Chinook River Estuary Restoration – Tidal Effects
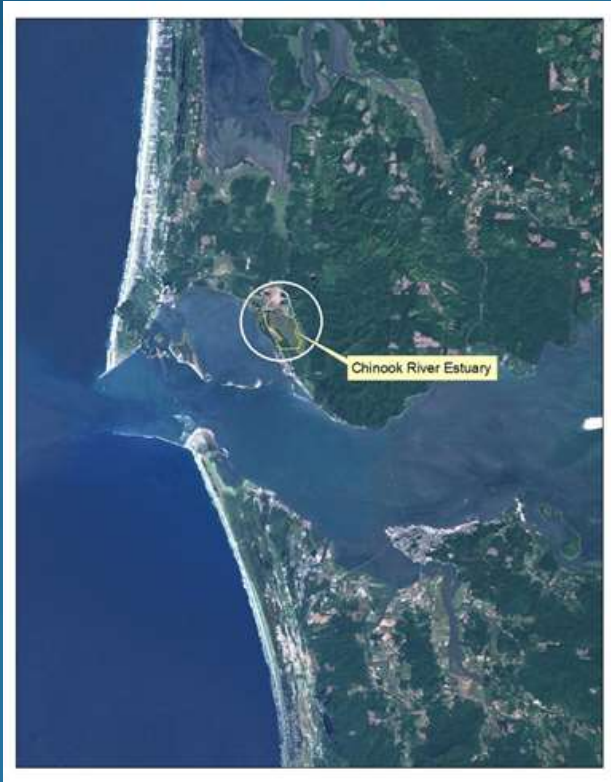

Steve Vigg, Presenter
Columbia River Estuary
Conference -- May 30, 2014

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Reference:
ERTG Template for Chinook Estuary Restoration (February 2014)

Outline:

1. Vision – Conceptual Model & Restoration Approach

2. Hypotheses for Adaptive Management

3. Empirical Data – Tidal Dynamics

4. Application: Resource Management

Vision: Naturally functioning Chinook River Estuary …

Stressor: Flow Regulation →

Physical Controlling Factors:
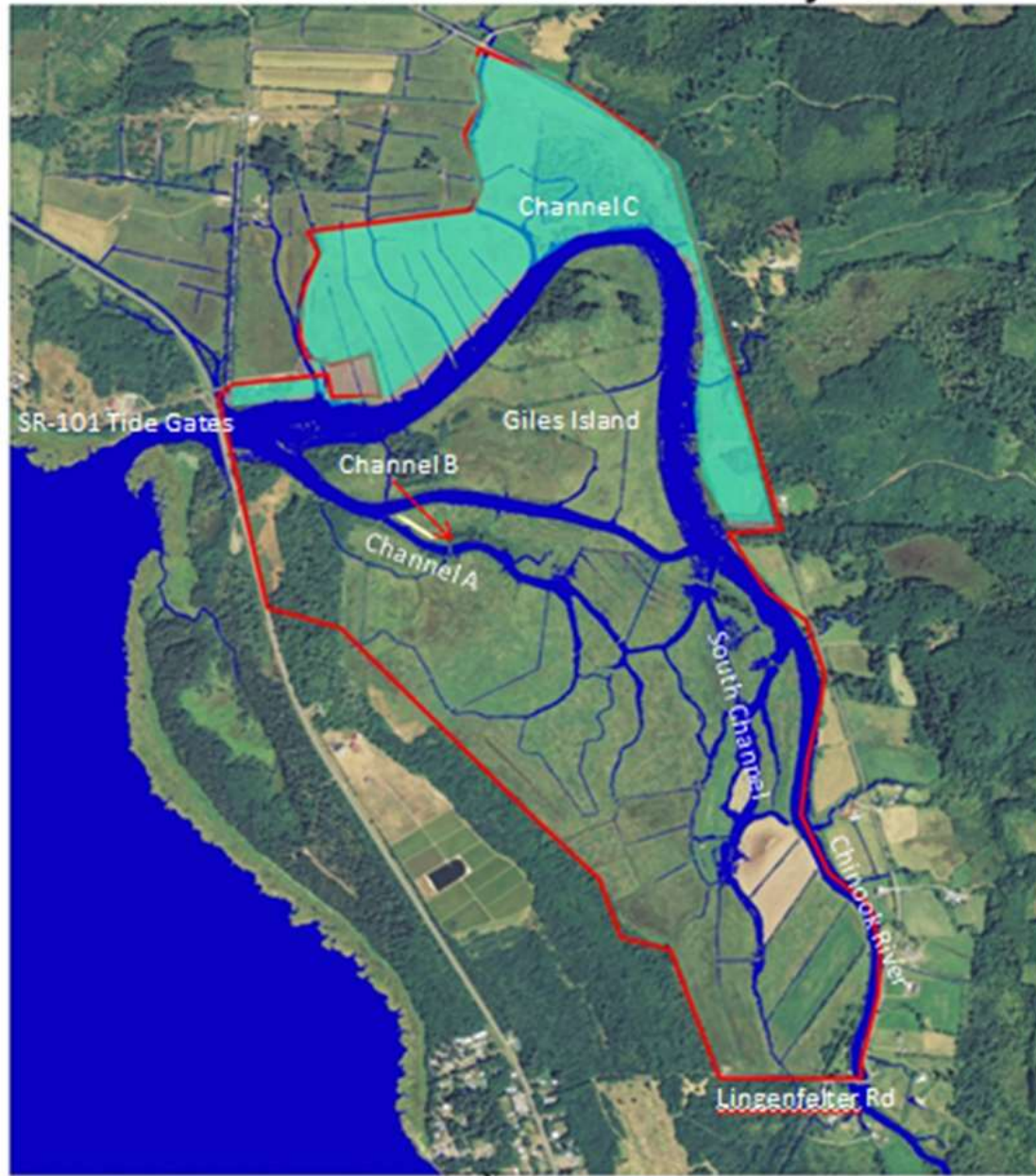- Temperature
- Salinity
- Water Surface Elevation

Columbia River Estuary Conceptual Model (Thom et al. 2004)

Restoration Approach…

1. Acquire Key Property in Tidal Zone

2. Improve Tide Gate Operations

3. Tidal Channel Enhancement

4. AEMR and Adaptive Management

Key Acquisition:

Tidal Channel Network at 6' WSE

WDFW Chinook Wildlife Area Boundary 2013

Channel C

SR-101 Tide Gates

Channel B

Giles Island

Channel A

South Channel

Chinook River

Lingenfelter Rd

Legend

2013 201 ac Acquisition

WDFW Chinook WLA Boundary

0 0.075 0.15   0.3   0.45   0.6
Miles

Washington Department of FISH and WILDLIFE

Hypotheses: Empirical Tide Gate → Water Surface Elevation Experiment (2011-14)
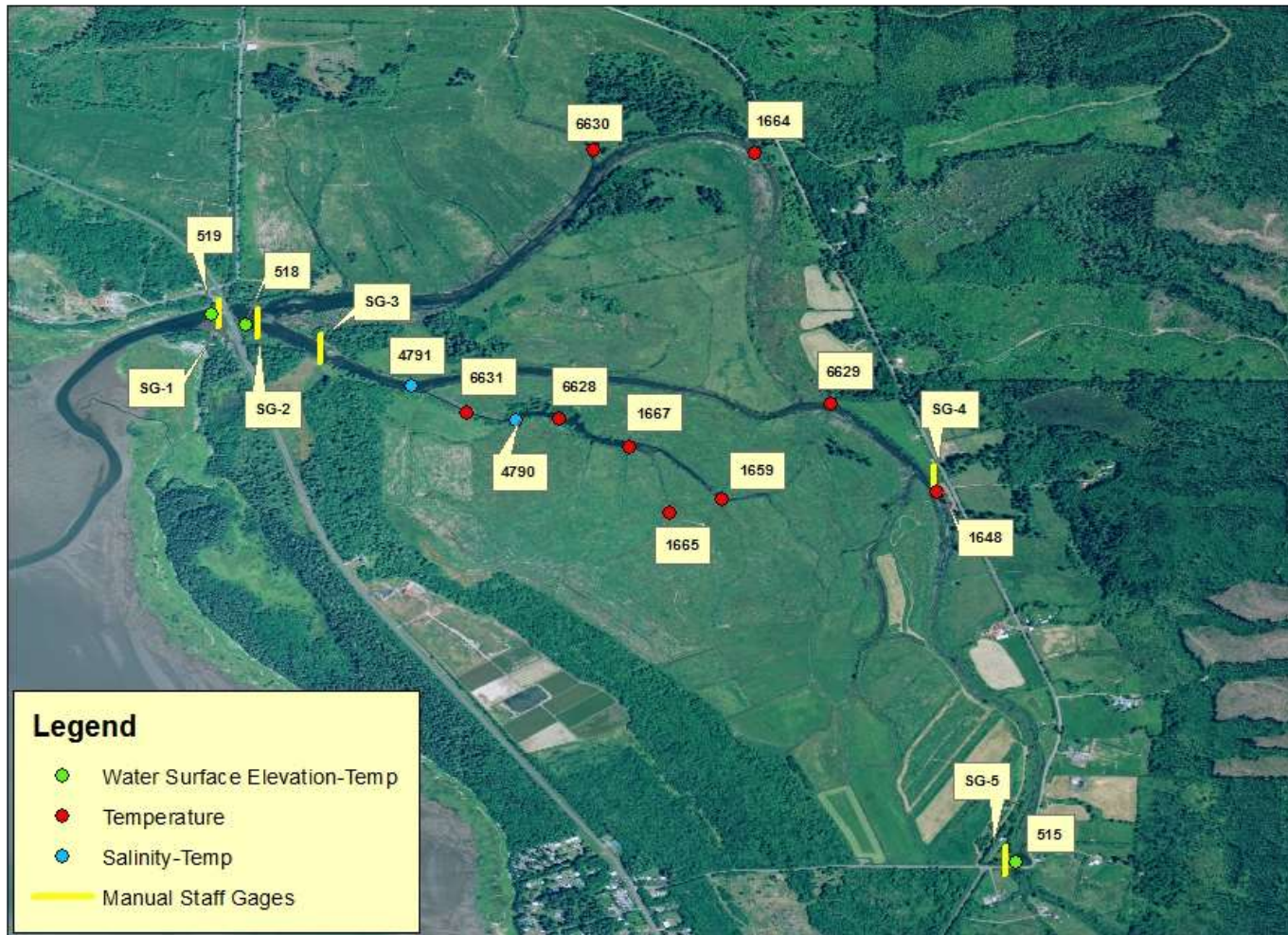
Hypotheses to test (cause-effect):

1. **Tides effect temperature in Chinook Estuary*.**

2. **Tides effect salinity in Estuary*.**

3. **Tides effect WSE in Estuary*.**

Alternative Ho: Precipitation/ tributary inflow effects temperature, salinity, WSE in Estuary*.

▸ *Estuary Zones include: lower, middle, upper.

Methods: sampling stations

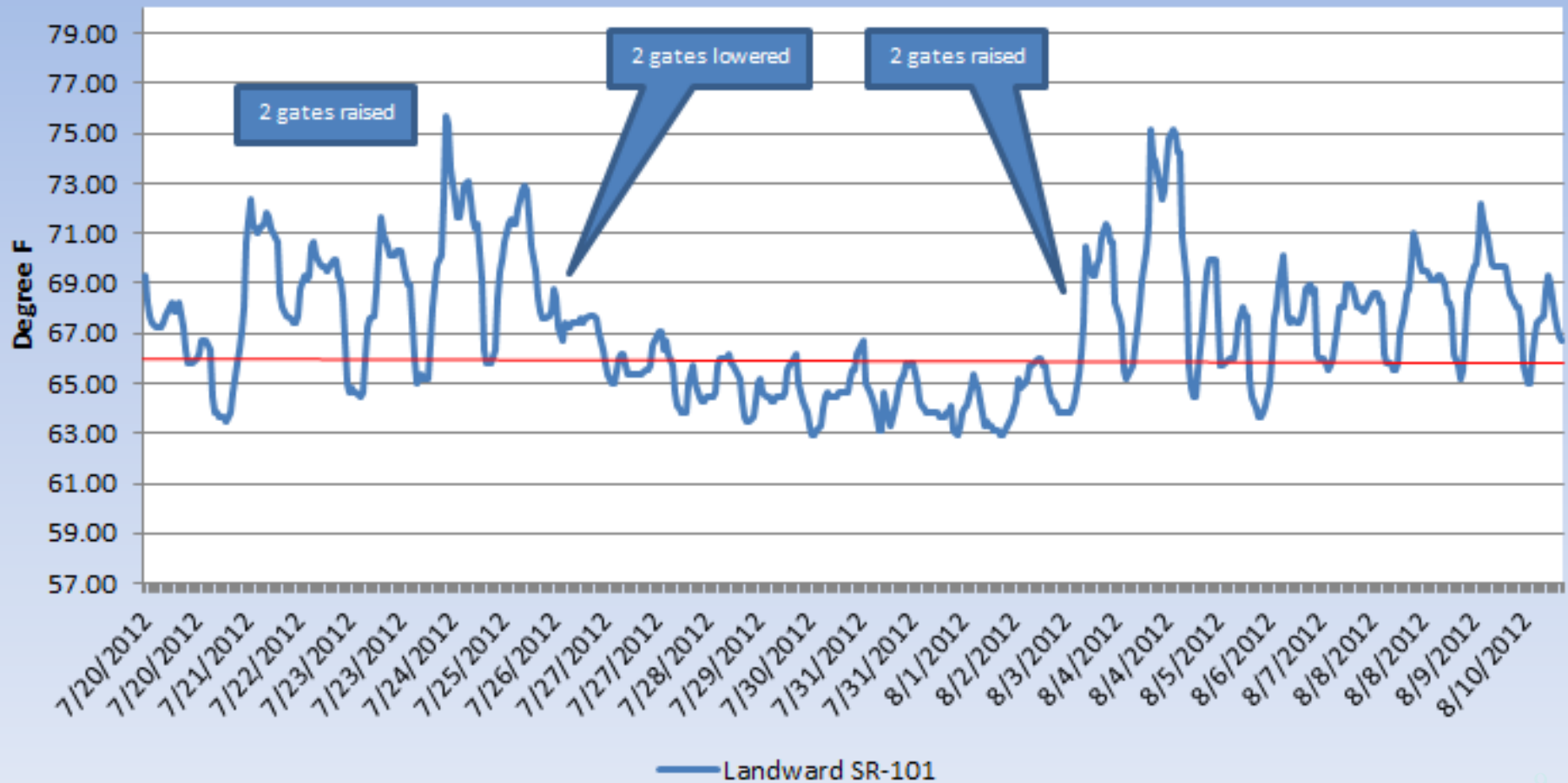Chinook Estuary Instrumentation Dec 2012

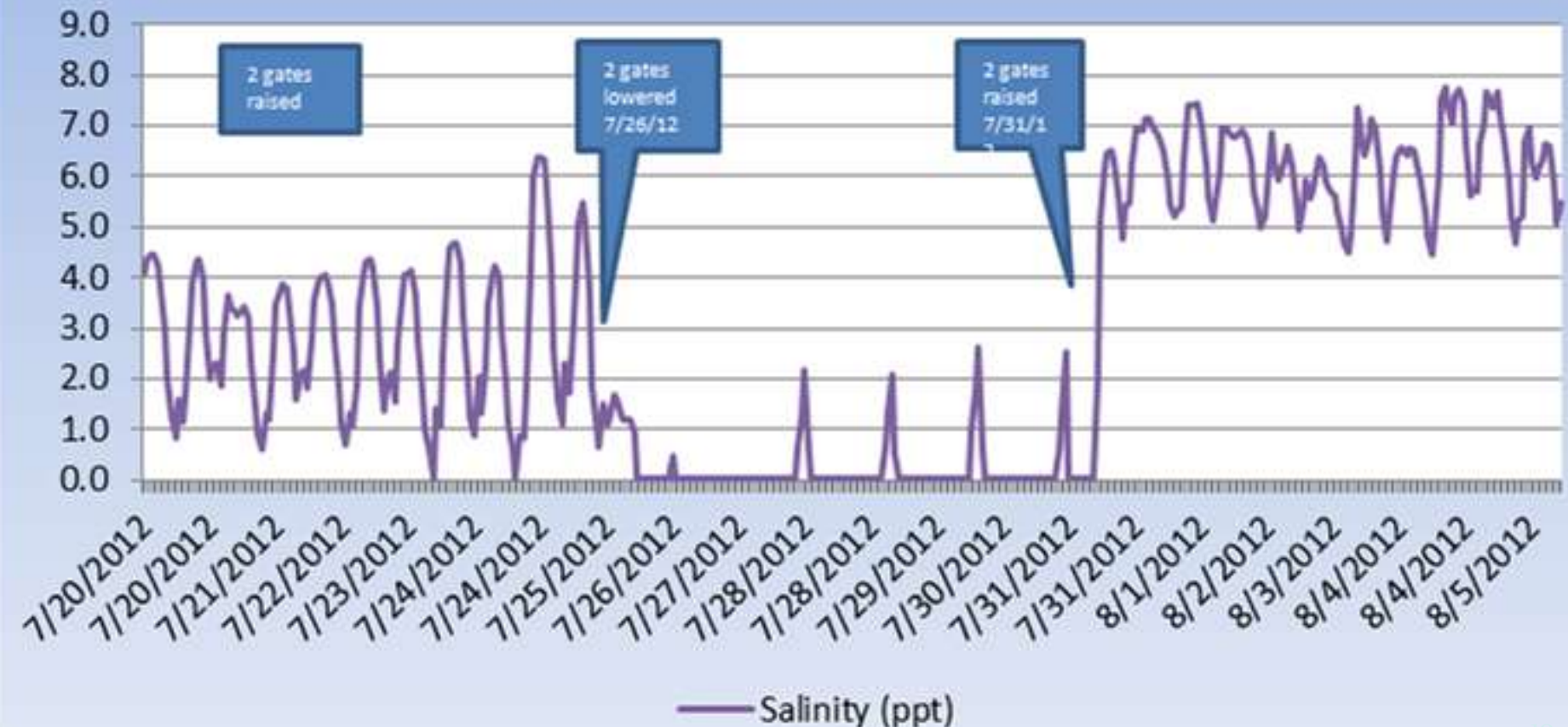# Temperature Effects: 2 Tide Gates Open → Closed → Open

Landward SR-101 Water Temperature
July 20 to August 5, 2012

Salinity Effects: 2 Tide Gates Open → Closed → Open
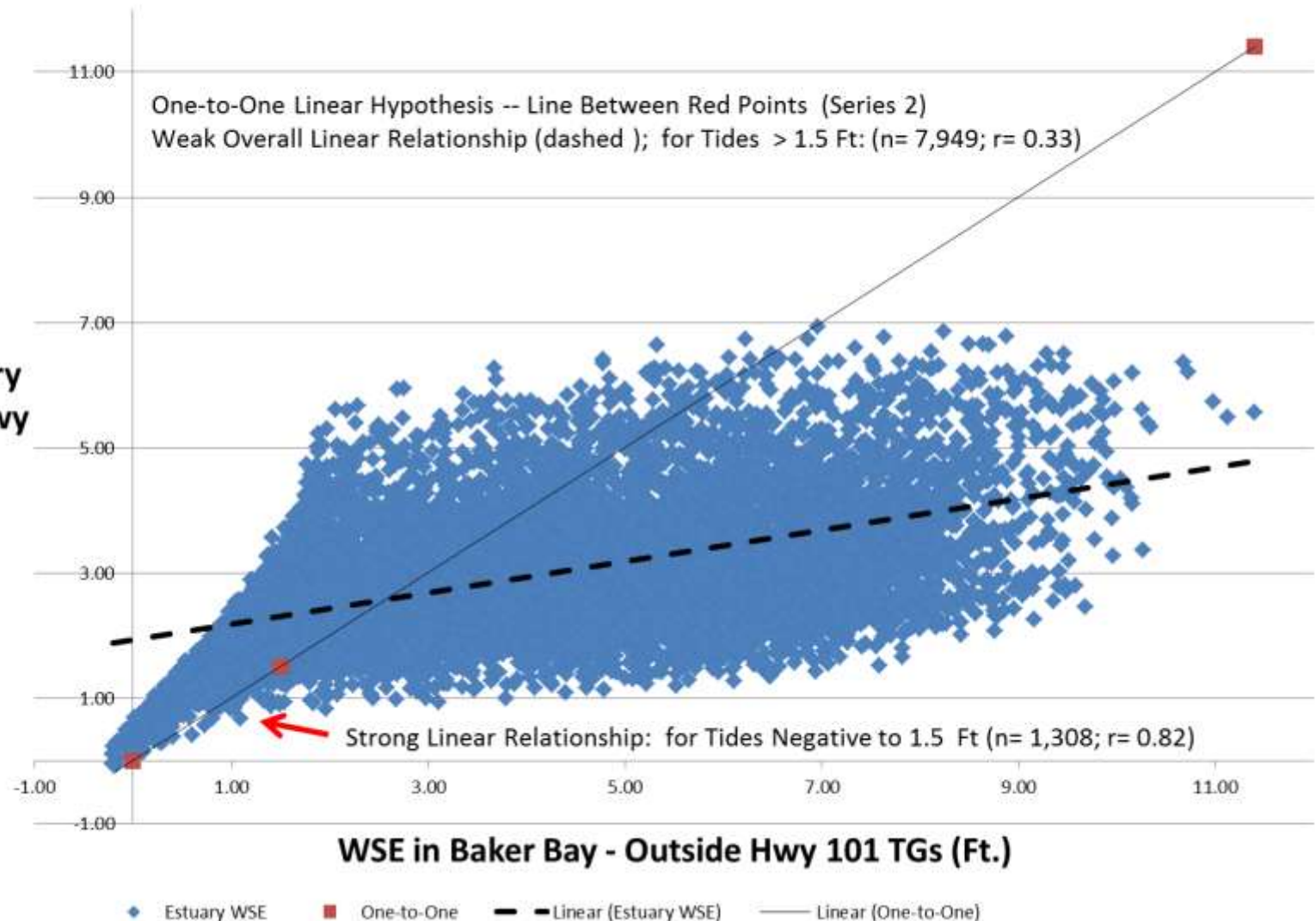

Chinook River Salinity
July 20 to August 5 2012

Findings from Empirical Tide Gate → Water Surface Elevation Monitoring in Lower Estuary (2011-13)

- **All TG's Closed:** Weak tidal functional relationship to WSE (r= 0.33)

- **1 TG Open:** Medium tidal functional relationship to WSE (r= 0.75)

- **2 TGs Open:** Strong tidal functional relationship to WSE (r= 0.84)

All Tide Gates Closed - Tidal Effect on Water Surface Elevations in Chinook Estuary -- Just Inside the Hwy 101 Tide Gates

One-to-One Linear Hypothesis -- Line Between Red Points (Series 2)
Weak Overall Linear Relationship (dashed); for Tides > 1.5 Ft: (n= 7,949; r= 0.33)

Chinook Estuary WSE - Inside Hwy 101 TGs (Ft.)

Strong Linear Relationship: for Tides Negative to 1.5 Ft (n= 1,308; r= 0.82)

WSE in Baker Bay - Outside Hwy 101 TGs (Ft.)

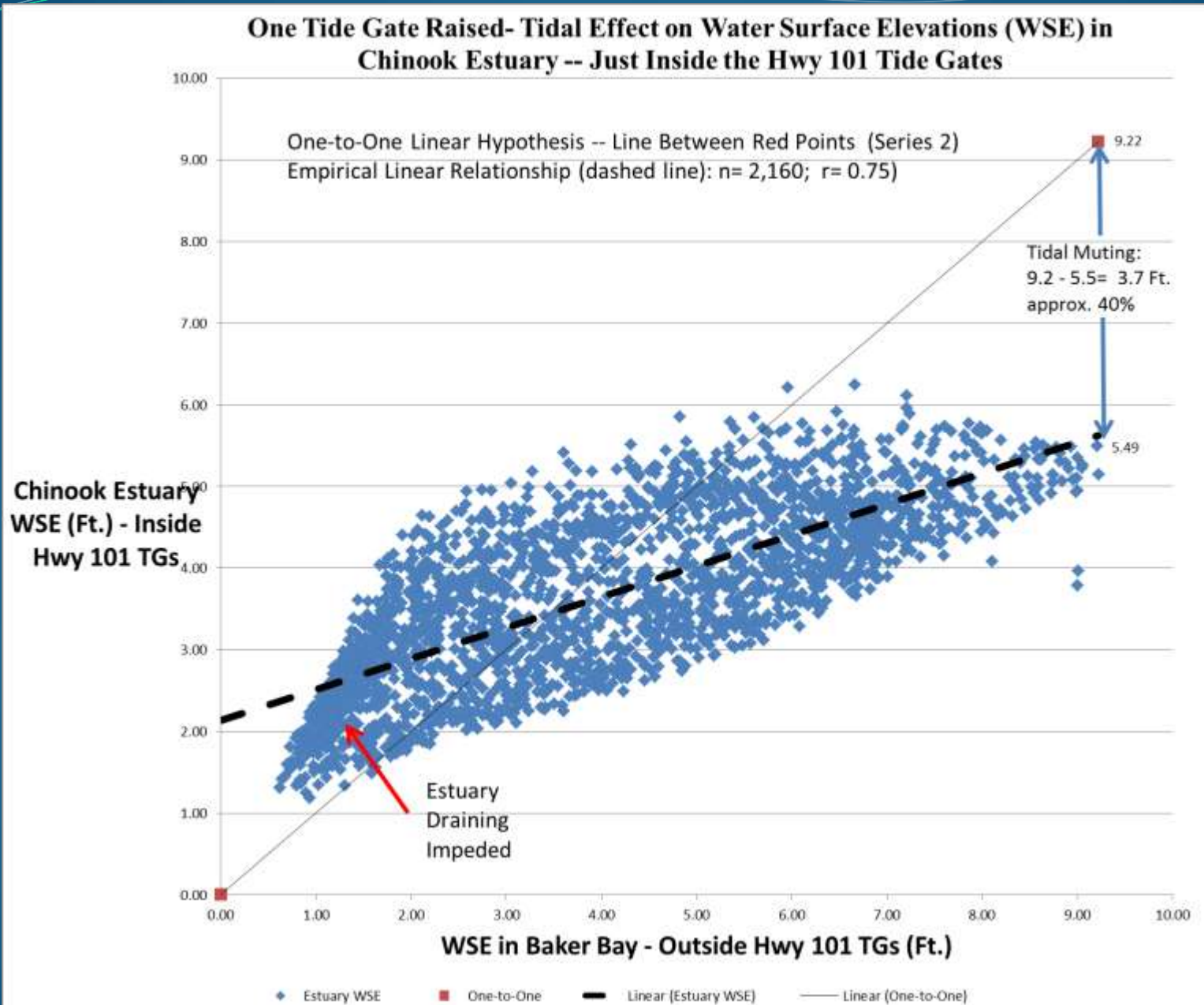◆ Estuary WSE   ■ One-to-One   ▬ ▬ Linear (Estuary WSE)   ── Linear (One-to-One)

One Tide Gate Open (Lower Estuary)

One Tide Gate Raised- Tidal Effect on Water Surface Elevations (WSE) in Chinook Estuary -- Just Inside the Hwy 101 Tide Gates

One-to-One Linear Hypothesis -- Line Between Red Points (Series 2)
Empirical Linear Relationship (dashed line): n= 2,160; r= 0.75)

Tidal Muting:
9.2 - 5.5= 3.7 Ft.
approx. 40%

Chinook Estuary WSE (Ft.) - Inside Hwy 101 TGs

Estuary Draining Impeded

WSE in Baker Bay - Outside Hwy 101 TGs (Ft.)

Estuary WSE   One-to-One   Linear (Estuary WSE)   Linear (One-to-One)

Functional Relationship 2 TGs Open - Tidal Effect on Water Surface Elevations in Chinook Estuary -- Just Inside the Hwy 101 Tide Gates

Linear Fit to Empirical Data (dashes): n= 5,195; r= 0.84 (Series 1)

One-to-One Linear Hypothesis -- Line Between Red Points (Series 2)

Tidal Muting - TG Effects

Chinook Estuary WSE - Inside Hwy 101 TGs (Ft.)

Impeded Estuary Draining

WSE in Baker Bay - Outside Hwy 101 TGs (Ft.)
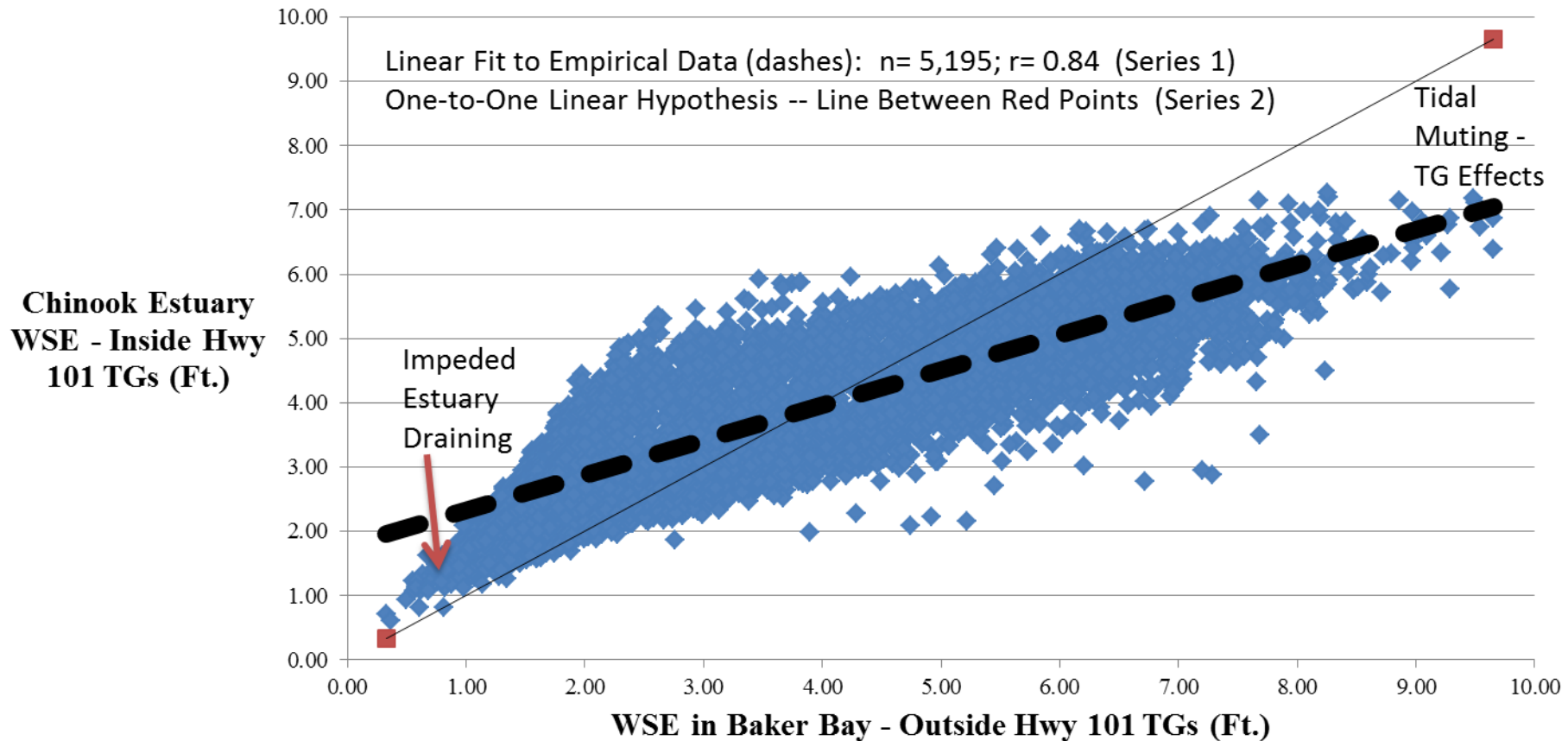
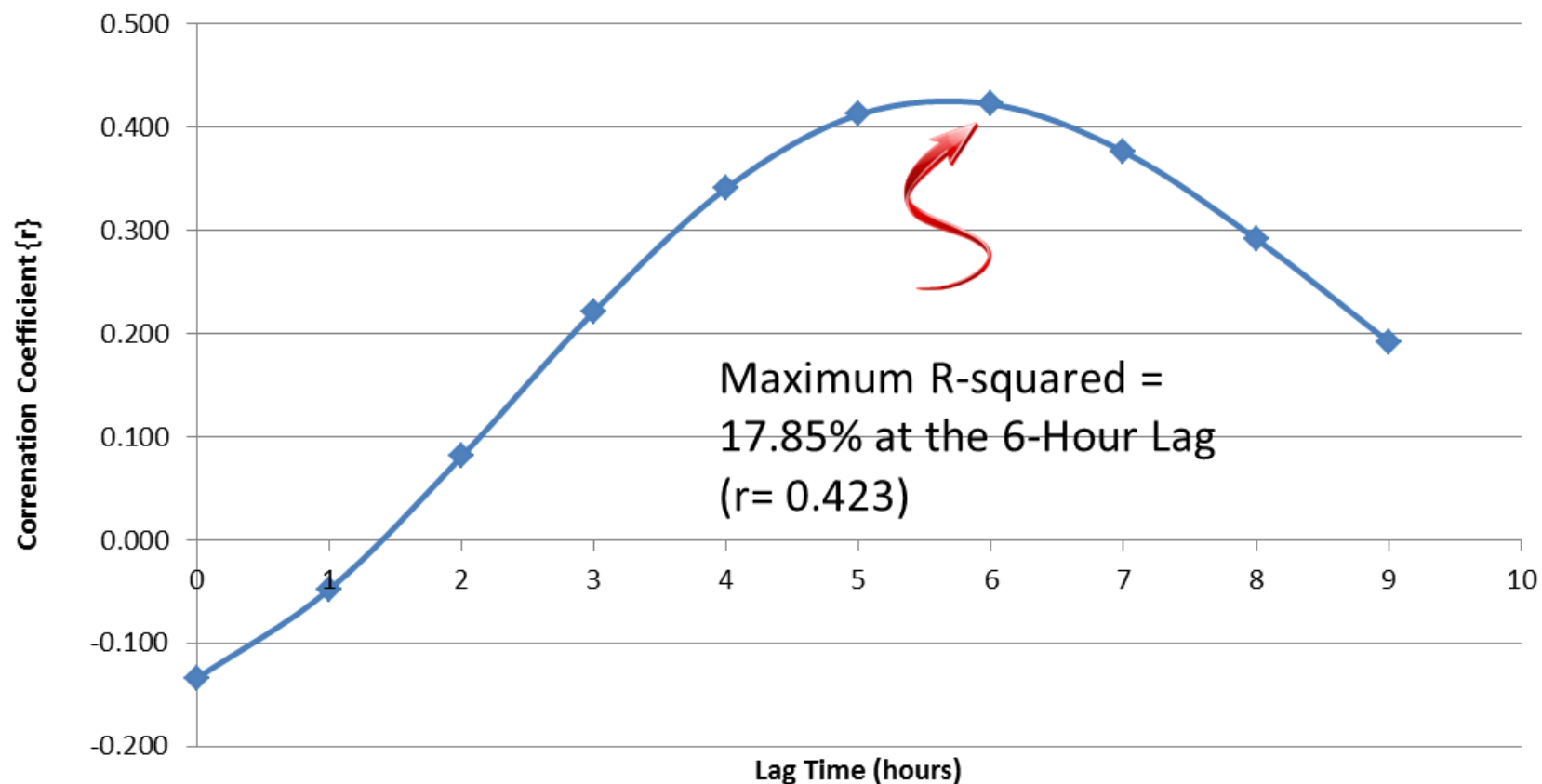# Findings from Empirical Tide Gate → Water Surface Elevation Monitoring in Upper Estuary (2011-13)

- **2 TGs Open:** Weak/delayed functional relationship to WSE in the Upper Estuary (r: -0.13 to 0.42)

- All TG conditions: Astoria precipitation has moderate functional relationship to WSE in the Upper Estuary (r= 0.61)

Effects of 2-TG Opening on WSE (Upper)

Tidal Effect (WSE outside TGs) on Upper Estuary
Water Surface Elevation at Lingenfelter
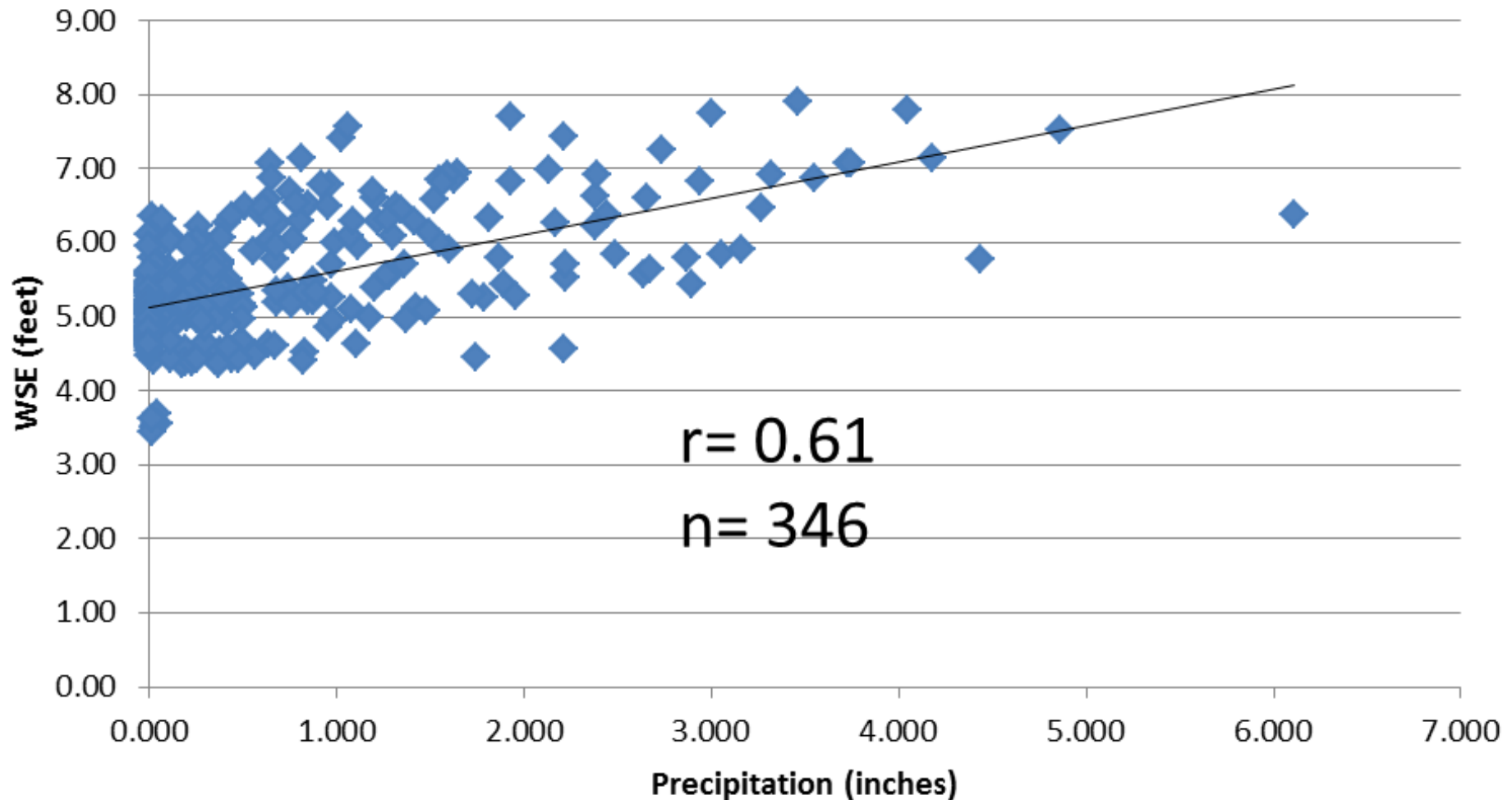(n= 4,063; r= -0.134) 2 TGs Open
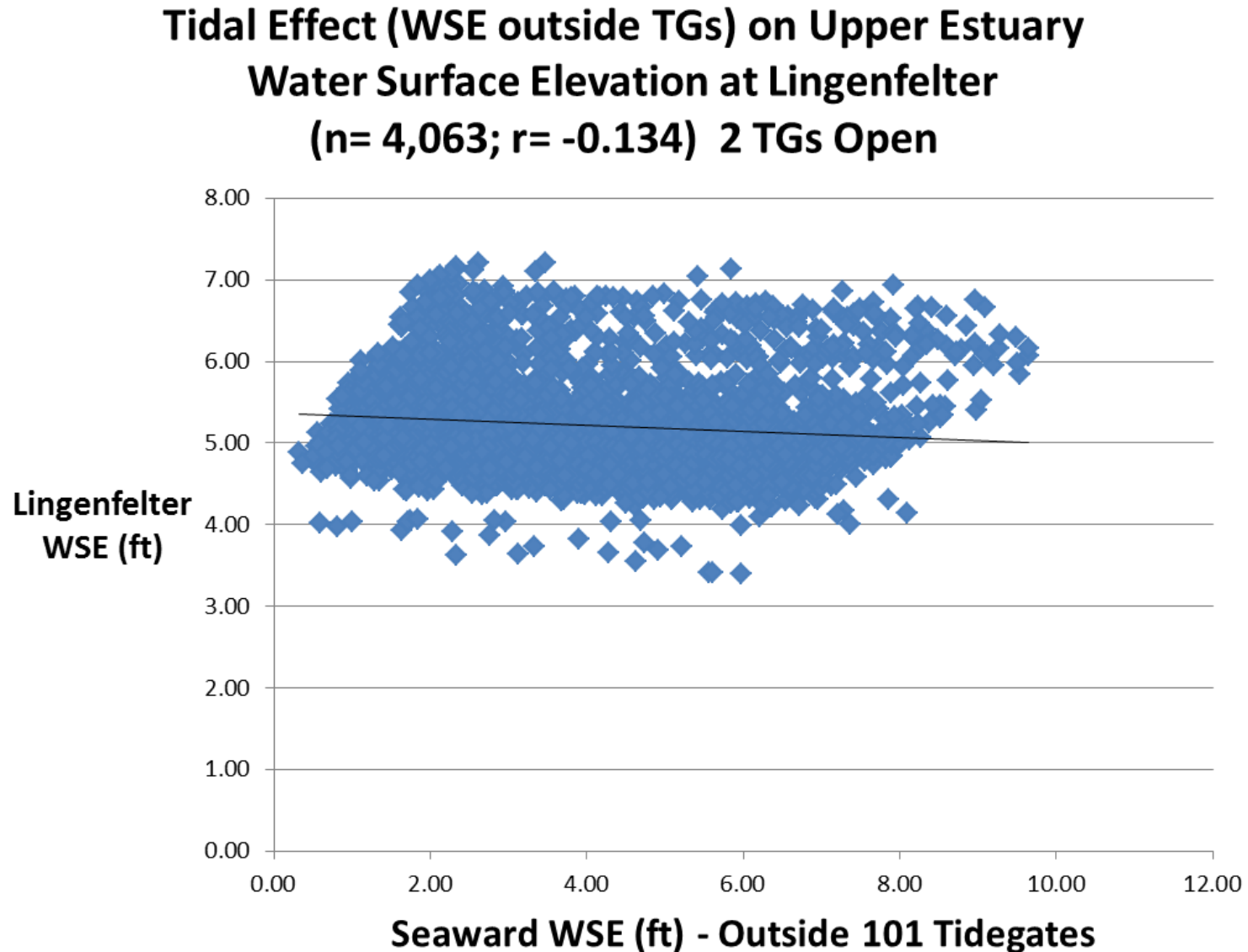
Lag Effect - 2-TG Opening on WSE (Upper)

Lag Correlation: Relationship between Tides outside Hwy 101 TGs and WSE in the Upper Estuary at Lingenfelter Culvert Gage -- 2 TGs Open

Maximum R-squared = 17.85% at the 6-Hour Lag (r= 0.423)

Precipitation Effect on WSE (Upper)

Upper Estuary: 3-Day Cumulative Rain vs. WSE

r= 0.61
n= 346

Hypotheses: Empirical Tide Gate → Water Surface Elevation Experiment (Future)

Additional Hypotheses to test (cause-effect):

1. Interaction between tides and precipitation effect WSE in the <u>Mid-Estuary</u>; and

2. Tributary inflow has direct functional relationship to WSE (flooding) in the <u>Upper Estuary</u>.
   (We need to measure daily on-site precipitation and Chinook River in-flow).

Application: Tide Gate Management
Reduce Stressor - Tidal Flow Regulation

Operational Goal:

Open (1-3) tide gates year-round to the extent possible to:

- **Remove detrimental ecological effects of tidal flow regulation;**

- **Protect adjacent landowners from flooding.**

Biological Goal:

Manage tide gates to maximize fish passage, tidal flux, inundation, and salinity intrusion to:

- Enable adult salmon spawning migration;

- Enhance juvenile salmonid rearing and foraging conditions.

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Tide Gate Mgt. Success Rate

Time	All Tide Gates Closed	Two TG's Open
July 2011-12 (365 days)	65%	21%
July 2012-13 (365 days)	39%	45%
July-Dec 2013 (184 days)	6%	93%
Jan-May 2014 (146 days)	14%	86%

Questions?

Baker Bay

SR-101 Tide Gates

Channel A

Channel B

Chinook River main stem

Browns Slough

Channel C