SOIL CORROSIVITY EVALUATION

for the

WESTSIDE SUBWAY EXTENSION

WESTWOOD/VA HOSPITAL STATION

in

LOS ANGELES, CA

prepared for

AMEC E&I
5628 East Slauson Avenue
Los Angeles, CA 90040

Project No.: 4953-10-1561

PROJECT MANAGER: MR. MARTY HUDSON

prepared by

HDR ENGINEERING, INC.
Consulting Corrosion Engineers
431 West Baseline Road
Claremont, California 91711

HDR|SCHIFF #172549

October 18, 2011

EXECUTIVE SUMMARY

The Westside Subway Extension is a proposed extension of the Metro Purple Line subway westward from the Wilshire/Western Station to the Veterans Administration West Los Angeles Hospital. Westwood/VA Hospital station is one of the eight stations planned for the project. The station will be approximately 880 feet long and about 70 to 80 feet below ground surface.

Laboratory tests on the soil samples provided by AMEC E&I have been completed. 17 of the samples were selected for analysis. This soil is classified as severely corrosive to ferrous metals and aggressive with respect to exposure of reinforcing steel to the migration of chloride based on the Metro Rail Design Criteria.

A dielectrically coated steel pipeline for this route should also have bonded joints and test stations. In addition, cathodic protection should be installed and applied concurrently with the pipeline.

Cathodically protect and provide corrosion monitoring for hydraulic elevators and associated components as required for compliance with Title 23 as necessary.

A dielectrically coated ductile iron pipe would also be a suitable choice. In addition, cathodic protection should be installed and applied concurrently with the pipeline.

A polyvinyl chloride (PVC) pipe would also be a suitable choice. Coat any iron parts, such as fittings and valves, with a high quality dielectric coating.

Type II cement may be used for concrete structures. Chloride levels were measured at levels where additional protective measures are required for concrete, including increased cover, admixtures, or other modifications of design base on the Metro Rail Design Criteria. Any contact between concrete structures and ground water should be prevented. Contact can be prevented with an impermeable waterproofing system.

Due to the soils at this site, post-tensioned slabs should be protected in accordance with soil considered aggressive (corrosive).

Table of Contents

INTRODUCTION

The existing subway system is owned and operated by Los Angeles County Metropolitan Transportation Authority (MTA) and provides public transportation throughout the City of Los Angeles, and surrounding areas.

The Westside Subway Extension is a proposed extension of the Metro Purple Line subway westward from the Wilshire/Western Station to the Veterans Administration West Los Angeles Hospital. In the Century City area, two alternative alignments are considered; one with a station along Santa Monica Boulevard, and one with a station along Constellation Boulevard. The proposed subway alignment is about 9 miles long. The depth to tunnel invert varies along the alignment from 40 to 160 feet below grade. The subway will consist of heavy rail transit operated in a twin tunnel configuration with eight new passenger stations, with two options in Century City.

Westwood/VA Hospital station is one of the eight stations planned for the project. The station will be approximately 880 feet long and about 70 to 80 feet below ground surface. Ground water was encountered at depths of about 40 to 70 feet below ground surface. The station will include walls below grade, utility piping, hydraulic elevator systems, concrete structures and post-tensioning systems.

An analysis of soil corrosivity along the route of the Metro rail alignment was requested. Laboratory tests on the soil samples provided by AMEC E&I have been completed. 17 of the samples were selected for analysis. HDR Engineering, Inc. (HDR|Schiff) assumes that the samples selected are representative of the most corrosive soils at the site.

The scope of this study is limited to a determination of soil corrosivity and general corrosion control recommendations for materials planned for construction. HDR|Schiff understands shoring piles will be used only temporarily during construction and will not be considered in this study. If steel piles are considered for use as permanent structures in the future, HDR|Schiff will be glad to perform Romanoff similitude analysis for metal loss and determine estimated corrosion rates.

LABORATORY TESTS ON SOIL SAMPLES

The electrical resistivity of each of the 17 samples was measured in a soil box per ASTM G187 in its as-received condition and again after saturation with distilled water. Resistivities are at about their lowest value when the soil is saturated. The pH of the saturated samples was measured per ASTM G 51. A 5:1 water:soil extract from each sample was chemically analyzed for the major soluble salts commonly found in soil per ASTM D4327, D6919, and D513. Test results are shown in Table 1 in the Appendix to this report.

SOIL CORROSIVITY

A major factor in determining soil corrosivity is electrical resistivity. The electrical resistivity of a soil is a measure of its resistance to the flow of electrical current. Corrosion of buried metal is an electrochemical process in which the amount of metal loss due to corrosion is directly proportional to the flow of electrical current (DC) from the metal into the soil. Corrosion currents, following Ohm's Law, are inversely proportional to soil resistivity. Lower electrical resistivities result from higher moisture and soluble salt contents and indicate corrosive soil.

A correlation between electrical resistivity and corrosivity toward ferrous metals is (Romanoff, 1989):

Soil Resistivity in ohm-centimeters	Corrosivity Category
Greater than 10,000	Mildly Corrosive
2,001 to 10,000	Moderately Corrosive
1,001 to 2,000	Corrosive
0 to 1,000	Severely Corrosive

Other soil characteristics that may influence corrosivity towards metals are pH, soluble salt content, soil types, aeration, anaerobic conditions, and site drainage.

Electrical resistivities were in the mildly corrosive to severely corrosive categories with as-received moisture. When saturated, the resistivities were in the moderately to severely corrosive categories. Some as-received resistivities were at or near their saturated values. The remaining resistivities dropped considerably with added moisture because the samples were dry as-received.

Soil pH values varied from 6.9 to 8.0. This range is neutral to moderately alkaline (Romanoff, 1989). These values do not particularly increase soil corrosivity.

The soluble salt content of the samples ranged from low to moderate.

The soluble salt content was moderate in the sample from boring G-203 @ 45.5’ and less in the others. Chloride salts were the predominant constituents. Chloride is particularly corrosive to ferrous metals, and in the higher concentrations measured in the soil samples, chloride can overcome the corrosion inhibiting effect of concrete on reinforcing steel.

Nitrate was detected in low concentrations.

Some of the samples were tested for sulfides as they exhibited characteristics typically associated with anaerobic conditions. Sulfide, which is aggressive to copper and ferrous metals, showed no reaction in a qualitative test. The positive redox potentials measured in the samples from G-203 @ 30’, 45.5’, and 80.5’, G-204 @ 10’, 40’, 80’, and 100’, and G-205 @ 50’ and 95.5’ indicates oxidizing conditions in which anaerobic, sulfide-producing bacteria are inactive.

The variation in soil types can create differential-aeration corrosion cells that would affect all metals.

This soil is classified as severely corrosive to ferrous metals and aggressive with respect to exposure of reinforcing steel to the migration of chloride based on the Metro Rail Design Criteria.

Heavy rail transit systems can present a multitude of DC stray current issues. These issues can affect not only the system of concern, but also other metallic utilities or structures proximal to rails, and DC substations if the proper mitigation practices are not followed. Stray current can increase corrosion rates above what would be expected from the chemical characteristics alone.

CONCLUSIONS

This soil is classified as severely corrosive to ferrous metals and aggressive with respect to exposure of reinforcing steel to the migration of chloride based on the Metro Rail Design Criteria.

A dielectrically coated steel pipeline for this route should also have bonded joints and test stations. In addition, cathodic protection should be installed and applied concurrently with the pipeline.

Cathodically protect and provide corrosion monitoring for hydraulic elevators and associated components as required for compliance with Title 23 as necessary.

A dielectrically coated ductile iron pipe would also be a suitable choice. In addition, cathodic protection should be installed and applied concurrently with the pipeline.

A polyvinyl chloride (PVC) pipe would also be a suitable choice. Coat any iron parts, such as fittings and valves, with a high quality dielectric coating.

Type II cement may be used for concrete structures. Chloride levels were measured at levels where additional protective measures are required for concrete, including increased cover, admixtures, or other modifications of design base on the Metro Rail Design Criteria. Any contact between concrete structures and ground water should be prevented. Contact can be prevented with an impermeable waterproofing system.

Due to the soils at this site, post-tensioned slabs should be protected in accordance with soil considered aggressive (corrosive).

Due to the nature and magnitude of the project and the long design service life requirements, tolerance for corrosion on all project components is low. Based on the need for high reliability and the corrosivity considerations discussed above, it is clear that corrosion protection must be provided for the components exposed to the environment discussed with consideration given to the level of risk and practicality.

RECOMMENDATIONS

DC Stray Current

A study of the impact of the DC powered heavy rail system was not detailed as part of the scope work in this project. It is recommended that the client pursue such a study in order to take the necessary precautions to avoid the deleterious effects known to result from DC stray current.

Steel Pipe

Implement *all* the following measures.

1. Underground steel pipe with rubber gasketed, mechanical, grooved end, or other nonconductive type joints should be bonded for electrical continuity. For pipe diameters less 18 inches use two joint bonds. For pipe diameters greater than or equal to 18 inches use three joint bonds. Electrical continuity is necessary for corrosion monitoring and cathodic protection.

2. Install corrosion monitoring test stations to facilitate corrosion monitoring and the application of cathodic protection:
    a. Two or four-wire test stations at each end of the pipeline depending on how the pipe terminates.
    b. Four-wire test stations at all buried insulating joints.
    c. Four-wire test stations at each end of all casings.
    d. Two-wire test stations at other locations as necessary so the interval between test stations does not exceed 1,200 feet.

    Where 4-wire test stations are required, use wires of difference size or insulation color for identification. Each wire should be independently welded or pin-brazed to the pipe.

3. To prevent dissimilar metal corrosion cells and to facilitate the application of cathodic protection, electrically isolate each buried steel pipeline per NACE Standard SP0286 from:
    a. Pumping plants.
    b. Reservoirs.
    c. Flow meters.
    d. Motorized operated valves.
    e. Dissimilar metals.
    f. Dissimilarly coated piping (cement-mortar vs. dielectric).
    g. Above ground steel pipe.
    h. All existing piping.

    Insulated joints should be placed above grade or in vaults where possible. Wrap all buried insulators with wax tape per AWWA C217.

4. Prevent contact between the steel pipe and concrete and/or reinforcing steel, such as at wall penetrations and thrust blocks, with such items as plastic sleeves, rubber seals, or 20 mil plastic tape.

5. Apply a suitable dielectric coating intended for underground use such as:
    a. Polyurethane per AWWA C222 *or*
    b. Extruded polyethylene per AWWA C215 *or*
    c. A tape coating system per AWWA C214 *or*
    d. Hot applied coal tar enamel per AWWA C203 *or*
    e. Fusion bonded epoxy per AWWA C213.

6. Buried steel and iron pipe, fittings, and valves in appurtenances, such as air valves and blowoffs, should be coated with a material listed above or with coal-tar epoxy, wax tape, moldable sealant, or equivalent. If copper is used, electrically insulate it from the steel with an insulating joint or with a dielectric union.

7. Apply cathodic protection to steel piping as per NACE Standard SP0169.

8. To insure that corrosion control is properly designed, preliminary construction drawings should be reviewed by a qualified corrosion engineer.

9. After the pipeline is backfilled, but before the construction contract is completed, the pipeline should be tested to insure that the joint bonds are intact and test stations properly installed. Also, native pipe-to-soil potentials should be measured and recorded. These data will be useful in determining if pipeline conditions change in the future.

10. Pipe-to-soil potentials should be measured biennially to determine if conditions on the pipeline are changing.

Hydraulic Elevator

Implement *all* the following measures:

1. Coat hydraulic elevator cylinders as described above for steel pipe, item #5a -#5e5 that is resistant to petroleum products (hydraulic fluid).
2. Electrically insulate each cylinder from building metals by installing dielectric material between the piston platen and car, insulating the bolts, and installing an insulated joint in the oil line.
3. Place each cylinder in a non-metallic casing with a plastic watertight seal at the bottom. Fill the annulus with dry sand with a minimum resistivity of 25,000 ohm-centimeters, a pH of between 6.5 and 7.5 and a maximum chloride content of 200 ppm.
4. A removable moisture-proof sealing lid installed on the top of the casing prior to installation of the cylinder. The top of the casing shall be permanently sealed against moisture intrusion after installation of the cylinder.
5. Apply cathodic protection to hydraulic cylinders as per NACE Standard SP0169.

6. The elevator oil line should be placed above ground if possible but, if underground, should be protected by one of the following corrosion control options:

   OPTION 1

   a. Provide a bonded dielectric coating.
   b. Electrically isolate the pipeline.
   c. Apply cathodic protection to steel piping as per NACE Standard SP0169.

   OPTION 2

   a. Place the oil line in a PVC casing pipe with solvent-welded joints to prevent contact with soil and soil moisture.

7. If Steel underground storage tanks are used, cathodic protection and corrosion control requirements shall comply with Title 23.

Reinforced Concrete Pipe (Non-Pressurized)

Implement *all* the following measures.

1. To prevent dissimilar metal corrosion cells electrically isolate the storm drain per NACE Standard SP0286 from all structures and facilities.

   Insulated joints should be placed above grade or in vaults where possible. Wrap all buried insulators with wax tape per AWWA C217.

2. Prevent contact between the steel pipe and concrete and/or reinforcing steel, such as at wall penetrations and thrust blocks, with such items as plastic sleeves, rubber seals, or 20 mil plastic tape.

3. Buried steel and iron pipe and fittings in appurtenances should be cement-mortar coated or concrete or cement slurry encased where possible. Otherwise, they should be wrapped with wax tape per AWWA Standard C-217

4. To insure that corrosion control is properly designed, preliminary construction drawings should be reviewed by a qualified corrosion engineer.

5. Apply a suitable dielectric waterproofing coating intended for underground use. This coating is to be compatible with and applied over the concrete/cement-mortar.

Iron Pipe

Implement *all* the following measures:

1. To prevent dissimilar metal corrosion cells and to facilitate the application of cathodic protection, electrically isolate each buried iron pipeline per NACE Standard SP0286 from:

   a. Pumping plants.

b. Reservoirs.
c. Flow meters.
d. Motorized operated valves.
e. Dissimilar metals.
f. Dissimilarly coated piping (cement-mortar vs. dielectric).
g. Above ground steel pipe.
h. All existing piping.

Insulated joints should be placed above grade or in vaults where possible. Wrap all buried insulators with wax tape per AWWA C217.

2. Bond all nonconductive type joints for electrical continuity. Electrical continuity is necessary for corrosion monitoring and cathodic protection. For pipe diameters less 18 inches use two joint bonds. For pipe diameters greater than or equal to 18 inches use three joint bonds. Electrical continuity is necessary for corrosion monitoring and cathodic protection.

3. Install corrosion monitoring test stations to facilitate corrosion monitoring and the application of cathodic protection:
    a. Two or four-wire test stations at each end of the pipeline depending on how the pipe terminates.
    b. Four-wire test stations at all buried insulating joints.
    c. Four-wire test stations at each end of all casings.
    d. Two-wire test stations at other locations as necessary so the interval between test stations does not exceed 1,200 feet.

    Where 4-wire test stations are required, use wires of difference size or insulation color for identification. Each wire should be independently welded or pin-brazed to the pipe.

4. Use iron pipe, fittings, and valves in appurtenances to the extent possible to avoid creating dissimilar metal corrosion cells. Steel appurtenances such as bolts should be coated with wax tape. If copper is used, electrically isolate it from the iron.

5. Prevent contact between iron and concrete including reinforcing steel, using such items as plastic sleeves, rubber seals, two layers of 8 mil thick polyethylene plastic, or 20 mil plastic tape.

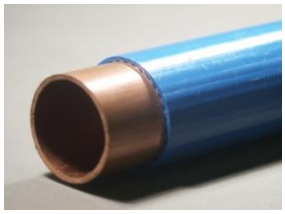
6. Apply a suitable coating intended for underground use such as:
    a. Epoxy coating; *or*
    b. Polyurethane; *or*
    c. Wax tape.

    NOTE: The thin factory-applied asphaltic coating applied to ductile iron pipe for transportation and aesthetic purposes does not constitute a corrosion control coating.

7. Apply cathodic protection to cast and ductile iron piping as per NACE Standard SP0169.

Copper Pipe

Protect buried copper pipe by *one* of the following measures:



1. Installation of a factory-coated copper pipe with a minimum 25-mil thickness such as Kamco's Aqua Shield™, Mueller's Streamline Protec™, or equal. The coating must be continuous with no cuts or defects.

2. Installation of 12-mil polyethylene pipe wrapping tape with butyl rubber mastic over a suitable primer. Protect wrapped copper tubing by applying cathodic protection per NACE Standard SP0169.

Polyvinyl Chloride (PVC) Pipe

1. No special measures are required to protect PVC.

2. Coat any iron parts, such as fittings and valves, with a high quality dielectric coating such as wax tape per AWWA C217, plastic pipe wrapping tape, coal tar epoxy, polyurethane, or equivalent.

3. Install electrically insulated joints in iron riser connections to above grade metallic piping.

4. Use iron pipe, fittings, and valves in appurtenances, such as air valves and blowoffs, to the extent possible to avoid creating dissimilar metal corrosion cells. Steel appurtenances such as bolts should be coated as described above. If copper is used, electrically isolate it from the iron.

All Pipe

1. On all pipes, appurtenances, and fittings not protected by cathodic protection or encased in concrete, coat pipe specials such as valves, bolts, flange joints, joint harnesses, and flexible couplings with wax tape per AWWA C217 after assembly.

2. Where metallic pipelines penetrate concrete structures such as building floors, vault walls, and thrust blocks use plastic sleeves, rubber seals, or other dielectric material to prevent pipe contact with the concrete and reinforcing steel.

Concrete Structures

The concrete mix design should provide the least permeable and mostly crack-free matrix to reduce penetration of aggressive ions and oxygen into the concrete. The concrete mixture should be designed to help protect the steel adequately from corrosion. Factors in concrete mix design that can reduce the permeability of the concrete include lowering the water-to-cement ratio by either increasing the cement content or decreasing water content. Finely divided materials such as fly ash, granulated blast furnace slag, silica fume, and other pozzolons can further reduce permeability of the concrete.

In addition, aggregates having water-soluble chloride ions on their surfaces, or even within their particles, can cause corrosion problems. If enough surface-borne chlorides are present, a portion will not be bound within the solid "paste" phase during hydration of the cement. Most of the chlorides released from the interior of an aggregate particle after the first few hours of hydration will not be bound at all. Unbound chloride ions can cause passivity breakdown of the steel created by the alkaline cement.

The following standards contain important guidelines for the maximum concentration of chloride, sulfate and carbonate ions on the mixing water and admixture:

- Portland Cement Association PCA Publication E B.001, Design and Control of Concrete mixtures
- American Concrete Institute ACI 318, Building Code Requirements for Reinforced Concrete Structures
- American Concrete Institute ACI 222, Corrosion of Metals in Concrete

Nevertheless, there are certain steps that can be taken to enhance the protective properties of the concrete. The most important factor is keeping the cement content high enough to maintain a pH of 12.5 or greater.

1. From a corrosion standpoint, Type II cement may be used for concrete structures and pipe because the sulfate concentration is negligible, 0 to 0.1 percent.
2. Chloride levels were measured at levels where additional protective measures may be required for concrete, including increased cover, admixtures, or other modifications of design based on the Metro Rail Design Criteria. Possible measures are presented below.
    a. Protective Concrete - A concrete mix designed to protect embedded steel and iron that should be based on the following parameters: 1) a chloride content of 250 ppm in the soil; 2) the desired service life; and 3) concrete cover. A protective concrete mix may include a corrosion inhibitor admixture and/or silica fume admixture.
    b. Waterproof Concrete - Waterproofing for concrete could be a gravel capillary break under the concrete, a waterproof membrane, and/or a liquid applied waterproof barrier coating such as Grace PrePrufe® products. Visqueen, similar rolled barriers, or bentonite-based membranes are not viable waterproofing systems, from a corrosion standpoint.
    c. Coat Embedded Metal - A coating for embedded steel and iron could be an epoxy coating applied to the metal. Purple fusion bonded epoxy (FBE) (ASTM A934) intended for prefabricated reinforcing steel reinforcing steel is suitable. The green flexible FBE (ASTM A775) is not recommended.
    d. Cathodic Protection - Cathodic protection is most practical for pipelines and must be designed for each application. The amount of cathodic protection current needed can be minimized by coating the steel or iron.

3. Due to the high ground water table encountered at this site, cyclical or continual wetting may be an issue. Any contact between concrete structures and ground water should be prevented. Contact can be prevented with an impermeable waterproofing system.

Post Tensioning Slabs: Unbonded Single-Stranded Tendons and Anchors

1. Soil is considered an aggressive environment for post-tensioning strands and anchors. Therefore, due to the soils found on-site, protect post-tensioning strands and anchors against corrosion in this aggressive (corrosive) environment. Implement *all* the following measures: (ACI 2001)(PTI 2006)(PTI 2000)
    a. Completely encapsulate the tendon and anchor with polyethylene to create a watertight seal.
    b. All components exposed to the job site should be protected within one working day after their exposure during installation.
    c. Ensure the minimum concrete cover over the tendon tail is 1-inch, or greater if required by the applicable building code.
    d. Caps and sleeves should be installed within one working day after the cutting of the tendon tails and acceptance of the elongation records by the engineer.
    e. Inspect the following to ensure the encapsulated system is completely watertight:
        i. Sheathing: Verify that all damaged areas, including pin-holes, are repaired.
        ii. Stressing tails: After removal, ensure they are cut to a length for proper installation of P/T coating filled end caps.
        iii. End caps: Ensure proper installation before patching the pocket former recesses.
        iv. Patching: Ensure the patch is of an approved material and mix design, and installed void-free.
    f. Limit the access of direct runoff onto the anchorage area by designing proper drainage.
    g. Provide at least 2 inches of space between finish grade and the anchorage area, or more if required by applicable building codes.

CLOSURE

Our services have been performed with the usual thoroughness and competence of the engineering profession. No other warranty or representation, either expressed or implied, is included or intended.

Please call if you have any questions.

Respectfully Submitted,
HDR ENGINEERING, INC.

Ian Budner
EIT Corrosion Technician

Steven R. Fox, P.E.
Vice President

11-1050SCS-RPT_Westwood-VA_Hospital_IB_rev00

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Romanoff, M. (1989). Underground Corrosion, National Bureau of Standards (NBS) Circular 579. Houston, TX, United States of America: Reprinted by NACE.

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Table 2 - Laboratory Tests on Soil Samples

AMEC E&I
Westside Subway Extension
Your #4953-09-0472, SA #09-0628SCSP
28-Dec-09

Sample ID			G-24 @ 20' CL w/ Gravel	G-24 @ 40' ML
Resistivity		**Units**		
as-received		ohm-cm	14,800	2,120
saturated		ohm-cm	1,920	2,120
pH			7.3	7.6
Electrical Conductivity		mS/cm	0.05	0.05
Chemical Analyses				
Cations				
calcium	Ca^{2+}	mg/kg	30	28
magnesium	Mg^{2+}	mg/kg	12	10
sodium	Na^{1+}	mg/kg	21	43
potassium	K^{1+}	mg/kg	2.1	2.3
Anions				
carbonate	CO_3^{2-}	mg/kg	ND	ND
bicarbonate	HCO_3^{1-}	mg/kg	76	49
flouride	F^{1-}	mg/kg	10	3.2
chloride	Cl^{1-}	mg/kg	11	9.2
sulfate	SO_4^{2-}	mg/kg	23	46
phosphate	PO_4^{3-}	mg/kg	16	6.6
Other Tests				
ammonium	NH_4^{1+}	mg/kg	ND	ND
nitrate	NO_3^{1-}	mg/kg	0.6	1.8
sulfide	S^{2-}	qual	na	na
Redox		mV	na	na

Electrical conductivity in millisiemens/cm and chemical analysis were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.
Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed

Table 1 - Laboratory Tests on Soil Samples

AMEC E&I
Westside Subway Extension
Your #4953-10-1561, HDR|Schiff #11-0633LAB
7-Jul-11

Sample ID			S-115 @19-20' ML	S-115 @ 39-40' SM	S-115 @ 68-69' ML	S-115 @ 96-97' ML	S-115 @ 116-117' ML
Resistivity		**Units**					
as-received		ohm-cm	1,880	128,000	2,840	3,760	4,400
saturated		ohm-cm	1,600	5,600	1,280	1,880	1,760
pH			7.1	7.2	7.3	7.3	7.4
Electrical Conductivity		mS/cm	0.06	0.05	0.07	0.08	0.07
Chemical Analyses							
Cations							
calcium	Ca^{2+}	mg/kg	38	22	38	35	35.1
magnesium	Mg^{2+}	mg/kg	20.9	6.4	11	13.2	12.1
sodium	Na^{1+}	mg/kg	91	64	41	44	35
potassium	K^{1+}	mg/kg	3.4	3.1	6.0	10.6	13.1
Anions							
carbonate	CO_3^{2-}	mg/kg	ND	ND	ND	ND	ND
bicarbonate	HCO_3^{1-}	mg/kg	73	64	73	128	64
fluoride	F^{1-}	mg/kg	12	5.7	3.5	4.4	4.2
chloride	Cl^{1-}	mg/kg	3.8	3.1	11	16	8.3
sulfate	SO_4^{2-}	mg/kg	14	19	47	85	68
phosphate	PO_4^{3-}	mg/kg	19	14.6	2.4	1.8	1.7
Other Tests							
ammonium	NH_4^{1+}	mg/kg	ND	ND	ND	ND	ND
nitrate	NO_3^{1-}	mg/kg	ND	ND	1.4	2.7	1.1
sulfide	S^{2-}	qual	na	na	na	na	na
Redox		mV	na	na	na	na	na

Electrical conductivity in millisiemens/cm and chemical analysis were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.
Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed

Table 1 - Laboratory Tests on Soil Samples

AMEC E&I
Westside Subway Extension
Your #4953-10-1561, HDR|Schiff #11-0699LAB
20-Jul-11

Sample ID			G-203 @ 30' ML	G-203 @ 45.5' SM	G-203 @ 80.5' SM	G-204 @ 10' ML	G-204 @ 40' ML
Resistivity		**Units**					
as-received		ohm-cm	4,800	800	5,200	2,600	1,360
saturated		ohm-cm	1,720	760	3,360	2,400	960
pH			8.0	7.5	8.0	7.4	7.1
Electrical Conductivity		mS/cm	0.16	0.27	0.06	0.05	0.22
Chemical Analyses							
Cations							
calcium	Ca^{2+}	mg/kg	25	41	19	18	44
magnesium	Mg^{2+}	mg/kg	8.7	21	7.2	9.1	26
sodium	Na^{1+}	mg/kg	139	222	44	69	136
potassium	K^{1+}	mg/kg	3.6	7.4	4.8	1.8	9.1
Anions							
carbonate	CO_3^{2-}	mg/kg	ND	ND	ND	ND	ND
bicarbonate	HCO_3^{1-}	mg/kg	107	52	58	70	40
fluoride	F^{1-}	mg/kg	7.8	3.3	2.7	11.8	3.7
chloride	Cl^{1-}	mg/kg	43	242	16	2.1	115
sulfate	SO_4^{2-}	mg/kg	150	250	50	7.3	264
phosphate	PO_4^{3-}	mg/kg	6.6	ND	1.6	31	ND
Other Tests							
ammonium	NH_4^{1+}	mg/kg	ND	ND	ND	ND	ND
nitrate	NO_3^{1-}	mg/kg	ND	ND	0.7	ND	ND
sulfide	S^{2-}	qual	Negative	Negative	Negative	Negative	Negative
Redox		mV	35	105	60	131	119

Electrical conductivity in millisiemens/cm and chemical analysis were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.
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AMEC E&I
Westside Subway Extension
Your #4953-10-1561, HDR|Schiff #11-0699LAB
20-Jul-11

Sample ID			G-204 @ 80' CL	G-204 @ 100' ML/CL	G-205 @ 35.5' ML	G-205 @ 50' ML	G-205 @ 95.5' ML
Resistivity		**Units**					
as-received		ohm-cm	1,400	1,880	840	12,000	1,560
saturated		ohm-cm	1,400	1,880	760	3,560	1,560
pH			7.9	7.0	6.9	7.7	7.5
Electrical Conductivity		mS/cm	0.08	0.09	0.34	0.07	0.07
Chemical Analyses							
Cations							
calcium	Ca^{2+}	mg/kg	36	33	41	19	30
magnesium	Mg^{2+}	mg/kg	13	14	17	4.6	10.9
sodium	Na^{1+}	mg/kg	41	46	304	66	39
potassium	K^{1+}	mg/kg	11.8	14.1	5.3	3.3	12.2
Anions							
carbonate	CO_3^{2-}	mg/kg	ND	ND	ND	ND	ND
bicarbonate	HCO_3^{1-}	mg/kg	67	46	49	43	46
fluoride	F^{1-}	mg/kg	5.0	4.9	5.1	3.4	4.8
chloride	Cl^{1-}	mg/kg	16	24	74.7	42.9	15
sulfate	SO_4^{2-}	mg/kg	81	103	559	28	73
phosphate	PO_4^{3-}	mg/kg	1.3	1.3	4.0	4.3	2.1
Other Tests							
ammonium	NH_4^{1+}	mg/kg	ND	ND	ND	ND	ND
nitrate	NO_3^{1-}	mg/kg	3.3	1.4	ND	ND	1.8
sulfide	S^{2-}	qual	Negative	Negative	Negative	Negative	Negative
Redox		mV	92	93	69	74	72

Electrical conductivity in millisiemens/cm and chemical analysis were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.
Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed

FIGURES F-10.70.1 THROUGH F-10.70.16
SOIL CORROSIVITY EVALUATION FOR CENTURY CITY SANTA MONICA STATION

SOIL CORROSIVITY EVALUATION

for the

WESTSIDE SUBWAY EXTENSION

CENTURY CITY SANTA MONICA STATION

in

LOS ANGELES, CA

prepared for

AMEC E&I
5628 East Slauson Avenue
Los Angeles, CA 90040

Project No.: 4953-10-1561

PROJECT MANAGER: MR. MARTY HUDSON

prepared by

HDR ENGINEERING, INC.
Consulting Corrosion Engineers
431 West Baseline Road
Claremont, California 91711

HDR|SCHIFF #172549

October 18, 2011

EXECUTIVE SUMMARY

The Westside Subway Extension is a proposed extension of the Metro Purple Line subway westward from the Wilshire/Western Station to the Veterans Administration West Los Angeles Hospital. Santa Monica Century City station is one of the eight stations planned for the project. The station will be approximately 1,360 feet long and about 70 to 85 feet below ground surface.

Laboratory tests on the provided soil samples provided by AMEC E&I have been completed. Seven of the samples were selected for analysis. This soil is classified as severely corrosive to ferrous metals and aggressive to copper.

A dielectrically coated steel pipeline for this route should also have bonded joints and test stations. In addition, cathodic protection should be installed and applied concurrently with the pipeline.

Cathodically protect and provide corrosion monitoring for hydraulic elevators and associated components as required for compliance with Title 23 as necessary.

A dielectrically coated ductile iron pipe would also be a suitable choice. In addition, cathodic protection should be installed and applied concurrently with the pipeline. A polyethylene wrap may be used on non-pressurized iron pipe due to corrosive soils along portions of the route.

A polyvinyl chloride (PVC) pipe would also be a suitable choice. Coat any iron parts, such as fittings and valves, with a high quality dielectric coating.

Type II cement may be used for concrete structures. Standard concrete cover over reinforcing steel may be used. Any contact between concrete structures and ground water should be prevented. Contact can be prevented with an impermeable waterproofing system.

Due to the soils at this site, post-tensioned slabs should be protected in accordance with soil considered aggressive (corrosive).

TABLE OF CONTENTS

INTRODUCTION

The existing subway system is owned and operated by Los Angeles County Metropolitan Transportation Authority (MTA) and provides public transportation throughout the City of Los Angeles, and surrounding areas.

The Westside Subway Extension is a proposed extension of the Metro Purple Line subway westward from the Wilshire/Western Station to the Veterans Administration West Los Angeles Hospital. In the Century City area, two alternative alignments are considered; one with a station along Santa Monica Boulevard, and one with a station along Constellation Boulevard. The proposed subway alignment is about 9 miles long. The depth to tunnel invert varies along the alignment from 40 to 160 feet below grade. The subway will consist of heavy rail transit operated in a twin tunnel configuration with eight new passenger stations, with two options in Century City.

Santa Monica Century City station is one of the eight stations planned for the project. The station will be approximately 1,360 feet long and about 70 to 85 feet below ground surface. Ground water was encountered at depths of about 25 to 50 feet below ground surface. The station will include walls below grade, utility piping, hydraulic elevator systems, concrete structures and post-tensioning systems.

An analysis of soil corrosivity along the route of the Metro rail alignment was requested. Laboratory tests on the provided soil samples provided by AMEC E&I have been completed. Seven of the samples were selected for analysis. HDR Engineering, Inc. (HDR|Schiff) assumes that the samples selected are representative of the most corrosive soils at the site.

The scope of this study is limited to a determination of soil corrosivity and general corrosion control recommendations for materials planned for construction. HDR|Schiff understands shoring piles will be used only temporarily during construction and will not be considered in this study. If steel piles are considered for use as permanent structures in the future, HDR|Schiff will be glad to perform Romanoff similitude analysis for metal loss and determine estimated corrosion rates.

LABORATORY TESTS ON SOIL SAMPLES

The electrical resistivity of each of the seven samples was measured in a soil box per ASTM G187 in its as-received condition and again after saturation with distilled water. Resistivities are at about their lowest value when the soil is saturated. The pH of the saturated samples was measured per ASTM G 51. A 5:1 water:soil extract from each sample was chemically analyzed for the major soluble salts commonly found in soil per ASTM D4327, D6919, and D513. Test results are shown in Table 1 in the Appendix to this report.

SOIL CORROSIVITY

A major factor in determining soil corrosivity is electrical resistivity. The electrical resistivity of a soil is a measure of its resistance to the flow of electrical current. Corrosion of buried metal is an electrochemical process in which the amount of metal loss due to corrosion is directly proportional to the flow of electrical current (DC) from the metal into the soil. Corrosion currents, following Ohm's Law, are inversely proportional to soil resistivity. Lower electrical resistivities result from higher moisture and soluble salt contents and indicate corrosive soil.

A correlation between electrical resistivity and corrosivity toward ferrous metals is (Romanoff, 1989):

Soil Resistivity in ohm-centimeters	Corrosivity Category
Greater than 10,000	Mildly Corrosive
2,001 to 10,000	Moderately Corrosive
1,001 to 2,000	Corrosive
0 to 1,000	Severely Corrosive

Other soil characteristics that may influence corrosivity towards metals are pH, soluble salt content, soil types, aeration, anaerobic conditions, and site drainage.

Electrical resistivities were in the mildly corrosive to corrosive categories with as-received moisture. When saturated, the resistivities were in the moderately to severely corrosive categories. The resistivities dropped considerably with added moisture because the samples were dry as-received.

Soil pH values varied from 7.1 to 7.8. This range is neutral to mildly alkaline (Romanoff, 1989). These values do not particularly increase soil corrosivity.

The soluble salt content of the samples was low.

The nitrate concentration was high enough to be deleterious to copper.

Tests were not made for sulfide and negative oxidation-reduction (redox) potential because these samples did not exhibit characteristics typically associated with anaerobic conditions.

The variation in soil types can create differential-aeration corrosion cells that would affect all metals.

This soil is classified as severely corrosive to ferrous metals and aggressive to copper.

Heavy rail transit systems can present a multitude of DC stray current issues. These issues can affect not only the system of concern, but also other metallic utilities or structures proximal to rails, and DC substations if the proper mitigation practices are not followed. Stray current can increase corrosion rates above what would be expected from the chemical characteristics alone.

CONCLUSIONS

This soil is classified as severely corrosive to ferrous metals and aggressive to copper.

A dielectrically coated steel pipeline for this route should also have bonded joints and test stations. In addition, cathodic protection should be installed and applied concurrently with the pipeline.

Cathodically protect and provide corrosion monitoring for hydraulic elevators and associated components as required for compliance with Title 23 as necessary.

A dielectrically coated ductile iron pipe would also be a suitable choice. In addition, cathodic protection should be installed and applied concurrently with the pipeline. A polyethylene wrap may be used on non-pressurized iron pipe due to corrosive soils along portions of the route.

A polyvinyl chloride (PVC) pipe would also be a suitable choice. Coat any iron parts, such as fittings and valves, with a high quality dielectric coating.

Type II cement may be used for concrete structures. Standard concrete cover over reinforcing steel may be used. Any contact between concrete structures and ground water should be prevented. Contact can be prevented with an impermeable waterproofing system.

Due to the soils at this site, post-tensioned slabs should be protected in accordance with soil considered aggressive (corrosive).

Due to the nature and magnitude of the project and the long design service life requirements, tolerance for corrosion on all project components is low. Based on the need for high reliability and the corrosivity considerations discussed above, it is clear that corrosion protection must be provided for the components exposed to the environment discussed with consideration given to the level of risk and practicality.

RECOMMENDATIONS

DC Stray Current

A study of the impact of the DC powered heavy rail system was not detailed as part of the scope work in this project. It is recommended that the client pursue such a study in order to take the necessary precautions to avoid the deleterious effects known to result from DC stray current.

Steel Pipe

Implement *all* the following measures.

1. Underground steel pipe with rubber gasketed, mechanical, grooved end, or other nonconductive type joints should be bonded for electrical continuity. For pipe diameters less 18 inches use two joint bonds. For pipe diameters greater than or equal to 18 inches use three joint bonds. Electrical continuity is necessary for corrosion monitoring and cathodic protection.

2. Install corrosion monitoring test stations to facilitate corrosion monitoring and the application of cathodic protection:
    a. Two or four-wire test stations at each end of the pipeline depending on how the pipe terminates.
    b. Four-wire test stations at all buried insulating joints.
    c. Four-wire test stations at each end of all casings.
    d. Two-wire test stations at other locations as necessary so the interval between test stations does not exceed 1,200 feet.

    Where 4-wire test stations are required, use wires of difference size or insulation color for identification. Each wire should be independently welded or pin-brazed to the pipe.

3. To prevent dissimilar metal corrosion cells and to facilitate the application of cathodic protection, electrically isolate each buried steel pipeline per NACE Standard SP0286 from:
    a. Pumping plants.
    b. Reservoirs.
    c. Flow meters.
    d. Motorized operated valves.
    e. Dissimilar metals.
    f. Dissimilarly coated piping (cement-mortar vs. dielectric).
    g. Above ground steel pipe.
    h. All existing piping.

    Insulated joints should be placed above grade or in vaults where possible. Wrap all buried insulators with wax tape per AWWA C217.

4. Prevent contact between the steel pipe and concrete and/or reinforcing steel, such as at wall penetrations and thrust blocks, with such items as plastic sleeves, rubber seals, or 20 mil plastic tape.

5. Apply a suitable dielectric coating intended for underground use such as:
    a. Polyurethane per AWWA C222 *or*
    b. Extruded polyethylene per AWWA C215 *or*
    c. A tape coating system per AWWA C214 *or*
    d. Hot applied coal tar enamel per AWWA C203 *or*
    e. Fusion bonded epoxy per AWWA C213.

6. Buried steel and iron pipe, fittings, and valves in appurtenances, such as air valves and blowoffs, should be coated with a material listed above or with coal-tar epoxy, wax tape, moldable sealant, or equivalent. If copper is used, electrically insulate it from the steel with an insulating joint or with a dielectric union.

7. Apply cathodic protection to steel piping as per NACE Standard SP0169.

8. To insure that corrosion control is properly designed, preliminary construction drawings should be reviewed by a qualified corrosion engineer.

9. After the pipeline is backfilled, but before the construction contract is completed, the pipeline should be tested to insure that the joint bonds are intact and test stations properly installed. Also, native pipe-to-soil potentials should be measured and recorded. These data will be useful in determining if pipeline conditions change in the future.

10. Pipe-to-soil potentials should be measured biennially to determine if conditions on the pipeline are changing.

Hydraulic Elevator

Implement *all* the following measures:

1. Coat hydraulic elevator cylinders as described above for steel pipe, item #5a -#5e5 that is resistant to petroleum products (hydraulic fluid).
2. Electrically insulate each cylinder from building metals by installing dielectric material between the piston platen and car, insulating the bolts, and installing an insulated joint in the oil line.
3. Place each cylinder in a non-metallic casing with a plastic watertight seal at the bottom. Fill the annulus with dry sand with a minimum resistivity of 25,000 ohm-centimeters, a pH of between 6.5 and 7.5 and a maximum chloride content of 200 ppm.
4. A removable moisture-proof sealing lid installed on the top of the casing prior to installation of the cylinder. The top of the casing shall be permanently sealed against moisture intrusion after installation of the cylinder.
5. Apply cathodic protection to hydraulic cylinders as per NACE Standard SP0169.
6. The elevator oil line should be placed above ground if possible but, if underground, should be protected by one of the following corrosion control options:

   OPTION 1

   a. Provide a bonded dielectric coating.
   b. Electrically isolate the pipeline.
   c. Apply cathodic protection to steel piping as per NACE Standard SP0169.

   OPTION 2

   a. Place the oil line in a PVC casing pipe with solvent-welded joints to prevent contact with soil and soil moisture.

7. If Steel underground storage tanks are used, cathodic protection and corrosion control requirements shall comply with Title 23.

Reinforced Concrete Pipe

Implement *all* the following measures.

1. To prevent dissimilar metal corrosion cells electrically isolate the storm drain per NACE Standard SP0286 from all structures and facilities.

   Insulated joints should be placed above grade or in vaults where possible. Wrap all buried insulators with wax tape per AWWA C217.

2. Prevent contact between the steel pipe and concrete and/or reinforcing steel, such as at wall penetrations and thrust blocks, with such items as plastic sleeves, rubber seals, or 20 mil plastic tape.

3. Buried steel and iron pipe and fittings in appurtenances should be cement-mortar coated or concrete or cement slurry encased where possible. Otherwise, they should be wrapped with wax tape per AWWA Standard C-217

4. To insure that corrosion control is properly designed, preliminary construction drawings should be reviewed by a qualified corrosion engineer.

5. Apply a suitable dielectric waterproofing coating intended for underground use. This coating is to be compatible with and applied over the concrete/cement-mortar.

Iron Pipe

Implement *all* the following measures:

1. To prevent dissimilar metal corrosion cells and to facilitate the application of cathodic protection, electrically isolate each buried iron pipeline per NACE Standard SP0286 from:
   a. Pumping plants.
   b. Reservoirs.
   c. Flow meters.
   d. Motorized operated valves.
   e. Dissimilar metals.
   f. Dissimilarly coated piping (cement-mortar vs. dielectric).
   g. Above ground steel pipe.
   h. All existing piping.

   Insulated joints should be placed above grade or in vaults where possible. Wrap all buried insulators with wax tape per AWWA C217.

2. Bond all nonconductive type joints for electrical continuity. Electrical continuity is necessary for corrosion monitoring and cathodic protection. For pipe diameters less 18 inches use two joint bonds. For pipe diameters greater than or equal to 18 inches use three joint bonds. Electrical continuity is necessary for corrosion monitoring and cathodic protection.

3. Install corrosion monitoring test stations to facilitate corrosion monitoring and the application of cathodic protection:
    a. Two or four-wire test stations at each end of the pipeline depending on how the pipe terminates.
    b. Four-wire test stations at all buried insulating joints.
    c. Four-wire test stations at each end of all casings.
    d. Two-wire test stations at other locations as necessary so the interval between test stations does not exceed 1,200 feet.

    Where 4-wire test stations are required, use wires of difference size or insulation color for identification. Each wire should be independently welded or pin-brazed to the pipe.

4. Use iron pipe, fittings, and valves in appurtenances to the extent possible to avoid creating dissimilar metal corrosion cells. Steel appurtenances such as bolts should be coated with wax tape. If copper is used, electrically isolate it from the iron.

5. Prevent contact between iron and concrete including reinforcing steel, using such items as plastic sleeves, rubber seals, two layers of 8 mil thick polyethylene plastic, or 20 mil plastic tape.

6. Apply a suitable coating intended for underground use such as:
    a. Polyethylene encasement per AWWA C105; *or*
    b. Epoxy coating; *or*
    c. Polyurethane; *or*
    d. Wax tape.

    NOTE: The thin factory-applied asphaltic coating applied to ductile iron pipe for transportation and aesthetic purposes does not constitute a corrosion control coating.

7. Apply cathodic protection to cast and ductile iron piping as per NACE Standard SP0169.

Iron Pipe (Non-Pressurized)

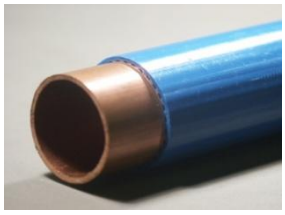
1. Encase iron pipe, fittings, and valves in an 8 mil polyethylene wrap per AWWA Standard C105/ANSI 21.5.

Copper Pipe

Protect buried copper pipe by *one* of the following measures:

1. Installation of a factory-coated copper pipe with a minimum 25-mil thickness such as Kamco's Aqua Shield™, Mueller's Streamline Protec™, or equal. The coating must be continuous with no cuts or defects.

2. Installation of 12-mil polyethylene pipe wrapping tape with butyl rubber mastic over a suitable primer. Protect wrapped copper tubing by applying cathodic protection per NACE Standard SP0169.



Polyvinyl Chloride (PVC) Pipe

1. No special measures are required to protect PVC.

2. Coat any iron parts, such as fittings and valves, with a high quality dielectric coating such as wax tape per AWWA C217, plastic pipe wrapping tape, coal tar epoxy, polyurethane, or equivalent.

3. Install electrically insulated joints in iron riser connections to above grade metallic piping.

4. Use iron pipe, fittings, and valves in appurtenances, such as air valves and blowoffs, to the extent possible to avoid creating dissimilar metal corrosion cells. Steel appurtenances such as bolts should be coated as described above. If copper is used, electrically isolate it from the iron.

All Pipe

1. On all pipes, appurtenances, and fittings not protected by cathodic protection or encased in concrete, coat pipe specials such as valves, bolts, flange joints, joint harnesses, and flexible couplings with wax tape per AWWA C217 after assembly.

2. Where metallic pipelines penetrate concrete structures such as building floors, vault walls, and thrust blocks use plastic sleeves, rubber seals, or other dielectric material to prevent pipe contact with the concrete and reinforcing steel.

Concrete Structures

The concrete mix design should provide the least permeable and mostly crack-free matrix to reduce penetration of aggressive ions and oxygen into the concrete. The concrete mixture should be designed to help protect the steel adequately from corrosion. Factors in concrete mix design that can reduce the permeability of the concrete include lowering the water-to-cement ratio by either increasing the cement content or decreasing water content. Finely divided materials such

as fly ash, granulated blast furnace slag, silica fume, and other pozzolons can further reduce permeability of the concrete.

In addition, aggregates having water-soluble chloride ions on their surfaces, or even within their particles, can cause corrosion problems. If enough surface-borne chlorides are present, a portion will not be bound within the solid "paste" phase during hydration of the cement. Most of the chlorides released from the interior of an aggregate particle after the first few hours of hydration will not be bound at all. Unbound chloride ions can cause passivity breakdown of the steel created by the alkaline cement.

The following standards contain important guidelines for the maximum concentration of chloride, sulfate and carbonate ions on the mixing water and admixture:

- Portland Cement Association PCA Publication E B.001, Design and Control of Concrete mixtures
- American Concrete Institute ACI 318, Building Code Requirements for Reinforced Concrete Structures
- American Concrete Institute ACI 222, Corrosion of Metals in Concrete

Nevertheless, there are certain steps that can be taken to enhance the protective properties of the concrete. The most important factor is keeping the cement content high enough to maintain a pH of 12.5 or greater.

1. From a corrosion standpoint, Type II cement may be used for concrete structures and pipe because the sulfate concentration is negligible, 0 to 0.1 percent.

2. Standard concrete cover over reinforcing steel may be used for concrete structures and pipe in contact with these soils due to the low chloride concentration found onsite.

3. Due to the high ground water table encountered at this site, cyclical or continual wetting may be an issue. Any contact between concrete structures and ground water should be prevented. Contact can be prevented with an impermeable waterproofing system.

Post Tensioning Slabs: Unbonded Single-Stranded Tendons and Anchors

1. Soil is considered an aggressive environment for post-tensioning strands and anchors. Therefore, due to the soils found on-site, protect post-tensioning strands and anchors against corrosion in this aggressive (corrosive) environment. Implement *all* the following measures: (ACI 2001)(PTI 2006)(PTI 2000)

    a. Completely encapsulate the tendon and anchor with polyethylene to create a watertight seal.

    b. All components exposed to the job site should be protected within one working day after their exposure during installation.

    c. Ensure the minimum concrete cover over the tendon tail is 1-inch, or greater if required by the applicable building code.

d. Caps and sleeves should be installed within one working day after the cutting of the tendon tails and acceptance of the elongation records by the engineer.

e. Inspect the following to ensure the encapsulated system is completely watertight:
   i. Sheathing: Verify that all damaged areas, including pin-holes, are repaired.
   ii. Stressing tails: After removal, ensure they are cut to a length for proper installation of P/T coating filled end caps.
   iii. End caps: Ensure proper installation before patching the pocket former recesses.
   iv. Patching: Ensure the patch is of an approved material and mix design, and installed void-free.

f. Limit the access of direct runoff onto the anchorage area by designing proper drainage.

g. Provide at least 2 inches of space between finish grade and the anchorage area, or more if required by applicable building codes.

CLOSURE

Our services have been performed with the usual thoroughness and competence of the engineering profession. No other warranty or representation, either expressed or implied, is included or intended.

Please call if you have any questions.

Respectfully Submitted,
HDR ENGINEERING, INC.

Ian Budner
EIT Corrosion Technician

Steven R. Fox, P.E.
Vice President

11-1050SCS-RPT_Santa_Monica-Century_City_IB_rev00

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ACI 423.6-01: Specification for Unbonded Single Strand Tendons. American Concrete Institute (ACI), 2001

AWWA. (C105-05). "American National Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems". Denver, CO: www.awwa.org/.

Post-Tensioning Manual, sixth edition. Post-Tensioning Institute (PTI), Phoenix, AZ, 2006.

Romanoff, M. (1989). Underground Corrosion, National Bureau of Standards (NBS) Circular 579. Houston, TX, United States of America: Reprinted by NACE.

Specification for Unbonded Single Strand Tendons. Post-Tensioning Institute (PTI), Phoenix, AZ, 2000.

Table 1 - Laboratory Tests on Soil Sample(s)

AMEC E&I
Westside Subway Extension
Your #4953-10-1561, HDR|Schiff #11-0344LAB
8-Apr-11

Sample ID			154 40' ML/CL	154 60' CLAYEY ML
Resistivity		**Units**		
as-received		ohm-cm	8,400	3,640
saturated		ohm-cm	1,480	880
pH			7.8	7.8
Electrical Conductivity		mS/cm	0.06	0.05
Chemical Analyses				
Cations				
calcium	Ca^{2+}	mg/kg	20	27
magnesium	Mg^{2+}	mg/kg	6.7	8.8
sodium	Na^{1+}	mg/kg	59	51
potassium	K^{1+}	mg/kg	4.2	3.4
Anions				
carbonate	CO_3^{2-}	mg/kg	ND	ND
bicarbonate	HCO_3^{1-}	mg/kg	64	76
fluoride	F^{1-}	mg/kg	8.2	6.3
chloride	Cl^{1-}	mg/kg	4.6	14
sulfate	SO_4^{2-}	mg/kg	16	19
phosphate	PO_4^{3-}	mg/kg	8.3	4.1
Other Tests				
ammonium	NH_4^{1+}	mg/kg	ND	ND
nitrate	NO_3^{1-}	mg/kg	55	12
sulfide	S^{2-}	qual	na	na
Redox		mV	na	na

Electrical conductivity in millisiemens/cm and chemical analysis were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.
Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed

Figure F-10.70.15

Table 1 - Laboratory Tests on Soil Samples

AMEC E&I
Westside Subway Extension
Your #4953-10-1561, HDR|Schiff #11-0633LAB
7-Jul-11

Sample ID			G-156 @ 10' CL	G-156 @ 25' SM	G-156 @ 45' CL	G-156 @ 70' SM/SW	G-156 @ 80' CL
Resistivity		**Units**					
as-received		ohm-cm	10,400	9,600	1,160	6,000	4,400
saturated		ohm-cm	1,480	1,720	800	2,200	1,200
pH			7.5	7.1	7.2	7.4	7.3
Electrical Conductivity		mS/cm	0.09	0.08	0.12	0.08	0.06
Chemical Analyses							
Cations							
calcium	Ca^{2+}	mg/kg	22	21	41	21	2.5
magnesium	Mg^{2+}	mg/kg	7.2	5.6	11	5.3	6.7
sodium	Na^{1+}	mg/kg	75	55	80	62	40
potassium	K^{1+}	mg/kg	6.2	7.2	6.0	5.3	7.3
Anions							
carbonate	CO_3^{2-}	mg/kg	ND	ND	ND	ND	ND
bicarbonate	HCO_3^{1-}	mg/kg	67	61	73	40	67
fluoride	F^{1-}	mg/kg	1.1	0.6	1.2	0.7	4.2
chloride	Cl^{1-}	mg/kg	22	23	29	23	18
sulfate	SO_4^{2-}	mg/kg	86	70	120	81	33
phosphate	PO_4^{3-}	mg/kg	10	3.3	3.6	2.0	0.7
Other Tests							
ammonium	NH_4^{1+}	mg/kg	ND	ND	ND	ND	ND
nitrate	NO_3^{1-}	mg/kg	1.9	5.2	0.7	2.6	2.5
sulfide	S^{2-}	qual	na	na	na	na	na
Redox		mV	na	na	na	na	na

Electrical conductivity in millisiemens/cm and chemical analysis were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.
Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed

FIGURES F-11.1 THROUGH F-11.6
ANALYTICAL TESTING OF BAT SAMPLES (PE PHASE)

CHAIN OF CUSTODY RECORD

AirTECHNOLOGY Laboratories, Inc.

18501 E. Gale Ave., Suite 130
City of Industry, CA 91748
Ph: 626-964-4032
Fx: 626-964-5832

TURNAROUND TIME				DELIVERABLES		PAGE: OF
Standard ☐	48 hours ☐			EDD ☐		Condition upon receipt:
Same Day ☐	72 hours ☐			EDF ☐		Sealed Yes ☐ No ☐
24 hours ☐	96 hours ☐			Level 3 ☐		Intact Yes ☐ No ☐
Other:				Level 4 ☐		Chilled 13.0 deg C

Project No.:	4953-10-1561
Project Name:	METRO WSE
Report To:	
Company:	MACTEC Engineering
Street:	5628 E Slauson Ave
City/State/Zip:	LA, CA
Phone& Fax:	323 889.5300 / Fax: 323-721-6700
e-mail:	

BILLING

P.O. No.:

Bill to:

ANALYSIS REQUEST

LAB USE ONLY	SAMPLE IDENTIFICATION	SAMPLE DATE	SAMPLE TIME	CONTAINER QTY/TYPE	MATRIX	PRESERVATION	Methane RSK 175	Butane Ethane				
↑	CB101 - RUN1 - TUBE1	6/9/11	1430	5ml	water	None						
C061008-01	CB101 - RUN2 - TUBE1	6/10/11	1100	35	"	"	X	XX				Depth - 57'
↓	- RUN2 - TUBE2	6/10/11	1100	5	"	"						

AUTHORIZATION TO PERFORM WORK	Rajni Sukhwani	COMPANY MACTEC	DATE/TIME 6/10/11	
SAMPLED BY	Rajni Sukhwani	COMPANY MACTEC	DATE/TIME 6/10/11	
RELINQUISHED BY	Rajni Sukhwani DATE/TIME 6/10/11 1717	RECEIVED BY	DATE/TIME 6/10/11 1717	
RELINQUISHED BY	DATE/TIME	RECEIVED BY	DATE/TIME	
RELINQUISHED BY	DATE/TIME	RECEIVED BY	DATE/TIME	

METHOD OF TRANSPORT (circle one): Walk-in FedEx UPS Courier ATLI Other_____

COMMENTS

* Smpls provided w/significant headspace. gD

DISTRIBUTION: White & Yellow - Lab Copies / Pink - Customer Copy

Preservation: H=HCl N=None / Container: B=Bag C=Can V=VOA O=Other *Rev. 03 - 5/7/09*

Figure F-11.1

Client:	**MACTEC Engineering**
Attn:	**S. V. (Jag) Jagannath**
Project Name:	**Metro WSE**
Project No.:	**4953-10-1561**
Date Received:	**06/10/11**
Matrix:	**Water**
Reporting Units:	**ug/L**

RSK175

Lab No.:	**C061008-01**							
Client Sample I.D.:	**CB101 - Run2 - Tube 1**							
Date Sampled:	**06/10/11**							
Date Analyzed:	**06/15/11**							
QC Batch No.:	**110614GC11A2**							
Analyst Initials:	**ZK**							
Dilution Factor:	**1.0**							
ANALYTE	**Result ug/L**	**RL ug/L**						
Ethane	**8.4**	0.72						
Methane	**530**	1.2						
Butane	**ND**	0.50						

ND = Not Detected (below RL)
RL = Reporting Limit

Reviewed/Approved By: _____ **Date** 6/23/11

Mark Johnson
Operations Manager

The cover letter is an integral part of this analytical report

AirTECHNOLOGY *Laboratories, Inc.*

18501 E. Gale Avenue, Suite 130 ♦ City of Industry, CA 91748 ♦ Ph: (626) 964-4032 ♦ Fx: (626) 964-5832

Figure F-11.2

QC Batch # 110614GC11A2
Matrix: Water
Units: ug/L

QC for RSK175

Lab No.:	Blank		LCS		LCSD			
Fixed Gas Date Analyzed:	6/15/2011		6/15/2011		6/15/2011			
Hydrocarbon Date Analyzed:	6/14/2011		6/14/2011		6/14/2011			
Analyst Initials:	ZK		ZK		ZK			
Dilution Factor:	1.0		1.0		1.0			
ANALYTE	RL	Results	%R	Criteria	%R	Criteria	RPD	Criteria
Methane	1.0	ND	107	70-130	105	70-130	1.0	<30
Ethane	1.0	ND	92	70-130	92	70-130	0.8	<30
n-Butane	1.0	ND	94	70-130	93	70-130	1.2	<30

ND = Not Detected (Below RL).

RL = PQL X Dilution Factor

Reviewed/Approved By: _____ Date: 6/23/11

Mark Johnson
Operations Manager

The cover letter is an integral part of this analytical report.

AirTECHNOLOGY Laboratories, Inc.

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City of Industry, CA 91748
Ph: 626-964-4032
Fx: 626-964-5832

CHAIN OF CUSTODY RECORD

TURNAROUND TIME				DELIVERABLES		PAGE: OF
Standard ☐	48 hours ☐			EDD ☐		Condition upon receipt:
Same Day ☐	72 hours ☐			EDF ☐		Sealed Yes ☐ No ☐
24 hours ☐	96 hours ☐			Level 3 ☐		Intact Yes ☐ No ☐
Other:				Level 4 ☐		Chilled _____ deg C

Project No.: 4953-10-157
Project Name: Metro WSE
Report To: Jag/Han
Company: MACTEC
Street: 5628 E Slauson
City/State/Zip: LA, CA
Phone& Fax: 323,889-58 / Fax 323-721-6700
e-mail:

BILLING

P.O. No.:
Bill to:

ANALYSIS REQUEST

ASTM 1945 JD 6/10/11
Methane
Ethane
Butane

LAB USE ONLY	SAMPLE IDENTIFICATION	SAMPLE DATE	SAMPLE TIME	CONTAINER QTY/TYPE	MATRIX	PRESERVATION						
C061007												
~~C061008~~ 01	C1193. 30	6/10/11		2	Air		+					Test 1 tube per depth
02	55			2	Air		+					2nd tube is a
03	75			2	Air		+					backup.

JD 6/10/11

AUTHORIZATION TO PERFORM WORK: Rajni Sukhwani	COMPANY: MACTEC	DATE/TIME: 6/10/11	
SAMPLED BY	COMPANY	DATE/TIME	
RELINQUISHED BY: Rajni Sukhwani	DATE/TIME: 6/10/11 1447	RECEIVED BY: K. Jaramillo	DATE/TIME: 6/10/11 1717
RELINQUISHED BY	DATE/TIME	RECEIVED BY	DATE/TIME
RELINQUISHED BY	DATE/TIME	RECEIVED BY	DATE/TIME

COMMENTS

METHOD OF TRANSPORT (circle one): Walk-In FedEx UPS Courier ATLI Other_____

DISTRIBUTION: White & Yellow - Lab Copies / Pink - Customer Copy

Preservation: H=HCl N=None / Container: B=Bag C=Can V=VOA O=Other

Rev. 03 - 5/7/09

Figure F-11.4

Client: MACTEC Engineering
Attn: S. V. (Jag) Jagannath

Client's Project: Metro WSE; 4953-10-1561
Date Received: 6/10/2011
Matrix: Air
Units: % v/v

Natural Gas Analysis by ASTM-D1945

Lab No.:		C061007-01		C061007-02		C061007-03					
Client Sample I.D.:		C119B - 30		C119B - 55		C119B - 75					
Date Sampled:		6/10/2011		6/10/2011		6/10/2011					
Fixed Gases Date Analyzed:		6/15/2011		6/15/2011		6/15/2011					
Hydrocarbon Date Analyzed:		6/15/2011		6/15/2011		6/15/2011					
Analyst Initials:		ZK		ZK		ZK					
QC Batch #:		110614GC11A2		110614GC11A2		110614GC11A2					
Dilution Factor:		1.0		1.0		1.0					
ANALYTE	PQL	RL	Results	RL	Results	RL	Results				
Methane	0.0010	0.0010	ND	0.0010	ND	0.0010	0.012				
Ethane	0.010	0.010	ND	0.010	ND	0.010	ND				
n-Butane	0.010	0.010	ND	0.010	ND	0.010	ND				

PQL = Practical Quantitation Limit
ND = Not Detected (Below RL).
RL = PQL X Dilution Factor

Reviewed/Approved By: _____ Date: 6/23/11
Mark J. Johnson
Operations Manager

The cover letter is an integral part of this analytical report.

Figure F-11.5

QC Batch # 110614GC11A2
Matrix: Air
Units: % v/v

QC for Natural Gas Analysis by ASTM-D1945

Lab No.:	Blank		LCS		LCSD			
Fixed Gas Date Analyzed:	6/15/2011		6/15/2011		6/15/2011			
Hydrocarbon Date Analyzed:	6/14/2011		6/14/2011		6/14/2011			
Analyst Initials:	ZK		ZK		ZK			
Dilution Factor:	1.0		1.0		1.0			
ANALYTE	RL	Results	%R	Criteria	%R	Criteria	RPD	Criteria
Methane	0.0010	ND	107	70-130	105	70-130	1.0	<30
Ethane	0.010	ND	92	70-130	92	70-130	0.8	<30
n-Butane	0.010	ND	94	70-130	93	70-130	1.2	<30

PQL = Practical Quantitation Limit

ND = Not Detected (Below RL).

RL = PQL X Dilution Factor

Reviewed/Approved By: _____ Date: 6/23/11

Mark Johnson
Operations Manager

The cover letter is an integral part of this analytical report

FIGURES F-11.7 THROUGH F-11.34
ANALYTICAL TESTING OF GROUNDWATER SAMPLES (PE PHASE)

AMERICAN SCIENTIFIC LABORATORIES, LLC
Environmental Testing Services
2520 N. San Fernando Rd., Los Angeles, CA 90065 Tel: (323) 223-9700 Fax: (323) 223-9500

ANALYTICAL RESULTS

Ordered By

MACTEC Engineering & Consulting Inc
5628 East Slauson Ave.
Los Angeles, CA 90040-

Telephone: (323)889-5300
Attn: Marty Hudson

Site

241 Moreno Drive
Beverly Hills, CA

Page: **2**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 1664, Revision A, Oil and Grease (HEM)

QC Batch No: 042611-1

Our Lab I.D.		**267815**	**267817**			
Client Sample I.D.		G-166-D	G-165-D			
Date Sampled		**04/22/2011**	**04/22/2011**			
Date Prepared		**04/26/2011**	**04/26/2011**			
Preparation Method						
Date Analyzed		**04/26/2011**	**04/26/2011**			
Matrix		Water	Water			
Units		mg/L	mg/L			
Dilution Factor		1	1			
Analytes	**PQL**	**Results**	**Results**			
Conventionals						
Oil and Grease	**5.00**	**ND**	**ND**			

QUALITY CONTROL REPORT

QC Batch No: 042611-1

Analytes	LCS % REC	LCS DUP % REC	LCS RPD % REC	LCS/LCSD % Limit	LCS RPD % Limit					
Conventionals										
Oil and Grease	**92**	**95**	**3.2**	**80-120**	**<20**					

FIGURE F-11.7

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Attn: Marty Hudson

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Page: **3**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 418.1, TRPH

QC Batch No: W-042811-1

Our Lab I.D.		**267815**	**267817**			
Client Sample I.D.		G-166-D	G-165-D			
Date Sampled		**04/22/2011**	**04/22/2011**			
Date Prepared		**04/27/2011**	**04/27/2011**			
Preparation Method						
Date Analyzed		**04/28/2011**	**04/28/2011**			
Matrix		Water	Water			
Units		mg/L	mg/L			
Dilution Factor		1	1			
Analytes	**PQL**	**Results**	**Results**			
Total Recoverable Petroleum Hydrocarbons	**0.500**	**ND**	**ND**			

QUALITY CONTROL REPORT

QC Batch No: W-042811-1

Analytes	MS % REC	MS DUP % REC	RPD %	MS/MSD % Limit	MS RPD % Limit					
Total Recoverable Petroleum Hydrocarbons	**104**	**103**	**<1**	**70-130**	**15**					

FIGURE F-11.8

AMERICAN SCIENTIFIC LABORATORIES, LLC
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Attn: Marty Hudson

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Page: **4**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 600, General Minerals

QC Batch No: 042211-1

Our Lab I.D.		**267815**	**267816**	**267817**		
Client Sample I.D.		G-166-D	G-166-S	G-165-D		
Date Sampled		**04/22/2011**	**04/22/2011**	**04/22/2011**		
Date Prepared		**04/22/2011**	**04/22/2011**	**04/22/2011**		
Preparation Method						
Date Analyzed		**04/22/2011**	**04/22/2011**	**04/22/2011**		
Matrix		Water	Water	Water		
Units		mg/L	mg/L	mg/L		
Dilution Factor		1	1	1		
Analytes	**PQL**	**Results**	**Results**	**Results**		
Conventionals						
Alkalinity,Total	**10.0**	**215**	**135**	**145**		
Bicarbonate (as CaCO3)	**10.0**	**215**	**135**	**145**		
Carbonate (as CaCO3)	**10.0**	**ND**	**ND**	**ND**		
Hydroxide (as CaCO3)	**10.0**	**ND**	**ND**	**ND**		
Chloride	**1.00**	**352**	**599**	**753**		
Conductivity (umho/cm @77F)	**1.00**	**1620**	**2350**	**2780**		
Fluoride	**0.100**	**0.500**	**1.15**	**1.25**		
Hardness (Ca,Mg) as CaCO3	**10.0**	**440**	**260**	**900**		
Nitrate as N	**0.100**	**4.17**	**1.18**	**6.95**		
pH	**1.00**	**7.53**	**8.01**	**7.10**		
Sulfate	**1.00**	**45.4**	**268**	**54.4**		
Surfactants(MBAS)	**0.0500**	**ND**	**ND**	**ND**		
Total Dissolved Solids(TDS)	**10.0**	**1070**	**1510**	**1800**		
ICP Metals						
Calcium	**1.00**	**715**	**644**	**394**		
Copper	**0.0100**	**ND**	**ND**	**0.0177**		
Iron	**0.0500**	**1.70**	**0.787**	**1.73**		
Magnesium	**0.250**	**95.2**	**10.6**	**7.70**		
Manganese	**0.0200**	**1.74**	**1.15**	**1.23**		
Potassium	**1.00**	**15.5**	**23.9**	**4.80**		
Sodium	**1.00**	**189**	**492**	**167**		
Zinc	**0.0100**	**0.0630**	**0.0198**	**0.0687**		

QUALITY CONTROL REPORT

QC Batch No: 042211-1

Analytes	LCS % REC	LCS/LCSD % Limit								
Conventionals										

FIGURE F-11.9

AMERICAN SCIENTIFIC LABORATORIES, LLC
Environmental Testing Services
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ANALYTICAL RESULTS

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 600, General Minerals

QUALITY CONTROL REPORT

QC Batch No: 042211-1

Analytes	LCS % REC	LCS/LCSD % Limit								
Conventionals										
Alkalinity,Total	**95**	**80-120**								
Bicarbonate (as CaCO3)	**95**	**80-120**								
Carbonate (as CaCO3)	**95**	**80-120**								
Hydroxide (as CaCO3)	**95**	**80-120**								
Chloride	**98**	**80-120**								
Conductivity (umho/cm @77F)	**97**	**80-120**								
Fluoride	**98**	**80-120**								
Hardness (Ca,Mg) as CaCO3	**100**	**80-120**								
Nitrate as N	**100**	**80-120**								
pH	**100**	**80-120**								
Sulfate	**95**	**80-120**								
Surfactants(MBAS)	**92**	**80-120**								
Total Dissolved Solids(TDS)	**102**	**80-120**								
ICP Metals										
Calcium	**106**	**80-120**								
Copper	**109**	**80-120**								
Iron	**105**	**80-120**								
Magnesium	**101**	**80-120**								
Manganese	**113**	**80-120**								
Potassium	**98**	**80-120**								
Sodium	**111**	**80-120**								
Zinc	**112**	**80-120**								

AMERICAN SCIENTIFIC LABORATORIES, LLC
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ANALYTICAL RESULTS

Ordered By

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Attn: Marty Hudson

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Beverly Hills, CA

Page: **6**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 6010B/7470A, CCR Title 22 Metals (TTLC)

QC Batch No: 042611-1

Our Lab I.D.		267815	267816	267817		
Client Sample I.D.		G-166-D	G-166-S	G-165-D		
Date Sampled		04/22/2011	04/22/2011	04/22/2011		
Date Prepared		04/26/2011	04/26/2011	04/26/2011		
Preparation Method						
Date Analyzed		04/26/2011	04/26/2011	04/26/2011		
Matrix		Water	Water	Water		
Units		mg/L	mg/L	mg/L		
Dilution Factor		1	1	1		
Analytes	**PQL**	**Results**	**Results**	**Results**		
AA Metals						
Mercury	0.0005	ND	ND	ND		
ICP Metals						
Antimony	0.0100	ND	ND	ND		
Arsenic	0.0100	0.0258	0.0267	0.0120		
Barium	0.0100	1.21	0.921	0.840		
Beryllium	0.0050	ND	ND	ND		
Cadmium	0.0050	ND	ND	ND		
Chromium	0.0100	ND	ND	ND		
Cobalt	0.0100	ND	0.0164	0.0160		
Copper	0.0100	ND	ND	0.0177		
Lead	0.0050	ND	ND	ND		
Molybdenum	0.0100	0.0260	0.0706	ND		
Nickel	0.0100	0.0646	0.0626	0.0490		
Selenium	0.0100	0.0209	0.0192	ND		
Silver	0.0100	ND	ND	ND		
Thallium	0.0100	ND	ND	ND		
Vanadium	0.0100	ND	ND	ND		
Zinc	0.0100	0.0630	0.0198	0.0687		

QUALITY CONTROL REPORT

QC Batch No: 042611-1

Analytes	LCS % REC	LCS/LCSD % Limit								
AA Metals										
Mercury	107	80-120								
ICP Metals										
Antimony	100	80-120								
Arsenic	101	80-120								

FIGURE F-11.11

AMERICAN SCIENTIFIC LABORATORIES, LLC
Environmental Testing Services
2520 N. San Fernando Rd., Los Angeles, CA 90065 Tel: (323) 223-9700 Fax: (323) 223-9500

ANALYTICAL RESULTS

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 6010B/7470A, CCR Title 22 Metals (TTLC)

QUALITY CONTROL REPORT

QC Batch No: 042611-1

Analytes	LCS % REC	LCS/LCSD % Limit								
ICP Metals										
Barium	**105**	**80-120**								
Beryllium	**107**	**80-120**								
Cadmium	**104**	**80-120**								
Chromium	**103**	**80-120**								
Cobalt	**102**	**80-120**								
Copper	**104**	**80-120**								
Lead	**105**	**80-120**								
Molybdenum	**100**	**80-120**								
Nickel	**106**	**80-120**								
Selenium	**100**	**80-120**								
Silver	**100**	**80-120**								
Thallium	**104**	**80-120**								
Vanadium	**100**	**80-120**								
Zinc	**106**	**80-120**								

FIGURE F-11.12

AMERICAN SCIENTIFIC LABORATORIES, LLC
Environmental Testing Services
2520 N. San Fernando Rd., Los Angeles, CA 90065 Tel: (323) 223-9700 Fax: (323) 223-9500

ANALYTICAL RESULTS

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Page: **8**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 8015B, TPH DROs and OROs (Diesel and Oil Range Organics)

QC Batch No: W-042711-1P

Our Lab I.D.		267815	267816	267817		
Client Sample I.D.		G-166-D	G-166-S	G-165-D		
Date Sampled		04/22/2011	04/22/2011	04/22/2011		
Date Prepared		04/27/2011	04/27/2011	04/27/2011		
Preparation Method						
Date Analyzed		04/27/2011	04/27/2011	04/27/2011		
Matrix		Water	Water	Water		
Units		mg/L	mg/L	mg/L		
Dilution Factor		1	1	1		
Analytes	**PQL**	**Results**	**Results**	**Results**		
TPH DROs (C10 to C28)	0.500	ND	ND	ND		
TPH OROs (C28+)	0.500	ND	ND	ND		

Our Lab I.D.		267815	267816	267817		
Surrogates	**% Rec.Limit**	**% Rec.**	**% Rec.**	**% Rec.**		
Surrogate Percent Recovery						
Chlorobenzene	70-120	116	95	116		

QUALITY CONTROL REPORT

QC Batch No: W-042711-1P

Analytes	MS % REC	MS DUP % REC	RPD %	MS/MSD % Limit	MS RPD % Limit					
Diesel	102	101	<1	75-120	<20					

FIGURE F-11.13

AMERICAN SCIENTIFIC LABORATORIES, LLC
Environmental Testing Services
2520 N. San Fernando Rd., Los Angeles, CA 90065 Tel: (323) 223-9700 Fax: (323) 223-9500

ANALYTICAL RESULTS

Ordered By

MACTEC Engineering & Consulting Inc
5628 East Slauson Ave.
Los Angeles, CA 90040-

Telephone: (323)889-5300
Attn: Marty Hudson

Site

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Beverly Hills, CA

Page: **9**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 8081A, Organochlorine Pesticides

QC Batch No: 042711-1

Our Lab I.D.		267815	267817			
Client Sample I.D.		G-166-D	G-165-D			
Date Sampled		04/22/2011	04/22/2011			
Date Prepared		04/27/2011	04/27/2011			
Preparation Method						
Date Analyzed		04/27/2011	04/27/2011			
Matrix		Water	Water			
Units		ug/L	ug/L			
Dilution Factor		1	1			
Analytes	**PQL**	**Results**	**Results**			
Aldrin	0.0400	ND	ND			
alpha-Hexachlorocyclohexane (Alpha-BHC)	0.120	ND	ND			
Beta-Hexachlorocyclohexane (Beta-BHC)	0.110	ND	ND			
Gamma-Chlordane	0.400	ND	ND			
alpha-Chlordane	0.400	ND	ND			
4,4'-DDD (DDD)	0.100	ND	ND			
4,4'-DDE (DDE)	0.0900	ND	ND			
4,4'-DDT (DDT)	0.0400	ND	ND			
delta-Hexachlorocyclohexane (Delta-BHC)	0.110	ND	ND			
dieldrin	0.0500	ND	ND			
Endosulfan 1	0.0600	ND	ND			
Endosulfan 11	0.0900	ND	ND			
Endosulfan sulfate	0.0700	ND	ND			
Endrin	0.0800	ND	ND			
Endrin aldehyde	0.0900	ND	ND			
Endrin ketone	0.0700	ND	ND			
gamma-Hexachlorocyclohexane (Gamma-BHC, Lindane)	0.0600	ND	ND			
Heptachlor	0.0300	ND	ND			
Heptachlor epoxide	0.0700	ND	ND			
Methoxychlor	0.100	ND	ND			
Toxaphene	10.0	ND	ND			

Our Lab I.D.		267815	267817			
Surrogates	**% Rec.Limit**	**% Rec.**	**% Rec.**			
Surrogate Percent Recovery						
Decachlorobiphenyl	43-169	63	60			

FIGURE F-11.14

AMERICAN SCIENTIFIC LABORATORIES, LLC
Environmental Testing Services
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ANALYTICAL RESULTS

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 8081A, Organochlorine Pesticides

QUALITY CONTROL REPORT

QC Batch No: 042711-1

Analytes	LCS % REC	LCS DUP % REC	LCS RPD % REC	LCS/LCSD % Limit	LCS RPD % Limit					
Aldrin	**116**	**105**	**10.0**	**42-122**	**<30**					
4,4'-DDT (DDT)	**109**	**107**	**1.9**	**25-160**	**<30**					
dieldrin	**119**	**115**	**3.4**	**36-146**	**<30**					
Endrin	**115**	**113**	**1.8**	**30-147**	**<30**					
gamma-Hexachlorocyclohexane (Gamma-BHC, Lindane)	**106**	**113**	**6.4**	**32-127**	**<30**					
Heptachlor	**119**	**108**	**9.7**	**34-111**	**<30**					

FIGURE F-11.15

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ANALYTICAL RESULTS

Ordered By

MACTEC Engineering & Consulting Inc
5628 East Slauson Ave.
Los Angeles, CA 90040-

Telephone: (323)889-5300
Attn: Marty Hudson

Site

241 Moreno Drive
Beverly Hills, CA

Page: **11**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 8082, Polychlorinated Biphenyls(PCBs) by Gas Chromatography

QC Batch No: 042711-1

Our Lab I.D.		267815	267817			
Client Sample I.D.		G-166-D	G-165-D			
Date Sampled		04/22/2011	04/22/2011			
Date Prepared		04/27/2011	04/27/2011			
Preparation Method						
Date Analyzed		04/27/2011	04/27/2011			
Matrix		Water	Water			
Units		ug/L	ug/L			
Dilution Factor		1	1			
Analytes	**PQL**	**Results**	**Results**			
Aroclor-1016 (PCB-1016)	0.650	ND	ND			
Aroclor-1221 (PCB-1221)	1.00	ND	ND			
Aroclor-1232 (PCB-1232)	0.650	ND	ND			
Aroclor-1242 (PCB-1242)	0.650	ND	ND			
Aroclor-1248 (PCB-1248)	0.650	ND	ND			
Aroclor-1254 (PCB-1254)	0.650	ND	ND			
Aroclor-1260 (PCB-1260)	0.650	ND	ND			

Our Lab I.D.		267815	267817			
Surrogates	**% Rec.Limit**	**% Rec.**	**% Rec.**			
Surrogate Percent Recovery						
Decachlorobiphenyl	43-169	63	60			

QUALITY CONTROL REPORT

QC Batch No: 042711-1

Analytes	LCS % REC	LCS DUP % REC	LCS RPD % REC	LCS/LCSD % Limit	LCS RPD % Limit					
Aroclor-1260 (PCB-1260)	106	100	5.8	39-150	<30					

FIGURE F-11.16

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ANALYTICAL RESULTS

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5628 East Slauson Ave.
Los Angeles, CA 90040-

Telephone: (323)889-5300
Attn: Marty Hudson

Site

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Page: **12**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 8260B, Volatile Organic Compounds

QC Batch No: W-042611-2B

Our Lab I.D.		267814	267815	267816	267817	
Client Sample I.D.		G-165-S	G-166-D	G-166-S	G-165-D	
Date Sampled		04/22/2011	04/22/2011	04/22/2011	04/22/2011	
Date Prepared		04/27/2011	04/27/2011	04/27/2011	04/27/2011	
Preparation Method						
Date Analyzed		04/27/2011	04/27/2011	04/27/2011	04/27/2011	
Matrix		Water	Water	Water	Water	
Units		ug/L	ug/L	ug/L	ug/L	
Dilution Factor		1	1	1	1	
Analytes	**PQL**	**Results**	**Results**	**Results**	**Results**	
Acetone	5.00	ND	ND	ND	ND	
Benzene	1.00	ND	ND	ND	ND	
Bromobenzene (Phenyl bromide)	1.00	ND	ND	ND	ND	
Bromochloromethane (Chlorobromomethane)	1.00	ND	ND	ND	ND	
Bromodichloromethane (Dichlorobromomethane)	1.00	2.81	ND	1.23	ND	
Bromoform (Tribromomethane)	5.00	ND	ND	ND	ND	
Bromomethane (Methyl bromide)	3.00	ND	ND	ND	ND	
2-Butanone (MEK, Methyl ethyl ketone)	5.00	ND	ND	ND	ND	
n-Butylbenzene	1.00	ND	ND	ND	ND	
sec-Butylbenzene	1.00	ND	ND	ND	ND	
tert-Butylbenzene	1.00	ND	ND	ND	ND	
Carbon disulfide	1.00	ND	ND	ND	ND	
Carbon tetrachloride (Tetrachloromethane)	1.00	ND	ND	ND	ND	
Chlorobenzene	1.00	ND	ND	ND	ND	
Chloroethane	3.00	ND	ND	ND	ND	
2-Chloroethyl vinyl ether	5.00	ND	ND	ND	ND	
Chloroform (Trichloromethane)	1.00	2.87	1.14	1.47	ND	
Chloromethane (Methyl chloride)	3.00	ND	ND	ND	ND	
4-Chlorotoluene (p-Chlorotoluene)	1.00	ND	ND	ND	ND	
2-Chlorotoluene (o-Chlorotoluene)	1.00	ND	ND	ND	ND	
1,2-Dibromo-3-chloropropane (DBCP)	5.00	ND	ND	ND	ND	
Dibromochloromethane	1.00	4.32	ND	2.43	ND	
1,2-Dibromoethane (EDB, Ethylene dibromide)	1.00	ND	ND	ND	ND	
Dibromomethane	1.00	ND	ND	ND	ND	
1,2-Dichlorobenzene (o-Dichlorobenzene)	1.00	ND	ND	ND	ND	
1,3-Dichlorobenzene (m-Dichlorobenzene)	1.00	ND	ND	ND	ND	
1,4-Dichlorobenzene (p-Dichlorobenzene)	1.00	ND	ND	ND	ND	
Dichlorodifluoromethane	3.00	ND	ND	ND	ND	
1,1-Dichloroethane	1.00	ND	ND	ND	ND	

FIGURE F-11.17

AMERICAN SCIENTIFIC LABORATORIES, LLC
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ANALYTICAL RESULTS

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 8260B, Volatile Organic Compounds

QC Batch No: W-042611-2B

Our Lab I.D.		267814	267815	267816	267817	
Client Sample I.D.		G-165-S	G-166-D	G-166-S	G-165-D	
Date Sampled		04/22/2011	04/22/2011	04/22/2011	04/22/2011	
Date Prepared		04/27/2011	04/27/2011	04/27/2011	04/27/2011	
Preparation Method						
Date Analyzed		04/27/2011	04/27/2011	04/27/2011	04/27/2011	
Matrix		Water	Water	Water	Water	
Units		ug/L	ug/L	ug/L	ug/L	
Dilution Factor		1	1	1	1	
Analytes	**PQL**	**Results**	**Results**	**Results**	**Results**	
1,2-Dichloroethane	1.00	ND	ND	ND	ND	
1,1-Dichloroethene (1,1-Dichloroethylene)	1.00	ND	ND	ND	ND	
cis-1,2-Dichloroethene	1.00	ND	ND	ND	ND	
trans-1,2-Dichloroethene	1.00	ND	ND	ND	ND	
1,2-Dichloropropane	1.00	ND	ND	ND	ND	
1,3-Dichloropropane	1.00	ND	ND	ND	ND	
2,2-Dichloropropane	1.00	ND	ND	ND	ND	
1,1-Dichloropropene	1.00	ND	ND	ND	ND	
cis-1,3-Dichloropropene	1.00	ND	ND	ND	ND	
trans-1,3-Dichloropropene	1.00	ND	ND	ND	ND	
Ethylbenzene	1.00	ND	ND	ND	ND	
Hexachlorobutadiene (1,3-Hexachlorobutadiene)	3.00	ND	ND	ND	ND	
2-Hexanone	5.00	ND	ND	ND	ND	
Isopropylbenzene	1.00	ND	ND	ND	ND	
p-Isopropyltoluene (4-Isopropyltoluene)	1.00	ND	ND	ND	ND	
MTBE	2.00	ND	ND	ND	ND	
4-Methyl-2-pentanone (MIBK, Methyl isobutyl ketone)	5.00	ND	ND	ND	ND	
Methylene chloride (Dichloromethane, DCM)	5.00	ND	ND	ND	ND	
Naphthalene	1.00	ND	ND	ND	ND	
n-Propylbenzene	1.00	ND	ND	ND	ND	
Styrene	1.00	ND	ND	ND	ND	
1,1,1,2-Tetrachloroethane	1.00	ND	ND	ND	ND	
1,1,2,2-Tetrachloroethane	1.00	ND	ND	ND	ND	
Tetrachloroethene (Tetrachloroethylene)	1.00	ND	ND	ND	ND	
Toluene (Methyl benzene)	1.00	ND	ND	ND	ND	
1,2,3-Trichlorobenzene	1.00	ND	ND	ND	ND	
1,2,4-Trichlorobenzene	1.00	ND	ND	ND	ND	
1,1,1-Trichloroethane	1.00	ND	ND	ND	ND	
1,1,2-Trichloroethane	1.00	ND	ND	ND	ND	
Trichloroethene (TCE)	1.00	ND	ND	ND	ND	
Trichlorofluoromethane	1.00	ND	ND	ND	ND	
1,2,3-Trichloropropane	1.00	ND	ND	ND	ND	
1,2,4-Trimethylbenzene	1.00	ND	ND	ND	ND	
1,3,5-Trimethylbenzene	1.00	ND	ND	ND	ND	
Vinyl acetate	5.00	ND	ND	ND	ND	

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ANALYTICAL RESULTS

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 8260B, Volatile Organic Compounds

QC Batch No: W-042611-2B

Our Lab I.D.		267814	267815	267816	267817	
Client Sample I.D.		G-165-S	G-166-D	G-166-S	G-165-D	
Date Sampled		04/22/2011	04/22/2011	04/22/2011	04/22/2011	
Date Prepared		04/27/2011	04/27/2011	04/27/2011	04/27/2011	
Preparation Method						
Date Analyzed		04/27/2011	04/27/2011	04/27/2011	04/27/2011	
Matrix		Water	Water	Water	Water	
Units		ug/L	ug/L	ug/L	ug/L	
Dilution Factor		1	1	1	1	
Analytes	**PQL**	**Results**	**Results**	**Results**	**Results**	
Vinyl chloride (Chloroethene)	3.00	ND	ND	ND	ND	
o-Xylene	1.00	ND	ND	ND	ND	
m- & p-Xylenes	2.00	ND	ND	ND	ND	

Our Lab I.D.		267814	267815	267816	267817	
Surrogates	% Rec.Limit	% Rec.	% Rec.	% Rec.	% Rec.	
Surrogate Percent Recovery						
Bromofluorobenzene	70-120	100	101	100	101	
Dibromofluoromethane	70-120	86	89	88	90	
Toluene-d8	70-120	96	97	96	98	

QUALITY CONTROL REPORT

QC Batch No: W-042611-2B

Analytes	MS % REC	MS DUP % REC	RPD %	MS/MSD % Limit	MS RPD % Limit					
Benzene	91	85	6.8	75-120	15					
Chlorobenzene	111	105	5.6	75-120	15					
1,1-Dichloroethene (1,1-Dichloroethylene)	80	76	5.1	75-120	15					
MTBE	102	103	<1	75-120	15					
Toluene (Methyl benzene)	109	103	5.7	75-120	15					
Trichloroethene (TCE)	98	91	7.4	75-120	15					

FIGURE F-11.19

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ANALYTICAL RESULTS

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MACTEC Engineering & Consulting Inc
5628 East Slauson Ave.
Los Angeles, CA 90040-

Telephone: (323)889-5300
Attn: Marty Hudson

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Page: **15**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 8260B, TPH GROs(Gasoline Range Organics)

QC Batch No: W-042611-2B

Our Lab I.D.		267814	267815	267816	267817	
Client Sample I.D.		G-165-S	G-166-D	G-166-S	G-165-D	
Date Sampled		04/22/2011	04/22/2011	04/22/2011	04/22/2011	
Date Prepared		04/27/2011	04/27/2011	04/27/2011	04/27/2011	
Preparation Method						
Date Analyzed		04/27/2011	04/27/2011	04/27/2011	04/27/2011	
Matrix		Water	Water	Water	Water	
Units		ug/L	ug/L	ug/L	ug/L	
Dilution Factor		1	1	1	1	
Analytes	**PQL**	**Results**	**Results**	**Results**	**Results**	
TPH GROs (C6 to C10)	50.0	ND	ND	ND	ND	

Our Lab I.D.		267814	267815	267816	267817	
Surrogates	% Rec.Limit	% Rec.	% Rec.	% Rec.	% Rec.	
Surrogate Percent Recovery						
Bromofluorobenzene	70-120	100	101	100	101	
Dibromofluoromethane	70-120	86	89	88	90	
Toluene-d8	70-120	96	97	96	98	

QUALITY CONTROL REPORT

QC Batch No: W-042611-2B

Analytes	MS % REC	MS DUP % REC	RPD %	MS/MSD % Limit	MS RPD % Limit					
Benzene	91	85	6.8	75-120	15					
Chlorobenzene	111	105	5.6	75-120	15					
1,1-Dichloroethene (1,1-Dichloroethylene)	80	76	5.1	75-120	15					
Toluene (Methyl benzene)	109	103	5.7	75-120	15					
Trichloroethene (TCE)	98	91	7.4	75-120	15					

FIGURE F-11.20

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ANALYTICAL RESULTS

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5628 East Slauson Ave.
Los Angeles, CA 90040-

Telephone: (323)889-5300
Attn: Marty Hudson

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Page: **16**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 8270C, Semivolatile Organics

QC Batch No: 042711-1

Our Lab I.D.		267815	267816	267817		
Client Sample I.D.		G-166-D	G-166-S	G-165-D		
Date Sampled		04/22/2011	04/22/2011	04/22/2011		
Date Prepared		04/27/2011	04/27/2011	04/27/2011		
Preparation Method						
Date Analyzed		04/27/2011	04/27/2011	04/27/2011		
Matrix		Water	Water	Water		
Units		ug/L	ug/L	ug/L		
Dilution Factor		1	1	1		
Analytes	**PQL**	**Results**	**Results**	**Results**		
Acenaphthene	10.0	ND	ND	ND		
Acenaphthylene	10.0	ND	ND	ND		
Anthracene	10.0	ND	ND	ND		
Benz(a)anthracene (Benzo(a)anthracene)	10.0	ND	ND	ND		
Benzo(a)pyrene	10.0	ND	ND	ND		
Benzo(b)fluoranthene	10.0	ND	ND	ND		
Benzo(ghi)perylene	10.0	ND	ND	ND		
Benzo(k)fluoranthene	10.0	ND	ND	ND		
Benzidine	20.0	ND	ND	ND		
Benzoic acid	10.0	ND	ND	ND		
Benzyl alcohol	10.0	ND	ND	ND		
Bis(2-chloroethoxy)methane	10.0	ND	ND	ND		
Bis(2-chloroethyl)ether	10.0	ND	ND	ND		
Bis(2-chloroisopropyl) ether	10.0	ND	ND	ND		
Bis(2-ethylhexyl) phthalate	10.0	ND	ND	ND		
4-Bromophenyl phenyl ether	10.0	ND	ND	ND		
Butyl benzyl phthalate (Benzyl butyl phthalate)	10.0	ND	ND	ND		
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	1.00	ND	ND	ND		
4-Chloroaniline	10.0	ND	ND	ND		
2-Chloronaphthalene	10.0	ND	ND	ND		
2-Chlorophenol (o-Chlorophenol)	1.00	ND	ND	ND		
4-Chlorophenyl phenyl ether	10.0	ND	ND	ND		
Chrysene	10.0	ND	ND	ND		
Di-n-butyl phthalate	10.0	ND	ND	ND		
Di-n-octyl phthalate (Dioctyl ester)	10.0	ND	ND	ND		
Dibenz(a,h)anthracene	10.0	ND	ND	ND		
Dibenzofuran	10.0	ND	ND	ND		
1,3-Dichlorobenzene (m-Dichlorobenzene)	10.0	ND	ND	ND		
1,2-Dichlorobenzene (o-Dichlorobenzene)	10.0	ND	ND	ND		

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ANALYTICAL RESULTS

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 8270C, Semivolatile Organics

QC Batch No: 042711-1

Our Lab I.D.		267815	267816	267817		
Client Sample I.D.		G-166-D	G-166-S	G-165-D		
Date Sampled		04/22/2011	04/22/2011	04/22/2011		
Date Prepared		04/27/2011	04/27/2011	04/27/2011		
Preparation Method						
Date Analyzed		04/27/2011	04/27/2011	04/27/2011		
Matrix		Water	Water	Water		
Units		ug/L	ug/L	ug/L		
Dilution Factor		1	1	1		
Analytes	**PQL**	**Results**	**Results**	**Results**		
1,4-Dichlorobenzene	10.0	ND	ND	ND		
3,3'-Dichlorobenzidine	20.0	ND	ND	ND		
2,4-Dichlorophenol	1.00	ND	ND	ND		
Diethyl phthalate (Diethyl ester)	10.0	ND	ND	ND		
2,4-Dimethylphenol	1.00	ND	ND	ND		
Dimethyl phthalate (Dimethyl ester)	10.0	ND	ND	ND		
2,4-Dinitrophenol	1.00	ND	ND	ND		
2,4-Dinitrotoluene	10.0	ND	ND	ND		
2,6-Dinitrotoluene (2,6-DNT)	10.0	ND	ND	ND		
1,2-Diphenylhydrazine	10.0	ND	ND	ND		
Fluoranthene	10.0	ND	ND	ND		
Fluorene	10.0	ND	ND	ND		
Hexachlorobenzene	10.0	ND	ND	ND		
Hexachlorobutadiene (1,3-Hexachlorobutadiene)	20.0	ND	ND	ND		
Hexachlorocyclopentadiene	10.0	ND	ND	ND		
Hexachloroethane	10.0	ND	ND	ND		
Indeno(1,2,3-cd)pyrene	10.0	ND	ND	ND		
Isophorone	10.0	ND	ND	ND		
2-methyl-4,6-Dinitrophenol	1.00	ND	ND	ND		
2-Methylnaphthalene	10.0	ND	ND	ND		
2-Methylphenol (o-Cresol, 2-Cresol)	1.00	ND	ND	ND		
4-Methylphenol (p-Cresol, 4-Cresol)	1.00	ND	ND	ND		
N-Nitroso-Di-n-propylamine	10.0	ND	ND	ND		
N-Nitrosodimethylamine (NDMA)	10.0	ND	ND	ND		
N-Nitrosodiphenylamine	10.0	ND	ND	ND		
Naphthalene	10.0	ND	ND	ND		
2-Nitroaniline	10.0	ND	ND	ND		
3-Nitroaniline	10.0	ND	ND	ND		
4-Nitroaniline	10.0	ND	ND	ND		
Nitrobenzene (NB)	10.0	ND	ND	ND		
2-Nitrophenol (o-Nitrophenol)	1.00	ND	ND	ND		
4-Nitrophenol	1.00	ND	ND	ND		
Pentachlorophenol	1.00	ND	ND	ND		
Phenanthrene	10.0	ND	ND	ND		
Phenol	1.00	ND	ND	ND		

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ANALYTICAL RESULTS

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: 8270C, Semivolatile Organics

QC Batch No: 042711-1

Our Lab I.D.		267815	267816	267817		
Client Sample I.D.		G-166-D	G-166-S	G-165-D		
Date Sampled		04/22/2011	04/22/2011	04/22/2011		
Date Prepared		04/27/2011	04/27/2011	04/27/2011		
Preparation Method						
Date Analyzed		04/27/2011	04/27/2011	04/27/2011		
Matrix		Water	Water	Water		
Units		ug/L	ug/L	ug/L		
Dilution Factor		1	1	1		
Analytes	**PQL**	**Results**	**Results**	**Results**		
Pyrene	10.0	ND	ND	ND		
1,2,4-Trichlorobenzene	10.0	ND	ND	ND		
2,4,5-Trichlorophenol	1.00	ND	ND	ND		
2,4,6-Trichlorophenol	1.00	ND	ND	ND		

Our Lab I.D.		267815	267816	267817		
Surrogates	**% Rec.Limit**	**% Rec.**	**% Rec.**	**% Rec.**		
Surrogate Percent Recovery						
2-Fluorophenol	21-105	27	35	29		
Phenol-d6	10-107	29	34	29		
2,4,6-Tribromophenol	10-123	69	77	59		
Nitrobenzene-d5	35-114	64	55	53		
2-Fluorobiphenyl	18-116	52	54	52		
Terphenyl-d14	33-141	93	102	99		

QUALITY CONTROL REPORT

QC Batch No: 042711-1

Analytes	LCS % REC	LCS DUP % REC	LCS RPD % REC	LCS/LCSD % Limit	LCS RPD % Limit					
Acenaphthene	64	68	6.1	43-118	<30					
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	65	64	1.6	23-117	<30					
2-Chlorophenol (o-Chlorophenol)	49	54	9.7	27-113	<30					
1,4-Dichlorobenzene	50	55	9.5	36-105	<30					
2,4-Dinitrotoluene	102	102	<1	24-120	<30					
N-Nitroso-Di-n-propylamine	75	81	7.7	41-116	<30					
4-Nitrophenol	63	56	11.8	10-133	<30					
Pentachlorophenol	64	65	1.6	9-118	<30					
Phenol	35	40	13.3	12-110	<30					
Pyrene	115	113	1.8	26-127	<30					
1,2,4-Trichlorobenzene	64	71	10.4	39-98	<30					

AMERICAN SCIENTIFIC LABORATORIES, LLC
Environmental Testing Services
2520 N. San Fernando Rd., Los Angeles, CA 90065 Tel: (323) 223-9700 Fax: (323) 223-9500

ANALYTICAL RESULTS

Ordered By

MACTEC Engineering & Consulting Inc
5628 East Slauson Ave.
Los Angeles, CA 90040-

Telephone: (323)889-5300
Attn: Marty Hudson

Site

241 Moreno Drive
Beverly Hills, CA

Page: **19**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: RSKSOP-175, Dissolved Gases

QC Batch No: 042911-1

Our Lab I.D.		267814	267815	267816	267817	
Client Sample I.D.		G-165-S	G-166-D	G-166-S	G-165-D	
Date Sampled		04/22/2011	04/22/2011	04/22/2011	04/22/2011	
Date Prepared		04/29/2011	04/29/2011	04/29/2011	04/29/2011	
Preparation Method						
Date Analyzed		04/29/2011	04/29/2011	04/29/2011	04/29/2011	
Matrix		Water	Water	Water	Water	
Units		ug/L	ug/L	ug/L	ug/L	
Dilution Factor		1	1	1	1	
Analytes	**PQL**	**Results**	**Results**	**Results**	**Results**	
Methane	1.00	ND	2.50	4.92	5.91	

QUALITY CONTROL REPORT

QC Batch No: 042911-1

Analytes	LCS % REC	LCS DUP % REC	LCS RPD % REC	LCS/LCSD % Limit	LCS RPD % Limit					
Methane	90	93	3.3	70-130	<30					

FIGURE F-11.24

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Beverly Hills, CA

Page: **20**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: SM2540-D, Total Suspended Solids (TSS)

QC Batch No: 042711-1

Our Lab I.D.		**267815**	**267816**	**267817**		
Client Sample I.D.		G-166-D	G-166-S	G-165-D		
Date Sampled		**04/22/2011**	**04/22/2011**	**04/22/2011**		
Date Prepared		**04/27/2011**	**04/27/2011**	**04/27/2011**		
Preparation Method						
Date Analyzed		**04/27/2011**	**04/27/2011**	**04/27/2011**		
Matrix		Water	Water	Water		
Units		mg/L	mg/L	mg/L		
Dilution Factor		1	1	1		
Analytes	**PQL**	**Results**	**Results**	**Results**		
Conventionals						
Solids, Total Suspended (TSS)	**10.0**	**163000**	**164000**	**7970**		

QUALITY CONTROL REPORT

QC Batch No: 042711-1

Analytes	LCS % REC	LCS DUP % REC	LCS RPD % REC	LCS/LCSD % Limit	LCS RPD % Limit					
Conventionals										
Solids, Total Suspended (TSS)	**104**	**101**	**2.9**	**80-120**	**20**					

FIGURE F-11.25

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ANALYTICAL RESULTS

Ordered By

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Attn: Marty Hudson

Site

241 Moreno Drive
Beverly Hills, CA

Page: **21**

Project ID: 4953-10-1531 G165-66
Project Name: MTA Westside Extension

ASL Job Number	Submitted	Client
49598	04/22/2011	MACTEC

Method: SM4500-S-2-D, Sulfide (Methylene Blue Method)

QC Batch No: 042211-1

Our Lab I.D.		267815	267816	267817		
Client Sample I.D.		G-166-D	G-166-S	G-165-D		
Date Sampled		04/22/2011	04/22/2011	04/22/2011		
Date Prepared		04/22/2011	04/22/2011	04/22/2011		
Preparation Method						
Date Analyzed		04/22/2011	04/22/2011	04/22/2011		
Matrix		Water	Water	Water		
Units		mg/L	mg/L	mg/L		
Dilution Factor		1	1	1		
Analytes	**PQL**	**Results**	**Results**	**Results**		
Conventionals						
Sulfide, total	0.0200	ND	ND	ND		

QUALITY CONTROL REPORT

QC Batch No: 042211-1

Analytes	SM Result	SM DUP Result	RPD %	SM RPD % Limit						
Conventionals										
Sulfide, total	ND	ND	<1	20						

FIGURE F-11.26

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LABORATORY REPORT

May 6, 2011

Molky Brar
American Scientific Laboratories
2520 North San Fernando Road
Los Angeles, CA 90065

RE: 49598

Dear Molky:

Enclosed are the results of the samples submitted to our laboratory on April 25, 2011. For your reference, these analyses have been assigned our service request number P1101541.

All analyses were performed according to our laboratory's NELAP and DoD-ELAP-approved quality assurance program. The test results meet requirements of the current NELAP and DoD-ELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP and DoD-ELAP-accredited analytes, refer to the certifications section at www.caslab.com. Results are intended to be considered in their entirety and apply only to the samples analyzed and reported herein.

Columbia Analytical Services, Inc. is certified by the California Department of Health Services, NELAP Laboratory Certificate No. 02115CA; Arizona Department of Health Services, Certificate No. AZ0694; Florida Department of Health, NELAP Certification E871020; New Jersey Department of Environmental Protection, NELAP Laboratory Certification ID #CA009; New York State Department of Health, NELAP NY Lab ID No: 11221; Oregon Environmental Laboratory Accreditation Program, NELAP ID: CA20007; The American Industrial Hygiene Association, Laboratory #101661; United States Department of Defense Environmental Laboratory Accreditation Program (DoD-ELAP), Certificate No. L10-3; Pennsylvania Registration No. 68-03307; TX Commission of Environmental Quality, NELAP ID T104704413-10-1; Minnesota Department of Health, NELAP Certificate No. 219474; Washington State Department of Ecology, ELAP Lab ID: C946. Each of the certifications listed above have an explicit Scope of Accreditation that applies to specific matrices/methods/analytes; therefore, please contact me for information corresponding to a particular certification.

If you have any questions, please call me at (805) 526-7161.

Respectfully submitted,

Columbia Analytical Services, Inc.

Sue Anderson
Project Manager

Client: American Scientific Laboratories CAS Project No: P1101541
Project: 49598

CASE NARRATIVE

The samples were received intact under chain of custody on April 25, 2011 and were stored in accordance with the analytical method requirements. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the samples at the time of sample receipt.

Hydrogen Sulfide Analysis

The samples were analyzed for hydrogen sulfide using a gas chromatograph equipped with a sulfur chemiluminescence detector (SCD).

The results of analyses are given in the attached laboratory report. All results are intended to be considered in their entirety, and Columbia Analytical Services, Inc. (CAS) is not responsible for utilization of less than the complete report.

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DETAIL SUMMARY REPORT

Client: American Scientific Laboratories
Project ID: 49598

Service Request: P1101541

Date Received: 4/25/2011
Time Received: 11:10

Client Sample ID	Lab Code	Matrix	Date Collected	Time Collected	Sulfur Liq - Sulfur
267814	P1101541-001	Water	4/22/2011	11:45	X
267815	P1101541-002	Water	4/22/2011	12:35	X
267816	P1101541-003	Water	4/22/2011	13:20	X
267817	P1101541-004	Water	4/22/2011	14:35	X

FIGURE F-11.29

Columbia Analytical Services, Inc.
An Employee - Owned Company

2655 Park Center Drive, Suite A
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

~~Air~~ - Chain of Custody Record & Analytical Service Request

Page ____ of ____

Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) 10 Day - Standard

CAS Project No. 110154 1

CAS Contact

Company Name & Address (Reporting Information)
American Scientific Labs
2500 N. San Fernando Road
L.A. CA 90065

Project Name

Project Number 49598

Project Manager Molly Brar
molly@asllab.com

P.O. # / Billing Information

Phone 323 223 9700
Fax 323 223 9500

Email Address for Result Reporting
molly@asllab.com

Sampler (Print & Sign)

Analysis Method and/or Analytes

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected	Sample Type (Air/Tube/Solid)	Canister ID (Bar Code # - AC, SC, etc.)	Flow Controller (Bar Code - FC #)	Sample Volume	(Dissolved) Hydrogen Sulfide				Comments e.g. Actual Preservative or specific instructions
267814	1	4-22-11	11:45	water			20ml	X				unpreserved
267815	2	"	12:35	"				X				"
267816	3	"	13:20	"				X				"
267817	4	"	14:35	"				X				"

Report Tier Levels - please select
Tier I - (Results/Default if not specified) ____
Tier II - (Results + QC) ____
Tier III - (Data Validation Package) 10% Surcharge ____
Tier V - (client specified) ____
EDD required Yes / No
Type: ____ EDD Units: ____

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Alex	4-25-11	11:10		4/25/11	1110
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Date:	Time:

Cooler / Blank
Temperature 6 °C

FIGURE F-11.30

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Sample Acceptance Check Form

Client: American Scientific Laboratories Work order: P1101541

Project: 49598

Sample(s) received on: 4/25/11 Date opened: 4/25/11 by: SSTAPLES

Note: This form is used for all samples received by CAS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client and/or as required by the method/SOP.

		Yes	No	N/A
1	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
2	Container(s) **supplied by CAS**?	☐	☒	☐
3	Did **sample containers** arrive in good condition?	☒	☐	☐
4	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
5	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
6	Was **sample volume** received adequate for analysis?	☒	☐	☐
7	Are samples within specified holding times?	☒	☐	☐
8	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☒	☐	☐
	Cooler Temperature 6 °C Blank Temperature ____ °C	☒	☐	☐
9	Was a **trip blank** received?	☐	☐	☒
10	Were **custody seals** on outside of cooler/Box?	☐	☒	☐
	Location of seal(s)? ____ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
	Were custody seals on outside of sample container?	☐	☒	☐
	Location of seal(s)? ____ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
11	Do containers have appropriate **preservation**, according to method/SOP or Client specified information?	☒	☐	☐
	Is there a client indication that the submitted samples are **pH** preserved?	☐	☐	☒
	Were **VOA vials** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and if necessary alter it?	☐	☐	☒
12	**Tubes:** Are the tubes capped and intact?	☐	☐	☒
	Do they contain moisture?	☐	☐	☒
13	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P1101541-001.01	40mL VOA NP		6		P	
P1101541-001.02	40mL VOA NP				P	
P1101541-001.03	40mL VOA NP				P	
P1101541-002.01	40mL VOA NP		6		P	
P1101541-002.02	40mL VOA NP				P	
P1101541-002.03	40mL VOA NP				P	
P1101541-003.01	40mL VOA NP		6		P	
P1101541-003.02	40mL VOA NP				P	

Explain any discrepancies: (include lab sample ID numbers):

Vials contained precipitate

RSK - MEEPP, HCL (pH<2); RSK - CO2, (pH 5-8); Sulfur (pH>4)

FIGURE F-11.31

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Sample Acceptance Check Form

Client: American Scientific Laboratories Work order: P1101541

Project: 49598

Sample(s) received on: 4/25/11 Date opened: 4/25/11 by: SSTAPLES

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P1101541-003.03	40mL VOA NP				P	
P1101541-004.01	40mL VOA NP		6		A	
P1101541-004.02	40mL VOA NP				A	
P1101541-004.03	40mL VOA NP				A	

Explain any discrepancies: (include lab sample ID numbers):

RSK - MEEPP, HCL (pH<2); RSK - CO2, (pH 5-8); Sulfur (pH>4)

FIGURE F-11.32

RESULTS OF ANALYSIS

Client: **American Scientific Laboratories**
Client Project ID: **49598** CAS Project ID: P1101541

Hydrogen Sulfide

Test Code: GC/SCD Reduced Sulfur Analysis
Instrument ID: Agilent 6890A/GC13/SCD Date(s) Collected: 4/22/11
Analyst: Wade Henton/Lauryn Keeler Date Received: 4/25/11
Matrix: Water Date Analyzed: 4/26/11
Test Notes:

Client Sample ID	CAS Sample ID	Liquid Amount: Amount ml(s)	Purge Volume Liter(s)	Injection Volume ml(s)	**Result µg/L**	MRL µg/L	Data Qualifier
267814	P1101541-001	10.0	0.30	1.0	ND	0.84	
267815	P1101541-002	10.0	0.30	1.0	ND	0.84	
267816	P1101541-003	10.0	0.30	1.0	ND	0.84	
267817	P1101541-004	10.0	0.30	1.0	ND	0.84	
Method Blank	P110426-MB	10.0	0.30	1.0	ND	0.84	

ND = Compound was analyzed for, but not detected above the laboratory reporting limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

FIGURE F-11.33

LABORATORY CONTROL SAMPLE / DUPLICATE LABORATORY CONTROL SAMPLE SUMMARY

Client: **American Scientific Laboratories**
Client Sample ID: **Duplicate Lab Control Sample**
Client Project ID: **49598**

CAS Project ID: P1101541
CAS Sample ID: P110426-DLCS

Test Code: GC/SCD Reduced Sulfur Analysis
Instrument ID: Agilent 6890A/GC13/SCD
Analyst: Wade Henton/Lauryn Keeler
Matrix: Water
Test Notes:

Date Collected: NA
Date Received: NA
Date Analyzed: 4/26/11
Liquid Amount: 10.0 ml(s)
Purge Volume: 0.30 Liter(s)
Injection Volume: 0.20 ml(s)

CAS #	Compound	Spike Amount LCS / DLCS ug/L	Result LCS ug/L	Result DLCS ug/L	% Recovery LCS	% Recovery DLCS	CAS Acceptance Limits	RPD	RPD Limit	Data Qualifier
7783-06-4	Hydrogen Sulfide	419	338	414	**81**	**99**	53-127	20	30	

FIGURE F-11.34

FIGURES F-12.1 THROUGH F-12.10
ANALYTICAL TESTING OF TAR SANDS (PE PHASE)

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Ordered By

MACTEC Engineering & Consulting Inc
5628 East Slauson Ave.
Los Angeles, CA 90040-

Telephone (323) 889-5300
Attn Hari Ponnaboyina

Number of Pages 9
Date Received 04/20/2011
Date Reported 04/21/2011

Job Number	Ordered	Client
49568	04/20/2011	MACTEC

Project ID: 4953-10-1561 G-118
Project Name: Westside Subway Extension
Site: Los Angeles

Enclosed are the results of analyses on 2 samples analyzed as specified on attached chain of custody.

Wendy Lu
Organics Supervisor

Rojert G. Araghi
Laboratory Director

AMERICAN SCIENTIFIC LABORATORIES, LLC
Environmental Testing Services
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CHAIN OF CUSTODY RECORD

COC# GLOBAL ID _____ E REPORT: ☐ PDF ☐ EDF ☐ EDD ASL JOB# 49568

Company: MACTEC		Report To: Hari Ponnaboyina	
Address: 5628 E. Slauson	Project Name: Westside Subway Extension	Address: – same –	
Los Angeles, CA 90040	Site Address: Los Angeles	Invoice To: MACTEC	
Telephone: Fax: 323-859-5342		Address: -Same	
Special Instruction:	Project ID: 4953-10-1561		
E-mail:	Project Manager: Marty Hvalson	P.O.#:	

ITEM	LAB USE ONLY Lab ID	SAMPLE DESCRIPTION Sample ID	Date	Time	Container(s) #	Container(s) Type	Matrix	Preservation	EPA 8015 (Mod Scan)	EPA 8260	EPA 8270	Remarks
1	267662	G-118 @ 49'	4/20/11		1	Bag	Tar Sands		✓	✓	✓	
2	267663	G-118 @ 55'	4/20/11		1	Bag	Tar Sands		✓	✓	✓	

Collected By: Daniel Wader	Date 3/23/11 Time	Relinquished By:	Date 4/20/11 Time
Relinquished By: Daniel Wader	Date 3/23/11 Time	Received For Laboratory	Date 4-20-11 Time 11:43
Received By: Hari Ponnaboyina	Date 3/23/11 Time	Condition of Sample:	TAT ☐ Normal ☑ Rush

White - *Report*, Yellow - *Laboratory*, Pink - *Client*

Figure F-12.2

AMERICAN SCIENTIFIC LABORATORIES, LLC
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ANALYTICAL RESULTS

Ordered By

MACTEC Engineering & Consulting Inc
5628 East Slauson Ave.
Los Angeles, CA 90040-

Telephone: (323)889-5300
Attn: Hari Ponnaboyina

Site

Los Angeles

Page: 2

Project ID: 4953-10-1561 G-118
Project Name: Westside Subway Extension

ASL Job Number	Submitted	Client
49568	04/20/2011	MACTEC

Method: 8015B, TPH DROs and OROs (Diesel and Oil Range Organics)

QC Batch No: S-042011-1P

Our Lab I.D.		267662	267663			
Client Sample I.D.		G-118 @ 49'	G-118 @ 55'			
Date Sampled		04/20/2011	04/20/2011			
Date Prepared		04/20/2011	04/20/2011			
Preparation Method						
Date Analyzed		04/20/2011	04/20/2011			
Matrix		Solid	Solid			
Units		mg/Kg	mg/Kg			
Dilution Factor		1	1			
Analytes	**PQL**	**Results**	**Results**			
TPH DROs (C10 to C28)	10.0	47200	97000			
TPH OROs (C28+)	50.0	21700	23600			

Our Lab I.D.		267662	267663			
Surrogates	**% Rec.Limit**	**% Rec.**	**% Rec.**			
Surrogate Percent Recovery						
Chlorobenzene	70-120	117	116			

QUALITY CONTROL REPORT

QC Batch No: S-042011-1P

Analytes	MS % REC	MS DUP % REC	RPD %	MS/MSD % Limit	MS RPD % Limit					
Diesel	100	100	<1	75-120	<20					

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ANALYTICAL RESULTS

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Attn: Hari Ponnaboyina

Site

Los Angeles

Page: 3

Project ID: 4953-10-1561 G-118
Project Name: Westside Subway Extension

ASL Job Number	Submitted	Client
49568	04/20/2011	MACTEC

Method: 8015B, TPH GROs (Gasoline Range Organics)

QC Batch No: S-042011-1

Our Lab I.D.		**267662**	**267663**			
Client Sample I.D.		G-118 @ 49'	G-118 @ 55'			
Date Sampled		04/20/2011	04/20/2011			
Date Prepared		04/20/2011	04/20/2011			
Preparation Method						
Date Analyzed		04/20/2011	04/20/2011			
Matrix		Solid	Solid			
Units		mg/Kg	mg/Kg			
Dilution Factor		5	5			
Analytes	**PQL**	**Results**	**Results**			
TPH GROs (C6 to C10)	2.50	85.7	51.9			

Our Lab I.D.		**267662**	**267663**			
Surrogates	**% Rec.Limit**	**% Rec.**	**% Rec.**			
Surrogate Percent Recovery						
Bromofluorobenzene	70-120	104	86			

QUALITY CONTROL REPORT

QC Batch No: S-042011-1

Analytes	MS % REC	MS DUP % REC	RPD %	MS/MSD % Limit	MS RPD % Limit					
Benzene	98	98	<1	75-120	<20					
Toluene	111	111	<1	75-120	<20					

Figure F-12.4

AMERICAN SCIENTIFIC LABORATORIES, LLC
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ANALYTICAL RESULTS

Ordered By

MACTEC Engineering & Consulting Inc
5628 East Slauson Ave.
Los Angeles, CA 90040-

Telephone: (323)889-5300
Attn: Hari Ponnaboyina

Site

Los Angeles

Page: **4**

Project ID: 4953-10-1561 G-118
Project Name: Westside Subway Extension

ASL Job Number	Submitted	Client
49568	04/20/2011	MACTEC

Method: 8260B, Volatile Organic Compounds

QC Batch No: S-042011-1C

Our Lab I.D.		267662	267663			
Client Sample I.D.		G-118 @ 49'	G-118 @ 55'			
Date Sampled		04/20/2011	04/20/2011			
Date Prepared		04/20/2011	04/20/2011			
Preparation Method						
Date Analyzed		04/20/2011	04/20/2011			
Matrix		Solid	Solid			
Units		ug/kg	ug/kg			
Dilution Factor		5	5			
Analytes	**PQL**	**Results**	**Results**			
Acetone	250	ND	ND			
Benzene	10.0	ND	ND			
Bromobenzene (Phenyl bromide)	50.0	ND	ND			
Bromochloromethane (Chlorobromomethane)	50.0	ND	ND			
Bromodichloromethane (Dichlorobromomethane)	50.0	ND	ND			
Bromoform (Tribromomethane)	250	ND	ND			
Bromomethane (Methyl bromide)	150	ND	ND			
2-Butanone (MEK, Methyl ethyl ketone)	250	ND	ND			
n-Butylbenzene	50.0	ND	ND			
sec-Butylbenzene	50.0	ND	ND			
tert-Butylbenzene	50.0	ND	ND			
Carbon disulfide	50.0	ND	ND			
Carbon tetrachloride (Tetrachloromethane)	50.0	ND	ND			
Chlorobenzene	50.0	ND	ND			
Chloroethane	150	ND	ND			
2-Chloroethyl vinyl ether	250	ND	ND			
Chloroform (Trichloromethane)	50.0	ND	ND			
Chloromethane (Methyl chloride)	150	ND	ND			
4-Chlorotoluene (p-Chlorotoluene)	50.0	ND	ND			
2-Chlorotoluene (o-Chlorotoluene)	50.0	ND	ND			
1,2-Dibromo-3-chloropropane (DBCP)	250	ND	ND			
Dibromochloromethane	50.0	ND	ND			
1,2-Dibromoethane (EDB, Ethylene dibromide)	50.0	ND	ND			
Dibromomethane	50.0	ND	ND			
1,2-Dichlorobenzene (o-Dichlorobenzene)	50.0	ND	ND			
1,3-Dichlorobenzene (m-Dichlorobenzene)	50.0	ND	ND			
1,4-Dichlorobenzene (p-Dichlorobenzene)	50.0	ND	ND			
Dichlorodifluoromethane	150	ND	ND			
1,1-Dichloroethane	50.0	ND	ND			

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ANALYTICAL RESULTS

Project ID: 4953-10-1561 G-118
Project Name: Westside Subway Extension

ASL Job Number	Submitted	Client
49568	04/20/2011	MACTEC

Method: 8260B, Volatile Organic Compounds

QC Batch No: S-042011-1C

Our Lab I.D.		**267662**	**267663**			
Client Sample I.D.		G-118 @ 49'	G-118 @ 55'			
Date Sampled		04/20/2011	04/20/2011			
Date Prepared		04/20/2011	04/20/2011			
Preparation Method						
Date Analyzed		04/20/2011	04/20/2011			
Matrix		Solid	Solid			
Units		ug/kg	ug/kg			
Dilution Factor		5	5			
Analytes	**PQL**	**Results**	**Results**			
1,2-Dichloroethane	50.0	ND	ND			
1,1-Dichloroethene (1,1-Dichloroethylene)	50.0	ND	ND			
cis-1,2-Dichloroethene	50.0	ND	ND			
trans-1,2-Dichloroethene	50.0	ND	ND			
1,2-Dichloropropane	50.0	ND	ND			
1,3-Dichloropropane	50.0	ND	ND			
2,2-Dichloropropane	50.0	ND	ND			
1,1-Dichloropropene	50.0	ND	ND			
cis-1,3-Dichloropropene	50.0	ND	ND			
trans-1,3-Dichloropropene	50.0	ND	ND			
Ethylbenzene	10.0	26.0	16.5			
Hexachlorobutadiene (1,3-Hexachlorobutadiene)	150	ND	ND			
2-Hexanone	250	ND	ND			
Isopropylbenzene	50.0	ND	ND			
p-Isopropyltoluene (4-Isopropyltoluene)	50.0	ND	ND			
MTBE	25.0	ND	ND			
4-Methyl-2-pentanone (MIBK, Methyl isobutyl ketone)	250	ND	ND			
Methylene chloride (Dichloromethane, DCM)	250	ND	ND			
Naphthalene	50.0	ND	ND			
n-Propylbenzene	50.0	ND	ND			
Styrene	50.0	ND	ND			
1,1,1,2-Tetrachloroethane	50.0	ND	ND			
1,1,2,2-Tetrachloroethane	50.0	ND	ND			
Tetrachloroethene (Tetrachloroethylene)	50.0	ND	ND			
Toluene (Methyl benzene)	10.0	ND	ND			
1,2,3-Trichlorobenzene	50.0	ND	ND			
1,2,4-Trichlorobenzene	50.0	ND	ND			
1,1,1-Trichloroethane	50.0	ND	ND			
1,1,2-Trichloroethane	50.0	ND	ND			
Trichloroethene (TCE)	50.0	ND	ND			
Trichlorofluoromethane	50.0	ND	ND			
1,2,3-Trichloropropane	50.0	ND	ND			
1,2,4-Trimethylbenzene	50.0	ND	ND			
1,3,5-Trimethylbenzene	50.0	ND	ND			
Vinyl acetate	250	ND	ND			

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ANALYTICAL RESULTS

Project ID: 4953-10-1561 G-118
Project Name: Westside Subway Extension

ASL Job Number	Submitted	Client
49568	04/20/2011	MACTEC

Method: 8260B, Volatile Organic Compounds

QC Batch No: S-042011-1C

Our Lab I.D.		267662	267663			
Client Sample I.D.		G-118 @ 49'	G-118 @ 55'			
Date Sampled		04/20/2011	04/20/2011			
Date Prepared		04/20/2011	04/20/2011			
Preparation Method						
Date Analyzed		04/20/2011	04/20/2011			
Matrix		Solid	Solid			
Units		ug/kg	ug/kg			
Dilution Factor		5	5			
Analytes	**PQL**	**Results**	**Results**			
Vinyl chloride (Chloroethene)	150	ND	ND			
o-Xylene	10.0	ND	ND			
m- & p-Xylenes	20.0	ND	ND			

Comment(s):
267662:267663: Raised DL due to matrix.

Our Lab I.D.		267662	267663			
Surrogates	**% Rec.Limit**	**% Rec.**	**% Rec.**			
Surrogate Percent Recovery						
Bromofluorobenzene	70-120	94	106			
Dibromofluoromethane	70-120	101	94			
Toluene-d8	70-120	98	96			

QUALITY CONTROL REPORT

QC Batch No: S-042011-1C

Analytes	MS % REC	MS DUP % REC	RPD %	MS/MSD % Limit	MS RPD % Limit					
Benzene	86	88	2.3	75-120	15					
Chlorobenzene	89	92	3.3	75-120	15					
1,1-Dichloroethene (1,1-Dichloroethylene)	94	96	2.1	75-120	15					
MTBE	95	100	5.1	75-120	15					
Toluene (Methyl benzene)	85	89	4.6	75-120	15					
Trichloroethene (TCE)	96	98	2.1	75-120	15					

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ANALYTICAL RESULTS

Ordered By

MACTEC Engineering & Consulting Inc
5628 East Slauson Ave.
Los Angeles, CA 90040-

Telephone: (323)889-5300
Attn: Hari Ponnaboyina

Site

Los Angeles

Page: 7

Project ID: 4953-10-1561 G-118
Project Name: Westside Subway Extension

ASL Job Number	Submitted	Client
49568	04/20/2011	MACTEC

Method: 8270C, Semivolatile Organics

QC Batch No: 042011-1

Our Lab I.D.		267662	267663			
Client Sample I.D.		G-118 @ 49'	G-118 @ 55'			
Date Sampled		04/20/2011	04/20/2011			
Date Prepared		04/20/2011	04/20/2011			
Preparation Method						
Date Analyzed		04/20/2011	04/20/2011			
Matrix		Solid	Solid			
Units		ug/kg	ug/kg			
Dilution Factor		5	5			
Analytes	**PQL**	**Results**	**Results**			
Acenaphthene	1650	ND	ND			
Acenaphthylene	1650	ND	ND			
Anthracene	1650	ND	ND			
Benz(a)anthracene (Benzo(a)anthracene)	1650	ND	ND			
Benzo(a)pyrene	1650	ND	ND			
Benzo(b)fluoranthene	1650	ND	ND			
Benzo(ghi)perylene	1650	ND	ND			
Benzo(k)fluoranthene	1650	ND	ND			
Benzoic acid	8500	ND	ND			
Benzyl alcohol	3300	ND	ND			
Bis(2-chloroethoxy)methane	1650	ND	ND			
Bis(2-chloroethyl)ether	1650	ND	ND			
Bis(2-chloroisopropyl) ether	1650	ND	ND			
Bis(2-ethylhexyl) phthalate	1650	ND	ND			
4-Bromophenyl phenyl ether	1650	ND	ND			
Butyl benzyl phthalate (Benzyl butyl phthalate)	1650	ND	ND			
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	3300	ND	ND			
4-Chloroaniline	3300	ND	ND			
2-Chloronaphthalene	1650	ND	ND			
2-Chlorophenol (o-Chlorophenol)	1650	ND	ND			
4-Chlorophenyl phenyl ether	1650	ND	ND			
Chrysene	1650	ND	ND			
Di-n-butyl phthalate	1650	ND	ND			
Di-n-octyl phthalate (Dioctyl ester)	1650	ND	ND			
Dibenz(a,h)anthracene	1650	ND	ND			
Dibenzofuran	1650	ND	ND			
1,3-Dichlorobenzene (m-Dichlorobenzene)	1650	ND	ND			
1,2-Dichlorobenzene (o-Dichlorobenzene)	1650	ND	ND			
1,4-Dichlorobenzene	1650	ND	ND			

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ANALYTICAL RESULTS

Project ID: 4953-10-1561 G-118
Project Name: Westside Subway Extension

ASL Job Number	Submitted	Client
49568	04/20/2011	MACTEC

Method: 8270C, Semivolatile Organics

QC Batch No: 042011-1

Our Lab I.D.		**267662**	**267663**			
Client Sample I.D.		G-118 @ 49'	G-118 @ 55'			
Date Sampled		04/20/2011	04/20/2011			
Date Prepared		04/20/2011	04/20/2011			
Preparation Method						
Date Analyzed		04/20/2011	04/20/2011			
Matrix		Solid	Solid			
Units		ug/kg	ug/kg			
Dilution Factor		5	5			
Analytes	**PQL**	**Results**	**Results**			
3,3'-Dichlorobenzidine	3300	ND	ND			
2,4-Dichlorophenol	8500	ND	ND			
Diethyl phthalate (Diethyl ester)	1650	ND	ND			
2,4-Dimethylphenol	1650	ND	ND			
Dimethyl phthalate (Dimethyl ester)	1650	ND	ND			
2,4-Dinitrophenol	8500	ND	ND			
2,4-Dinitrotoluene	1650	ND	ND			
2,6-Dinitrotoluene (2,6-DNT)	1650	ND	ND			
Fluoranthene	1650	ND	ND			
Fluorene	1650	ND	ND			
Hexachlorobenzene	1650	ND	ND			
Hexachlorobutadiene (1,3-Hexachlorobutadiene)	1650	ND	ND			
Hexachlorocyclopentadiene	3300	ND	ND			
Hexachloroethane	1650	ND	ND			
Indeno(1,2,3-cd)pyrene	1650	ND	ND			
Isophorone	1650	ND	ND			
2-methyl-4,6-Dinitrophenol	8500	ND	ND			
2-Methylnaphthalene	1650	ND	ND			
2-Methylphenol (o-Cresol, 2-Cresol)	1650	ND	ND			
4-Methylphenol (p-Cresol, 4-Cresol)	1650	ND	ND			
N-Nitroso-Di-n-propylamine	1650	ND	ND			
N-Nitrosodiphenylamine	1650	ND	ND			
Naphthalene	1650	ND	ND			
2-Nitroaniline	8500	ND	ND			
3-Nitroaniline	8500	ND	ND			
4-Nitroaniline	8500	ND	ND			
Nitrobenzene (NB)	1650	ND	ND			
2-Nitrophenol (o-Nitrophenol)	1650	ND	ND			
4-Nitrophenol	8500	ND	ND			
Pentachlorophenol	8500	ND	ND			
Phenanthrene	1650	ND	ND			
Phenol	1650	ND	ND			
Pyrene	1650	ND	ND			
1,2,4-Trichlorobenzene	1650	ND	ND			
2,4,5-Trichlorophenol	1650	ND	ND			

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ANALYTICAL RESULTS

Project ID: 4953-10-1561 G-118
Project Name: Westside Subway Extension

ASL Job Number	Submitted	Client
49568	04/20/2011	MACTEC

Method: 8270C, Semivolatile Organics

QC Batch No: 042011-1

Our Lab I.D.		267662	267663			
Client Sample I.D.		G-118 @ 49'	G-118 @ 55'			
Date Sampled		04/20/2011	04/20/2011			
Date Prepared		04/20/2011	04/20/2011			
Preparation Method						
Date Analyzed		04/20/2011	04/20/2011			
Matrix		Solid	Solid			
Units		ug/kg	ug/kg			
Dilution Factor		5	5			
Analytes	**PQL**	**Results**	**Results**			
2,4,6-Trichlorophenol	1650	ND	ND			

Comment(s):
Elevated PQLs due to matrix.

Our Lab I.D.		267662	267663			
Surrogates	**% Rec.Limit**	**% Rec.**	**% Rec.**			
Surrogate Percent Recovery						
2-Fluorophenol	21-105	43	43			
Phenol-d6	10-107	46	40			
2,4,6-Tribromophenol	10-123	47	28			
Nitrobenzene-d5	35-114	71	56			
2-Fluorobiphenyl	18-116	59	70			
Terphenyl-d14	33-141	57	70			

QUALITY CONTROL REPORT

QC Batch No: 042011-1

Analytes	LCS % REC	LCS DUP % REC	LCS RPD % REC	LCS/LCSD % Limit	LCS RPD % Limit					
Acenaphthene	91	105	14.3	43-118	<30					
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	79	94	17.3	23-117	<30					
2-Chlorophenol (o-Chlorophenol)	81	97	18.0	27-123	<30					
1,4-Dichlorobenzene	69	67	2.9	36-105	<30					
2,4-Dinitrotoluene	51	58	12.8	24-120	<30					
N-Nitroso-Di-n-propylamine	90	109	19.1	41-116	<30					
4-Nitrophenol	51	58	12.8	10-133	<30					
Pentachlorophenol	53	48	9.9	9-118	<30					
Phenol	84	101	18.4	12-110	<30					
Pyrene	104	108	3.8	26-127	<30					
1,2,4-Trichlorobenzene	75	76	1.3	39-98	<30					

FIGURES F-13.1 THROUGH F-13.51
ABRASION TESTING (PE PHASE)

Soil Abrasion Test

(SAT: NTNU's new soil abrasion test, Tunnels & Tunnelling International, May 2006, 43-45)

The University of Texas at Austin

Geotechnical Engineering Center
Department of Civil, Architectural and Environmental Engineering

Project Name	Westside Subway Extension
Client project NO.	4953-10-1561
Location	Los Angeles, California
UT reference	2011_ MACTEC_001_001

Test Date	7/8/11-7/18/11
Tested by	Moo Yeon Kim
Checked by	Mahdi Heidari
Sample moisture condition	Dried in ventilated oven at 30°C for 3 days
Steel test piece condition	Ground and polished by bench grinder

Summary

Boring No.	Test Depth (ft)	AVS
S-101	60-61	31
S-102	67-68	22.5
S-104	59.5-60.5	14.5
S-104	81-82	35
S-107	57-57.9	23.5
S-108	91-92	13.5
S-109	80-81	11.5
S-110	40.5-41.5	10
S-110	44-45	5
S-111	65-66	27.5
S-114	67-68	38
S-115	89-90 (GM)	5.5
S-115	89-90	8

301 East Dean Keeton building ECJ B220
1 University Station C1792, Austin TX 78712 USA

Dr. Fulvio Tonon
Phone: +1-512-471-4929
Fax: +1-512-471-6548

Soil Abrasion Test

(SAT: NTNU's new soil abrasion test, Tunnels & Tunnelling International, May 2006, 43-45)

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Geotechnical Engineering Center
Department of Civil, Architectural and Environmental Engineering

Project Name	Westside Subway Extension
Client project NO.	4953-10-1561
Location	Los Angeles, California
UT reference	2011_ MACTEC_001_001
Sample ID.	
Boring No.	S-101
Depth Interval	60-61 ft
Sample received	7/8/2011
Test date	7/18/2011

Tested by	Moo Yeon Kim
Checked by	Mahdi Heidari
Steel test piece condition	Ground and polished by bench grinder
Sample moisture condition	Dried in ventilated oven at 30°C for 3 days
Geologic unit	N/A
Soil type description	SP/SW

Test no.	Test 1	Test 2	AVS
Weight loss in mg	33	29	31

Photograph of the test sample

301 East Dean Keeton building ECJ B220
1 University Station C1792, Austin TX 78712 USA

Dr. Fulvio Tonon
Phone: +1-512-471-4929
Fax: +1-512-471-6548

Figure F-13.2

Soil Abrasion Test

(SAT: NTNU's new soil abrasion test, Tunnels & Tunnelling International, May 2006, 43-45)

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Project Name	Westside Subway Extension
Client project NO.	4953-10-1561
Location	Los Angeles, California
UT reference	2011_ MACTEC_001_001
Sample ID.	
Boring No.	S-102
Depth Interval	67-68 ft
Sample received	7/8/2011
Test date	7/17/2011

Tested by	Moo Yeon Kim
Checked by	Mahdi Heidari
Steel test piece condition	Ground and polished by bench grinder
Sample moisture condition	Dried in ventilated oven at 30°C for 3 days
Geologic unit	N/A
Soil type description	SP-SM

Test no.	Test 1	Test 2	AVS
Weight loss in mg	22	23	22.5

Photograph of the test sample

301 East Dean Keeton building ECJ B220
1 University Station C1792, Austin TX 78712 USA

Dr. Fulvio Tonon
Phone: +1-512-471-4929
Fax: +1-512-471-6548

Soil Abrasion Test

(SAT: NTNU's new soil abrasion test, Tunnels & Tunnelling International, May 2006, 43-45)

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Department of Civil, Architectural and Environmental Engineering

Project Name	Westside Subway Extension
Client project NO.	4953-10-1561
Location	Los Angeles, California
UT reference	2011_ MACTEC_001_001
Sample ID.	
Boring No.	S-104
Depth Interval	59.5-60.5 ft
Sample received	7/8/2011
Test date	7/17/2011

Tested by	Moo Yeon Kim
Checked by	Mahdi Heidari
Steel test piece condition	Ground and polished by bench grinder
Sample moisture condition	Dried in ventilated oven at 30°C for 3 days
Geologic unit	N/A
Soil type description	SP-SM

Test no.	Test 1	Test 2	AVS
Weight loss in mg	13	16	14.5

Photograph of the test sample

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1 University Station C1792, Austin TX 78712 USA

Dr. Fulvio Tonon
Phone: +1-512-471-4929
Fax: +1-512-471-6548

Soil Abrasion Test

(SAT: NTNU's new soil abrasion test, Tunnels & Tunnelling International, May 2006, 43-45)

The University of Texas at Austin

Geotechnical Engineering Center
Department of Civil, Architectural and Environmental Engineering

Project Name	Westside Subway Extension
Client project NO.	4953-10-1561
Location	Los Angeles, California
UT reference	2011_ MACTEC_001_001
Sample ID.	
Boring No.	S-104
Depth Interval	81-82 ft
Sample received	7/8/2011
Test date	7/18/2011

Tested by	Moo Yeon Kim
Checked by	Mahdi Heidari
Steel test piece condition	Ground and polished by bench grinder
Sample moisture condition	Dried in ventilated oven at 30°C for 3 days
Geologic unit	N/A
Soil type description	SP

Test no.	Test 1	Test 2	AVS
Weight loss in mg	36	34	35

Photograph of the test sample

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1 University Station C1792, Austin TX 78712 USA

Dr. Fulvio Tonon
Phone: +1-512-471-4929
Fax: +1-512-471-6548

Soil Abrasion Test

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Geotechnical Engineering Center
Department of Civil, Architectural and Environmental Engineering

Project Name	Westside Subway Extension
Client project NO.	4953-10-1561
Location	Los Angeles, California
UT reference	2011_ MACTEC_001_001
Sample ID.	
Boring No.	S-107
Depth Interval	57-57.9 ft
Sample received	7/8/2011
Test date	7/18/2011

Tested by	Moo Yeon Kim
Checked by	Mahdi Heidari
Steel test piece condition	Ground and polished by bench grinder
Sample moisture condition	Dried in ventilated oven at 30°C for 3 days
Geologic unit	N/A
Soil type description	SP

Test no.	Test 1	Test 2	AVS
Weight loss in mg	24	23	23.5

Photograph of the test sample

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1 University Station C1792, Austin TX 78712 USA

Dr. Fulvio Tonon
Phone: +1-512-471-4929
Fax: +1-512-471-6548

Soil Abrasion Test

(SAT: NTNU's new soil abrasion test, Tunnels & Tunnelling International, May 2006, 43-45)

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Geotechnical Engineering Center
Department of Civil, Architectural and Environmental Engineering

Project Name	Westside Subway Extension
Client project NO.	4953-10-1561
Location	Los Angeles, California
UT reference	2011_ MACTEC_001_001
Sample ID.	
Boring No.	S-108
Depth Interval	91-92 ft
Sample received	7/8/2011
Test date	7/18/2011

Tested by	Moo Yeon Kim
Checked by	Mahdi Heidari
Steel test piece condition	Ground and polished by bench grinder
Sample moisture condition	Dried in ventilated oven at 30°C for 3 days
Geologic unit	N/A
Soil type description	SC/SM

Test no.	Test 1	Test 2	AVS
Weight loss in mg	15	12	13.5

Photograph of the test sample

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1 University Station C1792, Austin TX 78712 USA

Dr. Fulvio Tonon
Phone: +1-512-471-4929
Fax: +1-512-471-6548

Soil Abrasion Test

(SAT: NTNU's new soil abrasion test, Tunnels & Tunnelling International, May 2006, 43-45)

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Department of Civil, Architectural and Environmental Engineering

Project Name	Westside Subway Extension
Client project NO.	4953-10-1561
Location	Los Angeles, California
UT reference	2011_ MACTEC_001_001
Sample ID.	
Boring No.	S-109
Depth Interval	80-81 ft
Sample received	7/8/2011
Test date	7/17/2011

Tested by	Moo Yeon Kim
Checked by	Mahdi Heidari
Steel test piece condition	Ground and polished by bench grinder
Sample moisture condition	Dried in ventilated oven at 30°C for 3 days
Geologic unit	N/A
Soil type description	SC/CL

Test no.	Test 1	Test 2	AVS
Weight loss in mg	13	10	11.5

Photograph of the test sample

301 East Dean Keeton building ECJ B220
1 University Station C1792, Austin TX 78712 USA

Dr. Fulvio Tonon
Phone: +1-512-471-4929
Fax: +1-512-471-6548

Soil Abrasion Test

(SAT: NTNU's new soil abrasion test, Tunnels & Tunnelling International, May 2006, 43-45)

The University of Texas at Austin

Geotechnical Engineering Center
Department of Civil, Architectural and Environmental Engineering

Project Name	Westside Subway Extension
Client project NO.	4953-10-1561
Location	Los Angeles, California
UT reference	2011_ MACTEC_001_001
Sample ID.	
Boring No.	S-110
Depth Interval	40.5-41.5 ft
Sample received	7/8/2011
Test date	7/18/2011

Tested by	Moo Yeon Kim
Checked by	Mahdi Heidari
Steel test piece condition	Ground and polished by bench grinder
Sample moisture condition	Dried in ventilated oven at 30°C for 3 days
Geologic unit	N/A
Soil type description	CH/GC

Test no.	Test 1	Test 2	AVS
Weight loss in mg	11	9	10

Photograph of the test sample

301 East Dean Keeton building ECJ B220
1 University Station C1792, Austin TX 78712 USA

Dr. Fulvio Tonon
Phone: +1-512-471-4929
Fax: +1-512-471-6548

Soil Abrasion Test

(SAT: NTNU's new soil abrasion test, Tunnels & Tunnelling International, May 2006, 43-45)

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Geotechnical Engineering Center
Department of Civil, Architectural and Environmental Engineering

Project Name	Westside Subway Extension
Client project NO.	4953-10-1561
Location	Los Angeles, California
UT reference	2011_ MACTEC_001_001
Sample ID.	
Boring No.	S-110
Depth Interval	44-45 ft
Sample received	7/8/2011
Test date	7/18/2011

Tested by	Moo Yeon Kim
Checked by	Mahdi Heidari
Steel test piece condition	Ground and polished by bench grinder
Sample moisture condition	Dried in ventilated oven at 30°C for 3 days
Geologic unit	N/A
Soil type description	N/A

Test no.	Test 1	Test 2	AVS
Weight loss in mg	5	5	5

Photograph of the test sample

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1 University Station C1792, Austin TX 78712 USA

Dr. Fulvio Tonon
Phone: +1-512-471-4929
Fax: +1-512-471-6548

Figure F-13.10

Soil Abrasion Test

(SAT: NTNU's new soil abrasion test, Tunnels & Tunnelling International, May 2006, 43-45)

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Geotechnical Engineering Center
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Project Name	Westside Subway Extension
Client project NO.	4953-10-1561
Location	Los Angeles, California
UT reference	2011_ MACTEC_001_001
Sample ID.	
Boring No.	S-111
Depth Interval	65-66 ft
Sample received	7/8/2011
Test date	7/17/2011

Tested by	Moo Yeon Kim
Checked by	Mahdi Heidari
Steel test piece condition	Ground and polished by bench grinder
Sample moisture condition	Dried in ventilated oven at 30°C for 3 days
Geologic unit	N/A
Soil type description	SP

Test no.	Test 1	Test 2	AVS
Weight loss in mg	28	27	27.5

Photograph of the test sample

301 East Dean Keeton building ECJ B220
1 University Station C1792, Austin TX 78712 USA

Dr. Fulvio Tonon
Phone: +1-512-471-4929
Fax: +1-512-471-6548