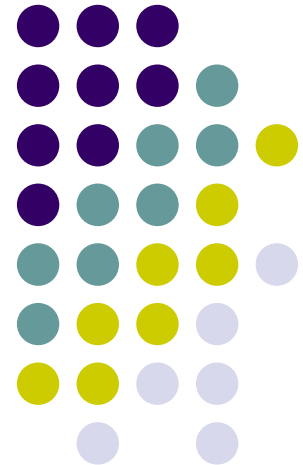


# Recommendations for a Water Quality Buffer System for the Inland Bays Watershed



*Delaware Center for the Inland Bays  
Scientific & Technical Advisory Committee  
Meeting June 6<sup>th</sup>, 2008*

Chris Bason  
Science & Technical Coordinator



# Talk Outline

- Put development of buffer system into context
- Define water quality buffers
- Describe the recommendations by waterbody types
- Apply the buffer systems to developments proposed to the Preliminary Landuse Service



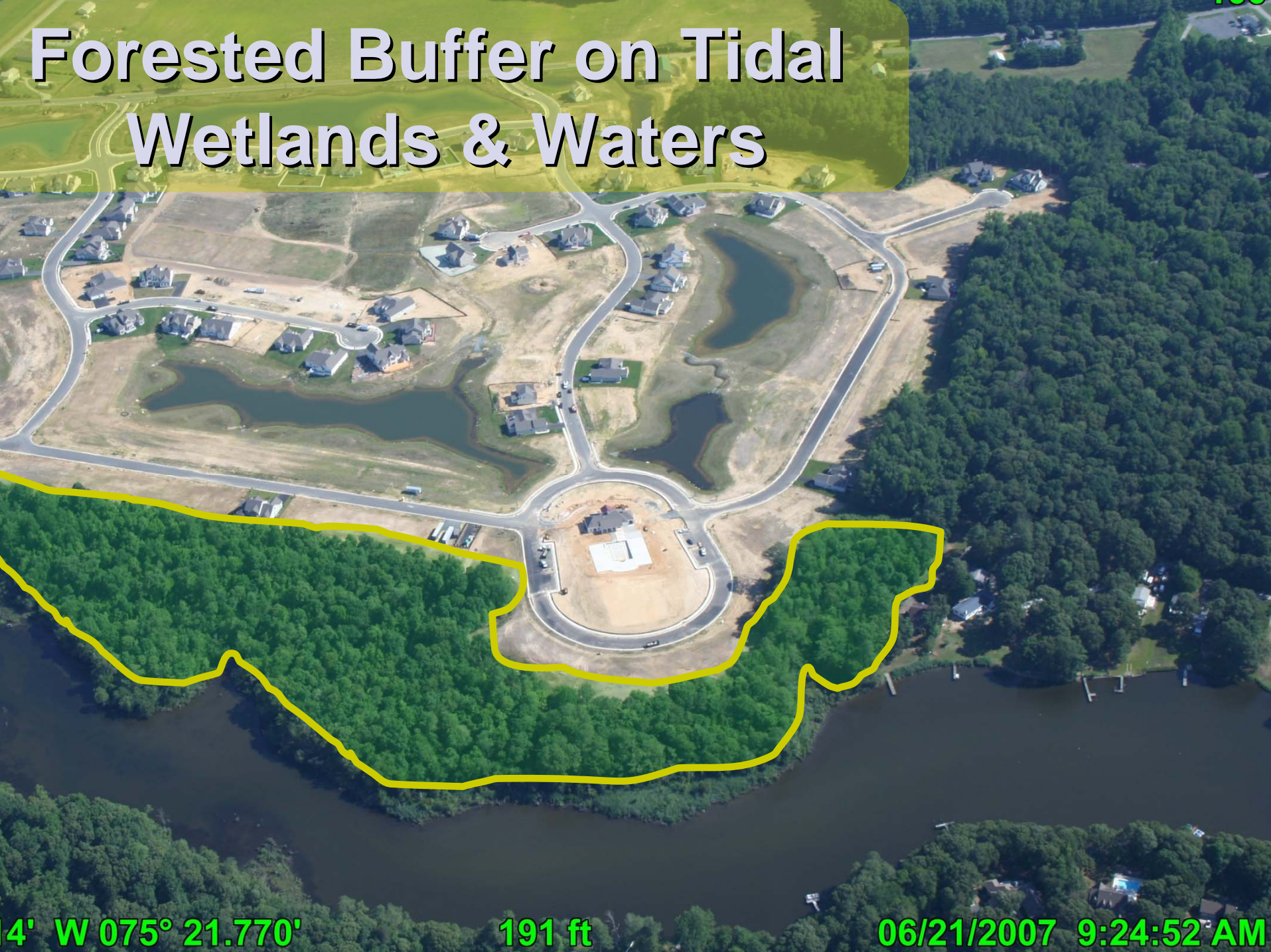
# Context for the Development of the Buffer System

- Focus on Atlantic Coastal Plain
- As a recommendation for the Pollution Control Strategy to meet Total Maximum Daily Loads reductions for nitrogen and phosphorus
- To maximize nutrient reductions and limit its affect on development site design
- Include flexibility per Comprehensive Conservation and Management Plan
- ***For application on developing lands***





# Forested Buffer on Tidal Wetlands & Waters



4' W 075° 21.770'

191 ft

06/21/2007 9:24:52 AM



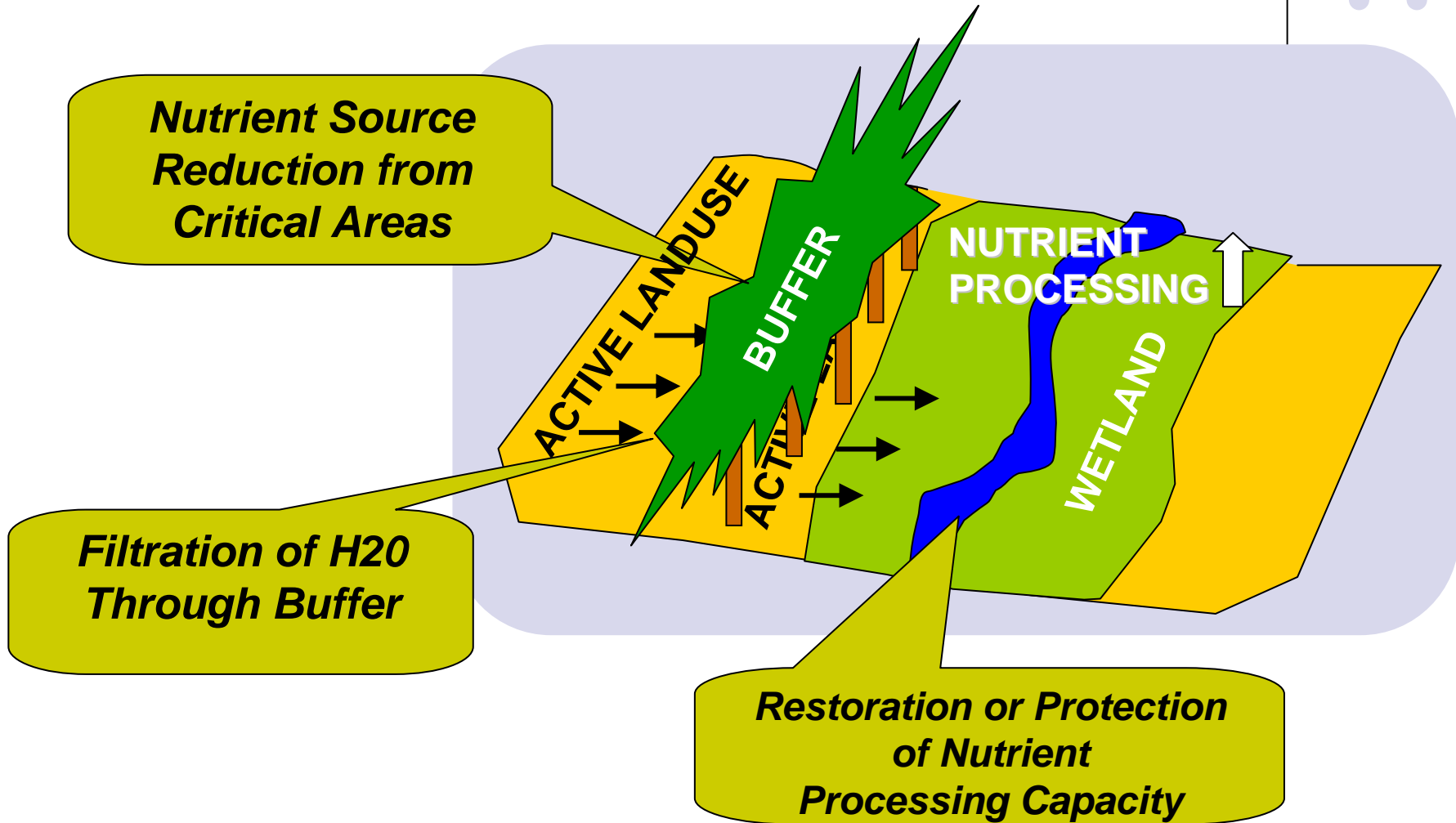
# Definition of Water Quality Buffers

Water quality buffers are natural areas between active landuses and wetlands or waterbodies. Buffers are managed for the primary purposes of:

1. sustainable removal and retention of pollutants entering wetlands or waterbodies,
2. to protect wetlands or waterbodies against encroachment and physical alterations, and
3. to allow wetlands or waterbodies to maximize their own natural capacities to reduce pollution.



# General Description of Water Quality Buffer Function: Riparian Ecosystem



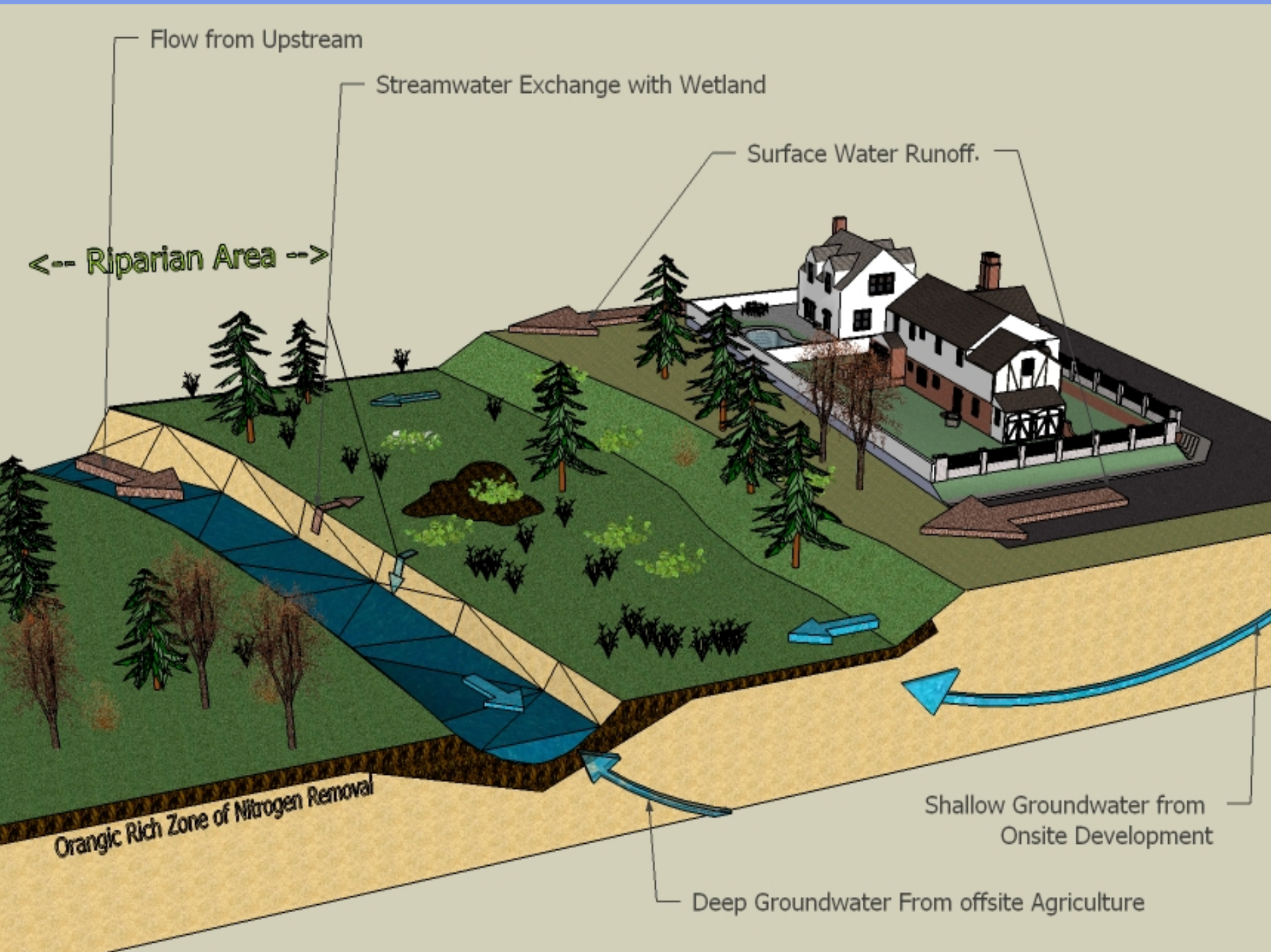


Flow from Upstream

Streamwater Exchange with Wetland

Surface Water Runoff.

<-- Riparian Area -->



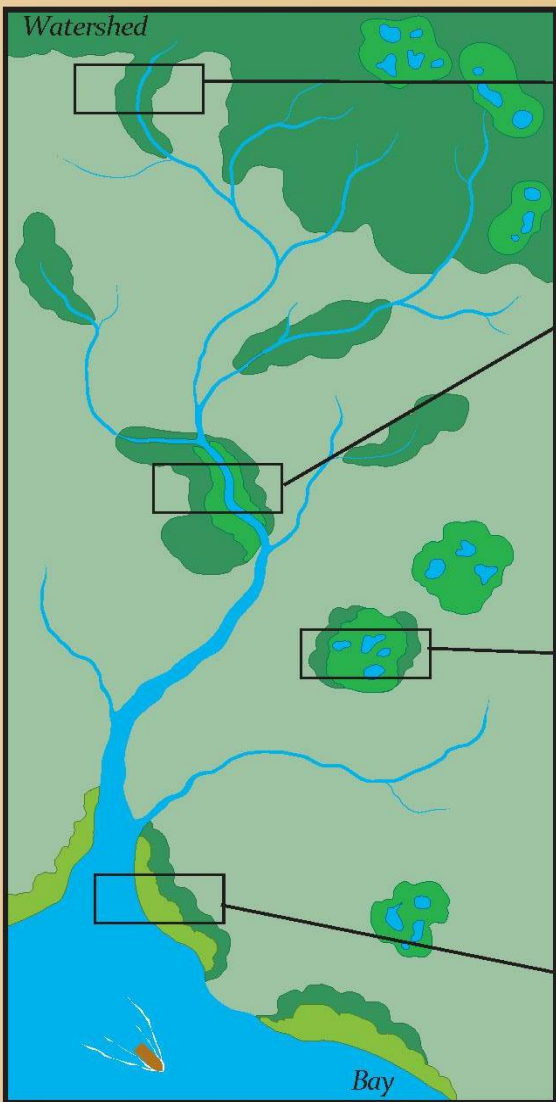
Organic Rich Zone of Nitrogen Removal

Shallow Groundwater from Onsite Development

Deep Groundwater From offsite Agriculture

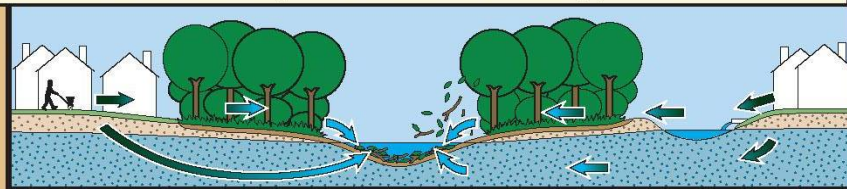


# Wetlands & Waterways of the Inland Bays Watershed



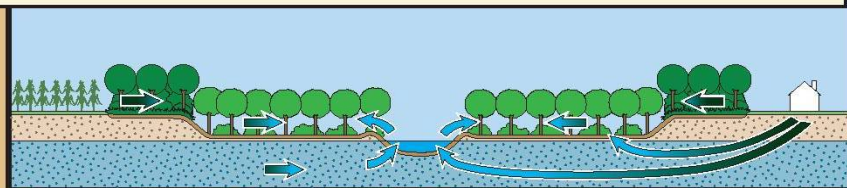
## Headwaters

- Are closest to landuses such as development and receive the highest concentrations of pollutants.
- Forested buffers filter pollutants from surface water runoff and groundwater.
- The roots, leaves, and branches from the forested buffers slows water in the channel filtering more nutrients and decreasing pollution downstream.



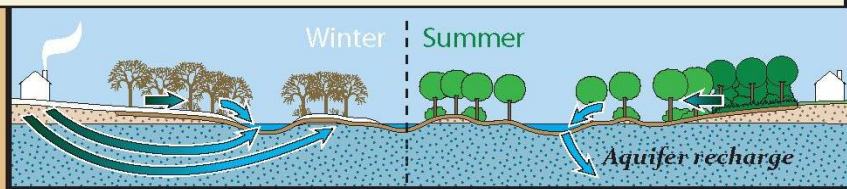
## Larger Streams & Riverine Wetlands

- Are fed mostly by groundwater and floodwaters from upstream.
- The wetlands filter pollutants and store floodwaters from the stream.
- Forested buffers protect stream channels and their wetlands because they work together to filter nutrients.



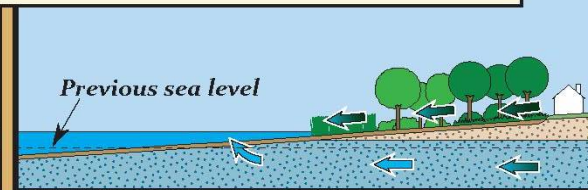
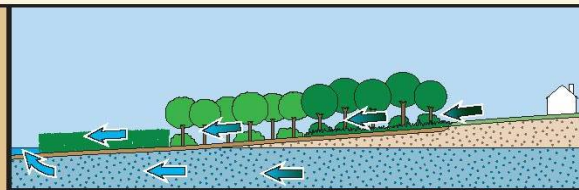
## Flats & Depressional Wetlands

- Are very important for habitat and water quality, but many are not legally protected.
- In winter and summer they store and filter ground and surface water.
- In summer they also can supply clean water to drinking water aquifers.



## Saltmarshes

- Saltmarshes filter and store great amounts of nutrients in their grasses and soils.
- Saltmarshes need wide buffers because they move landward as sea level rises.
- Rising sea level reduces salt marsh area, which reduces capacity to filter nutrients.
- Sea levels are expected to rise faster in the coming years.



Flow of Water



More polluted

Less polluted



# Importance of Riparian Buffers



- **Effective:** Coastal Plain riparian buffers were found to retain 23 to 65 lbs of nitrogen (67-89% of inputs) and 1.1 to 2.6 lbs of phosphorus (24-81% of inputs) per acre of buffer per year (*Lowrance et al. '97*).
- **Efficient:** Long term investment with little to no maintenance relative to other pollution control measures
- **Variable:** Difference in effectiveness results from great variability among riparian areas

# Characteristics of a Buffer System



- Extent: What waterbodies to buffer
- Vegetation Type
- Width
  - By waterbody type
  - Along an individual waterbody: fixed width vs. variable width
  - Where to buffer from





# Buffer Extent

- “Perhaps the most important guiding principles to emerge from the current scientific literature that should be considered when implementing riparian setback regulations are:
    - (1) The importance of contiguity in riparian protection and
    - (2) The great value and importance of protecting the least disturbed riparian corridors in communities.”
- *David Correll, of the Smithsonian Environmental Research Center, after a career studying riparian zones (Ecological Engineering 2005)*

# What waterways are the most important to buffer for water quality protection?

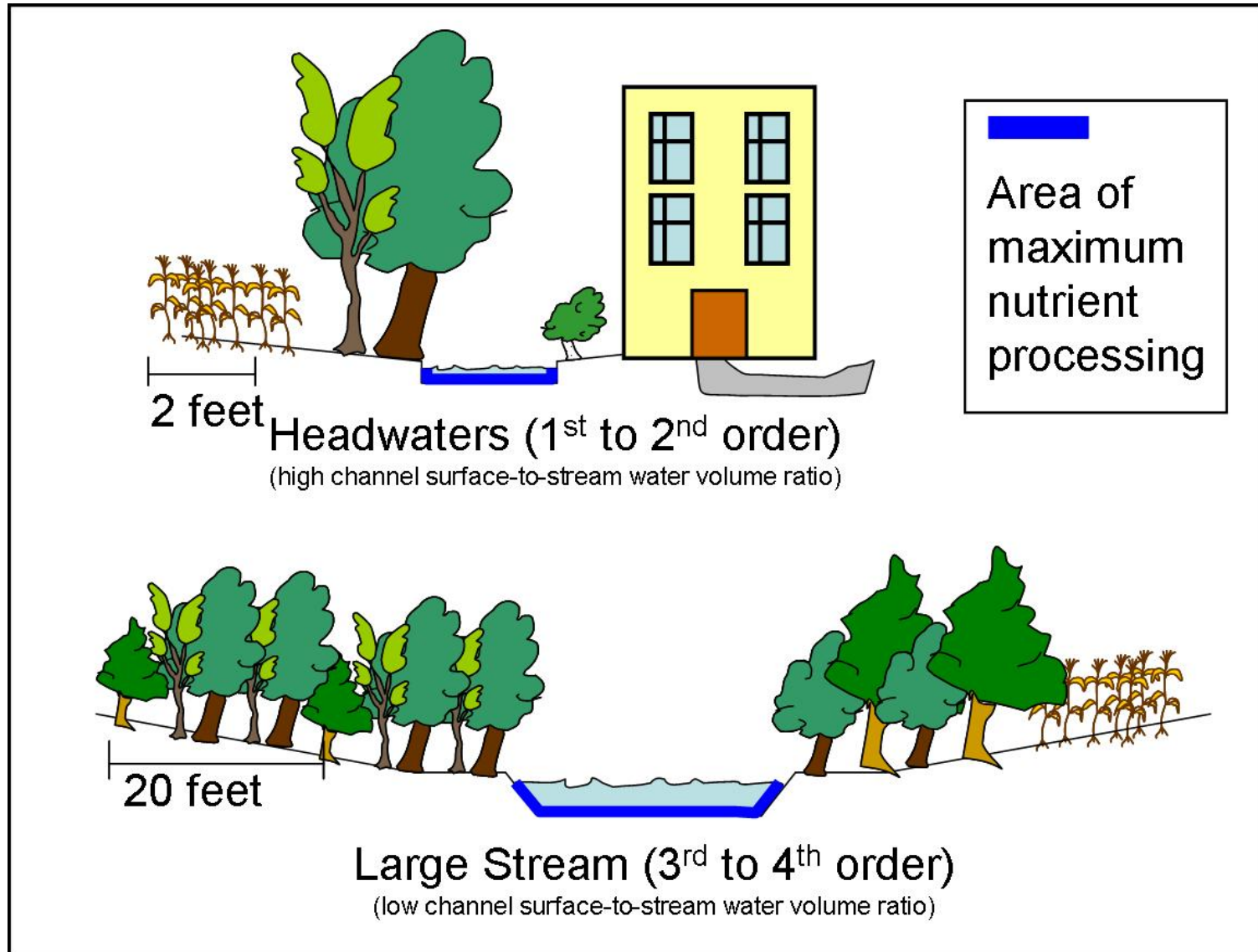


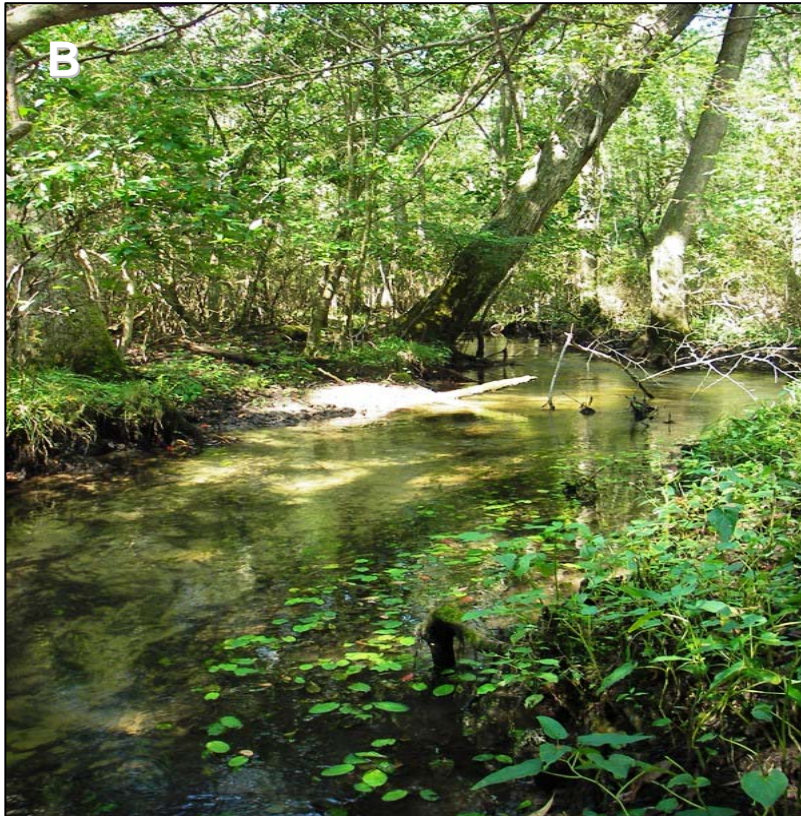
## ***HEADWATERS***

- Comprise ~75% of waterway length in watersheds
- Tend to have the highest nutrient concentrations because they are the first to receive inputs -- are in “tight” connection with landuses
- Rates of nitrogen removal are higher  
(*Peterson et al. '01, Seitzinger et al. '02, Alexander et al. '07*)



# Nutrient Processing by Stream Size





# Vegetation Type

## *Grass vs. Forest*



- Forested buffers remove 36% more N on average than grassed buffers (*Mayer et al. 2007*)
- Forested buffers take up 11 – 37 lbs of N and 2 – 5 lbs of P per acre per year into wood (*Correll et al. '89&'84 Fail et al. '87&86*)
- Soil organic matter is over twice as high in forested buffers (*Brinson et al. 2006*)
- Forested buffers improve instream processing of nutrients (*Sweeney et al. 2004*)



# Buffer Width: Where to Buffer From in Riparian Ecosystems

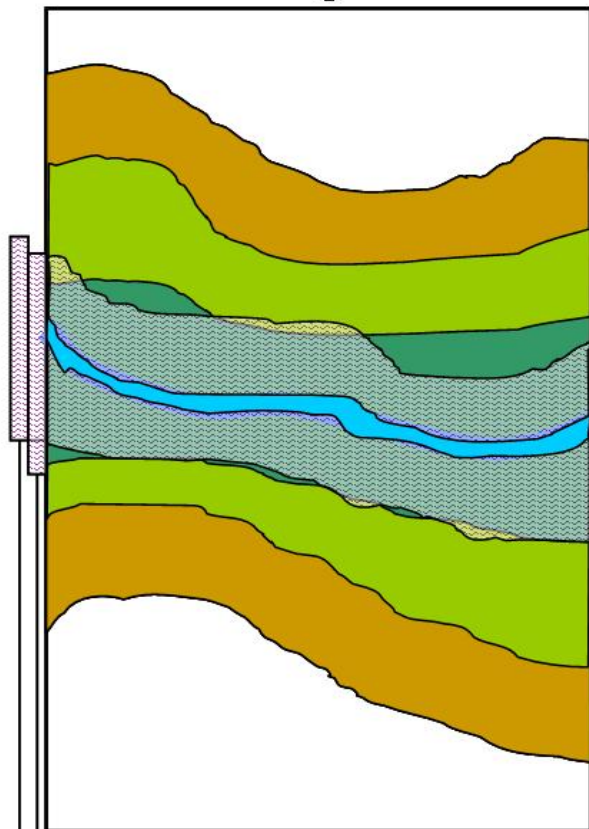
## Channel or Wetland?



- Streams and their wetlands are linked in their capacity to filter pollution
- Where wetlands are present, buffers begin at edge of wetland
- Wetlands of 21 non-tidal waterways were 112' wide from the channel to the upland edge.



## Buffering from Channel Edge



Development

Riparian Forest

Riparian Wetland

Channel

Riparian Wetland

Riparian Forest

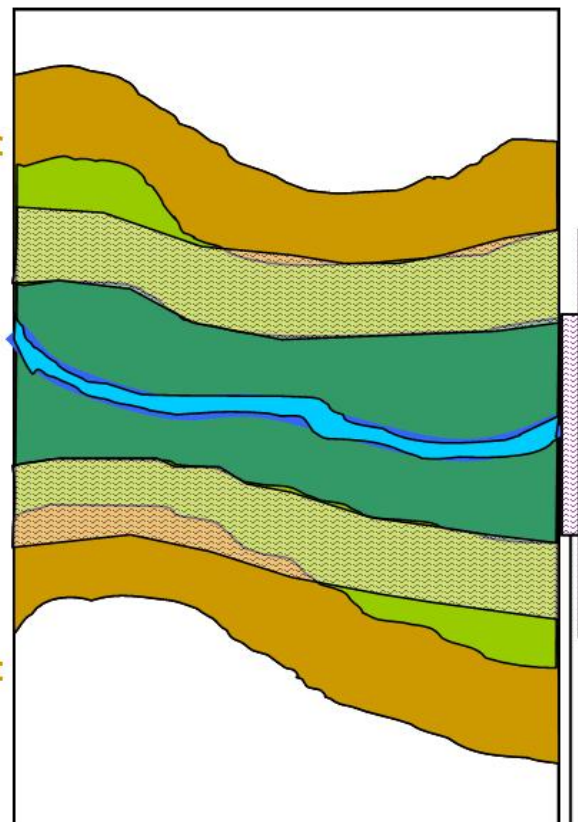
Development

*Existing protections*

*Extent of new protection*

- Alone, may not protect all wetlands
- Adds little protection to wetlands already protected under CWA.
- Does not protect existing riparian upland forest

## Buffering from Wetland Edge



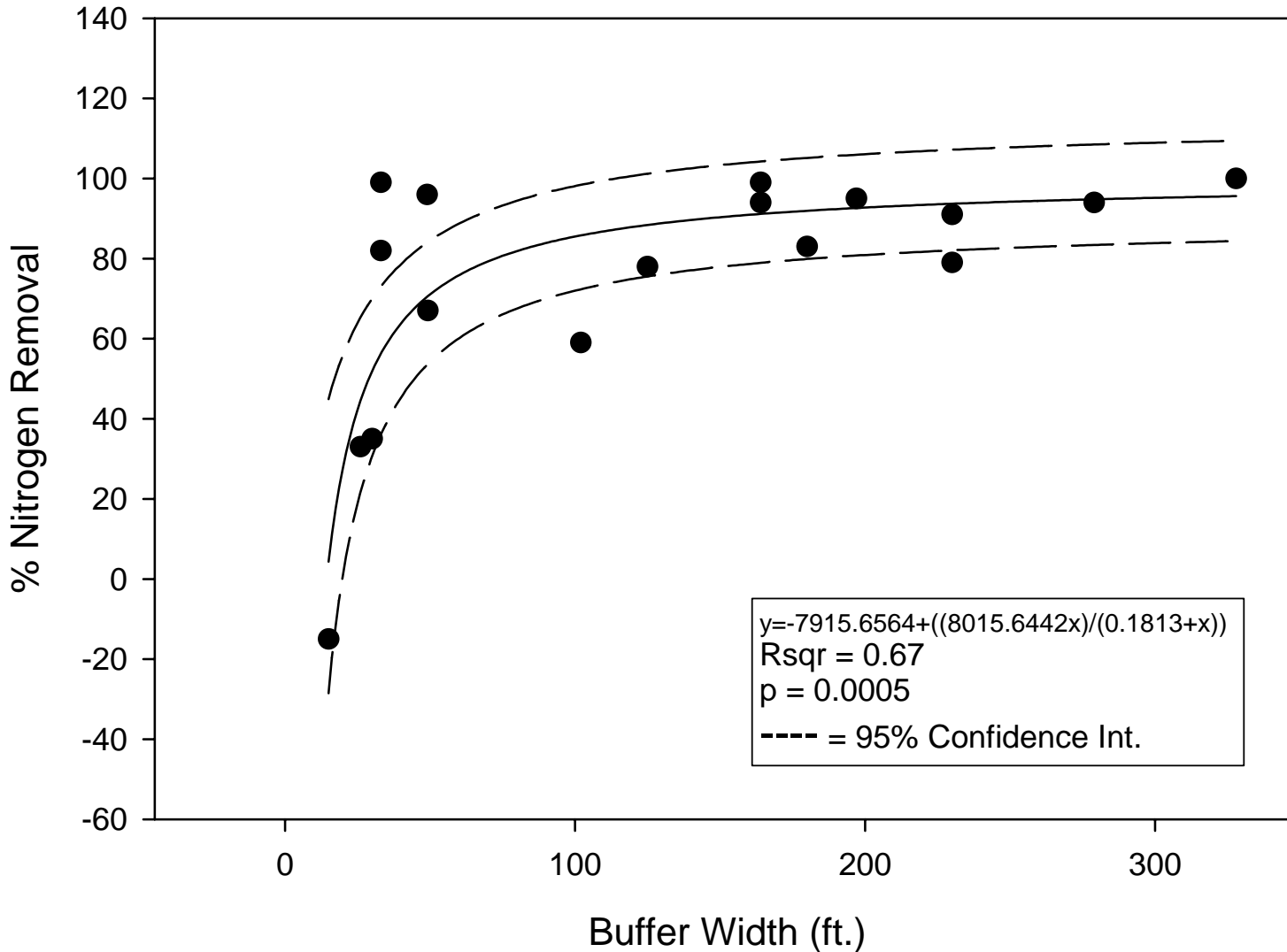
- Buffers entire functional ecosystem
- Protects valuable existing riparian upland forest
- Protects against closest sources of pollutants



# So How Wide Should a Buffer Be?



# Effect of Buffer Width on Nitrogen Removal for 17 Atlantic Coastal Plain Riparian Buffers

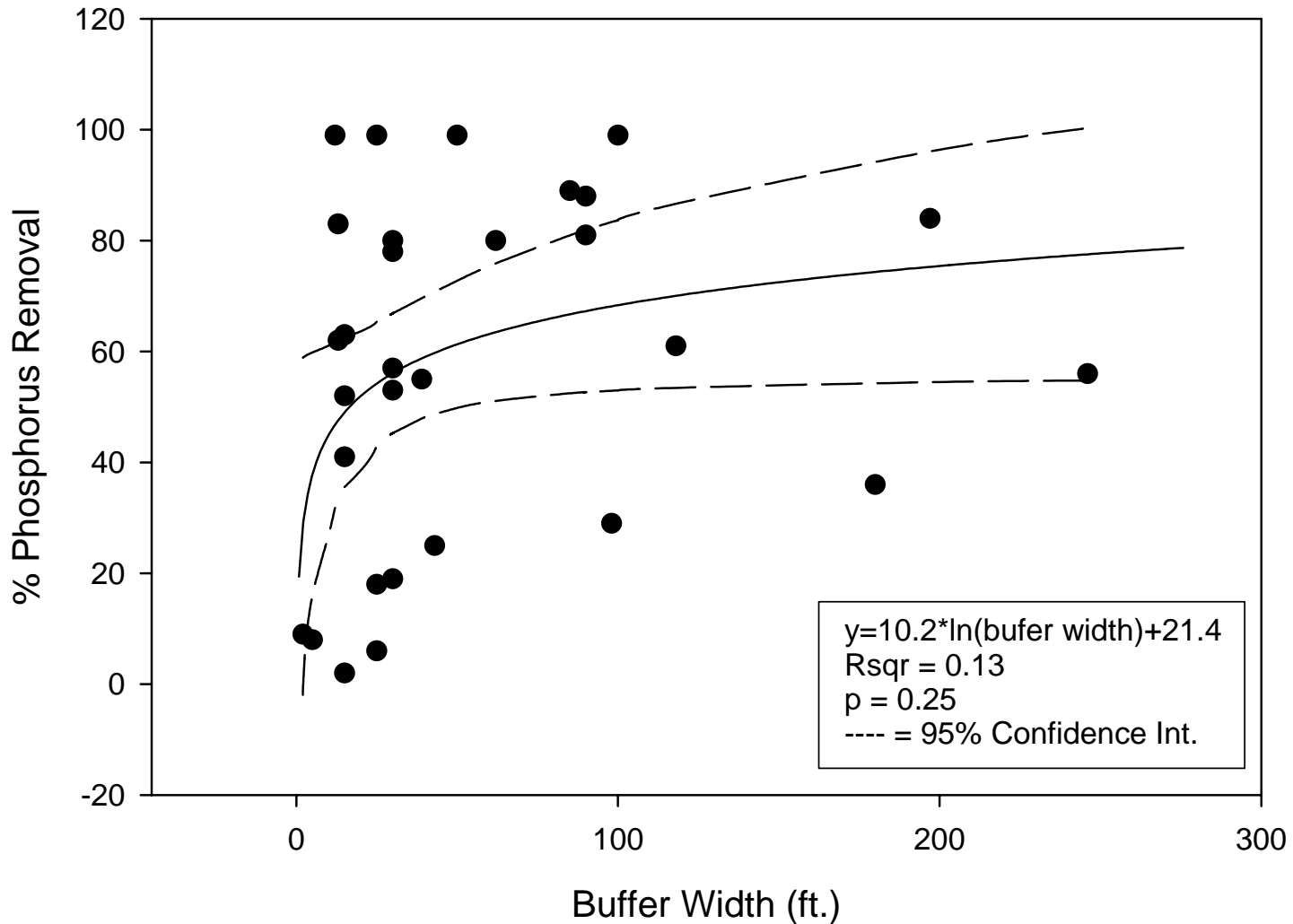
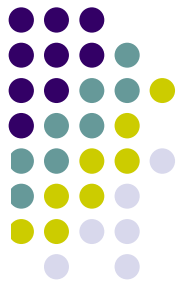


# Effect of Riparian Buffer Width on Nitrogen



- A point was identified between 80 and 90 feet, where only a 2% increase in removal efficiency was gained for each additional foot of width.
- At 80 feet wide, buffers averaged nearly 80% nitrogen removal, with at least 67% removal occurring for most buffers (95% confidence interval lower bound).
- The data also suggests a threshold of 150 feet and above where buffers more consistently reach their maximum potential for nitrogen removal and where they averaged 90% reduction.

# Effect of Buffer Width on Phosphorus Removal for 31 Buffers from All Over





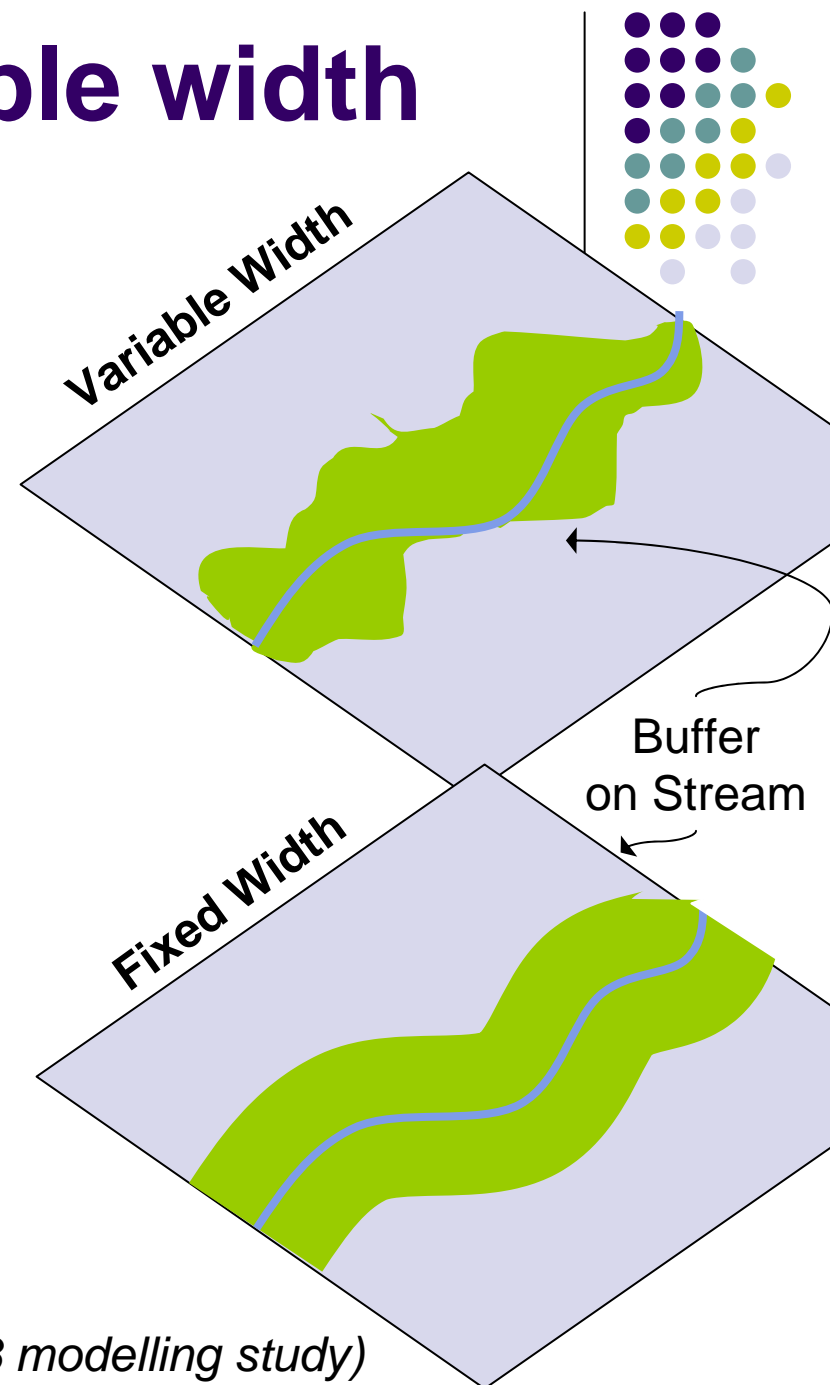
# Effect of Riparian Buffer Width on Phosphorus



- Highly variable and not a significant relationship between width and removal
- The data indicates that around 80 feet removal averaged 66% with around 50% removal occurring for most buffers (lower 95% confidence interval)
- Also around 80 feet there visually appeared to be a point where buffers more consistently removed more phosphorus

# Buffer Width: Variable width vs. Fixed width

- Variable width buffers remove less pollution than fixed width buffers of equivalent average width
- Areas of narrow/absent buffers contribute relatively high levels of pollution
- Extra pollutant discharge from below average width buffers is more than the extra pollutant retention from above average width buffers
- Effect most important for narrow average width buffers



*(Weller et al '98 modelling study)*

# Tidal Wetlands and Waters



- As much as 75% of the nitrogen from the Rehoboth Bay watershed moves as groundwater that regularly discharges near and within tidal wetlands (*Volk et al. 2006 and Ullman personal comm. 2007*).
- Migrate inland with rising seas
- Buffer width determined by nutrient reduction and migration
- Wendy Carey's Phd Thesis documented rates

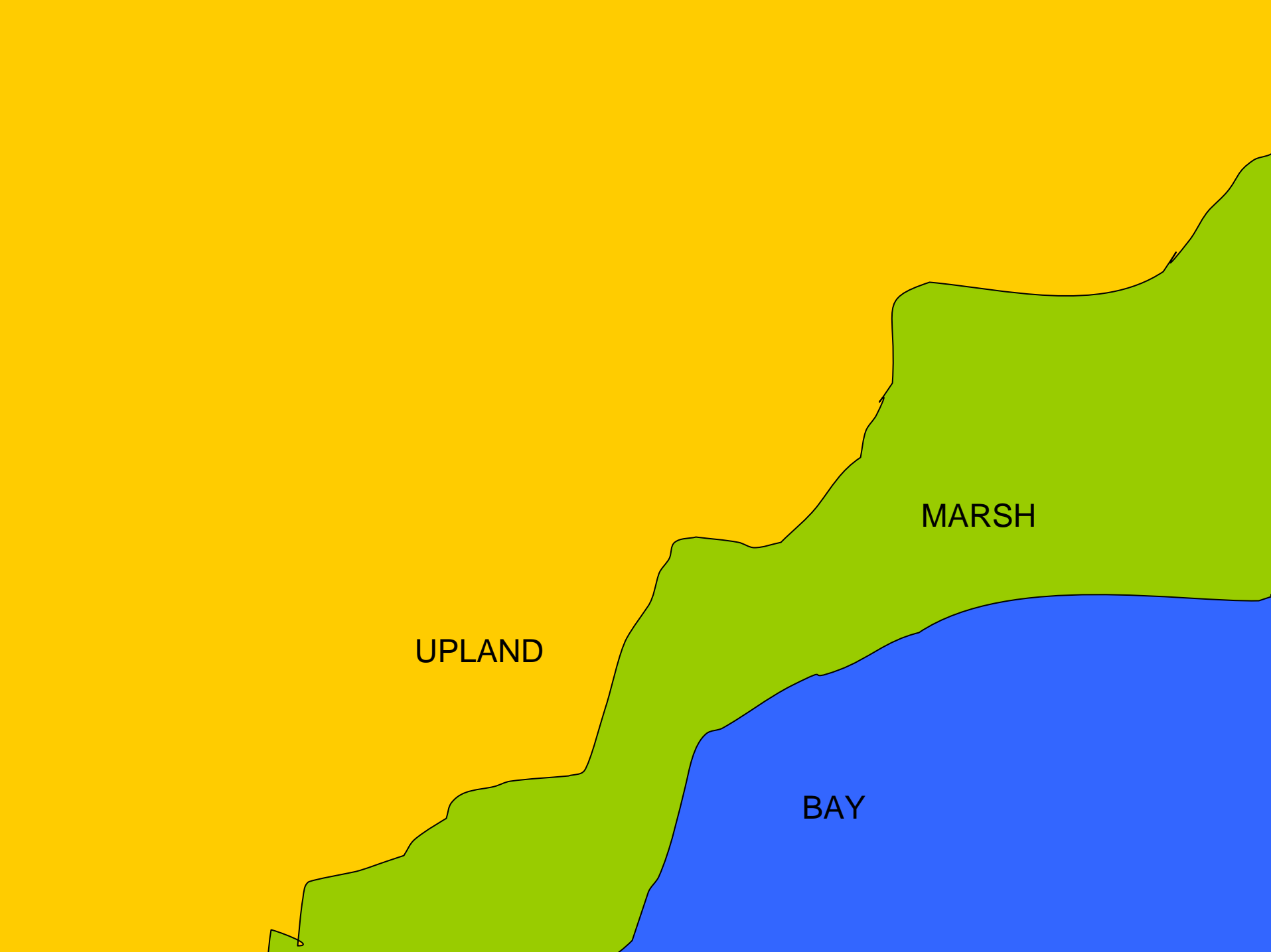




UPLAND

MARSH

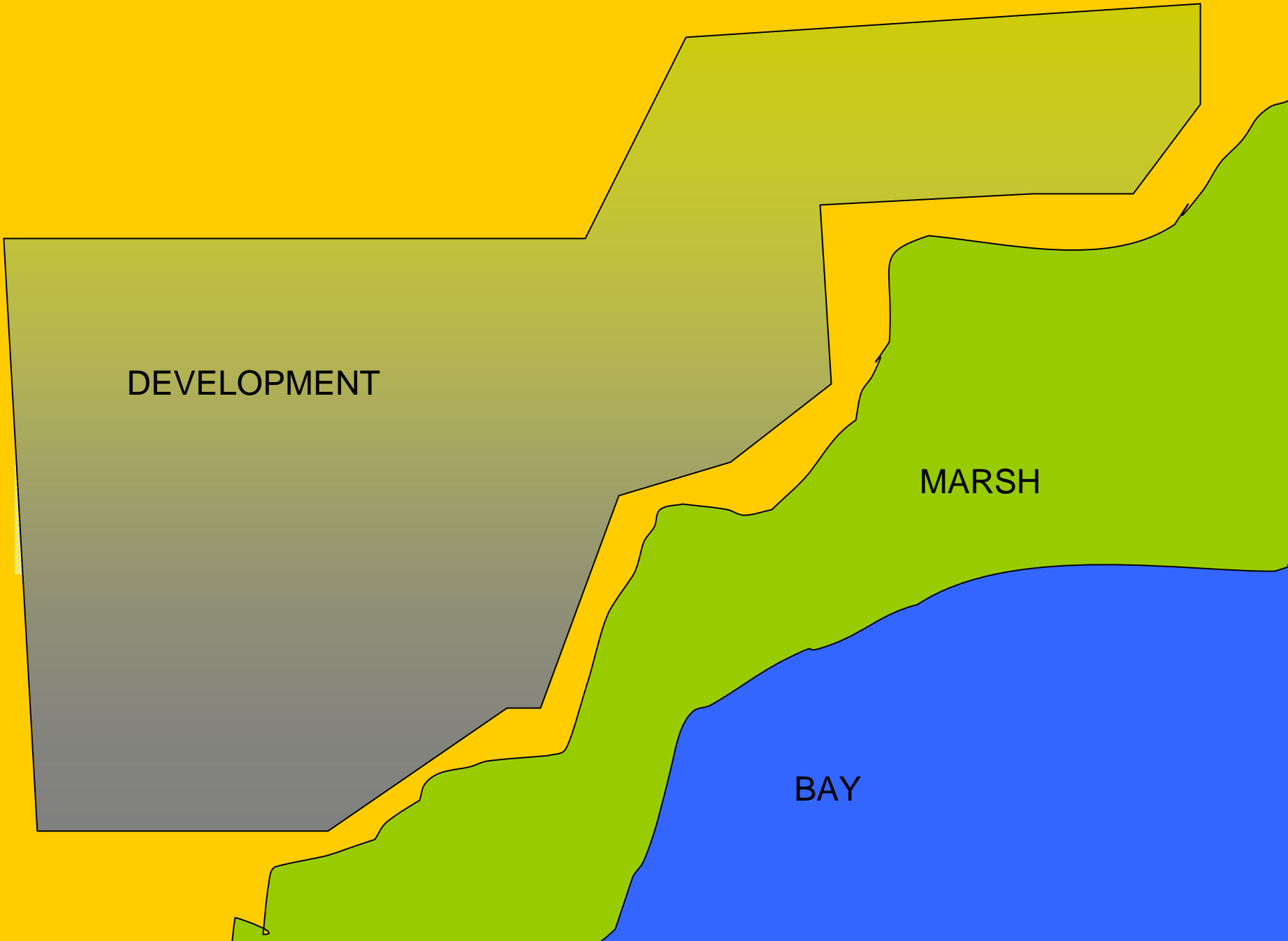
BAY



UPLAND

MARSH

BAY



DEVELOPMENT

MARSH

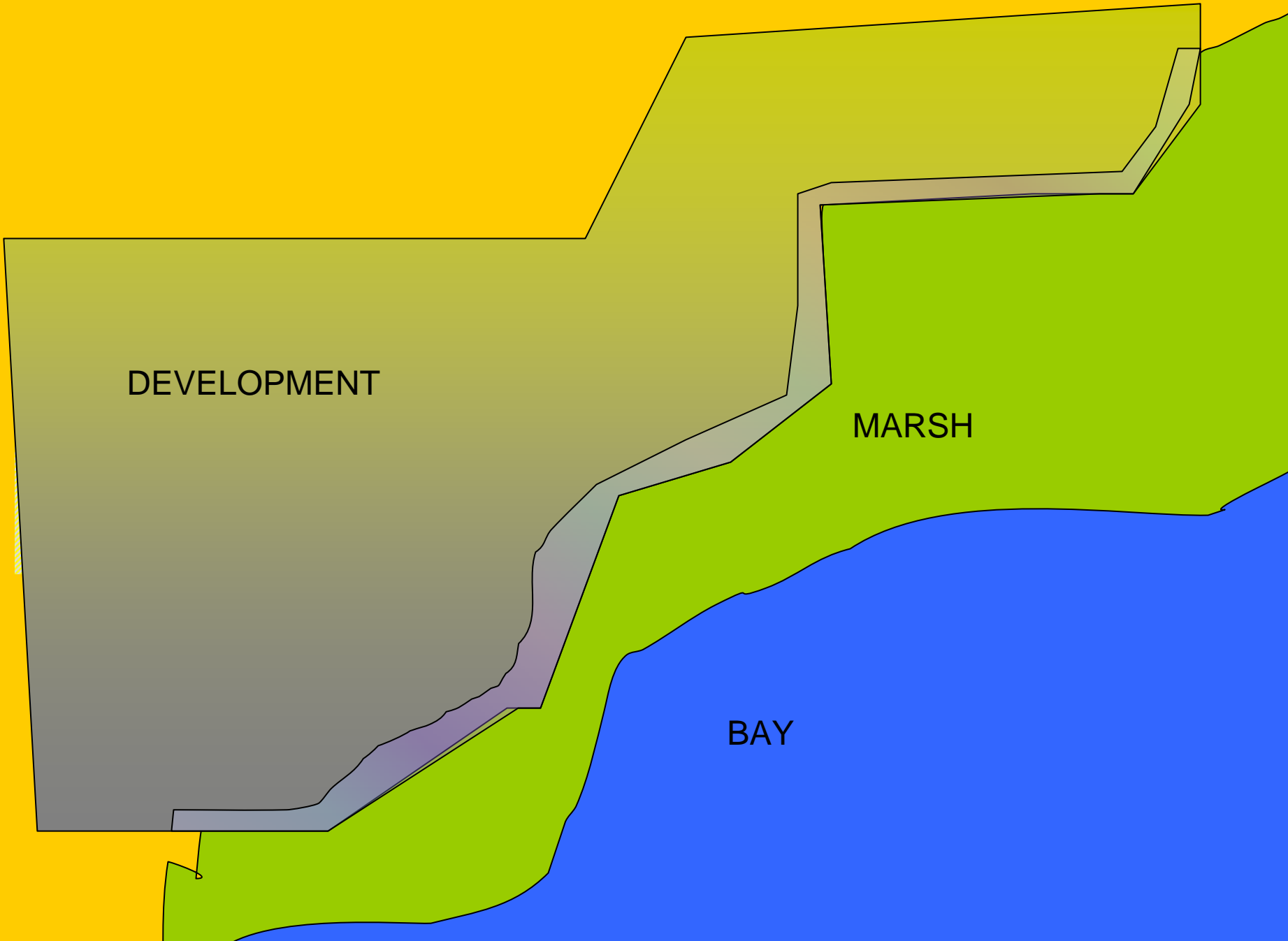
BAY

DEVELOPMENT

MARSH

BAY

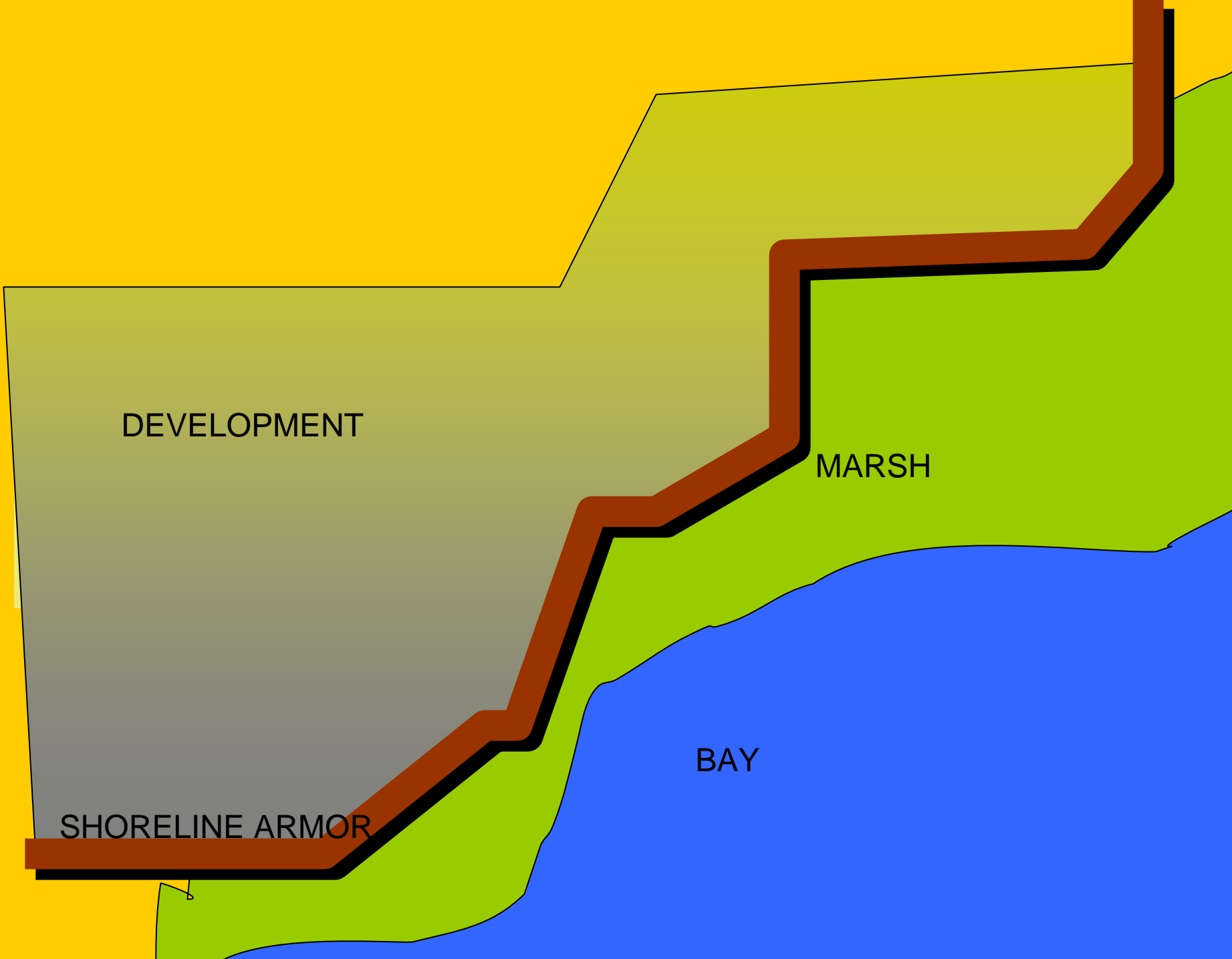




DEVELOPMENT

MARSH

BAY

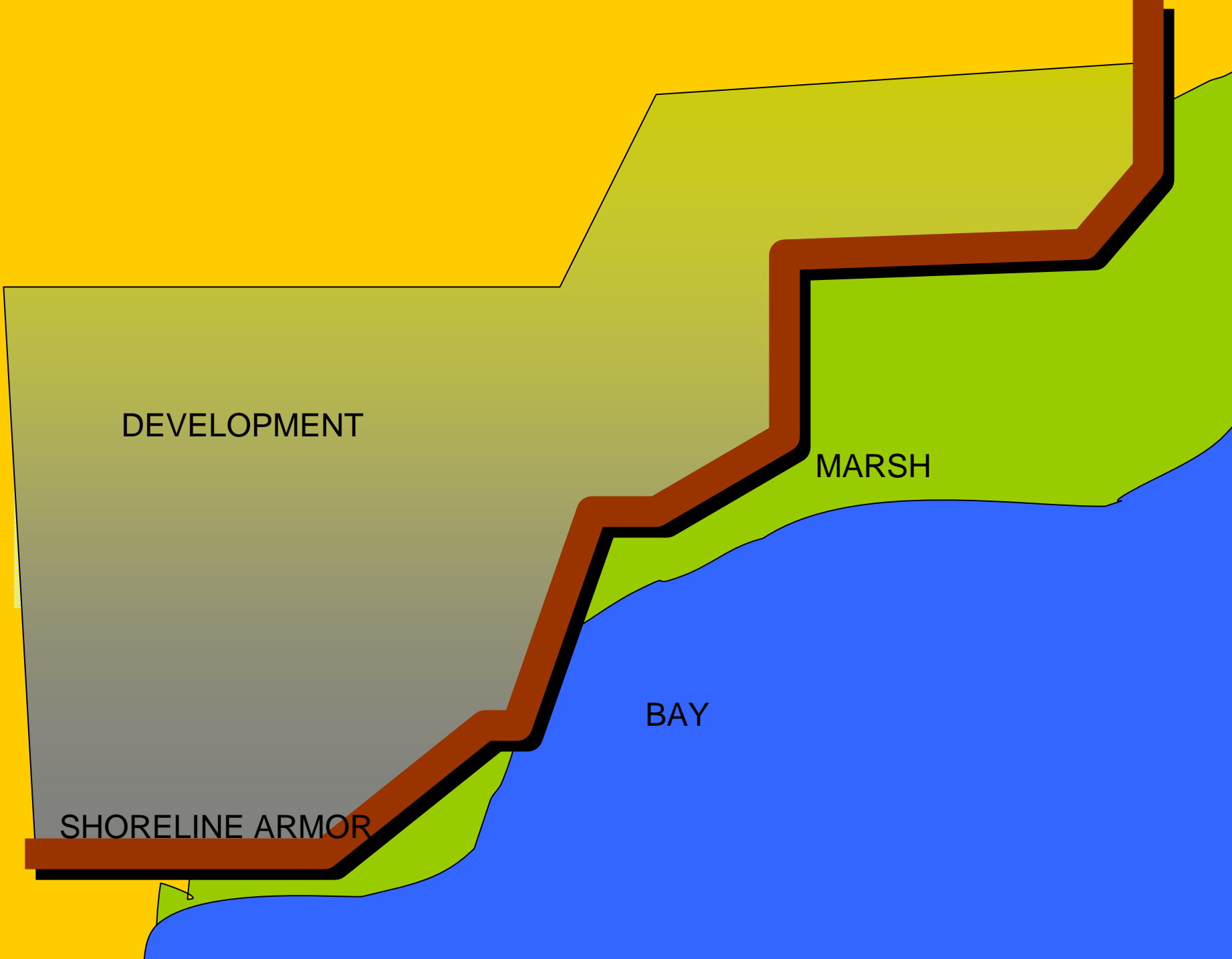


DEVELOPMENT

MARSH

BAY

SHORELINE ARMOR

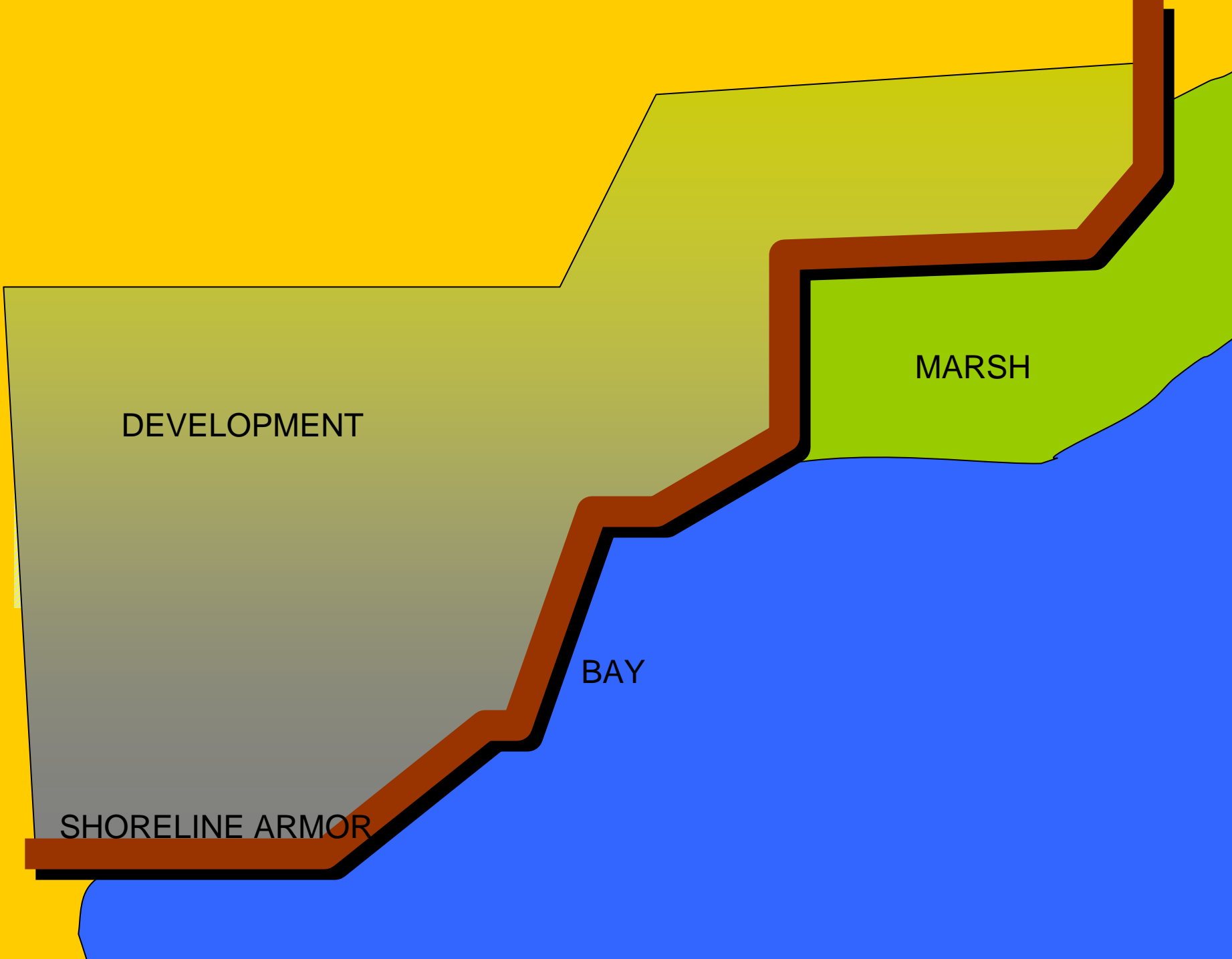


DEVELOPMENT

MARSH

BAY

SHORELINE ARMOR



DEVELOPMENT

MARSH

BAY

SHORELINE ARMOR

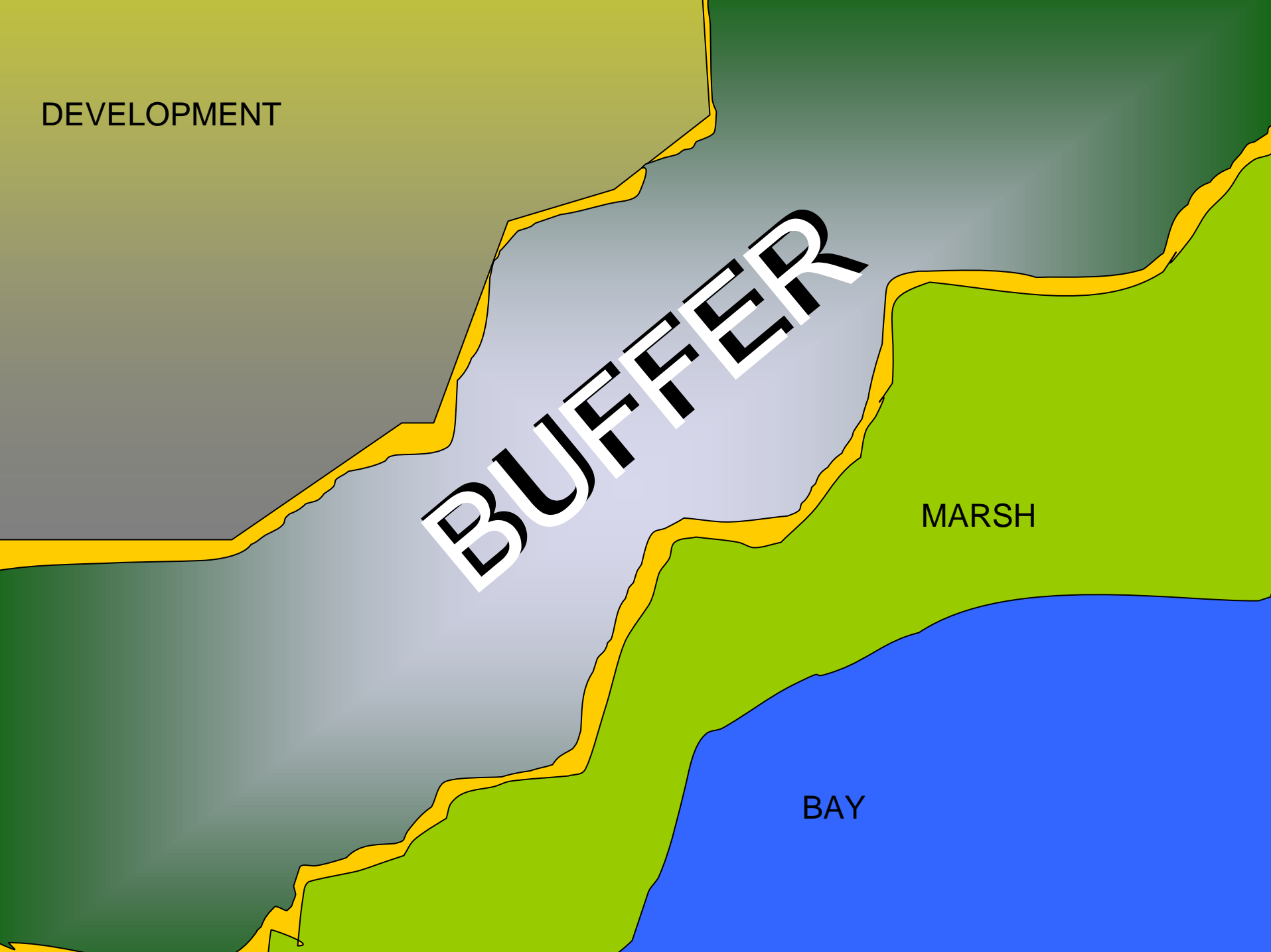


DEVELOPMENT

**BUFFER**

MARSH

BAY

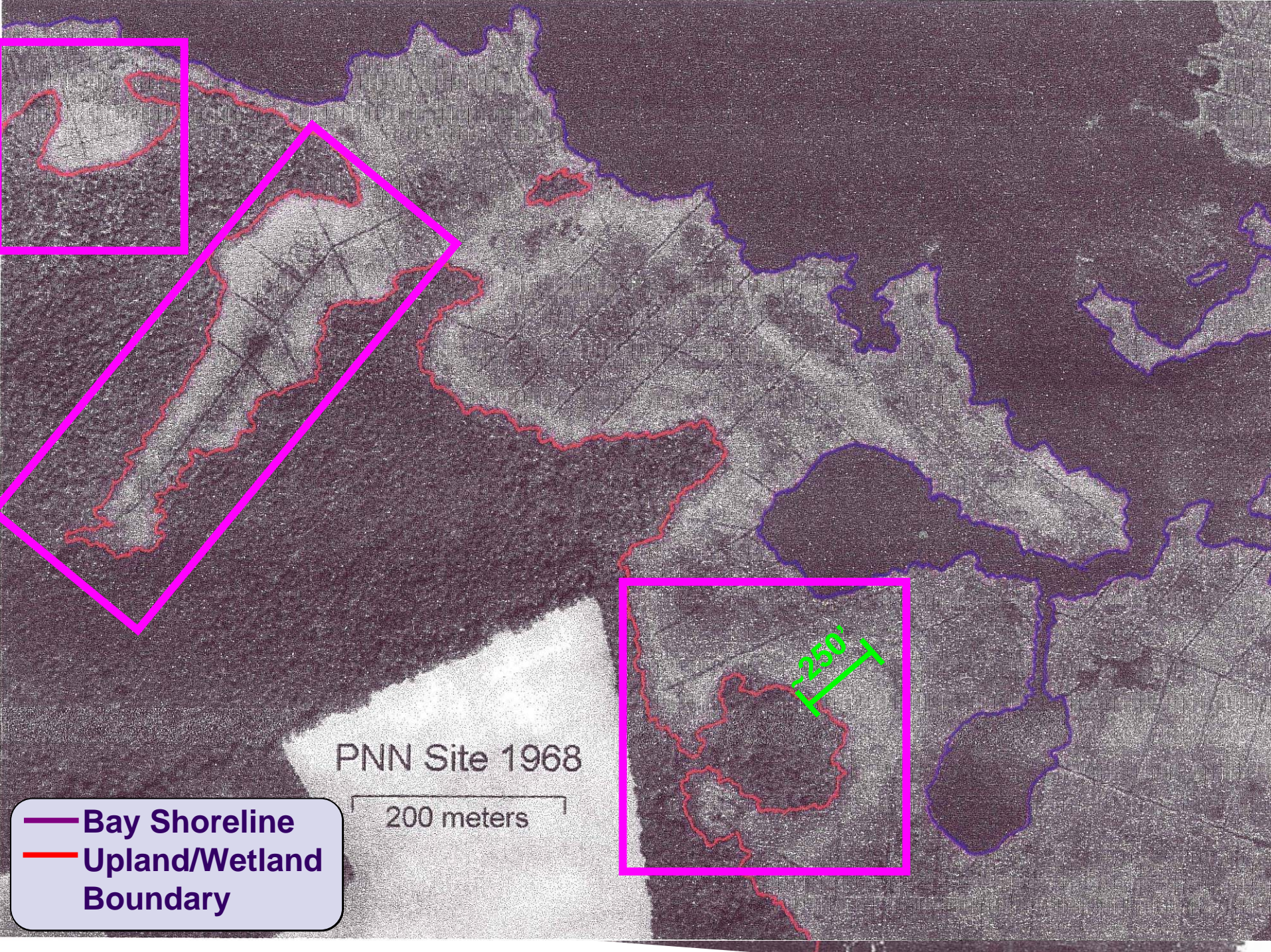


# Tidal Wetlands and Waters



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- Migrate inland with rising seas
- Width of buffer determined by nutrient reduction efficiency and migration rates
- Wendy Carey's Phd Thesis documented rates
  - Ground truthed aerial photography interpretation of marsh migration using vegetation types
  - Used metric mapping work of Leatherman at the University of Maryland Coastal Research Lab





PNN Site 1968

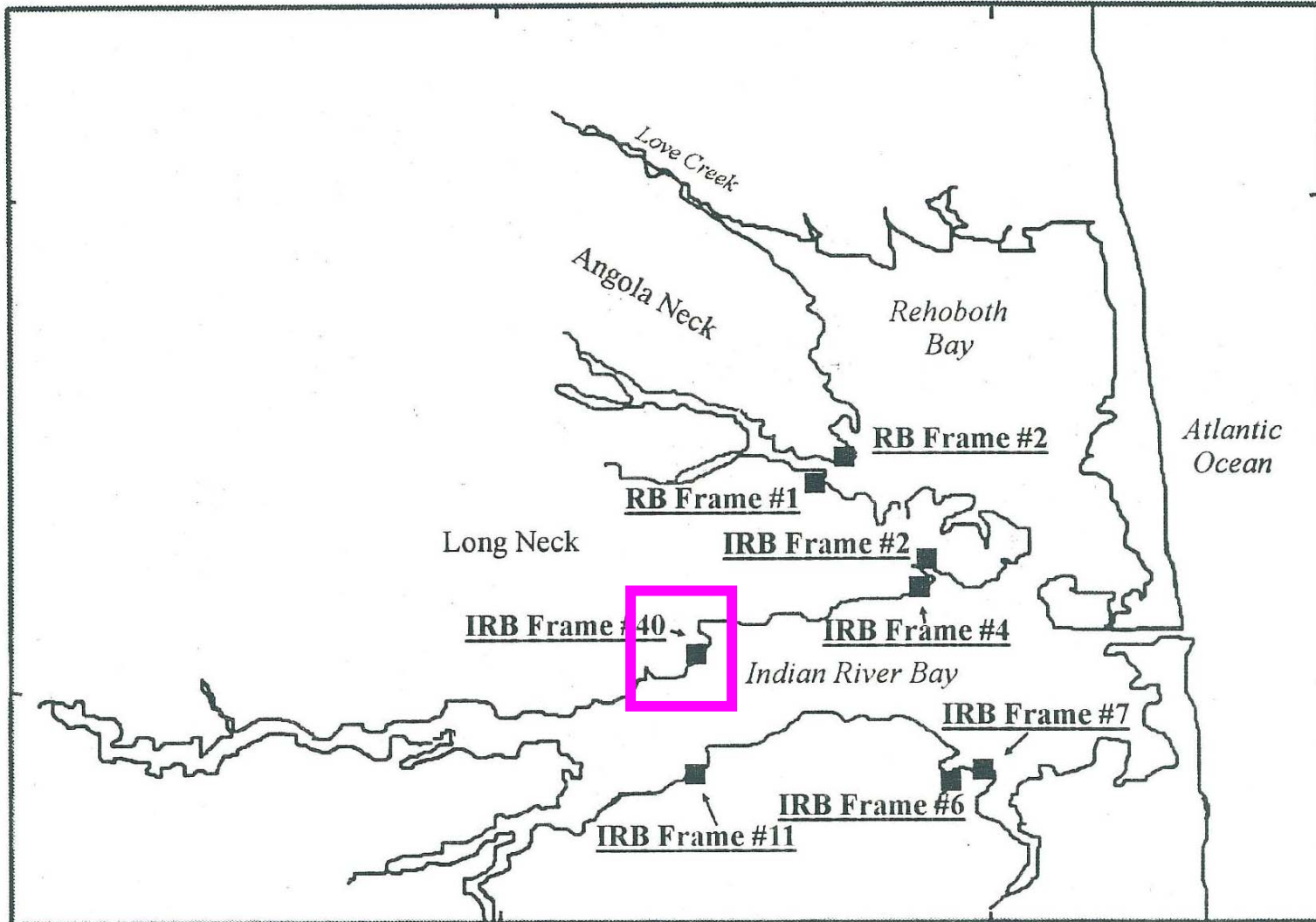
200 meters

- Bay Shoreline
- Upland/Wetland Boundary

250



# Location of 8 Metric Mapping Sites





# DATA YEARS

1926  
1938  
1954  
1968  
1989

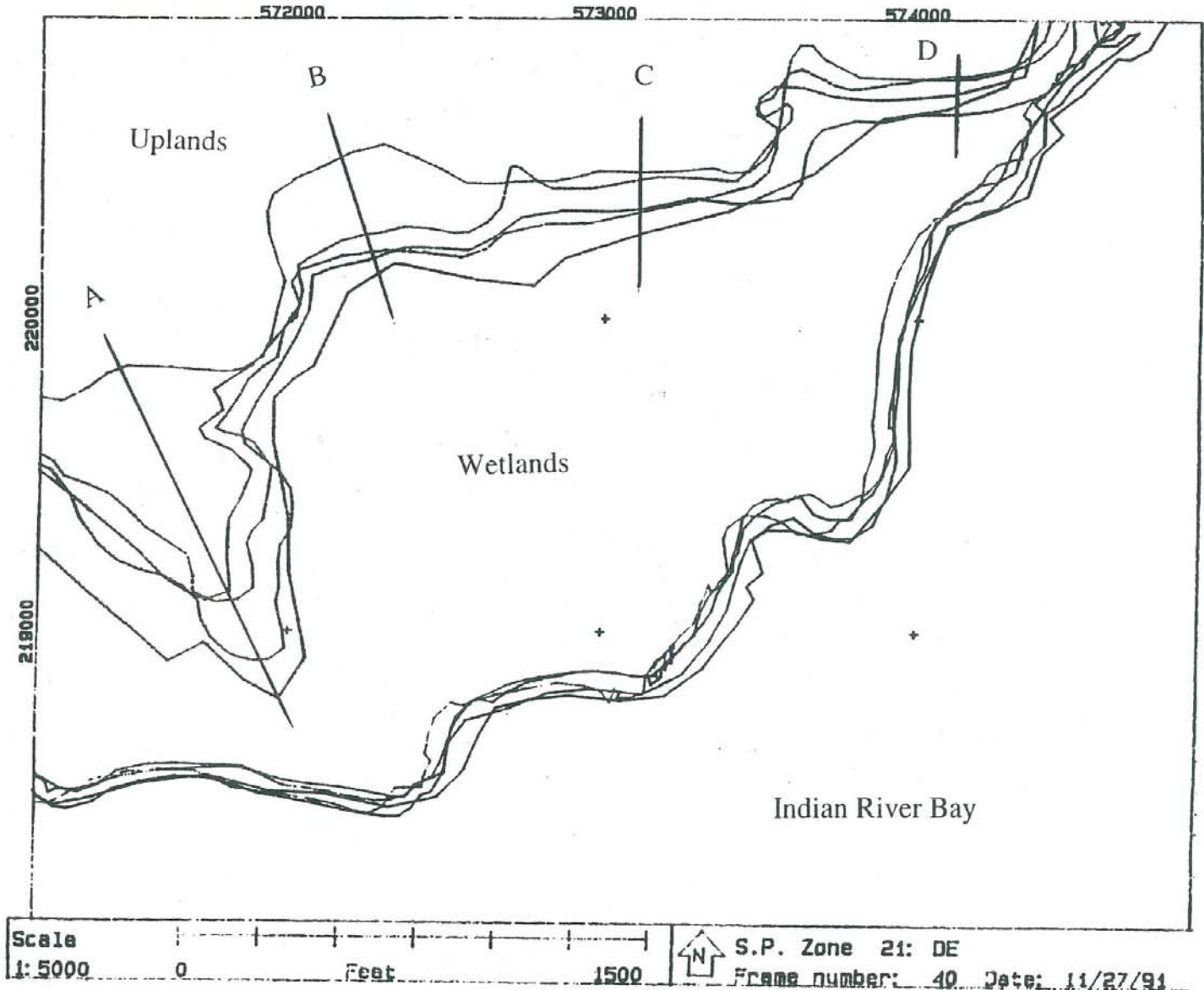
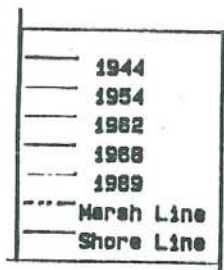


Figure 7.17 Metric map for Indian River Bay, Frame #40.

# Rates of tidal wetland migration inland by adjacent slope in the Inland Bays

*derived from metric mapping analysis 1926-1989*



<b>Slope of Adjacent Upland</b>	<b>Indian River Bay</b>	<b>Rehoboth Bay</b>
Gradual ( $<0.08$ rise/run)	5.25 ft/yr	6.07 ft/yr
Steep ( $>0.09$ rise/run)	1.44 ft/yr	0.82 ft/yr

\*Rates are highly variable but controlled primarily by slope





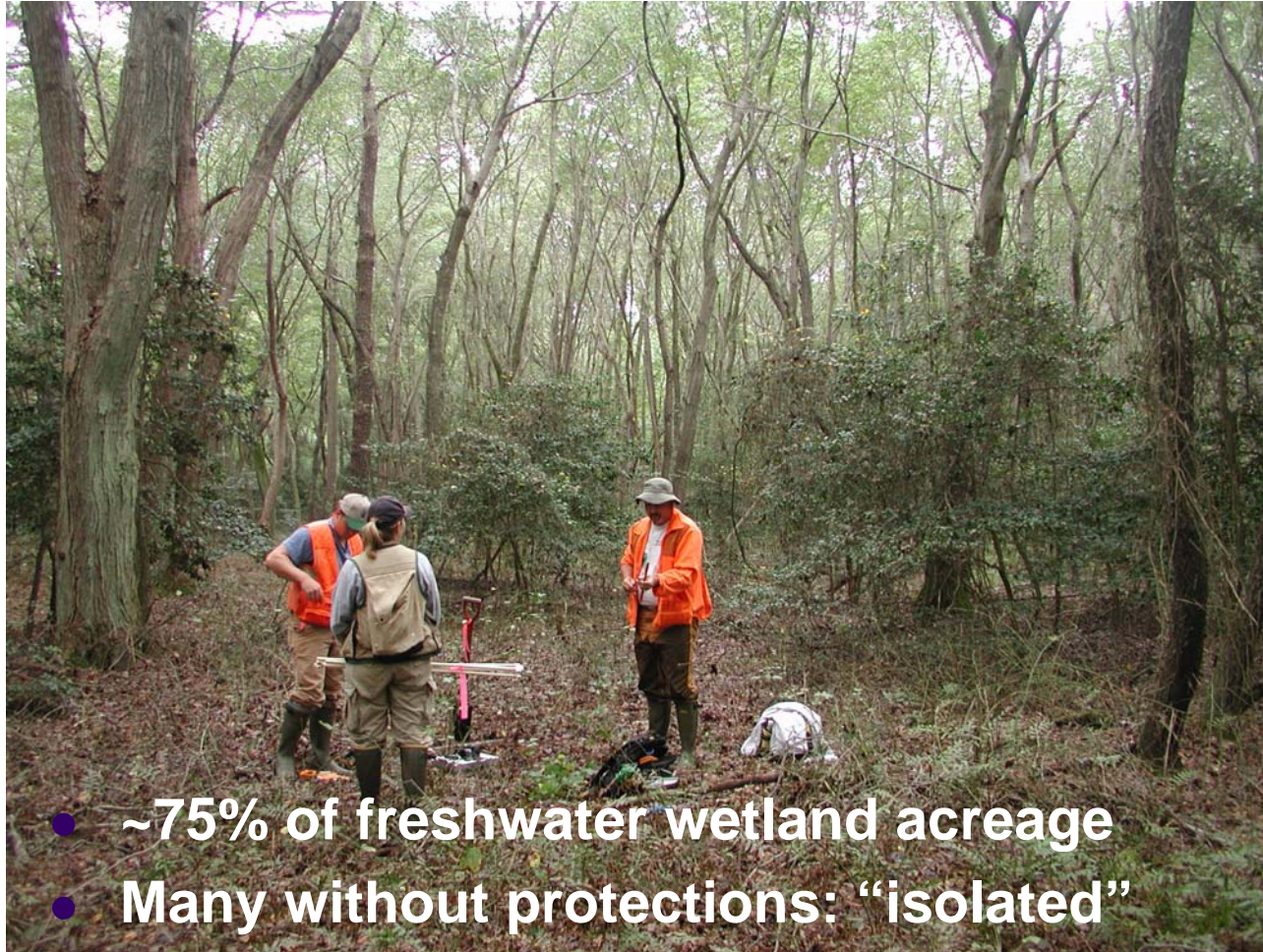
# Years upland buffers of different widths will provide protection to tidal wetlands or waters



Upland Buffer Width	Indian River Bay		Rehoboth Bay	
	Gradual Slope	Steep Slope	Gradual Slope	Steep Slope
50'	10	35	8	61
75'	14	52	12	91
100'	19	69	17	122
200'	38	139	33	244
300'	57	208	49	366
400'	76	278	66	488
500'	95	347	82	610



# Flats & Depressional Wetlands



- ~75% of freshwater wetland acreage
- Many without protections: “isolated”



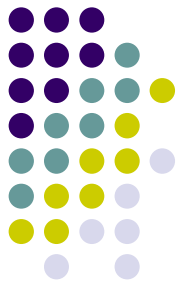


# Flats & Depressional Wetlands

- No information found relating buffer width to pollutant removal
- Nearby development can alter hydrodynamics to affect water storage and nutrient processing
- 50 and 100 foot buffers more or less arbitrarily selected
- More study needed to confirm effectiveness of buffers for nutrient removal



# Protection Alternatives: Width



<b>Buffer System Characteristic</b>	<b>Adequate Alternative</b>	<b>Optimum Alternative</b>
Buffer Width Variation	Variable Width	Fixed Width
<i>Tidal Wetlands &amp; Waters</i>		
Gradual Upland/Wetland Boundary	300 ft (53 yrs)	500 ft (88 yrs)
Steep Upland/Wetland Boundary	80 ft (71 yrs)	150 ft (132yrs)
<i>Nontidal Wetlands and Waterways</i>		
Flats and Depressional Wetlands	50 ft	100 ft
Riparian Wetlands	80 ft	150 ft
Headwaters Streams & Ditches	80 ft	150 ft
Larger Streams & Ditches	80 ft	150 ft

† Dominance corresponds to the vegetation requirements of the 2005 version of the PCS. See Tidal Wetlands & Waters section for elaboration on a recommended vegetation type for these buffers.

‡‡ 82% nitrogen removal on average with at least 67% removal for most buffers. 79% phosphorus removal on average with moderate variability.

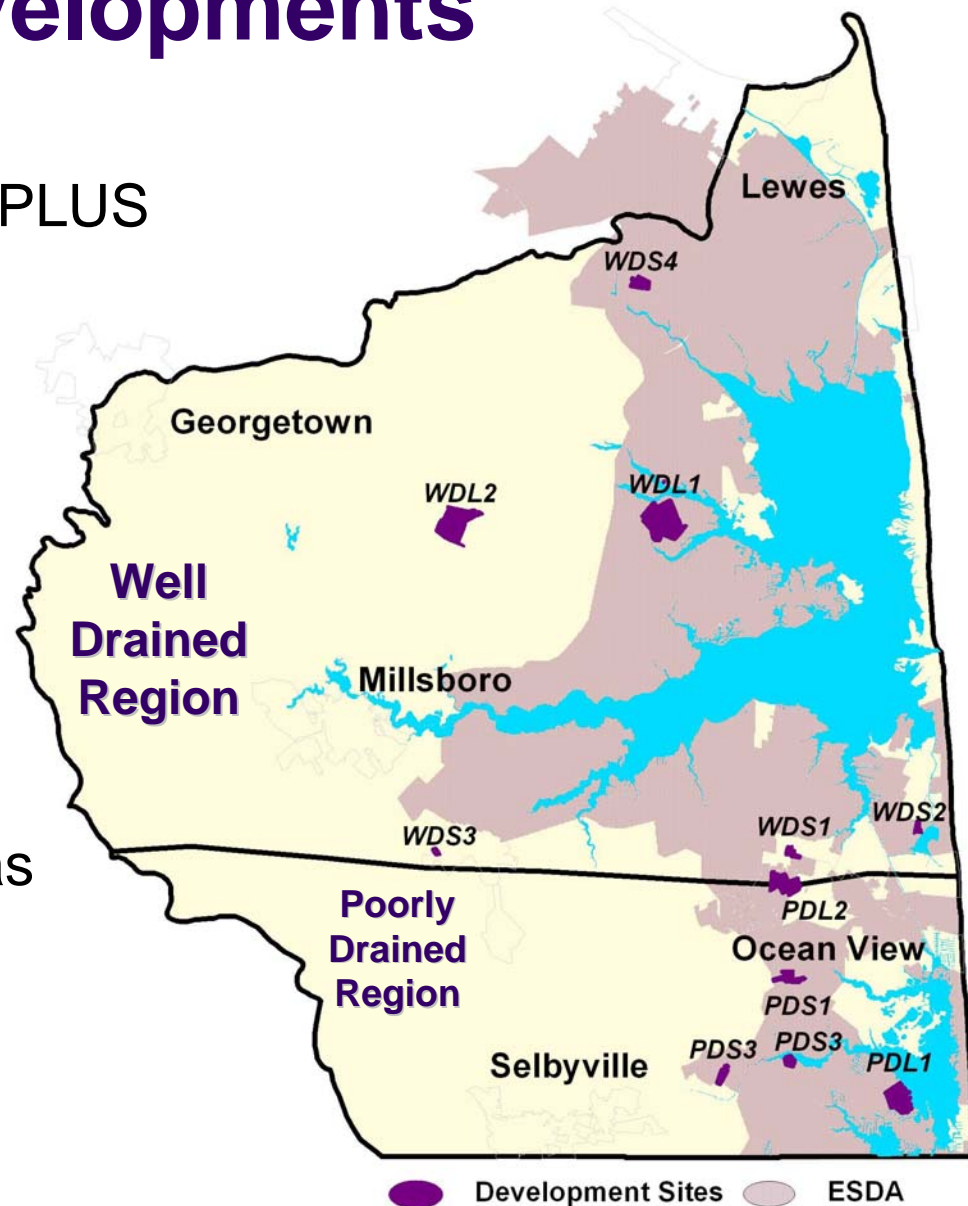
‡‡‡90% nitrogen removal on average with at least 78% removal for most buffers. 86% phosphorus removal on average with low variability.

*(Estimated Average # of Years upland buffer will remain)*

# Analysis of Recommendations Applied to Developments



- 11 randomly selected PLUS applications: '04-'06.
- Separated into large (>75th%tile) & small projects (<50th%tile) and by watershed region
- Estimated % developable acreage as buffer by waterbody type and buffer alternative





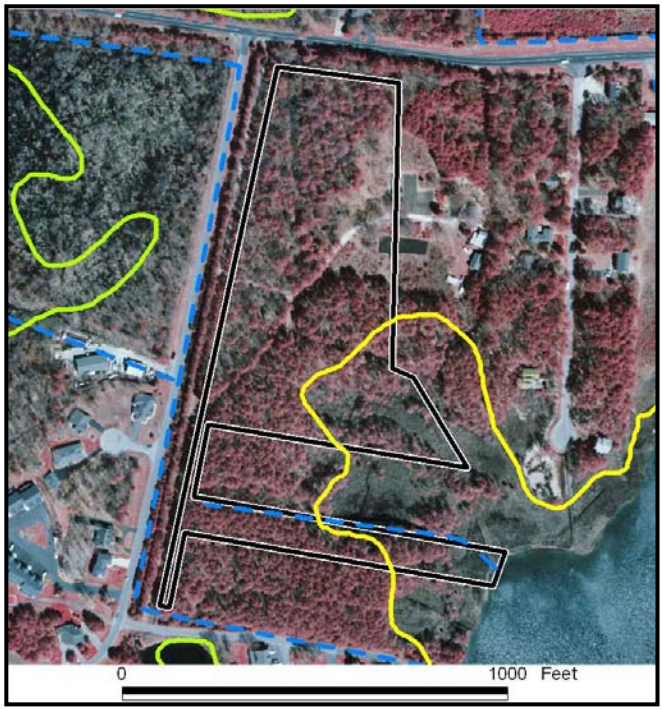
# Results

- On average, buffers were within range of current County open space requirements
  - Adequate = 13.8% of developable acreage
  - Optimum = 33.2% of developable acreage
- Buffer acreage evenly split between nontidal wetlands, ditches, and tidal areas.
- Sites with tidal wetlands by low lying uplands had very large areas as buffers
- Smaller sites, and sites in poorly drained regions tended to have larger areas as buffers



# Applying Recommendations: Bethany Woods

Site Characteristics



Acreage	12
Developable Ac.	9
% Dev. Ac. in Buffer (Adequate)	61
% Dev. Ac. in Buffer (Optimum)	89

**Development** ———

**Waterbody Type**

- Tidal
- Nontidal Wtlnds
- Major Ditches

**Buffer Types**

- Nontidal Waterway
- Nontidal Wetland
- Tidal Wetlands

Adequate Alternative



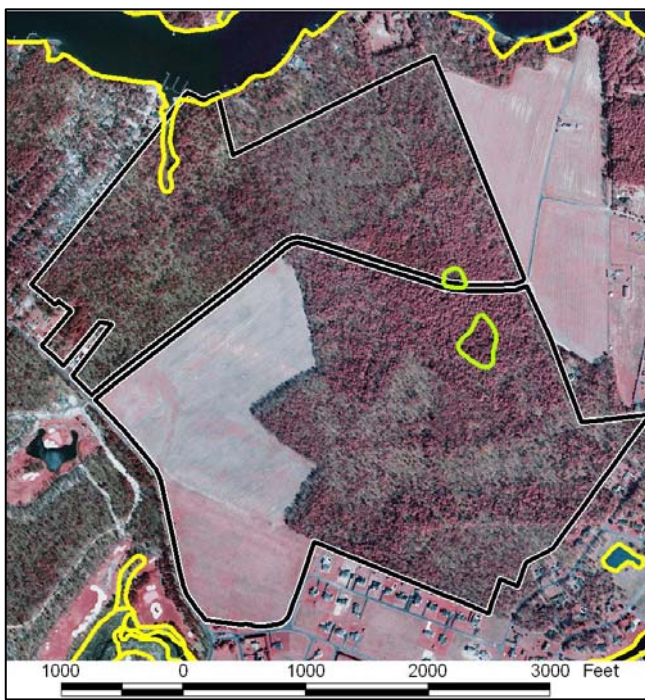
Optimum Alternative





# Applying Recommendations: Bridlewood

Site Characteristics



Acreage	314
Developable Ac.	309
% Dev. Ac. in Buffer (Adequate)	1.8
% Dev. Ac. in Buffer (Optimum)	3.7

Development

Tidal

Nontidal Wtlnds

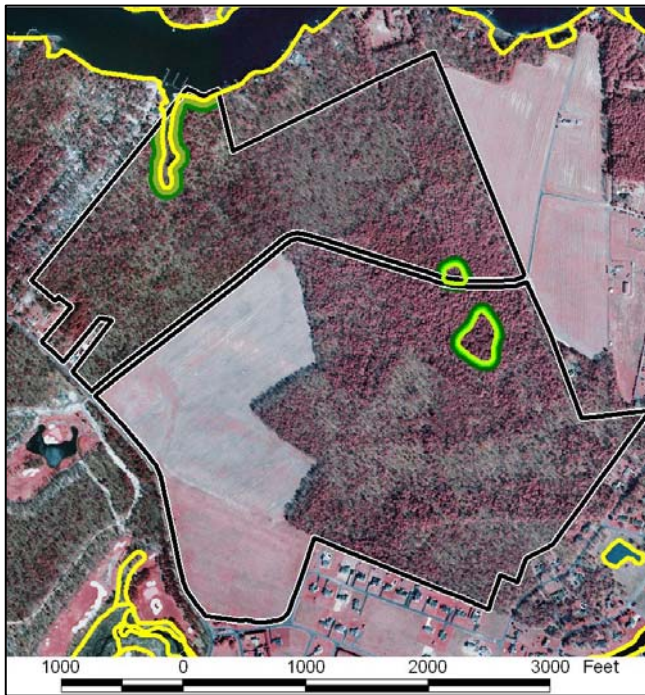
Buffer Types

Nontidal Waterway

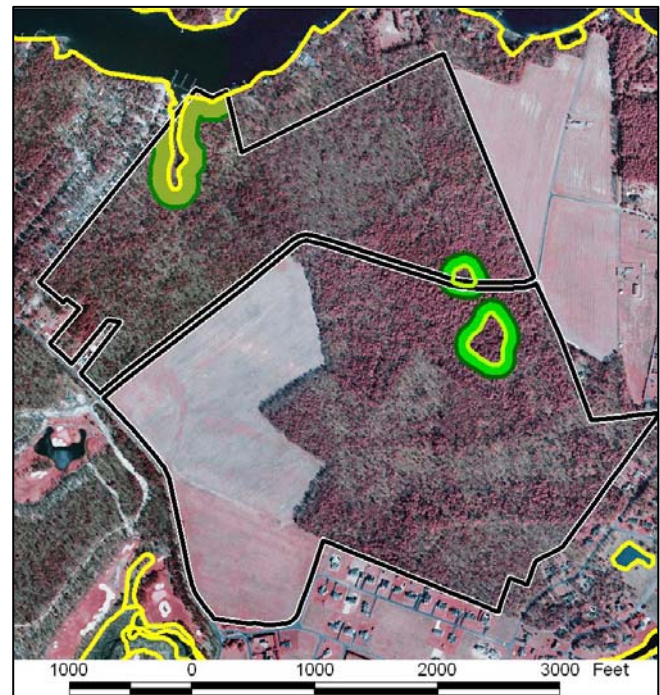
Nontidal Wetland

Tidal Wetlands

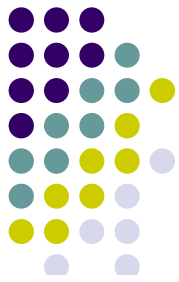
Adequate Alternative



Optimum Alternative



# Additional Recommendations: Ditches

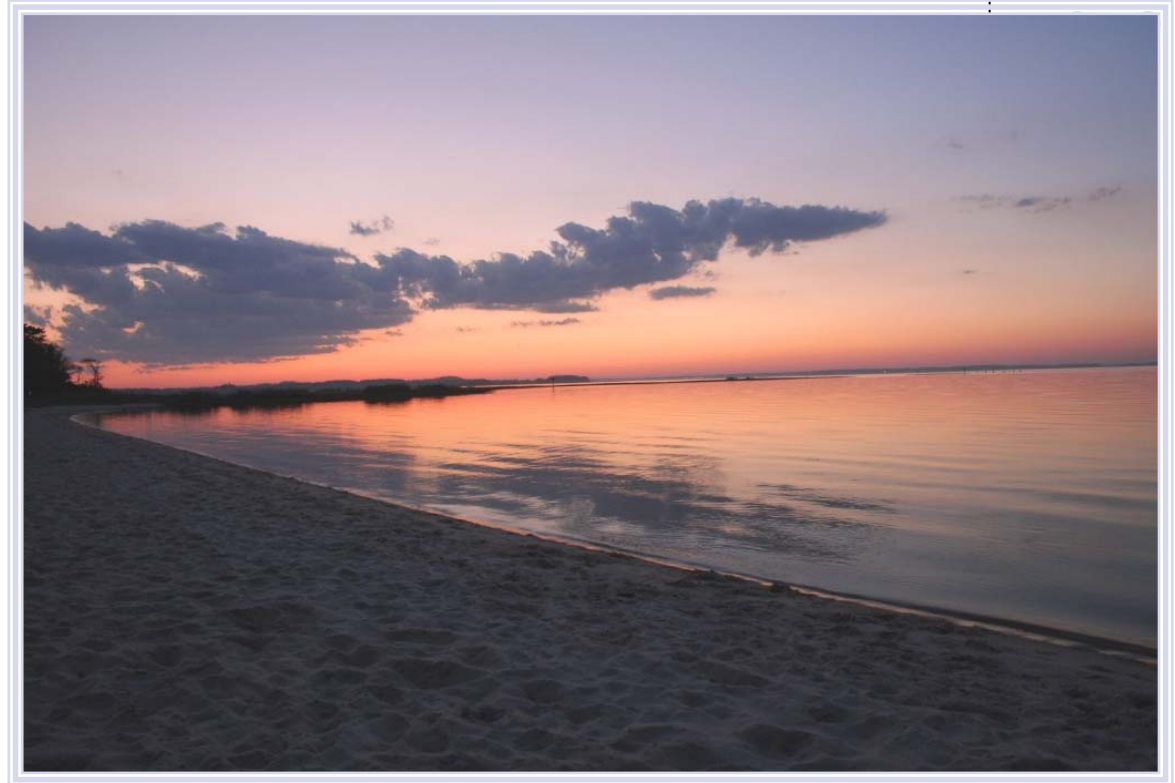


- Encourage filling or integration into stormwater controls those ditches unnecessary for drainage.
- Smaller buffer widths should be afforded ( $\geq 35'$ ) on shallow ditches ( $< 3$  ft deep) to allow buffering of other features.
- Buffers may be more efficient for nitrogen removal where ditches are many
  - Longer residence time in zones of denitrification
  - Higher Organic Matter content in soils

# Acknowledgements



- Jenn Volk
- Lyle Jones
- Amy Jacobs
- Kent Price
- Scott Andres
- Robin Tyler
- Bill Ullman



Report to be available @ [www.inlandbays.org](http://www.inlandbays.org)

[chrisbason@inlandbays.org](mailto:chrisbason@inlandbays.org) for questions





# Water Quality Buffer Regulations In & Around Delaware



	New Castle Co.	Kent Co.	Sussex Co.	New Jersey	Maryland Critical Areas	CIB Sufficient Buffer	CIB Optimum Buffer
Preserves	Existing native vegetation	Existing natural buffers	Nothing Specified	Existing vegetation	Existing natural vegetation	Existing native vegetation	Existing native vegetation
Width							
Tidal Wetlands & Waters	100 ft.	100 ft.	50 ft.	300 ft.	200 ft.	80-300 ft.	150-500 ft.
Nontidal Wetlands	50 ft.	0 ft.	0 ft.	0 – 150 ft.	25 ft.	50	100
Headwaters	100 ft.	50 ft.	0 ft.	300 ft.	100 ft.	80	150
Larger Waterways	100 ft.	100 ft.	0 – 50 ft.	300 ft.	100 ft.	80	150
Vegetation	Natural/Forest	Natural /Forest <i>(in TMDL basin)</i>	Natural/Forest	Existing Vegetation or Natural /Forest	Natural /Forest	Natural /Forest	Natural /Forest
Management Plan	No	No	No	Yes	Yes	Yes	Yes

# Notes



- Adapted from Jen Volk, DNREC 2007
- New Jersey's special resource protection areas, Kent Co.'s TMDL basins, and Maryland's Critical Areas are comparable to the Inland Bays designation as water's of Ecological & Recreational Significance.
- Maryland and New Jersey's nontidal wetlands buffers are part of their wetlands laws.
- Kent Co. had proposed a more protective buffer system in 2007