Tidal Forecasting in the Delta

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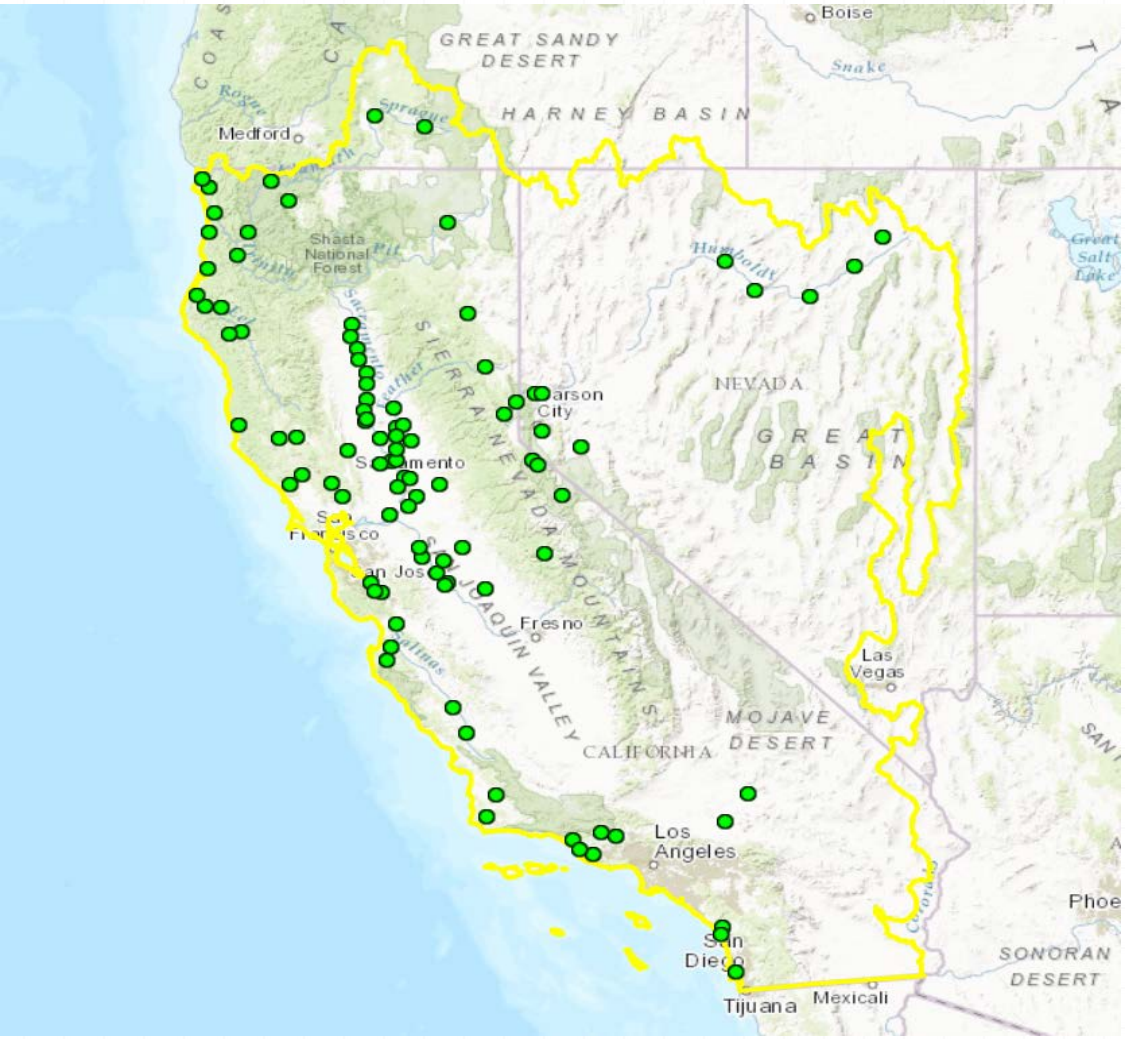
Outline of Presentation

- River Forecasting Section—Brief Introduction
- Science of Tide Forecasting
- Forecasting Tides in Delta—Locations
- Challenges on Tide Forecasting
- Summary and Conclusions

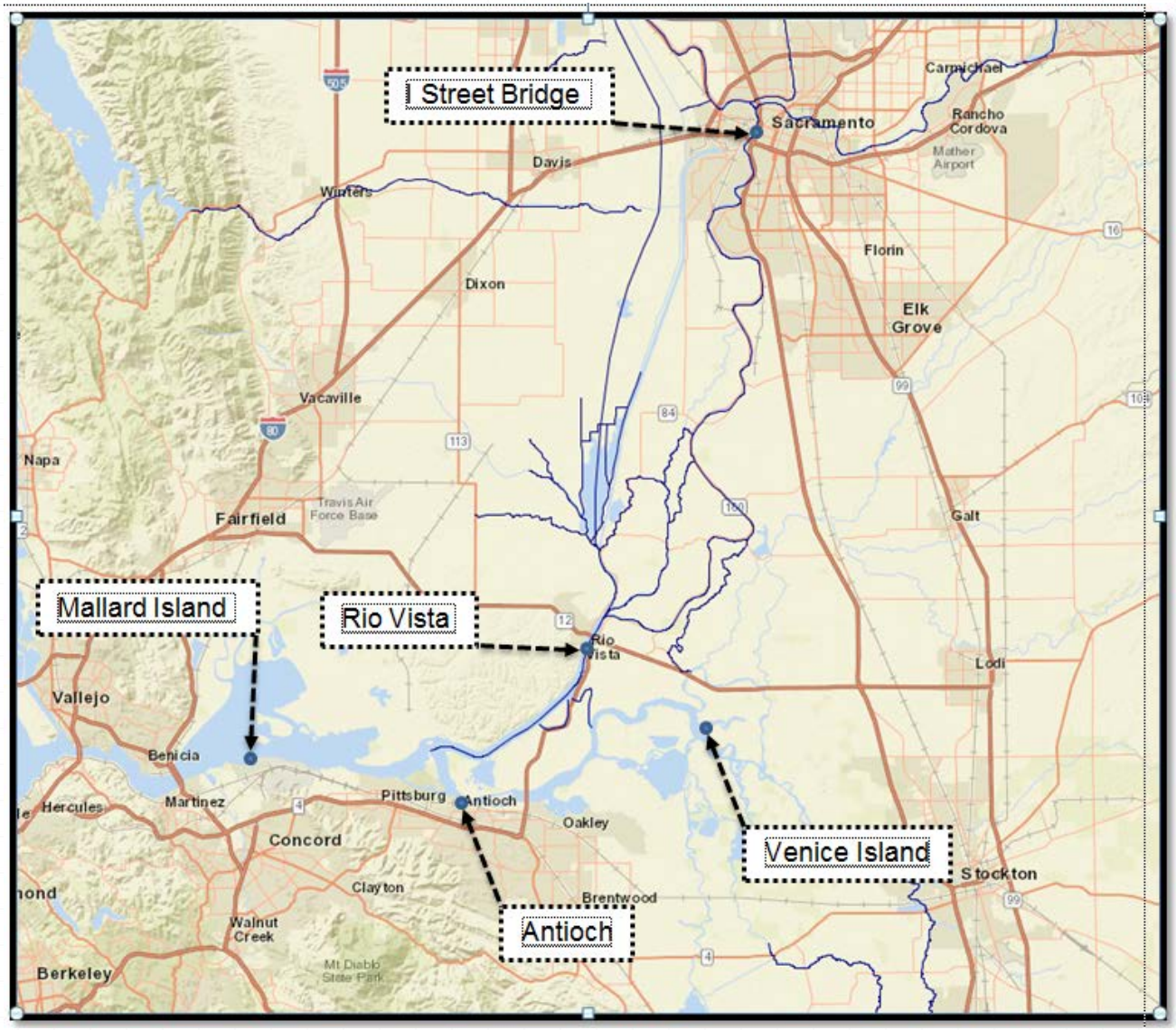
River Forecasting Section Brief Introduction

- Collaboration with National Weather Service (NWS)-California Nevada River Forecasting Center (CNRFC) to forecast rivers and tide conditions in California.
- Daily status of river flow and stage conditions are forecasted throughout California and Nevada (97 forecast locations).
- Tidal forecasts are produced for five locations: Mallard Island, Antioch, Venice Island, Rio Vista, and I Street Bridge.

River Forecast Locations throughout California and Nevada



Tidal Forecast Locations in Delta



What is Tide Forecasting?

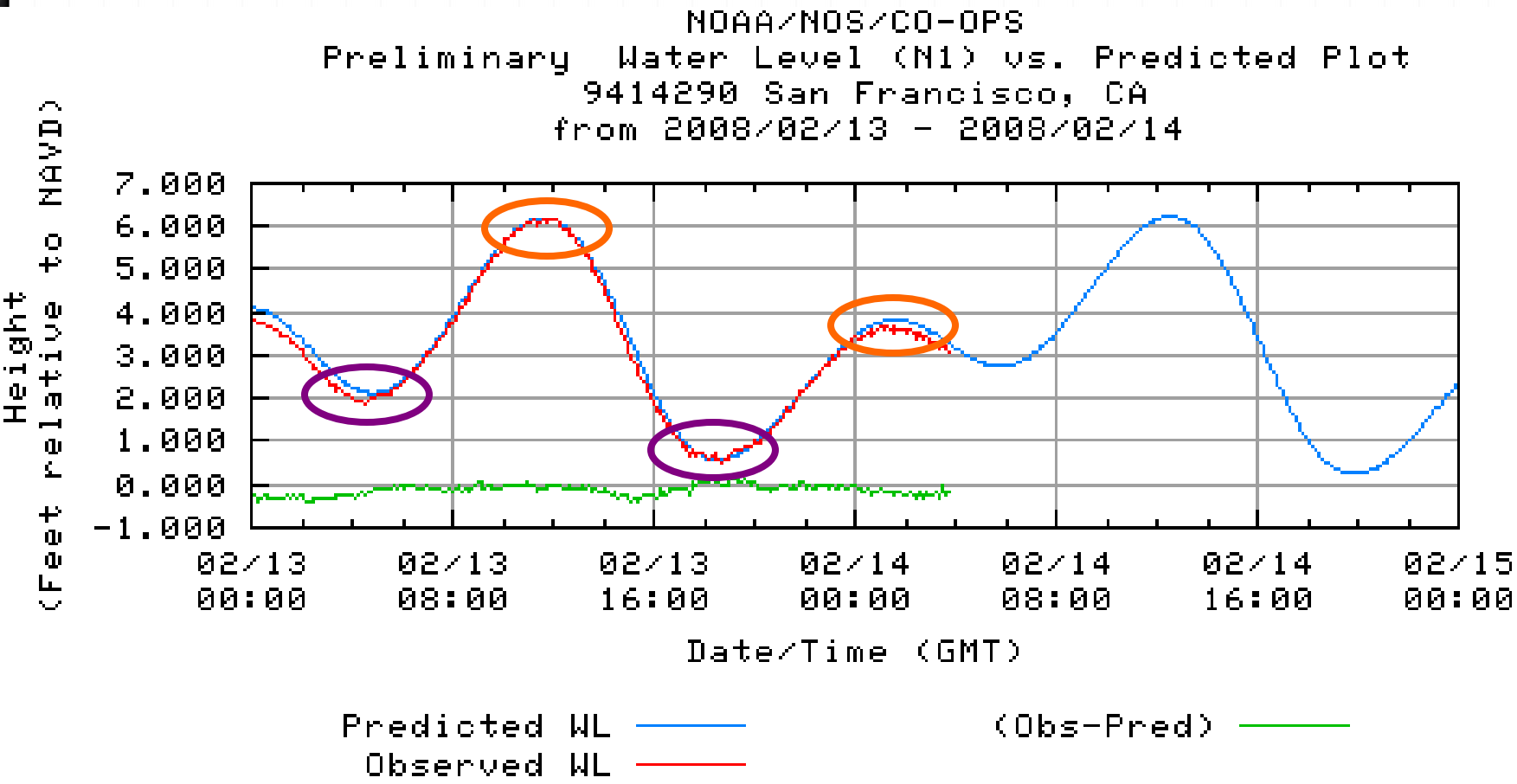
- Fundamentally based on the motion of the Earth, sun, and moon and their celestial locations astronomical tides are forecasted.

- Flood/ebb tide travel time, river inflow, river bed frictions, and bathymetry are also used to adjust tidal fluctuations in local levels.

- Other variables (e. g., wind speed-direction, barometric pressure etc.) are adjusted to predict tides in delta once Golden Gate tides are forecasted.

Diurnal Tides = Twice a Day

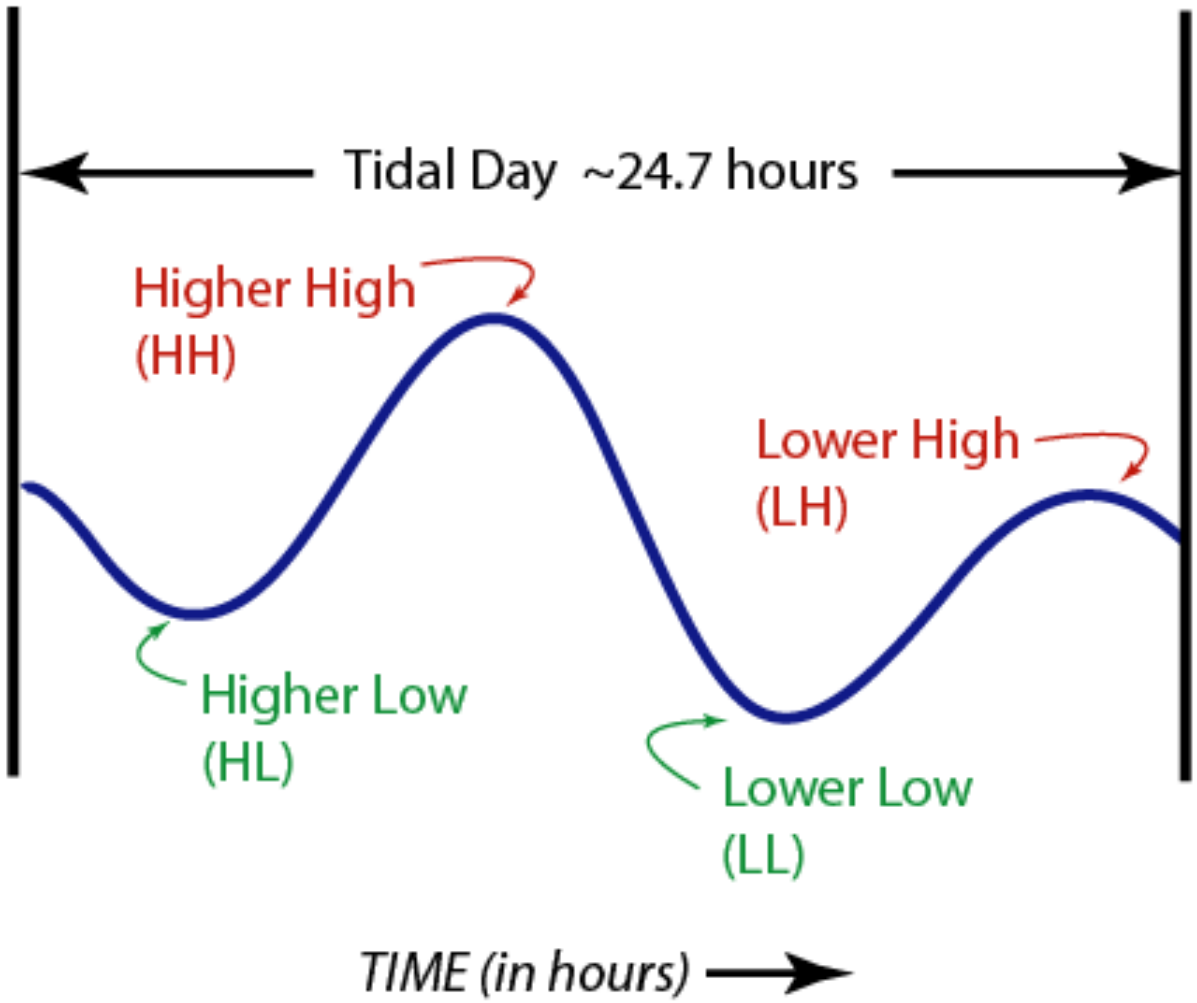
San Francisco at Golden Gate Example



High Tides

Low Tides

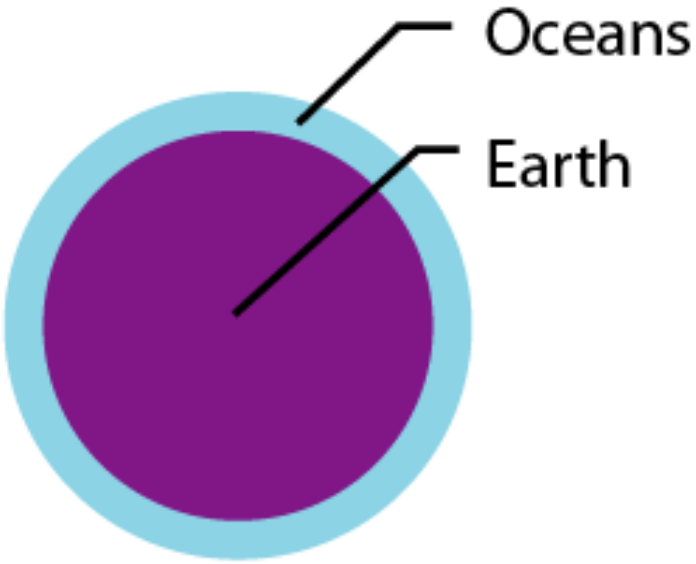
Types of High and Low Tides



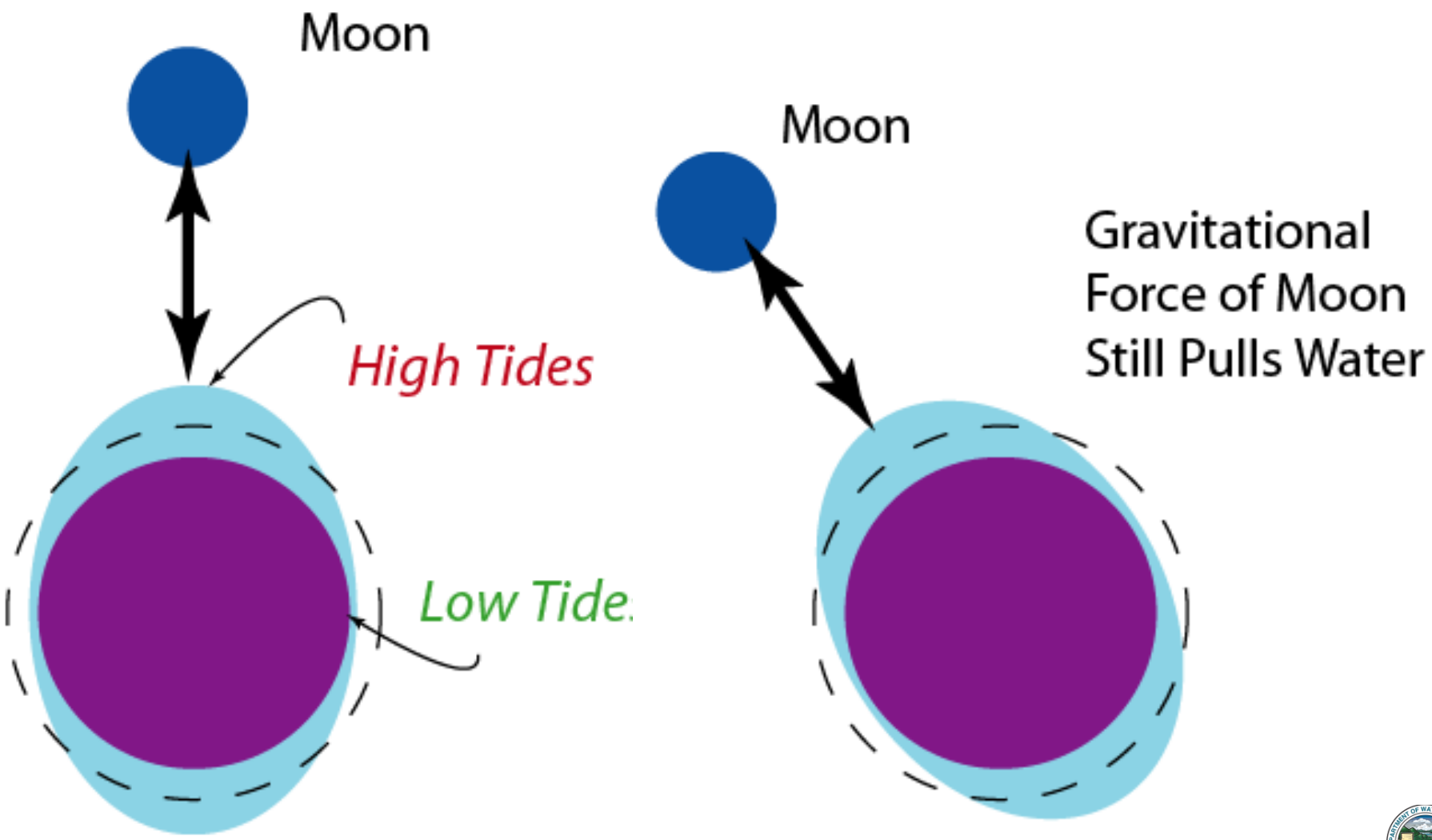
Earth, Sun, & Moon

Tides are a product of the gravitational forces acting on the Earth's oceans from the:

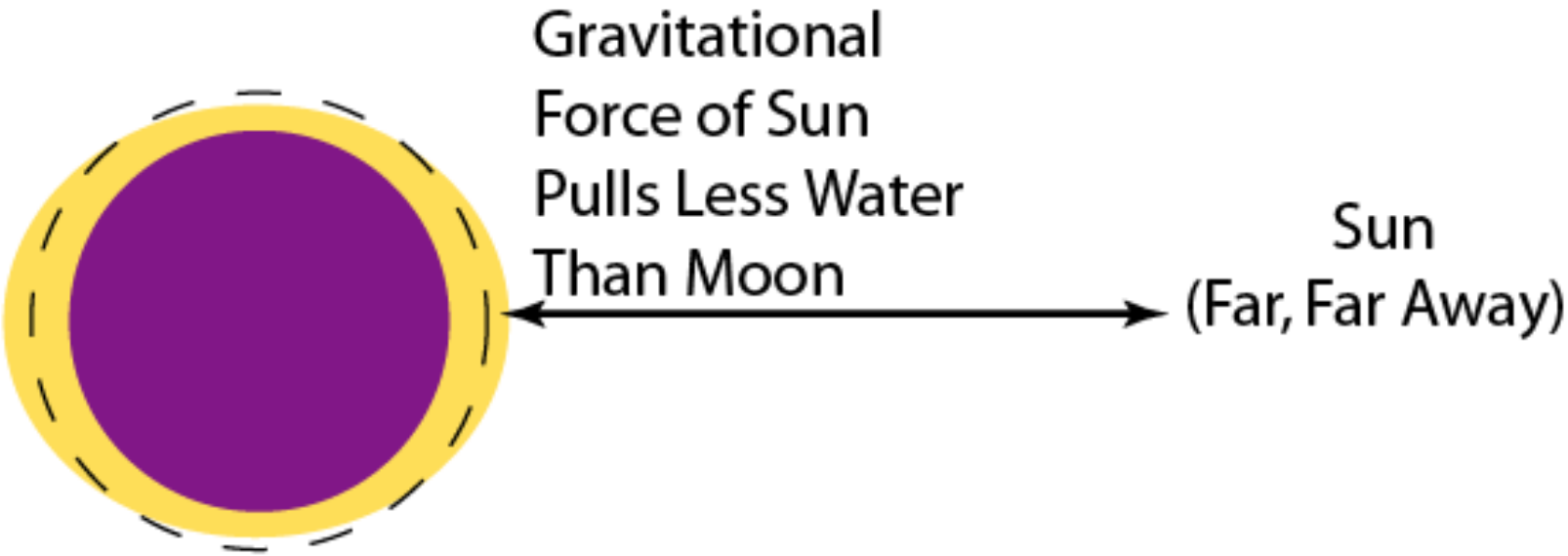
- Earth
- Moon
- Sun



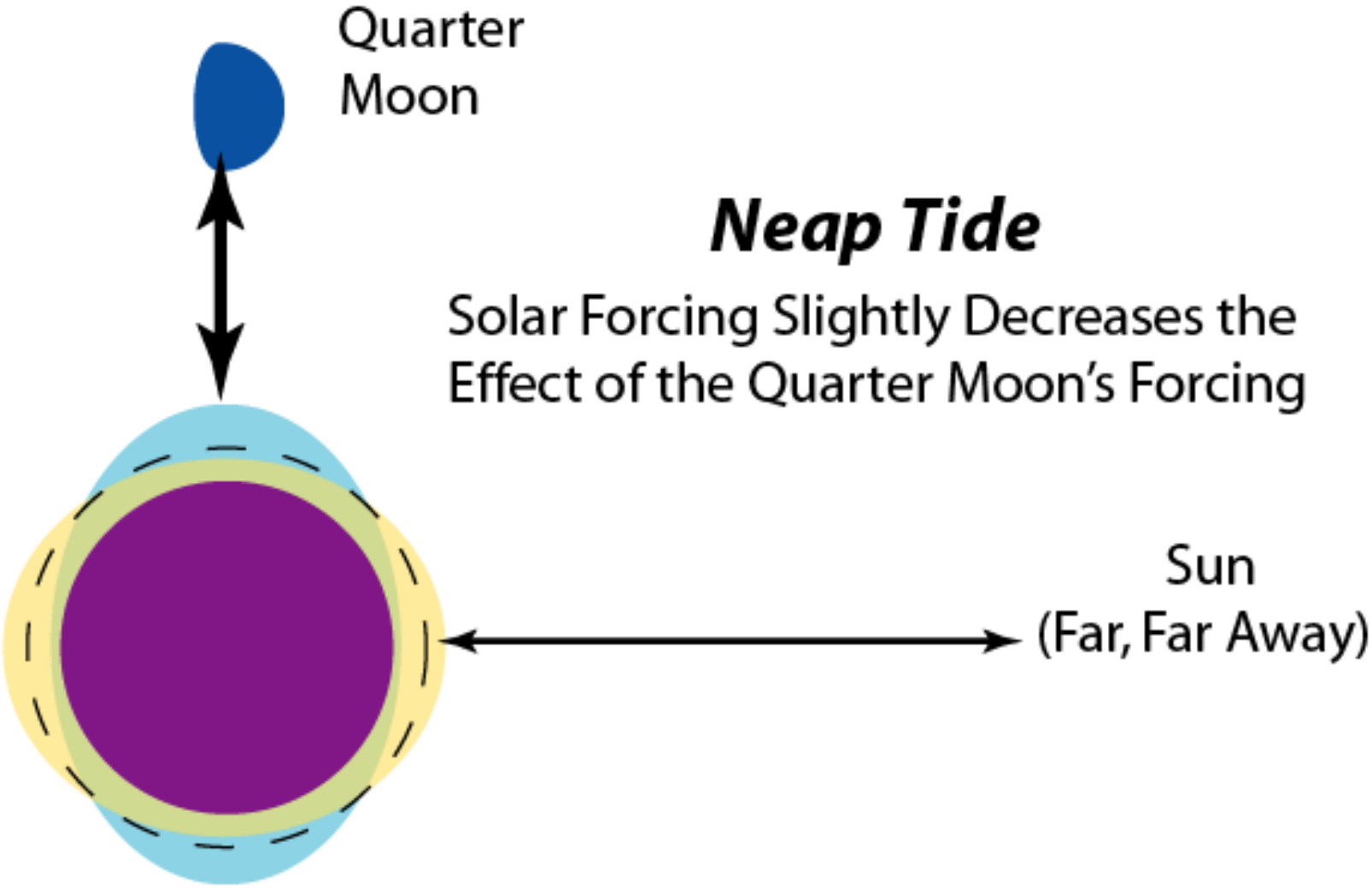
Force of Moon Only



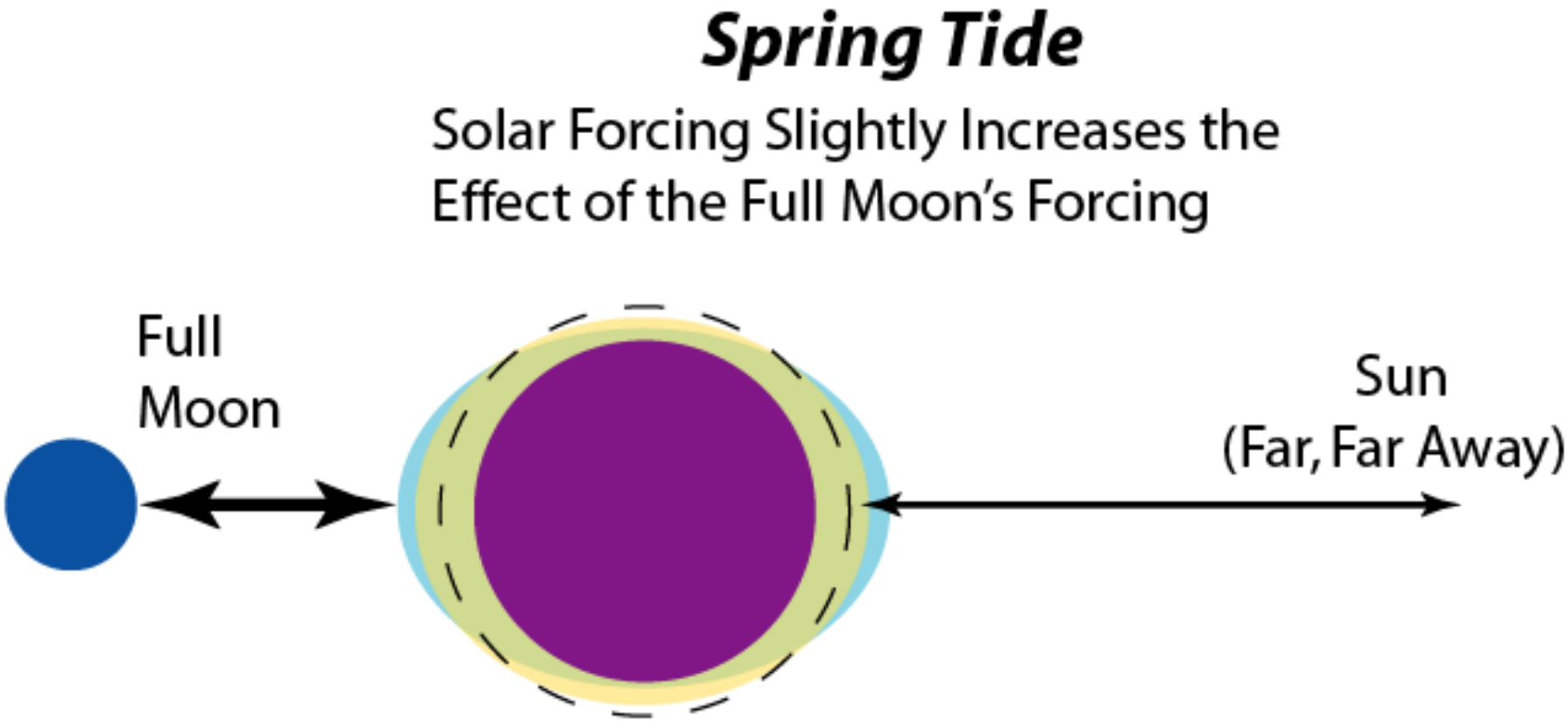
Force of Sun Only

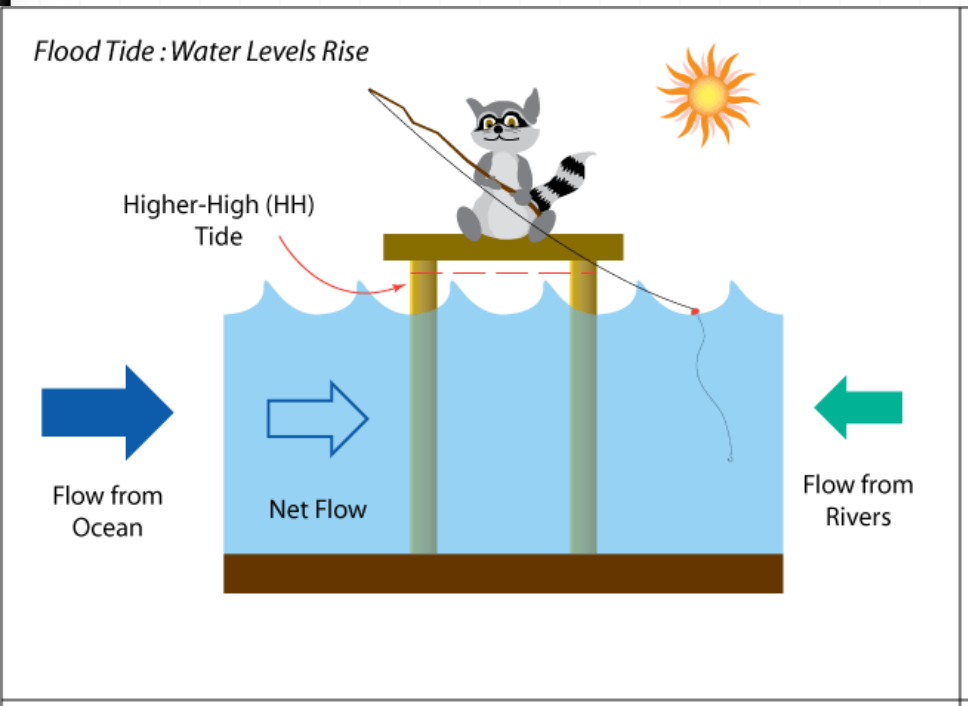


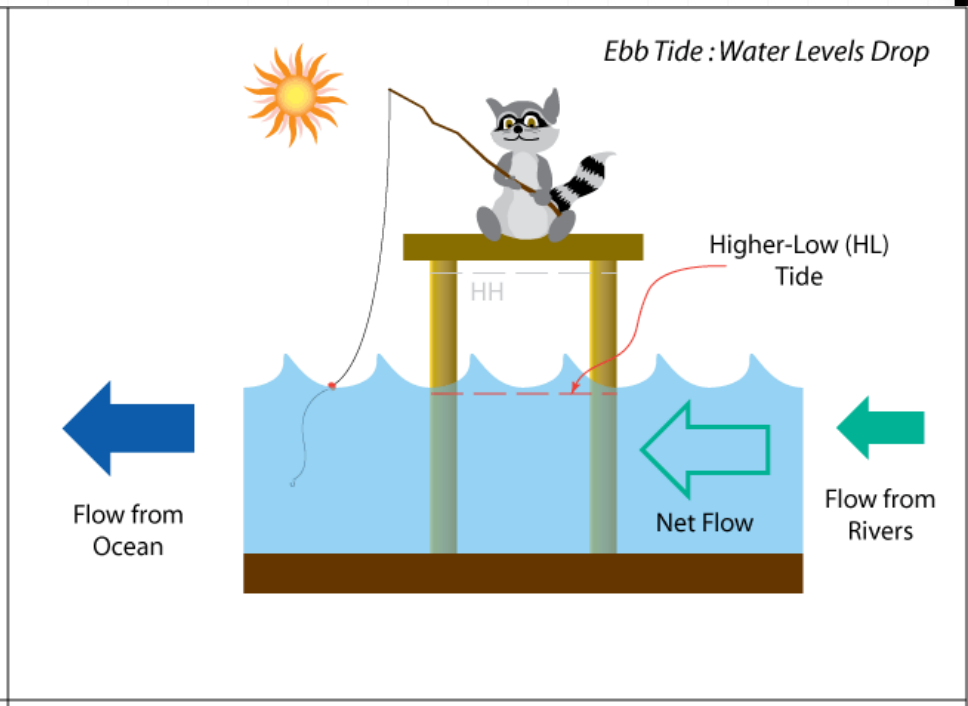
Gravitational Forces Cancel

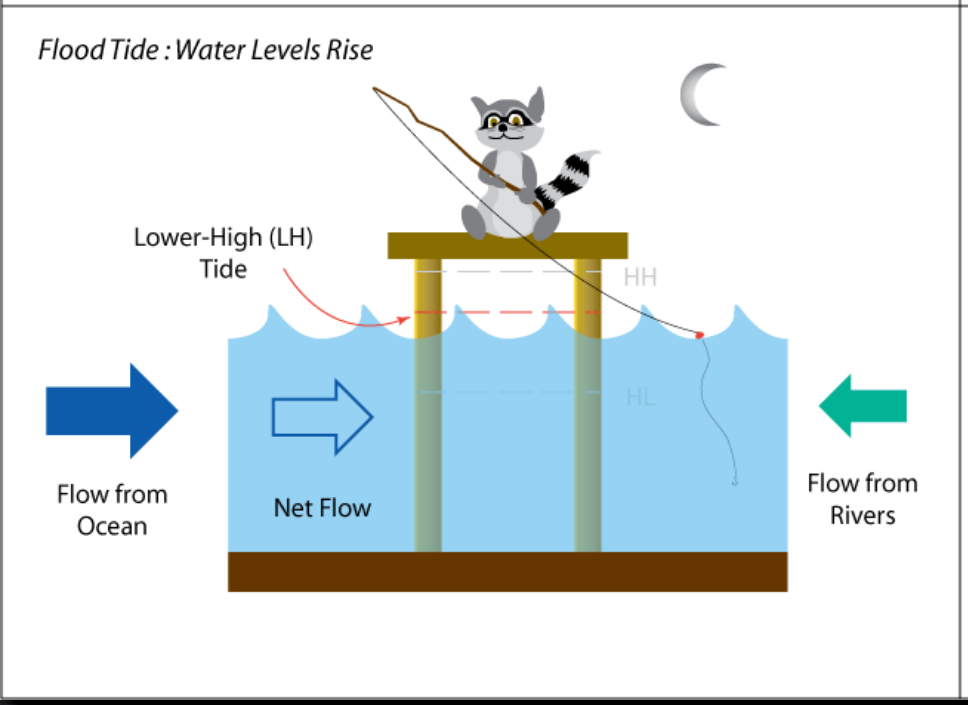


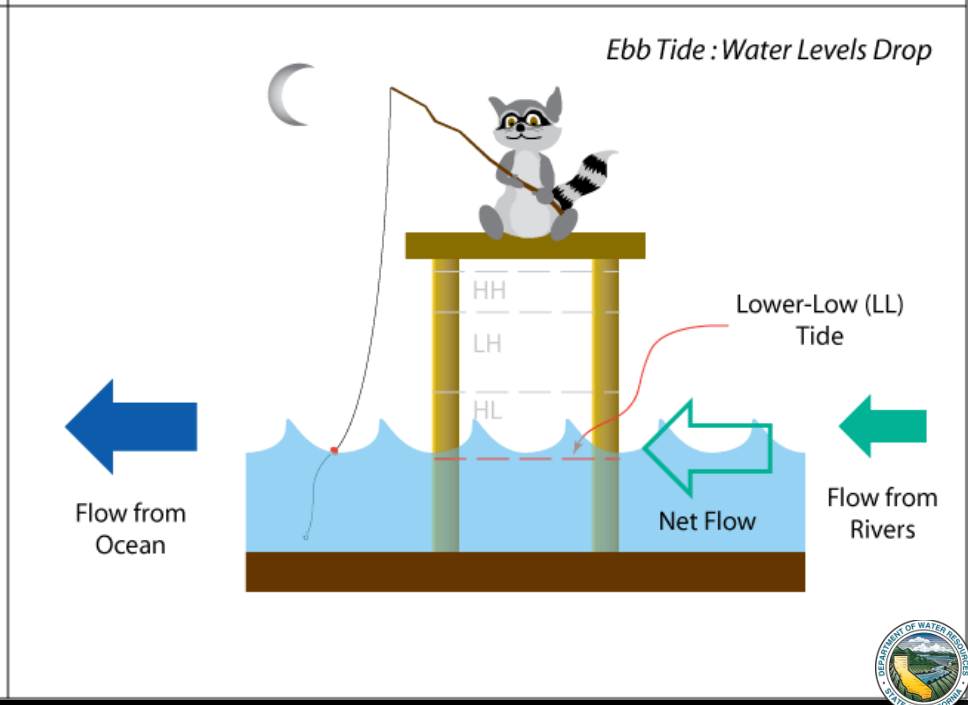
Gravitational Forces Add




Flood Tide : Water Levels Rise
Higher-High (HH) Tide
Flow from Ocean
Net Flow
Flow from Rivers


Ebb Tide : Water Levels Drop
HH
Higher-Low (HL) Tide
Flow from Ocean
Net Flow
Flow from Rivers


Flood Tide : Water Levels Rise
Lower-High (LH) Tide
HH
HL
Flow from Ocean
Net Flow
Flow from Rivers


Ebb Tide : Water Levels Drop
HH
LH
HL
Lower-Low (LL) Tide
Flow from Ocean
Net Flow
Flow from Rivers

Tidal Constituents

Principal Lunar

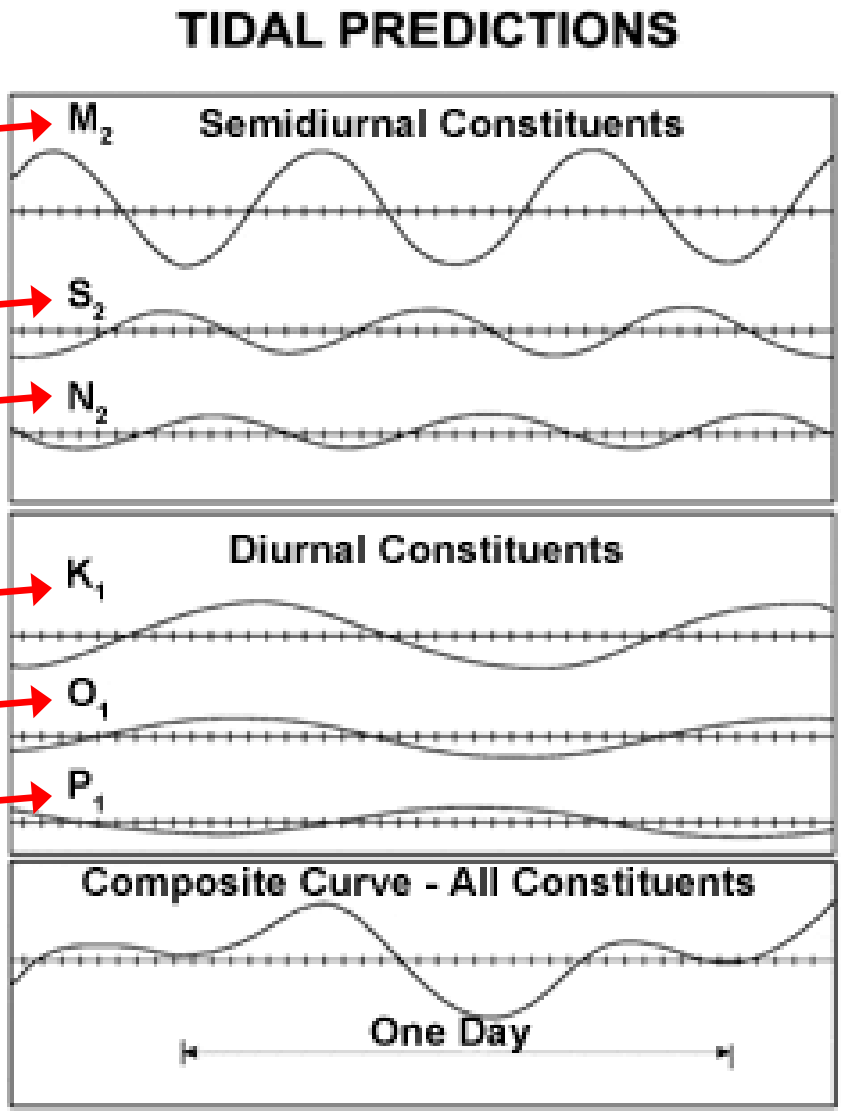
Principal Solar

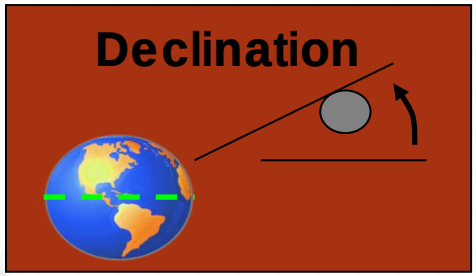
Large Lunar Elliptic

Lunar-Solar Declinational

Principal Lunar Declinational

Principal Solar Declinational





Other Forces on Tides

Short-Term Forcings

Forcing	Impact on Tides
Low Pressure System	↑
High Pressure System	↓
High Winds	↑
High River Outflows	↑

Long-Term Forcings

- Local Subsidence
- Local Uplifting
- Thermal Expansion of Oceans
- Melting of Polar Ice
- Detention / Retention of River Outflow

Why Tides Are Important

- Our economy and lives are tied with coastal areas
- Knowing when and where water will be highest allows us to reduce the negative impacts of:
  - Costal & low-lying area flooding
  - Unnavigable waterways
  - Poor water quality

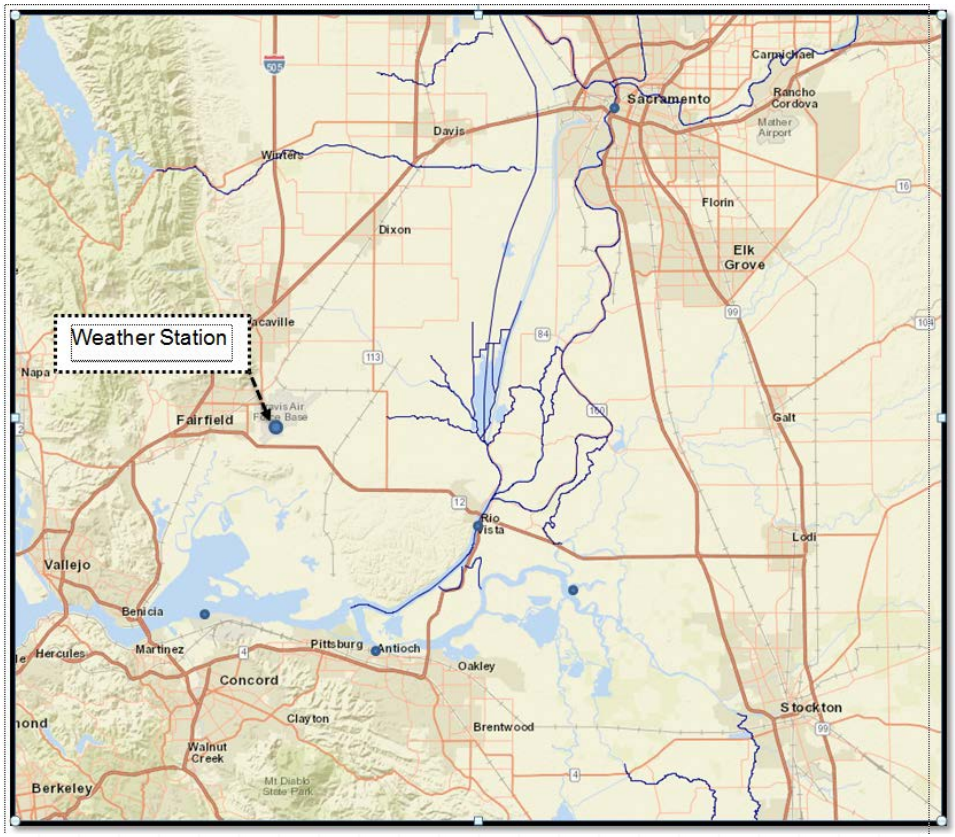
How We Forecast Tides

- Golden Gate tides are forecasted using a mathematical model which incorporates motion and location of earth, sun and moon and corresponding gravitational attractions.

- In addition, more than sixty different variables are also used to forecast tides.

- Forecasts at other stations are made from Golden Gate tides with a delay and height adjustment that are calculated using the four preceding highs and lows.

Travis AFB weather station: Wind Speed and Direction Applied for Tide Forecasting



Tide Forecasting: Basics Cont'd..

Station	Delay Constant Offset (hours)	Height Constant Offset (feet)
Antioch	4.89	-0.18
Venice Island	6.42	0.27
Rio Vista	2.71	-3.24
I Street Bridge	11.63	-1.92

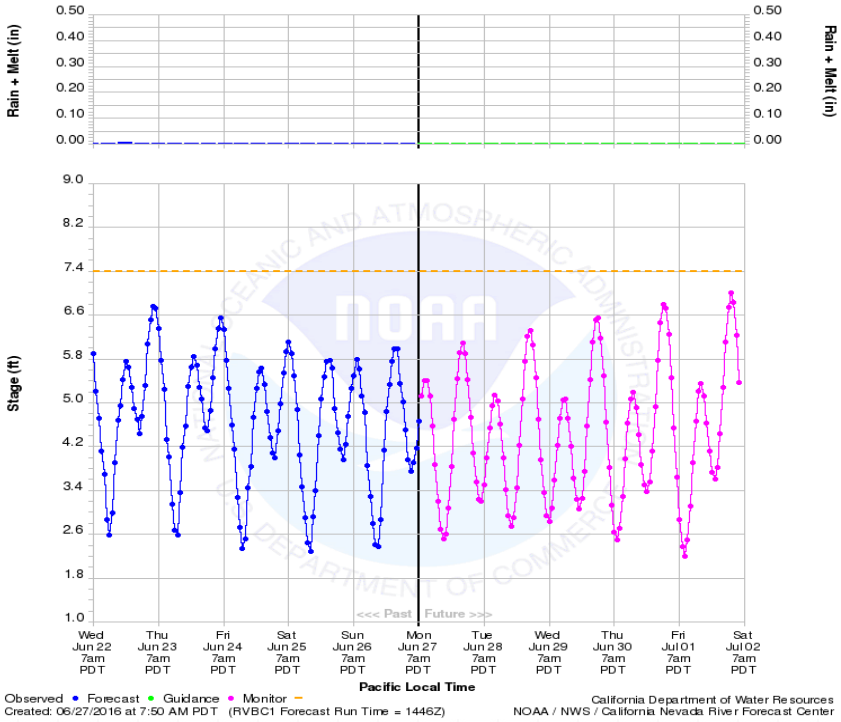
In addition to delay and height constants, other assumptions are applied while predicting tides, which are:

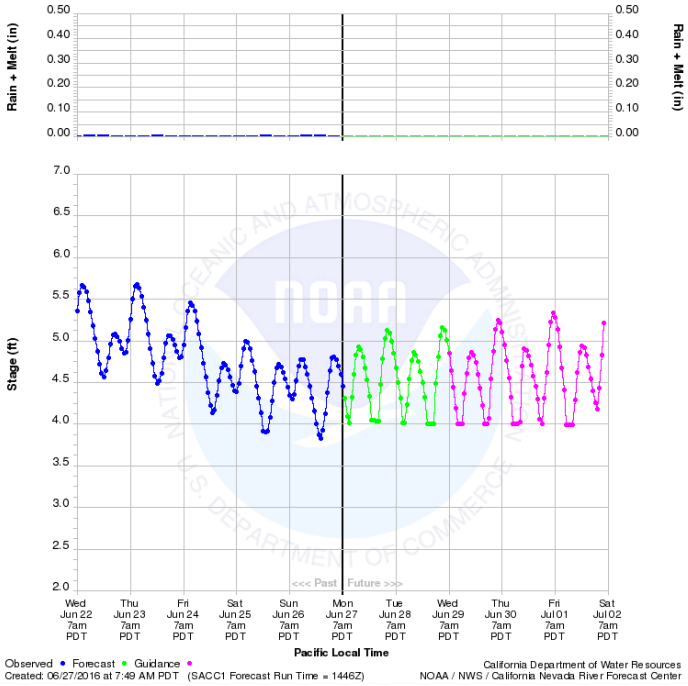
(i) Wave speed upstream is linear,

(ii) Magnitude of the tide height decays linearly

(iii) Freshwater influx, bathymetry, and bottom friction act as a damping force on the wave function.

Forecasted Tides in Delta





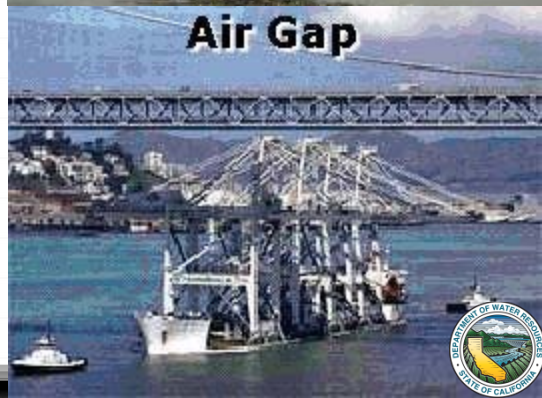
An example of tide forecasts at Rio Vista(left) and I Street Bridge (Right)

Why do we forecast tides?

- Forecasted tide data is being used for navigational purpose, e. g., San Francisco Bar Pilots.
- Local agencies use forecasted levels of tidal data to obtain the information on water quality, e. g., salinity, electrical conductivity, suspended solids, etc.
- Forecasted water level is useful for fishermen and thus in fishing industries.
- During extreme flooding events, it is helpful to declare advanced warnings and evacuations.

Who is Affected by Tides

- Ecosystem
  (Fish, Mammals, Birds, Invertebrates)
- Fisheries
- Property Owners
- Recreational Activities
  (Boaters, Rec. Fishing, & Swimmers)
- Water Supply
  (Agricultural & Municipal / Industrial)
- Navigation / Transportation
  (Bar Pilots / Construction)



Tide Forecasting: Applications

- Estimate water surface elevation at any station in delta
- Construct tide factor contours in delta
- Develop levee fragility curves based on hydrologic, hydraulics and seismic hazards

Tide Forecasting: Challenges

- Real time forecasting is limited to very few locations
- Linear interpolation of wave, time and frictional attenuation may be overly simplified
- Datum changes may occur due to ground motions, subsidence and seismic activities
- Datum re-validation is not practicable due to multiple constraints, e. g., economic, technical and, political

Conclusion

- River forecasting section is responsible to forecast daily variation of tidal fluctuations at five locations in delta.
- Forecasted tidal levels are synchronized with river inflow to obtain the stage and flow at multiple locations.
- Tide forecast is primarily driven to navigational purpose.
- Forecasted tide information is also used by researchers, environmentalists, fishing industries, local agencies, and other stakeholders.

Questions?

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http://cdec.water.ca.gov/rivforecasts.html