# Recent LTL Excursions
# ?? Extraordinary...??

W. Walker

TOC Workgroup

August 18, 2009

? ?

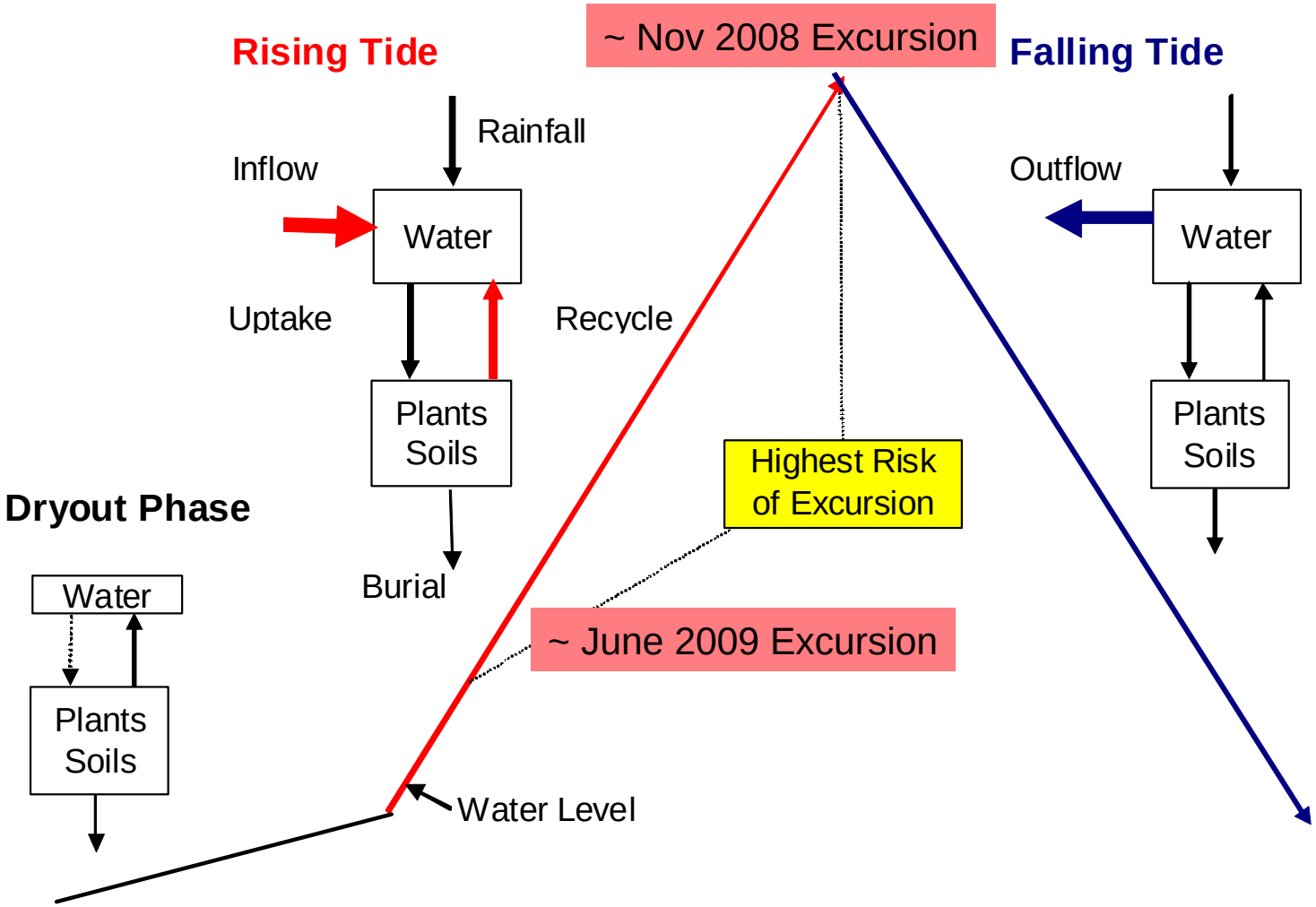
"..*substantial evidence that exceedance is due to error or extraordinary natural phenomena…"*

*? ?*

# August 2008 & September 2009 Sampling Events

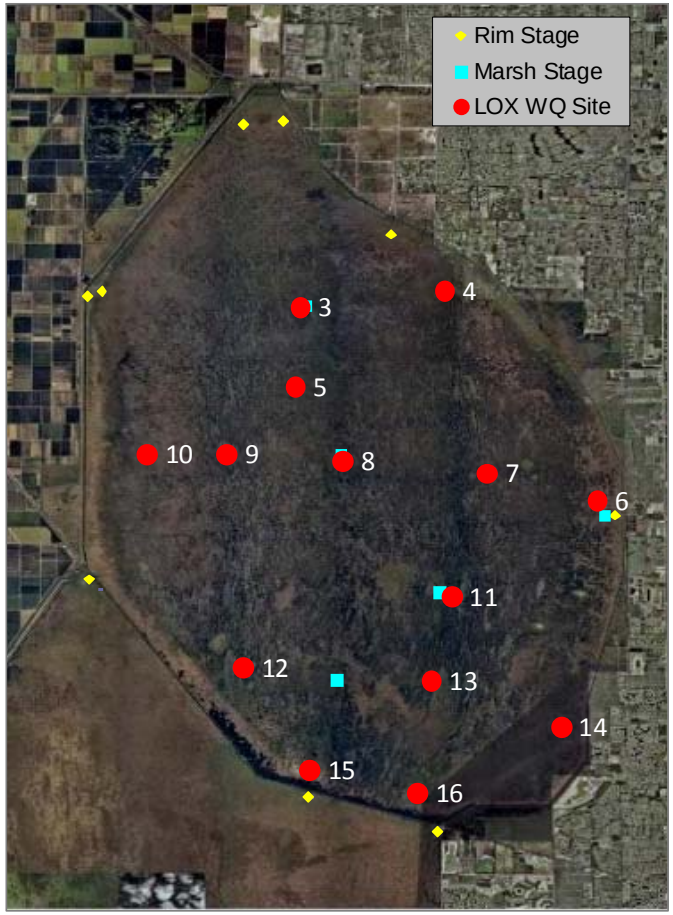
- Refuge hydrologic variables within range of data from previous sampling events (rainfall, stage, stage increase, flow, TP load) on a 30-day & 7-day basis
- Inflows & hydraulic gradients within ranges observed in previous excursions
- Antecedent hydrologic conditions of limited use for evaluating causal relationships because of the complexity and long time scales associated with loading, storage, recycling, and transport of P in the marsh.

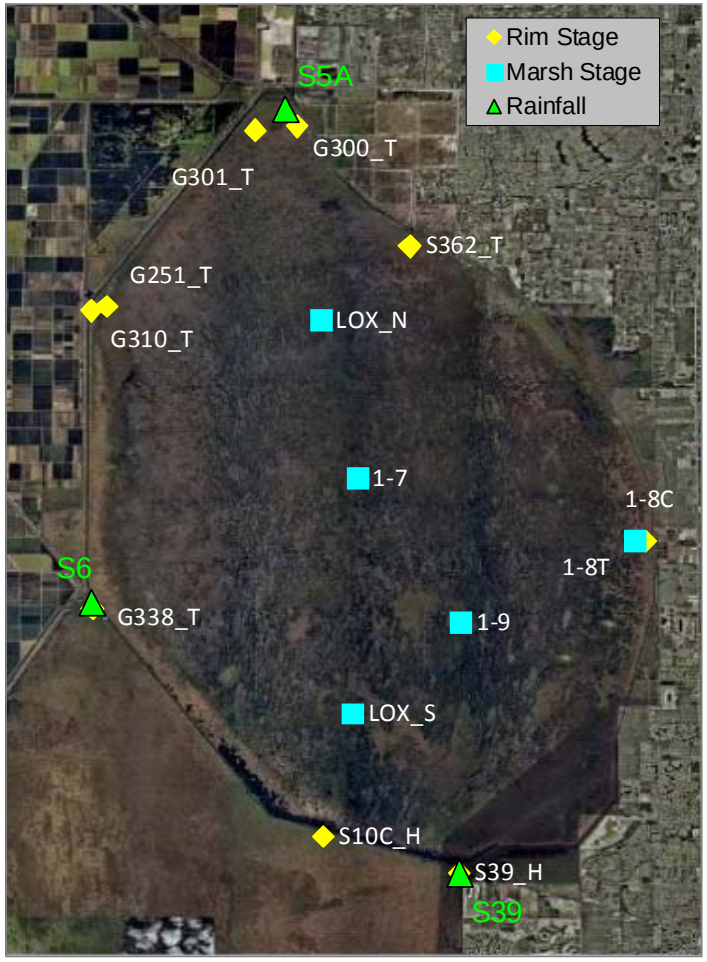
# Phosphorus Fluxes over Yearly Stage Cycle



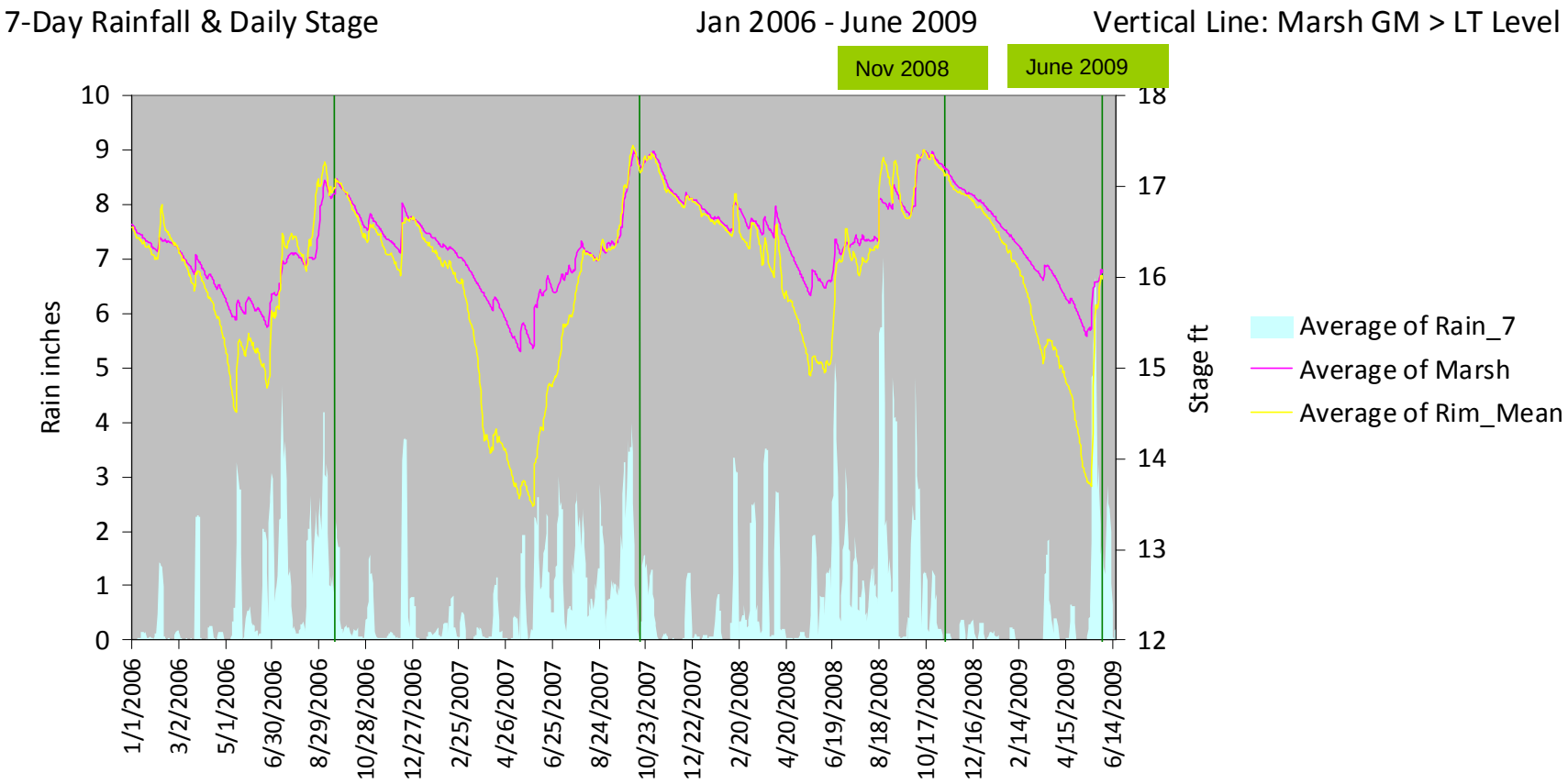

Restoration time scale following reduction in external load
~3 years for P stored in water column & vegetation;
Longer if P is recycled from soils

# Interior Marsh Water Quality, Stage, & Rainfall Sites



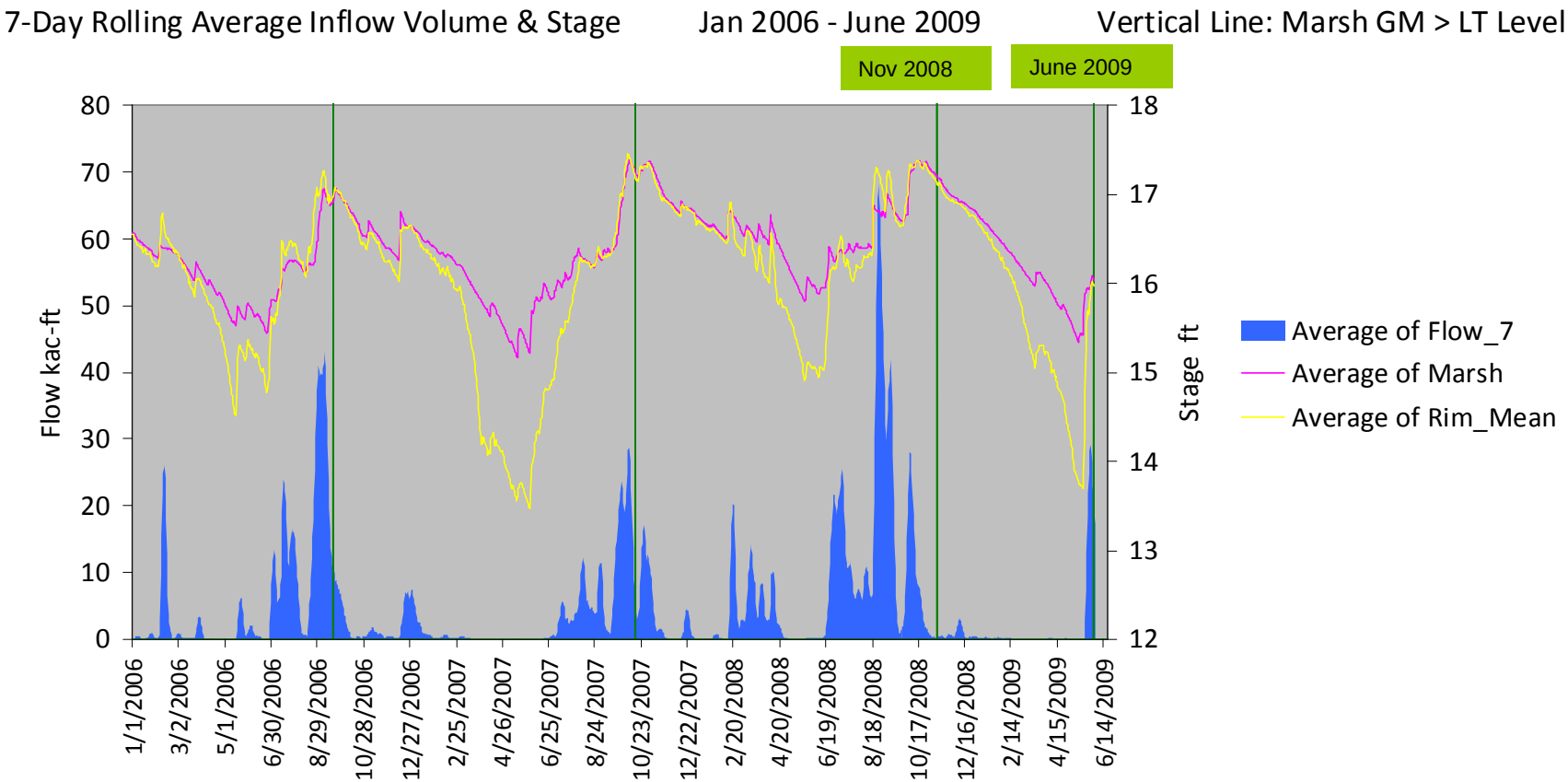



# 7-Day Rainfall & Daily Stage, 2006-2009




Marsh = Sites 7 & 9  Rim =  1-8C, S362, G300, G301, G338, G310, G251

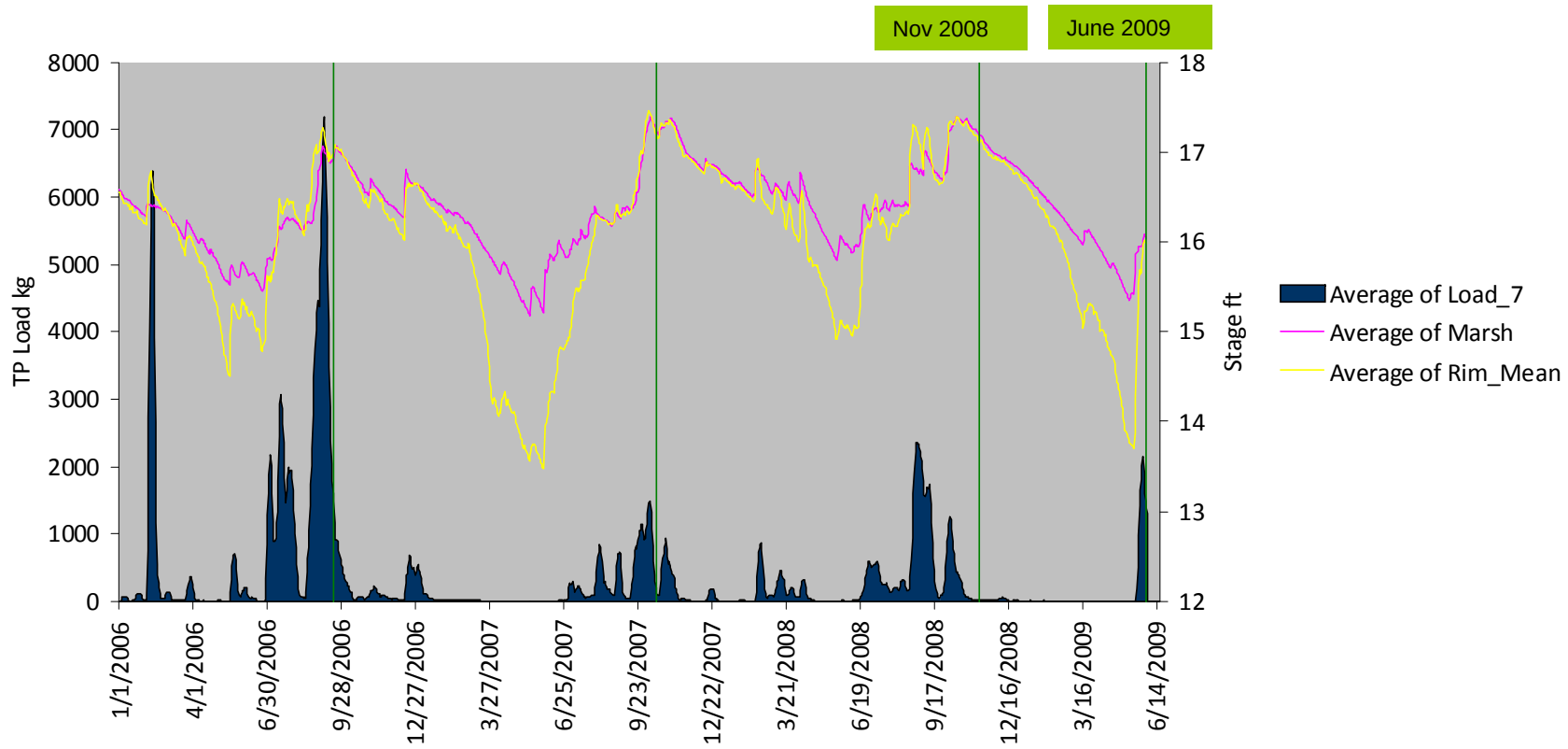
# 7-Day Inflow Volume & Daily Stage, 2006-2009




Marsh = Sites 7 & 9  Rim =  1-8C, S362, G300, G301, G338, G310, G251

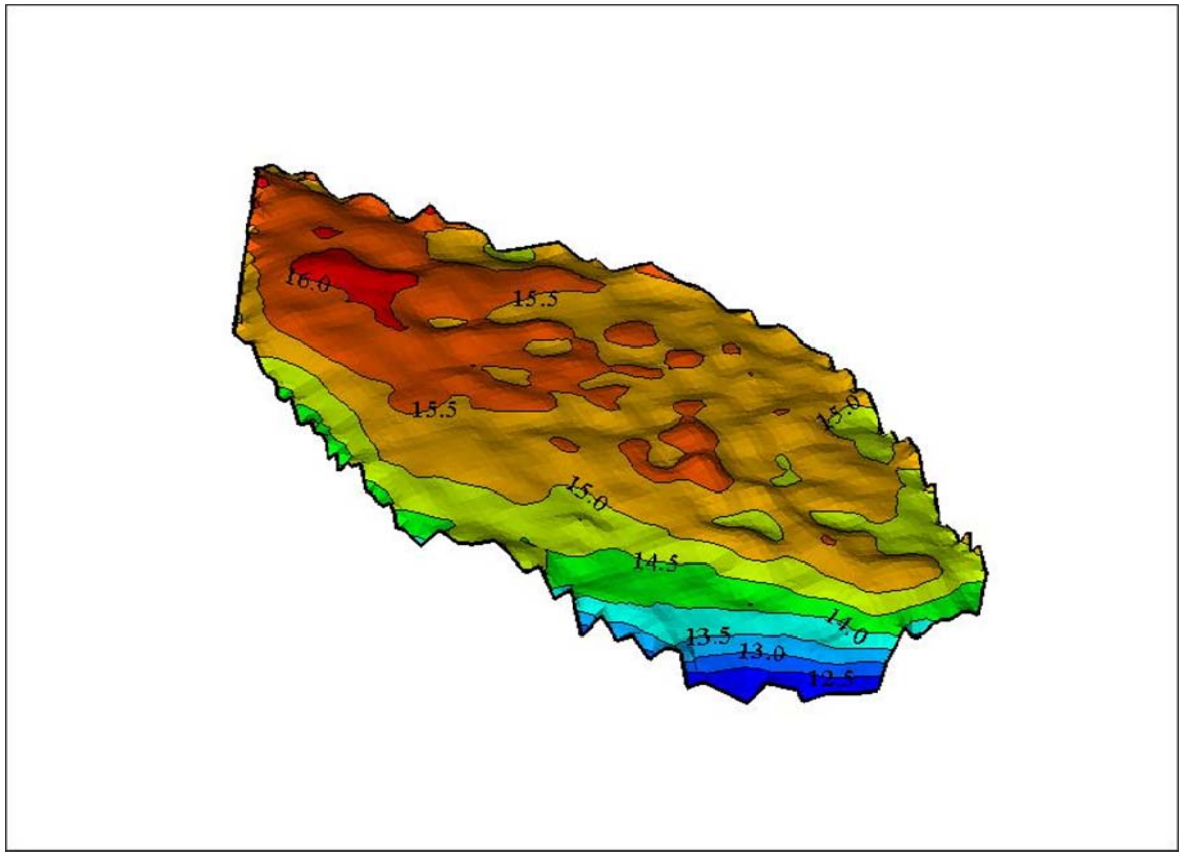
# 7-Day Inflow TP Load & Daily Stage, 2006-2009

7-Day Rolling Average Inflow Volume & Stage  Jan 2006 - June 2009  Vertical Line: Marsh GM > LT Level




Marsh = Sites 7 & 9  Rim =  1-8C, S362, G300, G301, G338, G310, G251

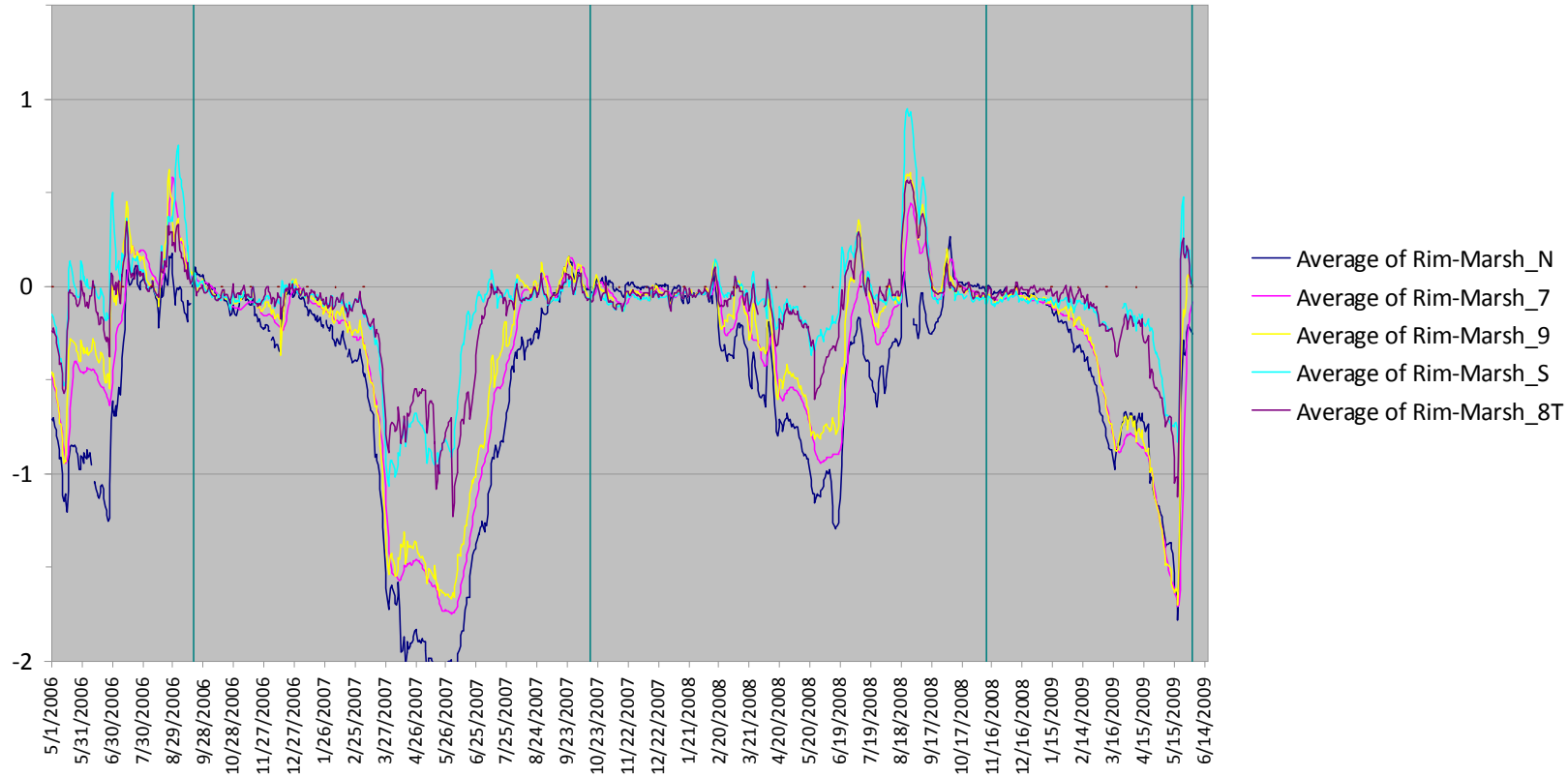
# Refuge Topography




E.A. Meselhe (2009) based on USGS topography data. Elevations in feet, NGVD29.

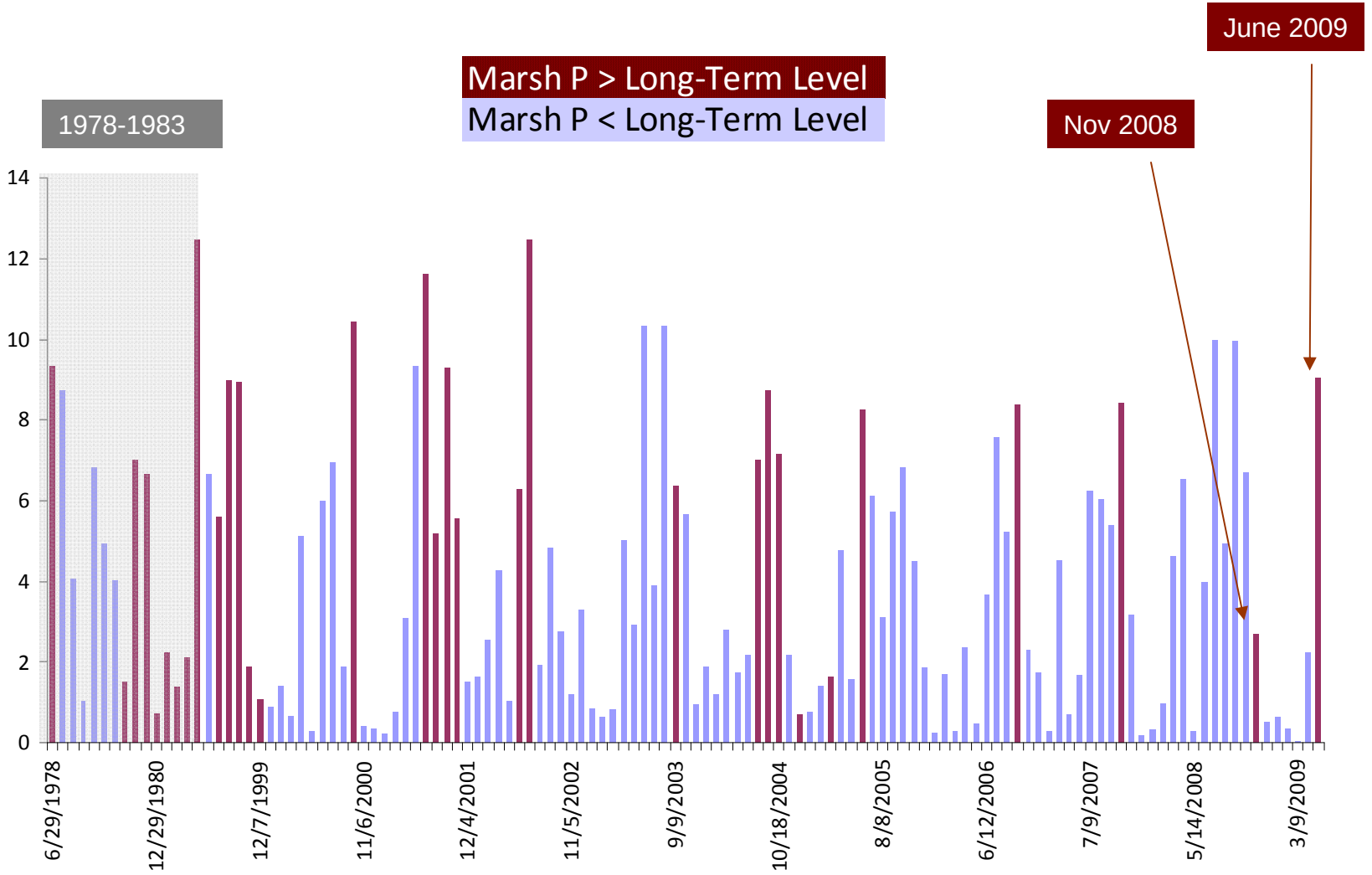
# Hydraulic Gradients Between Rim Canal & Marsh Sites
# May 2006- June 2009

Mean Rim Stage - Marsh Stage at Various Sites  Period: 200605-200906  Vertical Line: Marsh GM > LT Level




Units: feet.  Rim = Average of 1-8C, S362, G300, G301, G338, G310, G251

# Antecedent Conditions for Each Sampling Event
# 1978-1983 & 1999-2009
# 30-Day Rainfall (Inches) S5A+S6+S139

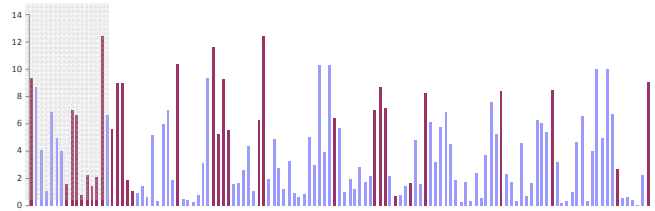


# 30-Day Antecedent Conditions for Each Sampling Event, 1978-1983 & 1999-2009

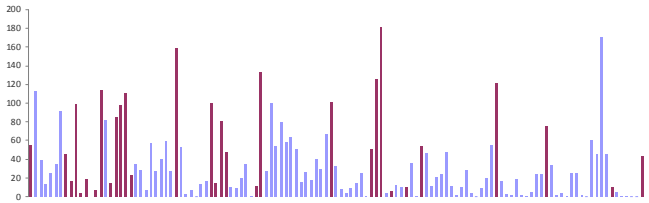
## Rainfall, Inflow Volume, TP Load, TP Conc, Marsh & Rim Stage, Increase in Marsh & Rim Stage

1978 - 1983

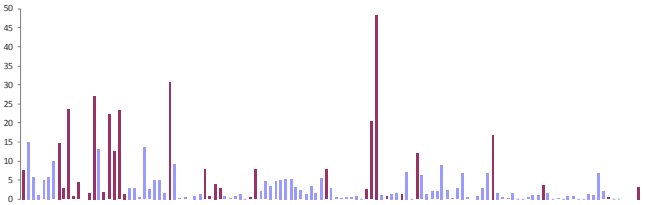
30-Day Rainfall inches S5A, S6, S139



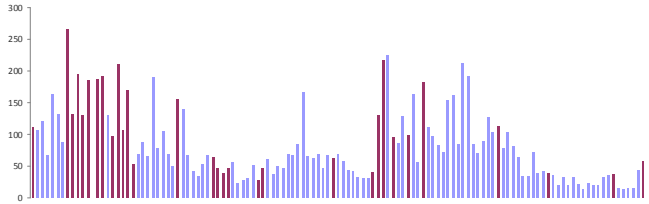
30-Day Inflow Volume kac-ft



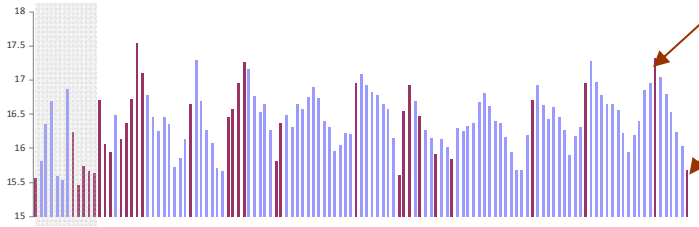
30-Day Inflow Load mt



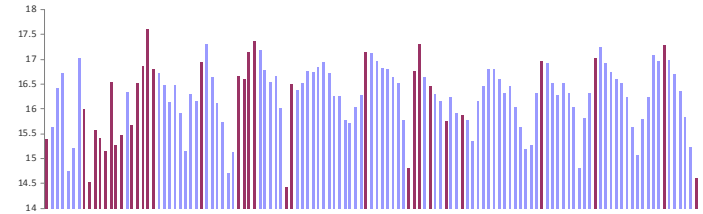
30-Day Inflow Conc ppb



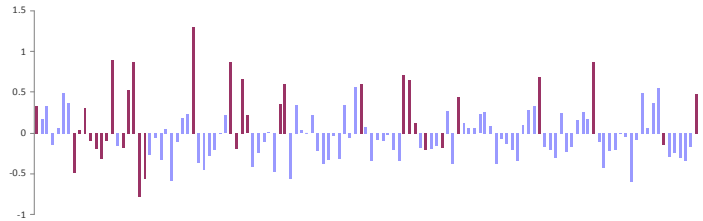
30-Day Average Marsh Stage ft 1-7 & 1-9




30-Day Average Rim Canal Stage ft



30-Day Increase in Marsh Stage inches 1-7 + 1-9



30-Day Increase in Rim Canal Stage ft

Marsh P > Long-Term Level

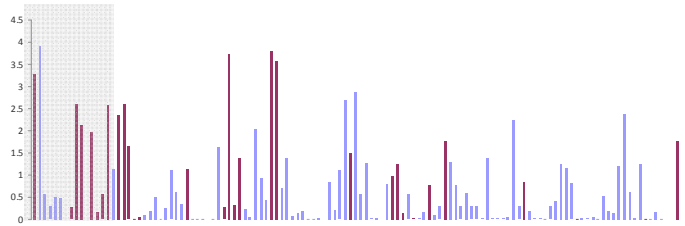
Marsh P < Long-Term Level

# 7-Day Antecedent Conditions for Each Sampling Event, 1978-1983 & 1999-2009

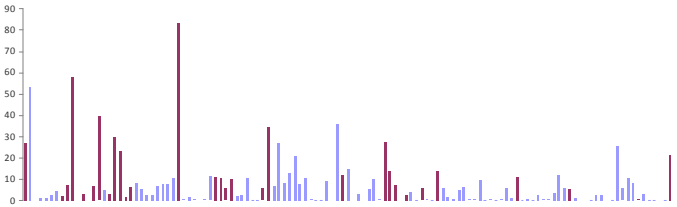
## Rainfall, Inflow Volume, TP Load, TP Conc, Marsh & Rim Stage, Increase in Marsh & Rim Stage

1978 - 1983

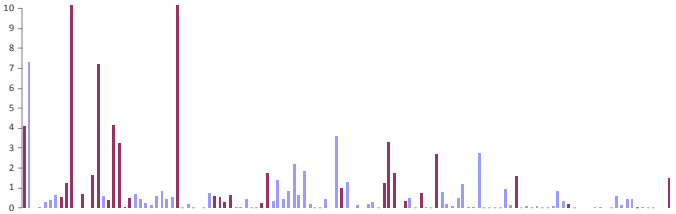
7-Day Rainfall inches S5A, S6, S139



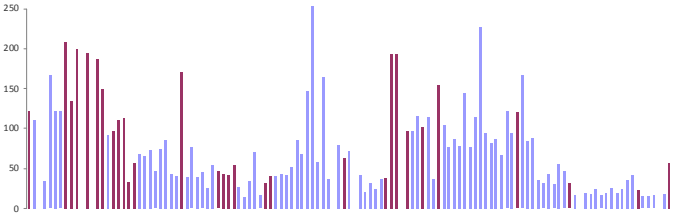
7-Day Inflow Volume kac-ft



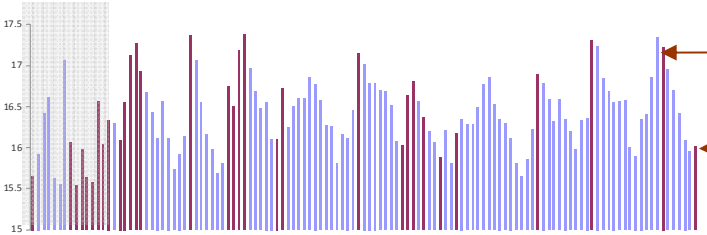
7-Day Inflow Load mt



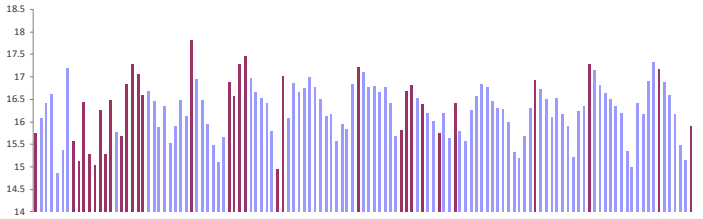
7-Day Inflow Conc ppb



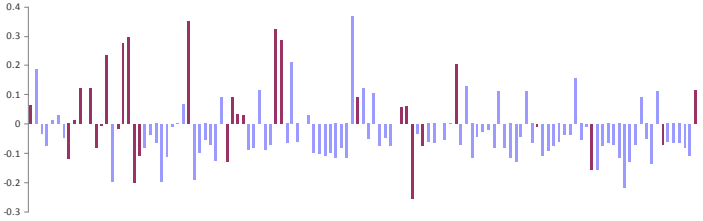
7-Day Average Marsh Stage ft 1-7 & 1-9



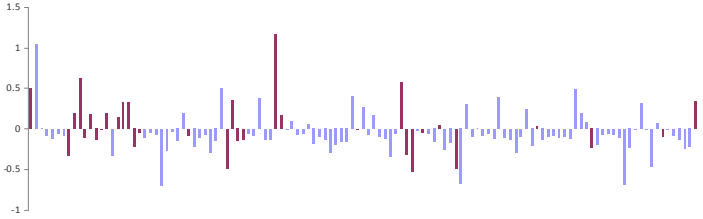

7-Day Average Rim Canal Stage ft



7-Day Increase in Marsh Stage ft 1-7 + 1-9



7-Day Increase in Rim Canal Stage ft

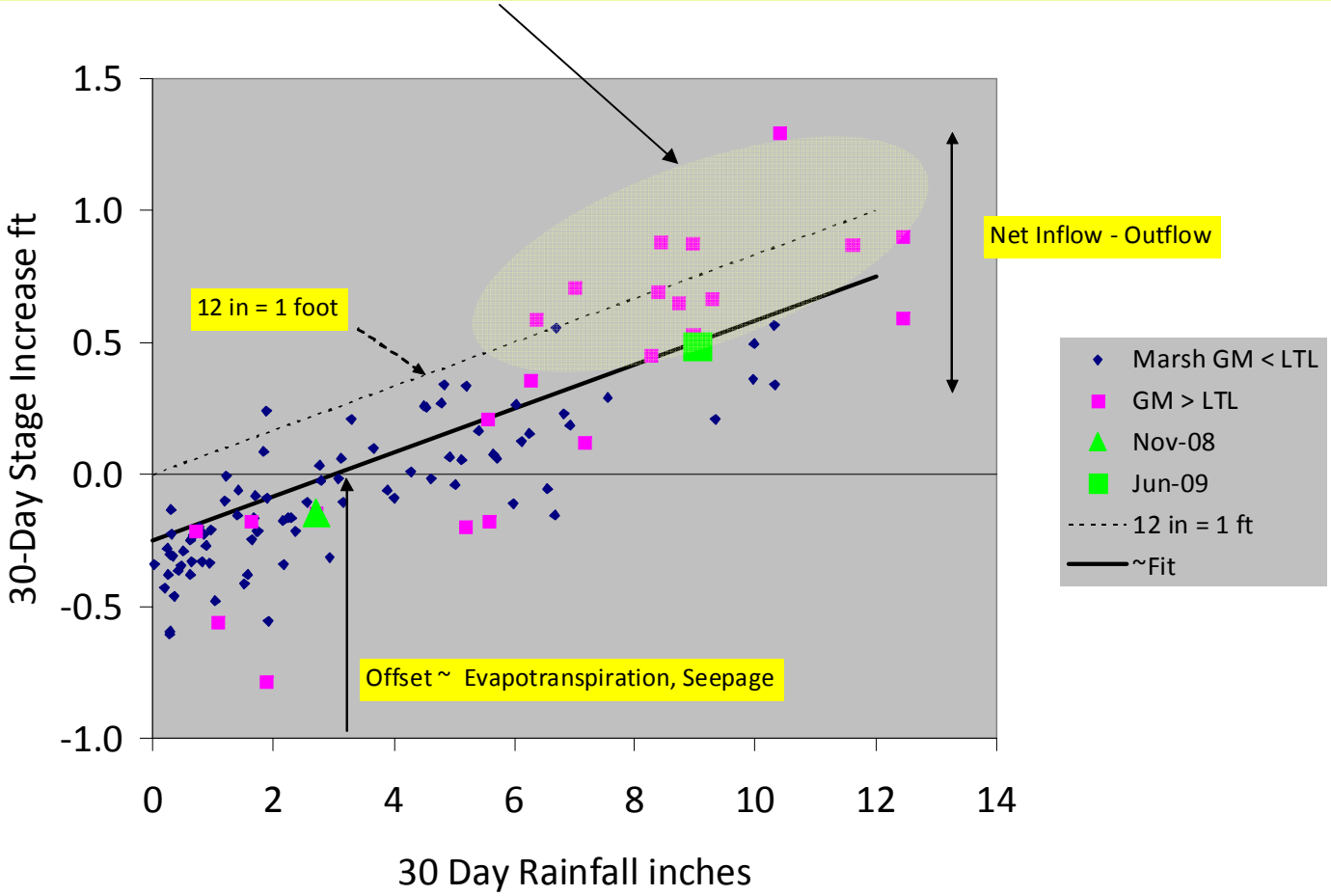


Marsh P > Long-Term Level

Marsh P < Long-Term Level

# 30-Day Increase in Stage vs. Rainfall

Greater risk of Marsh TP > LTL following heavy rainfall & rising stage in periods with positive net inflow vs. periods with net outflow.

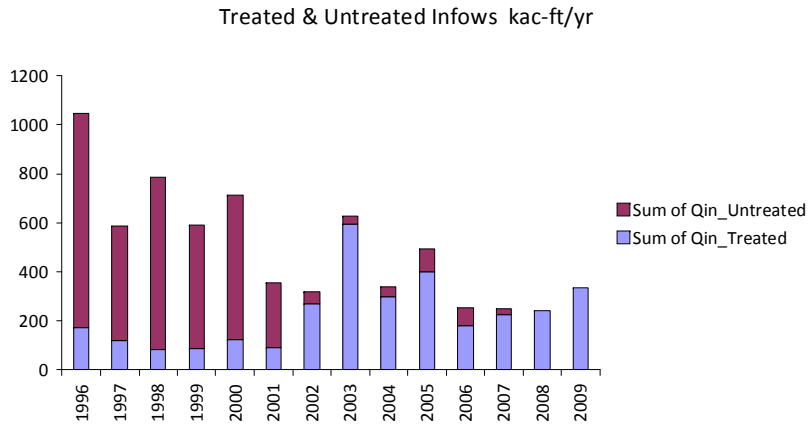


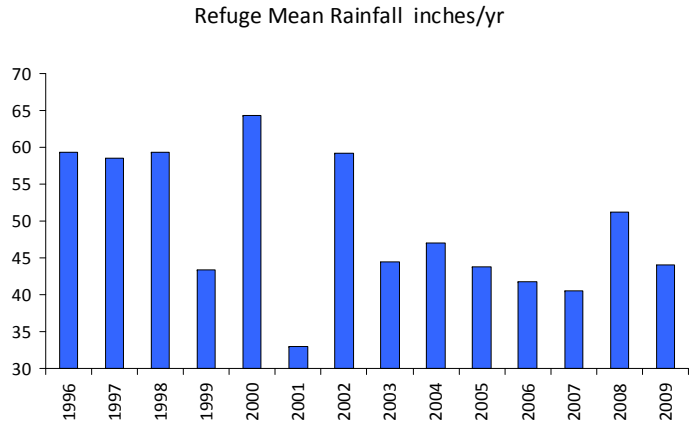

Marsh Stage = Sites 7 & 9, Rainfall = Mean ( S5 + S6 + S39 ); Monthly Sampling Events, 1999-2009

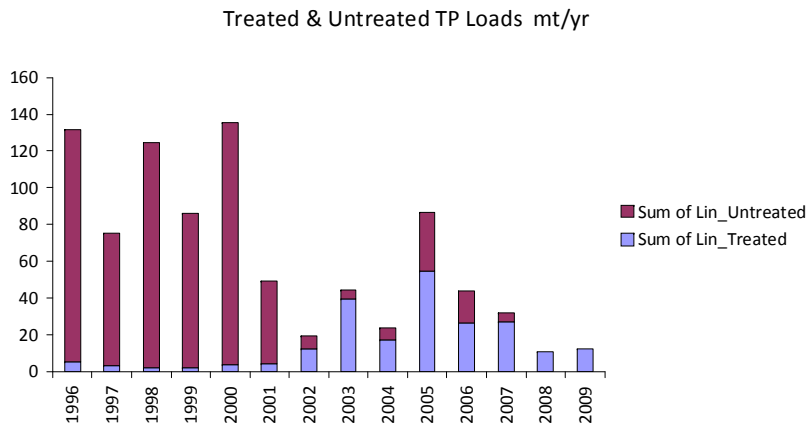
# Long-Term Perspective

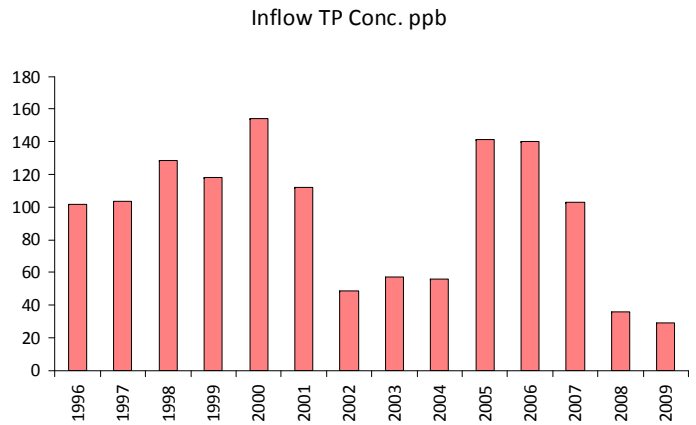
- Given long time scales of P storage & recycling, causal factors & progress are best evaluated by tracking long-term trends in the marsh following long-term reductions in external loads.
- Indications of long-term improvement in marsh conditions:
  - Decreasing frequency of marsh GM > LTL.
  - Decreasing trends in TP concentrations at some sites
  - Effects of reduced loading confounded with drought
- Indications that CD objectives have not yet been achieved:
  - Exceedance of LTLs for Interior Marsh
  - Interior GM > long-term objective (7 ppb) in each Water Year (2000-2009).
  - Exterior Marsh not restored

# Trends in Rainfall & Refuge Inflows, WY 1996-2009

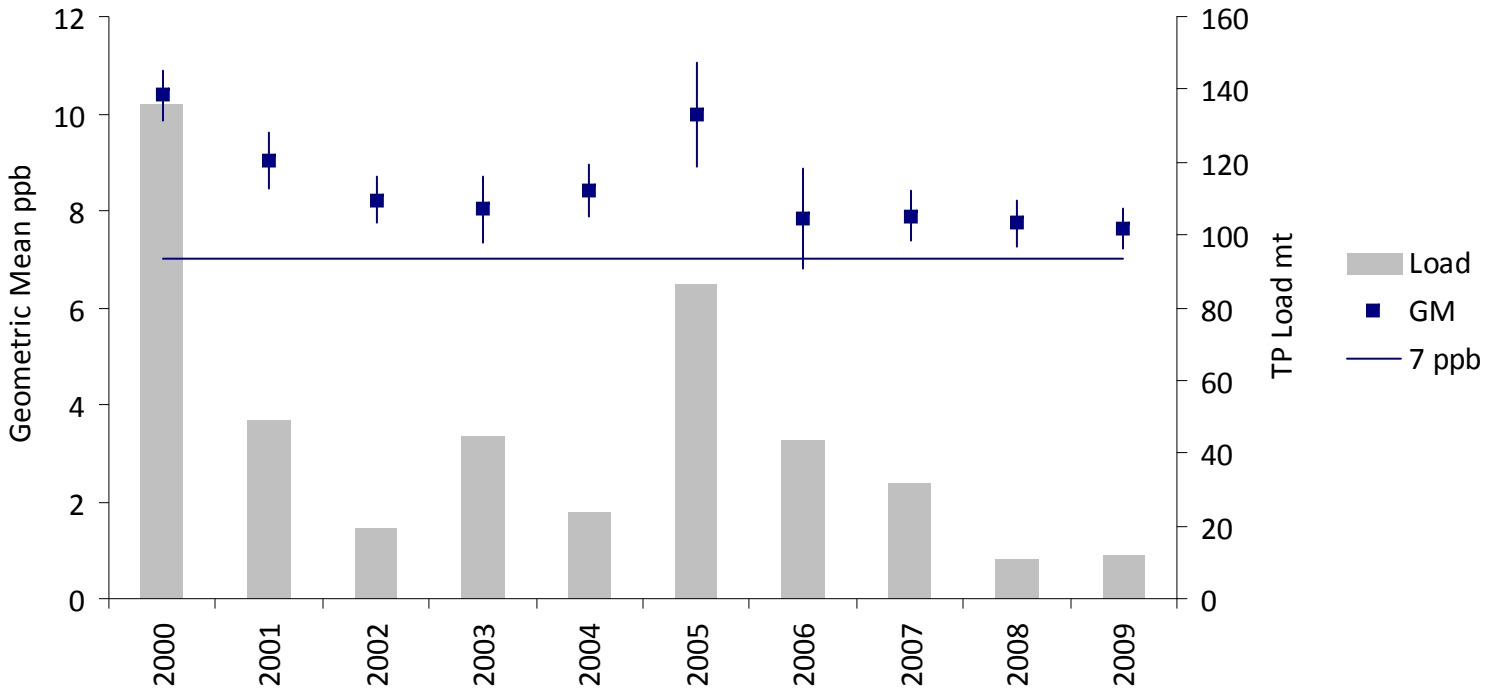


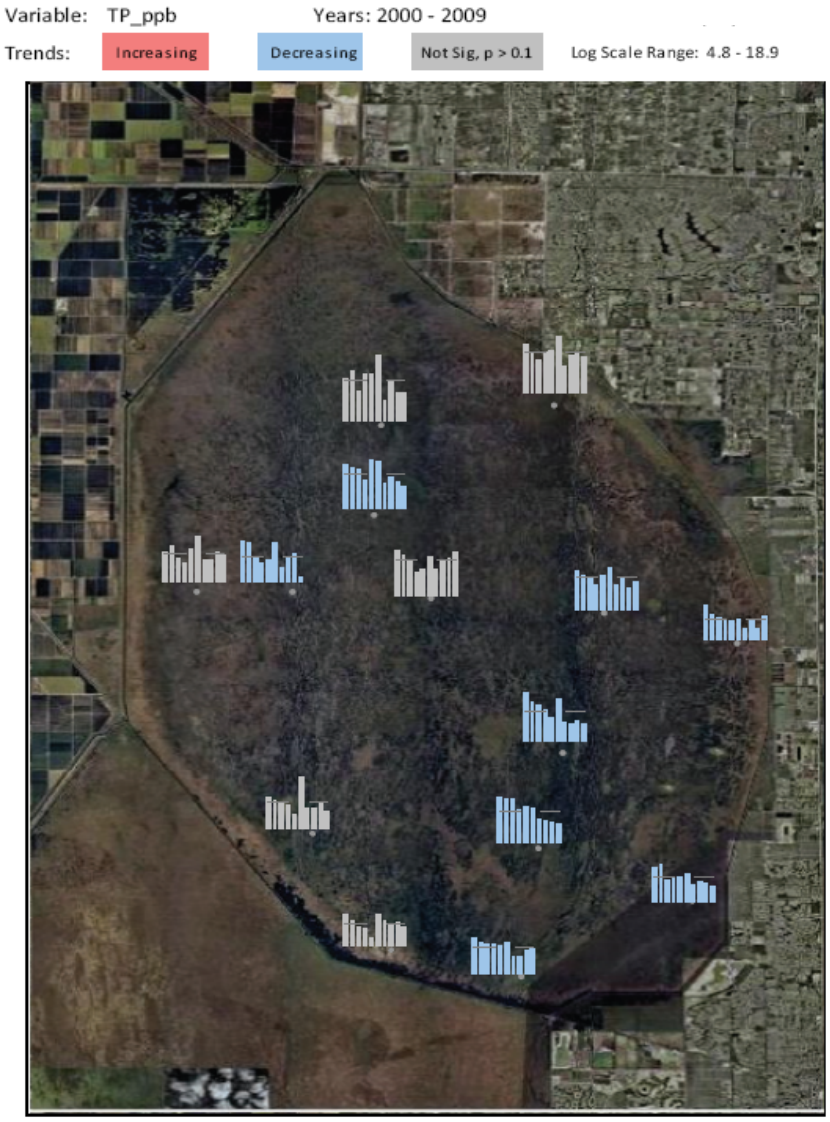



# 10-Year Trend in Marsh Geometric Mean TP vs. Consent Decree Goal ( < 7 ppb ) Consistent with Achieving Long-Term Levels

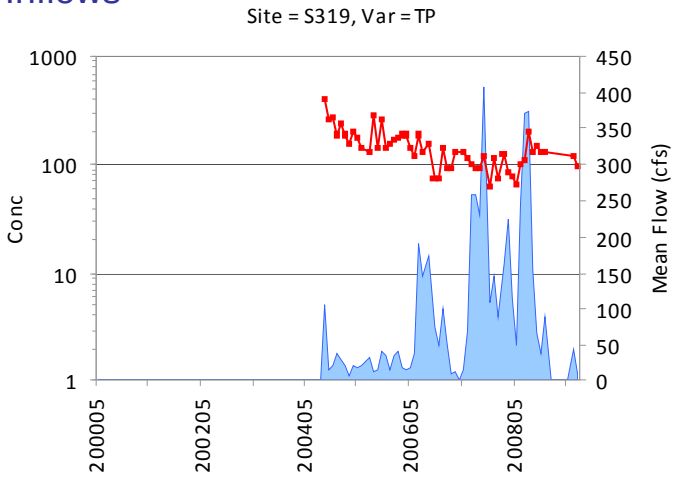


# Trends in Marsh Total P & Conductivity, WY 2000-2009

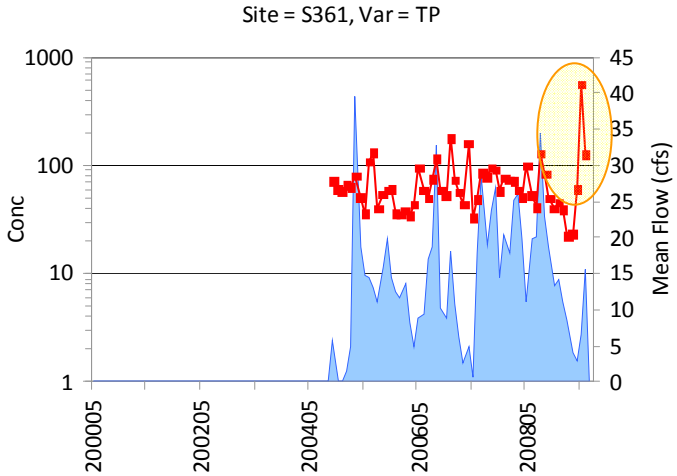


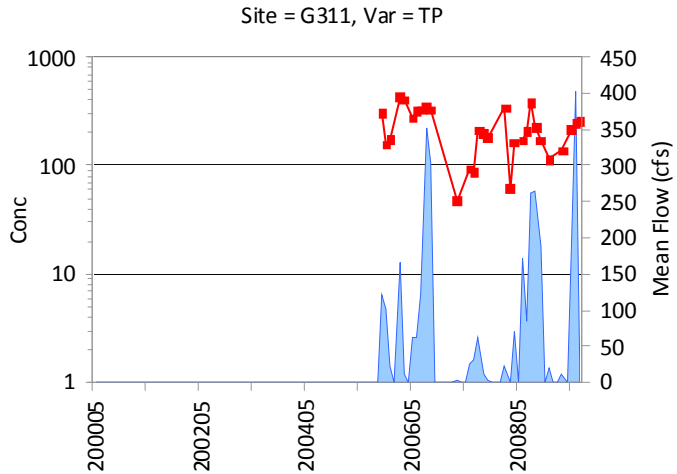

# Monthly Flows & TP Concentrations – STA 1E Inflows & Outflows
# May 2001 – June 2009

## Inflows

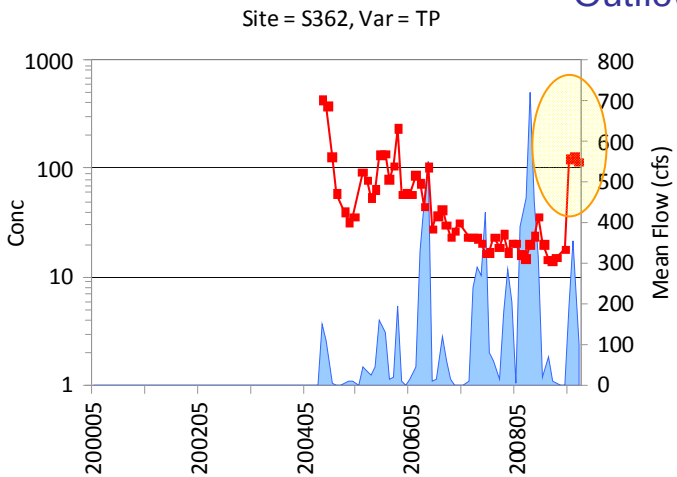



## Inflow



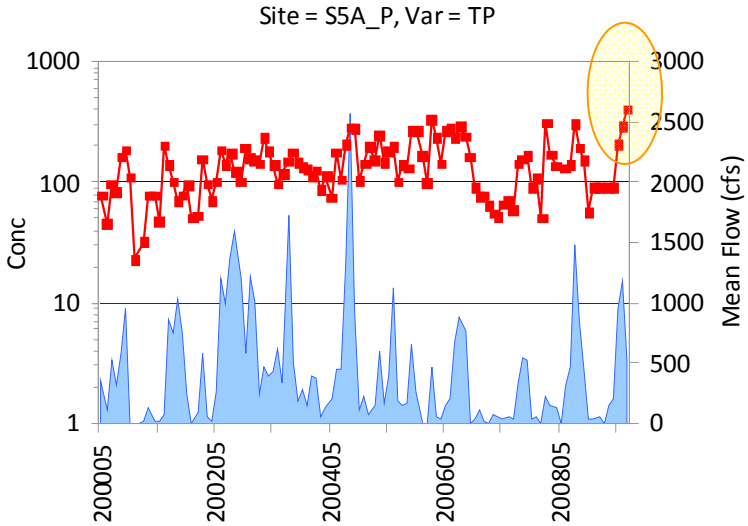



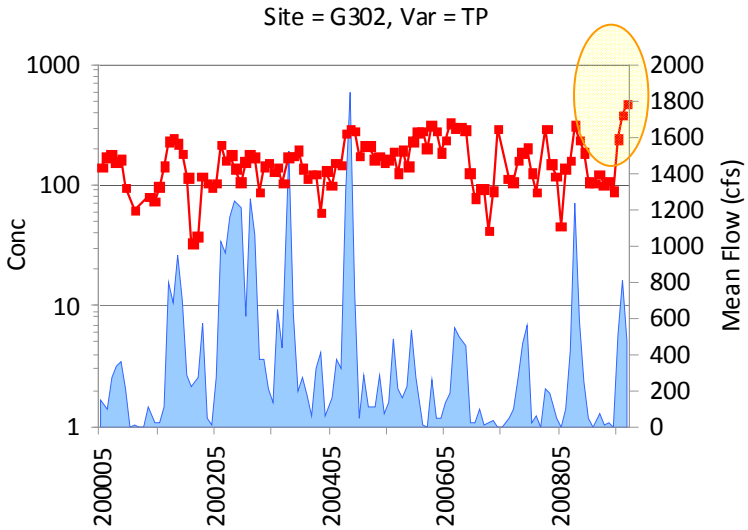

## Outflow



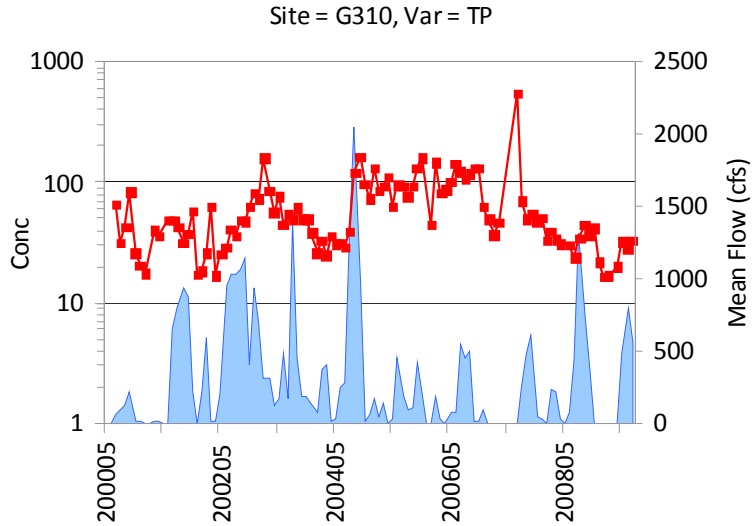
# Monthly Flows & TP Concentrations – STA 1W Inflows & Outflows
# May 2001 – June 2009

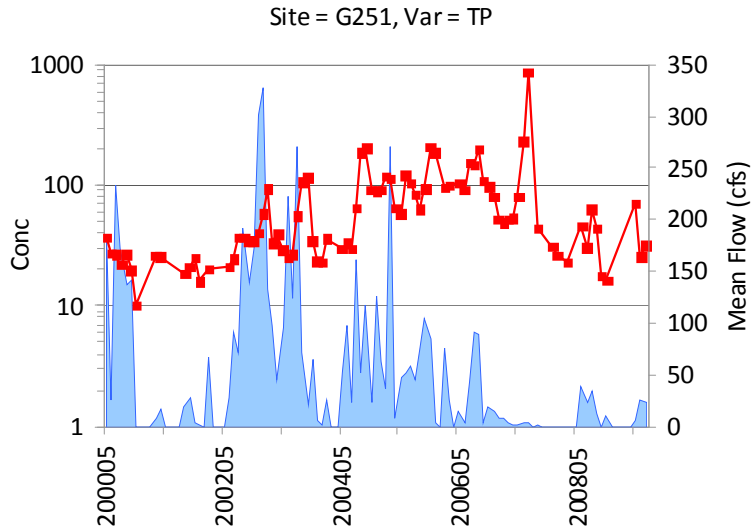
## Inflows



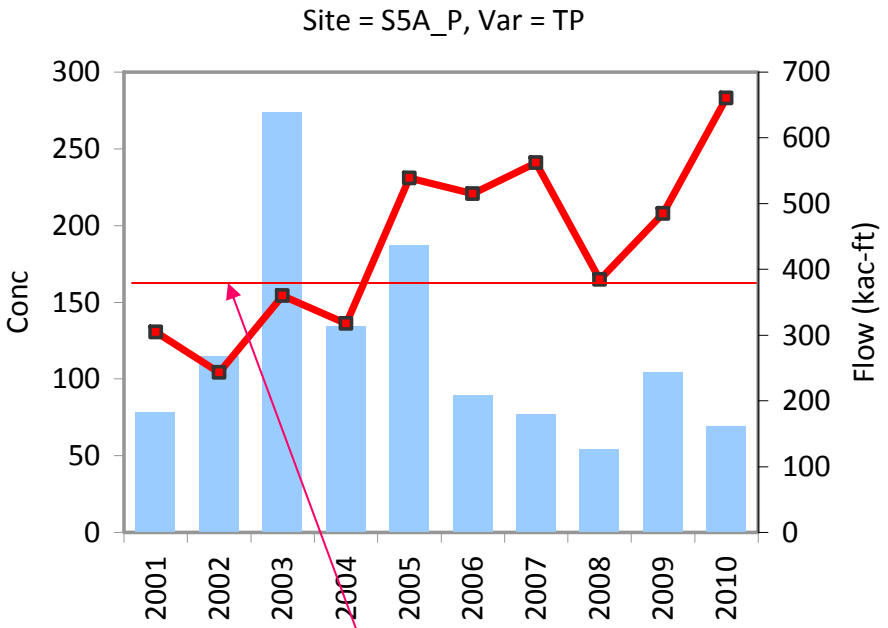



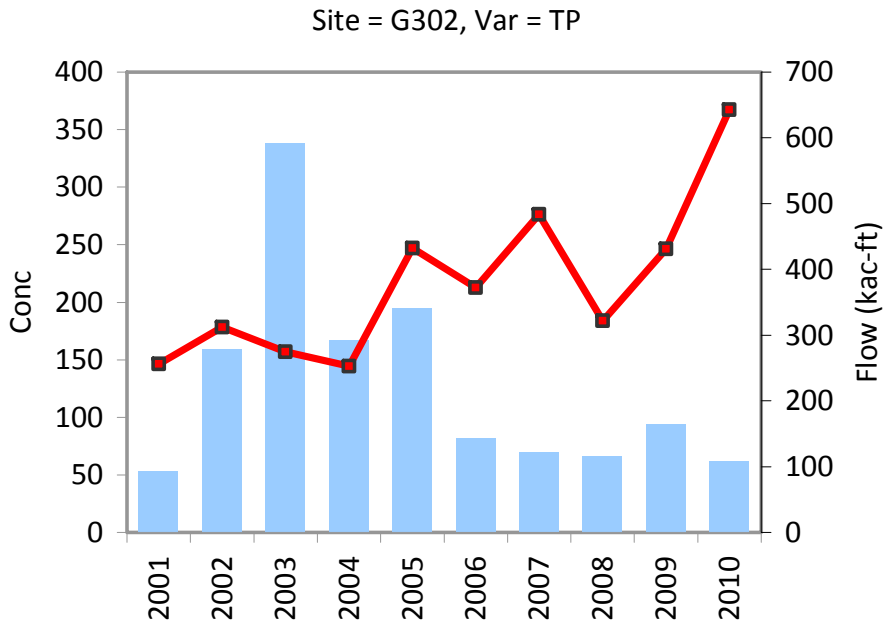

## Outflows



# Trends in Yearly Flow and TP Concentration at S5A Pump Station & Inflow to STA1W

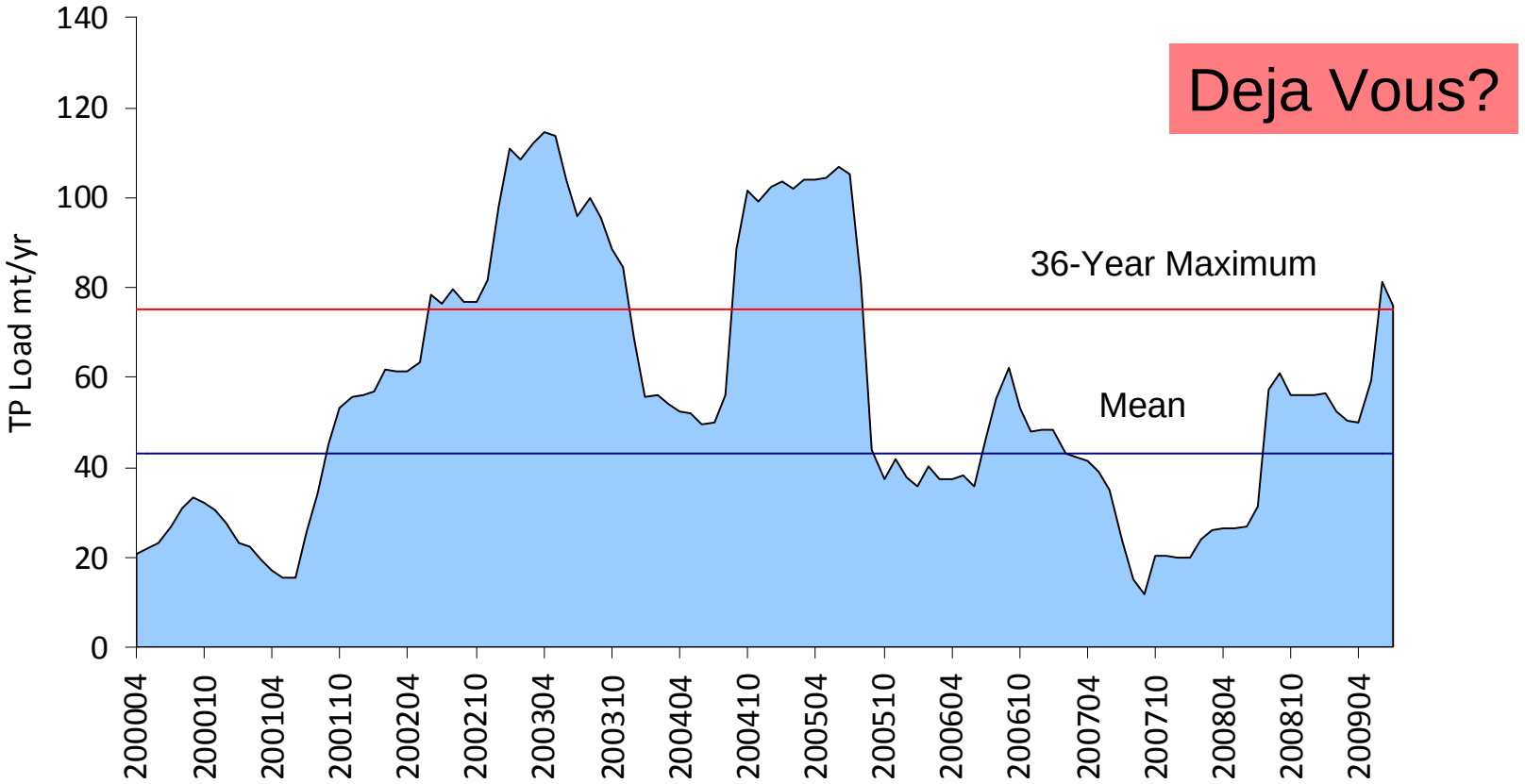



Design Assumption for STA1W Inflow TP Conc, EAA Regional Feasibility Study ~ 160 ppb

WY 2010 data for May-June Only

# 12-Month Rolling STA 1W Inflow TP Load vs. Existing Operational Envelope April 2000 – June 2009



# Recommendations

- Continue tracking compliance & trends in marsh
- Focus on load reduction measures
- Recent increases in STA outflow concentrations may cause reversal of favorable marsh trends:
  - Overloading of both STA's relative to existing & future operational envelopes
  - Problems with depths & vegetation in STA-1E
- Re-evaluate proposed remedy (EAARFS):
  - Increasing trends in S5A TP Concs (200-250 ppb vs. EAARFS assumed 160 ppb)
  - Predicted pulsed inflows to STA-1W - risk of bypass & P spikes to marsh.
  - Plans will not meet QBEL (max yearly < 17 ppb) required to restore exterior marsh
  - Risk to Refuge water supply