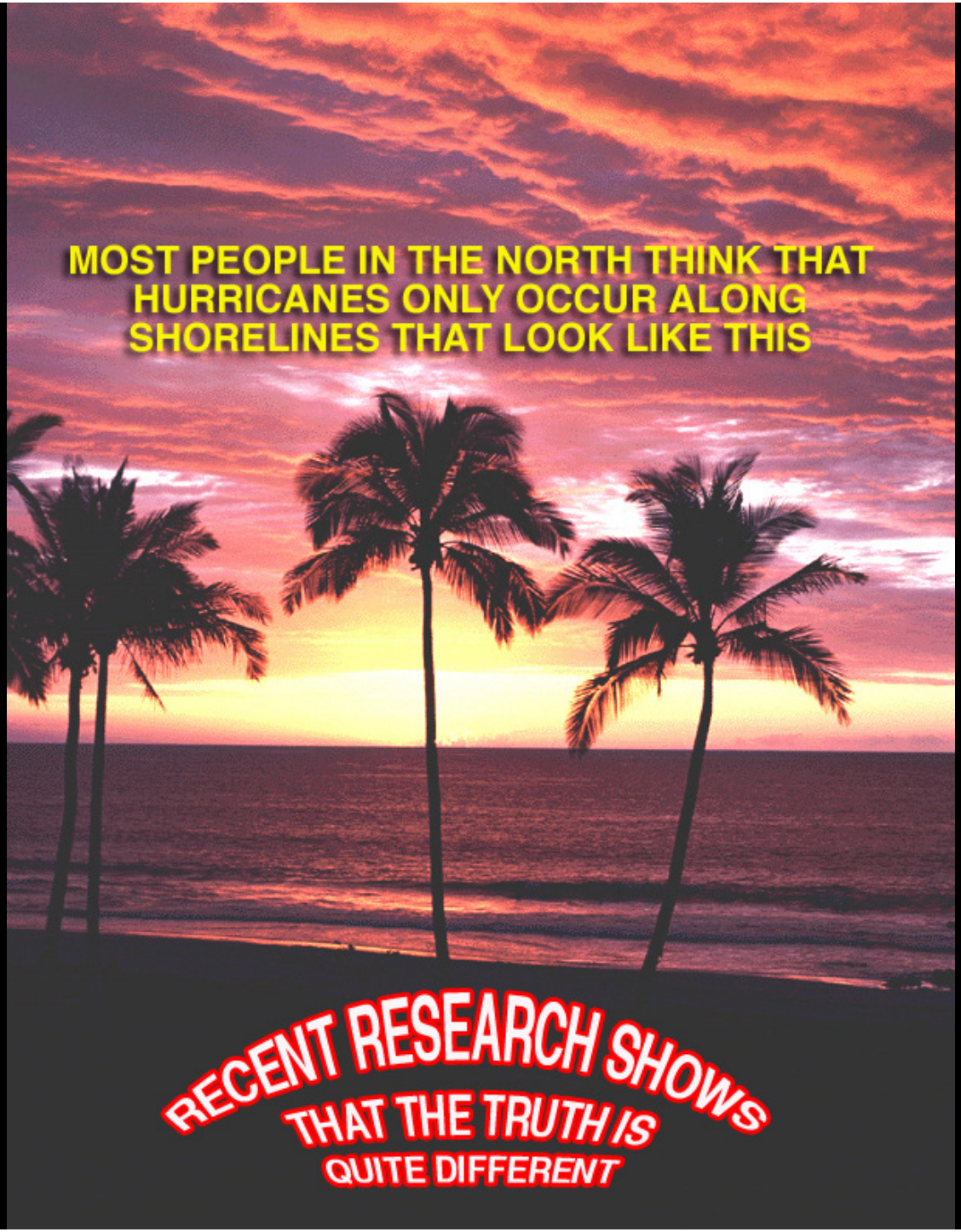
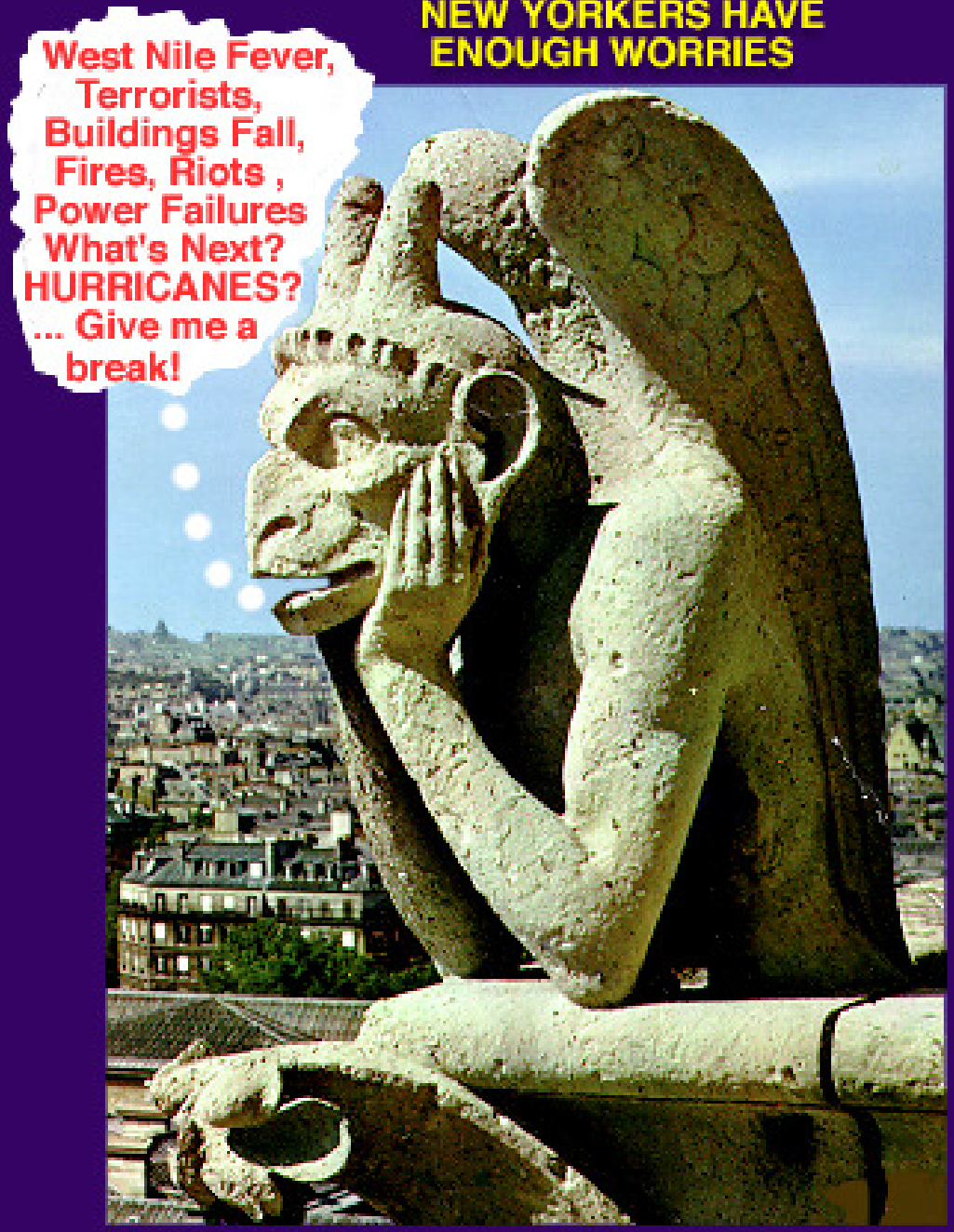
THE UNIQUE VULNERABIITY OF THE N.Y. - N.J. METROPOLITAN REGION TO HURRICANE DAMAGE

-A HISTORICAL & OCEANOGRAPHIC PERSPECTIVE BASED ON RECENT RESEARCH AND RE-INTERPRETATION OF HISTORICAL DATA-

Nicholas K. Coch
School of Earth & Envir Sci
Queens College, CUNY

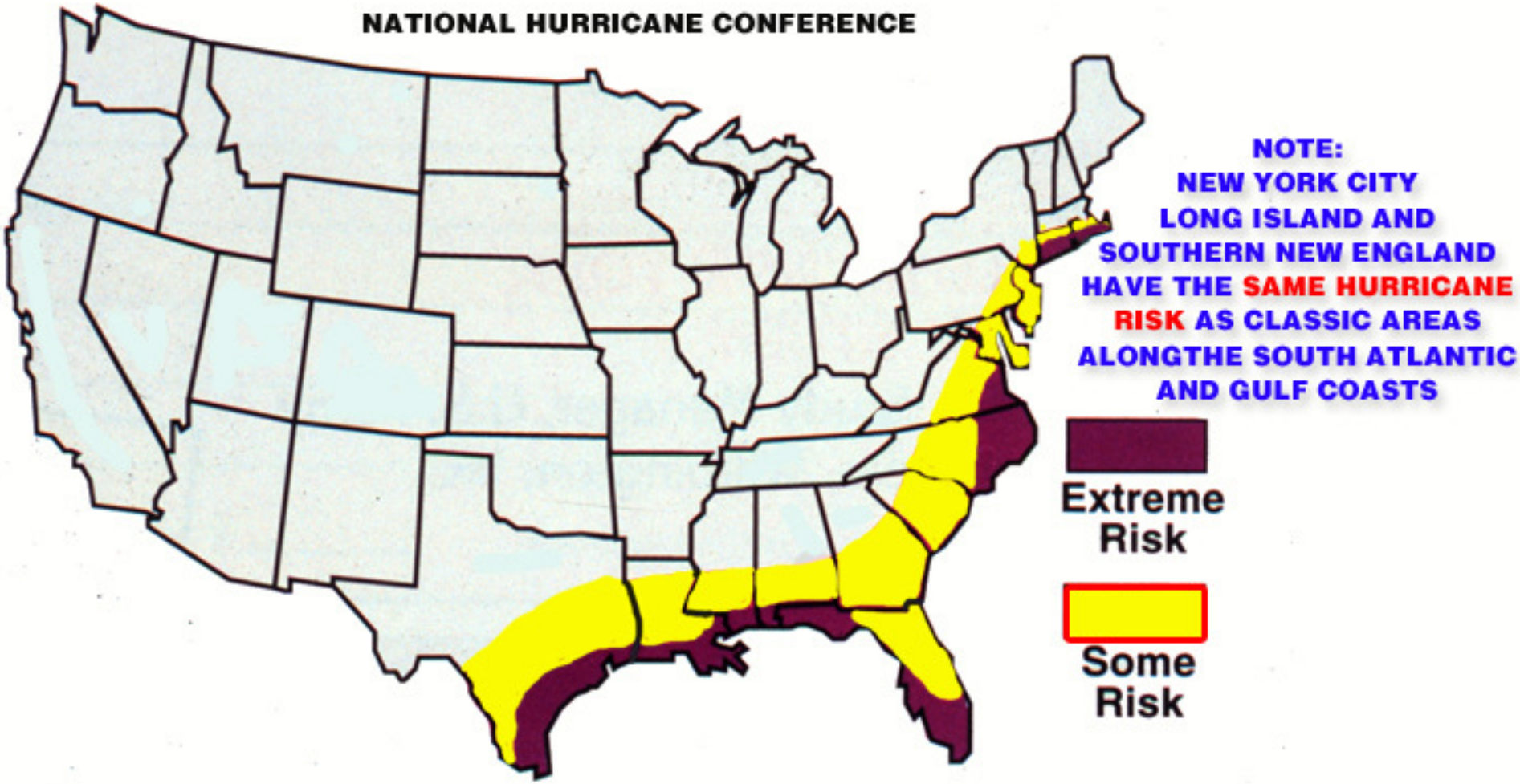

MOST PEOPLE IN THE NORTH THINK THAT
HURRICANES ONLY OCCUR ALONG
SHORELINES THAT LOOK LIKE THIS
RECENT RESEARCH SHOWS
THAT THE TRUTH IS
QUITE DIFFERENT

NEW YORKERS HAVE ENOUGH WORRIES



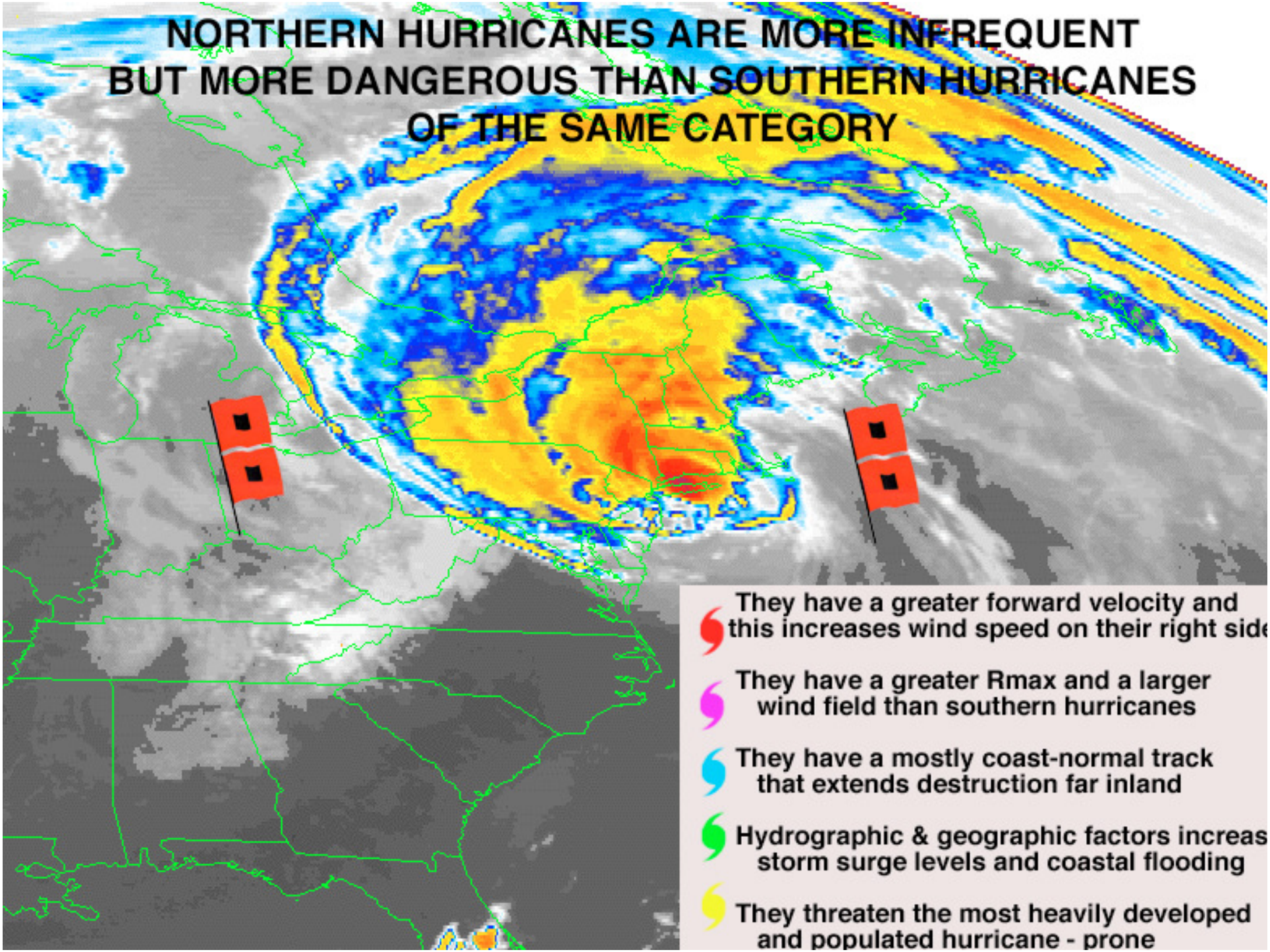
HURRICANE RISK PROFILE

Based on data from 1900 to 1992



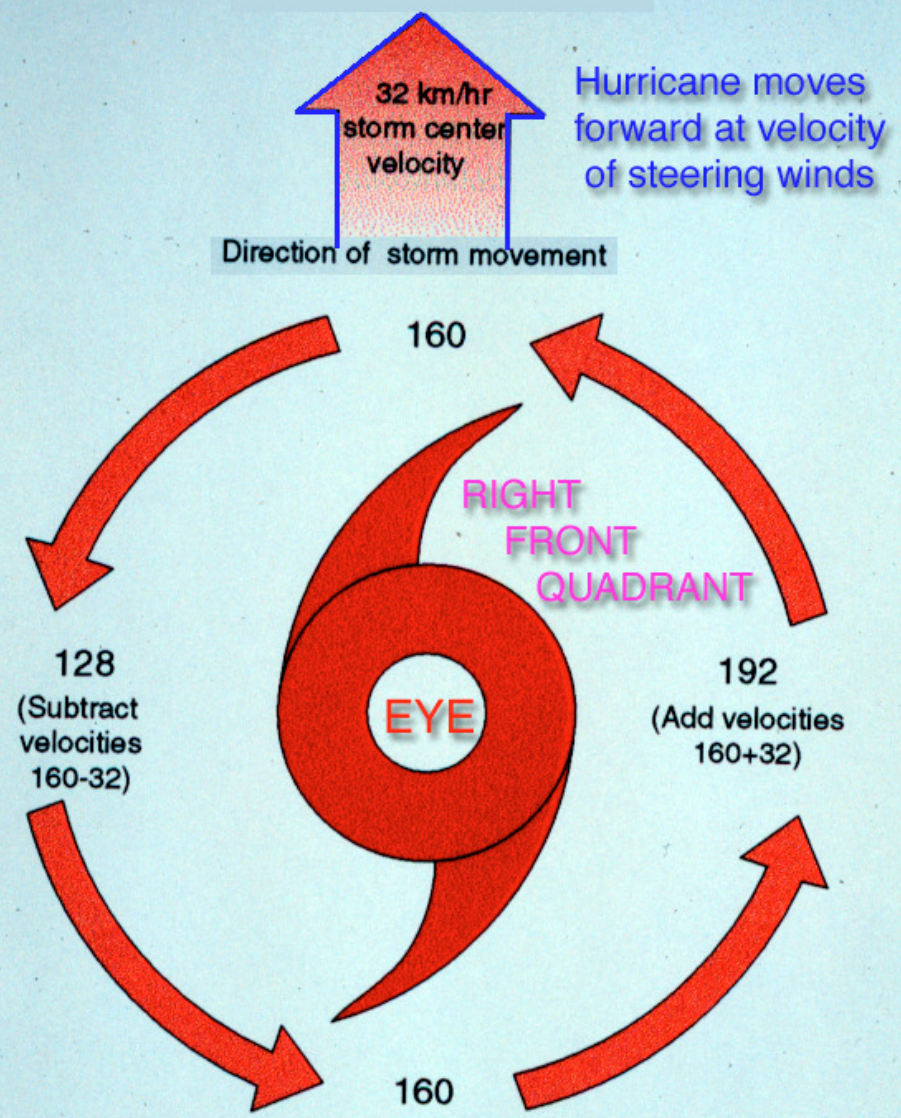
NEW YORK CITY HAS A HURRICANE HISTORY

NORTHERN HURRICANES ARE MORE INFREQUENT BUT MORE DANGEROUS THAN SOUTHERN HURRICANES OF THE SAME CATEGORY



- They have a greater forward velocity and this increases wind speed on their right side
- They have a greater Rmax and a larger wind field than southern hurricanes
- They have a mostly coast-normal track that extends destruction far inland
- Hydrographic & geographic factors increas storm surge levels and coastal flooding
- They threaten the most heavily developed and populated hurricane - prone

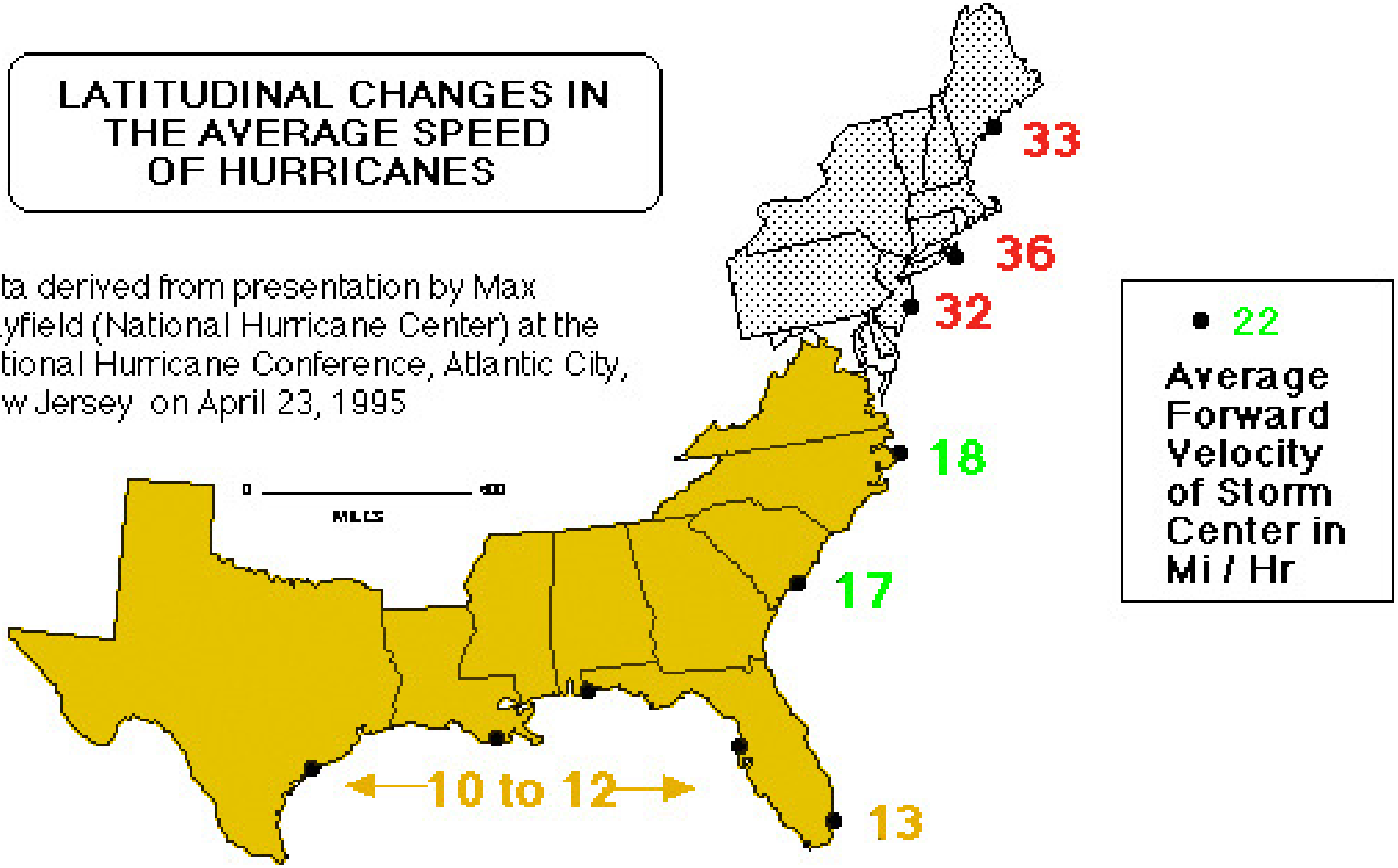
VELOCITY RELATIONSHIPS IN HURRICANES

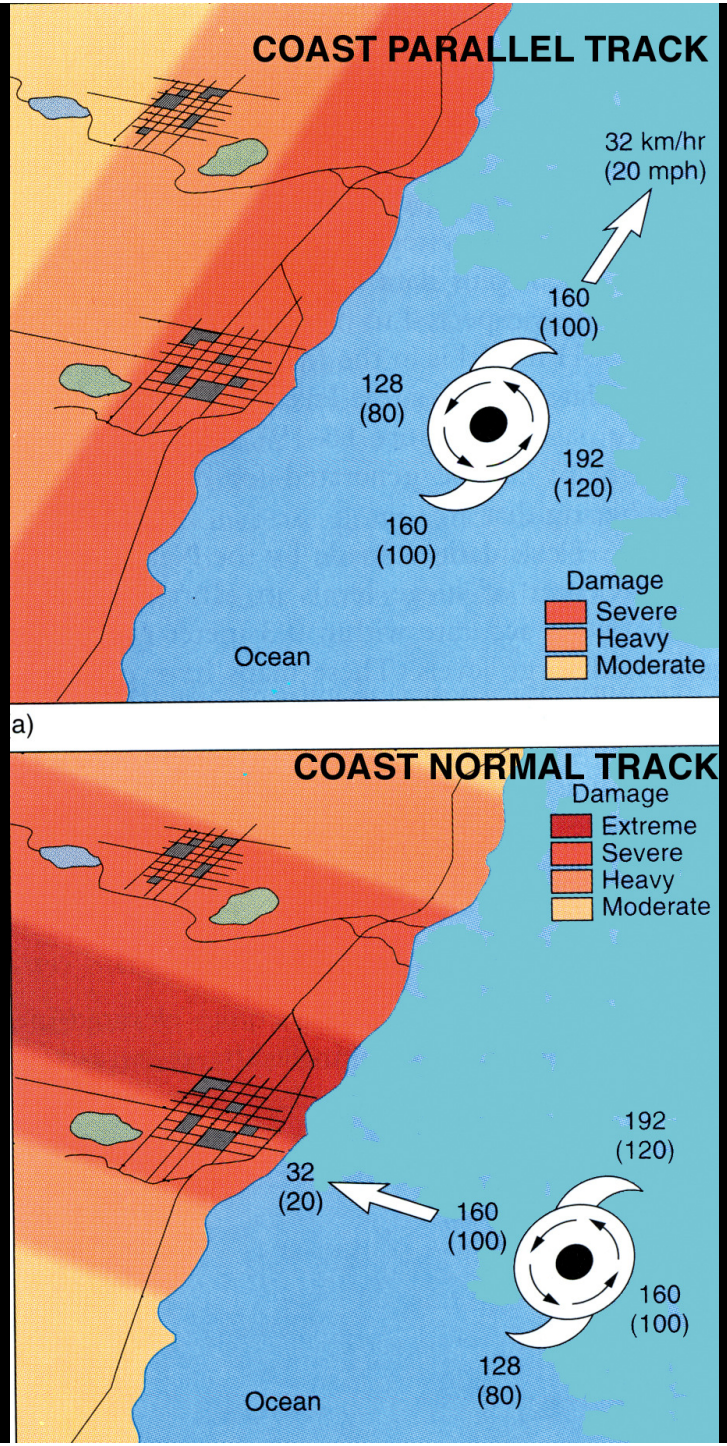


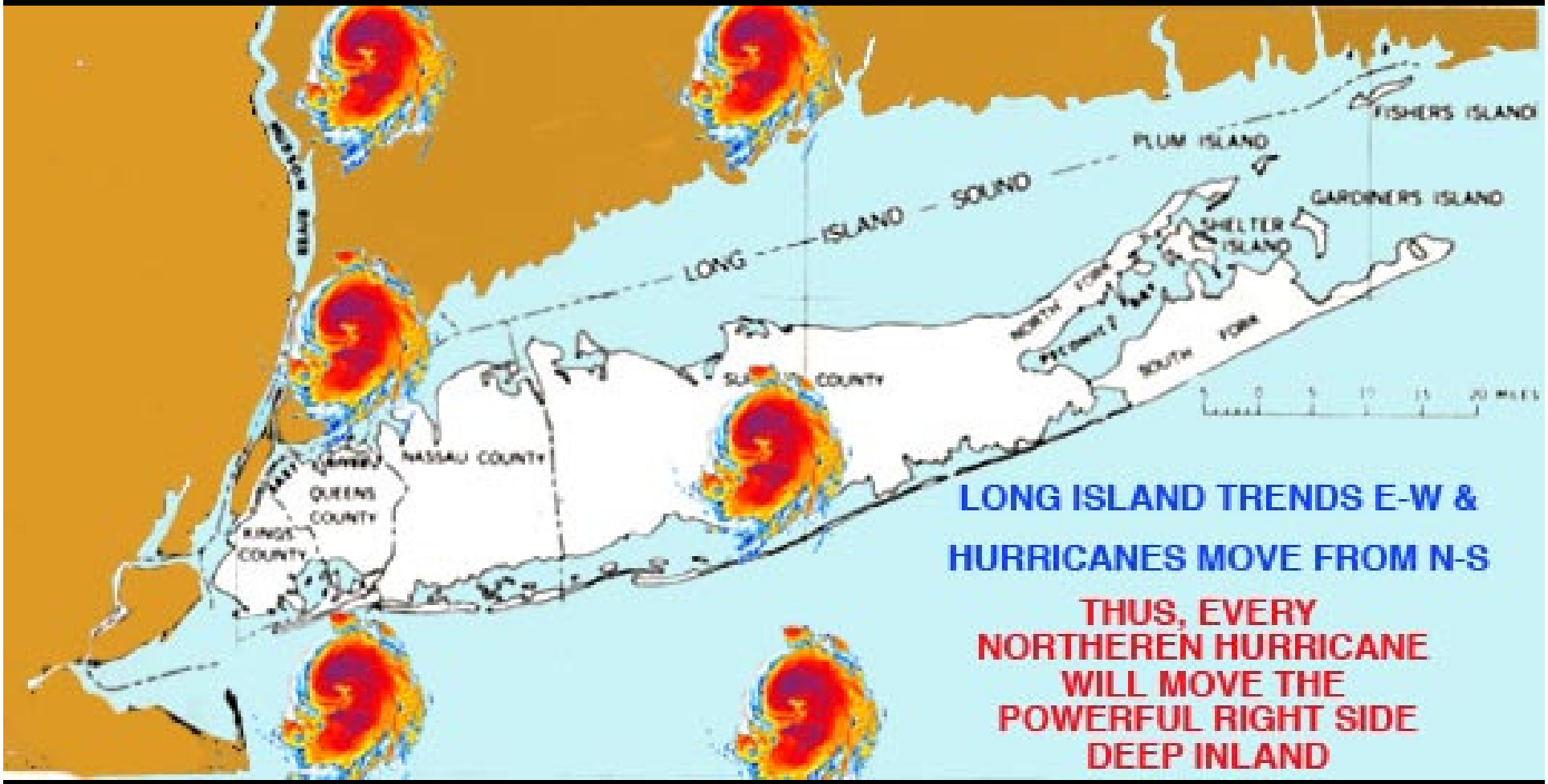
Vortex winds flow counterclockwise around the eye

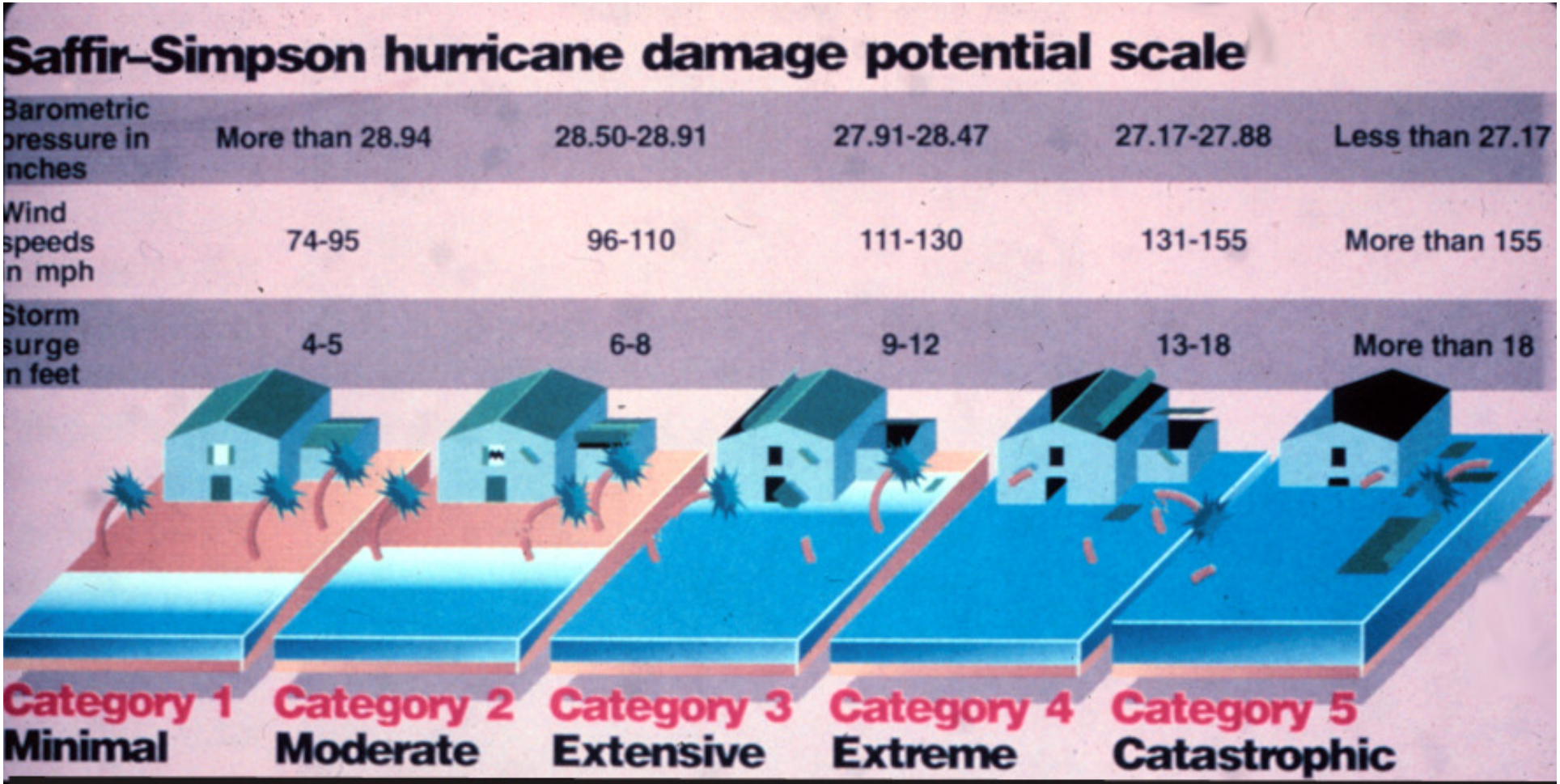
LATITUDINAL CHANGES IN THE AVERAGE SPEED OF HURRICANES

Data derived from presentation by Max Mayfield (National Hurricane Center) at the National Hurricane Conference, Atlantic City, New Jersey on April 23, 1995




COAST PARALLEL TRACK
32 km/hr
(20 mph)
160
(100)
128
(80)
192
(120)
160
(100)
Damage
Severe
Heavy
Moderate
Ocean
a)
COAST NORMAL TRACK
Damage
Extreme
Severe
Heavy
Moderate
192
(120)
32
(20)
160
(100)
160
(100)
128
(80)
Ocean


FISHERS ISLAND
PLUM ISLAND
GARDINERS ISLAND
SHELTER ISLAND
LONG ISLAND SOUND
NORTH FORK
SOUTH FORK
COUNTY
NASSAU COUNTY
QUEENS COUNTY
KINGS COUNTY
LONG ISLAND TRENDS E-W &
HURRICANES MOVE FROM N-S
THUS, EVERY
NORTHEREN HURRICANE
WILL MOVE THE
POWERFUL RIGHT SIDE
DEEP INLAND



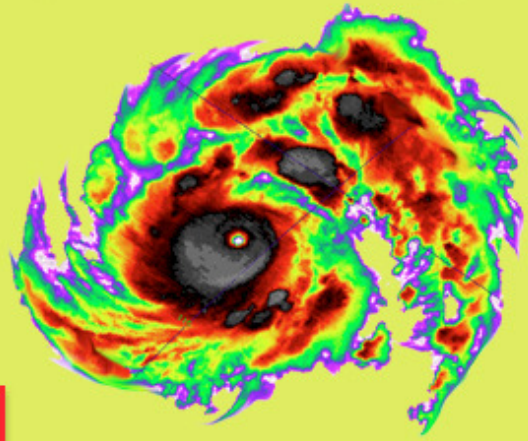
MANY PEOPLE RELY ON THIS AS AN ***ABSOLUTE*** PREDICTOR OF HURRICANE DAMAGE. HOWEVER, A NUMBER OF OTHER FACTORS DETERMINE THE ***ACTUAL*** DESTRUCTION THAT WILL RESULT FROM A HURRICANE

FACTORS DETERMINING HURRICANE DESTRUCTION

PROGRESSION
(Forward Velocity)

PERIMETER
(Rmax, Wind field)

POWER
(Category)



POSITION
(Tidal level)

PLACE
(Relative to eye track)

PRECIPITATION
(Prior to, & during landfall)

PATH
(Coast parallel or normal)

POPULATION
(People + Structures)

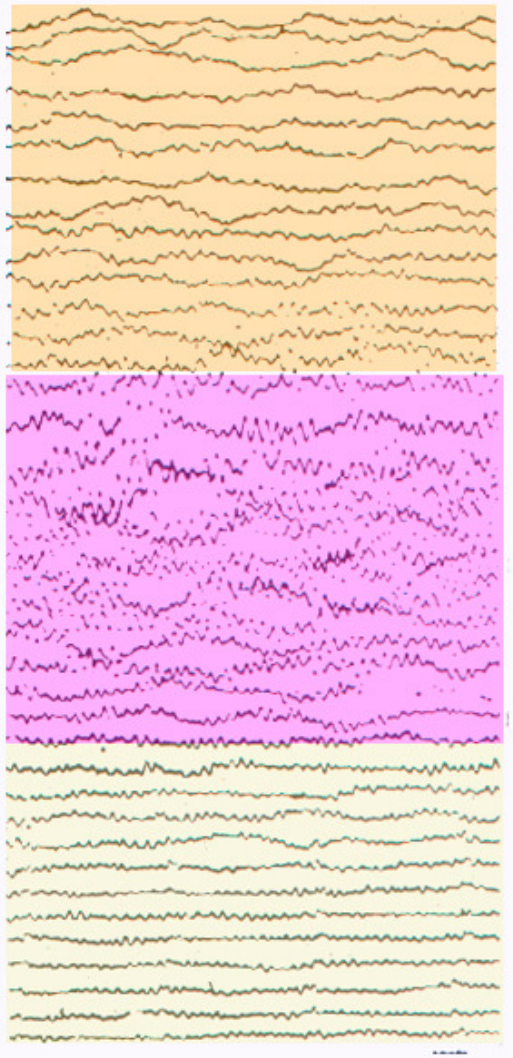
PERCEPTION
(Of the hazards)

PREPARATION
(Evacuation & Mitigation)

DON'T BE A SAFFIR - SIMPSON SUCKER !

CATEGORY IS ONLY ONE OF MANY FACTORS THAT DETERMINE THE DEGREE OF HURRICANE DAMAGE

THE WAVES OF THE 1938 HURRICANE WERE SO HIGH THAT THE IMPACTS WERE RECORDED ON THE SEISMOGRAPH AT FORDHAM UNIVERSITY IN NEW YORK CITY



SWELLS FROM APPROACHING STORM. GALE TO HURRICANE-FORCE WINDS

(7.5 HOURS RECORD)

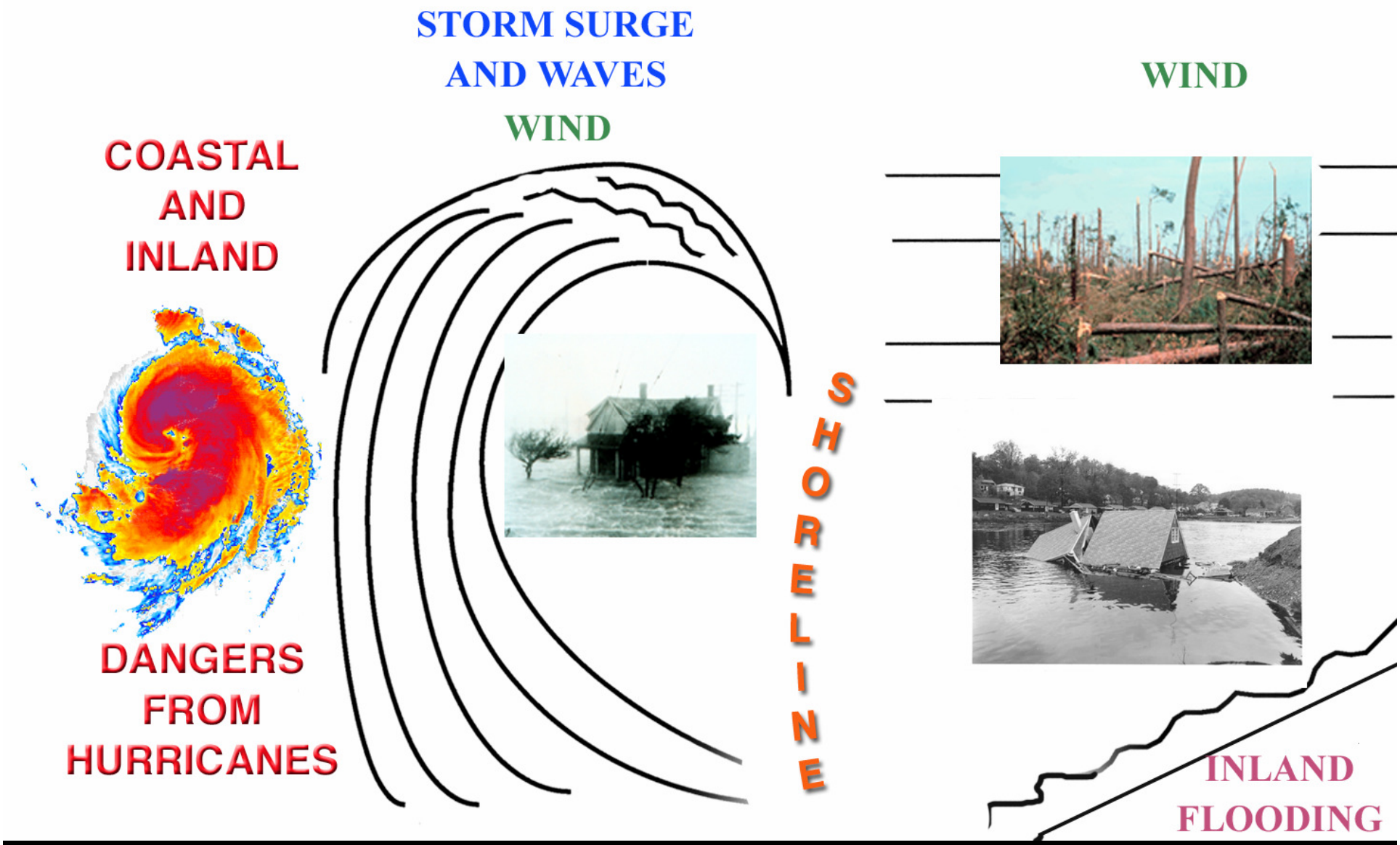
CATEGORY 3 FORCE HURRICANE WINDS ASSOCIATED WITH PASSAGE OF FRONT AND REAR EYEWALLS OF HURRICANE

(7 HOURS RECORD)

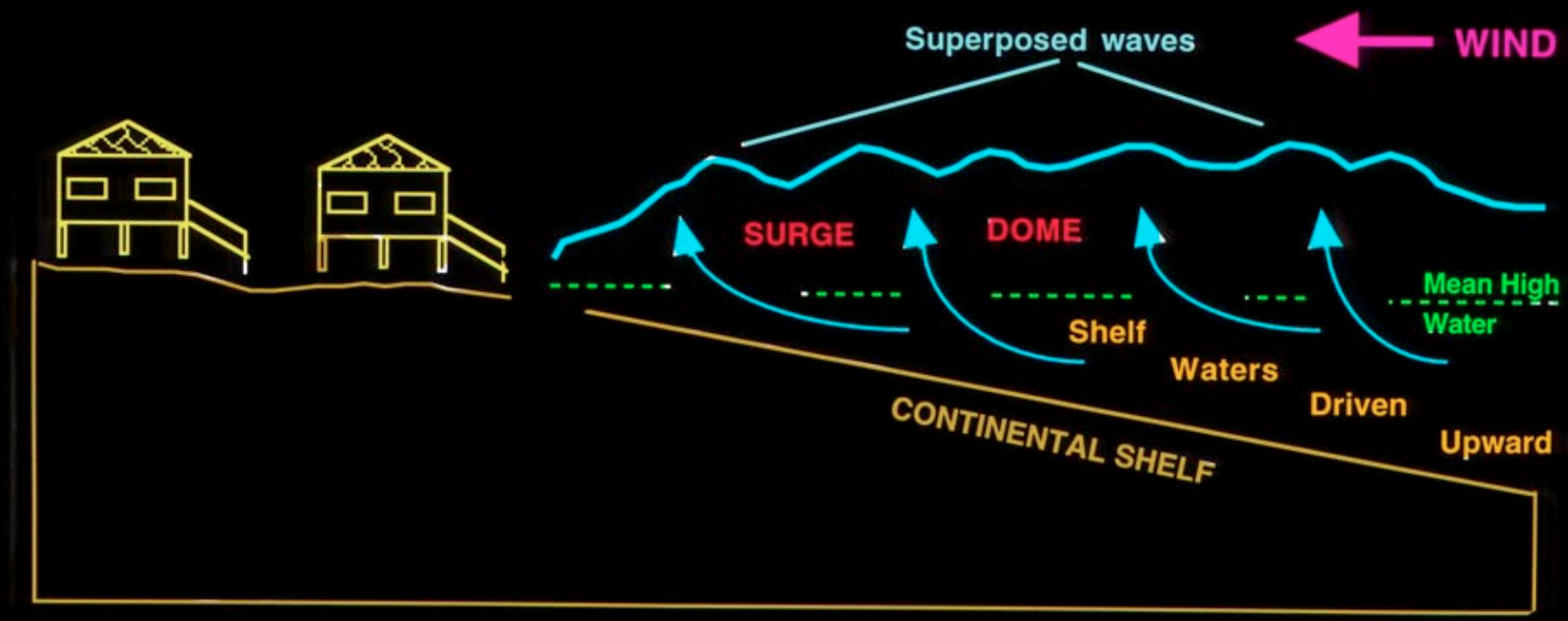
SEAS SUBSIDE AS HURRICANE MOVES INTO NEW ENGLAND

(6 HOURS RECORD)

Data From
Fordham University

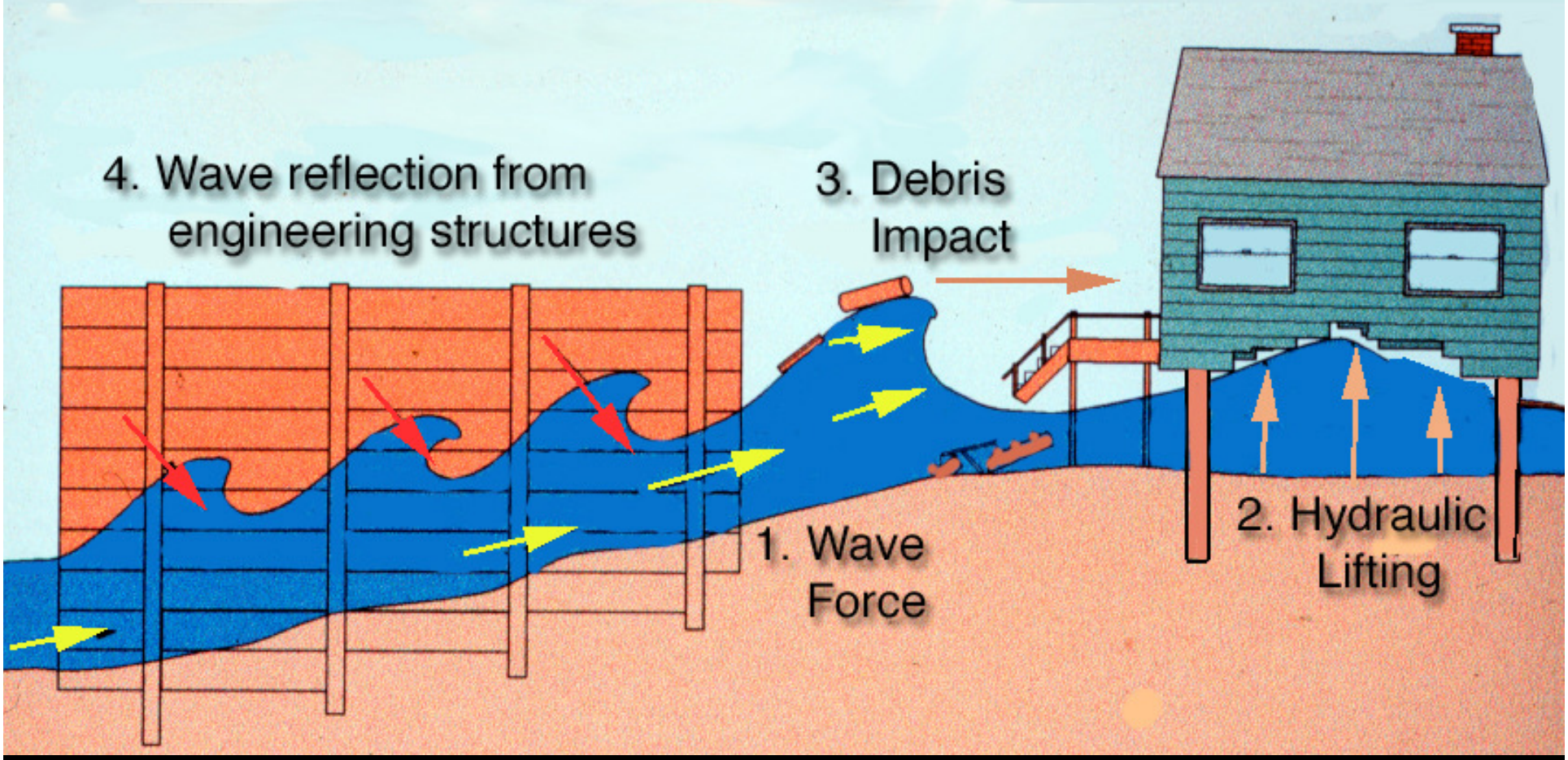

STORM SURGE
AND WAVES
WIND
WIND
COASTAL
AND
INLAND
DANGERS
FROM
HURRICANES
SHORELINE
INLAND
FLOODING

ORIGIN OF STORM SURGE

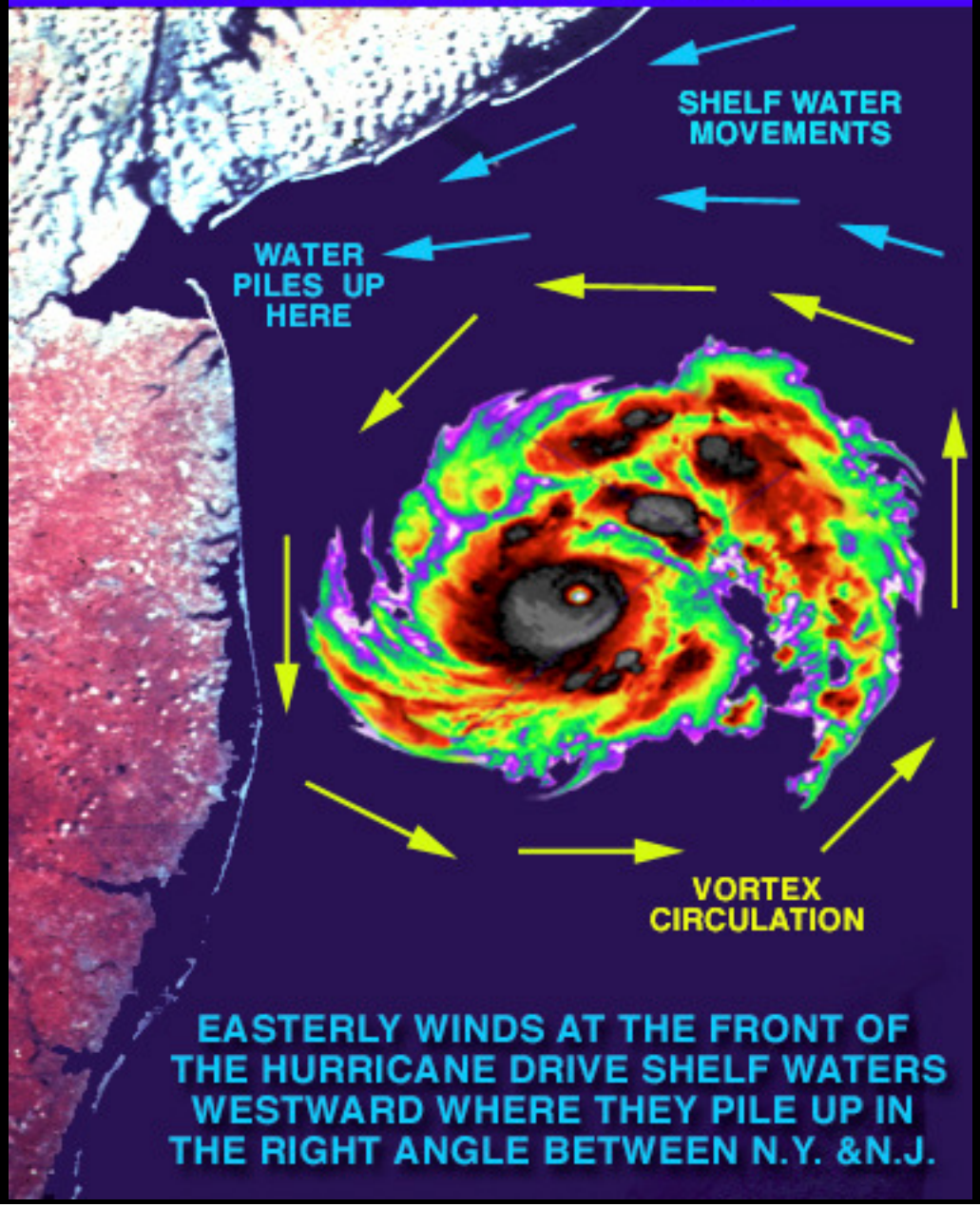


ONSHORE WINDS DRIVE CONTINENTAL SHELF WATERS LANDWARD FORCING THEM UP INTO A BROAD DOME. WINDS RAISE WAVES ON THE DOME, INCREASING WATER LEVELS

STRUCTURES AT THE SHORE ARE FULLY EXPOSED TO WIND AND ARE SUBJECT TO A VARIETY OF WATER DAMAGE

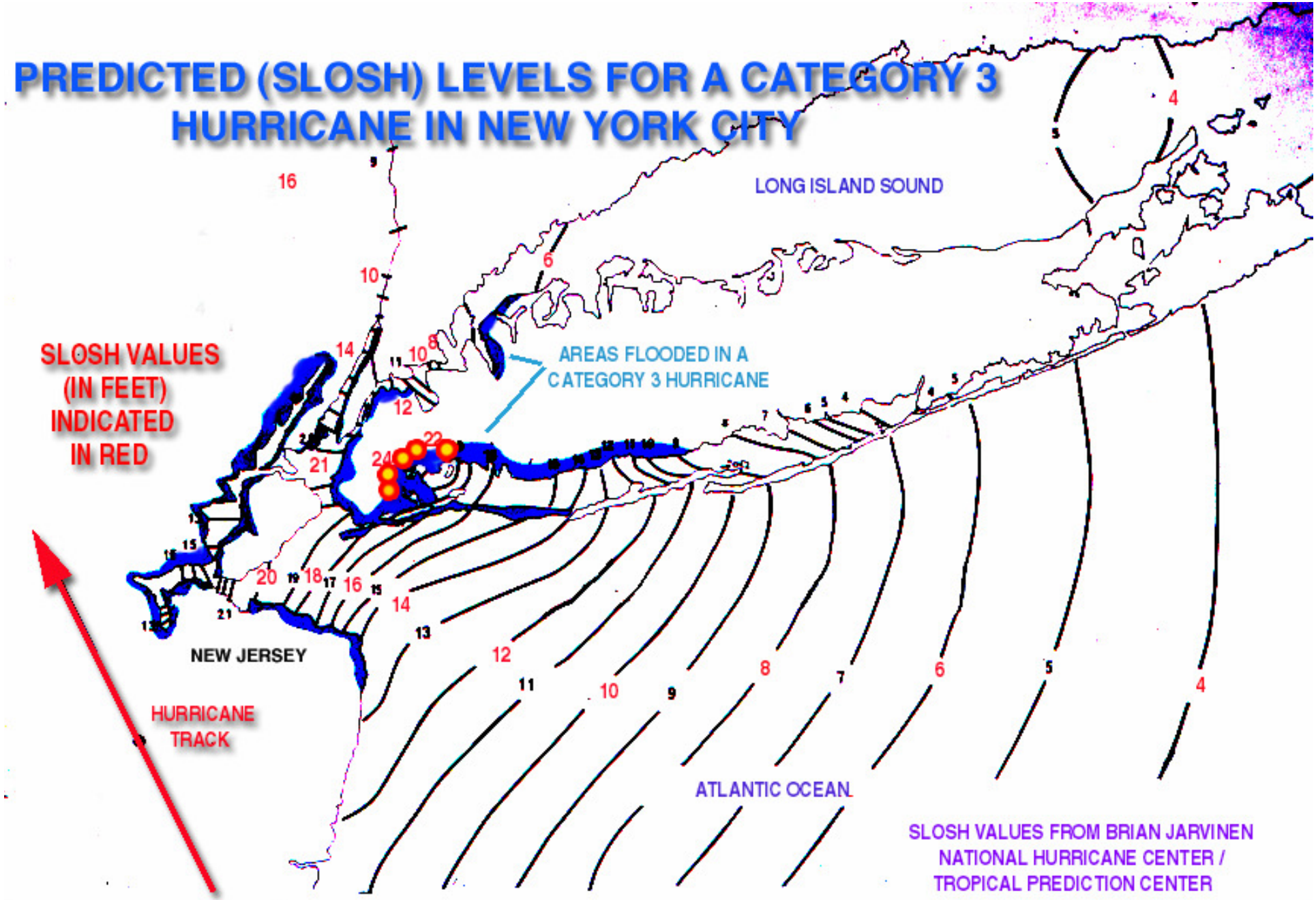


ORIGIN OF AMPLIFICATION OF STORM SURGE & WAVE HEIGHTS IN THE N.Y.BIGHT APEX



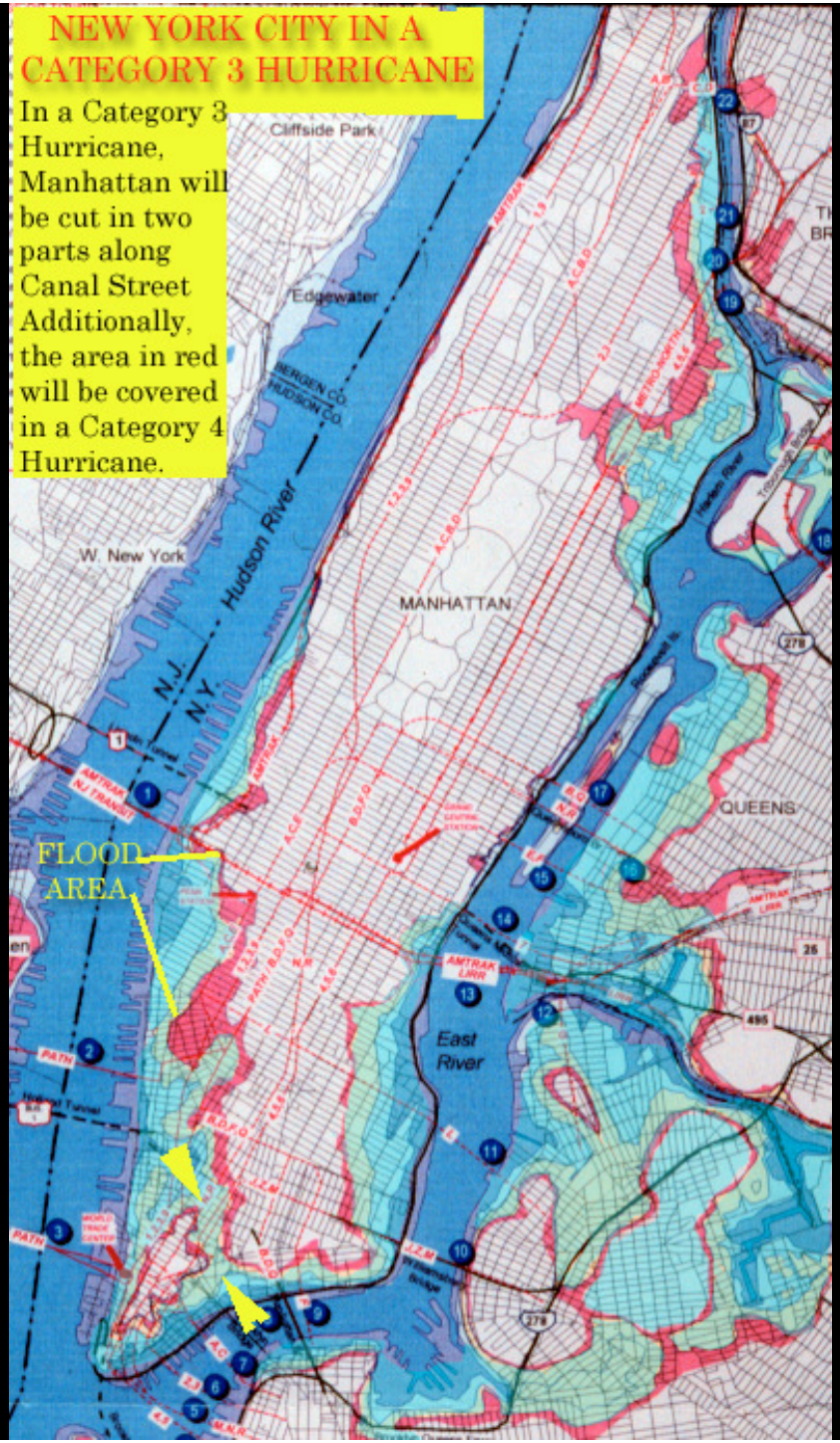
EASTERLY WINDS AT THE FRONT OF THE HURRICANE DRIVE SHELF WATERS WESTWARD WHERE THEY PILE UP IN THE RIGHT ANGLE BETWEEN N.Y. &N.J.

PREDICTED (SLOSH) LEVELS FOR A CATEGORY 3 HURRICANE IN NEW YORK CITY



NEW YORK CITY IN A CATEGORY 3 HURRICANE

In a Category 3 Hurricane, Manhattan will be cut in two parts along Canal Street Additionally, the area in red will be covered in a Category 4 Hurricane.



CHOKE POINTS STOP EVACUATION WHERE ELEVATED ROAD SECTIONS DROP IN ELEVATION BELOW HURRICANE STORM SURGE LEVELS

FACILITIES IN COASTAL CITIES ARE HIGHLY VULNERABLE TO HURRICANE STORM SURGE

"All the News That's Fit to Print"

The New York Times

Late Edition
New York: **Today**, sticky with lingering showers, high 83. **Tonight**, clearing, low 73. **Tomorrow**, sunny and very warm, high 89. **Yesterday**, high 76, low 69. Weather map, page B9.

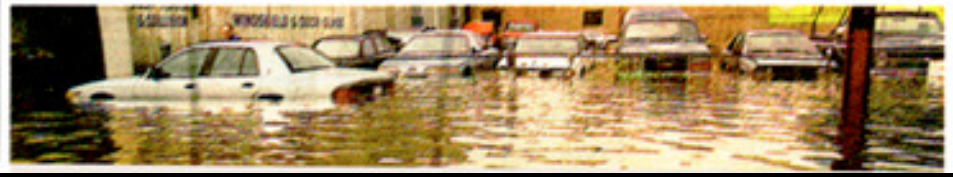
VOL. CXLVIII . . . No. 51,627 Copyright © 1999 The New York Times NEW YORK, FRIDAY, AUGUST 27, 1999 $1 beyond the greater New York metropolitan area. 60 CENTS

IF THREE INCHES OF RAIN IN TWO HOURS CRIPPLED NEW YORK CITY ON AUGUST 26, 1999 THEN . . .

WHAT WOULD HAPPEN IF WE WERE HIT BY A MAJOR HURRICANE?

Surprise Deluge Cripples Morning Rush in New York

Jim Wilson/The New York Times



Rains Submerge Highways and Halt Trains

EFFECTS OF HURRICANE STORM SURGE ON POWER AND COMMUNICATIONS IN NEW YORK CITY

THE NEW YORK TIMES **METRO** FRIDAY, JANUARY 12, 2001

Wires Corroded by Rock Salt Cause Explosion in Manhole

By SUSAN SAULNY

As temperatures rose into the mid-40's yesterday, the last remnants of the blizzard of 2000 seemed to melt into history.

bution engineer, added that this snowstorm followed a general trend relating to salt damage.

"Not immediately, but when there's a thaw, that runoff, the melt-

WHAT WILL HAPPEN WHEN SALT WATER FILLS ALL THE CONDUITS FOR HOURS, OR DAYS, AFTER A HURRICANE?

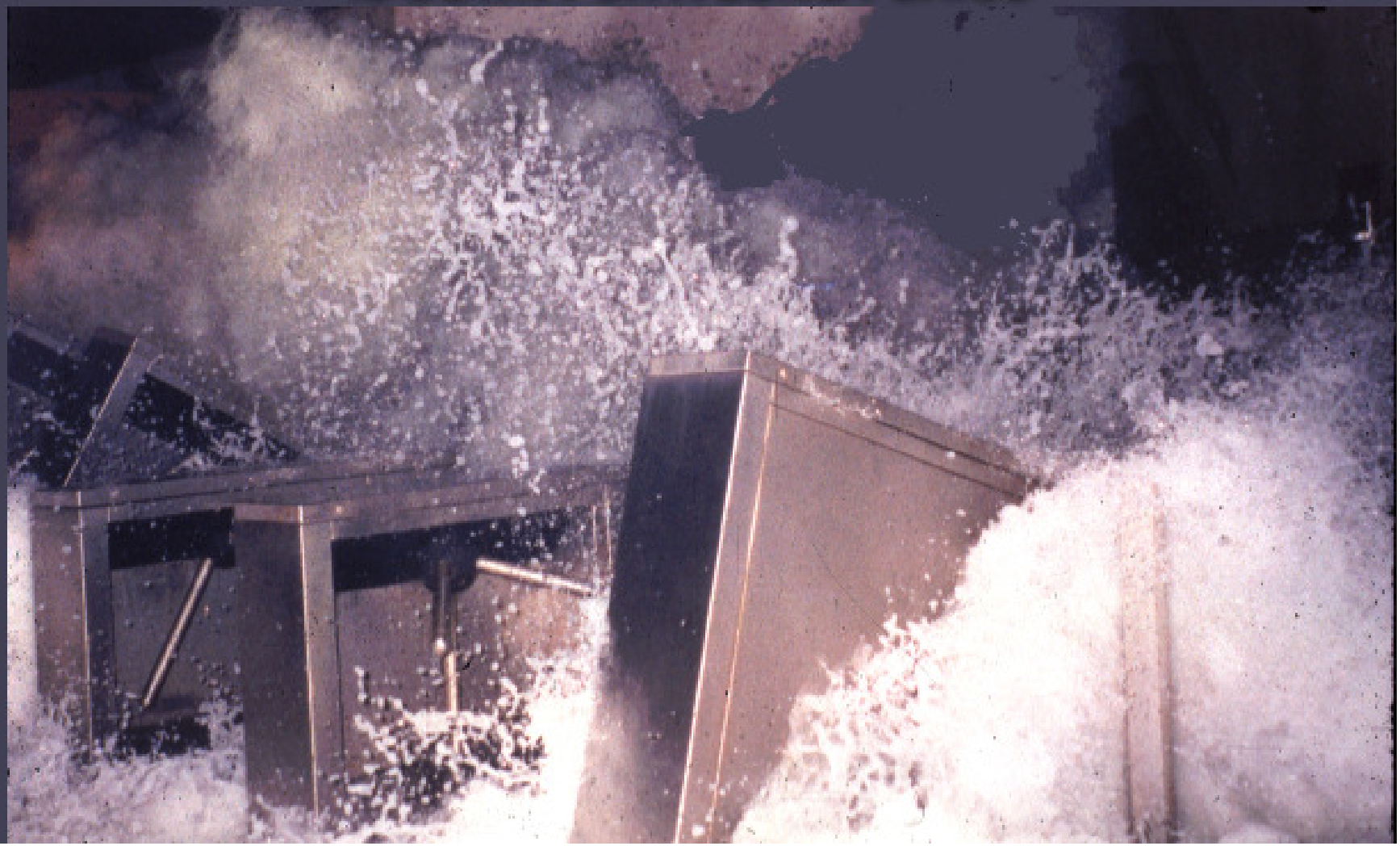
William C. Lopez for The New York Times

When Salty Water Is Like Dynamite

Workers began repairs yesterday on East 60th Street after an underground explosion. Officials said snow runoff combined with road salt had corroded electrical lines. Page B4.

WHEN RAIN RUNOFF GETS INTO THE SUBWAYS, IT IS PUMPED OUT AND THE SYSTEM DRIES OUT.

WHEN STORM SURGE (SALT WATER) ENTERS THE SUBWAYS IN A HURRICANE, CORROSION OCCURS AND THE SYSTEM IS DOWN FOR A LONG PERIOD



SEAWALLS ALONG THE
NEW YORK CITY SHORELINE
FAIL IN A NOR'EASTER STORM
WHAT WOULD HAPPEN
IN A HURRICANE?

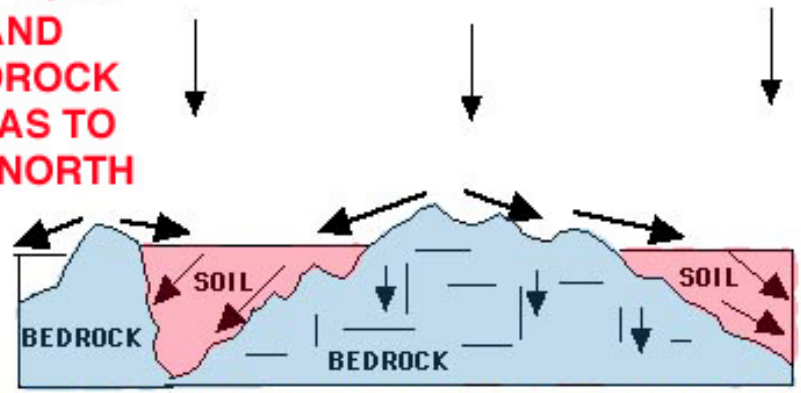
STORM SURGE PROTECTION
FOR COASTAL COMMUNITIES?
HURRICANES
NOT ALLOWED
PAST THIS POINT

ROCKAWAY, N.Y. IN THE "BIG ONE"

WHERE ARE YOU
SAFE FROM SURGE?

HYDRAULIC RESPONSE OF DIFFERENT GEOLOGIC TERRANES TO INTENSE HURRICANE-INDUCED RAINFALL

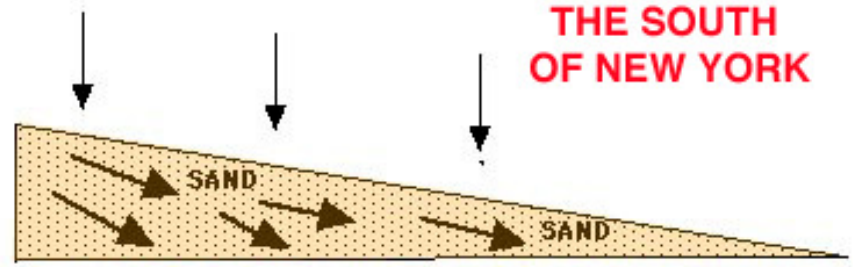
NEW YORK AND BEDROCK AREAS TO THE NORTH



BEDROCK AREA WITH PATCHY SOIL

Infiltration limited to patchy soil and rock fractures. Most of the precipitation is surface runoff and stream discharge rises rapidly (Short Lag Time)

COASTAL PLAIN COASTS TO THE SOUTH OF NEW YORK

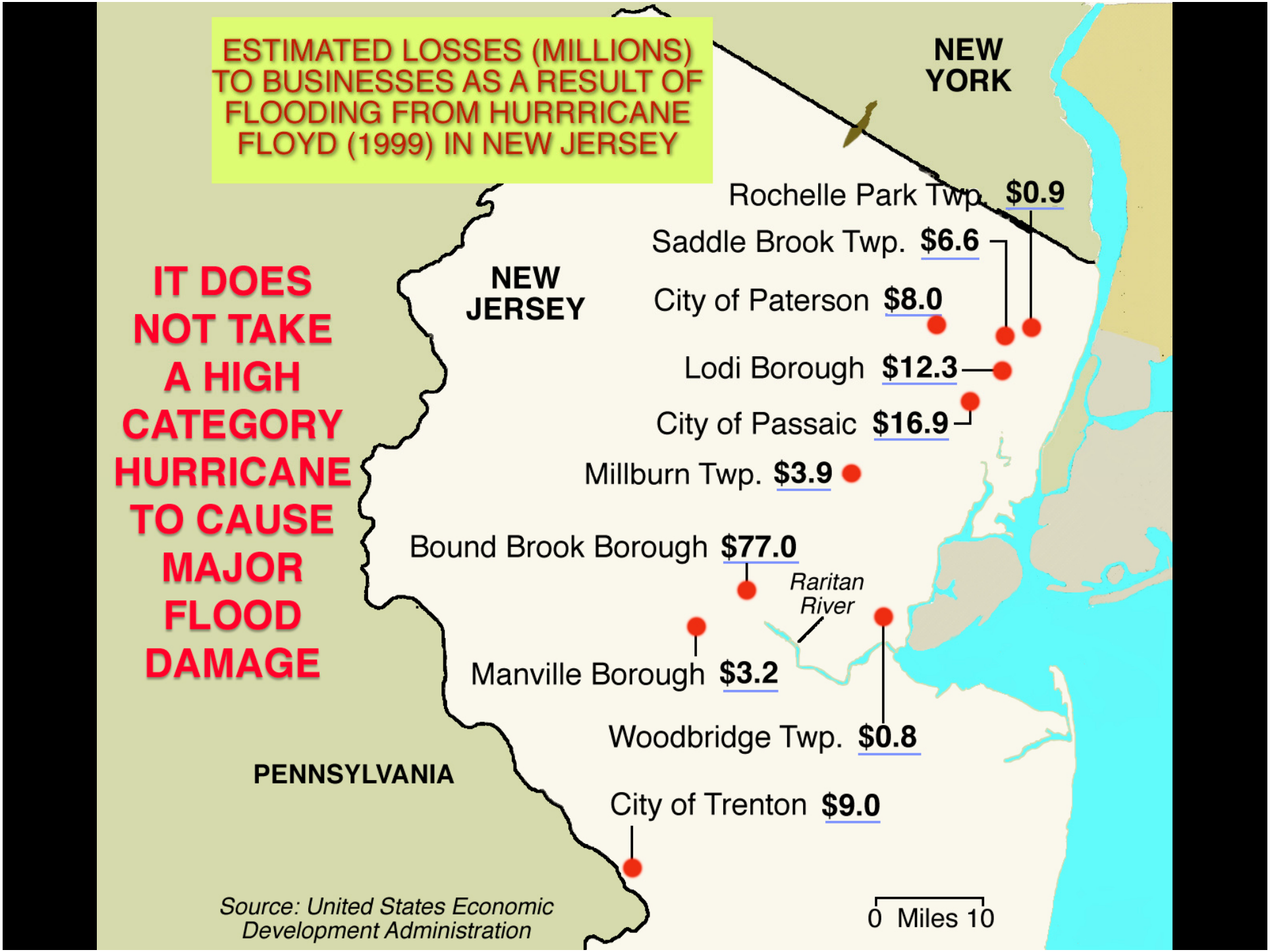


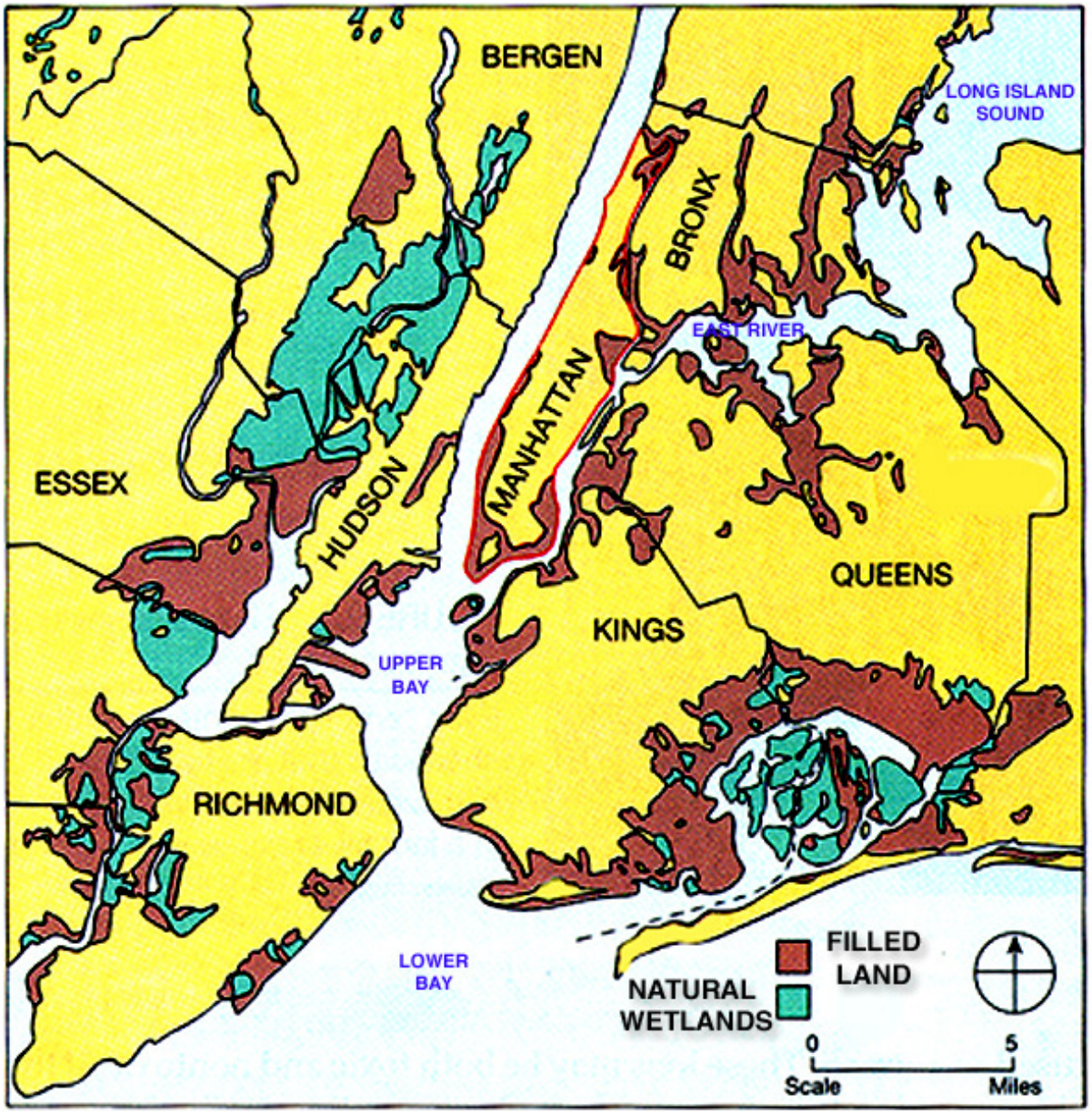
SANDY COASTAL OR GLACIAL PLAINS

Most of the precipitation passes into the porous sand and flows slowly underground to streams. Stream discharge rises slowly. (Long Lag Time)

WHY DO NORTHERN URBAN AREAS FLOOD SO READILY IN HURRICANES?

- Presence of bedrock, rather than coastal plain sands, reduces rain infiltration
- Extensive surface paving increases surface flow and decreases lag time.
- Original drainage courses were filled in during development

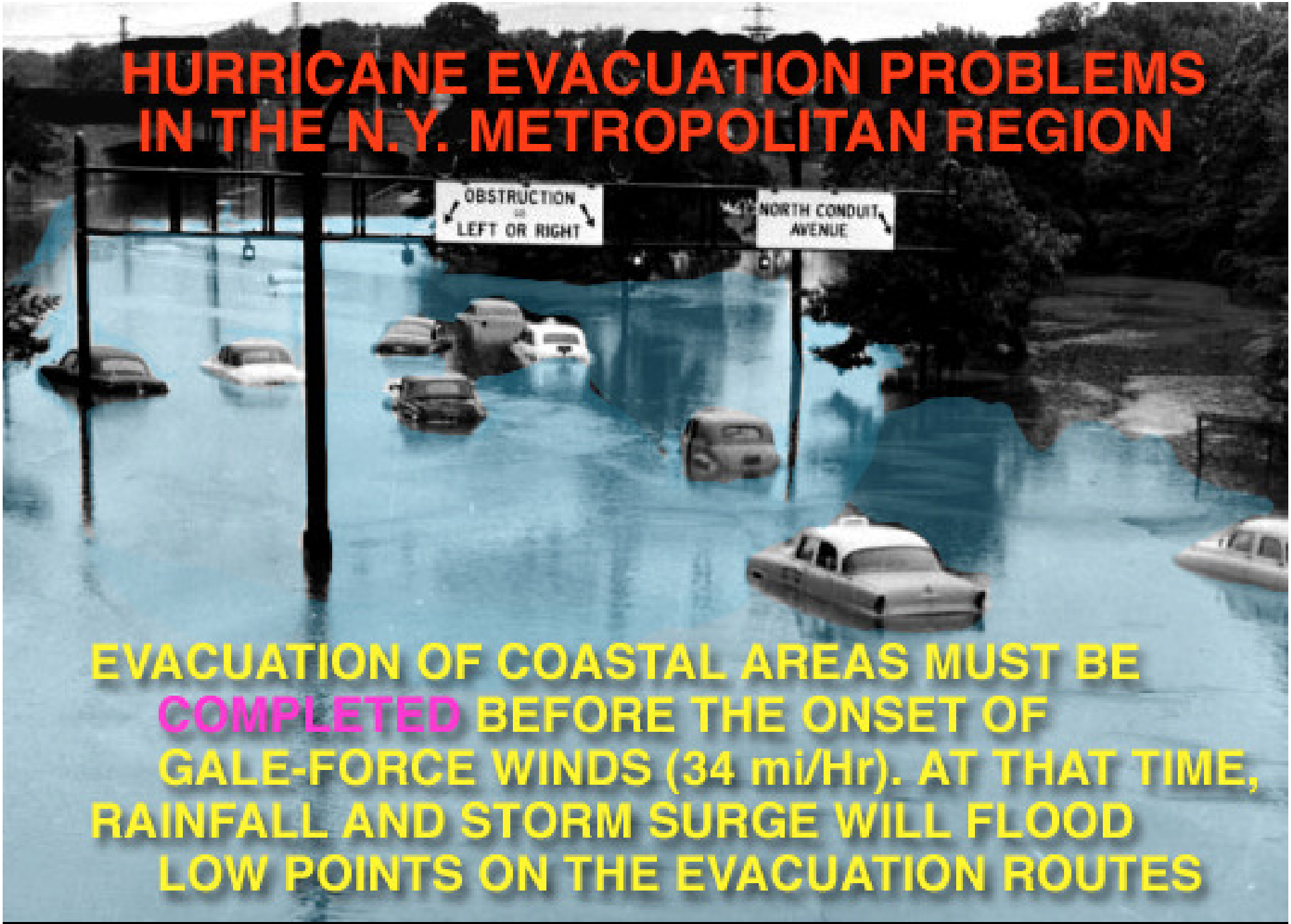

ESTIMATED LOSSES (MILLIONS) TO BUSINESSES AS A RESULT OF FLOODING FROM HURRRICANE FLOYD (1999) IN NEW JERSEY
IT DOES NOT TAKE A HIGH CATEGORY HURRICANE TO CAUSE MAJOR FLOOD DAMAGE
NEW YORK
NEW JERSEY
PENNSYLVANIA
Rochelle Park Twp. $0.9
Saddle Brook Twp. $6.6
City of Paterson $8.0
Lodi Borough $12.3
City of Passaic $16.9
Millburn Twp. $3.9
Bound Brook Borough $77.0
Raritan River
Manville Borough $3.2
Woodbridge Twp. $0.8
City of Trenton $9.0
Source: United States Economic Development Administration
0 Miles 10



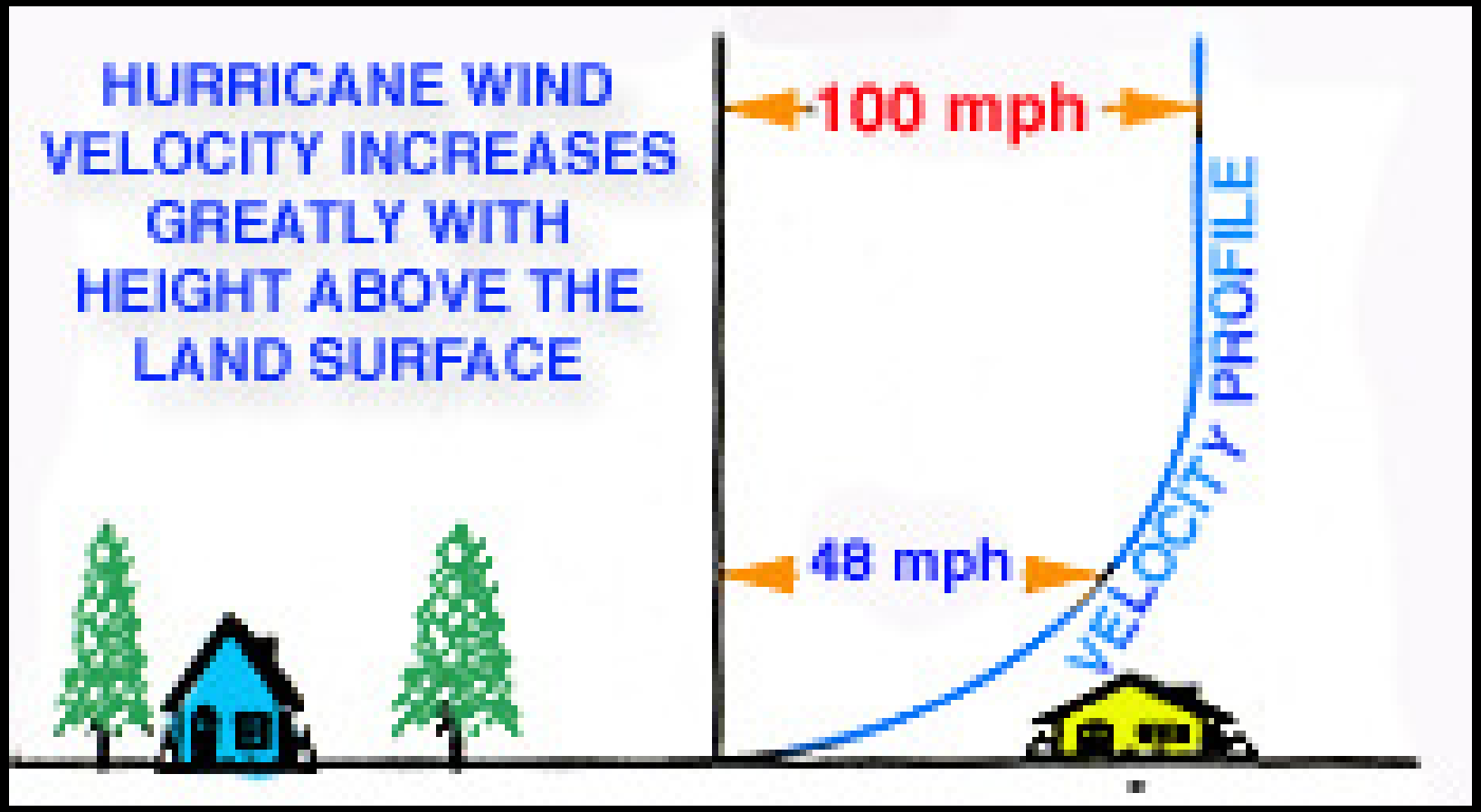
THE N.Y. -N.J. AREA HAS GROWN A GREAT DEAL AS WATER BODIES & WETLANDS HAVE BEEN FILLED IN FOR DEVELOPMENT

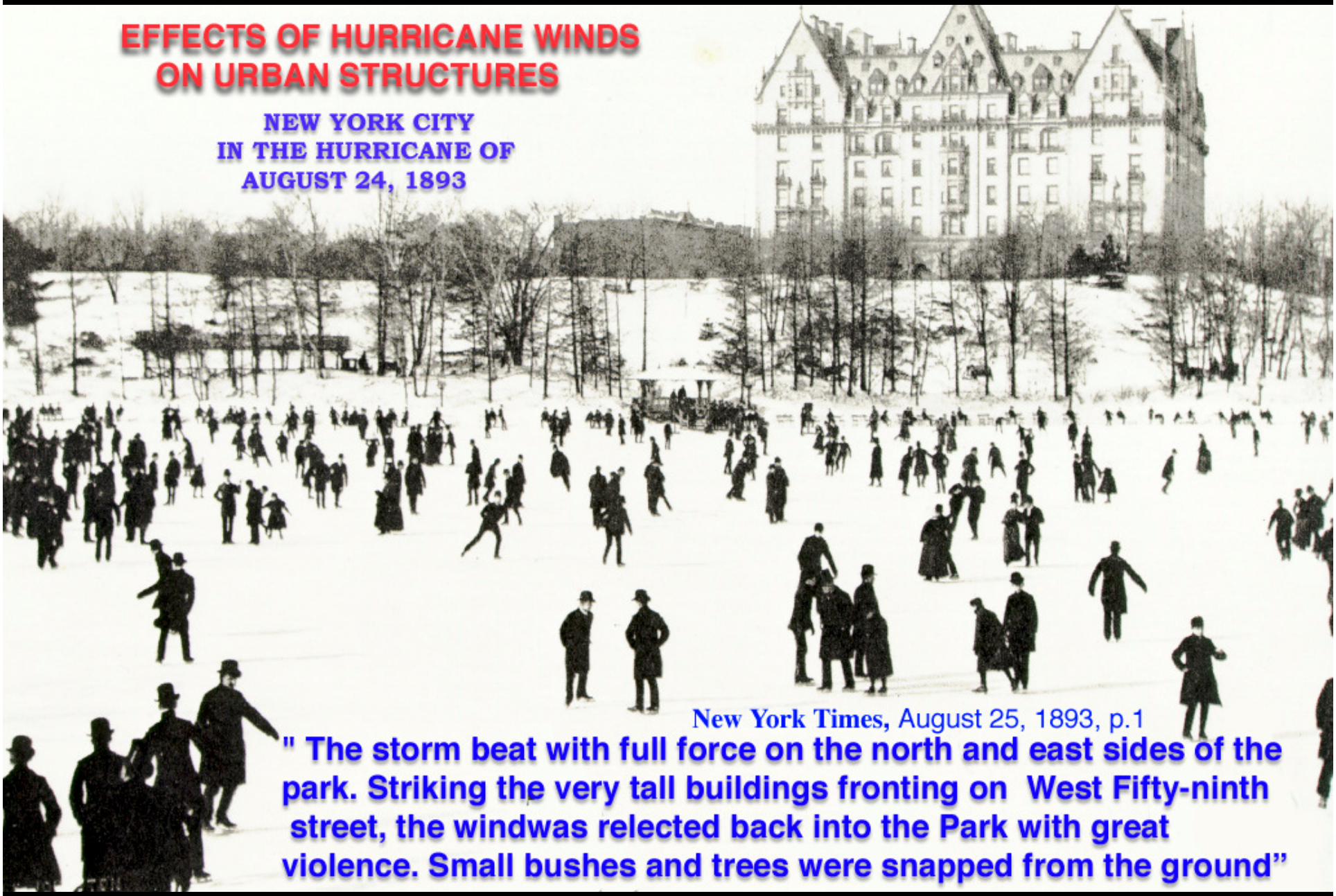
PEOPLE LIVING AND WORKING IN THESE DEVELOPMENTS ARE WELL WITHIN THE FLOOD LEVELS THAT WILL ACCOMPANY THE LANDFALL OF A MAJOR HURRICANE

HURRICANE EVACUATION PROBLEMS IN THE N.Y. METROPOLITAN REGION

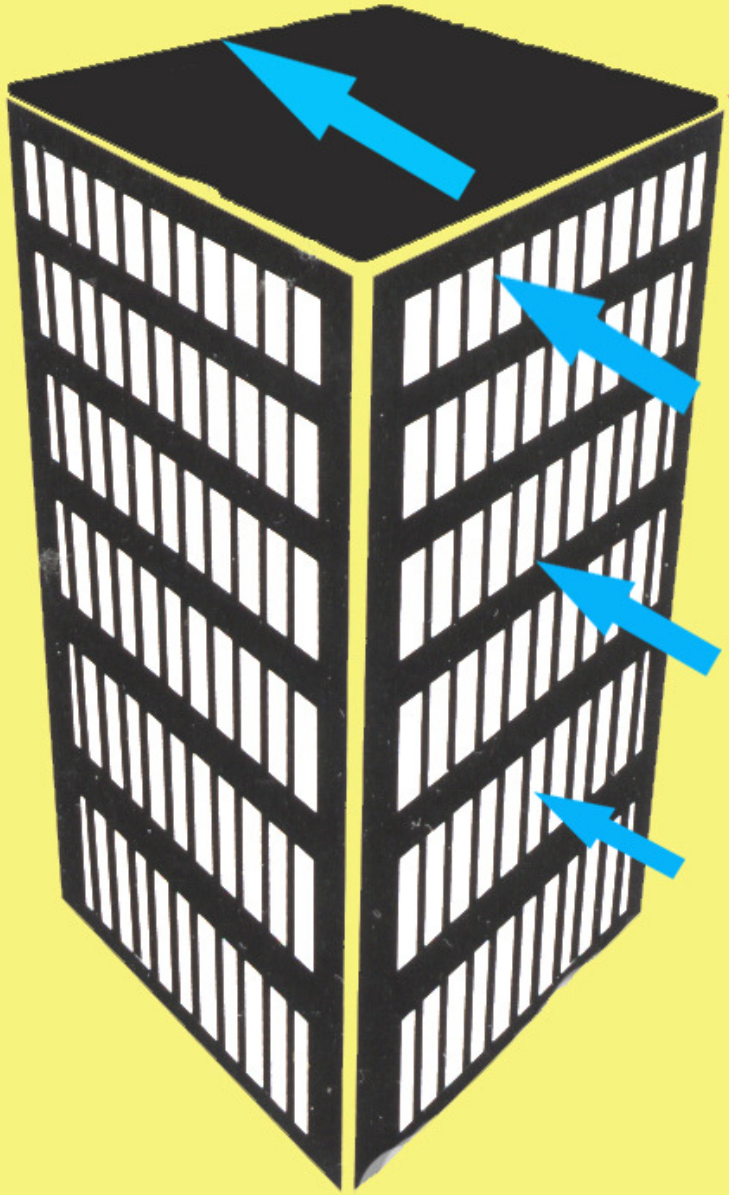


EVACUATION OF COASTAL AREAS MUST BE COMPLETED BEFORE THE ONSET OF GALE-FORCE WINDS (34 mi/Hr). AT THAT TIME, RAINFALL AND STORM SURGE WILL FLOOD LOW POINTS ON THE EVACUATION ROUTES


HURRICANE WIND VELOCITY INCREASES GREATLY WITH HEIGHT ABOVE THE LAND SURFACE
100 mph
48 mph
VELOCITY PROFILE


EFFECTS OF HURRICANE WINDS
ON URBAN STRUCTURES
NEW YORK CITY
IN THE HURRICANE OF
AUGUST 24, 1893
New York Times, August 25, 1893, p.1
" The storm beat with full force on the north and east sides of the park. Striking the very tall buildings fronting on West Fifty-ninth street, the windwas relected back into the Park with great violence. Small bushes and trees were snapped from the ground"

RESPONSE OF HIGH-RISE URBAN STRUCTURES TO HURRICANE WINDS



LEEWARD FACE (SUCTION)

Suction forces remove windows and cladding

Water damage to interior increases greatly

Debris adds to debris load in air flow down wind

WINDWARD FACE (COMPRESSION)

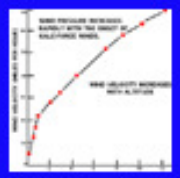
Wind pressure and debris break glass

Interior pressure rises rapidly

Interior partitions are destroyed

Wind and water destroy interior

Debris and glass fall to street

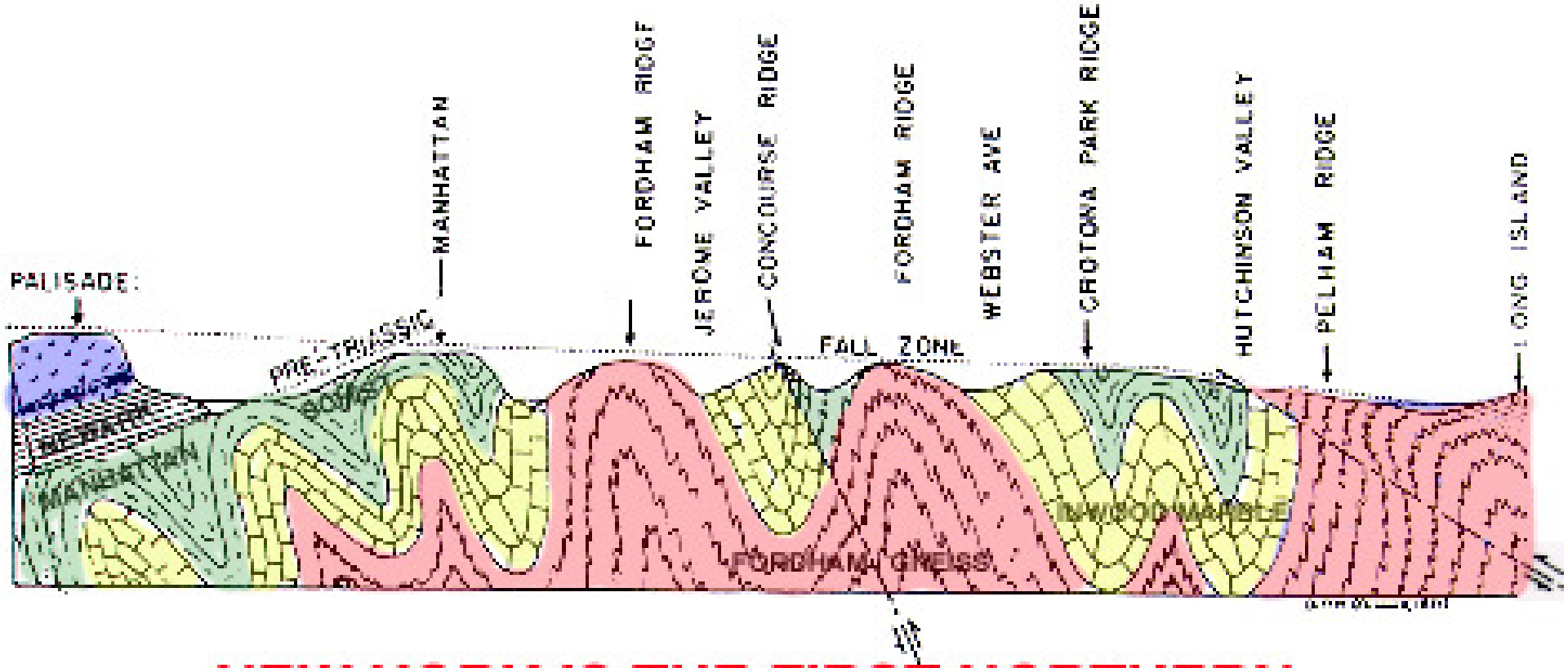


WIND PRESSURE INCREASES RAPIDLY WITH ALTITUDE

FLYING DEBRIS BREAKS WINDOWS REGARDLESS OF THEIR WIND RATING

COMPRESSION FORCES ON WINDWARD FACES. SUCTION FORCES ON THE LEEWARD FACES

THE BERNOULLI EFFECT INCREASES WIND SPEED AS WINDS ARE DRIVEN INTO NARROW SPACES BETWEEN SKYSCRAPERS



NEW YORK IS THE FIRST NORTHERN HURRICANE-PRONE CITY WITH A BEDROCK TOPOGRAPHY. THESE RIDGES AND LINEAR VALLEYS WILL AMPLIFY STORM WINDS

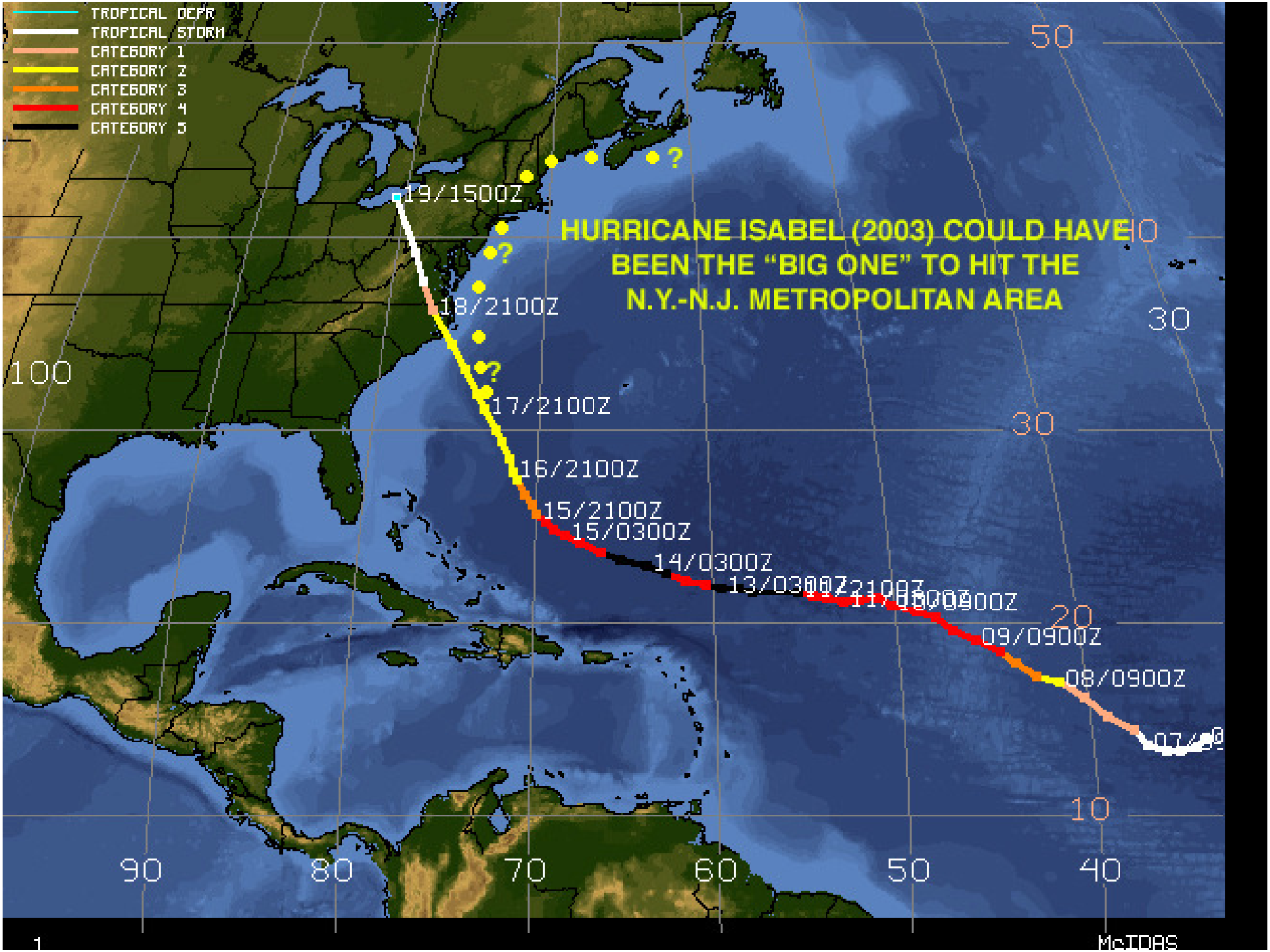
FLYING DEBRIS CAUSES MUCH MORE
HURRICANE WIND DAMAGE THAN
PREVIOUSLY THOUGHT

URBAN TREES ARE MUCH MORE VULNERABLE TO HURRICANE WINDS
TREE ROOT GROWTH IS LIMITED BY UTILITIES
SALT PENETRATES ROOTS IN WINTER
PAVEMENT LIMITS RAIN PENETRATION
AUTO EMISSIONS, AND DOG WASTES WEAKEN TREE ROOTS OVER TIME
WELL DEVELOPED CANOPIES INCREASE WIND DRAG
WIDE SPACING DECREASES LATERAL SUPPORT

One foot of reinforced concrete
Roof supports
NATIONAL HURRICANE CENTER MIAMI, FLORIDA
Heavy shutters roll down
1.5 inch thick windows
A REAL HURRICANE-PROOF STRUCTURE

HURRICANE WIND DAMAGE MITIGATION

- Building placement
- Interior location of critical facilities
- Protective glass
- Shutters
- Debris control


TROPICAL DEPR
TROPICAL STORM
CATEGORY 1
CATEGORY 2
CATEGORY 3
CATEGORY 4
CATEGORY 5
HURRICANE ISABEL (2003) COULD HAVE BEEN THE "BIG ONE" TO HIT THE N.Y.-N.J. METROPOLITAN AREA
19/1500Z
18/2100Z
17/2100Z
16/2100Z
15/2100Z
15/0300Z
14/0300Z
09/0900Z
08/0900Z
50
40
30
20
10
100
90
80
70
60
50
40
McIDAS

WAITING FOR HURRICANE X

Bonnie wasn't the disaster she might have been. But the Big One is inevitable, and could hit anytime

by ERIK LARSON

ANYONE TRYING TO RECOVER IN THE WAKE of last week's visit by Hurricane Bonnie probably isn't feeling especially lucky at the moment. Good fortune isn't the first thing you think of when your living room is full of mud, your roof is missing, your power has been out for days on end. But considering the destruction that often accompanies storms of this magnitude, residents of North and South Carolina and Virginia got off remarkably lightly. Only three people died. Property damage was far lower than it might have been. Beaches remained largely intact.

If anything, the storm reinforced the popular belief that hurricanes are so thoroughly tracked, probed and forecast these days that they cannot possibly cause great loss of life. Scientists don't share that optimism, however. Many believe we're entering a cycle in which violent storms are going to be more frequent, and in which the likelihood of a disastrous strike will be greater than ever. The scientists' pet nightmare is of the Big One—a catastrophic storm that could do $100 billion dollars' worth of damage and kill thousands of people. No one knows when or where the Big One will hit, but the certainty is growing that it will.

Even a Little One like Bonnie, of course, can do plenty of harm. Some half a million people were forced to flee inland last week, as the 400-mile-wide storm—mammoth in size even by hurricane standards—swirled toward Cape Fear, N.C. And though Bonnie's 115-m.p.h. winds slowed rapidly as she lumbered inland, her forward progress slowed too, with the result that the storm hovered over the state and pummeled it for more than a day. Downed power lines robbed over 240,000 people of electricity. Even worse than the winds were the rains—more than 12 in. in some places—which caused flooding in North and

Photograph for TIME by Steve Liss

WHAT WILL THE SCENARIO BE?

HOW WILL WE MINIMIZE DAMAGE?

HOW BAD COULD THE DAMAGE BE?

LET'S GO TO THE VIDEOTAPE!

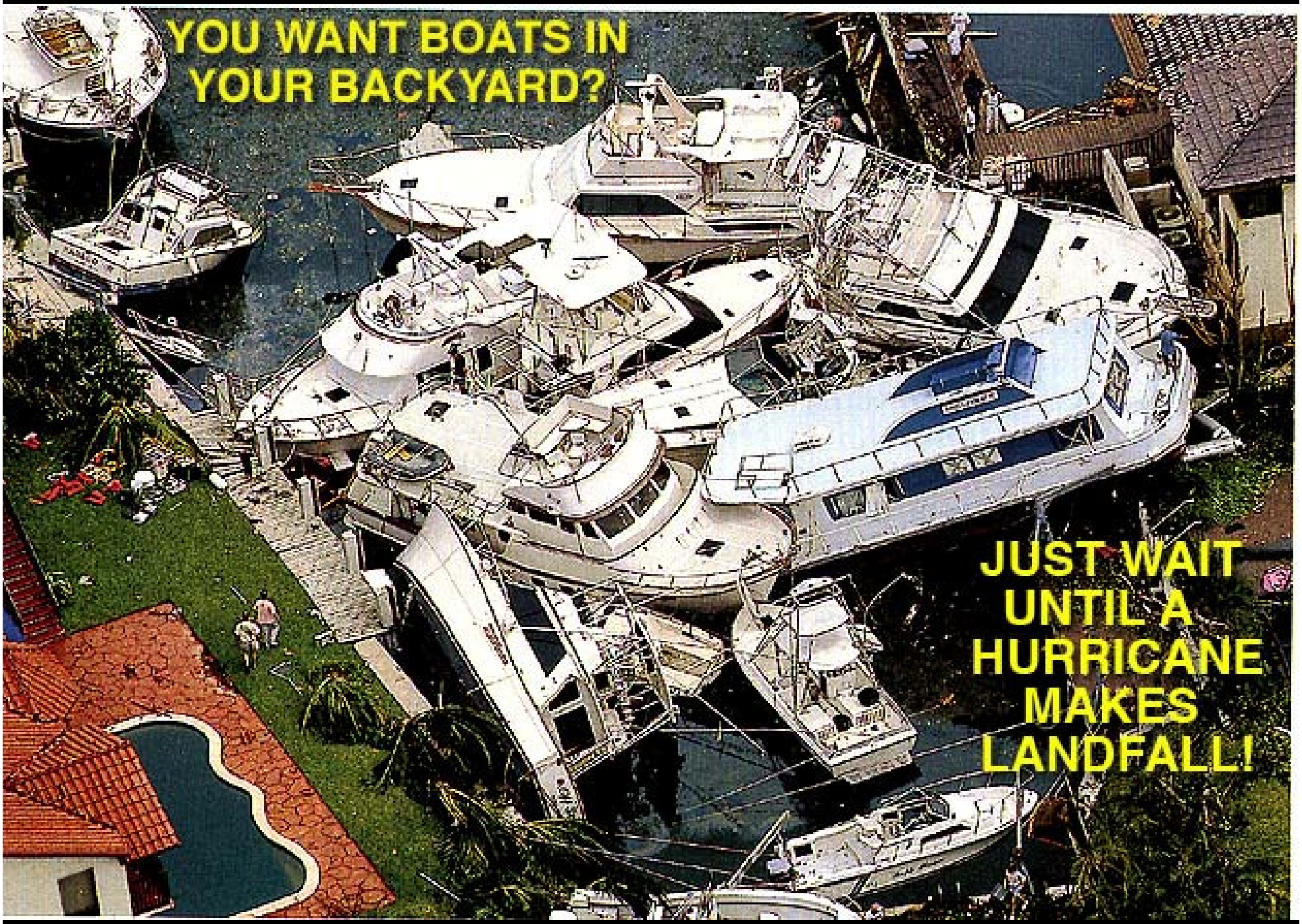
ARE NEW YORK'S BEACHES

ALL WASHED UP?

NO... BUT THE *STRUCTURES* ON THEM ARE!

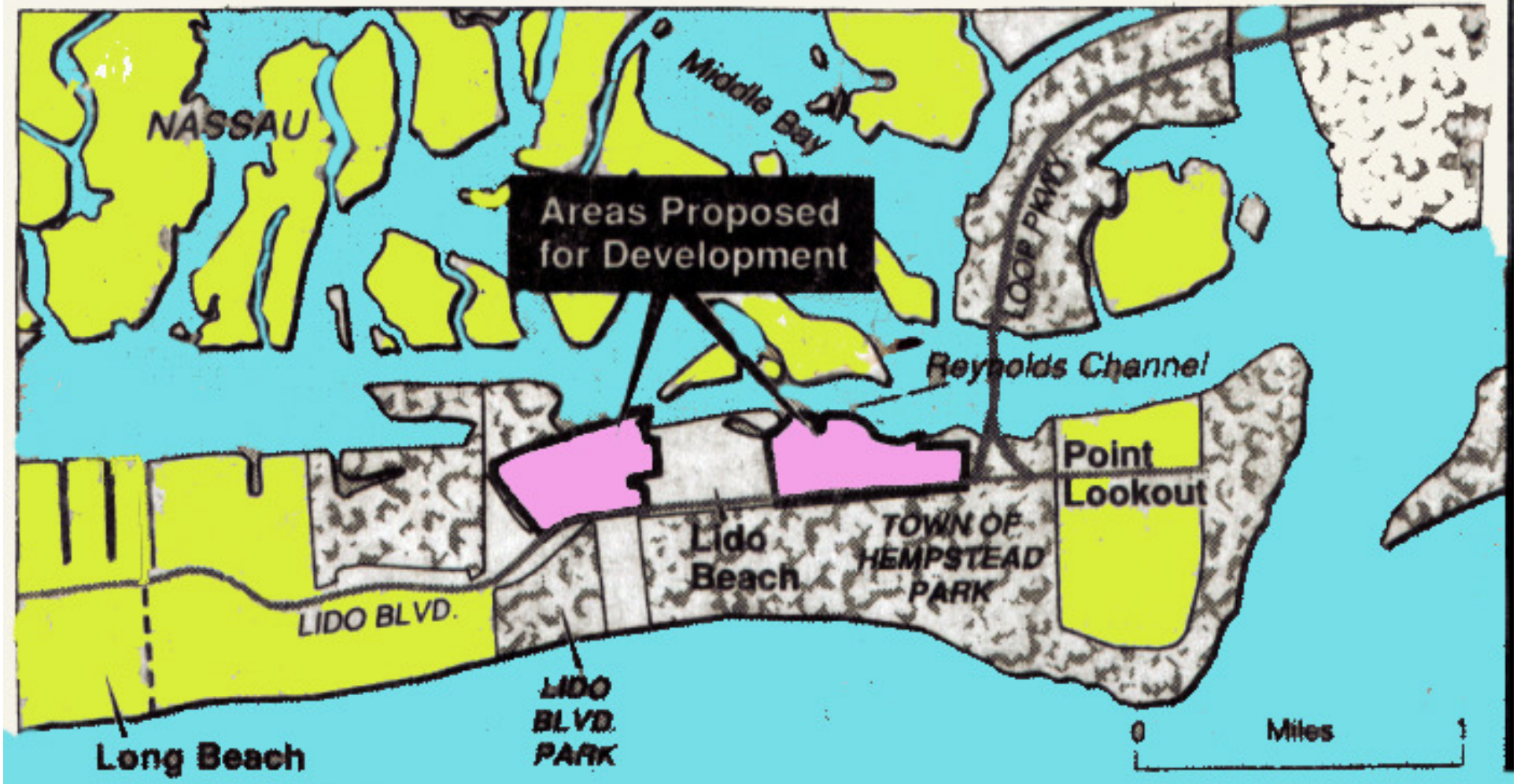
STABILIZED INLETS TRAP SAND IN BAYS AND
CUT OFF SUPPLY TO DOWNDRIFT BEACHES
FLOOD TIDAL
DELTA
INLET
JETTY

PEOPLE LIVE IN CANAL DEVELOPMENTS
BECAUSE THEY LIKE TO HAVE THEIR
BOATS IN THEIR BACKYARDS


YOU WANT BOATS IN
YOUR BACKYARD?
JUST WAIT
UNTIL A
HURRICANE
MAKES
LANDFALL!

Homes Due in Wetlands

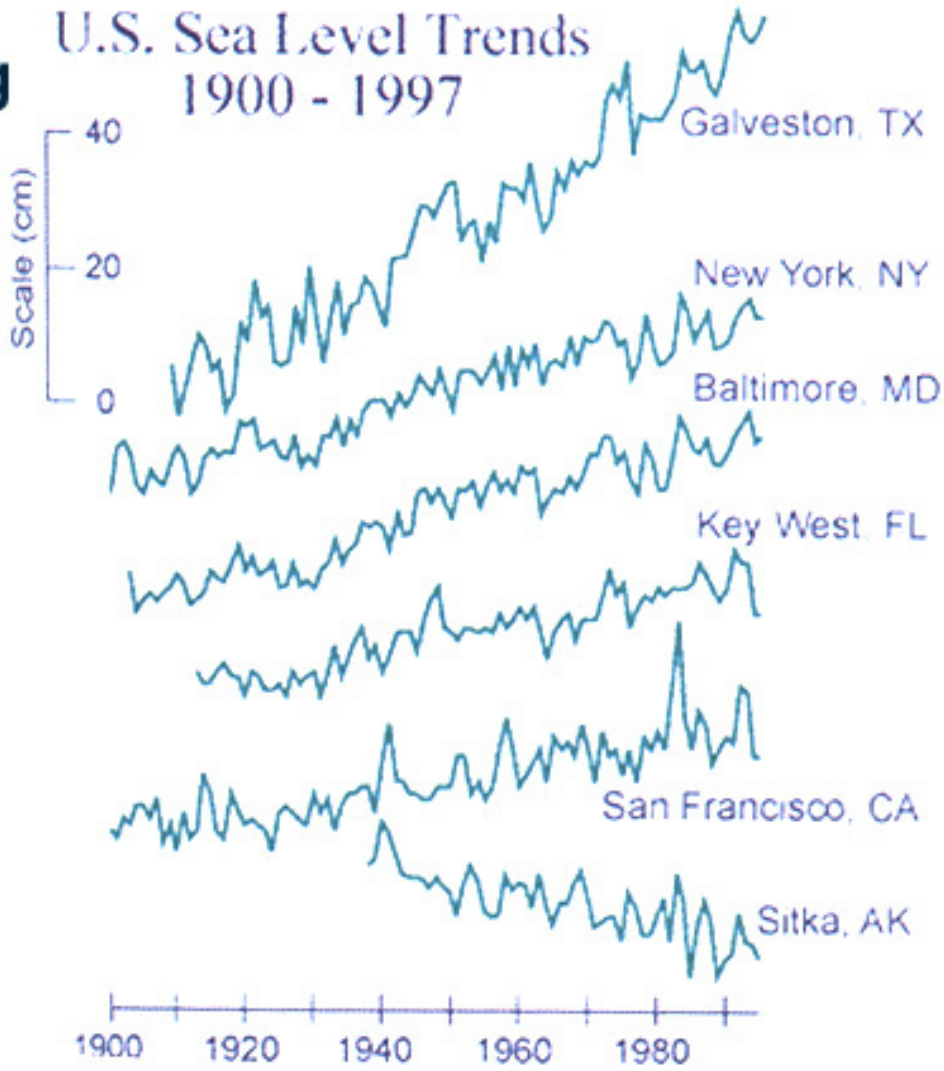
NEWSDAY



WHY DO WE NEED TO DEVELOP THESE AREAS?
WHY DO THEY CALL THEM WETLANDS?

SEA LEVELS ARE RISING ALL OVER THE U.S.

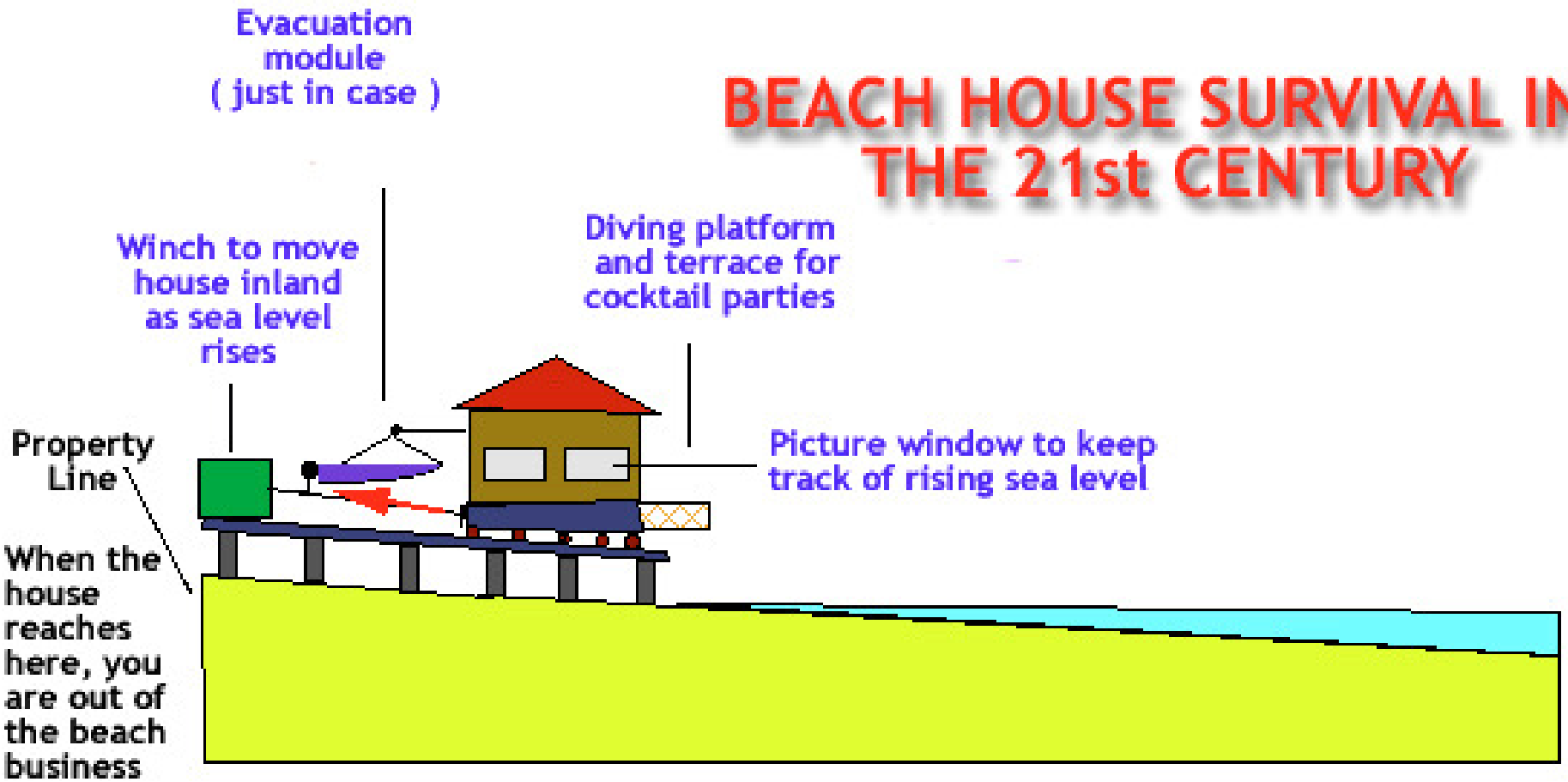
- Increased shoreline erosion
- More frequent inland flooding
- Hurricanes surge and waves destroy structures at greater heights

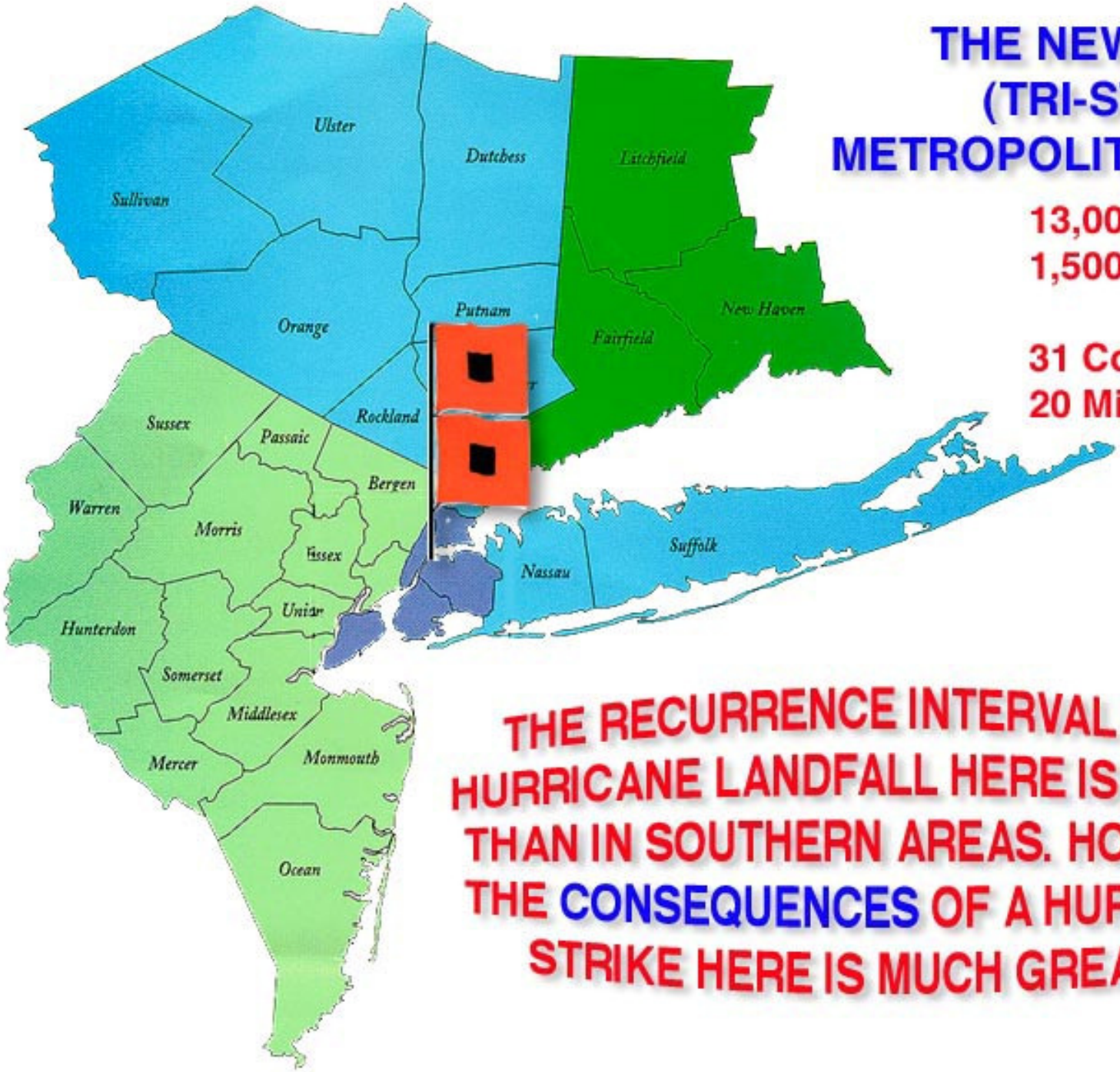


ONE SOLUTION FOR THE EFFECTS OF BEACH EROSION

REVERSE THE HOUSE!

BEACH HOUSE SURVIVAL IN THE 21st CENTURY





THE NEW YORK (TRI-STATE) METROPOLITAN REGION

13,000 Square miles
1,500 Cities, towns & villages
31 Counties
20 Million people

THE RECURRENCE INTERVAL FOR A HURRICANE LANDFALL HERE IS LONGER THAN IN SOUTHERN AREAS. HOWEVER, THE CONSEQUENCES OF A HURRICANE STRIKE HERE IS MUCH GREATER.

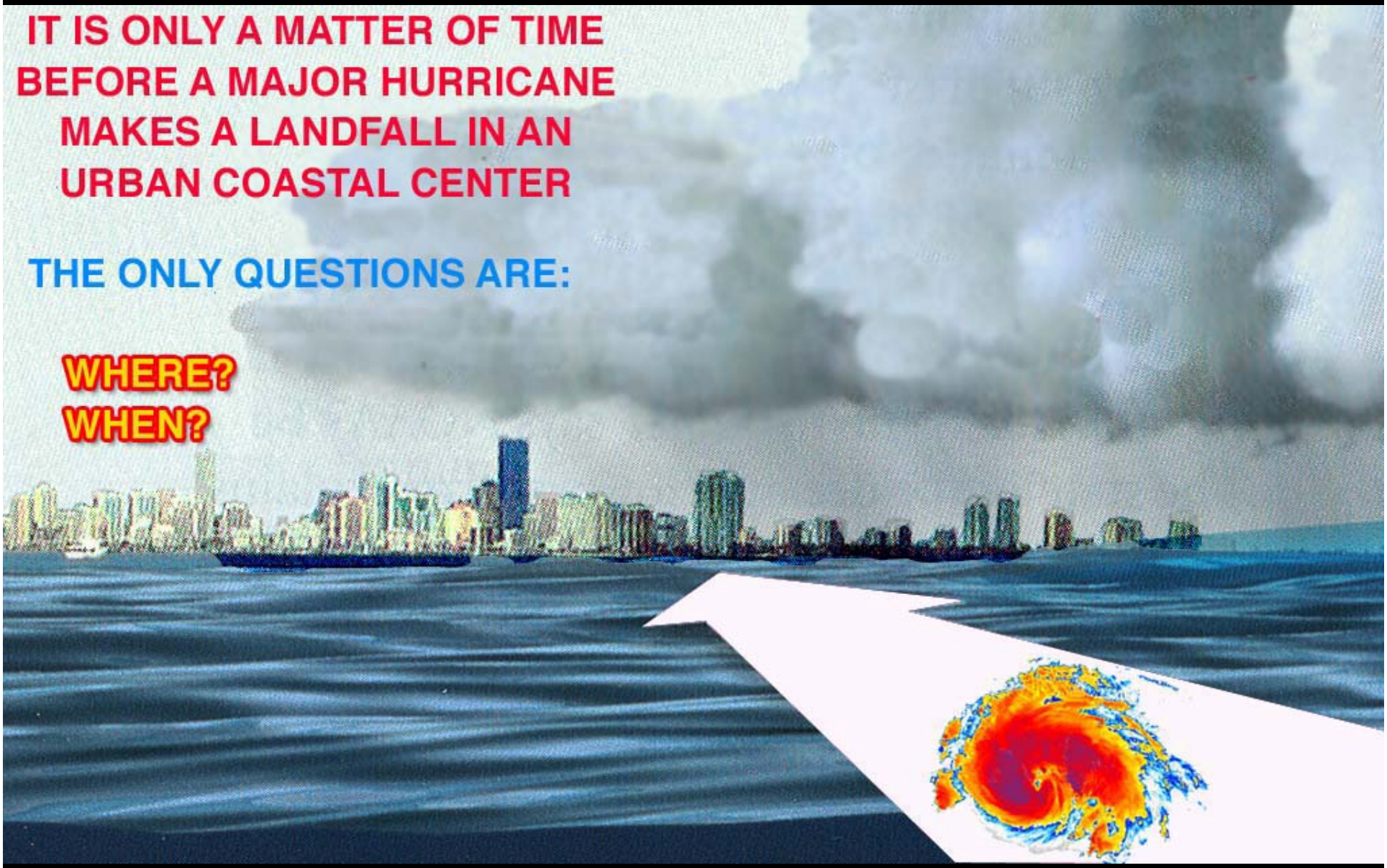
PRESENT VIEW OF MAJOR HURRICANE FREQUENCY IN THE NORTHEASTERN UNITED STATES

HURRICANE	1635	1815	1821	1893	1938
Interval (years)	180	6	72	45	

Average recurrence interval of a major hurricane = 90-100 years

Note: The 1821 and 1893 storms affected Western Long Island and Western New England

ARE WE HEADED FOR
STORMY WATERS?


IT IS ONLY A MATTER OF TIME
BEFORE A MAJOR HURRICANE
MAKES A LANDFALL IN AN
URBAN COASTAL CENTER
THE ONLY QUESTIONS ARE:
WHERE?
WHEN?

What more can I say?
DISCOVER
The
END
is
NEAR
THANK YOU!