APPENDIX F

Geotechnical Report

NEW JERSEY TURNPIKE AUTHORITY

INTERCHANGE 12 IMPROVEMENTS

TREMLEY POINT CONNECTOR ROAD
PHASE-I GEOTECHNICAL REPORT

JULY 27, 2006

PREPARED BY:

Edwards AND Kelcey

TABLE OF CONTENTS

INTRODUCTION

This report presents a summary of the subsurface investigation program including soil boring and laboratory test data collected during Phase I of the program for the Connector Road project. The Connector Road project is part of New Jersey Turnpike Interchange 12 Improvements Project. The project is located in Linden / Carteret, New Jersey. The purpose of this study is to investigate subsurface soil, groundwater conditions and rock quality along three alignment alternates at the project site. The project site traverses the border of Middlesex and Union Counties, as shown on Figure 1. The approximate location for the proposed preferred alignment of the Connector Road is superimposed on Figure 1.

The scope of work undertaken for Phase I of the subsurface investigation program includes preparing and executing a subsurface exploration program, drilling and sampling of 32 soil borings, installing two observation wells, and performing laboratory testing on select soil and rock samples. Phase I investigation also included environmental testing of the soils. The PMK Group, a sub-consultant to Edwards and Kelcey, conducted the environmental study. The results of the environmental study will be presented in a separate report.

Elevations in this report are in feet and are referenced to the 1988 NAVD datum.

PROJECT DESCRIPTION

The New Jersey Turnpike Interchange 12 Improvements include upgrading and expanding Interchange 12 in Carteret and constructing a new "Connector Road" between Industrial Road in Carteret and Tremley Point Road in Linden. The improvements will result in increased capacity of the Toll Plaza, relieve traffic congestion and divert truck traffic from local roads to the new connector roadway. The proposed new roadway extends a distance of approximately 5750 feet. The new connection will provide direct access of truck traffic from the Turnpike Interchange 12 to the city of Linden. The Connector Road will be comprised of elevated viaduct structures, retaining walls and embankment. The Connector Road also includes a bridge that crosses over the Rahway River. The alignment of the preferred alternate along with alternates 5 and 7 alignments are shown on Figure 2, "Boring Location Plan-Phase I".

The New Jersey Turnpike Authority (NJTA) awarded the contract for final design to Edwards and Kelcey (EK) in December 2005. EK had previously performed feasibility studies for the Interchange Improvements and Connector Road segments of the project. A preliminary subsurface investigation program for the proposed Connector Road was performed as part of the feasibility study. Geotechnical and foundation issues for the proposed roadway are discussed in a geotechnical report titled "Preliminary Geotechnical Report for Connector Road (Industrial Road to Tremley Point Road", dated June 25, 2004. During the feasibility study, EK was not able to obtain a permit to access the wetlands. Accordingly, the preliminary investigation was limited to areas outside the wetland areas.

The subsurface investigation conducted in Phase I is designed to study the soil conditions in wetlands areas and along the three alternates considered. In addition, the investigation covered the Cytec property where the alignment could possibly shift to minimize disturbance to the wetlands. The preferred alignment borders a former American Cyanamid Carteret Landfill. The landfill consists of unlined impoundment containing contaminated sludge and confined with earthen dikes. This area is referred to as Cytec Lagoon. The environmental issues related to the construction of the connector road through this property are beyond the scope of this report. This report addresses the geotechnical and foundation considerations and supplements the 2004 preliminary report.

SUBSURFACE EXPLORATION

The Phase I subsurface investigation program consisted of drilling a total of 32 soil borings. Soil borings drilled along the preferred alignment are designated as CR- borings. The borings drilled along alternate alignments number 5 and 7 are designated A5- and A7-, respectively. Eighteen soil borings were drilled along the preferred alignment. Four soil borings were located along Alternate-5 and seven soil borings along Alternate-7. Most of the soil borings are drilled in wetland areas with several borings drilled in the Rahway River.

Three borings were added to the boring program at the Cytec lagoon area to obtain environmental information and analyze the contaminants in the lagoon. The soil borings at the Cytec lagoon are designated E- borings. The E- borings are also designed to provide geotechnical information needed for the design of the connector road viaduct.

Five soil borings were drilled during the feasibility study stage of the project in 2004. The soil borings were drilled along the preferred alignment of the proposed Connector Road, and are designated B-10 through B-15 (excluding B-12). EK was not able to drill boring B-12 at the time due to inability to obtain a wetland permit. The feasibility study borings are included in this report. The location of all test borings done is shown on Figure 2, Boring Location Plan-Phase I.

The purpose of the borings is to provide information on both geotechnical and environmental issues that will influence the final design and cost of the project for the various alignments considered. PMK Group, a sub-consultant to EK provided full-time environmental and geotechnical monitoring during drilling of test borings and installation of groundwater observation wells. Information related to the results of the environmental sampling and testing program will be provided by PMK in a separate report. Information related to the results of the geotechnical program will be provided herein.

Logs of test borings were prepared by PMK and are included in Appendix A. The boring locations and ground surface elevation at each boring were surveyed by EK staff and/or estimated from topographic plans.

The test borings were drilled by Warren George Inc. of Jersey City, New Jersey. The soil borings were drilled the period of November 2005 through January 2006. The borings were drilled using truck mounted or track mounted drill rigs and rotary drilling techniques. Soil borings were drilled in wetlands using a "Marsh Buggy" that utilized a drill rig mounted on track-chain pontoon. Continuous sampling was performed through the fill and organic layer or to a minimum of 10 feet. Sampling at standard 5-foot intervals was performed thereafter. Samples were obtained using standard 2 inch O.D. by 1-3/8 inch I.D. split-spoon samplers. Undisturbed samples of the organic layer were obtained using 3-inch O.D. Shelby tubes.

Standard Penetration Test (SPT) was conducted at each sampling interval. The SPT consists of driving the split-spoon sampler 24 inches below the bottom of the borehole using a 140-pound hammer falling freely through 30 inches. The number of blows required to drive the sampler each 6-inch interval is recorded on the boring logs. The SPT N-value is generally the number of blows required to advance the sampler the middle 12 inches of the 24-inch sampling range.

All soil borings were drilled to the top of rock, which was encountered between 20 and 50 feet below ground surface. Rock was then cored 5 feet using an NX size core barrel with a diamond bit in all borings except the Rahway River boring. The water borings in the Rahway River were drilled 30 feet into the rock.

A groundwater observation well was installed in boring CR-1 and CR-57. The observation well installation consisted of placing PVC pipe with a 5-foot long screen in a separate hole drilled

adjacent to the corresponding boring. Groundwater readings were taken during the boring program. Results of groundwater monitoring are shown on the boring log and the soil profile.

A summary of subsurface conditions encountered in the test borings is presented in Table I.

LABORATORY TESTING

Laboratory testing was performed on the undisturbed soil samples obtained in the boring program. In addition, Point Load and Unconfined Compression strength tests were performed on select rock core samples. The rock cores tested were selected from the river borings drilled where rock-socked caisson foundation is anticipated. The unconfined compressive strength of the rock samples tested ranged from 1460 to 10430 psi. A summary of the rock laboratory test data can be found in Appendix B.

Classification and performance tests were performed on the undisturbed soil samples recovered. The classification tests include Grain size distribution and Atterberg limits tests for purposes of soil classification. Note that the field boring logs have not been edited to reflect the laboratory sample classification. Performance tests consisting of One-Dimensional Consolidation and Unconfined Compression tests were also conducted on the undisturbed soil samples.

One-Dimensional Consolidation tests were conducted on 10 undisturbed tube soil samples to determine the consolidation characteristics of the various soft organic deposits. The compression ratio ($Cc/[1+e_o]$) for the samples tested ranged from 0.063 to 0.460. It should be noted that the material tested varied in consistency from organic clayey silt to peat with varying amounts of sand. Unconfined Compression tests were also performed on eight of the 10 tube samples to evaluate the undrained shear strength of the soft organic layer. The test data indicated an undrained shear strength that varies from 60 to 290 pounds per square foot (psf).

The Laboratory testing was performed by Geotesting Services, Inc. of Tottowa, New Jersey. The results of the laboratory tests are included in Appendix B.

SITE AND SUBSURFACE CONDITIONS

The Connector Road is abutted to the south by Industrial Road; to the east by a facility owned by Kinder Morgan and an undeveloped property owned by Carteret Development LLC and EFC Land Development; to the west by the Slayton Development site and an undeveloped property in the City of Linden; and to the north by Tremley Point Road. Most of the area proposed for the alignment of the connector road is currently undeveloped and designated as wetlands.

The subsurface soil investigation performed in Phase I encountered similar soil conditions as the feasibility borings indicated. In general, the subsurface soils in the area of investigation consist of man-placed fill over organic soils over glacial alluvial deposits over decomposed rock and bedrock. Since most of the soil borings are drilled in wetland areas, very few borings indicated man-placed fill material. The thickness and nature of the organic soil were more defined along the proposed alternate alignments. In addition, the depth to rock and the rock strength properties were tested in this phase of the project.

Subsurface soil and rock strata encountered in the Phase I test borings are described below in order of increasing depth below ground surface. Soil boring logs providing description of soil and rock samples recovered in the test borings are included in Appendix A. A summary of subsurface conditions encountered at the locations of test borings is presented in Table I. Soil profiles along the three alternates considered are shown on Figures 3 through 9. Data from the soil borings done in the feasibility study are included in the soil profiles.

- **Miscellaneous Fill**
  The fill was encountered in two borings on the Carteret side; CR-1 and CR-68, nine and 15 feet thick respectively. The fill found in CR-68 is medium dense to very dense mixture of sand, silt and gravel. Loose fill mixed with pieces of brick and wood was encountered in CR-1 located in the vicinity of the railroad tracks. At the Cytec property (E-borings), eight feet of fill was encountered in the lagoon overlaying the organic natural deposits.

- **Organic Deposits**
  Organic deposits were encountered in all soil borings with the exception of CR-1. The material consisted of very soft deposits of organic Silt, silty Clay and Peat. In some areas organic silt mixed with higher contents of sand was found. The SPT N-value ranged from weight of rod (WR) to 3. Boring drilled in the Rahway River, encountered black organic Silt deposits mixed with Peat in certain samples. The SPT N-values in these borings were generally weight of rods or weight of hammer.

- **Glacial Alluvial**
  This layer can generally described as red brown or brown clayey SILT with varying amounts of coarse to fine sand and coarse to fine gravel. This layer ranged in thickness from 3 to 33 feet. In general, the glacial alluvial is medium dense to very dense in consistency.

- **Decomposed Rock**
  A layer of decomposed rock was encountered overlying bedrock in some borings. The decomposed rock was described as completely weathered red brown shale, and ranged in thickness from 1 to 15 feet. SPT N-values in this layer are generally very high.

- **Rock**
  Bedrock was cored in all borings drilled. The rock at the site was generally described as very closely to medium fractured, slightly to highly weathered, red brown Shale. Recovery ranged from 32 to 100% and RQD ranged from 0 to 91%.

Groundwater Conditions

The observation well measurements taken during the recent boring program indicate the groundwater level is at El. 3.9 at CR-1 and at El. 2.98 at CR-57. Groundwater levels are influenced by many factors such as precipitation, surface runoff, and seasonal variations. Water levels encountered during construction may differ from those reported here.

GEOTECHNICAL EVALUATION

The proposed Connector Road project begins at-grade at Industrial Road, rises in grade to cross over the Rahway River, and meets Tremley Point Road at-grade. Just north of Industrial Road, the proposed new roadway crosses over the existing Conrail track with a single span bridge. The existing grade at Industrial Road will be raised approximately 25 feet to accommodate the bridge over Conrail. The raising of Industrial Road is part of another project that the Connector Road will tie in to.

The construction of the new roadway will consist of; elevated viaduct structures, retaining walls and embankment construction. The work will be in areas that currently exist as wetlands. The wetlands are covered by soft compressible soils. The thickness of this layer varies throughout the project site. On the Carteret side, the thickness of the soft organic soils varies from 5 to 12 feet and is up to 16 feet thick in areas along Alternate 7. The organic layer is thicker on the Linden side of the Rahway River, 20 to 25 feet thick, and it thins out close to Tremley Point Road. In the Rahway River, black organic Silt mixed with Peat in some borings was encountered. The thickness of soft organic Silt in the Rahway River varies from 8 to 16 feet thick.

Embankment construction will require that the organic soils be excavated and replaced prior to placing fill. Alternately, the embankment areas will need to be surcharged prior to roadway construction. In the feasibility study it was assumed that excavating and replacing the organic is an option if the organic deposits are found to be less than two feet thick. The subsurface investigation program conducted in this phase of the project indicates that this option may not be economical.

The proposed embankment fill along the proposed alignment may reach up to 25 feet high. Surcharging the embankment fill areas will be required in order to consolidate the soft cohesive soils and provide a stable foundation for the embankment load. The surcharge shall be designed to minimize the long term settlement from the anticipated loading conditions.

Rock is encountered at shallow depth and is relatively consistent throughout the area. In general, rock is found at shallower depths on the Linden side compared to the Carteret side of the Rahway River. Bedrock at the project site can found at elevation that ranges from -19.4 to -50.6 feet. The top of the rock surface elevation varies from El. -26 to -37 at the Carteret side and from El. -19 to -30 on the Linden side of the Rahway River. The depth to rock below the existing ground surface is presented in Table 1, Summary of Test Boring Data.

The presence of the soft deposits of organic clayey Silt and Peat will preclude the use of shallow spread footing foundations. Deep foundations shall be used to provide positive support for the bridge, viaduct and retaining walls. Steel H-piles or concrete-filled steel pipe piles can be used. The selection of the pile type will be based on the final pier configurations, spans and loading condition. The piles shall be end-bearing piles driven to bedrock.

The pier foundation for the proposed bridge spanning the Rahway River may require drilled shafts with a rock socket. The borings drilled in the river for the three alternate alignments indicate relatively shallow rock surface and thick organic deposits. The anticipated high vertical and lateral loading conditions for the bridge foundation may require that the foundation derive their resistance from the rock socket.

CONCLUSION

The Phase II of the subsurface investigation program will resume once a decision is made on the roadway alignment. A more extensive boring and laboratory testing program will be performed based on the design alignment and profile. The design recommendation based on engineering analyses will be presented in that stage. Comparing the alternates considered at this point, EK do not see a major advantage of one alignment over the others from a geotechnical and foundation point of view. The depth to rock and thus foundation cost may vary. However, the variation is small and will not influence the decision. Embankment surcharge will be required regardless of the alignment chosen. Excavating and replacing the soft organic soil prior to construction the embankment may not be economical. Based on the height of the embankment, the surcharge may need to be constructed in stages to ensure a stable section.

From a geotechnical perspective, EK does not see a major advantage in any of the alternates.

New Jersey Turnpike Authority

INTERCHANGE 12 IMPROVEMENTS

TREMLEY POINT CONNECTOR ROAD
PHASE-I GEOTECHNICAL REPORT

TABLES

TABLE I.
SUMMARY OF TEST BORING DATA
FILE NO. 050011.102
NJ TURNPIKE INTERCHANGE 12 IMPROVEMENTS
CONNECTOR ROAD-PHASE I SOIL BORING PROGRAM
LINDEN / CARTERET, NEW JERSEY

TEST BORING NO.	GROUND SURFACE ELEVATION (feet)	DEPTH OF EXPLORATION (feet)	APPROXIMATE THICKNESS OF STRATUM (feet)				DEPTH TO ROCK (feet)	ELEVATION TOP OF ROCK (feet)	GROUNDWATER ELEVATION [4] (feet)
			FILL	ORGANIC DEPOSITS	GLACIAL ALLUVIAL	DECOMPOSED ROCK			
CONNECTOR ROAD PREFERRED ALIGNMENT (ALTERNATE 6)									
CR-1(OW)	7.00	40.3	9	NE	26.3	NE	35.3	-28.30	3.9
CR-5	2.30	37.0	NE	6	26.0	NE	32.0	-29.70	--
CR-10	2.40	45.0	NE	10	30.0	NE	40.0	-37.60	--
CR-22	2.42	36.0	NE	10	21.0	NE	31.0	-28.58	--
CR-24	2.03	39.0	NE	12	22.0	NE	34.0	-31.97	--
CR-26	2.34	40.0	NE	12	23.0	NE	35.0	-32.66	--
CR-33	-7.43	59.0	NE	8	21.0	NE	29.0	-36.43	--
CR-36	-7.70	56.5	NE	10	7.0	10	26.5	-34.20	--
CR-41	7.60	35.0	NE	25	5.0	NE	30.0	-22.40	--
CR-45	6.76	32.0	NE	15	12.0	NE	27.0	-20.24	--
CR-57(OW)	6.98	42.0	NE	4	33.0	NE	37.0	-30.02	2.98
CR-64	2.20	45.0	NE	8	32.0	NE	40.0	-37.80	--
CR-66	2.93	34.0	NE	8	22.0	NE	30.0	-27.07	--
CR-68	12.82	50.0	15	5	25.0	NE	45.0	-32.18	--
CR-69	2.73	34.0	NE	10	19.0	NE	29.0	-26.27	--
CR-72	8.18	35.0	NE	10	20.0	NE	30.0	-21.82	--
CR-74	6.07	30.5	NE	12	13.0	1	25.5	-19.43	--
CR-77	4.52	45.0	NE	4	36.0	NE	40.0	-35.48	--
ALTERNATE 5 ALIGNMENT									
A5-1	-8.14	52.5	NE	10	10	2.5	22.5	-30.64	--
A5-2	-5.80	50.1	NE	15	3	2.1	20.1	-25.90	--
A5-3	4.54	35.0	NE	25	5	NE	30	-25.46	--
A5-4	4.71	35.0	NE	25	5	NE	30	-25.29	--

TEST BORING NO.	GROUND SURFACE ELEVATION (feet)	DEPTH OF EXPLORATION (feet)	APPROXIMATE THICKNESS OF STRATUM (feet)				DEPTH TO ROCK (feet)	ELEVATION TOP OF ROCK (feet)	GROUNDWATER ELEVATION [4] (feet)
			FILL	ORGANIC DEPOSITS	GLACIAL ALLUVIAL	DECOMPOSED ROCK			
ALTERNATE 7 ALIGNMENT									
A7-1	2.88	45.0	NE	16	24	NE	40	-37.12	--
A7-2	2.61	37.0	NE	10	22	NE	32	-29.39	--
A7-3	-3.50	60.0	NE	16	14	NE	30	-33.50	--
A7-4	-10.40	64.0	NE	10	20	4	34	-44.40	--
A7-5	-4.00	63.0	NE	10	23	NE	33	-37.00	--
A7-6	2.60	38.0	NE	20	13	NE	33	-30.40	--
A7-7	-6.39	42.0	NE	20	7	NE	27	-33.39	--
CYTEC PROPERTY									
E-1	4.28	45.0	8	7	25	NE	40	-35.72	--
E-2	4.41	60.0	8	6	26	15	55	-50.59	--
E-3	4.43	50.5	8	12	24	1.5	45.5	-41.07	--

NOTES:

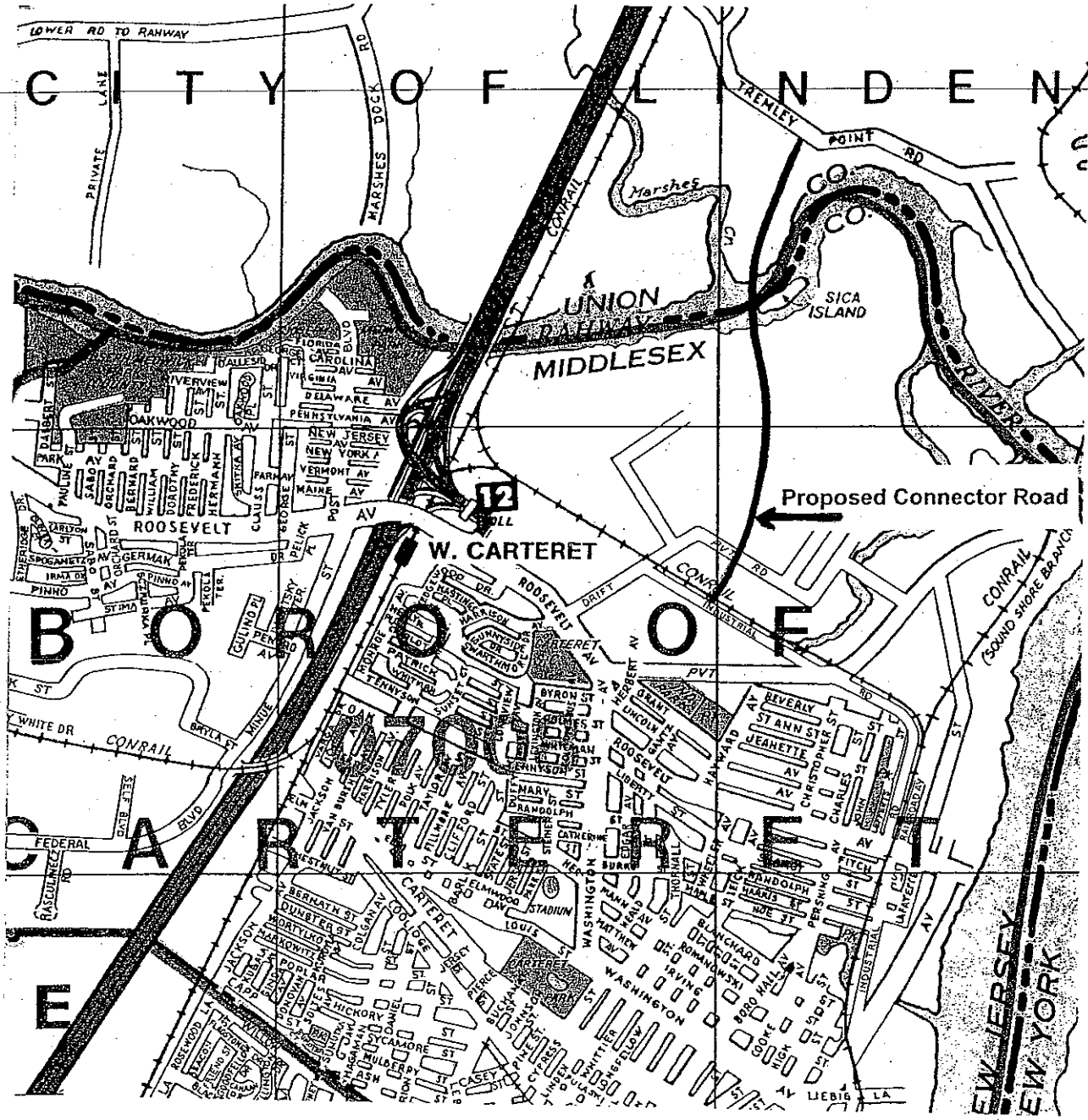
1. BORING CR-1 WAS RELOCATED TO STATION 2+27 DUE TO EXISTING UNDERGROUND UTILITIES.
2. ELEVATIONS ARE IN FEET AND REFER TO THE NAVD 1988 DATUM.
3. GROUND SURFACE ELEVATIONS WERE SURVEYED BY EK.
4. MUDLINE ELEVATION FOR RAHWAY RIVER BORINGS ARE ESTIMATED FROM RIVER SOUNDINGS.
5. GROUNDWATER ELEVATION REPRESENTS MAXIMUM OF GROUNDWATER LEVELS MEASURED.
6. 'NE' INDICATES STRATUM NOT ENCOUNTERED; 'ND' INDICATES VALUE NOT DETERMINED.

New Jersey Turnpike Authority

INTERCHANGE 12 IMPROVEMENTS

P TREMLEY POINT CONNECTOR ROAD
PHASE-I GEOTECHNICAL REPORT

FIGURES



Edwards AND Kelcey

NEW JERSEY TURNPIKE AUTHORITY
INTERCHANGE 12 IMPROVEMENTS
CARTERET, NEW JERSEY

PROJECT LOCUS

NOTE: FROM MIDDLESEX COUNTY HAGSTROM MAP, 1994

JULY 2006

FIGURE 1

BOROUGH OF CARTERET
MIDDLESEX COUNTY

CITY OF LINDEN
UNION COUNTY

INDUSTRIAL ROAD

TREMLEY POINT ROAD

CONNECTOR ROAD

RAHWAY RIVER

ALTERNATE 7 ℄

CITY AND COUNTY LINE

PREFERRED ALTERNATE (ALTERNATE 6) ℄

ALTERNATE 5 ℄

A7-1 A7-2 A7-3 A7-4 A7-5 A7-6 A7-7

A5-1 A5-2 A5-3 A5-4

CR-1 (OW) B-10 OW CR-5 CR-20 CR-54 CR-55 CR-56 CR-57 CR-58 CR-59 CR-60 CR-61 CR-62 CR-63 CR-64 CR-65 CR-66 CR-67 CR-68 CR-69 CR-70 CR-71 CR-72 CR-73 CR-74 CR-75 CR-76 CR-77 CR-78 (OW)

B-11 B-11A B-11B B-12 B-13 B-14 B-15

E-1 E-2 E-3

(NOT DRILLED)

LEGEND

CR-1	SOIL BORING LOCATION	E-1	CYTEC LANDFILL BORING
A5-1	ALTERNATE 5 - SOIL BORING LOCATION	B-10	SOIL BORINGS DRILLED IN PREVIOUS INVESTIGATION
A7-1	ALTERNATE 7 - SOIL BORING LOCATION	OW	OBSERVATION WELL
			WETLANDS

NEW JERSEY TURNPIKE AUTHORITY
INTERCHANGE 12 IMPROVEMENTS
TREMLEY POINT CONNECTOR ROAD
BORING LOCATION PLAN – PHASE I

JULY 2006

1" = 200'

FIGURE 2