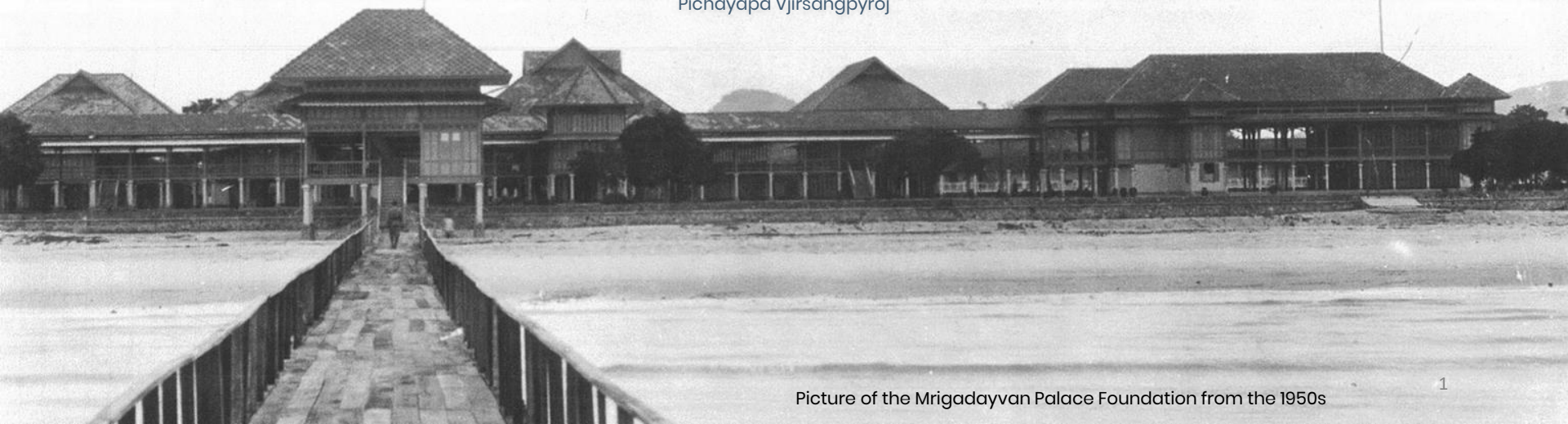


# Assessing the Impacts of Human Activity on Groundwater Salinity at the Mrigadayavan Palace in Cha Am, Thailand

Worcester Polytechnic Institute: Natalie Cohn, Nicole Cotto, Margaret Raque, & Megan Seely  
Chulalongkorn University: Penpicha Janprasert, Chisanupong Kunmas, Radmehr Mohammadali, &  
Pichayapa Vjirsangpyroj





# The Mrigadayavan Summer Palace

- Summer Palace of King Rama VI
  - Built in 1924
- Abandoned from 1925–1965
  - Border Police occupied site
- Registered as a site of national heritage in 1981
- Attempted restoration in 1987

# The Mrigadayavan Palace Foundation



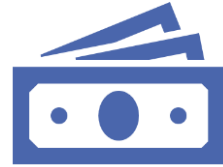
## Established

In 1995 after failed  
1987 restoration  
effort



## Goal

1. Restore the Palace  
to its 1924 condition  
by 2024
2. Sustainable  
development and  
conservation



## Funding Sources

Donations  
Admission Fees  
Gift Shop Sales  
Local Businesses

# Location

- Cha Am District in the Phetchaburi Province
- Coastal location, Gulf of Thailand
  - 3 hours south of Bangkok
  - North of Hua Hin





# Project Description

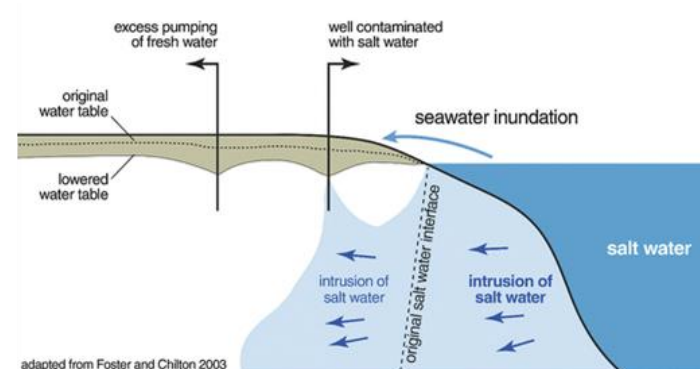
Sponsor Request:

- Identify causes of increasing local groundwater salinity
- Provide recommendations to restore and protect the groundwater



# Salinity

- **Definition**  
Concentration of salt dissolved in water
- **Global Impact**  
Potable water and farming complications
- **Local Impact**  
Agricultural difficulty on Palace grounds
- **Local Cause:** Seawater intrusion



## briny water

brine pools  
50+ ppt

## saline water

seawater, salt lakes  
30-50 ppt

## brackish water

estuaries, mangrove swamps,  
brackish seas and lake, brackish  
swamps  
.5-30 ppt

## fresh water

ponds, lakes, rivers, streams,  
aquifers  
0-.5 ppt

parts per thousand

50+ ppt

30 ppt

.5 ppt

0 ppt

\*traditional ways to express salinity is in "parts per thousand" or ppt

# Sustainable Water Management

## Definition

- The ability to meet the water needs of the present without compromising the ability of future generations to do the same

## The Mrigadayavan Palace

- Currently imports freshwater from other towns
- Does not pump water from on-site wells to prevent further seawater intrusion
- Nearby rice farming indicates freshwater aquifer
- Uses all plants and fruits grown on site to produce foods and goods for sale in the gift shop



The WPI-Chulalongkorn team interviewing Palace employees at a well

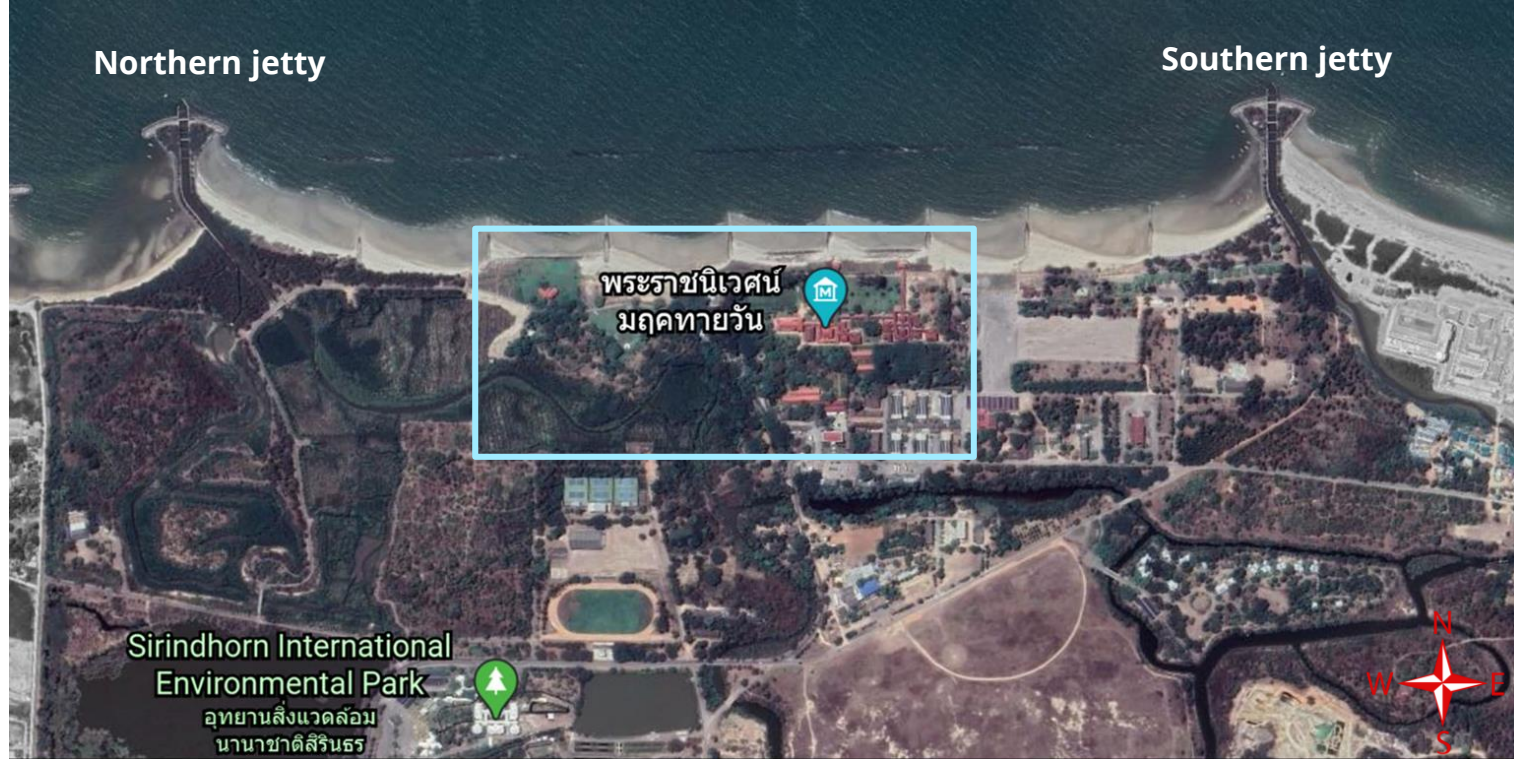


## **Project Objectives**

1. Determine salinity levels of groundwater and soil on the Palace grounds
2. Identify community awareness of increased groundwater salinity and the impacts of the mangroves and jetties
3. Analyze the causes of increased salinity on the Palace groundwater
4. Identify restoration strategies to restore fresh groundwater



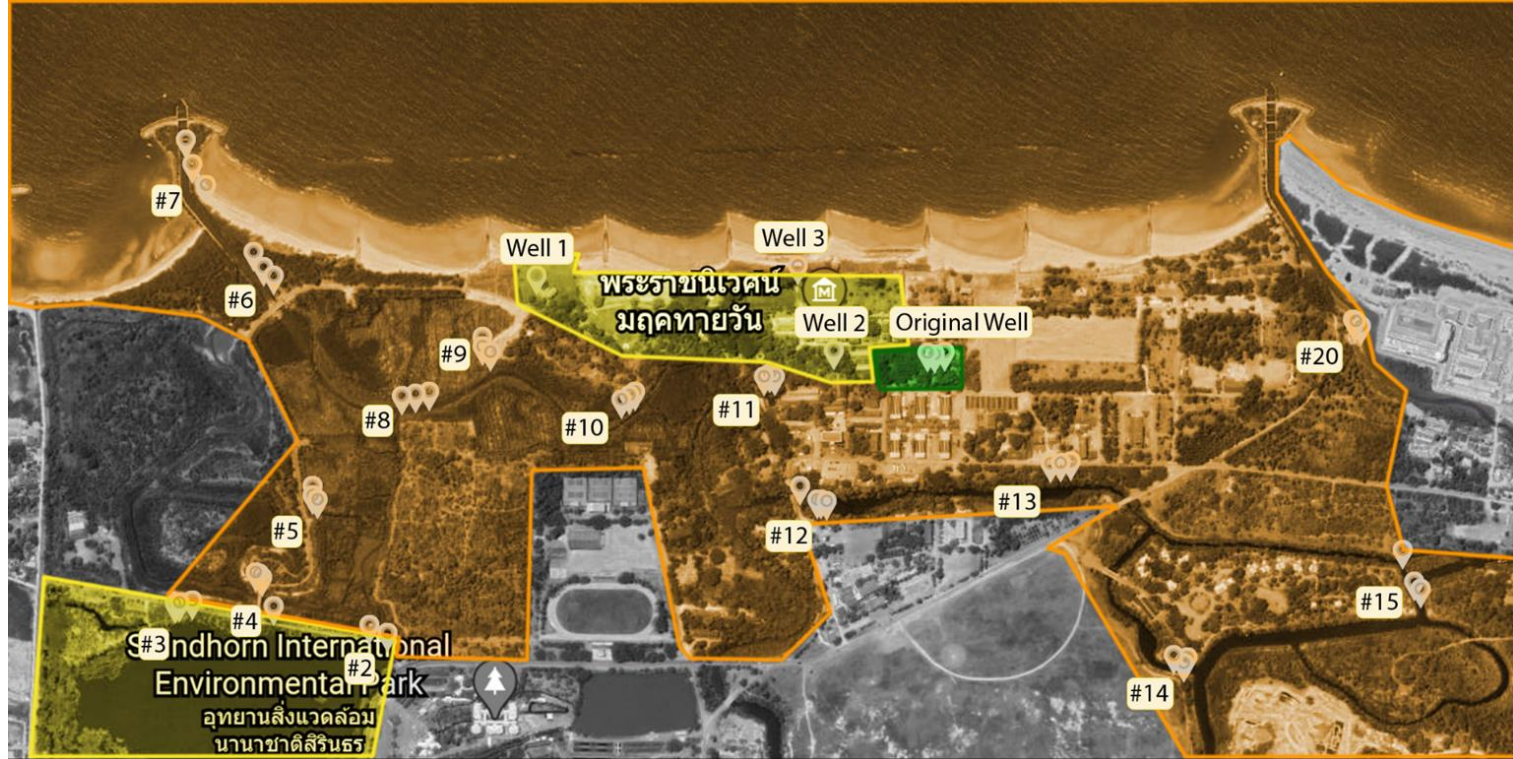
**1: Determine salinity  
levels of groundwater  
and soil on the Palace  
grounds**



## Aerial View of the Mrigadayavan Palace

*Image from 2019 Google Earth*

*Palace grounds are as indicated by the blue box.*



## Groundwater Salinity Gradient at the Mrigadayavan Palace

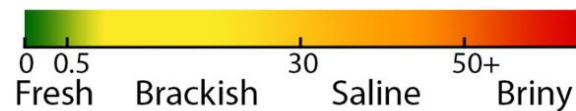
*Taken by the Mrigadayavan Palace Foundation on December 28, 2019*

### Map Key

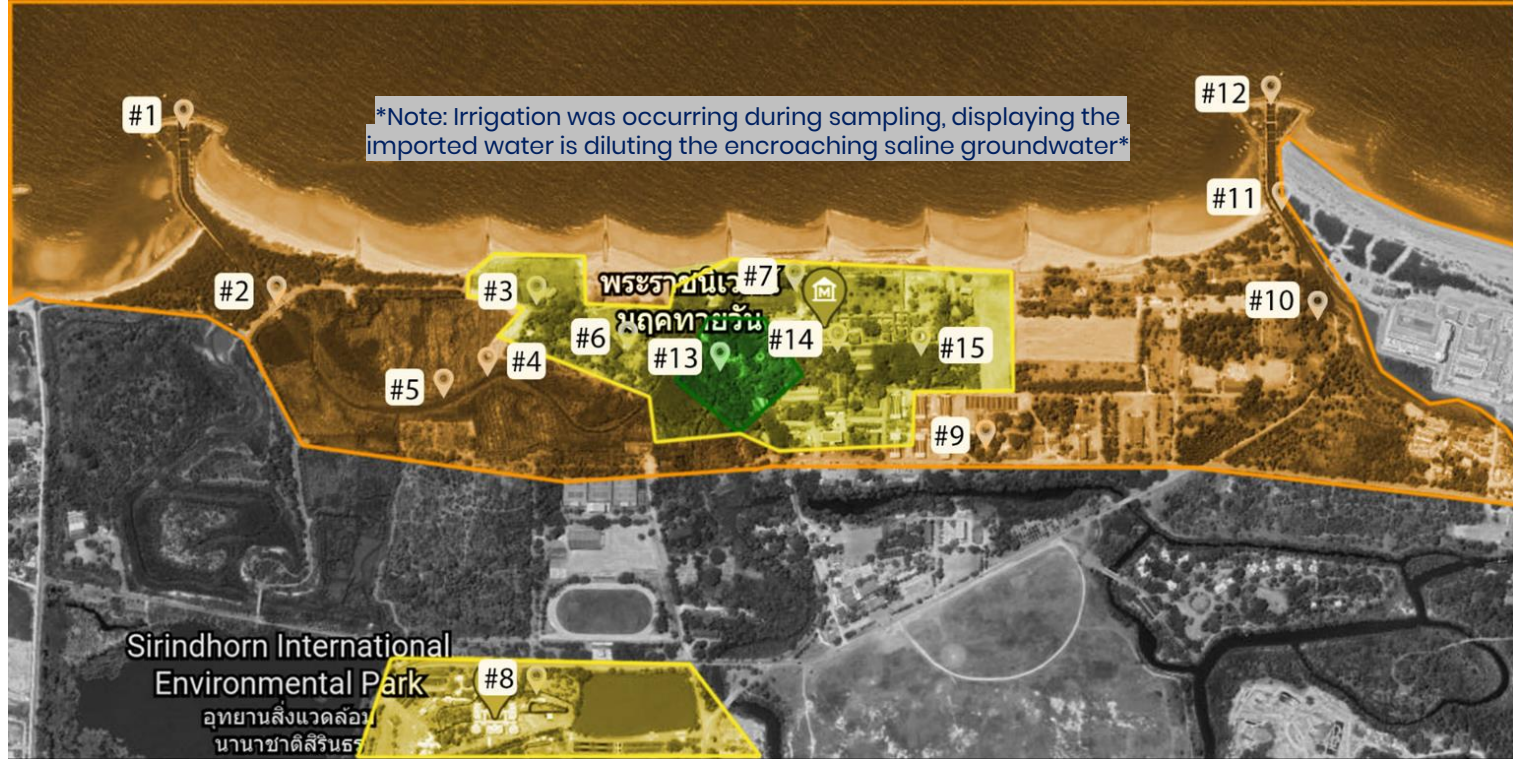
-  Sampling Location
-  Site Number

*Black and white areas were not assessed*

### Salinity Gradient Key (in ppt)







## Groundwater Salinity Gradient at the Mrigadayavan Palace

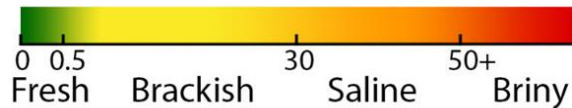
Taken by the IQP-ISSP Team on January 21, 2020

### Map Key

- 📍 Sampling Location
- 📍 Site Number

Black and white areas were not assessed

### Salinity Gradient Key (in ppt)







## Soil Salinity Gradient at the Mrigadayavan Palace

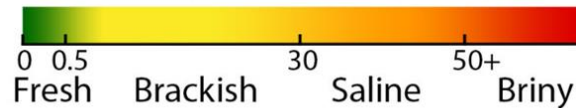
Taken by the IQP-ISSP Team on January 21, 2020

### Map Key

- Sampling Location
- Site Number

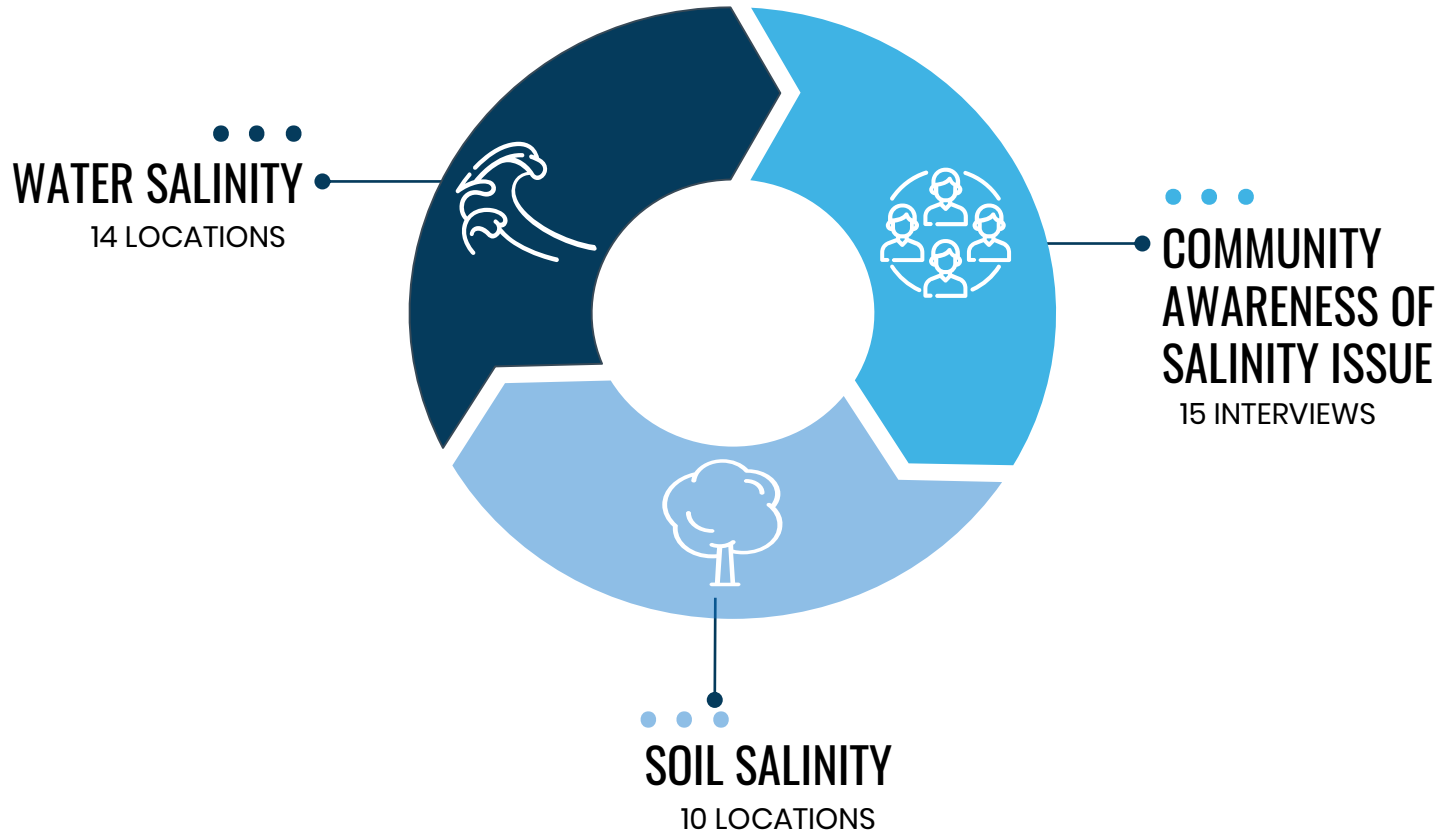
Black and white areas were not assessed

### Salinity Gradient Key (in ppt)



**2: Identify community awareness of increased groundwater salinity and the impacts of the mangroves and jetties**

# On-Site Data Collection



# Community Interview Profiles



Fishermen



Merchants



Residents



Policemen

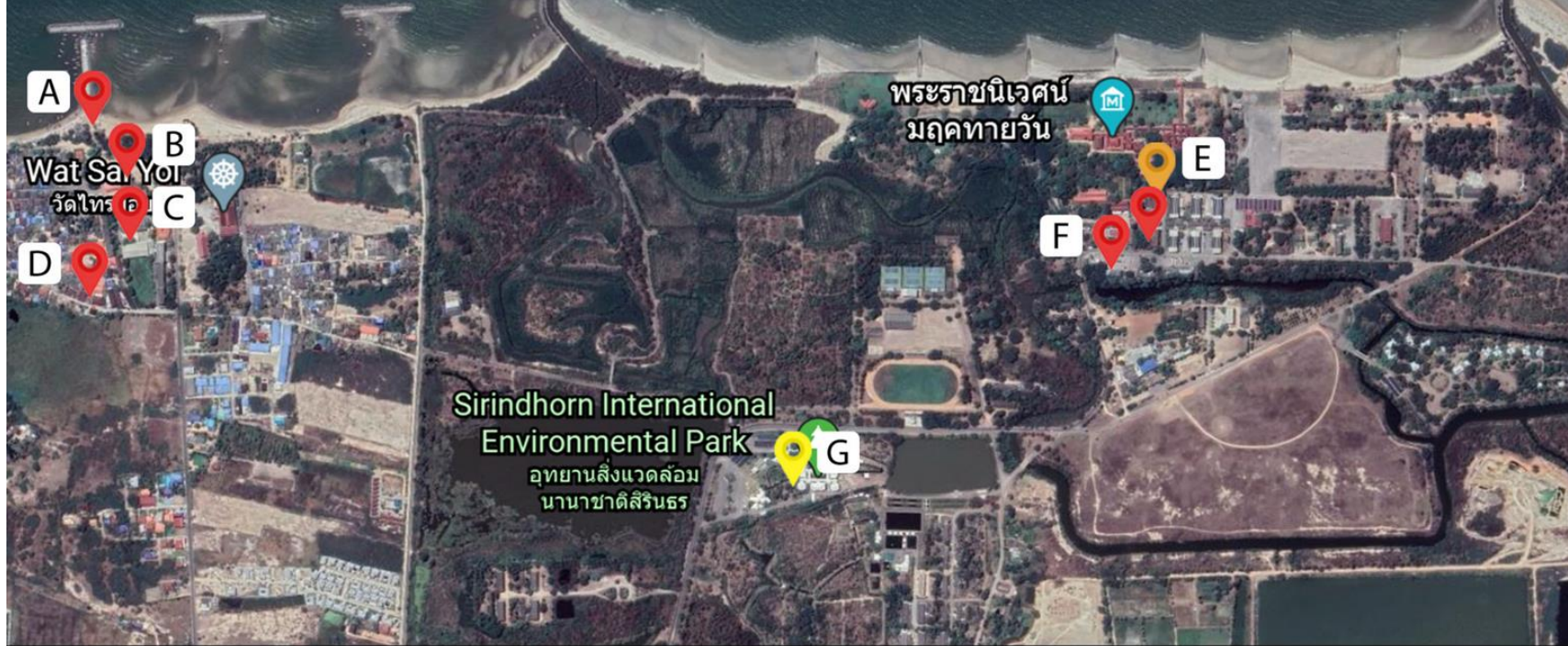


Teachers



Environmental Park





## Community Interview Locations Around the Mrigadayavan Palace

*Conducted by the IQP-ISSP Team from January 20-22, 2020*

### Map Key



Community residents  
or workers



Border Police



Sirindhorn International  
Environmental Park

**A** -Fisherman

**B** -Merchant

**C** -Teacher

**D** -Resident

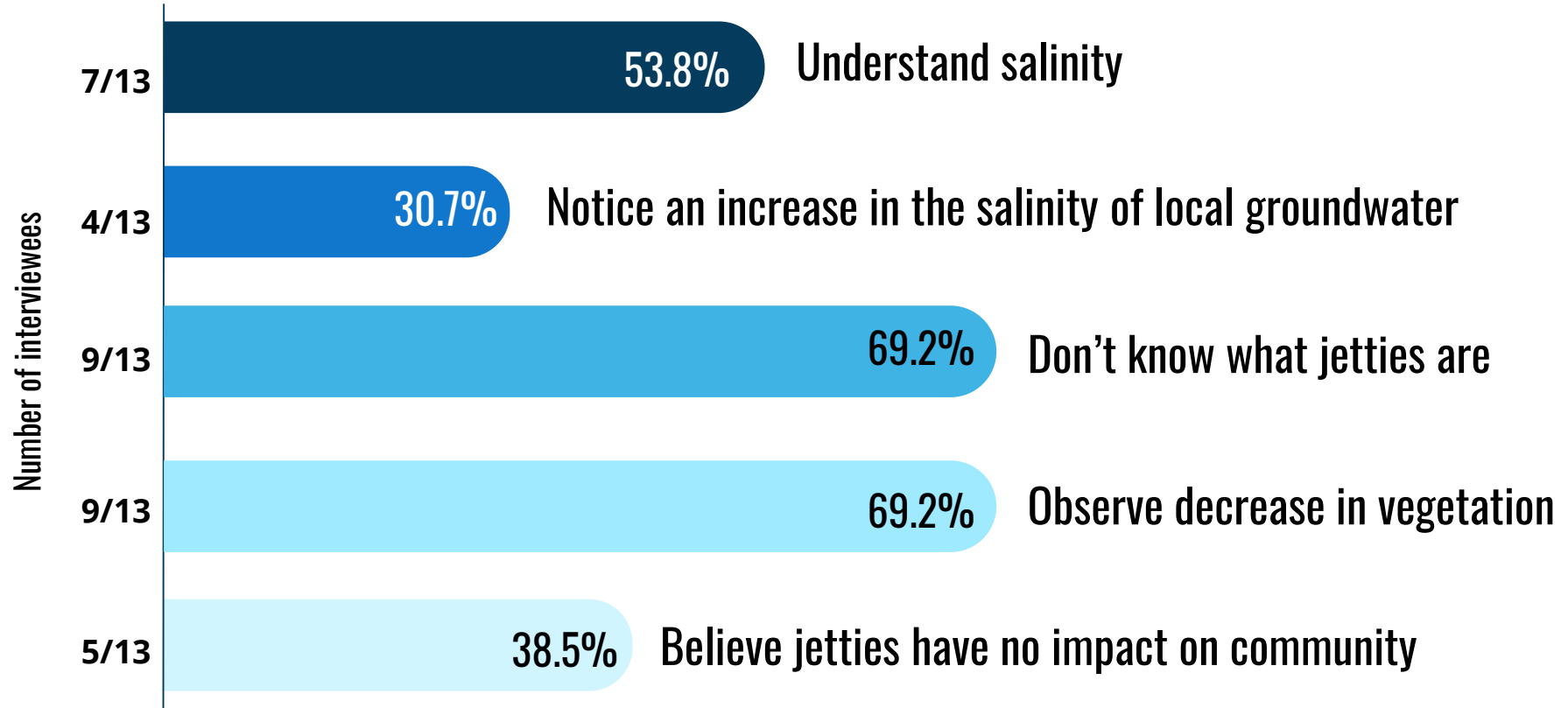
**E** -Border Police

**F** -Merchant

**G** -Env. Park

*Black and white areas were not assessed*

# Interview Responses of 13 People



### **3: Analyze the causes of increased salinity on the Palace groundwater**

# The Jetties

*built in 2005*

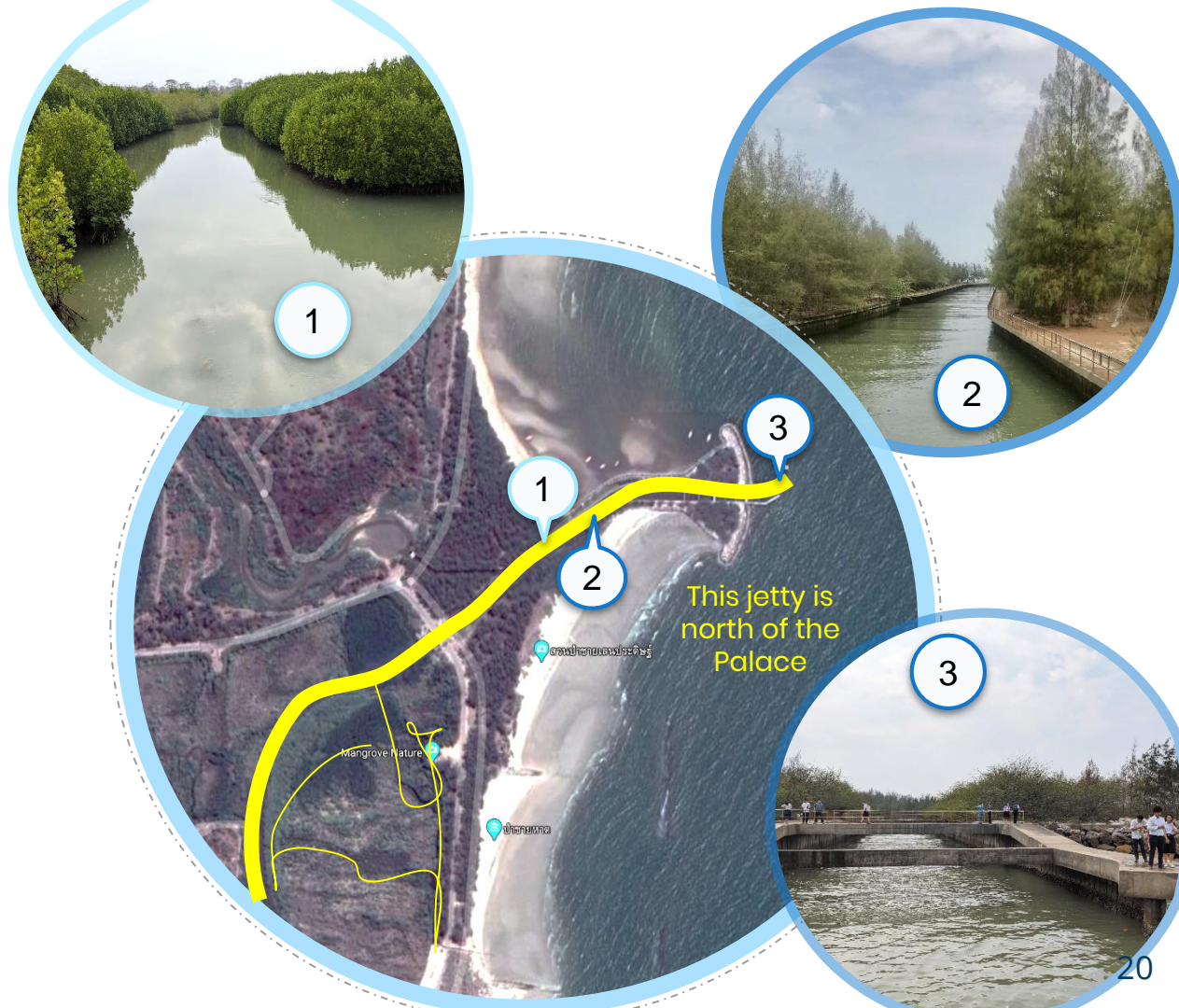
**Jetty:** a breakwater constructed to protect or defend a harbor, stretch of coast, or riverbank

## Seawater Supply

...

Mangroves can grow in brackish water (0.5-30 ppt)

These mangroves do not have a specific care schedule





# Palace Data – North Jetty

12/28/19

30.53

#7

30.57

#6

# Our Data – North Jetty

1/21/20

#1

30.8

#2

30.9

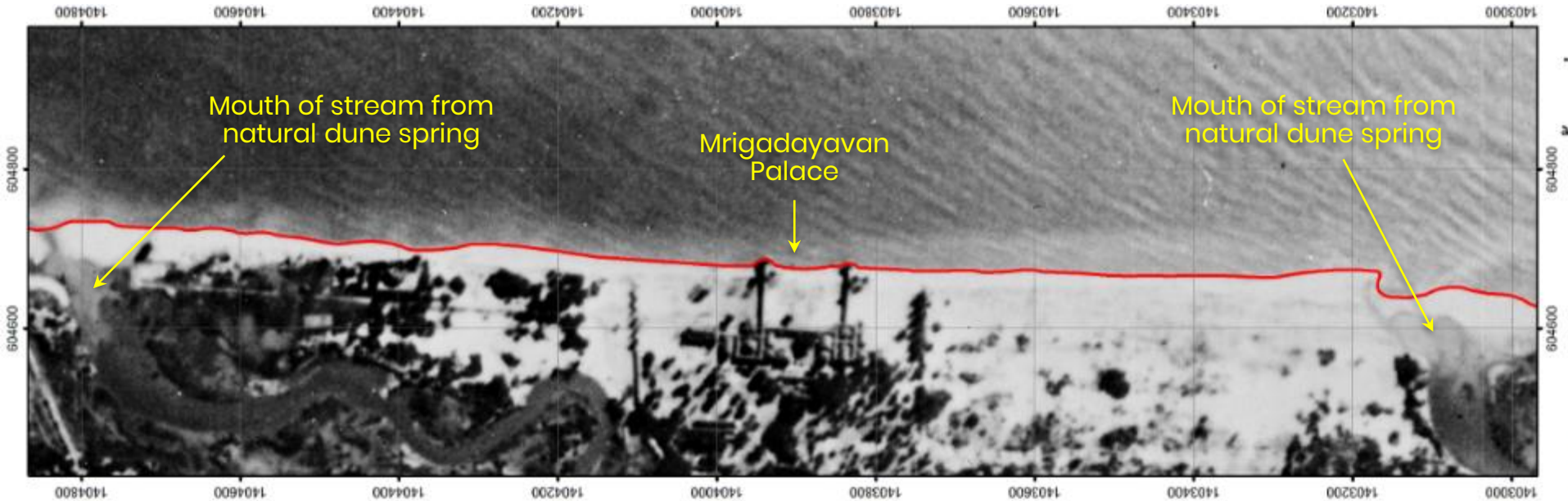
#5

Notable increase in salinity levels in just 1 month

# Other observations:

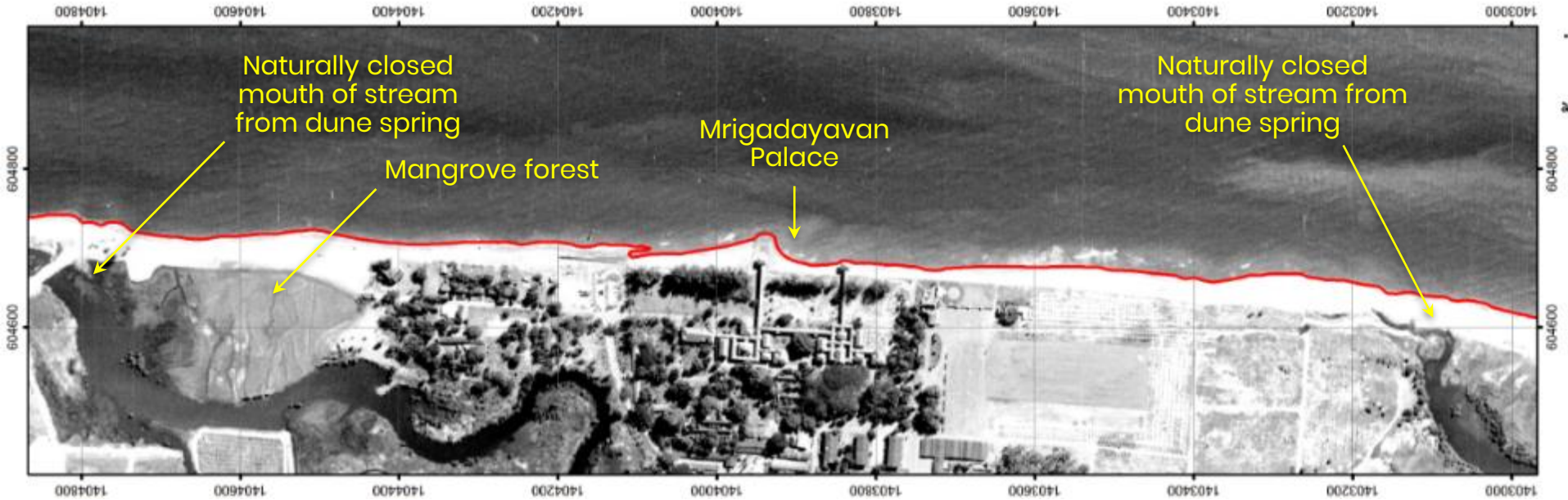
Updrift and downdrift,  
pollution of the land and gulf,  
& poor conditions

1954



Earliest aerial image of the Palace

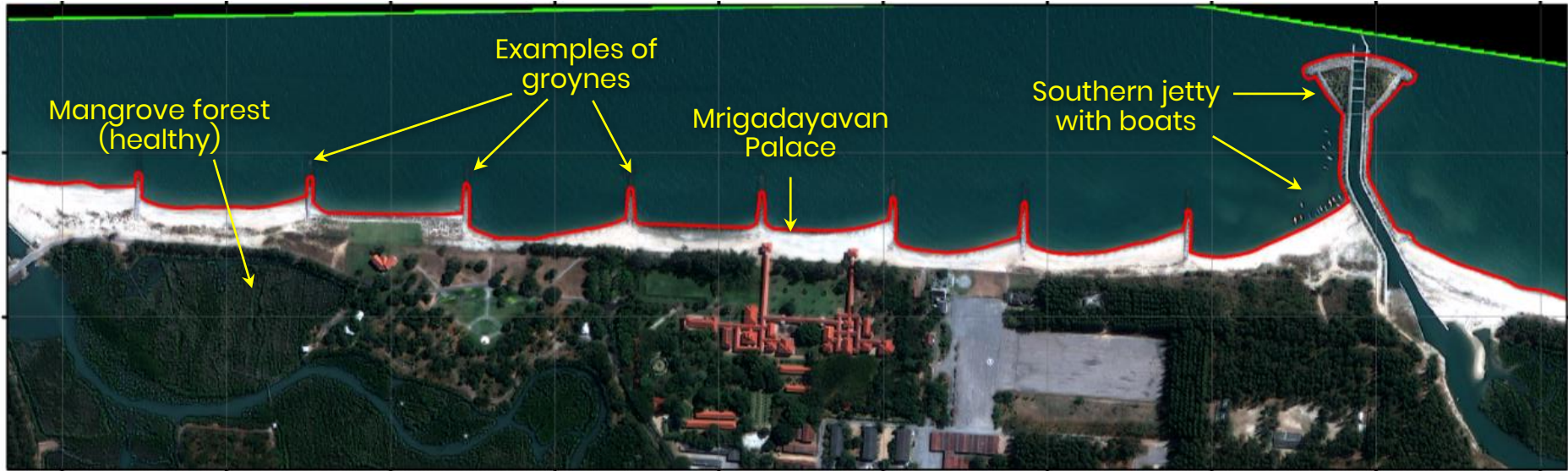
**1995**



**1 year after mangroves were planted**

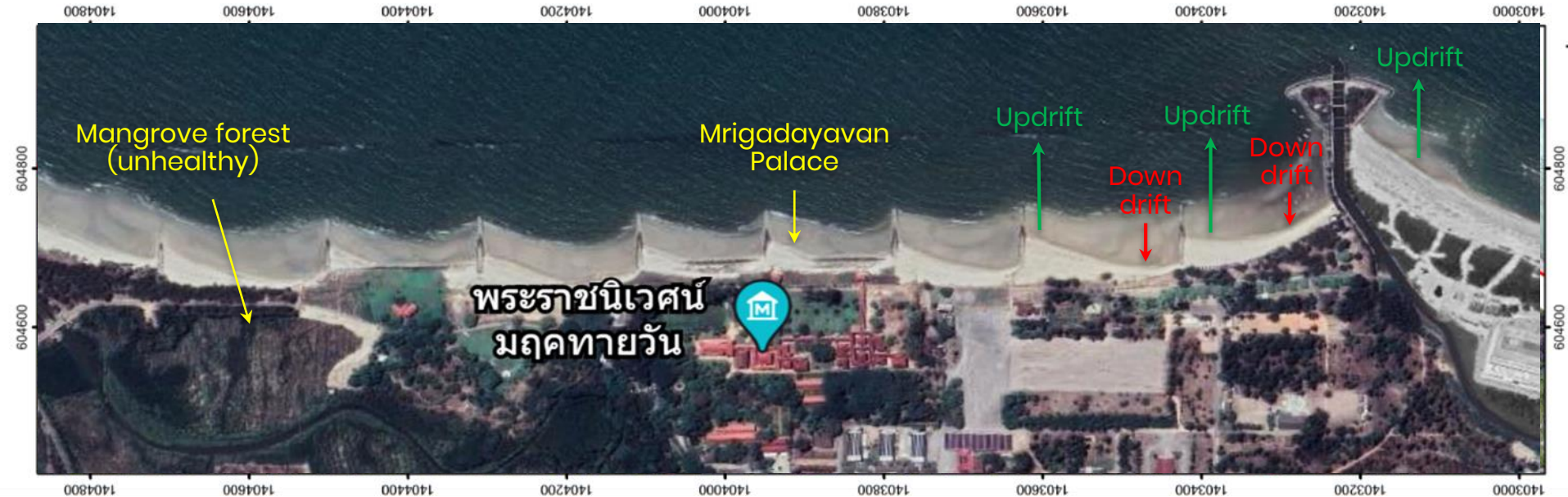


**2008**



**3 years after jetty and groyne construction, boats sheltered by jetty**

2019



Current aerial image of the Palace (at low tide)

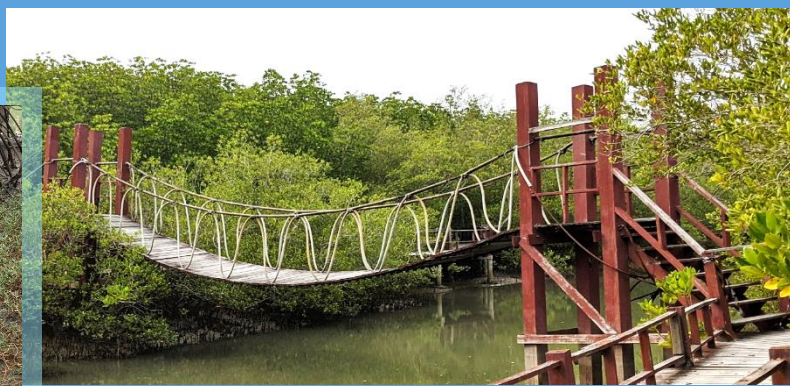


# State of the Mangroves

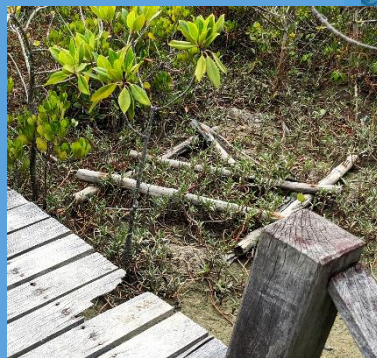
- Constantly fed seawater by jetties
- Non-native
- No maintenance
- Few visitors
- Serve environmental purposes only



Bridge supports are being unearthed



Bridge across seawater stream is closed and said would likely "collapse" if crossed



Walkway and railings are falling apart



Signs are illegible, rusting, and peeling



**Gulf of Thailand**

**Stream output from the northern jetty**





**Dumped trash on top of ashes  
along the beach outside the  
town north of the Palace**





**“Homes” on the jetty (above)  
and along the beach (right)**







**A man rests in a hammock, surrounded by trash, fishing equipment, and shack-like housing, while resorts loom in the background**

# **4: Identify strategies to restore fresh groundwater**



# Recommendations for the Jetties



Fill in the  
jetties



Jetty  
removal

# Additional Recommendations for the Jetties



Install saline  
water pump for  
mangroves  
(if needed after a  
few years)

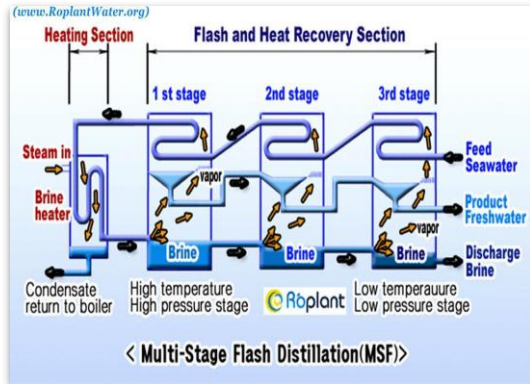


Advocate for  
boat dock  
for  
community

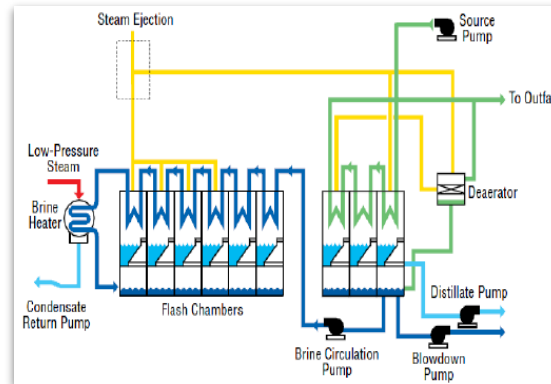


Install water  
barrier

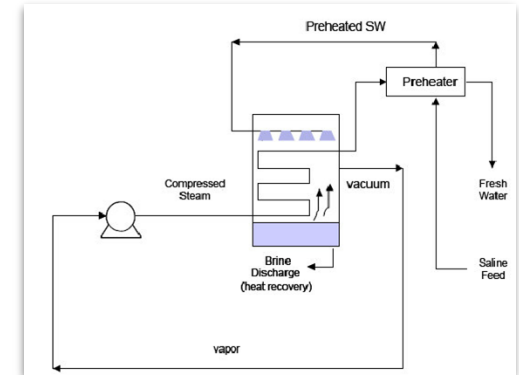
# Recommendations for Desalination Methods



Multistage  
Flash  
Distillation

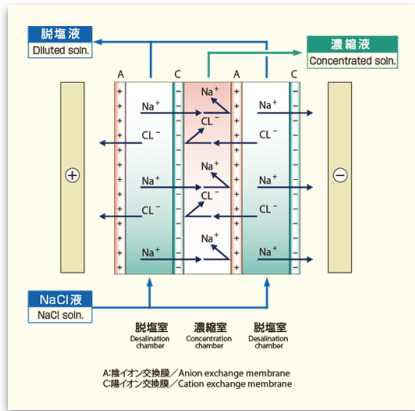


Multi Effect  
Distillation

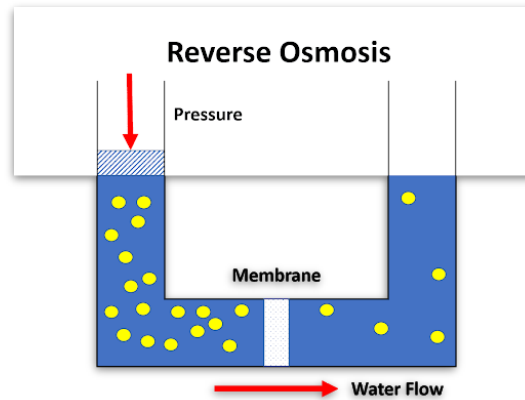


Vapor  
Compression

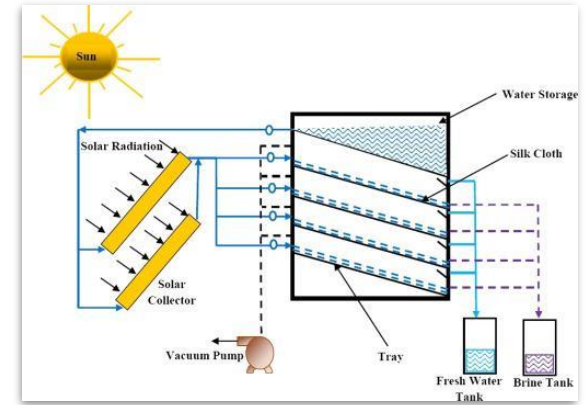
# Recommendations for Desalination Methods



Electrodialysis



Reverse osmosis



Solar Desalination



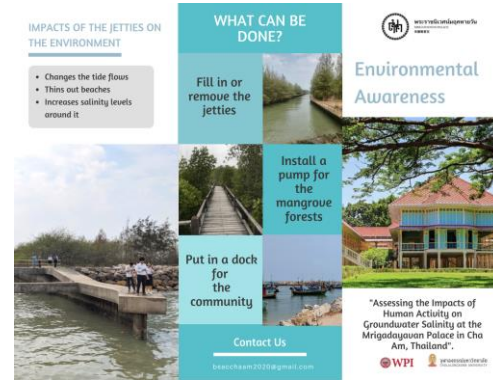
# Increase Community Awareness



## Presentation for locals

Delivered at community meeting  
place or the Palace

*English and Thai versions available*



## Brochure for visitors and locals

Distributed at a residential place  
and/or the Palace

*English and Thai versions available*

# Acknowledgements



พระราชนิเวศน์มฤคทายวัน  
MRIGADAYAVAN PALACE  
美麗閣夏宮

*Our sponsor*



*Our university*



จุฬาลงกรณ์มหาวิทยาลัย  
CHULALONGKORN UNIVERSITY

*Our host university*

For more information contact: [gr-BKKC20-salinity@wpi.edu](mailto:gr-BKKC20-salinity@wpi.edu)