120	22.1	12.8	1.3	13.0	11.5	24.5	21.7	6.38E-07
9/2/2004	120	22.1	10.4	1.4	10.1	8.9	19.0	16.8	6.33E-07
9/2/2004	60	22.1	8.9	1.5	7.8	7.4	14.8	14.0	5.74E-07
					Averages:		21.3		6.28E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-16	Sample No.	K-1
Depth (ft)	62.0 to 62.6	Lab No.	K6/271
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report **- ASTM D5084 Method C**

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	**Color**	**USCS Classification**	**SpGr**	**LL**	**PL**	**PI**	**%Pass No. 4**	**%Pass No. 200**
K6/272	Olive	(Visual) Clayey Sand (SC).	2.68				100.0	16.4

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm²)	Length, L (cm)	Volume (cm³)	Moist Mass (gms)
Initial	5.624	24.842	7.162	177.919	337.6
Final	5.565	24.324	6.951	169.072	330.7
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	36.7%	1.356	1.351	0.982	100%
Final	33.0%	1.355	1.351	0.884	100%

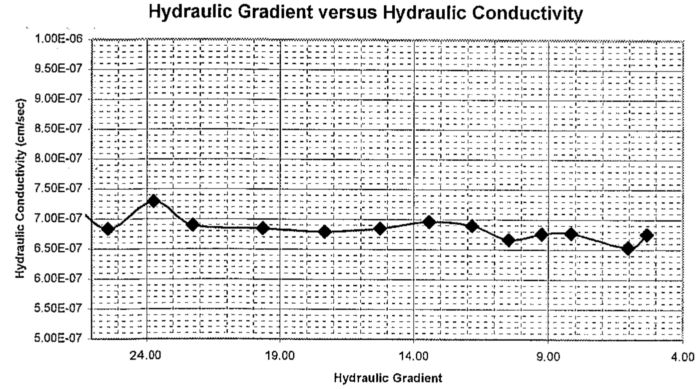
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm²)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
9/2/2004	*~Start~*	22.1	17.2	1.1					
9/2/2004	60	22.1	16.2	1.2	16.0	15.0	28.9	27.0	7.32E-07
9/2/2004	60	22.1	14.4	1.3	14.1	13.1	25.4	23.7	7.29E-07
9/2/2004	120	22.1	12.2	1.3	12.3	10.9	22.3	19.6	6.84E-07
9/2/2004	120	22.1	9.9	1.4	9.6	8.5	17.3	15.3	6.91E-07
					Averages:		22.4		7.09E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	**Work Order No.**	330e
Hole No.	SHE-16	**Sample No.**	K-2
Depth (ft)	73.0 to 73.5	**Lab No.**	K6/272
Sample Received	5-May-04	**Report Date**	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/273	Olive Gray	(Visual) Sandy Fat Clay (CH).	2.70				100.0	56.8

Specimen Results

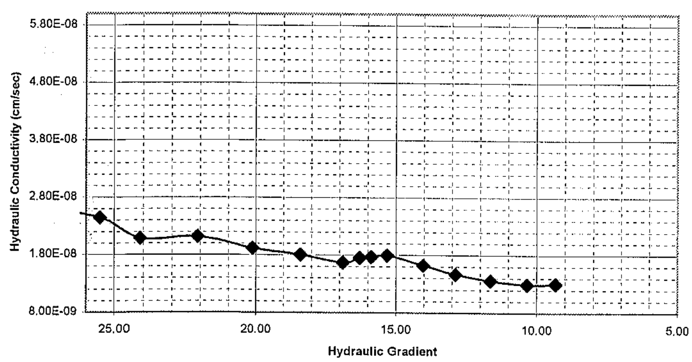
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.444	23.278	7.118	165.698	294.5
Final	5.451	23.335	7.098	165.636	294.9
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	44.6%	1.230	1.225	1.204	100%
Final	44.6%	1.230	1.225	1.203	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
9/7/2004	~Start~	22.1	18.0	1.1					
9/7/2004	1080	22.1	17.3	1.1	16.9	16.2	29.9	28.6	2.74E-08
9/7/2004	1860	22.0	14.9	1.2	14.4	13.6	25.5	24.1	2.09E-08
9/7/2004	3420	22.0	12.7	1.3	12.5	11.4	22.1	20.1	1.91E-08
9/7/2004	3900	21.9	11.0	1.4	10.4	9.6	18.4	16.9	1.54E-08
					Averages:		23.2		2.07E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-16	Sample No.	K-3
Depth (ft)	89.3 to 89.8	Lab No.	K6/273
Sample Received	5-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/274	Olive Gray	Clayey Sand High LL (SC-H).	2.72	110	41	69	100.0	44.0

Specimen Results

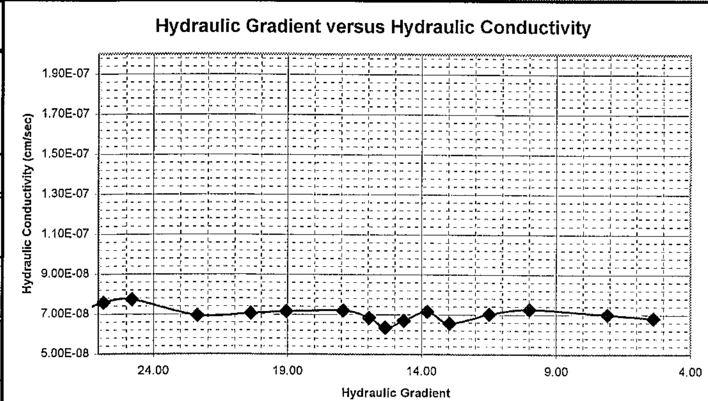
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.404	22.935	7.110	163.069	293.1
Final	5.451	23.339	7.080	165.232	292.6
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	43.9%	1.244	1.239	1.192	100%
Final	44.9%	1.244	1.239	1.222	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
9/9/2004	*~Start~*	22.1	17.1	1.1					
9/9/2004	300	22.1	16.6	1.2	15.9	15.4	28.2	27.4	6.92E-08
9/9/2004	360	22.1	15.2	1.2	14.6	14.0	25.8	24.8	7.74E-08
9/9/2004	900	22.0	12.8	1.3	12.6	11.5	22.4	20.4	7.17E-08
9/9/2004	1140	22.0	11.0	1.4	10.7	9.6	19.1	16.9	7.20E-08
					Averages:		23.1		7.26E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-16	Sample No.	K-4
Depth (ft)	99.3 to 99.8	Lab No.	K6/274
Sample Received	5-May-04	Report Date	14-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/275	Dark Olive Gray	Silty Sand (SM-H), with High LL plastic fines.	2.71	99	44	55	100.0	46.5

Specimen Results

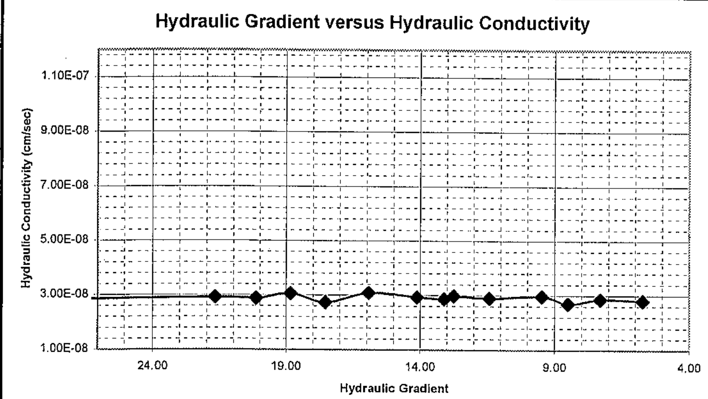
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.455	23.368	7.106	166.046	287.4
Final	5.479	23.575	7.093	167.219	288.4
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	50.1%	1.156	1.150	1.360	100%
Final	50.7%	1.156	1.150	1.376	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
9/10/2004	*~Start~*	21.9	18.3	1.1					
9/10/2004	8040	21.9	13.6	1.3	17.2	12.3	30.5	21.7	2.91E-08
9/10/2004	1500	21.9	12.0	1.4	11.4	10.6	20.1	18.8	3.05E-08
9/10/2004	2160	21.9	10.4	1.4	9.9	9.0	17.5	15.9	3.09E-08
9/10/2004	1800	21.9	8.9	1.5	8.0	7.4	14.1	13.1	2.86E-08
					Averages:		19.0		2.98E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-16	Sample No.	K-5
Depth (ft)	111.0 to 111.5	Lab No.	K6/275
Sample Received	5-May-04	Report Date	14-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/276	Olive Gray & Dark Gray	Sandy Lean Clay (CL).	2.70	46	21	25	100.0	50.1

Specimen Results

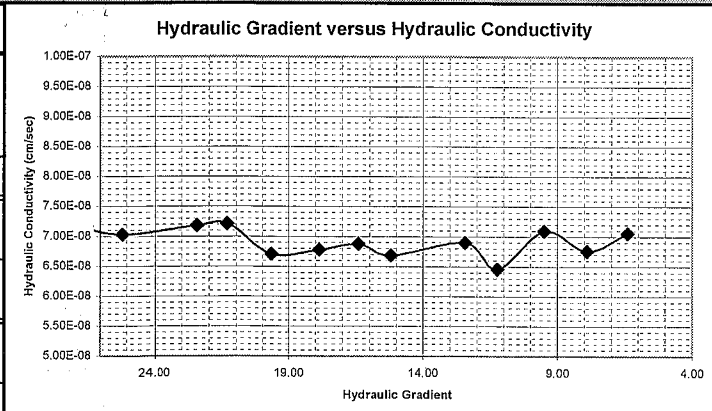
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.407	22.964	7.276	167.080	283.8
Final	5.461	23.426	6.767	158.515	273.4
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	56.3%	1.078	1.072	1.521	100%
Final	51.5%	1.077	1.072	1.392	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
11/16/2004	*~Start~*	20.8	16.4	1.2					
11/16/2004	480	20.8	15.7	1.2	15.3	14.5	28.3	26.9	7.21E-08
11/16/2004	1080	20.8	13.4	1.3	13.6	12.1	25.2	22.4	7.18E-08
11/16/2004	840	20.7	12.0	1.4	11.5	10.6	21.3	19.6	6.70E-08
11/16/2004	840	20.7	10.3	1.4	9.6	8.8	17.9	16.4	6.87E-08
					Averages:		22.3		6.99E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-17	Sample No.	K-1
Depth (ft)	58.1 to 58.6	Lab No.	K6/276
Sample Received	18-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/277	Olive Gray & Dark Gray	(Visual) Sandy Fat Clay (CH).	2.69				100.0	59.6

Specimen Results

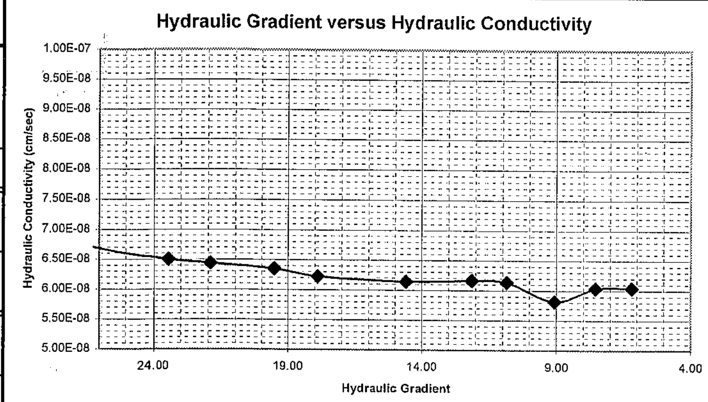
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.510	23.846	7.054	168.197	291.3
Final	5.463	23.437	6.827	160.002	277.9
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	55.2%	1.089	1.083	1.487	100%
Final	50.7%	1.089	1.083	1.366	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
11/17/2004	~Start~	20.8	16.5	1.2					
11/17/2004	720	20.8	15.5	1.2	15.3	14.3	28.2	26.3	6.71E-08
11/17/2004	720	20.8	13.2	1.3	12.8	11.9	23.4	21.9	6.44E-08
11/17/2004	960	20.8	11.1	1.4	10.6	9.7	19.5	17.9	6.22E-08
11/17/2004	2040	20.8	8.1	1.5	7.9	6.6	14.6	12.1	6.16E-08
					Averages:		20.5		6.38E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-17	Sample No.	K-2
Depth (ft)	62.8 to 63.4	Lab No.	K6/277
Sample Received	18-May-04	Report Date	3-Feb-05

Permeability Test Report **- ASTM D5084 Method C**

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/278	Olive Gray & Dark Gray	Fat Clay (CH), with some sand.	2.69	82	24	58	100.0	71.4

Specimen Results

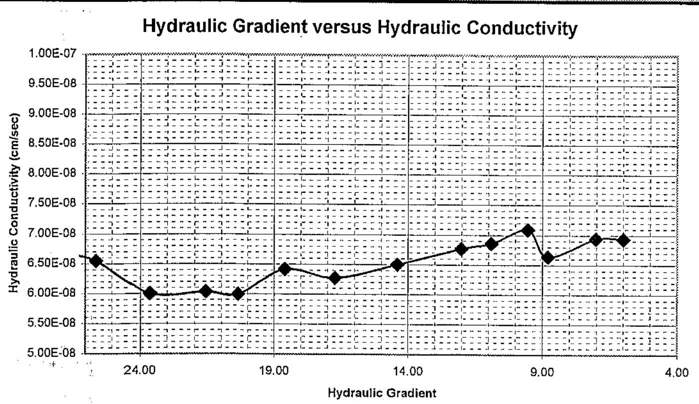
Trial	Diameter, D (cm)	Area, A (cm²)	Length, L (cm)	Volume (cm³)	Moist Mass (gms)
Initial	5.550	24.191	7.063	170.866	272.8
Final	5.538	24.084	7.007	168.765	269.9
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	72.1%	0.921	0.914	1.937	100%
Final	70.8%	0.921	0.914	1.901	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm²)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
11/17/2004	*~Start~*	21.1	17.4	1.1					
11/17/2004	660	21.1	16.4	1.2	16.3	15.2	29.1	27.3	6.82E-08
11/17/2004	900	21.2	14.5	1.2	14.3	13.3	25.6	23.7	5.71E-08
11/17/2004	660	21.3	12.7	1.3	12.1	11.4	21.6	20.4	5.94E-08
11/17/2004	1140	21.4	10.8	1.4	10.4	9.3	18.6	16.7	6.27E-08
					Averages:		22.9		6.18E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-17	Sample No.	K-3
Depth (ft)	70.4 to 71.0	Lab No.	K6/278
Sample Received	18-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/279	Dark Olive Gray	Clayey Sand High LL (SC-H).	2.77	64	25	39	100.0	21.4

Specimen Results

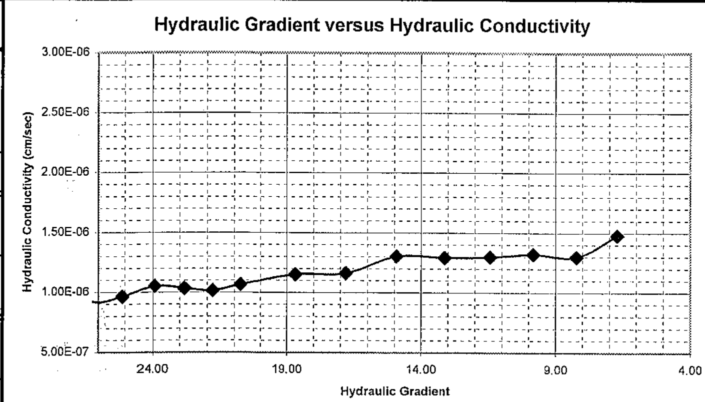
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.651	25.081	7.106	178.236	341.2
Final	5.627	24.864	6.938	172.506	334.1
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	35.4%	1.403	1.398	0.979	100%
Final	33.1%	1.402	1.398	0.915	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
11/18/2004	*~Start~*	20.9	16.3	1.2					
11/18/2004	30	20.9	15.7	1.2	15.1	14.5	27.4	26.2	9.23E-07
11/18/2004	30	20.9	14.5	1.2	13.9	13.2	25.1	23.9	1.05E-06
11/18/2004	30	20.9	13.4	1.3	12.6	12.1	22.8	21.8	1.02E-06
11/18/2004	60	20.9	11.7	1.4	11.5	10.3	20.8	18.7	1.15E-06
					Averages:		23.3		1.04E-06

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-17	Sample No.	K-4
Depth (ft)	77.3 to 77.9	Lab No.	K6/279
Sample Received	18-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/280	Dark Olive Gray	(Visual) Poorly Graded Silty Sand (SP-SM).	2.81				100.0	11.8

Specimen Results

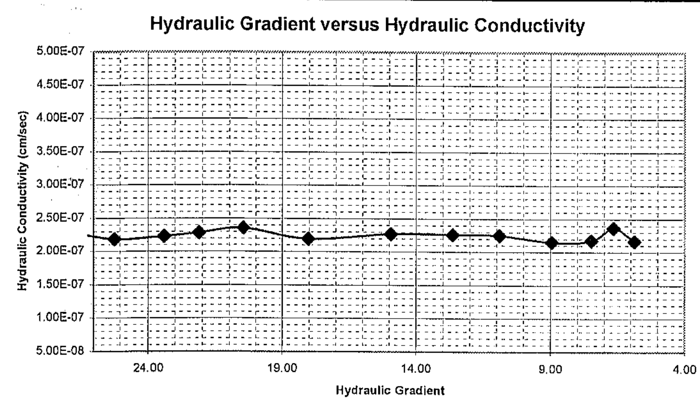
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.376	22.698	7.118	161.575	311.7
Final	5.400	22.903	7.104	162.694	311.2
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	34.9%	1.424	1.419	0.982	100%
Final	35.4%	1.424	1.419	0.995	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
11/18/2004	~Start~	21.1	18.0	1.1					
11/18/2004	300	21.1	16.5	1.2	16.9	15.3	29.8	27.1	2.31E-07
11/18/2004	240	21.1	14.5	1.2	14.3	13.3	25.2	23.4	2.23E-07
11/18/2004	240	21.1	12.9	1.3	12.5	11.6	22.1	20.5	2.35E-07
11/18/2004	600	21.1	9.9	1.4	10.2	8.5	18.0	14.9	2.27E-07
					Averages:		22.6		2.29E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-17	Sample No.	K-5
Depth (ft)	86.9 to 87.4	Lab No.	K6/280
Sample Received	18-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/281	Olive	Sandy Clayey Inorganic Silt High LL (MH).	2.71	106	46	60	100.0	54.6

Specimen Results

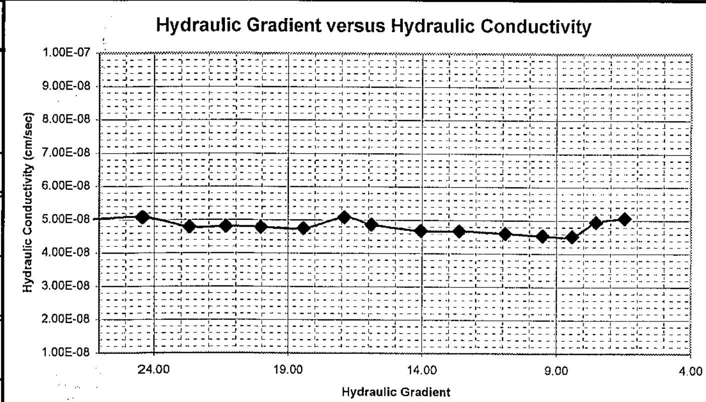
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.423	23.097	7.121	164.470	298.8
Final	5.418	23.054	7.092	163.489	299.2
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	40.6%	1.295	1.290	1.101	100%
Final	40.2%	1.295	1.290	1.089	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
11/19/2004	~Start~	21.4	16.3	1.2					
11/19/2004	1320	21.4	15.0	1.2	15.2	13.8	26.8	24.4	5.07E-08
11/19/2004	900	21.5	13.4	1.3	12.8	12.1	22.7	21.4	4.81E-08
11/19/2004	1260	21.6	11.8	1.4	11.3	10.4	20.0	18.4	4.73E-08
11/19/2004	900	21.8	10.4	1.4	9.6	9.0	16.9	15.9	4.87E-08
					Averages:		20.8		4.87E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-17	Sample No.	K-6
Depth (ft)	104.8 to 105.2	Lab No.	K6/281
Sample Received	18-May-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/284	Dark Olive Gray	Clayey Organic Silt (OH), with a trace of sand.	2.52	328	108	220	100.0	97.9

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.637	24.958	7.094	177.039	228.3
Final	5.617	24.782	7.015	173.840	225.9
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	180.7%	0.462	0.454	4.555	100%
Final	176.7%	0.462	0.454	4.454	100%

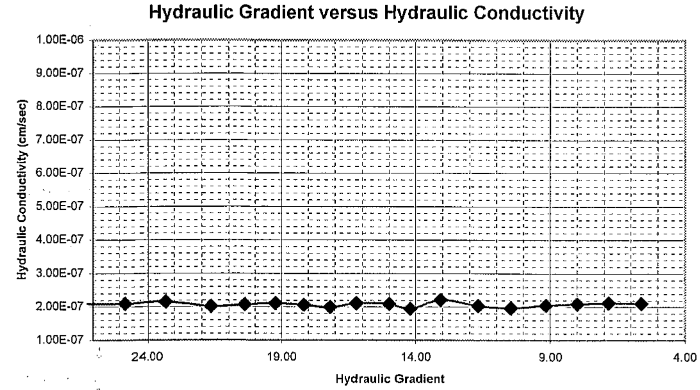
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
11/20/2004	~Start~	22.1	17.0	1.1					
11/20/2004	180	22.1	16.2	1.2	15.9	15.0	28.4	26.8	2.12E-07
11/20/2004	180	22.1	14.3	1.3	13.9	13.0	24.8	23.3	2.16E-07
11/20/2004	180	22.1	12.7	1.3	12.1	11.4	21.7	20.4	2.15E-07
11/20/2004	180	22.1	11.5	1.4	10.7	10.1	19.2	18.2	2.06E-07
					Averages:		22.8		2.12E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-18	Sample No.	K-1
Depth (ft)	91.5 to 92.2	Lab No.	K6/284
Sample Received		Report Date	3-Feb-05

***Permeability Test Report* - ASTM D5084 Method C**

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/285	Dark Olive Gray	(Visual) Silty Sand (SM).	2.77				100.0	20.2

Specimen Results

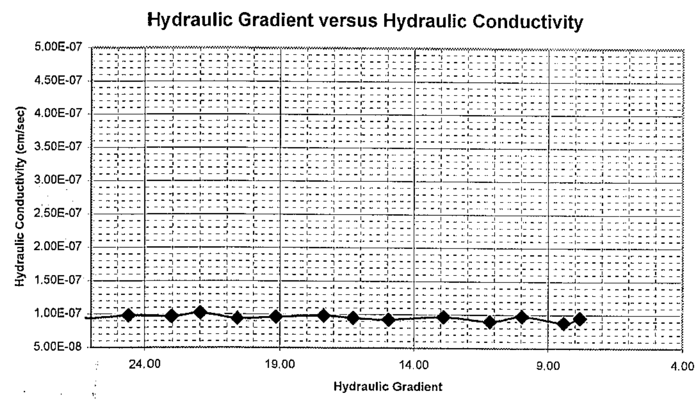
Trial	Diameter, D (cm)	Area, A (cm²)	Length, L (cm)	Volume (cm³)	Moist Mass (gms)
Initial	5.094	20.383	7.179	146.338	282.0
Final	5.109	20.499	7.163	146.841	281.0
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	35.0%	1.412	1.407	0.968	100%
Final	35.2%	1.412	1.407	0.975	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm²)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
11/20/2004	~Start~	22.4	17.4	1.1					
11/20/2004	360	22.4	16.7	1.2	16.3	15.5	28.5	27.2	1.01E-07
11/20/2004	480	22.4	15.3	1.2	14.9	14.0	26.1	24.6	9.81E-08
11/20/2004	360	22.5	13.8	1.3	13.1	12.5	23.0	22.0	1.02E-07
11/20/2004	600	22.6	12.3	1.3	11.8	10.9	20.6	19.1	9.66E-08
					Averages:		23.9		9.95E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-18	Sample No.	K-2
Depth (ft)	97.2 to 97.9	Lab No.	K6/285
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/286	Olive Gray	Silty Sand (SM-H), with High LL plastic fines.	2.67	131	53	78	100.0	34.5

Specimen Results

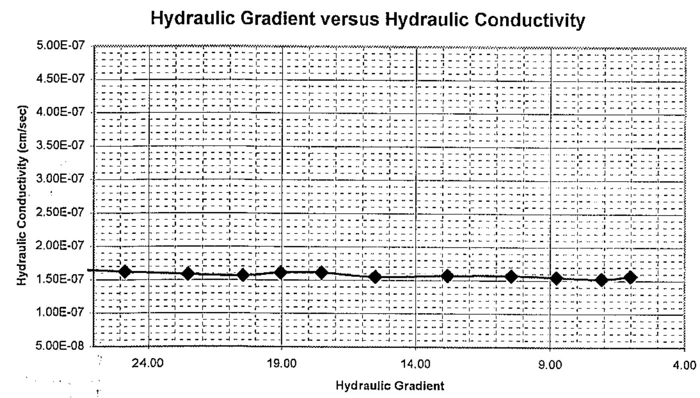
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.478	23.564	7.104	167.410	275.5
Final	5.466	23.463	7.031	164.958	275.0
	Water Content, %	**Wet Density (g/cc)**	**Dry Density (g/cc)**	**Void Ratio**	**Saturation, %**
Initial	57.4%	1.051	1.045	1.556	99%
Final	56.8%	1.051	1.045	1.519	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
11/22/2004	~Start~	21.6	17.4	1.1					
11/22/2004	300	21.6	16.3	1.2	16.2	15.1	29.0	27.0	1.65E-07
11/22/2004	420	21.6	13.9	1.3	13.9	12.6	24.8	22.5	1.59E-07
11/22/2004	300	21.7	12.0	1.4	11.5	10.7	20.5	19.0	1.68E-07
11/22/2004	540	21.7	10.1	1.4	9.8	8.7	17.5	15.5	1.55E-07
					Averages:		22.0		1.62E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-18	Sample No.	K-3
Depth (ft)	120.9 to 121.5	Lab No.	K6/286
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/287	Olive Gray	(Visual) Silty Sand (SM).	2.68				100.0	24.6

Specimen Results

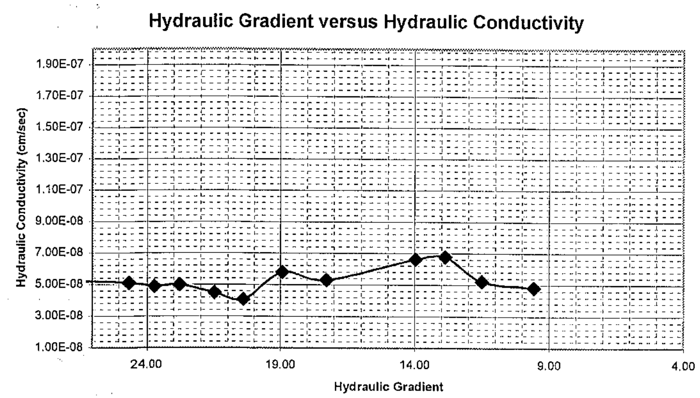
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.478	23.564	7.151	168.518	296.7
Final	5.464	23.444	7.126	167.064	298.4
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	44.6%	1.223	1.218	1.200	100%
Final	44.1%	1.223	1.218	1.181	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
11/22/2004	~Start~	21.9	16.9	1.1					
11/22/2004	660	21.9	16.2	1.2	15.8	15.0	27.7	26.4	5.20E-08
11/22/2004	540	21.9	14.7	1.2	14.0	13.5	24.6	23.7	4.91E-08
11/22/2004	900	21.9	13.5	1.3	12.9	12.2	22.8	21.5	4.49E-08
11/22/2004	900	22.0	12.1	1.4	11.6	10.7	20.4	18.9	5.78E-08
					Averages:		23.3		5.09E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-18	Sample No.	K-4
Depth (ft)	133.3 to 134.0	Lab No.	K6/287
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/288	Olive Gray	Sandy Fat Clay (CH).	2.72	72	31	41	100.0	51.4

Specimen Results

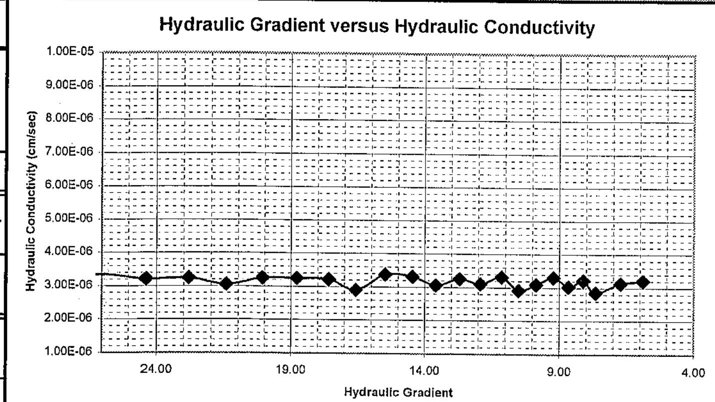
Trial	Diameter, D (cm)	Area, A (cm²)	Length, L (cm)	Volume (cm³)	Moist Mass (gms)
Initial	5.393	22.845	7.166	163.708	314.2
Final	5.406	22.953	7.114	163.284	310.8
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	36.7%	1.367	1.362	0.997	100%
Final	36.5%	1.367	1.362	0.992	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm²)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20^\circ C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
12/2/2004	*~Start~*	20.6	17.0	1.1					
12/2/2004	15	20.6	16.0	1.2	15.8	14.8	27.9	26.0	3.34E-06
12/2/2004	15	20.6	14.2	1.3	13.8	12.9	24.4	22.8	3.24E-06
12/2/2004	15	20.6	12.7	1.3	12.2	11.4	21.4	20.1	3.26E-06
12/2/2004	15	20.6	11.4	1.4	10.6	10.0	18.8	17.6	3.22E-06
					Averages:		22.4		3.27E-06

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-19	Sample No.	K-1
Depth (ft)	86.2 to 87.0	Lab No.	K6/288
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/289	Olive Gray	Clayey Inorganic Silt High LL (MH), with a trace of sand.	2.71	156	63	93	100.0	95.6

Specimen Results

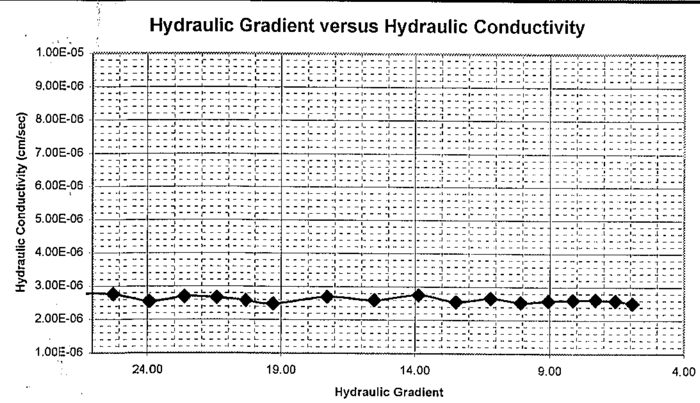
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.413	23.014	7.132	164.143	286.7
Final	5.420	23.072	7.087	163.514	282.5
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	55.5%	1.087	1.081	1.502	100%
Final	55.2%	1.087	1.081	1.493	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
12/2/2004	*~Start~*	20.6	17.1	1.1					
12/2/2004	15	20.6	16.3	1.2	16.0	15.1	28.3	26.7	2.77E-06
12/2/2004	15	20.6	14.8	1.2	14.2	13.5	25.2	23.9	2.55E-06
12/2/2004	15	20.6	13.4	1.3	12.8	12.1	22.6	21.4	2.64E-06
12/2/2004	15	20.6	12.3	1.3	11.5	10.9	20.3	19.3	2.49E-06
					Averages:		23.5		2.61E-06

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-19	Sample No.	K-2
Depth (ft)	96.7 to 97.5	Lab No.	K6/289
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/290	Olive Gray	Clayey Sand High LL (SC-H).	2.68	84	31	53	100.0	38.4

Specimen Results

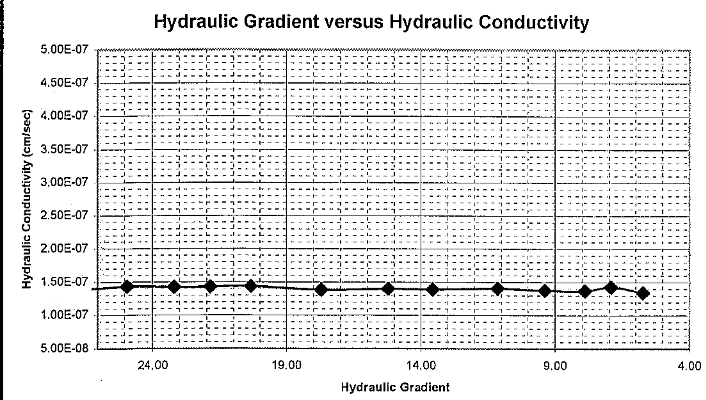
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.375	22.691	7.137	161.956	277.2
Final	5.416	23.036	7.099	163.537	276.2
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	51.1%	1.128	1.123	1.387	100%
Final	51.9%	1.128	1.123	1.410	99%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
12/6/2004	~Start~	21.0	17.7	1.1					
12/6/2004	360	21.0	16.7	1.2	16.6	15.5	29.3	27.4	1.37E-07
12/6/2004	360	21.0	14.4	1.3	14.1	13.1	24.9	23.2	1.42E-07
12/6/2004	360	21.1	12.8	1.3	12.4	11.5	21.9	20.3	1.45E-07
12/6/2004	780	21.1	10.1	1.4	10.0	8.6	17.7	15.2	1.40E-07
					Averages:		22.5		1.41E-07

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-19	Sample No.	K-3
Depth (ft)	118.5 to 119.3	Lab No.	K6/290
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/291	Olive Gray	(Visual) Sandy Clayey Inorganic Silt High LL (MH).	2.70				100.0	51.8

Specimen Results

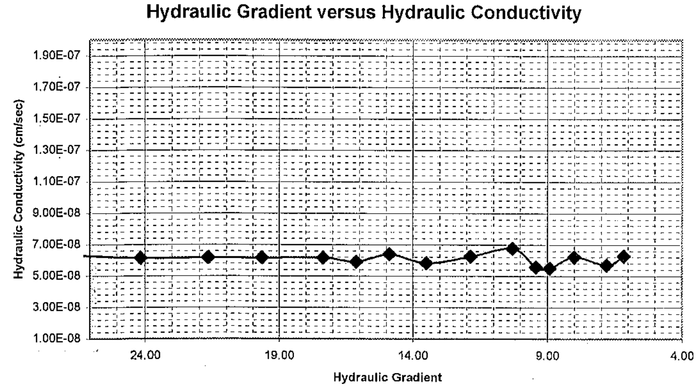
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.465	23.455	7.140	167.469	280.9
Final	5.440	23.241	7.131	165.735	280.9
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	53.6%	1.098	1.092	1.477	98%
Final	53.6%	1.098	1.092	1.451	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
12/6/2004	*~Start~*	21.1	17.4	1.1					
12/6/2004	480	21.1	16.8	1.2	16.3	15.6	28.6	27.4	6.36E-08
12/6/2004	1260	21.1	13.6	1.3	13.7	12.3	24.1	21.7	6.17E-08
12/6/2004	1440	21.1	11.3	1.4	11.2	9.9	19.6	17.4	6.19E-08
12/6/2004	900	21.0	9.9	1.4	9.2	8.5	16.1	14.9	6.39E-08
					Averages:		21.2		6.28E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-19	Sample No.	K-4
Depth (ft)	131.8 to 132.4	Lab No.	K6/291
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/292	Olive Gray	Clayey Inorganic Silt High LL (MH), with a little sand.	2.70	135	55	80	100.0	87.3

Specimen Results

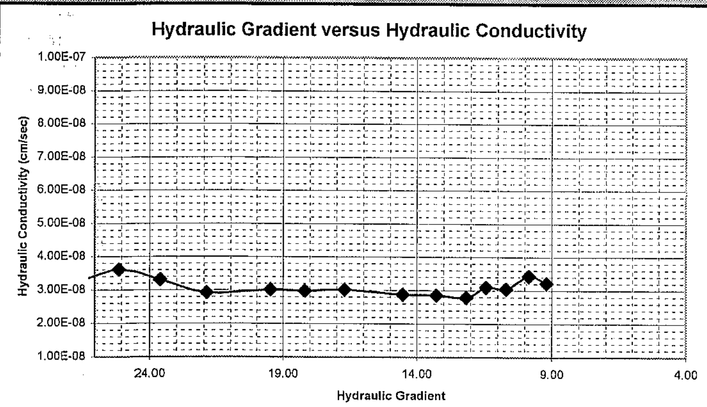
Trial	Diameter, D (cm)	Area, A (cm²)	Length, L (cm)	Volume (cm³)	Moist Mass (gms)
Initial	5.469	23.492	7.131	167.520	272.2
Final	5.482	23.601	7.055	166.515	271.0
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	65.8%	0.979	0.972	1.779	100%
Final	65.2%	0.979	0.972	1.762	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm²)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

		Consolidation Stress (psi)
Chamber Pressure (psi)	65.0	
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
12/7/2004	~Start~	20.6	17.1	1.1					
12/7/2004	1380	20.6	16.2	1.2	16.0	15.0	28.4	26.6	3.28E-08
12/7/2004	1380	21.3	14.5	1.2	14.1	13.3	25.1	23.6	3.07E-08
12/7/2004	2700	21.1	12.3	1.3	12.3	11.0	21.9	19.5	3.02E-08
12/7/2004	1980	21.0	10.8	1.4	10.2	9.4	18.2	16.7	3.01E-08
					Averages:		22.5		3.10E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-19	Sample No.	K-5
Depth (ft)	142.0 to 142.6	Lab No.	K6/292
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/293	Olive Gray	(Visual) Clayey Inorganic Silt High LL (MH), with a trace of sand.	2.69				100.0	91.5

Specimen Results

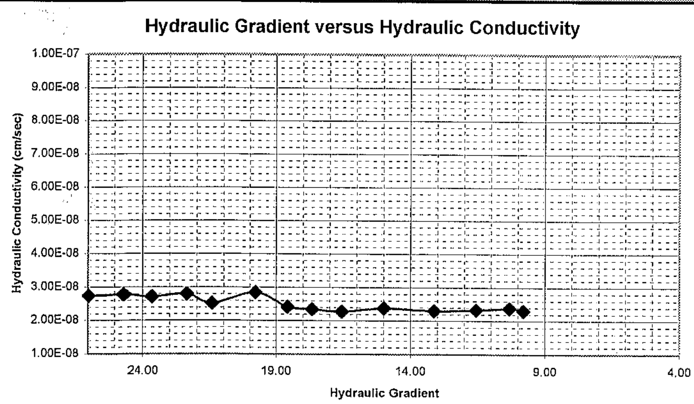
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.447	23.303	7.126	166.056	260.8
Final	5.444	23.274	7.083	164.859	259.5
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	76.5%	0.886	0.880	2.059	100%
Final	75.7%	0.886	0.880	2.037	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
12/8/2004	~Start~	20.8	17.0	1.1					
12/8/2004	2100	20.8	15.9	1.2	15.9	14.7	28.1	26.0	2.74E-08
12/8/2004	1140	20.8	14.6	1.2	13.9	13.4	24.7	23.7	2.65E-08
12/8/2004	1200	20.8	13.4	1.3	12.6	12.1	22.4	21.4	2.52E-08
12/8/2004	1860	20.7	11.9	1.4	11.2	10.5	19.8	18.6	2.42E-08
					Averages:		23.1		2.58E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-19	Sample No.	K-6
Depth (ft)	152.5 to 153.1	Lab No.	K6/293
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/294	Olive Gray	Clayey Organic Silt (OH).	2.59	250	83	167	100.0	99.7

Specimen Results

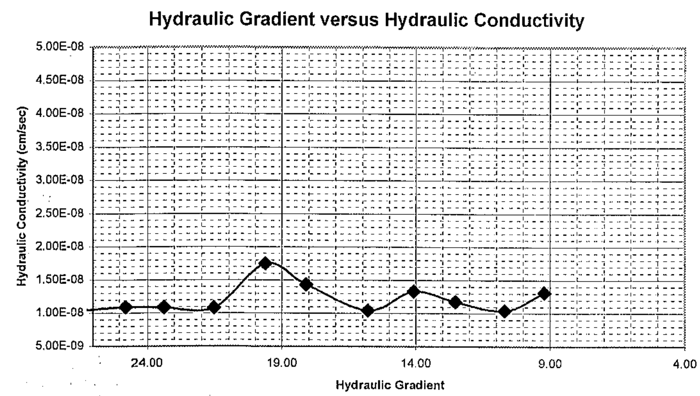
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.492	23.688	7.134	168.983	234.1
Final	5.500	23.758	7.111	168.951	234.1
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	123.2%	0.626	0.618	3.191	100%
Final	123.2%	0.626	0.618	3.191	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
12/13/2004	~Start~	20.6	18.7	1.1					
12/13/2004	3900	20.6	17.5	1.1	17.6	16.4	31.1	28.9	1.34E-08
12/13/2004	6180	20.6	15.3	1.2	15.4	14.0	27.2	24.8	1.09E-08
12/13/2004	5340	20.7	13.5	1.3	13.3	12.2	23.4	21.5	1.09E-08
12/13/2004	4860	20.3	11.6	1.4	11.1	10.3	19.6	18.1	1.18E-08
					Averages:		24.3		1.18E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-19	Sample No.	K-7
Depth (ft)	162.3 to 162.9	Lab No.	K6/294
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/295	Olive Gray	(Visual) Clayey Organic Silt (OH), with some sand.	2.55				100.0	70.3

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm²)	Length, L (cm)	Volume (cm³)	Moist Mass (gms)
Initial	5.489	23.666	7.256	171.712	223.9
Final	5.472	23.517	7.200	169.329	223.8
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	154.7%	0.520	0.512	3.972	99%
Final	153.3%	0.520	0.512	3.903	100%

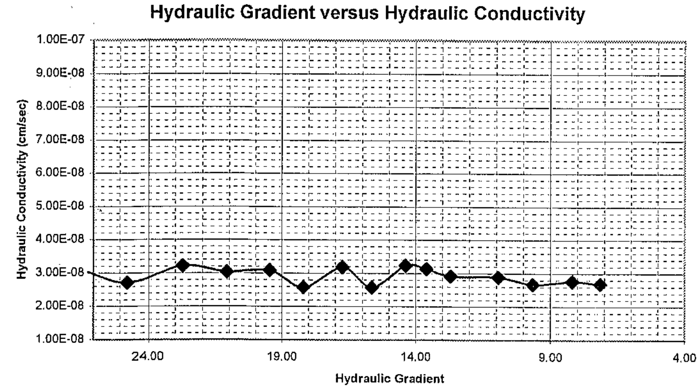
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm²)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
12/21/2004	~Start~	16.6	17.2	1.1					
12/21/2004	1380	16.6	16.4	1.2	16.1	15.2	28.0	26.5	3.10E-08
12/21/2004	2100	16.6	14.3	1.3	14.2	13.0	24.7	22.7	3.22E-08
12/21/2004	2100	16.6	12.5	1.3	12.1	11.2	21.1	19.5	3.08E-08
12/21/2004	2100	16.6	11.0	1.4	10.4	9.6	18.2	16.7	3.18E-08
					Averages:		22.2		3.15E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-19	Sample No.	K-8
Depth (ft)	167.1 to 167.6	Lab No.	K6/295
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/296	Olive	Silty Sand (SM-H), with High LL plastic fines.	2.68	69	37	32	100.0	31.1

Specimen Results

Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.525	23.974	7.193	172.452	333.3
Final	5.480	23.586	7.170	169.123	333.5
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	29.1%	1.502	1.497	0.790	99%
Final	28.2%	1.502	1.497	0.755	100%

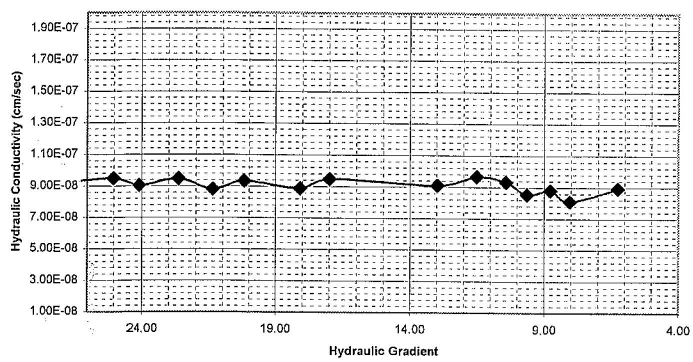
Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW

Hydraulic Gradient versus Hydraulic Conductivity



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
1/6/2005	~Start~	20.1	16.5	1.2					
1/6/2005	540	20.1	15.5	1.2	15.3	14.3	26.8	25.0	9.51E-08
1/6/2005	480	20.1	14.2	1.3	13.8	12.9	24.1	22.6	9.49E-08
1/6/2005	420	20.1	12.9	1.3	12.2	11.5	21.4	20.2	9.91E-08
1/6/2005	480	20.1	11.1	1.4	10.3	9.7	18.1	17.0	9.47E-08
					Averages:		21.9		9.60E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-19	Sample No.	K-9
Depth (ft)	188.8 to 189.3	Lab No.	K6/296
Sample Received	2-Nov-04	Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/297	Olive Gray	Silty Sand (SM-H), with High LL plastic fines.	2.66	132	58	74	100.0	42.6

Specimen Results

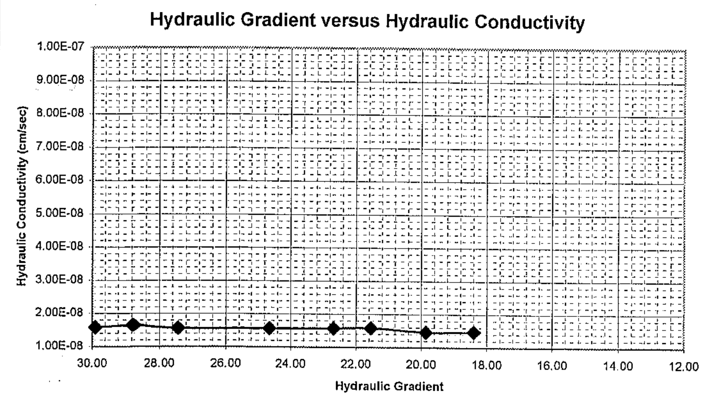
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.523	23.959	7.187	172.195	296.1
Final	5.517	23.908	7.158	171.142	296.7
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	49.3%	1.156	1.151	1.312	100%
Final	48.8%	1.156	1.151	1.298	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
12/23/2004	~Start~	18.9	18.2	1.1					
12/23/2004	1740	18.9	17.5	1.1	17.1	16.4	29.9	28.8	1.65E-08
12/23/2004	5040	19.0	15.3	1.2	15.7	14.1	27.4	24.6	1.57E-08
12/23/2004	2340	19.9	13.6	1.3	12.9	12.3	22.7	21.5	1.59E-08
12/23/2004	3600	20.6	11.9	1.4	11.3	10.5	19.8	18.4	1.51E-08
					Averages:		24.1		1.58E-08

Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-19	Sample No.	K-10
Depth (ft)	202.1 to 202.6	Lab No.	K6/297
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C

U.S. Army Corps of Engineers, Savannah District
Environmental & Materials Unit, Marietta, Georgia

Sample Results

		ASTM D2087	ASTM D854	ASTM D4318 Atterberg Limits			ASTM D422	
Lab No.	Color	USCS Classification	SpGr	LL	PL	PI	%Pass No. 4	%Pass No. 200
K6/298	Olive	Silty Sand (SM-H), with High LL plastic fines.	2.69	97	47	50	100.0	45.5

Specimen Results

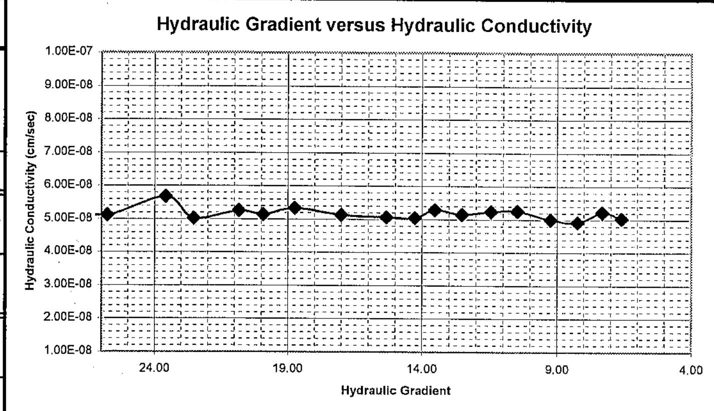
Trial	Diameter, D (cm)	Area, A (cm^2)	Length, L (cm)	Volume (cm^3)	Moist Mass (gms)
Initial	5.523	23.956	7.169	171.727	324.4
Final	5.521	23.941	7.164	171.515	325.0
	Water Content, %	Wet Density (g/cc)	Dry Density (g/cc)	Void Ratio	Saturation, %
Initial	34.1%	1.406	1.401	0.917	100%
Final	34.1%	1.406	1.401	0.915	100%

Permeameter Conditions

Permeant Fluid	Mercury Permometer Area of Tubes (cm^2)	
	pipet	annulus
De-aired tap water	0.0314	0.7671

Chamber Pressure (psi)	65.0	Consolidation Stress (psi)
Back Pressure (psi)	60.0	5.0

Conducted By	Sample Testing By:	Report Preparation By:
	MW	MW



Specimen Permeability Results

Start Time:			Permometer Reading		Head Loss		Hydraulic Gradient		Hydraulic Conductivity, $k_{20°C}$ (cm/sec)
Date	Time Elapsed (sec)	Temp. (°C)	Pipet (cm)	Annulus (cm)	Start	Final	Start	Final	
1/7/2005	*~Start~*	19.4	17.6	1.1					
1/7/2005	600	19.4	17.0	1.1	16.5	15.8	28.9	27.7	5.29E-08
1/7/2005	1140	19.4	14.7	1.2	14.7	13.5	25.8	23.6	5.68E-08
1/7/2005	1080	19.4	13.2	1.3	12.9	11.9	22.5	20.8	5.26E-08
1/7/2005	840	19.4	12.1	1.4	11.4	10.7	19.9	18.7	5.33E-08
					Averages:		23.5		5.39E-08

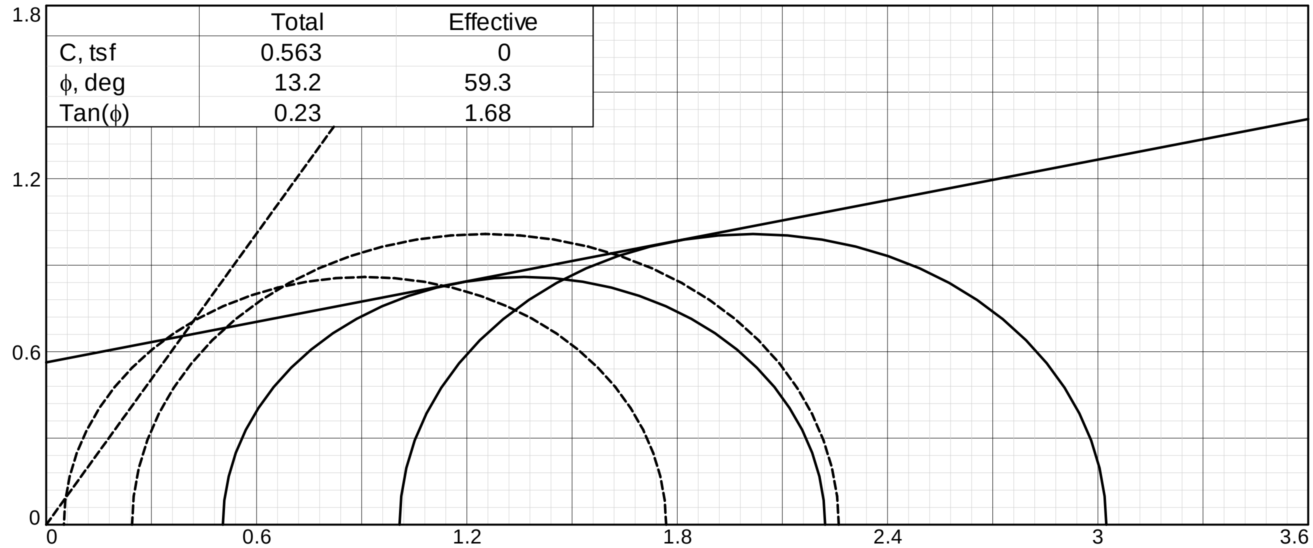
Remarks:

(1) Other tests were conducted in General Accordance with ASTM's D422, D4318, D2216, and D2487. (2) Specific Gravity value was determined from testing per ASTM D854. (3) Samples were received in a foam padded box. Samples were wrapped in suran wrap, aluminum foil, and a covering of duct tape to prevent moisture loss.

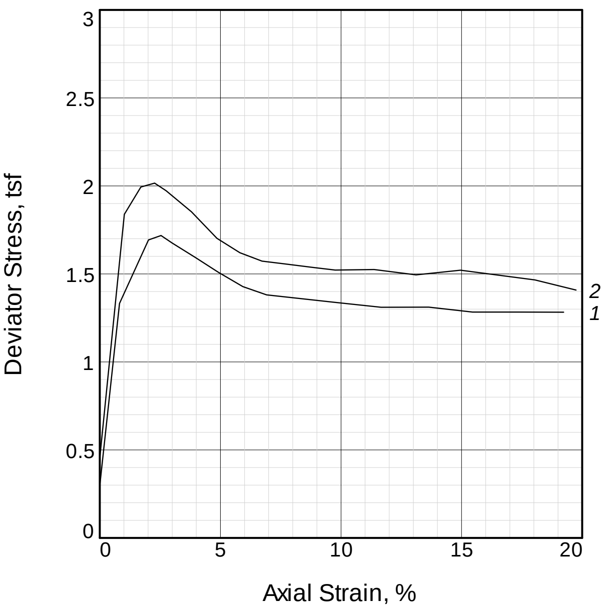
Project Information

Project	Savannah Harbor Expansion		
Location	Savannah, Georgia		
Requisition No.	W33SJG40168635	Work Order No.	330e
Hole No.	SHE-19	Sample No.	K-11
Depth (ft)	213.7 to 214.2	Lab No.	K6/298
Sample Received		Report Date	3-Feb-05

Permeability Test Report - ASTM D5084 Method C



	Total	Effective
C, tsf	0.563	0
ϕ, deg	13.2	59.3
Tan(ϕ)	0.23	1.68



Sample No.		1	2
Initial	Water Content,	70.5	62.1
	Dry Density, pcf	57.5	62.3
	Saturation,	98.4	98.1
	Void Ratio	1.9390	1.7133
	Diameter, in.	1.38	1.38
	Height, in.	3.07	3.07
At Test	Water Content,	71.3	62.6
	Dry Density, pcf	57.7	62.7
	Saturation,	100.0	100.0
	Void Ratio	1.9294	1.6935
	Diameter, in.	1.38	1.39
	Height, in.	3.04	2.98
Strain rate, %/min.		0.10	0.12
Back Pressure, tsf		5.04	5.04
Cell Pressure, tsf		5.54	6.05
Fail. Stress, tsf		1.72	2.02
Total Pore Pr., tsf		5.49	5.80
Ult. Stress, tsf		1.72	2.02
Total Pore Pr., tsf		5.49	5.80
$\bar{\sigma}_1$ Failure, tsf		1.77	2.26
$\bar{\sigma}_3$ Failure, tsf		0.05	0.24

Type of Test:
CU with Pore Pressures

Sample Type: Undisturbed

Description: Olive Gray & Dark Gray, Fat Clay (CH), with some sand.

LL= 87 **PL=** 30 **PI=** 57

Specific Gravity= 2.707

Remarks: Tested in General accordance with ASTM's D4767, D422, D4318, D854, D2216, & D2487.

Client: US Army Engineer District, Savannah

Project: Savannah Harbor Expansion
Savannah, Georgia

Source of Sample: SHE-17 **Depth:** 69.1 - 70.1

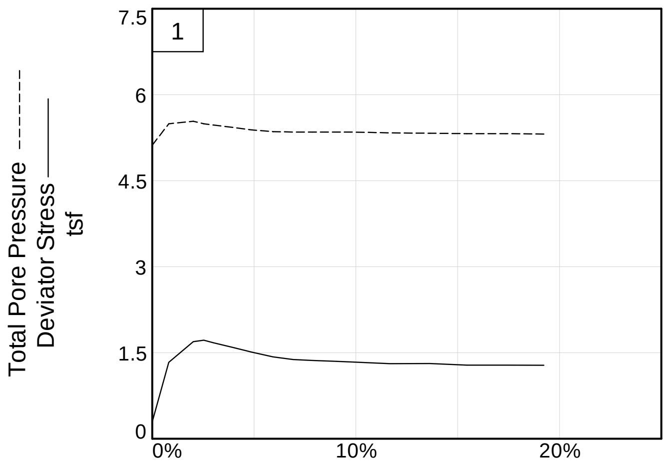
Sample Number: k6/282 SHE-17

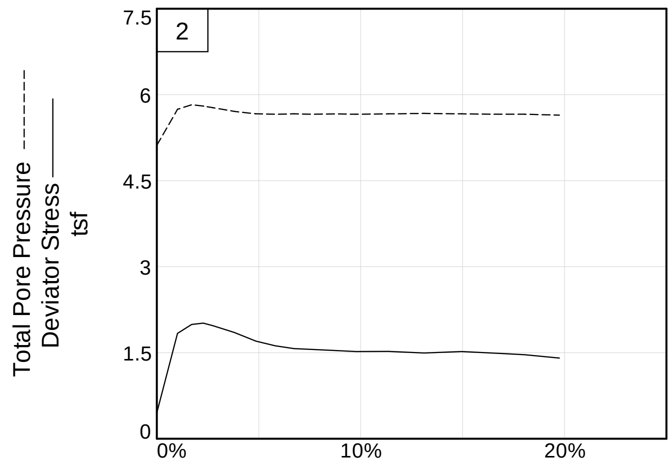
Proj. No.: PR&C No. W33SJG40168635 **Date:** 5 Jan 2005

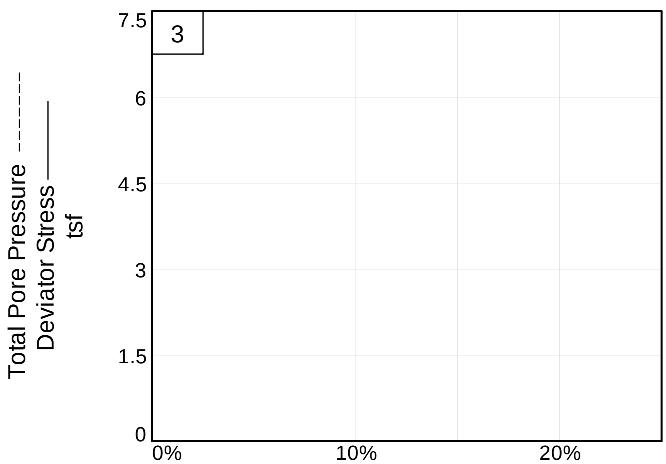
TRIAXIAL SHEAR TEST REPORT

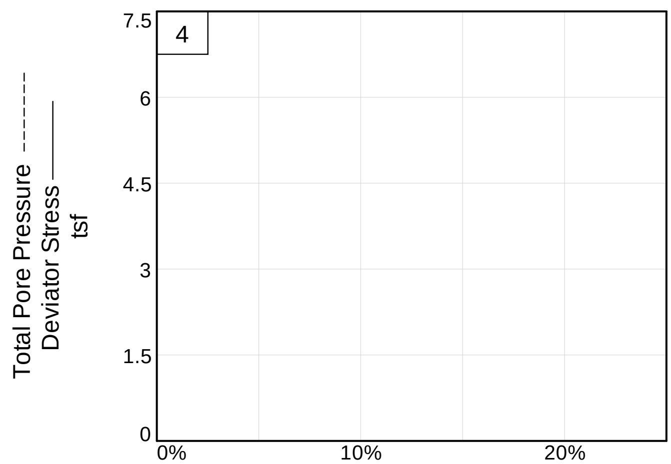
U.S. Army Corp of Engineers

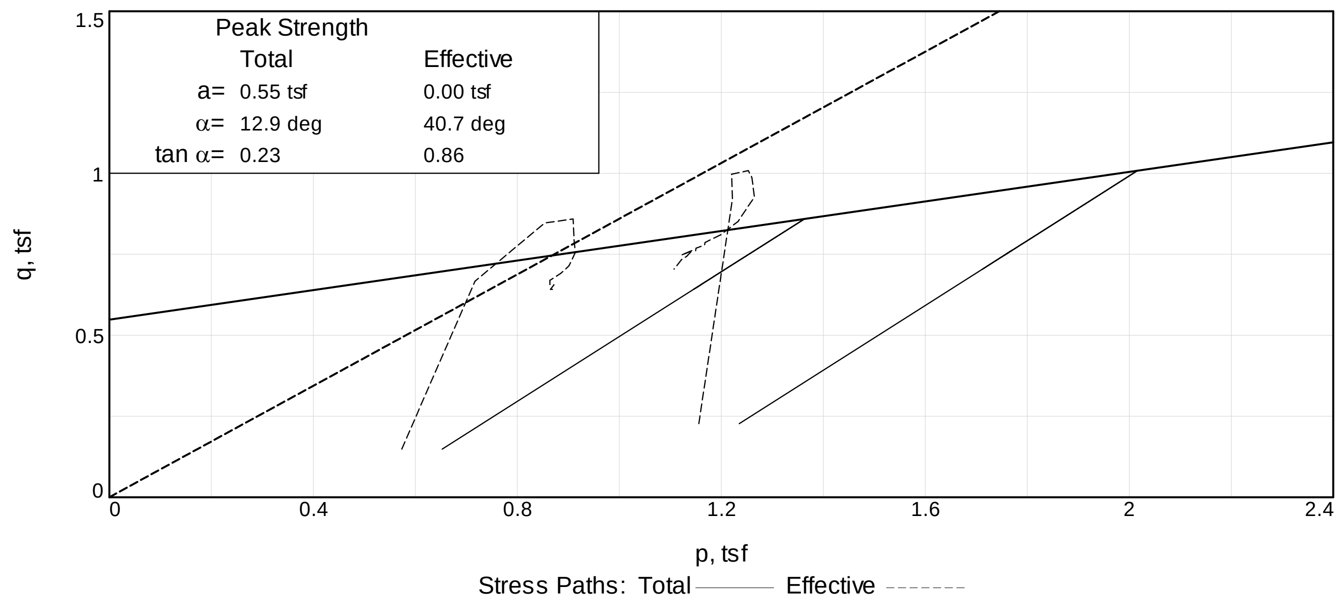
Tested By: MW **Checked By:** MW











Client: US Army Engineer District, Savannah

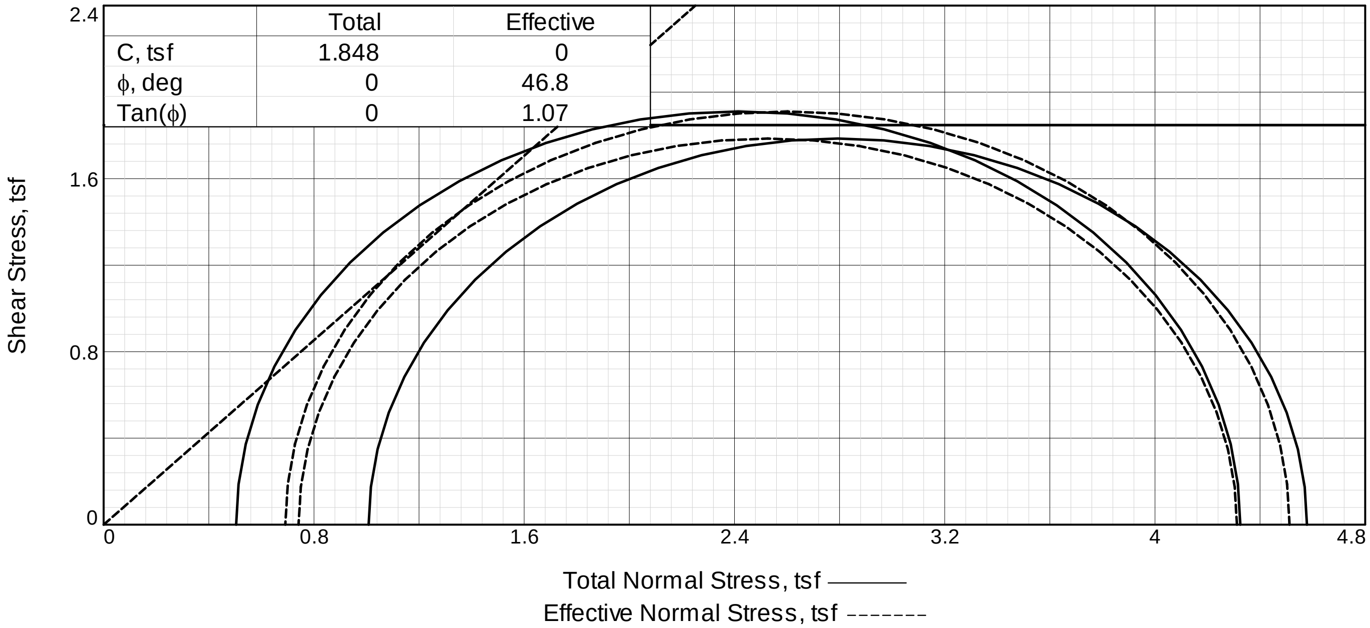
Project: Savannah Harbor Expansion

Source of Sample: SHE-17 **Depth:** 69.1 - 70.1 **Sample Number:** k6/282 SHE-17

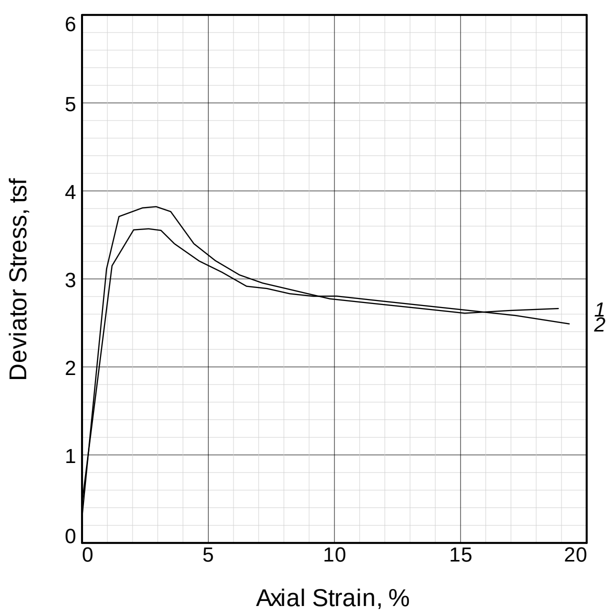
Project No.: PR&C No. W33SJG40168635

U.S. Army Corp of Engineers

Tested By: MW **Checked By:** MW



	Total	Effective
C, tsf	1.848	0
ϕ, deg	0	46.8
Tan(ϕ)	0	1.07



	Sample No.	1	2
Initial	Water Content,	35.8	37.8
	Dry Density, pcf	85.9	84.3
	Saturation,	97.4	98.8
	Void Ratio	1.0281	1.0686
	Diameter, in.	1.38	1.38
	Height, in.	3.07	3.07
At Test	Water Content,	37.9	39.2
	Dry Density, pcf	84.7	83.2
	Saturation,	100.0	100.0
	Void Ratio	1.0586	1.0946
	Diameter, in.	1.40	1.40
	Height, in.	3.05	3.04
	Strain rate, %/min.	0.12	0.13
	Eff. Cell Pressure, tsf	0.50	1.01
	Fail. Stress, tsf	3.82	3.57
	Total Pore Pr., tsf	4.85	5.31
	Strain, %	2.9	2.6
	Ult. Stress, tsf	3.82	3.57
	Total Pore Pr., tsf	4.85	5.31
	Strain, %	2.9	2.6
	$\bar{\sigma}_1$ Failure, tsf	4.51	4.31
	$\bar{\sigma}_3$ Failure, tsf	0.69	0.74

Type of Test:
CU with Pore Pressures

Sample Type:

Description: Dark Olive Gray, Clayey Sand High LL (SC-H).

LL= 62 **PL=** 23 **PI=** 39

Specific Gravity= 2.792

Remarks: Tested in General accordance with ASTM's D4767, D422, D4318, D854, D2216, & D2487.

Client: US Army Engineer District, Savannah

Project: Savannah Harbor Expansion
Savannah, Georgia

Source of Sample: SHE-17 **Depth:** 79.0 - 80.0

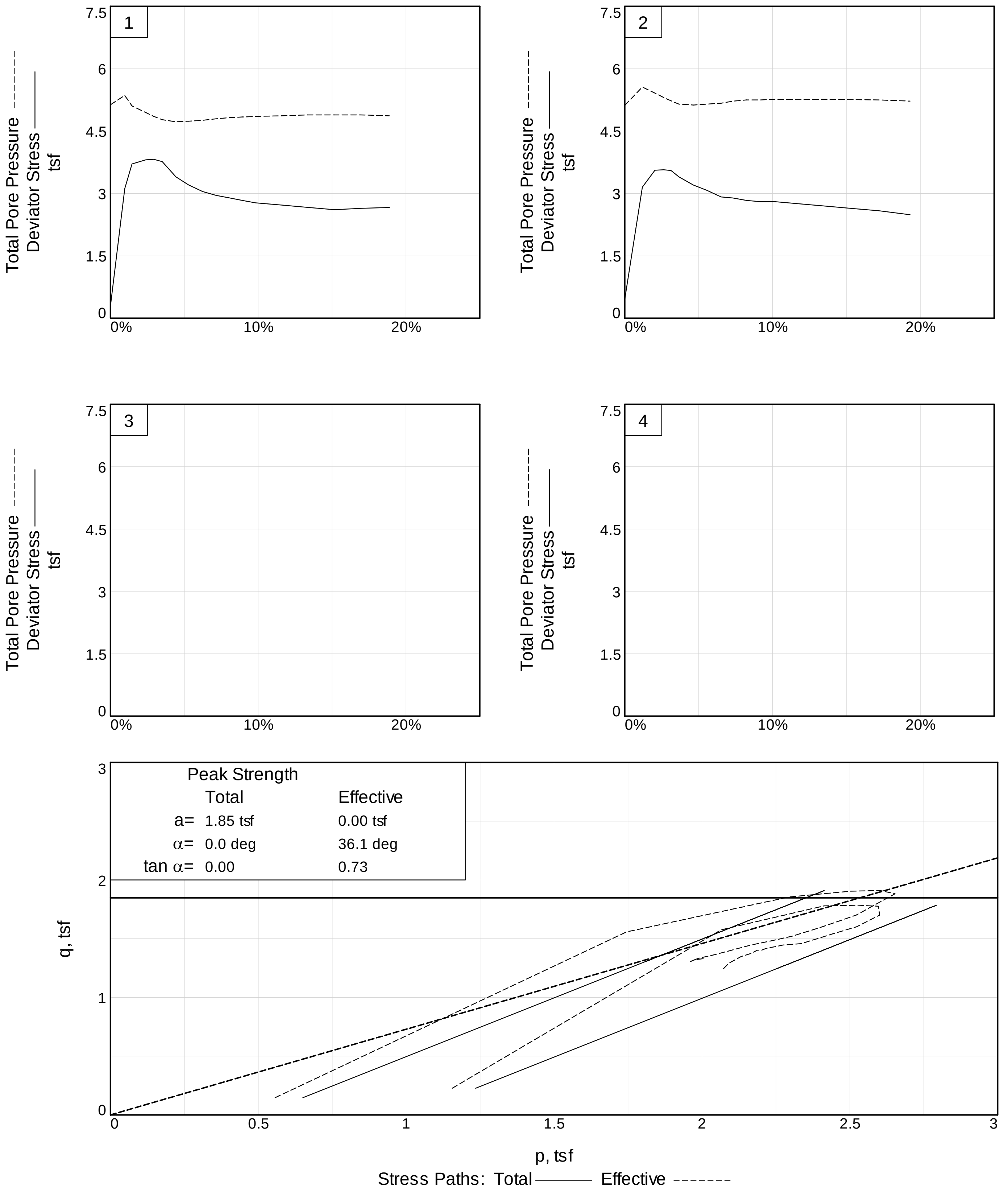
Sample Number: k6/283 SHE-17

Proj. No.: PR&C No. W33SJG40168635 **Date:** 11 Jan 2005

TRIAXIAL SHEAR TEST REPORT

U.S. Army Corp of Engineers

Tested By: MW **Checked By:** MW



Client: US Army Engineer District, Savannah

Project: Savannah Harbor Expansion

Source of Sample: SHE-17 **Depth:** 79.0 - 80.0 **Sample Number:** k6/283 SHE-17

Project No.: PR&C No. W33SJG40168635

U.S. Army Corp of Engineers

Tested By: MW **Checked By:** MW

APPENDIX F

Independent Technical Review Documentation

Peer Review Process for Aquifer Evaluation Portion of the Proposed Savannah Harbor Expansion Project

The Aquifer Evaluation, i.e. the Supplemental Studies report, was prepared as part of the Tier II Environmental Impact Statement for the proposed Savannah Harbor Expansion Project. It is a detailed technical report, the findings and recommendations of which will be used to support project decision documents requiring authorization by the U. S. Congress, and therefore is subject to peer review. The intent of this review process follows that of EC 1105-2-408 which provides guidance for peer review of Corps of Engineers water resource decision documents.

1. Independent Technical Review (ITR). The ITR portion of the review process of consisted of two simultaneous reviews. One review was performed by the three cooperating agencies that reviewed and provided input to the initial scope of work. The agencies were not involved in the day-to-day technical work; however, representatives from each agency have attended several update meetings and given input throughout the data collection and reporting process. The following individuals served as technical experts for their respective agency and were given the opportunity to provide technical comments on the final work products:

USGS – GA District	Mr. John Clarke
USGS – SC District	Dr. James Landmeyer
GA DNR-EPD	Dr. William McLemore (State Geologist)
SCDHEC	Mr. Camille Ransom

The second simultaneous review was performed by the Corps of Engineers Hydrologic Engineering Center (HEC) in Davis, CA. HEC is the Corps designated Center of Expertise for a number of hydrological-related technical subjects, including ground-water hydrology. The representatives from HEC were not involved in the day-to-day technical work. The following individuals reviewed the work, in particular the 3-D numerical hydraulic model, and provided technical comments on the final work products:

HEC	Mr. Jon Fenske
HEC	Mr. Stan Gibson

2. External Peer Review (EPR). Upon completion of the ITR, an EPR of the Aquifer Evaluation will be performed by a panel of three to four independent experts who have been recommended by either the cooperating agencies listed above or the Aquifer Committee of the Stakeholders Evaluation Group. These technical experts will have no affiliation with the Corps of Engineers or any previous involvement with the proposed Savannah Harbor Expansion Project.

A peer review leader from the Corps of Engineers Center of Expertise for deep draft navigation planning (DDCX) in Mobile, AL will organize and conduct the external review. The peer review leader will also be responsible for maintaining the review records and formulating the charge to reviewers including specific questions as well as a broad evaluation of the final work product.

Comments and recommendations that resulted from the ITR (included in this appendix) have been incorporated into the present draft version of the Aquifer Evaluation report. Comments and recommended actions that result from the EPR will also be included in this appendix and incorporated into the final Aquifer Evaluation report.

Independent Technical Review

Savannah Harbor Expansion Project
Aquifer Evaluation
Supplemental Studies to Determine Potential Ground-Water Impacts to the Upper Floridan Aquifer

Reviewer	Agency	Date Received
Mr. John Clarke	USGS Georgia Water Science Center	15-Jun-05
Mr. Stan Gibson	USACE Hydrologic Engineering Center	18-Jul-05
Mr. Jon Fenske	USACE Hydrologic Engineering Center	18-Jul-05
Dr. James Landmeyer	USGS South Carolina Water Science Center	23-Aug-05
Dr. William McLemore	Georgia Environmental Protection Division	No response received.
Mr. Camille Ransom	South Carolina Department of Health and Environmental Control	No response received.

Response Author	Agency	Date Completed
Ms. Mackie McIntosh	USACE Savannah District	27-Sep-05
Mr. Mark Maimone	CDM	27-Sep-05
Mr. Paul Hossain	CDM	27-Sep-05

USACE Comment #	Reviewer	Report Section	Page	Figure	Comment	Response Author	Response / Action
1	John Clarke	Study Area	3-1		Provide reference for cited thickness of sedimentary deposits in Chatham County (4,000 ft)	Mackie McIntosh	*Miller (1986) shows 2000 feet underlying Chatham County. Edited text accordingly.*
2	John Clarke	Study Area	3-2		Provide reference for Ridgeland Trough. Suggest that all structural features mentioned by shown on a map because you use these as points of reference in your text discussion. The Floridan aquifer system was *formerly* known as the principal artesian aquifer.	Mackie McIntosh	*Edited text to read: "In general, Tertiary strata in Chatham County dip 10 to 15 feet per mile to the south-southwest. However, the dips are locally controlled by structural "highs" and "lows". Prominent structures include the Beaufort arch, a domal structure near Beaufort, South Carolina (Siple, 1960), the Tybee high, an anticlinal structure with a northwest-southeast trending axis near the mouth of the Savannah River (Furlow, 1969), and the Ridgeland trough, a structural low with a northeast-trending axis extending northeastward through northern Chatham County, Georgia into Jasper County, South Carolina (Heron and Johnson, 1966)." Added modified structural map from Clarke et al. (1990). Changed last sentence in paragraph to read "formerly known as..."*
3	John Clarke	Study Area	3-2		Exposure history of Miocene—be sure to mention this was delineated using GIS.	Mackie McIntosh	*Inserted clause in sentence "The GIS analyses presented in Figures 3-2a and b..."*
4	John Clarke	Study Area	3-4		Suggest cite Krause and Randolph (1989) for predevelopment head estimates. Discuss this relative to Chatham County, where head was between +30 and +50 ft above sea level.	Mackie McIntosh	*Added "and from 30 to 50 feet above sea level in Chatham County (Krause and Randolph, 1989)" in discussion and changed initial citation according to Plate 9 of Krause and Randolph (1989).*
5	John Clarke	Study Area	3-4		For 1998 map, also discuss in terms relative to Chatham County (range is -10 to deeper than -100 ft).	Mackie McIntosh	*Edited sentence to read: "In contrast, in May of 1998 Peck et al. reported the maximum head as 60 feet above sea level occurring south of Brunswick with maximum drawdown occurring near the city of Savannah, where heads ranged from -10 feet to -100 feet below sea level (Figure 3-5)."*
6	John Clarke	Study Area	3-5		Clarke and others (1999) not listed in references.	Mackie McIntosh	*Added to references.*
7	John Clarke	Study Area	3-6		Definition of Upper Floridan vs. Lower Floridan aquifer is somewhat controversial—Krause and Randolph (1989) assign zones 1&2 to Upper Floridan; Miller (1986) and Falls (2005) assign zones 1-4 to Upper Floridan. Suggest state that Floridan aquifer system has been subdivided into 5 zones, the upper two of which are most productive and assigned to the Upper Floridan.	Mackie McIntosh	*Omitted definition of 5 zones and mentioned only the ones relevant to the current study. Edited sentence to read "In the study area, the Upper Floridan aquifer is 150 to 250 feet thick, and the uppermost two zones, zone 1 and zone 2, are the most productive (McCollum and Counts, 1964; Krause and Randolph, 1989)."*
8	John Clarke	Study Area	3-6		upper and lower Brunswick are lower case (not Upper/Lower).	Mackie McIntosh	*Nomenclature is documented both ways in Weems and Edwards (2001), lower case in Clarke and Krause (2000), and upper case in Clarke et al (2004). Edited text using lower case nomenclature.*
9	John Clarke	Study Area	3-7		Zones 1&2 combine to provide 70% of flow based on McCollum and Counts flowmeter tests (not 30% as stated on top of page).	Mackie McIntosh	*30% refers to total (surface and ground) freshwater usage as seen in Fanning, 2002. Perhaps more relevant to discuss as a percentage of ground-water flow, in which case, the correct figure would be 70% (taken from McCollum and Counts, but adapted from Krause and Randolph's verbiage). Edited sentence to read ..."combine to supply more than seventy percent of the water pumped from open holes tapping the entire aquifer (Krause and Randolph, 1989).*
10	John Clarke	Study Area	3-7		try and limit discussion of transmissivity to Chatham County area. Also, not sure if you were aware of recent report on this subject http://water.usgs.gov/pubs/sir/2004/5264/	Mackie McIntosh	*Eliminated first sentence of paragraph and reworked remaining sentences to cover only area between Port Royal Sound and Savannah.*
11	John Clarke	Study Area		3-5	Problems with shading patterns—the blue shade is not identified. Suggest limit shading to areas where head is below sea level. Don't shade states, simply label states along Savannah River border.	Mackie McIntosh	*Added color ramp to distinguish the contours less than 0 ft MSL. Kept the shading in the states and ocean to keep consistent with all other figures in report that have an overview map. Too crowded in Savannah River area to add any labels.*
12	John Clarke	Methods	4-1		Suggest mention/describe how the scope of work was developed by the aquifer committee and working group.	Mackie McIntosh	*Added: "The Savannah District used input from various agencies including the USGS, GAEPD, SCDHEC, SEG, and Georgia Ports Authority to develop a scope of work for the supplemental studies. "*

USACE Comment #	Reviewer	Report Section	Page	Figure	Comment	Response Author	Response / Action
13	John Clarke	Methods	4-14		The only models that evaluated saltwater encroachment were the Smith and Bush models that used SUTRA 2D. Other models simulated flow only.	Mackie McIntosh	*Edited text to read: "The early models, the RASA model, and its offspring models simulated ground-water flow influenced by pumping in Savannah and indicated fairly high vertical downward flows (leakage) through the upper confining unit to the Upper Floridan aquifer, but none of these models addressed vertical salt-water intrusion. Of these models, only Smith (1988) and Bush (1988) used SUTRA 2D to specifically simulate solute transport of chlorides; however, the simulations addressed only lateral seawater encroachment in two dimensions. The RASA model and its successors simulated regional ground-water flow in three dimensions but did not address seawater encroachment or salt-water intrusion."*
14	John Clarke	Methods	4-19		Range of chloride concentration in the river are low relative to chloride profile levels. The maximum level of 10,000 mg/L is lower than the maximum observed in the porewater profiles at SHE-13 (19,760), SHE-14 (14,405), SHE-17 (15,601), SHE-16 (12,381).	Mark Maimone	*We are aware of this. The chloride concentrations were, of necessity, taken from the surface water model for existing conditions, and not interpolated from the profiles. This was done because the primary goal of the simulations was to compare pre- and post-dredging conditions. Chloride concentrations for post-dredging conditions required the use of the model, of course, so a comparison was only possible by modeling both conditions. The impact of consequence is the difference between pre- and post-dredging.*
15	John Clarke	Methods	4-19		Table 4-2: I'm not familiar with a "rising water boundary"? Is this a specified head boundary that varies over time?	Mark Maimone	*This is a boundary that allows the head to rise to the land surface elevation, after which it acts as a fixed head, discharging water to the surface. Added definitions of all boundary conditions to text in Appendix B.*
16	John Clarke	Methods	4-20		Table 4-3: Table states that Lower Floridan is absent in the area of concern (not according to my knowledge of area).	Mackie McIntosh	*Corrected table.*
17	John Clarke	Methods	4-20		Well specific data are available for many permits, but are certainly not limited to >1 MGD level. GaEPD requires permits for withdrawals above 100,000 gal/d. Many of the smaller permits are well specific. In fact, problems with separating by well often arise from larger permitees who do not subdivide by well.	Mackie McIntosh	*Edited text to read: "The well specific pumping data are based on either individual well or facility permits. Typically, well specific data are available for 100,000 gallons per day permits or larger, and in most cases, the total permit capacity is known but the individual well production is not known."*
18	John Clarke	Methods	4-20		Pumping data are for the entire model domain, which includes many more counties in Georgia than the 24 coastal counties.	Mark Maimone	*The model contained pumping from the entire model domain. Text corrected.*
19	John Clarke	Methods	4-22		surficial head change: on what basis were water table heads varied over time? There are no long-term declines/changes documented in this layer, yet it is stated that the period 1900-1960 was held constant, followed by changes every 10 years based on linear interpolation between 1900 and 2000 values. (relates to comment #15).	Mark Maimone and Paul Hossain	*The surficial aquifer head data from the USGS model calibrated to 2000 conditions indicated somewhat lowered heads in the Savannah area. CDM had originally utilized the 2000 surficial head conditions for the historical simulation, however, based on a comments from the Aquifer Committee, CDM developed a very simple a pre-development surficial aquifer head condition that eliminated some of the lowered heads within Savannah. This was primarily for presentation reasons The water table elevation changes between the more recent values and the pre-1960 elevations were minimal. The small changes had no impact on the simulations results in the underlying aquifers.*
20	John Clarke	Methods	4-24		Model calibration: Perhaps the model calibration of head could have been achieved by locking in the lower Kv values and adjusting boundary conditions and/or aquifer transmissivity to raise heads in the Floridan. Your approach; however, would result in a more conservative estimate of rates of saltwater movement (more rapid), which may be appropriate for regulatory evaluations.	Mark Maimone	*Our intent was to consistently try to be conservative with our parameter estimates to address the question of non-uniqueness of the model. Thus, we believe we have bounded the problem without attempting to fully calibrated the model. The relevant simulations, focusing on the change from pre- to post-dredging are likely to be conservative in that they exaggerate the impacts.*
21	John Clarke	Methods	4-24		Table 4-4: should include observed head at Hutchinson Island and also list for what time period.	Mackie McIntosh	*Added head data to table.*

USACE Comment #	Reviewer	Report Section	Page	Figure	Comment	Response Author	Response / Action
22	John Clarke	Methods	4-24		Need to describe why analysis was limited to upper 50-60 ft of Upper Floridan. I assume this was to include the most permeable portion of the aquifer?	Mark Maimone and Mackie McIntosh	*Added to text: " Upon breakthrough, the salt water leaking downward through the Miocene confining layer will be diluted into the fresh-water Upper Floridan aquifer. However, assuming mixing of the salt water throughout the full thickness of the Upper Floridan aquifer would result in very low concentrations and would not be a conservative assumption. Therefore, an aquifer thickness of 50 to 60 feet was used to calculate the final concentration of chlorides in the Upper Floridan aquifer. The chosen aquifer thickness limited the chloride mixing to the upper, more conductive portion of the aquifer, resulting in higher and thus more conservative estimates of chloride concentration."*
23	John Clarke	Methods	4-25		There is no discussion regarding the sensitivity of the model to porosity of the confining unit. Was this ever tested? The effective porosity of 0.1 listed in table 4-5 is low given the values reported from the borehole sample analysis (around 0.6). (Again, you utilized a conservative value that would result in more rapid transport times).	Mark Maimone	*Added to text under Conservative Assumptions: "The model was sensitive to the porosity of the confining unit, with lower values increasing the rate of movement of salt downward. This was tested, but with little field data to adequately defend a "calibrated" value, a low end value was selected to be conservative. " This was consistent with the overall approach to modeling taken for the study.*
24	John Clarke	Methods	4-24		Pages 4-24 through 4-26, input parameters: Suggest refer reader to appropriate sections for more complete discussion of values and how they were derived.	Mark Maimone and Mackie McIntosh	*Most of the parameters listed mention the source of the data. Only the Kv value for the Miocene Confining Unit could be explained further. The bounding values selected came from the calibration process, followed by an order of magnitude change in either direction. All values fell within the range of core samples as described in section 5.6.4.2. The text refers the reader to Appendix B both on p. 4-23 and 4-24 for a more complete discussion of input parameters and results of the Kv sensitivity analysis. The main body of the report sufficiently summarizes the input parameters; CDM's report contains more detail for those readers who need additional background information.*
25	John Clarke	Methods	4-25		Table 4-5: various transport modeling input parameters are listed, yet no discussion of the justification for assigning these values is offered. Are these "textbook" values, or was field data used for some of the values?	Mark Maimone and Mackie McIntosh	*The transport parameters are not based on field data, but are values that have generally provided reasonable dispersion results in most modeling studies. Dispersion of the chloride front was a fairly minor aspect of the overall transport in comparison to the advective transport downward, and varying these parameters would not result in any significant changes in the results. Added to text: "The applied values have generally provided reasonable dispersion results in other modeling studies and are not based on field data. Advective transport dominated chloride transport in the SHE model; therefore, variation of the dispersion transport parameters did not significantly affect results."*
26	John Clarke	Methods	4-29		No discussion of laboratory determination of porosity, yet these values are later discussed.	Mackie McIntosh	*Added sentence to 4.6.4.1: "Porosity (n) was calculated using standard dry unit weight and specific gravity determination techniques and the relationship n = e/(1+e), where e is the void ratio of the sample."*
27	John Clarke	Methods		4-10	It is very difficult to distinguish hydrogeologic units by color since the chloride distribution is also in color. Suggest eliminate color for units and simply use labeled lines. What does the line at the top of the green pattern represent? Is this the river bottom?	Mackie McIntosh	*Figure edited for clarity as suggested by reviewer.*
28	John Clarke	Results	5-4		"..and show an overall decrease in concentration as elevation decreases" is somewhat confusing—suggest say, "..and show an overall decrease in concentration with increased depth."	Mackie McIntosh	*Edited sentence to read as suggested.*

USACE Comment #	Reviewer	Report Section	Page	Figure	Comment	Response Author	Response / Action
29	John Clarke	Results	5-4		Suggests that all land borings were made outside of paleochannels; however, what about the Bull River site? This site, completed in a paleochannel, seems to have been omitted from this report. Also—the supply well completed on Hutchinson Island that was used for wireline transducer experiments—is not described in this report. Both of these sites provide important information and should be included in the evaluation.	Mackie McIntosh	*The Bull River site was not included in this evaluation because it was not located in the immediate vicinity of the navigation channel. It is discussed briefly in the methods section to credit C. Ransom and J. Landmeyer as first using the method to measure chloride intrusion in the confining unit. As for "the supply well on Hutchinson Is. that was used for wireline transducer experiments" -- it appears to be SHE-9, which is located in the disposal areas (Jasper County). The wireline transducer data from this well is included in the methods (4.6.3) and results (5.6.3) of this study. No supply well with wireline transducers was installed on Hutchinson Island to my knowledge.*
30	John Clarke	Results	5-7		Discussion of sample anomalies in 10-PW-1 and 10-PW-2 are offered, yet these sites are never described in terms of location, nor are the profiles ever shown.	Mackie McIntosh	*Second paragraph on p 5-7 states origin of samples at SHE-10. "...All porewater samples within the Miocene confining unit were taken at the time of drilling with the exception of 10-PW-1 and 10-PW-2. These samples were taken in 2005 in an effort to fill in data gaps and complete the profile to the top of the limestone." Anomaly discussed again on p. 5-8. Also, values are listed in table at location SHE-10 and values are included in cross section (figure 5-1). Added references to Table 5-1 and Figure 5-1 in discussion of sample origin on p. 5-7.*
31	John Clarke	Results	5-9		The terms "punctuated increases" and "punctuated spike" are used in this section. Why not simply say, "increased."	Mackie McIntosh	*Adopted suggested verbiage.*
32	John Clarke	Results	5-10		Not clear what you mean by "sequentially decreased." Why not just say, "decreased."	Mackie McIntosh	*"Sequentially" refers to sample by sample. The overall trend line shows a decrease in concentration; however, some samples indicated that higher chloride concentrations than the preceding sample taken at a shallower depth. Added a sentence for clarification.*
33	John Clarke	Results		5-1	Confusing mix of color patterns showing lithology and unit. Suggest show color pattern for lithology and lines for unit tops/bottoms. The green for Miocene unit should be converted to a lithology—I assume this unit includes the calcareous siltstone/sandstone, phosphatic sand, and fine sandy clay. Oligocene yellow and Pleistocene-recent gray also need to be converted to lithologies.	Mackie McIntosh	*Revised all cross sections (figs 3-3, 5-1, 5-11, 5-12) according to reviewer's suggestions.*
34	John Clarke	Results		5-5	Lines showing top of Miocene and top of Upper Floridan should be reversed.	Mackie McIntosh	*Corrected figure.*
35	John Clarke	Results	5-20		"Simulations using the lower value of hydraulic conductivity showed no increase in concentration at most of the wells." This statement seems unnecessary—why would you expect an increase in concentration with decreased Kv? Statement seems to imply that some wells did show an increase?	Mackie McIntosh	*The statement was made with respect to time, not the higher Kv value. Eventually, breakthrough will occur at all the wells regardless of Kv. The smaller value increases the amount of time it takes for breakthrough to occur. Clarified sentence to read: "Simulations using the lower value of hydraulic conductivity showed that downward migration of chloride from the river would not contribute to any increase in total chloride concentration at most of the wells by the year 2200."*
36	John Clarke	Results		5-9	Plots shown out of chronological order	Mackie McIntosh	*Switched graphic (W:\projects\SHE_QA\FIGURES\NEW_TEST\SHE_5-9rev)*
37	John Clarke	Results	5-22		I assume the simulated pumping test was run with the "mid-range" Kv? Need to explicitly state which Kv value was used.	Mark Maimone and Mackie McIntosh	*The simulated pumping test was performed using the mid-range Kv value, representing the simulation that most closely represented a calibrated model based on the USGS model calibrated hydraulic properties. The value is explicitly stated in Methods Section 4.5. Added sentence to Results section: "All simulation results are based on applying the mid-range value of vertical hydraulic conductivity to the Miocene confining layer (1.5x10-4 ft/day)."*

USACE Comment #	Reviewer	Report Section	Page	Figure	Comment	Response Author	Response / Action
38	John Clarke	Results	5-22	5-10	Figure 5-10: All of your discussion in the 2nd paragraph of section 5.5.1 relates to the 2000 gpm pumping rate, yet you show a plot for 1000 gpm. This is confusing—should replace graph with 2000 example.	Mackie McIntosh	*Replaced figure with 2000 gpm at observation point 1100 feet away from pumping well.*
39	John Clarke	Results	5-24		Suggest mention problems related to interference from tides, nearby and regional pumpage as other factors making pumping test less feasible.	Mackie McIntosh	*Added sentence: "In addition, numerous sources of interference including tidal variations, other local pumping wells, and regional pumping would mask the observation data, and further complicate interpreting any results. The small drawdowns at high pumping rates as seen in the simulation results, combined with the amount of background interference in the area of concern, indicated that this task was not practical. "*
40	John Clarke	Results	5-25		Rather than use term "reduced potential" suggest use "head." Not clear what you mean by reduced potential.	Mackie McIntosh	*Reworded sentence to read: "Water levels recorded in well clusters on the north end of Tybee Island and at Fort Pulaski indicated that pumping the Upper Floridan aquifer has not only reduced heads in the aquifer, but also that the head differences have propagated through the overlying confining layer."*
41	John Clarke	Results	5-26		Porosity is mentioned in section 5.6.4, but is not mentioned in the earlier methods section.	Mackie McIntosh	*see USACE comment #26 above.*
42	John Clarke	Results		5-8	What is the "noise" shown on the chloride trend plots? If average annual pumpage is used and kept constant into the future, then patterns of head change (and solute transport) should be constant.	Mark Maimone	*The noise or small, random fluctuations in chloride concentration are primarily the result of two factors. One is the model's use of the random walk method of imparting random displacement of particles to simulate local dispersion. Each particle represents a discrete amount of "chloride". Because of the area of the model covered and the relatively wide range of concentrations that had to be simulated, the addition or subtraction of only a few particles result in relatively large changes in concentration at the lower end of the concentration range. Thus, the seemingly random small fluctuations in concentration in an otherwise steady flow system.*
43	John Clarke	Summary	6-3		There is no mention of the simulated chloride concentrations in production wells.	Mackie McIntosh	*The conclusions presented represented the bigger picture -- increased concentration in production wells goes hand in hand with the increased concentrations in the aquifer, which are discussed at length. The simulation results discussed as overall trends as opposed to one point along the river and is more appropriate for drawing conclusions about the entire study.*
44	John Clarke	Summary	6-3		Section 6.4: Suggest mention interference problems (see comment 39).	Mackie McIntosh	*Added: "In addition, the interference expected from tidal variations, local pumping wells, and regional pumping trends would further obscure any meaningful results. The long duration and sustained pumping rate required combined with the expected minimal and indistinct response make the task of performing an aquitard test impractical."*
45	John Clarke	Conclusions	7-1		"Ground-water model results indicated that any addition contribution of chloride by paleochannels is negligible when compared to the total contribution along the river." I did not see discussion of this in earlier modeling section (5.4) and am unclear of what is meant by "is negligible when compared to the total contribution along the river."	Mackie McIntosh and Mark Maimone	*Edited sentence to read: "Ground-water model results indicated that any additional contribution of chloride by the dredging of the paleochannels is negligible when compared to the total contribution from dredging of the river outside paleochannels along the river bottom. The impacts of dredging in the in-fill sediments of the paleo-channels, which were simulated in the model to represent sand, are small when compared to the impacts of dredging in the channel where Miocene confining unit is dredged."*
46	John Clarke	Conclusions	7-3		3rd paragraph: "low contribution of saline water from the river." The low contribution might be due to a variety of factors (including Kv, gradient, porosity), but I think what you intended to say was "lower salinity of river water."	Mackie McIntosh	*Adopted suggested verbiage.*

USACE Comment #	Reviewer	Report Section	Page	Figure	Comment	Response Author	Response / Action
47	John Clarke	Appendix B	2-4		I am unclear about "rising water boundary" (see comment 15 above).	Mark Maimone	*See USACE comment #15 above.*
48	John Clarke	Appendix B	2-4		maximum chloride concentrations in river are 10,000 mg/L, yet porewater profiles show maximum concentrations are nearly 20,000 mg/L (see comment 14 above).	Mark Maimone	*See USACE comment #14 above.*
49	John Clarke	Appendix B	2-5		Section 2.4.6: implies that water table heads are fixed, yet a "rising head boundary" is mentioned elsewhere (page 2-8) and page 4-22 of main report indicates that head was changed over time. (see comments 15 and 19 above).	Mark Maimone and Paul Hossain	*The surficial nodes were all assigned a fixed head. Only in the upstream portion of the Savannah river within the study area were some of the river nodes assigned a rising node boundary to allow the surficial aquifer to discharge to the river.*
50	John Clarke	Appendix B		2-29 through 2-40	The lines representing top of Miocene and Upper Floridan should be reversed.	Mark Maimone and Paul Hossain	*Corrected figures.*
51	John Clarke	Appendix B	3-2		suggest add observed values at Hutchinson Island and add date of simulation/observation.	Mackie McIntosh	*Added values to table.*
52	John Clarke	Appendix B		3-5 through 3-16	The lines representing top of Miocene and Upper Floridan should be reversed.	Mark Maimone and Paul Hossain	*Corrected figures.*
53	John Clarke	Appendix B		3-17 through 3-48	need to explain "noise" on trend plots (see comment 42 above).	Mark Maimone	*See USACE comment #42 above.*
54	Stan Gibson	Appendix C			The GIS was well conceived and remarkably well documented. It has been constructed as a valuable interactive tool to organize the copious data and help maximize its usefulness. The latest technology was utilized to develop a powerful conceptual tool. It appears very well done.	Mackie McIntosh	*No response needed.*
55	Stan Gibson	Appendix B			Please include more documentation on the groundwater code used. Proprietary, in-house code will always be viewed with more skepticism than public domain code (or at least widely used products). 25 years of development and experience is not nearly as impressive as a few solid peer reviewed references. If these references do not exist, then include significant references for the specific methodologies employed (e.g. the use of random walk algorithms for salinity dispersion). Additionally, include a citation of the IGWA report in which the model was reviewed so a reader could track down their thoughts.	Mark Maimone and Mackie McIntosh	*Added citations in Section 4.4.3.1 and appropriate references.*
56	Stan Gibson	Appendix B			The model outcome is the result of a long string of strongly conservative assumptions. While the conservatism often seemed excessive, it achieved its objective of demonstrating that dredging would not adversely affect ground water chloride levels.	Mark Maimone	*No response really required to this observation.*

USACE Comment #	Reviewer	Report Section	Page	Figure	Comment	Response Author	Response / Action
57	Jon Fenske	Appendix B			It is clear that many conservative assumptions were used in developing the model and interpreting model results. However, to fully assess the model, a complete justification for all input values must be provided. The overriding concern from reviewing this study is the uniqueness of the calibrated solution. For example, it may be possible to match steady-state and transient aquifer heads by increasing the vertical hydraulic conductivity (Kv) in the Miocene confining unit, and decreasing the horizontal hydraulic conductivity (Kh) in the Upper Floridan aquifer. The calibration of the solute model to measured chloride levels in the confining unit are not as reliable since only one measuring date was available; furthermore, a similar replication of the chloride front may be possible by raising both vertical hydraulic conductivity and porosity values. Documentation should be provided which addresses these concerns. Specific comments are listed below.	Mark Maimone	*In fact, the model could not be calibrated by increasing the Kv of the confining unit and decreasing the Kh of the Upper Floridan aquifer without creating a serious mismatch of data vs. simulation in the cone of depression. Kh values from pump tests in the Upper Floridan exist, limiting our options in that regard as well. Our intent was to consistently try to be conservative with our parameter estimates to avoid the question of non-uniqueness of the model. Thus, we believe we have bounded the problem without attempting to fully calibrated the model. The relevant simulations, focusing on the change from pre- to post-dredging are likely to be conservative in that they exaggerate the impacts.*
58	Jon Fenske	Appendix B			The value of simulated porosity assigned to the Miocene confining layer governs the velocity of vertical flow i.e. how fast the chloride front moves. In the report (p. 5-27), a laboratory value of 0.5 is measured. In the model (App B, p.3-3, Table 3-2), a value of 0.1 for effective porosity is used. Although this value appears reasonable, more explanation is needed. A sensitivity analysis should be performed where the value of porosity is varied by factors of 0.5 and 2, and the resulting affect on the chloride plume discussed.	Mark Maimone	*The model was sensitive to the porosity of the confining unit, with lower values increasing the rate of movement of salt downward. This was tested, but with little field data to adequately defend a "calibrated" value, a low end value was selected to be conservative. This was consistent with the overall approach to modeling taken for the study.*
59	Jon Fenske	Appendix B			In the model document (App B, p.3-2, Table 3-1), results of a sensitivity analysis on the Kv of the Miocene confining unit are documented. Statistics for using a high Kv value should be included. Additionally, mean absolute residual should be included.	Mark Maimone	*The modeling approach selected was designed to avoid as much as possible issues of the adequacy of calibration and the potential for non-uniqueness affecting the results. This was done for two reasons. One, because it is difficult to obtain adequate, representative field data for several important parameters such as Kv and porosity of the Miocene confining unit. Second, to present a very conservative set of results to focus attention on the relatively limited impacts of dredging even with overly conservative assumptions, thereby avoiding a discussion on the accuracy of the model. For this reason, residual statistics for the various simulations are generally not provided.*
60	Jon Fenske	Appendix B			More justification is needed, for simulating the surficial aquifer as a constant head boundary. A constant head boundary represents an infinite source of water. With simulated groundwater pumping continuing for 200 yrs in the Upper Floridan, it may be possible for a drawdown from the wells to eventually affect the water table.	Mark Maimone	*This represents a conservative assumption, and is therefore in line with our overall modeling approach. Drawdown of the surficial aquifer would decrease the gradient, and thus slow the rate of salt water penetration. Maintaining fixed water table elevations maintains the gradient as it now exists into the future. Also, it should be noted that after 50 to 75 years of significant pumping in the Savannah area, no impacts to the water table elevation have been documented. Although this might still occur, significant drawdowns would not be expected considering the length of time already elapsed.*
61	Jon Fenske	Appendix B			The model was simulated under transient conditions for 200 yr predictive runs. There are no figures or tables that list the values of storage (specific yield and specific storage) required as input for transient runs.	Mark Maimone and Paul Hossain	*Added text to end of section 4.4.5.1 :"With little data available, conservative storativity and specific yield values were used. The values, applied to all layers and hydrologic units in the model, are 0.00001 for storativity, and 0.1 for the specific yield."*

USACE Comment #	Reviewer	Report Section	Page	Figure	Comment	Response Author	Response / Action
62	Jon Fenske	Appendix B			A more complete listing of calibration statistics would be helpful. Values to include are: mean residual, mean absolute residual, root mean square residual, standard deviation, maximum and minimum residual, head range, and residual standard deviation over head range. Additionally, a histogram of model residuals, and a 45-degree line plot of measured vs. simulated heads would be instructive.	Mark Maimone	*The modeling approach selected was designed to avoid as much as possible issues of the adequacy of calibration and the potential for non-uniqueness affecting the results. This was done for two reasons. One, because it is difficult to obtain adequate, representative field data for several important parameters such as Kv and porosity of the Miocene confining unit. Second, to present a very conservative set of results to focus attention on the relatively limited impacts of dredging even with overly conservative assumptions, thereby avoiding a discussion on the accuracy of the model. For this reason, an extensive discussion of calibration was purposely avoided.*
63	Jon Fenske	Appendix B			It would be very useful if the model calibration could focus on nested piezometer data above and below the confining layer.	Mark Maimone	*See USACE comment #62 above.*
64	Jon Fenske	Appendix B			The term 'verification" implies an unrealistic level of certainty in groundwater models.	Mark Maimone and Mackie McIntosh	*Agreed. Edited Headings to read "Calibration" instead of "Verification."*
65	Jon Fenske	Appendix B			The domain of the finite-element model was based on the USGS regional flow model and covered 42,250 square miles with 16, 362 triangular elements. Please provide justification for the grid spacing at the river of 125 ft. What is the approximate width of the river?	Mark Maimone and Mackie McIntosh	*The spacing was designed to place at least two nodes within the river in addition to nodes at either bank. In this way, the exchange of water between the river and the groundwater system could be adequately simulated. Added: "In order to represent the proposed dredging, discretization was finest in the area of the Savannah River to ensure the chloride source area (i.e. the river) was sufficiently defined. Node spacing was on the order of 125 feet within the river, which allowed any given transect across the width of the river to contain four nodes."*
66	Jon Fenske	Methods	4-21		Page 4-21 of the report states: "Typically, a calibration is considered adequate when there is no systematic head bias across the model, and the standard deviation of residuals should be within 10-15% of the total measured head gradient across the model domain". What is the reference for this? Replace the word "gradient" with "range".	Mark Maimone and Mackie McIntosh	*Agreed. The guideline was contained in the discussion during the development of ASTM, Standard Guide for Calibrating a Ground-Water Flow Model Application. ASTM Standard D 5918-96. CDM has generally used this as a guidance for model acceptability. Edited text to read: " According to ASTM Standard D 5918-96 Standard Guide for Calibrating a Ground-Water Flow Model Application, a calibration is considered adequate when there is no systematic head bias across the model and the standard deviation of residuals is within 10 to 15% of the total measured head range across the model domain."*
67	Jon Fenske	General			Model results clearly indicated that the proposed dredging does not represent a significant hazard to the Upper Floridan aquifer. The model included many conservative assumptions, and the model simulations provided a bracketed range of results to evaluate the probable range of impacts following dredging activities. However, future reviewers may question the reliability of porosity and K values. Additional information should be provided that provides full justification for all parameters and interpretation of model results	Mark Maimone	*At this point, we believe that the approach of using conservative assumption is a more robust approach than trying to justify parameter selection.*
68	Jim Landmeyer	Executive Summary	II		Page II, last paragraph, the statement "...that increased salinity in the Savannah River..." What caused the increase of salinity in the River? If you are referring to this at one location, does the deepening of the channel cause the saltwater wedge at the bottom of the channel to move landward? This needs to be made more clear.	Mackie McIntosh	*Edited sentence to read: "The porewater profiles and model results from this study indicated that both the increased salinity along the bottom of the Savannah River and the reduced thickness of the confining layer due to dredging will not significantly affect the timing of breakthrough of chlorides along the navigation channel in the Upper Floridan aquifer."*
69	Jim Landmeyer	General		Most Figures	The inset study map has coastal SC looking rather odd; no Hilton Head Island, and Charleston, SC looks like a secluded backwater. May need a higher resolution map, since it is used repetitively.	Mackie McIntosh	*Edited overview maps on all applicable figures.*
70	Jim Landmeyer	Overview	2-3		last paragraph, where it says "...drilling eight core borings..." you might want to add (SHE-1 to SHE-8), since they are located on the figure 2.2.	Mackie McIntosh	*Added SHE-1 to SHE-8 in parentheses.*

USACE Comment #	Reviewer	Report Section	Page	Figure	Comment	Response Author	Response / Action
71	Jim Landmeyer	Study Area	3-3		the Peck et al. reference should have the date (1999).	Mackie McIntosh	*Added 1999 in parentheses.*
72	Jim Landmeyer	Study Area	3-4		there was one plume (Smith 1988), but there are now 3 separate saltwater plumes identified in this area (the Ransom et al. reference is OK).	Mackie McIntosh	*Edited sentence to read: "The plumes associated with this lateral encroachment have been well documented as elevated chloride concentrations in Floridan wells at the north end of Hilton Head Island, South Carolina (Smith, 1988; Ransom et al., in press)."*
73	Jim Landmeyer	Study Area		3-3	the Legend contains items not yet shown on this graph – just delete the ones not shown (ie, chloride).	Mackie McIntosh	*See USACE comment #33 above.*
74	Jim Landmeyer	Methods	4-4		section 4.1.1., the last sentence is awkward; do you mean "...to ensure in-situ salt water..." (ie, drop the non).	Mackie McIntosh	*The "in-situ" salt water is what we are trying to capture. Non in-situ refers to all waters not associated with the porewater at any given depth, i.e. the overlying river or ocean water.*
75	Jim Landmeyer	Methods	4-6		Page 4-6 and throughout, our office is now called the "USGS Water Science Center."	Mackie McIntosh	*"USGS" is sufficient for this report.*
76	Jim Landmeyer	Methods	4-24		below Table 4-4, there should be a statement regarding the limitations that result when any numerical model simulation is run far out into the future; basically, the farther one gets away from the calibrated data set, the more uncertain and non-unique the results can become. Adding this caveat will provide some degree of liability insurance.	Mark Maimone	*Added text: "Simulations of future conditions become less certain the farther one gets away from the calibrated data set and selected input parameters. Future pumping rates and boundary conditions will change over time. The projection simulations done for this study assume a continuation of current conditions for the next 200 years, making results beyond the 20-year time horizon less and less certain."*
77	Jim Landmeyer	Results		5-9	the left-to-right order of the simulations is out of order (2000-2200-2050) and needs to be changed.	Mackie McIntosh	*See USACE comment #36 above.*

APPENDIX G

External Peer Review Documentation

External Peer Review Documentation

Proposed Savannah Harbor Expansion Project
Aquifer Evaluation
Supplemental Studies to Determine Potential Ground-Water Impacts to the Upper Floridan Aquifer

Table of Contents

1. Overview of External Peer Review Process

An external peer review (EPR) of the Aquifer Evaluation was performed by a panel of three independent experts upon completion of the independent technical review (ITR) process. The three appointed experts were recommended either by cooperating governmental agencies or the Aquifer Committee of the Stakeholders Evaluation Group as noted below and have no affiliation with the U.S. Army Corps of Engineers or any previous involvement with the proposed Savannah Harbor Expansion Project.

Nominating Agency	Reviewer	Reviewer Affiliation
SEG	Dr. Thomas Burbey	Virginia Polytechnic Institute and State University, Department of Hydrogeosciences
SCDHEC	Mr. Larry Hayes	Private Consultant (USGS South Carolina, Retired)
USGS	Ms. Eve Kuniansky	USGS Georgia Water Science Center

The reviewers were issued a copy of the Aquifer Evaluation report entitled *Supplemental Studies to Determine Potential Ground-Water Impacts to the Upper Floridan Aquifer*, dated 27 September 2005, which had been revised to incorporate comments from the ITR. The reviewers were also provided with a charge (see Section 4) to provide them with a basic study background and to facilitate their responses. The charge contained six questions, and the reviewers were given the option to use them as a guide or respond specifically to each question. One reviewer responded to the charge questions and provided additional comments, one reviewer responded only to the charge questions, and one reviewer provided comments to the report but did not respond to the charge questions. The original transcripts of comments are included as Section 5 of this Appendix.

A number of comments were broad in nature and/or focused on several overlapping themes, including the chosen conceptual approach for the modeling portion of the study. Responding to such comments in a matrix format was deemed impractical and insufficient; therefore, a general response was prepared in order to adequately address these concerns (Section 3.1). Responses to individual comments, including responses to comments that specifically answered the six charge questions, are summarized in a comment/response matrix (Section 3.2). The individual responses also include a summary of revisions that were incorporated into the Final Report.

Once responses were complete and revisions were incorporated into the Final Report, the appropriate functional chiefs, in this case Chiefs of Engineering in both Savannah and Wilmington Districts, were briefed as to the conclusions of the report and the nature of the comments provided. An EPR review package consisting of the documents that comprise this Appendix was then forwarded to the peer review leader at the National Deep Draft Planning Center of Expertise (DDNPCX) in Mobile District. The peer review leader, acting as a liaison, transmitted the package to the EPR reviewers along with a request for feedback regarding whether or not the responses adequately addressed their concerns. The peer review leader then added any feedback provided by the reviewers to the EPR review package and transmitted the package back to the authors. As of the publishing date of the Final Report, none of the peer reviewers had responded to the package of comment responses and revisions (see Memorandum for Record in Section 2 of this Appendix). Finally, the authors reviewed the EPR reviewer feedback and determined if any comment resolutions were disputed. The authors then briefed the functional chiefs with a summary of the feedback and made recommendations. For disputed comments/responses, the functional chiefs decided whether or not further action was required to resolve the comments and documented the decision in writing. The written response is included in Section 2 of this Appendix.

2. USACE Memorandums for Record

CESAM-PD 28 February 2007

MEMORANDUM FOR RECORD

SUBJECT: External Peer Review, *Supplemental Studies to determine Potential Ground-Water Impacts to the Upper Floridan Aquifer*

1. Subject document was provided to Mr. Larry R. Hayes (retired), Ms. Eve Kunianski (USGS), and Dr. Thomas J. Burbey (VPI) for review on 3 January 2006. The Charge to Reviewers is attached (attachment 1). Following their review the comments (attachment 2) were provided to the Savannah Harbor Improvements Team for response and revision of the report. The District responses are attached (attachment 3).

2. A copy of these responses was provided to the reviewers as a courtesy on 14 December 2006 with the request that if they wished to comment further based on the responses that we would be happy to consider these comments as well. No additional responses have been received.

3. Based on the fact that no additional comment has been made relative to the responses to original comments or revisions to the report, the External Peer Review is considered complete.

Susan Ivester Rees

Susan Ivester Rees, Ph.D.
Program Manager, Mississippi
Coastal Improvements Program

COMPLETION OF EXTERNAL PEER REVIEW

Proposed Savannah Harbor Expansion Project
Potential Aquifer Impact Study

Savannah District has completed the report *Supplemental Studies to Determine Potential Ground-Water Impacts to the Upper Floridan Aquifer* for the proposed Savannah Harbor Expansion Project. In accordance with USACE ER 1110-2-1150, ENGINEERING AND DESIGN FOR CIVIL WORKS PROJECTS, notice is hereby given that an independent external peer review, appropriate to the level of risk and complexity inherent in the project, has been conducted. Compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified during the external peer review process. This included: review of assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with existing Corps' policy. The external peer review was accomplished by a team of three independent experts in the field of ground-water hydrogeology.

CERTIFICATION OF EXTERNAL PEER REVIEW:

External peer review of this study resulted in minor revisions and strengthened the report; however, the comments provided did not result in revision of any of the report's major conclusions or recommendations. Comments not related to the modeling portion of the study generally concerned clarification and formatting and were addressed as revisions to the body of the final report. Comments concerning the overall approach, those pertaining to the conceptual model, or those that were broad in scope were addressed in a general response or alongside the original comment in a comment/response matrix included in the report's external peer review documentation (Appendix G).

As noted above, all concerns resulting from external peer review of the project have been considered.

Ralph E. Barnett
Chief, Engineering Division (Savannah District)

11 Sep 2007
(Date)

D. Wayne Bissett
Chief, Engineering Branch (Wilmington District)

14 Sept. 2007
(Date)

3. Response to External Peer Review Comments

Proposed Savannah Harbor Expansion Project
Aquifer Evaluation
Supplemental Studies to Determine Potential Ground-Water Impacts to the Upper Floridan Aquifer

Reviewer	Agency	Date Received
Dr. Thomas Burbey	Virginia Polytechnic Institute and State University, Department of Hydrogeosciences	07-Feb-06
Ms. Eve Kuniansky	USGS Georgia Water Science Center	07-Mar-06
Mr. Larry Hayes	Private Consultant (USGS South Carolina, Retired)	21-Mar-06

Response Author	Agency	Date Completed
Ms. Mackie McIntosh	USACE Savannah District	24-Oct-06
Dr. Mark Maimone	CDM	24-Oct-06

3.1 General Response to External Peer Review Comments

The Savannah District wishes to express thanks and gratitude to the external peer reviewers for their time and effort providing feedback regarding the draft report *Supplemental Studies to Determine Potential Ground-Water Impacts to the Upper Floridan Aquifer* (supplemental studies). The comments provided were instrumental in determining weaknesses, identifying areas of the report that needed clarification, and strengthening the document for final publication. The three appointed reviewers provided different backgrounds and experience in the field of hydrogeology, and their comments proved invaluable in gaining insight to how individuals from different perspectives may interpret the findings of the report. While the comments did not affect the conclusions or recommendations, the suggestions provided allowed the authors to refine the arguments presented and ultimately strengthen the Final Report.

Most of the comments were specific in nature and referred to individual pages or figures in the document. After compiling the comments from all three reviewers it became apparent, however, that a significant number of comments were broad in scope and focused on several recurring themes. Responding to these comments on an individual basis would not only be impractical but also insufficient; therefore, it was determined that a general response clarifying the original scope of work and study approach would be the most effective way of addressing the concerns presented by the three reviewers. This general response to comments addresses concerns related to these broad, overlapping comments. Specific responses to individual comments and requested revisions that were incorporated into the Final Report are included as Section 3.2 of this Appendix.

A number of the comments concerned the ground-water modeling approach (EPR comments 2, 3, 17, 33, 63, 68, 94, 124, C-1), and in particular, why the chosen model was not rigorously calibrated (EPR comments 2, 6, 25, 26, 84). The authors agree that the approach taken is somewhat unorthodox, and, in order to understand why this approach was chosen, it is important that reviewers know the history of the aquifer studies and how the authors arrived at the chosen conceptual model. The authors initially did not feel it was appropriate to include such information in the main body of report, and the tone of comments provided during the independent technical review (ITR), which were provided by reviewers who generally were familiar with the aquifer studies since their inception in the mid 1990's, supported this notion. Instead, the model objectives were clearly stated in the charge to reviewers (p. 35 of this Appendix). Upon receipt of the external peer review (EPR) comments, however, it became apparent that the chosen modeling approach should have been more thoroughly explained for readers who are unfamiliar with the project.

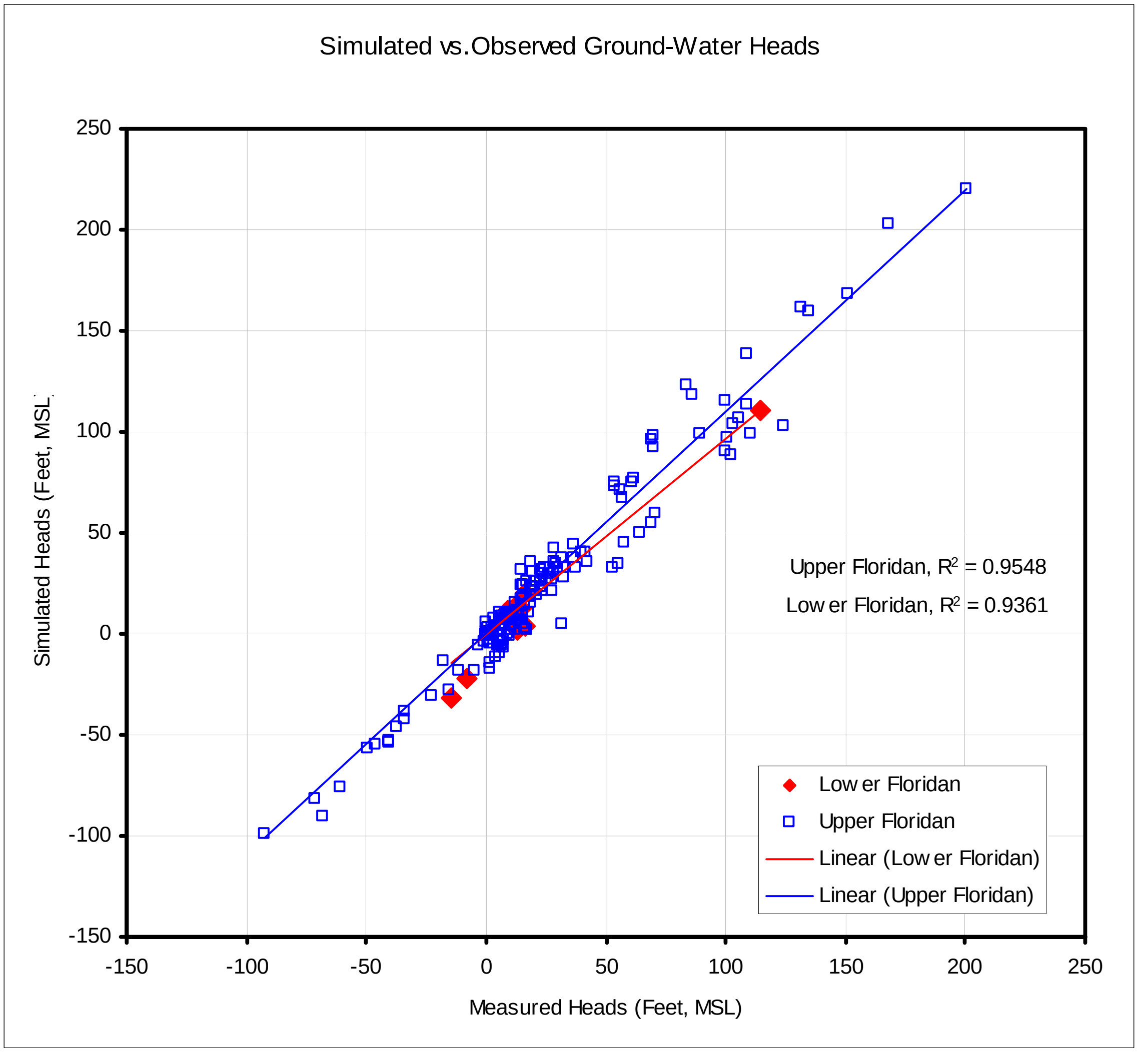
As noted in the Project Overview section of the report, the supplemental studies were commissioned following the release of the 1998 report *Potential Ground-Water Impacts*, which was completed as part of the Savannah Harbor Expansion Feasibility Study and the Tier I Environmental Impact Statement (EIS). The 1998 report concluded that the quantity of water moving vertically through the confining unit within the navigation channel was insignificant when compared to the quantity of water moving laterally through the Upper Floridan aquifer; therefore, the proposed dredging would have no noticeable effect on the quality of ground water within the Upper Floridan aquifer. The scope of the initial aquifer studies was small, however, and field data presented in the report was somewhat limited. Following the release of the report, it was determined that expanded field studies and data analysis were needed to ascertain the validity of the report conclusions. In order to outline a proposed plan of study, the SEG formed an Aquifer Committee and a Working Group sub-committee. The Working Group, which consisted of ten technical representatives from various public and private agencies, developed a plan of ten potential study tasks with specific objectives, including a scope of work (SOW) for the ground-water model portion of the study. A series of iterative discussions took place from 2001 to 2002 between members of the Working Group plus a number of technical experts and vested parties who were familiar with the area and the project, including representatives from the SEG, U.S.

Geological Survey (USGS), South Carolina Department of Health and Environmental Control (SCDHEC), Georgia Environmental Protection Department (GAEPD), and Georgia Ports Authority (GPA) and U.S. Army Corps of Engineers (USACE). The Working Group held several meetings and participated in an online forum to discuss potential study tasks and eventually narrowed the scope to the six major tasks that comprised the supplemental studies, including the 3-D coupled flow and transport ground-water model. The Working Group submitted their recommendations and proposed SOW to the Aquifer Committee, who then submitted a final proposed study plan to the SEG in June of 2002.

In October of 2002, a small group of agency representatives outlined a specific technical proposal for the supplemental studies ground-water model. Using the SEG final proposed study plan as guidance, the representatives agreed that the ground-water model was intended to act as a screening tool to verify the conclusions from the 1998 report. The recommendations from the meeting, as summarized from 2002 and 2003 correspondence with CDM, indicated that the results would be presented as a difference in downward flow of salt water through the channel for the pre- and post-dredging scenarios. The focus of the model structure "should not be on whether the correct set of values can be estimated through rigorous calibration, but rather what the results from the range of values are saying about the significance of the (dredging) impacts." The memo also stated that the input properties should be conservative, and "if results with conservative assumptions when translated into chloride concentration changes in the Upper Floridan were shown to be minimal, that should suffice." The model, as agreed upon, was not intended to "establish pre- and post-project rates of intrusion everywhere, only through the (navigation) channel." Instead, the model would focus on a range of values and the significance of any dredging impacts, not the absolute chloride concentrations in the Upper Floridan aquifer. Furthermore, the memo specifically states that the model should not be designed to answer the larger questions of salt-water intrusion in the Savannah area.

Using the model as a screening tool rather than performing a full-blown modeling study allowed the authors to shift emphasis to a bracketed range of reasonable responses to dredging impacts instead of one unique solution. The authors implicitly recognized the non-uniqueness of the model; this was intended from the outset. All realistic scenarios are included in the bracketed range of results, and the impact of the results was the same regardless of which end of the range is closer to the most likely outcome. The model results indicated that dredging would not significantly impact the rate of salt-water intrusion at either end of the range of results, thereby affirming the unimportance of finding a unique solution.

Provided this background, it is reasonable to question that, if the model was not intended to simulate regional salt-water intrusion, then why was a regional domain applied? At the time the supplemental studies objectives were being formulated, the Georgia Coastal Sound Science Initiative (SSI) was initiated. The SSI workplan, published in February 2000, tasked the USGS with developing a regional ground-water flow and solute transport model to characterize salt-water intrusion in the coastal Georgia region. The USGS implemented a multi-million dollar data collection and analysis program applied over several years and made the data available for use by outside parties, and the data in and around the Savannah area was detailed enough to allow for evaluating impacts solely along the navigation channel. At the time the supplemental studies model objectives were being refined, the USGS had already completed a working conceptual model and a fully-calibrated, documented flow model that encompassed the supplemental studies project area. It follows logically that the technical experts and vested parties, both as a cost savings and as an acknowledgement of the tremendous and thorough efforts of the USGS, would incorporate the existing data and flow model into the supplemental studies approach. Upon gaining technical approval of the modeling approach, CDM replicated the USGS flow model (layering, boundaries, properties, pumping, etc.) and refined the grid structure in the supplemental studies project area. Using their proprietary code, they were able to reproduce and match simulated versus observed heads very well as shown in the graph below.



It is important to reiterate that the refined grid structure incorporated USACE historical and recent geological, geophysical, and porewater data along the navigation channel to ensure sufficient resolution and model accuracy. During the development process, the CDM model was able to closely replicate the small scale data very well when superimposed on the larger scale regional flow model as shown in Table 3-1 of Appendix B (see below).

A number of the EPR comments focused on the chosen value of vertical hydraulic conductivity (Kv) for the Miocene confining layer (EPR comments 29, 43, 45, 47, 50, 122, 123, C-3, C-4, C-5, C-10, C-11). Based on the comments received, the authors realize that the discussion in

Appendix B should have been broadened to include the results of all Kv values (low, mid, and high). As such, the model simulations were run using the high-value Kv (1.50E-03 ft/day), and the results are included as Attachment 1.

Table 3-1 from Appendix B is expanded below to include the simulated heads and calibration statistics of all three Kv values compared to USGS Well 37Q185, located near the center of the cone of depression:

Sensitivity Parameters		Calibration Statistics		Upper Floridan Head At Well 37Q185	
Unit	**Vertical Hydraulic Conductivity (ft/day)**	**Mean Difference (ft)**	**Standard Deviation (ft)**	**Simulated (ft MSL)**	**Observed Mean Year 2000 (ft MSL)**
Miocene Confining Layer	Low-Value 1.50E-05	-5.5	12.4	-126.7	-96.8
	Mid-Value 1.50E-04	-1.121	10.86	-100.8	-96.8
	High-Value 1.50E-03	4.49	14.5	-66.7	-96.8

As shown above, the simulated head distribution using the mid-value Kv was the most accurate when compared to field data. On the low end of the range, a reduction in the Kv by an order of magnitude resulted in simulated heads in the cone of depression in the Upper Floridan aquifer to be about 30 feet too low when compared to field data. Using the high-value Kv, the cone of depression was simulated 30 feet too high. An expanded list of sensitivity runs is summarized below, each of which indicates that the chosen low, mid, and high-value Kv values best represented a broad range of plausible results:

Miocene Confining Unit Sensitivity Runs			Simulated Head At Well 37Q185	Comparison to Field Data At Well 37Q185 (-96.8 ft MSL)	
Description	Property	Vertical Hydraulic Conductivity (ft/day)	Upper Floridan (ft MSL)	Mean Difference (ft)	Standard Deviation (ft)
Sensitivity Analysis Run 4	44,52, &64, Kv=0.15E-5	1.50E-6	-144.1	-8.42	16.145
Sensitivity Analysis Run 3	44,52, &64, Kv=0.15E-4	1.50E-5	-126.7	-5.5	12.4
Baseline, Recalibration of Miocene Confining in Savannah Area	44,52, &64, Kv=0.15E-3	1.50E-4	-100.8	-1.121	10.86
Sensitivity Analysis Run 5	44,52, &64, Kv=0.15E-1	8.25E-4	-76.8	2.96	13
Sensitivity Analysis Run 2	44,52, &64, Kv=0.15E-2	1.50E-3	-66.7	4.49	14.5
Sensitivity Analysis Run 1	44,52, &64, Kv=0.15E-1	1.50E-2	-31.8	8.133	19.171

The calibration statistics also indicated that the mid-value Kv is more accurate than either the low or high-value, and both the high-value and the mid-value vertical hydraulic conductivities resulted in simulated chloride concentrations at the bottom of the confining unit that were significantly higher than those measured in the SHE boreholes. In fact, the high-value Kv simulation results (see Attachment 1 Figures 1-12) showed initial salt water concentrations completely penetrating the Miocene confining unit, which is clearly not indicated by field observations. Based on the results of the tables and plots above and comparison with measured porewater values, the data suggests that the actual Miocene confining layer properties are probably bracketed between the low and mid-value Kv.

A number of EPR comments indicated that the reviewers did not feel the model results were representative of a "worst-case scenario" or even conservative, and most comments referenced the choice of Kv for the Miocene confining unit to support this notion (EPR comments 43, 45, 47, 50, 122, 123, C-3, C-4, C-5, C-10). The reviewers generally thought that the model results were closer to a most-likely or expected response. The authors concede that the mid-value Kv may be close to the real value and not necessarily conservative. Applying the mid-value Kv in the flow model, however, overestimated the depth of chloride penetration in the solute transport model; therefore, the authors feel that applying the mid-value Kv yielded conservative results.

Regardless, simulations were also run forward in time with a 1-year time-step for a period of 200 years using the high-value Kv. The year 2000 simulated distribution of chlorides in the Miocene unit was used as the initial condition (Figures 1-12 in Attachment 1) despite the fact that using the high-value Kv showed significant penetration of chlorides into the Miocene confining units as of "today" (i.e. the start of the projection simulation). Figures 13-24 in Attachment 1 show the simulated chloride profile results for both the no-dredging and dredging scenarios, and figures 25-55 show individual time histories at selected borehole locations and production wells. Overall, the simulation results and the figures support the same conclusions drawn in the main report: the difference in chloride concentration in the Upper Floridan aquifer between the results of the dredging scenario and no-dredging scenario were small, and dredging the channel would not significantly impact the rate at which vertical salt-water intrusion is occurring.

There were, in addition, a number of other conservative assumptions built in to the model (see Section 4.4.5.2 and excerpt below) that, when combined, indicate that the range of model results for the low and mid-value Kv were indeed conservative:

> *The model simulations intended to provide a bracketed range of results to evaluate the probable range of impacts following dredging activities. In order to accomplish this objective, several conservative assumptions were used in the input parameters as described above in Section 4.4.5.1. In summary, the conservative assumptions applied to the model simulations were:*

- *Pumping rates from the Upper Floridan aquifer in the Savannah area were assumed to remain as they are at present although withdrawal rates are expected to decrease in the future.*

- *The model utilized the simulated present-day chloride distributions (as opposed to observed porewater values). These values generally overestimated penetration concentrations when compared with measured porewater values.*

- *The model was sensitive to the porosity of the confining unit, with lower values increasing the rate of movement of salt downward. This was tested, but with little field data to adequately defend a "calibrated" value, a low end value (0.1) was selected to be conservative.*

- *Paleochannel in-fill material was assumed to have hydraulic properties comparable to that of surficial aquifer sands, although actual core permeability results indicate the paleochannels contain a significant amount of material that is less permeable.*

- *Three additional feet of confining layer material were assumed to have been removed throughout the project area to allow for possible disturbance by the cutter-head during dredging activities.*

- *Historical simulations were run using current-day navigation channel geometry and depths.*

The EPR reviewers also expressed concern about the choice of modeling only the chloride sources within the navigation channel (4 square miles) instead of modeling the entire chloride source area (1,200 square miles), or about half the entire area contained within the zero contour of the cone of depression (2,300 square miles) (EPR comments 17, 63, 124, C-1). The authors agree that modeling the entire source area would further dwarf the impacts of dredging on water quality in the Upper Floridan aquifer. In fact, it is reasonable to state that had the entire source area been modeled, it would have been very difficult or impossible to discern impacts specifically due to thinning the confining layer along the navigation channel (i.e. dredging). However, the SOW for the supplemental studies was very clear: to examine dredging impacts, not pumping impacts, on water quality in the Upper Floridan aquifer. The USGS was tasked with modeling regional pumping impacts at a refined scale; whereas, the objectives of the supplemental studies were much narrower. The authors felt that eliminating other source areas was the most effective way to evaluate impacts specifically due to dredging and potentially the only way to isolate and discern the enhanced chloride intrusion specifically due to dredging. In addition, the data available along the navigation channel was very detailed, but there was very little to no data available in other areas. The available data may not be representative of areas outside the navigation channel and within the cone of depression, i.e. in areas overlain by salt marshes.

Both the ITR and the EPR reviewers provided valuable input, and the revisions resulting from their comments will significantly strengthen the aquifer studies Final Report. It should again be noted that the comments provided did not result in revision of any of the major conclusions or recommendations set forth in the Draft Report. Comments not related to the modeling portion of the study generally concerned sentence clarification, typographical errors, or figure formatting, and the authors intend to address the majority of these comments as revisions to the main body of the Final Report. Comments concerning the overall approach, conceptual model, or those that were broad in scope are addressed either in this general response or alongside the original comment in the comment/response matrix included in Section 3.2 of this Appendix.

3.2 Comment / Response Matrix

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
1	1 (General)	General			Throughout the report I was waiting to see a map view illustration showing the saline concentration of the channel and bay areas. This gives the reader a framework to understand where the source of the saline water may originate from.	*The Atlantic Ocean, rivers and creeks, and salt water marshes, all of which are shown in maps throughout the report, are sources of salt water. In the Savannah area, this accounts for approximately 1,200 square miles, or about half the area of the cone of depression (as noted in Section 3.2.). The average bottom salinity of the Savannah River is provided in cross section format in Appendix B. Generally speaking, the surface salt-water wedge extends well beyond the upstream extent of the navigation channel (sta. 109+000).*
2	2 (General)	General			My biggest concern has to do with the modeling investigation. I don't think it's good to assume that what's good at a regional scale works at a small scale. The objectives of the USGS regional model are quite different than the objectives and goals of this investigation. It is the objectives around which a conceptual model is built. Thus, for different objectives one should assume that a potentially very different conceptual and ultimately numerical model will ensue. My point being that your key objective is the navigation canal and its potential connection with the underlying Upper Floridan Aquifer by way of the Miocene confining unit. This is the focus and your model should have more adequately detailed this unit instead of using the layering of the regional model. More layers should have been used to simulate this unit. However, this was not by biggest concern. I was more concerned that you never discussed your method of calibration. You simply state what the model was calibrated to without stating your method. (Continued)	*We used the USGS model as a basis for a number of reasons. Using their extensive research and calibration efforts lends credibility to our model, and avoids duplication of effort and wasted funds. Our modeling objectives are different, as you note, and we have changed the grid and added additional detail along the river to meet our specific objectives. The layering scheme is identical to the USGS for the reasons stated above, however, we added many additional layers for contaminant transport, as needed, to get more detail on the movement of chlorides through the Miocene. The response on calibration is provided in the General Response.*
3	3 (General)	General			Related to the modeling effort, the layering within the Miocene should be more refined. I believe at least 5 layers should be used to better simulate the chloride movement through the unit. Table 2-2 of Appendix B is confusing to me. You're relating the model units between the regional model and the Savannah Harbor model and layer 7 is listed as "not present" in your model. Well what is layer 7 simulated as then? Also related to layering, what was the justification for one model layer for the Upper Floridan? The only real justification is if all the pumping wells are fully penetrating and the layer is dominated by horizontal flow. However, if pumping in the Savannah area induces vertical flow in this unit, then you must consider using additional layers to simulate the potential for vertical flow components that could enhance vertical flow through the Miocene confining unit. (Continued)	*Layer 7 of the USGS model did not have the advantage of the local boring data along the river. In their model, the Miocene aquifer was assumed to occur beneath the river. We corrected the USGS model assumptions by removing the Miocene aquifer in the area of Savannah, replacing it with Miocene confining unit as shown in the borings. Using one layer for the flow system in the Upper Floridan matched the USGS model. Flow is dominated by horizontal flow in the Upper Floridan aquifer, and most supply wells are effectively acting as fully penetrating of the upper permeable zone. We do use additional layers in the contaminant transport runs, but not in the flow simulations. Other than these changes to fine tune the model to local data, the parameter distribution is the calibrated distribution of USGS publications.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
4	1	Introduction	1-1		There are numerous references to places in the text that do not show up on an illustration. According to the USGS publication "Suggestions to Authors", every formal place that is discussed in the text must be shown on an illustration. On page 1.1 in the introduction Oceans Bar and the Georgia Ports Authority are used as the beginning and end of the study area channel, yet neither are shown on a map. There were several other occurrences where places or data points were provided in the text without a location reference via illustration.	*Figure 1-1 revised to include the text references.*
5	2	Study Area		3-5	On Figure 3-5, water level is used in the top figure where potentiometric surface should be used instead. Water level typically refers to an unconfined aquifer or water table. On the same illustration, I would recommend using one color for seawater. In the illustration you have the saltwater wedge as pink and the ocean as green.	*Figure 3-5 was taken from a USGS publication, and we feel it adequately illustrates the regional hydrogeologic setting. The color differences are used to distinguish between surface water and ground water, which, in this study is an important distinction in order for the reader to understand both the lateral and vertical mechanisms that contribute to salt-water intrusion. Changed "water level" to "potentiometric surface" as suggested and updated source citation.*
6	3	Methods	4-3		On the top of page 4-3, "worst case dredging scenario" is extremely vague at this point of the report. I suggest a better description of what you mean here.	*"Worst-case" refers to a maximum project depth of 48 feet below MLW and the associated overdepth dredging allowances. Edited text on page 4-3 to include definition.*
7	4	Results	5-3		On page 5-3, first and last line on the page refers to figure 5-3. In both cases it should be figure 5-4.	*Corrected text to refer to Figure 5-1, which is a cross section along the length of the navigation channel.*
8	5	Results			Many of your linear plots of concentration would be much better represented as log plots. For example Figure 5-2 would more accurately represent the data if the Chloride concentration was plotted as Log Cl.	*The point is noted and will be taken into account in future publications. The authors felt that, for this study, it was important to point out the fluctuation in values, especially within paleochannel material. Log plots would tend to minimize these fluctuations, therefore, in order to present the data in the most transparent manner, linear plots were more appropriate.*
9	6	Results			On page 5-13, in referring to the seismic interpretation, you mention the "yellow reflector", yet there is no yellow in figure 5-3, which the statement is referring to.	*Replaced figure with section showing all four prominent reflectors.*
10	7	Results		5-1	Many of the boreholes shown in figure 5-1 are not shown in plan view. It would be helpful if these were shown in plan view.	*Edited cross sections and maps appropriately to show all boring locations in both plan view and cross section.*
11	1	Appendix A			Well written, documented, and defended. Congratulations to the authors.	*No response needed.*
12	2	Appendix A	2		It has been . . . than currently exists. It seems to me the issue of concern is not removal of "higher-permeability sediments", which are insignificant in retarding the downward movement of saltwater relative to the much lower permeability of the Miocene confining unit, but possible removal of the lower-permeability Miocene confining unit. Where dredging would remove only the higher permeability fill sediments, you have an opportunity to show that natural erosion has a much greater impact on saltwater intrusion than dredging would.	*The authors agree that the impact of removing paleochannel material is to some degree not significant when compared to the removal of confining layer material. In the past, however, the SEG and local media have focused on the paleochannels and their potential impacts on the rate of salt-water intrusion. As such, it was deemed necessary to perform a more detailed investigation and explicitly address these concerns.*
13	3	Appendix A	28		If these relic... than currently exists. Same comment as above. Your statement is only true if deepening the channel would reduce the thickness of the lower-permeability Miocene confining unit.	*See response to EPR comment #12.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
14	4	Appendix A			Should include a "defense" of software programs used to analyze data to justify that software is appropriate and valid for intended usage.	*HYPACK MAX is a proprietary software package developed by Coastal Oceanographics to perform exactly the types of analyses that were completed as part of OSI's deliverables. It is the industry standard for marine surveying and subbottom profiling, and OSI was instrumental in its development and implementation. HYPACK MAX is also the Corps-wide standard survey software package for marine surveying and subbottom profiling.*
15	5	Appendix B	1-1		Should spell "CDM" out the first time it is used.	*CDM is no longer referred to as "Camp, Dresser, and McKee, Inc" in their publications. Edited text in main report to eliminate reference to "Camp, Dresser, and McKee, Inc.".*
16	6	Appendix B	1-2		In Section 3, authors discuss potential increase in chlorides in various wells due to dredging and consequent migration of saltwater moving downward through the sediments underlying the Savannah River and the migration to the wells. Yet no discussions occur in the section on "Model Calibration" and "Model Application" about lateral flow and solute transport. Why not?	*Horizontal transport to the wells is not the focus of this investigation, and no data were available to calibrate transport of chlorides within the Upper Floridan aquifer. We believe that, by providing relative changes between dredging and non-dredging conditions, we have addressed the proper objectives of the study, even if the absolute concentrations and timing of impact are not accurate. We do list the flow parameters for the Upper Floridan aquifer in section 2, however, without data, our ability to simulate accurately the concentrations reaching supply wells and the length of time it takes for chlorides to reach the wells cannot be tested or calibrated.*
17	7	Appendix B	1-2		Other chloride sources... in the simulations" These "other chloride sources" may be the more significant source of high chlorides into the Upper Floridian Aquifer, with chlorides due to dredging being relatively insignificant. I understand your intent to try to show that part of the saltwater contamination due only to dredging, but in doing this you have missed the opportunity to show the relative insignificance of dredging versus natural sources of saltwater contamination. Your approach also puts you in the position of having to provide a rigorous defense that your model can simulate point to point flow and transport of chlorides through a limestone aquifer with considerable variations in vertical and lateral flow characteristics. If your model is "truly" calibrated, you should be able to simulate the "real world conditions" of natural recharge/discharge impacts and dredging impacts to a composite saltwater contamination scenario. (Continued)	*Although it is clear that including all the other sources would emphasize even more the marginal impact of dredging on chlorides in the Miocene and Upper Floridan aquifer, modeling other sources would have greatly added to the complexity of the simulations and opened the discussion up to a larger question not relevant to the study. As for point to point flow through limestone, the model results and conclusions are based on simulated transport within the Miocene confining unit as opposed to absolute concentrations in the Upper Floridan aquifer. See the General Response for discussion related to calibration.*
18	8	Appendix B	2-1		You say the DYNFLOW code has been reviewed and tested and documented, but omit any discussion of results. You should discuss strengths and weaknesses identified in the testing and results that would support use of the code as it applied in this report.	*DYNFLOW has been reviewed and tested, and the appropriate documentation is referenced. In addition, certification documentation for each code is included in this appendix. The SHE aquifer studies were never intended to be a full blown modeling study; therefore, discussion of strengths and weaknesses and general background information on modeling codes was not included. See General Response for discussion regarding development of the conceptual model and modeling objectives.*
19	9	Appendix B	2-2		Same comment as above, but perhaps even more so since solute transport codes by their very nature may be more difficult to validate for specific uses.	*See response to EPR comment #18.*
20	10	Appendix B	2-4	2-4	No head boundaries are given for north boundary of model.	*See Appendix B, page 2-5, section 2.4.4.. All boundaries are no flow boundaries except for those indicated in Figure 2-4 as fixed head boundaries.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
21	11	Appendix B	2-4		Tetra Tech, November, 2004 is not included in list of references.	*Added "Tetra Tech, unpublished data. 2004." to References Section 8.*
22	12	Appendix B	2-4	2-5	Suggest you be consistent with rest of report and give chlorides in mg/L.	*Consistent units are used throughout the Main Report. As backup documentation, the current text is sufficient.*
23	13	Appendix B	2-4		Harvey, 1969 is not included in list of references.	*Added reference to report.*
24	14	Appendix B	2-4		You say "This (rising water boundary) was not used in the model." Yet in replying to ITR comment 49 (John Clarke) you say "some of river nodes [were] assigned a rising node" and table 4-2 of main report shows rising nodes being used.	*Added Text to Appendix B, page 2-5, section 2.4.6..*
25	15	Appendix B	2-5		You need to defend use of fixed heads for the water table (2.4.6). See ITR comment 19 (Clarke).	*The use of fixed heads for the surficial aquifer was a useful simplification. Long term data has shown that surficial aquifer heads have not changed appreciably despite the large increase in pumping in the Upper Floridan aquifer. The surficial aquifer heads were calculated from well data by the USGS and adjusted using more local wells available. Two sets were used, one for pre-development, and one for present day, with intermediate values used for the historic simulation. Changes were small in the Savannah area , and the changes in head in the surficial aquifer were less than 5% of the change in the Upper Floridan between 1900 and 2000. Thus, the leakage from the surficial aquifer to the Upper Floridan across the Miocene confining unit is largely unaffected by small changes in the surficial aquifer heads.*
26	16	Appendix B		2-6 through 2-10	You need to give a zero reference for the vertical scale, i.e. MLW or MSL or whatever. Also, the scale should be expanded to more clearly show thicknesses of units of importance, i.e. the Surficial Aquifer, Miocene units, and Upper Floridan Aquifer.	*All figures in Appendix B are referenced to MSL. Edited figure and added an inset map of the Savannah area.*
27	17	Appendix B	2-6		No levels are shown in Table 2-2; also layers 5 and 6 are not given a Savannah Harbor Area Hydrologic Unit name. Why not?	*Levels are the boundaries of layers. See Figure 2-1 of Appendix B for a graphical explanation. Since the Miocene aquifers are known to be missing along the channel area, there is no separate Upper Floridan confining unit, it is simply an extension of the Miocene confining unit. This was discussed with the USGS once it was apparent that the Miocene aquifer was absent beneath the river.*
28	18	Appendix B		2-11 through 2-17	You say "Figures 2-11 through 2-17... entire model domain". You must describe the basis upon which these figures were developed, including reasons for differences in horizontal and vertical hydraulic properties, and regional differences. In using both lines of equal thickness and colors, neither of which is defined on the thickness maps, some of the maps become cluttered and barely readable. Suggest that either color or lines of equal thickness be used but not both. Also, whatever you use must be clearly defined on the map using a standard legend format.	*We believe that the figures are adequate to display the general pattern of hydraulic conductivities and thicknesses. We have chosen to base our model on the extensively researched USGS regional model. Our mid-Kv model is identical in most cases to the USGS regional model (see Payne et al., 2005), and information on hydraulic properties and distribution is available from the USGS. In addition, USACE field data along the Savannah River was used to adapt the regional model to a localized scale appropriate for the Study Area.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
29	19	Appendix B		2-12	This is perhaps the most important figure of the seven. Yet the thickness layer is difficult, if not impossible, to decipher because of the problems mentioned above. This "Model Layer Thickness" part should be expanded in scale to more clearly show the confining layer thickness over the Savannah River area. Also, in Appendix B, figure 2-12, do the hydraulic properties and thicknesses shown in these figures represent values used in the model's river and nearby nodes? Statements on page 2-9 indicate a "yes" to this question. Thus, the use of 1.5E-4 appears to be the "expected or most likely value" not a "conservative" value as stated on page 2-9. Lastly, it is surprising to see that the vertical and horizontal conductivity are the same in a unit consisting of layers of sand and clay as presented in Appendices D and E. Do you have any evidence to support that vertical and horizontal conductivities are the same in the Miocene Confining unit?	*We believe that the cross-sections provide the needed detail along the river to judge the thickness of the Miocene confining unit, rather than the plan view, which is intended to provided an overview of USGS values. The hydraulic properties are identical to those in the USGS model, and further explanation is provided in Payne et al., 2005. Based on the homogeneity of most of the core samples taken of the Miocene material, the horizontal hydraulic conductivity might not be that dissimilar to the vertical. Sensitivity testing showed, in any event, that the model was not sensitive to the Kh of the Miocene confining unit.*
30	20	Appendix B	2-6		Ground Water Recharge Section 2.7: Need to present a defense for use of fixed heads in the surficial aquifer considering the importance of recharge from the surficial aquifer to the Upper Floridian Aquifer in those areas where pumpage has considerably lowered the Floridian heads.	*See response to USACE comment #25.*
31	21	Appendix B	2-6		Need to defend using the year 2000 pumping for future pumping. It is hard to accept it is a "conservative" approach to limit pumping to the 2000 rate considering the present and future population growth in southern Beaufort and Jasper counties and in the coastal area of Georgia. As a check what differences exist between 2005 to 2000 pumping rates?	*Pumping in the future should be addressed by GAEPD. We used a simple assumption based on a current understanding of State policy. Recently released GAEPD document, "Coastal Georgia Water and Wastewater Permitting Plan for Managing Salt Water Intrusion," indicates that Chatham and Effingham Counties will reduce pumping from the Upper Floridan aquifer by 5 MGD by the end of 2008. USGS water usage data indicates that usage in Chatham county has decreased from a peak of 90 MGD in 1990 to current levels which hover around 80 MGD (Fanning, 2000). There is no data to indicate a predictable increase in pumping in nearby South Carolina counties in the future. Furthermore, it is not our objective to model pumping impacts during the next 100 years, but to compare dredging to non-dredging conditions. We don't believe that varying the future pumping will materially affect the conclusions about dredging impacts. See General Response for discussion involving overlapping regional studies.*
32	22	Appendix B	2-7		Section 2.9.1: Refer to USACE [ITR] comments 62 & 63 by Jim Fenske. I agree with these comments, and do not believe the author has adequately addressed these comments.	*In fact this was not the intended design of the model. Our modeling objectives are outlined in the General Response and focus on the relative difference in impacts with and without dredging by bounding the problem. See General Response for discussion on development of the conceptual model, use of the existing USGS model, and calibration of the SHE model.*
33	23	Appendix B	2-7		"This modeling study... effect on results." If the model is uncalibrated, one may be able to test model sensitivity to various input parameters, but cannot relate results to actual (real world) flow in transport conditions. Also, isn't the real design of the modeling study to construct and calibrate a flow and transport model that can be used to simulate with reasonable accuracy the potential intrusion of seawater (chlorides) into the Upper Floridan Aquifer?	*See response to EPR comment #32 and General Response.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
34	24	Appendix B		2-21	the small scale and clutter of Figure 2-21 makes it difficult to decipher comparisons, especially in the deep cone of depression surrounding Savannah. This figure does not meet acceptable graphic standards, and should be redrawn at a larger scale to acceptable graphic standards.	*Edited figure and added an inset map of the Savannah area.*
35	25	Appendix B	2-7		"Typically a calibration…the model domain." Need to provide the basis for this statement, especially the part about "10 to 15% of the total measured head gradient across the model domain" where an extremely deep cone of depression exists due to pumping.	*Keeping the standard deviations within 10 percent of the range of values found in the model is a general guideline found in ASTM standards. A cone of depression makes it more difficult to match heads, but also increases the range of values, making the impact on the percentage difficult to assess. In any event, whether we consider the -100 MSL heads as part of the range or not, we are within 10%.*
36	26	Appendix B	2-7	2-21	Section 2.9.1: Need to describe hydraulic and geohydrologic input data used in this steady state calibration. A reader can assume these data are those discussed in Sections 2.6 through 2.8, but one should not have to make an assumption of this type.	*Correct. Model accuracy tests used the parameters described in sections 2.6 through 2.8.*
37	27	Appendix B		2-22 through 2-23	Because of the small scale, it is very difficult, if not impossible, to clearly compare results between the two models in the area of most interest, i.e. areas adjacent to the Savannah River where dredging may occur. This figure should be reconstructed at a larger scale.	*Edited figure and added an inset map of the Savannah area.*
38	28	Appendix B	2-8	2-17	Section 2.9.2: Figure 2-17 shows hydraulic properties and thicknesses of the Lower Floridan, do you mean Figure 2-18?	*Edited text to include correct figure reference (Figure 2-18).*
39	29	Appendix B		2-24 through 2-26	Need to discuss basis of construction for these figures.	*Pre-development is represented by a steady state simulation with all pumping removed from the modeled area. The same lateral southern boundary conditions as current day were used because they had no effect on the results in the area of interest. Surficial heads are fixed for each decade, and are varied by decade as discussed in Appendix B on page 2-8.*
40	30	Appendix B		2-24 through 2-26	All of these figures fail to meet standard graphic standards and are in need of improvement (explanations of features shown or figures incomplete, missing, or unclear).	*We feel the figures are of sufficient quality to convey the intended message.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
41	31	Appendix B	2-8	2-27 through 2-28	These figures are difficult to analyze because the measured and simulated heads overlap and run together in the latter years. The importance of these figures warrant their reconstruction at a larger scale showing clear definition between measured and simulated heads. On figure 2-28, well 37Q016, the simulated heads show a large dip that is not shown by the measured heads. This discrepancy should be explained.	*The scale of the graphics was selected to provide an impression of the model's ability to reproduce long term trends (1900 through 2000) in response to changes in pumping. Calibration was not the focus, and thus more detailed figures were not considered to be useful. The model used 10-year averages for pumping, missing year to year changes in the actual pumping. Thus the response of the model is not always matching the data. It is most likely that the dip is caused by inaccurate representation of pumping in the model. This would not affect the results of the projection simulations nor the conclusions of the report in any significant way.*
42	32	Appendix B		2-29 through 2-40	"illustrate the measured and simulated chloride..." But figures 2-30 and 2-37 have no measured values. You should acknowledge this or delete the figures. Top of Miocene and top of Upper Floridan (Should spell UF out in all figures.) should be solid lines to be consistent with symbol explanations. Chloride concentration and penetration differences between simulated and observed values should be explained. Observed chloride value data points should be shown on figures. Simulated values are based on the year 2000; are measured values from the year 2000? If not, use of data from a different year should be acknowledged and justified.	*We recognize that on several figures, no field data were available, but we included the figures to complete the run of the river simulation results. We believe the figures are of sufficient quality to make the point of a general match between simulated chloride concentrations and measured chloride concentrations in the Miocene, taking into account the extreme variability of the data based on local heterogeneity. Additionally, as explained in the report, the year 2000 simulated chloride values from the Tetra Tech Model were used as the initial condition, not observed values. This was necessary in order to incorporate the projected surface-water bottom salinities after dredging. Because the intent is to bracket the actual results, we don't wish to encourage close examination of the match in the figures. We believe it emphasizes the wrong thing (focus on calibration, not on our overall approach). Note also that our model is aimed at matching decade long pumping and transport trends. To this end, we found it acceptable and logical to use 2000 as the start of the projections, as opposed to 2001 - 2005 when data were collected.*
43	33	Appendix B	2-9		but is perhaps...of saltwater. The case has not been made that 1.5E-4 is a conservative conductivity value. Report data and analysis suggest 1.5E-4 is the expected or most likely conductivity value. If by conservative the author means a higher conductivity value than expected, which would result in greater than expected saltwater intrusion, a conductivity value on the order of E-3 would be conservative, likely resulting in simulated saltwater penetration to be deeper and chloride concentrations to be greater than would realistically be expected. A value in the E-3 range as conservative is supported in data contained in Section 3 of the main report.	*We agree that the mid-Kv is the most likely hydraulic conductivity, but because of the other conservative assumptions and the fact that simulated values were consistently higher than observed values at the bottom of the Miocene confining unit, we believe that the mid-Kv simulation still represents an over-prediction of rate of chloride penetration. Additional information, including the simulation results of the high-Kv, is provided in the General Response to strengthen the case.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
44	34	Appendix B	2-9		Note that in … 2-35 and 2-38. A careful look at these figures does not support the above quoted statement. Figure 2-30 does not contain any measured data, and Figures 2-29, 2-31, 2-35, and 2-38 do not show reasonable matches between observed and simulated chloride concentrations until near the top of the Upper Floridan. Chloride concentration differences between observed and simulated values throughout the Miocene confining unit should be explained.	*The modeled chloride concentrations of the mid-Kv and low-Kv were intended to bound the actual chloride concentrations in the Miocene confining unit. No data exist for the Upper Floridan aquifer. Exact matches were not the intent, but over prediction using the mid-Kv was intended. The actual data shows the effects of many local heterogeneities in the system such as paleochannels and variation in hydraulic properties. These localized variations, however, tended to follow the same consistent trend once the porewater hit the Miocene confining unit. These could not be simulated with averaged properties, so an exact match was not attempted. Discrepancies between the concentration at the top of the Miocene taken from the surface water model, and those measured near the top of the Miocene pore water occur as well, but in most cases, the model was somewhat higher. We needed to use model values rather than measured because we needed the surface water model to provide projected concentrations of chloride at the bottom of the river for dredged conditions.*
45	35	Appendix B	2-9		"A second set… the two simulations." Data and analyses form the main report and supporting appendices do not support saying "The true system response lies somewhere in between the two simulations." The preponderance of evidence presented in the report and supporting appendices suggest that I.5E-4 is a reasonable or most likely value for the vertical conductivity of the Miocene confining unit, not a conservative value, and simulations made using 1.5E-4 would unlikely show results decidedly skewed towards either underestimates or overestimates of saltwater penetration - assuming the model is adequately calibrated for its intended use. To bound probable system response, three simulations are needed - a simulation using 1.5E-4 (most likely case), a simulation using 1.5E-3 (worst or "conservative" case resulting in greatest saltwater intrusion), and a simulation using 1.5E-6 (best case resulting in least saltwater intrusion). (Continued)	*A third simulation was run with the high Kv value. Results are provided in the General Response.*
46	36	Appendix B	3-1		"generally result in… higher than measured." Data and analyses contained in Section 2 do not fully support the above statement. Figures 2-31, 2-35, and 2-38 show that in parts of the Miocene confining bed observed values of chloride are higher than simulated values. The authors should discuss possible alternate reasons for these differences within the Miocene, and then select and defend their preferred explanation for the differences. Also, no observed chloride values are available for the Upper Floridan; consequently, no comparison can be made between simulated and observed chloride values in the Upper Floridan, which leads to questions about how can one defend model calibration, and it's ability to simulate with reasonable fidelity chlorides in the Upper Floridan.	*In most of the plots, the simulated salt water penetration is deeper, and at higher concentrations, than the data show for the mid-Kv, and even for some of the low-Kv plots. For some shallow data, especially within the paleochannels, the reverse is true. This is probably due to local sand lenses which are not adequately modeled by our lumped parameters. We could not attempt to model all the local heterogeneities present in the Miocene confining unit and did not expect to match local fluctuations. The samples taken deeper into the confining unit at lower elevations are the focus of the comparison, and the model's conservative nature is generally demonstrated.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
47	37	Appendix B	3-1		"the calibrated value...sets of results." Data and analyses do not support that "the true conditions are bounded by the two sets of results". Data and analyses support using 1.5E-4 (calibrated value) to represent "true conditions". This "true condition" is bounded on the "best case" level (value of conductivity that is likely to show saltwater penetration to be less than would be expected under "true conditions"), but is not bounded on the "worst case" level (use of a value of conductivity that is likely to show saltwater penetrations to be more than would be expected under "true conditions").	*See response to EPR comment #43 and General Response.*
48	38	Appendix B	3-2		Table 3-1 shows simulated head 30 feet too low, not 25.	*Corrected text to read 30 ft.*
49	39	Appendix B	3-2		"but the model somewhat overstated the rate of penetration." As discussed above, if penetration into the Upper Floridan is being implied, no observed data are shown to support that simulated chlorides are greater with depth than observed chlorides. It should be acknowledged that chloride comparisons are available only for the Miocene confining unit.	*The report is clear that data are available from pore water only from the Miocene confining unit. The expectation that chloride concentrations in the Upper Floridan would be overestimated seems reasonable if the model is overestimating the breakthrough concentration at the bottom of the Miocene. That is the basis of the statement.*
50	40	Appendix B	3-2		Table 3-1: See USACE [ITR] comment 59 (Fenske). For reasons presented in my above comments, I fully support Fenske's comment, and urge the authors to implement his suggestion. The authors' response to Fenske's comment and discussion on page 3-7 and 3-2 do not adequately address the concerns.	*See General Response.*
51	41	Appendix B	3-2		"the higher vertical... Floridan chloride concentrations." Since no observed chloride data were shown for the Upper Floridan in the SHE boreholes (figures 2-29 through 2-40), what is the basis for saying the higher conductivity value results in "unrealistic Upper Floridan chloride concentrations "? Also, it may be that higher simulated chloride concentrations in the Miocene result from the model ignoring dilution effects since it is not unreasonable to expect that low chloride water moving horizontally through relatively permeable sands in the Miocene unit is mixing with high chloride water moving downward from the overlying saltwater sources. Until various reasons for chloride differences between simulated and observed values are identified and discussed, no sound basis exists for simply assuming the differences exist because "conservative" conductivity values are used as model input. Remember, the chloride concentration difference also exists even when using the calibrated value, "which represents the mid range of reasonable values".	*We do not believe that horizontal flow in the Miocene confining unit is a major factor. Beneath the river, there is no Miocene aquifer, and every core taken showed a pliable, homogeneous, clay-like material. We believe that it is unlikely that horizontal flow in the confining unit would have a major effect on chloride concentrations with only small, thin, dead end pockets of sand in a clay/silt matrix present. It is true that there are no data in the Upper Floridan aquifer to show concentrations of chlorides due to downward leakage of salt water through the Miocene confining unit. However, our contention that we would overestimate future chloride concentrations in the Upper Floridan is based on our belief that we are overestimating the rate of salt water penetration of the Miocene confining unit (See also Main Report section 5.2.). Either way, the focus is on the difference between dredging and non-dredging simulations, which are not affected much by the discussion of the proper Kv value for the Miocene (See also General Response).*
52	42	Appendix B	3-2	3-1 through 3-3	These figures are very difficult to decipher because of too many similar colors. These figures would be improved if colors were used only for chloride concentrations, and if geohydrologic units were defined by another method. A reference needs to be given for the vertical scale. A-A and B-B should be labeled as A-A' and B-B' to clearly show relation of cross sections to location maps. Titles should include "simulated chloride" before "concentrations" and "current" should be defined.. No explanations of blue and red lines and of vertical and horizontal scales are given. These figures should be reconstructed to standard graphic requirements.	*We agree but will not attempt to change this in the backup documentation of Appendix B. This problem was addressed in Figure 4-10 of the Main Report.*
53	43	Appendix B	3-3		two different values... potential impacts. as discussed before, "range of potential impacts" may not be bracketed.	*See General Response for simulation results using the high Kv value.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
54	44	Appendix B	3-3		On page 3-2, it is stated that initial model input is based on the year 2000 (figures 3-1 and 3-2), but in Section 3.3 1990 is shown as start of simulations. What is correct? Is a 200 or 210 year simulation used?	*We started the simulation in 1990 to avoid initial condition instability. The results were documented and analyzed starting in 2000, so we prefer to refer to it as a 200 year simulation.*
55	45	Appendix B	3-4		Concentrations after 200 years After 210 years if 1990 was starting year as presented on page 3-3. Need to resolve confusion about "starting year".	*See response to EPR comment #54.*
56	46	Appendix B	3-4		Should include in narrative and in Figures 3-5 through 3-16 actual conductivity values (1.5E-4 and 1.5E-5) used in the simulations (Don't leave reader guessing.).	*We feel the figures are of sufficient quality to convey the intended message. Figures presented in the main report will be updated to include K values.*
57	47	Appendix B		3-5 through 3-16	Include actual conductivity values for "A" (1.5E-4 ft/d). As presently presented, titles for "A" are incomplete. A possible title for "A" could be "Simulated Chloride Profiles at SHE [borehole number] using a vertical conduction value of 1.5E-4 for the Miocene Confining Unit". A similar title should be used for the "B" graphs. Color lines for top of Upper Floridan and Miocene should be consistent with Legend (Legend shows "unbroken" lines, whereas the lines on the graph are "broken".	*See response to EPR comment #56.*
58	48	Appendix B	3-4		"The results show… consequent dilution effect." For clarity suggest wording to read "due to considerable horizontal flow of fresh water within the aquifer mixing with and diluting the relative very low volume of saltwater migrating downward from the Savannah River".	*Adapted suggested verbiage in main report. As backup documentation, wording in Appendix B is adequate.*
59	49	Appendix B		3-7 through 3-28	Chloride scales for these figures should be expanded to more clearly show differences between dredging and no-dredging simulations, i.e. 0-100 mg/L, or 0-250mg/L or… as appropriate based on upper chloride levels. Reasons for "fluctuations" embedded in chloride trends should be discussed. As mentioned before, graph titles should give conductivity values used for "A" and "B" plots (1.5E-4 ft/d and 1.5E-5 ft/d respectively). For the reasons given in a number of my previous comments, a third plot using 1.5E-3 ft/d is needed to truly bound expected chloride concentrations.	*Focusing attention on the chloride concentration does not match the intent of this approach (see also the General Response). This places too much emphasis on absolute concentrations, which will be inaccurate because other sources are ignored. Also, although the mid-KV is the most likely value for the vertical hydraulic conductivity of the Miocene confining unit, the assumed porosity is low. Thus the results are generally overpredicting depth of penetration and the timing of breakthrough. For these reasons, we believe the figures adequate to make the point that dredging will not significantly alter the rate of salt water movement. Results for the mid-Kv are still representative of an upper bound, but this is further supported by the high-Kv simulation results shown in the tables in the General Response.*
60	50	Appendix B		3-17	Title and Legend on "B" give SHE-5. Should title and legend read SHE-15?	*Corrected figure.*
61	51	Appendix B		3-18	Similar problem as above. Either the "B" plots are on the wrong figure or are labeled incorrectly.	*Corrected figure.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
62	52	Appendix B	3-5	3-17 through 3-28	The concentrations shown are computed for the top 50 to 60 feet of the Upper Floridan. Yet, the figures' titles read "Concentrations at the top of Upper Floridan Aquifer". Figure titles should be revised to show agreement with the text wording. The rationale for selecting the "top 50 to 60 feet" should be explained. If the top 10 feet of the Upper Floridan would have been selected, would simulated chloride concentration plots have differed significantly from those given in this report?	*The top 50 to 60 feet of the Upper Floridan aquifer was the depth to which particles tended penetrate, prior to lateral movement toward the pumping center in Savannah. It is probable that flow is concentrated in discrete permeable zones within the Upper Floridan aquifer, and the model does not attempt to simulate these zones. According to USGS, in most cases the upper permeable zone is considered the top 200 feet of the Upper Floridan aquifer. In the absence of data, we believed that 60 feet was a reasonable assumption. If we used a larger depth of penetration, simulated concentrations would decrease. We do not believe that the absolute concentrations simulated in the Upper Floridan aquifer are all that accurate because of the difficulty of simulating high and low flow zones, and of course, because only the dredged area of the river is simulated as a source. However the main concern is the comparison between dredging and non-dredging, not the expected concentrations (See also General Response).*
63	53	Appendix B	3-5		Should explain why 250mg/L was selected as "breakthrough" value and its significance. I really don't see the justification for ignoring the importance of the composite effects of all sources of saltwater contamination (amount due to both the Savannah River and other sources of saltwater) that could cause chlorides to exceed 250mg/L (the EPA limit). It is the composite sources of chlorides that are of importance to those who wish to obtain fresh drinking water supplies (chlorides less than 250 mg/L) from the Upper Floridian. Even a small increase in chlorides due to dredging could be significant if chloride concentrations without dredging are close to 250 mg/L.	*250 mg/l is simply the EPA drinking water standard, and thus a convenient value to use. The authors disagree that even small contributions from dredging are significant if concentrations are close to 250 mg/L; if Savannah area pumping rates remain the same, total chloride concentrations in nearby production wells are expected to exceed the drinking water standard regardless of whether or not the proposed dredging occurs. Any potential increase specifically due to the proposed dredging is negligible when compared with the contributions from other chloride sources (i.e. the Atlantic Ocean). See also General Response.*
64	54	Appendix B		3-30 through 3-52	Should give actual Miocene confining unit vertical conductivities used for simulations "A" (1.5E-4 ft/d) and "B" (1.5E-5 ft/d). As said before, a third case using a Miocene confining unit vertical hydraulic conductivity of 1.5E-3 ft/d should be presented as a bound for the worst case.	*See response to EPR comment #56.*
65	55	Appendix B		3-30 through 3-48	Reasons for the fluctuations imposed on the chloride trends should be explained.	*The fluctuations are primarily caused by the modeling method. We use particles of a certain "weight", representing a discrete amount of chloride. These particles are summed and divided by the amount of water in the aquifer where the particles occur. Because of the large number of particles required to simulate the entire river, the particles have a certain size, which means that taking a concentration at a particular time step will be subject to some variation depending on whether an additional particle just enters the layer or falls just short. More particles would smooth out the results but result in uneconomical simulation time requirements.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
66	56	Appendix B	3-5 and 3-6	3-30 through 3-48	I assume from the statement made on page 3-5 ("for the top 50 to 60 feet of the Upper Floridan Aquifer.") that model simulations are based on flow through the "top 50 to 60 feet of the aquifer". Evidence has been given by previous investigations, however, that show much of the flow through the Upper Floridan may take place through high-permeability zones consisting of only a small percentage of total aquifer thickness. Could this "preferred flow" occur between the Savannah River and the wells used in Figures 3-30 through 3-48 and, if so, what would the impact be to breakthrough times and chloride values?	*We don't believe the simulated concentration of chloride at wells would be appreciably different if the total flow reaching the wells occurred through a few high permeability zones, or as simulated using our distributed flow through a matrix approximation. It is likely, however, that the time of travel could be less if these zones flow faster than our equivalent hydraulic capacity. Unfortunately there are no data to test these conclusions. Aside from the change in timing, the change with and without dredging would not be significantly different, so the conclusion that dredging has little significant impact would not change.*
67	57	Appendix B	3-6	3-49 through 3-52	These are important figures and should be expanded in scale to more clearly show differences between dredging and no dredging. All the expanded figures should include lines of equal head showing the potentiometric surface of the Upper Floridan Aquifer. The "Year 2000" maps should include any available field measurements of head and chlorides allowing the reader to compare simulated and measured values. These figures as drawn do not meet normal graphic standards (no explanation of vertical and horizontal scales, no statement of conductivity values used for Figures 3-45 and 3-52 - reader should not have to assume what conductivity values were used.	*The importance of these figures should not be overstated. We are not showing the cause of the chloride penetration of the Miocene confining unit to the Upper Floridan aquifer, which we know to be the steep gradient between the surficial aquifer and the Upper Floridan aquifer. Because only the river is included as a source, the distribution and concentrations are not really relevant or realistic. The figures are meant to convey a side by side overview showing the minimal difference between dredging and non-dredging scenarios. These figures, placed side by side in Figure 5-9 in the Main Report, make this point adequately.*
68	58	Appendix B			USACE [ITR] comments 54, 57, 60, 62, 67 bring out important weaknesses in the modeling approach that have not been adequately resolved. This along with concerns expressed in my review comments lead me to question the validity, conservatism, and defensibility of simulation results and analyses presented in Appendix B and in various sections of the main report, "Supplemental Studies to Determine Potential Ground-Water Impact to the Upper Floridan Aquifer". Nor is it clear to me that the model has been adequately calibrated for its intended purpose - simulation of transient flow and chloride transport vertically through the Miocene consigning unit and then horizontally through the upper 50-60 feet of the Floridan Aquifer.	*See General Response. We disagree that the model approach selected does not adequately address the question of dredging impacts. We believe that the model results, as presented, already demonstrate that dredging impacts on Upper Floridan water quality will not be significant. Suggestions to broaden the modeling effort and to focus on model calibration, although it might strengthen our arguments, would merely enhance an adequately documented conclusion at great expense and parallel a study already being carried out by the USGS.*
69	59	Appendix C			Insufficient documentation is provided to show that the GIS Analysis is valid for intended use. How would an independent reader know that the software and subroutines perform as intended in constructing Miocene thickness maps and other maps?	*The ArcGIS Desktop suite and its extensions are the industry standard for creating, importing, editing, querying, mapping, analyzing, and publishing geographic information. The intended purpose of this report was to provide a visually-enhanced representation of the history of the navigation channel and the underlying geologic framework. In this report, the GIS analyses are used to qualitatively assess the exposure of the Miocene confining layer through time and examine the geologic framework underlying the navigation channel. The Arc extension applications, although capable of doing so, were not intended in this report to be used for quantitative channel design applications.*
70	60	Executive Summary			For reasons given in review of Appendix B, I am not convinced "true conditions" are bracketed. For this and other concerns raised in my review, I question conclusions based on model simulations presented herein, in Section 63 of the Summary, and in the conclusion.	*The authors disagree that true conditions are not bracketed. Conservative assumptions and comparison of field data with simulated flow and transport indicate that the model overpredicted the rate of salt-water intrusion. In order to further support these conclusions, simulation results using the high-Kv value are included in the General Response.*
71	61	Overview	2-1		"MLW" should be defined the first time used.	*Corrected text on page 2-1.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
72	62	Study Area	3-2		Heron and Johnson, 1966 not given date on list of figures.	*Added date to citation in References. Heron and Johnson is used as a text reference on page 3-2. Figure 3-2 is adapted from Clarke et al., 1990 as noted on the figure, not Heron and Johnson.*
73	63	Study Area	3-2	3-1	The elevation of... roughly - 95 feel MLW Figure 3-1 shows the top of the Oligocene at about -120. If you don't wish to reference the bottom paragraph on page 3-2 to Figure 3-1, some other reference should be given.	*Edited text to indicate this is a specific reference to the study area along the navigation channel. Figure 3-1 is a generalized regional cross section; Figure 3-4 shows a more site-specific cross section that shows the specific elevations mentioned in the text.*
74	64	Study Area	3-3		Should provide reference for unit elevation given in discussion at top of page.	*The geologic framework was previously presented in sections 3.1 and 3.2; the documentation and references provided in those sections apply here as well. Unit thicknesses in study area determined from USACE boring data. The data was collected and/or analyzed during this study; therefore, there is no outside reference.*
75	65	Study Area	3-5		Can significant be qualified, i.e. percentage amount?	*As noted in the next clause, nearly half the water budget, or 40 MGD. Added "40 MGD" to text.*
76	66	Study Area	3-7		Should provide reference of unit elevations.	*See response to EPR comment #74.*
77	67	Study Area	3-7		Date for "(Fanning, 1990)" is 1999 in list of references.	*Corrected text citation to read "(Fanning, 1999)."*
78	68	Study Area	3-9		Should provide reference for unit thicknesses given in top paragraph.	*See response to EPR comment #74.*
79	69	Study Area	3-10		Should provide a reference for unit thicknesses given in middle paragraph.	*See response to EPR comment #74.*
80	70	Study Area		3-4	Should define genesis of all boreholes (SHE boreholes in dark type and SHE boreholes under these contained within parenthesis) in Legend. All symbols used in a figure should be defined in the figure legend.	*See response to EPR comment #7. Simplified figure and expanded legend to eliminate confusion.*
81	71	Study Area		3-6	Normally, contour numbers are included within a break on the contour line. This avoids guessing what contour value goes with what contour line. Can this be done in this figure where contour spacing allows?	*Edited figure and contour labels as suggested.*
82	72	Study Area			Congratulations for a well written section.	*No response needed.*
83	73	Methods	4-2		seven marine continuous borings and "two additional land borings" give boring numbers so a reader can go to Figure 4-1 and locate the borings.	*Added "(SHE-11 through SHE-17)" and "(SHE-18 and SHE-19)" to text.*
84	74	Methods	4-3	4-1	Section 4.1: "nine additional borings" Figure 4-1 shows 11 not 9 borings.	*GaDOT sponsored the drilling and porewater sampling conducted at SHE-9 and SHE-10 in 2001-2002. Technically, they are not part of the supplemental studies, but the data is meaningful and is included in this report. Clarified legend on Figure 4-1 and added sentence to methods section 4.1.2 to indicate genesis of borings SHE-9 and SHE-10. Their origin is also mentioned in the porewater results section 5.2.*
85	75	Methods	4-4		occasional core losses can occasional be quantified, i.e. percentage of losses?	*Added core recovery percentage (greater than 75% for all borings) to text.*
86	76	Methods	4-4		Section 4.1.2: "Two land borings" Figure 4-1 shows four land borings (SHE 19, SHE 10 and SHE 18) and these same land borings are discussed on page 4-9. Why are SHE 9 and SHE 10 not discussed in Section 4.1.2?	*See response to EPR comment #84.*
87	77	Methods	4-4		Section 4-2: "downward flow accounts" Should acknowledge the importance of other "portion[s] of the water budget" which are considerably more significant than vertical flow through the Miocene confining bed.	*The authors agree. See General Response regarding overlapping regional studies versus isolating effects specifically due to dredging.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
88	78	Methods	4-6		Section 4.2.1.1: "a procedure was... at SHE-9" Why was this procedure done only at SHE-9? Since this procedure was done only at SHE-9, how can one be assured that fresh water in the drilling fluid did not migrate into the core samples (especially into the more permeable zones), thus "contaminating" core samples with relatively fresh water? What were the selection criteria for the "given cross section"? Was this the only section tested or were other sections tested?	*The procedure was performed as a method validation check, and it was not feasible to perform this procedure on each individual boring. Water quality was continuously monitored throughout the drilling process, and core samples chosen for porewater analysis were consolidated and visually uncompromised. Free water was generally not visible on any given cross section of core, and only structurally intact cores were chosen for analysis. The consistency and homogeneity of Miocene cores within the study area indicated that repeating this procedure was not necessary. All these indications suggest that fluids did not migrate through the entire cross section of core; the "procedure" referenced was simply a way to validate that this indeed was the case.*
89	79	Methods	4-13		Garza and Krause, 1994. Date is 1996 in References, Section 8.	*Corrected text citation to read "(Garza and Krause, 1996)."*
90	80	Methods	4-15		"model was tested... and chloride concentrations" compelling evidence has not been presented confirming that the model can "adequately reproduce" chloride concentrations. Data shown in Appendix B, Figures 2-29 through 2-40 show that the model simulated chloride values differ considerably from observed chloride values, and no data are presented that show how well, or how poorly, the model is able to simulate chloride values in the Upper Floridan Aquifer. Thus, in using the model to simulate chloride transport through the Upper Floridan, the model is being used to simulate a set of conditions outside the conditions for which the model has been calibrated.	*The model was not intended to predict Upper Floridan well chloride concentrations. The model results and conclusions are based on simulated transport within the Miocene confining unit as opposed to absolute concentrations in the Upper Floridan aquifer. See also General Response regarding overlapping regional studies, isolating effects specifically due to dredging, and the development of the SHE conceptual model.*
91	81	Methods	4-16 through 4-17		Section 4.4.3.1: See my comments given in Appendix B.	*See General Response.*
92	82	Methods			Table 4-2: Boundary conditions should be defined here, or reader should be pointed to where these boundary conditions are described in Appendix B.	*Added text: "See Appendix B, Section 2.4. for further discussion regarding boundary conditions."*
93	83	Methods	4-20		Section 4.4.3.5: "the 2000 pumping... into the future". See my comments given in Appendix B.	*See response to EPR comment #31.*
94	84	Methods	4-22 through 4-27		Section 4.4.4.2 and 4.4.5: See my comments given in Appendix B.	*See EPR comment #33 and General Response.*
95	85	Methods	4-25		"general consensus among ... in the areas." A "general consensus" is not the same as in-place regulations or restrictions. To check this "consensus", differences between the years 2000 pumping to the year 2005 should be compared. Also, can you really ignore the increases in pumping taking place in nearby Jasper and Beaufort Counties, South Carolina?	*See response to EPR comment #31.*
96	86	Methods	4-27		"withdrawal rates are expected to decrease in the future." What evidence exists for this statement?	*See response to EPR comment #31.*
97	87	Methods	4-33		(Ransom and White, 1998) No date for this reference provided in Section 8, References.	*Corrected text in References Section 8.*
98	88	Results	5-1		Miocene units A and B suggest insert "Table 3.1" to help reader put these units into a framework relative to other sediments.	*Inserted reference to Table 3-1.*
99	89	Results	5-1		lower boundary of... from -40 to -50 MLW. Suggest you insert Figure 3-4.	*Inserted reference to Figure 5-1.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
100	90	Results	5-1		relict channels the Pleistocene Seems wording is incomplete.	*Added "indicated" to complete sentence (carries over to page 5-2).*
101	91	Results	5-2		Boring SHE 318 (Figure 3-3): Do you mean Figure 3-4? There is no Figure 3-3, and Figure 3-3a and 3-3b do not show any contacts.	*Corrected figure reference (Figure 5-1).*
102	92	Results	5-2		"Huddleston (1988)" is not included in Section 8, References.	*Added reference to Section 8: Huddleston, P. F., A Revision of the Lithostratigraphic Units of the Coastal Plain of Georgia. Georgia Department of Natural Resources, Environmental Protection Division, Georgia Geologic Survey, Bulletin 104, 1988. 162p.*
103	93	Results	5-2		Talmidge Bridge (Figure 3-3). Is the correct reference Figure 3-4?	*Corrected figure reference (Figure 5-1).*
104	94	Results	5-2		What is the meaning of "historically"?	*In this case, historically refers to borings that were not completed as part of the supplemental studies. Clarified sentence to better convey point.*
105	95	Results	5-3		contact at 67 MLW (Figure 3-3). Is the correct reference Figure 3-4?	*Corrected figure reference (Figure 5-1).*
106	96	Results	5-3		Bartholomew et. al. (2000) is not included in Section 8, References.	*Added reference to Section 8: Bartholomew, M.J., Rich, F.E., Whitaker, A.E., Lewis, S.E., Brodie, B.M., and Hill, A.A., Neotectonic features of the Lower Coastal Plain of Georgia and South Carolina. In, Abate, C, and Maybin, B.(eds.), A Compendium of Field Trips of South Carolina Geology with Emphasis on the Charleston, South Carolina Area, South Carolina Department of Natural Resources, Geological Survey, 2000. p. 19 - 30.*
107	97	Results	5-3		at SHE-14(figure 3-3). Is the correct reference 3-4?	*Corrected figure reference (Figure 5-1).*
108	98	Results	5-4		"The resulting profiles" If these are the profiles shown in Figures 2-29 through 2-40, Appendix B, these figures should be referenced.	*The profiles referenced here are the observed porewater values as the title of the section implies and as discussed in the sections following, not the simulated profiles in Appendix B.*
109	99	Results	5-4		Section 5.2: "All profiles indicated...with increased depth." Considering the chloride fluxuations with depth given in Table 5-1, Figure 5-1, shown in Figures 2-29(SHE-15), 2-31(SHE-19), 2-32(SHE-19), 2-33(SHE-10), 2-34(SHE-18), 235(SHE-11), and 2-38(SHE-14), this statement is somewhat misleading and should be revised to acknowledge and discuss chloride concentrations fluxuations with depth.	*The section includes a discussion of the fluctuations on page 5-9. The statement is true, and the interjection of the word "overall" indicates that there are indeed fluctuations/variations to be discussed further down. We have in no way tried to hide the data or indicate that the fluctuations are not significant. The fluctuations are discussed twice in Section 5.2.2. and again in the porewater profile summary (Section 5.2.3.).*
110	100	Results	5-4		Section 5.2.1: "The profiles show...with descending elevations." See above comment	*See response to EPR comment #108.*
111	101	Results	5-4		50 percent to 5,252 mg/L. Table 5-1 gives 5,253 mg/L as the highest value.	*Corrected text to read "5,253 mg/L."*
112	102	Results	5-4		no values above 100 mg/L below the Miocene A/B contact. Table 5-1 gives a chloride value of 176 below the Miocene A/B contact (first sample in the Miocene B unit).	*Sample P-6 (167 mg/L) was taken from Miocene unit A. Corrected table to reflect correct geologic unit.*
113	103	Results			Table 5-1: SHE-16 shows a chloride concentration in the top of the Oligocene (top of Upper Floridian) of 24 mg/L, and borehole SHE-14 shows a chloride concentration in the top of the Oligocene of 151 mg/L. It should be explained why these chloride values significantly exceed the chloride values at the bottom of the Miocene B unit.	*The aquifer may have higher background chloride concentrations at those locations (which would result in higher porewater concentrations), but there is no data exists to determine if that is the case. It could also potentially be related to sample integrity. The occurrence of soft, pliable limestone was rare (hence only two samples) and tended to be relatively unconsolidated when compared with the Miocene material. The lack of data and lack of confidence in the data led us to not use the results in any sort of significant decision-making process, hence the lack of discussion.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
114	104	Results		2-29 through 2-40	Because of the close tie to Table 5-1 and Figures 2-29 through 2-40, a common elevation reference should be used.	*Appendix B (Figures 2-29 through 2-40) is back-up documentation for arguments presented in the main report, and the authors believe it serves its purpose. Granted, ideally, Appendix B and the main report would be referenced to the same datum. Editing all elevation references in Appendix B, however, would require a significant effort that is outside the scope of the existing contract with CDM.*
115	105	Results			Table 5-1: Why, for SHE-15, are P-1 and P-2 shown at the bottom of the table instead of on page 5-5 with the other SHE-15 samples?	*The table is set up by boring name as two columns, and the incidental location of the page break separated the data from the remainder of the values at that boring location. Formatted the table to allow the reader to more easily navigate the data.*
116	106	Results	5-6		concentration (7209 ms/L) was observed... the riverbed (-41.3ft MLW). Table 5-1 shows this sample at a depth of -52.5. Which is correct?	*The -41.3 ft MLW refers to the elevation of the bottom of the river. The sample was collected at -52.5, app. 18 feet below the river bottom, as noted in Table 5-1 and in text. Added sample elevation to text to clarify.*
117	107	Results	5-7		fluctuated from 1.264. Table 5-1 gives low chloride value as 901 mg/L not 1.264.	*Corrected text to read "901 mg/L."*
118	108	Results	5-13	5-3	the yellow reflector. There is no yellow reflector shown on Figure 5-3.	*See response to EPR comment #9.*
119	109	Results	5-17 through 5-22		Ground Water Model: See comments made in Appendix B.	*See General Response.*
120	110	Results	5-23		Can a reference be given for the Clemson University test conducted in [sic] 1997?	*Added reference to text and Section 8: Sharp, W., Watson, S., and Hodges R.A., Aquifer Performance Test Report: Tybee Island Miocene (Upper Brunswick) Aquifer, Chatham County, Georgia, March 19-March 23, 1997. Clemson University Department of Geological Sciences, 1997. 18p.*
121	111	Results	5-27		Section 5.6.4.1 Suggestions in USACE comment 58 (Fenske) should be implemented.	*We tested the effects of porosity on the rate of chloride penetration early in the modeling effort. Porosity and transport rate are linearly related. Presenting additional results based on porosities higher than the low end one used (0.1) would not add to the presentation any vital additional information (See also General Response).*
122	112	Results	5-27 through 5-32		Table 5-5: See comments provided in Appendix B. All of the data shown herein seem to support the use of about 1.5E-4 as a realistic average values for the vertical hydraulic conductivity of the Miocene confining unit (a "realistic or expected" value, not a "conservative" value).	*See response to EPR comment #43 and General Response.*
123	113	Summary	6-1		In addition, the model... and no dredging conditions. Data and analysis does not support that true conditions" have been bracketed" yielding a best-case and worst-case scenario". Data and analysis support using 1.5E-4 ft/d for the "true conditions" scenario and 1.5E-5 ft/d for the "best case" scenario. To bracket "true conditions" a worst-case scenario needs to be provided. A vertical hydraulic conductivity of around 1.5E-3 is reasonable for the worst-case scenario.	*See response to EPR comment #43 and General Response.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
124	114	Conclusions	7-1		The pore water profiles...city of Savannah. Authors provide some evidence and analyses in support of the above conclusion. But, this reviewer believes that weaknesses exist in data analysis and model development and use that could be used to challenge to the final conclusion. Also your case is weakened by omitting years 2000 to 2200 simulations in the Savannah area showing (1) chlorides due to existing sources without dredging, (2) expected chlorides due to existing sources and dredging, and (3) a large-scale map showing differences between dredging and non-dredging simulations, with a statistical analysis included in the discussion of differences quantifying to the extent reasonable the significance of dredging to total chloride concentrations. After all, the proposed dredging area is relatively insignificant compared to presently existing sources of chloride.	*See response to EPR comment #17 and General Response.*
C-1	C-1				I suggest that the document conclusion could be strengthened by including years 2000 to 2200 simulations in the Savannah area showing three cases: (1) chlorides due to existing sources without dredging; (2) a composite of chlorides due to existing sources and those chlorides resulting from dredging; and (3) a large-scale map showing differences between dredging and non-dredging simulations, with a statistical analysis included in the discussion of differences, quantifying to the extent reasonable the significance of additional chlorides resulting from dredging to total chloride concentrations. These analyses might clearly show that, since the proposed dredging area is relatively insignificant compared to presently existing sources of chloride, the relative significance of additional chlorides due to dredging is also insignificant. Also, see review comments 1, 2, 7, and 53. Also, many of the figures, especially those in the modeling sections, do not meet normal graphic standards and should be redrawn.	*See response to EPR comment #17 and General Response.*
C-2	C-2				No, the authors have done a commendable job of including relevant studies.	*No response needed.*
C-3	C-3				No, see reply to question 4.	*See General Response.*
C-4	C-4				No, see attached specific review comments on modeling section and below general comment. Data and analyses do not convincingly support the statement that "true conditions" have been bracketed "yielding a best-case and worst-case scenario". In fact, data and analysis appear to support using 1.5E-4 ft/d for the expected true impacts of dredging, with 1.5E-5 ft/d representing the best case (conservative) scenario. To bracket "true conditions" a worst-case (non-conservative) scenario needs to be provided using a vertical hydraulic conductivity of around 1.5E-3. See review comments 33, 35, and 37.	*See response to EPR comment #43 and General Response.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
C-5	C-5				Data and analyses do not convincingly support the statement that "true conditions" have been bracketed "yielding a best-case and worst-case scenario". In fact, data and analysis appear to support using 1.5E-4 ft/d for the expected true impacts of dredging, with 1.5E-5 ft/d representing the best case (conservative) scenario. To bracket "true conditions" a worst-case (non-conservative) scenario needs to be provided using a vertical hydraulic conductivity of around 1.5E-3. See review comments 33, 35, and 37.	*See response to EPR comment #43 and General Response.*
C-6	C-6				No, see above comments and specific review comments.	*See response to EPR comment #43 and General Response.*
C-7	C-1				The document does not indicate that the DYNCFT part of the simulation code has been tested or verified by an independent group, such as the International Ground-Water Modeling Institute. This is the part of the simulation code that approximates the variable density component of the hydrodynamics. The other two components of the code DYNFLOW and DYNTRACK had referenced documentation that the codes had been verified to work correctly. Since the simulation code applied for the SHE supplemental study appears to be a proprietary code developed by CDM it is important that the code have independent verification as no such verification is contained within the current document. Additionally, the documentation of the variable density approximation implemented in the DYNCFT part of the simulation code is minimal and no other reference to code documentation is provided.	*The IGWMI was no longer in existence when DYNCFT was developed; therefore, there is no third party verification documentation available. The code was tested by CDM personnel and compared to standard solutions as noted in the certification documentation that is included as part of this appendix.*
C-8	C-2				Dorothy F. Payne, Malek Abu Rumman, and John S. Clarke, 2005, Simulation of Ground-Water Flow in Coastal Georgia and Adjacent Parts of South Carolina and Florida-Predevelopment, 1980, and 2000: U.S. Geological Survey Scientific Investigations Report 2005-5089,81 pages. John S. Clarke, David C. Leeth, DiVette Taylor-Harris, Jaime A. Painter, and James L. Labowski, 2005, Summary of Hydraulic Properties of the Floridan Aquifer System in Coastal Georgia and Adjacent Parts of South Carolina and Florida: U.S. Geological Survey Scientific Investigations Report 2004-5264, 54 pages. Michael F. Peck and Keith W. McFadden, 2004, Potentiometric Surface of the Upper Floridan Aquifer in the Coastal Area of Georgia, September 2000: U.S. Geological Survey Open-File Report 2004-1030, 1 sheet.	*The authors are aware of these studies, all of which went to press after we completed our most recent draft with the exception of the updated potentiometric surface (Peck and McFadden). We examined this dataset and found that the data for one well in Savannah (near the center of the cone) appeared erroneous (-180 feet MSL). In addition, we did not have access to updated data from South Carolina in order to create a composite surface of the two states. As such, it was more accurate to use two datasets that were collected during similar timeframes as opposed to splicing the updated Georgia data with the 1998 South Carolina data. As for the other studies, the authors were generally aware of these publications from the data collection stages to final publication through participation in various regional TAC meetings and advisory sessions. The conclusions presented in the aforementioned studies do not impact any conclusions in the report.*

EPR Comment #	Reviewer Comment #	Report Section	Page	Figure	Comment	Response / Action
C-9	C-3				There seemed to be a backwards thought process, in that, the conclusions indicate that the two simulations represented what was thought to be actual case and then the worse case scenario. When in fact the "sensitivity" simulation or "worse case" simulation was accomplished with a reduced conductance of the Miocene confining unit. This is a best case scenario, in that the transport of saline water through the confining unit would be reduced if the confining unit hydraulic conductivity is reduced. For a worst case scenario one would have an increased vertical hydraulic conductivity of the Miocene confining unit. Additionally, no runs were accomplished with changes in the porosity or storage parameters. A decrease in porosity would result in an increase in the velocity in the solute transport simulation. So a worst case scenario would have increased hydraulic conductivity of the Miocene confining unit and decreased porosity and for transient runs a decrease in storage parameters. (Continued)	*See response to EPR comment #43 and General Response.*
C-10	C-4				No, this is not conservative and is probably close to the correct choice and may not overpredict the impacts. In general, most geologic materials have heterogeneity and the transport occurs through the more permeable units, thus picking the mid-level Kv is appropriate and given the observed data provided a reasonable fit between simulated and observed data was achieved. A true worst case scenario as discussed above would be a conservative simulation to overpredict impacts.	*See response to EPR comment #43 and General Response.*
C-11	C-5				Aside from perhaps using a higher Kv for the Miocene confining unit and decreased porosity as the worse case scenario, the approach is good.	*See response to EPR comment #43 and General Response.*
C-12	C-6				Aside from documentation of the code verification for DYNCFT and doing a true worst case scenario simulation rather than a best case simulation, there is ample documentation to support the conclusions.	*See response to EPR comment #C-7.*

4. Charge to Reviewers

Charge to Reviewers
for
Supplemental Studies to Determine Potential Ground-Water Impacts to the Upper Floridan Aquifer
Proposed Savannah Harbor Expansion Project

Background

The U.S. Army Corps of Engineers is studying the potential effects on the Upper Floridan aquifer due to a proposed harbor expansion of the Port of Savannah. The proposed Savannah Harbor Expansion Project consists of deepening approximately 35 miles of navigation channel. The initial phase of the study was conducted under the authority of Section 203 of the Water Resources Development Act of 1986. Completed in 1998, the Savannah Harbor Expansion Feasibility Study and Tier I Environmental Impact Statement (EIS) recommended deepening Savannah Harbor from the Ocean Bar upstream to the Georgia Ports Authority. Although authorized in 1999, the U. S. Army Chief of Engineers Record of Decision required additional analyses and approvals before commencement of expansion activities, namely a consensus mitigation plan, Tier II EIS, and General Reevaluation Report. The Geology/Hydrogeology and HTRW Design Section, U.S. Army Corps of Engineers, Savannah District prepared this supplemental studies report as part of the Tier II EIS that will serve as a basis for future decisions concerning the expansion of Savannah Harbor.

The intent of the current study was to determine if deepening the Savannah Harbor channel has the potential to impact water quality in the Upper Floridan aquifer, the primary source of drinking water in the coastal area. The study focuses on the Miocene-age upper confining unit of the Floridan aquifer, which in some areas of the present harbor is exposed in the bottom of the navigation channel. Special emphasis was placed on the role of buried paleochannels that have cut into the confining layer.

The clay-rich, low permeability confining layer protects the underlying porous limestone strata. Prior to the 1880's, wells drilled into the artesian aquifer would yield a head of water up to 35 feet above mean sea level (MSL) in the Savannah-Hilton Head, South Carolina area. However, since the 1880's, due to increasing withdrawals of water from the aquifer, a resulting cone of depression in the Savannah area has lowered the water level in the aquifer to as much as 130 feet below MSL. The net effect of this lowering of water level has reversed the natural pre-development flow of ground water from the aquifer upward through the confining layer to a downward flow of water through the confining layer toward the center of the area of greatest pumping from the aquifer (Savannah). Since much of the area within the drawdown cone of depression is overlain by saltwater, chloride levels in the Upper Floridan aquifer in the Savannah area are expected to increase.

Removing additional confining layer material during the dredging process would effectively reduce the thickness of the layer; therefore, it is necessary to determine what effect this may have on the level of chlorides in the Upper Floridan aquifer due to any potential increase in the rate of downward leakage of saltwater.

The methods employed in this study were intended to build and expand on the information from previous studies, particularly the 1998 Potential Ground-Water Impacts for the Savannah Harbor Expansion Feasibility Study that was prepared as part of the Tier I EIS (USACE, 1998). Following the release of the 1998 study, the Savannah District, with input from the United States Geological Survey (USGS), Georgia Environmental Protection Division (GAEPD), South Carolina Department of Health and Environmental Control (SCDHEC), and the project Stakeholders Evaluation Group (SEG), developed a conceptual plan and work outline to address comments from the 1998 report and establish new supplemental study objectives.

The principal objective of the current study was to determine how much proposed dredging activities would contribute to increased chloride levels in the Upper Floridan aquifer and evaluate the associated impacts on aquifer water quality. The proposed dredging activities to deepen the navigation channel would typically impact materials contained between -42 feet MLW and -58 feet MLW, which is comprised primarily of Miocene-aged sediments. Consequently, the study focused on the Miocene-aged upper confining unit along the navigation channel, especially in an area from about river station 30+000 to -30+000, where the confining layer naturally thins and relict channels have cut further down into the confining layer.

A 3-dimensional coupled flow and transport ground-water model was used to simulate the effects of dredging the navigation channel on water quality in the Upper Floridan aquifer.

The objectives of the 3-dimensional ground-water model were:

1) Develop a modeling tool which focused on aquifer system response due only to dredging the Savannah River navigation channel as proposed.

2) Assess a range of plausible aquifer responses to harbor dredging by varying input parameters.

3) Provide information on expected impacts of dredging on Upper Floridan aquifer water quality (worst case, most likely case).

Please find enclosed a copy of the draft study and appendices for your review. This version of the report reflects comments received on an earlier draft. Your comments will be greatly appreciated and will benefit the preparation of the final version of the report.

Charge Questions

To assist in your review of the report, we ask that you pay particular attention to the following questions:

1) Are there any elements you feel could be included in the framework of the report which would strengthen the document?

2) Are you aware of any other significant data/studies that are relevant and should be included or referenced in the report?

3) Do you feel that the two model simulations likely bracket the expected true impacts of dredging?

4) Do you feel that the model assumptions are consistently and sufficiently conservative to overpredict impacts using the mid-level Kv?

5) Do you feel that the combination of field data and model framework adequately address the impacts of dredging?

6) Do you feel the report contains sufficient documentation to adequately support the conclusions?

5. Original Comment Transcripts from External Peer Reviewers

To: Susan Ivester Rees, PhD.
Coastal Environment Team
Planning and Environmental Division
Mobile District, Army Corps of Engineers
P.O. Box 2288
Mobile, Alabama 36628-0001

Subject: Review of Supplemental Studies to Determine Potential Ground-Water Impacts to the Upper Floridan Aquifer

I want to thank the Corps of Engineers for allowing me the opportunity to review this extensive and thorough scientific investigation aimed at assessing the potential for increased chloride concentrations in the Upper Floridan Aquifer resulting from dredging the Savannah River navigation channel. It is clear that significant time and resources were involved in evaluating these potential impacts and that a well coordinated team of scientists and engineers helped reach your conclusion that dredging will have negligible affect on the underling potable aquifer.

The focus of my review is on the hydrogeology and ground-water flow modeling activities. Although I read the entire supplemental report, I will only comment on these components of the overall investigation. For a large part, the investigation covered the essential elements to address the problem of concern. Your description of methods and analysis are well documented and written. For that I commend the team.

General Comments:

1. Throughout the report I was waiting to see a map view illustration showing the saline concentration of the channel and bay areas. This gives the reader a framework to understand where the source of the saline water may originate from.
2. My biggest concern has to do with the modeling investigation. I don't think it's good to assume that what's good at a regional scale works at a small scale. The objectives of the USGS regional model are quite different than

the objectives and goals of this investigation. It is the objectives around which a conceptual model is built. Thus, for different objectives one should assume that a potentially very different conceptual and ultimately numerical model will ensue. My point being that your key objective is the navigation canal and its potential connection with the underlying Upper Floridan Aquifer by way of the Miocene confining unit. This is the focus and your model should have more adequately detailed this unit instead of using the layering of the regional model. More layers should have been used to simulate this unit. However, this was not by biggest concern. I was more concerned that you never discussed your method of calibration. You simply state what the model was calibrated to without stating your method. In other words, did you use a parameter estimation code such as UCODE, PEST, or MODFLOWP? Or did you simply use trial and error? Based on the discussion I assumed you used a trial and error calibration procedure.

I don't believe in this day of fast computers and sophisticated PE codes that trial and error is an acceptable form of calibration, particularly for sophisticated models such as this. It is extremely difficult to adequately calibrate a model such as this using trial and error without greatly overy-simplifying parameterization (both number of parameters and zones), which is what was done with regard to the vertical hydraulic conductivity, porosity and storage properties of the confining unit where a single values were assumed for the entire Miocene unit (page 4-23) (and sensitivity testing was done with another single value). In addition, you selected Storage values were selected without discussion. This is where a parameter estimation code such as UCODE could make your model so much more powerfully convincing because it can evaluate multiple parameters simultaneously AND it can help to evaluate the conceptual model used and assumed to be correct. It would allow you to be able to use specific zones within the confining unit (for example where paleochannels exist) where possible differences in Kv may be occurring. The truly great advantage of using the parameter estimation model is that you have some great observation data that will allow for accurate calibration. The types of observational data, steady state and transient head values, and estimated advective transport velocities (which you can get from your pore water samples) provide invaluable data for proper calibration of the possible heterogeneous Kv and storage values of the aquifer and confining unit. I simply don't trust simplified parameterization for convenience, particularly when this is the key to the entire investigation. You even mention that your Kv data are biased toward the low values (pg 5-31), so why trust these in the model? I've seen many cases where trial and error calibrations appear good and produce good head representations, but when a new conceptualization was produced with UCODE, an entirely different hydraulic conductivity distribution results and the head match is even better. The bottom line is, if you want to convince people that the dredging operations won't affect the saline concentrations of the Floridan aquifer, you better have confidence in your model and use PE, not trial and error.

3. Related to the modeling effort, the layering within the Miocene should be more refined. I believe at least 5 layers should be used to better simulate the chloride movement through the unit. Table 2-2 of Appendix B is confusing to me. You're relating the model units between the regional model and the Savannah Harbor model and layer 7 is listed as "not present" in your model. Well what is layer 7 simulated as then? Also related to layering, what was the justification for one model layer for the Upper Floridan? The only real justification is if all the pumping wells are fully penetrating and the layer is dominated by horizontal flow. However, if pumping in the Savannah area induces vertical flow in this unit, then you must consider using additional layers to simulate the potential for vertical flow components that could enhance vertical flow through the Miocene confining unit.

   I will say that based on the observational data, it appears that your conclusions are correct regarding the dredging operations. However, I don't believe your modeling effort yields further convincing proof of this conclusion. I'm skeptical of the results of the model based on the simplicity of the parameter value distribution and the lack of parameter estimation used.

Specific Comments:

1. There are numerous references to places in the text that do not show up on an illustration. According to the USGS publication "Suggestions to Authors", every formal place that is discussed in the text must be shown on an illustration. On page 1.1 in the introduction Oceans Bar and the Georgia Ports Authority are used as the beginning and end of the study area channel, yet neither are shown on a map. There were several other occurrences where places or data points were provided in the text without a location reference via illustration.

2. On Figure 3-5, water level is used in the top figure where potentiometric surface should be used instead. Water level typically refers to an unconfined aquifer or water table. On the same illustration, I would recommend using one color for seawater. In the illustration you have the saltwater wedge as pink and the ocean as green.

3. On the top of page 4-3, "worst case dredging scenario" is extremely vague at this point of the report. I suggest a better description of what you mean here.

4. On page 5-3, first and last line on the page refers to figure 5-3. In both cases it should be figure 5-4.

5. Many of your linear plots of concentration would be much better represented as log plots. For example Figure 5-2 would more accurately represent the data if the Chloride concentration was plotted as Log Cl.

6. On page 5-13, in referring to the seismic interpretation, you mention the "yellow reflector", yet there is no yellow in figure 5-3, which the statement is referring to.

7. Many of the boreholes shown in figure 5-1 are not shown in plan view. It would be helpful if these were shown in plan view.

To: Susan Ivester Rees, Ph.D
Lead Oceanographer
Costal Environment Team

Subject: Peer Review of *Supplemental Studies to Determine Potential Ground-Water Impacts to the Upper Floridan Aquifer*

A short answer to reviewer **Charge Questions** are provided below. More specific and detailed answers are provided in my attached review comments.

1) Are there any elements you feel could be included in the framework of the report which would strengthen the document?

I suggest that the document conclusion could be strengthened by including years 2000 to 2200 simulations in the Savannah area showing three cases: (1) chlorides due to existing sources without dredging; (2) a composite of chlorides due to existing sources and those chlorides resulting from dredging; and (3) a large-scale map showing differences between dredging and non-dredging simulations, with a statistical analysis included in the discussion of differences, quantifying to the extent reasonable the significance of additional chlorides resulting from dredging to total chloride concentrations. These analyses might clearly show that, since the proposed dredging area is relatively insignificant compared to presently existing sources of chloride, the relative significance of additional chlorides due to dredging is also insignificant. Also, see review comments 1, 2, 7, and 53.

Also, many of the figures, especially those in the modeling sections, do not meet normal graphic standards and should be redrawn.

2) Are you aware of any other significant data/studies that are relevant and should be included or referenced in the report?

No, the authors have done a commendable job of including relevant studies.

3) Do you feel that the two model simulations likely bracket the expected true impacts of dredging?

No, see reply to question 4.

4) Do you feel that the model assumptions are consistently and sufficiently conservative to over predict impacts using the mid-level KV?

No, see attached specific review comments on modeling section and below general comment.

Data and analyses do not convincingly support the statement that "true conditions" have been bracketed "yielding a best-case and worst-case scenario". In fact, data and analysis appear to support using 1.5E-4 ft/d for the expected true impacts of dredging, with 1.5E-5 ft/d representing the best case (conservative) scenario. To bracket "true conditions" a worst-case (non-conservative) scenario needs to be provided using a vertical hydraulic conductivity of around 1.5E-3. See review comments 33, 35, and 37.

5) Do you feel that the combination of field data and model framework adequately address the impacts of dredging?

No data or analyses were shown in the report that could be used to calibrate and verify the ability of the model to reasonably simulate solute transport in the Upper Floridan Aquifer. Also, see above comments and specific review comments. Also, see comments 8, 9, 39, 41, 58, and 80.

6) Do you feel the report contains sufficient documentation to adequately support the conclusions?

No, see above comments and specific review comments.

Comment Number. Report Section, page and/or figure number (s): Comment

1. Appendix. A: Well written, documented, and defended. Congratulations to the authors.

2. Appendix A, page 2: "It has been . . . than currently exists." It seems to me the issue of concern is not removal of "higher-permeability sediments", which are insignificant in retarding the downward movement of saltwater relative to the much lower permeability of the Miocene confining unit, but possible removal of the lower-permeability Miocene confining unit. Where dredging would remove only the higher permeability fill sediments, you have an opportunity to show that natural erosion has a much greater impact on saltwater intrusion than dredging would.

3. Appendix A, page 28: "If these relic… than currently exists." Same comment as above. Your statement is only true if deepening the channel would reduce the thickness of the lower-permeability Miocene confining unit.

4. Appendix A: Should include a "defense" of software programs used to analyze data to justify that software is appropriate and valid for intended usage.

5. Appendix B, page 1-1: Should spell "CDM" out the first time it is used.

6. Appendix B, page 1-2: In Section 3, authors discuss potential increase in chlorides in various wells due to dredging and consequent migration of saltwater moving downward through the sediments underlying the Savannah River and the migration to the wells. Yet no discussions occur in the section on "Model Calibration" and "Model Application" about lateral flow and solute transport. Why not?

7. Appendix B, page 1-2: "Other chloride sources... in the simulations" These "other chloride sources" may be the more significant source of high chlorides into the Upper Floridian Aquifer, with chlorides due to dredging being relatively insignificant. I understand your intent to try to show that part of the saltwater contamination due only to dredging, but in doing this you have missed the opportunity to show the relative insignificance of dredging versus natural sources of saltwater contamination. Your approach also puts you in the position of having to provide a rigorous defense that your model can simulate point to point flow and transport of chlorides through a limestone aquifer with considerable variations in vertical and lateral flow characteristics. If your model is "truly" calibrated, you should be able to simulate the "real world conditions" of natural recharge/discharge impacts and dredging impacts to a composite saltwater contamination scenario. A comparison of this scenario to your "impacts from dredging only" might support your conclusion that relative to all possible sources of chlorides dredging is insignificant. Also, one could make the case that a single chloride source is not in itself significant; what matters is that all combined sources do not result in water from a well having total chlorides exceeding the EPA limit of 250 mg/L. A last point is that if in salt marshes or other areas in which saltwater is present you are using freshwater

heads as model inputs, you are overestimating dilution of saltwater moving from the river channel towards nearby wells.

8. Appendix B, page 2-1: You say the DYNFLOW code has been reviewed and tested and documented, but omit any discussion of results. You should discuss strengths and weaknesses identified in the testing and results that would support use of the code as it applied in this report.

9. Appendix B, page 2-2: Same comment as above, but perhaps even more so since solute transport codes by their very nature may be more difficult to validate for specific uses.

10. Appendix B, page 2-4 and Figure 2-4: No head boundaries are given for north boundary of model.

11. Appendix B, page 2-4: Tetra Tech, November, 2004 is not included in list of references.

12. Appendix B, page 2-4 and Figure 2-5: Suggest you be consistent with rest of report and give chlorides in mg/L.

13. Appendix B, page 2-4: Harvey, 1969 is not included in list of references.

14. Appendix B, page 2-4: You say "This (rising water boundary) was not used in the model." Yet in replying to ITR comment 49 (John Clarke) you say "some of river nodes [were] assigned a rising node" and table 4-2 of main report shows rising nodes being used.

15. Appendix B, page 2-5: You need to defend use of fixed heads for the water table (2.4.6). See ITR comment 19 (Clarke).

16. Appendix B, Figure 2-6 thru 2-10: You need to give a zero reference for the vertical scale, i.e. MLW or MSL or whatever. Also, the scale should be expanded to more clearly show thicknesses of units of importance, i.e. the Surficial Aquifer, Miocene units, and Upper Floridian Aquifer.

17. Appendix B, page 2-6 and Table 2-2: No levels are shown in Table 2-2; also layers 5 and 6 are not given a Savannah Harbor Area Hydrologic Unit name. Why not?

18. Appendix B, Figures 2-11 through 2-17: You say "Figures 2-11 through 2-17... entire model domain". You must describe the basis upon which these figures were developed, including reasons for differences in horizontal and vertical hydraulic properties, and regional differences. In using both lines of equal thickness and colors, neither of which is defined on the thickness maps, some of the maps become cluttered and barely readable. Suggest that either color or lines of equal thickness be used but not

both. Also, whatever you use must be clearly defined on the map using a standard legend format.

19. Appendix B, Figure 2-12: This is perhaps the most important figure of the seven. Yet the thickness layer is difficult, if not impossible, to decipher because of the problems mentioned above. This "Model Layer Thickness" part should be expanded in scale to more clearly show the confining layer thickness over the Savannah River area. Also, in Appendix B, figure 2-12, do the hydraulic properties and thicknesses shown in these figures represent values used in the model's river and nearby nodes? Statements on page 2-9 indicate a "yes" to this question. Thus, the use of 1.5E-4 appears to be the "expected or most likely value" not a "conservative" value as stated on page 2-9. Lastly, it is surprising to see that the vertical and horizontal conductivity are the same in a unit consisting of layers of sand and clay as presented in Appendices D and E. Do you have any evidence to support that vertical and horizontal conductivities are the same in the Miocene Confining unit?

20. Appendix B, page 2-6: Ground Water Recharge Section 2.7: Need to present a defense for use of fixed heads in the surficial aquifer considering the importance of recharge from the surficial aquifer to the Upper Floridian Aquifer in those areas where pumpage has considerably lowered the Floridian heads.

21. Appendix B, page 2-6: Need to defend using the year 2000 pumping for future pumping. It is hard to accept it is a "conservative" approach to limit pumping to the 2000 rate considering the present and future population growth in southern Beaufort and Jasper counties and in the coastal area of Georgia. As a check what differences exist between 2005 to 2000 pumping rates?

22. Appendix B, page 2-7, Section 2.9.1: Refer to USAC comments 62 & 63 by Jim Fenske. I agree with these comments, and do not believe the author has adequately addressed these comments.

23. Appendix B, page 2-7: "This modeling study... effect on results". If the model is uncalibrated, one may be able to test model sensitivity to various input parameters, but cannot relate results to actual (real world) flow in transport conditions. Also, isn't the real design of the modeling study to construct and calibrate a flow and transport model that can be used to simulate with reasonable accuracy the potential intrusion of seawater (chlorides) into the Upper Floridian Aquifer?

24. Appendix B, Figure 2-21: the small scale and clutter of Figure 2-21 makes it difficult to decipher comparisons, especially in the deep cone of depression surrounding Savannah. This figure does not meet acceptable graphic standards, and should be redrawn at a larger scale to acceptable graphic standards.

25. Appendix B, page 2-7: "Typically a calibration...the model domain." Need to provide the basis for this statement, especially the part about "10 to 15% of the total

measured head gradient across the model domain" where an extremely deep cone of depression exists due to pumping.

26. Appendix B, page 2-7, Section 2.9.1 and Figure 2-21: Need to describe hydraulic and geohydrologic input data used in this steady state calibration. A reader can assume these data are those discussed in Sections 2.6 through 2.8, but one should not have to make an assumption of this type.

27. Appendix B, Figures 2-22 and 2-23: Because of the small scale, it is very difficult, if not impossible, to clearly compare results between the two models in the area of most interest, i.e. areas adjacent to the Savannah River where dredging may occur. This figure should be reconstructed at a larger scale.

28. Appendix B, page 2-8, Section 2.9.2: Figure 2-17 shows hydraulic properties and thicknesses of the Lower Floridian, do you mean Figure 2-18?

29. Appendix B, Figures 2-24 through 2-26: Need to discuss basis of construction for these figures.

30. Appendix B, Figures 2-24 through 2-26: All of these figures fail to meet standard graphic standards and are in need of improvement (explanations of features shown or figures incomplete, missing, or unclear).

31. Appendix B, page 2-8 Figures 2-27 and 2-28: These figures are difficult to analyze because the measured and simulated heads overlap and run together in the latter years. The importance of these figures warrant their reconstruction at a larger scale showing clear definition between measured and simulated heads. On figure 2-28, well 37Q016, the simulated heads show a large dip that is not shown by the measured heads. This discrepancy should be explained.

32. Appendix B, Figures 2-29 through 2-40: "illustrate the measured and simulated chloride" But figures 2-30 and 2-37 have no measured values. You should acknowledge this or delete the figures. Top of Miocene and top of Upper Floridian (Should spell UF out in all figures.) should be solid lines to be consistent with symbol explanations. Chloride concentration and penetration differences between simulated and observed values should be explained. Observed chloride value data points should be shown on figures. Simulated values are based on the year 2000; are measured values from the year 2000? If not, use of data from a different year should be acknowledged and justified.

33. Appendix B, page 2-9: "but is perhaps...of saltwater." The case has not been made that 1.5E-4 is a conservative conductivity value. Report data and analysis suggest 1.5E-4 is the expected or most likely conductivity value. If by conservative the author means a higher conductivity value than expected , which would result in greater than expected saltwater intrusion, a conductivity value on the order of E-3 would be conservative, likely resulting in simulated saltwater penetration to be deeper and chloride concentrations to be

greater than would realistically be expected. A value in the E-3 range as conservative is supported in data contained in Section 3 of the main report.

34. Appendix B, page 2-9: "Note that in ... 2-35 and 2-38". A careful look at these figures does not support the above quoted statement. Figure 2-30 does not contain any measured data, and Figures 2-29, 2-31, 2-35, and 2-38 do not show reasonable matches between observed and simulated chloride concentrations until near the top of the Upper Floridian. Chloride concentration differences between observed and simulated values throughout the Miocene confining unit should be explained.

35. Appendix B, page 2-9: "A second set... the two simulations". Data and analyses form the main report and supporting appendices do not support saying "The true system response lies somewhere in between the two simulations." The preponderance of evidence presented in the report and supporting appendices suggest that l.5E-4 is a reasonable or most likely value for the vertical conductivity of the Miocene confining unit, not a conservative value, and simulations made using 1.5E-4 would unlikely show results decidedly skewed towards either underestimates or overestimates of saltwater penetration - assuming the model is adequately calibrated for its intended use. To bound probable system response, three simulations are needed - a simulation using 1.5E-4 (most likely case), a simulation using 1.5E-3 (worst or "conservative" case resulting in greatest saltwater intrusion), and a simulation using 1.5E-6 (best case resulting in least saltwater intrusion). Such a set of simulations would provide both upper and lower bounds, and the most likely case for discussing saltwater penetration due to water moving into the Upper Floridian through the Miocene confining bed from overlying saltwater sources.

36. Appendix B, page 3-1: "generally result in... higher than measured". Data and analyses contained in Section 2 do not fully support the above statement. Figures 2-31, 2-35, and 2-38 show that in parts of the Miocene confining bed observed values of chloride are higher than simulated values. The authors should discuss possible alternate reasons for these differences within the Miocene, and then select and defend their preferred explanation for the differences. Also, no observed chloride values are available for the Upper Floridian; consequently, no comparison can be made between simulated and observed chloride values in the Upper Floridian, which leads to questions about how can one defend model calibration, and it's ability to simulate with reasonable fidelity chlorides in the Upper Floridian.

37. Appendix B, page 3-1: "the calibrated value...sets of results." Data and analyses do not support that "the true conditions are bounded by the two sets of results". Data and analyses support using 1.5E-4 (calibrated value) to represent "true conditions". This "true condition" is bounded on the "best case" level (value of conductivity that is likely to show saltwater penetration to be less than would be expected under "true conditions"), but is not bounded on the "worst case" level (use of a value of conductivity that is likely to show saltwater penetrations to be more than would be expected under "true conditions").

38. Appendix B, page 3-2: Table 3-1 shows simulated head 30 feet too low, not 25.

39. Appendix B, page 3-2: "but the mode somewhat overstated the rate of penetration" As discussed above, if penetration into the Upper Floridian is being implied, no observed data are shown to support that simulated chlorides are greater with depth than observed chlorides. It should be acknowledged that chloride comparisons are available only for the Miocene confining unit.

40. Appendix B, page 3-2, Table 3-1: See UAACE comment 59 (Fenske). For reasons presented in my above comments, I fully support Fenske's comment, and urge the authors to implement his suggestion. The authors' response to Fenske's comment and discussion on page 3-7 and 3-2 do not adequately address the concerns.

41. Appendix B, page 3-2: "the higher vertical... Floridian chloride concentrations". Since no observed chloride data were shown for the Upper Floridian in the SHE boreholes (figures 2-29 through 2-40), what is the basis for saying the higher conductivity value results in "unrealistic Upper Floridian chloride concentrations "? Also, it may be that higher simulated chloride concentrations in the Miocene result from the model ignoring dilution effects since it is not unreasonable to expect that low chloride water moving horizontally through relatively permeable sands in the Miocene unit is mixing with high chloride water moving downward from the overlying saltwater sources. Until various reasons for chloride differences between simulated and observed values are identified and discussed, no sound basis exists for simply assuming the differences exist because "conservative" conductivity values are used as model input. Remember, the chloride concentration difference also exists even when using the calibrated value, "which represents the mid range of reasonable values".

42. Appendix B, page 3-2, Figures 3-1 though 3-3: These figures are very difficult to decipher because of too many similar colors. These figures would be improved if colors were used only for chloride concentrations, and if geohydrologic units were defined by another method. A reference needs to be given for the vertical scale. A-A and B-B should be labeled as A-A' and B-B' to clearly show relation of cross sections to location maps. Titles should include "simulated chloride" before "concentrations" and "current" should be defined.. No explanations of blue and red lines and of vertical and horizontal scales are given. These figures should be reconstructed to standard graphic requirements.

43. Appendix B, page 3-3: "two different values... potential impacts." as discussed before, "range of potential impacts" may not be bracketed.

44. Appendix B, page 3-3: On page 3-2, it is stated that initial model input is based on the year 2000 (figures 3-1 and 3-2), but in Section 3.3 1990 is shown as start of simulations. What is correct? Is a 200 or 210 year simulation used?

45. Appendix B, page 3-4: "Concentrations after 200 years" After 210 years if 1990 was starting year as presented on page 3-3. Need to resolve confusion about "starting year".

46. Appendix B, page 3-4: Should include in narrative and in Figures 3-5 through 3-16 actual conductivity values (1.5E-4 and 1.5E-5) used in the simulations (Don't leave reader guessing.).

47. Appendix B, Figures 3-5 through 3-16: Include actual conductivity values for "A" (1.5E-4 ft/d). As presently presented, titles for "A" are incomplete. A possible title for "A" could be "Simulated Chloride Profiles at SHE [borehole number] using a vertical conduction value of 1.5E-4 for the Miocene Confining Unit". A similar title should be used for the "B" graphs. Color lines for top of Upper Floridian and Miocene should be consistent with Legend (Legend shows "unbroken" lines, whereas the lines on the graph are "broken".

48. Appendix B, page 3-4: "The results show... consequent dilution effect." For clarity suggest wording to read "due to considerable horizontal flow of fresh water within the aquifer mixing with and diluting the relative very low volume of saltwater migrating downward from the Savannah River".

49. Appendix B, figures 3-17 through 3-28: Chloride scales for these figures should be expanded to more clearly show differences between dredging and no-dredging simulations, i.e. 0-100 mg/L, or 0-250mg/L or... as appropriate based on upper chloride levels. Reasons for "fluctuations" embedded in chloride trends should be discussed. As mentioned before, graph titles should give conductivity values used for "A" and "B" plots (1.5E-4 ft/d and 1.5E-5 ft/d respectively). For the reasons given in a number of my previous comments, a third plot using 1.5E-3 ft/d is needed to truly bound expected chloride concentrations.

50. Appendix B, Figures 3-17: Title and Legend on "B" give SHE-5. Should title and legend read SHE-15?

51. Appendix B, Figure 3-18: Similar problem as above. Either the "B" plots are on the wrong figure or are labeled incorrectly.

52. Appendix B, page 3-5 and figure 3-17 through 3-28: "The concentrations shown are computed for the top 50 to 60 feet of the Upper Floridian". Yet, the figures' titles read "Concentrations at the top of Upper Floridian Aquifer". Figure titles should be revised to show agreement with the text wording. The rationale for selecting the "top 50 to 60 feet" should be explained. If the top 10 feet of the Upper Floridan would have been selected, would simulated chloride concentration plots have differed significantly from those given in this report?

53. Appendix B, page 3-5: Should explain why 250mg/L was selected as "breakthrough" value and its significance. I really don't see the justification for ignoring the importance of the composite effects of all sources of saltwater contamination (amount due to both the Savannah River and other sources of saltwater) that could cause chlorides to exceed 250mg/L (the EPA limit). It is the composite sources of chlorides that are of importance to those who wish to obtain fresh drinking water supplies (chlorides less than

250 mg/L) from the Upper Floridian. Even a small increase in chlorides due to dredging could be significant if chloride concentrations without dredging are close to 250 mg/L.

54. Appendix B, figures 3-30 through 3-52: Should give actual Miocene confining unit vertical conductivities used for simulations "A" (1.5E-4 ft/d) and "B" (1.5E-5 ft/d). As said before, a third case using a Miocene confining unit vertical hydraulic conductivity of 1.5E-3 ft/d should be presented as a bound for the worst case.

55. Appendix B, Figures 3-30 through 3-48: Reasons for the fluctuations imposed on the chloride trends should be explained.

56. Appendix B, page 3-5 and 3-6, Figures 3-30 through 3-48: I assume from the statement made on page 3-5 ("for the top 50 to 60 feet of the Upper Floridian Aquifer.") that model simulations are based on flow through the "top 50 to 60 feet of the aquifer". Evidence has been given by previous investigations, however, that show much of the flow through the Upper Floridian may take place through high-permeability zones consisting of only a small percentage of total aquifer thickness. Could this "preferred flow" occur between the Savannah River and the wells used in Figures 3-30 through 3-48 and, if so, what would the impact be to breakthrough times and chloride values?

57. Appendix B, page 3-6 and Figures 3-49 through 3-52: These are important figures and should be expanded in scale to more clearly show differences between dredging and no dredging. All the expanded figures should include lines of equal head showing the potentiometric surface of the Upper Floridian Aquifer. The "Year 2000" maps should include any available field measurements of head and chlorides allowing the reader to compare simulated and measured values. These figures as drawn do not meet normal graphic standards (no explanation of vertical and horizontal scales, no statement of conductivity values used for Figures 3-45 and 3-52 - reader should not have to assume what conductivity values were used.

58. Appendix B, General: USACE comments 54, 57, 60, 62, 67 bring out important weaknesses in the modeling approach that have not been adequately resolved. This along with concerns expressed in my review comments lead me to question the validity, conservatism, and defensibility of simulation results and analyses presented in Appendix B and in various sections of the main report, "Supplemental Studies to Determine Potential Ground-Water Impact to the Upper Floridian Aquifer". Nor is it clear to me that the model has been adequately calibrated for its intended purpose - simulation of transient flow and chloride transport vertically through the Miocene consigning unit and then horizontally through the upper 50-60 feet of the Floridian Aquifer.

59. Appendix C: General Comment: Insufficient documentation is provided to show that the GIS Analysis is valid for intended use. How would an independent reader know that the software and subroutines perform as intended in constructing Miocene thickness maps and other maps?

60. Executive Summary, General Statement: For reasons given in review of Appendix B, I am not convinced "true conditions" are bracketed. For this and other concerns raised in my review, I question conclusions based on model simulations presented herein, in Section 63 of the Summary, and in the conclusion.

61. Overview, page 2-1: "MLW" should be defined the first time used.

62. Study Area, page 3-2: "Heron and Johnson, 1966" not given date on list of figures.

63. Study Area, page 3-2 and Figure 3-1: "The elevation of... roughly - 95 feel MLW" Figure 3-1 shows the top of the Oligocene at about -120. If you don't wish to reference the bottom paragraph on page 3-2 to Figure 3-1, some other reference should be given.

64. Study Area, page 3-3: Should provide reference for unit elevation given in discussion at top of page.

65. Study Area, page 3-5: Can significant be qualified, i.e. percentage amount?

66. Study Area, page 3-7: Should provide reference of unit elevations.

67. Study Area, page 3-7: Date for "(Fanning, 1990)" is 1999 in list of references.

68. Study Area, page 3-9: Should provide reference for unit thicknesses given in top paragraph.

69. Study Area, page 3-10: Should provide a reference for unit thicknesses given in middle paragraph.

70. Study Area, Figure 3-4: Should define genesis of all boreholes (SHE boreholes in dark type and SHE boreholes under these contained within parenthesis) in Legend. All symbols used in a figure should be defined in the figure legend.

71. Study Area, Figure 3-6: Normally, contour numbers are included within a break on the contour line. This avoids guessing what contour value goes with what contour line. Can this be done in this figure where contour spacing allows?

72. Study Area, Congratulations for a well written section.

73. Methods, page 4-2: "seven marine continuous borings" and "two additional land borings" give boring numbers so a reader can go to Figure 4-1 and locate the borings.

74. Methods, page 4-3, Section 4.1, Figure 4-1: "nine additional borings" Figure 4-1 shows 11 not 9 borings.

75. Methods, page 4-4: "occasional core losses" can occasional be quantified, i.e. percentage of losses?

76. Methods, page 4-4, Section 4.1.2: "Two land borings" Figure 4-1 shows four land borings (SHE 19, SHE 10 and SHE 18) and these same land borings are discussed on page 4-9. Why are SHE 9 and SHE 10 not discussed in Section 4.1.2?

77. Methods, page 4-5, Section 4-2: "downward flow accounts" Should acknowledge the importance of other "portion[s] of the water budget" which are considerably more significant than vertical flow through the Miocene confining bed.

78. Methods, page 4-6, Section 4.2.1.1: "a procedure was... at SHE-9" Why was this procedure done only at SHE-9? Since this procedure was done only at SHE-9, how can one be assured that fresh water in the drilling fluid did not migrate into the core samples (especially into the more permeable zones), thus "contaminating" core samples with relatively fresh water? What were the selection criteria for the "given cross section"? Was this the only section tested or were other sections tested?

79. Methods, page 4-13: "Garza and Krause, 1994" Date is 1996 in References, Section 8.

80. Methods, page 4-15: "model was tested... and chloride concentrations" compelling evidence has not been presented confirming that the model can "adequately reproduce" chloride concentrations. Data shown in Appendix B, Figures 2-29 through 2-40 show that the model simulated chloride values differ considerably from observed chloride values, and no data are presented that show how well, or how poorly, the model is able to simulate chloride values in the Upper Floridian Aquifer. Thus, in using the model to simulate chloride transport through the Upper Floridian, the model is being used to simulate a set of conditions outside the conditions for which the model has been calibrated.

81. Methods, pages 4-16 and 4-17, Section 4.4.3.1: See my comments given in Appendix B.

82. Methods, Table 4-2: Boundary conditions should be defined here, or reader should be pointed to where these boundary conditions are described in Appendix B.

83. Methods, page 4-20, Section 4.4.3.5: "the 2000 pumping... into the future". See my comments given in Appendix B.

84. Methods, pages 4-22 through 4-27, Section 4.4.4.2 and 4.4.5: See my comments given in Appendix B.

85. Methods, page 4-25: "general consensus among ... in the areas." A "general consensus" is not the same as in-place regulations or restrictions. To check this "consensus", differences between the years 2000 pumping to the year 2005 should be compared. Also, can you really ignore the increases in pumping taking place in nearby Jasper and Beaufort Counties, South Carolina?

86. Methods, page 4-27: "withdrawal rates are expected to decrease in the future." What evidence exists for this statement?

87. Methods, page 4-33: "(Ranson and White, 1998)" No date for this reference provided in Section 8, References.

88. Results, page 5-1: "Miocene units A and B" suggest insert "Table 3.1" to help reader put these units into a framework relative to other sediments.

89. Results, page 5-1: "lower boundary of... from -40 to -50 MLW." Suggest you insert Figure 3-4.

90. Results, page 5-1: "relict channels the Pleistocene" Seems wording is incomplete.

91. Results, page 5-2: "boring SHE 318 (Figure 3-3): Do you mean Figure 3-4? There is no Figure 3-3, and Figure 3-3a and 3-3b do not show any contacts.

92, Results, page 5-2: "Huddlestun (1988)" is not included in Section 8, References.

93. Results, page 5-2: "Talmidge Bridge (Figure 3-3)." Is the correct reference Figure 3-4?

94. Results, page 5-2: What is the meaning of "historically"?

95. Results, page 5-3: "contact at 67 MLW (Figure 3-3)." Is the correct reference Figure 3-4?

96. Results, page 5-3: "Bartholomew et. al. (2000)" is not included in Section 8, References.

97. Results, page 5-3: "at SHE-14(figure 3-3)." Is the correct reference 3-4?

98. Results, page 5-4: "The resulting profiles" If these are the profiles shown in Figures 2-29 through 2-40, Appendix B, these figures should be referenced.

99. Results, page 5-4, Section 5.2: "All profiles indicated...with increased depth." Considering the chloride fluxuations with depth given in Table 5-1, Figure 5-1, shown in Figures 2-29(SHE-15), 2-31(SHE-19), 2-32(SHE-19), 2-33(SHE-10), 2-34(SHE-18), 2-35(SHE-11), and 2-38(SHE-14), this statement is somewhat misleading and should be revised to acknowledge and discuss chloride concentrations fluxuations with depth.

100. Results, page 5-4, Section 5.2.1: "The profiles show...with descending elevations." See above comment

101. Results, page 5-4: "50 percent to 5,252 mg/L". Table 5-1 gives 5,253 mg/L as the highest value.

102. Results, page 5-4: "no values above 100 mg/L below the Miocene A/B contact". Table 5-1 gives a chloride value of 176 below the Miocene A/B contact (first sample in the Miocene B unit).

103. Results, Table 5-1: SHE-16 shows a chloride concentration in the top of the Oligocene (top of Upper Floridian) of 24 mg/L, and borehole SHE-14 shows a chloride concentration in the top of the Oligocene of 151 mg/L. It should be explained why these chloride values significantly exceed the chloride values at the bottom of the Miocene B unit.

104. Results, Table 5-1 and Figures 2-29 through 2-40: Because of the close tie to Table 5-1 and Figures 2-29 through 2-40, a common elevation reference should be used.

105. Results, Table 5-1: Why, for SHE-15, are P-1 and P-2 shown at the bottom of the table instead of on page 5-5 with the other SHE-15 samples?

106. Results, page 5-6 and Table 5-1: "concentration (7209 ms/L) was observed... the riverbed (-41.3ft MLW)". Table 5-1 shows this sample at a depth of -52.5. Which is correct?

107. Results, page 5-7: "fluctuated from 1.264". Table 5-1 gives low chloride value as 901 mg/L not 1.264.

108. Results, page 5-13 and 5-3: "the yellow reflector". There is no yellow reflector shown on Figure 5-3.

109. Results, pages 5-17 through 5-22, Ground Water Model: See comments made in Appendix B.

110. Results, page 5-23: Can a reference be given for the Clemson University test conducted in 1977?

111. Results, page 5-27, Section 5.6.4.1 Suggestions in USACE comment 58 (Fenske) should be implemented.

112. Results, pages 5-27 through 5-32, and Table 5-5: See comments provided in Appendix B. All of the data shown herein seem to support the use of about 1.5E-4 as a realistic average values for the vertical hydraulic conductivity of the Miocene confining unit (a "realistic or expected" value, not a "conservative" value).

113. Summary, page 6-1: "In addition, the model... and no dredging conditions. Data and analysis does not support that "true conditions" have been bracketed" yielding a best-case and worst-case scenario". Data and analysis support using 1.5E-4 ft/d for the "true

conditions" scenario and 1.5E-5 ft/d for the "best case" scenario. To bracket "true conditions" a worst-case scenario needs to be provided. A vertical hydraulic conductivity of around 1.5E-3 is reasonable for the worst-case scenario.

114. Conclusions, page 7-5: "The pore water profiles...city of Savannah." Authors provide some evidence and analyses in support of the above conclusion. But, this reviewer believes that weaknesses exist in data analysis and model development and use that could be used to challenge to the final conclusion. Also your case is weakened by omitting years 2000 to 2200 simulations in the Savannah area showing (1) chlorides due to existing sources without dredging, (2) expected chlorides due to existing sources and dredging, and (3) a large-scale map showing differences between dredging and non-dredging simulations, with a statistical analysis included in the discussion of differences quantifying to the extent reasonable the significance of dredging to total chloride concentrations. After all, the proposed dredging area is relatively insignificant compared to presently existing sources of chloride.

TO: Susan Ivester Rees, Lead Oceanographer
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P.O. Box 2288
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SUBJECT: Requested Review of "Review of Supplemental Studies to Determine Potential Ground-Water Impacts to the Upper Floridan Aquifer, Proposed Savannah Harbor Expansion Project"

Charge Questions

Question 1) Are there any elements you feel could be included in the framework of the report which would strengthen the document?

Answer: The document does not indicate that the DYNCFT part of the simulation code has been tested or verified by an independent group, such as the International Ground-Water Modeling Institute. This is the part of the simulation code that approximates the variable density component of the hydrodynamics. The other two components of the code DYNFLOW and DYNTRACK had referenced documentation that the codes had been verified to work correctly. Since the simulation code applied for the SHE supplemental study appears to be a proprietary code developed by CDM it is important that the code have independent verification as no such verification is contained within the current document. Additionally, the documentation of the variable density approximation implemented in the DYNCFT part of the simulation code is minimal and no other reference to code documentation is provided.

Question 2) Are you aware of any other significant data/studies that are relevant and should be included.

See new references

Dorothy F. Payne, Malek Abu Rumman, and John S. Clarke, 2005, Simulation of Ground-Water Flow in Coastal Georgia and Adjacent Parts of South Carolina and Florida—Predevelopment, 1980, and 2000: U.S. Geological Survey Scientific Investigations Report 2005-5089, 81 pages

John S. Clarke, David C. Leeth, DáVette Taylor-Harris, Jaime A. Painter, and James L. Labowski, 2005, Summary of Hydraulic Properties of the Floridan Aquifer System in Coastal Georgia and Adjacent Parts of South Carolina and Florida: U.S. Geological Survey Scientific Investigations Report 2004-5264, 54 pages

Michael F. Peck and Keith W. McFadden, 2004, Potentiometric Surface of the Upper Floridan Aquifer in the Coastal Area of Georgia, September 2000: U.S. Geological Survey Open-File Report 2004-1030, 1 sheet

Question 3) Do you feel that the two model simulations likely bracket the expected true impacts of dredging?
Answer: There seemed to be a backwards thought process, in that, the conclusions indicate that the two simulations represented what was thought to be actual case and then the worse case scenario. When in fact the "sensitivity" simulation or "worse case" simulation was accomplished with a reduced conductance of the Miocene confining unit. This is a best case scenario, in that the transport of saline water through the confining unit would be reduced if the confining unit hydraulic conductivity is reduced. For a worst case scenario one would have an increased vertical hydraulic conductivity of the Miocene confining unit. Additionally, no runs were accomplished with changes in the porosity or storage parameters. A decrease in porosity would result in an increase in the velocity in the solute transport simulation. So a worst case scenario would have increased hydraulic conductivity of the Miocene confining unit and decreased porosity and for transient runs a decrease in storage parameters. Because the calibrated parameter values are assumed to be the correct values, then the increases or decreases in parameters for a worst case scenario should reflect the uncertainty in the parameter. The standard deviation of parameter information from observed data could be used, for example, for the increase perturbation of the hydraulic conductivity of the Miocene confining unit.

Question 4) Do you feel that the model assumptions are consistently and sufficiently conservative to overpredict impacts using the mid-level Kv?
Answer No, this is not conservative and is probably close to the correct choice and may not overpredict the impacts. In general, most geologic materials have heterogeneity and the transport occurs through the more permeable units, thus picking the mid-level Kv is appropriate and given the observed data provided a reasonable fit between simulated and observed data was achieved. A true worst case scenario as discussed above would be a conservative simulation to overpredict impacts.

Question 5) Do you feel that the combination of field data and model framework adequately address the impacts of dredging?
Answer: Aside from perhaps using a higher Kv for the Miocene confining unit and decreased porosity as the worse case scenario, the approach is good.

Question 6) Do you feel the report contains sufficient documentation to adequately support the conclusions?
Answer: Aside from documentation of the code verification for DYNCFT and doing a true worst case scenario simulation rather than a best case simulation, there is ample documentation to support the conclusions.

ATTACHMENT 1

High-Value K_v Simulation Results

United States Army Corps of Engineers
Savannah District

Savannah Harbor Expansion
Three-Dimensional Salt Water Intrusion Modeling

October 24, 2006

Technical Memorandum Addendum #1

High-Value Kv Model Simulation Results

The model application used two values of vertical hydraulic conductivity (Kv) for the Miocene confining unit: the calibrated value, which represents the mid-range of reasonable values, and a lower value. In doing so, the two sets of results appeared to bound true conditions. In response to reviewer questions, a third simulation was performed to check the impact of a higher Kv value for the Miocene confining unit, this time assigning a value of $1.5x10^{-3}$ ft/day, an order of magnitude higher than the calibrated value. This value appears to be too high based on the calibration statistics of the well readings within the pumping cone of depression. The simulation produced heads in the cone of depression in the Upper Floridan aquifer that were more than 20 feet too high when compared to field data. The calibrated value of hydraulic conductivity produced accurate head distribution within the cone of depression, but the model results overestimated the rate of penetration when compared to the porewater sample data. This overestimation of the rate of penetration was even more exaggerated when the high K v parameter was used. Results of the high Kv sensitivity simulation are provided in figures 1 through 12. The figures clearly show that at every boring location, the projected concentration at the bottom of the Miocene confining unit is overestimated. In fact, with this high Kv value, the model simulates that salt water would have fully penetrated the Miocene confining unit entered the Upper Floridan aquifer. This is not supported by field data.

Despite the fact that this Kv value is clearly too high, simulations were also run forward in time with a 1-year time-step for a period of 200 years. The simulated 2000 distribution of chlorides in the Miocene unit was used as the initial condition. Note that these figures represented significant penetration of chlorides into the Miocene confining units as of “today” (i.e. the start of the projection simulation). Figures 13-24 show the simulated chloride profile results for both the no-dredging and dredging scenarios, and figures 25-55 show individual time histories at selected borehole locations and production wells. Overall, the same conclusions hold. The difference in chloride concentration in the Upper Floridan aquifer between the results of the dredging scenario and no dredging scenario were small.

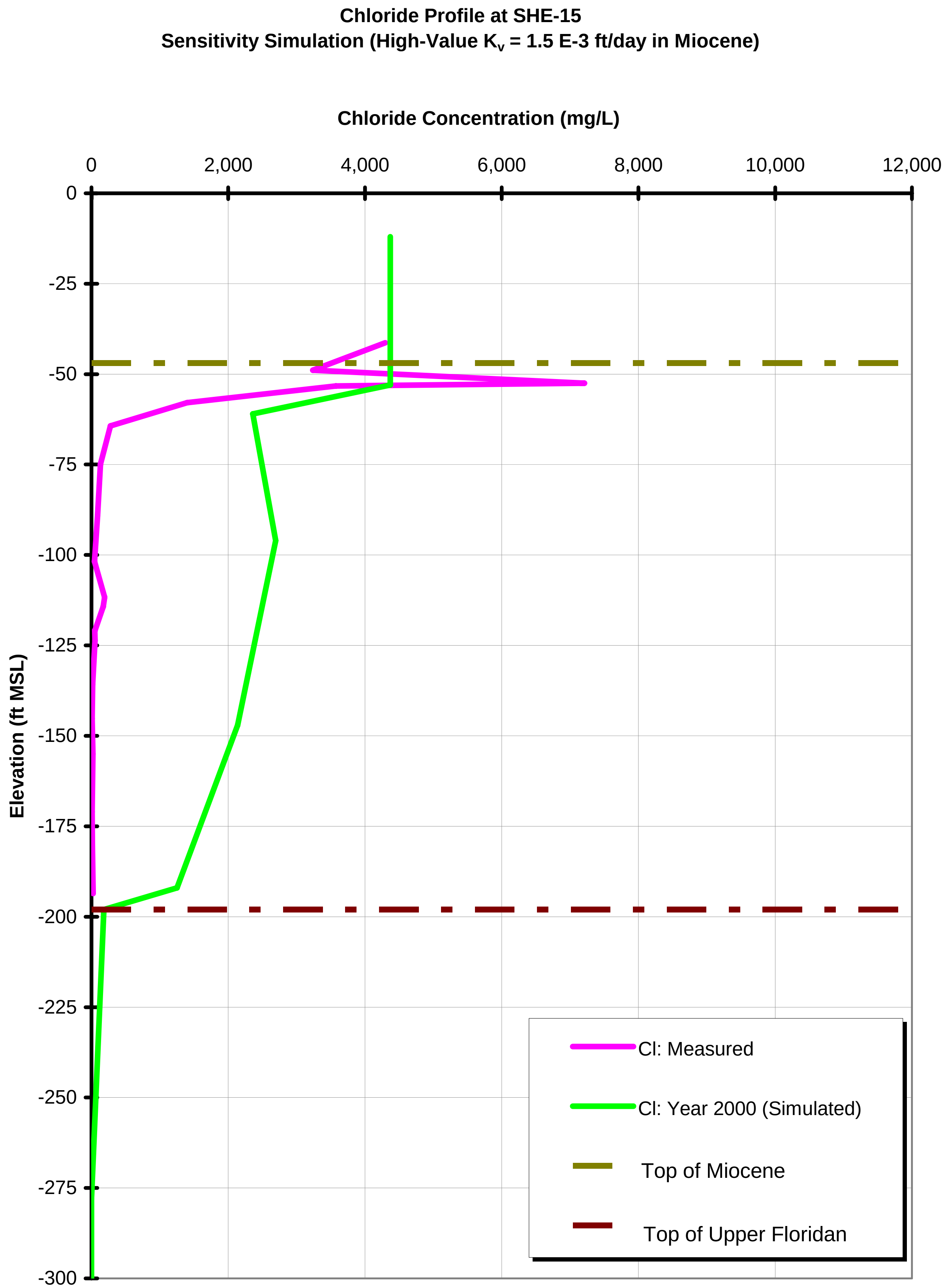

Figure 1
Measured and Simulated Chloride Measurements at SHE-15 Borehole
Sensitivity Simulation with High-Value K_v (1.5 E-3 ft/day) in Miocene Confining Unit

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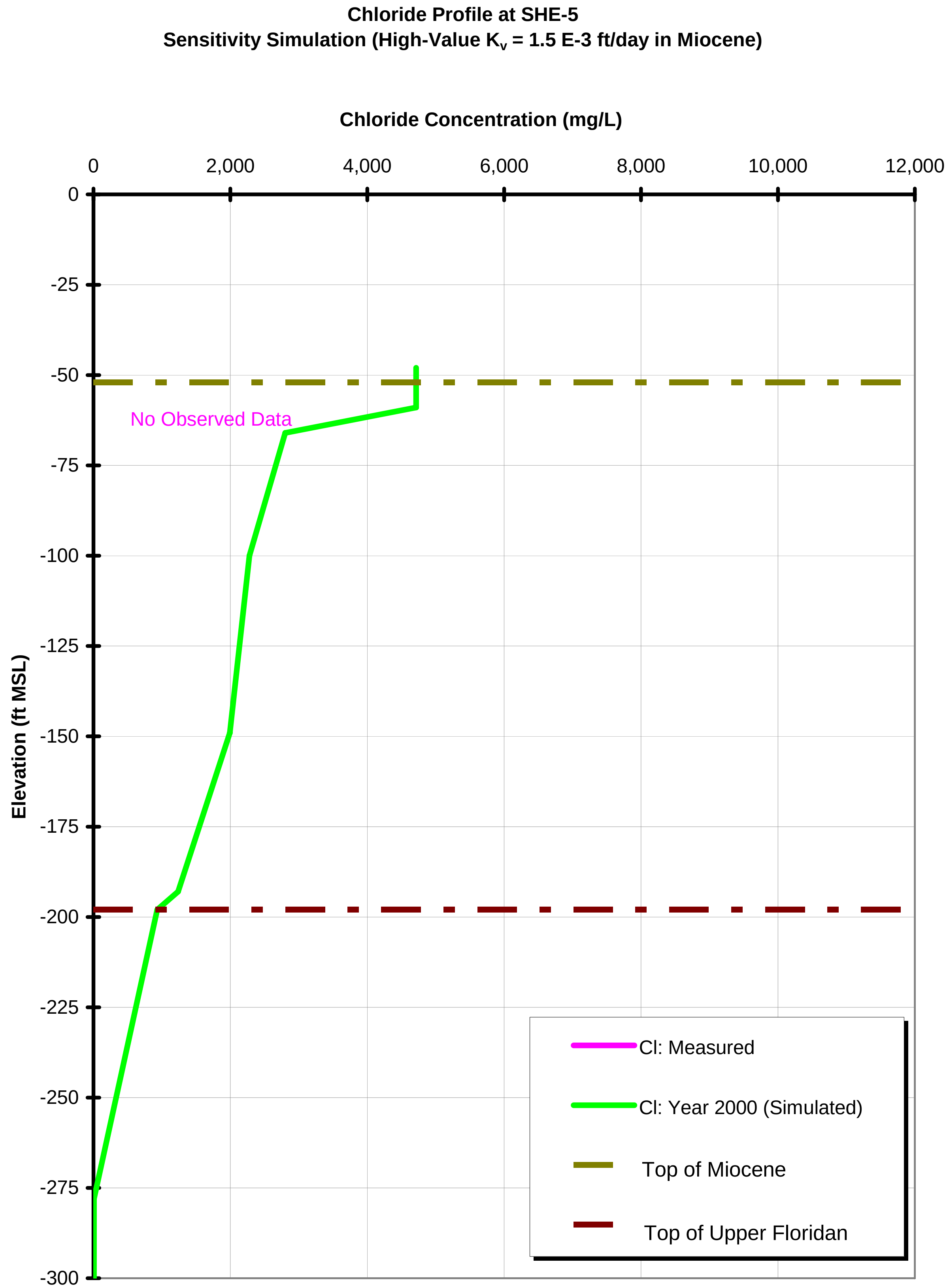

Figure 2
Measured and Simulated Chloride Measurements at SHE-5 Borehole
Sensitivity Simulation with High-Value K_v (1.5 E-3 ft/day) in Miocene Confining Unit

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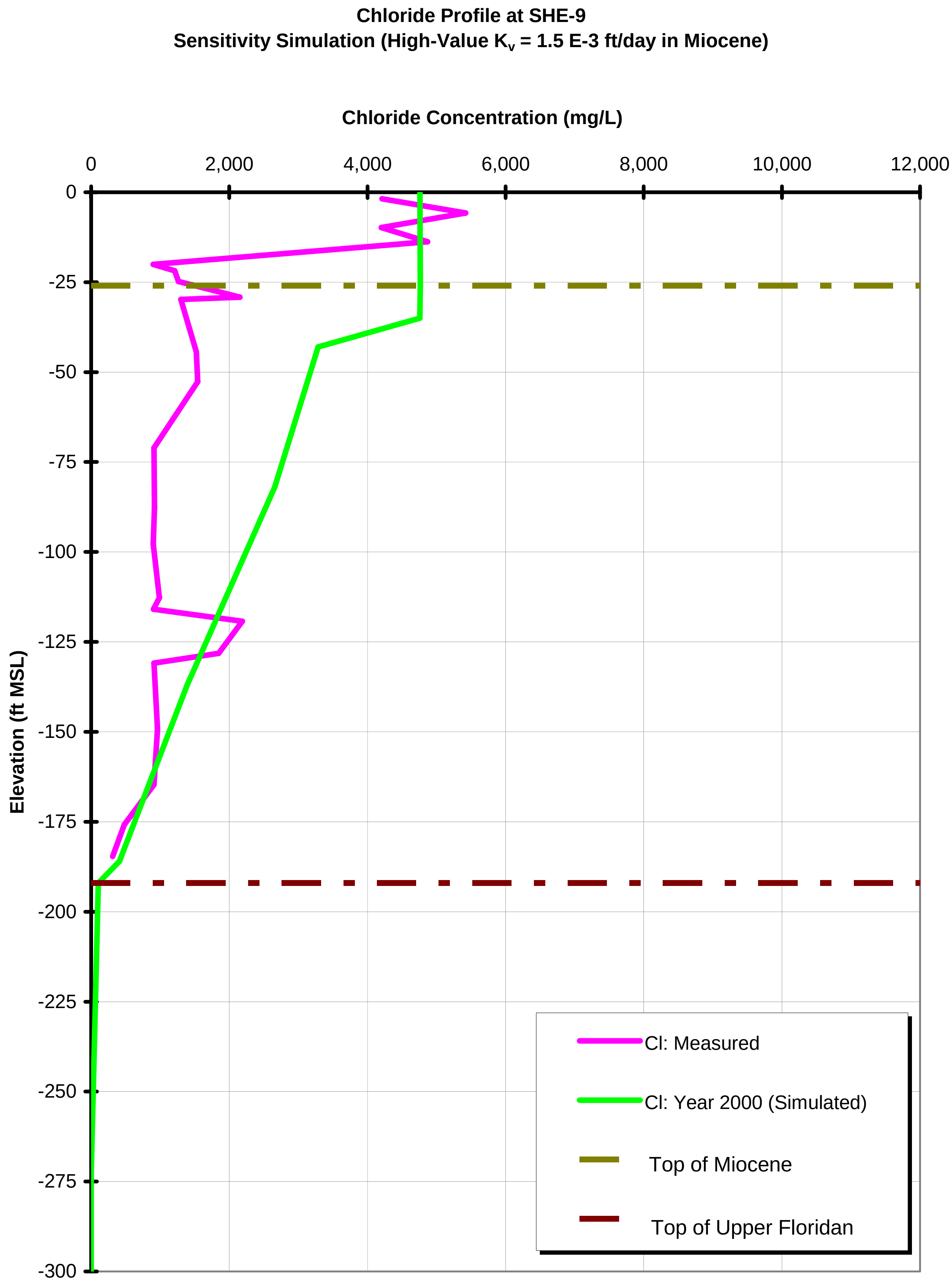

Figure 3
Measured and Simulated Chloride Measurements at SHE-9 Borehole
Sensitivity Simulation with High-Value K_v (1.5 E-3 ft/day) in Miocene Confining Unit

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Chloride Profile at SHE-19
Sensitivity Simulation (High-Value K_v = 1.5 E-3 ft/day in Miocene)

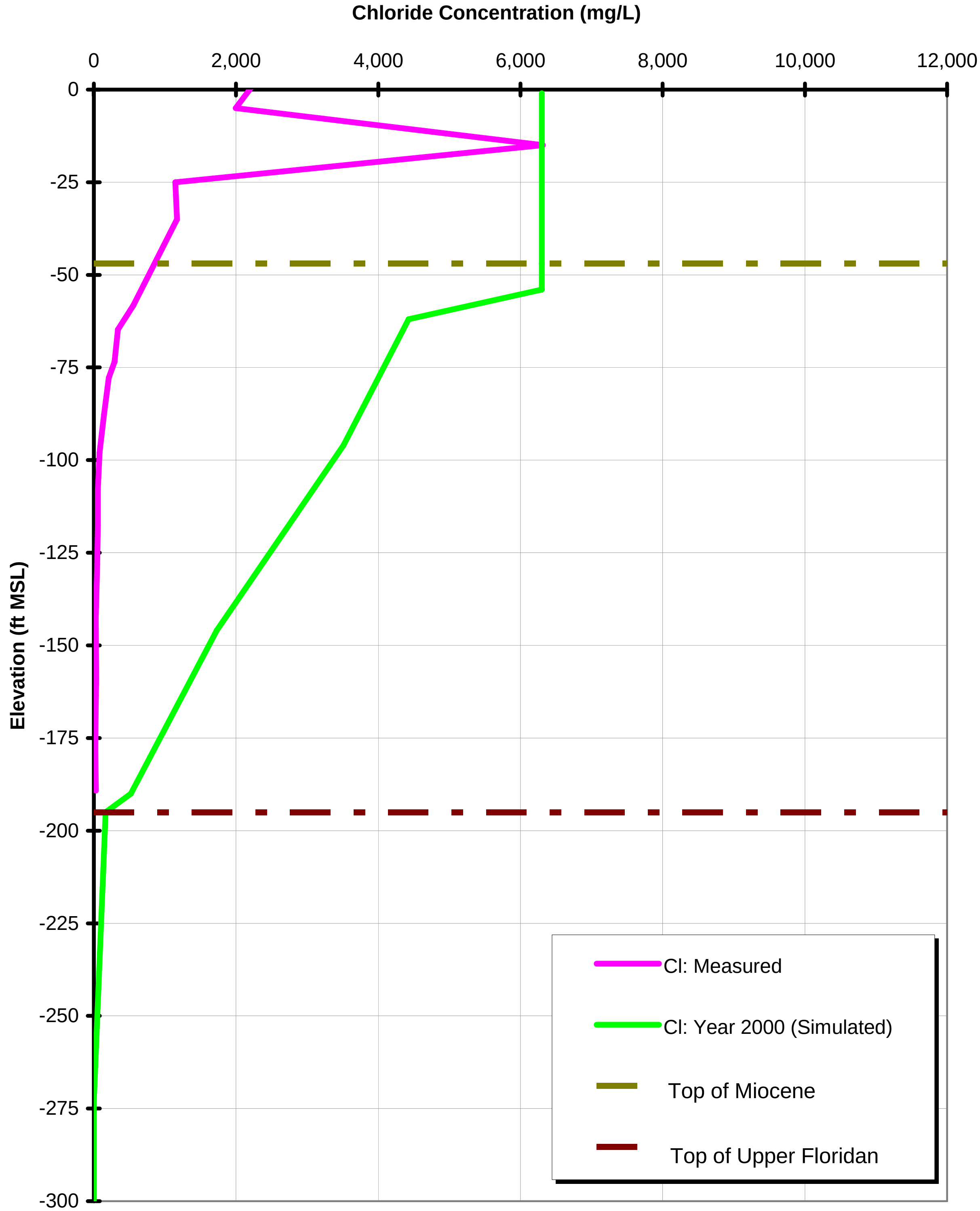

Figure 4
Measured and Simulated Chloride Measurements at SHE-19 Borehole
Sensitivity Simulation with High-Value K_v (1.5 E-3 ft/day) in Miocene Confining Unit

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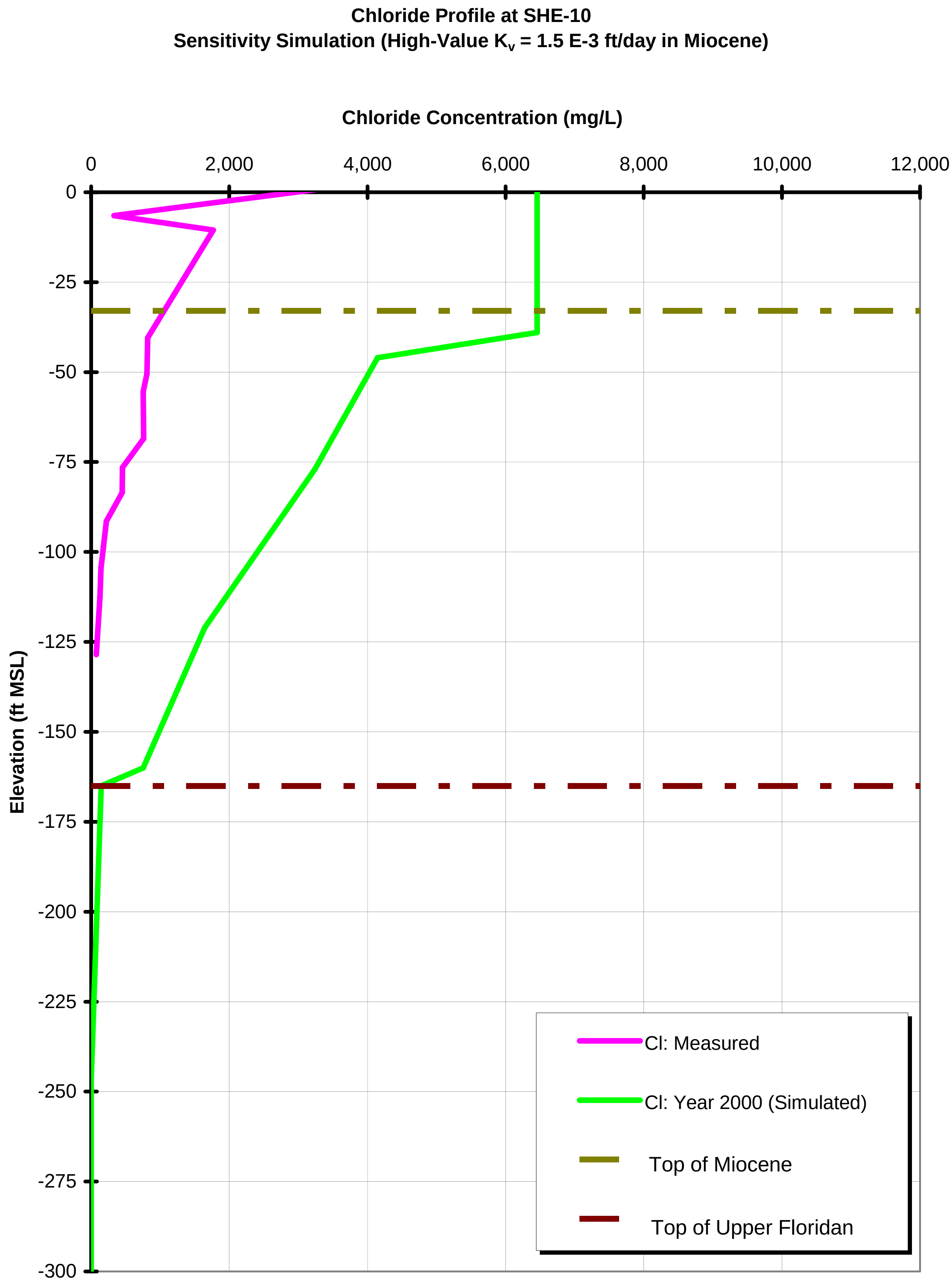

Figure 5
Measured and Simulated Chloride Measurements at SHE-10 Borehole
Sensitivity Simulation with High-Value K_v (1.5 E-3 ft/day) in Miocene Confining Unit

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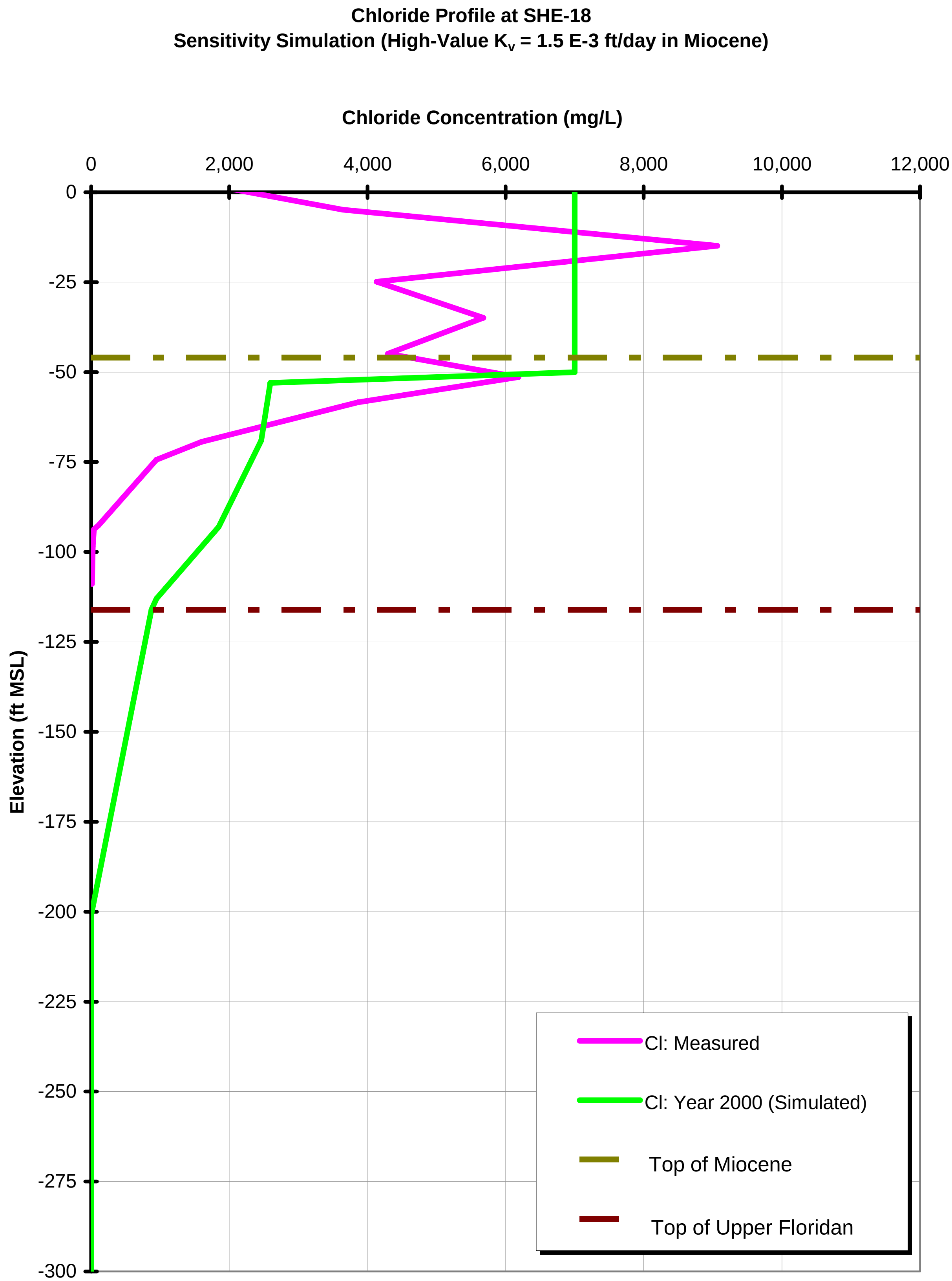

Figure 6
Measured and Simulated Chloride Measurements at SHE-18 Borehole
Sensitivity Simulation with High-Value K_v (1.5 E-3 ft/day) in Miocene Confining Unit

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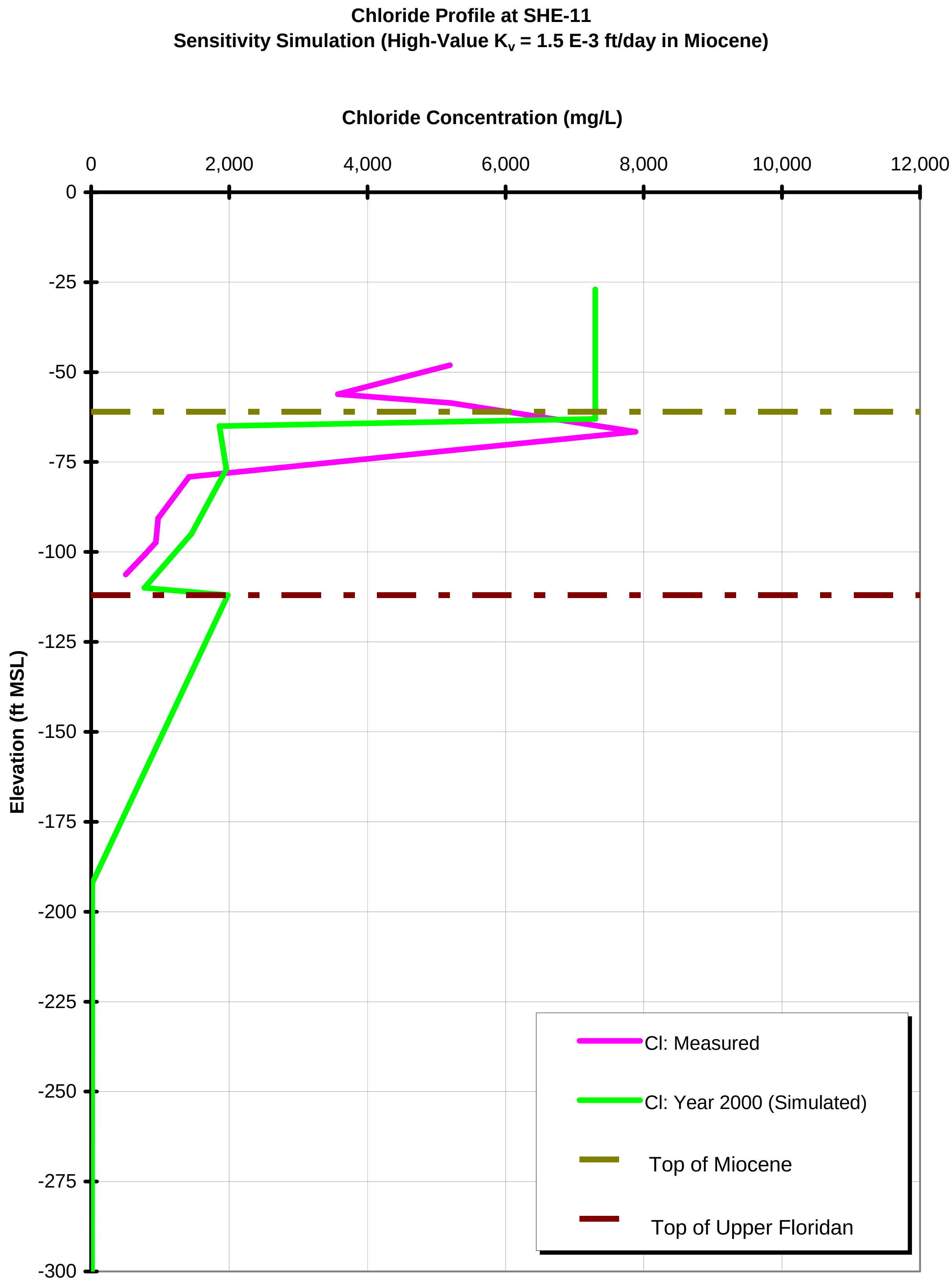

Figure 7
Measured and Simulated Chloride Measurements at SHE-11 Borehole
Sensitivity Simulation with High-Value K_v (1.5 E-3 ft/day) in Miocene Confining Unit

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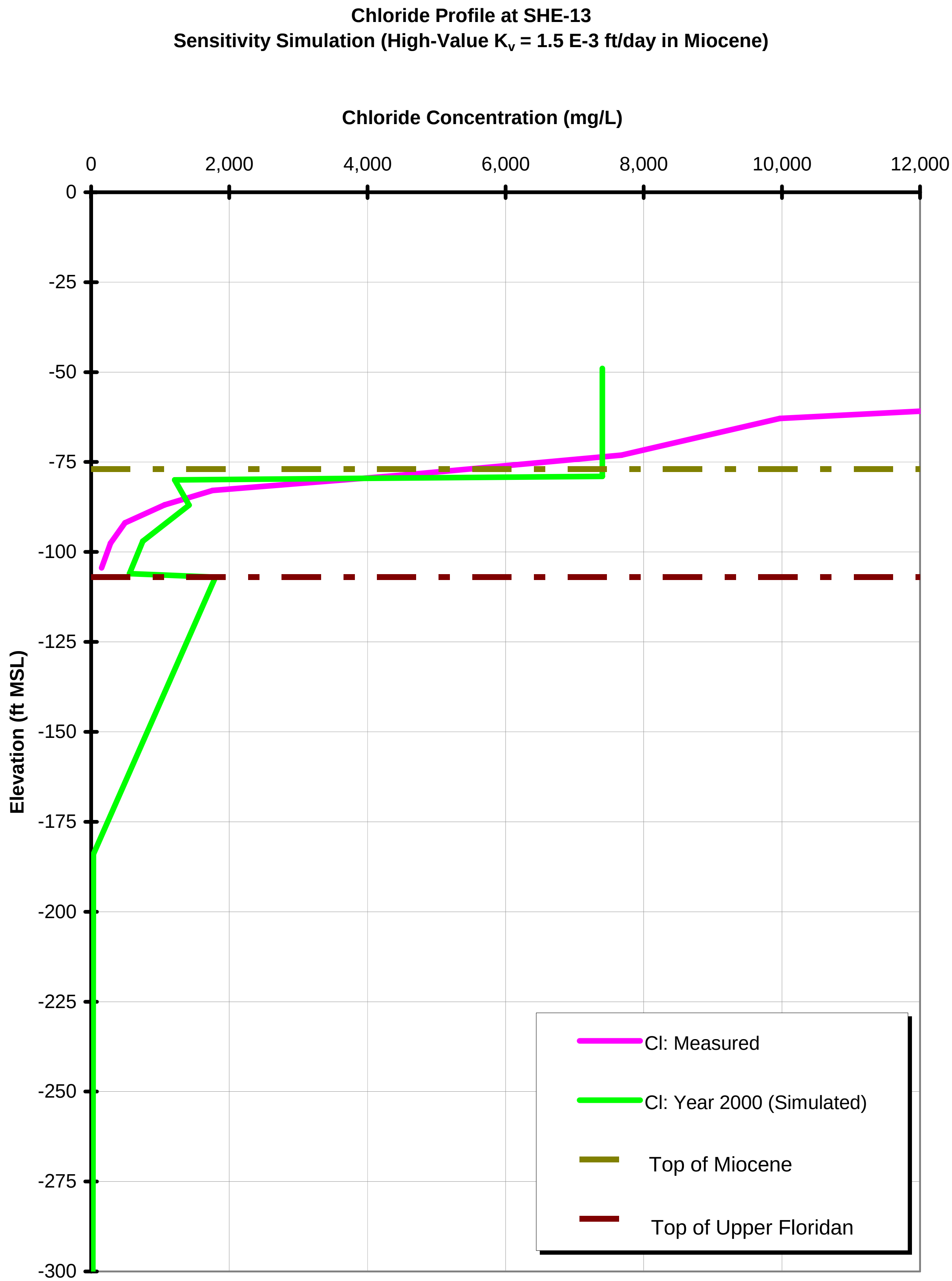

Figure 8
Measured and Simulated Chloride Measurements at SHE-13 Borehole
Sensitivity Simulation with High-Value K_v (1.5 E-3 ft/day) in Miocene Confining Unit

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Chloride Profile at SHE-2
Sensitivity Simulation (High-Value K_v = 1.5 E-3 ft/day in Miocene)

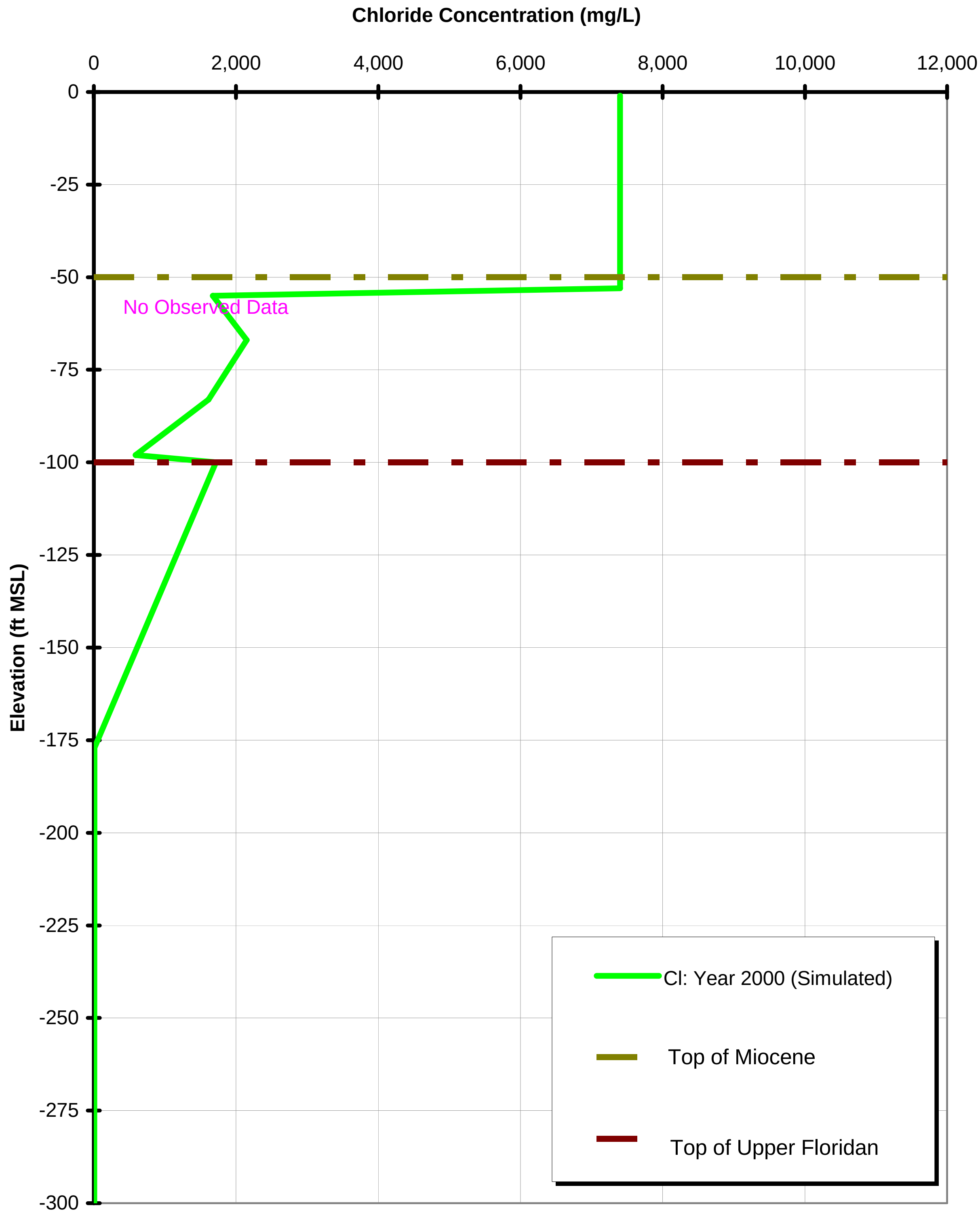

Figure 9
Measured and Simulated Chloride Measurements at SHE-2 Borehole
Sensitivity Simulation with High-Value K_v (1.5 E-3 ft/day) in Miocene Confining Unit

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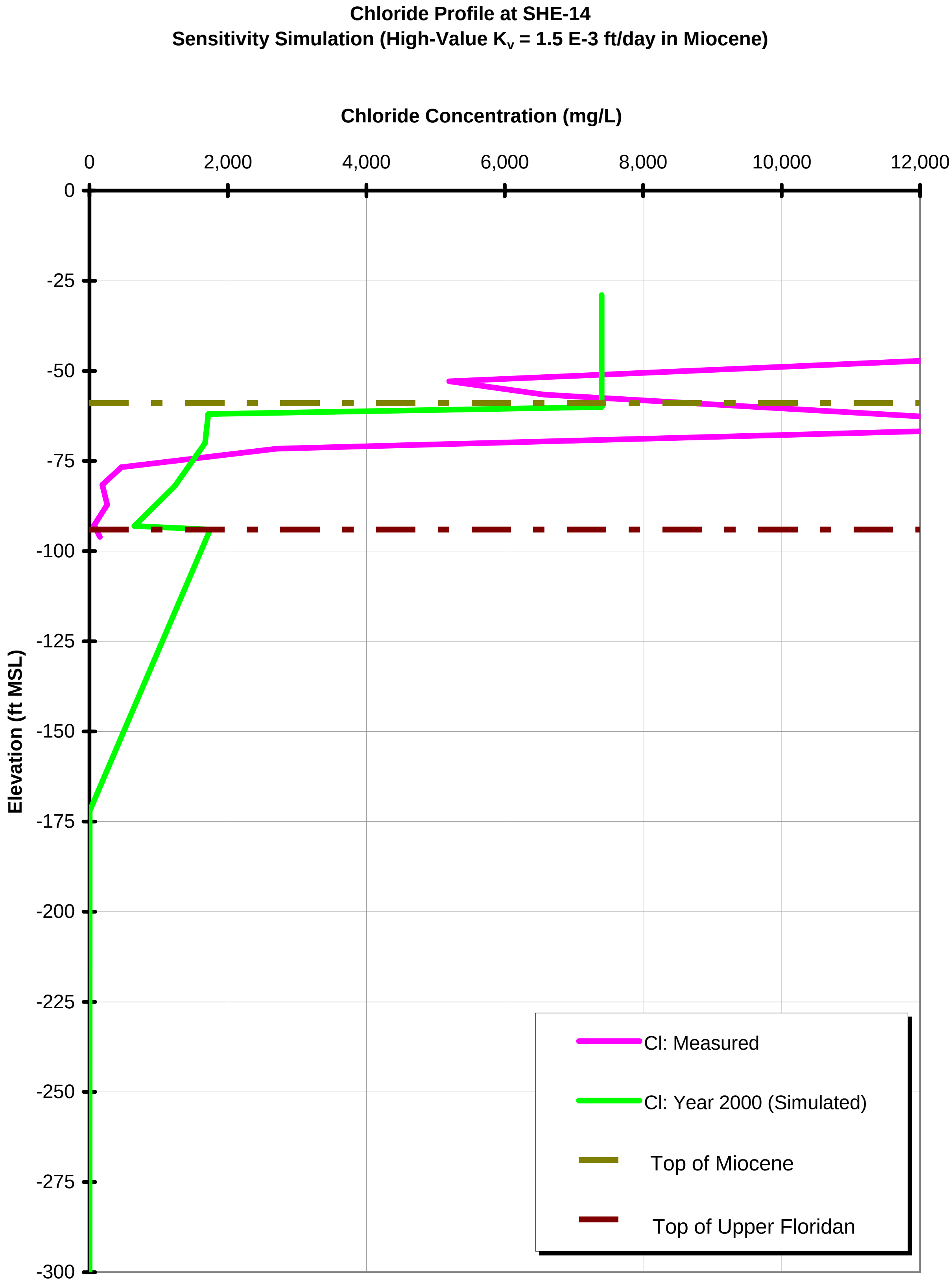

Figure 10
Measured and Simulated Chloride Measurements at SHE-14 Borehole
Sensitivity Simulation with High-Value K_v (1.5 E-3 ft/day) in Miocene Confining Unit

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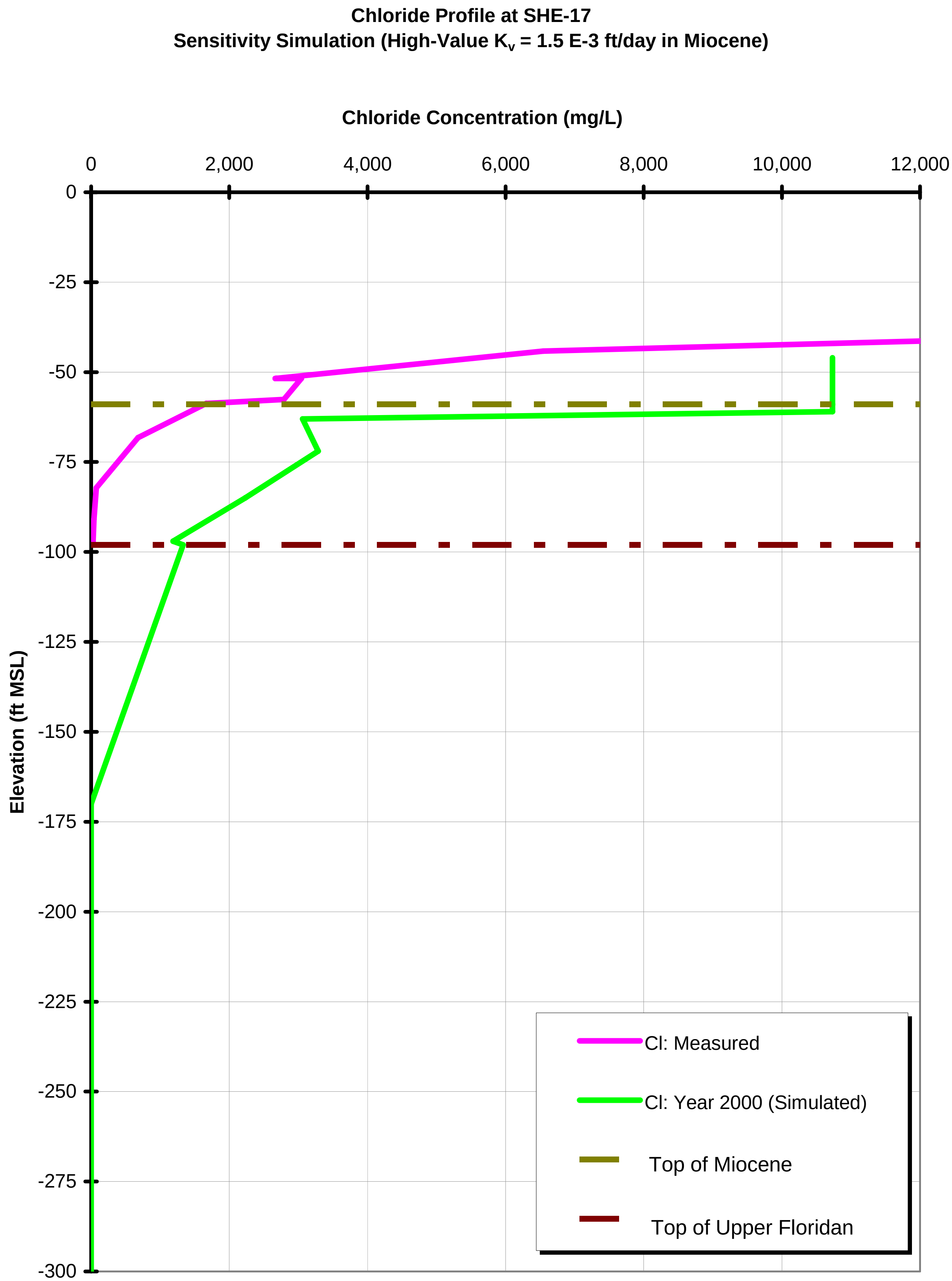

Figure 11
Measured and Simulated Chloride Measurements at SHE-17 Borehole
Sensitivity Simulation with High-Value K_v (1.5 E-3 ft/day) in Miocene Confining Unit

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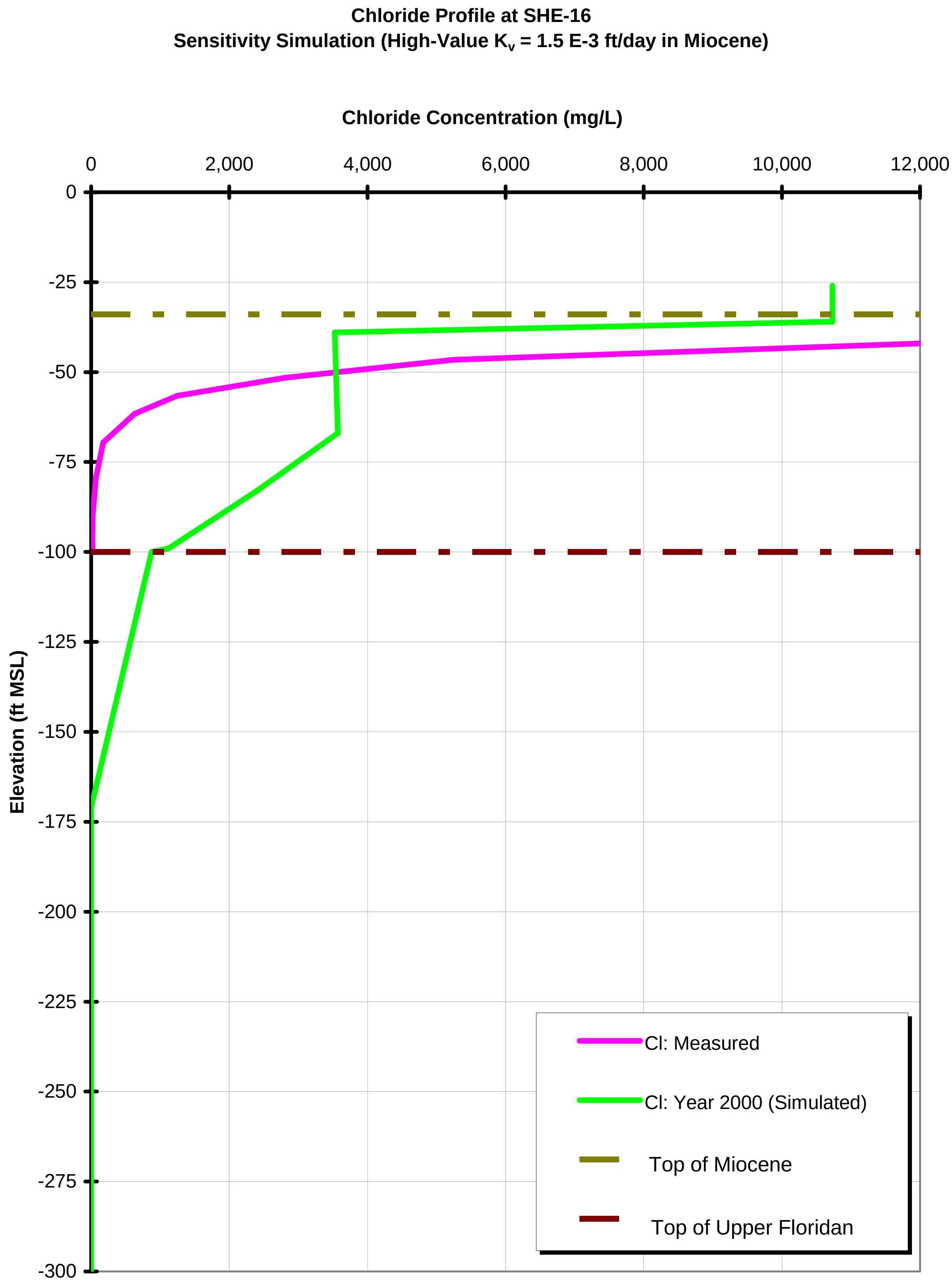

Figure 12
Measured and Simulated Chloride Measurements at SHE-16 Borehole
Sensitivity Simulation with High-Value K_v (1.5 E-3 ft/day) in Miocene Confining Unit

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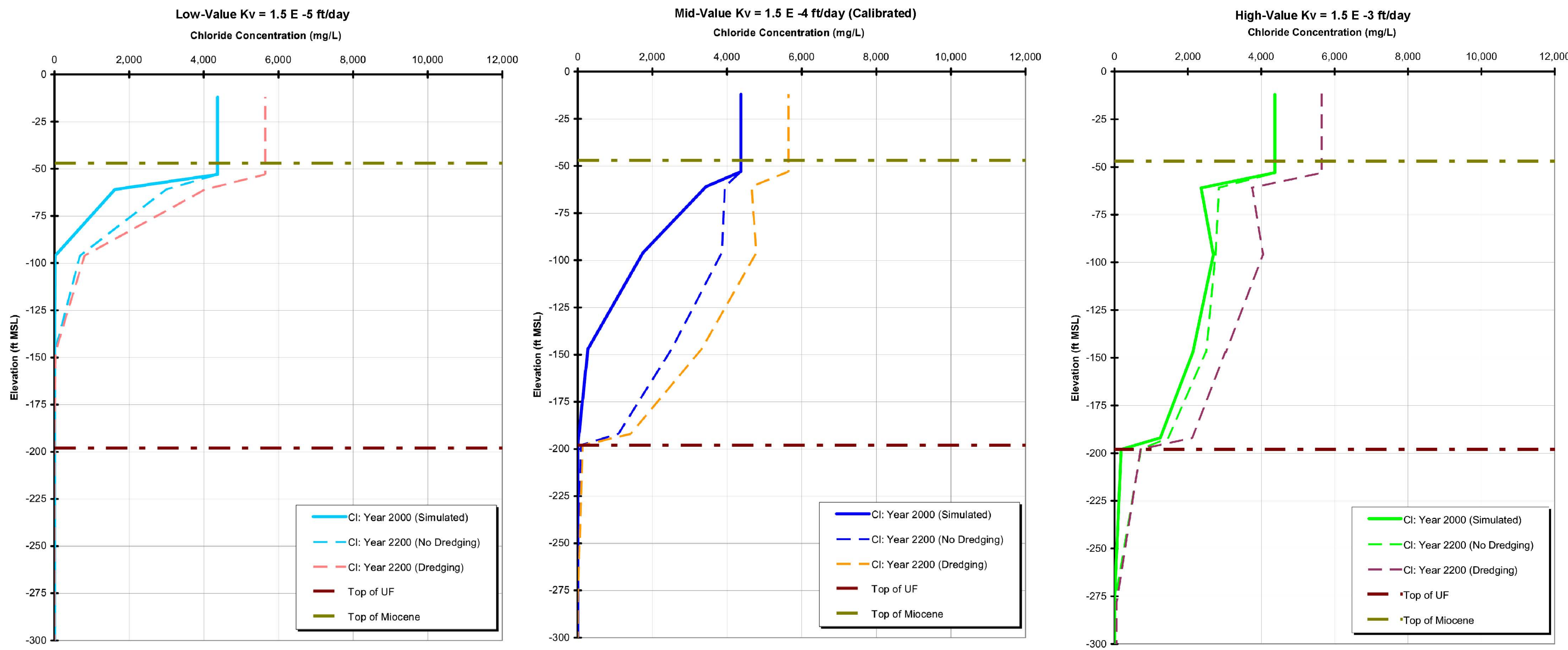
Comparison of Simulated Chloride Concentrations Profiles at SHE-15 for Dredging and No Dredging Conditions Using the Low, Mid, and High-Value Vertical Hydraulic Conductivities in the Miocene Confining Unit



Comparison of Simulated Chloride Concentrations Profiles at SHE-15

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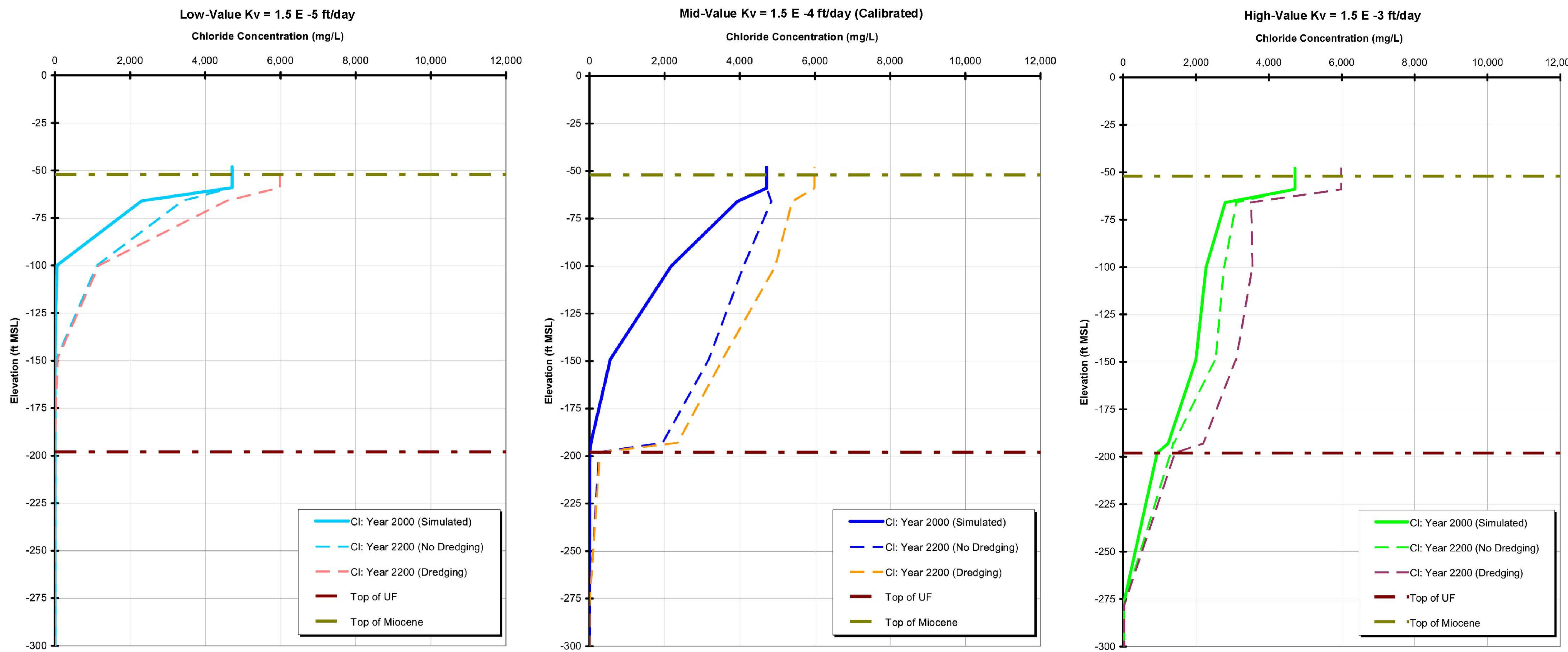
Figure 13

Comparison of Simulated Chloride Concentrations Profiles at SHE-5 for Dredging and No Dredging Conditions Using the Low, Mid, and High-Value Vertical Hydraulic Conductivities in the Miocene Confining Unit



Comparison of Simulated Chloride Concentrations Profiles at SHE-5

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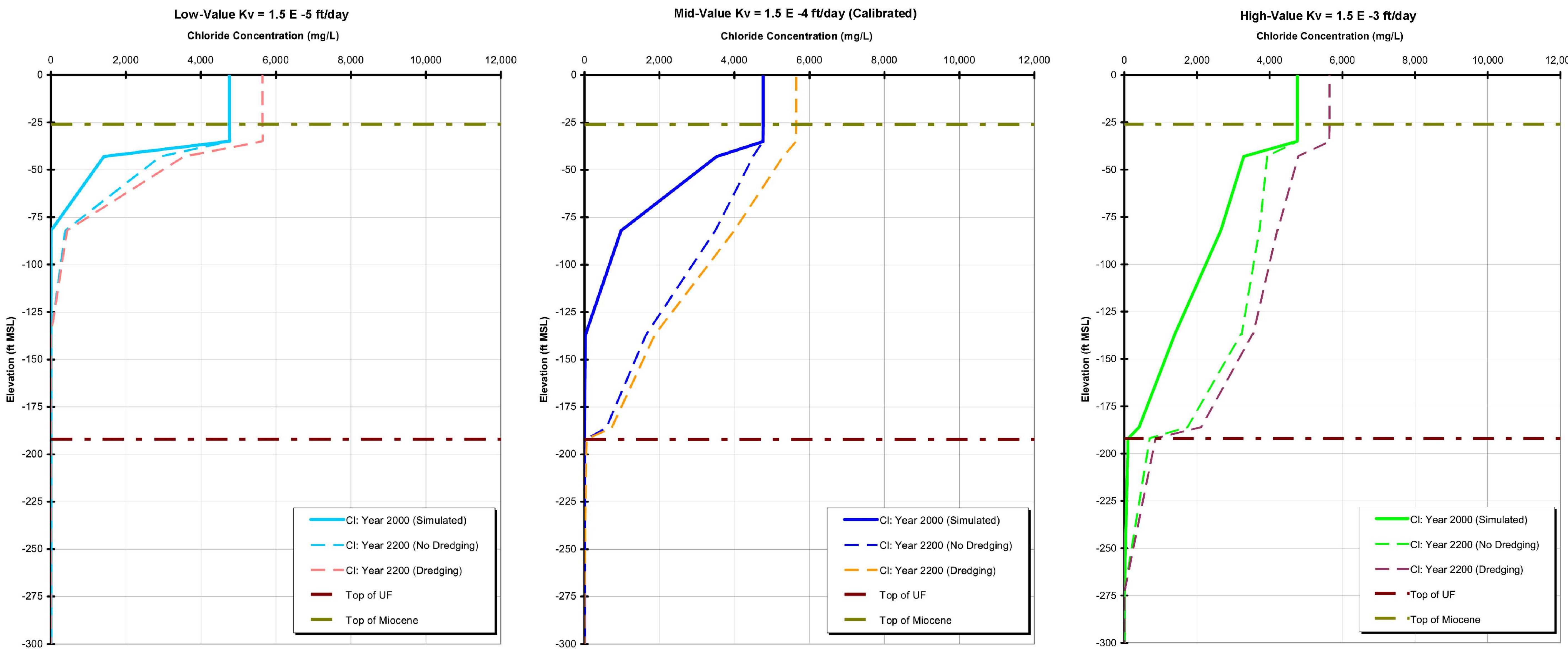
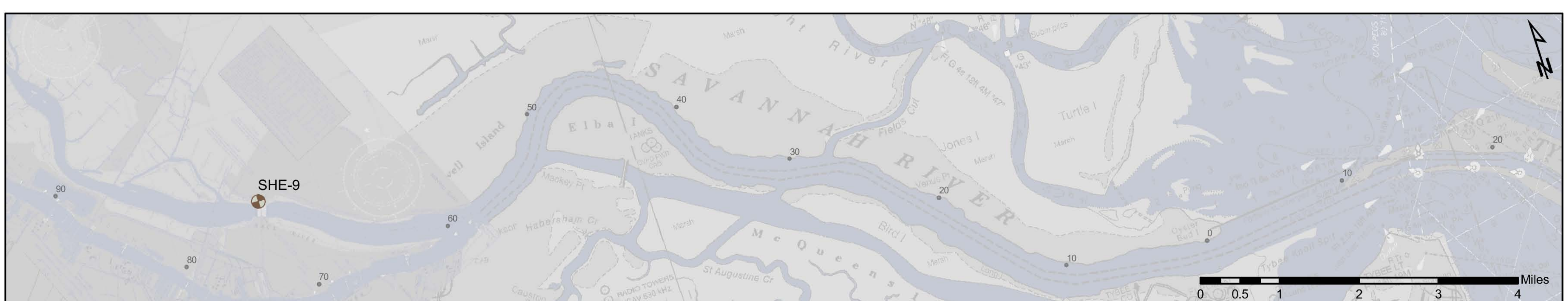
Figure 14

Comparison of Simulated Chloride Concentrations Profiles at SHE-9 for Dredging and No Dredging Conditions Using the Low, Mid, and High-Value Vertical Hydraulic Conductivities in the Miocene Confining Unit





Comparison of Simulated Chloride Concentrations Profiles at SHE-9

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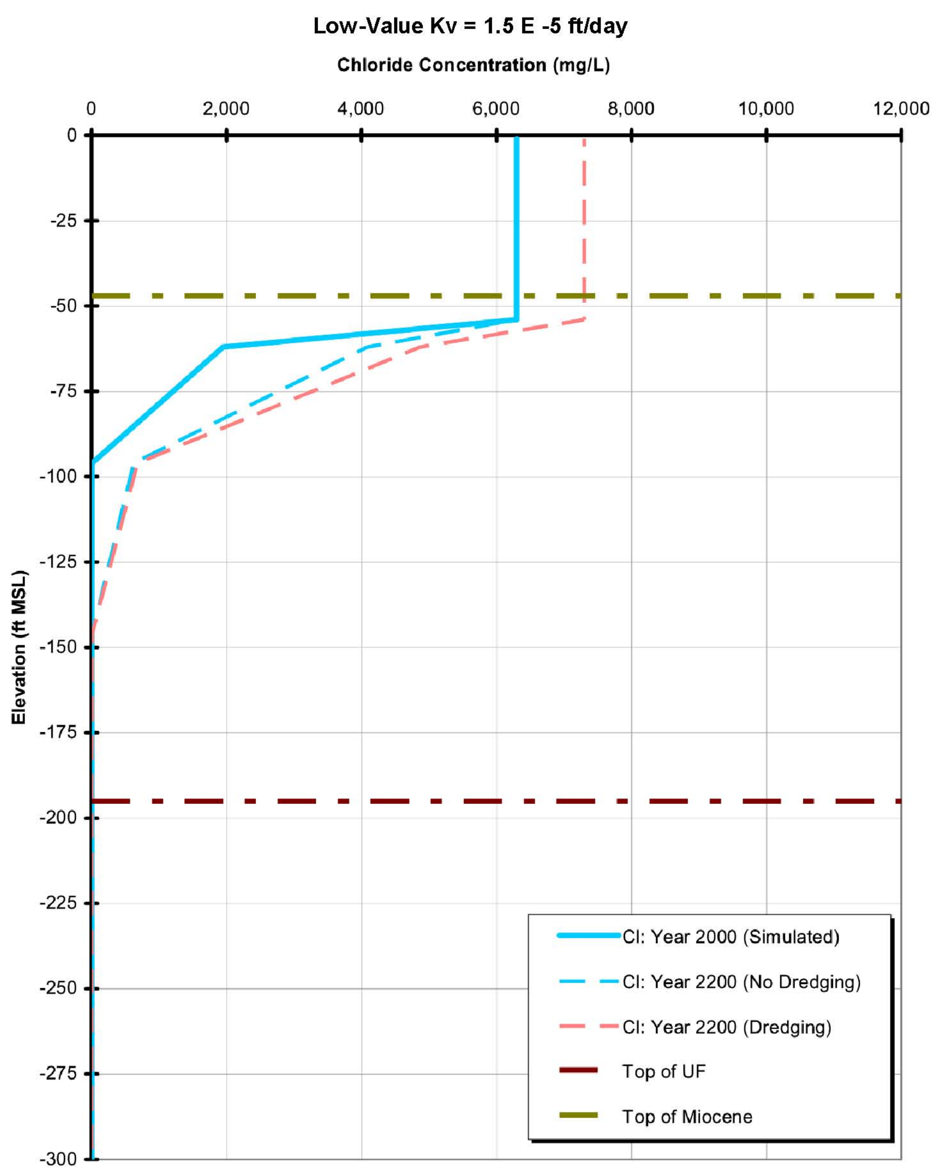
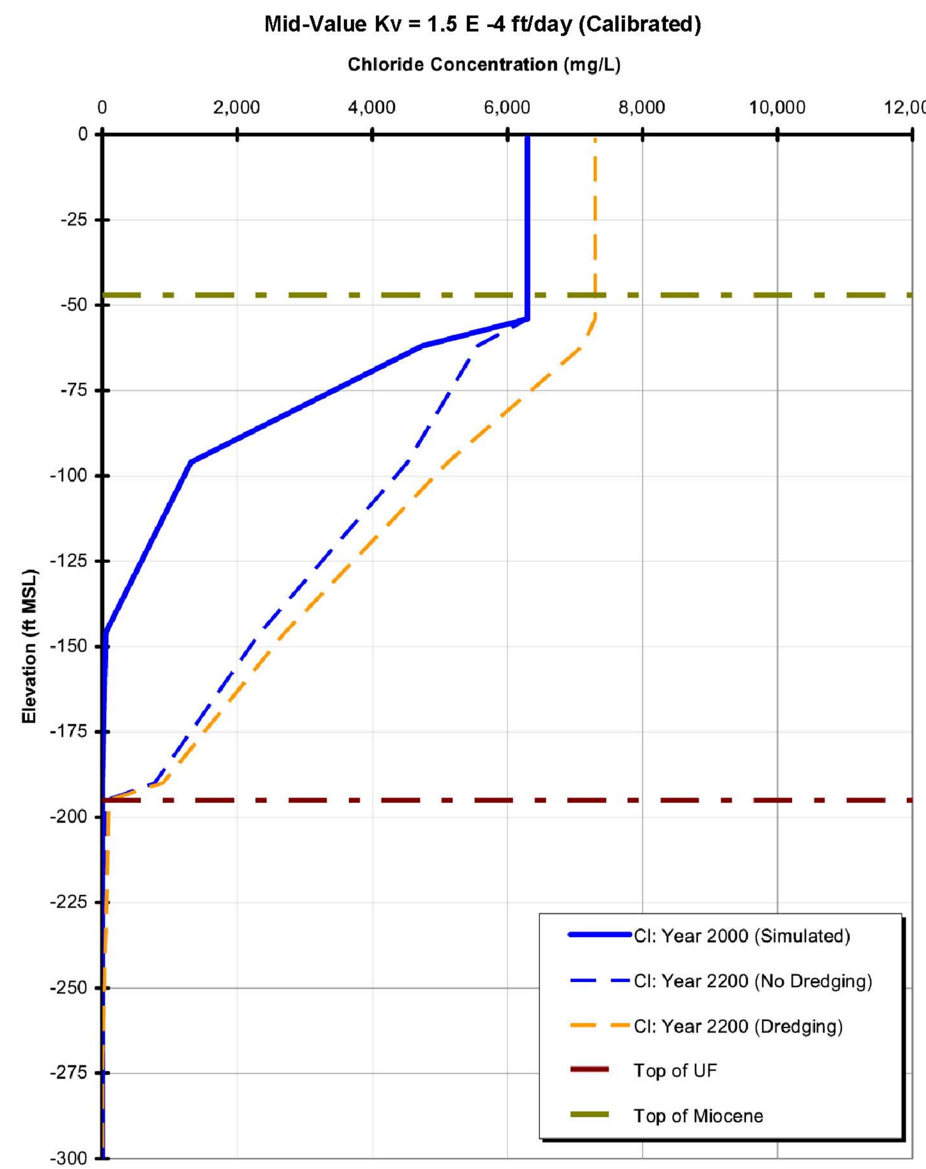
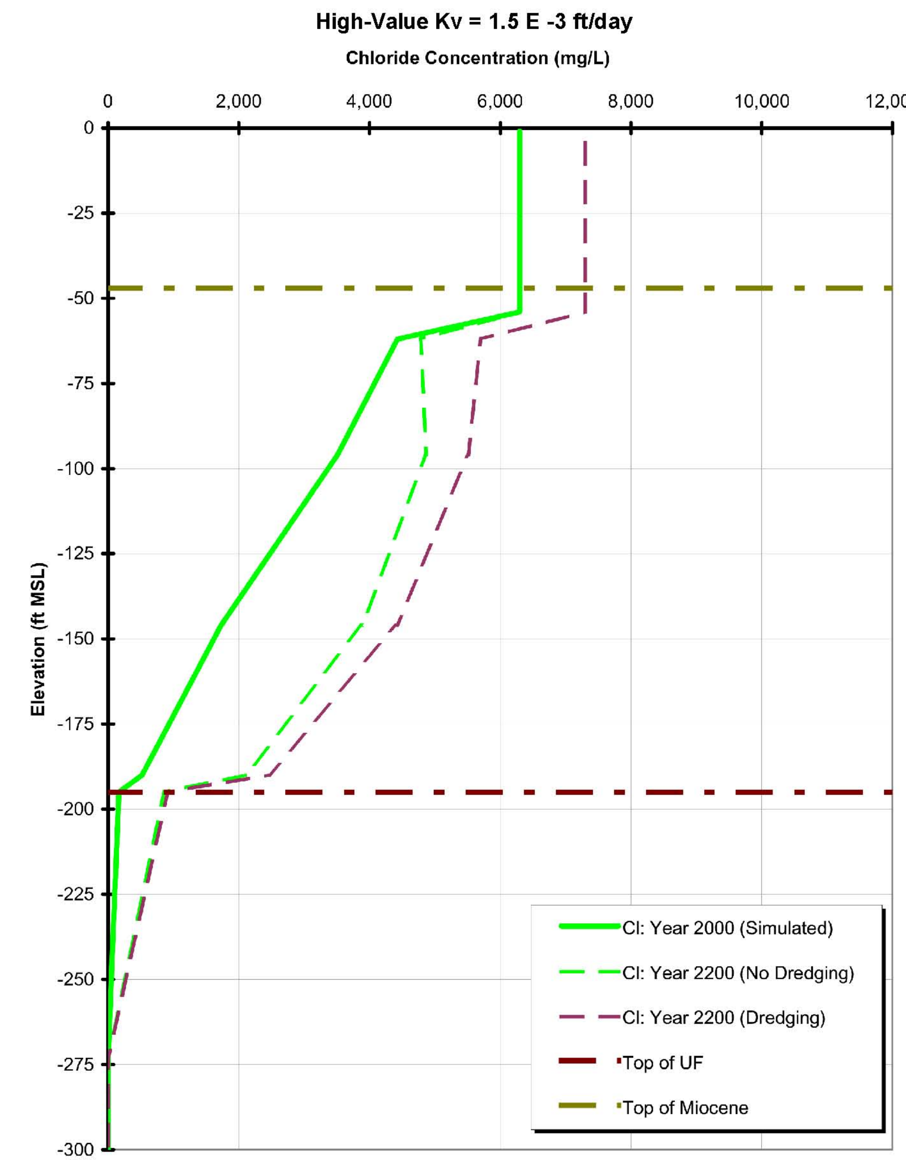
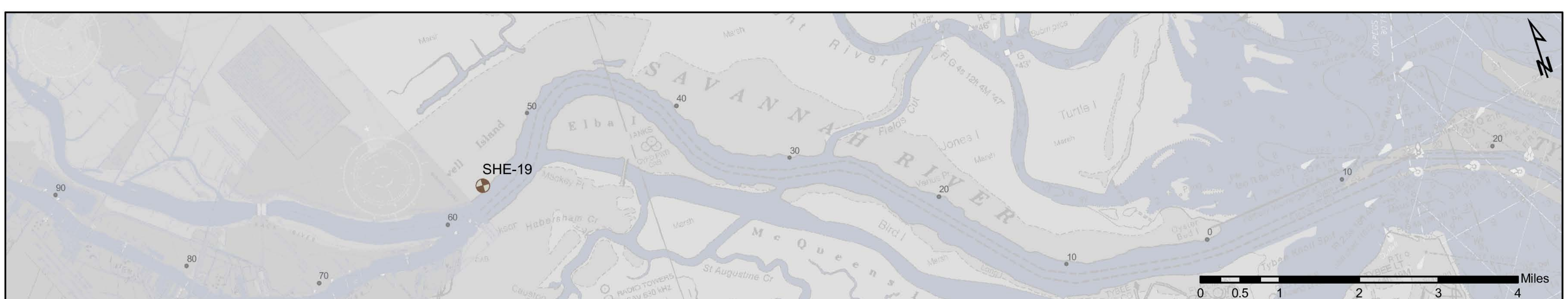
Figure 15

Comparison of Simulated Chloride Concentrations Profiles at SHE-19 for Dredging and No Dredging Conditions Using the Low, Mid, and High-Value Vertical Hydraulic Conductivities in the Miocene Confining Unit









Comparison of Simulated Chloride Concentrations Profiles at SHE-19

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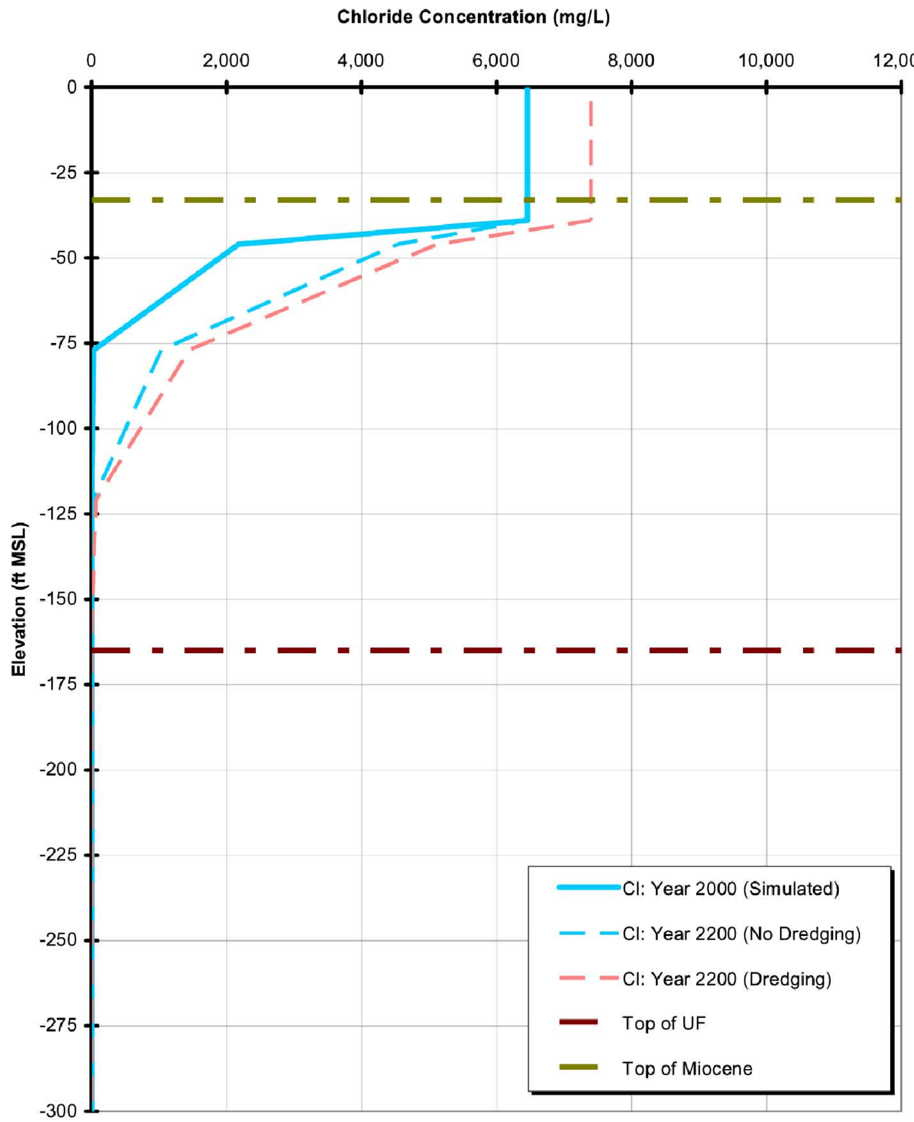
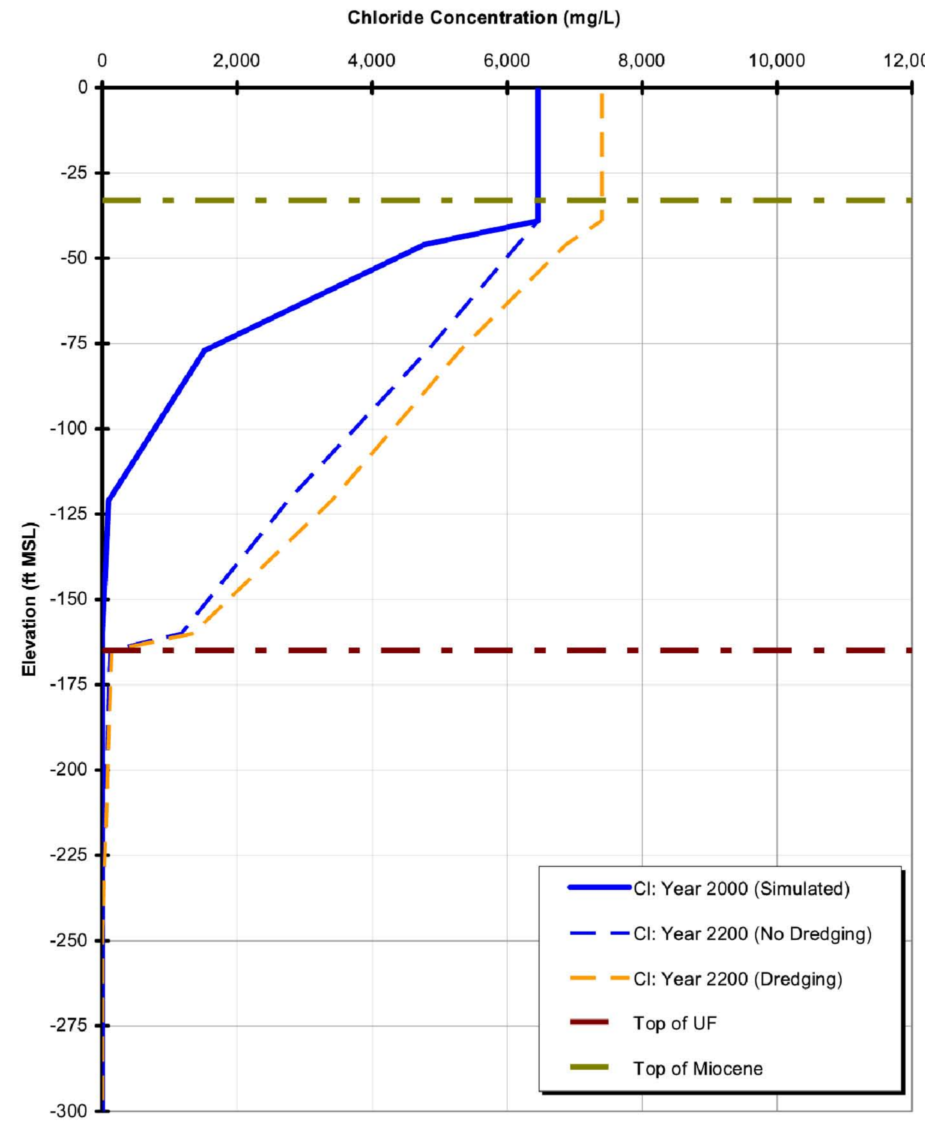
Figure 16

Comparison of Simulated Chloride Concentrations Profiles at SHE-10 for Dredging and No Dredging Conditions Using the Low, Mid, and High-Value Vertical Hydraulic Conductivities in the Miocene Confining Unit

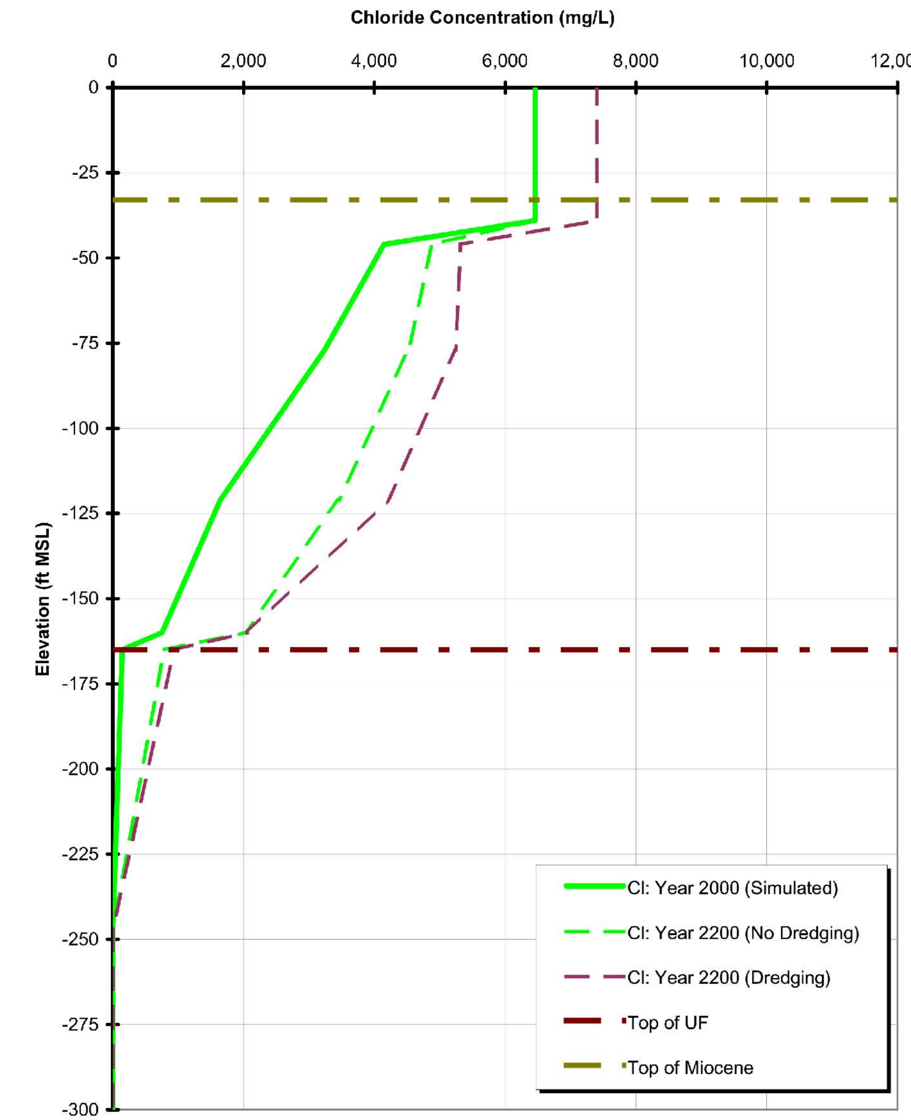
Low-Value Kv = 1.5 E -5 ft/day

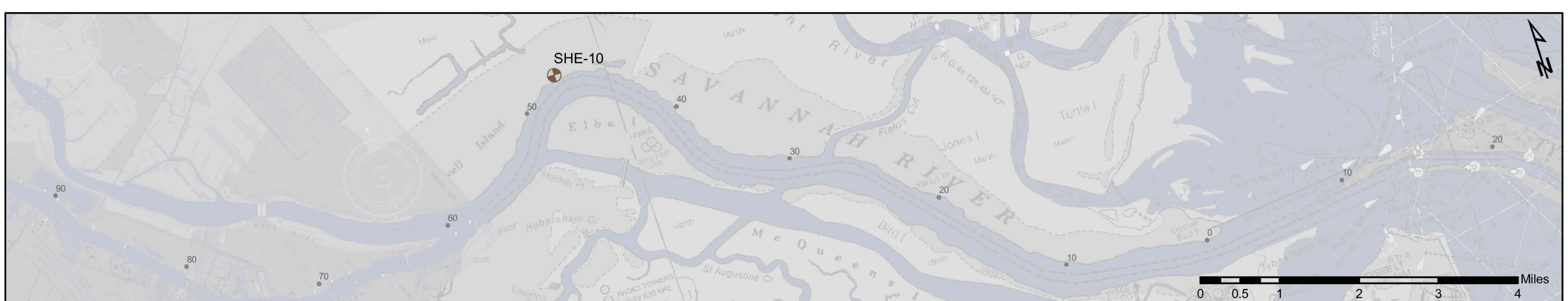


Mid-Value Kv = 1.5 E -4 ft/day (Calibrated)



High-Value Kv = 1.5 E -3 ft/day





Comparison of Simulated Chloride Concentrations Profiles at SHE-10

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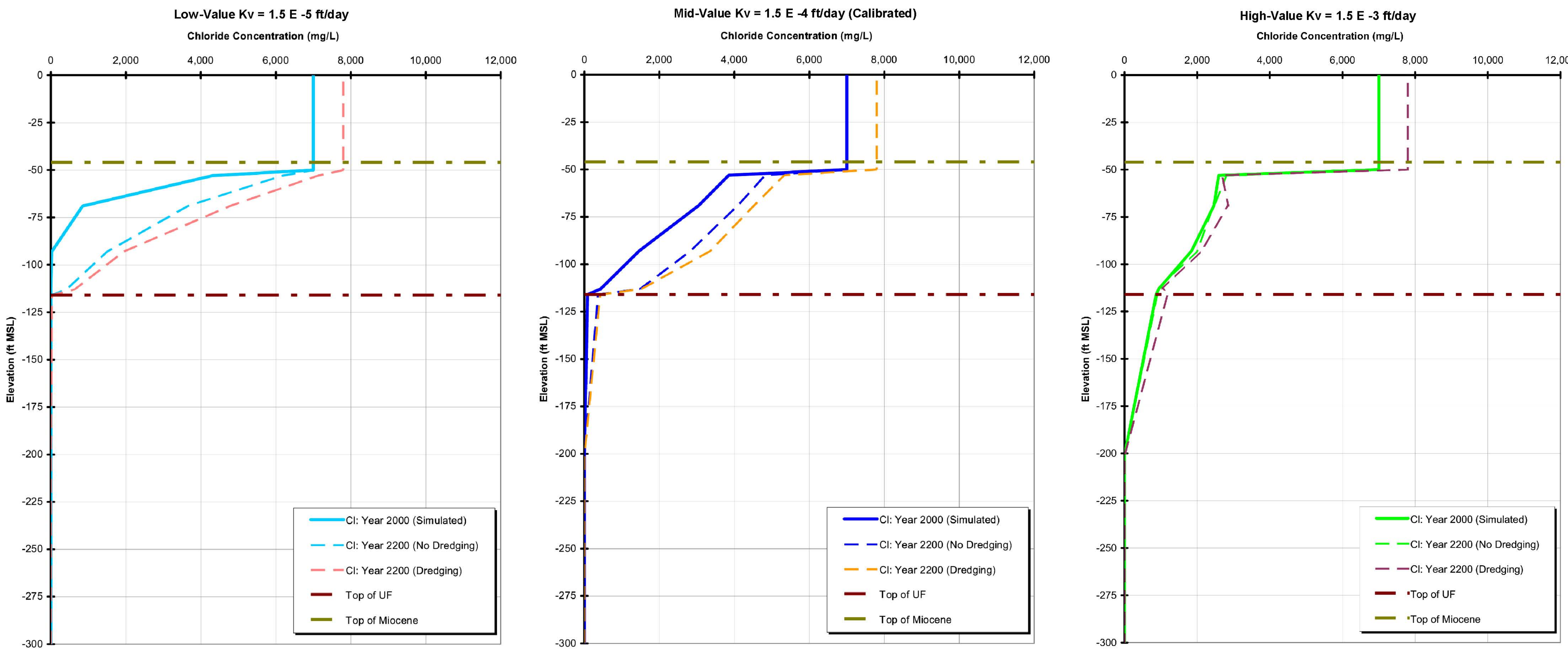
Figure 17

Comparison of Simulated Chloride Concentrations Profiles at SHE-18 for Dredging and No Dredging Conditions Using the Low, Mid, and High-Value Vertical Hydraulic Conductivities in the Miocene Confining Unit



Comparison of Simulated Chloride Concentrations Profiles at SHE-18

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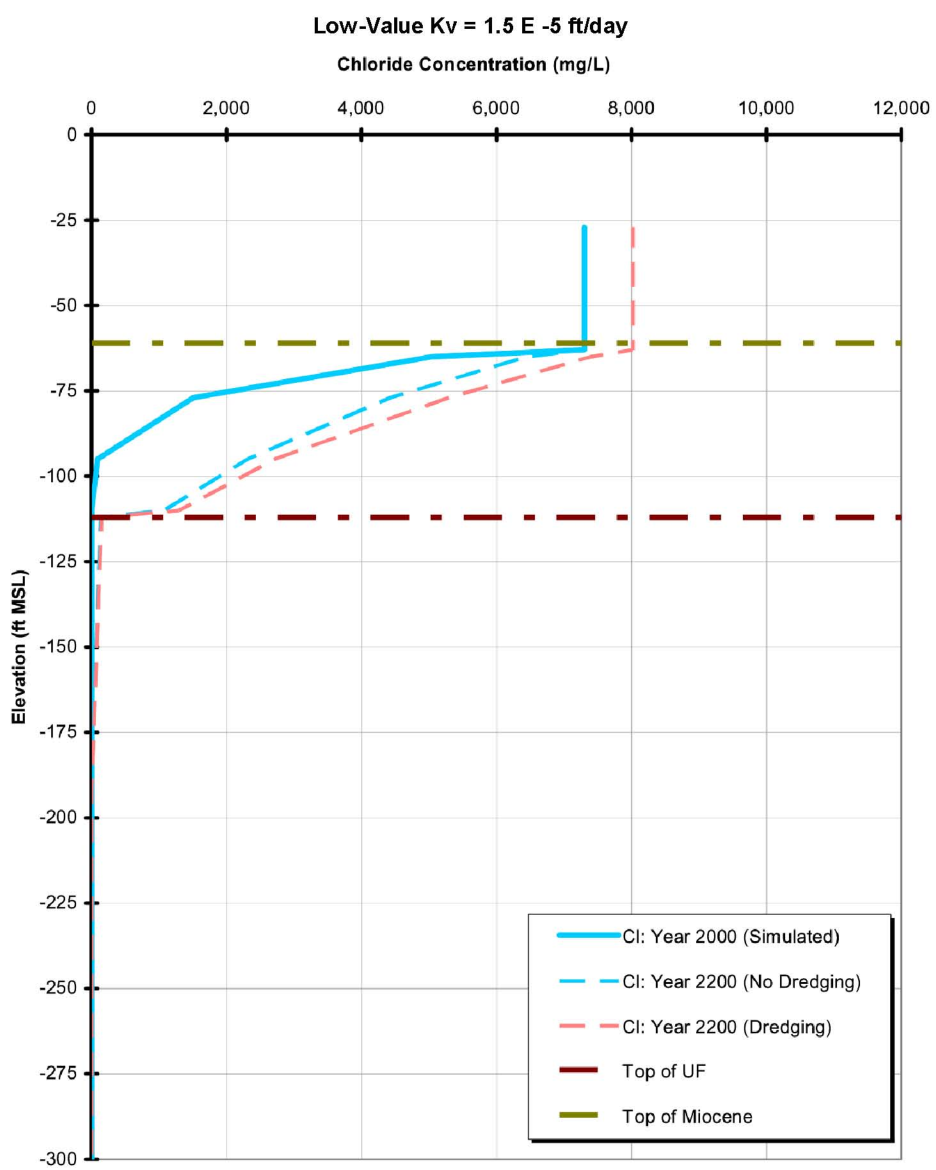
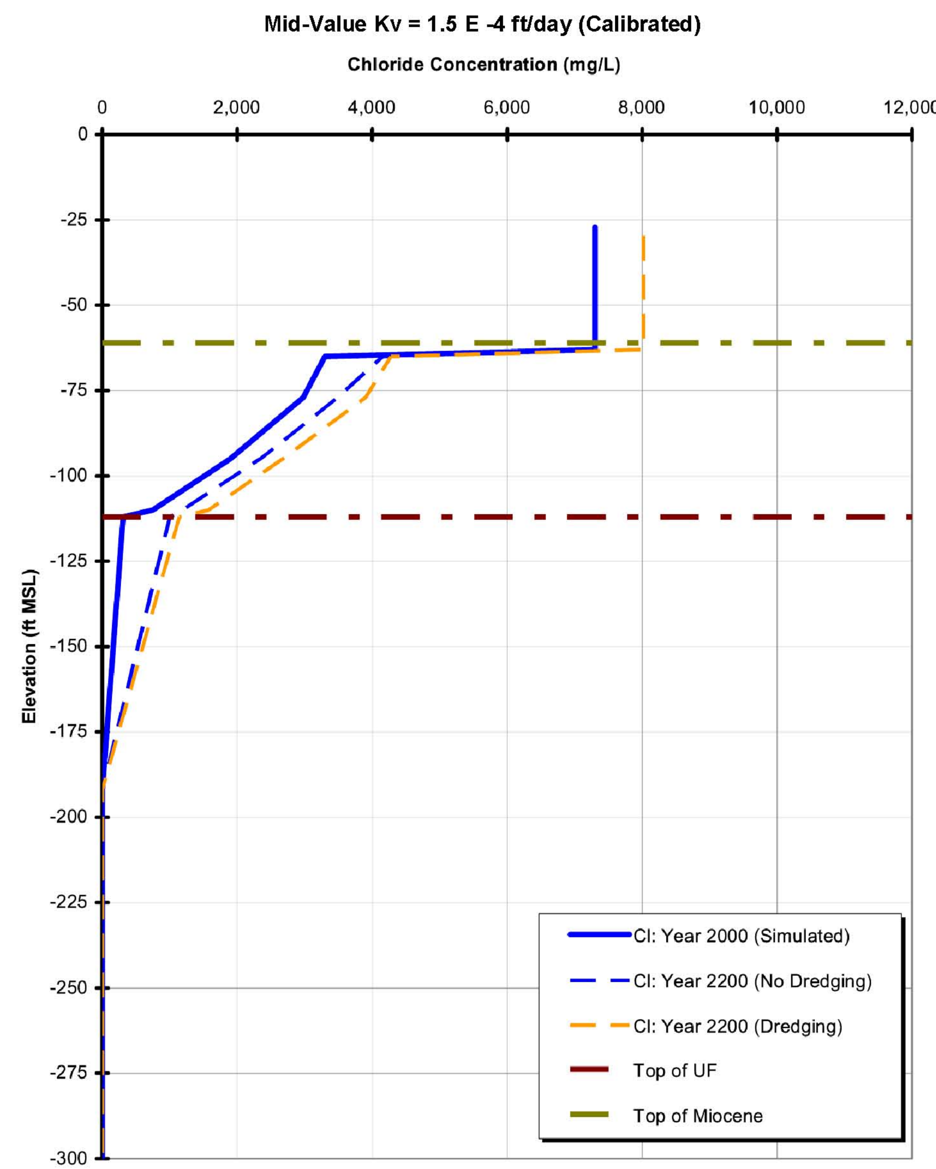
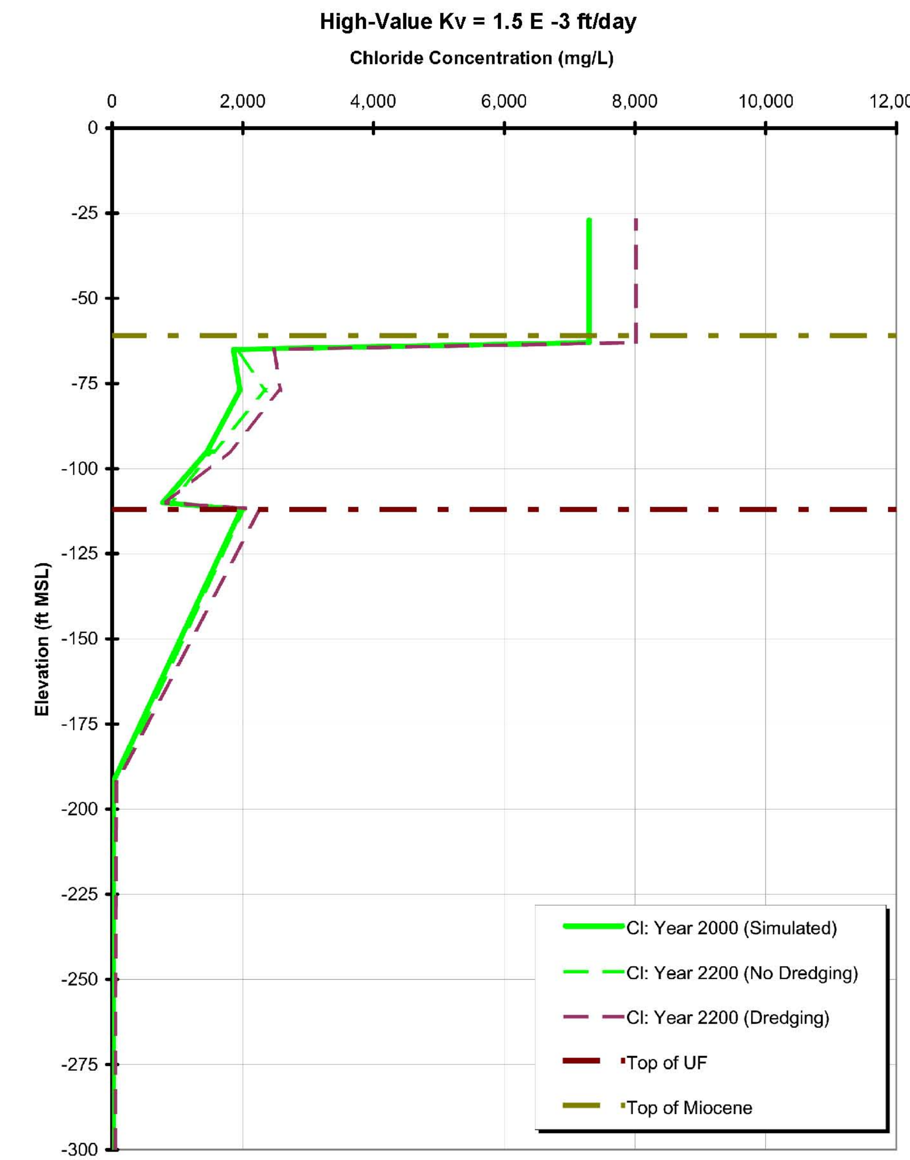
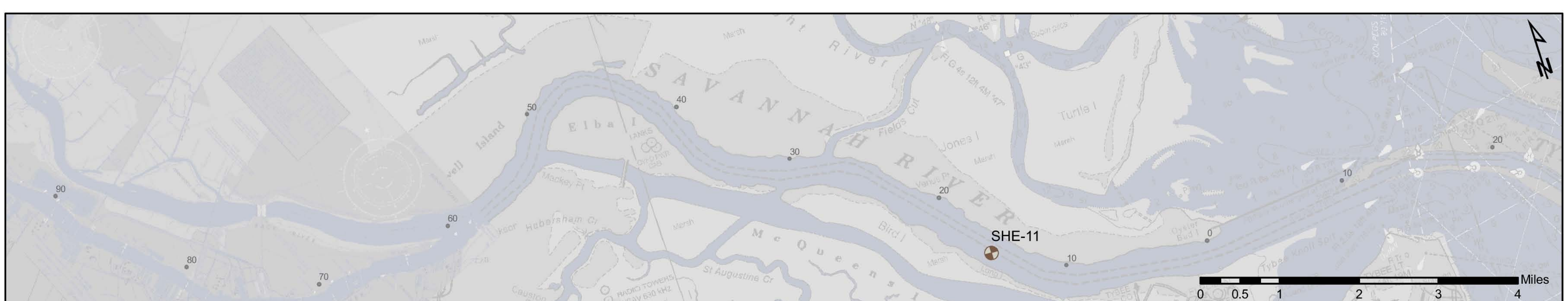
Figure 18

Comparison of Simulated Chloride Concentrations Profiles at SHE-11 for Dredging and No Dredging Conditions Using the Low, Mid, and High-Value Vertical Hydraulic Conductivities in the Miocene Confining Unit









Comparison of Simulated Chloride Concentrations Profiles at SHE-11

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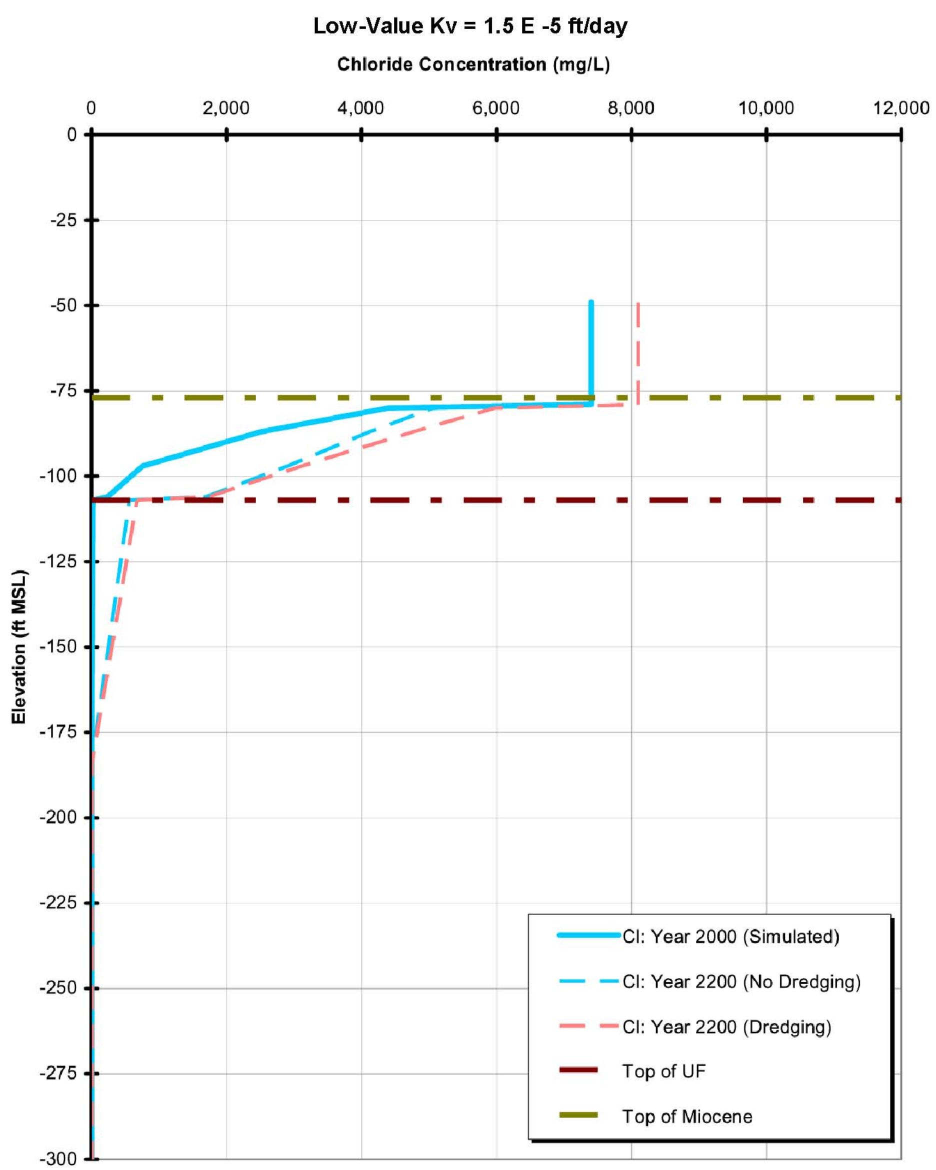
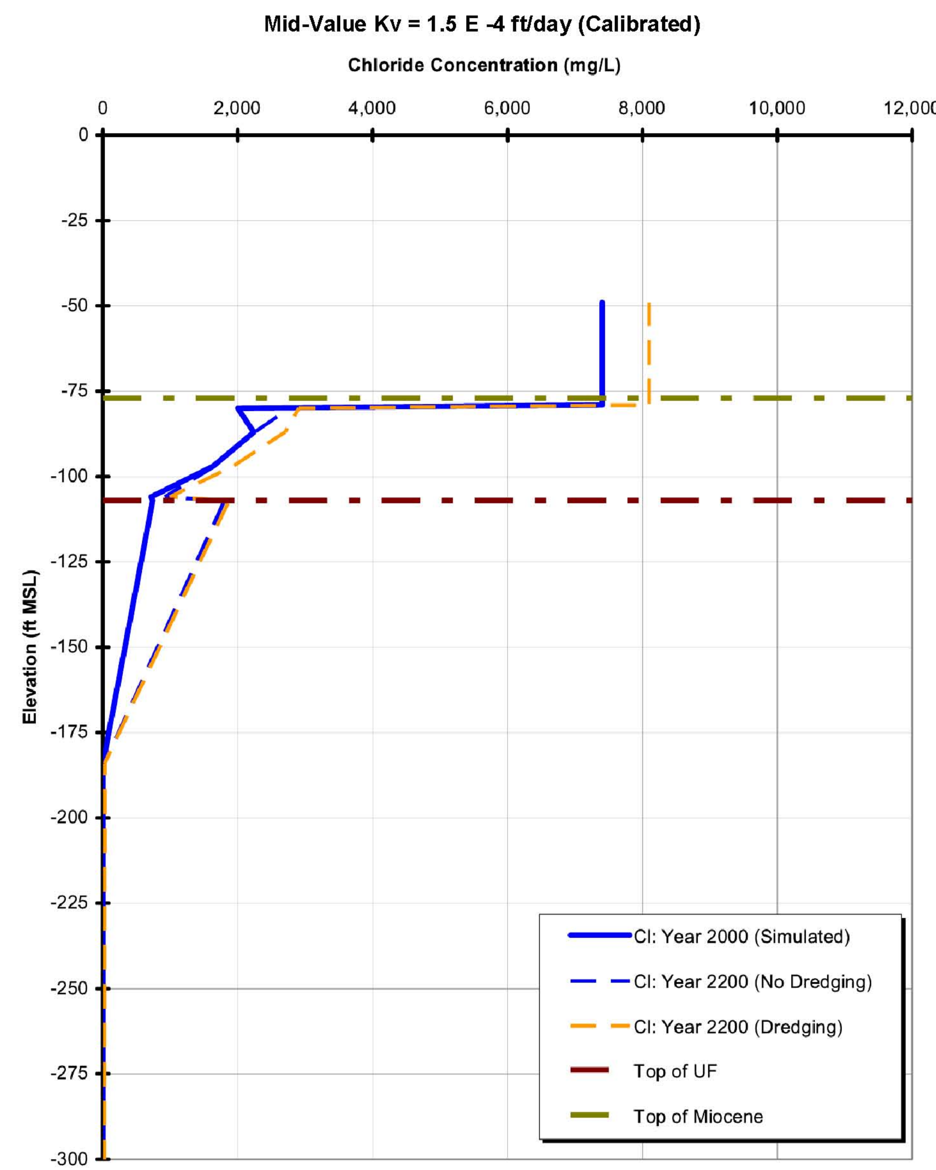
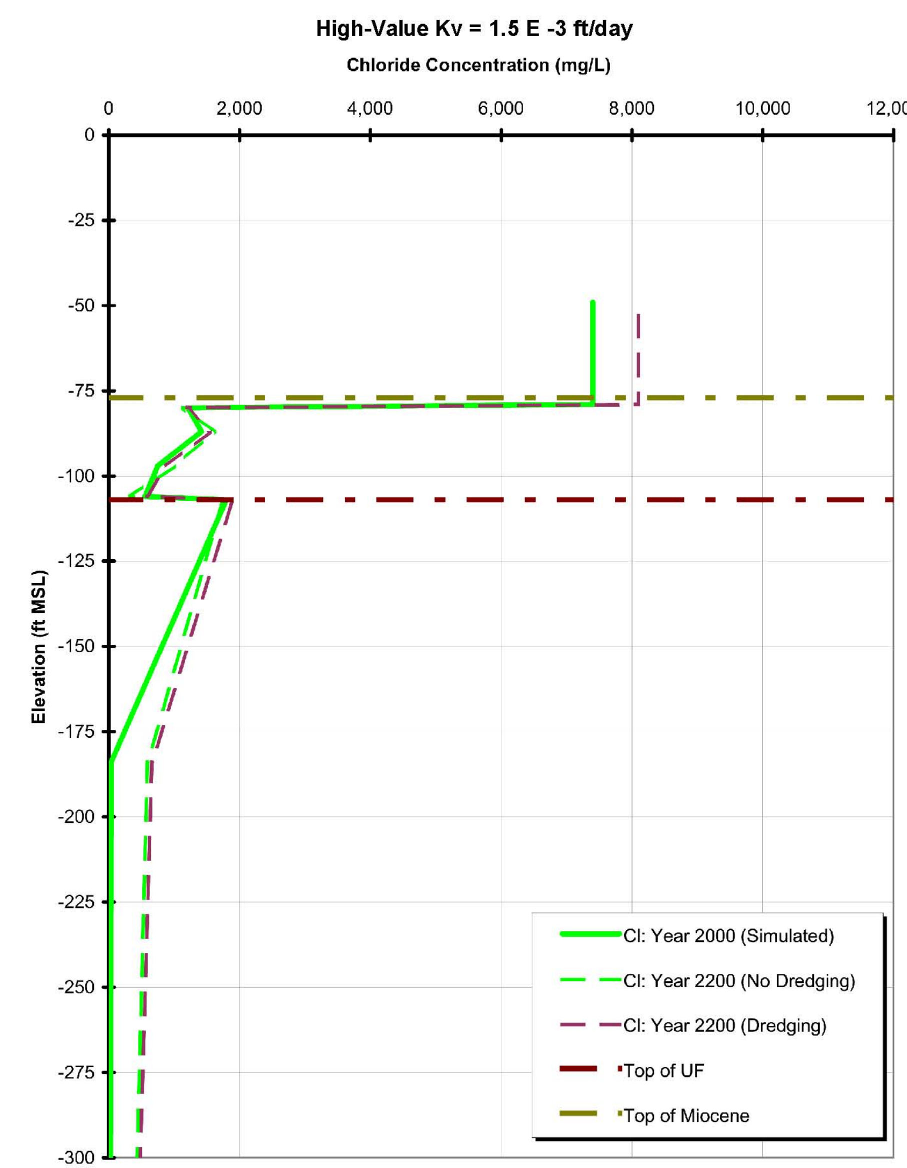
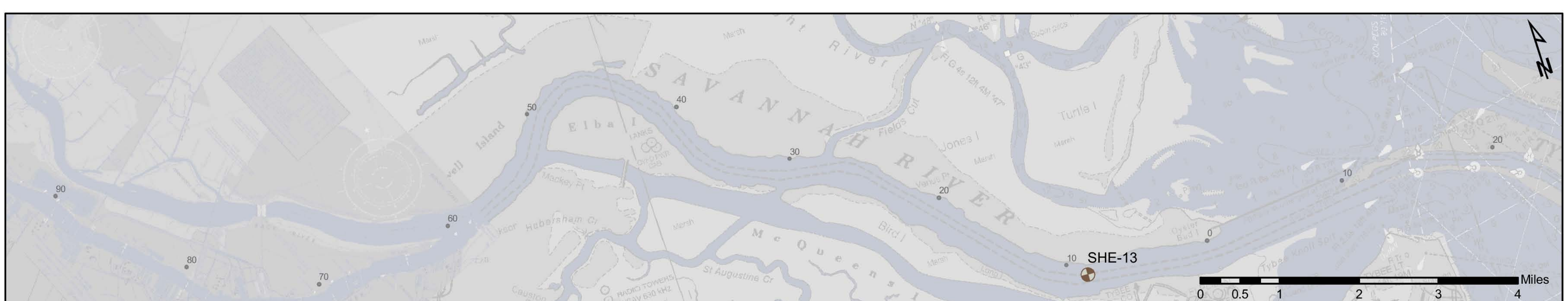
Figure 19

Comparison of Simulated Chloride Concentrations Profiles at SHE-13 for Dredging and No Dredging Conditions Using the Low, Mid, and High-Value Vertical Hydraulic Conductivities in the Miocene Confining Unit









Comparison of Simulated Chloride Concentrations Profiles at SHE-13

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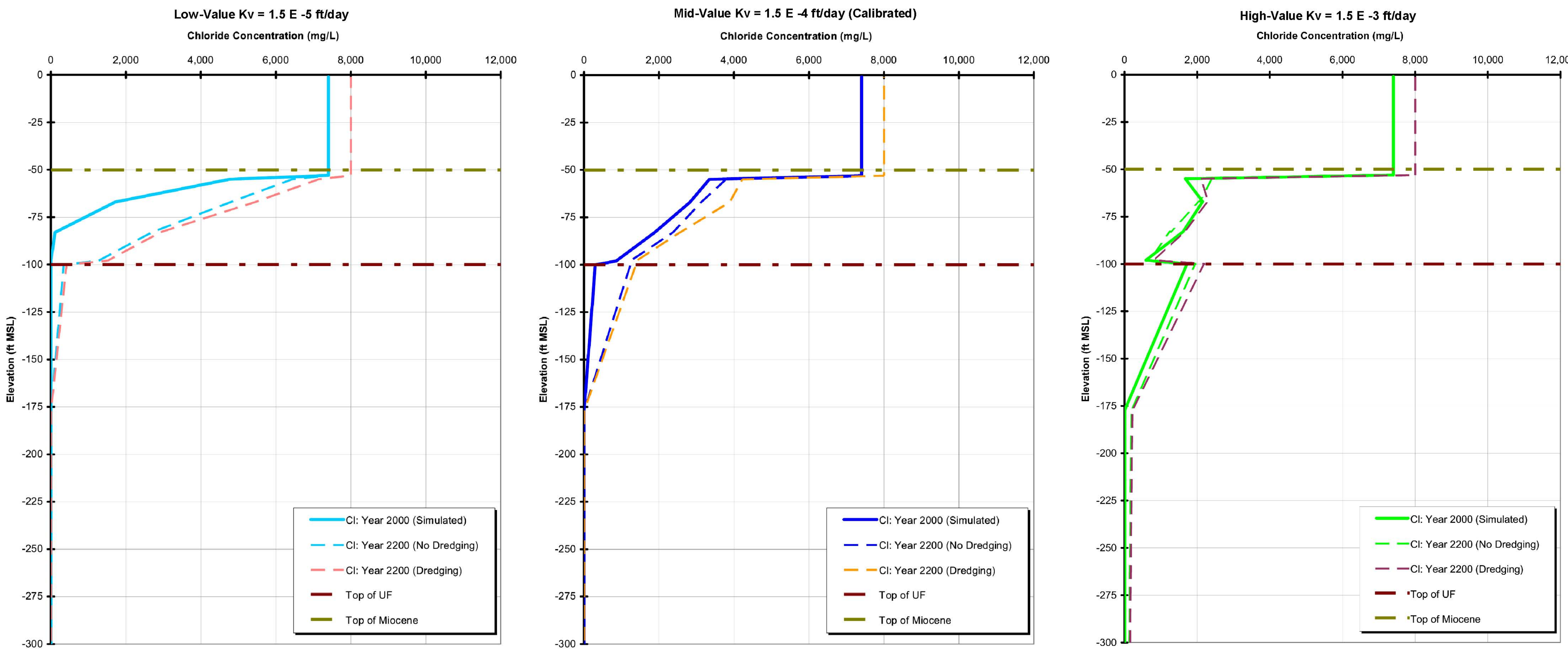
Figure 20

Comparison of Simulated Chloride Concentrations Profiles at SHE-2 for Dredging and No Dredging Conditions Using the Low, Mid, and High-Value Vertical Hydraulic Conductivities in the Miocene Confining Unit



Comparison of Simulated Chloride Concentrations Profiles at SHE-2

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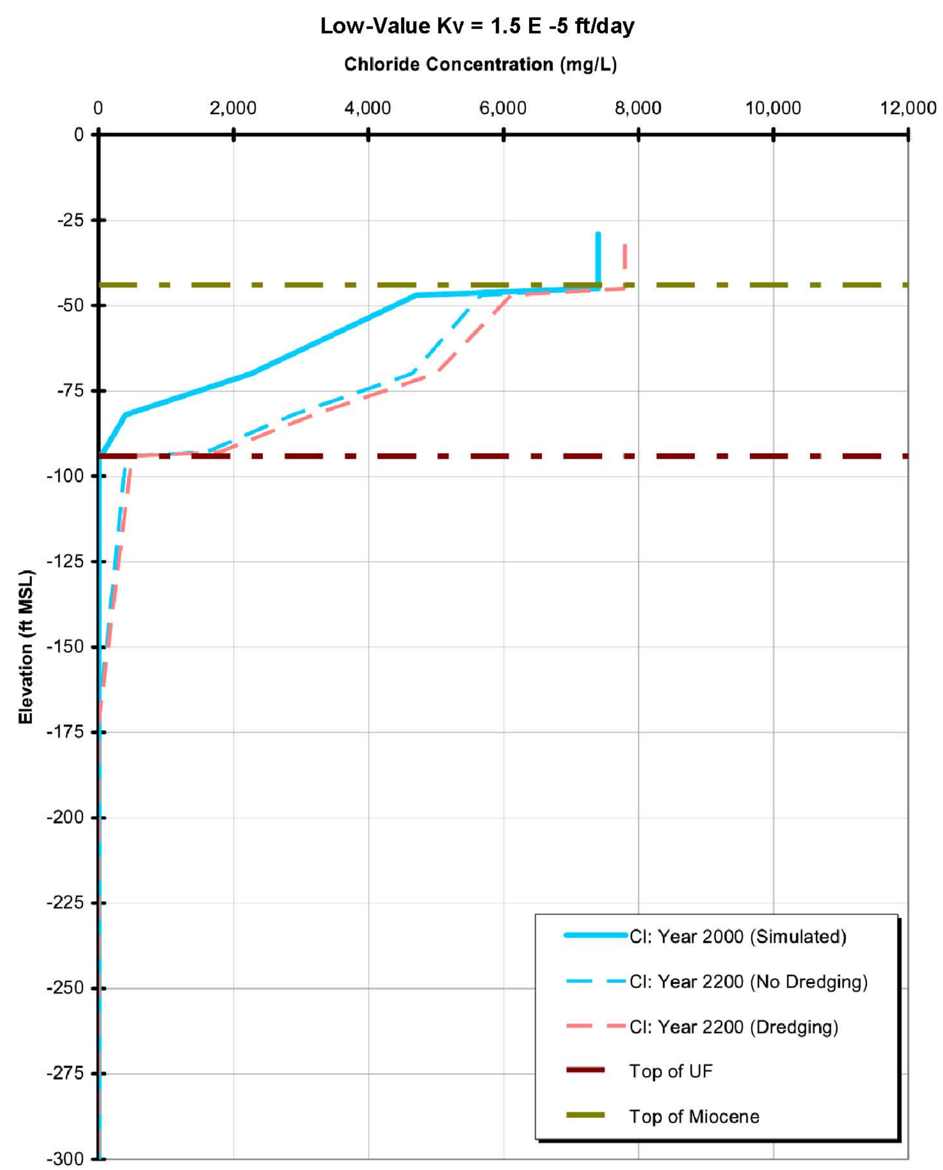
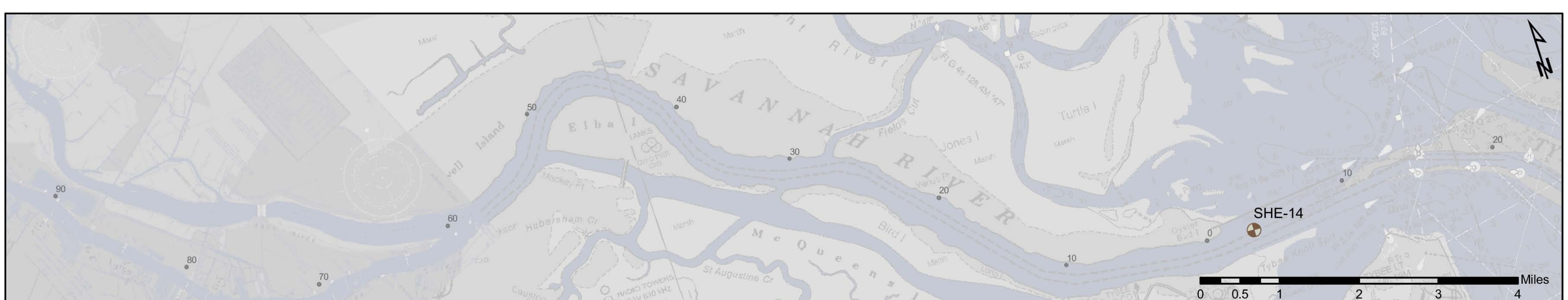
Figure 21

Comparison of Simulated Chloride Concentrations Profiles at SHE-14 for Dredging and No Dredging Conditions Using the Low, Mid, and High-Value Vertical Hydraulic Conductivities in the Miocene Confining Unit





Comparison of Simulated Chloride Concentrations Profiles at SHE-14

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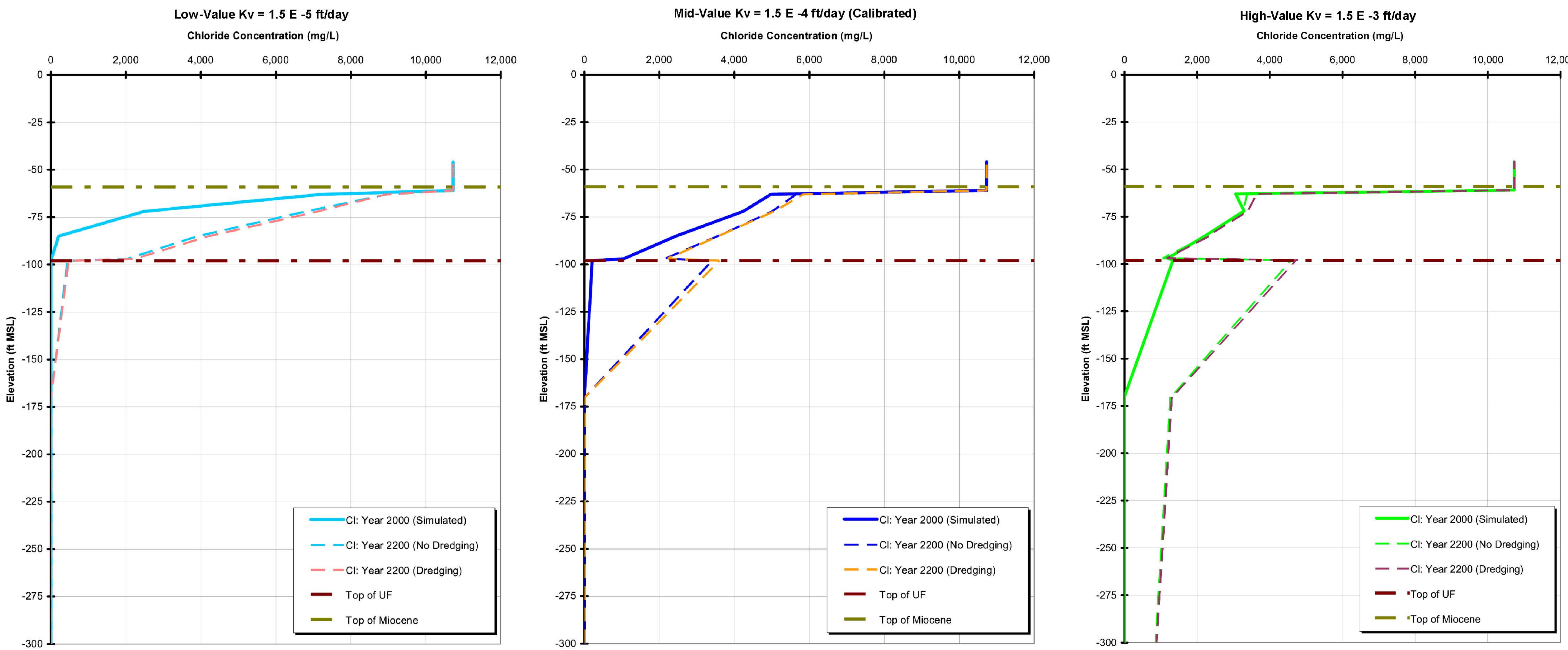
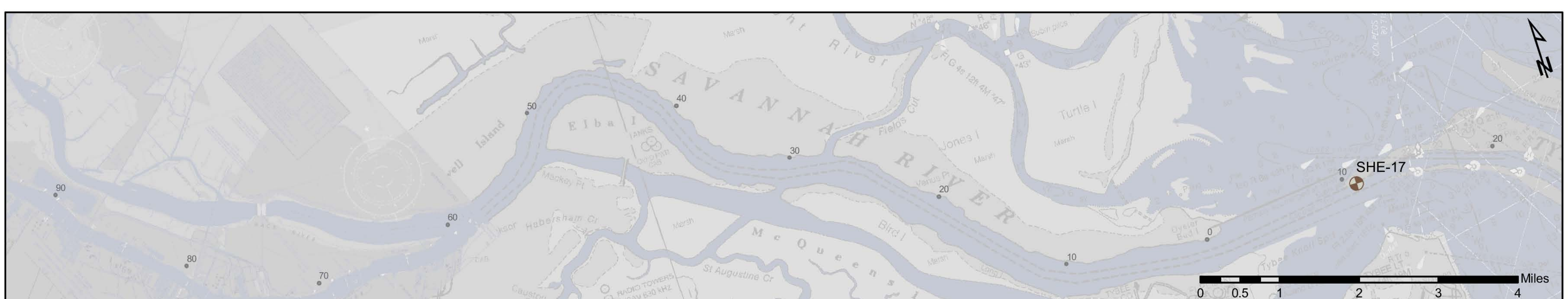
Figure 22

Comparison of Simulated Chloride Concentrations Profiles at SHE-17
for Dredging and No Dredging Conditions
Using the Low, Mid, and High-Value Vertical Hydraulic Conductivities in the Miocene Confining Unit





Comparison of Simulated Chloride Concentrations Profiles at SHE-17

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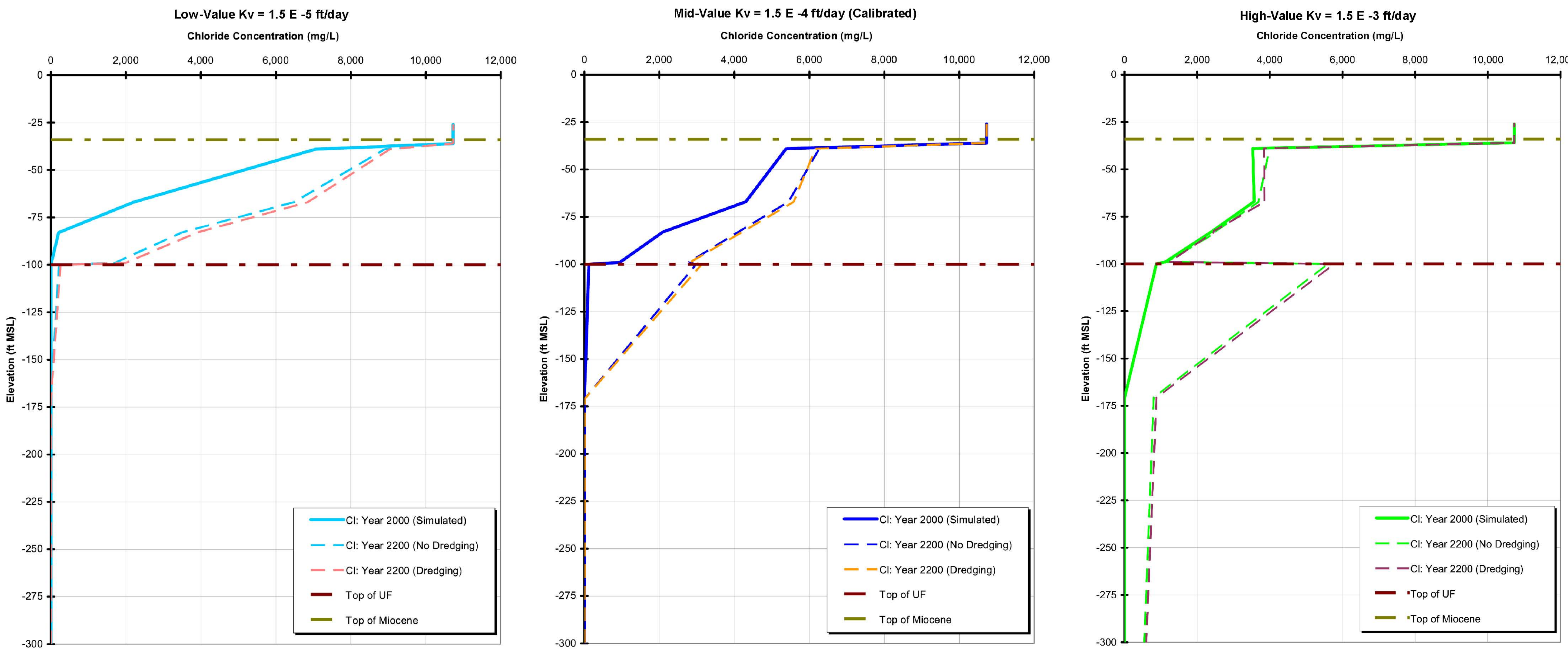
Figure 23

Comparison of Simulated Chloride Concentrations Profiles at SHE-16 for Dredging and No Dredging Conditions Using the Low, Mid, and High-Value Vertical Hydraulic Conductivities in the Miocene Confining Unit



Comparison of Simulated Chloride Concentrations Profiles at SHE-16

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Figure 24

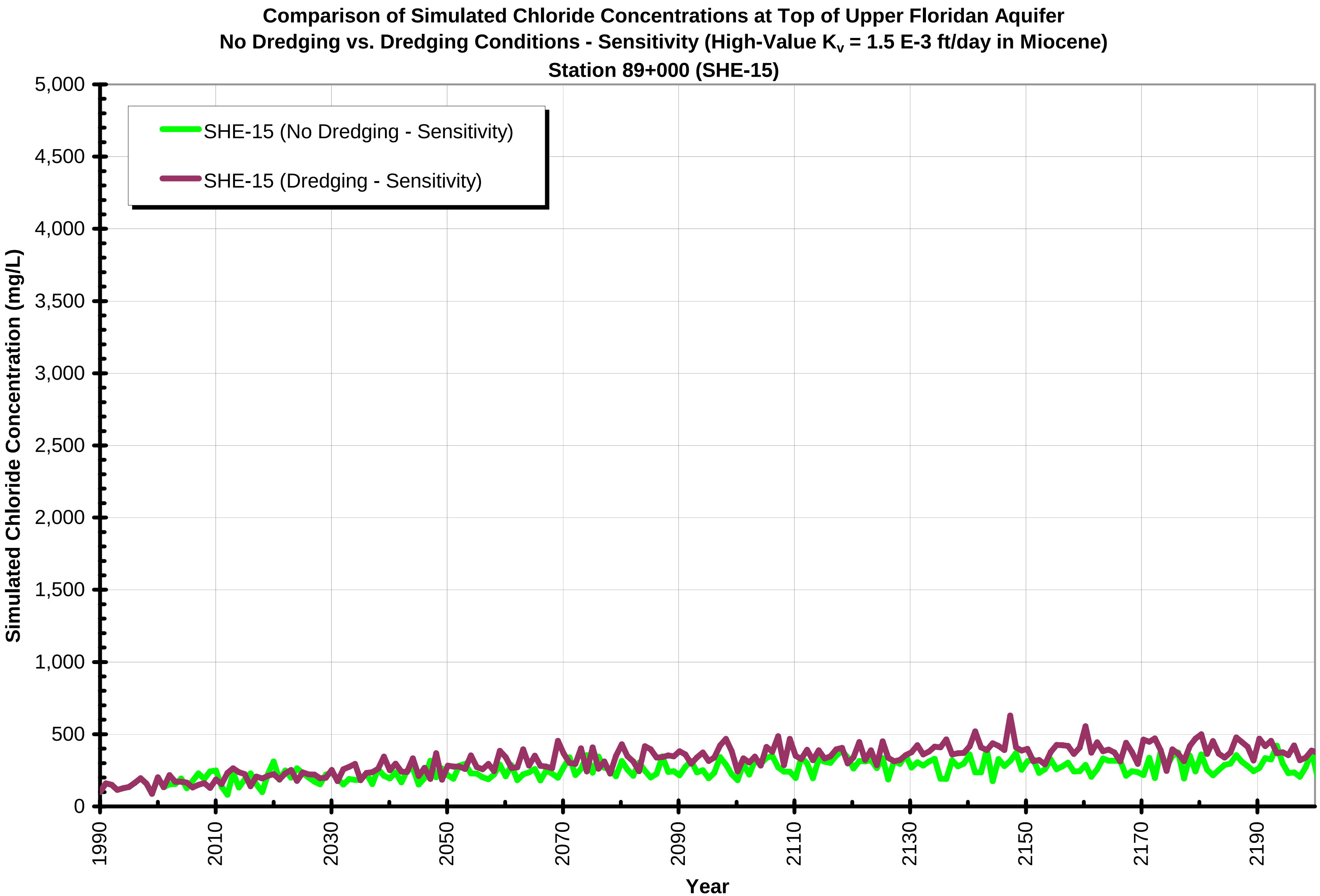

Figure 25
Comparison of Simulated Concentration Time Histories at SHE-15 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

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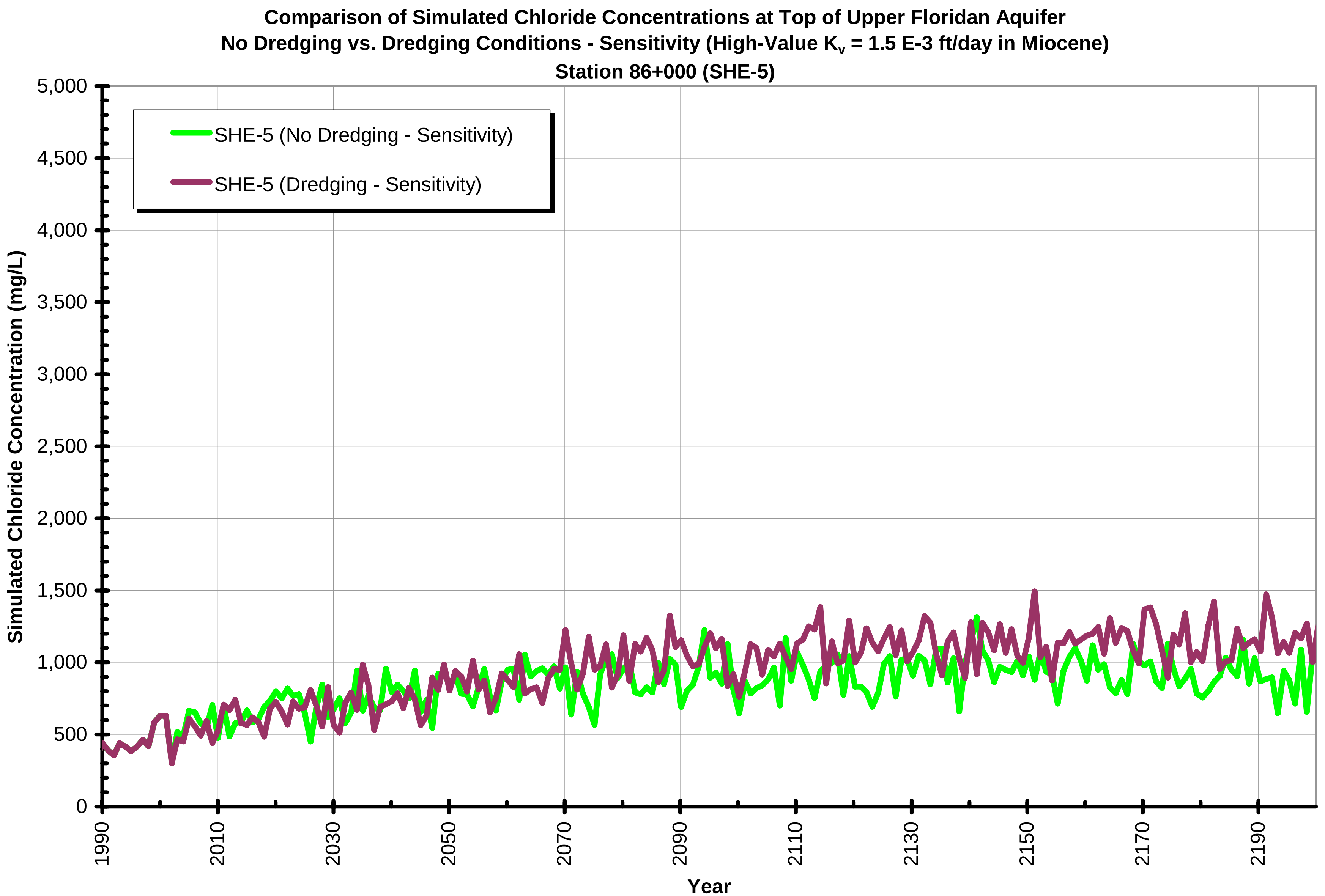

Figure 26
Comparison of Simulated Concentration Time Histories at SHE-5 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

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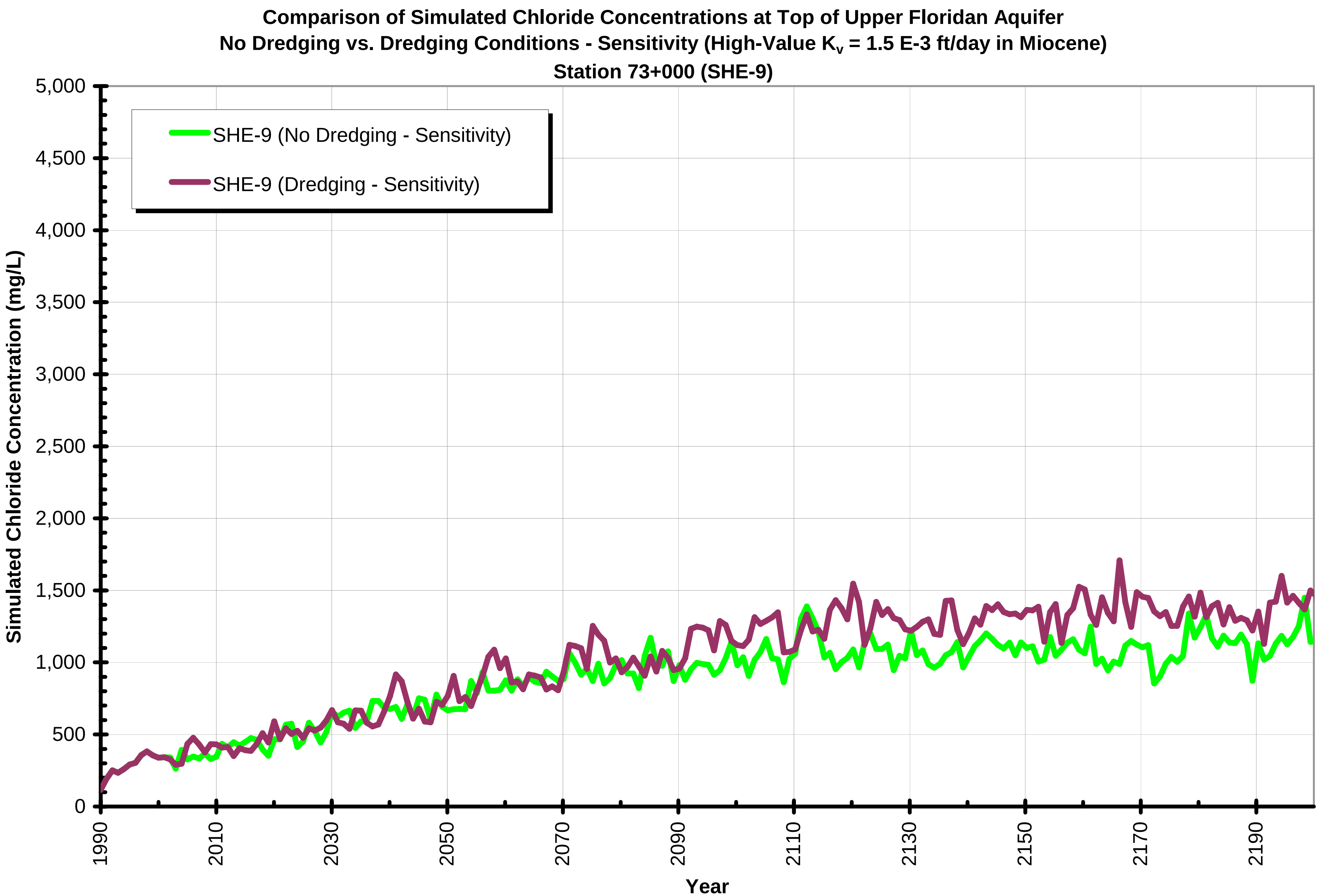

Figure 27
Comparison of Simulated Concentration Time Histories at SHE-9 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

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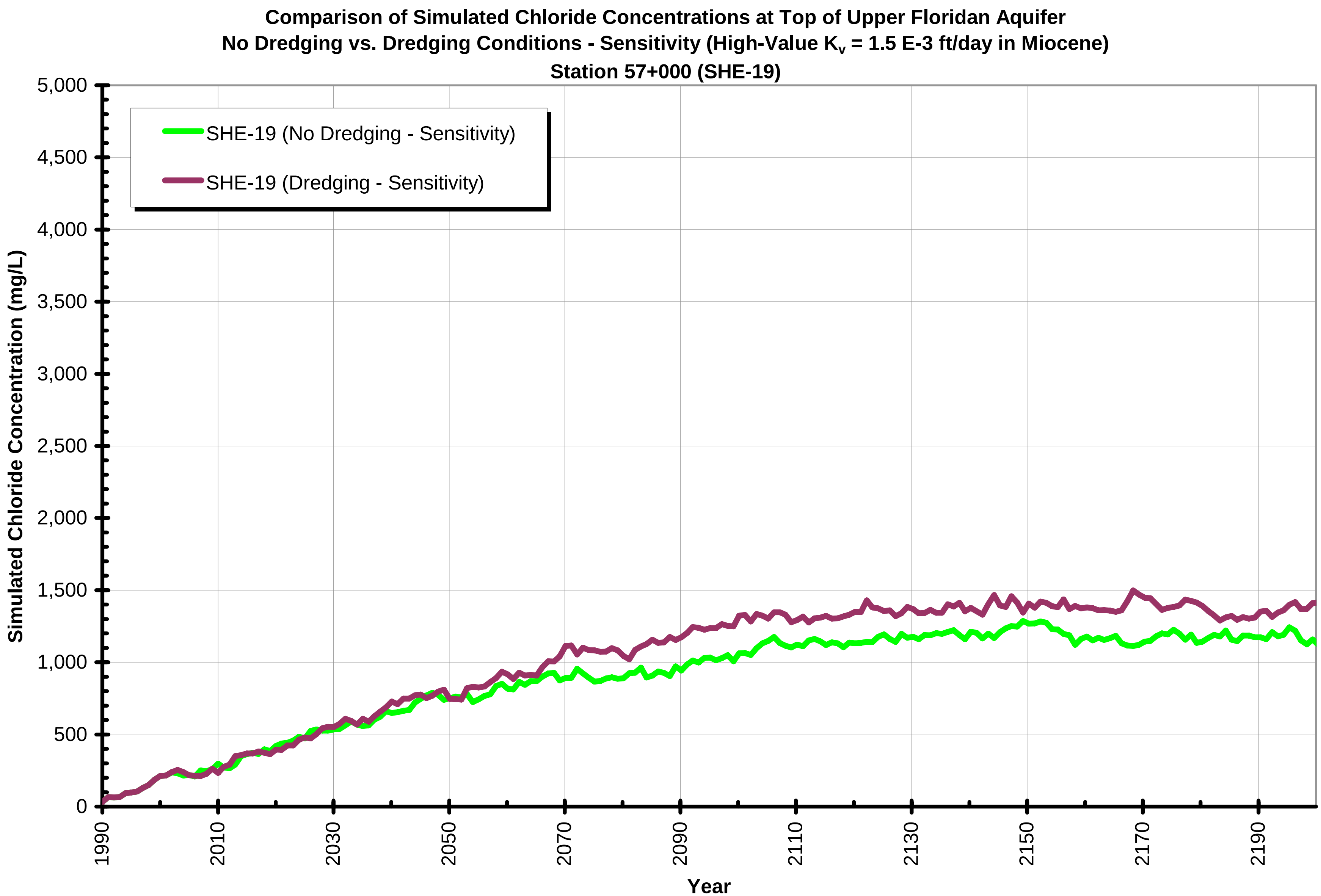

Figure 28
Comparison of Simulated Concentration Time Histories at SHE-19 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

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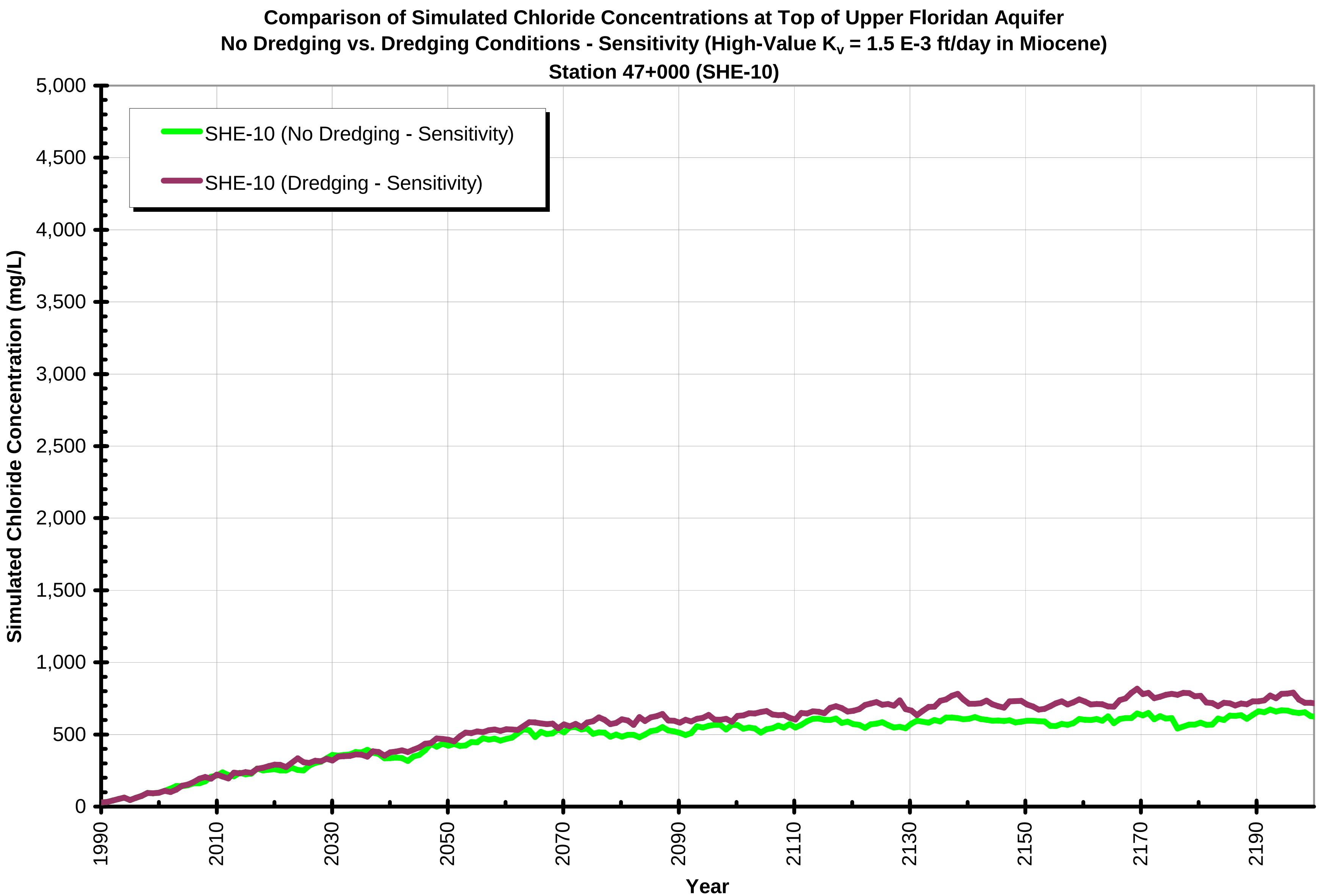

Figure 29
Comparison of Simulated Concentration Time Histories at SHE-10 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

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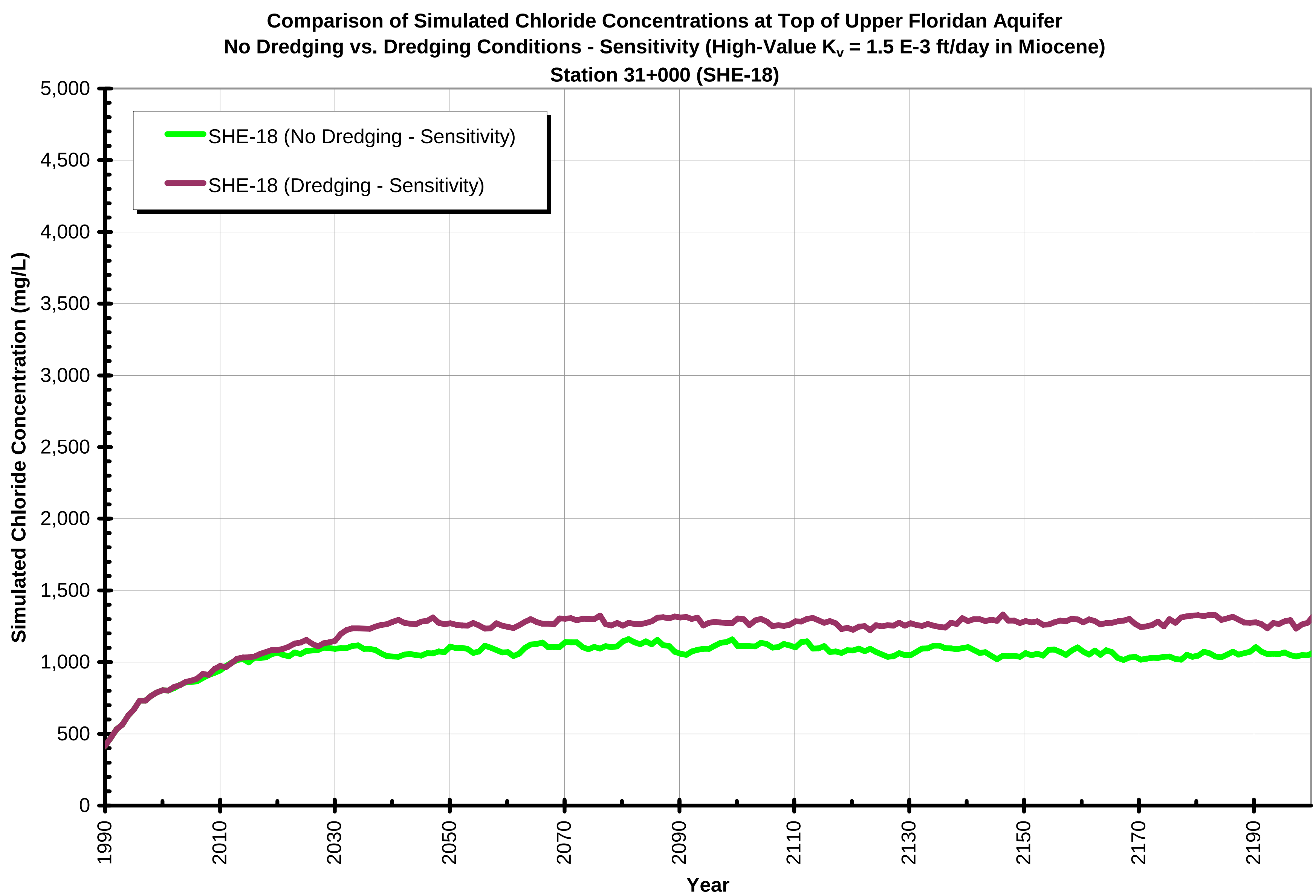

Figure 30
Comparison of Simulated Concentration Time Histories at SHE-18 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

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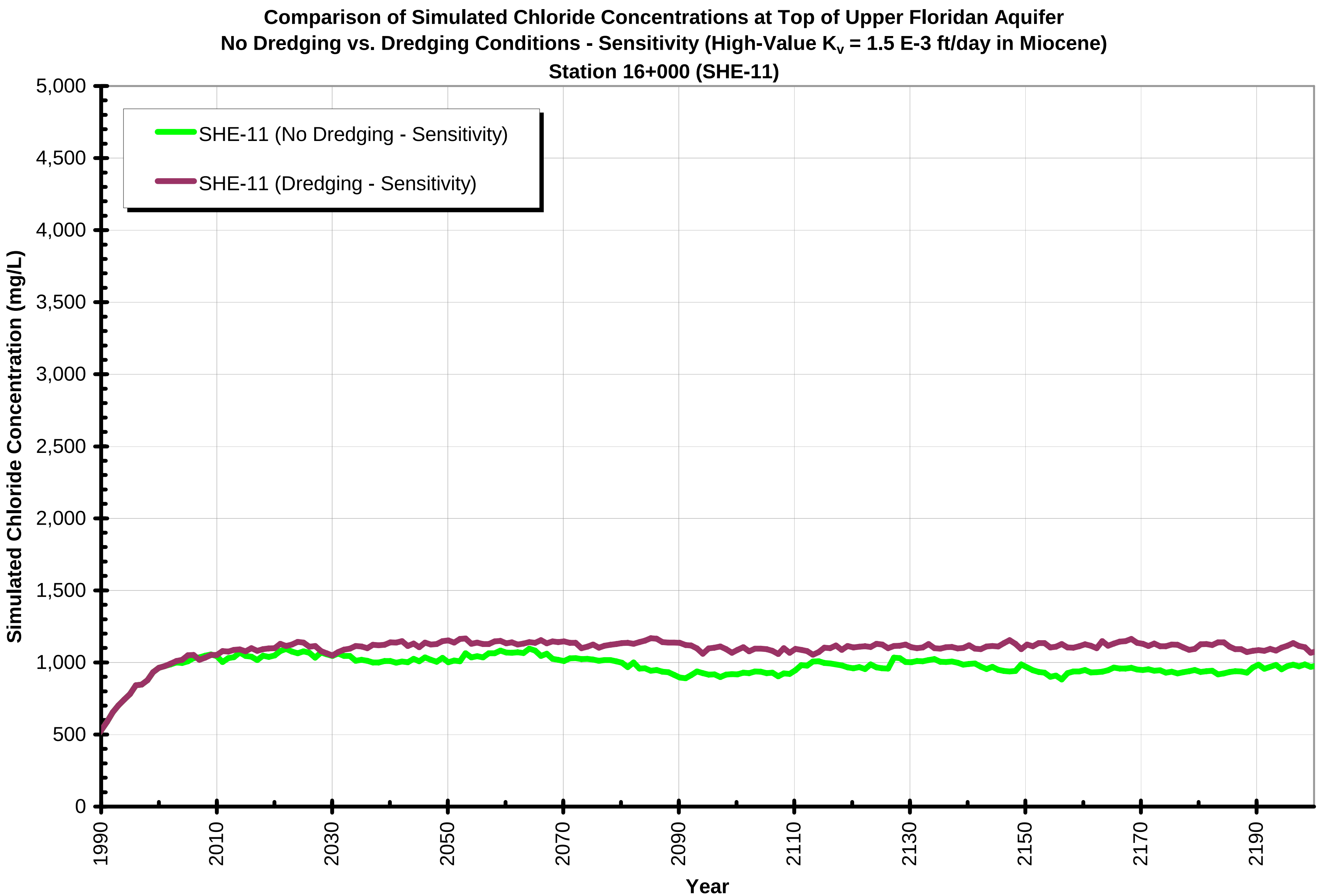

Figure 31
Comparison of Simulated Concentration Time Histories at SHE-11 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

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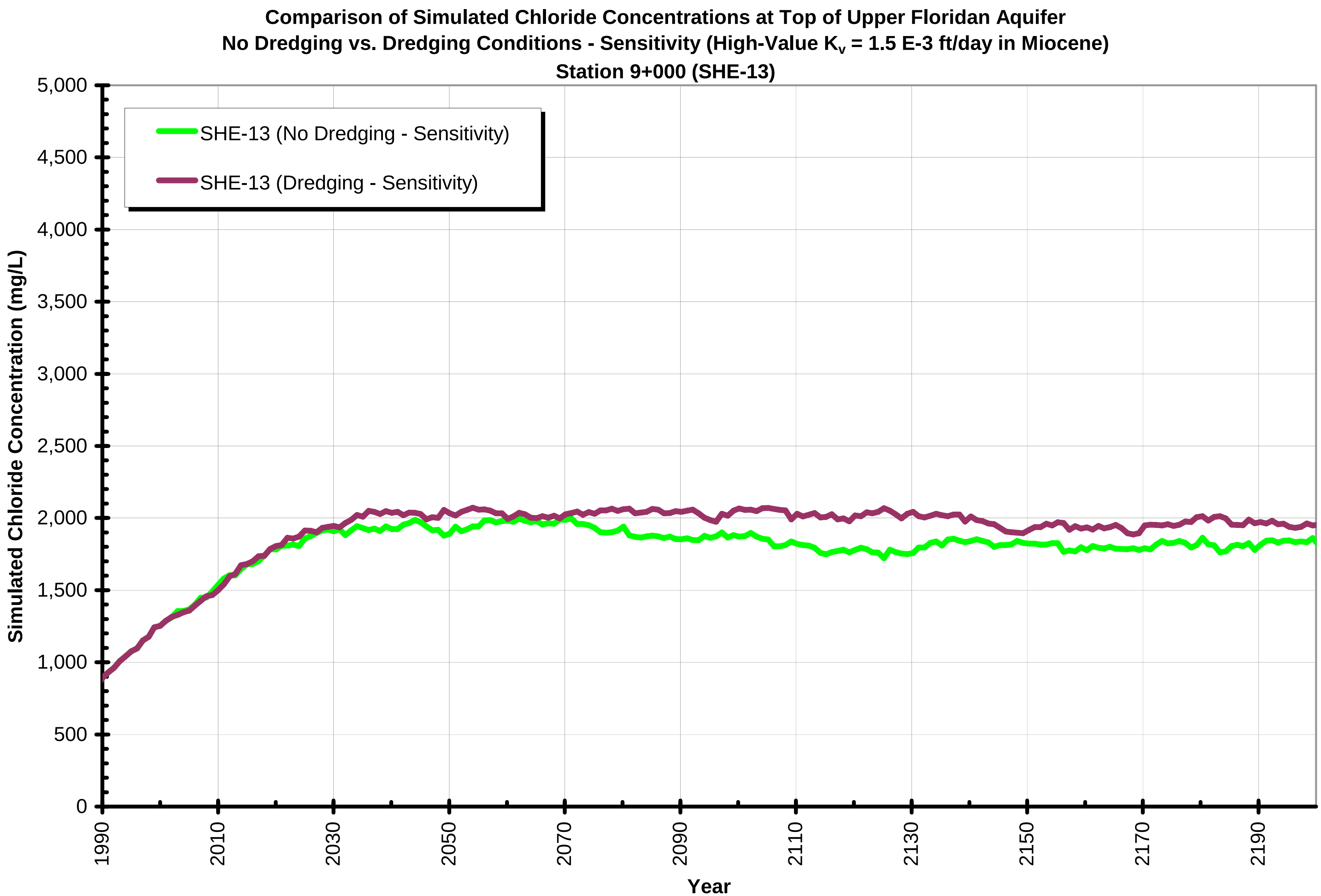

Figure 32
Comparison of Simulated Concentration Time Histories at SHE-13 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

Savannah Harbor Expansion
Groundwater Model Studies

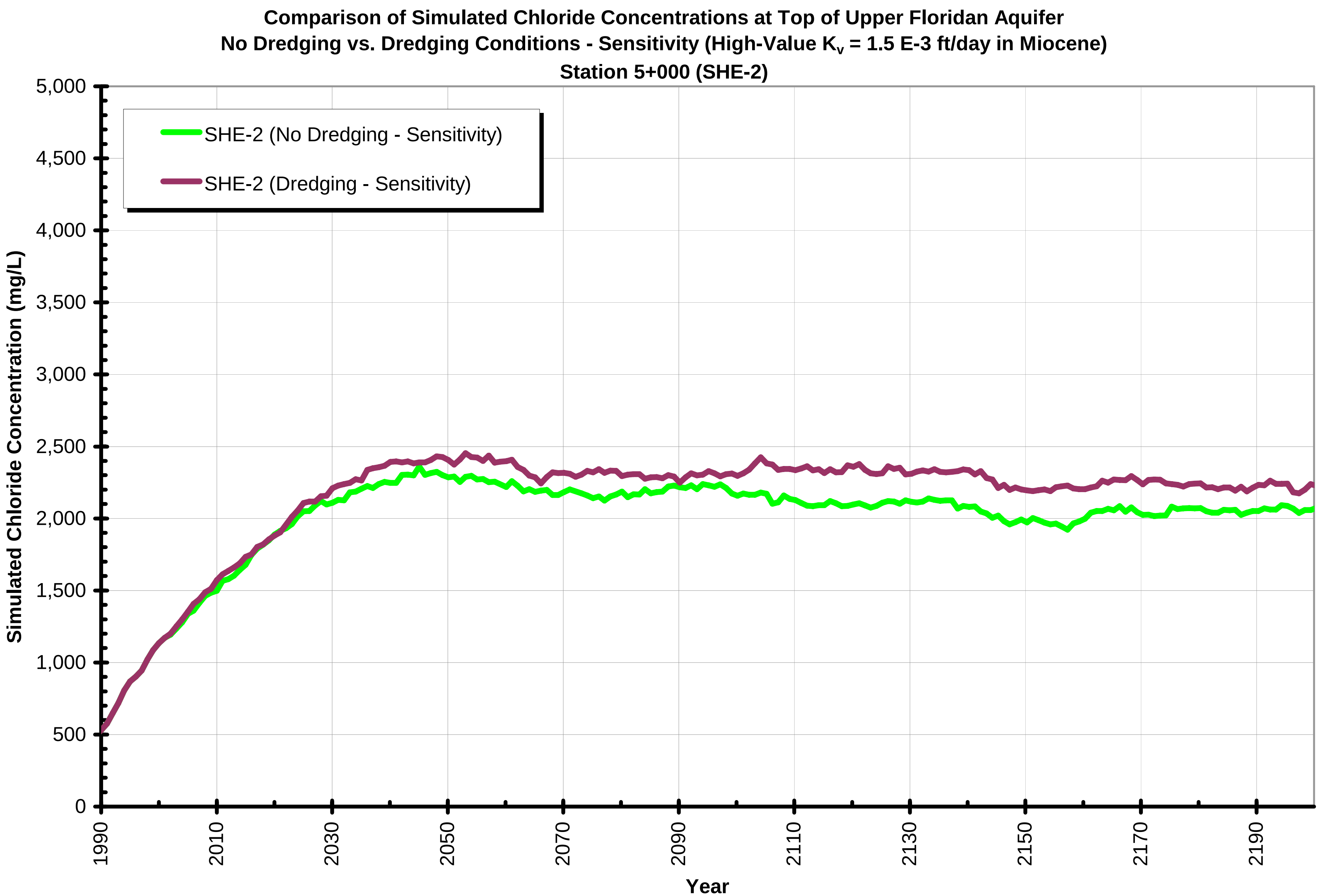

Figure 33
Comparison of Simulated Concentration Time Histories at SHE-2 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

Savannah Harbor Expansion
Groundwater Model Studies

CDM

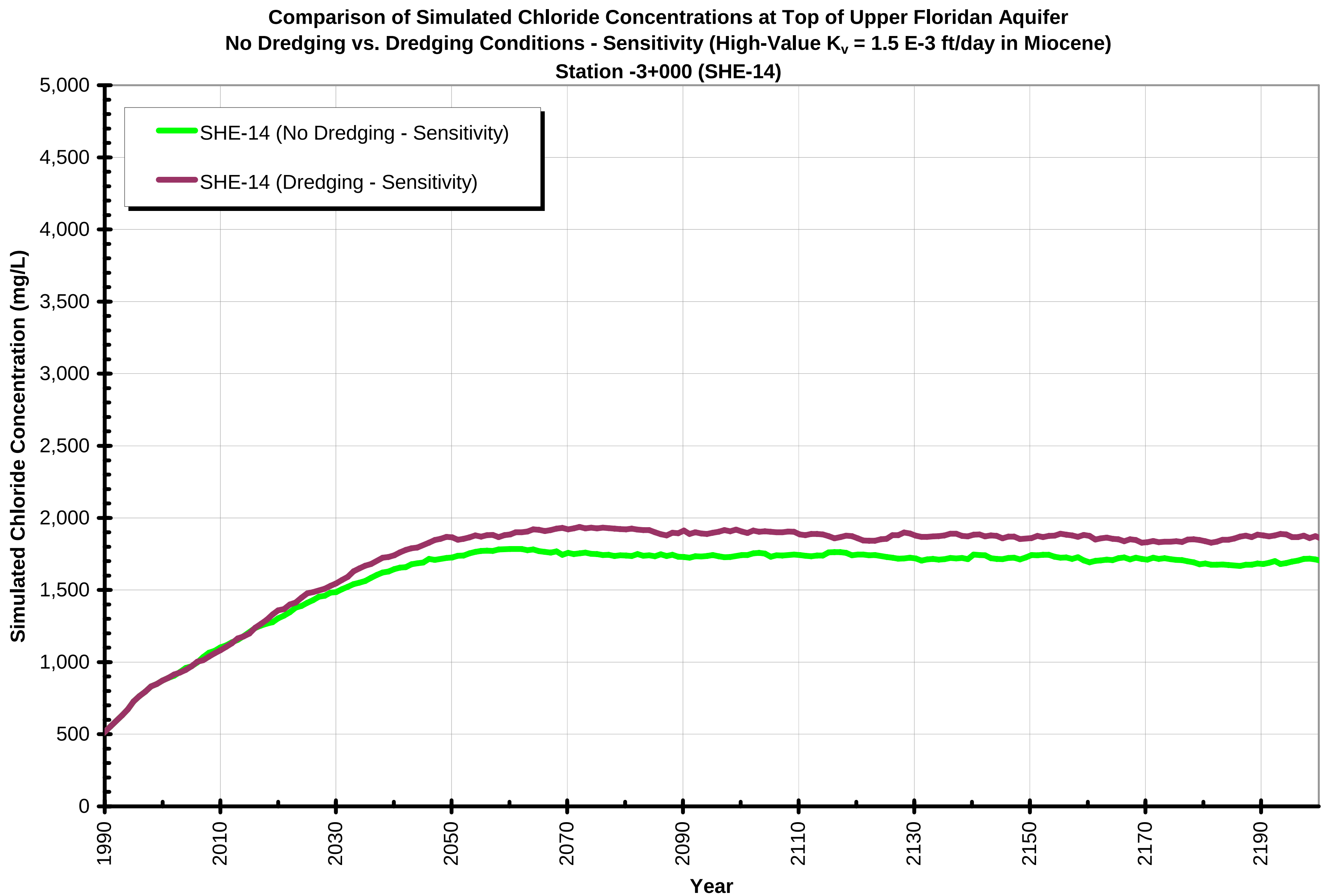

Figure 34
Comparison of Simulated Concentration Time Histories at SHE-14 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

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Groundwater Model Studies

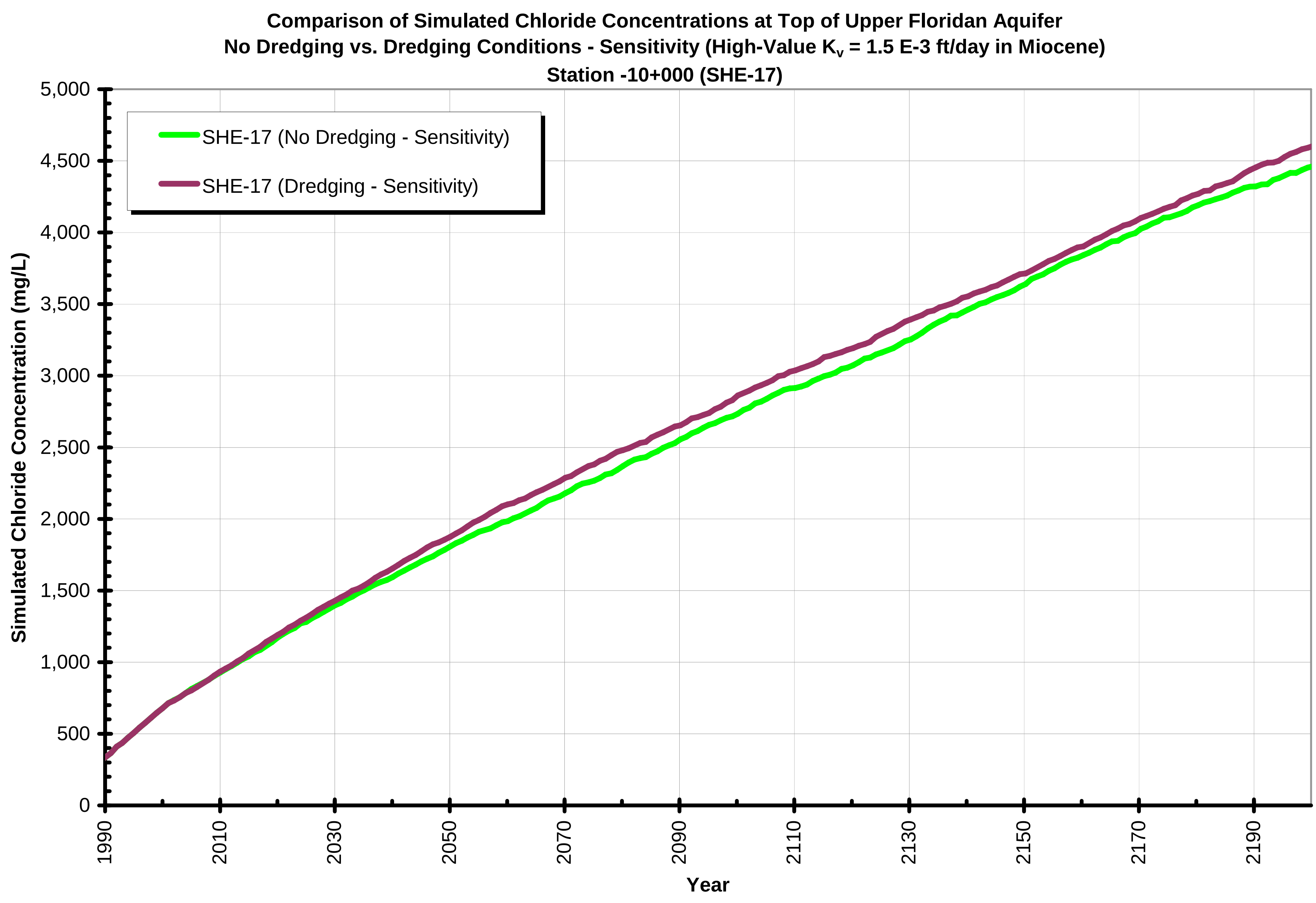

Figure 35
Comparison of Simulated Concentration Time Histories at SHE-17 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

Savannah Harbor Expansion
Groundwater Model Studies

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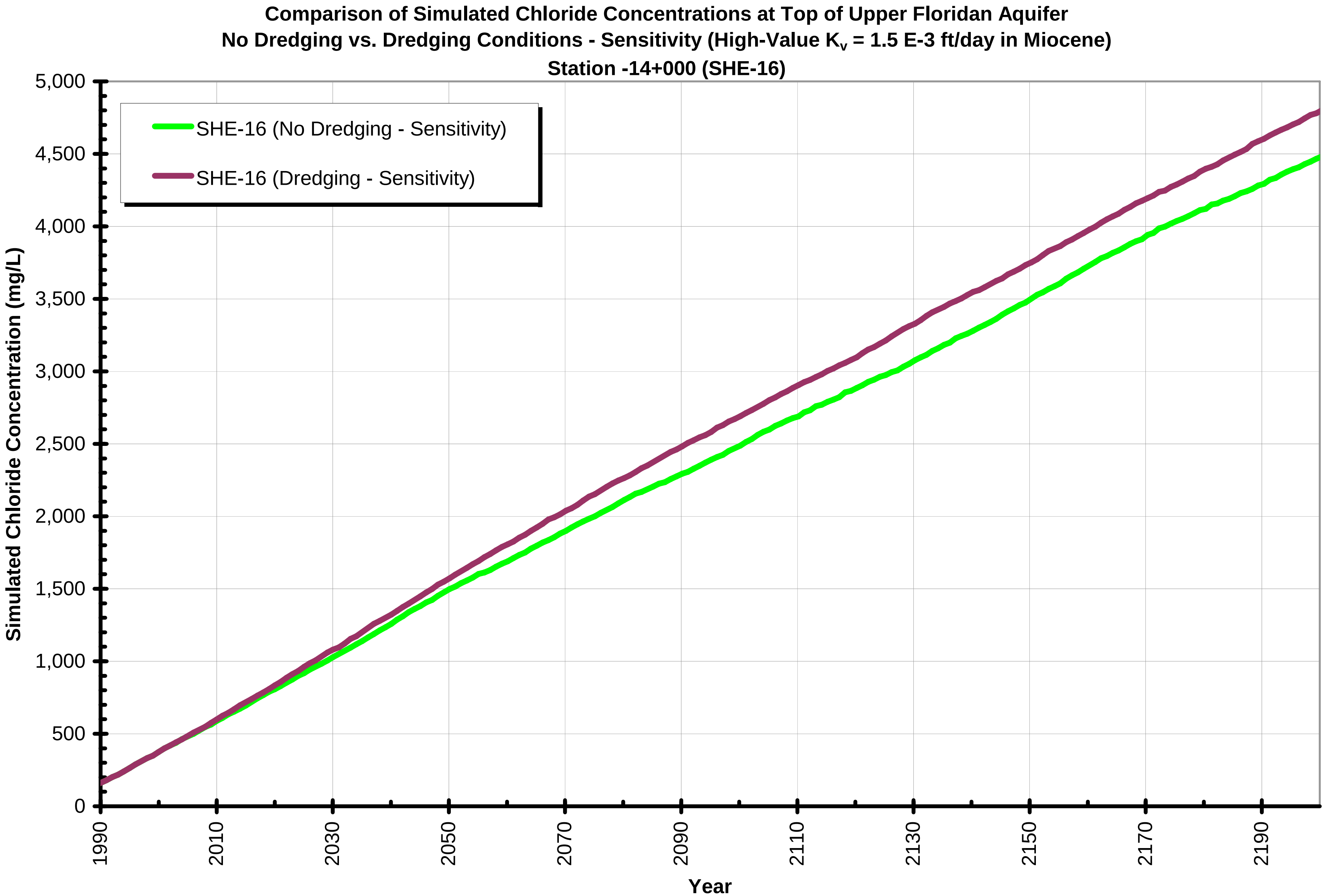

Figure 36
Comparison of Simulated Concentration Time Histories at SHE-16 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

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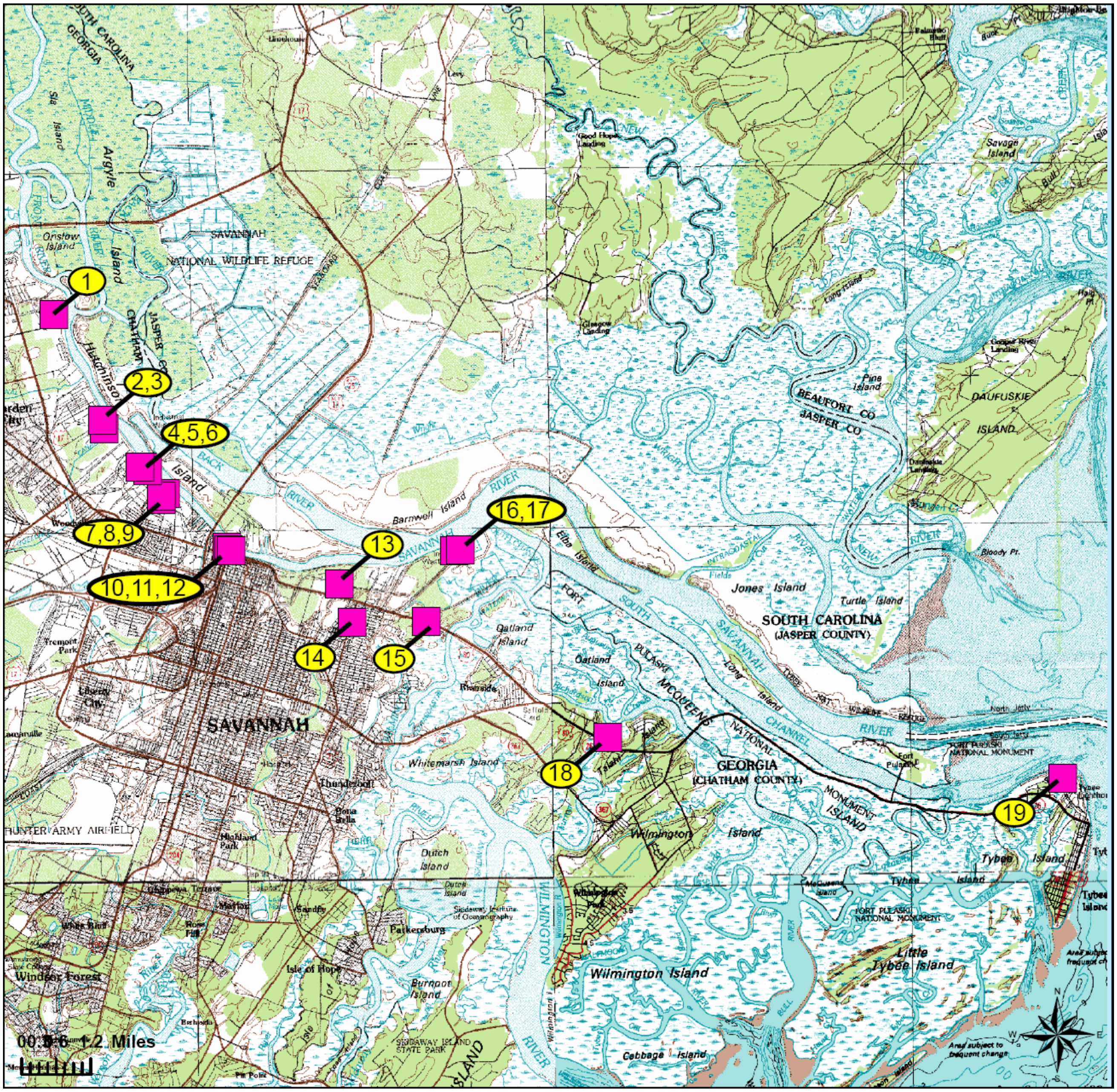
Groundwater Model Studies



ID	Name	ID	Name
1	Savannah Sugar Refinery Well (025I2901)	10	SEPCO - Riverside Thermo Plant Well (025T0301)
2	GAF Corp. Well (025I3501)	11	SEPCO - Riverside Thermo Plant Well (025T0302)
3	Gold Bond Building Products Well (025I3301)	12	SEPCO - Riverside Thermo Plant Well (025T0303)
4	International Paper Well #1	13	Southern States Phosphate Well (025I3101)
5	International Paper Well #2	14	Savannah Main Well #11
6	International Paper Well #5	15	City of Garden City Well (025M0101)
7	Hunt Wesson Well (025I2801)	16	Kemira Well (025I3001)
8	Hunt Wesson Well (025I2802)	17	Kemira Well (025I3002)
9	Hunt Wesson Well (025I2803)	18	Whitemarsh Island Well #28
		19	Tybee Island Well (025M0602)

Figure 37
Location of Selected Pumping Wells

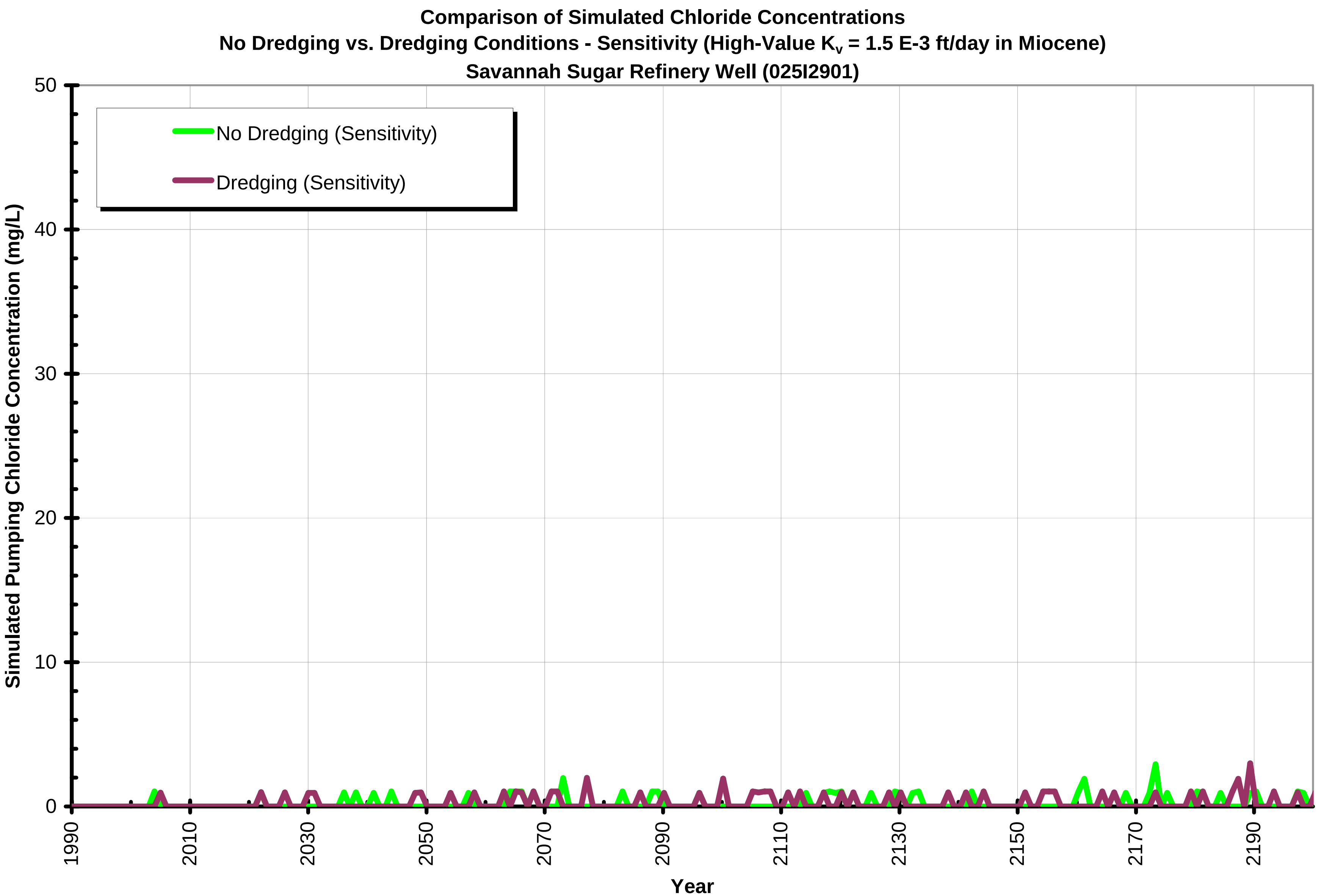


Figure 38

Comparison of Simulated Concentration Time Histories at Savannah Sugar Refinery Well for No Dredging vs. Dredging Conditions Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

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Groundwater Model Studies

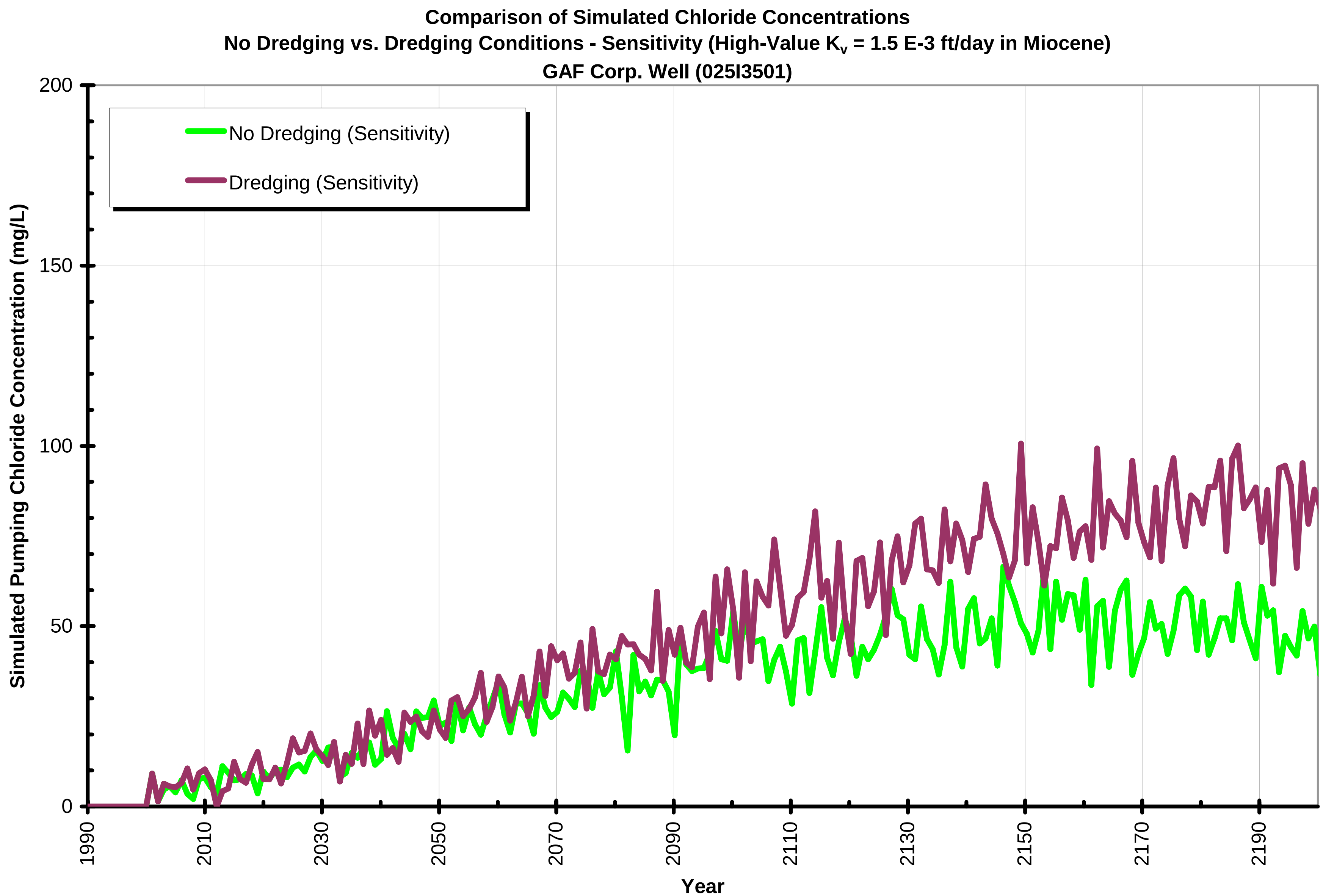

Figure 39
Comparison of Simulated Concentration Time Histories at GAF Corporation Well for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

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Groundwater Model Studies

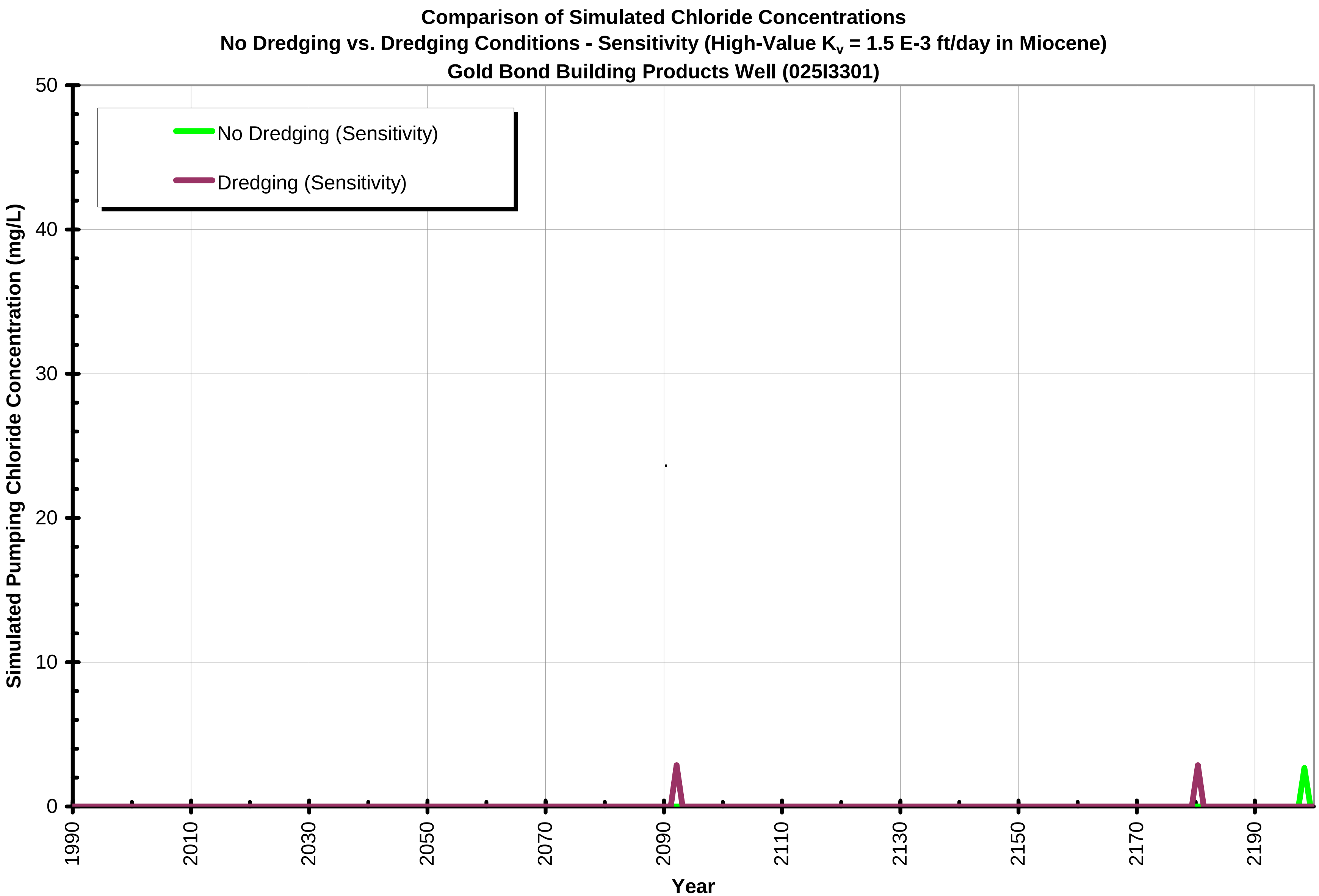

Figure 40

Comparison of Simulated Concentration Time Histories at Gold Bond Building Products Well for No Dredging vs. Dredging Conditions Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

Savannah Harbor Expansion
Groundwater Model Studies

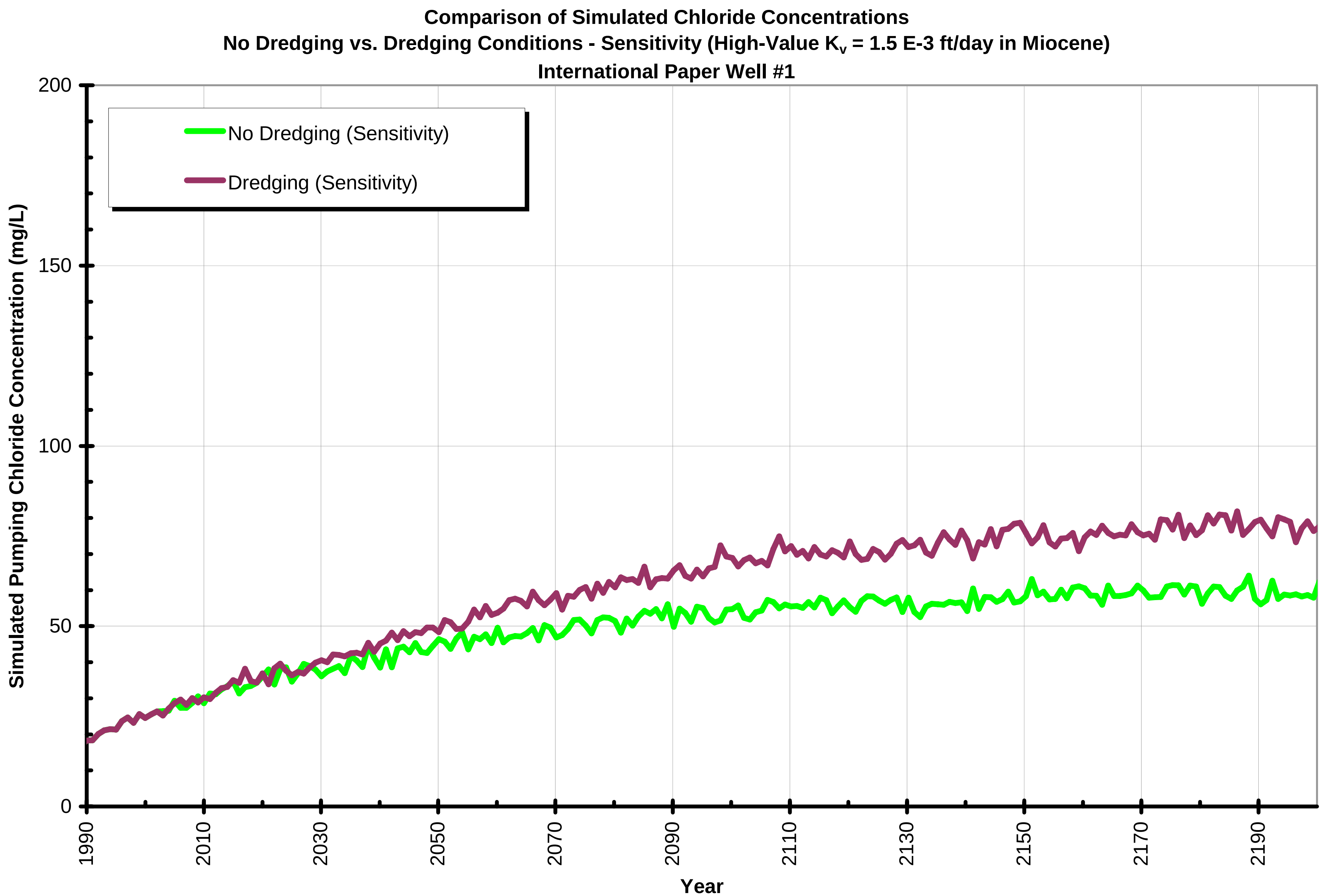

Figure 41
Comparison of Simulated Concentration Time Histories at International Paper Well #1 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

Savannah Harbor Expansion
Groundwater Model Studies

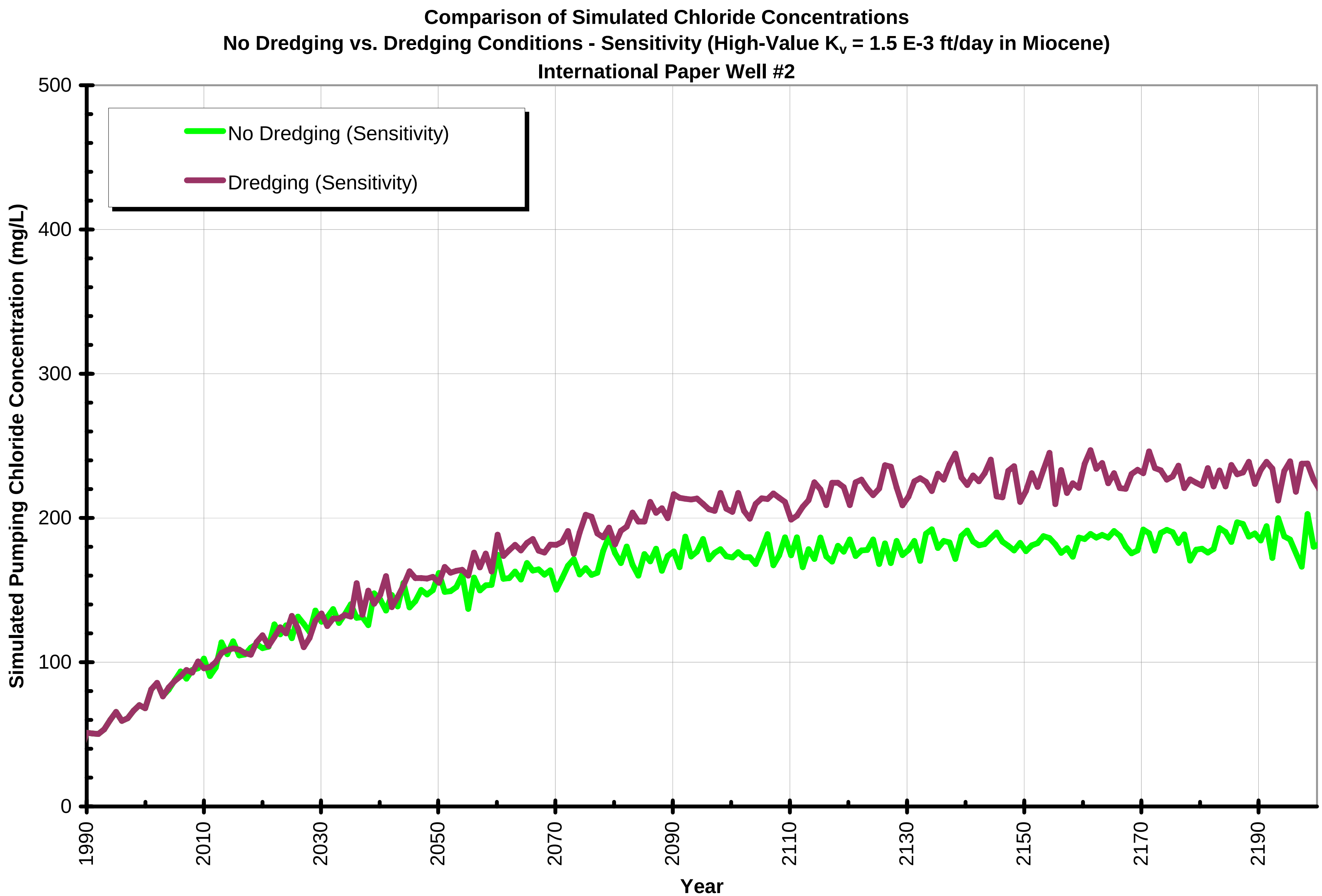

Figure 42
Comparison of Simulated Concentration Time Histories at International Paper Well #2 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

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Groundwater Model Studies

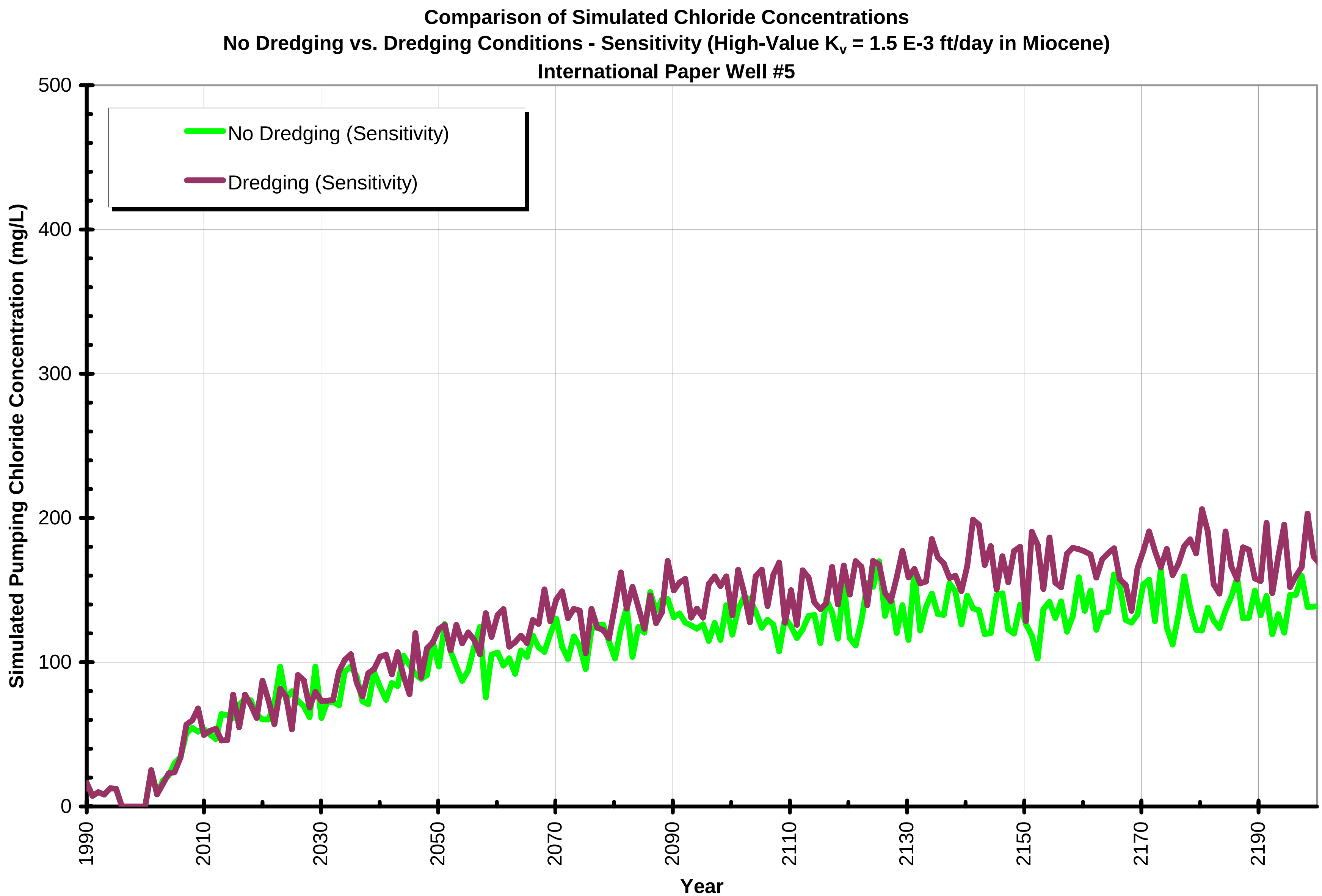

Figure 43
Comparison of Simulated Concentration Time Histories at International Paper Well #5 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

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Groundwater Model Studies

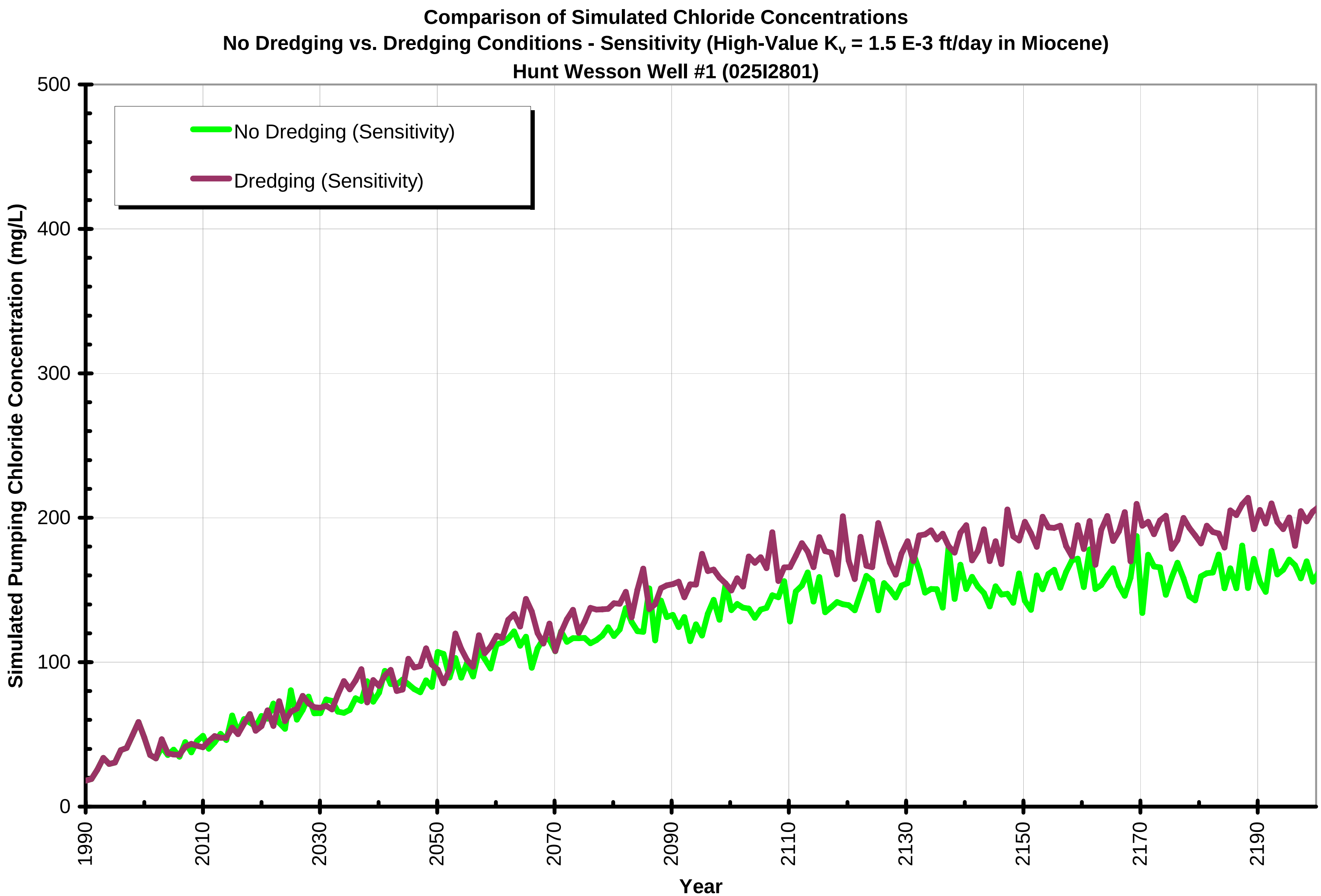

Figure 44

Comparison of Simulated Concentration Time Histories at Hunt Wesson Well #1 for No Dredging vs. Dredging Conditions Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

Savannah Harbor Expansion
Groundwater Model Studies

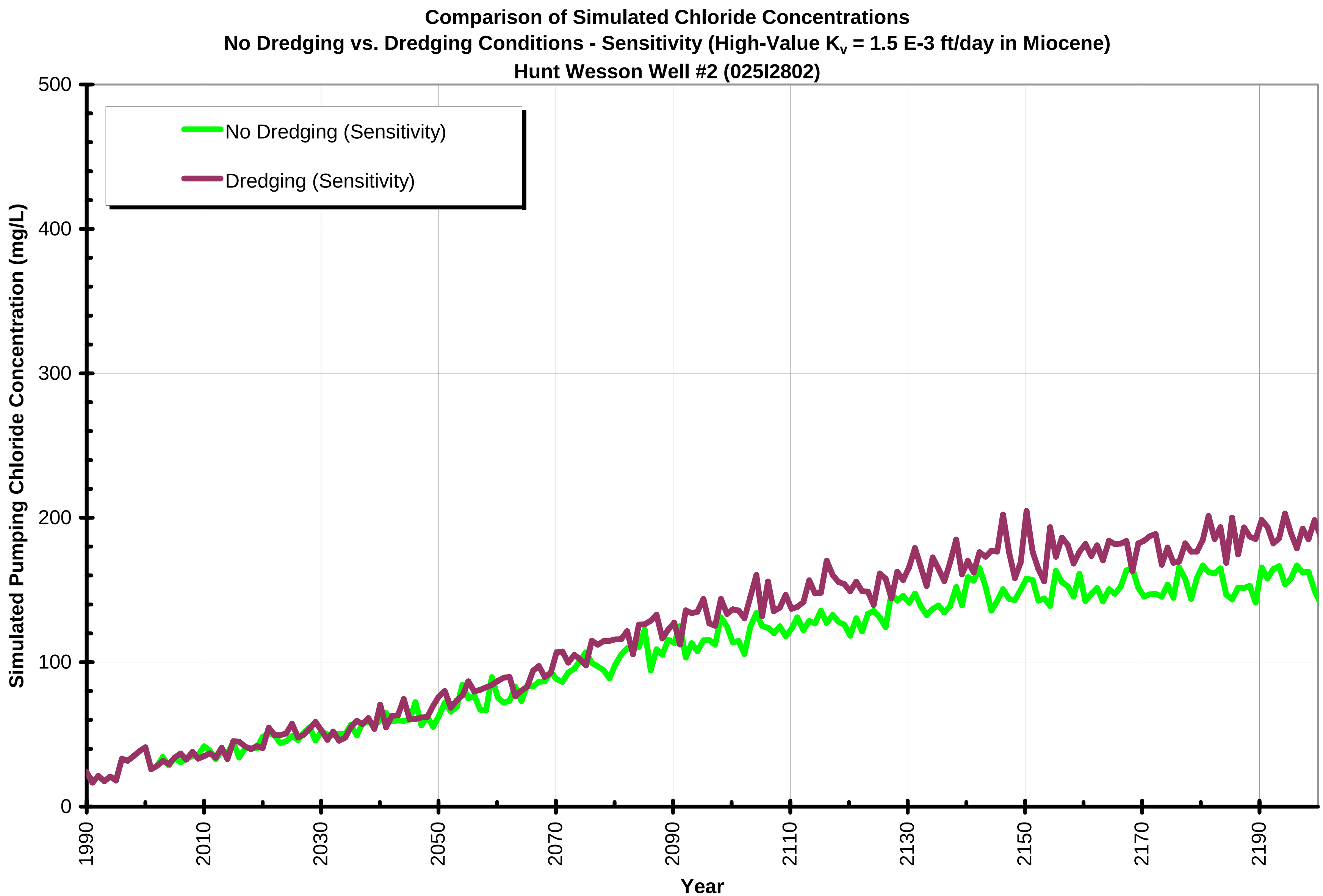

Figure 45
Comparison of Simulated Concentration Time Histories at Hunt Wesson Well #2 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

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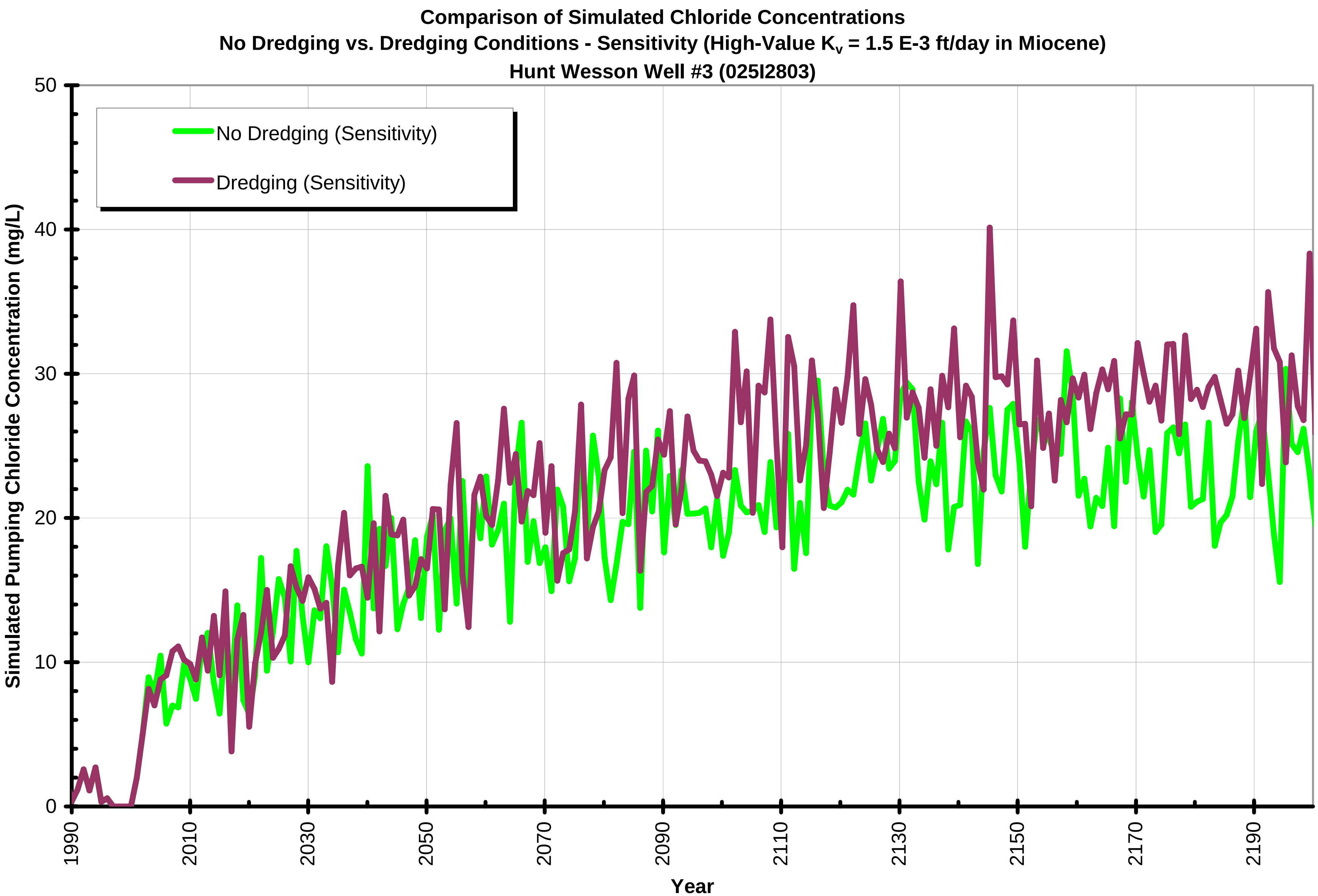

Figure 46

Comparison of Simulated Concentration Time Histories at Hunt Wesson Well #3 for No Dredging vs. Dredging Conditions

Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

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Groundwater Model Studies

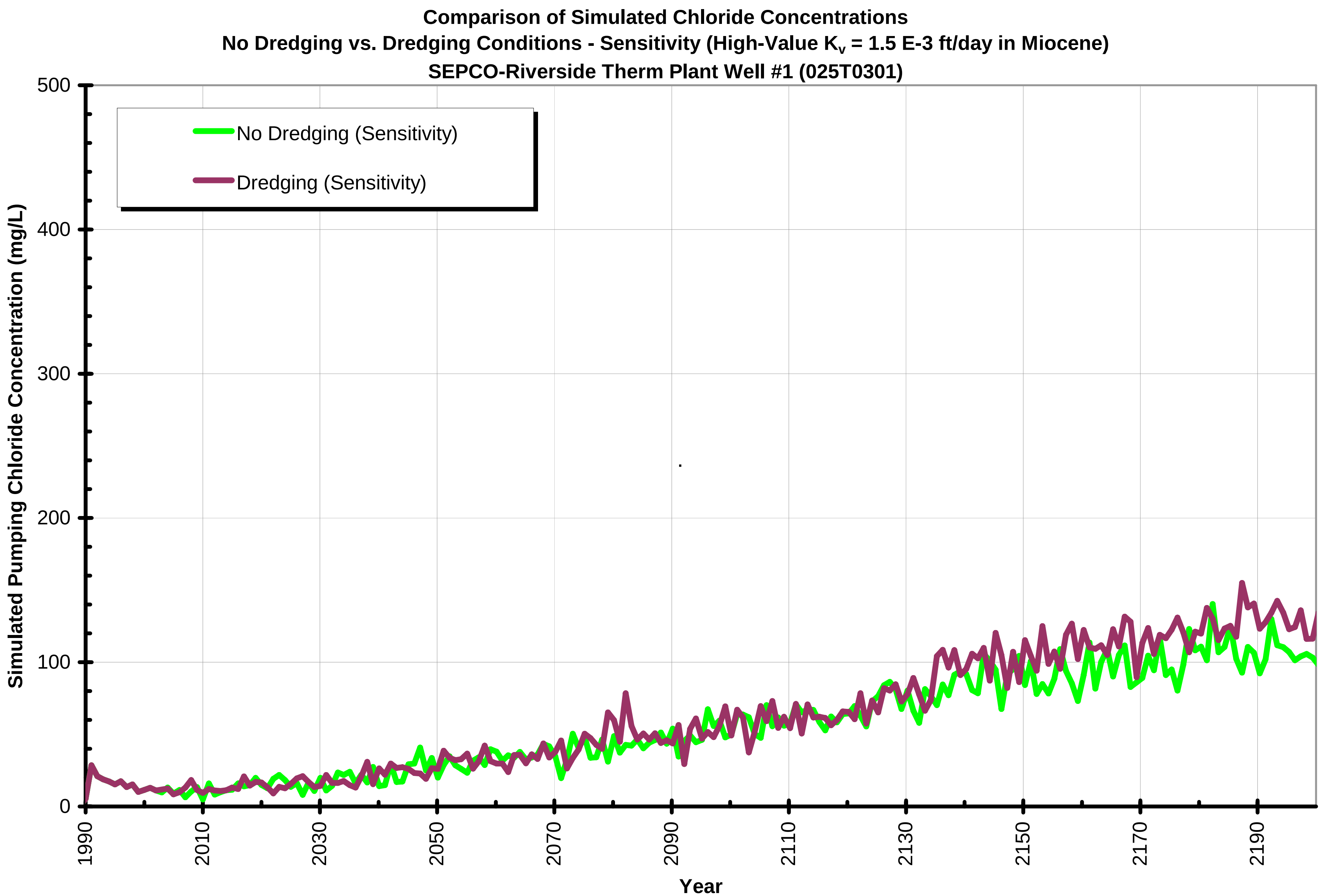

Figure 47

Comparison of Simulated Concentration Time Histories at SEPCO-Riverside Thermal Plant Well #1 for No Dredging vs. Dredging Conditions Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

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Groundwater Model Studies

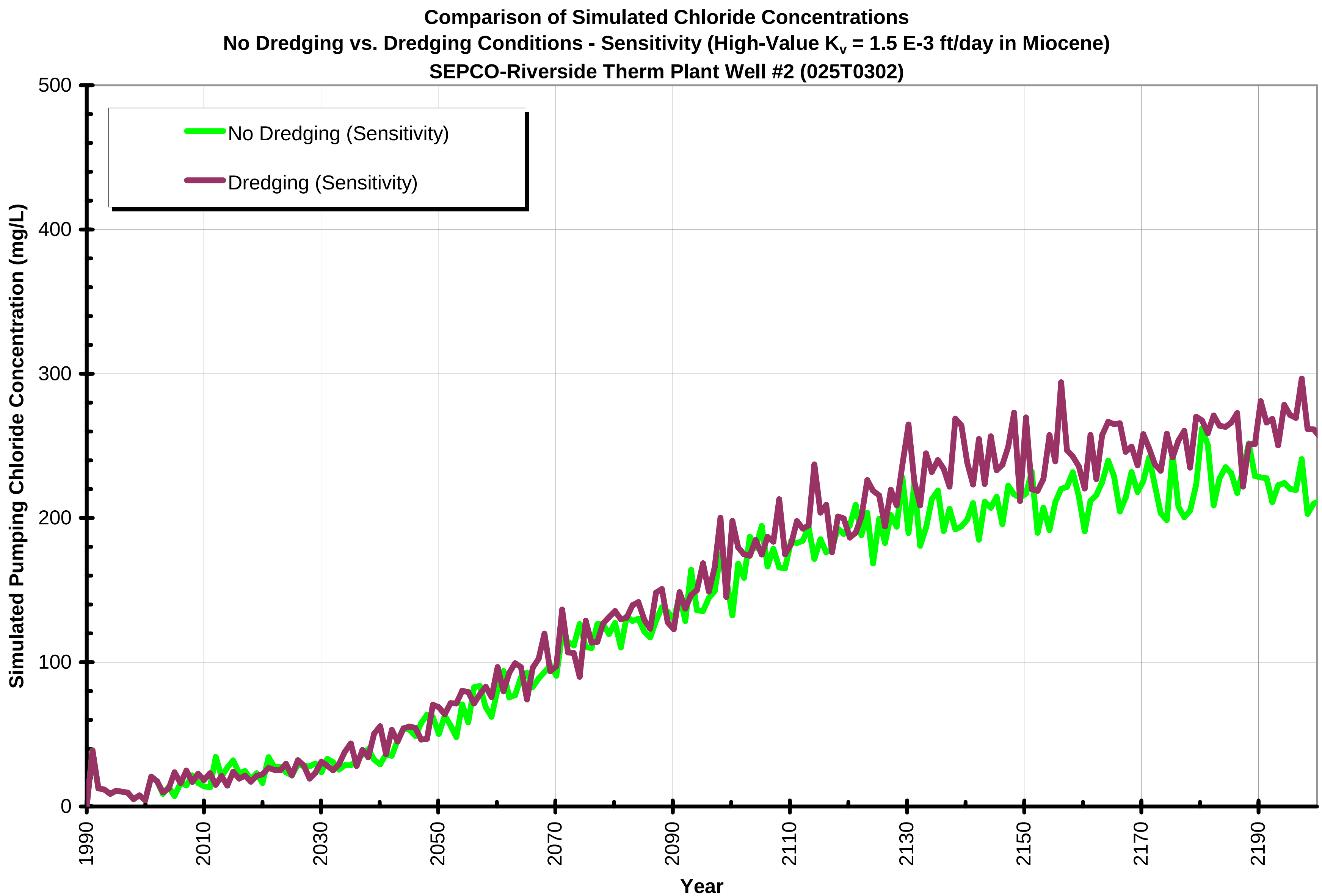

Figure 48

Comparison of Simulated Concentration Time Histories at SEPCO-Riverside Thermal Plant Well #2 for No Dredging vs. Dredging Conditions Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

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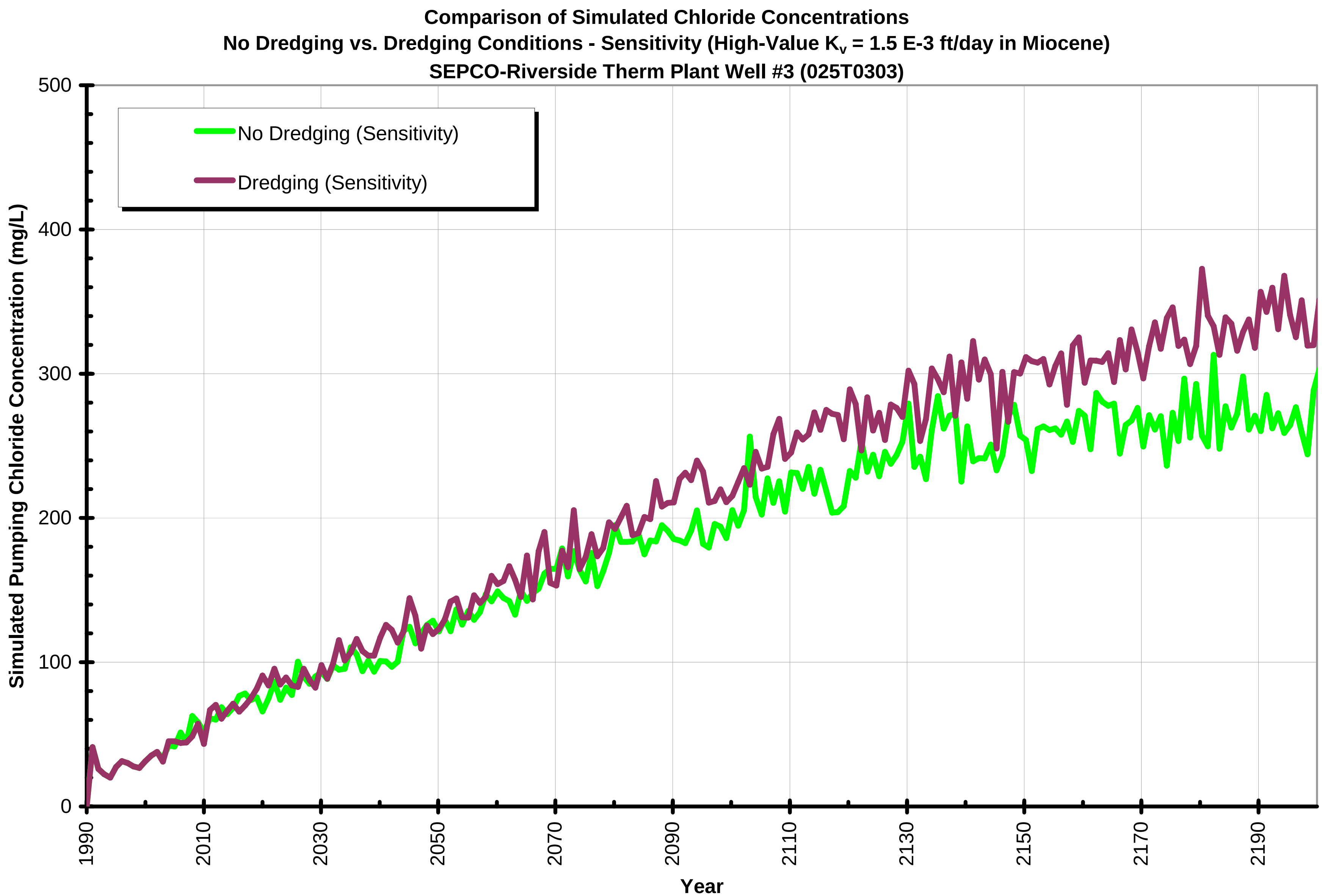

Figure 49

Comparison of Simulated Concentration Time Histories at SEPCO-Riverside Thermal Plant Well #3 for No Dredging vs. Dredging Conditions Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

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Groundwater Model Studies

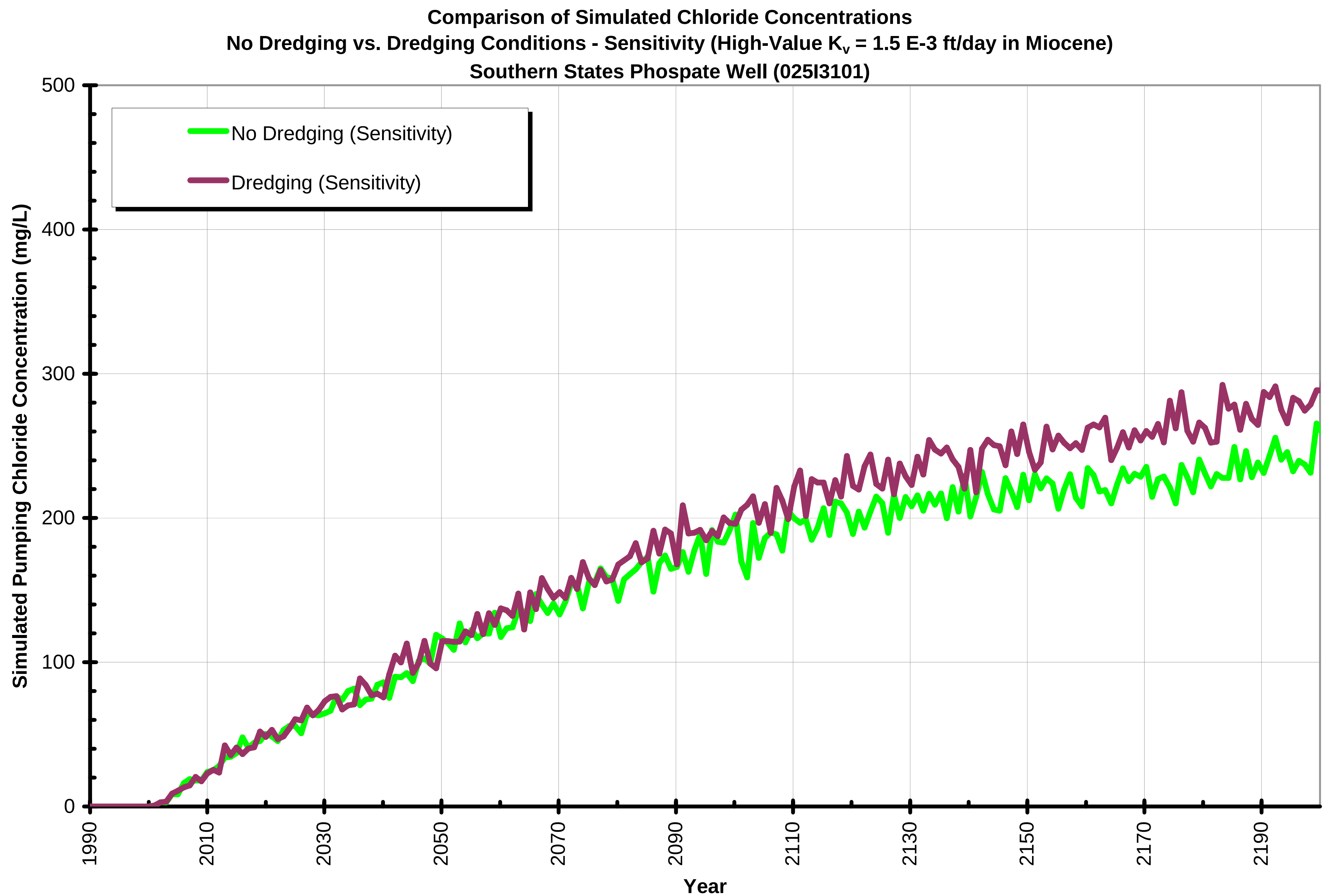

Figure 50
Comparison of Simulated Concentration Time Histories at Southern States Phosphate Well for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

Savannah Harbor Expansion
Groundwater Model Studies

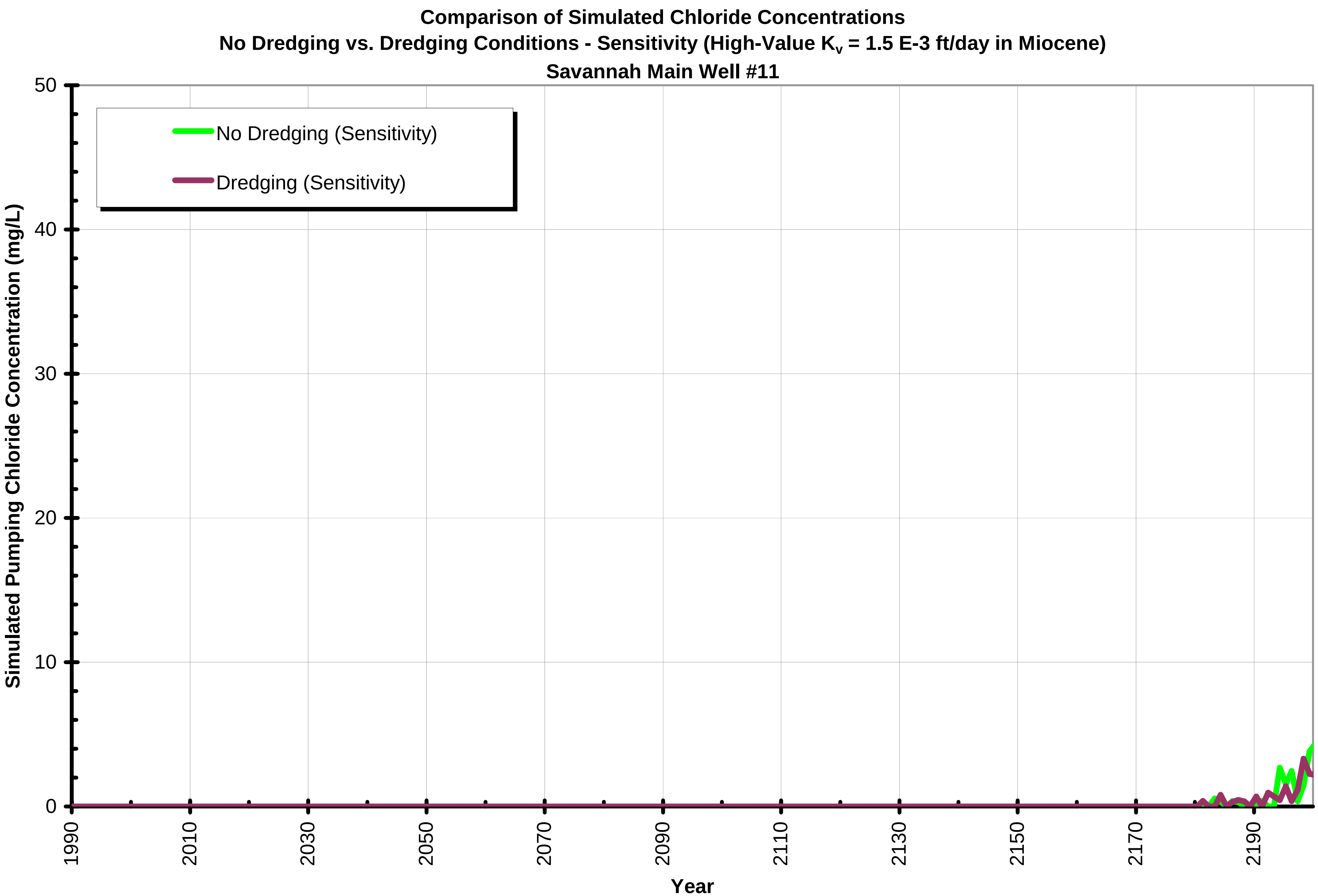

Figure 51
Comparison of Simulated Concentration Time Histories at Savannah Main Well #11 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

Savannah Harbor Expansion
Groundwater Model Studies

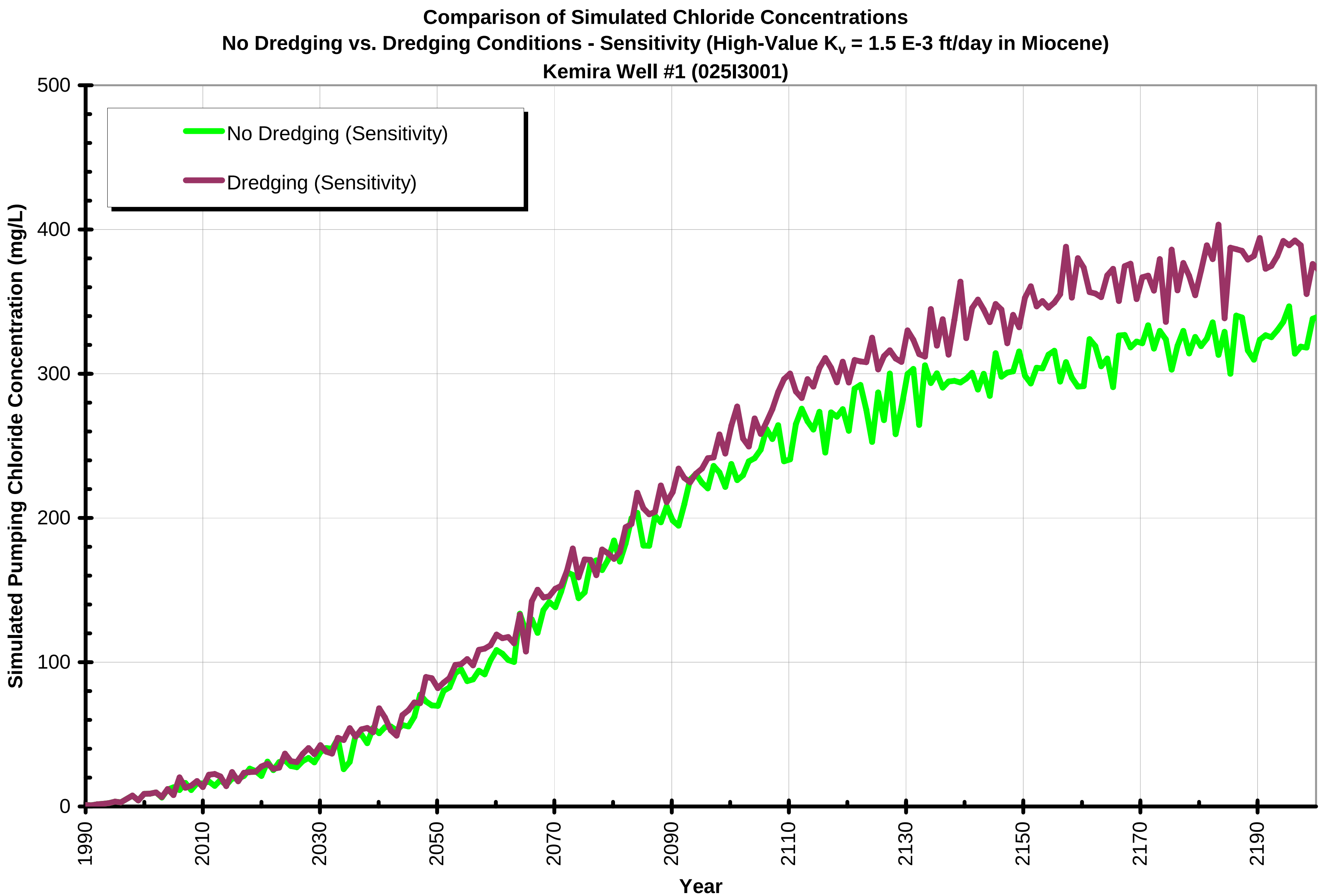

Figure 52
Comparison of Simulated Concentration Time Histories at Kemira Well #1 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

CDM

Savannah Harbor Expansion
Groundwater Model Studies

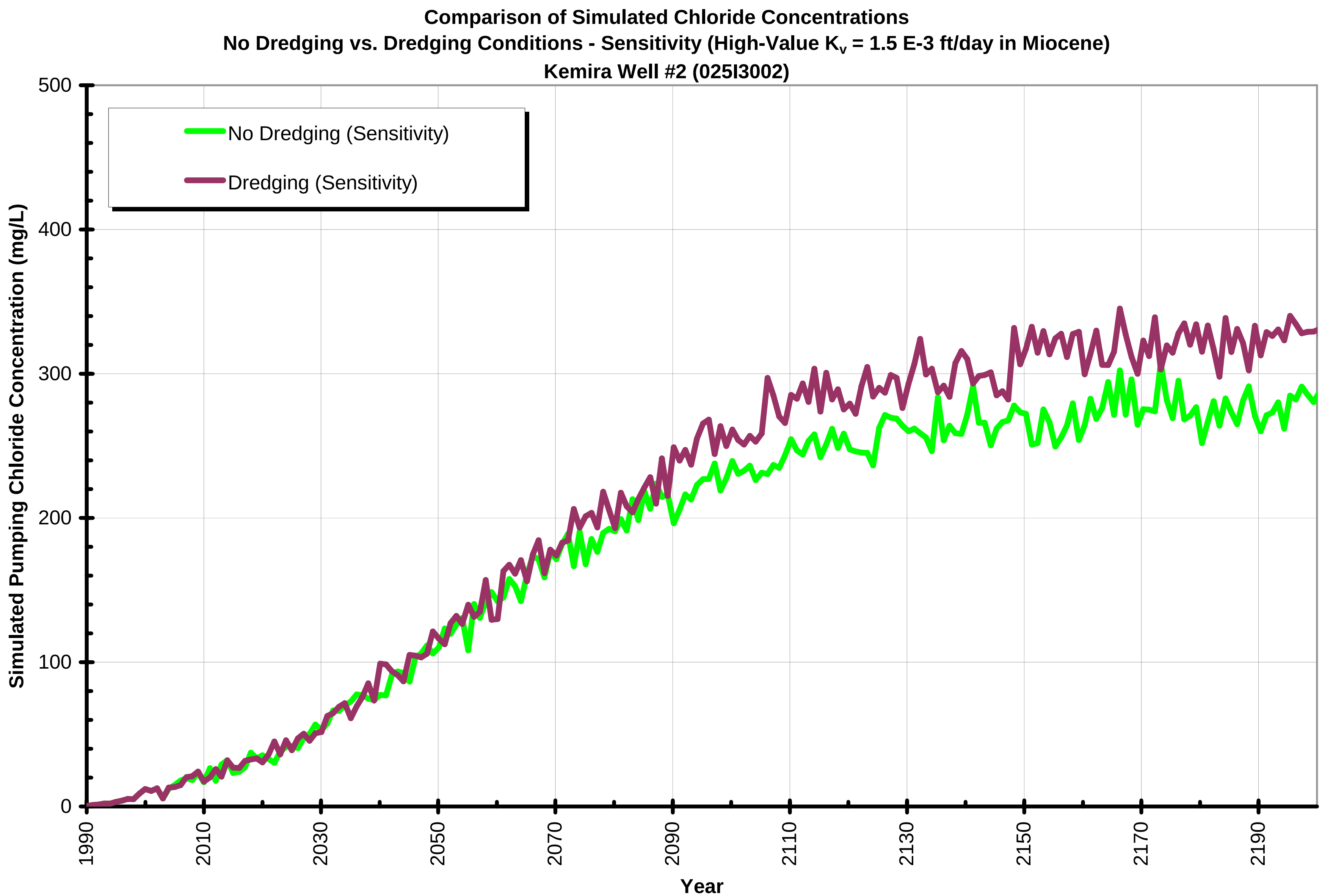

Figure 53
Comparison of Simulated Concentration Time Histories at Kemira Well #2 for No Dredging vs. Dredging Conditions
Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

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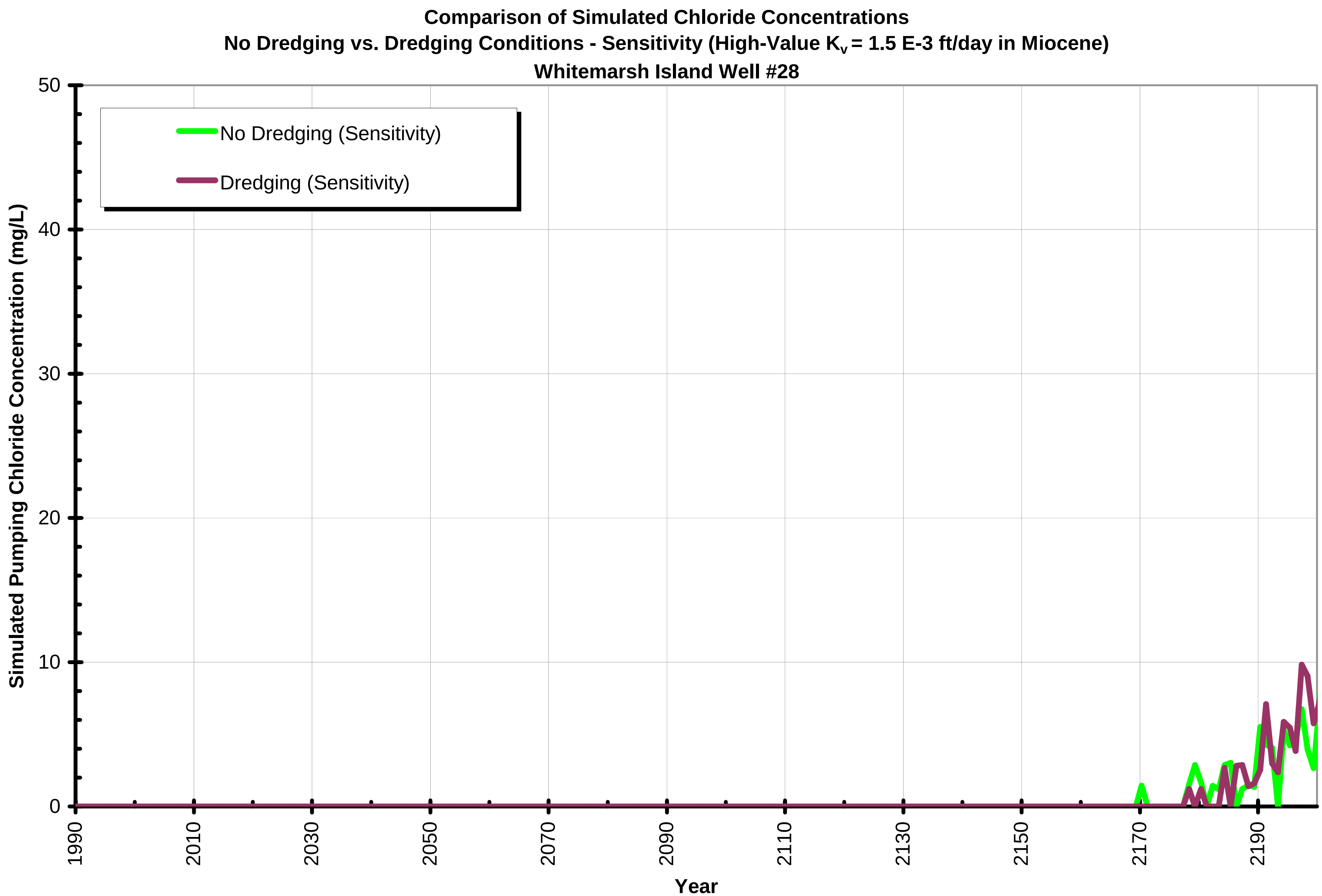

Figure 54

Comparison of Simulated Concentration Time Histories at Whitemarsh Island Well 28 for No Dredging vs. Dredging Conditions Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

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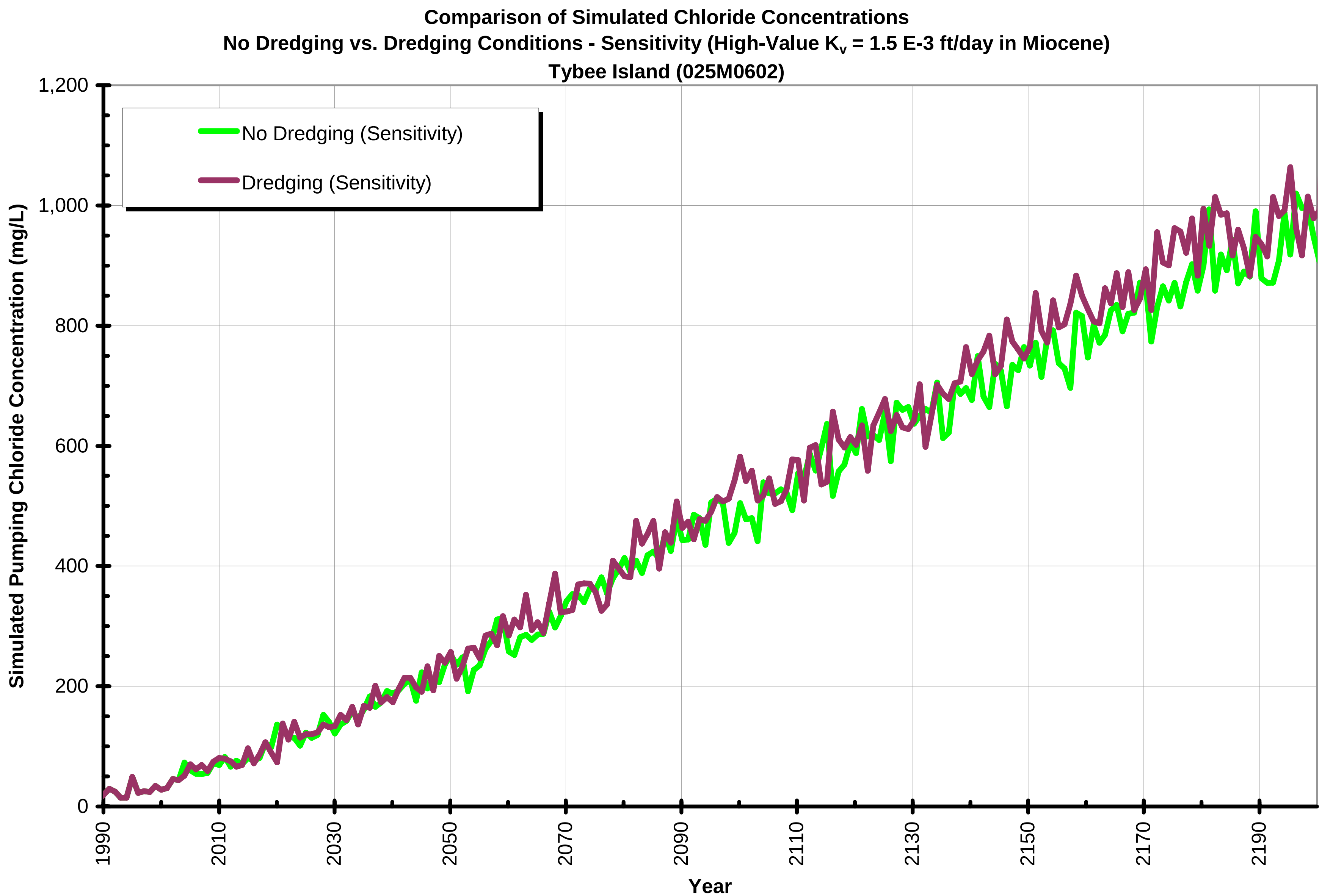

Figure 55

Comparison of Simulated Concentration Time Histories at Tybee Island Well for No Dredging vs. Dredging Conditions Using the High-Value K_v (1.5 E-3 ft/day) in the Miocene Confining Unit

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ATTACHMENT 2

Model Certification Documentation

Model Name: DYNFLOW

Model Description & Use: DYNFLOW is a fully three-dimensional, finite element groundwater flow model. This model has been developed over the past 25 years by CDM engineering staff, and is in general use for large scale basin modeling projects and site specific remedial design investigations. DYNFLOW uses a grid built with a large number of tetrahedral elements. These elements are triangular in plan view, and give a wide flexibility in grid variation over the area of study. An identical grid is used for each level of the model, but the thickness of each model layer (the vertical distance between levels in the model) can vary at each point in the grid. In addition, 2-dimensional elements can be inserted into the basic 3-dimensional grid to simulate thin features such as faults. One-dimensional elements can be used to simulate the performance of wells which are perforated in several model layers.

DYNFLOW accepts a variety of boundary conditions on the groundwater flow system including specified heads, specified fluxes, rivers, drains, and general head boundaries.

Peer Review: The DYNFLOW code has been reviewed and tested by the International Groundwater Modeling Center (IGWMC, 1985) and Dr. Paul van der Heijde(1999). DYNFLOW was evaluated by the ASCE Groundwater Quality Technical Committee (Pandit, 1997) as part of a study that summarized the capabilities, limitations and user assessment of widely used groundwater model codes. The code has been extensively tested and documented by CDM. It has been applied in hundreds of groundwater modeling studies by CDM and others.

Documentation / Support: DYNFLOW User's Manual and support are provided by CDM. DYNFLOW features and example applications are presented at www.dynsystem.com.

Points of Contact: Robert Fitzgerald, CDM, fitzgeraldrh@cdm.com
Brian Heywood, CDM, heywoodbj@cdm.com
Brendan Harley, CDM, harleybm@cdm.com

Applicable Projects: Regional water supply studies, pumping test evaluations, hazardous waste remediation studies, dewatering projects, integrated groundwater-surface water studies, ASR.

Model Name: DYNTRACK

Model Description & Use: DYNTRACK is a solute transport code that represents advective, dispersive, adsorptive and decay processes in groundwater flow fields (steady state or transient) computed by DYNFLOW. DYNTRACK has been developed over the past 20 years by CDM engineering staff.

A Langrangian approach is used to approximate the solution of the partial differential equation of transport (advection-dispersion equation). This process uses a random walk method to track a statistically significant number of particles, wherein each particle is advected with the mean velocity within a grid element and then randomly dispersed according to specified dispersion parameters. Adsorption computations may be based on linear, Langmuir or Freundlich isotherms. First order constituent decay may also be computed.

In DYNTRACK, a solute source can be represented as an instantaneous input of solute mass (represented by a fixed number of particles), as a continuous source from which mass is input at a constant rate, or as a specified concentration at a node. The concentration within a particular zone of interest is represented by the total number of particles that are present within the zone multiplied by their associated solute mass, divided by the volume of water within the zone.

Peer Review: The DYNTRACK code has been reviewed and tested by the International Groundwater Modeling Center (IGWMC, 1985). DYNTRACK was evaluated by the ASCE Groundwater Quality Technical Committee (Pandit, 1997) as part of a study that summarized the capabilities, limitations and user assessment of widely used groundwater model codes. The code has been extensively tested and documented by CDM. It has been applied in numerous of groundwater modeling studies by CDM and others.

Documentation / Support: DYNTRACK User's Manual and support are provided by CDM. DYNTRACK features and example applications are presented at www.dynsystem.com.

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Brian Heywood, CDM, heywoodbj@cdm.com
Brendan Harley, CDM, harleybm@cdm.com

Applicable Projects: Hazardous waste remediation studies, regional water quality studies.

Model Name: DYNCFT

Model Description & Use: The DYNFLOW groundwater flow code and the DYNTRACK solute transport code can be combined to simulate variable density effects on groundwater flow. The combined code is called DYNCFT. Coupling flow and transport computations allows the effect on groundwater flow of fluid density gradients associated with solute concentration gradients to be incorporated into model simulations (i.e., density-dependent flow). In DYNCFT the flow and transport computations are loosely coupled. At each time step, the flow computations are completed first, holding densities constant, then the transport computations are completed. The computed heads are then re-adjusted to account for the effects of the fluid density.

Since DYNCFT uses the DYNFLOW and DYNTRACK codes, all of the capabilities included in DYNFLOW and DYNTRACK (described previously) may be applied in DYNCFT simulations.

Peer Review: The DYNFLOW and DYNTRACK codes utilized by DYNCFT have been extensively tested and documented by CDM, reviewed and tested by the International Groundwater Modeling Center (IGWMC, 1985) and evaluated by the ASCE Groundwater Quality Technical Committee (Pandit, 1997). Coupled flow-transport computations have been tested using common benchmark solutions, and DYNCFT simulations of groundwater flow, heads and salt water intrusion in the Gaza Strip coastal aquifer were consistent with field measured conditions.

Documentation / Support: DYNCFT documentation and support are provided by CDM. DYNCFT features and an example application are presented at www.dynsystem.com.

Point of Contact(s): Robert Fitzgerald, CDM, fitzgeraldrh@cdm.com
Brian Heywood, CDM, heywoodbj@cdm.com
Brendan Harley, CDM, harleybm@cdm.com

Applicable Projects: Salt water intrusion studies, regional ASR studies.

References

International Ground Water Modeling Center, 1985. *Review of DYNFLOW and DYNTRACK Groundwater Simulation Computer Codes*. Report of Findings by Paul K.M. van der Heijde for U.S. Environmental Protection Agency. IGWMC 85-17

van der Heijde, Paul K.M., 1999. *DYNFLOW Version 5.18: Testing and Evaluation of Code Performance.*

Pandit, Ashok, Panigrahi, Bijay, Peyton, Lee, Redi, Lakshmi, Sayed, Sayed and Emmett, H., 1997. *Ground-Water Flow and Contamination Models: Description and Evaluation*. Report of the activities of the ASCE Groundwater Quality Committee in Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management.