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Large Scale Shoreline Protection with Minimized Downdrift Impact, Cotonou, Benin, West Africa

Mohammad Dibajnia, PhD, PEng; Rob Nairn, PhD, PEng, Dave Anglin, MSc, PEng; Brent Sumner, PE

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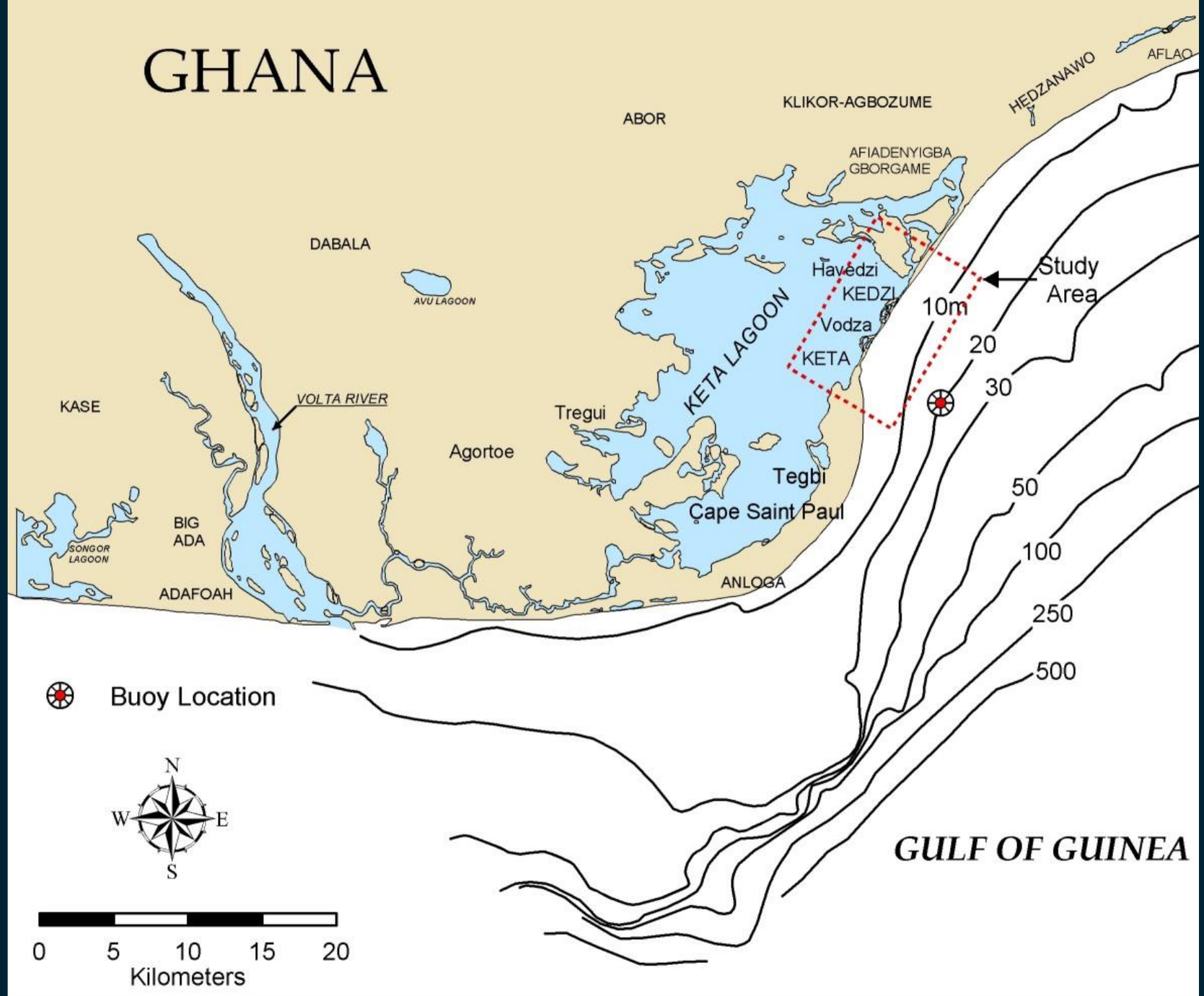
Outline

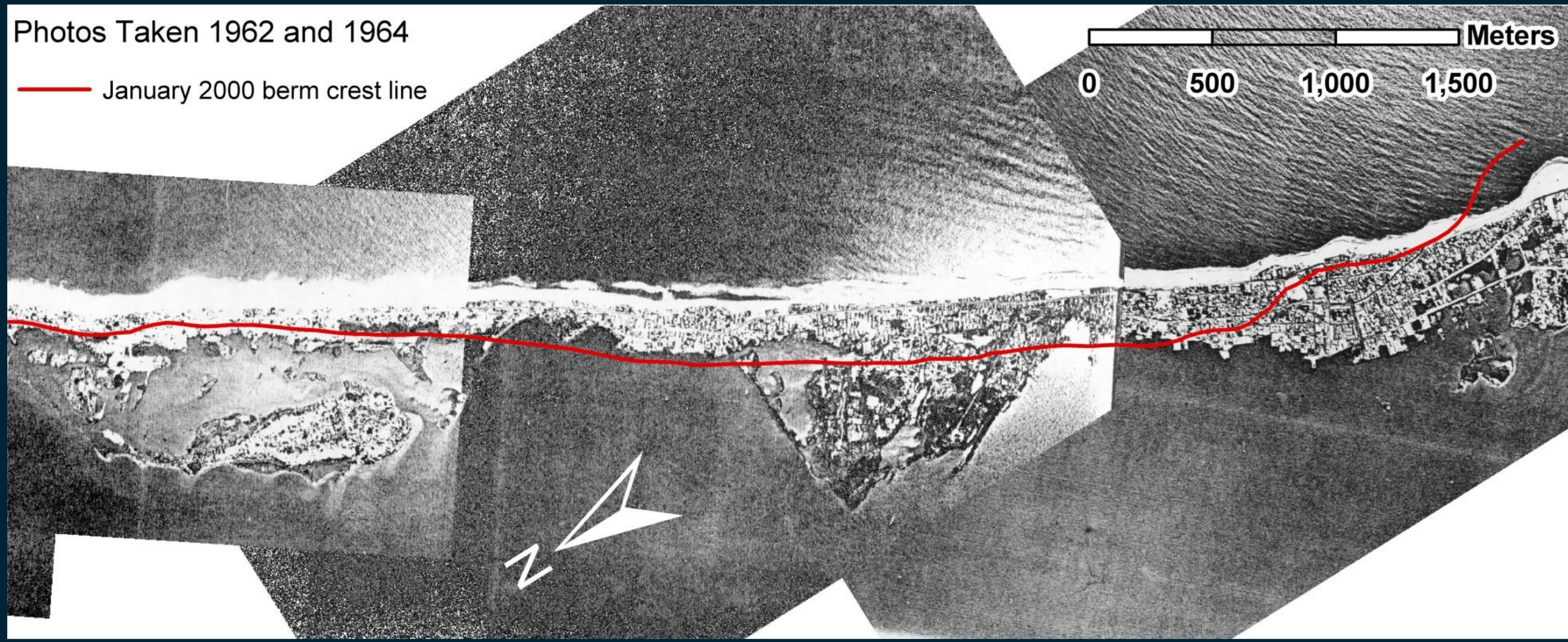
1. Review of predecessor project – Keta, Ghana
2. Cotonou Sedimentation/Erosion Problem
3. Solution and Design
4. Construction
5. Post-Construction Assessment

Keta Sea Defence Project (KSDP)

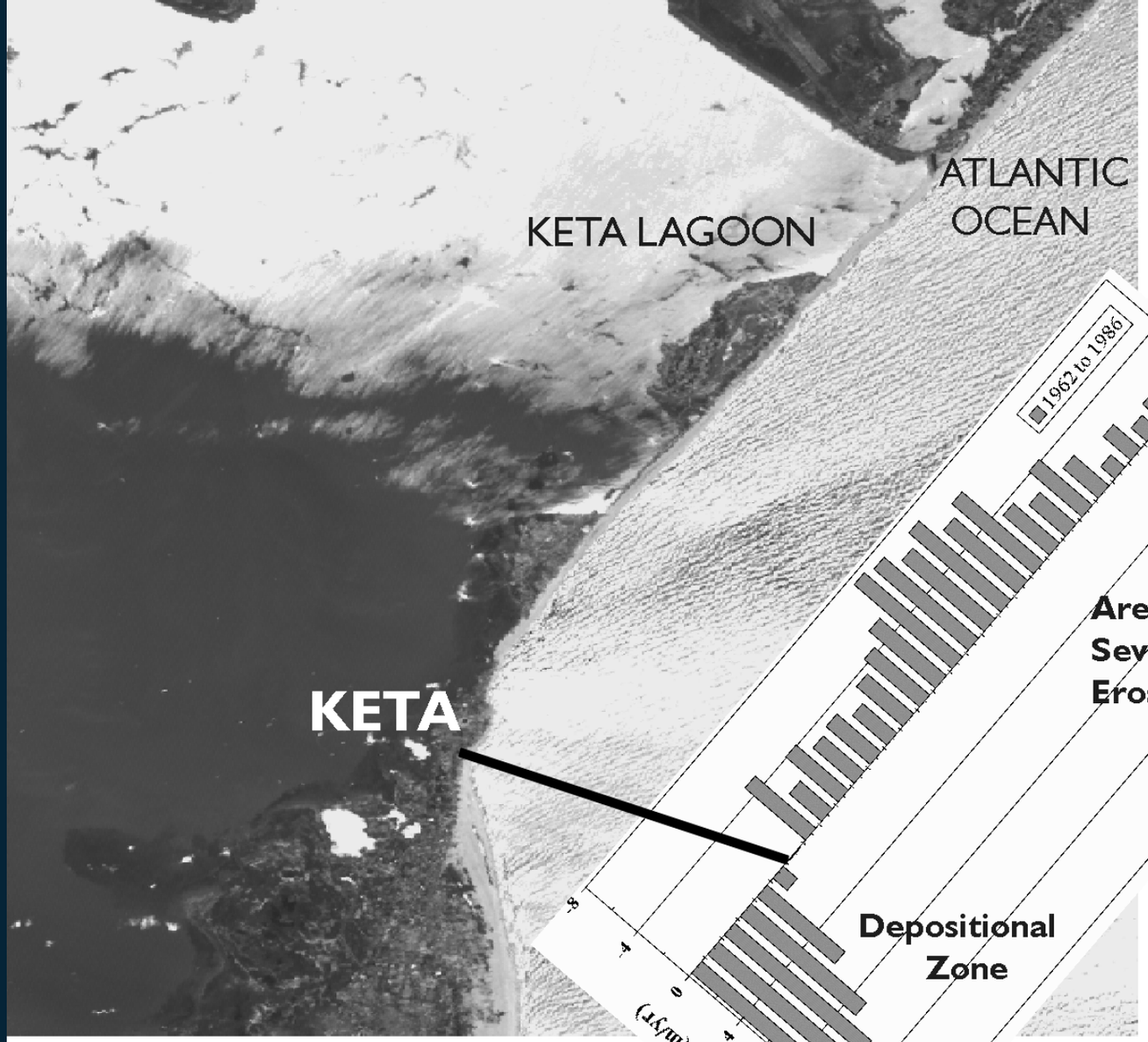
Design-Build: Great Lakes Dredge & Dock - Baird


GHANA
ABOR
KLIKOR-AGBOZUME
HEDZANAWO
AFLAO
AFIADENYIGBA
GBORGAME
DABALA
AVU LAGOON
Havedzi
KEDZI
Vodza
KETA
KETA LAGOON
Study
Area
10m
20
30
50
100
250
500
KASE
VOLTA RIVER
Tregui
Agortoe
Tegbi
Cape Saint Paul
BIG
ADA
SONGOR
LAGOON
ADAFOAH
ANLOGA
Buoy Location
N
W
E
S
0
5
10
15
20
Kilometers
GULF OF GUINEA

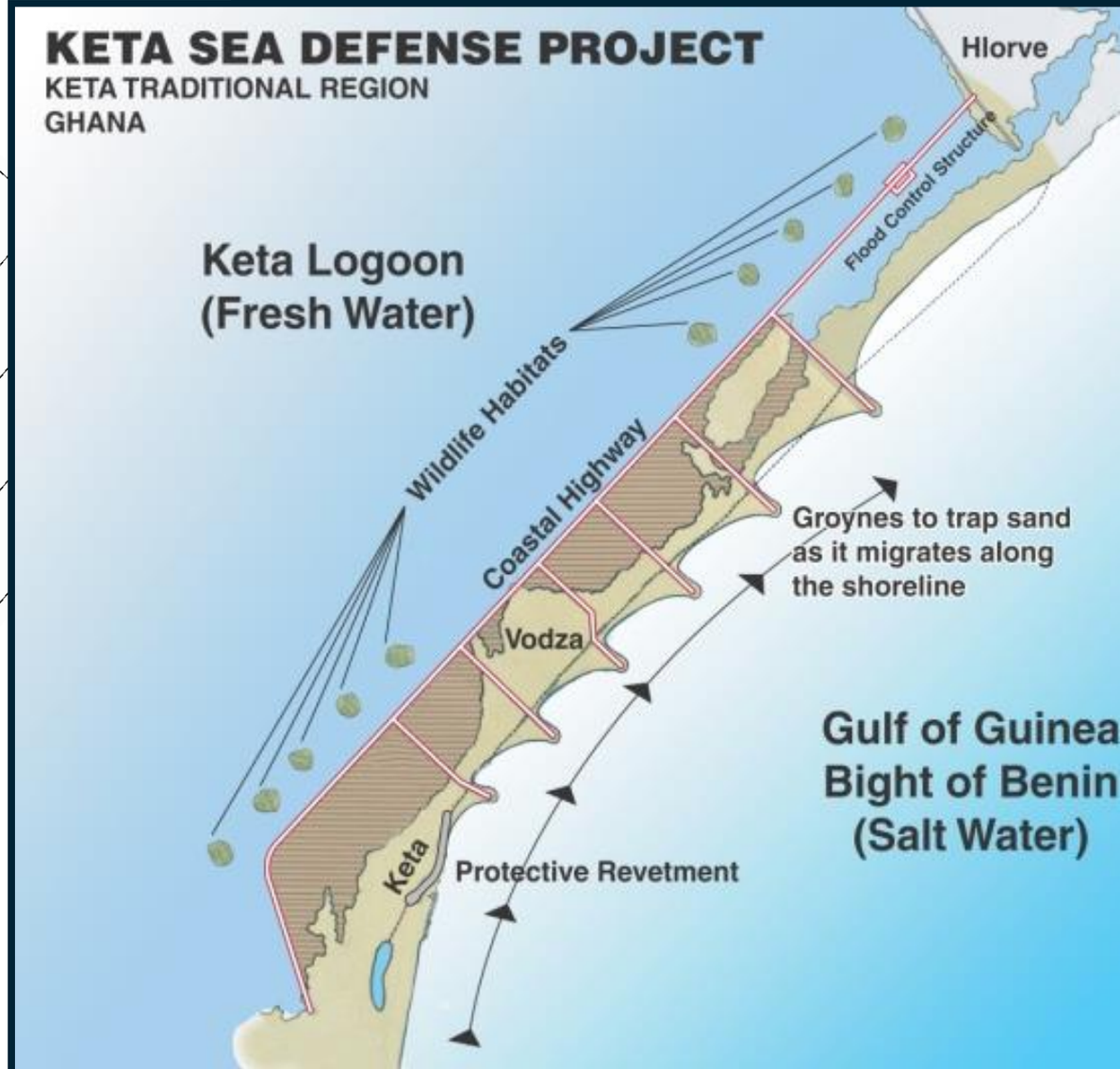
B. — 1981



Erosion Rates of 2 to 7 m/year

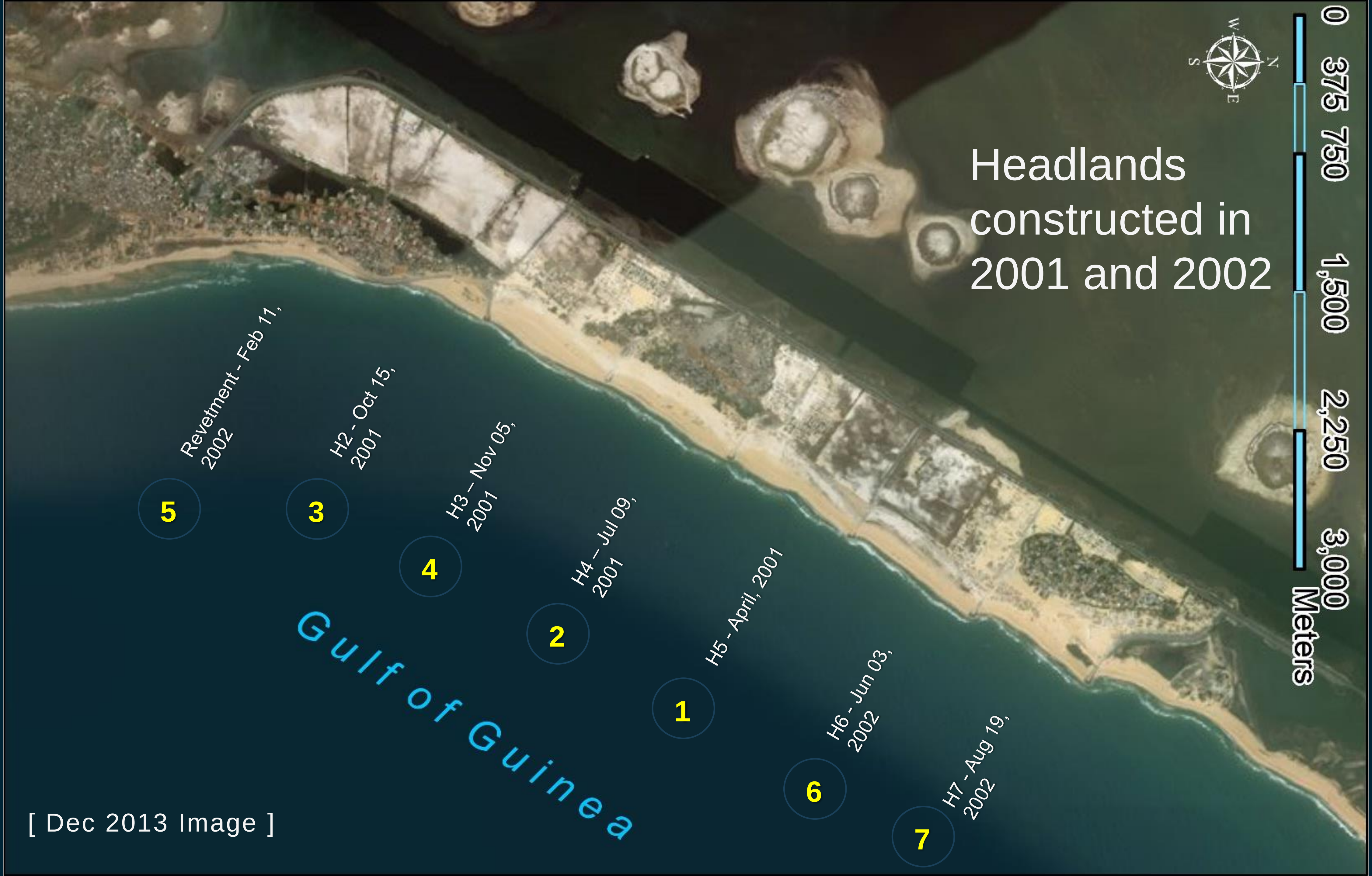

ATLANTIC
OCEAN
KETA LAGOON
KETA

1962 to 1986
Area of
Severe
Erosion
Depositional
Zone
-8
-4
0
4
8
12
16
Shoreline change (m/yr)


KETA SEA DEFENSE PROJECT
KETA TRADITIONAL REGION
GHANA
Hlorve
Keta Logoon
(Fresh Water)
Flood Control Structure
Wildlife Habitats
Coastal Highway
Groynes to trap sand
as it migrates along
the shoreline
Vodza
Gulf of Guinea
Bight of Benin
(Salt Water)
Keta
Protective Revetment

Keta Sea Defence, Ghana

- 12M m^3 of dredging
- 1M tonnes of rock
- 7.9 km (4.9 miles)



Headlands constructed in 2001 and 2002
Revetment - Feb 11, 2002
H2 - Oct 15, 2001
H3 – Nov 05, 2001
H4 – Jul 09, 2001
H5 - April, 2001
H6 - Jun 03, 2002
H7 - Aug 19, 2002
5
3
4
2
1
6
7
Gulf of Guinea
0 375 750 1,500 2,250 3,000 Meters
[Dec 2013 Image]

B. 1981

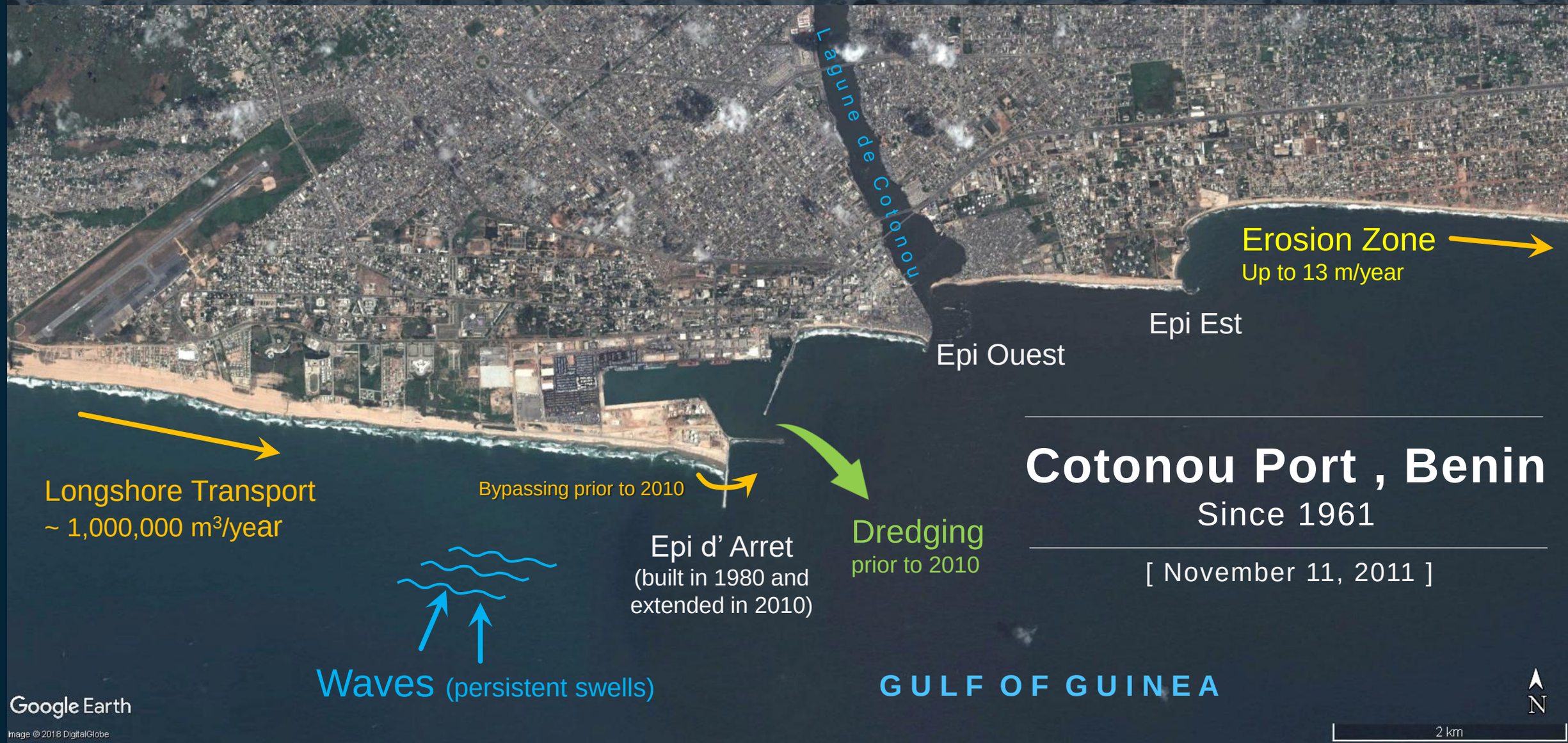
Keta Sea Defence, Ghana Since 2003

- Continuous supply of sediment from updrift
- Very limited downdrift impact (less than historic background rates)

Cotonou Sea Defence Project (CSDP)

Design: Baird; Construction Administration: Norda Stelo; Construction: Boskalis

The Challenge

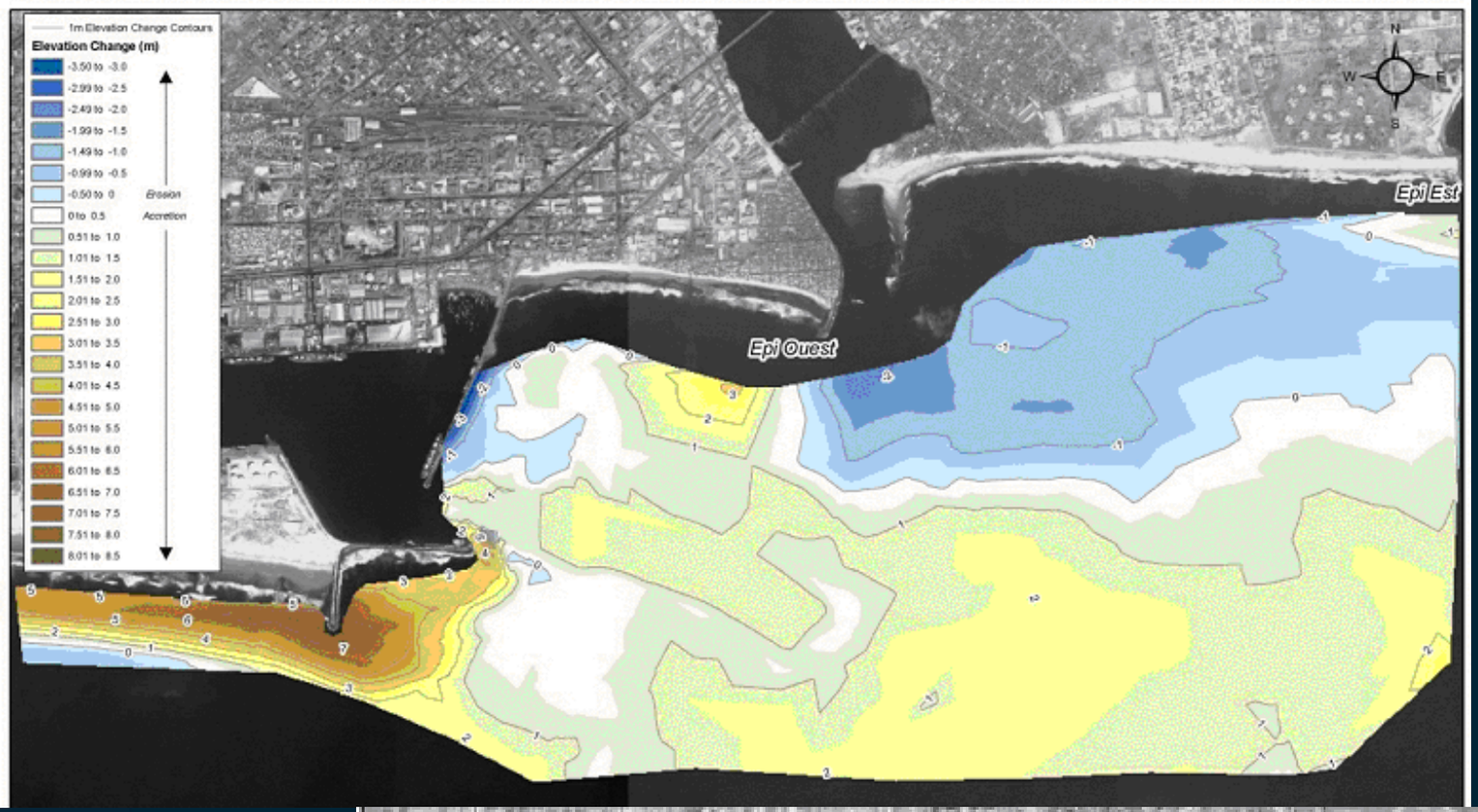


Cotonou Port , Benin

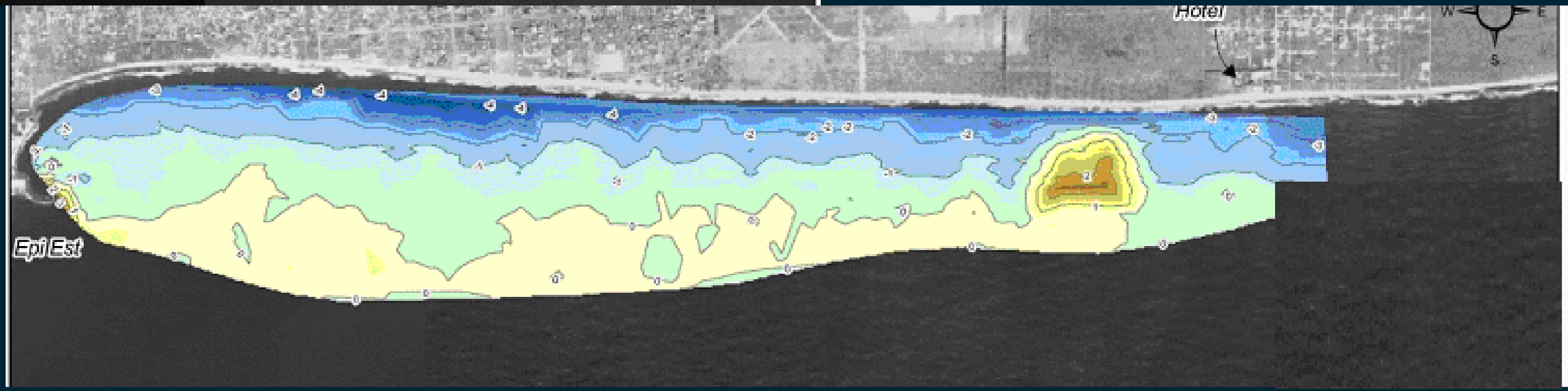
Since 1961

[November 11, 2011]

B. — 19 81

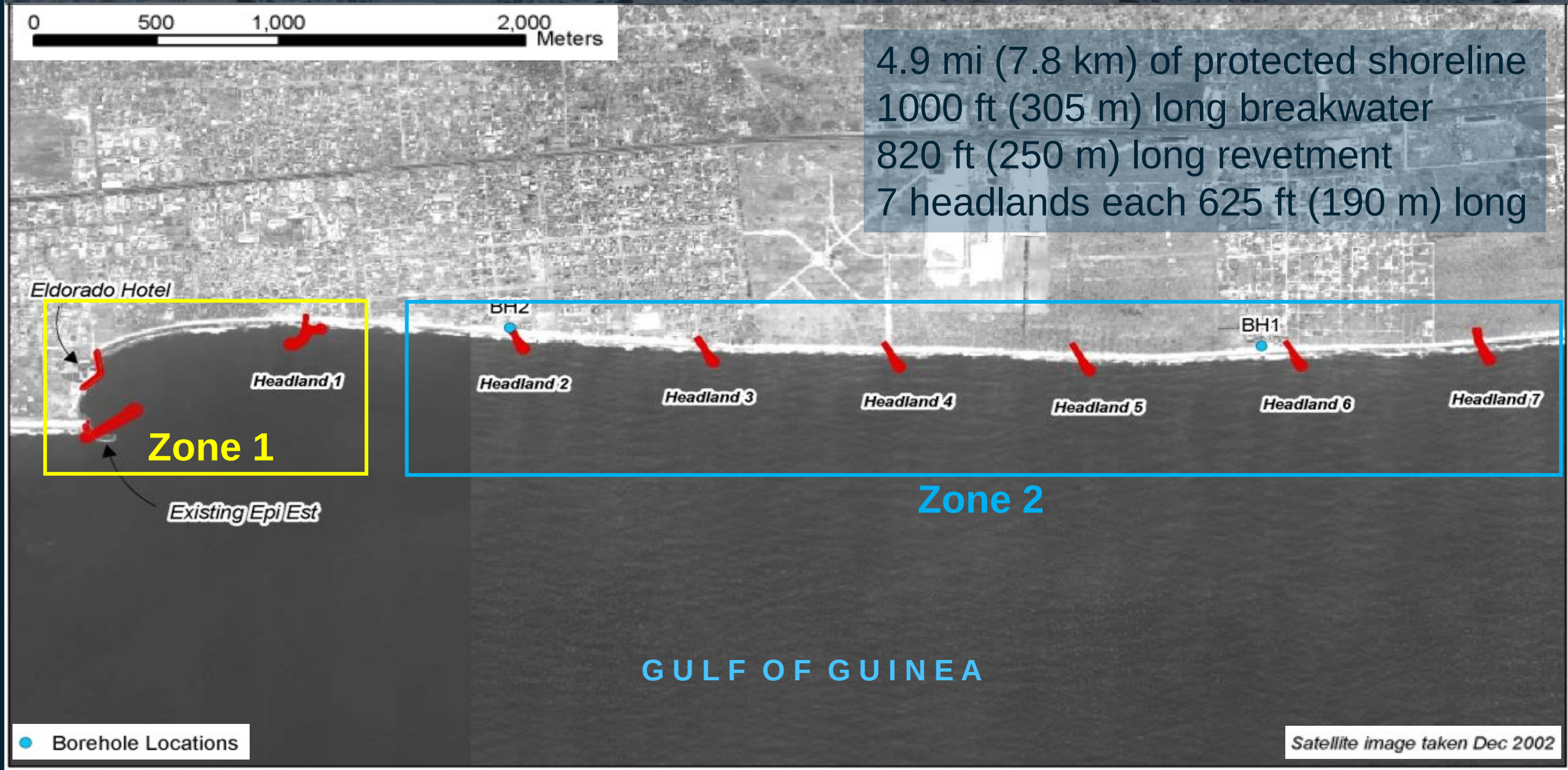


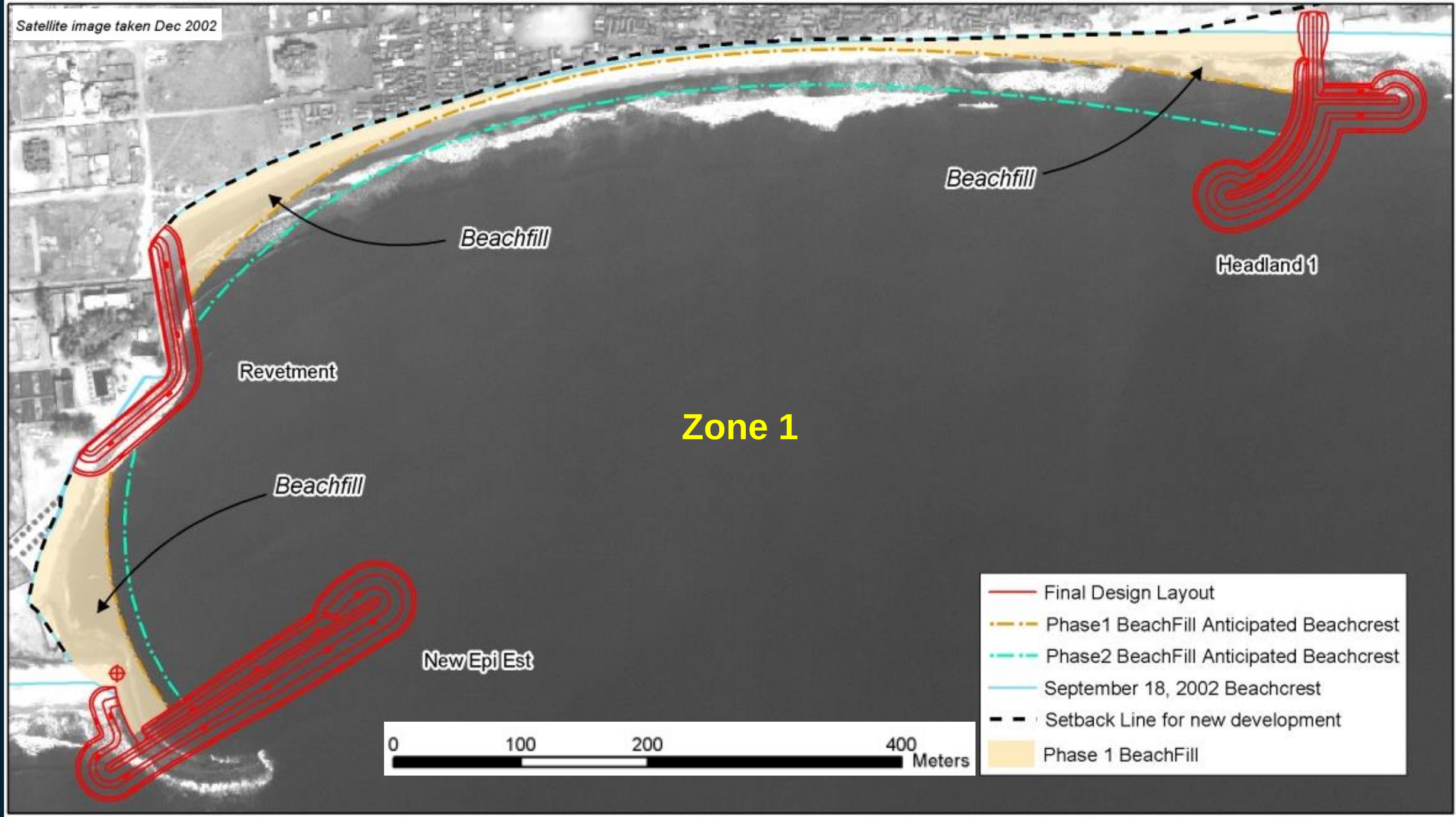
Bypassing Shoal Development 1980 - 2002

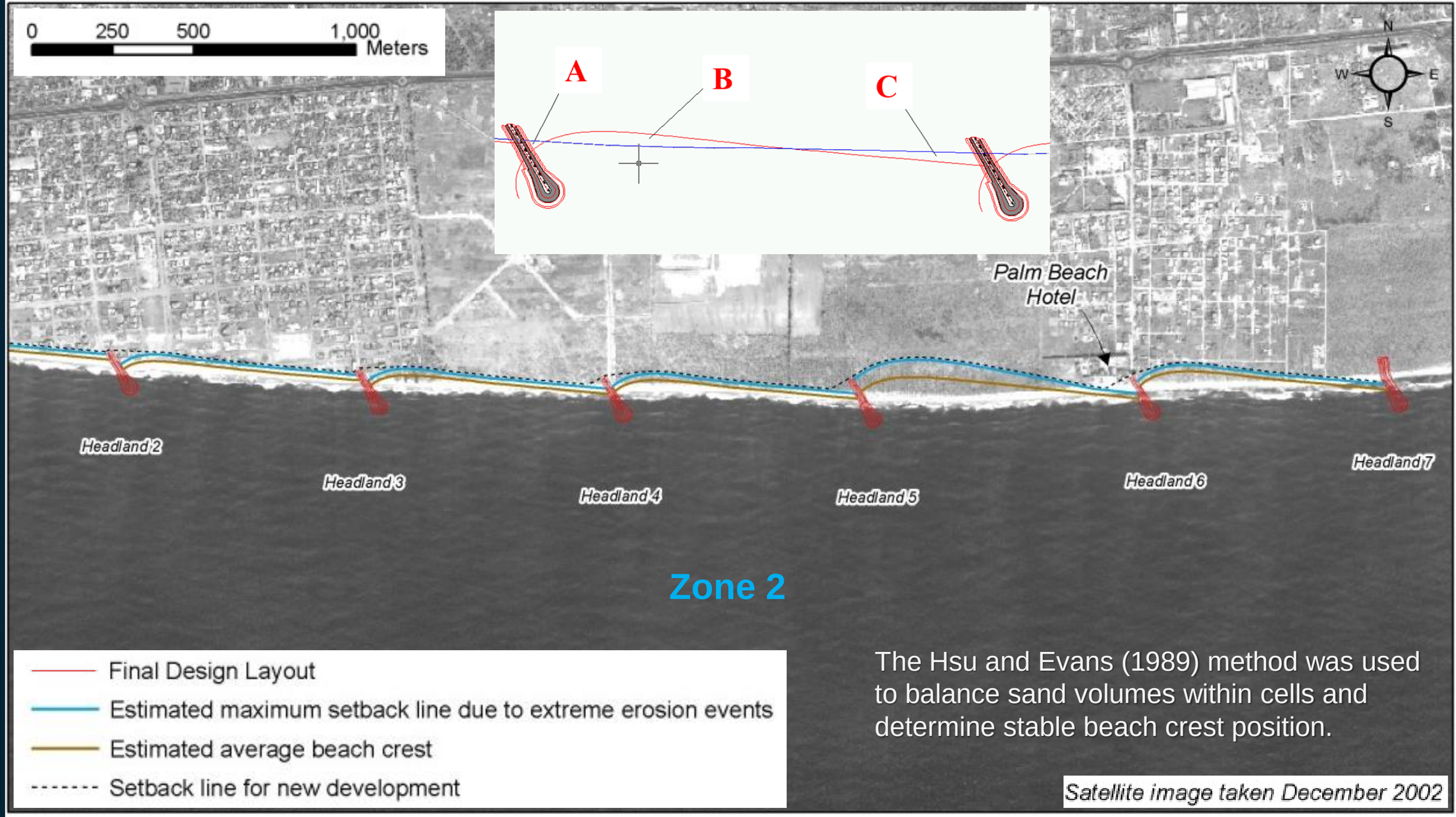


B. — 19 81

The Solution




Satellite image taken Dec 2002
Beachfill
Beachfill
Headland 1
Revetment
Zone 1
Beachfill
New Epi Est
0
100
200
400
Meters
Final Design Layout
Phase1 BeachFill Anticipated Beachcrest
Phase2 BeachFill Anticipated Beachcrest
September 18, 2002 Beachcrest
Setback Line for new development
Phase 1 BeachFill


0 250 500 1,000 Meters
A
B
C
N
W
E
S
Palm Beach Hotel
Headland 2
Headland 3
Headland 4
Headland 5
Headland 6
Headland 7
Zone 2
Final Design Layout
Estimated maximum setback line due to extreme erosion events
Estimated average beach crest
Setback line for new development
The Hsu and Evans (1989) method was used to balance sand volumes within cells and determine stable beach crest position.
Satellite image taken December 2002

Construction (2012-2014)

B. — 19 81

Construction Logistics

1. The quarries were far from the site (> 150 km) and required transport using conventional (on-road) trucks along public roads,

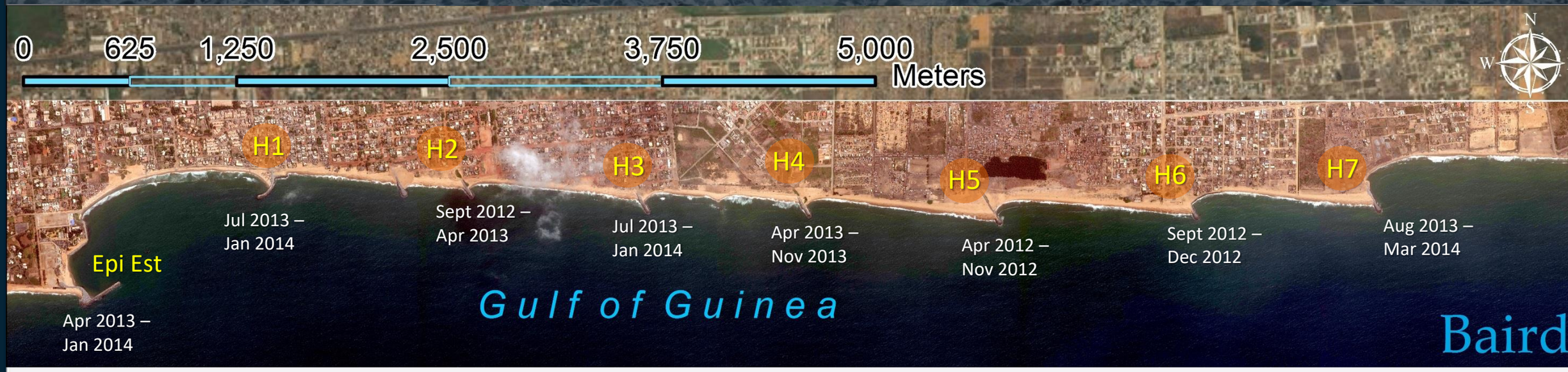
2. Had to rely on public roads for the transport from quarry to site. Impossible to control traffic and condition/maintenance of the roads that were in relatively poor condition,

3. Accordingly the supply of stone was not reliable and a very large stockpile was required before a headland could be started. This affected the order of the construction,

4. Built in a highly populated urban environment, preparation of the laydown areas (outside of the near term erosion zone) became an important early element,

5. Use of both armor stone and X-blocs (funding agency dependent).

Construction Sequence (2012-2014)



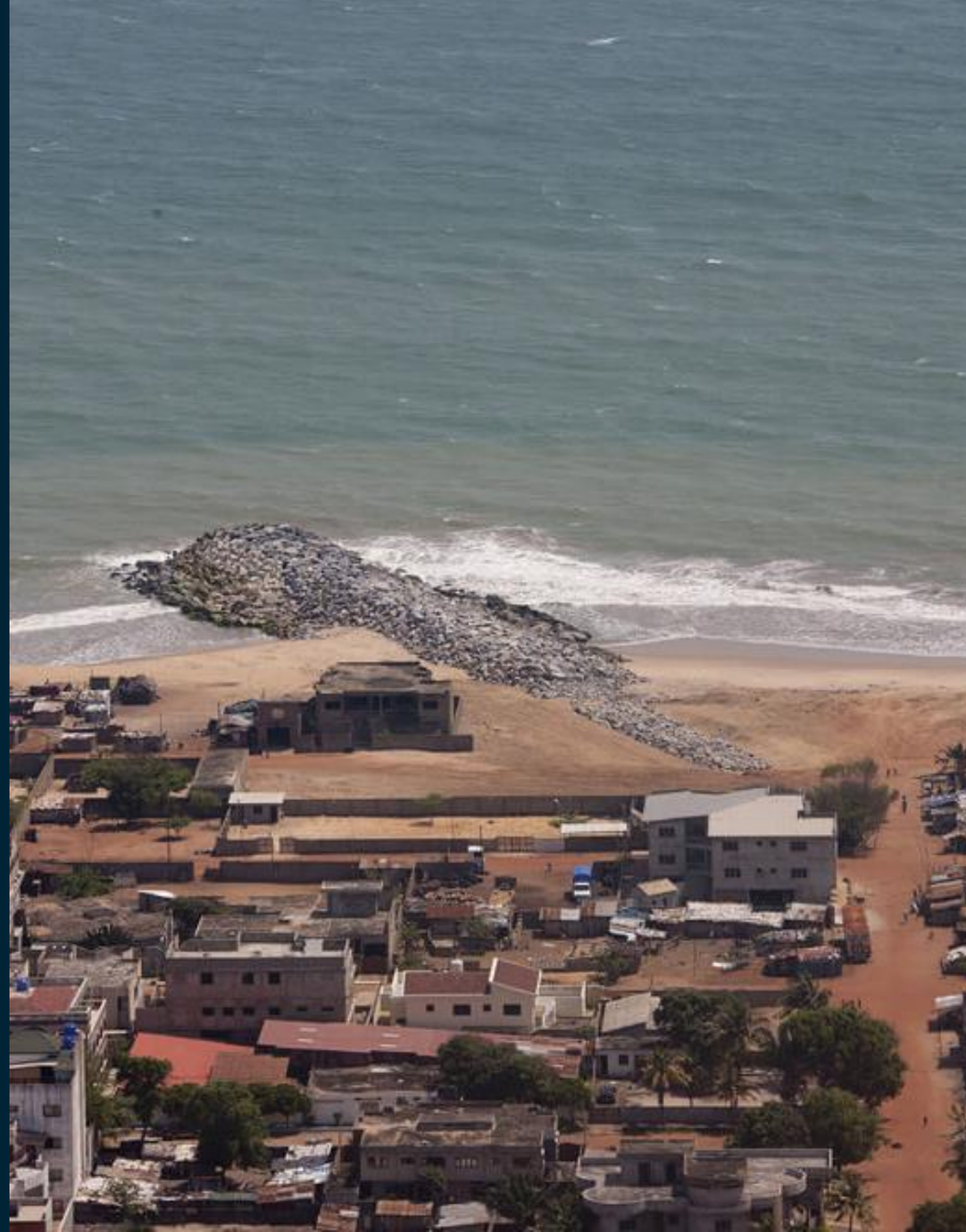
X-Blocs	X-Blocs	X-Blocs	X-Blocs	X-Blocs	Rock	Rock	Rock
5	5	3	5	4	1	2	6

Headlands 5 and 6 were constructed first. H7 was the last to be built. H6 experienced the greatest DD erosion requiring protection with revetment until H7 was built.

Construction (2012-2014)

Epi Est

B. — 1981



Construction (2012-2014)

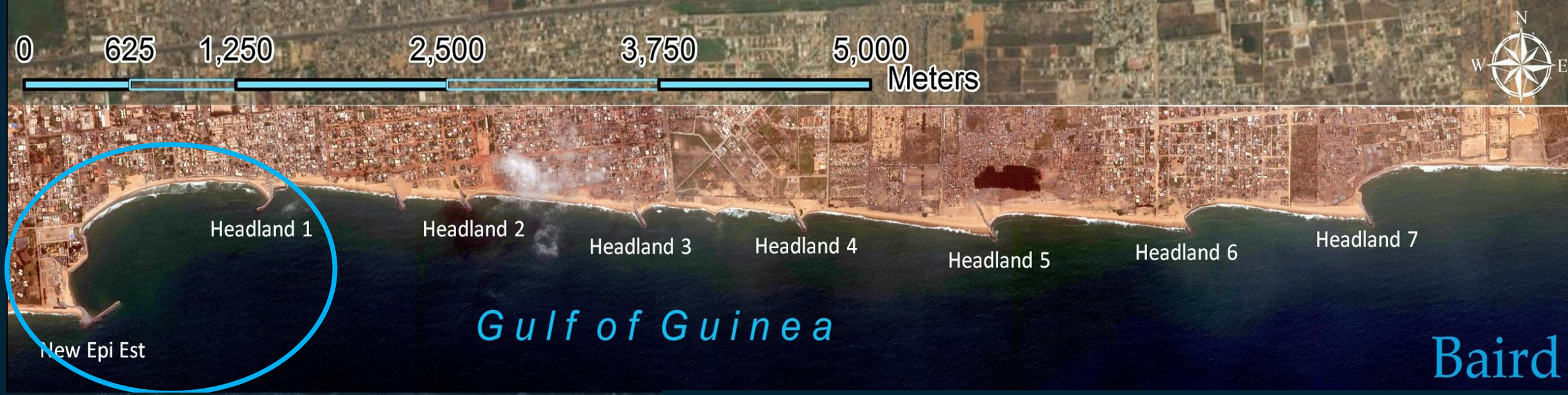
Headland 1

B. — 1981

Construction (2012-2014)

Headland 1

Post-Construction Shoreline Evolution Examples



Epi Est – H1

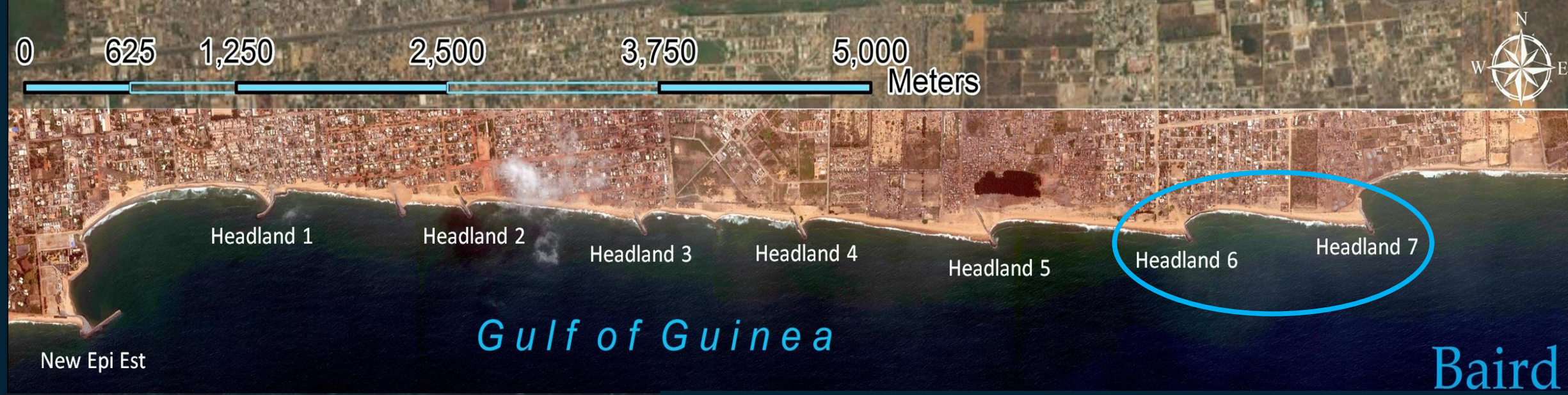
Critical bay to protect from the Client's perspective

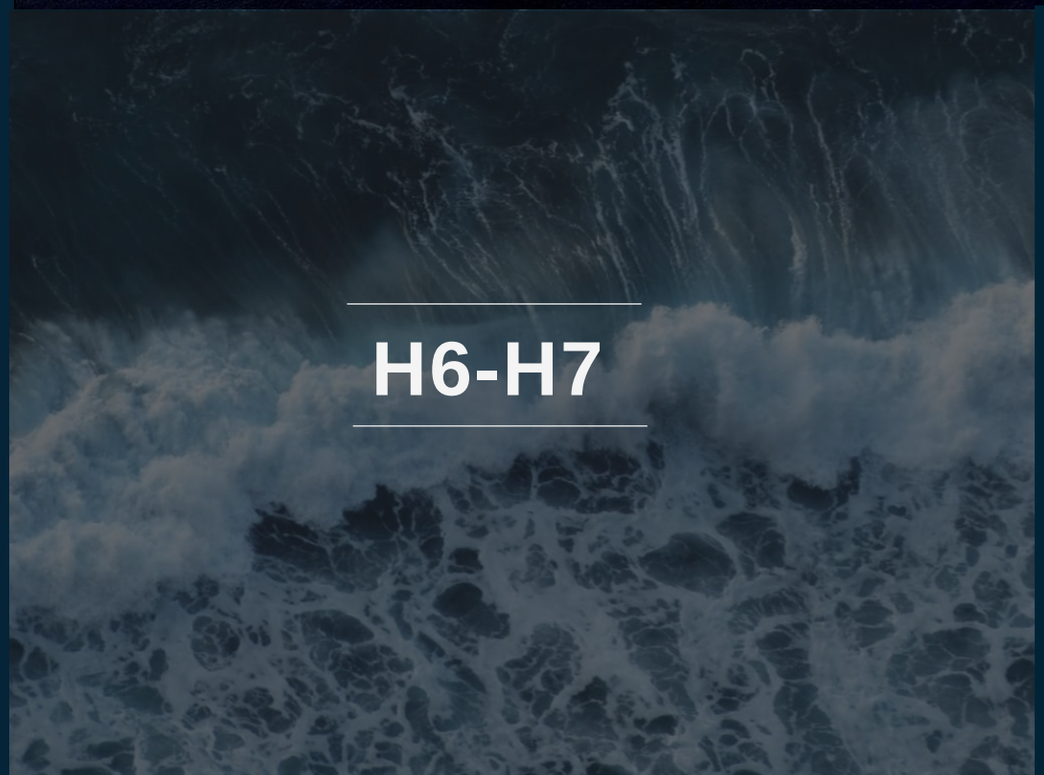
B. — 19 81


Epi Est
[November 25 2013]
Google Earth
Image © 2018 DigitalGlobe
N
300 m

Epi Est

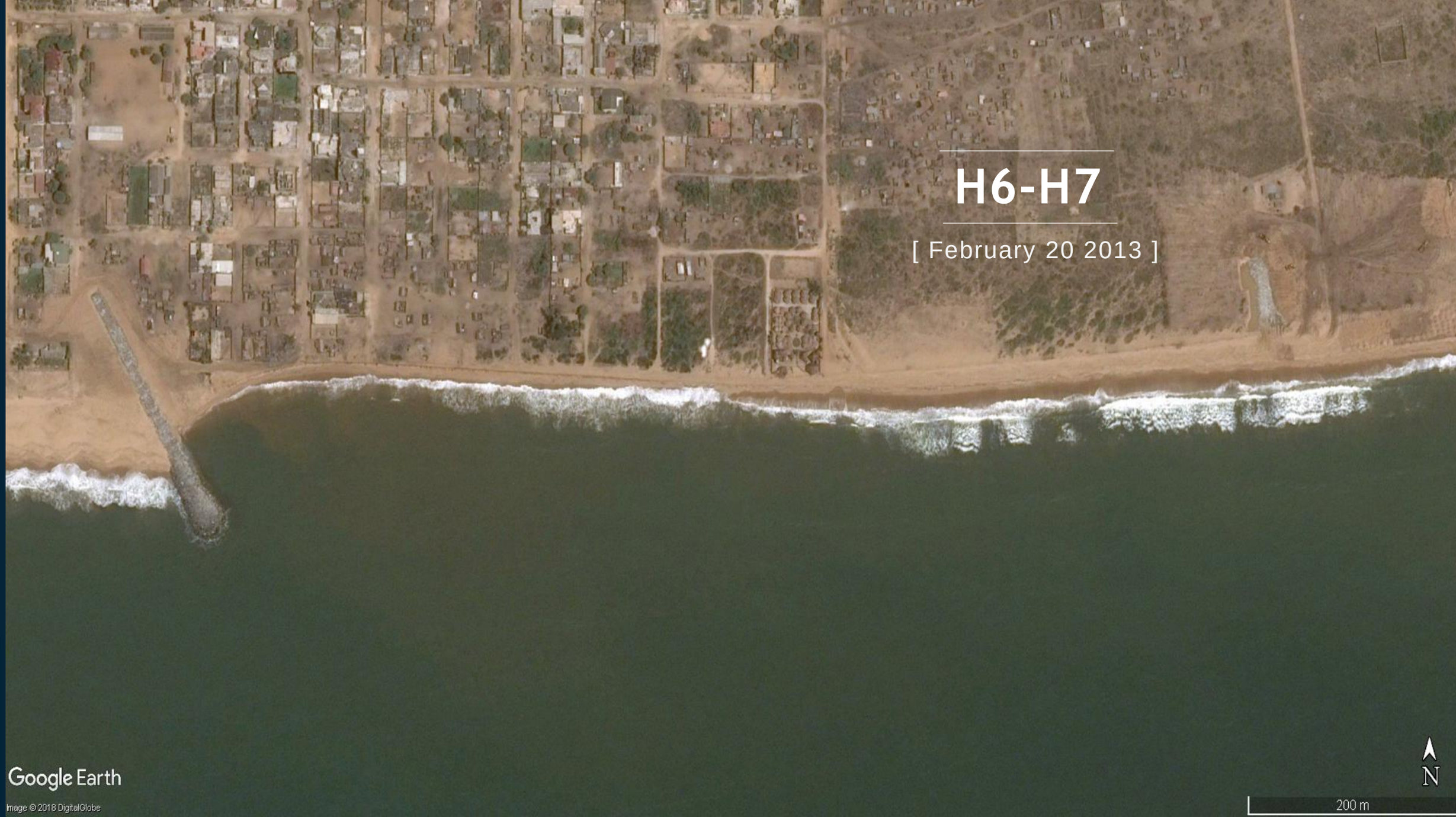
[March 24 2018]


0
625
1,250
2,500
3,750
5,000
Meters
N
W
E
S
Headland 1
Headland 2
Headland 3
Headland 4
Headland 5
Headland 6
Headland 7
Gulf of Guinea
New Epi Est
Baird

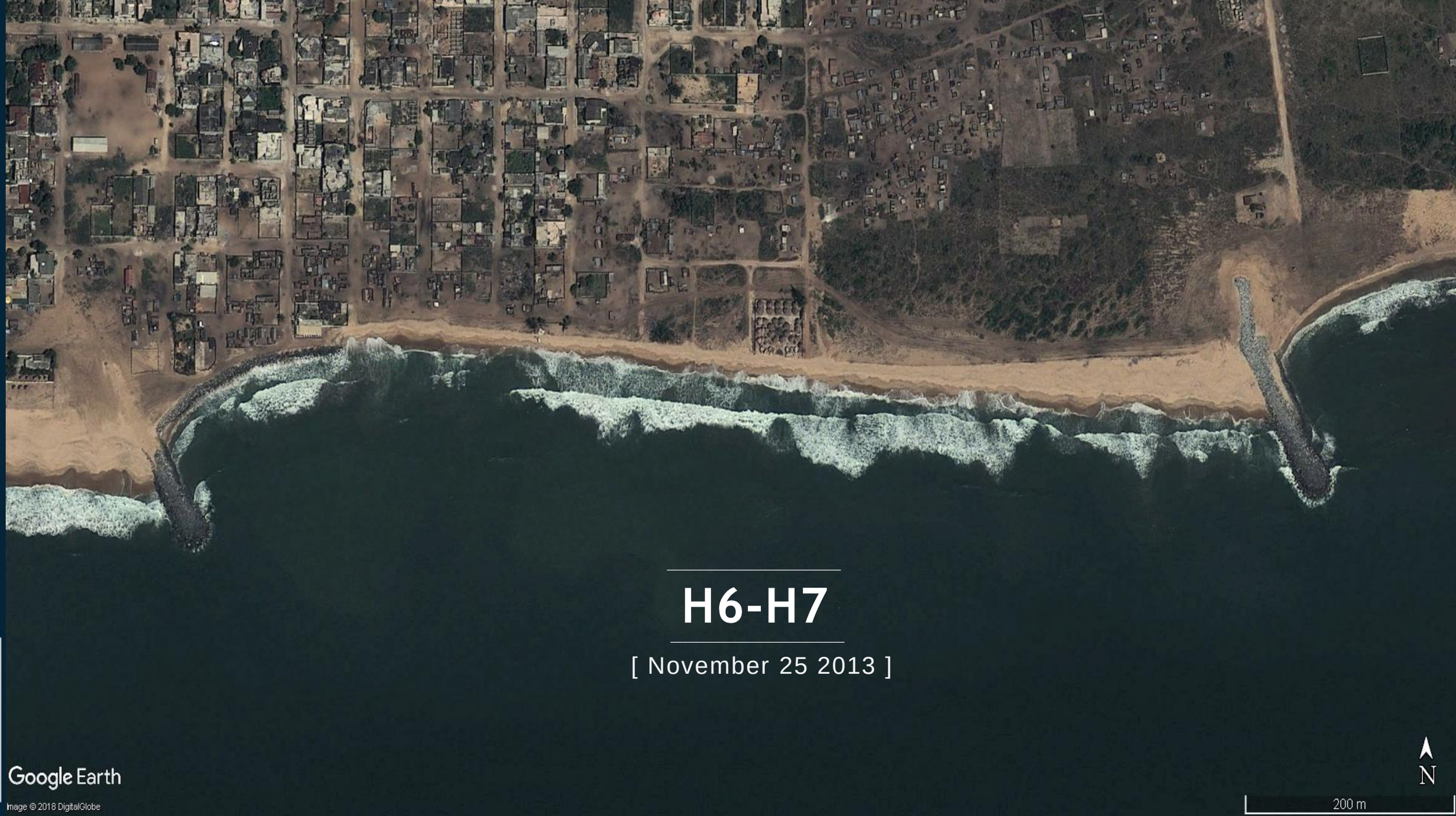


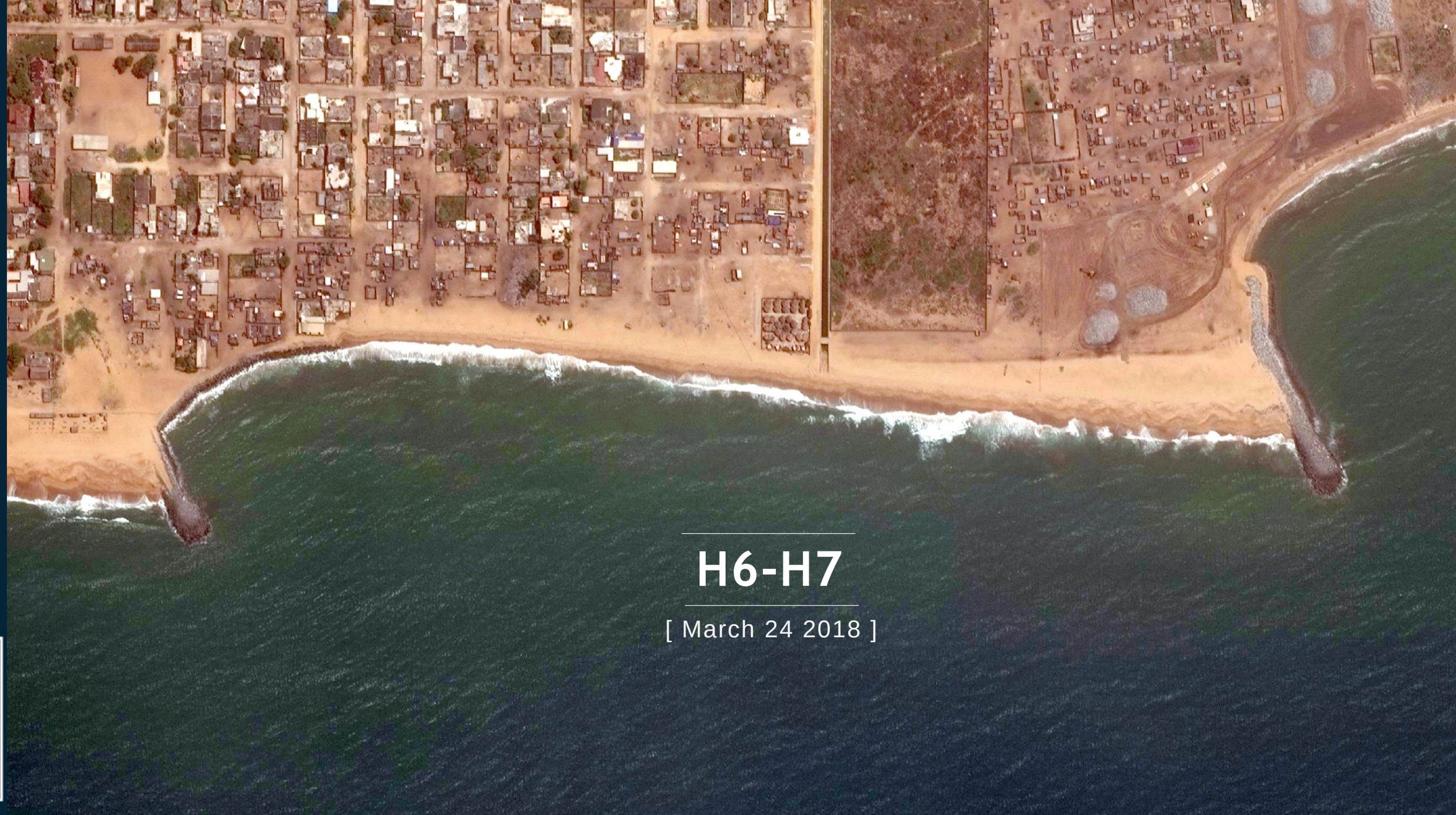
H6-H7

B. — 19 81


H6-H7
[February 20 2013]
Google Earth
Image © 2018 DigitalGlobe
N
200 m

B. — 19 81

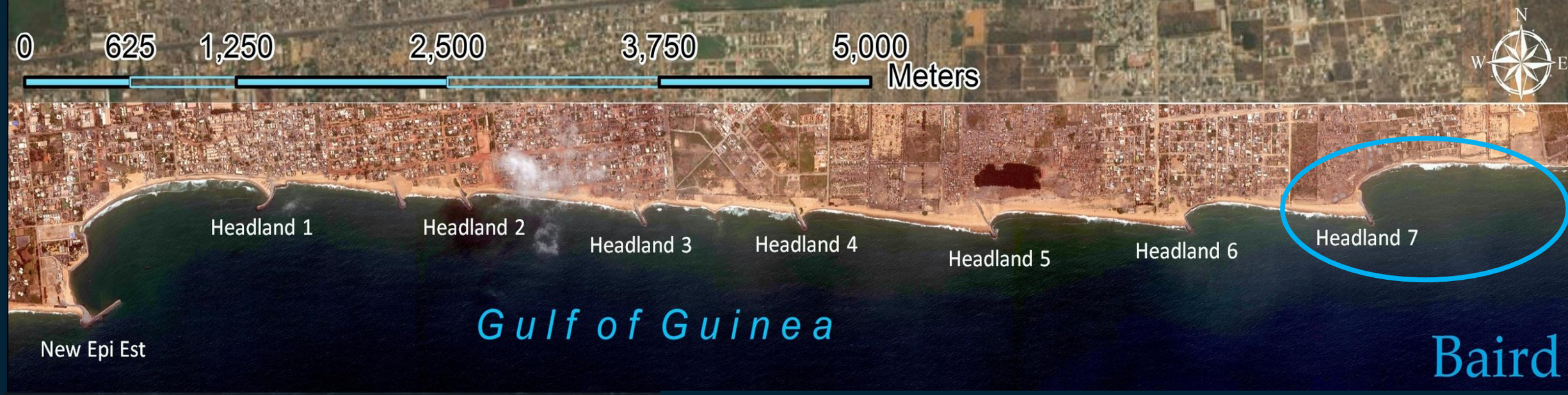

H6-H7
[November 25 2013]
Google Earth
Image © 2018 DigitalGlobe
N
200 m



H6-H7

[March 24 2018]

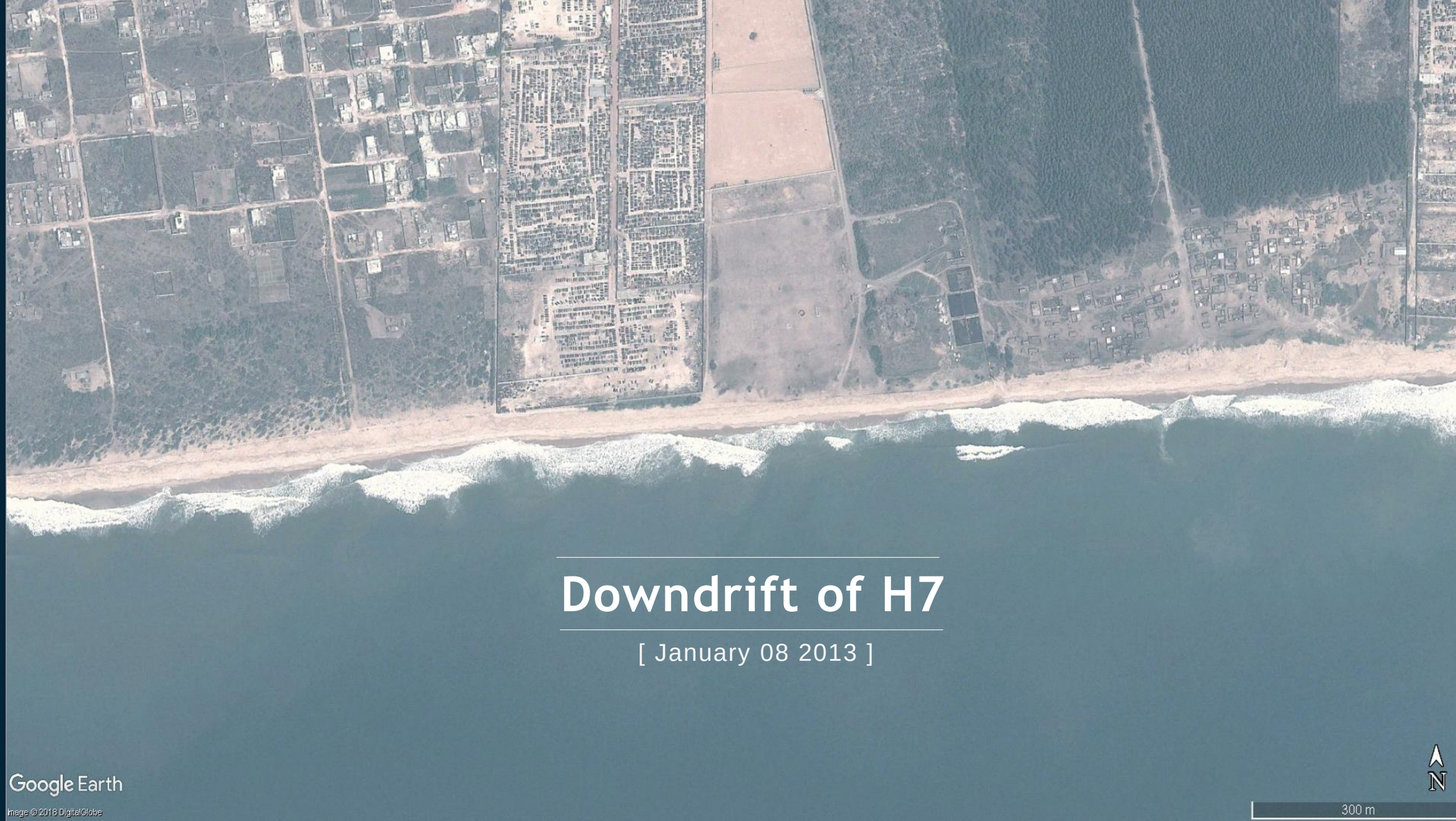
B. — 19 81



Downdrift of H7

Downdrift Erosion

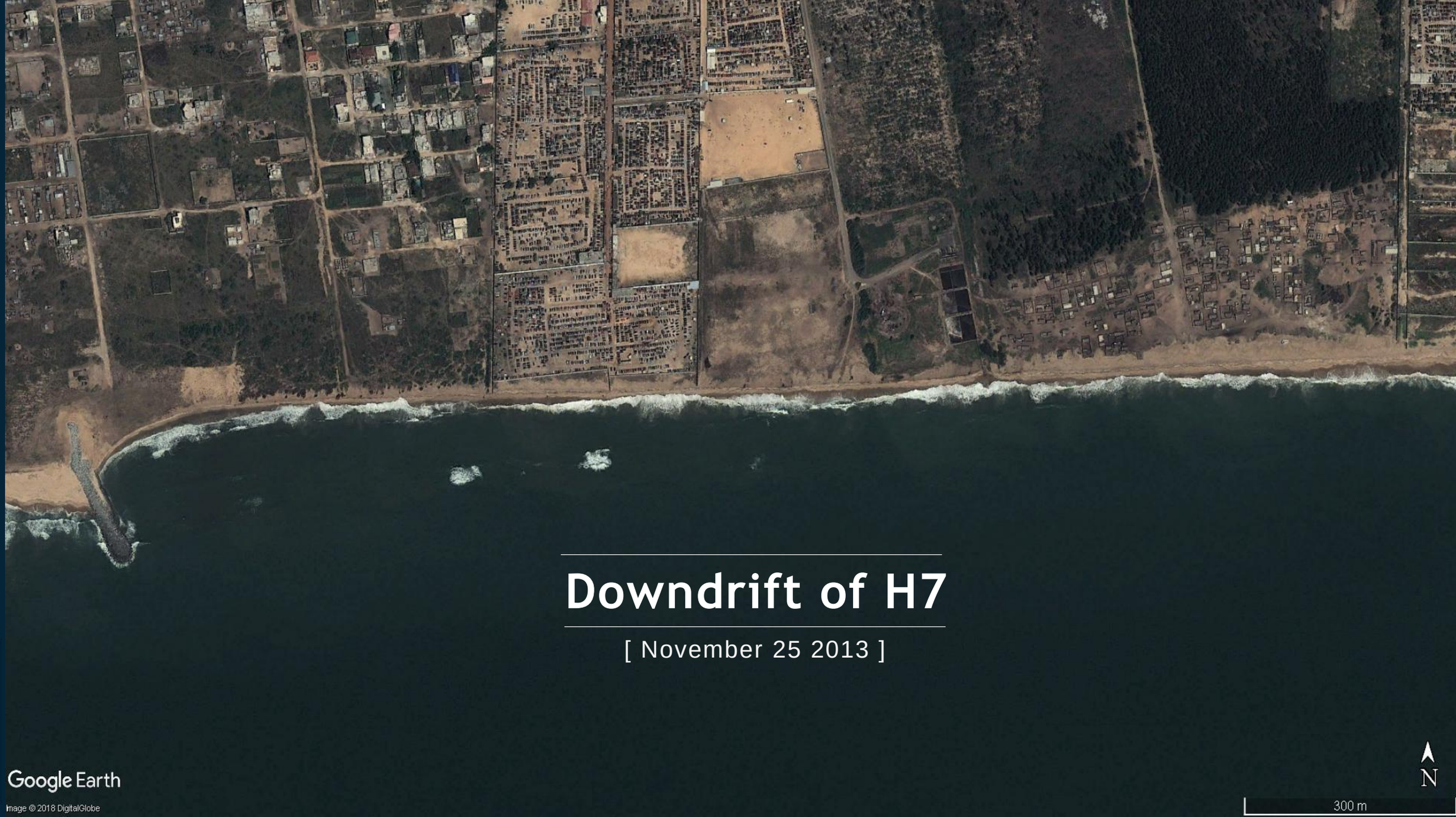
B. — 19 81



Downdrift of H7

[January 08 2013]

B. — 19 81



Downdrift of H7

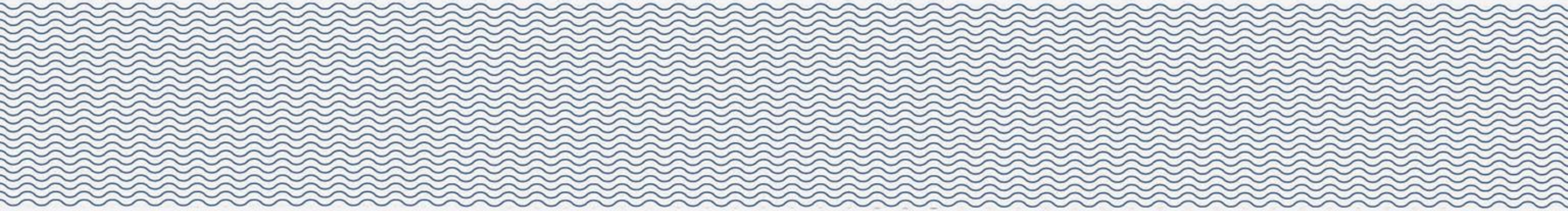
[November 25 2013]

Downdrift of H7

[March 24 2018]

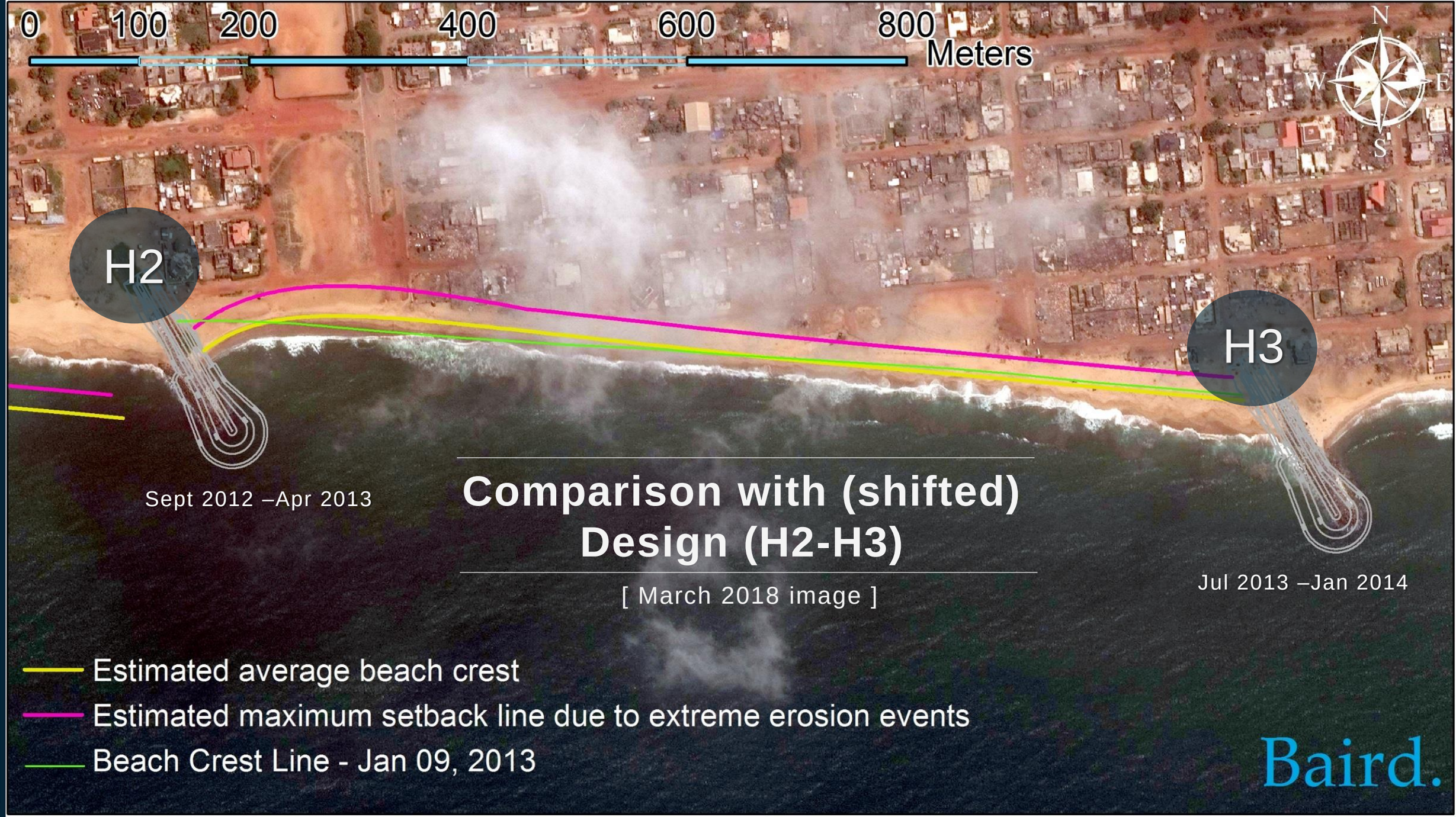
B. — 19 81

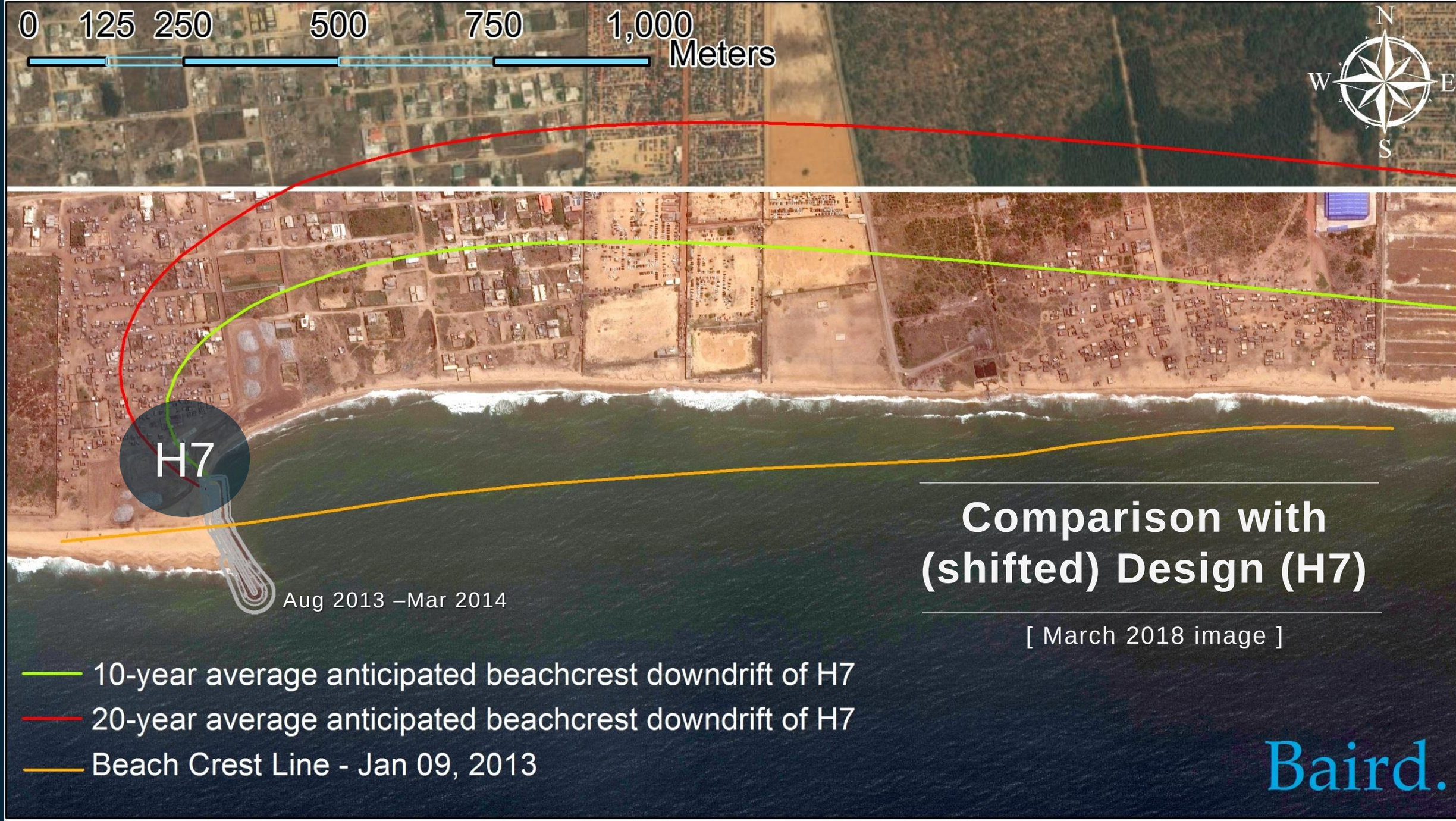
Comparison with Design

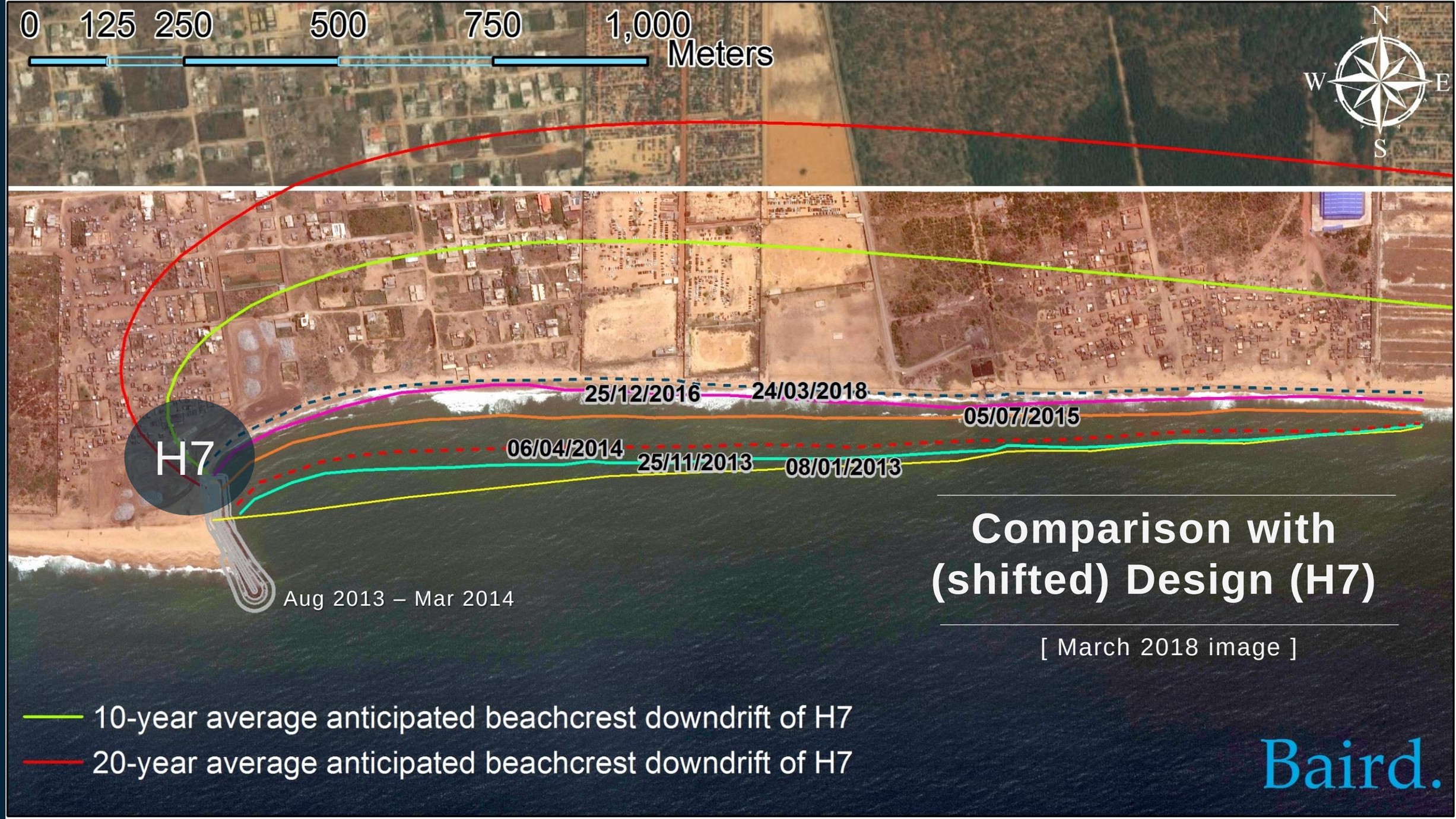



0
100
200
400
600
800
Meters
N
W
E
S
Comparison with Initial Design
[March 2018 image]
H2
H3
Gulf of Guinea
Estimated average beach crest
Estimated maximum setback line due to extreme erosion events
Design Layout, Jan 2003
Baird


0
100
200
400
600
800
Meters
N
W
E
S
H2
H3
Sept 2012 – Apr 2013
Jul 2013 – Jan 2014
Initial Design (shifted) on Pre-construction Image
[January 9, 2013 image]
Estimated average beach crest
Estimated maximum setback line due to extreme erosion events
Beach Crest Line - Jan 09, 2013
Baird.


0
100
200
400
600
800
Meters
N
W
E
S
H2
H3
Sept 2012 –Apr 2013
Jul 2013 –Jan 2014
Comparison with (shifted) Design (H2-H3)
[March 2018 image]
Estimated average beach crest
Estimated maximum setback line due to extreme erosion events
Beach Crest Line - Jan 09, 2013
Baird.


0 125 250 500 750 1,000
Meters
N
W
E
S
H7
Aug 2013 –Mar 2014
Comparison with (shifted) Design (H7)
[March 2018 image]
10-year average anticipated beachcrest downdrift of H7
20-year average anticipated beachcrest downdrift of H7
Beach Crest Line - Jan 09, 2013
Baird.



Comparison with (shifted) Design (H7)

[March 2018 image]

Baird.

Thank you.

Questions & Answers