Delaware River Basin Commission

Review & Evaluation of Ultimate BOD Data from Point Sources in the Delaware Estuary

Model Expert Panel Meeting

July 25 – 26, 2017

Namsoo Suk, Ph.D., DRBC

WQAC Meeting August 24, 2017

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WHYY – Radio Times program

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Review & Evaluation of BOD-90 Data for the Delaware Estuary

Erik L. Silldorff (November 18, 2016)

Background

Nutrient Control under DRBC's Regulation

- DRBC issued $CBOD_{20}$ wasteload allocations in 1968 for dischargers in Zones 2 – 5
- Required Zone % reduction of $CBOD_{20}$: 86% – 89.25%
- Effluent limitation for ammonia-nitrogen is 30-day average of 35 mg/L for dischargers in the Estuary

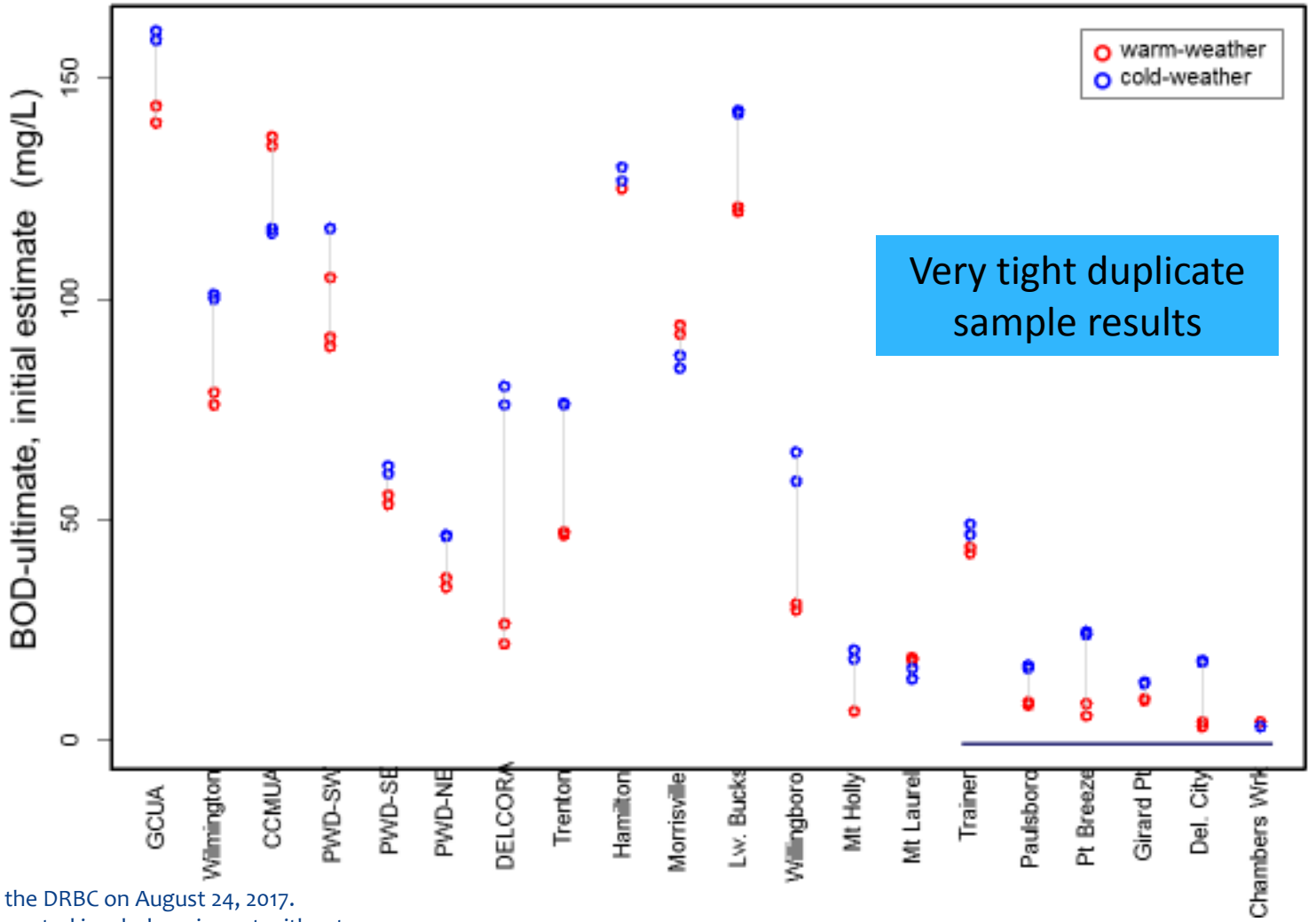
Ultimate BOD Monitoring

- 20 point source dischargers (14 municipal and 6 industrial)
- Effluents were collected in summer of 2015 and winter of 2016
- One duplicate analysis for each sample
- Work group was formed and established a procedure
- Single laboratory (NJDOH Lab) was used

Measured Parameters and Frequencies

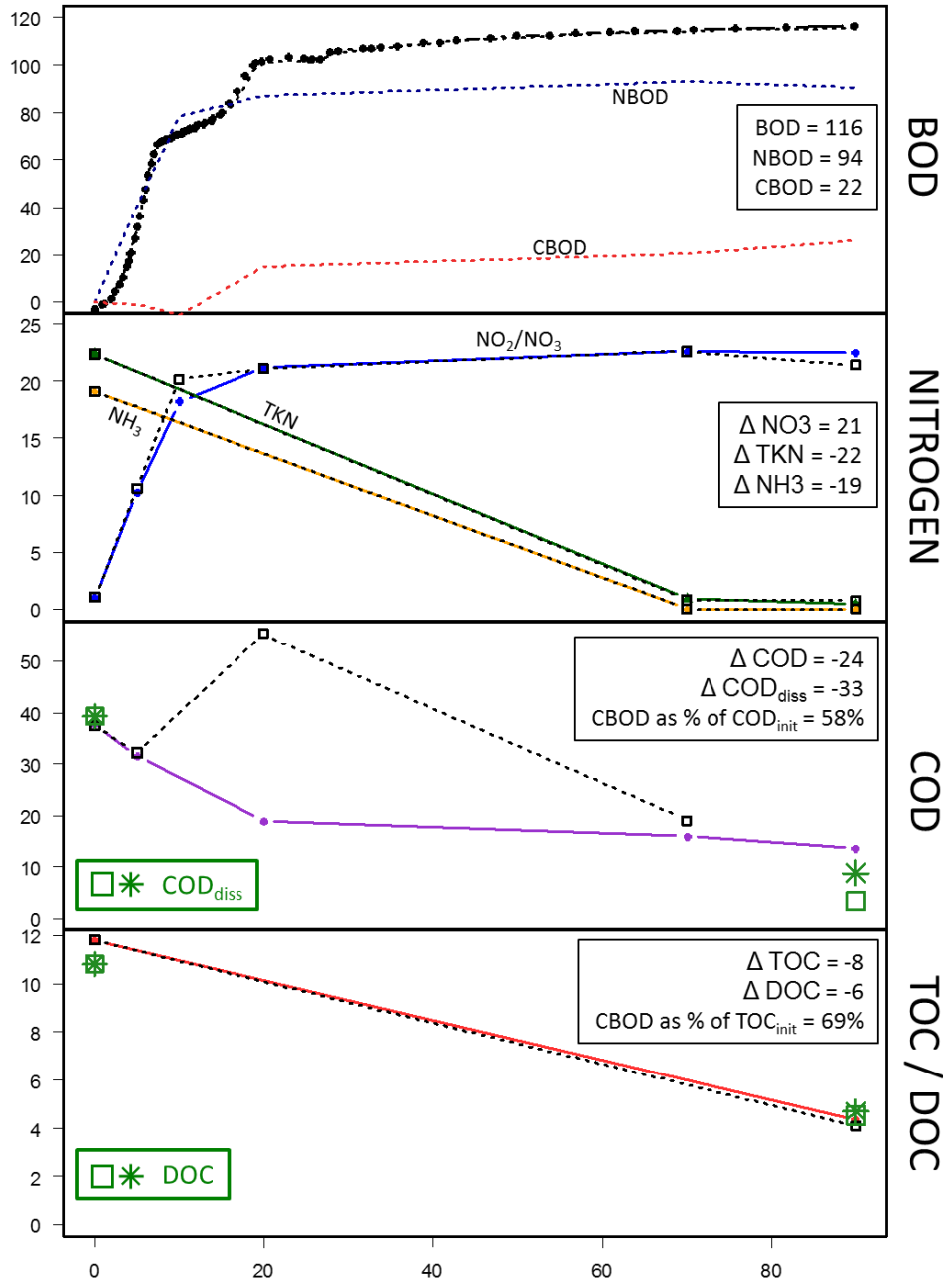
	Day 0	Day 5	Day 10	Day 20	Day 40	Day 60	Day 90
BOD		O	O	O	O	O	O
NH3-N	O					O	O
TKN	O					O	O
NO2+NO3-N	O	O	O	O	O	O	O
COD	O	O		O		O	O
TOC/DOC	O						O
TP/SRP	O						O

BOD-ult for each facility



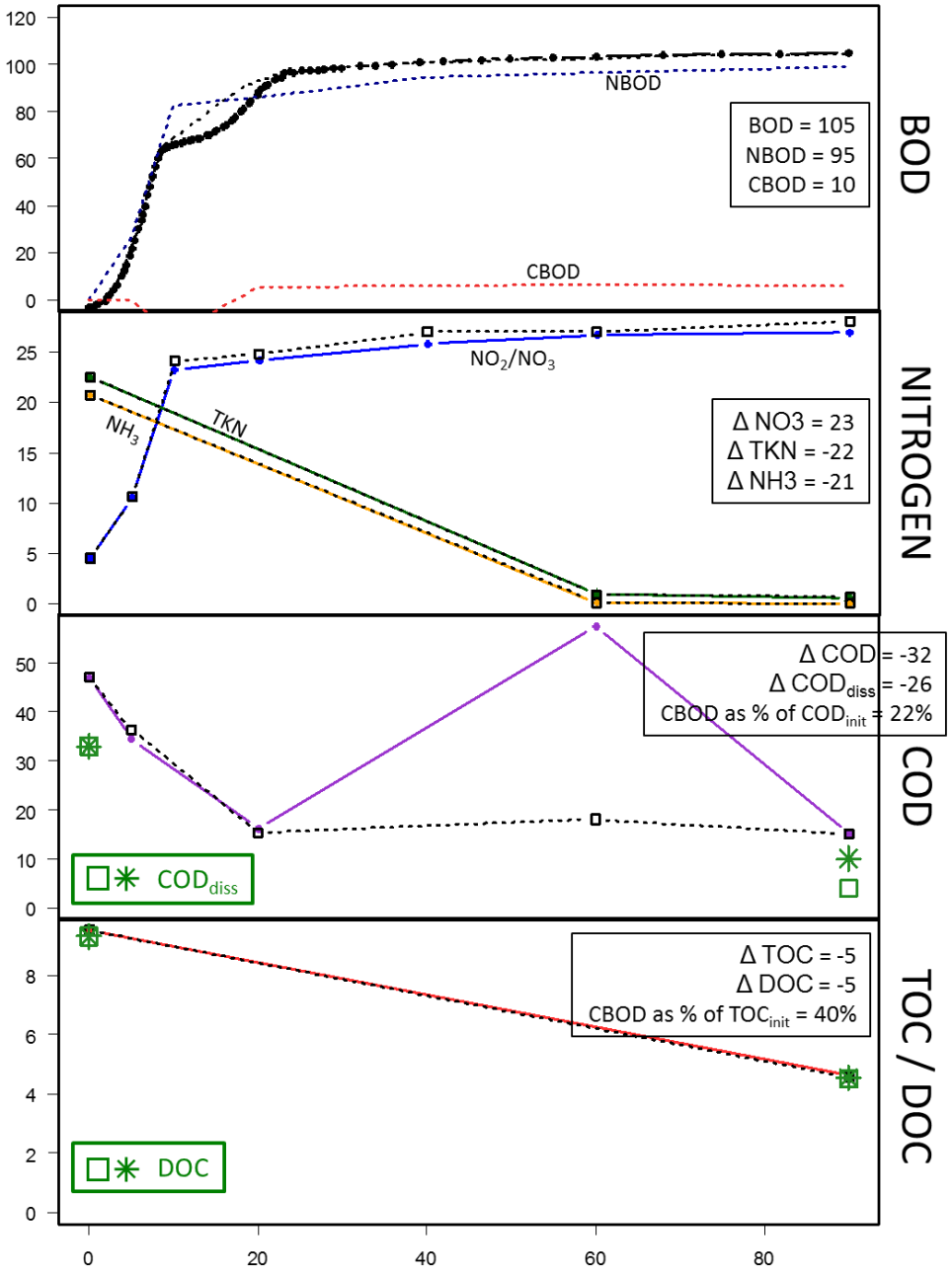
PWD - Southwest – winter

Q= 196 MGD



PWD - Southwest – summer (make-up)

Q= 133 MGD



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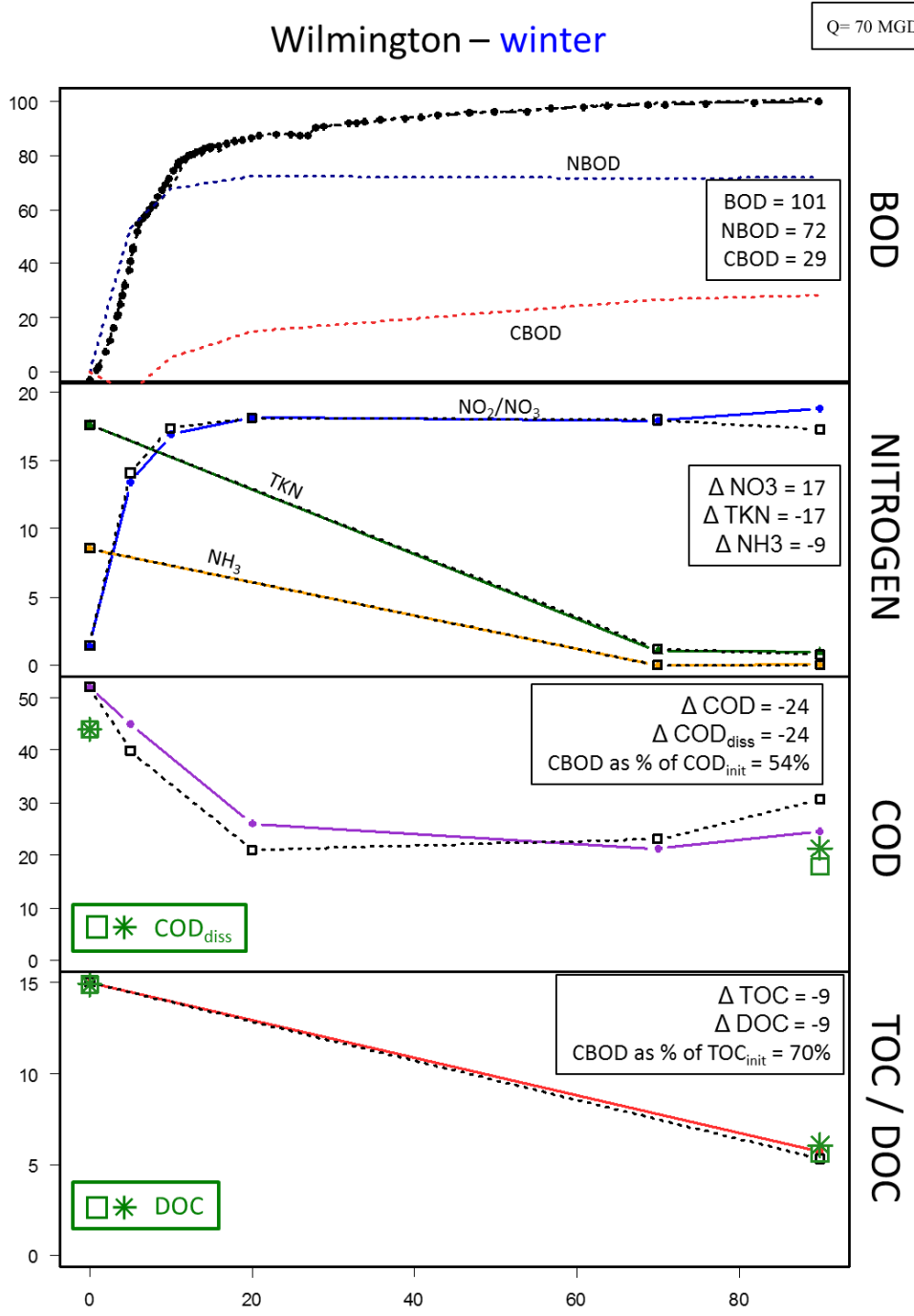
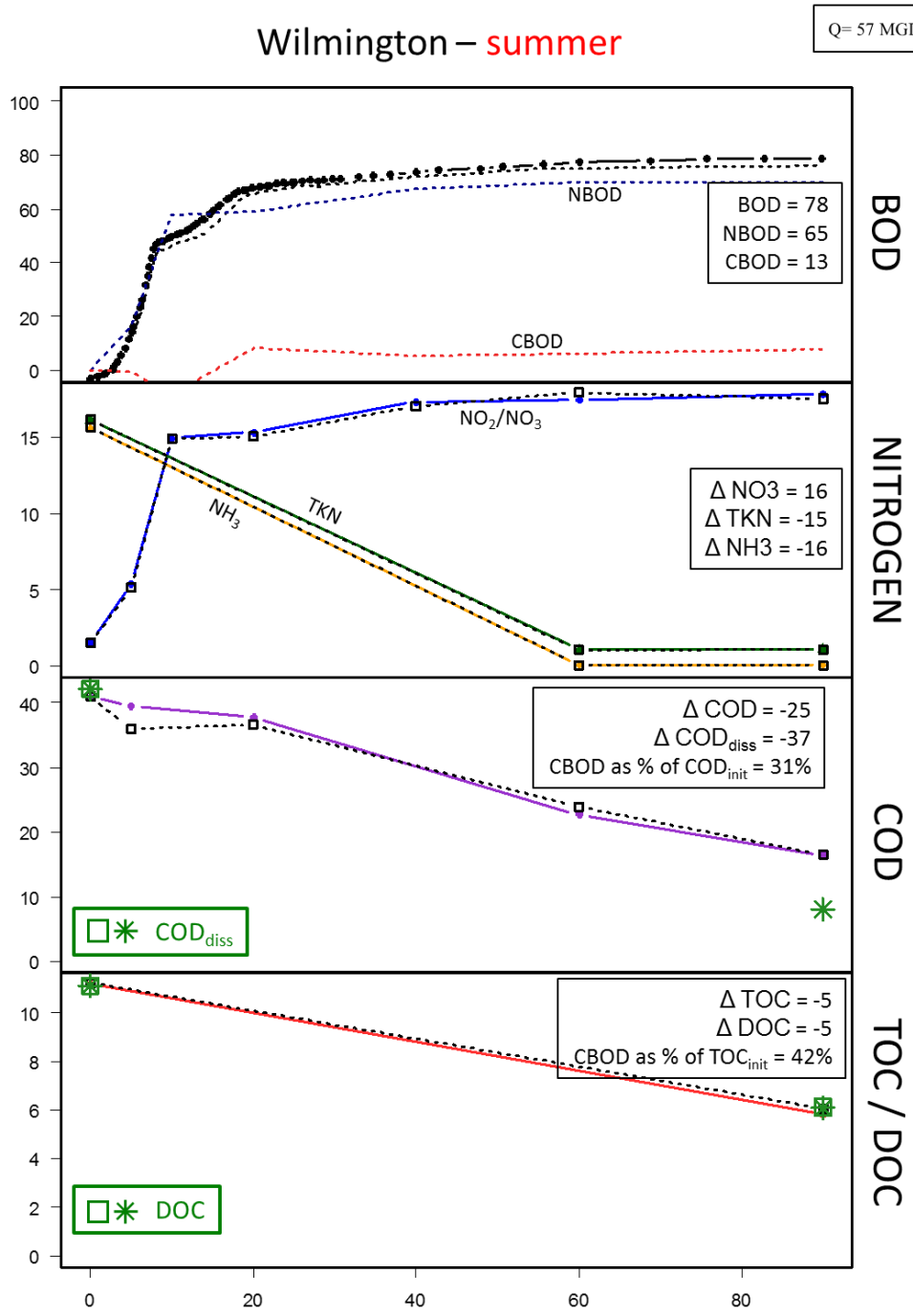
Wilmington – winter



Wilmington – summer



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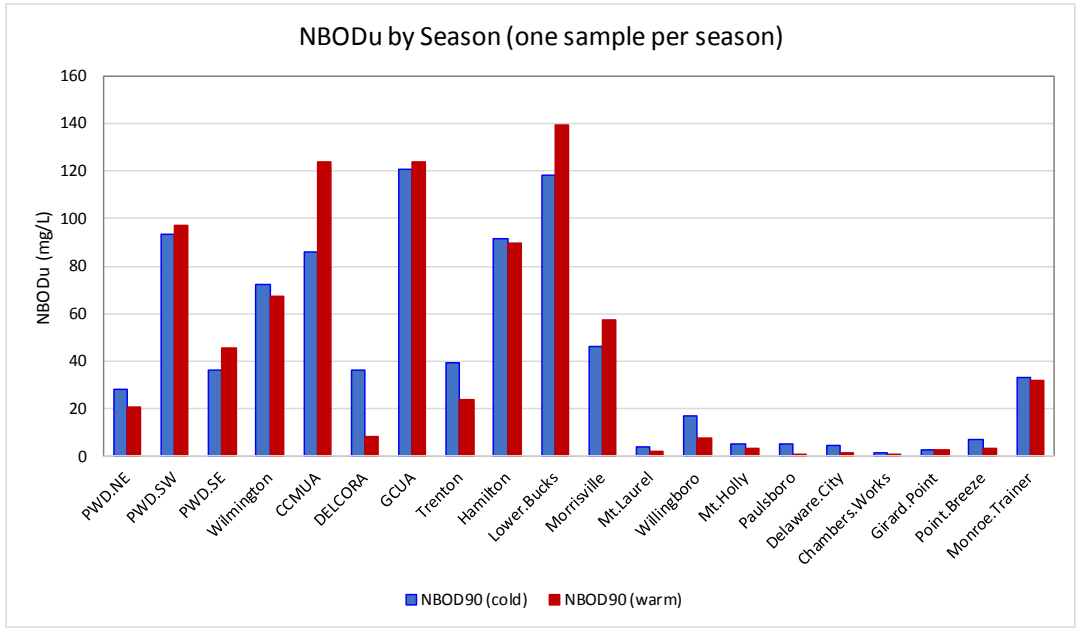
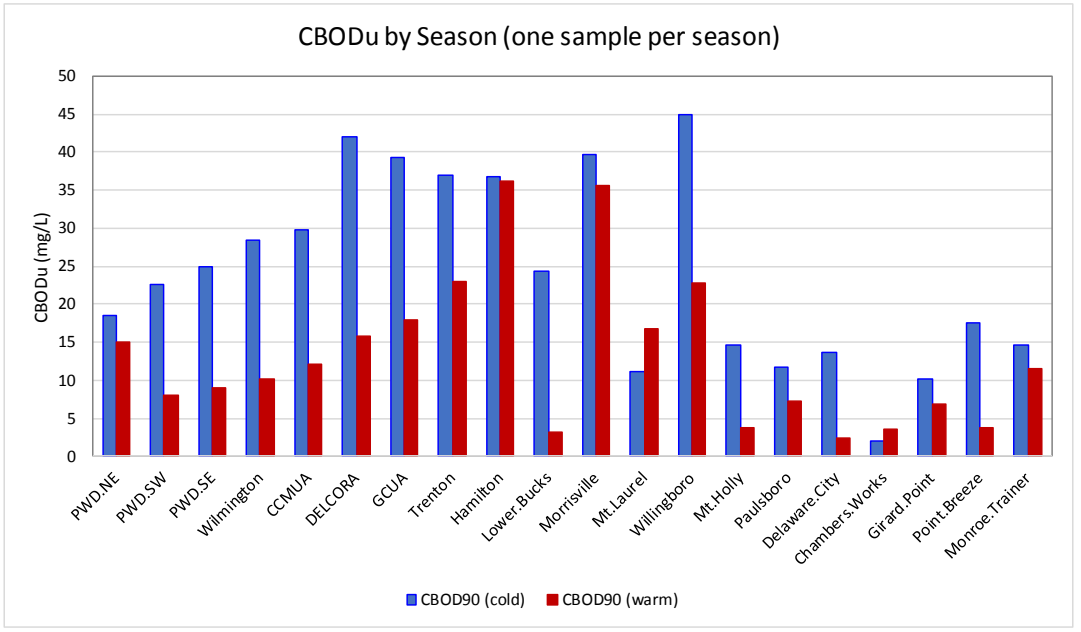
Seasonality ?

NBODu = (Δ TKN) * 4.57 or 4.33
Or
NBODu = (Δ NO_3-N) * 4.57 or 4.33

$CBOD_u = BOD_u - NBOD_u$





CBODu (cold) > CBODu (warm) for all but two

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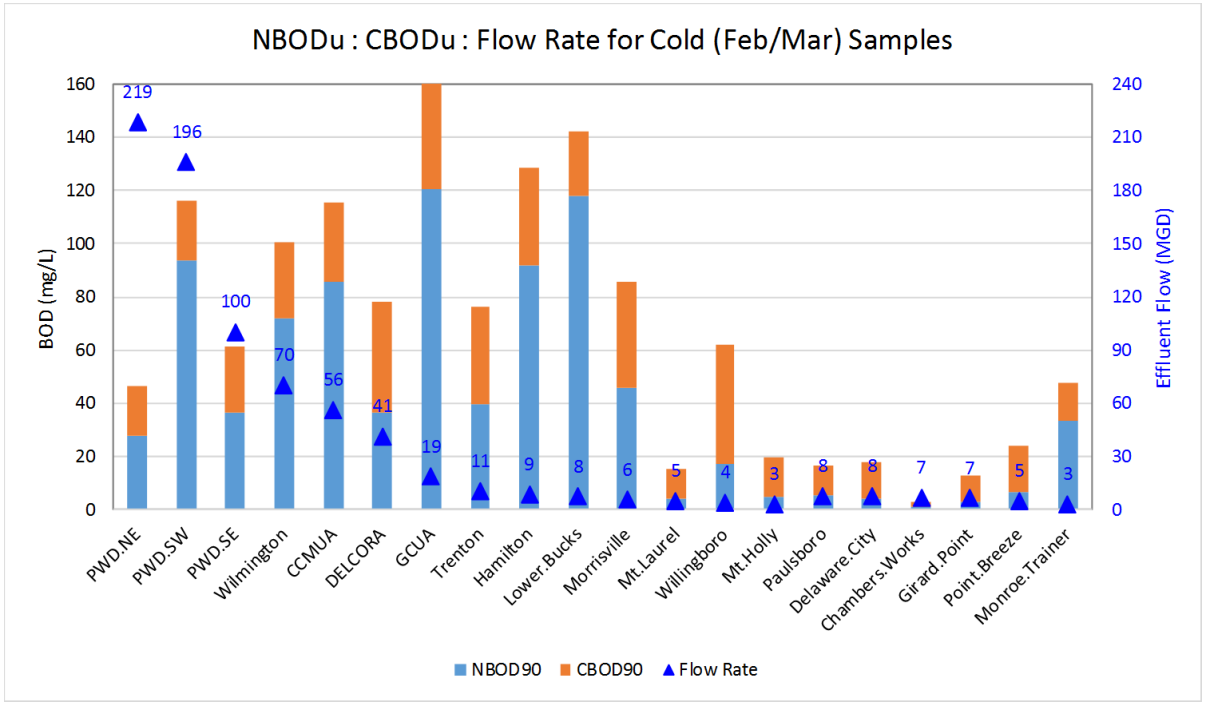
NBOD Estimate: Alternative Methods

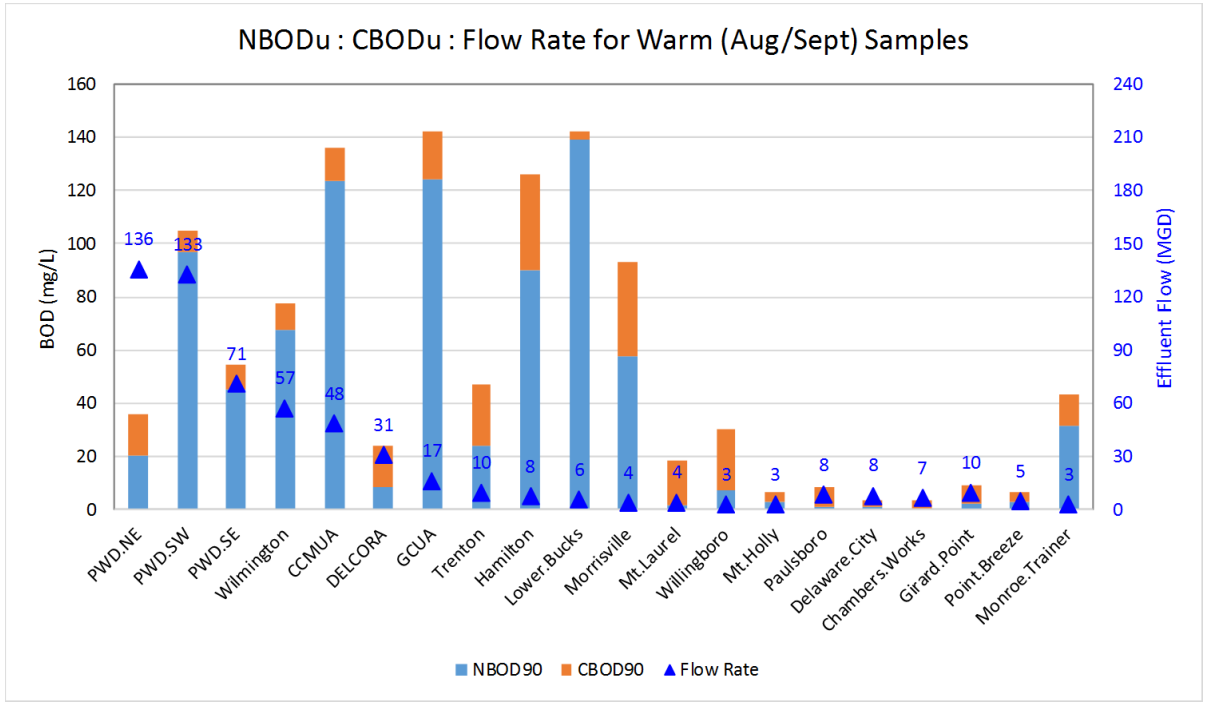
- **Stoichiometry indicates 4.57 mg/L of Oxygen consumption for each mg/L of reduced Nitrogen**

- **Empirical data suggest actual value of 4.33 mg/L**
  - → **biological uptake**
  - → **utilization of Oxygen from CO_2 and HCO_3**

- **Two possible methods for estimating net conversion**
  - → ***increase*** **in NO2-NO3 from Day 0 to Day 90**
  - → ***decrease*** **in TKN from Day 0 to Day 90**

$NBOD_u$: $CBOD_u$: Flow Rate by Season





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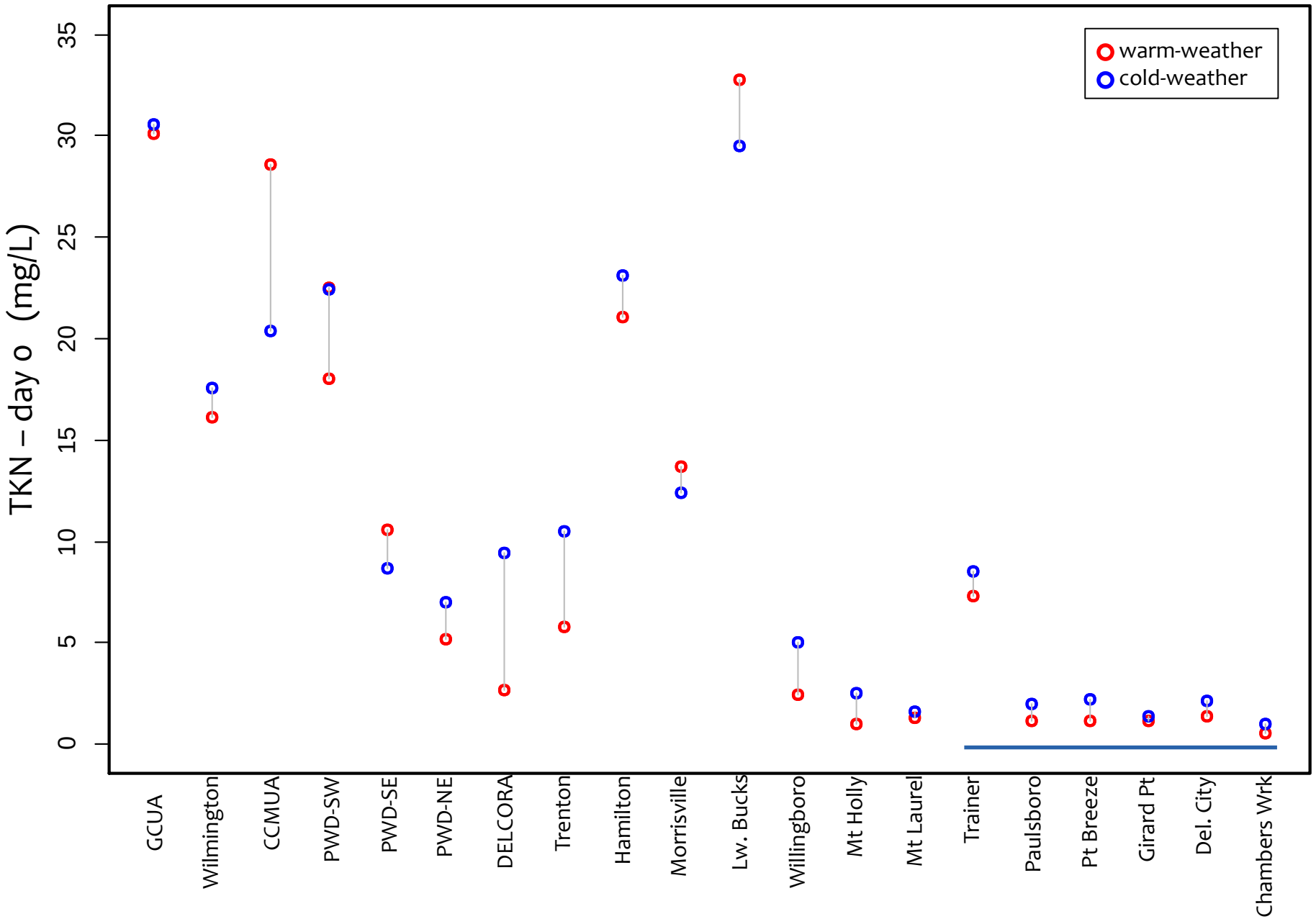
TKN for each facility (day 0)



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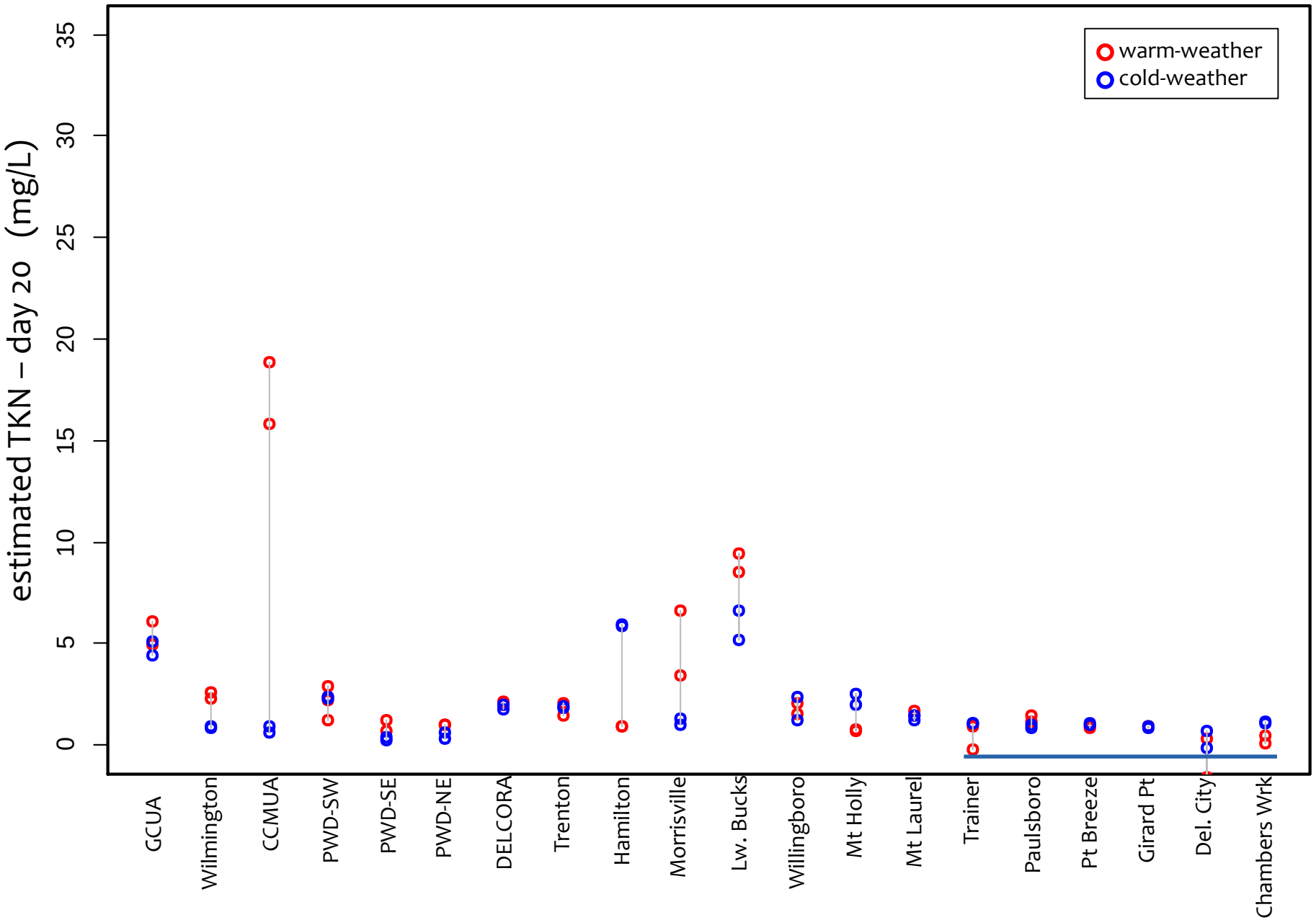
TKN for each facility (DAY 20... estimated from NO3 curve)



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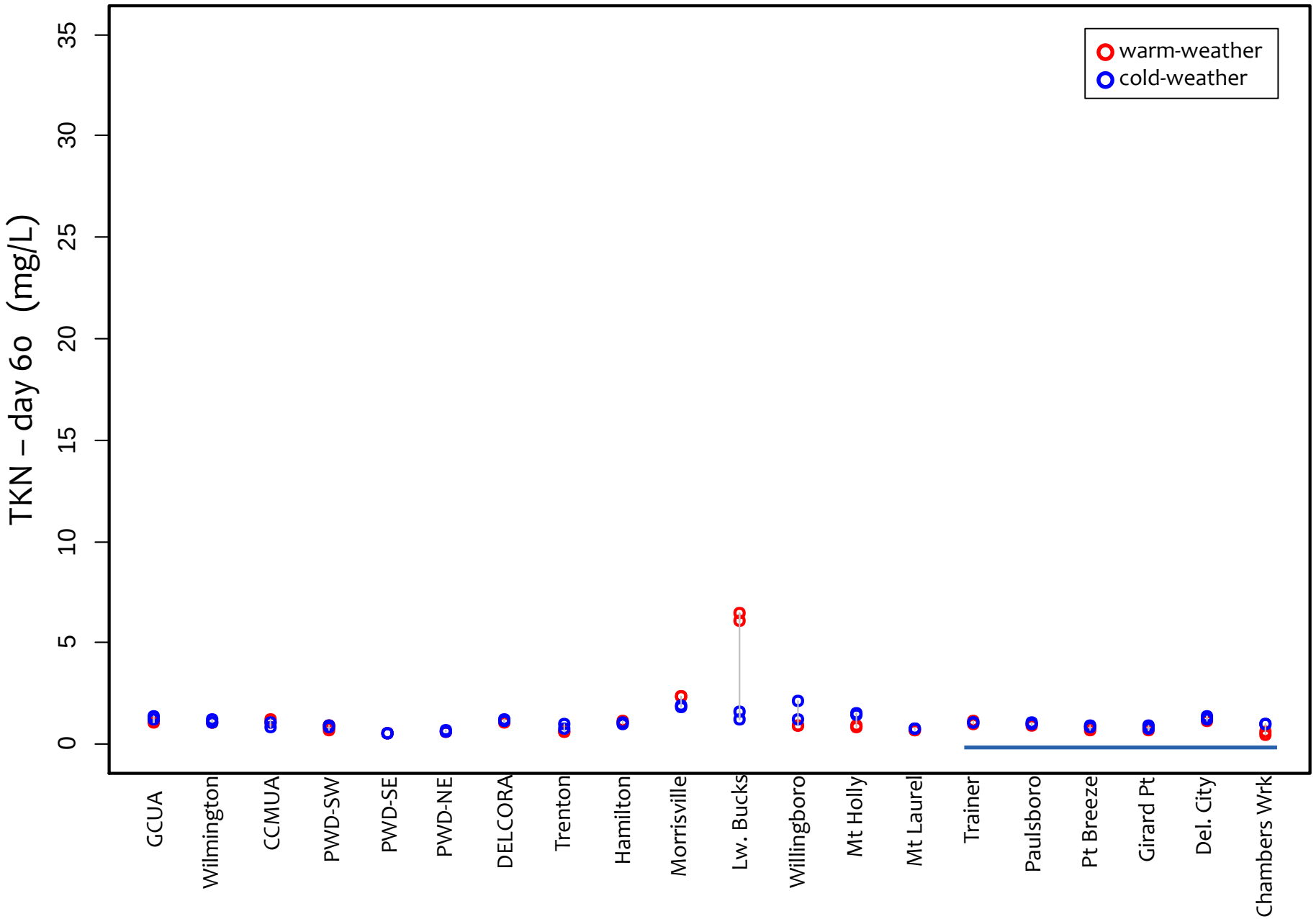
TKN for each facility (DAY 60)



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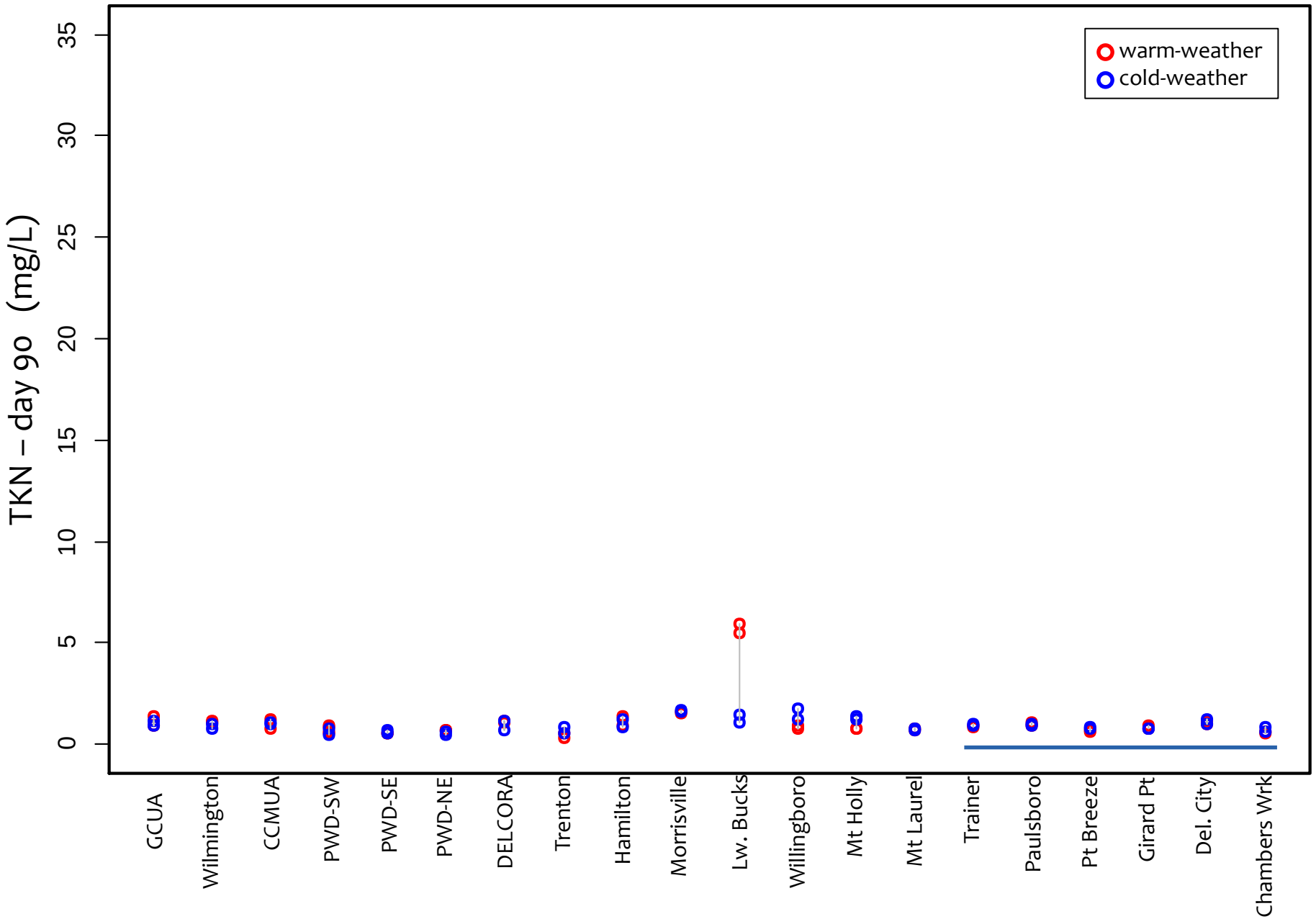
TKN for each facility (DAY 90)



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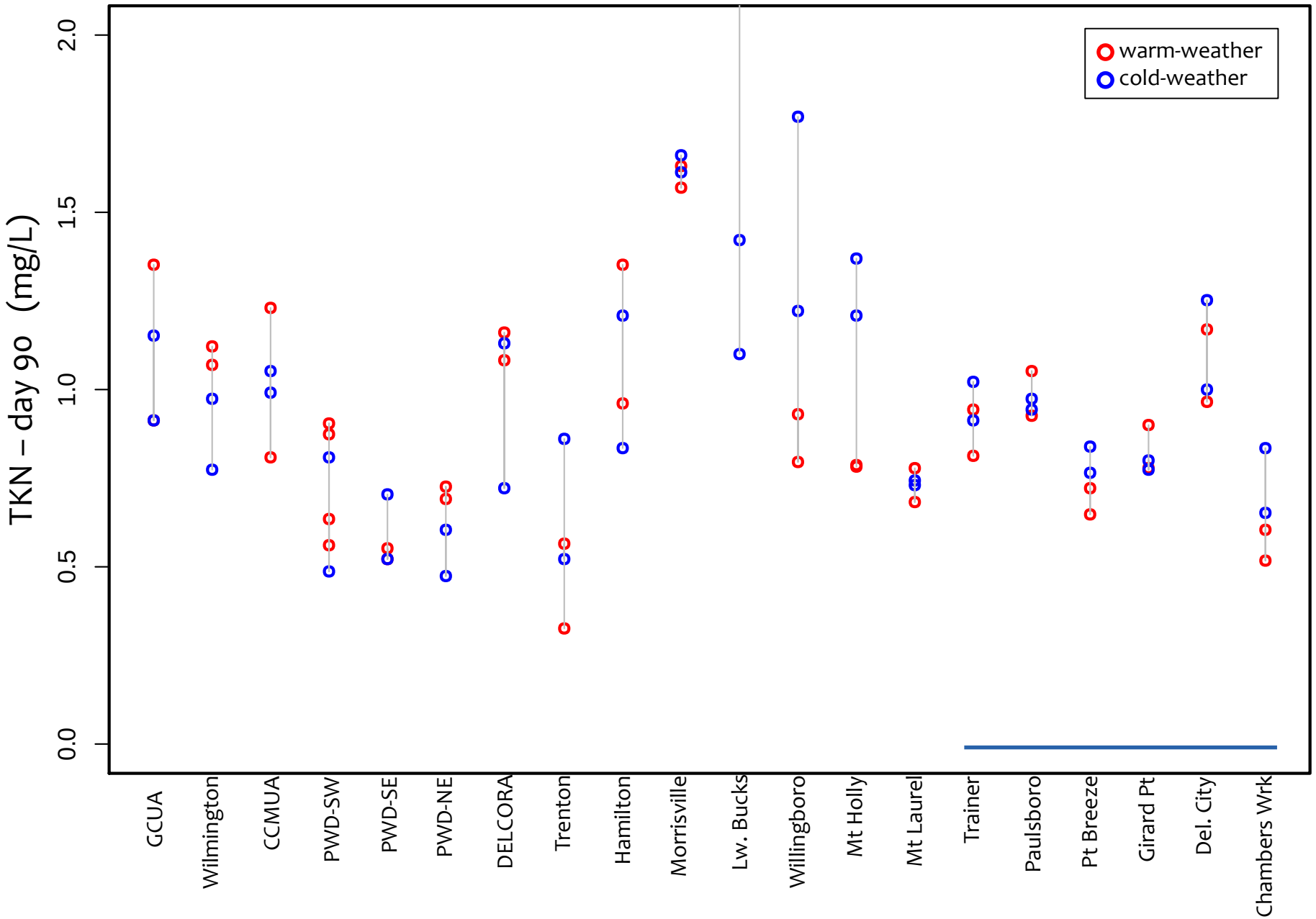
TKN for each facility (DAY 90 - zoom)



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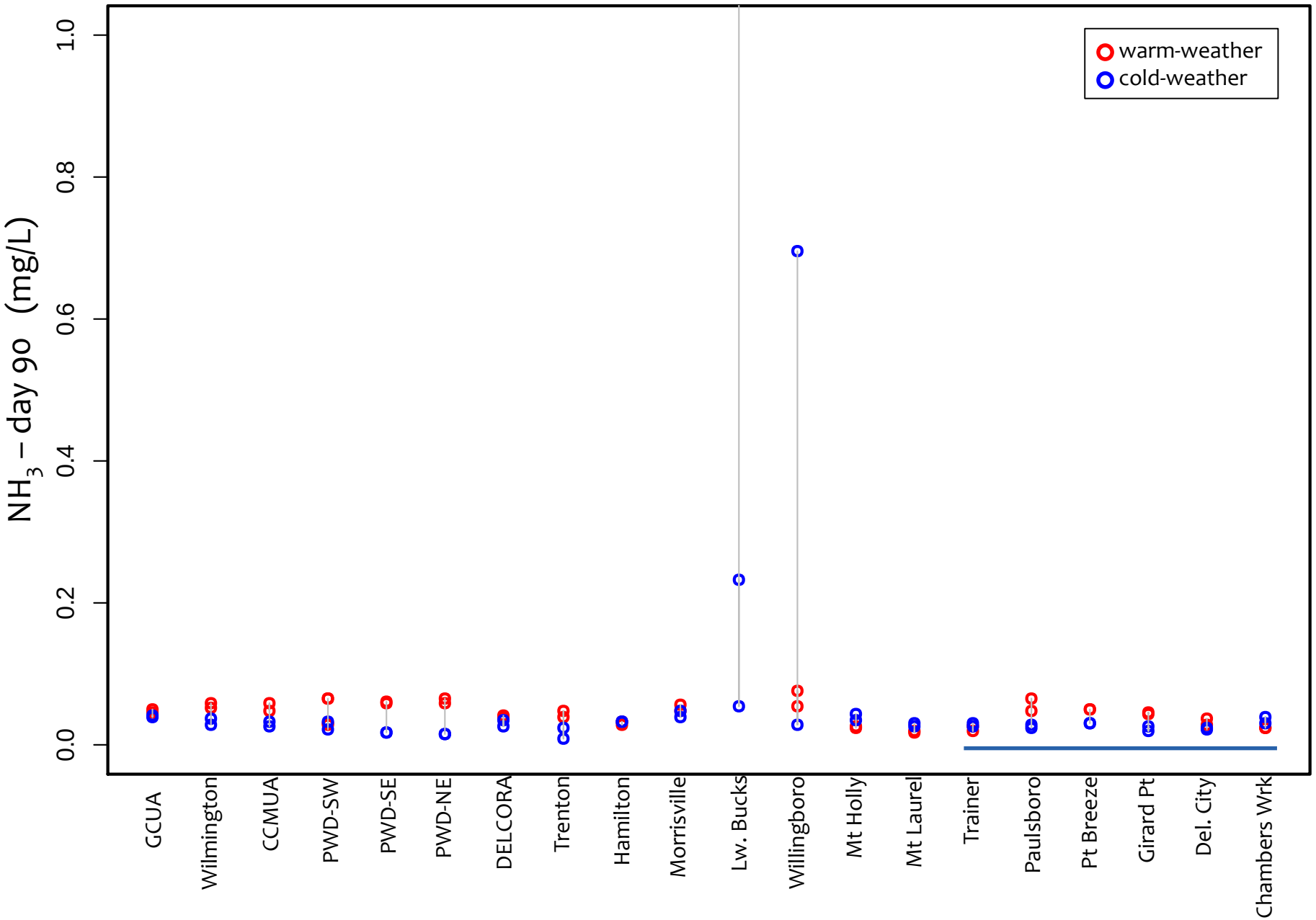
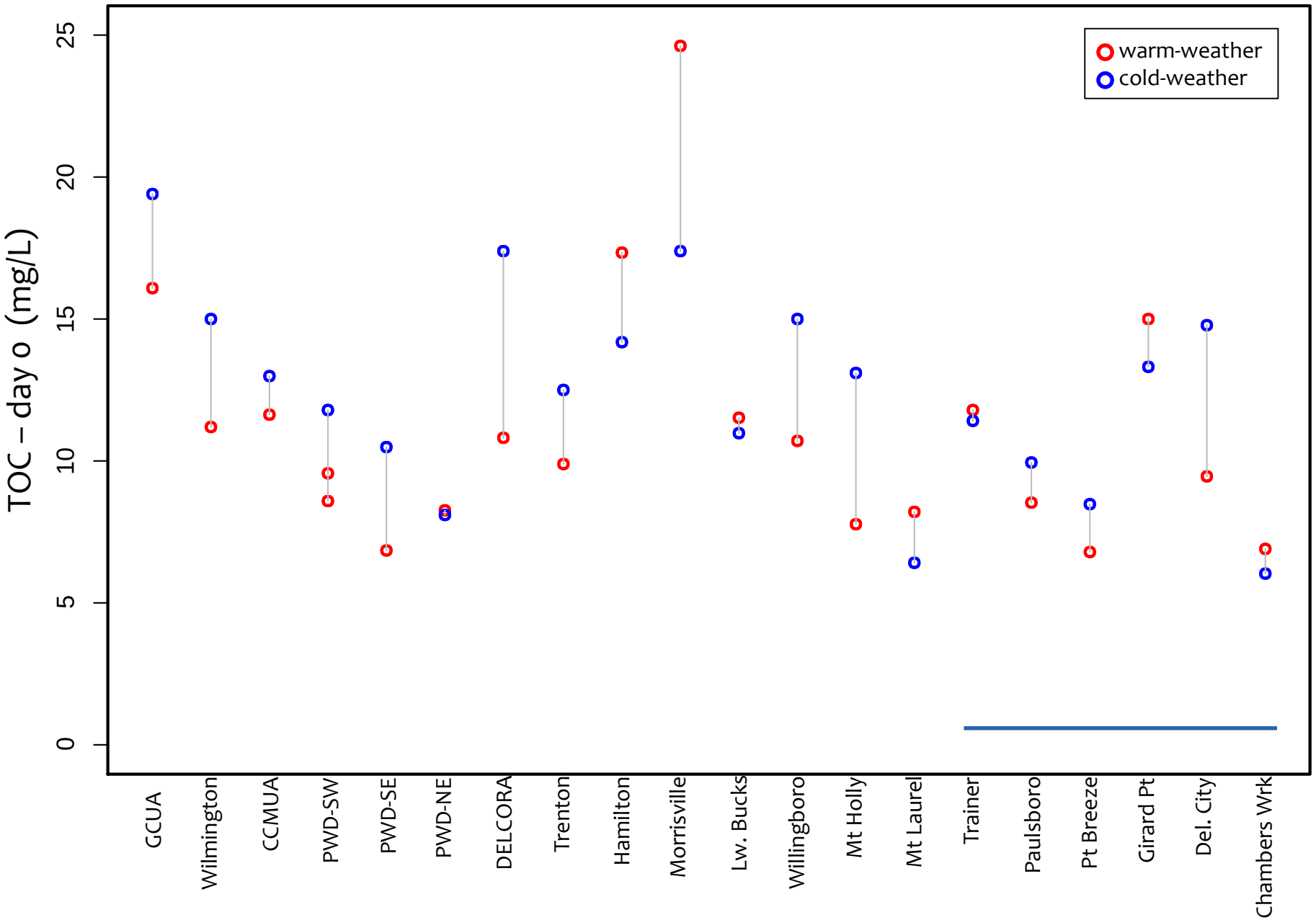
NH_3 for each facility (DAY 90 - zoom)



TOC (initial) for each facility



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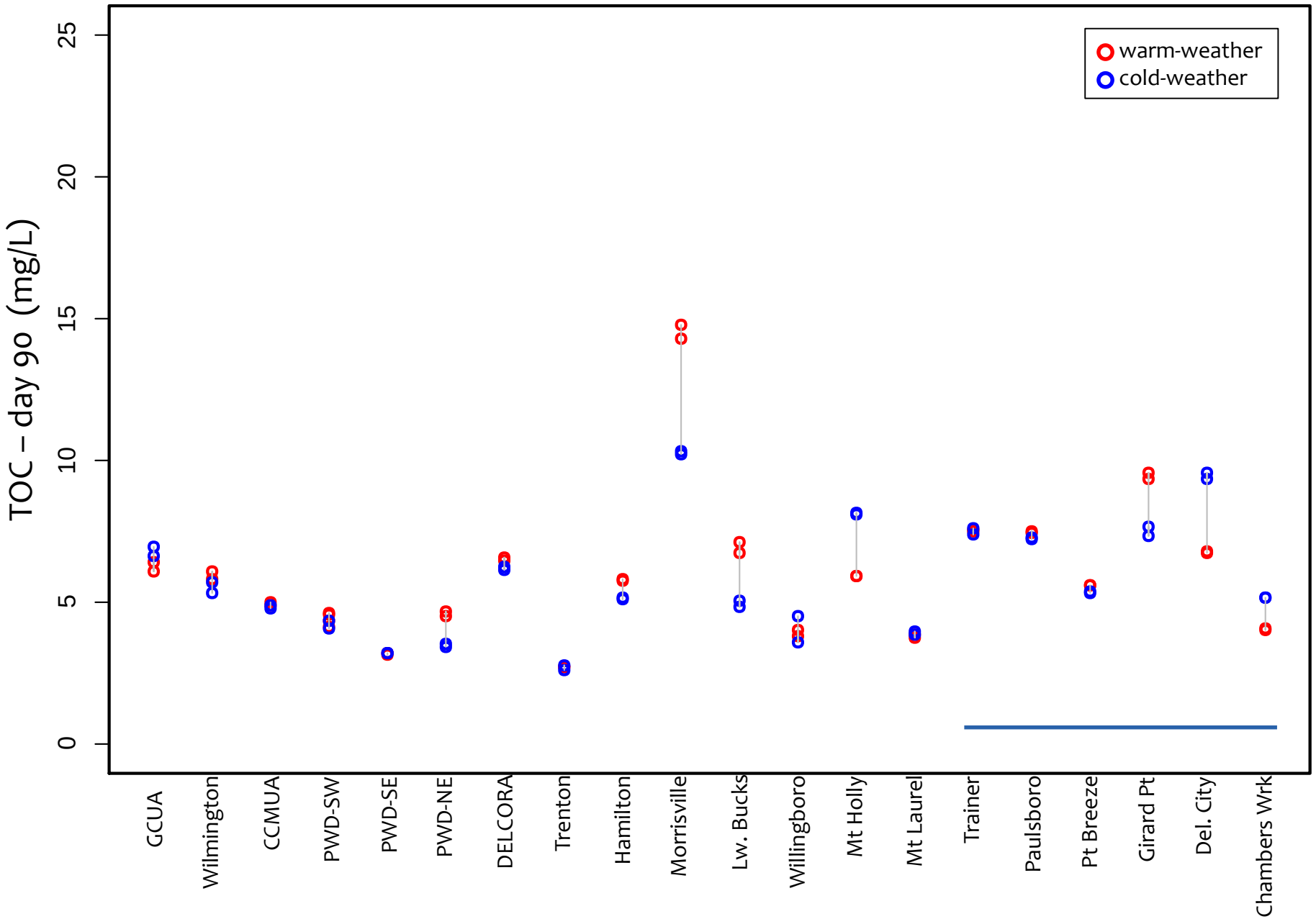
TOC for each facility (DAY 90)



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Initial Observations

- **Incredible range of BOD-90: <5 mg/L to >150 mg/L**
- **High BOD-90 clearly associated with high TKN**
- **Oxidation of TKN fast (Day 20) and nearly complete by Day 60**
  → **approximately 1 mg/L of refractory TKN remaining for most samples**
- **Oxidation of organic carbon much less complete, greater refractory pool *(parallel patterns in COD)***
- **COD curves mostly decline, but some with peculiar rebound**
  → Mt Laurel, Chambers Works, Delaware City

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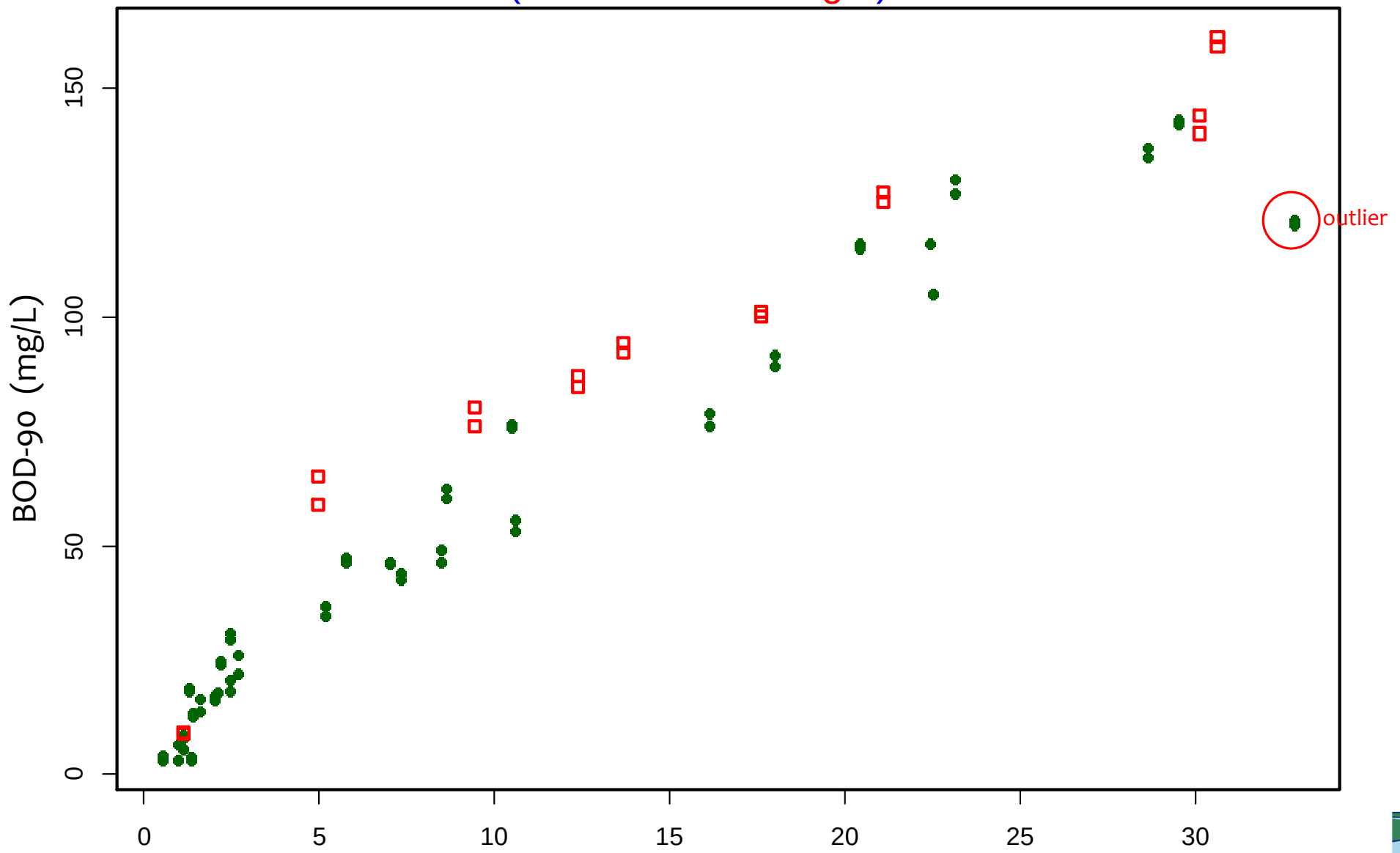
NBOD Estimate: Alternative Methods

- **NO_3 increase slightly higher than TKN decrease overall**
- **NO_3 more variable through time, leading to greater uncertainty**
- **TKN may have utility since observed on Day 0**
- **Utility & need for statistical models of NBOD, CBOD?**

Relationship between BOD-90 and TKN

(red: TOC > 15 mg/L)



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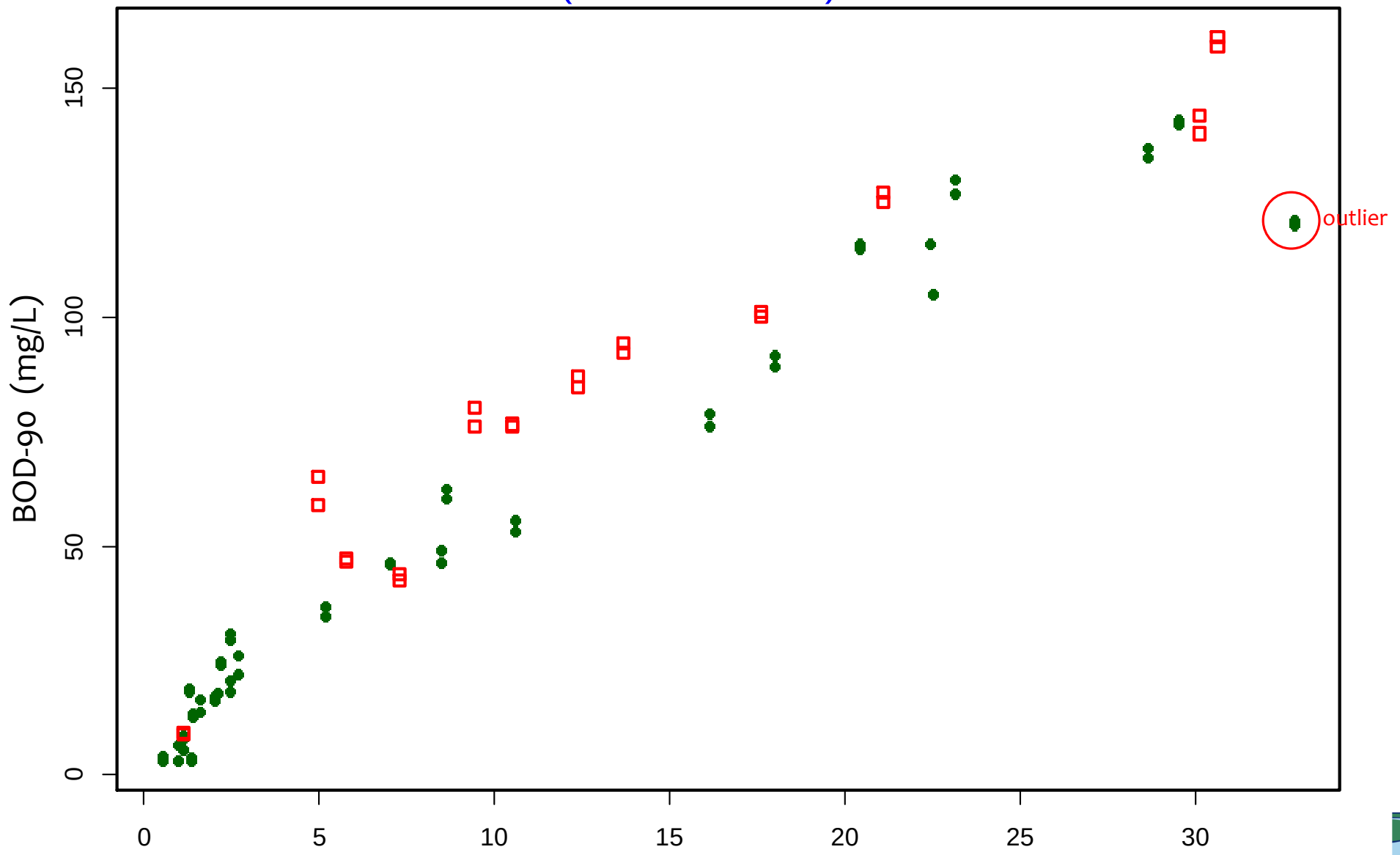
Relationship between BOD-90 and TKN

(red: COD > 50)



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BOD Estimation from Initial Conditions

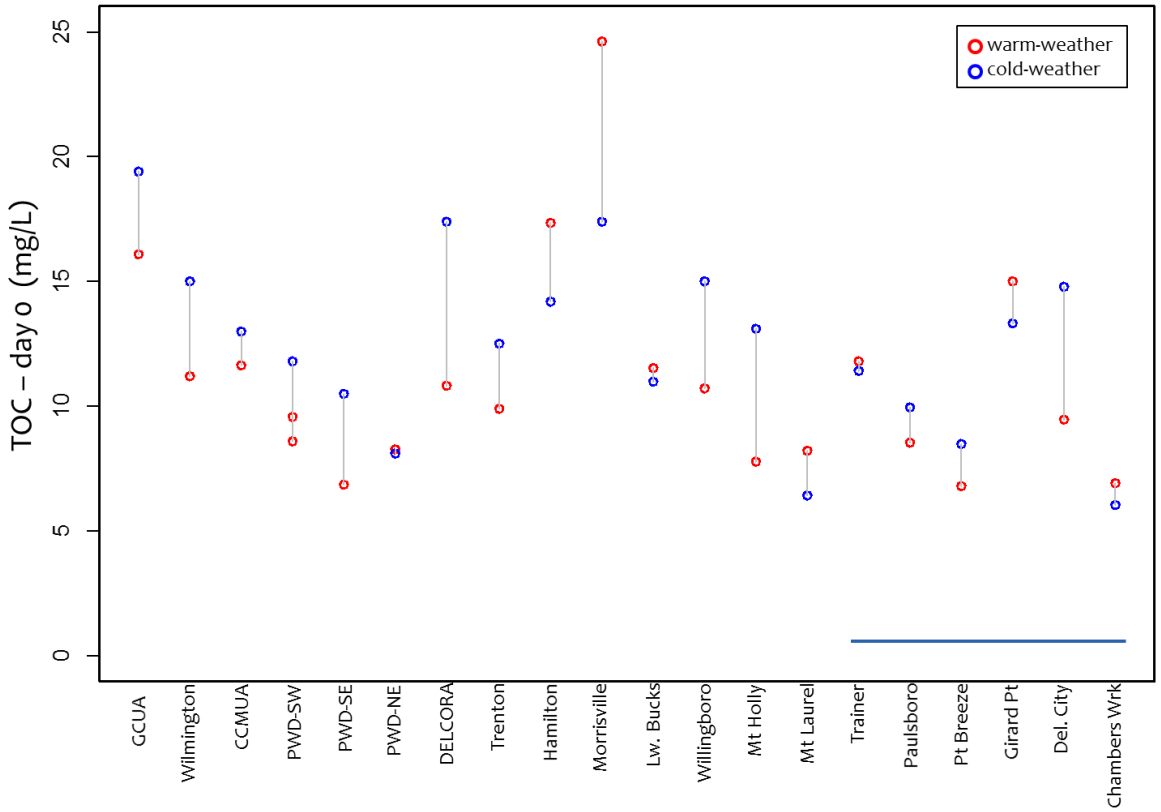
	All Facilities	Municipal Only	Municipal (drop outlier)
BOD_{90} ~ TKN + COD	**R^2 = 95.1%** k_{TKN} = 4.35	**R^2 = 95.4%** k_{TKN} = 4.02	**R^2 = 97.4%** k_{TKN} = 4.29
BOD_{90} ~ TKN + TOC	**R^2 = 95.7%** k_{TKN} = 4.22	**R^2 = 95.9%** k_{TKN} = 3.93	**R^2 = 97.5%** k_{TKN} = 4.19
BOD_{90} ~ TKN	**R^2 = 93.3%** k_{TKN} = 4.54	**R^2 = 92.2%** k_{TKN} = 4.28	**R^2 = 94.7%** k_{TKN} = 4.55

More work to do

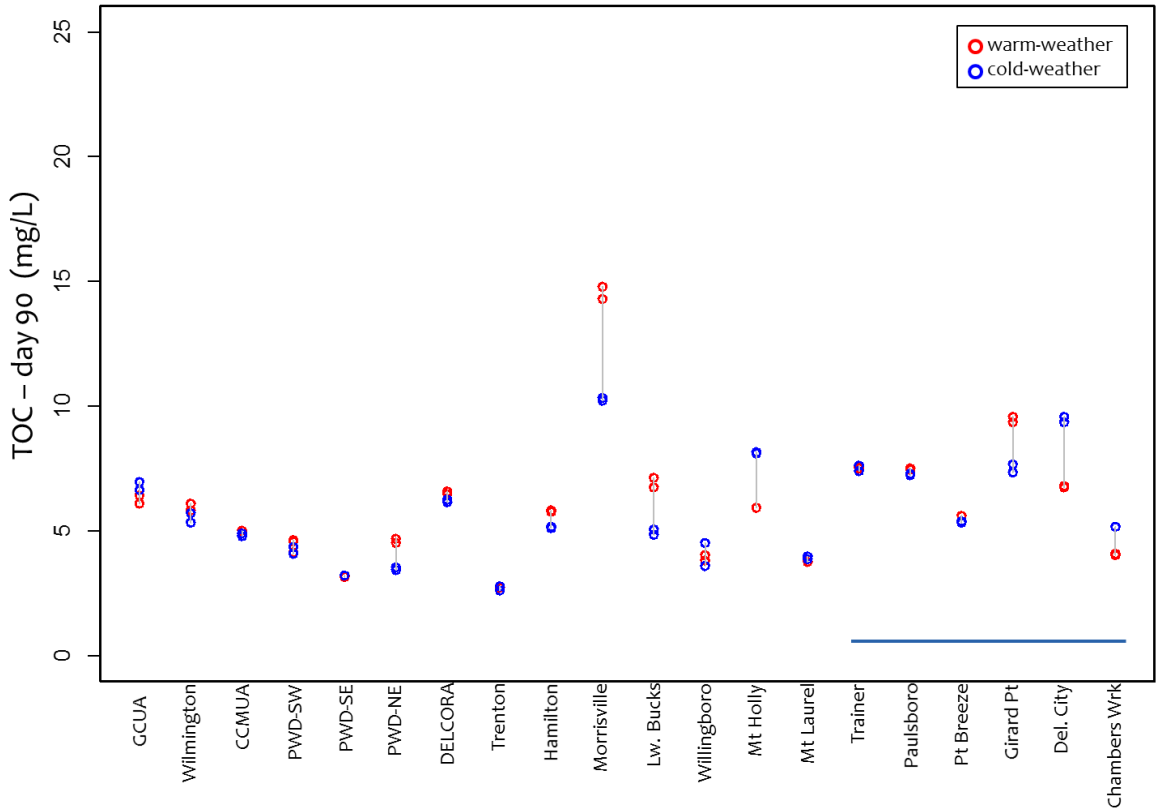
How to Estimate CBODu?

CBODu = 2.67 *[(TOC day 0) – 5 mg/L]?

TOC (initial) for each facility



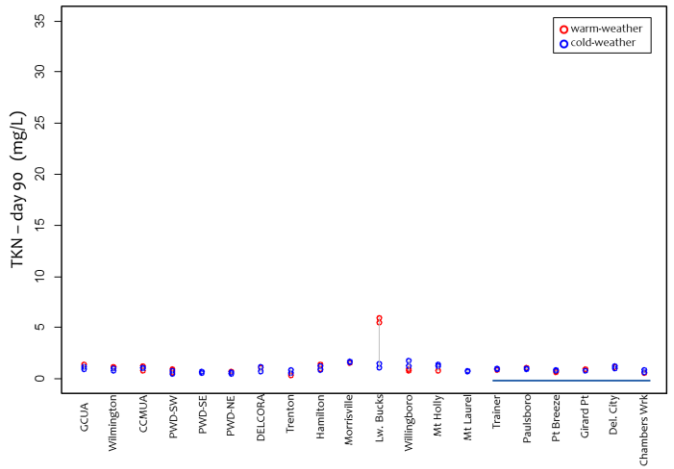
TOC for each facility (DAY 90)



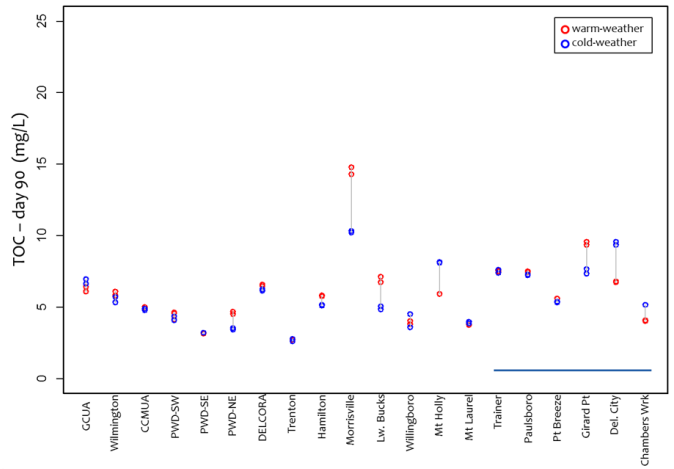
From Ultimate BOD Study from WWTPs

- After 90 days, TKN ≈ 1.0 mgN/L (refractory)
- After 90 days, NH4-N ≈ less than 0.1 mgN/L
- $NBOD_u$ = 4.57 * [(TKN @ day 0) – 1.0 mgN/L]; or
- $NBOD_u$ = 4.33 * [(TKN @ day 0) – 1.0 mgN/L]
- $CBOD_u$ = 2.67 * [($TOC_{@day\ 0}$) – 5.0 mgTOC/L]
- EP generally agreed on the use of fixed refractory carbon of 5.0 mg/L rather than a use of a certain percentage of $TOC_{@day\ 0}$ in $CBOD_u$ estimation

TKN for each facility (DAY 90)



TOC for each facility (DAY 90)



Recommendations (Tasks)

- Estimation of $CBOD_u$ for NPS and tributaries
  - Estimate and evaluate contributions of $CBOD_u$ from NPS and tributaries to the DO sag.
  - Discuss the results at the next EP meeting
- Sediment diagenesis & SOD
  - Use the screening model (spin up time for 1 year) – sensitivity and component analysis
  - Check the SOD hot spots near the DO Sag area
  - It is difficult to measure SOD in the field given that the Del. Estuary is a dynamic system – model will constrained by all external data
  - Potential field sampling during high flow to sample resuspended sediment