BOD Performance Correlation at Georgia's WWTPs

Richard O. Mines, Jr., Laura W. Lackey

Jennifer C. Sheppard

Mercer University

Glen Behrend

Georgia EPD

Acknowledgement

- This project was primarily performed by Ms. Jennie Sheppard, an undergraduate Environmental Engineering student at Mercer University.

Outline

- Objectives
- Importance
- Background & Literature Review
- Methods and Materials
- Results and Discussion
- Summary and Conclusions

Objectives

1. Determine the effect of influent flowrate on influent BOD concentration.
2. Determine the effect of influent BOD loading on effluent BOD concentration.
3. Determine the effect of rainfall on the influent BOD concentration.
4. Determine peaking factors for flows and mass loadings for Georgia's WWTPs.

Importance

- WWTP design should be based on mass influent loadings rather then concentration
- Influent flows and loadings impact the operation and performance of WWTPs
- Impact of rainfall on flows and loadings affects operation and performance of WWTPs

Hydraulic Design Flows

- ***Maximum monthly ADF*** is normally established as the design capacity of a WWTP. ***MMADF ≅ (1.2 - 1.3) ADF***
- ***MMADF*** is used for sizing primary clarification, biological treatment, secondary clarification and solids handling processes.
- ***Peak daily flow*** or ***peak hourly flow*** is used for sizing pumping stations, pumps, pipelines, channel, bar screens, and grit removal systems.
- ***PHF ≅ (2 –3) ADF***

Design Mass Loadings

- ***Annual average daily load (AADL)*** is used for estimating solids production and turndown for aeration blowers and RAS pumps.
- ***Maximum monthly average daily load (MMADL)*** is used for sizing primaries, biological treatment units, and secondary clarifiers.
- ***MMADL ≅ (1.2 – 1.3) AADL***
- ***Peak week average daily load (PWADL)*** is the controlling factor in sizing solids handling facilities.

Design Considerations

- Loading variations should not be estimated by multiplying a single concentration by various calculated flows.
- Should forecast wastewater flows and mass loadings separately.
- Peak flows and constituent loadings usually do not occur concurrently.
- Loading rather than concentration is the fundamental design parameter.

Combined Sewer System

Bertrand-Krajewski et al.

1. WWF ≈ 3.08 times DWF
2. Influent TSS loadings ≈ 10 times DWL
3. Influent BOD loadings ≈ 7 times DWL
4. Influent NH_3 loadings ≈ 1.2 times DWL
5. Effluent TSS loadings ≈ 7 times DWL
6. Active biomass fraction in AB reduced, affects performance for several days after storm events.

Modeling AS Plant with Storm Tanks

Lessard and Beck

1. Total volume of runoff was similar for two storm events (SDHI, LDLI).
2. Mass of COD and SS in influent greater for SDHI storm event.
3. Mass of ammonia in the influent was same for both storm events.
4. For SDHI, locate tank at plant influent or after primaries, operate in fill & bypass mode.
5. For LDLI, locate tank at plant influent, fill to capacity or locate after primary filling to capacity and allowing minor overflows.

High Flows & Plant Performance

Berthouex and Fan

- ***15 WWTPs*** evaluated; 24,554 days of data.
- ***High flow*** caused 298 SS upsets or ***19%*** of the solids upsets.
- ***High flow*** caused 174 BOD upsets or ***11%*** of the BOD upsets.
- ***Average upset length***: 3.5 days for TSS & 3.75 days for BOD.

Materials & Methods

- Obtained plant operating data from the ***Georgia Environmental Protection Division***
- Rainfall data were obtained from **NOAA**
- Plant operating data consisted of monthly averages of ***influent*** & ***effluent BOD*** and TSS; primarily effluent nitrogen, and phosphorus concentrations, and ***flowrates***
- Data from the ***2003 calendar year*** were evaluated

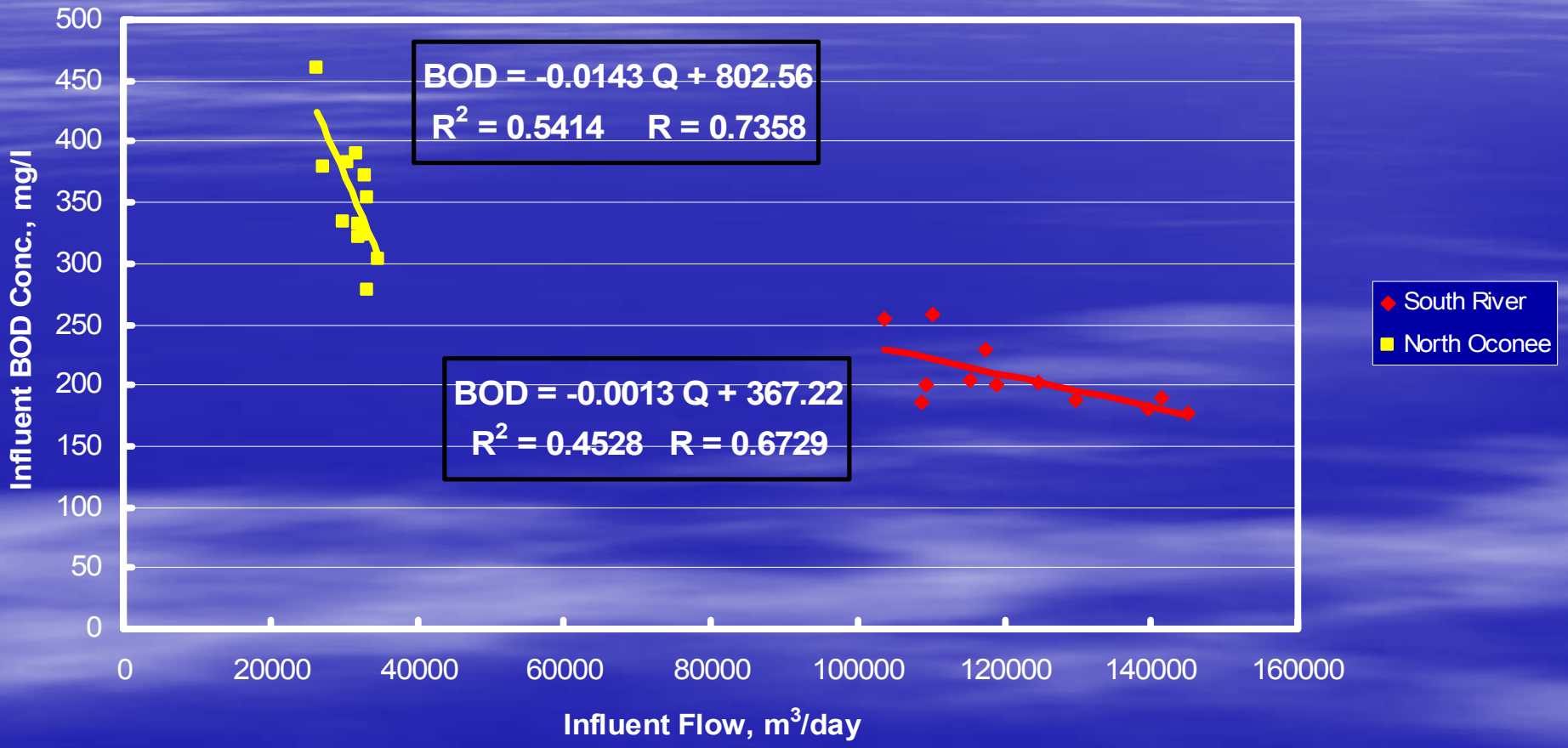
Facilities Evaluated

- 24 domestic wastewater treatment facilities located throughout the state of Georgia
- Capacity of the facilities were 37,850 m^3/day (10 mgd) up to 454,000 m^3/day (120 mgd)
- All the facilities used biological treatment in the form of activated sludge or some modification
- One facility used wetlands for effluent disposal

Data Reduction

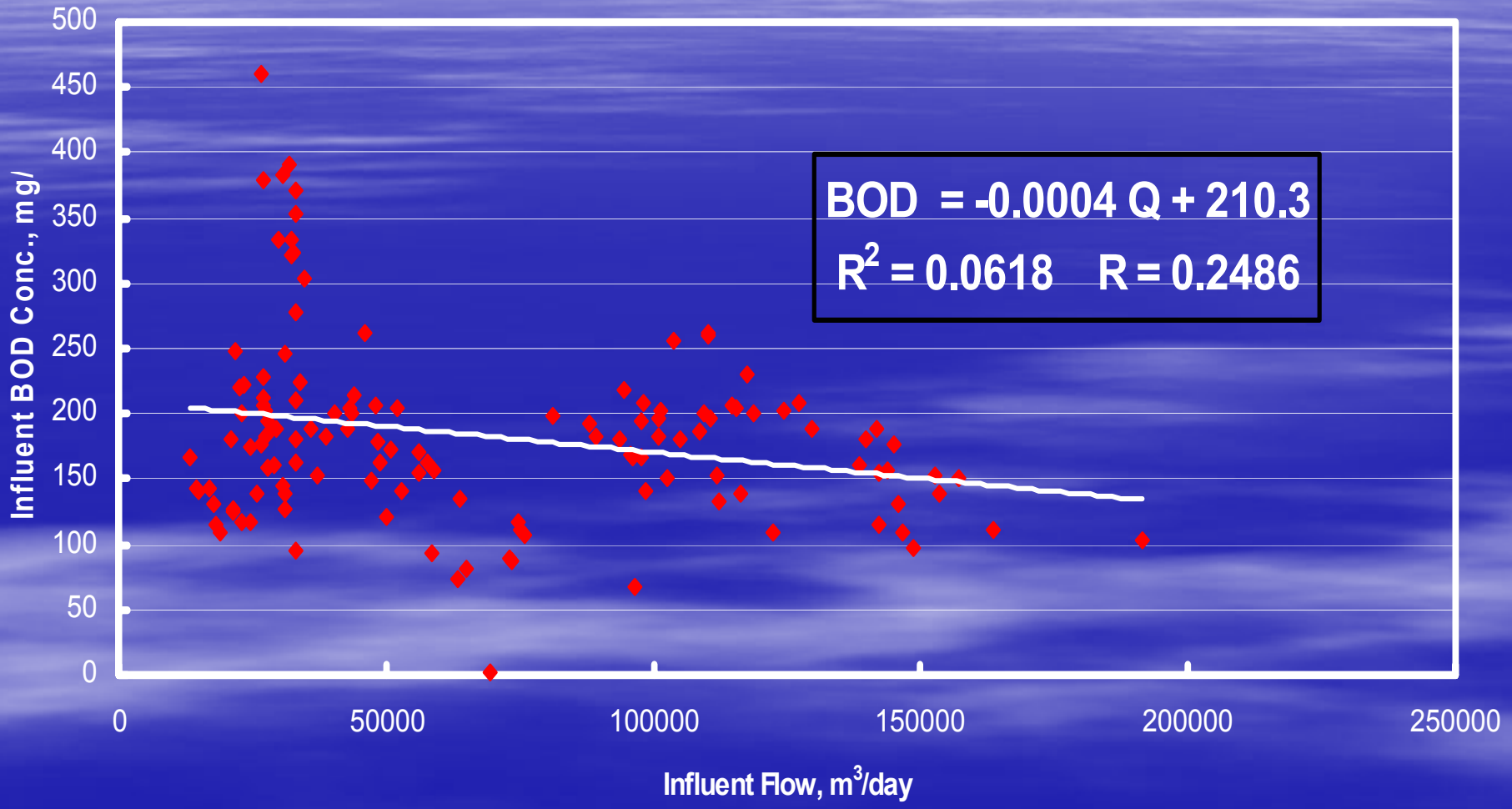
- Influent flowrate versus influent BOD concentration
- Influent BOD loading versus effluent BOD concentration
- Monthly average rainfall versus influent BOD concentration
- A **correlation coefficient (R)** value of 0.4 was considered significant.

Influent Q vs. Influent BOD



Influent Q vs. Influent BOD

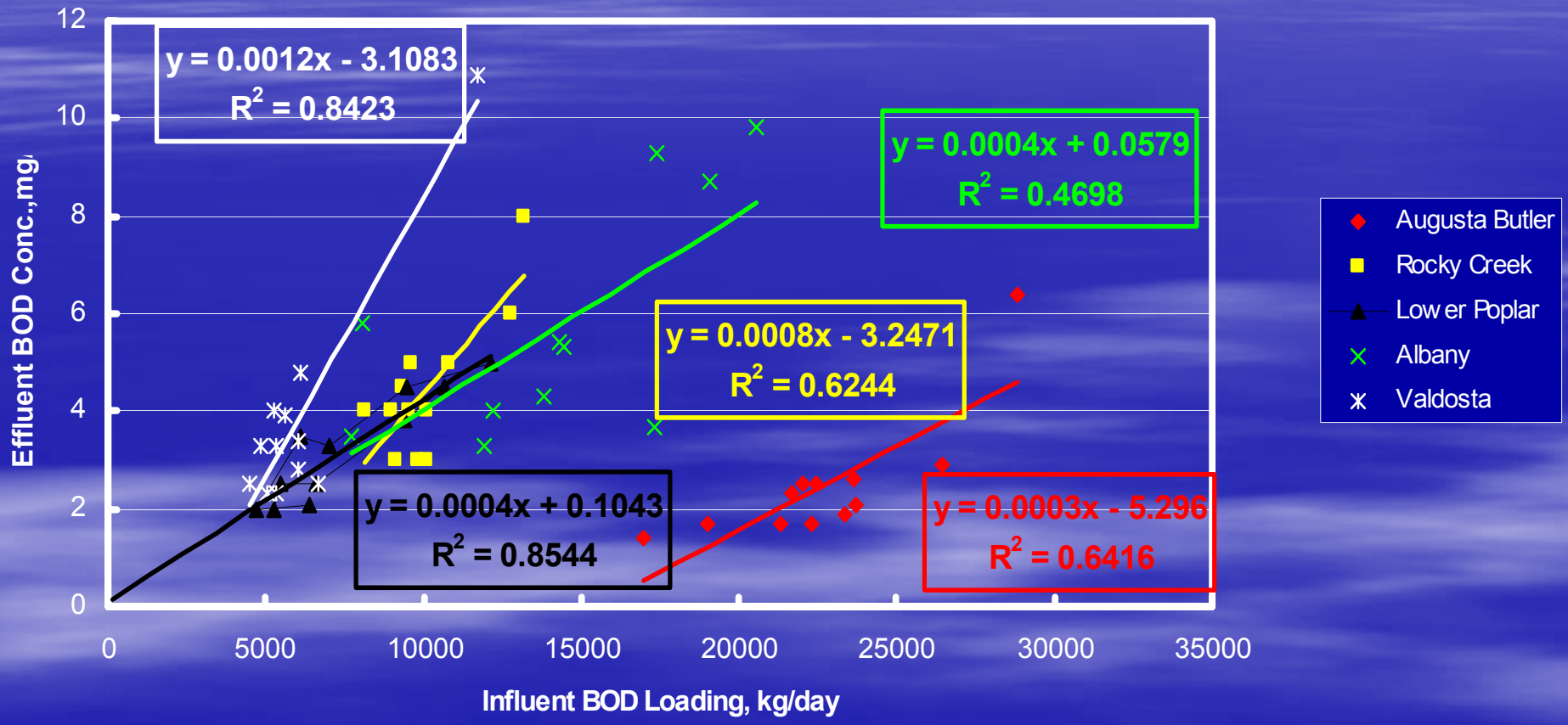
(11 facilities)



Influent Q vs. Influent BOD

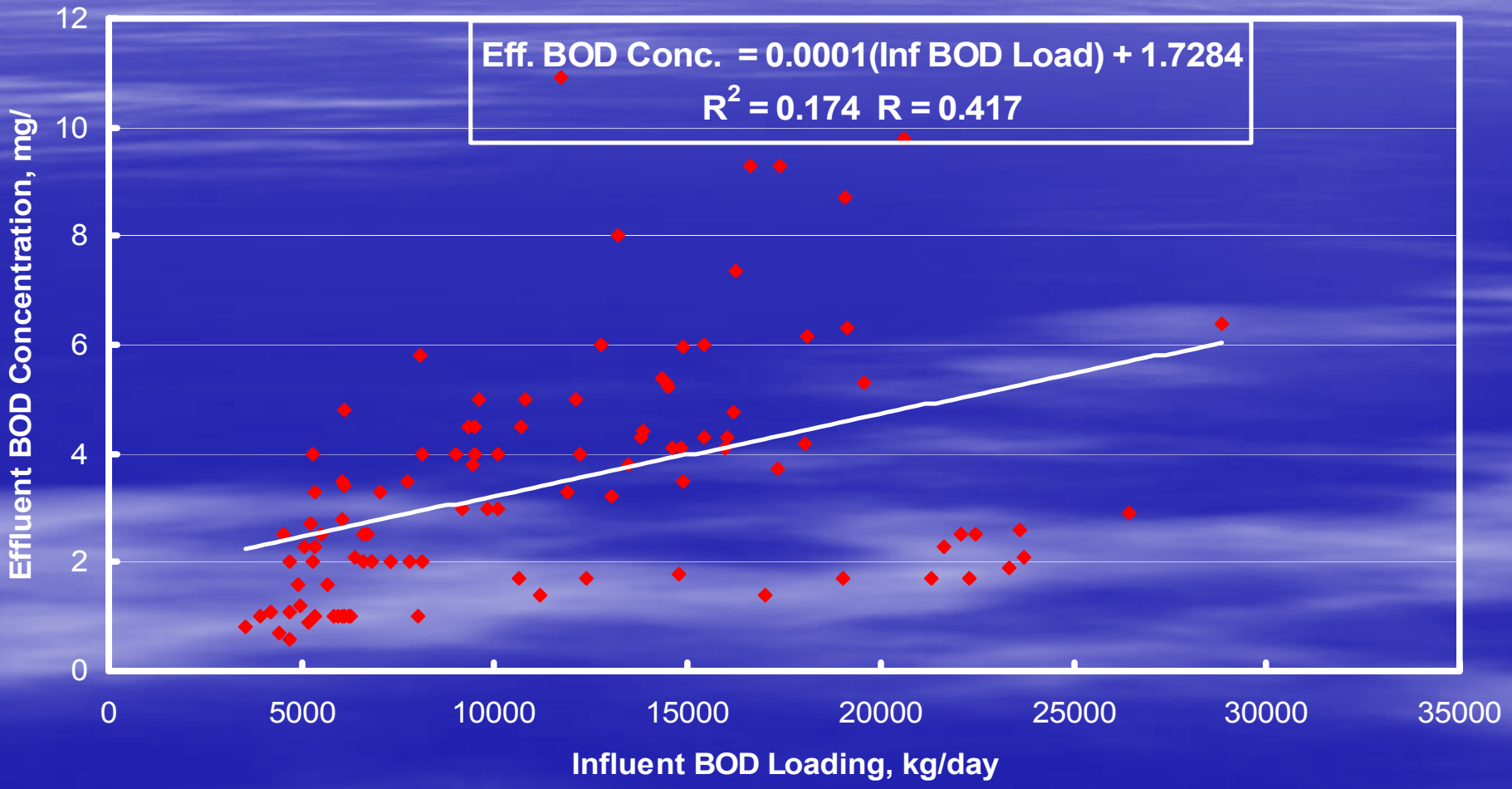
1. ***22*** out of ***24*** facilities had negative slope indicating that influent BOD concentration (mg/L) decreases with increase in influent flow (m^3/day).
2. ***16*** out of ***22*** facilities had a correlation coefficient of $R \geq 0.4$.
3. ***R*** ranged from 0.47 to 0.95, averaging ***0.47*** .
4. ***Influent BOD = -0.0004 (Q) + 210.3***

Influent BOD Loading vs. Effluent BOD



Influent BOD Loading vs. Effluent BOD

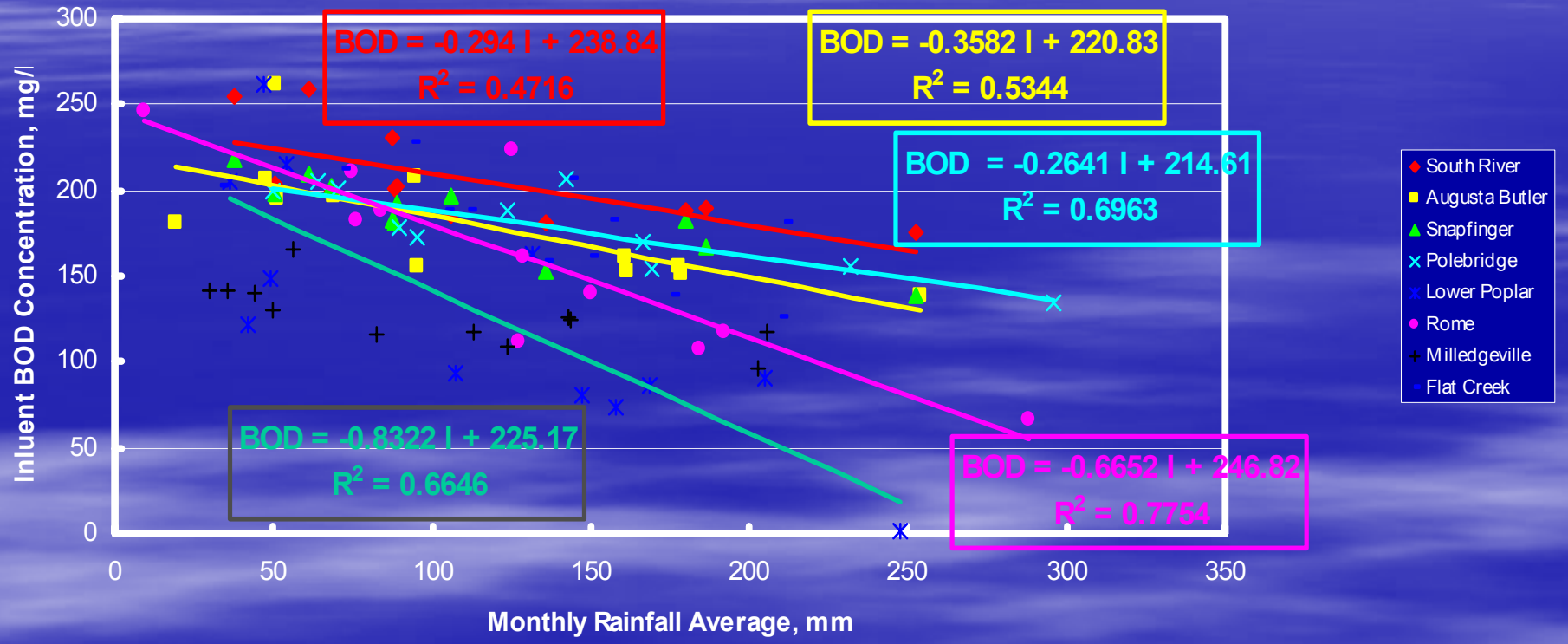
(9 facilities)



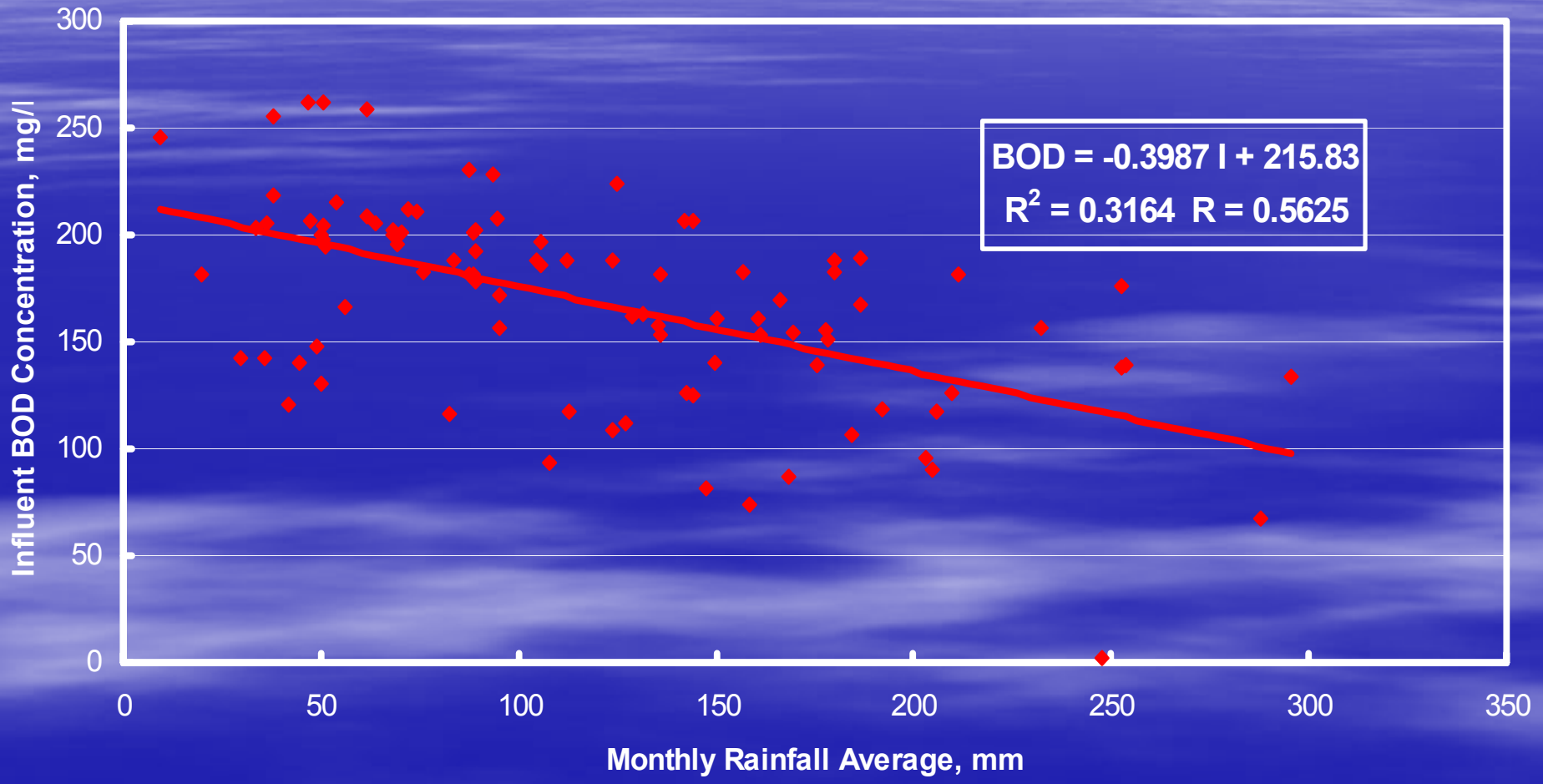
Influent BOD Loading vs Effluent BOD Concentration

1. ***15*** out of ***24*** facilities had positive slope indicating influent BOD loading (kg/day) correlates to the effluent BOD concentration (mg/L).
2. ***9*** out of ***15*** facilities had a correlation coefficient of $R \geq 0.4$.
3. ***Correlation coefficients*** ranged from 0.44 to 0.92, averaging ***0.68*** .
4. ***Effluent BOD = 0.0001(Inf. BOD Load) + 1.7824***

Monthly Rainfall vs. Influent BOD



Monthly Rainfall vs. Influent BOD



Monthly Rainfall vs. Influent BOD

1. ***22*** out of ***24*** facilities had a negative slope indicating a correlation between monthly rainfall intensity (mm) and influent BOD concentration (mg/L).
2. ***15*** out of ***22*** facilities had an correlation coefficient of $R \geq 0.4$.
3. ***Correlation coefficient*** ranged from 0.47 to 0.96; averaging ***0.47*** .
4. ***Influent BOD = -0.3987 (I) + 215.83***

Flow Peaking Factors

Parameter	Average	Range
Maximum Monthly: Average Daily Flow	*1.29*	*1.11-1.78*
Peak Daily: Average Daily Flow	*1.56*	*1.28-2.44*

Concentration Peaking Factors

Parameter	Average	Range
Maximum Monthly BOD: Average Daily BOD Conc.	*1.34*	*1.07 -- 2.04*
Peak Daily BOD: Average Daily BOD Concentration	*1.68*	*1.19 – 2.49*
Maximum Monthly TSS: Average Daily TSS Conc.	*1.36*	*1.12 – 1.79*
Peak Daily TSS: Average Daily TSS Concentration	*2.10*	*1.10 -- 2.69*

Loading Peaking Factors

Parameter	Average	Range
Maximum Monthly BOD: Average Daily BOD Loading	*1.58*	*1.10-- 4.64*
Peak Daily BOD: Average Daily BOD Loading	*1.83*	*0.97 – 5.38*
Maximum Monthly TSS: Average Daily TSS Loading	*1.64*	*1.13 – 4.49*
Peak Daily TSS: Average Daily TSS Loading	*2.33*	*1.32--6.74*

Misuse of Peaking Factors

$$\frac{MMBOD_{Conc}}{ADBOD_{Conc}} = 2.04 \quad MMBOD_{Conc} = 2.04(129) = 263\frac{mg}{L}$$

$$MMBOD_{Load} = 73429\frac{m^3}{d}(263)(1/1000) = 19312\frac{kg}{day}$$

$$Actual\ MMBOD_{Load} = 12108\frac{kg}{day} \qquad \frac{19312}{12108}(100) = 159\%$$

This results in a 59% over estimation.

Summary

- ***24*** WWTPs located throughout Georgia were ***evaluated***
- ***Capacity*** of the facilities ranged from ***37,850 m^3/day (10 mgd)*** to ***454,000 m^3/day (120 mgd)***
- All facilities used biological treatment in the form of activated sludge or some modification
- Correlations were established between ***influent flow and BOD concentration***; ***influent BOD loading and effluent BOD***, and ***monthly rainfall and influent BOD***
- ***Peaking factors*** for flows, and BOD & TSS loadings ***established***

Major Conclusions

1. A correlation between influent flow and influent BOD was established for 22 out of 24 facilities
2. ***Influent BOD = -0.0004 (Q) + 210.3***
3. A correlation between influent BOD loading and effluent BOD concentration was established for 15 out of 24 facilities
4. ***Effluent BOD =-0.0001(Inf. BOD Load)+1.7284***
5. A correlation between monthly rainfall and influent BOD concentration was established for 22 out of 24 facilities
6. ***Influent BOD Conc.= -0.3987 (I) + 215.83***
7. Peaking factors established for flows & loadings

Questions?