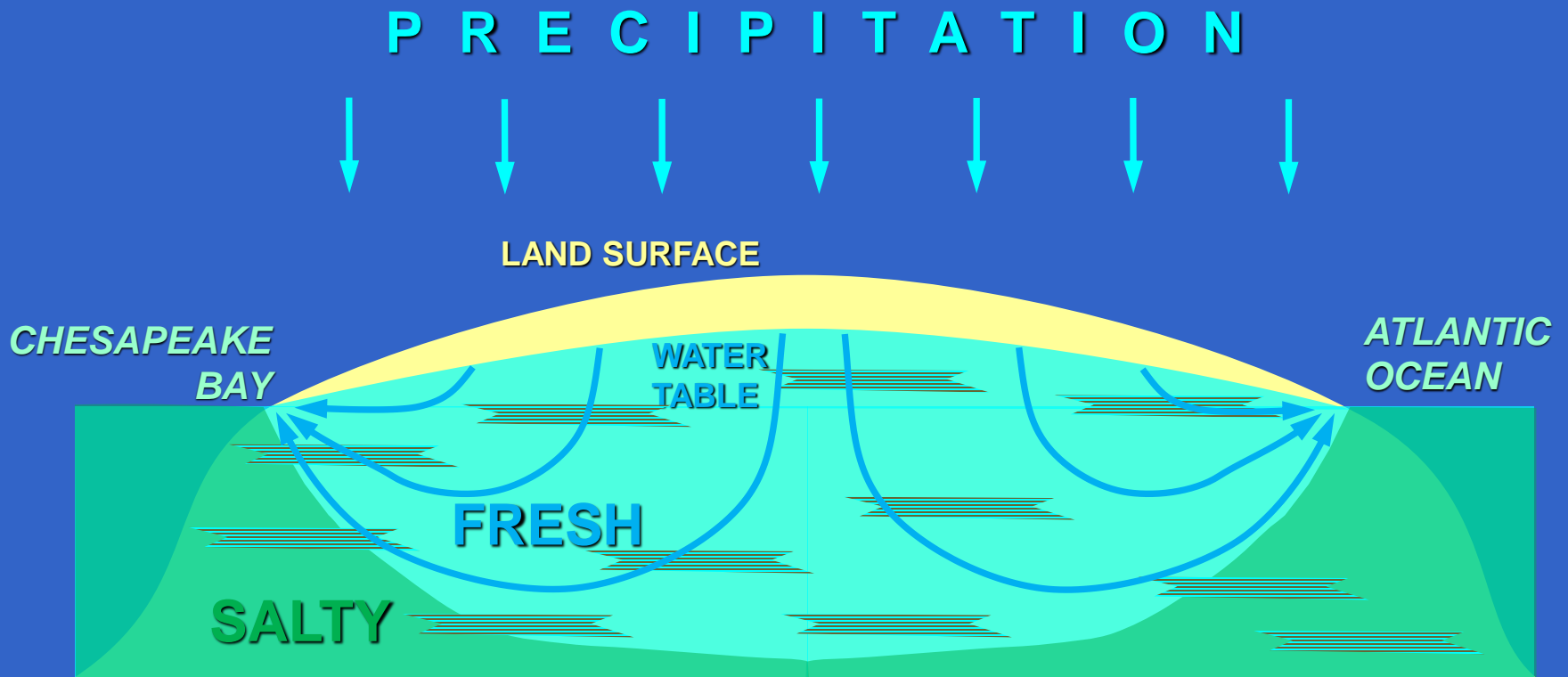


# *Well Logging to Monitor Groundwater Salinity*

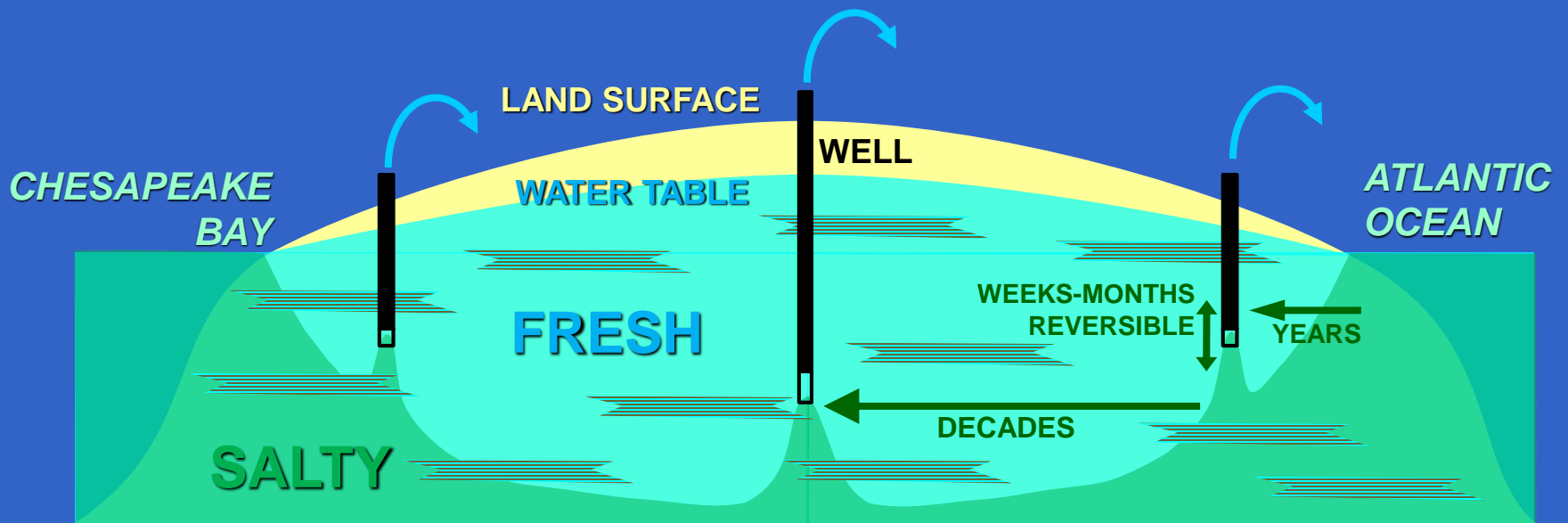
1. **basic concepts**
2. **preliminary results**
3. **tentative explanations**
4. **planning outlook**

# *Groundwater Flow*



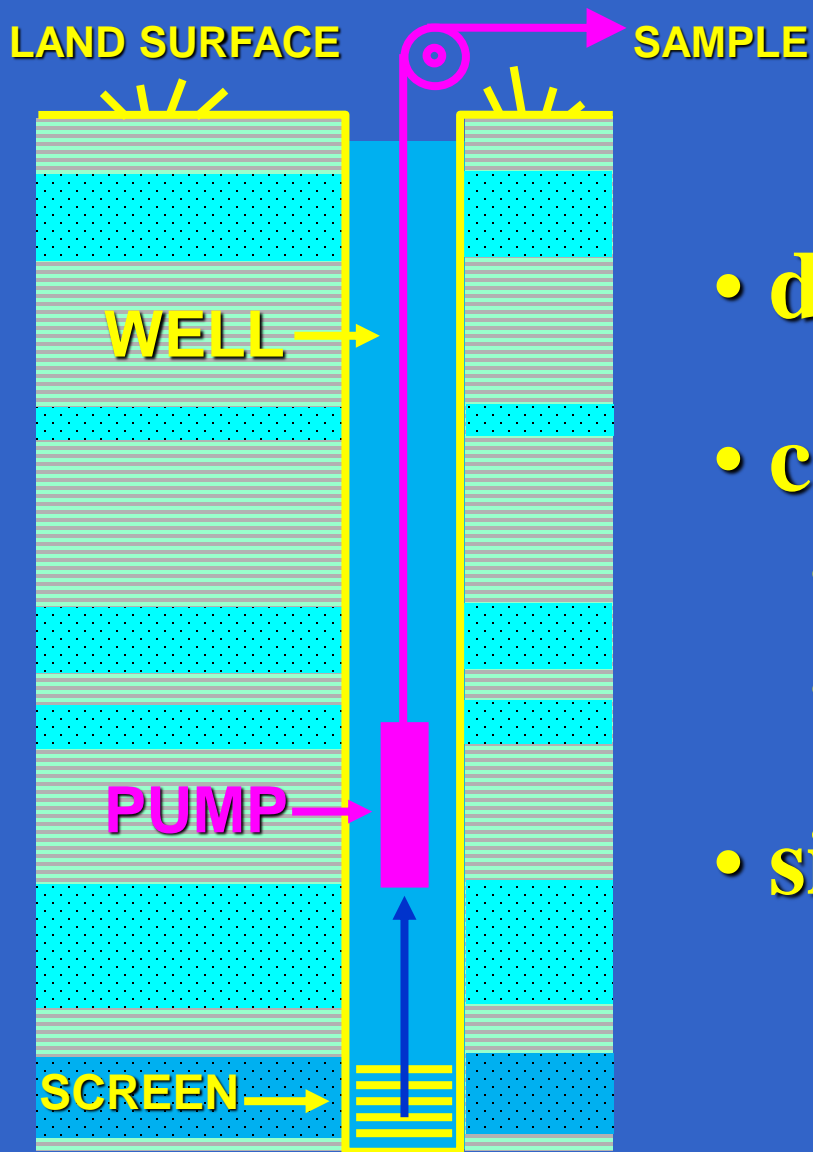
\*\*\* VERTICAL SCALE GREATLY EXAGGERATED \*\*\*

# *Pumping-Induced Saltwater Movement*



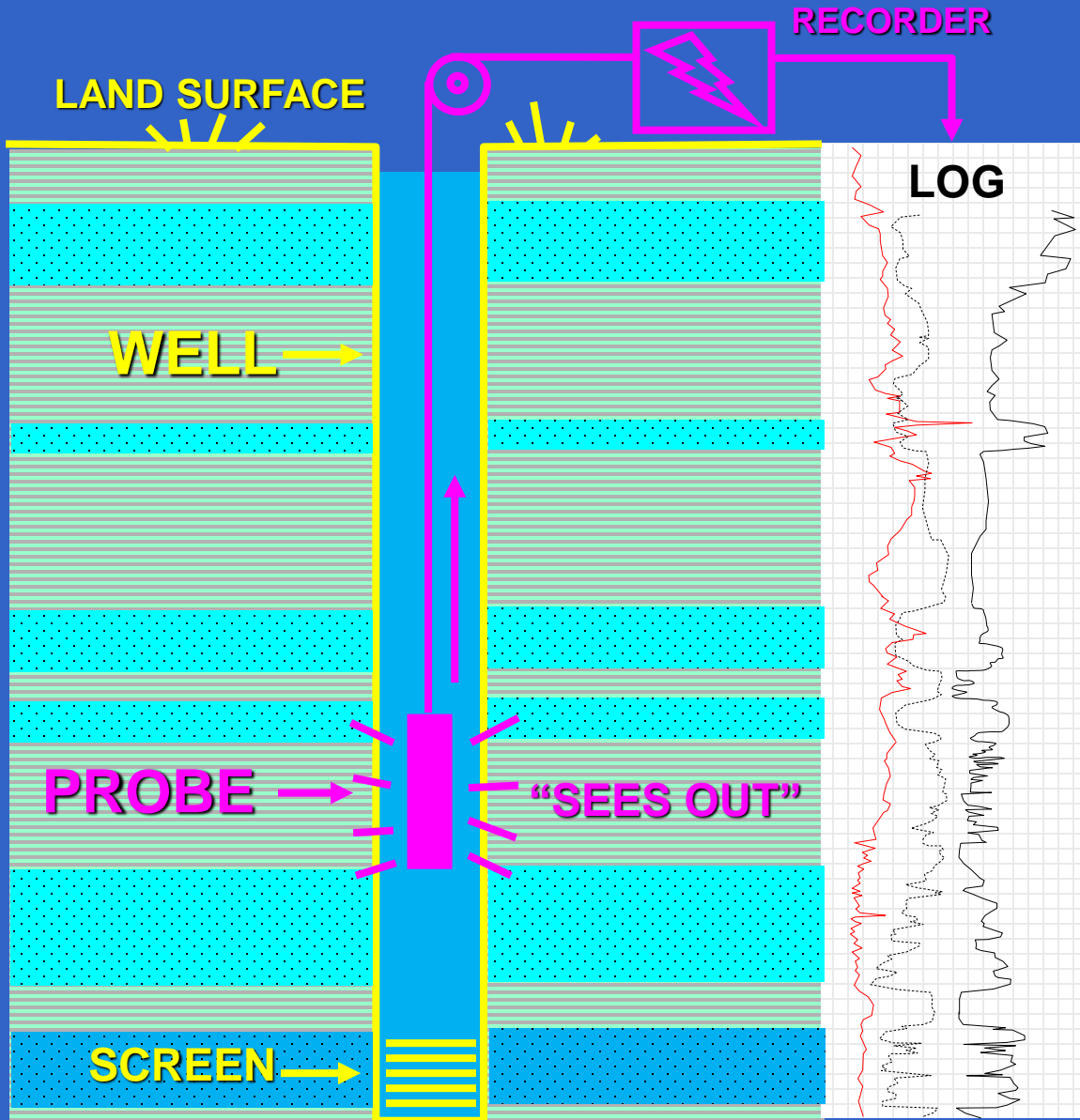
**\*\*\* VERTICAL SCALE GREATLY EXAGGERATED \*\*\***

# *Well-Sample Monitoring*



- **direct observation**
- **costly**
  - **slow sample collection**
  - **lab analyses**
- **single water zone**

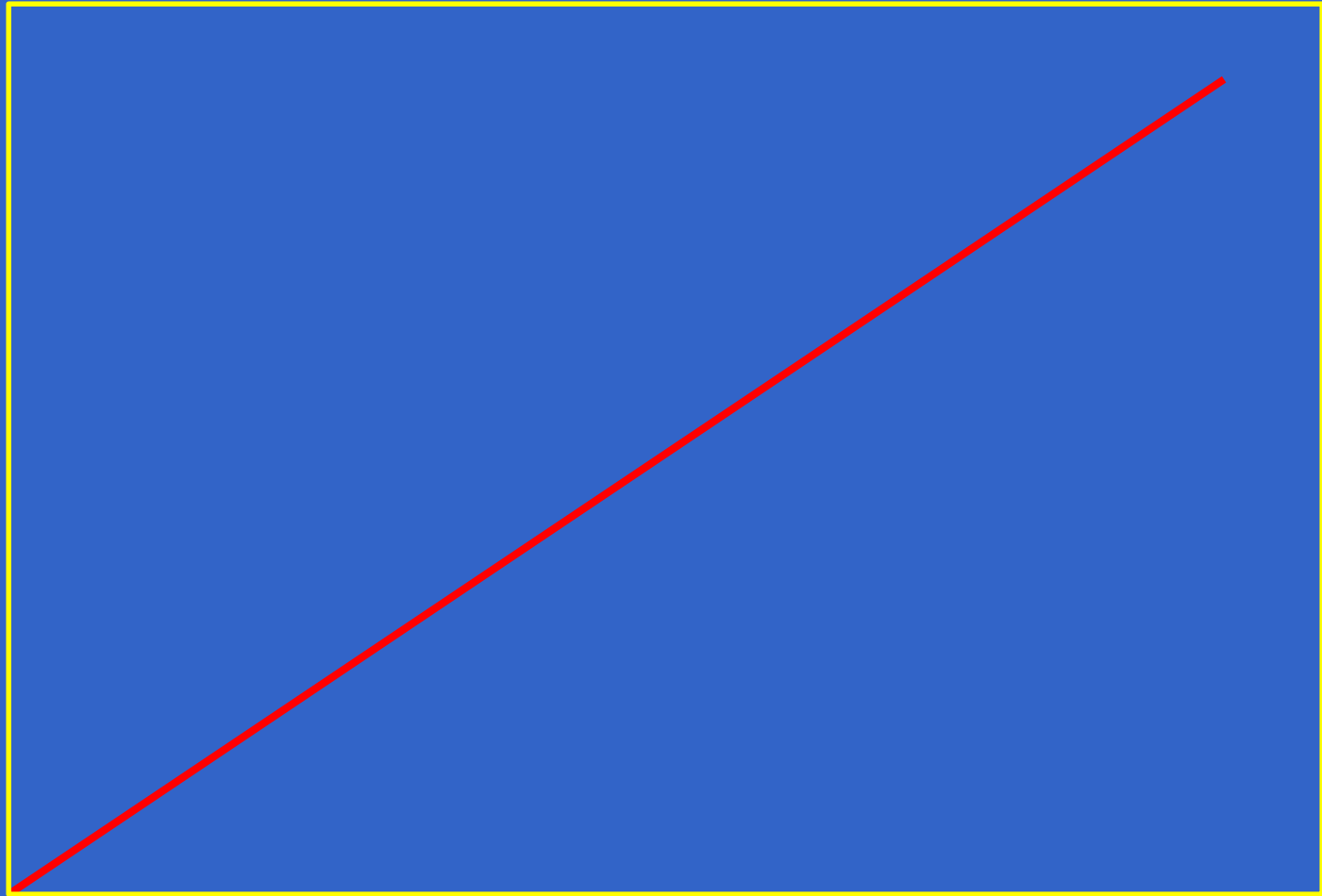
# Well-Log Monitoring



- low cost
  - fast field method
  - no lab
- entire profile
- indirect observation
- only shows changes in salinity over time

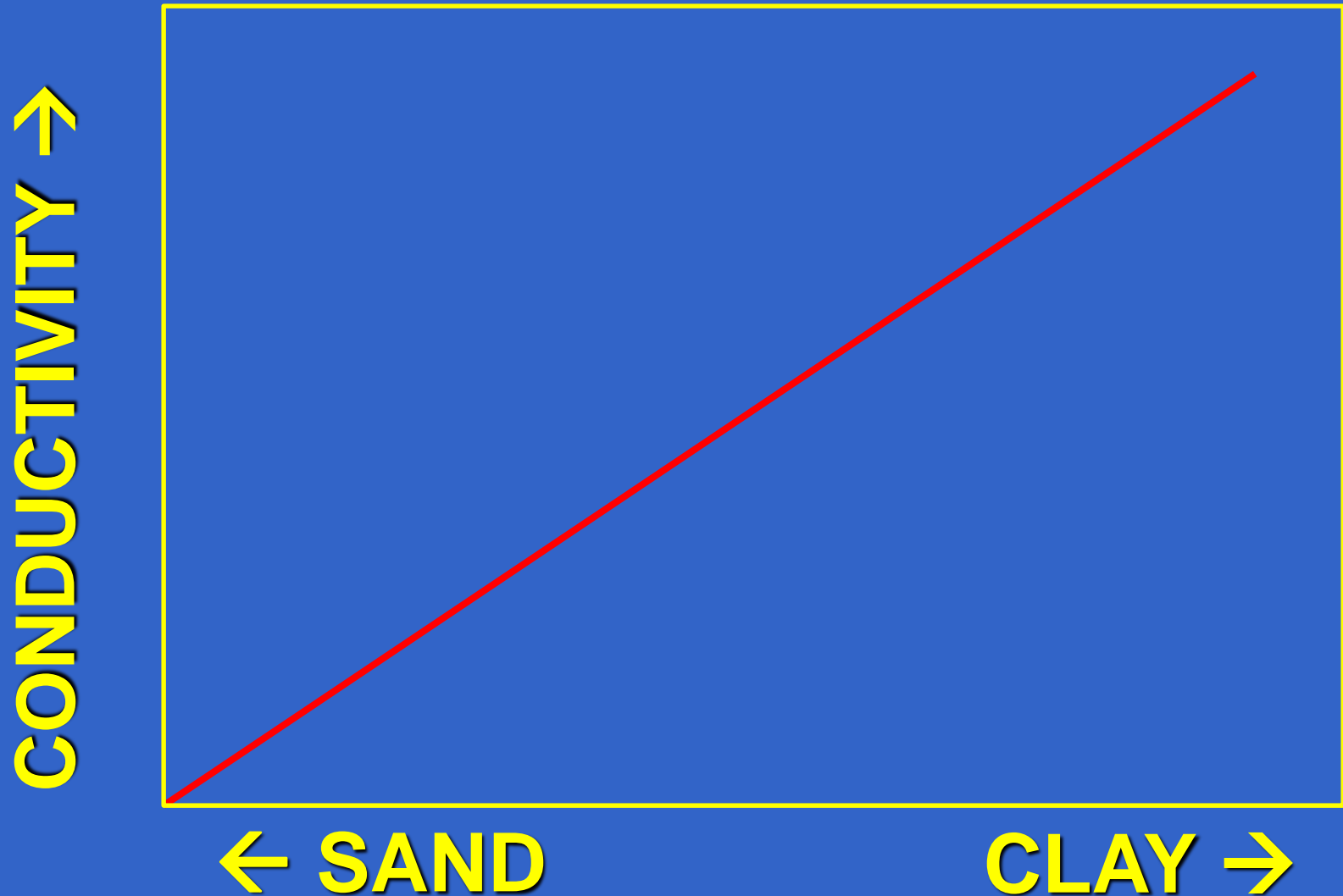
# *Conductivity and Salinity*

CONDUCTIVITY →

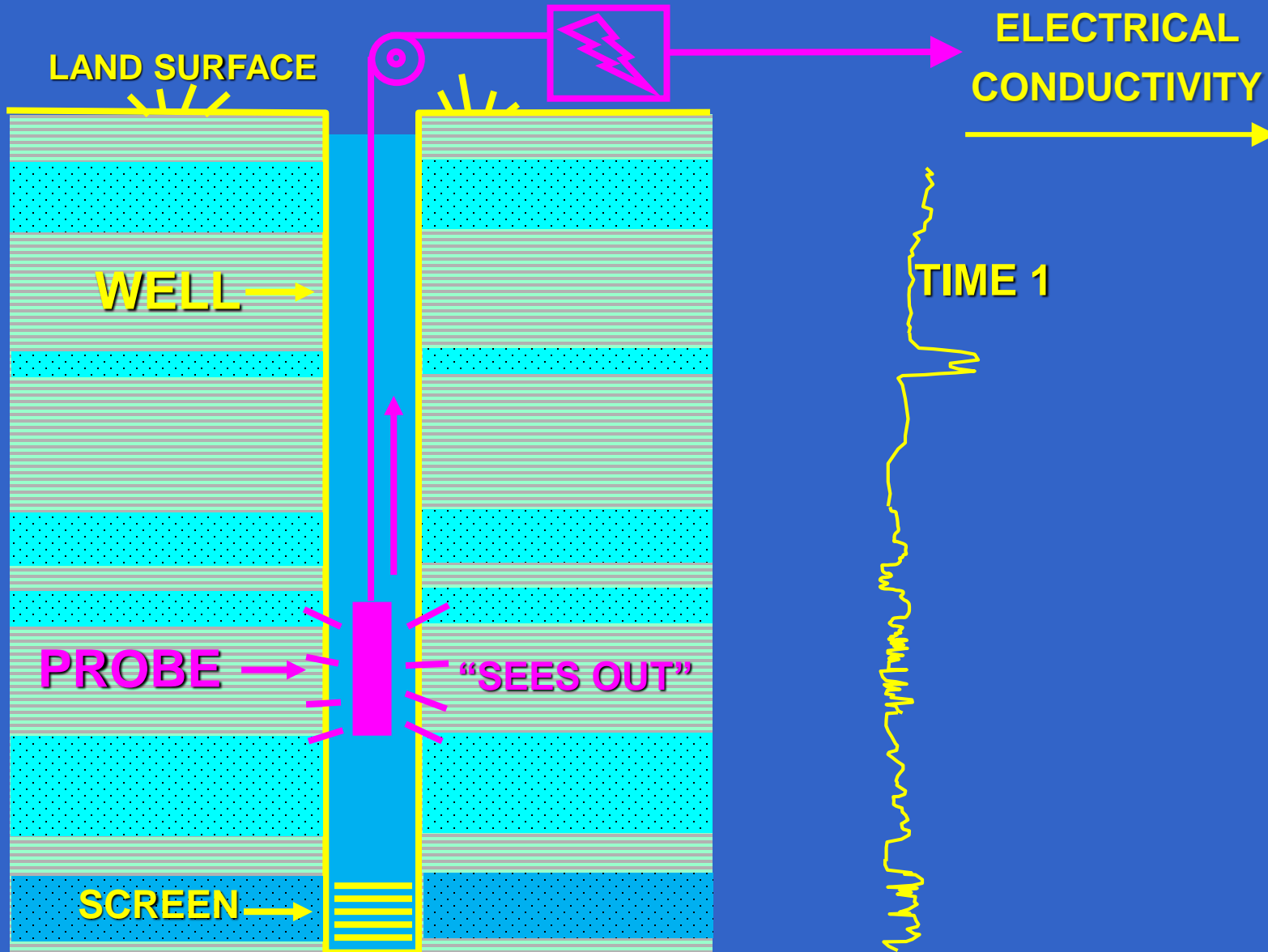


SALINITY →

# *Conductivity and Sediment Texture*

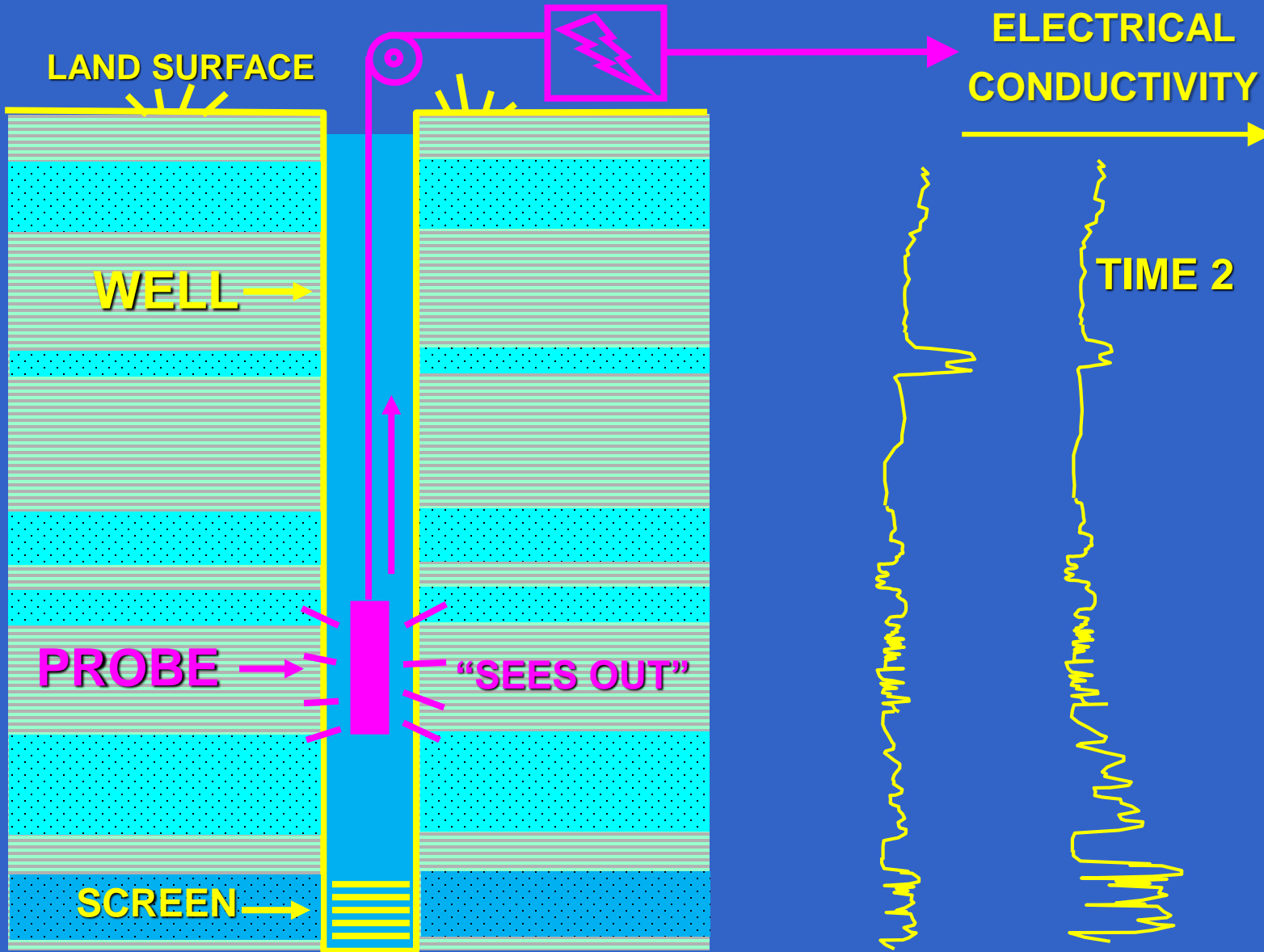


# Well-Log Monitoring

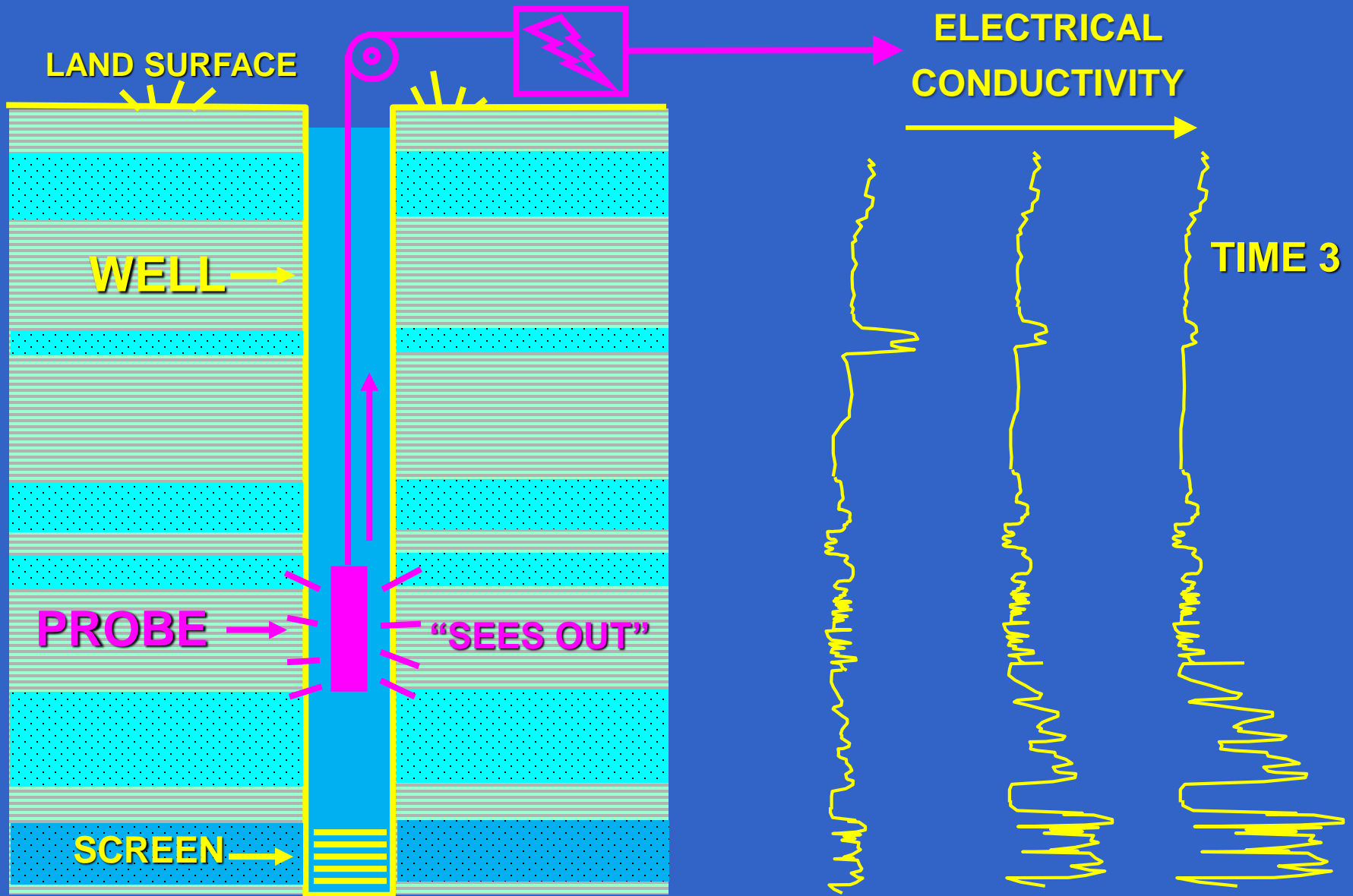




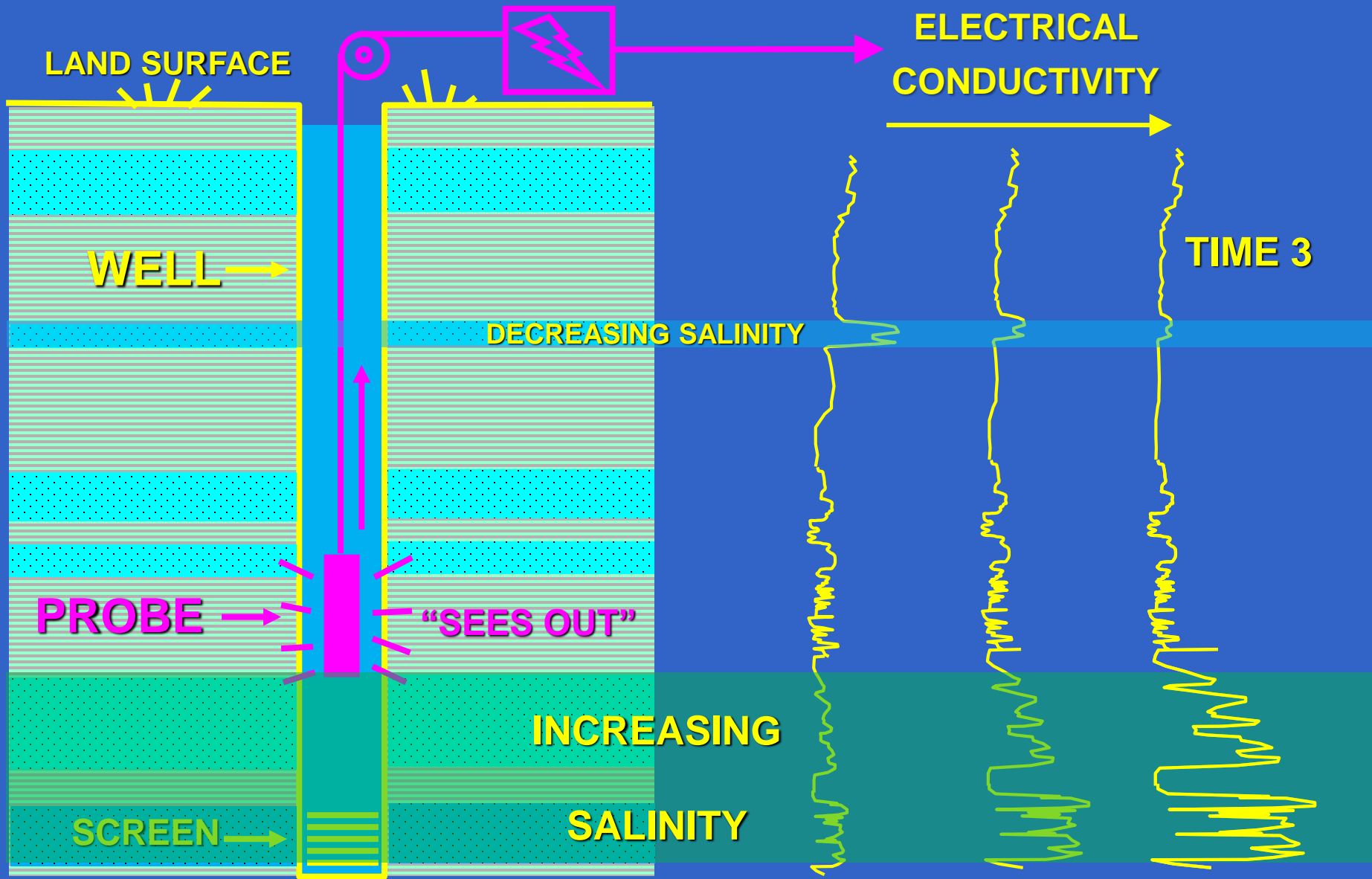
# Well-Log Monitoring



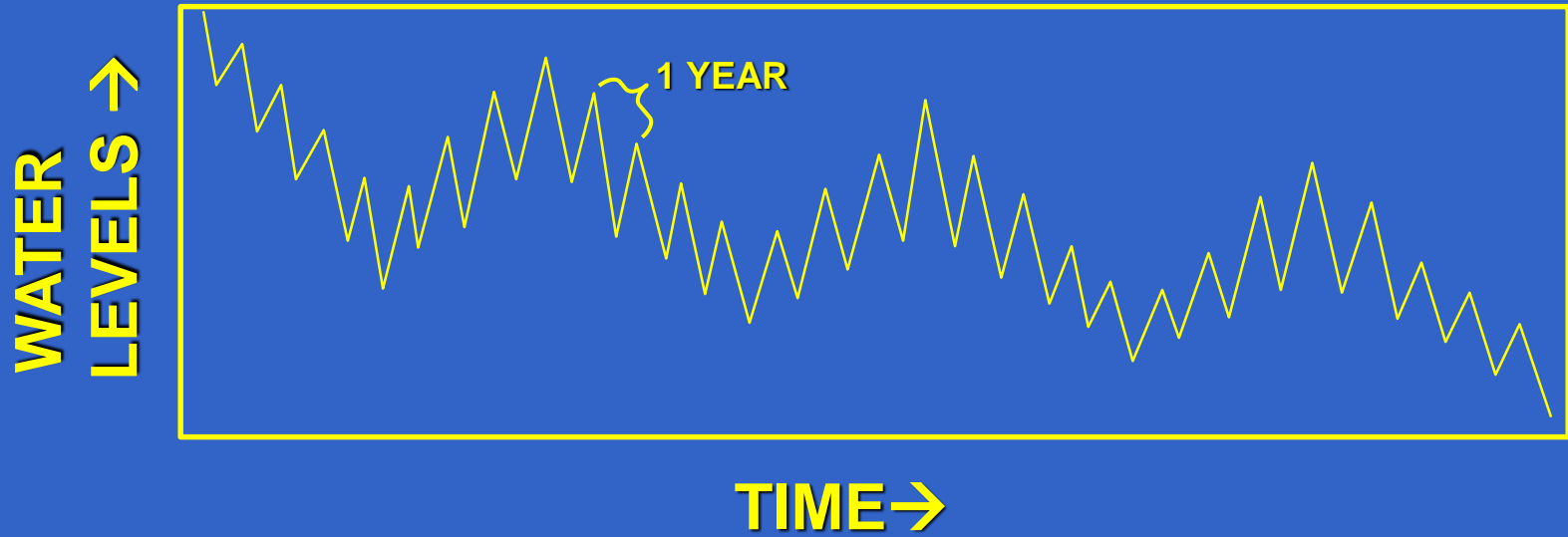
# Well-Log Monitoring



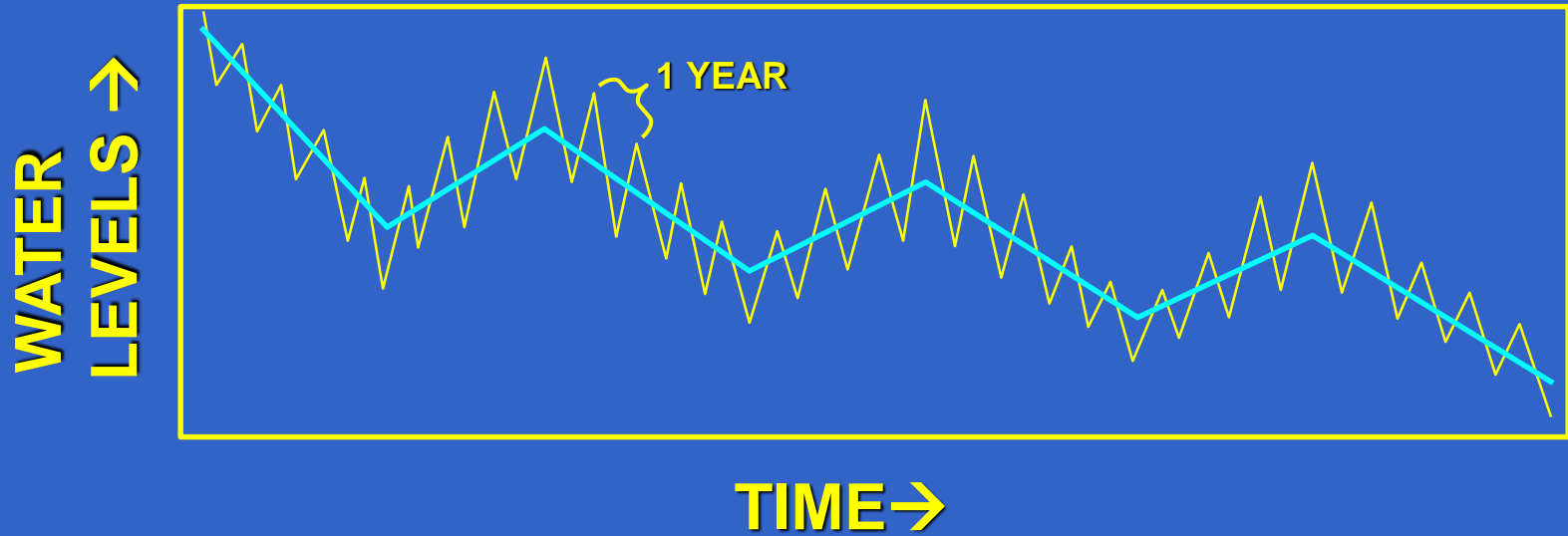
# Well-Log Monitoring



# *Water Levels*

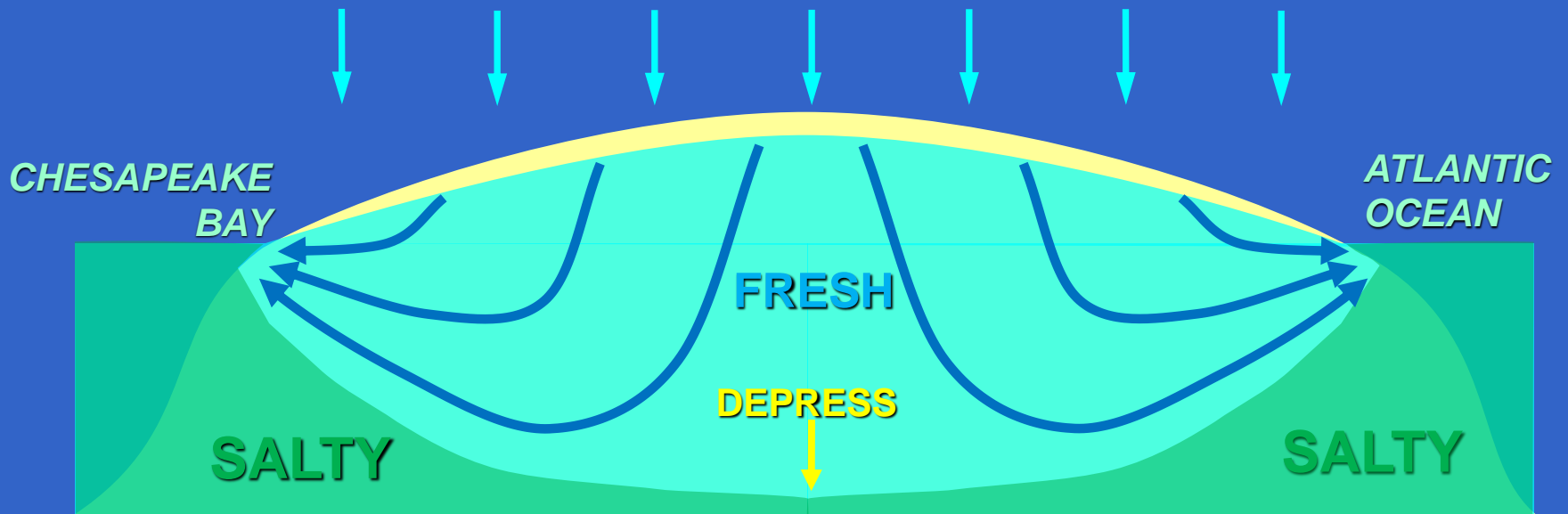


# *Water Levels*

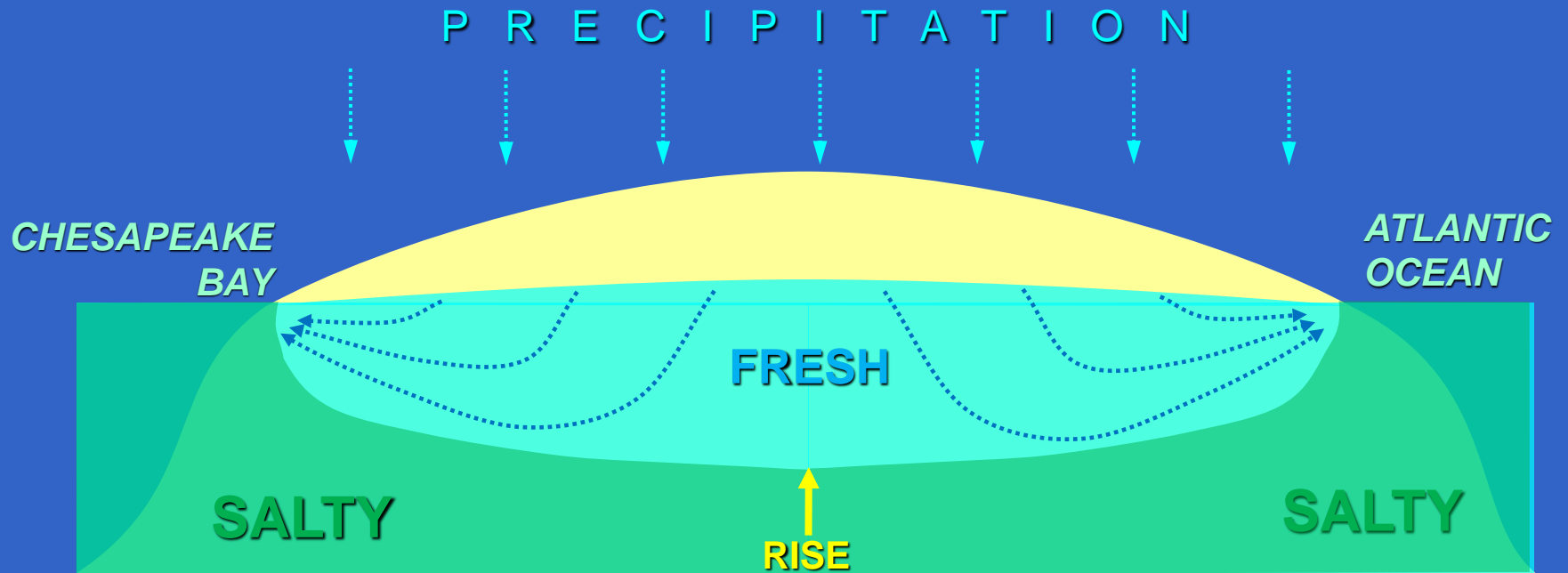


# *High Recharge or Low Withdrawal*

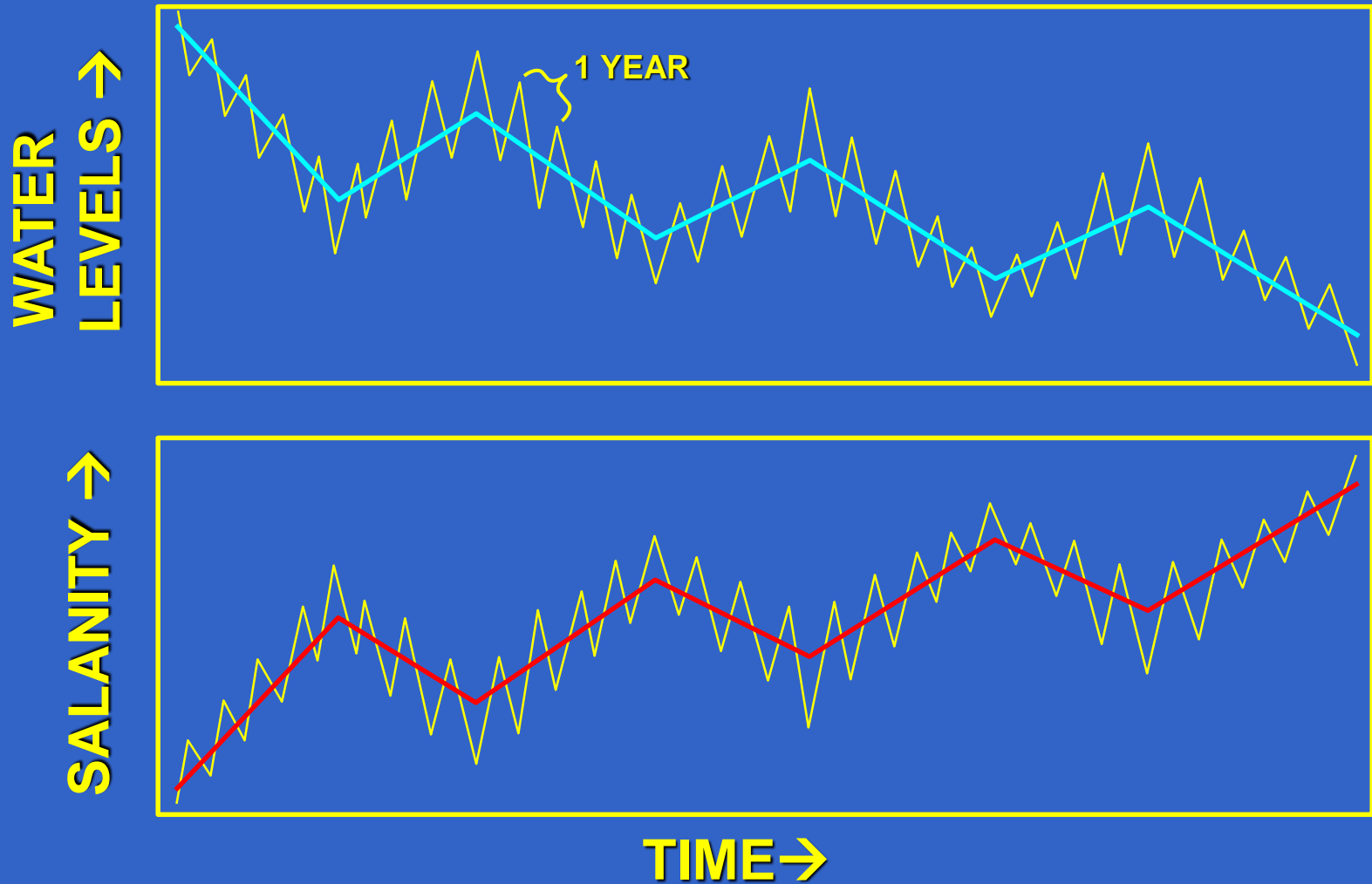
P R E C I P I T A T I O N



# *Low Recharge or High Withdrawal*

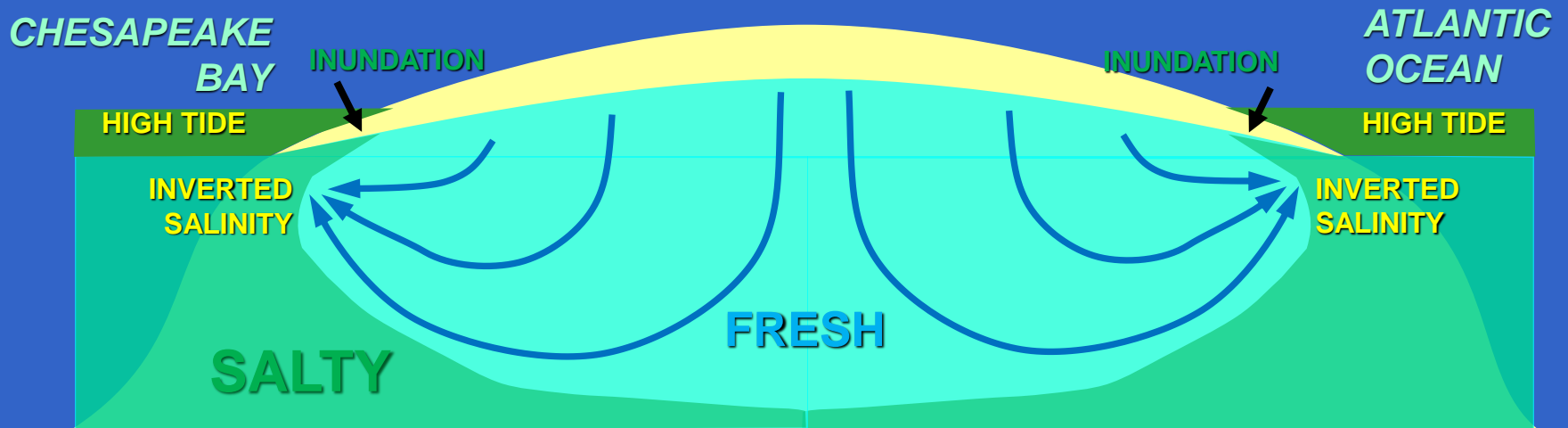


# *Water Levels and Salinity*



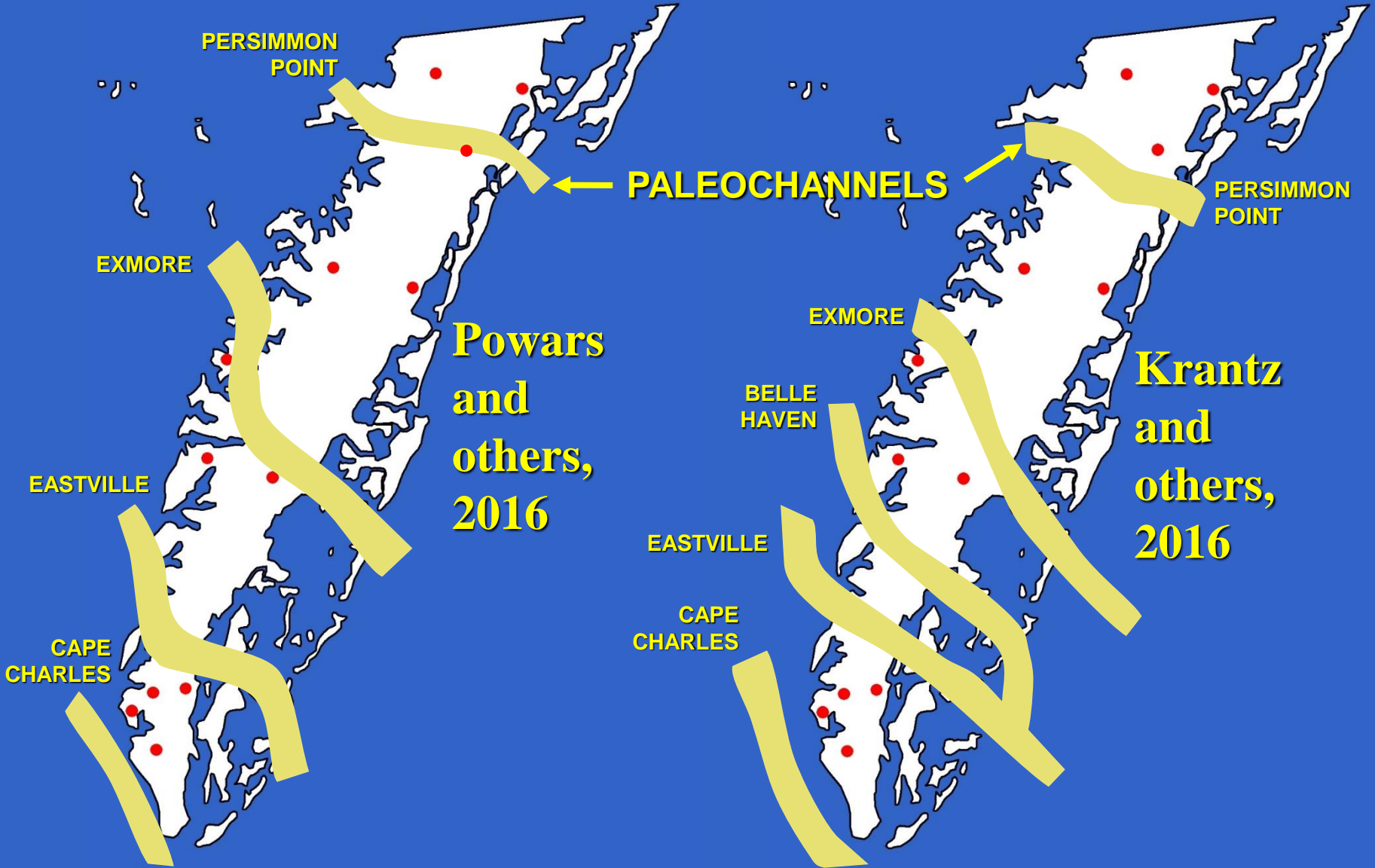


# Storm Surge



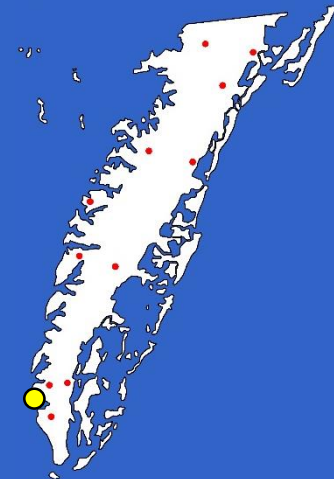
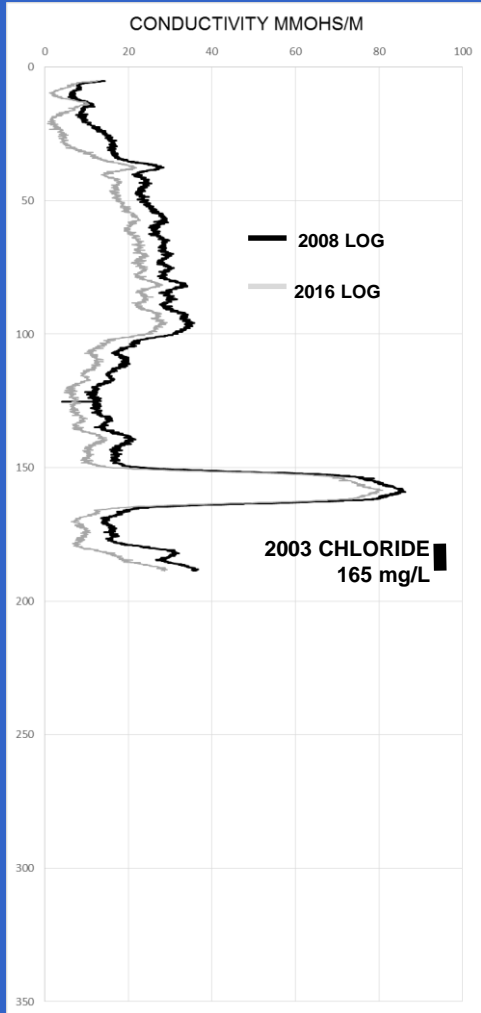
\*\*\* VERTICAL SCALE GREATLY EXAGGERATED \*\*\*

# Well-Logging Network



# Well 62G 15

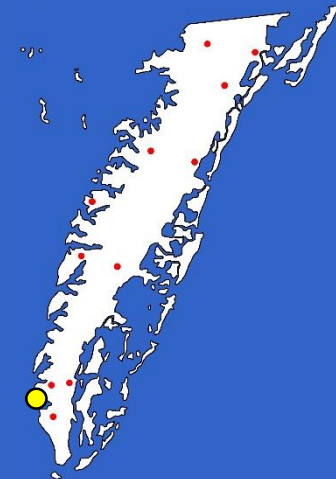
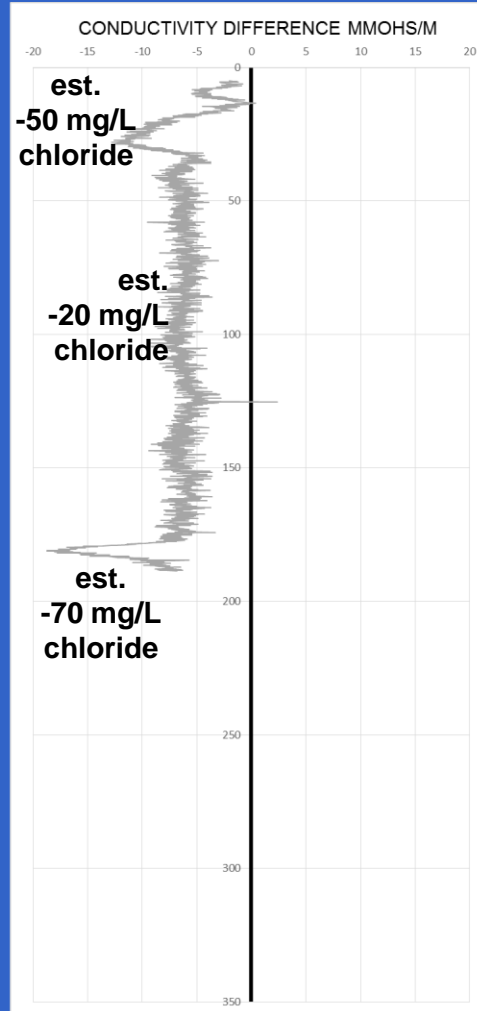
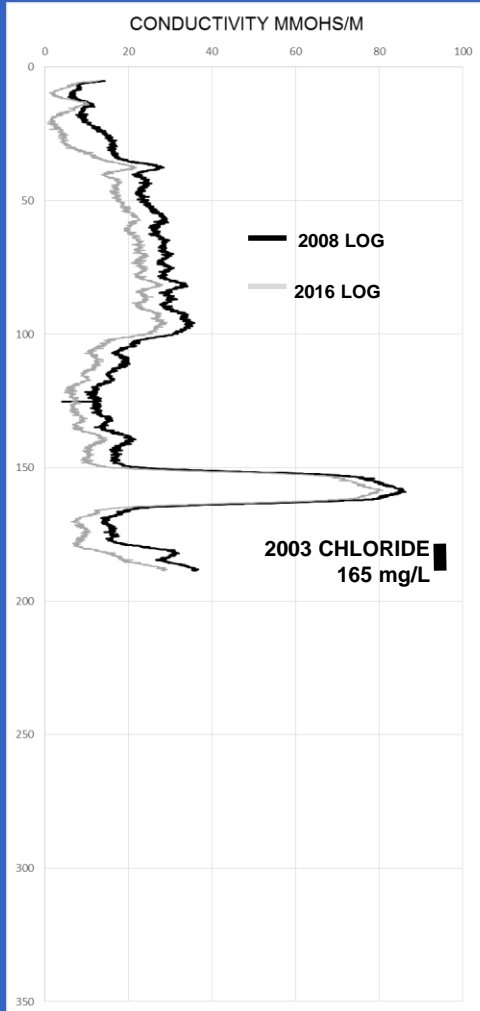
## LOG



# Well 62G 15

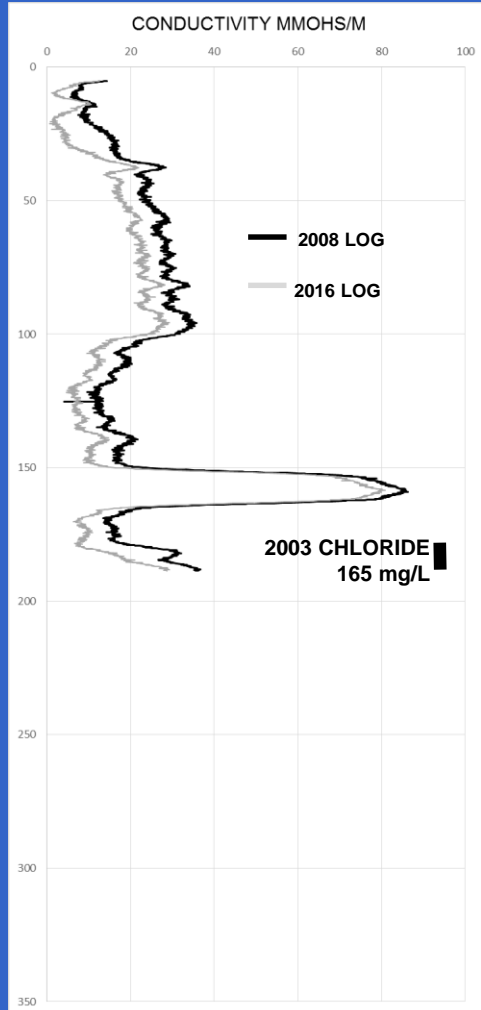
## LOG

## DIFFERENCE BETWEEN LOGS

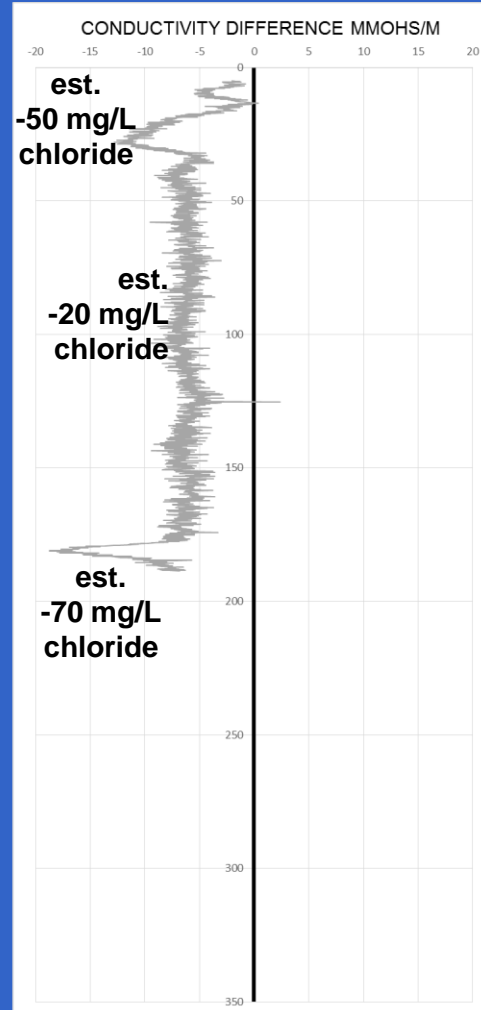


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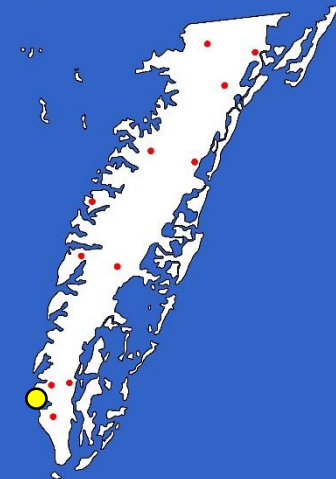
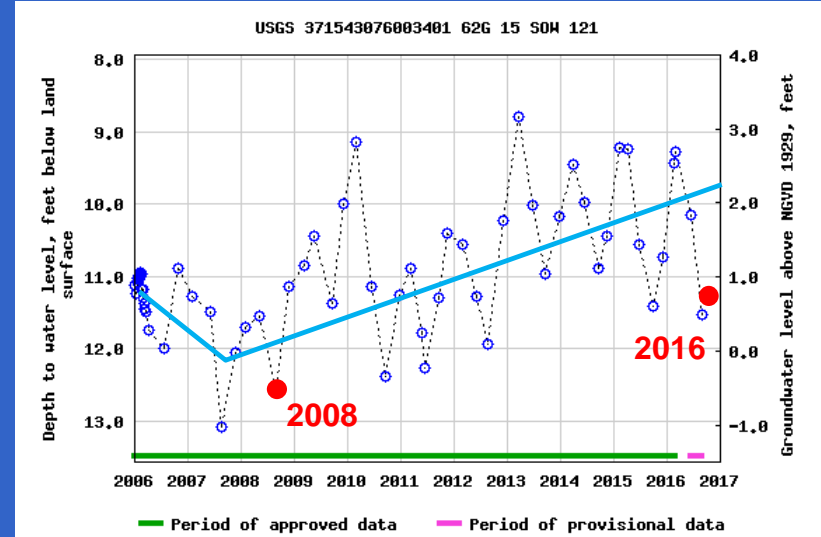
## LOG



## DIFFERENCE BETWEEN LOGS

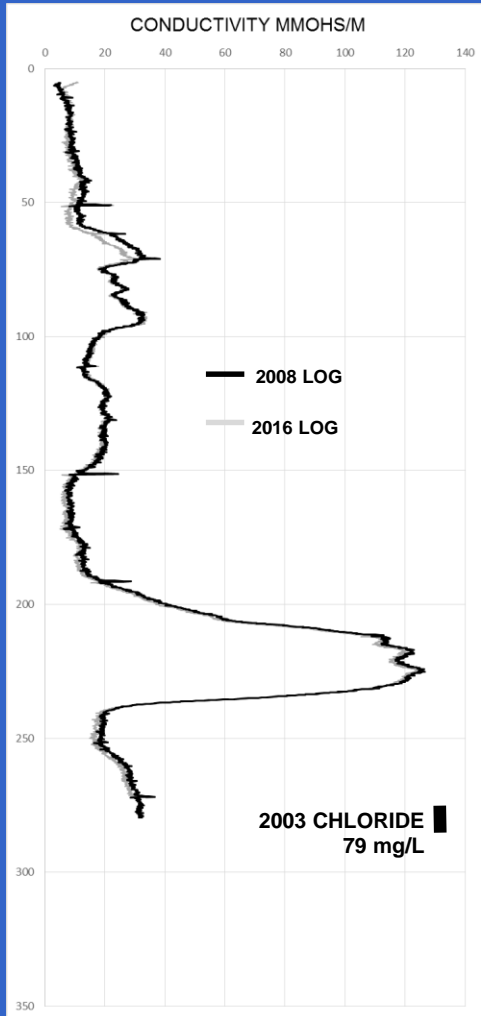


## WATER LEVELS

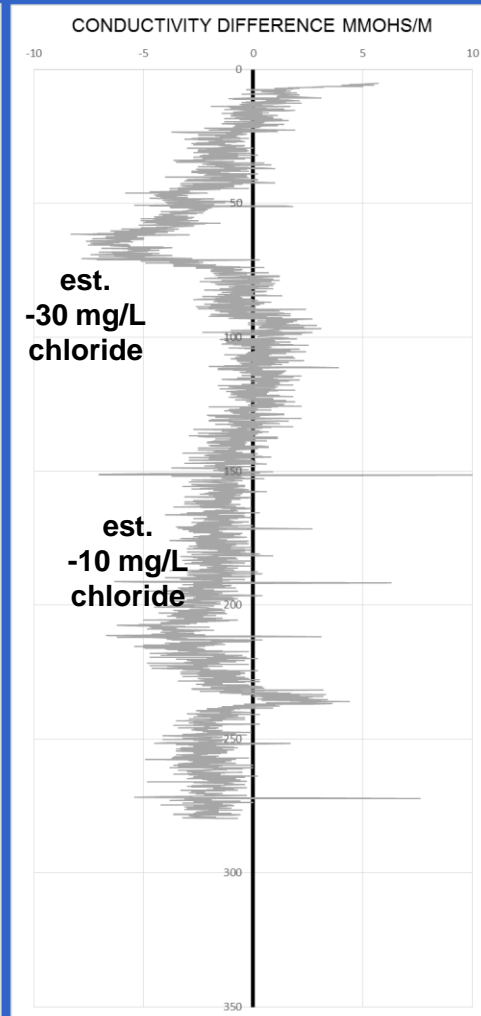


# Well 63F 16

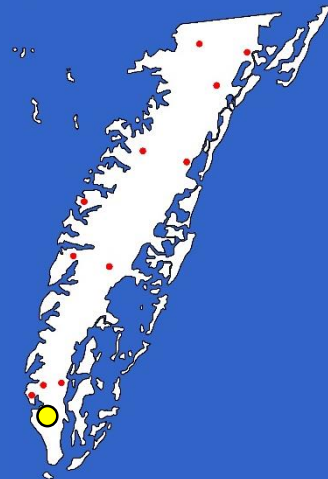
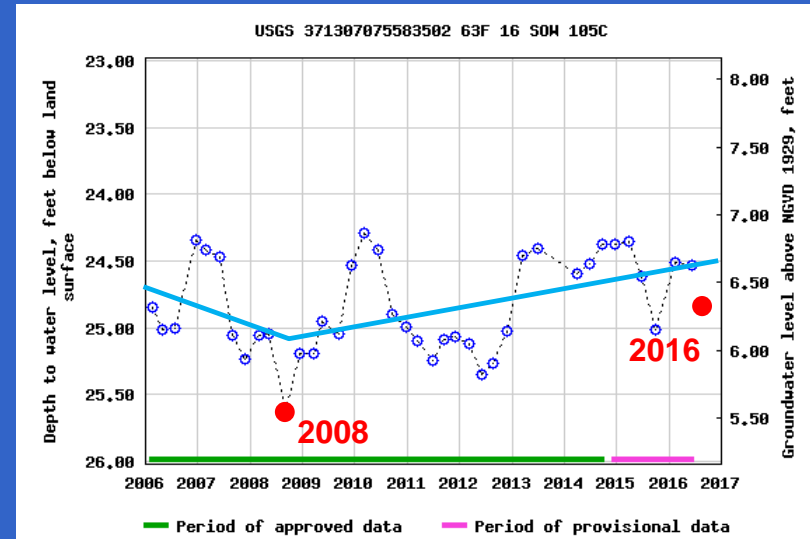
## LOG



## DIFFERENCE BETWEEN LOGS

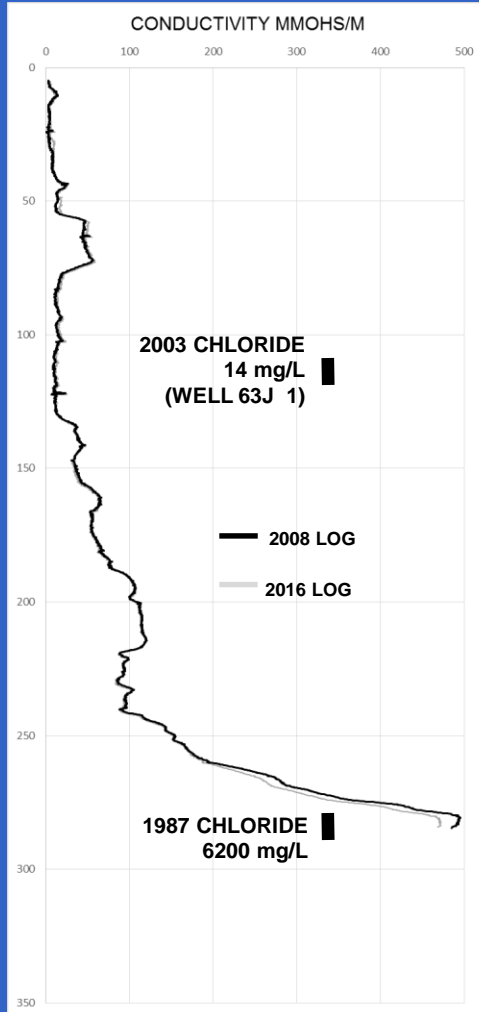


## WATER LEVELS

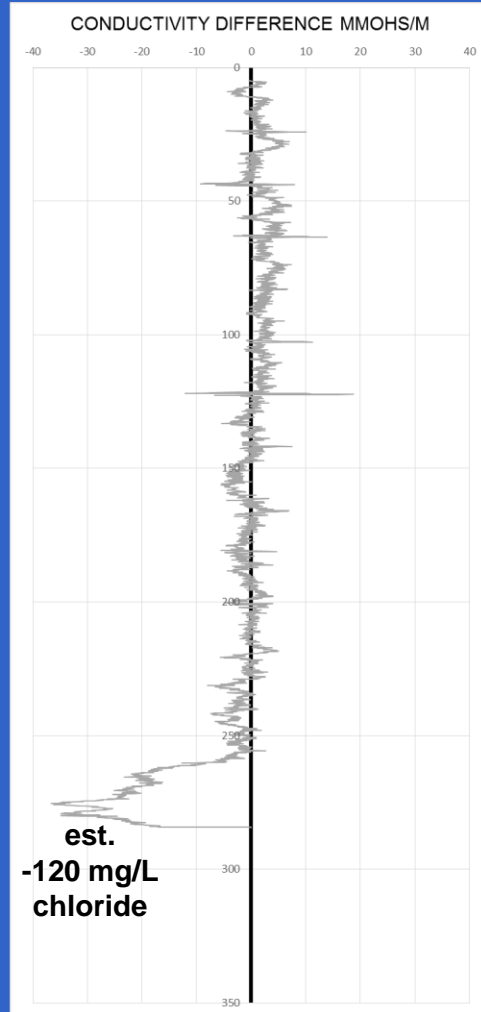


# Well 63J 3

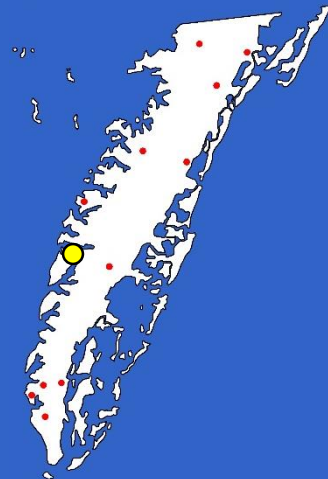
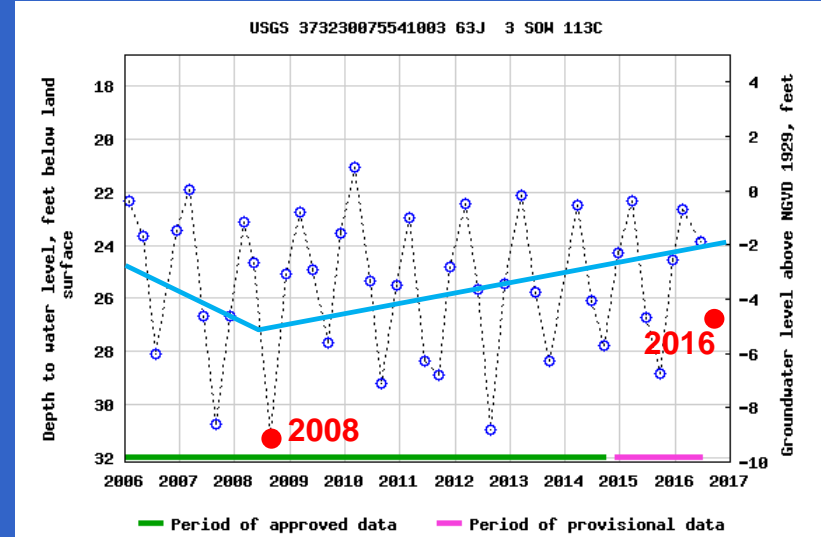
## LOG



## DIFFERENCE BETWEEN LOGS



## WATER LEVELS

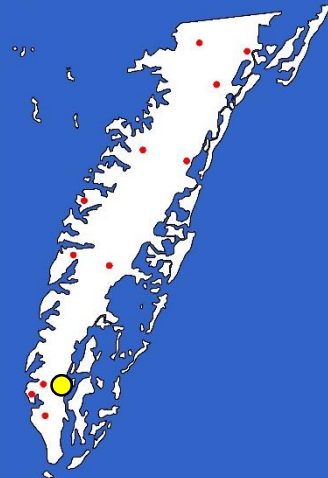
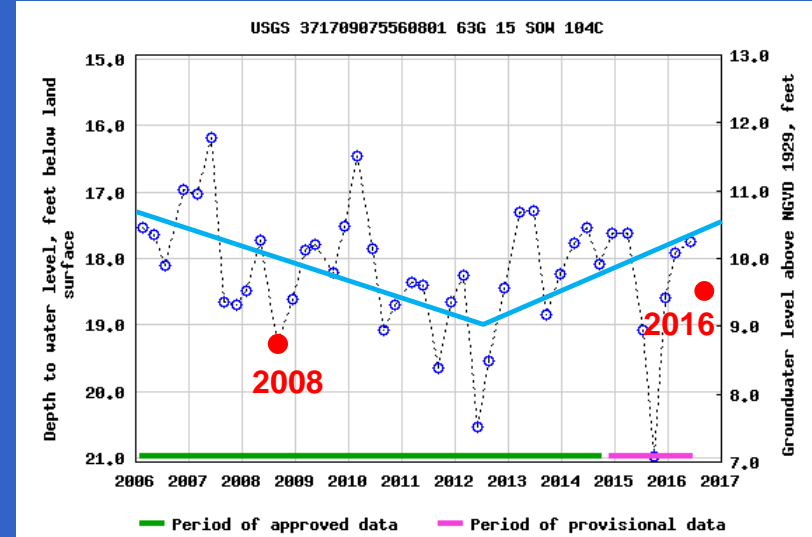
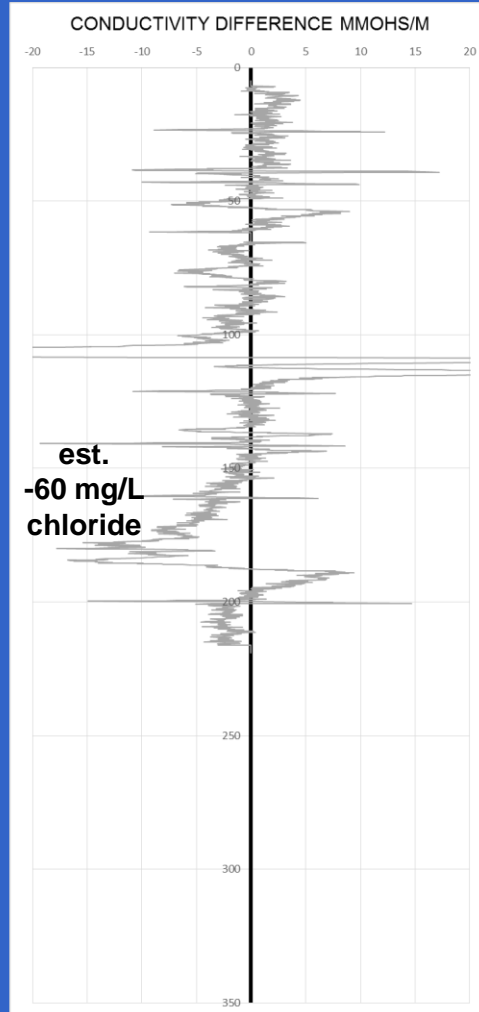
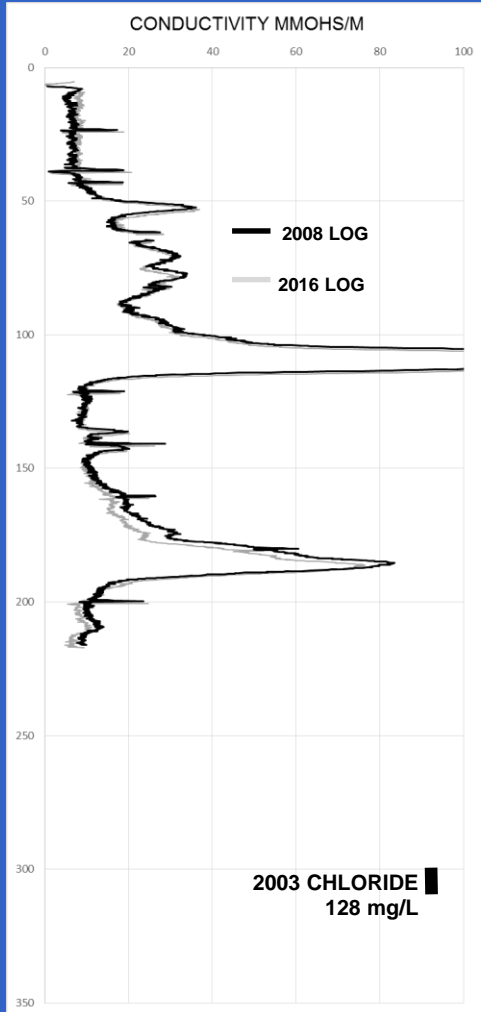


# Well 63G 15

## LOG

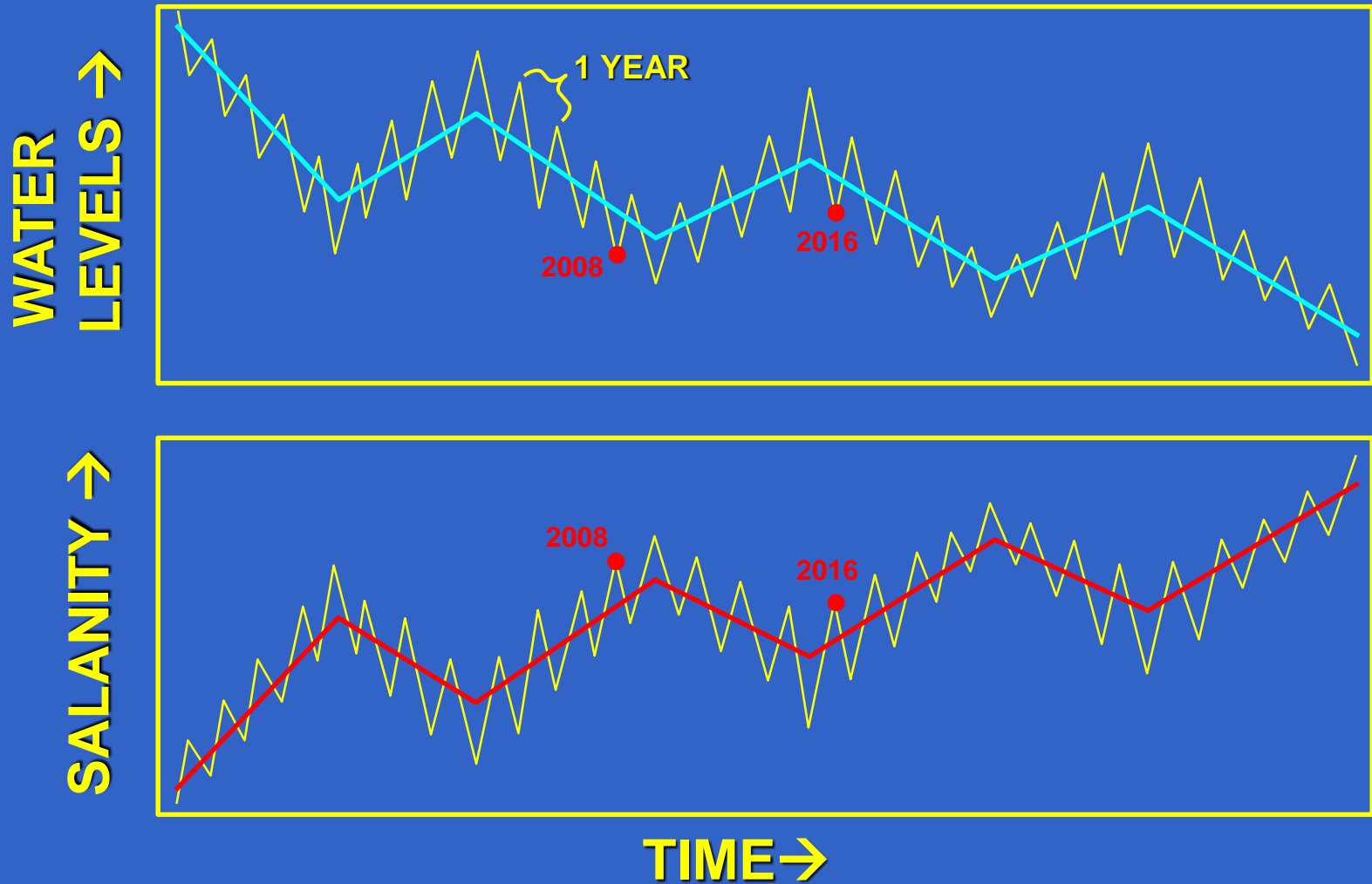
## DIFFERENCE BETWEEN LOGS

## WATER LEVELS



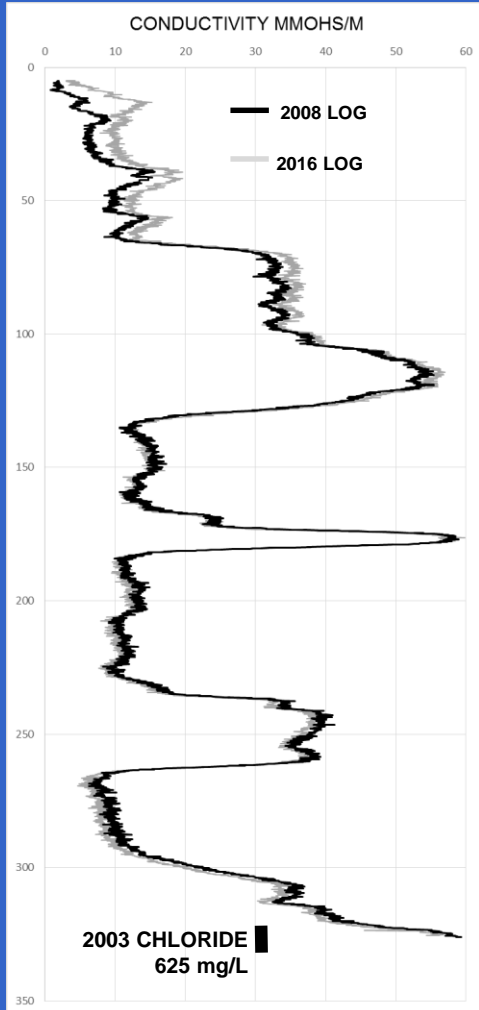


# *Water Levels and Salinity*

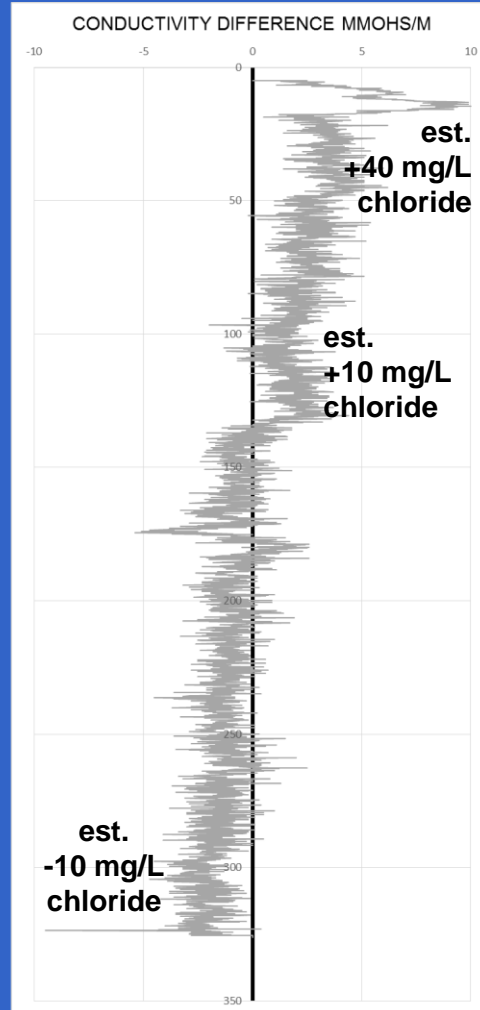


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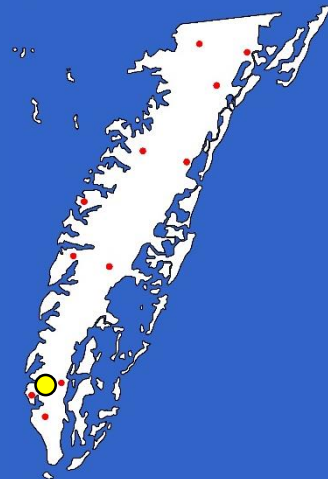
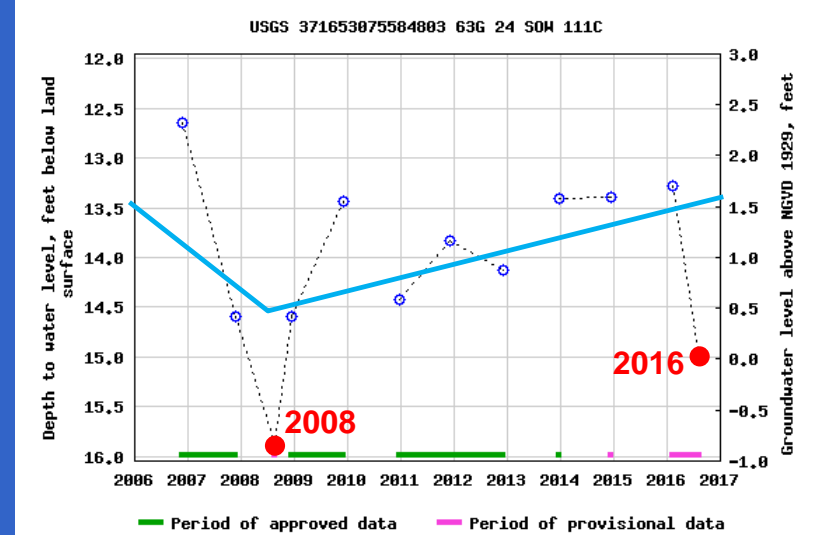
## LOG



## DIFFERENCE BETWEEN LOGS

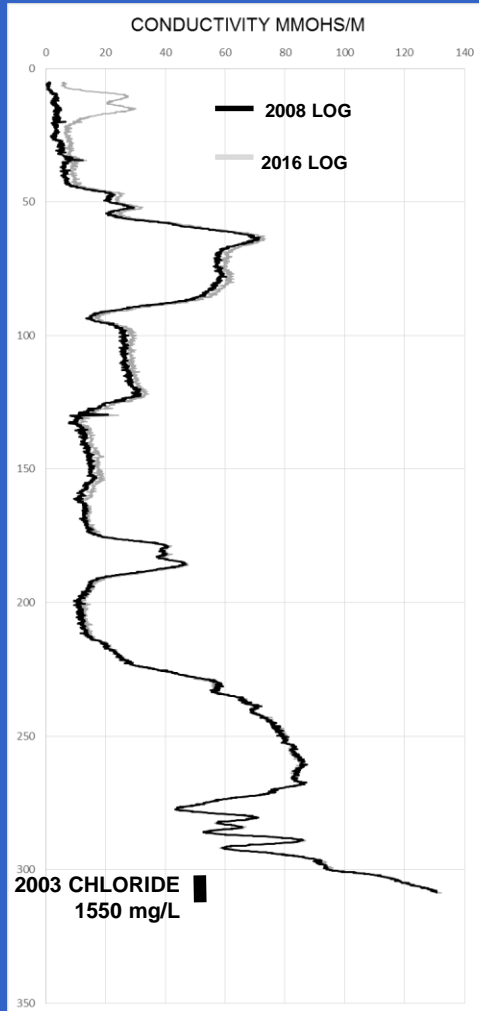


## WATER LEVELS

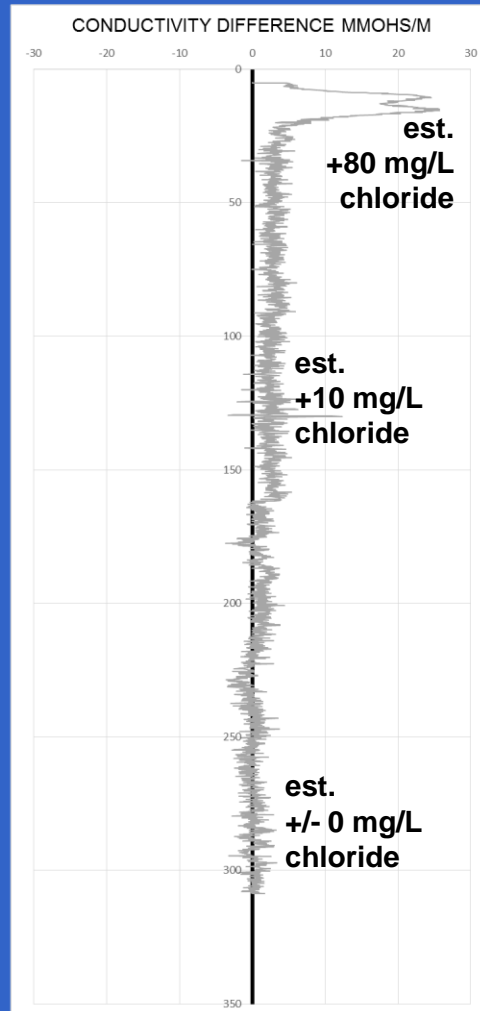


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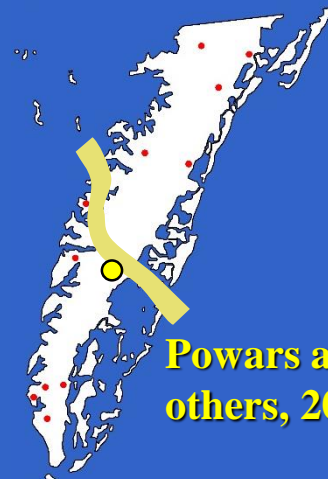
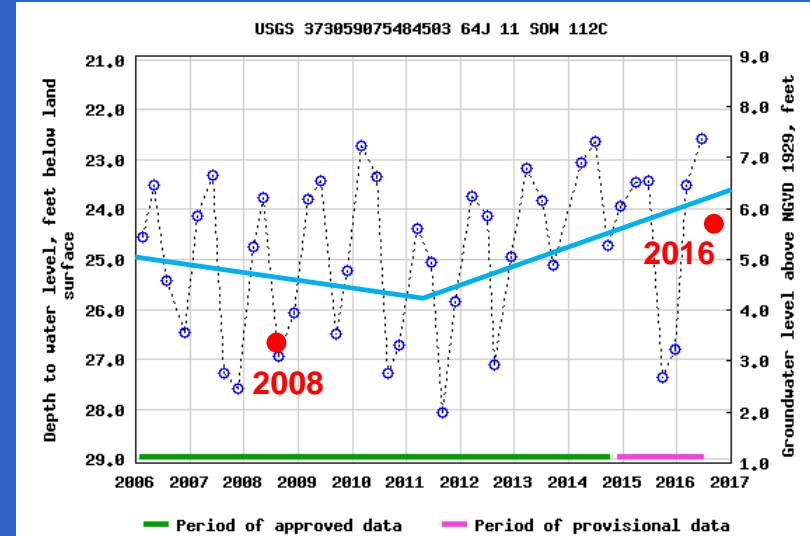
## LOG



## DIFFERENCE BETWEEN LOGS



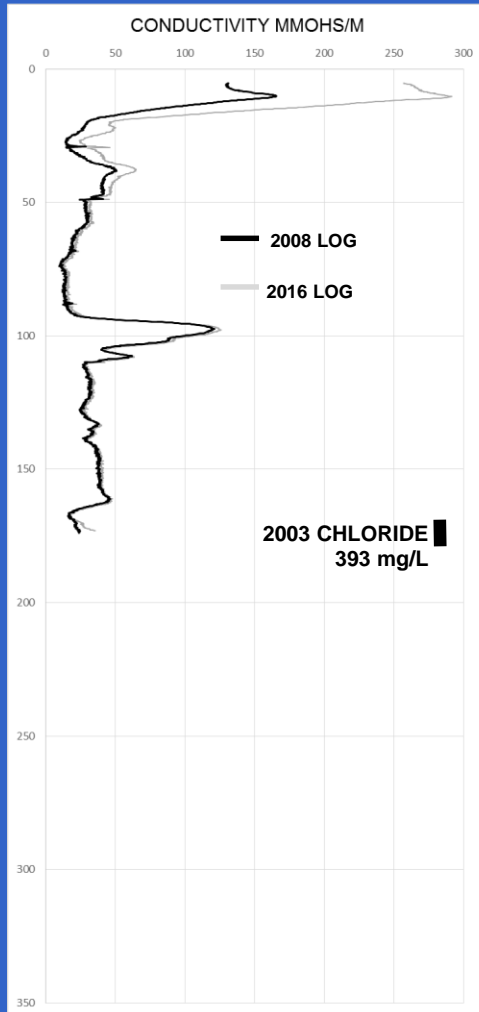
## WATER LEVELS



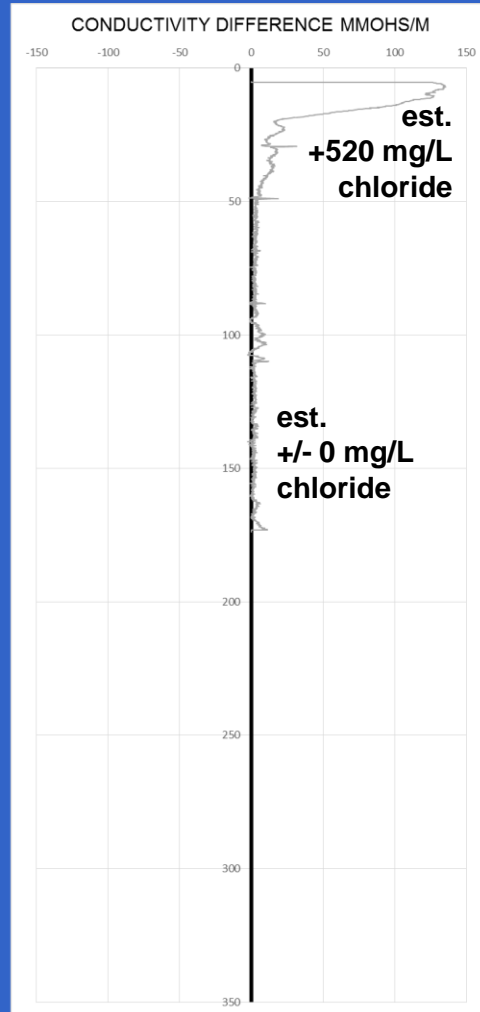
Powars and others, 2016

# Well 64K 7

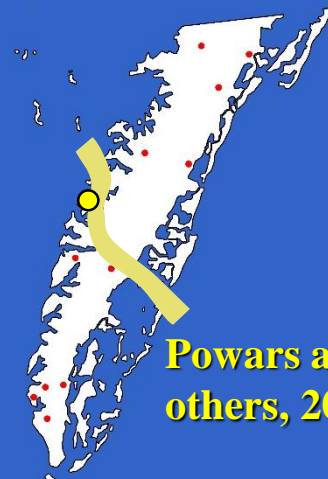
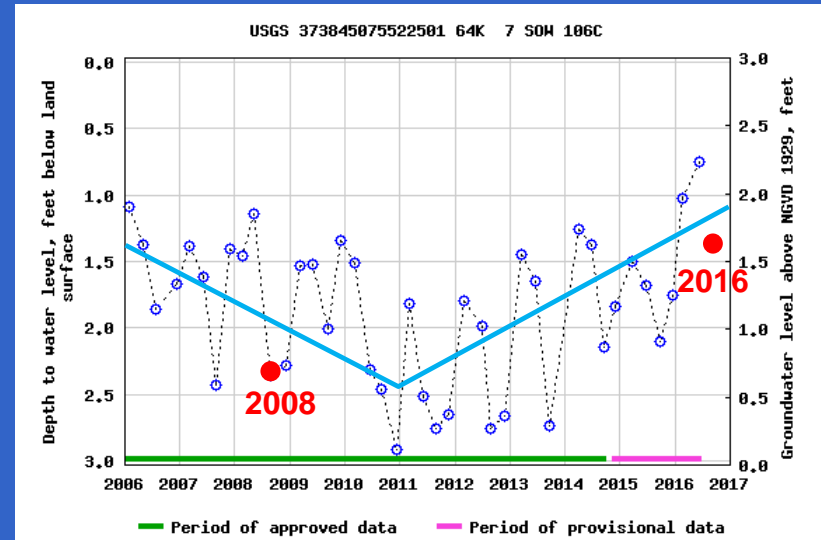
## LOG



## DIFFERENCE BETWEEN LOGS



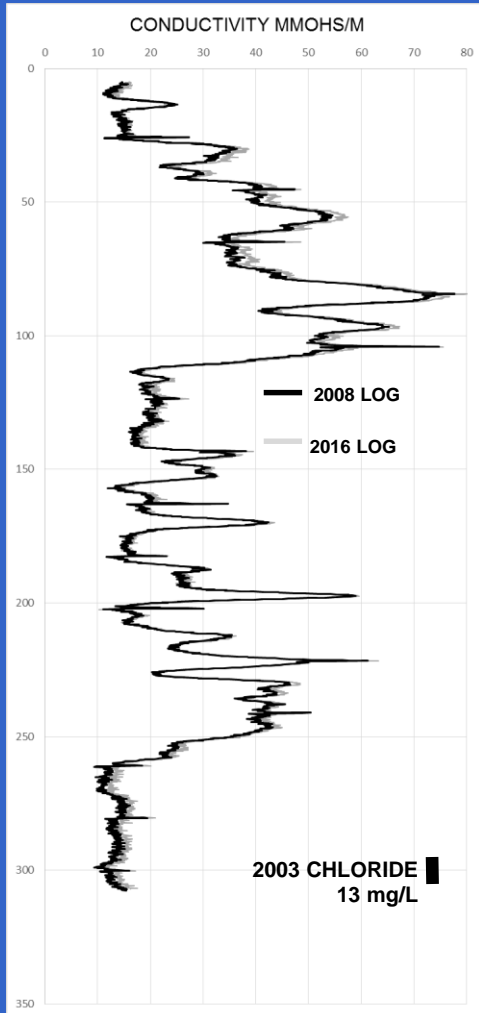
## WATER LEVELS



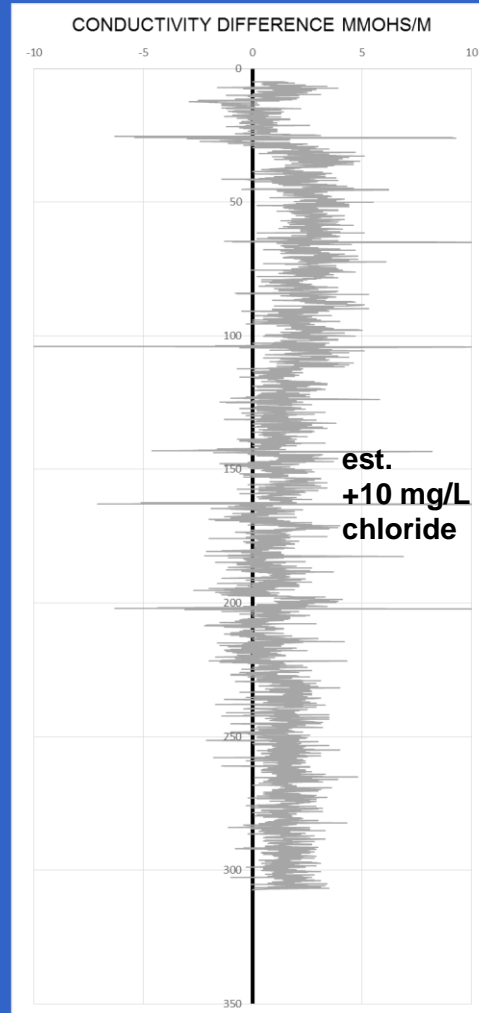
Powars and others, 2016

# Well 66L 1

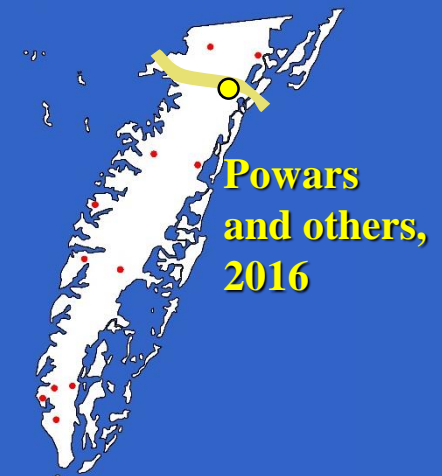
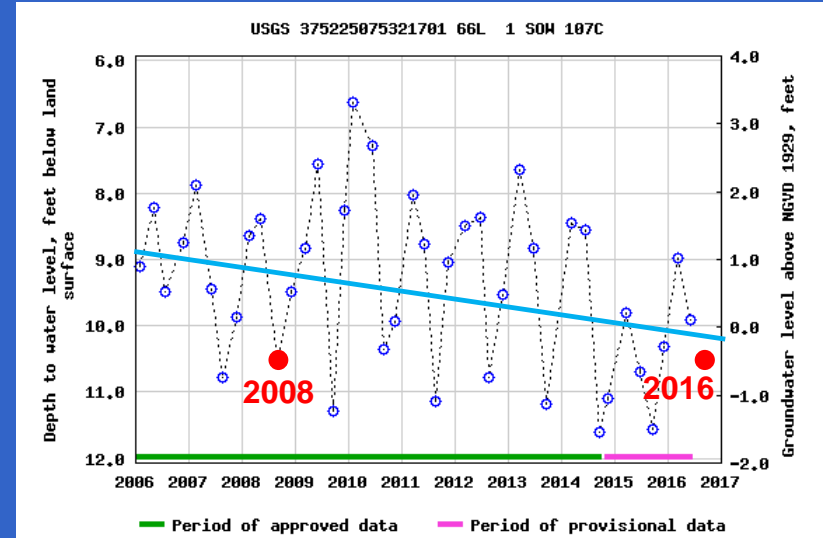
## LOG



## DIFFERENCE BETWEEN LOGS

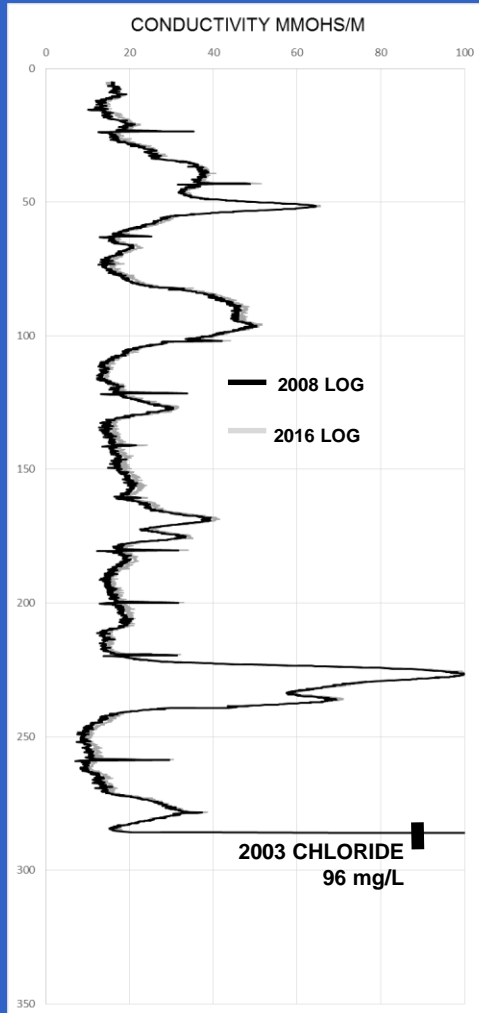


## WATER LEVELS

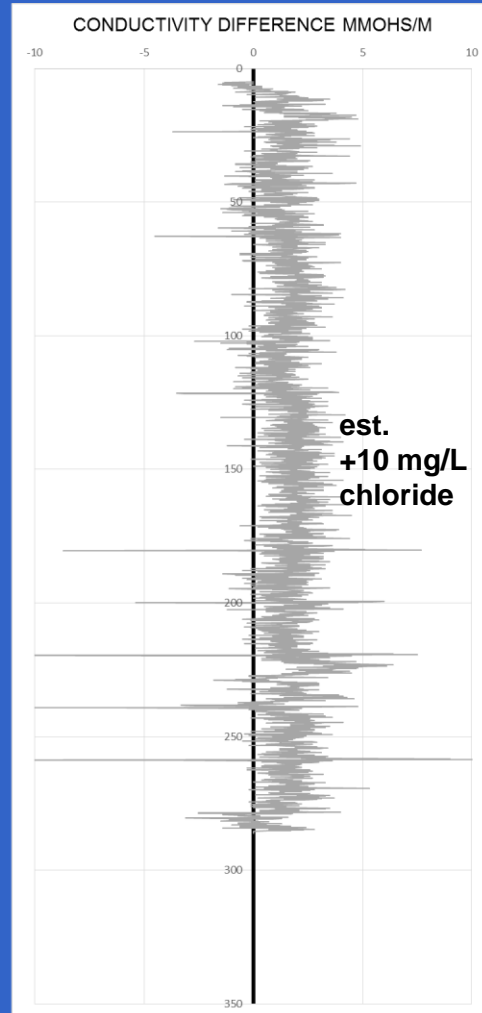


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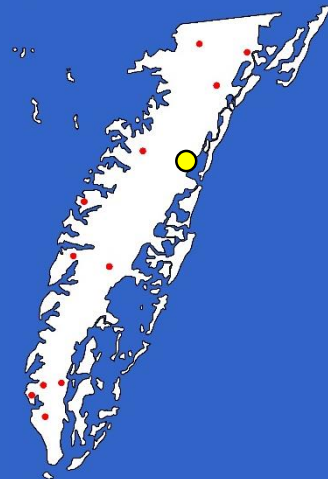
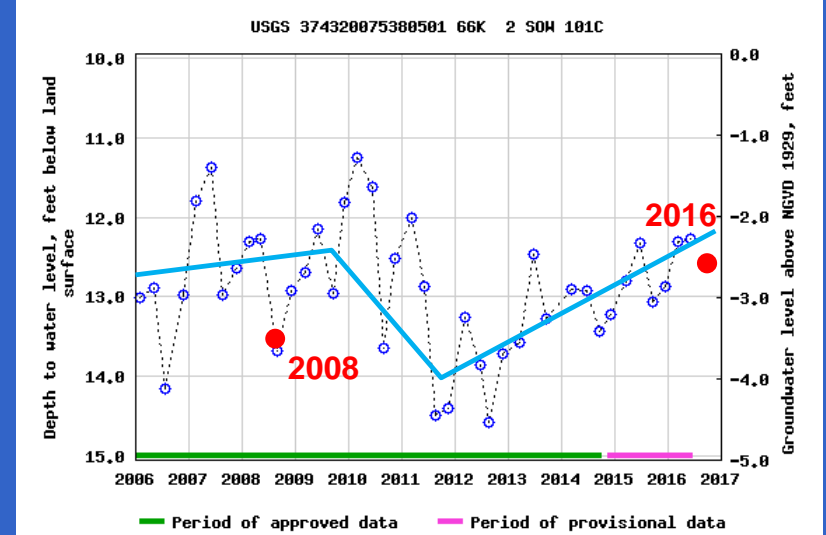
## LOG



## DIFFERENCE BETWEEN LOGS

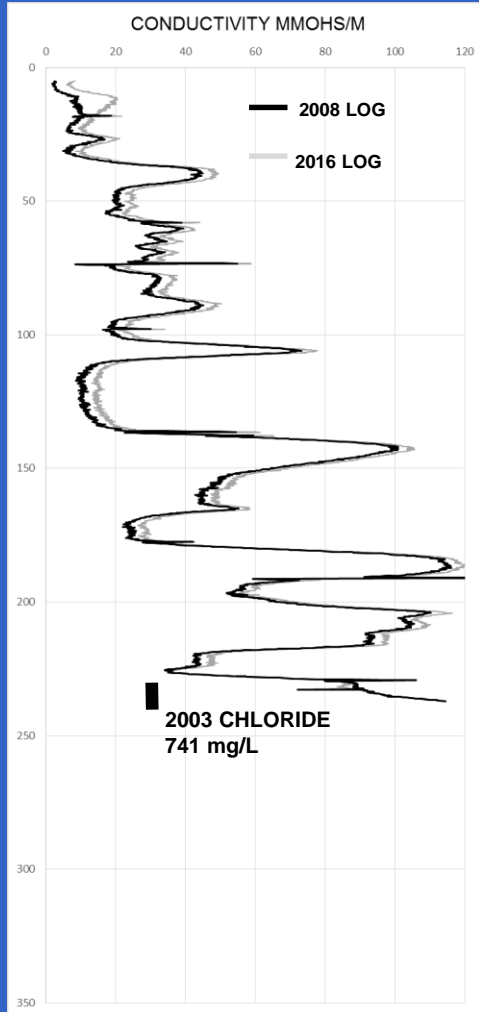


## WATER LEVELS

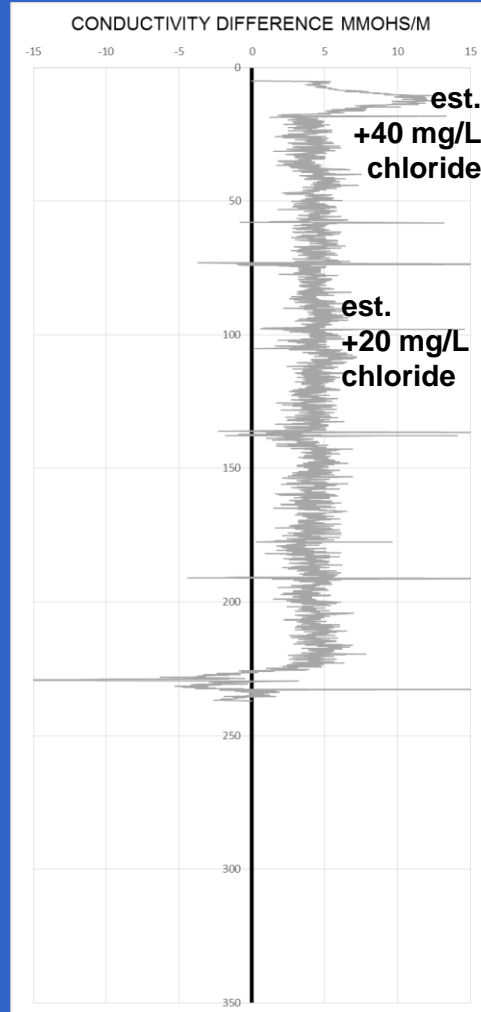


# Well 66M 18

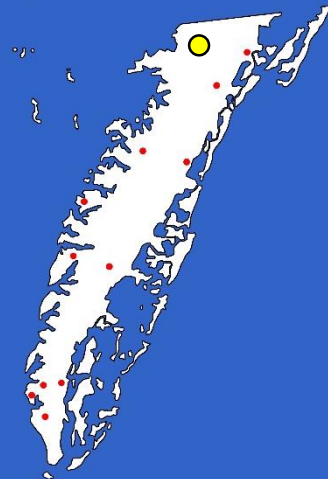
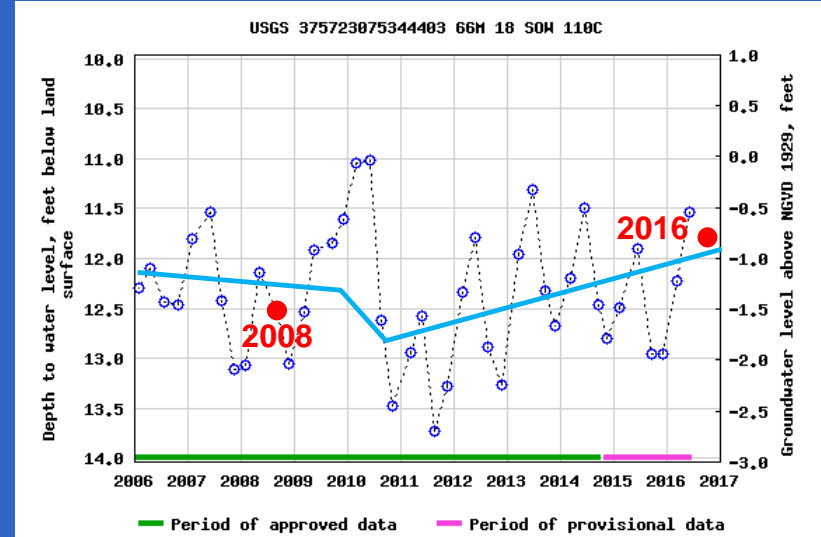
## LOG



## DIFFERENCE BETWEEN LOGS

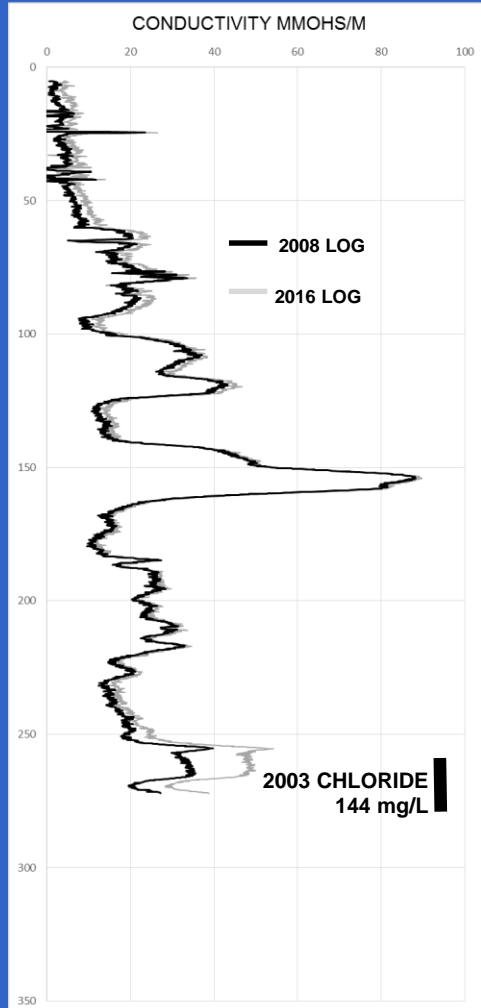


## WATER LEVELS

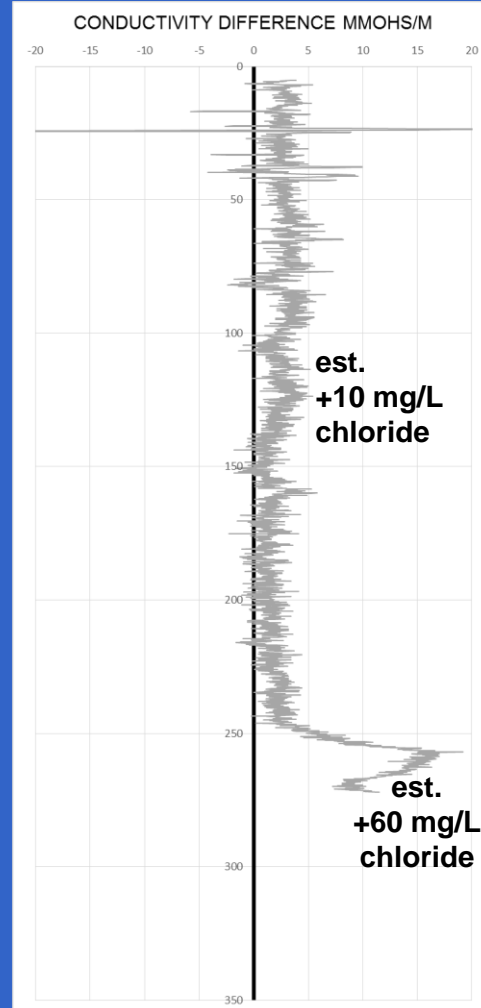


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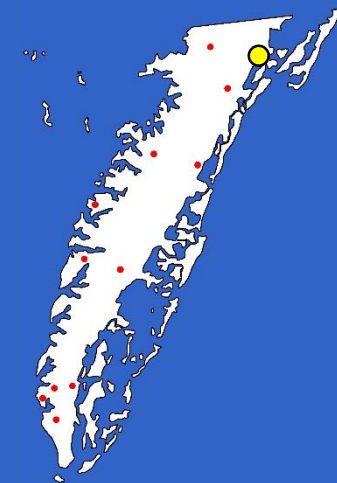
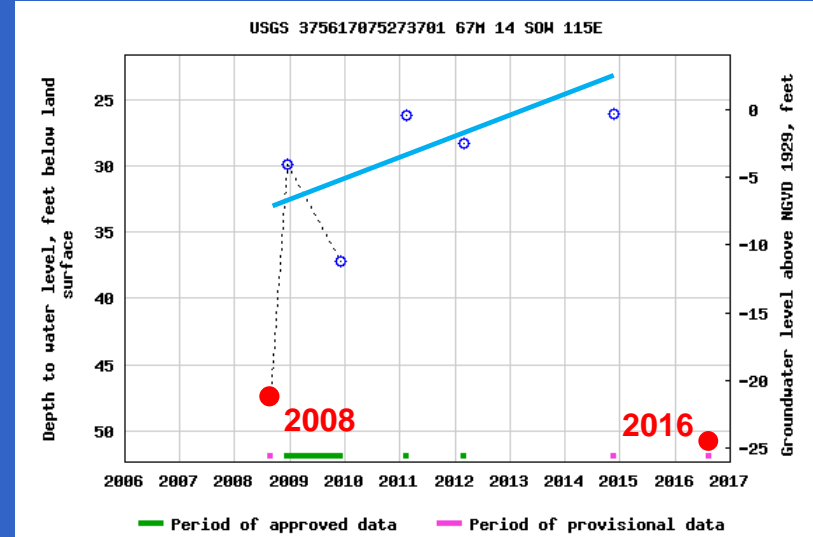
## LOG



## DIFFERENCE BETWEEN LOGS



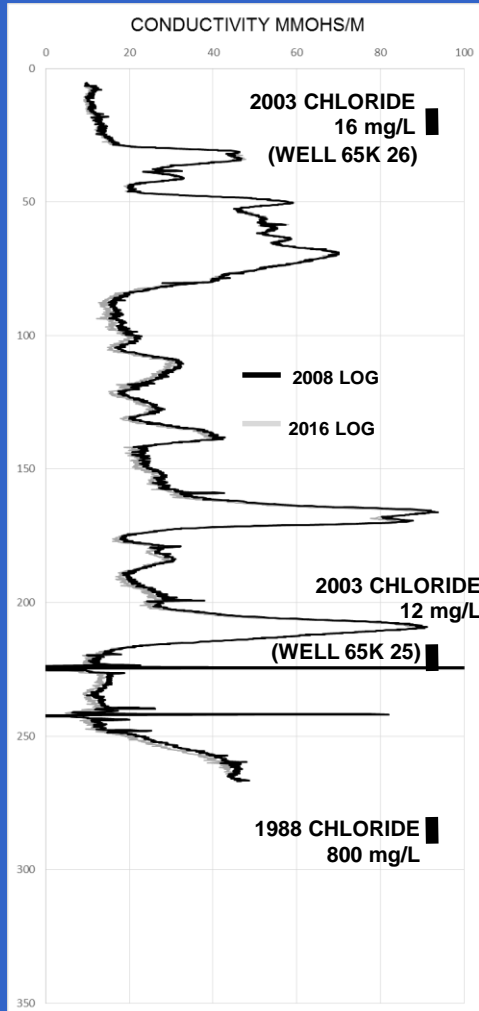
## WATER LEVELS



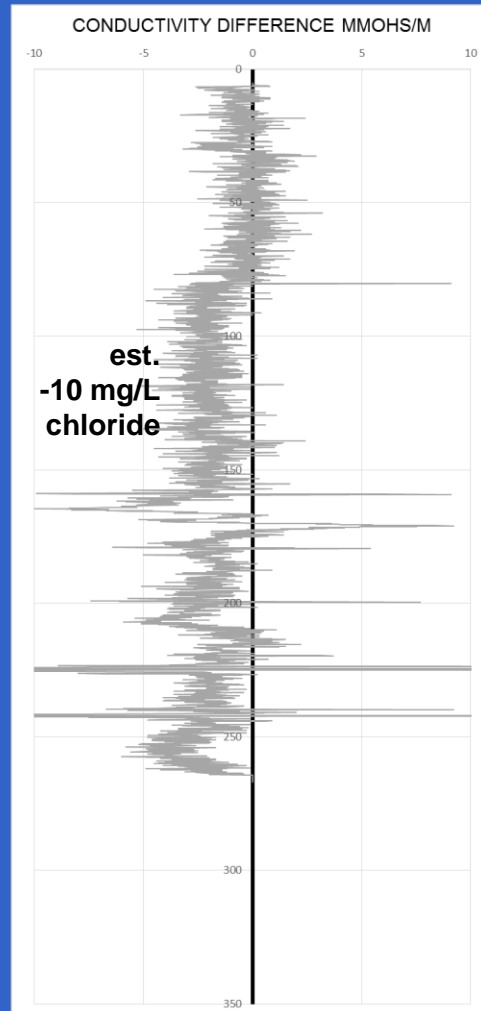


# Well 65K 23

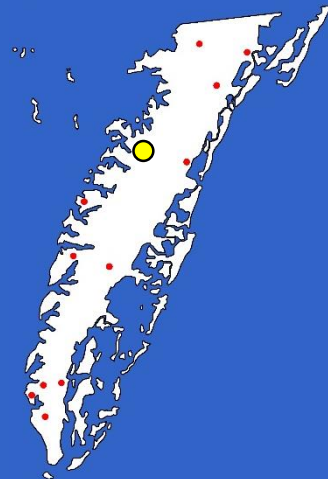
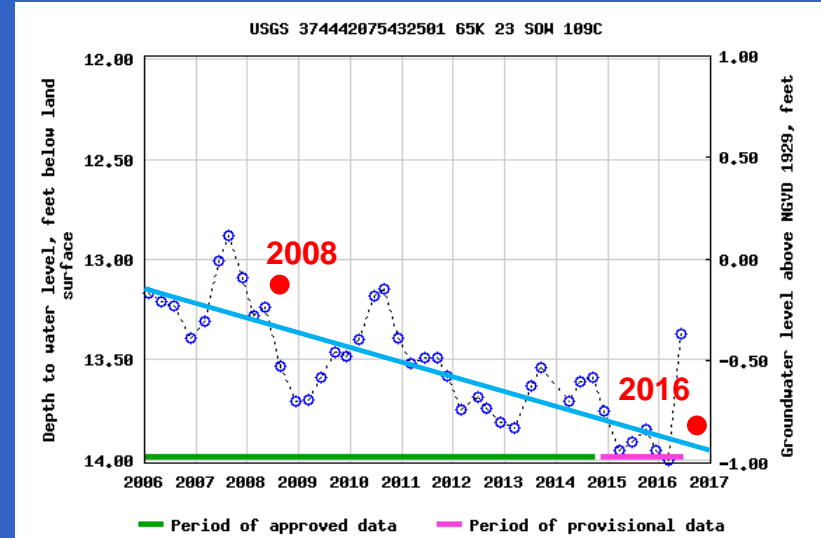
## LOG



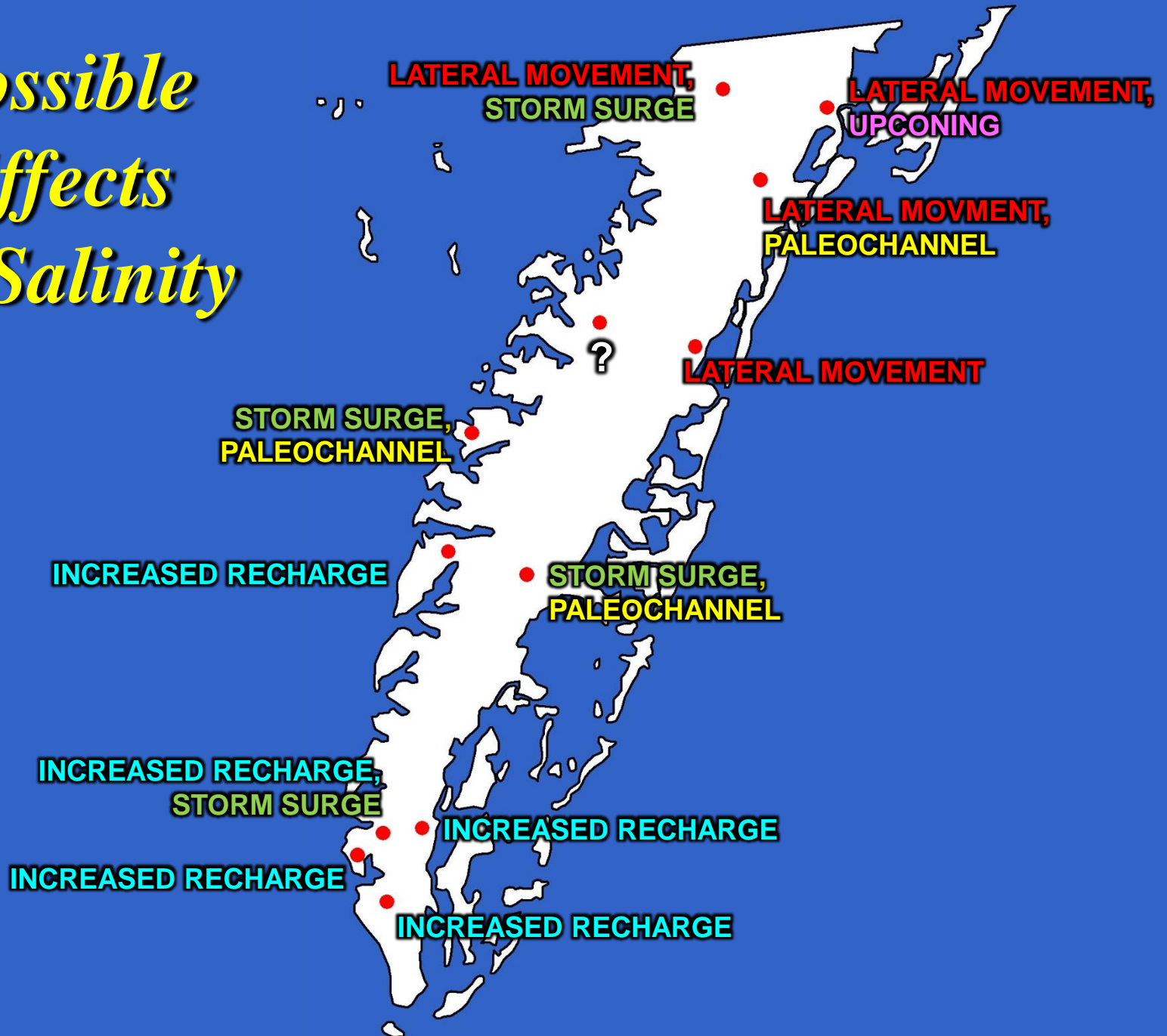
## DIFFERENCE BETWEEN LOGS



## WATER LEVELS



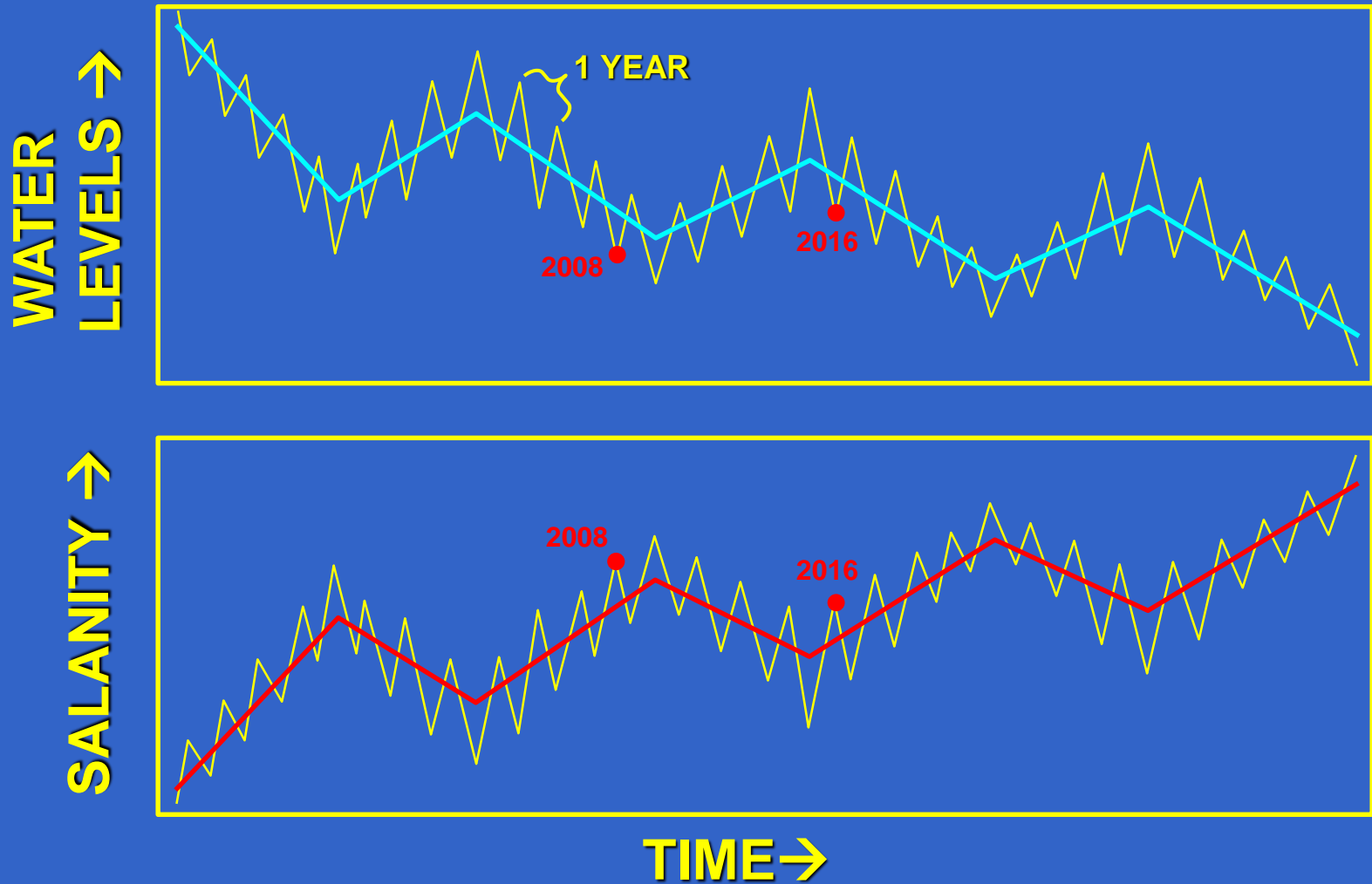
# *Possible Effects on Salinity*



# ***Tentative Findings***

- 1. small salinity changes from 2008 to 2016 in most wells**
- 2. increased recharge possibly decreased salinity in some wells to south**
- 3. lateral movement possibly increased salinity in some wells to north**
- 4. storm surge possibly increased salinity in some wells near coast**
- 5. salinity increase possibly enhanced in some wells near paleochannels**

# *Water Levels and Salinity*



# *Planning Outlook*

- groundwater-flow system changes on yearly, multi-yearly, and decadal time scales
- yearly well logging needed to relate salinity changes to groundwater flow
- multi-year/decade record needed to detect long-term trends in salinity