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HYDROLOGY, WATER QUALITY, SEDIMENT DEPOSITION, AND BIOLOGICAL CHARACTERISTICS OF LAGUNA GRANDE MARCH 2007- FEBRUARY 2009

USGS In cooperation with the

PUERTO RICO ENVIRONMENTAL QUALITY BOARD

for the

CONSERVATION TRUST OF PUERTO RICO

Fideicomiso de Conservación
de Puerto Rico

PROBLEM

- The CTPR was managing a natural reserve since 1986 with no baseline water quality or hydrologic data describing the lagoon's condition

- Human activities and disturbance are impacting the lagoon

- They needed data to establish standards and enforce regulated use of the reserve

Laguna Grande Location in Eastern Puerto Rico

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Bioluminescent Lagoon

Second Oldest Light House in Puerto Rico – 1880

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1880
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Laguna Grande Study Components

- **Hydrology**

  rainfall (UPR met station) estimate runoff drainage area
  tidal exchange

- **Bathymetric Survey**

  bottom topography calculate volume

- **Water Physical and Chemical Characteristics**

  pH dissolved oxygen DO saturation temperature turbidity salinity
  specific conductance transparency nutrients chlorophyll a

- **Biological Characteristics**

  primary productivity – L/D bottles method diel study
  fecal bacteria phytoplankton biomass

- **Sediment Deposition Rate**

  sediment cores

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LAGUNA GRANDE STATION LOCATIONS

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RAINFALL

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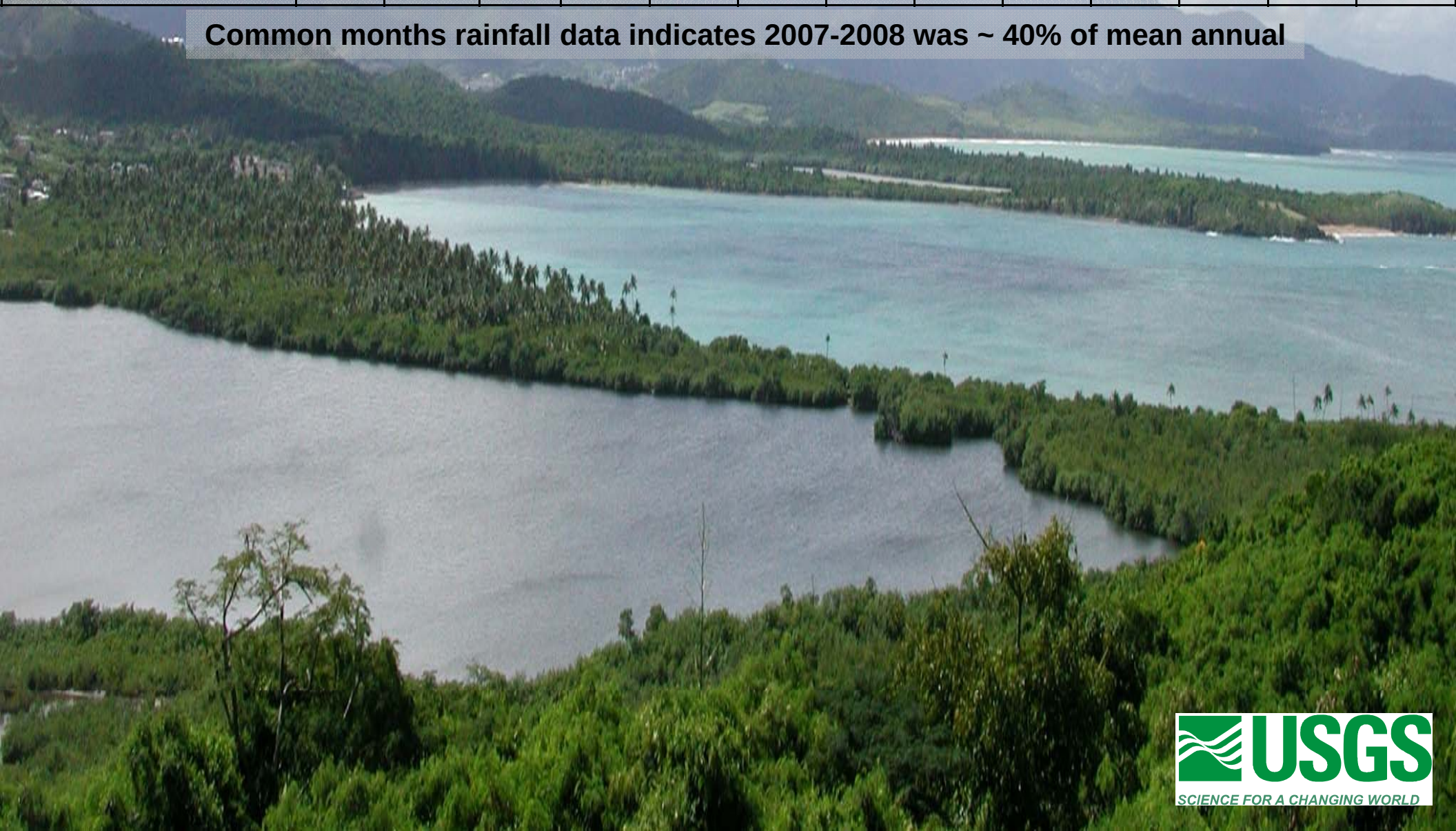
RAINFALL

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Long term mean rain fall in mm (NOAA)	89.15	68.83	75.69	98.30	188.72	126.24	134.11	157.48	166.37	197.89	182.12	120.39	1,604.77
Study rain fall in mm (UPR)	ND	ND	ND	ND	91.40	78.09	61.72	49.51	ND	ND	ND	37.78	NA
Difference					- 34.84	- 48.15	- 72.39	-107.97				-82.61	NA

Common months rainfall data indicates 2007-2008 was ~ 40% of mean annual



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DRAINAGE AREA – estimated at 2.3 Km²
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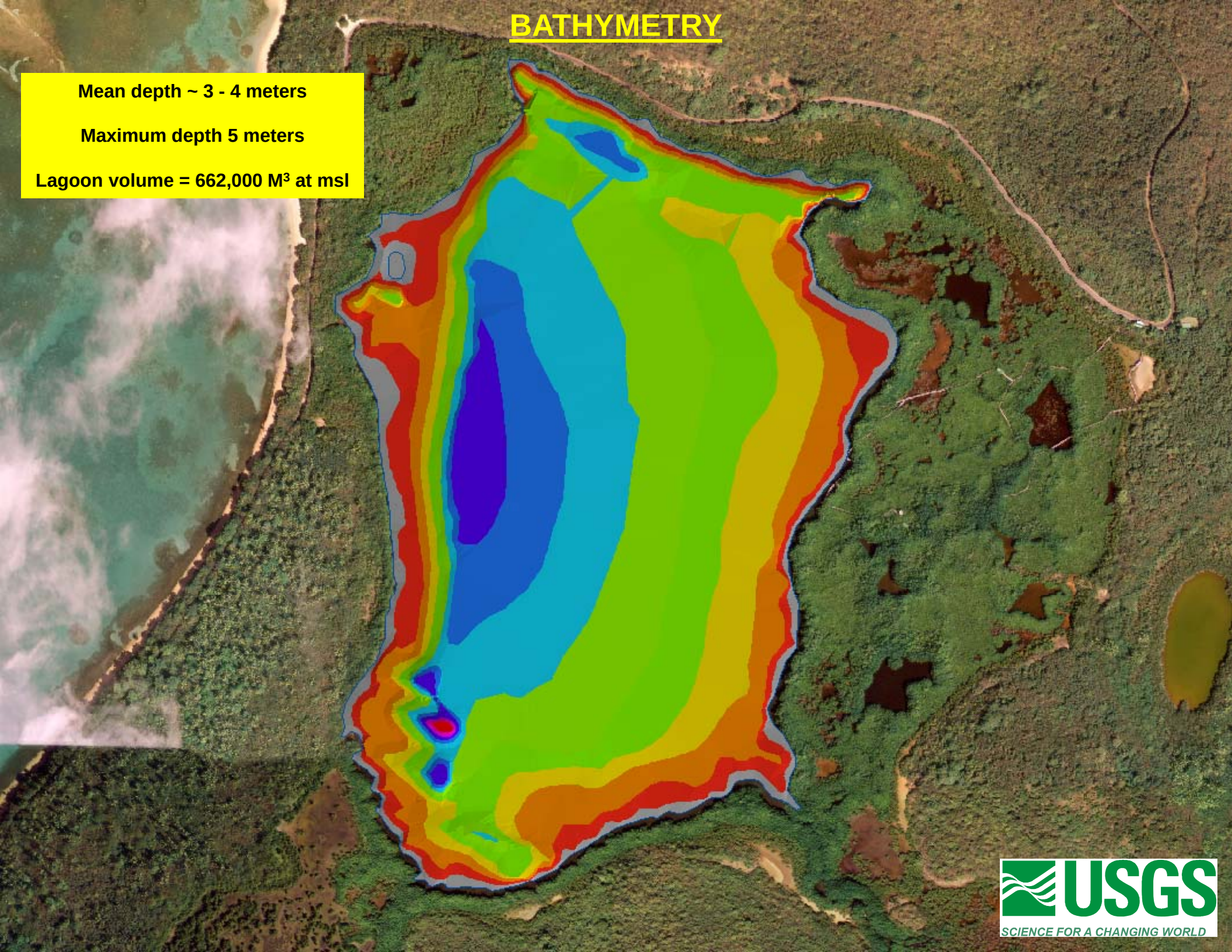
BATHYMETRY


Mean depth ~ 3 - 4 meters
Maximum depth 5 meters
Lagoon volume = 662,000 M3 at msl
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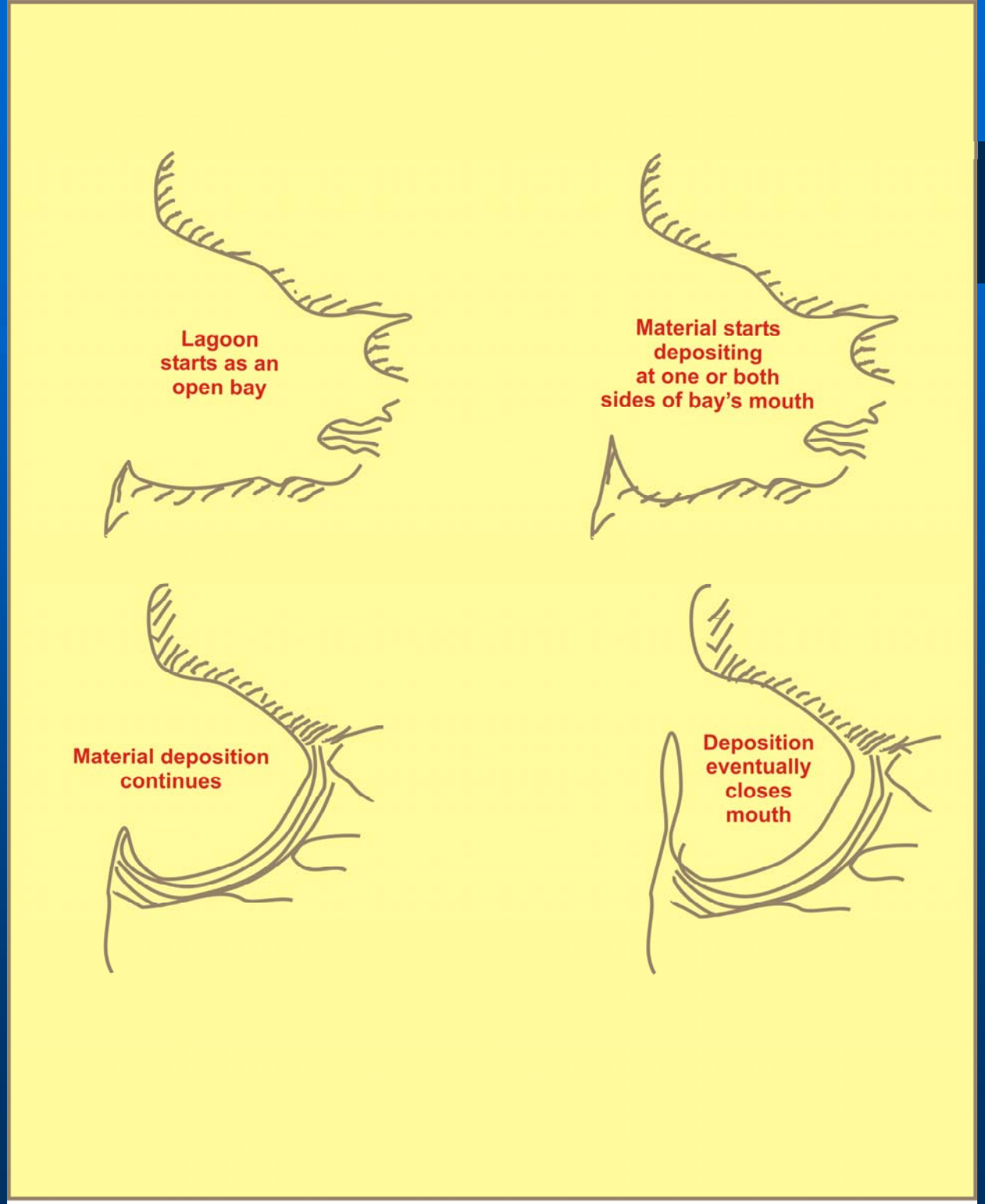

Figure 4. Depiction of typical costal lagoons formation mechanism (this however is not the only existing mechanism).

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SEAWATER EXCHANGE – HIGH AND LOW TIDES

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Sea Tidal Station

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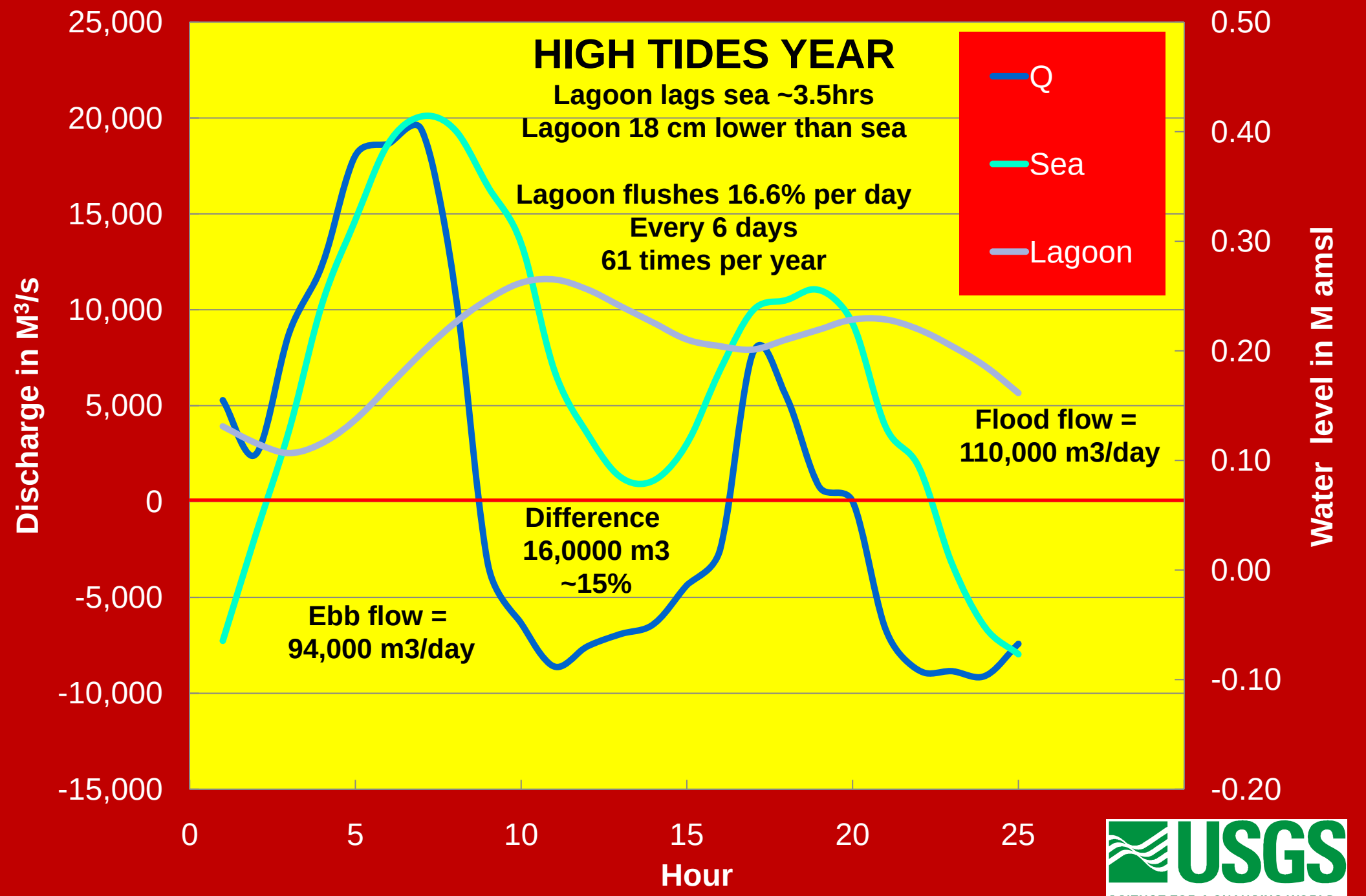
Discharge (Q) vs water levels Oct 21-22, 2008



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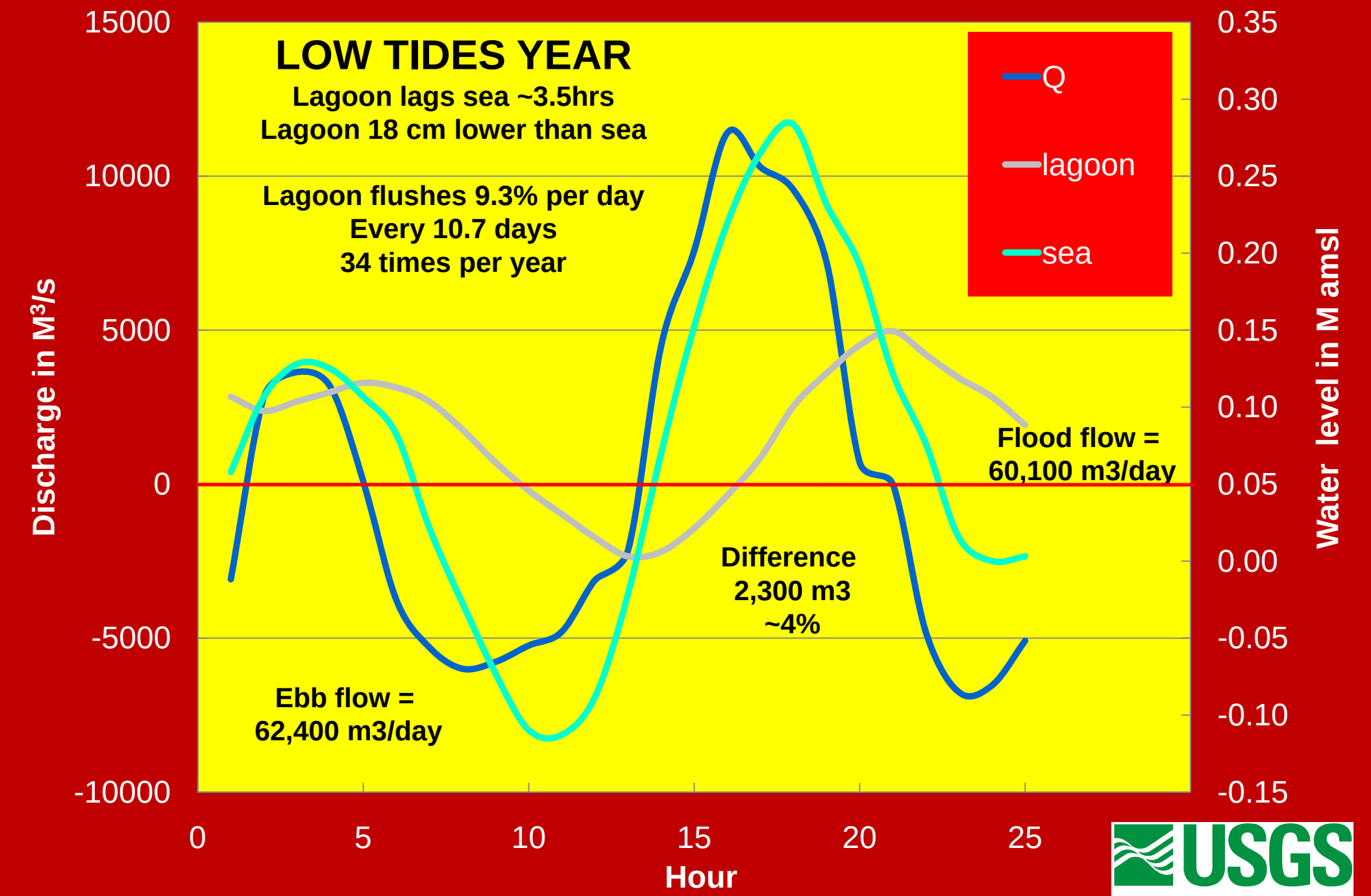
Discharge (Q) vs water levels February 17-18, 2009



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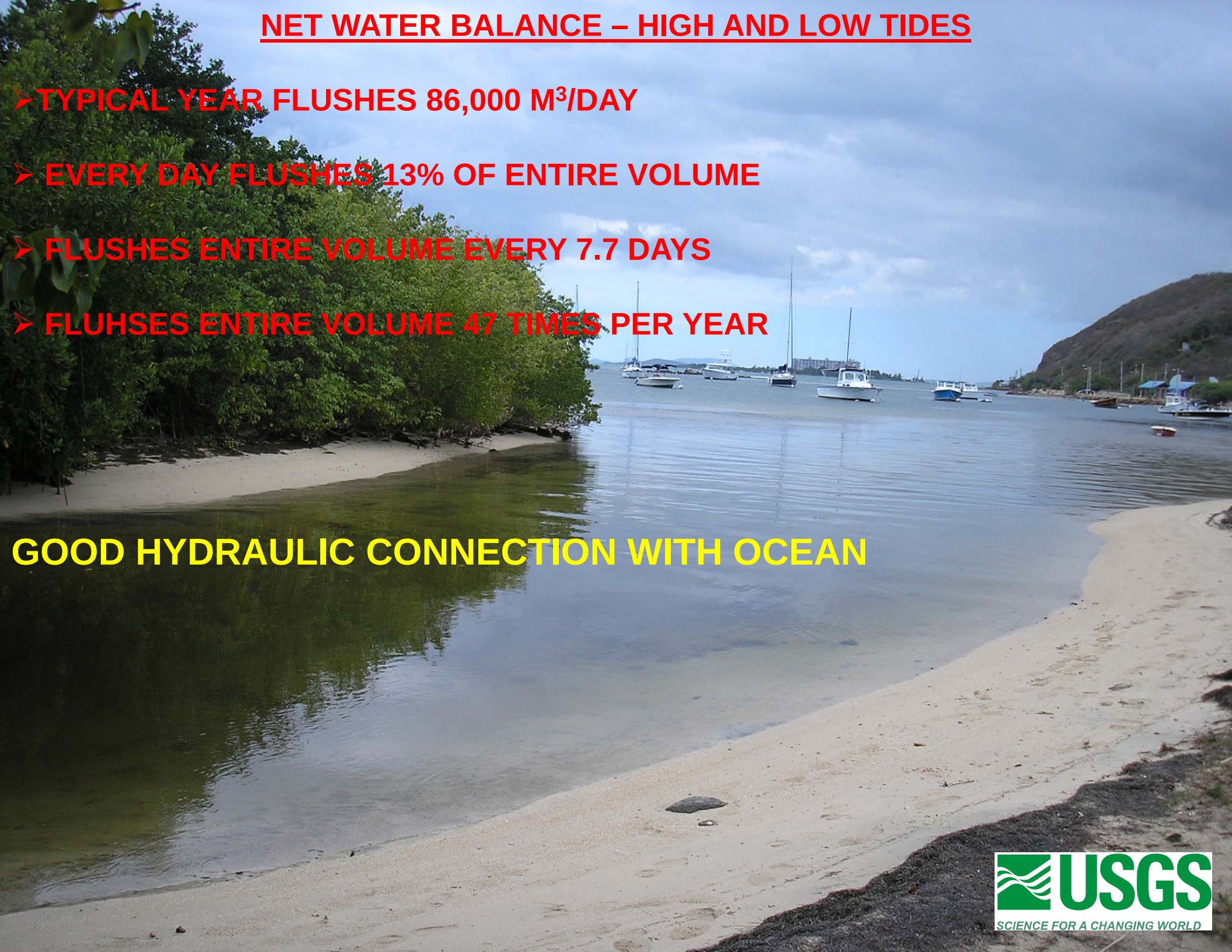
NET WATER BALANCE – HIGH AND LOW TIDES



- TYPICAL YEAR FLUSHES 86,000 M^3/DAY
- EVERY DAY FLUSHES 13% OF ENTIRE VOLUME
- FLUSHES ENTIRE VOLUME EVERY 7.7 DAYS
- FLUHSES ENTIRE VOLUME 47 TIMES PER YEAR

GOOD HYDRAULIC CONNECTION WITH OCEAN

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Porto Rico
1-16-31
1930
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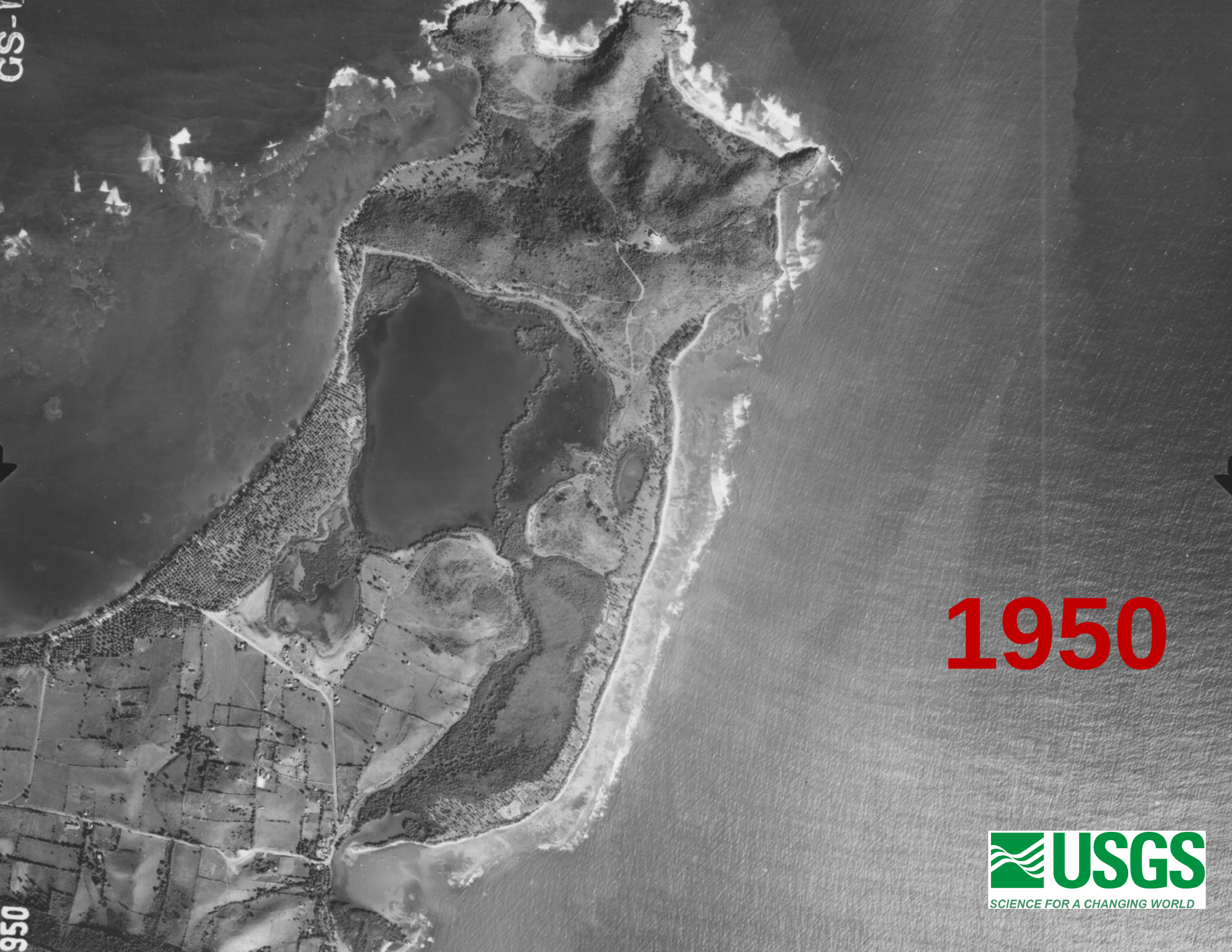
1950
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2007
© 2010 Google
© 2010 Europa Technologies
Image U.S. Geological Survey
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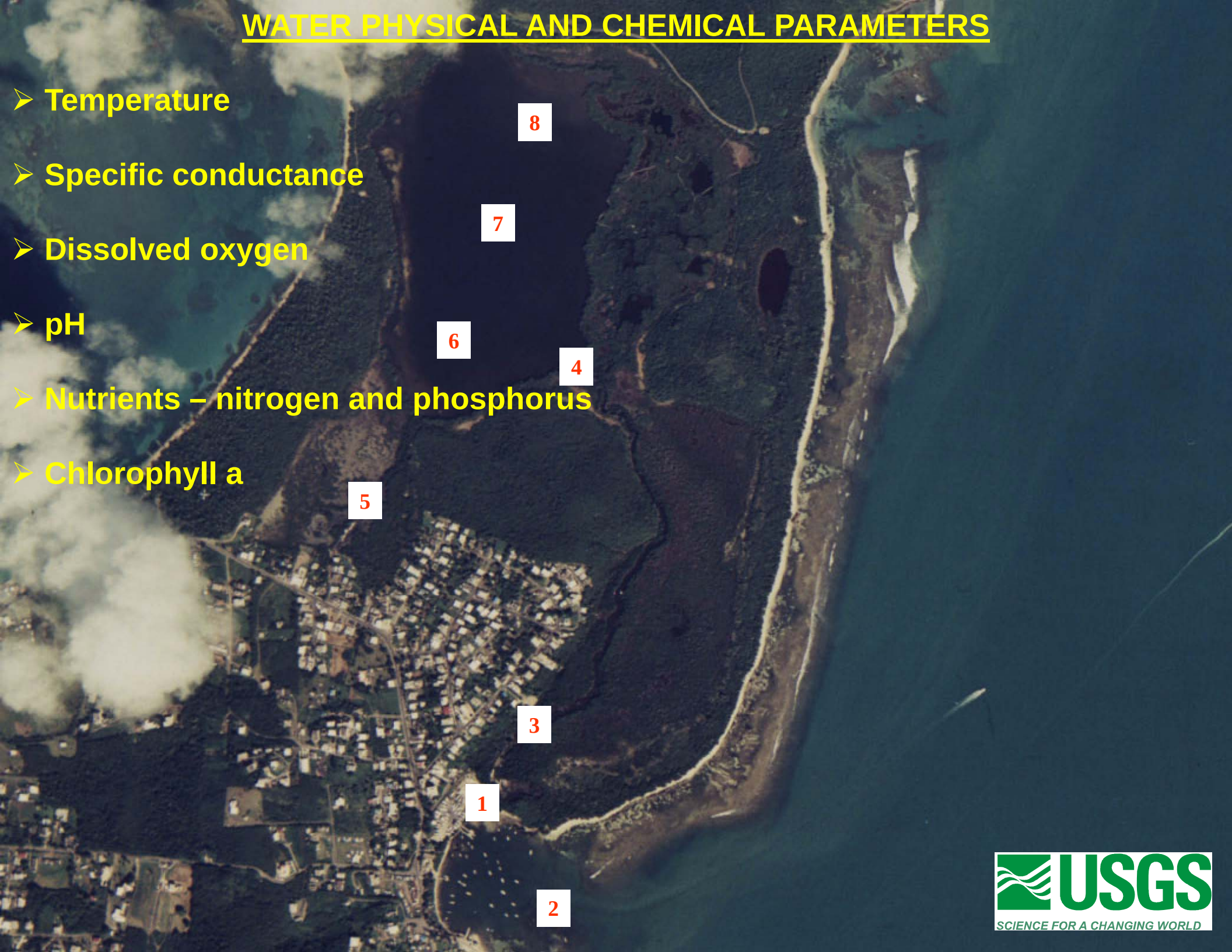
Pointer 18°22'19.66" N 65°37'26.36" W elev 25 ft
Streaming 100%
Eye alt 6668 ft

WATER PHYSICAL AND CHEMICAL PARAMETERS

- Temperature
- Specific conductance
- Dissolved oxygen
- pH
- Nutrients – nitrogen and phosphorus
- Chlorophyll a



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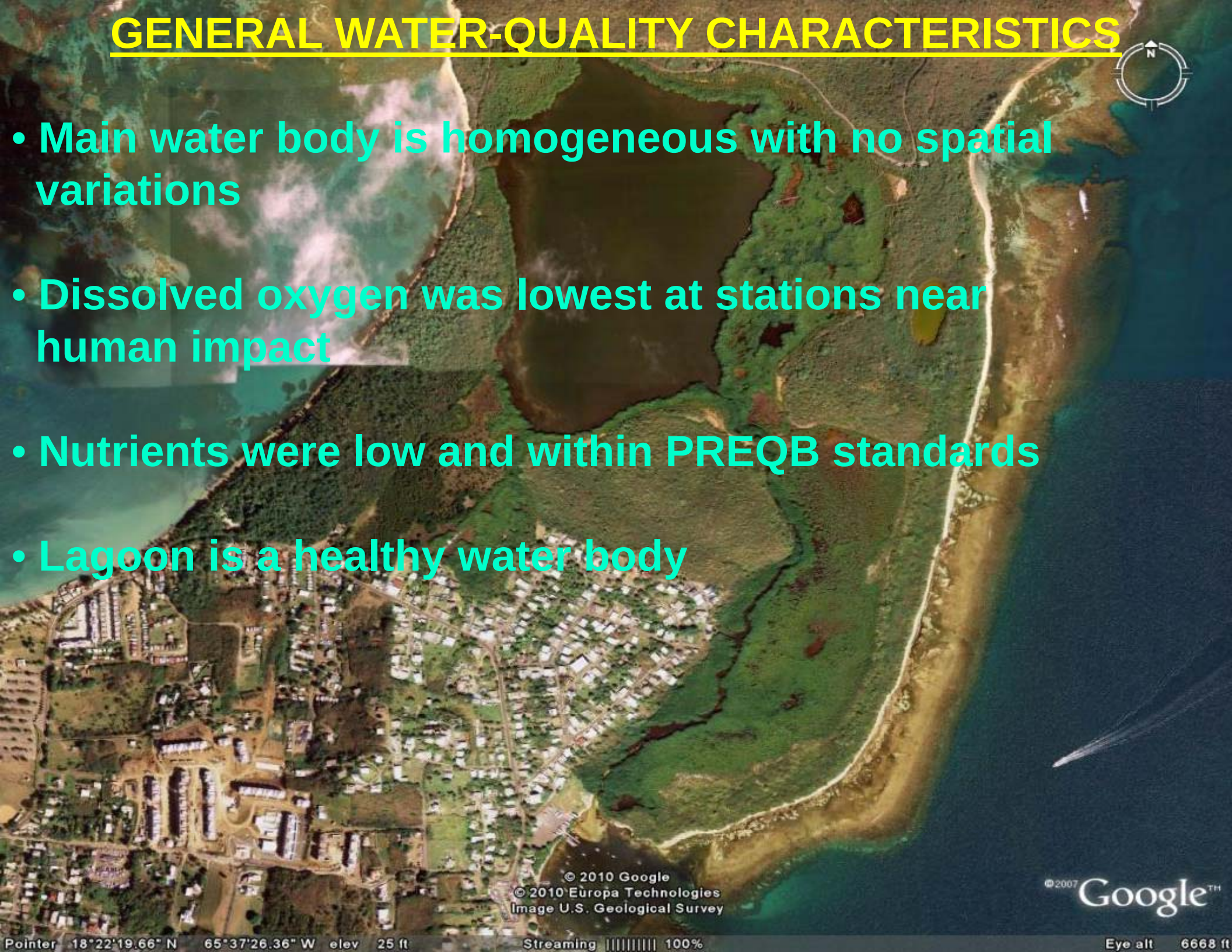
GENERAL WATER-QUALITY CHARACTERISTICS



- Main water body is homogeneous with no spatial variations
- Dissolved oxygen was lowest at stations near human impact
- Nutrients were low and within PREQB standards
- Lagoon is a healthy water body

SELECTED WATER BIOLOGICAL CHARACTERISTICS

- Primary productivity
  - ✓ Light/dark bottles
  - ✓ Diel studies – stations 6, 7, 8, 9, 10
- Phytoplankton biomass
- Fecal bacteria concentration stations 1, 3, 5, and 7

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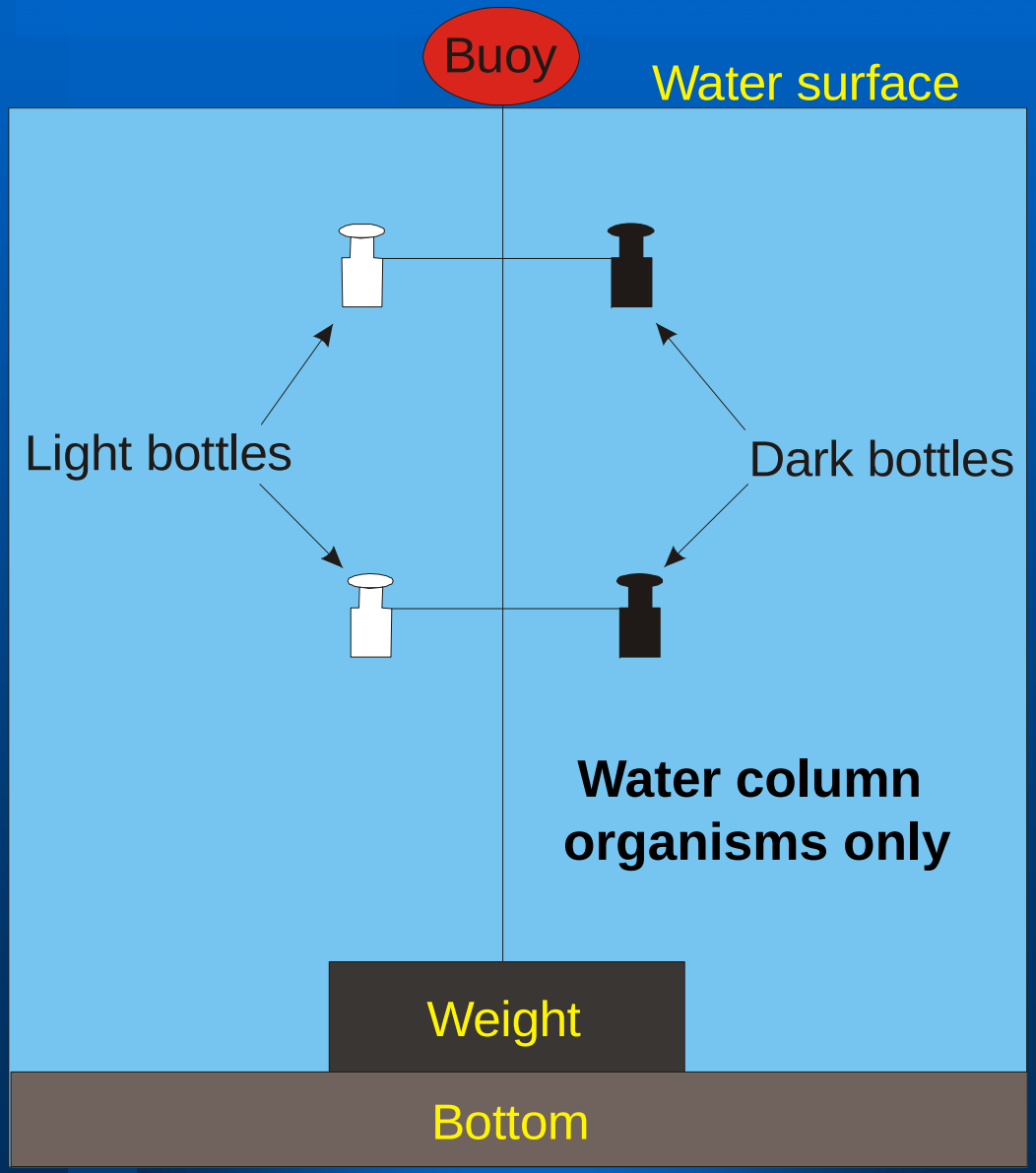
Primary Productivity

• Light/Dark bottles method – plankton productivity and respiration

Winkler titration

By measuring the production of O2, we can calculate The amount of organic matter creation

$$6\ CO_2 + 6\ H_2O + Light + CHL = C_6H_{12}O_6 + 6\ O_2$$



Method Principles:

Light bottles – photosynthesis, respiration

Dark bottles – respiration

Gross productivity (Pg) = OL – OD

Net productivity (Pn) = OL – OI

Respiration (R) = OI – OD

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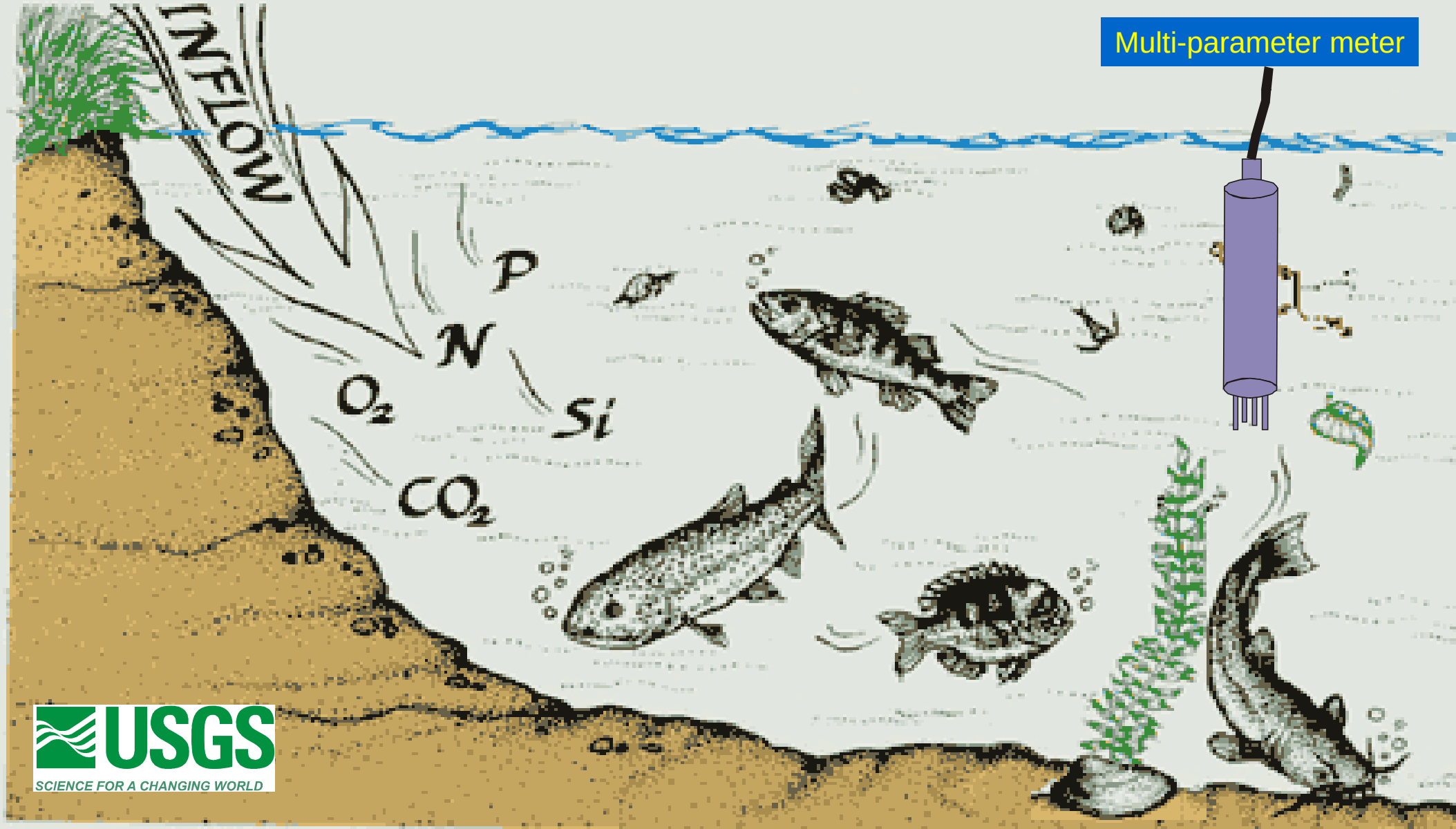
Biological Characteristics – Productivity

- **Diel method (diurnal cycle) – entire community productivity and respiration**



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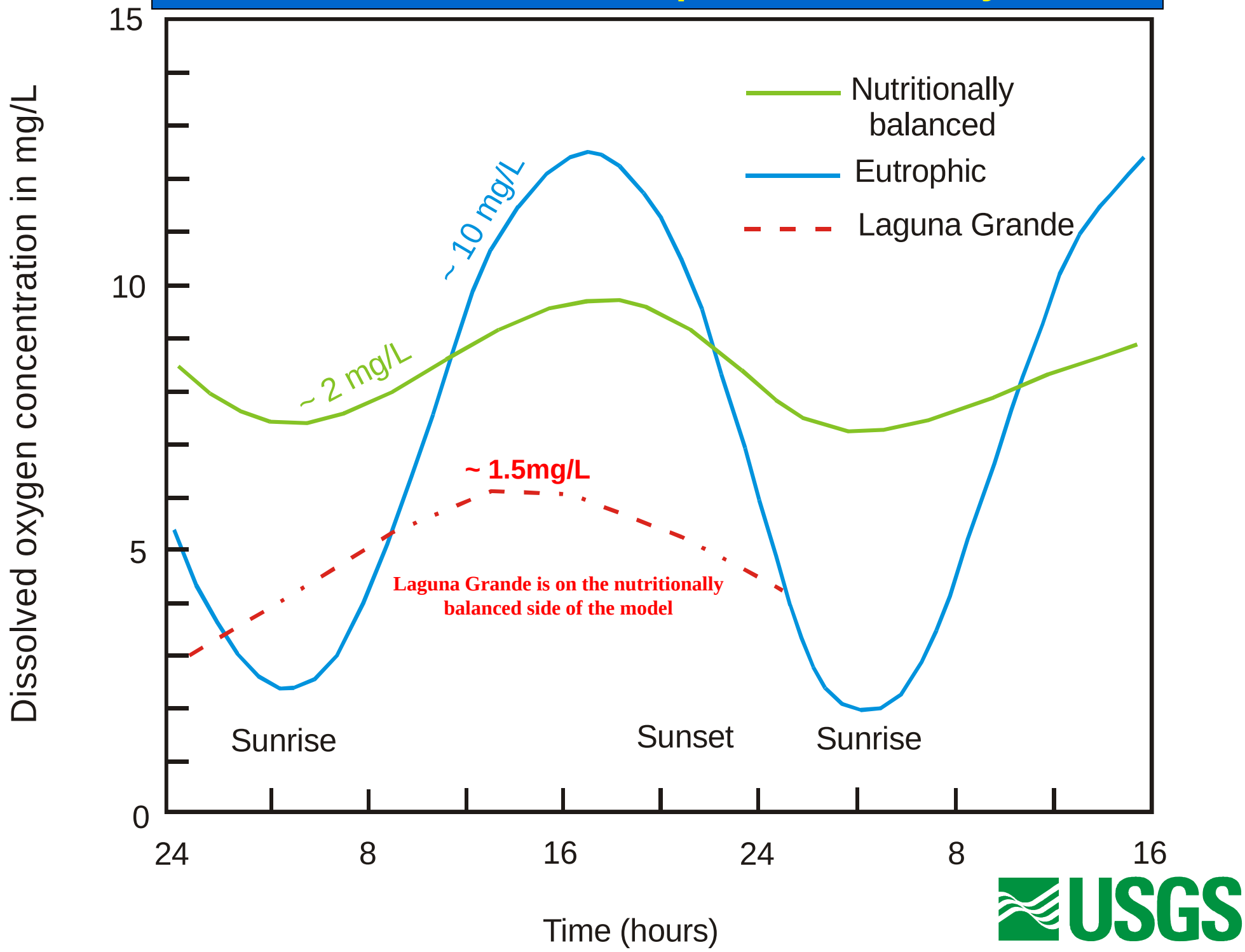
DO diurnal variation example conceived by Wetzel



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METABOLISM IN LAGUNA GRANDE

- Lagoon produces 507 metric tons of organic matter per year
- Carbon dioxide removal of nearly 1,400 metric tons per year
- 86% net productivity is by benthos
- 88% respiration is by benthos
- 88% gross productivity is by benthos
- P/B ratio – phytoplankton community has a turnover rate of 2 $^{1}/_{2}$ days

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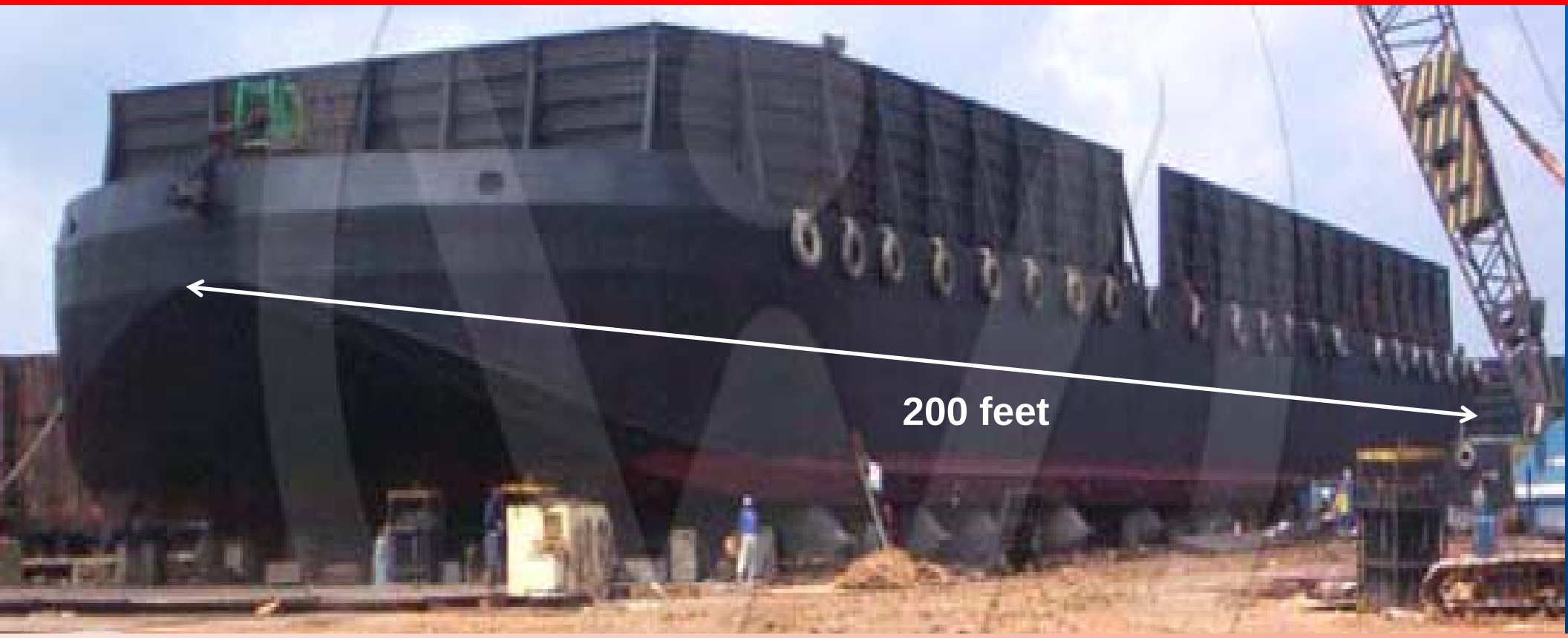
- Every three years the lagoon produces enough organic matter to fill this 200-foot, 1,500 metric-ton barge

- Based on the average daily flushing rate of the lagoon of 86,000 m^3/day, and water column net productivity of 0.3 gC/m^3-day, the lagoon exports 26 kilograms of organic matter per day (~ 0.005% of total production)



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Fecal Bacteria and Sources

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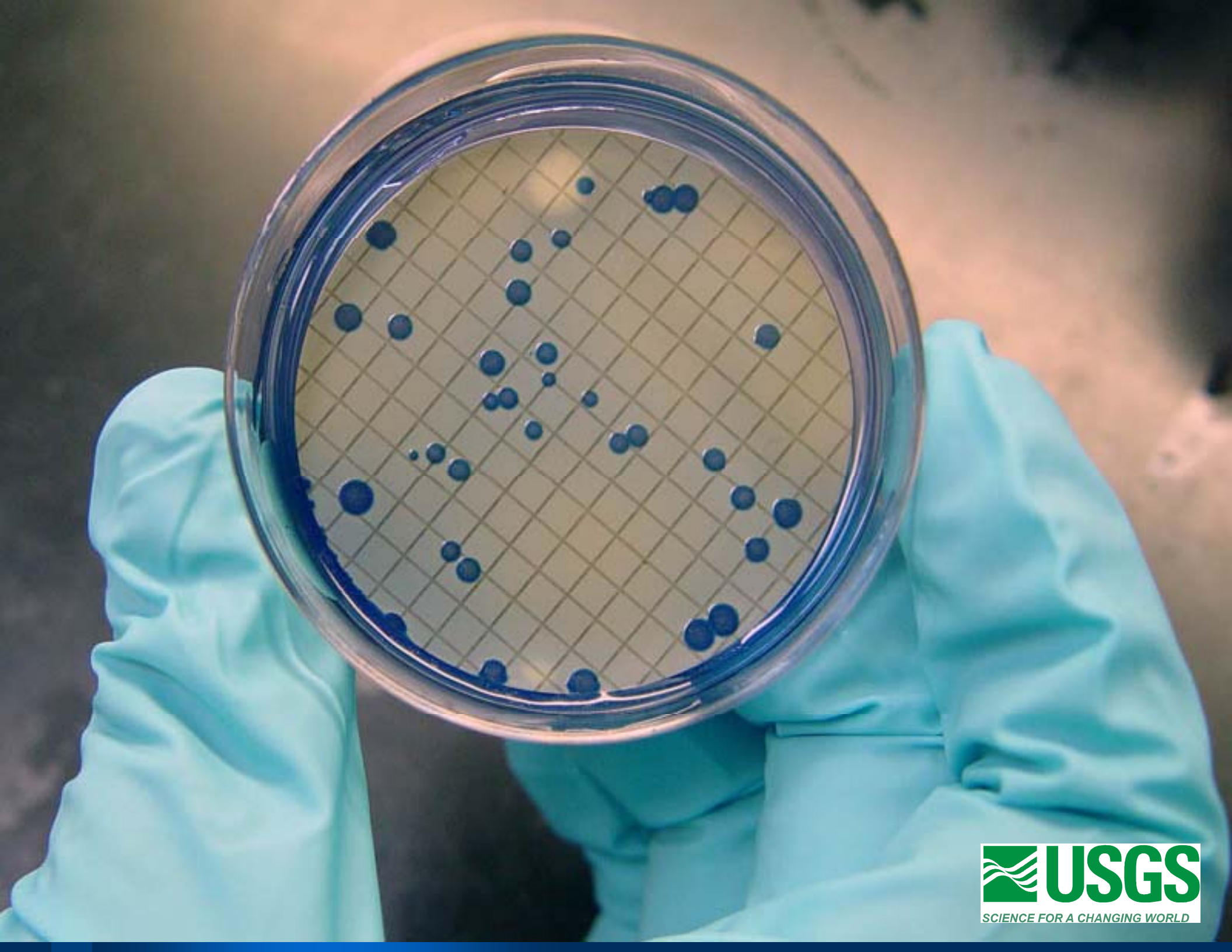

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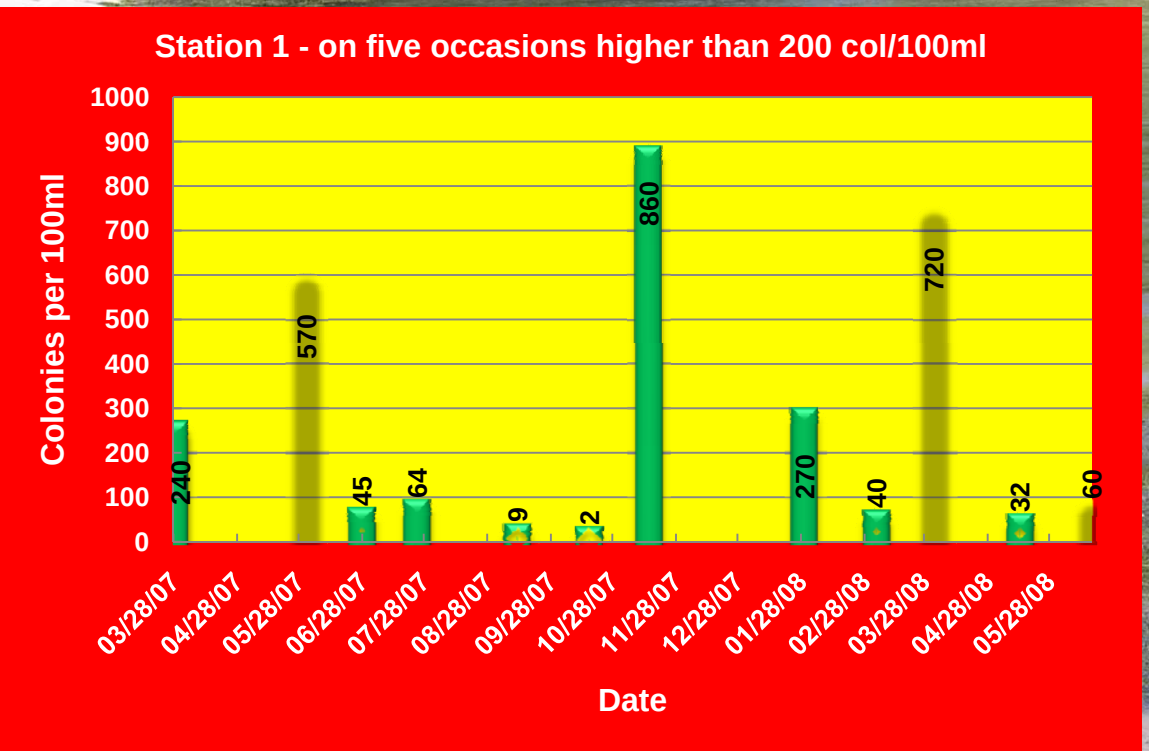
Station 1



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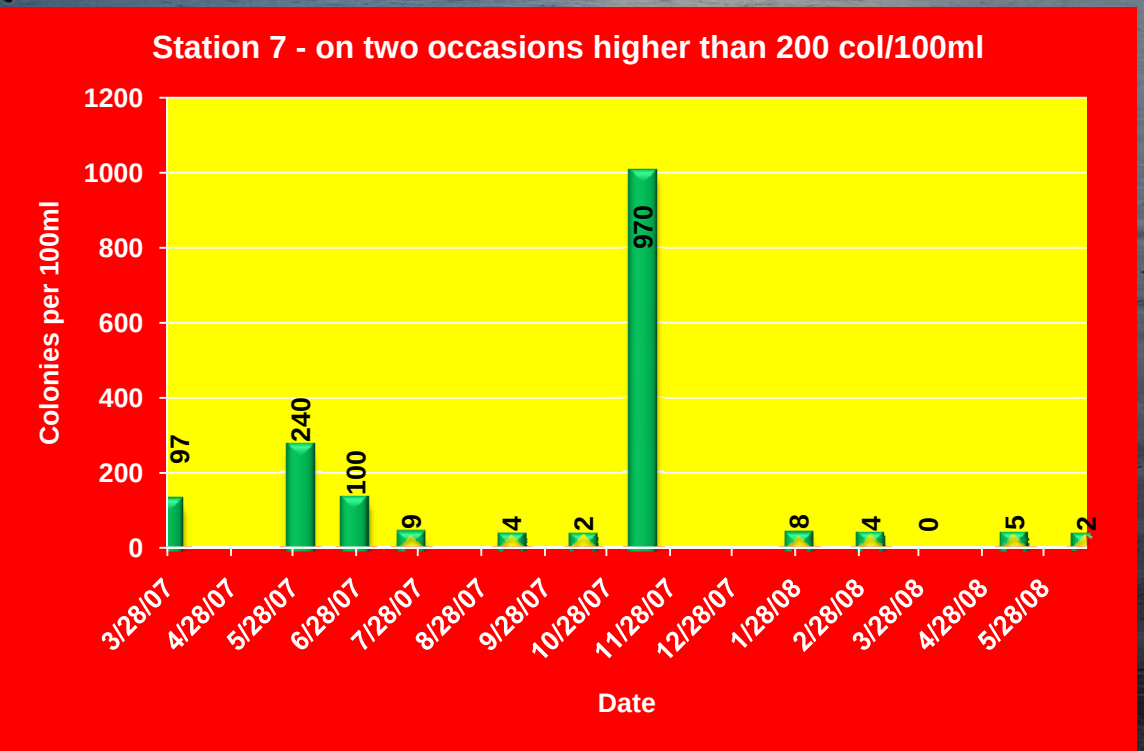
Station 7



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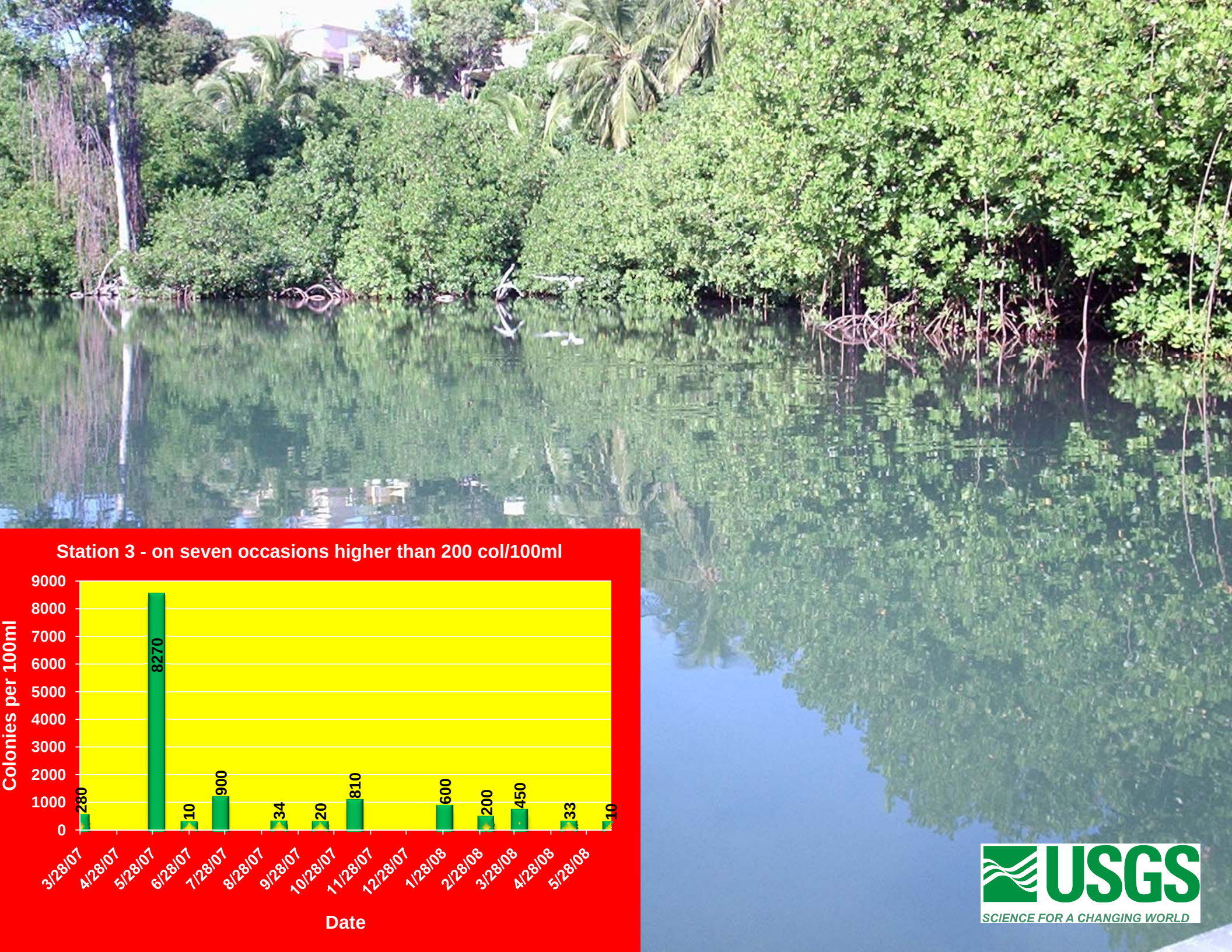

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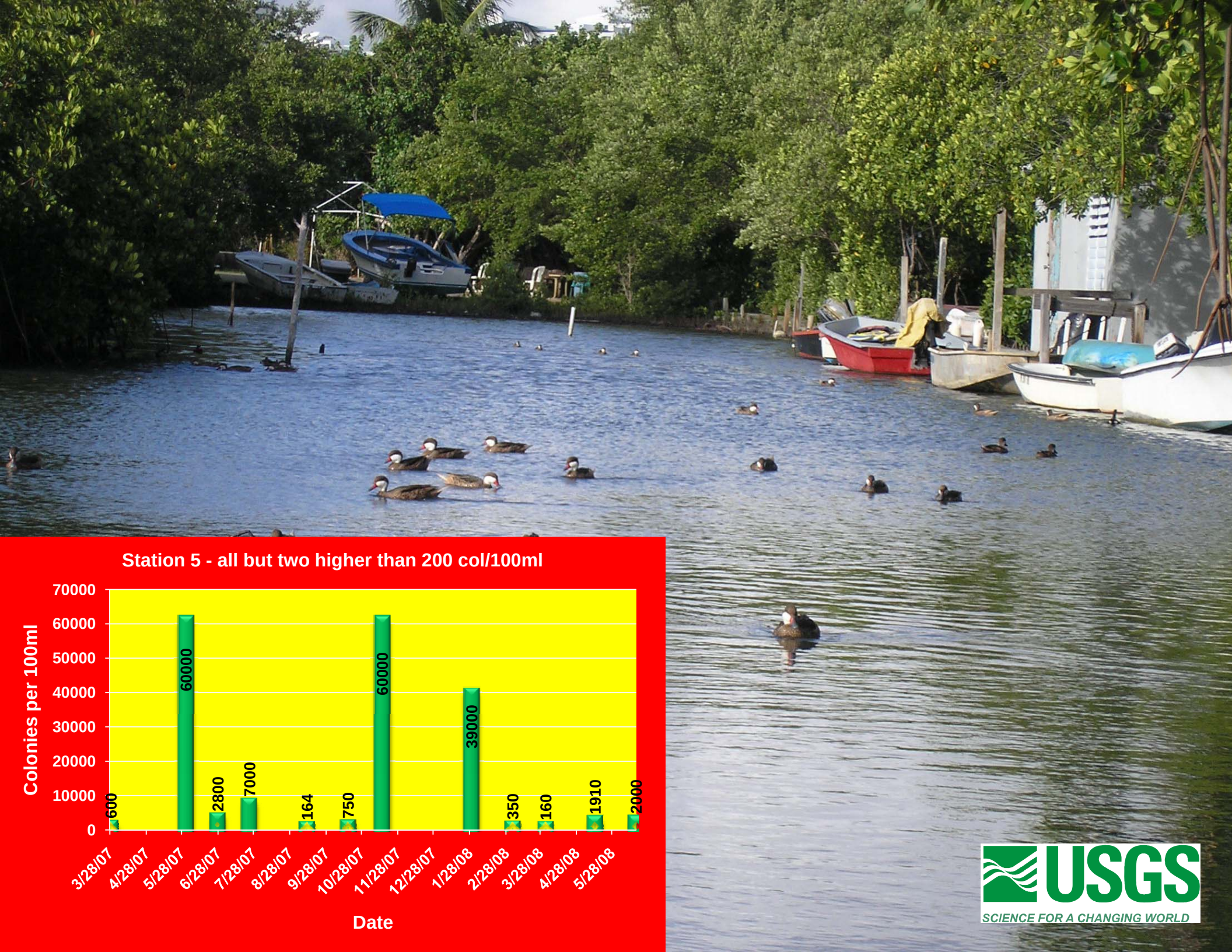

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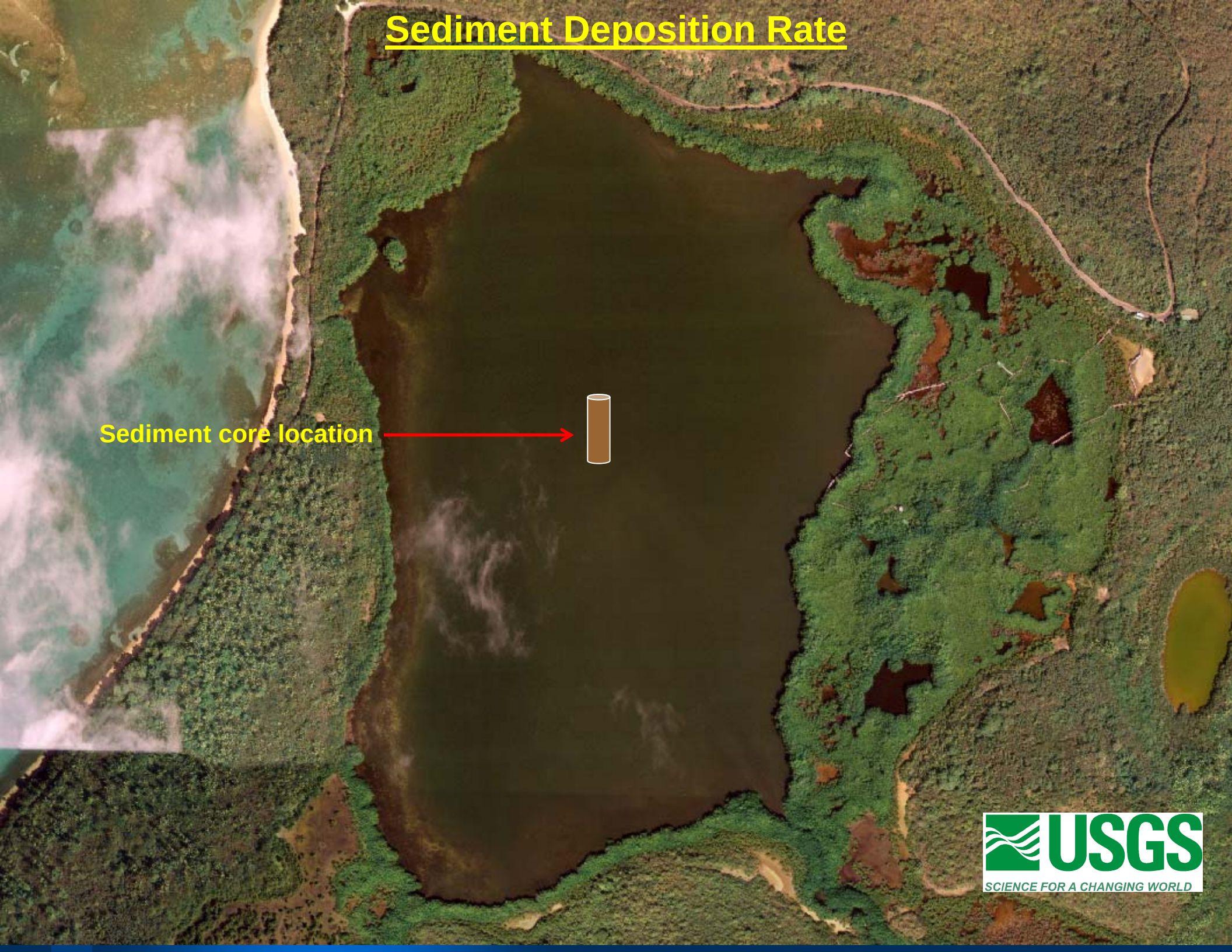
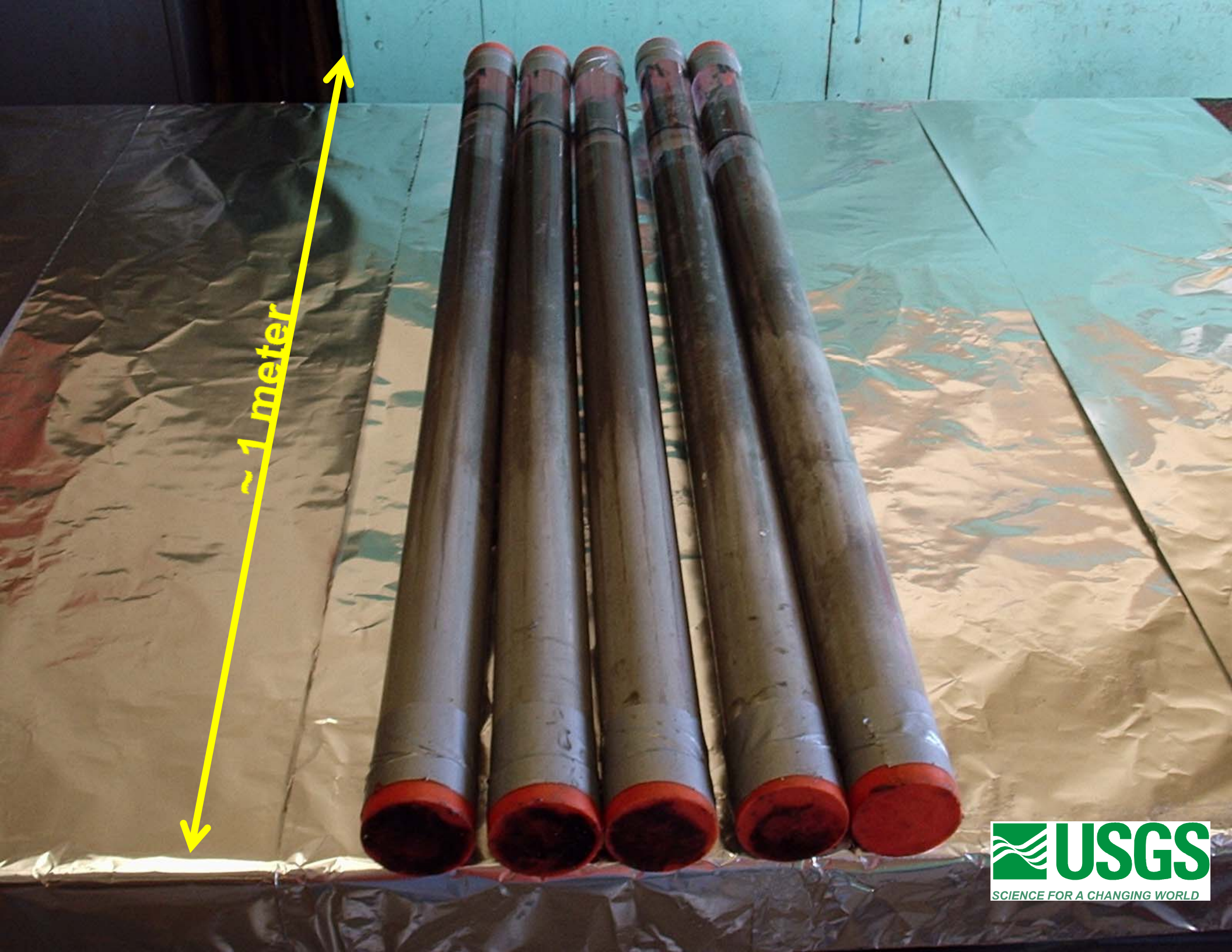
Sediment Deposition Rate




~ 1 meter
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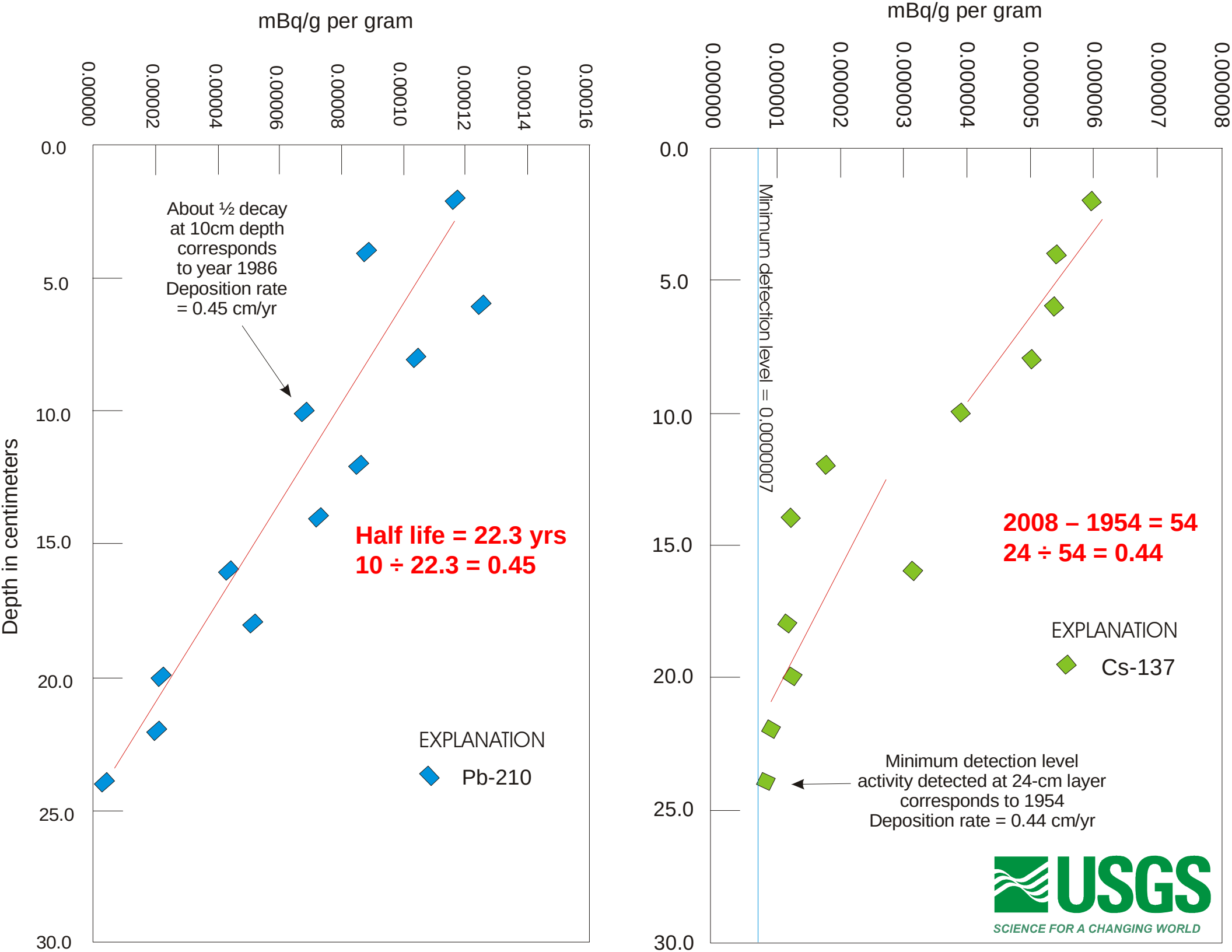
mBq/g per gram
0.000000
0.000002
0.000004
0.000006
0.000008
0.000010
0.000012
0.000014
0.000016
Depth in centimeters
0.0
5.0
10.0
15.0
20.0
25.0
30.0
About ½ decay at 10cm depth corresponds to year 1986 Deposition rate = 0.45 cm/yr
Half life = 22.3 yrs
10 ÷ 22.3 = 0.45
EXPLANATION
Pb-210
mBq/g per gram
0.000000
0.000001
0.000002
0.000003
0.000004
0.000005
0.000006
0.000007
0.000008
Minimum detection level = 0.0000007
2008 – 1954 = 54
24 ÷ 54 = 0.44
EXPLANATION
Cs-137
Minimum detection level activity detected at 24-cm layer corresponds to 1954 Deposition rate = 0.44 cm/yr
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Sediment Deposition Rate Results

- In average sediment deposits at a rate of about 0.44 centimeters per year
- Rate is similar to other coastal lagoons like Piñones and Torrecillas of the San Juan Bay Estuary System
- If rate continues unchanged the lagoon will become a marshland in about 700 to 900 years
- Rate could be accelerated by basin development

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Summary and Conclusions

- Rainfall was 44% (706 mm) of mean annual (1,605 mm)
- Lagoon has a volume of 662,000 cubic meters
- Lagoon recycles 13% of its water every day (47 times/yr or every 7.7 days)
- In general, all physical and chemical parameters were in compliance with PREQB standards
- Lagoon is homogeneous water body
- Lagoon is mesotrophic
- Produces 507 metric tons of organic matter every year
- Greatest impact is fecal contamination
- Lifespan of about 800 more years

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Summary and Conclusions – The Big Picture

- Unregulated lagoon use and basin development may have a greater impact in the future
- Results show the need to enforce PRQEB regulations
- A monitoring program is needed to document further impact and take timely actions

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