

DISTRICT OF COLUMBIA TIDAL WATER QUALITY MONITORING STATIONS TREND

GAM Model Results

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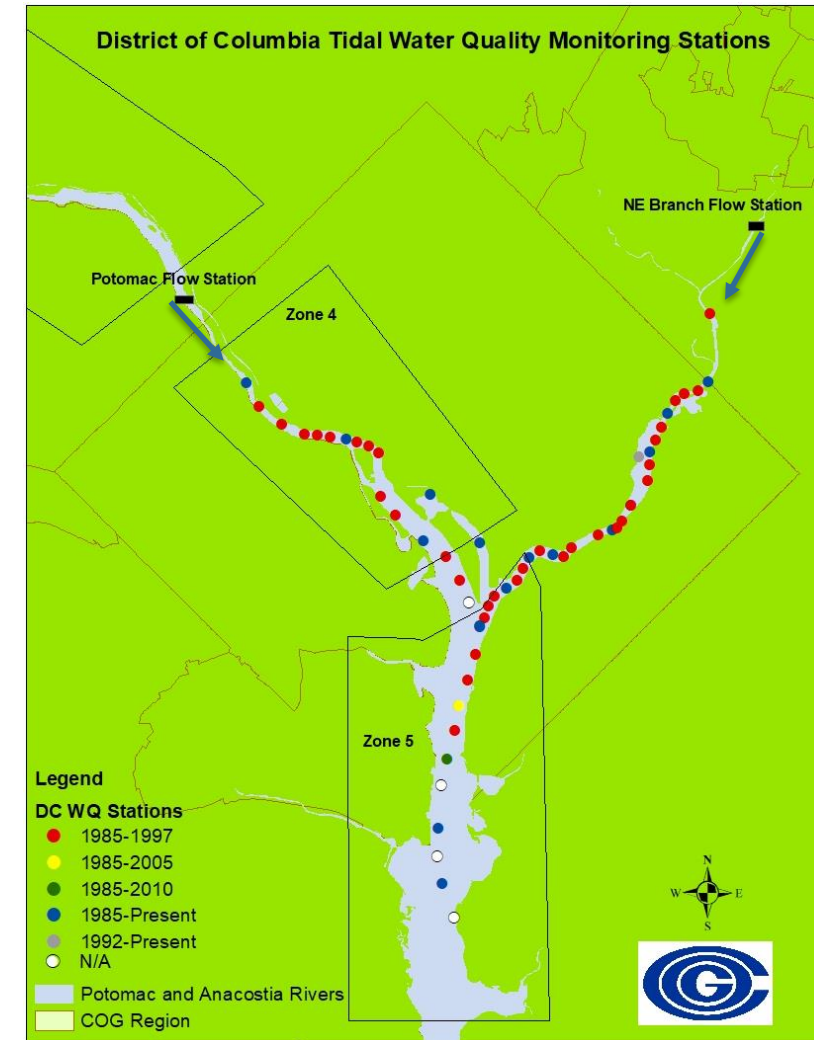
Water Resources Technical committee
September 08, 2023

What is GAM?

- Generalized Additive Model is a nonlinear statistical model used to model nonlinear data. The response variable depends nonlinearly on unknown smooth function of predictor variables.
- Chesapeake Bay (CBP) developed a GAM-based package R.
- There are 4 models within GAM.
- $\alpha = 0.05$ or 95% confidence level is used in the model.
- Metropolitan Washington Council of Governments (COG) agreed to work with District of Columbia Department of Energy and Environment (DOEE) and Chesapeake Bay (CBP) to produce trends results for stations in tidal Potomac and Anacostia Rivers

Water Quality Monitoring Stations

- Most of the Potomac and Anacostia River Stations do not have continuous records.
- All of DC stations are within the tidal Potomac and Anacostia Rivers.
- Potomac River stations are in zone 4 and 5, these zones are identified based on physiographic and hydrologic characteristics.
- Flows from the Potomac and Northeast Branch Anacostia Rivers Pump stations are used in this model.



Parameters List for 2022 GAM Results

- Based on what was decided and used last year, this is the list that we used to generate trends for DC stations.
- The percent change computations (set with `analySpec$gamDiffPeriods`) should at least contain 1999-2000 to 2021-2022 for comparison between stats.
- For this Trends we used the GAM models 2 and 4.

Parameter	Layer	Full years for GAM runs	Subsets for percent change ^b	
			Seasons	years
Dissolved Oxygen	S	1985-2022	Annual, Summer1 (Jun-Sep)	1985-1986 to 2021-2022; 2013-2014 to 2021-2022
Secchi Depth	S	1985-2022	Annual, SAV (Apr-Oct)	1985-1986 to 2021-2022; 2013-2014 to 2021-2022
Chlorophyll-a	S	Any year ^a - 2022	Annual, Spring1 (Mar-May), Summer2 (Jun-Sep)	2013-2014 to 2021-2022 (we just presented short-term for these stations based on data available for chl-a)
TSS	S	Any year ^a -2022	Annual	1999-2000 to 2021-2022; 2013-2014 to 2021-2022
Orthophosphate (PO4)	S	Any year ^a -2022	Annual	1999-2000 to 2021-2022; 2013-2014 to 2021-2022

Input Water Quality Data File

- Not enough TN data to run the model.
- TP data up to 1992 and no sufficient data to run gam4.
- There are gaps in data with other parameters.
- There are gaps in data for Stations with continuous records.
- DO, CHLA, SECCHI, PO4 and TSS.

	A	B	C	D	E	F	G	H		Q	R	S	T	U	V	W	X
1	station	date	layer	secchi	salinity	do	wtemp	tss	chl	po4_lo	po4_hi	tdn_lo	tdn_hi	tdp_lo	tdp_hi	nh4_lo	nh4_hi
2	CB3.3C	5/21/1985	AP	NA	10.5	6.2	18.1	6.9		0.003	0.003	0.52	0.52	0.036	0.036	0.104	0.104
3	CB3.3C	5/21/1985	B	NA	14.4	0	15.3	7.6		0.0063	0.0063	0.64	0.64	0.017	0.017	0.255	0.255
4	CB3.3C	5/21/1985	BP	NA	14.4	0	15.3	7.8		0.0042	0.0042	0.62	0.62	0.008	0.008	0.263	0.263
5	CB3.3C	5/21/1985	S	1.1	10.105	7.6	18.8	7		0.00575	0.00575	0.54	0.54	0.0255	0.0255	0.0665	0.0665
6	CB3.3C	6/4/1985	AP	NA	9.6	6	21.4	5		0.0033	0.0033	0.47	0.47	0	0.005	0.096	0.096
7	CB3.3C	6/4/1985	B	NA	14.6	0	17.7	10.4		0.00895	0.00895	0.61	0.61	0.004	0.0065	0.286	0.286
8	CB3.3C	6/4/1985	BP	NA	14.6	0	17.7	6.6		0.009	0.009	0.62	0.62	0.032	0.032	0.279	0.279
9	CB3.3C	6/4/1985	S	1.5	9.5	6.7	21.5	5.8		0.0048	0.0048	0.5	0.5	0.064	0.064	0.077	0.077
10	CB3.3C	6/18/1985	AP	NA	11.1	6.9	21.7	17.5		0.0035	0.0035	0.45	0.45	0.037	0.037	0.038	0.038
11	CB3.3C	6/18/1985	B	NA	16.6	0.6	19.6	31.2		0.014	0.014	0.65	0.65	0.014	0.014	0.317	0.317

Stations and Layers

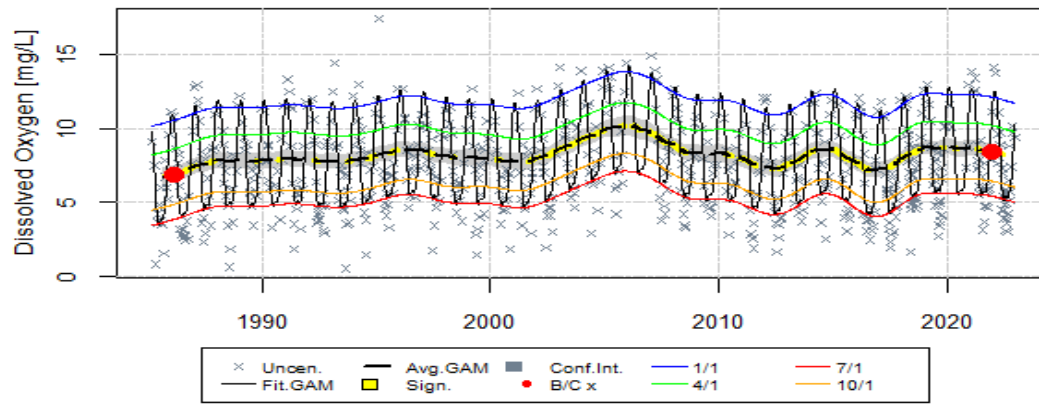
- `analySpec$stationFilt <-
c("PMS01","PMS10","PMS21","PMS29","PMS44","PMS48","PTB01","PWC04",
"ANA01","ANA05","ANA08","ANA11","ANA14","ANA19","ANA21","ANA24","ANA29","ANA30","KNG01",
"KNG02").`
- `# Layer filter`
- `#analySpec$layerFilt <- layerLukup$layers`
- `analySpec$layerFilt <- c('S','M','B')`
- `#analySpec$layerFilt <- c('S','AP','SAP')`
- `#analySpec$layerFilt <- c('B','BP','BBP')`
- `#analySpec$layerFilt <- c('S')`
- `analySpec$layerAggOption <- 4`

Analysis Periods and Seasons

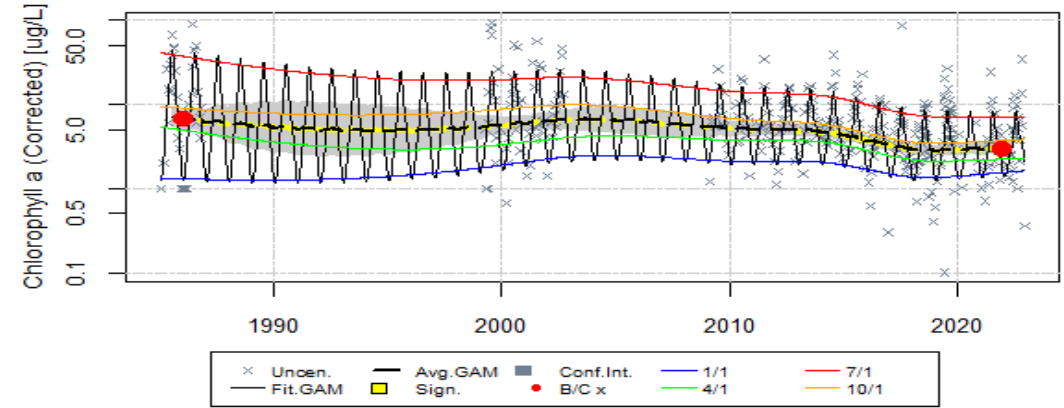
- ```
analySpec$gamDiffPeriods <- list(
 list(periodName = "Full Period", periodStart = c(NA), periodEnd = c(NA)),
 list(periodName = "1985/86-2021/22", periodStart = c(1985:1986), periodEnd = c(2021:2022)),
 list(periodName = "1999/00-2021/22", periodStart = c(1999:2000), periodEnd = c(2021:2022)),
 list(periodName = "2013/14-2021/22", periodStart = c(2013:2014), periodEnd = c(2021:2022)))
```
- list ( seasonName = "All", seasonMonths = c(1:12)),
    - list ( seasonName = "Summer1", seasonMonths = c(6:9))
    - List ( seasonName = "Summer2", seasonMonths = c(7:9)),
    - list ( seasonName = "Spring1", seasonMonths = c(3:5))
    - list ( seasonName = "SAV1", seasonMonths = c(4:10))*
  - For DO we used All and summer1
  - For CHLA we used All season, summer2 and spring1

# Anacostia River

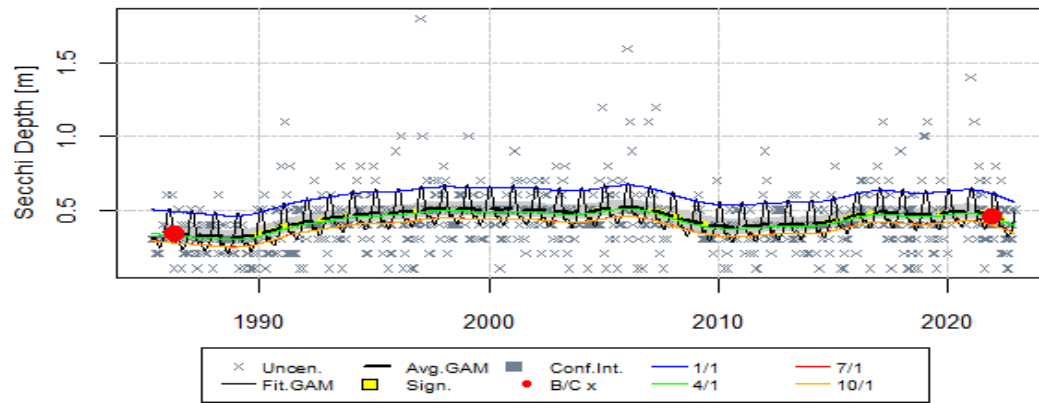
Dissolved Oxygen-Surface at ANA01



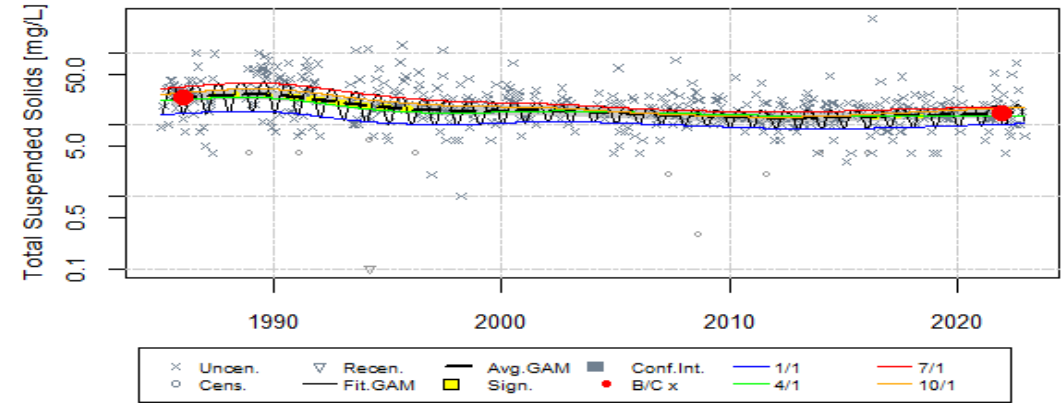
Chlorophyll a (Corrected)-Surface at ANA01



Secchi Depth-Surface at ANA01



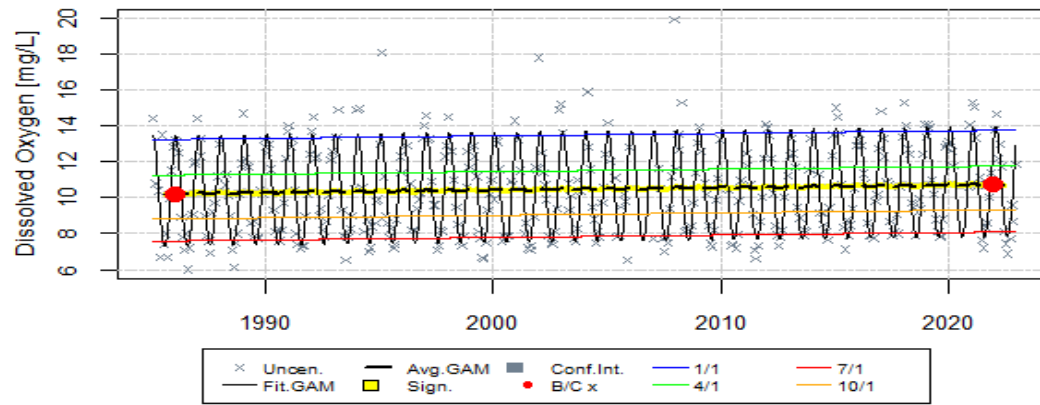
Total Suspended Solids-Surface at ANA01



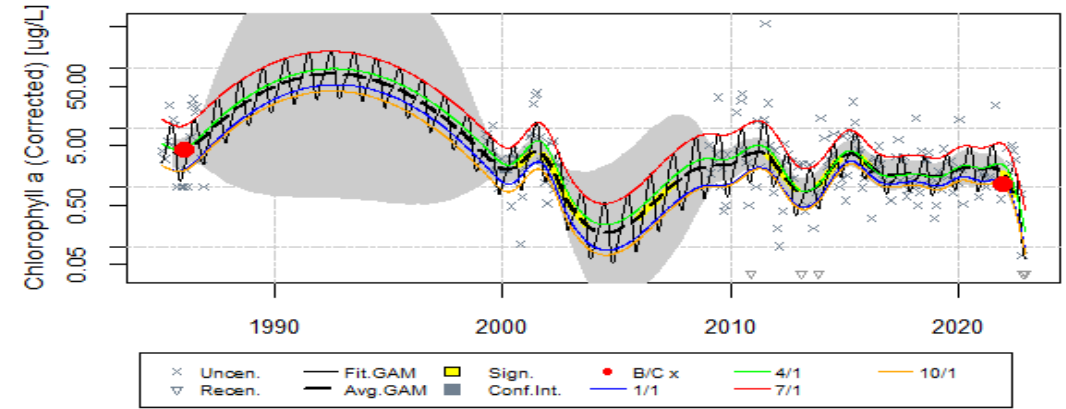


# Potomac River

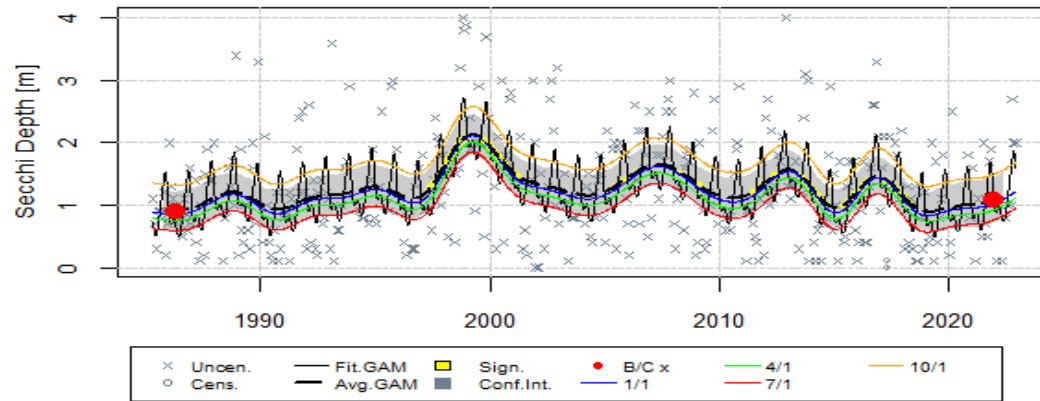
Dissolved Oxygen-Surface at PMS01



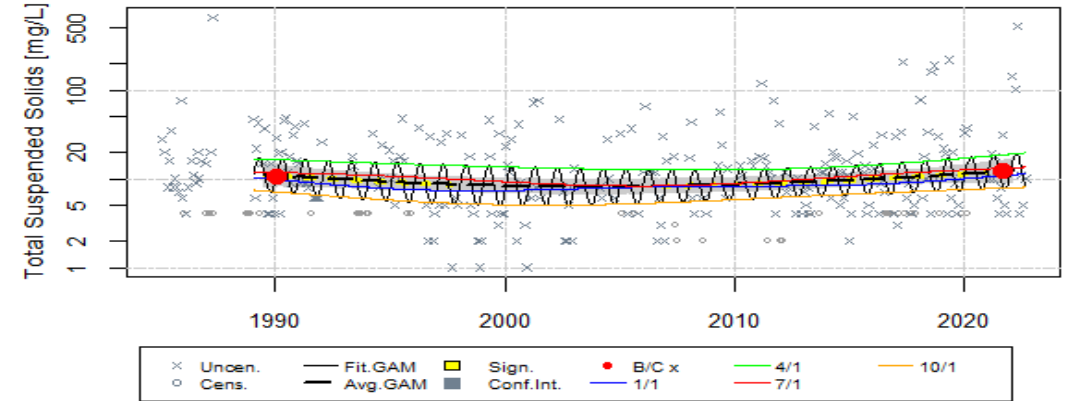
Chlorophyll a (Corrected)-Surface at PMS01



Secchi Depth-Surface at PMS01



Total Suspended Solids-Surface at PMS01



# Dissolved Oxygen Annual Trends 1985-2022

| Downstre  | Anacostia River | Raw Concentration |              |                    |                    |                    |                    | Flow-Wieghted Concentration |              |                    |                    |                    |                    |
|-----------|-----------------|-------------------|--------------|--------------------|--------------------|--------------------|--------------------|-----------------------------|--------------|--------------------|--------------------|--------------------|--------------------|
| Direction | Station         | Baseline Mean     | Current Mean | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends | Baseline Mean               | Current Mean | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends |
| ↓         | ANA01           | 6.86              | 8.42         | 1.56               | 18.54%             | <0.0001            | Yes                | 7.06                        | 8.41         | 1.35               | 16.04%             | <0.0001            | Yes                |
|           | ANA05           | 6.41              | 7.73         | 1.32               | 17.06%             | 0.0056             | Yes                | 6.67                        | 7.80         | 1.13               | 14.50%             | 0.0147             | Yes                |
|           | ANA08           | 6.19              | 7.29         | 1.11               | 15.15%             | 0.0162             | Yes                | 6.32                        | 7.37         | 1.05               | 14.26%             | 0.0207             | Yes                |
|           | ANA11           | 6.01              | 6.79         | 0.79               | 11.57%             | 0.1125             | Yes                | 5.79                        | 6.72         | 0.93               | 13.85%             | 0.0544             | Yes                |
|           | ANA14           | 5.84              | 6.67         | 0.84               | 14.36%             | 0.0208             | Yes                | 5.18                        | 6.76         | 1.58               | 30.49%             | <0.0001            | Yes                |
|           | ANA19           | 6.54              | 7.09         | 0.56               | 7.83%              | 0.2505             | No                 | 6.12                        | 7.40         | 1.27               | 17.22%             | 0.0055             | Yes                |
|           | ANA21           | 7.16              | 7.91         | 0.75               | 10.44%             | 0.035              | Yes                | 6.75                        | 8.06         | 1.31               | 19.38%             | 0.0003             | Yes                |
|           | ANA24           | 8.91              | 8.81         | -0.10              | -1.11%             | 0.815              | No                 | 8.68                        | 8.84         | 0.16               | 1.86%              | 0.6969             | No                 |
|           | ANA29           | 9.60              | 9.64         | 0.04               | 0.43%              | 0.9032             | No                 | 9.83                        | 9.55         | -0.28              | -2.85%             | 0.4055             | No                 |
| ↓         | KNG01           | 4.82              | 7.04         | 2.22               | 46.08%             | 0.0009             | Yes                | 4.90                        | 7.05         | 2.15               | 43.77%             | 0.0004             | Yes                |
|           | KNG02           |                   |              |                    |                    |                    |                    |                             |              |                    |                    |                    |                    |
| Downstre  | Potomac River   | Raw Concentration |              |                    |                    |                    |                    | Flow-Wieghted Concentration |              |                    |                    |                    |                    |
| Direction | Station         | Baseline Mean     | Current Mean | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends | Baseline Mean               | Current Mean | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends |
| ↓         | PMS01           | 10.22             | 10.72        | 0.50               | 4.89%              | 0.0069             | Yes                | 10.33                       | 10.67        | 0.34               | 3.32%              | 0.0558             | Yes                |
|           | PMS10           | 9.86              | 10.44        | 0.58               | 5.87%              | 0.0109             | Yes                | 9.93                        | 10.54        | 0.61               | 6.15%              | 0.0031             | Yes                |
|           | PMS21           | 10.13             | 10.32        | 0.18               | 1.79%              | 0.5302             | No                 | 10.17                       | 10.38        | 0.21               | 2.06%              | 0.4452             | Yes                |
|           | PMS29           | 9.76              | 9.88         | 0.12               | 1.26%              | 0.6743             | No                 | 9.67                        | 10.14        | 0.47               | 4.88%              | 0.0047             | Yes                |
|           | PMS44           | 9.29              | 9.83         | 0.54               | 5.77%              | 0.1648             | No                 | 9.37                        | 10.05        | 0.67               | 7.17%              | 0.0015             | Yes                |
| ↓         | PTB01           | 9.98              | 10.70        | 0.72               | 7.21%              | 0.0598             | Yes                | 10.16                       | 10.60        | 0.44               | 4.38%              | 0.2406             | No                 |
|           | PWC01           | 9.18              | 9.49         | 0.31               | 3.35%              | 0.4716             | No                 | 9.40                        | 9.45         | 0.05               | 0.51%              | 0.9087             | No                 |

# Chlorophyll-a Annual Trends 1985-2022

| Downstre  | Anacostia River | Raw Concentration |                 |                    |                    |                    |                    | Flow-Wieghted Concentration |                 |                    |                    |                    |                    |
|-----------|-----------------|-------------------|-----------------|--------------------|--------------------|--------------------|--------------------|-----------------------------|-----------------|--------------------|--------------------|--------------------|--------------------|
| Direction | Station         | Baseline Mean     | Current Mean    | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends | Baseline Mean               | Current Mean    | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends |
|           | ANA01           | 1.8935 (6.6427)   | 1.0984 (2.9993) | -0.80              | -54.85%            | <0.0001            | Yes                | 1.7763 (5.9078)             | 1.1543 (3.1717) | -0.62              | -46.31%            | 0.0001             | Yes                |
|           | ANA05           | -2.1256 (0.1194)  | 0.9637 (2.6214) | 3.09               | 2096.11%           | <0.0001            | Yes                | -2.1596 (0.1154)            | 1.0107 (2.7475) | 3.17               | 2281.46%           | <0.0001            | Yes                |
|           | ANA08           | 2.1009 (8.1733)   | 0.7098 (2.0336) | -1.39              | -75.12%            | <0.0001            | Yes                | 1.4555 (4.2865)             | 0.7681 (2.1556) | -0.69              | -49.71%            | 0.0169             | Yes                |
|           | ANA11           | -2.0458 (0.1293)  | 0.5538 (1.7399) | 2.60               | 1245.81%           | <0.0001            | Yes                |                             |                 |                    |                    |                    |                    |
|           | ANA14           | 2.2234 (9.2386)   | 0.6155 (1.8506) | -1.61              | -79.97%            | <0.0001            | Yes                | 2.2563 (9.5474)             | 0.5844 (1.794)  | -1.67              | -81.21%            | <0.0001            | Yes                |
|           | ANA19           | -2.8049 (0.0605)  | 0.6406 (1.8976) | 3.45               | 3036.04%           | <0.0001            | Yes                | -2.7134 (0.0663)            | 0.5906 (1.8051) | 3.30               | 2622.26%           | <0.0001            | Yes                |
|           | ANA21           | 1.9033 (6.7082)   | 0.6476 (1.911)  | -1.26              | -71.51%            | <0.0001            | Yes                | 1.7882 (5.9786)             | 0.6459 (1.9077) | -1.14              | -68.09%            | <0.0001            | Yes                |
|           | ANA24           | -2.6186 (0.0729)  | 0.7515 (2.1201) | 3.37               | 2808.08%           | <0.0001            | Yes                | -2.7028 (0.067)             | 0.7462 (2.1089) | 3.45               | 3046.90%           | <0.0001            | Yes                |
| ↓         | ANA29           | 1.8107 (6.1146)   | 0.6063 (1.8336) | -1.20              | -70.01%            | <0.0001            | Yes                | 1.3955 (4.037)              | 0.5595 (1.7498) | -0.84              | -56.65%            | 0.0044             | Yes                |
| ↓         | KNG01           | 2.5407 (12.6886)  | 1.2268 (3.4104) | -1.31              | -73.12%            | <0.0001            | Yes                | 2.4087 (11.1198)            | 1.17 (3.2221)   | -1.24              | -71.02%            | <0.0001            | Yes                |
| ↓         | KNG02           | 2.735 (15.41)     | 1.3799 (3.9744) | -1.36              | -74.21%            | <0.0001            | Yes                | 2.6741 (14.4999)            | 1.4112 (4.1009) | -1.26              | -71.72%            | <0.0001            | Yes                |

| Downstre  | Potomac River | Raw Concentration |                 |                    |                    |                    |                    | Flow-Wieghted Concentration |                  |                    |                    |                    |                    |
|-----------|---------------|-------------------|-----------------|--------------------|--------------------|--------------------|--------------------|-----------------------------|------------------|--------------------|--------------------|--------------------|--------------------|
| Direction | Station       | Baseline Mean     | Current Mean    | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends | Baseline Mean               | Current Mean     | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends |
|           | PMS01         | 1.4727 (4.361)    | 0.1119 (1.1184) | -1.36              | -74.36%            | <0.0001            | Yes                | 1.3112 (3.7108)             | 0.0571 (1.0588)  | -1.25              | -71.47%            | 0.0007             | Yes                |
|           | PMS10         | 1.2522 (3.4979)   | -0.236 (0.7897) | -1.49              | -77.42%            | <0.0001            | Yes                | 0.9209 (2.5115)             | -0.1794 (0.8358) | -1.10              | -66.72%            | 0.0001             | Yes                |
|           | PMS21         | 1.7188 (5.5779)   | 0.1844 (1.2025) | -1.53              | -78.44%            | <0.0001            | Yes                | 1.4798 (4.3919)             | 0.2136 (1.2382)  | -1.27              | -71.81%            | <0.0001            | Yes                |
|           | PMS29         | 1.8744 (6.5168)   | 0.6731 (1.9604) | -1.20              | -69.92%            | <0.0001            | Yes                | 1.6377 (5.1431)             | 0.7048 (2.0235)  | -0.93              | -60.66%            | <0.0001            | Yes                |
| ↓         | PMS44         | 1.522 (4.5814)    | 0.8339 (2.3022) | -0.69              | -49.75%            | 0.006              | Yes                | 1.3043 (3.6853)             | 0.8157 (2.2607)  | -0.49              | -38.66%            | 0.0355             | Yes                |
| ↓         | PTB01         | 2.4569 (11.6691)  | 1.4281 (4.1707) | -1.03              | -64.26%            | 0.0017             | Yes                | 2.5278 (12.5255)            | 1.4372 (4.209)   | -1.09              | -66.40%            | 0.0031             | Yes                |
| ↓         | PWC04         | 1.7272 (5.6248)   | 0.8686 (2.3836) | -0.86              | -57.62%            | <0.0001            | Yes                | 1.4974 (4.4701)             | 0.8803 (2.4116)  | -0.62              | -46.05%            | 0.0265             | Yes                |

# Chlorophyll-a Annual Trends 2013-2022

| Downstre  | Anacostia River | Raw Concentration |                 |                    |                    |                    |                    | Flow-Wieghted Concentration |                 |                    |                    |                    |                    |
|-----------|-----------------|-------------------|-----------------|--------------------|--------------------|--------------------|--------------------|-----------------------------|-----------------|--------------------|--------------------|--------------------|--------------------|
| Direction | Station         | Baseline Mean     | Current Mean    | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends | Baseline Mean               | Current Mean    | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends |
| ↓         | ANA01           | 1.6552 (5.2341)   | 1.0829 (2.9533) | -0.57              | -43.58%            | <0.0001            | Yes                | 1.6772 (5.3507)             | 1.2017 (3.3258) | -0.48              | -37.84%            | 0.0012             | Yes                |
|           | ANA05           | 1.6577 (5.2472)   | 0.9529 (2.5933) | -0.70              | -50.58%            | <0.0001            | Yes                |                             |                 |                    |                    |                    |                    |
|           | ANA08           | 1.5725 (4.8185)   | 0.8104 (2.2488) | -0.76              | -53.33%            | <0.0001            | Yes                |                             |                 |                    |                    |                    |                    |
|           | ANA11           | 1.6191 (5.0486)   | 0.5376 (1.7119) | -1.08              | -66.09%            | <0.0001            | Yes                |                             |                 |                    |                    |                    |                    |
|           | ANA14           | 1.5846 (4.8776)   | 0.6125 (1.8451) | -0.97              | -62.17%            | <0.0001            | Yes                | 1.5315 (4.6249)             | 0.6091 (1.8388) | -0.92              | -60.24%            | <0.0001            | Yes                |
|           | ANA19           | 1.6964 (5.4543)   | 0.6014 (1.8247) | -1.10              | -66.55%            | <0.0001            | Yes                |                             |                 |                    |                    |                    |                    |
|           | ANA21           | 1.5066 (4.5115)   | 0.604 (1.8294)  | -0.90              | -59.45%            | <0.0001            | Yes                | 1.5148 (4.5485)             | 0.6857 (1.9851) | -0.83              | -56.36%            | <0.0001            | Yes                |
|           | ANA24           | 1.1838 (3.2667)   | 0.7456 (2.1077) | -0.44              | -35.48%            | 0.0109             | Yes                |                             |                 |                    |                    |                    |                    |
|           | ANA29           | 0.9578 (2.606)    | 0.6103 (1.841)  | -0.35              | -29.35%            | 0.0719             | No                 |                             |                 |                    |                    |                    |                    |
| ↓         | KNG01           | 1.2831 (3.6077)   | 1.2182 (3.3809) | -0.06              | 80.31%             | -0.0629            | No                 |                             |                 |                    |                    |                    |                    |
|           | KNG02           | 2.0334 (7.6399)   | 1.37 (3.9354)   | -0.66              | -48.49%            | 0.0037             | Yes                |                             |                 |                    |                    |                    |                    |
| Downstre  | Potomac River   | Raw Concentration |                 |                    |                    |                    |                    | Flow-Wieghted Concentration |                 |                    |                    |                    |                    |
| Direction | Station         | Baseline Mean     | Current Mean    | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends | Baseline Mean               | Current Mean    | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends |
| ↓         | PMS01           | 0.2263 (1.2539)   | 0.1171 (1.1242) | -0.11              | -10.34%            | 0.7139             | No                 |                             |                 |                    |                    |                    |                    |
|           | PMS10           | 0.208 (1.2312)    | 0.0466 (0.9545) | -0.25              | -22.48%            | 0.1521             | No                 | 0.165 (1.1793)              | 0.0243 (1.0246) | -0.14              | -13.12%            | 0.4167             | No                 |
|           | PMS21           | 0.3049 (1.3565)   | 0.2633 (1.3012) | -0.04              | -4.08%             | 0.8143             | No                 | 0.289 (1.3351)              | 0.3101 (1.3635) | 0.02               | 2.13%              | 0.9031             | No                 |
|           | PMS29           | 0.586 (1.7969)    | 0.732 (2.0791)  | 0.15               | 15.71%             | 0.3469             | No                 | 0.722 (2.0585)              | 0.6408 (1.8981) | -0.08              | -7.79%             | 0.6222             |                    |
|           | PMS44           | 0.7124 (2.039)    | 0.8315 (2.2968) | 0.12               | 12.64%             | 0.5683             | No                 |                             |                 |                    |                    |                    |                    |
| ↓         | PTB01           | 1.8385 (6.2868)   | 1.4275 (4.1681) | -0.41              | -33.70%            | 0.0326             | Yes                |                             |                 |                    |                    |                    |                    |
|           | PWC01           | 1.4494 (4.2604)   | 0.8341 (2.3028) | -0.62              | -45.95%            | 0.0003             | Yes                | 1.5891 (4.8993)             | 0.7825 (2.1869) | -0.81              | -55.36%            | <0.0001            | Yes                |

# Secchi Depth Annual Trends 1985-2022

| Downstre Direction | Anacostia River Station | Raw Concentration |              |                    |                    |                    |                    | Flow-Wieghted Concentration |              |                    |                    |                    |                    |
|--------------------|-------------------------|-------------------|--------------|--------------------|--------------------|--------------------|--------------------|-----------------------------|--------------|--------------------|--------------------|--------------------|--------------------|
|                    |                         | Baseline Mean     | Current Mean | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends | Baseline Mean               | Current Mean | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends |
| ↓                  | ANA01                   | 0.34              | 0.45         | 0.11               | 32.36%             | 0.0049             | Yes                | 0.29                        | 0.47         | 0.18               | 59.65%             | <0.0001            | Yes                |
|                    | ANA05                   | 0.30              | 0.45         | 0.16               | 52.49%             | 0.0003             | Yes                | 0.28                        | 0.45         | 0.18               | 65.09%             | <0.0001            | Yes                |
|                    | ANA08                   | 0.29              | 0.43         | 0.15               | 50.69%             | <0.0001            | Yes                | 0.26                        | 0.46         | 0.20               | 78.92%             | <0.0001            | Yes                |
|                    | ANA11                   | 0.30              | 0.41         | 0.11               | 35.99%             | 0.0116             | Yes                | 0.27                        | 0.44         | 0.17               | 62.34%             | <0.0001            | Yes                |
|                    | ANA14                   | 0.37              | 0.39         | 0.02               | 5.09%              | 0.5794             | No                 | 0.36                        | 0.38         | 0.02               | 6.13%              | 0.4719             | No                 |
|                    | ANA19                   | 0.47              | 0.43         | -0.05              | -9.71%             | 0.5139             | No                 | 0.43                        | 0.47         | 0.04               | 9.00%              | 0.455              | No                 |
|                    | ANA21                   | 0.54              | 0.56         | 0.02               | 3.51%              | 0.6943             | No                 | 0.49                        | 0.59         | 0.10               | 20.45%             | 0.0175             | No                 |
|                    | ANA24                   | 0.75              | 0.63         | -0.11              | -15.16%            | 0.2745             | No                 | 0.63                        | 0.71         | 0.08               | 13.02%             | 0.2822             | No                 |
|                    | ANA29                   | 0.77              | 0.75         | -0.02              | -2.35%             | 0.8882             | No                 | 0.71                        | 0.82         | 0.10               | 14.43%             | 0.3809             | No                 |
| ↓                  | KNG01                   | 0.34              | 0.34         | 0.00               | 0.61%              | 0.9672             | No                 |                             |              |                    |                    |                    |                    |
|                    | KNG02                   | 0.29              | 0.36         | 0.07               | 24.60%             | 0.1131             | No                 |                             |              |                    |                    |                    |                    |

| Downstre Direction | Potomac River Station | Raw Concentration |              |                    |                    |                    |                    | Flow-Wieghted Concentration |              |                    |                    |                    |                    |
|--------------------|-----------------------|-------------------|--------------|--------------------|--------------------|--------------------|--------------------|-----------------------------|--------------|--------------------|--------------------|--------------------|--------------------|
|                    |                       | Baseline Mean     | Current Mean | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends | Baseline Mean               | Current Mean | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends |
| ↓                  | PMS01                 | 0.92              | 1.10         | 0.18               | 19.58%             | 0.4489             | No                 | 0.79                        | 1.18         | 0.39               | 48.84%             | 0.0209             | Yes                |
|                    | PMS10                 | 1.00              | 1.24         | 0.24               | 23.81%             | 0.0574             | No                 | 0.94                        | 1.17         | 0.23               | 24.94%             | 0.0123             | Yes                |
|                    | PMS21                 | 0.91              | 1.03         | 0.11               | 12.45%             | 0.2945             | No                 | 0.89                        | 0.98         | 0.09               | 10.42%             | 0.2613             | No                 |
|                    | PMS29                 | 0.87              | 0.87         | 0.00               | -0.30%             | 0.9764             | No                 | 0.82                        | 0.84         | 0.02               | 1.98%              | 0.8065             | No                 |
|                    | PMS44                 | 0.70              | 0.70         | 0.00               | 0.57%              | 0.9647             | No                 | 0.67                        | 0.70         | 0.03               | 4.40%              | 0.6835             | No                 |
|                    | PTB01                 | 0.69              | 0.92         | 0.23               | 33.89%             | 0.0016             | No                 | 0.72                        | 0.91         | 0.19               | 26.67%             | 0.004              | Yes                |
| ↓                  | PWC01                 | 1.02              | 1.02         | 0.00               | 0.16%              | 0.9721             | No                 | 0.94                        | 1.05         | 0.11               | 11.53%             | 0.0643             | Yes                |

# Total Suspended Solids Annual Trends 1985-2022

| Downstre Direction | Anacostia River Station | Raw Concentration |                  |                    |                    |                    |                    | Flow-Wieghted Concentration |                  |                    |                    |                    |                    |
|--------------------|-------------------------|-------------------|------------------|--------------------|--------------------|--------------------|--------------------|-----------------------------|------------------|--------------------|--------------------|--------------------|--------------------|
|                    |                         | Baseline Mean     | Current Mean     | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends | Baseline Mean               | Current Mean     | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends |
| ↓                  | ANA01                   | 3.1491 (23.3145)  | 2.6543 (14.2155) | -0.49              | -39.03%            | 0.0014             | Yes                | 3.2379 (25.4793)            | 2.6176 (13.7029) | -0.62              | -46.22%            | <0.0001            | Yes                |
|                    | ANA05                   | 3.3044 (27.2309)  | 2.8204 (16.783)  | -0.48              | -38.37%            | 0.0054             | Yes                | 3.3252 (27.8043)            | 2.6234 (13.7832) | -0.70              | -50.43%            | <0.0001            | Yes                |
|                    | ANA08                   | 3.3784 (29.3233)  | 2.8411 (17.1347) | -0.54              | -41.57%            | 0.0031             | Yes                | 3.4573 (31.7317)            | 2.6769 (14.5395) | -0.78              | -54.18%            | <0.0001            | Yes                |
|                    | ANA11                   | 3.3012 (27.1453)  | 2.6894 (14.7231) | -0.61              | -45.76%            | 0.0007             | Yes                | 3.4158 (30.4422)            | 2.7684 (15.9332) | -0.65              | -47.66%            | 0.0004             | Yes                |
|                    | ANA14                   | 2.9995 (20.0757)  | 2.7787 (16.0987) | -0.22              | -19.81%            | 0.12               | No                 | 3.0168 (20.4258)            | 2.7514 (15.6646) | -0.27              | -23.31%            | 0.0619             | Yes                |
|                    | ANA19                   | 2.6102 (13.6011)  | 2.4198 (11.2433) | -0.19              | -17.34%            | 0.2501             | No                 | 2.6289 (13.8586)            | 2.415 (11.1893)  | -0.21              | -19.26%            | 0.2046             | No                 |
|                    | ANA21                   | 2.34 (10.3815)    | 2.1757 (8.8081)  | -0.16              | -15.16%            | 0.2723             | No                 | 2.4569 (11.6689)            | 2.1325 (8.4357)  | -0.32              | -27.71%            | 0.0253             | Yes                |
|                    | ANA24                   | 2.0874 (8.064)    | 2.101 (8.1742)   | 0.01               | 1.37%              | 0.9417             | No                 | 2.1826 (8.8697)             | 2.0274 (7.5943)  | -0.16              | -14.38%            | 0.3744             | No                 |
|                    | ANA29                   | 2.1786 (8.8338)   | 2.2779 (9.7563)  | 0.10               | 10.44%             | 0.5035             | No                 | 2.3117 (10.0912)            | 2.1724 (8.7796)  | -0.14              | -13.00%            | 0.4983             | No                 |
|                    | KNG01                   | 3.9259 (50.6995)  | 3.1313 (22.9039) | -0.79              | -54.82%            | 0.0092             | Yes                | 3.9302 (50.9147)            | 3.0206 (20.5044) | -0.91              | -59.73%            | <0.0001            | Yes                |
| KNG02              | 3.4752 (32.3049)        | 3.0544 (21.2082)  | -0.42            | -34.35%            | 0.0102             | Yes                | 3.4852 (32.629)    | 3.0448 (21.0057)            | -0.44            | -35.62%            | 0.0107             | Yes                |                    |
| Downstre Direction | Potomac River Station   | Raw Concentration |                  |                    |                    |                    |                    | Flow-Wieghted Concentration |                  |                    |                    |                    |                    |
|                    |                         | Baseline Mean     | Current Mean     | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends | Baseline Mean               | Current Mean     | Difference in Mean | Percent Difference | Difference P-Value | Significant Trends |
| ↓                  | PMS01                   | 2.3804 (10.8092)  | 2.4986 (12.1654) | 0.12               | 12.55%             | 0.5973             | No                 | 2.5631 (12.9766)            | 2.3512 (10.4983) | -0.21              | -19.10%            | 0.3221             | No                 |
|                    | PMS10                   | 2.0092 (7.4575)   | 2.1087 (8.2378)  | 0.10               | 10.46%             | 0.6897             | No                 | 2.1528 (8.6093)             | 2.0314 (7.6248)  | -0.12              | -11.44%            | 0.5067             | No                 |
|                    | PMS21                   | 2.1688 (8.7477)   | 2.2055 (9.0744)  | 0.04               | 3.73%              | 0.8599             | No                 | 2.3073 (10.0469)            | 2.1296 (8.4116)  | -0.18              | -16.28%            | 0.3034             | No                 |
|                    | PMS29                   | 2.3066 (10.0406)  | 2.3345 (10.3243) | 0.03               | 2.83%              | 0.8756             | No                 | 2.2718 (9.6966)             | 2.3377 (10.3577) | 0.07               | 6.82%              | 0.6603             | No                 |
|                    | PMS44                   | 2.3909 (10.9229)  | 2.6057 (13.5402) | 0.21               | 23.96%             | 0.2514             | No                 | 2.3905 (10.9193)            | 2.512 (12.3299)  | 0.12               | 12.92%             | 0.4718             | No                 |
|                    | PTB01                   | 2.4315 (11.3763)  | 2.0174 (7.5189)  | -0.41              | -33.91%            | 0.0009             | Yes                | 2.3493 (10.478)             | 1.966 (7.1424)   | -0.38              | -31.83%            | 0.0693             | Yes                |
|                    | PWC01                   | 1.6258 (5.0823)   | 1.5999 (4.9526)  | -0.03              | -2.55%             | 0.9145             | No                 | 1.6968 (5.4565)             | 1.5849 (4.8787)  | -0.11              | -10.59%            | 0.6356             | No                 |

# Summary

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- COG will continue to work with DCDOEE and CBP to produce tidal trends.
- For flow weighted trends, we will continue using USGS flow gauge stations on Little Falls on the Potomac River and Northeast Branch Anacostia River.
- We will continue to use surface layer data.
- CBP reports summer DO trends because that is where most of the DO depletion occurs.
- CBP reports CHLA from 2013 to present because the big gaps in data would not provide valid or accurate trends.

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