APPENDIX I

CC B306-UD17
FAT CLAY (CH), trace sand, gray*
(LL=62, PL=24, PI=38; Gs=2.73)*

Borehole B-306
Sample UD17
Sample Depth = 68.0 to 70.0 ft
RCTS Test Depth = 69.3 ft
Total Unit Weight = 115.8 lb/ft^3
Water Content = 30.7 %
Estimated In-Situ Ko = 0.5*
Estimated In-Situ Mean Effective Stress = 23.6 psi*

*Data supplied by Schnabel Engineering, Inc.

FUGRO JOB #: 0401-1661
Testing Station: RC7

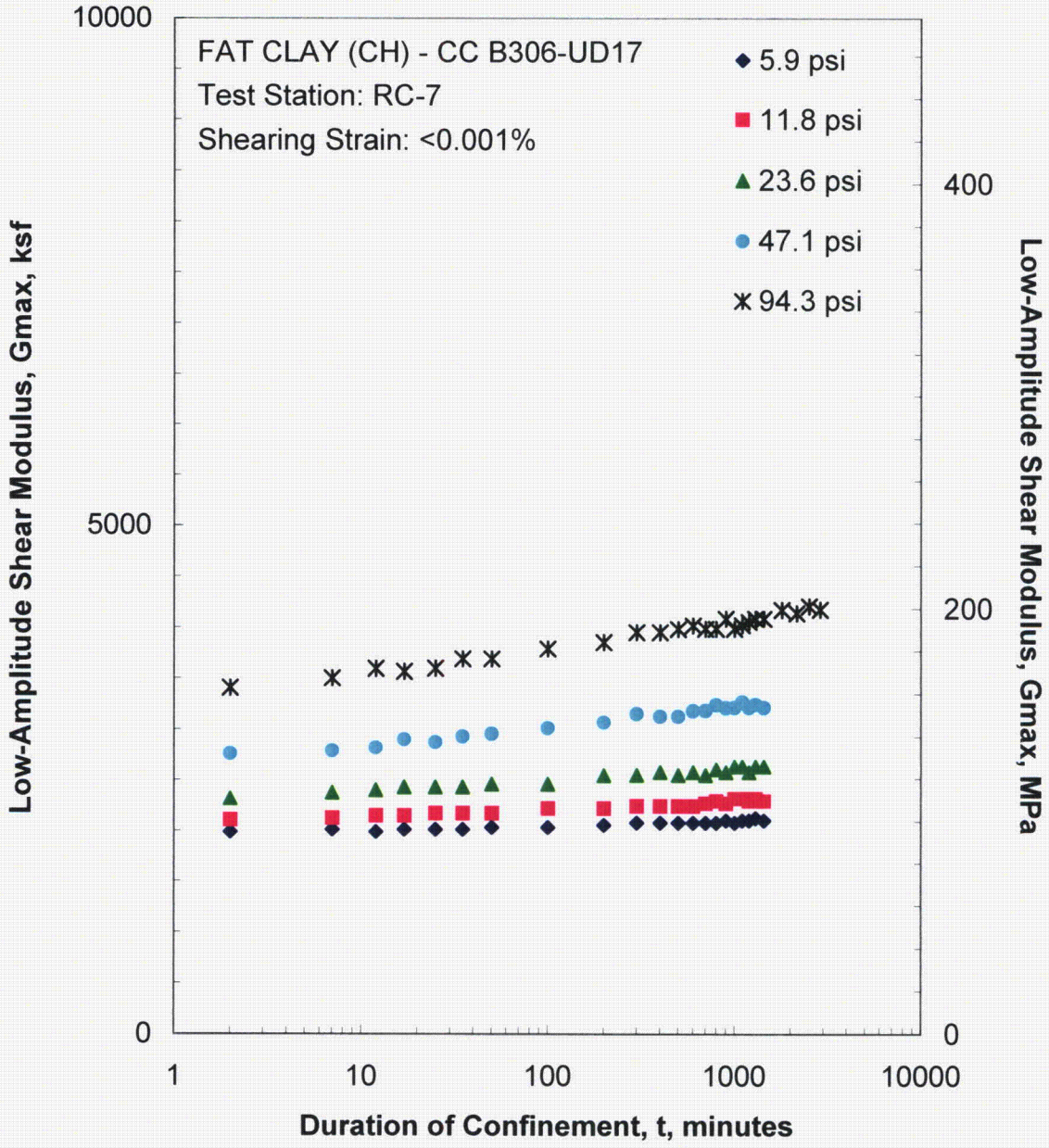


Figure I.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

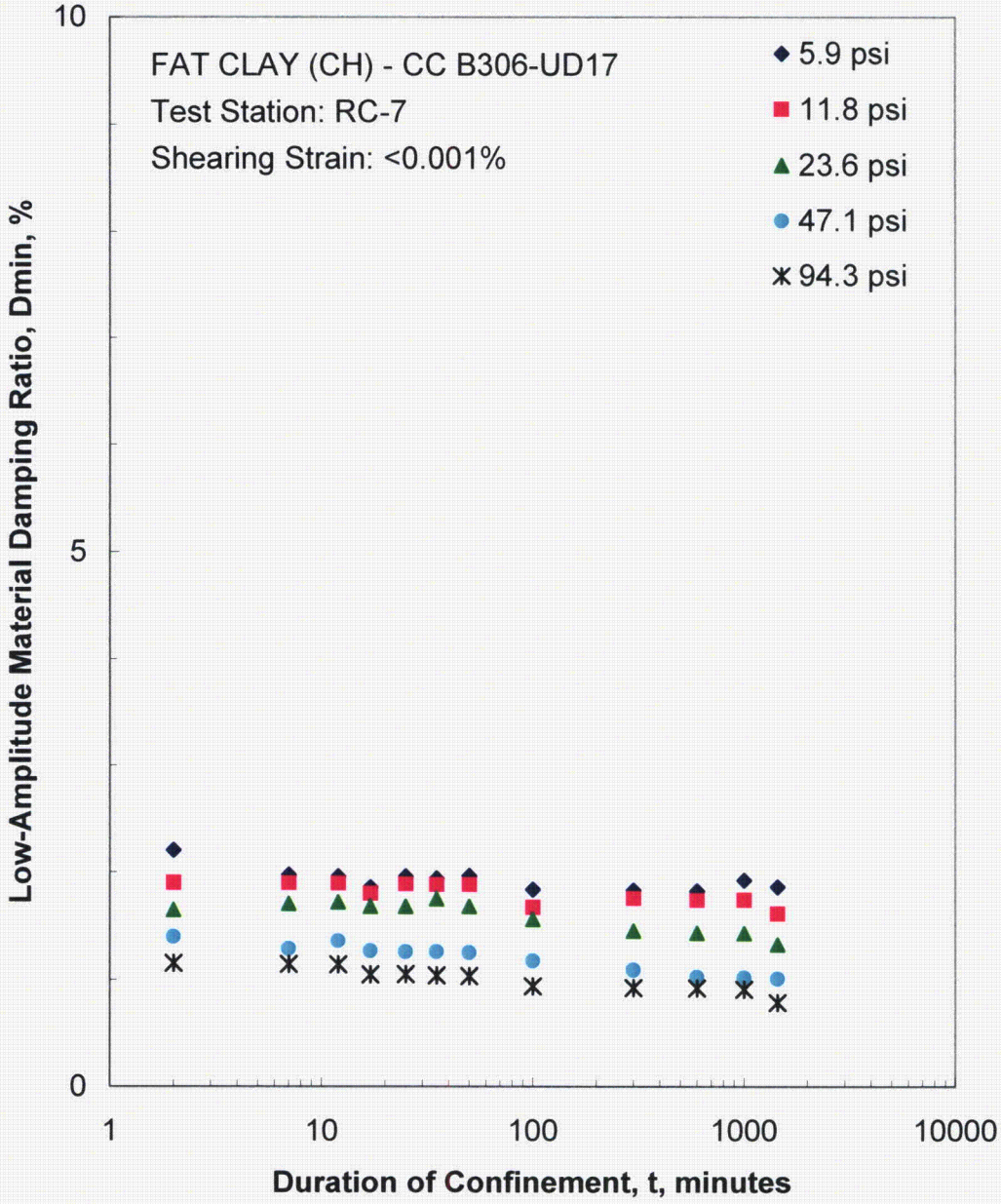


Figure I.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

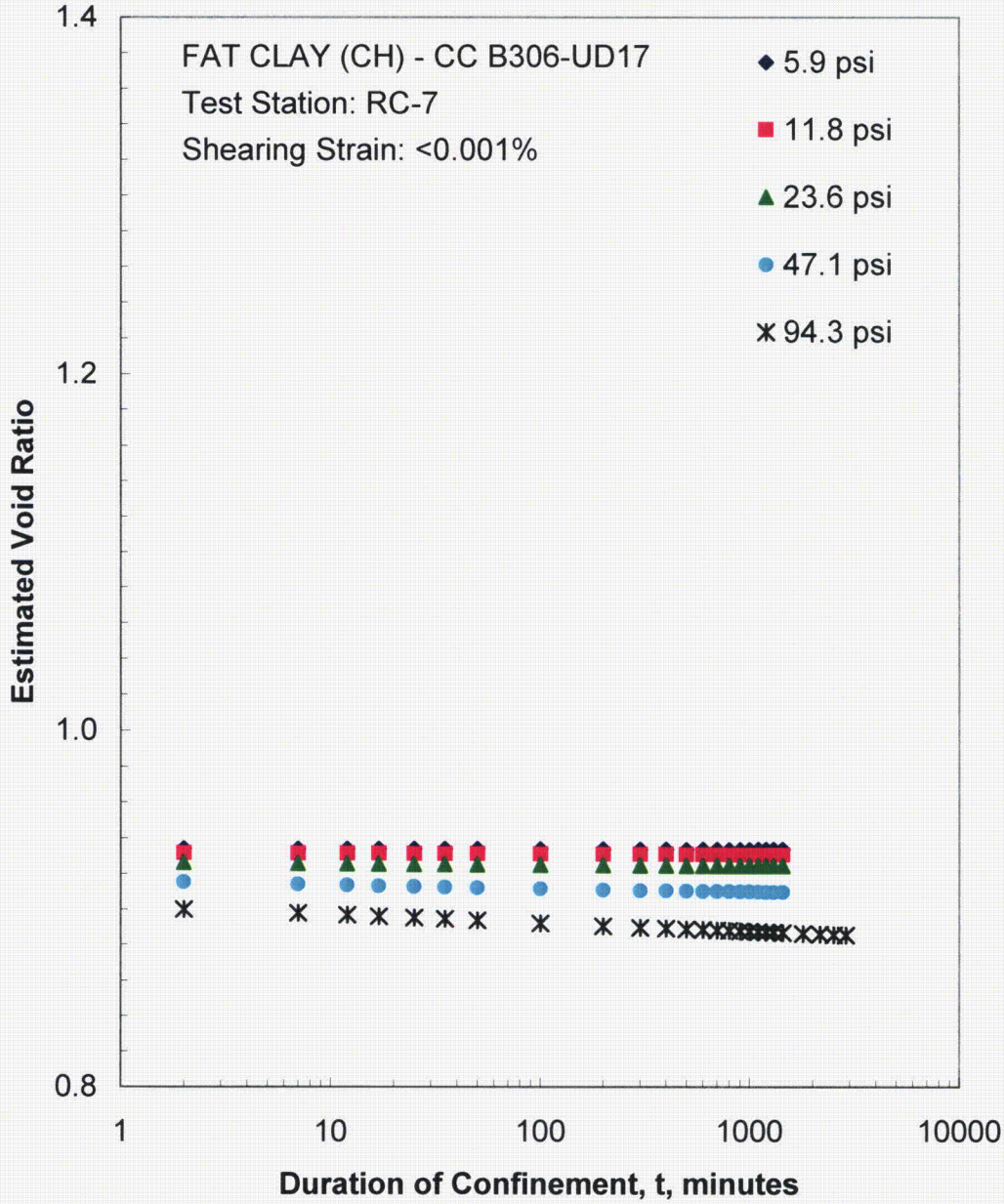


Figure I.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

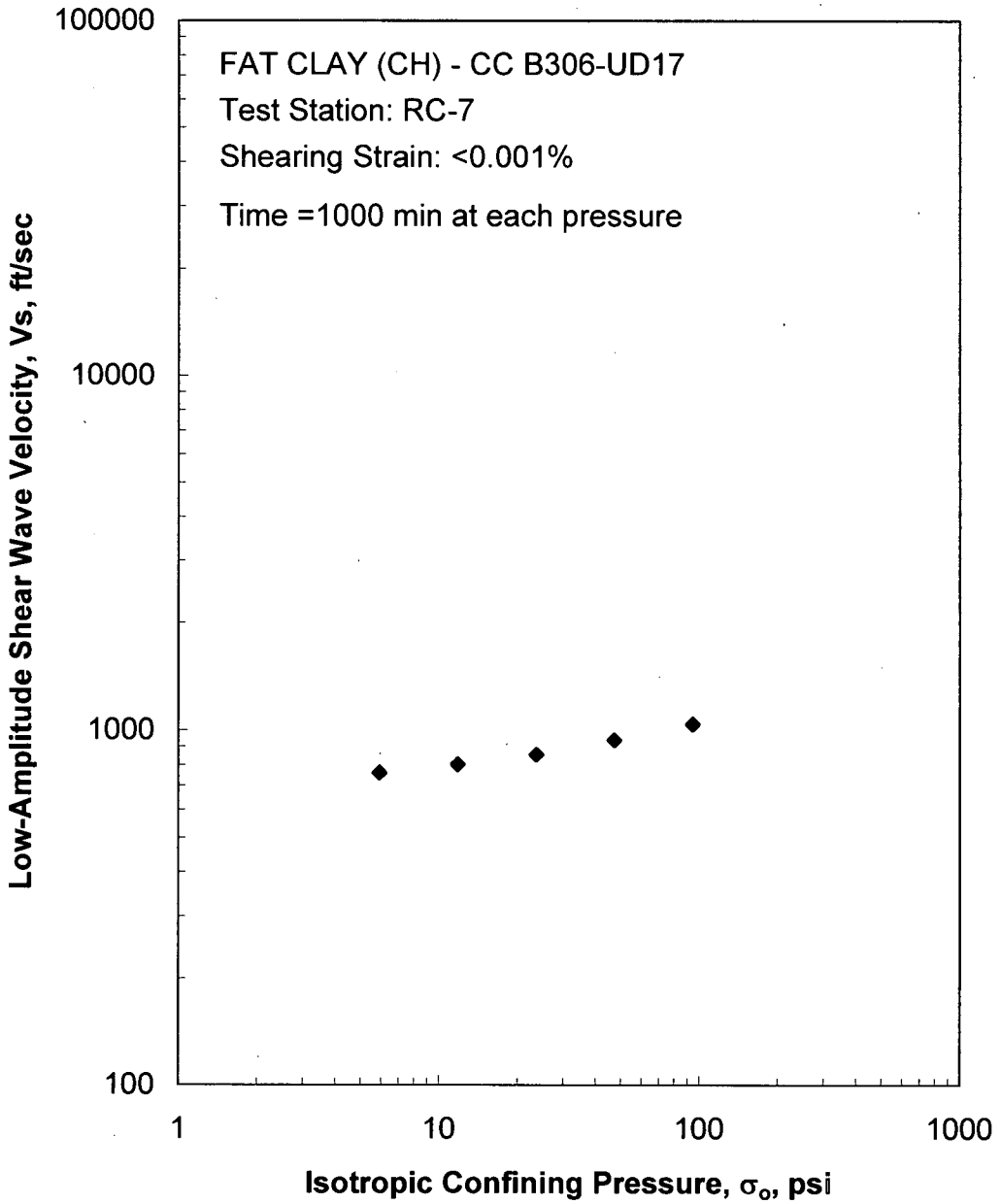


Figure I.4 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests

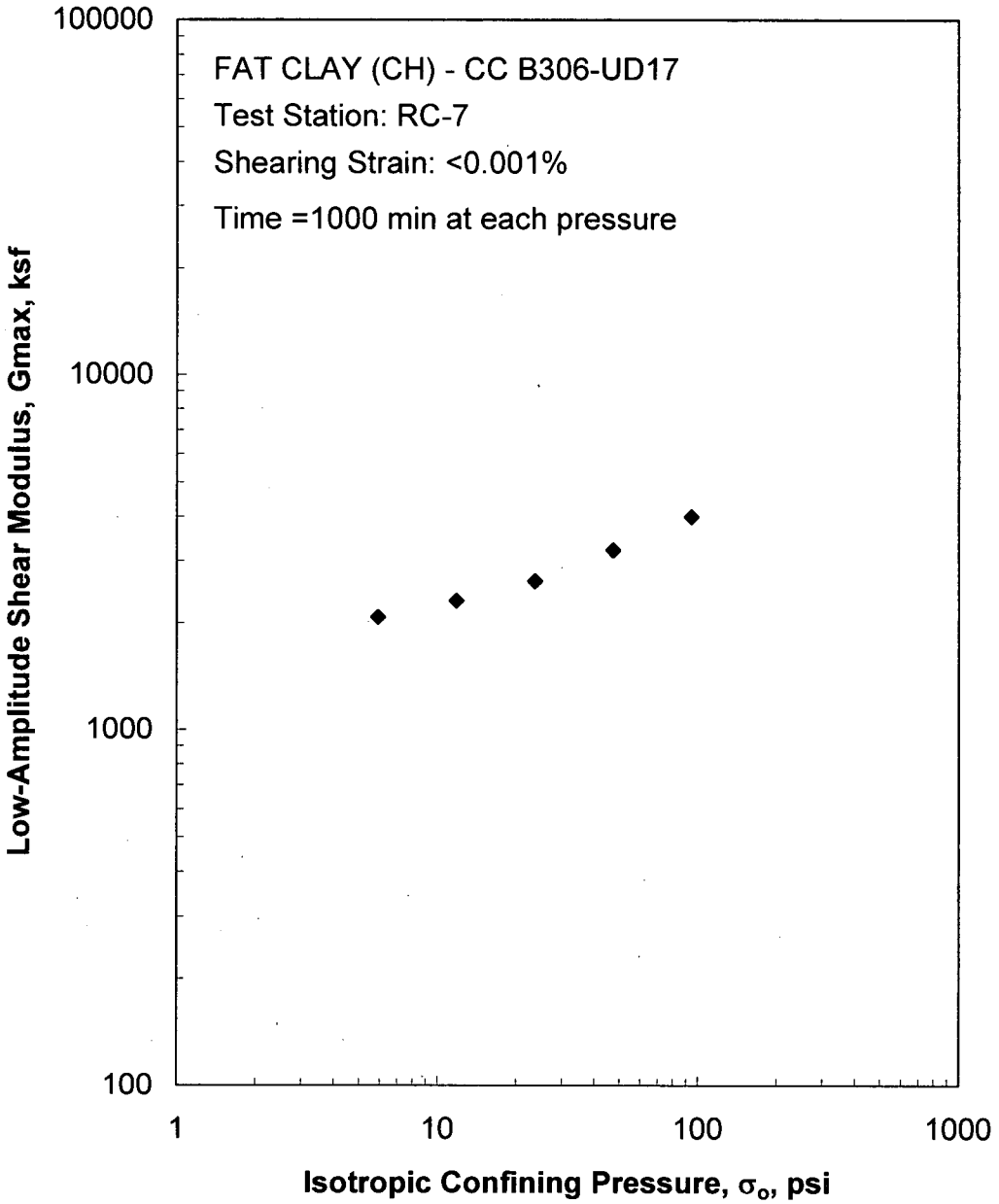


Figure I.5 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Tests

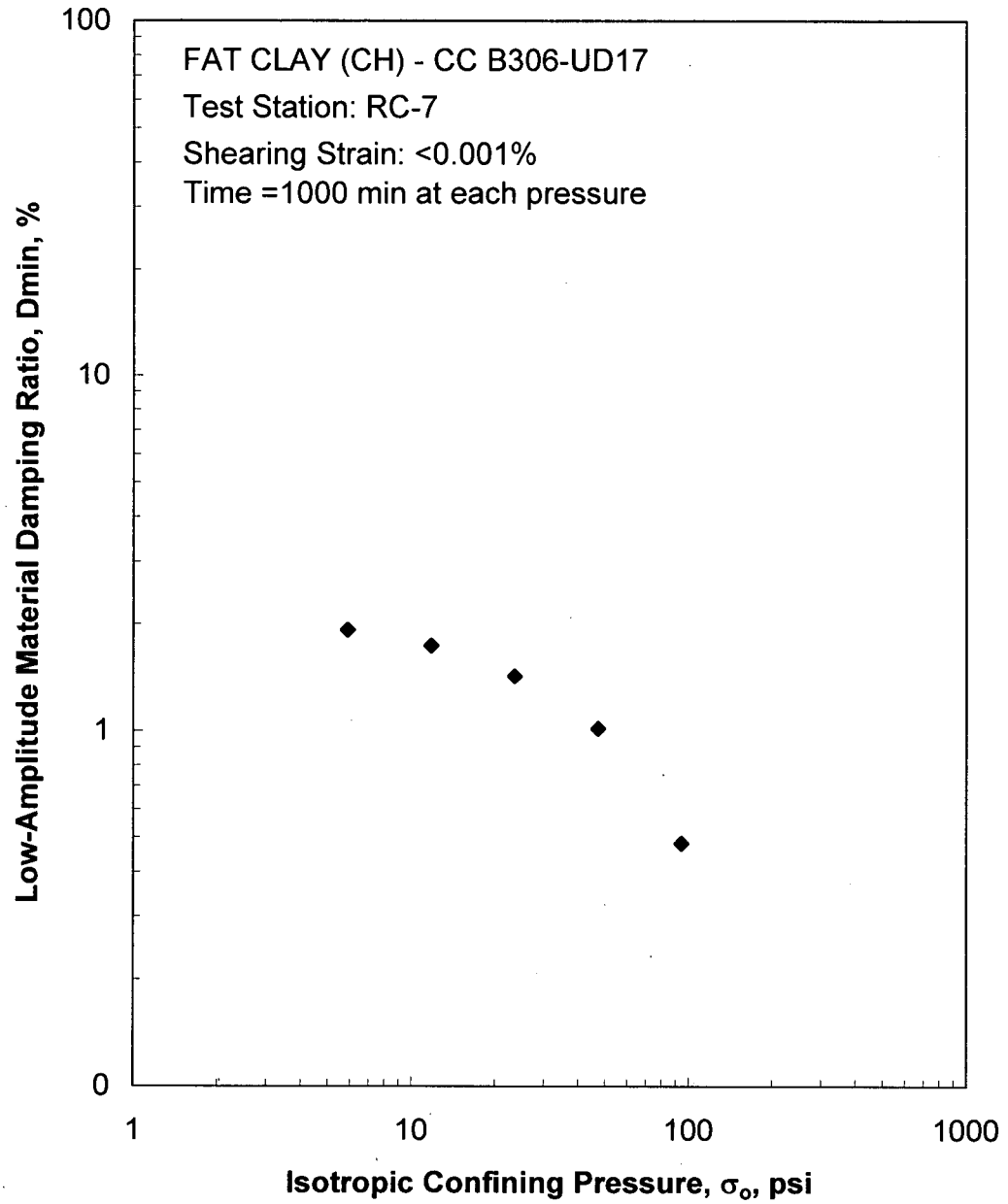


Figure I.6 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests

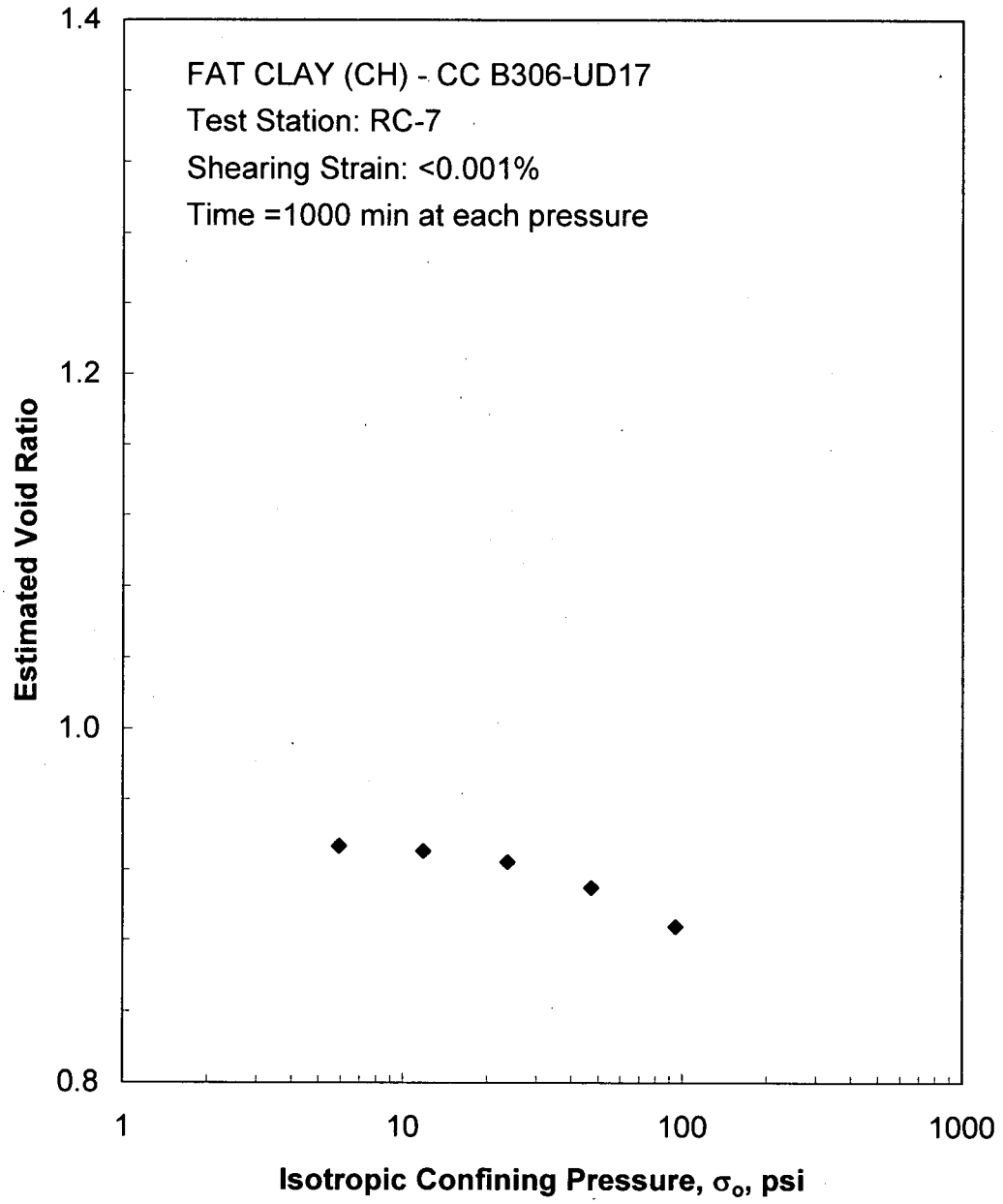


Figure I.7 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests

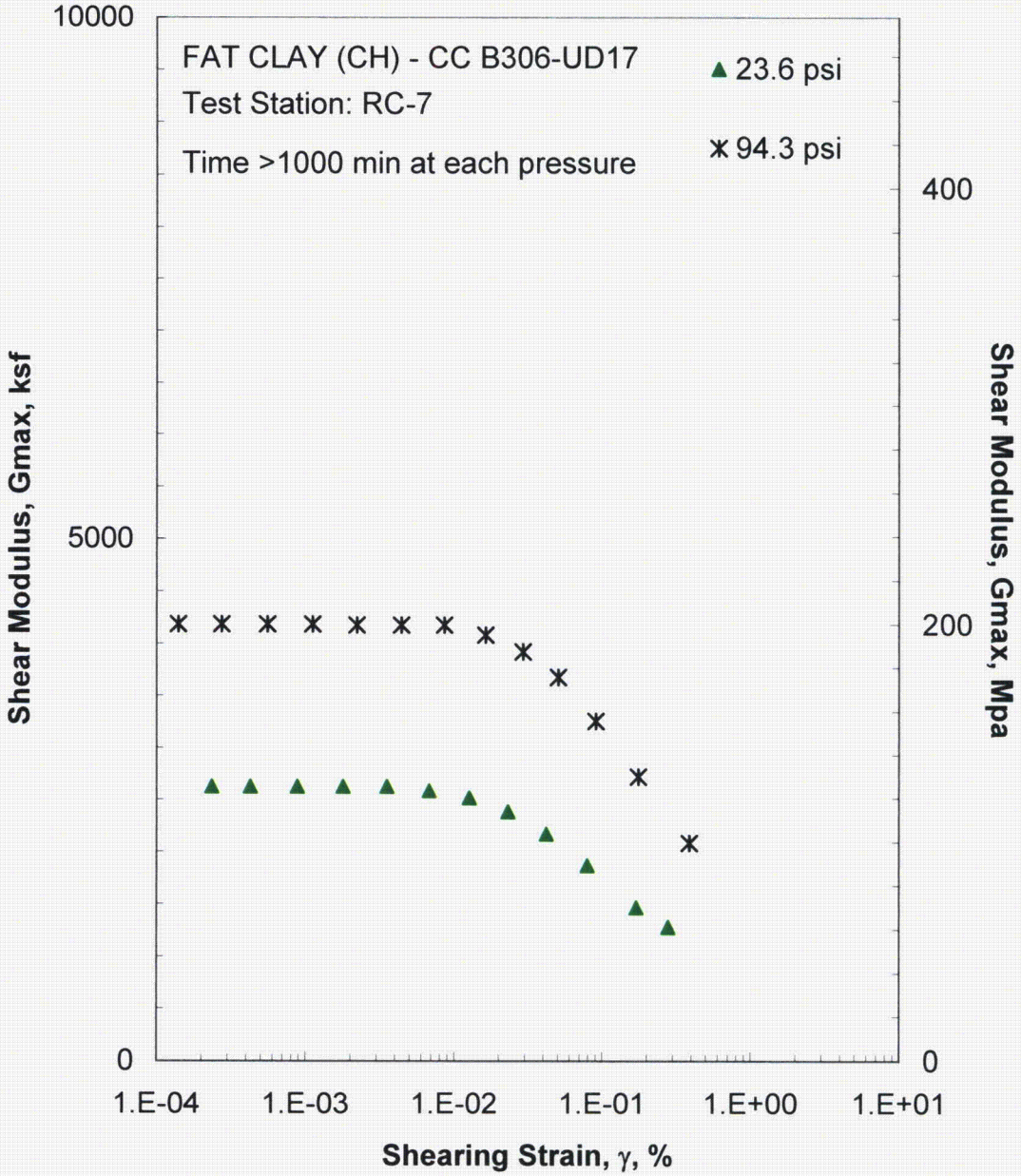


Figure I.8 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

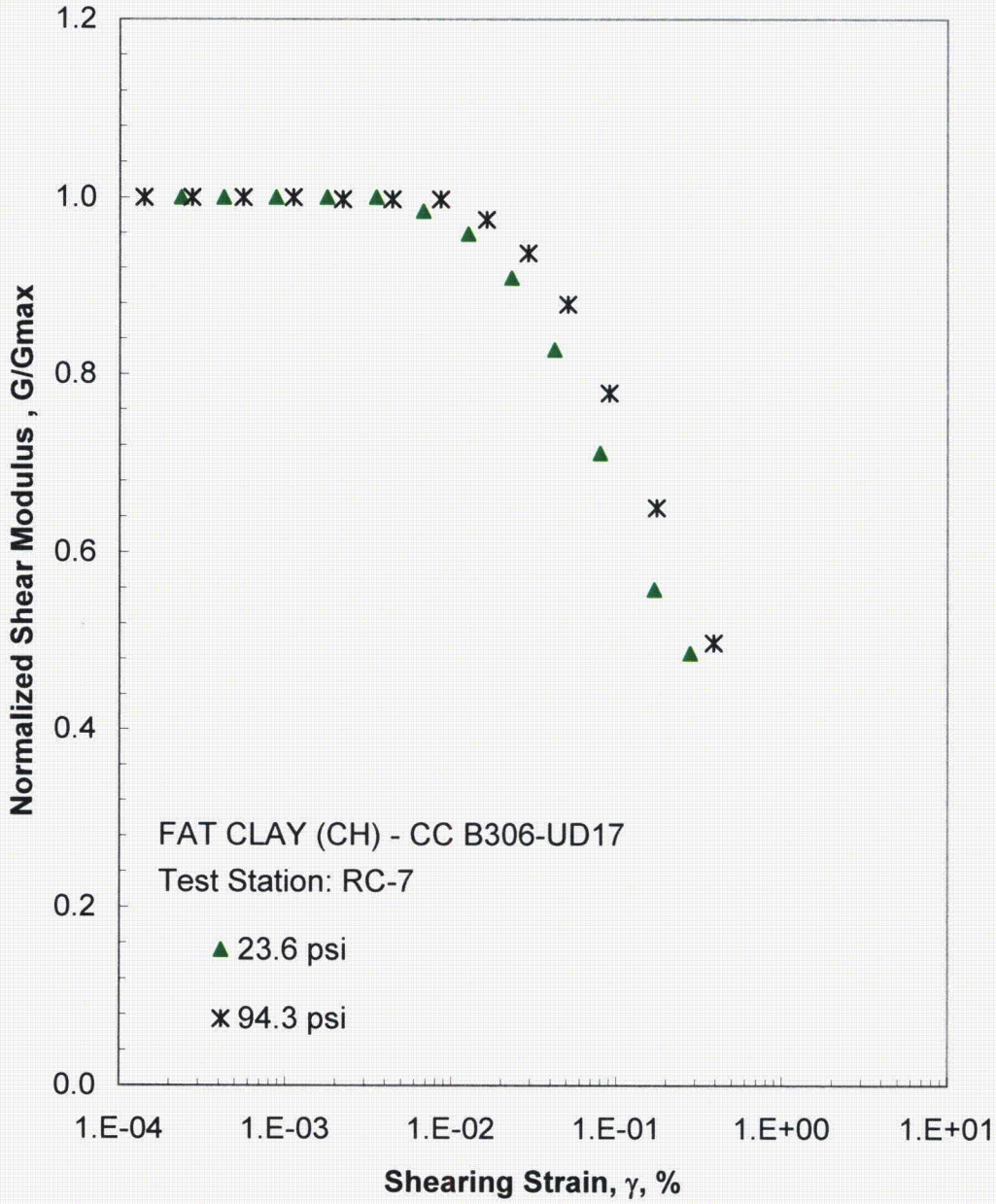


Figure I.9 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

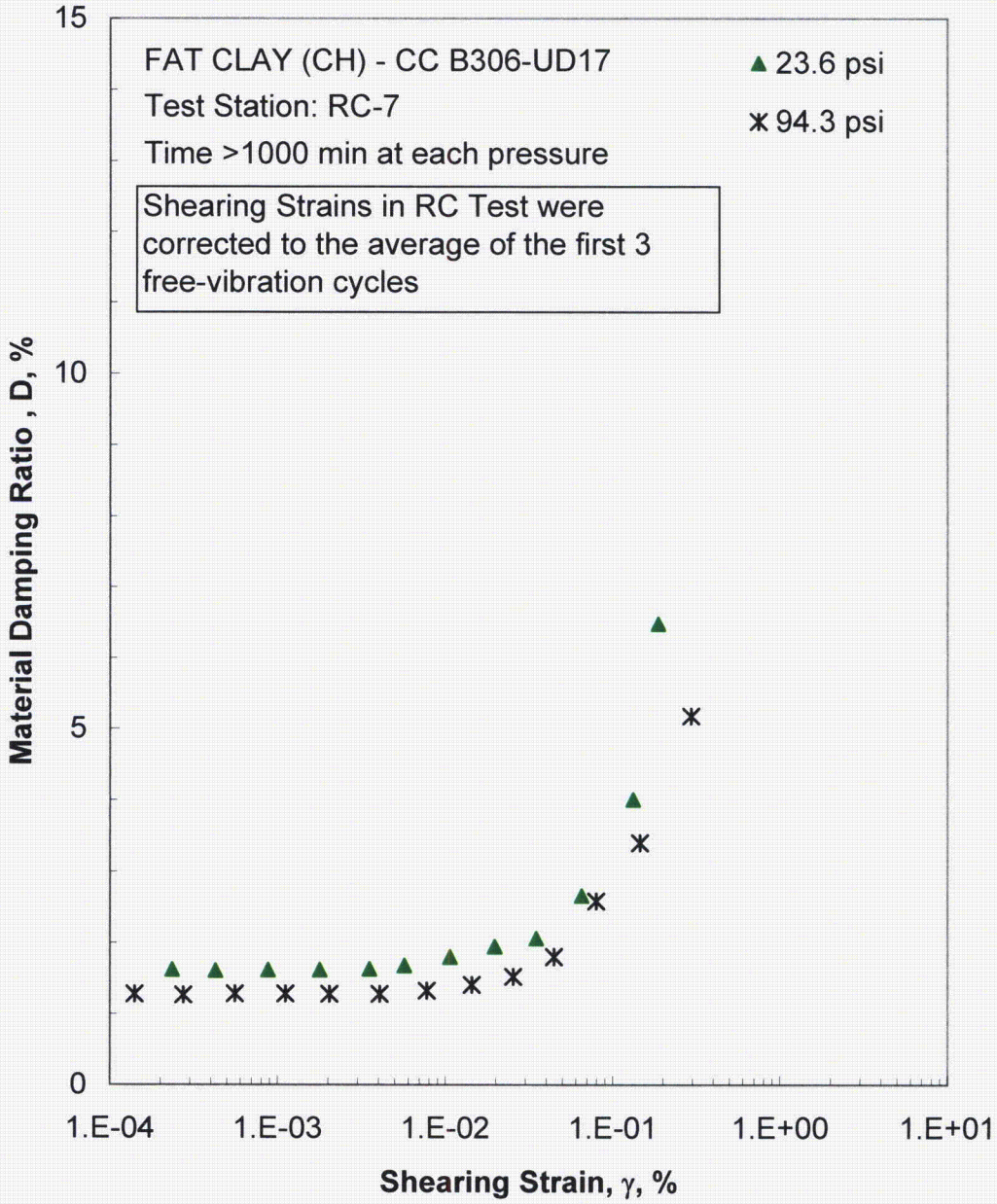


Figure I.10 Comparison of the Variation in Material Damping Ratio with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

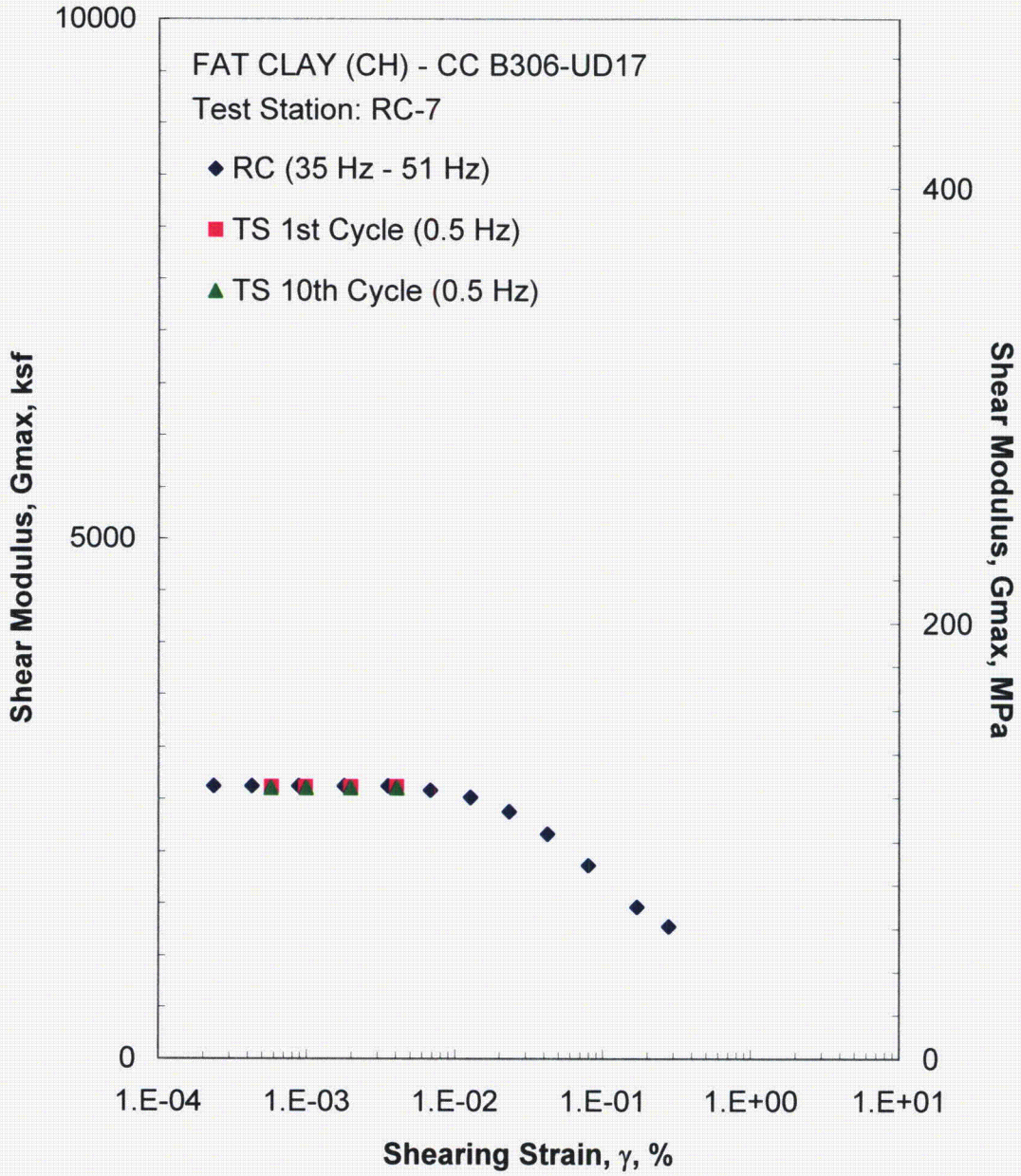


Figure I.11 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 23.6 psi from the Combined RCTS Tests

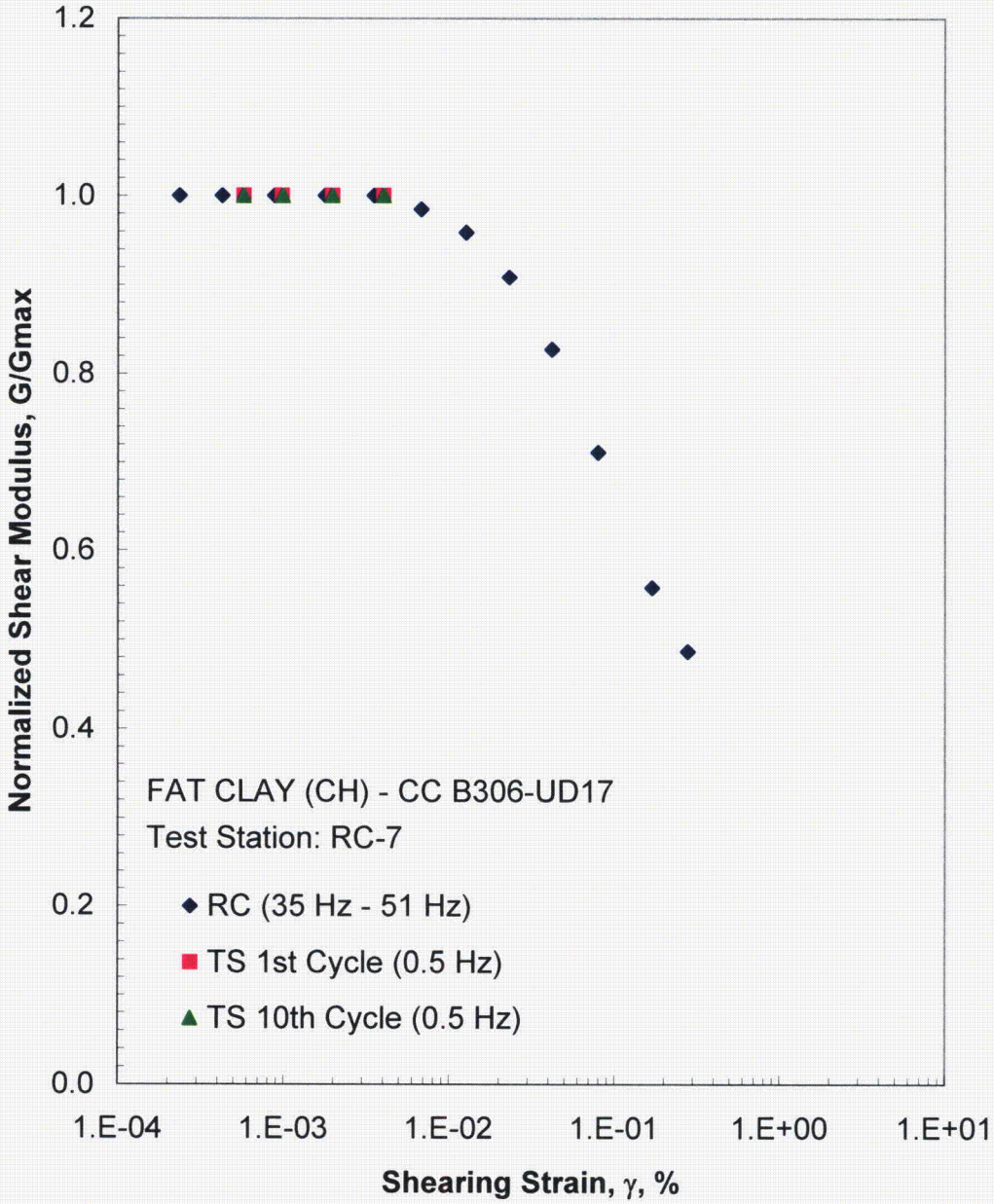


Figure I.12 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 23.6 psi from the Combined RCTS Tests

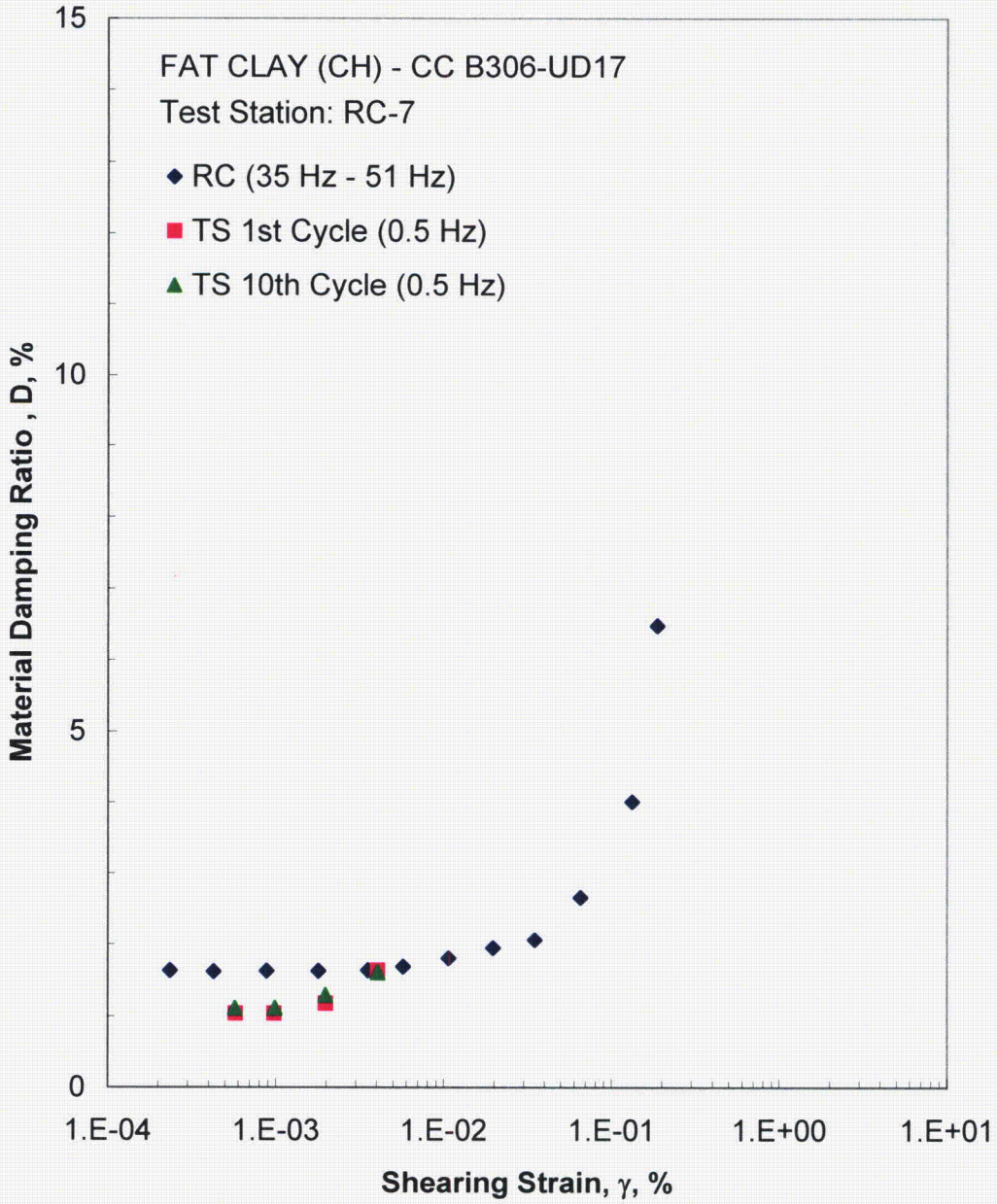


Figure I.13 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 23.6 psi from the Combined RCTS Tests

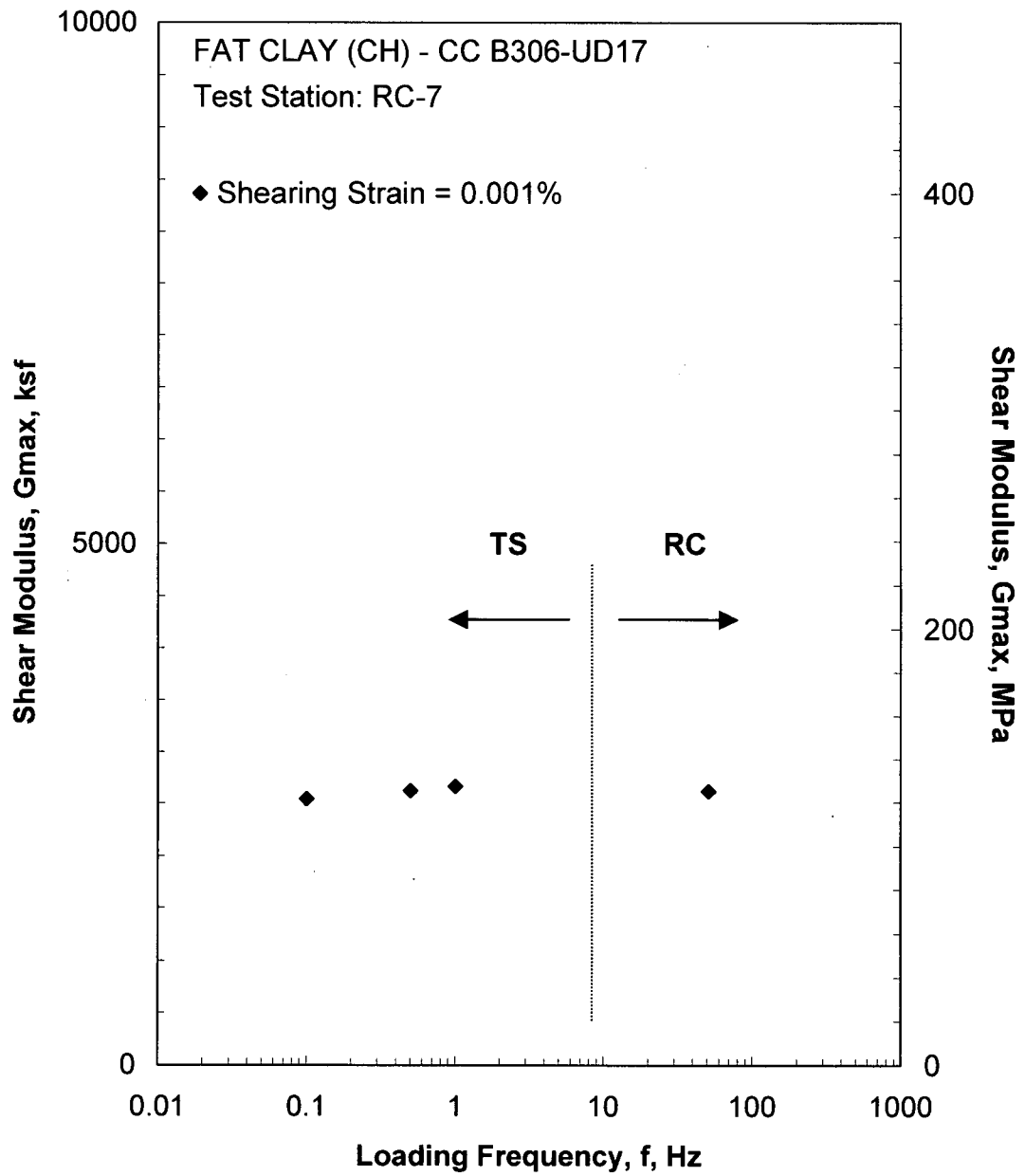


Figure I.14 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 23.6 psi from the Combined RCTS Tests

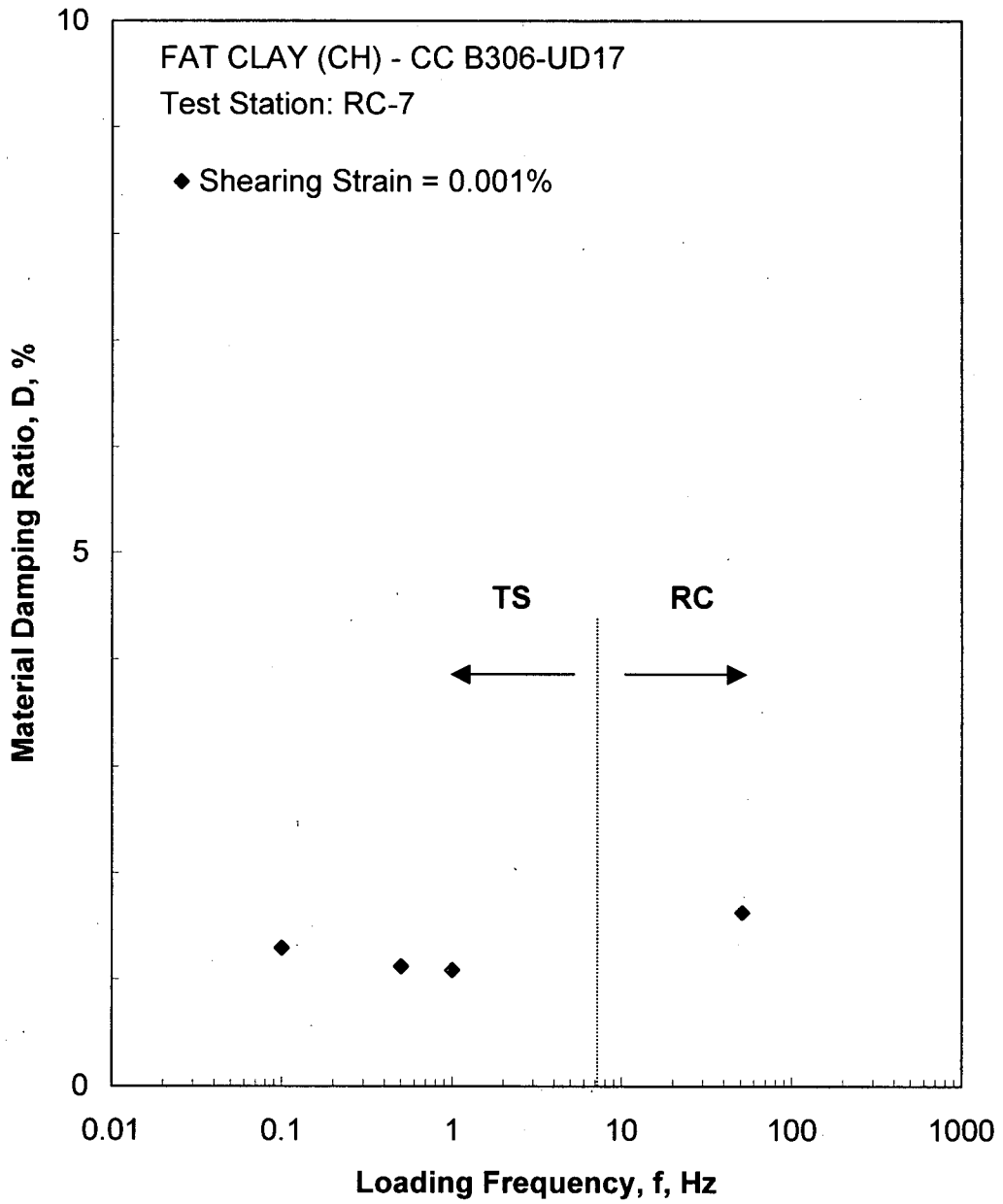


Figure I.15 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 23.6 psi from the Combined RCTS Tests

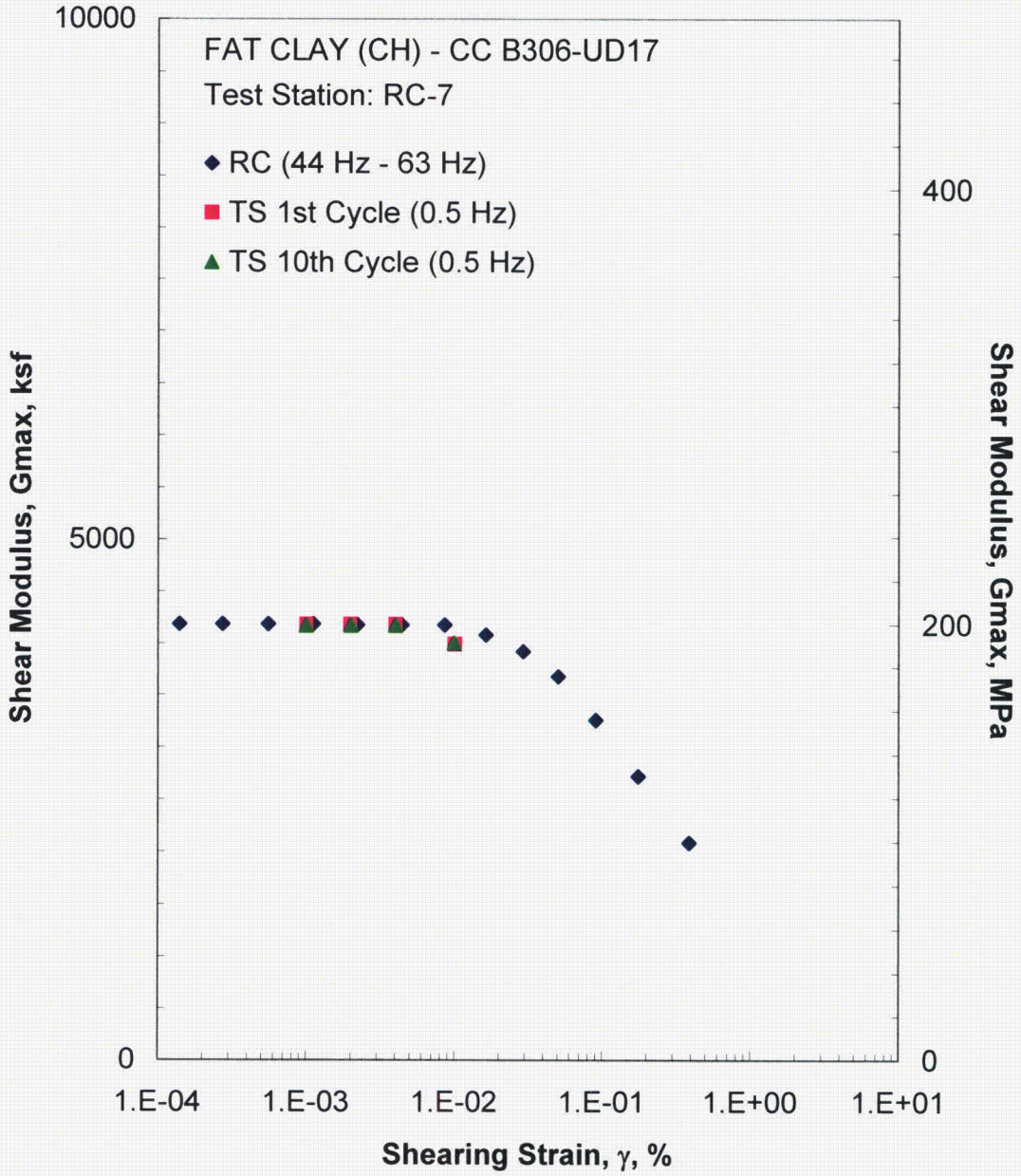


Figure I.16 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 94.3 psi from the Combined RCTS Tests

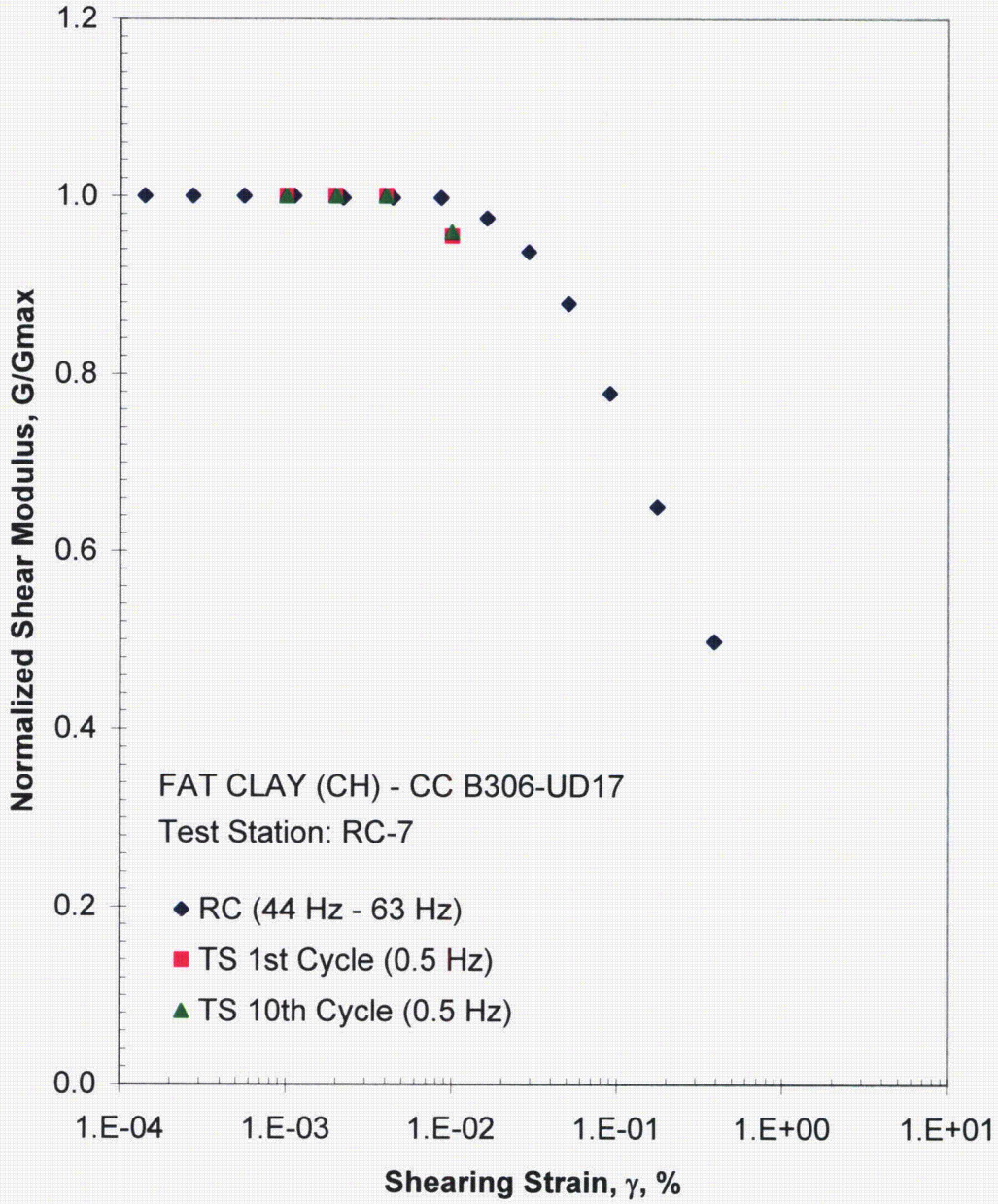


Figure I.17 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 94.3 psi from the Combined RCTS Tests

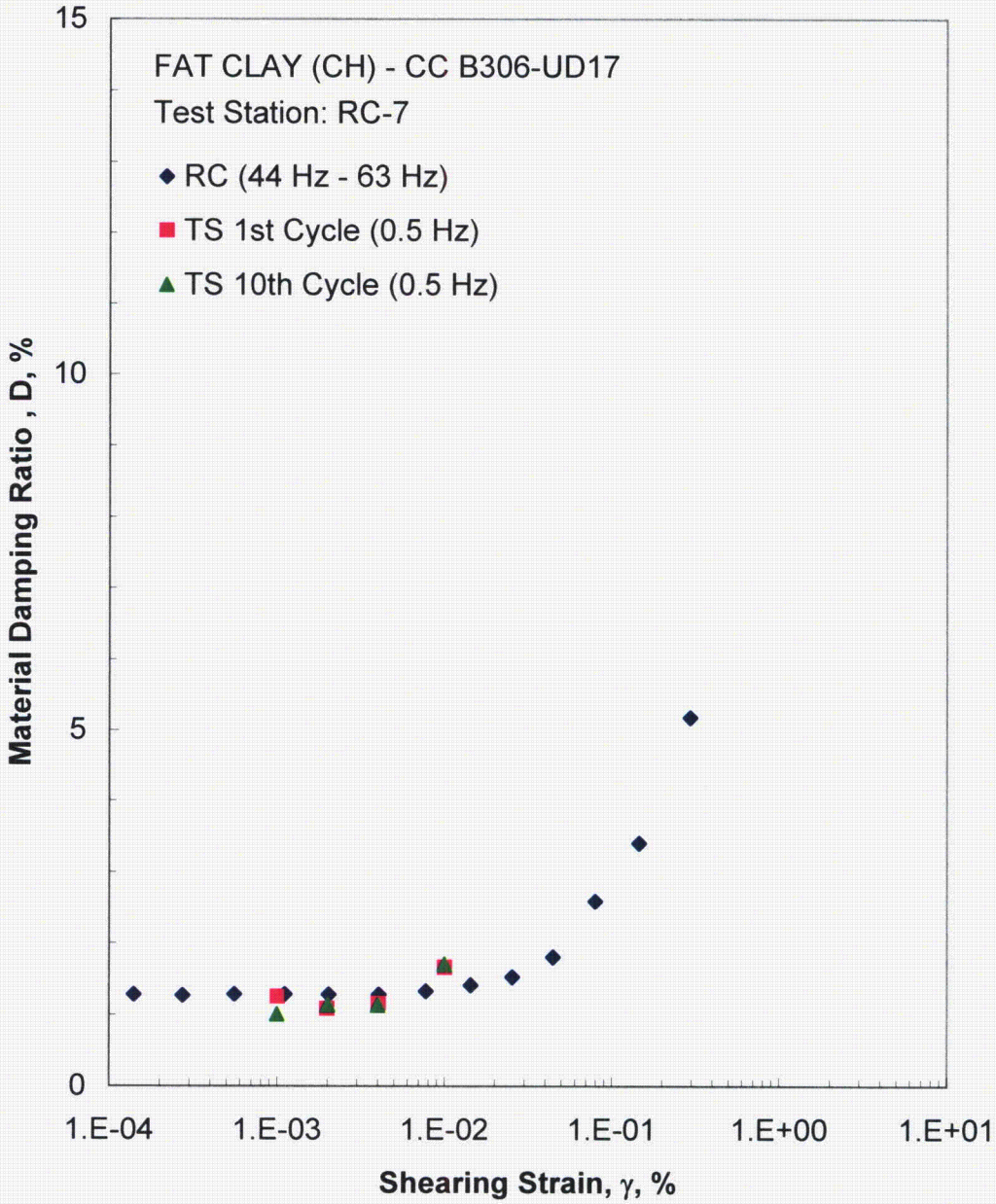


Figure I.18 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 94.3 psi from the Combined RCTS Tests

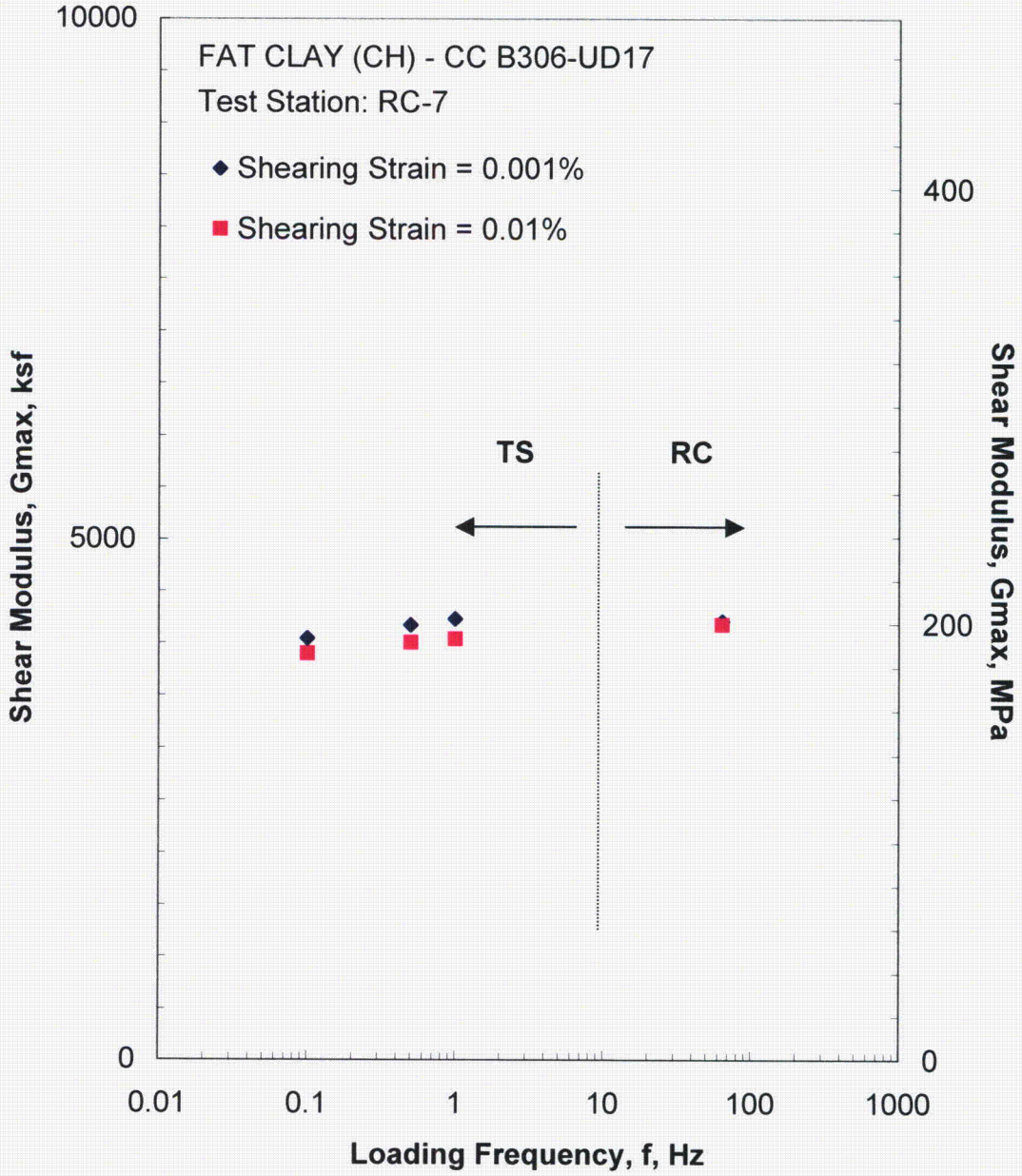


Figure I.19 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 94.3 psi from the Combined RCTS Tests

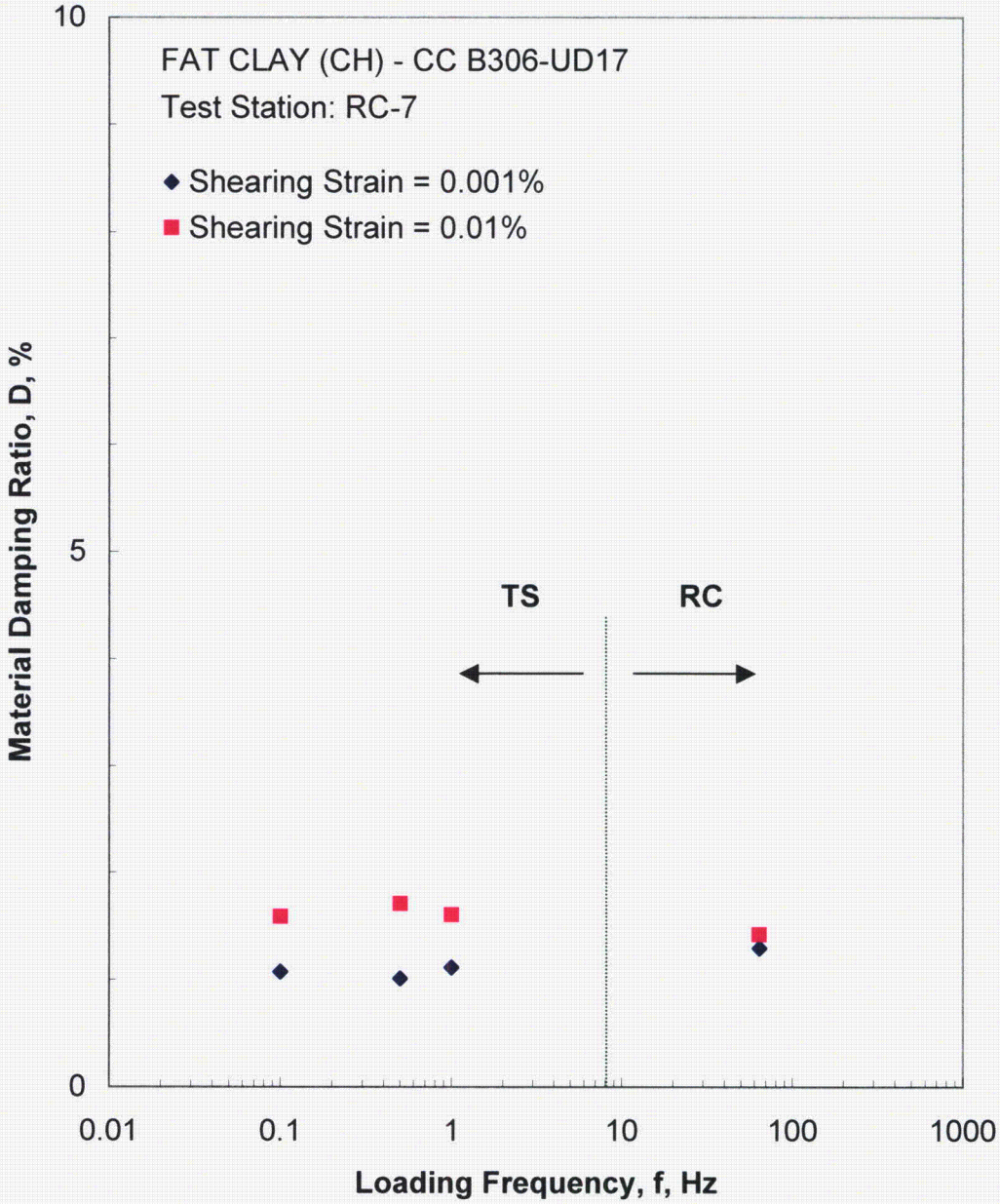


Figure I.20 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 94.3 psi from the Combined RCTS Tests

Table I.1 Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Estimated Void Ratio with Isotropic Confining Pressure from RC Tests of Specimen CC B306-UD17

Isotropic Confining Pressure, σ_o			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin	Estimated Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	(%)	
5.9	850	41	2078	100	759	1.92	0.933
11.8	1699	81	2314	111	800	1.74	0.931
23.6	3398	163	2629	126	852	1.43	0.924
47.1	6782	325	3212	154	938	1.01	0.910
94.3	13579	650	3986	191	1038	0.48	0.887

Table I.2 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen CC B306-UD17; Isoptropic Confining Pressure, σ_o=23.6 psi (3.4 ksf = 163 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
2.35E-04	2622	1.00	2.35E-04	1.63
4.26E-04	2622	1.00	4.26E-04	1.61
8.80E-04	2622	1.00	8.80E-04	1.62
1.79E-03	2622	1.00	1.79E-03	1.62
3.53E-03	2622	1.00	3.53E-03	1.63
6.81E-03	2581	0.98	5.72E-03	1.68
1.27E-02	2513	0.96	1.07E-02	1.80
2.31E-02	2381	0.91	1.96E-02	1.95
4.19E-02	2168	0.83	3.48E-02	2.06
7.93E-02	1863	0.71	6.50E-02	2.66
1.69E-01	1463	0.56	1.32E-01	4.01
2.78E-01	1275	0.49	1.87E-01	6.48

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table I.3 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen CC B306-UD17; Isotropic Confining Pressure, σ_o= 23.6 psi (3.4 ksf =163 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
5.75E-04	2612	1.00	1.03	5.73E-04	2601	1.00	1.11
9.77E-04	2612	1.00	1.03	9.91E-04	2601	1.00	1.11
1.98E-03	2612	1.00	1.17	1.97E-03	2601	1.00	1.29
4.02E-03	2612	1.00	1.63	4.05E-03	2601	1.00	1.60

Table I.4 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen CC B306-UD17; Isoptropic Confining Pressure, σ_o= 94.3 psi (13.6 ksf = 650 kPa)

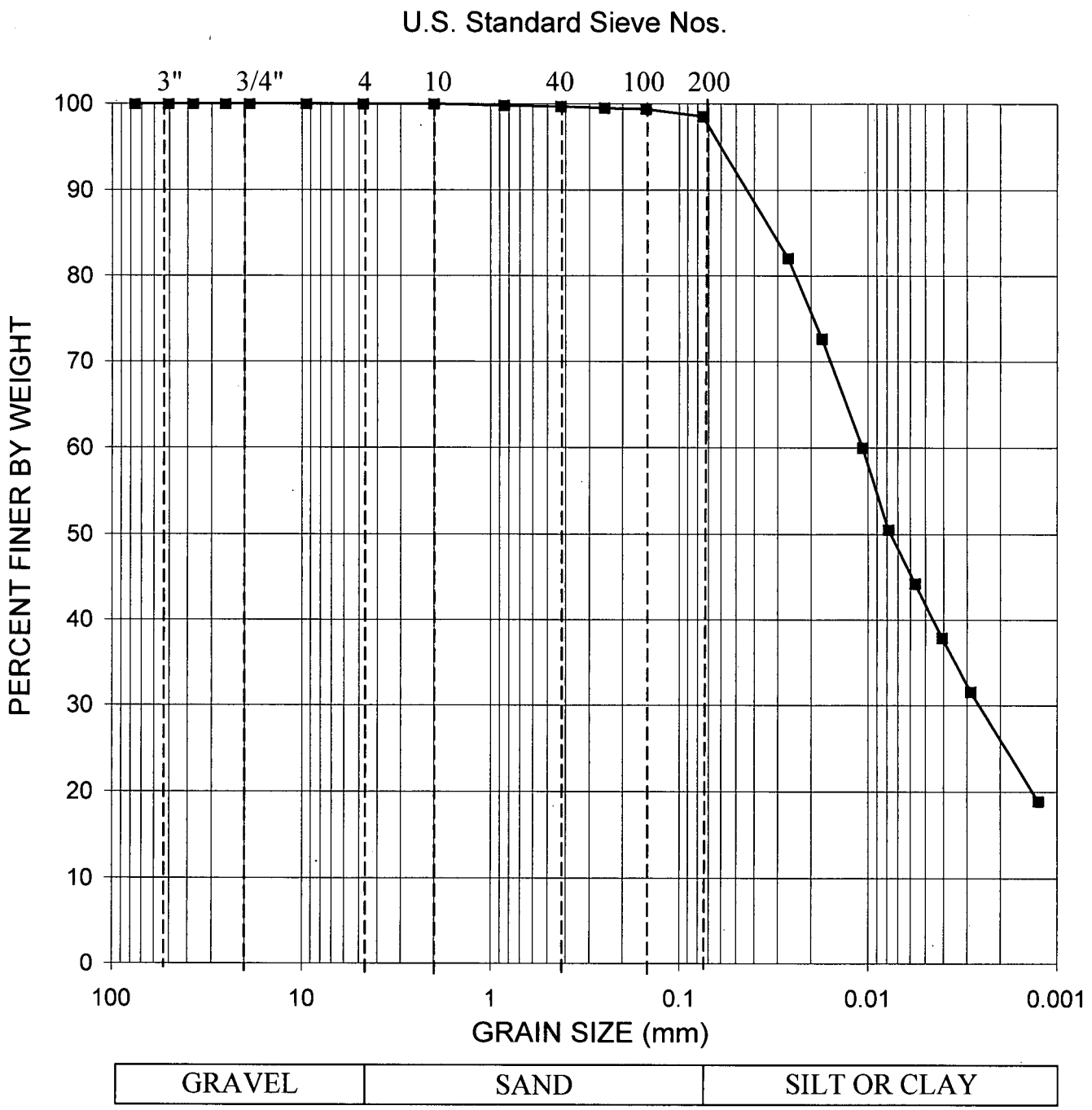
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
1.40E-04	4184	1.00	1.40E-04	1.28
2.73E-04	4184	1.00	2.73E-04	1.27
5.56E-04	4184	1.00	5.56E-04	1.29
1.11E-03	4184	1.00	1.11E-03	1.29
2.21E-03	4176	1.00	2.04E-03	1.29
4.40E-03	4176	1.00	4.05E-03	1.29
8.58E-03	4176	1.00	7.72E-03	1.33
1.63E-02	4080	0.98	1.43E-02	1.41
2.91E-02	3920	0.94	2.53E-02	1.53
5.04E-02	3676	0.88	4.44E-02	1.80
9.03E-02	3257	0.78	7.94E-02	2.59
1.75E-01	2719	0.65	1.45E-01	3.40
3.87E-01	2083	0.50	2.94E-01	5.18

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table I.5 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen CC B306-UD17; Isotropic Confining Pressure, σ_o=94.3 psi (13.6 ksf = 650 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
1.00E-03	4179	1.00	1.25	1.00E-03	4170	1.00	1.00
1.98E-03	4179	1.00	1.08	2.01E-03	4170	1.00	1.14
4.02E-03	4179	1.00	1.16	4.01E-03	4170	1.00	1.13
1.00E-02	3989	0.95	1.66	9.98E-03	4001	0.96	1.70



GRADATION CURVE

ASTM D422

Project:	Constellation Energy Group COLA Project, Calvert Cliffs NuclearPower Plant (CCNPP), Calvert County, Maryland		Contract No.:	06120048.00	Date:	9/21/2007
Boring No.	Depth (ft)	Sample Description	Class.	LL	PI	
B-306	68.0-70.0	FAT CLAY, trace sand, gray	CH	62	38	Schnabel Engineering

APPENDIX J

CC B409-UD15
POORLY GRADED SAND (SP-SM), with silt, gray*
(Non-Plastic; Gs=2.66)*

Borehole B-409
Sample UD15
Sample Depth = 35 to 36.1 ft
RCTS Test Depth = 36.1 ft
Total Unit Weight = 124.8 lb/ft^3
Water Content = 23.3 %
Estimated In-Situ Ko = 0.5*
Estimated In-Situ Mean Effective Stress = 11.8 psi*

*Data supplied by Schnabel Engineering, Inc.

FUGRO JOB #: 0401-1661
Testing Station: RC7

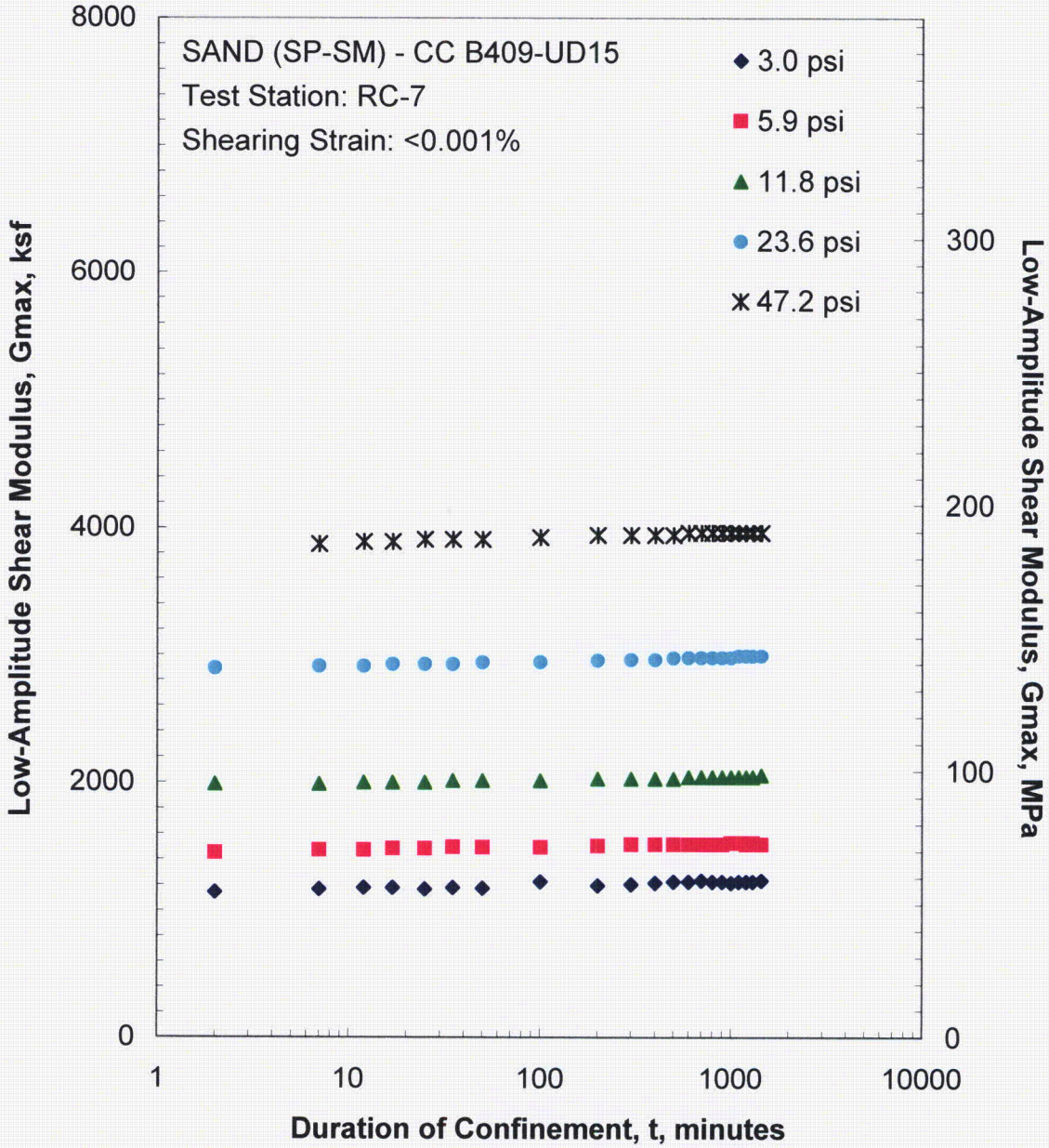


Figure J.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

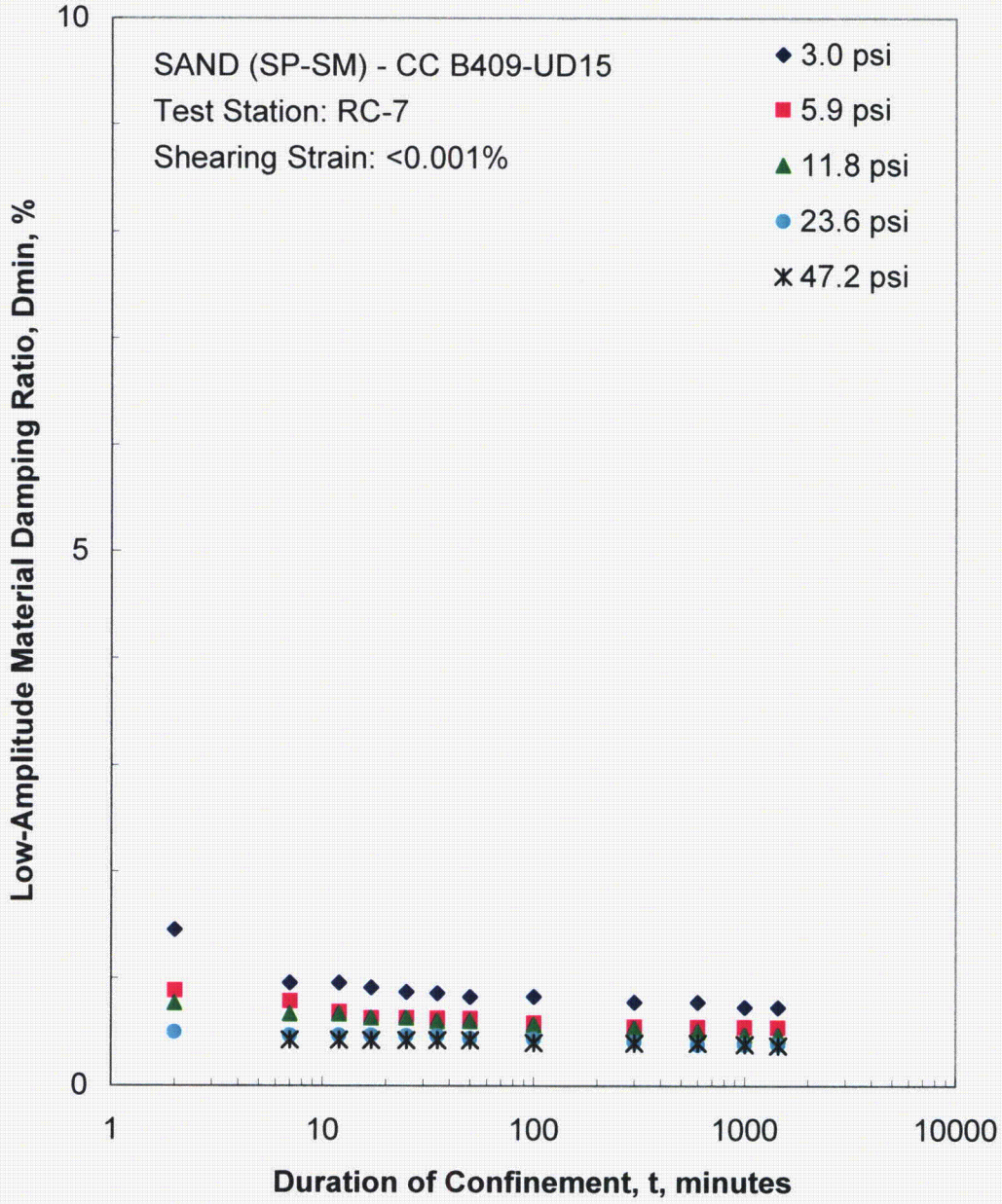


Figure J.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

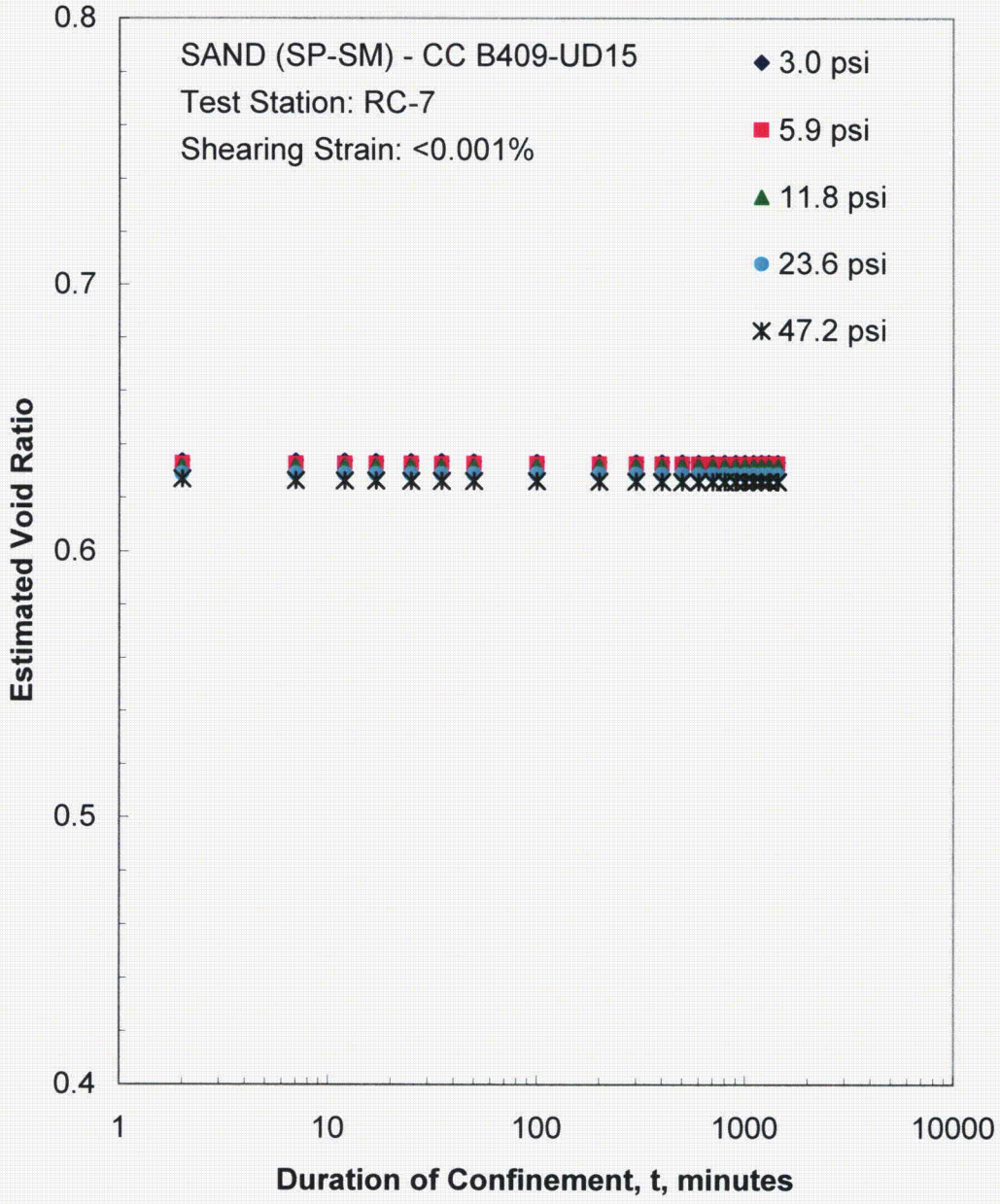


Figure J.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

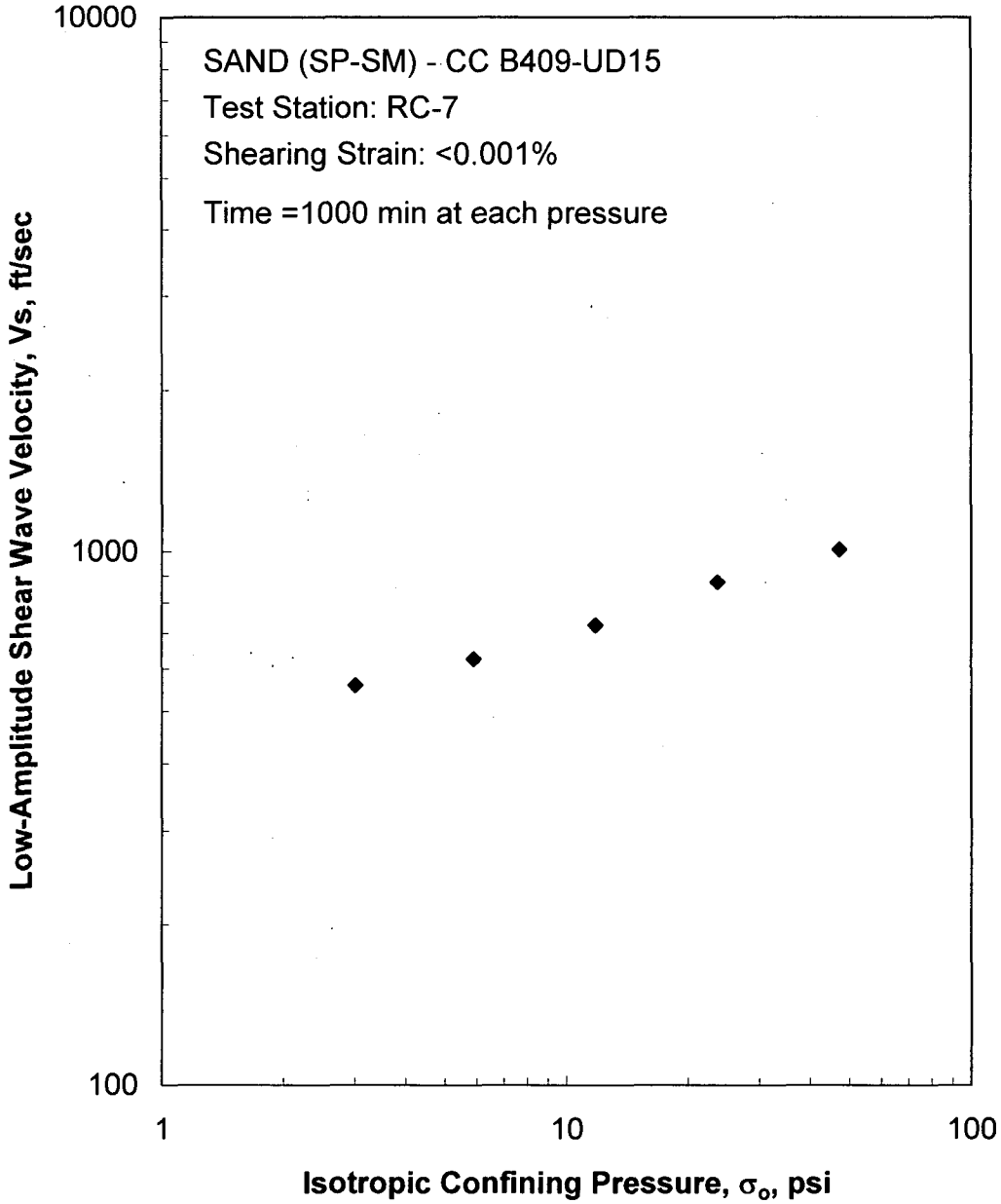


Figure J.4 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests

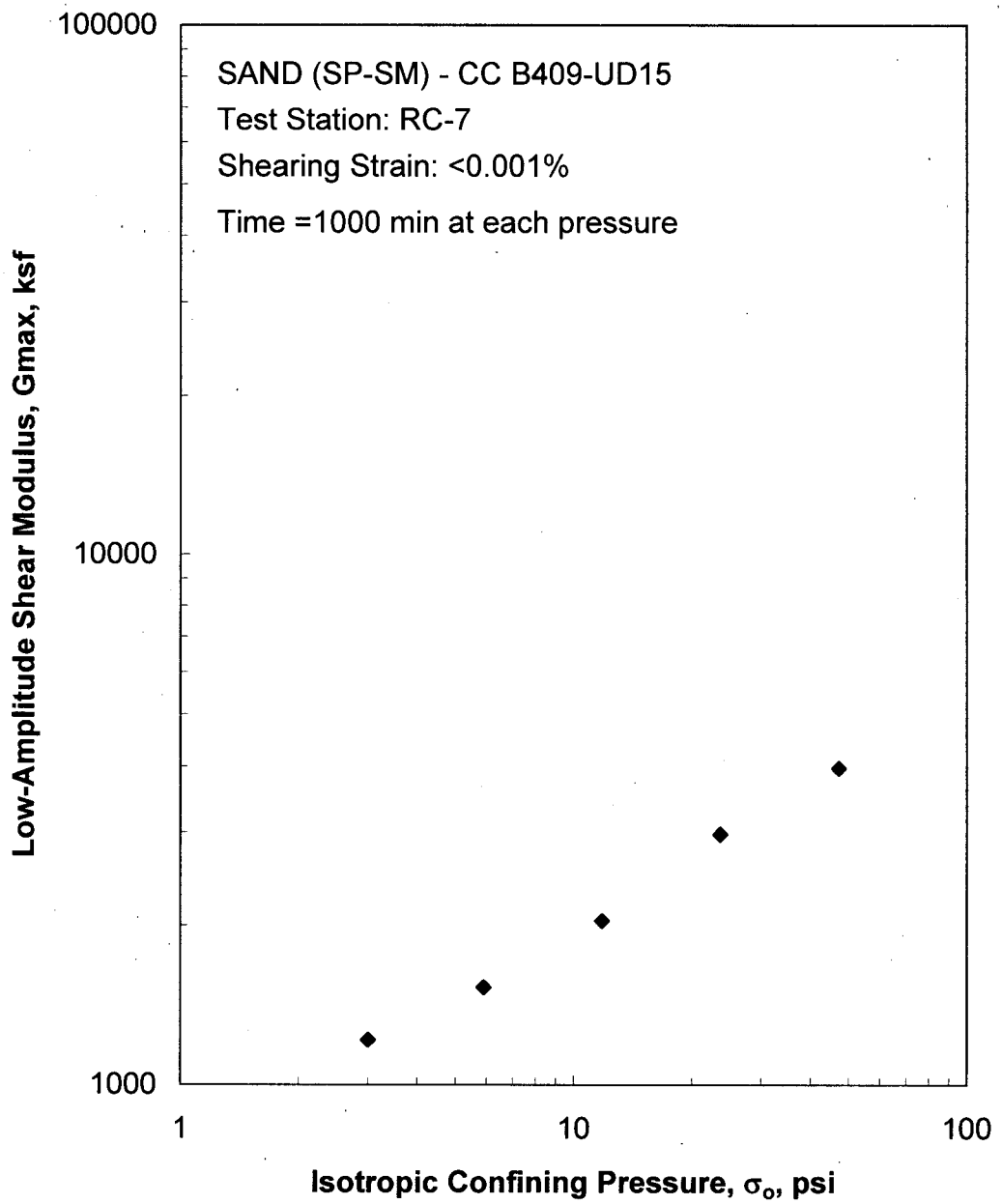


Figure J.5 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Tests

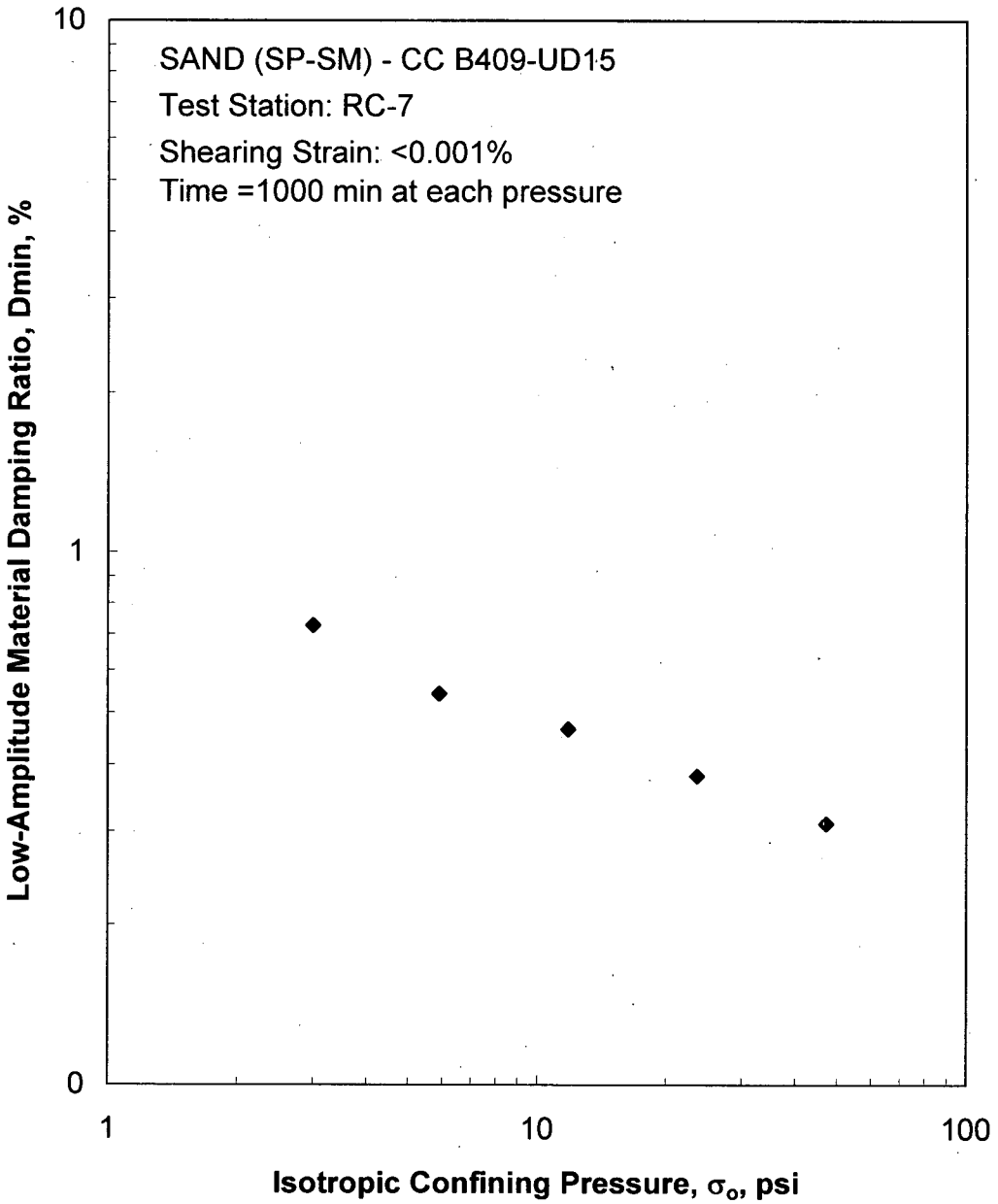


Figure J.6 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests

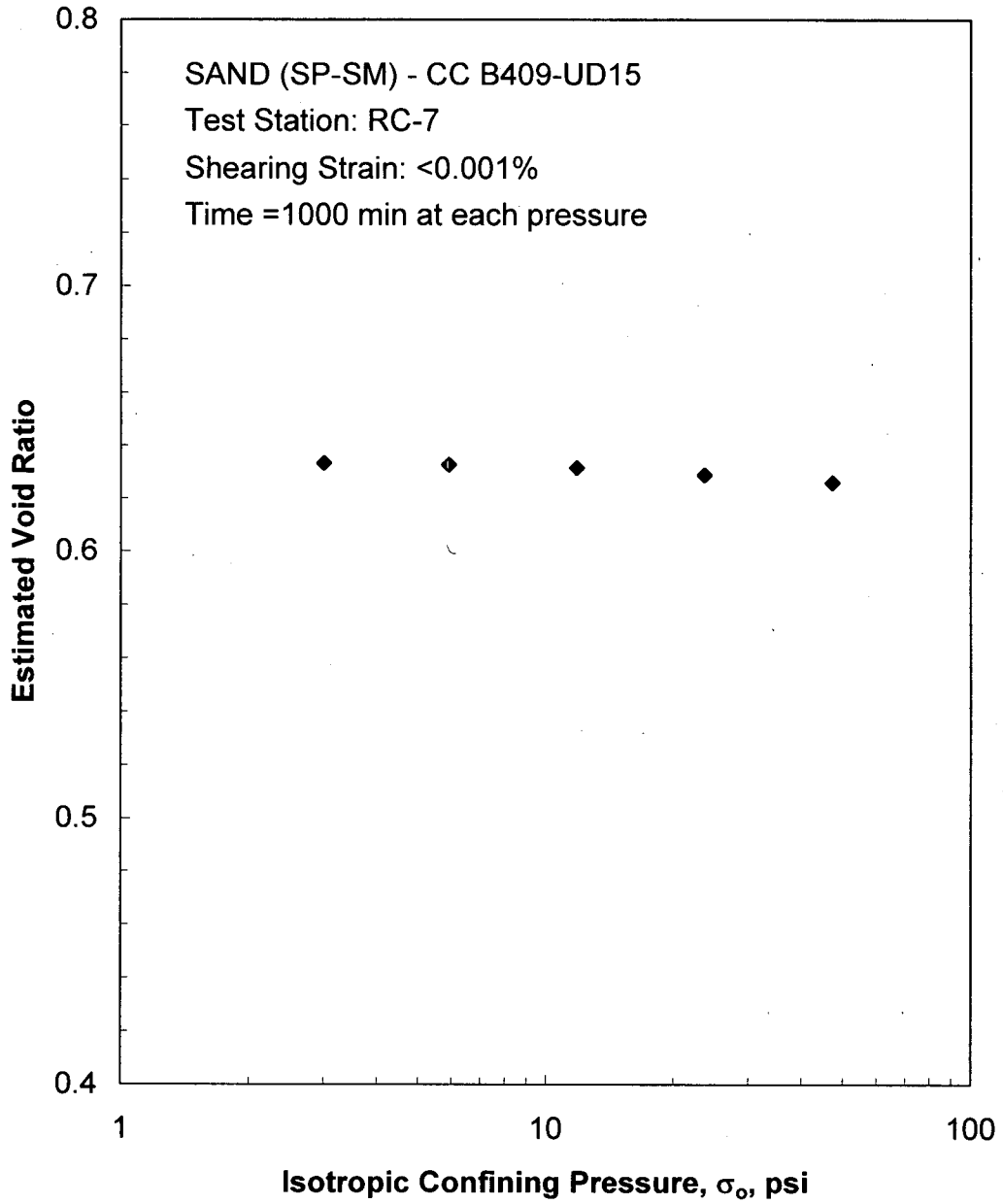


Figure J.7 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests

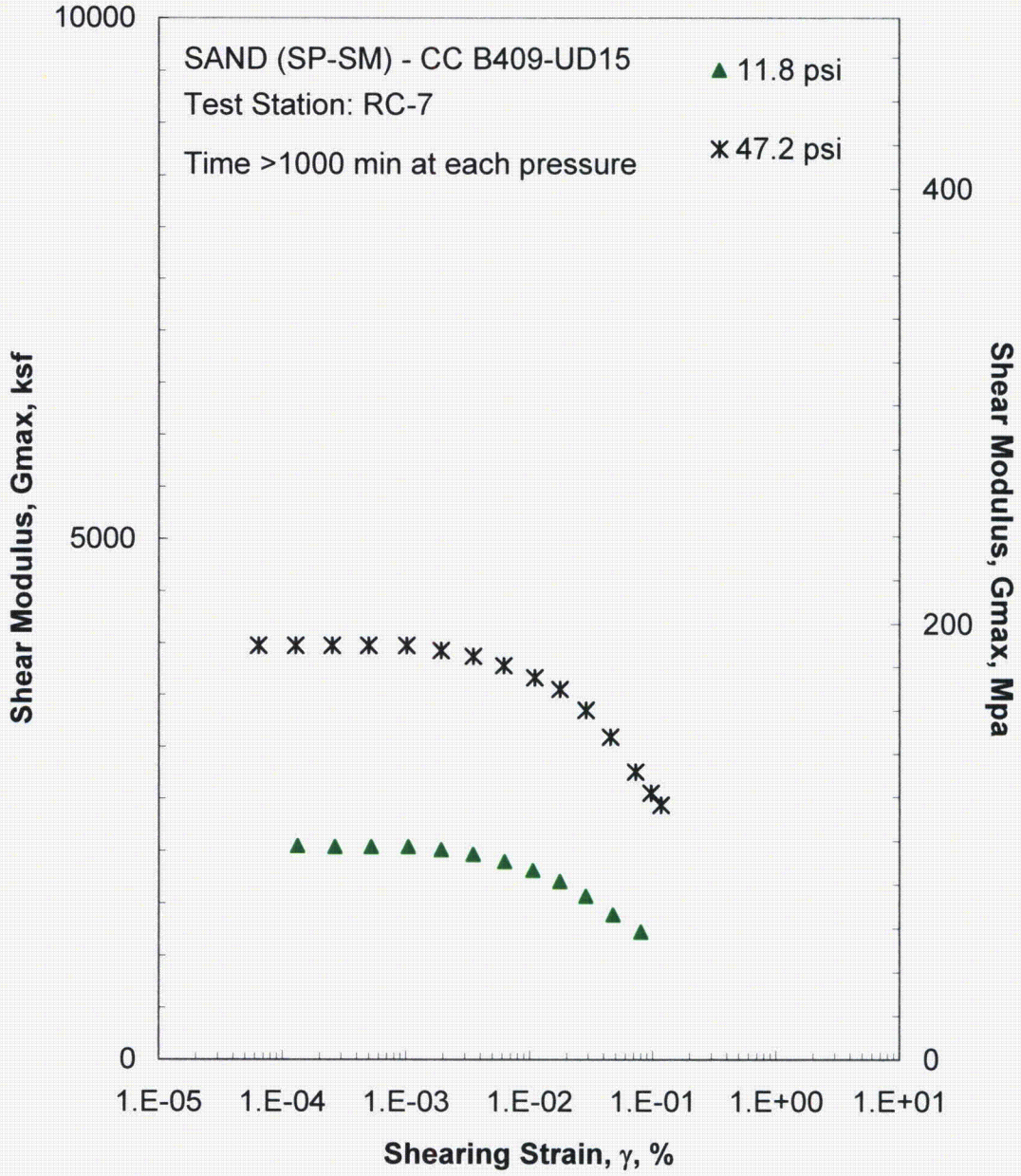


Figure J.8 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

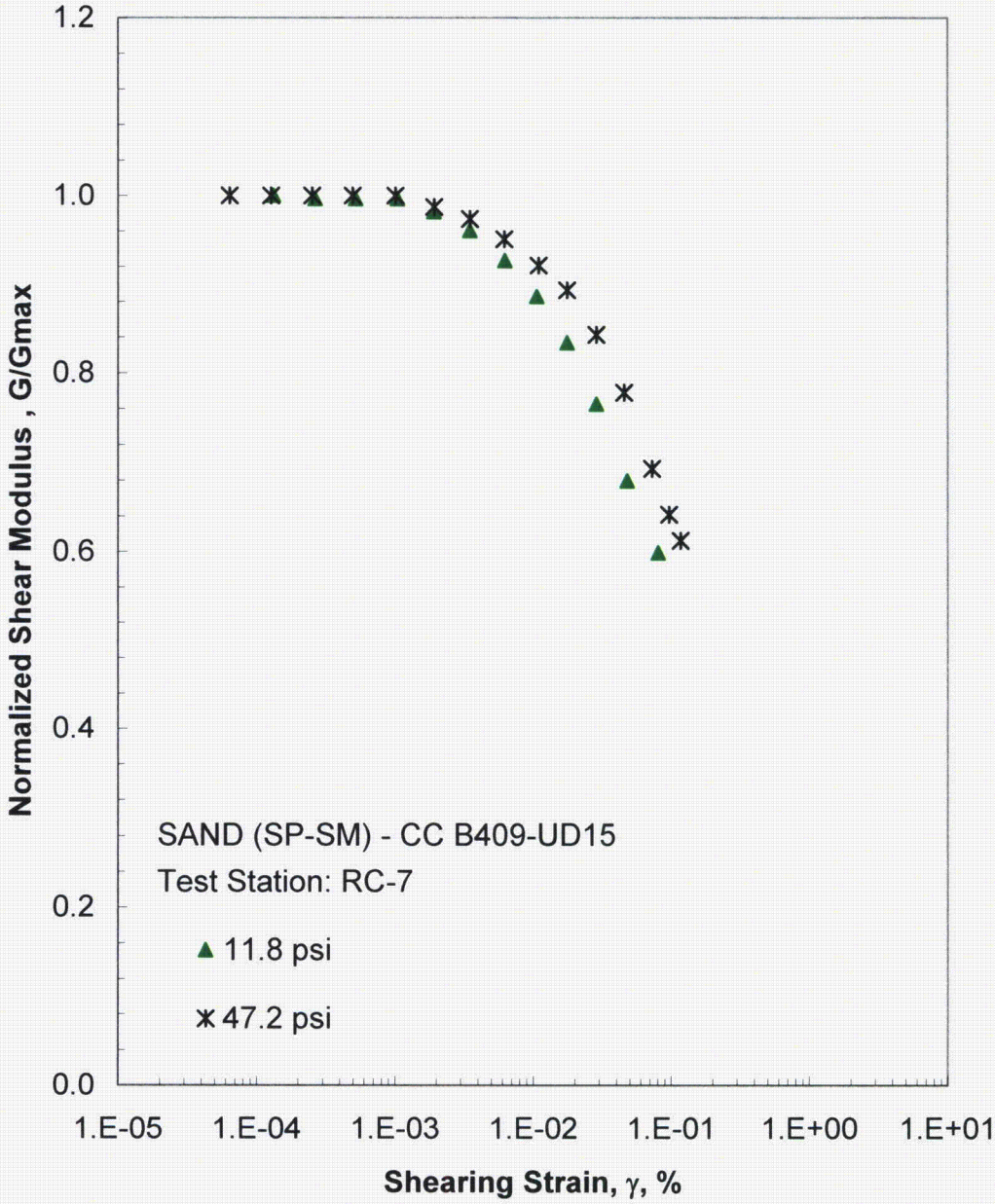


Figure I.9 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

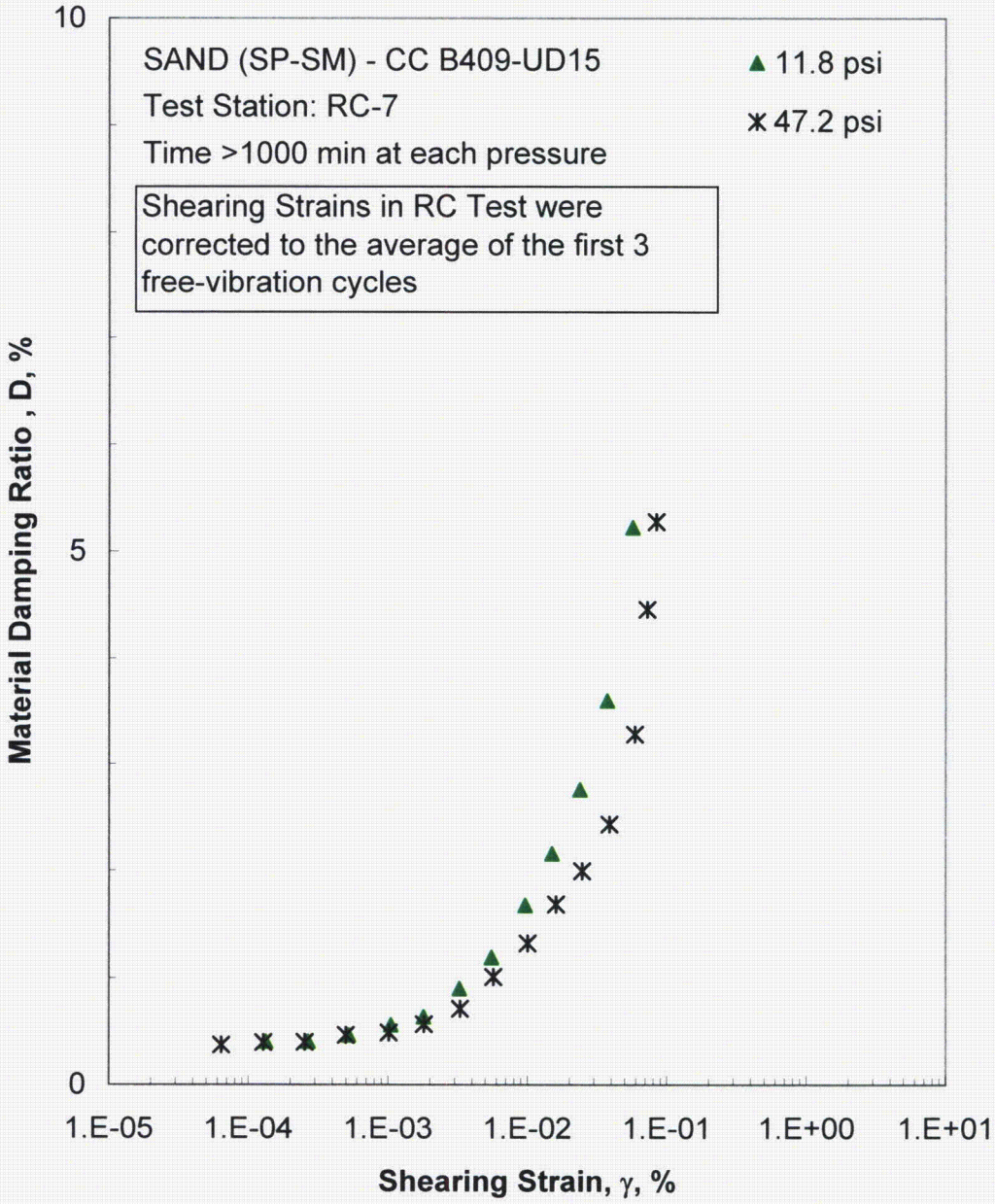


Figure J.10 Comparison of the Variation in Material Damping Ratio with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

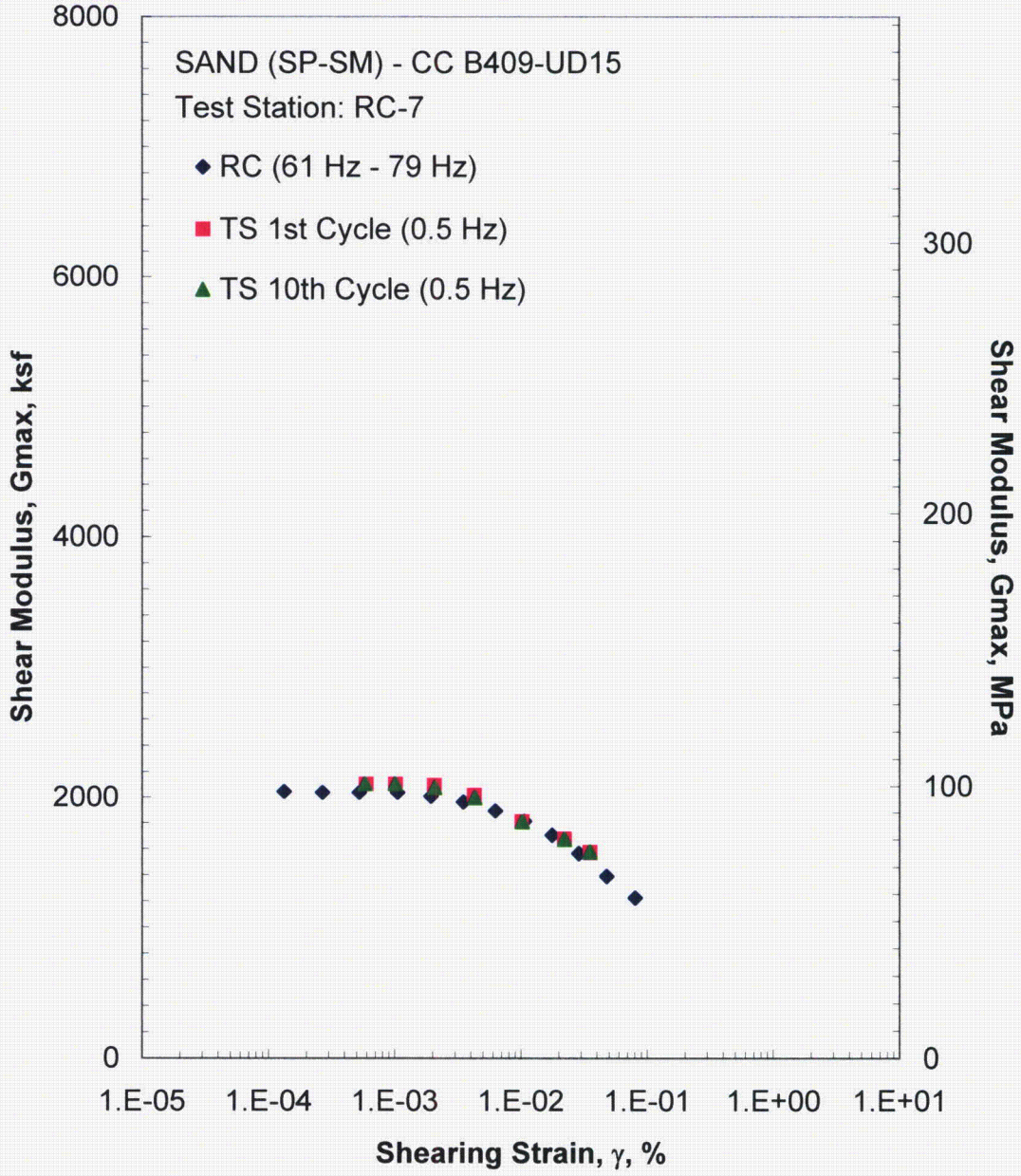


Figure J.11 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 11.8 psi from the Combined RCTS Tests

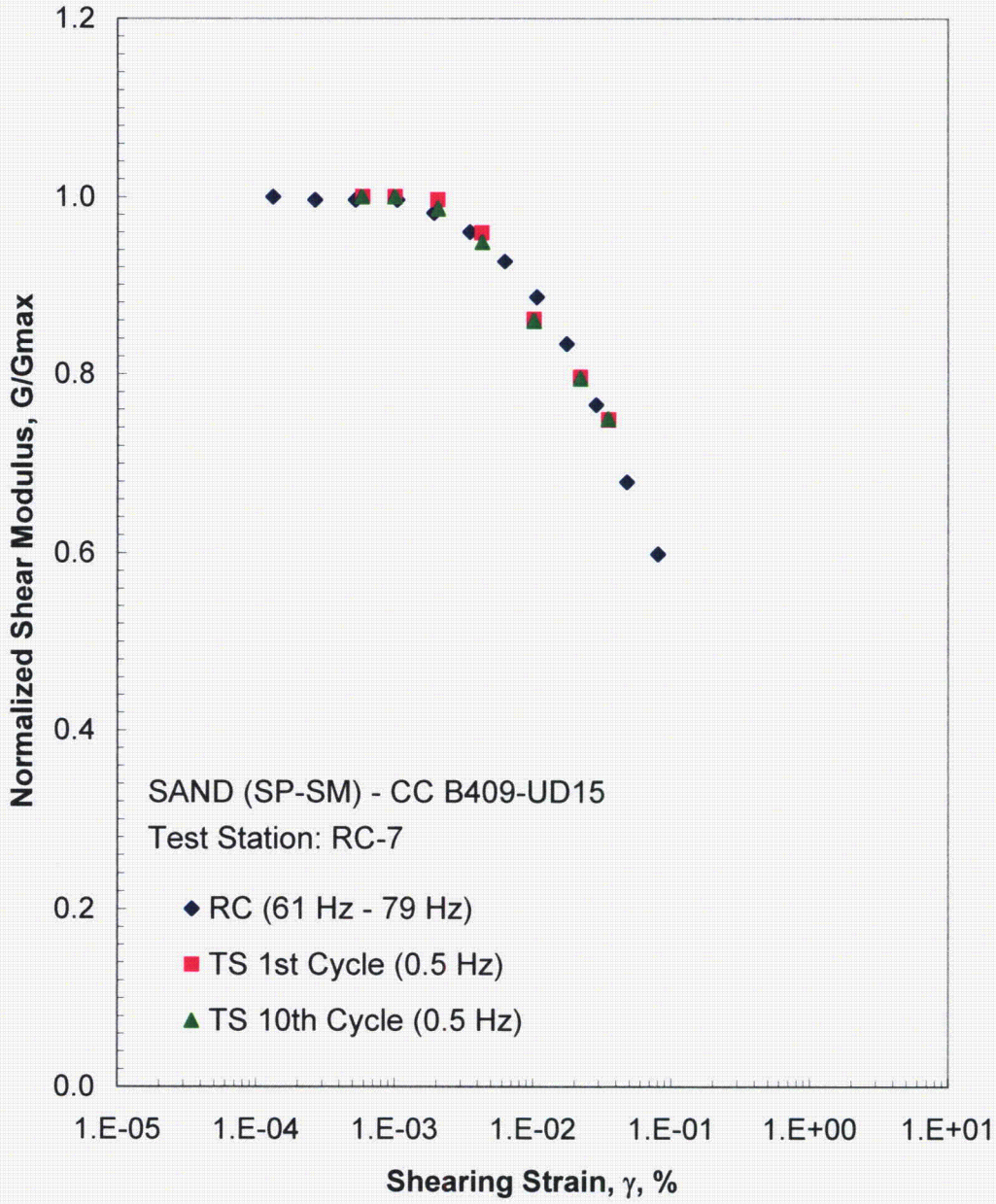


Figure J.12 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 11.8 psi from the Combined RCTS Tests

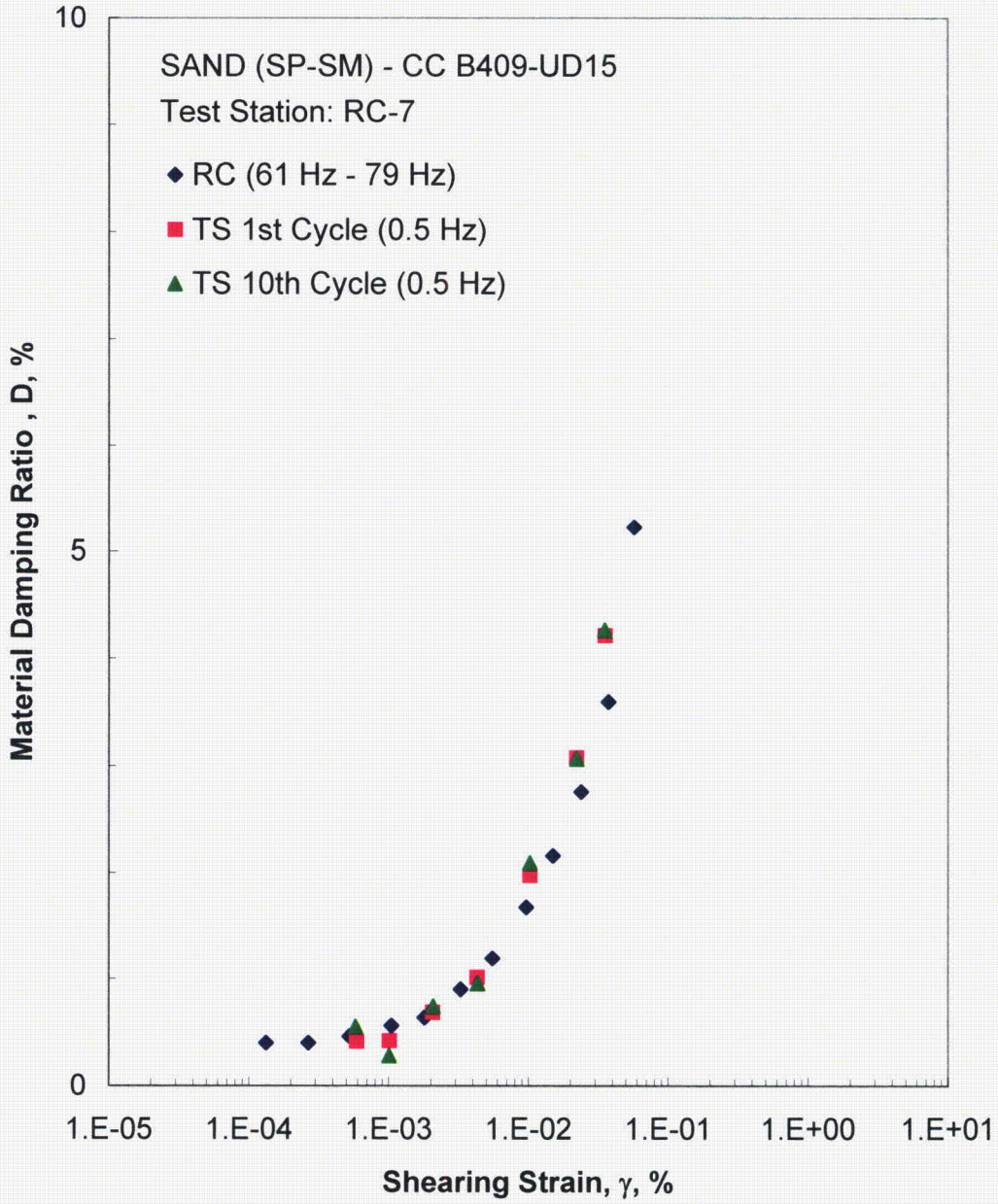


Figure J.13 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 11.8 psi from the Combined RCTS Tests

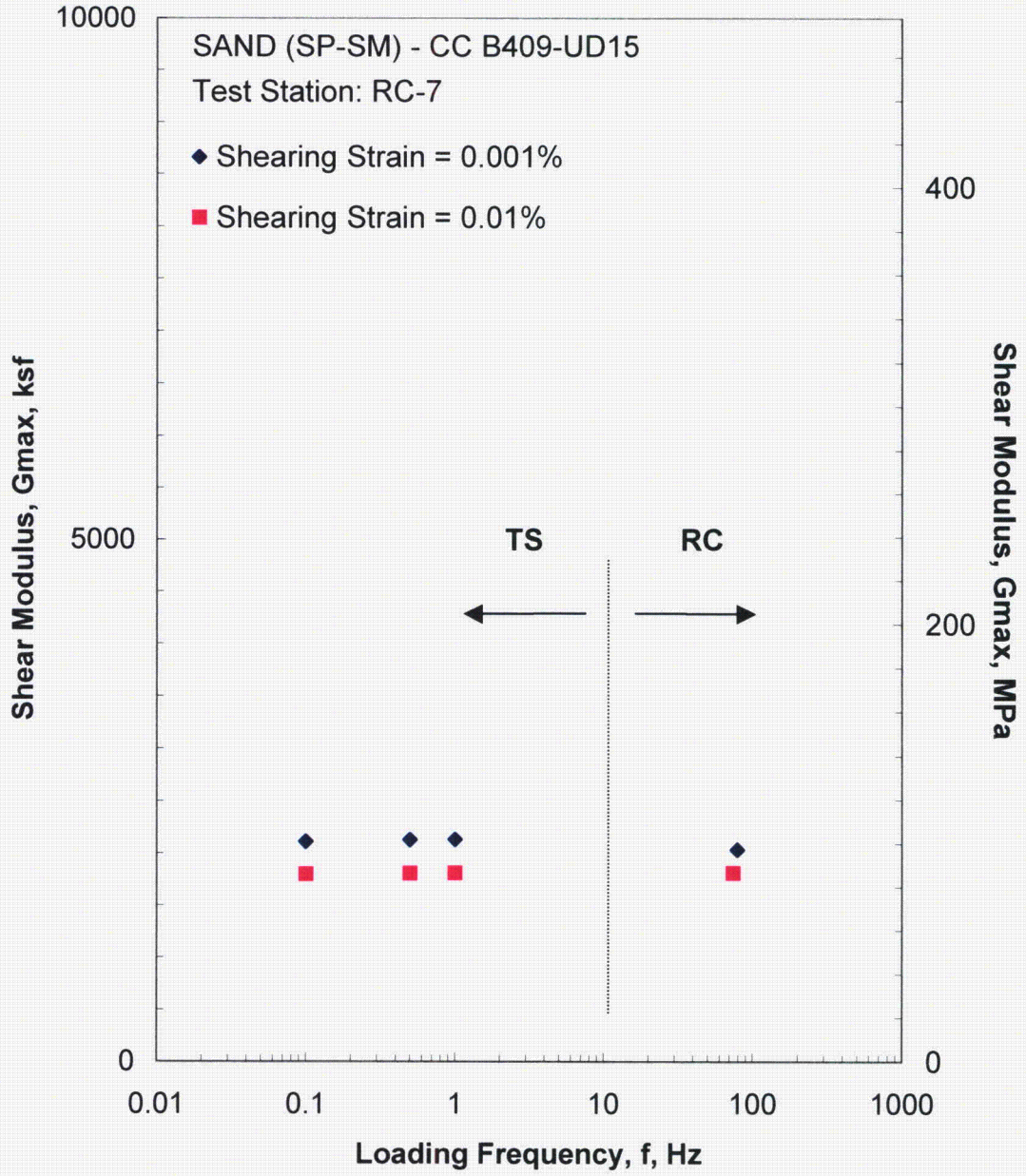


Figure J.14 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 11.8 psi from the Combined RCTS Tests

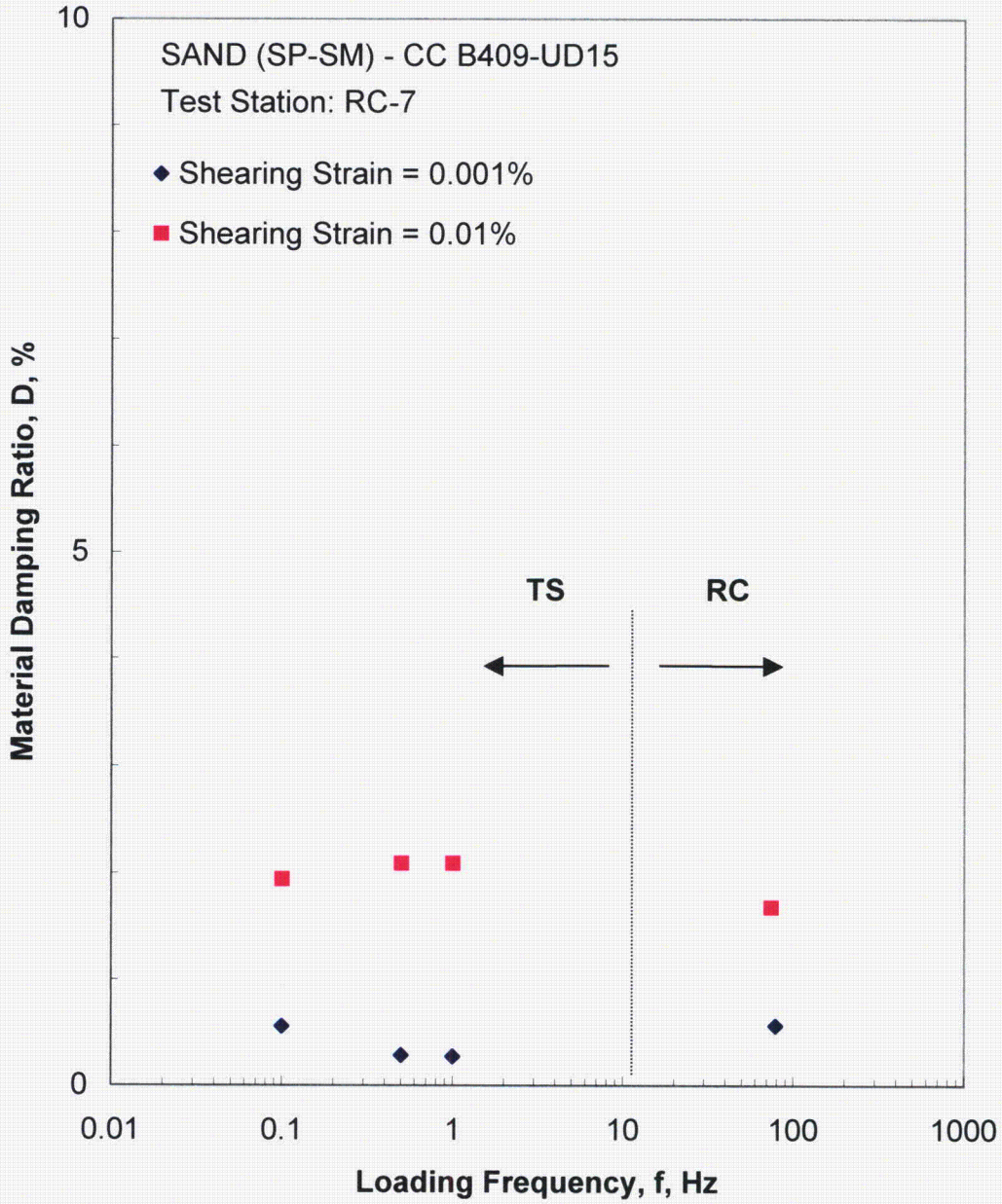


Figure J.15 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 11.8 psi from the Combined RCTS Tests

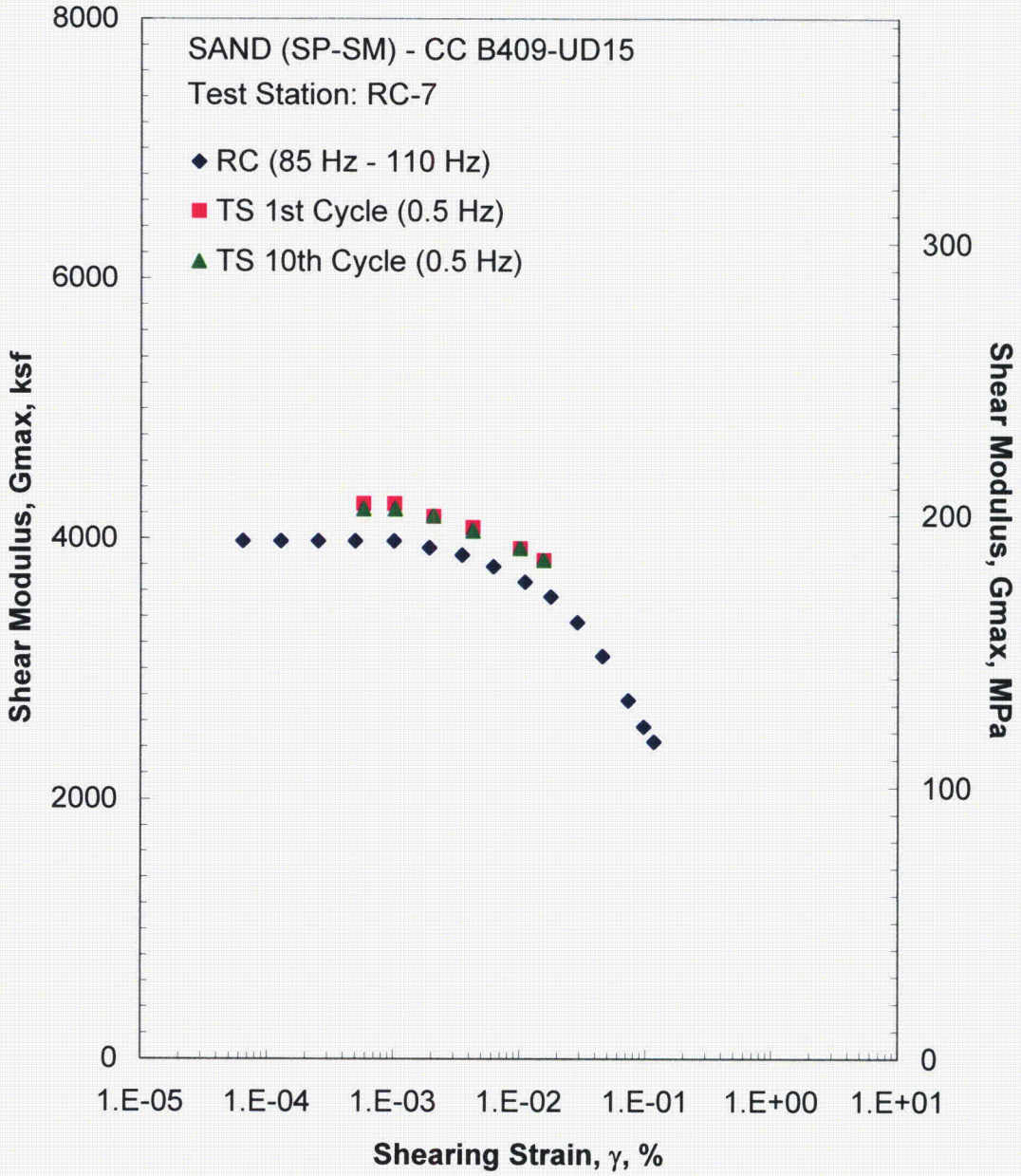


Figure J.16 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 47.2 psi from the Combined RCTS Tests

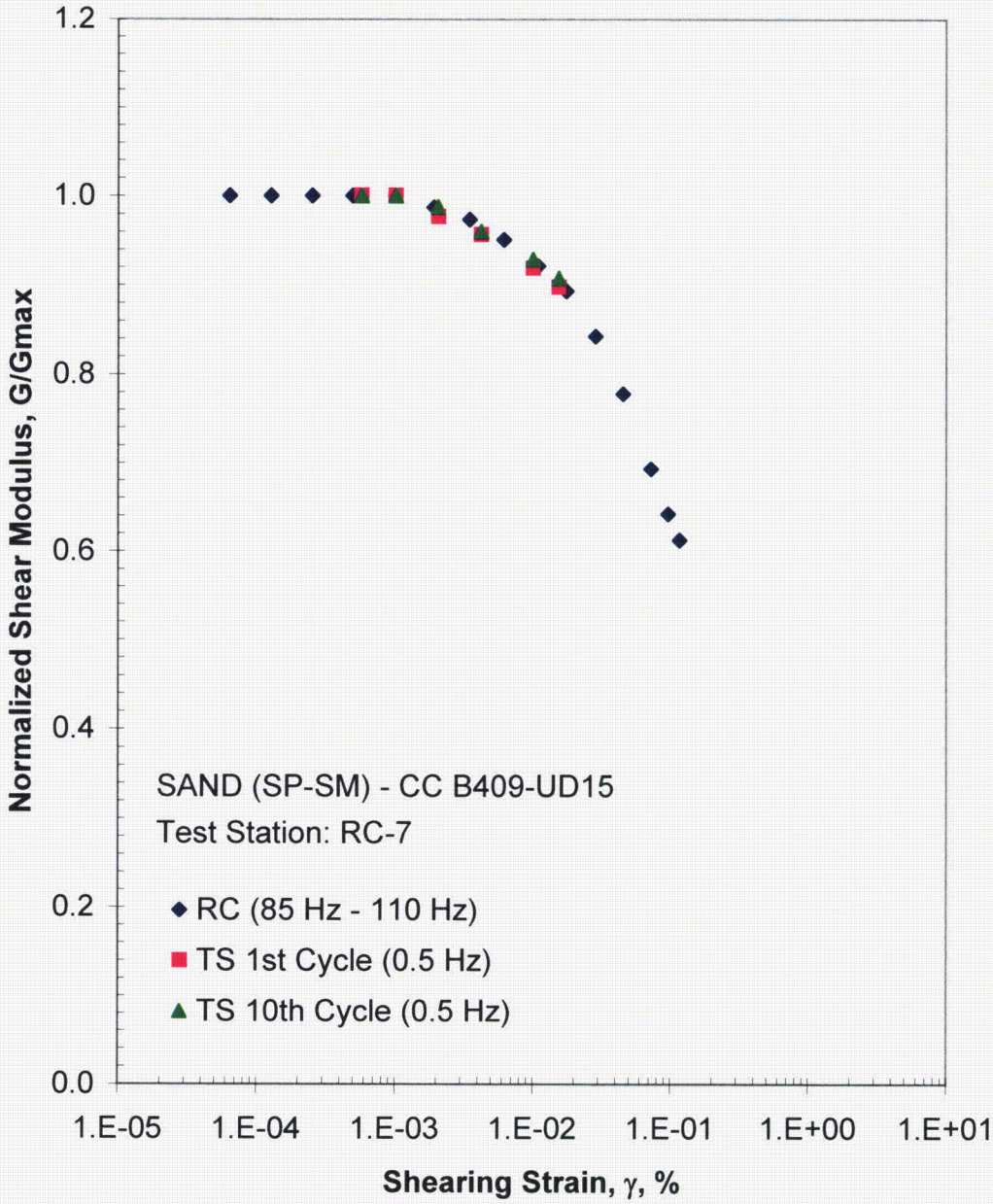


Figure J.17 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 47.2 psi from the Combined RCTS Tests

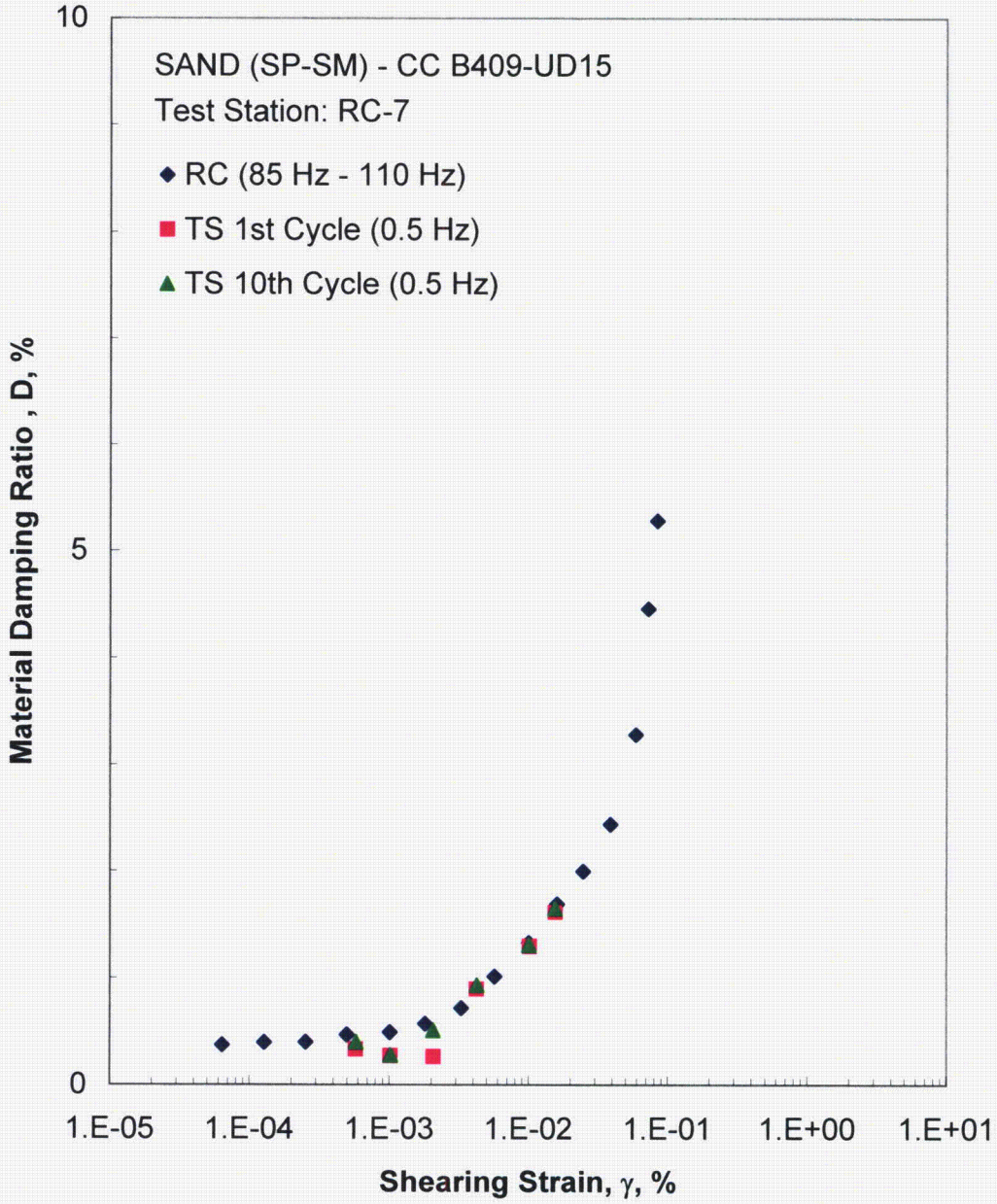


Figure J.18 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 47.2 psi from the Combined RCTS Tests

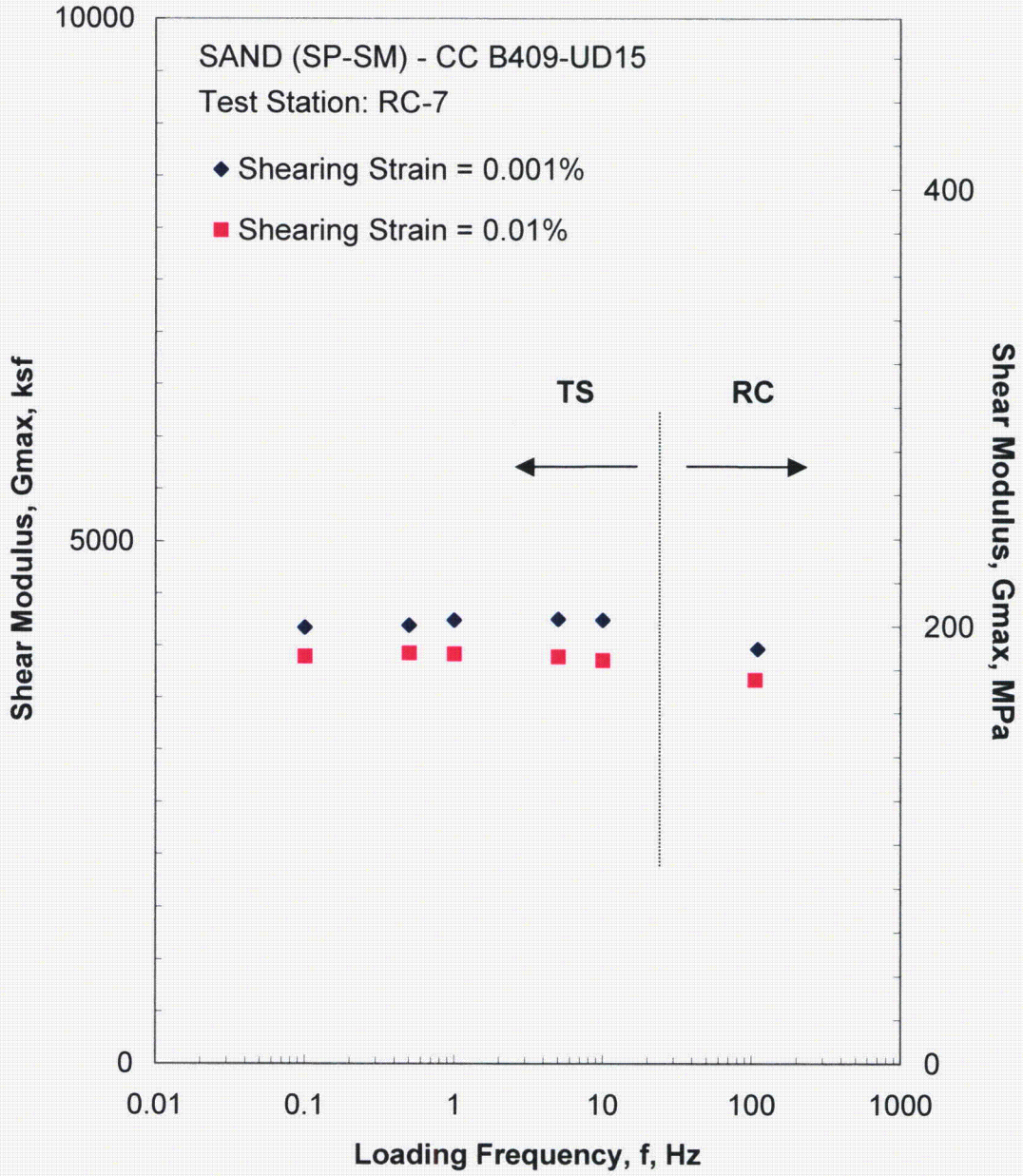


Figure J.19 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 47.2 psi from the Combined RCTS Tests

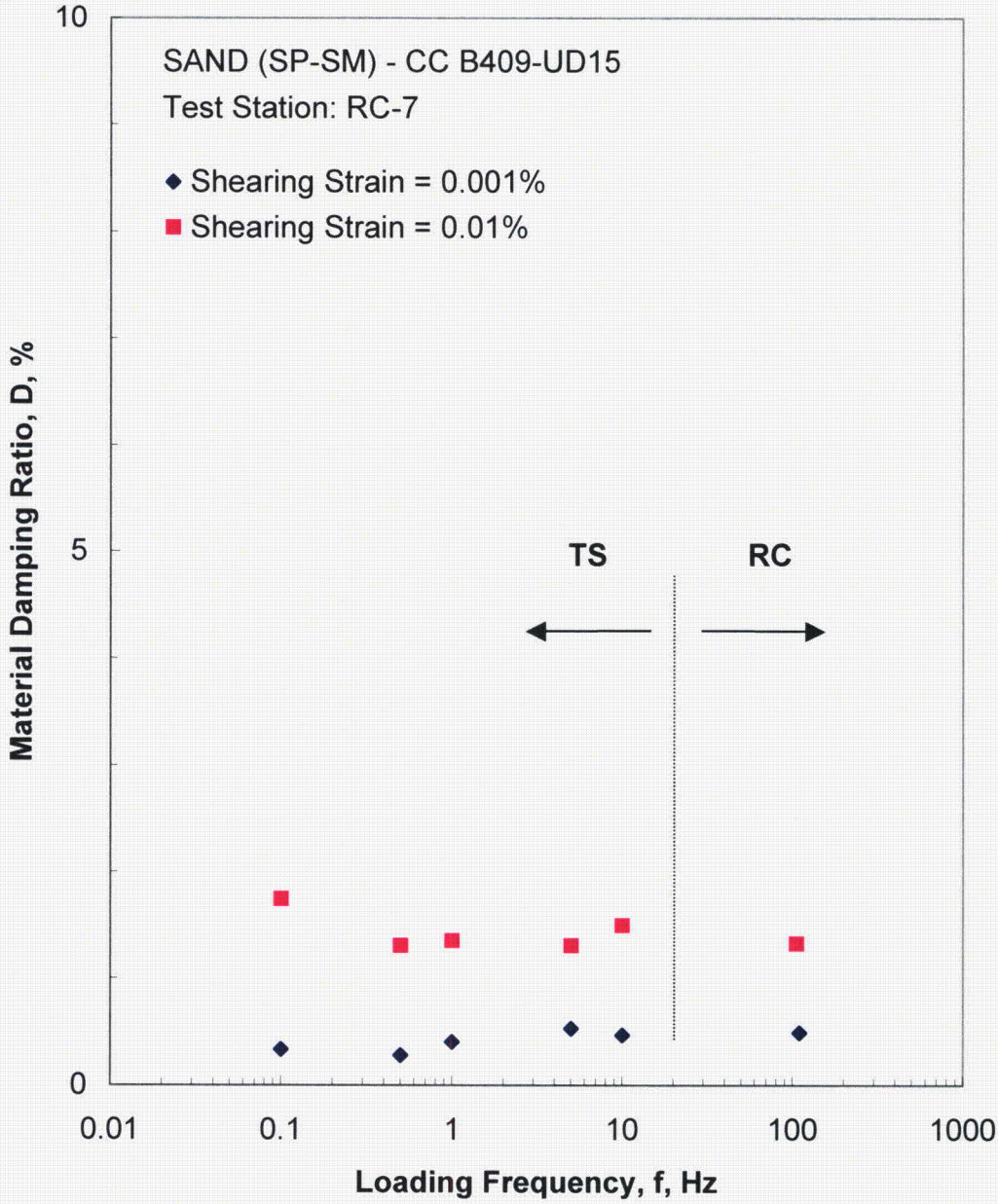


Figure J.20 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 47.2 psi from the Combined RCTS Tests

Table J.1 Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Estimated Void Ratio with Isotropic Confining Pressure from RC Tests of Specimen CC B409-UD15

Isotropic Confining Pressure, σ_o			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin	Estimated Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	(%)	
3.0	432	21	1213	58	559	0.73	0.633
5.9	850	41	1527	73	627	0.54	0.633
11.8	1699	81	2039	98	724	0.47	0.631
23.6	3398	163	2972	143	874	0.38	0.629
47.2	6797	325	3962	190	1008	0.31	0.626

Table J.2 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen CC B409-UD15; Isoptropic Confining Pressure, σ_o=11.8 psi (1.7 ksf = 81 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
1.33E-04	2044	1.00	1.33E-04	0.40
2.67E-04	2036	1.00	2.67E-04	0.40
5.23E-04	2036	1.00	5.23E-04	0.46
1.05E-03	2036	1.00	1.05E-03	0.56
1.93E-03	2006	0.98	1.79E-03	0.63
3.50E-03	1962	0.96	3.26E-03	0.90
6.25E-03	1893	0.93	5.50E-03	1.19
1.06E-02	1810	0.89	9.58E-03	1.67
1.75E-02	1703	0.83	1.49E-02	2.16
2.86E-02	1563	0.76	2.38E-02	2.76
4.77E-02	1388	0.68	3.72E-02	3.60
8.01E-02	1223	0.60	5.69E-02	5.22

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table J.3 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen CC B409-UD15; Isotropic Confining Pressure, σ_o= 11.8 psi (1.7 ksf =81 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
5.89E-04	2101	1.00	0.41	5.81E-04	2104	1.00	0.55
1.01E-03	2101	1.00	0.42	1.01E-03	2104	1.00	0.28
2.05E-03	2094	1.00	0.68	2.07E-03	2075	0.99	0.74
4.27E-03	2015	0.96	1.01	4.31E-03	1995	0.95	0.95
1.02E-02	1809	0.86	1.97	1.02E-02	1807	0.86	2.09
2.20E-02	1673	0.80	3.08	2.21E-02	1671	0.79	3.07
3.52E-02	1572	0.75	4.21	3.51E-02	1576	0.75	4.26

Table J.4 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen CC B409-UD15; Isoptropic Confining Pressure, σ_o= 47.2 psi (6.8 ksf = 325 kPa)

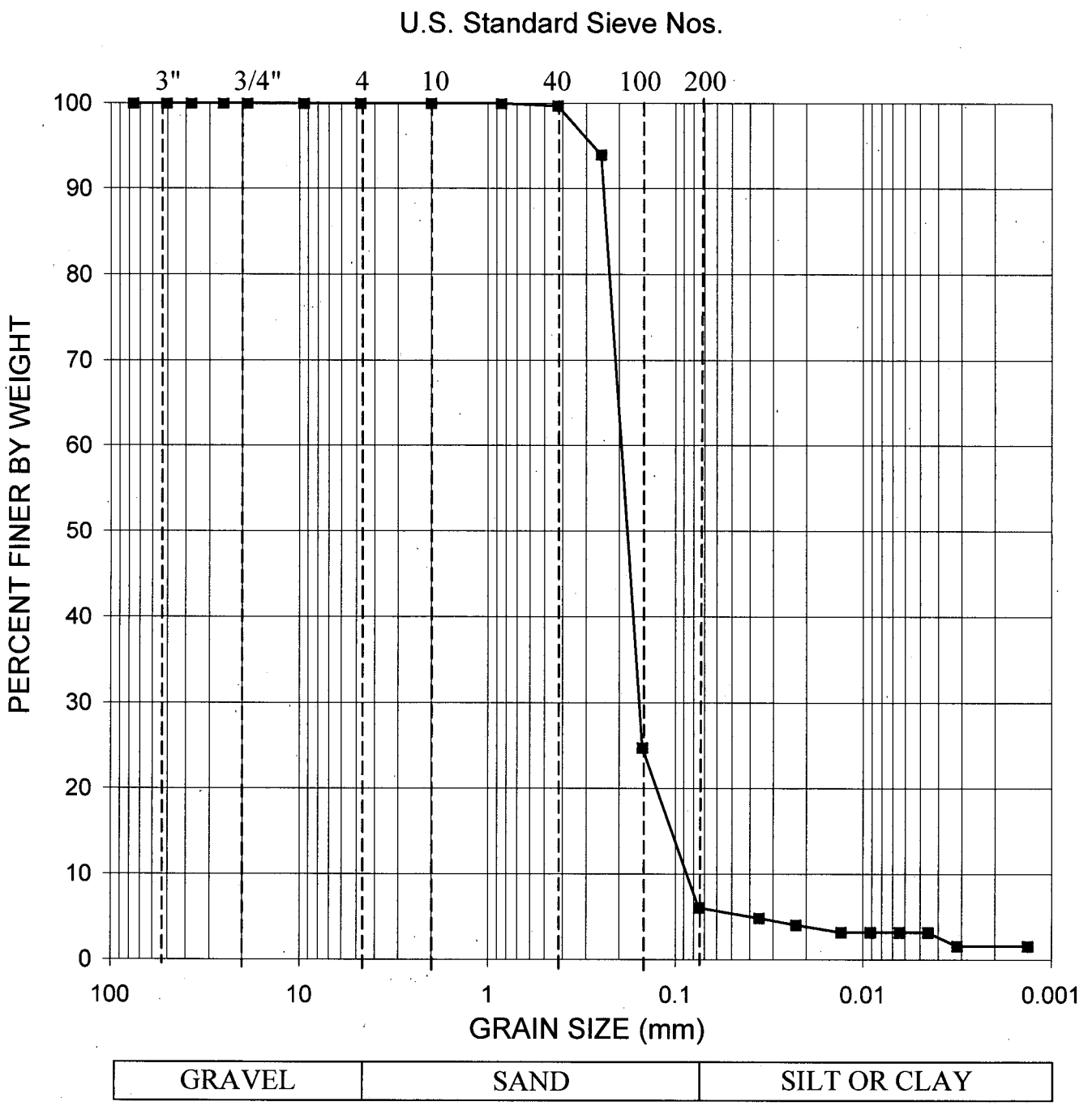
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
6.40E-05	3977	1.00	6.40E-05	0.37
1.28E-04	3977	1.00	1.28E-04	0.40
2.53E-04	3977	1.00	2.53E-04	0.40
4.97E-04	3977	1.00	4.97E-04	0.47
1.01E-03	3977	1.00	1.01E-03	0.49
1.92E-03	3926	0.99	1.81E-03	0.57
3.50E-03	3872	0.97	3.29E-03	0.71
6.17E-03	3782	0.95	5.68E-03	1.01
1.10E-02	3663	0.92	9.98E-03	1.32
1.76E-02	3550	0.89	1.60E-02	1.69
2.86E-02	3351	0.84	2.46E-02	1.99
4.54E-02	3093	0.78	3.85E-02	2.44
7.25E-02	2755	0.69	5.87E-02	3.28
9.65E-02	2551	0.64	7.24E-02	4.46
1.17E-01	2435	0.61	8.40E-02	5.28

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table J.5 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen CC B409-UD15; Isotropic Confining Pressure, σ_o=47.2 psi (6.8 ksf = 325 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
5.76E-04	4266	1.00	0.33	5.80E-04	4222	1.00	0.40
1.01E-03	4266	1.00	0.27	1.03E-03	4222	1.00	0.28
2.07E-03	4166	0.98	0.26	2.07E-03	4171	0.99	0.51
4.23E-03	4080	0.96	0.89	4.26E-03	4054	0.96	0.93
1.01E-02	3919	0.92	1.29	1.01E-02	3922	0.93	1.30
1.55E-02	3828	0.90	1.61	1.55E-02	3832	0.91	1.64



GRADATION CURVE

ASTM D422

Project:	Constellation Energy Group COLA Project, Calvert Cliffs NuclearPower Plant (CCNPP), Calvert County, Maryland		Contract No.:	06120048.00	Date:	9/21/2007
Boring No.	Depth (ft)	Sample Description	Class.	LL	PI	
B-409	35.0-36.1	POORLY GRADED SAND, with silt, gray	SP-SM	NP	NP	Schnabel Engineering

APPENDIX K

CC B404-UD22
SILTY SAND (SM), greenish gray*
(LL=53, PL=28, PI=25; Gs=2.63)*

Borehole B-404
Sample UD22
Sample Depth = 83.5 to 85.1 ft
RCTS Test Depth = 84.0 ft
Total Unit Weight = 115.4 lb/ft^3
Water Content = 32.2 %
Estimated In-Situ Ko = 0.5*
Estimated In-Situ Mean Effective Stress = 30.3 psi*

*Data supplied by Schnabel Engineering, Inc.

FUGRO JOB #: 0401-1661
Testing Station: RC7

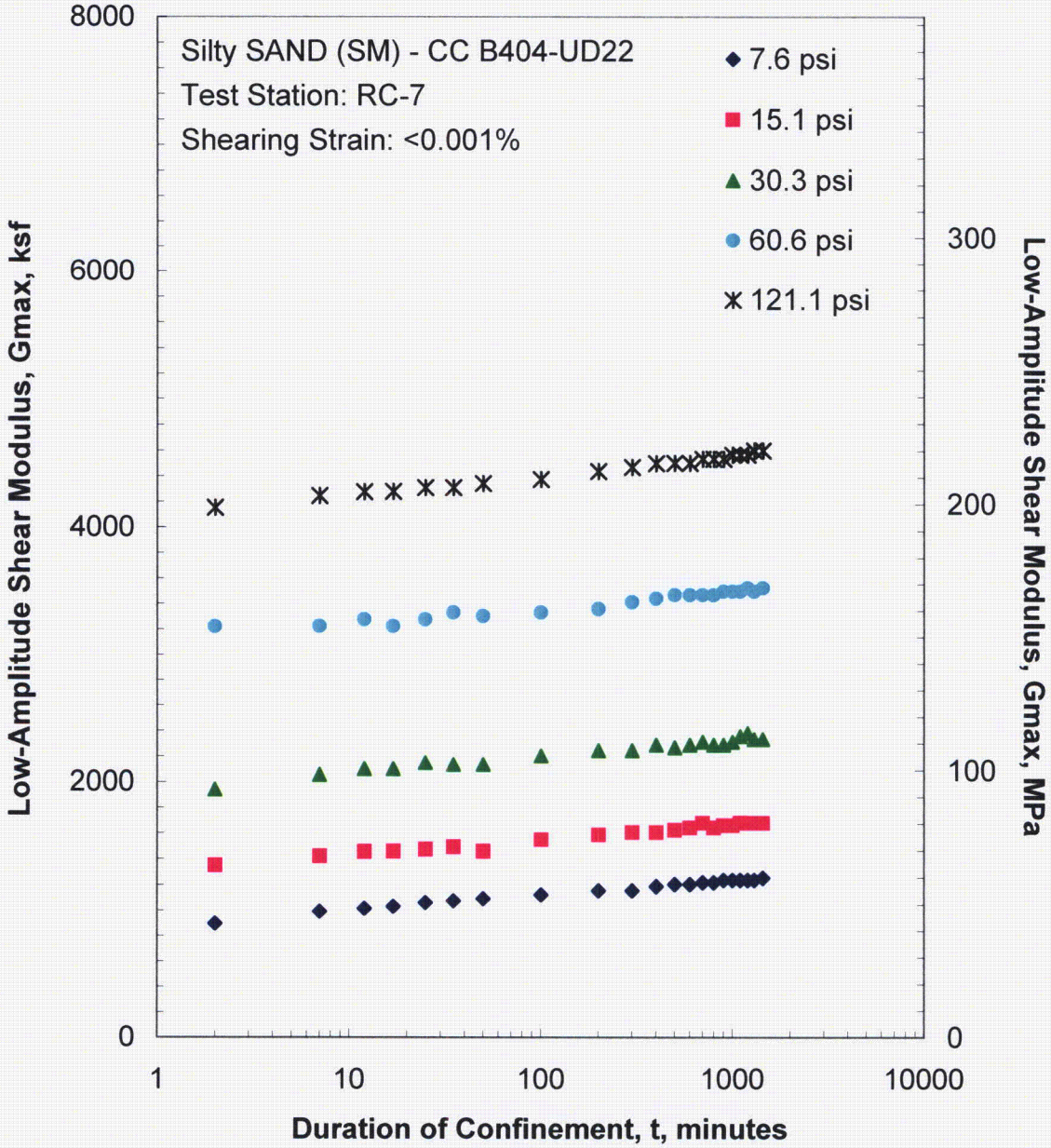


Figure K.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

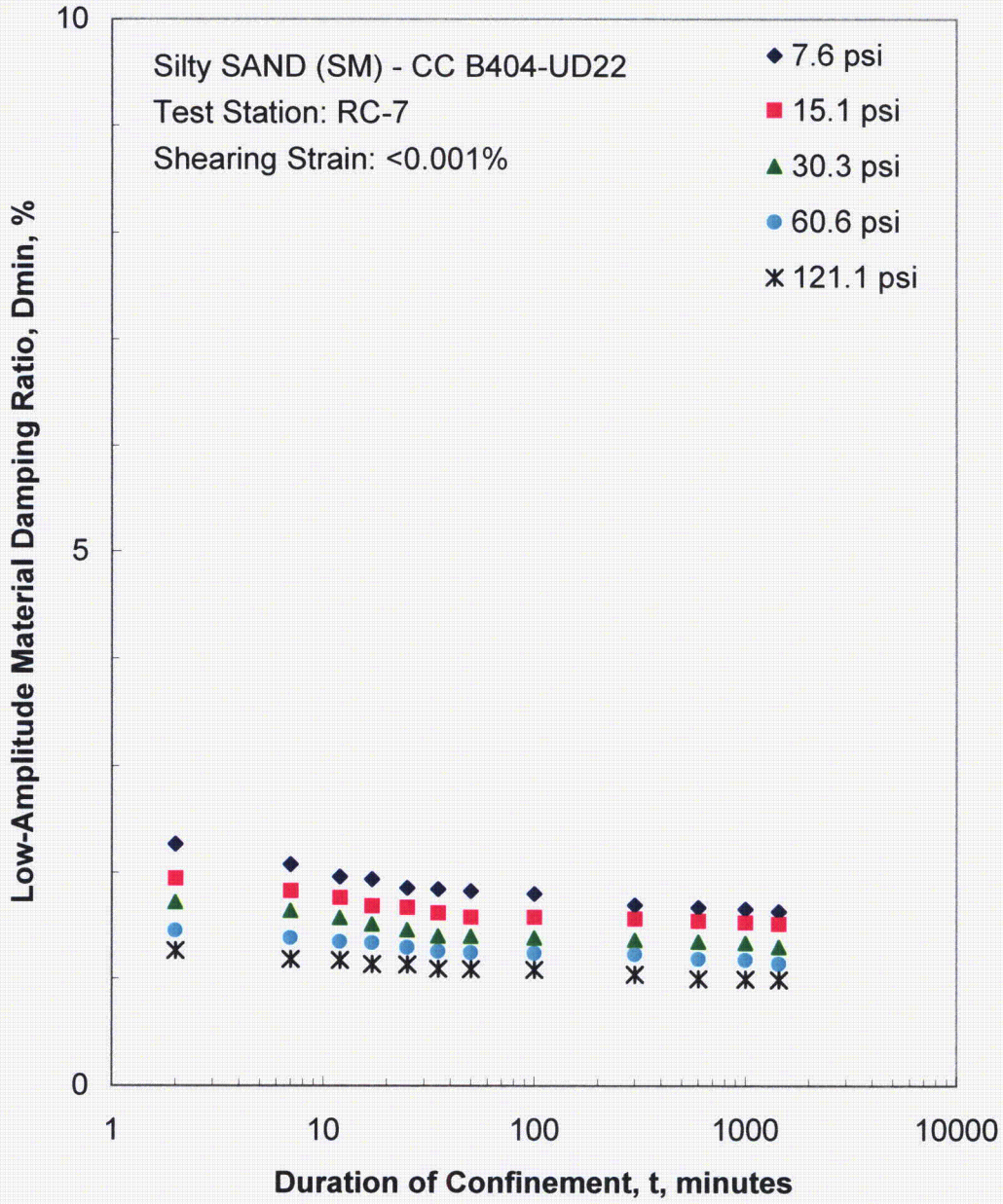


Figure K.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

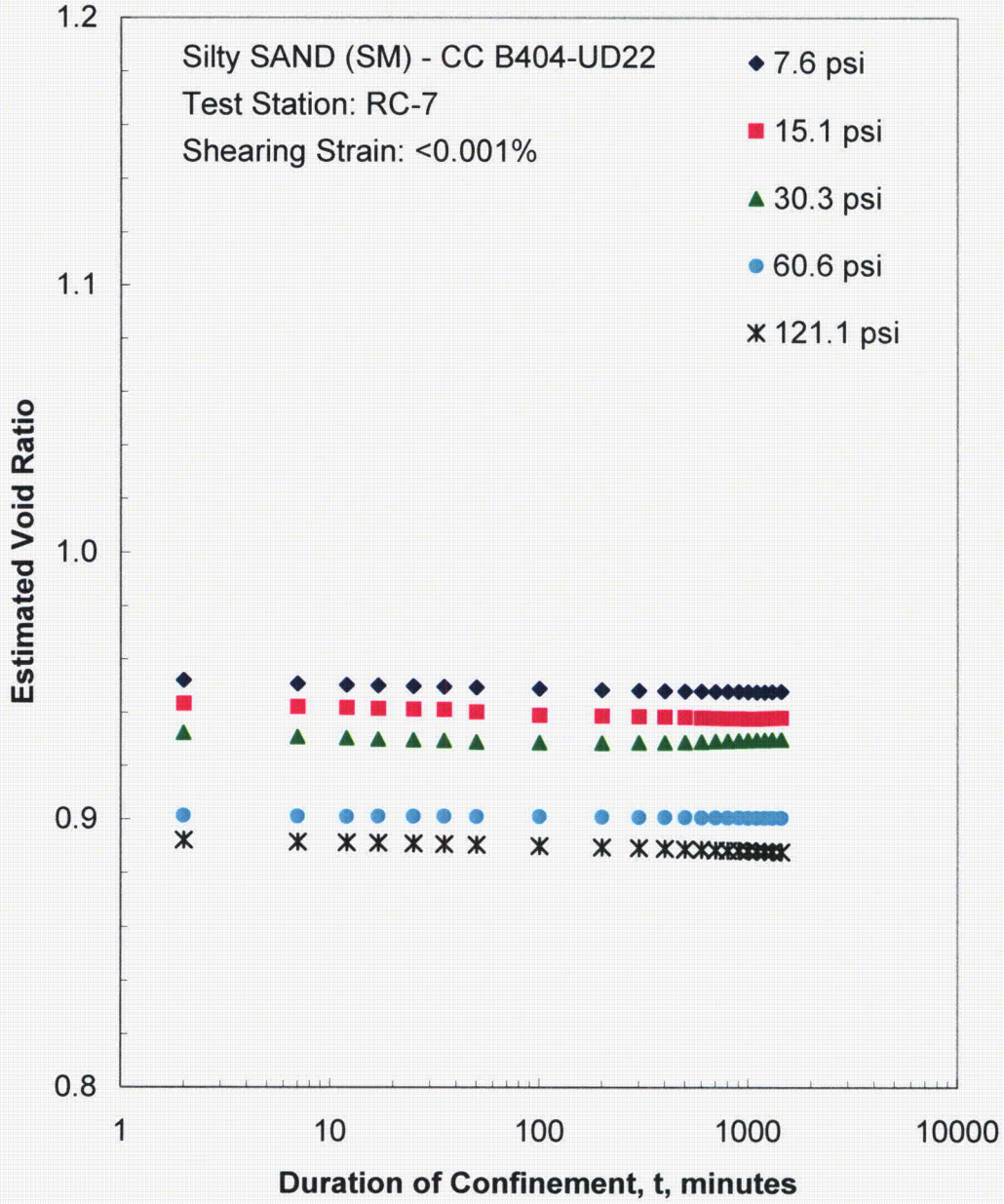


Figure K.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

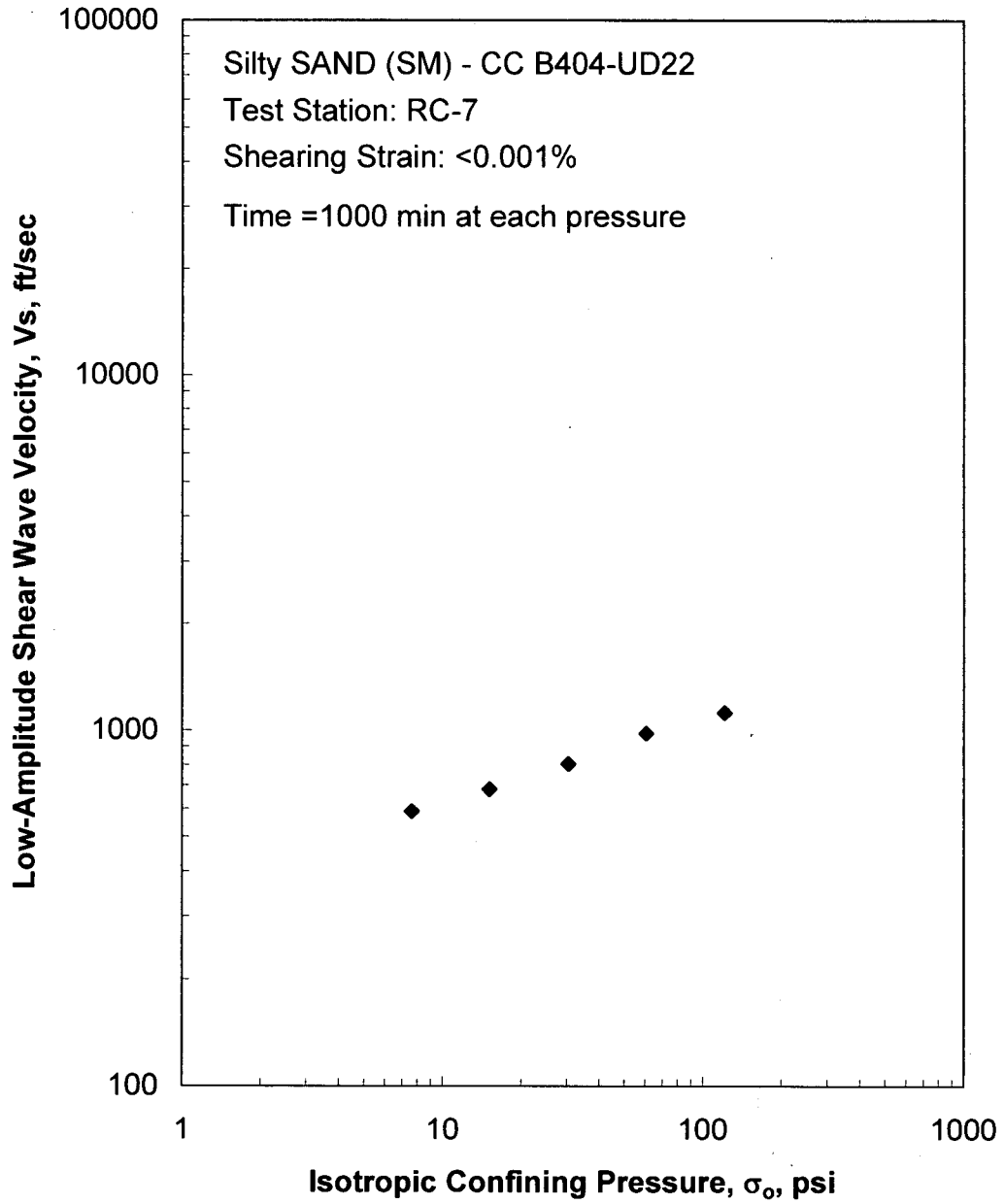


Figure K.4 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests

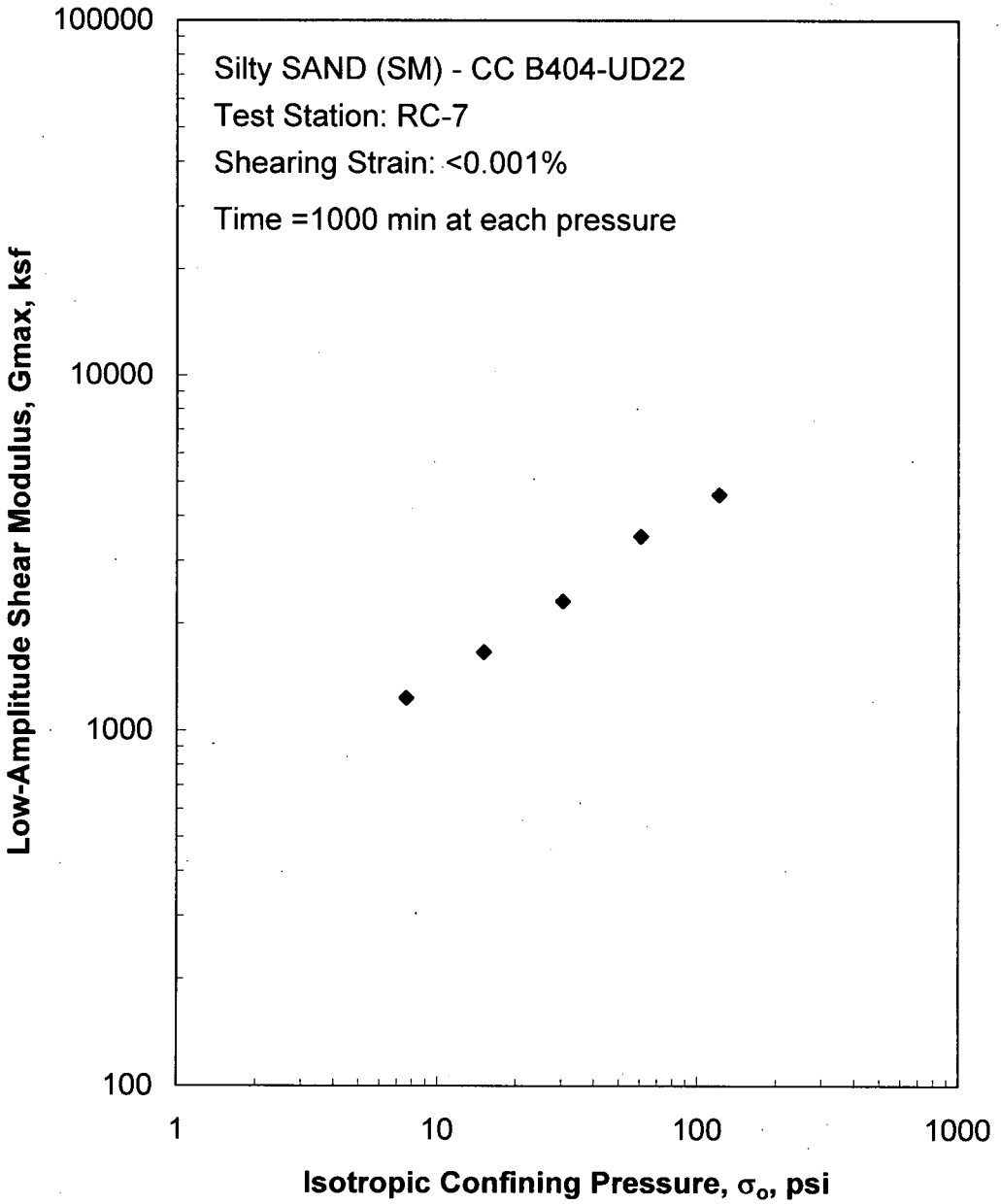


Figure K.5 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Tests

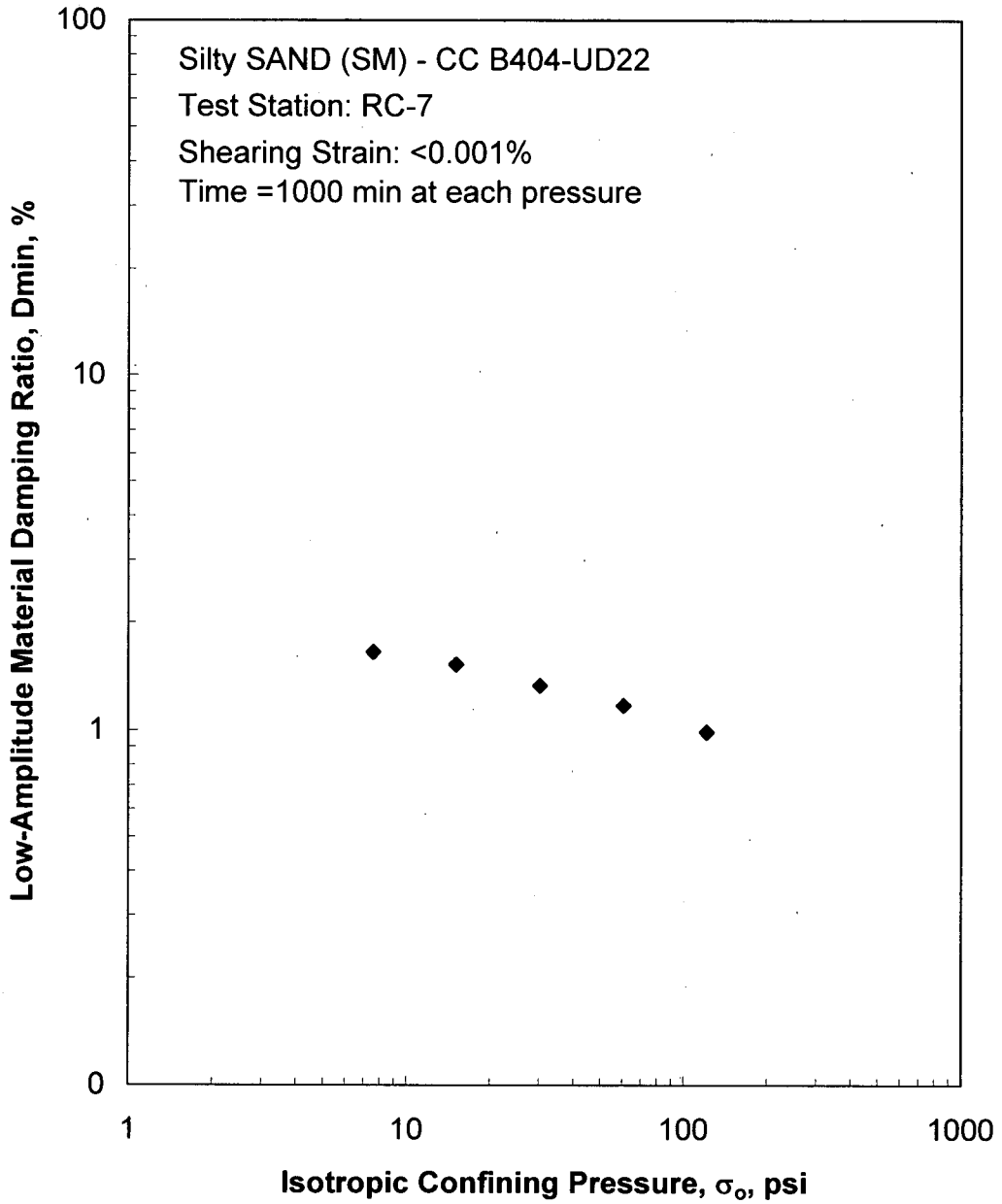


Figure K.6 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests

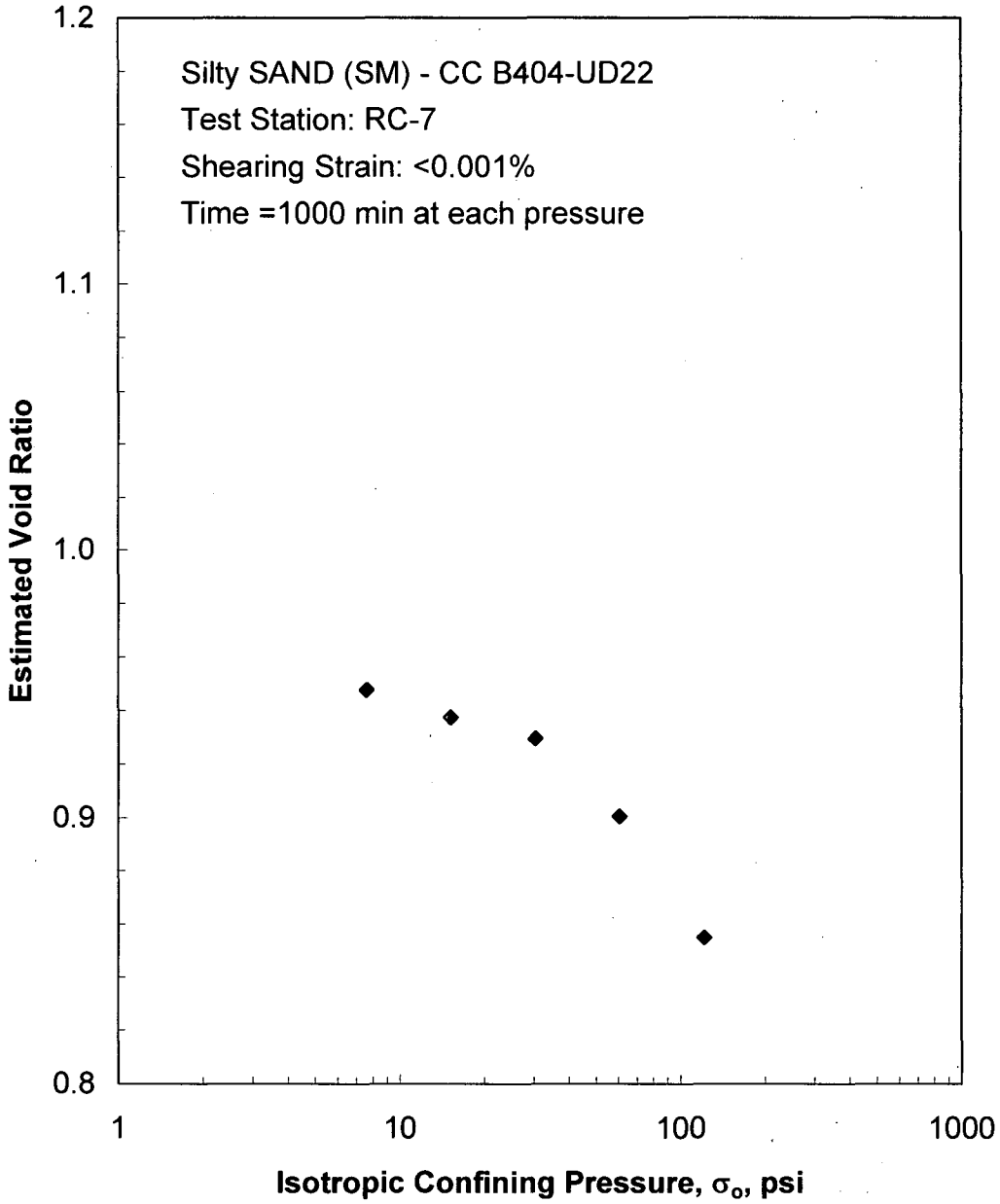


Figure K.7 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests

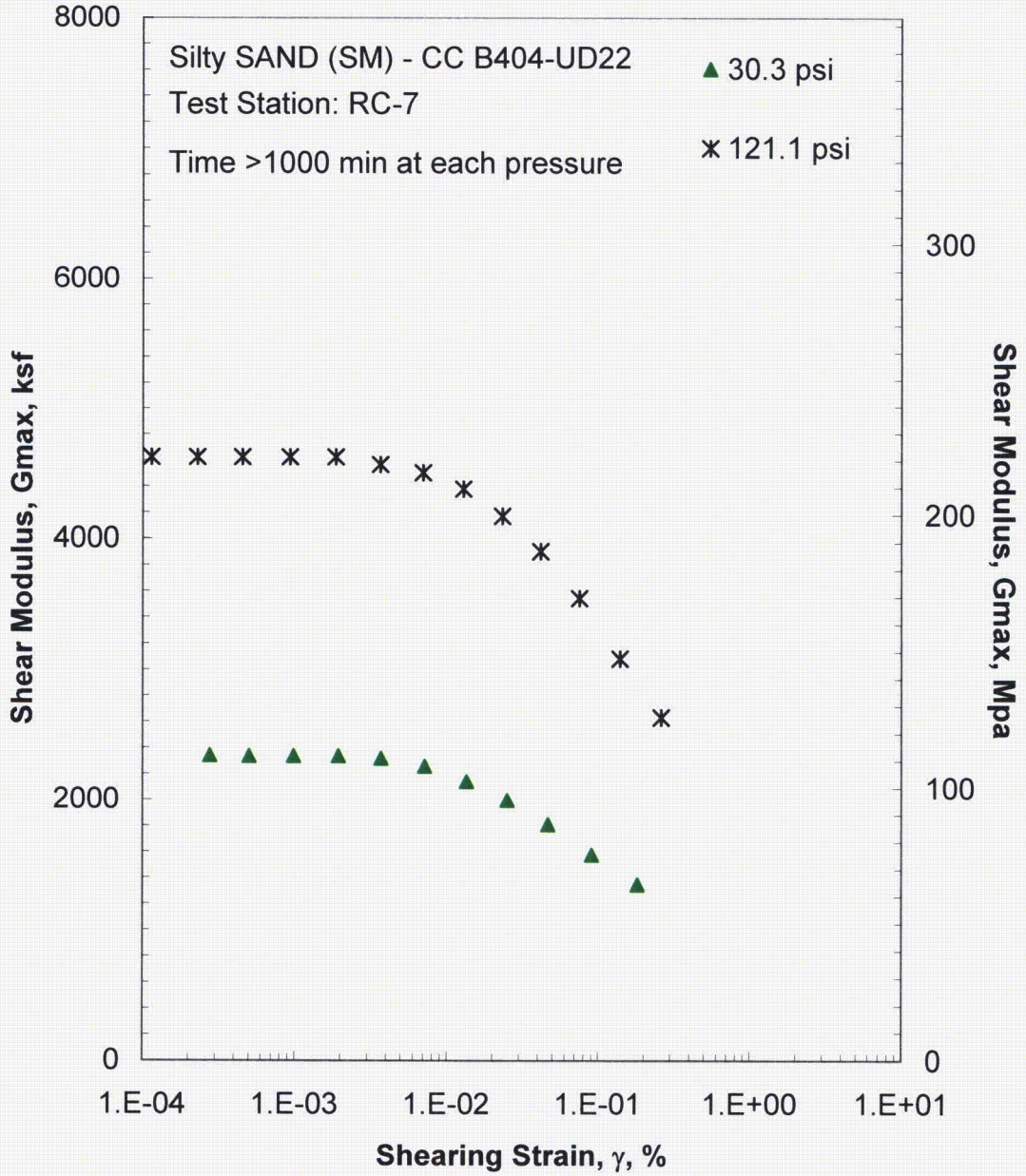


Figure K.8 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

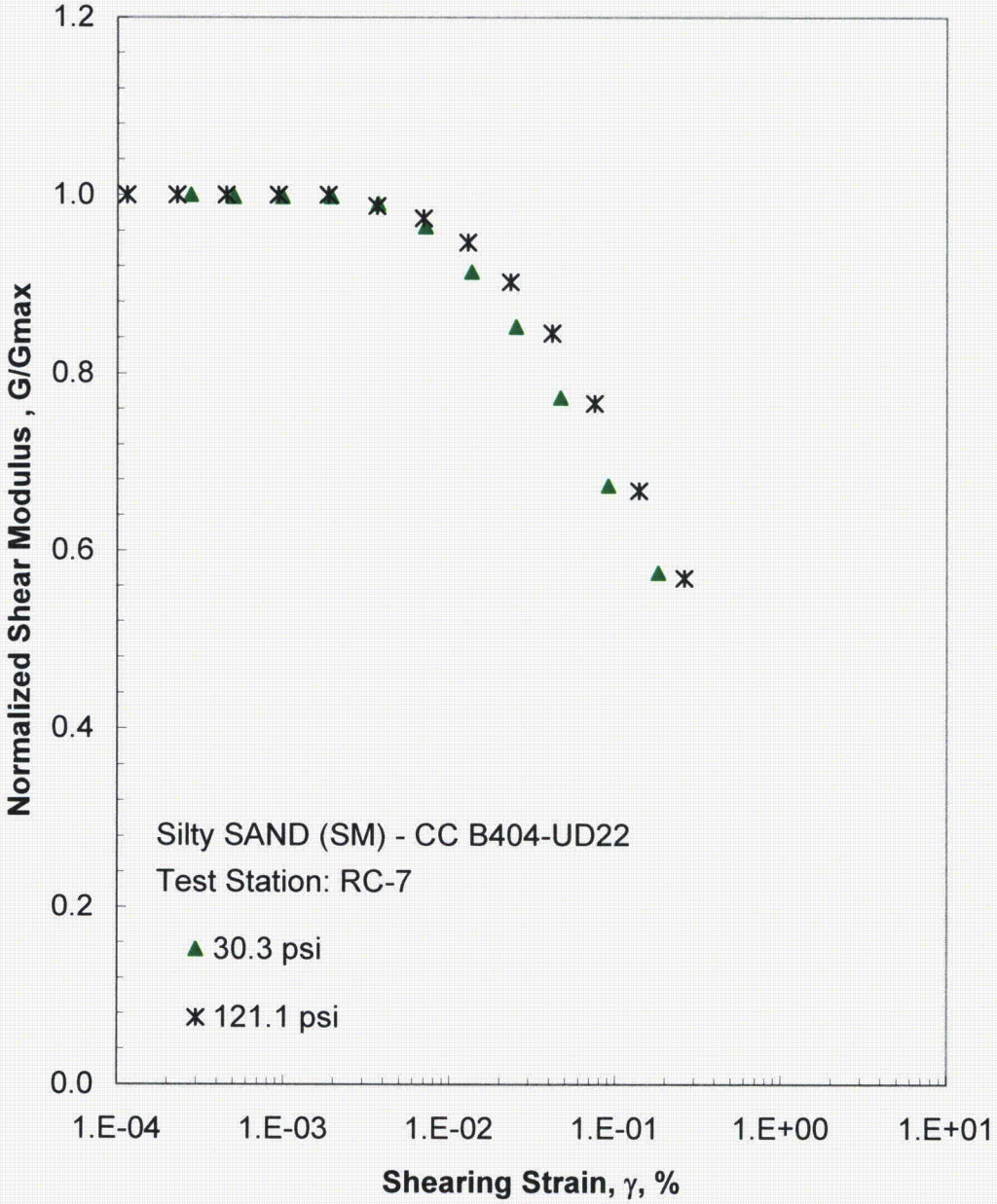


Figure K.9 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

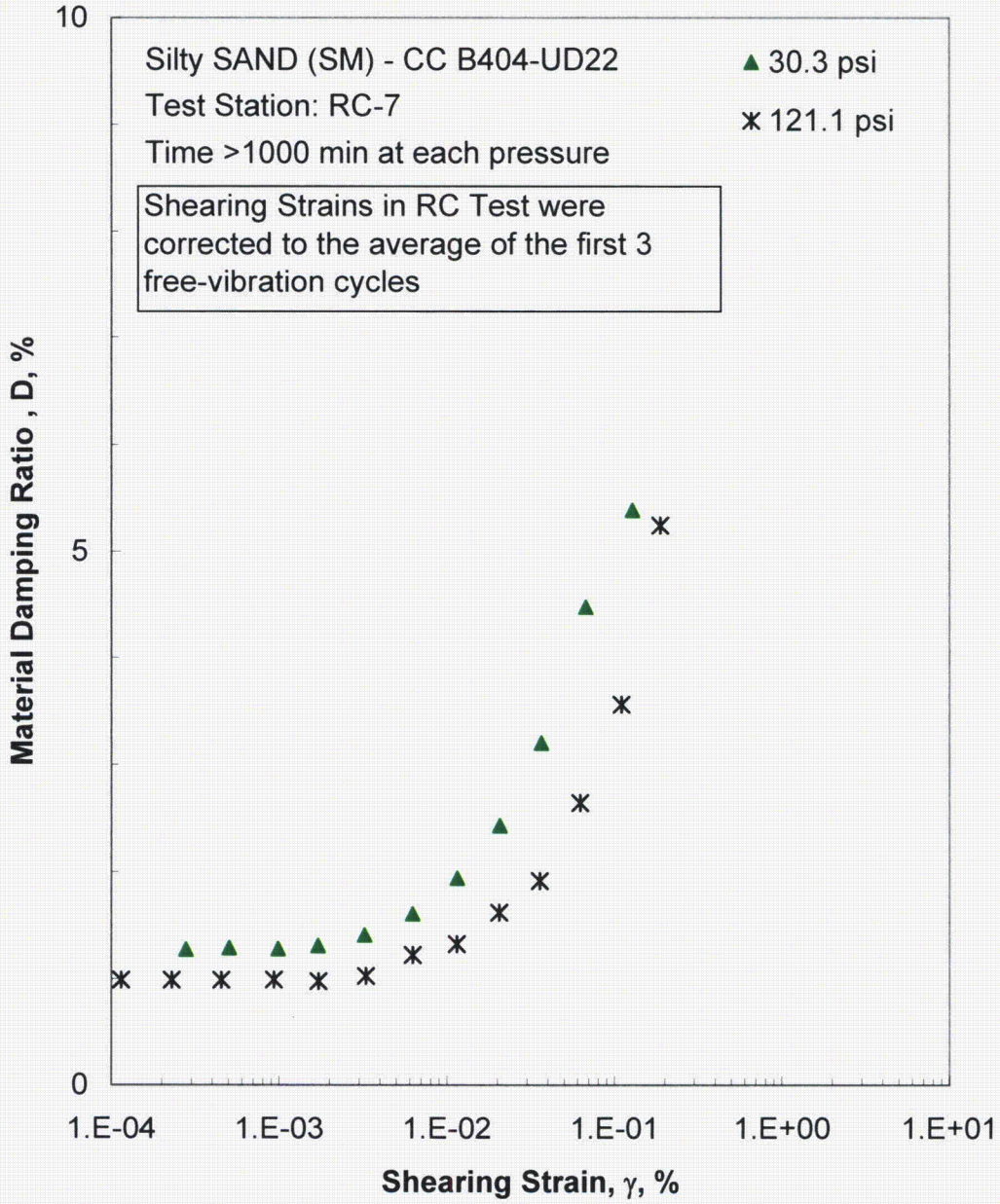


Figure K.10 Comparison of the Variation in Material Damping Ratio with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

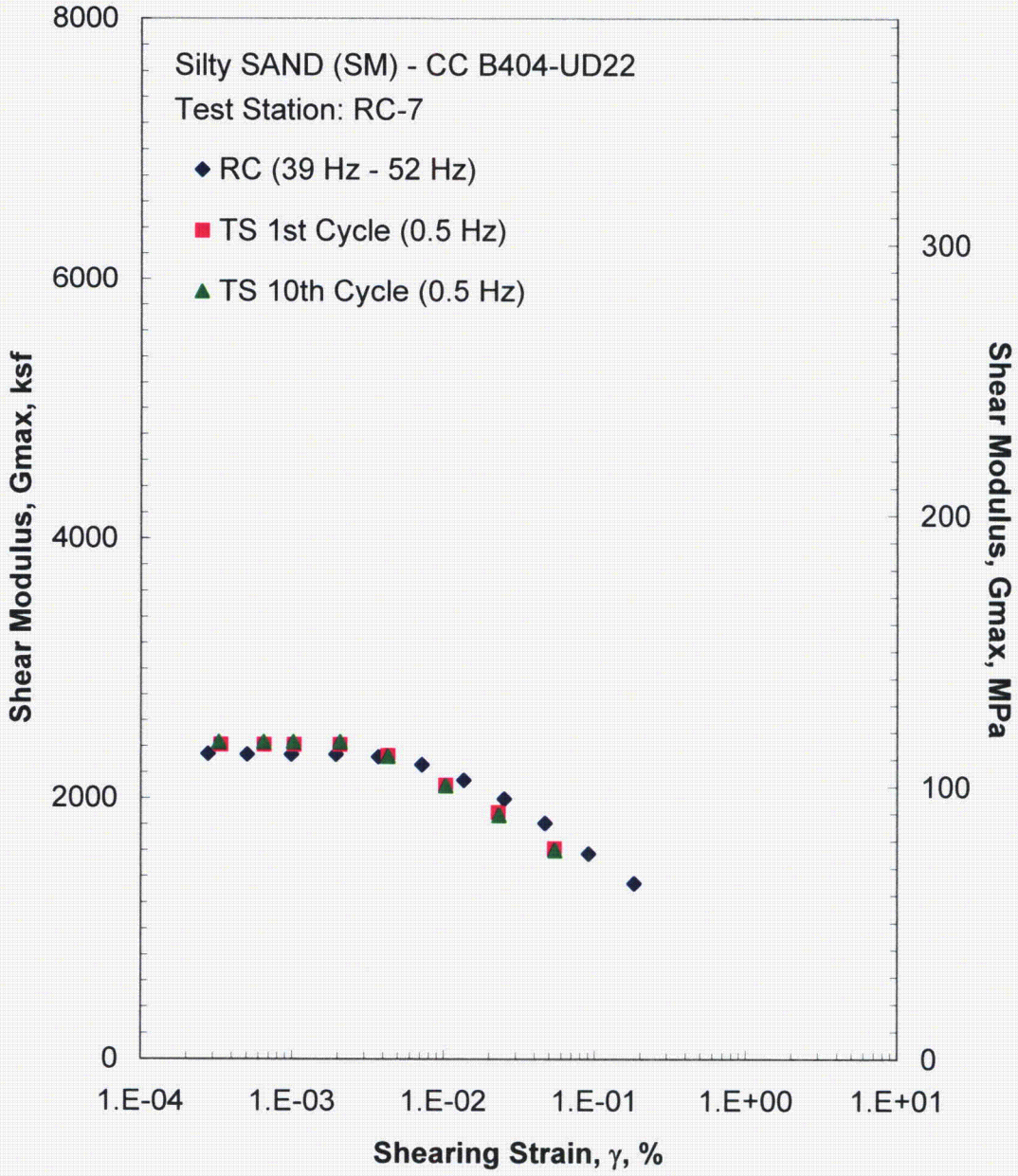


Figure K.11 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 30.3 psi from the Combined RCTS Tests

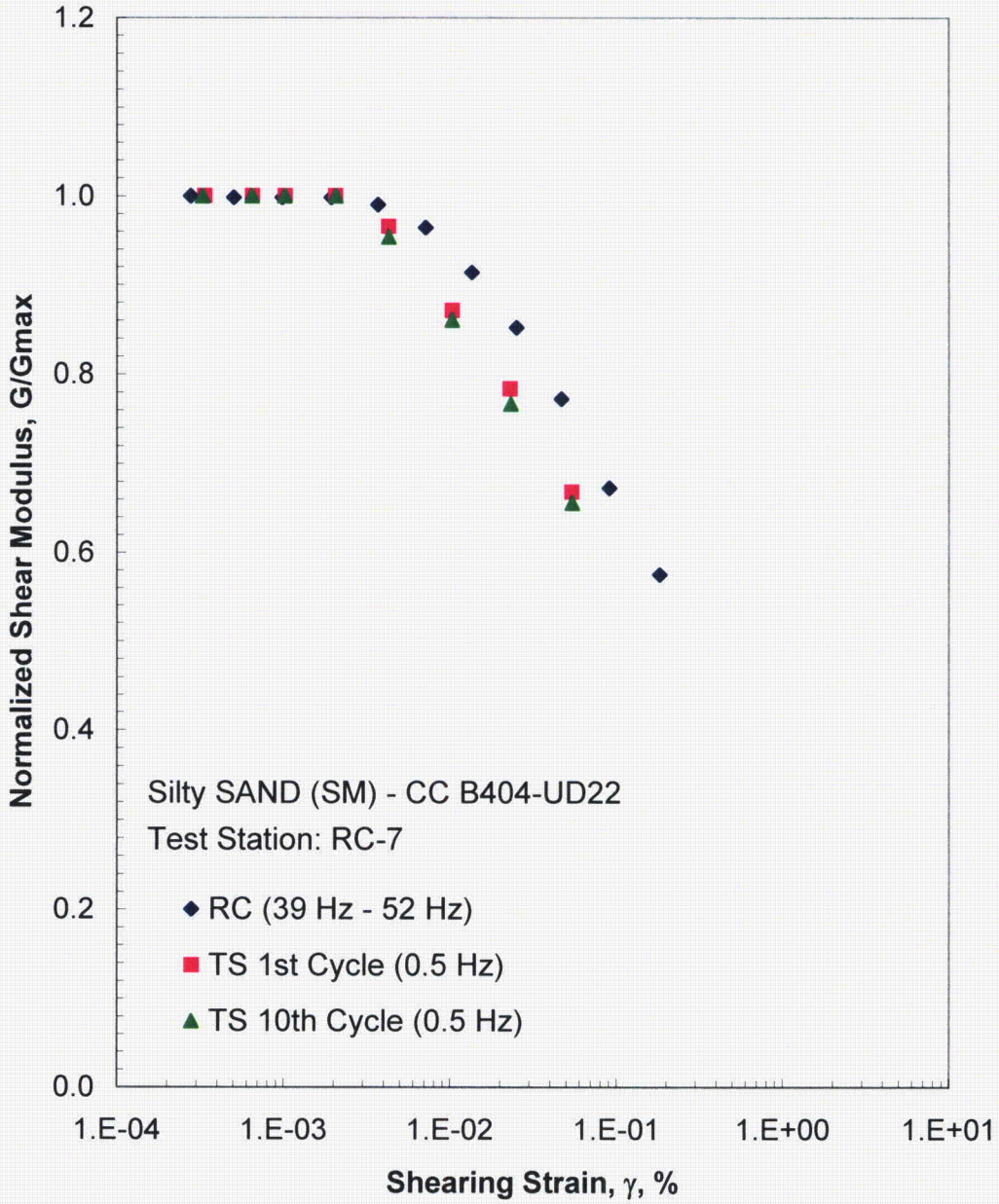


Figure K.12 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 30.3 psi from the Combined RCTS Tests

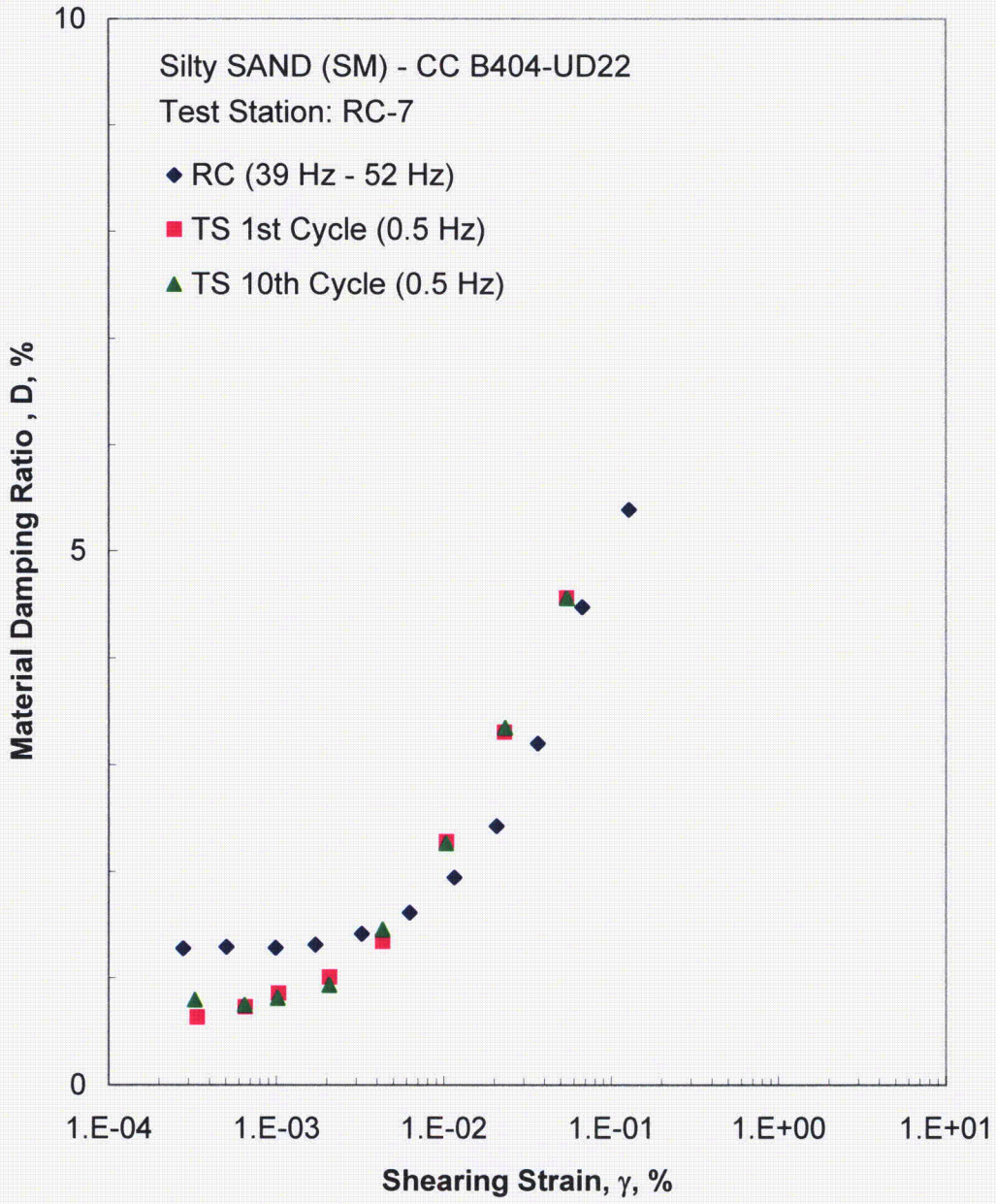


Figure K.13 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 30.3 psi from the Combined RCTS Tests

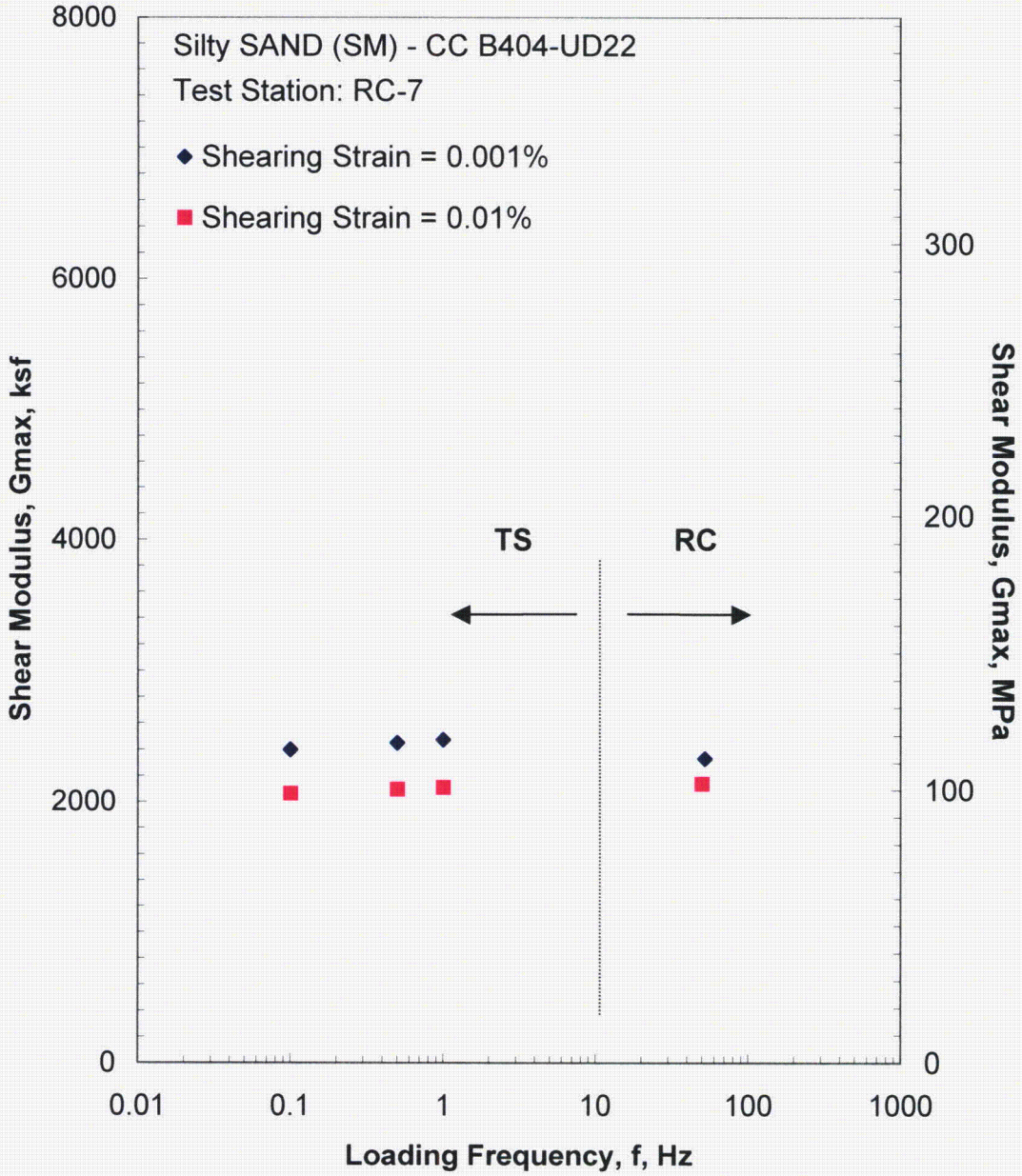


Figure K.14 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 30.3 psi from the Combined RCTS Tests

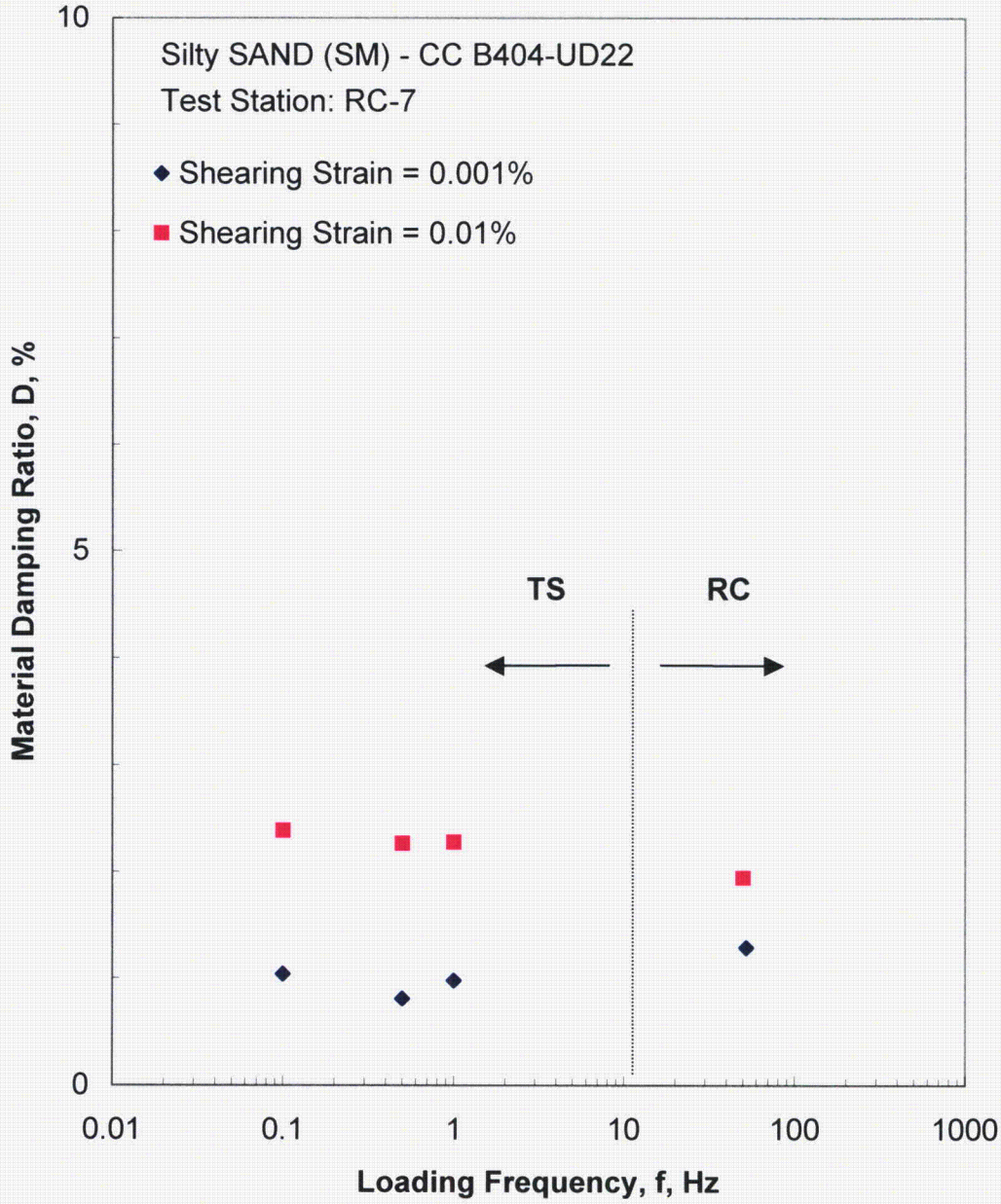


Figure K.15 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 30.3 psi from the Combined RCTS Tests

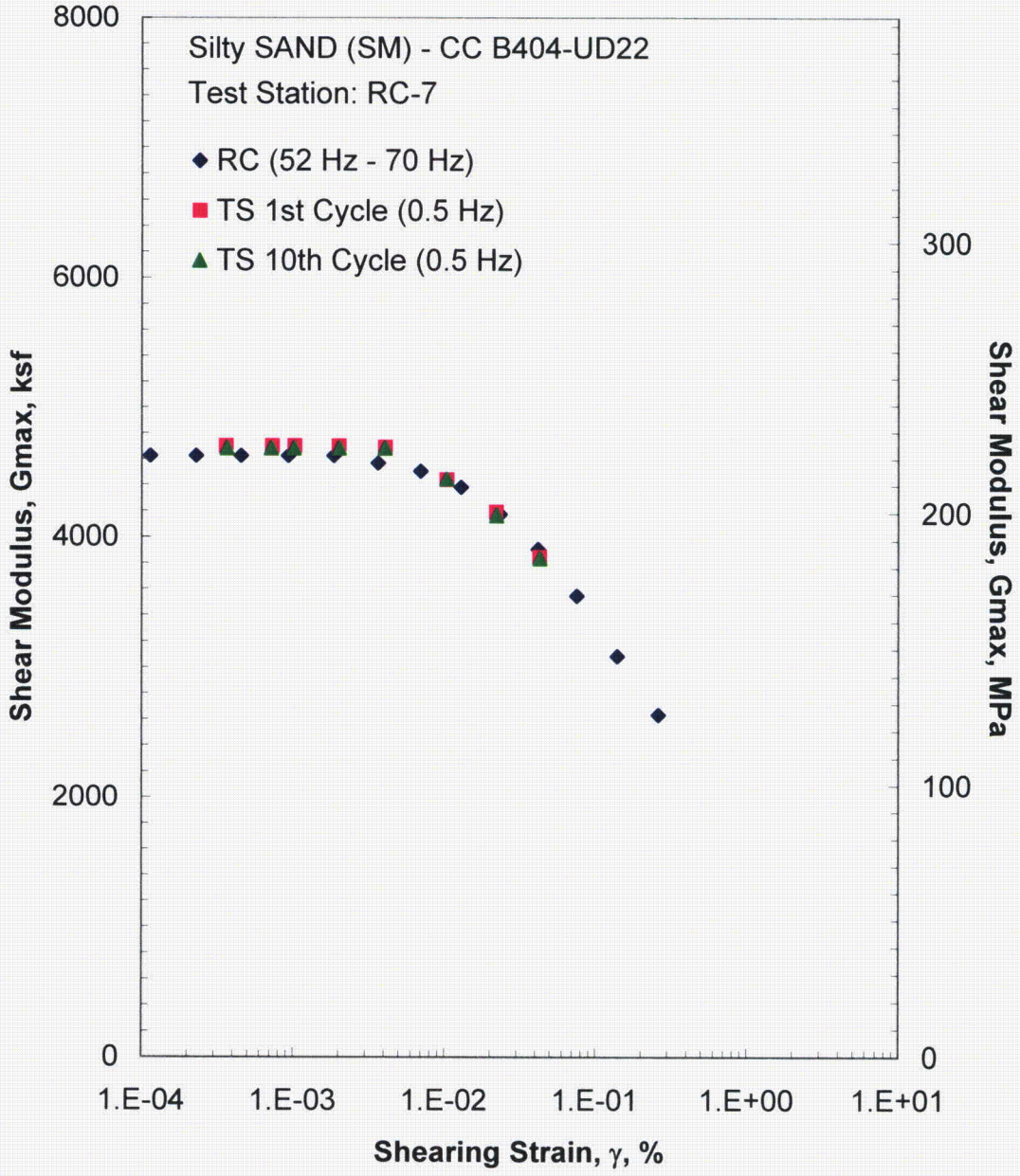


Figure K.16 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 121.1 psi from the Combined RCTS Tests

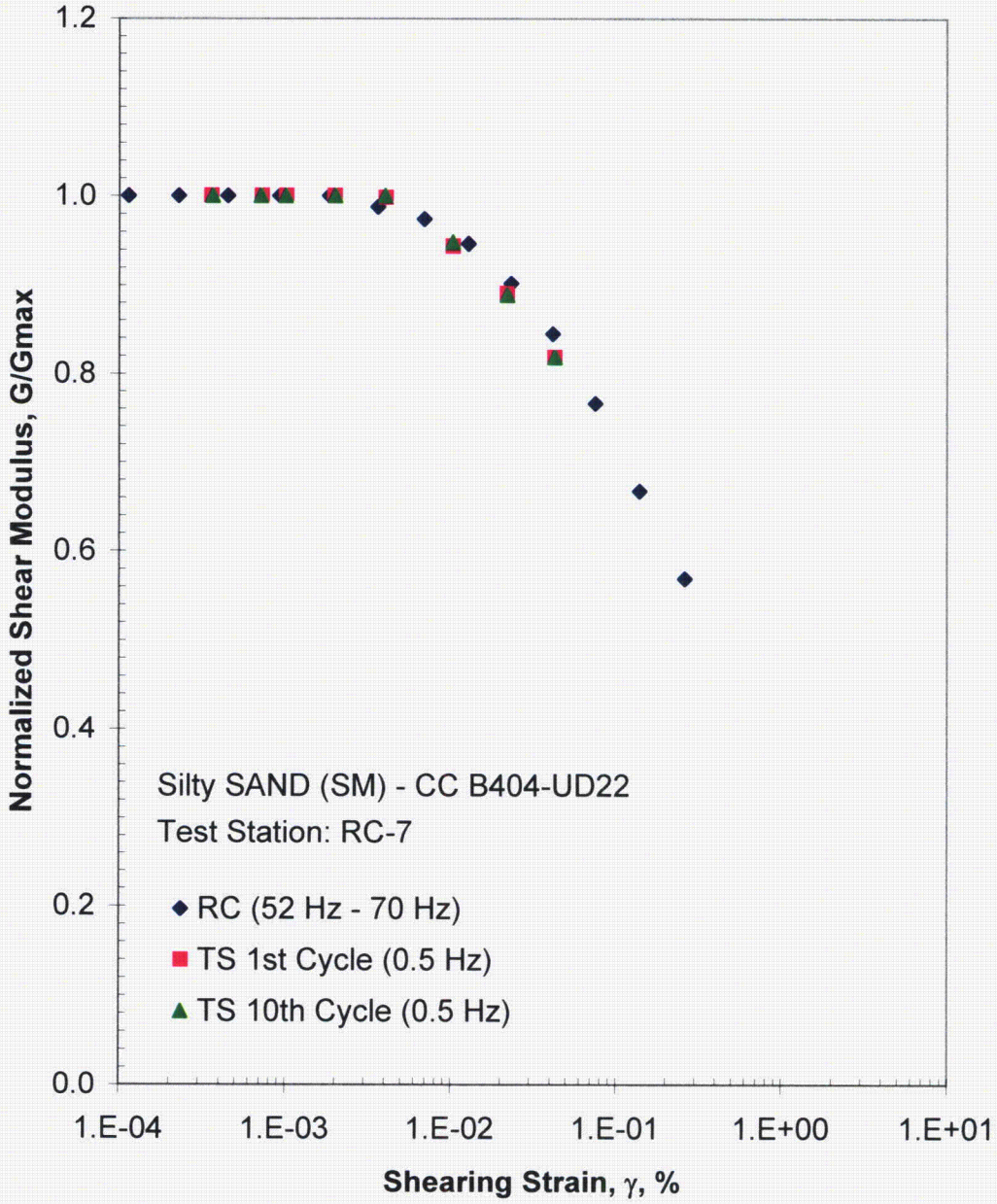


Figure K.17 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 121.1 psi from the Combined RCTS Tests

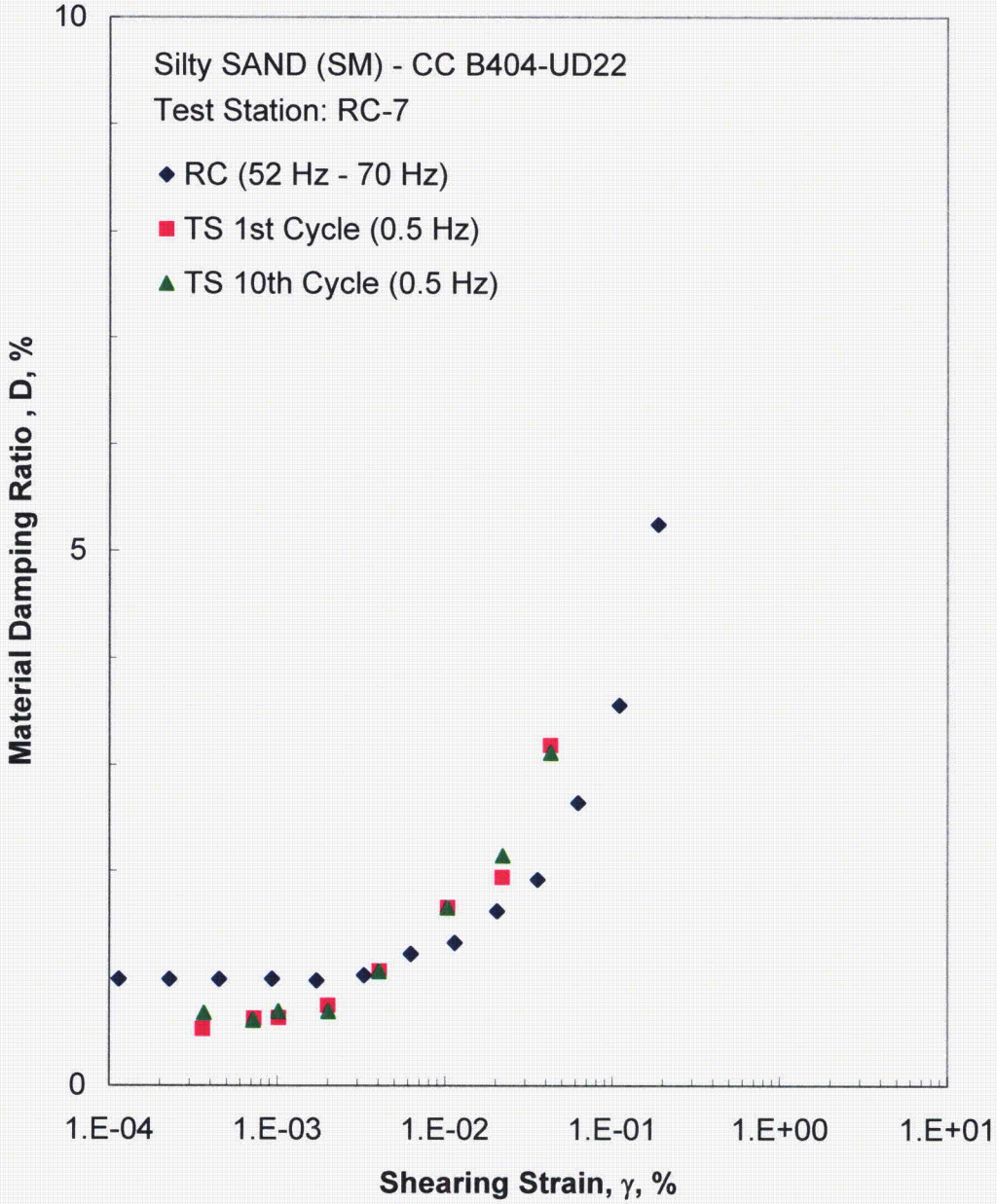


Figure K.18 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 121.1 psi from the Combined RCTS Tests

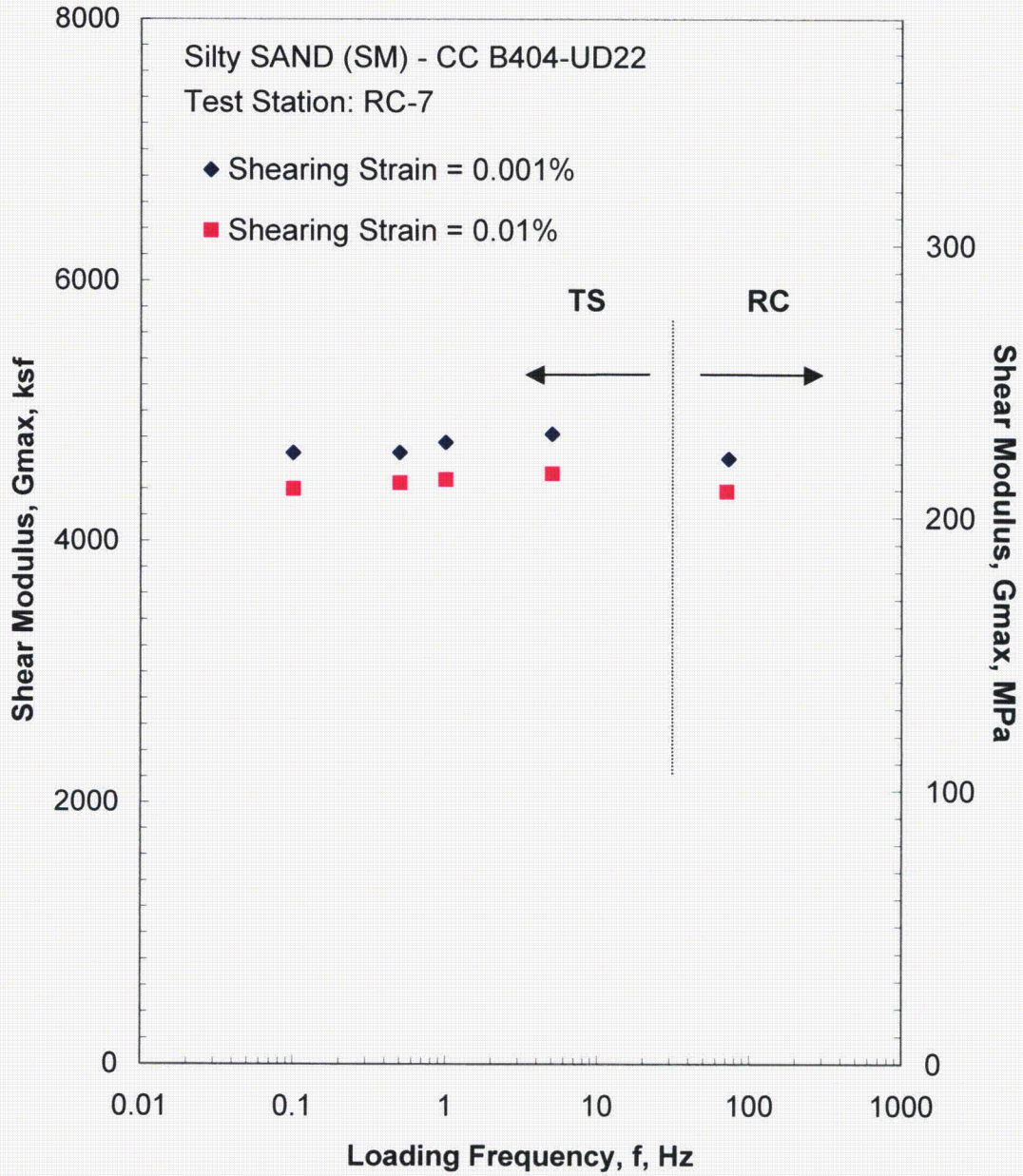


Figure K.19 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 121.1 psi from the Combined RCTS Tests

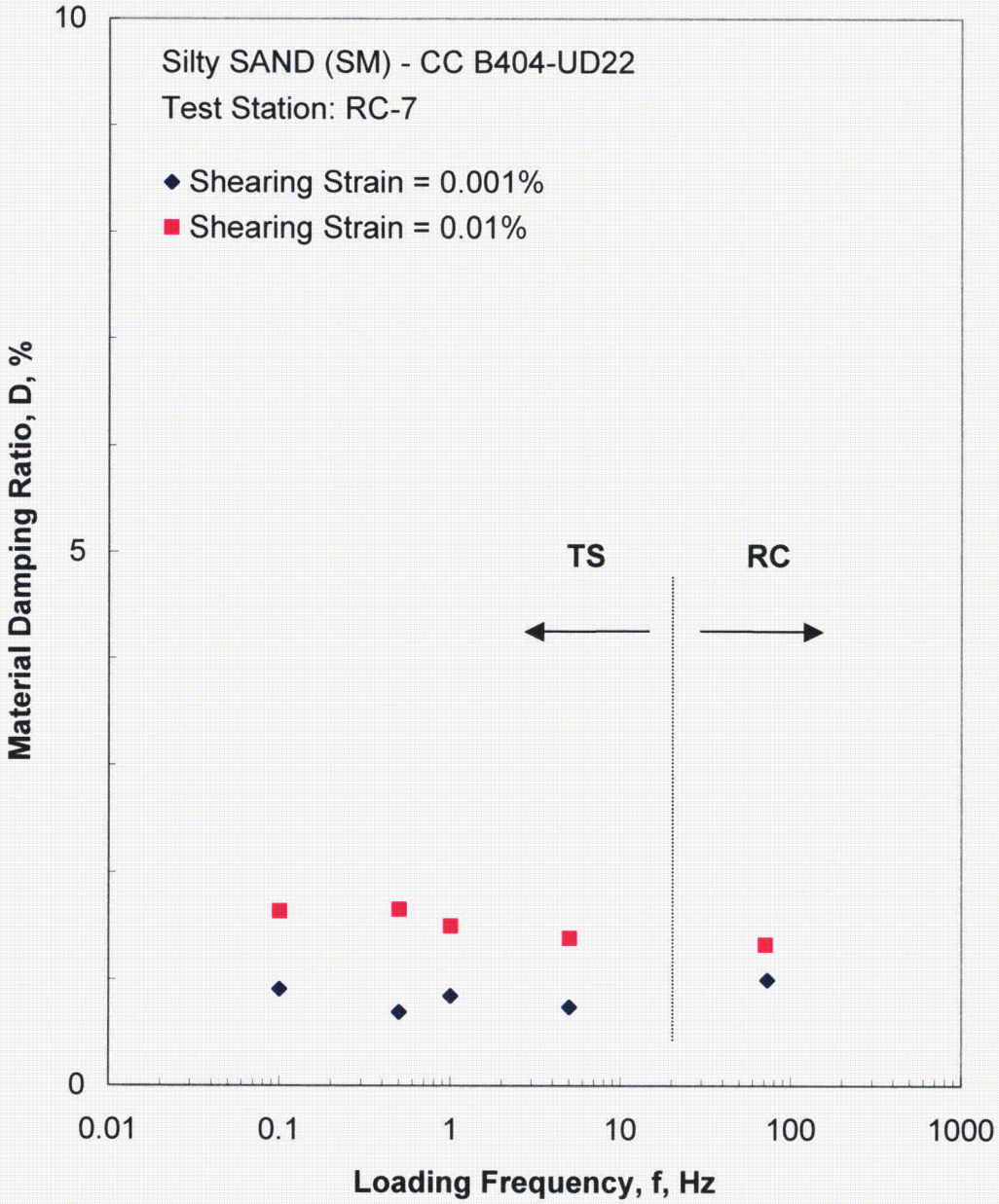


Figure K.20 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 121.1 psi from the Combined RCTS Tests

Table K.1 Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Estimated Void Ratio with Isotropic Confining Pressure from RC Tests of Specimen CC B404-UD22

Isotropic Confining Pressure, σ_o			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin	Estimated Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	(%)	
7.6	1094	52	1234	59	589	1.65	0.948
15.1	2174	104	1658	80	681	1.53	0.938
30.3	4363	209	2308	111	802	1.33	0.930
60.6	8726	418	3493	168	979	1.17	0.901
121.1	17438	834	4597	221	1119	0.99	0.855

Table K.2 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen CC B404-UD22; Isoptropic Confining Pressure, σ_o=30.3 psi (4.4 ksf = 209 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
2.78E-04	2339	1.00	2.78E-04	1.27
5.04E-04	2335	1.00	5.04E-04	1.29
9.88E-04	2335	1.00	9.88E-04	1.28
1.94E-03	2335	1.00	1.71E-03	1.31
3.71E-03	2316	0.99	3.23E-03	1.41
7.17E-03	2256	0.96	6.24E-03	1.61
1.36E-02	2137	0.91	1.15E-02	1.94
2.51E-02	1992	0.85	2.06E-02	2.43
4.66E-02	1807	0.77	3.64E-02	3.20
9.07E-02	1574	0.67	6.71E-02	4.47
1.82E-01	1345	0.57	1.27E-01	5.38

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table K.3 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen CC B404-UD22; Isotropic Confining Pressure, σ_o= 30.3 psi (4.4 ksf =209 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
3.37E-04	2410	1.00	0.63	3.27E-04	2433	1.00	0.79
6.51E-04	2410	1.00	0.72	6.49E-04	2433	1.00	0.74
1.03E-03	2410	1.00	0.85	1.02E-03	2433	1.00	0.80
2.07E-03	2410	1.00	1.00	2.07E-03	2433	1.00	0.93
4.29E-03	2327	0.97	1.34	4.31E-03	2320	0.95	1.45
1.03E-02	2098	0.87	2.28	1.03E-02	2093	0.86	2.26
2.29E-02	1888	0.78	3.30	2.32E-02	1865	0.77	3.35
5.38E-02	1610	0.67	4.56	5.43E-02	1596	0.66	4.55

Table K.4 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen CC B404-UD22; Isoptropic Confining Pressure, σ_o= 121.1 psi (17.4 ksf = 834 kPa)

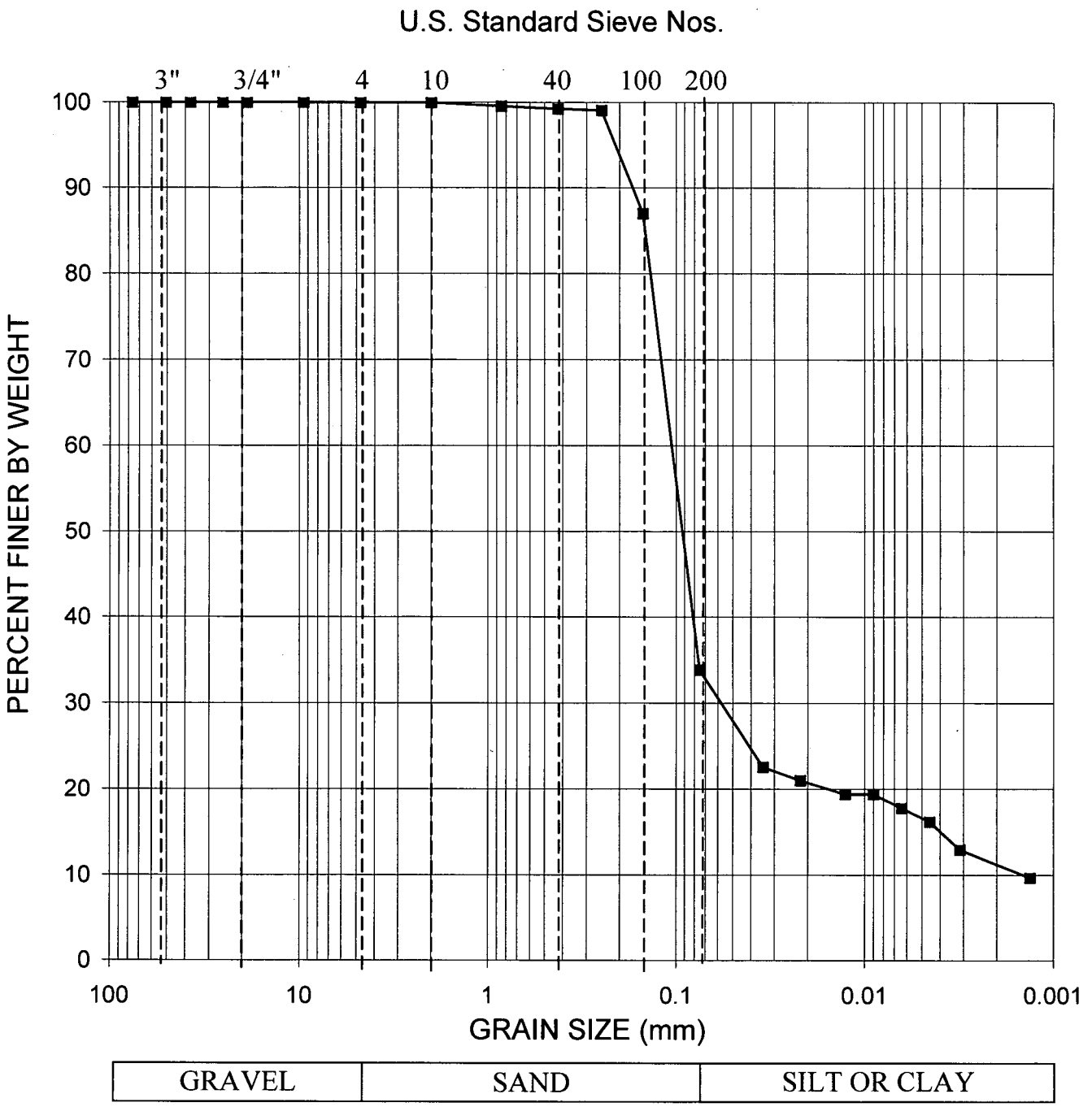
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
1.14E-04	4623	1.00	1.14E-04	0.99
2.28E-04	4623	1.00	2.28E-04	0.99
4.52E-04	4623	1.00	4.52E-04	0.99
9.31E-04	4623	1.00	9.31E-04	0.99
1.86E-03	4623	1.00	1.71E-03	0.98
3.64E-03	4565	0.99	3.28E-03	1.03
6.95E-03	4502	0.97	6.26E-03	1.22
1.28E-02	4376	0.95	1.14E-02	1.32
2.32E-02	4169	0.90	2.04E-02	1.62
4.14E-02	3904	0.84	3.56E-02	1.92
7.51E-02	3542	0.77	6.23E-02	2.64
1.39E-01	3083	0.67	1.10E-01	3.56
2.61E-01	2630	0.57	1.88E-01	5.24

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table K.5 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen CC B404-UD22; Isotropic Confining Pressure, σ_o=121.1 psi (17.4 ksf = 834 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
3.60E-04	4698	1.00	0.52	3.67E-04	4681	1.00	0.67
7.24E-04	4698	1.00	0.62	7.19E-04	4681	1.00	0.60
1.02E-03	4698	1.00	0.63	1.02E-03	4681	1.00	0.69
2.00E-03	4698	1.00	0.74	2.02E-03	4681	1.00	0.68
4.06E-03	4688	1.00	1.06	4.05E-03	4681	1.00	1.06
1.03E-02	4434	0.94	1.65	1.03E-02	4440	0.95	1.65
2.19E-02	4184	0.89	1.94	2.21E-02	4159	0.89	2.14
4.25E-02	3844	0.82	3.18	4.26E-02	3831	0.82	3.11



GRADATION CURVE

ASTM D422

Project:	Constellation Energy Group COLA Project, Calvert Cliffs NuclearPower Plant (CCNPP), Calvert County, Maryland		Contract No.:	06120048.00	Date:	10/18/2007
Boring No.	Depth (ft)	Sample Description	Class.	LL	PI	
B-404	83.5-85.1	SILTY SAND, greenish gray	SM	53	25	Schnabel Engineering

APPENDIX L

CC B401-UD42
SILTY SAND (SM), greenish gray*
(LL=82, PL=55, PI=27; Gs=2.52)*

Borehole B-401
Sample UD42
Sample Depth = 198.5 to 200.3 ft
RCTS Test Depth = 200.3 ft
Total Unit Weight = 101.2 lb/ft^3
Water Content = 48.8 %
Estimated In-Situ Ko = 0.5*
Estimated In-Situ Mean Effective Stress = 62.5 psi*

*Data supplied by Schnabel Engineering, Inc.

FUGRO JOB #: 0401-1661
Testing Station: RC7

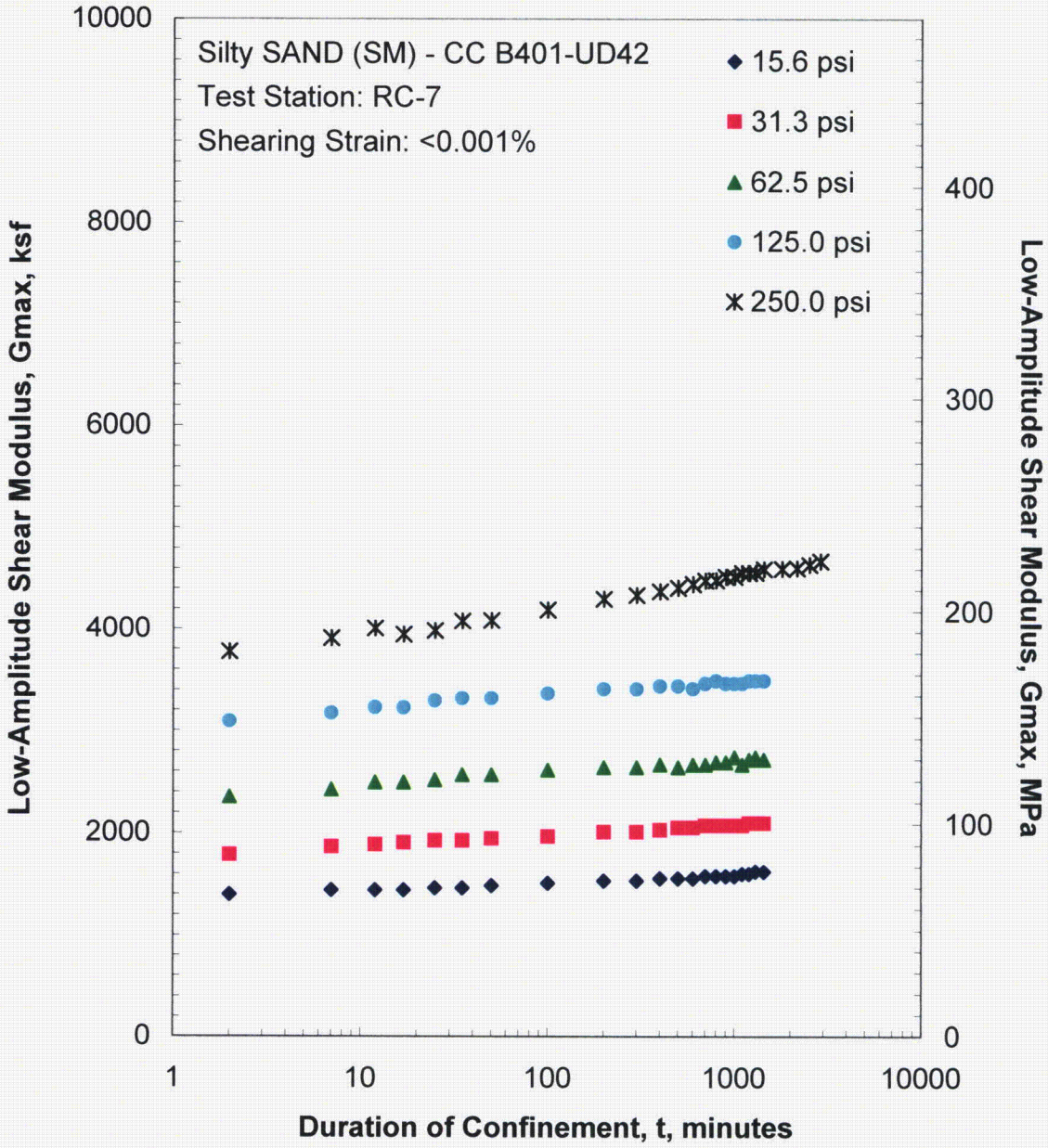


Figure L.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

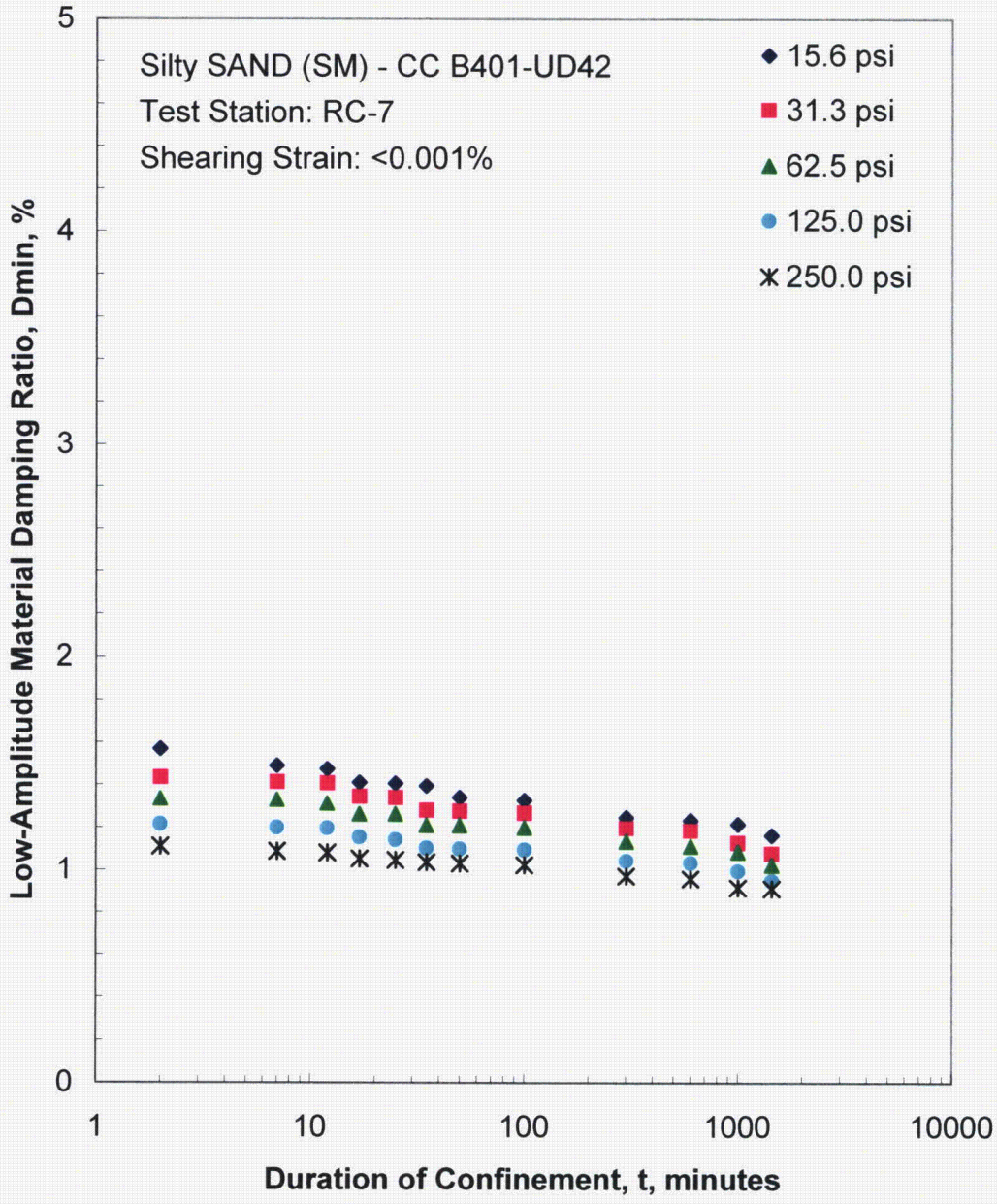


Figure L.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

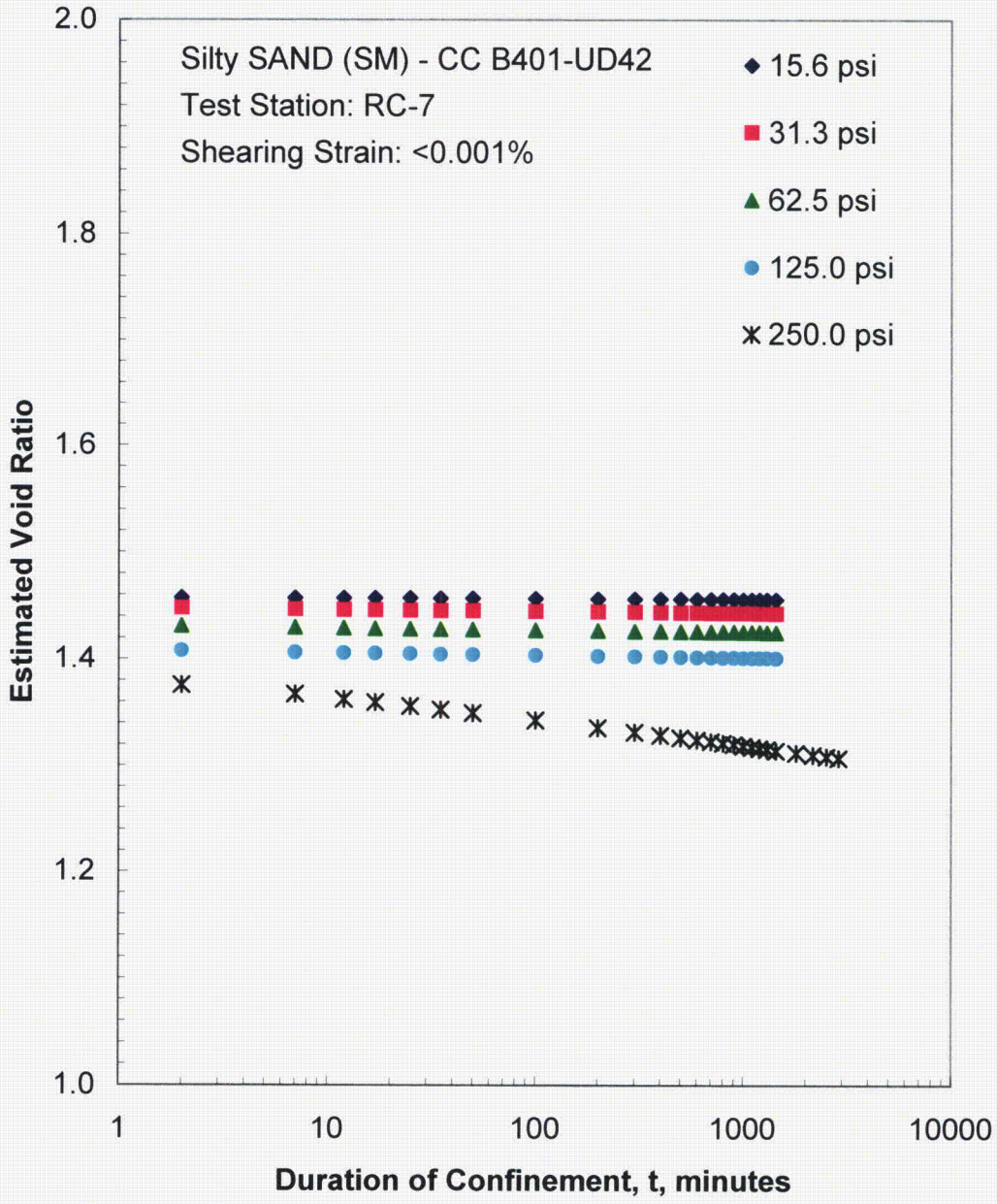


Figure L.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

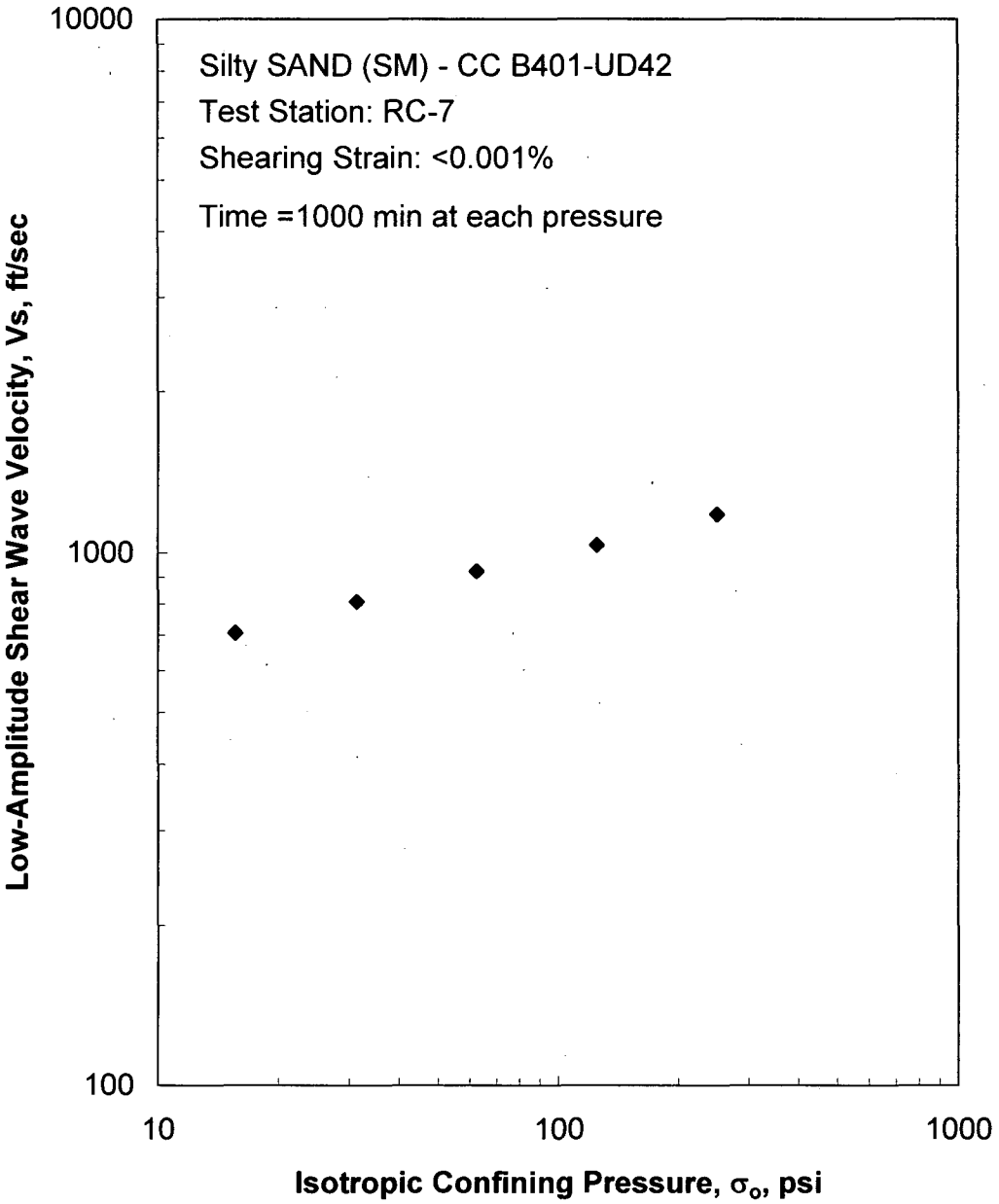


Figure L.4 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests

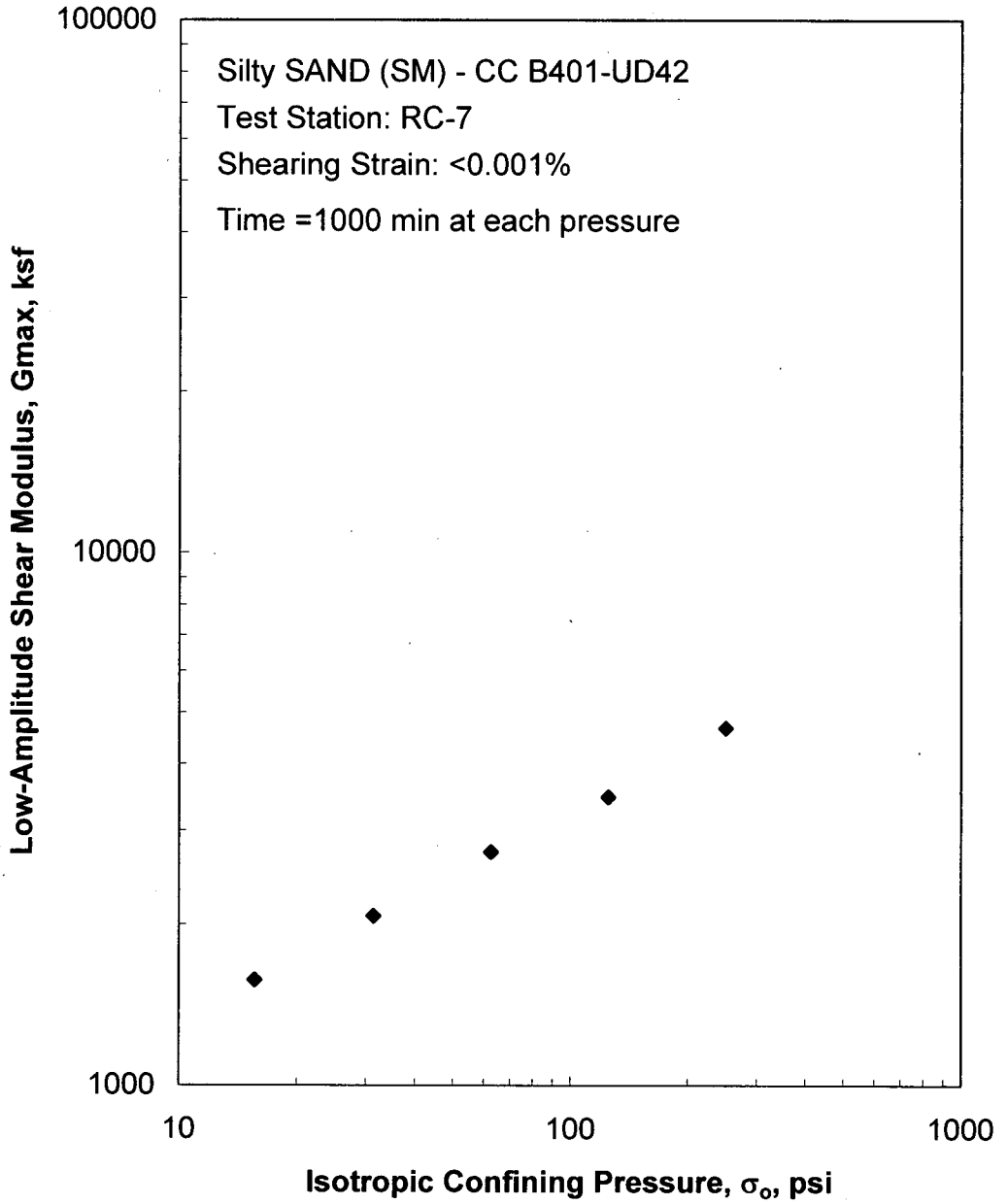


Figure L.5 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Tests

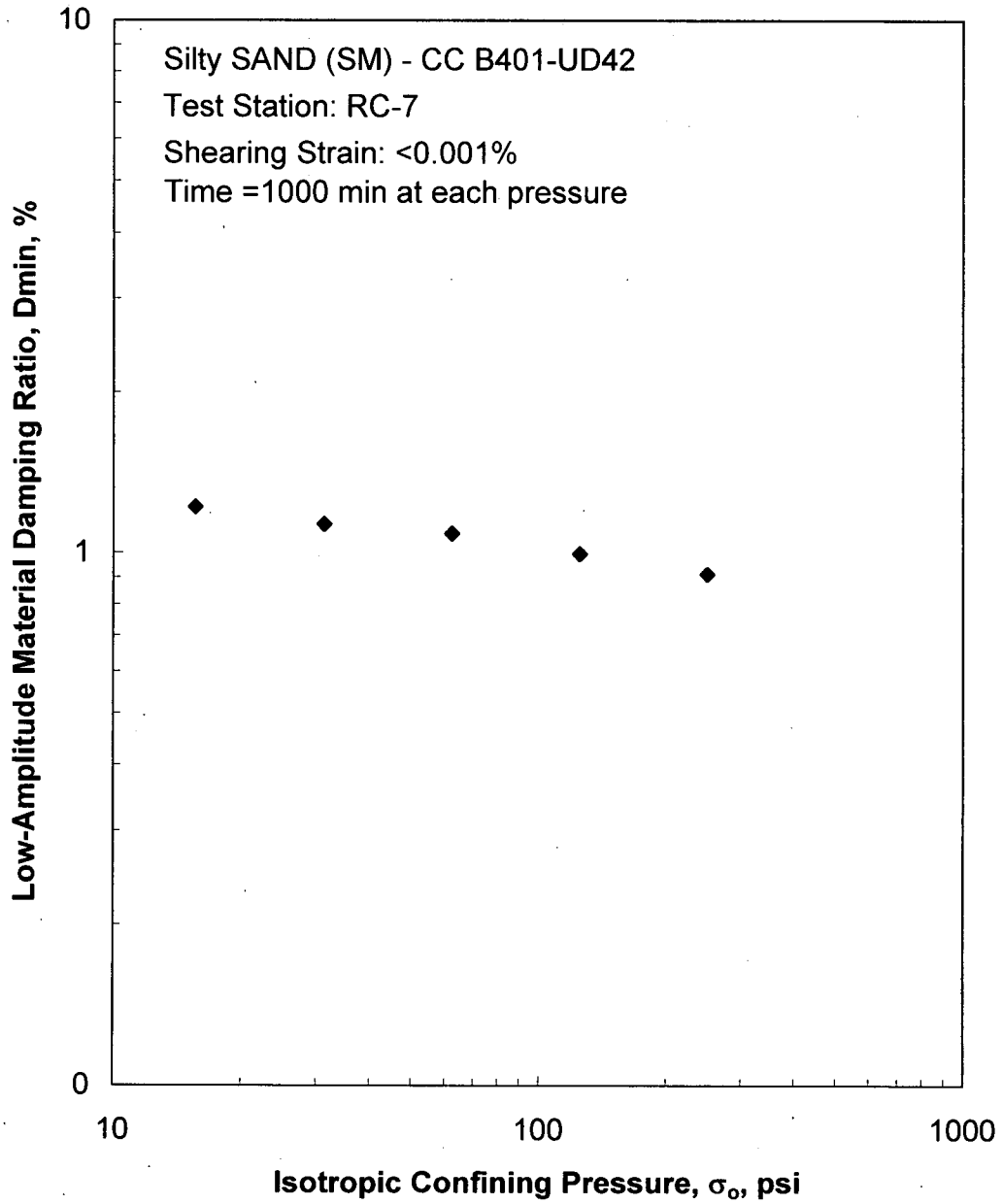


Figure L.6 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests

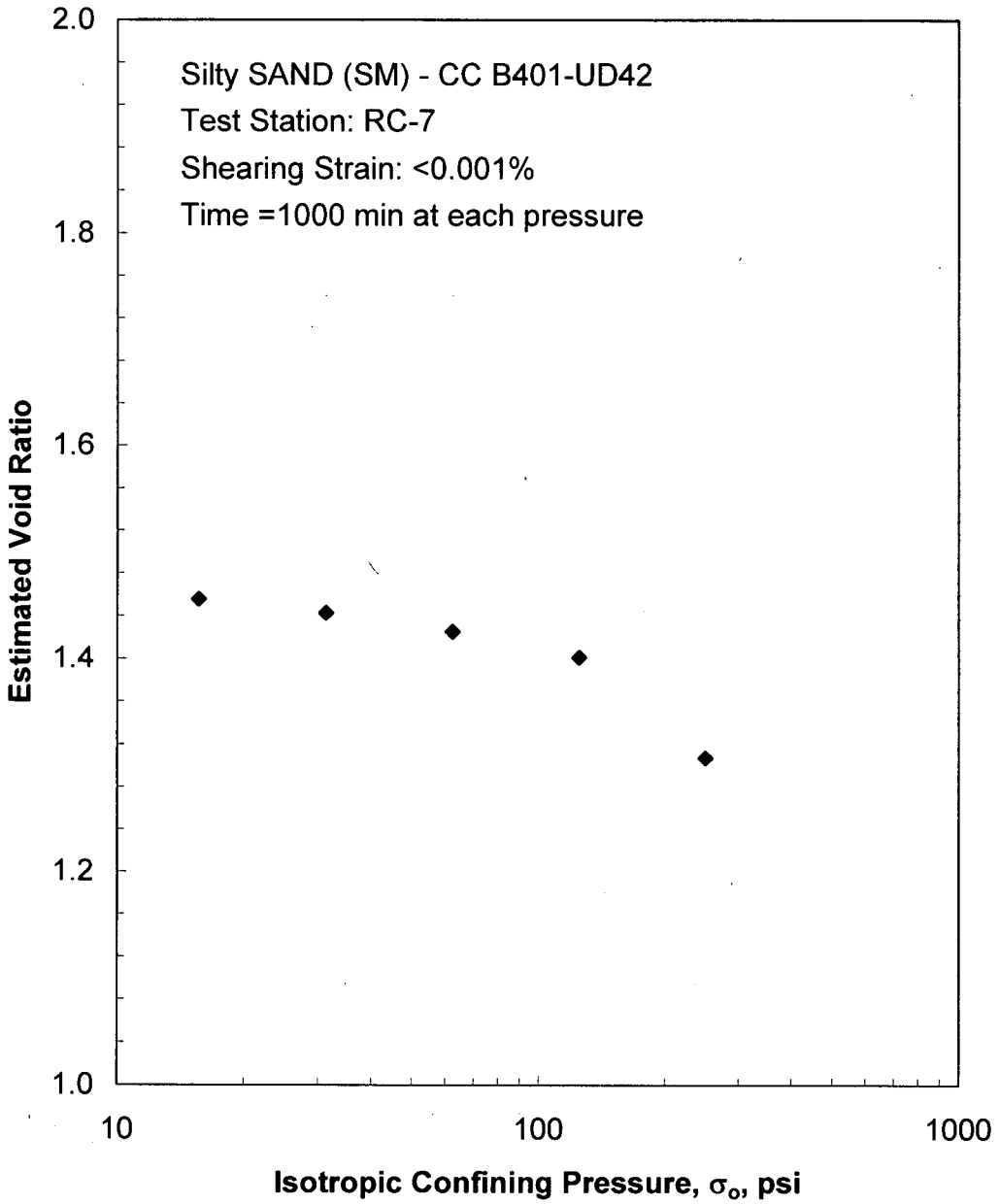


Figure L.7 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests

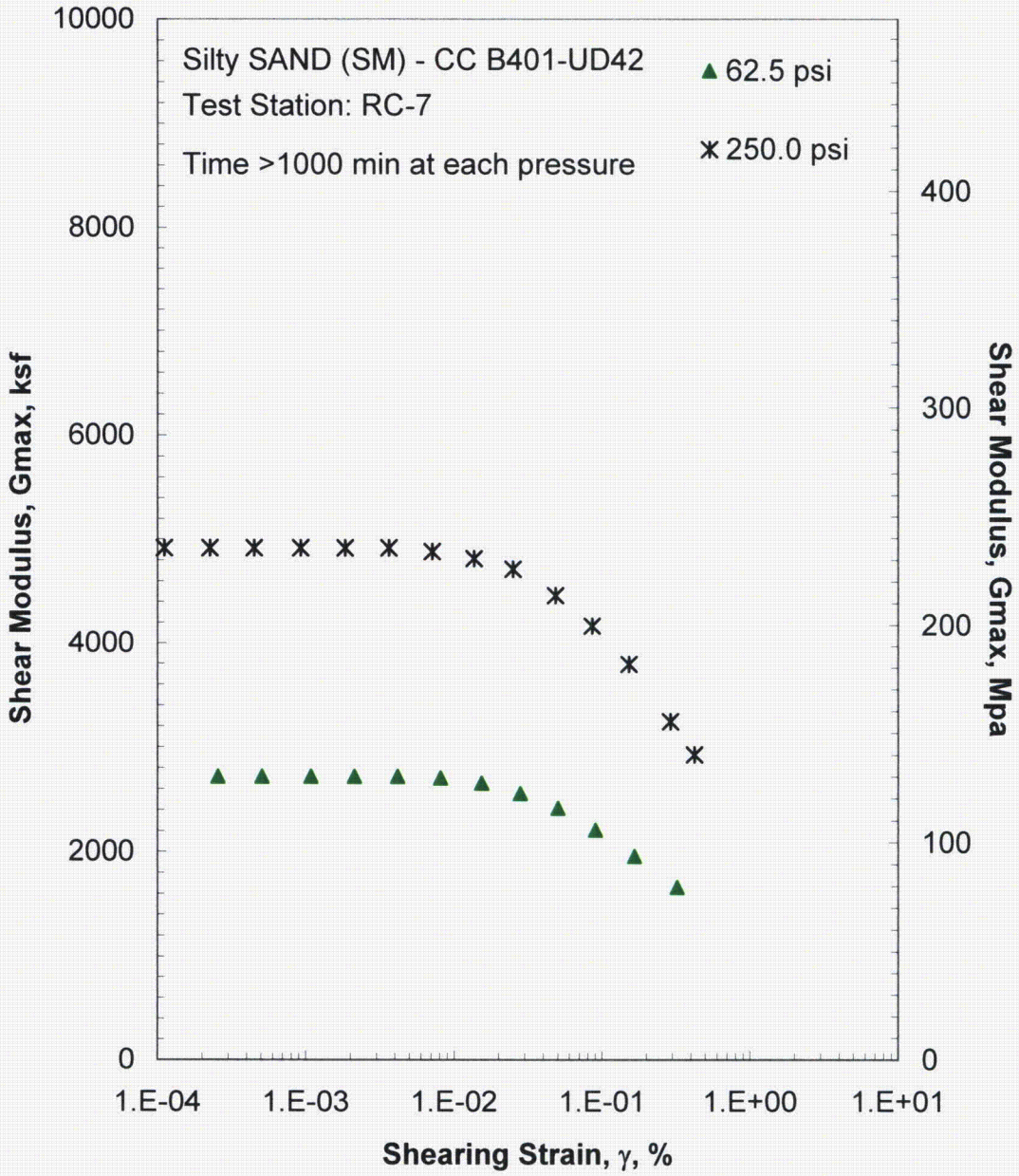


Figure L.8 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

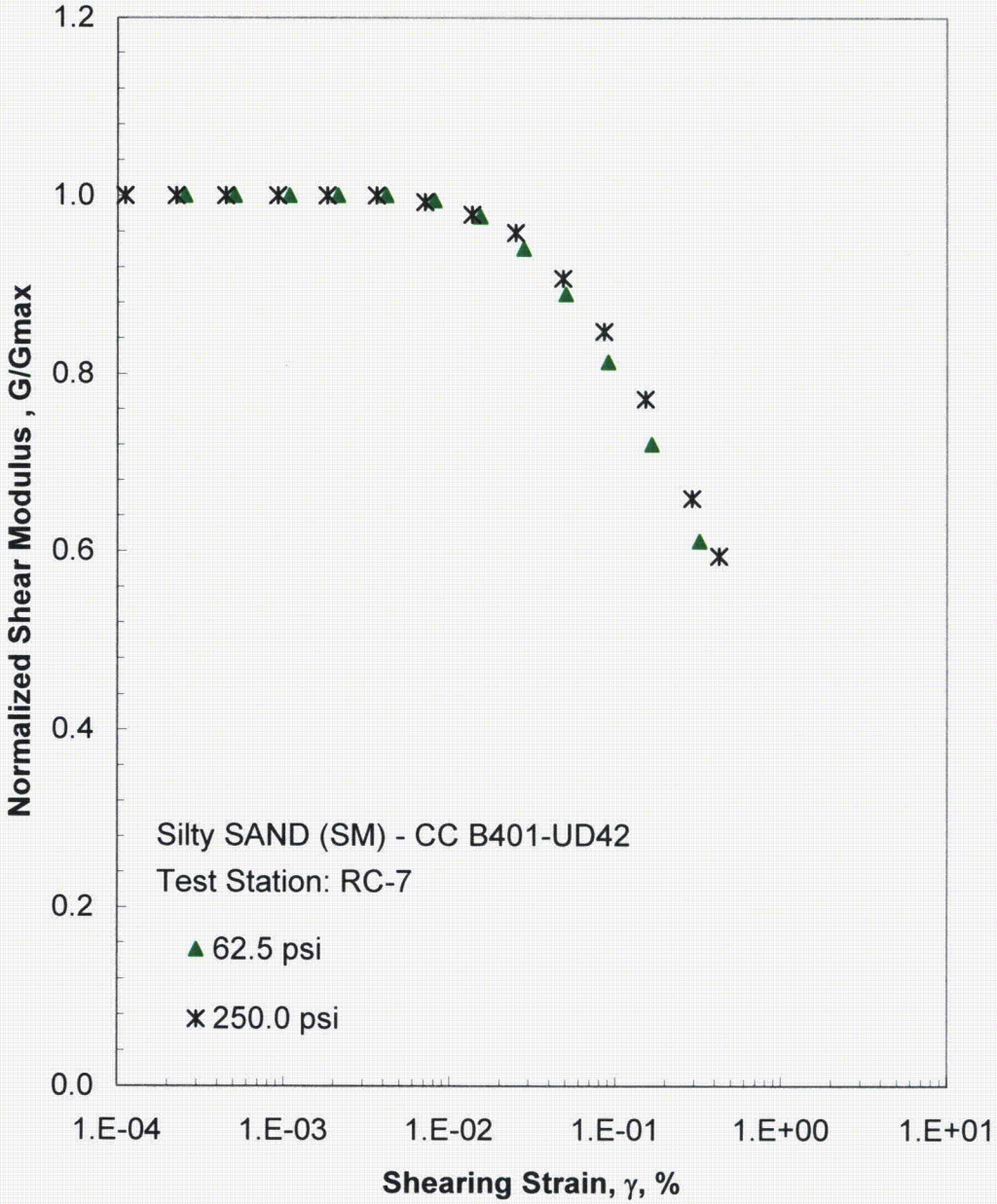


Figure L.9 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

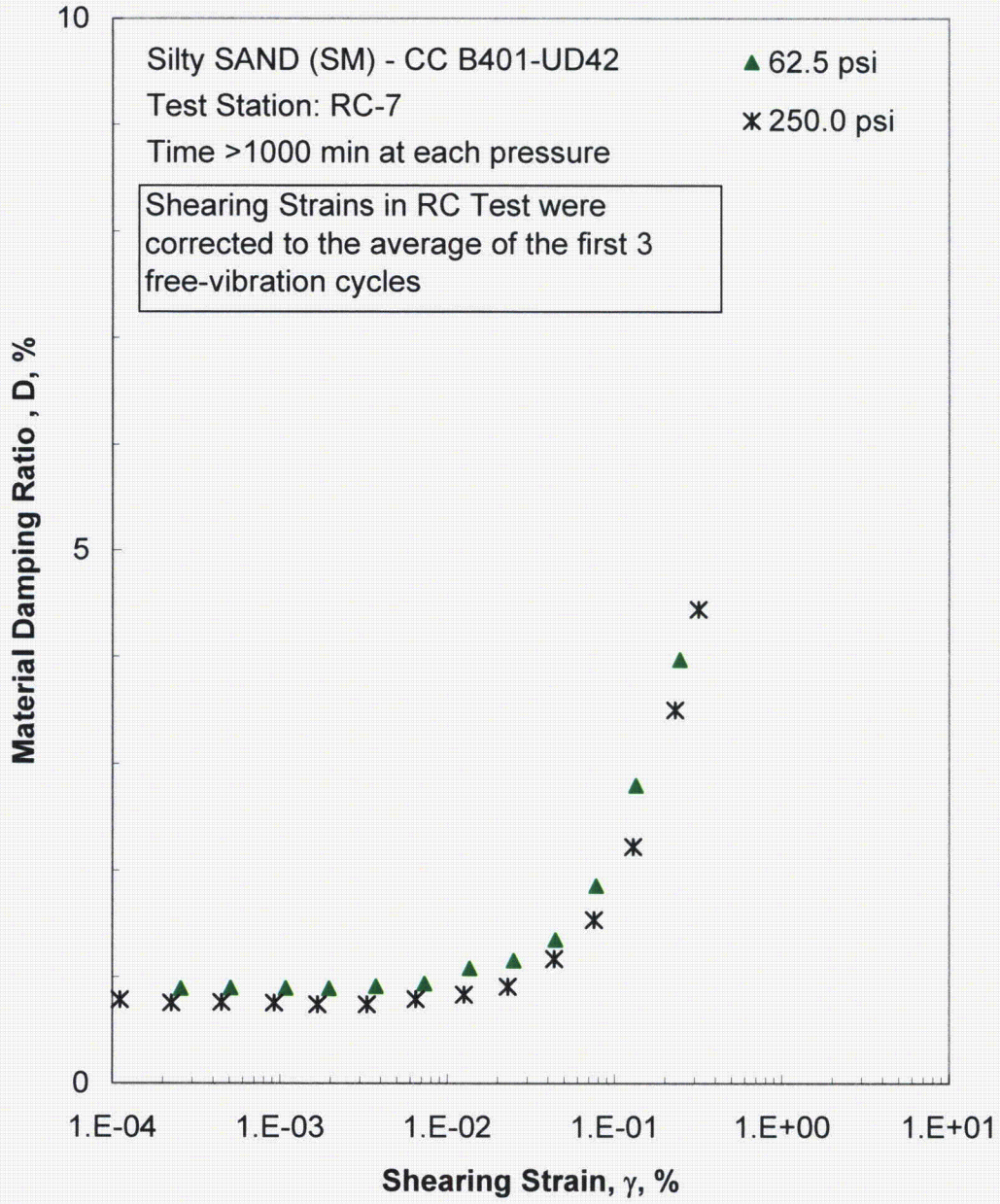


Figure L.10 Comparison of the Variation in Material Damping Ratio with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

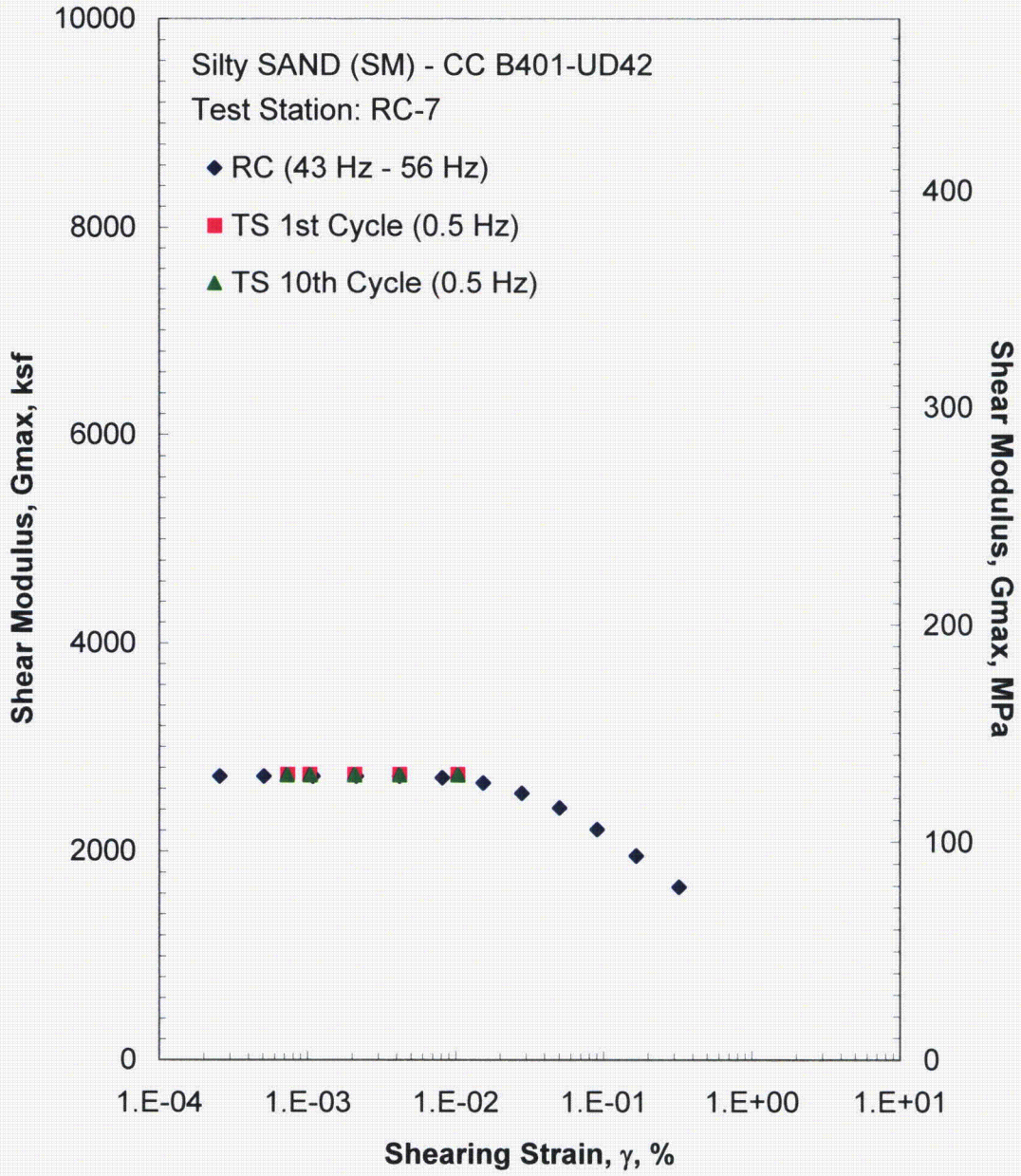


Figure L.11 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 62.5 psi from the Combined RCTS Tests

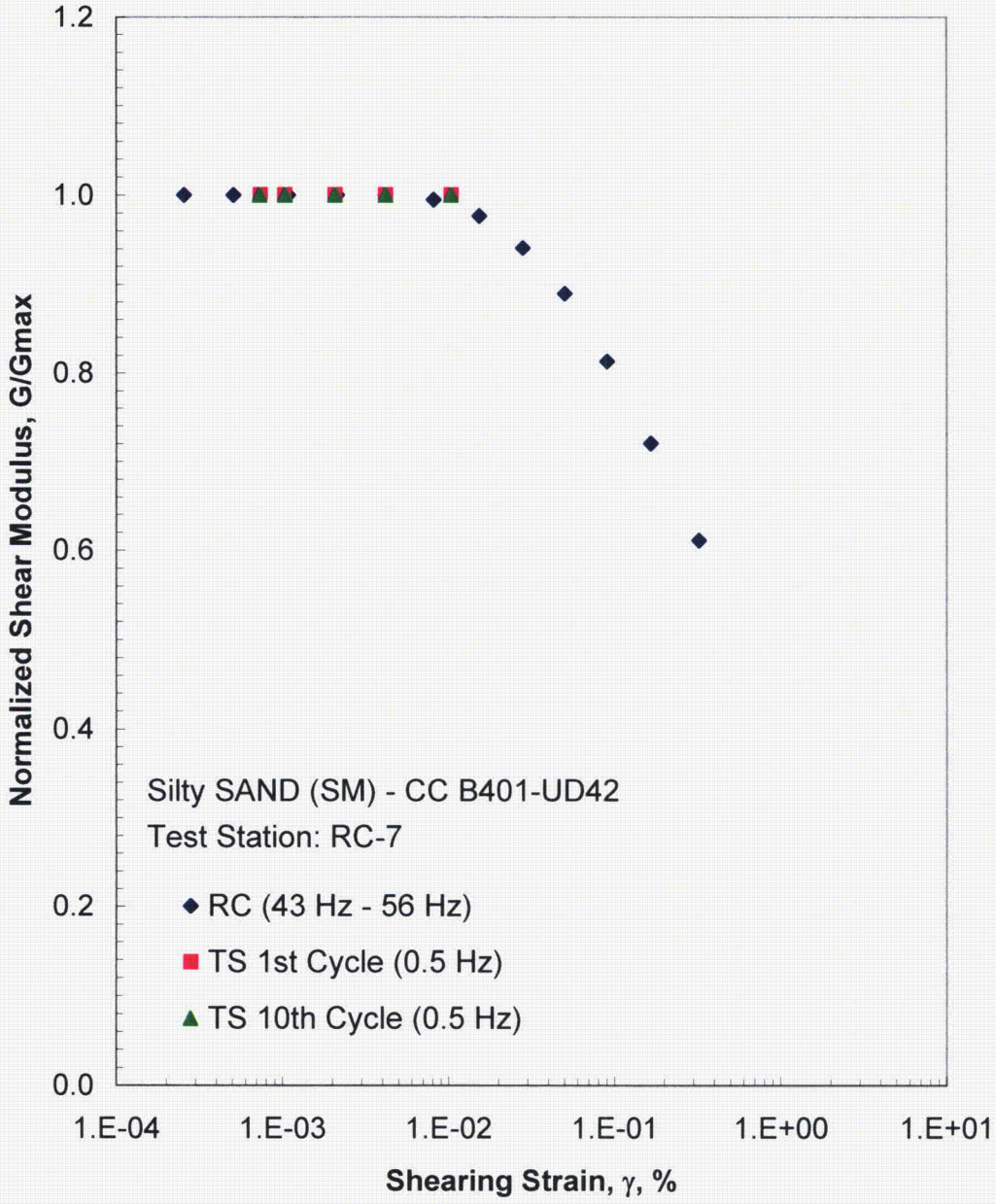


Figure L.12 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 62.5 psi from the Combined RCTS Tests

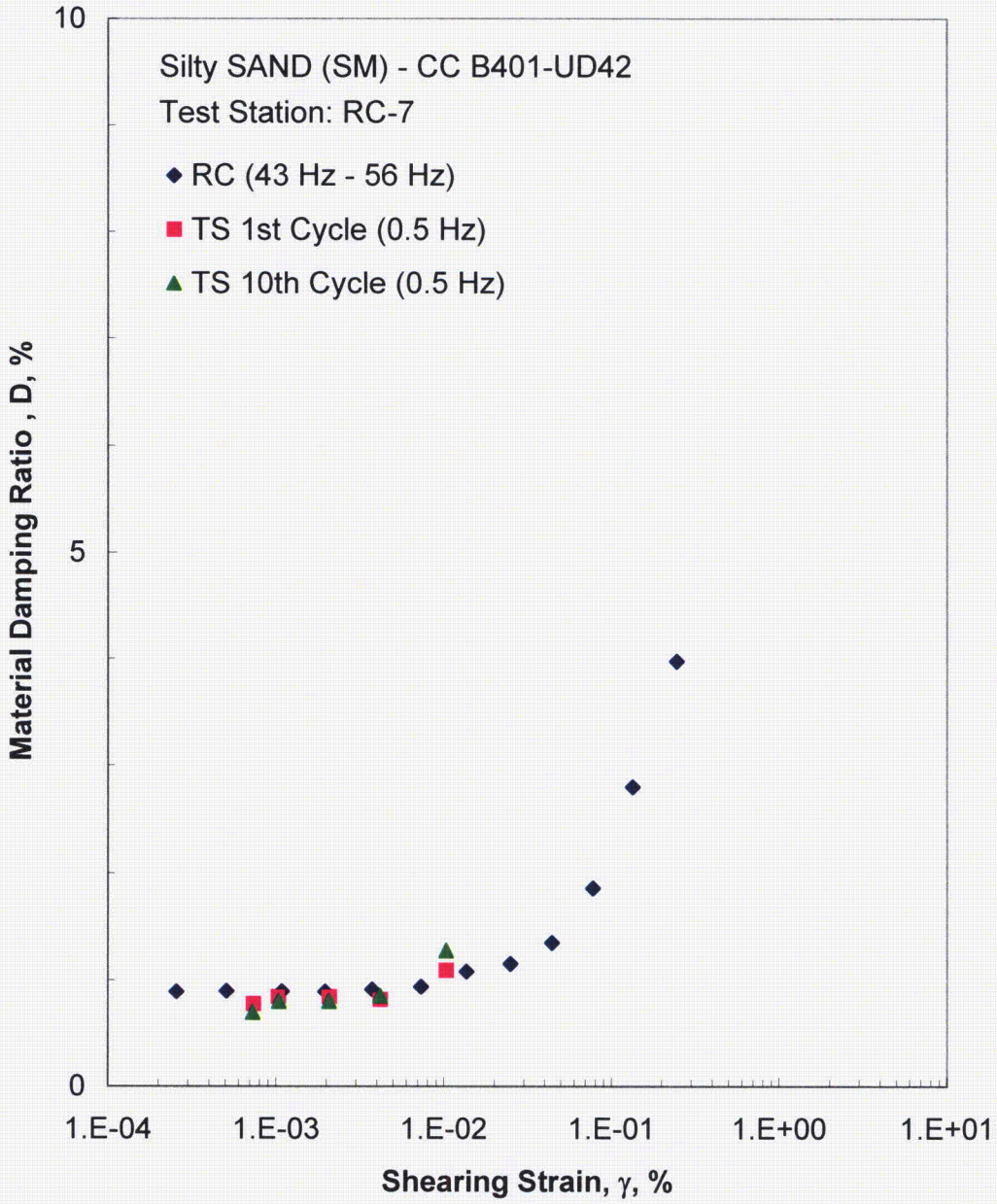


Figure L.13 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 62.5 psi from the Combined RCTS Tests

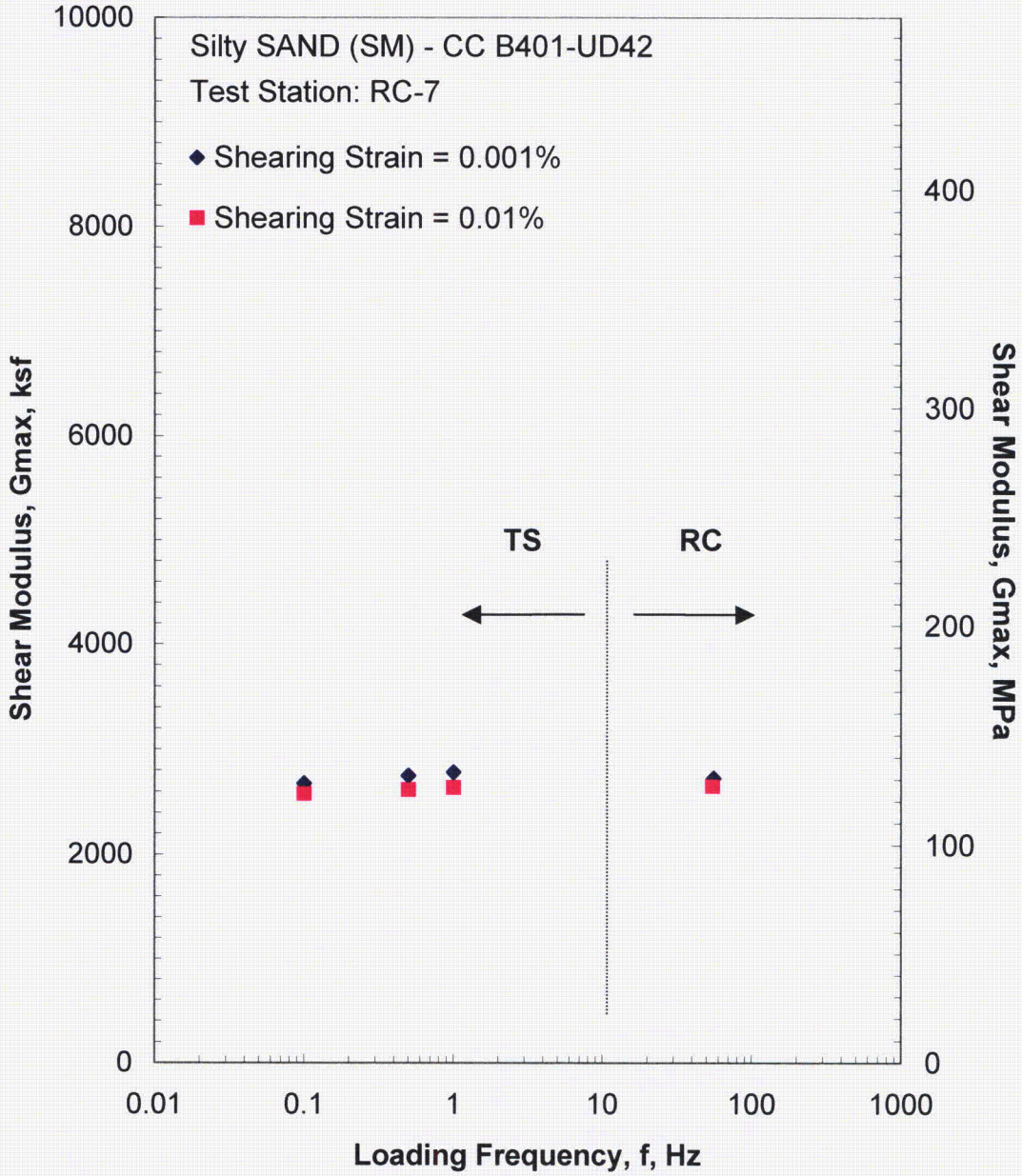


Figure L.14 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 62.5 psi from the Combined RCTS Tests

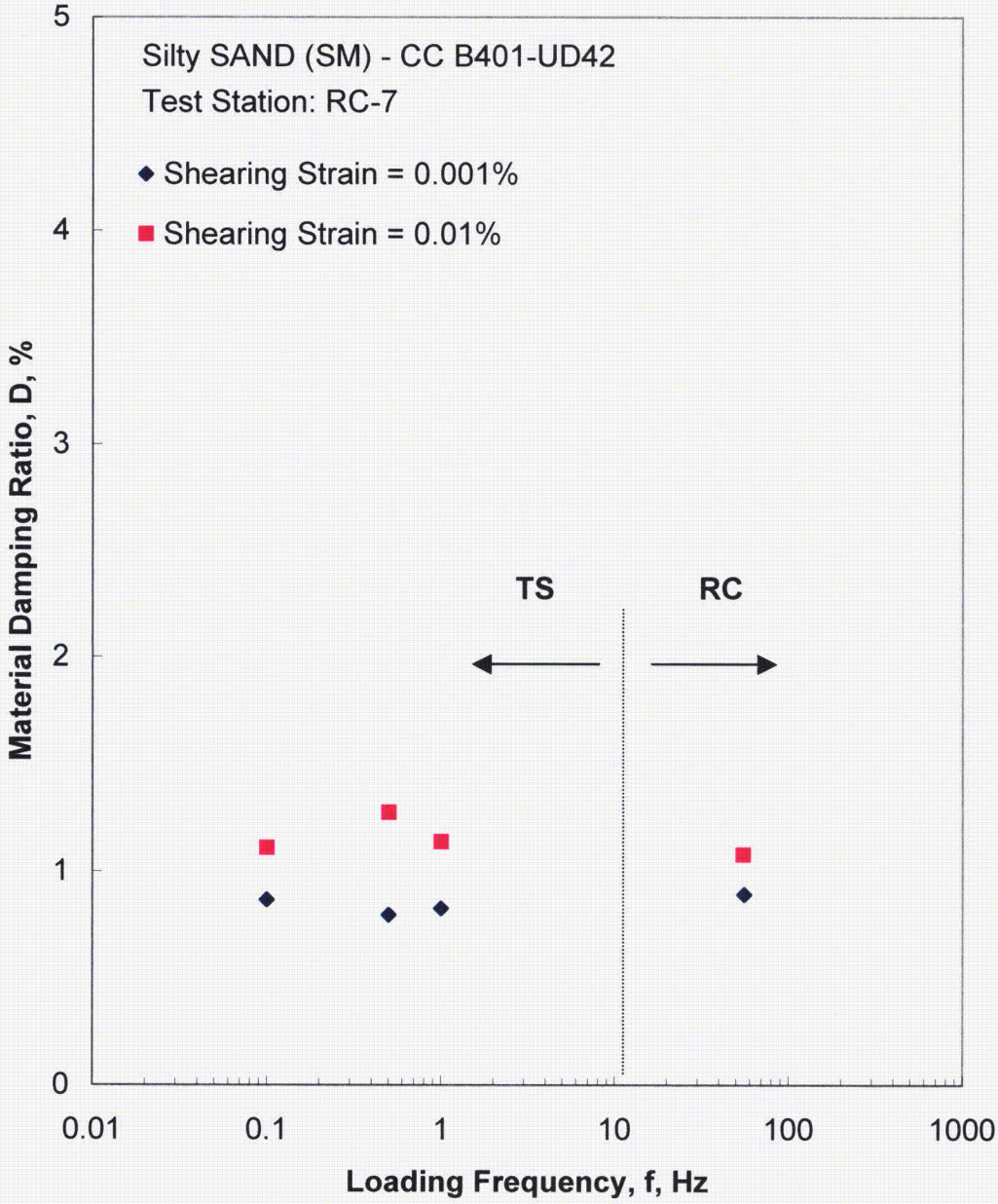


Figure L.15 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 62.5 psi from the Combined RCTS Tests

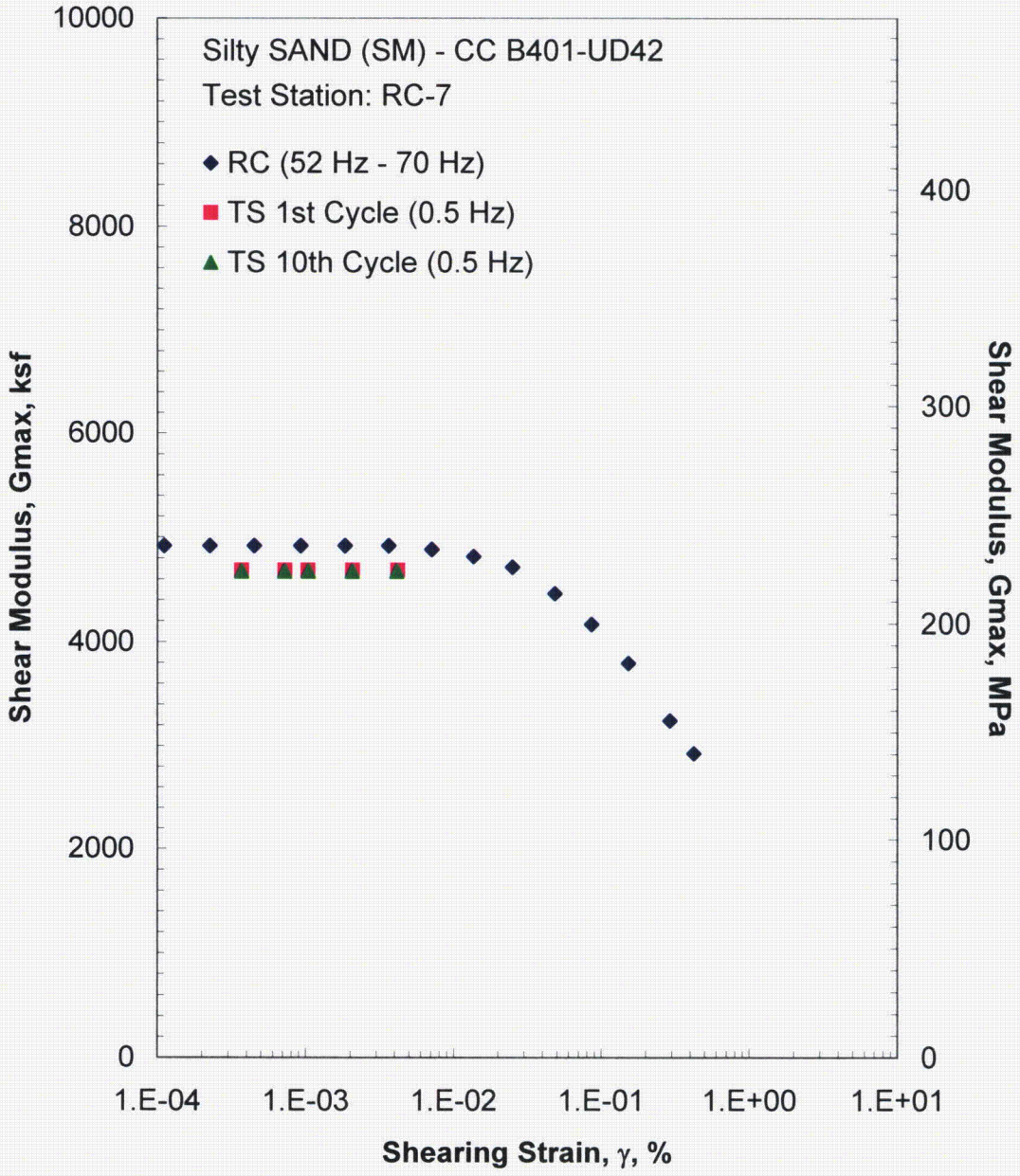


Figure L.16 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 250.0 psi from the Combined RCTS Tests

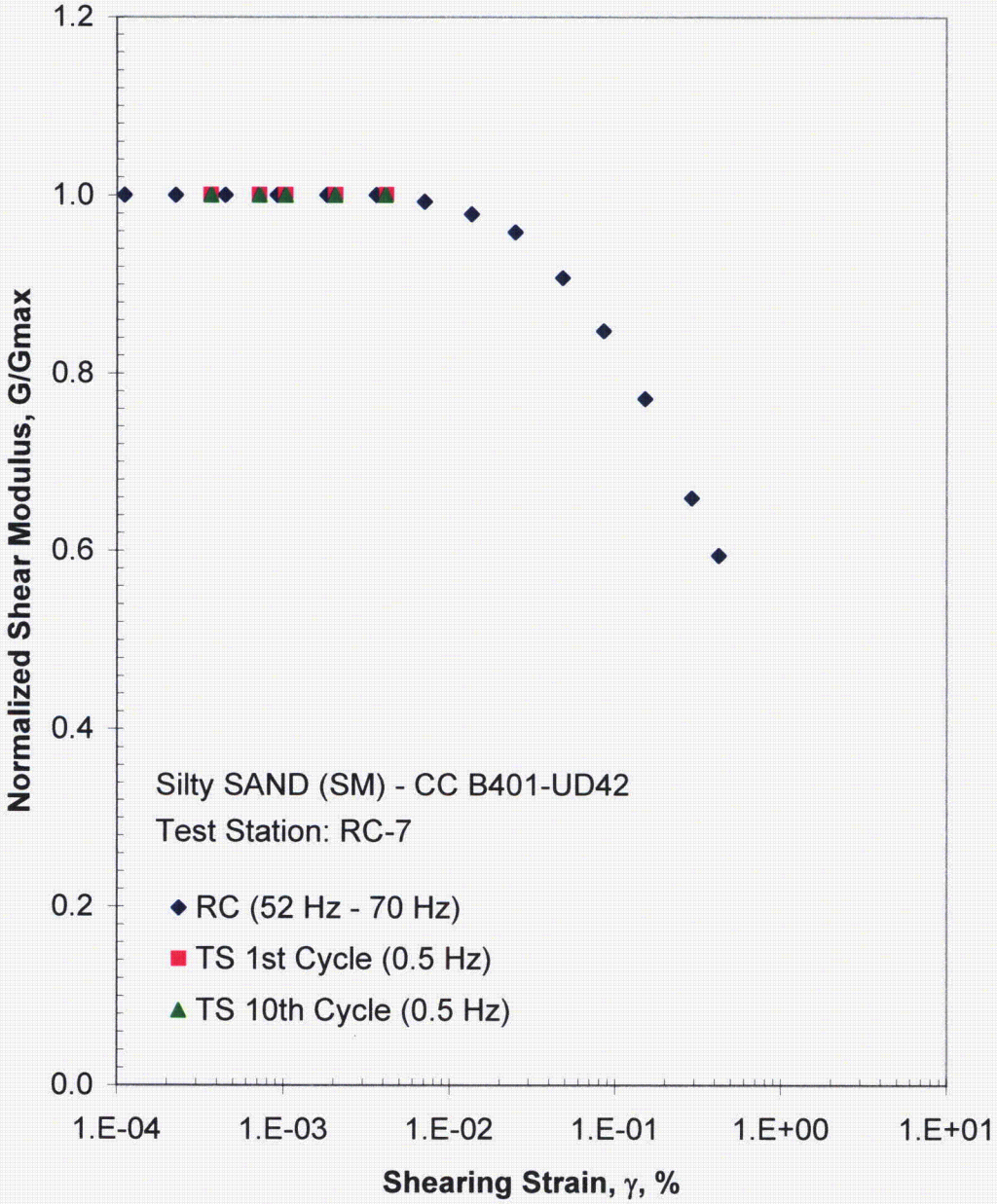


Figure L.17 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 250.0 psi from the Combined RCTS Tests

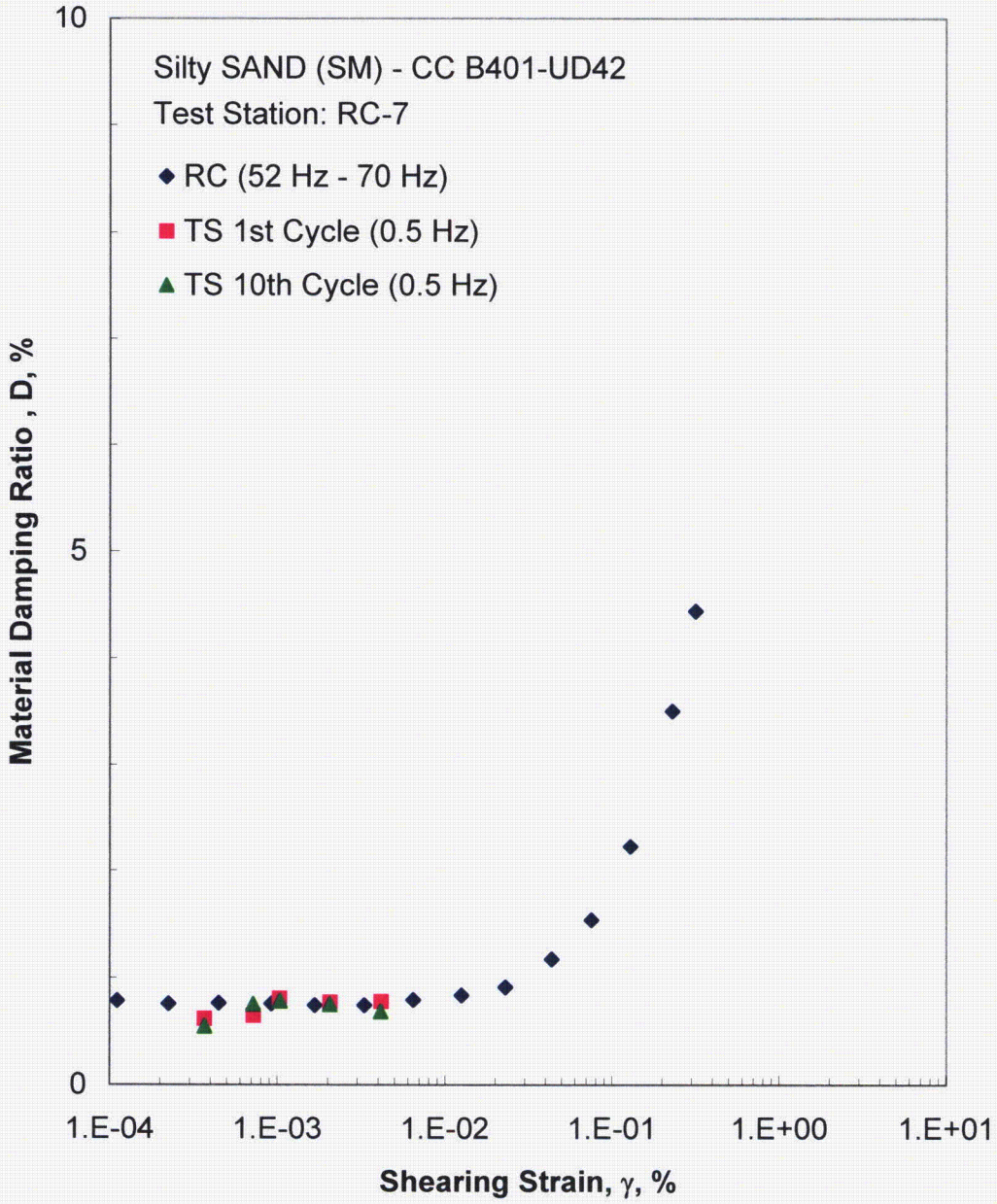


Figure L.18 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 250.0 psi from the Combined RCTS Tests

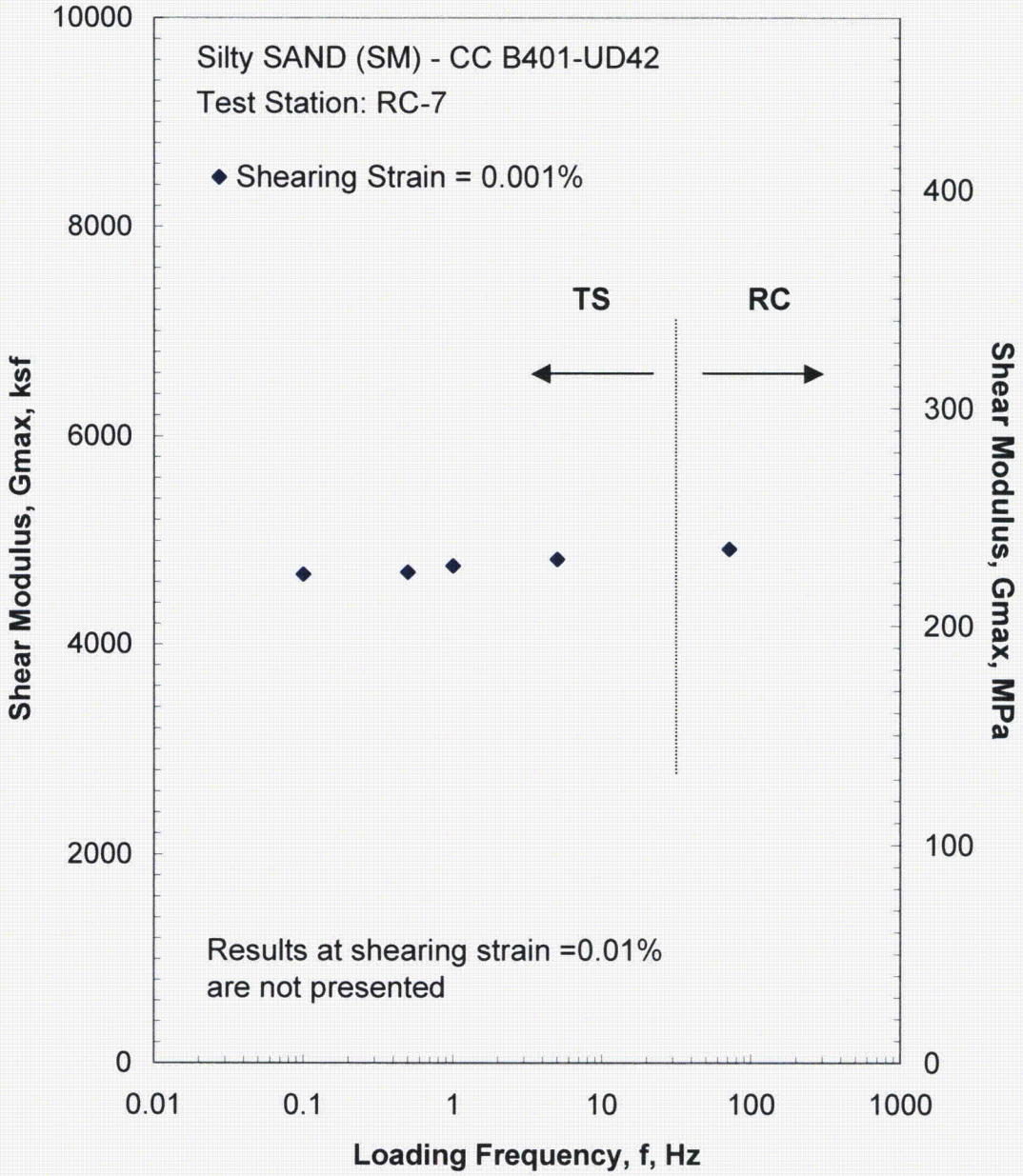


Figure L.19 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 250.0 psi from the Combined RCTS Tests

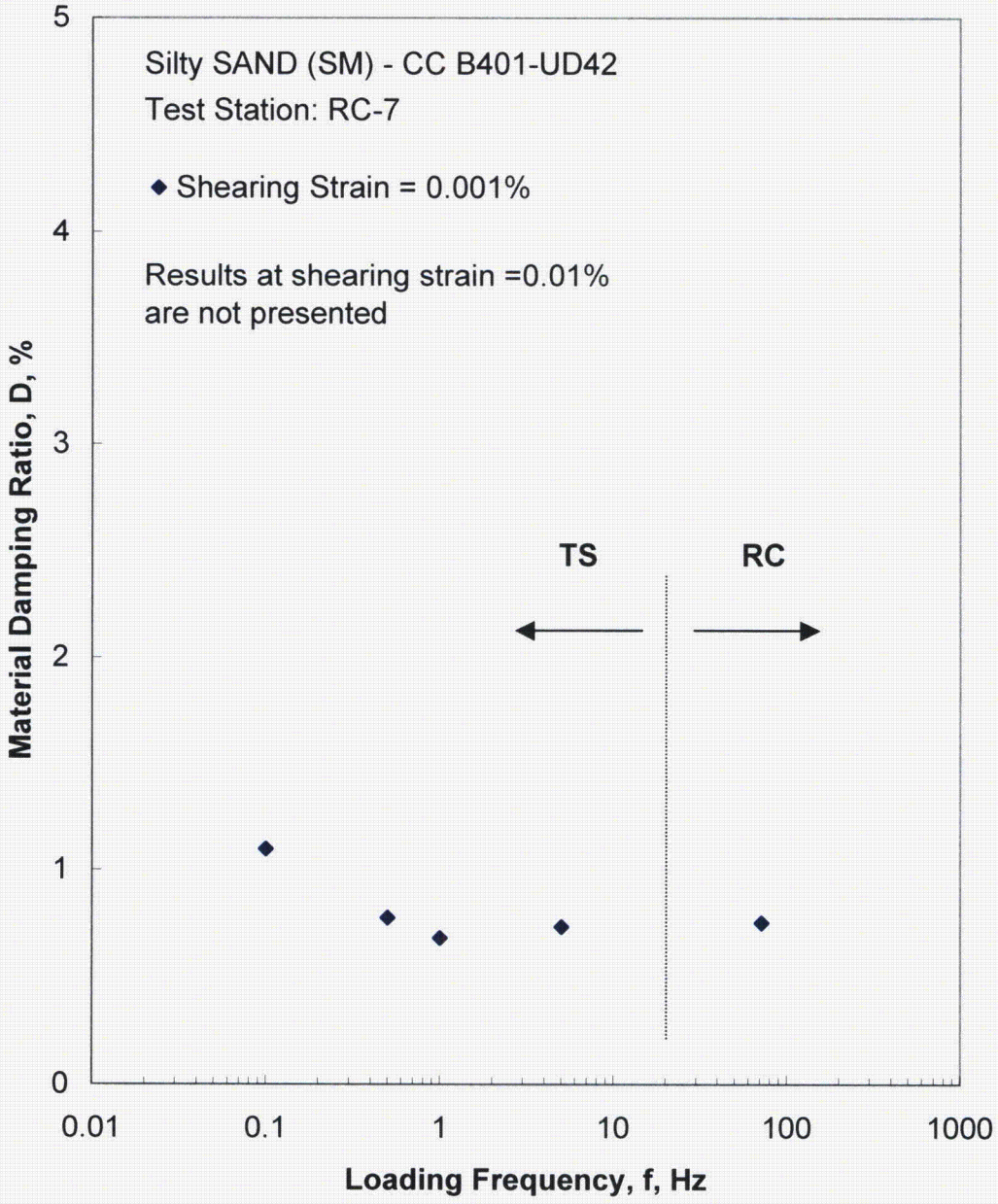


Figure L.20 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 250.0 psi from the Combined RCTS Tests

Table L.1 Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Estimated Void Ratio with Isotropic Confining Pressure from RC Tests of Specimen CC B401-UD42

Isotropic Confining Pressure, σ_o			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin	Estimated Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	(%)	
15.6	2246	107	1576	76	705	1.21	1.455
31.3	4507	216	2072	99	806	1.13	1.443
62.5	9000	431	2736	131	923	1.08	1.425
125.0	18000	861	3461	166	1033	0.99	1.401
250.0	36000	1723	4674	224	1176	0.91	1.307

Table L.2 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen CC B401-UD42; Isoptropic Confining Pressure, σ_o=62.5 psi (9.0 ksf = 431 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
2.56E-04	2714	1.00	2.56E-04	0.89
5.08E-04	2714	1.00	5.08E-04	0.89
1.09E-03	2714	1.00	1.09E-03	0.89
2.13E-03	2714	1.00	1.96E-03	0.89
4.16E-03	2714	1.00	3.75E-03	0.91
8.12E-03	2699	0.99	7.30E-03	0.93
1.53E-02	2650	0.98	1.36E-02	1.08
2.79E-02	2553	0.94	2.49E-02	1.15
5.01E-02	2413	0.89	4.41E-02	1.35
9.01E-02	2206	0.81	7.75E-02	1.86
1.66E-01	1955	0.72	1.34E-01	2.80
3.22E-01	1658	0.61	2.45E-01	3.97

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table L.3 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen CC B401-UD42; Isotropic Confining Pressure, σ_o= 62.5 psi (9.0 ksf =431 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
7.34E-04	2730	1.00	0.77	7.31E-04	2727	1.00	0.69
1.03E-03	2730	1.00	0.84	1.04E-03	2727	1.00	0.80
2.08E-03	2730	1.00	0.84	2.08E-03	2727	1.00	0.80
4.19E-03	2730	1.00	0.81	4.19E-03	2727	1.00	0.85
1.04E-02	2730	1.00	1.09	1.03E-02	2727	1.00	1.27

Table L.4 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen CC B401-UD42; Isoptropic Confining Pressure, σ_o= 250.0 psi (36.0 ksf = 1723 kPa)

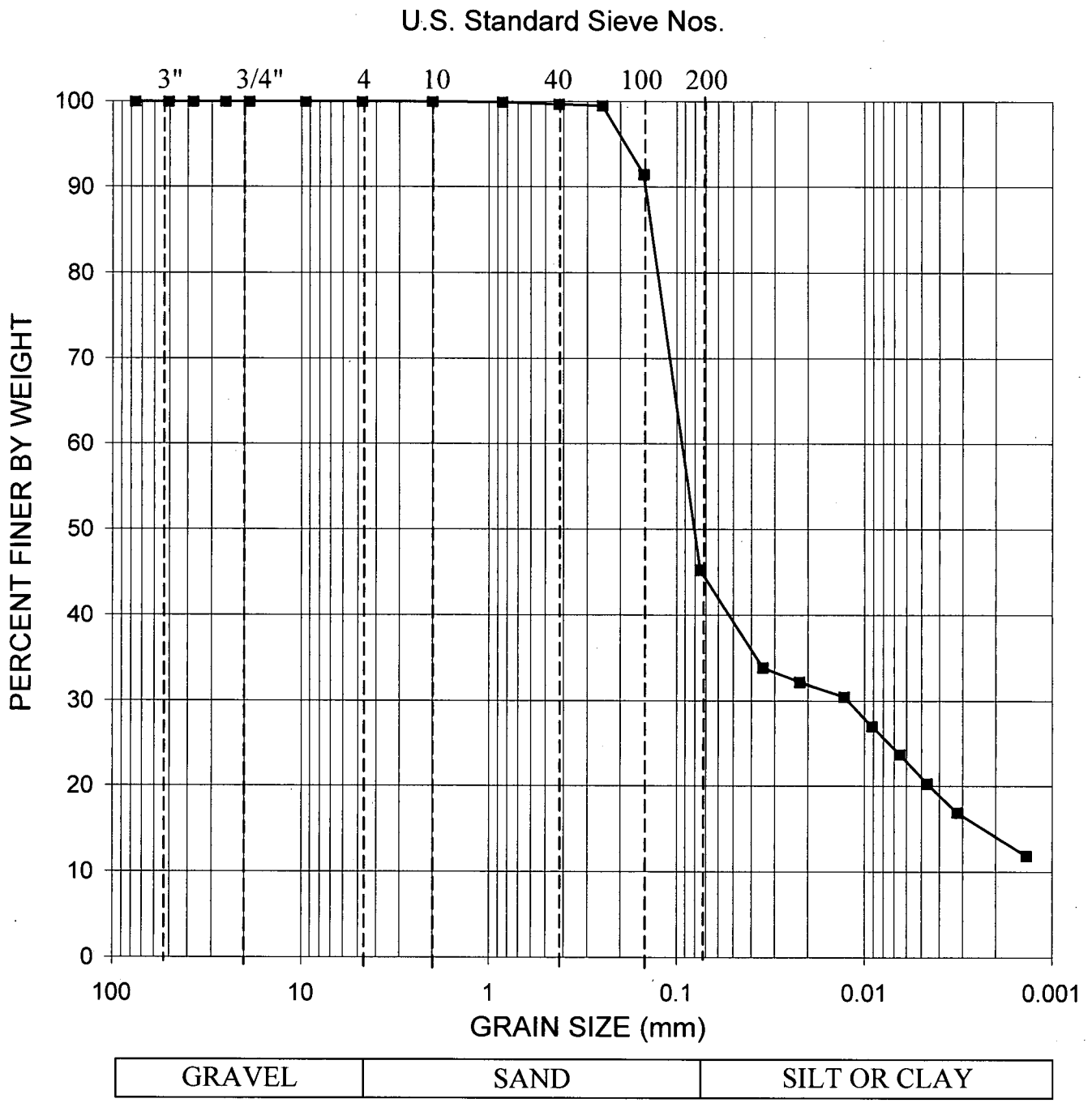
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
1.11E-04	4917	1.00	1.11E-04	0.78
2.25E-04	4917	1.00	2.25E-04	0.75
4.48E-04	4917	1.00	4.48E-04	0.76
9.23E-04	4917	1.00	9.23E-04	0.75
1.84E-03	4917	1.00	1.67E-03	0.74
3.63E-03	4917	1.00	3.30E-03	0.74
7.11E-03	4883	0.99	6.47E-03	0.79
1.36E-02	4814	0.98	1.25E-02	0.83
2.50E-02	4714	0.96	2.30E-02	0.91
4.82E-02	4461	0.91	4.34E-02	1.17
8.54E-02	4167	0.85	7.52E-02	1.54
1.52E-01	3792	0.77	1.29E-01	2.22
2.90E-01	3241	0.66	2.29E-01	3.50
4.21E-01	2923	0.59	3.16E-01	4.44

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table L.5 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen CC B401-UD42; Isotropic Confining Pressure, σ_o=250.0 psi (36.0 ksf = 1723 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
3.67E-04	4680	1.00	0.61	3.70E-04	4671	1.00	0.54
7.19E-04	4680	1.00	0.64	7.20E-04	4671	1.00	0.75
1.03E-03	4680	1.00	0.80	1.04E-03	4671	1.00	0.78
2.06E-03	4680	1.00	0.77	2.06E-03	4671	1.00	0.75
4.16E-03	4680	1.00	0.77	4.13E-03	4671	1.00	0.68



GRADATION CURVE

ASTM D422

Project:	Constellation Energy Group COLA Project, Calvert Cliffs NuclearPower Plant (CCNPP), Calvert County, Maryland		Contract No.:	06120048.00	Date:	10/18/2007
Boring No.	Depth (ft)	Sample Description	Class.	LL	PI	
B-401	198.5-200.3	SILTY SAND, greenish gray	SM	82	27	Schnabel Engineering

APPENDIX M

CC B409-UD39
Silty SAND (SM), contains shells, greenish gray*
(LL=61, PL=42, PI=19; Gs=2.64)*

Borehole B-409
Sample UD39
Sample Depth =95.0 to 96.6 ft
RCTS Test Depth = 96.1 ft
Total Unit Weight = 109.3 lb/ft^3
Water Content = 33.1 %
Estimated In-Situ Ko = 0.5*
Estimated In-Situ Mean Effective Stress = 28.0 psi*

*Data supplied by Schnabel Engineering, Inc.

FUGRO JOB #: 0401-1661
Testing Station: RC7

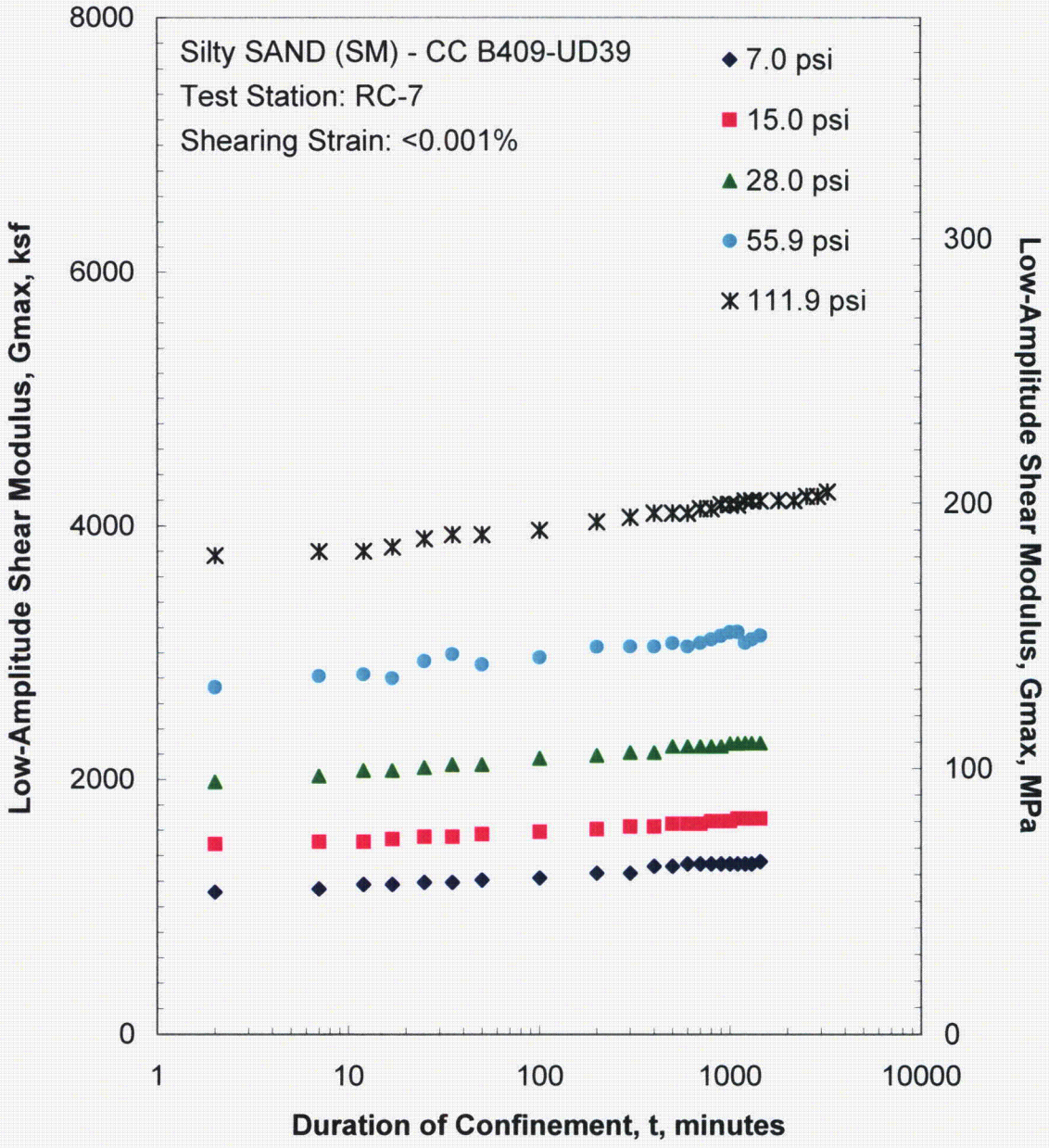


Figure M.1 Variation in Low-Amplitude Shear Modulus with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

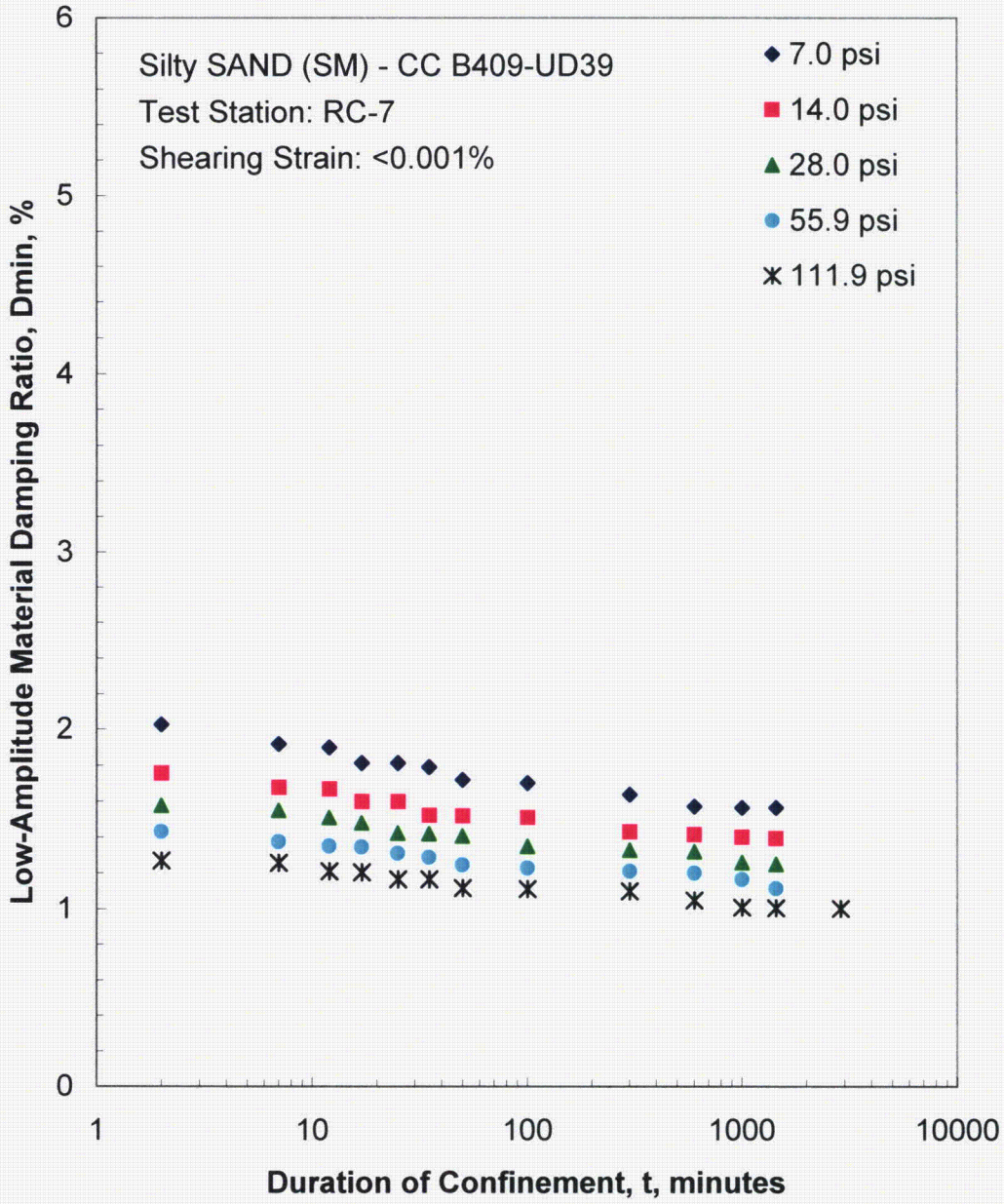


Figure M.2 Variation in Low-Amplitude Material Damping Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

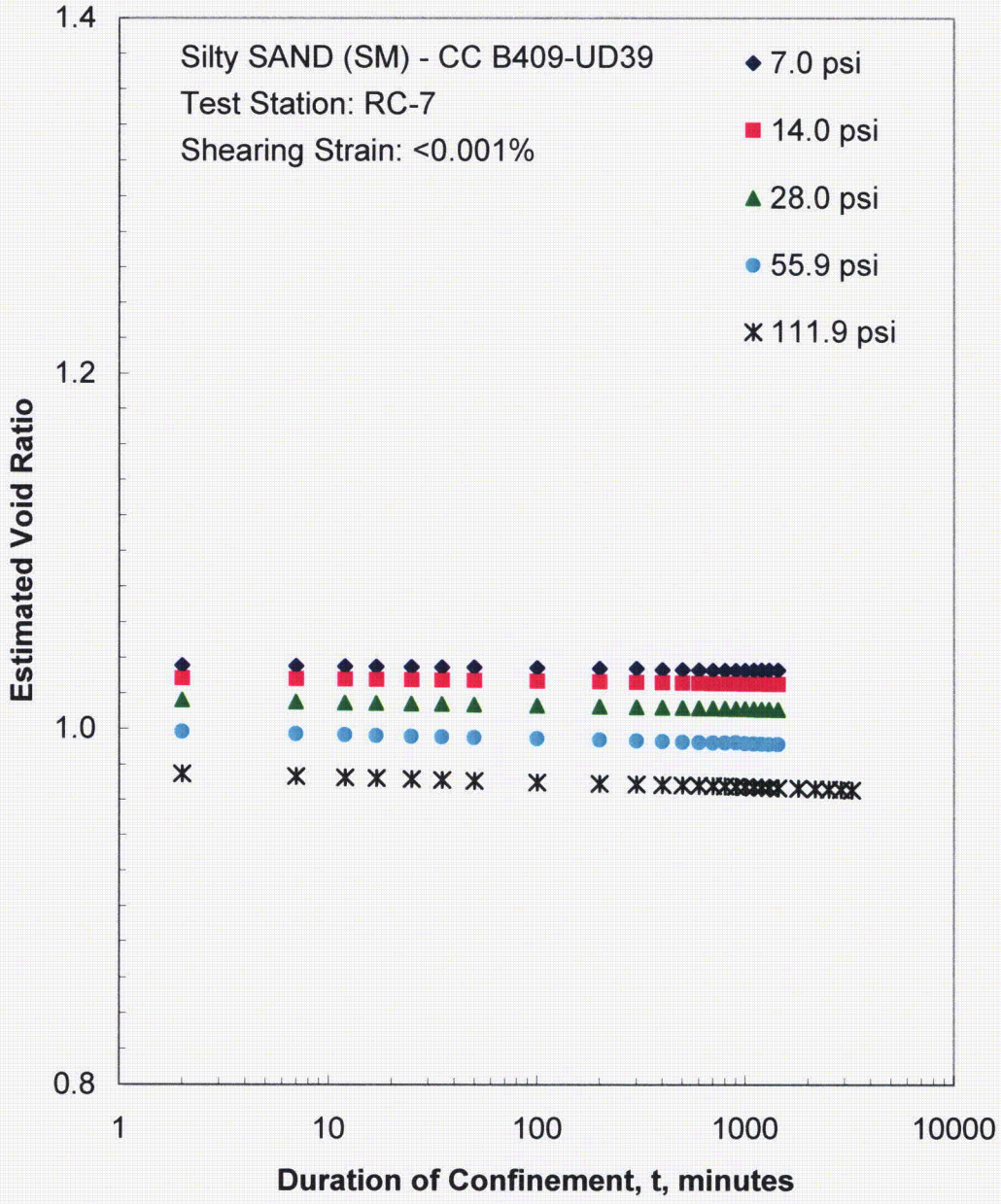


Figure M.3 Variation in Estimated Void Ratio with Magnitude and Duration of Isotropic Confining Pressure from Resonant Column Tests

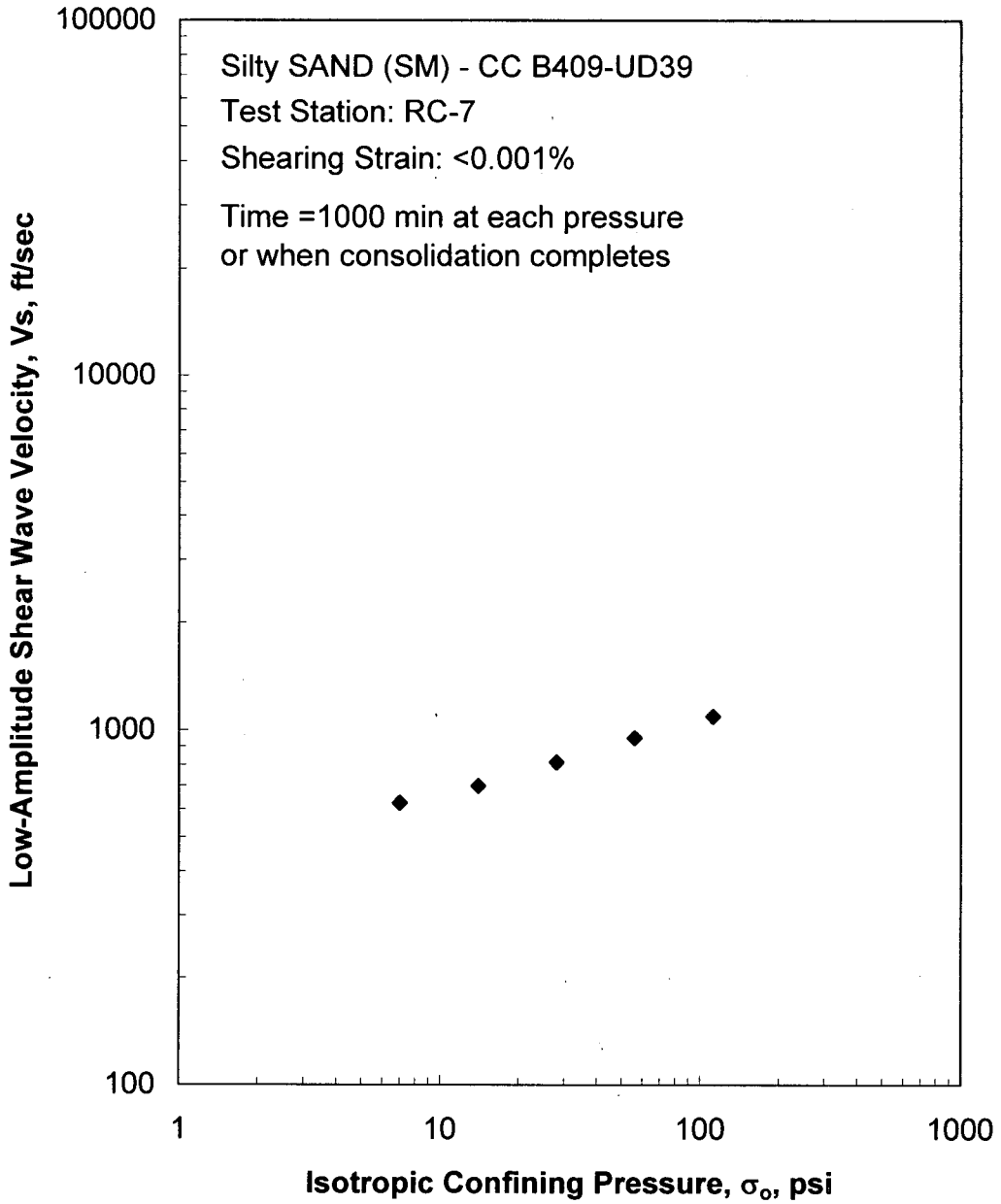


Figure M.4 Variation in Low-Amplitude Shear Wave Velocity with Isotropic Confining Pressure from Resonant Column Tests

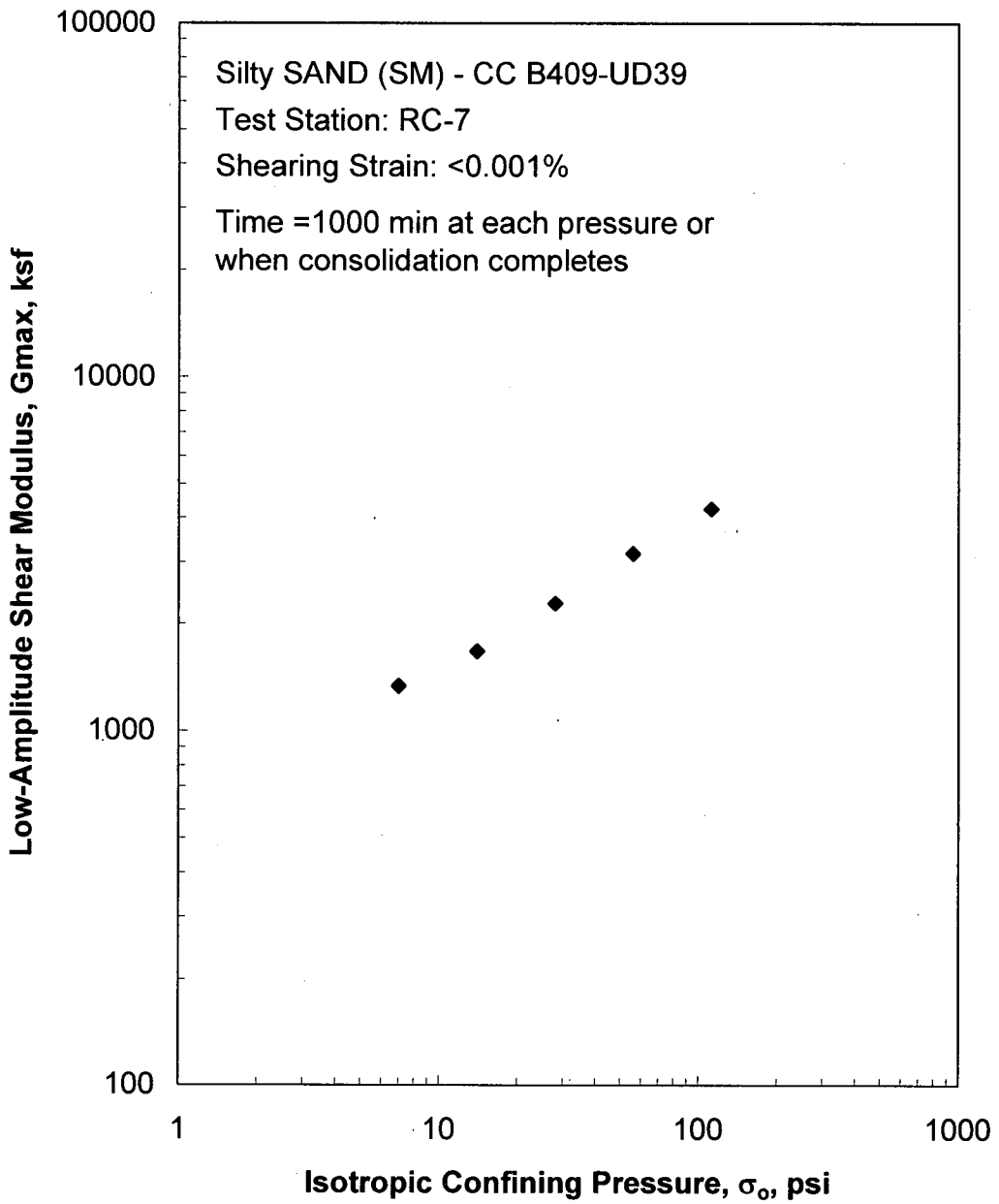


Figure M.5 Variation in Low-Amplitude Shear Modulus with Isotropic Confining Pressure from Resonant Column Tests

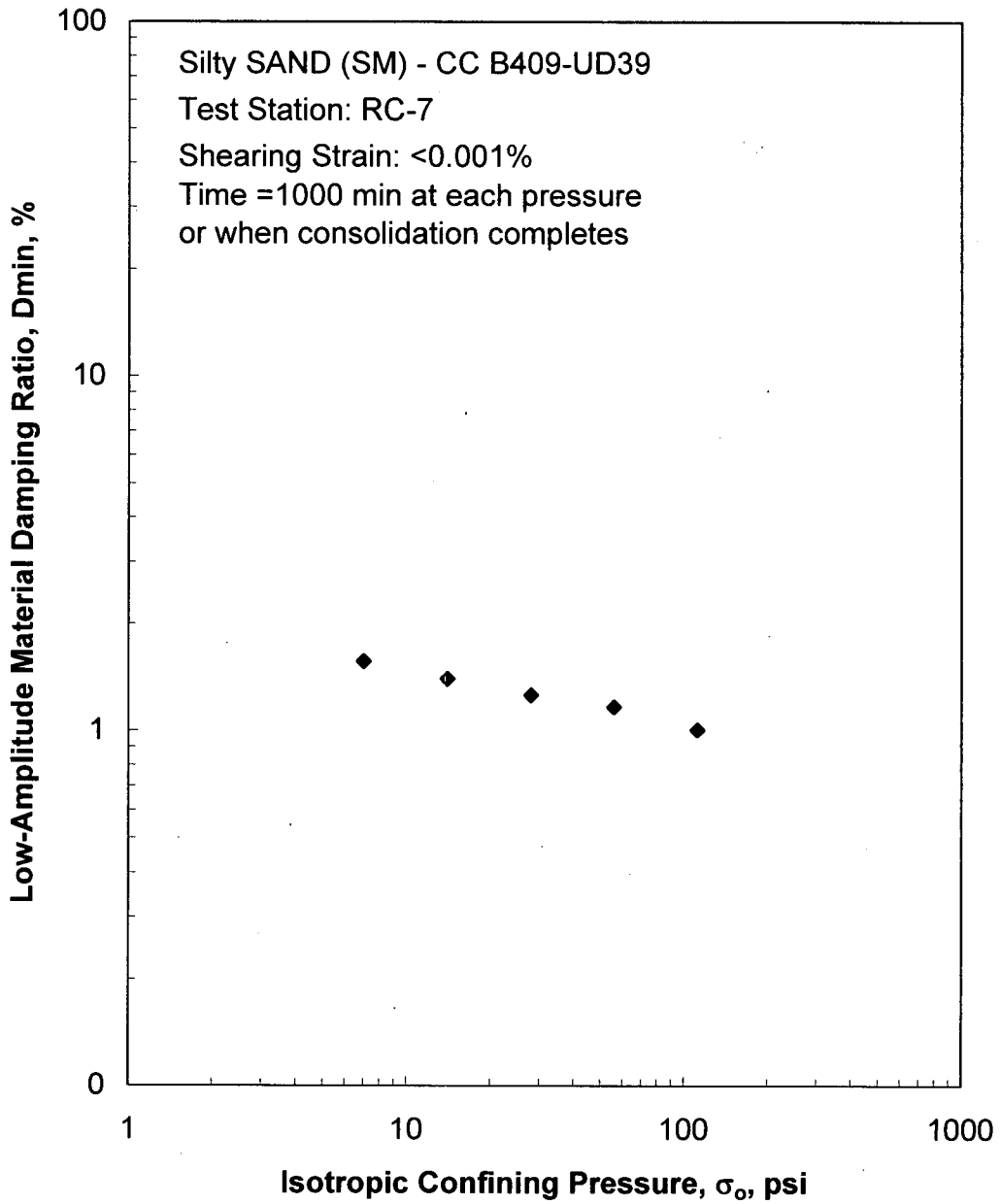


Figure M.6 Variation in Low-Amplitude Material Damping Ratio with Isotropic Confining Pressure from Resonant Column Tests

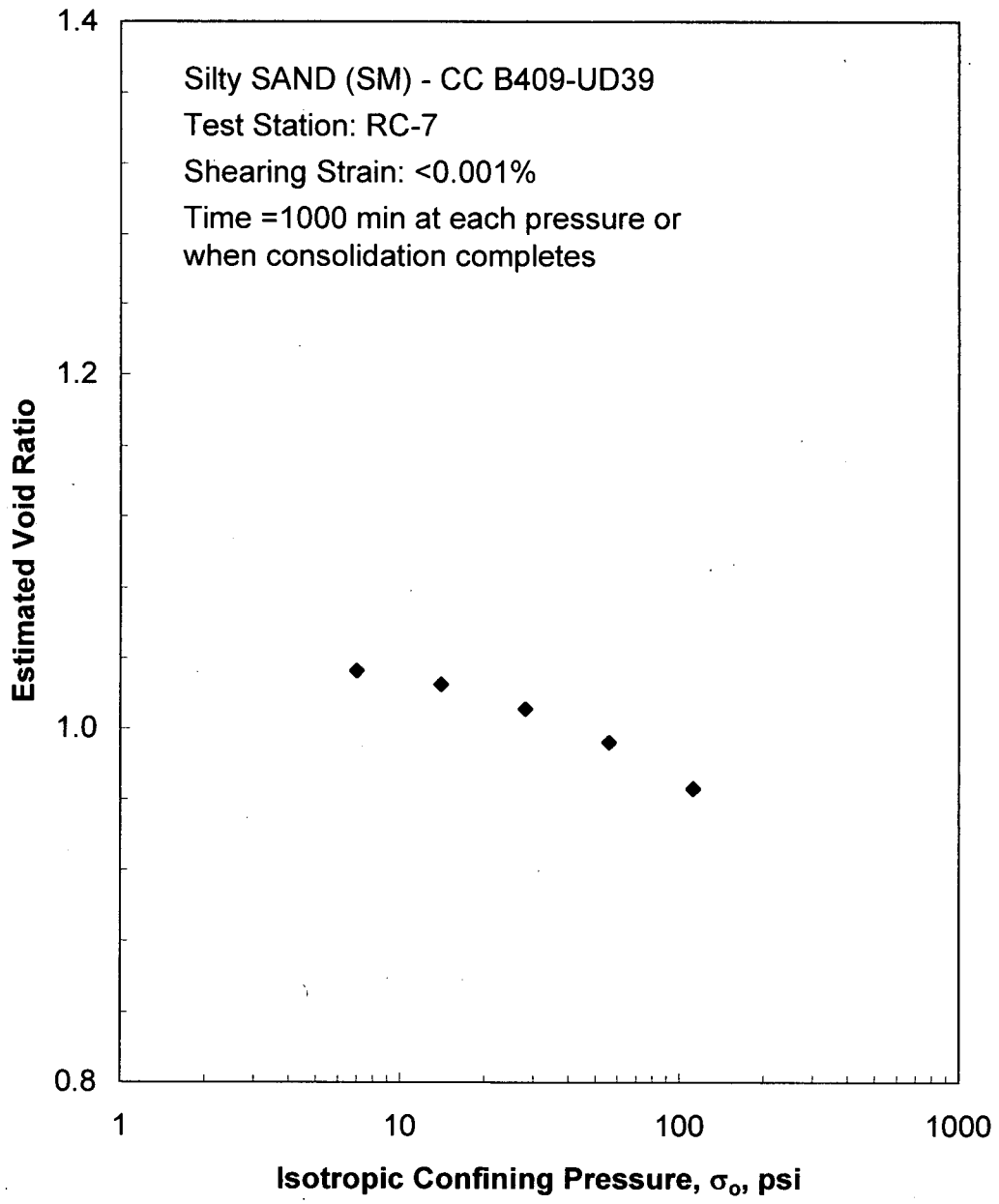


Figure M.7 Variation in Estimated Void Ratio with Isotropic Confining Pressure from Resonant Column Tests

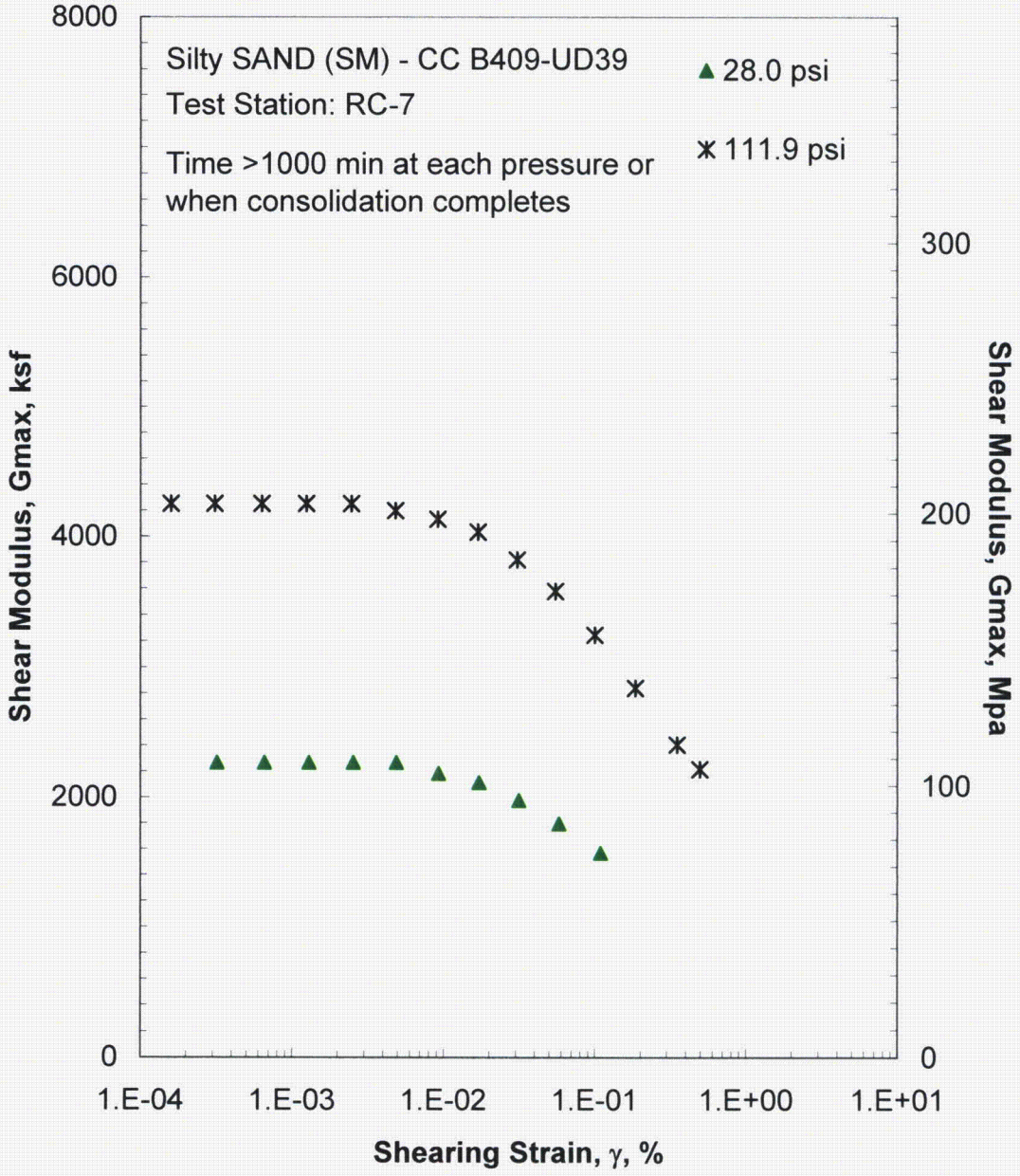


Figure M.8 Comparison of the Variation in Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

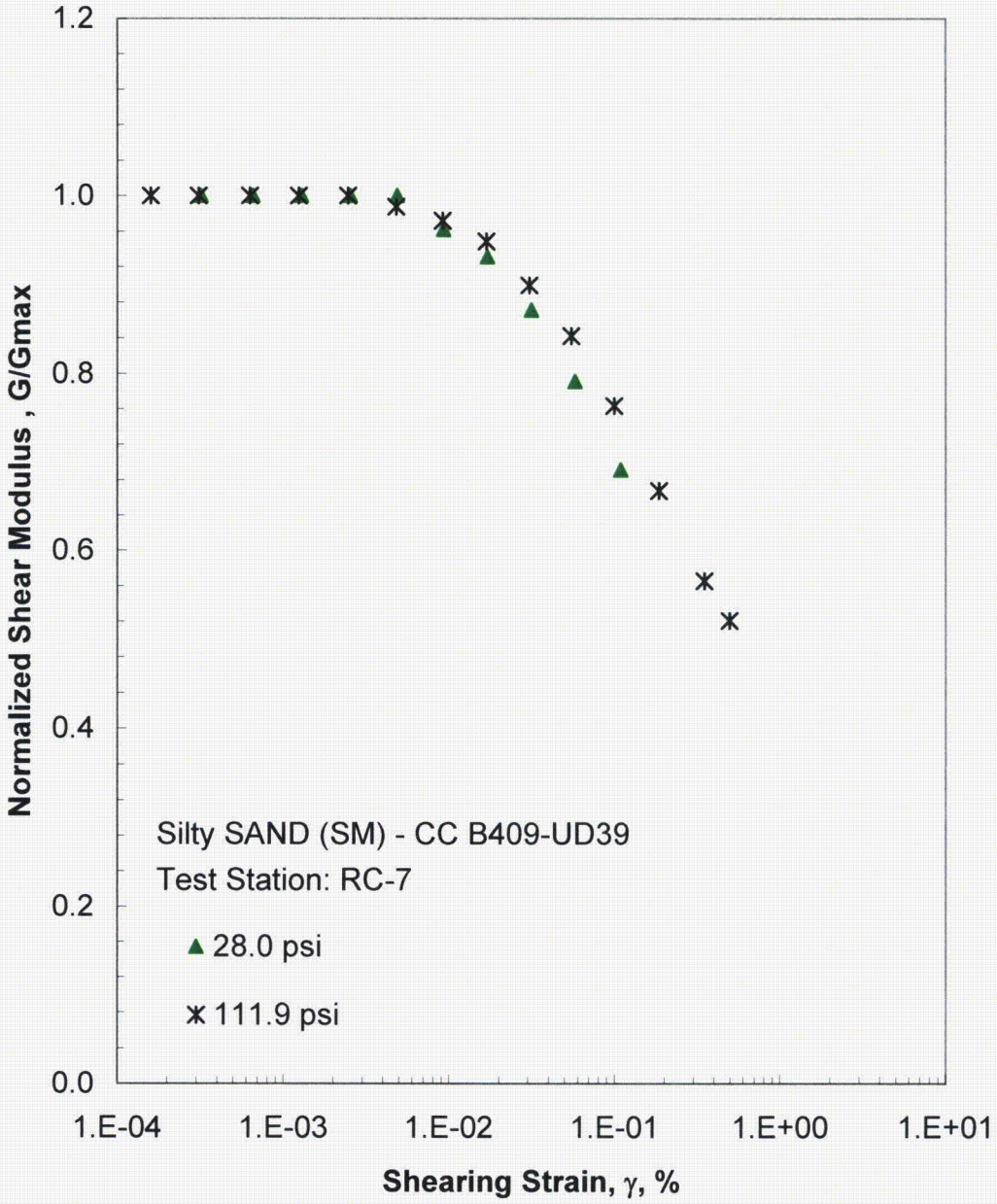


Figure M.9 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

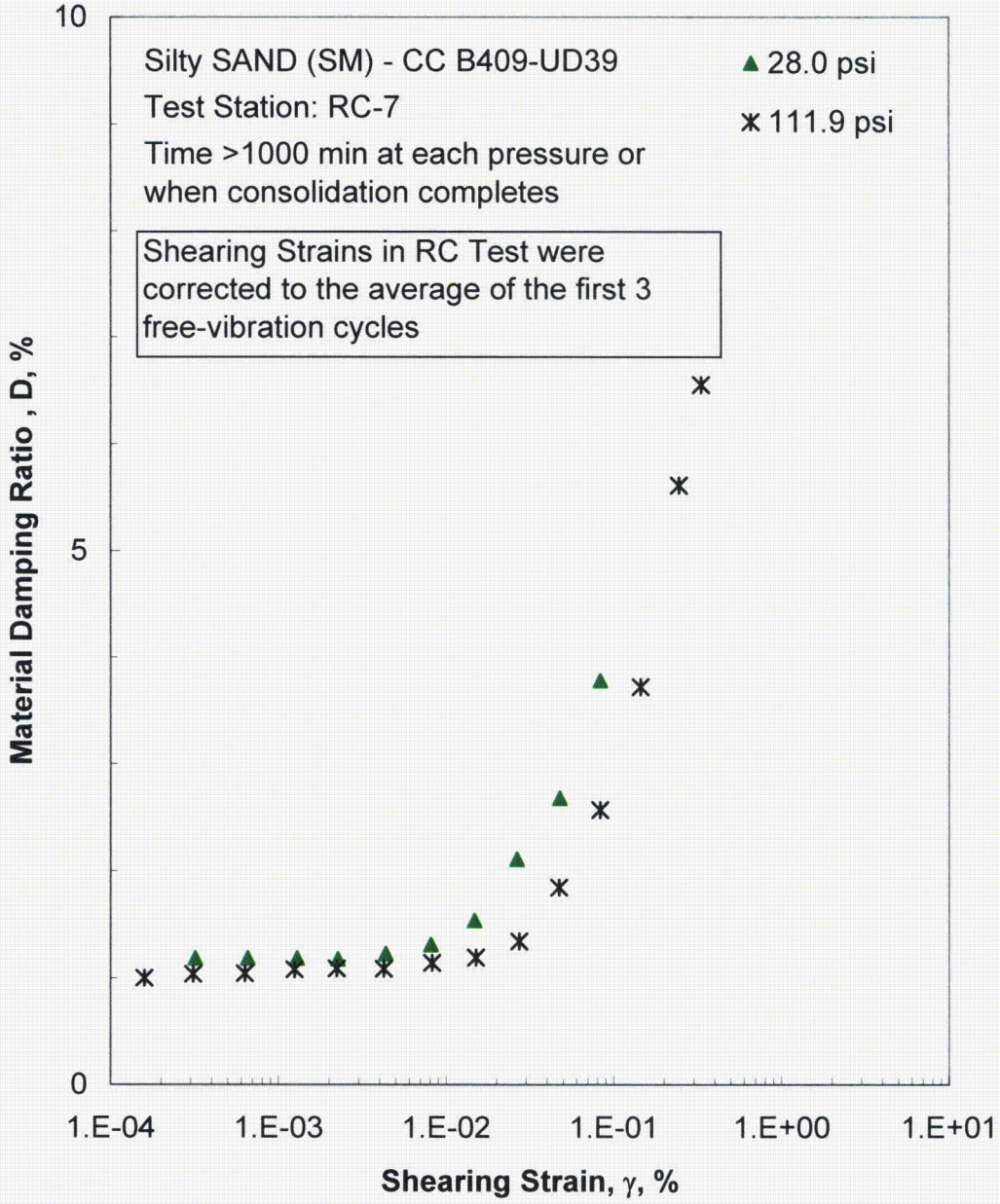


Figure M.10 Comparison of the Variation in Material Damping Ratio with Shearing Strain and Isotropic Confining Pressure from the Resonant Column Tests

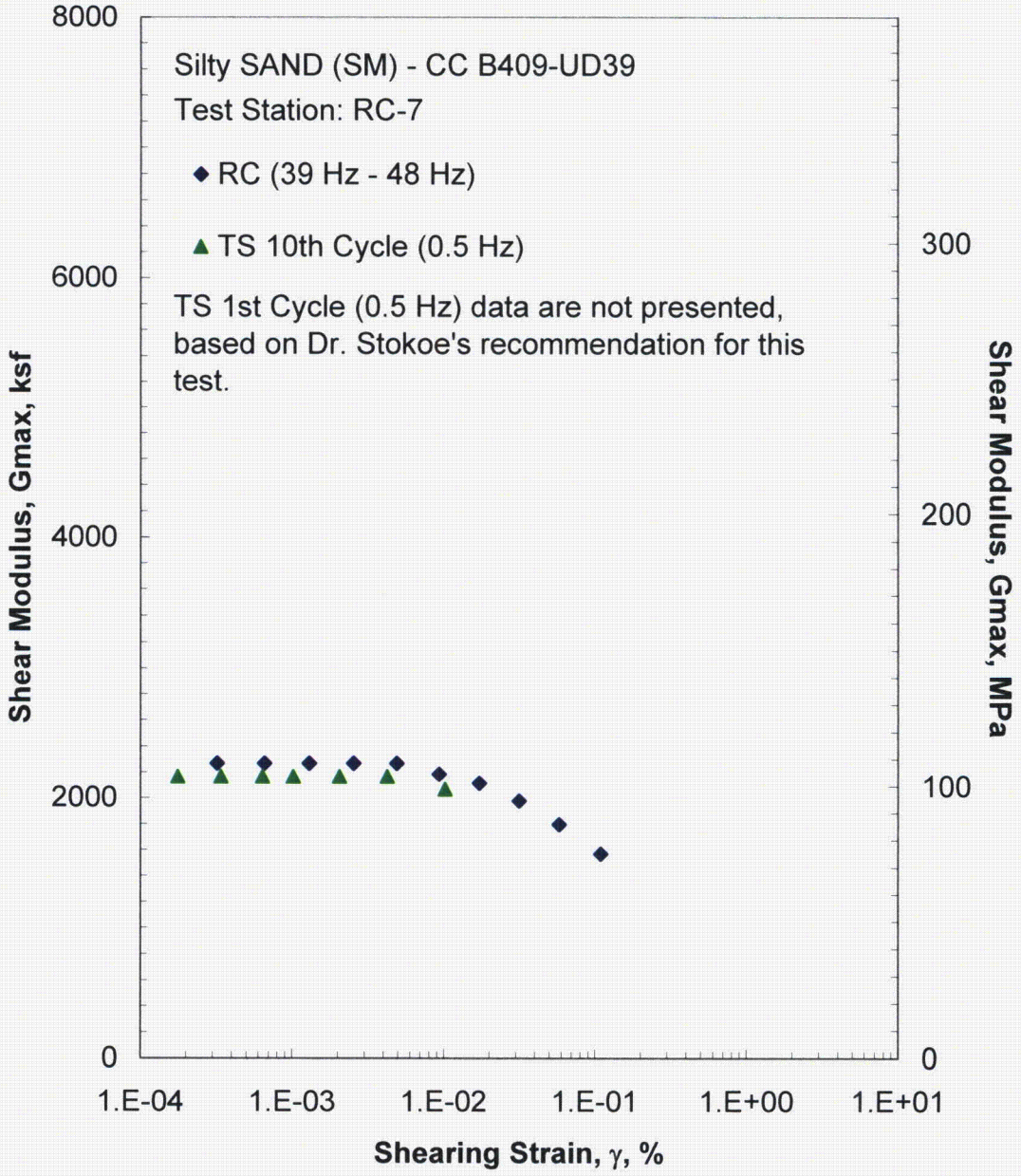


Figure M.11 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 28.0 psi from the Combined RCTS Tests

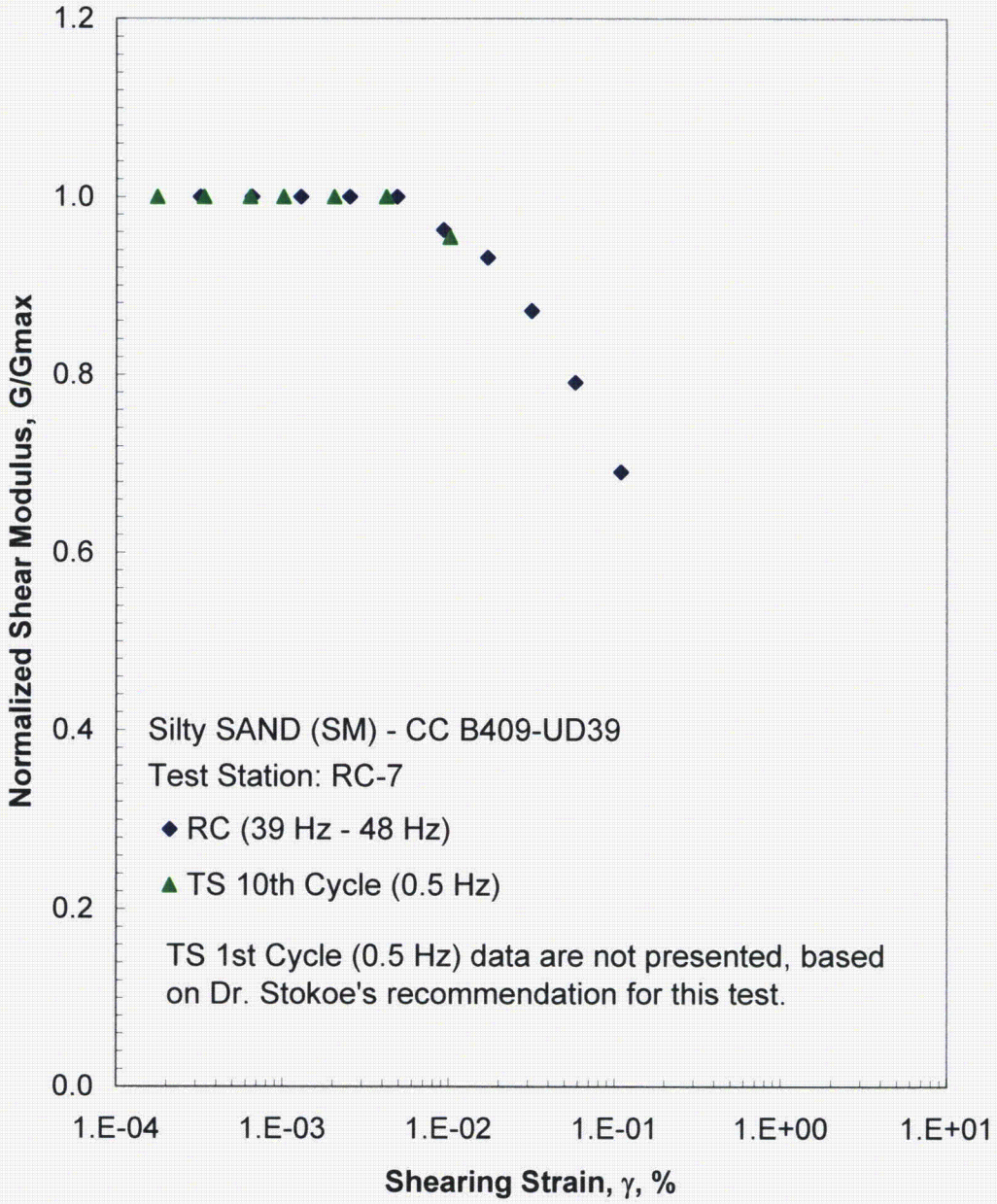


Figure M.12 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 28.0 psi from the Combined RCTS Tests

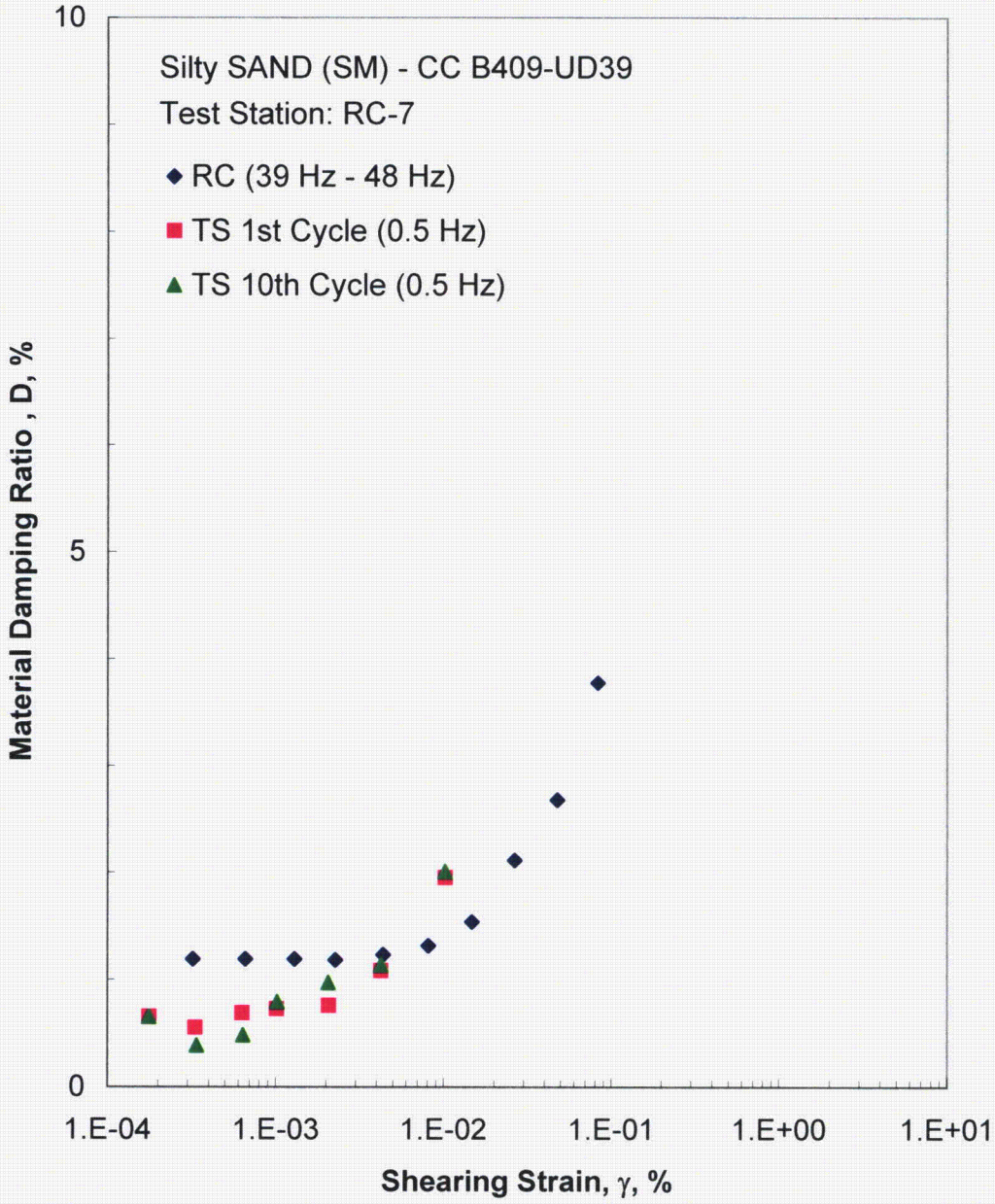


Figure M.13 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 28.0 psi from the Combined RCTS Tests

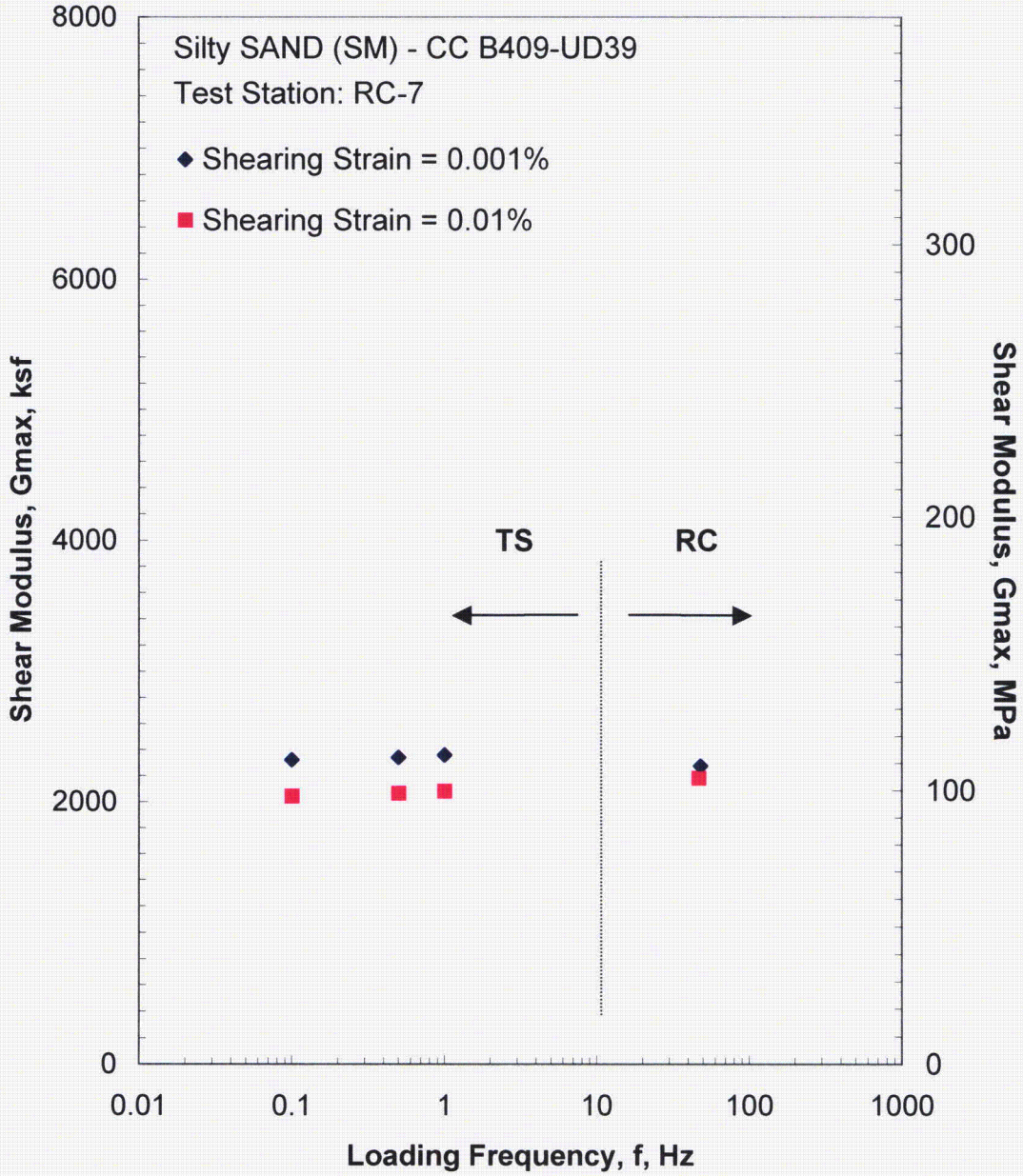


Figure M.14 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 28.0 psi from the Combined RCTS Tests

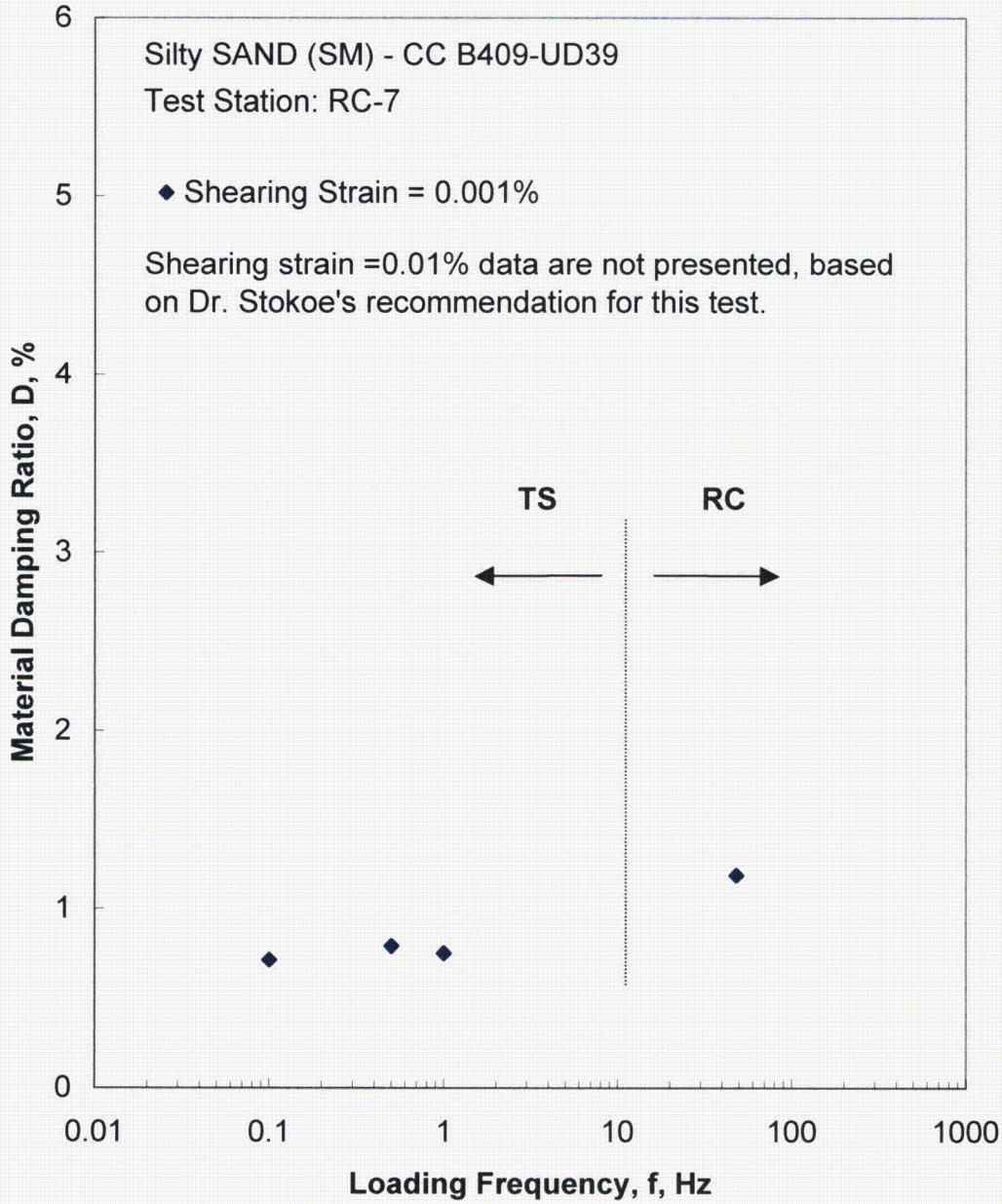


Figure M.15 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 28.0 psi from the Combined RCTS Tests

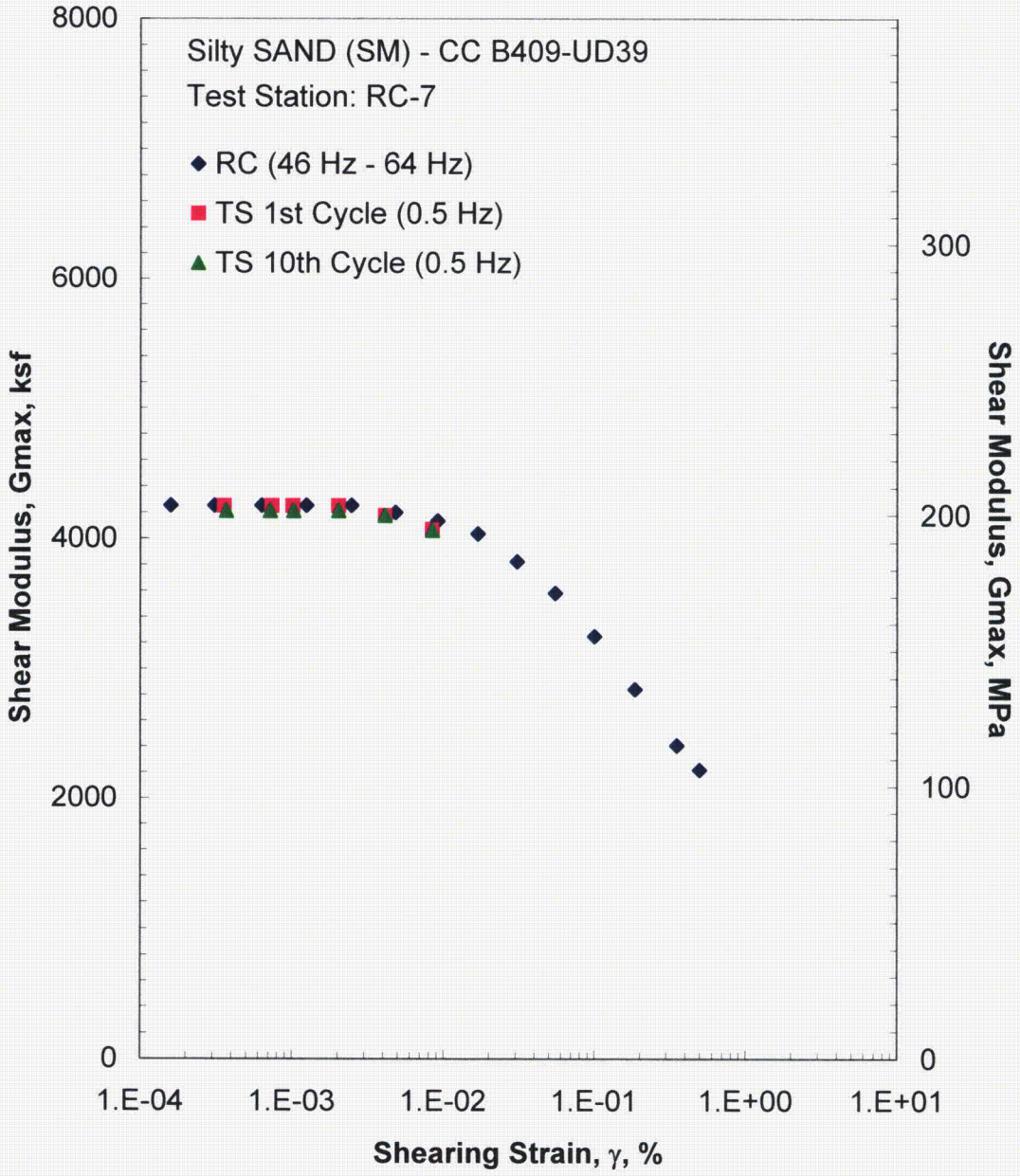


Figure M.16 Comparison of the Variation in Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 111.9 psi from the Combined RCTS Tests

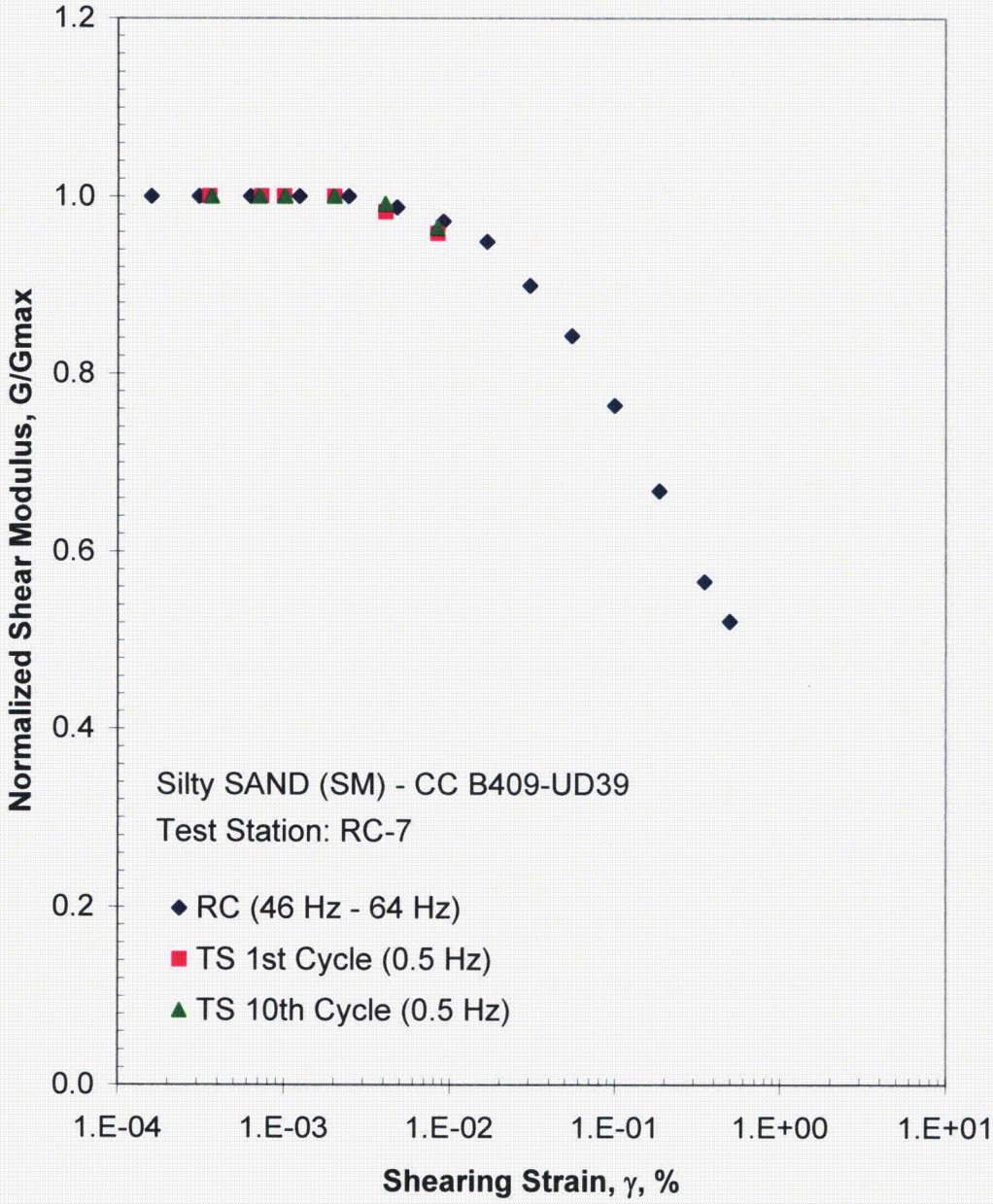


Figure M.17 Comparison of the Variation in Normalized Shear Modulus with Shearing Strain at an Isotropic Confining Pressure of 111.9 psi from the Combined RCTS Tests

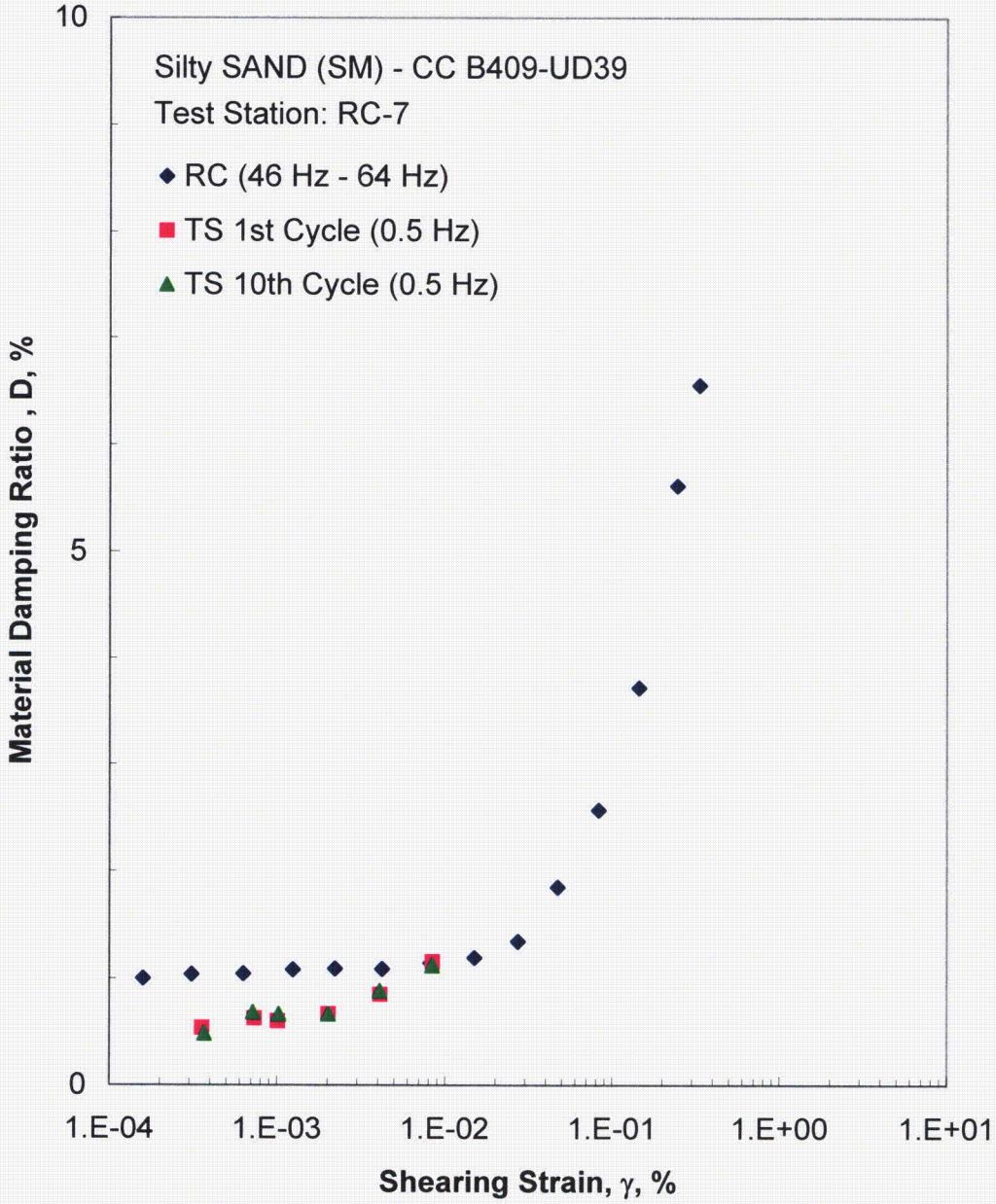


Figure M.18 Comparison of the Variation in Material Damping Ratio with Shearing Strain at an Isotropic Confining Pressure of 111.9 psi from the Combined RCTS Tests

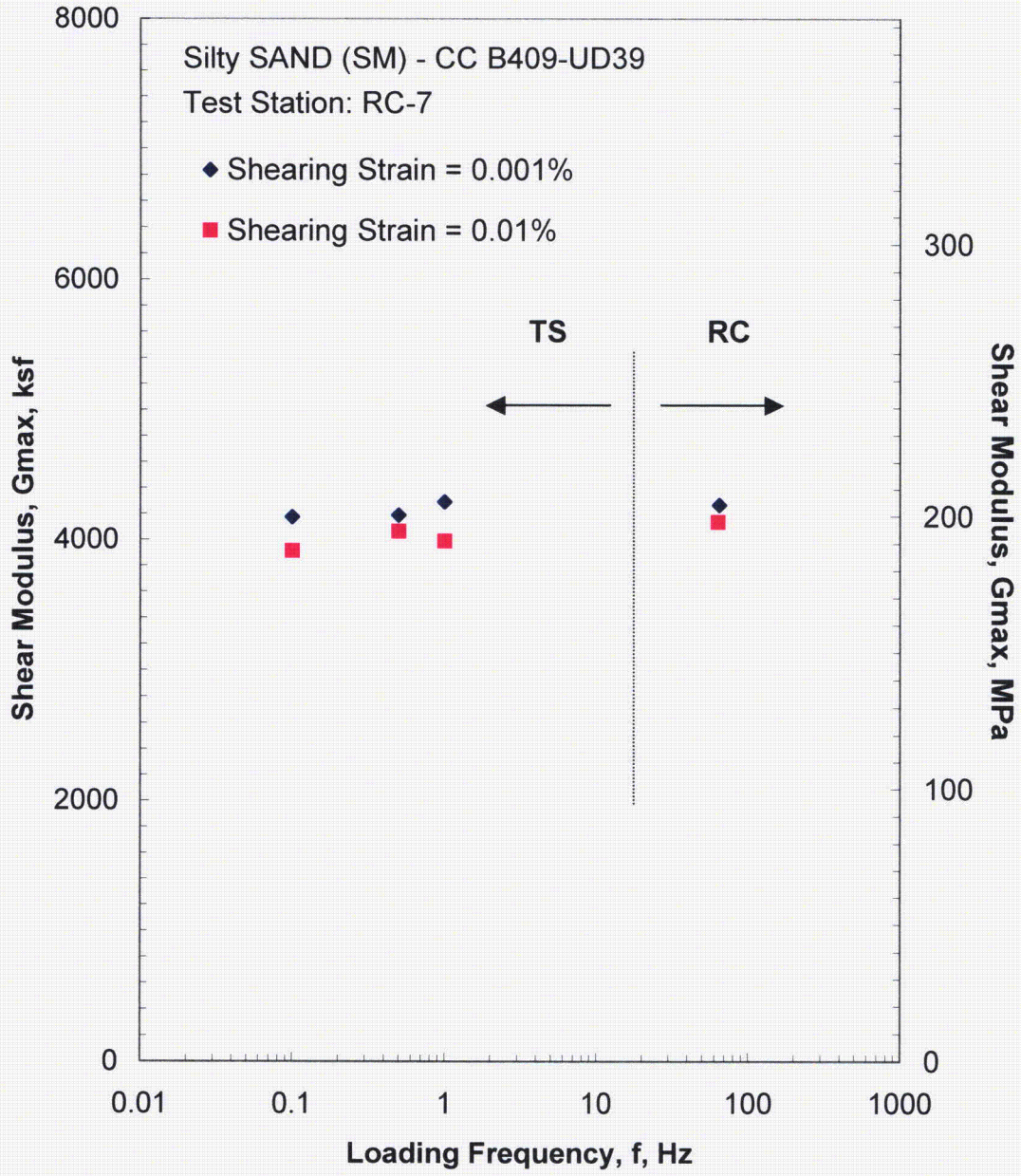


Figure M.19 Comparison of the Variation in Shear Modulus with Loading Frequency at an Isotropic Confining Pressure of 111.9 psi from the Combined RCTS Tests

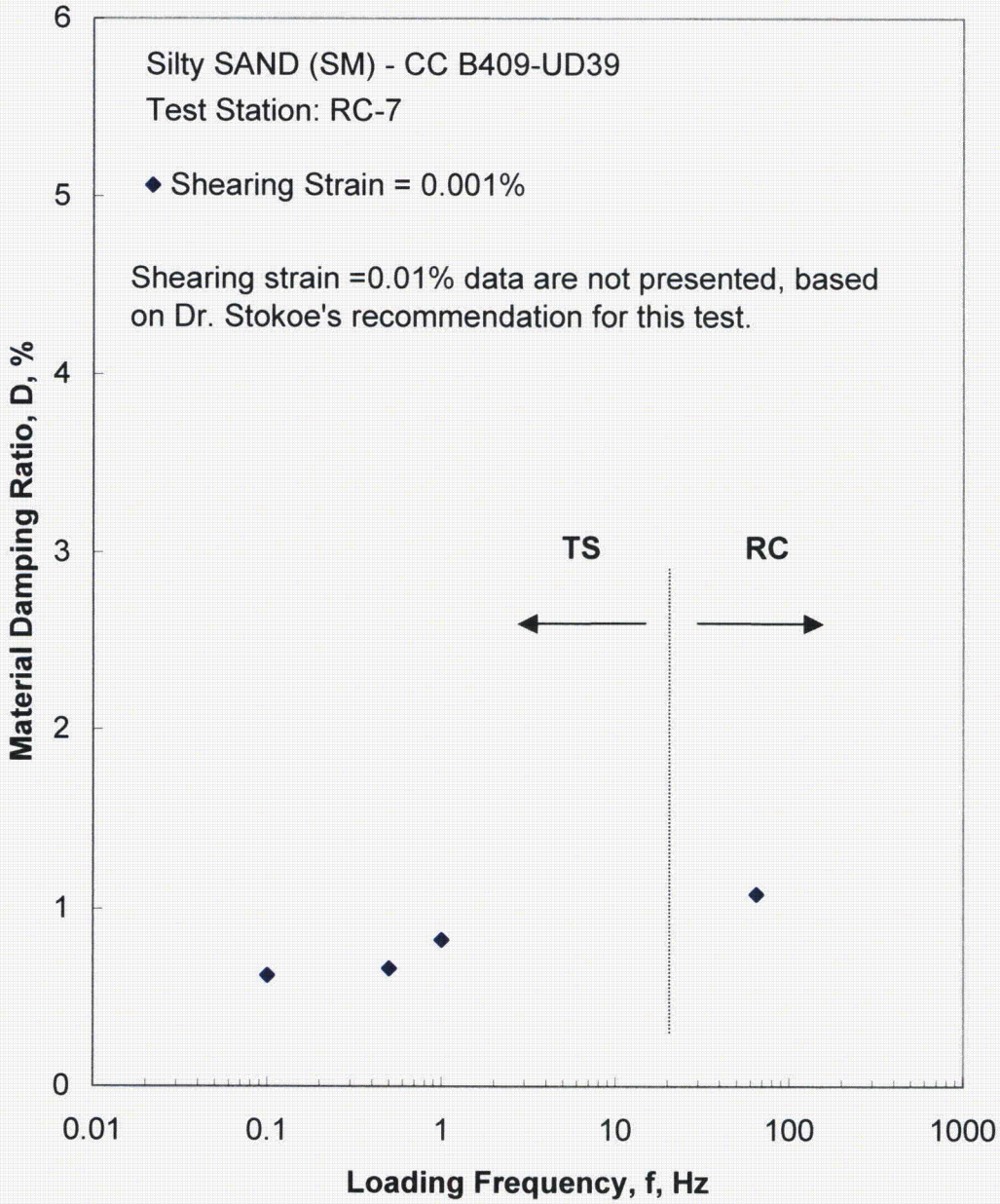


Figure M.20 Comparison of the Variation in Material Damping Ratio with Loading Frequency at an Isotropic Confining Pressure of 111.9 psi from the Combined RCTS Tests

Table M.1 Variation in Low-Amplitude Shear Wave Velocity, Low-Amplitude Shear Modulus, Low-Amplitude Material Damping Ratio and Estimated Void Ratio with Isotropic Confining Pressure from RC Tests of Specimen CC B409-UD39

Isotropic Confining Pressure, σ_o			Low-Amplitude Shear Modulus, G_{max}		Low-Amplitude Shear Wave Velocity, Vs	Low-Amplitude Material Damping Ratio, Dmin	Estimated Void Ratio, e
(psi)	(psf)	(kPa)	(ksf)	(MPa)	(fps)	(%)	
7.0	1008	48	1335	64	624	1.56	1.033
14.0	2016	96	1670	80	696	1.40	1.025
28.0	4032	193	2285	110	812	1.26	1.011
55.9	8050	385	3165	152	951	1.16	0.992
111.9	16114	771	4231	203	1092	1.00	0.966

Table M.2 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen CC B409-UD39; Isoptropic Confining Pressure, σ_o=28.0 psi (4.0 ksf = 193 kPa)

Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
3.20E-04	2266	1.00	3.20E-04	1.19
6.58E-04	2266	1.00	6.58E-04	1.19
1.30E-03	2266	1.00	1.30E-03	1.19
2.55E-03	2266	1.00	2.27E-03	1.18
4.90E-03	2266	1.00	4.36E-03	1.23
9.32E-03	2180	0.96	8.11E-03	1.31
1.72E-02	2110	0.93	1.48E-02	1.53
3.15E-02	1973	0.87	2.65E-02	2.11
5.79E-02	1793	0.79	4.75E-02	2.68
1.09E-01	1566	0.69	8.30E-02	3.78

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table M.3 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen CC B409-UD39; Isotropic Confining Pressure, σ_o=28.0 psi (4.0 ksf =193 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
---	---	---	---	1.77E-04	2163	1.00	0.65
---	---	---	---	3.39E-04	2163	1.00	0.38
---	---	---	---	6.40E-04	2163	1.00	0.48
---	---	---	---	1.02E-03	2163	1.00	0.79
---	---	---	---	2.06E-03	2163	1.00	0.97
---	---	---	---	4.24E-03	2163	1.00	1.13
---	---	---	---	1.02E-02	2064	0.95	2.01

Table M.4 Variation in Shear Modulus and Material Damping Ratio with Shearing Strain from RC Tests of Specimen CC B409-UD39; Isoptropic Confining Pressure, σ_o= 111.9 psi (16.1 ksf = 771 kPa)

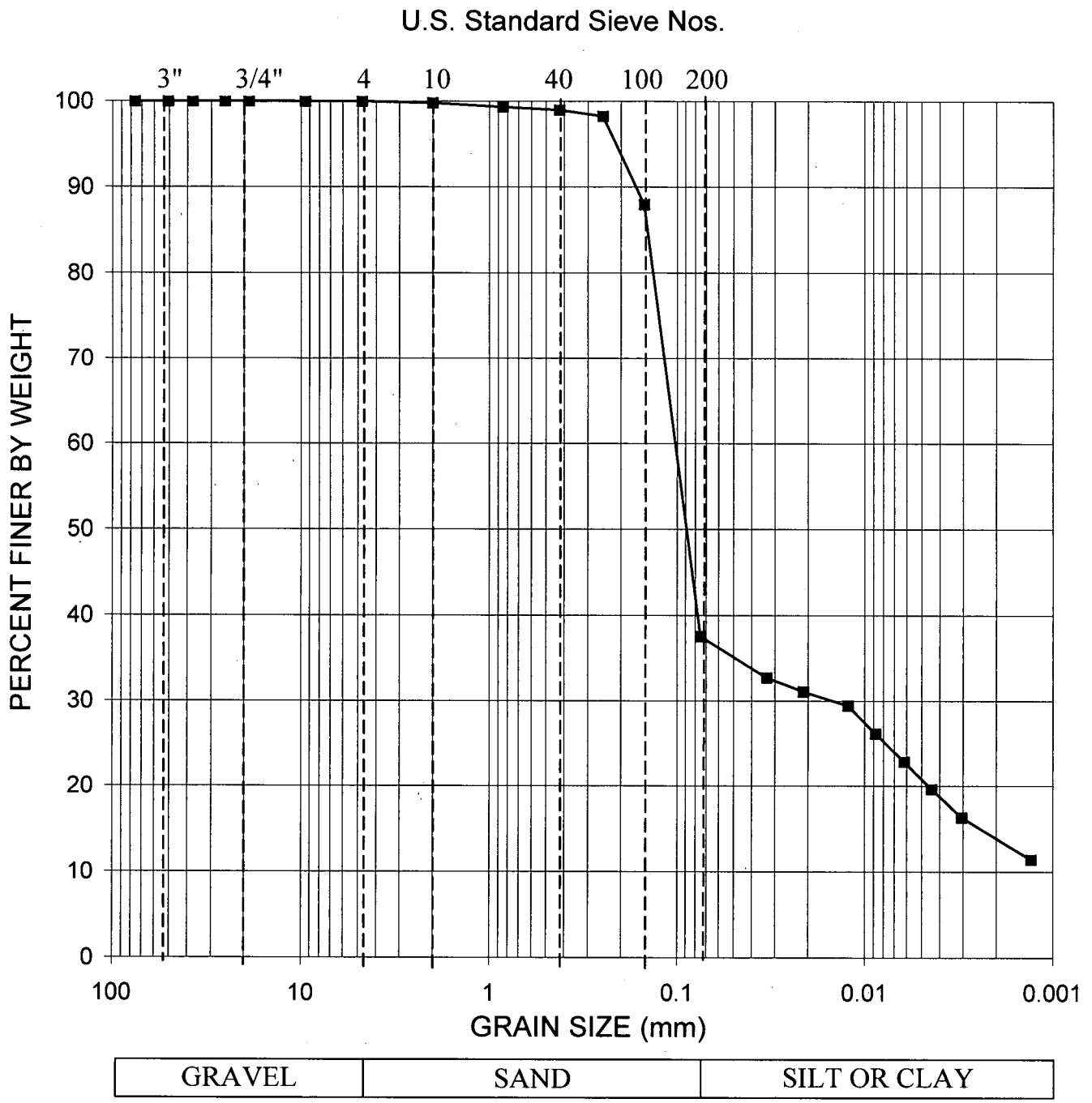
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Average[+] Shearing Strain, %	Material Damping Ratio[x], D, %
1.59E-04	4251	1.00	1.59E-04	1.00
3.09E-04	4251	1.00	3.09E-04	1.04
6.30E-04	4251	1.00	6.30E-04	1.04
1.25E-03	4251	1.00	1.25E-03	1.08
2.47E-03	4251	1.00	2.22E-03	1.09
4.81E-03	4198	0.99	4.23E-03	1.09
9.15E-03	4132	0.97	8.23E-03	1.14
1.69E-02	4033	0.95	1.50E-02	1.19
3.06E-02	3821	0.90	2.72E-02	1.34
5.48E-02	3580	0.84	4.71E-02	1.85
9.97E-02	3246	0.76	8.28E-02	2.57
1.85E-01	2840	0.67	1.45E-01	3.72
3.50E-01	2406	0.57	2.45E-01	5.61
4.95E-01	2215	0.52	3.32E-01	6.55

[+] Average Shearing Strain from the First Three Cycles of the Free Vibration Decay Curve

[x] Average Damping Ratio from the First Three Cycles of the Free Vibration Decay Curve

Table M.5 Variation in Shear Modulus, Normalized Shear Modulus and Material Damping Ratio with Shearing Strain from TS Tests of Specimen CC B409-UD39; Isotropic Confining Pressure, σ_o=111.9 psi (16.1 ksf = 771 kPa)

First Cycle				Tenth Cycle			
Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %	Peak Shearing Strain, %	Shear Modulus, G, ksf	Normalized Shear Modulus, G/G_{max}	Material Damping Ratio, D, %
3.56E-04	4247	1.00	0.53	3.69E-04	4209	1.00	0.48
7.33E-04	4247	1.00	0.62	7.19E-04	4209	1.00	0.68
1.01E-03	4247	1.00	0.60	1.02E-03	4209	1.00	0.66
2.02E-03	4246	1.00	0.66	2.03E-03	4209	1.00	0.66
4.11E-03	4171	0.98	0.85	4.10E-03	4174	0.99	0.88
8.42E-03	4067	0.96	1.15	8.44E-03	4060	0.96	1.12



GRADATION CURVE

ASTM D422

Project:	Constellation Energy Group COLA Project, Calvert Cliffs NuclearPower Plant (CCNPP), Calvert County, Maryland		Contract No.:	06120048.00	Date:	10/18/2007
Boring No.	Depth (ft)	Sample Description	Class.	LL	PI	
B-409	95.0-96.5	SILTY SAND, contains shells, greenish gray	SM	61	19	Schnabel Engineering

SUMMARY OF SOIL LABORATORY TEST RESULTS

Schnabel Engineering

Project Name: Constellation Generation Group COLA Project
Calvert Cliffs Nuclear Power Plant (CCNPP)
Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-301	2.5	SPT	SP-SM	8.1	0.7						6.6																		
B-301	10.5	SPT	SP-SM	6.2	0.1						14.3																		
B-301	18.5	SPT	SP-SM	10.9	0.8						19.0																		
B-301	28.5	SPT	CL	58.5	0.0	48	17	31			28.9																		
B-301	33.5	UD	CH	80.5	0.0	59	17	42			31.1	117.5	2.74																
B-301	48.5	SPT	CL								29.6																		
B-301	63.5	SPT	SP	2.1	0.0						20.4																		
B-301	83.5	SPT	SM	21.0	2.4						26.5																		
B-301	93.5	SPT	SM								25.8																		
B-301	103.5	SPT	CL								17.8																		
B-301	108.5	SPT	SM	34.7	1.5						23.2																		
B-301	118.5	SPT	SM	19.6	0.3						33.1																		
B-301	128.5	SPT	SC	32.3	0.0						42.3																		
B-301	143.5	SPT	CL	55.5	0.0						45.0																		
B-301	148.5	SPT	MH			114	55	59			62.2																		
B-301	153.5	SPT	SM	45.4	0.0						34.0																		
B-301	158.5	UD	CH	99.5	0.0	76	30	46			38.7	112.2	2.68					X	-	UU	NA	61.2	NA	NA	Dev	0.005	0.243	1.01	20
B-301	168.5	UD	CH	66.2	0.0	112	39	73			65.4	97.3	2.62													0.012	0.453	1.82	16
B-301	178.5	SPT	MH	60.0	0.0	111	47	64			60.4																		
B-301	193.5	SPT	MH			98	45	53			53.2																		
B-301	198.5	SPT	MH	79.0	0.0	157	71	86			82.6																		
B-301	203.5	SPT	SC								27.5																		
B-301	208.5	SPT	SM								32.4																		
B-301	218.5	SPT	CL	50.7	0.0						47.9																		
B-301	228.5	SPT	SC	46.9	0.0						54.0																		
B-301	238.5	SPT	CL	72.9	0.0						56.8																		
B-301	253.5	SPT	MH	64.6	0.0	137	87	50			72.7																		
B-301	263.5	SPT	CL	85.2	0.0						100.9																		
B-301	273.5	SPT	MH			199	119	80			102.0																		
B-301	283.5	SPT	CL	73.5	0.0						91.3																		
B-301	293.5	SPT	MH	73.1	0.0	117	73	44			64.4																		
B-301	303.5	SPT	SC	44.6	0.0						24.8																		
B-301	313.5	SPT	SC	26.6	1.7						20.0																		
B-301	323.5	SPT	SC	22.1	11.4						27.8																		
B-301	333.5	SPT	SC								31.8																		
B-301	343.5	SPT	SC	17.9	14.0	47	24	23			22.9																		
B-301	353.5	SPT	SC	18.0	0.2	58	22	36			36.1																		

Schnabel Engineering

Project Name: Constellation Generation Group COLA Project
Calvert Cliffs Nuclear Power Plant (CCNPP)
Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f deg.	C' psi	Failure Cnieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-301	363.5	SPT	SM	28.6	1.4	54	36	18			37.2																		
B-301	373.5	SPT	SC	16.0	0.0	61	26	35			30.3																		
B-301	388.5	SPT	SC	15.7	0.0						32.7																		
B-301	398.5	SPT	SC								33.7																		
B-304	0.0	SPT	SM								17.1																		
B-304	2.5	SPT	SM								25.9																		
B-304	5.0	SPT	ML								29.4																		
B-304	7.5	SPT	CH	71.8	0.0	57	23	34			34.1																		
B-304	10.5	SPT	CH	57.4	0.0	59	19	40			31.4																		
B-304	13.5	SPT	CH			63	23	40			31.7																		
B-304	18.5	SPT	CH	96.9	0.0	62	21	41			32.1																		
B-304	23.5	SPT	CL			38	20	18			25.6																		
B-304	28.5	SPT	SM								32.3																		
B-304	33.5	SPT	SP								20.1																		
B-304	38.5	SPT	SP-SM	8.5	1.3						19.3																		
B-304	43.5	SPT	SP-SM								21.9																		
B-304	48.5	SPT	GM-GC			25	18	7			14.5																		
B-304	53.5	SPT	SM								13.5																		
B-304	58.5	SPT	SM	12.4	5.4	NP	NP	NP			29.1																		
B-304	63.5	SPT	SM	14.6	3.8	30	23	7			29.4																		
B-304	68.5	SPT	SM								29.5																		
B-304	78.5	SPT	SC			32	19	13			16.3																		
B-304	83.5	SPT	SM								21.8																		
B-304	88.5	SPT	SM	35.9	0.0	49	28	21			38.7																		
B-304	93.5	SPT	SM								33.0																		
B-304	98.5	UD	SC	47.3	0.0	79	28	51			42.1	113.2	2.65					X	-	Qu	NA	26.0	NA	NA	Dev	0.003	0.251	1.03	20
B-304	103.5	SPT	SC	35.4	0.0						44.0																		
B-304	108.5	SPT	SM	28.2	2.4						33.8																		
B-304	113.5	SPT	SC	36.3	0.4						43.9																		
B-304	118.5	SPT	SC								47.9																		
B-304	123.5	SPT	ML								60.2																		
B-304	128.5	SPT	SC	42.7	0.3						34.9																		
B-304	133.5	SPT	ML								45.0																		
B-304	138.5	UD	SC	45.7	0.0	43	26	17			36.5	113.4	2.65					X	-	Qu	NA	36.4	NA	NA	Dev	0.003	0.143	0.95	16
B-304	143.5	SPT	CH	91.3	0.0	134	49	85			70.0																		
B-304	148.5	SPT	MH								72.1																		
B-304	153.5	SPT	MH								70.9																		

Schnabel Engineering

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Calvert Cliffs Nuclear Power Plant (CCNPP)
Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f deg.	C' psi	Failure Crieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-304	158.5	SPT	MH	59.1	0.0	92	53	39			55.1																		
B-304	163.5	SPT	MH								47.2																		
B-304	168.5	SPT	MH								62.9																		
B-304	173.5	SPT	MH	94.0	0.0	158	84	74			84.0																		
B-304	178.5	SPT	SC								27.5																		
B-304	183.5	SPT	SC	43.6	0.0						39.2																		
B-304	188.5	SPT	SC								42.8																		
B-304	193.5	SPT	CL								51.1																		
B-304	198.5	SPT	CL	55.9	0.0						55.8																		
B-305	39.5	UD	SC	49.5	0.0	72	22	50			34.7	117.2	2.71																
B-306	68.0	UD	CH	98.6	0.0	62	24	38			30.7	115.8	2.73																
B-307	5.0	SPT	SC	38.4	0.6						11.6																		
B-307	13.5	SPT	SM			NP	NP	NP			7.9																		
B-307	23.5	SPT	SP-SM	11.2	3.3						13.0																		
B-307	33.5	SPT	SM			NP	NP	NP			14.5																		
B-307	43.5	SPT	SM								24.8																		
B-307	48.5	SPT	CL								25.1																		
B-307	53.5	SPT	CH								28.1																		
B-307	58.5	SPT	CH	60.5	0.3	62	20	42			33.1																		
B-307	63.5	SPT	CH			52	18	34			35.5																		
B-307	68.5	SPT	CH	98.5	0.0	66	23	43			34.0																		
B-307	73.5	SPT	SC								24.9																		
B-307	83.5	SPT	SM	13.0	0.6						20.6																		
B-307	88.5	SPT	ML			NP	NP	NP			21.5																		
B-307	93.5	SPT	SM	17.9	4.6						27.7																		
B-307	108.5	SPT	SP-SM	9.8	2.7	NP	NP	NP			29.2																		
B-307	118.5	SPT	SM	17.9	0.0	32	25	7			28.9																		
B-307	123.5	UD	SC	30.0	6.4	35	19	16			29.8	123	2.70					X	-	CIU-bar	Test Not Performed								
B-307	133.5	SPT	SM	21.8	0.3						26.0																		
B-307	143.5	SPT	MH			59	33	26			36.8																		
B-307	148.5	SPT	MH								50.6																		
B-307	153.5	SPT	SM	24.4	0.0	58	37	21			38.8																		
B-307	178.5	UD	SC	37.7	0.0	41	25	16			33.5	117	2.67					X	-	DS	NA	NA	35	0	NA				
B-307	188.5	SPT	SM	45.6	0.0	61	39	21			43.0																		
B-307	200.0	SPT	MH	66.2	0.0	137	61	76			68.7																		
B-310	78.5	UD	Reserve Sample - Tests Not Performed																										
B-313	0.0	SPT	SM								9.9																		

Schnabel Engineering

Project Name: Constellation Generation Group COLA Project
Calvert Cliffs Nuclear Power Plant (CCNPP)
Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-313	2.5	SPT	CL-ML			19	14	5			11.8																		
B-313	5.0	SPT	CH			67	21	46			27.6																		
B-313	7.5	SPT	CL			30	17	13			15.1																		
B-313	10.5	SPT	ML								27.0																		
B-313	13.5	SPT	ML								31.5																		
B-313	18.5	SPT	SP-SM								23.1																		
B-313	23.5	SPT	SM			NP	NP	NP			21.1																		
B-313	28.5	SPT	SM			NP	NP	NP			18.2																		
B-313	33.5	SPT	CL			38	21	17			28.1																		
B-313	38.5	SPT	SM								17.1																		
B-313	43.5	SPT	ML			34	27	7			29.3																		
B-313	48.5	SPT	SM								27.9																		
B-313	53.5	SPT	SM			NP	NP	NP			31.5																		
B-313	63.5	SPT	CL			33	17	16			26.2																		
B-313	73.5	SPT	ML								28.4																		
B-313	83.5	SPT	MH								37.3																		
B-313	88.5	SPT	MH			98	47	51			55.0																		
B-313	93.5	UD	CL			49	25	24			35.6	116	2.69					X	-	UU	NA	38.8	NA	NA	Dev	0.005	0.166	1.07	16
																		X	-	DS	NA	NA	29	11	NA				
B-313	98.5	SPT	ML			42	28	14			32.4																		
B-313	103.5	SPT	MH			70	45	25			43.4																		
B-313	108.5	SPT	MH			106	55	51			57.7																		
B-313	113.5	SPT	MH			72	46	26			44.3																		
B-313	118.5	SPT	MH			81	42	39			43.5																		
B-313	123.5	UD	SC			44	26	18			33.1	116	2.67					X	-	UU	NA	41.3	NA	NA	Dev	0.002	0.205	0.98	23
																		X	-	DS	Test Not Performed								
B-313	128.5	SPT	MH			132	60	72			66.0																		
B-313	133.5	SPT	MH								69.1																		
B-313	138.5	SPT	MH			106	51	55			62.9																		
B-313	143.5	SPT	CH								49.1																		
B-313	148.5	SPT	CH			103	30	73			49.4																		
B-314	0.4	SPT	SM								9.7																		
B-314	2.5	SPT	SM			NP	NP	NP			14.1																		
B-314	5.0	SPT	CH			73	25	48			35.0																		
B-314	7.5	SPT	CH			59	21	38			41.2																		
B-314	10.5	SPT	CH			73	25	48			26.2																		
B-314	13.5	UD	SC	35.0	0.0	54	11	43			25.9	119	2.74					X	-	UU	Test Not Performed					0.010	0.110	0.86	10.5

Schnabel Engineering

Project Name: Constellation Generation Group COLA Project
Calvert Cliffs Nuclear Power Plant (CCNPP)
Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cer	Cec	eo	Pp' tsf
B-314	18.5	SPT	SM								24.2																		
B-314	23.5	SPT	SM			NP	NP	NP			22.6																		
B-314	28.5	SPT	SM								20.3																		
B-314	33.5	SPT	CL			42	22	20			25.4																		
B-314	38.5	SPT	SM			NP	NP	NP			26.8																		
B-314	43.5	SPT	SM								31.9																		
B-314	48.5	SPT	SM								25.4																		
B-314	53.5	SPT	SM			NP	NP	NP			32.8																		
B-314	58.5	SPT	SP			NP	NP	NP			33.0																		
B-314	63.5	SPT	CH			59	24	35			40.3																		
B-314	68.5	SPT	ML			NP	NP	NP			19.5																		
B-314	73.5	SPT	ML			NP	NP	NP			27.9																		
B-314	78.5	SPT	ML			NP	NP	NP			36.5																		
B-314	83.5	SPT	MH			57	36	21			41.2																		
B-314	88.5	SPT	CH			68	20	48			34.3																		
B-314	93.5	SPT	SM								36.4																		
B-314	98.5	SPT	SM								31.0																		
B-315	7.5	SPT	SP-SM	8.3	3.2						5.6																		
B-315	13.5	SPT	SM	14.0	0.0						28.3																		
B-315	18.5	SPT	SC								28.3																		
B-315	23.5	UD	SC	35.0	0.0	41	11	30			23.3	126	2.73					X	-	UU	NA	17	NA	NA	Dev	0.020	0.170	0.92	10.2
B-315	28.5	SPT	SM								27.6																		
B-315	38.5	SPT	SM	13.2	6.9	NP	NP	NP			22.2																		
B-315	53.5	SPT	ML			NP	NP	NP			25.6																		
B-315	63.5	SPT	SP-SM	11.9	0.3	NP	NP	NP			29.4																		
B-315	73.5	SPT	CH			58	18	40			36.3																		
B-315	83.5	SPT	SM	28.6	0.1	NP	NP	NP			29.6																		
B-315	93.5	SPT	SM								35.6																		
B-316	2.5	SPT	CL			35	16	19			19.1																		
B-316	7.5	SPT	CL	55.5	0.0						14.5																		
B-316	23.5	SPT	SP-SM	8.8	0.0	NP	NP	NP			20.0																		
B-316	33.5	SPT	SP-SM	11.3	1.6	43	17	26			20.1																		
B-316	38.5	SPT	CL								28.5																		
B-316	43.5	UD	CL	71.0	0.0	44	16	28			28.6	121	2.79					X	-	Qu	NA	7.9	NA	NA	Dev	0.017	0.266	0.94	9.3
																		X	-	UU	NA	9.9	NA	NA	Dev				
B-316	48.5	SPT	MH	69.5	0.0						38.0																		

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Project Name: Constellation Generation Group COLA Project
Calvert Cliffs Nuclear Power Plant (CCNPP)
Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f deg.	C' psi	Failure Crieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-316	53.5	UD	CL	50.0	1.0	33	11	22			26.2	103	2.77					X	-	DS	NA	NA	30.1	4.5	NA				
																		X	-	CIU-bar	12.5	14.3	32.1	6.84	PSR				
B-316	58.5	SPT	SC								24.4																		
B-316	63.5	SPT	SC								31.3																		
B-316	68.5	SPT	SM	16.5	0.1						19.8																		
B-316	73.5	SPT	SP								21.2																		
B-316	93.5	SPT	SC	17.7	0.5						32.0																		
B-316	98.5	SPT	SC								27.7																		
B-317	23.5	SPT	ML								28.4																		
B-317	28.5	UD	CL	97.8	2.2	27	19	8			31.7	122.3	2.75					X	-	CIU-bar	17	5	31	3.1	PSR				
B-317	33.5	SPT	CH								30.2																		
B-317	48.5	UD	CL	69.8	0.0	35	17	18			22.8	125.5	2.7					X	-	CIU-bar	19.5	8.2	33.5	4.2	PSR				
B-317	58.5	SPT	SP-SM								26.0																		
B-317	73.5	SPT	SC								22.3																		
B-319	2.5	SPT	SP-SM	8.1	0.2						5.7																		
B-319	7.5	SPT	SP			NP	NP	NP			4.7																		
B-319	13.5	SPT	SP-SM	8.6	1.3						7.6																		
B-319	23.5	SPT	SC	20.0	1.4						19.8																		
B-319	28.5	SPT	SC								24.5																		
B-319	33.5	UD	CL	72.0	0.0	49	12	37			29.2	120	2.67					X	-	UU	NA	10.1	NA	NA	Dev	0.010	0.190	0.85	5.4
																		X	-	DS	NA	NA	24.9	6.2	NA				
B-319	38.5	SPT	CH								27.9																		
B-319	43.5	UD	CH	87.0	0.0	58	13	45			32.1	121	2.73					X	-	UU	NA	12	NA	NA	Dev	0.040	0.280	0.82	12
																		X	-	DS	NA	NA	20.8	9.1	NA				
B-319	48.5	SPT	CH			79	27	52			38.6																		
B-319	58.5	SPT	ML			40	32	8			26.7																		
B-319	73.5	SPT	SM	13.6	4.6						17.5																		
B-319	83.5	SPT	SM	25.7	14.0						18.2																		
B-319	88.5	SPT	SM	18.9	1.4						29.8																		
B-319	98.5	SPT	SM	12.9	0.6	NP	NP	NP			30.0																		
B-320	2.5	SPT	SP-SM								10.4																		
B-320	7.5	SPT	SP								6.3																		
B-320	18.5	SPT	SP								9.1																		
B-320	33.5	SPT	SC	42.5	0.0	33	18	15			26.1																		
B-320	38.5	UD	SC	49.0	0.0	36	16	20			29.4	124	2.63					X	-	CIU-bar	13.3	8.03	27.9	3.79	PSR				
																		X	-	DS	NA	NA	26.0	2.9	NA				
B-320	43.5	SPT	CH	60.7	0.0	56	19	37			30.0																		

Schnabel Engineering

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SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cer	Cec	eo	Pp' tsf
B-320	48.5	UD	CH	81.5	0.0	59	19	40			34.4	114	2.74					X	-	UU	NA	12.7	NA	NA	Dev				
																		X	-	DS	NA	NA	21.9	9.6	NA				
B-320	53.5	SPT	CH			69	24	45			34.9																		
B-320	73.5	SPT	SM	15.3	5.0						18.8																		
B-320	93.5	SPT	SM	15.1	1.8						25.4																		
B-320	103.5	SPT	SM	16.8	0.0						29.2																		
B-320	113.5	SPT	CL			44	16	28			28.5																		
B-320	128.5	SPT	MH			50	30	20			34.1																		
B-320	148.5	SPT	SM	47.7	1.4						37.0																		
B-321	2.5	SPT	SC	31.0	0.9						9.7																		
B-321	5.0	SPT	SP-SM								7.4																		
B-321	7.5	SPT	CL								25.2																		
B-321	10.5	SPT	CH	65.9	0.0	55	20	35			36.2																		
B-321	13.5	SPT	SC								30.0																		
B-321	18.5	SPT	SC	35.3	0.0						29.7																		
B-321	23.5	UD	CL	99.7	0.0	45	18	27			26.2	117.8	2.79					X	-	UU	NA	32	NA	NA	Dev	0.009	0.306	1.03	19
B-321	28.5	SPT	SM	43.6	0.0	47	29	18			27.0																		
B-321	33.5	SPT	SP-SM								30.9																		
B-321	38.5	SPT	SP-SM	9.0	1.5						27.1																		
B-321	43.5	SPT	SP-SM								26.0																		
B-321	48.5	SPT	MH	73.0	0.0						35.1																		
B-321	53.5	SPT	SM	14.3	8.6	NP	NP	NP			25.0																		
B-321	58.5	SPT	SM	18.6	5.1						27.4																		
B-321	63.5	SPT	SM								27.6																		
B-321	68.5	SPT	SM	16.0	0.2						28.4																		
B-321	73.5	UD	SM	15.3	0.0	NP	NP	NP			28.5	120.5	2.67					X	-	CIU-bar	20	13.5	30	7	PSR	0.003	0.064	0.72	14.2
B-321	78.5	SPT	SM								34.9																		
B-321	83.5	SPT	SM								20.6																		
B-321	88.5	SPT	SM	30.0	0.2						31.0																		
B-321	93.5	SPT	SC	32.2	1.0	59	26	33			36.9																		
B-321	98.5	SPT	SM	29.8	0.0						36.1																		
B-321	103.5	SPT	SM								58.2																		
B-321	108.5	SPT	SM								42.6																		
B-321	113.5	SPT	SM	36.3	0.9						34.6																		
B-321	118.5	SPT	SM								39.8																		
B-321	123.5	SPT	SM								43.1																		
B-321	128.5	SPT	MH	60.8	0.0						49.5																		

Schnabel Engineering

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Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cer	Cec	eo	Pp' tsf
B-321	133.5	SPT	MH								42.3																		
B-321	138.5	SPT	MH								39.7																		
B-321	143.5	SPT	MH	84.6	0.0						60.2																		
B-321	148.5	SPT	MH								66.0																		
B-323	2.5	SPT	SP								5.0																		
B-323	7.5	SPT	SP-SM	8.2	1.1						13.0																		
B-323	13.5	SPT	SP-SM	8.4	0.0						16.2																		
B-323	18.5	SPT	SM			NP	NP	NP			11.9																		
B-323	28.5	SPT	SP								17.6																		
B-323	38.5	SPT	SP-SM	11.4	0.9						20.7																		
B-323	48.5	SPT	CH	51.0	0.0	50	17	33			28.1																		
B-323	58.5	SPT	CH	89.1	0.0	65	22	43			35.1																		
B-323	68.5	SPT	SC	32.8	0.0	46	24	22			29.0																		
B-323	83.5	UD	CL	72.7	0.0	42	20	22			36.2	117	2.76					X	-	UU	NA	40	NA	NA	Dev				
B-323	93.5	SPT	SM	27.9	6.8	NP	NP	NP			26.3																		
B-323	103.5	SPT	SP-SM	10.6	0.8	NP	NP	NP			28.6																		
B-323	113.5	SPT	SM	18.1	0.0						30.2																		
B-323	123.5	SPT	SM								19.4																		
B-323	133.5	SPT	SM	30.2	0.1						33.1																		
B-323	143.5	SPT	MH	52.1	0.0	73	38	35			48.3																		
B-323	153.5	SPT	ML			39	30	9			31.3																		
B-323	163.5	SPT	MH	63.3	0.0						54.2																		
B-323	173.5	SPT	CH	56.9	0.0	97	31	66			44.0																		
B-323	183.5	SPT	CH	94.0	0.0	124	33	91			68.3																		
B-323	193.5	SPT	CH	70.3	0.0	116	36	80			58.1																		
B-323	198.5	SPT	MH			97	62	35			52.9																		
B-326	5.0	SPT	SP-SM								8.2																		
B-326	13.5	SPT	SP-SM	10.5	0.0						12.2																		
B-326	23.5	SPT	SM	23.7	1.0						22.7																		
B-326	33.5	UD	CL	62.0	0.0	41	16	25			27.6	120	2.76					X	-	Qu	NA	11.9	NA	NA	Dev				
																		X	-	UU	NA	8.4	NA	NA	Dev				
B-326	43.5	UD	OH	89.3	0.0	63	22	41	45	0.4	33.9	111	2.70					X	-	Qu	NA	19.7	NA	NA	Dev				
																		X	-	DS	NA	NA	19.0	4.9	NA				
B-327	113.5	UD	CH	51.9	0.0	60	24	36			44.3	107	2.70													0.003	0.374	1.34	20.6
B-328	2.5	SPT	SP-SM	8.7	0.0	NP	NP	44			4.5																		
B-328	7.5	SPT	CH								30.0																		
B-328	10.5	SPT	CH			59	17	42			28.8																		

Schnabel Engineering

Project Name: Constellation Generation Group COLA Project
Calvert Cliffs Nuclear Power Plant (CCNPP)
Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cer	Cec	eo	Pp' tsf
B-328	18.5	SPT	MH			64	36	28			35.1																		
B-328	23.5	SPT	CH			77	28	49			33.0																		
B-328	28.5	SPT	SC	42.6	0.1	40	21	19			30.5																		
B-328	33.5	SPT	SP-SM								18.2																		
B-328	38.5	SPT	SP-SM	7.8	0.0						22.6																		
B-328	43.5	SPT	SP-SM	10.8	4.2	NP	NP	NP			24.2																		
B-328	48.5	SPT	ML								25.8																		
B-328	53.5	SPT	SM	21.9	9.6						24.0																		
B-328	63.5	UD	OH	87.0	0.0	72	41	31	50		44.2	121	2.66					X	-	UU	Test Not Performed					<0.01	0.060	0.90	2.3
																		X	-	CIU-bar	13.4	23.3	34.6	0.236	PSR				
B-328	68.5	SPT	SM			NP	NP	NP			29.4																		
B-328	73.5	SPT	SM			NP	NP	NP			32.2																		
B-328	83.5	SPT	SM	18.6	15.7	NP	NP	NP			21.2																		
B-328	88.5	SPT	MH			47	31	16			34.0																		
B-328	98.5	SPT	MH			53	34	19			38.2																		
B-328	103.5	SPT	SM	36.6	0.0						62.7																		
B-328	113.5	SPT	MH								30.5																		
B-328	118.5	SPT	MH								44.7																		
B-328	123.5	UD	MH	82.6	0.0	72	45	27			45.6	102	2.76					X	-	CIU-bar	Test Not Performed					0.020	0.380	1.74	10.0
B-328	133.5	SPT	MH	52.8	0.0	70	51	19			48.2																		
B-328	143.5	SPT	MH								59.3																		
B-328	148.5	SPT	MH			134	100	34			74.8																		
B-331	5.0	SPT	CL	66.9	0.0	43	15	28			20.2																		
B-331	18.5	UD	CH	97.1	0.0	57	23	34			30.8	111	2.71					X	-	Qu	NA	28.2	NA	NA	Dev				
																		X	-	UU	NA	22.7	NA	NA	Dev				
B-331	33.5	SPT	SP-SM	8.3	0.8						21.9																		
B-331	43.5	SPT	SM	50.6	0.0						31.6																		
B-331	58.5	SPT	SM								26.6																		
B-331	73.5	SPT	SM								35.8																		
B-331	88.5	SPT	SM								32.7																		
B-333	2.5	SPT	SP-SM	6.9	0.4						6.2																		
B-333	7.5	SPT	SP-SM	5.3	0.1						4.8																		
B-333	23.5	SPT	CH	74.2	0.0	57	33	24			32.0																		
B-333	28.5	UD	CH	85.3	0.0	52	19	33			38.9	114	2.82					X	-	Qu	NA	10.4	NA	NA	Dev	0.021	0.316	1.15	9.3
B-333	38.5	UD	CH	98.8	0.0	61	23	38			39.7	115	2.85					X	-	Qu	NA	20.7	NA	NA	Dev	0.009	0.240	1.10	15.2
B-333	43.5	SPT	SM	38.8	0.0						26.1																		

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Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Criterion[6]	Cer	Cec	eo	Pp' tsf
B-333	48.5	UD	SC	20.0	2.0	34	13	21			25.2	Test Not Performed	2.73					X	-	Qu	Test Not Performed								
B-333	53.5	SPT	SM	13.4	1.6						20.9																		
B-333	58.5	SPT	SM								34.5																		
B-333	68.5	SPT	SM	23.2	20.4						19.3																		
B-333	78.5	SPT	SP-SM	10.8	5.7	NP	NP	NP			28.7																		
B-333	93.5	SPT	SM	23.7	23.3						16.1																		
B-334	0.0	SPT	SP-SM	11.2	0.0						9.6																		
B-334	5.0	SPT	SM	21.3	0.0						15.9																		
B-334	10.5	SPT	SM			NP	NP	NP			15.6																		
B-334	18.5	SPT	CL								31.3																		
B-334	23.0	UD	CH	79.0	0.0	51	16	35			35.3	119	2.7					X	-	UU	NA	10.1	NA	NA	Dev	0.020	0.220	1.12	5.3
B-334	28.5	SPT	CH								42.5																		
B-334	33.0	UD	CL	95.0	0.0	47	13	34			32.6	115	2.71					X	-	UU	Test Not Performed					0.020	0.210	1.06	5.4
B-334	43.5	SPT	SM								27.0																		
B-334	48.5	SPT	SM	26.2	0.0						27.2																		
B-334	53.5	SPT	SP-SM								21.4																		
B-334	63.5	SPT	GM	29.8	36.1	NP	NP	NP			19.0																		
B-334	73.5	SPT	SM	12.6	9.9						27.3																		
B-334	83.5	SPT	SM	13.8	0.1						28.0																		
B-334	98.5	SPT	SM	16.6	1.0						28.9																		
B-336	13.5	SPT	SC								11.4																		
B-336	28.5	SPT	CH								26.9																		
B-336	48.5	SPT	CL								25.9																		
B-336	68.5	SPT	SM								19.6																		
B-336	83.5	SPT	SM								27.3																		
B-336	98.5	SPT	SC								32.1																		
B-337	33.5	SPT	ML								29.0																		
B-337	48.5	SPT	SC								39.9																		
B-337	53.5	UD	SC	39.0	2.0	38	19	19			25.7	126	2.75					X	-	UU	NA	6.2	NA	NA	Dev				
B-337	73.5	SPT	SM								30.9																		
B-337	88.5	SPT	SM								21.0																		
B-339	5.0	SPT	SP	4.6	0.1						6.9																		
B-339	13.5	SPT	SM	12.1	10.8						19.9																		
B-339	28.5	SPT	CH			55	19	36			31.5																		
B-339	33.5	SPT	CH	62.7	0.0	62	21	41			27.0																		
B-339	38.5	SPT	CH			71	17	54			28.6																		

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Project Name: Constellation Generation Group COLA Project
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Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-339	43.5	SPT	CH	86.9	0.0	60	22	38			31.0																		
B-339	48.5	SPT	CL			40	20	20			27.8																		
B-339	53.5	SPT	SM	33.7	0.0	48	30	18			30.8																		
B-339	58.5	SPT	SP-SM			NP	NP	NP			28.1																		
B-339	63.5	SPT	SC	15.5	9.9	49	21	28			25.0																		
B-339	68.5	SPT	MH			53	38	15			38.8																		
B-339	78.5	SPT	SM	23.6	18.6						16.6																		
B-339	83.5	SPT	SM								31.5																		
B-339	88.5	SPT	SP-SM	11.0	0.4						29.0																		
B-339	93.5	SPT	SP-SM								31.7																		
B-339	98.5	SPT	SP-SM								32.7																		
B-340	66.0	UD	Reserve Sample - Tests Not Performed																										
B-401	2.5	SPT	SM								3.6																		
B-401	10.5	SPT	CH	85.3	0.0	66	20	46			26.6																		
B-401	13.5	SPT	CH			62	20	42			34.2																		
B-401	18.5	SPT	MH			70	37	33			36.9																		
B-401	23.5	SPT	CL	52.1	0.0	47	28	19			27.9																		
B-401	33.5	SPT	SP								20.8																		
B-401	43.5	SPT	SM	21.2	13.1						21.4																		
B-401	53.5	SPT	SM								31.6																		
B-401	58.5	SPT	SM	13.1	4.3						25.0																		
B-401	78.5	SPT	SM								17.5																		
B-401	88.5	SPT	SM	38.3	0.5						35.3																		
B-401	98.5	UD	MH	64.8	0.0	78	48	30			50.5	117	2.70					X	-	UU	NA	19.6	NA	NA	Dev	Test Not Performed			
																		X	-	DS	Test Not Performed								
B-401	108.5	SPT	SM	34.2	1.9						35.6																		
B-401	113.5	SPT	CL								46.1																		
B-401	123.5	UD	MH	82.4	0.0	85	54	31			57.4	103	2.65					X	-	Qu	Test Not Performed					0.030	0.430	1.74	13
																		X	-	UU	NA	72.3	NA	NA	Dev				
B-401	128.5	SPT	ML	56.6	0.0						43.8																		
B-401	138.5	UD	CH	67.5	0.0	80	31	49			44.1	104.1	2.63																
B-401	143.5	SPT	MH			142	104	38			77.1																		
B-401	148.5	SPT	MH	86.6	0.0	150	89	61			72.7																		
B-401	153.5	SPT	MH			142	93	49			68.8																		
B-401	158.5	UD	MH	59.2	0.0	81	54	27			49.9	105	2.65					X	-	Qu	Test Not Performed					0.030	0.350	1.56	14
																		X	-	UU	Test Not Performed								
B-401	168.5	SPT	MH	71.8	0.0	103	52	51			53.9																		

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Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f deg.	C' psi	Failure Crieterion[6]	Ccr	Cec	eo	Pp' tsf
B-401	173.5	UD	CH	98.2	0.0	57	17	40			33.7	95	2.76					X	-	UU	Test Not Performed					0.040	0.540	2.80	11
																		X	-	DS	NA	NA	18.9	32.5	NA				
B-401	183.5	SPT	SM	32.2	0.0						31.2																		
B-401	193.5	SPT	ML								49.2																		
B-401	198.5	UD	SM	45.3	0.0	82	55	27			48.8	101.2	2.52																
B-401	203.5	SPT	MH			94	69	25			58.4																		
B-401	208.5	SPT	MH	64.5	0.0	113	74	39			62.7																		
B-401	213.5	UD	Reserve Sample - Tests Not Performed																										
B-401	218.5	SPT	MH	64.6	0.0						77.4																		
B-401	228.5	UD	MH	80.4	0.0	139	88	51		1.7	58.6	98.2	2.48																
B-401	238.5	SPT	MH								122.5																		
B-401	243.5	UD	MH	98.7	0.0	140	65	75			96.2	86.0	2.36													0.006	0.519	2.41	18.3
B-401	248.5	SPT	MH			218	100	118			122.8																		
B-401	258.5	SPT	MH								130.2																		
B-401	268.5	SPT	SM	43.0	0.0						63.5																		
B-401	284.5	SPT	MH			76	42	34			30.2																		
B-401	293.5	SPT	SC								20.7																		
B-401	307.5	SPT	SM	16.3	0	57	42	15			27.4																		
B-401	318.5	SPT	CH			58	28	30			28.9																		
B-401	338.5	SPT	ML								25.3																		
B-401	348.5	UD	SM	23.0	0.0	52	39	13			35.6	116.4	2.78																
B-401	368.5	SPT	SP-SM	11.7	0.0						36.9																		
B-401	400.0	SPT	SM	18.2	0.0						33.1																		
B-404	52.0	UD	SP-SM	10.8	2.0	NP	NP	NP			27.7	117.6	2.66																
B-404	83.5	UD	SM	33.9	0.0	53	28	25			32.2	115.4	2.63																
B-406	63.5	UD	OH	90.1	0.0	63	19	44	41	1.6	36.1	122.0	2.74					X	-	Qu	NA	20	NA	NA	Dev	0.04	0.3	1.17	10.5
																		X	-	UU	NA	8.2	NA	NA	Dev				
B-407	2.5	SPT	ML			NP	NP	NP			4.8																		
B-407	10.5	SPT	SP-SM								12.3																		
B-407	18.5	SPT	SM	30.4	0.0						24.9																		
B-407	28.5	SPT	MH								35.1																		
B-407	33.5	SPT	MH	96.0	0.0	77	43	34			39.4																		
B-407	43.5	SPT	SM	17.4	1.6						23.3																		
B-407	63.5	SPT	SM								28.1																		
B-407	68.5	SPT	SM	11.4	6.0						30.0																		
B-407	73.5	SPT	SM								27.3																		
B-407	83.5	SPT	SM	14.8	12.5						38.3																		

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Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cer	Cec	eo	Pp' tsf
B-407	88.5	SPT	SM								12.4																		
B-407	98.5	SPT	SP-SM								30.8																		
B-407	108.5	SPT	ML	56.2	0.0						47.8																		
B-407	118.5	SPT	SM								34.2																		
B-407	123.0	SPT	MH								42.2																		
B-407	138.5	SPT	SM	43.3	0.0						49.2																		
B-407	143.5	SPT	MH			92	63	29			56.4																		
B-407	148.5	SPT	CH			81	45	45			43.1																		
B-407	158.5	SPT	MH								78.4																		
B-407	163.5	SPT	MH			120	50	70			62.7																		
B-407	168.5	SPT	MH			104	69	35			55.2																		
B-407	173.5	SPT	CH			102	37	65			53.7																		
B-407	178.5	SPT	CH			102	40	62			50.9																		
B-407	183.5	SPT	MH	59.1	0.0	154	97	57			82.2																		
B-407	188.5	SPT	SM								32.6																		
B-407	193.5	SPT	SM								31.6																		
B-407	198.5	SPT	SM	22.4	0.0						32.7																		
B-409	17.5	UD	Reserve Sample - Tests Not Performed																										
B-409	35.0	UD	SP-SM	6.0	0.0	NP	NP	NP			23.3	124.8	2.66																
B-409	95.0	UD	SM	37.6	0.0	61	42	19			33.1	109.3	2.64																
B-411	2.5	SPT	SP-SM								6.8																		
B-411	7.5	SPT	CL								27.4																		
B-411	13.5	SPT	CH								31.0																		
B-411	23.5	UD	OH	95.0	0.0	61	19	42	44	1.0	37.9	118	2.67					X	-	Qu	Test Not Performed					0.050	0.260	1.51	4.9
B-411	33.5	SPT	ML			34	29	5			24.4																		
B-411	43.5	SPT	SM	15.0	0.0						24.0																		
B-411	53.5	SPT	CL			44	17	27			25.2																		
B-411	63.5	SPT	SP-SM	11.4	6.5						34.4																		
B-411	73.5	SPT	SP-SM								32.0																		
B-411	83.5	SPT	SP-SM								36.4																		
B-411	93.5	SPT	CL								31.6																		
B-411	103.5	SPT	ML			43	30	13			38.2																		
B-411	113.5	SPT	ML								40.4																		
B-411	123.5	SPT	MH			63	43	20			42.7																		
B-413	7.5	SPT	SP-SM	10.2	0.0						9.7																		
B-413	18.5	SPT	SP-SM	10.1	1.2						12.9																		
B-413	33.5	SPT	SP-SM	8.2	0.0						8.6																		

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Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f deg.	C' psi	Failure Crieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-413	48.5	SPT	SM	31.5	0.0	NP	NP	NP			26.9																		
B-413	53.5	SPT	MH			56	27	26			25.7																		
B-413	58.5	SPT	MH	70.5	0.0	58	29	29			27.5																		
B-413	73.0	UD	CH	97.5	0.0	51	15	36			35.5	103	2.73					X	-	UU	NA	10.6	NA	NA	Dev	0.030	0.240	1.13	10.5
																		X	-	DS	NA	NA	31.4	6.4	NA				
																		X	-	CIU-bar	Test Not Performed								
B-413	78.5	SPT	SM	34.6	0.0						26.1																		
B-413	83.5	SPT	SP-SM								21.0																		
B-413	98.5	SPT	SM	15.9	17.2						34.9																		
B-413	108.5	SPT	SP-SM	9.6	7.4						24.8																		
B-413	113.5	SPT	SM								26.3																		
B-413	118.5	SPT	SM	16.2	4.8						32.5																		
B-413	123.5	SPT	SM								35.1																		
B-413	128.5	SPT	SM								18.7																		
B-413	133.5	SPT	SM	28.8	3.8						24.8																		
B-413	138.5	SPT	SM								27.5																		
B-413	143.5	SPT	SM								32.1																		
B-413	148.5	SPT	SM	28.7	0.0						39.8																		
B-414	7.5	SPT	SP-SM								4.2																		
B-414	18.5	SPT	SP-SM								9.2																		
B-414	33.5	SPT	SP-SM								9.7																		
B-414	43.5	SPT	SM	22.1	2.4	NP	NP	NP			20.6																		
B-414	48.5	SPT	SM	33.5	0.0	NP	NP	NP			27.7																		
B-414	53.5	SPT	CL	60.4	0.0	42	23	19			28.0																		
B-414	58.0	UD	CH	84.9	0.0	58	19	39			33.2	117.1	2.71																
B-414	63.5	SPT	CH								38.3																		
B-414	68.0	UD	CH	96.8	0.1	51	15	36			36.7	103	2.78					X	-	Qu	NA	4.7	NA	NA	Dev	0.040	0.280	1.43	4
																		X	-	CIU-bar	10.4	13.2	20	10.2	PSR				
B-414	73.5	SPT	CL	52.8	0.0	39	20	19			22.9																		
B-414	78.5	SPT	ML								29.8																		
B-414	83.5	SPT	SM	16.6	0.0						19.0																		
B-414	93.5	SPT	SM	39.7	10.0						20.1																		
B-414	98.5	SPT	GM	19.6	40.9						13.5																		
B-415	5.0	SPT	SP-SM	5.8	0.3						3.6																		
B-415	13.5	SPT	SP	3.4	0.0						2.5																		
B-415	28.5	SPT	SP-SM	10.4	0.3						13.5																		
B-415	43.5	SPT	SM	31.1	0.2	26	22	4			28.2																		

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Project Name: Constellation Generation Group COLA Project
Calvert Cliffs Nuclear Power Plant (CCNPP)
Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cer	Cec	eo	Pp' tsf
B-415	58.5	SPT	CH	93.3	0.0	61	21	40			36.6																		
B-415	73.5	SPT	SM	47.8	0.0	40	30	10			26.3																		
B-415	83.5	SPT	SM	17.8	2.4						17.0																		
B-416	5.0	SPT	SP-SM								3.8																		
B-416	13.5	SPT	SM								13.0																		
B-416	28.5	SPT	CH	87.7	0.0	58	17	41			33.7																		
B-416	43.5	SPT	SC								25.6																		
B-416	58.5	SPT	SM	15.5	0.0						26.2																		
B-416	73.5	SPT	SP-SC								29.5																		
B-416	88.5	SPT	SC								33.5																		
B-418	2.5	SPT	SC								27.9																		
B-418	7.5	SPT	SM			NP	NP	NP			30.9																		
B-418	13.5	SPT	CL			49	22	27			32.7																		
B-418	23.5	SPT	SP-SM								25.2																		
B-418	33.5	SPT	SP-SM								28.4																		
B-418	43.5	SPT	SC								27.4																		
B-418	53.5	SPT	SP-SC								23.3																		
B-418	63.5	SPT	SM								32.1																		
B-418	73.5	SPT	SC								41.7																		
B-418	88.5	SPT	MH			76	49	27			49.8																		
B-418	98.5	SPT	CL			46	25	21			36.7																		
B-418	108.5	SPT	MH			55	38	17			39.8																		
B-418	123.5	SPT	CH			106	41	65			56.4																		
B-418	138.5	SPT	MH			103	63	40			64.4																		
B-418	148.5	SPT	CH			69	27	42			52.6																		
B-418	168.5	SPT	MH			76	49	27			57.3																		
B-418	183.5	SPT	MH			100	60	40			56.7																		
B-418	198.5	SPT	MH			109	71	38			66.5																		
B-420	0.0	SPT	CH			52	21	31			17.2																		
B-420	2.5	SPT	CH			68	23	45			28.6																		
B-420	5.0	SPT	CH	89.7	0.0	64	22	42			29.7																		
B-420	7.5	SPT	CH			71	19	52			38.3																		
B-420	13.5	SPT	CH	94.2	0.0	74	31	43			42.1																		
B-420	18.5	SPT	CH								28.6																		
B-420	23.5	SPT	ML			NP	NP	NP			24.4																		
B-420	33.5	SPT	SM								24.2																		
B-420	38.5	SPT	CL			30	19	11			20																		

Schnabel Engineering

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Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-420	43.5	SPT	SM	17.1	7.8						26.5																		
B-420	48.5	SPT	SM								28.4																		
B-420	53.5	SPT	SM								28.0																		
B-420	58.5	SPT	SM								34.9																		
B-420	63.5	UD	SC	19.1	6.7	49	11	38			28.3	117	2.75					X	-	Qu	NA	16.0	NA	NA	Dev	0.010	0.130	1.26	1.1
																		X	-	DS	NA	NA	34.0	3.4	NA				
B-420	68.5	SPT	SM	20.7	28.9						16.8																		
B-420	73.5	SPT	SM								24.4																		
B-420	78.5	SPT	SM	39.5	2.2	48	32	15			26.2																		
B-420	83.5	SPT	MH			60	39	21			47.3																		
B-420	88.5	SPT	CH			90	35	55			55.3																		
B-420	93.5	SPT	CH								39.4																		
B-420	98.5	SPT	ML			49	30	19			34.8																		
B-420	103.5	SPT	SM	38.1	0.0	57	42	15			38.5																		
B-420	108.5	SPT	MH			80	51	29			46.4																		
B-420	113.5	SPT	CH			118	38	80			64.9																		
B-420	118.5	SPT	MH			65	40	25			41.6																		
B-420	123.5	SPT	CH			83	29	54			47.5																		
B-420	128.5	UD	OH	50.1	0.3	59	34	25	40		39.0	109	2.62					X	-	UU	Test Not Performed					Test Not Performed			
																		X	-	CIU-bar	15.4	21.3	29.1	13.2	PSR				
B-420	133.5	SPT	MH	76.6	0.0	147	75	72			73.4																		
B-420	138.5	SPT	MH			145	76	69			78.8																		
B-420	143.5	SPT	MH	75.4	0.0	107	56	51			58.9																		
B-420	148.5	SPT	MH	61.3	0.0	127	100	27			74.2																		
B-421	0.0	SPT	SP-SM								11.6																		
B-421	2.5	SPT	SP-SM								14.8																		
B-421	5.0	SPT	SC								11.9																		
B-421	7.5	SPT	SM	14.0	0.0						7.6																		
B-421	10.5	SPT	SP			NP	NP	NP			11.8																		
B-421	13.5	SPT	SP								9.2																		
B-421	18.5	SPT	SW-SM	10.1	0.0						9.4																		
B-421	23.5	SPT	SM			NP	NP	NP			11.0																		
B-421	28.5	SPT	SP-SM	11.4	1.8						15.6																		
B-421	38.5	SPT	SP-SM								17.3																		
B-421	43.5	SPT	MH								31.5																		
B-421	48.5	UD	CH	69.5	0.0	50	18	32			28.8	122.68	2.69																
B-421	53.5	SPT	CH								29.6																		

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SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-421	58.5	UD	CH	86.9	0.0	78	32	46			34.2	119.44	2.72																
B-421	63.5	SPT	CH								28.6																		
B-421	68.5	SPT	SM	33.1	0.3						22.2																		
B-421	73.5	SPT	SM								24.9																		
B-421	78.5	SPT	SM								19.7																		
B-421	83.5	SPT	SM								20.5																		
B-421	88.5	SPT	SM	14.5	11.4						26.0																		
B-421	93.5	SPT	SP-SC			NP	NP	NP			20.7																		
B-421	98.5	SPT	SP-SM								28.4																		
B-421	103.5	SPT	SM								26.0																		
B-421	108.5	SPT	SM	14.0	0.1	NP	NP	NP			26.1																		
B-421	113.5	SPT	SM	18.4	0.0						31.7																		
B-421	118.5	SPT	ML			NP	NP	NP			27.8																		
B-421	128.5	SPT	ML								22.0																		
B-421	133.5	SPT	SM	41.7	0.0						29.0																		
B-421	138.5	SPT	CH			53	25	28			38.5																		
B-421	143.5	SPT	SM								46.8																		
B-421	148.5	SPT	SM								47.4																		
B-423	2.5	SPT	SM	12.5	0.1						4.9																		
B-423	13.5	SPT	SM			NP	NP	NP			12.3																		
B-423	18.5	SPT	SM								10.4																		
B-423	23.5	SPT	SP-SM	11.8	0.0						16.6																		
B-423	28.5	SPT	SM								17.4																		
B-423	33.5	SPT	SM			NP	NP	NP			13.6																		
B-423	38.5	SPT	SC	36.9	0.0	43	15	28			43.9																		
B-423	43.5	SPT	CH	73.0	0.0	55	20	35			30.9																		
B-423	48.5	SPT	CH			61	16	45			36.6																		
B-423	53.5	SPT	CH	81.2	0.0	80	34	46			38.1																		
B-423	58.5	SPT	MH			78	45	33			33.8																		
B-423	63.5	SPT	ML			37	27	10			21.9																		
B-423	68.5	SPT	SM			NP	NP	NP			25.4																		
B-423	73.5	SPT	SM								22.8																		
B-423	78.5	SPT	ML	11.3	9.3						21.9																		
B-423	83.5	SPT	SM								25.6																		
B-423	88.5	SPT	SM								23.1																		
B-423	93.5	SPT	SM	13.0	1.1						29.8																		
B-423	98.5	SPT	SM								27.4																		

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Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cer	Cec	eo	Pp' tsf
B-423	103.5	UD	SP-SC	9.7	14.4	24	18	6			23.1	120	2.74					X	-	CIU-bar	14.1	32.5	27	11.4	PSR				
																		X	-	DS	Test Not Performed								
B-423	108.5	SPT	SP-SC								30.8																		
B-423	118.5	SPT	SM	19.6	13.9	NP	NP	NP			26.2																		
B-423	123.5	SPT	SM								33.9																		
B-423	128.5	SPT	SM	21.4	0.0						31.9																		
B-423	133.5	SPT	ML								37.1																		
B-423	138.5	SPT	SM	43.2	0.0						45.1																		
B-423	143.5	SPT	SM								38.9																		
B-423	148.5	SPT	SM	32.9	4.6						32.8																		
B-423	153.5	SPT	CL								44.9																		
B-423	158.5	UD	OH	87.6	0.0	74	18	56	49	1.3	44.9	108	2.70					X	-	UU	NA	16.6	NA	NA	Dev	0.010	0.310	1.46	11.5
B-423	163.5	SPT	MH								59.7																		
B-423	168.5	SPT	ML								41.0																		
B-423	173.5	SPT	SM								49.7																		
B-423	178.5	UD	SM	46.4	0.0	64	34	30			41.5	112	2.36					X	-	UU	NA	2.63	NA	NA	Dev	0.030	0.310	1.71	7
B-423	183.5	SPT	SM								73.3																		
B-423	188.5	UD	MH	90.6	0.0	111	70	41			72.4	96	2.50					X	-	DS	NA	NA	18.5	23.0	NA				
B-423	193.5	SPT	MH								71.0																		
B-423	200.0	SPT	CL								45.3																		
B-425	0.0	SPT	SP-SM								13.7																		
B-425	3.5	SPT	SP-SM	7.9	0.0						7.3																		
B-425	5.0	SPT	SP-SM								2.5																		
B-425	8.5	SPT	SP-SM								10.8																		
B-425	10.0	SPT	SP-SM								14.2																		
B-425	13.5	SPT	SP-SM	6.5	0.4						16.4																		
B-425	20.0	SPT	SP-SM								11.1																		
B-425	25.0	SPT	SP-SM								11.6																		
B-425	30.0	SPT	SP-SM	11.3	0.2						15.2																		
B-425	35.0	SPT	SP-SM								12.0																		
B-425	40.0	SPT	SP-SM	7.4	0.9						14.9																		
B-425	45.0	SPT	SW-SM								13.7																		
B-425	50.0	SPT	SW-SM	10.1	10.9	28	17	11			12.1																		
B-425	55.0	SPT	CL			46	19	27			28.2																		
B-425	57.0	UD	CH	81.8	0.0	55	25	30			31.2	119.69	2.71																
B-425	60.0	SPT	CH			63	21	42			35.1																		
B-425	65.0	UD	CH	89.6	0.0	69	28	41			39.5	114.52	2.72																

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Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-425	70.0	SPT	MH			77	42	35			38.4																		
B-425	75.0	UD	SC	45.1	0.1	41	20	21			21.8	125.36	2.69																
B-425	80.0	SPT	SC								31.7																		
B-425	85.0	SPT	SP								19.0																		
B-425	90.0	SPT	SP								20.5																		
B-425	95.0	SPT	SP								17.9																		
B-427	2.5	SPT	SM	30.6	0.0						9.4																		
B-427	7.5	SPT	SP-SM								7.9																		
B-427	18.5	SPT	SM	12.5	1.1						8.2																		
B-427	28.5	SPT	SP-SM	8.4	0.2						12.2																		
B-427	38.5	SPT	SP								13.6																		
B-427	48.5	SPT	SP-SM	6.3	0.1						18.6																		
B-427	63.5	UD	OH	61.3	38.7	56	18	38	36		32.8	116	2.74					X	-	Qu	NA	25	NA	NA	Dev	0.030	0.260	1.02	8.7
																		X	-	UU	NA	10.6	NA	NA	Dev				
																		X	-	DS	NA	NA	29.2	6.1	NA				
B-427	78.5	SPT	SM								23.1																		
B-427	93.5	SPT	SM	34.8	24.7						12.0																		
B-427	103.5	SPT	SP-SM	11.2	4.1						24.8																		
B-427	118.5	SPT	SM	24.2	0.0						29.2																		
B-427	128.5	SPT	SM								31.4																		
B-427	138.5	SPT	SM	29.8	0.0						38.5																		
B-427	148.5	SPT	SM	33.1	0.0						44.3																		
B-428	60.0	UD	CH	92.6	0.0	61	17	44	46		37	120	2.78					X	-	Qu	NA	33.9	NA	NA	Dev				
																		X	-	UU	NA	10.3	NA	NA	Dev				
B-428	63.0	UD	CH							0.1																			
B-429	45.0	UD	Reserve Sample - Tests Not Performed																										
B-433	5.0	SPT	ML								27.0																		
B-433	10.5	SPT	SW-SM	10.2	0.1						5.8																		
B-433	23.5	SPT	SW-SM								14.4																		
B-433	33.5	SPT	MH								23.3																		
B-433	38.5	UD	CH	91.0	0.0	61	14	47			33.5	113	2.77					X	-	Qu	NA	26.4	NA	NA	Dev	0.040	0.280	1.00	8.3
																		X	-	UU	NA	22.5	NA	NA	Dev				
																		X	-	DS	NA	NA	20.2	9.4	NA				
B-433	43.5	SPT	CH			59	22	37			33.50																		
B-433	48.5	UD	CH	94.5	0.0	64	23	41			33.6	121	2.66					X	-	Qu	NA	6.6	NA	NA	Dev	0.030	0.310	1.16	10
																		X	-	CIU-bar	8.3	6.14	19.3	4.22	PSR				
B-433	53.5	SPT	CL			45	18	27			21.0																		

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Project Name: Constellation Generation Group COLA Project
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Calvert County, Maryland

Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cer	Cec	eo	Pp' tsf
B-433	58.5	SPT	SM	48.2	0.0	44	35	9			29.3																		
B-433	73.5	SPT	SW-SM	11.6	7.8						23.7																		
B-433	93.5	SPT	ML	12.1	1.1						31.5																		
B-434	7.5	SPT	SP-SM								11.8																		
B-434	13.5	SPT	SM	13.9	0.8						7.0																		
B-434	18.5	SPT	SP-SM								10.6																		
B-434	28.5	SPT	SM	27.2	0.1						21.9																		
B-434	33.5	SPT	SM								26.6																		
B-434	38.5	SPT	SM			NP	NP	NP			27.4																		
B-434	48.5	SPT	CH			73	24	49			38.2																		
B-434	53.5	UD	CH	94.9	0.0	56	23	32			87.8	118	2.84					X	-	Qu	NA	28.5	NA	NA	Dev	0.010	0.368	1.09	14
																		X	-	UU	NA	25.4	NA	NA	Dev				
B-434	58.5	SPT	CH	94.7	0.0	86	22	64			36.6																		
B-434	63.5	UD	SM	36.9	0.0	---	---	NP			23.7	100.5	2.72					X	-	DS	Test Not Performed					0.004	0.111	0.72	11.8
																		X	-	CIU-bar	Test Not Performed								
B-434	68.5	SPT	SM								25.0																		
B-434	73.5	SPT	SM								22.6																		
B-434	78.5	SPT	SM								15.6																		
B-434	83.5	SPT	CL			30	22	8			19.8																		
B-434	88.5	SPT	SM								15.6																		
B-434	93.5	SPT	SP			NP	NP	NP			31.2																		
B-434	98.5	SPT	SM								25.6																		
B-436	7.5	SPT	SP-SM	4.9	0.5						3.3																		
B-436	23.5	SPT	SP-SM	8.1	3.1						11.1																		
B-436	33.5	SPT	SM	26.3	0.0						25.2																		
B-437	13.5	UD	SP-SM	5.6	0.0	NP	NP	NP			7.2	124.1	2.66																
B-437	98.5	UD	Reserve Sample - Tests Not Performed																										
B-440	2.5	SPT	SM	33.2	0.1						8.6																		
B-440	7.5	SPT	Test Not Performed																										
B-440	13.5	SPT	SM	19.7	11.8						16.1																		
B-440	23.5	SPT	SP-SM	8.4	0.0						22.1																		
B-440	33.5	SPT	SM	28.4	10.8						20.1																		
B-440	43.5	SPT	SM	17.6	5.3						27.1																		
B-440	51.0	UD	SC	18.0	0.0	30	21	9			30.0	116	2.75					X	-	Qu	NA	5.1	NA	NA	Dev				
																		X	-	DS	NA	NA	30.3	5.5	NA				
B-440	63.5	SPT	SM	19.5	16.8						19.4																		
B-440	78.5	SPT	SM	28.7	0.0						41.0																		

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Project Number: 06120048.00

SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-701	7.5	SPT	SM	27.9	0.9						15.9																		
B-701	10.5	SPT	SW-SM	6.3	45.7						12.4																		
B-701	18.5	SPT	SM	21.1	2.8						28.2																		
B-701	28.5	SPT	SM	34.3	1.7						37.3																		
B-701	43.5	UD	MH	64.1	0.0	54	33	21			37.3	116	2.64					X	-	UU	NA	24.6	NA	NA	Dev				
B-701	48.5	SPT	SM	17.5	3.9						33.1																		
B-701	53.5	SPT	ML								42.5																		
B-701	58.5	SPT	MH								55.7																		
B-701	63.5	SPT	ML								40.4																		
B-701	68.5	SPT	MH								48.0																		
B-703	18.5	SPT	OH	83.4	0.0	69	25	44	39	0.9	45.1	106	2.70					X	-	Qu	Test Not Performed					0.003	0.300	1.31	9
B-707	2.5	SPT	CH								27.3																		
B-707	7.5	SPT	CH	74.6	0.0	59	21	38			32.8																		
B-707	13.5	SPT	CH								32.7																		
B-707	23.5	SPT	SC								29.5																		
B-707	33.5	SPT	MH	70.8	21.0	59	45	14			45.5																		
B-707	48.5	SPT	SP-SM								27.0																		
B-709	7.5	SPT	SC								27.3																		
B-709	13.5	SPT	SM								29.1																		
B-709	23.5	SPT	SC								30.4																		
B-709	33.5	SPT	ML								33.8																		
B-709	48.5	SPT	CL								23.0																		
B-722	5.0	SPT	SP								3.5																		
B-722	13.5	SPT	SP								12.4																		
B-722	23.5	SPT	ML								21.1																		
B-722	33.5	UD	SM	20.1	0.0	NP	NP	NP			26.8	120	2.76					X	-	Qu	NA	4.1	NA	NA	Dev	0.010	0.040	0.78	6
																		X	-	UU	NA	8.5	NA	NA	Dev				
B-722	43.5	SPT	CH								37.1																		
B-722	53.5	SPT	CH								41.9																		
B-722	63.5	SPT	CH								47.5																		
B-722	73.5	SPT	SM								18.8																		
B-723	28.5	UD	CH	89.7	0.0	56	15	41			31.9	120	2.71					X	-	Qu	NA	5.8	NA	NA	Dev	0.010	0.500	0.83	10.5
																		X	-	UU	NA	16.7	NA	NA	Dev				
B-723	38.5	UD	CH	95.2	0.0	64	19	45			33.9	112	2.73					X	-	UU	NA	11.7	NA	NA	Dev	0.030	0.240	1.15	6.4
B-724	73.5	UD	OL	60.1	0.1	45	24	21	32	3.2	31.9	103	2.7					X	-	DS	NA	NA	27.5	8.2	NA				
B-726	23.5	UD	CH	96.0	0.0	69	22	47			35.7	117	2.7					X	-	UU	NA	11.8	NA	NA	Dev	0.040	0.290	1.16	10.3
B-729	2.5	SPT	SC								16.0																		

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SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-729	7.5	SPT	SP-SM								13.5																		
B-729	18.5	SPT	SP-SM								14.2																		
B-729	28.5	SPT	SP-SM								12.5																		
B-729	38.5	SPT	SM								18.4																		
B-729	48.5	SPT	ML								28.2																		
B-729	58.5	SPT	SM								28.8																		
B-729	68.5	UD	OH	92.7	0.0	56	18	38	40	1.4	32.8	118	2.79					X	-	UU	NA	19.2	NA	NA	Dev	0.040	0.290	1.05	12
B-732	15.0	UD	SC	32.0	2.7	26	19	7			23.1	124	2.75					X	-	Qu	NA	6.9	NA	NA	Dev	0.010	0.080	0.82	4
																		X	-	UU	NA	3.3	NA	NA	Dev				
B-733	23.5	UD	CH	78.0	22.0	51	15	36			33.2	119	2.73					X	-	Qu	NA	6	NA	NA	Dev	0.020	0.180	1.00	5.7
																		X	-	UU	NA	8.1	NA	NA	Dev				
B-735	2.5	SPT	SP-SM	6.2	3.8						7.6																		
B-735	10.5	SPT	SM	27.8	0.0						13.5																		
B-735	18.5	SPT	SM	28.1	0.0	NP	NP	NP			28.7																		
B-735	28.0	UD	CH	87.1	12.9	51	16	35			32.3	119						X	-	UU	NA	17.5	NA	NA	Dev	0.030	0.250	1.01	7.5
																		X	-	DS	NA	NA	27.2	4.9	NA				
B-735	43.5	SPT	CH	98.5	0.0	85	30	55			39.6																		
B-735	58.5	SPT	SP-SM	5.8	0.0						20.9																		
B-735	73.5	SPT	SM	14.3	14.7						24.5																		
B-737	10.5	UD	CH	92.9	0.0	75	23	52			37.6	113	2.63					X	-	UU	NA	8.6	NA	NA	Dev	0.030	0.200	1.13	6.1
																		X	-	DS	NA	NA	22.7	5.2	NA				
B-738	5.0	SPT	SM								9.0																		
B-738	10.5	SPT	SP								12.3																		
B-738	18.5	SPT	CH								24.2																		
B-738	28.5	SPT	MH								28.4																		
B-738	35.0	UD	SC-SM	25.1	0.0	26	22	4			26.4	118	2.67					X	-	Qu	NA	5.7	NA	NA	Dev	0.010	0.040	0.78	8
																		X	-	UU	NA	15.9	NA	NA	Dev				
B-738	48.5	SPT	CH								32.1																		
B-738	58.5	SPT	SC								28.7																		
B-738	68.5	SPT	CL								30.9																		
B-743	23.5	UD	CL	57.2	0.0	38	13	25			21.1	115	2.69					X	-	DS	NA	NA	29.2	3.7	NA				
B-746	2.5	SPT	ML								14.4																		
B-746	7.5	SPT	SM	27.3	0.0						25.1																		
B-746	13.5	UD	SC-SM	28.8	0.0	25	21	4			27.2	121	2.76					X	-	UU	NA	7.1	NA	NA	Dev	0.010	0.060	0.83	10.8
B-746	23.5	SPT	CH	86.5	0.0	52	17	35			30.8																		
B-746	33.5	SPT	CH	93.6	0.0	64	24	40			34.8																		
B-746	43.5	SPT	ML			40	34	6			29.2																		

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SUMMARY OF SOIL LABORATORY TEST RESULTS[1]

Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f deg.	C' psi	Failure Crieterion[6]	Cεr	Cεc	eo	Pp' tsf
B-746	58.5	SPT	SM								17.9																		
B-746	68.5	SPT	SM								24.8																		
B-747	2.5	SPT	SM	36.2	0.0						7.5																		
B-747	5.0	SPT	ML	71.2	0.0						12.7																		
B-747	10.5	SPT	SP-SM	4.8	0.0						20.3																		
B-747	13.5	SPT	SM	20.4	0.0						26.6																		
B-747	18.5	SPT	SM	15.0	0.1						23.9																		
B-747	23.5	SPT	ML	66.3	0.0						28.2																		
B-747	28.5	SPT	ML								32.6																		
B-747	33.5	SPT	CH	77.5	0.0						34.2																		
B-747	38.5	SPT	CH	81.5	0.1						32.6																		
B-747	43.5	SPT	CH								27.5																		
B-747	48.5	SPT	CH								39.4																		
B-747	53.5	SPT	MH	76.1	0.0	78	47	31			48.6																		
B-747	58.0	UD	CH			53	16	37			35.0	108	2.73					X	-	UU	NA	23.6	NA	NA	Dev	0.020	0.260	1.09	11.3
B-747	63.5	SPT	SC	38.0	18.3	43	20	23			27.6																		
B-747	68.5	SPT	SM			NP	NP	NP			30.3																		
B-747	73.5	SPT	SP-SM			NP	NP	NP			28.1																		
B-752	2.5	SPT	SP-SM	10.0	0.5						5.9																		
B-752	10.5	SPT	SW-SM	10.2	0.4						6.7																		
B-752	18.5	SPT	SW-SM	13.2	6.7						12.7																		
B-752	28.5	SPT	SM	36.9	0.0						29.0																		
B-752	33.5	SPT	CH	67.0	0.0	52	23	29			29.1																		
B-752	38.5	SPT	MH	80.4	0.0	63	31	32			33.1																		
B-752	43.5	SPT	MH			71	26	19			37.1																		
B-752	48.5	SPT	CH			68	24	44			40.3																		
B-752	53.5	SPT	SM	44.9	0.0	40	29	11			27.7																		
B-752	58.0	UD	OH	97.9	0.0	65	17	48	46	0.6	45.3	110	2.79					X	-	UU	NA	21.8	NA	NA	Dev	0.050	0.400	1.73	10.3
B-752	63.5	SPT	MH			64	43	21			37.0																		
B-752	68.5	SPT	ML	60.5	0.0						34.6																		
B-752	83.5	SPT	SP-SM	10.9	8.3						28.0																		
B-752	98.5	SPT	SC	27.2	6.2						31.6																		
B-765	100.0	UD	Tests Not Performed																										
TP-B307	4.5	Bulk	SP-SM	5.8	0.0						2.3			109.3	10.5	14.8	4.4												
TP-B314	4.0	Bulk	CH	93.1	0.0	71	24	47			37.0			114.6	15.5														
TP-B315	6.0	Bulk	SP-SM	9.7	0.2						5.4			114.9	11.4	11.6	18.9												
TP-B334	3.0	Bulk	SM	13.9	0.0						7.4			116.3	9.3														

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Boring / Test Pit No.	Sample Top Depth (ft.)	Sample Type[2]	USCS Sample Class. (D 2487)[3]	Sieve Results (D 422)		Atterberg Limits[4] (D 4318)				Organic Content (%)	Natural Moisture (%) (D 2216)	Moist Unit Weight (PCF)	Specific Gravity (D 854)	Moisture-Density Relationship (D 1557)		Bearing Ratio (D 1883)		Specimen		Shear Strength						Consolidation (D 2435)			
																					Total		Effective						
				Percent Passing No. 200	Percent Retained No. 4	LL	PL	PI	Oven Dried LL					Dry Unit Wt. (PCF)	Optium Moisture (%)	Dry	Soaked	Intact	Compacted	Test Type[5]	f deg.	C psi	f' deg.	C' psi	Failure Crieterion[6]	Cer	Cec	eo	Pp' tsf
TP-B334	6.0	Bulk	SM	13.2	0.0						14.5			129.8	8.0														
TP-B335	3.0	Bulk	CL	65.3	0.0	30	20	10			19.0			128.8	9.9														
TP-B335	5.0	Bulk	SM	24.6	0.0						8.9			130.5	7.6	36.2	18.0												
TP-B407	4.5	Bulk	SW-SM	9.0	2.2						7.1			118.9	8.8	14.8	17.0												
TP-B414	6.0	Bulk	SP-SM	6.4	0.0						6.0			105.4	11.9														
TP-B415	3.0	Bulk	SP	3.5	0.2						10.2			116.7	9.8	11.1	4.7												
TP-B423	5.0	Bulk	CL	51.1	0.0	24	16	8			16.0			123.4	10.8														
TP-B434	2.0	Bulk	CL	59.8	0.2	25	18	7			21.0			127.1	10.1	9.3	3.2												
TP-B435	5.0	Bulk	SM	13.2	0.0						6.0			119.1	8.9														
TP-B435	7.0	Bulk	SP-SM	8.3	0.8						4.6			123.9	8.9	26.8	33.7												
TP-B435	9.0	Bulk	SC	14.1	0.0	34	17	17			6.7			130.2	7.3	34.4	41.8												
TP-B715	5.5	Bulk	SP-SM	11.0	0.9						4.8			110.7	11.8														
TP-B716	6.0	Bulk	SP-SM	6.0	1.0						3.8			116.3	9.4														
TP-B717	7.0	Bulk	SP-SM	6.4	2.6						3.4			123.8	10.2	17.2	23.1												
TP-B719	0.5	Bulk	CL	84.5	0.0	35	22	13			23.9			118.4	13.5														
TP-B719	7.0	Bulk	SM	44.3	0.0						26.7			119.6	10.0	41.3	29.0												
TP-B727	6.0	Bulk	SM	30.1	0.0						10.3			130.5	6.8														
TP-B744	1.5	Bulk	CL	64.2	0.0	25	17	8			18.0			131.2	8.0														
TP-B758	2.0	Bulk	SP-SM	8.4	0.8						6.0			121.0	8.8														
TP-B758	7.5	Bulk	SM	31.1	2.6						11.8			127.3	8.9	11.3	4.4												
TP-C309	2.0	Bulk	SP	3.7	1.2						4.3			111.2	13.9														
TP-C309	7.0	Bulk	SP-SM	7.8	0.0						8.7			112.3	9.8														
TP-C723	2.5	Bulk	SC	39.5	0.0	30	15	15			12.0			132.8	7.3	26.8	17.2												
TP-C723	6.0	Bulk	SP-SM	7.5	1.2						4.6			113.8	6.8														
B-301	368.5	SPT (Composite)	SM	15.0	0.0	40	36	4			34.4	116.4	2.86																
B-301	378.5																												
B-301	383.5																												
B-301	388.5																												
B-301	398.5																												
B-401	358.5																												
B-401	378.5																												

NOTES:

1. Tests are in accordance with applicable ASTM standards.
2. Sample type: SPT = sample obtained from split spoon, UD = undisturbed sample in thin walled sampler
3. Visual-manual procedures (ASTM D 2488) used as appropriate.
4. Key: LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; NP = Nonplastic
5. Test Type: Qu - unconfined compression; UU - Triaxial Unconsolidated, Undrained; CIU-bar - Triaxial Consolidated Undrained; CD - Triaxial Consolidated Drained; DS - Drained Direct Shear
6. Failure Criterion: Dev. - maximum deviator stress; PSR - maximum principal stress ratio; Strain - defined level of axial strain

REPLACEMENT BORING LOG SHEETS

- B-301, Sheets 1 and 2 of 13
- B-305, Sheets 1 and 2 of 5
- B-306, Sheets 2 and 3 of 5
- B-401, Sheets 4 through 13 of 13
- B-404, Sheets 1 through 4 of 7
- B-409, Sheets 2 through 5 of 5
- B-437, Sheets 1 and 2 of 4

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-301** Contract Number: 06120048 Sheet: 1 of 13

Boring Contractor: UNI-TECH DRILLING
MALAGA, NEW JERSEY

Boring Foreman: J. Evans

Drilling Method: Mud Rotary

Drilling Equipment: Failing-1500 (Truck)

Schnabel Representative: K. Megginson

Dates Started: 5/25/06 **Finished:** 6/6/06

Location: Northing: 217024.06 ft
Easting: 960815.05 ft

Ground Surface Elevation: 94.5 (feet)

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Encountered	5/25	---	10.5'	---	---
Start of day	5/26	---	25.0'	---	---
Start of day	5/30	---	41.0'	---	---
Start of day	6/1	---	10.0'	---	---

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	CLAYEY SAND, fine to medium grained, contains root fragments, moist, brown. Majority of root system extends about 0.7 ft below ground surface.	SC				3+3+4 N = 7 REC = 9"		
2.0	POORLY GRADED SAND WITH SILT, trace gravel, fine to medium grained, moist, stratified orangeish brown and brown, contains fine to coarse silty sand lense at 3.5 ft.	SP-SM	92.5			3+4+5 N = 9 REC = 13"	w=6.6% *	
	fine to coarse grained, brown.				5	4+7+7 N = 14 REC = 10"		
	fine to medium grained,stratified light brown and yellowish brown					4+7+8 N = 15 REC = 12"		
	wet, brown and light brown			▽	10	6+9+9 N = 18 REC = 9"	w=14.3% *	
	light orangeish brown.					8+6+8 N = 14 REC = 10"		
14.5	CLAYEY SAND, fine to medium grained, moist, brown	SC	80.0		15			
17.0	POORLY GRADED SAND WITH SILT, trace gravel, fine to coarse grained, wet, dark orangeish brown and orangeish brown, contains fine to medium clayey sand pockets.	SP-SM	77.5		20	6+11+10 N = 21 REC = 14"	w=19% *	Drilling foreman used 5.4" O.D. Drag Bit from 0 to 18.5 ft. Switched to 4-3/4" O.D. Drag bit below 18.5 ft.
22.0	SANDY LEAN CLAY, fine to medium, trace mica, moist, gray.	CL	72.5			3+3+5 N = 8 REC = 18"		
	continued on next page				25			

Comments:
1. Boring backfilled with cement/bentonite grout via tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/6/06.
3. * = See Appendix I for additional lab testing data.
4. Ground water observation well OW-301 installed at nearby location.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant, Calvert County, Maryland	Boring Number: **B-301** Contract Number: 06120048 Sheet: 2 of 13

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		CL						
27.0	SANDY LEAN CLAY, with fine to medium sand, trace mica, contains fine to medium sandy fat clay and fine to medium clayey sand pockets, moist, gray.	CL	67.5		30	2+4+3 N = 7 REC = 18"	w=28.9% LL=48 PL=17 *	
32.0	FAT CLAY, with fine to medium sand and mica, moist, gray.	CH	62.5		35	REC = 22"	w=31.1% LL=59 PL=17 *	Osterberg sampler tube push from 33.5 to 35.5 ft
	gray and dark gray, trace organic matter (±1%), contains fine to medium silty sand pockets.				40	4+5+5 N = 10 REC = 18"		
	gray and light greenish gray.				45	REC = 22"	PP=2.00 tsf	Osterberg sampler tube push from 43.5 to 45.2 ft
47.0	SANDY LEAN CLAY, fine to medium, trace mica, contains indurated lean clay pockets, moist, gray.	CL	47.5		50	5+6+8 N = 14 REC = 18"	w=29.6% *	
52.0	CLAYEY SAND, fine to medium grained, trace fine to medium shell fragments (±5%), strong HCl reaction, moderate cementation, moist, dark gray, contains indurated silt layer from 54.5 to 54.7 ft (layer exhibits fissility).	SC	42.5		55	11+48+50/3" N = 98/9" REC = 16"		Switched to 4-3/4" Tri-cone roller bit below 53.5 ft. Moderate difficulty in rotary advancement from 54.5 to 56.5 ft (slight rig chatter).
57.0	POORLY GRADED SAND, trace silt, fine to medium grained, wet, gray, weak *continued on next page*	SP	37.5					

Comments:
1. Boring backfilled with cement/bentonite grout via tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/6/06.
3. * = See Appendix I for additional lab testing data.
4. Ground water observation well OW-301 installed at nearby location.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-305** Contract Number: 06120048 Sheet: 1 of 5

Boring Contractor: CONNELLY AND ASSOCIATES, INC.
FREDERICK, MARYLAND

Boring Foreman: T. Connelly

Drilling Method: Mud Rotary

Drilling Equipment: CME-550

Schnabel Representative: K. Bell

Dates Started: 7/17/06 **Finished:** 7/20/06

Location: Northing: 217166.25 ft
Easting: 960686.74 ft

Ground Surface Elevation: 72.0 (feet)

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/18	---	37.5'	---	---
Start of Day	7/19	---	35.0'	---	---
Start of Day	7/20	---	24.0'	---	---

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.5	POORLY GRADED SAND WITH SILT, fine to medium grained, moist, yellowish brown, trace root fragments, trace wood fragments.	SP-SM	71.5			woh+1+2 N = 3 REC = 11"		
		SP-SM						
2.0	POORLY GRADED SAND WITH SILT, fine to medium grained, moist, yellowish brown, trace root fragments, trace wood fragments.	SC	70.0			1+1+3 N = 4 REC = 7"		
4.5	CLAYEY SAND, fine to medium grained, moist, yellowish brown and orangeish brown, trace root fragments, trace wood fragments.	SM	67.5		5	2+2+3 N = 5 REC = 12"		
	SILTY SAND, fine grained, moist, gray and orangeish brown, trace root fragments.					woh+woh+1 N = 1 REC = 4"		
10.0	FAT CLAY, moist, gray and orangeish brown, trace sand.	CH	62.0		10	2+2+2 N = 4 REC = 15"		
						REC = 22"	PP=2.50 tsf	
					15	2+3+4 N = 7 REC = 18"		color change in mud tub from orangeish brown to gray
						3+4+6 N = 10 REC = 18"		
19.0	SILTY SAND, fine to medium grained, moist, gray.	SM	53.0		20	REC = 16"		
22.5	ELASTIC SILT, moist, gray, trace sand.	MH	49.5			4+4+6 N = 10 REC = 18"		
					25			

continued on next page

Comments:
1. Boring backfilled with cement/bentonite grout through
2. * = See Appendix I for additional lab testing data.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant, Calvert County, Maryland	Boring Number: **B-305** Contract Number: 06120048 Sheet: 2 of 5

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		MH				5+7+9 N = 16 REC = 18"		
27.0	SANDY SILT, moist, gray.	ML	45.0			5+5+7 N = 12 REC = 18"		
	weak cementation				30	4+5+8 N = 13 REC = 18"		
						8+13+25 N = 38 REC = 18"		Harder drilling
35.0	CLAYEY SAND, fine to medium grained, wet, gray and white, contains fine to medium shell fragments, 30-40%, HCl reaction strong.	SC	37.0	▽	35	REC = 5"		resumed drilling on 7/18/06 @7:30am Harder drilling
						32+45+48 N = 93 REC = 12"		
					40	REC = 23"	w=34.7% LL=72 PL=22 *	
						30+50/5" N = 50/5" REC = 10"		
					45	50/5" N = 50/5" REC = 4"		
47.0	CLAYEY SAND, fine to medium grained, wet, white and gray, with fine to coarse shell fragments, 60-70%, HCl reaction strong.	SC	25.0			40+50/5" N = 50/5" REC = 8"		
50.8	LEAN CLAY, wet, gray, trace sand, contains fine to medium shell fragments, 20-30%, HCl reaction moderate.	CL	21.2		50	12+8+8 N = 16 REC = 16"		
						REC = 8"	PP=>4.5 tsf	harder
55.0	SILTY SAND, fine to medium grained, wet, greenish gray, strong cementation.	SM	17.0		55	50/5" N = 50/5" REC = 5"		
	with fine to coarse shell fragments, *continued on next page*					36+50/1"		

Comments:
1. Boring backfilled with cement/bentonite grout through
2. * = See Appendix I for additional lab testing data.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-306** Contract Number: 06120048 Sheet: 2 of 5

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		SM						
	trace fine gravel.					8+13+17 N = 30 REC = 16"		
	medium to coarse grained,dark orangeish brown.				30			
	orangeish brown and black.					5+8+10 N = 18 REC = 13"		
					35			
	light orangeish brown, with 3" layer of fine gravel.					4+9+10 N = 19 REC = 14"		
					40			
41.0	CLAYEY SAND, fine to medium grained, moist, orange and gray.	SC	77.6					
						3+2+2 N = 4 REC = 18"		
					45			
	gray, contains mica.					3+3+5 N = 8 REC = 18"		
					50			
51.0	LEAN CLAY, with sand, fine to medium grained, moist, gray.	CL	67.6					
						3+3+5 N = 8 REC = 18"		
					55			

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Comments:
1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. * = See Appendix I for additional lab testing data.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-306** Contract Number: 06120048 Sheet: 3 of 5

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	greenish gray.	CL			60	REC = 24"	PP=2.00 tsf	
	with fine to medium sand lenses.				65	6+6+7 N = 13 REC = 18"	PP=1.50 tsf	
67.0	FAT CLAY, trace fine sand, moist, light gray.	CH	51.6		70	REC = 24"	w=30.7% LL=62 PL=24 PP=3.15 tsf *	
71.0	SILTY SAND, fine grained, moist, greenish gray, contains mica.	SM	47.6		75	6+8+10 N = 18 REC = 18"		
	dark gray, with fine shell fragments, weak HCl reaction.				80	38+50/4" N = 50/4" REC = 10"		
81.0	POORLY GRADED SAND, fine to medium grained, moist, gray, with fine to medium shell fragments, weak HCl reaction.	SP	37.6		85	50/3" N = 50/3" REC = 4"		
87.0	SILTY SAND, fine to medium grained, moist, light gray, with fine to medium shell fragments, strong HCl reaction.	SM	31.6		90	35+29+41 N = 70 REC = 18"		

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Comments:
1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. * = See Appendix I for additional lab testing data.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-401** Contract Number: 06120048 Sheet: 4 of 13

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		SM						
92.0	ELASTIC SILT, moist, gray and light greenish gray, trace fine to coarse shell fragments (±<5%),weak HCl reaction.	MH	-19.9		95	6+11+16 N = 27 REC = 18"		
					100	REC = 15"	w=50.5% LL=78 PL=48 PP=>4.5 tsf *	*Osterberg sampler tube push from 98.5 to 99.8 ft
103.5	SILTY SAND, fine to medium sandy, light greenish gray, trace fine to coarse shell fragments (±5%) and organic matter (±<1%), contains clayey sand layers.	SM	-31.4		105	5+9+22 N = 31 REC = 18"		
					110	5+10+17 N = 27 REC = 13"	w=35.6% *	
112.0	LEAN CLAY, moist, gray and light greenish gray, with fine to medium sand, trace and fine to coarse shell fragments (±5%), strong HCl reaction.	CL	-39.9		115	4+8+10 N = 18 REC = 18"	w=46.1% *	
117.0	SILT, moist, gray and light greenish gray, with fine to medium sand, trace mica and fine to medium shell fragments (±5%), weak HCl reaction.	ML	-44.9		120	5+9+12 N = 21 REC = 18"		
122.0	ELASTIC SILT, moist, gray, trace fine to medium sand, mica, and fine to medium shell fragments (±1%), weak HCl reaction.	MH	-49.9			REC = 16"	w=57.4%	*Osterberg

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Comments:

1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/29/06.
3. * = See Appendix I for additional lab testing data.
4. Ground water observation well OW-401 installed at a nearby location.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant, Calvert County, Maryland	Boring Number: **B-401** Contract Number: 06120048 Sheet: 5 of 13

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		MH			125		LL=85 PL=54 PP=>4.5 tsf *	sampler tube push from 123.5 to 124.8 ft
128.5	SANDY SILT, gray and greenish gray, with fine to medium sand, trace fine to medium shell fragments (±<5%), strong HCl reaction.	ML	-56.4		130	5+6+11 N = 17 REC = 18"	w=43.8% *	
	fine to medium sandy, greenish gray, very weak HCl reaction.				135	7+9+11 N = 20 REC = 18"		
137.0	SANDY FAT CLAY, moist, greenish gray, fine to medium sand, strong HCl reaction.	CH	-64.9		140	REC = 23"	w=44.1% LL=80 PL=31 PP=>4.5 tsf *	*Osterberg sampler tube push from 138.5 to 140.5 ft
142.0	ELASTIC SILT, moist, greenish gray, trace fine to medium sand, weak HCl reaction	MH	-69.9		145	7+9+11 N = 20 REC = 18"	w=77.1% LL=142 PL=104 *	
	trace mica.				150	8+10+12 N = 22 REC = 18"	w=72.7% LL=150 PL=89 *	**Resumed drilling at 6:55 AM on 6/21/06.
					155	6+8+11 N = 19 REC = 18"	w=68.8% LL=142 PL=93 *	

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Comments:

1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/29/06.
3. * = See Appendix I for additional lab testing data.
4. Ground water observation well OW-401 installed at a nearby location.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant, Calvert County, Maryland	Boring Number: **B-401** Contract Number: 06120048 Sheet: 6 of 13

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	dark greenish gray.	MH				REC = 10"	w=49.9% LL=81 PL=54 PP=>4.5 tsf *	*Osterberg sampler tube push from 158.5 to 159.3 ft
	with fine to medium sand.				160 165 170	8+10+15 N = 25 REC = 18"	w=53.9% LL=103 PL=52 *	
172.0	FAT CLAY, trace fine sand, greenish gray.	CH	-99.9		175 180	REC = 11" 4+10+21 N = 31 REC = 0"	w=33.7% LL=57 PL=17 PP=>4.5 tsf *	*Osterberg sampler tube push from 173.5 to 174.4 ft
182.0	SILTY SAND, fine to medium grained, contains clayey sand pockets, wet, dark greenish gray, trace fine to medium shell fragments (±1%), moderate HCl reaction.	SM	-109.9		185	7+15+22 N = 37 REC = 18"	w=31.2% *	
187.0	CLAYEY SAND, fine to medium grained, contains sandy lean clay pockets, wet, dark greenish gray and brownish gray, trace fine to medium shell fragments (±1%)	SC	-114.9		190	5+9+19 N = 28 REC = 11"		

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Comments:

1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/29/06.
3. * = See Appendix I for additional lab testing data.
4. Ground water observation well OW-401 installed at a nearby location.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-401** Contract Number: 06120048 Sheet: 7 of 13

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		SC						
192.0	SANDY SILT, fine to medium, contains clayey sand pockets, moist, dark greenish gray, very weak HCl reaction	ML	-119.9		195	6+9+17 N = 26 REC = 18"	w=49.2% *	
197.0	SILTY SAND, fine grained, moist, greenish gray, very weak HCL reaction, trace mica.	SM	-124.9		200	REC = 22"	w=48.8% LL=82 PL=55 PP=>4.5 tsf *	*Osterberg sampler tube push from 198.5 to 200.3 ft
202.0	ELASTIC SILT, with fine to medium sand, trace mica and organic matter (±1%), moist, greenish gray, very weak HCl reaction.	MH	-129.9		205	5+8+13 N = 21 REC = 18"	w=58.4% LL=94 PL=69 *	
	trace fine to medium shell fragments (±1%).				210	7+11+16 N = 27 REC = 18"	w=62.7% LL=113 PL=74 *	**Resumed drilling at 7:00 AM on 6/22/06.
212.0	ELASTIC SILT, trace fine to medium sand, contains indurated silt pockets, moist, greenish gray, very weak HCl reaction.	MH	-139.9		215	REC = 13"	PP=>4.5 tsf	*Osterberg sampler tube push from 213.5 to 214.6 ft
	trace mica.				220	7+11+15 N = 26 REC = 18"	w=77.4% *	

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Comments:

1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/29/06.
3. * = See Appendix I for additional lab testing data.
4. Ground water observation well OW-401 installed at a nearby location.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-401** Contract Number: 06120048 Sheet: 8 of 13

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	trace organic matter (±<1%).	MH			225	9+13+18 N = 31 REC = 18"		
	contains indurated silt pockets.				230	REC = 13"	w=58.6% LL=139 PL=88 PP=>4.5 tsf *	*Osterberg sampler tube push from 228.5 to 229.6 ft
					235	10+15+21 N = 36 REC = 18"		
	weak HCl reaction.				240	8+11+21 N = 32 REC = 18"	w=122.5% *	
	mostly indurated silt layers.				245	REC = 8"	w=96.2% LL=140 PL=65 PP=>4.5 tsf *	*Osterberg sampler tube push from 243.5 to 244.4 ft
					250	7+8+17 N = 25 REC = 18"	w=122.8% LL=218 PL=100 *	
					255	7+10+15 N = 25 REC = 18"		

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Comments:

1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/29/06.
3. * = See Appendix I for additional lab testing data.
4. Ground water observation well OW-401 installed at a nearby location.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant, Calvert County, Maryland	Boring Number: **B-401**
			Contract Number: 06120048
			Sheet: 9 of 13

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		MH						
	trace fine to medium sand, very weak HCl reaction.				260	8+11+19 N = 30 REC = 18"	w=130.2% *	
					265	9+16+21 N = 37 REC = 0"		**Resumed drilling at 7:15 AM on 6/23/06.
267.0	SILTY SAND, dark green, with fine to medium sand, trace organic matter (±<1%), very weak HCl reaction.	SM	-194.9		270	7+12+18 N = 30 REC = 18"	w=63.5% *	
	greenish gray, weak HCl reaction.				275	8+12+15 N = 27 REC = 18"		
	trace fine to medium sand, moderate HCl reaction.				280	50/3" N = 50/3" REC = 4"		*Switched to 5" O.D. Tri-cone roller bit below 278.5 ft.
283.0	SANDY ELASTIC SILT, moist, dark greenish gray, trace fine to coarse sand, some fine to coarse shell fragments (±30%), strong HCl reaction.	MH	-210.9		285	11+13+17 N = 30 REC = 18"	w=30.2% LL=76 PL=42 *	*Very to extremely difficult rotary advancement from 278 to 280 ft (moderate rig chatter). *Switched to 5" O.D. Drag bit below 284.5 ft.
287.0	CLAYEY SAND, fine to medium grained, wet, dark brownish gray and blackish gray, few fine to coarse shell fragments (±10%), trace mica, strong	SC	-214.9			9+17+23		**Resumed drilling at 11:00 AM on 6/26/06.

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Comments:
1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/29/06.
3. * = See Appendix I for additional lab testing data.
4. Ground water observation well OW-401 installed at a nearby location.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-401** Contract Number: 06120048 Sheet: 10 of 13

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	HCl reaction, glauconitic	SC			290	N = 40 REC = 18"		
	dark brownish gray and dark greenish gray, trace fine to coarse shell fragments (±5%). fine to coarse grained, moist, dark brownish gray and blackish gray, trace fine gravel and fine to medium shell fragments (±<5%) below 294.5 ft.				295	8+12+50/2" N = 62/8" REC = 14"	w=20.7% *	*Switched to 5" O.D. Tri-cone roller bit below 293.5 ft. *Extremely difficult rotary advancement from 294.5 to 295.5 ft (very strong rig chatter).
	brownish gray and light blackish gray, trace fine to coarse shell fragments (±5%), weak HCl reaction, contains lean clay layers and pockets.				300	9+14+18 N = 32 REC = 18"		*Extremely difficult rotary advancememt from 297.3 to 298.3 ft (mod to strong rig chatter). **Resumed drilling at 7:20 AM on 6/27/06. *Switched to 4-3/4" O.D. Drag bit below 298.5 ft.
					305			
306.0	SILTY SAND, fine to coarse, contains clayey sand pockets, moist, dark greenish gray and dark blackish brown, very weak HCl reaction	SM	-233.9			10+12+20 N = 32 REC = 18"	w=27.4% LL=57 PL=42 *	
					310			
					315			
317.0	SANDY FAT CLAY, fine to medium grained, moist, dark greenish gray and dark blackish gray, very weak HCl reaction, glauconitic.	CH	-244.9		320	18+26+35 N = 61 REC = 18"	w=28.9% LL=58 PL=28 *	

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Comments:

1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/29/06.
3. * = See Appendix I for additional lab testing data.
4. Ground water observation well OW-401 installed at a nearby location.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-401** Contract Number: 06120048 Sheet: 11 of 13

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		CH			325			
					330	11+11+17 N = 28 REC = 0"		
					335			
337.0	SILT with fine to coarse sand, trace fine gravel and mica, contains sandy lean clay pockets, moist, dark brownish gray and blackish gray, moderate HCl reaction, silt exhibits fissility.	ML	-264.9		340	8+12+29 N = 41 REC = 8"	w=25.3% *	
345.0	SILTY SAND, fine to coarse grained, moist, dark brownish gray and blackish gay, moderate HCl reaction	SM	-272.9		345			
					350	REC = 7"	w=35.6% LL=52 PL=39 *	*Osterberg sampler tube push from 348.5 to 350.5 ft
					355			

continued on next page

Comments:

1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/29/06.
3. * = See Appendix I for additional lab testing data.
4. Ground water observation well OW-401 installed at a nearby location.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-401** Contract Number: 06120048 Sheet: 12 of 13

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	contains clayey sand pockets, trace mica, very weak HCl reaction	SM			360	30+50/5" N = 50/5" REC = 9"		
367.0	POORLY GRADED SAND WITH SILT, fine to medium grained, contains silty sand and lean clay pockets, trace mica, moist, dark brownish gray and blackish gray, very weak HCl reaction.	SP-SM	-294.9		370	16+25+44 N = 69 REC = 18"	w=36.9% *	**Resumed drilling at 7:00 AM on 6/28/06.
377.0	SILTY SAND, fine to medium grained, moist, dark brownish gray and blackish gray, trace mica, very weak HCl reaction.	SM	-304.9		380	16+21+36 N = 57 REC = 18"		
	fine to coarse grained, contains lean clay pockets, moist, dark brownish gray *continued on next page*				385			

Comments:
1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/29/06.
3. * = See Appendix I for additional lab testing data.
4. Ground water observation well OW-401 installed at a nearby location.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-401** Contract Number: 06120048 Sheet: 13 of 13

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	and blackish gray, trace mica, very weak HCl reaction.	SM				12+20+32 N = 52 REC = 18"		
					390			
					395			
								**Resumed grouting at 7:00 AM on 6/29/06.
	fine to medium grained.				400	11+15+29 N = 44 REC = 18"	w=33.1% *	
401.5	BOTTOM OF BORING @ 401.5 FT.		-329.4					

Comments:

1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/29/06.
3. * = See Appendix I for additional lab testing data.
4. Ground water observation well OW-401 installed at a nearby location.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-404** Contract Number: 06120048 Sheet: 1 of 7

Boring Contractor: UNI-TECH DRILLING
MALAGA, NEW JERSEY

Boring Foreman: J. Blemings

Drilling Method: Mud Rotary

Drilling Equipment: CME-750 (ATV)

Schnabel Representative: B. Bradfield

Dates Started: 6/22/06 **Finished:** 6/27/06

Location: Northing: 216441.34 ft
Easting: 961596.49 ft

Ground Surface Elevation: 67.9 (feet)

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Encountered	6/22	---	30.0'	---	---
Start of day	6/23	---	27.5'	---	---

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	SILTY SAND, fine to coarse grained, moist, orangeish brown, trace fine rounded gravel, contains root fragments.	SM				1+2+2 N = 4 REC = 13"		1.5'- Mud rotary with 3 7/8" drag bit
2.0	SANDY SILT, fine to coarse, moist, orangeish brown and gray, contains decomposed root fragments.	ML	65.9			5+5+5 N = 10 REC = 8"		
4.5	LEAN CLAY with sand, moist, orangeish brown and gray, colors layered <1/2" thick.	CL	63.4		5	4+4+5 N = 9 REC = 12"		
7.0	FAT CLAY with sand, moist, gray and orangeish brown, colors layered 1/4" to 3/4" thick.	CH	60.9			2+2+2 N = 4 REC = 18"		
10.0	LEAN CLAY with sand, moist, gray, contains mica.	CL	57.9		10	3+3+5 N = 8 REC = 18"		
	With darker gray pockets up to 1" thick.				15	4+5+6 N = 11 REC = 18"		
					20	3+6+7 N = 13 REC = 18"		
22.0	CLAYEY SAND, fine to medium grained, moist, dark gray, contains mica.	SC	45.9		25	3+4+7 N = 11 REC = 18"		

continued on next page

Comments:
1. Boring backfilled with cement/bentonite grout via tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/27/06.
3. * = See Appendix I for additional lab testing data.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant, Calvert County, Maryland	Boring Number: **B-404** Contract Number: 06120048 Sheet: 2 of 7

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		SC						
27.5	POORLY GRADED SAND, fine to medium grained, wet, orange and yellowish brown, trace silt.	SP	40.4					29-30'- Harder drilling
				▽	30	40+50/3" N = 50/3" REC = 8"		
	None silt, with gray clay lenses <1/4" thick.				35	21+50/5" N = 50/5" REC = 10"		
					40	WOH/18" N = WOH/18" REC = 2"		
39.9	CLAYEY SAND, fine to medium grained, moist, gray.	SC	28.0					
43.0	SILTY SAND, fine to coarse grained, wet, light gray and brownish white, 20-30% cemented sand, 30-40% fine to coarse shell fragments.	SM	24.9		45	48+32+29 N = 61 REC = 18"		
47.5	POORLY GRADED SAND WITH SILT, fine to medium grained, wet, gray and brownish white, 20-30% fine to medium shell fragments, moderate HCl reaction, HCl reaction localized to shell fragments.	SP-SM	20.4		50	4+4+5 N = 9 REC = 18"		
	20-30% fine to medium shell fragments, strong HCl reaction.					REC = 18"	w=27.7% LL=NP PL=NP *	52'- Shelby tube pushed
	10-20% fine to medium shell fragments, HCl reaction localized to shell fragments.				55	5+10+10 N = 20 REC = 18"		
57.5	SILTY SAND, fine to medium grained, *continued on next page*	SM	10.4					

Comments:
1. Boring backfilled with cement/bentonite grout via tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/27/06.
3. * = See Appendix I for additional lab testing data.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant, Calvert County, Maryland	Boring Number: **B-404**
			Contract Number: 06120048
			Sheet: 3 of 7

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	wet, dark gray, 0-10% fine to medium shell fragments, weak HCl reaction.	SM			60	4+5+7 N = 12 REC = 18"		
62.5	CLAYEY SAND, fine to medium grained, wet, dark gray, 0-10% fine to medium shell fragments, weak HCl reaction, HCl reaction localized to shell fragments.	SC	5.4		65	2+3+4 N = 7 REC = 18"		
	Gray and brownish white, 20-30% fine to medium shell fragments, strong HCl reaction.					REC = 18"		66'- Shelby tube pushed
	Wet, dark gray and brownish white, 30-40% fine to medium shell fragments, strong HCl reaction.				70	10+14+13 N = 27 REC = 18"		68.5'- Start of day 6/23/06
	20-30% fine to medium shell fragments, 10-20% cemented sand, strong HCl reaction, cemented sand fragments <3/4" in diameter.				75	4+19+21 N = 40 REC = 13"		
77.5	SILTY SAND, fine to medium grained, wet, dark gray, 0-10% fine to medium shell fragments, weak HCl reaction.	SM	-9.6		80	6+7+10 N = 17 REC = 15"		
	greenish gray and brownish white, 20-30% fine to medium shell fragments, strong HCl reaction.				85	REC = 17"	w=32.2% LL=53 PL=28 *	83.5'- Shelby tube pushed
87.5	SILTY SAND, fine to medium grained, wet, greenish gray and dark gray, 0-10% fine to medium shell fragments, weak HCl reaction.	SM	-19.6		90	5+8+11 N = 19		

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Comments:
1. Boring backfilled with cement/bentonite grout via tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/27/06.
3. * = See Appendix I for additional lab testing data.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant, Calvert County, Maryland	Boring Number: **B-404**
			Contract Number: 06120048
			Sheet: 4 of 7

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		SM				REC = 18"		
92.5	SANDY ELASTIC SILT, fine to medium, moist, greenish gray, 0-10% fine to medium shell fragments, contains mica, weak HCl reaction.	MH	-24.6		95	6+9+10 N = 19 REC = 18"		
97.5	SILTY SAND, fine to medium grained, wet, greenish gray, 0-10% fine to medium shell fragments, contains mica, weak HCl reaction.	SM	-29.6		100	4+9+12 N = 21 REC = 18"		
103.0	CLAYEY SAND, fine to medium grained, moist, greenish gray and brownish white, 30-40% fine to medium shell fragments, contains mica, strong HCl reaction, shell fragments decomposed and fractured.	SC	-35.1		105	7+12+15 N = 27 REC = 18"		
107.5	FINE TO MEDIUM SANDY ELASTIC SILT, moist, greenish gray, 10-20% fine to medium shell fragments, contains mica, moderate HCl reaction, shell fragments decomposed.	MH	-39.6		110	4+6+10 N = 16 REC = 18"		
	0-10% fine to medium shell fragments, weak HCl reaction, shell fragments decomposed.				115	5+7+10 N = 17 REC = 18"		
117.5	SANDY SILT, fine to medium, moist, greenish gray, 0-10% fine to medium shell fragments, contains mica, weak HCl reaction, HCl reaction localized to shell fragments.	ML	-49.6		120	5+8+10 N = 18 REC = 18"		
						5+5+7		

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Comments:

1. Boring backfilled with cement/bentonite grout via tremie pipe upon completion.
2. Downhole geophysical logging performed on 6/27/06.
3. * = See Appendix I for additional lab testing data.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant, Calvert County, Maryland	Boring Number: **B-409**
			Contract Number: 06120048
			Sheet: 2 of 5

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	fine to medium grained, moist, orange, small 1/16" clay layers.	SP-SC				15+26+28 N = 54 REC = 18"		
27.0	POORLY GRADED SAND, fine to medium grained, moist, orange.	SP	34.6			38+50/5" N = 50/5" REC = 11"		
29.0	POORLY GRADED SAND with silt, fine to medium grained, moist, gray	SP-SM	32.6		30	18+50/5" N = 50/5" REC = 11"		
						30+40+40 N = 80 REC = 18"		
					35		w=23.3% LL=NP PL=NP *	pitcher sample pushed
37.0	CLAYEY SAND, fine to medium grained, moist, gray, contains cemented sand, with fine to coarse shell fragments, 10% shell frag, gray colored.	SC	24.6			3+26+6 N = 32 REC = 12"		
	wet, grayish green.				40	WOH+WOR +WOR N = WOR REC = 18"		
	contains cemented sand.					3+38+28 N = 66 REC = 18"		43' cemented layer, grinding
44.5	SILTY SAND, fine to medium grained, moist, green, with fine to coarse shell fragments, contains cemented sand, strong HCl reaction, 20-30% shell frag.	SM	17.1		45	5+6+6 N = 12 REC = 18"		
						4+5+5 N = 10 REC = 18"		
					50	REC = 24"		tube pushed
						4+5+5 N = 10 REC = 18"		
54.5	POORLY GRADED SAND WITH SILT, fine to medium grained, moist, green, strong HCl reaction, 10-20% shell frag.	SP-SM	7.1		55	4+5+6 N = 11 REC = 18"		
	weak HCl reaction.					4+3+5		

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Comments:

1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. * = See Appendix I for additional lab testing data.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant, Calvert County, Maryland	Boring Number: **B-409**
			Contract Number: 06120048
			Sheet: 3 of 5

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		SP-SM				N = 8 REC = 18"		
59.5	SILTY SAND, fine to medium grained, moist, green, with fine to coarse shell fragments, strong HCl reaction, 10-20% shell frag.	SM	2.1		60	2+3+2 N = 5 REC = 18"		
	contains fine to coarse shell fragments, moderate HCl reaction.					REC = 24"		tube pushed
	with fine to coarse shell fragments, strong HCl reaction, 30-40% shell frag.				65	3+6+9 N = 15 REC = 18"		
67.0	CLAYEY SAND, fine to medium grained, moist, green and white, contains cemented sand, with fine to coarse shell fragments, strong HCl reaction, 70-80% shell frag.	SC	-5.5			8+14+16 N = 30 REC = 18"		
69.5	WELL GRADED SAND WITH CLAY, fine to medium grained, wet, green and white, with fine to coarse shell fragments, strong HCl reaction, 70-90% shell frag.	SW-SC	-8.0		70	11+6+12 N = 18 REC = 18"		
	moist, green, with silt, with fine to coarse shell fragments, strong HCl reaction, 60-80% shell frag.					7+29+45 N = 74 REC = 18"		
74.5	SILTY SAND, fine to medium grained, moist, green, trace fine to coarse shell fragments, moderate HCl reaction, 0-10% shell frag.	SM	-13.0		75	5+7+13 N = 20 REC = 18"		
	with fine to coarse shell fragments, strong HCl reaction, 20-30% shell frag.					5+7+9 N = 16 REC = 18"		79' start of day 6/23/06
					80	5+7+10 N = 17 REC = 18"		
						7+8+11 N = 19 REC = 18"		
	trace fine to medium shell fragments, moderate HCl reaction, 0-10% shell frag.				85	4+5+7 N = 12 REC = 18"		
	with fine to coarse shell fragments, strong HCl reaction, 10-20% shell frag.					4+5+8 N = 13 REC = 18"		
89.5	SANDY SILT, fine to medium, moist, green, trace fine to medium shell fragments, moderate HCl reaction,	ML	-28.0		90	5+7+9 N = 16		

continued on next page

Comments:
1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. * = See Appendix I for additional lab testing data.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant, Calvert County, Maryland	Boring Number: **B-409**
			Contract Number: 06120048
			Sheet: 4 of 5

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
	0-10% shell frag.	ML				REC = 18"		
92.0	SILTY SAND, fine to medium grained, moist, green, trace fine to medium shell fragments, moderate HCl reaction, 0-10% shell frag.	SM	-30.5			5+6+6 N = 12 REC = 18"		
	contains fine to medium shell fragments, greenish gray				95	REC = 19"	w=33.1% LL=61 PL=42 *	95' tube pushed
97.0	SILTY SAND, fine to medium grained, moist, green, with fine to coarse shell fragments, strong HCl reaction, 10-20% shell frag.	SM	-35.5			4+6+5 N = 11 REC = 18"		
	30-50% shell frag.				100	2+5+6 N = 11 REC = 18"		
102.0	CLAYEY SAND, fine to medium grained, moist, green, with fine to coarse shell fragments, strong HCl reaction, 50-60% shell frag.	SC	-40.5			8+10+8 N = 18 REC = 18"		
104.5	SANDY SILT, fine to medium, moist, green, with fine to coarse shell fragments, strong HCl reaction, 10-20% shell frag.	ML	-43.0		105	4+5+8 N = 13 REC = 18"		105' start of day 6/26/06
	oliveish green, trace fine to coarse shell fragments, weak HCl reaction, 0-5% shell frag.					4+6+6 N = 12 REC = 18"		
	moderate HCl reaction, 0-10% shell frag.				110	5+6+7 N = 13 REC = 18"		
	with sand.					5+6+8 N = 14 REC = 18"		
114.5	ELASTIC SILT, moist, oliveish green, trace fine to medium shell fragments, weak HCl reaction, 0-10% shell frag.	MH	-53.0		115	6+6+9 N = 15 REC = 18"		
117.0	SANDY SILT, fine to medium, moist, oliveish green, trace fine to coarse shell fragments, moderate HCl reaction, 0-10% shell frag.	ML	-55.5			4+6+8 N = 14 REC = 18"		
	with fine to coarse shell fragments, strong HCl reaction, 10-25% shell frag.				120	4+5+5 N = 10 REC = 18"		
122.0	ELASTIC SILT, moist, oliveish green, trace fine to medium shell fragments, with sand, weak HCl reaction, 0-5% shell frag.	MH	-60.5			4+5+7 N = 12 REC = 18"		

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Comments:
1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. * = See Appendix I for additional lab testing data.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-409** Contract Number: 06120048 Sheet: 5 of 5

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		MH						
	no shells.				125	5+5+7 N = 12 REC = 18"		
	with clay.					4+5+6 N = 11 REC = 18"		
					130	5+5+7 N = 12 REC = 18"		130' start of day 6/27/06
						6+7+9 N = 16 REC = 18"		
					135	5+6+9 N = 15 REC = 18"		
						REC = 18"	PP=4.00 tsf	137.5' tube pushed
					140	5+6+8 N = 14 REC = 18"		
						5+6+8 N = 14 REC = 18"		
					145	4+6+7 N = 13 REC = 18"		
147.5	LEAN CLAY, moist, oliveish green, with silt.	CL	-86.0			7+8+10 N = 18 REC = 18"		
150.0	BOTTOM OF BORING @ 150.0 FT.		-88.5		150			

Comments:
1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. * = See Appendix I for additional lab testing data.

TEST BORING LOG 06120048 PLOG SPT 300 & 400.GPJ SCHNABEL.GDT 10/31/07

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant Calvert County, Maryland	Boring Number: **B-437** Contract Number: 06120048 Sheet: 1 of 4

Boring Contractor: UNI-TECH DRILLING
MALAGA, NEW JERSEY

Boring Foreman: J. Evans

Drilling Method: Mud Rotary

Drilling Equipment: Failing-1500 (Truck)

Schnabel Representative: K. Megginson

Dates Started: 7/10/06 **Finished:** 7/11/06

Location: Northing: 216521.76 ft
Easting: 960968.8 ft

Ground Surface Elevation: 110.6 (feet)

Groundwater Observations

	Date	Time	Depth	Casing	Caved
Encountered	7/10	---	18.5'	---	---
Start of day	7/11	---	20.0'	---	---

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
0.2	Rootmat and topsoil	FILL	110.4			3+3+6 N = 9 REC = 10"		
2.0	Silty Sand PROBABLE FILL fine to coarse grained, moist, brown, trace coarse gravel, contains root fragments and fine to coarse sandy fat clay layer from 0.2 to 0.4 ft.	SC	108.6			2+2+1 N = 3 REC = 18"		
4.5	CLAYEY SAND, fine to coarse grained, moist, brown.	CL	106.1		5	WOH+1+1 N = 2 REC = 14"		
	LEAN CLAY, moist, brown, trace fine to medium sand.							
	trace organic matter (±1%).					3+5+7 N = 12 REC = 18"		
9.5	CLAYEY SAND, fine to medium grained, moist, brown and light brown, trace organic matter (±1%), contains sandy lean clay pockets.	SC	101.1		10	4+7+8 N = 15 REC = 18"		
12.0	brown and grayish brown below 11 ft.	SP-SM	98.6					
	POORLY GRADED SAND, with silt, fine to coarse grained, moist, brown, trace fine gravel, contains clayey sand pockets.				15	REC = 23"	w=7.2% LL=NP PL=NP PP=NP tsf *	*Osterberg sampler tube push from 13.5 to 15.5 ft
	fine to medium grained, wet, brown.			▽				*5.4" O.D. Drag bit from 0 to 18.5 ft. *Swtiched to 4-3/4" O.D. Drag bit below 18.5 ft.
	fine to coarse grained, moist, yellowish brown and dark reddish brown, contains strongly cemented sand pockets and lenses below 19 ft .				20	7+17+12 N = 29 REC = 12"		
	wet, contains clayey sand lenses.				25	5+5+8 N = 13 REC = 13"		

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Comments:
1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. * = See Appendix I for additional lab testing data.

Schnabel Engineering	TEST BORING LOG	Project: Calvert Cliffs Nuclear Power Plant, Calvert County, Maryland	Boring Number: **B-437**
			Contract Number: 06120048
			Sheet: 2 of 4

DEPTH (FT)	STRATA DESCRIPTION	CLASS.	ELEV. (FT)	WL	SAMPLING DEPTH	SAMPLING DATA	TESTS	REMARKS
		SP-SM						
	fine to medium grained, mottled light gray and yellowish brown.				30	2+1+1 N = 2 REC = 18"		
	brown, yellowish brown, and light gray.				35	7+12+12 N = 24 REC = 10"		
37.0	LEAN CLAY, wet, yellowish brown and light gray, trace fine to medium sand.	CL	73.6					
39.5	SILTY SAND, fine to medium grained, wet, stratified brown and orangeish brown.	SM	71.1		40	1+3+6 N = 9 REC = 18"		
42.0	LEAN CLAY, wet, light grayish brown and yellowish brown, trace fine to medium sand, contains cemented sand fragments, contains silty sand layer from 43.8 to 44 ft.	CL	68.6					
44.0	FAT CLAY, moist, gray, trace fine to medium sand and mica.	CH	66.6		45	4+4+5 N = 9 REC = 18"		
	gray and dark gray, contains silty sand pockets.				50	2+3+4 N = 7 REC = 18"		
	gray, contains silty sand layers from 54.1 to 54.2 ft and from 54.8 to 55 ft.				55	2+3+4 N = 7 REC = 18"		
57.0	ELASTIC SILT, moist, gray, trace fine sand and mica.	MH	53.6					

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Comments:

1. Boring backfilled with cement/bentonite grout through tremie pipe upon completion.
2. * = See Appendix I for additional lab testing data.

Appendix 2.5-C

REPORT
Reconciliation of EPRI and RCTS Results
Calvert Cliffs Nuclear Power Plant Unit 3

Prepared for:

UniStar Nuclear Development, LLC

Prepared by:

Bechtel Power Corporation

25237-000-30R-GEK-00001-000

December 14, 2007

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1 PURPOSE

The purpose of this report is to 1) present and compare the soil strain-dependent EPRI curves with the site-specific Resonant Column Torsional Shear (RCTS) test results, 2) adopt final shear modulus and damping curves for the project, and 3) evaluate the soil amplification using both the EPRI-based and RCTS-based data.

This work was performed for Constellation Generating Group, LLC, per Purchase Order No. 500117, Rev. 1, dated April 11, 2006.

2 BACKGROUND

As part of the initial development of the soil dynamic properties for the Calvert Cliffs Nuclear Power Plant (CCNPP) Unit 3 project, EPRI shear modulus and damping curves were adopted. Use of EPRI curves was due to the absence of RCTS test results for the site soils at the time. The adopted EPRI curves and the basis for their selection are addressed in Reference 1.

As part of the subsurface investigation, RCTS tests were commissioned for the site soils and the results of these tests are now available. A total of 13 samples were identified for RCTS testing with 7 additional samples placed in reserve as backup, if needed to replace any of the original 13 samples. Thirteen RCTS tests, along with the necessary index tests, were performed. All of the RCTS results were reviewed and were found acceptable by Dr. Kenneth Stokoe of the University of Texas at Austin. The RCTS test results are presented in Reference 2.

Selection and quantity of RCTS tests were based on the site stratigraphy, the thickness of various soil strata, their position with respect to the Category I structures, and sample availability. The locations of RCTS samples, and other relevant information, are shown on a typical site stratigraphic profile in Figure 1. A summary of the RCTS samples and their index properties is shown in Table 1.

3 EPRI CURVES

Since the RCTS test results will be compared with the EPRI curves that were initially adopted, the EPRI curves are presented herein for ease of comparison. Selection of EPRI curves is addressed in Reference 1. The EPRI curves and numerical values are reproduced and shown in this report as Figure 2 and Table 2.

4 RCTS TEST RESULTS

RCTS tests were performed on soils from the upper 400 feet of the site. More than one sample was tested in most of the soil strata. Samples were tested at depths ranging from about 15 to 400 feet below the existing ground surface (the ground surface at the time of the geotechnical investigation). All samples tested were obtained from tube samples, except for one sample (sample identified by the laboratory as "Appendix No. H" in Table 1), which was obtained from reconstituting jar samples. The quantity of samples tested from each stratum, and their locations, are shown in Figure 1, indicating the following number of samples tested from each stratum:

- Stratum I-Terrace Sand: 1 sample
- Stratum IIa-Chesapeake Clay/Silt: 2 samples
- Stratum IIb-Chesapeake Cemented Sand: 3 samples
- Stratum IIc-Chesapeake Clay/Silt: 5 samples
- Stratum III-Nanjemoy Sand: 2 samples

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- Soils below Stratum III: 0 (zero) samples, given that the soil borings during the geotechnical investigation did not penetrate these soils

The RCTS test results for individual samples are summarized and presented in Figures 3 through 15, with the corresponding numerical values given in Tables 3 through 15. Other complimentary information is also presented on the respective figures for ready comparison, namely:

- Selected EPRI Curve: shear modulus and damping ratios from the initially adopted EPRI curves
- Randomized EPRI Curve: the randomized minimum and maximum values of shear modulus and damping ratios, as well as the mean values $\pm 1\sigma$ (sigma)
- RCTS Test Results: RCTS results at the mean in-situ stress (σ_o) and at 4 times the mean in-situ stress
- Relationship from RCTS Results: curves representing the G/G_{max} and damping ratios from the RCTS tests for comparison with EPRI and randomized curves

A "key" is shown on each figure, identifying the above information.

The curves fitted to the RCTS data are based on test results at confining stresses representing the in-situ stress for the test sample. In general, the results indicate that the RCTS curves offer higher shear modulus and lower damping ratios than those represented by the initially adopted EPRI curves. This is discussed below in more detail.

5 EVALUATION OF RCTS TEST RESULTS

As noted above, the RCTS test results indicate higher shear modulus ratio and lower damping ratio than the initially adopted EPRI curves. The relative differences in both shear modulus ratio and damping ratio between RCTS and the initially adopted EPRI curves was calculated at different strain levels and are shown in Figure 16. The results indicate from zero to over 200% difference in G/G_{max} values over a shear strain range from 1E-4% to 1%. Similarly, the results indicate about ±60% difference in damping ratio values over a shear strain range from 1E-4% to 1%. These differences in both the G/G_{max} and damping ratios are over extreme strain values (from 1E-4 to 1%), a strain range unlikely to be experienced by the site soils. It should be noted that results of seismic analyses using the initially adopted EPRI curves indicated that the mean (of maximum) strain values were mostly in the 1E-2% range (Reference 3). These strain values, for each soil stratum, are shown on the respective curves for that stratum in Figure 17.

Figure 17 indicates that at a strain level of about 1E-2±%, the difference between the initially adopted EPRI and the actual RCTS G/G_{max} values is much more limited than the previously noted 200%, actually ranging from about 1 to 11%, or average of about 6% for the noted strain level. This difference is not considered significant, given the natural variation in soils and the expected variation in RCTS test results. It is also noted that in the randomization of the G/G_{max} values at a strain level of 1E-2%, the minimum and maximum values (with respect to the mean) are allowed to vary by as much as ±7%, and sometimes by as much as ±8%. The observed average value of 6% noted above is within the acceptable 7-8% range for randomization.

Similarly, from Figure 17, at a strain level of 1E-2±%, the difference between the initially adopted EPRI and the actual RCTS damping ratio values range from about -50% to +15%, or average of about 33%. Again, this difference is not considered significant, given the natural variation in soils and the expected variation in RCTS test results. It is also noted that in the randomization of the damping ratio values at a strain level of 1E-2%, the minimum and maximum values (with respect to the mean)

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are allowed to vary from about -50% to +100%, or average of about 75%. The observed average value of 33% noted above is well within the acceptable -50% to +100% range for randomization.

Finally, the results of all 13 RCTS tests are combined, in terms of shear modulus and damping ratios, and are presented in Figure 18. Three distinct groups are noted in the G/G_{max} curves for the site soils. Given the relative similarity in responses among various groups of tests, and particularly in light of small variations at low strain levels (approximately 1E-2%), it is possible to provide an average curve for each of the three distinct groups. A similar approach is followed for the damping curves shown in Figure 18. The average curves for the three distinct groups, for both shear modulus and damping ratios, are presented in Figure 19. The numerical values for these average curves are given in Table 16. These represent the strain-dependent properties for soils in the upper approximately 400 feet at the CCNPP Unit 3 site. For comparison purposes, these curves are shown along with the initially adopted EPRI curves in Figure 20.

6 STRAIN-DEPENDENT PROPERTIES FOR SOILS BELOW 400 FEET

As noted earlier, RCTS tests were performed on soils collected from the upper 400 feet of the site. RCTS tests were not performed on soils below 400 feet, for the boring depths were limited to about 400 feet, and therefore, soils samples were not available for testing. These deeper soils, in descending order, are the Marlboro Clay, Aquia/Brightseat Sand, Patapsco Sand, and the Patuxent/Arundel Clay.

To assess their utilization, EPRI curves initially adopted for these soils were compared with the set of curves derived from the RCTS results for the upper soils, as shown in Figure 21. The results indicate the following relative to the RCTS-based curves

- Marlboro Clay and Patuxent/Arundel Clay Curves: the EPRI curves are identical and fall nearly half-way between the RCTS-based curves for the Stratum I Sand (Curve 3) and Strata II and III soils (Curve 2) in their G/G_{max} relationship and closer to Curve 3 in their damping relationship. Based on the available RCTS results, it is inconceivable for these soils at such great depths (and expected high strength) to behave as "softly" as Stratum I Sand (Curve 3) which is at relatively shallow depths and primarily non-plastic. Therefore, as a minimum, the Marlboro and Patuxent/Arundel clays are expected to behave closer to that represented by Curve 2. On this basis, Curve 2 is a reasonable representation for these soils and is used for the dynamic characterization of Marlboro Clay and Patuxent/Arundel Clay.
- Aquia/Brightseat Sand and Patapsco Sand: the EPRI curves are nearly identical and follow Curve 2 closely in their G/G_{max} and damping relationship. Based on the RCTS results, and given their depths, these soils are expected to behave somewhere in the region represented by Curves 1 and 2, and possibly closer to Curve 1. Given that a number of the RCTS tests on sandy soils banded closely and were represented by Curve 2, the deeper sandy soils of the Aquia/Brightseat and Patapsco are expected to produce relationships that are mimicked by Curve 2, as a minimum. On this basis, Curve 2 is a reasonable representation for these soils and is used for the dynamic characterization of Aquia/Brightseat Sand and Patapsco Sand.

It is important to note that the calculated maximum strains based on the initially adopted EPRI curves for soils below 400 feet are in the 10^{-3}% to 10^{-2}% range for the 1E-4 and 1E-5 rock input motions, respectively, as shown in Figure 22. At these strain levels, the difference between the EPRI-based and RCTS-based curves are minor to insignificant, as evident in Figure 21.

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7 CONCLUSIONS

A total of 13 RCTS tests were performed on soils from the CCNPP Unit 3 site. Final shear modulus ratio and damping ratio curves for all the soils at the CCNPP Unit 3 site are summarized in Figure 23, with the numerical values given in Table 17.

A comparison of the RCTS results with the initially adopted EPRI curves indicate that the difference between these curves at a mean strain level of about 1E-2% (the approximate mean strain level calculated in the soils from the initial seismic evaluation based on EPRI curves) is well within ranges considered acceptable for the randomization of these curves. This suggests that a new seismic analysis using the RCTS results would not significantly change the outcome of the initial seismic analysis that was based on the EPRI curves. This is particularly supported by the shape of the RCTS test curves that indicate consistently higher shear modulus and lower damping than the initially adopted EPRI curves, since such stiffer dynamic response should result in strains somewhat lower than (or at least similar to) the initially observed value of 1E-2±%, a level at which the RCTS and EPRI curves converge even closer with practically insignificant differences.

8 CONFIRMATORY ANALYSIS

To assess the above observations, an analysis was performed, comparing the sensitivity in soil amplification for both the EPRI-based and RCTS-based curves. The work consisted of separately running a soil column analysis using the EPRI-based curves (Figure 2) and the RCTS-based curves (Figure 23), without randomization. The shear wave velocity profile and material parameters were per Reference 1. Amplifications, in terms of spectral ratio of response motion to input motion, at outcrop depths of 0 (zero) and 41 feet for both high frequency (HF) and low frequency (LF) 10^{-4} rock input motions, were obtained. The results are documented in Reference 4, and reported herein as Figures 24 and 25.

The results support the observations made earlier. They indicate that the differences in amplification factors are very small, especially at the LF input. At the HF input, small differences are evident; however, the RCTS-based results indicate reduced amplification, which should result in reduced spectral acceleration than from the EPRI-based curves. Accordingly, based on results of this analysis, it is concluded that the EPRI-based and site-specific RCTS-based curves arrive at very similar soil amplification, and therefore, the response motion (GMRS) presented in Reference 3 is sufficient for the CCNPP Unit 3 design.

9 REFERENCES

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Table 1. Summary of RCTS Samples and Index Properties

Appendix No.	Sample	Sample No.	Sample Top Depth (ft)	Sample Bottom Depth (ft)	Sample Type	Index Testing					
						Lab Class	UW (lb/ft^3)	MC (%)	SG	LL	PI
A	B-437	6	13.5	15.5	UD	SP-SM	124.1	7.2	2.66	NP	NP
B	B-301	10	33.5	35.5	UD	CH	117.5	31.1	2.74	59	42
C	B-305	17	39.5	41.5	UD	SC	117.2	34.7	2.71	72	50
D	B-404	14	52	53.6	UD	SP-SM	117.6	27.7	2.66	NP	NP
E	B-401	31	138.5	140.5	UD	CH	104.1	44.1	2.63	80	49
F	B-401	67	348.5	350.5	UD	SM	116.4	35.6	2.78	52	13
G	B-401	48	228.5	229.6	UD	MH	98.2	58.6	2.48	139	51
H	B-301	76	368.5	370	jar	SM	116.4	34.4	2.86	40	4
	B-301	77	378.5	379.5	jar						
	B-301	78	383.5	384.4	jar						
	B-301	79	388.5	390	jar						
	B-301	81	398.5	400	jar						
	B-401	68	358.5	359.4	jar						
	B-401	70	378.5	380	jar						
I	B-306	17	68	70	UD	CH	115.8	30.7	2.73	62	38
J	B-409	15	35	36.1	UD	SP-SM	124.8	23.3	2.66	NP	NP
K	B-404	22	83.5	85.1	UD	SM	115.4	32.2	2.63	53	25
L	B-401	42	198.5	200.3	UD	SM	101.2	48.8	2.52	82	27
M	B-409	39	95	96.6	UD	SM	109.3	33.1	2.64	61	19

Key:

Appendix No.	Sample designation assigned by the laboratory for tracking purposes
UD	Shelby tube sample
Jar	Glass jar sample
Lab Class	Laboratory classification of soils
UW	Total unit weight
MC	Moisture content
SG	Specific gravity
LL	Liquid limit
PI	Plasticity index

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Table 2. Summary Shear Modulus and Damping Ratios from Initially Adopted EPRI Curves

Depth 0-25 ft (Terrace Sand)			Depth 25-40 ft (Chesapeake Clay/Silt)			Depth 40-100 ft (Ches. Cemented Sand)			Depth 100-285 ft (Ches. Clay/Silt)			Depth 285-355 ft (Nanjemoy Cemented Clay/Silt)		
Cyclic Shear Strain (%)	G/G_{max}	D (%)	Cyclic Shear Strain (%)	G/G_{max}	D (%)	Cyclic Shear Strain (%)	G/G_{max}	D (%)	Cyclic Shear Strain (%)	G/G_{max}	D (%)	Cyclic Shear Strain (%)	G/G_{max}	D (%)
1.E-04	1	1.4	1.E-04	1	1.5	1.E-04	1	1	1.E-04	1	2	1.E-04	1	1.5
3.E-04	1	1.5	3.E-04	1	1.5	3.E-04	1	1	3.E-04	1	2	3.E-04	1	1.5
1.E-03	0.98	1.8	1.E-03	1	1.6	1.E-03	1	1.2	1.E-03	1	2	1.E-03	1	1.6
3.E-03	0.914	2.8	3.E-03	0.97	2.05	3.E-03	0.97	1.64	3.E-03	0.995	2.13	3.E-03	0.97	2.05
1.E-02	0.75	5	1.E-02	0.878	3.21	1.E-02	0.87	2.8	1.E-02	0.955	2.75	1.E-02	0.878	3.21
3.E-02	0.509	9.3	3.E-02	0.685	5.77	3.E-02	0.68	5.49	3.E-02	0.832	4.38	3.E-02	0.685	5.77
1.E-01	0.27	15.3	1.E-01	0.413	10.64	1.E-01	0.43	10.2	1.E-01	0.59	8	1.E-01	0.413	10.64
3.E-01	0.116	21.9	3.E-01	0.208	16.22	3.E-01	0.22	16.5	3.E-01	0.34	13.16	3.E-01	0.208	16.22
1.E+00	0.04	27	6.E-01	0.115	18.65	1.E+00	0.09	22.9	6.E-01	0.22	16.15	6.E-01	0.115	18.65
3.E+00	0.02	30	1.E+00	0.075	19	3.E+00	0.05	27	1.E+00	0.15	17.56	1.E+00	0.075	19

Depth 355-456 ft (Nanjemoy Sand)			Depth 456-471 ft (Marlboro Clay)			Depth 471-631 ft (Aquia/Brighseat Sand)			Depth 631-1,731 ft (Patapsco Sand)			Depth 1,731-2,531 ft (Patuxent/Arundel Clay)		
Cyclic Shear Strain (%)	G/G_{max}	D (%)	Cyclic Shear Strain (%)	G/G_{max}	D (%)	Cyclic Shear Strain (%)	G/G_{max}	D (%)	Cyclic Shear Strain (%)	G/G_{max}	D (%)	Cyclic Shear Strain (%)	G/G_{max}	D (%)
1.E-04	1	0.7	1.E-04	1	1.5	1.E-04	1	0.6	1.E-04	1	0.55	1.E-04	1	1.5
3.E-04	1	0.8	3.E-04	1	1.5	3.E-04	1	0.6	3.E-04	1	0.55	3.E-04	1	1.5
1.E-03	1	0.8	1.E-03	1	1.6	1.E-03	1	0.6	1.E-03	1	0.55	1.E-03	1	1.6
3.E-03	0.988	1.12	3.E-03	0.97	2.05	3.E-03	0.99	0.81	3.E-03	1	0.77	3.E-03	0.97	2.05
1.E-02	0.93	1.8	1.E-02	0.878	3.21	1.E-02	0.95	1.2	1.E-02	0.96	1.15	1.E-02	0.878	3.21
3.E-02	0.791	3.53	3.E-02	0.685	5.77	3.E-02	0.852	2.5	3.E-02	0.88	2.1	3.E-02	0.685	5.77
1.E-01	0.57	7.1	1.E-01	0.413	10.64	1.E-01	0.65	5.3	1.E-01	0.71	4.2	1.E-01	0.413	10.64
3.E-01	0.321	12.78	3.E-01	0.208	16.22	3.E-01	0.41	10.27	3.E-01	0.47	8.45	3.E-01	0.208	16.22
1.E+00	0.15	19.3	6.E-01	0.115	18.65	1.E+00	0.2	16.7	1.E+00	0.265	14.5	6.E-01	0.115	18.65
3.E+00	0.09	23	1.E+00	0.075	19	3.E+00	0.1	20.1	3.E+00	0.16	17.4	1.E+00	0.075	19

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Table 3. Summary of RCTS Laboratory Test Results (Appendix A Tests)

Test ID: Appendix A
Boring: B-437
Sample No.: UD6
Layer: Stratum I - Terrace Sand

Sample Depth = 14.9 ft
USCS Classification = SP-SM
Sample Description: poorly graded **SAND** with silt
Moisture Content = 3.0%
Total Unit Weight = 124.1 pcf
Specific Gravity = 2.66
LL = NP, PL = NP, PI = NP

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean}= 8.6 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
NP = Non-Plastic

Isotropic Confining Stress, σ_o = 8.6 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
6.00E-05	1.00	1.28	3.38E-04	1.00	1.59	3.26E-04	1.00	1.27
1.42E-04	1.00	1.36	8.87E-04	1.00	1.50	8.83E-04	1.00	1.49
3.49E-04	0.98	1.72	1.81E-03	1.00	1.67	1.82E-03	0.97	1.66
8.14E-04	0.96	2.13	3.54E-03	0.94	2.18	3.57E-03	0.91	1.96
1.91E-03	0.90	2.55	4.76E-03	0.91	2.51	4.78E-03	0.89	2.53
4.48E-03	0.80	3.05	1.07E-02	0.81	3.45	1.07E-02	0.79	3.32
1.05E-02	0.67	4.07	2.69E-02	0.65	7.89	2.60E-02	0.65	6.41
2.56E-02	0.53	5.74	---	---	---	---	---	---
6.21E-02	0.42	7.65	---	---	---	---	---	---
1.47E-01	0.33	10.43	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 34.4 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
2.30E-05	1.00	1.04	8.41E-04	0.97	1.20	8.53E-04	0.95	0.87
5.60E-05	1.00	1.03	1.67E-03	0.94	1.13	1.67E-03	0.94	1.00
1.39E-04	0.99	1.21	3.47E-03	0.90	1.16	3.48E-03	0.90	1.22
3.27E-04	0.98	1.38	7.34E-03	0.85	2.00	7.33E-03	0.85	1.86
8.17E-04	0.96	1.78	---	---	---	---	---	---
1.94E-03	0.92	1.99	---	---	---	---	---	---
4.68E-03	0.84	2.33	---	---	---	---	---	---
1.13E-02	0.73	3.05	---	---	---	---	---	---
2.62E-02	0.61	3.87	---	---	---	---	---	---
4.20E-02	0.53	4.35	---	---	---	---	---	---

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Table 4. Summary of RCTS Laboratory Test Results (Appendix B Tests)

Test ID: Appendix B
Boring: B-301
Sample No.: UD10
Layer: Stratum IIa - Ches. Clay/Silt

Sample Depth = 35.4 ft
USCS Classification = CH
Sample Description: fat **CLAY** with sand
Moisture Content = 30.1%
Total Unit Weight = 117.5 pcf
Specific Gravity = 2.74
LL = 55, PL = 17, PI = 42

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean} = 12 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index

Isotropic Confining Stress, σ_o = 12 psi

Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
9.80E-05	1.00	1.87	3.09E-04	1.00	1.90	3.13E-04	1.00	1.69
2.01E-04	1.00	1.86	6.03E-04	1.00	1.94	6.05E-04	1.00	2.14
4.96E-04	1.00	1.98	9.31E-04	1.00	2.09	9.60E-04	1.00	2.23
1.33E-03	0.99	2.17	1.89E-03	1.00	2.46	1.89E-03	1.00	2.34
3.18E-03	0.99	2.48	3.88E-03	0.99	2.93	3.92E-03	0.99	2.75
7.88E-03	0.95	3.11	9.62E-03	0.87	3.61	9.60E-03	0.88	3.48
1.85E-02	0.86	3.90	2.18E-02	0.77	4.92	2.23E-02	0.76	5.07
4.53E-02	0.71	5.86	6.48E-02	0.55	8.05	6.67E-02	0.55	8.00
1.20E-01	0.53	8.96	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 48.1 psi

Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
1.30E-04	1.00	1.24	3.03E-04	1.00	1.58	3.16E-04	1.00	1.70
2.19E-04	1.00	1.24	8.75E-04	1.00	1.13	8.78E-04	1.00	1.47
3.95E-04	1.00	1.24	1.74E-03	1.00	1.48	1.75E-03	1.00	1.18
7.64E-04	1.00	1.24	3.54E-03	1.00	1.69	3.54E-03	1.00	1.91
1.50E-03	1.00	1.41	9.67E-03	0.92	2.69	9.65E-03	0.93	2.61
2.91E-03	0.99	1.56	2.14E-02	0.83	3.63	2.17E-02	0.83	3.67
5.67E-03	0.98	2.05	5.55E-02	0.64	6.04	5.72E-02	0.63	6.16
2.14E-02	0.93	2.87	---	---	---	---	---	---
3.97E-02	0.85	3.49	---	---	---	---	---	---
7.56E-02	0.74	4.18	---	---	---	---	---	---
1.58E-01	0.60	5.65	---	---	---	---	---	---
3.79E-01	0.46	7.73	---	---	---	---	---	---
8.81E-01	0.33	10.75	---	---	---	---	---	---

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Table 5. Summary of RCTS Laboratory Test Results (Appendix I Tests)

Test ID: Appendix I
Boring: B-306
Sample No.: UD17
Layer: Stratum IIa - Ches. Clay/Silt

Sample Depth = 69.3 ft
USCS Classification = CH
Sample Description: fat **CLAY**, trace sand
Moisture Content = 31.2%
Total Unit Weight = 115.8 pcf
Specific Gravity = 2.73
LL = 62, PL = 24, PI = 38

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean} = 23.6 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index

Isotropic Confining Stress, σ_o = 23.6 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
2.35E-04	1.00	1.63	5.75E-04	1.00	1.03	5.73E-04	1.00	1.11
4.26E-04	1.00	1.61	9.77E-04	1.00	1.03	9.91E-04	1.00	1.11
8.80E-04	1.00	1.62	1.98E-03	1.00	1.17	1.97E-03	1.00	1.29
1.79E-03	1.00	1.62	4.02E-03	1.00	1.63	4.05E-03	1.00	1.60
3.53E-03	1.00	1.63	---	---	---	---	---	---
6.81E-03	0.98	1.68	---	---	---	---	---	---
1.27E-02	0.96	1.80	---	---	---	---	---	---
2.31E-02	0.91	1.95	---	---	---	---	---	---
4.19E-02	0.83	2.06	---	---	---	---	---	---
7.93E-02	0.71	2.66	---	---	---	---	---	---
1.69E-01	0.56	4.01	---	---	---	---	---	---
2.78E-01	0.49	6.48	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 94.3 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
1.40E-04	1.00	1.28	1.00E-03	1.00	1.25	1.00E-03	1.00	1.00
2.73E-04	1.00	1.27	1.98E-03	1.00	1.08	2.01E-03	1.00	1.14
5.56E-04	1.00	1.29	4.02E-03	1.00	1.16	4.01E-03	1.00	1.13
1.11E-03	1.00	1.29	1.00E-02	0.95	1.66	9.98E-03	0.96	1.70
2.21E-03	1.00	1.29	---	---	---	---	---	---
4.40E-03	1.00	1.29	---	---	---	---	---	---
8.58E-03	1.00	1.33	---	---	---	---	---	---
1.63E-02	0.98	1.41	---	---	---	---	---	---
2.91E-02	0.94	1.53	---	---	---	---	---	---
5.04E-02	0.88	1.80	---	---	---	---	---	---
9.03E-02	0.78	2.59	---	---	---	---	---	---
1.75E-01	0.65	3.40	---	---	---	---	---	---
3.87E-01	0.50	5.18	---	---	---	---	---	---

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Table 6. Summary of RCTS Laboratory Test Results (Appendix C Tests)

Test ID: Appendix C
Boring: B-305
Sample No.: UD17
Layer: Stratum IIb - Ches. Cem. Sand

Sample Depth = 41 ft
USCS Classification = SC
Sample Description: clayey **SAND** with shells
Moisture Content = 44.9%
Total Unit Weight = 117.2 pcf
Specific Gravity = 2.71
LL = 72, PL = 22, PI = 50

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean}= 20.7 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index

Isotropic Confining Stress, σ_o = 20.7 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
2.73E-04	1.00	1.59	5.00E-04	1.00	1.51	4.98E-04	1.00	1.35
5.73E-04	1.00	1.59	9.81E-04	1.00	1.34	1.00E-03	1.00	1.29
1.15E-03	1.00	1.59	1.99E-03	1.00	1.61	2.00E-03	1.00	1.41
2.31E-03	1.00	1.64	4.09E-03	0.97	1.53	4.08E-03	0.98	1.55
8.85E-03	0.98	1.74	9.66E-03	0.88	2.26	9.63E-03	0.89	2.26
1.67E-02	0.94	1.86	2.14E-02	0.79	3.60	2.18E-02	0.79	3.72
3.07E-02	0.88	2.01	5.52E-02	0.62	5.65	5.68E-02	0.60	5.67
5.65E-02	0.80	2.41	---	---	---	---	---	---
1.10E-01	0.69	3.35	---	---	---	---	---	---
2.41E-01	0.54	4.95	---	---	---	---	---	---
6.32E-01	0.38	8.54	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 82.8 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
6.65E-04	1.00	0.78	Test results discarded.			Test results discarded.		
1.29E-03	1.00	0.77	---	---	---	---	---	---
2.44E-03	1.00	0.88	---	---	---	---	---	---
4.90E-03	0.99	0.89	---	---	---	---	---	---
9.52E-03	0.98	0.93	---	---	---	---	---	---
1.78E-02	0.95	1.15	---	---	---	---	---	---
3.19E-02	0.90	1.44	---	---	---	---	---	---
5.75E-02	0.82	1.91	---	---	---	---	---	---
1.05E-01	0.72	2.68	---	---	---	---	---	---
2.17E-01	0.57	3.93	---	---	---	---	---	---
5.90E-01	0.38	6.15	---	---	---	---	---	---

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Table 7. Summary of RCTS Laboratory Test Results (Appendix J Tests)

Test ID: Appendix J
Boring: B-409
Sample No.: UD15
Layer: Stratum IIb - Ches. Cem. Sand

Sample Depth = 36.1 ft
USCS Classification = SP-SM
Sample Description: poorly graded **SAND** with silt
Moisture Content = 21.5%
Total Unit Weight = 124.8 pcf
Specific Gravity = 2.66
LL = NP, PL = NP, PI = NP

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean}= 11.8 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
NP = Non-Plastic

Isotropic Confining Stress, σ_o = 11.8 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
1.33E-04	1.00	0.40	5.89E-04	1.00	0.41	5.81E-04	1.00	0.55
2.67E-04	1.00	0.40	1.01E-03	1.00	0.42	1.01E-03	1.00	0.28
5.23E-04	1.00	0.46	2.05E-03	1.00	0.68	2.07E-03	0.99	0.74
1.05E-03	1.00	0.56	4.27E-03	0.96	1.01	4.31E-03	0.95	0.95
1.93E-03	0.98	0.63	1.02E-02	0.86	1.97	1.02E-02	0.86	2.09
3.50E-03	0.96	0.90	2.20E-02	0.80	3.08	2.21E-02	0.79	3.07
6.25E-03	0.93	1.19	3.52E-02	0.75	4.21	3.51E-02	0.75	4.26
1.06E-02	0.89	1.67	---	---	---	---	---	---
1.75E-02	0.83	2.16	---	---	---	---	---	---
2.86E-02	0.76	2.76	---	---	---	---	---	---
4.77E-02	0.68	3.60	---	---	---	---	---	---
8.01E-02	0.60	5.22	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 47.2 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
6.40E-05	1.00	0.37	5.76E-04	1.00	0.33	5.80E-04	1.00	0.40
1.28E-04	1.00	0.40	1.01E-03	1.00	0.27	1.03E-03	1.00	0.28
2.53E-04	1.00	0.40	2.07E-03	0.98	0.26	2.07E-03	0.99	0.51
4.97E-04	1.00	0.47	4.23E-03	0.96	0.89	4.26E-03	0.96	0.93
1.01E-03	1.00	0.49	1.01E-02	0.92	1.29	1.01E-02	0.93	1.30
1.92E-03	0.99	0.57	1.55E-02	0.90	1.61	1.55E-02	0.91	1.64
3.50E-03	0.97	0.71	---	---	---	---	---	---
6.17E-03	0.95	1.01	---	---	---	---	---	---
1.10E-02	0.92	1.32	---	---	---	---	---	---
1.76E-02	0.89	1.69	---	---	---	---	---	---
2.86E-02	0.84	1.99	---	---	---	---	---	---
4.54E-02	0.78	2.44	---	---	---	---	---	---
7.25E-02	0.69	3.28	---	---	---	---	---	---
9.65E-02	0.64	4.46	---	---	---	---	---	---
1.17E-01	0.61	5.28	---	---	---	---	---	---

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Table 8. Summary of RCTS Laboratory Test Results (Appendix D Tests)

Test ID: Appendix D
Boring: B-404
Sample No.: UD14
Layer: Stratum IIb - Ches. Cem. Sand

Sample Depth = 53.2 ft
USCS Classification = SP-SM
Sample Description: poorly graded **SAND** with silt
Moisture Content = 28.3%
Total Unit Weight = 117.6 pcf
Specific Gravity = 2.66
LL = NP, PL = NP, PI = NP

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean}= 21.9 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
NP = Non-Plastic

Isotropic Confining Stress, σ_o = 21.9 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
3.41E-04	1.00	0.93	3.32E-04	1.00	1.05	2.94E-04	1.00	0.97
6.94E-04	1.00	0.94	5.81E-04	1.00	1.28	6.02E-04	1.00	0.79
1.37E-03	1.00	0.96	1.01E-03	1.00	0.77	1.04E-03	1.00	0.67
2.63E-03	1.00	0.93	1.98E-03	1.00	1.07	2.05E-03	1.00	1.15
4.94E-03	0.97	1.04	4.10E-03	1.00	1.59	4.10E-03	1.00	1.48
9.13E-03	0.94	1.26	9.55E-03	0.92	2.23	9.58E-03	0.93	2.28
1.67E-02	0.89	1.72	2.04E-02	0.86	3.52	2.05E-02	0.86	3.53
3.06E-02	0.83	2.39	5.09E-02	0.69	6.25	5.10E-02	0.70	6.06
5.61E-02	0.76	3.09	---	---	---	---	---	---
9.74E-02	0.67	4.35	---	---	---	---	---	---
1.73E-01	0.56	5.28	---	---	---	---	---	---
3.48E-01	0.44	6.48	---	---	---	---	---	---
5.34E-01	0.38	7.68	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 87.6 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
2.57E-04	1.00	0.74	9.36E-04	1.00	0.79	9.44E-04	1.01	0.57
5.10E-04	1.00	0.66	1.93E-03	1.00	0.90	1.89E-03	1.01	0.89
1.05E-03	1.00	0.78	3.80E-03	1.00	0.77	3.84E-03	0.99	0.69
3.91E-03	0.98	0.71	9.97E-03	0.95	1.25	9.92E-03	0.96	1.39
7.29E-03	0.96	0.81	2.08E-02	0.92	1.95	2.08E-02	0.91	1.89
1.33E-02	0.93	0.89	3.88E-02	0.86	3.10	3.88E-02	0.86	2.95
2.35E-02	0.90	1.17	---	---	---	---	---	---
4.13E-02	0.84	1.72	---	---	---	---	---	---
7.11E-02	0.76	2.32	---	---	---	---	---	---
1.21E-01	0.67	2.90	---	---	---	---	---	---
2.11E-01	0.57	3.65	---	---	---	---	---	---
3.67E-01	0.48	4.84	---	---	---	---	---	---

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Table 9. Summary of RCTS Laboratory Test Results (Appendix K Tests)

Test ID: Appendix K
Boring: B-404
Sample No.: UD22
Layer: Stratum IIc - Ches. Clay/Silt (sandy portion)

Sample Depth = 84 ft
USCS Classification = SM
Sample Description: Silty **SAND**
Moisture Content = 32.2%
Total Unit Weight = 115.4 pcf
Specific Gravity = 2.63
LL = 53, PL = 28, PI = 25

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean} = 30.3 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
NP = Non-Plastic

Isotropic Confining Stress, σ_o = 30.3 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
2.78E-04	1.00	1.27	3.37E-04	1.00	0.63	3.27E-04	1.00	0.79
5.04E-04	1.00	1.29	6.51E-04	1.00	0.72	6.49E-04	1.00	0.74
9.88E-04	1.00	1.28	1.03E-03	1.00	0.85	1.02E-03	1.00	0.80
1.94E-03	1.00	1.31	2.07E-03	1.00	1.00	2.07E-03	1.00	0.93
3.71E-03	0.99	1.41	4.29E-03	0.97	1.34	4.31E-03	0.95	1.45
7.17E-03	0.96	1.61	1.03E-02	0.87	2.28	1.03E-02	0.86	2.26
1.36E-02	0.91	1.94	2.29E-02	0.78	3.30	2.32E-02	0.77	3.35
2.51E-02	0.85	2.43	5.38E-02	0.67	4.56	5.43E-02	0.66	4.55
4.66E-02	0.77	3.20	---	---	---	---	---	---
9.07E-02	0.67	4.47	---	---	---	---	---	---
1.82E-01	0.57	5.38	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 121.1 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
1.14E-04	1.00	0.99	3.60E-04	1.00	0.52	3.67E-04	1.00	0.67
2.28E-04	1.00	0.99	7.24E-04	1.00	0.62	7.19E-04	1.00	0.60
4.52E-04	1.00	0.99	1.02E-03	1.00	0.63	1.02E-03	1.00	0.69
9.31E-04	1.00	0.99	2.00E-03	1.00	0.74	2.02E-03	1.00	0.68
1.86E-03	1.00	0.98	4.06E-03	1.00	1.06	4.05E-03	1.00	1.06
3.64E-03	0.99	1.03	1.03E-02	0.94	1.65	1.03E-02	0.95	1.65
6.95E-03	0.97	1.22	2.19E-02	0.89	1.94	2.21E-02	0.89	2.14
1.28E-02	0.95	1.32	4.25E-02	0.82	3.18	4.26E-02	0.82	3.11
2.32E-02	0.90	1.62	---	---	---	---	---	---
4.14E-02	0.84	1.92	---	---	---	---	---	---
7.51E-02	0.77	2.64	---	---	---	---	---	---
1.39E-01	0.67	3.56	---	---	---	---	---	---
2.61E-01	0.57	5.24	---	---	---	---	---	---

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Table 10. Summary of RCTS Laboratory Test Results (Appendix M Tests)

Test ID: Appendix M
Boring: B-409
Sample No.: UD39
Layer: Stratum IIc - Ches. Clay/Silt (sandy portion)

Sample Depth = 96.1 ft
USCS Classification = SM
Sample Description: Silty **SAND**
Moisture Content = 33.1%
Total Unit Weight = 109.3 pcf
Specific Gravity = 2.64
LL = 61, PL = 42, PI = 19

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean}= 28 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
NP = Non-Plastic

Isotropic Confining Stress, σ_o = 28 psi

Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
3.20E-04	1.00	1.19	--	--	--	1.77E-04	1.00	0.65
6.58E-04	1.00	1.19	--	--	--	3.39E-04	1.00	0.38
1.30E-03	1.00	1.19	--	--	--	6.40E-04	1.00	0.48
2.55E-03	1.00	1.18	--	--	--	1.02E-03	1.00	0.79
4.90E-03	1.00	1.23	--	--	--	2.06E-03	1.00	0.97
9.32E-03	0.96	1.31	--	--	--	4.24E-03	1.00	1.13
1.72E-02	0.93	1.53	--	--	--	1.02E-02	0.95	2.01
3.15E-02	0.87	2.11	---	---	---	---	---	---
5.79E-02	0.79	2.68	---	---	---	---	---	---
1.09E-01	0.69	3.78	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 119.1 psi

Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
1.59E-04	1.00	1.00	3.56E-04	1.00	0.53	3.69E-04	1.00	0.48
3.09E-04	1.00	1.04	7.33E-04	1.00	0.62	7.19E-04	1.00	0.68
6.30E-04	1.00	1.04	1.01E-03	1.00	0.60	1.02E-03	1.00	0.66
1.25E-03	1.00	1.08	2.02E-03	1.00	0.66	2.03E-03	1.00	0.66
2.47E-03	1.00	1.09	4.11E-03	0.98	0.85	4.10E-03	0.99	0.88
4.81E-03	0.99	1.09	8.42E-03	0.96	1.15	8.44E-03	0.96	1.12
9.15E-03	0.97	1.14	---	---	---	---	---	---
1.69E-02	0.95	1.19	---	---	---	---	---	---
3.06E-02	0.90	1.34	---	---	---	---	---	---
5.48E-02	0.84	1.85	---	---	---	---	---	---
9.97E-02	0.76	2.57	---	---	---	---	---	---
1.85E-01	0.67	3.72	---	---	---	---	---	---
3.50E-01	0.57	5.61	---	---	---	---	---	---
4.95E-01	0.52	6.55	---	---	---	---	---	---

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Table 11. Summary of RCTS Laboratory Test Results (Appendix E Tests)

Test ID: Appendix E
Boring: B-401
Sample No.: UD31
Layer: Stratum IIc - Ches. Clay/Silt

Sample Depth = 140 ft
USCS Classification = CH
Sample Description: sandy fat **CLAY**
Moisture Content = 41.1%
Total Unit Weight = 104.1 pcf
Specific Gravity = 2.63
LL = 80, PL = 31, PI = 49

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean} = 46.6 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index

Isotropic Confining Stress, σ_o = 46.6 psi

Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
3.93E-04	1.00	1.24	5.40E-04	0.98	0.71	5.77E-04	1.00	0.80
6.95E-04	1.00	1.21	1.09E-03	0.99	1.05	1.12E-03	1.00	0.97
1.23E-03	1.00	1.27	2.14E-03	1.00	1.01	2.14E-03	1.00	0.89
2.15E-03	1.00	1.31	4.33E-03	0.99	1.04	4.37E-03	1.00	0.88
4.16E-03	1.00	1.35	---	---	---	---	---	---
9.87E-03	1.00	1.64	---	---	---	---	---	---
2.04E-02	0.98	1.91	---	---	---	---	---	---
3.91E-02	0.91	2.31	---	---	---	---	---	---
7.42E-02	0.82	2.99	---	---	---	---	---	---
1.54E-01	0.70	4.32	---	---	---	---	---	---
3.07E-01	0.58	5.67	---	---	---	---	---	---
4.91E-01	0.50	7.02	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 186.3 psi

Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
5.11E-04	1.00	1.17	3.38E-03	0.99	1.23	3.35E-03	1.00	1.30
1.06E-03	1.00	1.18	6.72E-03	1.00	1.26	6.74E-03	0.99	1.58
2.12E-03	1.00	1.16	1.01E-02	1.00	1.55	1.01E-02	1.00	1.62
4.21E-03	1.00	1.16	2.16E-02	0.95	1.89	2.17E-02	0.95	1.83
8.30E-03	0.99	1.36	---	---	---	---	---	---
1.59E-02	0.97	1.55	---	---	---	---	---	---
2.90E-02	0.94	1.82	---	---	---	---	---	---
5.14E-02	0.89	2.25	---	---	---	---	---	---
9.11E-02	0.82	2.79	---	---	---	---	---	---
1.69E-01	0.73	3.43	---	---	---	---	---	---
3.45E-01	0.60	5.02	---	---	---	---	---	---
6.57E-01	0.49	6.25	---	---	---	---	---	---

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Table 12. Summary of RCTS Laboratory Test Results (Appendix L Tests)

Test ID: Appendix L
Boring: B-401
Sample No.: UD42
Layer: Stratum IIc - Ches. Clay/Silt

Sample Depth = 200.3 ft
USCS Classification = SM
Sample Description: silty SAND
Moisture Content = 48.8%
Total Unit Weight = 101.2 pcf
Specific Gravity = 2.52
LL = 82, PL = 55, PI = 27

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean} = 62.5 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index

Isotropic Confining Stress, σ_o = 62.5 psi

Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
2.56E-04	1.00	0.89	7.34E-04	1.00	0.77	7.31E-04	1.00	0.69
5.08E-04	1.00	0.89	1.03E-03	1.00	0.84	1.04E-03	1.00	0.80
1.09E-03	1.00	0.89	2.08E-03	1.00	0.84	2.08E-03	1.00	0.80
2.13E-03	1.00	0.89	4.19E-03	1.00	0.81	4.19E-03	1.00	0.85
4.16E-03	1.00	0.91	1.04E-02	1.00	1.09	1.03E-02	1.00	1.27
8.12E-03	0.99	0.93	---	---	---	---	---	---
1.53E-02	0.98	1.08	---	---	---	---	---	---
2.79E-02	0.94	1.15	---	---	---	---	---	---
5.01E-02	0.89	1.35	---	---	---	---	---	---
9.01E-02	0.81	1.86	---	---	---	---	---	---
1.66E-01	0.72	2.80	---	---	---	---	---	---
3.22E-01	0.61	3.97	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 250 psi

Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
1.11E-04	1.00	0.78	3.67E-04	1.00	0.61	3.70E-04	1.00	0.54
2.25E-04	1.00	0.75	7.19E-04	1.00	0.64	7.20E-04	1.00	0.75
4.48E-04	1.00	0.76	1.03E-03	1.00	0.80	1.04E-03	1.00	0.78
9.23E-04	1.00	0.75	2.06E-03	1.00	0.77	2.06E-03	1.00	0.75
1.84E-03	1.00	0.74	4.16E-03	1.00	0.77	4.13E-03	1.00	0.68
3.63E-03	1.00	0.74	---	---	---	---	---	---
7.11E-03	0.99	0.79	---	---	---	---	---	---
1.36E-02	0.98	0.83	---	---	---	---	---	---
2.50E-02	0.96	0.91	---	---	---	---	---	---
4.82E-02	0.91	1.17	---	---	---	---	---	---
8.54E-02	0.85	1.54	---	---	---	---	---	---
1.52E-01	0.77	2.22	---	---	---	---	---	---
2.90E-01	0.66	3.50	---	---	---	---	---	---
4.21E-01	0.59	4.44	---	---	---	---	---	---

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Table 13. Summary of RCTS Laboratory Test Results (Appendix G Tests)

Test ID: Appendix G
Boring: B-401
Sample No.: UD48
Layer: Stratum IIc - Ches. Clay/Silt

Sample Depth = 229 ft
USCS Classification = MH
Sample Description: elastic SILT with sand
Moisture Content = 65.2%
Total Unit Weight = 98.2 pcf
Specific Gravity = 2.48
LL = 139, PL = 88, PI = 51

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean} = 70.3 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index

Isotropic Confining Stress, σ_o = 70.3 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
1.88E-04	1.00	0.98	1.03E-03	1.00	0.74	1.00E-03	1.00	0.66
3.83E-04	1.00	0.98	2.02E-03	1.00	0.67	2.04E-03	1.00	0.65
8.18E-04	1.00	0.95	4.11E-03	1.00	0.66	4.09E-03	1.00	0.65
1.62E-03	1.00	0.92	1.06E-02	0.96	1.04	1.07E-02	0.95	1.02
3.22E-03	1.00	0.92	2.25E-02	0.91	1.73	2.27E-02	0.90	1.52
6.24E-03	1.00	0.94	5.01E-02	0.82	2.70	5.05E-02	0.81	2.66
1.20E-02	0.98	0.96	---	---	---	---	---	---
2.19E-02	0.96	1.12	---	---	---	---	---	---
3.86E-02	0.92	1.31	---	---	---	---	---	---
6.82E-02	0.86	1.73	---	---	---	---	---	---
1.24E-01	0.77	2.32	---	---	---	---	---	---
2.34E-01	0.67	3.22	---	---	---	---	---	---
4.69E-01	0.55	5.08	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 281.3 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
1.31E-04	1.00	0.83	---	---	---	9.41E-04	1.00	0.62
2.63E-04	1.00	0.83	---	---	---	1.85E-03	1.00	0.79
5.21E-04	1.00	0.83	3.72E-03	1.00	0.66	3.76E-03	1.00	0.71
1.08E-03	1.00	0.83	1.02E-02	0.99	0.97	1.02E-02	0.99	1.03
2.15E-03	1.00	0.80	2.09E-02	0.96	1.22	2.10E-02	0.97	1.20
4.26E-03	1.00	0.81	4.14E-02	0.92	1.77	4.14E-02	0.93	1.76
8.33E-03	0.99	0.82	---	---	---	---	---	---
1.59E-02	0.99	0.82	---	---	---	---	---	---
2.94E-02	0.97	0.96	---	---	---	---	---	---
5.27E-02	0.92	1.10	---	---	---	---	---	---
9.31E-02	0.86	1.41	---	---	---	---	---	---
1.67E-01	0.78	2.03	---	---	---	---	---	---
3.15E-01	0.68	3.09	---	---	---	---	---	---
6.23E-01	0.55	4.70	---	---	---	---	---	---

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Table 14. Summary of RCTS Laboratory Test Results (Appendix F Tests)

Test ID: Appendix F
Boring: B-401
Sample No.: UD67
Layer: Stratum III - Nanjemoy Sand

Sample Depth = 349 ft
USCS Classification =SM
Sample Description: silty **SAND**
Moisture Content = 53.6%
Total Unit Weight = 116.4 pcf
Specific Gravity = 2.78
LL = 52, PL = 39, PI = 13

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean}= 113.9 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index

Isotropic Confining Stress, σ_o = 113.9 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
4.00E-05	1.00	2.98	6.31E-04	1.00	0.79	6.36E-04	1.00	0.98
8.00E-05	1.00	3.01	1.07E-03	1.00	0.52	1.06E-03	1.00	1.00
1.58E-04	1.00	3.07	2.15E-03	1.00	0.82	2.13E-03	1.00	0.72
3.15E-04	1.00	3.11	4.34E-03	0.99	1.20	4.34E-03	0.98	0.75
6.52E-04	1.00	3.27	1.05E-02	0.93	1.83	1.04E-02	0.94	1.80
1.31E-03	0.99	3.38	2.22E-02	0.88	2.49	2.24E-02	0.87	2.50
2.59E-03	0.99	3.60	3.92E-02	0.81	3.31	3.91E-02	0.81	3.24
5.09E-03	0.97	3.81	---	---	---	---	---	---
9.84E-03	0.94	4.03	---	---	---	---	---	---
1.87E-02	0.89	4.55	---	---	---	---	---	---
3.59E-02	0.81	5.01	---	---	---	---	---	---
7.02E-02	0.71	5.99	---	---	---	---	---	---
1.42E-01	0.60	7.70	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 455.6 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
Measurements for 455.6 psi tests were likely adversely affected by high straining during tests at 113.9 psi, therefore, discarded.								
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Table 15. Summary of RCTS Laboratory Test Results (Appendix H Tests)

Test ID: Appendix H
Borings: B-301 & B-401
Sample No.: Composite
Layer: Stratum III - Nanjemoy Sand

Sample Depth = 359-385 ft
USCS Classification = SM
Sample Description: silty **SAND**
Moisture Content = 19.2%
Total Unit Weight = 116.4 pcf
Specific Gravity = 2.86
LL = 40, PL = 36, PI = 4

Estimated In-Situ K_0 = 0.5
Estimated In-Situ σ'_{mean}= 120.4 psi

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index

Isotropic Confining Stress, σ_o = 120.4 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
1.08E-04	1.00	2.78	4.95E-04	1.00	1.42	4.97E-04	0.99	1.16
2.15E-04	1.00	2.78	9.93E-04	1.00	1.37	9.72E-04	1.00	0.94
4.28E-04	1.00	2.88	1.98E-03	1.00	1.11	1.95E-03	0.99	1.05
8.78E-04	1.00	2.94	3.99E-03	0.99	1.59	4.03E-03	0.96	1.69
1.75E-03	0.99	2.96	1.01E-02	0.93	2.16	1.01E-02	0.91	2.04
3.45E-03	0.97	3.33	2.17E-02	0.87	3.03	2.19E-02	0.84	2.99
6.70E-03	0.94	3.96	---	---	---	---	---	---
1.17E-02	0.89	4.47	---	---	---	---	---	---
2.51E-02	0.78	5.74	---	---	---	---	---	---
5.10E-02	0.65	6.86	---	---	---	---	---	---
1.04E-01	0.55	8.19	---	---	---	---	---	---

Isotropic Confining Stress, σ_o = 455.0 psi								
Resonant Column			Torsional Shear (1st Cycle)			Torsional Shear (10th Cycle)		
Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)	Peak Shear Strain (%)	Shear Modulus (G/G_{max})	Damping Ratio (%)
Measurements for 455.0 psi tests were likely adversely affected by high straining during tests at 120.4 psi, therefore, discarded.								
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Table 16. Summary Average Shear Modulus and Damping Ratios Values from RCTS Results

Stratum I-Terrace Sand (Depth 0-25 ft)		
Cyclic Shear Strain (%)	G/G_{max}	D (%)
1.E-04	1	1.4
3.E-04	1	1.5
1.E-03	0.98	1.8
3.E-03	0.915	2.3
1.E-02	0.76	3.8
3.E-02	0.56	6.5
1.E-01	0.34	10.5
3.E-01	0.2	14.8
1.E+00	0.1	

Stratum IIc-Chesapeake Clay/Silt (Depth 135-285 ft)		
Cyclic Shear Strain (%)	G/G_{max}	D (%)
1.E-04	1.0	1.1
3.E-04	1.0	1.1
1.E-03	1.0	1.1
3.E-03	1.0	1.13
1.E-02	0.99	1.2
3.E-02	0.94	1.5
1.E-01	0.80	2.4
3.E-01	0.63	4.1
6.E-01	0.50	5.8
1.E+00	0.40	7.4

Strata IIa, IIb, and III (Chesapeake & Nanjemoy Soils)		
Cyclic Shear Strain (%)	G/G_{max}	D (%)
1.E-04	1.0	1.3
3.E-04	1.0	1.3
1.E-03	1.0	1.4
3.E-03	0.99	1.6
1.E-02	0.94	2.2
3.E-02	0.82	3.2
1.E-01	0.62	5.4
3.E-01	0.42	8.4
6.E-01	0.31	10.6
1.E+00	0.25	12.6

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Table 17. Final Shear Modulus and Damping Ratios for the CCNPP Unit 3 Soils

Stratum I-Terrace Sand (Depth 0-25 ft, El. +85 to +60 ft)		
Cyclic Shear Strain (%)	G/G_{max}	D (%)
1.E-04	1	1.4
3.E-04	1	1.5
1.E-03	0.98	1.8
3.E-03	0.915	2.3
1.E-02	0.76	3.8
3.E-02	0.56	6.5
1.E-01	0.34	10.5
3.E-01	0.2	14.8
1.E+00	0.1	

Stratum IIc-Chesapeake Clay/Silt (Depth 135-285 ft, El. -50 to -200 ft)		
Cyclic Shear Strain (%)	G/G_{max}	D (%)
1.E-04	1.0	1.1
3.E-04	1.0	1.1
1.E-03	1.0	1.1
3.E-03	1.0	1.13
1.E-02	0.99	1.2
3.E-02	0.94	1.5
1.E-01	0.80	2.4
3.E-01	0.63	4.1
6.E-01	0.50	5.8
1.E+00	0.40	7.4

All Other Natural Soils		
Cyclic Shear Strain (%)	G/G_{max}	D (%)
1.E-04	1.0	1.3
3.E-04	1.0	1.3
1.E-03	1.0	1.4
3.E-03	0.99	1.6
1.E-02	0.94	2.2
3.E-02	0.82	3.2
1.E-01	0.62	5.4
3.E-01	0.42	8.4
6.E-01	0.31	10.6
1.E+00	0.25	12.6

Note: Depth=0 ft (El. 85 ft) is finished grade.

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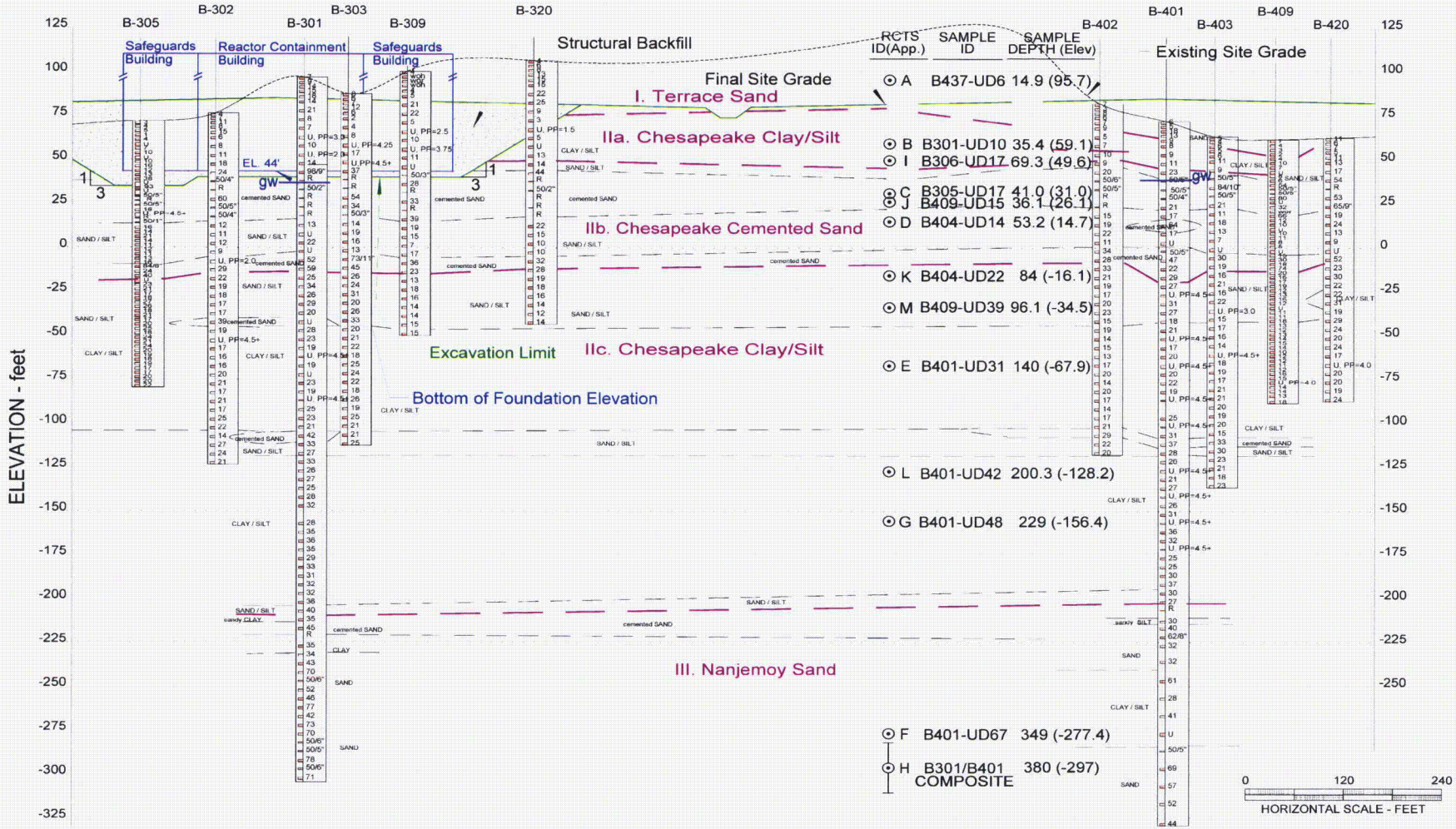
Figure 1. RCTS Test Locations



LEGEND:

⊙ RCTS SAMPLE

FIGURE 1:
RCTS TEST LOCATIONS
CCNPP UNIT 3

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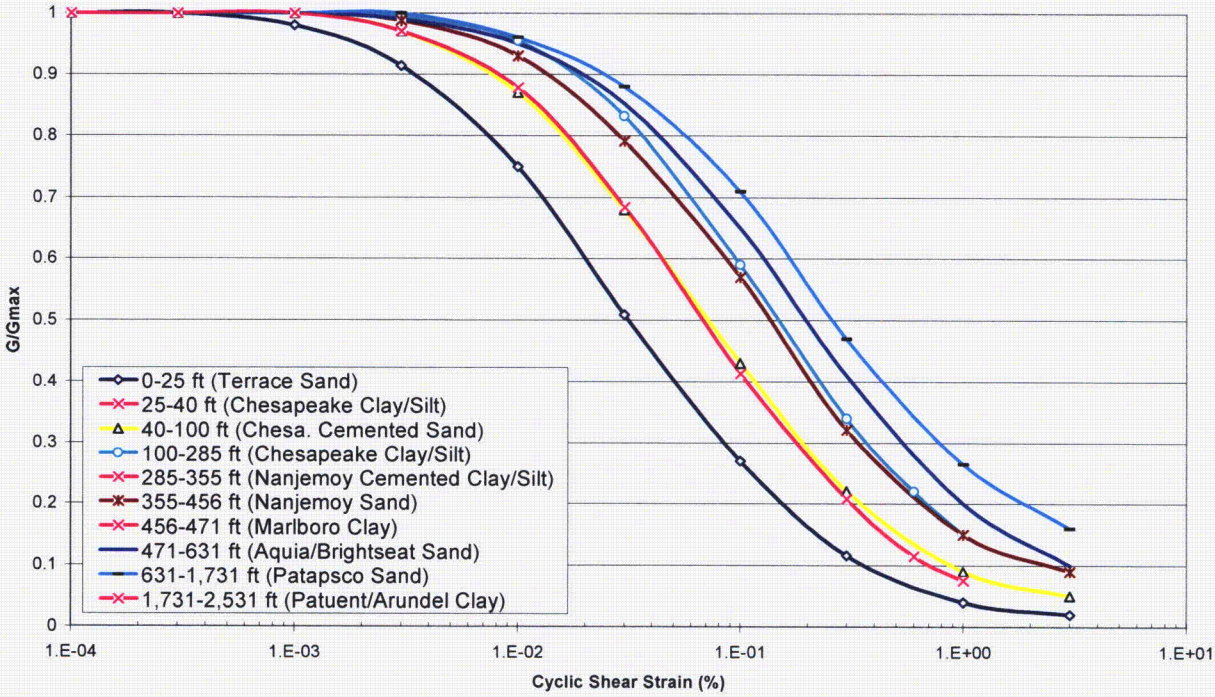
Figure 2. Shear Modulus and Damping Ratios from Initially Adopted EPRI Curves



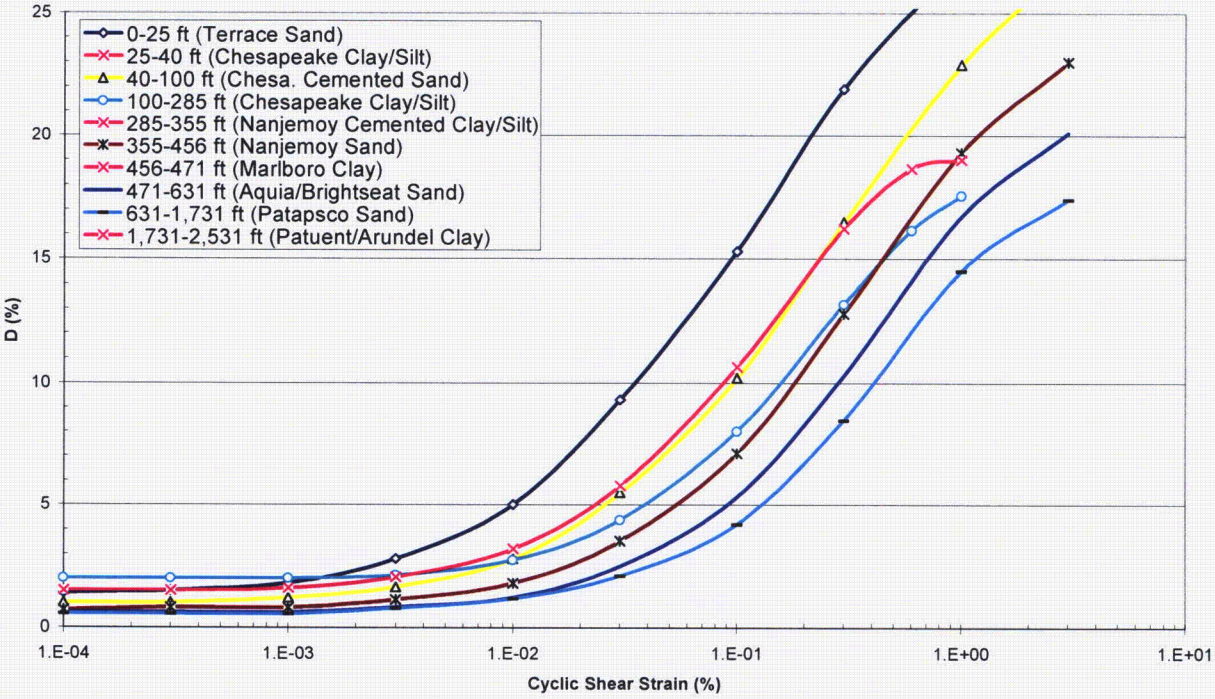


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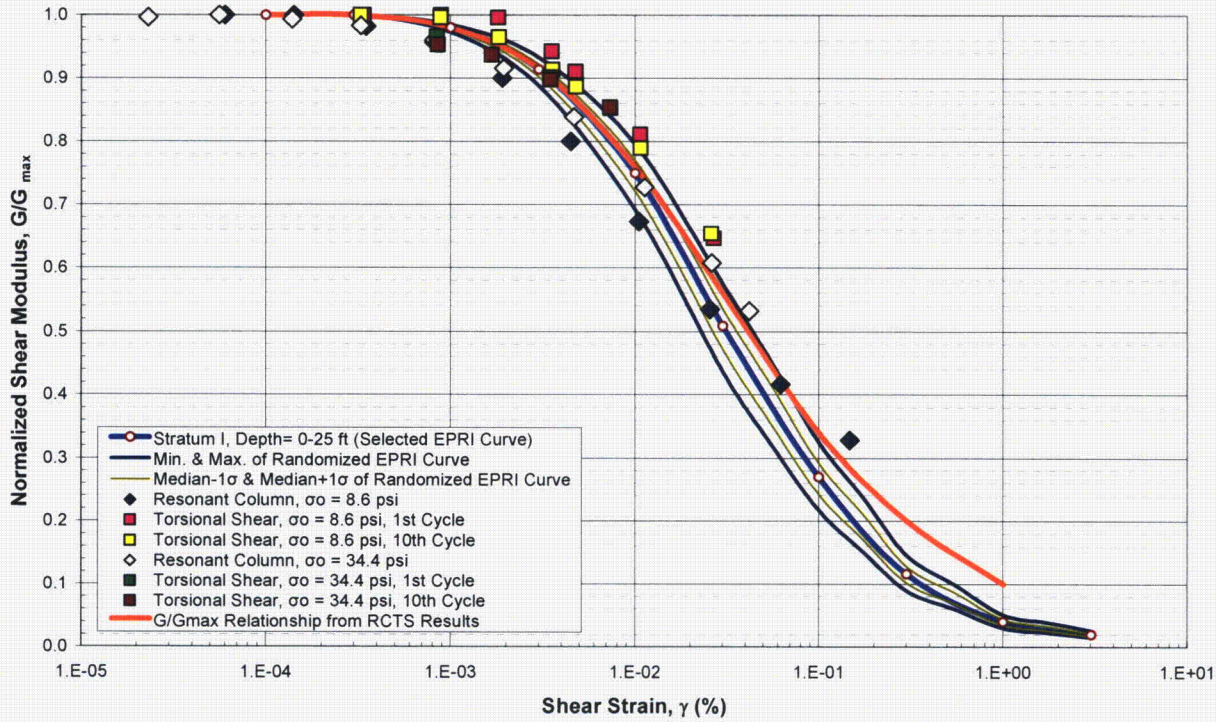
Figure 3. RCTS Test Results: Stratum I-Terrace Sand (Appendix A Tests)



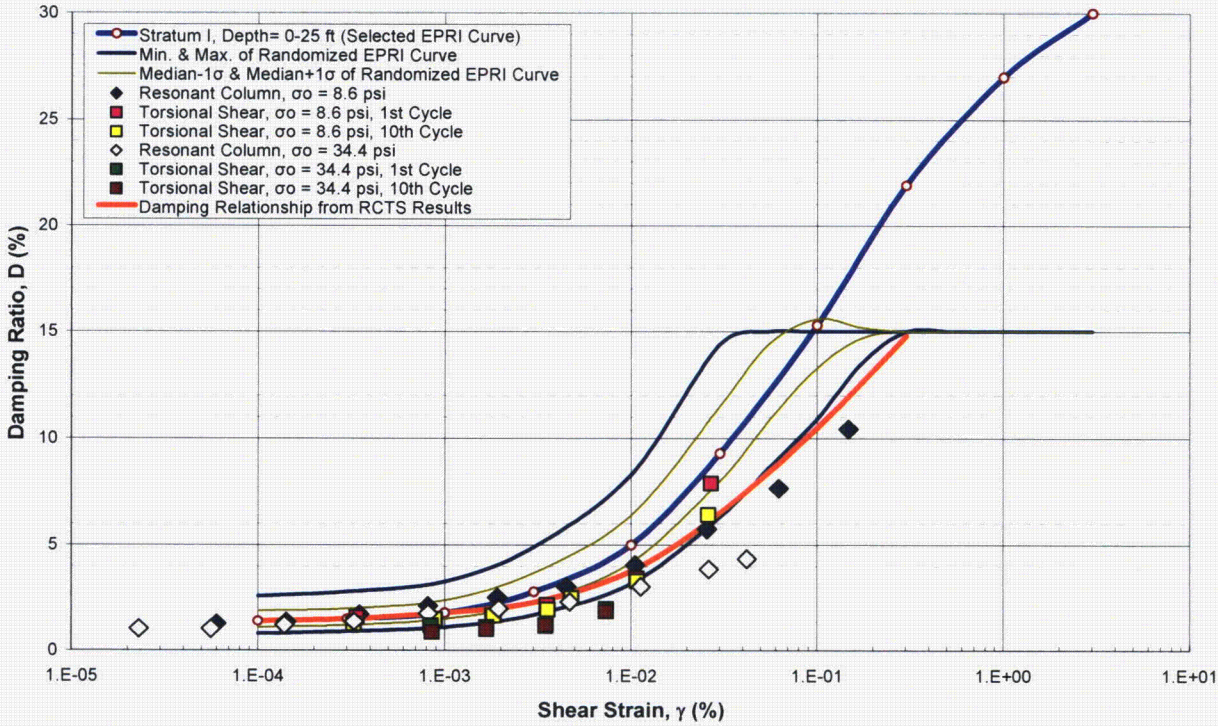


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Figure 4. RCTS Test Results: Stratum IIa-Chesapeake Clay/Silt (Appendix B Tests)

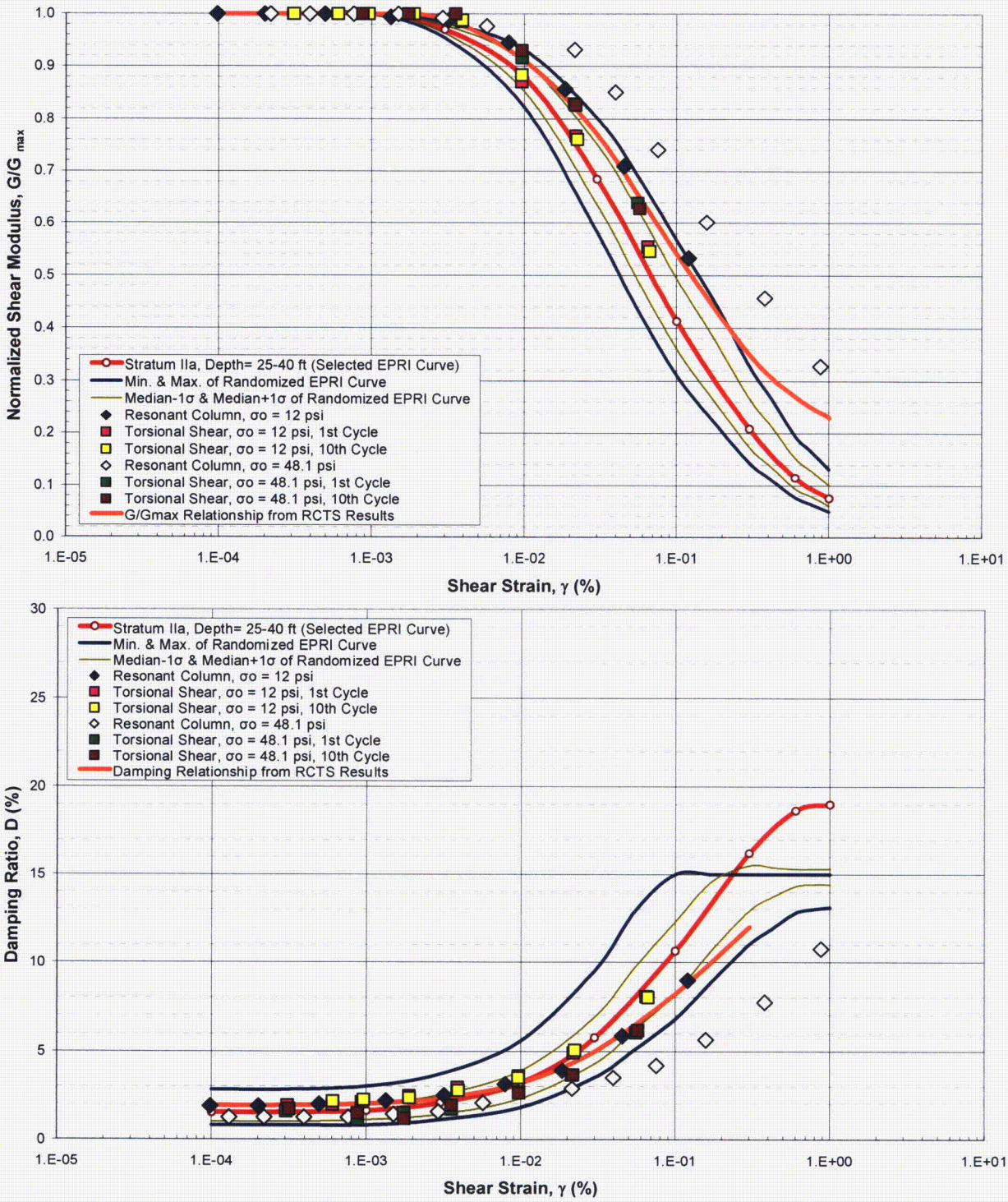

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Figure 5. RCTS Test Results: Stratum IIa-Chesapeake Clay/Silt (Appendix I Tests)

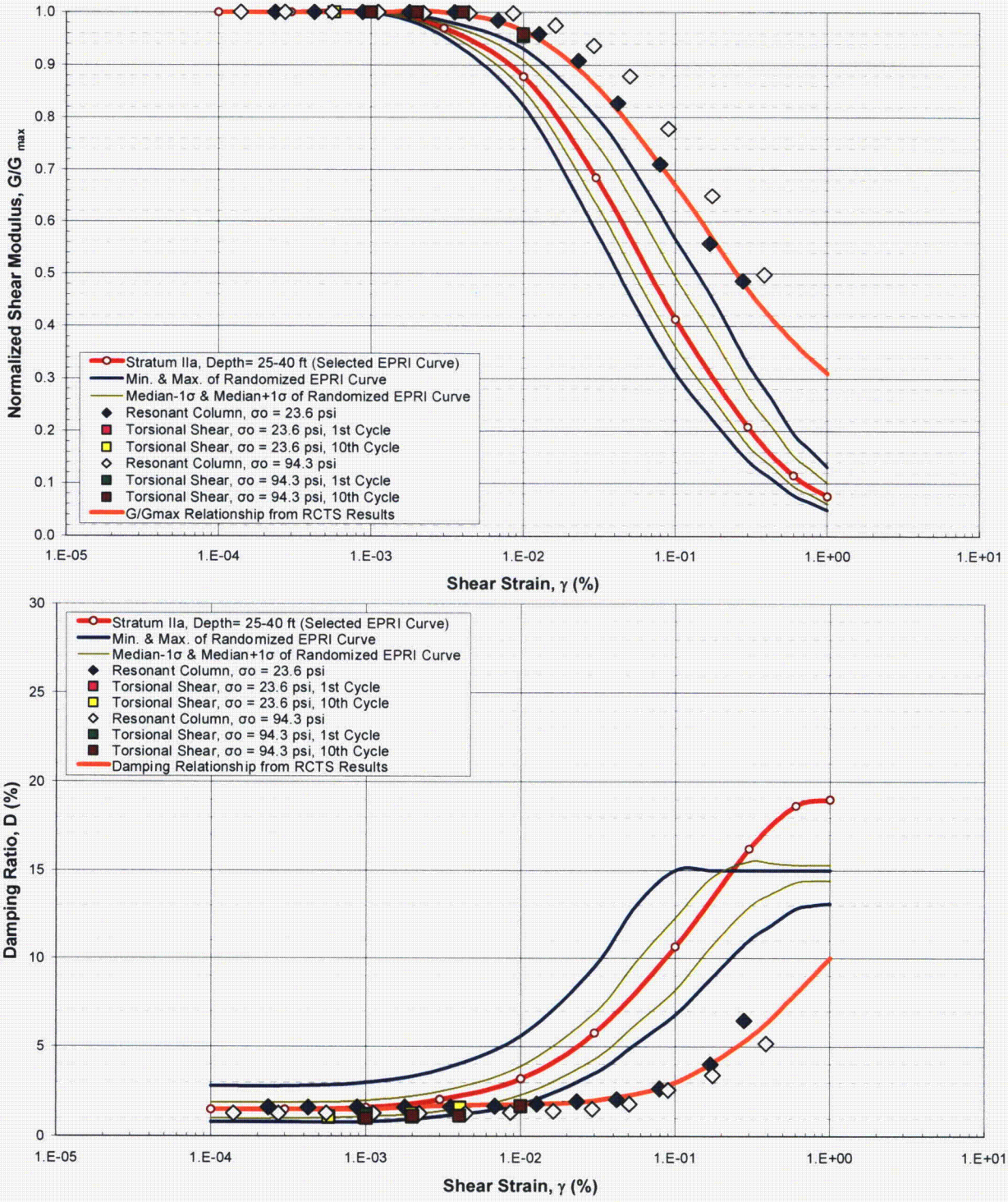

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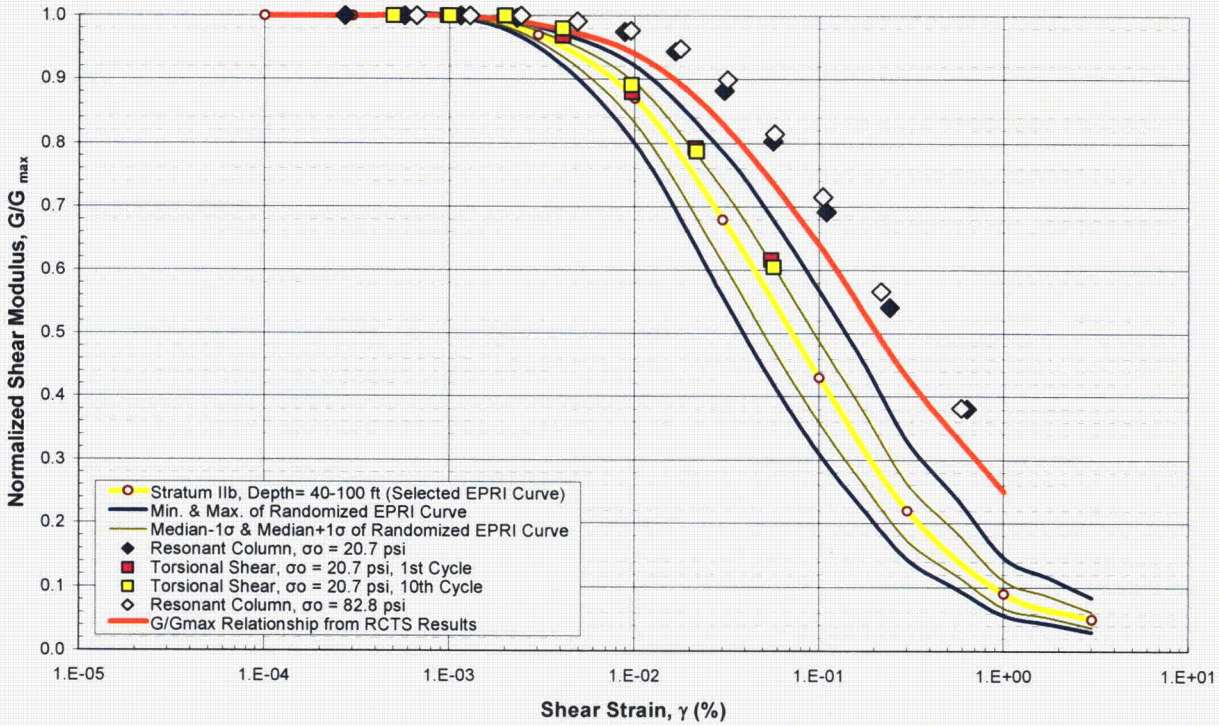
Figure 6. RCTS Test Results: Stratum IIb-Chesapeake Cemented Sand (Appendix C Tests)



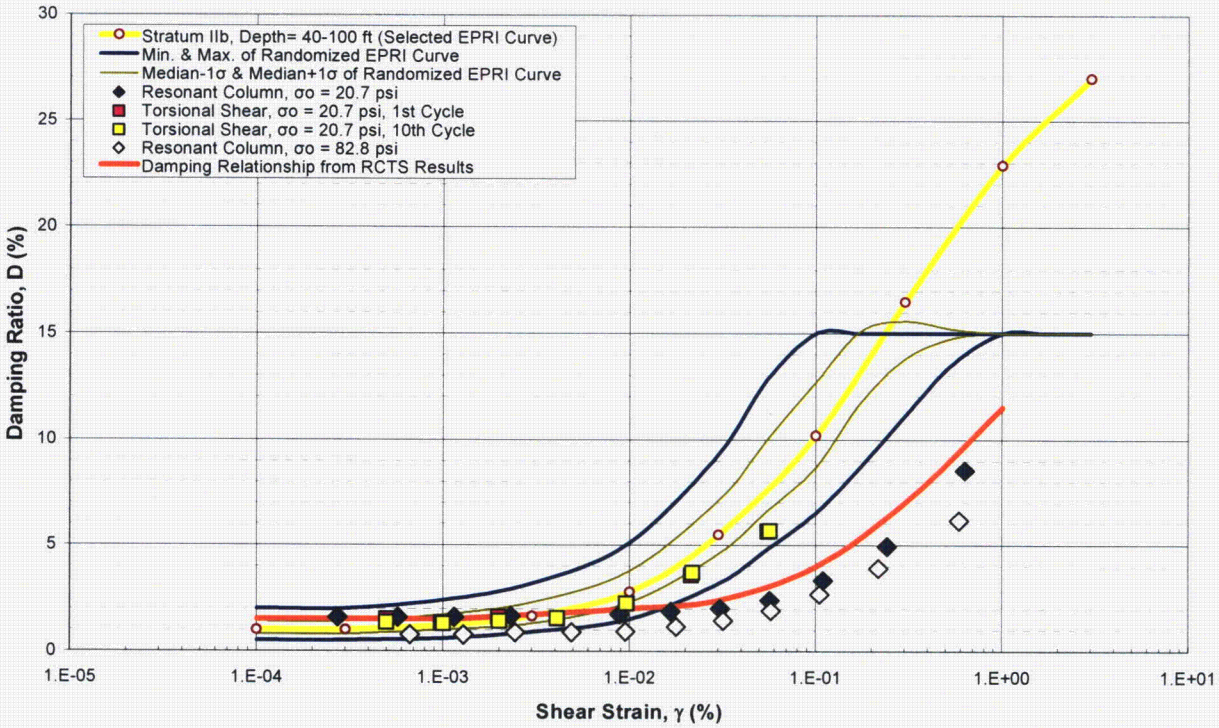


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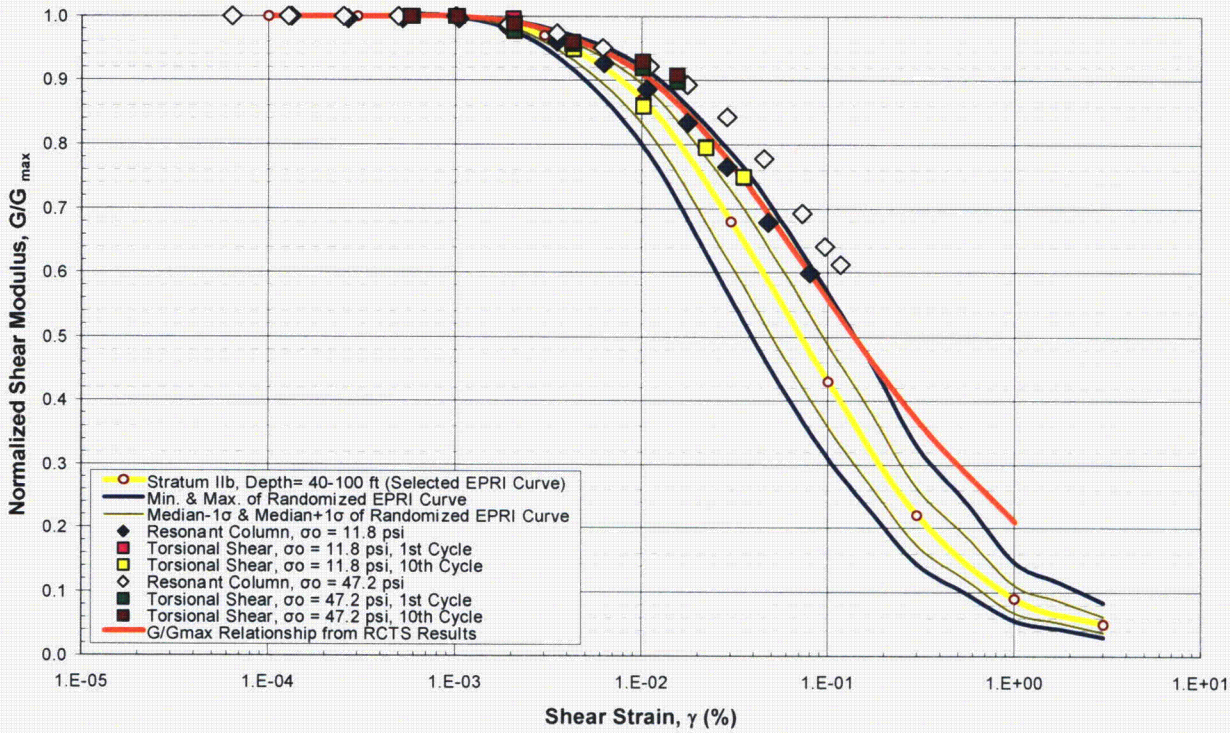
Figure 7. RCTS Test Results: Stratum IIb-Chesapeake Cemented Sand (Appendix J Tests)



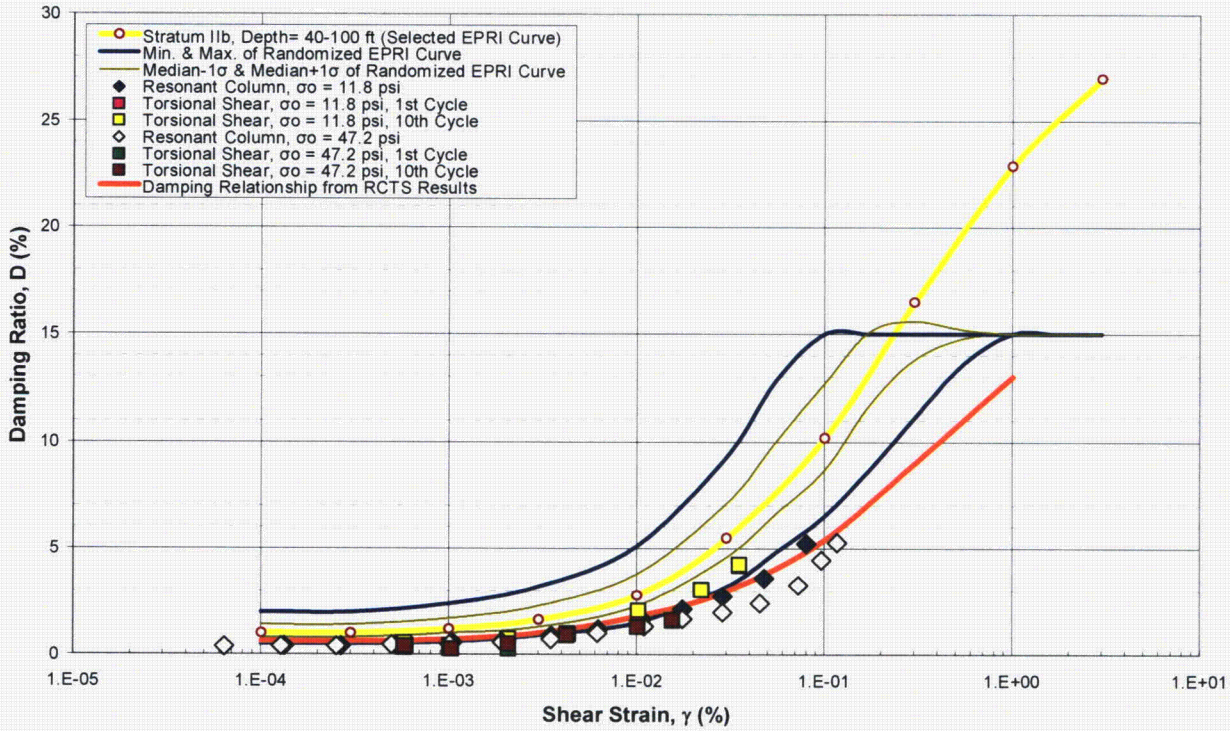


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Figure 8. RCTS Test Results: Stratum IIb-Chesapeake Cemented Sand (Appendix D Tests)

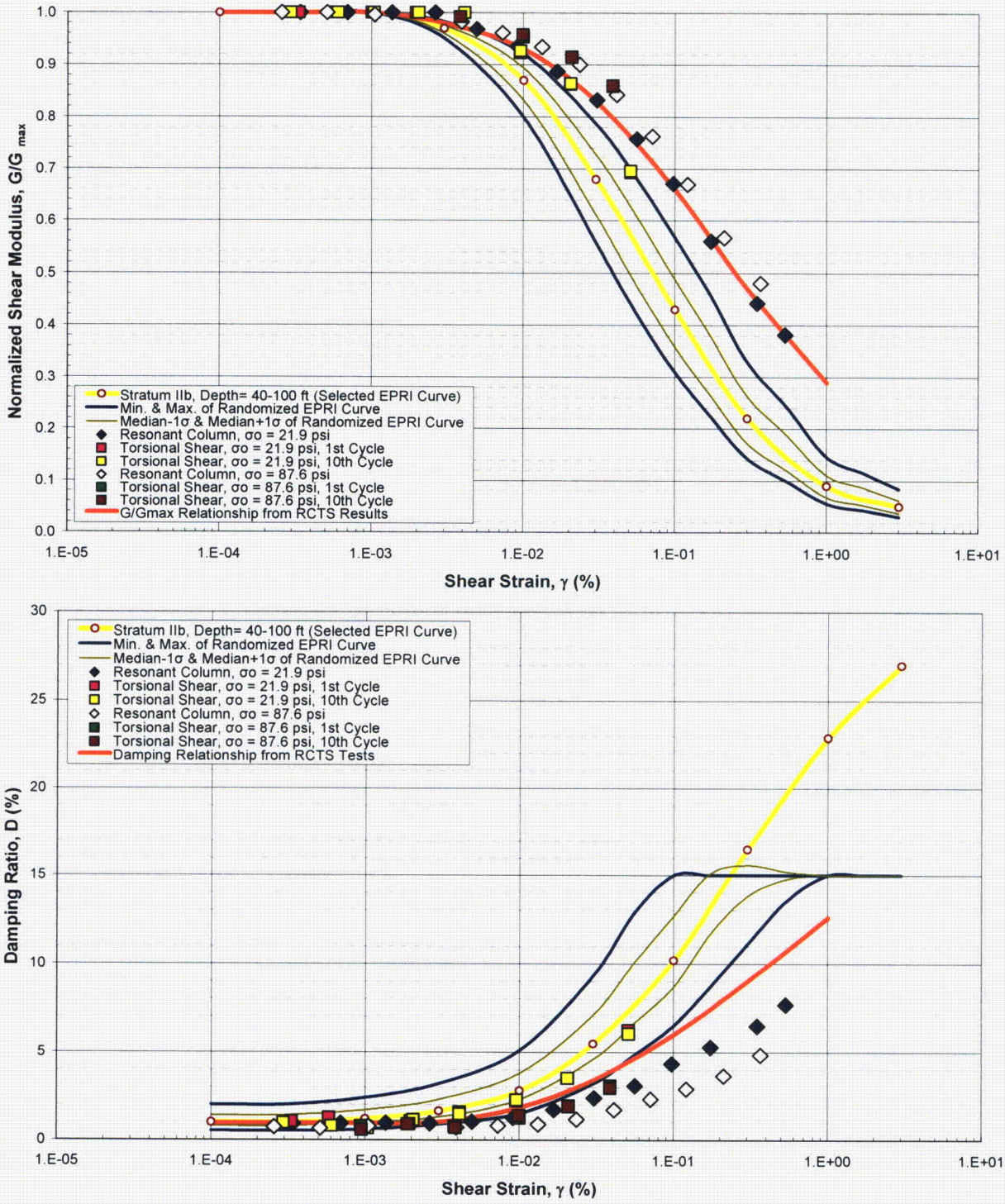

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Figure 9. RCTS Test Results: Stratum IIc-Chesapeake Clay/Silt (Appendix K Tests)

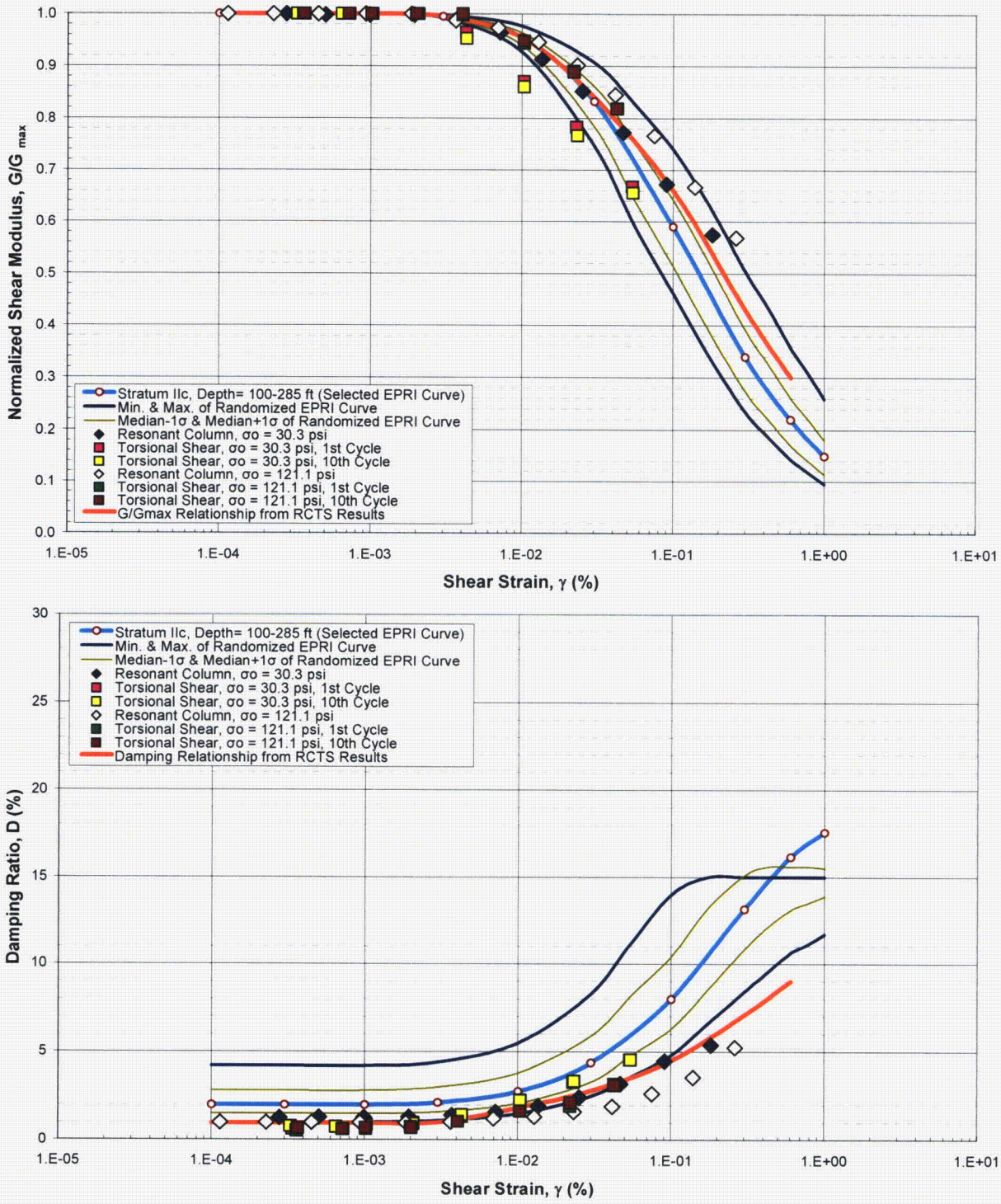

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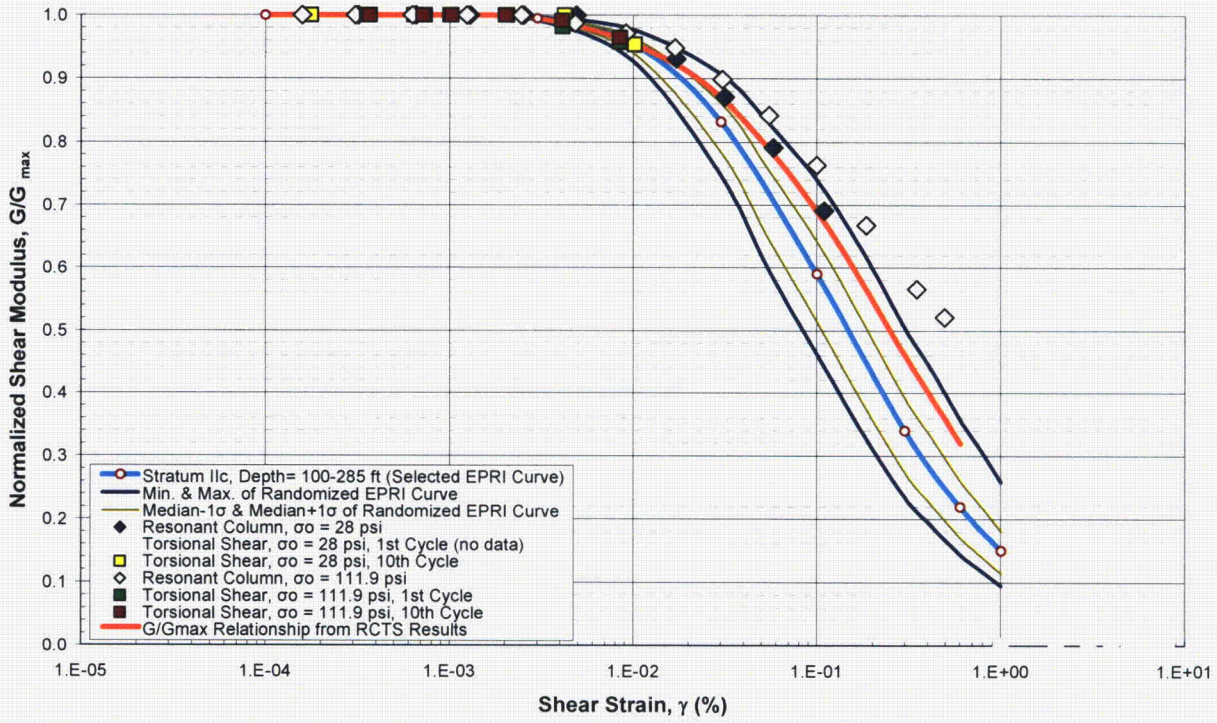
Figure 10. RCTS Test Results: Stratum IIc-Chesapeake Clay/Silt (Appendix M Tests)



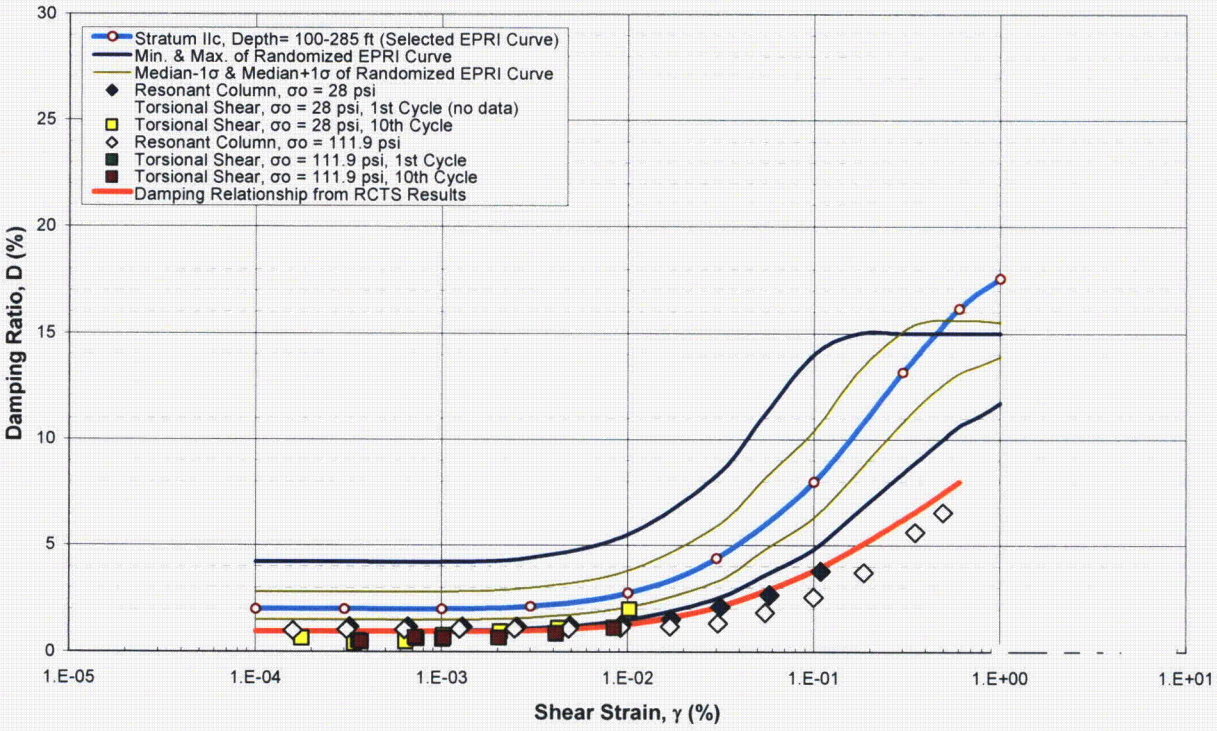


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Figure 11. RCTS Test Results: Stratum IIc-Chesapeake Clay/Silt (Appendix E Tests)

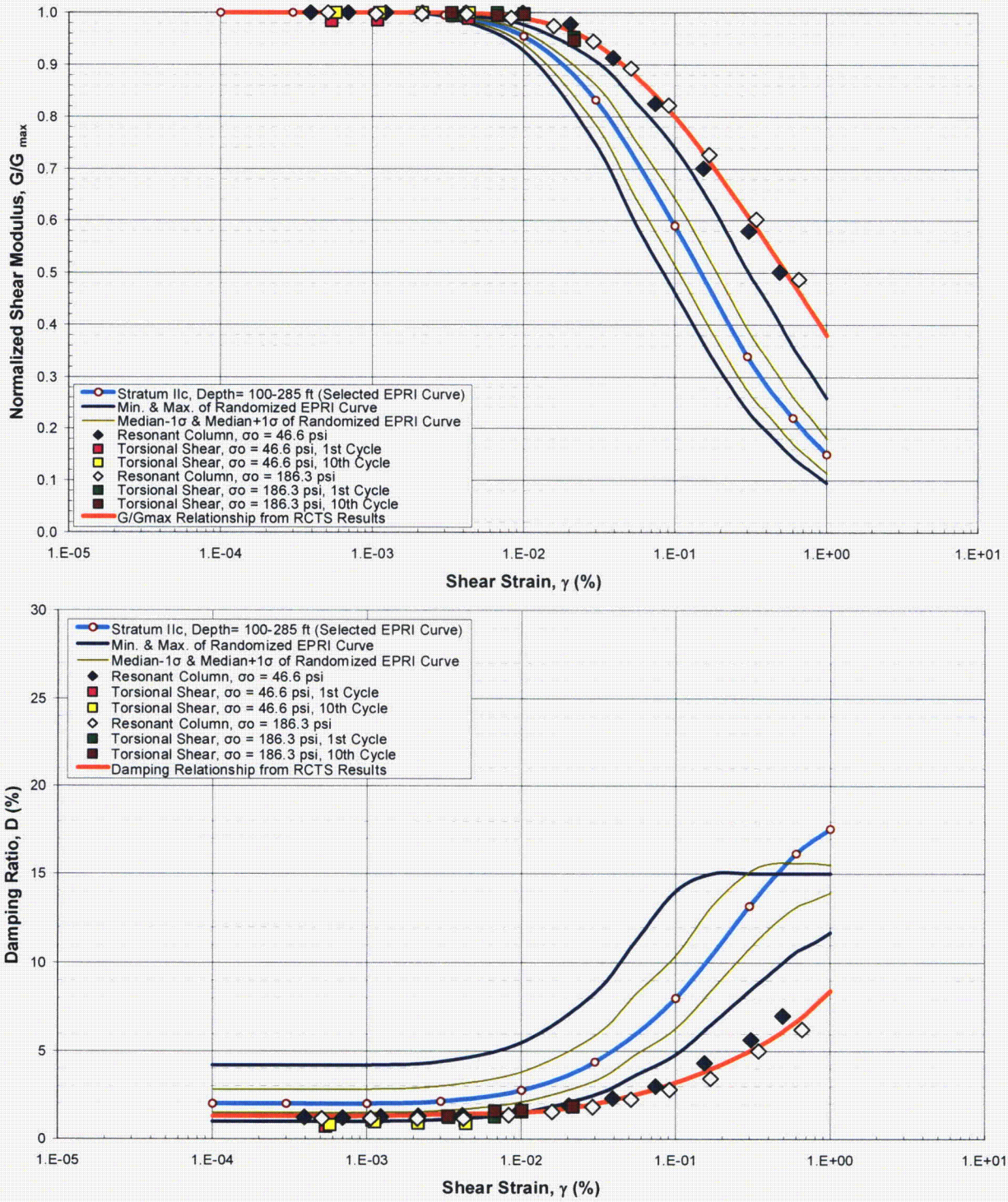

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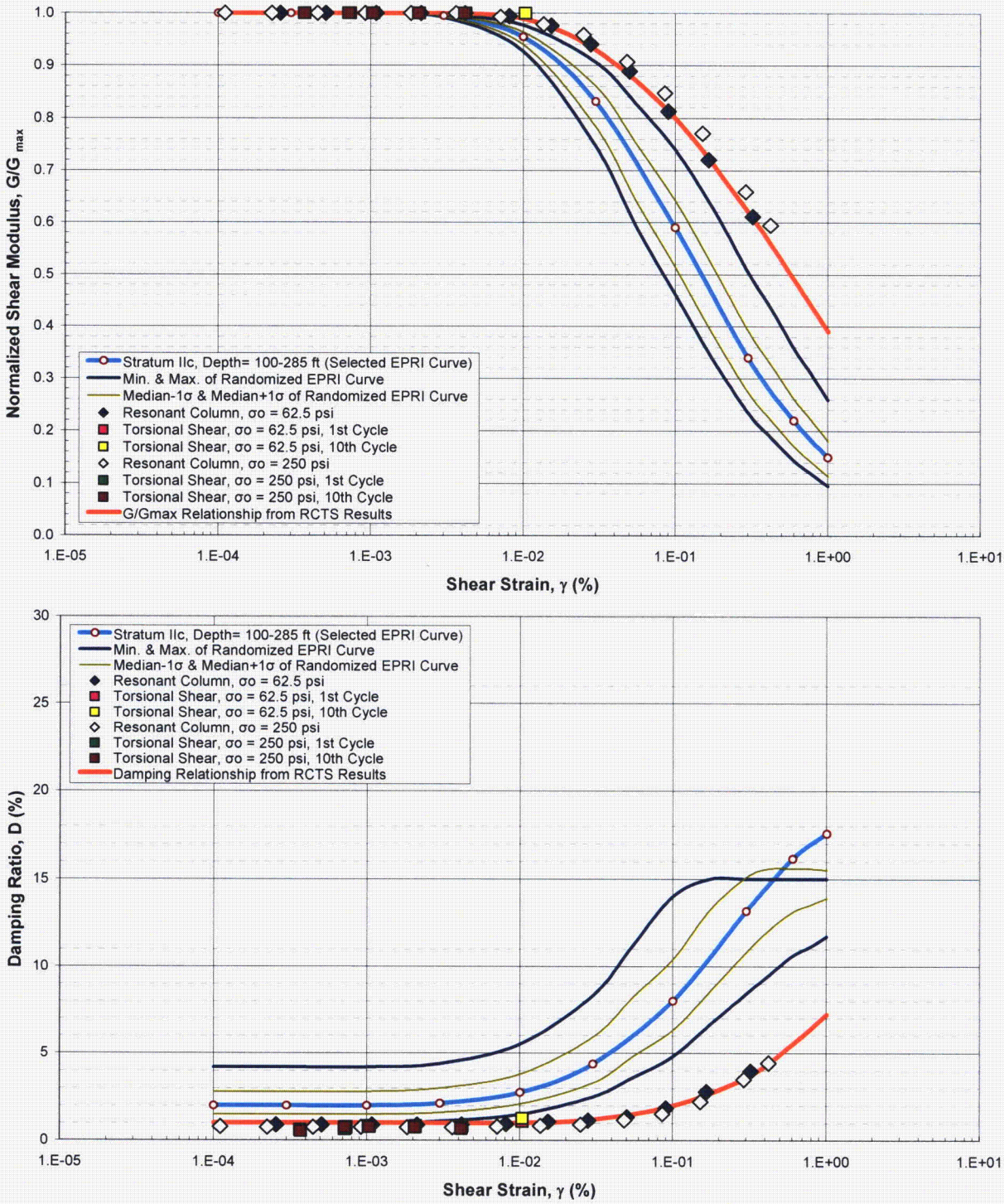
Figure 12. RCTS Test Results: Stratum IIc-Chesapeake Clay/Silt (Appendix L Tests)



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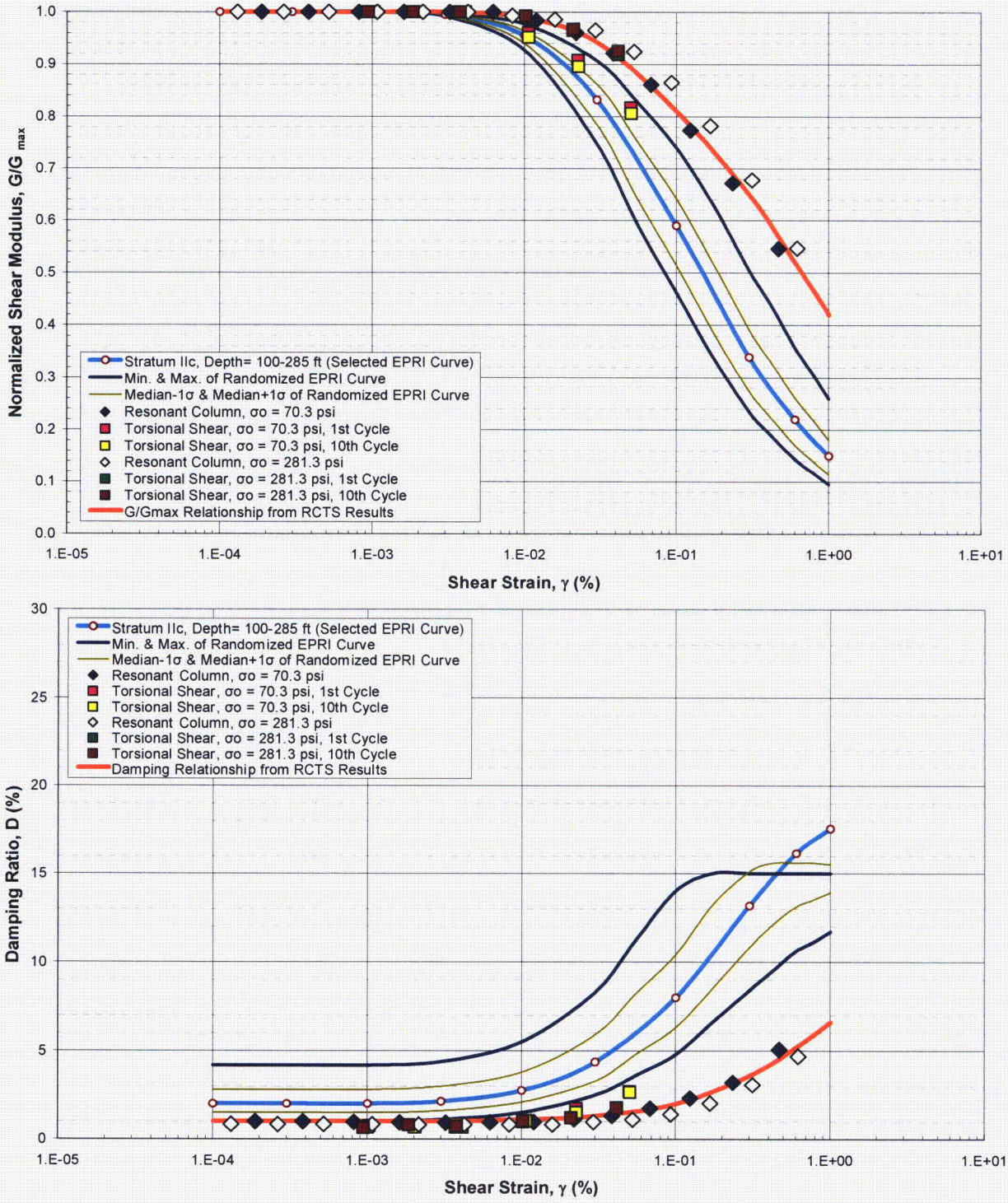

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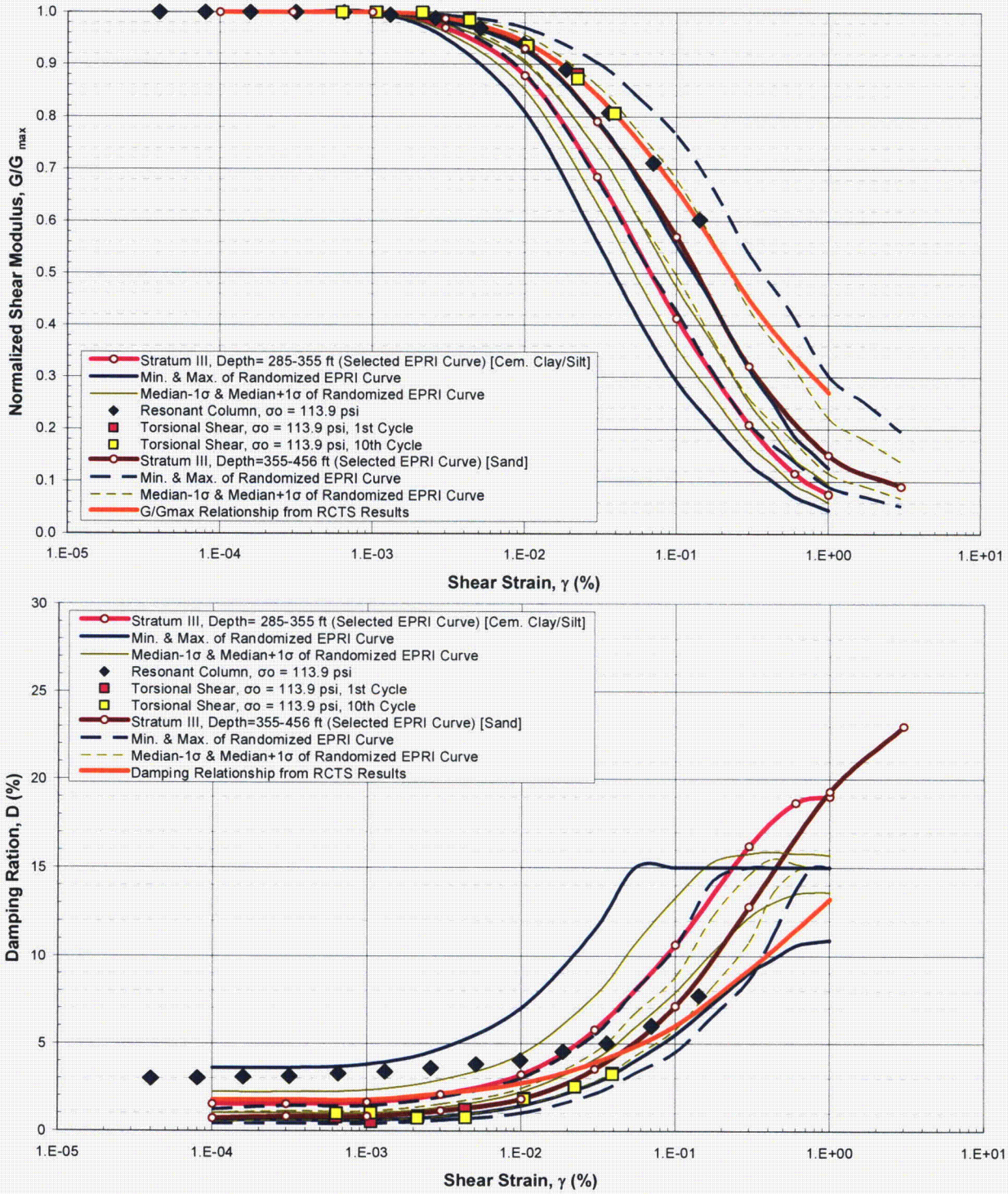

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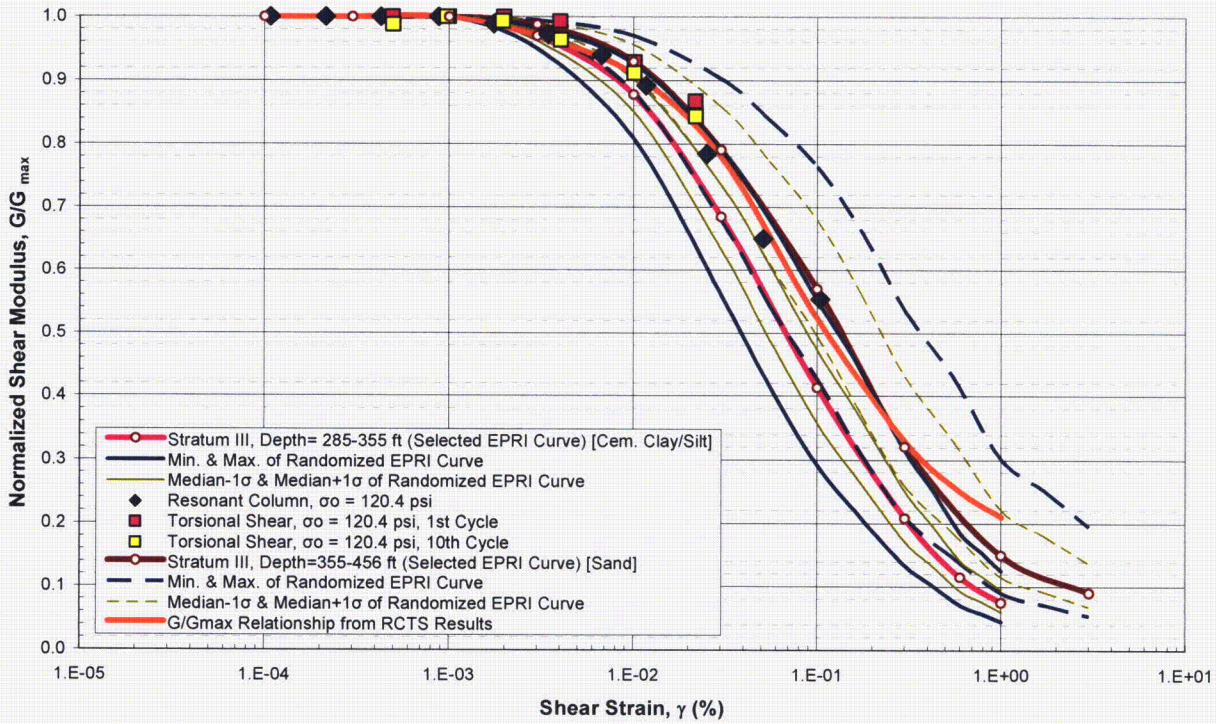

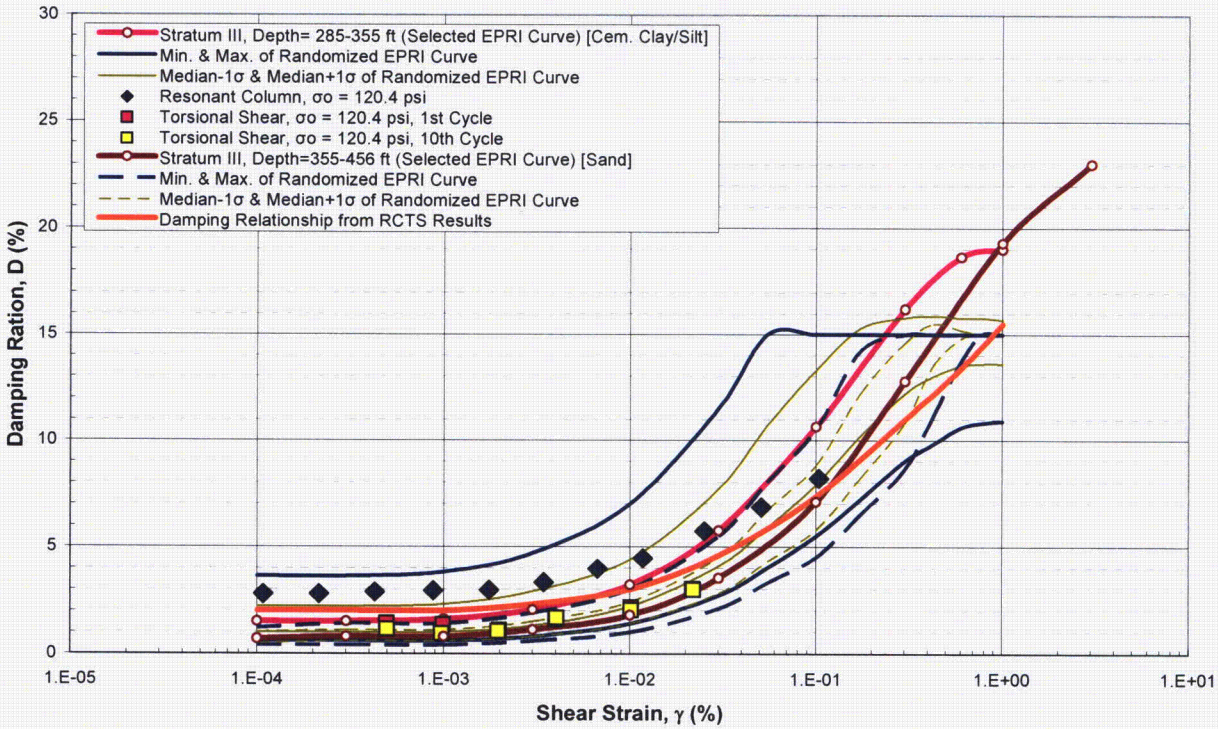

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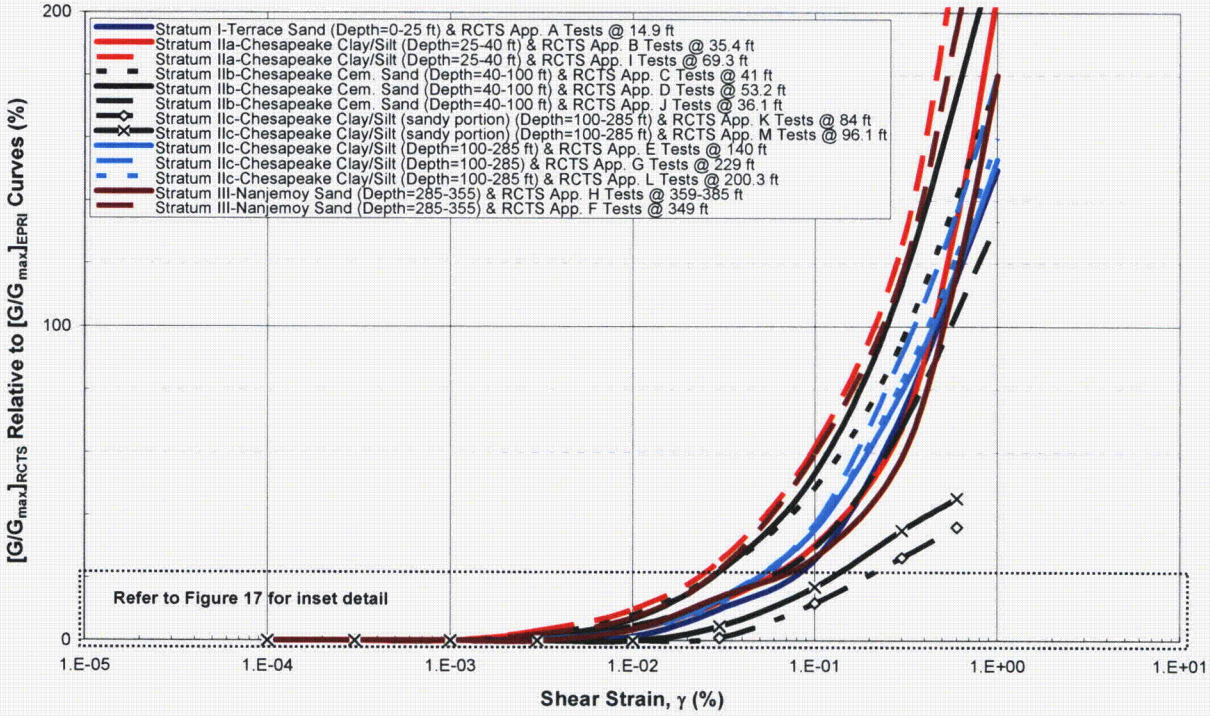
Figure 16. Difference Between RCTS and EPRI Curves: G/G_{max} and Damping



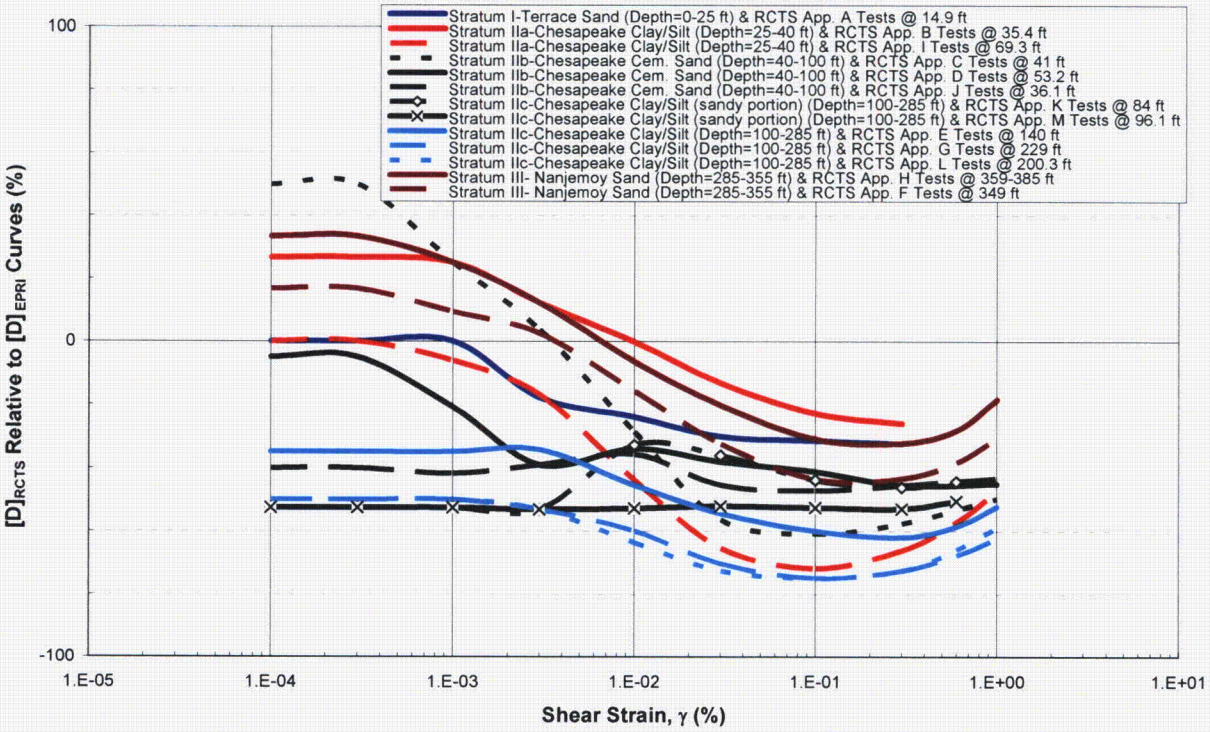


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Figure 17. Difference Between RCTS and EPRI Curves: G/G_{max} and Damping at 1E-2±% Strain

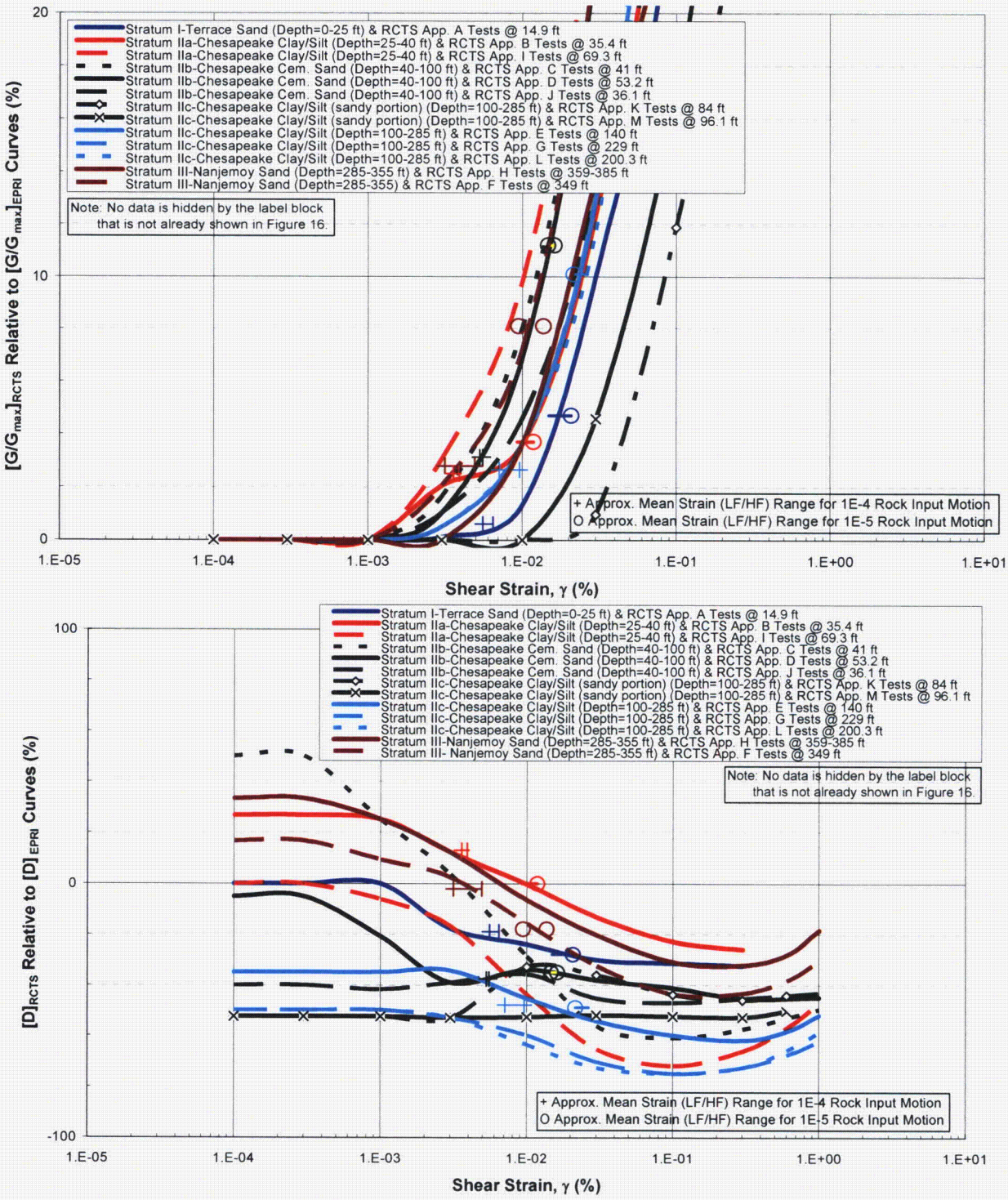

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Figure 18. Combined RCTS Test Results

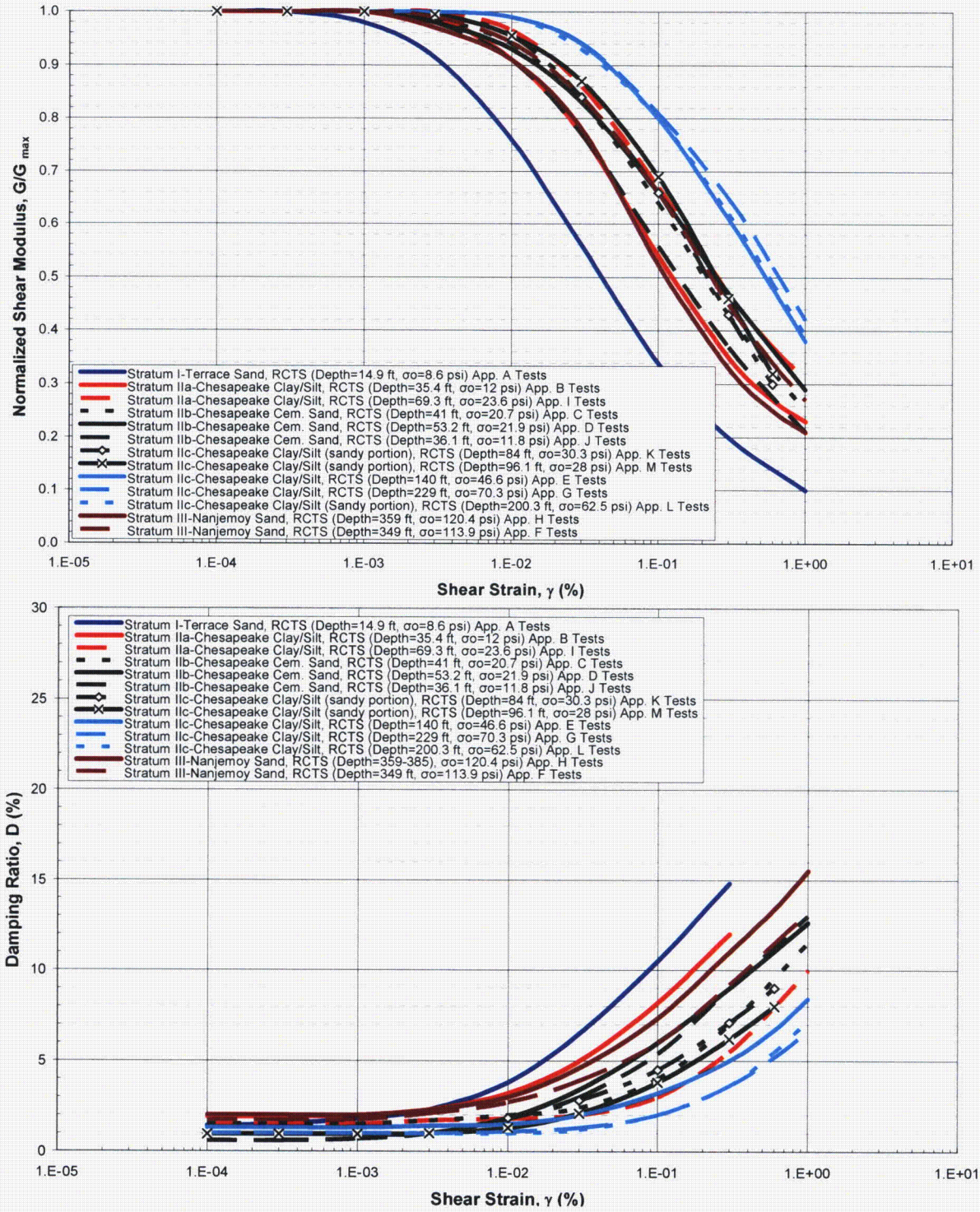

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Figure 19. Average Shear Modulus and Damping Ratio Curves from RCTS Test Results

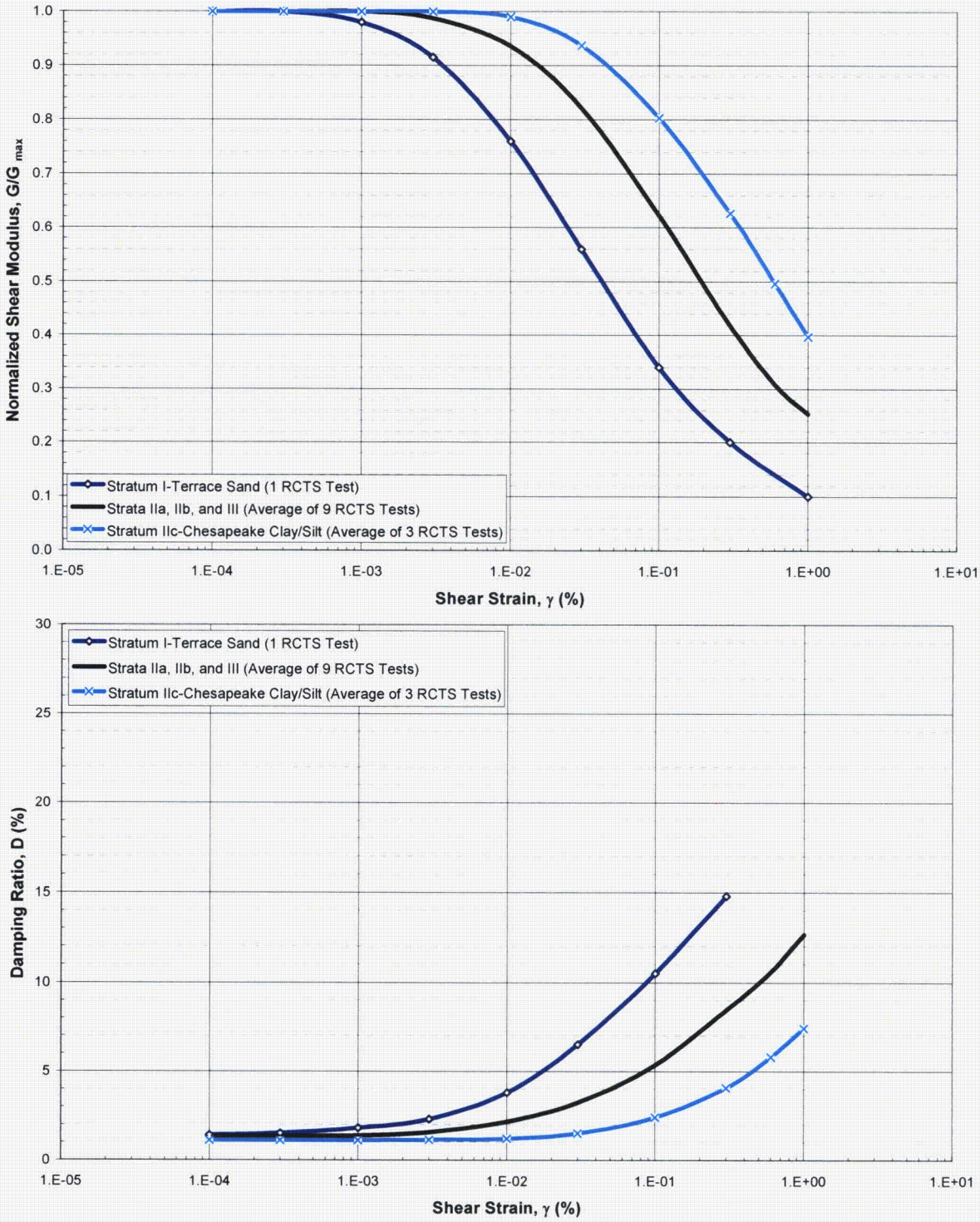

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Figure 20. Comparison of Average RCTS Test Results and Initially Adopted EPRI Curves

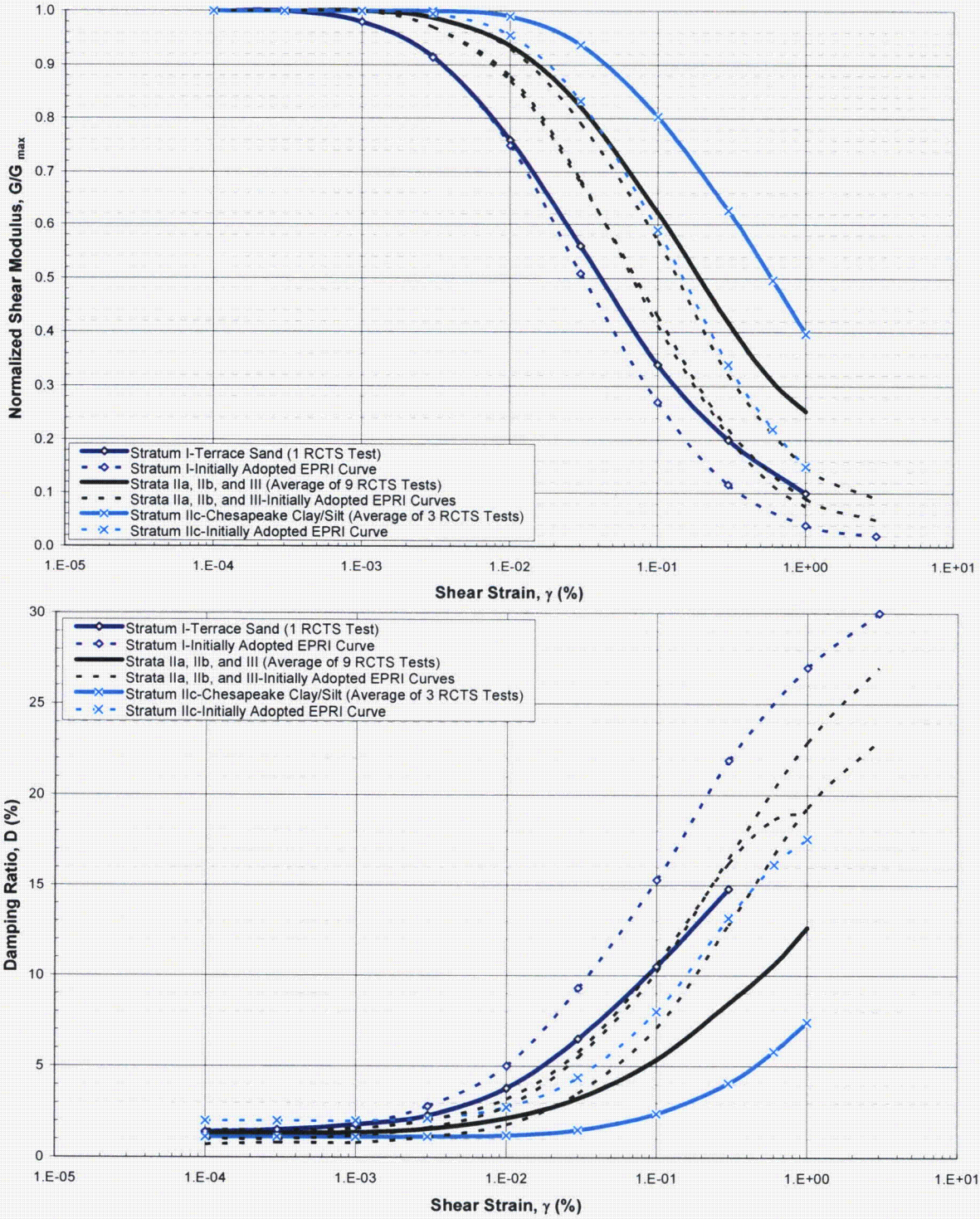

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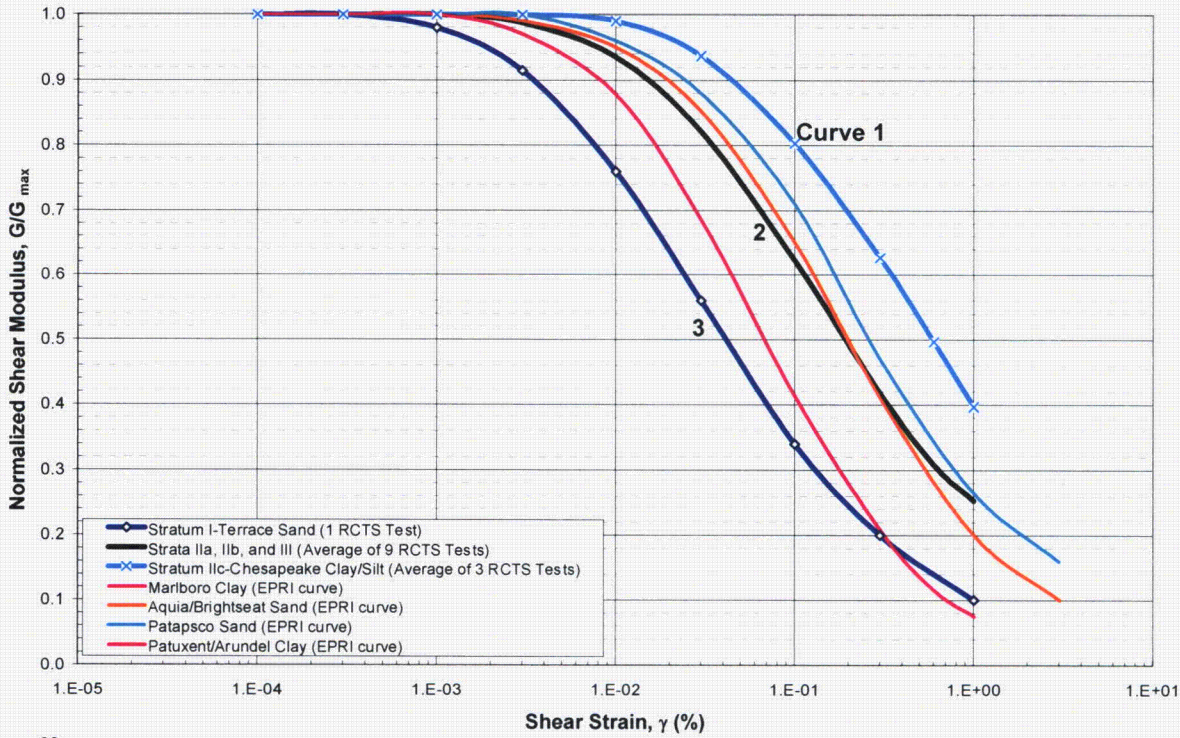
Figure 21. Selection of Shear Modulus and Damping Ratios for Soils Deeper than 400 Feet



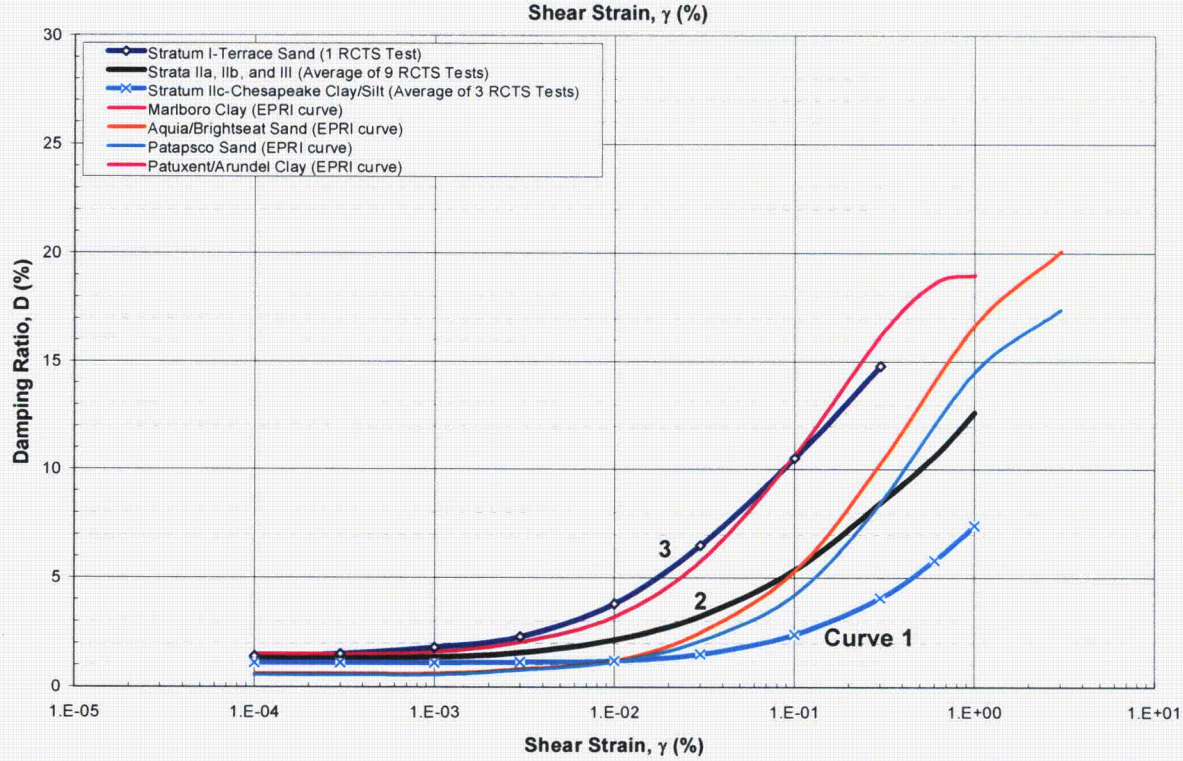


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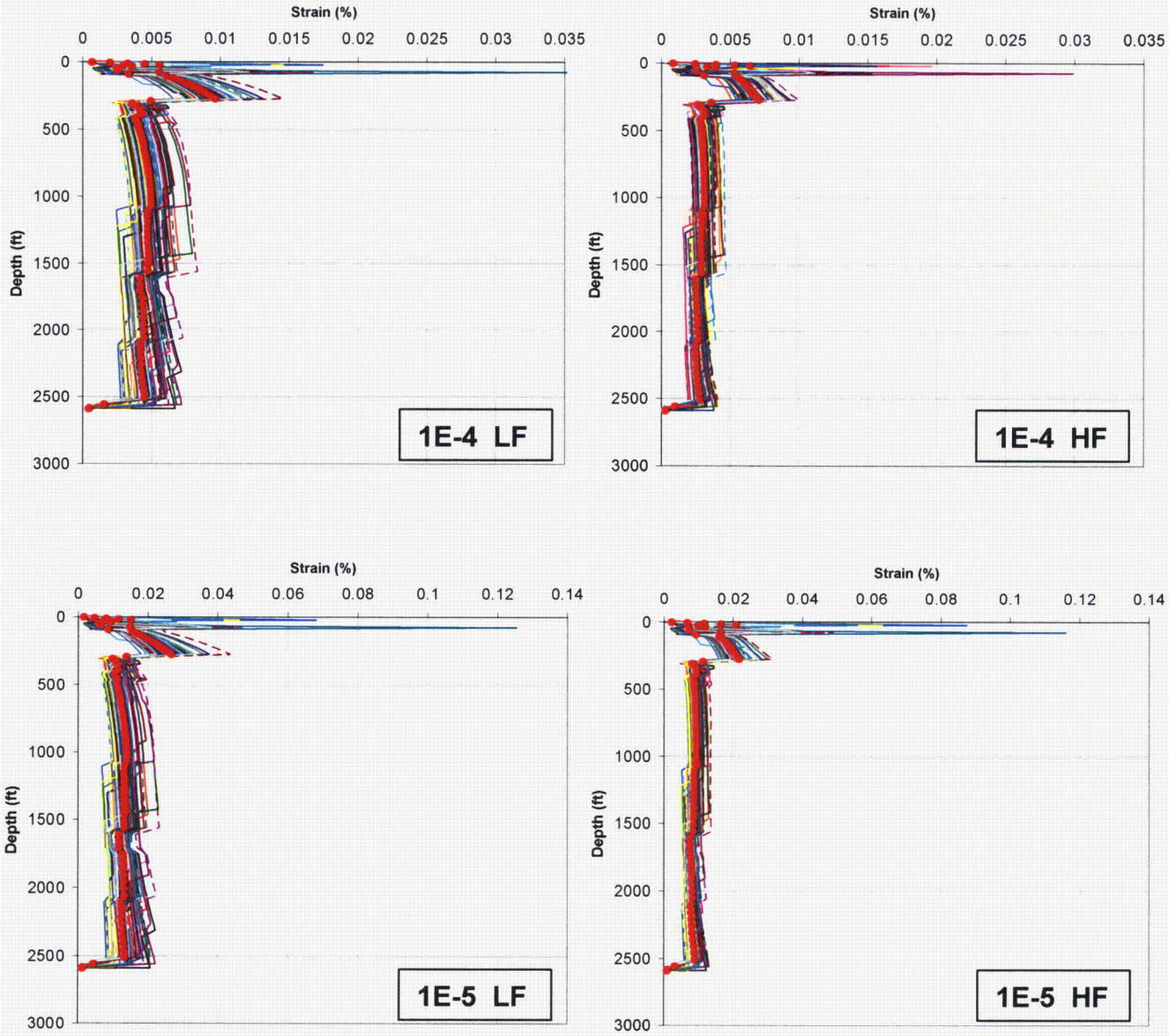
Figure 22. Calculated Maximum Strains Based on Initially Adopted EPRI Curves



Note: Strains shown are maximum, not effective, values.

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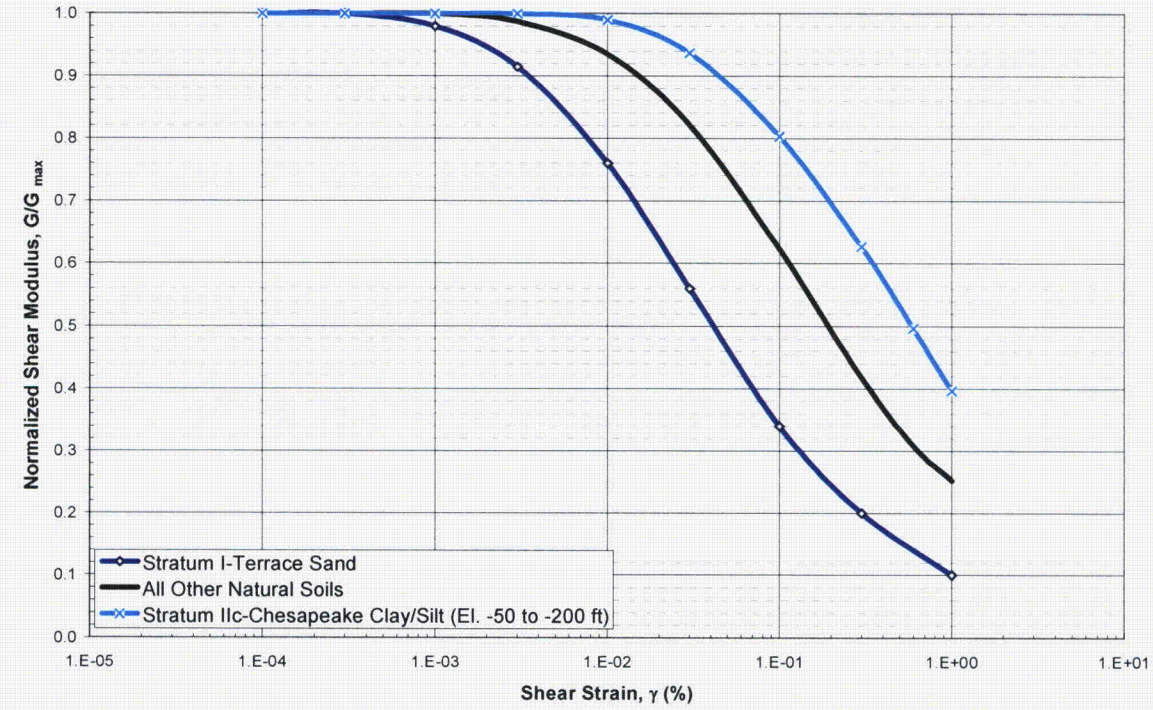
Figure 23. Final Shear Modulus and Damping Ratios for the CCNPP Unit 3 Soils



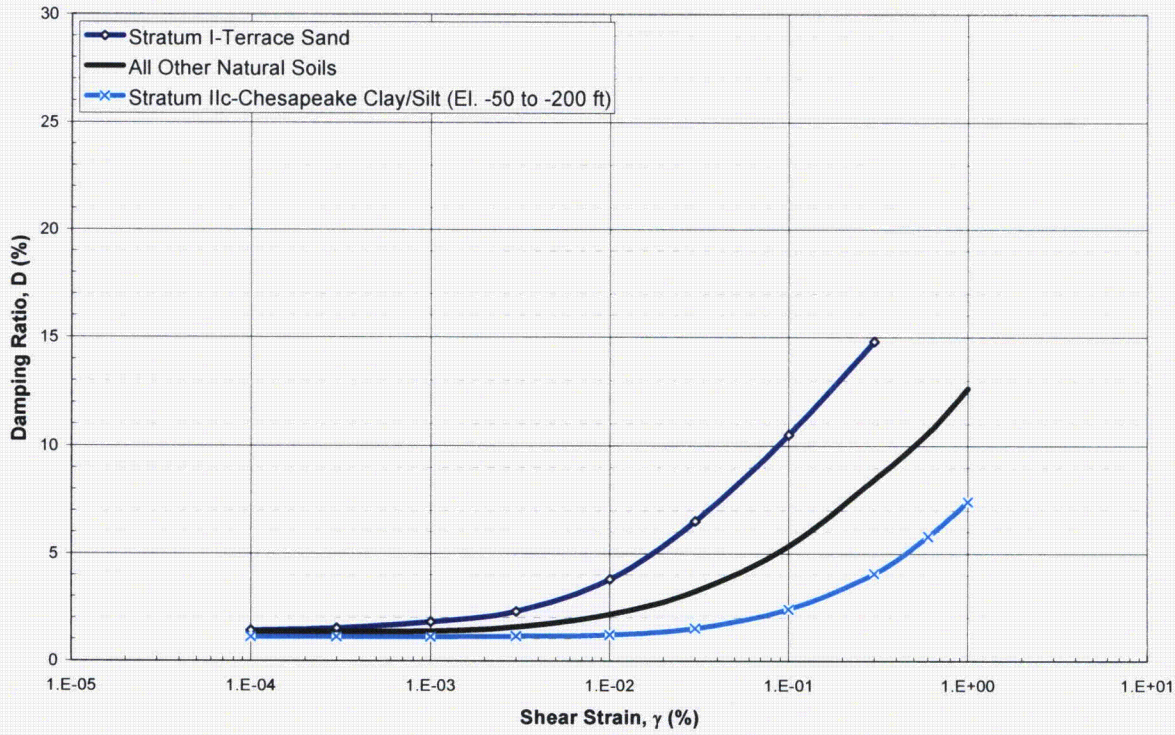


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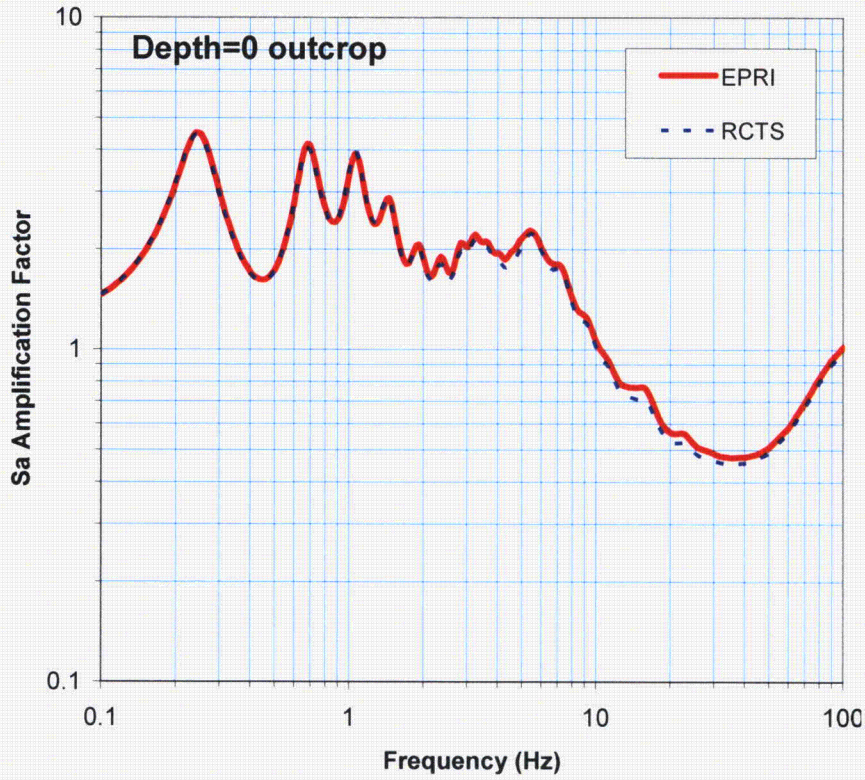
Figure 24. Comparison of Amplification Factors at 1E-4 LF for the CCNPP Unit 3 Soils



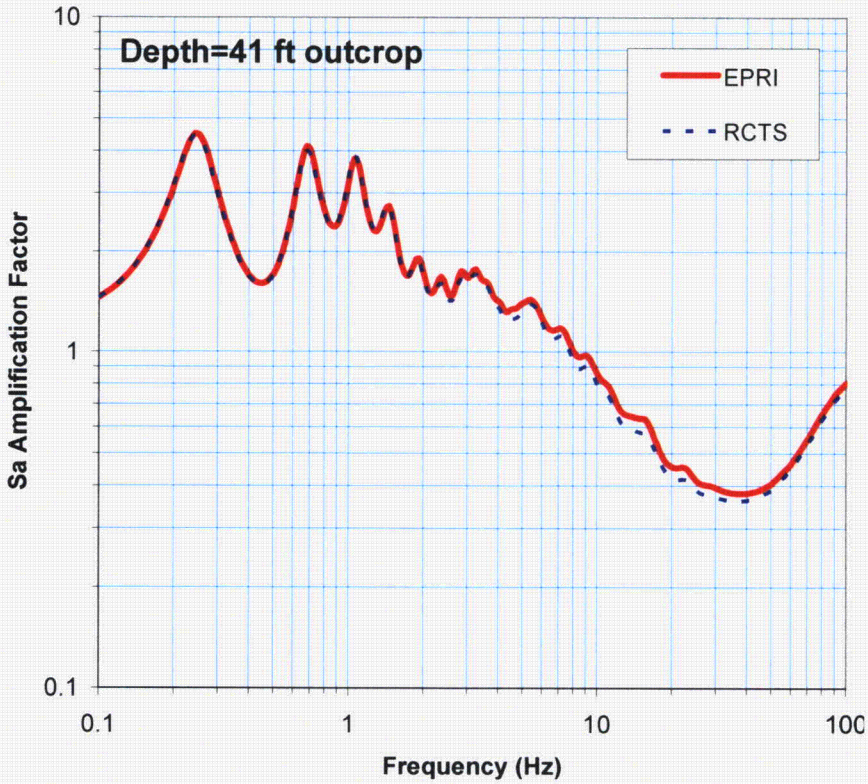


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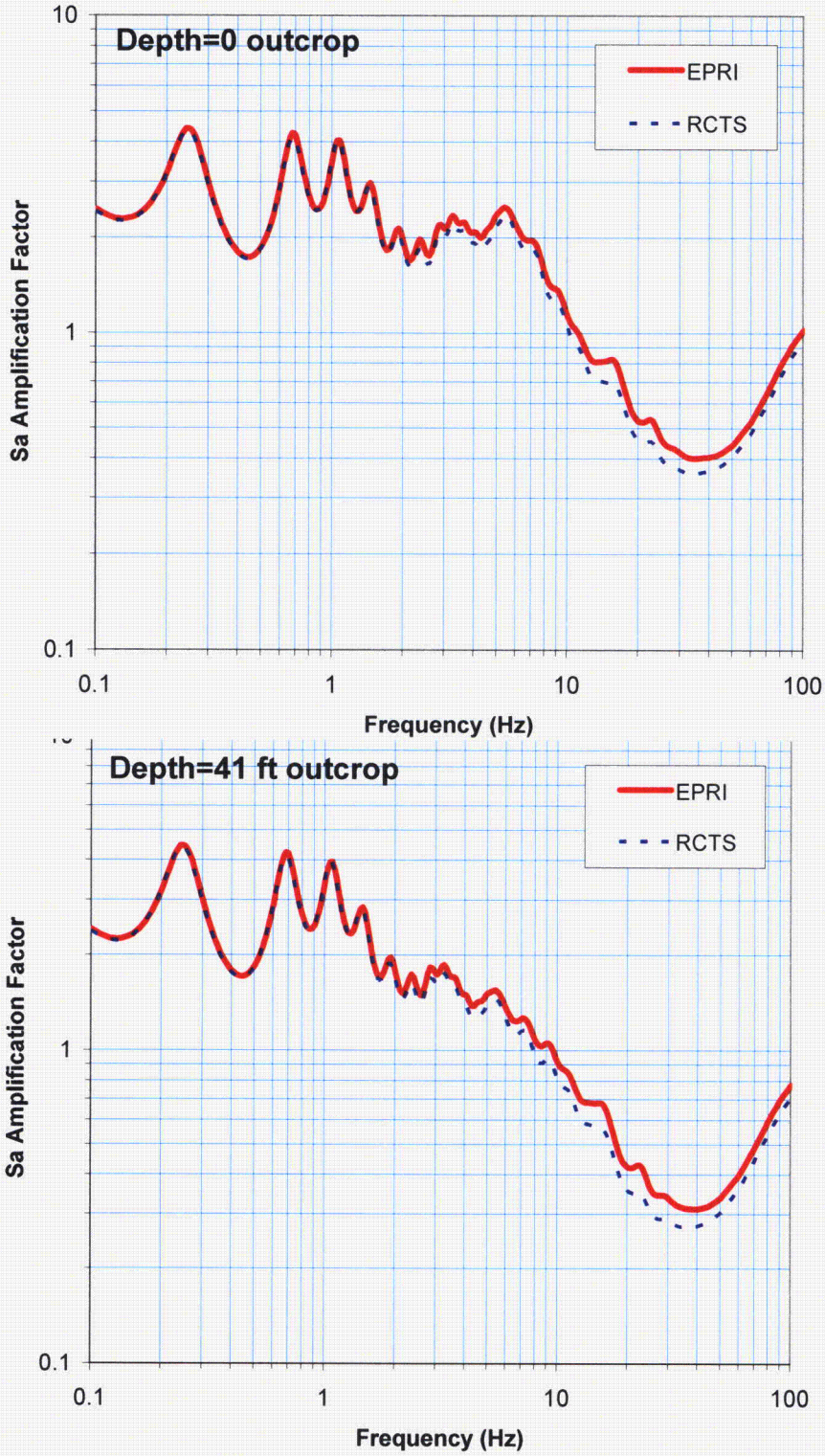
Figure 25. Comparison of Amplification Factors at 1E-4 HF for the CCNPP Unit 3 Soils



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7.1 DESIGN BASIS ACCIDENTS

Design basis accidents (DBAs) are events that are not expected to occur, but are evaluated to demonstrate the adequacy of the plant design since the consequences of their occurrence have the potential for radioactive material to be released to the environment. DBAs having a potential for radiological releases to the environment are identified in Section 7.1, Appendix A of NUREG-1555 (NRC, 1999) and are listed in Table 7.1-1 along with DBAs applicable for the U.S. EPR. The DBAs are based on Chapter 15 of NUREG-0800 (NRC, 2007) and Regulatory Guide 1.183 (NRC, 2000).

Sources of radioactivity are generated within the reactor core. Radioactivity releases are dependent on the specific accident and may be released from the primary coolant, from the secondary coolant, and from the core if the accident involves fuel failures. Design input used in the DBA radiological consequences evaluations for the U.S. EPR follows the Alternative Source Term Methodology outlined in Regulatory Guide 1.183 (NRC, 2000). The design basis primary and secondary coolant source term activity concentrations for the U.S. EPR are provided in Table 7.1-2 and Table 7.1-3, respectively. Table 7.1-4 lists the design basis source term inventories for the core.

Primary and secondary coolant concentrations are based on the proposed U.S. EPR Technical Specification limits for halogens and noble gases, the American National Standards Institute/American Nuclear Society (ANSI/ANS)-18.1 Standard (ANS, 1999) for activation products and tritium, and 0.25% fuel defects for remaining radionuclides. For certain accidents (i.e., Steam System Piping Failures, Feedwater Pipe Break and Steam Generator Tube Rupture), the radiological consequences analyses account for iodine spiking which causes the concentration of various radioactive iodines in the primary coolant to significantly increase to levels described in Table 7.1-2. The iodine appearance rates (i.e., rates at which iodine isotopes are transferred from the core to the primary coolant via assumed fuel cladding defects) used in DBA analyses for the U.S. EPR were based on a conservative Reactor Coolant System letdown purification flow rate. Referring to Table 7.1-3, no secondary coolant noble gas source term is applicable since noble gas leakage from the Reactor Coolant System is assumed to enter the steam phase directly. Design basis core source terms were determined for a power level of 4,612 MWt, which is equivalent to the rated core thermal power of 4,590 MWt plus 22 MWt (approximately 1/2% of rated thermal power) to account for heat balance measurement uncertainty. Core inventories are bounding for U-235 fuel enrichments ranging between two and five percent and burnups up to 62,000 MWd/MTU.

For each of the accident scenarios listed in Table 7.1-1, it is postulated that some quantity of radioactivity is released at the accident location inside a plant building and eventually released into the environment. Radiological consequences of these accidents depend on the type and amount of radioactivity released and meteorological conditions. Potential consequences are assessed to demonstrate that environmental impacts, quantified in doses to individuals at the exclusion area boundary (EAB) distance of 0.5 mi (0.8 km) and the low population zone (LPZ) distance of {1.5 mi (2.4km)}, meet regulatory dose acceptance criteria.

The accident doses are expressed as total effective dose equivalent (TEDE). For each applicable DBA, TEDE/accident doses are calculated based on time-dependent activities released to the environment. Dose receptor variables include the exposure interval, the atmospheric dispersion of the activity during transport from the release point to the EAB and LPZ, the breathing rate of an individual at the EAB and LPZ, and dose conversion factors for the inhalation and external exposure pathways. In accordance with Section C.4.1.5 of Regulatory Guide 1.183 (NRC, 2000), the period of most adverse release of radioactive materials to the

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environment was assumed to occur coincident with the period of most unfavorable atmospheric dispersion. Except for atmospheric dispersion, the other variables are independent of the {Calvert Cliffs Nuclear Power Plant (CCNPP)} site and specific to the U.S. EPR design.

{CCNPP} site-specific atmospheric dispersion characteristics are provided in Section 2.7. To determine {CCNPP} site-specific TEDE doses, TEDE doses for the U.S. EPR were multiplied by the ratio of {CCNPP} site atmospheric dispersion factors to the U.S. EPR atmospheric dispersion factors. Atmospheric dispersion factors are referred to as 'χ/Q'. The accident χ/Q values for the subject site are based on site-specific meteorological data. U.S. EPR accident χ/Q values were derived based on five years of meteorological data. The accident χ/Q values for use in the U.S. EPR DCD are the highest values determined using both Calvert Cliffs and Nine Mile meteorological data. Two runs using different meteorological data were made and the largest χ/Q values for each sector/distance combination were used. The site-specific values for CCNPP Unit 3 used Calvert Cliffs meteorological data. For the EAB and LPZ accident χ/Q values, all compass headings/wind direction sectors were calculated and the maximum χ/Q values were used in accordance with Regulatory Guide 1.145. Therefore, for the dose comparison to determine whether the CCNPP Unit 3 doses are less than the DCD values, it does not matter that different meteorological data were used. For the EAB, the postulated DBA doses and χ/Q values are calculated for a short-term (i.e., 0 to 2 hours). For the LPZ, doses and χ/Q values are calculated for the accident duration (i.e., 0 to 2 hours, 2 to 8 hours, 8 to 24 hours, 1 to 4 days and 4 to 30 days). No credit for building wake was taken for the accident χ /Q values for the EAB and LPZ determined for either the generic U.S. EPR or the site-specific CCNPP Unit 3 χ/Q s. For the generic U.S. EPR and the site-specific CCNPP Unit 3 EAB and LPZ, ground level releases were assumed; therefore, according to Regulatory Guide 1.145, the release point and receptor elevations were assumed to be the same (i.e., no terrain heights were input for the receptors). Since the growing season is taken into account for normal effluent χ/Qs and doses (i.e., not for accident scenarios), annual data were used to generate both sets of accident χ/Q values. Table 7.1-5 contains the 50th percentile {CCNPP} site-specific and U.S. EPR accident χ/Q values at the EAB and LPZ, and the {CCNPP} site to U.S. EPR atmospheric dispersion ratios. For DBAs applicable to the U.S. EPR, the time-dependent, postulated doses at the EAB and LPZ for the subject site are provided in Table 7.1-6 to Table 7.1-13. Table 7.1-14 summarizes the {CCNPP} site-specific TEDE doses and the applicable regulatory TEDE dose acceptance criteria.

As indicated by Table 7.1-5, considering that the χ/Q values for the subject site are bounded by those for the U.S. EPR, {CCNPP} site-specific TEDE doses are bounded by the U.S. EPR TEDE doses. Referring to Table 7.1-14, {CCNPP} site-specific accident doses are below regulatory dose acceptance criteria.

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7.1.1 REFERENCES

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Table 7.1-1 Design Basis Accidents
(Page 1 of 3)

NUREG-1555 DBA Description	U.S. EPR DBA Description	Remarks
Radiological Consequences of Main Steam Line Failures Outside Containment of a PWR	Steam System Piping Failures	Following the guidance provided in Section 15.0.3 of NUREG-0800 and Regulatory Guide 1.183, the limiting accident for the U.S. EPR was determined to be a double-ended guillotine break of a main steam line in one of the Safeguards Buildings.
Feedwater System Pipe Breaks Inside and Outside Containment (PWR)	Feedwater Pipe Break	Using the analytical approach and acceptance criteria described in Section 15.0.3 of NUREG-0800 and Regulatory Guide 1.183 for a Main Steam Line Break, the radiological consequences of a Feedwater Line Break (FWLB) were evaluated. The limiting FWLB accident was determined to be a double-ended guillotine break of a feedwater line to one of the steam generators inside Containment.
Reactor Coolant Pump Rotor Seizure	Reactor Coolant Pump Locked Rotor Accident	For the U.S. EPR, this postulated accident scenario is based on Section 15.0.3 of NUREG-0800 and the Alternate Source Term Methodology in Appendix G of Regulatory Guide 1.183.
Reactor Coolant Pump Shaft Break	Reactor Coolant Pump Shaft Break	This postulated accident scenario is based on Section 15.0.3 of NUREG-0800 and the Alternate Source Term Methodology in Appendix G of Regulatory Guide 1.183. U.S EPR radiological consequences are the same as those for the locked rotor accident.
Radiological Consequences of Control Rod Drop Accident (BWR)	Not Applicable	The U.S. EPR is a pressurized water reactor.

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Table 7.1-1 Design Basis Accidents
(Page 2 of 3)

NUREG-1555 DBA Description	U.S. EPR DBA Description	Remarks
Radiological Consequences of the Failure of Small Lines Carrying Primary Coolant Outside Containment	Failure of Small Lines Carrying Primary Coolant Outside Containment	Based on the guidance in Section 15.6.2 of NUREG-0800, the limiting accident scenario for the U.S. EPR was determined to be a double-ended guillotine break in the Fuel Building.
Radiological Consequences of Steam Generator Tube Failures (PWR)	Steam Generator Tube Rupture	The analysis was based on guidance in Section 15.0.3 of NUREG-0800 and in Regulatory Guide 1.183 and incorporated the clarifications provided in NRC Regulatory Issue Summary 2006-04, Section 9, namely, the inclusion of the alkalis (in addition to the halogens and noble gases). Two alternative accident scenarios were postulated: A Steam Generator Tube Rupture (SGTR) with a pre-accident iodine spike and a SGTR with a concurrent iodine spike.
Radiological Consequences of a Design Basis Loss of Coolant Accident Including Containment Leakage Contribution	Loss of Coolant Accidents resulting from a Spectrum of Postulated Piping Breaks within the Reactor Coolant Pressure Boundary	For the U.S. EPR, a STARDOSE analysis was performed to determine the EAB and LPZ cloud immersion and inhalation doses at the EAB and LPZ for Loss of Coolant Accidents using the Alternate Source Term Methodology.
Radiological Consequences of a Design Basis Loss of Coolant Accident: Leakage from Engineered Safety Feature Components Outside Containment	Loss of Coolant Accidents resulting from a Spectrum of Postulated Piping Breaks within the Reactor Coolant Pressure Boundary	For the U.S. EPR, a STARDOSE analysis was performed to determine the EAB and LPZ cloud immersion and inhalation doses at the EAB and LPZ for Loss of Coolant Accidents using the Alternate Source Term Methodology.
Radiological Consequences of a Design Basis Loss of Coolant Accident: Leakage from Main Steam Isolation Valve Leakage Control System (BWR)	Not Applicable	The U.S. EPR is a pressurized water reactor.

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Table 7.1-1 Design Basis Accidents
(Page 3 of 3)

NUREG-1555 DBA Description	U.S. EPR DBA Description	Remarks
Radiological Consequences of Fuel Handling Accidents	Fuel Handling Accident	The postulated accident scenario followed the guidance in Section 15.0.3 of NUREG-0800 and in Regulatory Guide 1.183, and was postulated to occur in either an open Containment or in the Fuel Building.
Not Applicable	Rod Ejection Accident	The analysis was based on the guidance in Section 15.0.3 of NUREG-0800 and in Regulatory Guide 1.183. The recent NRC concern regarding the fission-product gap inventory for reactivity-induced accidents and the interim acceptance criteria and guidance, were also considered.

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Table 7.1-2 U.S. EPR Design Basis Primary Coolant Activity[a, b]
(Page 1 of 3)

Radionuclide	Activity µCi/gm (Bq/gm)	Radionuclide	Activity µCi/gm (Bq/gm)
Noble Gases		**Tellurium Group**	
Kr-83m	1.28E-01 (4.74E+03)	Sb-125	1.56E-06 (5.77E-02)
Kr-85m	5.71E-01 (2.11E+04)	Sb-127	6.99E-06 (2.59E-01)
Kr-85	5.31E+00 (1.96E+05)	Sb-129	8.53E-06 (3.16E-01)
Kr-87	3.26E-01 (1.21E+04)	Te-127m	6.19E-04 (2.29E+01)
Kr-88	1.03 E+00 (3.81E+04)	Te-127	3.05E-03 (1.13E+02)
Kr-89	2.42E-02 (8.95E+02)	Te-129m	1.79E-03 (6.62E+01)
Xe-131m	1.08E+00 (4.00E+04)	Te-129	3.00E-03 (1.11E+02)
Xe-133m	1.35E+00 (5.00E+04)	Te-131m	4.36E-03 (1.61E+02)
Xe-133	9.47E+01 (3.50E+06)	Te-131	3.01E-03 (1.11E+02)
Xe-135m	1.95E-01 (7.22E+03)	Te-132	4.70E-02 (1.74E+03)
Xe-135	3.40E+00 (1.26E+05)	Te-134	6.80E-03 2.52E+02)
Xe-137	4.57E-02 (1.69E+03)	**Barium/Strontium Group**	
Xe-138	1.64E-01 (6.07E+03)	Sr-89	6.35E-04 (2.35E+01)
Halogens		Sr-90	4.32E-05 (1.60E+00)
Br-83	3.16E-02 (1.17E+03)	Sr-91	1.02E-03 (3.77E+01)
Br-84	1.67E-02 (6.18E+02)	Sr-92	1.73E-04 (6.40E+00)
Br-85	2.01E-03 (7.44E+01)	Ba-137m	1.50E-01 (5.55E+03)
I-129	4.59E-08 (1.70E-03)	Ba-139	2.30E-02 (8.51E+02)
I-130	4.97E-02 (1.84E+03)	Ba-140	6.74E-04 (2.49E+01)

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Table 7.1-2 U.S. EPR Design Basis Primary Coolant Activity[a, b]
(Page 2 of 3)

Radionuclide	Activity µCi/gm (Bq/gm)	Radionuclide	Activity µCi/gm (Bq/gm)
I-131	7.43E-01 (2.75E+04)	**Noble Metals**	
I-132	3.71E-01 (1.37E+04)	Mo-99	1.21E-01 (4.48E+03)
I-133	1.25E+00 (4.63E+04)	Tc-99m	5.24E-02 (1.94E+03)
I-134	2.40E-01 (8.88E+03)	Ru-103	1.00E-04 (3.70E+00)
I-135	7.90E-01 (2.92E+04)	Ru-105	1.47E-04 (5.44E+00)
Alkalis		Ru-106	5.83E-05 (2.16E+00)
Rb-86m	5.32E-07 (1.97E-02)	Rh-103m	8.85E-05 (3.27E+00)
Rb-86	3.66E-03 (1.35E+02)	Rh-105	6.62E-05 (2.45E+00)
Rb-88	1.02E+00 (3.77E+04)	Rh-106	5.84E-05 (2.16E+00)
Rb-89	4.72E-02 (1.75E+03)	**Cerium Group**	
Cs-134	4.18E-01 (1.55E+04)	Ce-141	9.12E-05 (3.37E+00)
Cs-136	1.00E-01 (3.70E+03)	Ce-143	7.96E-05 (2.95E+00)
Cs-137	1.60E-01 (5.92E+03)	Ce-144	6.93E-05 (2.56E+00)
Cs-138	2.35E-01 (8.07E+03)	Pu-238	5.97E-07 (2.21E-02)
Cerium Group (cont'd)		**Lanthanides** (cont'd)	
Pu-239	2.51E-08 (9.29E-04)	Cm--242	5.35E-06 (1.98E-01)
Pu-240	5.72E-08 (2.12E-03)	Cm--244	2.83E-06 (1.05E-01)
Pu-241	1.03E-05 (3.81E-01)	**Activation Products**	
Np-239	1.41E-03 (5.22E+01)	Na-24	3.7E-02 (1.37E+03)
Lanthanides		Cr-51	2.0E-03 (7.40E+01)
Y-90	1.03E-05 (3.81E-01)	Mn-54	1.0E-03 (3.70E+01)
Y-91m	5.23E-04 (1.94E+01)	Fe-55	7.6E-04 (2.81E+01)

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Table 7.1-2 U.S. EPR Design Basis Primary Coolant Activity[a, b]
(Page 3 of 3)

Radionuclide	Activity µCi/gm (Bq/gm)	Radionuclide	Activity µCi/gm (Bq/gm)
Y-91	8.10E-05 (3.00E+00)	Fe-59	1.9E-04 (7.03E+00)
Y-92	1.41E-04 (5.22E+00)	Co-58	2.9E-03 (1.07E+02)
Y-93	6.50E-05 (2.41E+00)	Co-60	3.4E-04 (1.26E+01)
Zr-95	9.31E-05 (3.44E+00)	Zn-65	3.2E-04 (1.18E+01)
Zr-97	7.37E-05 (2.73E+00)	W-187	1.8E-03 (6.66E+01)
Nb-95	9.35E-05 (3.46E+00)	**Tritium**	
Ag-110m	9.87E-07 (3.65E-02)	H-3	1.0E+00 (3.70E+04)
Ag-110	4.72E-08 (1.75E-03)		
La-140	1.76E-04 (6.51E+00)		
La-141	5.77E-05 (2.13E+00)		
La-142	3.38E-05 (1.25E+00)		
Pr-143	9.20E-05 (3.40E+00)		
Pr-144	6.94E-05 (2.57E+00)		
Nd-147	3.77E-05 (1.39E+00)		
Am-241	1.18E-08 (4.37E-04)		

Key:
µCi/gm – microcuries per gram
Bq/gm – Becquerels per gram

Notes:

(a) This table lists the design basis source term activity and the magnitude of source terms for offsite releases for the U.S. EPR primary coolant.

(b) Following an accident, iodine spiking causes the concentration of radioactive iodines I-131 through I-135 to significantly increase.

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Table 7.1-3 U.S. EPR Design Basis Secondary Coolant Activity[a,b] (Page 1 of 2)

Radionuclide	Activity µCi/gm (Bq/gm)	Radionuclide	Activity µCi/gm (Bq/gm)
Halogens		**Barium/Strontium Group** (cont'd)	
Br-83	1.61E-03 (5.96E+01)	Sr-90	4.81E-08 (1.78E-03)
Br-84	3.05E-04 (1.13E+01)	Sr-91	9.01E-07 (3.33E-02)
Br-85	3.93E-06 (1.45E-01)	Sr-92	1.00E-07 (3.70E-03)
I-129	4.81E-09 (1.78E-04)	Ba-137m	3.01E-04 (1.11E+01)
I-130	4.33E-03 (1.60E+02)	Ba-139	1.03E-05 (3.81E-01)
I-131	7.67E-02 (2.84E+03)	Ba-140	7.45E-07 (2.76E-02)
I-132	2.27E-02 (8.40E+02)	**Noble Metals**	
I-133	1.17E-01 (4.33E+03)	Mo-99	1.30E-04 (4.81E+00)
I-134	6.68E-03 (2.47E+02)	Tc-99m	7.47E-05 (2.76E+00)
I-135	5.99E-02 (2.22E+03)	Ru-103	1.11E-07 (4.11E-03)
Alkalis		Ru-105	1.09E-07 (4.03E-03)
Rb-86m	3.99E-12 (1.48E-07)	Ru-106	6.49E-08 (2.40E-03)
Rb-86	7.27E-06 (2.69E-01)	Rh-103m	9.97E-08 (3.69E-03)
Rb-88	1.26E-04 (4.66E+00)	Rh-105	7.58E-08 (2.80E-03)
Rb-89	5.02E-06 (1.86E-01)	Rh-106	6.49E-08 (2.40E-03)
Cs-134	8.38E-04 (3.10E+01)	**Cerium Group**	
Cs-136	1.98E-04 (7.33E+00)	Ce-141	1.01E-07 (3.74E-03)
Cs-137	3.21E-04 (1.19E+01)	Ce-143	8.24E-08 (3.05E-03)
Cs-138	5.00E-05 (1.85E+00)	Ce-144	7.72E-08 (2.86E-03)
Tellurium Group		Pu-238	6.65E-10 (2.46E-05)
Sb-125	1.74E-09 (6.44E-05)	Pu-239	2.80E-11 (1.04E-06)
Sb-127	7.60E-09 (2.81E-04)	Pu-240	6.37E-11 (2.36E-06)
Sb-129	6.01E-09 (2.22E-04)	Pu-241	1.15E-08 (4.26E-04)
Te-127m	6.89E-07 (2.55E-02)	Np-239	1.50E-06 (5.55E-02)
Te-127	2.82E-06 (1.04E-01)	**Lanthanides**	
Te-129m	1.99E-06 (7.36E-02)	Y-90	1.29E-08 (4.77E-04)
Te-129	1.94E-06 (7.18E-02)	Y-91m	5.38E-07 (1.99E-02)
Te-131m	4.48E-06 (1.66E-01)	Y-91	9.17E-08 (3.39E-03)
Te-131	1.33E-06 (4.92E-02)	Y-92	1.33E-07 (4.92E-03)
Te-132	5.07E-05 (1.88E+00)	Y-93	5.81E-08 (2.15E-03)
Te-134	1.64E-06 (6.07E+00)	Zr-95	1.04E-07 (3.85E-03)

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Table 7.1-3 U.S. EPR Design Basis Secondary Coolant Activity[a, b]
(Page 2 of 2)

Radionuclide	Activity µCi/gm (Bq/gm)	Radionuclide	Activity µCi/gm (Bq/gm)
Barium/Strontium Group		Zr-97	7.15E-08 (2.65E-03)
Sr-89	7.16E-07 (2.64E-02)	Nb-95	1.04E-07 (3.85E-03)
Lanthanides (cont'd)		**Activation Products**	
Ag-110m	1.10E-09 (4.07E-05)	Na-24	3.53E-05 (1.31E+00)
Ag-110	1.47E-11 (5.44E-07)	Cr-51	2.22E-06 (8.21E-02)
La-140	2.28E-07 (8.44E-03)	Mn-54	1.11E-06 (4.11E-02)
La-141	4.06E-08 (1.50E-03)	Fe-55	8.47E-07 (3.13E-02)
La-142	1.51E-08 (5.59E-04)	Fe-59	2.11E-07 (7.81E-03)
Pr-143	1.02E-07 (3.77E-03)	Co-58	3.23E-06 (1.20E-01)
Pr-144	7.72E-08 (2.86E-03)	Co-60	3.79E-07 (1.40E-02)
Nd-147	4.16E-08 (1.54E-03)	Zn-65	3.56E-07 (1.32E-02)
Am-241	1.32E-11 (4.88E-07)	W-187	1.81E-06 (6.70E-02)
Cm-242	5.96E-09 (2.21E-04)	**Tritium**	
Cm-244	3.15E-09 (1.17E-04)	H-3	1.0E-03 (3.70E+01)

Key:
µCi/gm – microcuries per gram
Bq/gm – Becquerels per gram

Notes:

(a) This table lists the design basis source term activity and the magnitude of source terms for offsite releases for the U.S. EPR secondary coolant.

(b) Noble gases are not applicable since they are assumed to enter the steam phase.

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Table 7.1-4 U.S. EPR Bounding Core Inventory[a,b,c]
(Page 1 of 2)

Radionuclide	Inventory Ci (Bq)	Radionuclide	Inventory Ci (Bq)
Noble Gases		**Tellurium Group**	
Kr-83m	1.96E+07 (7.25E+17)	Sb-125	3.83E+06 (1.42E+17)
Kr-85m	4.50E+07 (1.67E+18)	Sb-127	1.80E+07 (6.66E+17)
Kr-85	2.10E+06 (7.77E+16)	Sb-129	4.85E+07 (1.79E+18)
Kr-87	9.02E+07 (3.34E+18)	Te-127m	2.43E+06 (8.99E+16)
Kr-88	1.28E+08 4.74E+18)	Te-127	1.79E+07 (6.62E+17)
Kr-89	1.61E+08 (5.96E+18)	Te-129m	7.08E+06 (2.62E+17)
Xe-131m	1.54E+06 (5.70E+16)	Te-129	4.78E+07 (1.77E+18)
Xe-133m	8.92E+06 (3.30E+17)	Te-131m	2.04E+07 (7.55E+17)
Xe-133	2.89E+08 (1.07E+19)	Te-131	1.24E+08 (4.59E+18)
Xe-135m	5.49E+07 (2.03E+18)	Te-132	1.98E+08 (7.33E+18)
Xe-135	9.26E+07 (3.43E+18)	Te-134	2.50E+08 (9.25E+18)
Xe-137	2.52E+08 (9,32E+18)	**Barium/Strontium Group**	
Xe-138	2.45E+08 (9.07E+18)	Sr-89	1.61E+08 (5.96E+18)
Halogens		Sr-90	1.69E+07 (6.25E+17)
Br-83	1.96E+07 (7.25E+17)	Sr-91	2.07E+08 (7.66E+18)
Br-84	3.62E+07 (1.34E+18)	Sr-92	2.14E+08 (7.92E+18)
Br-85	4.45E+07 (1.65E+18)	Ba-137m	2.34E+07 (8.66E+17)
I-129	8.33E+00 (3.08E+11)	Ba-139	2.62E+08 (9.69E+18)
I-130	1.32E+07 (4.88E+17)	Ba-140	2.52E+08 (9.32E+18)
I-131	1.39E+08 (5.14E+18)	**Noble Metals**	
I-132	2.01E+08 (7.44E+18)	Mo-99	2.59E+08 9.58E+18)
I-133	2.90E+08 (1.07E+19)	Tc-99m	2.27E+08 (8.40E+18)
I-134	3.18E+08 (1.18E+19)	Ru-103	2.42E+08 (8.95E+18)
I-135	2.69E+08 (9.95E+18)	Ru-105	1.96E+08 (7.25E+18)
Alkalis		Ru-106	1.43E+08 (5.29E+18)
Rb-86m	5.53E+04 (2.05E+15)	Rh-103m	2.18E+08 (8.07E+18)
Rb-86	5.80E+05 (2.15E+16)	Rh-105	1.75E+08 (6.48E+18)
Rb-88	1.29E+08 (4.77E+18)	Rh-106	1.58E+08 (5.85E+18)
Rb-89	1.67E+08 (6.18E+18)	**Cerium Group**	
Cs-134	6.48E+07 (2.40E+18)	Ce-141	2.24E+08 (8.29E+18)
Cs-136	1.61E+07 (5.96E+17)	Ce-143	2.28E+08 (8.44E+18)
Cs-137	2.47E+07 (9.14E+17)	Ce-144	1.70E+08 (6.29E+18)

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Table 7.1-4 U.S. EPR Bounding Core Inventory[a, b,c]
(Page 2 of 2)

Radionuclide	Inventory Ci (Bq)	Radionuclide	Inventory Ci (Bq)
Cerium Group (cont'd)		**Lanthanides** (cont'd)	
Cs-138	2.69E+08 (9.95E+18)	Pu-238	1.46E+06 (5.40E+16)
Pu-239	6.14E+04 (2.27E+15)	Ag-110m	2.42E+06 (8.95E+16)
Pu-240	1.40E+05 (5.18E+15)	Ag-110	7.15E+07 (2.65E+18)
Pu-241	2.53E+07 (9.36E+17)	La-140	2.54E+08 (9.40E+18)
Np-239	3.82E+09 (1.41E+20)	La-141	2.41E+08 (8.92E+18)
Lanthanides		La-142	2.35E+08 (8.70E+18)
Y-90	1.79E+07 (6.62E+17)	Pr-143	2.26E+08 (8.36E+18)
Y-91m	1.20E+08 (4.44E+18)	Pr-144	1.72E+08 (6.36E+18)
Y-91	1.96E+08 (7.25E+18)	Nd-147	9.44E+07 (3.49E+18)
Y-92	2.14E+08 (7.92E+18)	Am-241	2.88E+04 (1.07E+15)
Y-93	2.34E+08 (8.66E+18)	Cm-242	1.31E+07 (4.85E+17)
Zr-95	2.29E+08 (8.47E+18)	Cm-244	6.94E+06 (2.57E+17)
Zr-97	2.43E+08 (8.99E+18)		
Nb-95	2.29E+08 (8.47E+18)		

Key:
Ci – curies
Bq - Becquerels

Notes:

(a) This table lists the design basis source term inventories for radiological consequences for the U.S. EPR core.

(b) Core inventories are bounding for U-235 fuel enrichment ranging between 2% and 5% and burnups up to 62,000 MWd/MTU.

(c) The design basis power level is 4,612 MWt.

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Table 7.1-5 {CCNPP} Site and U.S. EPR Atmospheric Dispersion Factors (Page 1 of 1)

Location	Time Period[c] (hours)	50th Percentile {CCNPP} Site χ/Q[a] (sec/m^3)	U.S. EPR Accident χ/Q[b] (sec/m^3)	χ/Q Ratio CCNPP Site / U.S. EPR
EAB 0.5 mi (0.80 km)	0 to 2	{8.035E-05}	1.00E-03	{8.04E-02}
LPZ {1.5 mi (2.4 km)}	0 to 2	{1.542E-05}	1.75E-04	{8.80E-02}
	2 to 8	{1.183E-05}	1.35E-04	{8.76E-02}
	8 to 24	{9.337E-06}	1.00E-04	{9.34E-02}
	24 to 96	{6.496E-06}	5.40E-05	{1.20E-01}
	96 to 720	{3.858E-06}	2.20E-05	{1.75E-01[c]}

Key:

χ/Q – atmospheric dispersion factor

sec/m^3 – seconds per cubic meter

Notes:

(a) For the 50th percentile χ/Q values, refer to Section 2.7.

(b) The indicated U.S. EPR χ/Q values are those used in the accident radiological evaluations.

(c) Bounding value used for the entire 720 hours (i.e., 30 day) interval for LOCA. At the LPZ, the worst χ/Q ratio at the end of the accident release applies.

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Table 7.1-6 Steam System Piping Failure
(Page 1 of 1)

Location	Time Period (hours)	U.S. EPR TEDE Dose[a] (rem / Sieverts)	χ/Q Ratio[b] (Site / U.S. EPR)	{CCNPP} Site TEDE Dose[c] (rem / Sieverts)
Pre-accident Iodine Spike				
EAB	0 to 2	2.40E-01 / 2.40E-03	{8.04E-02}	{1.93E-02/1.93E-04}
LPZ	0 to 9	6.00E-02 / 6.00E-04	{9.34E-02}	{5.60E-03/5.60E-05}
Concurrent Iodine Spike				
EAB	0 to 2	2.70E-01 / 2.70E-03	{8.04E-02}	{2.17E-02/2.17E-04}
LPZ	0 to 9	2.00E-01 / 2.00E-03	{9.34E-02}	{1.87E-02/1.87E-04}
3.3% Fuel-Rod Clad Failure				
EAB	0 to 2	5.30E+00 / 5.30E-02	{8.04E-02}	{4.26E-01/4.26E-03}
LPZ	0 to 9	2.60E+00 / 2.60E-02	{9.34E-02}	{2.43E-01/2.43E-03}
0.58% Full-Rod Fuel Melt				
EAB	0 to 2	5.80E+00 / 5.80E-02	{8.04E-02}	{4.66E-01/4.66E-03}
LPZ	0 to 9	2.80E+00 / 2.80E-02	{9.34E-02}	{2.62E-01/2.62E-03}

Key:
χ/Q – atmospheric dispersion factor
TEDE – Total effective dose equivalent

Notes:

(a) Doses for the U.S. EPR at the EAB were calculated for a 2 hour period. Doses at the LPZ were calculated for the duration of the releases (i.e., 9 hours).

(b) Obtained from Table 7.1-5.

(c) Per Regulatory Guide 1.183 (Table 6) the regulatory TEDE dose acceptance criteria for this accident is 25 rems (0.25 Sieverts) for the pre-accident iodine spike, fuel-rod clad failure and full-rod fuel melt and 2.5 rems (0.025 Sieverts) for the concurrent iodine spike.

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Table 7.1-7 Feedwater System Line Break
(Page 1 of 1)

Location	Time Period (hours)	U.S. EPR TEDE Dose[a] (rem / Sieverts)	χ/Q Ratio[b] (Site / U.S. EPR)	{CCNPP} Site TEDE Dose[c] (rem / Sieverts)
Coolant Concentrations at TS Limits				
EAB	0 to 2	2.90E-01 / 2.90E-03	{8.04E-02}	{2.33E-02/2.33E-04}
LPZ	0 to 8	5.00E-02 / 5.00E-04	{8.80E-02}	{4.40E-03/4.40E-05}
Pre-accident Iodine Spike				
EAB	0 to 2	4.10E-01/ 4.10E-03	{8.04E-02}	{3.30E-02/3.30E-04}
LPZ	0 to 8	7.00E-02 / 7.00E-04	{8.80E-02}	{6.16E-03/6.16E-05}
Concurrent Iodine Spike				
EAB	0 to 2	5.00E-01 / 5.00E-03	{8.04E-02}	{4.02E-02/4.02E-04}
LPZ	0 to 8	9.00E-02 / 9.00E-04	{8.80E-02}	{7.92E-03/7.92E-05}
4.4% Fuel-Rod Clad Failure				
EAB	0 to 2	1.57E+01 / 1.57E-01	{8.04E-02}	{1.26E+00/1.26E-02}
LPZ	0 to 8	2.90E+00 / 2.90E-02	{8.80E-02}	{2.55E-01/2.55E-03}
0.76% Full-Rod Fuel Melt				
EAB	0 to 2	1.61E+01 / 1.61E-01	{8.04E-02}	{1.29E+00/1.29E-02}
LPZ	0 to 8	3.10E+00 / 3.10E-02	{8.80E-02}	{2.73E-01/2.73E-03}

Key:
X/Q – atmospheric dispersion factor
TEDE – Total effective dose equivalent
TS – U.S. EPR Standard Technical Specifications

Notes:
(a) Doses for the U.S. EPR at the EAB were calculated for a 2 hour period. At the LPZ, the doses were calculated for an 8 hour release of primary coolant activity.
(b) Obtained from Table 7.1-5.
(c) Per Regulatory Guide 1.183 (Table 6), the regulatory TEDE dose acceptance criteria for this accident is 25 rems (0.25 Sieverts) for the pre-accident iodine spike, fuel-rod clad failure and full-rod fuel melt and 2.5 rems (0.025 Sieverts) for the coolant concentrations at TS limits and concurrent iodine spike.

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Table 7.1-8 Reactor Coolant Pump Locked Rotor Accident / Broken Shaft (Page 1 of 1)

Location	Time Period (hours)	U.S. EPR TEDE Dose[a] (rem / Sieverts)	χ/Q Ratio[b] (Site / U.S. EPR)	{CCNPP} Site TEDE Dose[c,d] (rem / Sieverts)
EAB	0 to 2	2.25E+00 / 2.25E-02	{8.04E-02}	{1.81E-01/1.81E-03}
LPZ	0 to 8	8.70E-01/ 8.70E-03	{8.80E-02}	{7.66E-02/7.66E-04}

Key:
χ/Q – atmospheric dispersion factor
TEDE – Total effective dose equivalent

Notes:

(a) Doses for the U.S. EPR at the EAB were calculated for a 2 hour period starting at t=0 hours (i.e., the assumed time at which releases to the atmosphere commence). At the LPZ, the doses were calculated for 8 hours.

(b) Obtained from Table 7.1-5.

(c) Per Regulatory Guide 1.183 (Table 6), the regulatory TEDE dose acceptance criterion for this accident is 2.5 rem (0.025 Sieverts).

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Table 7.1-9 Failure of Small Lines Carrying Primary Coolant Outside Containment (Page 1 of 1)

Location	Time Period (hours)	U.S. EPR TEDE Dose[a] (rem / Sieverts)	χ/Q Ratio[b] (Site / U.S. EPR)	{CCNPP} Site TEDE Dose[c] (rem / Sieverts)
Nuclear Sampling System Line Break (1/4 inch line)				
EAB	0 to 0.5	1.80E+00 / 1.80E-02	{8.04E-02}	{1.45E-01/1.45E-03}
LPZ	0 to 0.5	3.16E-01 / 3.16E-03	{8.80E-02}	{2.78E-02/2.78E-04}
Chemical and Volume Control System Line Break (6 inch line)				
EAB	0 to 0.5	7.15E-02 / 7.15E-04	{8.04E-02}	{5.75E-03/5.75E-05}
LPZ	0 to 0.5	1.25E-02 / 1.25E-04	{8.80E-02}	{1.10E-03/1.10E-05}

Key:
χ/Q – atmospheric dispersion factor
TEDE – Total effective dose equivalent

Notes:

(a) Doses for the U.S. EPR at the EAB and LPZ are for the accident duration of 0.5 hour.

(b) Obtained from Table 7.1-5.

(c) Per NUREG-0800 (Section 15.6.2, II) the regulatory TEDE dose acceptance criterion for this accident is 2.5 rem (0.25 Sieverts).

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Table 7.1-10 Steam Generator Tube Rupture
(Page 1 of 1)

Location	Time Period (hours)	U.S. EPR TEDE Dose[a] (rem / Sieverts)	χ/Q Ratio[b] (Site / U.S. EPR)	CCNPP Site TEDE Dose[c] (rem / Sieverts)
Pre-Accident Iodine Spike				
EAB	0 to 2	2.51E+00 / 2.51E-02	{8.04E-02}	{2.02E-01/2.02E-03}
LPZ	0 to 8	6.20E-01 / 6.20E-03	{8.80E-02}	{5.46E-02/5.46E-04}
Concurrent Iodine Spike				
EAB	0 to 2	2.39E+00 /2.39E-02	{8.04E-02}	{1.92E-01/1.92E-03}
LPZ	0 to 8	1.06E+00 / 1.06E-02	{8.80E-02}	{9.33E-02/9.33E-04}

Key:
χ/Q – atmospheric dispersion factor
TEDE – Total effective dose equivalent

Notes:

(a) Doses for the U.S. EPR at the EAB and LPZ are for the accident duration of 8 hours.

(b) Obtained from Table 7.1-5.

(c) The regulatory TEDE limits are 25 rem (0.25 Sieverts) and 2.5 rem (0.025 Sieverts) for the pre-accident iodine spike and 8 hour concurrent iodine spike, respectively.

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Table 7.1-11 Loss of Coolant Accident
(Page 1 of 1)

Location	Time Period (hours)	U.S. EPR TEDE Dose[a] (rem / Sieverts)	χ/Q Ratio[b] (Site / U.S. EPR)	{CCNPP} Site TEDE Dose[c] (rem / Sieverts)
EAB	0 to 2	1.37E+01 / 1.37E-01	{8.04E-02}	{1.10E+00/1.10E-02}
LPZ	0 to 720	2.14E+01 / 2.14E-01	{1.75E-01}	{3.75E+00/3.75E-02}

Key:
χ/Q – atmospheric dispersion factor
TEDE – Total effective dose equivalent

Notes:

(a) Doses for the U.S. EPR at the EAB are for the worst two-hour period (i.e., 1.5 to 3.5 hours) and those at the LPZ are for 30 days (i.e., 720 hours).

(b) Obtained from Table 7.1-5.

(c) The regulatory TEDE limit is 25 rem (0.25 Sieverts).

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Table 7.1-12 Fuel Handling Accident
(Page 1 of 1)

Location	Time Period (hours)	U.S. EPR TEDE Dose[a] (rem / Sieverts)	χ/Q Ratio[b] (Site / U.S. EPR)	{CCNPP} Site TEDE Dose[c] (rem / Sieverts)
EAB	0 to 2	5.62E+00 / 5.62E-02	{8.04E-02}	{4.52E-01/4.52E-03}
LPZ	0 to 2	1.04E+00 / 1.04E-02	{8.80E-02}	{9.15E-02/9.15E-04}

Key:
χ/Q – atmospheric dispersion factor
TEDE – Total effective dose equivalent

Notes:

(a) Doses for the U.S. EPR at the EAB and LPZ are for an accident scenario where the release of all activity from the Reactor Building or the Fuel Building occurs within a 2 hour interval.

(b) Obtained from Table 7.1-5.

(c) The regulatory TEDE limit is 6.3 rem (0.063 Sieverts).

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Table 7.1-13 Rod Ejection Accident
(Page 1 of 1)

Location	Time Period (hours)	U.S. EPR TEDE Dose[a] (rem / Sieverts)	χ/Q Ratio[b] (Site / U.S. EPR)	{CCNPP} Site TEDE Dose[c] (rem / Sieverts)
EAB	0 to 2	5.67E+00 / 5.67E-02	{8.04E-02}	{4.56E-01/4.56E-03}
LPZ	0 to 8	3.25E+00 / 3.25E-02	{8.80E-02}	{2.86E-01/2.86E-03}

Key:
χ/Q – atmospheric dispersion factor
TEDE – Total effective dose equivalent

Notes:

(a) Doses for the U.S. EPR at the EAB are for a two hour period and those at the LPZ are for the accident duration (i.e., 8 hour Reactor Coolant System leakage).

(b) Obtained from Table 7.1-5.

(c) The regulatory TEDE limit is 6.3 rem (0.063 Sieverts).

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Table 7.1-14 Summary of DBA {CCNPP} Site-Specific Doses (Page 1 of 1)

Design Basis Accident	EAB TEDE Dose[a] (rem / Sieverts)	LPZ TEDE Dose[a] (rem / Sieverts)	Regulatory TEDE Dose Acceptance Criteria[b] (rem / Sieverts)
Steam System Piping Failures			
Pre-accident Iodine Spike	{1.93E-02/1.93E-04}	{5.60E-03/5.60E-05}	25 / 0.25
Concurrent Iodine Spike	{2.17E-02/2.17E-04}	{1.87E-02/1.87E-04}	2.5 / 0.025
3.3% Fuel-Rod Clad Failure	{4.26E-01/4.26E-03}	{2.43E-01/2.43E-03}	25 / 0.25
0.58% Full-Rod Fuel Melt	{4.66E-01/4.66E-03}	{2.62E-01/2.62E-03}	25 / 0.25
Feedwater System Line Break			
Coolant Concentrations at TS Limits	{2.33E-02/2.33E-04}	{4.40E-03/4.40E-05}	2.5 / 0.025
Pre-accident Iodine Spike	{3.30E-02/3.30E-04}	{6.16E-03/6.16E-05}	25 / 0.25
Concurrent Iodine Spike	{4.02E-02/4.02E-04}	{7.92E-03/7.92E-05}	2.5 / 0.025
4.4% Fuel-Rod Clad Failure	{1.26E+00/1.26E-02}	{2.55E-01/2.55E-03}	25 / 0.25
0.76% Full-Rod Fuel Melt	{1.29E+00/1.29E-02}	{2.73E-01/2.73E-03}	25 / 0.25
Reactor Coolant Pump Locked Rotor Accident / Broken Shaft	{1.81E-01/1.81E-03	{7.66E-02/7.66E-04}	2.5 / 0.025
Failure of Small Lines Carrying Primary Coolant Outside Containment			
NSS Line Break (1/4 inch line)	{1.45E-01/1.45E-03}	{2.78E-02/2.78E-04}	2.5 / 0.025
CVCS Line Break (6 inch line)	{5.75E-03/5.75E-05}	{1.10E-03/1.10E-05}	2.5 / 0.025
Steam Generator Tube Rupture			
Pre-accident Iodine Spike	{2.02E-01/2.02E-03}	{5.46E-02/5.46E-04}	25 / 0.25
Concurrent Iodine Spike	{1.92E-01/1.92E-03}	{9.33E-02/9.33E-04}	2.5 / 0.025
LOCA	{1.10E+00/1.10E-02}	{3.75E+00/3.75E-02}	25 / 0.25
Fuel Handling Accident	{4.52E-01/4.52E-03}	{9.15E-02/9.15E-04}	6.3 / 0.063
Rod Ejection Accident	{4.56E-01/4.56E-03}	{2.86E-01/2.86E-03}	6.3 / 0.063

Key:
TEDE – Total effective dose equivalent
TBD – To be determined
NSS – Nuclear Sampling System
CVCS – Chemical and Volume Control System

Notes:

(a) For EAB and LPZ TEDE dose, see Tables 7.1-6 through 7.1-13.
(b) For Regulatory TEDE dose acceptance criteria, refer to Note (c) of appropriate table (Table 7.1-6 to Table 7.1-13).

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7.2 SEVERE ACCIDENTS

This section evaluates the potential environmental impacts of severe accidents on the {Calvert Cliffs Nuclear Power Plant (CCNPP)} site from the proposed U.S. EPR plant. The environmental impacts from a postulated severe accident have been estimated using {CCNPP} site-specific data to demonstrate acceptability for a Combined License (COL) Application.

Severe accidents are defined as accidents with substantial damage to the reactor core and degradation of containment systems. Because the probability of a severe accident is very low for the U.S. EPR, such accidents are not part of the design basis for the plant. However, the Nuclear Regulatory Commission (NRC) requires, in its Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants (FR, 1985), the completion of a probabilistic risk assessment (PRA) for severe accidents for new reactor designs. This requirement is codified in regulation 10 CFR 52.47, Contents of Applications.

A PRA was completed for the U.S. EPR as part of the application for design certification. This section presents the applicable results of the probabilistic risk assessment and includes site-specific characteristics of the {CCNPP} site and impacts of a severe accident over the entire life cycle. The purpose of this report is to identify the severe accident offsite radiological impacts, demonstrate that the impacts are acceptable, and support the severe accident mitigation alternatives analyses in Section 7.3.

7.2.1 METHODOLOGY

7.2.1.1 Offsite Consequences

The probabilistic risk assessment for the U.S. EPR established containment event trees that define the possible end states of the containment following an accident sequence. The end states are grouped into five broad categories as follows:

1. Containment intact, isolated and not bypassed (RC 101)
2. Containment bypassed (RC701, 702, 802)
3. Containment not isolated (isolation failure) (RC 201-206)
4. Early failures (excluding not isolated and bypassed) (RC 301-304, 401-404)
5. Late containment failures (RC 501-504, 602)

Using the Electric Power Research Institute code Modular Accident Analysis Program (MAAP), 23 release consequence (RC) categories are assigned to represent all potential severe accident release scenarios. The release categories are described in Table 7.2-1. An accident frequency (release category frequency) is assigned to each of the 23 categories, and these are shown in Table 7.2-3. The results from the U.S. EPR base case are applicable to {CCNPP Unit 3}.

The NRC code MACCS2 (Sandia, 1997) was used to model the environmental consequences of the severe accidents. MACCS2 was developed specifically for NRC to evaluate severe accidents at nuclear power plants. The exposure pathways modeled include external exposure to the passing plume, external exposure to material deposited on the ground, inhalation of material in the passing plume or resuspended from the ground, and ingestion of contaminated food and surface water.

The MACCS2 code primarily addresses dose from the air pathway, but also calculates dose from surface runoff and deposition on surface water. The code also evaluates the extent of contamination. The meteorology data used in the analysis was hourly data for one year that includes wind velocity (speed and direction), stability class, and rainfall.

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To assess human health impacts, the analysis determined the expected number of early fatalities, expected number of latent cancer fatalities, and collective whole body dose from a severe accident to the year 2050 population within a 50-mile radius of the plant. Economic costs were also determined, including the costs associated with short-term relocation of people, decontamination of property and equipment, and interdiction of food supplies.

MACCS2 requires five input files: MET, SITE, ATMOS, EARLY, and CHRONC. ATMOS provides data to calculate the amount of material released to the atmosphere that is dispersed and deposited. The calculation uses a Gaussian plume model. Important site-specific inputs in this file include the core inventory, release fractions, and geometry of the reactor and associated buildings. EARLY provides inputs to calculations regarding exposure in the time period immediately following the release. Important site-specific information includes emergency response information such as evacuation time. CHRONC provides data for calculating long-term impacts and economic costs and includes region-specific data on agriculture and economic factors. These files access a meteorological file, which uses actual {CCNPP} meteorological monitoring data from the years {1995 through 2004} and a site characteristics file, which uses site-specific population data, land usage, watershed index, and regions.

7.2.1.2 Population Data

{Several sources of historical and projected population data were referenced before deciding on appropriate data, including SECPOP1990, SECPOP2000, and 2030 projected data. These data included the 50-mile region surrounding the CCNPP 3 site.

Population growth rate was first determined by comparing SECPOP1990 and SECPOP2000 data, which were each adjusted to include transient population. This resulted in an exponential growth rate of 1.103 per decade. For comparison, population growth rate was also determined by comparing the SECPOP2000 data with the 2030 data. This resulted in an exponential growth rate of 1.146 per decade. The 1.146 per decade rate was chosen as it produces higher populations and more conservative severe accident consequence results.

There are several plausible year 2000 population distributions that could be used in this analysis, including the SECPOP2000 data, and the 2030 data (which is descaled to the year 2000 using the 1.146 per decade exponential growth rate from above). The 2030 descaled data was chosen to represent the 2000 population distribution, because a severe accident was shown to have more severe affects on this population.

In summary, the 2000 population distribution is modeled by taking the 2030 population distribution data, and descaling it by a growth rate of 1.146 per decade. The population growth rate is modeled as 1.146 per decade. Populations at any point in time are then modeled by scaling the assumed 2000 population by the assumed population growth rate.

The consequences of a severe accident at CCNPP Unit 3 were determined using 2050 population. The population for 2050 was chosen because CCNPP Unit 3 has an expected start-up date of 2015 and operating life of 60 years. Recognizing that consequences increase with time (i.e., increasing population), a time-averaged consequence can be estimated by looking at the midpoint of the U.S. EPR operational life, 2045. To be conservative, this was rounded up to 2050. As a sensitivity case, the endpoint of the U.S. EPR operational life, 2075, round up to 2080, is also evaluated. The 2080 population was not checked for realistic results, such as unattainable population densities and is believed to be overly conservative due to the projection of a conservative growth rate over a time period of 80 years.}

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7.2.1.3 Risk Calculation

Release heights vary, depending on the event sequence, ranging from ground level to the top of the containment annulus. The time window for the analysis is 24 hours following core damage.

The results of the MACCS2 calculations and accident frequency information were used to determine risk. The sum of all release category frequencies is the core damage frequency and includes internal and external initiating events. External events include internal fire events and internal flood events. Risk is the set of accident sequences, their respective frequencies and their respective consequences. Risk is often more simply quantified as the sum of the products of accident sequence frequencies and consequences. The consequence can be radiation dose or economic cost. Therefore, risk can be reported as a combination of person-rem per year and dollars per year.

7.2.2 CONSEQUENCES TO POPULATION GROUPS

This section evaluates impacts of severe accidents from air, surface water and groundwater pathways. The MACCS2 code was used to evaluate the doses from the air pathway and from water ingestion with {CCNPP} site-specific data. MACCS2 does not model other surface water and groundwater dose pathways. These were analyzed qualitatively based on a comparison of the U.S. EPR atmospheric doses to those of the existing U.S. nuclear fleet.

The current U.S. nuclear fleet has an exceptional safety record. Through evolutionary and innovative design, the U.S. EPR has enhanced the ability to both prevent potential core damage events and to mitigate them should they occur. A list of example U.S. EPR design features which reduce plant risk is provided below.

- Increased redundancy and separation
- Four safety trains including four EFW divisions
- Separate power divisions for each safety train, each with dedicated battery division and EDG
- Two divisions each have a backup alternate ac diesel generator for SBO-type scenario
- State-of-the-art digital I&C
- Stand-still Seal System for backup to RCP seals
- Main Feedwater System with Startup and Shutdown System
- In-containment refueling water storage tank to eliminate transfer to long term recirculation
- Two, dedicated severe accident battery divisions
- Dedicated severe accident depressurization valves to prevent high pressure melt scenarios which can challenge containment due to postulated direct containment heating
- Containment combustible gas control system, including passive autocatalytic recombiners and gas mixing system
- Core stabilization system
- Passive cooling of molten core debris
- Active spray for environmental control of the containment atmosphere
- Active recirculation cooling of the molten core debris and containment atmosphere

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The core damage frequency (CDF) is a measure of the impacts of potential accidents. CDF is estimated using PRA modeling which evaluates how changes to the reactor or auxiliary systems can change the severity of the accident. The CDF for the U.S. EPR is less than the CDFs for the current U.S. nuclear fleet.

7.2.2.1 Air Pathways

The potential severe accidents for the U.S. EPR were grouped into 23 release categories based on their similarity of characteristics. Each release category was assigned a set of characteristics representative of the elements of that class. Each release category was analyzed with MACCS2 to estimate population dose, number of early and latent fatalities, cost, and farm land requiring decontamination. The analysis assumed that 95 percent of the population was evacuated following declaration of a general emergency.

For each release category, risk was calculated by multiplying each consequence (population dose, fatalities, cost, and contaminated land) with its corresponding frequency. A summary of the results are provided in Table 7.2-3. The calculation considers other consequences, such as evacuation costs, value of crops contaminated and condemned, value of milk contaminated and condemned, cost of decontamination of property, and indirect costs resulting from loss of use of the property and incomes derived as a result of the accident.

7.2.2.2 Surface Water Pathways

Population can be exposed to radiation when airborne radioactivity is deposited onto surface water. The exposure pathway can be from drinking the water, external radiation from submersion in the water, external radiation from activities near the shoreline, or ingestion of fish or shellfish. MACCS2 only calculates the dose from drinking water. The MACCS2 severe accident dose-risk to the 50-mile population from drinking water is {6.39 E-03} person-rem per year for the U.S. EPR and for {CCNPP Unit 3}. This value is the sum of all 23 release categories.

Surface water pathways involving swimming, fishing, and boating are not modeled by MACCS2. {Surface water bodies within the 50-mile region of the CCNPP site include the Chesapeake Bay, Patuxent River, Potomac River, and other smaller bodies of water}. The NRC evaluated doses from the aquatic food pathway (fishing) for the current nuclear fleet discharging to various bodies of water {(including the existing CCNPP Units 1 and 2 on Chesapeake Bay)} in NUREG-1437, the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NRC, 1996). The NRC evaluation concluded that with interdiction, the risk associated with the aquatic food pathway is found to be small relative to the atmospheric pathway for most sites and essentially the same as the atmospheric pathway for the few sites with large annual aquatic food harvests {(which includes CCNPP Units 1 and 2)}. Because the U.S. EPR atmospheric pathway doses are significantly lower that those of the current U.S. nuclear fleet, the doses from surface water sources would be consistently lower for the U.S. EPR and for {CCNPP Unit 3}, as well.

7.2.2.3 Groundwater Pathways

Population can also receive a dose from groundwater pathways. Radioactivity released during an accident can enter groundwater that serves as a source of drinking water or irrigation, or can move through an aquifer that eventually discharges to surface water. The consequences of a radioactive spill not associated with an accident in COL application FSAR Section 2.4.13 have been evaluated and it has been determined that if radioactive liquids were released directly to groundwater, all isotopes would be below maximum permissible concentrations before they reached the {unnamed stream identified as Branch 2 and the Chesapeake Bay}.

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NUREG-1437 also evaluated the groundwater pathway dose, based on the analysis in NUREG-0440 (NRC, 1978), the Liquid Pathway Generic Study (LPGS). NUREG-0440 analyzed a core meltdown that contaminated groundwater that subsequently contaminated surface water. However, NUREG-0440 did not analyze direct drinking of groundwater because of the limited number of potable groundwater wells.

The LPGS results provide conservative, uninterdicted population dose estimates for six generic categories of plants. These dose estimates were one or more orders of magnitude less than those attributed to the atmospheric pathway. NUREG-1437 compared potential contamination at representative sites, {two of which (Hope Creek and Indian Point) were estuary sites similar to the CCNPP site}. The conclusion for those sites is that the uninterdicted population doses are significantly less than the NUREG-0440 generic site. {The proposed location for CCNPP Unit 3 has the same groundwater characteristics as the location of the existing units and the CDF for the U.S. EPR is lower than that of the existing units. Therefore, the doses from the U.S. EPR and CCNPP Unit 3 groundwater pathway would be smaller than from the existing CCNPP Units 1 and 2.}

7.2.3 CONCLUSIONS

The total calculated dose-risk to the {50-mile, year 2050} estimated population from airborne releases from a U.S. EPR reactor at {CCNPP} is expected to be approximately {0.41} person-rem per year (Table 7.2-3). The fraction of core inventory assumed to be released in each of the release categories is also included in Table 7.2-2. The number of persons exposed to doses greater than 2 Sv (200 rem) and 0.25 Sv (25 rem) are 3.38E-5 and 4.71E-4, respectively. It must be noted that these populations exceeding a dose are only calculated by MACCS2 for the early phase of an accident, the long-term dose that could be accumulated is not included in this result.

The U.S. EPR dose-risk at the {CCNPP} site is less than the population risk for all current reactors that have undergone license renewal, and less than that for the five reactors analyzed in NUREG-1150 (NRC, 1990). As reported in NUREG-1811 (NRC, 2006), the lowest dose-risk reported for reactors currently undergoing license renewal is 0.55 person-rem per year.

The qualitative analysis indicates that risk from the surface water pathway is small. The risks of groundwater contamination from a U.S. EPR accident are several orders of magnitude less than the risk from surface water contamination for currently licensed reactors. The risk of groundwater contamination from an U.S. EPR accident is smaller than the risk from currently licensed reactors. Additionally, interdiction could substantially reduce the groundwater pathway risks.

For comparison, as reported in ER Section 5.4, the total collective dose from normal operations is expected to be {5.7 person-rem per year for CCNPP Unit 3 (based on liquid and gaseous effluent for the projected 50-mile population for year 2080)}. As previously described, dose-risk is dose times frequency. Normal operation has a frequency of one. Therefore, the dose-risk for normal operation is {5.7 person-rem per year}. Comparing this value to the severe accident dose-risk of approximately {0.61} person-rem per year {(2080 conservative estimate)} indicates that the dose risk from severe accidents is less than {11} percent of dose risk from normal operations.

The probability-weighted number of cancer fatalities from a severe accident for the U.S. EPR at {CCNPP} is reported in Table 7.2-3 as {2.5 E-04} per year. The lifetime probability of an individual dying from any cancer is {2.3 E-01} (NCHS, 2007).

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Table 7.2-1 Release Category Descriptions

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Release Category	Description
RC101	No containment failure
RC201	Containment fails before vessel breach due to isolation failure, melt retained in vessel
RC202	Containment fails before vessel breach due to isolation failure, melt released from vessel, with molten core-concrete interaction (MCCI), melt not flooded ex-vessel, with containment spray
RC203	Containment fails before vessel breach due to isolation failure, melt released from vessel, with MCCI, melt not flooded ex-vessel, without containment spray
RC204	Containment fails before vessel breach due to isolation failure, melt released from vessel, without MCCI, melt flooded ex-vessel with containment spray
RC205	Containment failures before vessel breach due to isolation failure, melt released from vessel, without MCCI, melt flooded ex-vessel without containment spray
RC206	Small containment failure due to failure to isolate 2" or smaller lines
RC301	Containment fails before vessel breach due to containment rupture, with MCCI, melt not flooded ex-vessel, with containment spray
RC302	Containment fails before vessel breach due to containment rupture, with MCCI, melt not flooded ex-vessel, without containment spray
RC303	Containment fails before vessel breach due to containment rupture, without MCCI, melt flooded ex-vessel, with containment spray
RC304	Containment fails before vessel breach due to containment rupture, without MCCI, melt flooded ex-vessel, without containment spray
RC401	Containment failures after breach and up through debris quench due to containment rupture, with MCCI, without debris flooding, with containment spray
RC402	Containment failures after breach and up through debris quench due to containment rupture, with MCCI, without debris flooding, without containment spray
RC403	Containment failures after breach and up through debris quench due to containment rupture, without MCCI, with debris flooding, with containment spray
RC404	Containment failures after breach and up through debris quench due to containment rupture, without MCCI, with debris flooding, without containment spray
RC501	Long term containment failure after debris quench due to rupture, with MCCI, without debris flooding, with containment spray
RC502	Long term containment failure after debris quench due to rupture, with MCCI, without debris flooding, without containment spray
RC503	Long term containment failure after debris quench due to rupture, without MCCI, with debris flooding, with containment spray
RC504	Long term containment failure after debris quench due to rupture, without MCCI, with debris flooding, without containment spray
RC602	Long term containment failure due to basemat failure, without debris flooding, without containment spray
RC701	Steam Generator Tube Rupture with Fission Product Scrubbing
RC702	Steam Generator Tube Rupture without Fission Product Scrubbing
RC802	Interfacing System LOCA without Fission Product Scrubbing

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Table 7.2-2 Source Term Release Fractions

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Release Category	Xe + Kr + Non-Radioactive Inert Aerosols	CsI + RbI	TeO2	SrO	MoO2	CsOH + RbOH	BaO	La2O3 + Pr2O3 + Nd2O3 + Sm2O3 + Y2O3	CeO2	Sb	Te2	UO2 + NpO0 + PuO2
RC101	1.89E-03	3.05E-05	5.70E-05	8.02E-06	5.82E-05	2.57E-05	2.66E-05	4.14E-07	9.73E-07	6.73E-05	3.48E-08	1.77E-09
RC201	3.22E-01	8.14E-02	2.41E-02	6.89E-05	4.37E-03	8.45E-02	1.04E-03	6.41E-06	1.07E-05	1.18E-02	0.00E+00	0.00E+00
RC202	8.44E-01	3.05E-02	2.93E-02	7.59E-04	8.60E-03	2.22E-02	2.07E-03	1.09E-04	1.72E-04	5.34E-02	4.85E-06	1.42E-07
RC203	8.77E-01	3.56E-02	3.71E-02	2.04E-04	1.37E-02	2.28E-02	4.15E-03	2.98E-05	8.46E-05	8.32E-02	1.82E-06	2.08E-06
RC204	9.19E-01	2.98E-02	1.84E-02	5.49E-04	6.08E-03	1.93E-02	3.32E-03	7.88E-05	1.46E-04	8.14E-02	2.82E-06	6.64E-08
RC205	9.86E-01	4.08E-02	2.92E-02	4.75E-04	7.17E-03	2.56E-02	7.20E-03	7.58E-05	2.16E-04	2.68E-01	1.58E-07	1.20E-05
RC206	1.80E-01	8.85E-03	1.01E-02	2.19E-03	9.05E-03	8.16E-03	5.45E-03	9.71E-05	3.11E-04	1.05E-02	2.40E-06	2.83E-07
RC301	8.44E-01	3.05E-02	2.93E-02	7.59E-04	8.60E-03	2.22E-02	2.07E-03	1.09E-04	1.72E-04	5.34E-02	4.85E-06	1.42E-07
RC302	8.77E-01	3.56E-02	3.71E-02	2.04E-04	1.37E-02	2.28E-02	4.15E-03	2.98E-05	8.46E-05	8.32E-02	1.82E-06	2.08E-06
RC303	9.19E-01	2.98E-02	1.84E-02	5.49E-04	6.08E-03	1.93E-02	3.32E-03	7.88E-05	1.46E-04	8.14E-02	2.82E-06	6.64E-08
RC304	9.86E-01	4.08E-02	2.92E-02	4.75E-04	7.17E-03	2.56E-02	7.20E-03	7.58E-05	2.16E-04	2.68E-01	1.58E-07	1.20E-05
RC401	8.02E-01	6.76E-03	3.21E-03	2.88E-03	2.81E-03	2.81E-03	5.80E-03	1.09E-04	2.64E-04	4.81E-03	9.11E-07	5.95E-06
RC402	9.72E-01	2.81E-02	7.82E-03	4.08E-03	3.95E-03	1.30E-02	8.22E-03	1.57E-04	3.94E-04	1.06E-02	2.78E-05	1.21E-05
RC403	8.02E-01	6.76E-03	3.21E-03	2.88E-03	2.81E-03	2.81E-03	5.80E-03	1.09E-04	2.64E-04	4.81E-03	9.11E-07	5.95E-06
RC404	9.72E-01	2.81E-02	7.82E-03	4.08E-03	3.95E-03	1.30E-02	8.22E-03	1.57E-04	3.94E-04	1.06E-02	2.78E-05	1.21E-05
RC501	9.82E-01	1.93E-03	6.25E-04	1.12E-05	5.81E-05	1.93E-03	6.10E-05	4.92E-07	9.46E-07	3.79E-03	2.37E-05	4.65E-09
RC502	9.82E-01	1.93E-03	6.25E-04	1.12E-05	5.81E-05	1.93E-03	6.10E-05	4.92E-07	9.46E-07	3.79E-03	2.37E-05	4.65E-09
RC503	1.00E+00	8.52E-03	4.27E-02	8.02E-06	5.82E-05	7.92E-04	2.66E-05	4.14E-07	9.73E-07	9.46E-04	1.90E-04	1.78E-09
RC504	1.00E+00	8.52E-03	4.27E-02	8.02E-06	5.82E-05	7.92E-04	2.66E-05	4.14E-07	9.73E-07	9.46E-04	1.90E-04	1.78E-09
RC602	1.09E-13	4.06E-33	6.40E-33	5.13E-43	5.23E-33	4.12E-33	2.77E-33	4.28E-53	1.63E-43	6.63E-33	1.66E-73	4.56E-83
RC701	1.09E-01	8.12E-02	1.28E-01	1.03E-02	1.05E-01	8.25E-02	5.55E-02	8.56E-04	3.25E-03	1.33E-01	3.32E-06	9.13E-07
RC702	8.86E-01	9.30E-01	8.93E-01	1.33E-01	7.83E-01	8.83E-01	4.24E-01	6.90E-03	2.17E-02	9.13E-01	4.75E-05	2.29E-05
RC802	3.22E-01	8.14E-02	2.41E-02	6.89E-05	4.37E-03	8.45E-02	1.04E-03	6.41E-06	1.07E-05	1.18E-02	0.00E+00	0.00E+00

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Table 7.2-3 {U.S. EPR Severe Accidents Analysis Impacts – 50-mile Radius and 2050 Population}

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		Number of Fatalities (per year)		Environmental Risk		
Release Category	Release Category Frequency (per year)	Early Fatalities	Late Cancers	Population Dose-Risk (person-rem per year)	Cost (dollars per year)	Land Requiring Decontamination (acres per year)
RC101	0.00E+00	0.00E+00	8.31E-06	1.60E-02	4.64E+00	2.81E-04
RC201	9.51E-12	3.68E-11	1.09E-06	2.13E-03	4.29E+00	5.41E-05
RC202	1.56E-17	4.04E-15	1.00E-10	1.91E-07	2.28E-04	5.89E-09
RC203	1.61E-16	8.15E-14	2.44E-09	4.29E-06	5.29E-03	1.30E-07
RC204	1.05E-14	2.51E-12	5.54E-08	1.10E-04	1.20E-01	3.52E-06
RC205	3.92E-12	1.39E-10	1.27E-06	2.46E-03	2.68E+00	6.48E-05
RC206	1.32E-08	1.95E-08	3.03E-05	5.18E-02	5.46E+01	1.60E-03
RC301	6.34E-16	1.65E-13	4.08E-09	7.79E-06	9.29E-03	2.40E-07
RC302	2.87E-15	1.46E-12	4.36E-08	7.67E-05	9.45E-02	2.32E-06
RC303	9.96E-13	2.38E-10	5.27E-06	1.05E-02	1.14E+01	3.34E-04
RC304	1.68E-10	5.97E-09	5.46E-05	1.06E-01	1.15E+02	2.78E-03
RC401	0.00E+00	0.00E+00	1.38E-08	2.84E-05	2.13E-02	1.07E-06
RC402	0.00E+00	0.00E+00	4.90E-07	1.03E-03	1.16E+00	3.84E-05
RC403	0.00E+00	0.00E+00	6.82E-07	1.40E-03	1.05E+00	5.29E-05
RC404	0.00E+00	0.00E+00	2.40E-05	5.04E-02	5.70E+01	1.88E-03
RC501	0.00E+00	0.00E+00	1.04E-10	2.32E-07	2.78E-05	1.09E-08
RC502	0.00E+00	0.00E+00	4.37E-08	9.73E-05	1.17E-02	4.55E-06
RC503	0.00E+00	0.00E+00	7.88E-08	1.75E-04	2.31E-02	2.53E-05
RC504	0.00E+00	0.00E+00	2.57E-05	5.70E-02	7.53E+00	8.23E-03
RC602	0.00E+00	0.00E+00	1.42E-07	3.17E-04	3.79E-02	1.48E-05
RC701	0.00E+00	2.23E-11	1.36E-05	2.37E-02	1.90E+01	7.99E-04
RC702	2.74E-08	3.37E-08	7.84E-05	8.48E-02	8.86E+01	1.06E-03
RC802	1.00E-12	6.63E-11	5.04E-07	1.07E-03	1.48E+00	3.67E-05
Total	**4.08E-08**	**5.97E-08**	**2.45E-04**	**4.09E-01**	**3.69E+02**	**1.73E-02**

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7.3 SEVERE ACCIDENT MITIGATION ALTERNATIVES

The purpose of the severe accident mitigation alternatives (SAMA) analysis is to review and evaluate both design and non-hardware (i.e., operation and maintenance programs) alternatives that could significantly reduce the radiological risk from a postulated severe accident by preventing core damage and significant releases from the containment. The U.S. EPR Design Certification Environmental Report (U.S. EPR DC ER) (AREVA, 2007) for the U.S. EPR submitted by AREVA NP evaluated both design and non-hardware alternatives.

The primary focus of the U.S. EPR DC ER was the severe accident mitigation design alternatives (SAMDA). However, non-hardware alternatives were identified in the analysis and will be addressed when the plant design is finalized and processes and procedures are being developed for the U.S. EPR. The conclusions drawn in the U.S. EPR DC ER are applicable to {CCNPP Unit 3}.

7.3.1 SAMDA ANALYSIS METHODOLOGY

The methodology used to develop a comprehensive list of U.S. EPR SAMDA candidates, define the screening criteria used to categorize the SAMDA candidates, and the cost-benefit evaluation is summarized in this section based on the U.S. EPR DC ER (AREVA, 2007) for the U.S. EPR.

The comprehensive list of SAMDA candidates was developed for the U.S. EPR by reviewing industry documents for generic PWR enhancements and considering plant-specific enhancements. The SAMDA candidates were defined as enhancements to the U.S. EPR plant that have the potential to prevent core damage and significant releases from the containment. The primary industry document supporting the development of U.S. EPR generic PWR SAMDA candidates was NEI 05-01 (NEI, 2005).

The top 100 U.S. EPR Level 1 PRA cutsets were evaluated to identify plant-specific modifications for inclusion in the comprehensive list of SAMDA candidates. The top 100 cutsets represent approximately 50 percent of the total core damage frequency (CDF) for the U.S. EPR. The percentage of contribution to the total CDF for the cutsets below the top 100 was minimal. Therefore, these cutsets were not likely contributors for identification of cost beneficial enhancements for the U.S. EPR design.

An extensive evaluation of the top 100 cutsets was completed in order to establish that all possible design alternatives for the U.S. EPR were addressed. Through the evaluation, numerous U.S. EPR specific operator actions and hardware-based SAMDA candidates were developed. The U.S. EPR DC ER (AREVA, 2007) provides a detailed list of the SAMDA candidates for the U.S. EPR. The SAMDA candidates identified in the U.S. EPR DC ER are applicable to {CCNPP Unit 3}.

The SAMDA candidates developed for the U.S. EPR design were qualitatively screened using seven categories. The intent of the screening is to identify the candidates for further risk-benefit calculation. For each SAMDA candidate, a screening criteria and basis for screening was identified to justify the implementation or exclusion of the SAMDA candidate in the U.S. EPR. The seven categories used during the screening process included:

- Not applicable. The SAMDA candidates were identified to determine which are definitely not applicable to the U.S. EPR. Potential enhancements that are not considered applicable to the U.S. EPR are those developed for systems specifically associated with boiling water reactors (BWR) or with specific PWR equipment that is not in the U.S. EPR design.

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- Already implemented. The SAMDA candidates were reviewed to ensure that the U.S. EPR design does not already include features recommended by a particular SAMDA candidate. Also, the intent of a particular SAMDA candidate may have been fulfilled by another design feature or modification. In these cases the SAMDA candidates are already implemented in the U.S. EPR plant design. If a SAMDA candidate has already been implemented at the plant, it is not retained.
- Combined. If one SAMDA candidate is similar to another SAMDA candidate, and can be combined with that candidate to develop a more comprehensive or plant-specific SAMDA candidate, only the combined SAMDA candidate is retained for screening.
- Excessive implementation cost. If a SAMDA candidate requires extensive changes that will obviously exceed the maximum benefit, even without an implementation cost estimate and therefore incurs an excessive implementation cost, it is not retained.
- Very low benefit. If a SAMDA candidate is related to a non-risk significant system for which change in reliability is known to have negligible impact on the risk profile, it is deemed to have a very low benefit and is not retained.
- Not required for design certification. Evaluation of any potential procedural or surveillance action SAMDA candidates are not appropriate until the plant design is finalized and the plant procedures are being developed. Therefore, if a SAMDA candidate is related to any of these enhancements, it is not retained for this analysis.
- Considered for further evaluation. If a particular SAMDA candidate was not categorized by any of the preceding categories, then the SAMDA candidate is considered for further evaluation and subject to a cost-benefit analysis.

The screening categories were chosen based on guidance from NEI 05-01. The U.S. EPR DC ER contains a detailed description of each of the categories. The screening categories are applicable to {CCNPP Unit 3}.

After the screening process was completed, the SAMDA candidates that were placed in the Considered for Further Evaluation category would require a cost-benefit evaluation. The cost-benefit evaluation of each SAMDA candidate would determine the cost of implementing the specific SAMDA candidate with the maximum averted cost risk from the implementation of the specific SAMDA candidate. The maximum averted cost risk, typically referred to as the maximum benefit, equates to the cost obtained by the elimination of all severe accident risk.

7.3.2 SEVERE ACCIDENT COST IMPACT AND MAXIMUM BENEFIT FOR {CCNPP UNIT 3}

The severe accident impact is determined by summing the occupational exposure cost, on-site cost, public exposure, and off-site property damage. The methodologies provided in NEI 05-01 (NEI, 2005) and NUREG/BR-1084 (NRC, 1997) were used as guidance. The principal inputs to the calculations were the CDF, 2,000 dollars per person-rem (NRC, 1997), licensing period of 60 years, 7% best estimate discount rate (NEI, 2005), and 3% upper bound discount rate (NEI, 2005). The maximum benefit calculation performed in the U.S. EPR DC ER used the whole body dose and economic impact from U.S. EPR Level 3 PRA analysis, which was based on population data from 2000. The maximum benefit calculation for {CCNPP Unit 3} uses the economic impact and whole body dose for a 2050 population (Table 7.3-1). The best estimate and upper bound severe accident impact cost for {CCNPP Unit 3} is also shown in Table 7.3-1.

The severe accident impact cost calculated in Table 7.3-1 accounts for the risk of internal events, internal flooding, and internal fires. To determine the total cost of severe accident risk

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the contribution of external events (e.g., seismic risk, as other external event contributors are small) needs to be included. Assuming that fire risk is the dominant contributor to external events risk, the seismic risk contribution was conservatively accounted for by assuming that it is equivalent to the internal fire risk. A scaling factor was calculated by dividing the internal fire CDF (1.76 E-07 per year) by the total CDF (5.30 E-07 per year) resulting in an increase of 33 percent (AREVA, 2007). Increasing the severe accident impact by 33 percent includes the seismic risk and is the maximum benefit for {CCNPP Unit 3}.

The maximum benefit for {CCNPP Unit 3 is $62,038 (best estimate) and $107,253 (upper bound). The best estimate maximum benefit for CCNPP Unit 3 is approximately $11,000} higher than the maximum benefit calculated in the U.S. EPR DC ER. The minimum implementation cost for a SAMDA candidate was determined to be $150,000 (AREVA, 2007), which exceeds the maximum benefit calculated for {CCNPP Unit 3}. Therefore, the U.S. EPR DC ER analysis is applicable to {CCNPP Unit 3}.

7.3.3 RESULTS AND SUMMARY

A total of 167 SAMDA candidates developed from industry and U.S. EPR documents were evaluated in the U.S. EPR DC ER completed by AREVA NP. The basis for screening is provided in detail for each SAMDA candidate in the U.S. EPR DC ER. Below is a summary of the results of the SAMDA analysis performed for the U.S. EPR and is applicable to {CCNPP Unit 3}.

- Twenty-one SAMDA candidates were not applicable to the U.S. EPR design.
- Sixty-seven SAMDA candidates were already implemented into the U.S. EPR design either as suggested in the SAMDA or an equivalent replacement that fulfilled the intent of the SAMDA. These SAMDA candidates are summarized in Table 7.3-2.
- Four SAMDA candidates were combined with another SAMDA because they had the same intent.
- Fifty-one SAMDA candidates were categorized as not required for design certification because they were related to a procedural or surveillance action. Evaluation of any potential administrative SAMDA candidates (i.e., those candidates related to procedures and training) is not appropriate until the plant design is finalized and plant administrative processes, procedures and training program are being developed. However, the plant administrative processes, procedures, and training program will be developed to address appropriate maintenance and use of the U.S. EPR design features which have been credited with the reduction of risk associated with postulated severe accidents. As such, appropriate administrative controls on plant operations will be incorporated into the {CCNPP Unit 3} management systems as part of the initial administrative processes, procedures and training program development process.
- One SAMDA candidate was categorized as very low benefit.
- Twenty-three SAMDA candidates were categorized as excessive implementation cost.
- None of the SAMDA candidates were categorized as consider for further evaluation.

The low probability of core damage events in the U.S. EPR coupled with reliable severe accident mitigation features provide significant protection to the public and the environment. Specific severe accident mitigation design alternatives from previous industry studies, and from U.S. EPR probabilistic risk assessment (PRA) insights, were measured against broad acceptance criteria in the U.S. EPR DC ER (AREVA, 2007). Since none of the SAMDA

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candidates were categorized as considered for further evaluation, a cost-benefit analysis (i.e., risk reduction, value impact ratios) was not required for the U.S. EPR SAMDA analysis. The overall conclusion of the U.S. EPR SAMDA analysis is that no additional plant modifications are cost beneficial to implement due to the robust design of the U.S. EPR with respect to prevention and mitigation of severe accidents. The maximum benefit from the U.S. EPR DC ER was reevaluated for {CCNPP Unit 3}. The detailed analysis and conclusions in the U.S. EPR DC ER remain applicable for {CCNPP Unit 3}.

7.3.4 REFERENCES

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Table 7.3-1 Severe Accident Cost Impact

(Page 1 of 1)

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	Best Estimate (7% Discount Rate)	Upper Bound (3% Discount Rate)
Averted Occupational Exposure	$264	$607
Averted On-site Costs	$29,680	$47,011
Averted Public Exposure	$11,509	$22,757
Averted Off-site Property Damage Costs	$5,192	$10,266
Severe Accident Cost Impact Internal Events, Internal Flooding, Internal Fire	$46,645	$80,641
Maximum Benefit Internal Events, Internal Flooding, Internal Fire, Seismic	**$62,038**	**$107,253**

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Table 7.3-2 SAMDA Candidates – Already Implemented

(Page 1 of 2)

SAMDA ID	Potential Enhancement
AC/DC-01	Provide additional DC battery capacity.
AC/DC-03	Add additional battery charger or portable, diesel-driven battery charger to existing DC system.
AC/DC-04	Improve DC bus load shedding.
AC/DC-06	Provide additional DC power to the 120/240V vital AC system.
AC/DC-07	Add an automatic feature to transfer the 120V vital AC bus from normal to standby power.
AC/DC-09	Provide an additional diesel generator.
AC/DC-11	Improve 4.16 kV bus cross-tie ability.
AC/DC-14	Install a gas turbine generator.
AC/DC-16	Improve uninterruptible power supplies.
AC/DC-24	Bury off-site power lines.
AT-01	Add an independent boron injection system.
AT-02	Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.
AT-07	Install motor generator set trip breakers in control room.
AT-08	Provide capability to remove power from the bus powering the control rods.
CB-01	Install additional pressure or leak monitoring instruments for detection of ISLOCAs.
CB-04	Install self-actuating containment isolation valves.
CB-10	Replace SGs with a new design.
CB-12	Install a redundant spray system to depressurize the primary system during an SGTR.
CB-14	Provide improved instrumentation to detect SGTR, such as Nitrogen-16 monitors.
CB-16	Install a highly reliable (closed loop) SG shell-side heat removal system that relies on natural circulation and stored water sources.
CB-20	Install relief valves in the CCWS.
CC-01	Install an independent active or passive high pressure injection system.
CC-04	Add a diverse low pressure injection system.
CC-05	Provide capability for alternate injection via diesel-driven fire pump.
CC-06	Improve ECCS suction strainers.
CC-07	Add the ability to manually align ECCS recirculation.
CC-10	Provide an in-containment reactor water storage tank.
CC-15	Replace two of the four electric safety injection pumps with diesel-powered pumps.
CC-17	Create a reactor coolant depressurization system.
CC-21	Modify the containment sump strainers to prevent plugging.
CP-01	Create a reactor cavity flooding system.
CP-03	Use the fire water system as a backup source for the containment spray system.
CP-07	Provide post-accident containment inerting capability.
CP-08	Create a large concrete crucible with heat removal potential to contain molten core debris.

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Table 7.3-2 SAMDA Candidates – Already Implemented
(Page 2 of 2)

SAMDA ID	Potential Enhancement
CP-11	Increase depth of the concrete base mat or use an alternate concrete material to ensure melt-through does not occur.
CP-13	Construct a building to be connected to primary/secondary containment and maintained at a vacuum.
CP-17	Install automatic containment spray pump header throttle valves.
CP-20	Install a passive hydrogen control system.
CP-21	Erect a barrier that would provide enhanced protection of the containment walls (shell) from ejected core debris following a core melt scenario at high pressure.
CP-22	Install a secondary containment filtered ventilation.
CW-01	Add redundant DC control power for SW pumps.
CW-02	Replace ECCS pump motors with air-cooled motors.
CW-04	Add a SW pump.
CW-05	Enhance the screen wash system.
CW-06	Cap downstream piping of normally closed component cooling water drain and vent valves.
CW-10	Provide hardware connections to allow another essential raw cooling water system to cool charging pump seals.
CW-15	Use existing hydro test pump for RCP seal injection.
CW-16	Install improved RCP seals.
CW-17	Install an additional component cooling water pump.
EPR-01	Provide an additional SCWS train.
EPR-05	Add redundant pressure sensors to the pressurizer and SG.
FR-03	Install additional transfer and isolation switches.
FR-05	Enhance control of combustibles and ignition.
FW-01	Install a digital feed water upgrade.
FW-02	Create ability for emergency connection of existing or new water sources to feedwater and condensate systems.
FW-04	Add a motor-driven feedwater pump.
FW-07	Install a new condensate storage tank (auxiliary feedwater storage tank).
FW-11	Use fire water system as a backup for SG inventory.
FW-15	Replace existing pilot-operated relief valves with larger ones, such that only one is required for successful feed and bleed.
HV-01	Provide a redundant train or means of ventilation to the switch gear rooms.
HV-02	Add a diesel building high temperature alarm or redundant louver and thermostat.
HV-04	Add a switchgear room high temperature alarm.
HV-05	Create ability to switch EFW room fan power supply to station batteries in an SBO.
SR-01	Increase seismic ruggedness of plant components.
SR-02	Provide additional restraints for CO_2 tanks.
OT-01	Install digital large break LOCA protection system.

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7.4 TRANSPORTATION ACCIDENTS

The NRC evaluated the environmental effects of transportation of fuel and waste for light water reactors in WASH-1238, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Plants" (AEC, 1972) and NUREG-75/038, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, Supplement 1" (NRC, 1975) and found the impacts to be small. These NRC analyses provided the basis for Table S-4 in 10 CFR 51.52 (CFR, 2007) which summarizes the environmental impacts of transportation of fuel and radioactive wastes to and from a reference reactor.

10 CFR 51.52 requires that:

> Every environmental report prepared for ... a light-water-cooled nuclear power reactor... contain a statement concerning transportation of fuel and radioactive wastes to and from the reactor. That statement shall indicate that the reactor and this transportation either meet all of the conditions in paragraph (a) of this section or all of the conditions in paragraph (b) of this section.

Table S-4 of 10 CFR 51.52 addresses two categories of environmental considerations: (1) normal conditions of transport and (2) accidents in transport.

The U.S. EPR design varies from the conditions of 10 CFR 51.52(a). Specifically,

- The reactor has a core thermal power level exceeding 3,800 MWth,
- The reactor fuel has a uranium-235 enrichment that may exceed 4% by weight,
- The uranium dioxide pellets are not encapsulated in Zircaloy rods,
- The average level of burnup of the irradiated fuel removed from the reactor will exceed 33,000 MWd/MTU.

Because the U.S. EPR varies from the conditions of 10 CFR51.52(a), a full description and analysis of transportation environmental impacts is required in accordance with 10 CFR 51.52(b). This section describes the environmental impact of postulated transportation accidents involving the shipment of radioactive materials including unirradiated (new) fuel, irradiated fuel, and radioactive waste as required by 10 CFR 51.52. The environmental impacts from the incident-free transportation of fuel and wastes to and from the new reactor is summarized in Section 5.11.

These evaluated impacts are compared to the respective impacts in 10 CFR 51.52 as shown in Table 7.4-1.

Radiological and non-radiological types of accident effects are analyzed. Two computer programs were used to perform this analysis. The TRAGIS (ORNL, 2003) computer code was used to determine the distance traveled by truck, the roads taken, and the population density along the routes. The RADTRAN 5.6 computer code was used to calculate population doses from the shipment (direct and effluent sources, not ingestion) given the routes defined by TRAGIS. The inputs to these codes are listed in Tables 7.4-2 through 7.4-7 and Tables 7.4-9 through 7.4-11.

7.4.1 RADIOLOGICAL IMPACTS

The radiological impact population dose was calculated using the RADTRAN computer code. The population dose impact from postulated accidents associated with the transportation of unirradiated fuel, irradiated fuel, and radioactive waste are provided in Table 7.4-12. The dose impact from all postulated transportation accident sources is {2.0E-4 person-rem/year (2.0E-6 person-Sv/year)}.

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7.4.1.1 Unirradiated (New) Fuel

The WASH-1238 analysis (AEC, 1972) of postulated accidents during the transportation of unirradiated fuel found accident impacts to be negligible. The analysis states "the impact on the environment from radiation in transportation accidents involving unirradiated (current) fuel is considered to be negligible."

Additionally, as noted in NUREG-1815 (NRC, 2006), accident frequencies are likely to be lower in the future than those used in the analysis in WASH-1238 (AEC, 1972) because traffic accident, injury, and fatality rates have fallen since the initial analyses were performed.

Finally, advanced fuel behaves like fuel evaluated in the analyses provided in WASH-1238 (AEC, 1972). Again as noted in NUREG-1815 (NRC, 2006), there is no significant difference in the consequences of accidents severe enough to result in a release of unirradiated fuel particles to the environment between advanced LWRs and previous-generation LWRs because the fuel form, cladding, and packaging are similar to those analyzed in WASH-1238 (AEC, 1972).

Based on this information, the dose impact from nuclides released from postulated accidents involving new fuel is assumed to be negligible when compared to dose impact from postulated irradiated fuel and radiation waste transportation accidents. Therefore, quantitative analysis of dose from new fuel accidents was not performed.

7.4.1.2 Irradiated Fuel

The dose impact from postulated accidents during the shipment of irradiated fuel was evaluated using the TRAGIS code (ORNL, 2003) to define appropriate routing and population density along the route. This information was used as input to the RADTRAN code with U.S. EPR-specific design information to calculate a postulated annual dose from irradiated fuel transportation accidents.

The evaluation model assumed that irradiated fuel will be shipped to the site of the proposed Yucca Mountain repository. The distance from the {Calvert Cliffs Nuclear Plant (CCNPP)} site to the proposed repository is {2,680 mi (4,313 km)} based on a TRAGIS Highway Route Controlled Quantity (HRCQ) distance.

The model accident rate is the probability that an accident will occur during the trip along each route through each state. The route's average accident rate is the sum of the distance weighted accident rate through each state.

State-specific accident data from Table 4 of ANL/ESD/TM-150 (ANL, 1999) are shown in Table 7.4-4. Only the interstate data are used because the HRCQ route is mainly on Interstate roads.

The distance and demographic data for input to RADTRAN are listed in Table 7.4-2. The U.S. EPR average annual quantity of irradiated fuel shipped is assumed, consistent with NUREG-1815 (NRC, 2006), to equal the average annual reload quantity. For the U.S. EPR this is 37.5 MTU of irradiated fuel per year (as provided in Section 5.11) to be shipped.

The source term in Table 7.4-3 is based on an equilibrium burnup of 52 GWd/MTU. The activity was decayed 5 years to account for the minimum decay period prior to shipment of irradiated fuel to the proposed geologic repository at Yucca Mountain, NV. The nuclides evaluated are those dominant nuclides described and listed in Appendix G of NUREG-1815 (NRC, 2006).

In addition to the source term assumed above, Cobalt-60 was used to represent fuel surface contamination and added at a level of 0.2 Ci/rod. This use of Cobalt-60 in the model was consistent with previously performed studies (SNL, 1991) (NRC, 2000) (DOE, 2002) that quantified fuel rod contamination levels and that concluded the maximum contribution from

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contamination is Cobalt-60. NUREG/CR-6672 estimated the maximum contamination from Cobalt-60 for PWR fuel at zero year decay is 0.168 Ci/rod (6.22E9 Bq/rod) (or approximately 0.2 Ci/rod (7.4E9 Bq/rod)). A U.S. EPR-specific calculation of Ci/rod was carried out that confirmed the 0.2 Ci/rod (7.4E9 Bq/rod) value was conservative.

The accident severity categories and related releases from Appendix G of NUREG-1815 (NRC, 2006) were used and are presented in Table 7.4-5. The model deposition velocities were consistent with Appendix E in DOE/EIS-0250 (DOE, 2002). The model severity fractions, release fractions, aerosol and respirable fractions are the conditional probabilities, given an accident occurs, for specific severity categories. The model severity and release fractions are for the 19 severity categories and the 5 chemical groups identified in NUREG-1815 (NRC, 2006), and are presented in Table 7.4-5. Gases are not deposited and have a 0.0 m/s deposition velocity. All other chemical groups are defined consistent with DOE/EIS-0250 (DOE, 2002) at 0.03 ft/s (0.01 m/s). Other RADTRAN parameters used were the default values from the RADCAT 2.3 User Guide (SNL, 2006), and from Appendix G of NUREG-1815 (NRC, 2006).

The evaluation determined that the dose impact from postulated transportation accidents involving irradiated fuel was {5.14E-06 person-rem/MTU (5.14E-08 person-Sv/MTU)}. Using the average annual reload requirements for a U.S. EPR of 37.5 MTU, the annual population dose impact is {1.9E-04 person-rem/year (1.9E-06 person-Sv/year)} from postulated transportation accidents involving irradiated fuel.

7.4.1.3 Radioactive Waste

The population risk from radwaste transportation accidents is {8.2E-06 person-rem/yr (8.2E-08 person-Sv/year).} This is the population dose for an accident divided by the mean number of years between accidents.

The TRAGIS computer code was used to calculate the routes, distances, and demographics along the route. It was conservatively assumed that all radwaste would be shipped to the farthest disposal repository in commercial mode. The route was from the plant to the {Hanford site located in Washington State.} It was along roads which allowed trucks and avoided ferry crossings. TRAGIS calculated the total one-way distance to be {2,733 mi (4,399 km)}. The distances through each state are listed in Table 7.4-11. The distances and population densities through the rural, suburban and urban settings are listed in Table 7.4-9 as well as the time spent stopped. These were all used as inputs to RADTRAN.

The RADTRAN computer code was used to calculate accident probability and population risk for the route. In an average year 2.54E+03 Ci (9.41E+13 Bq), is forecast to be shipped. This is described in Table 7.4-8 and will involve 15 shipments per year (as described in Section 5.11). The fraction of various nuclides released, by accident category, are listed in Table 7.4-5. These release fractions are a function of 19 accident severity categories and 5 chemical groups. The values are from NUREG-1815 (NRC, 2006). The model release fractions, aerosol and respirable fractions are the conditional probabilities, given an accident occurs, for specific severity categories.

The model deposition velocities are consistent with Appendix E in DOE/EIS-0250 (DOE, 2002). All chemical groups are defined at 0.01 m/s.

Other RADTRAN parameters were the default values from the RADCAT 2.3 User Guide (SNL, 2006), and from Appendix G of NUREG-1815 (NRC, 2006).

The source term in Table 7.4-10 is based on the sum of all waste type expected (average) annual activities. The radionuclides chosen are >1% of the total activity (with the exception of Ag-110m, which is not in the RADTRAN 5.6 Library), and those in Table G-9 of NUREG-1815

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(NRC, 2006) plus isotopes in the same family (such as Co-58 and Ru-103). On page G-23 of that report the NRC performed a screening analysis that showed that these were the dominant nuclides.

The model accident rate is the probability that an accident will occur during the trip along each road through each state. The route's average accident rate is the sum of the distance weighted accident rate through each state. Table 7.4-11 presents the individual state accident rate data compiled from ANL/ESD/TM-150 (ANL, 1999) and the associated average rate. Since the commercial route is mainly on Interstate roads, only the interstate rate data was used in the model.

The result from RADTRAN is the annual population dose per year of {8.2E-06 person-rem/yr (8.2E-08 person-Sv/yr)}.

7.4.2 NON-RADIOLOGICAL IMPACTS

Two non-radiological impacts associated with the postulated accidents during transportation of new fuel, irradiated fuel, and radioactive waste were calculated, the fatal injury rate per 100 reactor years and the nonfatal injury rate per 10 reactor years.

7.4.2.1 New Fuel

TRAGIS (ORNL, 2003) was used to calculate the commercial routing through each state. Interstate travel is the dominant road designation and was used for all route types. It was assumed that all shipments came from the fuel fabrication facility furthest from {CCNPP located in Richland, WA.}

As described in Section 5.11.3.1, the average number of new fuel shipments was assumed to be 7.5 per year, each covering the {2,723 mi (4,381 km)} distance, including the return of the empty truck the same distance. This is based on the distances and road types from the calculation of radiological impacts above and the fatal injury rates from Table 4 of ANL/ESD/TM-150 (ANL, 1999).

Based on the above and the average fatality rate from Table 7.4-7 of {1.63E-08 fatalities/truck-mi (1.01E-08 fatalities/truck-km)}, the non-radiological fatal injury rate impact associated with postulated accidents as a result of new fuel shipments is {6.6E-02} per 100 reactor years.

Based on the same routes, distances, and assumptions above and the average nonfatal injury rate from Table 7.4-7 of {3.68E-07 nonfatal injuries/truck-mi (2.29E-07 nonfatal injuries/truck-km)}, the non-radiological nonfatal injury rate impact associated with postulated accidents as a result of new fuel shipments is {1.5E-01} nonfatal injuries per 10 reactor years.

7.4.2.2 Irradiated Fuel

The methodology for evaluating the fatal and nonfatal injury rates as a result of postulated accidents during the transportation of irradiated fuel is the same as that described in Section 7.4.2.1 above with the exceptions of the number of trips and the routing assumed in the TRAGIS evaluation. Twenty-one irradiated fuel shipments from the {CCNPP} site to the proposed Yucca Mountain repository per year were evaluated (as discussed in Section 5.11) and the TRAGIS Highway Route Controlled Quantity was utilized as the basis to calculate the shipping distance.

Based on the above and the accident rates from Table 7.4-4, the non-radiological fatal injury rate impact associated with postulated accidents as a result of irradiated fuel shipments is {1.78E-01} per 100 reactor years.

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Based on the above and the accident rates from Table 7.4-6, the non-radiological nonfatal injury rate impact associated with postulated accidents as a result of irradiated fuel shipments is {4.08E-01} nonfatal injuries per 10 reactor years.

7.4.2.3 Radioactive Waste

The fatal injury rate for accidents associated with radwaste shipments is {1.06E-01} fatal injuries per 100 reactor years. This is based on the fatality rates from Table 4 of ANL/ESD/TM-150 (ANL, 1999). TRAGIS was used to calculate the commercial routing through each state. Interstate travel is the dominant road designation and was used for all route types.

It is assumed that all shipments go from the CCNPP site to the farthest potential disposal repository located in {Hanford, WA 2,733 mi (4,399 km)} and that the truck conservatively returns to the plant empty (doubling the traveled distance.) The state-specific fatality rates are in Table 7.4-11. The number of radwaste shipments from the site to {Hanford} per year is 15 as described in Section 5.11.3.3. The distance weighted fatality rate from Table 7.4-11 is {1.29E-08 fatalities/truck-mi (8.00E-09 fatalities/truck-km)}. The Radwaste Fatality (SFF) rate was calculated to be {1.06E-01 fatal injuries/100 reactor years.}

The nonfatal injury rate associated with radwaste shipments is {3.06E-01} nonfatal injuries per 10 reactor years. This is based on the distances and road types from the radiological impact calculations and the injury rates from Table 4 of ANL/ESD/TM-150 (ANL, 1999). TRAGIS was used to calculate the commercial routing through each state. Interstate travel is the dominant road designation and was used for all route types.

It is assumed that all shipments go from the site to the farthest potential disposal repository located in {Hanford, WA 2,733 mi (4,399 km)} and that the truck conservatively returns to plant empty (doubling the traveled distance.) The state-specific fatality rates are in Table 7.4-11. The number of radwaste shipments from the site to {Hanford} per year is 15 as described in Section 5.11.3.3. The average injury rate from Table 7.4-11 is {3.73E-07 injuries/truck-mi (2.32E-07 injuries/truck-km)}. The nonfatal Radwaste Injury rate was calculated to be {3.06E-01} nonfatal injuries/10 reactor years.

7.4.3 SUMMARY AND CONCLUSION

A detailed accident analysis of the environmental impacts for the transportation of unirradiated fuel, irradiated fuel, and radioactive waste (DOE, 1981) transported to and from the {CCNPP} site has been performed in accordance with 10 CFR 51.52(b) (CFR, 2007).

Table 7.4-12 summarizes the radiological impact, and Table 7.4-13 summarizes the non-radiological impact. These environmental impact results are bounded by 10 CFR 51.52(c) (CFR, 2007), Table S-4. These impacts represent the contribution of postulated transportation accidents to the environmental costs of operating the proposed facility.

As shown in Table 7.4-13, the calculated impacts from transportation accidents are less than those corresponding impacts listed in Table S-4 of 10 CFR 51.52 (CFR, 2007). Therefore the corresponding impacts from transportation accidents for the transportation of fuel and waste to and from the proposed facility are small and will be less than those accepted by 10 CFR 51.52 (CFR, 2007).

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7.4.4 REFERENCES

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Table 7.4-1 10 CFR 51.52 Summary Table S-4 Excerpt Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor Accidents in Transport (Page 1 of 1)

Types of Effects	Environmental Risk
Radiological Effects	**Small**
Common (nonradiological) causes	1 fatal injury in 100 reactor years 1 nonfatal injury in 10 reactor years $475 property damage per reactor year

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Table 7.4-2 RADTRAN/TRAGIS Model Irradiated Fuel Input Parameters (Page 1 of 1)

Parameter	CCNPP Model U.S. EPR (English Units)	CCNPP Model U.S. EPR (SI Units)
TRAGIS Input:		
Route Mode	HRCQ	
Route Origin	CCNPP	
Route Destination	Yucca Mt, NV	
RADTRAN Input TRAGIS:		
Total Shipping Distance	2,680 mi	4,312.7 km
Travel Distance – Rural	2,036 mi	3,275.2 km
Travel Distance – Suburban	568 mi	914 km
Travel Distance – Urban	77 mi	123.8 km
Population Density – Rural	30 person/mi^2	11.5 person/km^2
Population Density – Rural	817 person/mi^2	315.5 person/km^2
Population Density – Rural	6,166 person/mi^2	2,381.8 person/km^2
Stop Time, hr/trip	5.0 (1)	
RADTRAN Input from NRC Models		
Vehicle Speed	55 mph	88.49 km/hr
Traffic Count – Rural	329 mph	530 km/hr
Traffic Count – Suburban	472 mph	760 km/hr
Traffic Count – Urban	1,492 mph	2,400 km/hr
Dose Rate at 3.3 ft (1 m) from Vehicle	14 mrem/hr	0.14 mSv/hr
Packaging Length	17 ft	5.2 m
Packaging Diameter	3 ft	1.0 m
Number of Truck Crew	2	
Population Density at Stops (radii: 3.3 to 33 ft (1 to 10 m))	77,666 person/mi^2	30,000 person/km^2
Population Density at Stops (radii: 33 to 2,625 ft (10 to 800 m))	880 person/mi^2	340 person/km^2
Shielding Factor at Stops (radii: 3.3 to 33 ft (1 to 10 m))	1	
Shielding Factor at Stops (radii: 33 to 2,625 ft (10 to 800 m))	0.2	

Note:

(1) Based on TRAGIS output: 10 stops at 30 minutes each.

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Table 7.4-3 Irradiated Fuel Source Term
(Page 1 of 1)

Radionuclide (a)	CCNPP Model U.S. EPR 5 Year Decay Ci/MTU	CCNPP Model U.S. EPR 5 Year Decay Bq/MTU
Am-241	1.25E+03	4.62E+13
Am-242m	2.38E+01	8.82E+11
Am-243	3.22E+01	1.19E+12
Cm-144	1.52E+04	5.62E+14
Cm-242	4.35E+01	1.61E+12
Cm-243	3.19E+01	1.18E+12
Cm-244	4.84E+03	1.79E+14
Cm-245	6.19E-01	2.29E+10
Co-60	7.59E+01	2.81E+12
Cs-134	5.84E+04	2.16E+15
Cs-137	1.42E+05	5.25E+15
Eu-154	1.16E+04	4.31E+14
Eu-155	5.73E+03	2.12E+14
I-129	4.65E-02	1.72E+09
Kr-85	1.05E+04	3.88E+14
Pm-147	3.54E+04	1.31E+15
Pu-238	6.95E+03	2.57E+14
Pu-239	4.24E+02	1.57E+13
Pu-240	7.24E+02	2.68E+13
Pu-241	1.17E+05	4.34E+15
Pu-242	2.28E+00	8.44E+10
Ru-106	2.05E+04	7.59E+14
Sb-125	5.35E+03	1.98E+14
Sr-90	1.03E+05	3.81E+15
Y-90	1.03E+05	3.82E+15

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Table 7.4-4 Irradiated Fuel CCNPP Model Accident and Fatality Rates (Page 1 of 1)

State	Accident Rate Accidents / truck-mi (Accidents / truck-km)	Fatality Rate Fatalities / truck-mi (Fatalities / truck-km)	Distance mi (km)	Accident Rate distance weighted fraction accident / truck-mi (accident / truck-km)	Fatality Rate distance weighted fraction fatality / truck-mi (fatality / truck-km)
AZ	2.12E-07 (1.32E-07)	1.51E-08 (9.40E-09)	29.3 (47.1)	2.32E-09 (1.44E-09)	1.66E-10 (1.03E-10)
IL	3.57E-07 (2.22E-07)	1.34E-08 (8.30E-09)	162.2 (261.7)	2.17E-08 (1.35E-08)	8.11E-10 (5.04E-10)
IN	3.62E-07 (2.25E-07)	1.08E-08 (6.70E-09)	151.2 (243.4)	2.04E-08 (1.27E-08)	6.08E-10 (3.78E-10)
IA	1.80E-07 (1.12E-07)	1.51E-08 (9.40E-09)	307.0 (494.1)	2.06E-08 (1.28E-08)	1.74E-09 (1.08E-09)
MD	8.69E-07 (5.40E-07)	1.05E-08 (6.50E-09)	235.4 (378.8)	7.63E-08 (4.74E-08)	9.19E-10 (5.71E-10)
NE	5.13E-07 (3.19E-07)	2.20E-08 (1.37E-08)	456.6 (734.8)	8.75E-08 (5.44E-08)	3.75E-09 (2.33E-09)
NV	3.62E-07 (2.25E-07)	1.06E-08 (6.60E-09)	167.5 (269.5)	2.27E-08 (1.41E-08)	6.63E-10 (4.12E-10)
OH	2.64E-07 (1.64E-07)	6.28E-09 (3.90E-09)	239.9 (386.1)	2.37E-08 (1.47E-08)	5.62E-10 (3.49E-10)
PA	8.27E-07 (5.14E-07)	2.17E-08 (1.35E-08)	107.2 (172.6)	3.32E-08 (2.06E-08)	8.69E-10 (5.40E-10)
UT	4.67E-07 (2.90E-07)	1.92E-08 (1.19E-08)	379.2 (610.3)	6.6E-08 (4.10E-08)	2.70E-09 (1.68E-09)
WV	2.77E-07 (1.72E-07)	2.70E-08 (1.68E-08)	43.3 (69.7)	4.47E-09 (2.78E-09)	4.28E-10 (2.72E-10)
WY	1.08E-06 (6.74E-07)	1.74E-08 (1.08E-08)	400.5 (644.6)	1.63E-07 (1.01E-07)	2.59E-09 (1.61E-09)
Sum:			2680 (4312.7)	5.41E-07 (3.36E-07)	1.58E-08 (9.84E-09)
				Fatalities per Accident (1) :	2.93E-02

Note:

(1) Fatalities per accident = Fatality Rate / Accident Rate.

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Table 7.4-5 Irradiated Fuel and Radioactive Waste Models Severity and Release Fractions (Page 1 of 1)

			Release Fractions			
Severity Category	Severity Fraction	Gas	Cesium	Ruthenium	Particulate	Corrosion Product
0	1.53E-08	0.8	2.40E-08	6.00E-07	6.00E-07	2.00E-03
1	5.88E-05	0.14	4.10E-09	1.00E-07	1.00E-07	1.40E-03
2	1.81E-06	0.18	5.40E-09	1.30E-07	1.30E-06	1.80E-03
3	7.49E-08	0.84	3.60E-05	3.80E-06	3.80E-06	3.20E-03
4	4.65E-07	0.43	1.30E-08	3.20E-07	3.20E-07	1.80E-03
5	3.31E-09	0.49	1.50E-08	3.70E-07	3.70E-07	2.10E-03
6	0	0.85	2.70E-05	2.10E-06	2.10E-06	3.10E-03
7	1.13E-08	0.82	2.40E-08	6.10E-07	6.10E-07	2.00E-02
8	8.03E-11	0.89	2.70E-08	6.70E-07	6.70E-07	2.20E-03
9	0	0.91	5.90E-06	6.80E-07	6.80E-07	2.50E-03
10	1.44E-10	0.82	2.40E-08	6.10E-07	6.10E-07	2.00E-03
11	1.02E-12	0.89	2.70E-08	6.70E-07	6.70E-07	2.20E-03
12	0	0.91	5.90E-06	6.80E-07	6.80E-07	2.50E-03
13	7.49E-11	0.84	9.60E-05	8.40E-05	1.80E-05	6.40E-03
14	0	0.85	5.50E-05	5.00E-05	9.00E-06	5.90E-03
15	0	0.91	5.90E-06	6.40E-06	6.80E-07	3.30E-03
16	0	0.91	5.90E-06	6.40E-06	6.80E-07	3.30E-03
17	5.86E-06	0.84	1.70E-05	6.70E-08	6.70E-08	2.50E-03
18	0.99993	0	0	0	0	0

Note:

Aerosol and Respirable Fractions set to 1.0.

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Table 7.4-6 Irradiated Fuel CCNPP Transportation Injury Rates (Page 1 of 1)

State	Injury Rate Injury / truck-mi (Injury / truck-km)	Distance mi (km)	Injury Rate Distance Weighted Fraction Injury / truck-mi (Injury / truck-km)
AZ	1.88E-07 (1.17E-07)	29.3 (47.1)	2.06E-09 (1.28E-09)
IL	2.41E-07 (1.50E-07)	162.6 (261.7)	1.46E-08 (9.10E-09)
IN	2.25E-07 (1.40E-07)	151.2 (243.4)	1.27E-08 (7.90E-09)
IA	1.38E-07 (8.60E-08)	307.0 (494.1)	1.59E-08 (9.85E-09)
MD	7.39E-07 (4.59E-07)	235.4 (378.8)	6.49E-08 (4.03E-08)
NE	3.17E-07 (1.97E-07)	456.6 (734.8)	5.41E-08 (3.36E-08)
NV	2.38E-07 (1.48E-07)	167.5 (269.5)	1.49E-08 (9.25E-09)
OH	2.25E-07 (1.40E-07)	239.9 (386.1)	2.01E-08 (1.25E-08)
PA	6.16E-07 (3.83E-07)	107.2 (172.6)	2.46E-08 (1.53E-08)
UT	4.07E-07 (2.53E-07)	379.2 (610.3)	5.76E-08 (3.58E-08)
WV	1.80E-07 (1.12E-07)	43.3 (69.7)	2.91E-09 (1.81E-09)
WY	5.20E-07 (3.23E-07)	400.5 (644.6)	7.77E-08 (4.83E-08)
	Sum:	2680 (4312.7)	3.62E-07 (2.25E-07)

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Table 7.4-7 New Fuel CCNPP Transportation Fatality and Injury Rates (Page 1 of 1)

State	Fatality Rate Fatalities / Truck-mi (fatality / truck-km)	Injury Rate Injuries Truck-mi (injury / truck-km)	Distance mi (km)	Fatality Rate Distance Weighted Fraction Fatality / Truck-mi (fatality / truck-km)	Injury Rate Distance Weighted Fraction Injury / Truck-mi (injury / truck-km)
ID	6.12E-09 (3.80E-09)	4.94E-07 (3.07E-07)	275.6 (443.5)	6.20E-10 (3.85E-10)	5.01E-08 (3.11E-08)
IL	1.34E-08 (8.30E-09)	2.41E-07 (1.50E-07)	162.6 (261.7)	7.98E-10 (4.96E-10)	1.44E-08 (8.96E-09)
IN	1.08E-08 (6.70E-09)	2.25E-07 (1.40E-07)	151.2 (243.4)	5.99E-10 (3.72E-10)	1.25E-08 (7.78E-09)
IA	1.51E-08 (9.40E-09)	1.38E-07 (8.60E-08)	305.3 (491.3)	1.69E-09 (1.05E-09)	1.55E-08 (9.64E-09)
MD	1.05E-08 (6.50E-09)	7.39E-07 (4.59E-07)	153.7 (247.4)	5.91E-10 (3.67E-10)	4.17E-08 (2.59E-08)
NE	2.20E-08 (1.37E-08)	3.17E-07 (1.97E-07)	452.7 (728.5)	3.67E-09 (2.28E-09)	5.28E-08 (3.28E-08)
OH	6.28E-09 (3.90E-09)	2.25E-07 (1.40E-07)	239.9 (386.1)	5.54E-10 (3.44E-10)	1.98E-08 (1.23E-08)
OR(1)	3.28E-08 (2.04E-08)	2.19E-07 (1.36E-07)	208.5 (335.5)	2.51E-09 (1.56E-09)	1.67E-08 (1.04E-08)
PA	2.17E-08 (1.35E-08)	6.16E-07 (3.83E-07)	187.3 (301.5)	1.50E-09 (9.29E-10)	4.25E-08 (2.64E-08)
UT	1.92E-08 (1.19E-08)	4.07E-07 (2.53E-07)	149.1 (240)	1.05E-09 (6.52E-10)	2.24E-08 (1.39E-08)
WA	2.90E-09 (1.80E-09)	2.90E-07 (1.80E-07)	35.7 (57.4)	3.80E-11 (2.36E-11)	3.80E-09 (2.36E-09)
WY	1.74E-08 (1.08E-08)	5.20E-07 (3.23E-07)	400.5 (644.6)	2.56E-09 (1.59E-09)	7.64E-08 (4.75E-08)
		Sum:	2723 (4380.9)	1.63E-08 (1.01E-08)	3.68E-07 (2.29E-07)

Note:

Interstate data not provided.

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Table 7.4-8 EPR Radwaste Annual Generation
(Page 1 of 1)

Waste Type	Annual Activity [a] Bq	Ci
Evaporator Concentrates	5.55E+12	1.50E+02
Spent Resins (other)	3.96E+13	1.07E+03
Spent Resins (Radwaste Demineralizer System)	5.55E+12	1.50E+02
Wet Waste from Demineralizers	5.55E+12	1.50E+02
Waste Drum for Solids Collection from Centrifuge System of KPF	5.55E+12	1.50E+02
Filters (quantity)	2.54E+13	6.86E+02
Sludge	5.55E+12	1.50E+02
Mixed Waste	1.48E+09	4.00E-02
Non-Compressible Dry Active Waste (DAW)	1.10E+10	2.97E-01
Compressible DAW	2.22E+11	6.01E+00
Combustible DAW	1.18E+12	3.19E+01
Total	9.41E+13	2.54E+03

Note:

(a) Refer to Section 3.5.

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Table 7.4-9 RADTRAN/TRAGIS Radwaste Model Input Parameters (Page 1 of 1)

Parameter		CCNPP Model EPR
TRAGIS Input:		
Route Mode		Commercial
Route Origin		CCNPP
Route Destination		Hanford, WA
RADTRAN Input from TRAGIS:		
Total Shipping Distance, mi (km)		2,733 (4,399)
Travel Distance - Rural, mi (km)		2,063 (3,320)
Travel Distance - Suburban, mi (km)		594 (955.5)
Travel Distance - Urban, mi (km)		76.5 (123.2)
Population Density - Rural, person/mi^2 (person/km^2)		30 (11.6)
Population Density - Suburban, person/mi^2 (person/km^2)		835 (322.4)
Population Density - Urban, person/mi^2 (person/km^2)		6,085 (2,349.5)
Stop Time, hr/trip		5.0 [(b)]
RADTRAN Input from NRC Models [(a)]		
Vehicle Speed, mph (km/hr)		55 (88.49)
Traffic Count - Rural, vehicles/hr		530
Traffic Count - Suburban, vehicles/hr		760
Traffic Count - Urban, vehicles/hr		2,400
Dose Rate at 3 ft (1 m) from Vehicle, mrem/hr (mSv/hr)		14 (0.14)
Packaging Length, ft (m)		17 (5.2)
Packaging Diameter, ft (m)		3.3 (1.0)
Number of Truck Crew		2
Population Density at Stops (radii: 3.3 to 33 ft (1 to 10 m)), person/mi^2 (person/km^2)		77,700 (30,000)
Population Density at Stops (radii: 33 to 2,655 ft (10 to 800 m)), person/mi^2 (person/km^2)		881 (340)
Shielding Factor at Stops (radii: 3.3 to 33 ft (1 to 10 m))		1
Shielding Factor at Stops (radii: 33 to 2,655 ft (10 to 800 m))		0.2

Notes:

(a) From NUREG-1815 for spent fuel shipments.
(b) Based on TRAGIS output: 11 stops at 30 minutes each.

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Table 7.4-10 Radwaste Annual Source Term
(Page 1 of 1)

Radionuclide	RADTRAN Input Annual Activity Bq	Ci
Ce-144	3.89E+10	1.05E+00
Co-58	5.36E+12	1.45E+02
C0-60	9.87E+12	2.67E+02
Cs-134	1.06E+13	2.85E+02
Cs-137	1.94E+13	5.25E+02
Fe-55	1.98E+13	5.36E+02
I-129	3.35E+07	9.06E-04
I-131	3.39E+08	9.16E-03
Mn-54	1.55E+13	4.18E+02
Pu-241	1.26E+10	3.39E-01
Ru-103	8.04E+11	2.17E+01
Ru-106	1.04E+12	2.80E+01
Sb-124	4.22E+08	1.14E-02
Sb-125	1.38E+09	3.74E-02
Sr-89	4.92E+08	1.33E-02
Sr-90	1.24E+11	3.36E+00
Y-90	1.21E+11	3.27E+00
Zn-65	4.06E+12	1.10E+02

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Table 7.4-11 Radwaste CCNPP Transportation Accident, Fatality and Injury Rates (Page 1 of 1)

	Accident Rate	Fatality Rate	Injury Rate	Distance	Distance Weighted Fraction		
State	Accidents / truck-mi (Accidents / truck-km)	Fatalities / truck-mi (Fatalities / truck-km)	Injuries / truck-mi (Injuries / truck-km)	mi (km) [a]	Accident Rate	Fatality Rate	Injury Rate
ID	4.75E-07 (2.95E-07)	6.12E-09 (3.80E-09)	4.94E-07 (3.07E-07)	72 (116.6)	7.82E-09	1.01E-10	8.14E-09
IL	3.57E-07 (2.22E-07)	1.34E-08 (8.30E-09)	2.41E-07 (1.50E-07)	118 (190.7)	9.62E-09	3.60E-10	6.50E-09
IN	3.62E-07 (2.25E-07)	1.08E-08 (6.70E-09)	2.25E-07 (1.40E-07)	151 (243.4)	1.24E-08	3.71E-10	7.75E-09
MD	8.69E-07 (5.40E-07)	1.05E-08 (6.50E-09)	7.39E-07 (4.59E-07)	154 (247.4)	3.04E-08	3.66E-10	2.58E-08
MN	2.75E-07 (1.71E-07)	4.82E-09 (3.00E-09)	1.35E-07 (8.40E-08)	275 (442.4)	1.72E-08	3.02E-10	8.45E-09
MT	9.98E-07 (6.20E-07)	2.19E-08 (1.36E-08)	4.12E-07 (2.56E-07)	552 (888.5)	1.25E-07	2.75E-09	5.17E-08
OH	2.64E-07 (1.64E-07)	6.28E-09 (3.90E-09)	2.25E-07 (1.40E-07)	240 (386.1)	1.44E-08	3.42E-10	1.23E-08
PA	8.27E-07 (5.14E-07)	2.17E-08 (1.35E-08)	6.16E-07 (3.83E-07)	187 (301.5)	3.52E-08	9.25E-10	2.62E-08
SD	3.75E-07 (2.33E-07)	9.82E-09 (6.10E-09)	2.77E-07 (1.72E-07)	412 (662.4)	3.51E-08	9.19E-10	2.59E-08
WA	4.26E-07 (2.65E-07)	2.90E-09 (1.80E-09)	2.90E-07 (1.80E-07)	175 (281.5)	1.70E-08	1.15E-10	1.15E-08
WI	7.23E-07 (4.49E-07)	1.46E-08 9.10E-09	5.36E-07 3.33E-07	188 (301.9)	3.08E-08	6.25E-10	2.29E-08
WY	1.08E-07 (6.74E-07)	1.74E-08 (1.08E-08)	5.20E-07 (3.23E-07)	209 (336.7)	5.16E-08	8.27E-10	2.47E-08
Sum:				2,733 mi (4,399 km)	6.23E-07 (3.87E-07)	1.29E-08 (8.00E-09) Per truck-mi (per truck-km)	3.73E-07 (2.32E-07)
Fatalities per Accident [b] :						2.07E-02 Fatalities per accident	

Notes:

(a) From TRAGIS.

(b) Fatalities per accident = Fatality Rate / Accident Rate.

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Table 7.4-12 Population Dose from Transportation Accidents
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Environmental Impact	New Fuel	Irradiated Fuel	Radwaste	Total
U.S. EPR Dose Person-rem/ U.S. EPR-reactor-year (person-Sv/ U.S. EPR-reactor-year)	See below	1.9E-04 (1.9E-06)	8.2E-06 (8.2E-08)	2.0E-04 (2.0E-06)
Normalized Dose Person-rem/1000 MWe reactor-year (person-Sv/1000 MWe reactor-year)	See below	1.1E-04 (1.1E-06)	4.6E-06 (4.6E-08)	1.1E-04 (1.1E-06)
The dose from new fuel accidents is assumed to be negligible compared to the doses from Irradiated Fuel and Radioactive Waste as described in Section 7.4.2.				

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Table 7.4-13 U.S. EPR Summary of Annual Transportation Accident Non-Radiological Impact (Page 1 of 1)

Environmental Impact	New Fuel	Irradiated Fuel	Radwaste	Total	10 CFR 51.52 Table S-4
Fatal Injury per 100 reactor years	0.066	0.18	1.1E-01	0,36	1.0
Non-Fatal Injury per 10 reactor years	0.15	0.41	3.1E-01	0.87	1.0

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