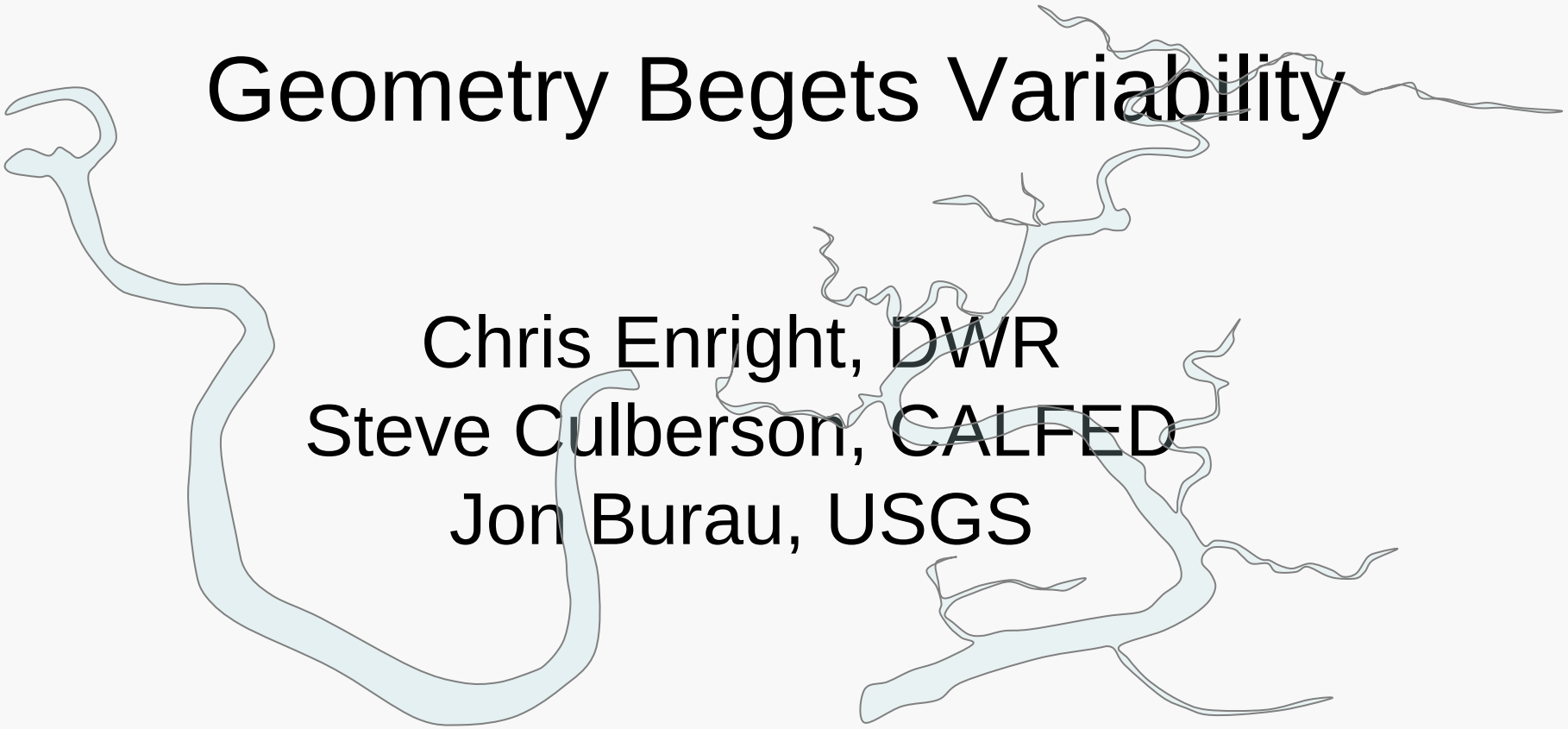
Comparing Natural and Modified Sloughs in Suisun Marsh:

Geometry Begets Variability

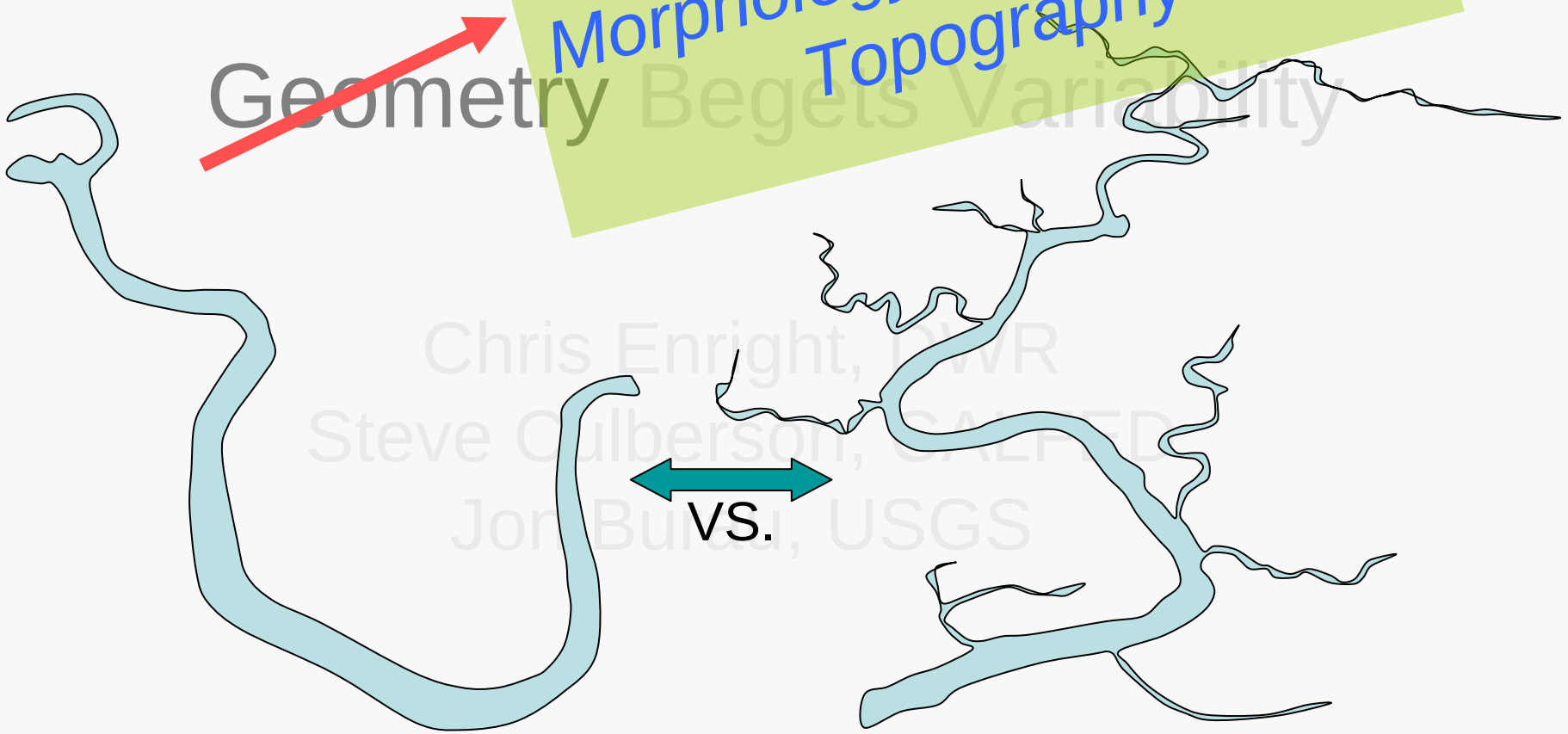


Chris Enright, DWR
Steve Culberson, CALFED
Jon Burau, USGS

Comparing Natural and Modified Sloughs in Suisun Marsh

Geometry Begets Variability

Biogeomorphology, Planform, Connectivity, Hydrography, Shape, Morphology, Hypsography, Topography

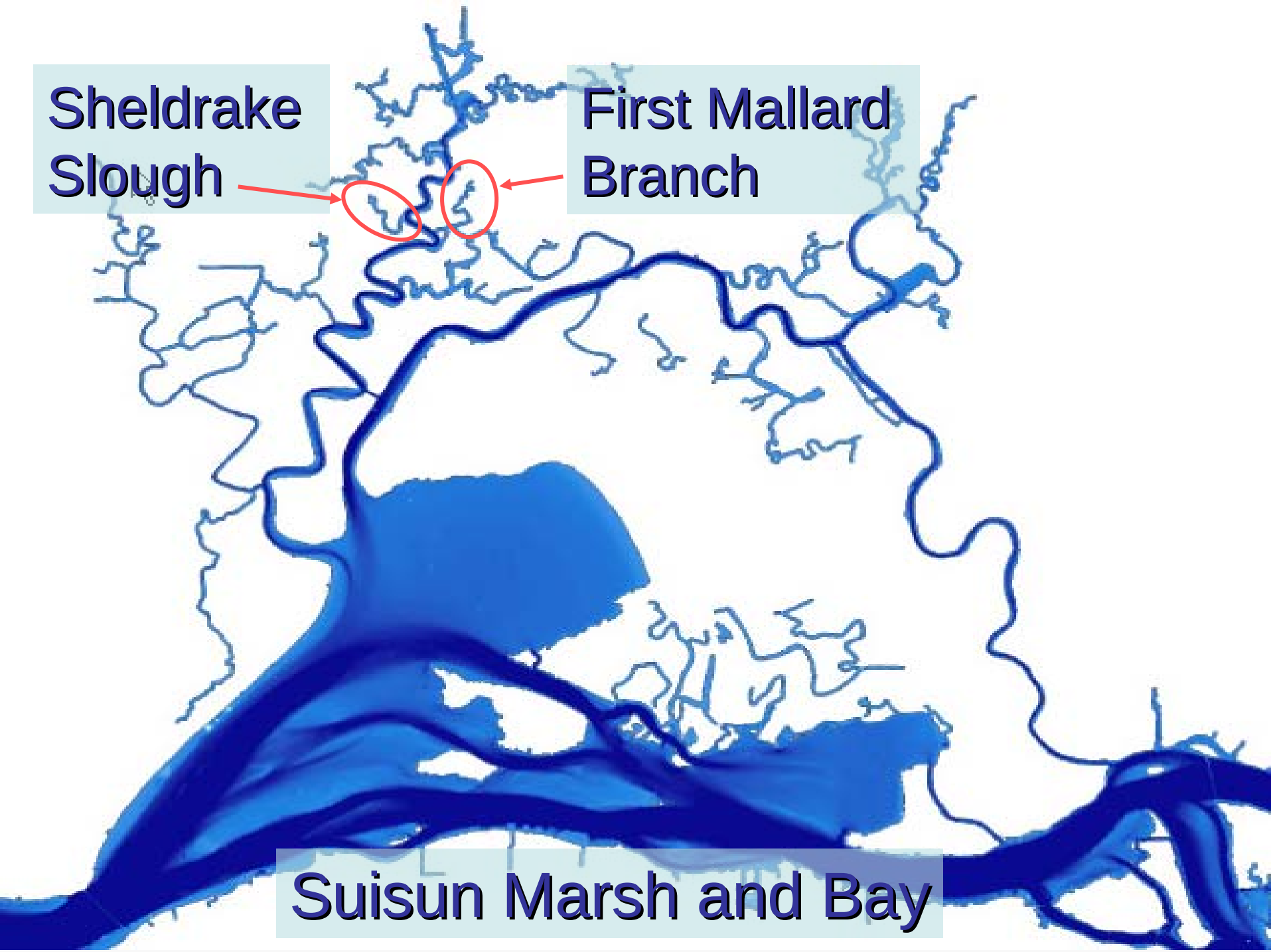


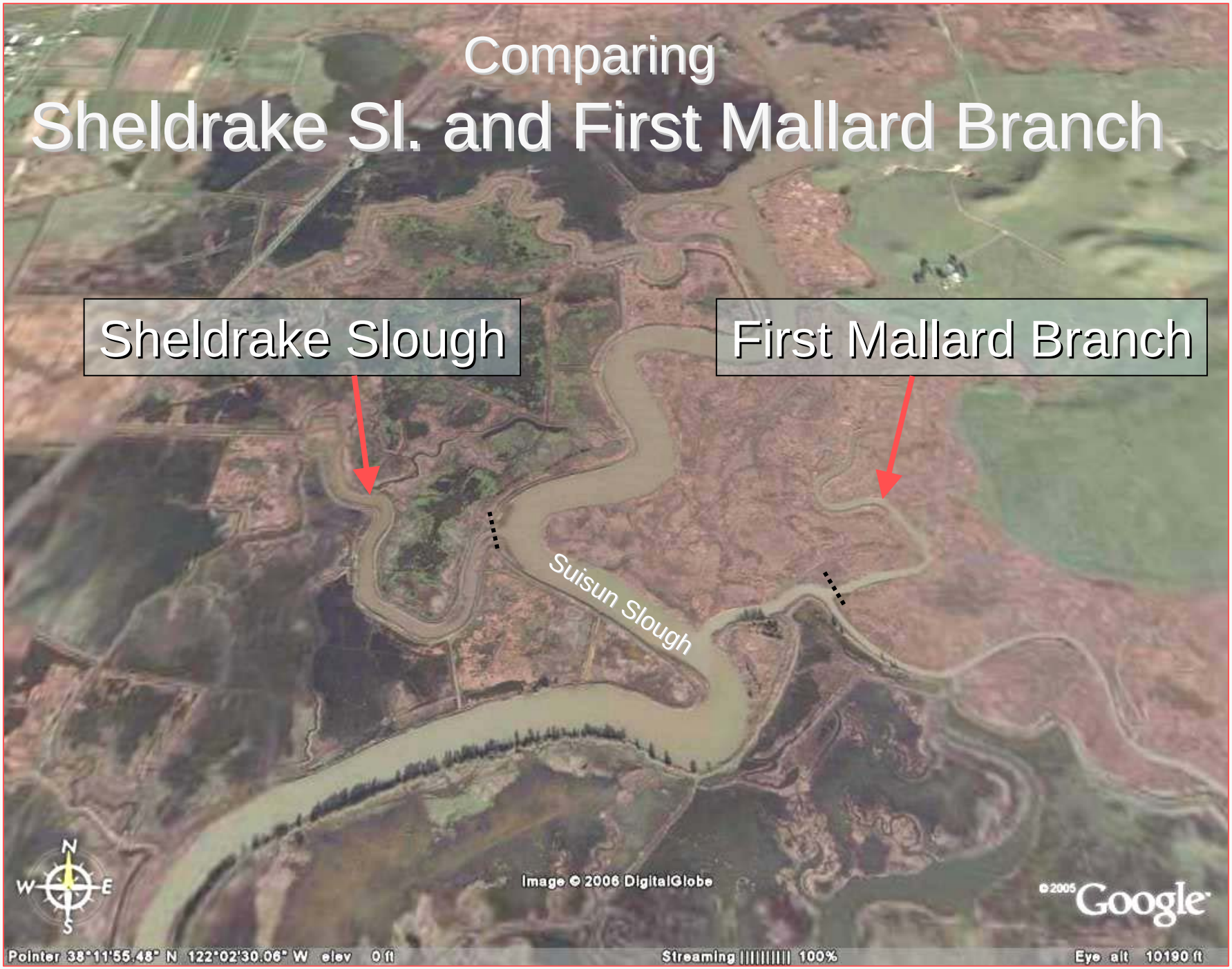
Chris Enright, RWR
Steve Culberson, CALFED
Jon Burau, USGS

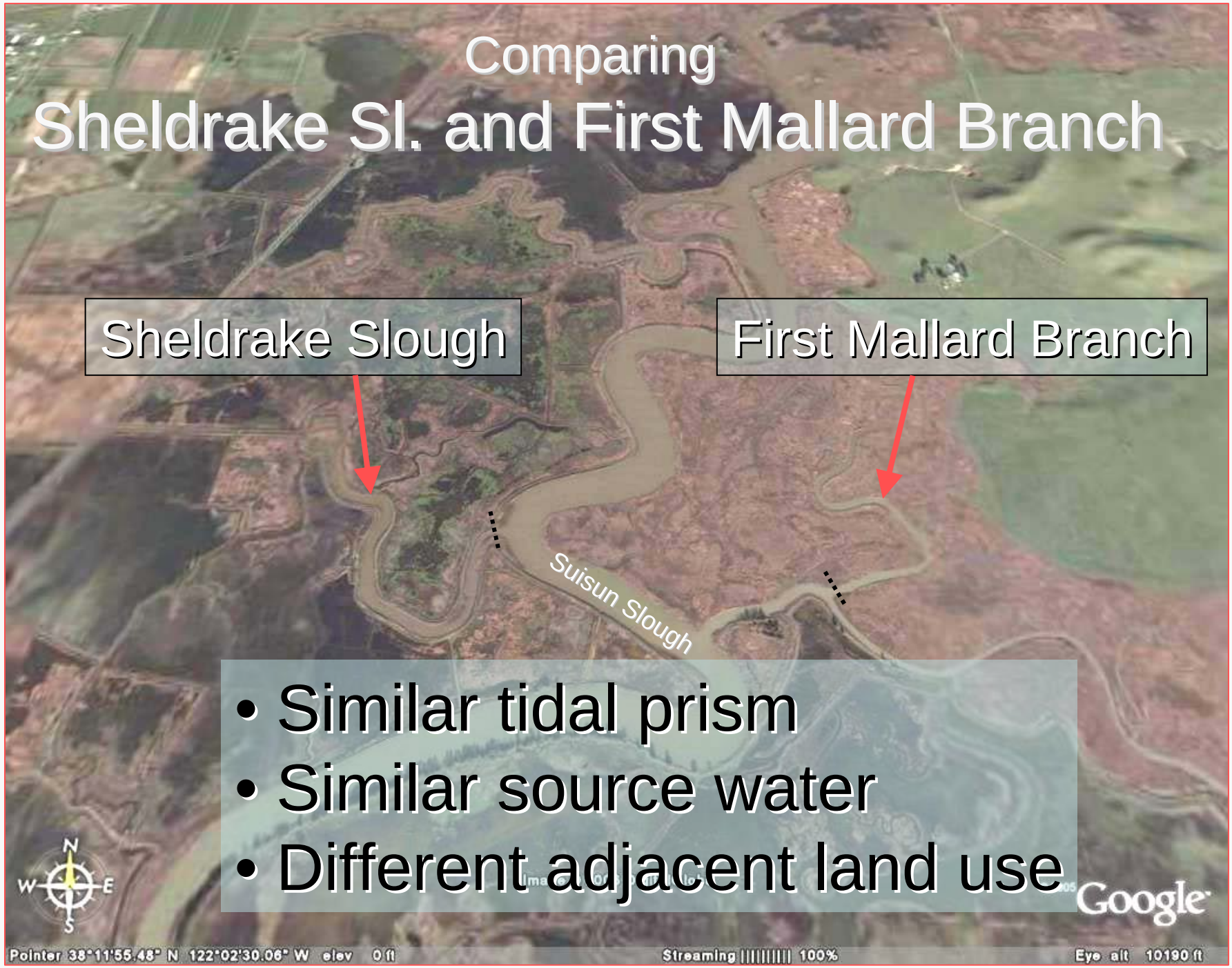
General Conceptual Model

- Geometry “filters” estuarine drivers (tides, etc)
- Complex geometry begets more variable process response.
- Suisun Marsh was historically more complex (geometry and aquatic-terrestrial connectivity)
- Native plants and animals figured out variability.
- Restoration goal: restore “geometric” complexity.
- How?

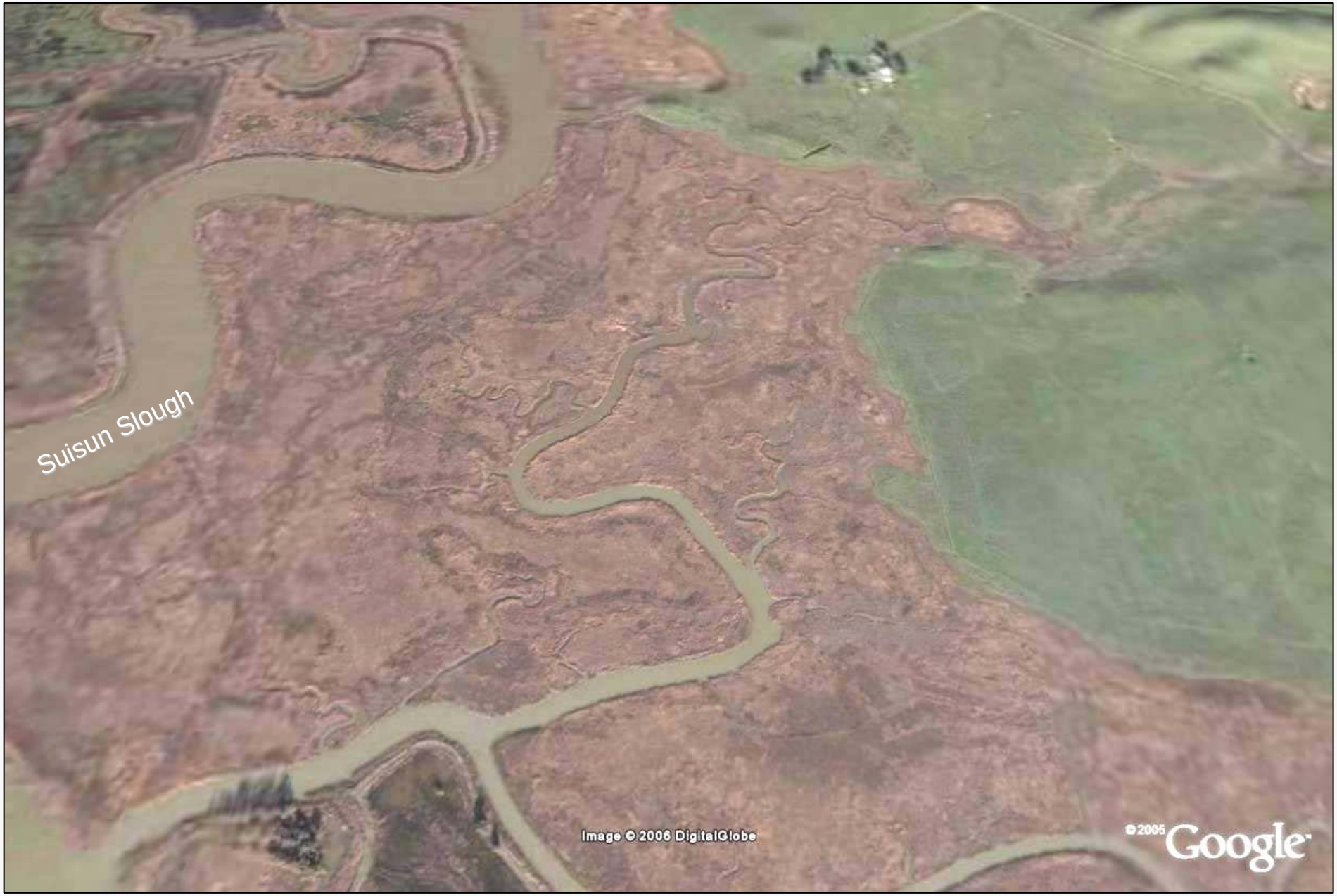
Find intertidal elevations and let tide in!


Sheldrake Slough
First Mallard Branch
Suisun Marsh and Bay


Comparing
Sheldrake Sl. and First Mallard Branch
Sheldrake Slough
First Mallard Branch
Suisun Slough
N
W
E
S
Image © 2006 DigitalGlobe
©2005 Google
Pointer 38°11'55.48" N 122°02'30.06" W elev 0 ft
Streaming 100%
Eye alt 10190 ft


Comparing
Sheldrake Sl. and First Mallard Branch
Sheldrake Slough
First Mallard Branch
Suisun Slough
• Similar tidal prism
• Similar source water
• Different adjacent land use
Google
Pointer 38°11'55.48" N 122°02'30.06" W elev 0 ft
Streaming 100%
Eye alt 10190 ft

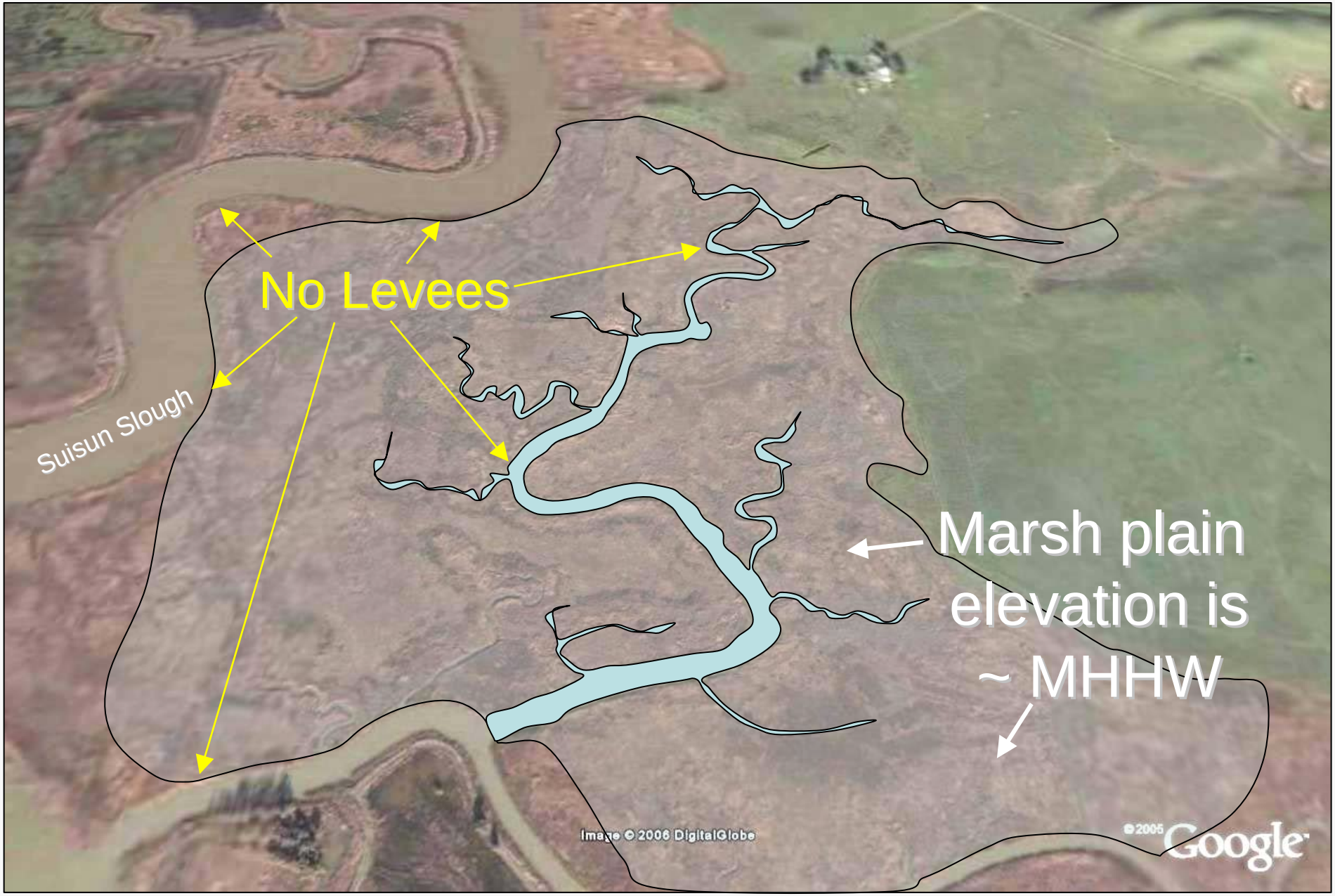
First Mallard Branch



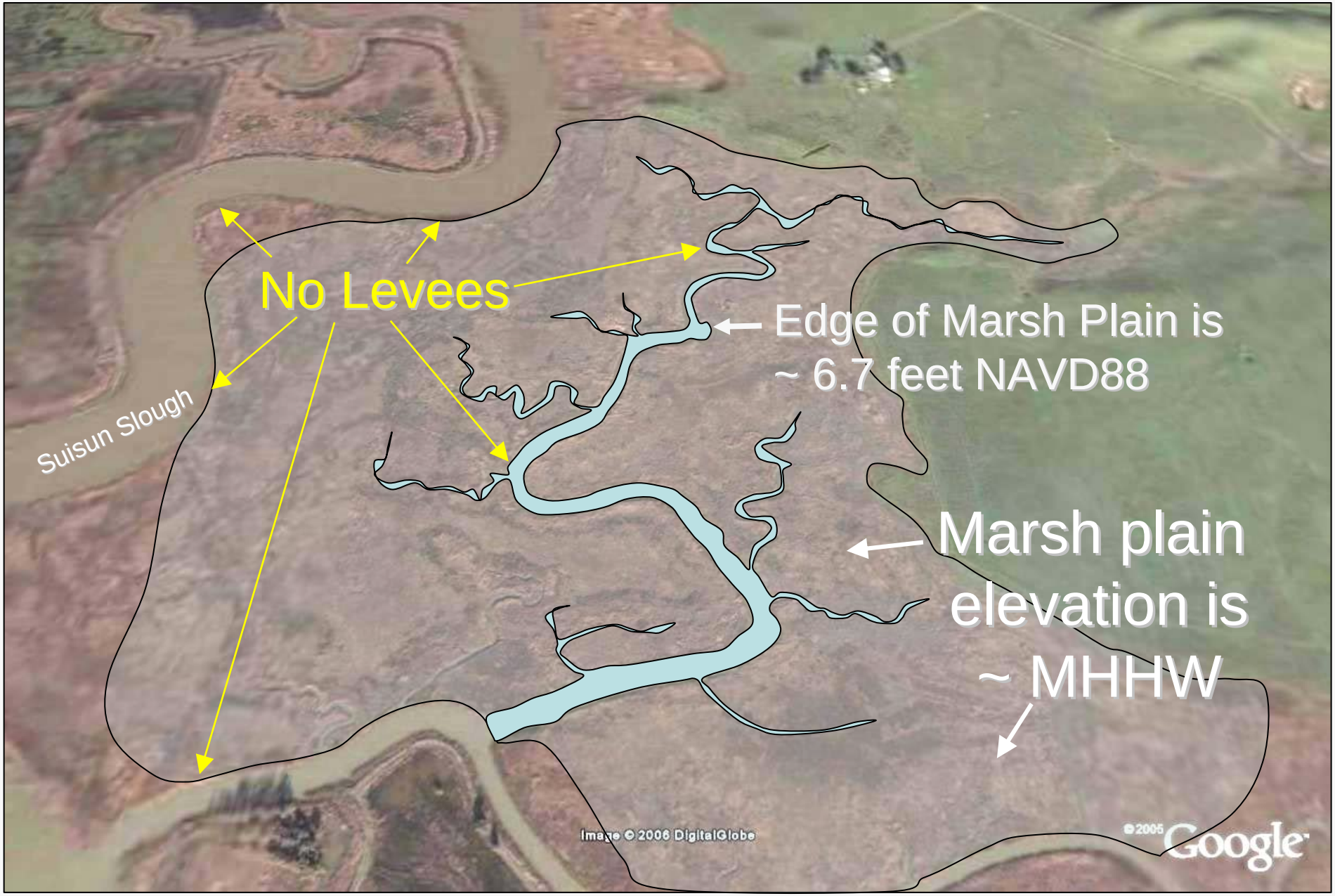
First Mallard Branch

First Mallard Branch

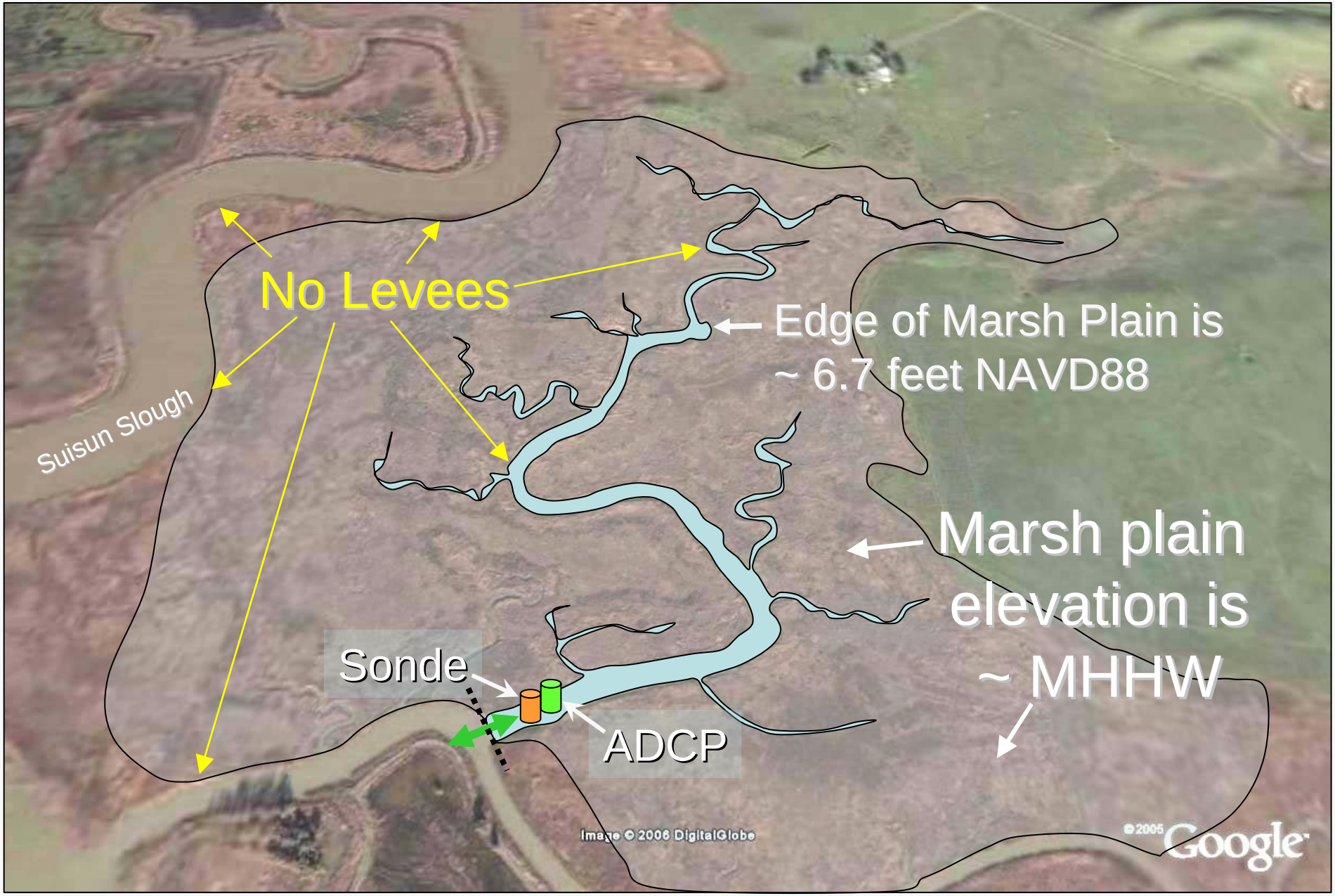
First Mallard Branch



First Mallard Branch



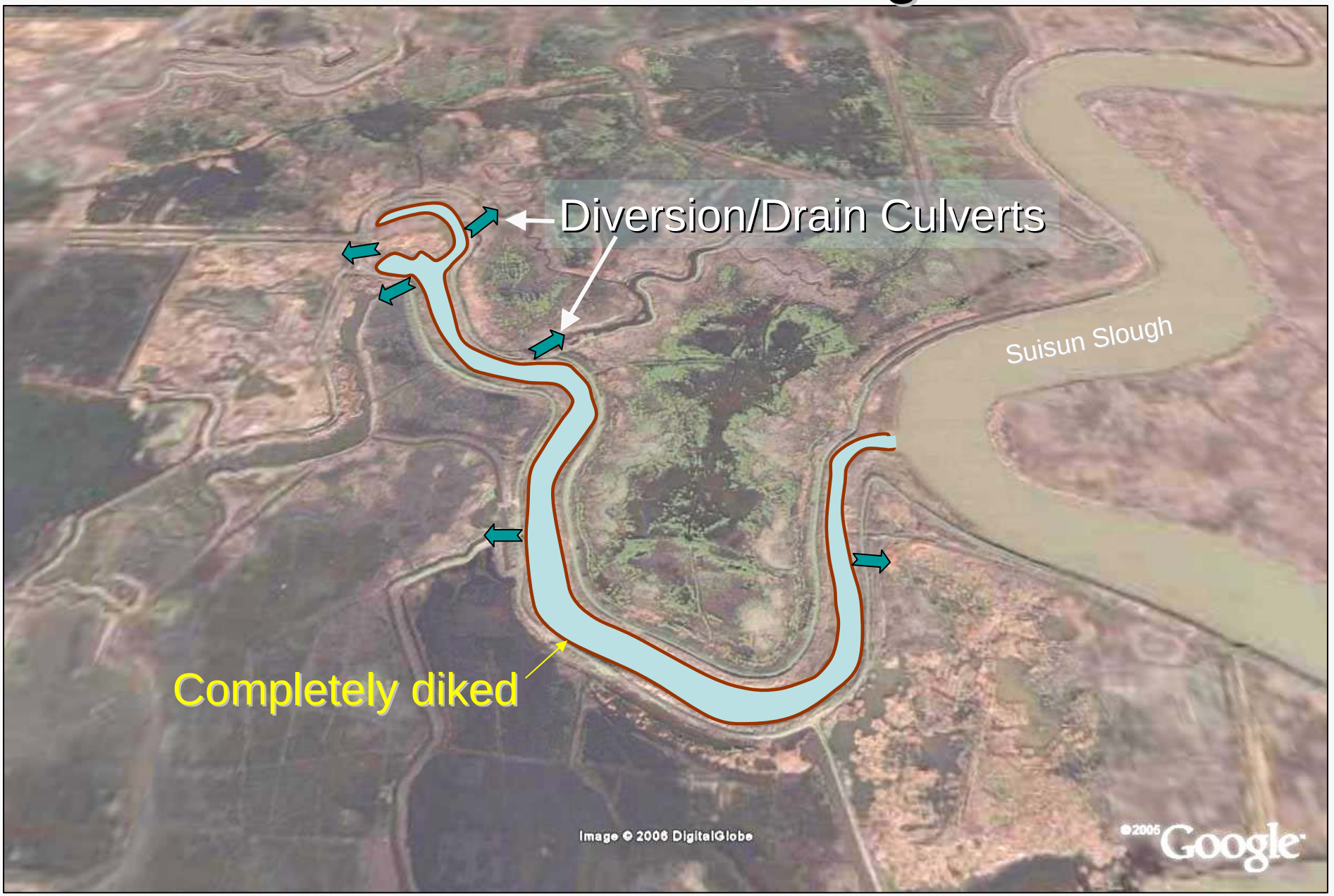
First Mallard Branch



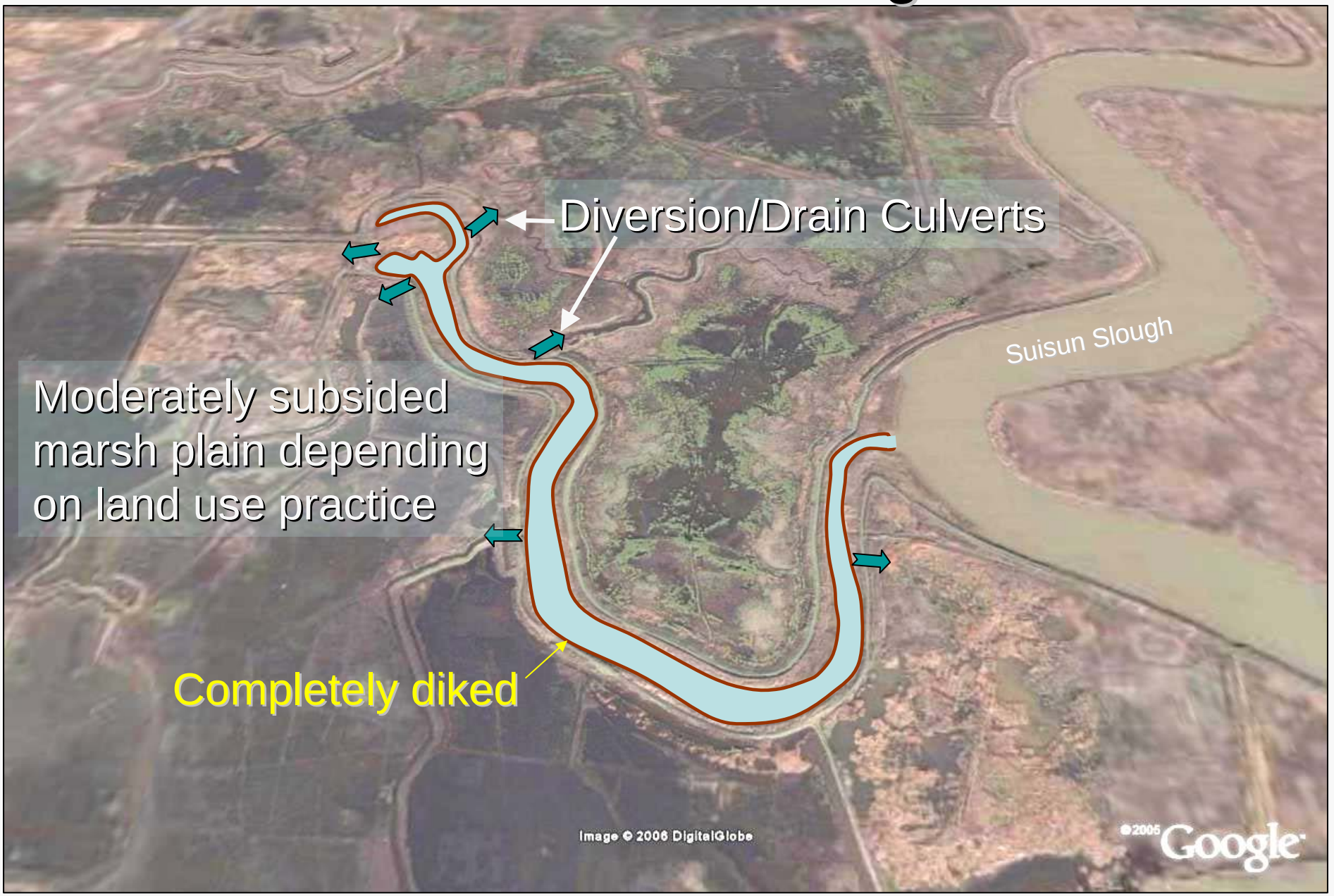
Sheldrake Slough

Sheldrake Slough

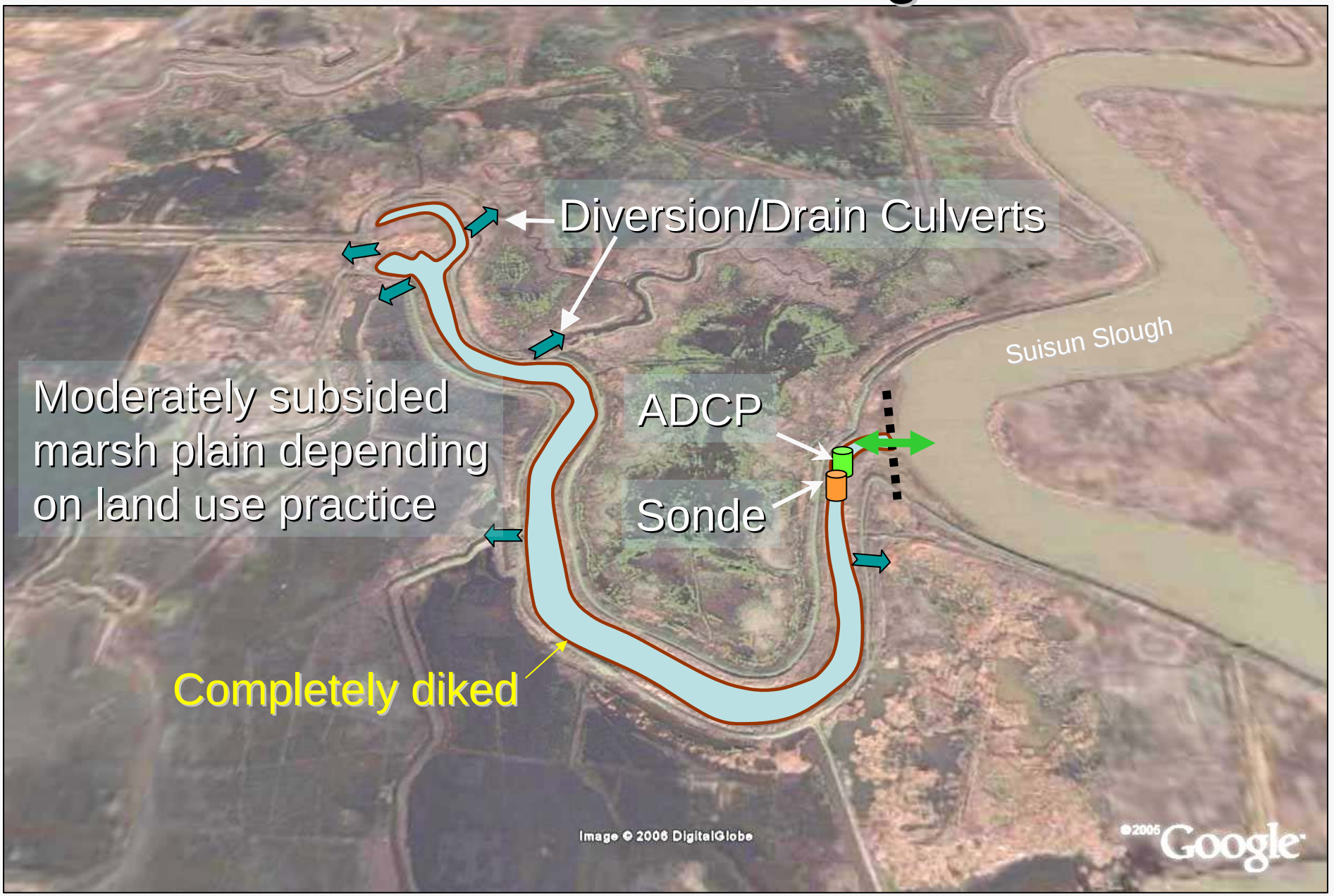
Sheldrake Slough



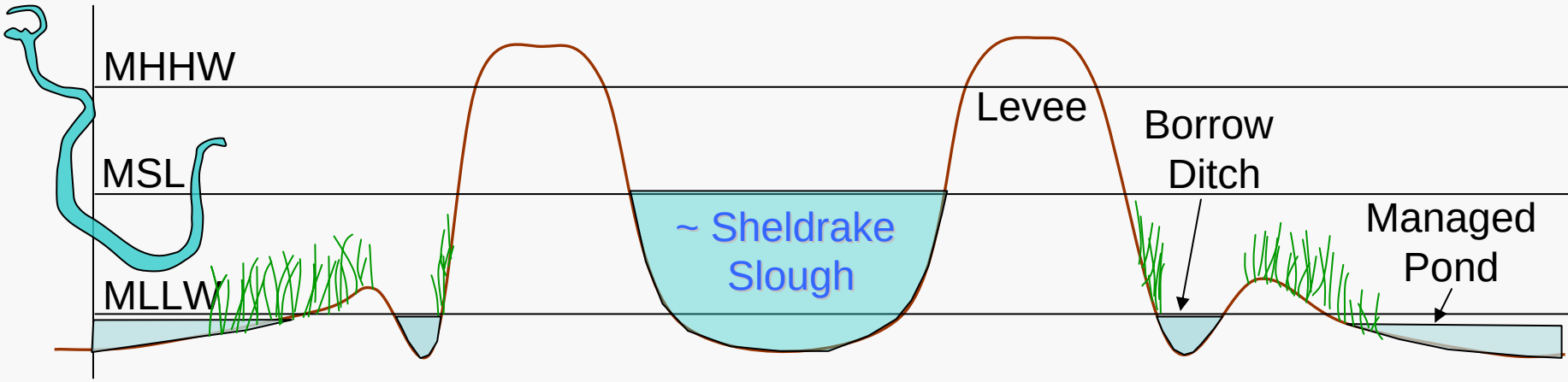
Sheldrake Slough



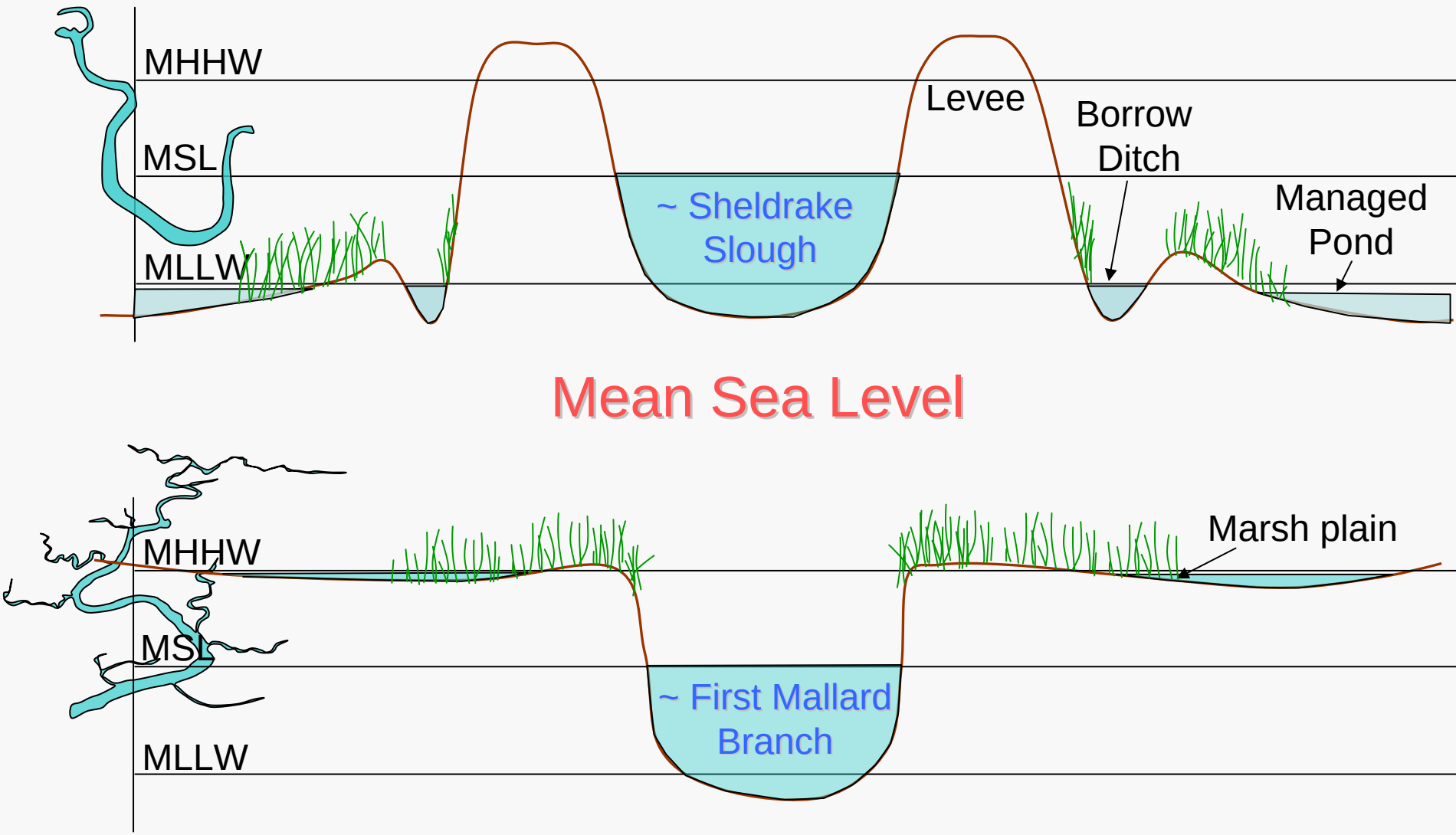
Sheldrake Slough



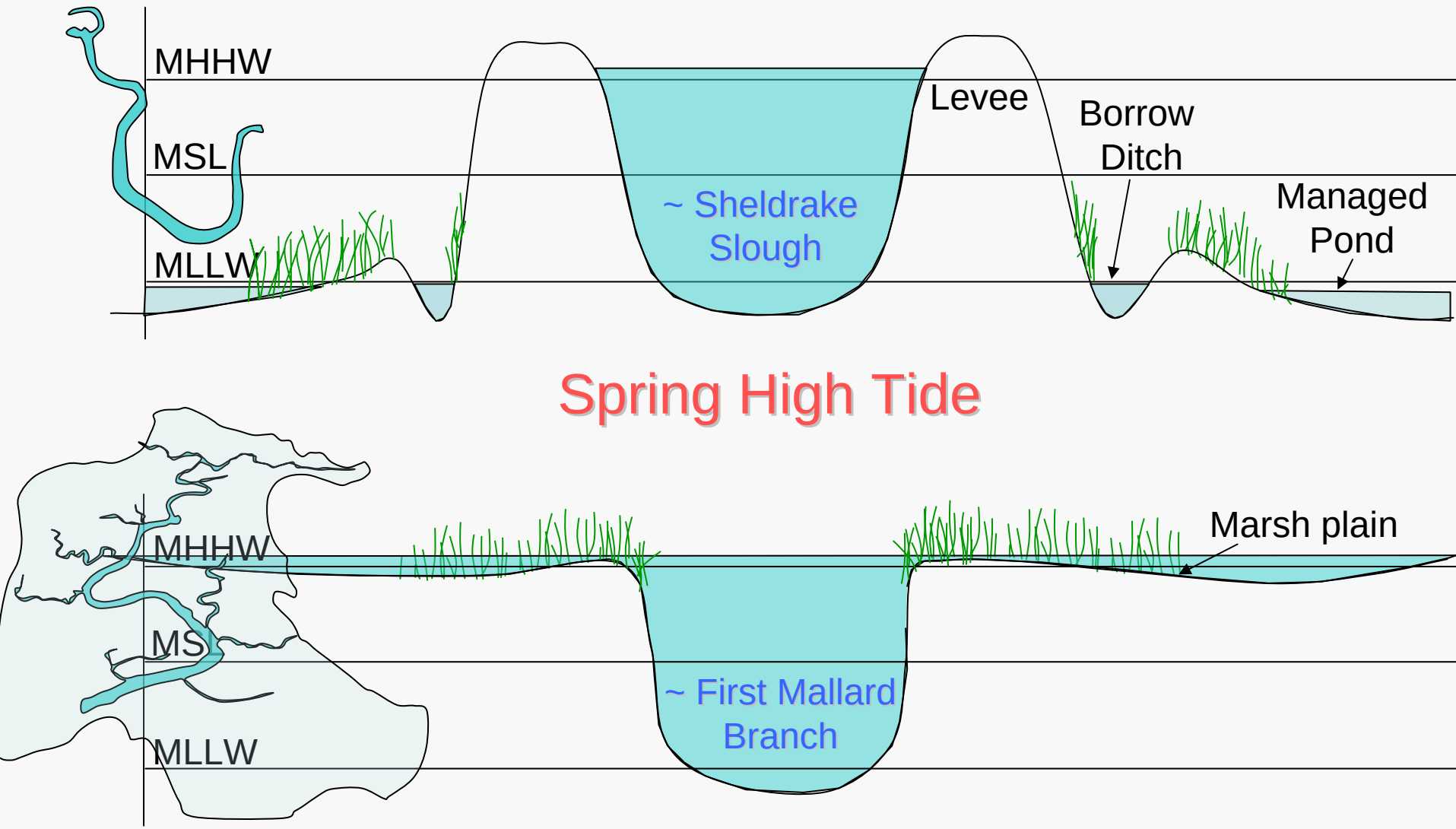
Comparing Typical Cross-section Hypsography

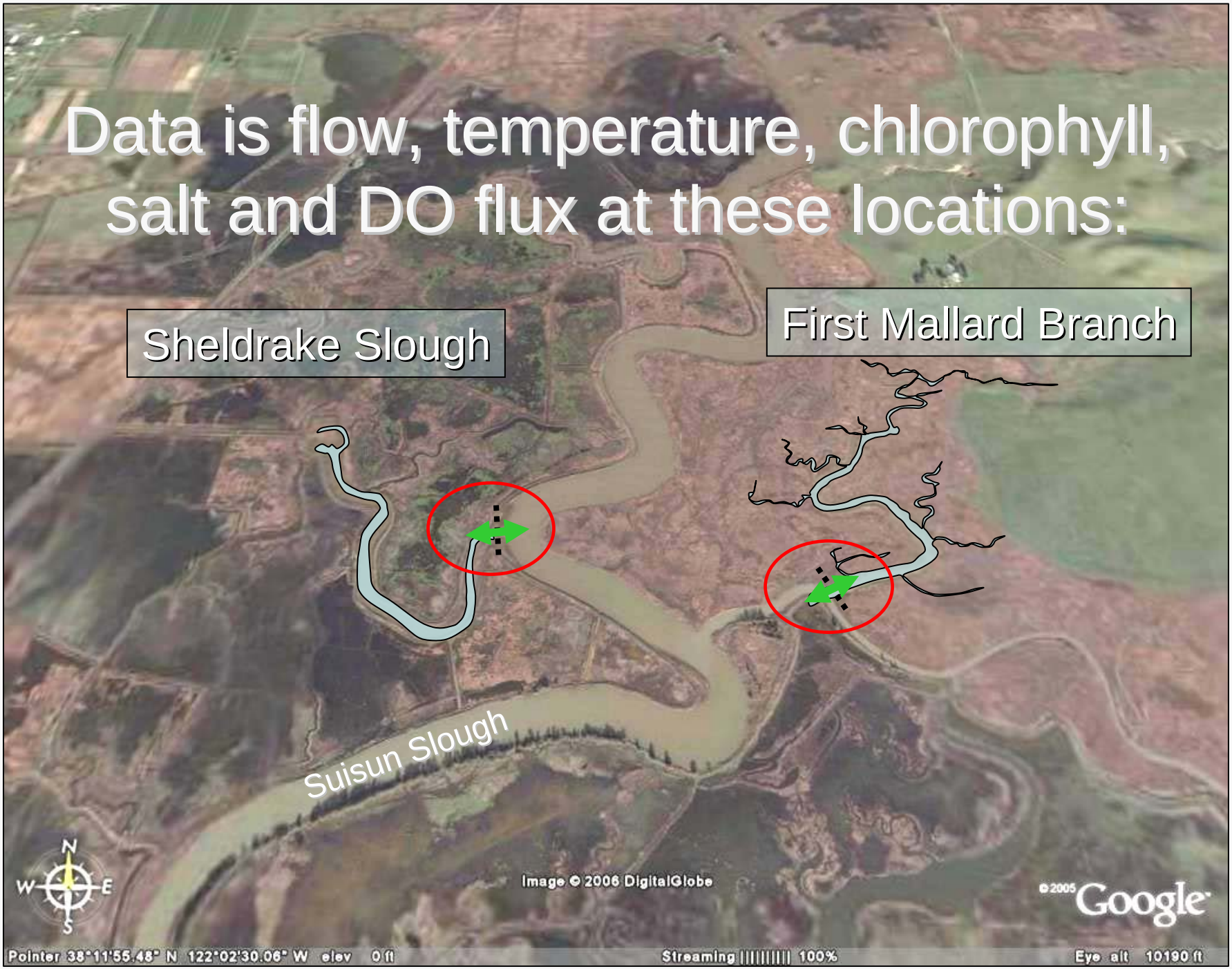


Comparing Typical Cross-section Hypsography

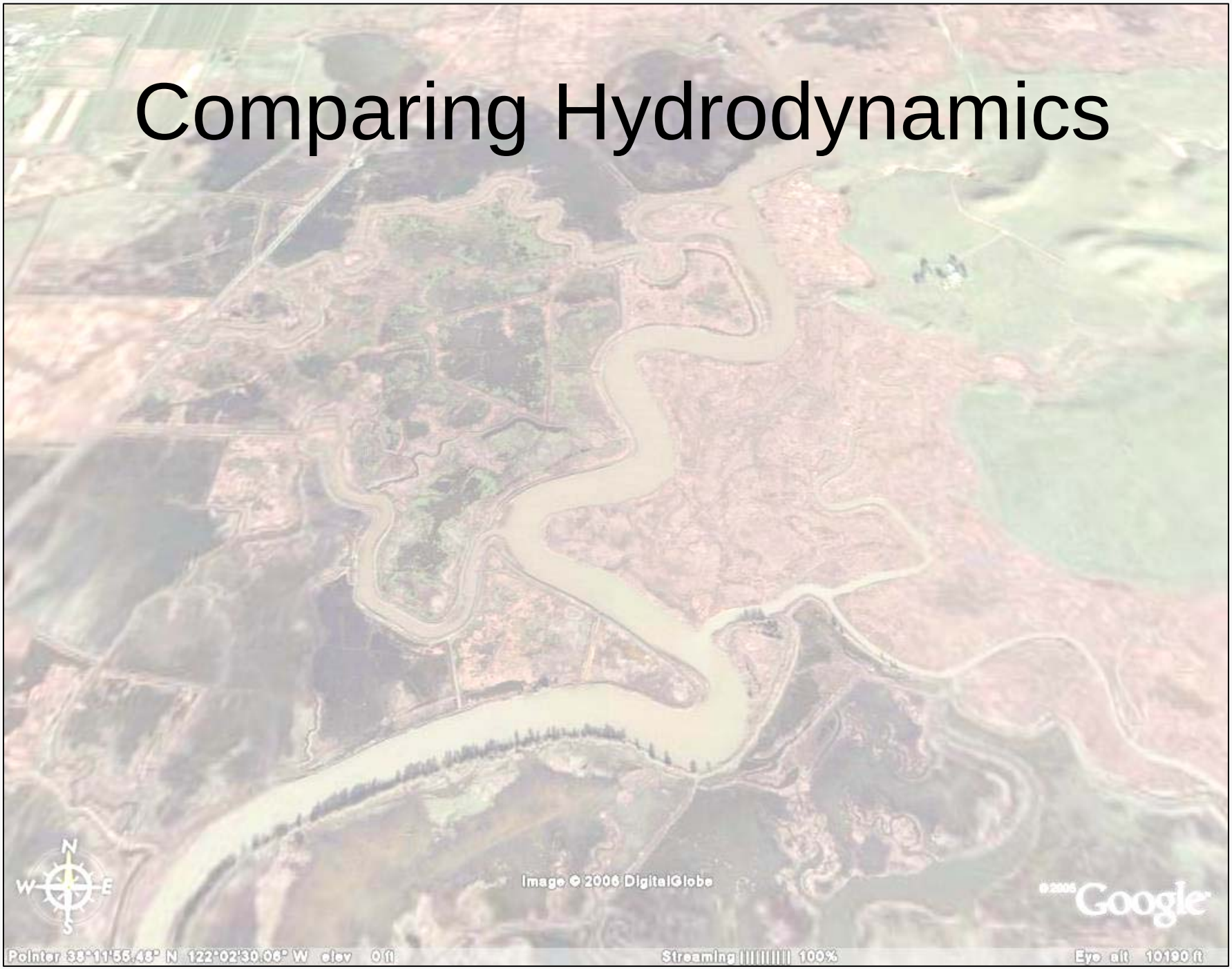


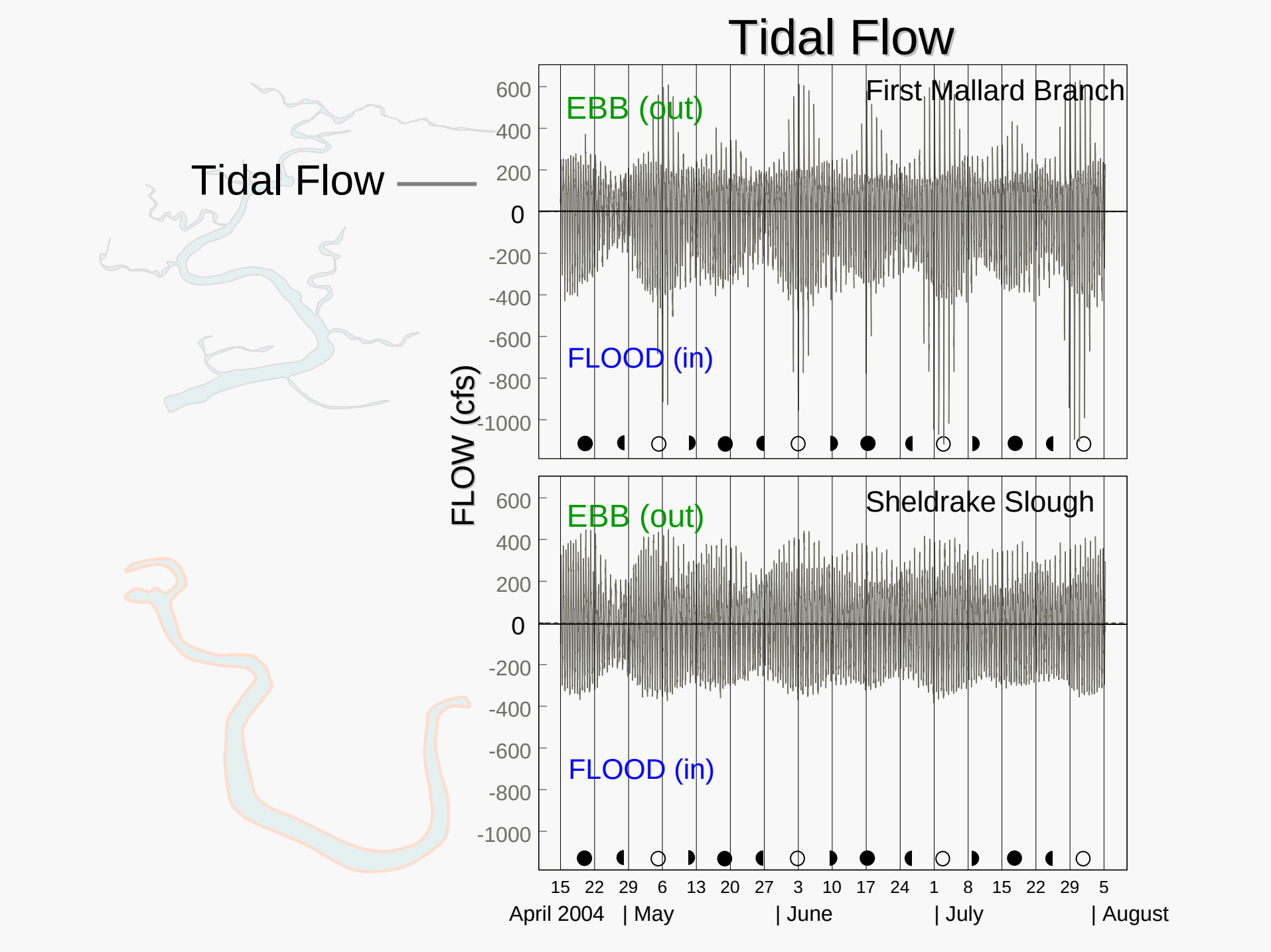
Comparing Typical Cross-section Hypsography




Data is flow, temperature, chlorophyll, salt and DO flux at these locations:
Sheldrake Slough
First Mallard Branch
Suisun Slough
Image © 2006 DigitalGlobe
©2005 Google
Pointer 38°11'55.48" N 122°02'30.06" W elev 0 ft
Streaming 100%
Eye alt 10190 ft

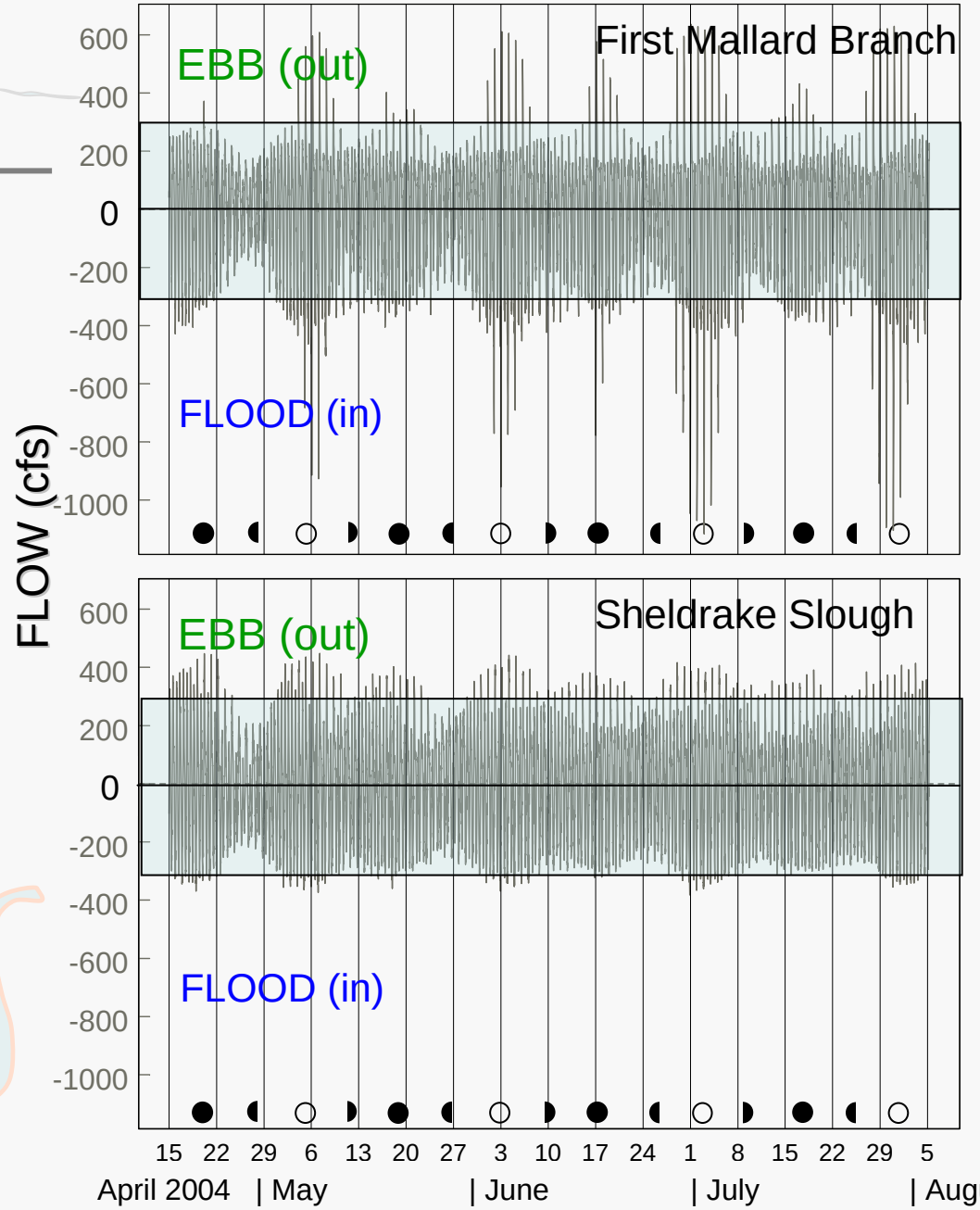
Comparing Hydrodynamics




Tidal Flow
Tidal Flow
First Mallard Branch
EBB (out)
FLOOD (in)
Sheldrake Slough
EBB (out)
FLOOD (in)
FLOW (cfs)
600
400
200
0
-200
-400
-600
-800
-1000
15 22 29 6 13 20 27 3 10 17 24 1 8 15 22 29 5
April 2004 | May | June | July | August

Tidal Flow

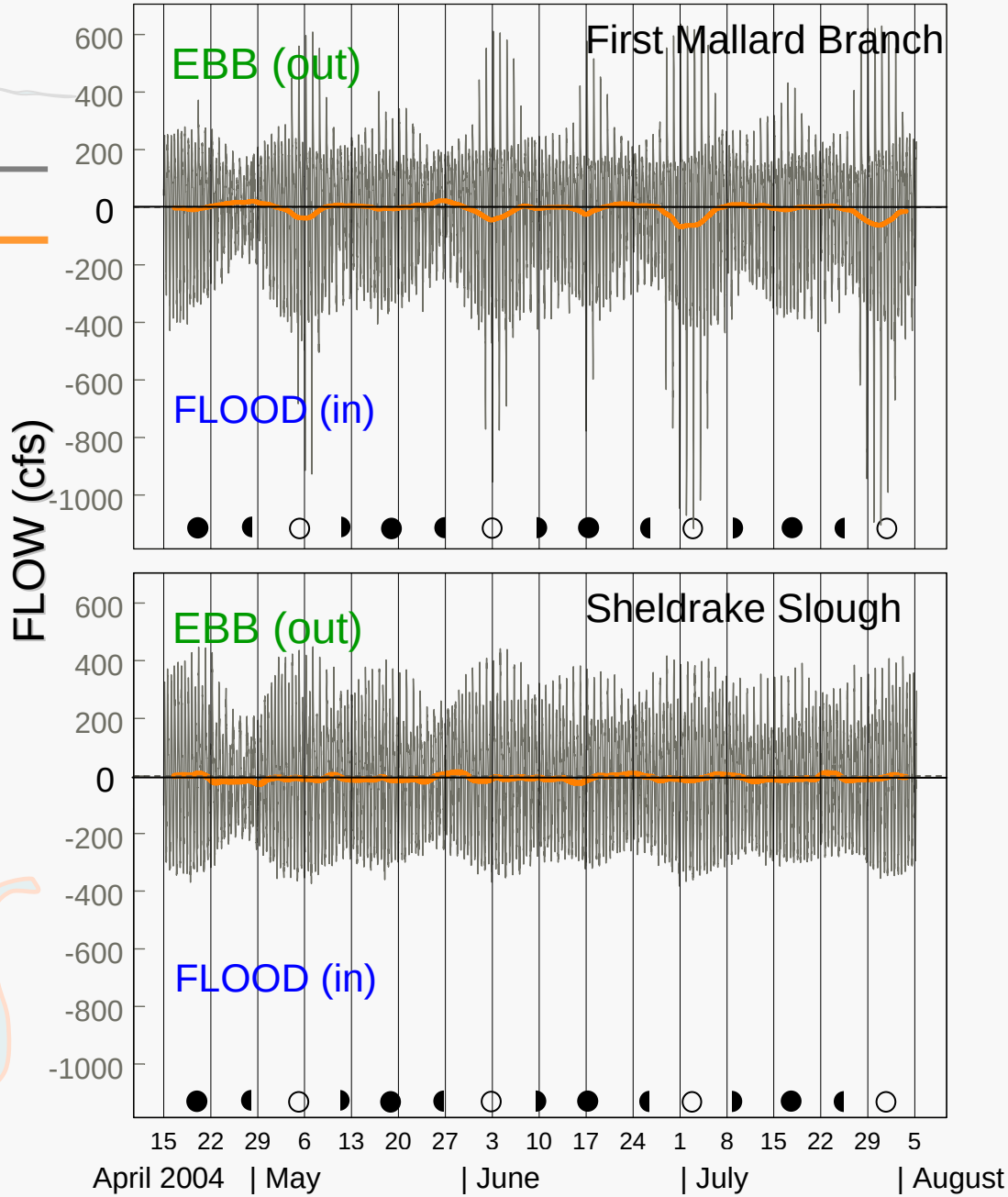
Tidal Flow



Tidal and Net Flow

Tidal Flow

Residual “Net” Flow

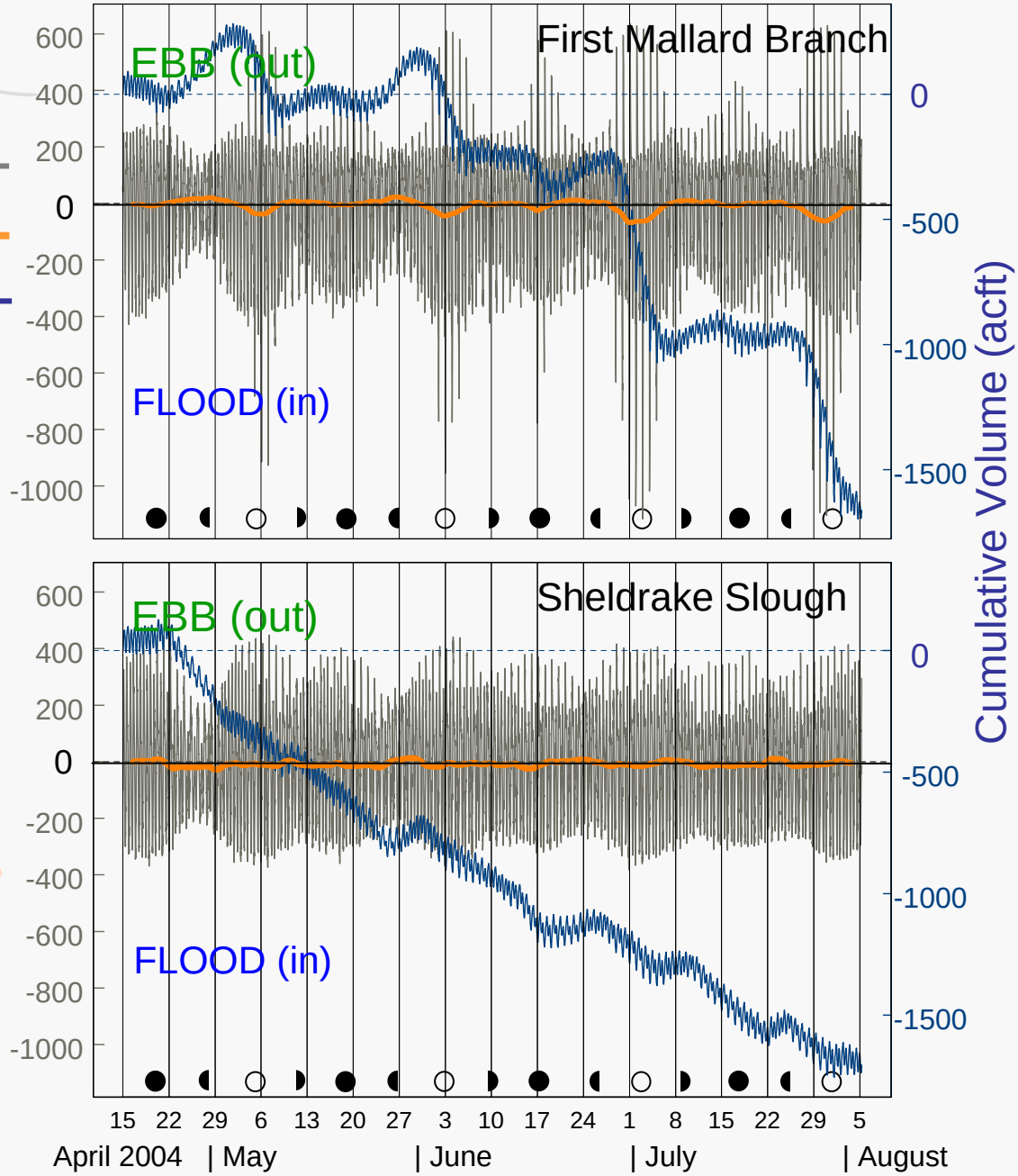


Tidal/Net Flow and Cumulative Volume

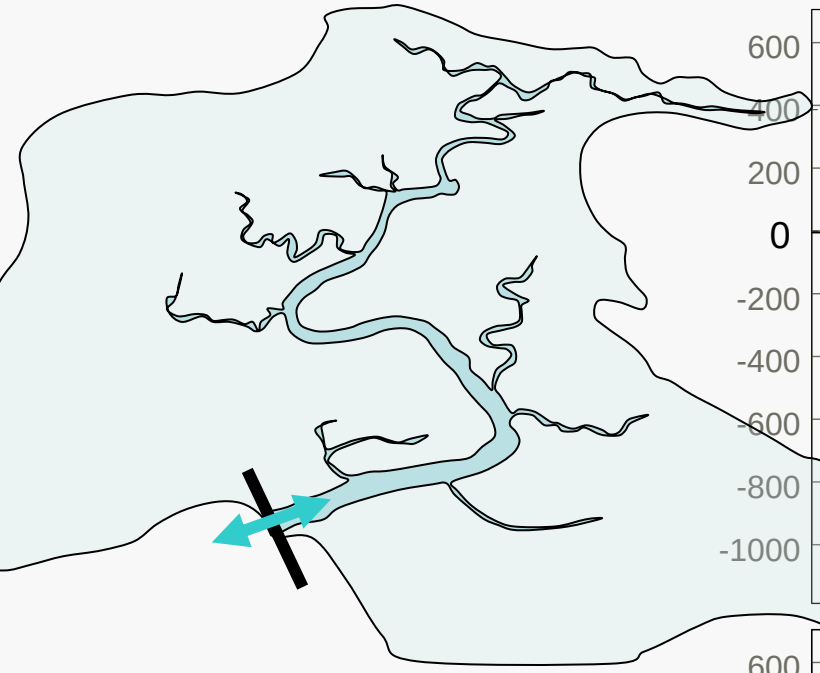
Tidal Flow

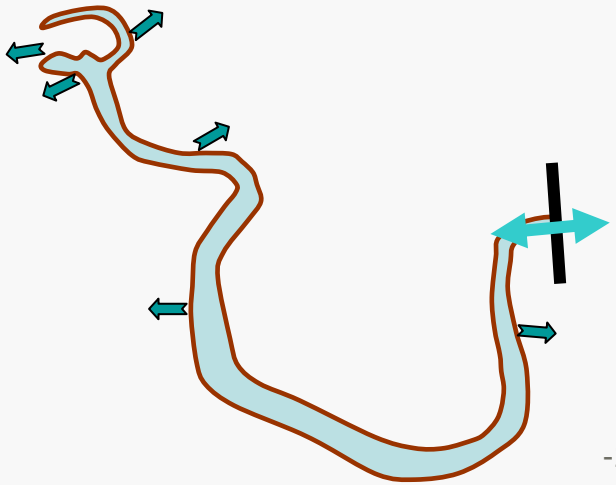
Residual “Net” Flow

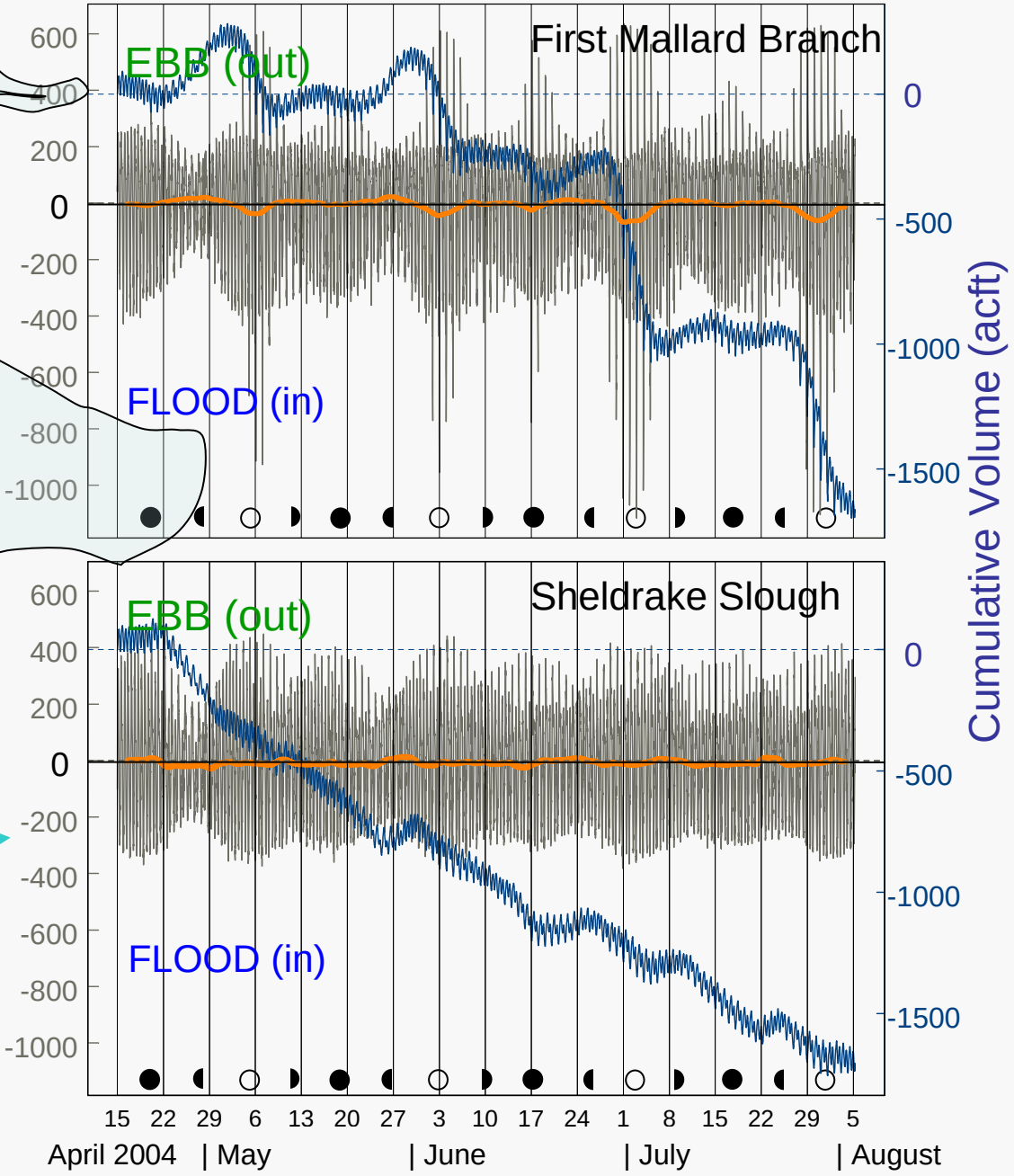
Cumulative Volume



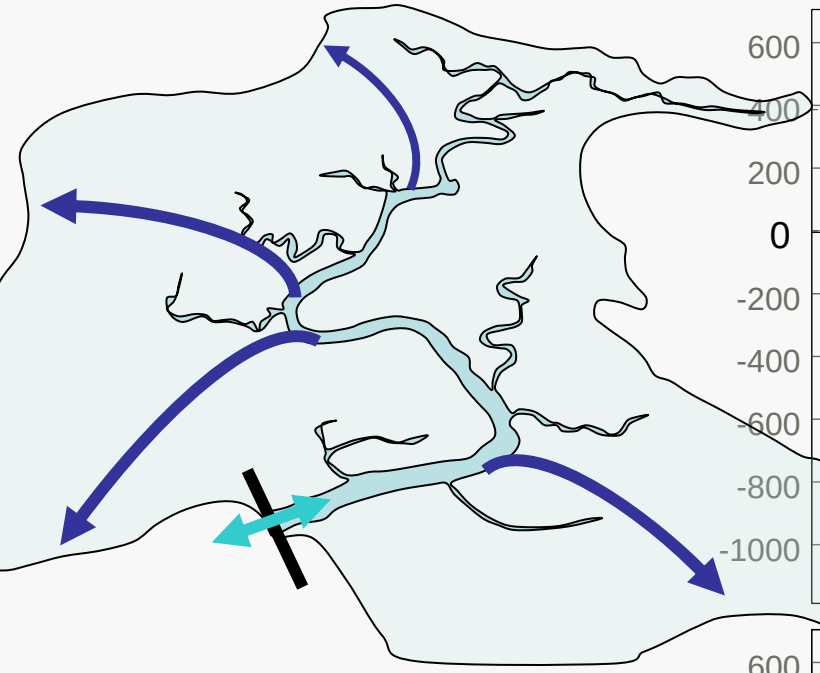
Tidal/Net Flow and Cumulative Volume

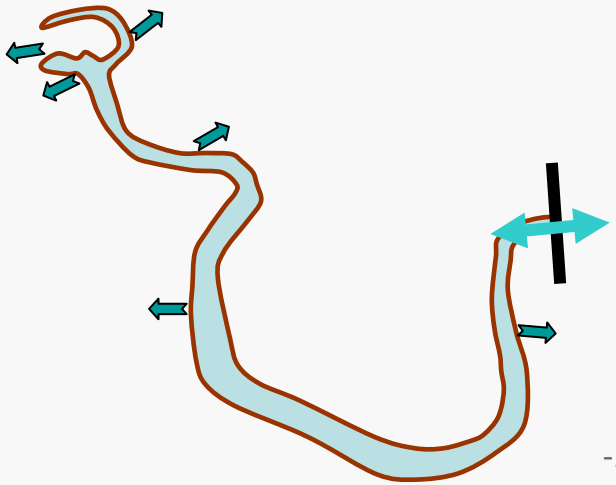






Tidal/Net Flow and Cumulative Volume





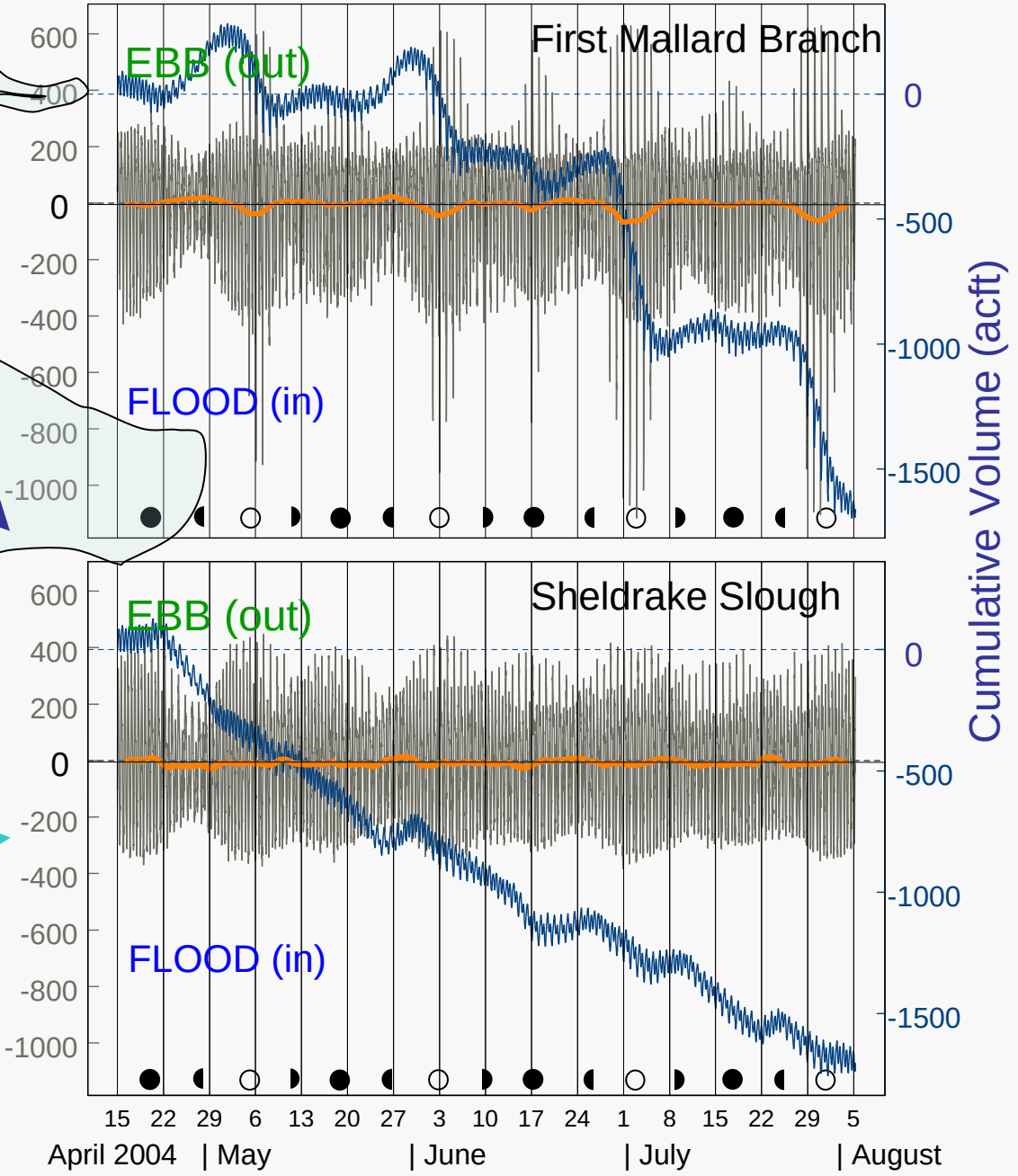
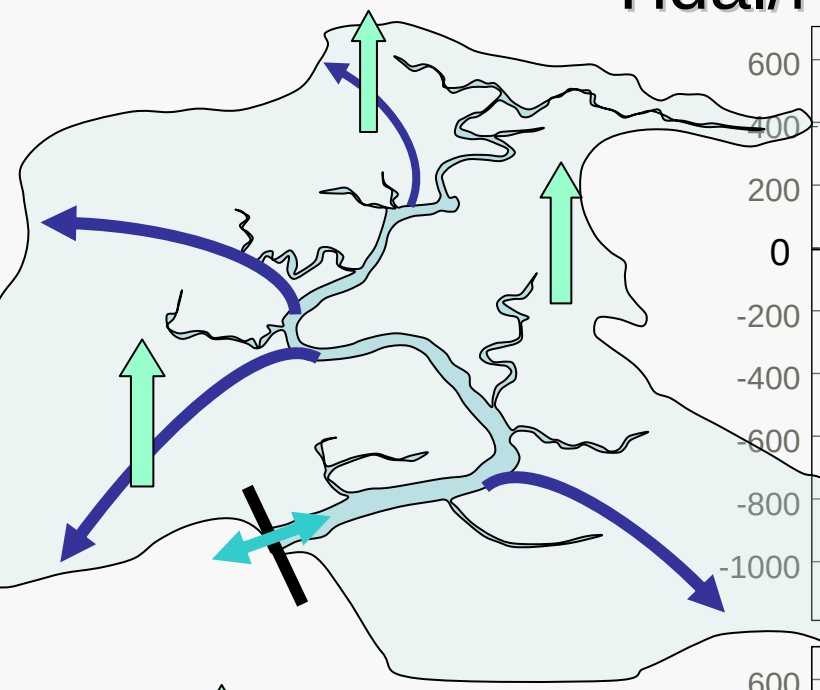
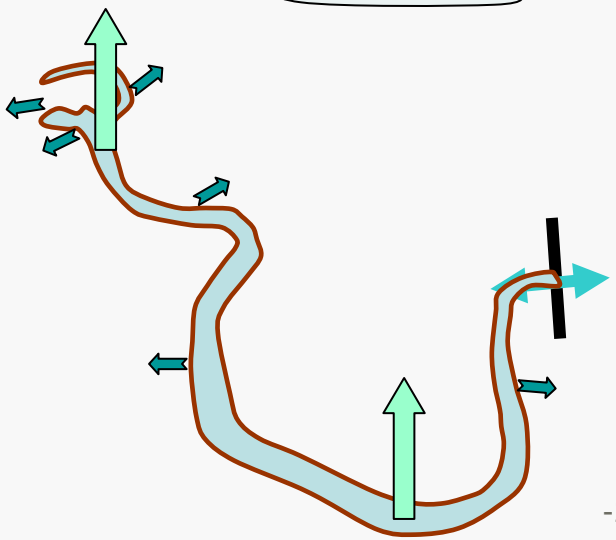
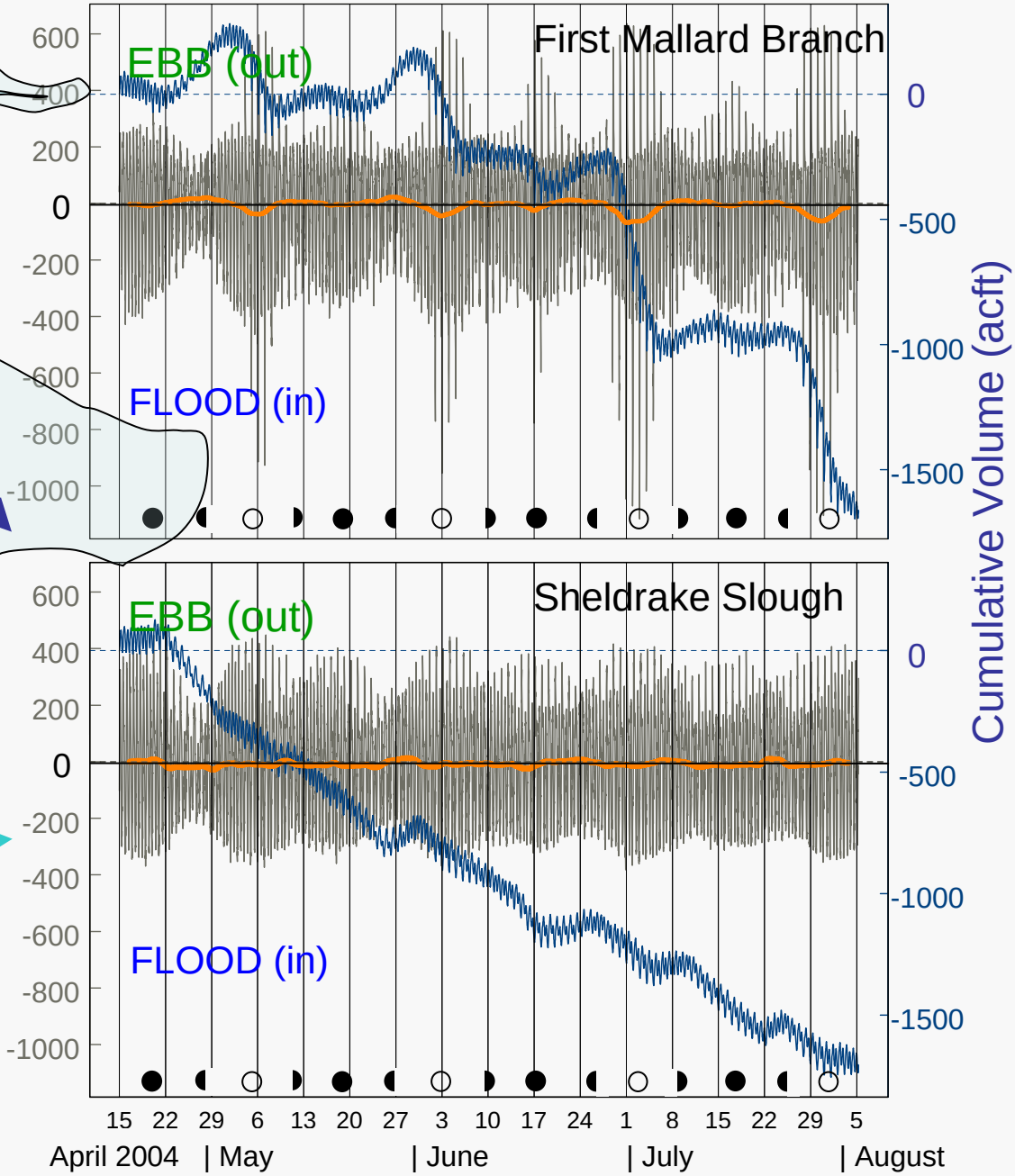


photo by Rob Schroeter
First Mallard Branch Marsh Plain
Suisun Slough

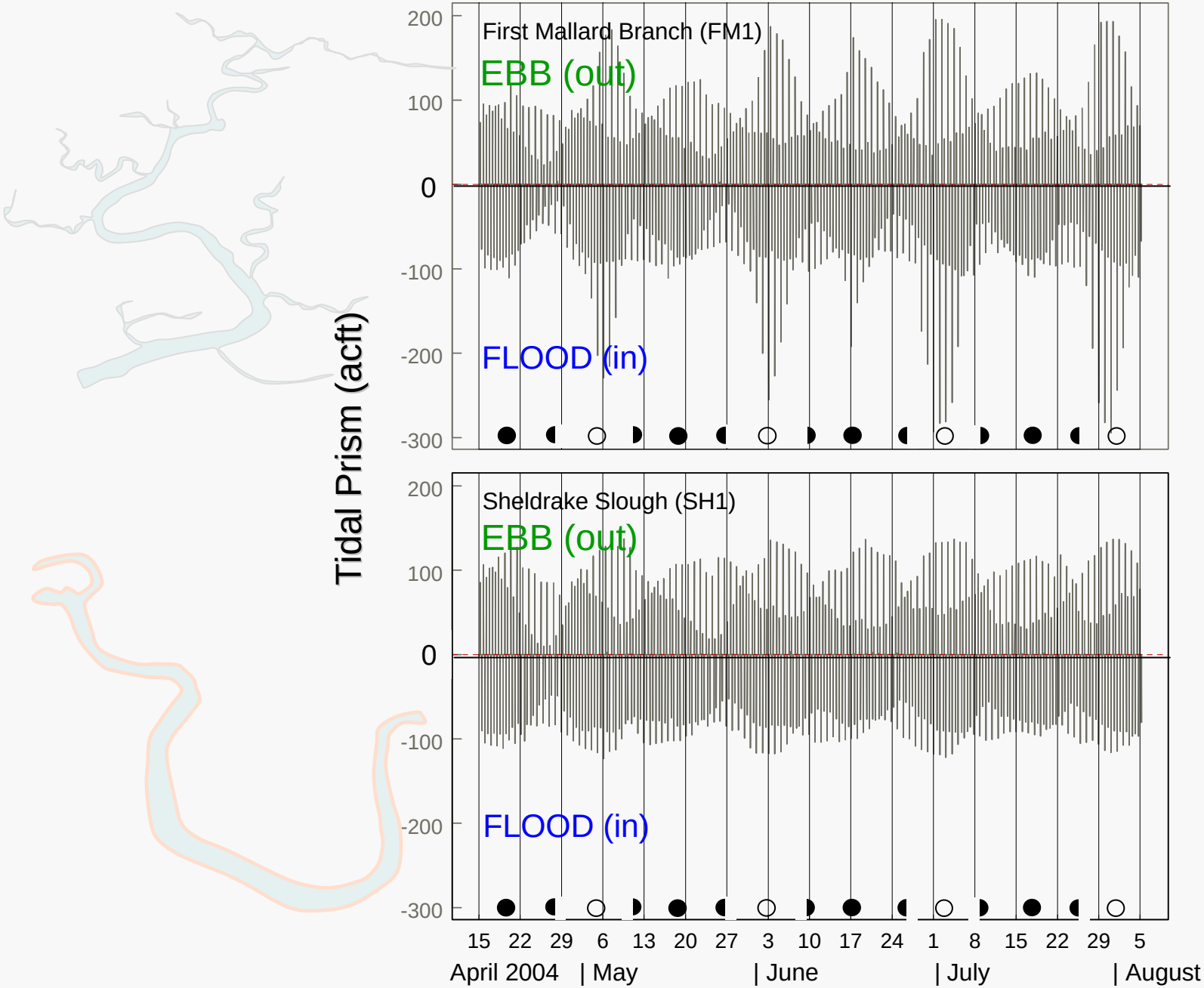
Tidal/Net Flow and Cumulative Volume



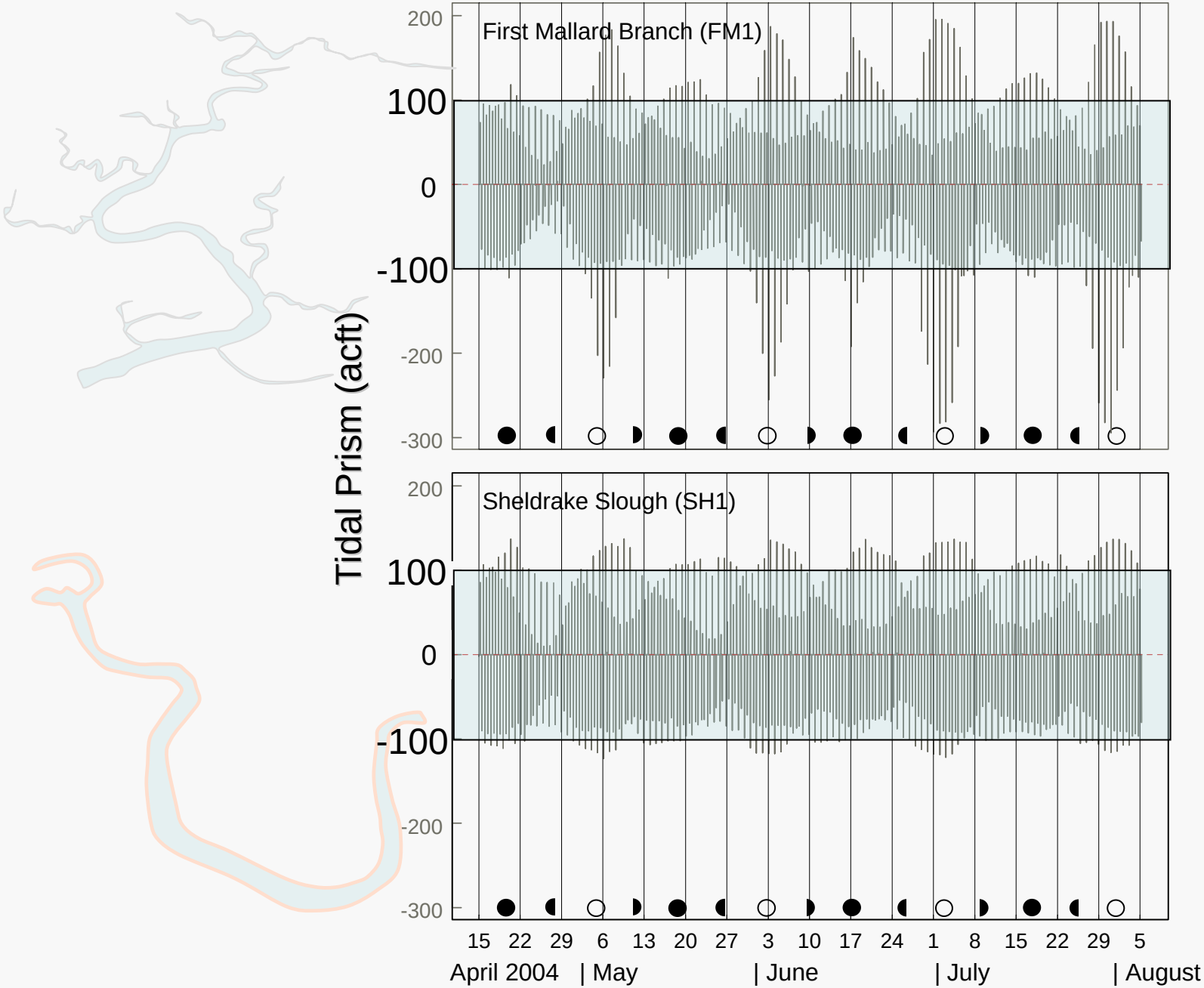




Tidal Prism


First Mallard Branch (FM1)
EBB (out)
FLOOD (in)
Sheldrake Slough (SH1)
EBB (out)
FLOOD (in)
Tidal Prism (acft)
200
100
0
-100
-200
-300
15 22 29 6 13 20 27 3 10 17 24 1 8 15 22 29 5
April 2004 | May | June | July | August

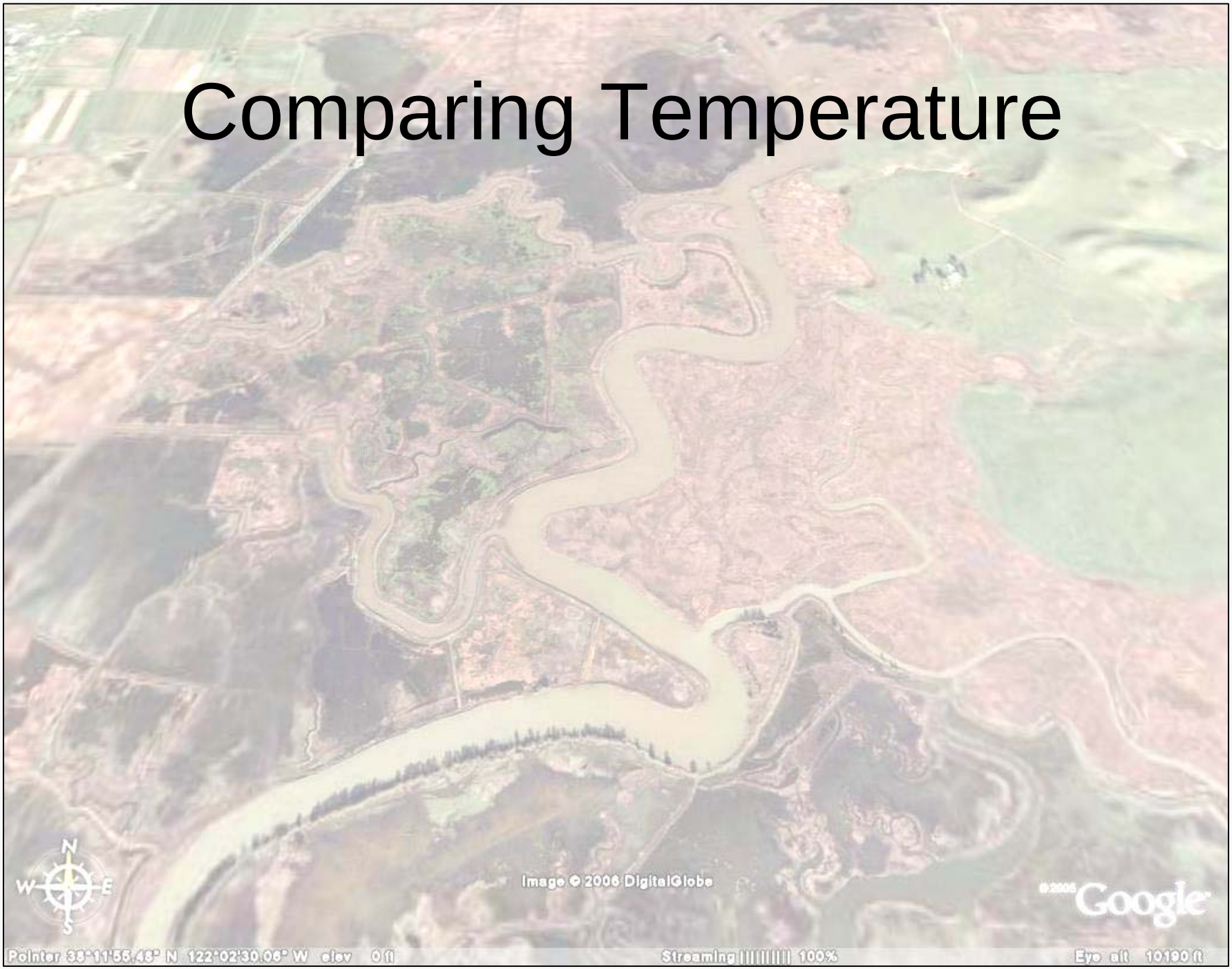
Tidal Prism


First Mallard Branch (FM1)
Sheldrake Slough (SH1)
Tidal Prism (acft)
200
100
0
-100
-200
-300
15 22 29 6 13 20 27 3 10 17 24 1 8 15 22 29 5
April 2004 | May | June | July | August

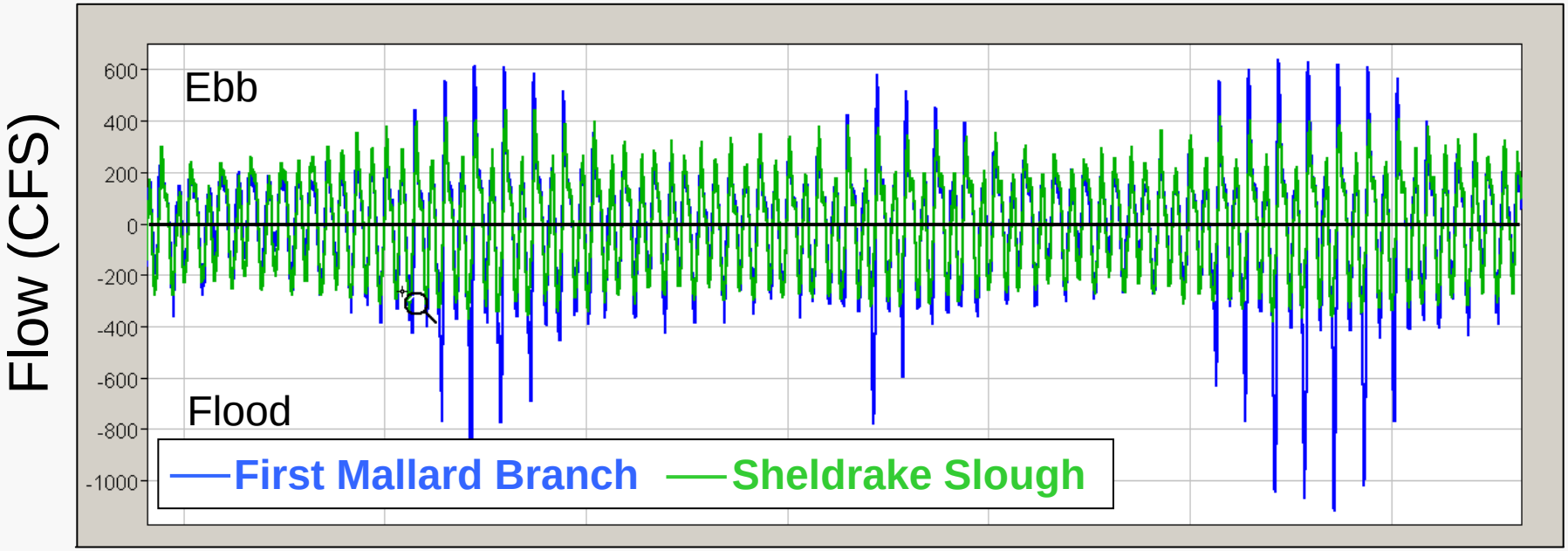
Hydrodynamics Summary

- Tidal flow, net flow, and water flux depend on geometry.
- Flow on tidal and spring-neap timescale is more variable at First Mallard Slough.

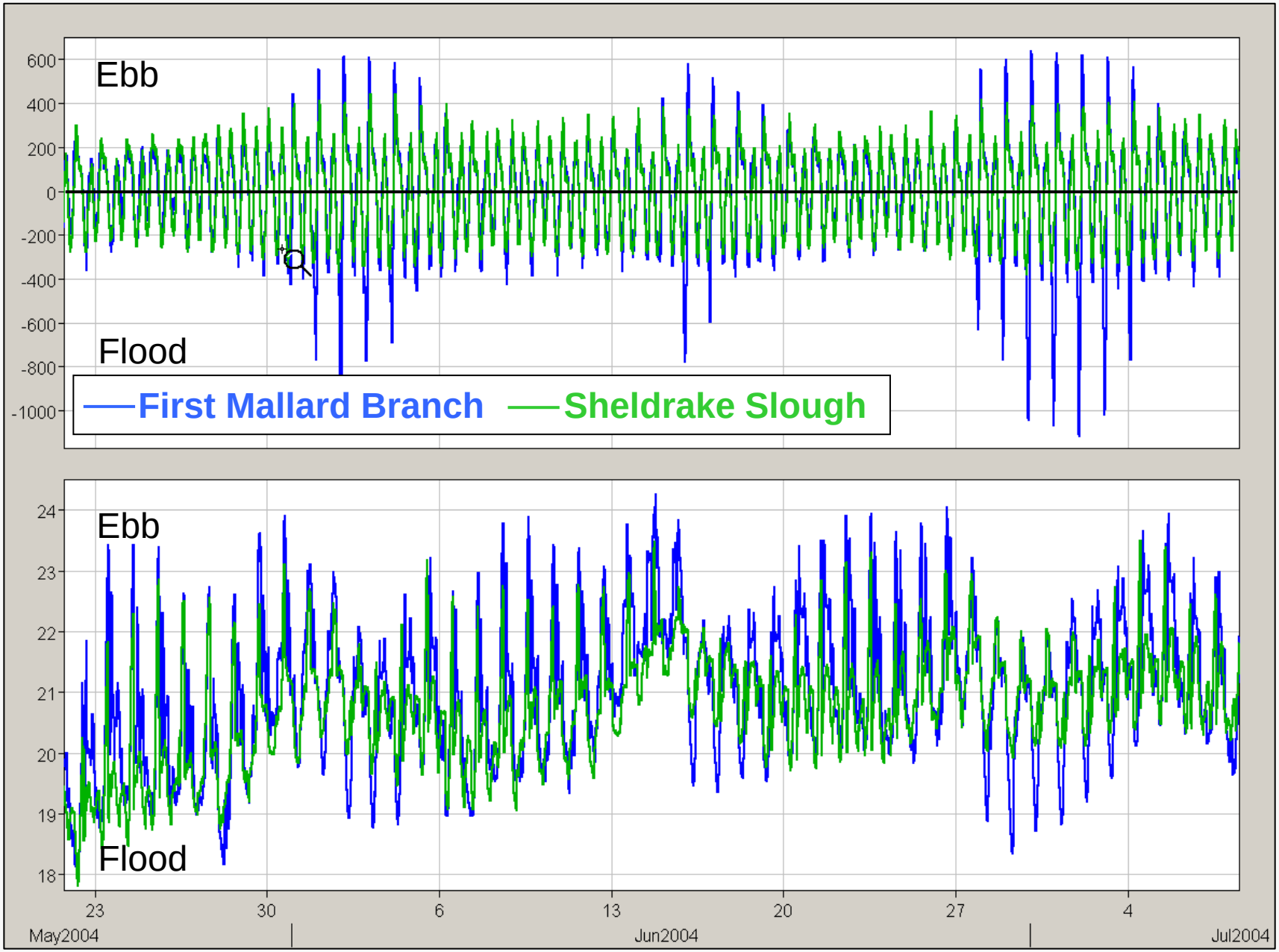
Comparing Temperature



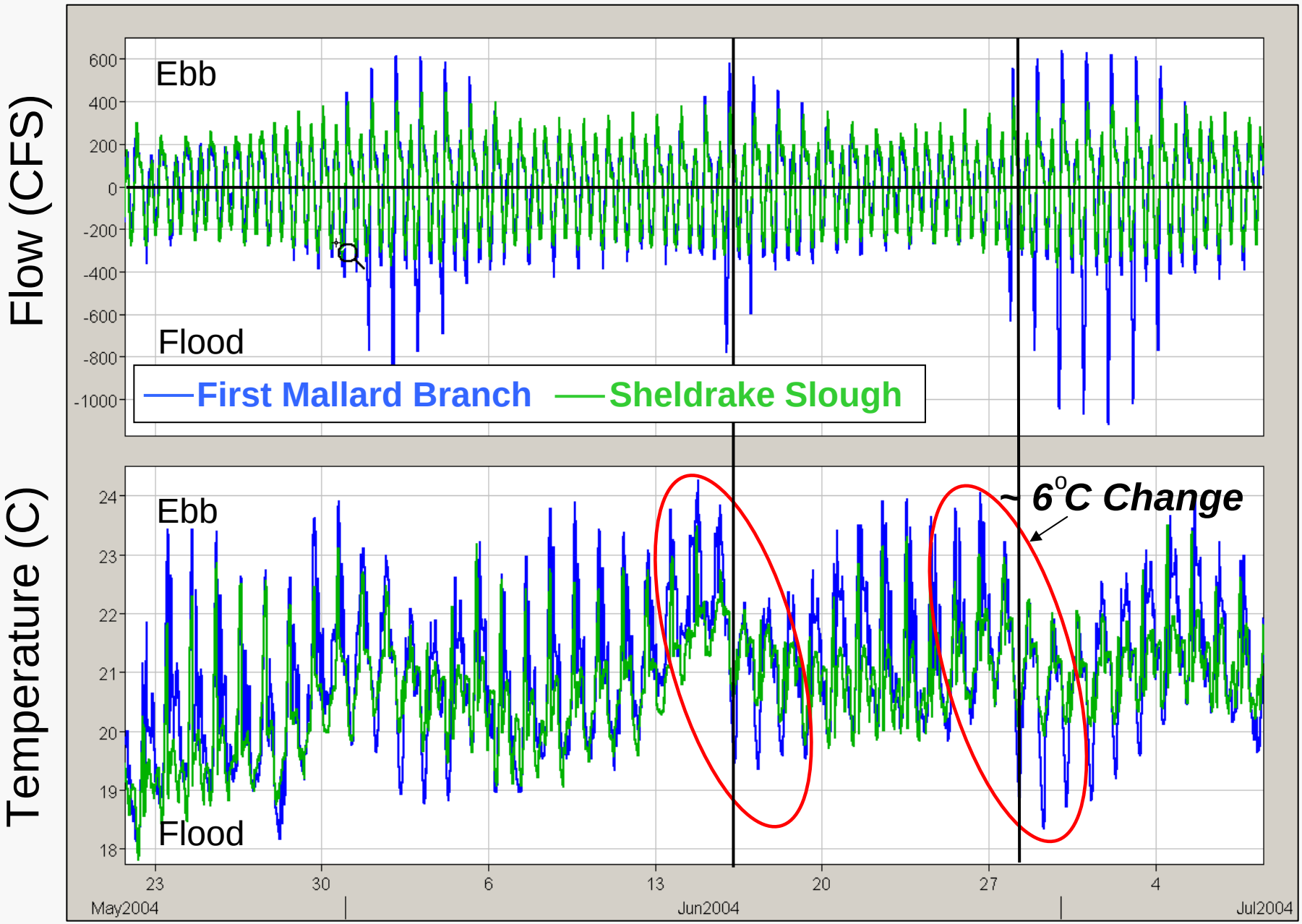
Flow and Temperature Variability



Flow and Temperature Variability

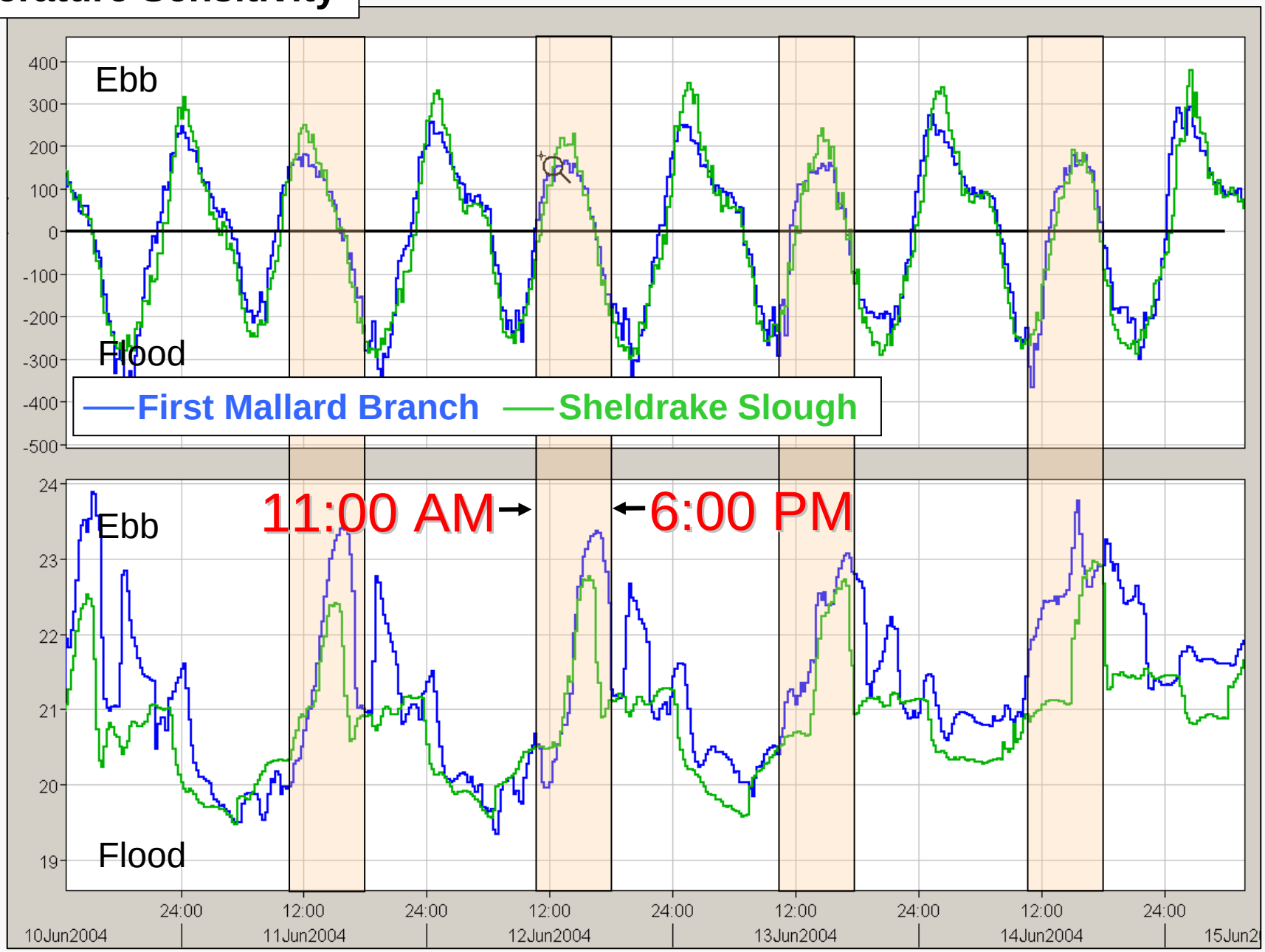


Flow and Temperature Variability



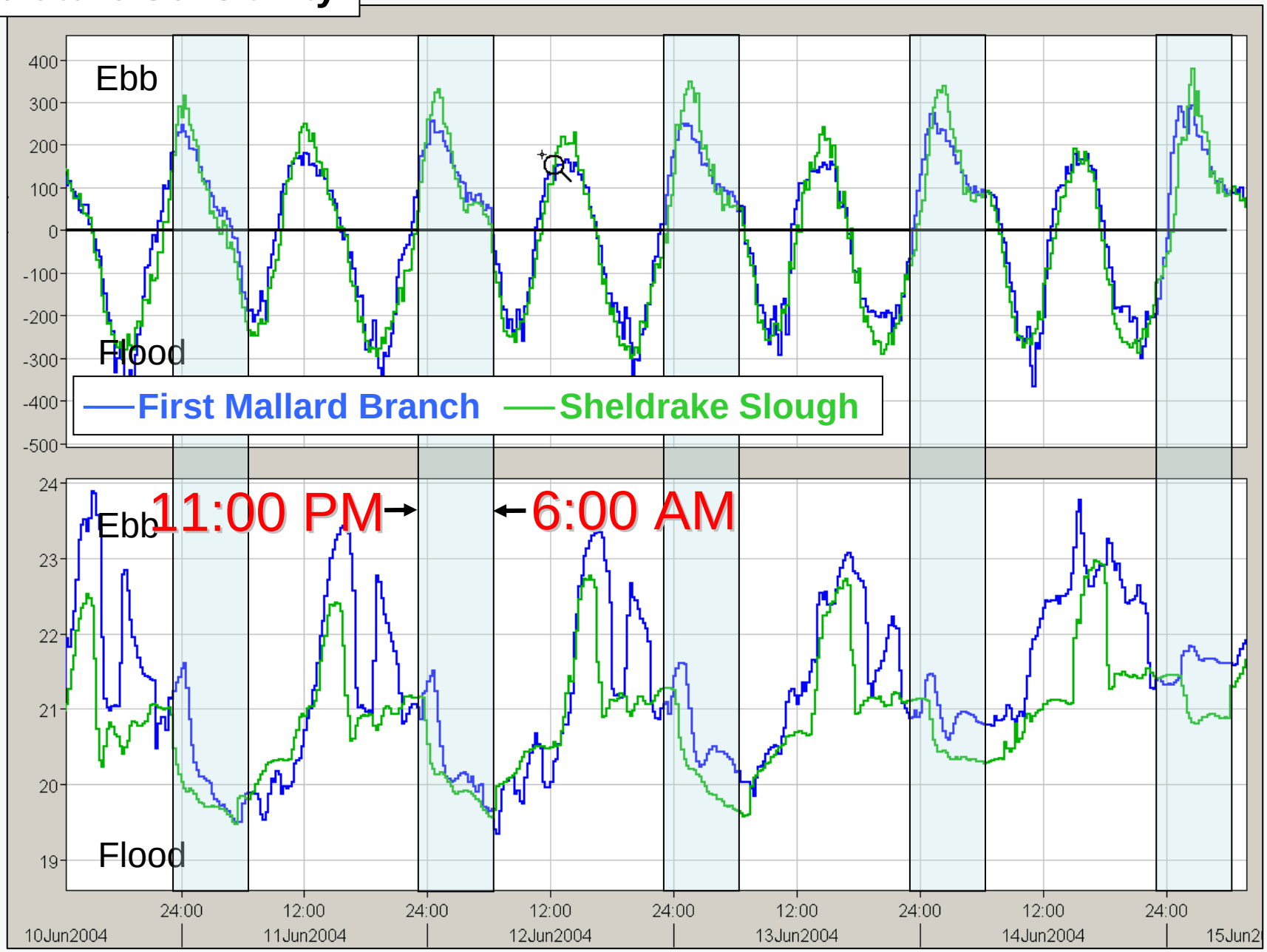
Neap Tide Diurnal Temperature Sensitivity

Warmest water out in afternoon



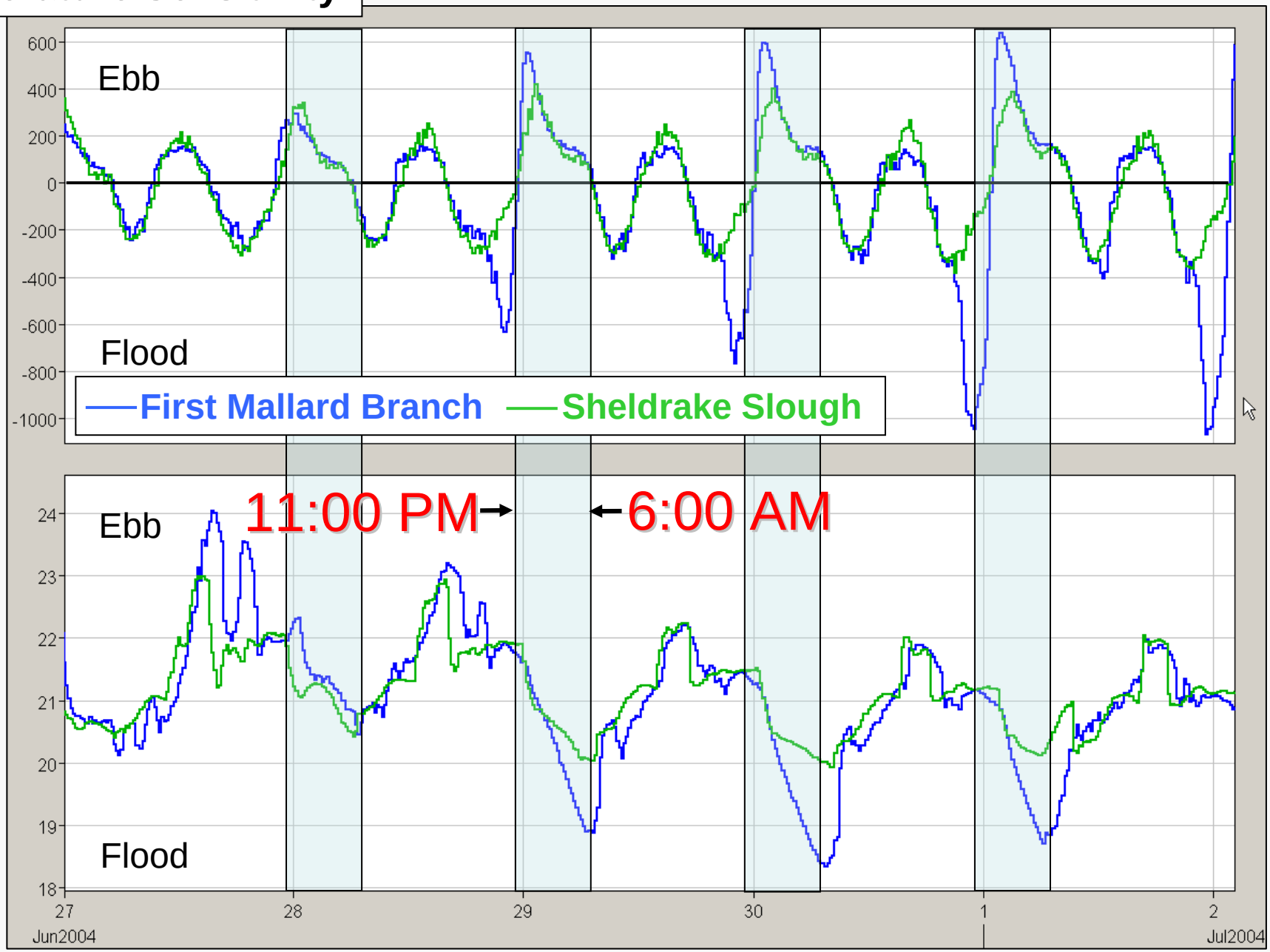
Neap Tide Diurnal Temperature Sensitivity

Coolest water out overnight, >3°C change



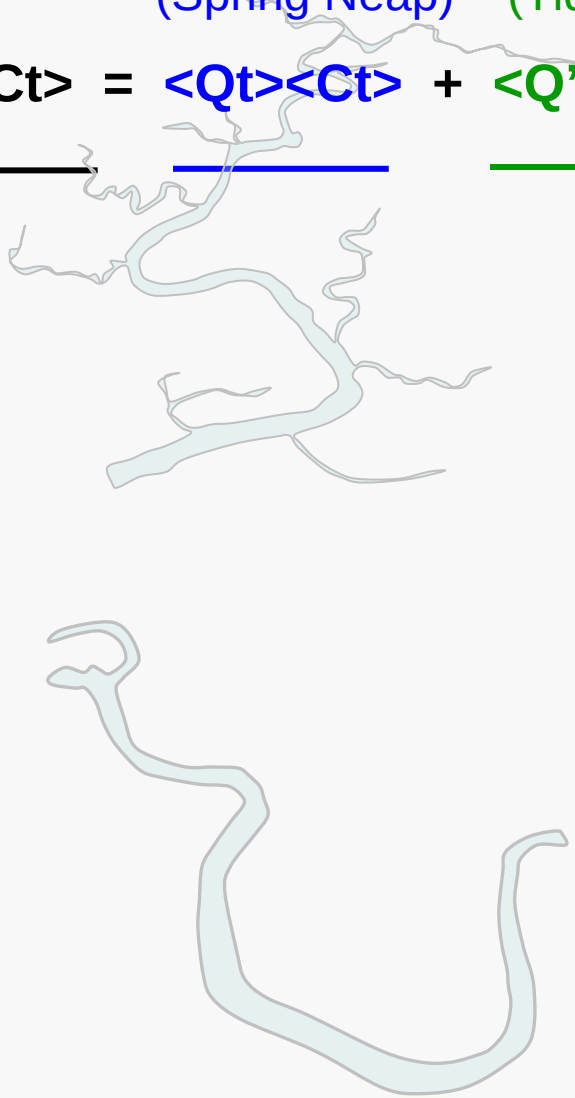
Spring Tide Diurnal Temperature Sensitivity

Coolest water out overnight, >5°C change

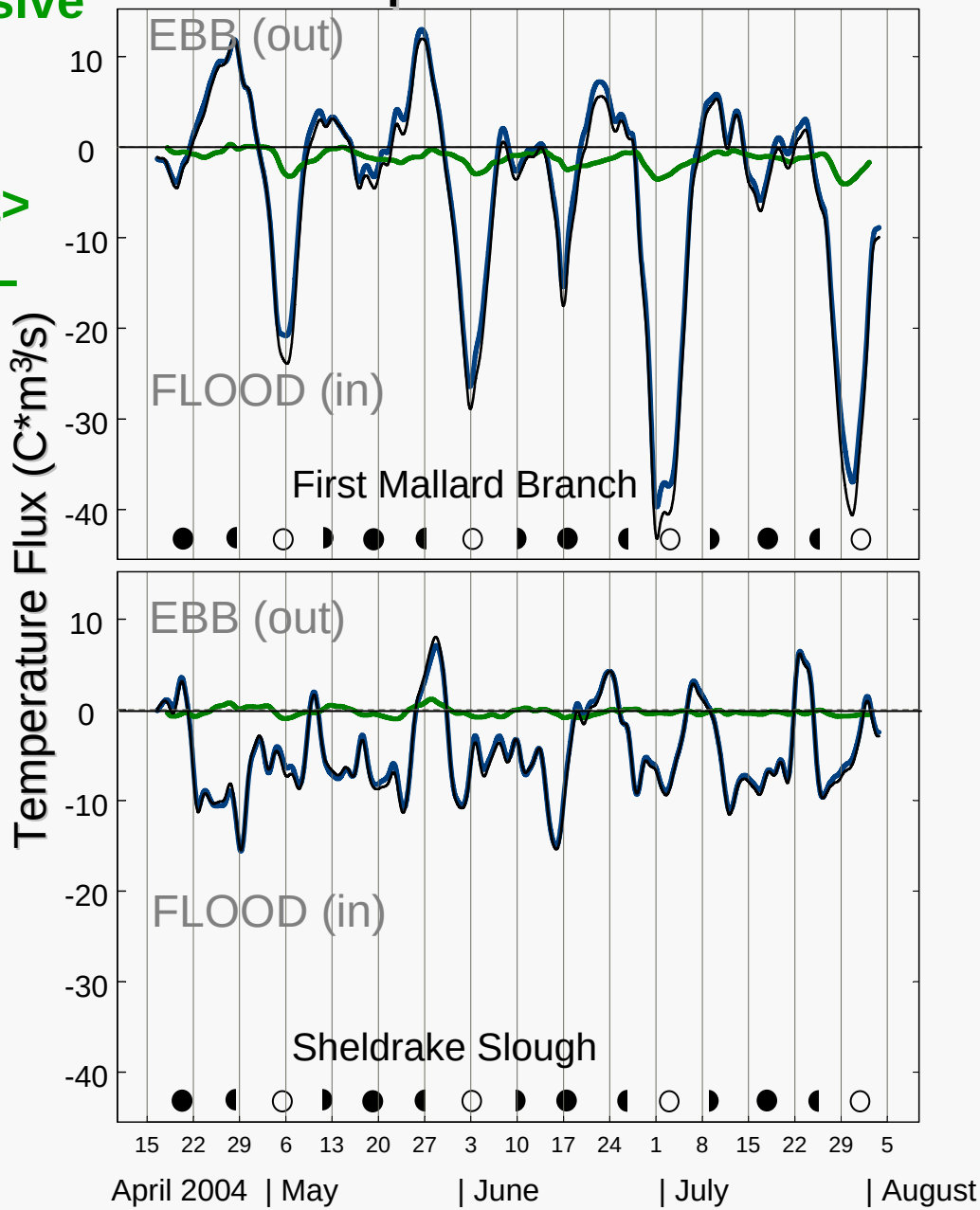


Total Flux = Advective Flux (Spring Neap) + Dispersive Flux (Tides)

$$\langle Qt*Ct \rangle = \langle Qt \rangle \langle Ct \rangle + \langle Q't*C't \rangle$$



Temperature Flux



Temperature Summary

- Temperature variability due to diel timing of tides.
- Both sloughs generate temperature extremes high and low. First Mallard does it more.
- Both sloughs generally cool during spring tides, more so at First Mallard.
- Magnitude of heating/cooling (and magnitude of temperature gradients) affected by geometry.

Comparing Variability of other Constituent Fluxes

- Chlorophyll
- Salt
- Dissolved Oxygen

Same Y-Axis Scale

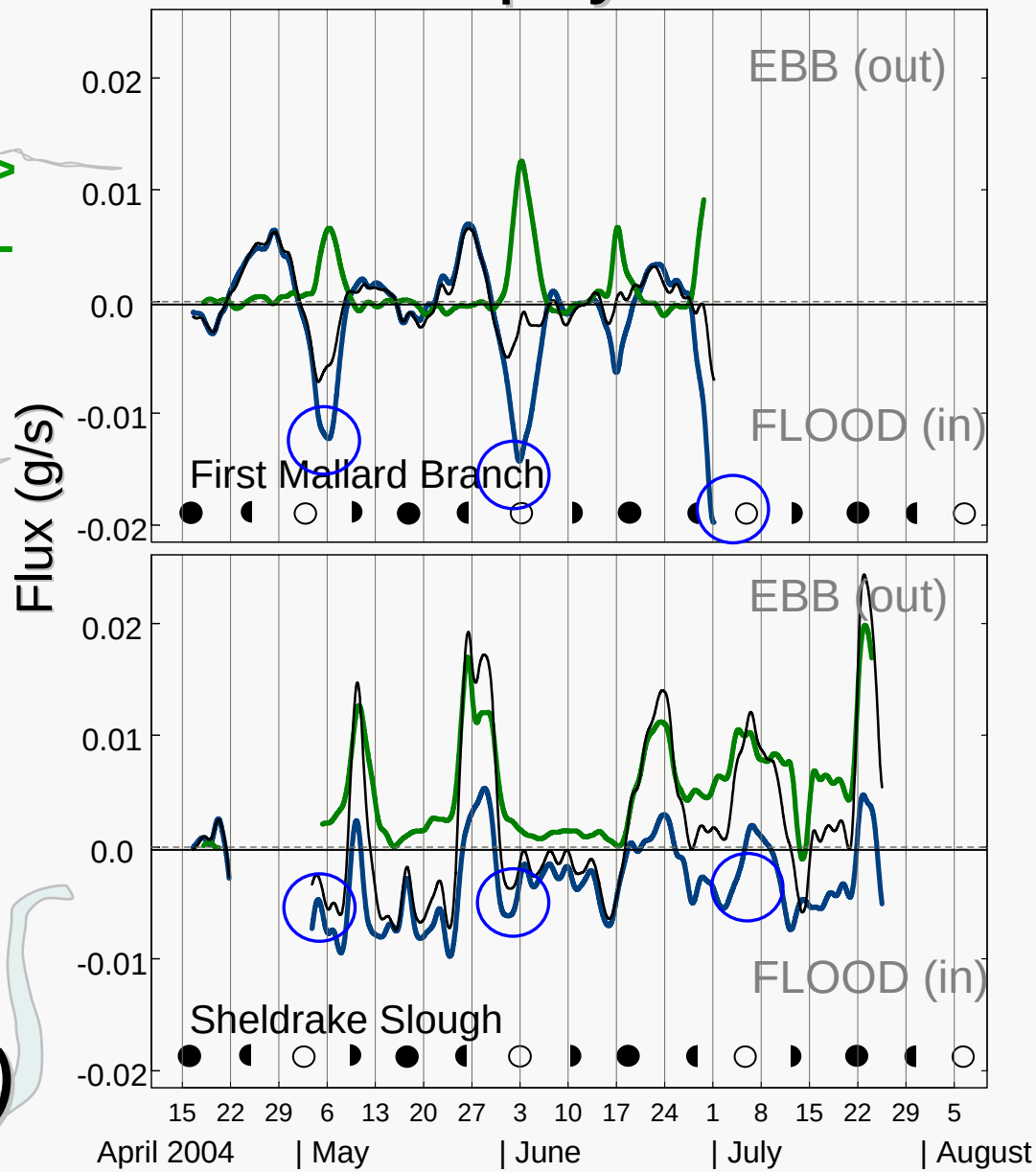
Image © 2006 DigitalGlobe
©2006 Google
Pointer 38°11'55.48" N 122°02'30.06" W elev 0 ft
Streaming 100%
Eye alt 10190 ft

Total Flux = Advective Flux + Dispersive Flux

(Spring-Neap) (Tides)

<Qt*Ct> = <Qt><Ct> + <Q't*C't>

Chlorophyll Flux



Spring Tide

Advective Flux

Note to self:
Bergamaschi got .1-.5 gC/m3/day(?) at Brown's Island

Total Flux = Advective Flux + Dispersive Flux

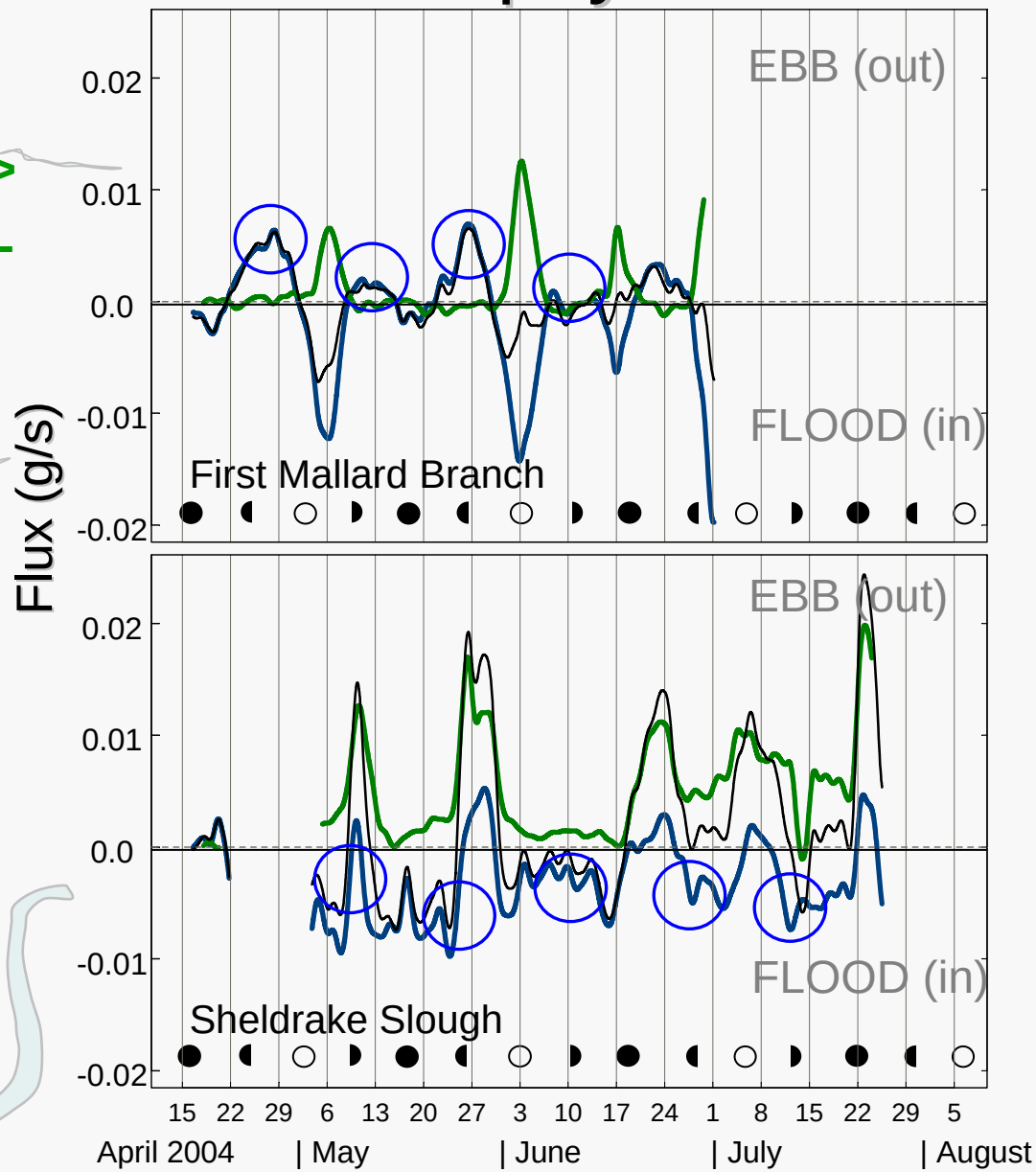
(Spring-Neap) (Tides)

<Qt*Ct> = <Qt><Ct> + <Q't*C't>

Neap Tide

Advective Flux

Chlorophyll Flux

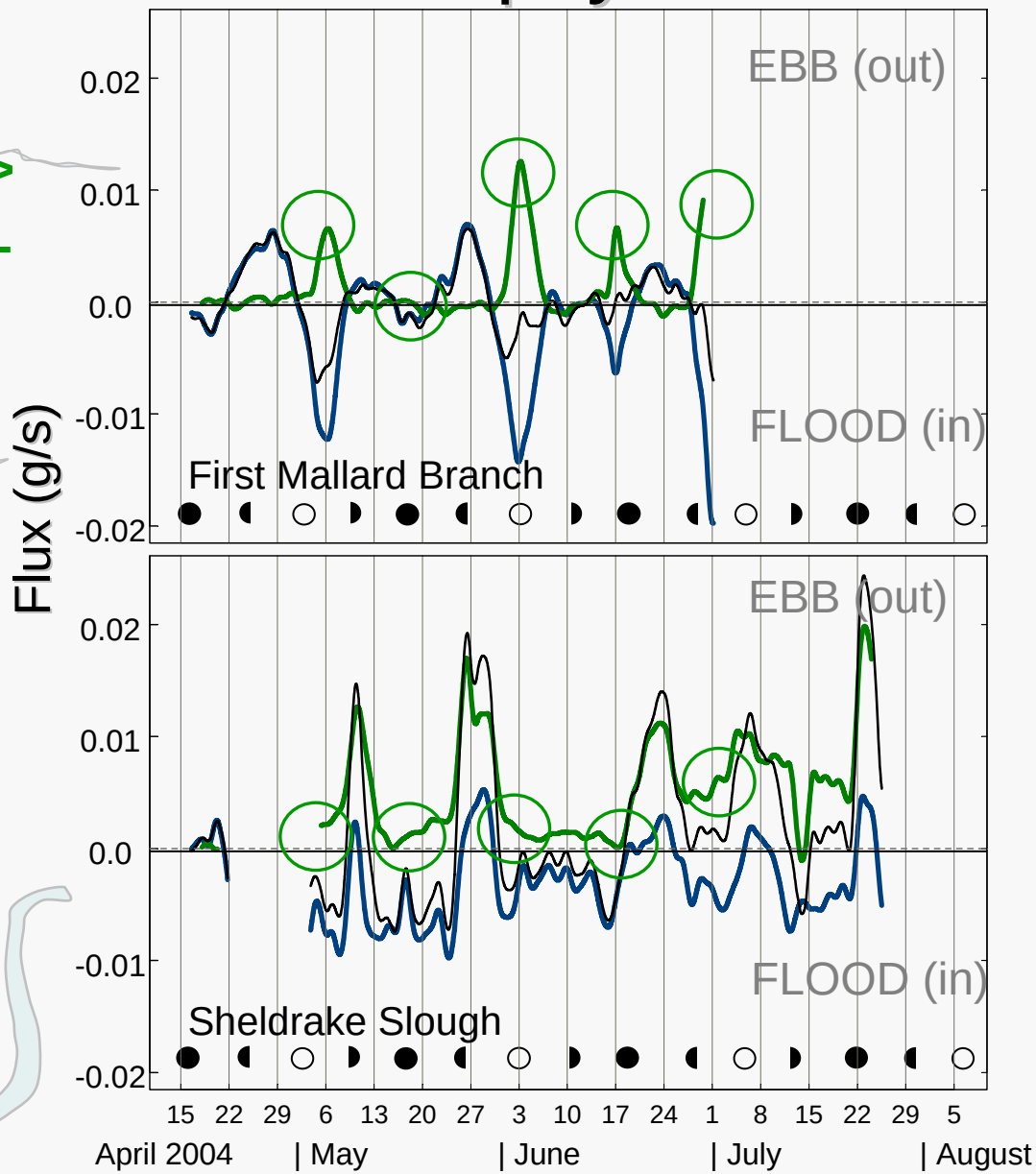


Total Flux = Advective Flux (Spring-Neap) + Dispersive Flux (Tides)

<Qt*Ct> = <Qt><Ct> + <Q't*C't>

Spring Tide
Dispersive Flux

Chlorophyll Flux



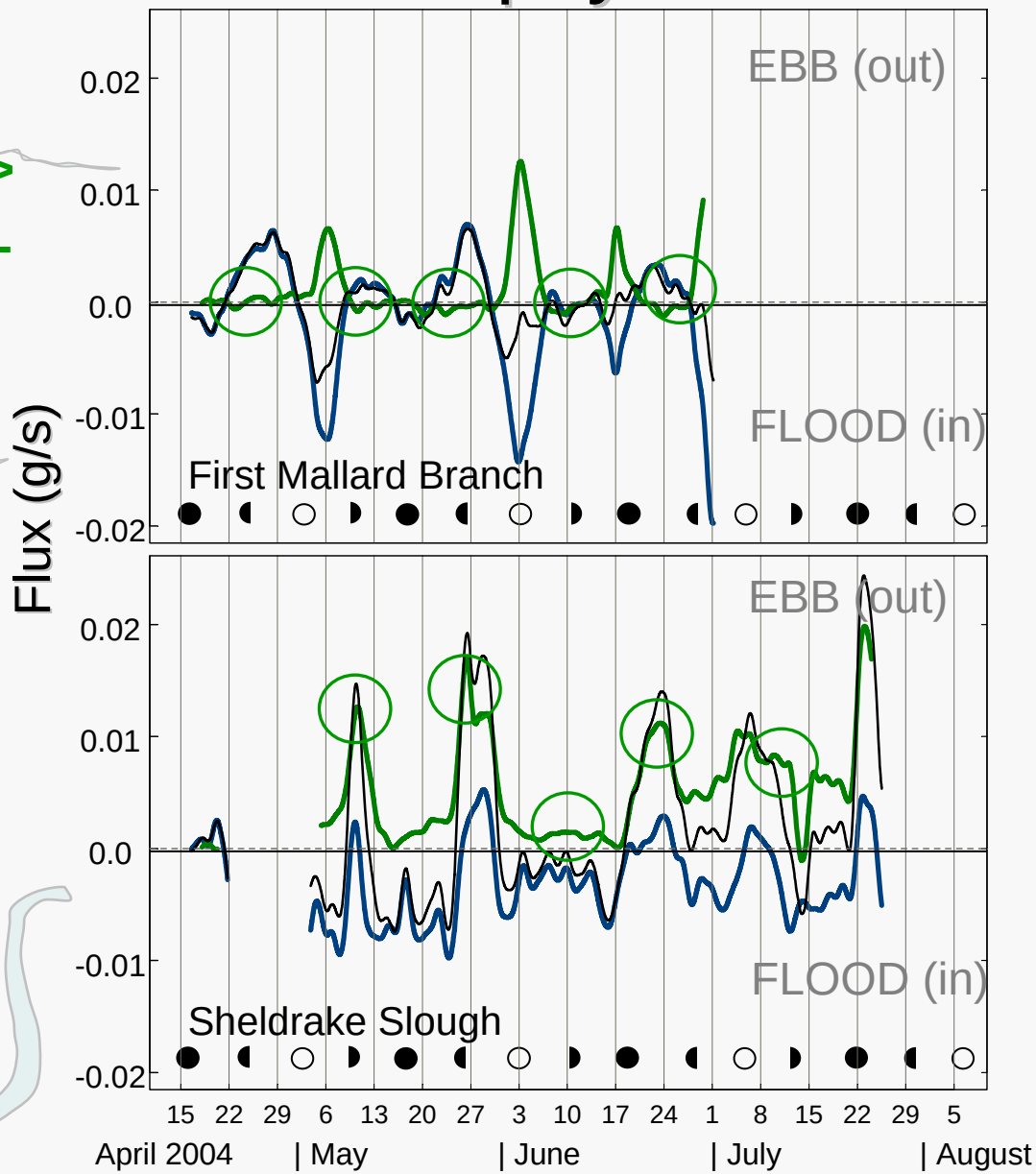
Total Flux = Advective Flux (Spring-Neap) + Dispersive Flux (Tides)

<Qt*Ct> = <Qt><Ct> + <Q't*C't>

Neap Tide

Dispersive Flux

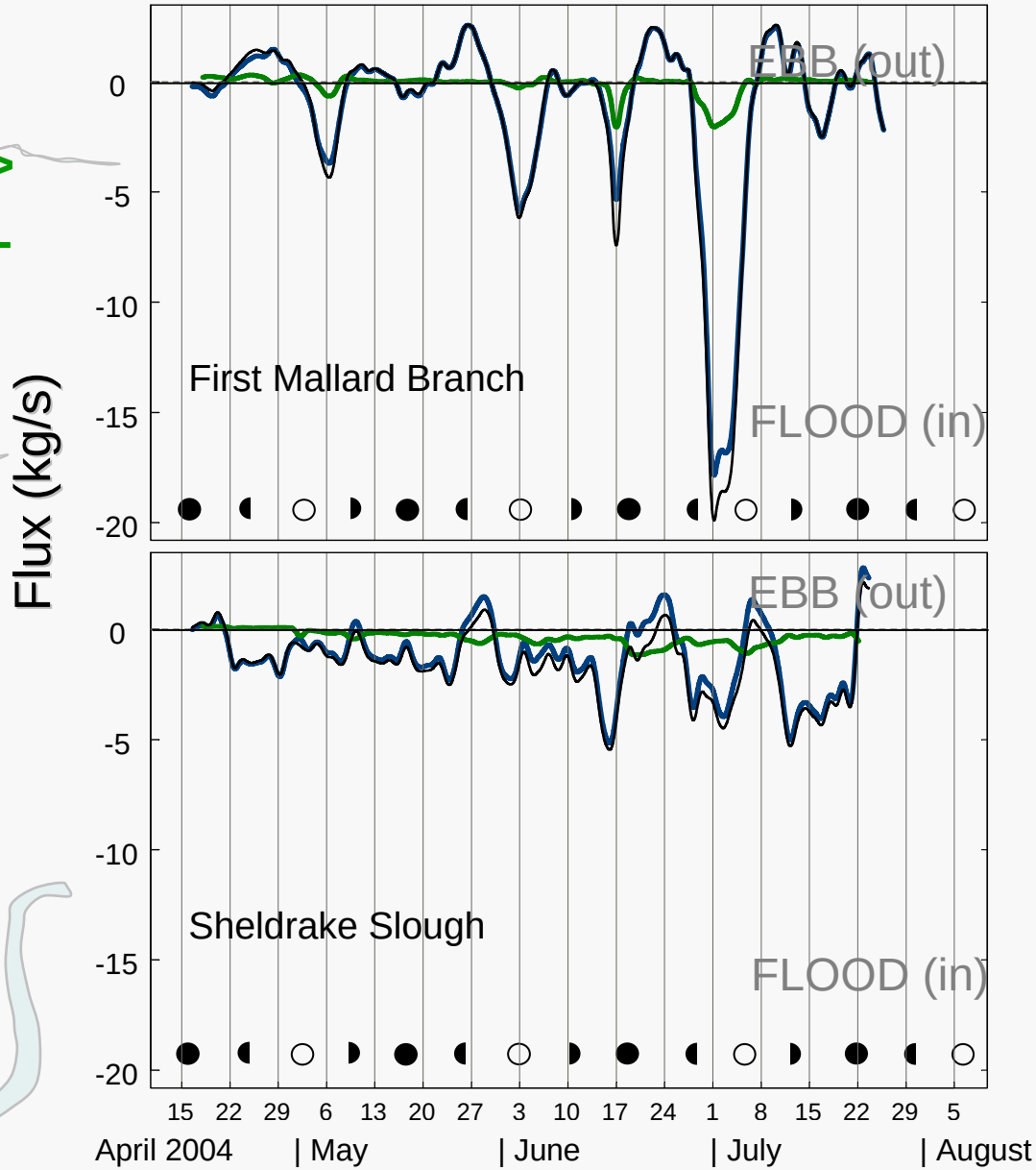
Chlorophyll Flux



Total Flux = Advective Flux (Spring-Neap) + Dispersive Flux (Tides)

<Qt*Ct> = <Qt><Ct> + <Q't*C't>

Salt Flux

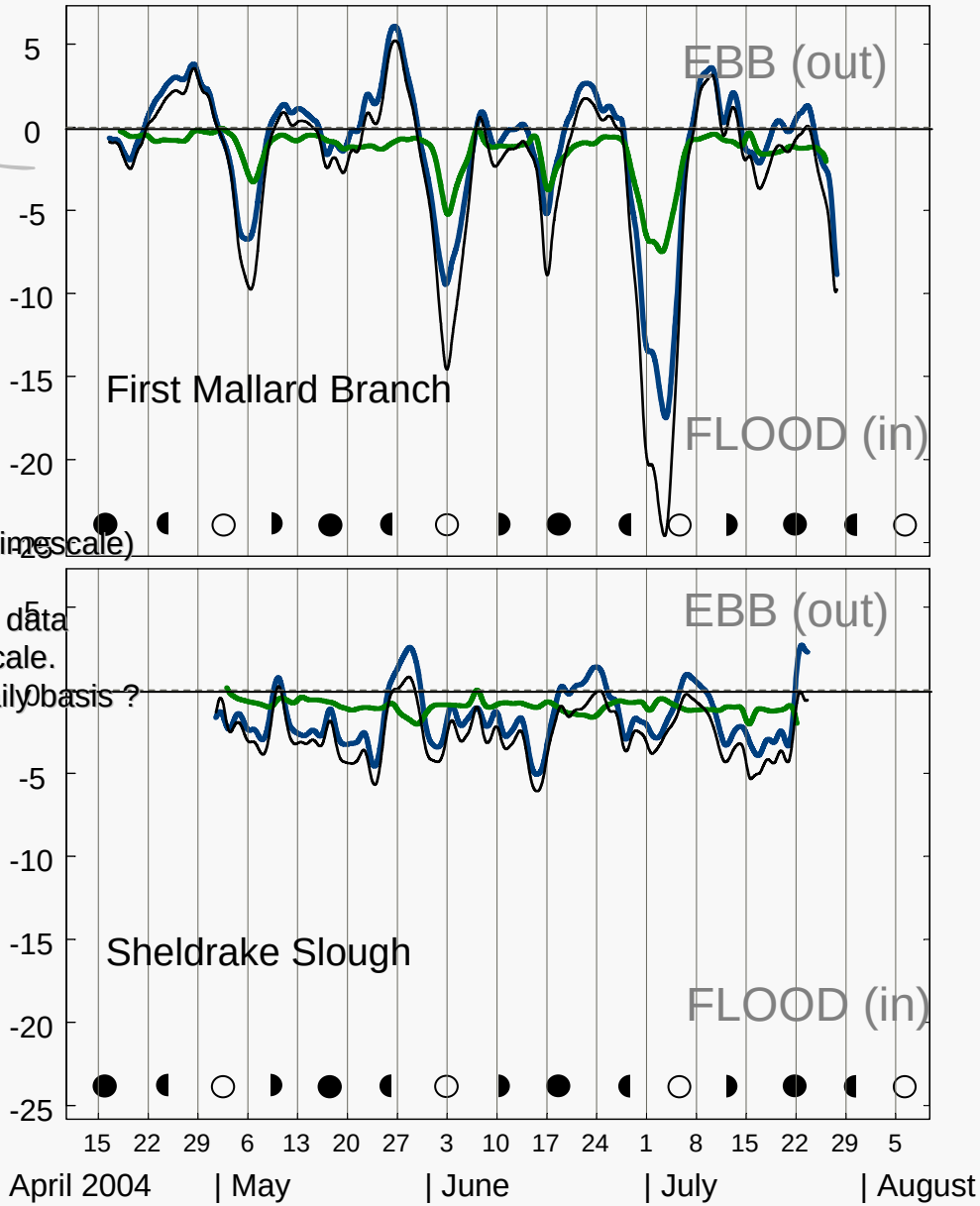


DO Flux

Total Flux = Advective Flux + Dispersive Flux

(Spring-Neap) (Tides)

<Qt*Ct> = <Qt><Ct> + <Q't*C't>



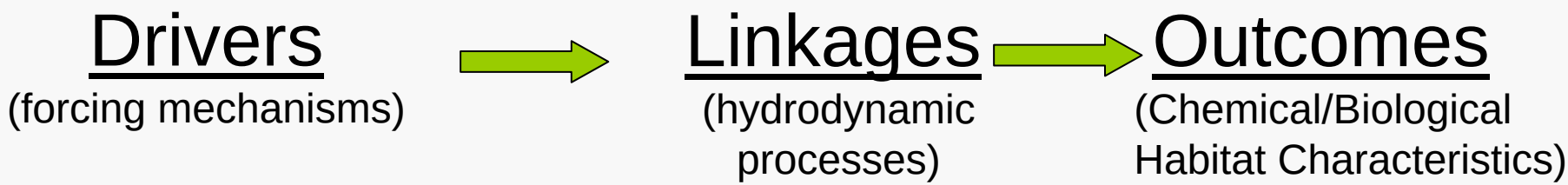
all plots tend to show more wiggles (aliasing vis-à-vis tidal timescale) in Sheldrake Slough

seemingly on the tidal timescale even though this is filtered data

which suggests existence of a forcing not at the tidal timescale.

could this be a diel forcing due to covert operations on a daily basis ?

Conceptual Model



Conceptual Model

- Meteorology
- Tides
- River inputs
- Exports/ Diversions/ Drainages

Conceptual Model

Drivers
(forcing mechanisms)

- Meteorology
- Tides
- River inputs
- Exports/ Diversions/ Drainages

Linkages
(hydrodynamic processes)

- Advection
- Dispersion
  - network
  - velocity shear
  - tidal trapping
- Gravitational Circulation

Outcomes
(Chemical/Biological Habitat Characteristics)

Conceptual Model

Drivers
(forcing mechanisms)

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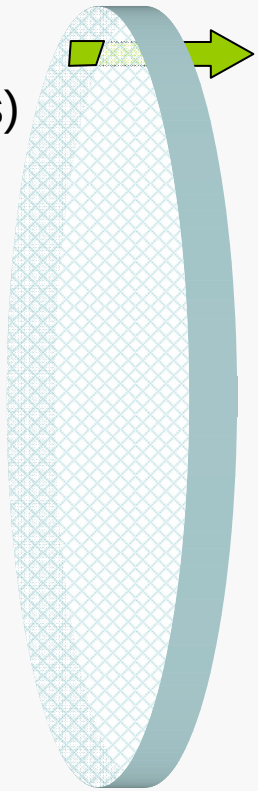
Outcomes
(Chemical/Biological Habitat Characteristics)

Gradients of

- Residence time
- Salinity
- Temperature
- Sediment
- Biota
- Toxics
- etc.

Conceptual Model

Geometry
(Like a Filter)



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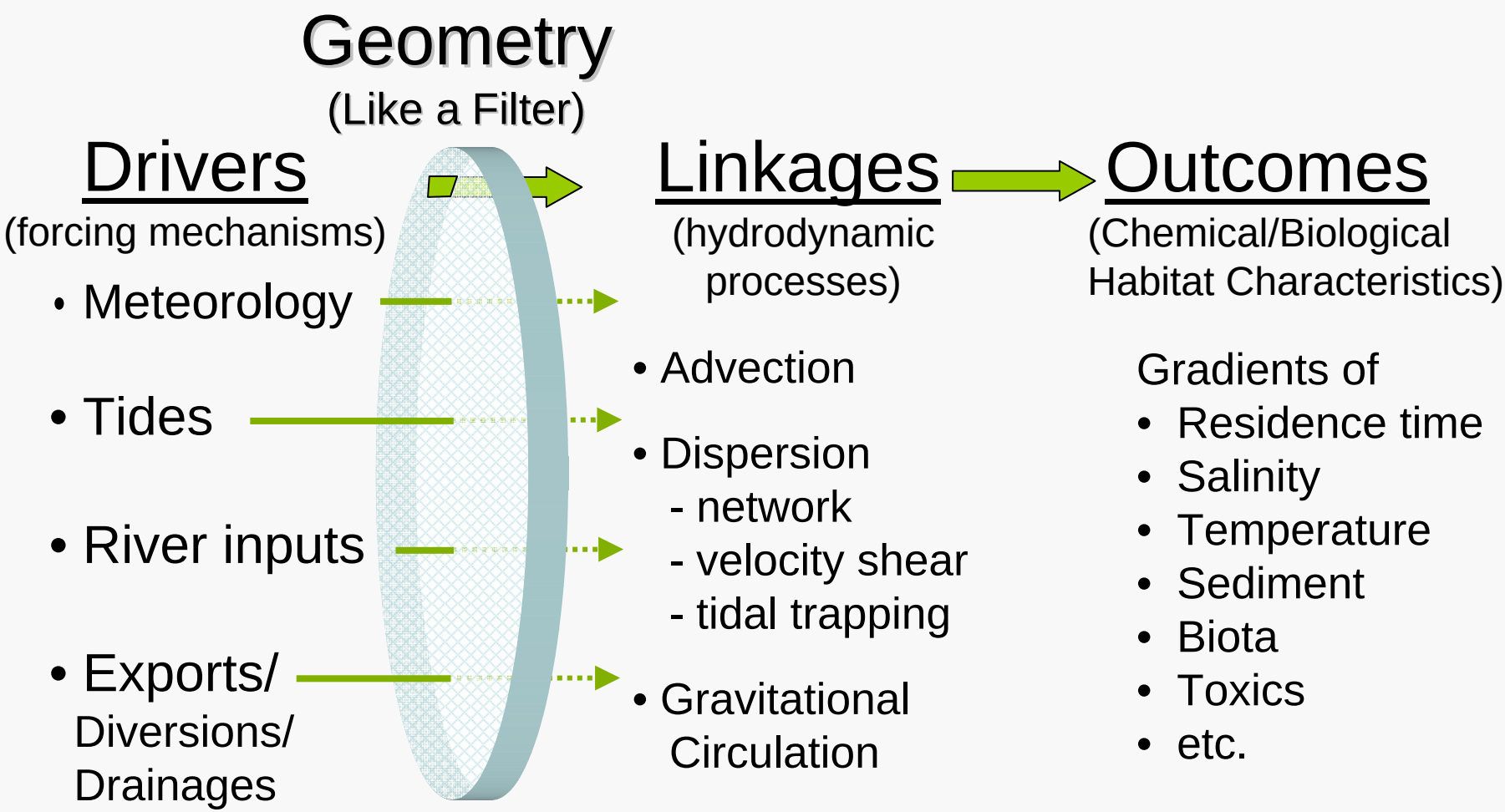

Conceptual Model

Geometry
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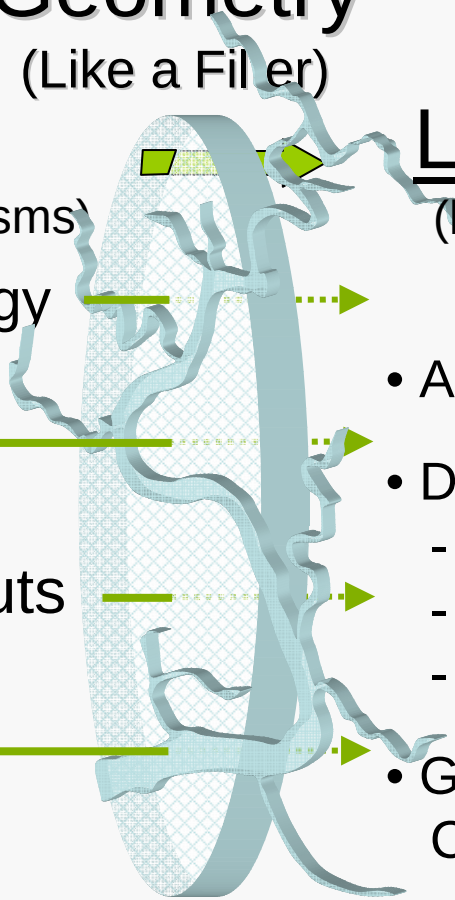

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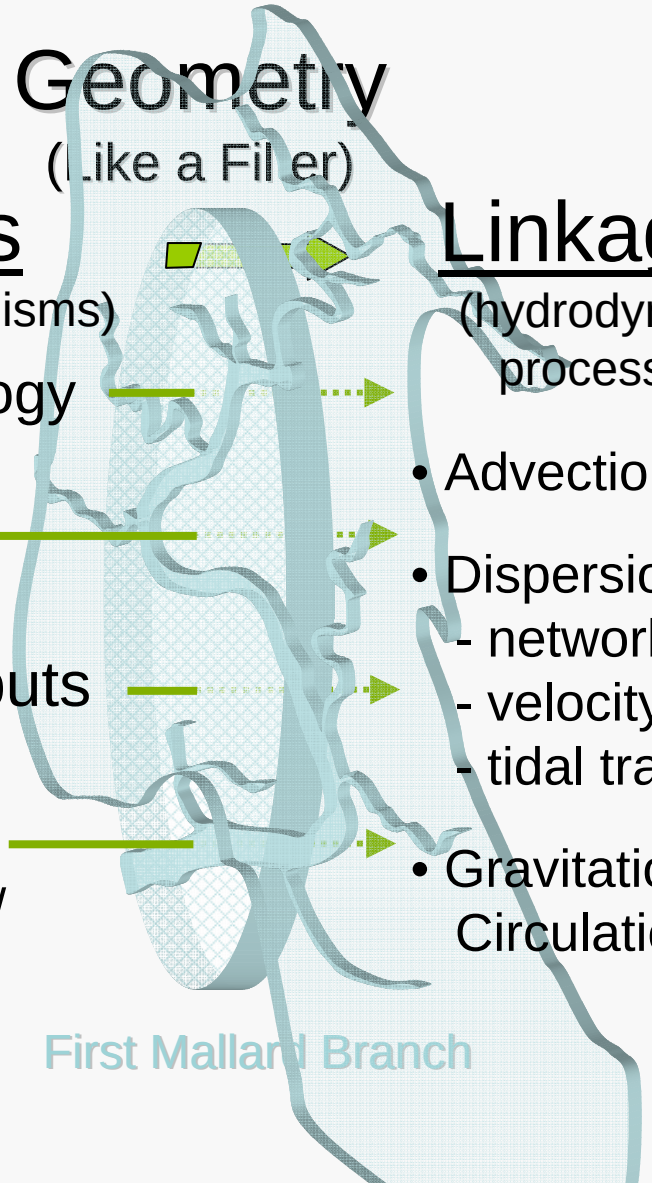
First Mallard Branch

Conceptual Model



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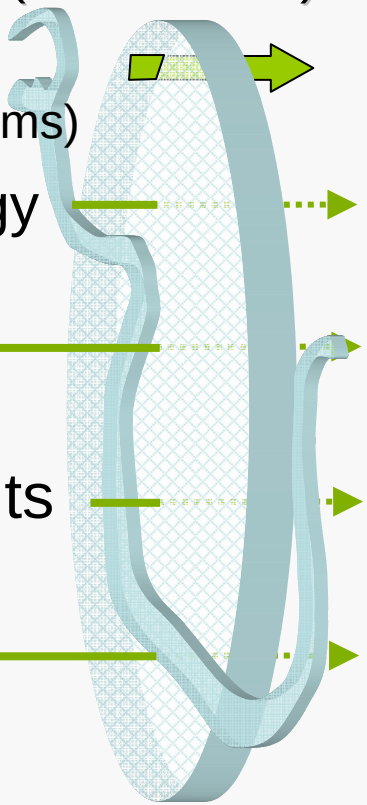

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Sheldrake Slough

Summary

- First Mallard tightly coupled to spring-neap cycle. Sheldrake is not.
- Temperature variability due to diel timing of tides. Geometry determines magnitude of variability.
- Chlorophyll flux by opposite transport processes.
- Sloughs generate temperature extremes both high and low. First Mallard does it more.
- Physical, chemical, and biological signals (gradients) are all more variable at First Mallard.

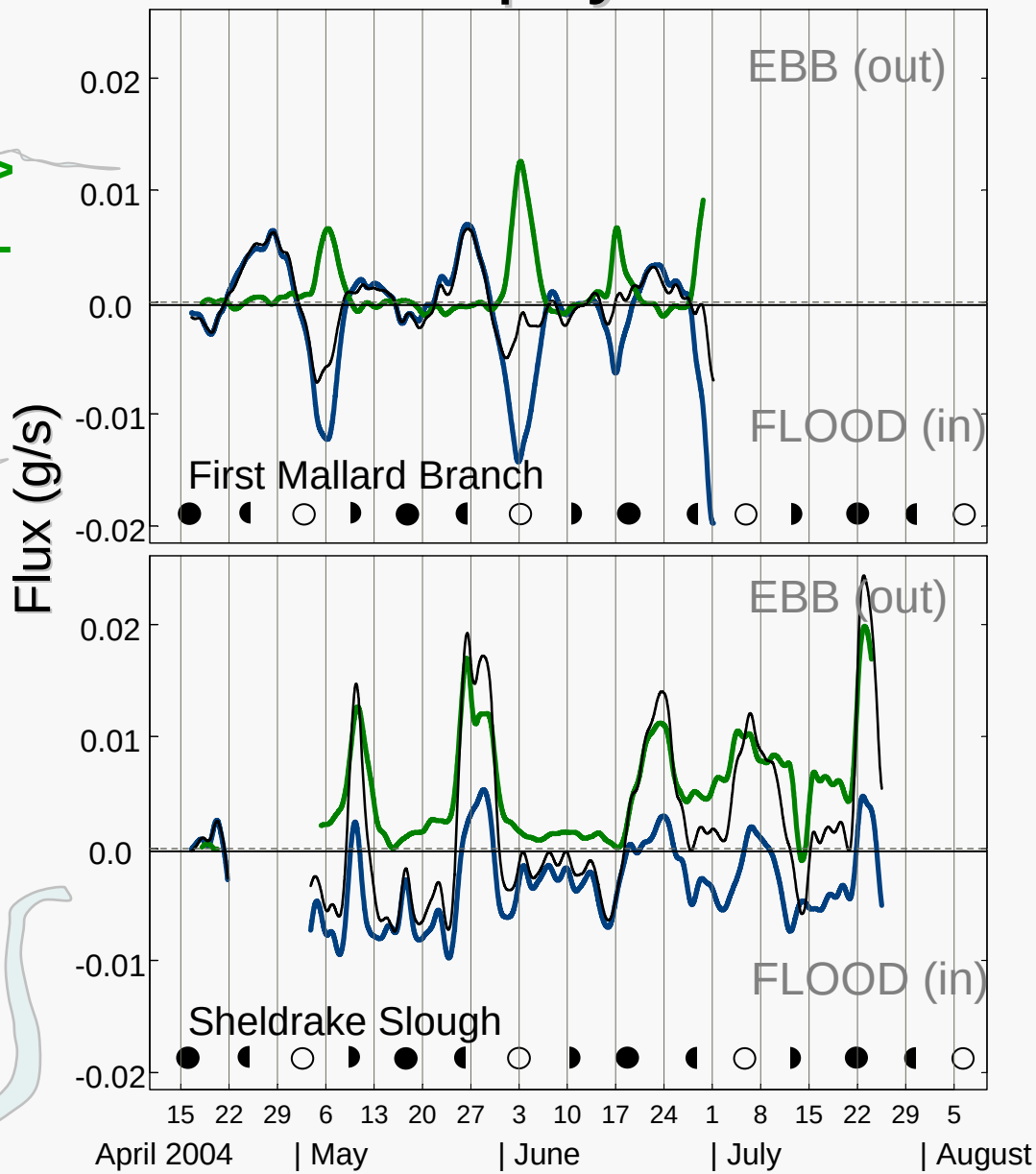
General Conceptual Model

- Geometry “filters” estuarine drivers (tides, river input)
- Complex geometry begets more variable process response.
- Native plants and animals figured out variability.
- Let’s put intertidal elevation landscapes on a trajectory to complex geometry by letting the tides in.

Thank You

- Angelo Garcia
- Curt Battenfeld
- Jay Cuetara
- Randy Smith
- Aaron Miller
- Kate Le
- Brad Tom
- Victor Pacheco
- Randy Beckwith

Total Flux = Advective Flux (Spring-Neap) + Dispersive Flux (Tides)

<Qt*Ct> = <Qt><Ct> + <Q't*C't>

Chlorophyll Flux