Slope Evolution Study

Presentation

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Lusby, MD

February 25, 2019

Background to Previous Presentations

- This basic Powerpoint was presented to the Environmental Committee of the Department of Planning and Zoning before I retired from the U.S. Geological Survey in 2005. I've added a few new things.

The Background to Slope Studies Savigear (1952)

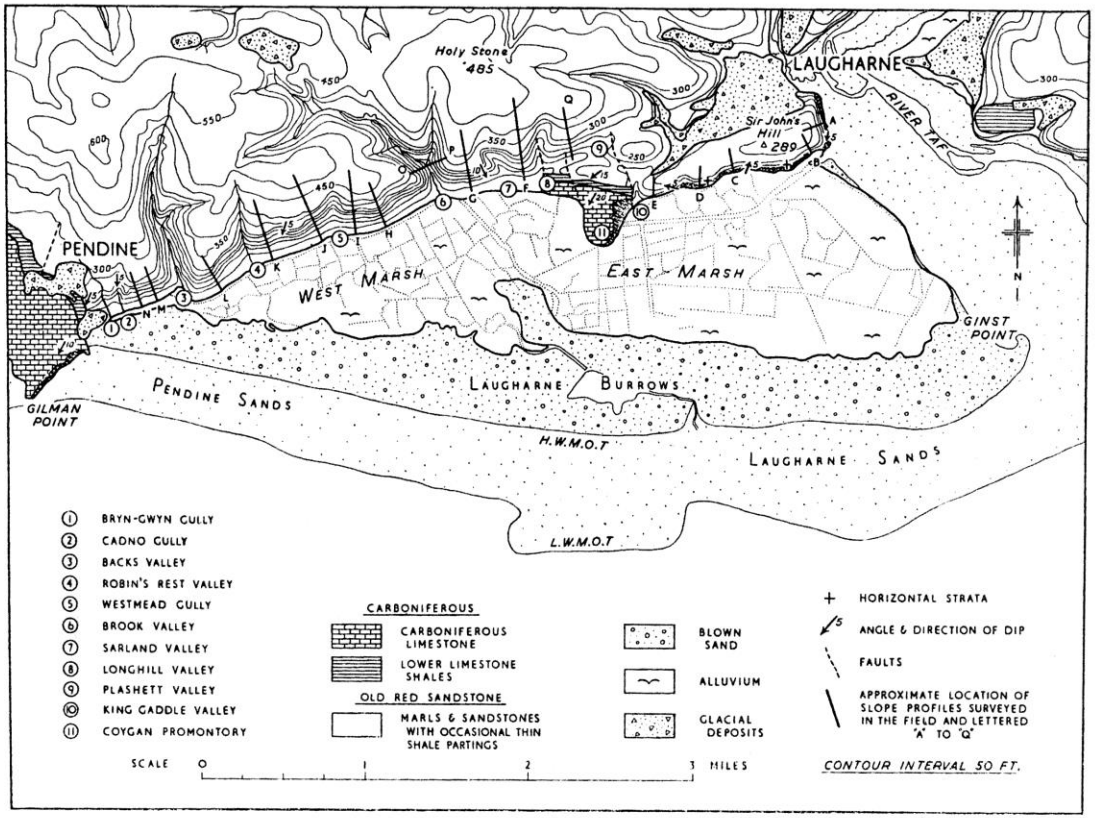

FIGURE 1—The nature of the area between Pendine and the Taf estuary.

Progressive Slope Development

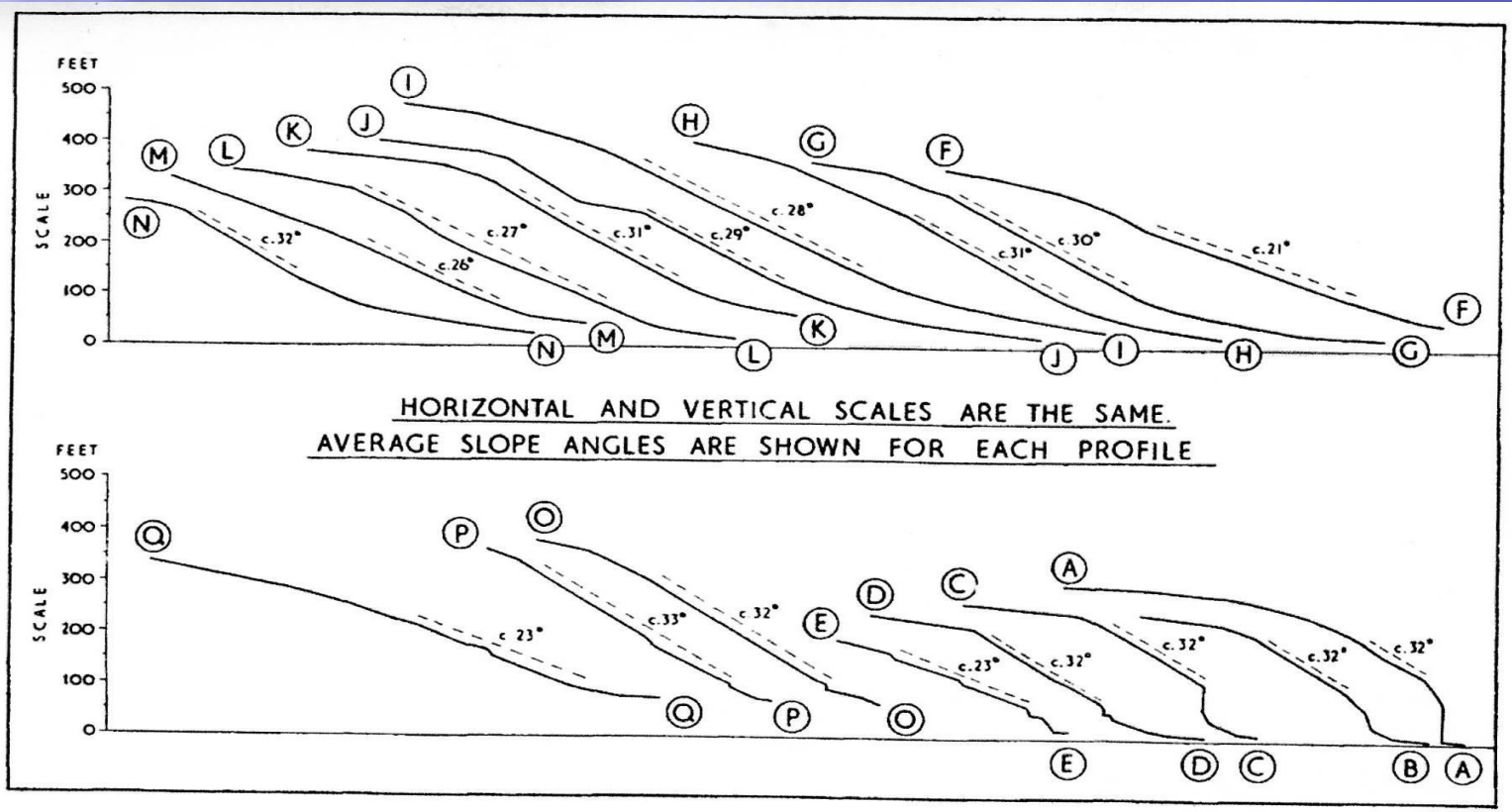

FIGURE 2—The general forms of certain portions of the seaward and valley slopes between Pendine and the Taf estuary, illustrated by slope profiles.
The approximate locations of the slopes, from which the data for the construction of each profile were obtained, are indicated on the map in Figure 1.

Because of the difficulty of obtaining

So You'd Like to Stop Shore Erosion along the Calvert Cliffs. You'd better think before you act.

Curtis Larsen and Inga Clark
U.S. Geological Survey
Reston, VA 20192
And
Martha Herzog
National Oceanic and Atmospheric Administration
Silver Spring, MD

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The Conclusion First:

There are two processes acting on eroding sea cliffs.

The most obvious process is bluff retreat driven by wave action at the base of he bluff.

The second is slope failure and bluff top retreat until a stable angle of repose is attained. Along the Calvert Cliffs, the stable angle is 35 degrees.

Once wave actiom ends, the bluff top recedes until the stable slope angle is reached. IN CALVERT COUNTY THIS TAKES PLACE IN ONLY 30 YEARS—THE LENGTH OF A MORTGAGE.

In short, any attempt to stop bluff recession by retarding wave erosion of the toe of the bluff results in immediate bluff top retreat.

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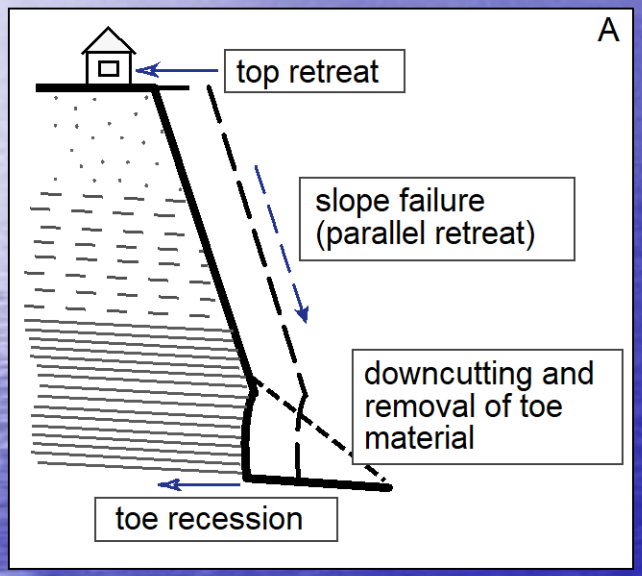

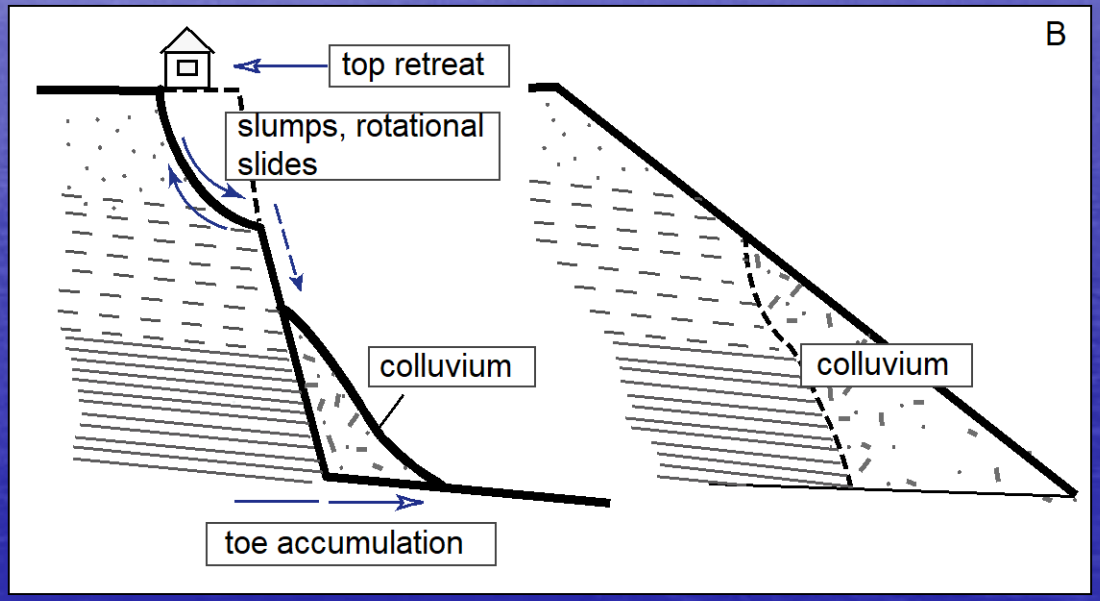

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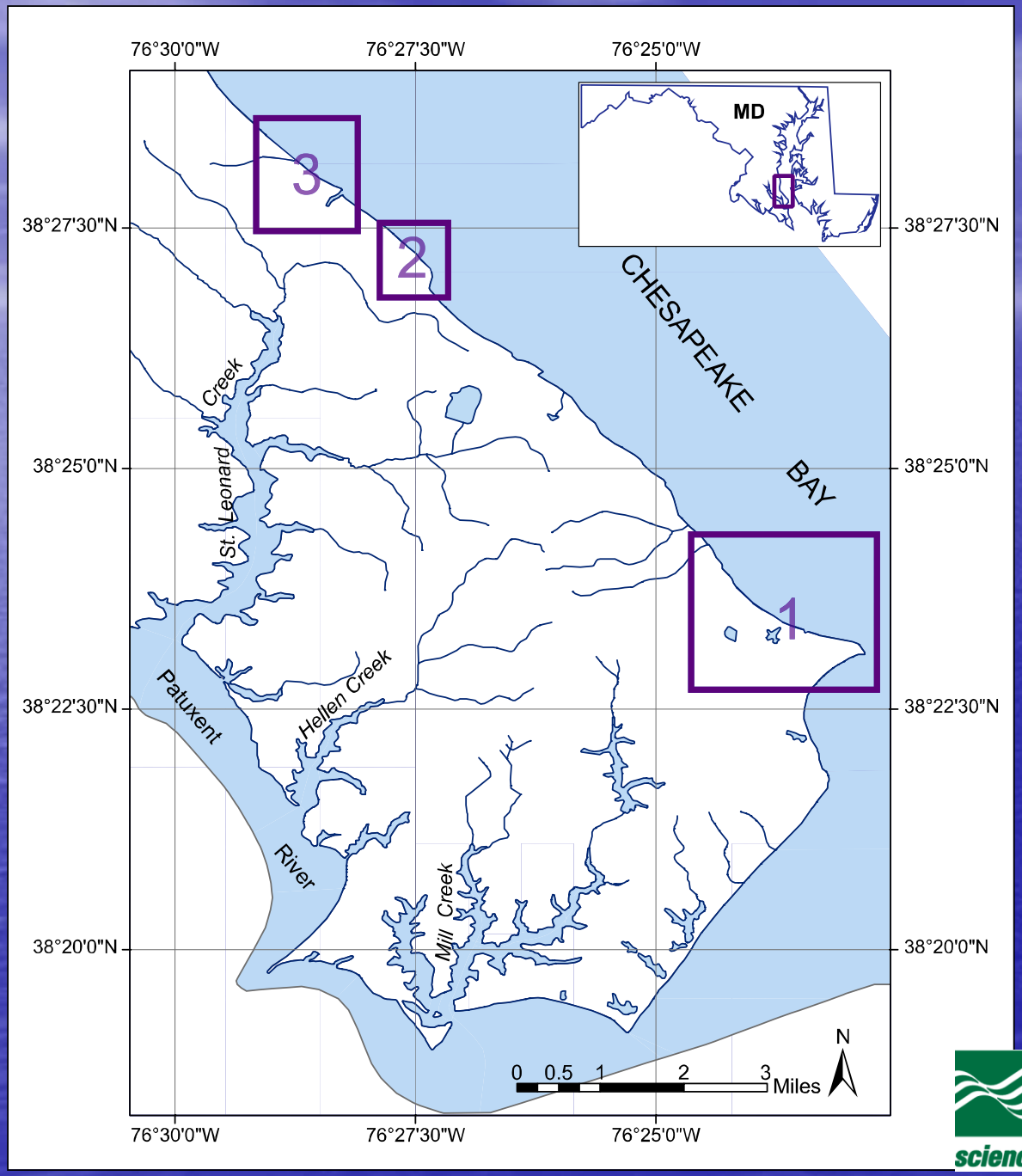

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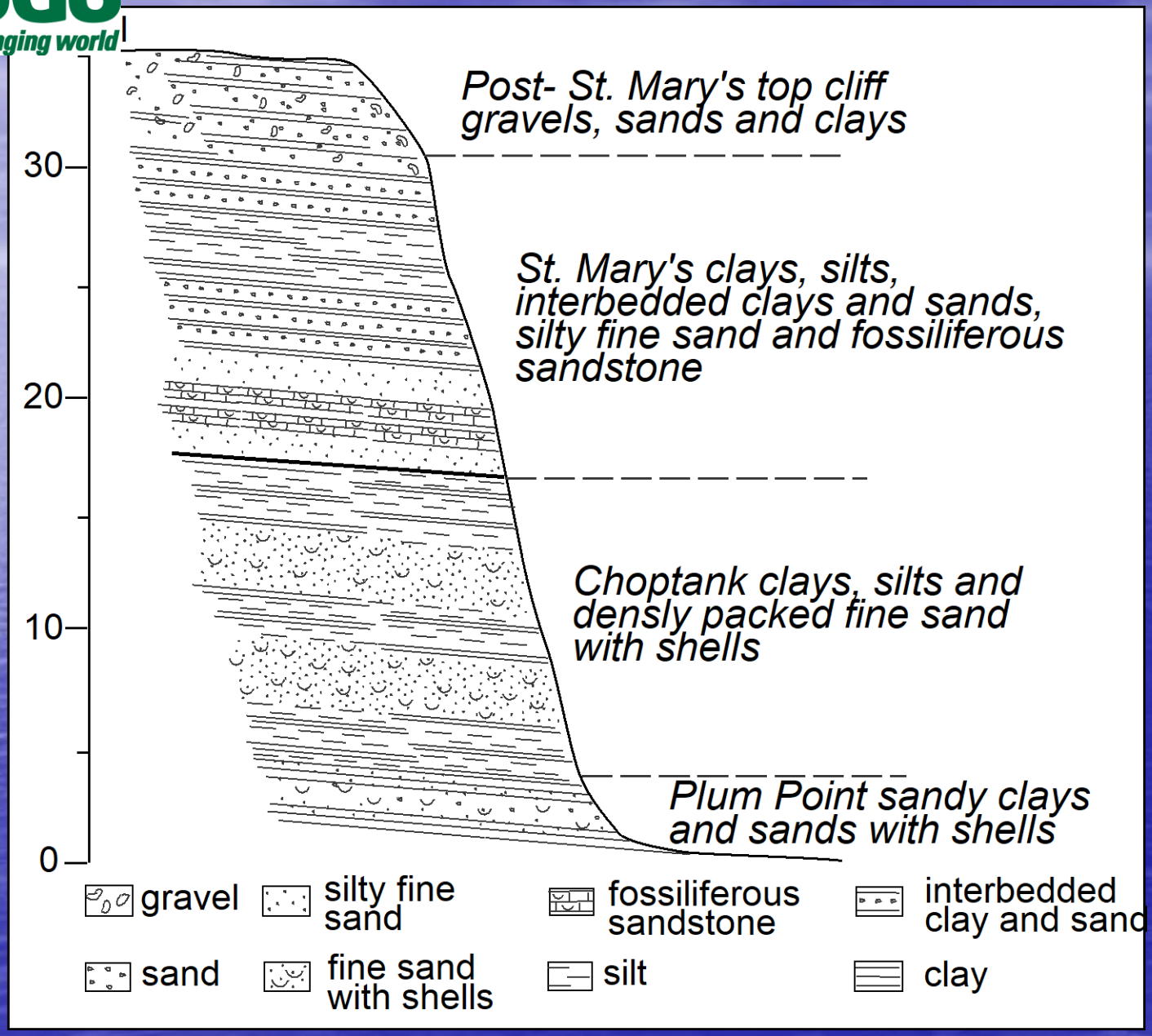
Post- St. Mary's top cliff gravels, sands and clays
St. Mary's clays, silts, interbedded clays and sands, silty fine sand and fossiliferous sandstone
Choptank clays, silts and densly packed fine sand with shells
Plum Point sandy clays and sands with shells
30
20
10
0
gravel
silty fine sand
fossiliferous sandstone
interbedded clay and sand
sand
fine sand with shells
silt
clay

Cove Point

Cove Point is a cuspate foreland comprised of former active beach ridges that is migrating southward along the western shore of the Bay. It moves southward driven southward by strong winter winds over the maximum "fetch" from the north and northeast. A thesis study by Michael Beardslee of the Univ. of MD dated the movement.

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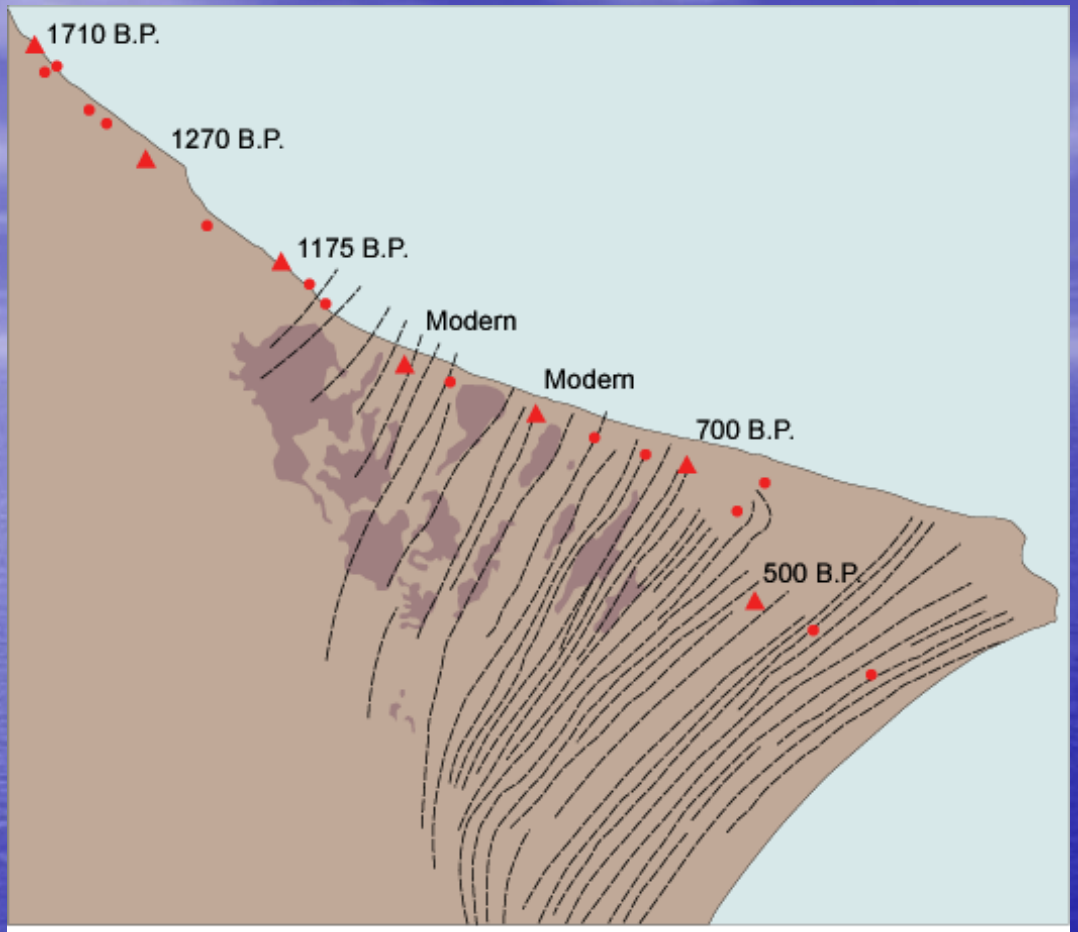

1996 GPS Shoreline

1938 Beach Ridge

1990 Pond

Vibracore

Vibracore with Radiocarbon Date

0 0.5 1 Kilometers

Materials dated were wood pieces, three phragmites rhizomes, and one organic sediment.

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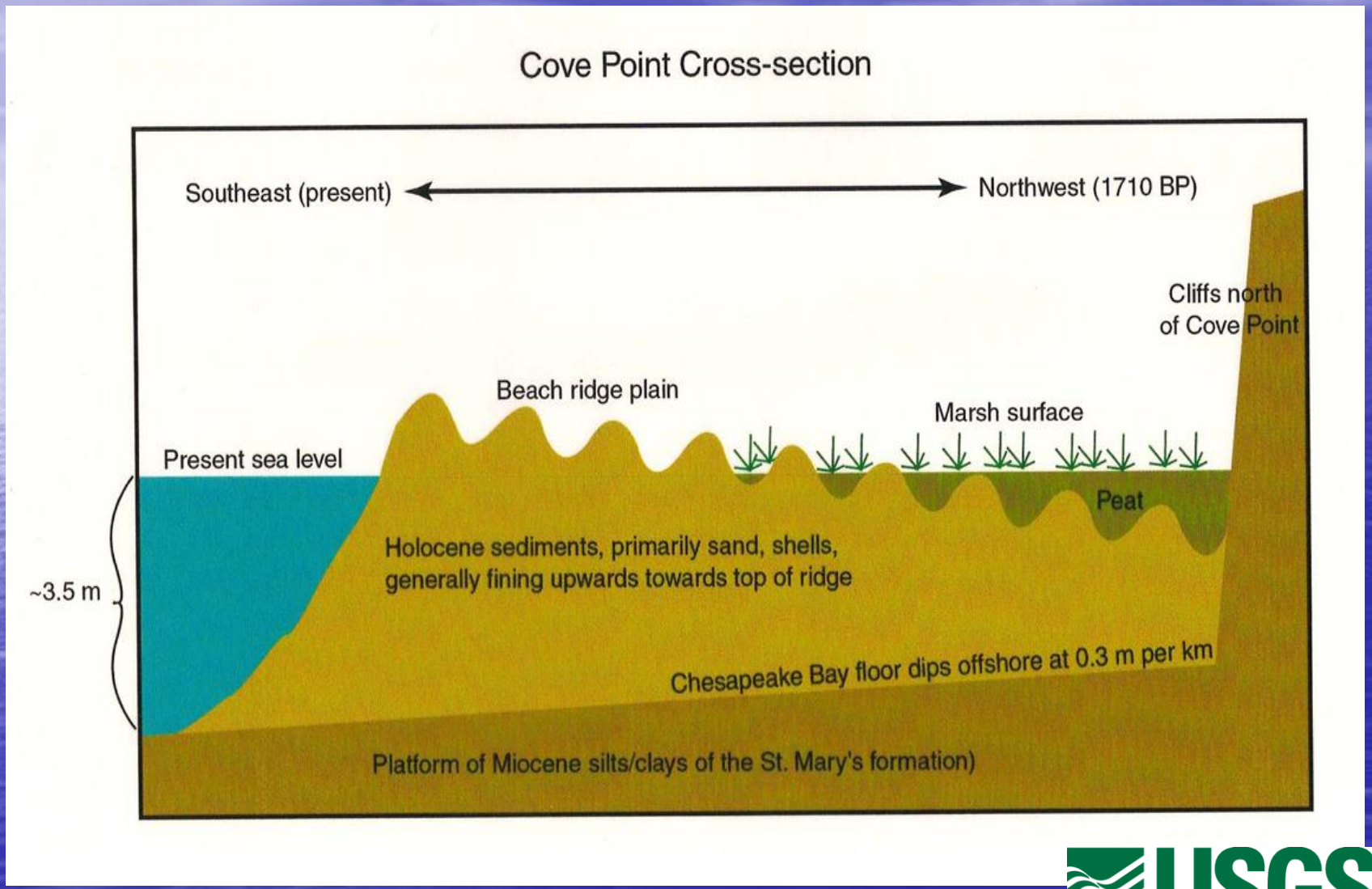

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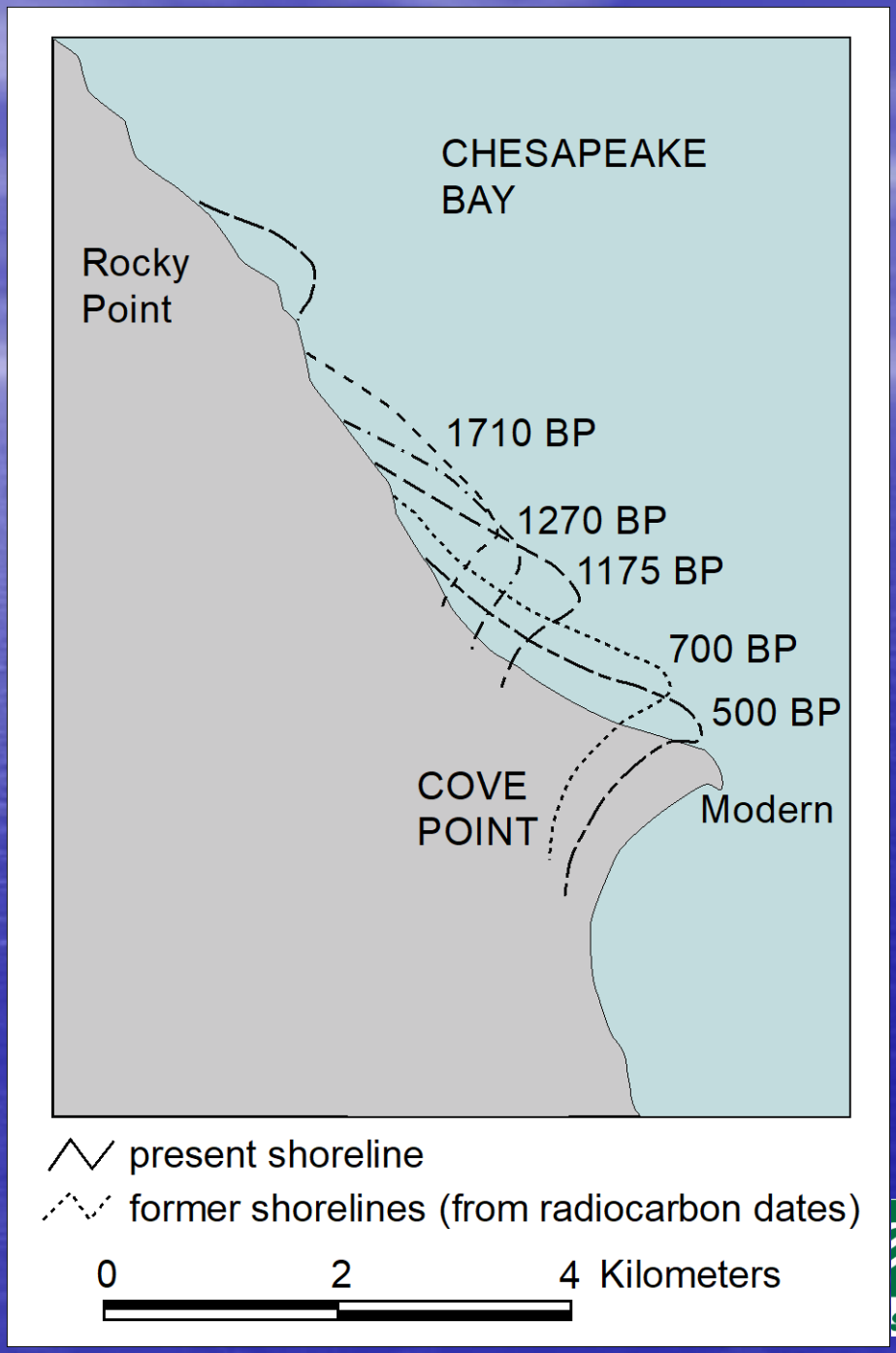

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The Fossil Bluff Line

As Cove Point migrated southward it progressively protected actively eroding bluffs from wave action. As a result, the bluff tops began to retreat to establish a stable slope or "angle of repose". Martha Herzog studied this area to document progressive changes in the slopes over the past 1700 years to determine the rate of change by measuring slopes along this fossil bluff line.

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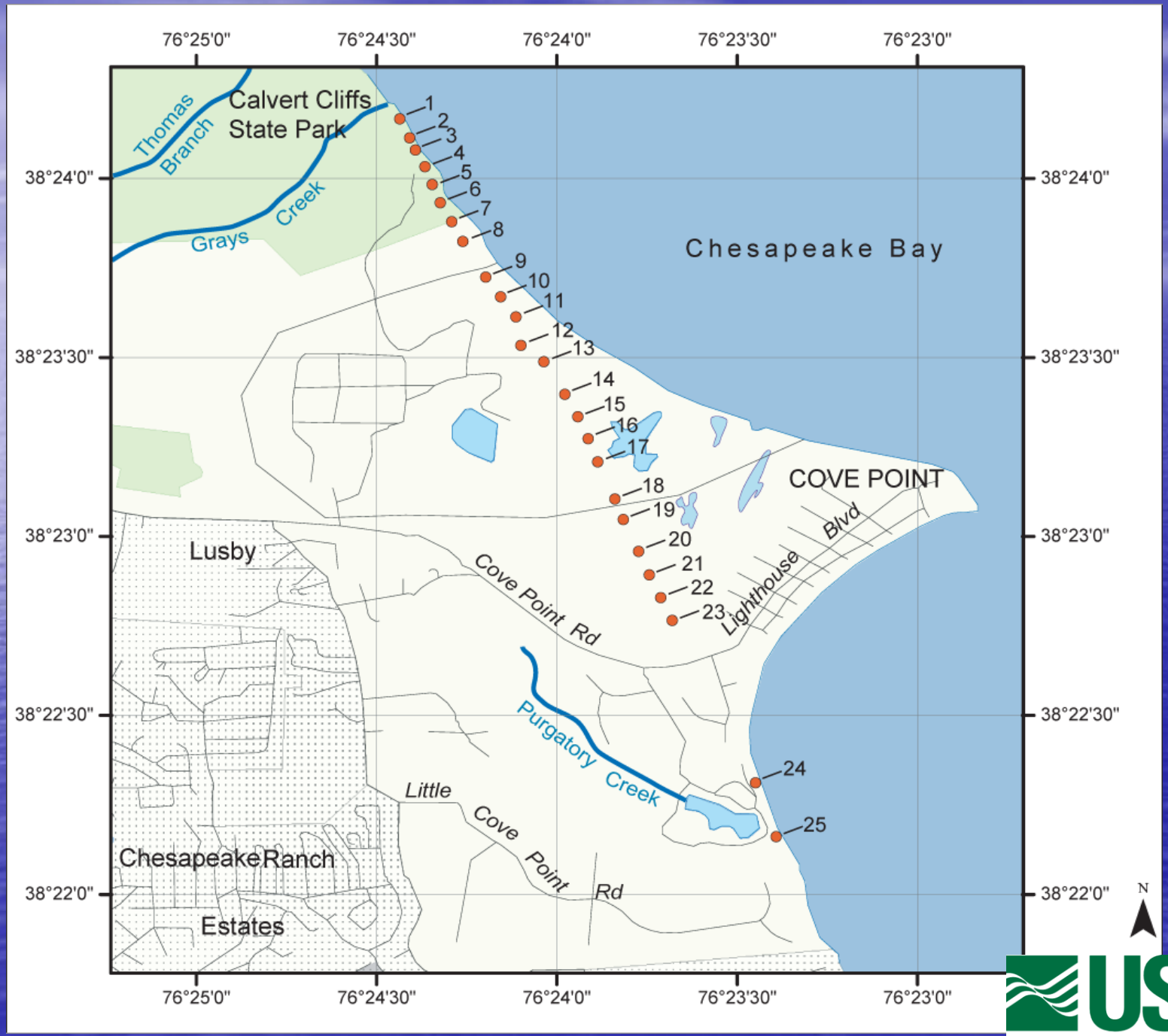

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The Results were Surprising!

- There was no progressive change in slope.
- Rather, all slopes measured had become stabilized over the 1700 years preserved behind Cove Point.
- The mean stable slope angle determined was 35 degrees.
- Over a centennial time scale all slopes had attained stability.

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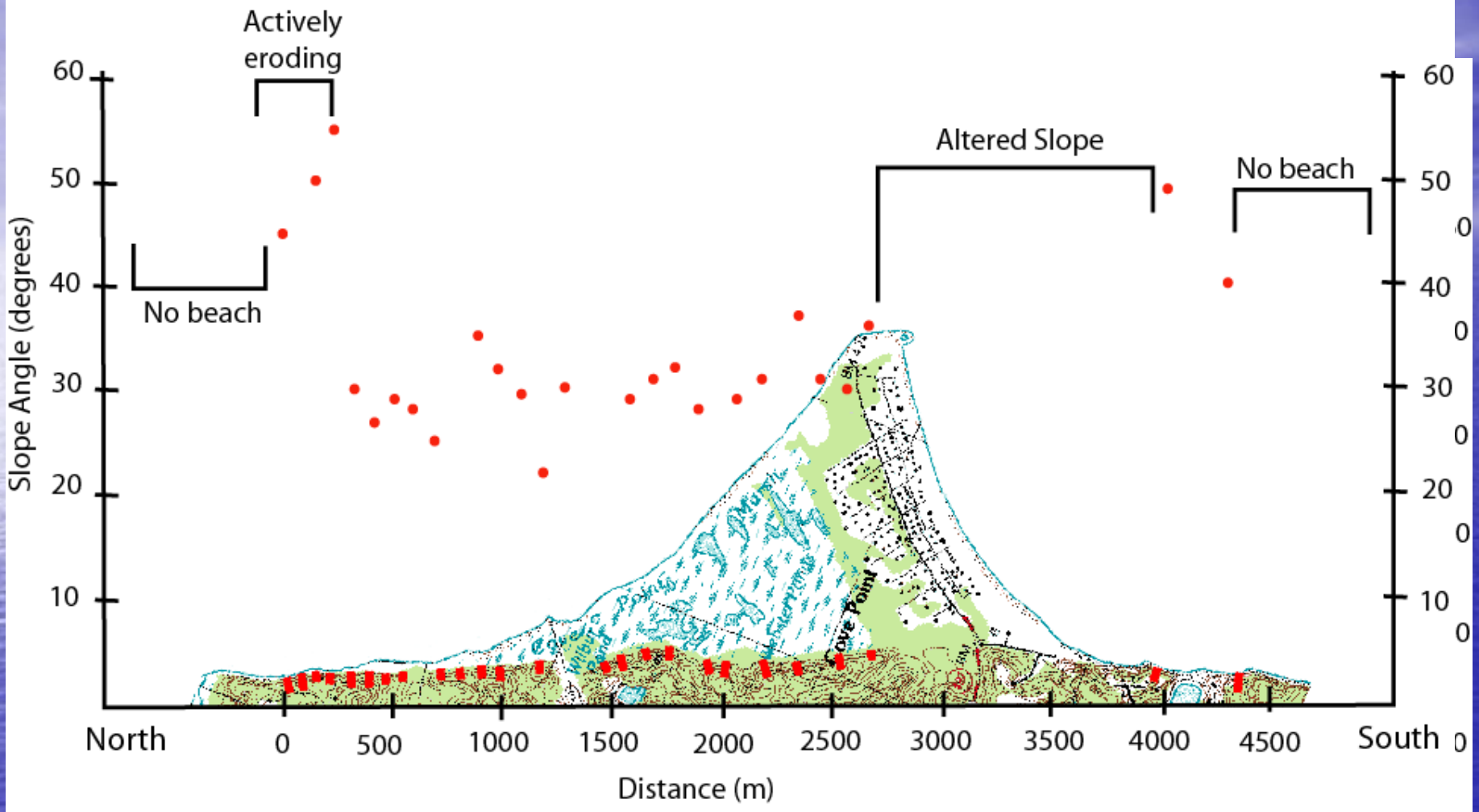
Cove Point, Maryland



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Flag Ponds Nature Area.

Flag Ponds is a series of sand spits deposited southward along the western side of the Bay derived from sediment from eroding bluffs to the north. These spits progressively protected bluffs from wave attack as well. It provided a second "fossil bluff" line for measuring the rate of change in slopes. Pollen studies of sediments overlying the formerly active beach deposits at the base of the fossil bluff contained Ragweed pollen. This pollen is a time marker for the beginning of European settlement in the area. Hence, these spits were at most 400 yeas old.

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Slope Angles were again Measured.

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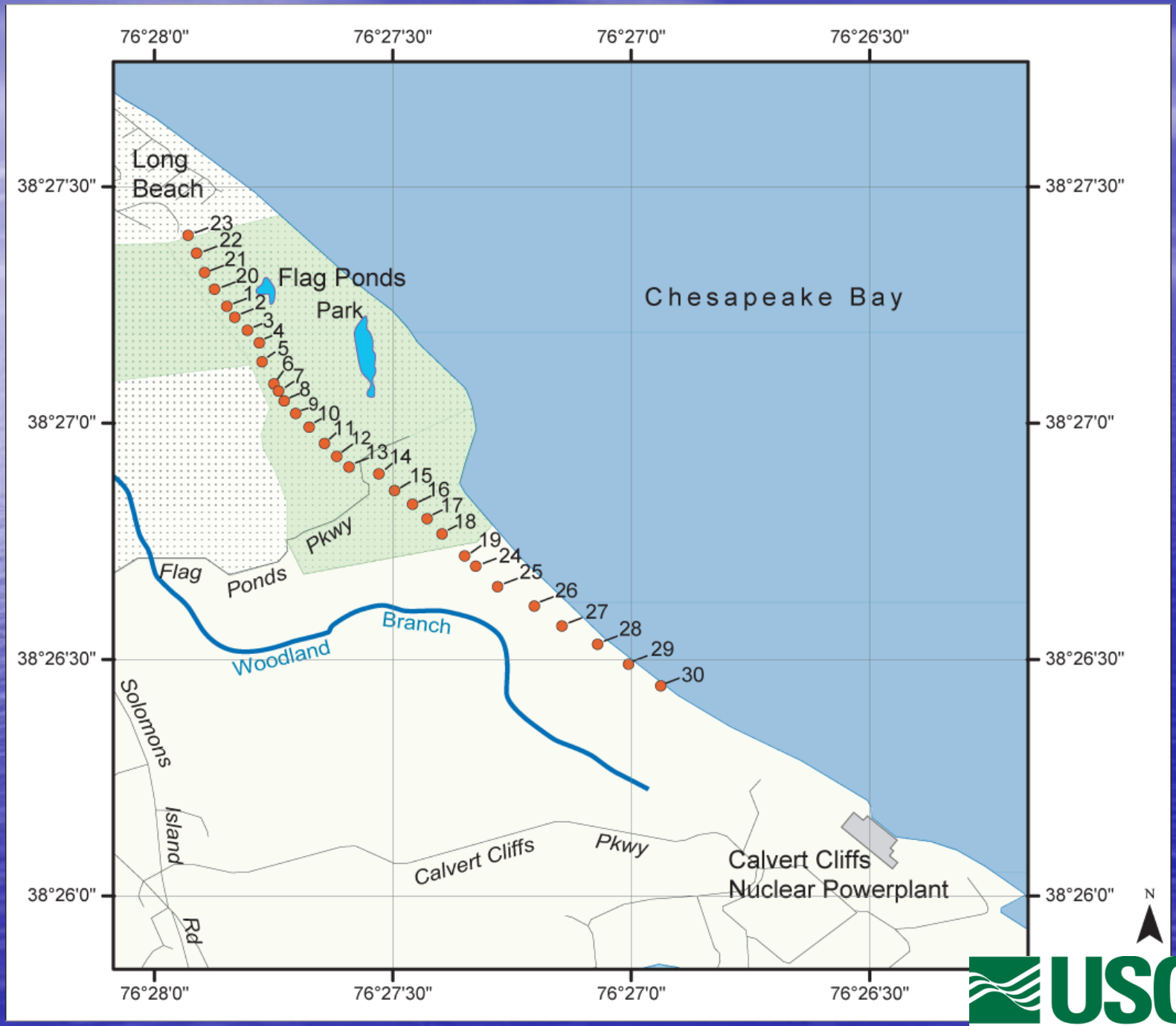

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Here again all protected slopes had failed and evolved into stable slopes with a mean slope angle of 35 degrees and Within a time frame of 400 years! Clearly this was a rapid process!

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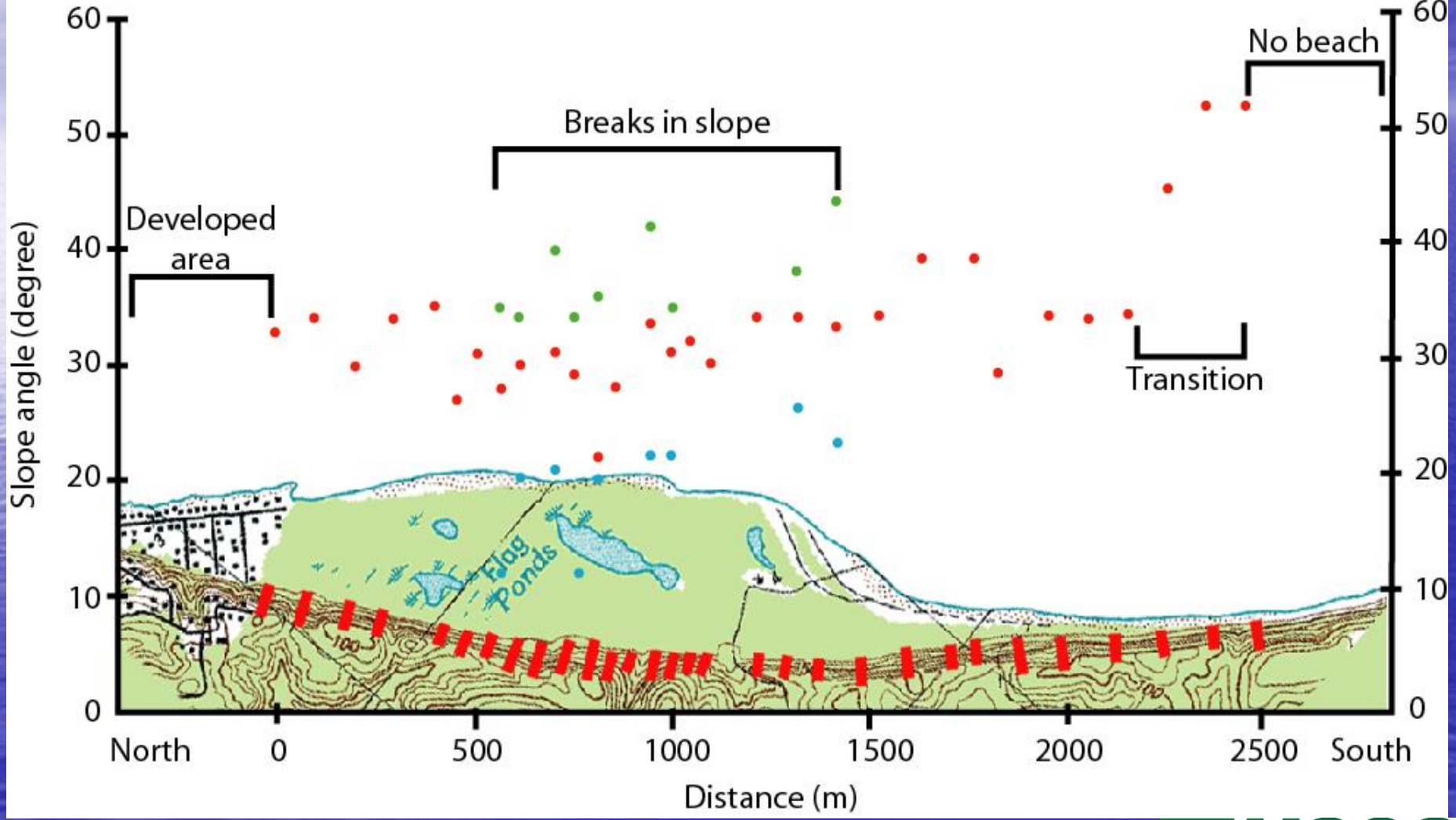
Flag Ponds, Maryland



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Flag Harbor

Flag Harbor provided an accurate key to understand the process of slope evolution. The harbor had been created by dredging a channel to link a ravine eroded in the bluffs to establish a marina. The entrance to this channel was then protected by harbor jetties in 1947 to maintain the channel entrance. The northern jetty progressively trapped sediment moving southward along the shore.

For our study, this provided progressive south to north protection of a very young "fossil bluff" behind this wedge of sediment.

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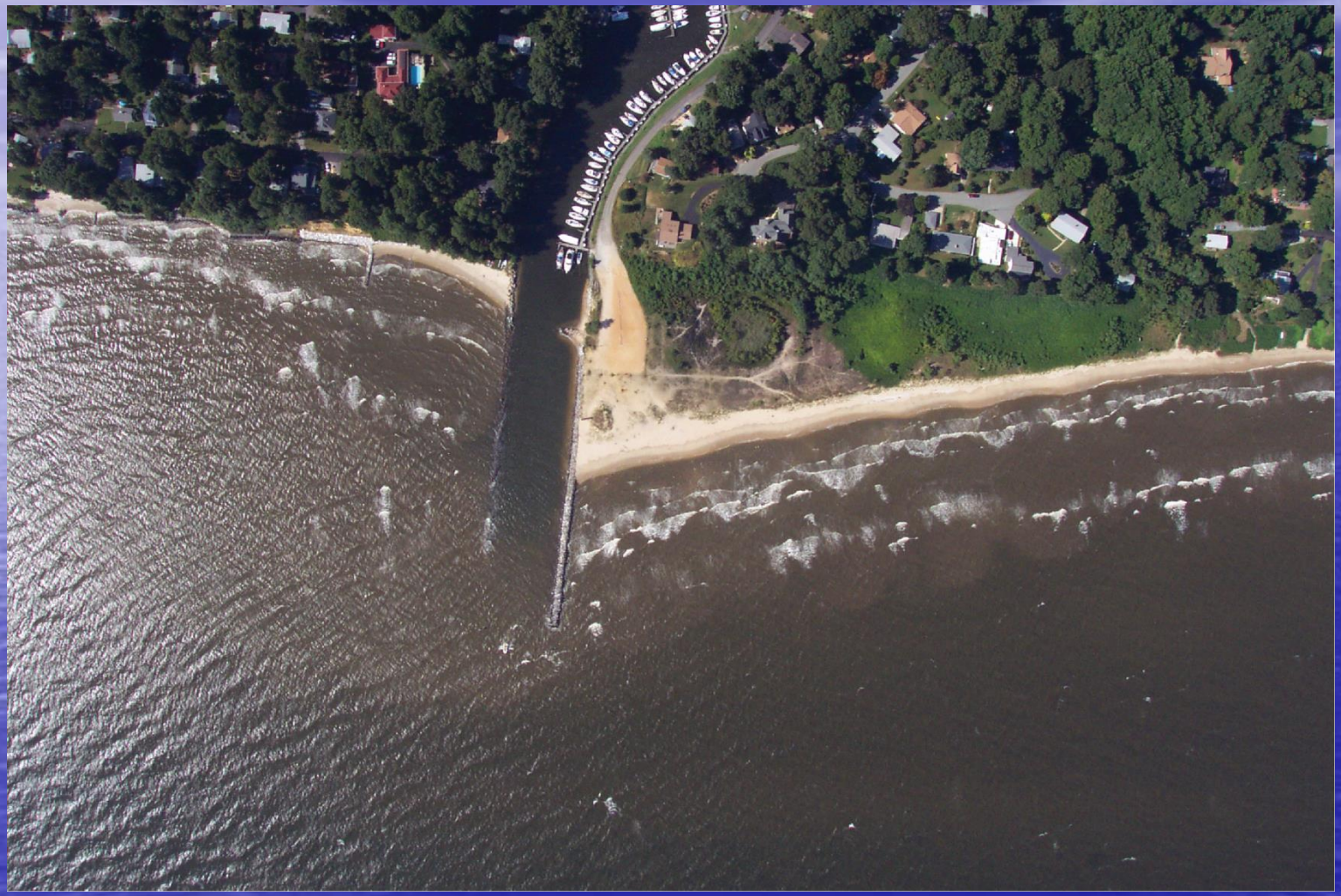

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Again we measured the Slopes.

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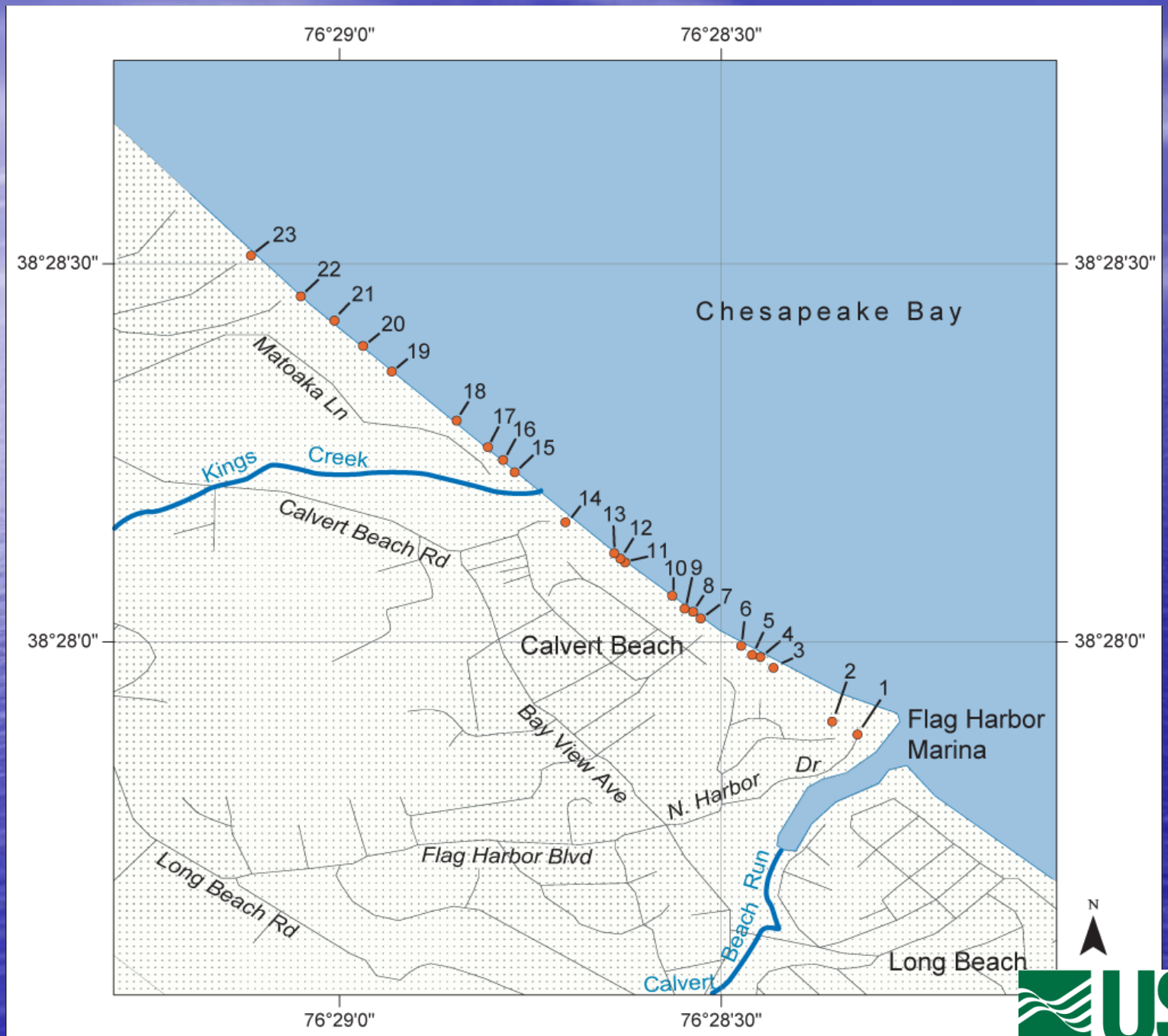

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Photos showing a south to north progression in slopes.

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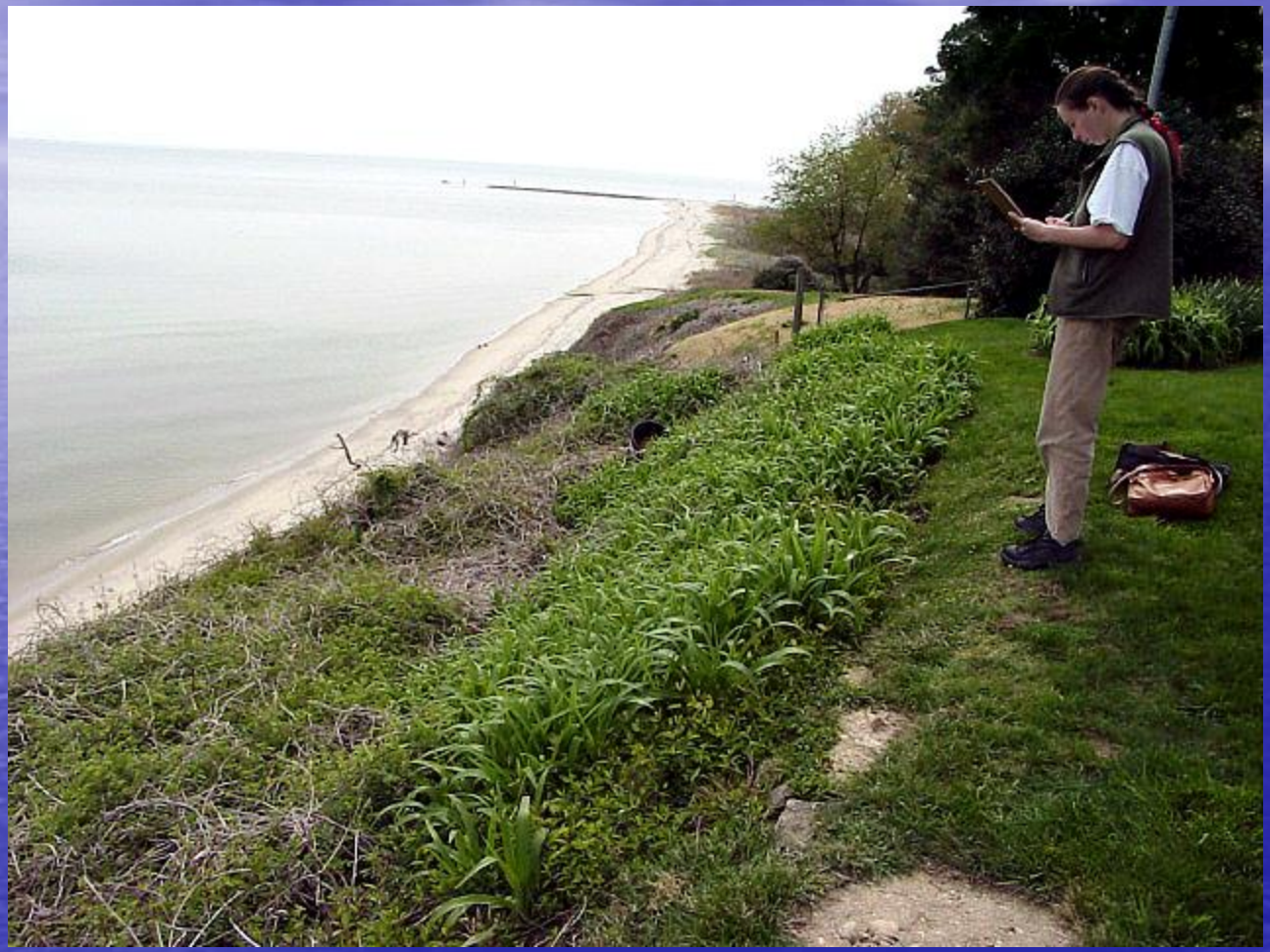

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This time there were rates we could relate to in our modern time frame.

The slopes protected since 1947 had all failed and currently had mean slope angles of 40-45 degrees. As important, they were still failing as they tried to attain a stable slope angle.

To the north the progressive change from active wave action and bluff-sloughing to slope retreat through bluff top failure was documented. Once artificially protected, the slope angles changed from 70 degree to 45 degree slopes in 25 years!!

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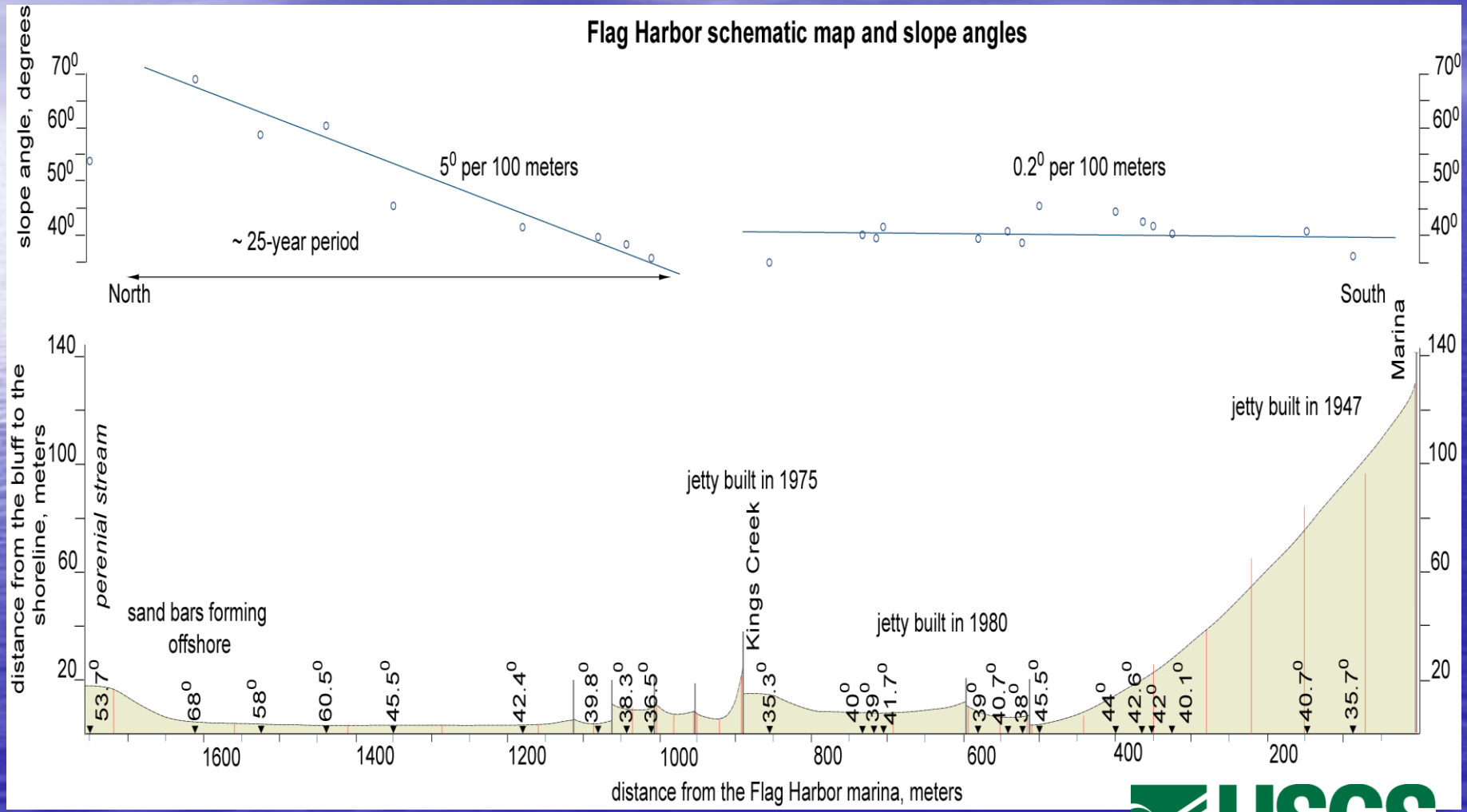

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The Conclusion Again:

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The Dilemmas

Let the bluffs erode or protect them from receding?

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Consider Current Bluff Retreat:

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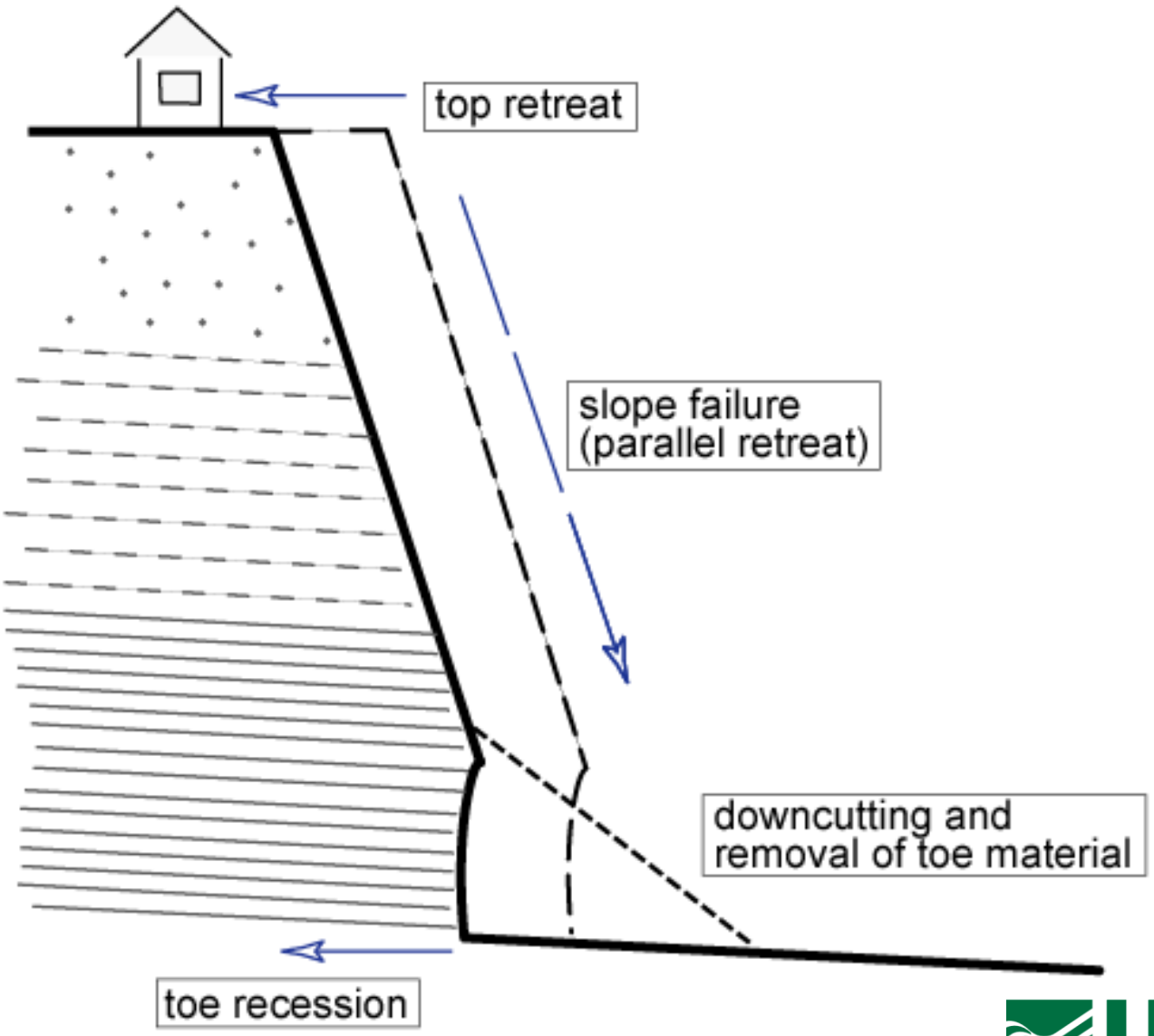

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Example 1:

- A 20 m (60 ft) bluff standing and receding at 1 m (3 ft) per year and with
- A house located 30 m (100 ft) from the bluff edge.

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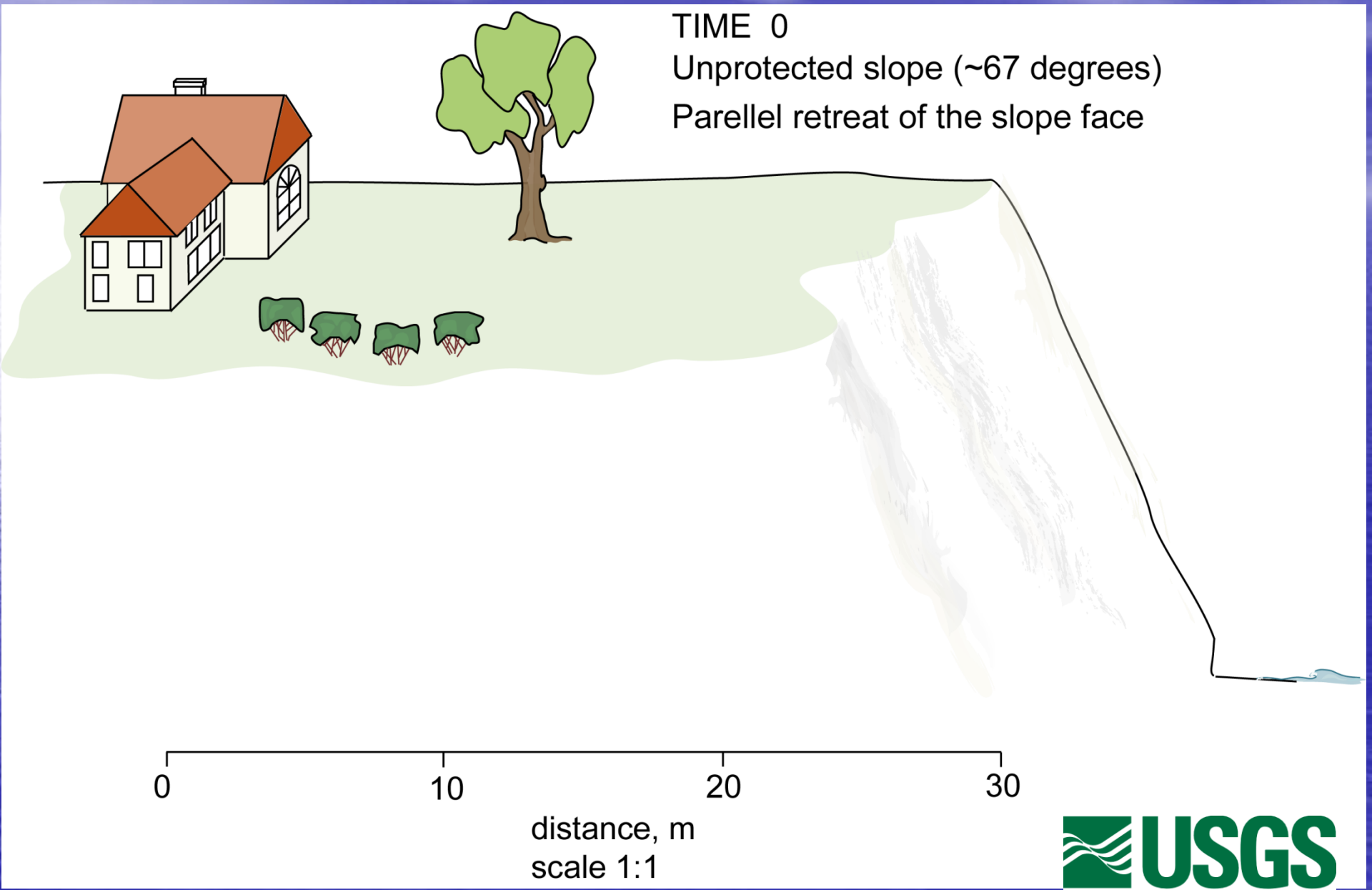

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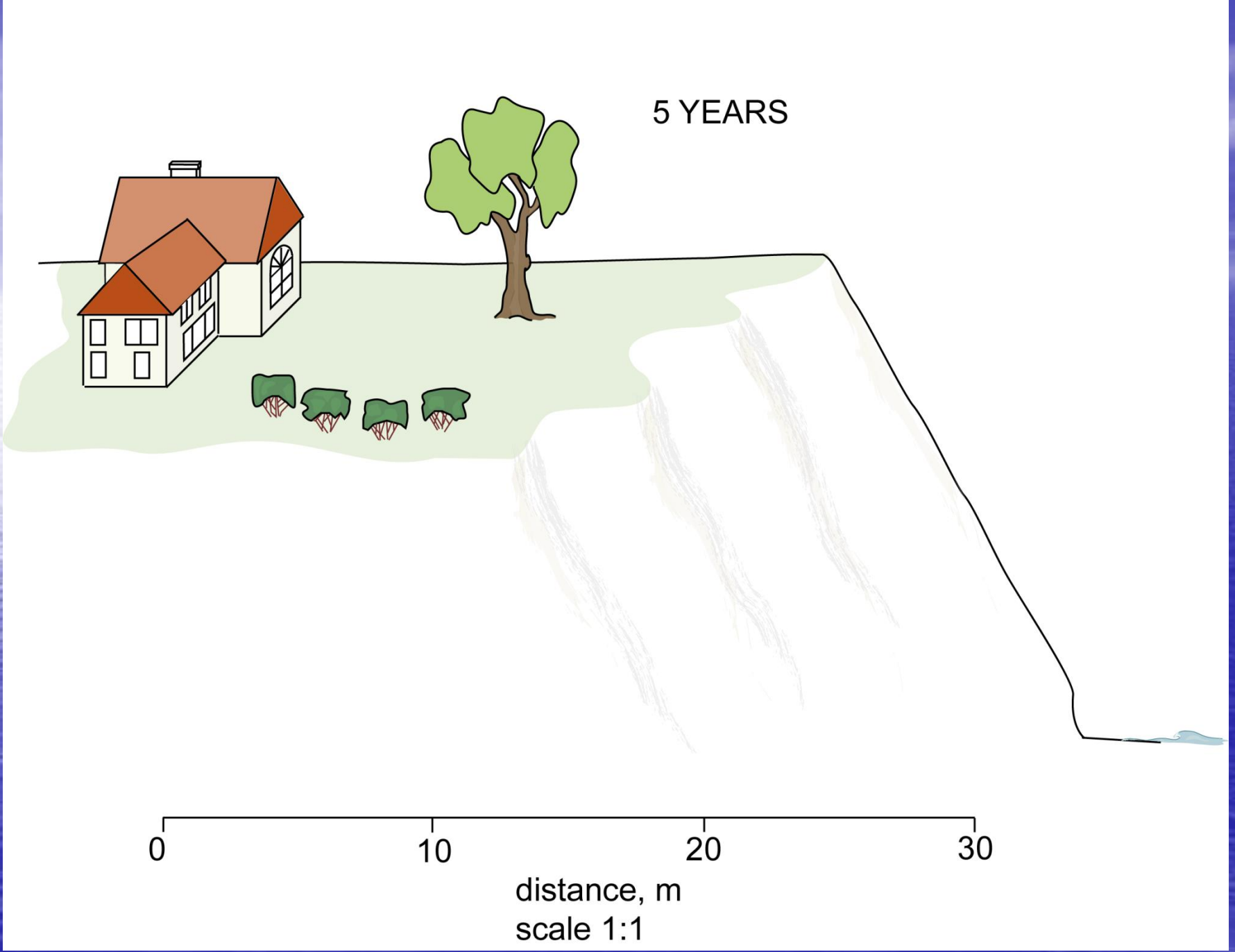
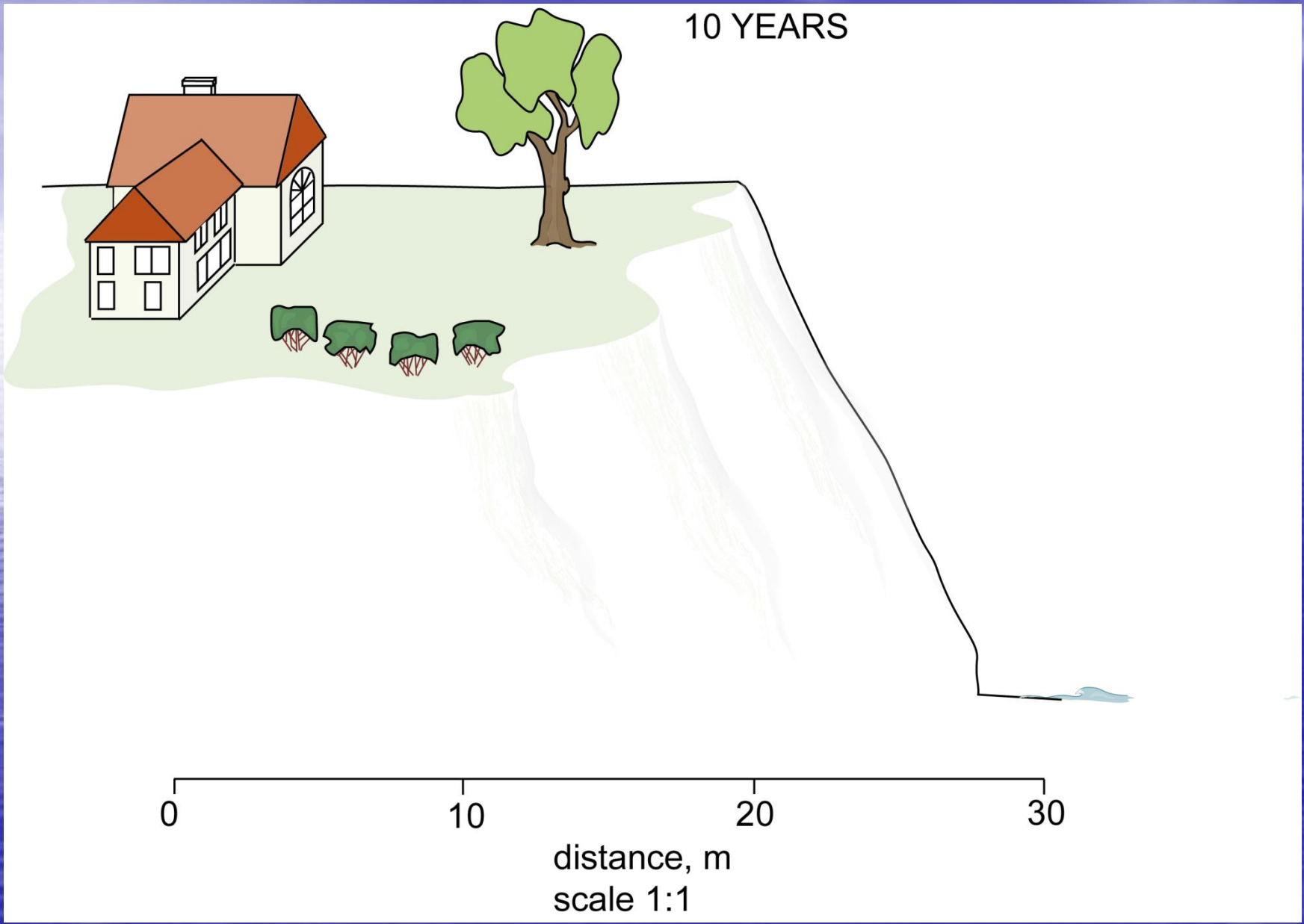

5 YEARS
0
10
20
30
distance, m
scale 1:1


10 YEARS
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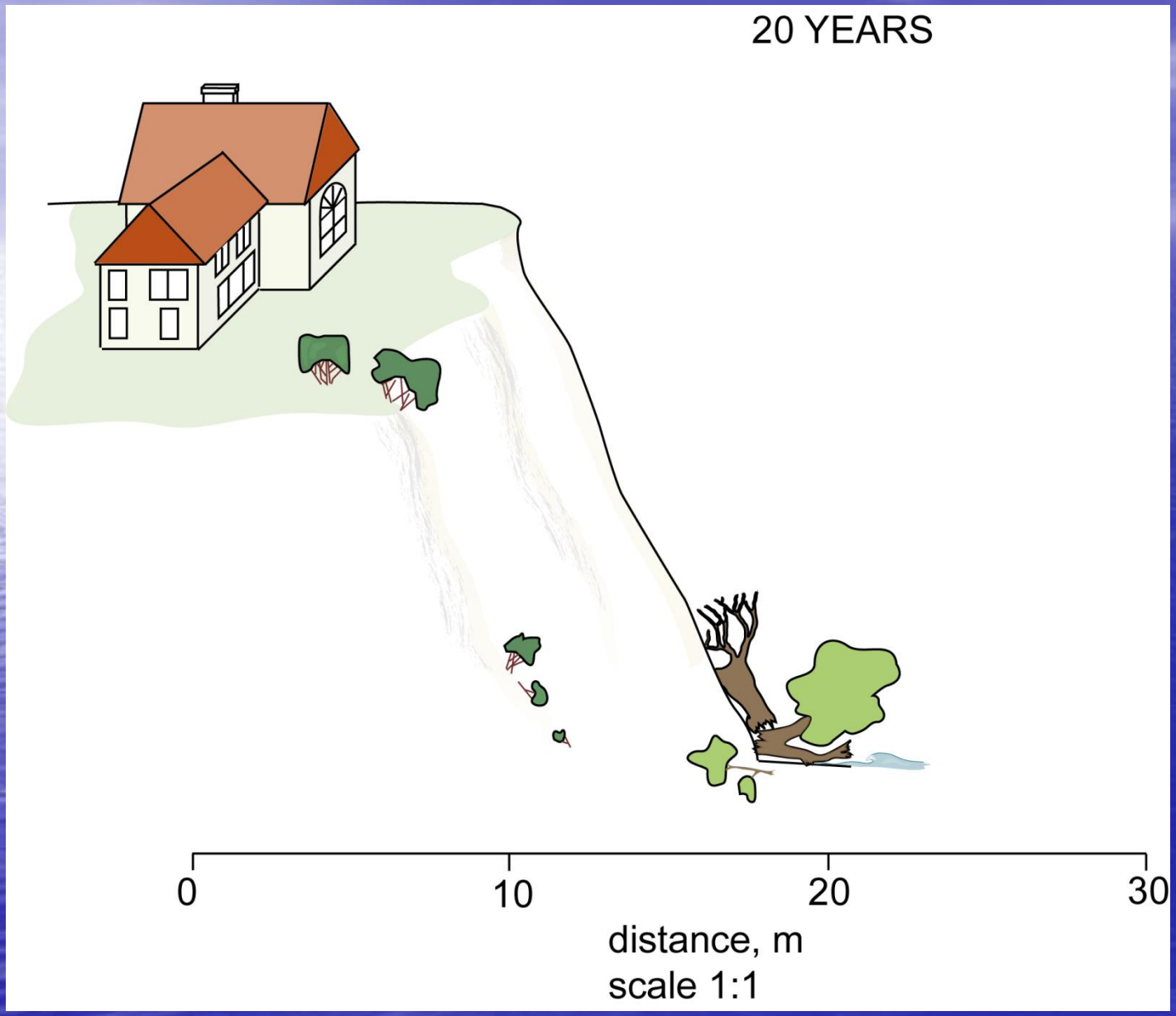
20 YEARS
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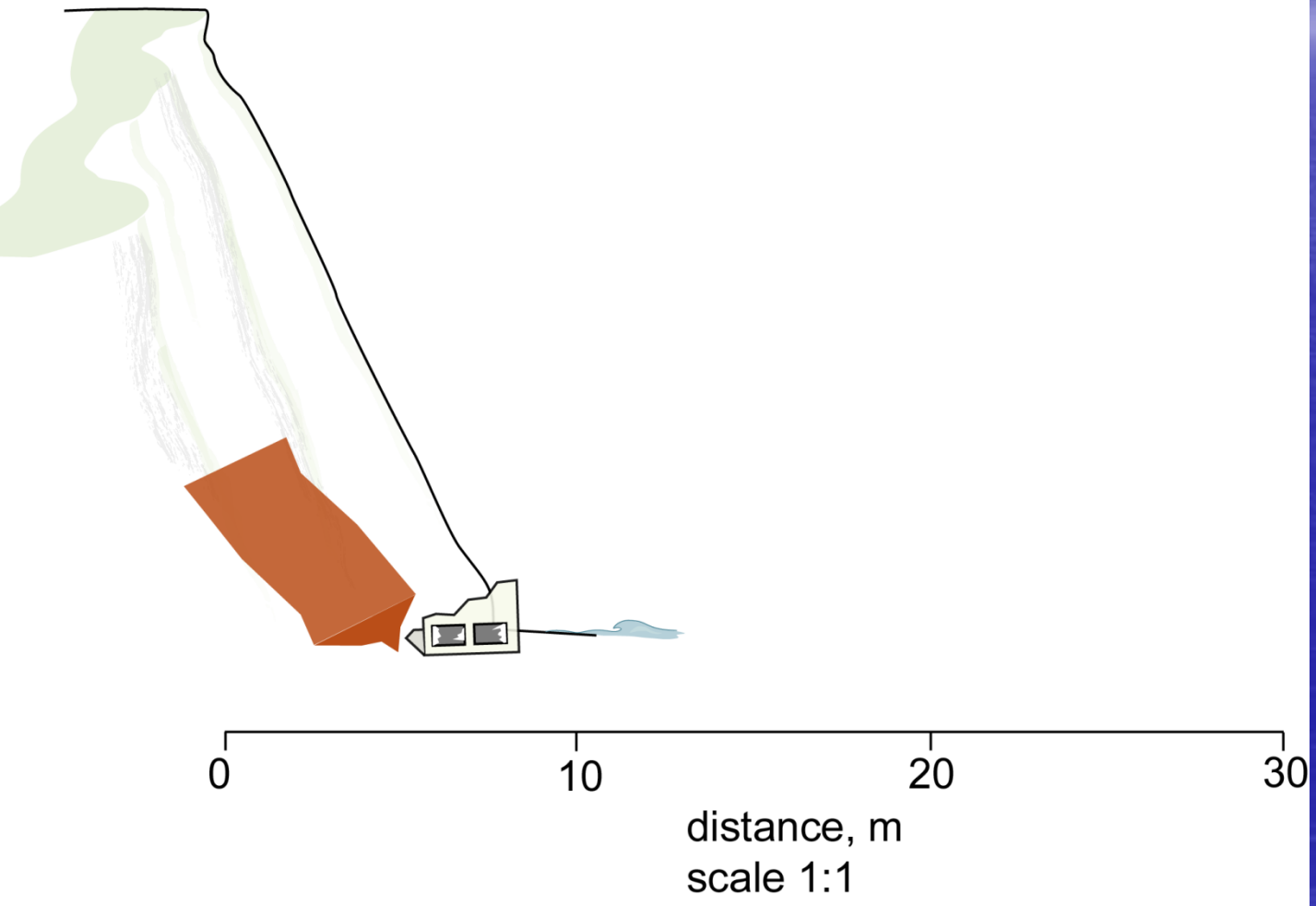
30 YEARS



And Evolution of a Stable Slope

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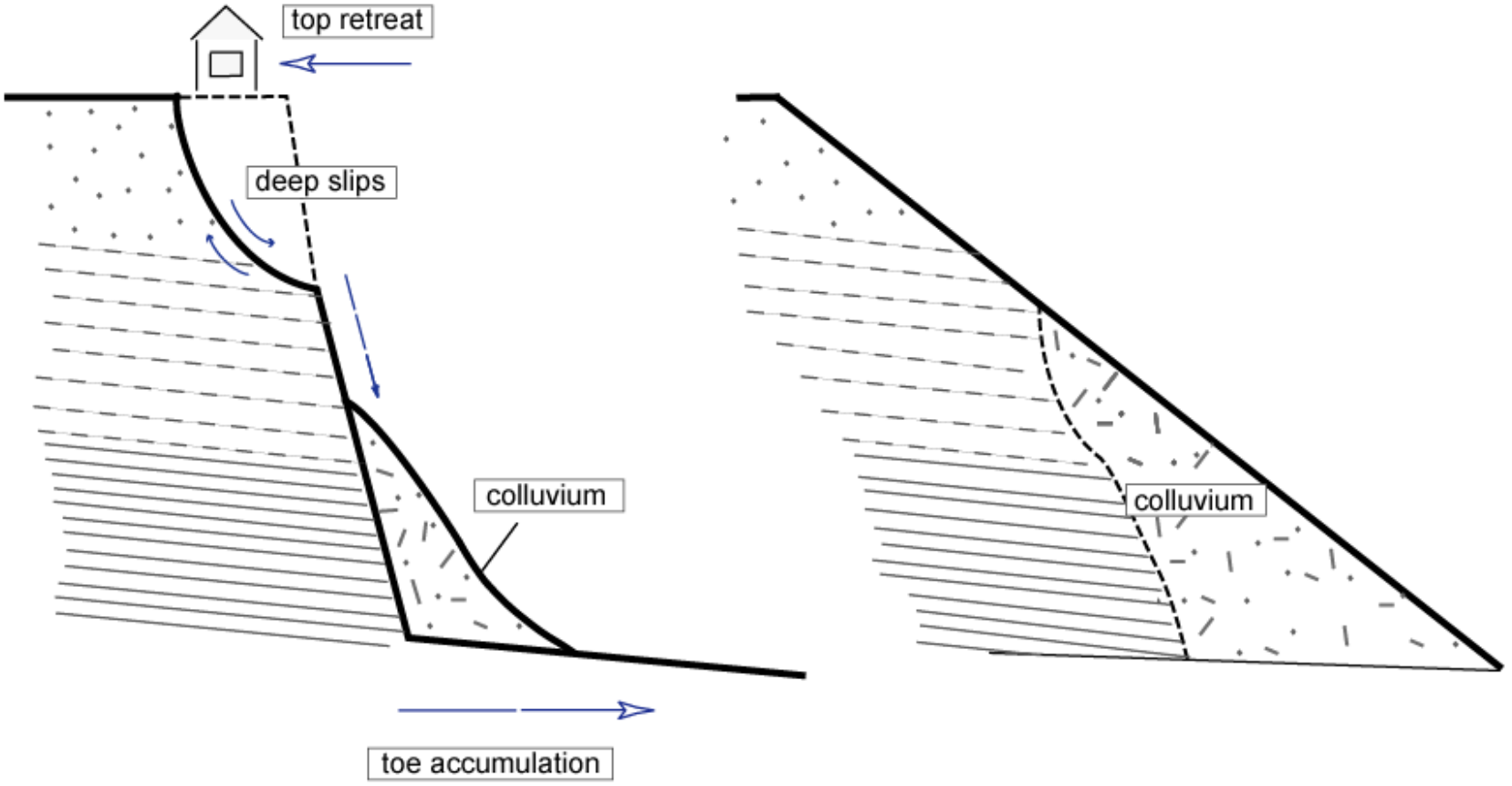

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Example 2:

- Here is that same house, but this time we have protected the base of the bluff with armor stone or “rip rap”.

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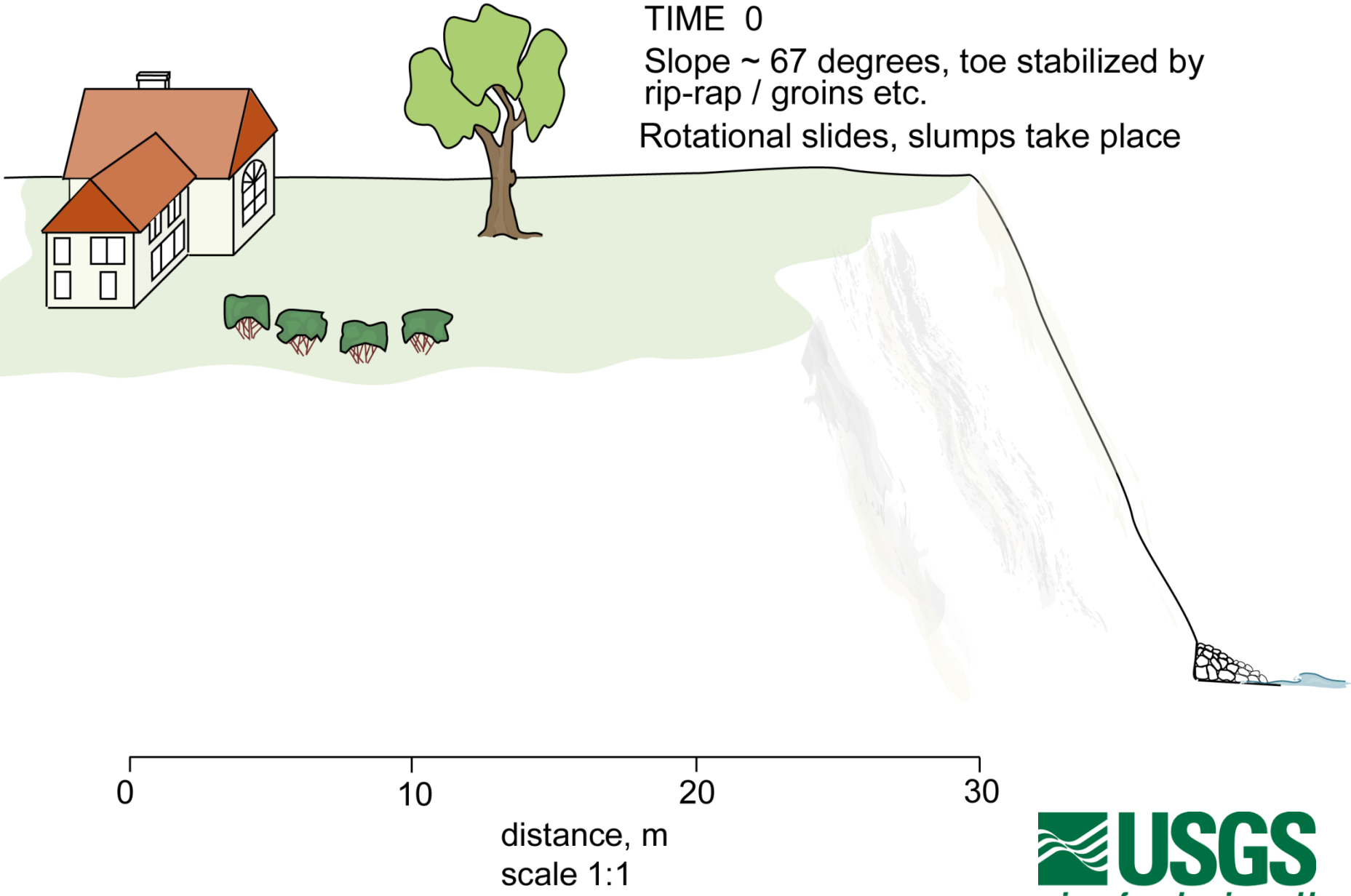

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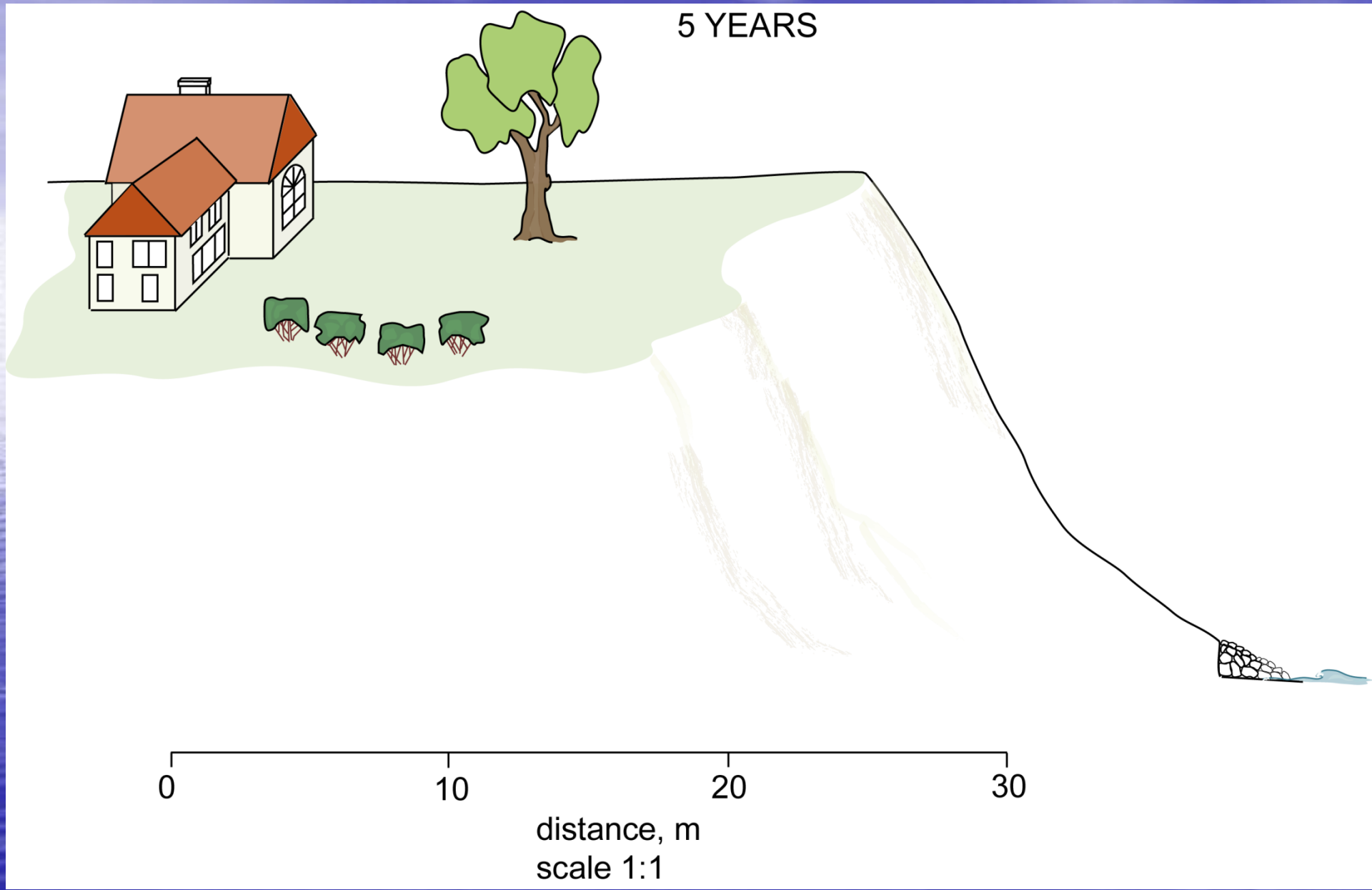
5 YEARS
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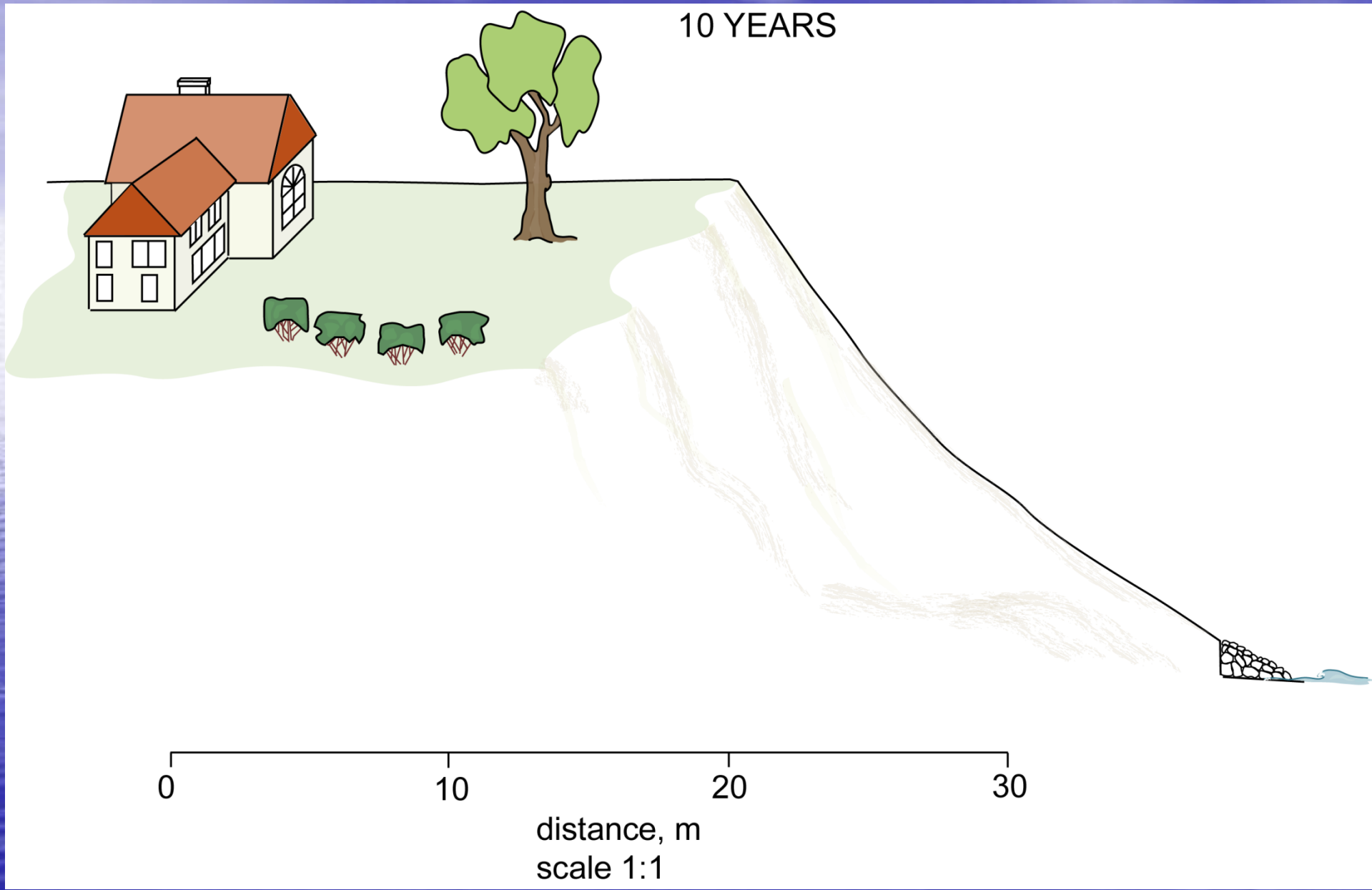
10 YEARS
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distance, m
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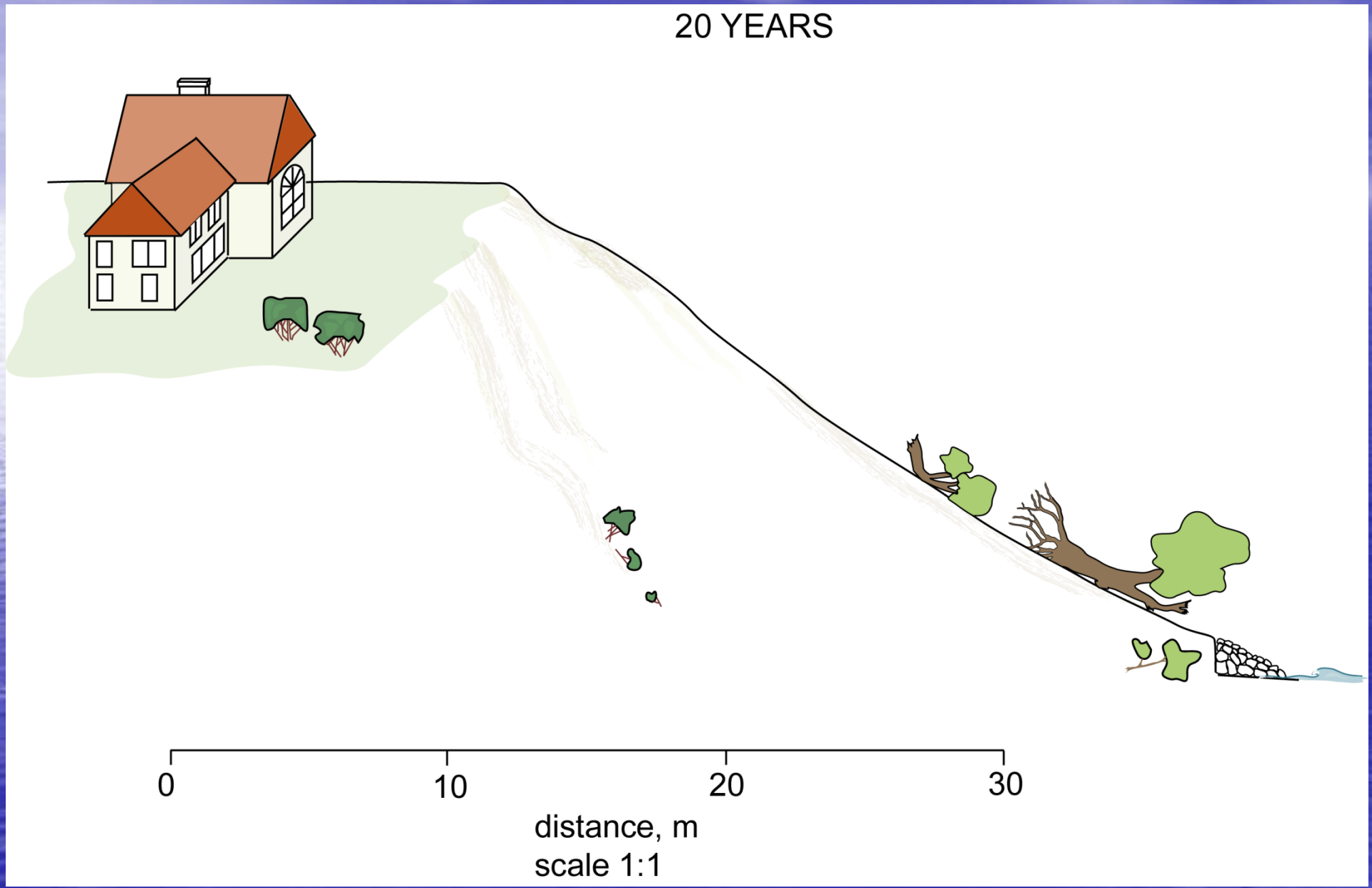
20 YEARS
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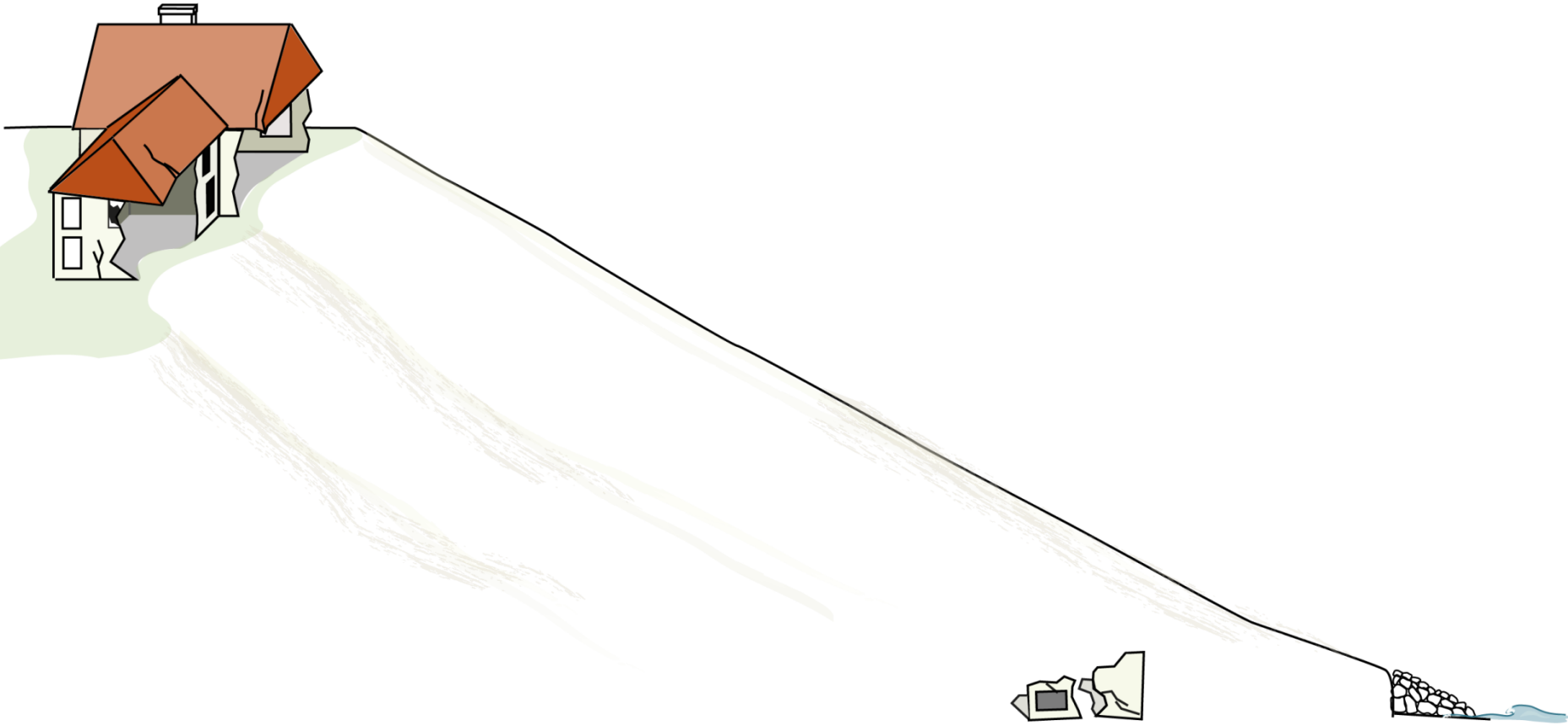
distance, m
scale 1:1

30 YEARS



0 10 20 30

distance, m

scale 1:1

So What Can We Do?

- The property owner doesn't want to hear this.
- The real estate interests certainly don't either.
- Can zoning help?
- Are setbacks possible?

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If we choose setbacks, they aren't simple static lines.

Here is an example of the degree of slope retreat as a function of bluff height.

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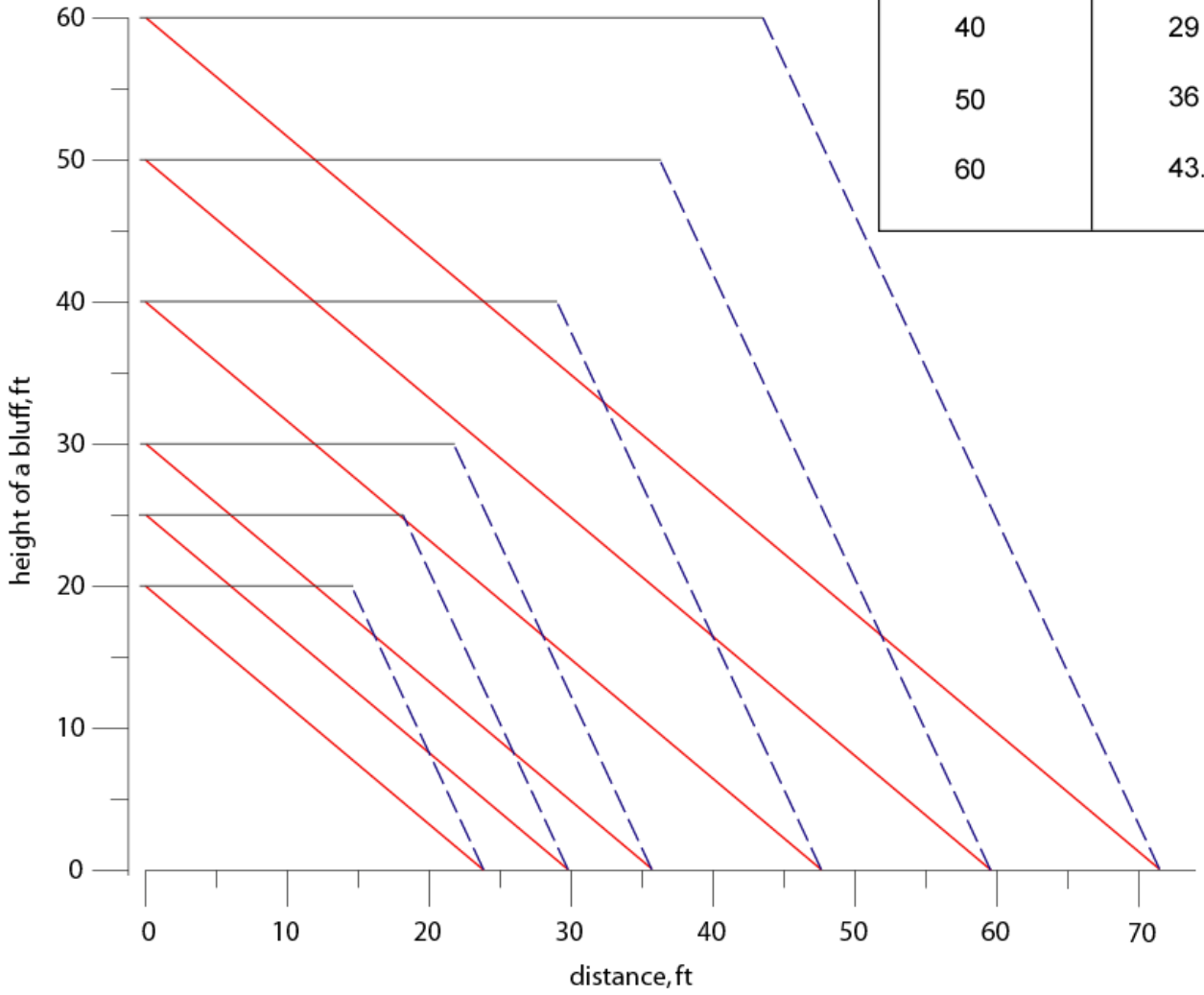
Slope Set-Back Calculators for
Calvert Cliffs, Calvert County, MD

40 degree angle of repose

bluff height, ft	set-back, ft
20	14.5
25	18
30	22
40	29
50	36
60	43.5



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Or Should We Just Let the Bluffs Retreat?

Is it cheaper to buy threatened properties rather than try to protect them?

Perhaps it would be more user friendly to help property owners to move their houses away from the brink.

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Those of us in the scientific community can't make policy.

When push comes to shove, the tough decisions rest with state and local government. But our sense is that they don't want to hear this message either. BUT we will at least help to explain the realities.

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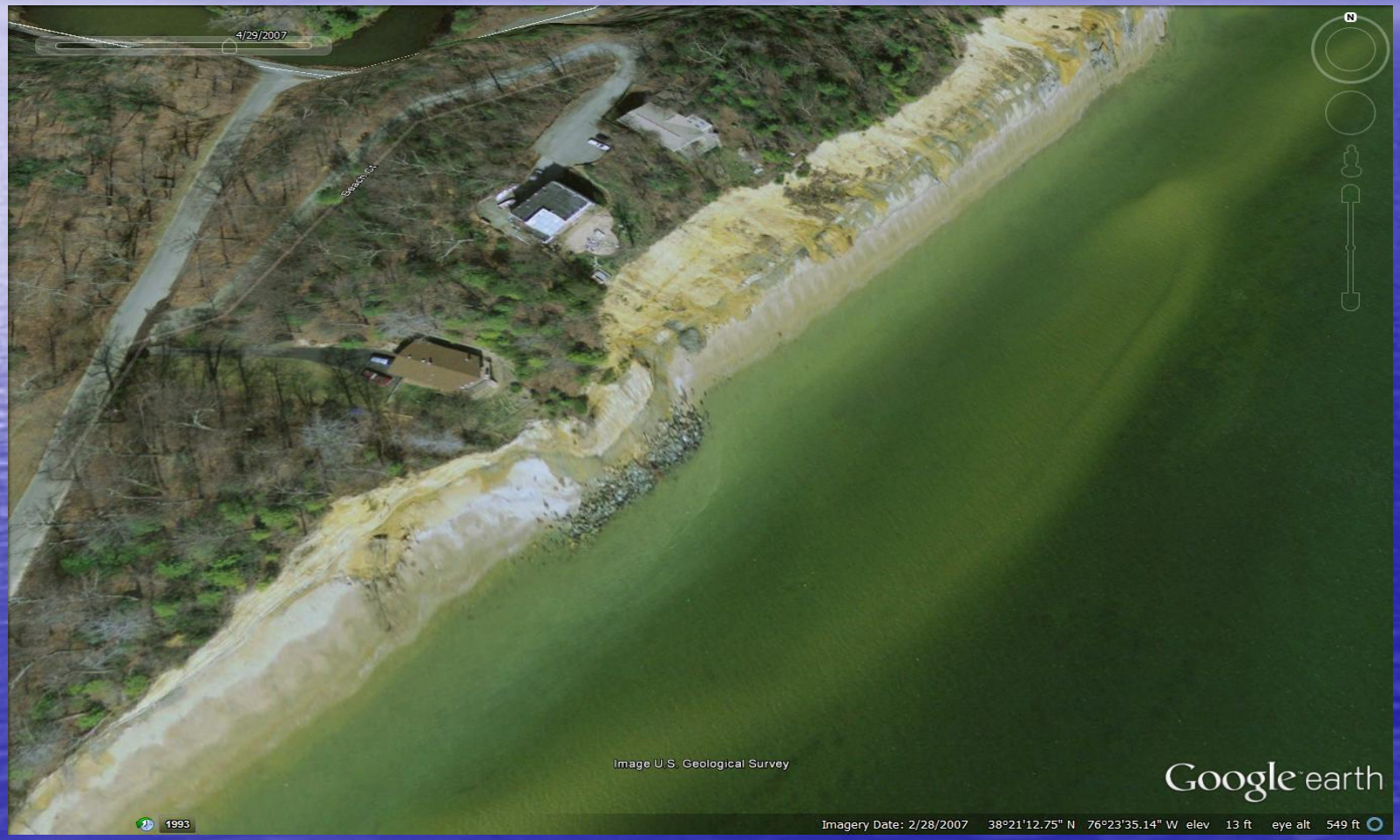
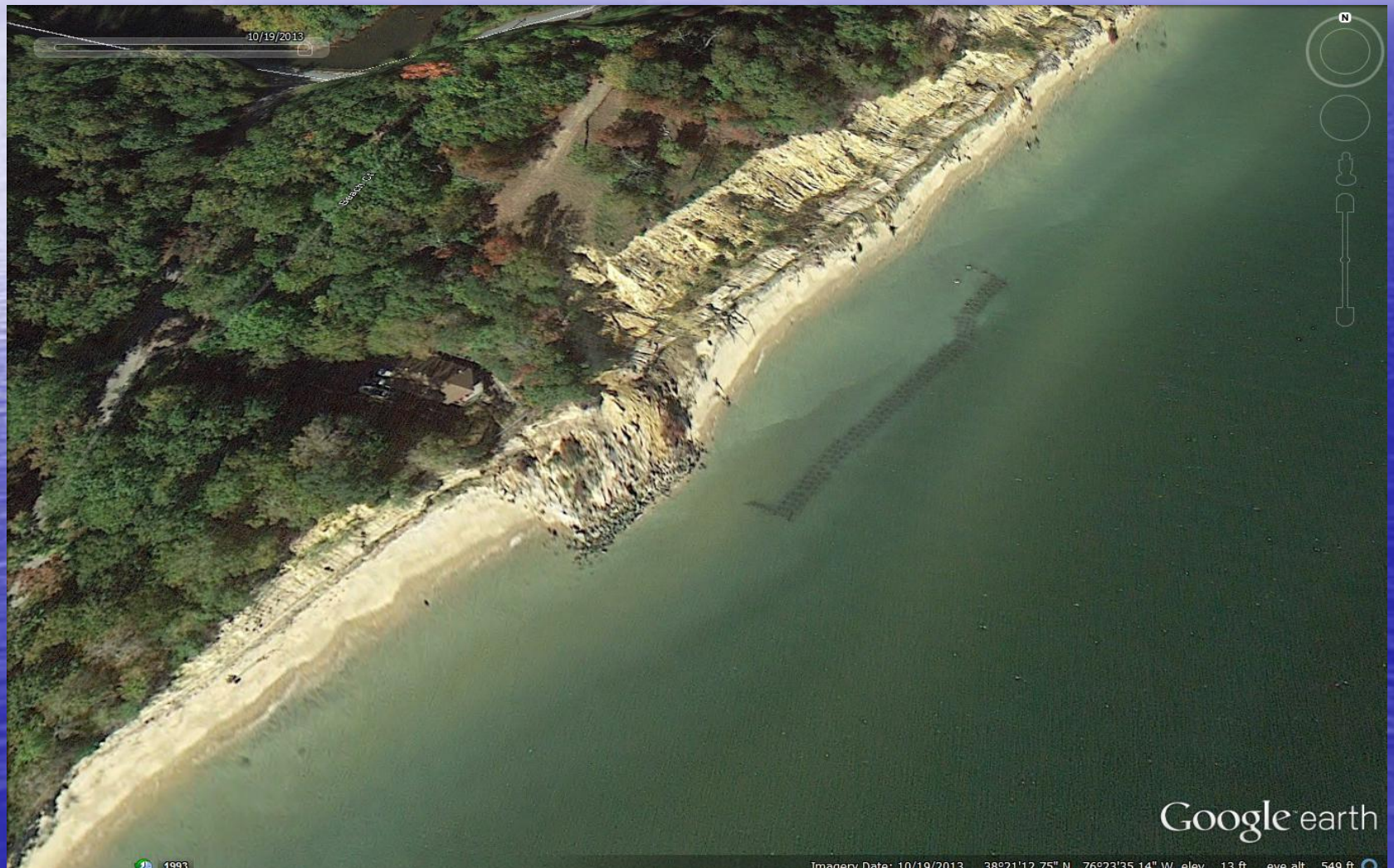
ADDENDUM

Here are some situations where engineered structures were used to protect the cliff base from wave action.

Placement of Offshore Breakwater.



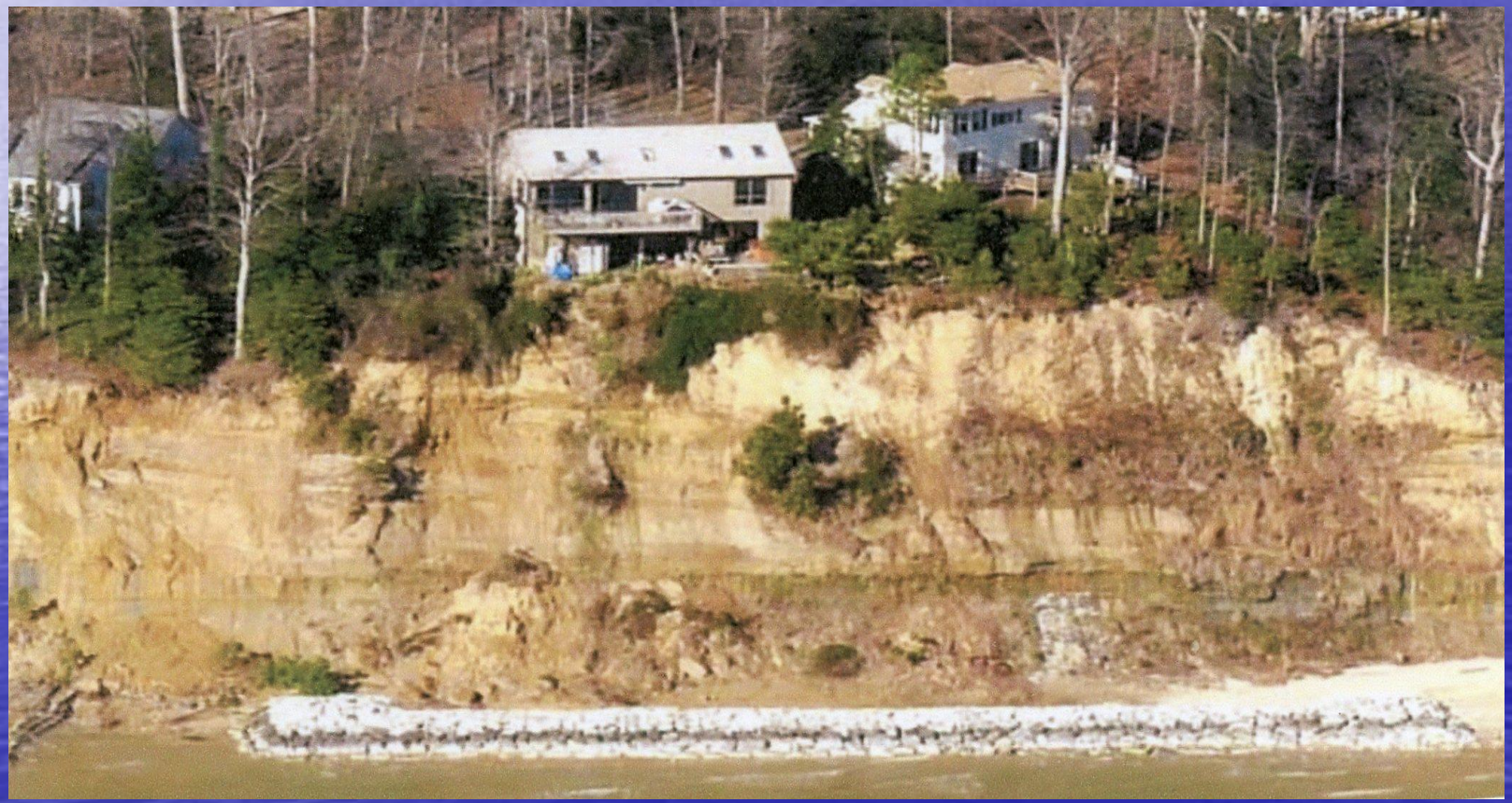
Ten Years Later



Close Up off Slide with protetion

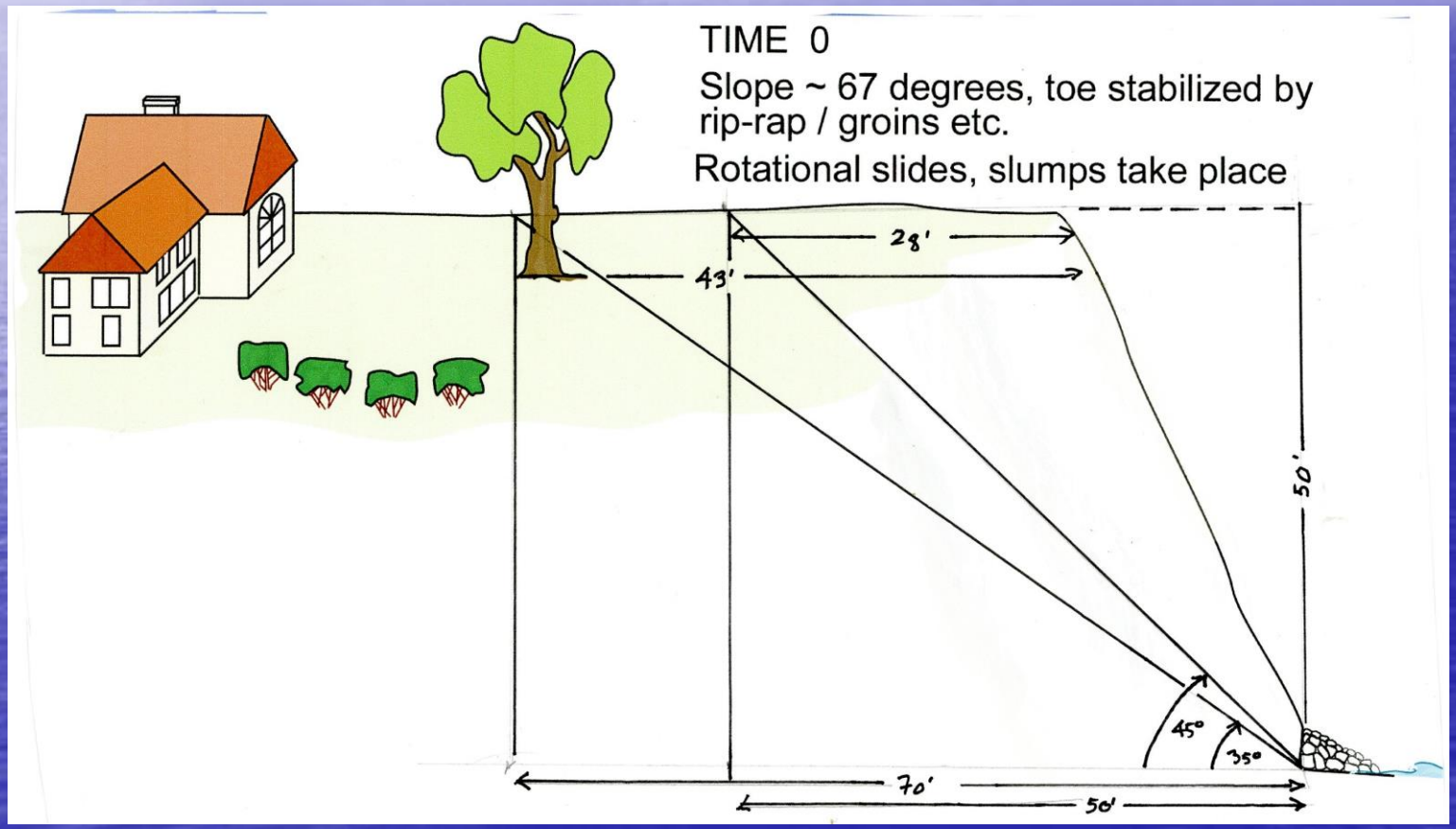
Another Example

Yet another example



What is Happening Here?

And if we protect the base of the cliff from wave action



Highway engineers design stable slopes. Why not follow.

Alright, enough is enough

- Hopefully I’ve raised some questions