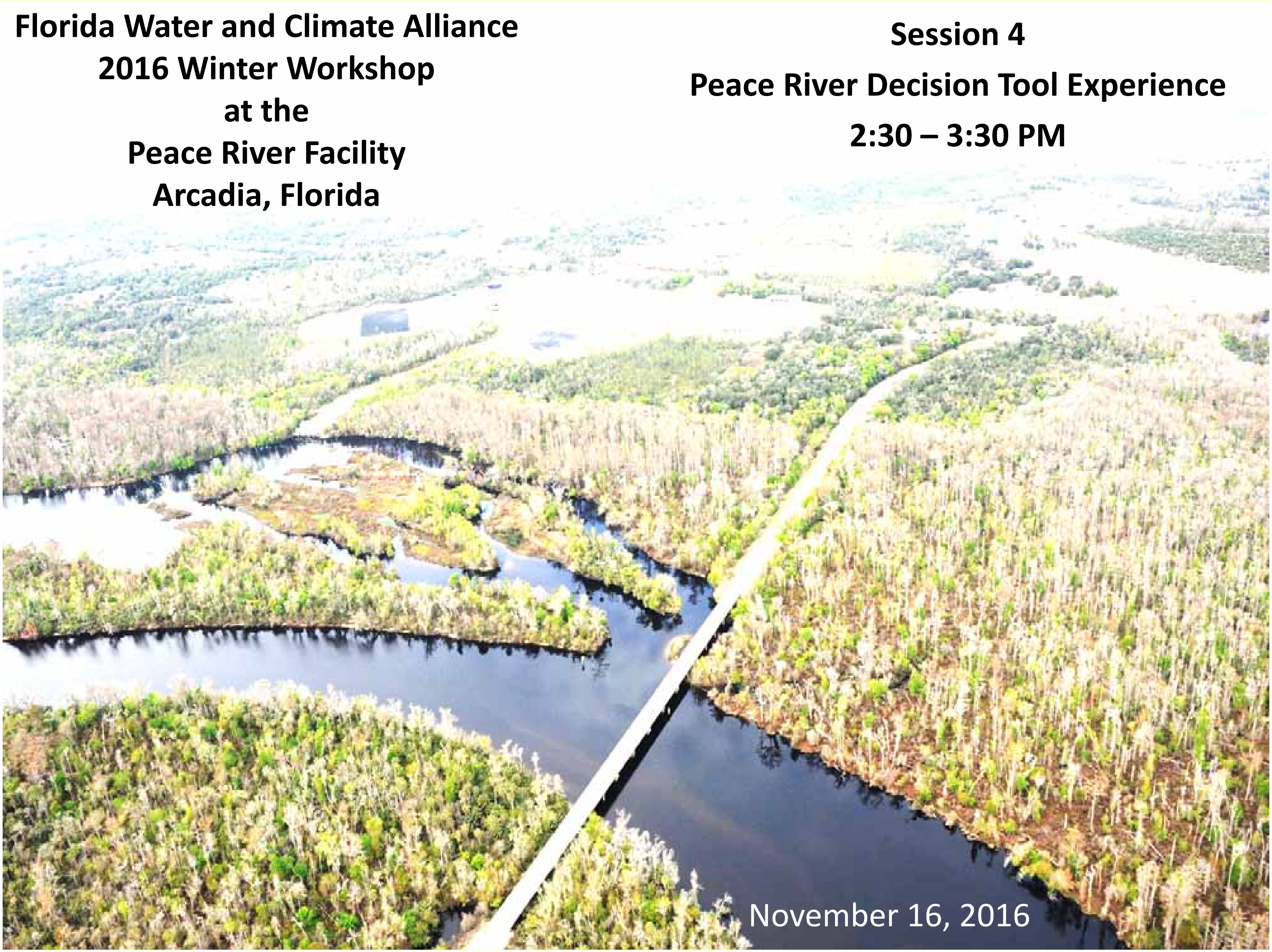
Florida Water and Climate Alliance
2016 Winter Workshop
at the
Peace River Facility
Arcadia, Florida

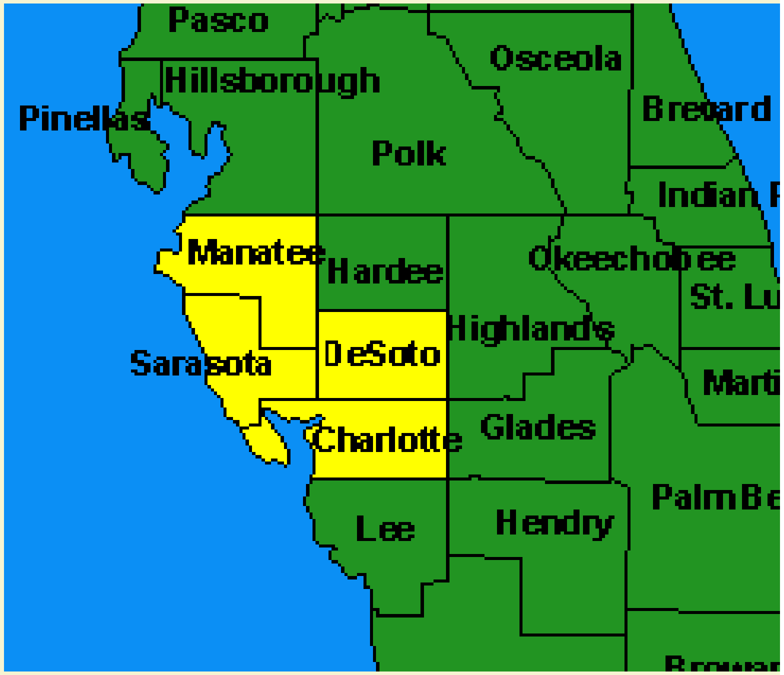
Session 4
Peace River Decision Tool Experience
2:30 – 3:30 PM



November 16, 2016

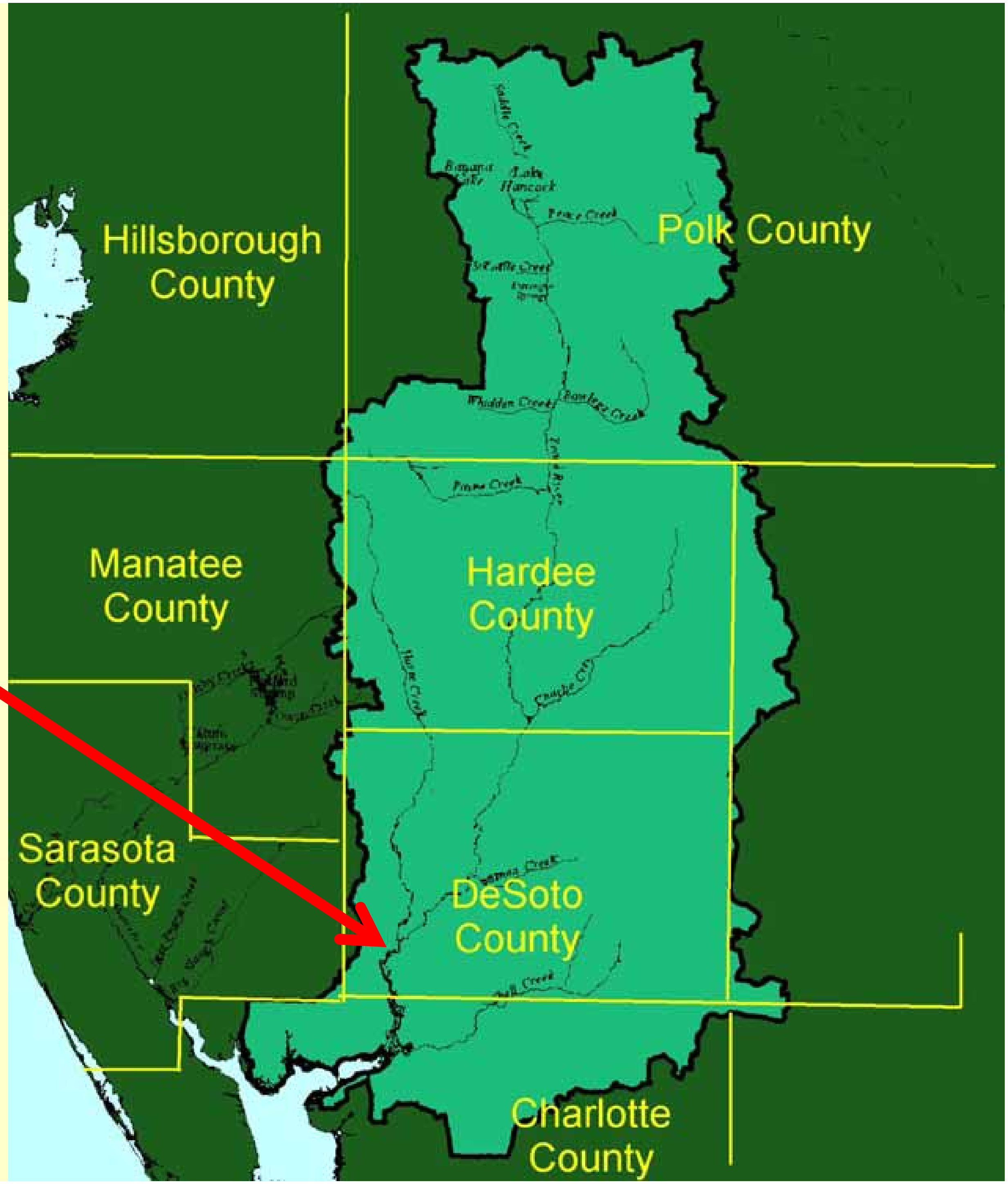
The Peace River Manasota Regional Water Supply Authority

- Created in 1982
- 4 Member Counties
- Serves a population of about 500,000



Drainage Basin & the Peace River Facility

- Location of Peace River Facility

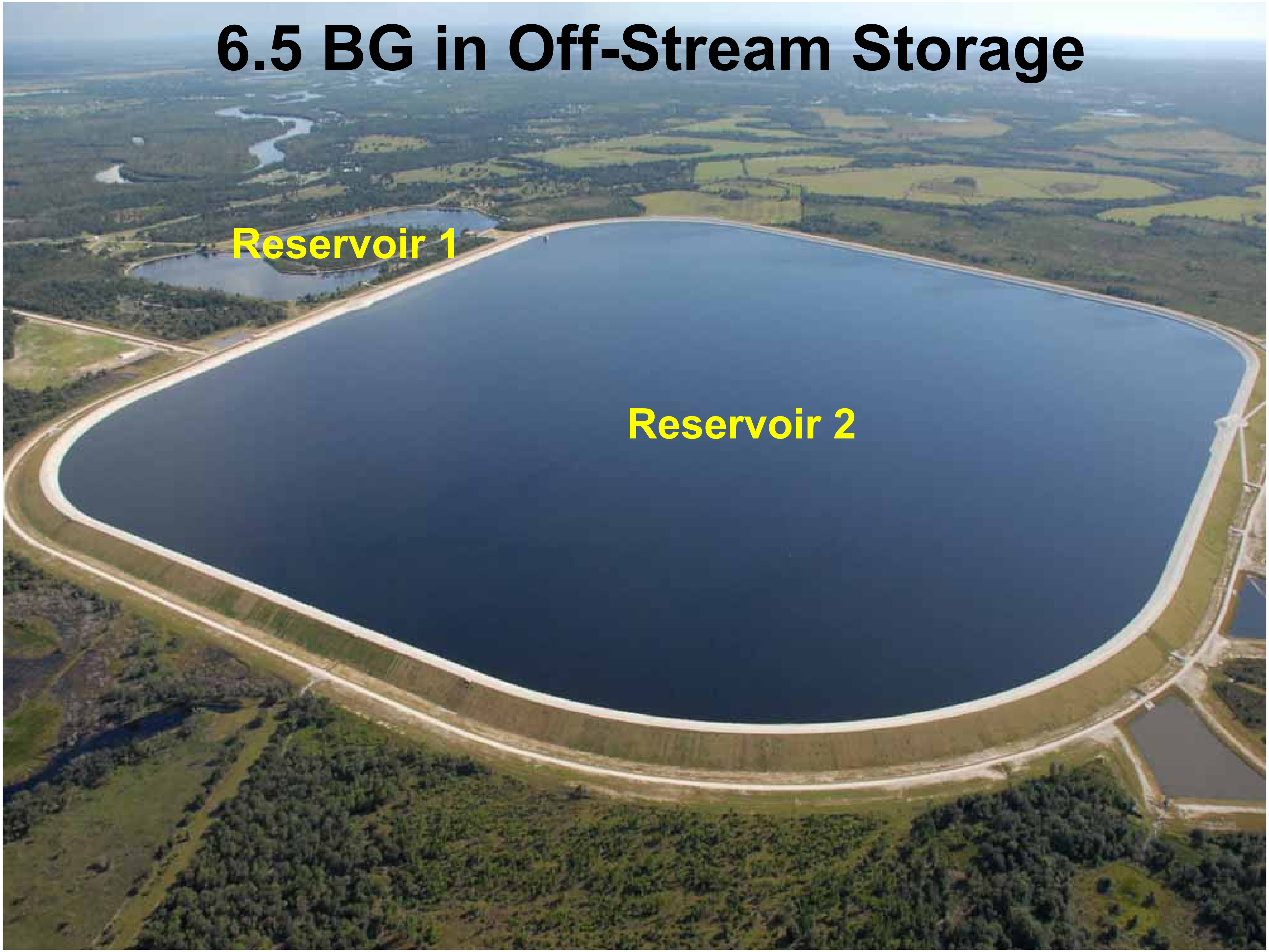


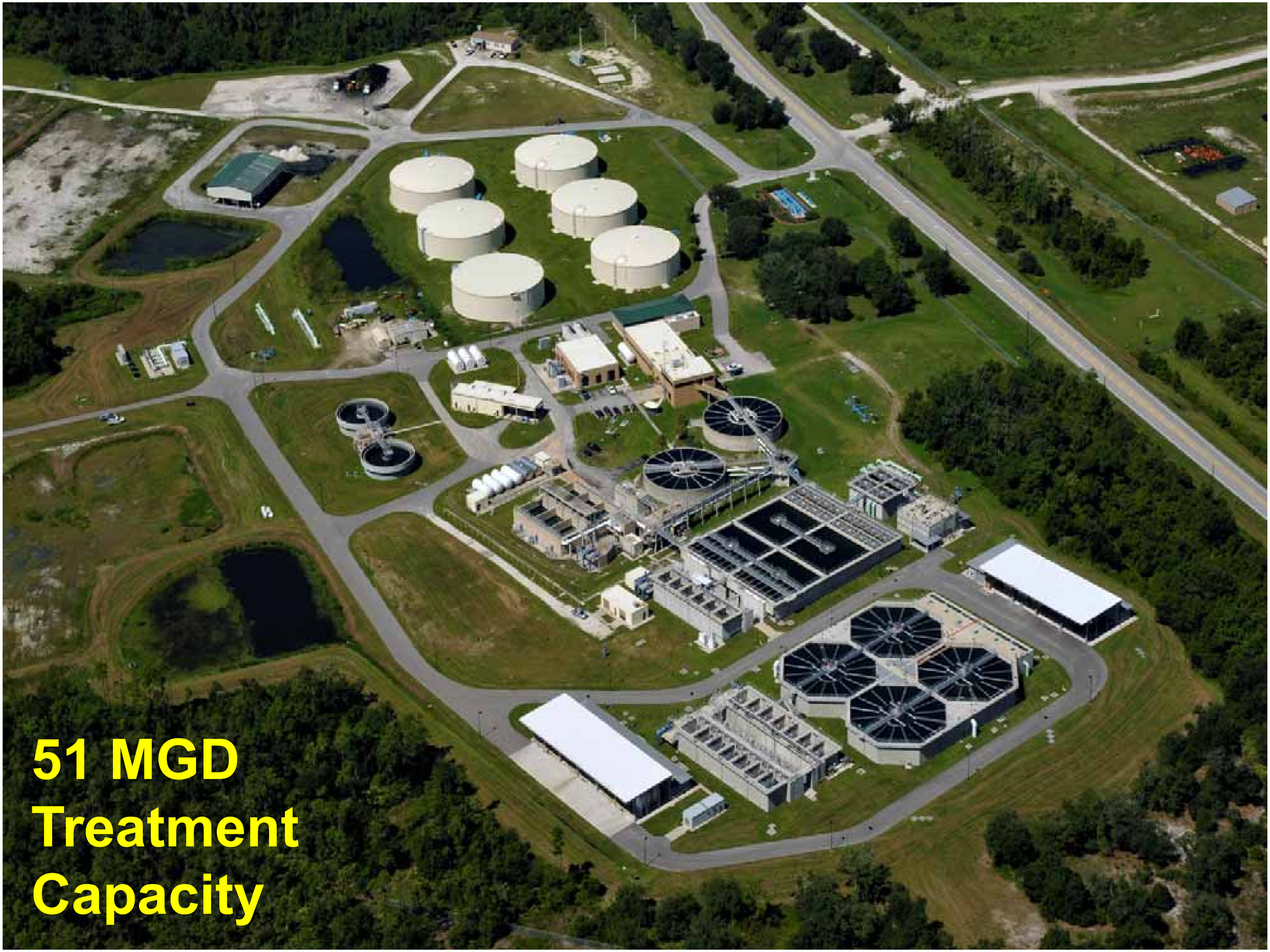
The Peace River Facility

The Peace River is our Source Water

120 MGD River Intake Pump Station

How Much is 120 MGD?


6.5 BG in Off-Stream Storage
Reservoir 1
Reservoir 2


51 MGD
Treatment
Capacity

6 BG in Underground Storage

21 Finished Water ASR Wells

During Months without ASR Recovery

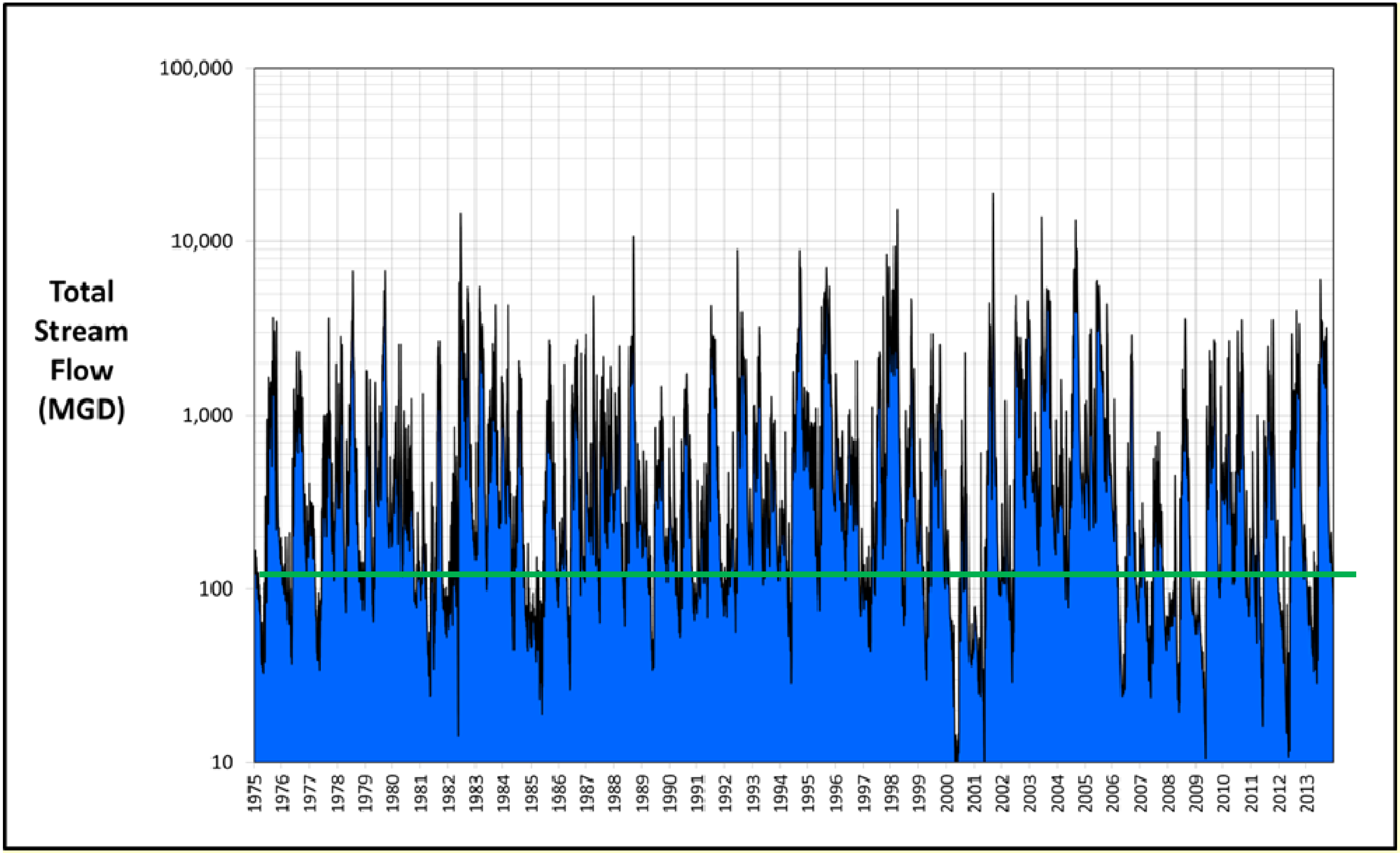
During Months with ASR Recovery

The Upper Peace River can go Completely Dry

Picture from FDEP's "Florida's Water" webpage

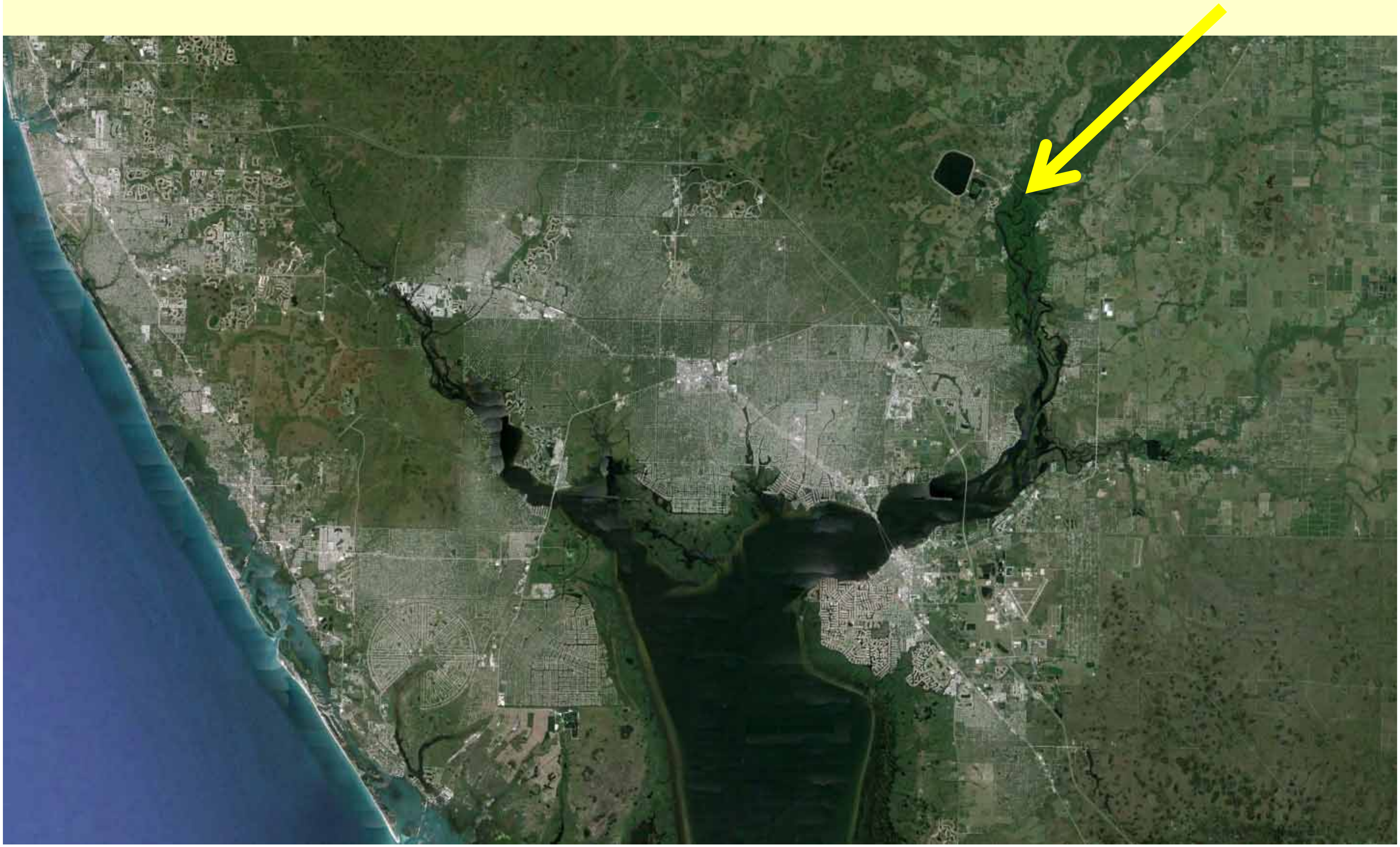
Picture by Sam Stone during 2000-1 drought

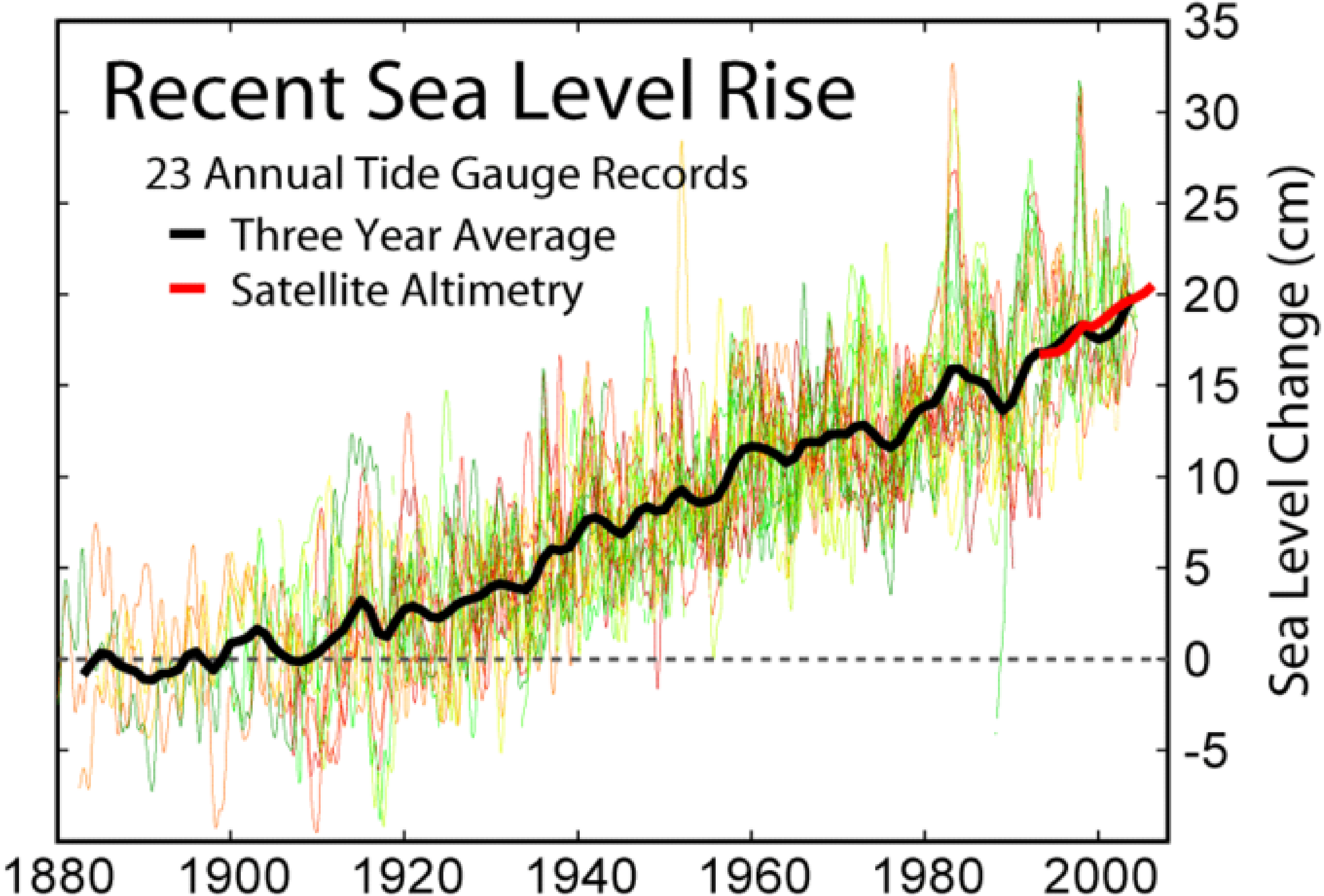
The Peace River near Arcadia - typical dry and wet season views



- River flows vary dramatically (8 Mgd – 18 Bgd)

Although more than 25 miles from the Gulf of Mexico, our river intake is tidally influenced

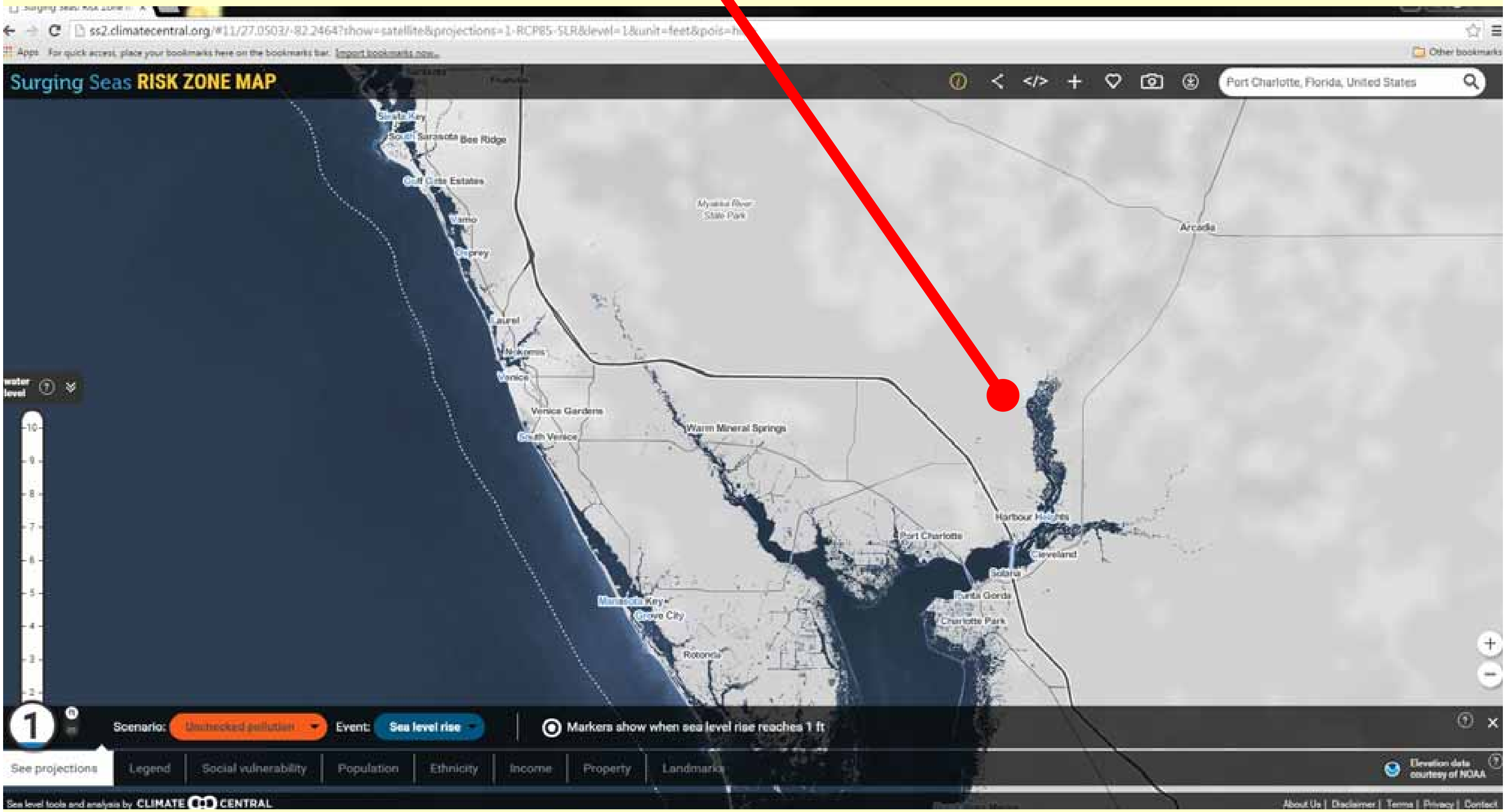



Recent Sea Level Rise
23 Annual Tide Gauge Records
Three Year Average
Satellite Altimetry
Sea Level Change (cm)
35
30
25
20
15
10
5
0
-5
1880
1900
1920
1940
1960
1980
2000

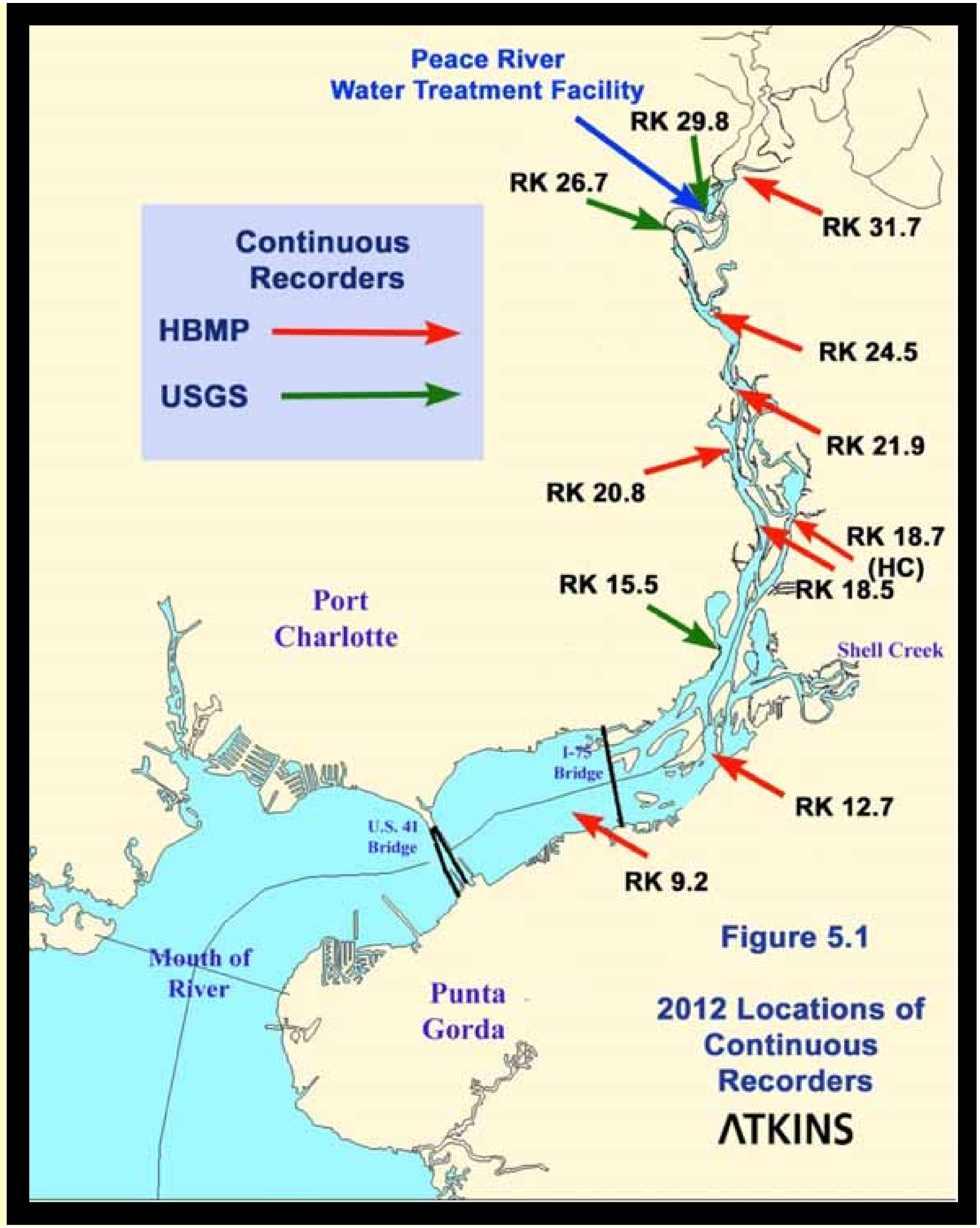
How Much is 3 millimeters a Year?

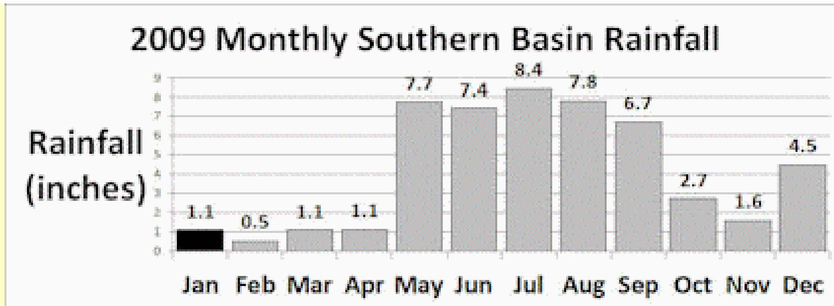
- Take 2 pennies and stack them on top of each other = 3 mm
- This is 1.2 inches in 10 years
- This is 1 foot in 100 years
- Some Suggest that due to the Anthropogenic Linkage, this Rate is Accelerating

The Peace River Facility

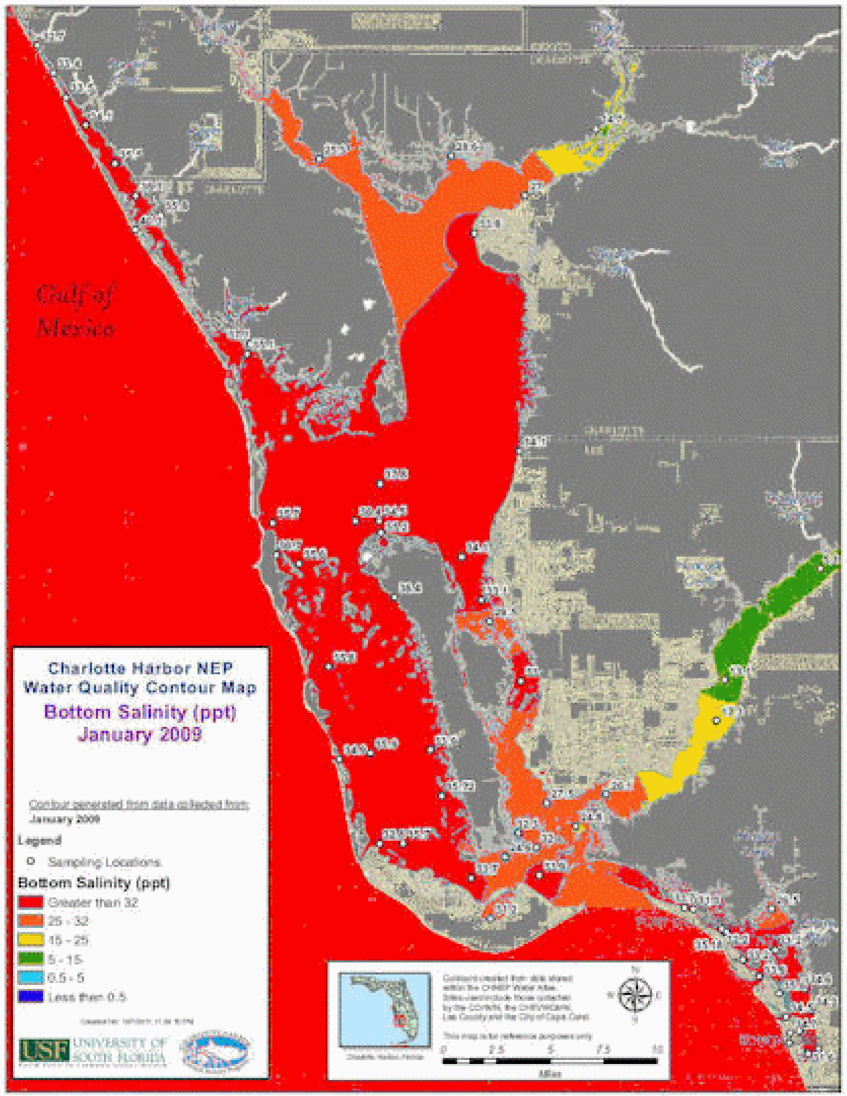


2010-2013 USGS top/bottom continuous (15-minute) recorder data at the Facility's intake





2009 Monthly Southern Basin Rainfall
Rainfall (inches)
1.1
0.5
1.1
1.1
7.7
7.4
8.4
7.8
6.7
2.7
1.6
4.5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec



Gulf of Mexico
Charlotte Harbor NEP
Water Quality Contour Map
Bottom Salinity (ppt)
January 2009
Legend
Sampling Locations
Bottom Salinity (ppt)
Greater than 32
25 - 32
15 - 25
5 - 15
0.5 - 5
Less than 0.5
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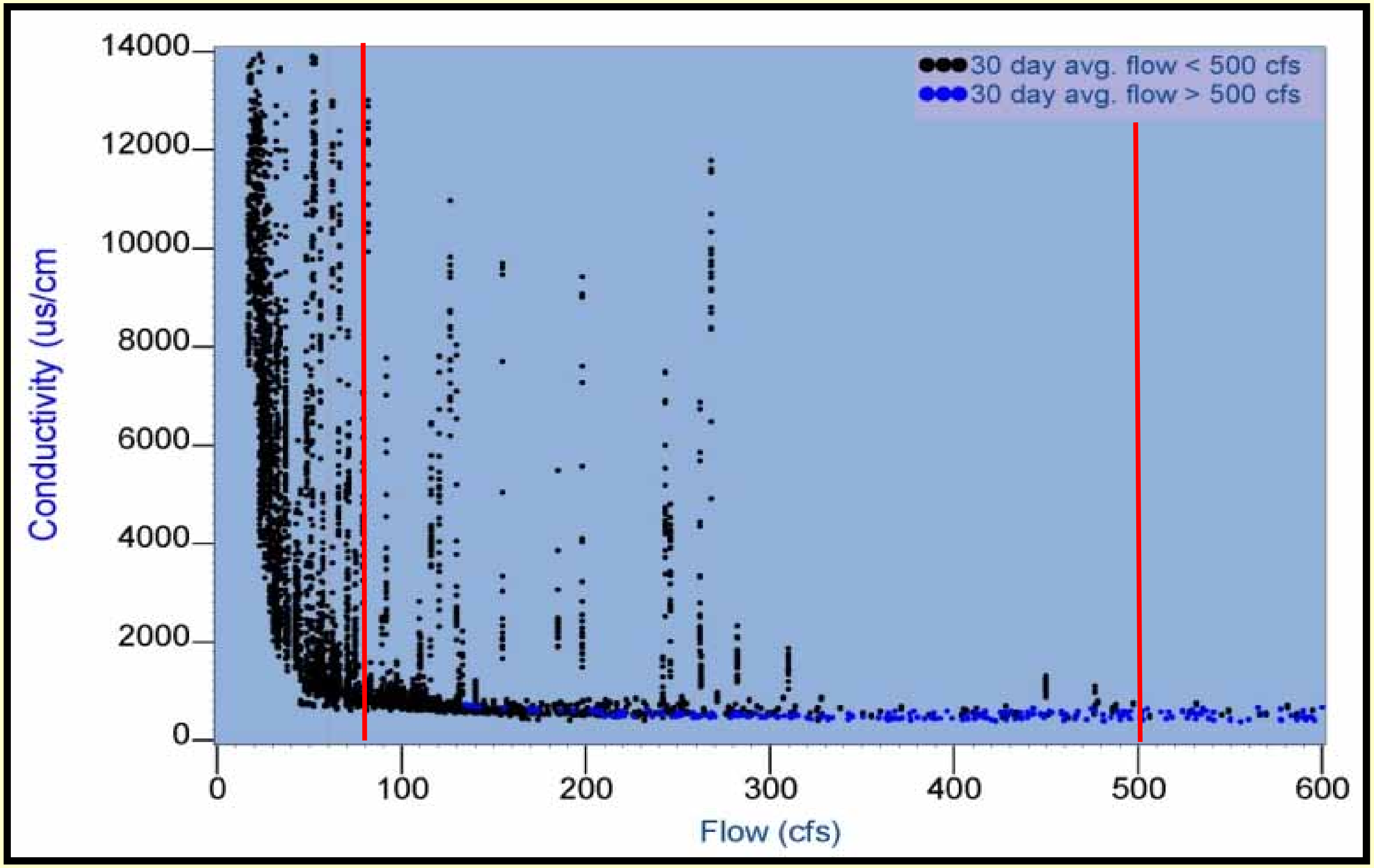
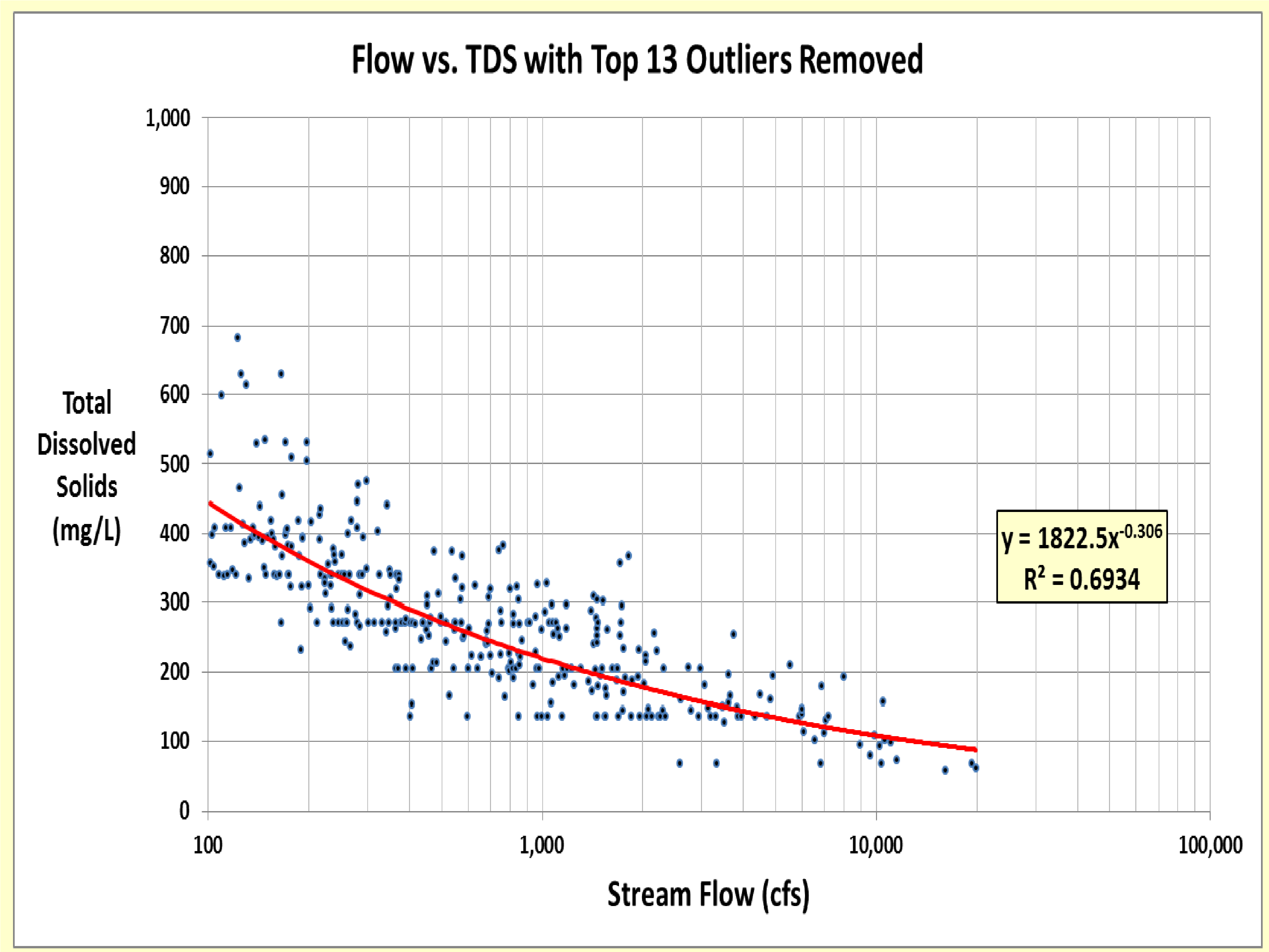
Data Used in Statistical Model Development



Model domain = hourly averaged data when upstream flow was >80 and < 500 cfs & 30-day preceding flow < 500 cfs


Flow vs. TDS with Top 13 Outliers Removed
1,000
900
800
700
600
500
400
300
200
100
0
Total Dissolved Solids (mg/L)
100
1,000
10,000
100,000
Stream Flow (cfs)
y = 1822.5x-0.306
R2 = 0.6934

$$Salinity = \beta_\alpha + (\beta_1 x\ Flow1) + (\beta_2 \times Flow2) + (\beta_3 x Stage) + (\beta_4 x (Stage / Flow))$$

where:

β_α = specific intercept

β_1 = "short-term" flow slopes (linear and/or non-linear)

β_2 = "long-term" flow slopes (linear and/or non-linear)

β_3 = gage height specific slope

β_4 = gage height/flow interaction specific slope

Limited number of parameters to non-autocorrelated accounting for 1% variation

- **Model $R^2 = 0.61$**

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	27833.30249	248.2545839	112.12	<.0001
GHEIGHT	204.44555	19.0693389	10.72	<.0001
F5	20.77362	0.4809903	43.19	<.0001
LF52	-1615.49370	35.3412817	-45.71	<.0001
F53	-0.00003	0.0000007	-40.77	<.0001
F30	15.21454	0.2983358	51.00	<.0001
LF302	-1634.36143	26.4809404	-61.72	<.0001
FGH	-0.52691	0.1023138	-5.15	<.0001

Probability (%)	2025		2050		2075	
	cm	inches	cm	inches	cm	inches
90% (best case)	7	2.8	13	5.0	20	7.7
50% (median expected)	13	5.1	24	9.4	37	14.4
5% (worst case)	22	8.7	41	16.1	63	24.6

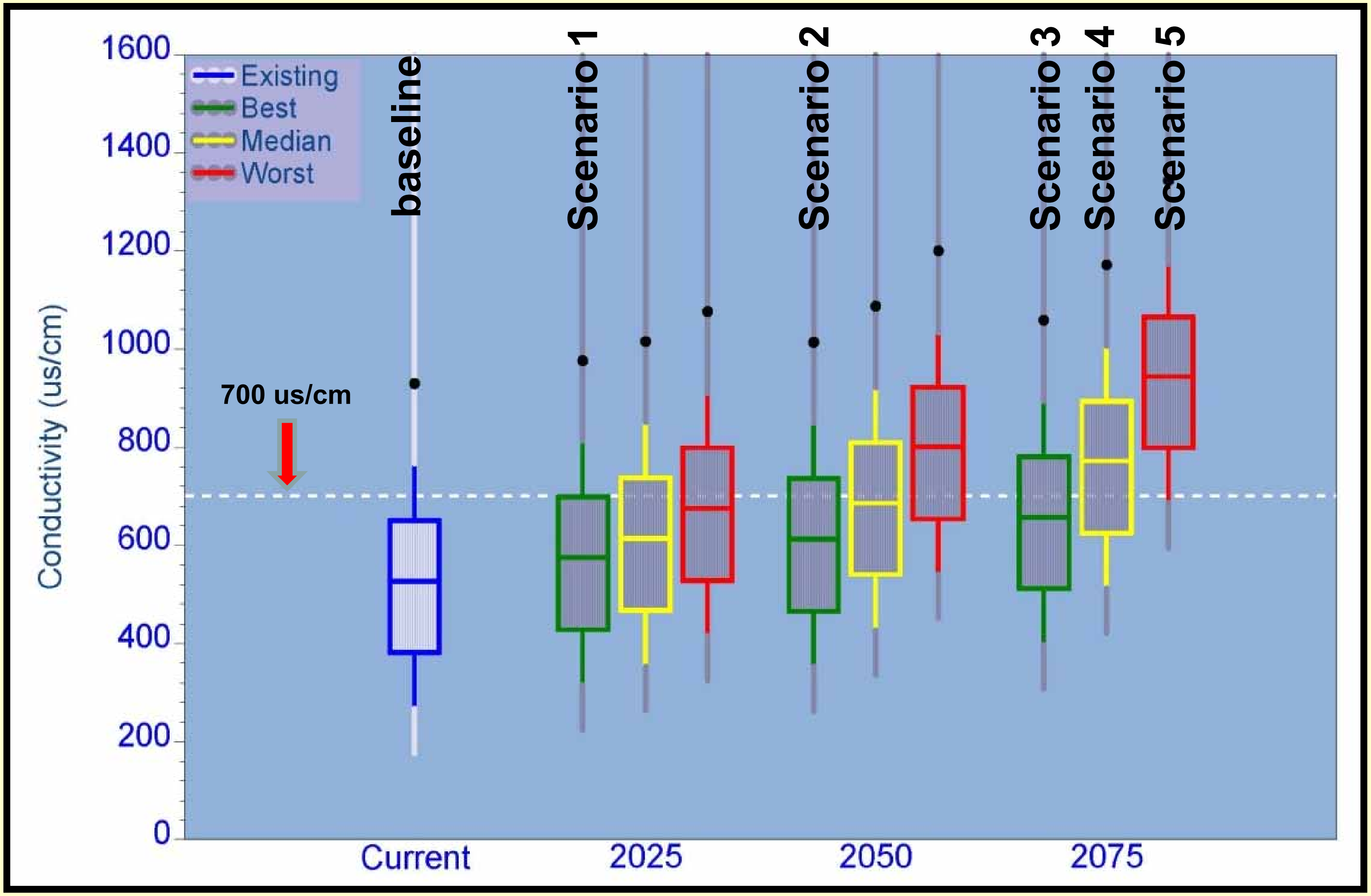
Projected potential probabilities of future increases in near future sea-level rise along southwest Florida coast (IPCC))

- **Future sea-level changes applied in the statistically based modeling used USEPA estimates estimating the probability of occurrence**

- **Provided potential range of sea-level change at three future 25-year intervals**

6 Scenarios Selected

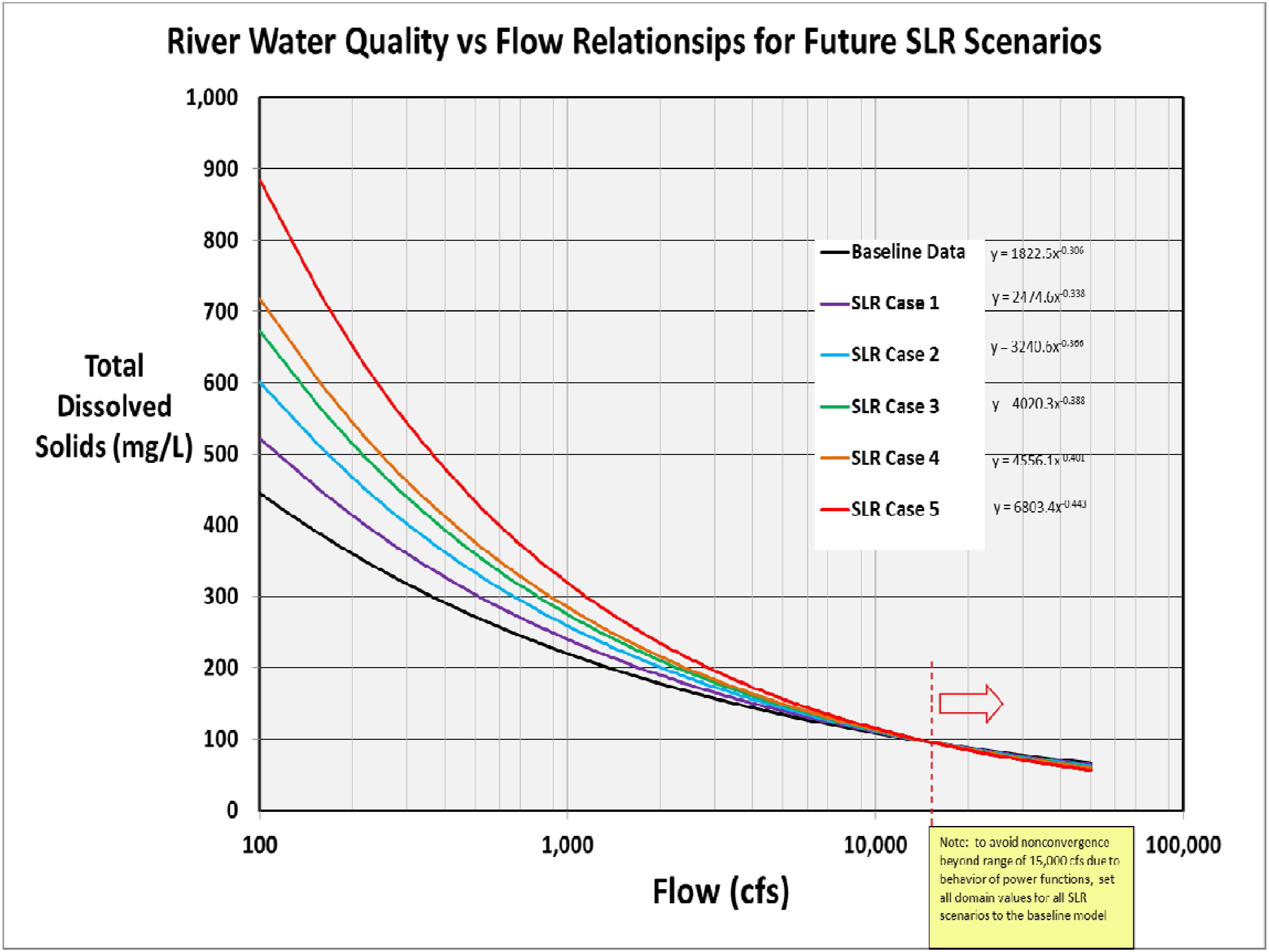
Scenario	Sea Level Rise (inches)
baseline	0
1	2.8
2	5.0
3	7.7
4	14.4
5	24.6

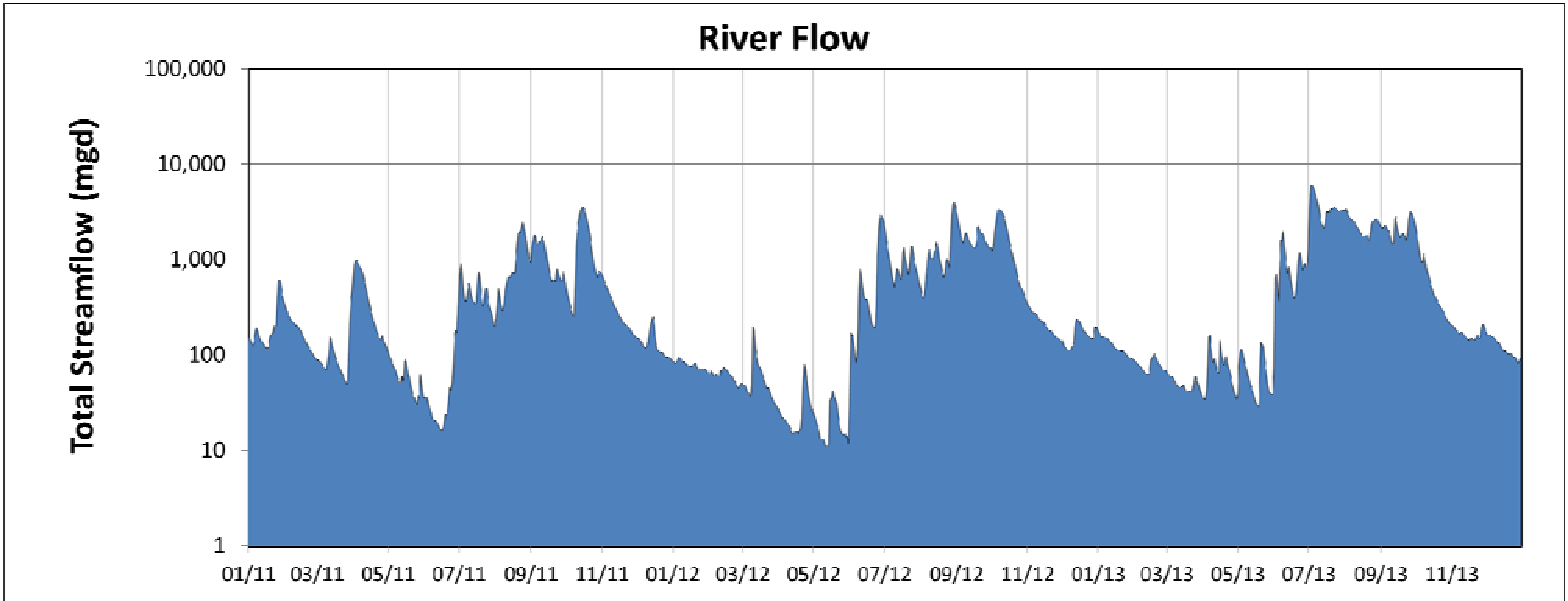


Predicted statistical distribution of conductivity at the Facility intake under each future sea-level rise alternative **(using available 2010-2013 flow and stage data)**

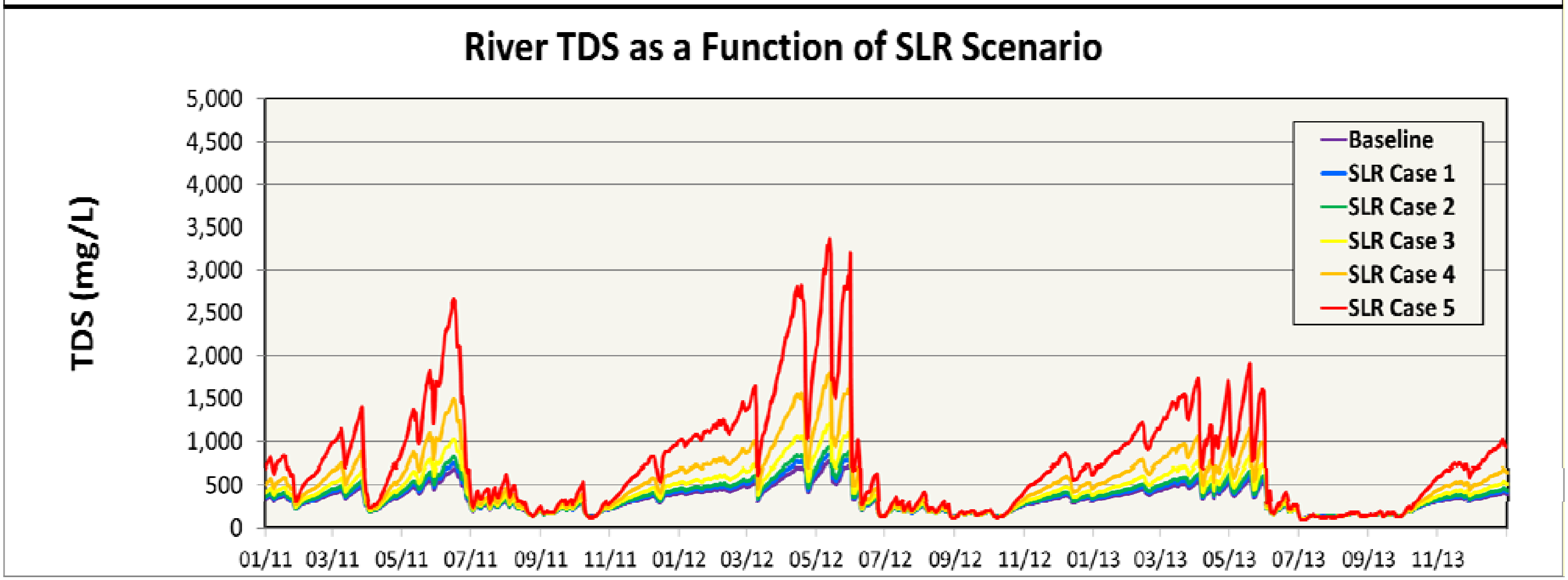
Formulating Future SLR Scenario Curves for River/TDS Relationship

- Use SAS model to project median TDS for scenario at 300 cfs river flow
- Mimic proportional TDS expansion and compression ratios taken from baseline data for 100 and 500 CFS limits, respectively
- Set high flow convergence to good quality water, i.e. 15,000 cfs = 100 mg/L TDS
- Fit polynomial expression to the datum


River Water Quality vs Flow Relationsips for Future SLR Scenarios
Total Dissolved Solids (mg/L)
1,000
900
800
700
600
500
400
300
200
100
0
100
1,000
10,000
100,000
Flow (cfs)
Baseline Data
SLR Case 1
SLR Case 2
SLR Case 3
SLR Case 4
SLR Case 5
$y = 1822.5x^{-0.306}$
$y = 2474.6x^{-0.338}$
$y = 3240.6x^{-0.366}$
$y = 4020.3x^{-0.388}$
$y = 4556.1x^{-0.401}$
$y = 6803.4x^{-0.443}$
Note: to avoid nonconvergence beyond range of 15,000 cfs due to behavior of power functions, set all domain values for all SLR scenarios to the baseline model



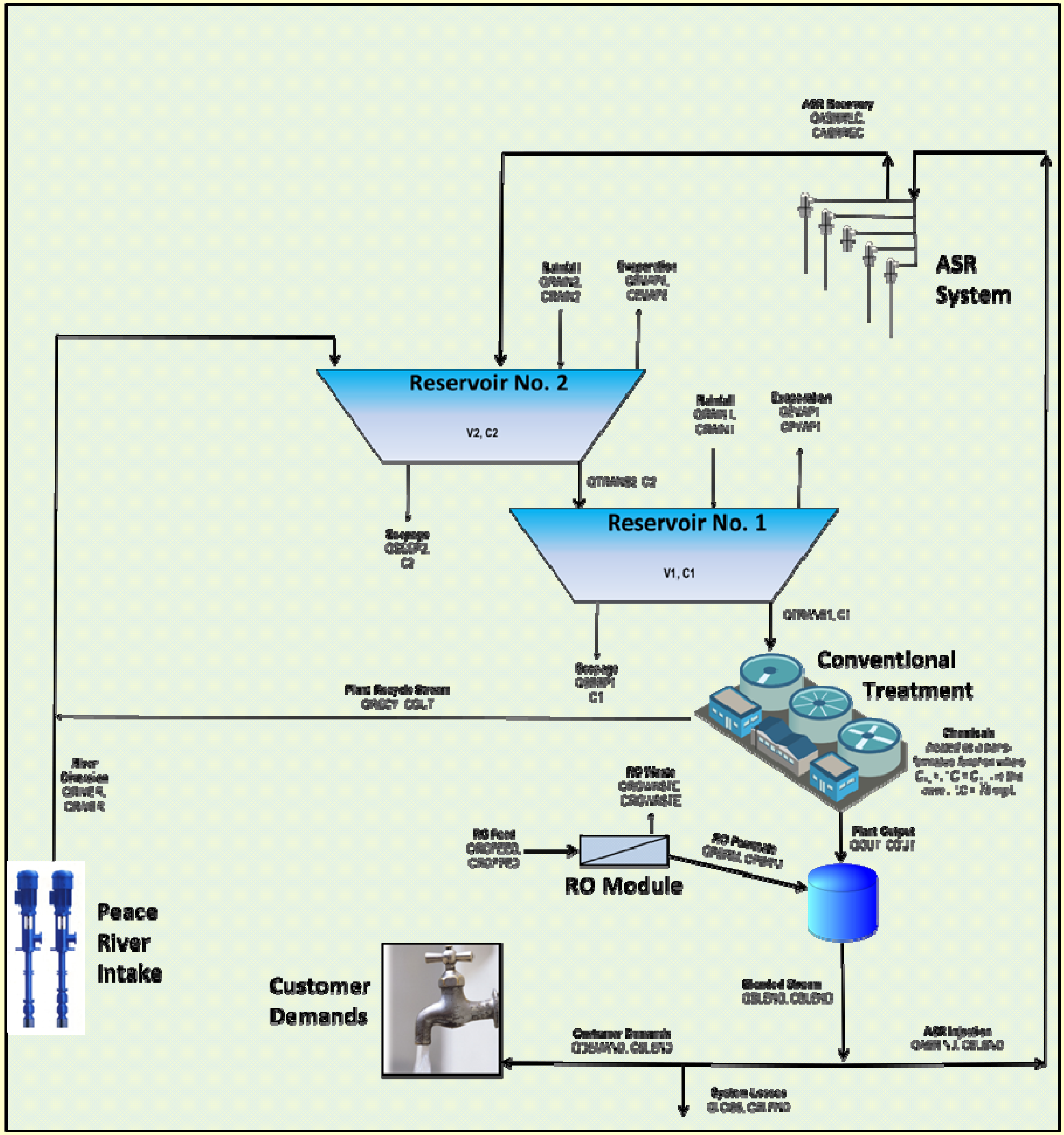
River Flow
Total Streamflow (mgd)
100,000
10,000
1,000
100
10
1
01/11
03/11
05/11
07/11
09/11
11/11
01/12
03/12
05/12
07/12
09/12
11/12
01/13
03/13
05/13
07/13
09/13
11/13



River TDS as a Function of SLR Scenario
TDS (mg/L)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
01/11
03/11
05/11
07/11
09/11
11/11
01/12
03/12
05/12
07/12
09/12
11/12
01/13
03/13
05/13
07/13
09/13
11/13
Baseline
SLR Case 1
SLR Case 2
SLR Case 3
SLR Case 4
SLR Case 5

System Reliability Modeling Starts by Defining Fundamental Solvent & Solute Mass Balance Relationships

(Solute in this case is TDS)



- Solving for Day Ending reservoir and ASR volumes is straightforward

- Solving for Day-Ending TDS concentrations is more rigorous *(examples below)*

Equation 2: *(Reservoir No. 1 Day-Ending TDS in a 2 Reservoir System)*

$$C1_{t+1} = \left[\frac{\left[V1_t{*}C1_t + QTRANS2_t{*}[(C2_t+C2_{t+1})/2] + QRAIN1_t{*}CRAIN1_t - QEVAP1_t{*}CEVAP1_t - C1_t{*}[(QSEEP1_t + QTRANS1_t)/2]\right]}{\left[V1_t + QTRANS2_t + QRAIN1_t - QEVAP1_t - QTRANS1_t/2 - QSEEP1_t/2\right]} \right]$$

Equation 3: *(Reservoir No. 2 Day-Ending TDS in a 2 Reservoir System)*

$$C2_{t+1} = \left[\frac{\left[V2_t{*}C2_t + QRIVER_t{*}CRIVER_t + QRECY_t{*}(COUT_t) - \frac{(QTRANS2_t+QSEEP2_t){*}C2_t}{2} + QASRREC_t{*}CASREC_t + QRAIN2_t{*}CRAIN2_t - QEVAP2_t{*}CEVAP2_t\right]}{\left[V2_t + QRIVER_t + QRECY_t + QASRREC_t + QRAIN2_t - QEVAP2_t - QTRANS2_t/2 - QSEEP2_t/2\right]} \right]$$

System Reliability Model

- PRO-PAT Model (Peace River Operability Platform Assessment Tool)
- Excel-based decision tool
- 6 embedded SLR scenarios
- Model has 109 Variables
  - 49 operational variables
  - 60 climate associated variables
    - Can apply a monthly multiplier for rainfall
    - Can change monthly multiplier for evaporation
    - Can apply a monthly flow multiplier for 3 streams

Reliability Measures

- **Quantity Reliability**

$$\frac{\text{(\# days met full demands)}}{\text{(total days)}}$$

- **Quality Reliability**

$$\frac{\text{(\# days met full demands with TDS} < \text{500 mg/L)}}{\text{(total days)}}$$

Summary

- Decisions Made Today Must be Considered in View of What is Likely in 50 – 100 years
- Strategic Planning Must Consider Adaptation Management Strategies
- Guidelines can only speak to process generalities – Utilities must employ creativity in customizing Adaptive Management Decision Tools and Strategies for their own reality
- Don’t be afraid to borrow approaches from others, we are all in this together!
- Likewise, share approaches you have developed with others!

Acknowledgements

- Ralph Montgomery - Atkins
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- Others
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  - Pete Larkin, PG - CH2M HILL
  - Ryan Messer, PE – CH2M HILL
  - Florida Water and Climate Alliance