Hydraulic Design of tidegates and other Water Control structures for Ecosystem Restoration projects on the Columbia River estuary

Patrick S. O’Brien PE
patrick.s.o’brien@usace.army.mil
Hydrologic, Coastal, & River Engineering Section
US Army Corps of Engineers
Portland District

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New Orleans, Louisiana

- Surrounded by Levees for flood protection from Mississippi River + Hurricanes
- Drainage network of canals
- Gravity drainage into canals
- Network of pumping stations drains canals into Lake Pontchartrain
- Significant tidal effect
- High Water Table


N
W
E
S
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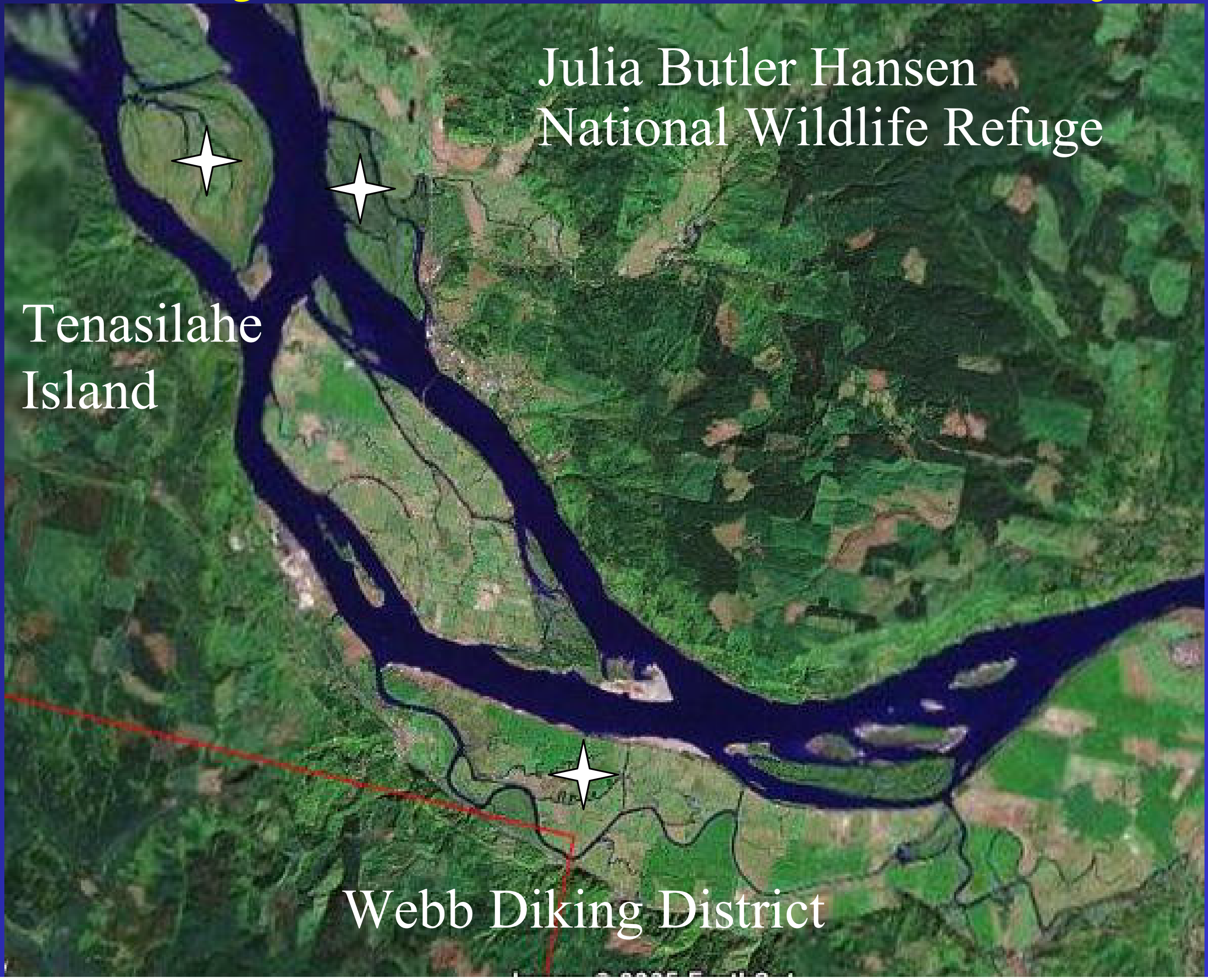
Ecosystem Restoration Projects in Col R Estuary



Webb Managed Wetland

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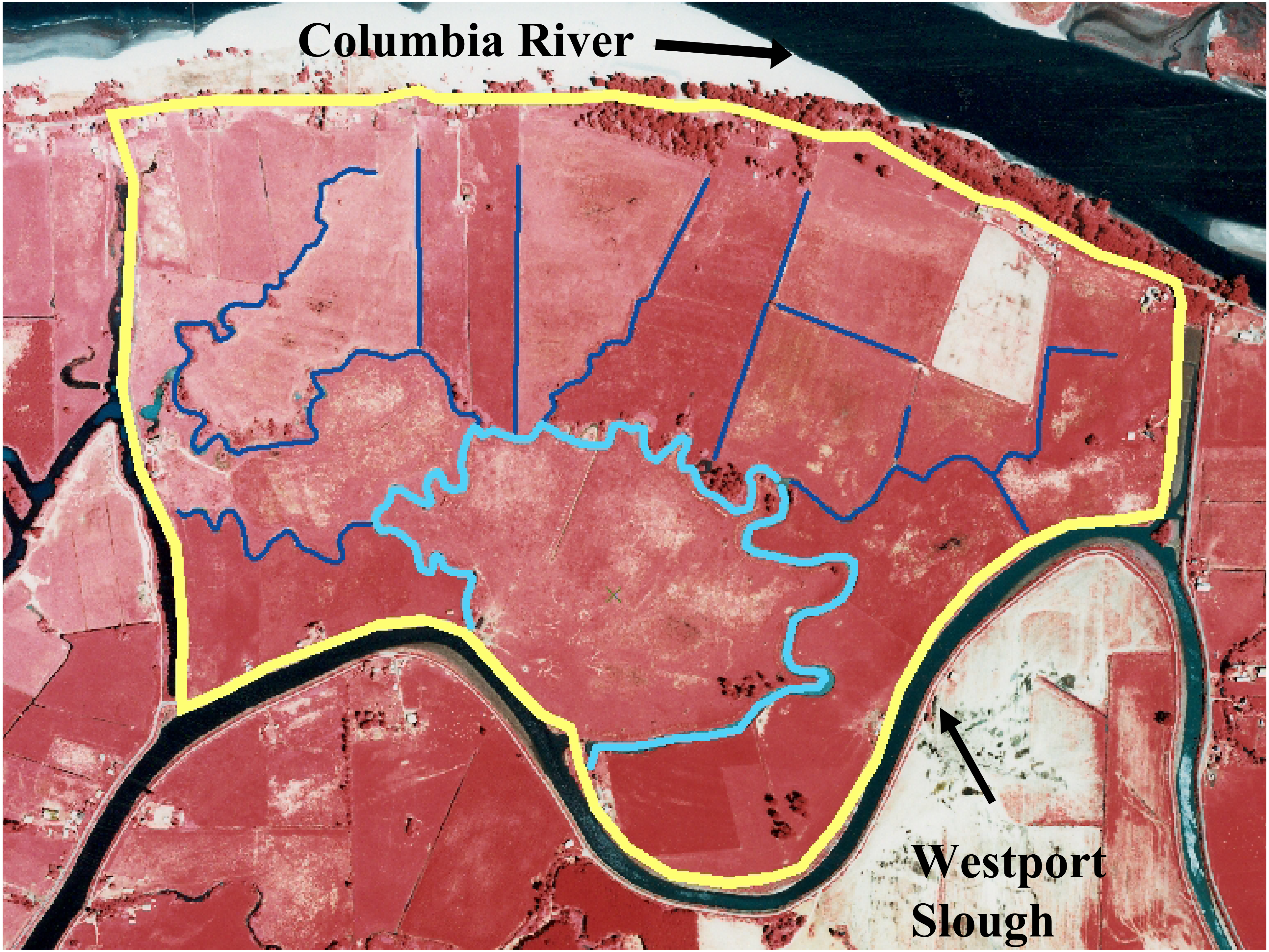
- Located at CRM 46
- Wildlife mitigation project associated with Columbia River Channel Deepening
- Project sponsors – Lower Columbia River Ports
- Diking District area 733 acres
- Project consists of 74 acre managed wetland built on Port of Portland land
- 6 mo execution from design to P & S
- Small project with lots of complexities
- Must deliver quality product capable of withstanding close scrutiny by stakeholders


Columbia River
Westport
Slough

Webb Managed Wetland

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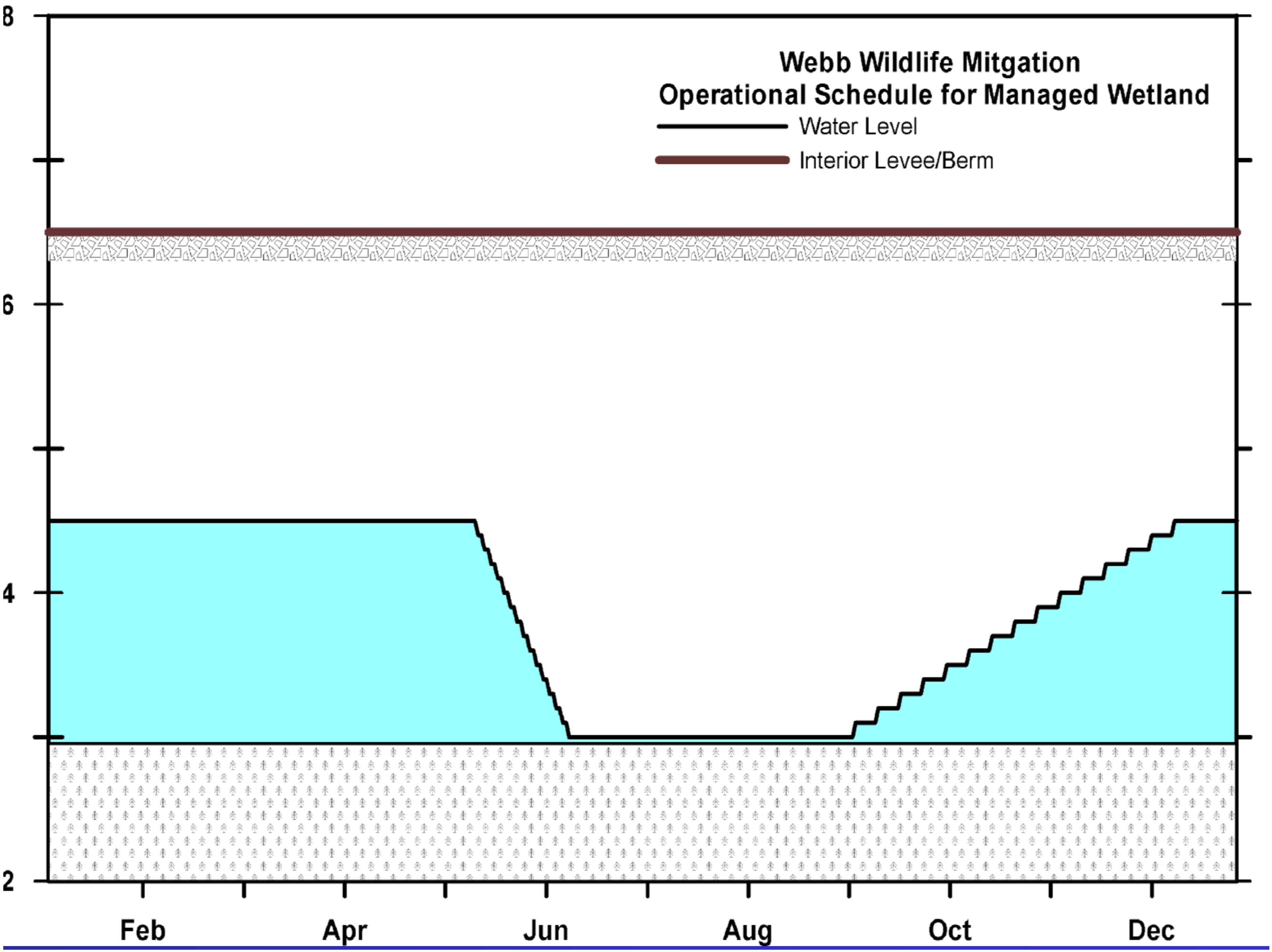
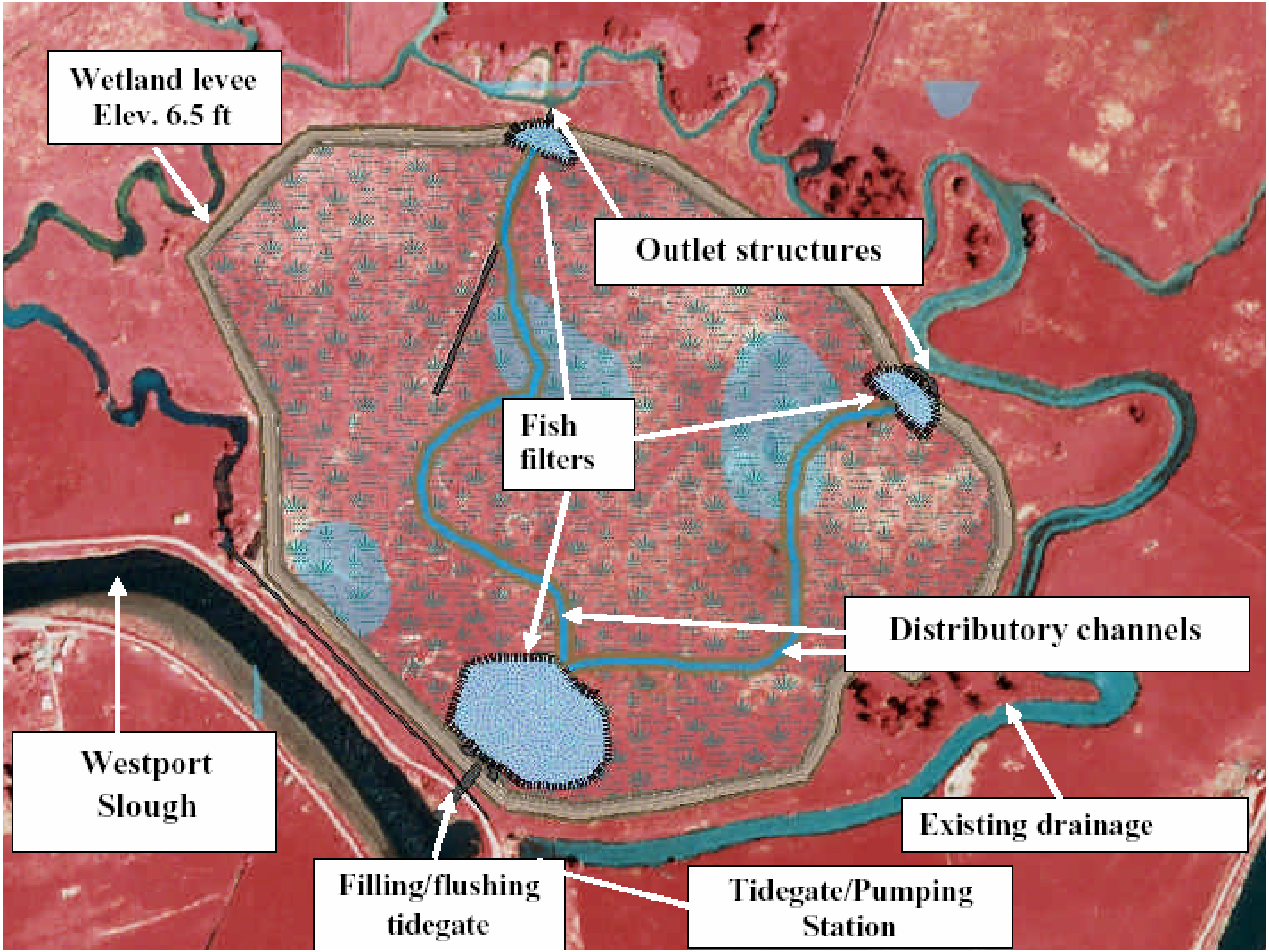
- Goals – passive management of water level between 3 and 4.5 feet
- Provide flushing water to main drainage slough
- Minimize standing water
- Opposed by landowners in the Diking district – lots of legal issues
- Concerns – Flood control, drainage, mosquitoes (west Nile virus), birds (avian flu)
- Public meeting Aug 10. Construction start ~ late Aug – early Sep pending signed MOA
- P & S complete, some remaining parts will be added as mods to the contract



Webb Wildlife Mitgation
Operational Schedule for Managed Wetland
Water Level
Interior Levee/Berm
8
6
4
2
Feb
Apr
Jun
Aug
Oct
Dec


Wetland levee
Elev. 6.5 ft
Outlet structures
Fish
filters
Distributory channels
Westport
Slough
Existing drainage
Filling/flushing
tidegate
Tidegate/Pumping
Station

Summer low water operation

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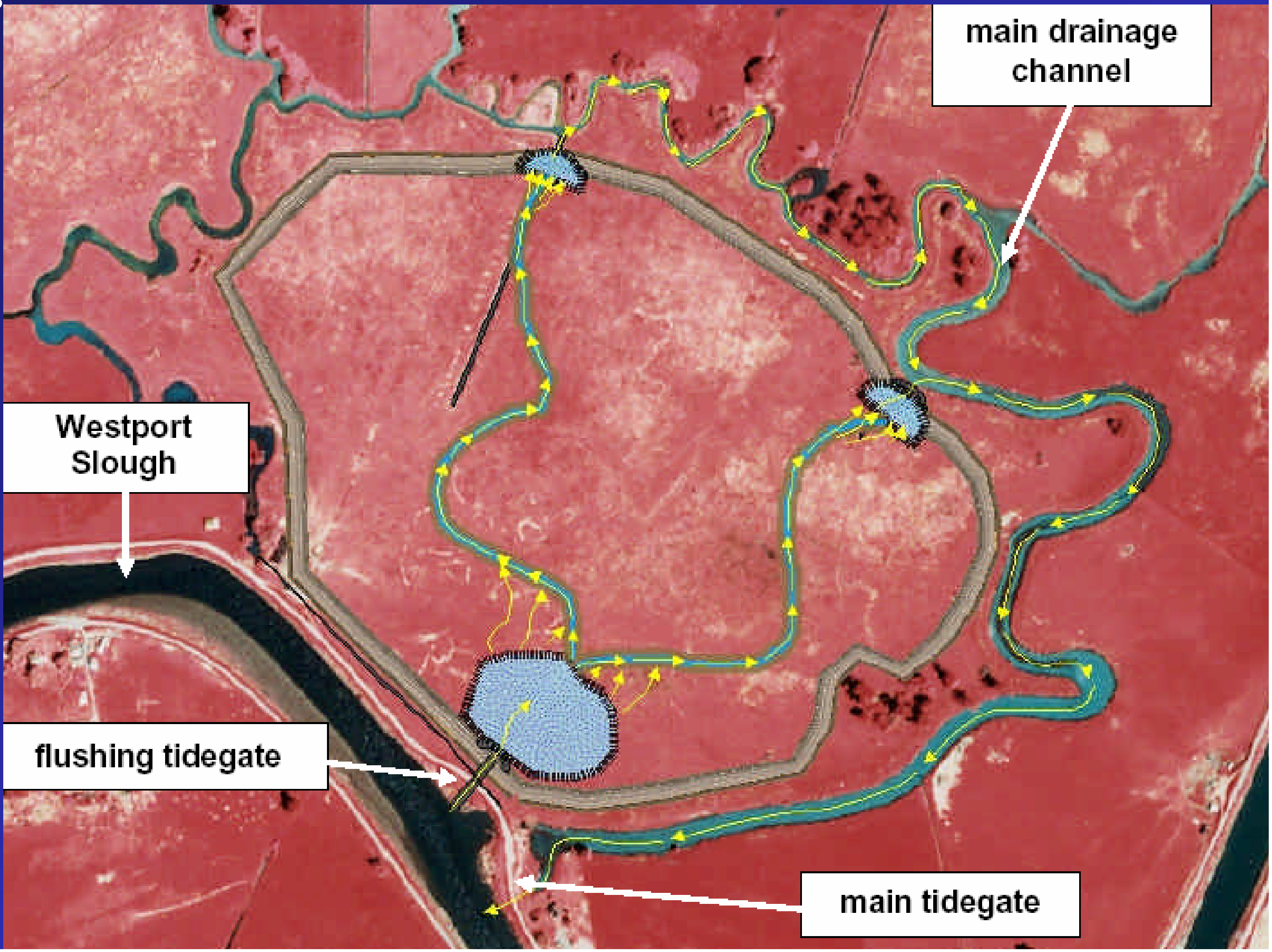

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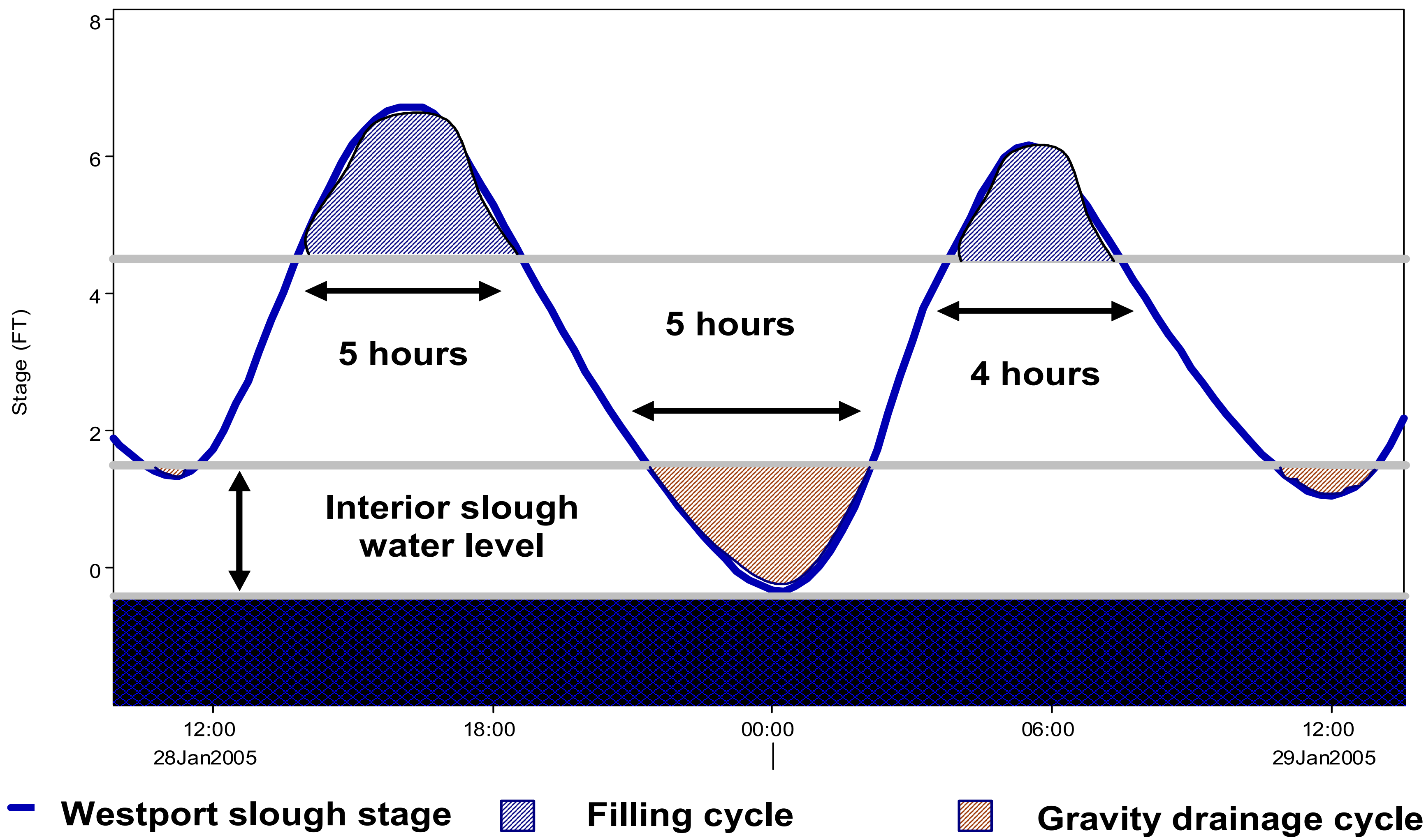
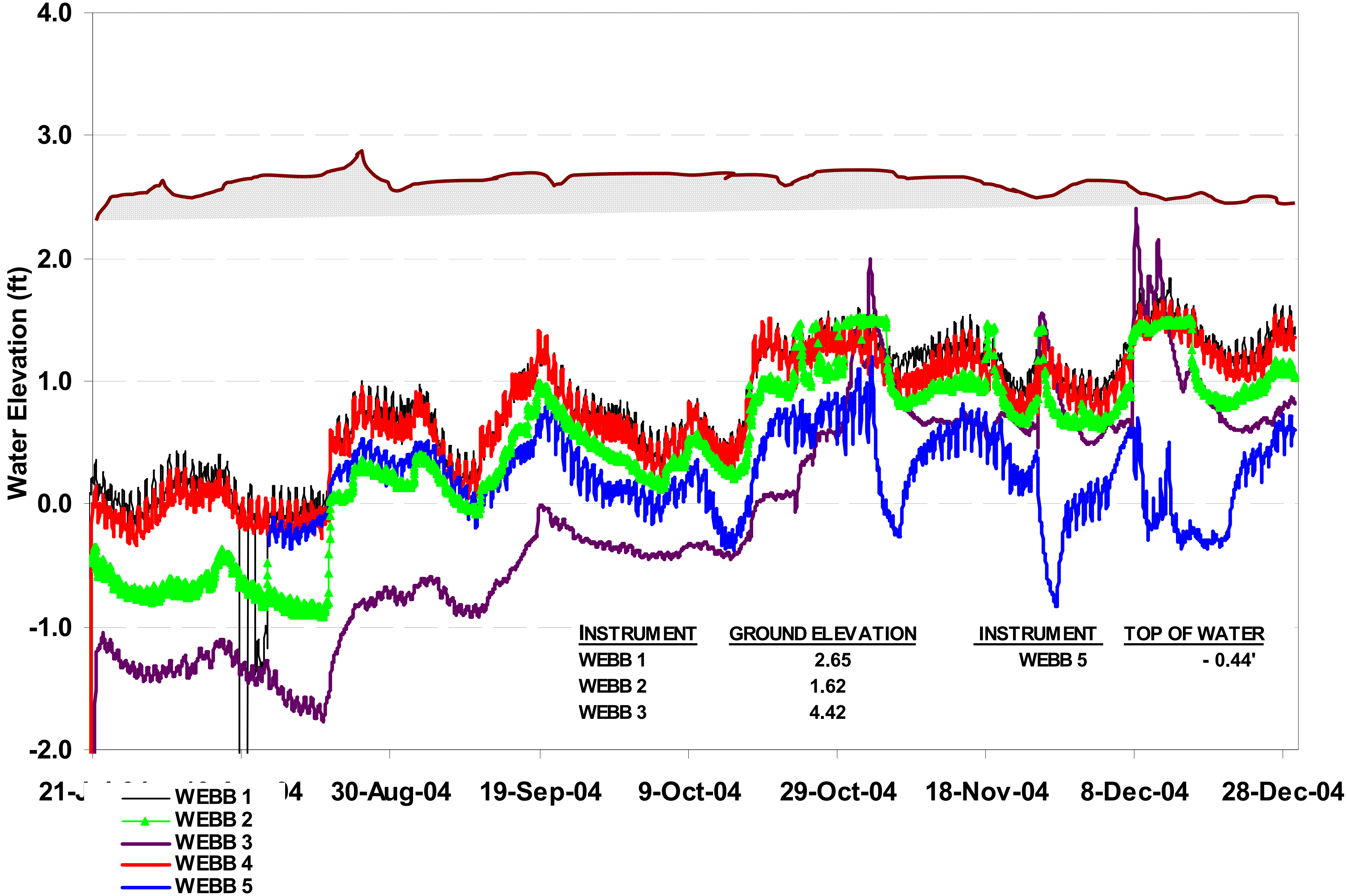
Hydrology & Climatology

- Interior drainage system
- High water table, responds rapidly to tidal cycle
- Gravity drainage into Westport Slough, 8 – 10 ft stage variation
- 48 cfs pump station, used to keep water table down and pasture land dry
- Drain tiles present

Drainage Cycle





4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
Water Elevation (ft)
30-Aug-04
19-Sep-04
9-Oct-04
29-Oct-04
18-Nov-04
8-Dec-04
28-Dec-04
WEBB 1
WEBB 2
WEBB 3
WEBB 4
WEBB 5
INSTRUMENT
GROUND ELEVATION
WEBB 1 2.65
WEBB 2 1.62
WEBB 3 4.42
INSTRUMENT
TOP OF WATER
WEBB 5 - 0.44'

Hydrology & Climatology

- Design has to consider rainfall runoff
- Small area ~ considered rational method
- Peak flow important, but continuous flow hydrographs needed.
- Quick-easy-cheap way to develop with and without project hydrology
- MGSFlood – WA DOT free program used
- **http://www.wsdot.wa.gov/eesc/design/hydraulics/downloads.htm**

MGSFlood schematic with inflow points to HEC RAS

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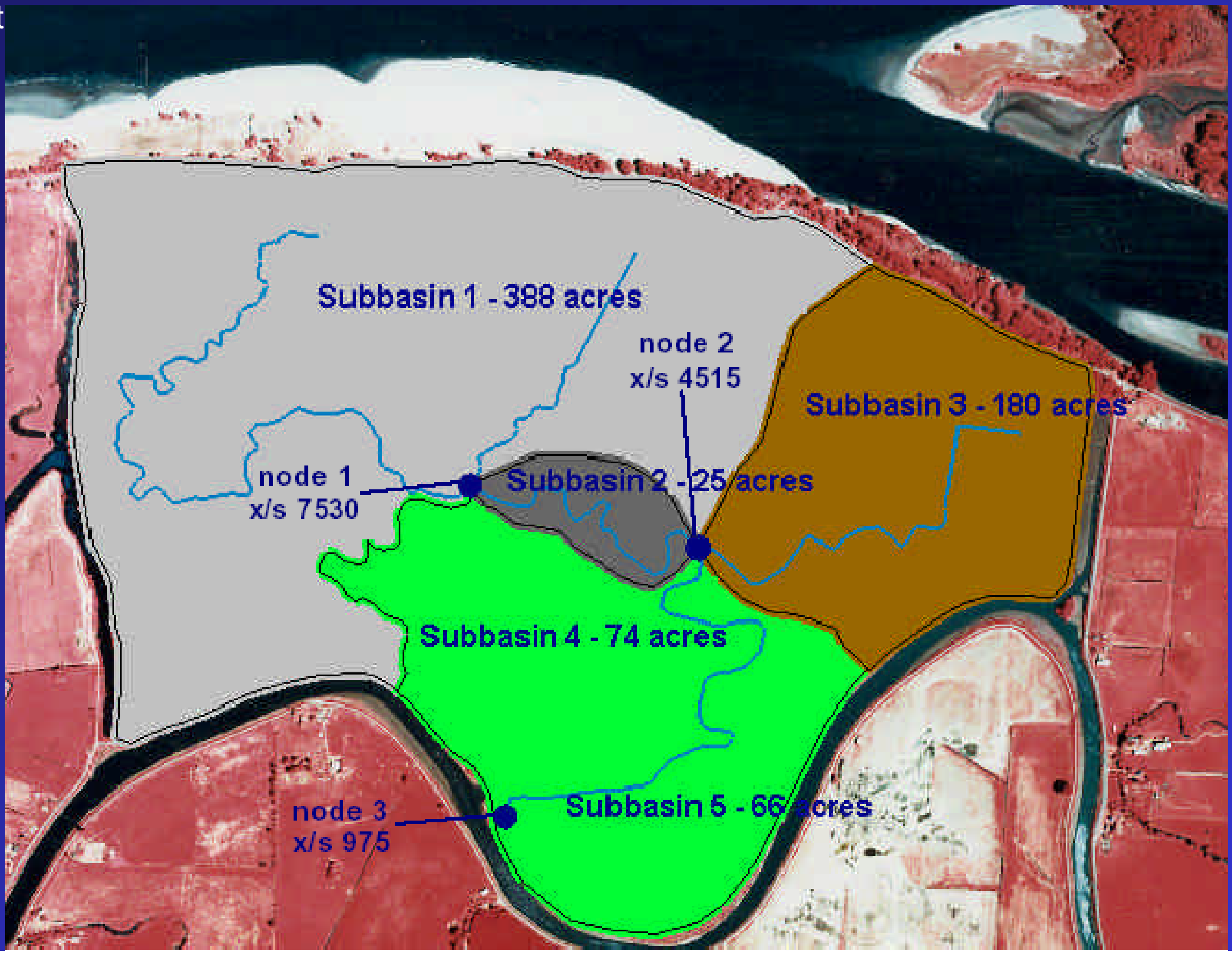
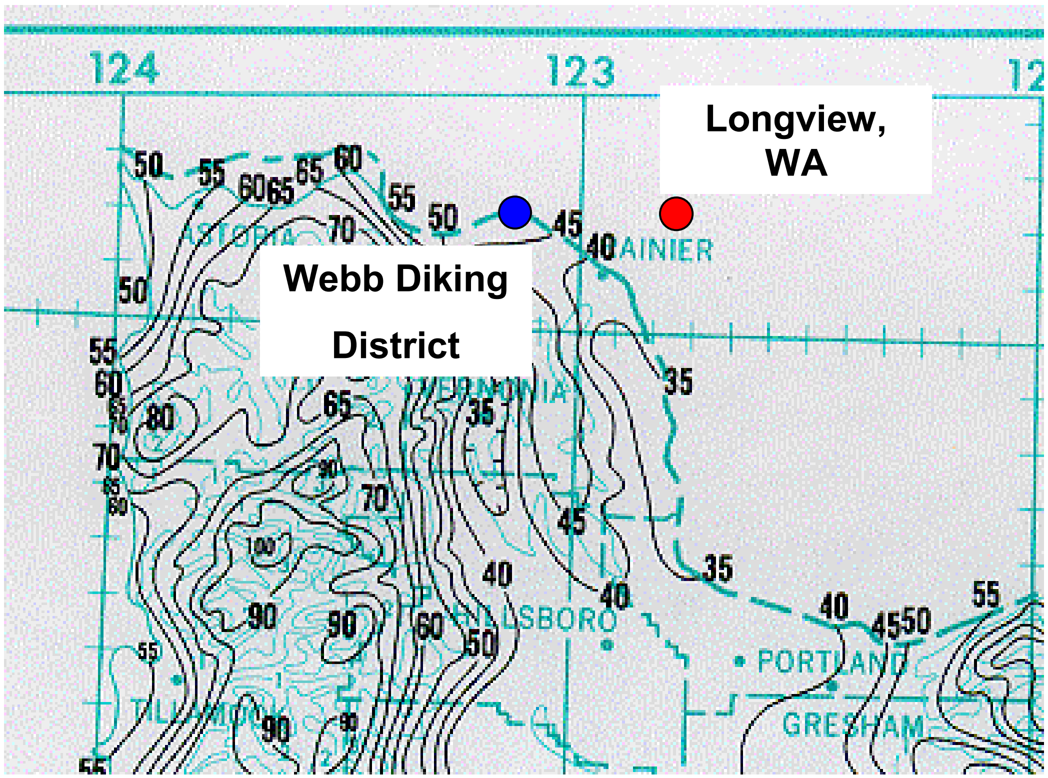


MGSFlood Rainfall data

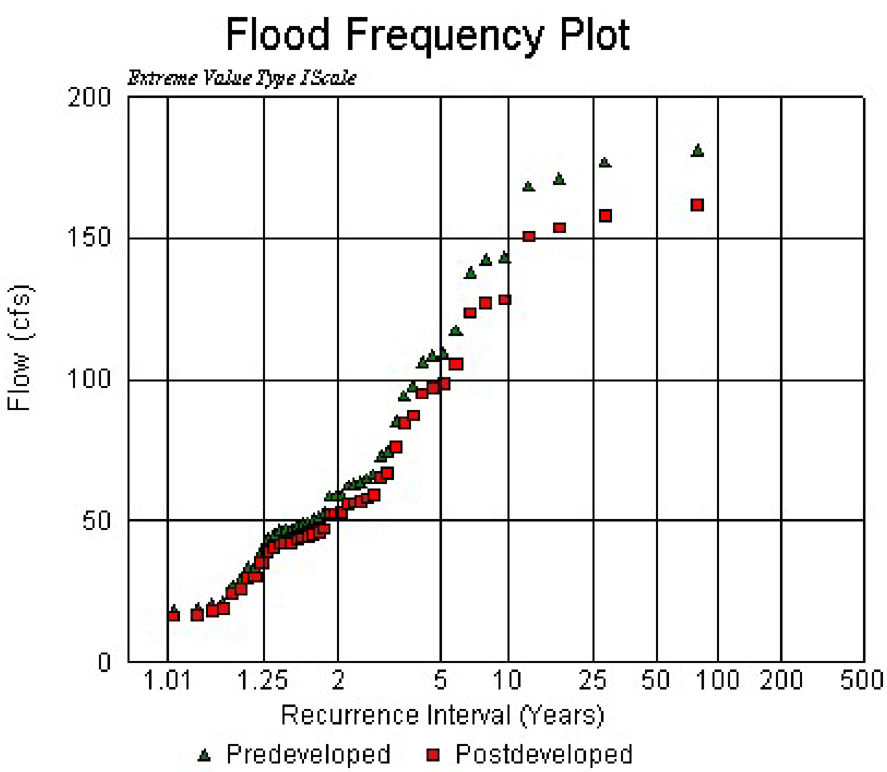


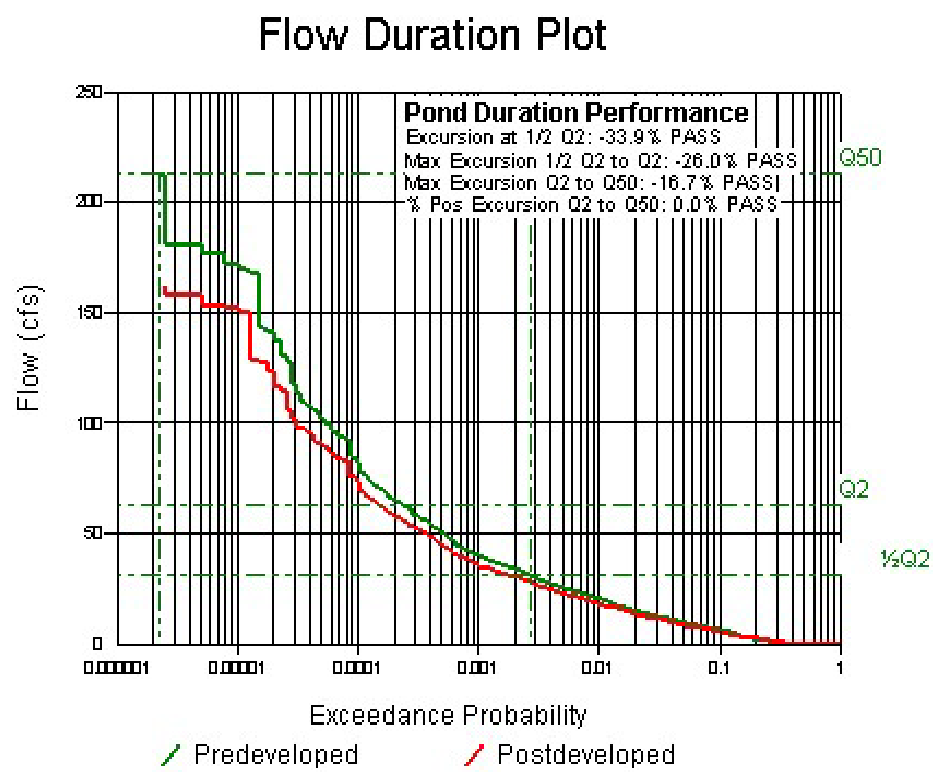
25 Year 24 hour Isopluvial Map – NOAA Atlas #2

- Project area – Webb
  25 yr – 24 hr = 5.25 inches
- Use Longview, WA gage 44 yr POR 25 yr – 24 hr
  4.21 inches
- Precipitation Scale Factor 5.25 / 4.1 1.247
- Continuous Flow Hydrographs developed with HSPF FORTRAN routine

MGS Flood Outputs

- Computed continuous flow for POR +





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Do we really need a Hydraulic Model ?

- Test and evaluate performance of design over range of tidal and rainfall conditions
- Answer a battery of questions that come up
  How long to fill wetland ?
  How fast can we drain it ?
- Communication tool – helps you communicate the hydraulics and hydrology to
  - the other members of the design team
  - May provides data for of the parts of the design
  - Resource agencies for permitting
  - Public - through graphics, want to keep it simple, common sense

Webb HEC-RAS

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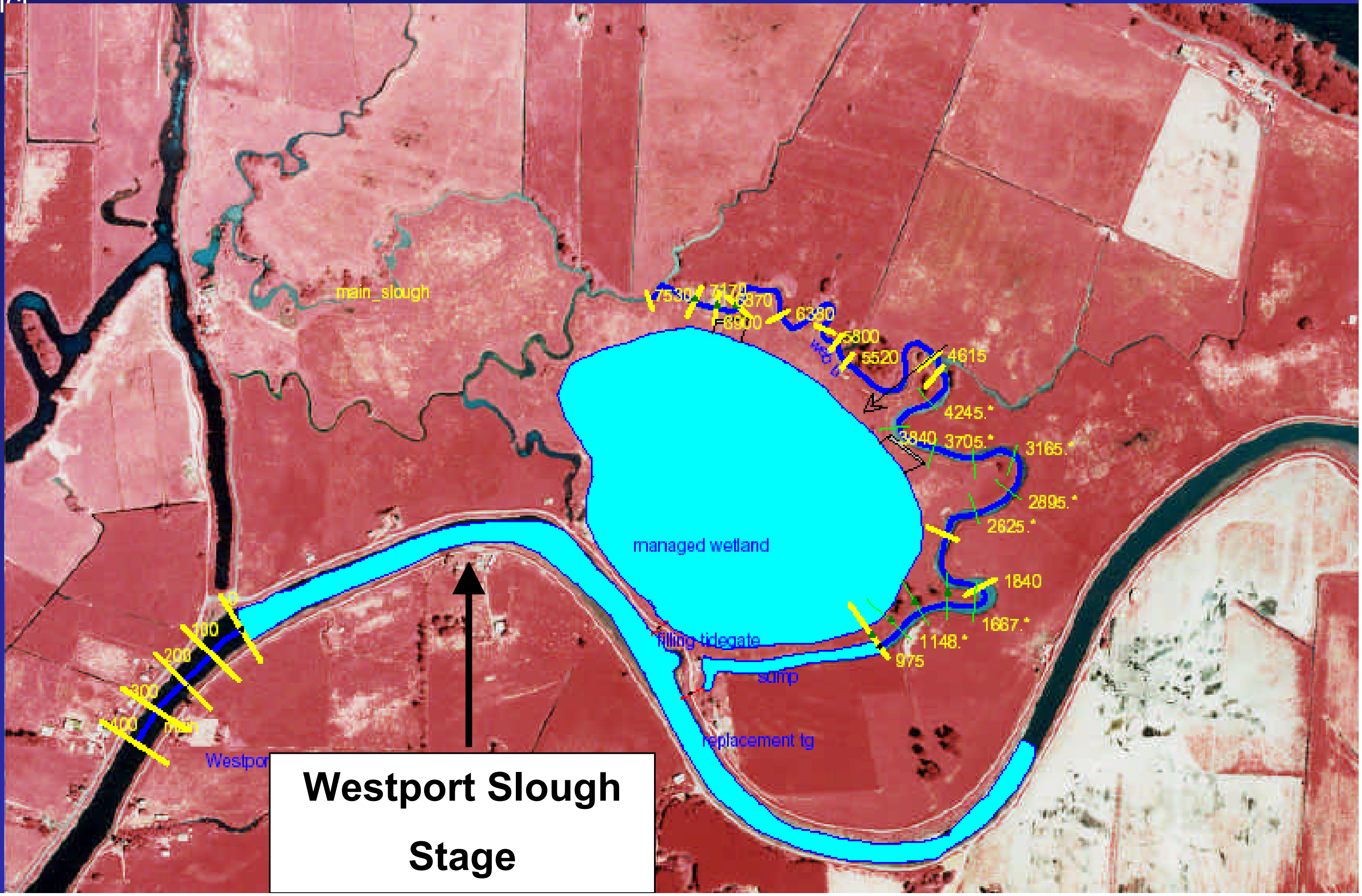

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Data requirements

- Basic model setup relies on representation of design water control structures (tidegates) as culverts defined by flow direction
- Managed wetland – elevation – volume curve defines storage curve
- Existing and replacement tidegate, pump station

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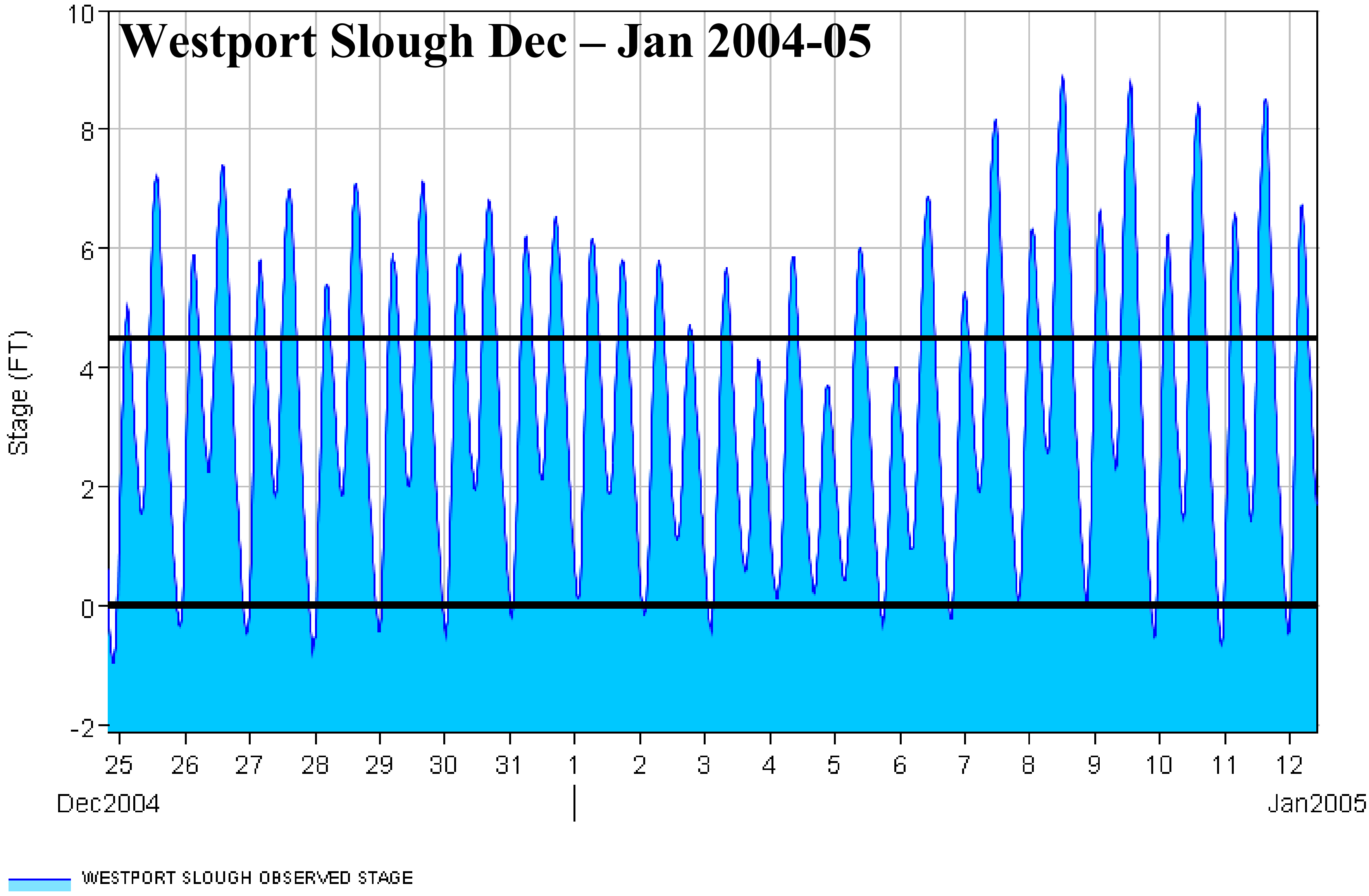
Data requirements

- Minimal survey data – cross sections of main drainage channel, spot elevations in 74 acre proposed managed wetland
- 1 day effort ~ 4 K
- Sutron gage at Westport slough (most important) ! 5 K



Westport Slough Dec – Jan 2004-05
Stage (FT)
10
8
6
4
2
0
-2
25
26
27
28
29
30
31
1
2
3
4
5
6
7
8
9
10
11
12
Dec2004
Jan2005
WESTPORT SLOUGH OBSERVED STAGE

STORAGE AREA CONNECTIONS

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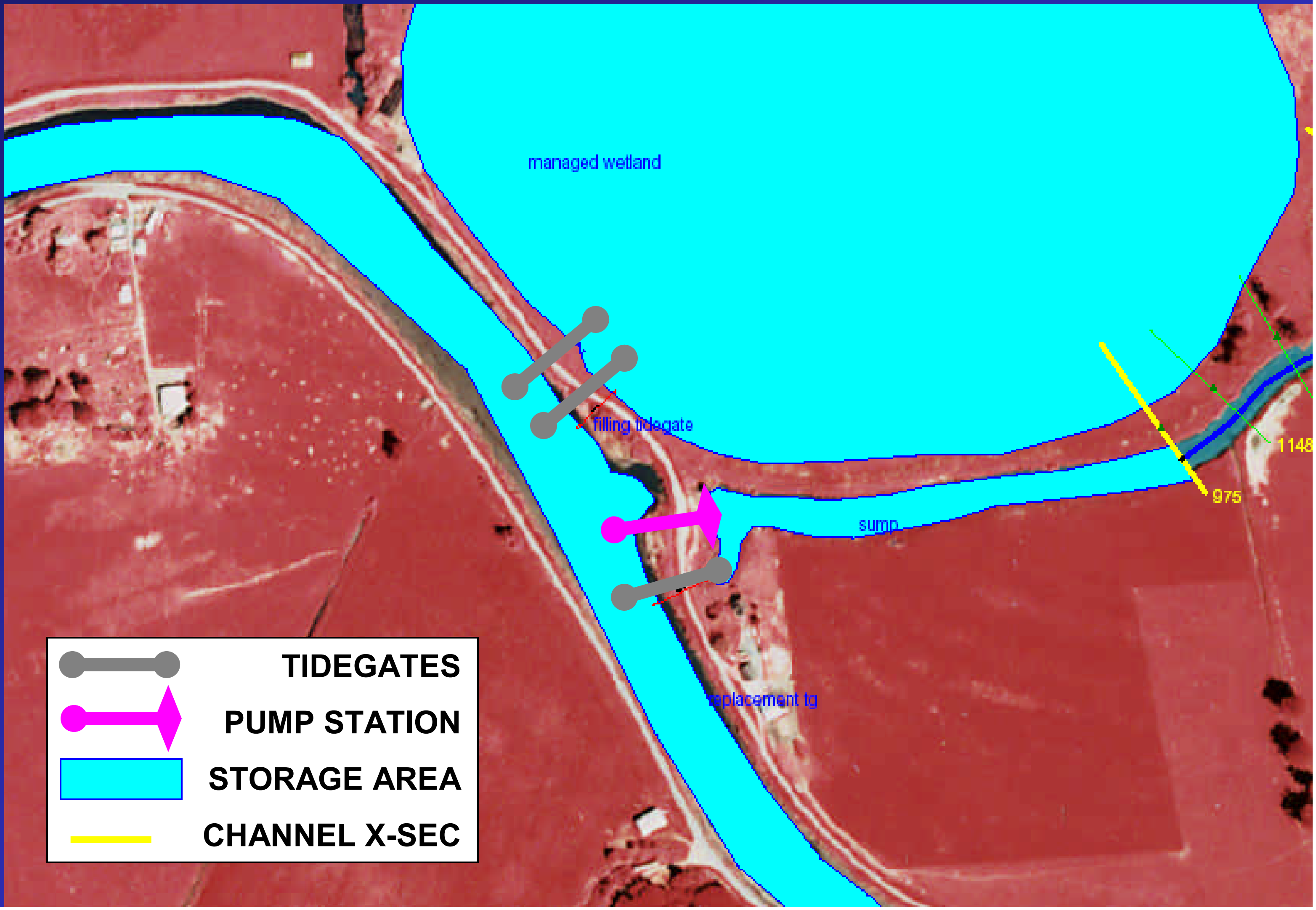

Replacement Tidegate

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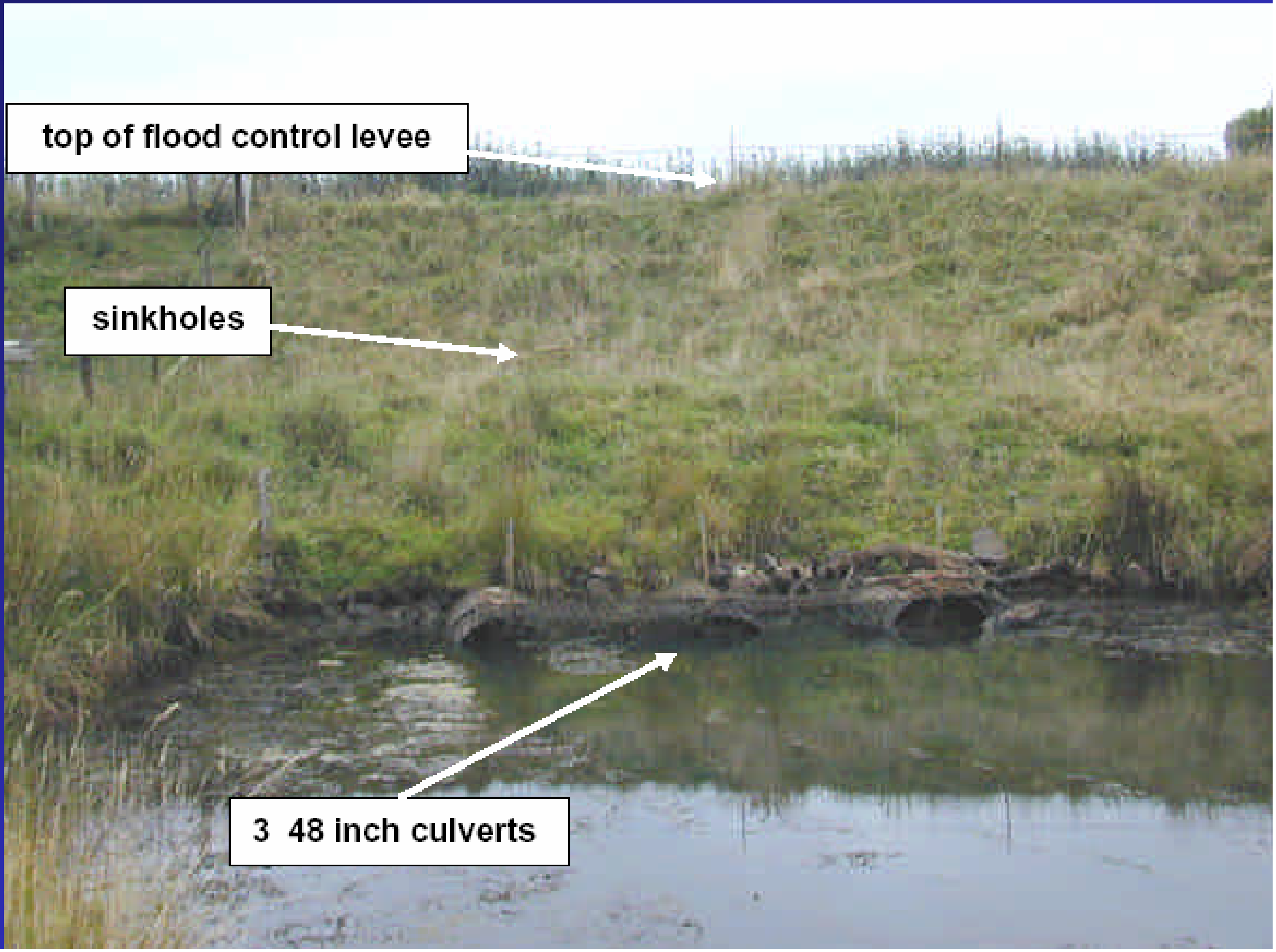

Replacement Tidegate
4 60in culverts/side opening tidegates

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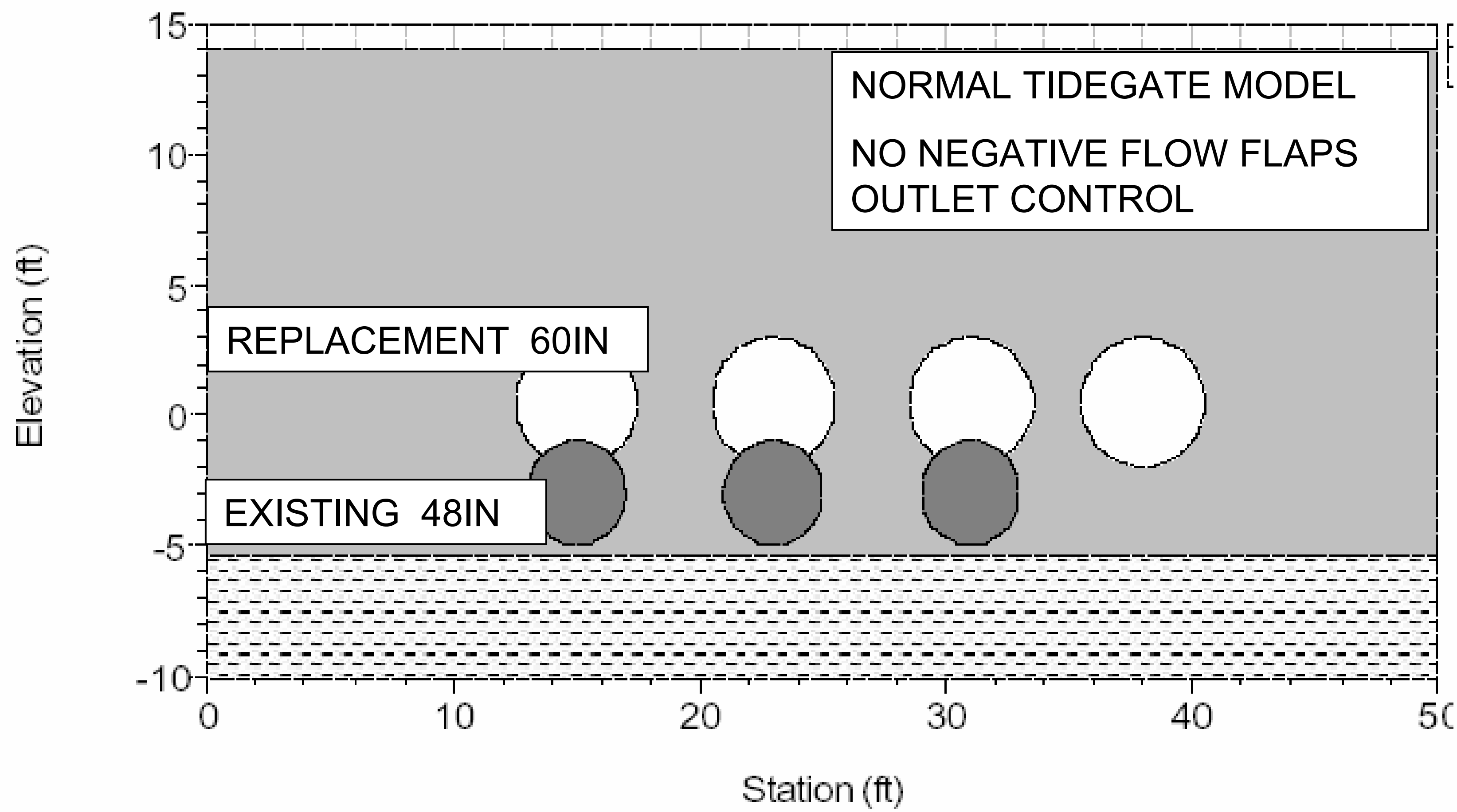

Coalbank Slough, Coos Bay

Five foot diameter aluminum tidegates designed by Nehalem Marine. Picture taken December 3, 2002 at 5:03 p.m. Coos Bay low tide -1.4 feet at 6:59 p.m. The side-hinged gate is 3 inches from being fully open. Water beginning to break over downstream control riffle. Shutter speed: 1 second.

Photo courtesy of Leo Kuntz, Nehalem Marine

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Tidegate Hydraulics

Top opening

n = 0.026

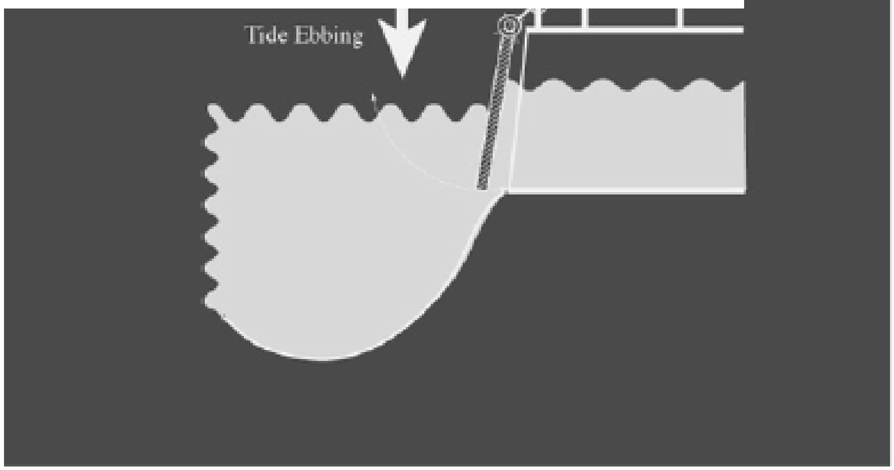
n = 0.030

Side opening

n = 0.021

n = 0.023

- ***Source – Tide Gates in the Pacific Northwest - Operation, Types and Environmental Effects Giannico and Soulder OSU-T-05-001 2005 Oregon State University***



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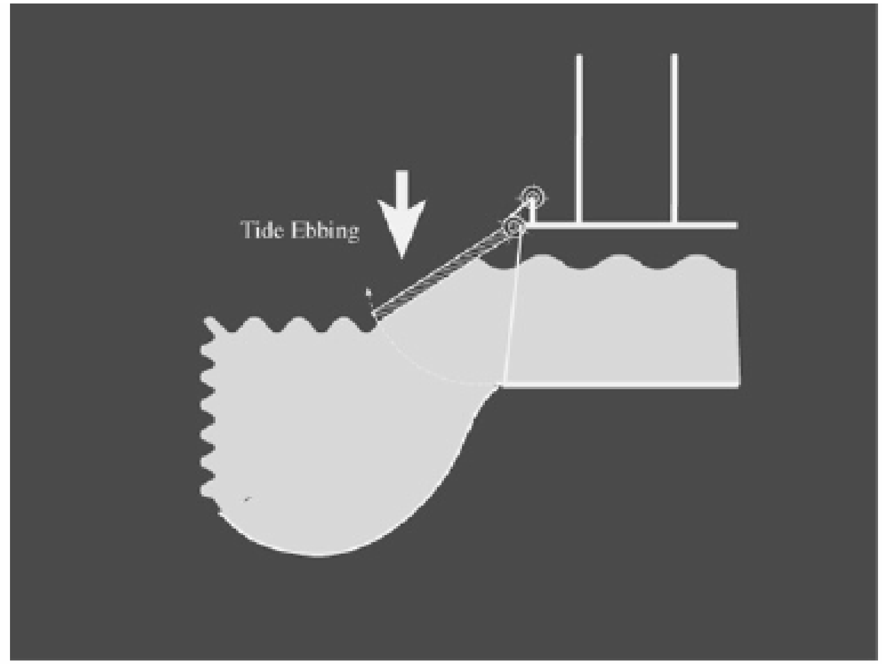
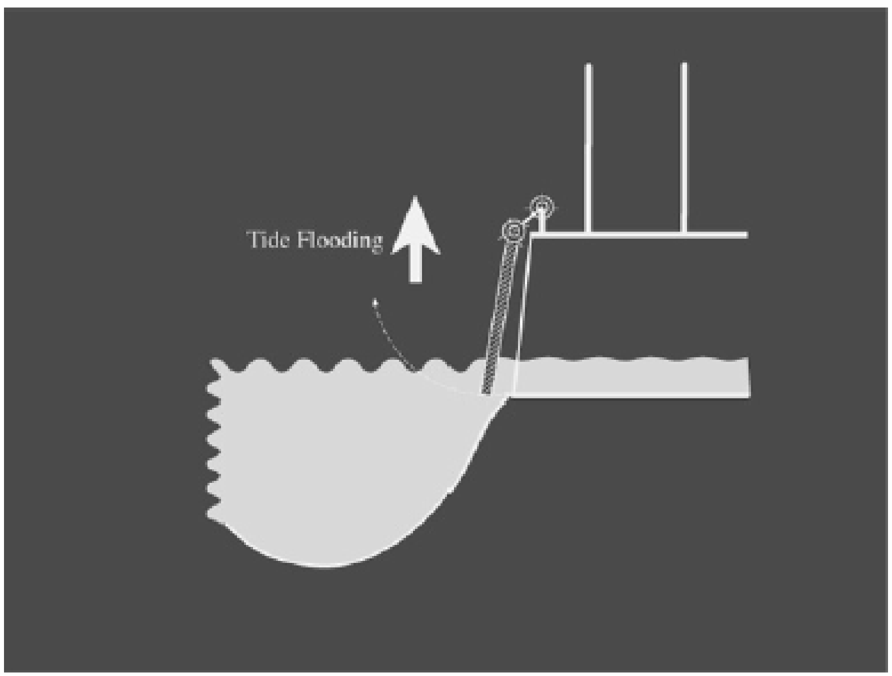
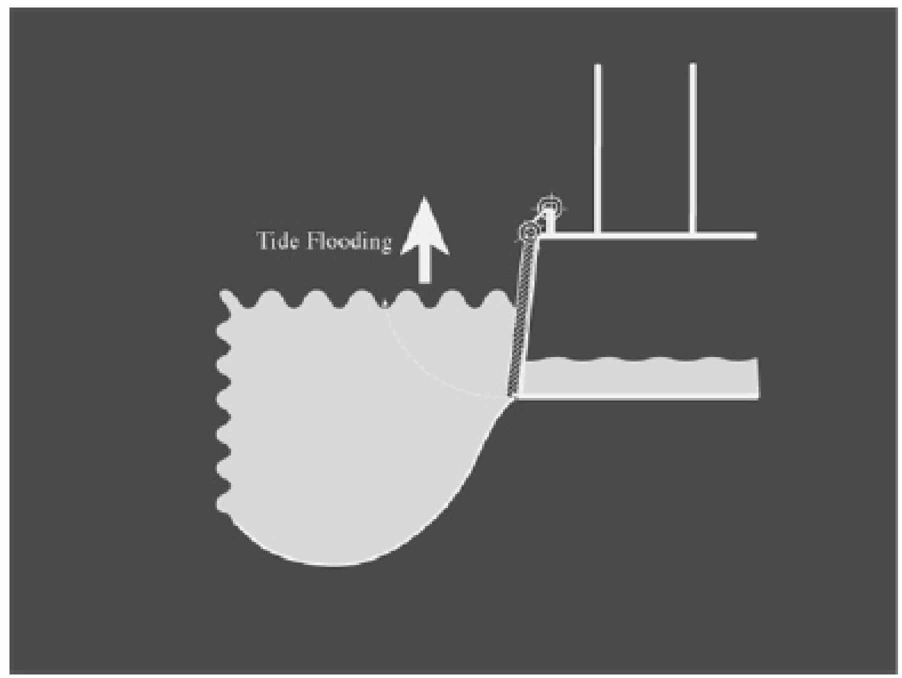


B





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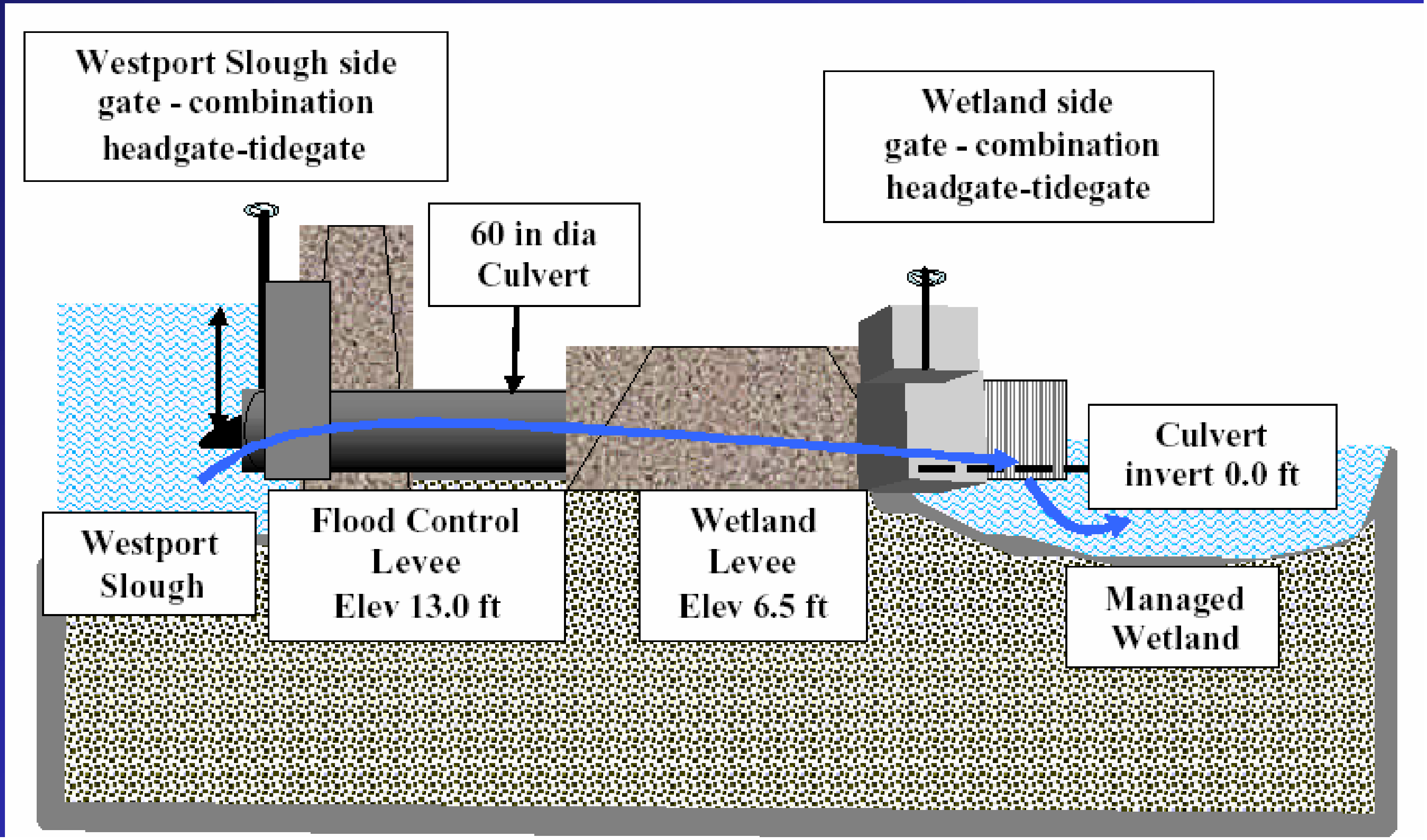
Filling/Flushing Tidegate



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Filling/Flushing Tidegate

Filling – Flushing Tidegate

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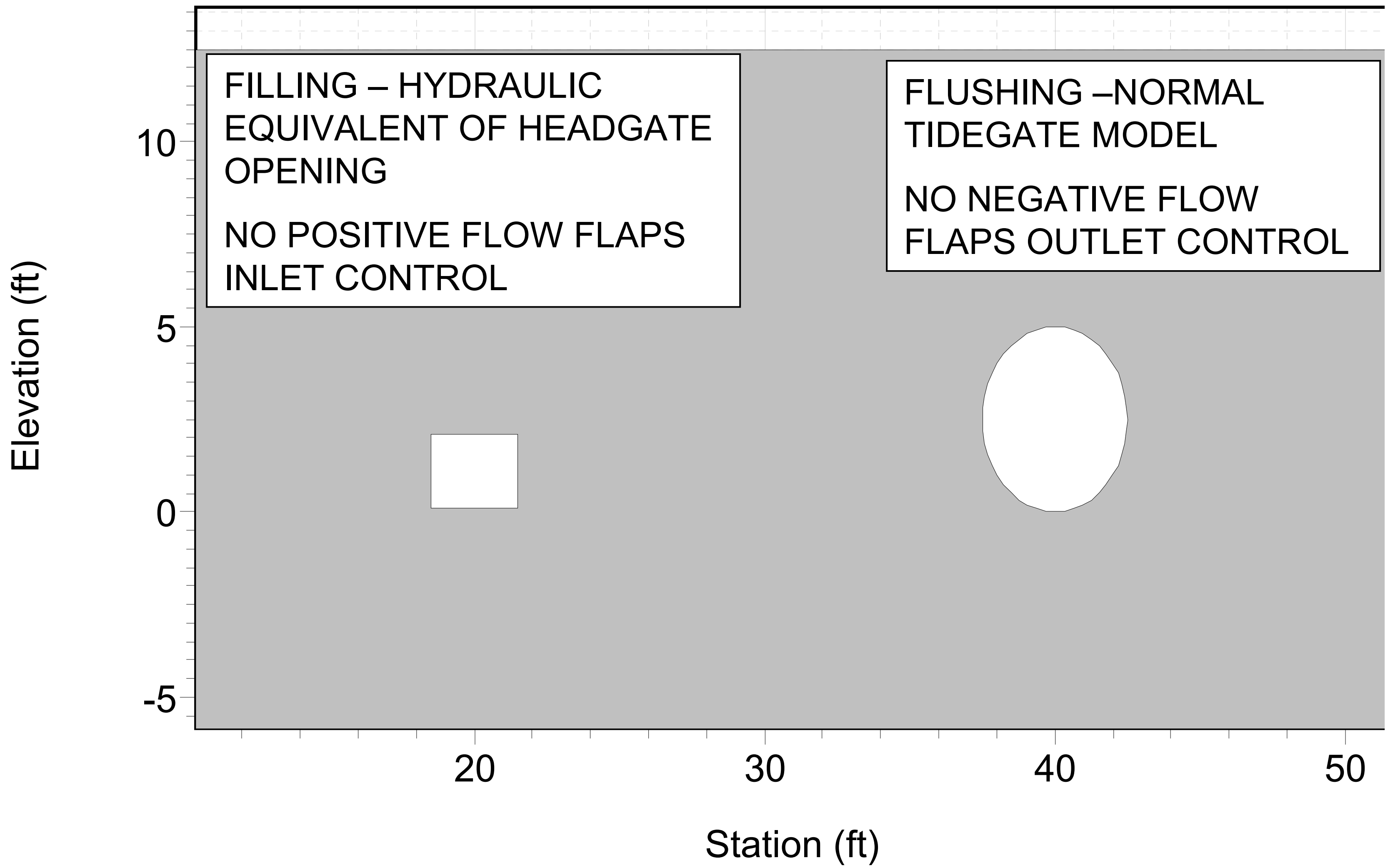

STORAGE AREA CONNECTIONS

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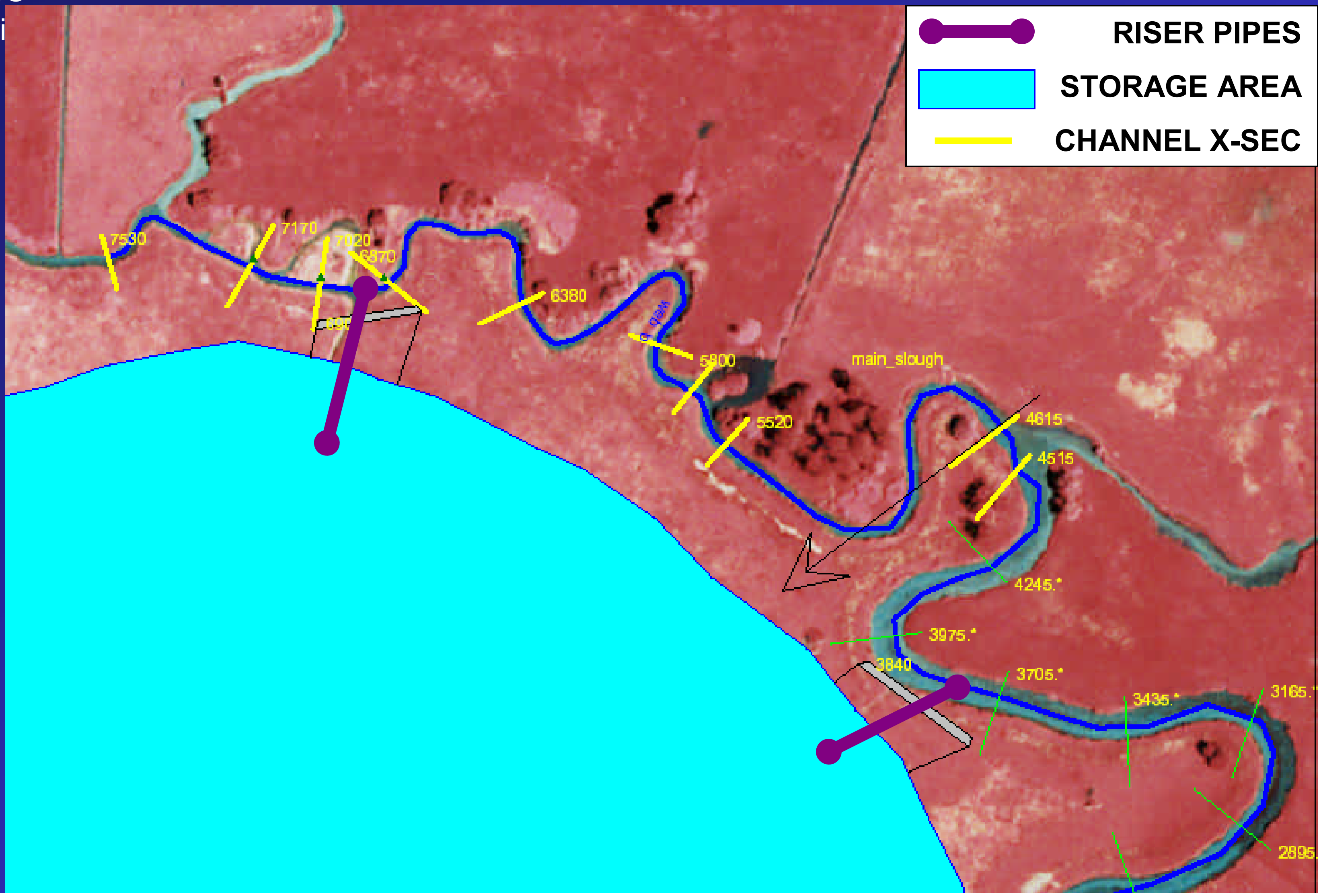

Fish Filter – Riser Pipe – Slough Connection

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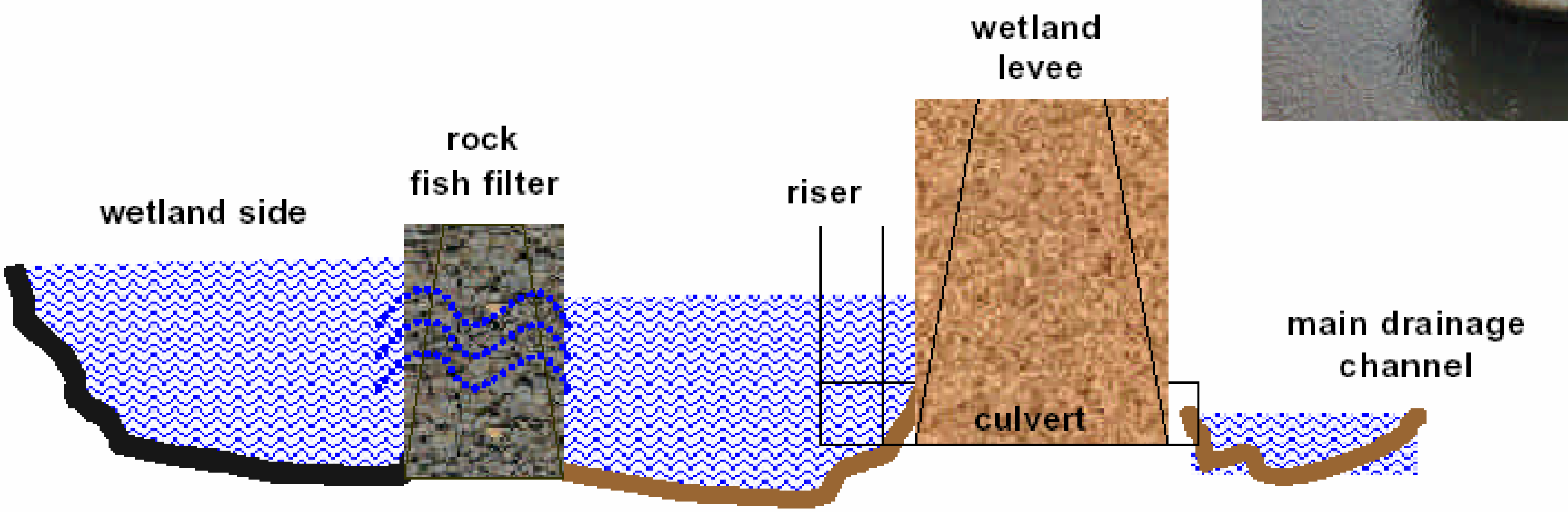

Fish Filter – Riser Pipe – Slough Connection

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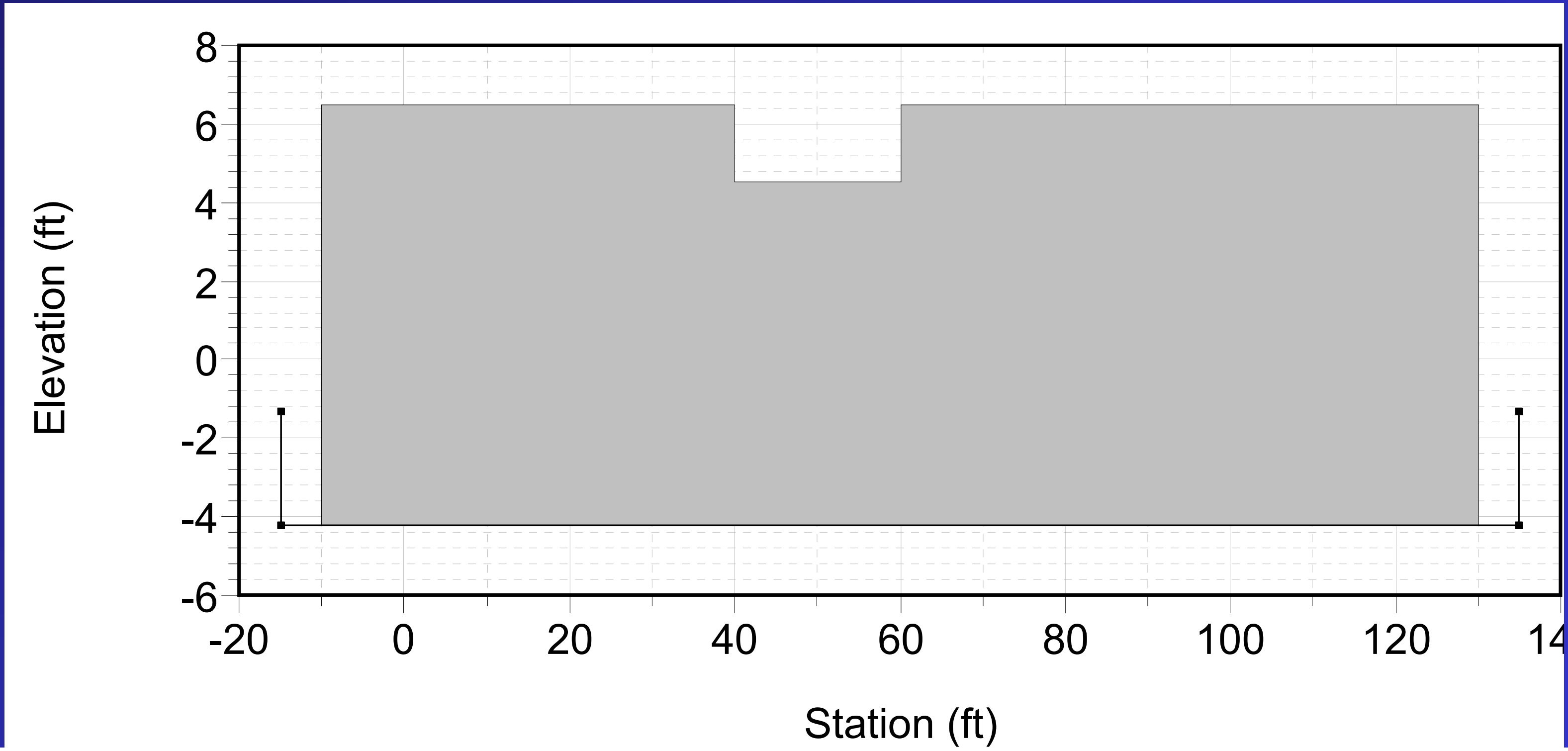
- Lateral Connection – Storage Area to River Reach
- Weir notch set to desired water level (4.5 feet)



Fish Filter Design

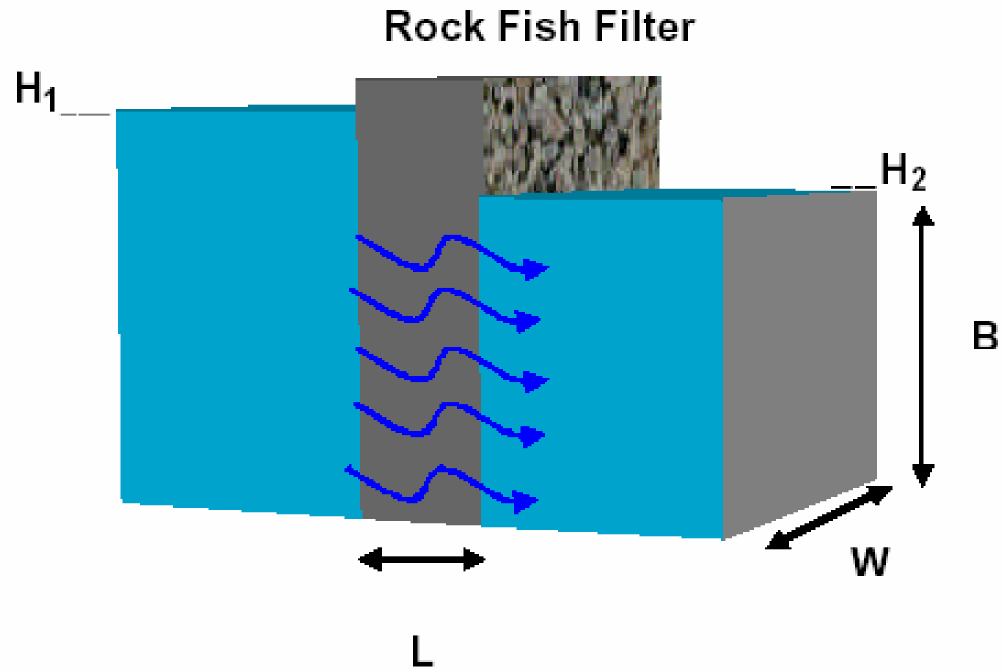
- Volume ~ 10 acre ft/day 10 acft/74 ac = 0.135 ft/day (1.62 in) variation of water level in pond
- Desired Flow Rate through filters ~ 25 cfs

$$\frac{\textbf{10 ac ft}}{\textbf{5 hr}} = \textbf{24.2 cfs} \sim \textbf{25 cfs}$$

Darcy's Law Application to Fish Filter Design

- $Q = k \times i \times A$
- $H_1 = 5.5$ ft
- $H_2 = 4.5$ ft
- $L_{avg} = 18.5$ ft
- $I = \frac{H_1 - H_2}{L_{avg}}$

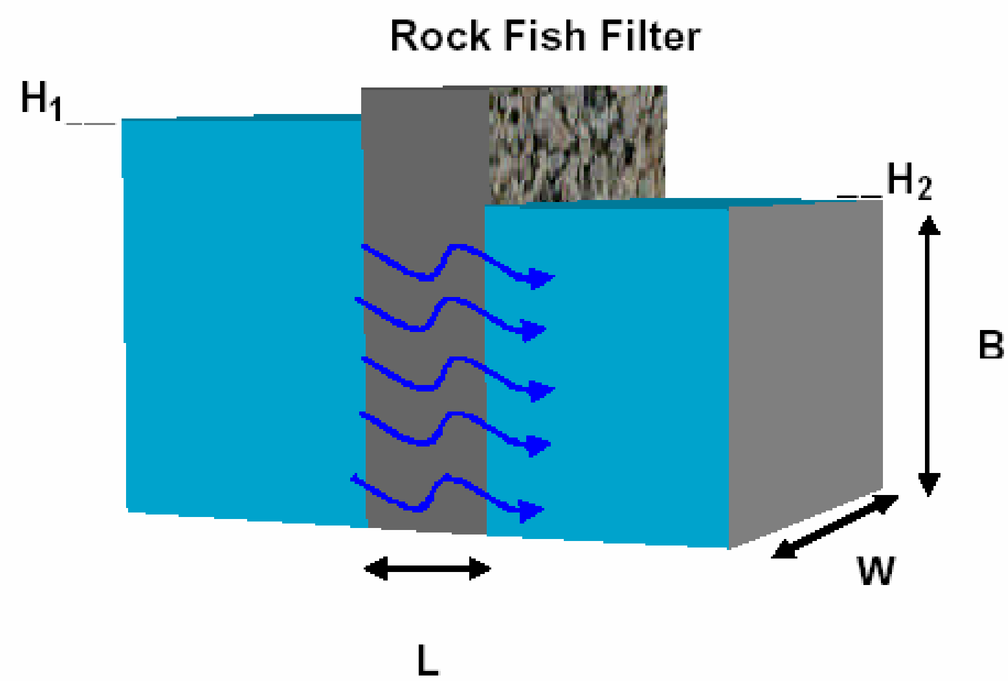
Assumed hydraulic conductivity of rock filter k
$k = 2$ in/sec (5×10^{-1} m/sec)



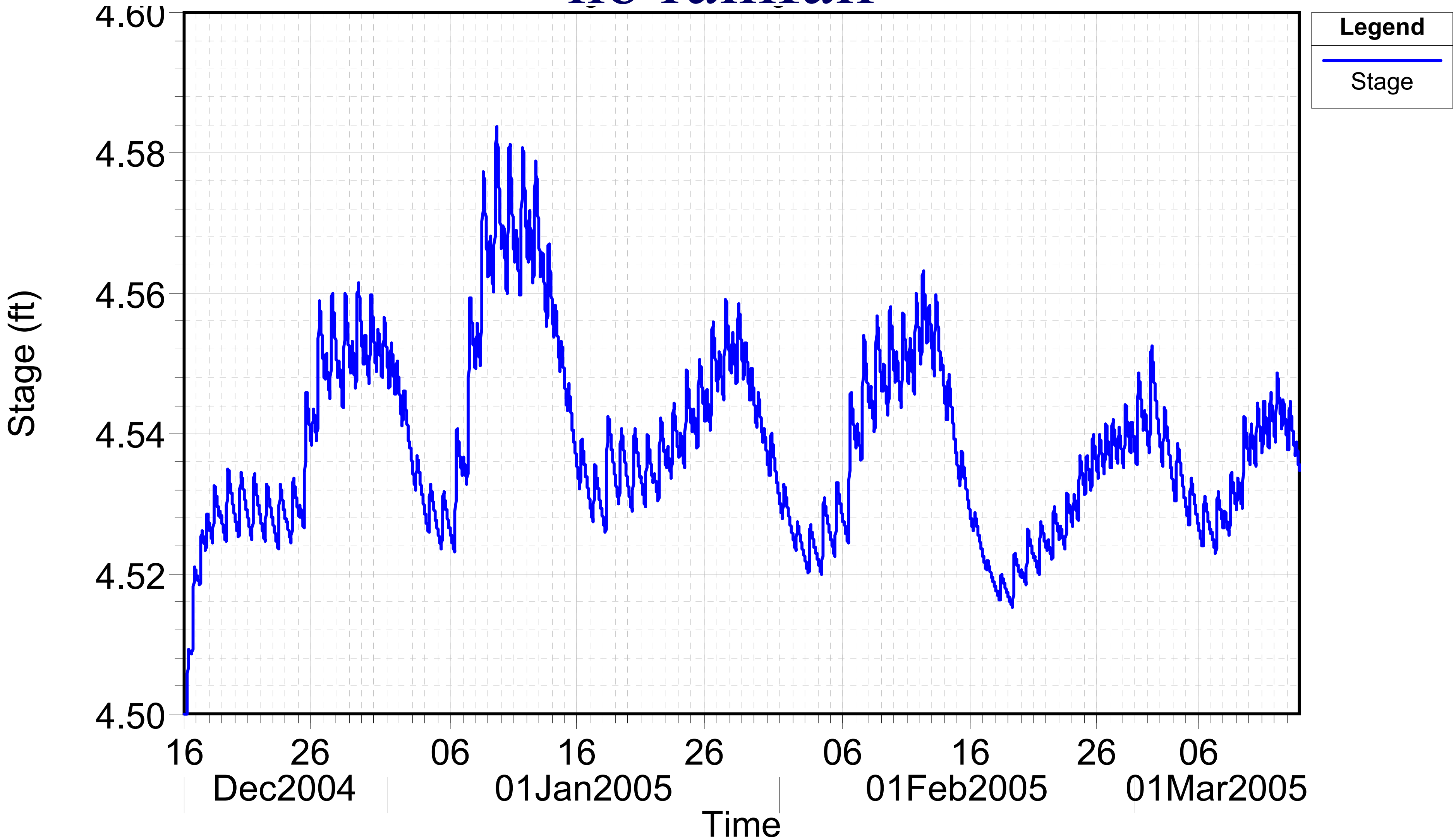
Darcy's Law Application to Fish Filter Design

- Cross sectional area needed to pass 25 cfs
  A = Q / k x i
- **B = 4.5 ft** Design water level in wetland = saturated thickness of filter ***B***
- Lineal feet of rock filter needed **L_{filter} = A/B**
- **Solve for footprint of filter using area of semi circle**

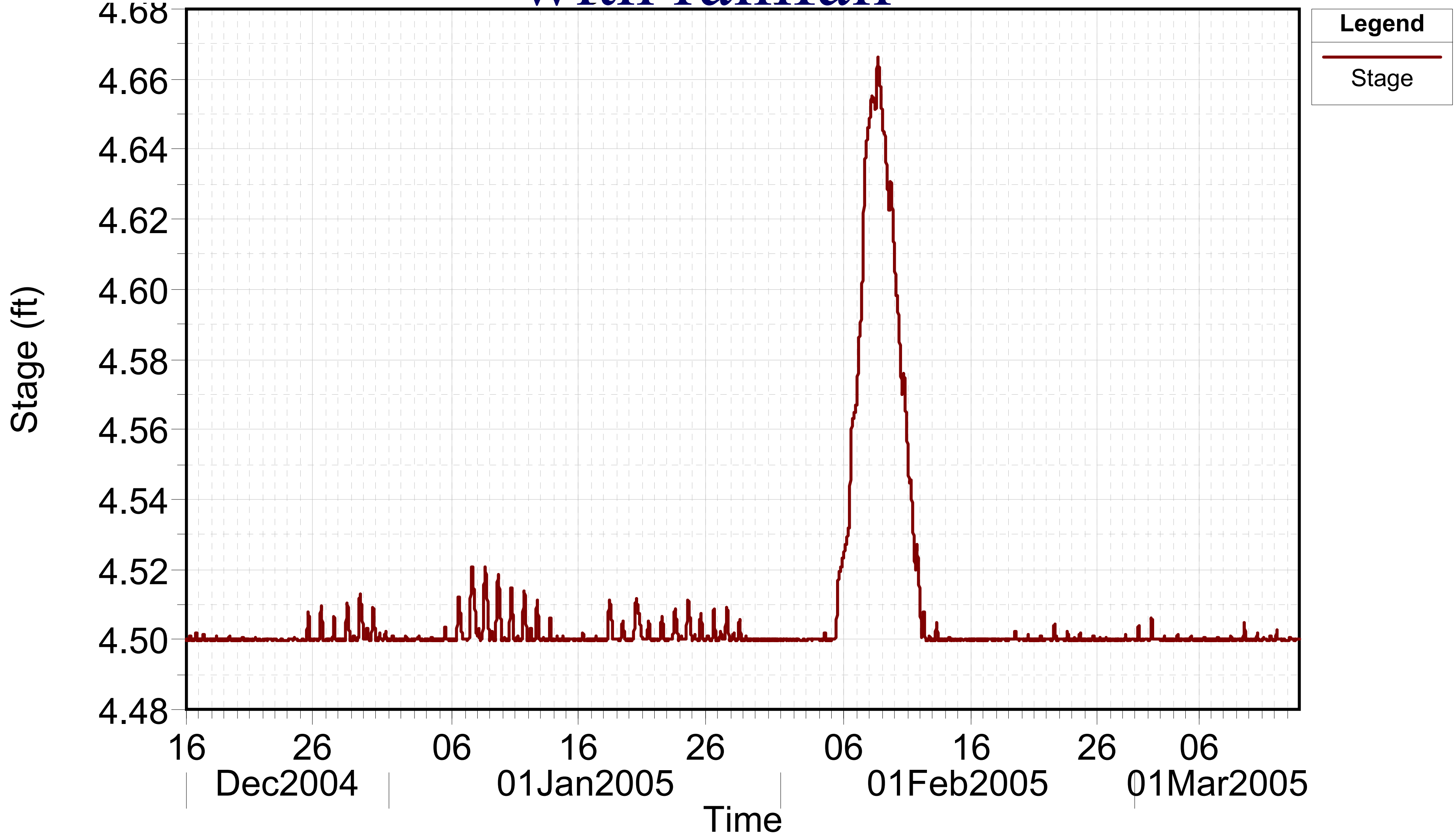
Inlet fish filter 1.3 ac Outlet fish filters 0.65 ac ea



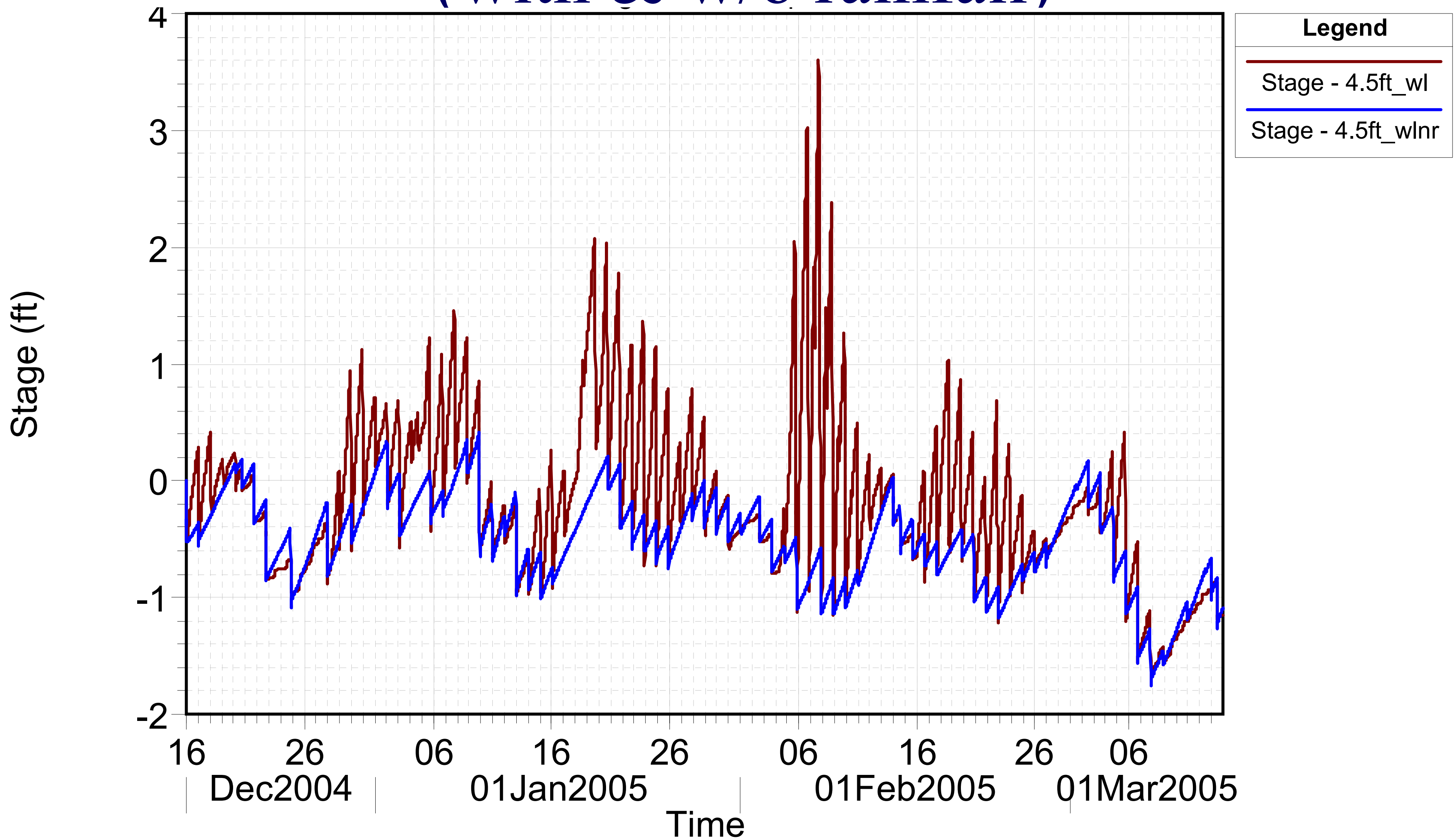
HEC RAS output
Managed Wetland Water Level – no rainfall



HEC RAS output
Managed Wetland Water Level – with rainfall



HEC RAS output
Main Drainage Channel Water Level
(with & w/o rainfall)



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Tidegate Hydraulic Studies and Information

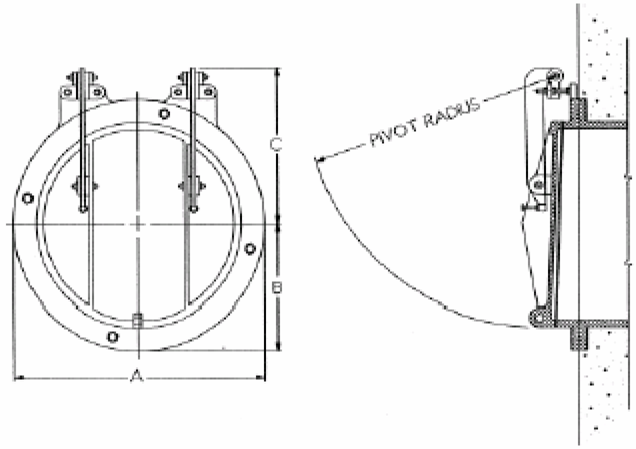
- University of Louisiana Lafayette

Laboratory Experimental Study for the Hydraulics and Structural Performance of Flap Gates

Sponsor: Louisiana Department of Natural Resources

Brief Description:

The objective of this laboratory experiment is to test the hydraulic and structural performance of flap gates, which is a widely used structure in coastal Louisiana. It is mainly used to control the progression of salinity within Louisiana's coastal wetlands. A quantitative measure of energy losses through flap gates is not precisely known. Published literature discussing such losses is quite scarce and fairly outdated.



The two figures shown in this page are typical examples of flap gates used in coastal Louisiana. The proposed study herein will investigate and quantify the head losses due to the gate's own weight, the friction of the gate's bearing, and the flow turbulence downstream of the gate. Chart, tables, and possibly equations describing and quantifying such losses will be documented and provided to Louisiana Department of Natural Resources (LDNR). This document will be valuable for performing detailed data analysis of field observations, and for calibrating numerical models.

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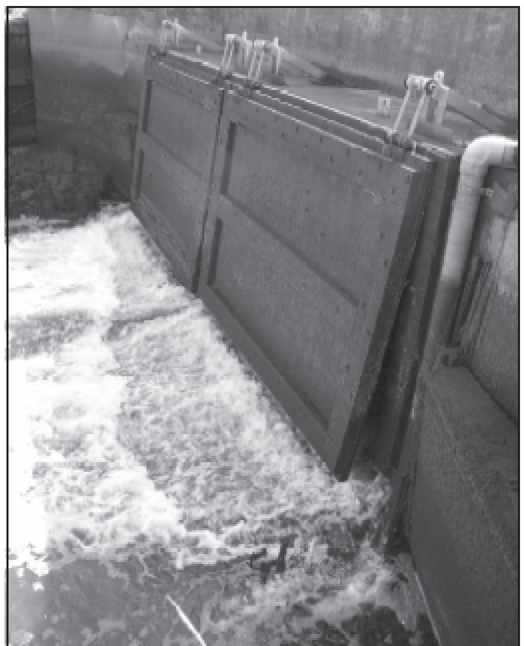
Tidegate Hydraulic Studies and Information

- Oregon State University- available on line

Tide Gates in the Pacific Northwest



Operation, Types, and Environmental Effects

Guillermo Giannico
and Jon A. Souder

US Army Corps
of Engineers
Portland District

Julia Butler Hansen NWR Biological Monitoring

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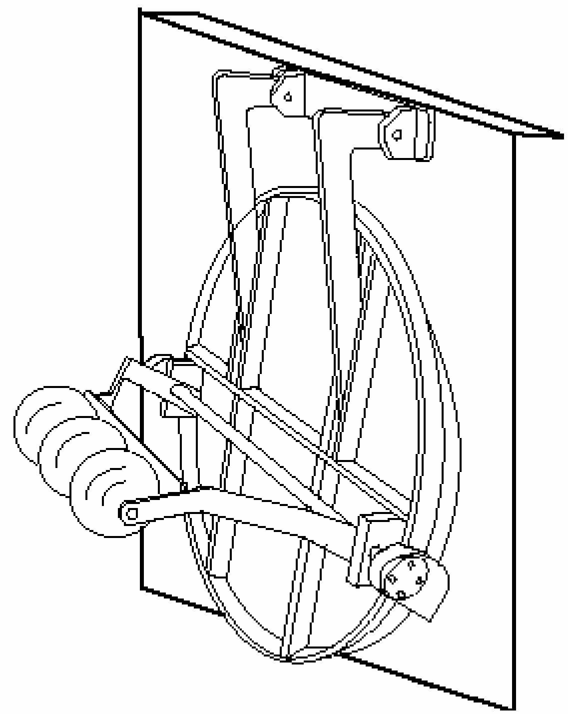
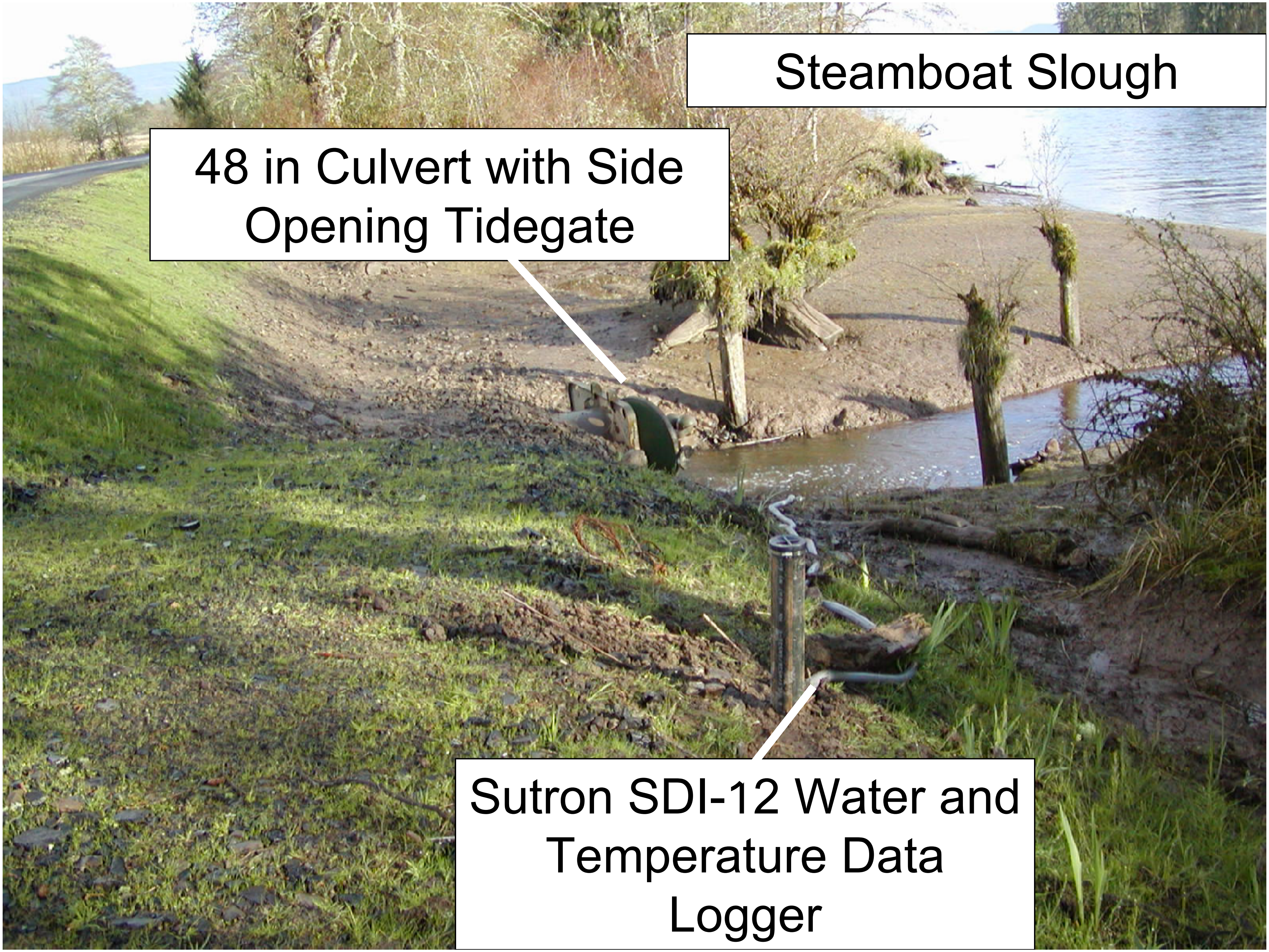
Modeling and Output Presentation for Environmental Compliance and Permitting

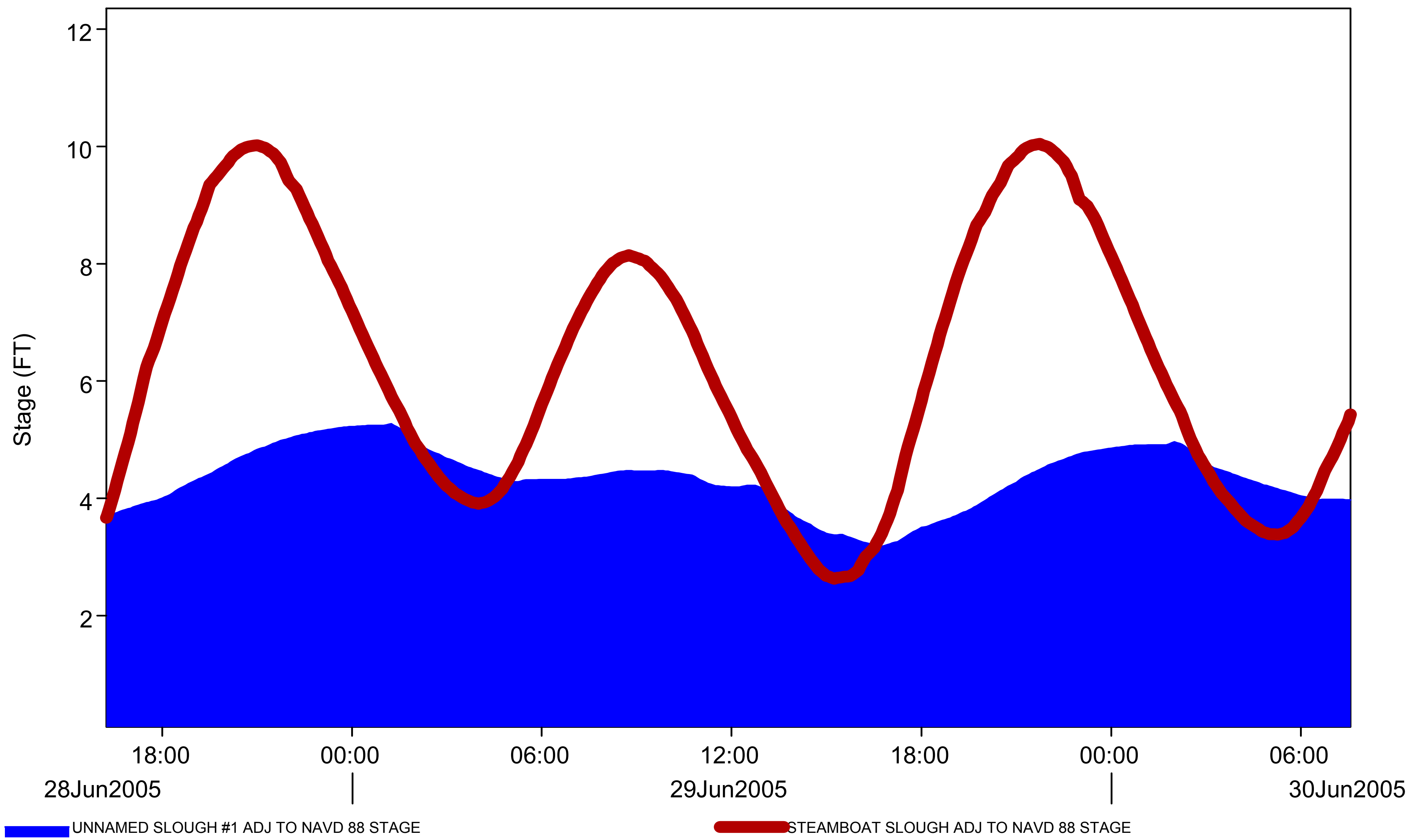
- Resource agencies want details of tidegate performance
- When are tidegates open ?
- How long – time windows ?
- Velocity data important – fish passage criteria…
- Develop presentation of data to answer questions
- Muted tidegate questions – how much backflow ?

“Muted” Tidegates

- The “mitigator”
- Invented by Leo Kuntz, NEHALEM MARINE
- JBHNWR model is side hinged
- Floats connected to cam which prevent the tidegate to completely close
- Allows some water to move upstream against past the tidegate

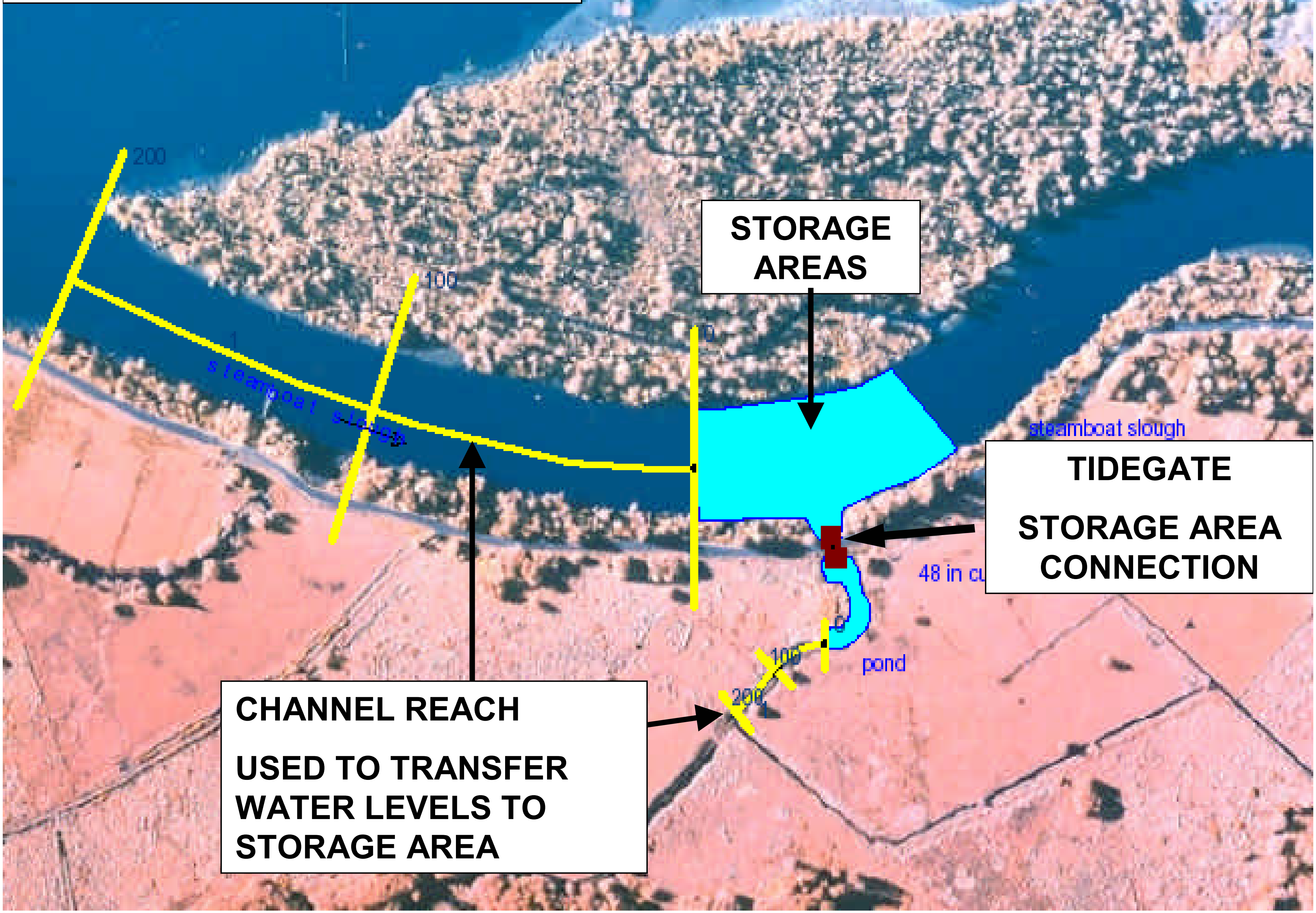



Steamboat Slough
48 in Culvert with Side Opening Tidegate
Sutron SDI-12 Water and Temperature Data Logger



Stage (FT)
12
10
8
6
4
2
18:00
00:00
06:00
12:00
18:00
00:00
06:00
28Jun2005
29Jun2005
30Jun2005
UNNAMED SLOUGH #1 ADJ TO NAVD 88 STAGE
STEAMBOAT SLOUGH ADJ TO NAVD 88 STAGE

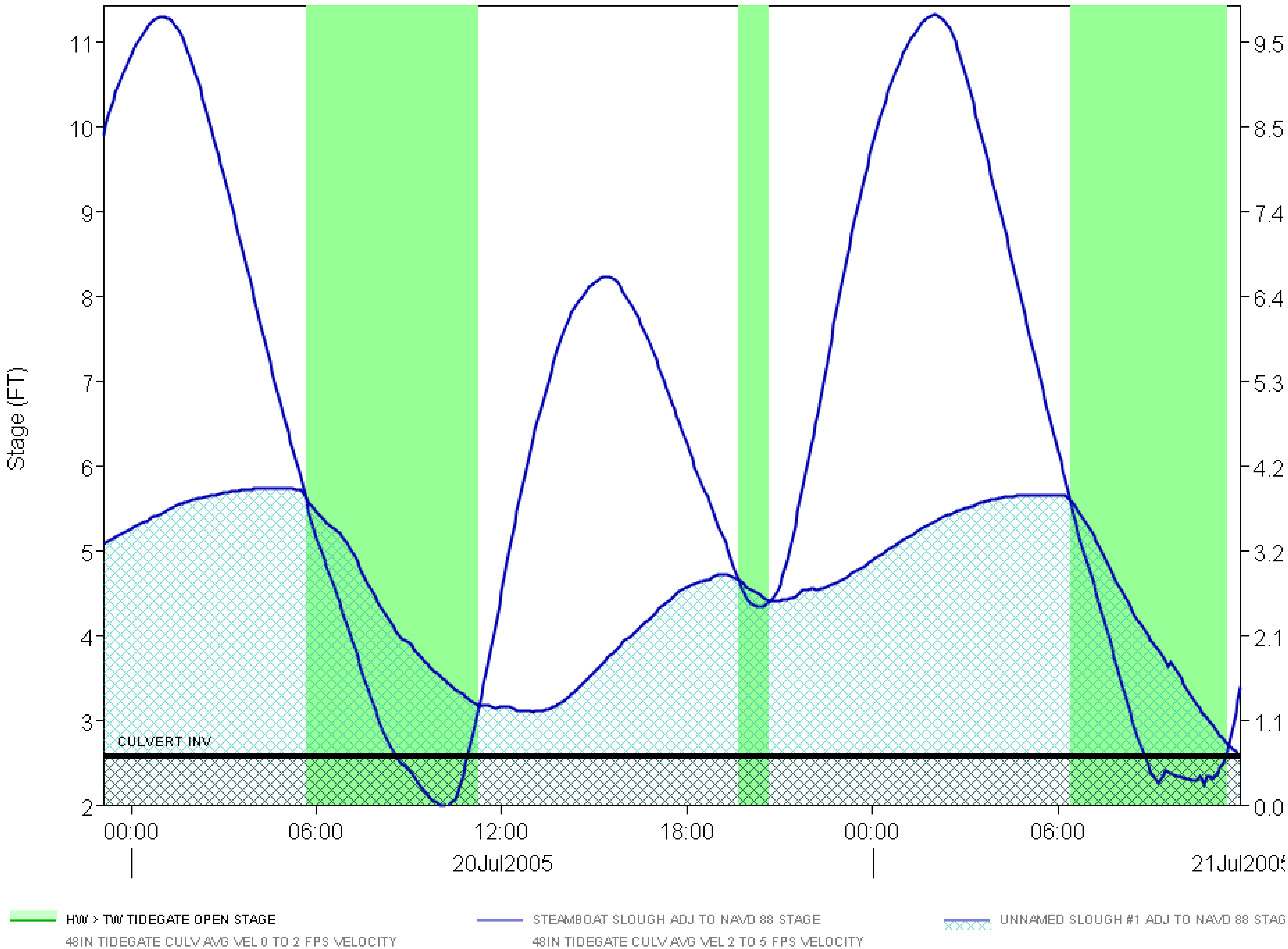
HEC RAS schematic



Average Water Velocities required at high flow in Oregon to ensure upstream passage of Salmon and Steelhead

Culvert Length	Adult Salmon and Steelhead	Juvenile Salmon and Steelhead
<60 ft (<18.3 m)	6 ft/sec (1.83 m/sec)	2 ft/sec (0.61 m/sec)
60–100 ft (18.3–30.5 m)	5 ft/sec (1.52 m/sec)	2 ft/sec (0.61 m/sec)
100–200 ft (30.5–61 m)	4 ft/sec (1.22 m/sec)	---
200–300 ft (61–91.5 m)	3 ft/sec (0.92 m/sec)	---
>300 ft (>91.5 m)	2 ft/sec (0.61 m/sec)	---

- ***Source – Tide Gates in the Pacific Northwest - Operation, Types and Environmental Effects Giannico and Soulder OSU-T-05-001 2005 Oregon State University*** **http://seagrant.oregonstate.edu**



Stage (FT)
11
10
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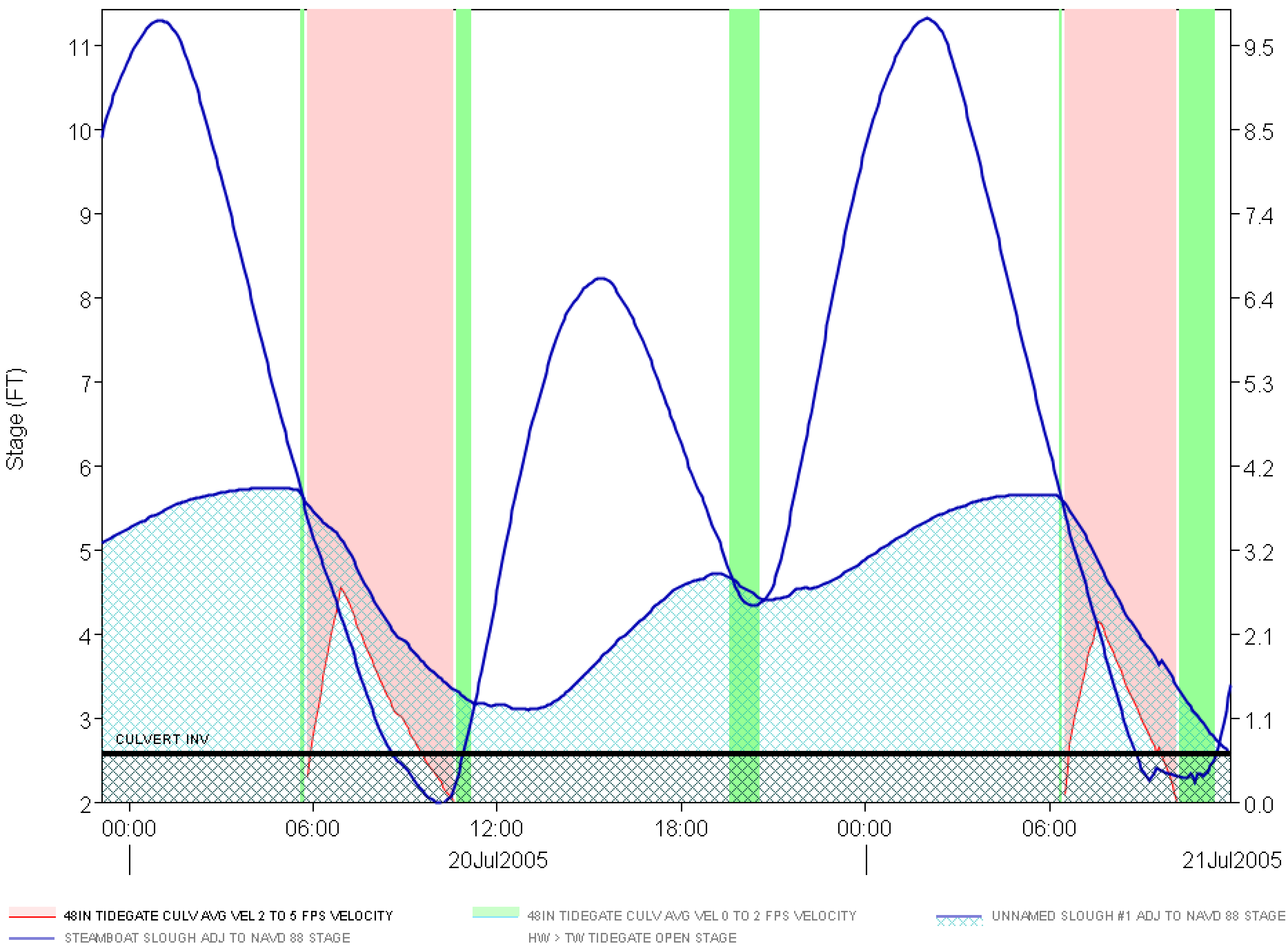
7
6
5
4
3
2
9.5
8.5
7.4
6.4
5.3
4.2
3.2
2.1
1.1
0.0
CULVERT INV
00:00
06:00
12:00
18:00
00:00
06:00
20Jul2005
21Jul2005
HW > TW TIDEGATE OPEN STAGE
48IN TIDEGATE CULV AVG VEL 0 TO 2 FPS VELOCITY
STEAMBOAT SLOUGH ADJ TO NAVD 88 STAGE
48IN TIDEGATE CULV AVG VEL 2 TO 5 FPS VELOCITY
UNNAMED SLOUGH #1 ADJ TO NAVD 88 STAG



Stage (FT)
11
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9.5
8.5
7.4
6.4
5.3
4.2
3.2
2.1
1.1
0.0
CULVERT INV
00:00
06:00
12:00
18:00
00:00
06:00
20Jul2005
21Jul2005
48IN TIDEGATE CULV AVG VEL 2 TO 5 FPS VELOCITY
STEAMBOAT SLOUGH ADJ TO NAVD 88 STAGE
48IN TIDEGATE CULV AVG VEL 0 TO 2 FPS VELOCITY
HW > TW TIDEGATE OPEN STAGE
UNNAMED SLOUGH #1 ADJ TO NAVD 88 STAGE

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Documents and Publications

- Webb H&H report
  https://www.nwp.usace.army.mil/issues/crcip/cms/docs/webb/webbhhreport.pdf
- MGSFlood software & manuals (WHAM)
  https://www.nwp.usace.army.mil/issues/crcip/cms/docs/webb/webbhhreport.pdf
- OSU Tidegate Report
  http://seagrant.oregonstate.edu/sgpubs/onlinepubs/t05001.pdf