SALT MARSH RESTORATION

Dr. John M. Teal, Scientist Emeritus, Woods Hole Oceanographic Institution;

Teal Partners

Where are we going and How to get there

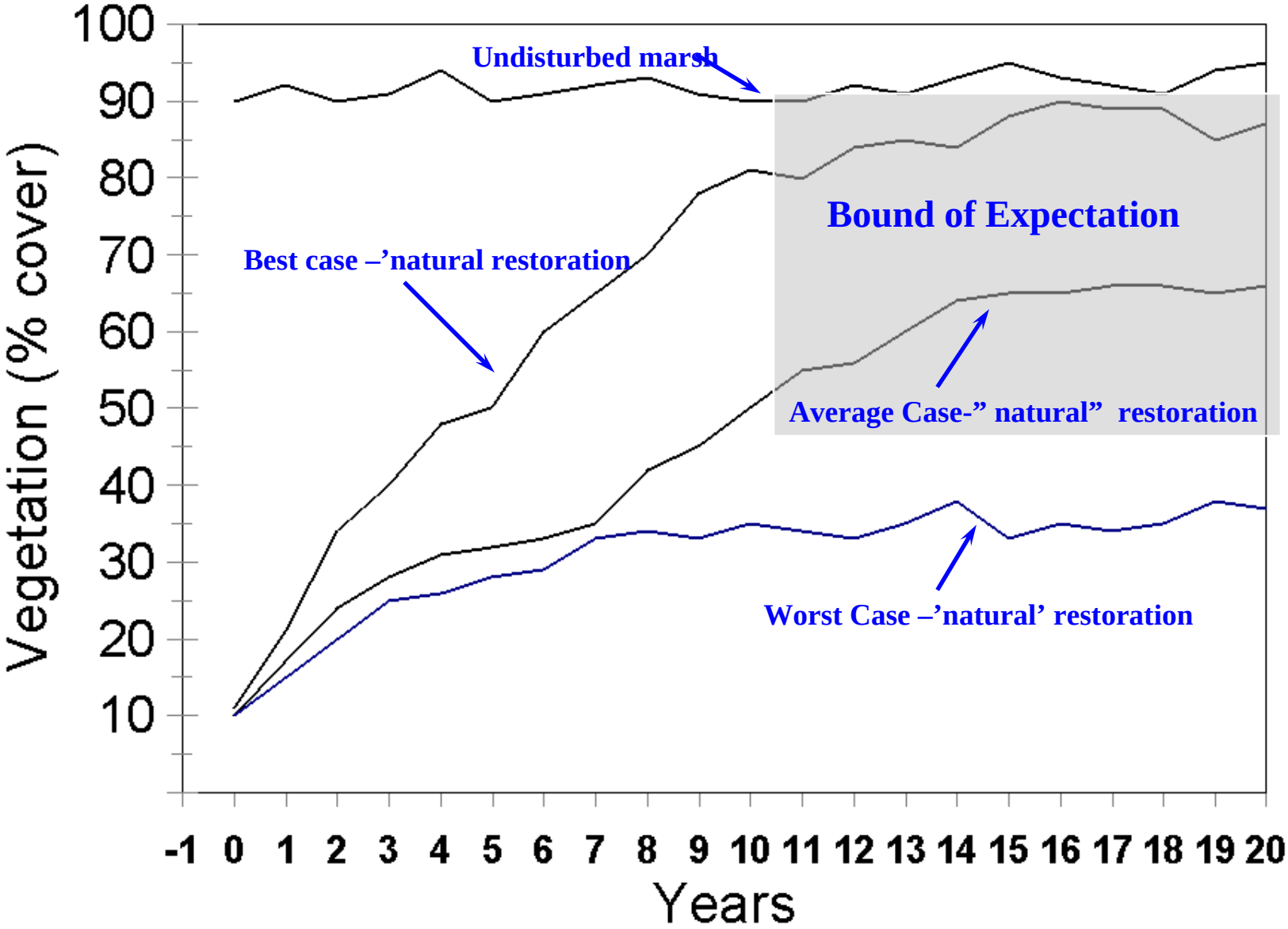
- Checklist like
  - Doctors need
  - Pilots use

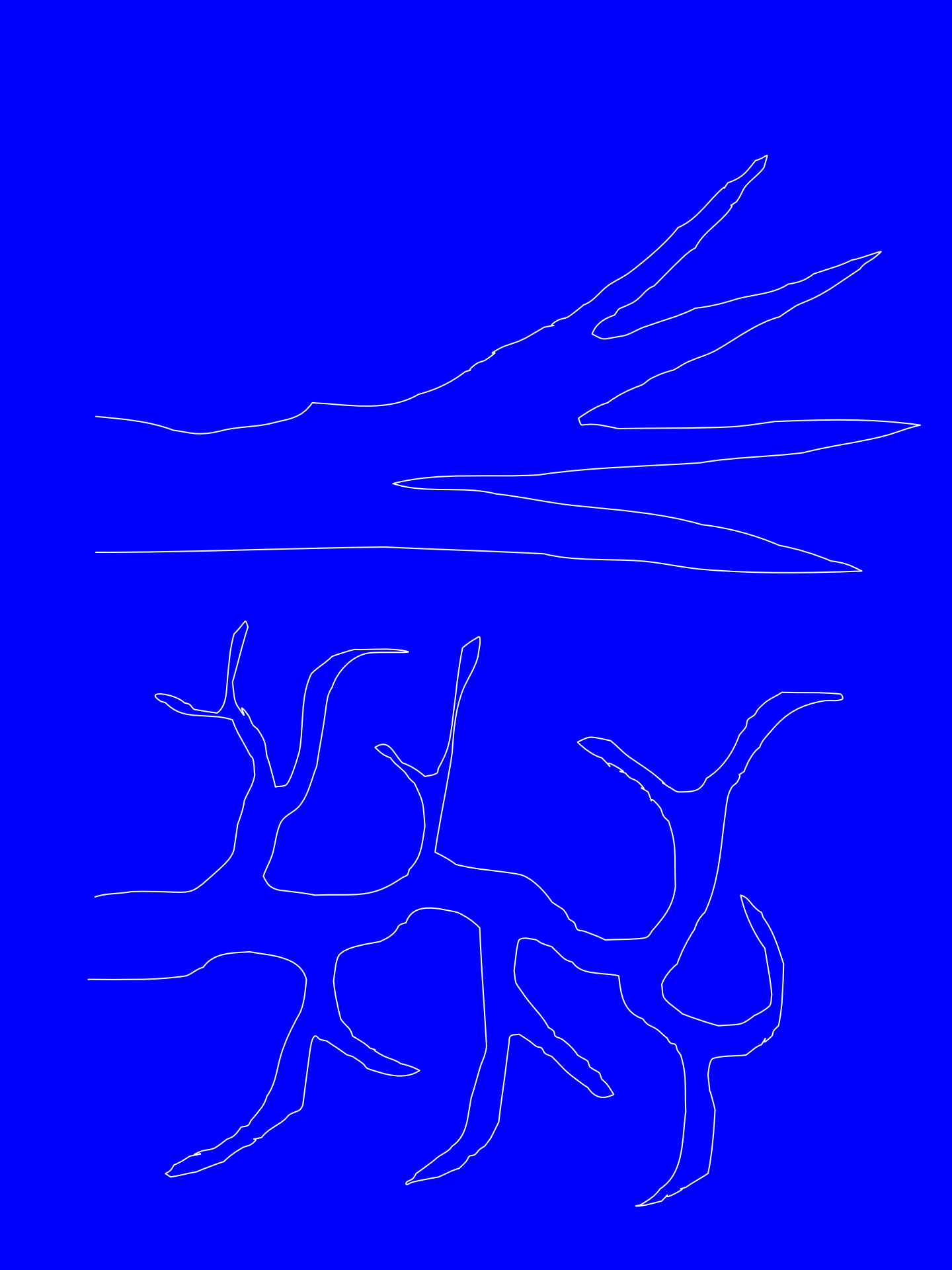
New Jersey
C & D Canal
Delaware Bay
Atlantic Ocean
Delaware
Preservation Sites
Wetland Restoration Sites
Fish Ladder Sites

Wetland Restoration Principles

- 1. State goals clearly, as agreed by the stakeholders; make the goals site specific and realistic.

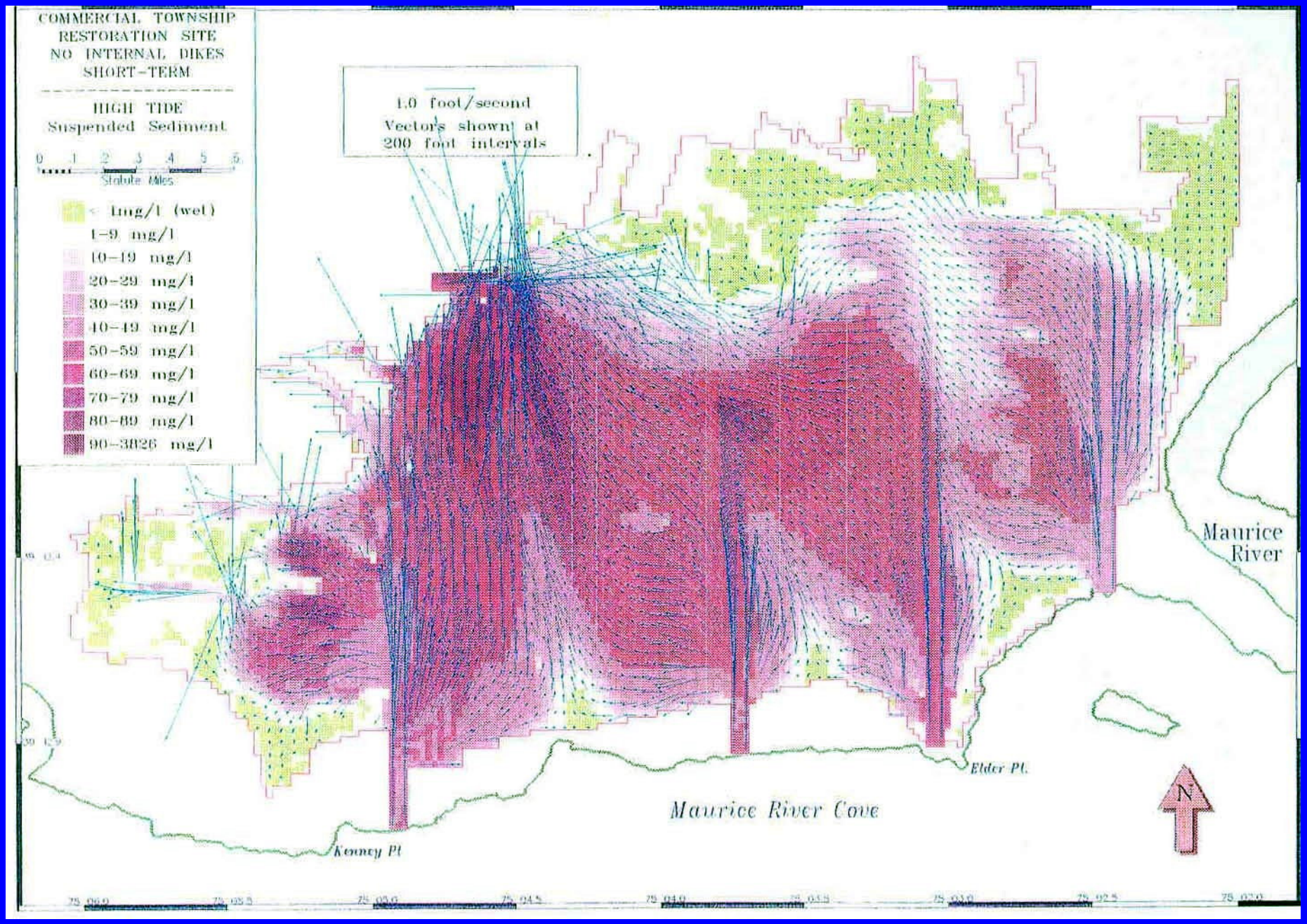
Hypothetical Restoration Trajectories

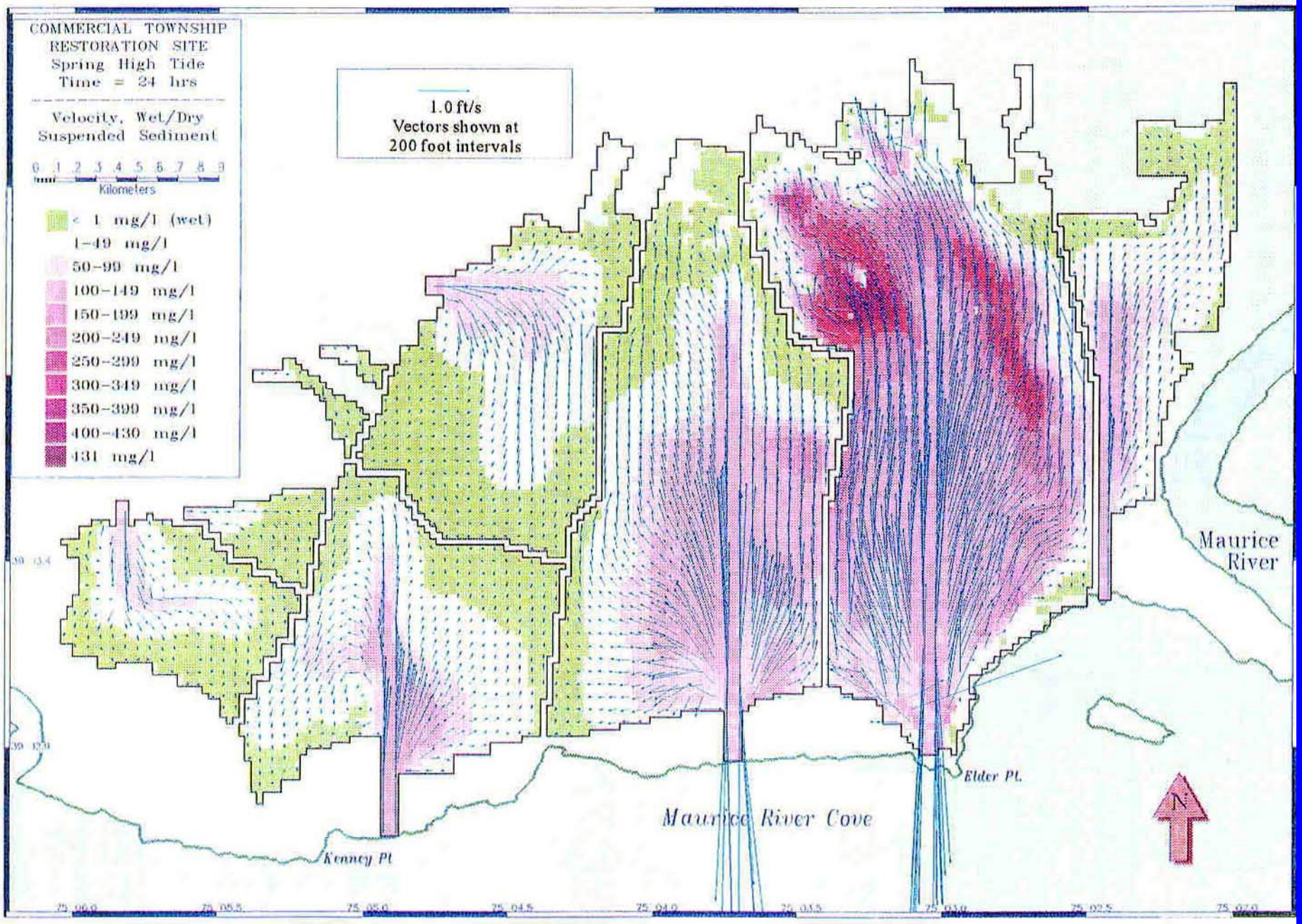




Mad Horse Creek

Moores Beach


COMMERCIAL TOWNSHIP
RESTORATION SITE
NO INTERNAL DIKES
SHORT-TERM
HIGH TIDE
Suspended Sediment
0 1 2 3 4 5 6
Statute Miles
< 1mg/l (wet)
1-9 mg/l
10-19 mg/l
20-29 mg/l
30-39 mg/l
40-49 mg/l
50-59 mg/l
60-69 mg/l
70-79 mg/l
80-89 mg/l
90-3826 mg/l
1.0 foot/second
Vectors shown at
200 foot intervals
Maurice
River
Elder Pt.
Maurice River Cove
Kenny Pt
N

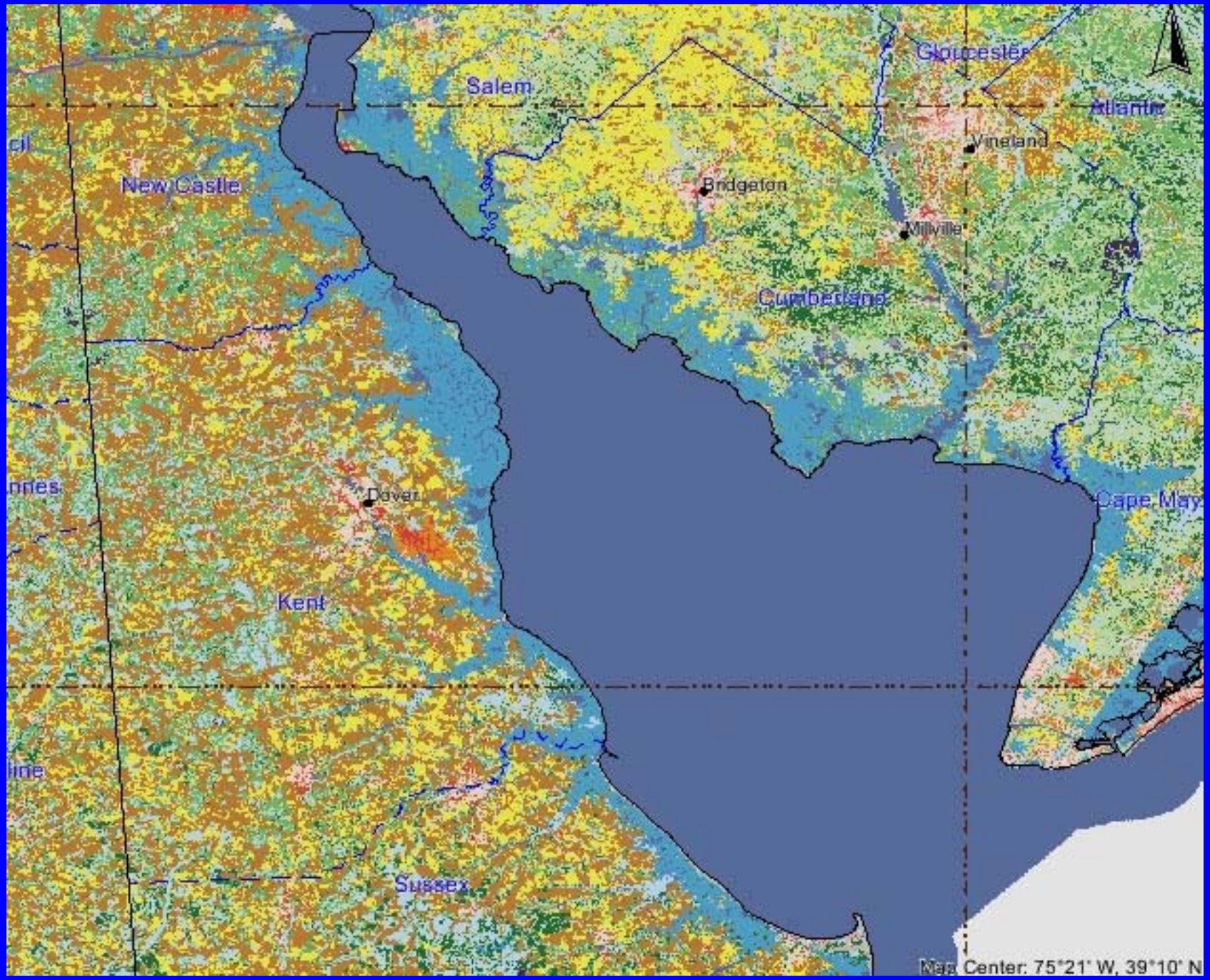

COMMERCIAL TOWNSHIP
RESTORATION SITE
Spring High Tide
Time = 24 hrs
Velocity, Wet/Dry
Suspended Sediment
0 1 2 3 4 5 6 7 8 9
Kilometers
< 1 mg/l (wet)
1-49 mg/l
50-99 mg/l
100-149 mg/l
150-199 mg/l
200-249 mg/l
250-299 mg/l
300-349 mg/l
350-399 mg/l
400-430 mg/l
431 mg/l
1.0 ft/s
Vectors shown at
200 foot intervals
Maurice River
Elder Pt.
Maurice River Cove
Kenney Pt
N

Wetland Restoration Principles

- 1. State goals clearly, as agreed by the stakeholders; make the goals site specific and realistic.
- 2. Restore degraded sites rather than create new wetlands.

Wetland Restoration Principles

- 1. State goals clearly, as agreed by the stakeholders; make the goals site specific and realistic.
- 2. Restore degraded sites rather than create new wetlands.
- 3. Select (consider) sites in a landscape ecology framework.


Gloucester
Salem
Atlantic
Vineland
New Castle
Bridgeton
Millville
Cumberland
Dover
Cape May
Kent
Sussex
Map Center: 75°21' W, 39°10' N

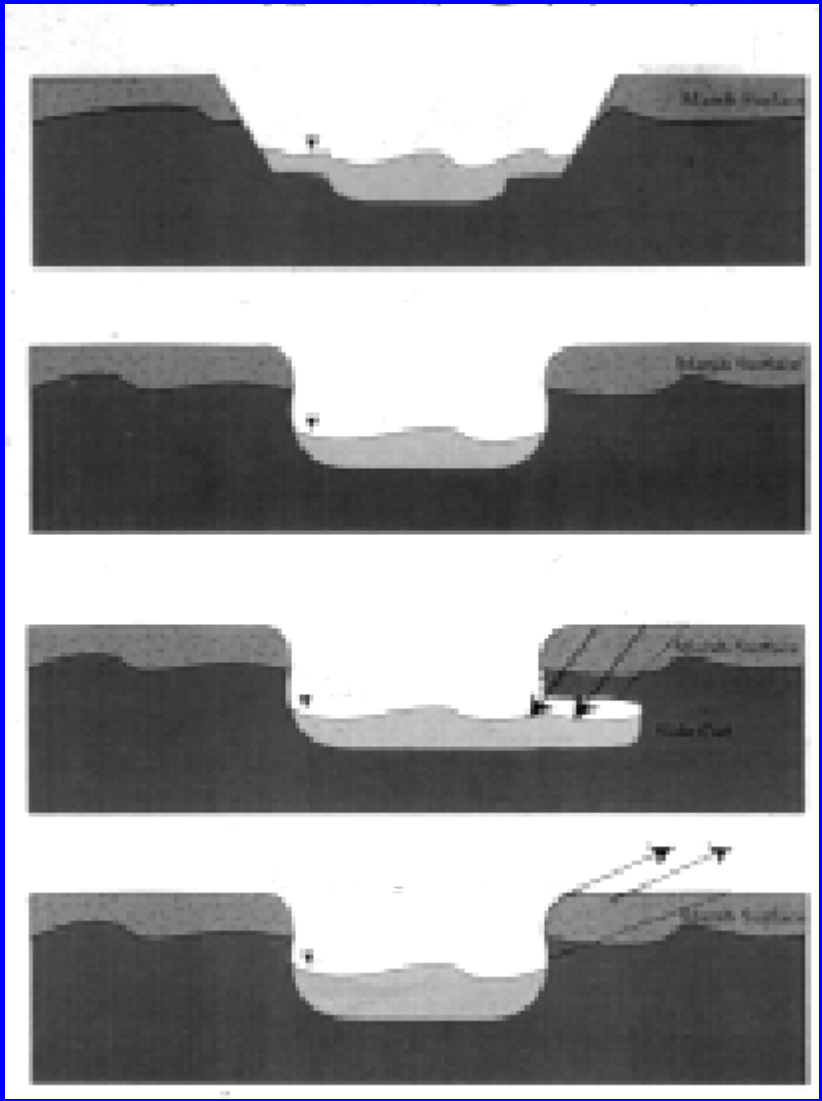
Wetland Restoration Principles

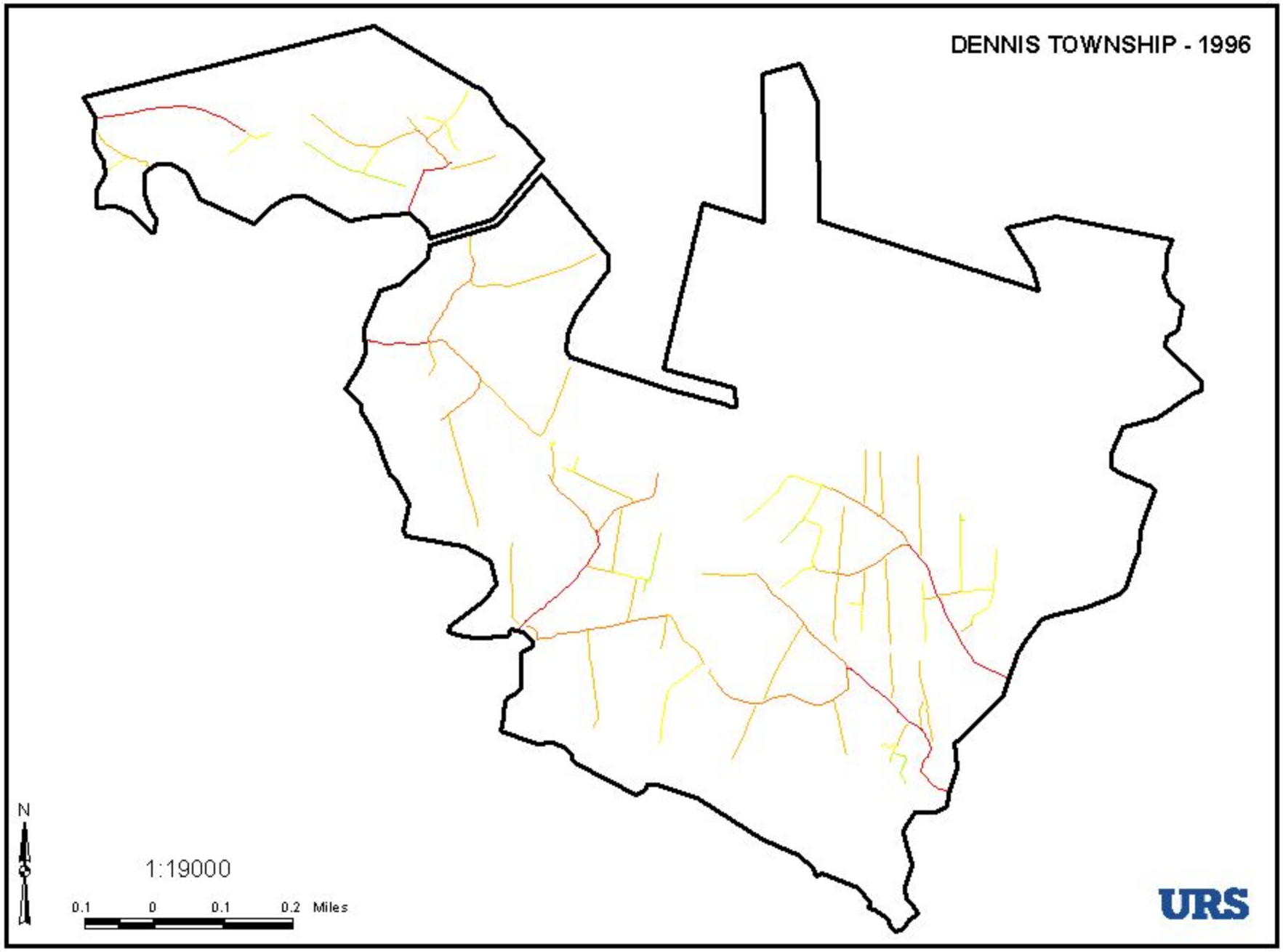
- 1. State goals clearly, as agreed by the stakeholders; make the goals site specific and realistic.
- 2. Restore degraded sites rather than create new wetlands.
- 3. Select sites in a landscape ecology framework.
- 4. Use ecological engineering (self design).

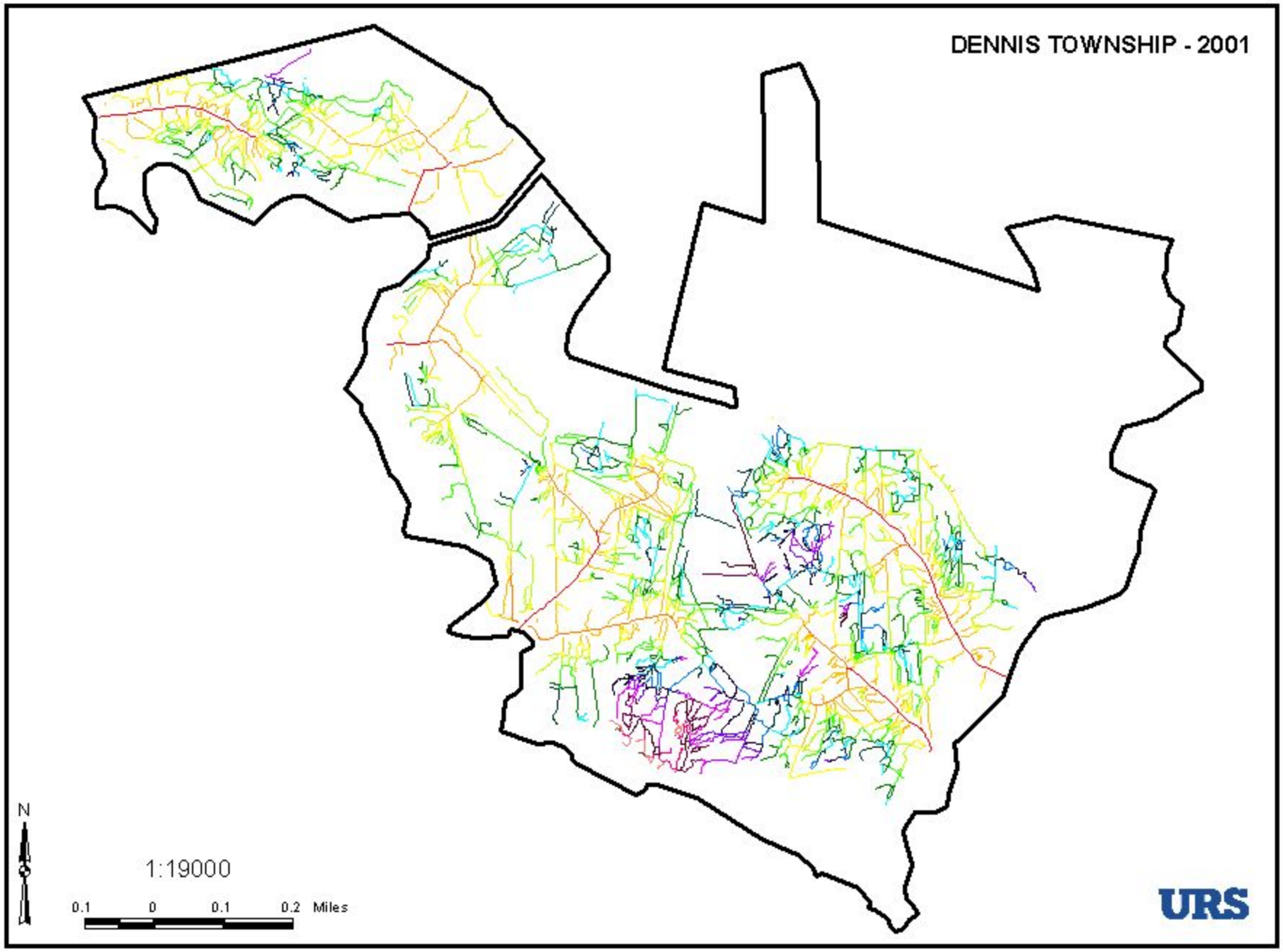
Sheet Drain Area

Old Sheet Drain Area + 1 yr

Channel Construction Techniques




DENNIS TOWNSHIP - 1996
N
1:19000
0.1
0
0.1
0.2
Miles
URS

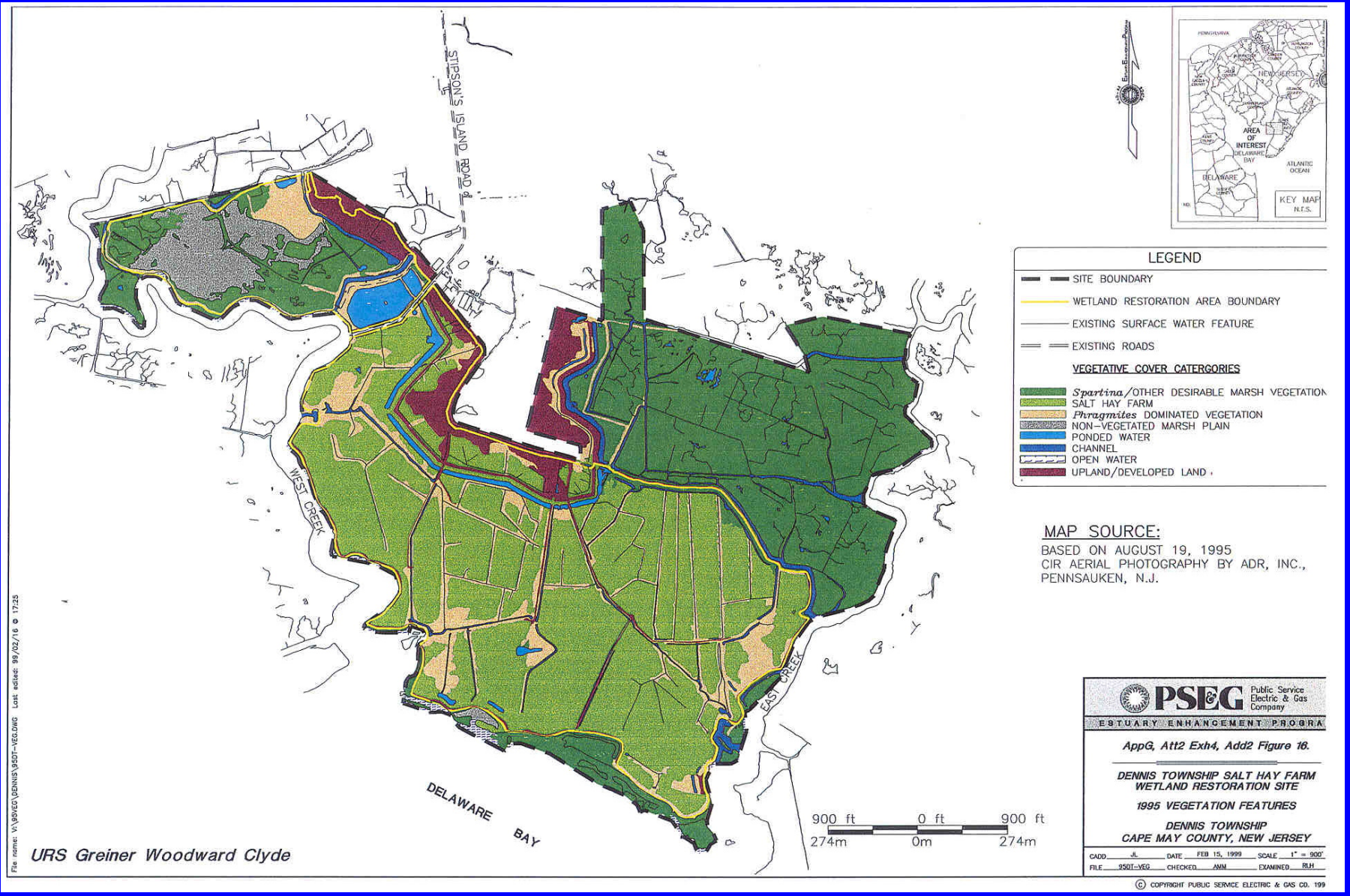

DENNIS TOWNSHIP - 2001
N
1:19000
0.1
0
0.1
0.2
Miles
URS

Wetland Restoration Principles

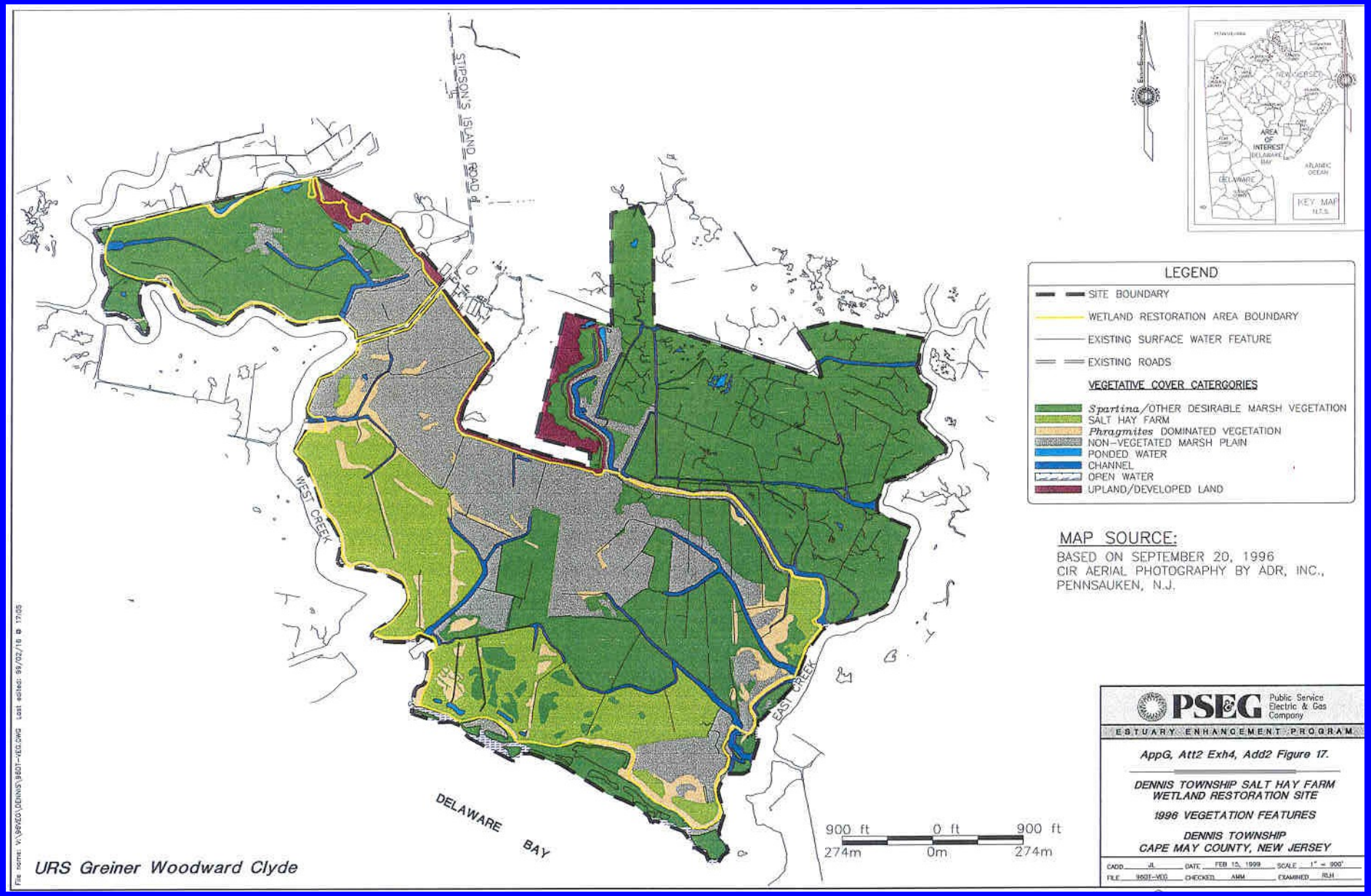
- 1. State goals clearly, as agreed by the stakeholders; make the goals site specific and realistic.
- 2. Restore degraded sites rather than create new wetlands.
- 3. Select sites in a landscape ecology framework.
- 4. Use ecological engineering.
- 5. Design restored sites to be *self-sustaining* and guided by adaptive management.

- Restoration – self maintaining
- Engineering – intervention and cost for(ever?)

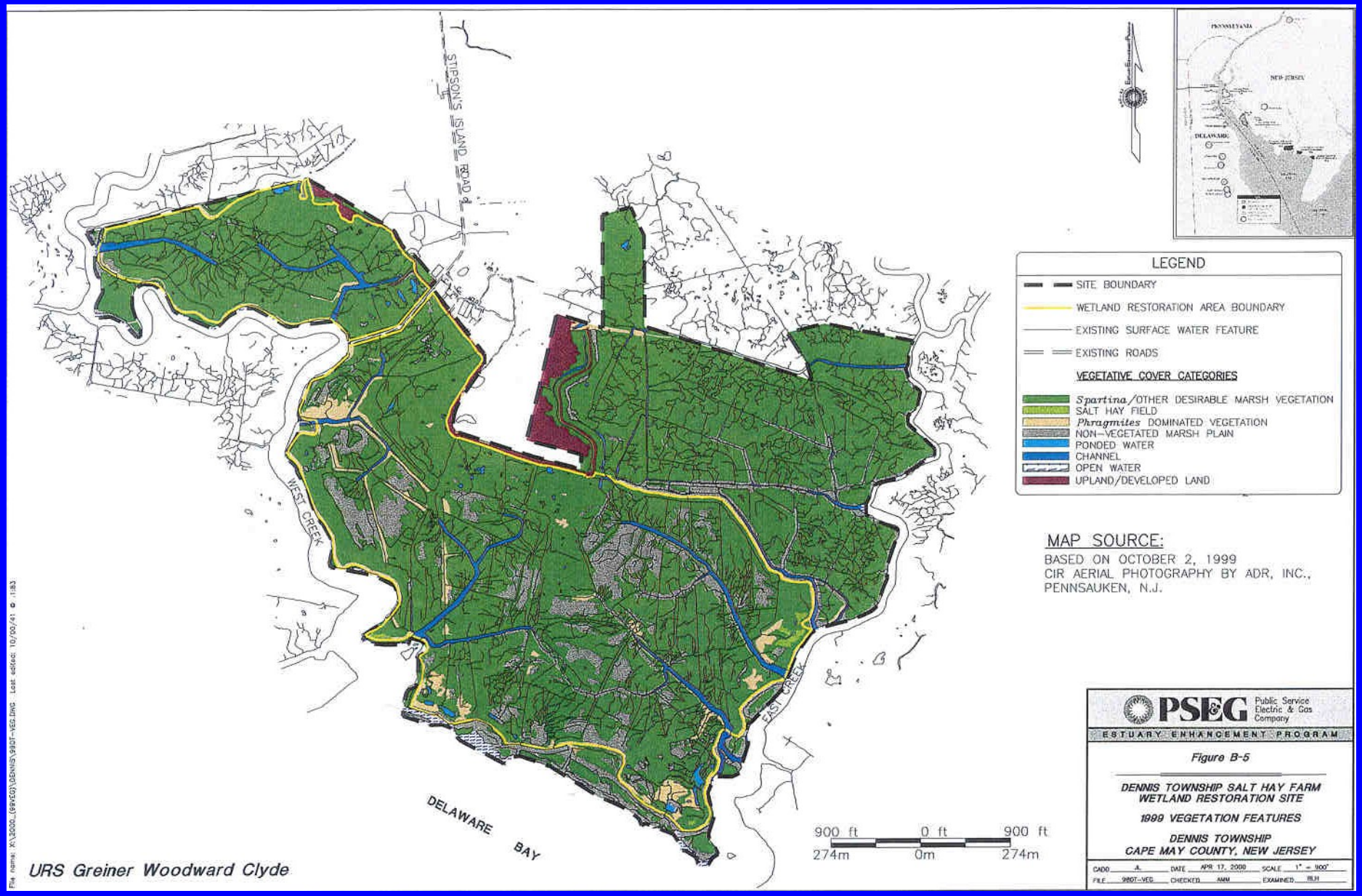
1995


STIPSON'S ISLAND ROAD
WEST CREEK
EAST CREEK
DELAWARE BAY
900 ft 0 ft 900 ft
274m 0m 274m
AREA OF INTEREST
DELAWARE BAY
ATLANTIC OCEAN
DELAWARE
NEW JERSEY
KEY MAP N.T.S.
LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
VEGETATIVE COVER CATERGORIES
Spartina/OTHER DESIRABLE MARSH VEGETATION
SALT HAY FARM
Phragmites DOMINATED VEGETATION
NON-VEGETATED MARSH PLAIN
PONDED WATER
CHANNEL
OPEN WATER
UPLAND/DEVELOPED LAND
MAP SOURCE:
BASED ON AUGUST 19, 1995
CIR AERIAL PHOTOGRAPHY BY ADR, INC.,
PENNSAUKEN, N.J.
PSEG Public Service Electric & Gas Company
ESTUARY ENHANCEMENT PROGRA
AppG, Att2 Exh4, Add2 Figure 16.
DENNIS TOWNSHIP SALT HAY FARM
WETLAND RESTORATION SITE
1995 VEGETATION FEATURES
DENNIS TOWNSHIP
CAPE MAY COUNTY, NEW JERSEY
CADD JL DATE FEB 15, 1999 SCALE 1" = 900'
FILE 95DT-VEG CHECKED AMM EXAMINED RLH
URS Greiner Woodward Clyde
© COPYRIGHT PUBLIC SERVICE ELECTRIC & GAS CO. 199

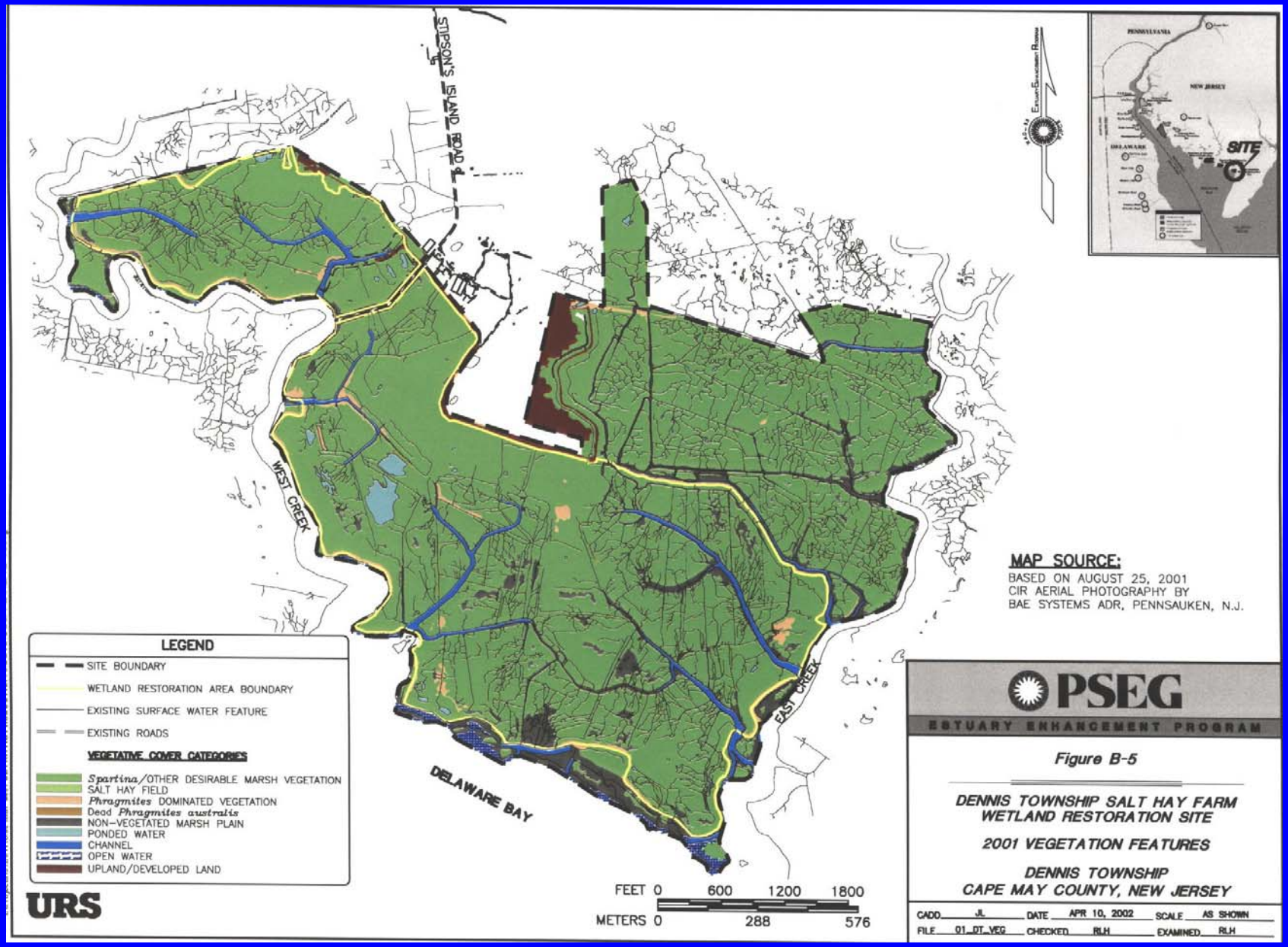
1996


STIPSON'S ISLAND ROAD
WEST CREEK
EAST CREEK
DELAWARE BAY
900 ft 0 ft 900 ft
274m 0m 274m
LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
VEGETATIVE COVER CATERGORIES
Spartina/OTHER DESIRABLE MARSH VEGETATION
SALT HAY FARM
Phragmites DOMINATED VEGETATION
NON-VEGETATED MARSH PLAIN
PONDED WATER
CHANNEL
OPEN WATER
UPLAND/DEVELOPED LAND
MAP SOURCE:
BASED ON SEPTEMBER 20, 1996
CIR AERIAL PHOTOGRAPHY BY ADR, INC.,
PENNSAUKEN, N.J.
AREA OF INTEREST
DELAWARE BAY
ATLANTIC OCEAN
NEW JERSEY
DELAWARE
KEY MAP
N.T.S.
PSEG Public Service Electric & Gas Company
ESTUARY ENHANCEMENT PROGRAM
AppG, Att2 Exh4, Add2 Figure 17.
DENNIS TOWNSHIP SALT HAY FARM
WETLAND RESTORATION SITE
1996 VEGETATION FEATURES
DENNIS TOWNSHIP
CAPE MAY COUNTY, NEW JERSEY
CADD JL DATE FEB 15, 1999 SCALE 1" = 900'
FILE 9601-VEG CHECKED AMM EXAMINED RLH
URS Greiner Woodward Clyde

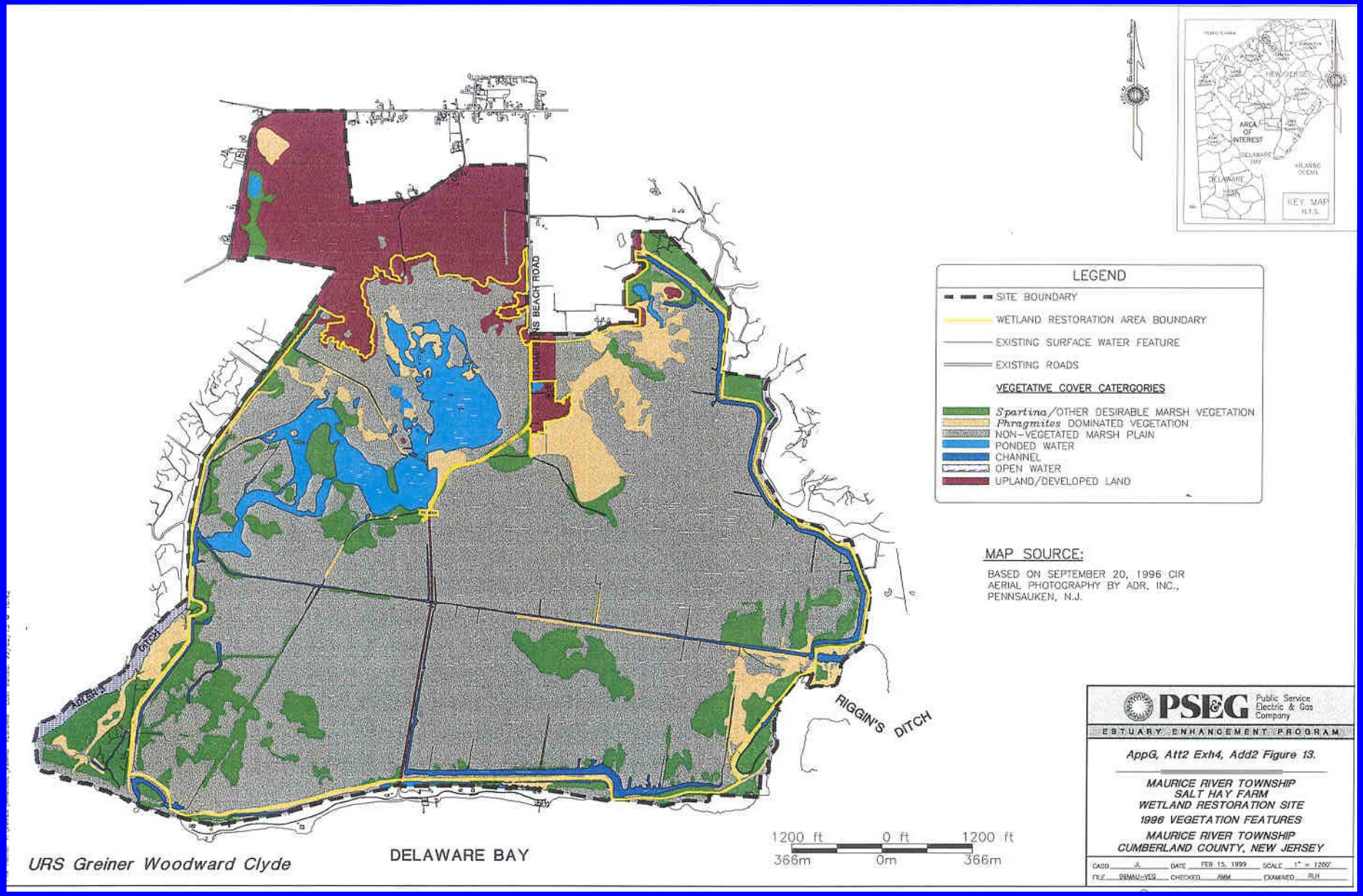
1999


STIPSON'S ISLAND ROAD
WEST CREEK
EAST CREEK
DELAWARE BAY
PENNSYLVANIA
NEW JERSEY
DELAWARE
LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
VEGETATIVE COVER CATEGORIES
Spartina/OTHER DESIRABLE MARSH VEGETATION
SALT HAY FIELD
Phragmites DOMINATED VEGETATION
NON-VEGETATED MARSH PLAIN
PONDED WATER
CHANNEL
OPEN WATER
UPLAND/DEVELOPED LAND
MAP SOURCE:
BASED ON OCTOBER 2, 1999
CIR AERIAL PHOTOGRAPHY BY ADR, INC.,
PENNSAUKEN, N.J.
900 ft 0 ft 900 ft
274m 0m 274m
PSEG Public Service Electric & Gas Company
ESTUARY ENHANCEMENT PROGRAM
Figure B-5
DENNIS TOWNSHIP SALT HAY FARM
WETLAND RESTORATION SITE
1999 VEGETATION FEATURES
DENNIS TOWNSHIP
CAPE MAY COUNTY, NEW JERSEY
CADD A. DATE APR 17, 2000 SCALE 1" = 900'
FILE 98OT-VEG CHECKED AMM EXAMINED BLH
URS Greiner Woodward Clyde

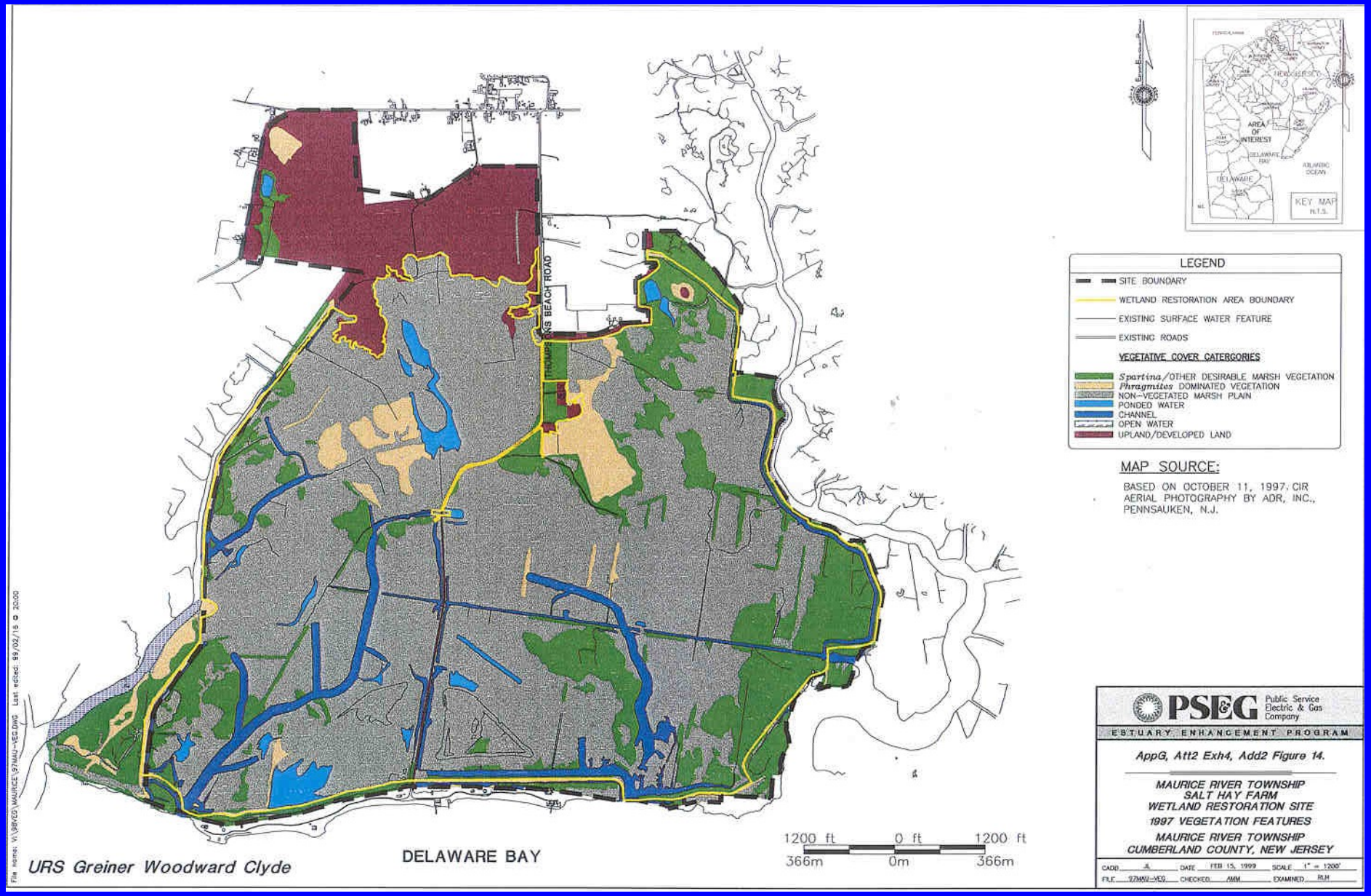
2001


STIPSON'S ISLAND ROAD
WEST CREEK
EAST CREEK
DELAWARE BAY
PENNSYLVANIA
NEW JERSEY
DELAWARE
SITE
MAP SOURCE:
BASED ON AUGUST 25, 2001
CIR AERIAL PHOTOGRAPHY BY
BAE SYSTEMS ADR, PENNSAUKEN, N.J.
LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
VEGETATIVE COVER CATEGORIES
Spartina/OTHER DESIRABLE MARSH VEGETATION
SALT HAY FIELD
Phragmites DOMINATED VEGETATION
Dead Phragmites australis
NON-VEGETATED MARSH PLAIN
PONDED WATER
CHANNEL
OPEN WATER
UPLAND/DEVELOPED LAND
FEET 0 600 1200 1800
METERS 0 288 576
URS
PSEG
ESTUARY ENHANCEMENT PROGRAM
Figure B-5
DENNIS TOWNSHIP SALT HAY FARM
WETLAND RESTORATION SITE
2001 VEGETATION FEATURES
DENNIS TOWNSHIP
CAPE MAY COUNTY, NEW JERSEY
CADD JL DATE APR 10, 2002 SCALE AS SHOWN
FILE 01_DT_VEG CHECKED RLH EXAMINED RLH

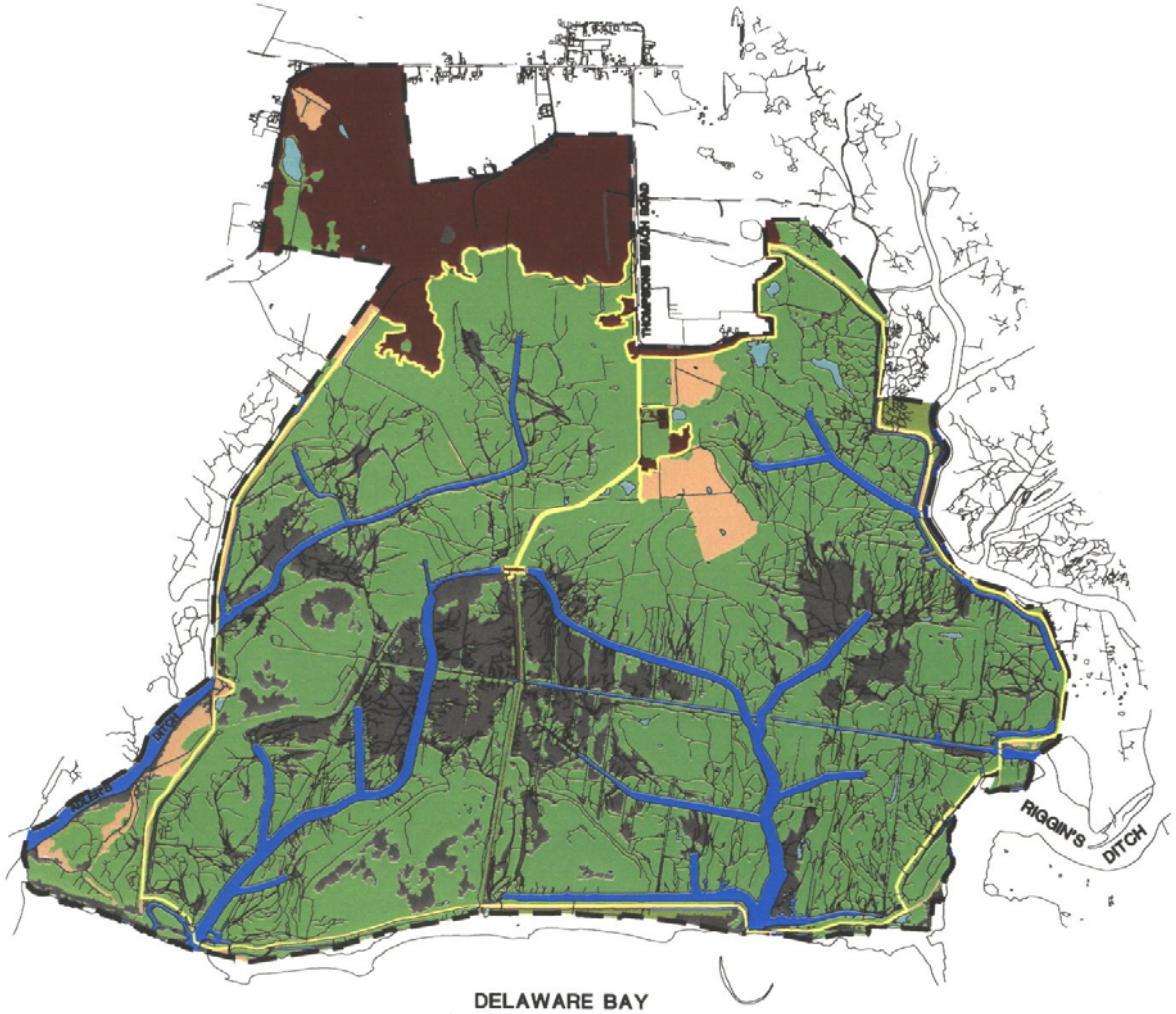
1996

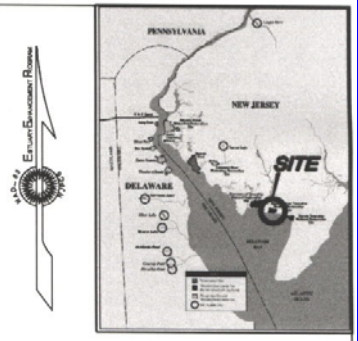

LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
VEGETATIVE COVER CATERGORIES
Spartina/OTHER DESIRABLE MARSH VEGETATION
Phragmites DOMINATED VEGETATION
NON-VEGETATED MARSH PLAIN
PONDED WATER
CHANNEL
OPEN WATER
UPLAND/DEVELOPED LAND
MAP SOURCE:
BASED ON SEPTEMBER 20, 1996 CIR AERIAL PHOTOGRAPHY BY ADR, INC., PENNSAUKEN, N.J.
AREA OF INTEREST
KEY MAP N.T.S.
NS BEACH ROAD
RIGGIN'S DITCH
DELAWARE BAY
1200 ft 0 ft 1200 ft
366m 0m 366m
URS Greiner Woodward Clyde
PSEG Public Service Electric & Gas Company
ESTUARY ENHANCEMENT PROGRAM
AppG, Att2 Exh4, Add2 Figure 13.
MAURICE RIVER TOWNSHIP
SALT HAY FARM
WETLAND RESTORATION SITE
1996 VEGETATION FEATURES
MAURICE RIVER TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY
DATE FEB 15, 1999
SCALE 1" = 1200'

1997


THOMAS'S BEACH ROAD
DELAWARE BAY
1200 ft 0 ft 1200 ft
366m 0m 366m
URS Greiner Woodward Clyde
AREA OF INTEREST
DELAWARE BAY
ATLANTIC OCEAN
DELAWARE
KEY MAP
N.T.S.
LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
VEGETATIVE COVER CATERGORIES
Spartina/OTHER DESIRABLE MARSH VEGETATION
Phragmites DOMINATED VEGETATION
NON-VEGETATED MARSH PLAIN
PONDED WATER
CHANNEL
OPEN WATER
UPLAND/DEVELOPED LAND
MAP SOURCE:
BASED ON OCTOBER 11, 1997, CIR AERIAL PHOTOGRAPHY BY ADR, INC., PENNSAUKEN, N.J.
PSEG Public Service Electric & Gas Company
ESTUARY ENHANCEMENT PROGRAM
AppG, Att2 Exh4, Add2 Figure 14.
MAURICE RIVER TOWNSHIP
SALT HAY FARM
WETLAND RESTORATION SITE
1997 VEGETATION FEATURES
MAURICE RIVER TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY
CADD JL DATE FEB 15, 1999 SCALE 1" = 1200'
FILE 97MAU-VEG CHECKED AMM EXAMINED RLH

2001





LEGEND

- SITE BOUNDARY
- WETLAND RESTORATION AREA BOUNDARY
- EXISTING SURFACE WATER FEATURE
- EXISTING ROADS

VEGETATIVE COVER CATEGORIES

- *Spartina*/OTHER DESIRABLE MARSH VEGETATION
- DESIRABLE MARSH VEGETATION/*Phragmites*
- *Phragmites* DOMINATED VEGETATION
- Dead *Phragmites australis*
- NON-VEGETATED MARSH PLAIN
- PONDED WATER
- CHANNEL
- OPEN WATER
- UPLAND/DEVELOPED LAND

MAP SOURCE:

BASED ON AUGUST 25, 2001
CIR AERIAL PHOTOGRAPHY BY ADR, INC.,
PENNSAUKEN, N.J.

FEET 0 900 1800 2700
METERS 0 432 864

URS

PSEG
ESTUARY ENHANCEMENT PROGRAM

Figure B-4

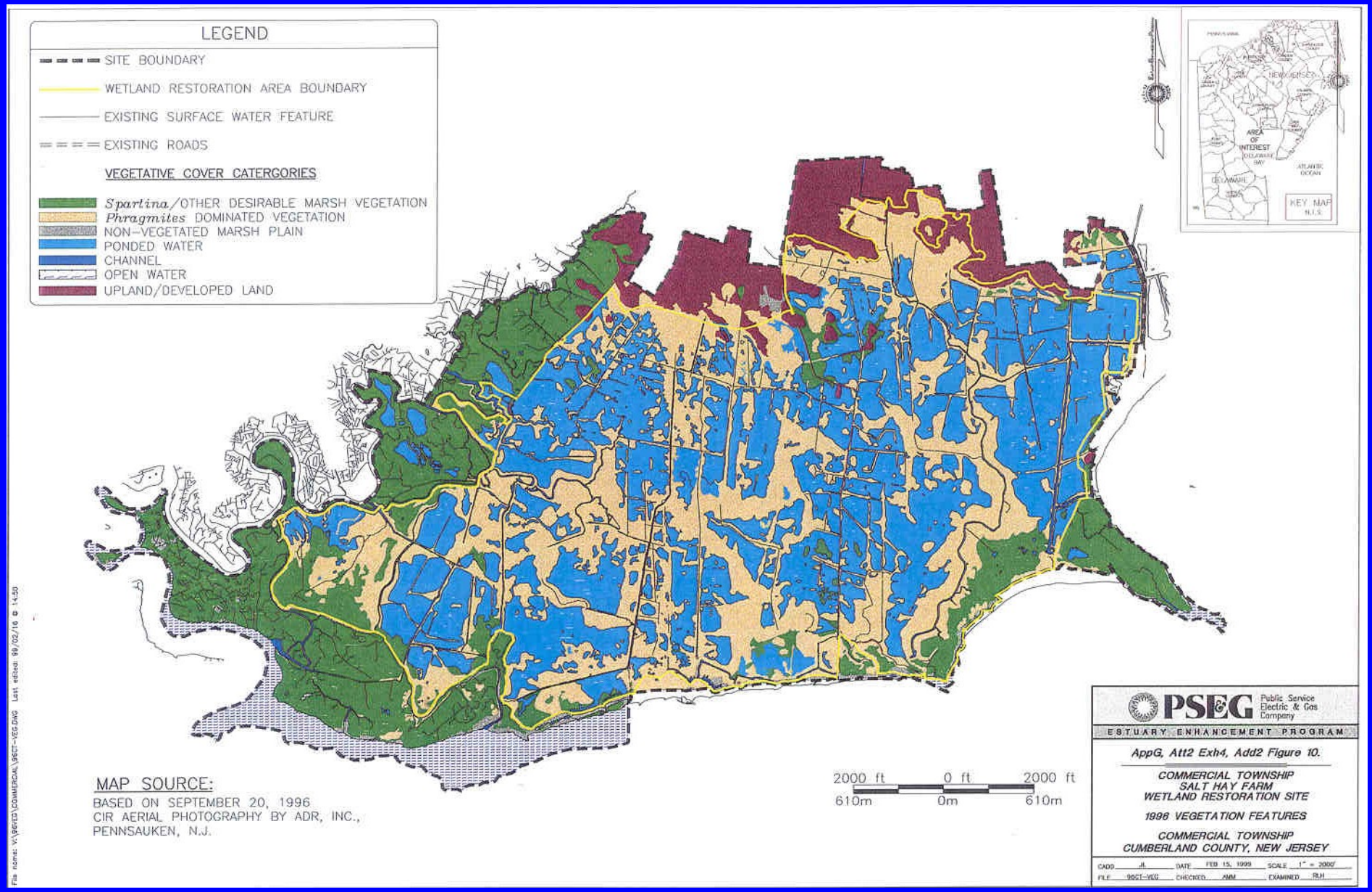
MAURICE RIVER TOWNSHIP
SALT HAY FARM
WETLAND RESTORATION SITE

2001 VEGETATION FEATURES

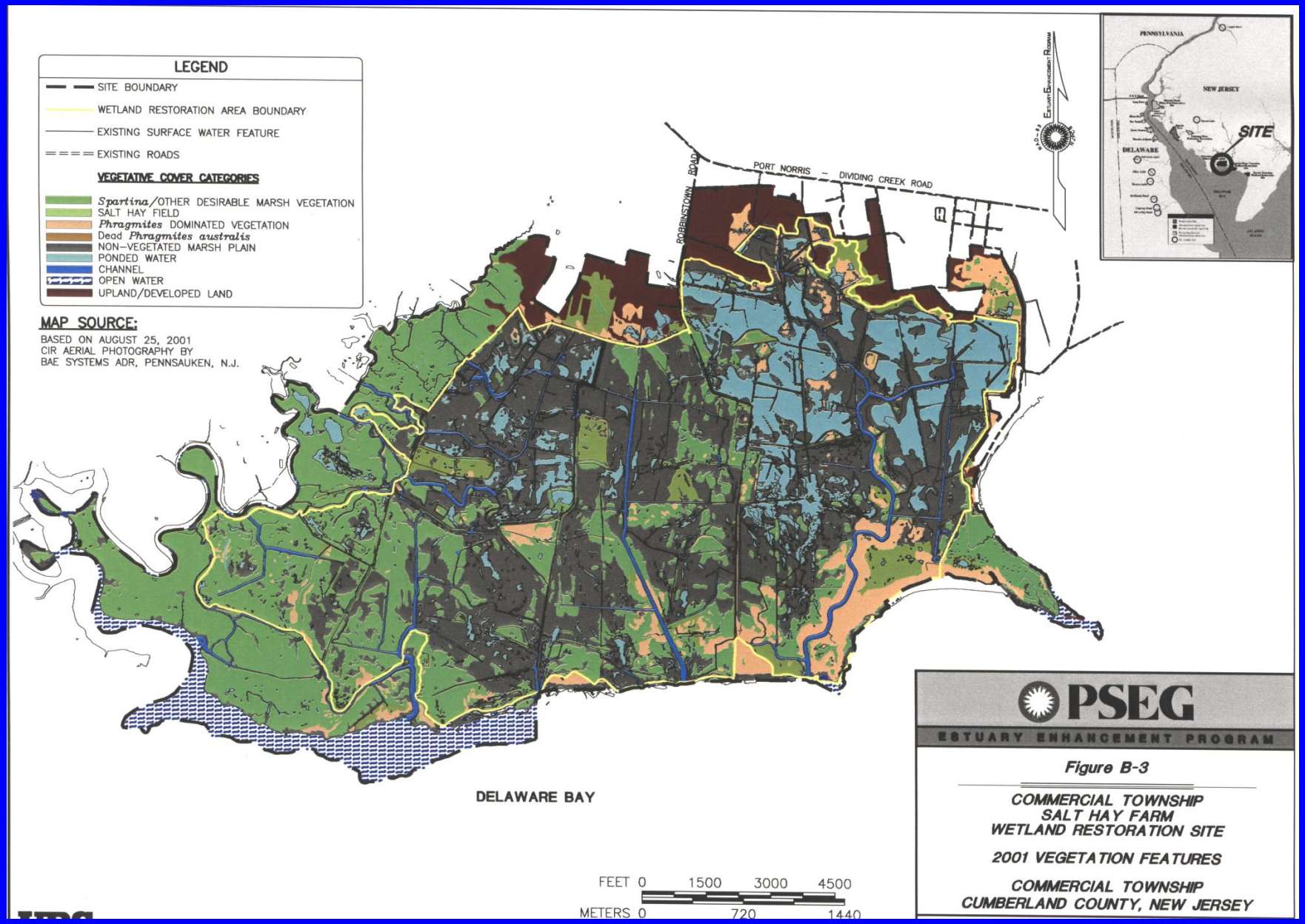
MAURICE RIVER TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY

CADD JL DATE APR 10, 2002 SCALE AS SHOWN
FILE 01_MR_VEG CHECKED RLH EXAMINED RLH

1996

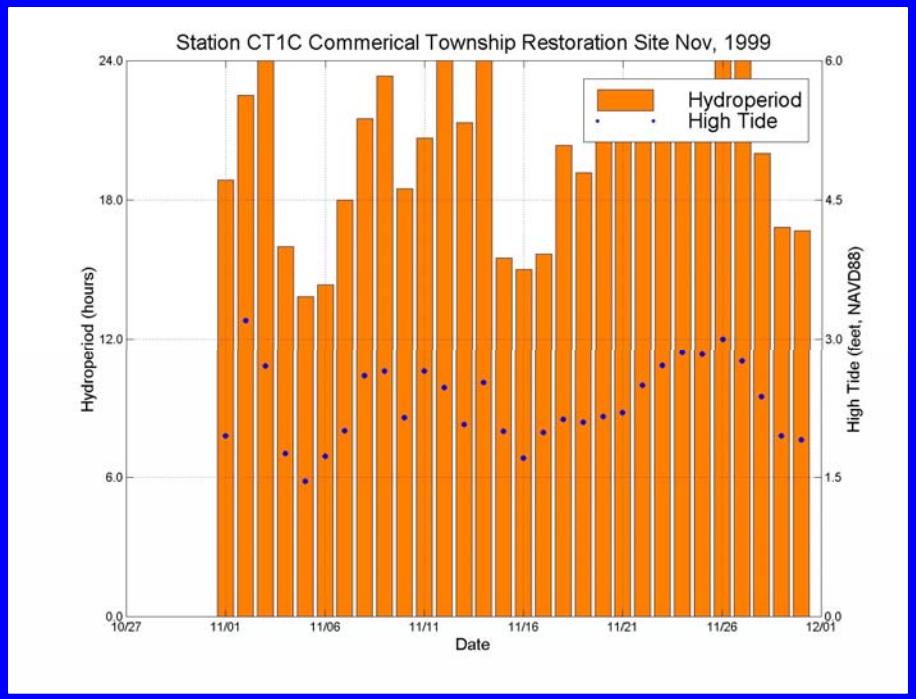

LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
VEGETATIVE COVER CATERGORIES
Spartina/OTHER DESIRABLE MARSH VEGETATION
Phragmites DOMINATED VEGETATION
NON-VEGETATED MARSH PLAIN
PONDED WATER
CHANNEL
OPEN WATER
UPLAND/DEVELOPED LAND
NEW JERSEY
AREA OF INTEREST
DELAWARE BAY
ATLANTIC OCEAN
DELAWARE
KEY MAP
MAP SOURCE:
BASED ON SEPTEMBER 20, 1996
CIR AERIAL PHOTOGRAPHY BY ADR, INC.,
PENNSAUKEN, N.J.
2000 ft 0 ft 2000 ft
610m 0m 610m
PSEG Public Service Electric & Gas Company
ESTUARY ENHANCEMENT PROGRAM
AppG, Att2 Exh4, Add2 Figure 10.
COMMERCIAL TOWNSHIP
SALT HAY FARM
WETLAND RESTORATION SITE
1996 VEGETATION FEATURES
COMMERCIAL TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY
CADD JL DATE FEB 15, 1999 SCALE 1" = 2000'
FILE 96CT-VEG CHECKED AMM EXAMINED RJH

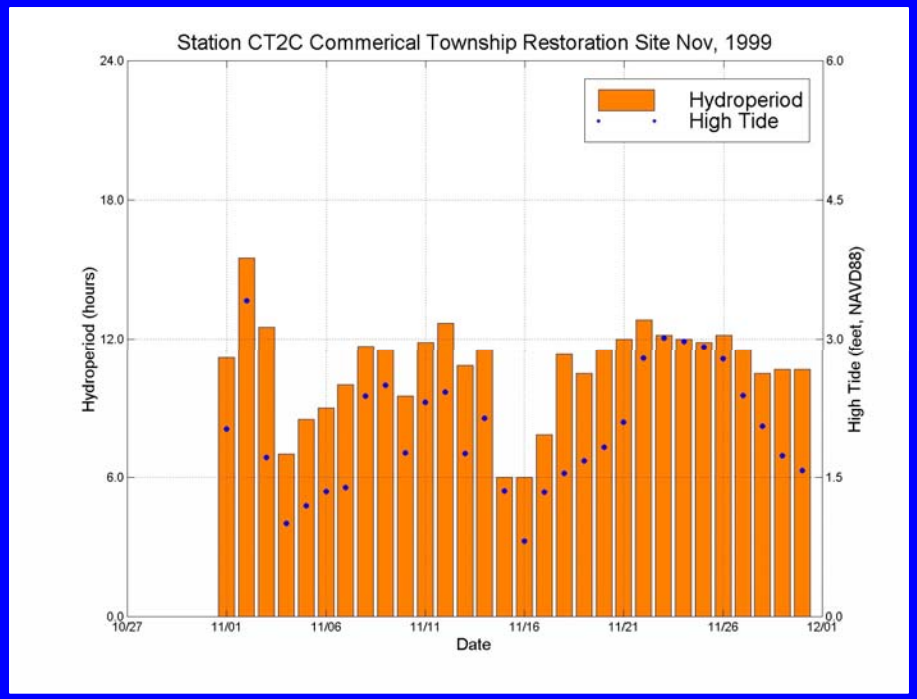
2001


LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
VEGETATIVE COVER CATEGORIES
Spartina/OTHER DESIRABLE MARSH VEGETATION
SALT HAY FIELD
Phragmites DOMINATED VEGETATION
Dead Phragmites australis
NON-VEGETATED MARSH PLAIN
PONDED WATER
CHANNEL
OPEN WATER
UPLAND/DEVELOPED LAND
MAP SOURCE:
BASED ON AUGUST 25, 2001
CIR AERIAL PHOTOGRAPHY BY
BAE SYSTEMS ADR, PENNSAUKEN, N.J.
ROBBINSTOWN ROAD
PORT NORRIS – DIVIDING CREEK ROAD
ESTUARY ENHANCEMENT PROGRAM
PENNSYLVANIA
NEW JERSEY
DELAWARE
SITE
DELAWARE BAY
FEET 0 1500 3000 4500
METERS 0 720 1440
PSEG
ESTUARY ENHANCEMENT PROGRAM
Figure B-3
COMMERCIAL TOWNSHIP
SALT HAY FARM
WETLAND RESTORATION SITE
2001 VEGETATION FEATURES
COMMERCIAL TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY

Wetland Restoration Principles

- 1. State goals clearly, as agreed by the stakeholders; make the goals site specific and realistic.
- 2. Restore degraded sites rather than create new wetlands.
- 3. Select sites in a landscape ecology framework.
- 4. Use ecological engineering.
- 5. Design restored sites to be self-sustaining and guided by adaptive management.
- 6. Plan, implement and continue site monitoring until success is achieved.



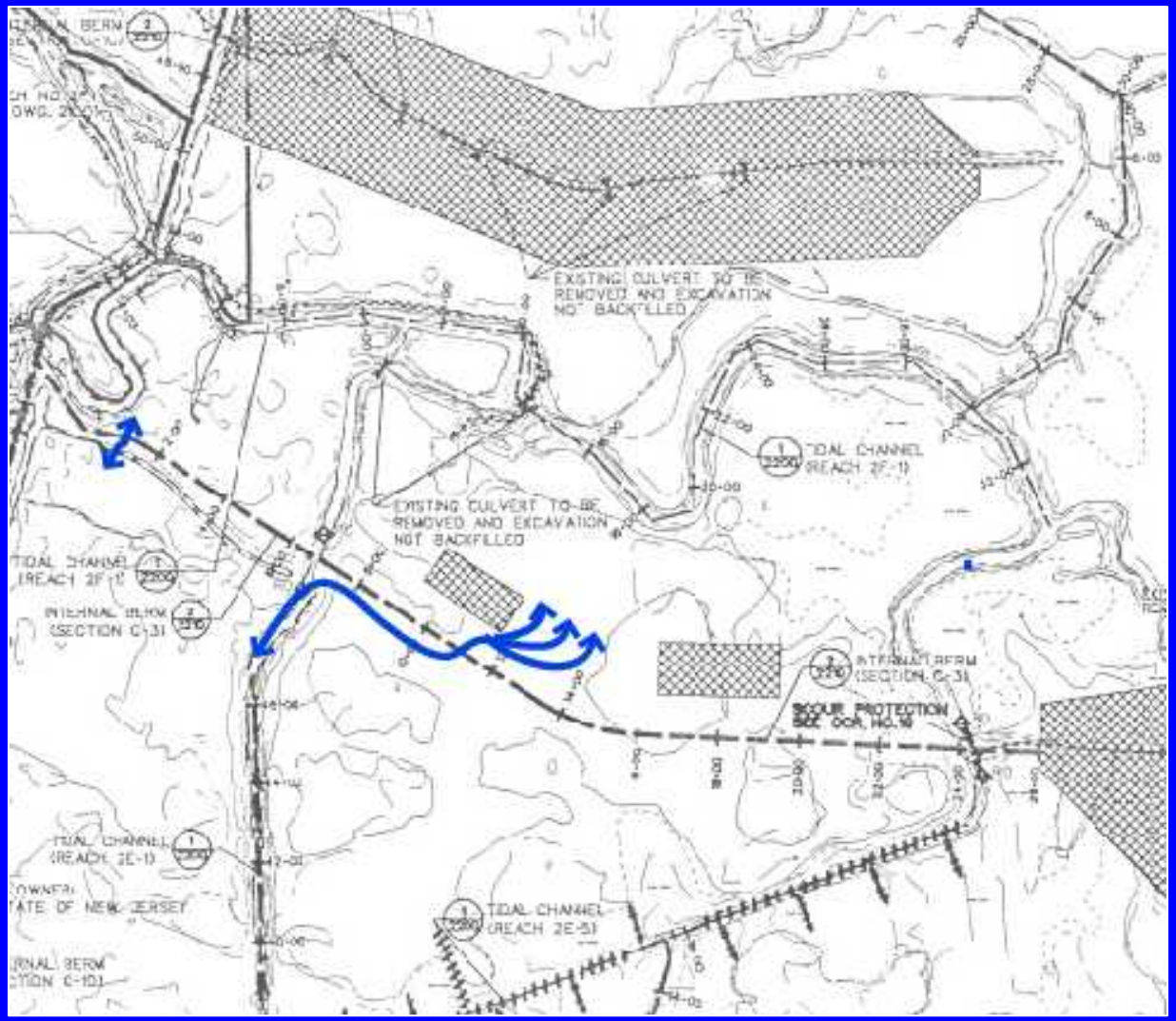


- Site Regions 2F and 2E

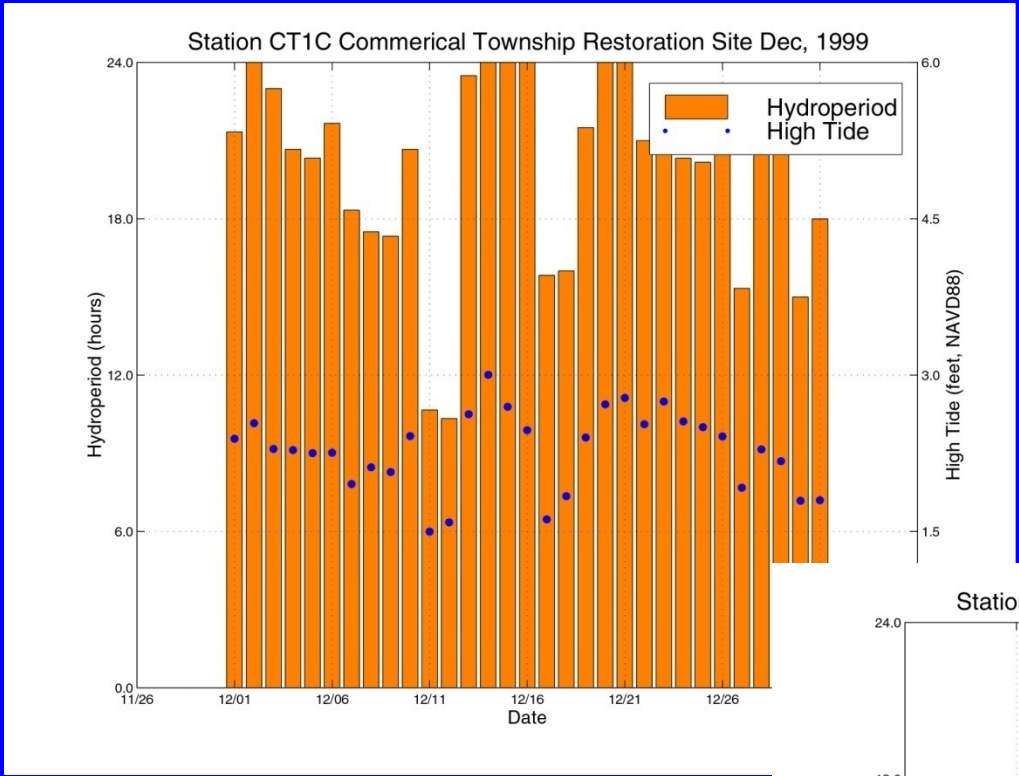
Tidal Analysis

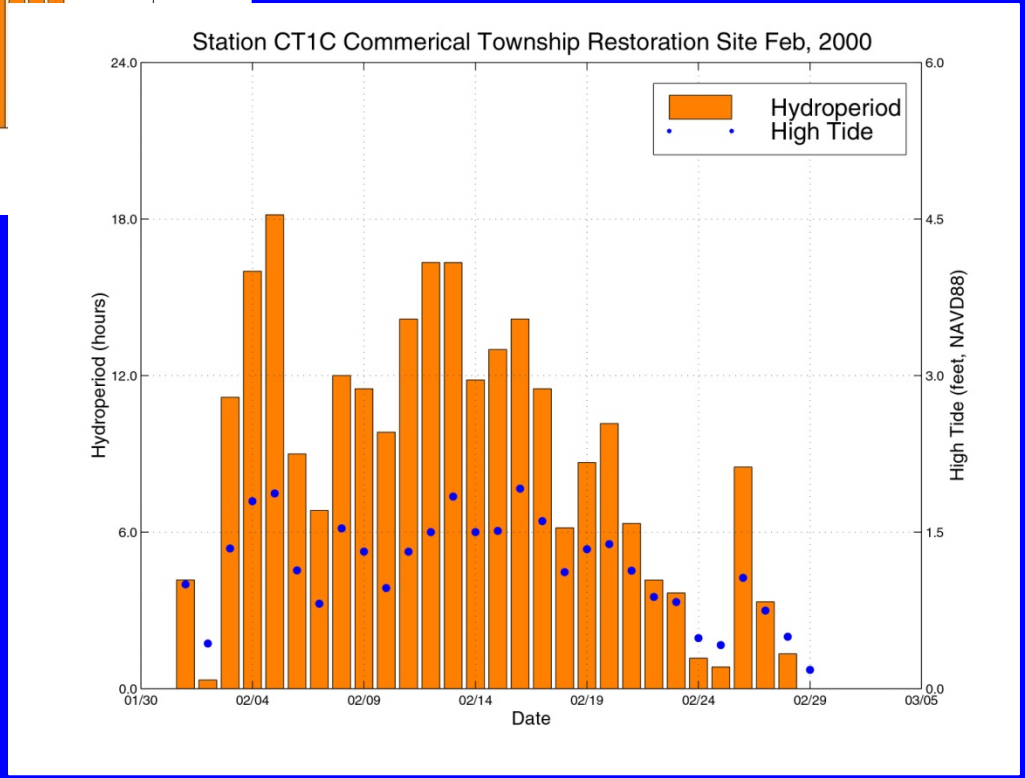
Regional Berm 3C breach – Looking from Region 2E toward 2F

Regional Berm 3C breach – Looking from Region 2F toward 2E

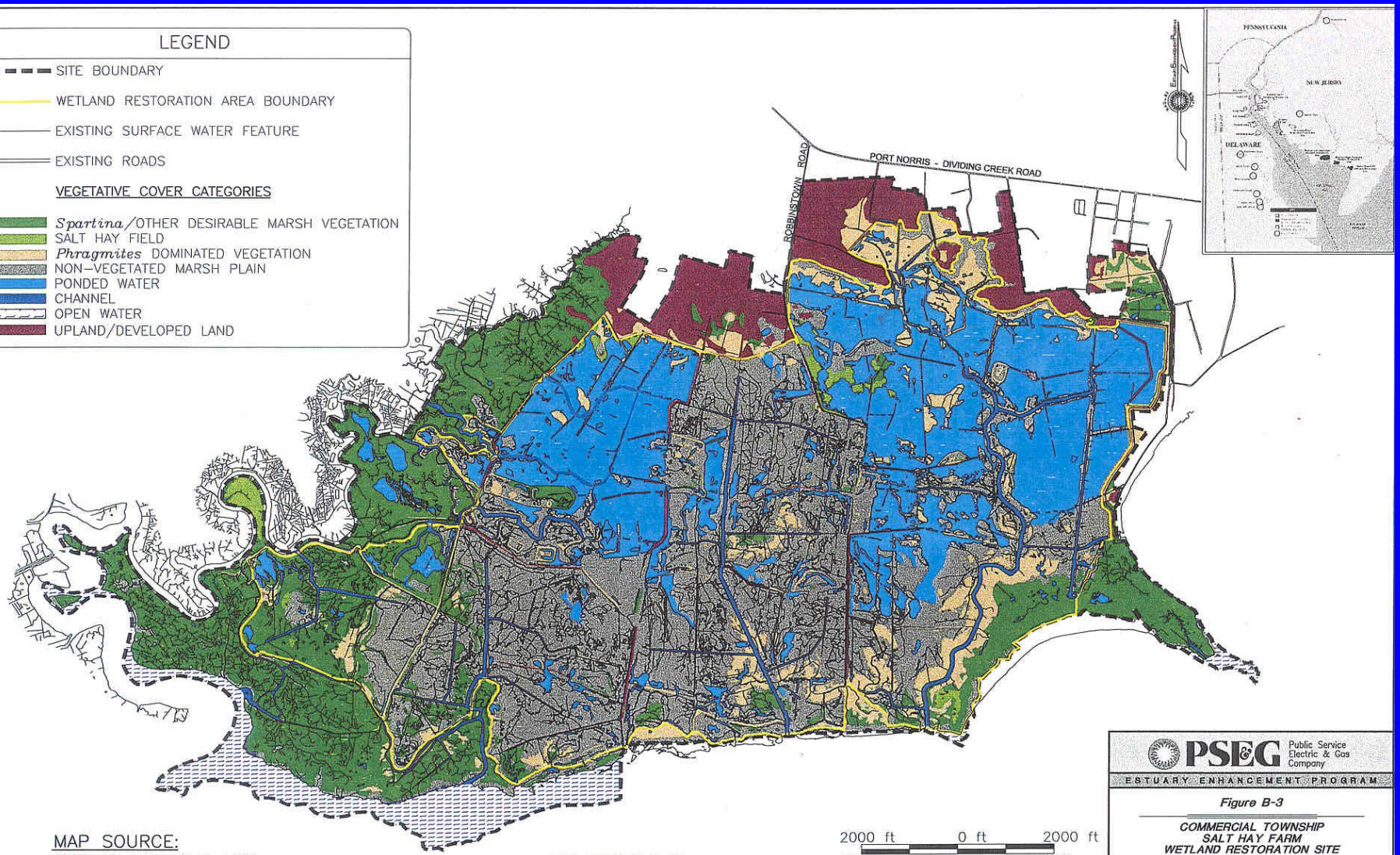


- **Tidal flow from Region 2E into 2F during flood tide**
- **Tidal flow from Region 2F into 2E during ebb tide**
- **No adverse effects on re-vegetation of marsh plain in local area of breach**





- **Tide data indicates improved hydroperiod in Region 2F**
- **Adaptive management recommendation to leave breach & continue evaluation**



MAP SOURCE:
BASED ON OCTOBER 2, 1999
CIR AERIAL PHOTOGRAPHY BY ADR, INC.,
PENNSAUKEN, N.J.

PSEG Public Service Electric & Gas Company

ESTUARY ENHANCEMENT PROGRAM

Figure B-3

COMMERCIAL TOWNSHIP
SALT HAY FARM
WETLAND RESTORATION SITE

1999 VEGETATION FEATURES

COMMERCIAL TOWNSHIP
CUMBERLAND COUNTY, NEW JERSEY

CADD JL DATE APR 17, 2000 SCALE 1" = 2000'
FILE 99CT-VEG CHECKED AMM EXAMINED RLH

File name: X:\2000_(99VEG)\COMMERCIAL\99CT-VEG.DWG Last edited: 10/00/41 @ .1:21

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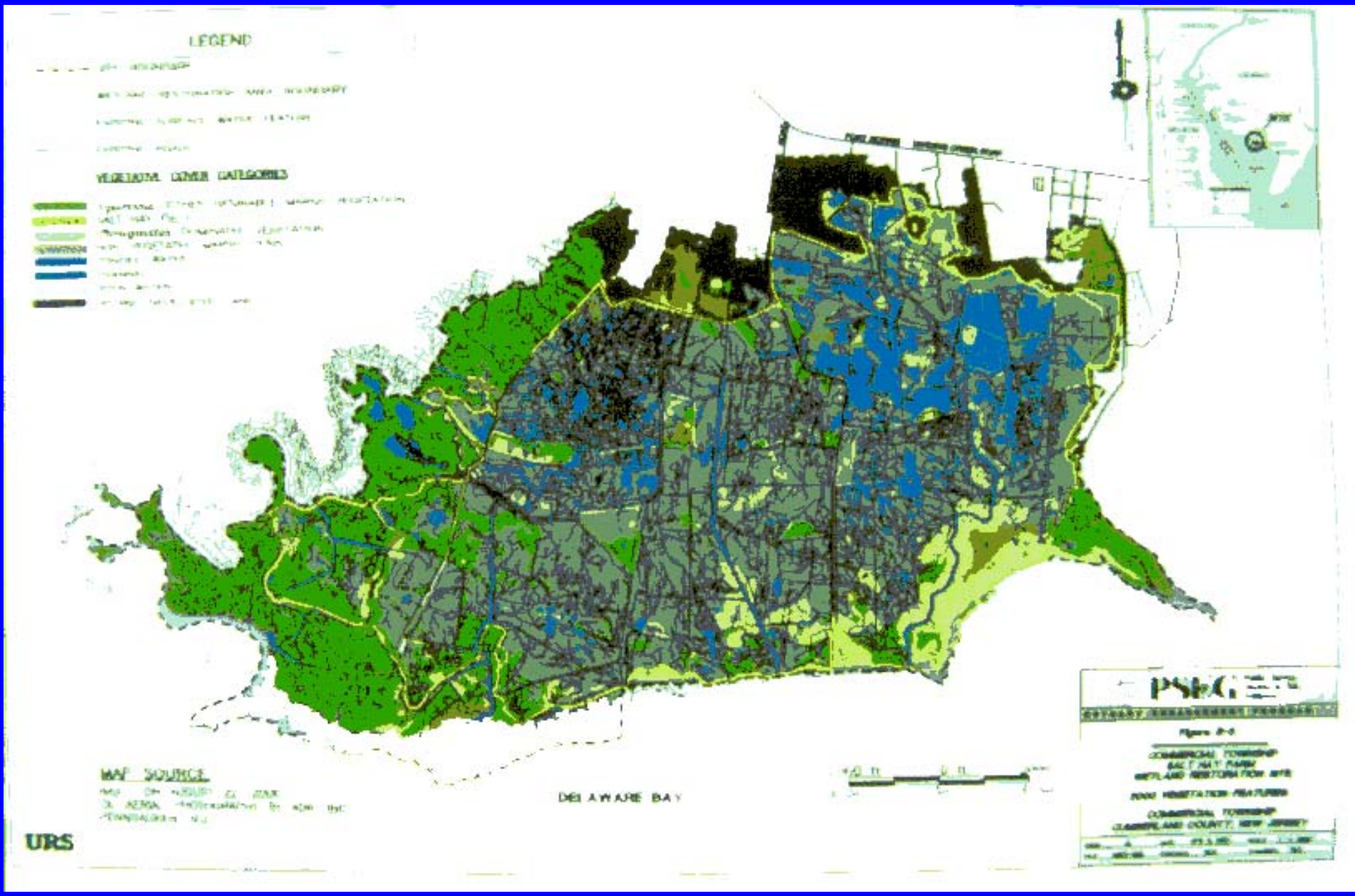
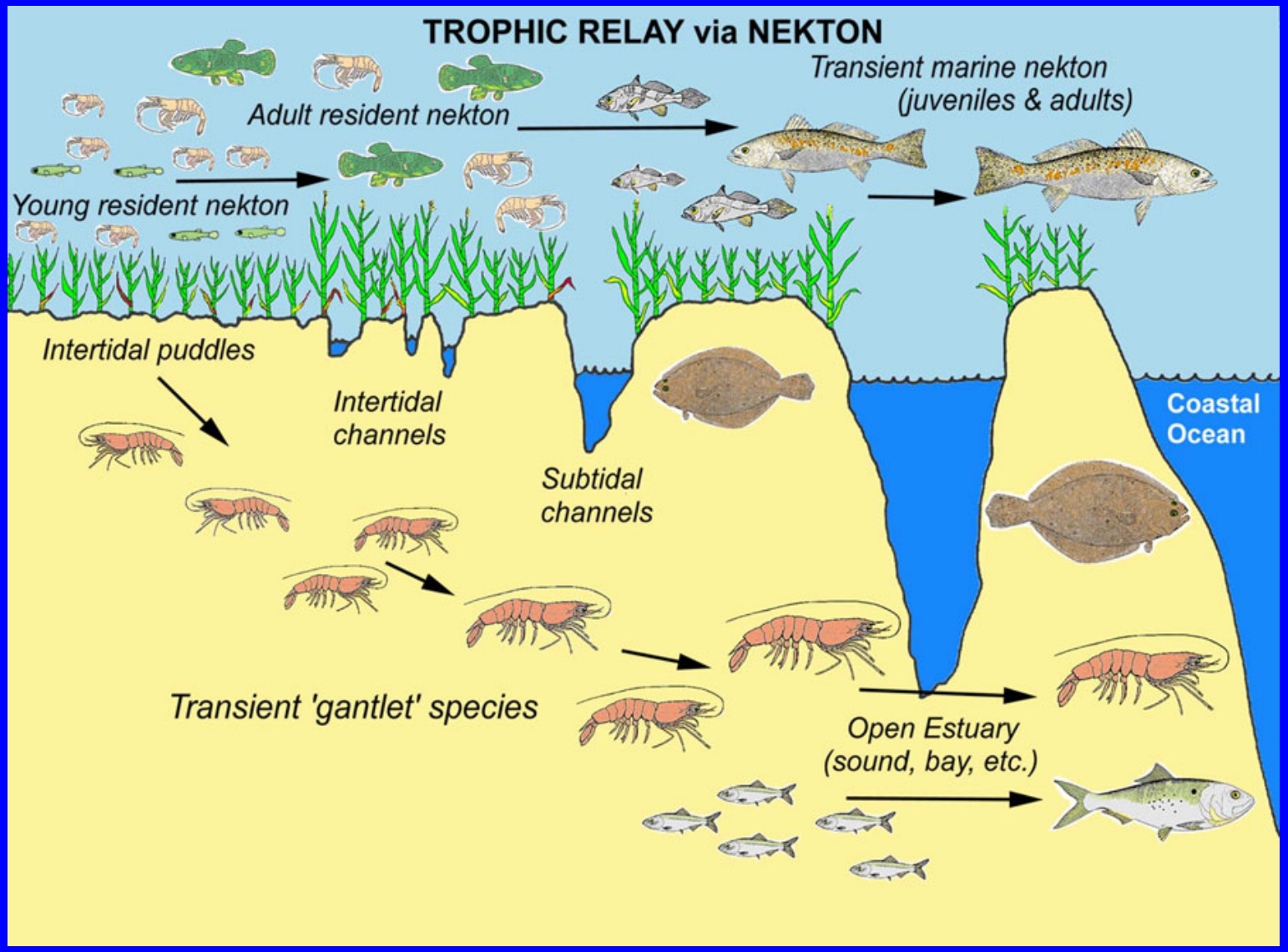

LEGEND
VEGETATION COVER CATEGORIES
MAP SOURCE
DELAWARE BAY
URS
PSEG

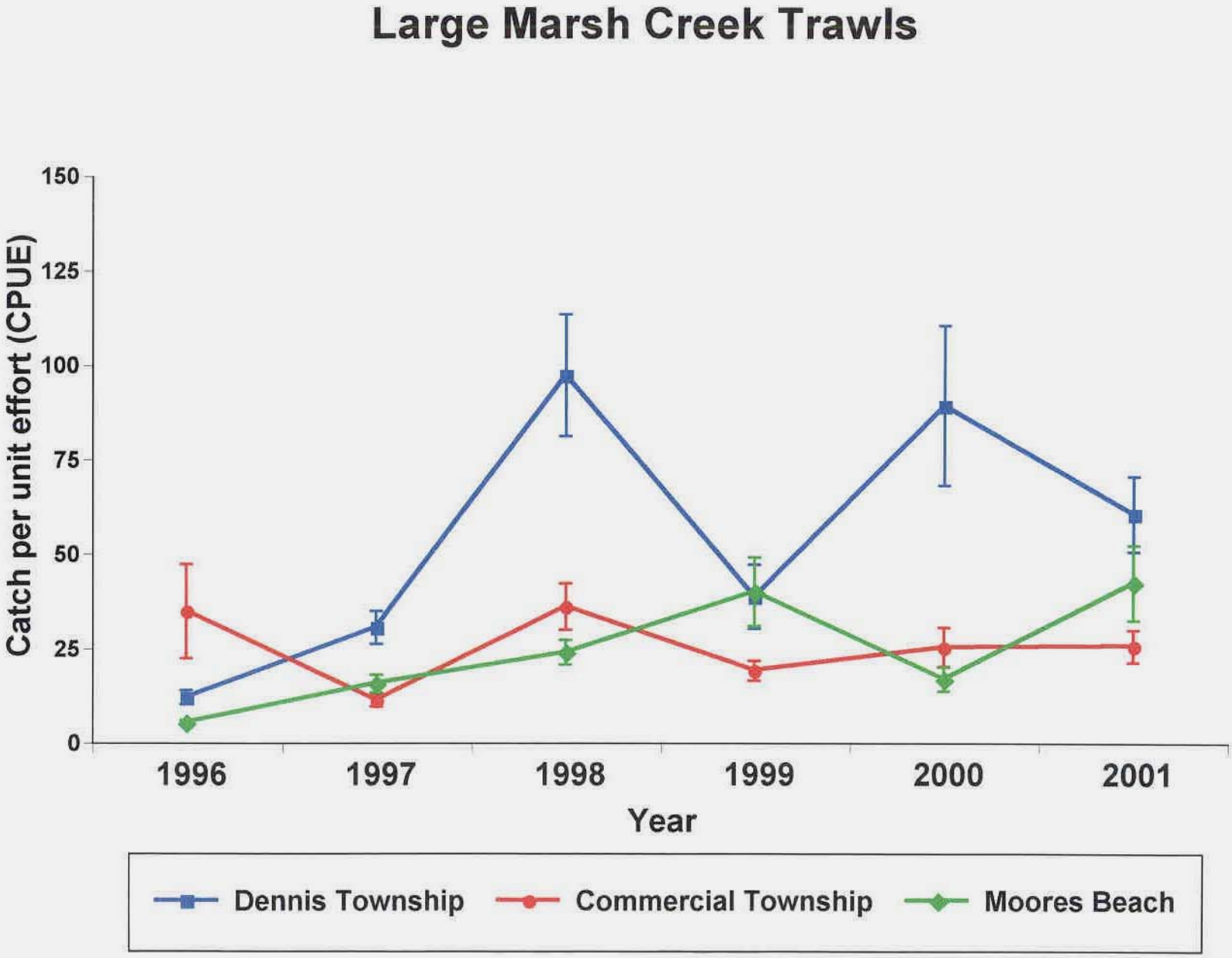
Wetland Restoration Principles

- 1. State goals clearly, as agreed by the stakeholders; make the goals site specific and realistic.
- 2. Restore degraded sites rather than create new wetlands. 3. Select sites in a landscape ecology framework.
- 4. Use ecological engineering.
- 5. Design restored sites to be self-sustaining and guided by adaptive management.
- 6. Plan, implement and continue site monitoring until success is achieved.
- 7. Include functional as well as structural components in performance criteria.

Fundulus heteroclitus

Life styles of the rich and mobile




Large Marsh Creek Trawls
Catch per unit effort (CPUE)
150
125
100
75
50
25
0
1996
1997
1998
1999
2000
2001
Year
Dennis Township
Commercial Township
Moores Beach

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- 8. Consider people and property adjacent to restoration site.
- 9. Put restoration sites under conservation restrictions to insure their protection in perpetuity.
- 10. Encourage public access in site management plans.

Education & Ecotourism

Workshops for educators and environmental organizations

Teacher Workshop at CRW

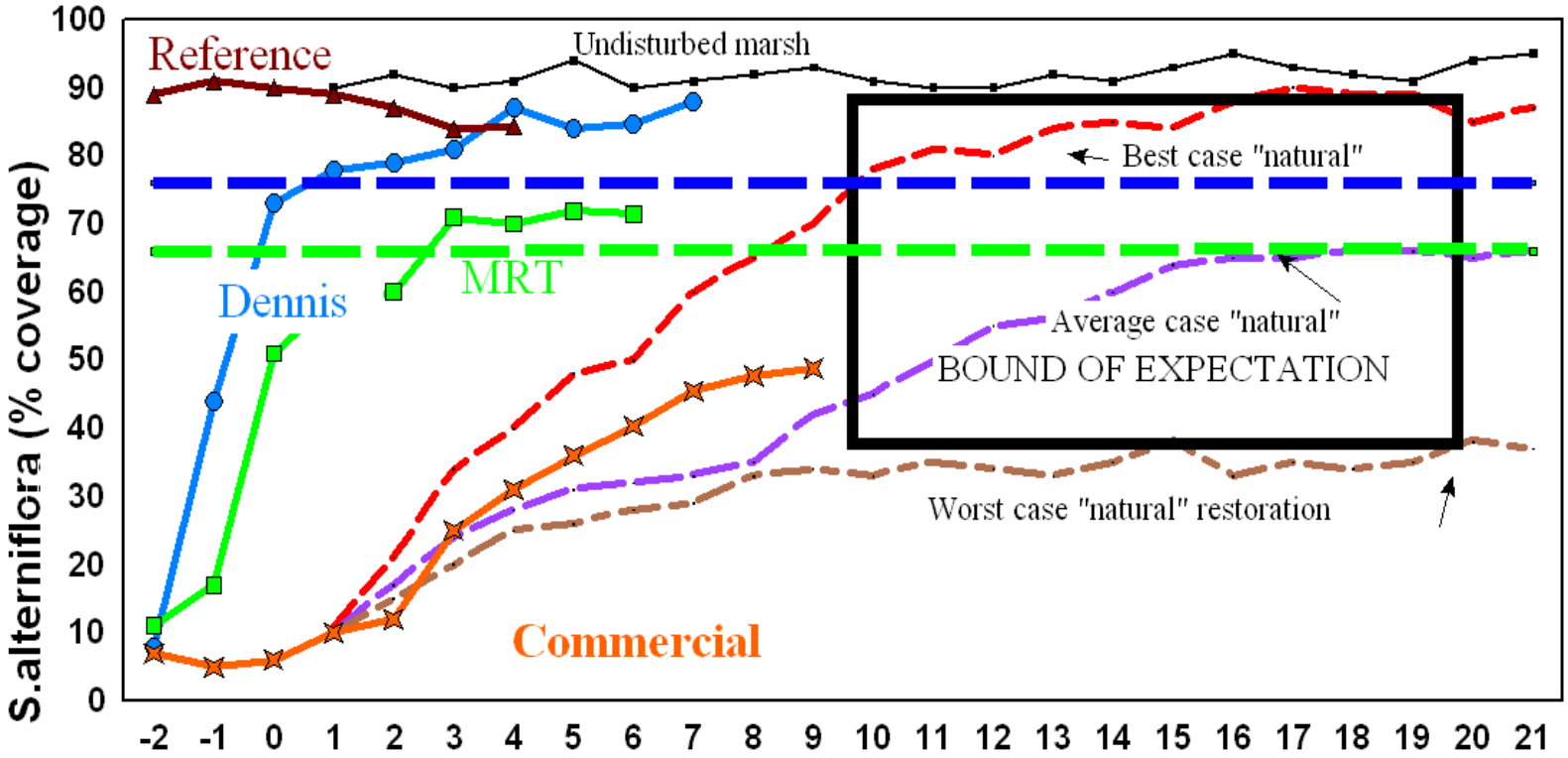
Education and outdoor learning experiences for children

Observation Platform (Alloway Creek Site)

Facilities with wonderful vistas and education signs

Boardwalk at CRW

PSEG


Reference
Undisturbed marsh
Best case "natural"
Dennis
MRT
Average case "natural"
BOUND OF EXPECTATION
Worst case "natural" restoration
Commercial
S.alterniflora (% coverage)
100
90
80
70
60
50
40
30
20
10
0
-2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

Why Control Our Invasive? *Phragmites*

- Eliminates tidal channels
- Steepens channel banks
- Reduces habitat value
  - Birds
  - Fish habitat
  - Fish access
- Reduces detrital export
- Makes mosquito control more difficult
- Decreases diversity within marsh

Phragmites Control Program 1996-97

- Aerial spray of all PSEG *Phragmites* marshes with Glyphosate
- Apparent successful *Phragmites* kill
- Surprising rate of recovery
  - Rhizome survival
  - Apical dominance removal

Public Concerns

- Use of Any Chemicals
- Use of Herbicides (Glyphosate) especially?
- Unwanted actions of Herbicide
- Continued Spraying Forever?

Response to Public Concerns

- Open meeting on *Phragmites* control
  - PSEG scientists vs. Opposition Group
  - Responses limited to 3 minutes

  Opposition effectively repeated short objections

  PSEG scientists unable to keep explanations to time limit

- Restrictions Negotiated

  – PSEG & Regulators agreed to:

  Test program to experiment with various methods for *Phragmites* control

  Reduce the amount of herbicide used

Test Program

Herbicide application

Micro-topography - Scarification

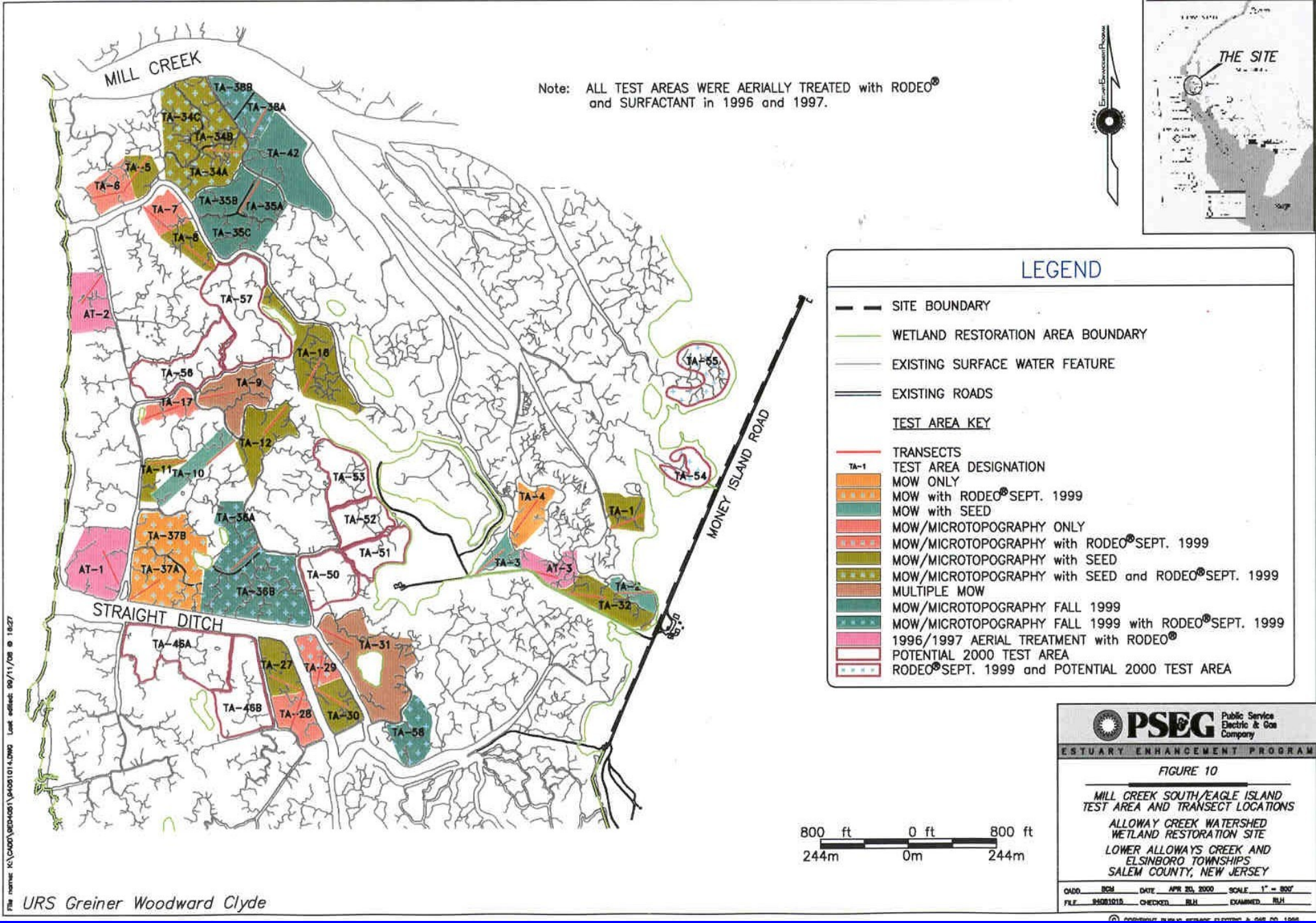
Planting

Mowing, once or many times

Rhizome ripping

Combinations of all these

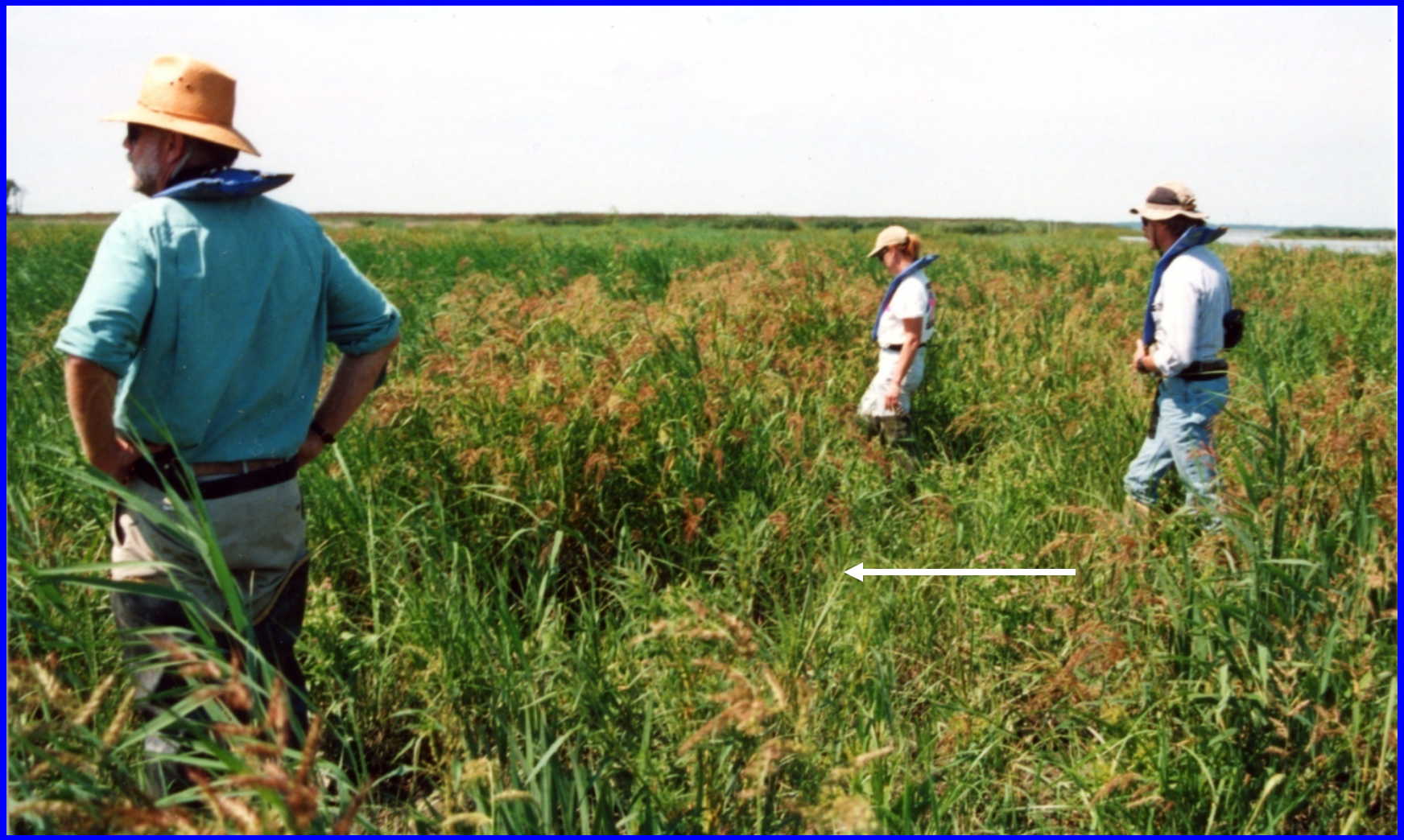
Grazing on *Phragmites*


MILL CREEK
STRAIGHT DITCH
MONEY ISLAND ROAD
Note: ALL TEST AREAS WERE AERIALLY TREATED with RODEO® and SURFACTANT in 1996 and 1997.
THE SITE
TA-38B
TA-38A
TA-34C
TA-34B
TA-42
TA-5
TA-6
TA-34A
TA-35B
TA-35A
TA-7
TA-8
TA-35C
TA-57
AT-2
TA-16
TA-55
TA-56
TA-9
TA-17
TA-12
TA-11
TA-10
TA-53
TA-54
TA-4
TA-1
TA-36A
TA-52
TA-37B
TA-51
AT-1
TA-37A
TA-50
TA-3
AT-3
TA-2
TA-36B
TA-32
TA-46A
TA-31
TA-27
TA-29
TA-46B
TA-28
TA-30
TA-58
800 ft 0 ft 800 ft
244m 0m 244m
LEGEND
SITE BOUNDARY
WETLAND RESTORATION AREA BOUNDARY
EXISTING SURFACE WATER FEATURE
EXISTING ROADS
TEST AREA KEY
TRANSECTS
TA-1 TEST AREA DESIGNATION
MOW ONLY
MOW with RODEO® SEPT. 1999
MOW with SEED
MOW/MICROTOPOGRAPHY ONLY
MOW/MICROTOPOGRAPHY with RODEO® SEPT. 1999
MOW/MICROTOPOGRAPHY with SEED
MOW/MICROTOPOGRAPHY with SEED and RODEO® SEPT. 1999
MULTIPLE MOW
MOW/MICROTOPOGRAPHY FALL 1999
MOW/MICROTOPOGRAPHY FALL 1999 with RODEO® SEPT. 1999
1996/1997 AERIAL TREATMENT with RODEO®
POTENTIAL 2000 TEST AREA
RODEO® SEPT. 1999 and POTENTIAL 2000 TEST AREA
PSEG Public Service Electric & Gas Company
ESTUARY ENHANCEMENT PROGRAM
FIGURE 10
MILL CREEK SOUTH/EAGLE ISLAND TEST AREA AND TRANSECT LOCATIONS
ALLOWAY CREEK WATERSHED WETLAND RESTORATION SITE
LOWER ALLOWAYS CREEK AND ELSINBORO TOWNSHIPS SALEM COUNTY, NEW JERSEY
CADD BGM DATE APR 20, 2000 SCALE 1" = 800'
FILE 94081015 CHECKED BLH EXAMINED BLH
URS Greiner Woodward Clyde

Test Conclusions

- Herbicide is needed regardless of what else is done
- I suggest that a cost/benefit analysis would show that herbicide alone is the most effective means of killing *Phragmites.*

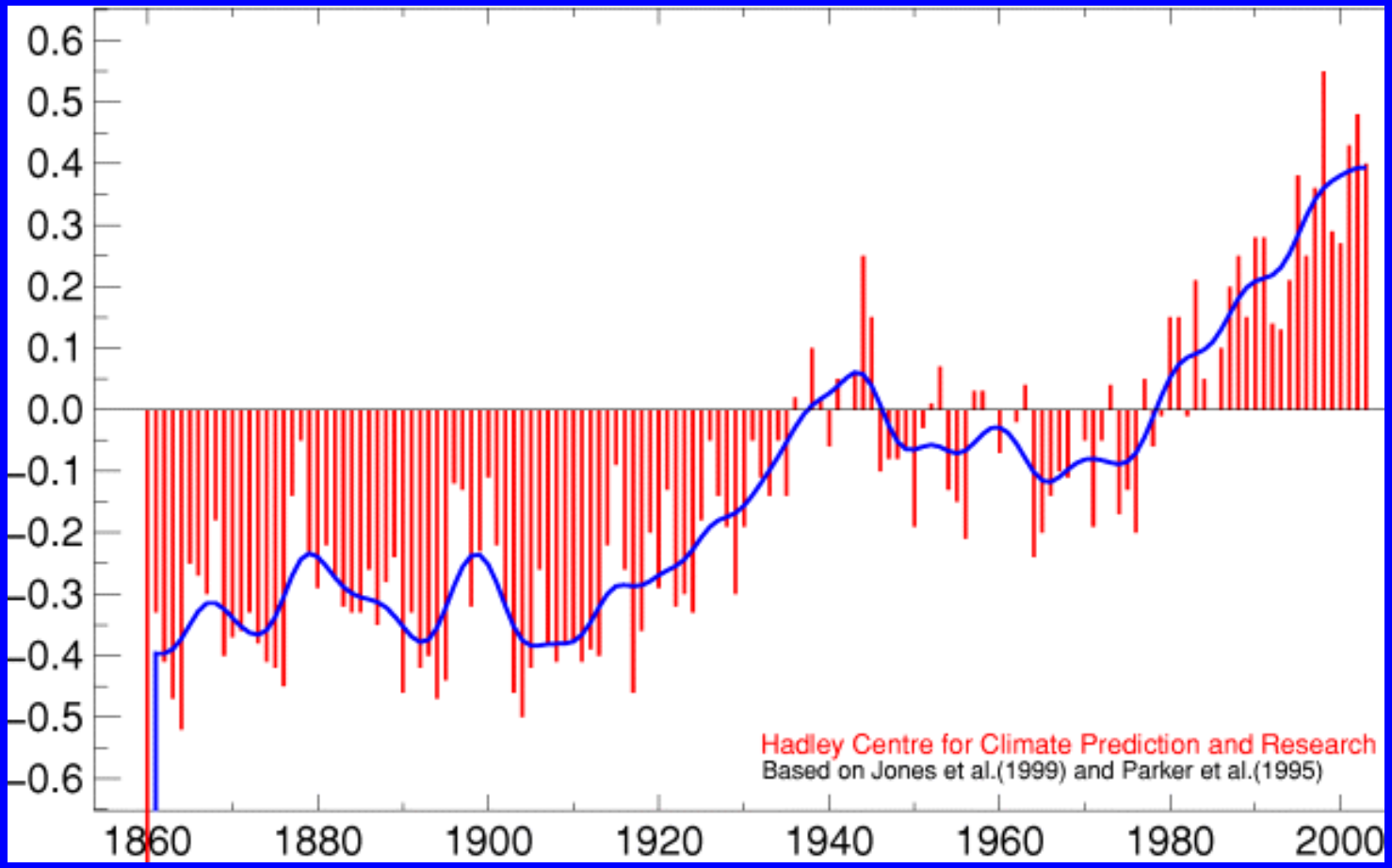
Former *Phragmites* Site



Don’t ignore sea level rise

Sea level rise

- 0.2-0.3mm/yr currently and past 300 yrs or 1 foot per 100 years
- Projections: 0.3 – 0.6mm/yr over next century; not including increases from glacier melting or
  1.5 to 3 times present rate



Global average temperatures 1860-2002 (difference from 1961-1990 normals, °C), using air measurements at land stations and sea surface temperatures measured by ships and buoys. (From the Hadley Centre, U.K. © Crown copyright)

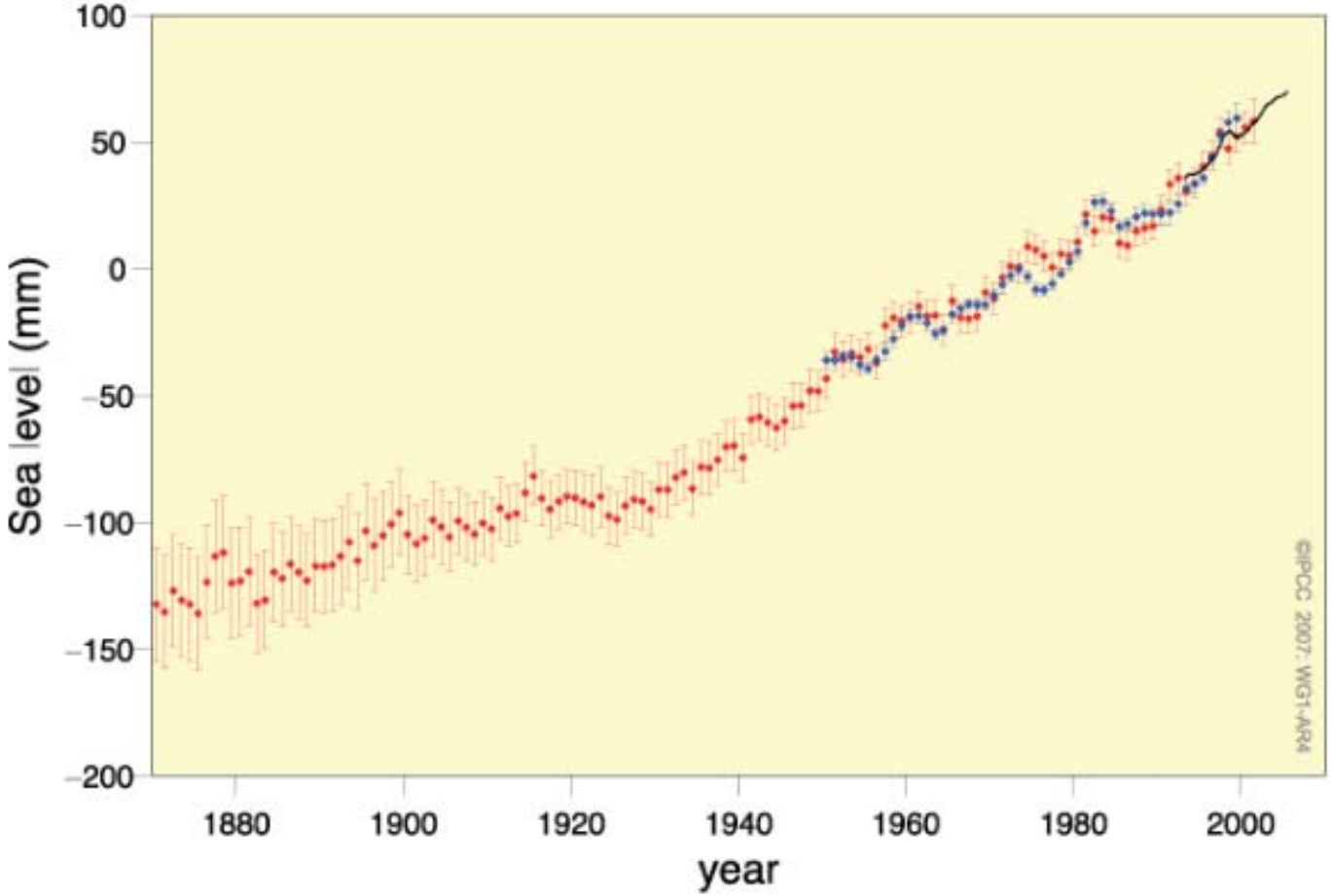


Figure TS.18. Annual averages of the global mean sea level based on reconstructed sea level fields since 1870 (red), tide gauge measurements since 1950 (blue) and satellite altimetry since 1992 (black). Units are in mm relative to the average for 1961 to 1990. Error bars are 90% confidence intervals. {Figure 5.13}

The End