Assessing the economic and ecological impacts of sea level rise for select vulnerable locations within the Middle Peninsula

2009

With well over 1,000 miles of linear shoreline, the Middle Peninsula is under direct threat from accelerated climate change. Specifically, sea level rise will impact coastal communities and infrastructure, as well as the region's natural resources.

Total Long term Costs of Selected Areas in the Middle Peninsula
$187,005,132.10 – $249,451,074.50

This project was funded by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant **FY2008 NA08NOS4190466 Task 12.04 of** the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended. The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Department of Commerce, NOAA, or any of its sub agencies.

Table of Contents

Executive Summary

Climate change is a phenomenon that can be defined as changes in climate (eg. temperature, precipitation and wind) that can be measured over an extended period of time. Although temperature, precipitation and wind are considered the three direct factors attributing to climate change, as they change they have countless anthropogenic and ecological indirect impacts:

Water Resources may become stressed as the frequency of droughts increase; also the frequency and intensity of flooding events may increase.

Agriculture may be at increased risk of heat stress as well as pest outbreaks and weeds; also changes in crop yield may prevail.

Biodiversity may be impacted by shifts in specie distribution and/or loss of species and habitats.

Forests are at increased risk of insect outbreaks, forest fires, and intrusion of invasive species.

Coastal Ecosystems may experience increased coastal erosion and risk of pollution due to inundated infrastructure [as a result of sea level rise as well as storm events]; increased rates of saltwater intrusion into freshwater resources may also occur.

Aquatic Systems may lose near shore habitats and coastal wetlands as sea level rises; shifts in specie ranges and distributions may occur.

Public Health may be exposed to more heat related stress, an increase in vector borne illnesses (ie. West Nile); and reduced summer air quality due to increased production of ground level ozone may impact public health.

Transportation and road access may become limited as the frequency of flooded roads may occur due to sea level rise and intense storms; also this will increase the maintenance costs of impacted/damaged roads.

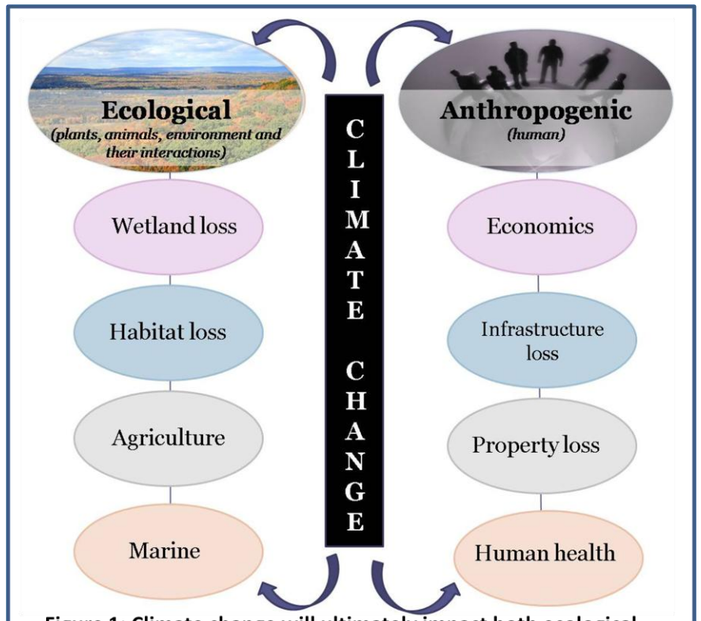


Figure 1: Climate change will ultimately impact both ecological and anthropogenic dynamics.

Infrastructure (public and private) may be impacted if located within floodplains or low lying coastal areas, causing insurance premiums to increase; loss of private and public infrastructure due to sea level rise (loss of private and public investments) may also occur.

Emergency Response may have to redefine service areas and services as roads become flooded due to sea level rise and/or storm events; also there may be increased demands for services related to extreme weather events**.**

According to the Intergovernmental Panel on Climate Change (IPCC), Virginia temperatures are estimated to increase by 3°F in the winter, spring and summer, and increase 4°F in the fall, while precipitation is estimated to increase by 20% in all seasons by 2100. The National Wildlife Federation predicts that within the Upper Tidewater Region (where the Middle Peninsula is located), sea level will rise 11.2 inches by 2050 and 27.2 inches by 2100. However, other reports document variations in quantitative estimates of sea level rise, due to variable discrepancies amongst the scientific models being utilized.

Consequently, due to the unbiased geographic nature of climate change, the Middle Peninsula will experience both ecologic and anthropogenic impacts (Figure 1). Therefore to understand these implications the Middle Peninsula Planning District Commission (MPPDC), funded through the Virginia Coastal Zone Management (CZM) Program, has began a three year endeavor to specifically assess and discuss the economic and ecologic impacts of climate change. Working closely with member localities and a variety of stakeholder groups, year one of this project has focused on the collection, assessment and analysis of potential ecologic (ie. wetlands, conserved lands, etc) and anthropogenic (ie. personal property, public property, etc) impacts of climate change, particularly due to sea level rise. Additionally an economic and ecological impact assessment of sea level rise in select locations within the Middle Peninsula was conducted.

In February 2009, a Climate Change Advisory Workgroup, consisting of appointed county representatives and stakeholders groups, including transportation, sanitation, public health, recreation, science research, planners, and local businesses, was established. The Workgroup was tasked with identifying critical anthropogenic and ecological impacts of climate change and sea level rise to their respective sector as well as to the region. A series of monthly meetings with the Workgroup pin pointed specific impacts of concern which were then able to be mapped and assessed using GIS (Geographic Information System).

Since LIDAR data for the Middle Peninsula is not currently available, GIS provided a format for assessing sea level rise impacts using elevation/topographic data. MPPDC assessed economic and ecological impacts of a 1ft sea level rise by 2050. *Please note that these estimates may be considered conservative, especially as recent reports highlight accelerated rates of climate change.*

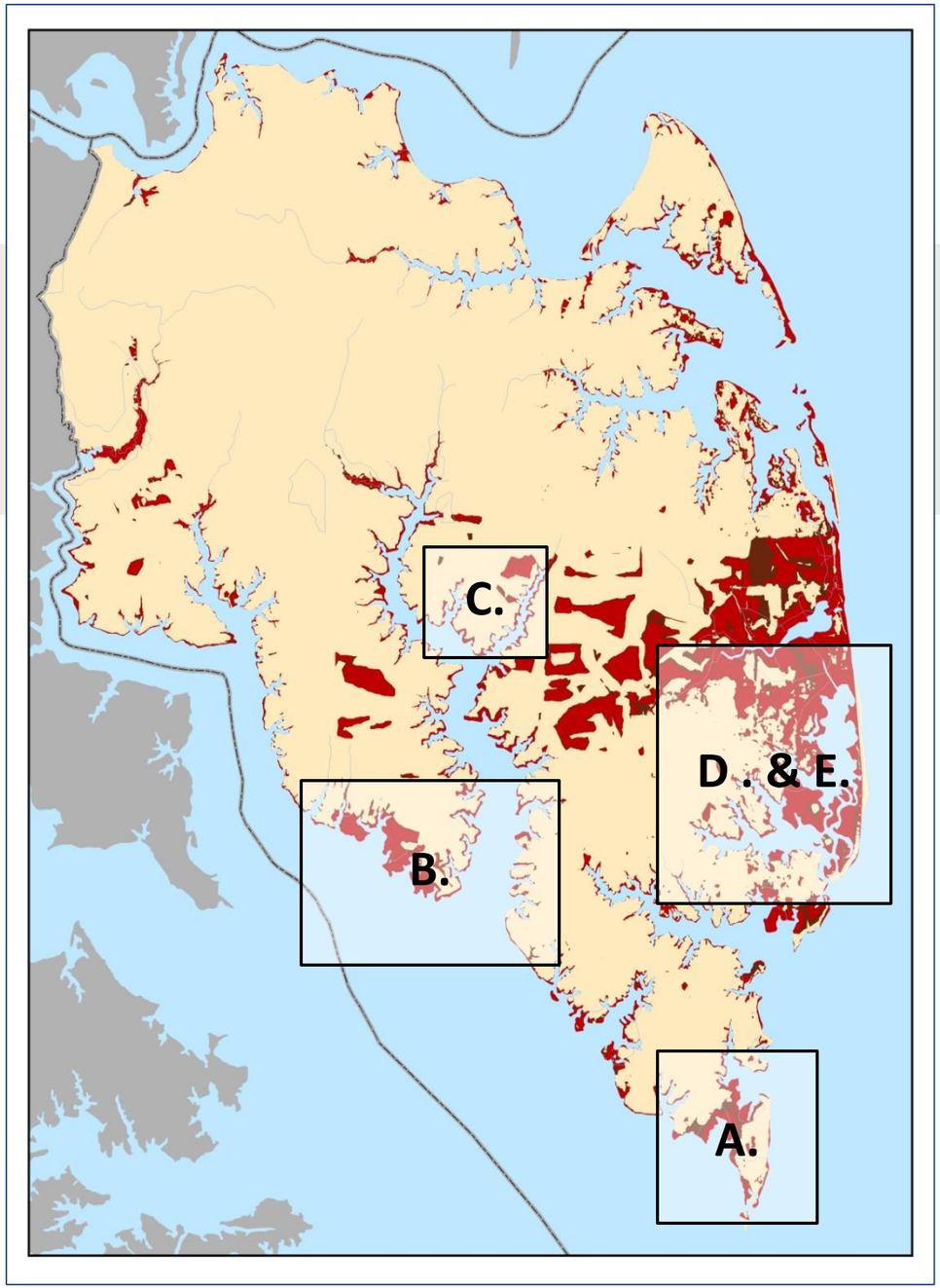
To access the impacts, the number of structures (eg. homes, business, onsite disposal systems, roads and shoreline hardening) and the amount of wetland acres inundated by sea level rise were quantified for select areas of the Middle Peninsula. Cost estimates were then collected in order to calculate the total long term impact costs of sea level rise. The table below depicts the total long term impact costs counties may endure as sea level continues to rise.

Table 1: Total (ie. Anthropogenic costs + Ecological costs) long term impact costs of select areas within the Middle Peninsula

County	Total Long Term Impact Costs
Mathews	$87,307,088.81 – $95,310,925.72
King and Queen	$12,241,827.90 – $28,769,415.95
Middlesex	$44,735,683.61 – $45,604,189.41
King William	$4,184,119.88 – $22,808,296.26
Gloucester	$26,453,620.67 – $38,895,790.63
Essex	$12,082,791.25 – $18,062,456.50
TOTAL COSTS:	**$187,005,132.10 – $249,451,074.50**

This document is a consortium of selected areas within the Middle Peninsula that highlight the economic and ecological impacts of sea level rise. This document also begins to pose pertinent questions that local governments will need to consider concerning public health, safety and welfare.

Mathews County

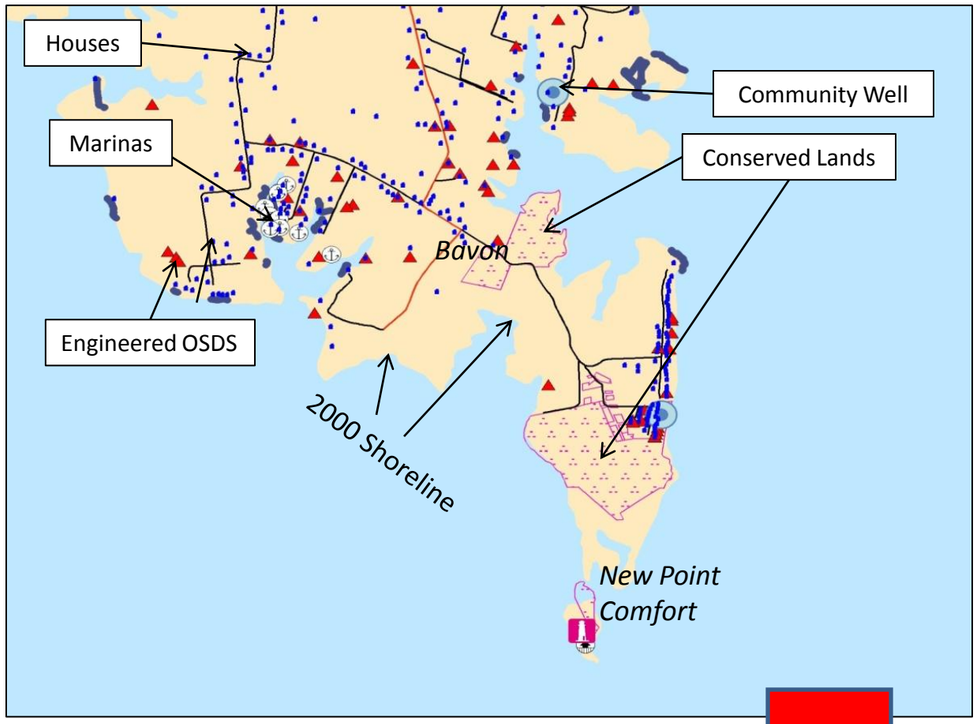


A. New Point Comfort
B. Bohannon
C. Retz
D. Onemo and Diggs
E. Onemo and Diggs – Ecological impacts

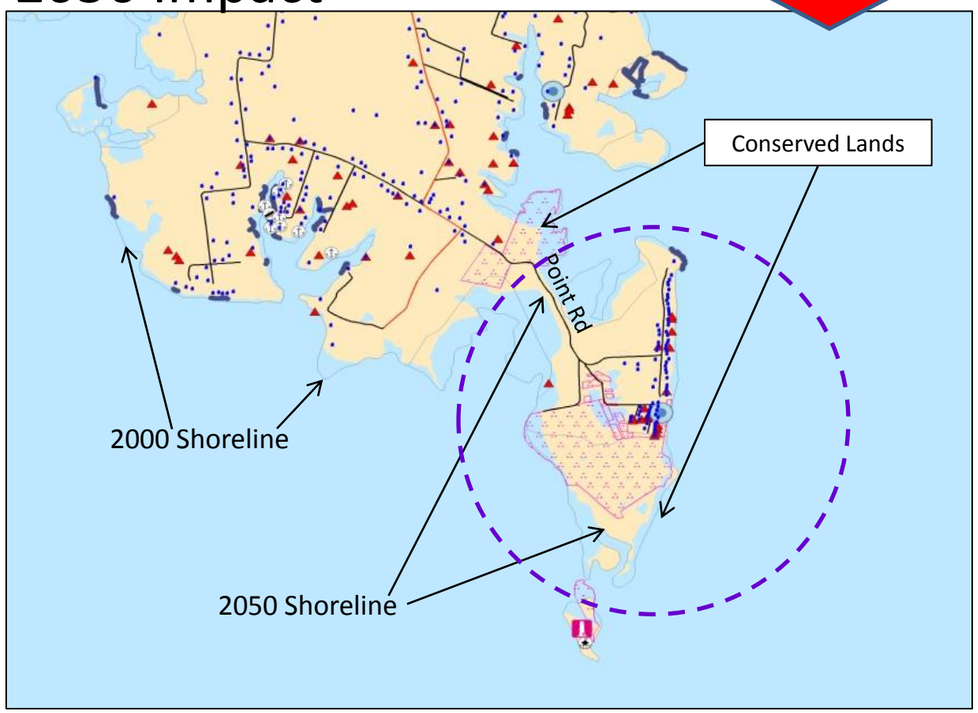
A

New Point Comfort: If Point Road floods consider the amount of infrastructure impacted

2000 Current



2050 Impact



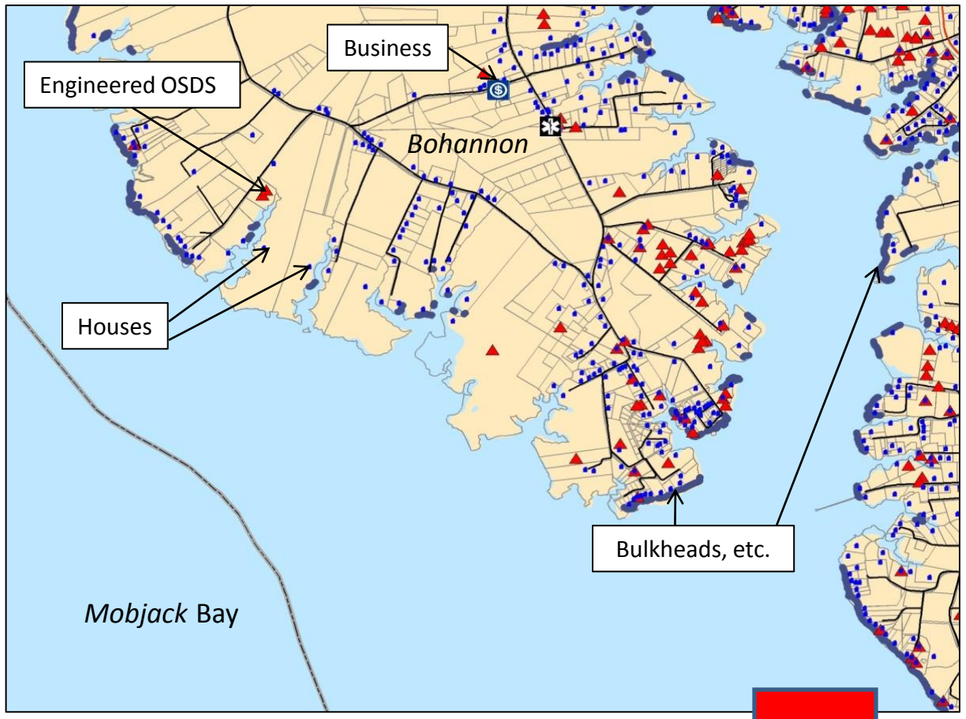
Infrastructure	Amount of Structures Impacted	Average Cost	Total Cost
Houses	72	$228,669 Estimated median house or condo value in 2007 (City-Data.com)	$16,464,168
Engineered OSDS	20	$18,000 (MPPDC Regional Estimate)	$360,000
Conventional OSDS	52	$4,000 (MPPDC Regional Estimate)	$208,000
Community Well (with 41 connections)	1	$40,000 (MPPDC Regional Estimate)	$40,000
Private Wells	31	$3,000 (MPPDC Regional Estimate)	$93,000
Shoreline Harding	658.122 ft of riprap	$60/foot (University of Minnesota)	$39,487.37
VDOT Road Segments	1,250.67 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $186,349.83 Long term: $931,749.15
TOTAL			**Short term:$17,391,005.20** **Long term: $18,136,404.52**

- How will residents get to their house?
- How do residents get access to schools?
- How are OSDS and wells serviced?
- How are the roads serviced?
- How will conserved lands be accessed?
- How will EMS service this area?

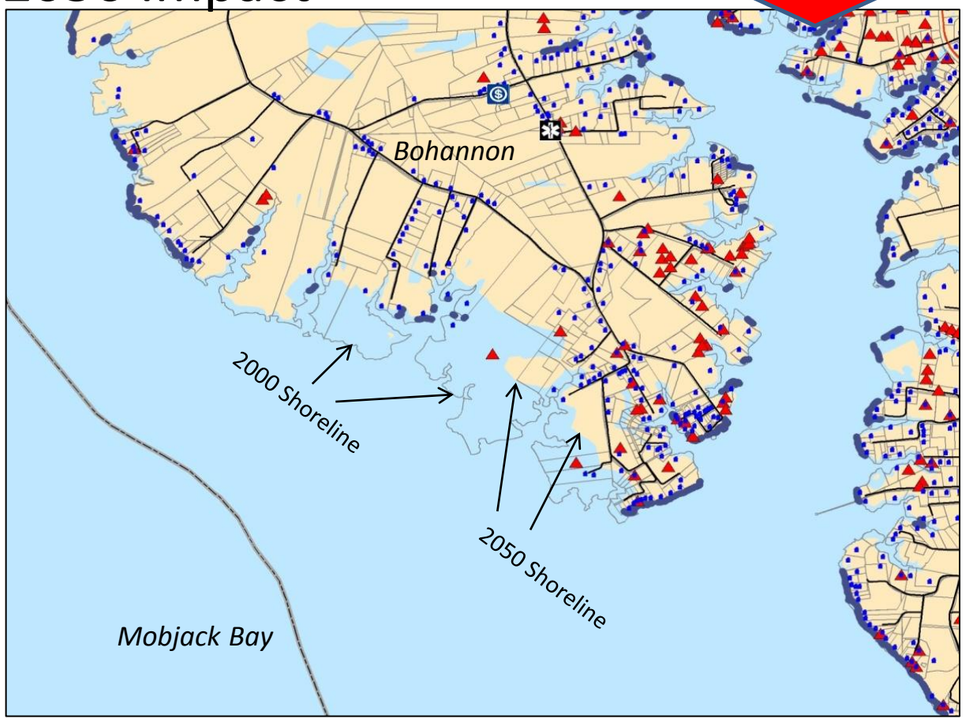
B

Bohannon: Inundation of low lying coastal areas will cause redistribution and/or lose of tax revenues

2000 Current



2050 Impact

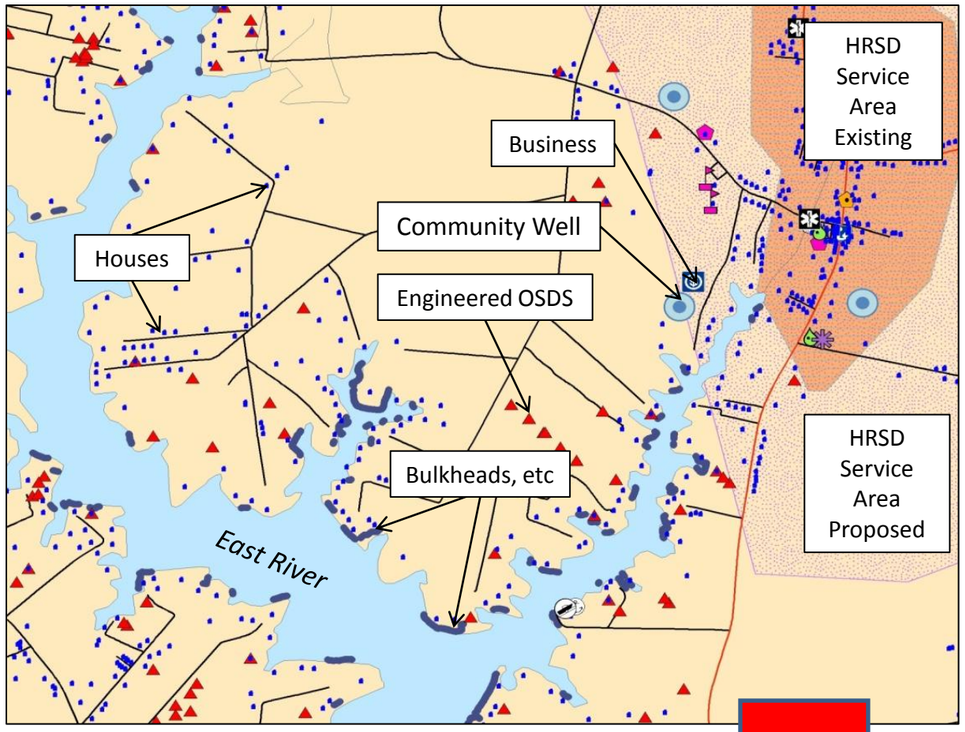


Infrastructure	Amount of flooded structures	Average Cost	Total Cost
Houses	39	$228,669 Estimated median house or condo value in 2007 (City-Data.com)	$8,918,091
Engineered OSDS	8	$18,000 (MPPDC Regional Estimate)	$144,000
Conventional OSDS	31	$4,000 (MPPDC Regional Estimate)	$124,000
Private Wells	39	$3,000 (MPPDC Regional Estimate)	$117,000
Shoreline Hardening	13,928.04 ft	$450/foot (MPPDC Regional Estimate)	$6,267,618
VDOT Road Segments	391.35 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $58,311.15 Long term: $291,555.75
TOTAL			**Short term: $15,629,020.15** **Long term: $15,862,264.75**

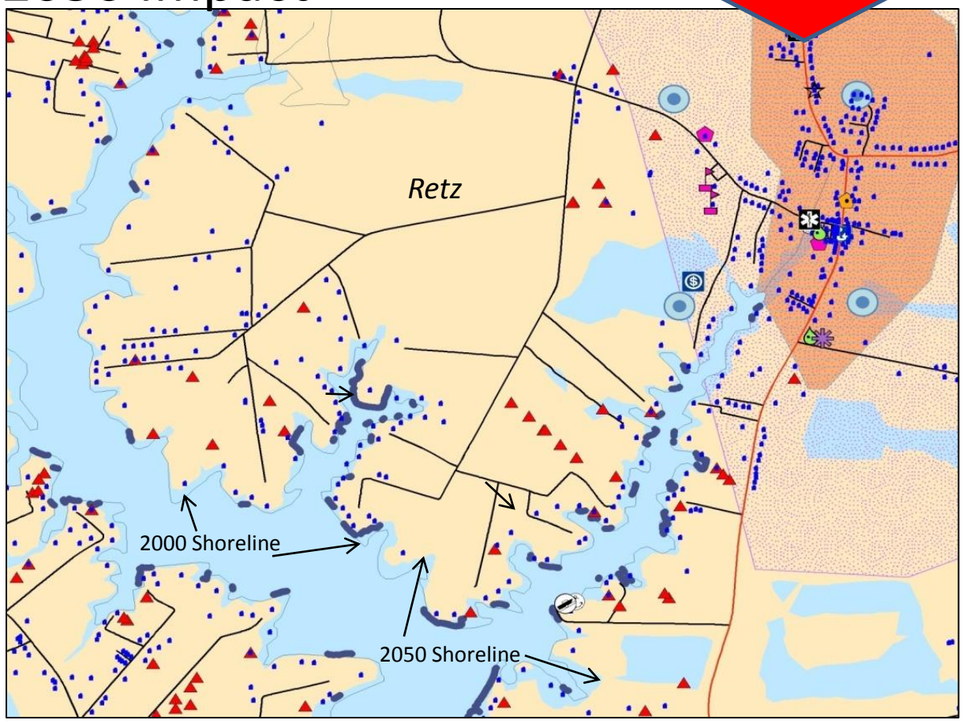
*****30% of all the parcels depicted in this snapshot are directly impacted by sea level rise. How are tax revenue losses compensated for?***

Total Parcels in Mathews County	11,107
Total Parcels in Snapshot	778
Impacted Parcels	217
Percentage of Impacted Parcels in Snapshot	30%

2000 Current



2050 Impact



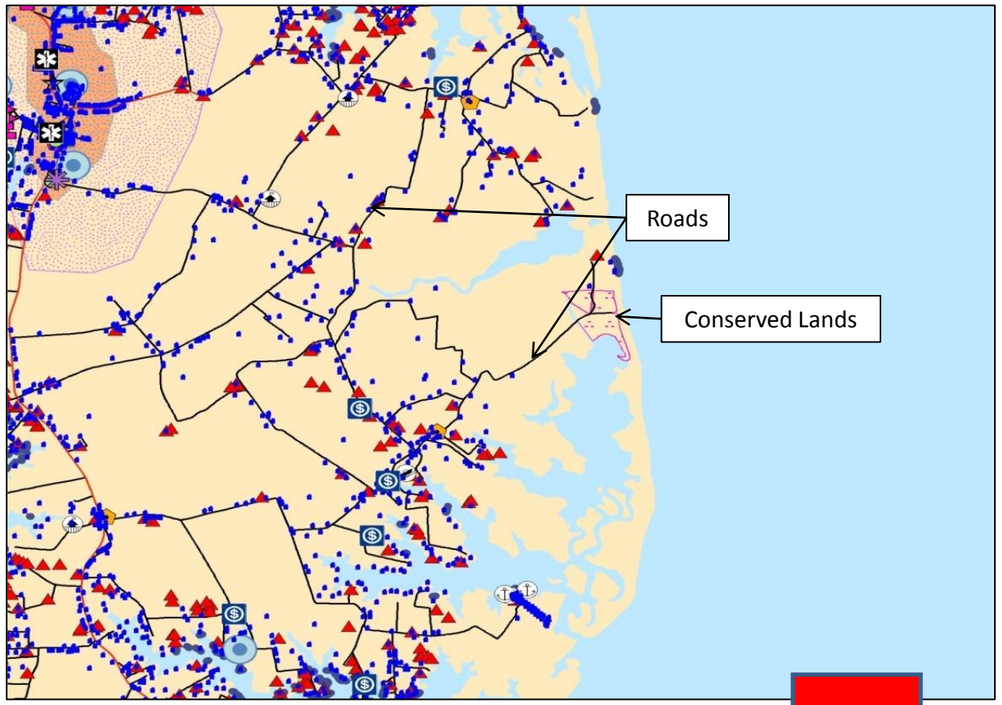
Retz: How will constituents handle private infrastructure maintenance, enhancement and/or losses?

Infrastructure	Amount of Structures Impacted	Average Cost	Total Cost
Houses	17	$228,669 Estimated median house or condo value in 2007 (City-Data.com)	$3,887,373
Engineered OSDS	5	$18,000 (MPPDC Regional Estimate)	$90,000
Community Well	1	$40,000 (MPPDC Regional Estimate)	$40,000
Private Wells	17	$3,000 (MPPDC Regional Estimate)	$51,000
Conventional OSDS	15	$4,000 (MPPDC Regional Estimate)	$60,000
Shoreline Harding	6,658.95 ft	$450/foot (MPPDC Regional Estimate)	$2,996,527.50
VDOT Road Segments	854.77 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $127,360.73 Long term: $636,803.65
TOTAL			**Short term:$7,252,261.23 Long term: $7,761,704.15**

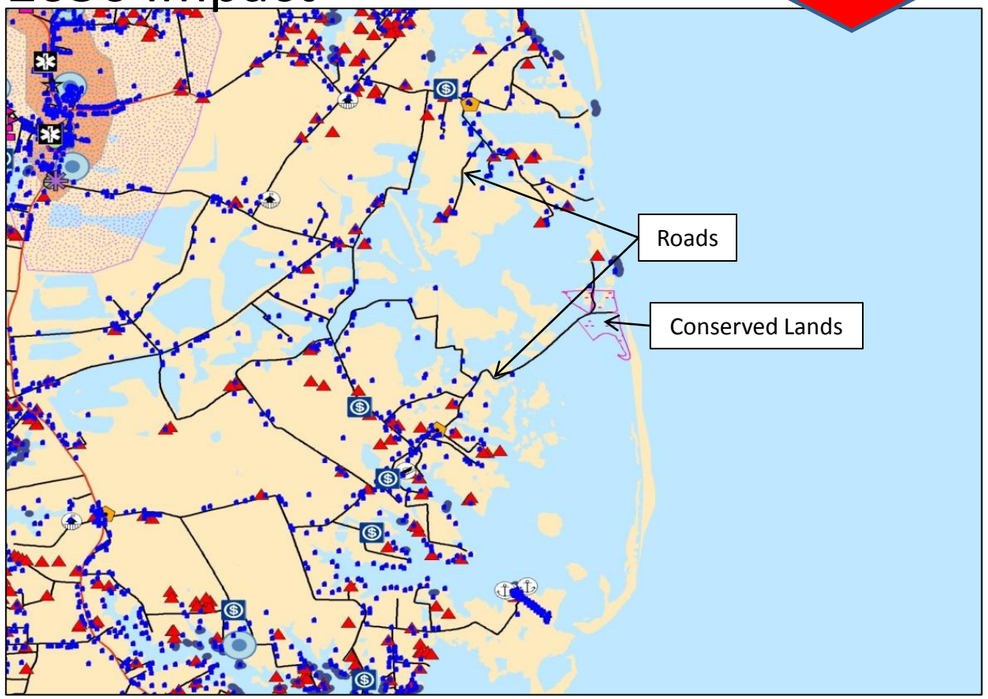
Proposed Hampton Road Sanitation Districts (HRSD) Service Areas will be inundated. Consequently proposed areas may need to be reevaluated and altered.

D

2000 Current



2050 Impact



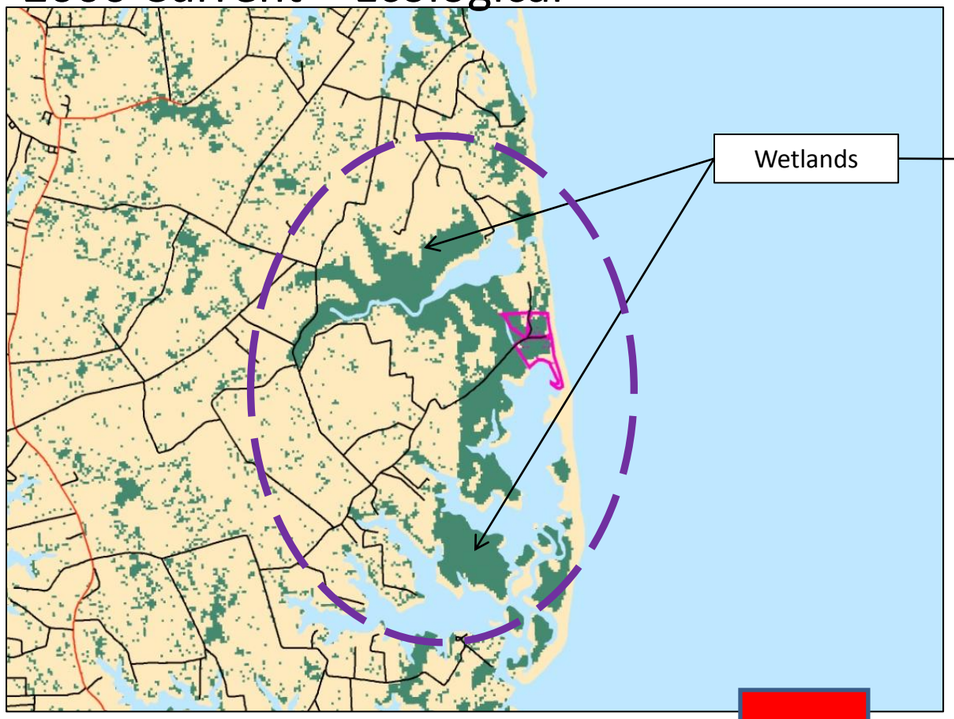
Onemo and Diggs: With the most costly impact due to infrastructure inundation, how will constituents and local government respond and adapt to sea level rise?

Infrastructure	Amount of Structures Impacted	Average Cost	Total Cost
Houses	59	$228,669 Estimated median house or condo value in 2007 (City-Data.com)	$13,491,471
Engineered OSDS	17	$18,000 (MPPDC Regional Estimate)	$306,000
Community Well	1	$40,000 (MPPDC Regional Estimate)	$40,000
Private Wells	59	$3,000 (MPPDC Regional Estimate)	$177,000
Conventional OSDS	42	$4,000 (MPPDC Regional Estimate)	$168,000
Shoreline Harding	9,374.4 ft	$450/foot (MPPDC Regional Estimate)	$4,218,480
VDOT Road Segments	35,645.68 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $5,311,105 Long term: $26,556,031.60
TOTAL			**Short term:$23,712,056** **Long term: $44,956,982.60**

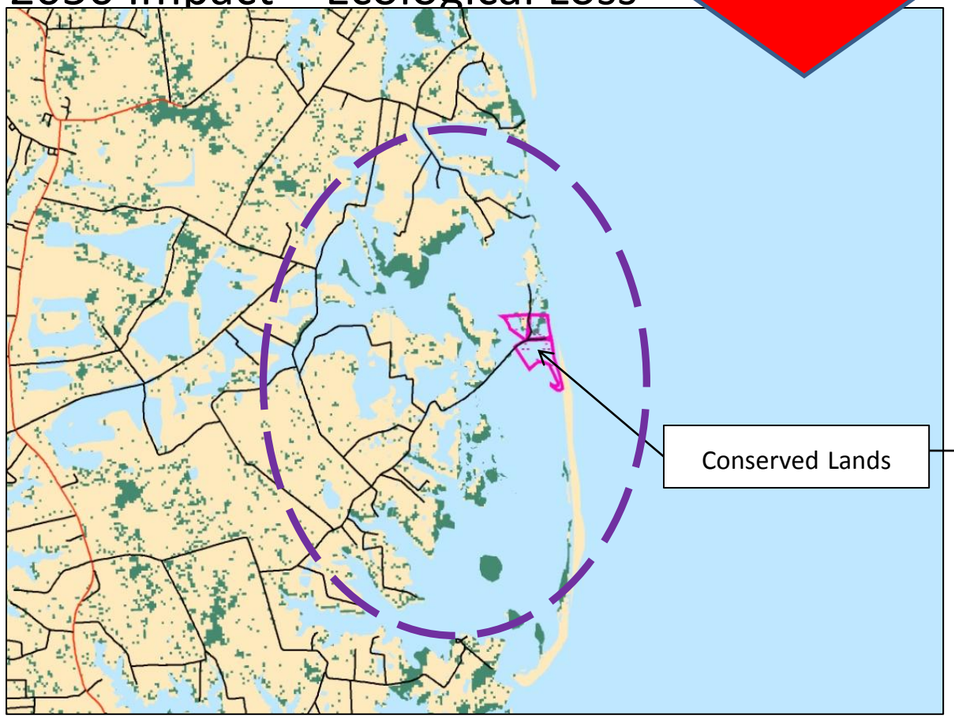
E

Onemo and Diggs: Inundated wetlands will result in fish, reptile, bird, and wildlife habitat impact and loss

2000 Current – Ecological



2050 Impact – Ecological Loss



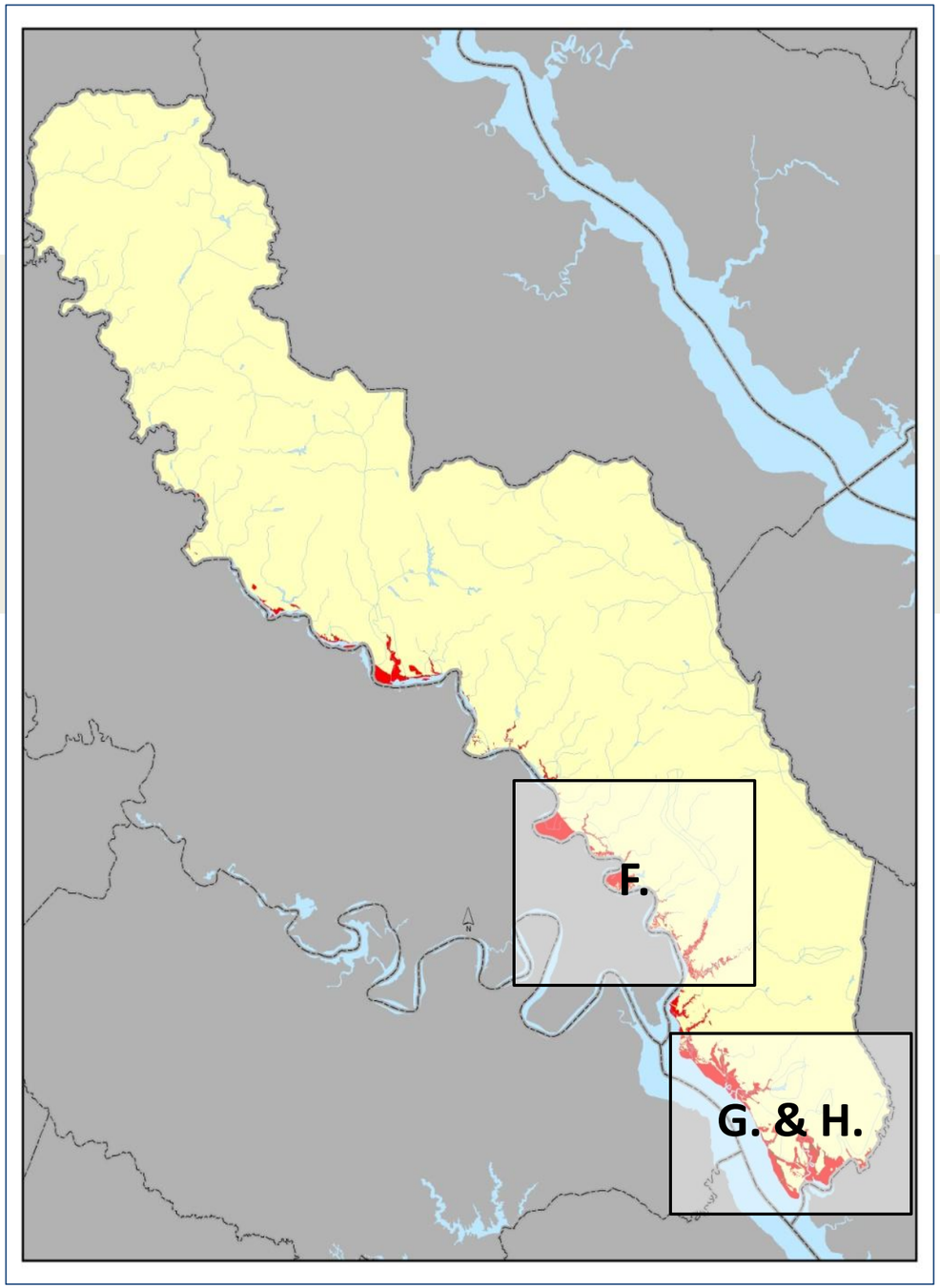
Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors *Fishing and Shellfish Habitat* *Waterfowl Habitat* *Mammal and Reptile*	 $48[a] $253[b] $18[c]	 954.77 954.77 954.77	 $45,828.96 $241,556.81 $17,185.86
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	954.77	$276,568.23 - $8,179,199.52
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	954.77	$8,592.93 - $109,798.55
Total value lost or redistributed: $589,732.79 - $8,593,569.70			

Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and wildlife habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -altering aesthetics of River and Bay vista -waterfowl habitat loss may impact bird watching

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

Conserved Lands Impacted	
Bethel Beach Natural Area Preserve	Quantitative: 63.31 acres of terrestrial land converts to subaqueous land due to inundation Qualitative: -Public access and enjoyment of to terrestrial conserved land will be limited - Habitat loss will impact the globally rare northeastern beach tiger beetle and beach plant as well as colonial nesting birds

King and Queen County



F. Roane

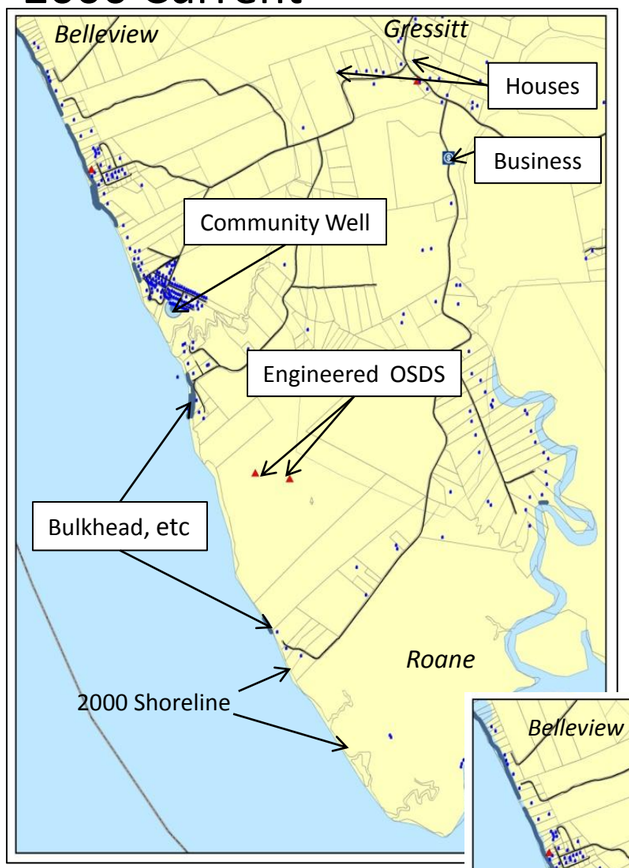
G. Roane –
Ecological Impacts

H. Heart Quake Trail Area –
Ecological Impacts

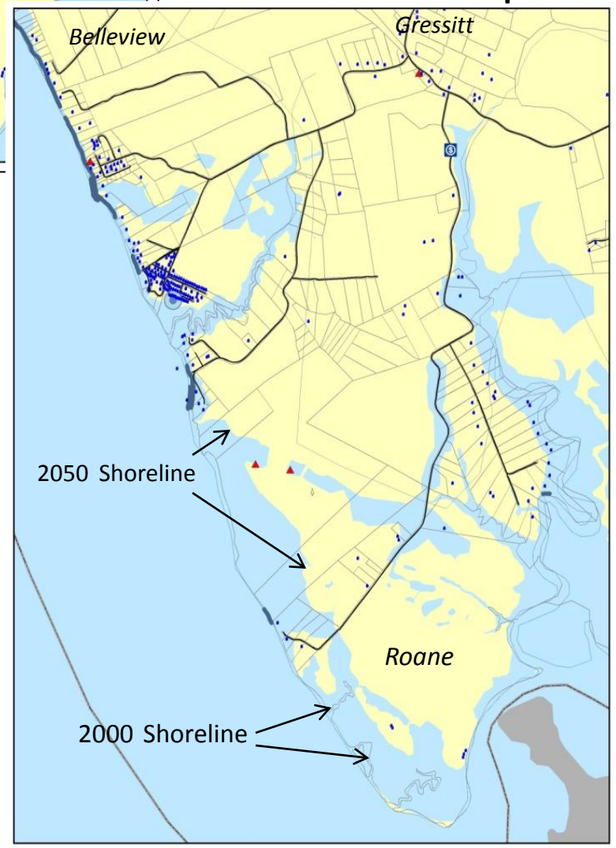
F

Roane: Significant inundation of private infrastructure may be costly to the constituent but may have public implications especially as onsite septic disposal systems are impacted.

2000 Current



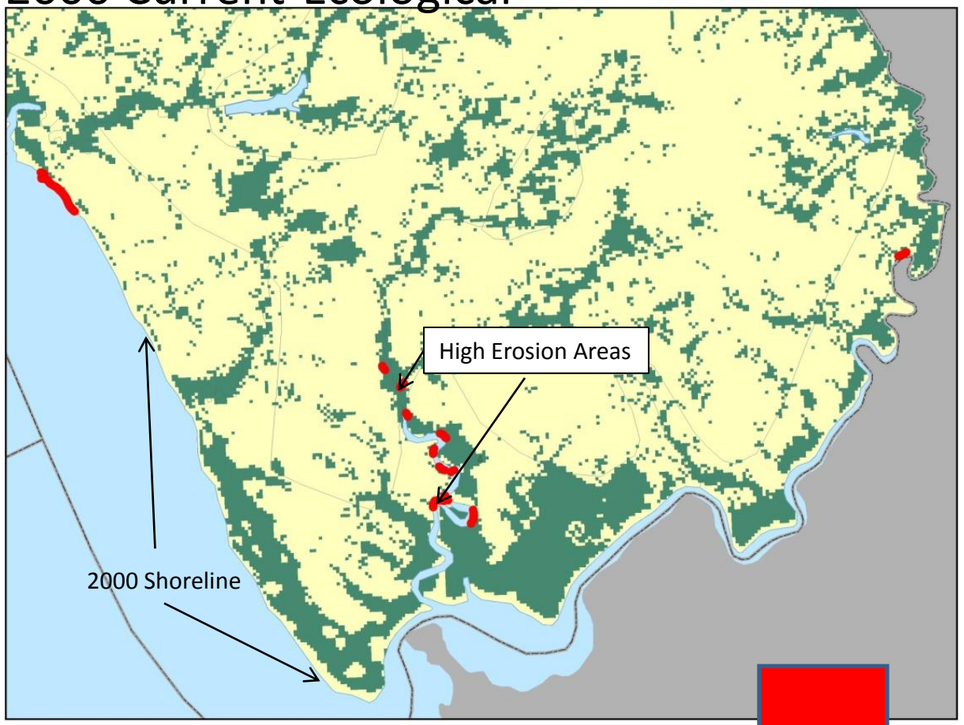
2050 Impact



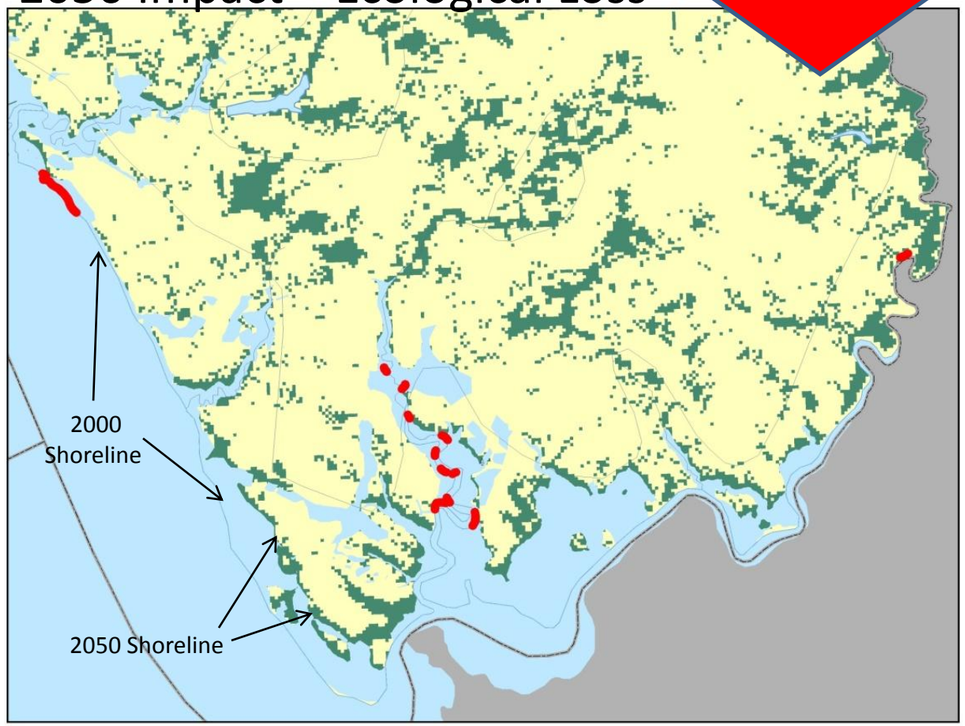
Infrastructure	Amount of flooded structures	Average Cost	Total Cost
Houses	37	$228,669 Estimated median house or condo value in 2007 (City-Data.com)	$8,918,091
Engineered OSDS	1	$18,000 (MPPDC Regional Estimate)	$144,000
Conventional OSDS	36	$4,000 (MPPDC Regional Estimate)	$124,000
Community Well (65 connections)	1	$40,000 (MPPDC Regional Estimate)	$40,000
Private Wells	37	$3,000 (MPPDC Regional Estimate)	$111,000
Shoreline Hardening	6,977.04 ft	$200/foot (MPPDC Regional Estimate)	$1,395,408.26
VDOT Road Segments	7,934.30 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $58,311.15 Long term: $291,555.75
TOTAL			**Short term: $10,790,810.41** **Long term: $11,024,055.01**

**NOTE: There are 37 private wells that are directly impacted by inundation, however 232 private wells may be indirectly impacted in this snapshot by salt water intrusion as sea level rises.

2000 Current-Ecological



2050 Impact – Ecological Loss



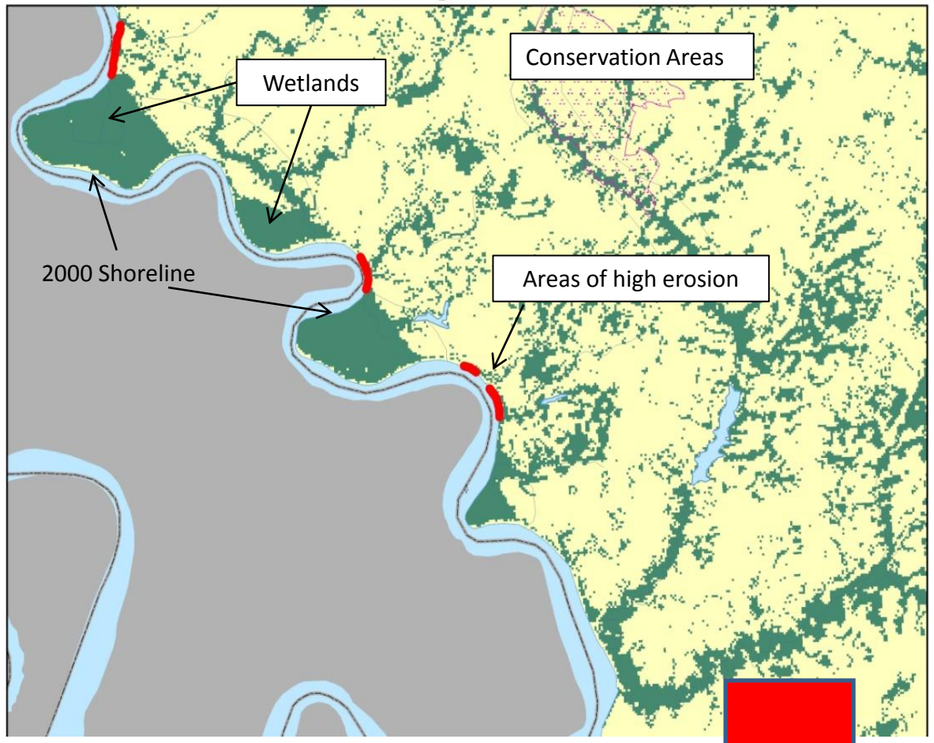
Roane: Inundation of wetlands will expose inlands to more frequent and intense storm surges due to climate change

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	1,247.57	$59,883.36
Waterfowl Habitat	$253[b]	1,247.57	$315,635.21
Mammal and Reptile	$18[c]	1,247.57	$22,456.26
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	1,247.57	$361,383 - $10,687,520.49
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	1,247.57	$11,228.13 - $143,470.55
Total value lost or redistributed: $770,585.96 - $11,228,965.87			
Qualitative Losses from Wetland Inundation			
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife		-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista -biodiversity	

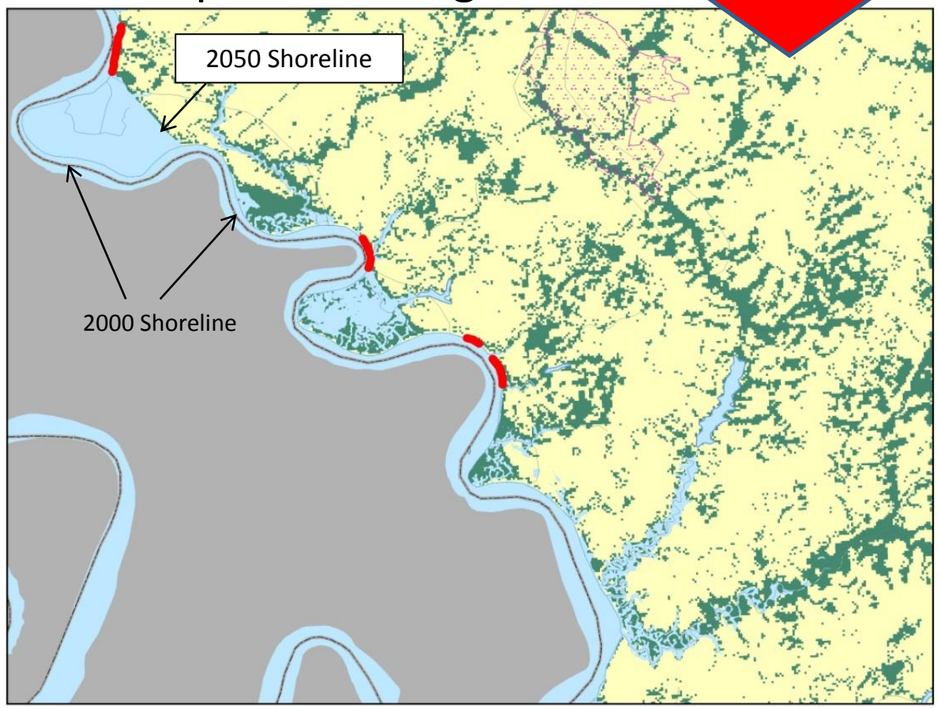
[a] Bell, 1989 [b] Guta and Foster, 1975 [c]Farber and Costanza, 1987 [d]Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j]Bell, 1989

4,014.60 ft of High Erosion Areas will be most vulnerable sea level rise, ultimately altering the geomorphology of the area

2000 Current-Ecological



2050 Impact – Ecological Loss



Heart Quake Trail Area: Inundation of tidal wetlands lining the Mattaponi River will reduce habitat and spawning grounds for anadromous migratory fish (ie. Shad, herring and stripped bass) and the associated angling industry

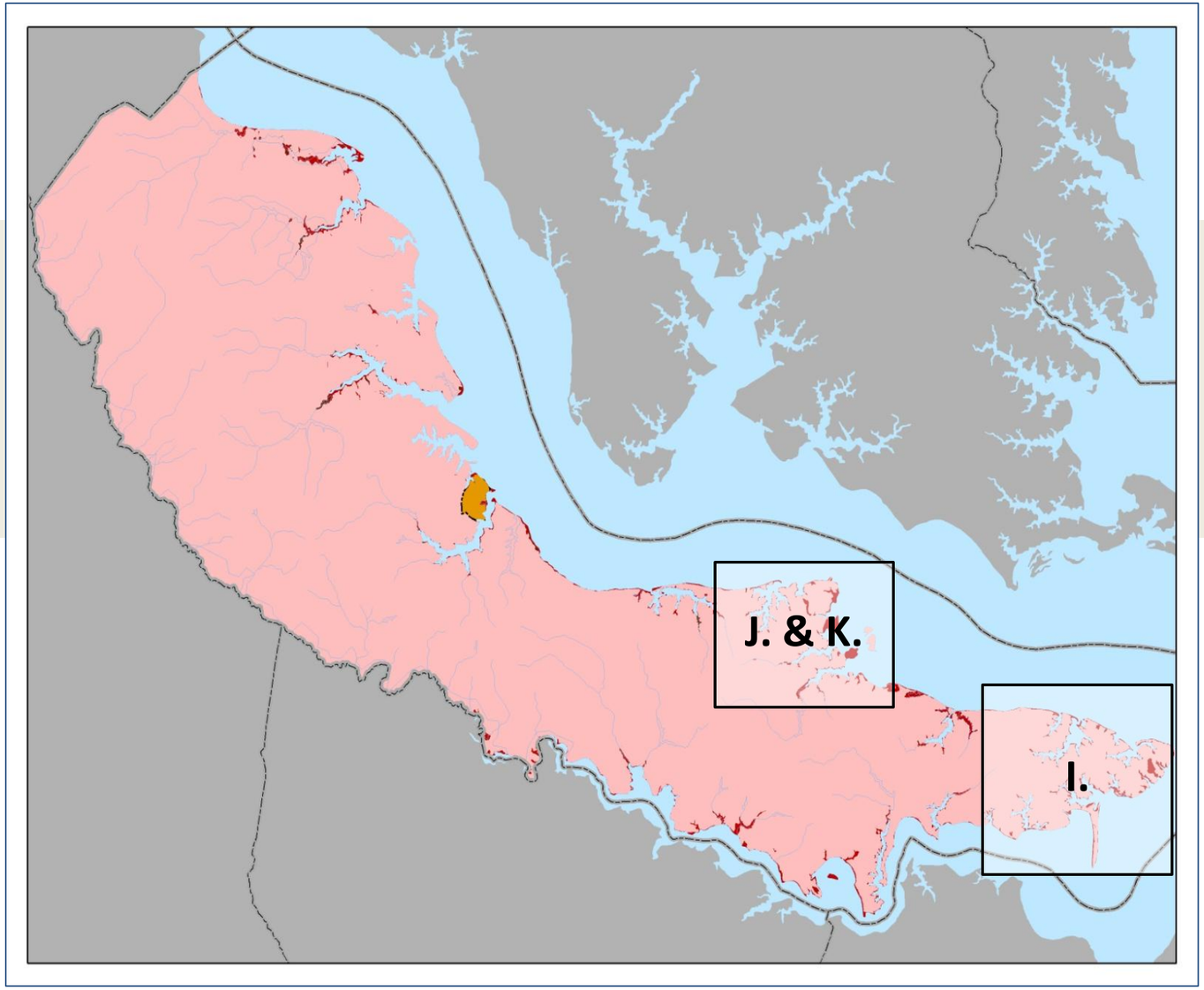
Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	723.99	$34,751.52
Waterfowl Habitat	$253[b]	723.99	$183,169.47
Mammal and Reptile	$18[c]	723.99	$13,031.82
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	723.99	$209,718.18 - $6,202,183.41
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	723.99	$6,515.91 - $83,258.85
Total value lost or redistributed: $447,186.90 - $6,516,395.07			

Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -migratory fish and waterfowl habitat	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista -biodiversity

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

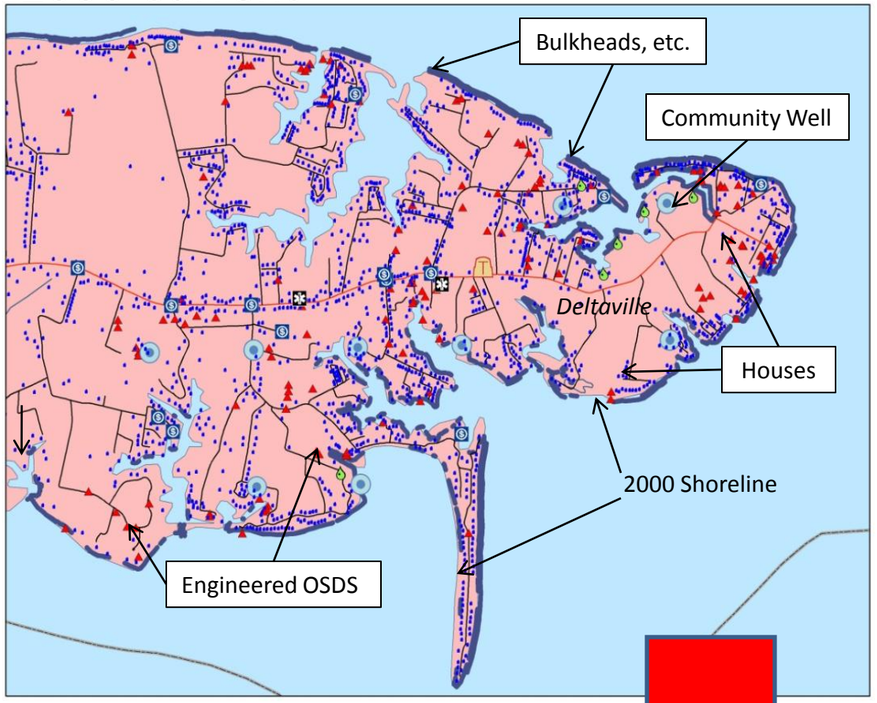
5,375 ft of High Erosion Areas will be most vulnerable sea level rise, ultimately altering the geomorphology of the area

Middlesex County

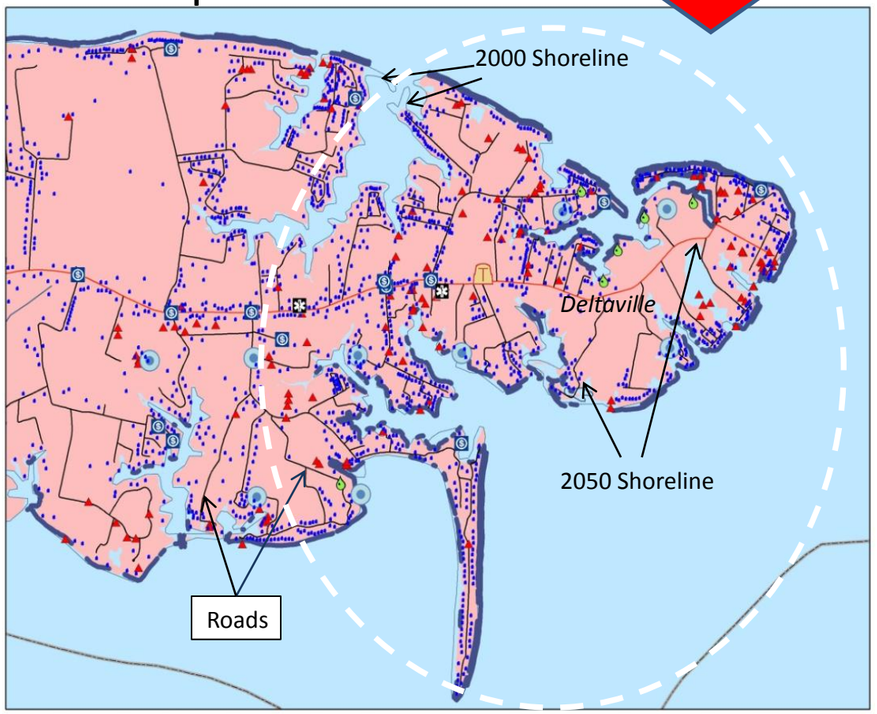


I. Deltaville
J. Locklies
K. Locklies – Ecological Impacts

2000 Current



2050 Impact

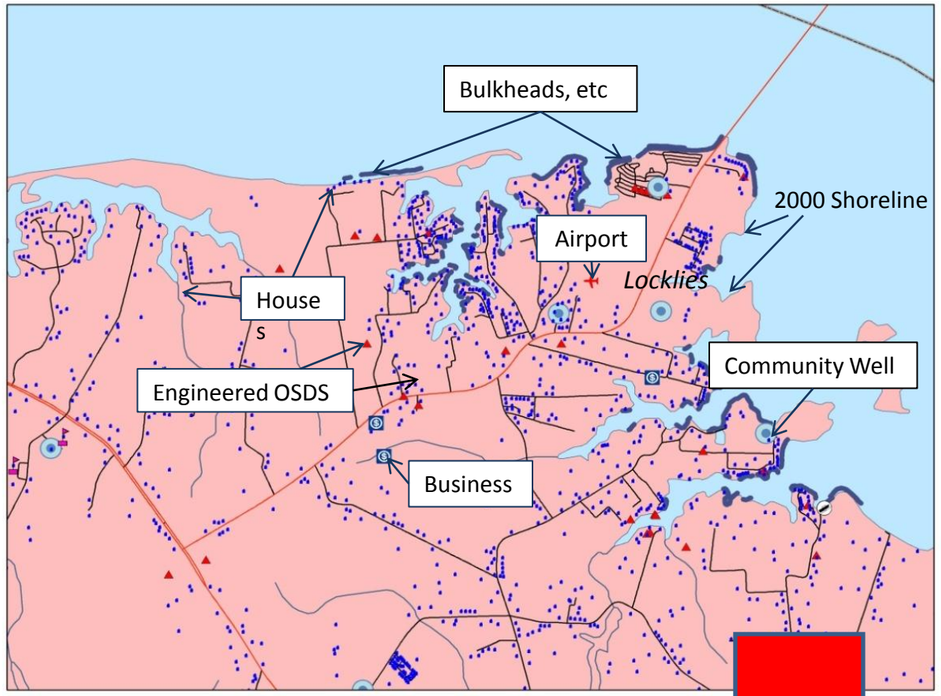


Deltaville: A desired Bay and River vista draw people to the coast, but coastal living may come at higher cost due to inundation of public and private infrastructure

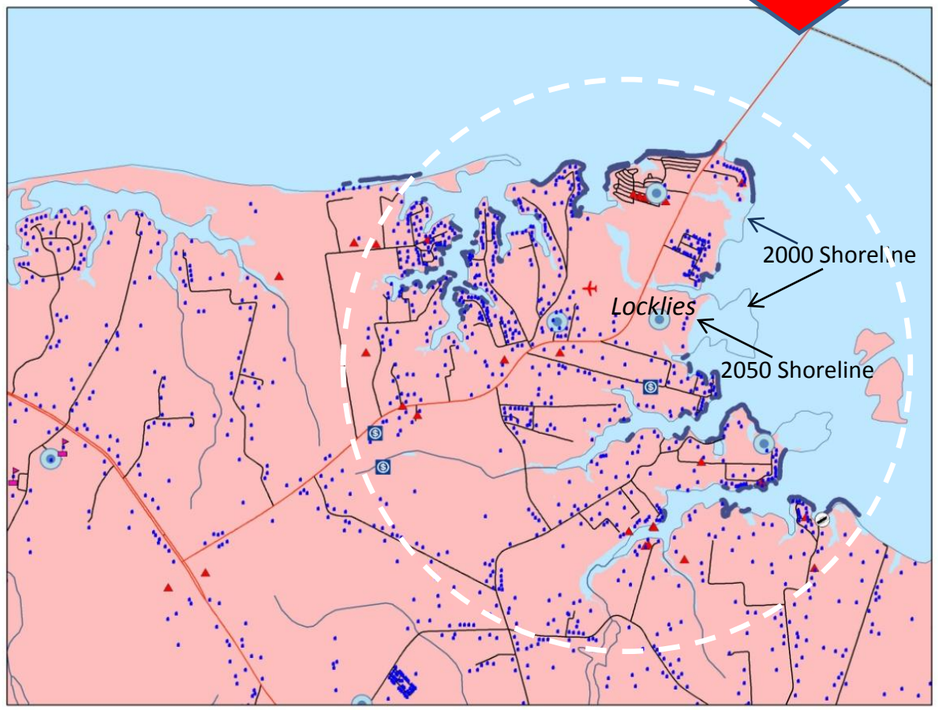
Infrastructure	Amount of flooded structures	Average Cost	Total Cost
Houses	17	$226,617 Estimated median house or condo value in 2007 (City-Data.com)	$3,852,489
Engineered OSDS	20	$18,000 (MPPDC Regional Estimate)	$360,000
Conventional OSDS	14	$4,000 (MPPDC Regional Estimate)	$56,000
Community Well (with 2 connections)	2	$40,000 (MPPDC Regional Estimate)	$80,000
Private Wells	17	$3,000 (MPPDC Regional Estimate)	$51,000
Shoreline Hardening	51,255.16 ft	$450/foot (MPPDC Regional Estimate)	$23,064,822
VDOT Road Segments	3,582.51 ft	Short term: $149/sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $533,793.99 Long term: $2,668,969.95
TOTAL			**Short term: $27,947,104.99** **Long term: $30,082,280.95**

J

2000 Current



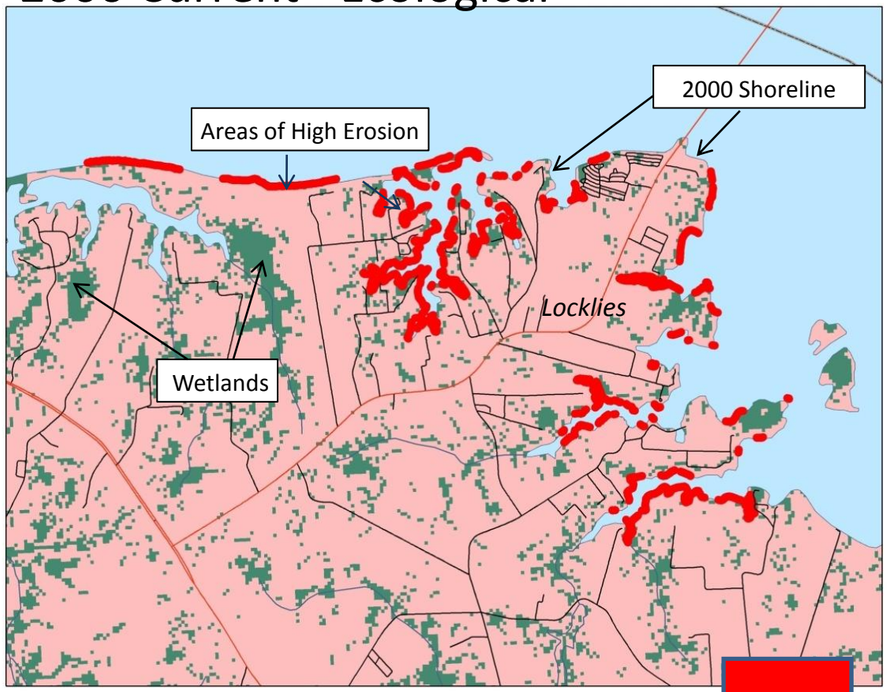
2050 Impact



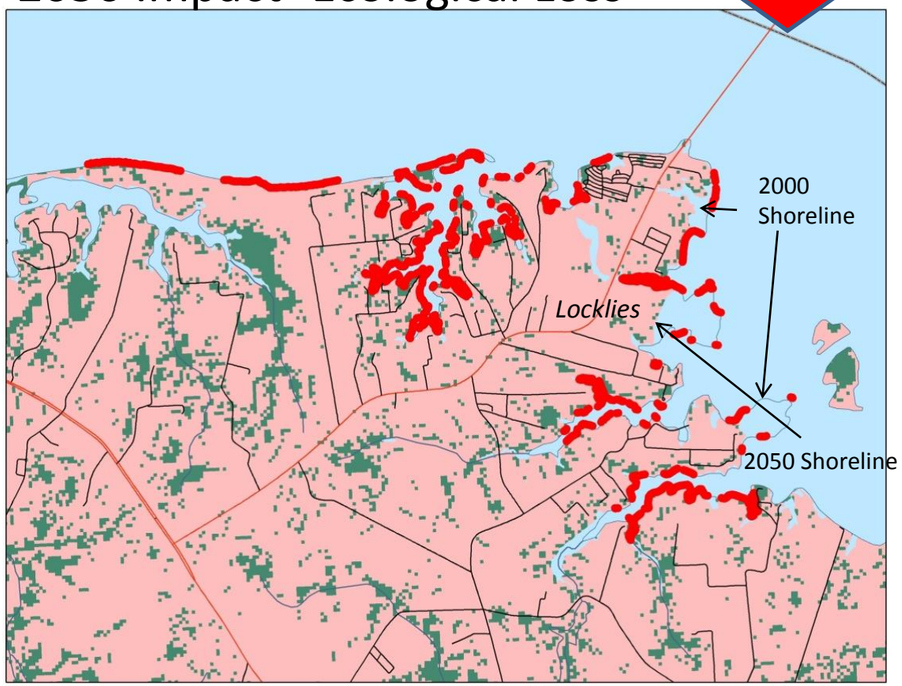
Locklies: Will shoreline hardening be sufficient to protect coastal communities from sea level rise?

Infrastructure	Amount of flooded structures	Average Cost	Total Cost
Houses	4	$226,617 Estimated median house or condo value in 2007 (City-Data.com)	$906,468
Engineered OSDS	3	$18,000 (MPPDC Regional Estimate)	$54,000
Conventional OSDS	4	$4,000 (MPPDC Regional Estimate)	$16,000
Private Wells	4	$3,000 (MPPDC Regional Estimate)	$12,000
Shoreline Hardening	27,461.38 ft	$450/foot (MPPDC Regional Estimate)	$12,357,621
VDOT Road Segments	1,668.89 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $248,664.61 Long term: $1,243,323.05
TOTAL			**Short term: $13,594,753.61** **Long term: $14,589,412.05**

2000 Current - Ecological



2050 Impact- Ecological Loss



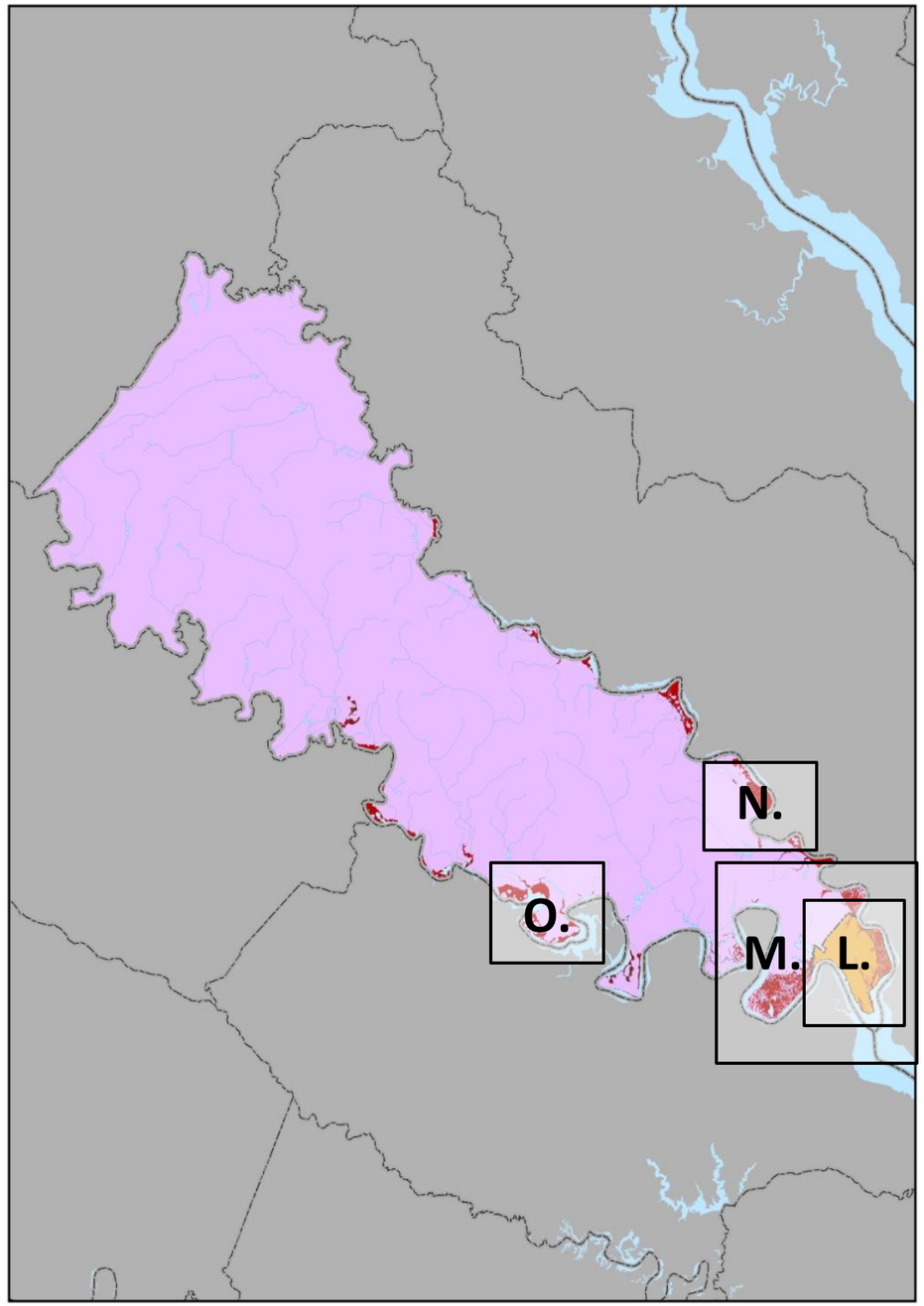
Locklies: With abundant sandy and loamy soils on the coastal, high erosion areas are numerous which will likely be highly vulnerable to sea level rise and storm surges

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	103.6	$4,972.80
Waterfowl Habitat	$253[b]	103.6	$26,210.80
Mammal and Reptile	$18[c]	103.6	$1,864.80
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	103.6	$30,009.81 - $887,507.01
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	103.6	$932.40- $11,914.00
Total value lost or redistributed: $63,990.61 - $932,469.41			
Qualitative Losses from Wetland Inundation			
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity		-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista	

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

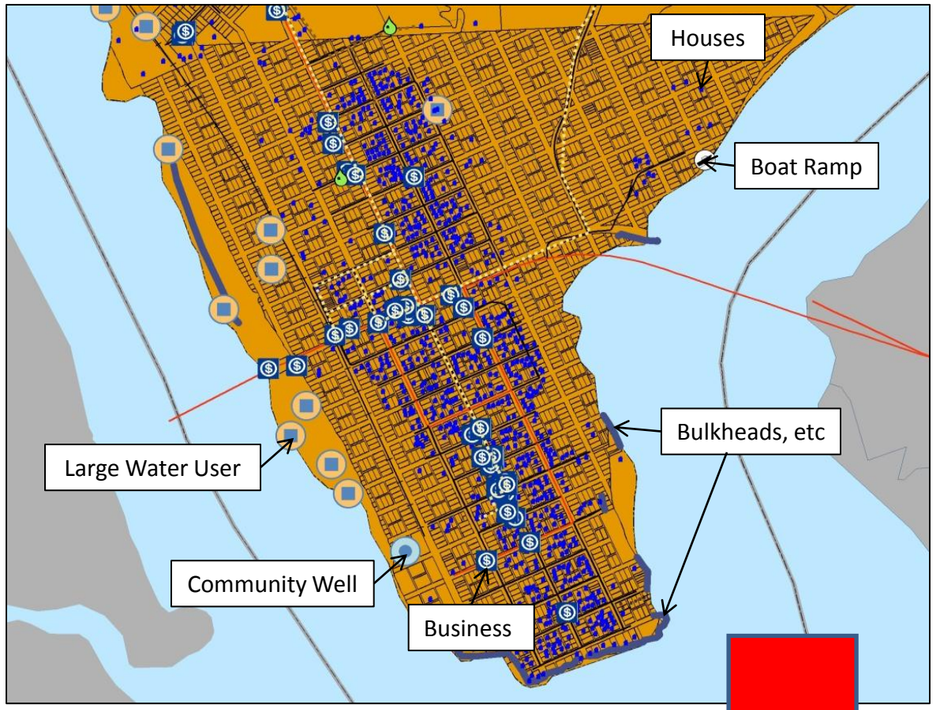
52,655.23 ft of High Erosion Areas will be most vulnerable sea level rise, ultimately altering the geomorphology of the area

King William County

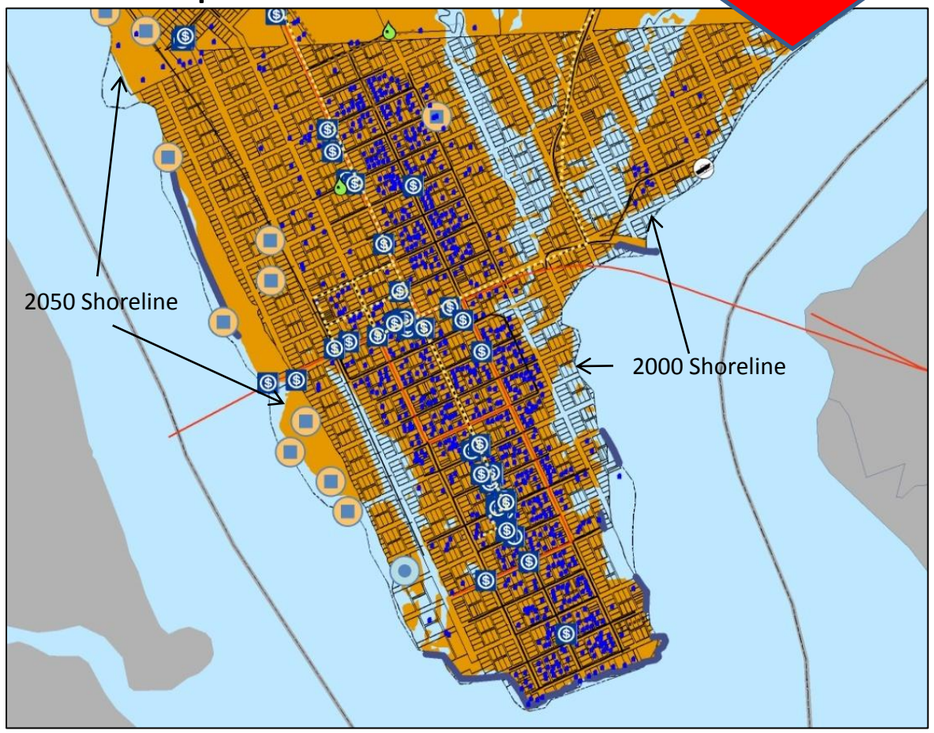


L. Town of West Point
M. Romancoke to West Point – Ecological Impacts
N. Winona Park Road – Ecological Impacts
O. Pamunkey Tribe Reservation- Ecological Impacts

2000 Current



2050 Impact



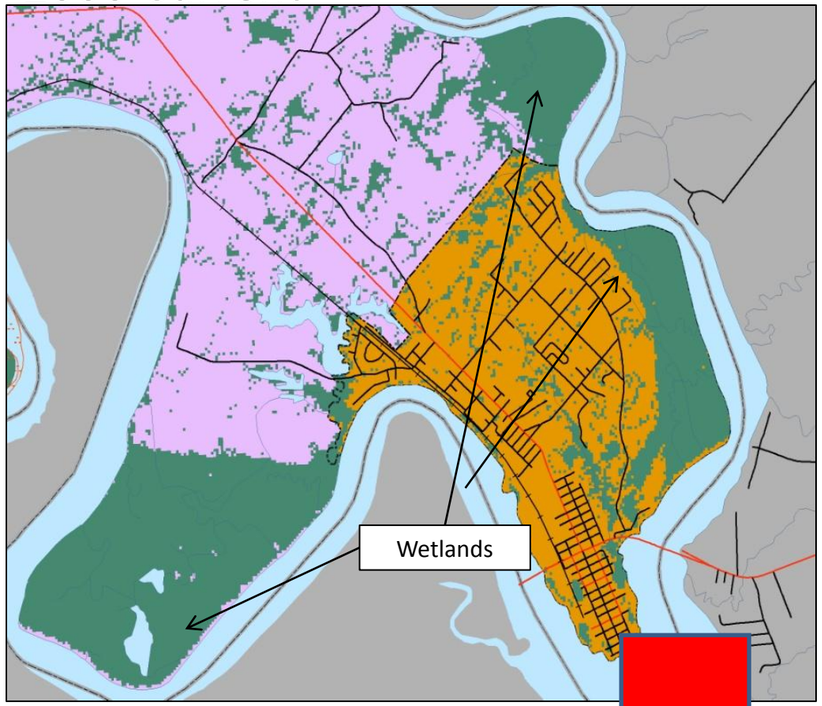
Town of West Point: Private and Public investments are directly impacted by sea level rise

Infrastructure	Amount of flooded structures	Average Cost	Total Cost
Houses	5	$224,339 Estimated median house or condo value in 2007 (City-Data.com)	$1,121,695
Conventional OSDS	5	$4,000 (MPPDC Regional Estimate)	$20,000
Private Wells	5	$3,000 (MPPDC Regional Estimate)	$15,000
Shoreline Hardening	6,052.89 ft	$200/foot (MPPDC Regional Estimate)	$1,210,578
Railroad Tracks	2,200.24 ft	$165.00/foot of track not including the price of the land (Track Guy Consultants)	$363,039.60
VDOT Road Segments	109.47 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $16,311.03 Long term: $81,555.15
TOTAL			**Short term: $2,746,623.63** **Long term: $2,811,867.75**

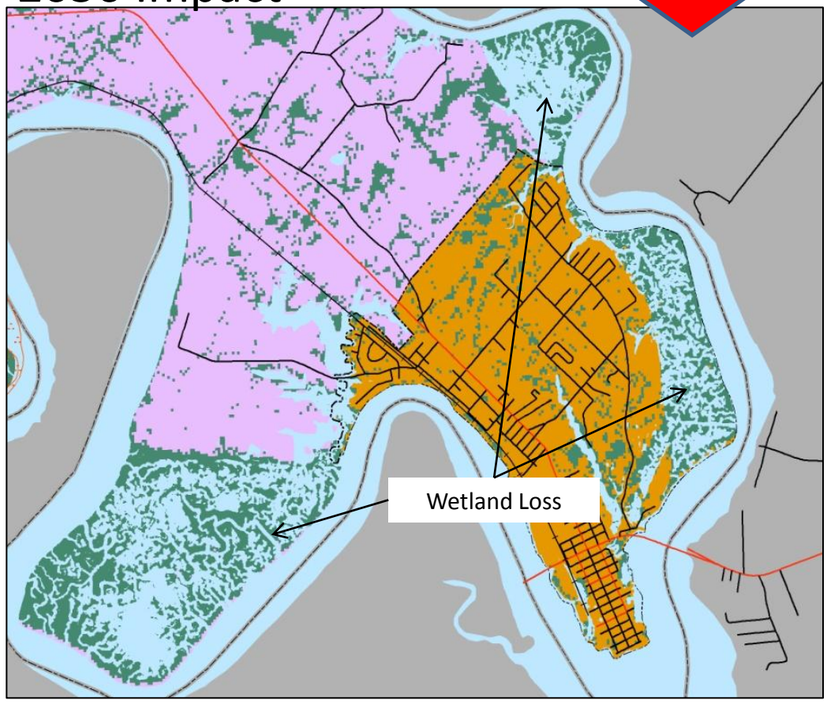
Total Parcels in Mathews County	11,107
Total Parcels in Snapshot	2979
Impacted Parcels	570
Percentage of Impacted Parcels in Snapshot	19.1%

Smurfit Stone may encounter higher operation and maintenance costs due 3 of 7 intake pipes being impacted by sea level rise

2000 Current



2050 Impact



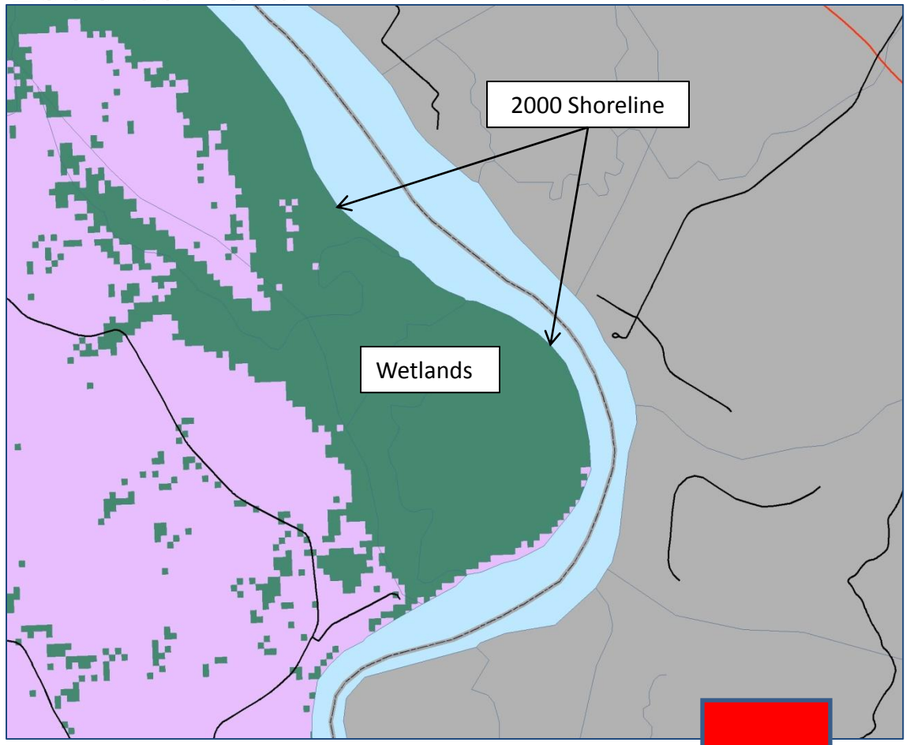
Romancoke to West Point: Significant losses of wetlands surrounding the Town of West Point may increase the towns vulnerability to flooding from climate change, storm surges and tidal changes

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors *Fishing and Shellfish Habitat* *Waterfowl Habitat* *Mammal and Reptile*	 $48[a] $253[b] $18[c]	 1,247.57 1,247.57 1,247.57	 $59,883.36 $315,635.21 $22,456.26
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	1,247.57	$361,383 - $10,687,520.49
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	1,247.57	$11,228.13 - $143,470.55
Total value lost or redistributed: $770,585.96 - $11,228,965.87			

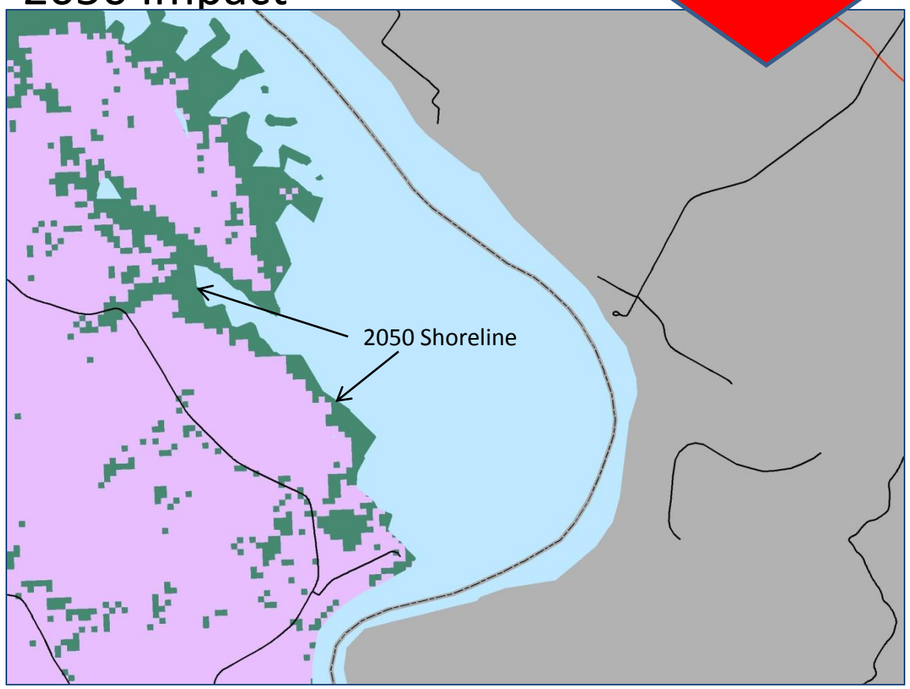
Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

2000 Current



2050 Impact



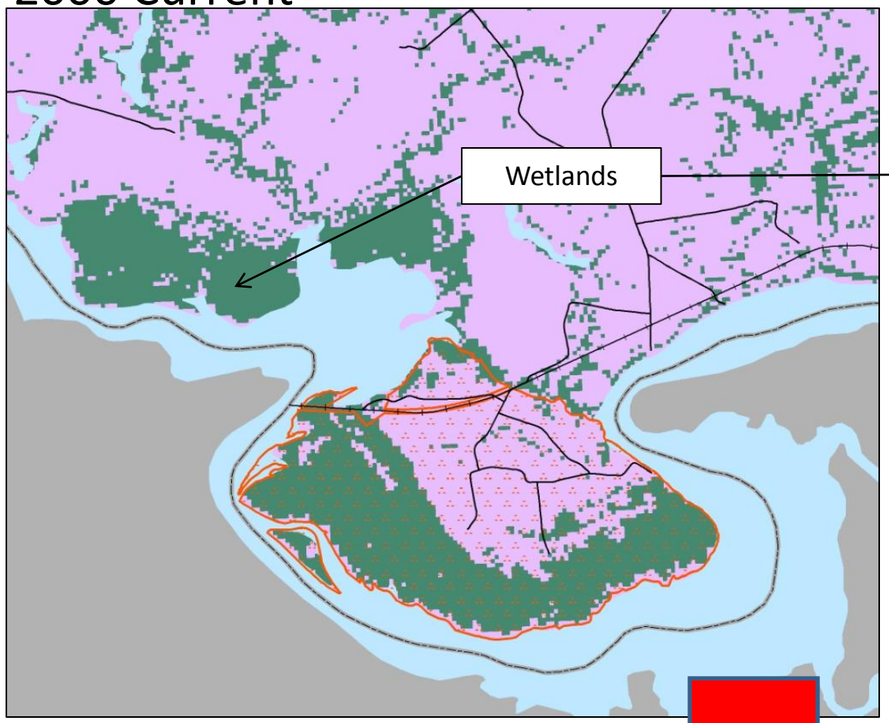
Winona Park Road: 62% of wetlands recorded in 2000 will be inundated due to sea level rise in 2050

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	560.81	$26,918.88
Waterfowl Habitat	$253[b]	560.81	$141,884.93
Mammal and Reptile	$18[c]	560.81	$10,094.58
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	560.81	$162,449.83- $4,804,274.20
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	560.81	$5,047.29- $64,493.15
Total value lost or redistributed: $346,395.51- $5,047,665.74			

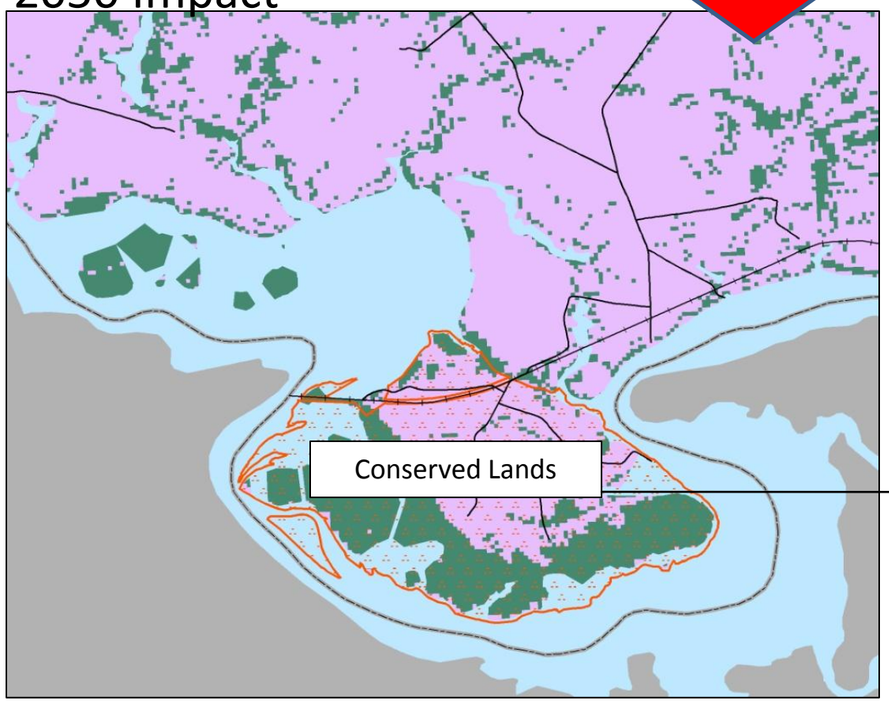
Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

2000 Current



2050 Impact



Pamunkey Tribe Reservation: 11% of the tribe's terrestrial land is inundated and converts to subaqueous lands

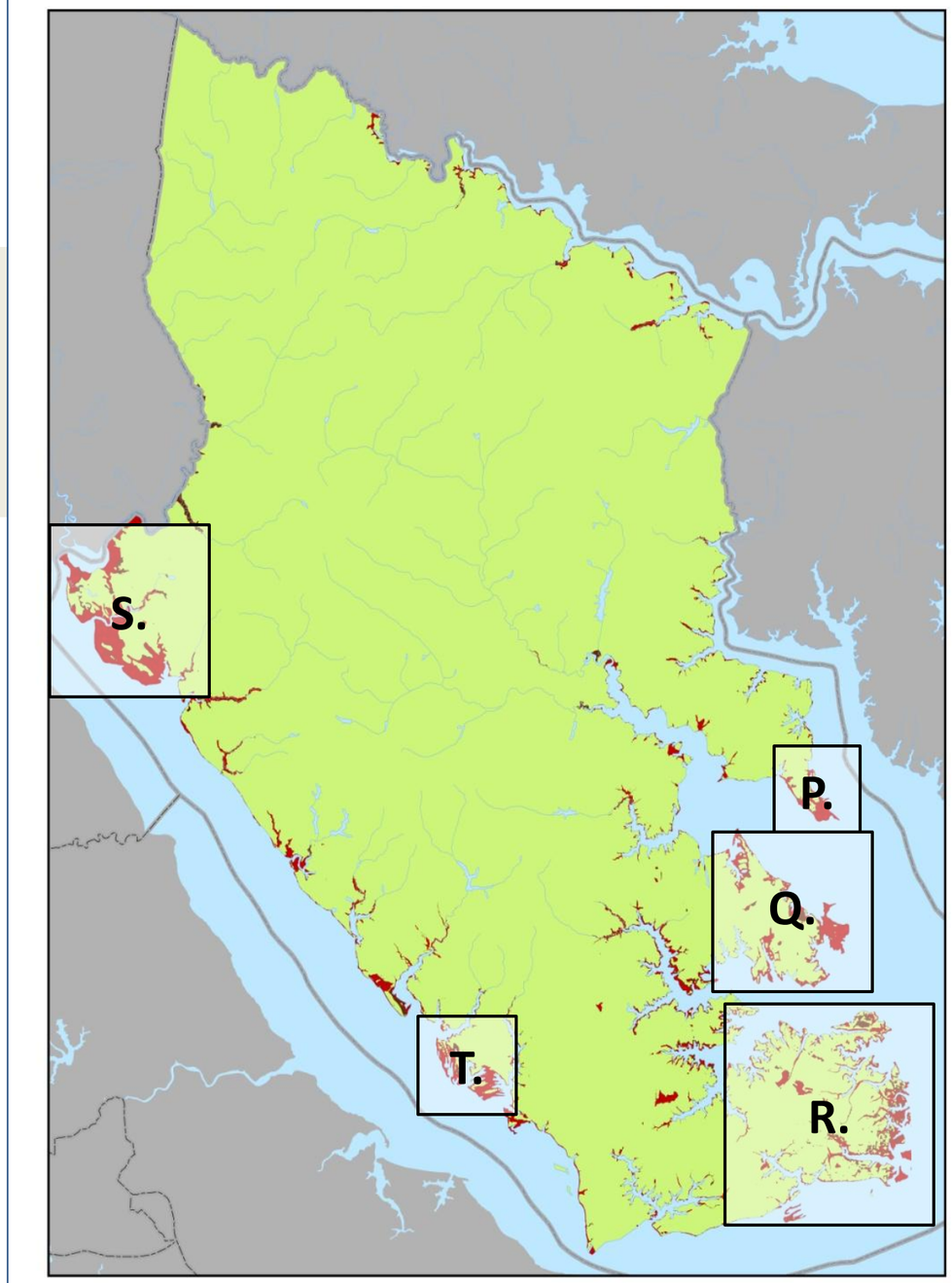
Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	413.28	$19,837.44
Waterfowl Habitat	$253[b]	413.28	$104,559.84
Mammal and Reptile	$18[c]	413.28	$7,439.04
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	413.28	$119,714.82- $3,540,433.38
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	413.28	$3,719.52 - $47,527.20
Total value lost or redistributed: $255,270.66 - $3,719,796.90			

Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista -saltwater intrusion may impact the tribe's subsistence living on natural resources in the area

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981
[i] Farber and Costanza, 1987 [j] Bell, 1989

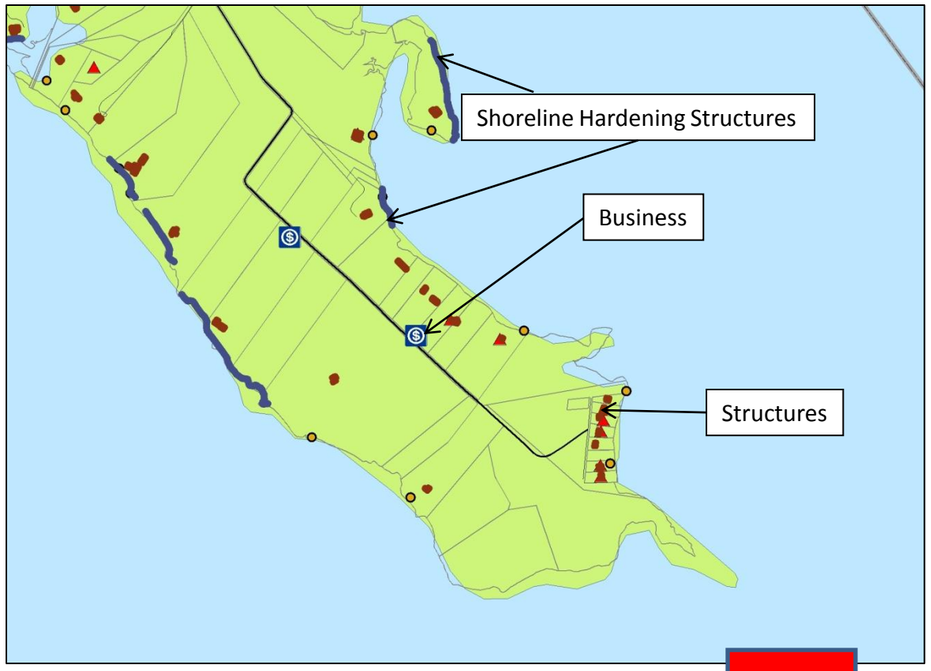
Conserved Lands Impacted	
Pamunkey Tribe Reservation	Quantitative: 127.62 acres of terrestrial land converts to subaqueous land due to inundation Qualitative: saltwater intrusion and loss of wetlands may impact the tribe's subsistence lifestyle centered around pottery making, fishing, hunting and trapping

Gloucester County

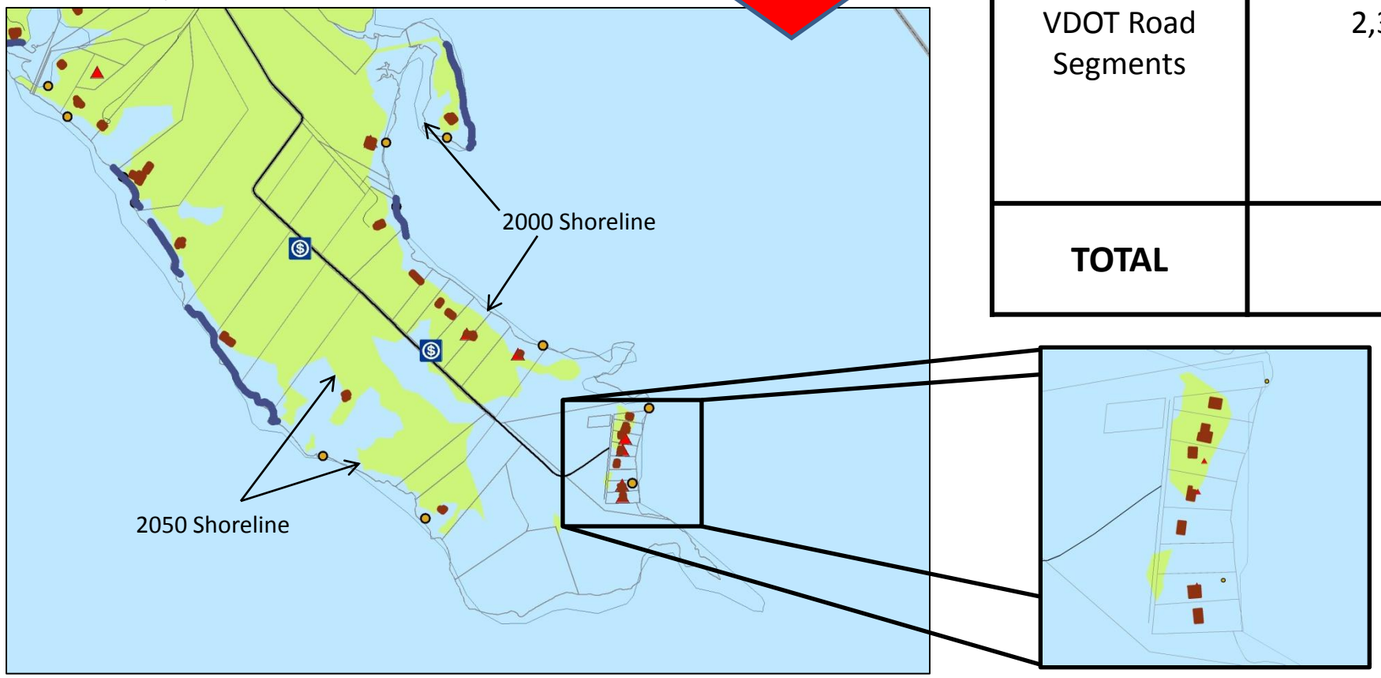


P. Ware Neck Point
Q. Nexara
R. Guinea
S. Purtan Bay and West End–
Ecological Impacts
T. Catlett Islands –
Ecological Impacts

2000 Current



2050 Impact



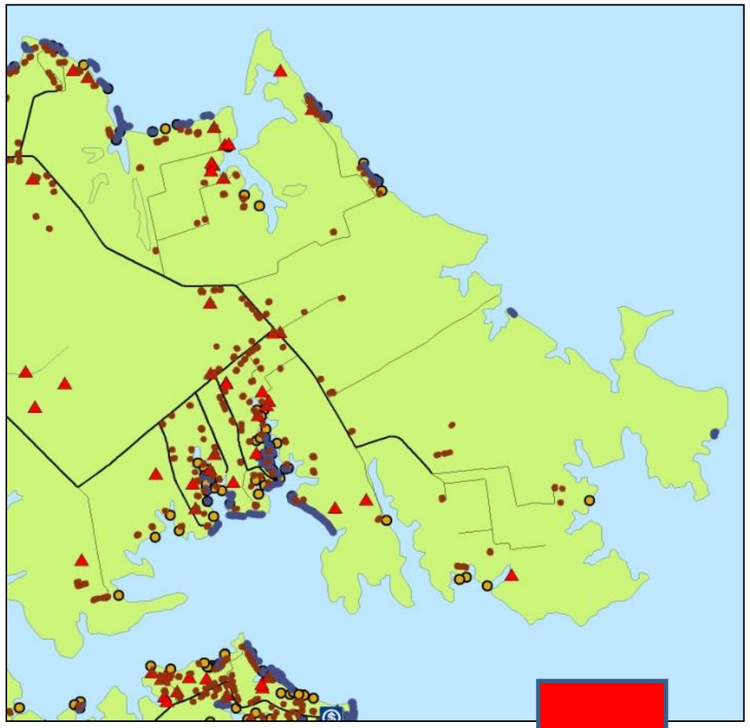
Ware Neck Point: Typical road access to coastal developments become limited as roads are inundated

Infrastructure	Amount of Flooded Structures	Average Cost	Total Costs
Houses	9	$227,293 Estimated median house or condo value in 2007 (City-Data.com)	$2,045,637
Engineered OSDS	3	$18,000 (MPPDC Regional Estimate)	$54,000
Conventional OSDS	6	$4,000 (MPPDC Regional Estimate)	$24,000
Private Wells	9	$3,000 (MPPDC Regional Estimate)	$27,000
Shoreline Hardening	8,099 ft	$450/foot (MPPDC Regional Estimate)	$3,644,550
VDOT Road Segments	2,300 ft	Short Term: $149/sq ft Long Term: $745/sq ft Additional right of way acquisition when raised 10 inches (VDOT Estimate)	Short Term: $342,700 Long Term: $1,713,500
TOTAL			**Short term: $ 6,137,887** **Long term: $ 7,508,687**

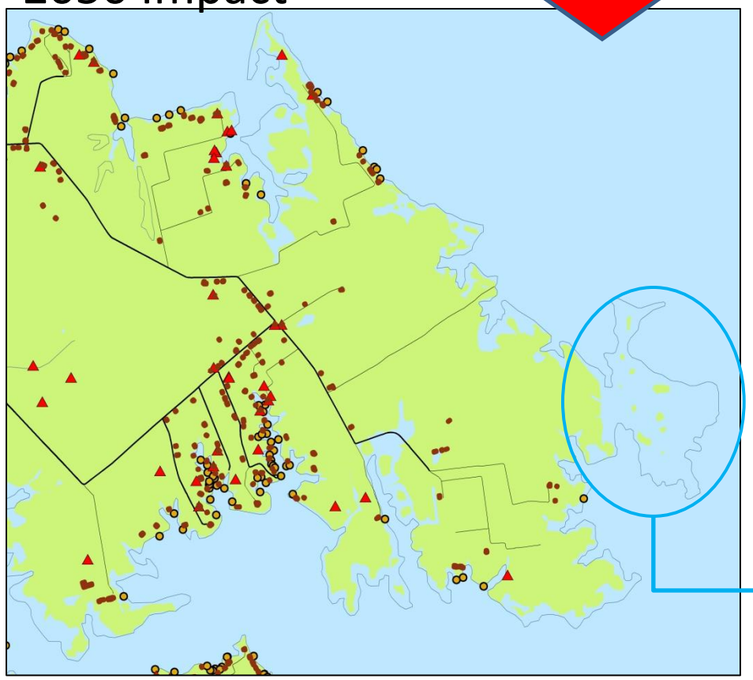
As roads to private property are inundated…..

- How will residents get to their houses?
- How do residents get access to schools?
- How are OSDS and wells serviced?
- How are the roads serviced?
- How will localities recover the lost revenue from property taxes?

2000 Current



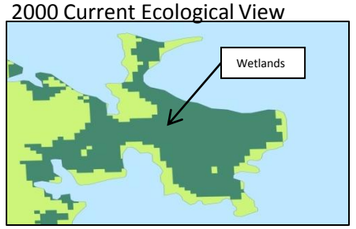
2050 Impact



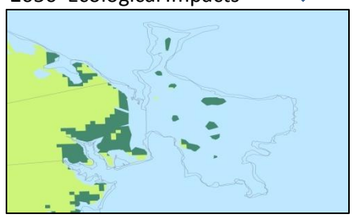
Naxera Area: Costly anthropogenic and ecological impacts due to sea level rise

Infrastructure	Amount of Structures Impacted	Average Cost	Total Costs
Houses	14	$227,293 Estimated median house or condo value in 2007 (City-Data.com)	$3,182,102
Engineered OSDS	1	$18,000 (MPPDC Regional Estimate)	$18,000
Conventional OSDS	13	$4,000 (MPPDC Regional Estimate)	$52,000
Private Wells	14	$3,000 (MPPDC Regional Estimate)	$42,000
Shoreline Hardening	5,112.48 ft	$450/ft (MPPDC Regional Estimate)	$2,300,616
VDOT Road Segments	1,500 ft	Short Term: $149/sq ft Long Term: $745/sq ft Additional right of way acquisition when raised 10 inches (VDOT Estimate)	Short Term: $223,500 Long Term: $1,117,500
TOTAL			**Short term: $ 5,818,218** **Long term: $ 6,712,218**

2000 Current Ecological View



2050 Ecological Impacts



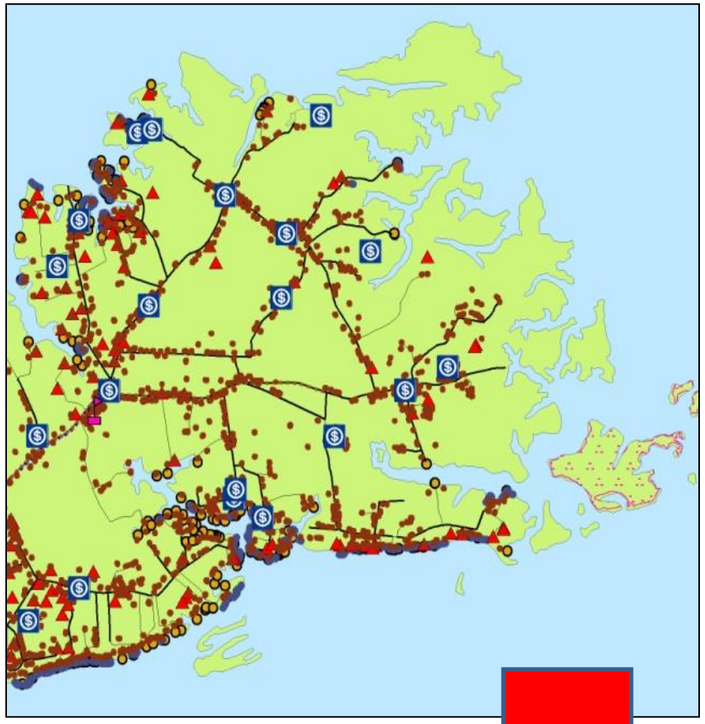
360 Acre Parcel Almost Completely Lost!

-Majority of acreage lost are covered by wetlands (dark green)

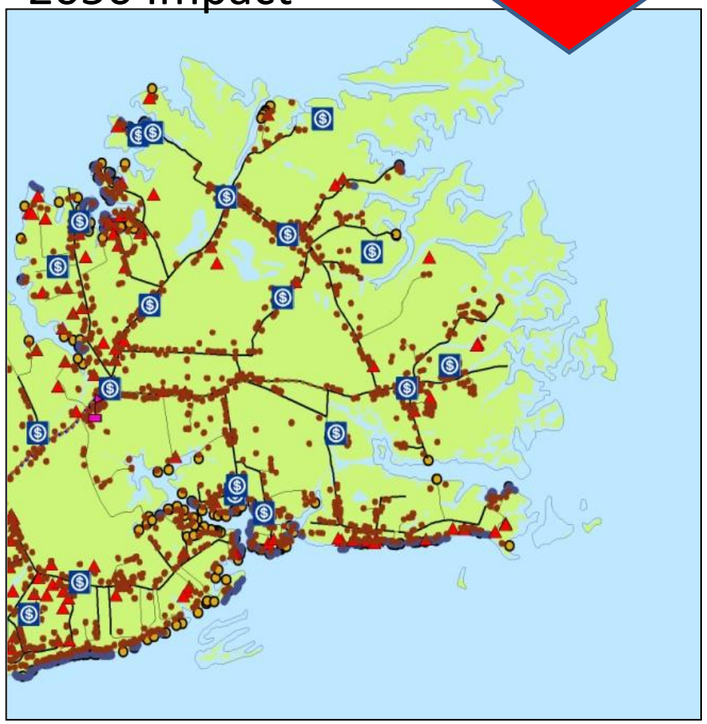
-Estimated Cost of Wetland Loss=

$70,617.35 - $1,032,376.85

2000 Current



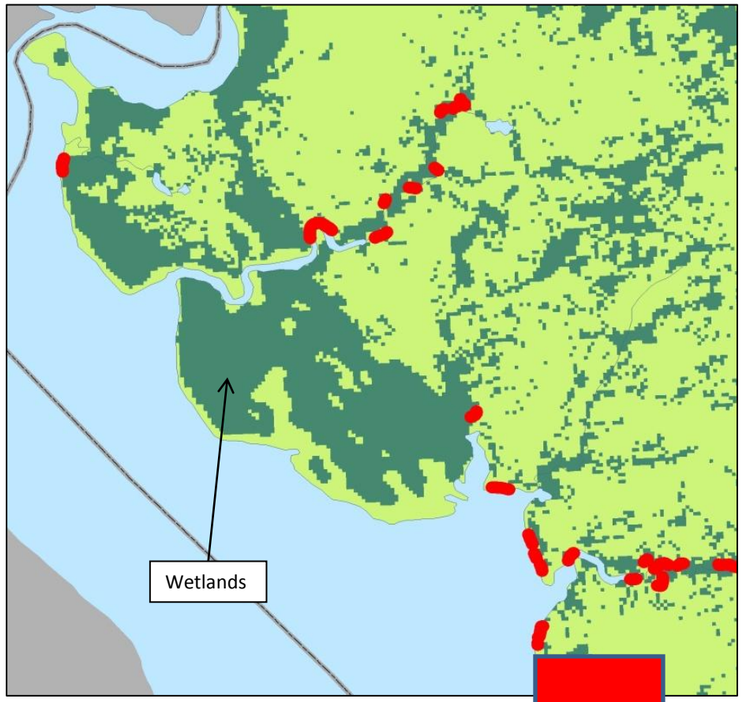
2050 Impact



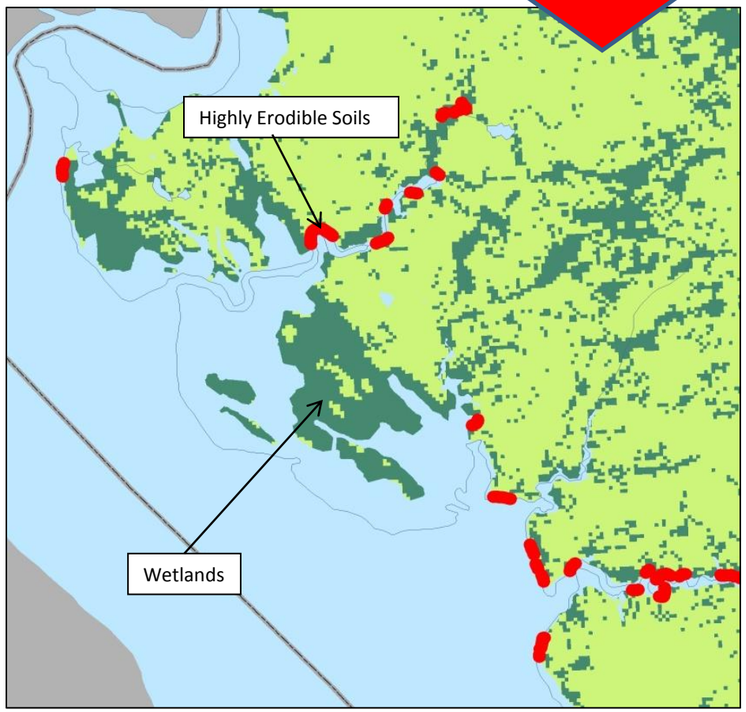
Guinea Area: Inundation of private investments simultaneously have public health implications

Infrastructure	Amount of Flooded Structures	Average Cost	Total Costs
Houses	37	$227,293 Estimated median house or condo value in 2007 (City-Data.com)	$8,409,841
Engineered OSDS	2	$18,000 (MPPDC Regional Estimate.)	$36,000
Conventional OSDS	35	$4,000 (MPPDC Regional Estimate)	$140,000
Private Wells	37	$3,000 (MPPDC Regional Estimate)	$111,000
Shoreline Structures	11,294.9	$450/ft (MPPDC Regional Estimate)	$5,082,705
VDOT Road Segments	1,009 ft	Short Term: $149/sq ft Long Term: $745/sq ft Additional right of way acquisition when raised 10 inches (VDOT Estimate)	Short Term: $150,341 Long Term: $751,705
TOTAL			**Short term: $ 13,929,887** **Long term: $ 14,537,251**

2000 Current



2050 Impact



Purtan Bay and West End Inundated wetlands may increase expose the southern tip of King and Queen County to the open waters of the York River. Ultimately increasing vulnerability to coastal erosion , storm surges and inundation.

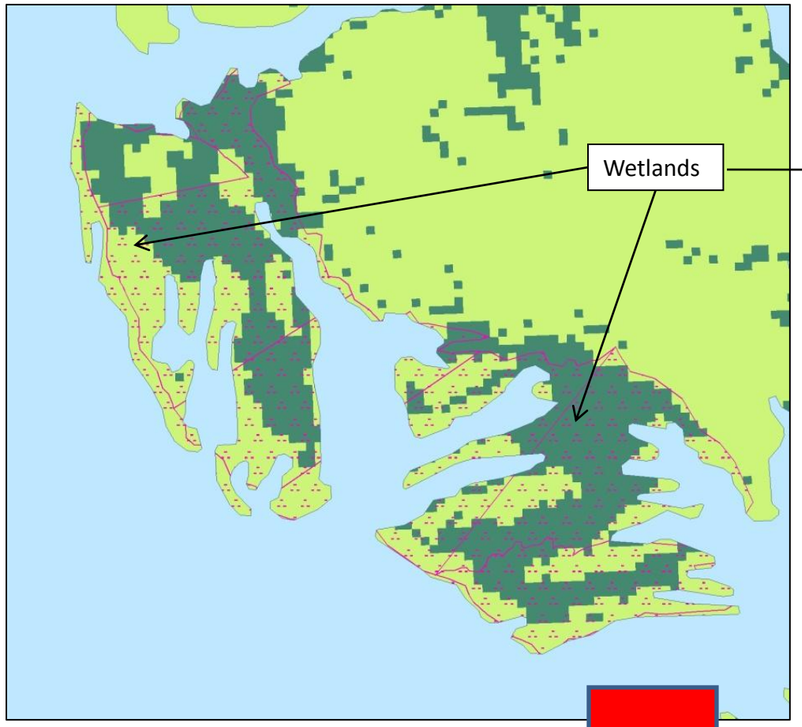
Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	879.84	$42,232.32
Waterfowl Habitat	$253[b]	879.84	$222,599.52
Mammal and Reptile	$18[c]	879.84	$15,837.12
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	879.84	$254,863.25 - $7,537,298.93
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	879.84	$7,918.56 - $101,181.60
Total value lost or redistributed: $543,450.77 - $7,919,149.49			

Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista

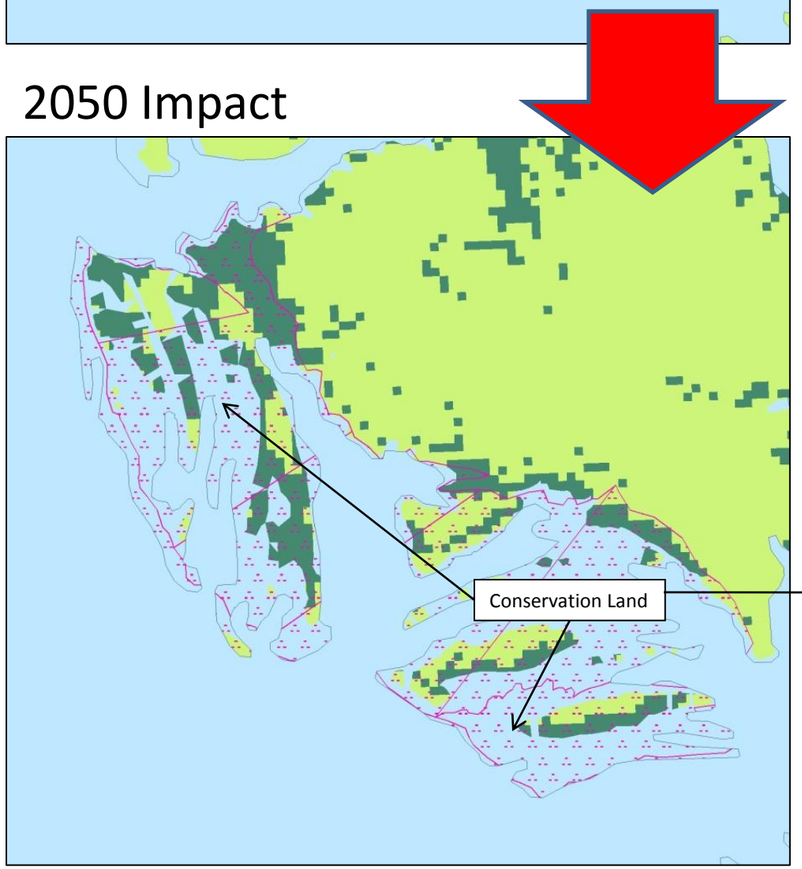
[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

53,495.58 ft of High Erosion Areas will be most vulnerable sea level rise, ultimately altering the geomorphology of the area

2000 Current



2050 Impact



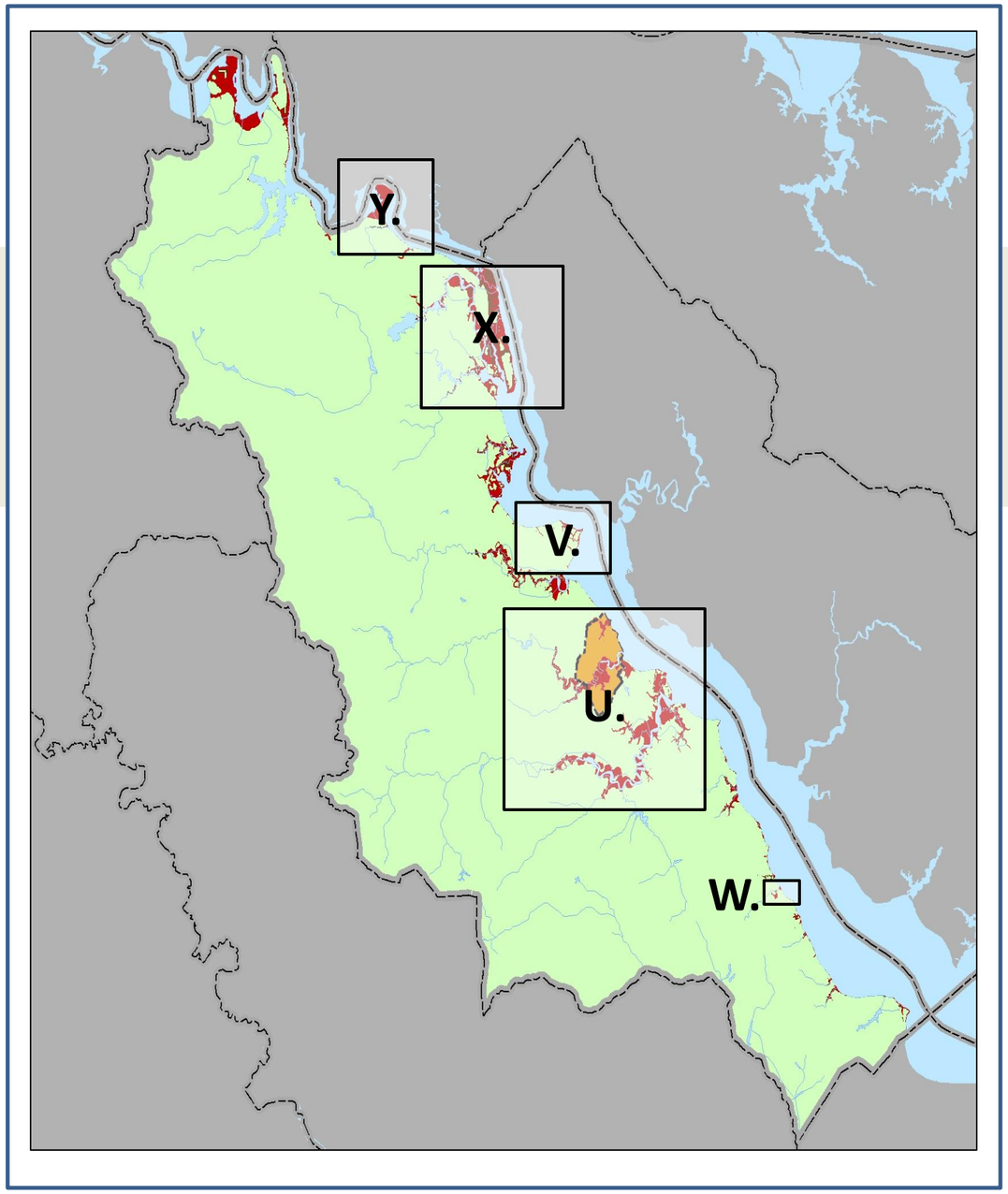
Catlett Islands: Loss of forested wetlands may limit wetland ecology research on these inlands which is currently being conducted by VIMS

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	131.78	$6,325.44
Waterfowl Habitat	$253[b]	131.78	$33,340.34
Mammal and Reptile	$18[c]	131.78	$2,372.04
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	131.78	$38,172.71 -$1,128,915.77
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	131.78	$1,186.02 - $15,154.70
Total value lost or redistributed: $81,396.55 - $1,186,108.29			

Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

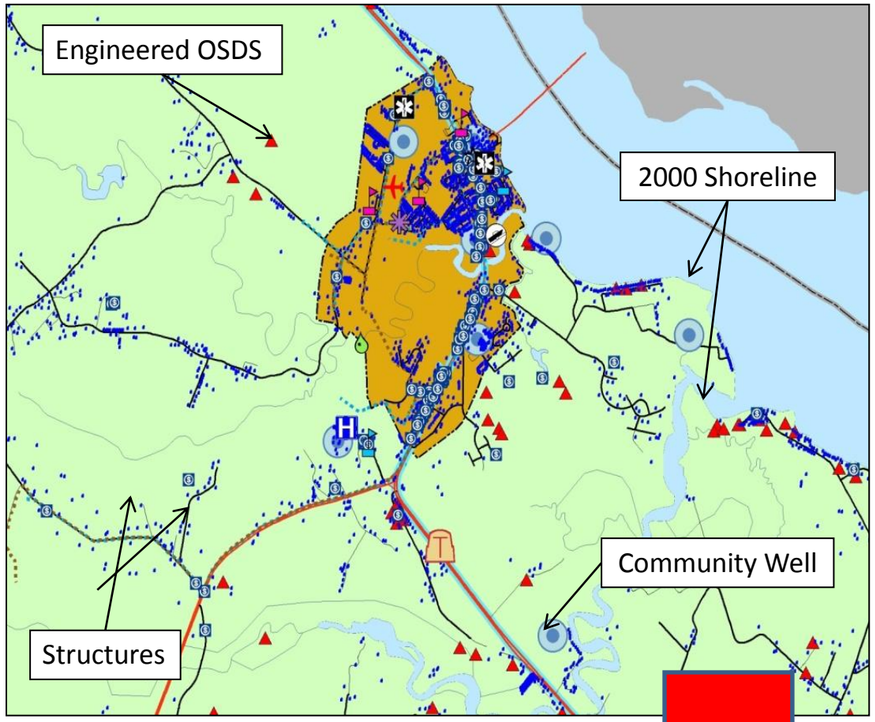
Conserved Lands Impacted	
Catlett Islands - National Estuarine Research Reserve	Quantitative: •Currently there was 536.48 subaqueous acres and 497.39 terrestrial acres of the reserve •In 2050, 375.99 acres of terrestrial land converts to subaqueous land due to inundation



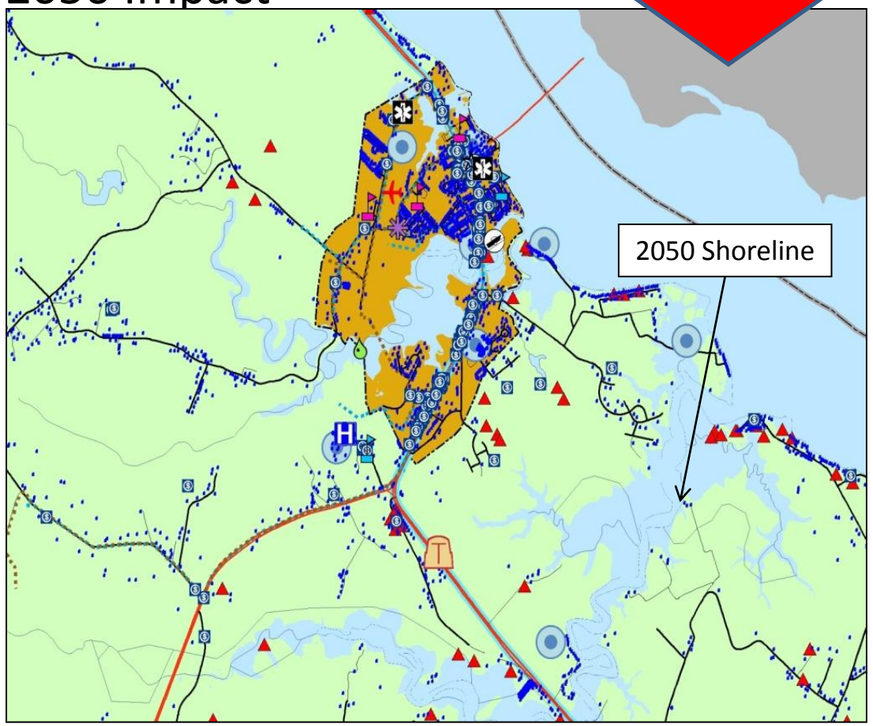
Essex County

U. Town of Tappahannock and Piscataway Creek
V. Gynnfield Subdivision
W. Lower Essex- Cottage Row Road
X. Kendall Road – Ecological Impacts
Y. Layton Peninsula – Ecological Impacts

2000 Current



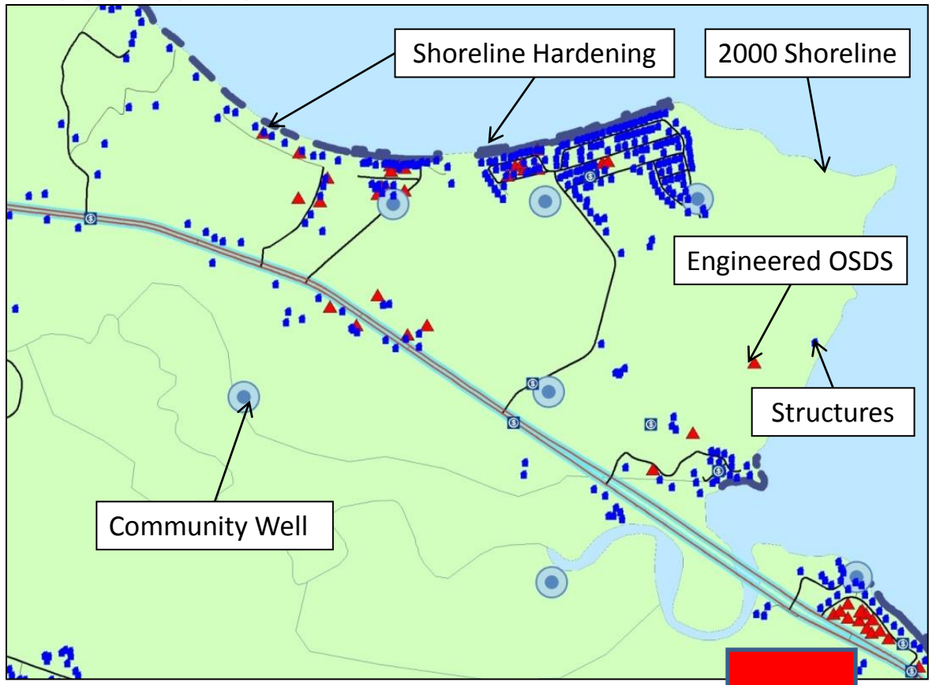
2050 Impact



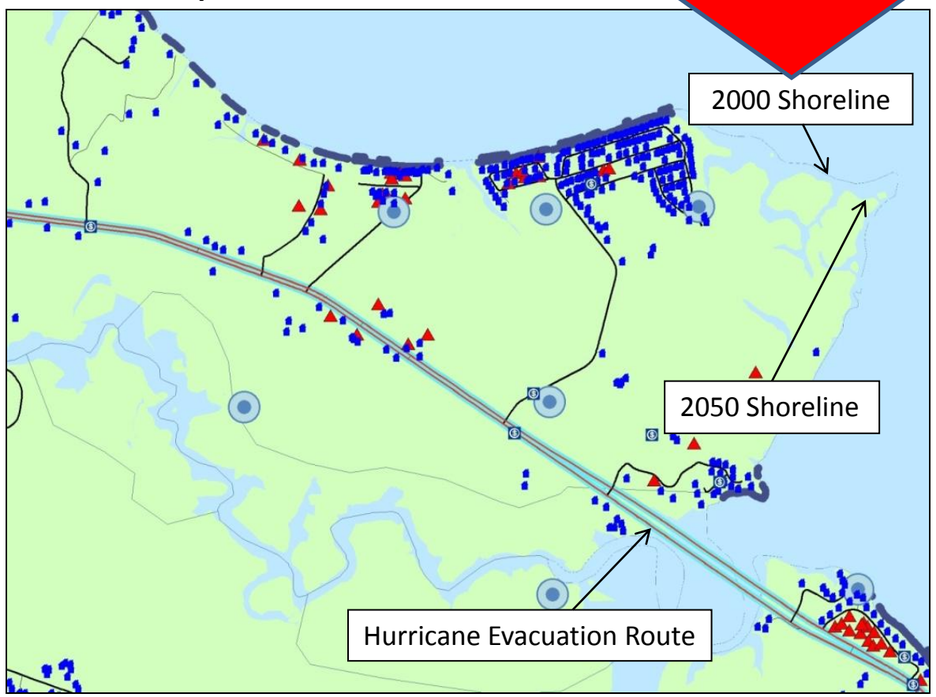
Town of Tappahannock & Piscataway Creek Area

Infrastructure	Amount of Flooded Structures	Average Cost	Total Costs
Houses	7	$197,337 Estimated median house or condo value in 2007 (City-Data.com)	$1,381,359
Engineered OSDS	8	$18,000 (MPPDC Regional Estimate)	$144,000
Conventional OSDS	5	$4,000 (MPPDC Regional Estimate)	$20,000
Community Well	1	$40,000 (MPPDC Regional Estimate)	$40,000
Private Wells	2	$3,000 (MPPDC Regional Estimate)	$6,000
Public Water Lines	220 ft	$190/ft (Hampton Roads Sanitation District Estimate)	$41,800
Public Sewer Lines	573.74 ft	$500/ft (Hampton Roads Sanitation District Estimate)	$286,870
Shoreline Hardening	12,341.18 ft	$200/ft (MPPDC Regional Estimate)	$2,468,236
VDOT Road Segments	3,253 ft	Short Term: $149/sq ft Long Term: $745/sq ft Additional right of way acquisition when raised 10 inches (VDOT Estimate)	Short Term: $484,697 Long Term: $2,423,485
TOTAL			**Short term : $4,872,962** **Long term: $6,811,750**

2000 Current



2050 Impact

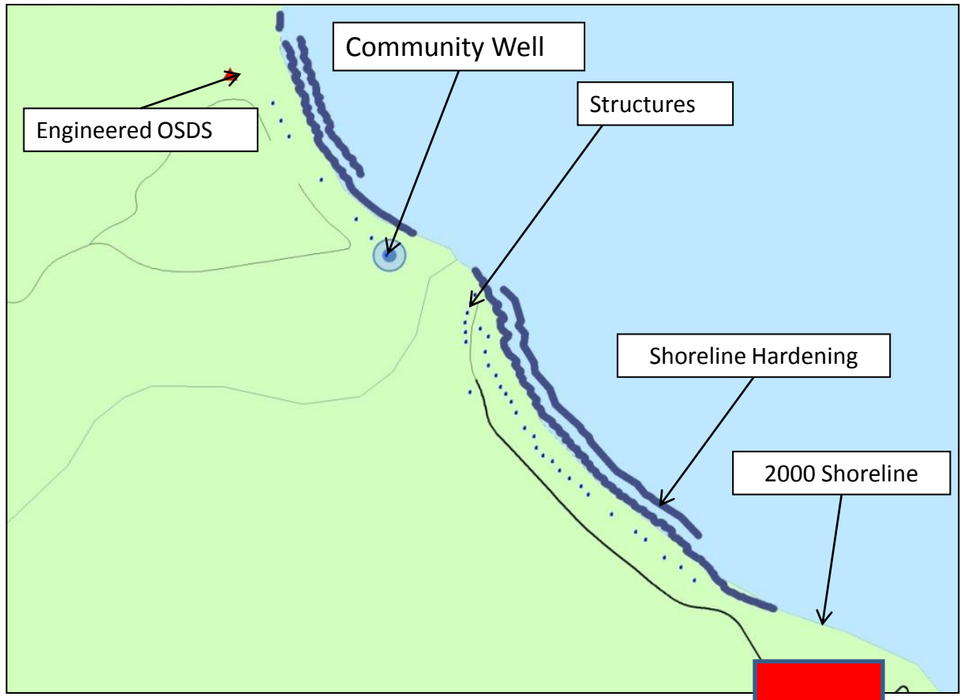


Gwynnfield Subdivision Area: More frequent flooding of Hurricane Evacuation Route 17 will hinder coastal evacuation from Essex, Mathews, and Gloucester Counties

Infrastructure	Amount of Flooded Structures	Average Cost	Total Costs
Houses	1	$197,337 Estimated median house or condo value in 2007 (City-Data.com)	$197,337
Conventional OSDS	1	$4,000 (MPPDC Regional Estimate)	$4,000
Shoreline Hardening	3,876.79	$200/foot (MPPDC Regional Estimate)	$775,358
VDOT Road Segments	2,330 ft	Short Term: $149/sq ft Long Term: $745/sq ft Additional right of way acquisition when raised 10 inches (VDOT Estimate)	Short Term: $347,170 Long Term: $1,735,850
TOTAL			**Short term: $1,323,865** **Long term: $2,712,545**

2,160 feet of Route 17 impacted. Route 17 is the designated Hurricane Evacuation Route for parts of the Hampton Road Area.

2000 Current

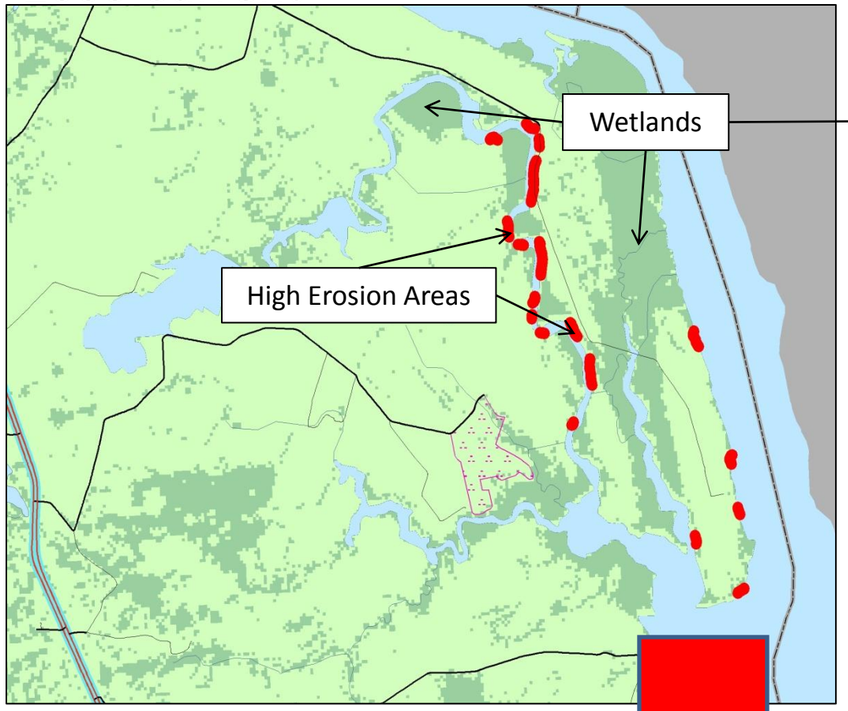


2050 Impact

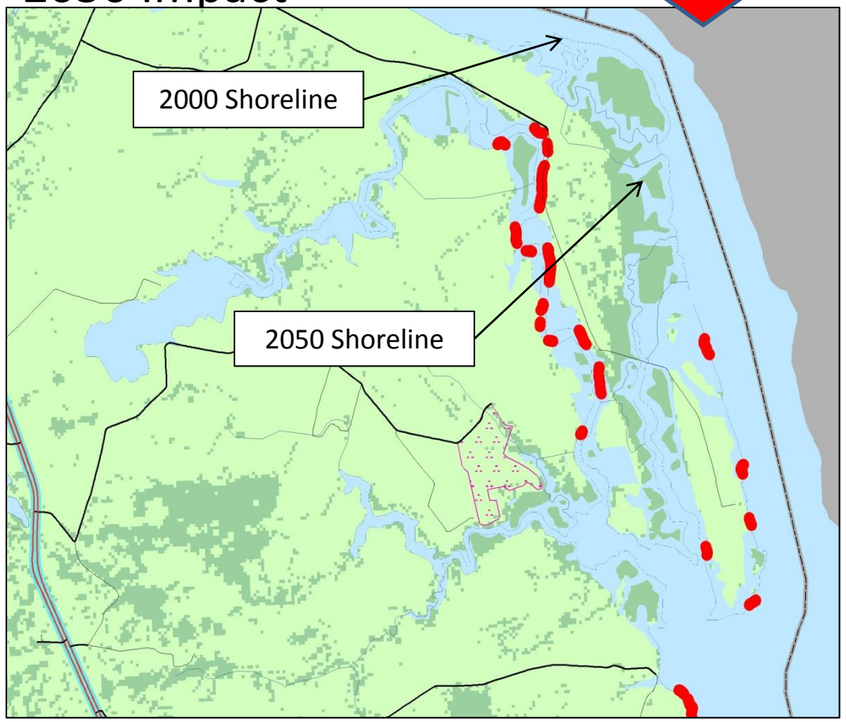
Lower Essex-Cottage Row Road Area: Capital investments to re-locate to the coast may be high but sustaining coastal living may be even higher

Infrastructure	Amount of Flooded Structures	Average Cost	Total Costs
Houses	8	$197,337 Estimated median house or condo value in 2007 (City-Data.com)	$1,578,696
Conventional OSDS	8	$4,000 (MPPDC Regional Estimate)	$32,000
Private Wells	8	$3,000 (MPPDC Regional Estimate)	$24,000
Shoreline Hardening	2,028.54	$200/ft (MPPDC Regional Estimate)	$405,708
VDOT Road Segments	292 ft	Short Term: $149/sq ft Long Term: $745/sq ft Additional right of way acquisition when raised 10 inches (VDOT Estimate)	Short Term: $43,508 Long Term: $217,540
TOTAL			**Short term: $2,083,912** **Long term: $2,257,944**

2000 Current



2050 Impact



Kendall Road Area

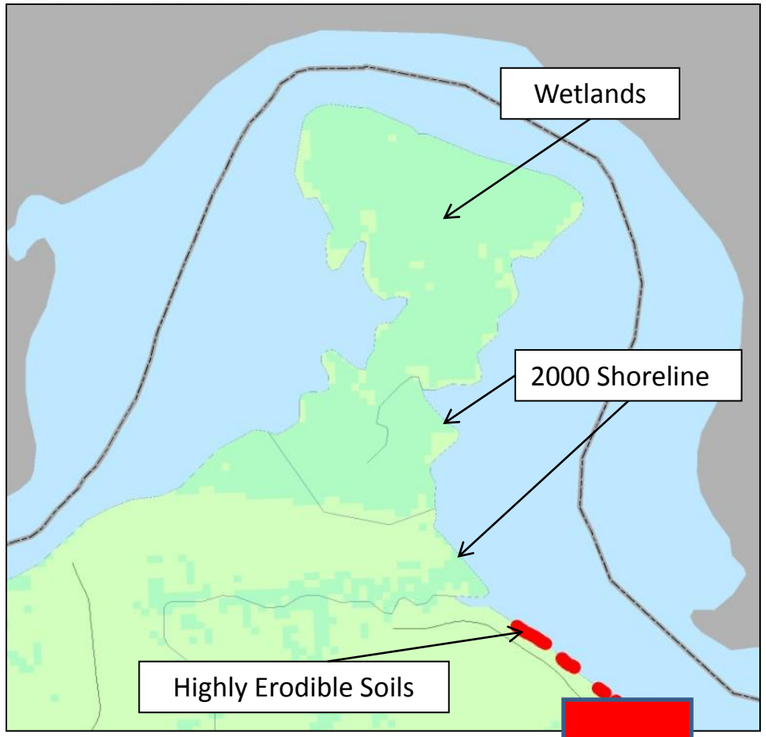
Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors *Fishing and Shellfish Habitat* *Waterfowl Habitat* *Mammal and Reptile*	 $48[a] $253[b] $18[c]	 499.95 499.95 499.95	 $23,997.60 $126,487.35 $8,999.10
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	499.95	$14,420.52 - $4,282,906.67
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	499.95	$4,499.55- $57,494.25
Total value lost or redistributed: $178,404.12– $4,499,884.97			

Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista

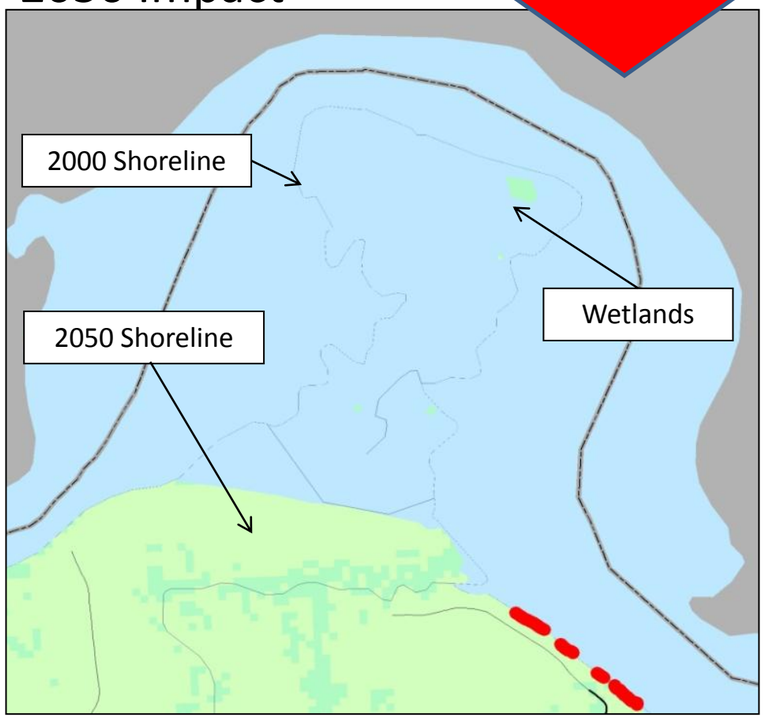
[a] Bell, 1989 [b] Guta and Foster, 1975 [c]Farber and Costanza, 1987 [d]Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j]Bell, 1989

7,887.73 ft of High Erosion Areas will be most vulnerable sea level rise, ultimately altering the geomorphology of the area

2000 Current



2050 Impact



Layton Peninsula: As an entire ecologic community is altered due to sea level rise, the Rappahannock River may widen and increase coastal erosion to the area

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	197.80	$9,494.40
Waterfowl Habitat	$253[b]	197.80	$50,043.40
Mammal and Reptile	$18[c]	197.80	$3,560.40
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	197.80	$57,296.73 - $1,694,487.33
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	197.80	$1,780.20 - $22,747.00
Total value lost or redistributed: $122,148.13 – $1,780,332.53			
Qualitative Losses from Wetland Inundation			
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity		-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista	
[a] Bell, 1989 [b] Guta and Foster, 1975 [c]Farber and Costanza, 1987 [d]Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j]Bell, 1989			

866.90 ft of High Erosion Areas will be most vulnerable sea level rise, ultimately altering the geomorphology of the area

Middle Peninsula

Total Economic Impacts of Select Areas:

Summary by County

County	Anthropogenic		Ecological	Total Short term costs	Total Long term costs
	Short term	Long term			
Mathews	$63,984,342.58	$86,717,356.02	$589,732.79 – $8,593,569.70	**$64,574,075.37 – $72,577,912.28**	**$87,307,088.81 – $95,310,925.72**
King and Queen	$10,790,810.41	$11,024,055.01	$1,217,772.89 – $17,745,360.94	**$12,008,583.30 – $28,536,171.35**	**$12,241,827.90 – $28,769,415.95**
Middlesex	$41,541,858.60	$44,671,693.00	$63,990.61 – $932,469.41	**$41,605,849.21 – $42,474,328.01**	**$44,735,683.61 – $45,604,189.41**
King William	$2,746,623.63	$2,811,867.75	$1,372,252.13 – $19,996,428.51	**$4,118,875.76 – $22,743,052.14**	**$4,184,119.88 – $22,808,296.26**
Gloucester	$25,885,992	$28,758,156.00	$695,464.67 – $10,137,634.63	**$26,581,456.67 – $36,023,626.64**	**$26,453,620.67 – $38,895,790.63**
Essex	$8,280,739	$11,782,239.00	$300,552.25 – $6,280,217.50	**$8,581,291.25 – $14,560,956.50**	**$12,082,791.25 – $18,062,456.50**

Total Economic Impact of Select Areas within the Middle Peninsula

Anthropogenic		Ecological
Short term	Long term	
$126,230,366.20	$185,765,366.80	$4,239,764.75 – $63,685,680.69

Total Short term Costs of Selected Areas in the Middle Peninsula	Total Long term Costs of Selected Areas in the Middle Peninsula
$157,470,131.60 – $211,916,046.90	$187,005,132.10 – $249,451,074.50