



WESTSIDE SUBWAY EXTENSION PROJECT

Preliminary Geotechnical and Environmental Report

(Volume 1) (Part 2 of 2)



December 2011

THIS PAGE INTENTIONALLY LEFT BLANK



Table of Contents

VOLUME 1

EXECUTIVE SUMMARYES-1

1.0 INTRODUCTION 1-1

1.1 Scope of Work..... 1-2

1.1.1 Geotechnical Investigation 1-2

1.1.2 Noise and Vibration Monitoring Program 1-3

1.1.3 Fault Hazard Investigation for Santa Monica Fault and West Beverly Hills Lineament..... 1-4

1.1.4 Hydrogeologic Studies for Stations and Tunnel 1-4

1.1.5 Geologic/Seismic Hazards Evaluation..... 1-4

1.1.6 Subsurface Gas Investigation 1-5

1.1.7 Phase II Environmental Investigation 1-5

1.1.8 Oil Well Surveys 1-6

1.1.9 Existing Foundation Data Record Search 1-6

1.2 Report Structure 1-6

1.3 Limitations and Basis for Recommendations..... 1-7

2.0 PROJECT DESCRIPTION..... 2-1

2.1 General..... 2-1

2.2 Stations/Crossovers..... 2-2

2.3 Cross Passages 2-5

3.0 FIELD EXPLORATIONS..... 3-1

3.1 General..... 3-1

3.1.1 Health and Safety Plan..... 3-1

3.1.2 Permits..... 3-1

3.1.3 Mark Borings and Underground Service Alert (Dig Alert) 3-2

3.1.4 Utility Clearance..... 3-2

3.1.5 Traffic Control Measures 3-2

3.1.6 Public Notification of Field Work..... 3-3

3.2 Geotechnical Explorations..... 3-3

3.2.1 Prior Explorations - Advanced Conceptual Engineering (ACE) Phase 3-3

3.2.2 Current Explorations - Preliminary Engineering (PE) Phase 3-5

3.2.3 Sonic Core Borings 3-15

3.2.4 Cone Penetration Testing 3-16

3.2.5 Dilatometer Testing 3-16

3.2.6 BAT® Groundwater/Gas Sampling in CPTs 3-16

3.2.7 Groundwater Monitoring Wells 3-18

3.3 Fault Investigation..... 3-20

3.4 Subsurface Gas Investigation 3-20

3.4.1 General..... 3-20

3.4.2 Advanced Conceptual Engineering (ACE) Phase..... 3-24

3.4.3 Preliminary Engineering (PE) Phase 3-24

3.4.4 Summary of Results (PE phase)..... 3-45

3.5	Hydrogeologic Investigation.....	3-46
3.5.1	Summary of Explorations	3-47
3.6	Phase II Environmental Site Assessment.....	3-53
3.6.1	Summary of Phase II Environmental Explorations	3-53
3.6.2	Summary of Phase II Environmental Field Observations.....	3-56
3.7	Oil Well Surveys	3-60
4.0	LABORATORY TESTING	4-1
4.1	Geotechnical Exploration Testing.....	4-1
4.1.1	Field Moisture Content and Dry Density.....	4-1
4.1.2	Sieve Analysis and Passing No. 200 Sieve	4-1
4.1.3	Atterberg Limits	4-2
4.1.4	Tar Content.....	4-2
4.1.5	Direct Shear	4-5
4.1.6	Consolidation.....	4-5
4.1.7	Expansion/Collapse.....	4-5
4.1.8	Triaxial Consolidation-Undrained.....	4-6
4.1.9	Unconfined Compression	4-6
4.1.10	Soil Abrasion	4-6
4.1.11	Analytical Testing of Groundwater	4-9
4.1.12	Corrosion	4-9
4.2	Subsurface Gas Exploration Testing	4-10
4.3	Hydrogeologic Investigation Testing	4-10
4.4	Phase II Environmental Site Assessment Testing	4-10
4.4.1	Summary of Laboratory Test Results	4-12
5.0	PROJECT GEOLOGY.....	5-1
5.1	Geologic Setting of Study Area	5-1
5.2	Overview of Stratigraphy.....	5-3
5.2.1	Younger Alluvium (Regional geologic map symbols: Qyf and Qf; Profile symbol: Qal).....	5-4
5.2.2	Older Alluvium (Regional geologic map symbol: Qof; Profile symbol: Qalo).....	5-4
5.2.3	Lakewood Formation (Profile symbol: Qlw).....	5-9
5.2.4	San Pedro Formation (Regional geologic map and profile symbol: Qsp)	5-9
5.2.5	Fernando Formation (Profile symbol: Qf)	5-9
5.2.6	Tar Sands	5-10
5.3	Geologic Structure.....	5-10
5.4	Groundwater	5-10
5.5	Geologic/Seismic Hazards.....	5-13
5.5.1	Faults.....	5-13
5.5.2	Seismicity.....	5-19
5.5.3	Historic Earthquakes.....	5-19
5.5.4	Ground Motion Evaluation.....	5-20
5.5.5	Liquefaction	5-21
6.0	FAULT INVESTIGATION SUMMARY	6-1



7.0 ENGINEERING PROPERTIES OF PRINCIPAL GEOLOGIC UNITS 7-1

8.0 SUBSURFACE GAS INVESTIGATION SUMMARY..... 8-1

9.0 PHASE II ENVIRONMENTAL SITE ASSESSMENT SUMMARY..... 9-1

 9.1 Findings Discussion..... 9-1

 9.1.1 Conclusions and Recommendations 9-13

10.0 OIL WELL SURVEY SUMMARY 10-1

 10.1.1 Beverly Hills High School (football and lacrosse fields and tennis courts) 10-1

 10.1.2 1950 Century Park East..... 10-1

 10.1.3 Parking lot northeast of Constellation and Avenue of the Stars 10-1

 10.1.4 Northwest quadrant of Wilshire and Fairfax (Johnie’s Coffee Shop) 10-1

 10.1.5 Beverly Hills High School (football and lacrosse fields and tennis courts) 10-1

 10.1.6 1950 Century Park East..... 10-2

 10.1.7 Parking lot northeast of Constellation and Avenue of the Stars 10-2

 10.1.8 Northwest quadrant of Wilshire and Fairfax (Johnie’s Coffee Shop) 10-2

 10.1.9 Summary 10-3

11.0 REFERENCES 11-1

List of Plates

- Plate 1: Exploration Map
- Plates 1-00 to 1-21: Boring Plan and Geologic Profile
- Plates 1-22 to 1-28: Subsurface Gas Data
- Plates 2-0 to 2-7: Soil Profiles
- Plate 3-1: Plot of Subsurface Gas Data - Fairfax area
- Plate 3-2: Plot of Subsurface Gas Data - Century City area

List of Tables

Table 3-1:	Summary of Prior Geotechnical Borings (ACE Phase).....	3-4
Table 3-2:	Groundwater Monitoring Well Data (ACE Phase)	3-6
Table 3-3:	Summary of Geotechnical Rotary-Wash and Sonic Borings (PE Phase)	3-8
Table 3-4:	Pressuremeter Test Results (PE Phase)	3-12
Table 3-5:	Noise/Vibration Test Locations and Test Depths.....	3-15
Table 3-6:	Monitoring Well Data in Geotechnical Borings (PE Phase).....	3-19
Table 3-7:	2009/2010 Field and Lab Gas Monitoring Data in Prior (ACE Phase) Gas Monitoring Wells.....	3-25
Table 3-8:	Current (2011) Field Gas Monitoring Data in Prior (ACE Phase and TRC) Gas Monitoring Wells and Vapor Probes.....	3-29
Table 3-9:	2011 Field and Lab Measurements of Methane, Hydrogen Sulfide, Oxygen and Carbon dioxide Concentrations in Air Monitoring of Nested Probes and Wells (PE Phase).....	3-38
Table 3-10:	2011 Lab Gas Test Data in Water Samples Collected from Monitoring Wells (PE Phase)	3-43
Table 3-11:	List of Analytes and Test Methodology	3-49
Table 3-12:	List of Analytes and Effluent Limits	3-50
Table 3-13:	Summary of Suspect Sources for Environmental Site Assessment.....	3-54
Table 3-14:	Summary of Explorations for Environmental Site Assessment	3-55
Table 3-15:	Summary of Explorations	3-57
Table 4-1:	Laboratory Tests Performed for ACE and PE Phases.....	4-1
Table 4-2:	Tar Content Test Results.....	4-2
Table 4-3:	Tar Content Classification	4-4
Table 4-4:	Direct Shear Rate of Shearing	4-5
Table 4-5:	Unconfined Compression Strength Test Results.....	4-6
Table 4-6:	Classification of Abrasivity of Soil and Rock	4-7
Table 4-7:	Abrasion Test Results.....	4-7
Table 4-8:	Abrasion Test Results by Geologic Formations.....	4-9
Table 4-9:	Analytical Test Program for ESA.....	4-11
Table 4-10:	Soil Sample Analytical Laboratory Results (VOCs/SVOCs/TPH).....	4-21
Table 4-11:	Soil Sample Analytical Laboratory Results - Title 22 Metals.....	4-25
Table 4-12:	Groundwater Sample Analytical Results	4-26
Table 5-1:	List of Historic Earthquakes with Magnitude greater than 5.5 (Within last 150 years and within 60 Km of the west terminus of tunnel alignment)	5-19
Table 5-2:	List of Historic Earthquakes with Magnitude greater 5.5 (Within last 150 years and within 60 Km of the east terminus of tunnel alignment)	5-20
Table 5-3:	Peak Ground Acceleration for ODE and MDE	5-20
Table 5-4:	Liquefaction Summary for Wilshire/La Cienega Station.....	5-22



Table 5-5: Liquefaction Summary for Westwood/UCLA Station..... 5-23
 Table 7-1: Engineering Properties of Principal Geologic Units..... 7-3
 Table 9-1: Impacted Soil and/or Groundwater Boring Locations 9-3
 Table 9-2: Impacted Groundwater Boring Locations at Stations 9-13

List of Figures

Figure 2-1: Tunnel Alignment 2-3
 Figure 3-1: Methane Hazard Zones..... 3-21
 Figure 3-2: Pump Test Well Locations at Westwood/UCLA Station..... 3-46
 Figure 3-3: Generalized Profile for Westwood/UCLA Station Pumping Test..... 3-48
 Figure 5-1: Geologic Time Scale 5-2
 Figure 5-2: Regional Geologic Map 5-7
 Figure 5-3: Santa Monica Fault Zone 5-15
 Figure 6-1: Santa Monica Fault Zone and West Beverly Hills Lineament..... 6-1

VOLUME 2

Appendix A (Geotechnical Investigation)

Figure A-1.0: Unified Soil Classification System
 Figures A-1.1a through A-1.19c: Logs of Rotary-Wash Borings (ACE Phase)
 Figures A-1.20a through A-1.21l: Logs of Sonic Core Borings (ACE Phase)
 Figures A-2.1a through A-2.80c: Logs of Rotary-Wash Borings (PE Phase)
 Figures A-3.1a through A-3.17f: Logs of Sonic Core Borings (PE Phase)
 Figures A-4.1 through A-4.101: CPT Logs (PE Phase)
 Figures A-5.1 through A-5.3: DMT Plots (PE Phase)
 Figure A-6: Crandall Sampler
 Figures A-7.1 through A-7.6: Ground Water Monitoring Well Diagrams (ACE Phase)
 Figures A-8.1 through A-8.11: Ground Water Monitoring Well Diagrams (PE Phase)
 Figures A-9.1 through A-9.101: Sonic Core Photographic Logs (PE Phase)
 Figures A-10.1 through 10.78: Noise/Vibration Testing (PE Phase)

Appendix B (Subsurface Gas Investigation)

Figures B-1.1a through B-1.20b: Logs of Hollow-Stem Auger Borings (ACE Phase)
 Figures B-2.1a through B-2.19c: Logs of Hollow-Stem Auger Borings (PE Phase)
 Figures B-3.0 through B-3.24: Gas Monitoring Well Diagrams (ACE Phase)
 Figures B-4.1 through B-4.19: Gas Monitoring Well Diagrams (PE Phase)
 Figures B-5.1 through B-5.8: Field Soil Gas and Hydrogen Sulfide Measurements

Appendix C (Hydrogeologic Investigation)

Figures C-1.1a through C-1.3d: Logs of Borings (PE Phase)

Figures C-2.1 through C-2.4: Ground-water Monitoring Well Diagrams

Figures C-3.1 through C-3.84: Notice of Intent (NOI)

Figures C-4.1 through C-4.2: National Pollution Discharge Elimination System (NPDES) Permit

Figures C-5.1 through C-5.18: California Regional Water Quality Control Board Permit

Appendix D (Environmental Site Assessment)

Figures D-1.1a through D-1.31b: Logs of Borings (PE Phase)

Appendix E (Oil Well Survey)

Figures E-1.1 through E-1.50: Oil Well Survey Reports

VOLUME 3

Appendix F (Laboratory Testing)

Table F-1.1 ACE Lab Summary (Rotary-Wash)

Table F-1.2 PE Lab Summary (Rotary-Wash)

Table F-1.3 PE Lab Summary (Sonic Cores)

Figures F-1.1 through F-1.67 Direct Shear Test Data (ACE & PE Phases)

Figures F-2.1 through F-2.422 Triaxial Test Data (PE Phase)

Figures F-3.1 through F-3.7 Consolidation Test Data (ACE Phase)

Figures F-4.1 through F-4.97 Consolidation Test Data (PE Phase)

Figures F-5.1 through F-5.11 Particle Size Distribution (ACE Phase)

Figures F-6.1 through F-6.224 Particle Size Distribution (PE Phase)

Figures F-7.1.1 through F-7.1.2 Atterberg Limits (ACE Phase)

Figures F-7.2.1 through F-7.2.26 Atterberg Limits (PE Phase)

Figures F-8.1 through F-8.26 Hydroconsolidation Test Data (PE Phase)

Figures F-9.1 through F-9.15 Corrosion Test Data (ACE Phase)

Figures F-10.1 through F-10.62 Corrosion Test Data (PE Phase)

Figures F-10.63.1 through F-10.63.18 Soil Corrosivity Evaluation – Wilshire/La Brea Station

Figures F-10.64.1 through F-10.64.19 Soil Corrosivity Evaluation – Wilshire/Fairfax Station

Figures F-10.65.1 through F-10.65.19 Soil Corrosivity Evaluation – Wilshire/La Cienega Station

Figures F-10.66.1 through F-10.66.18 Soil Corrosivity Evaluation – Wilshire/Rodeo Station

Figures F-10.67.1 through F-10.67.16 Soil Corrosivity Evaluation – Century City Constellation Station

Figures F-10.68.1 through F-10.68.19 Soil Corrosivity Evaluation – Westwood/UCLA Station

Figures F-10.69.1 through F-10.69.19 Soil Corrosivity Evaluation – Westwood/VA Hospital Station

Figures F-10.70.1 through F-10.70.16 Soil Corrosivity Evaluation – Century City Santa Monica Station

Figures F-11.1 through F-11.6 Analytical Testing of BAT Samples (PE Phase)

Figures F-11.7 through F-11.34 Analytical Testing of Groundwater Samples

Figures F-12.1 through F-12.10 Analytical Testing of Tar Sands (PE Phase)

Figures F-13.1 through F-13.51 Abrasion Testing (PE Phase)

Figures F-14.1 through F-14.12 Unconfined Compression Test Data (PE Phase)

Appendix G (Subsurface Gas Investigation)

Figures G-1.1 through G-1.43: Analytical Test Results (ACE Phase)

Figures G-2.1 through G-2.28: Analytical Test Results (PE Phase)

Figures G-3.1.1 through G-3.11.13: Vapor Sample Data (PE Phase)

Appendix H (Hydrogeologic Investigation)

Figures H-1.1 through H-1.91: Analytical Test Results of Groundwater Samples (PE Phase)

Appendix I (Environmental Site Assessment)

Figures I-1.1 through I-1.1071: Analytical Test Results of Soil and Groundwater Samples (PE Phase)

THIS PAGE INTENTIONALLY LEFT BLANK