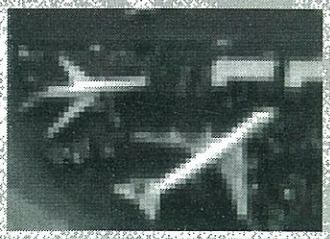
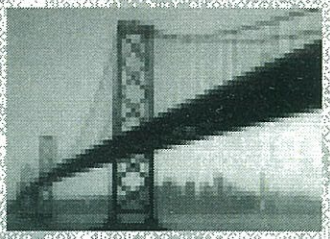
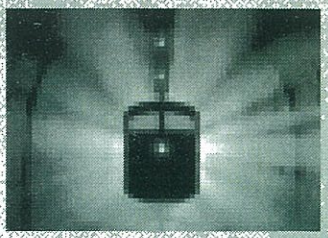
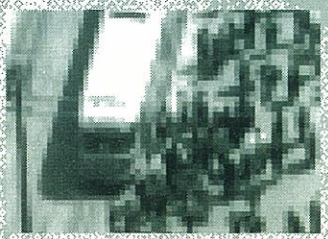
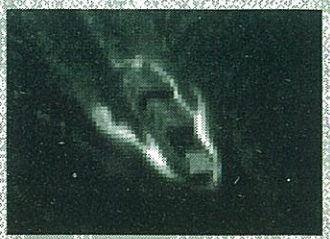
U.S. Army Corps of Engineers • FEMA
National Weather Service
NY/NJ/CT State Emergency Management











INTERIM PROJECT FINDINGS

September 1995

METRO NEW YORK HURRICANE TRANSPORTATION STUDY

Key Findings of the Metro New York Hurricane Transportation Study

- Coastal storms that would present moderate hazards in other regions of the country could result in heavy loss of life and disastrous disruptions to communication and travel in the Metro New York area.

- Depending upon the intensity, approach direction, and forward speed of a landfalling hurricane in Metro New York, a storm surge of up to 30 feet above normal tide level could be generated in some locations.

- When potential storm surge heights are compared to critical tunnel entrance elevations, as low as 7 feet above mean sea level, the vulnerability of under ground mass transit is apparent. The December 1992 extra-tropical storm (nor'easter) was a "wake-up call" highlighting this vulnerability.

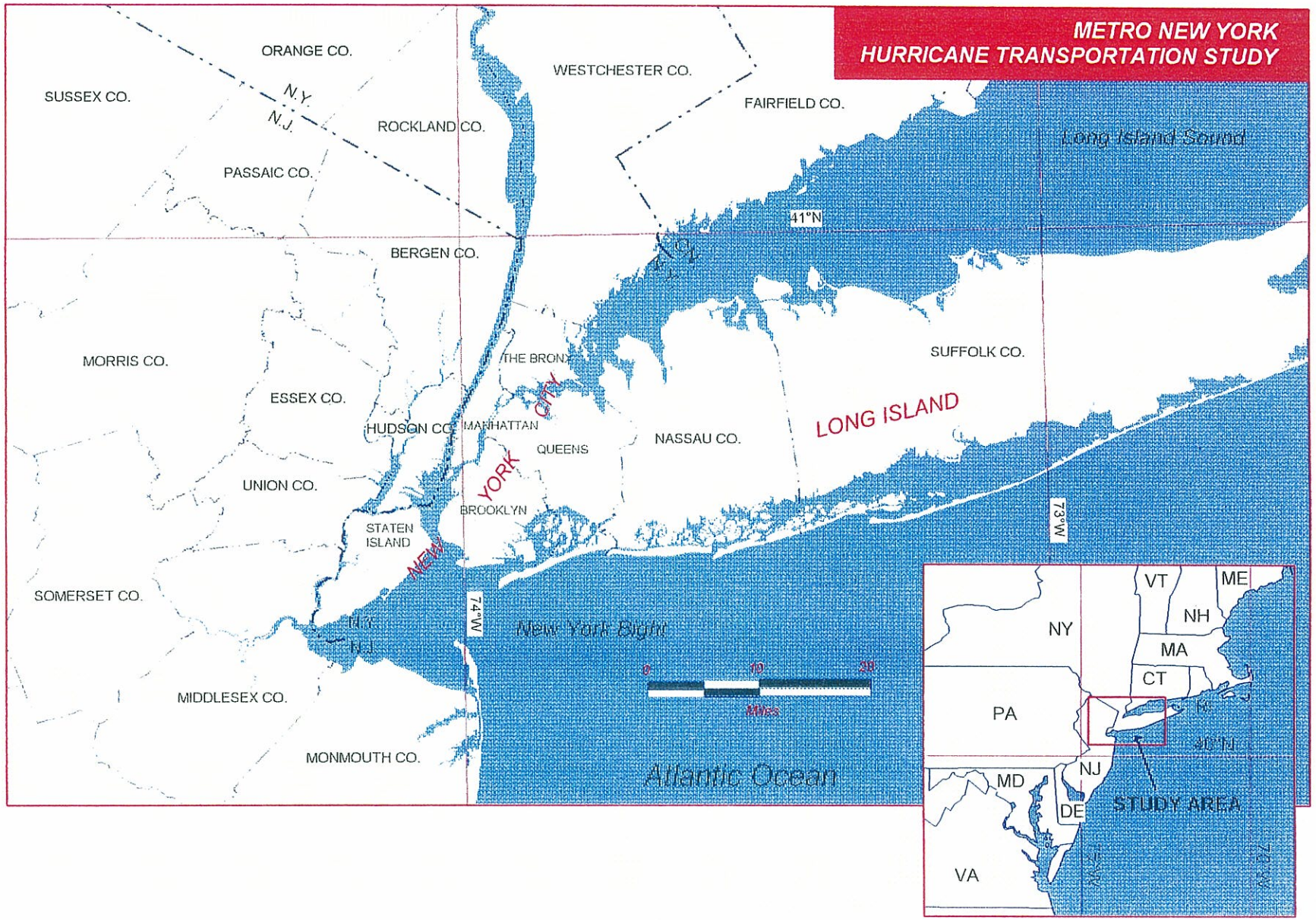
- As a hurricane approaches, the rate-of-rise of storm surge could increase quite dramatically. With a Category 3 hurricane, flood depths in the Metro area could rise as quickly as 12 feet per hour. Emergency management officials must anticipate, rather than react to, this hazard for an effective hurricane emergency response.

- Extreme winds associated with an approaching hurricane will have major impacts on the operation of high-level bridges and high-rise buildings. For a Category 3 hurricane, sustained tropical storm winds may arrive on the surface 3 1/2 hours before the peak winds but, for the same circumstances, would probably occur 6 hours in advance of the peak winds at heights of 150-200 feet.

- Heavy rainfall preceding hurricane landfall could severely affect critical mass transit and highway locations, particularly in northern New Jersey areas that are subject to riverine flooding.

- Due to the varying degrees of vulnerability of seaports, bridges, airports, mass transit, and highway facilities to storm surge, wind and rainfall, their closure is expected to occur at different time. The study has recognized that, for a category 3 hurricane directly affecting the area, the seaports and high-level bridges will probably be the first to close. The airports and-lower level bridges would be next to cease operation, with remaining surface and tunnel transportation closing last.

- Mitigation measures to reduce potential loss of life and property will be important. A timely decision to curtail or close government and private business before a storm arrives would greatly reduce the demand for evacuation and sheltering resources. Coordinated, early decision making among governmental and transportation agencies will help ensure the success of hurricane response.


METRO NEW YORK
HURRICANE TRANSPORTATION STUDY
ORANGE CO.
SUSSEX CO.
N.Y.
N.J.
ROCKLAND CO.
WESTCHESTER CO.
FAIRFIELD CO.
Long Island Sound
PASSAIC CO.
41°N
BERGEN CO.
MORRIS CO.
ESSEX CO.
THE BRONX
SUFFOLK CO.
HUDSON CO.
MANHATTAN
NEW YORK CITY
QUEENS
NASSAU CO.
LONG ISLAND
UNION CO.
BROOKLYN
STATEN ISLAND
73°W
SOMERSET CO.
74°W
New York Bight
0
10
20
Miles
MIDDLESEX CO.
MONMOUTH CO.
Atlantic Ocean
VT
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CT
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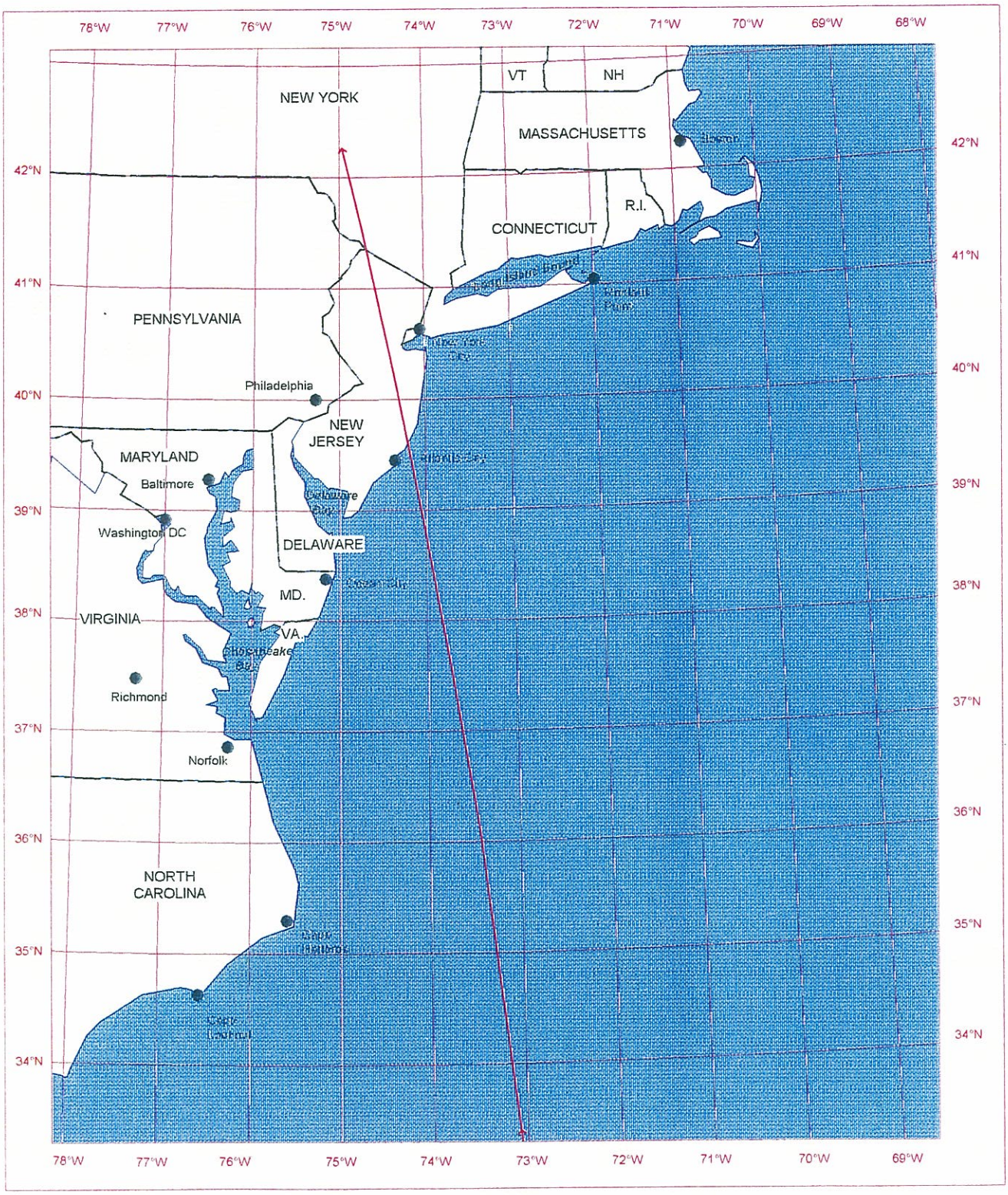
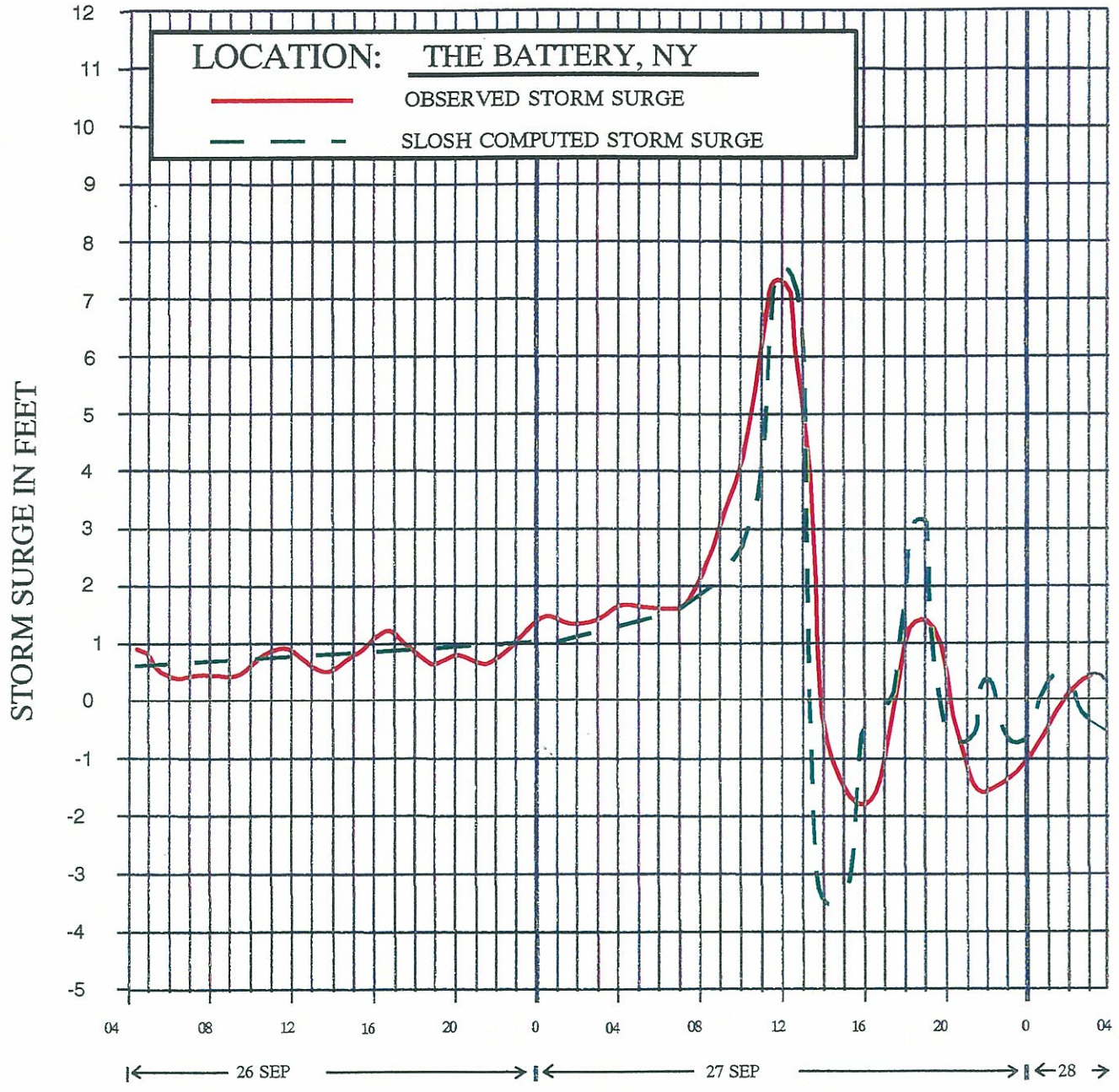
STUDY AREA
VA

STUDY AREA



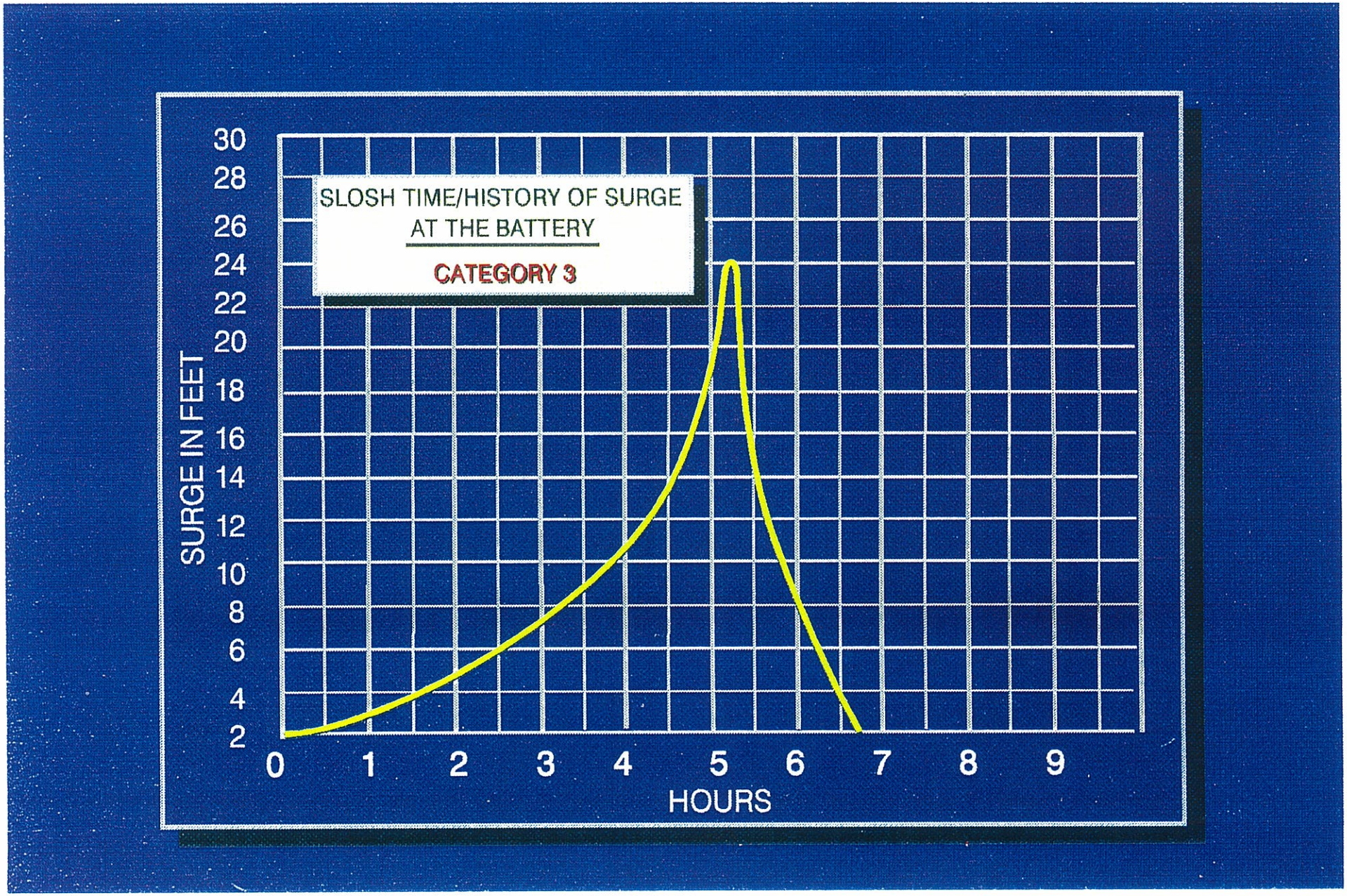
WORST CASE TRACK FOR HURRICANES IMPACTING

THE METRO NEW YORK CITY AREA



OBSERVED VS. COMPUTED STORM SURGE

AT THE BATTERY, HURRICANE GLORIA, SEPT 1985


SLOSH TIME/HISTORY OF SURGE
AT THE BATTERY
CATEGORY 3
SURGE IN FEET
30
28
26
24
22
20
18
16
14
12
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6
4
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1
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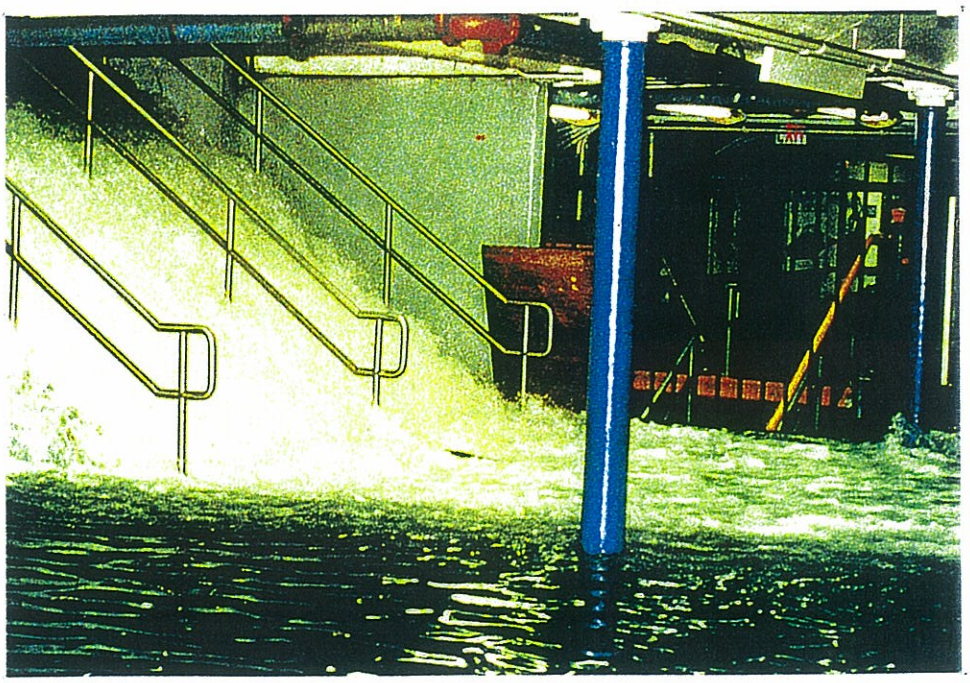
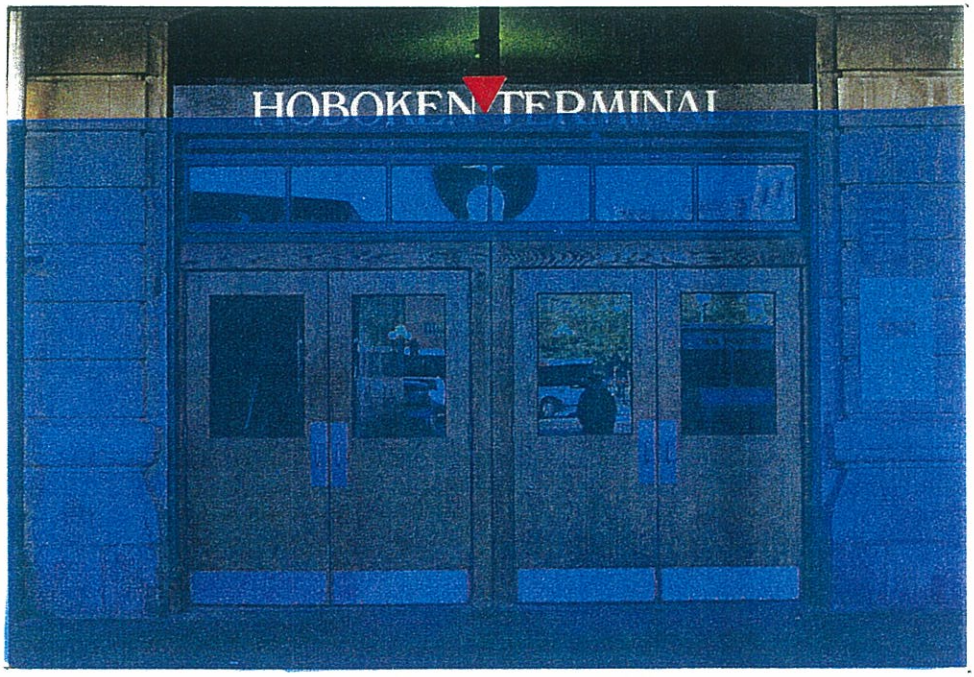
9
HOURS

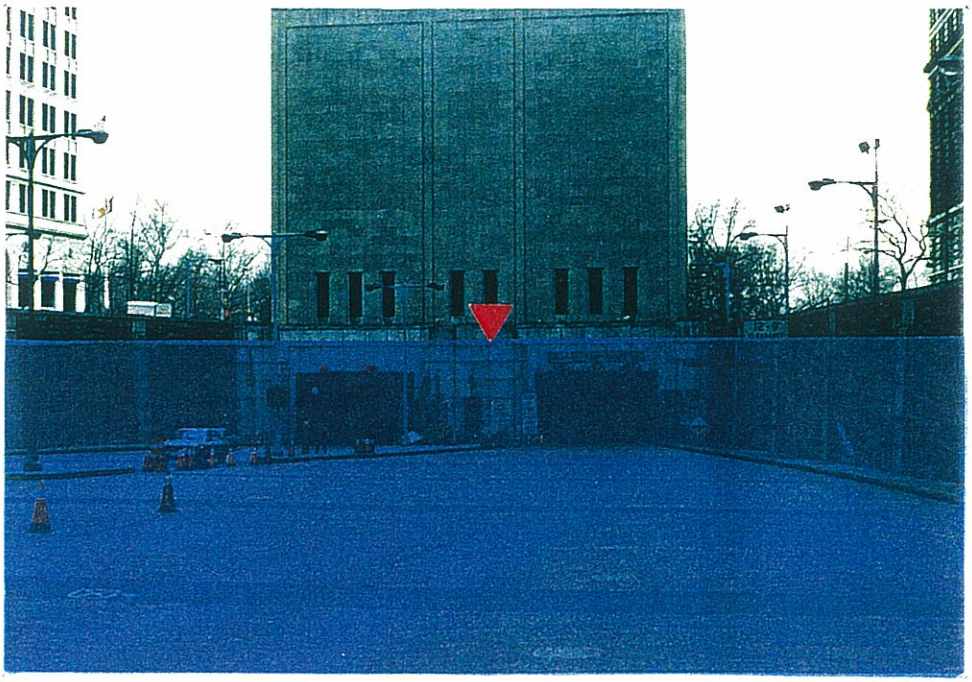


Floodwater cascades into the Hoboken PATH Station
December 11, 1992

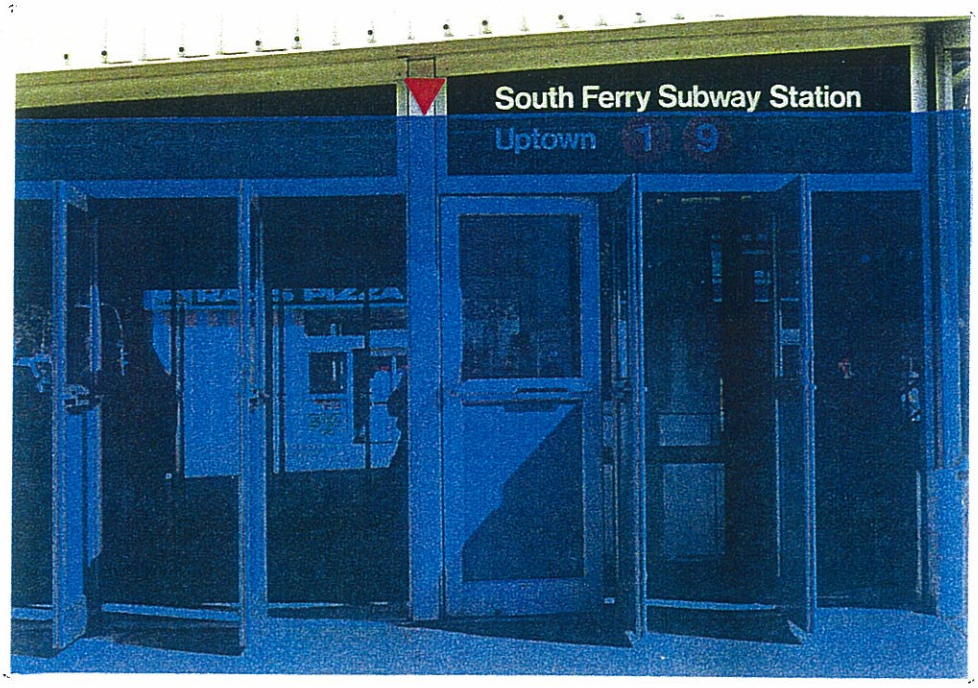


Potential Category 2 hurricane surge
at Hoboken Terminal

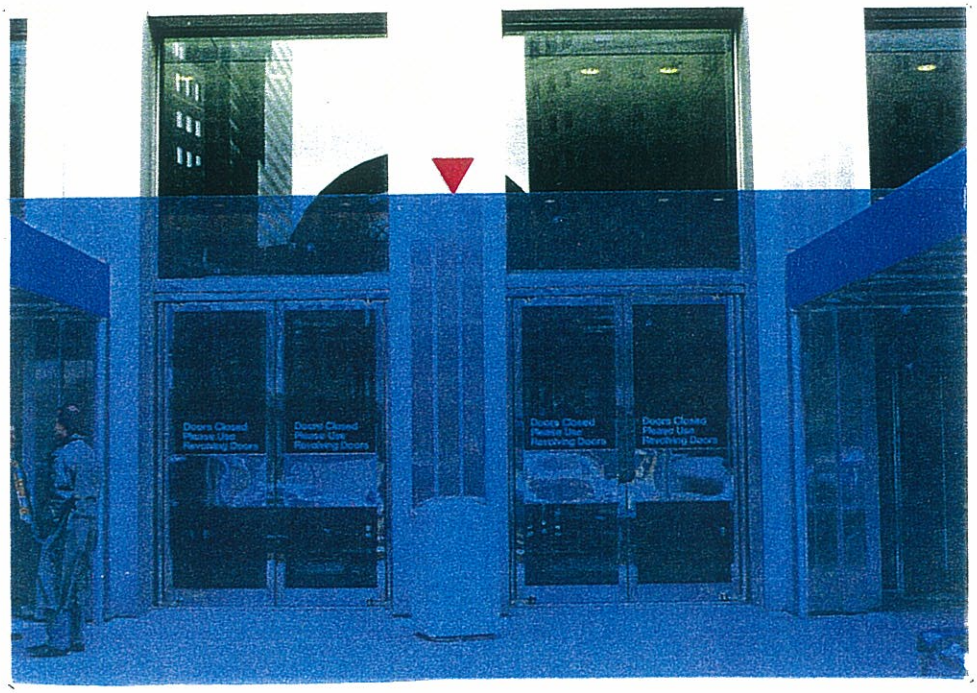
Potential Category 2 hurricane surge
at Manhattan Holland Tunnel entrance



Potential Category 1 hurricane surge
at Manhattan Brooklyn-Battery entrance



Potential Category 2 hurricane surge
at South Ferry (Battery) Subway Station



Potential Category 3 hurricane surge
at World Trade Center, West Street

BACKGROUND

Early in 1990, The Federal Emergency Management Agency (FEMA) and the U.S. Army Corps of Engineers (USACE) were conducting various phases of Hurricane Evacuation Studies for New York, New Jersey, and Connecticut under FEMA's Hurricane Program. The primary focus of those studies was determining the areas subject to storm surge inundation, the number of residents at risk to hurricane winds and surge, and the time needed to evacuate those people from their homes to safe shelter. For the Hazards Analysis phase of the studies, the Storm Surge Group at the National Hurricane Center used the Sea, Lake, and Overland Surge from Hurricanes (SLOSH) numerical model to compute worst-case potential hurricane surges in the Metropolitan (Metro) New York area. Previously, projections of hurricane surge heights were based on records of past storms. Work with the SLOSH model revealed that, because of the configuration of the shoreline and the bathymetry of the New York Bight, there is a potential for a much higher hurricane surge in the Metro area than could have been predicted from an analysis of the relatively short historic record. When the consequences of widespread flooding of underground transit systems and destruction from hurricane wind pressures on high-rise structures were considered, the generally unrecognized potential for catastrophe became especially disturbing. Storms that would present low to moderate hazards in other regions of the country could result in heavy loss of life and disastrous disruptions to communication and travel.

During the summer of 1990, state emergency management officials from New York, New Jersey, and Connecticut realized the complexity of the problem and expressed concern that the general treatment given transportation-related issues in the hurricane evacuation studies would not provide sufficient support for comprehensive regional emergency transportation plans. FEMA and the USACE were asked to expand the scope of those studies to address specific transportation vulnerability issues in the Metro New York area.

In response to this request, an Executive Study Committee was formed and held an initial meeting on June 20, 1991. A significant need was identified beyond the normal scope of the Hurricane Evacuation Studies to educate local government and transportation agency officials about the extraordinary wind and surge hazards, establish the vulnerability of the transportation systems, formulate coordinated emergency transportation plans, and mount an intensive public awareness campaign. The committee decided that a planning effort by Federal, state, and local officials, working in concert with all major transportation agencies, was required to protect the public from the inevitable major hurricane event that will strike the Metro New York area. The Metro New York Hurricane Transportation Study (Metro Study) was conceived as the vehicle through which that goal could best be

accomplished. Responsibility for the various tasks was assigned according to areas of expertise among Federal agencies, state emergency management offices, transportation agencies, and consultants.

The extratropical storm (nor'easter) of December 11-12, 1992, resulted in a number of major transportation problems in the study area, providing a "wake-up" to the vulnerability of most systems to high winds and/or storm surge that could accompany any severe coastal storm. Virtually every transportation system in the Metro New York area was severely affected. Problems ranged from extended delays on functioning systems to total shut-downs and roadway closures. After that experience, officials began to plan in earnest for a serious hurricane strike.

Although the potential effects of extratropical storms are not specifically addressed in Hurricane Evacuation Studies, the Hazards Analysis provides considerable insight into probable inundation patterns and wind hazards. The analyses in the completed New York, New Jersey, and Connecticut evacuation studies clearly show that, in some areas, a minimal hurricane could produce winds and surge in excess of those experienced in December, 1992.

The Metro Study is not complete, but a large volume of information has been collected and preliminary conclusions on vulnerability have been drawn. Thus far the study effort has concentrated on wind and surge hazards, system operational plans, demands and capacities, and vulnerability. Future work will primarily involve coastal storm emergency planning, mitigation issues, and decision making.

This year (1995), the New York State Emergency Management Office and the New Jersey Office of Emergency Management are assisting the Port Authority of New York and New Jersey with their Coastal Storm Emergency Planning Project, which is intended to be a guide for other transportation agencies' hurricane preparedness planning. The objectives of this Port Authority project are:

(1) To develop coastal storm emergency response plans which protect life and property,

(2) To prepare an overall coastal storm emergency response plan which ensures a maximum level of coordinated and compatible decision-making, both within the Port Authority system and between the Port Authority and the City of New York and State of New Jersey governmental officials.

(3) To develop an overall strategy for coastal storm hazard mitigation for the Port Authority and its facilities, including both short-term and long-term initiatives.

PURPOSE

The purpose of this study is to supplement the New York, New Jersey, and Connecticut Hurricane Evacuation Studies by assessing the potential impacts of hurricanes and other severe coastal storms on the users and infrastructure of the Metro New York transportation network and by providing information and assistance toward developing regional plans for those emergencies. The study has the following specific goals:

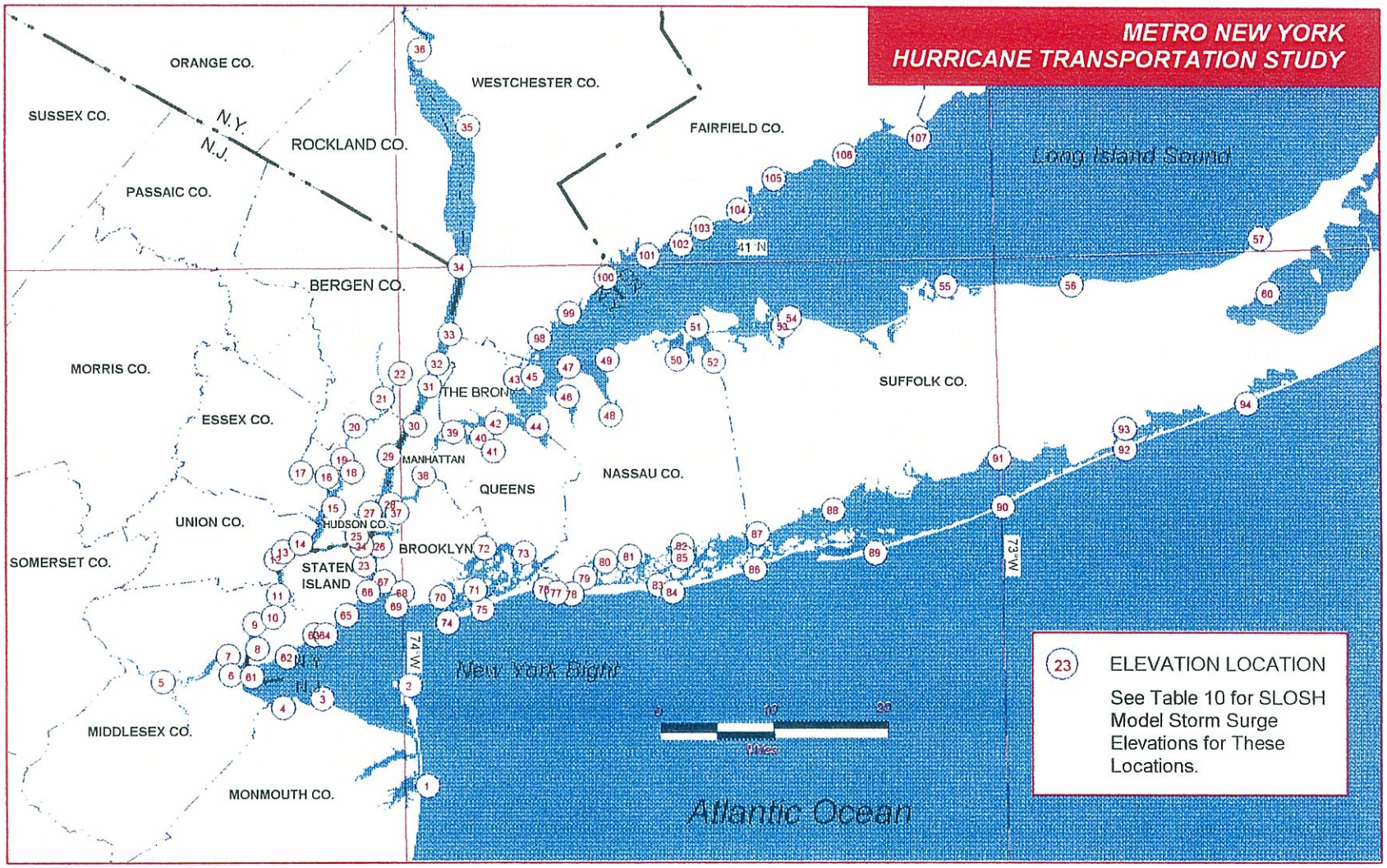
(1) Identify the potential wind and surge hazards to the facilities and users of each major metropolitan transportation system

(2) Determine the vulnerability to those hazards and recommend mitigation measures

(3) Identify offices with decision-making responsibilities related to coastal storm threats

(4) Recommend decision-making and coordinative procedures

(5) Formulate specific response actions that should be taken by transportation agencies in coordination with state and local governments.



SLOSH CRITICAL POINTS

SLOSH SURGE ELEVATIONS

	Location	Maximum Surge Height (ft)* Still-Water Elevation Cat 1	Cat 2	Cat 3	Cat 4
1.	MONMOUTH BEACH, N.J.	6.2	10.2	13.8	17.4
2.	SANDY HOOK, N.J.	7.7	12.3	16.5	21.7
3.	KEANSBURG, N.J.	9.7	15.6	20.8	26.2
4.	KEYPORT HARBOR, N.J.	10.3	16.6	22.4	27.4
5.	SAYREVILLE, N.J.	8.2	11.6	17.1	27.8
6.	AMBOY, N.J.	10.8	18.7	23.8	26.9
7.	VICTORY BRIDGE, RARITAN R.	10.7	18.0	19.7	24.9
8.	TOTTENVILLE, STATEN ISLAND	10.4	20.0	23.2	26.9
9.	WOODBRIDGE, N.J.	10.0	12.5	19.3	21.9
10.	FRESH KILLS LANDFILL, STATEN IS.	8.6	10.5	12.8	17.3
11.	TRAVIS, STATEN ISLAND	9.0	10.5	14.3	17.7
12.	LINDEN, N.J.	9.0	10.6	14.3	18.0
13.	GOETHALS BRIDGE, ARTHUR KILL	8.9	10.7	14.4	17.8
14.	ELIZABETH, N.J.	8.4	10.3	13.6	17.2
15.	NEWARK BAY BRIDGE, BAYONNE	7.1	9.1	11.8	15.0
16.	US 1 @ PASSAIC RIVER, NEWARK	7.4	9.2	11.9	14.0
17.	PASSAIC RIVER, HARRISON, N.J.	8.5	10.0	13.4	15.9
18.	PULASKI SKYWAY, HACKENSACK R.	6.8	9.0	11.8	14.4
19.	N.J. TURNPIKE, KEARNY, N.J.	6.9	7.4	8.5	12.2
20.	ROUTE 3, SECAUCUS, N.J.	5.2	6.3	7.7	11.4
21.	RIDGEFIELD.PARK, HACKENSACK R.	Dry	Dry	Dry	9.9
22.	PALISADES PARK, OVERPECK CR.	Dry	Dry	Dry	9.2
23.	STAPLETON, STATEN ISLAND	9.9	15.4	21.1	26.0
24.	ST. GEORGE, STATEN ISLAND	10.0	16.0	22.0	26.7
25.	BAYONNE, N.J.	9.2	12.5	19.3	27.9
26.	BUSH TERMINAL, BROOKLYN	10.4	15.7	22.3	27.6
27.	LIBERTY ISLAND, N.J.	10.3	15.7	22.8	28.0
28.	BATTERY, MANHATTAN	10.5	16.6	23.9	28.7
29.	LINCOLN TUNNEL	7.5	17.2	20.5	30.8
30.	W 96TH STREET, MANHATTAN	8.2	15.0	17.7	28.1
31.	GEORGE WASHINGTON BRIDGE	6.9	14.1	16.8	26.7
32.	SPUYTEN DUYVIL, MANHATTAN	6.1	13.0	14.8	24.6
33.	CITY LINE, NY C-YONKERS	5.5	11.6	13.4	22.5

SLOSH SURGE ELEVATIONS

	Location	Maximum Surge Height (ft)* Still-Water Elevation Cat 1	Cat 2	Cat 3	Cat 4
34.	TAPPAN, PALISADES STATE PARK	4.6	9.5	10.5	17.5
35.	OSSINING, N.Y.	2.9	7.6	8.7	14.6
36.	PEEKSKILL/INDIAN POINT, N.Y.	2.0	6.6	7.8	13.7
37.	MANHATTAN BRIDGE, EAST R.	10.1	15.8	22.4	25.6
38.	NEWTOWN CREEK, QUEENS/KINGS	9.6	14.4	21.0	23.6
39.	HELL GATE, WARDS ISLAND	7.9	11.7	14.9	18.1
40.	LA GUARDIA AIRPORT	6.4	11.2	15.7	20.8
41.	FLUSHING BAY, FLUSHING CR.	6.6	11.6	16.3	20.9
42.	WHITESTONE (BRONX)	6.5	11.3	16.6	22.2
43.	PELHAM BAY, BRONX	6.4	11.6	17.5	22.4
44.	WILLETS POINT, QUEENS	6.3	11.4	18.3	23.0
45.	CITY ISLAND, BRONX	6.3	11.5	17.3	22.2
46.	MANORHAVEN, MANHASSET BAY	6.5	11.7	17.8	22.7
47.	SANDS POINT, LONG IS. SOUND	6.1	11.1	16.3	21.5
48.	ROSLYN, HEMPSTEAD HARBOR	6.2	11.3	16.5	21.8
49.	GLEN COVE, LONG IS. SOUND	6.0	10.9	16.0	21.0
50	MILL NECK, BAYVILLE, NASSAU CO.	5.7	10.3	15.2	19.8
51.	CENTRE ISLAND, OYSTER BAY	5.7	10.3	15.2	19.8
52.	COLD SPRING HARBOR, OYSTER BAY	5.7	10.3	15.1	19.8
53.	NORTHPORT BAY, SUFFOLK CO.	5.4	9.8	13.7	18.1
54.	ASHAROKEN, N. SHORE, SUFFOLK	5.2	9.3	13.6	18.0
55.	PORT JEFFERSON, NORTH SHORE	5.0	9.0	13.1	17.3
56.	SHOREHAM, LONG ISLAND SOUND	4.6	8.1	11.8	15.5
57.	MATTITUCK, NORTH SHORE	4.3	7.6	11.0	14.6
58.	ORIENT, NORTH FORK	4.5	7.4	10.4	13.4
59.	SHELTER ISLAND, GARDINERS BAY	5.1	8.5	12.0	15.5
60.	JAMESPORT, GREAT PECONIC BAY	3.8	6.8	10.2	13.8
61.	WARD POINT, STATEN ISLAND	10.7	17.5	23.2	27.6
62.	HUGUENOT, STATEN ISLAND	10.2	16.6	22.1	27.4
63.	GREAT KILL, STATEN ISLAND	10.1	15.9	21.2	27.1
64.	OAKWOOD BEACH, STATEN ISLAND	9.7	15.7	21.0	27.0
65.	MIDLAND BEACH, STATEN ISLAND	9.4	15.3	20.7	26.8
66.	SOUTH BEACH, STATEN ISLAND	9.1	15.0	20.4	26.4
67.	FORT HAMILTON, BROOKLYN	9.3	15.2	20.9	27.0
68.	GRAVESEND BAY, BROOKLYN	9.2	15.2	20.8	27.2

SLOSH SURGE ELEVATIONS

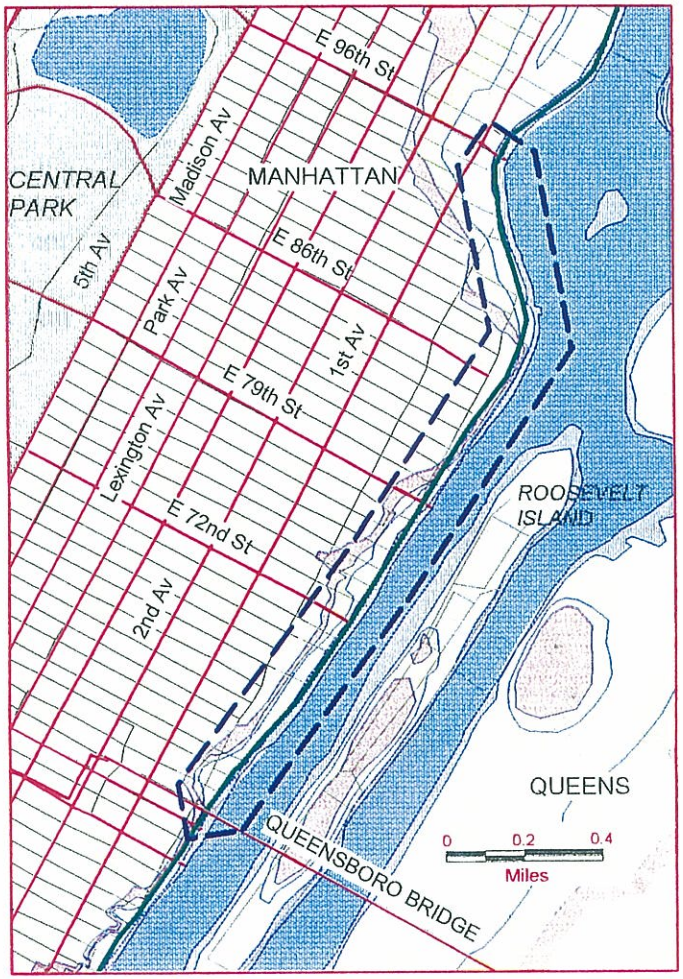
	Location	Maximum Surge Height (ft)* Still-Water Elevation Cat 1	Cat 2	Cat 3	Cat 4
69.	SEAGATE, CONEY ISLAND	9.1	15.0	20.5	26.4
70.	SHEEPSHEAD BAY, CONEY ISLAND	7.8	15.1	21.0	27.4
71.	FLOYD BENNETT NAVAL AIR STAT.	6.7	14.0	21.7	28.5
72.	PENNSYLVANIA AVE, JAMAICA BAY	6.2	15.7	25.0	31.3
73.	KENNEDY INTERNATN'L AIRPORT	6.6	15.6	24.5	31.2
74.	BREEZY POINT, ROCKAWAY INLET	9.1	14.3	20.0	25.9
75.	ROCKAWAY BEACH, QUEENS	9.1	14.0	20.4	26.6
76.	EAST ROCKAWAY INLET	9.0	14.8	20.0	25.2
77.	LAWRENCE, NASSAU COUNTY	6.7	15.7	20.4	25.4
78.	LONG BEACH, NASSAU COUNTY	8.7	15.5	20.1	24.8
79.	ISLAND PARK, LONG BEACH	8.3	16.0	21.0	25.7
80.	EAST ROCKAWAY, HEWLETT BAY	6.1	17.0	22.1	26.9
81.	OCEANSIDE, MIDDLE BAY	6.1	16.7	23.0	28.3
82.	FREEPORT, SOUTH SHORE, NASSAU	7.7	14.9	23.2	29.4
83.	LOOP PARKWAY, JONES INLET	7.7	14.9	21.0	26.3
84.	JONES BEACH STATE PARK	8.4	13.8	19.1	24.1
85.	WANTAGH PRKWAY, EAST BAY	2.3	13.3	20.5	27.0
86.	GILGO BEACH, SUFFOLK COUNTY	8.0	13.6	17.3	23.5
87.	AMITYVILLE, GREAT SOUTH BAY	2.5	8.7	19.7	26.8
88.	WEST ISLIP, GREAT SOUTH BAY	3.2	8.4	15.9	22.6
89.	ATLANTIQUE, FIRE ISLAND	6.8	11.4	15.4	19.8
90.	DAVIS PARK, FIRE ISLAND	6.5	11.3	15.9	19.6
91.	PATCHOGUE, GREAT SOUTH BAY	2.4	4.8	9.2	15.1
92.	SMITH PT./MORICHES, GRT SO. BAY	6.2	10.6	14.8	18.2
93.	CENTER MORICHES, MORICHES BAY	5.5	9.7	13.2	19.7
94.	WEST HAMPTON, MORICHES BAY	6.0	10.4	14.1	18.1
95.	MECOX BAY, SOUTH SHORE	5.7	9.9	14.0	17.9
96.	NAPEAGUE BEACH, SOUTH SHORE	5.2	8.9	12.6	16.2
97.	MONTAUK POINT, SOUTH FORK	4.9	7.9	10.7	13.5
98.	NEW ROCHELLE, WESTCHESTER CO	6.1	11.2	16.4	21.5
99.	MAMARONECK HARBOR, L.I. SOUND	6.0	11.0	15.9	21.0
100.	PORT CHESTER, N.Y. STATE LINE	5.8	10.6	15.6	20.5

CRITICAL ELEVATIONS FOR TUNNEL FLOODING

Mass Transit	Elevation (NGVD)
TA-Cranberry Street Tunnel @ Front St Vent	7.0
PATH-Exchange Place Station	7.0
TA-14th Street Tunnel @ Avenue D Vent	7.2
PATH-Morton Street Shaft	7.3
PATH-Hoboken Station	7.4
TA-Montague Street Tunnel @ grates in Broad St	7.5
PATH-Washington Street Shaft	7.6
PATH/TA-World Trade Center Ramp D	8.1
TA-Greenpoint Jackson Ave (Newtown Cr)	8.1
TA-A,C,E Lines @ Canal Street Station	8.7
AMTRAK/LIRR-East River Tunnel @ L.I. Shaft	9.0
TA-South Ferry Station	9.1
TA-Whitehall Street Station	9.1
TA-Clark Street Tunnel @ Front Street Vent	9.1
PATH-15th Street Shaft	9.6
PATH-Railroad Avenue Shaft	9.7
PATH-Grove Street Station	9.8
TA-Joralemon Tunnel @ State Street Grate	9.8
TA-1,2,3,9 Lines @ Canal Street Grate	9.8
TA-Lexington Ave Tunnel @ 135th St Bronx Vent	9.9
PATH-Pavonia Avenue Station	10.0
AMTRAK/LIRR @ West Side Yard	10.0
TA-53rd Street Tunnel @ Nott Avenue Vent	10.0
TA-Rutgers Street Tunnel @ South Street Vent	10.6
TA/METRO NORTH-Steinway Tunnel @ 50th Ave Vent	11.0
AMTRAK/LIRR @ East River Tunnel Top-of-Ramp	12.0
AMTRAK/LIRR @ Weehawken Shaft	12.3
PATH/TA-World Trade Center Concourse	12.6
TA-63rd Street Tunnel @ Queensbridge Vent	12.7
TA-Yankee Stadium Tunnel @ 157th Street Vent	12.8
AMTRAK/LIRR @ East River Tunnel 1st Ave Shaft	14.5

CRITICAL ELEVATIONS FOR TUNNEL FLOODING

Highway Tunnels	Elevation (NGVD)
Holland Tunnel New Jersey Entrance	7.6
Holland Tunnel New Jersey Land Vent Shaft	7.6
Brooklyn-Battery Tunnel West Street Entrance	8.6
Brooklyn-Battery Tunnel Battery Ent @ Morris St	8.6
Holland Tunnel New York River Vent Shaft	8.6
Holland Tunnel New York Land Vent Shaft	8.6
Holland Tunnel New York Entrance	9.5
Holland Tunnel New Jersey River Vent Shaft	10.6
Lincoln Tunnel New Jersey Vent Shaft	10.6
Lincoln Tunnel New York Third Tube Vent Shaft	10.6
Queens Midtown Tunnel Queens Entrance	10.6
Lincoln Tunnel New York River Vent Shaft	11.6
Brooklyn-Battery Tunnel Brooklyn Entrance	11.6
Queens Midtown Tunnel Queens Vent Shaft	12.6
Brooklyn-Battery Tunnel Governors Is Vent	12.6
Brooklyn Battery Tunnel Manhattan Vent Shaft	13.6
Queens Midtown Tunnel Manhattan Entrance	14.6
Brooklyn-Battery Tunnel Brooklyn Vent Shaft	14.6
Lincoln Tunnel New York Land Vent Shaft	19.6
Lincoln Tunnel New York Entrance	22.6
Queens Midtown Tunnel Manhattan Vent Shaft	22.6
Lincoln Tunnel New Jersey Entrance	27.6

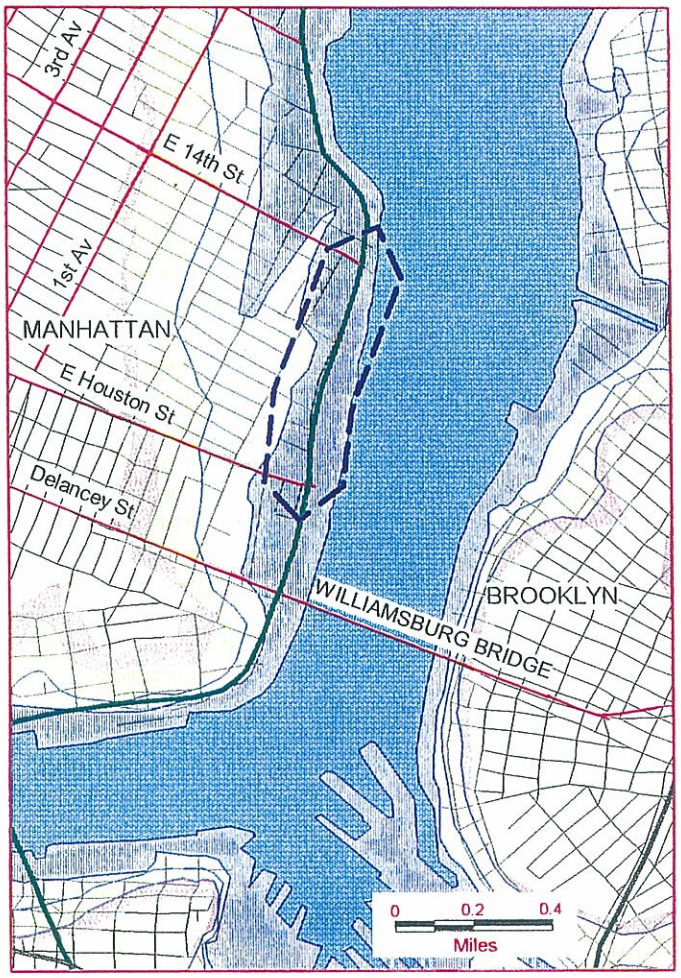


FLOOD AREA
CATEGORY 1 HURRICANE

ADDTIONAL FLOOD AREA
CATEGORY 2 HURRICANE

ADDITIONAL FLOOD AREA
CATEGORY 3 HURRICANE

ADDITIONAL FLOOD AREA
CATEGORY 4 HURRICANE



CRITICAL ELEVATIONS (NGVD)

Queensboro Bridge	6.0 feet

POTENTIAL HURRICANE SURGE

Category 1	9.2 feet
Category 2	14.1 feet
Category 3	17.4 feet
Category 4	22.3 feet

Major flooding occurred along these sections of FDR Drive during the December 1992 Northeaster. The storm tide elevation at the Battery was approximately 8.0 feet NGVD.

CRITICAL ELEVATIONS (NGVD)

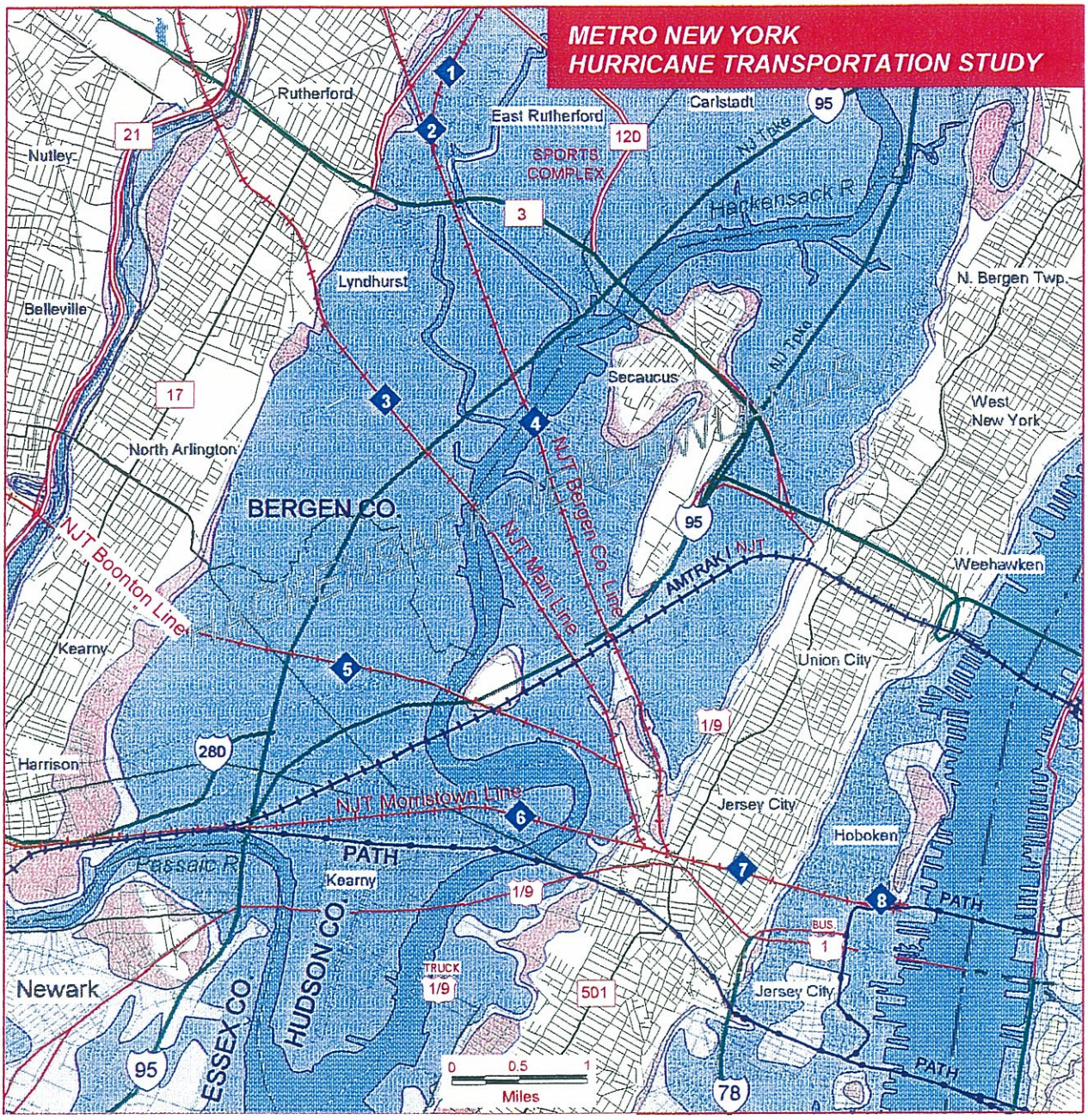
Vic. of Williamsburg Bridge	6.0 feet

POTENTIAL HURRICANE SURGE

Category 1	9.7 feet
Category 2	14.7 feet
Category 3	22.0 feet
Category 4	24.9 feet

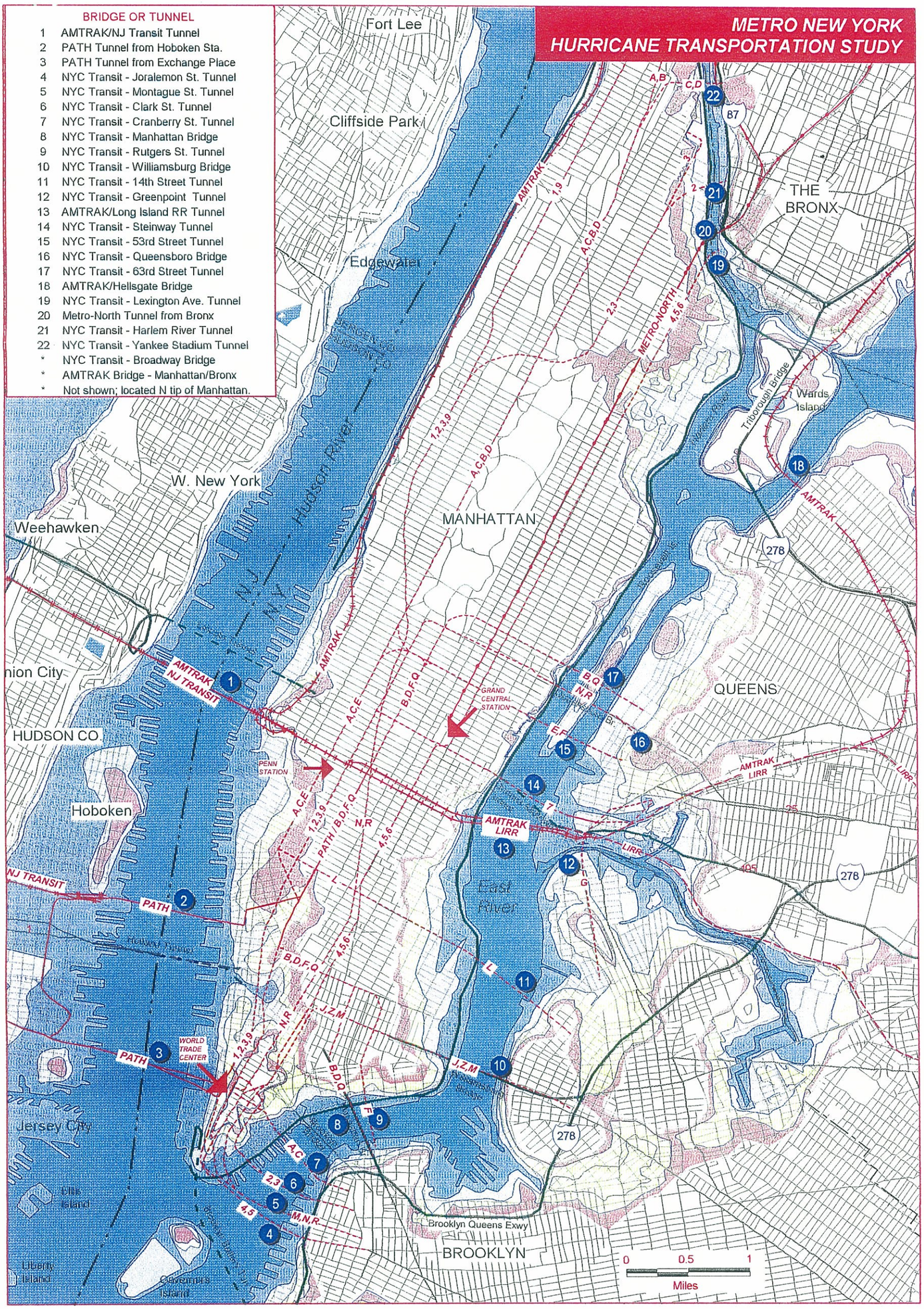
DECEMBER, 1992 NORTHEASTER

FDR DRIVE FLOODING LOCATIONS

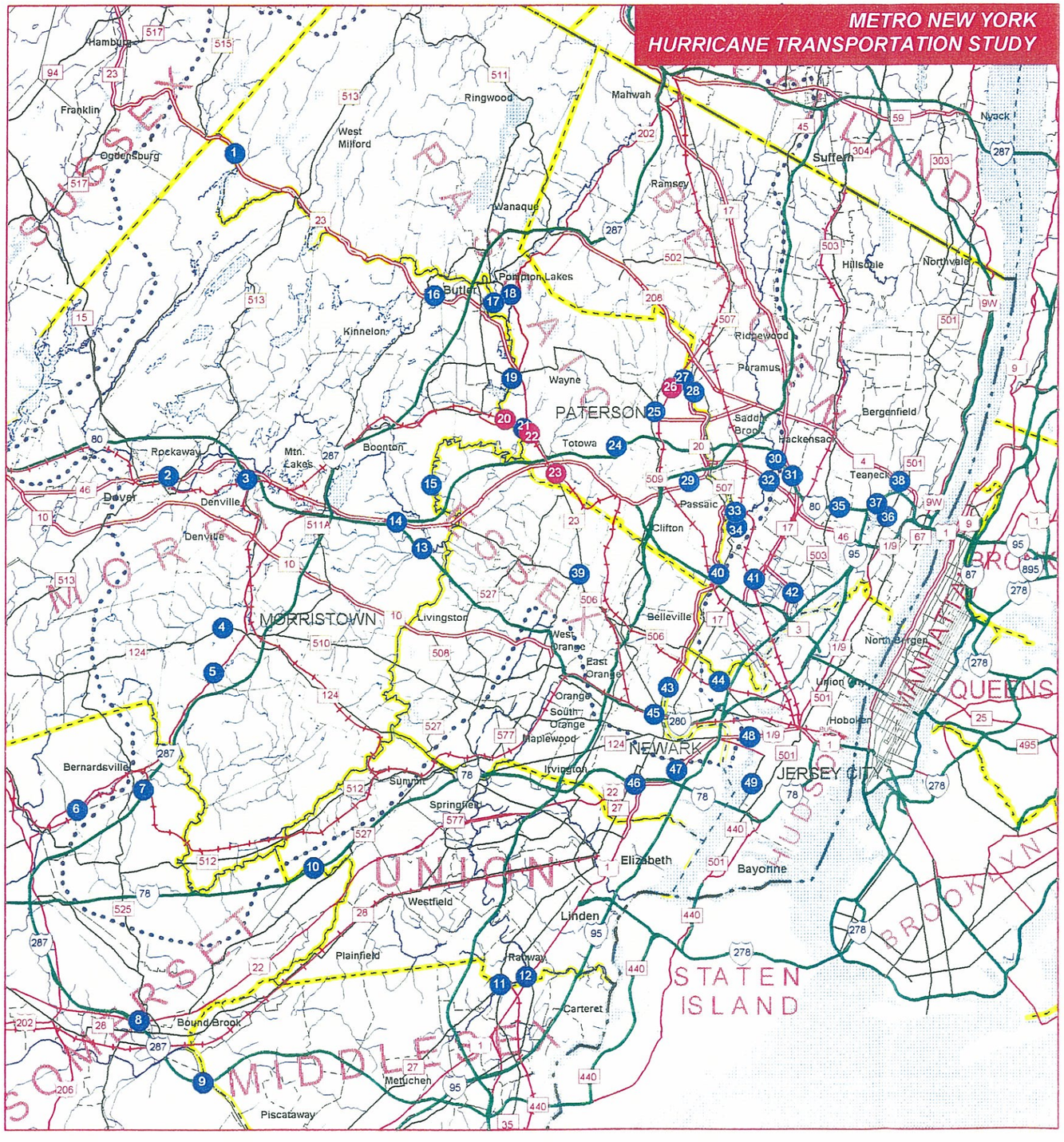


DECEMBER, 1992 NORTHEASTER

SELECTED NJ TRANSIT FLOODING LOCATIONS



MANHATTAN PASSENGER RAIL WATER CROSSINGS



MAP KEY	TYPE	SOURCE	LOCATION
1	Hwy	DOT	NJ 23, mp 23.8; Rockaway, Morris Co.
2	Hwy	DOT	US 46, mp 39.0 to 40.0; Parsippany-Troy Hills, Morris Co.
3	Hwy	DOT	NJ 53, mp 0.0 to 7.4; Morris Plains Borough thru Denville T., Morris Co.
4	Hwy	DOT	NJ 24, mp 0.0 to 7.4 ; Morris T. & Jefferson T., Morris Co.
5	Hwy	DOT	US 202, mp 39.0 to 47.0; Ha
6	Hwy	DOT	US 202, mp 34.3 to 34.6; Bernardsville Bor., Somerset Co.
7	Hwy	DOT	I-287, mp 28.1 SB; Bernards T., Somerset Co.
8	Hwy	DOT	US 22, mp 32.0 EB at I-287 Interchange; Bridgewater T.
9	Hwy	DOT	I-287, mp 12.1 NB; Franklin T., Somerset Co.
10	Hwy	DOT	I-78, mp 42.2, Esit 41; Watchnung Bor., Somerset Co.
11	Hwy	DOT	NJ 35, mp 58.0; Rahway, Union Co.
12	Hwy	DOT	US 1/9, mp 38.6; Rahway, Union Co.
13	Hwy	FIS	Edwards Road over Whippany River; Hanover T./Parsippany Hills T.
14	Hwy	DOT	US 46 WB at I-80; Parsippany-Troy Hills, Morris Co.
15	Hwy	FIS	Horsneck Road Bridge over Passaic R.; Fairfield T./ Montville T.
16	Hwy	DOT	NJ 23, mp 13.6 and 15.2; Butler T., Morris Co.
17	Hwy	FIS	Riverdale Rd. at Pequannock River; Riverdale T.
18	Hwy	FIS	Paterson-Hamburg Tpk. over Ramapo River; Pompton Lakes T.
19	Hwy	FIS	Pompton Tpk. over Pompton River in Pequannock T.
20	NJT	FIS	NJ Transit Boonton Line over Pompton River; Wayne T.
21	Hwy	FIS	US 202 over Pompton River; Lincoln Park
22	NJT	1984	NJ Transit Boonton Line over Pequannock River;
23	NJT	FIS	NJ Transit Boonton Line over Passaic River at Little Falls
24	Hwy	FIS	Totowa Road Bridge; W. Paterson/Totowa
25	Hwy	FIS	Arch St. Bridge in Paterson
26	NJT	FIS	NJ Transit Main Line over Passaic River at Paterson
27	Hwy	FIS	NJ 20/Lincoln Ave; Paterson/Hawthorne
28	Hwy	DOT	NJ 20, mp 3.3 along Passaic River in Paterson, Passaic Co.
29	Hwy	DOT	US 46, mp 62.5 to 62.8; Clifton, Passaic Co.
30	Hwy	DOT	I-80 WB, mp 63.9; vicinity of Saddle River in Lodi, Bergen Co
31	Hwy	DOT	NJ 17, mp 10.0; Lodi, Bergen Co.
32	Hwy	DOT	US 46, mp 66.5 over Saddle River in Lodi
33	Hwy	FIS	Wall St. Bridge in Passaic
34	Hwy	FIS	8th Street Bridge in over Passaic River
35	Hwy	DOT	I-80 EB, mp 67.1; vicinity of Hackensack River in Bogota Bor.
36	Hwy	DOT	NJ 93, mp 1.7 to 2.6; Leonia Bor., Bergen Co.
37	Hwy	DOT	I-95 SB, mp 74.1; Teaneck T., Bergen Co.
38	Hwy	DOT	NJ 4, mp 9.7: Englewood, Bergen Co.
39	Hwy	DOT	NJ 23 NB, mp 0.3; Verona Bor., Bergaen Co.
40	Hwy	FIS	NJ 21 mp 9.9 to 10.9, Clifton
41	Hwy	DOT	NJ 17, mp 4.93 & mp 5.2 to 5.8; East Rutherford
42	Hwy	DOT	NJ 120, mp 1.0; Carlstadt/E. Rutherford vicinity of Sports Complex
43	Hwy	DOT	NJ 21 NB, mp 4.5; City of Newark
44	Hwy	DOT	NJ 7, mp 3.1 to 3.6; Kearny
45	Hwy	DOT	I-280, mp 13.8 to 14.5; City of Newark
46	Hwy	DOT	I-78 EB, mp 56.2 to 57.0; City of Newark
47	Hwy	DOT	US 1/9 SB, mp 49.4; City of Newark
48	Hwy	DOT	US 1/9T, mp 1.45; Kearny vicinity of Hackensack River
49	Hwy	DOT	NJ 440, mp 22.1; Jersey City

21 HIGHWAY FLOOD PROBLEM LOCATION

22 NEW JERSEY TRANSIT FLOOD PROBLEM LOCATION

SOURCES

DOT = Locations Subject to Traffic Disruption from Flooding as reported by New Jersey Department of Transportation Construction & Maintenance Offices 1992.

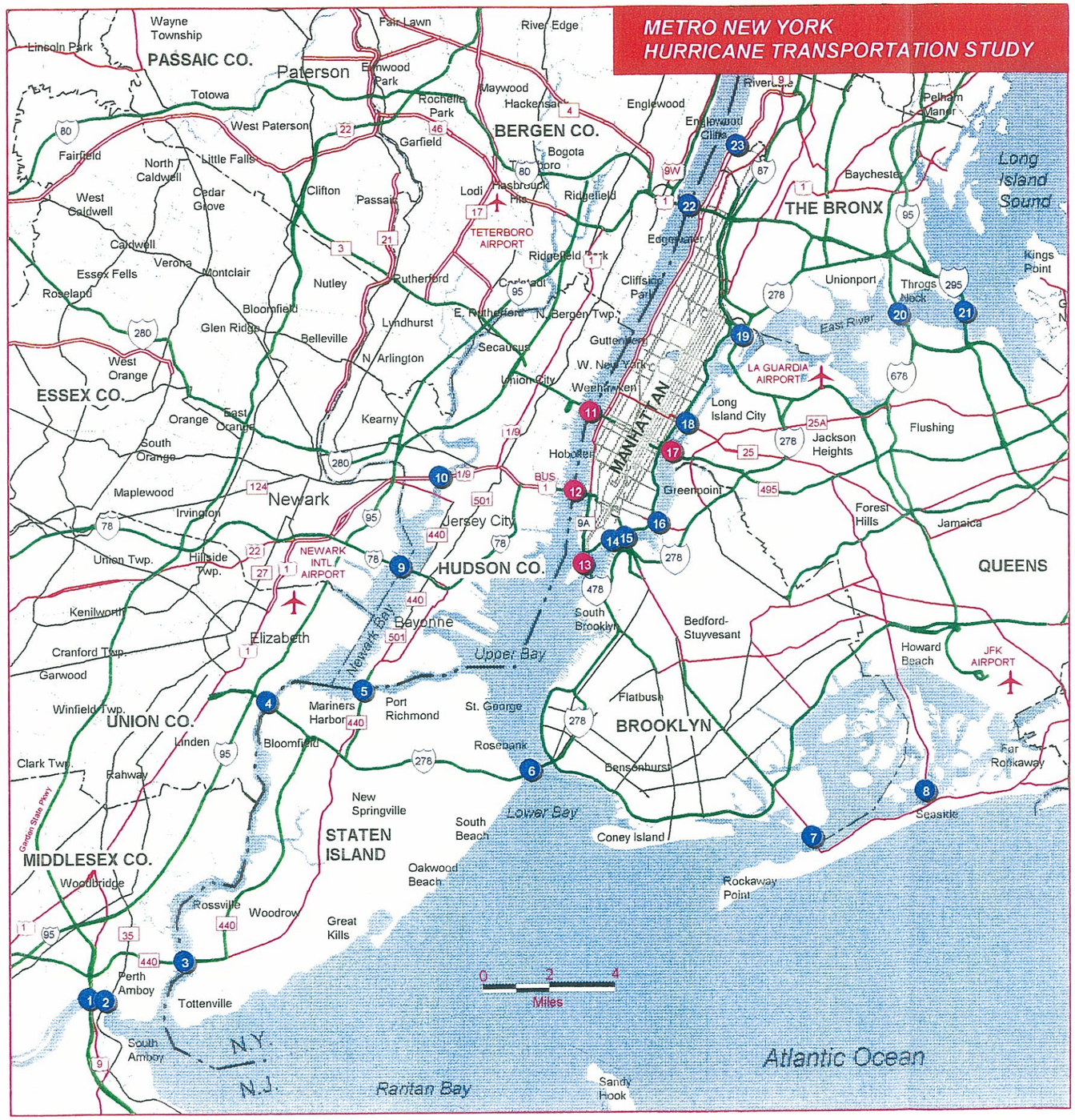
FIS = Locations Identified as Subject to Flooding by National Flood Insurance Program (NFIP) Flood Insurance Studies.

1984 = Track Problems Reported by New Jersey Transit - 1984 Passaic Basin Flooding.

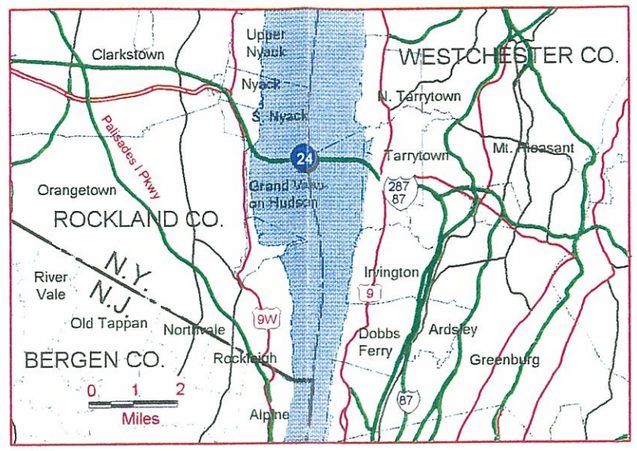
This figure shows selected highway and rail flood problem locations in and near the Passaic River Basin. See Appendices for additional locations.

PASSAIC BASIN REGION

RAIL AND HIGHWAY FLOOD PROBLEM LOCATIONS

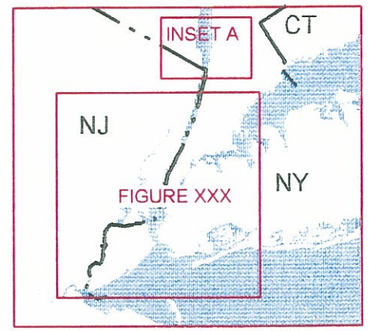


INSET A



BRIDGE OR TUNNEL

1	Garden State Parkway
2	Victory Bridge - NJ 35
3	Outerbridge Crossing
4	Goethals Bridge
5	Bayonne Bridge
6	Verrazano Bridge
7	Marine Parkway Bridge
8	Cross Bay Bridge
9	New Jersey Turnpike
10	Pulaski Skyway
11	Lincoln Tunnel
12	Holland Tunnel
13	Brooklyn Battery Tunnel
14	Brooklyn Bridge
15	Manhattan Bridge
16	Williamsburg Bridge
17	Queens-Midtown Bridge
18	Queensboro Bridge
19	Triborough Bridge
20	Bronx-Whitestone Bridge
21	Throgs Neck Bridge
22	George Washington Bridge
23	Henry Hudson Bridge
24	Tappan Zee Bridge



MAP LOCATOR

BRIDGE

TUNNEL

(SEE TABLE AT LEFT FOR BRIDGE/TUNNEL NAMES.)

INTERSTATE AND OTHER LIMITED ACCESS HIGHWAYS

MULTI-LANE, DIVIDED HIGHWAYS

FOUR LANE HIGHWAYS

OTHER PRINCIPAL ROADS

NEW YORK CITY AREA

HIGHWAY WATER CROSSINGS

BROOKLYN-BATTERY TUNNEL

CRITICAL ELEVATIONS (NGVD)

Brooklyn Plaza at Hamilton Avenue	11.6 ft.
Manhattan Plaza	12.6 ft.
Governor's Island Blower Bldg. Floor	12.6 ft.
Manhattan Blower Bldg. Floor	13.6 ft.
Brooklyn Blower Bldg. Floor	14.6 ft.

POTENTIAL HURRICANE SURGE

Category 1	10.5 ft.
Category 2	16.6 ft.
Category 3	19.3 ft.
Category 4	27.9 ft.

HOURS BEFORE EYE LANDFALL HAZARDS COULD OCCUR

	SURGE FLOODING*	SUSTAINED TROPICAL STORM WINDS*
Category 1	—	—
Category 2	at landfall	—
Category 3	0.8 hours	—
Category 4	1.1 hours	—

* Assumes 40 mph forward speed and hypothetical SLOSH model storm parameters regarding storm intensity and size

QUEENS MIDTOWN TUNNEL

CRITICAL ELEVATIONS (NGVD)

Queens Plaza at Borden Avenue	10.6 ft.
Queens Blower Bldg. Floor	12.6 ft.
Manhattan Plaza at 36th Street	14.6 ft.
Manhattan Blower Bldg. Floor	22.6 ft.

POTENTIAL HURRICANE SURGE

Category 1	9.6 ft.
Category 2	14.4 ft.
Category 3	21.0 ft.
Category 4	23.6 ft.

HOURS BEFORE EYE LANDFALL HAZARDS COULD OCCUR

	SURGE FLOODING*	SUSTAINED TROPICAL STORM WINDS*
Category 1	—	—
Category 2	0.3 hours	—
Category 3	1.0 hours	—
Category 4	1.2 hours	—

* Assumes 40 mph forward speed and hypothetical SLOSH model storm parameters regarding storm intensity and size

TRIBOROUGH BRIDGE

CRITICAL ELEVATIONS (NGVD)

Center Span	145.6 ft.
E. 125th/2nd Avenue Approach	15.0 ft.

POTENTIAL HURRICANE SURGE

Category 1	8.4 ft.
Category 2	12.7 ft.
Category 3	16.4 ft.
Category 4	20.4 ft.

HOURS BEFORE EYE LANDFALL HAZARDS COULD OCCUR

	SURGE FLOODING*	SUSTAINED TROPICAL STORM WINDS*
Category 1	—	3.0 hours
Category 2	—	5.0 hours
Category 3	0.3 hours	6.0 hours
Category 4	0.8 hours	7.0 hours

* Assumes 40 mph forward speed and hypothetical SLOSH model storm parameters regarding storm intensity and size

PATH TUNNELS

CRITICAL ELEVATIONS (NGVD)

Exchange Place Station	7.0 ft.
Morton Street Shaft	7.3 ft.
Hoboken Station	7.4 ft.
Washington Street Shaft	7.6 ft.
World Trade Center (Ramp D)	8.1 ft.
15th Street Shaft	9.6 ft.
Railroad Avenue Shaft	9.7 ft.
Grove Street Station	9.8 ft.
Pavonia Avenue	10.0 ft.
World Trade Center Concourse	12.6 ft.

POTENTIAL HURRICANE SURGE

Category 1	10.9 ft.
Category 2	17.7 ft.
Category 3	23.3 ft.
Category 4	28.2 ft.

TIME HAZARDS COULD OCCUR (HOURS BEFORE CLOSEST APPROACH OF EYE)

	SURGE FLOODING*	SUSTAINED TROPICAL STORM WINDS*
Category 1	0.3 hours	—
Category 2	1.2 hours	—
Category 3	1.7 hours	—
Category 4	2.0 hours	—

* Assumes 40 mph forward speed and hypothetical SLOSH model storm parameters regarding storm intensity and size

HOLLAND TUNNEL

CRITICAL ELEVATIONS (NGVD)

New Jersey Land Vent Shaft	7.6 ft.
New Jersey Top-of-Ramp	7.6 ft.
New York River Vent Shaft	8.6 ft.
New York Land Vent Shaft	8.6 ft.
New York Top-of-Ramp	9.5 ft.
New Jersey River Vent Shaft	10.6 ft.

POTENTIAL HURRICANE SURGE

Category 1	10.9 ft.
Category 2	17.7 ft.
Category 3	23.3 ft.
Category 4	28.2 ft.

TIME HAZARDS COULD OCCUR (HOURS BEFORE CLOSEST APPROACH OF EYE)

	SURGE FLOODING*	SUSTAINED TROPICAL STORM WINDS*
Category 1	0.2 hours	—
Category 2	1.0 hours	—
Category 3	1.6 hours	—
Category 4	1.9 hours	—

* Assumes 40 mph forward speed and hypothetical SLOSH model storm parameters regarding storm intensity and size

PASSENGER SHIP TERMINAL

CRITICAL ELEVATIONS (NGVD)

Facility Low Point	8.9 ft.

POTENTIAL HURRICANE SURGE

Category 1	7.4 ft.
Category 2	17.5 ft.
Category 3	22.6 ft.
Category 4	28.9 ft.

TIME HAZARDS COULD OCCUR (HOURS BEFORE CLOSEST APPROACH OF EYE)

	SURGE FLOODING*	SUSTAINED TROPICAL STORM WINDS*
Category 1	—	2.0 hours
Category 2	0.8 hours	3.0 hours
Category 3	1.3 hours	3.5 hours
Category 4	1.5 hours	4.5 hours

* Assumes 40 mph forward speed and hypothetical SLOSH model storm parameters regarding storm intensity and size.

JOHN F. KENNEDY INTERNATIONAL AIRPORT

CRITICAL ELEVATIONS (NGVD)

Lowest Point on Runway	11.7 ft.

POTENTIAL HURRICANE SURGE

Category 1	6.6 ft.
Category 2	15.6 ft.
Category 3	24.5 ft.
Category 4	31.2 ft.

TIME HAZARDS COULD OCCUR (HOURS BEFORE CLOSEST APPROACH OF EYE)

	SURGE FLOODING*	SUSTAINED TROPICAL STORM WINDS*
Category 1	—	2.0 hours
Category 2	0.3 hours	3.0 hours
Category 3	0.8 hours	3.5 hours
Category 4	1.2 hours	4.5 hours

* Assumes 40 mph forward speed and hypothetical SLOSH model storm parameters regarding storm intensity and size.

LAGUARDIA AIRPORT

CRITICAL ELEVATIONS (NGVD)

Lowest Point on Runway	6.8 ft

POTENTIAL HURRICANE SURGE

Category 1	6.4 ft.
Category 2	11.2 ft.
Category 3	15.7 ft.
Category 4	20.8 ft.

TIME HAZARDS COULD OCCUR (HOURS BEFORE CLOSEST APPROACH OF EYE)

	SURGE FLOODING*	SUSTAINED TROPICAL STORM WINDS*
Category 1	—	2.0 hours
Category 2	0.5 hours	3.0 hours
Category 3	1.3 hours	3.5 hours
Category 4	2.0 hours	4.5 hours

* Assumes 40 mph forward speed and hypothetical SLOSH model storm parameters regarding storm intensity and size

NEWARK INTERNATIONAL AIRPORT

CRITICAL ELEVATIONS (NGVD)

Lowest Point on Runway	10.3 ft

POTENTIAL HURRICANE SURGE

Category 1	8.4 ft.
Category 2	10.3 ft.
Category 3	13.6 ft.
Category 4	17.2 ft.

TIME HAZARDS COULD OCCUR (HOURS BEFORE CLOSEST APPROACH OF EYE)

	SURGE FLOODING*	SUSTAINED TROPICAL STORM WINDS*
Category 1	—	2.0 hours
Category 2	@ peak	3.0 hours
Category 3	0.3 hours	3.5 hours
Category 4	0.5 hours	4.5 hours

* Assumes 40 mph forward speed and hypothetical SLOSH model storm parameters regarding storm intensity and size

U.S. HIGHWAY 1 AND 9

Critical Locations

Mileage 2.1 in Hudson County at Jersey City near Communitarian Avenue — 2.0 feet

Potential Hurricane Surge (above NGVD)

Category 1	9.8 feet
Category 2	11.9 feet
Category 3	14.6 feet
Category 4	17.2 feet

NEW JERSEY ROUTE 7

Critical Locations

Milepost 2.2 in Hudson County at Kearney under Turnpike Eastern Alignment — 5.3 feet

Milepost 3.65 in Hudson County at Kearney over Saw Mill Creek — 6.0 feet

Potential Hurricane Surge (above NGVD)

Category 1	-
Category 2	9.9 feet
Category 3	10.4 feet
Category 4	15.1 feet

NEW JERSEY ROUTE 17

Critical Locations

Milepost 4.95 in Bergen County at East Rutherford Borough — 3.9 feet

Milepost 8.2 in Bergen County at Hasbrouck Heights South of Williams Ave. — 8.0 feet

Potential Hurricane Surge (above NGVD)

Category 1	8.2 feet
Category 2	9.1 feet
Category 3	10.2 feet
Category 4	13.9 feet

NEW JERSEY ROUTE 3

Critical Locations

Milepost 9.25 in Hudson County at Secaucus — 8.0 feet

Potential Hurricane Surge (above NGVD)

Category 1	11.7 feet
Category 2	13.3 feet
Category 3	16.7 feet
Category 4	21.9 feet

NEW JERSEY ROUTE 169

Critical Locations

Milepost 2.15 in Hudson County at Bayonne at East 21st. Street — 10.1 feet

Potential Hurricane Surge (above NGVD)

Category 1	11.7 feet
Category 2	13.3 feet
Category 3	16.7 feet
Category 4	21.9 feet

INTERSTATE 95

Critical Locations

Milepost 74.8 at Teaneck Township in Bergen County at Overpeck Creek — 5.8 feet

Milepost 74.15 at Teaneck Township in Bergen County under Port Lee/ Degraw Avenue Overpass — 6.9 feet

Milepost 73.2 at Ridgefield Park Township in Bergen County South or Teaneck Twp. line — 9.3 feet

Potential Hurricane Surge (above NGVD)

Category 1	8.2 feet
Category 2	9.1 feet
Category 3	10.2 feet
Category 4	13.9 feet

WORLD TRADE CENTER

Critical Locations

Entrance Ramp D-West Street	8.1 feet
World Trade Center Concourse	12.6 feet

Potential Hurricane Surge (above NGVD)

Category 1	10.6 feet
Category 2	16.4 feet
Category 3	24.3 feet
Category 4	28.6 feet

Time Hazards Could Occur (hours before closest approach of eye)

	Surge Flooding *
Category 1	0.3 hours
Category 2	0.9 hours
Category 3	1.4 hours
Category 4	1.8 hours

* assumes 40 mph forward speed and hypothetical SLOSH model storm parameters regarding storm intensity and size

CRANBERRY STREET TUNNEL (A& C Lines)

Critical Locations

Front Street at Fulton Street Fan Plant	7.0 feet
Furman Street at Cranberry Street Fan Plant	12.8 feet

Potential Hurricane Surge (above NGVD)

Category 1	10.2 feet
Category 2	16.0 feet
Category 3	25.1 feet
Category 4	31.3 feet

Time Hazards Could Occur (hours before closest approach of eye)

	Surge Flooding *
Category 1	0.3 hours
Category 2	1.1 hours
Category 3	1.7 hours
Category 4	2.0 hours

* assumes 40 mph forward speed and hypothetical SLOSH model storm parameters regarding storm intensity and size

PENN STATION - NORTH (HUDSON) RIVER TUNNEL

Critical Locations

West Side Storage Yard Berm	10.0 feet
Weehawken Shaft	12.3 feet

Potential Hurricane Surge (above NGVD)

Category 1	7.5 feet
Category 2	17.2 feet
Category 3	20.5 feet
Category 4	30.8 feet

Time Hazards Could Occur (hours before closest approach of eye)

	Surge Flooding *
Category 1	–
Category 2	0.5 hours
Category 3	1.0 hours
Category 4	1.2 hours

* assumes 40 mph forward speed and hypothetical SLOSH model storm parameters regarding storm intensity and size