Land use impacts from sea level and water table rise

How will groundwater in aquifers react to a rise in sea level?

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Impacts from the Invisible Flood

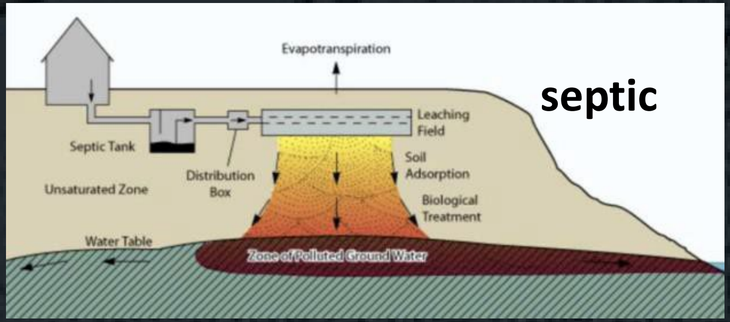
Underground infrastructure

Sewers

Drinking Water

Electric

Basement flooding



septic

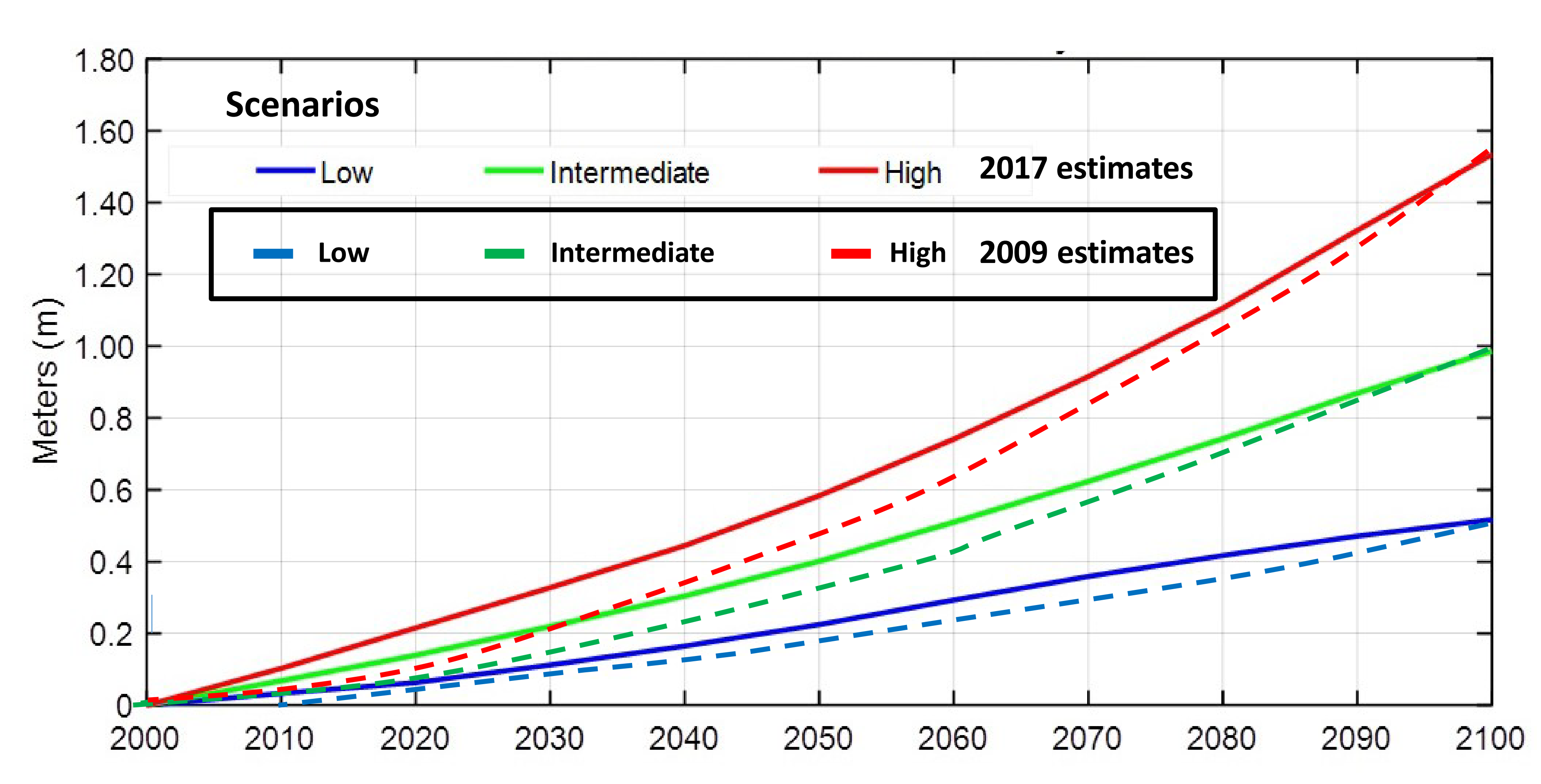
flooding (groundwater inundation)

Street flooding

Flooded fields

Sea level rise scenarios (DNREC 2017 and DNREC 2009)

The 2009 scenarios were used in the groundwater model.



1.5 m = 4.9 ft

1.0 m = 3.3 ft

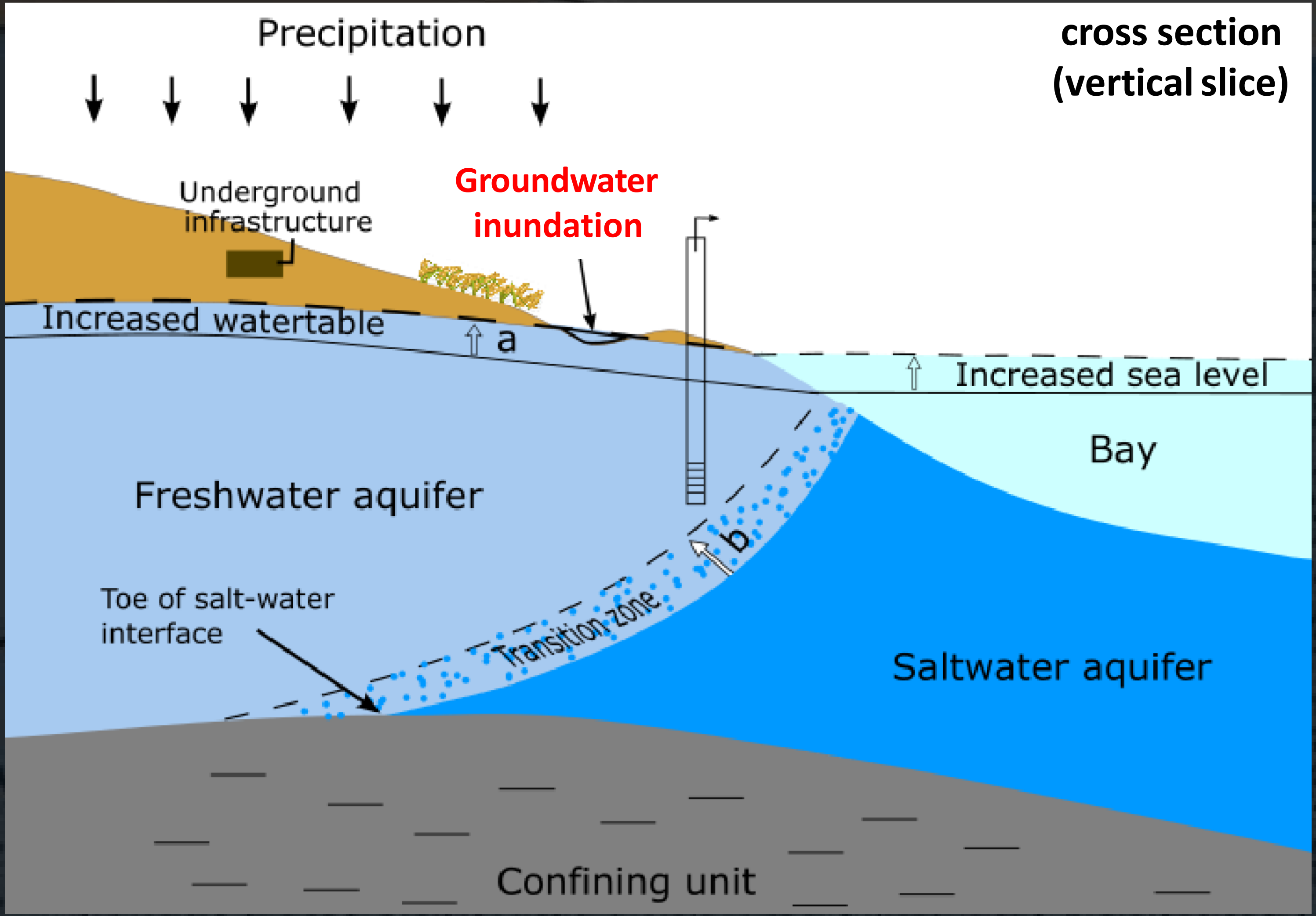
0.5 m = 1.6 ft

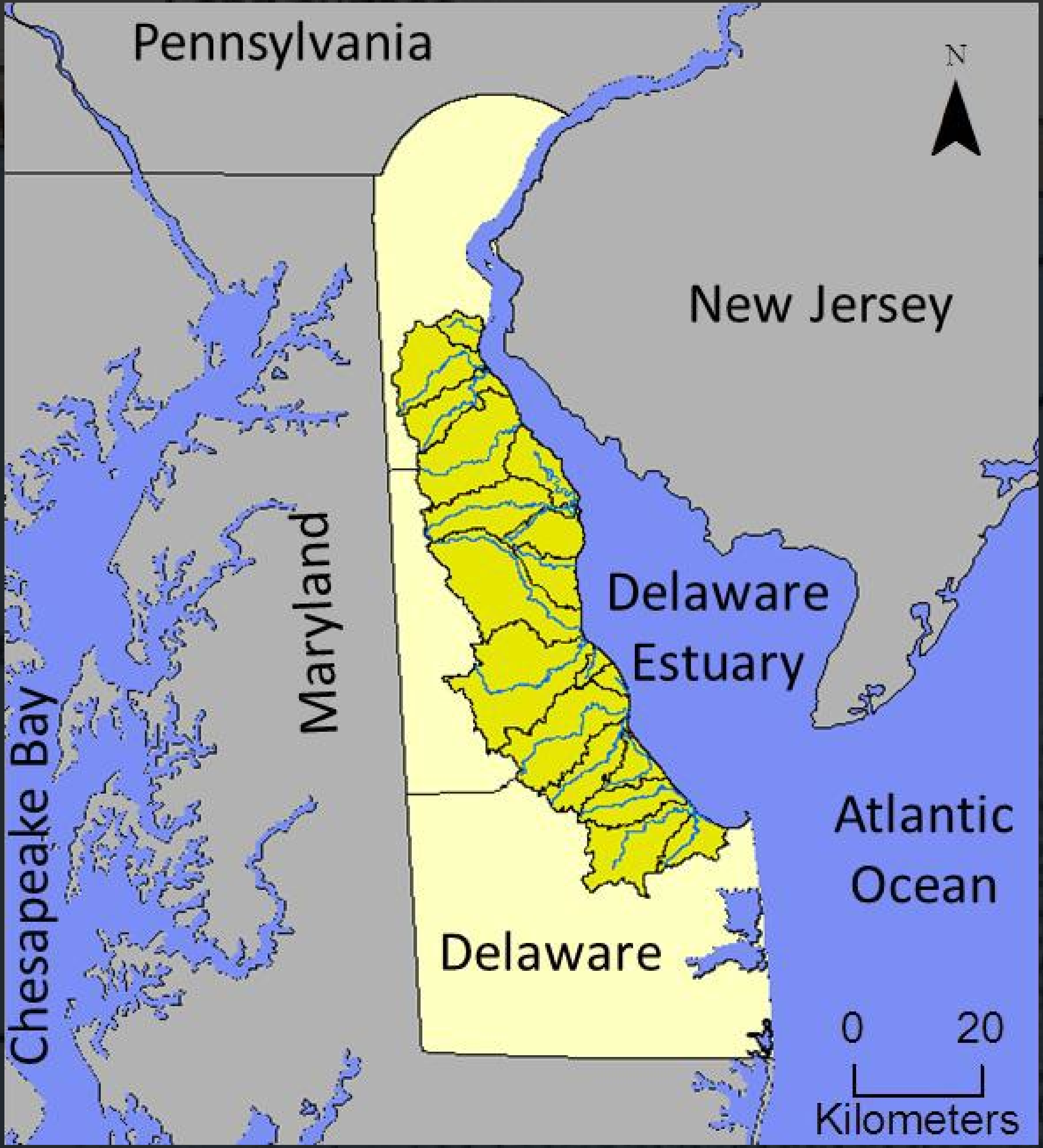
Sea level in year 2100 is the same for the 2009 and 2017 scenario sets.

Schematic representation of issues addressed: rising water table and salt-water intrusion

Columbia Aquifer

sand & gravel, high permeability





STUDY AREA

Delaware Bay watersheds

Augustine Creek
Appoquinimink River
Blackbird Creek
Smyrna River
Duck Creek
Leipsic River
Muddy Branch
Little River
Saint Jones River
Murderkill River
Brockonbridge Gut
Grecos Canal
Mispillion River
Cedar Creek
Slaughter Creek
Primehook Creek
Broadkill River
Old Mill Creek

How will groundwater react to a rise in sea level?

We use a groundwater flow model as a tool to tackle this question.

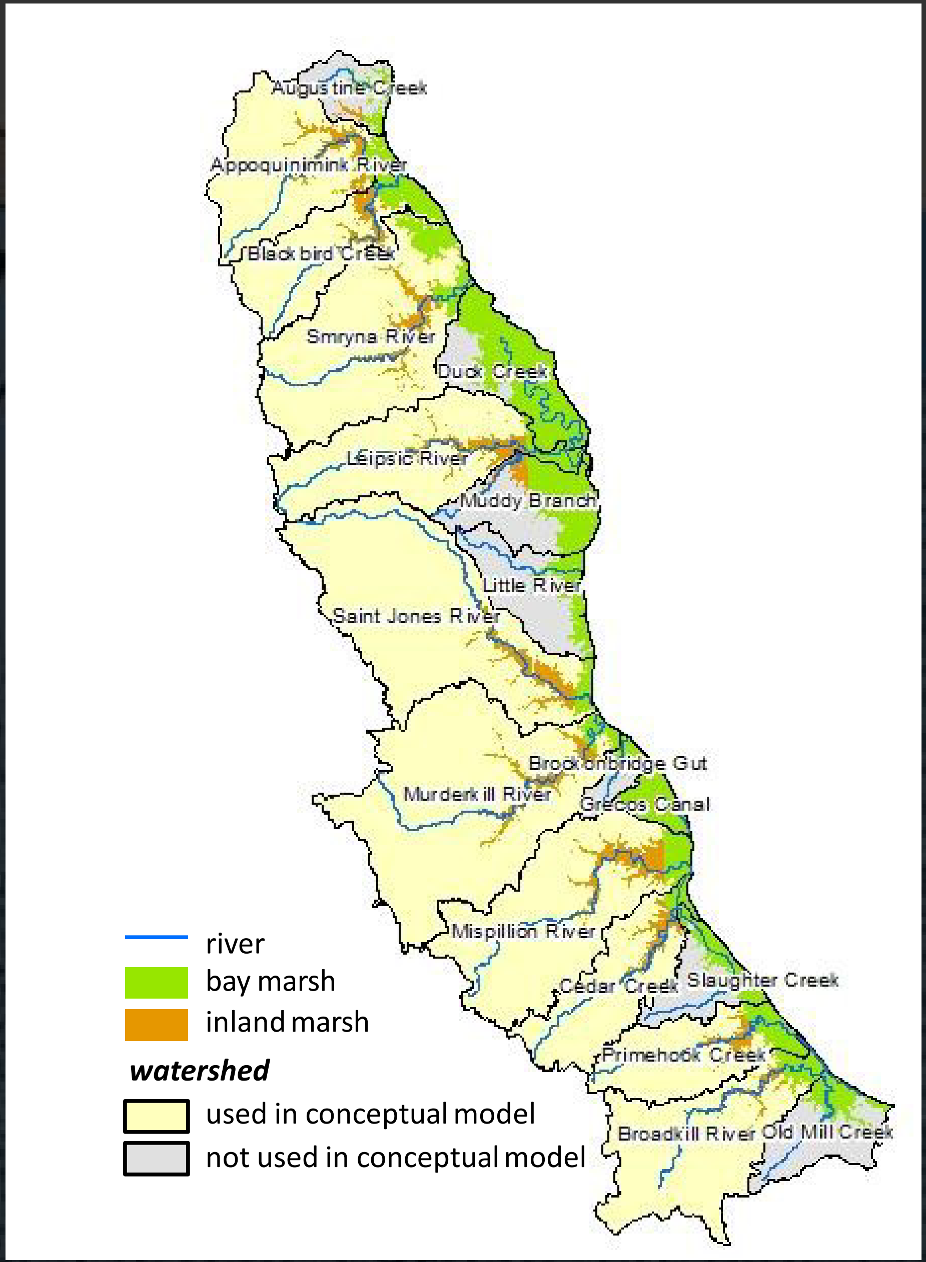
The model is based on the spatial characteristics of Delaware Bay watersheds, tidal wetlands, and rivers.

<u>Characteristics:</u>

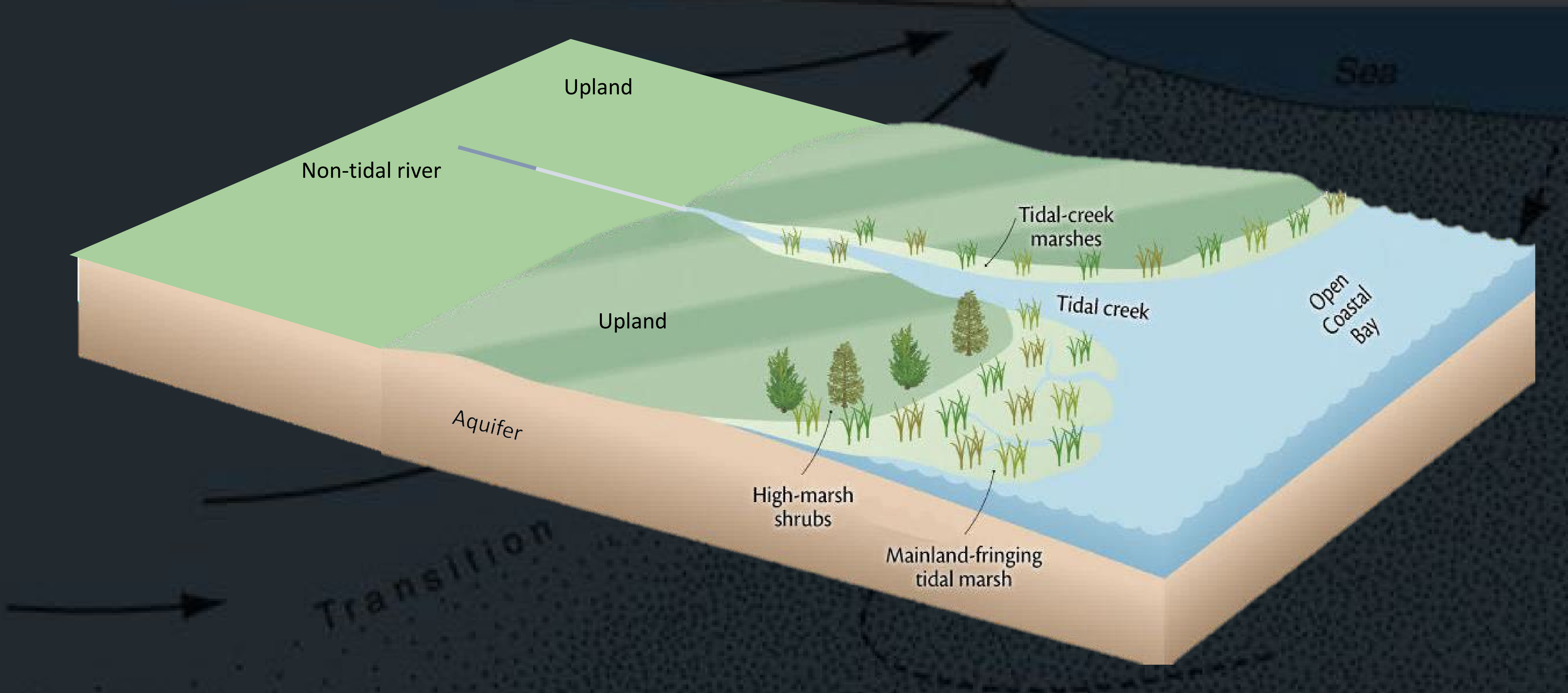
Geometry of watersheds, rivers, tidal wetlands

aquifer properties

surface water salinity

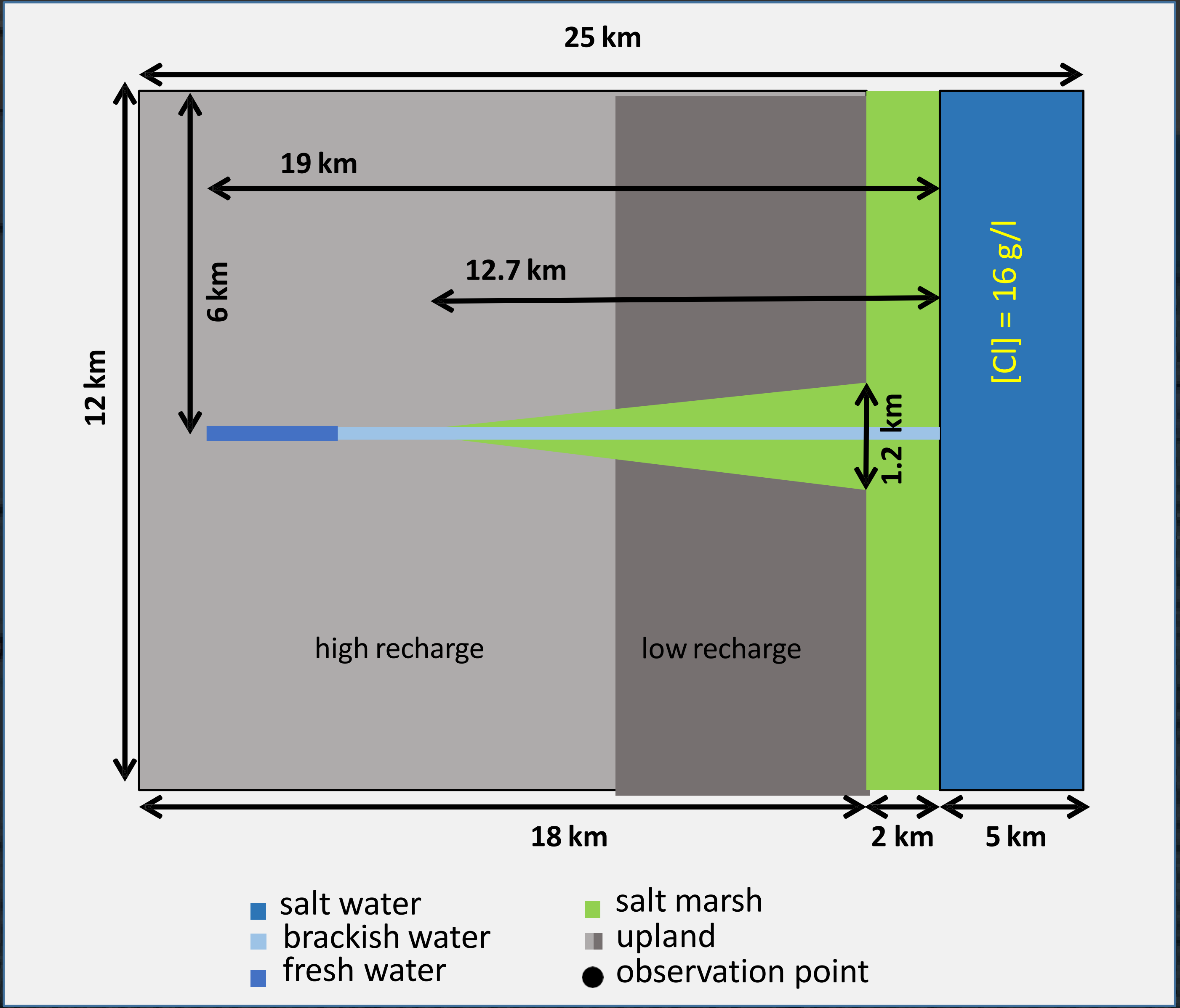


Simple Conceptual Model



modified from University of Maryland Center for Environmental Science

Simplified representation of a Delaware Bay watershed.

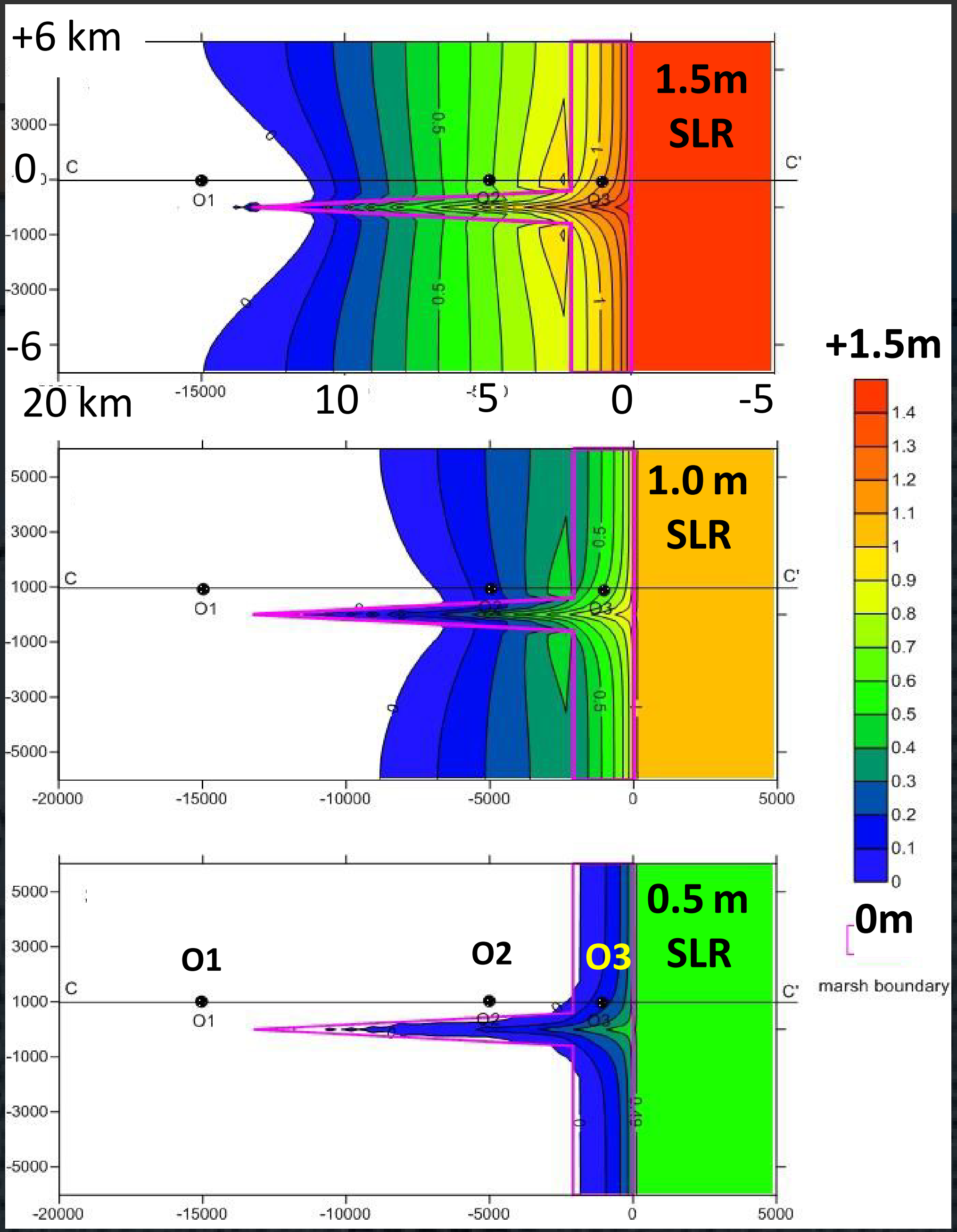


Model solves an equation for transient, variable density groundwater flow in three dimensions.

Contour map of changes in water table elevation caused by sea-level rise (year 2100).

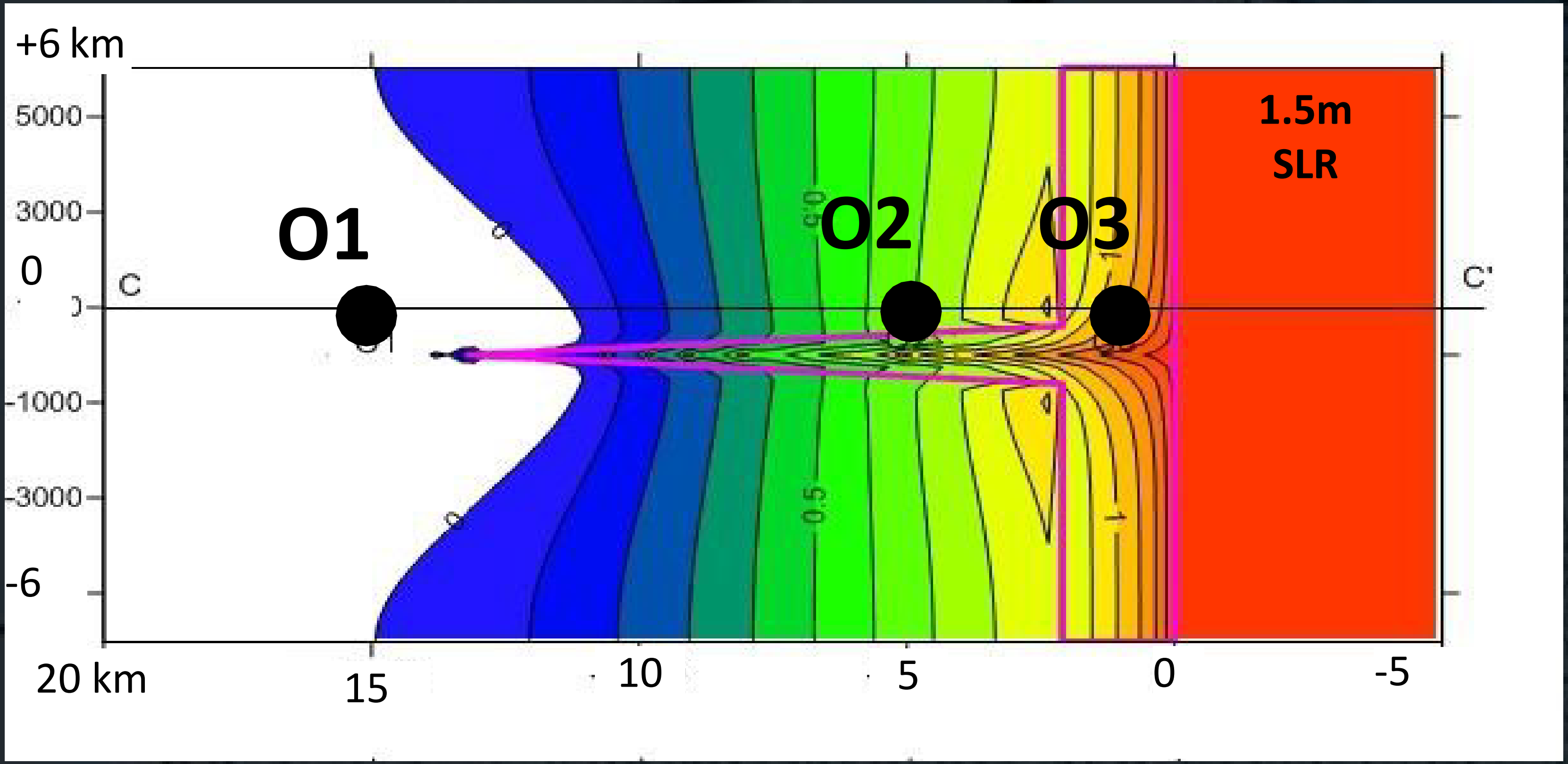
sea-level rise scenarios of

+1.5, + 1.0, and +0.5 meters.



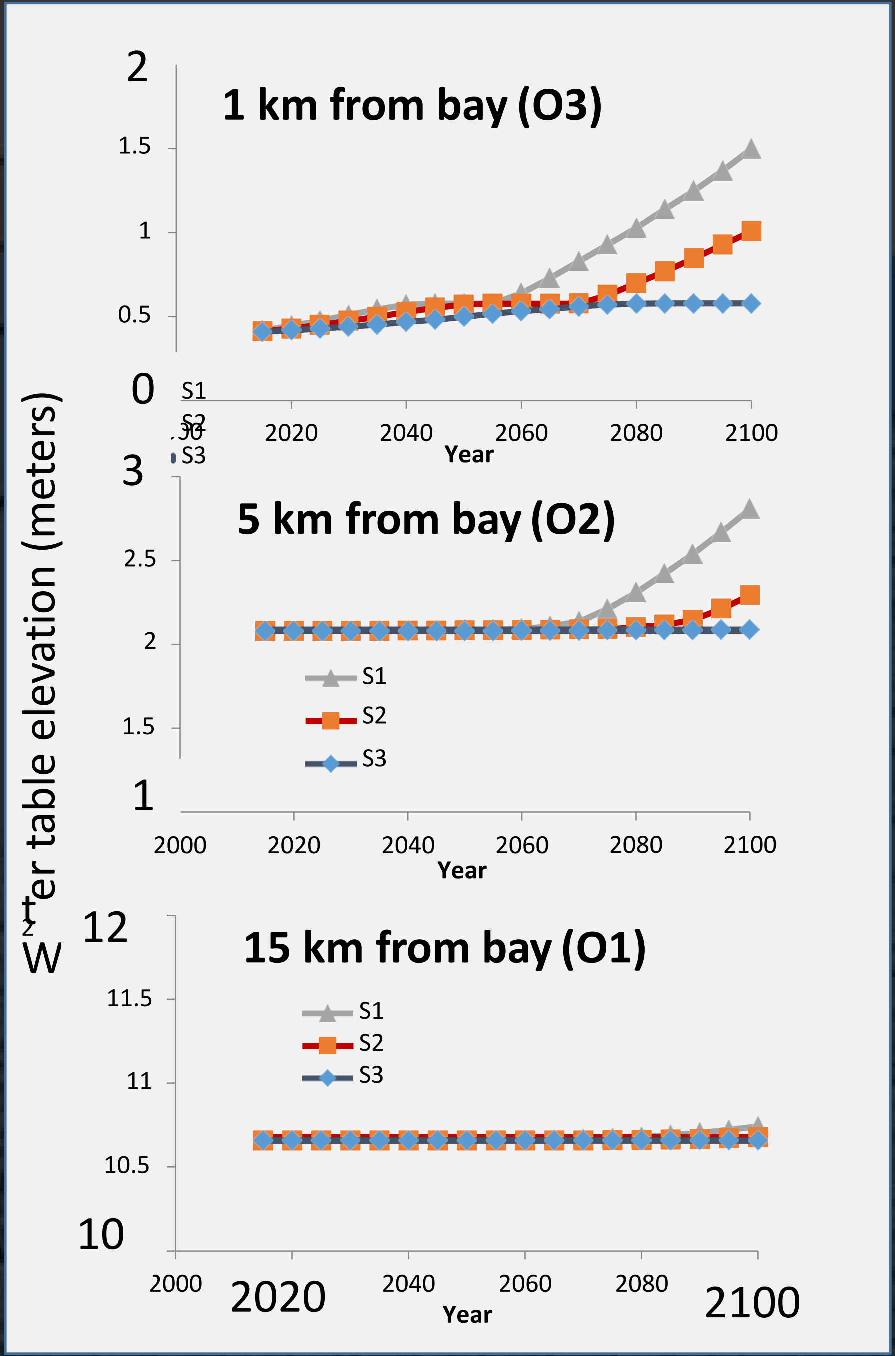
We just looked at the change in the water table elevation in space.

We can also look at elevation changes in time at select points.

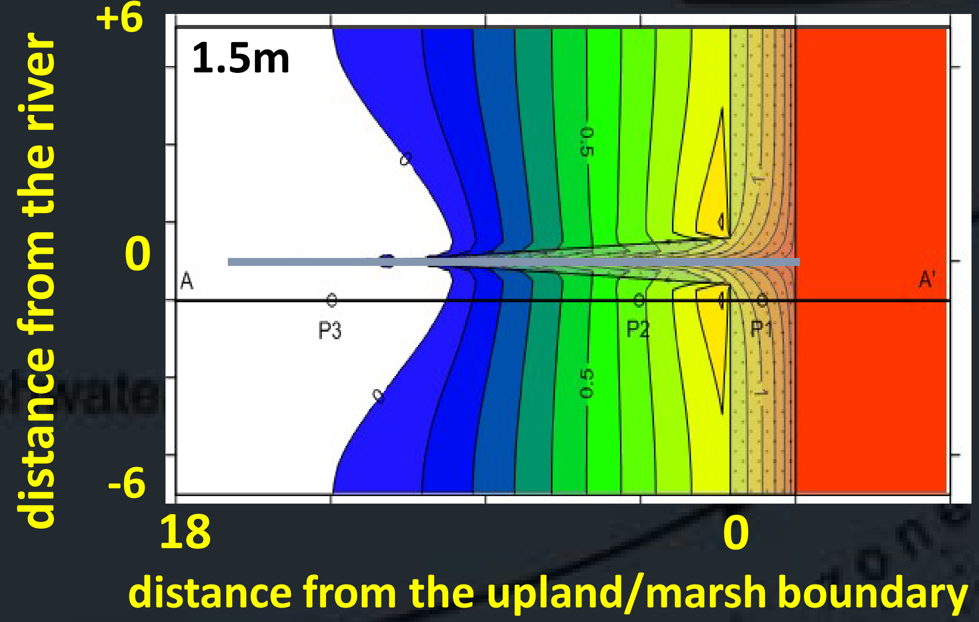


Let's look at three points at different distances from the bay.

Water table elevation with time at 3 points that are one km away from the river.

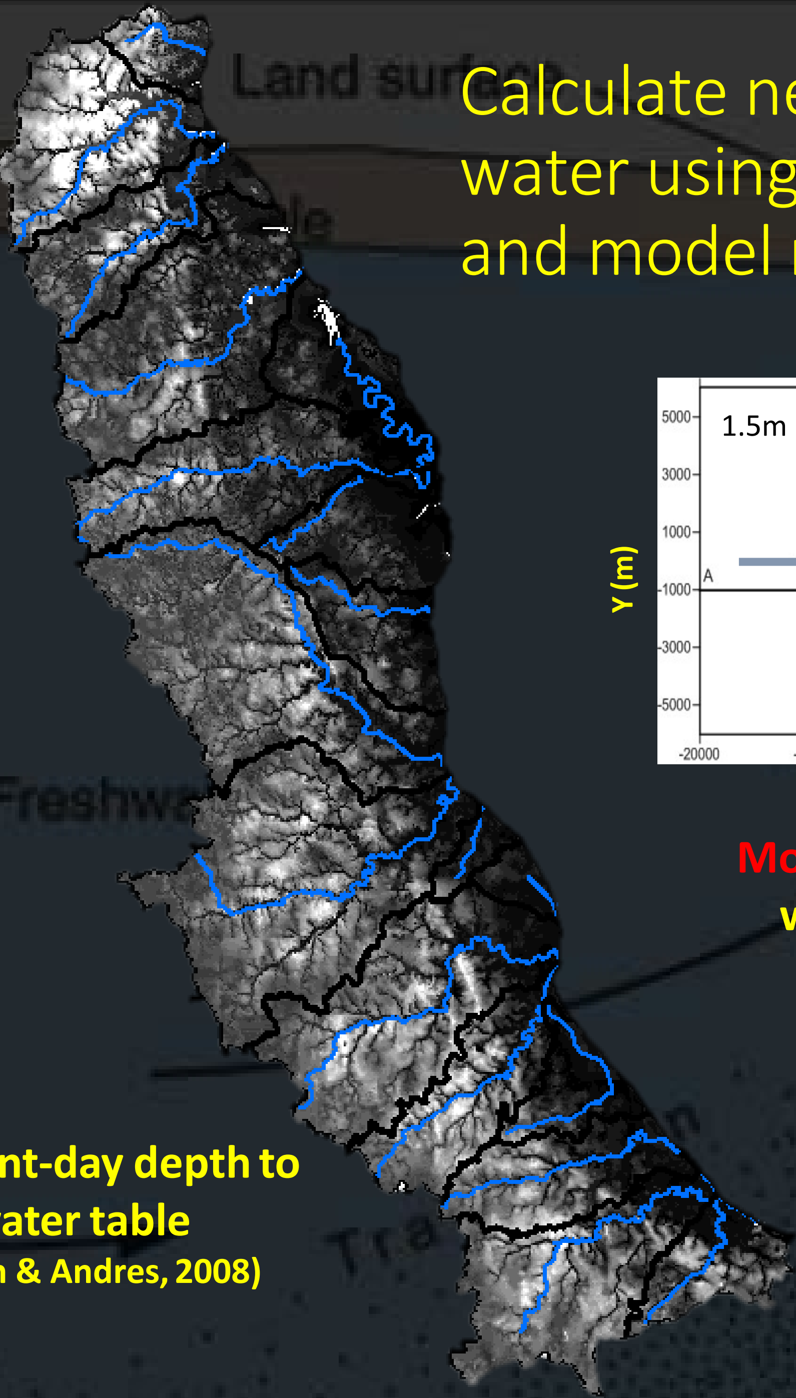


How do we apply the modeled water-table rise to actual Delaware Bay watersheds?

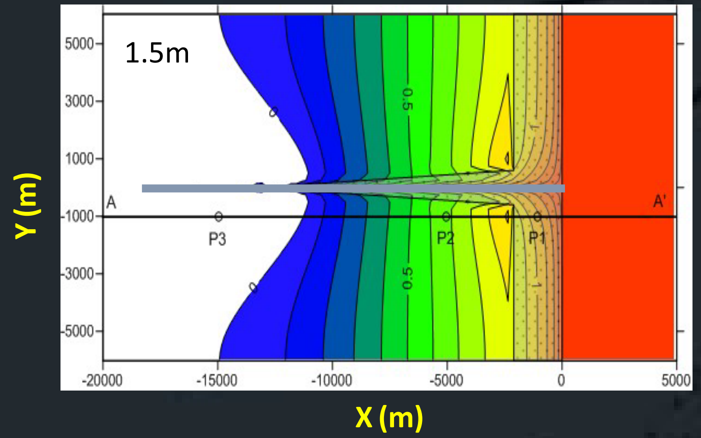


Modeled water table elevation output into a coordinate system representing distance from the upland/bay-marsh boundary (X) and distance from the river (Y).

Calculate new depth to water using existing map and model results.

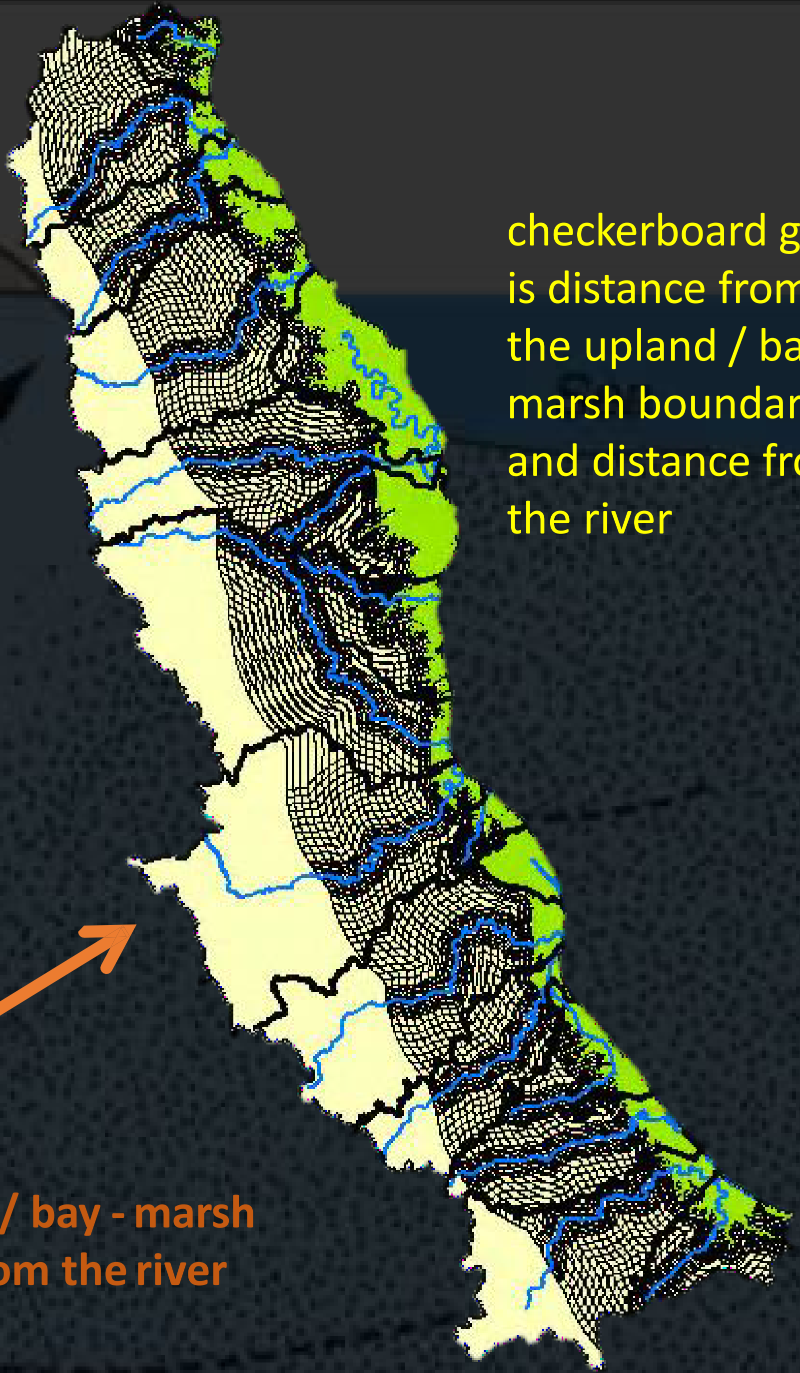


Present-day depth to the water table
(Martin & Andres, 2008)



Model results = change in water table elevation

distance from the upland / bay - marsh boundary and distance from the river



checkerboard grid is distance from the upland / bay - marsh boundary and distance from the river

Defining Impacts


Street flooding


Flooded fields

Critical depth to water

depth where there are impacts to land uses


Sewers

depth to water	impact
0 meters	water at land surface
0.5 meters (1.6 feet)	approximate effective rooting depth for Delaware crops

0.5 m can also represent septic tanks, underground infrastructure (basement, pipe, electric)

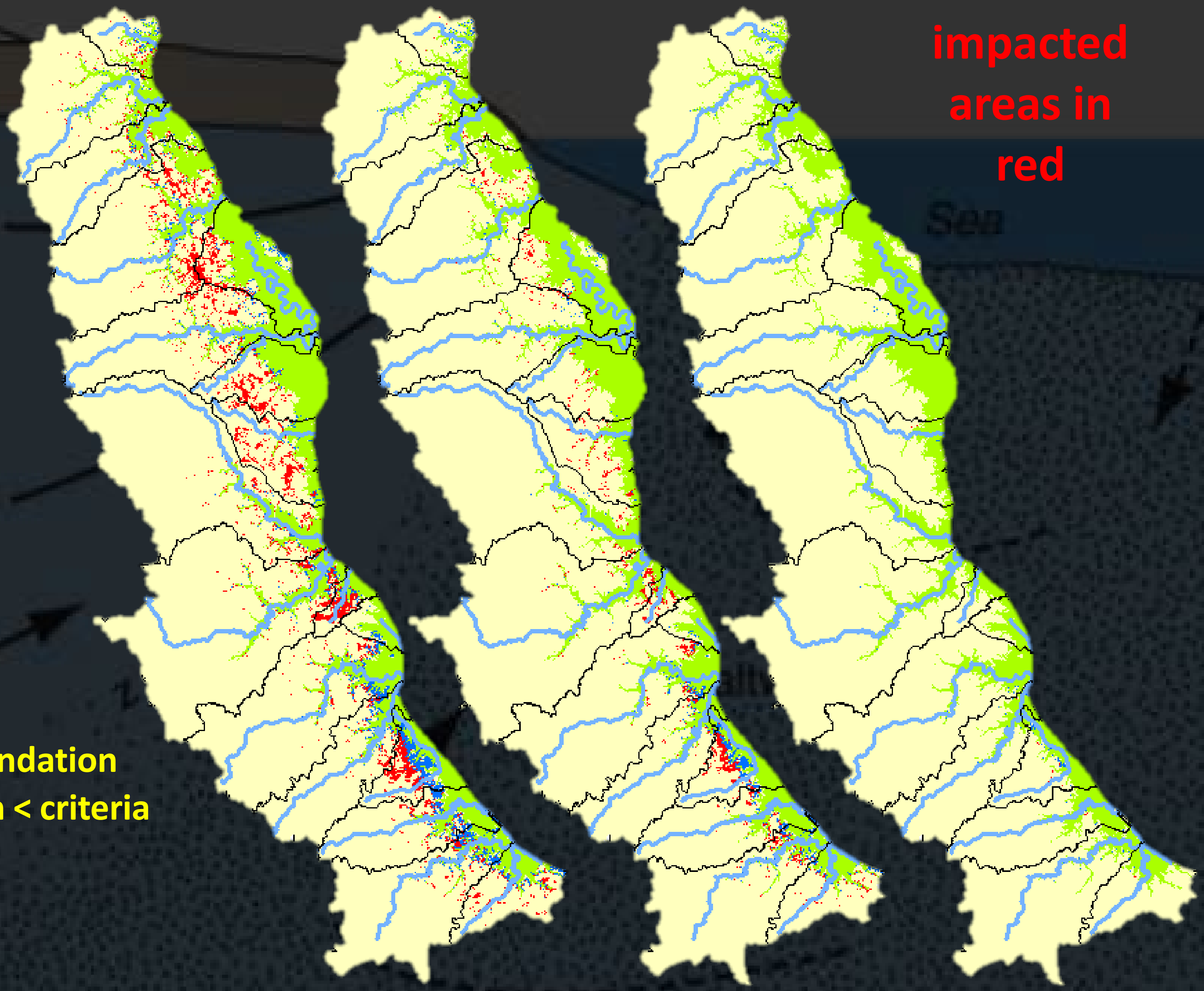
To Remember when viewing results

Delaware Bay beaches not in model as they are not captured in the conceptual model.

Tidal wetlands are fully inundated in year 2100 and there is no landward migration.

In calculations of impacted areas: Present-day tidal and non-tidal wetlands are excluded even if the critical depth to water is exceeded.

Scenario: 1.5 m 1.0 m 0.5 m



impacted areas in red

Maps for depth criteria of 0 m (water table is above the land surface)

Year 2100

- surface water inundation
- water table depth < criteria
- tidal wetland
- river

A groundwater flood can last weeks to months!!

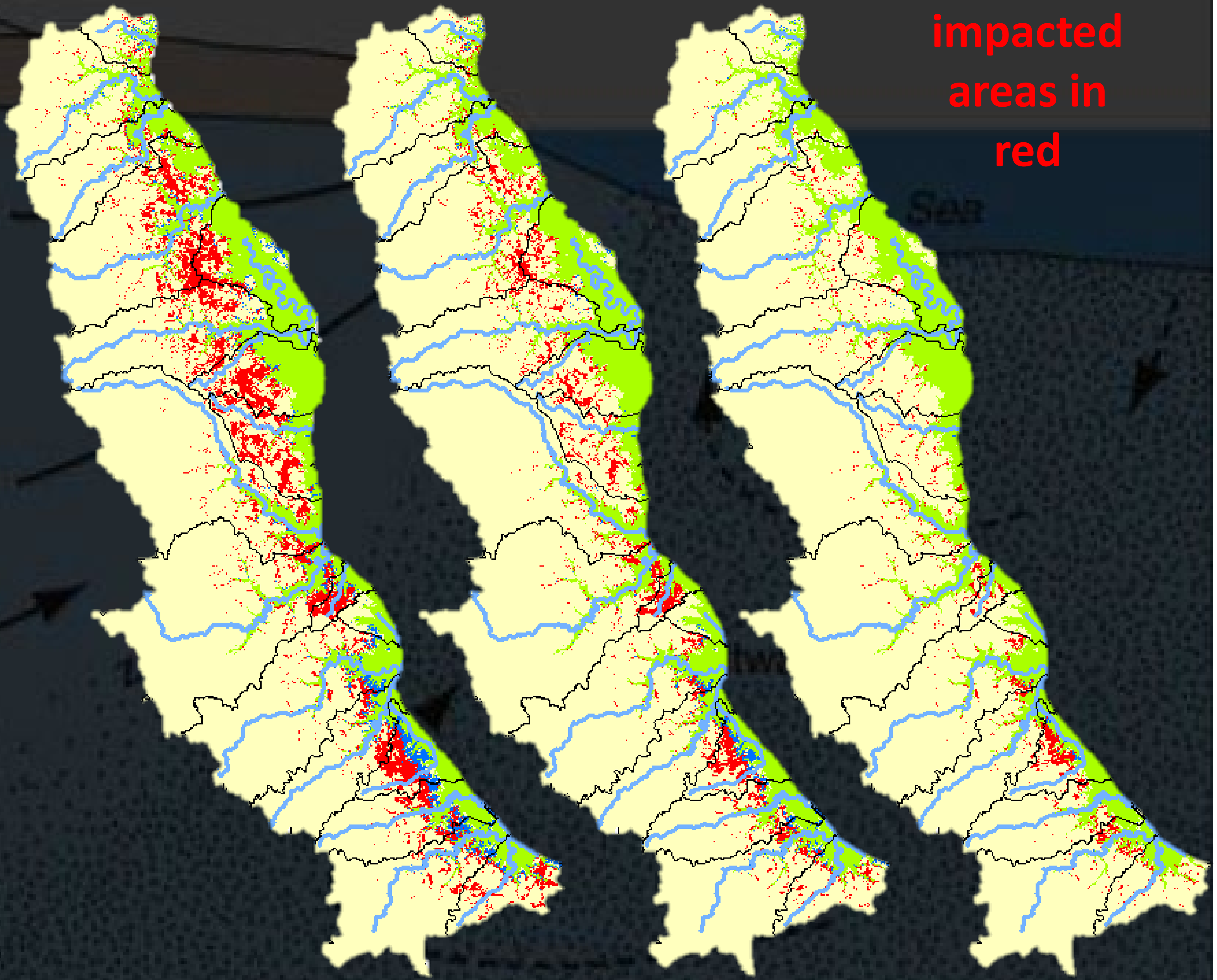
Scenarios: 1.5 m 1.0 m 0.5 m

impacted areas in red

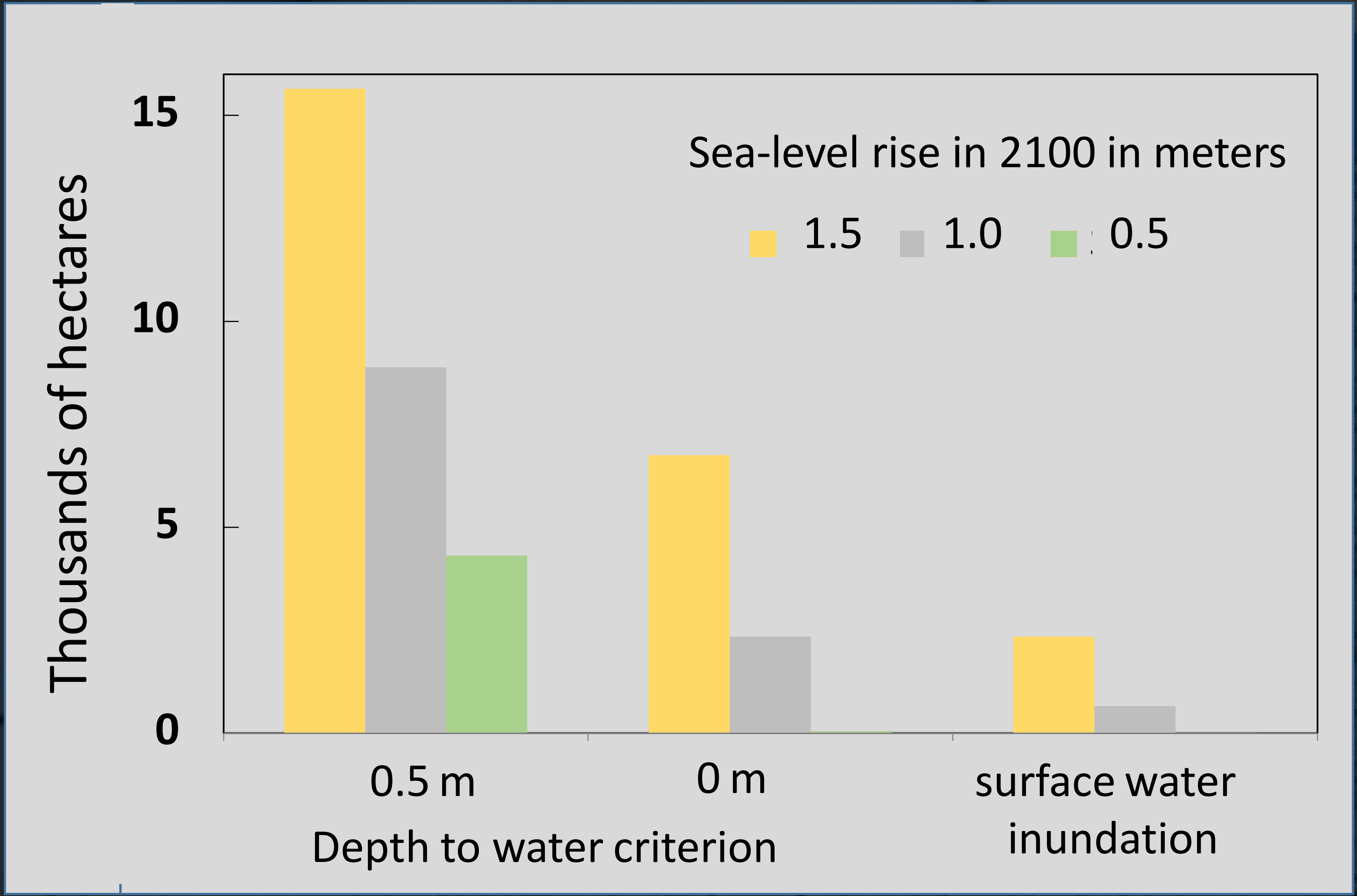
Maps for depth criteria of 0.5 m

(effective rooting depth for typical crops)

Year 2100



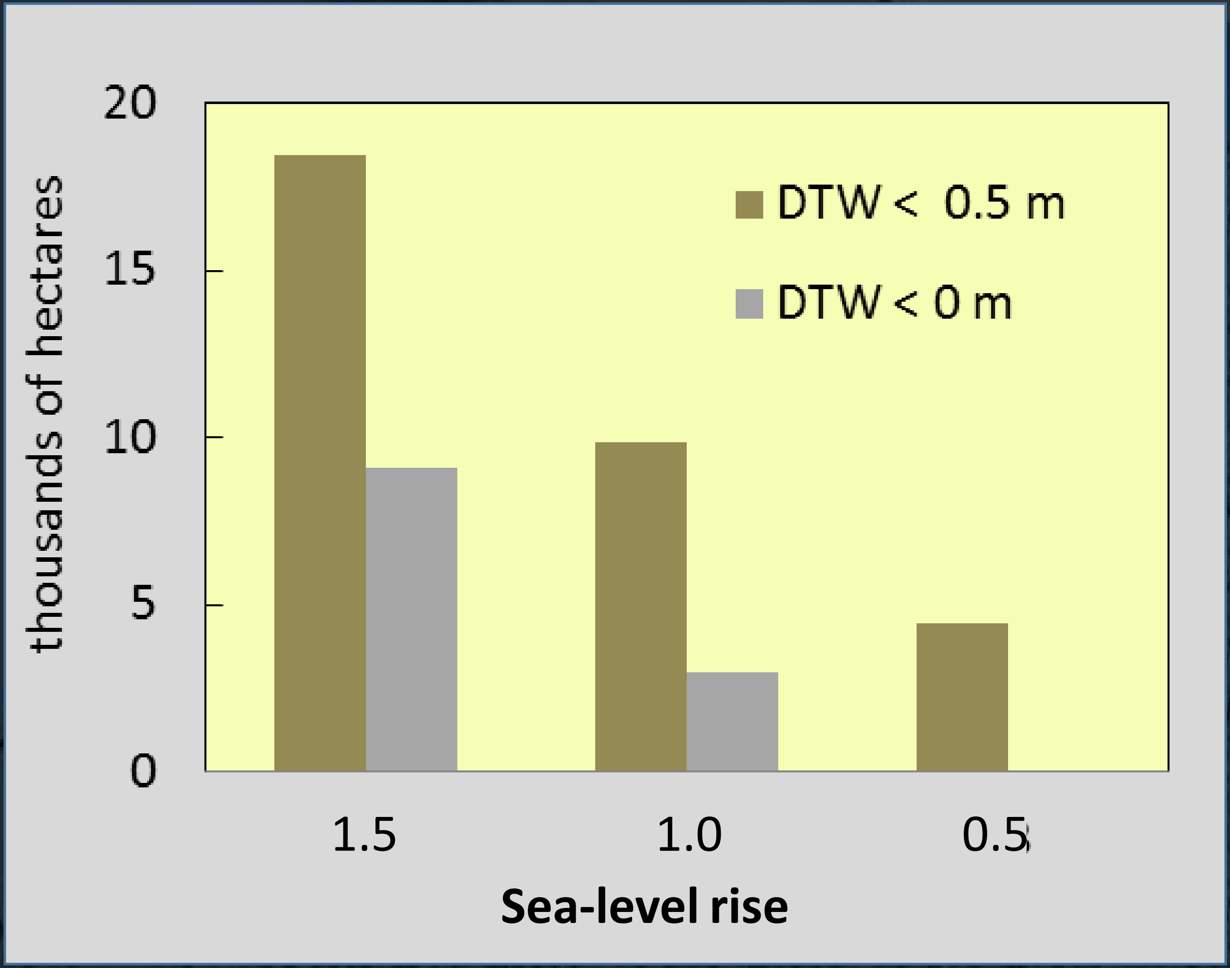
Areas impacted by sea-level rise by a rising water table or surface water flooding.



Values do not include any wetlands.

1 hectare = 2.5 acres

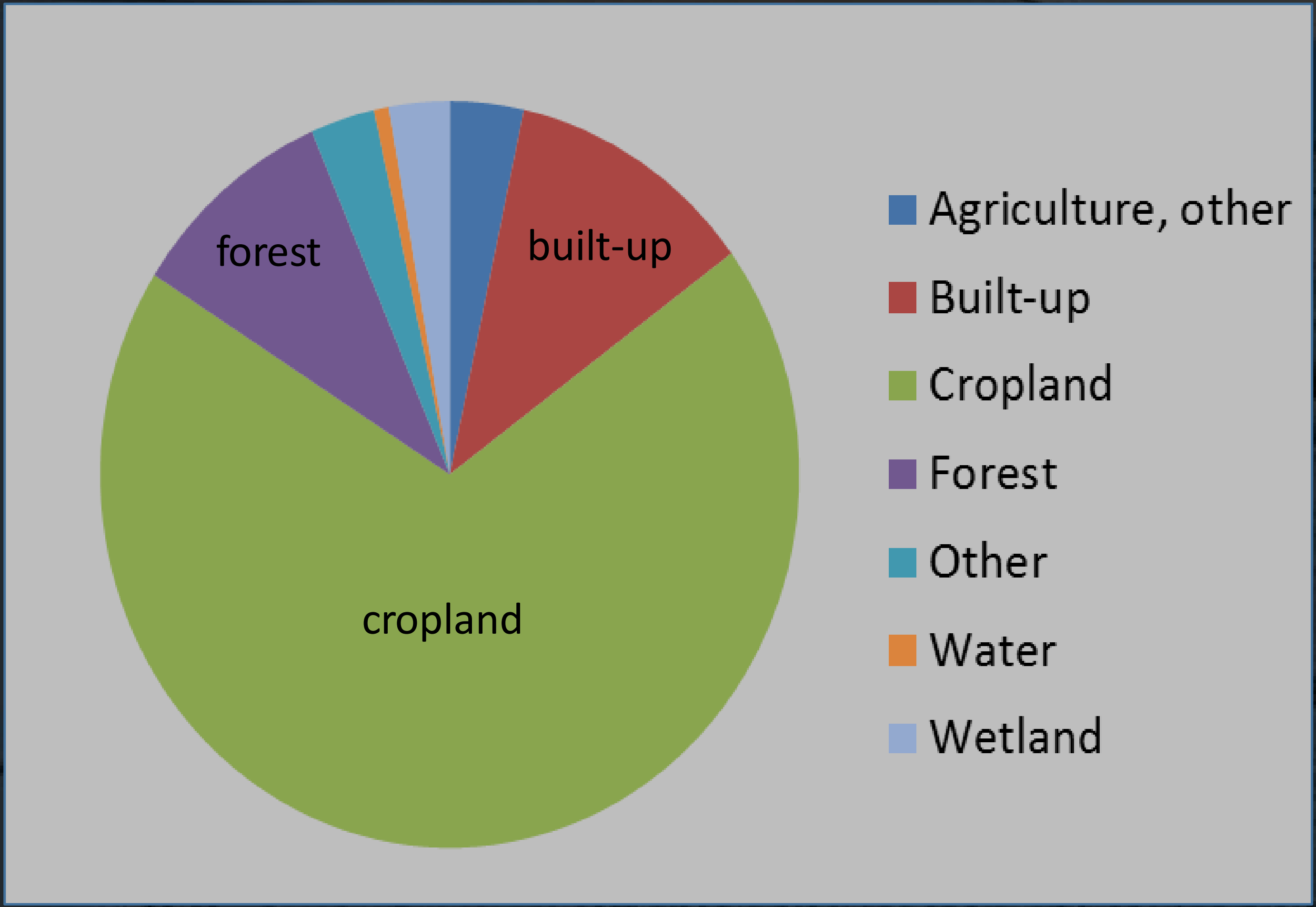
Areas impacted by sea-level rise for different scenarios and depths to water (DTW).



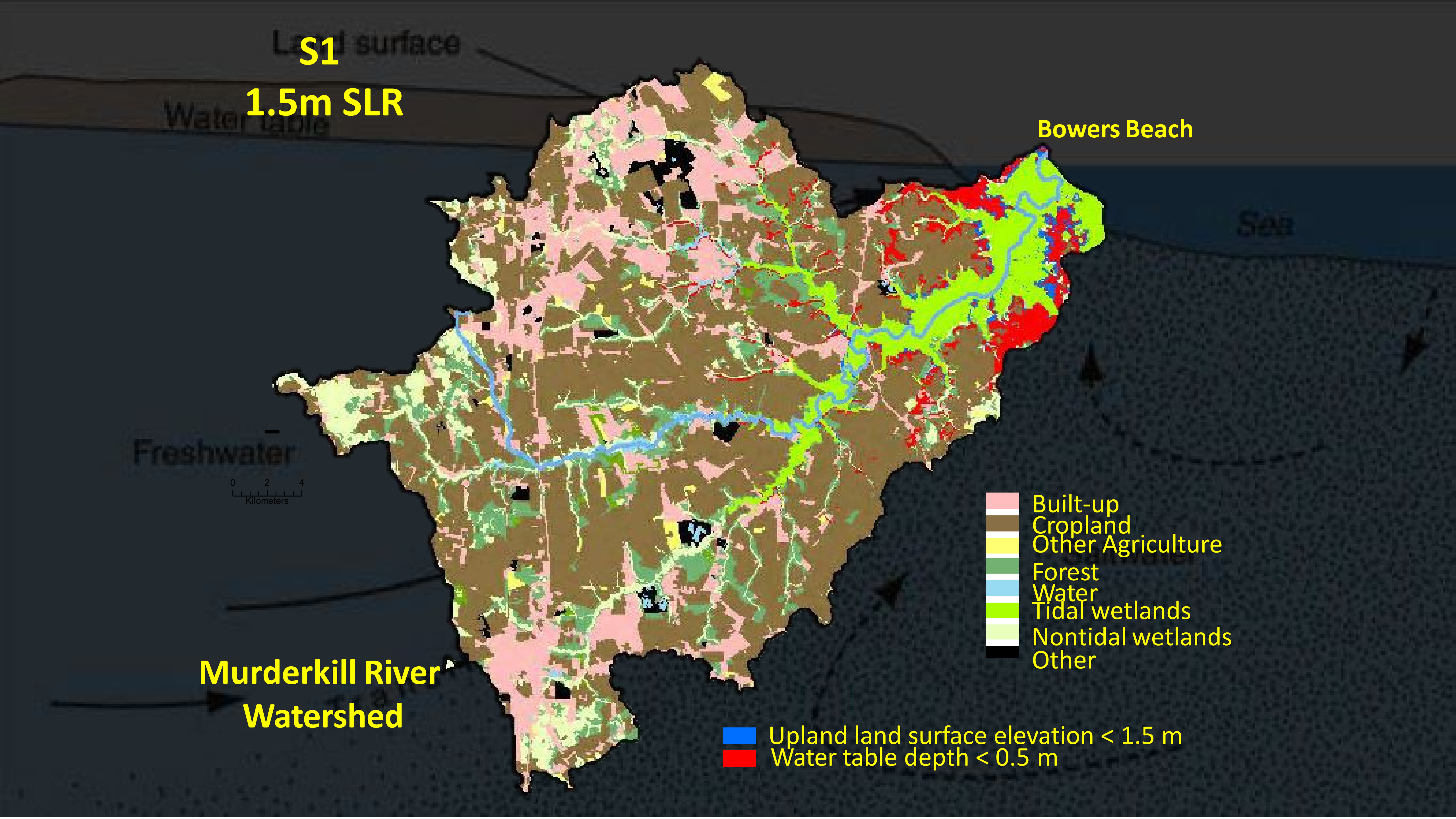
Values do not include any wetlands

1 hectare = 2.5 acres

60% of land use impacted in all scenarios is cropland.



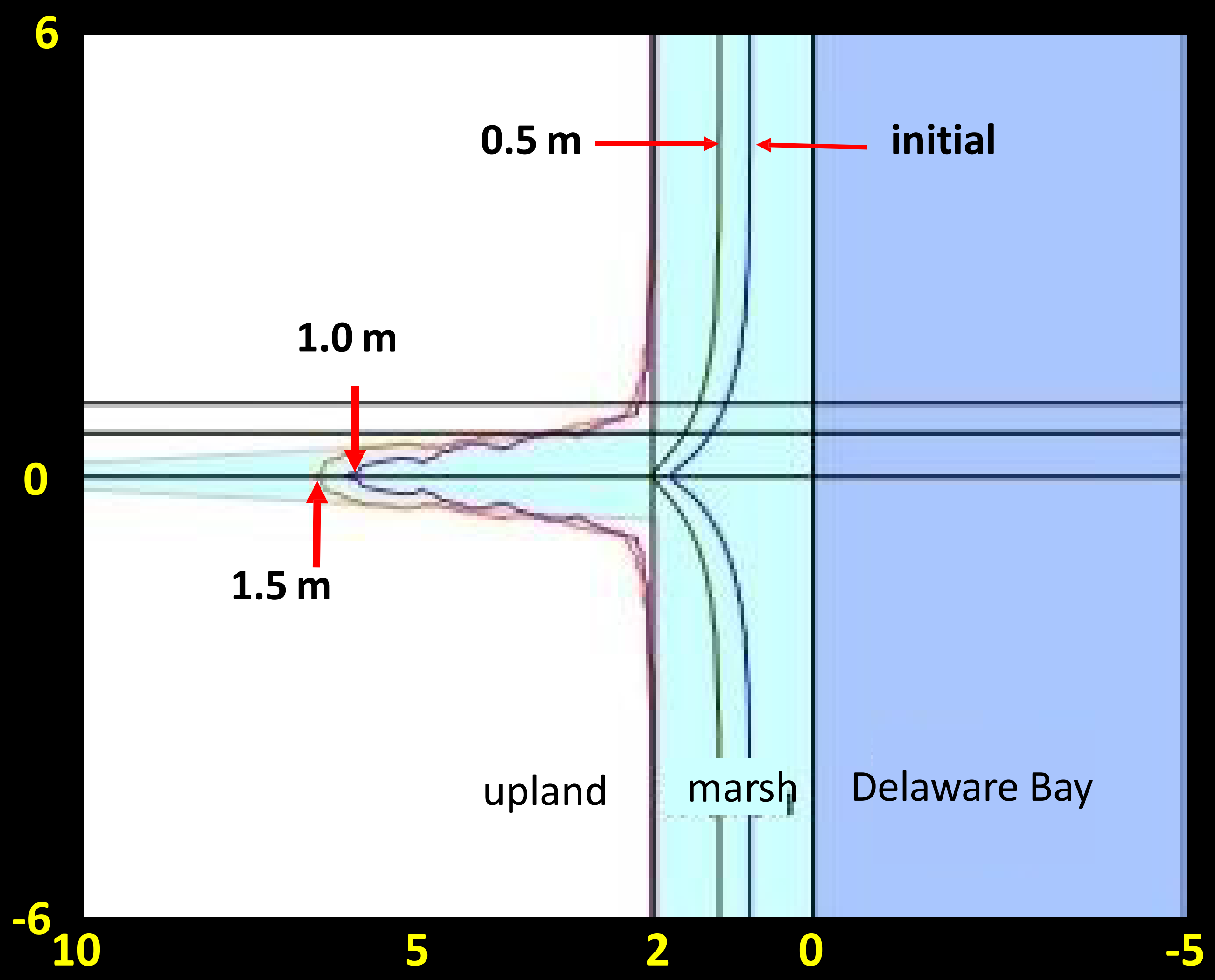
1.5m SLR & 0.5m critical depth



S1
1.5m SLR
Bowers Beach
Sea
Freshwater
0 2 4
Kilometers
Built-up
Cropland
Other Agriculture
Forest
Water
Tidal wetlands
Nontidal wetlands
Other
Murderkill River Watershed
Upland land surface elevation < 1.5 m
Water table depth < 0.5 m

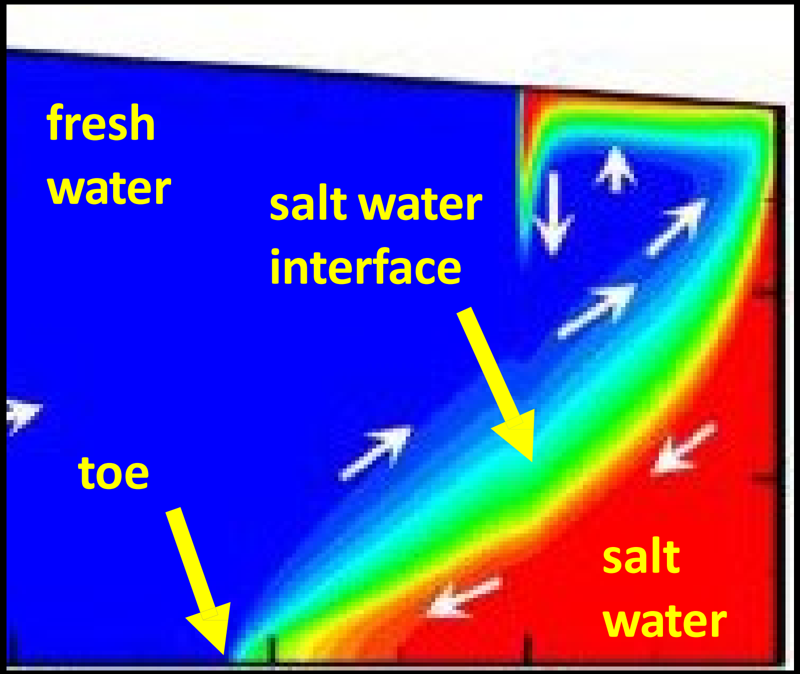
Position of the saltwater interface toe

initial case and three sea-level rise scenarios.

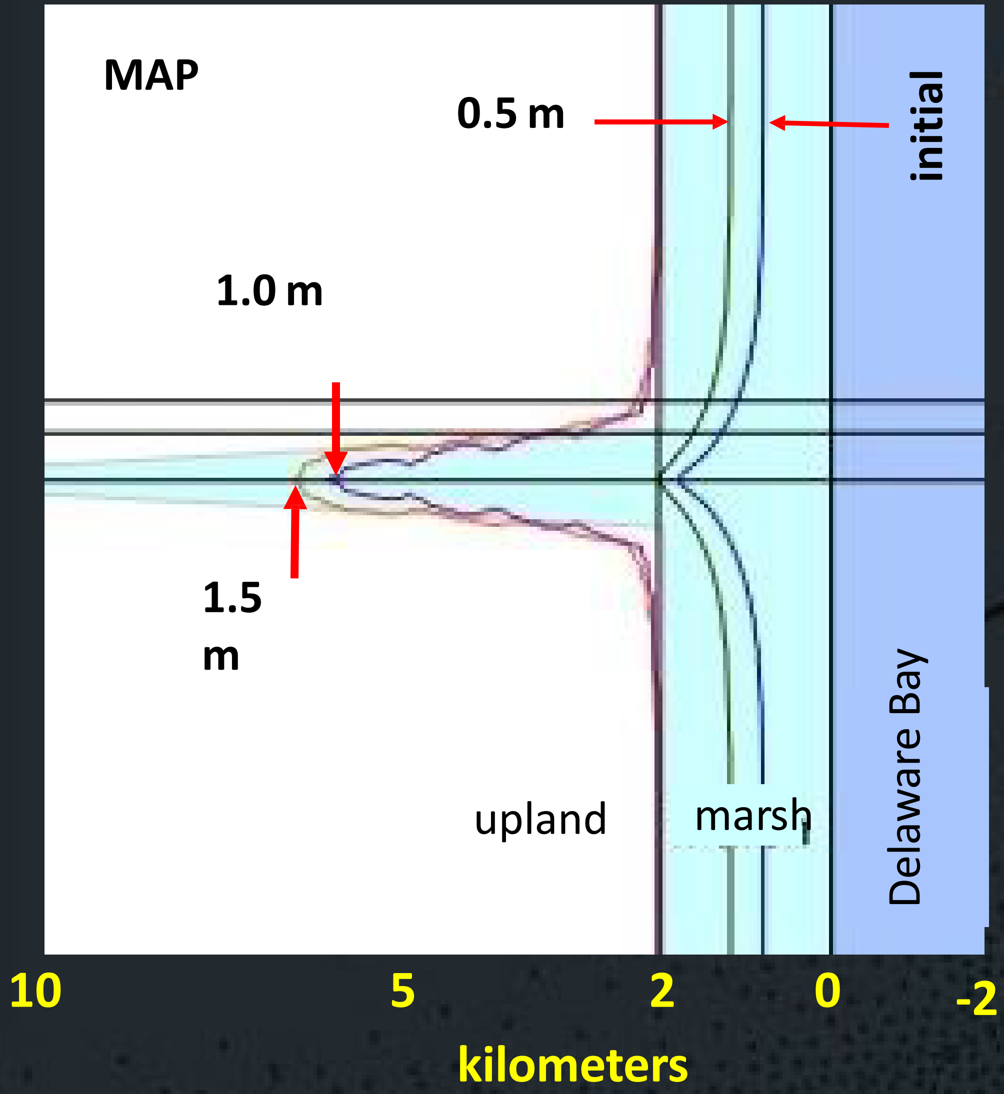


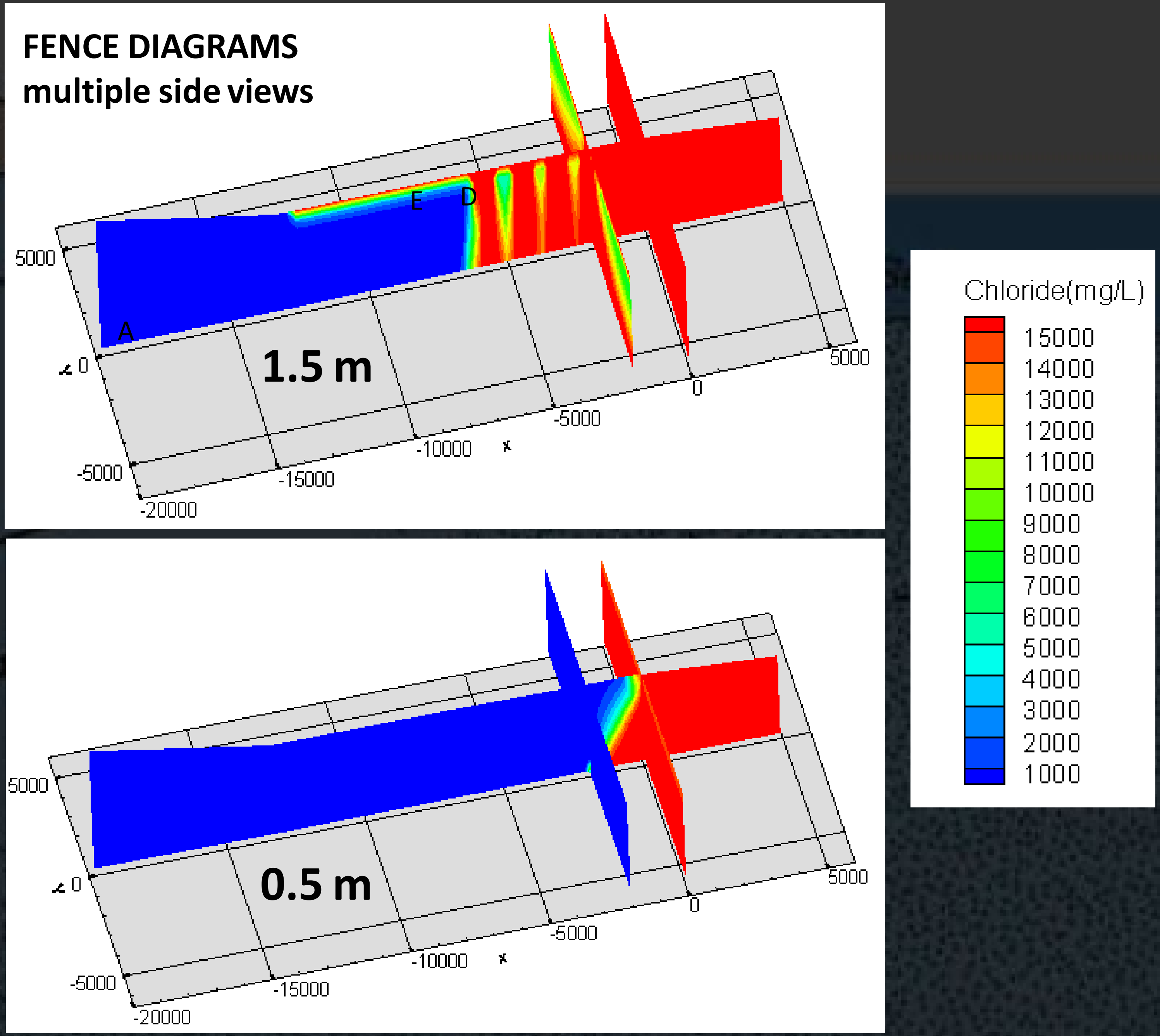
sea-level rise	location
initial	under marsh
0.5 m	under marsh
1.0 m	under river at 6.2 km
1.5 m	under river at 6.7 km

cartoon showing a cross section (side view)



Salt water distribution in year 2100 for the three scenarios.





Implications

- <u>Impacts on agriculture</u>
  - loss of arable land due to groundwater inundation
  - decrease in crop yield because of the water table rising above the effective rooting depth
  - hindrances to planting and harvesting due to an increase in waterlogged soils.

Flooded fields

Implications

- <u>Impacts on water and wastewater Infrastructure including</u>
  - decreased efficiencies or failures of septic tanks, wastewater spray fields and rapid infiltration basins
  - backup of water in storm sewer pipes as hydraulic gradients in the pipes decrease
  - increased flow of water into leaky storm and sewer pipes that will decrease capacity to carry storm flows and sanitary sewage
  - corrosion of underground pipes and other underground infrastructure due to saltier water in the aquifer.

Conclusions

Water-table rise in year 2100

- Significant rise in the water table in areas up to 10 km from Delaware Bay after 2060.
- Total area impacted by water-table rise is from 60 hectares (150 acres) to 18,500 ha (46,250 acres)
- 3 to 9 times more area is impacted by a rising water table than from surface-water inundation
- Over 60% of the area impacted in all scenarios is cropland.

Salt-water intrusion in year 2100

- Salt water in aquifer base migrates up to 6.7 km inland from marsh/bay boundary under the river.
- By year 2100, at 4 km from the river, salt water in the base of the aquifer migrates up to 3.5 km.

A groundwater flood can last weeks to months!!