Non-tidal long-term monitoring program trends results through 2022

The Maryland Department of Natural Resources regularly monitors non-tidal waters at 52 long-term non-tidal monitoring program stations. Monitoring data provide information on the past and present concentrations of pollutants in our waterways. Monitoring data cannot, however, identify the sources of the pollutants nor predict future pollutant loads resulting from planned pollutant reduction efforts, the impacts of climate change, growth, etc.; for that information, we must depend on models and additional information.

This document consists only of a description of temporal trend analysis results from long-term non-tidal monitoring program concentration data. It does not employ other models or incorporate other information or data to interpret results. However, knowledge of trends in water quality conditions is useful for understanding and reporting on the water quality condition of Maryland's waters.

Water quality trends are calculated according to a generalized additive model (GAM), applied using the Baytrends R package which was developed by and for the Chesapeake Bay Program (Murphy et al. 2019). Each station and parameter is analyzed separately, and a GAM is derived from all the data for that station from 1986-2022. The trend significance and amount of change is determined using the two-year means for the start and end of the trend period of interest, 1999/2000 and 2021/2022. Each mean is calculated from the 24 values predicted by the GAM for the 15th of each month within each two-year time period. This method ensures that 24 values are always available for the calculation as data are drawn from the predictive model rather than from the raw dataset that may be impacted by missing samples or irregular sampling intervals.

Trends are determined using a flow-adjustment method. The flow-adjusted method uses daily flow data from the closest USGS gage with a measurement for the entire 1986-2022 period for each station to include the impact of changes in river flow on the nutrients and sediment levels; higher nutrients and sediments are associated with high river flows. Changes in the levels of nutrients and sediments are flow-adjusted by using flow as one of the factors that determine the differences between years. The flow-adjusted method is much more robust for determining the impact of changes in water quality concentrations over a long-time period. A more detailed analysis method description is available on the Eyes on the Bay website (https://eyesonthebay.dnr.maryland.gov/eyesonthebay/documents/MDNR106draftQAPP_1920.pdf).

Statistical analysis of monitoring data collected at long-term non-tidal stations from 1999 through 2022 demonstrated significant reductions in nitrogen concentrations at 60% of non-tidal stations (Figure 1), phosphorus concentrations at 58% of non-tidal stations (Figure 2), and sediment concentrations at 23% of non-tidal stations (Figure 3).

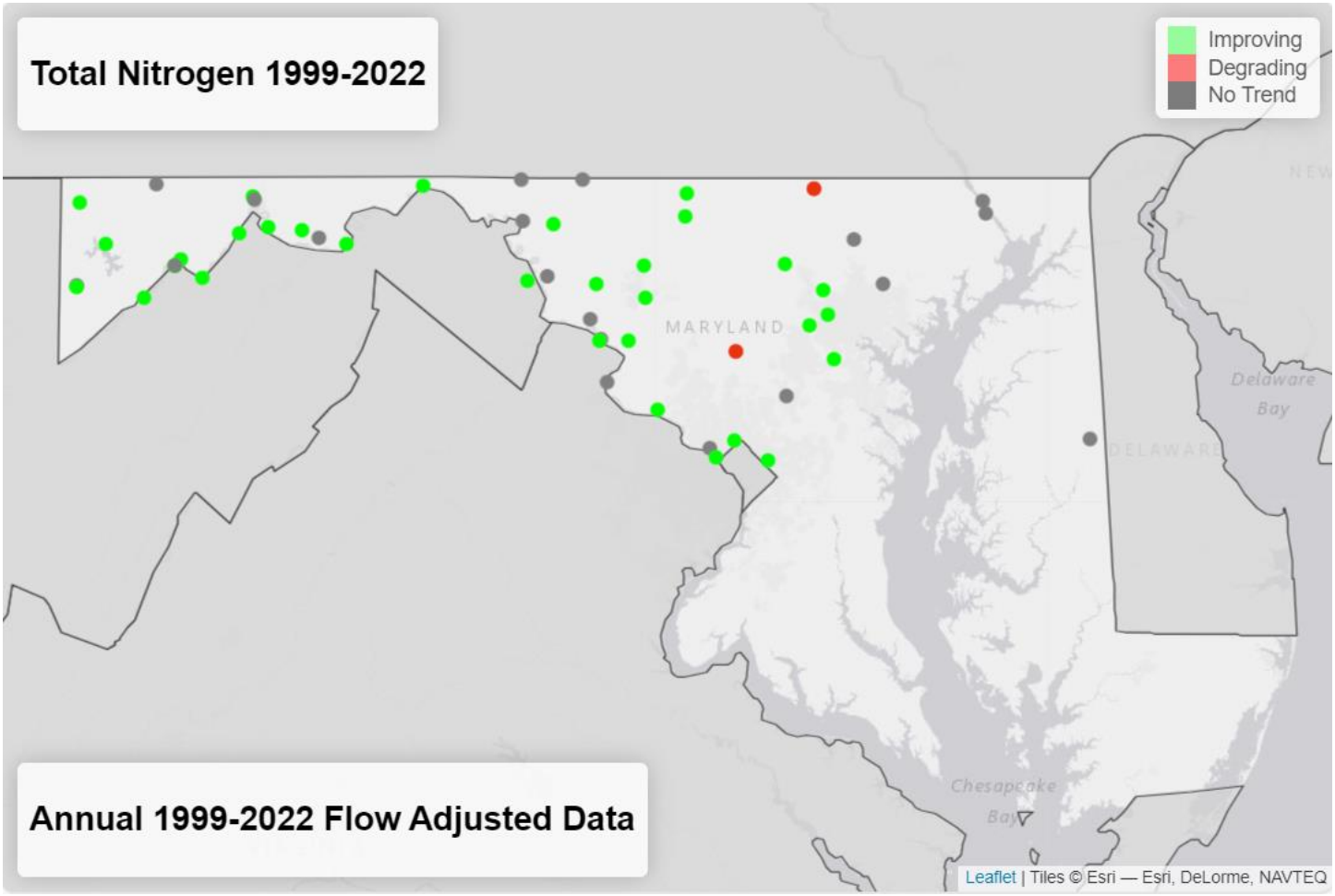

Figure 1. Trends in flow-adjusted total nitrogen concentrations 1999–2022

- 60% of stations (31 of 52) have improved total nitrogen levels compared to 1999
- 4% of stations (2 of 52) have degraded total nitrogen levels compared to 1999
- 36% of stations (19 of 52) do not have total nitrogen levels that are significantly different from 1999

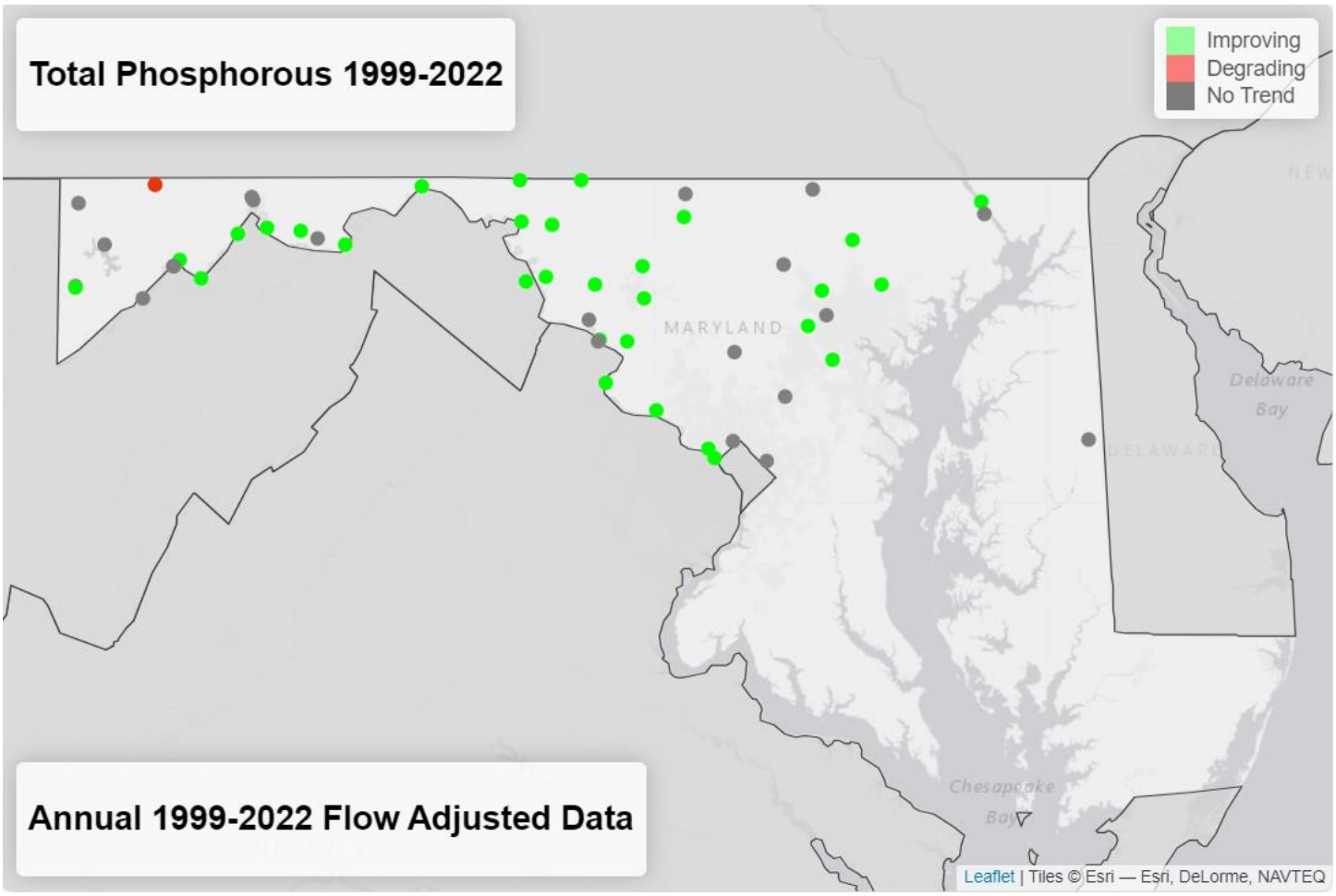

Figure 2. Trends in flow-adjusted total phosphorus concentrations 1999–2022

- 58% of stations (30 of 52) have improved total phosphorus levels compared to 1999
- 2% of stations (1 of 52) have degraded total phosphorus levels compared to 1999
- 40% of stations (21 of 52) do not have total phosphorus levels that are significantly different from 1999

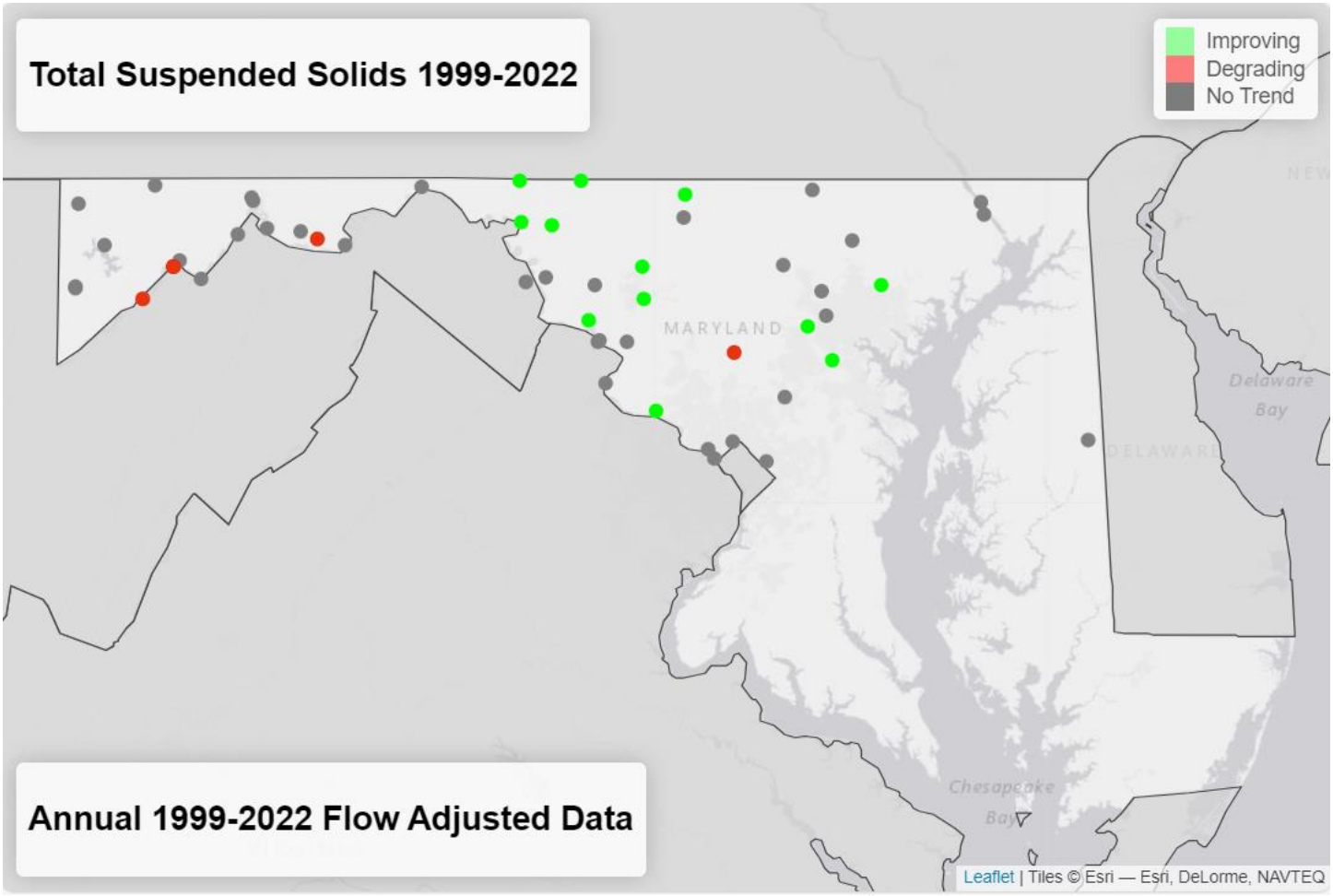

Figure 3. Trends in flow-adjusted total suspended solids concentrations 1999–2022

- 23% of stations (12 of 52) have improved total suspended solids levels compared to 1999
- 10% of stations (5 of 52) have degraded total suspended solids levels compared to 1999
- 67% of stations (35 of 52) do not have total suspended solids levels that are significantly different from 1999

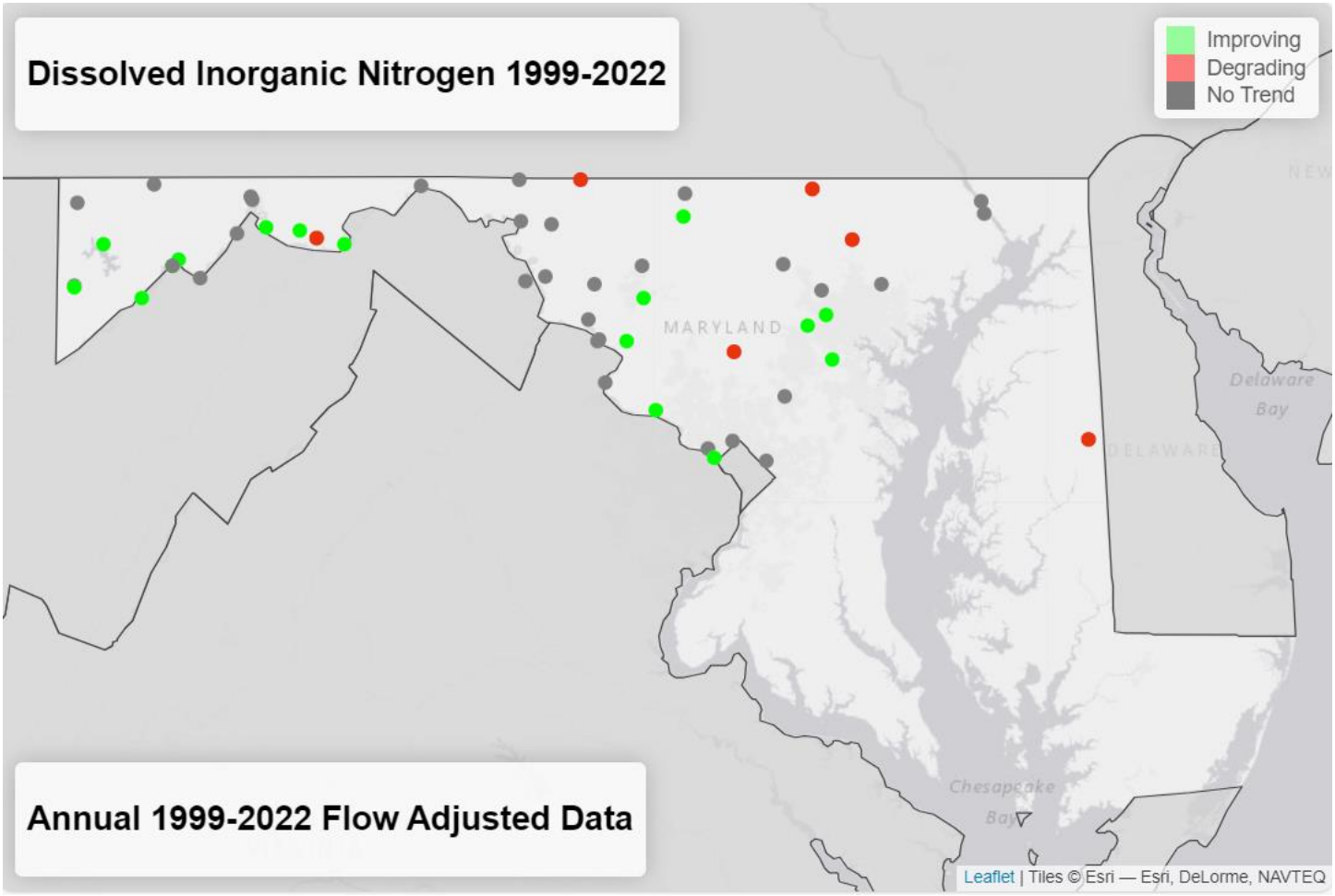

Figure 4. Trends in flow-adjusted dissolved inorganic nitrogen concentrations 1999–2022

- 31% of stations (16 of 52) have improved dissolved inorganic nitrogen levels compared to 1999
- 11% of stations (6 of 52) have degraded dissolved inorganic nitrogen levels compared to 1999
- 58% of stations (30 of 52) do not have dissolved inorganic nitrogen levels that are significantly different from 1999

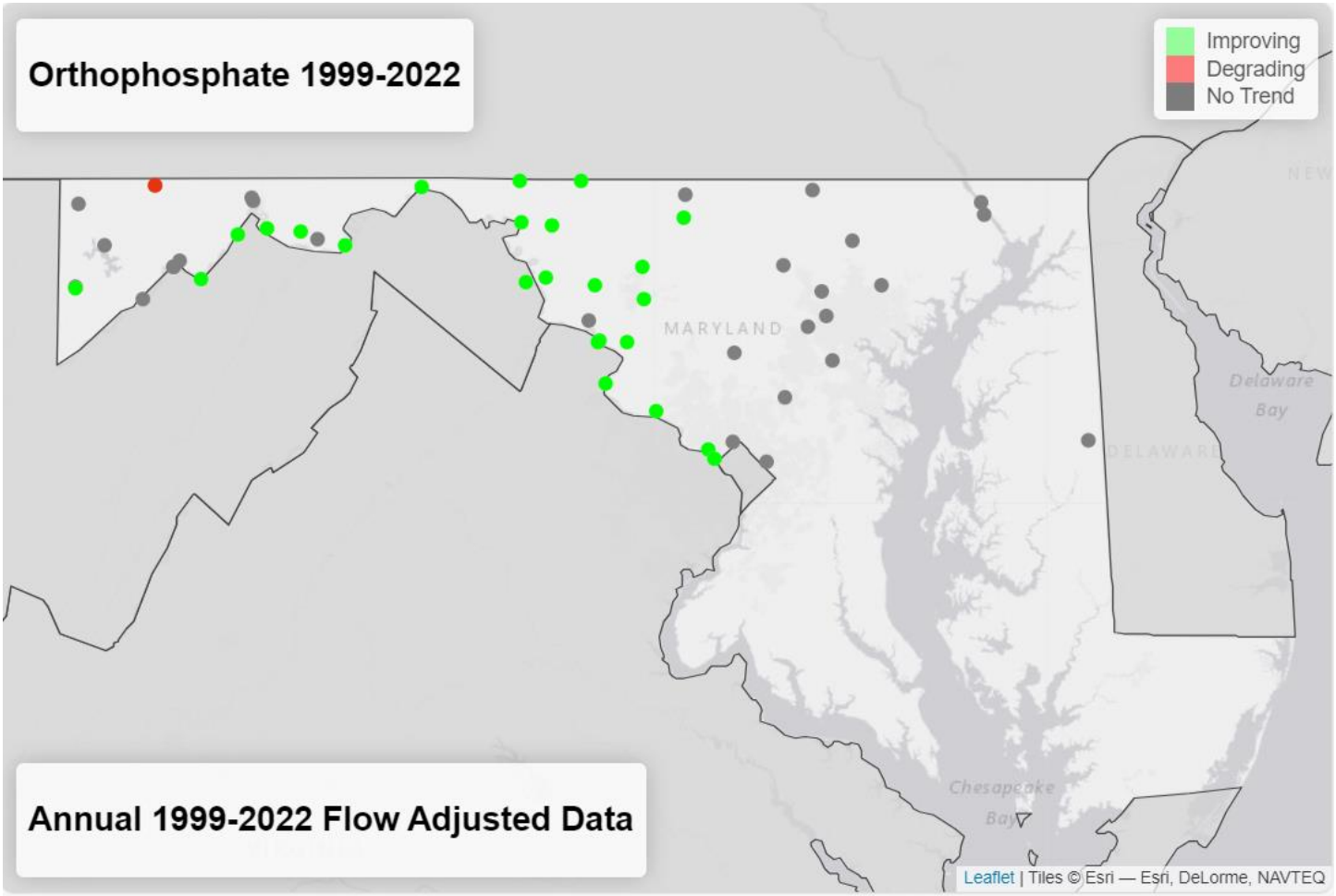

Figure 5. Trends in flow-adjusted orthophosphate concentrations 1999–2022

- 46% of stations (24 of 52) have improved orthophosphate levels compared to 1999
- 2% of stations (1 of 52) have degraded orthophosphate levels compared to 1999
- 52% of stations (27 of 52) do not have orthophosphate levels that are significantly different from 1999

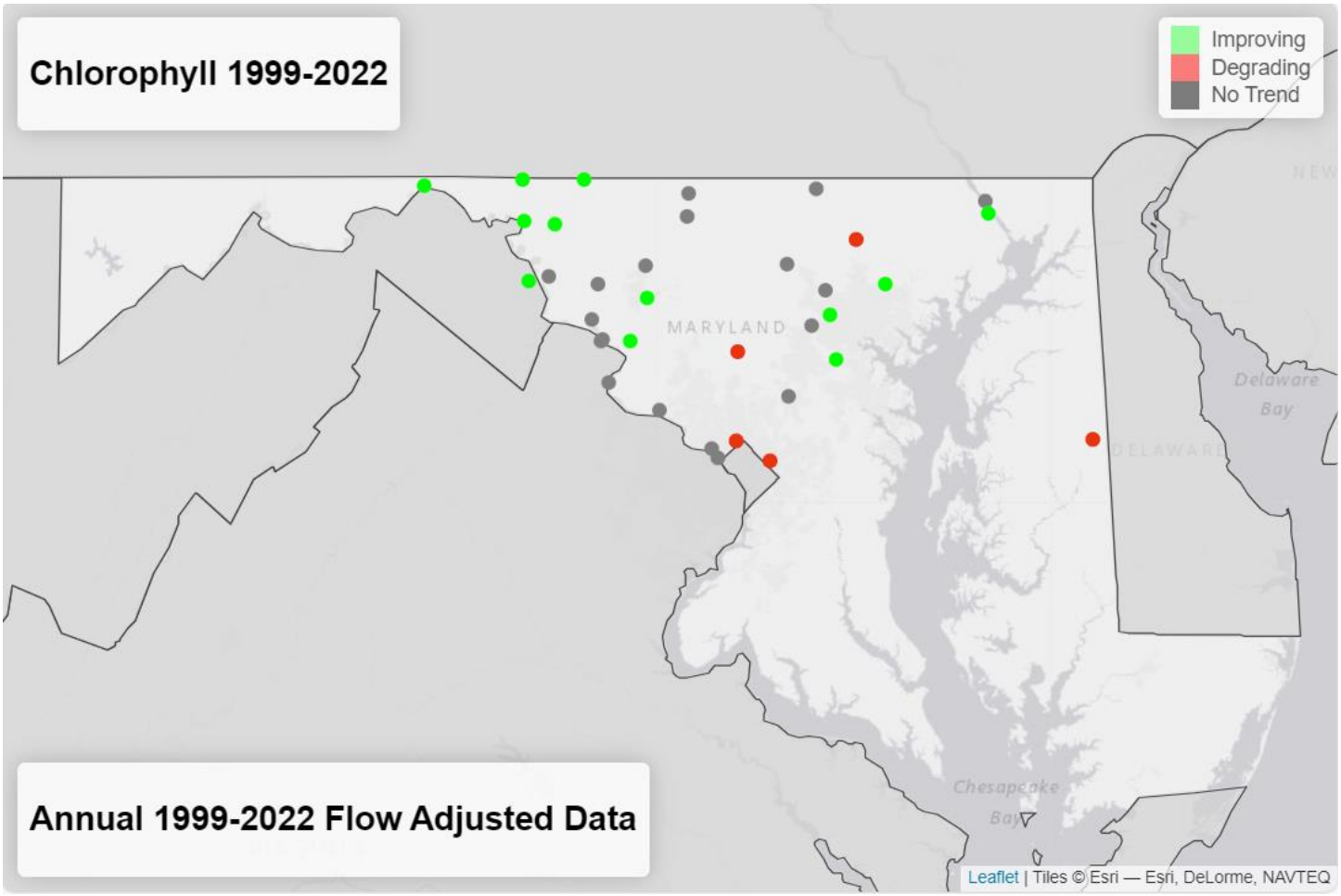

Figure 6. Trends in flow-adjusted chlorophyll-α concentrations 1999–2022

- 34% of stations (12 of 35) have improved chlorophyll levels compared to 1999
- 14% of stations (5 of 35) have degraded chlorophyll levels compared to 1999
- 52% of stations (18 of 35) do not have chlorophyll levels that are significantly different from 1999

Note that chlorophyll- α levels are not measured at all non-trend stations.

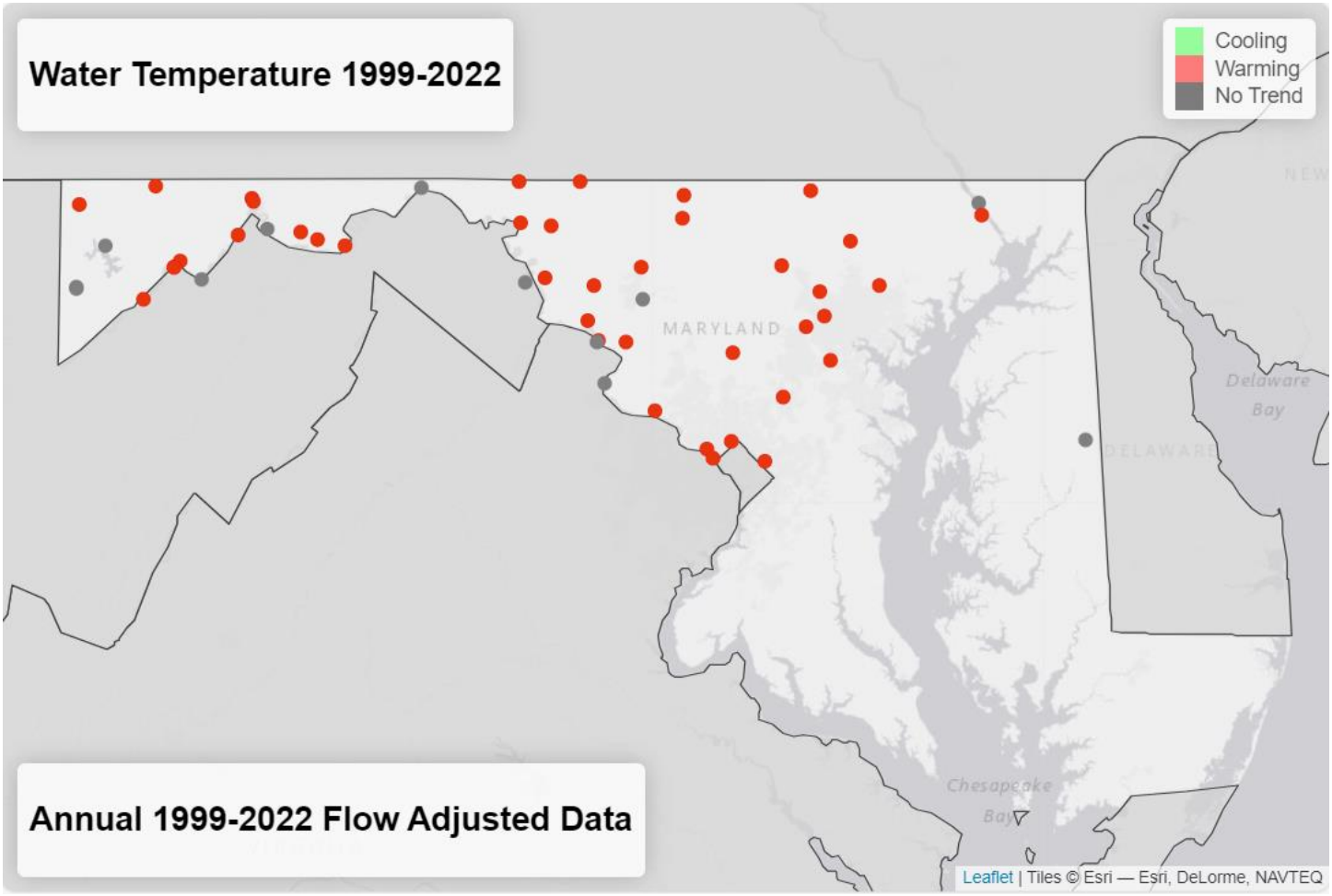

Figure 7. Trends in flow-adjusted water temperature concentrations 1999–2022

- 0% of stations (0 of 52) have cooling water temperature levels compared to 1999
- 77% of stations (40 of 52) have warming water temperature levels compared to 1999
- 23% of stations (12 of 52) do not have water temperature levels that are significantly different from 1999

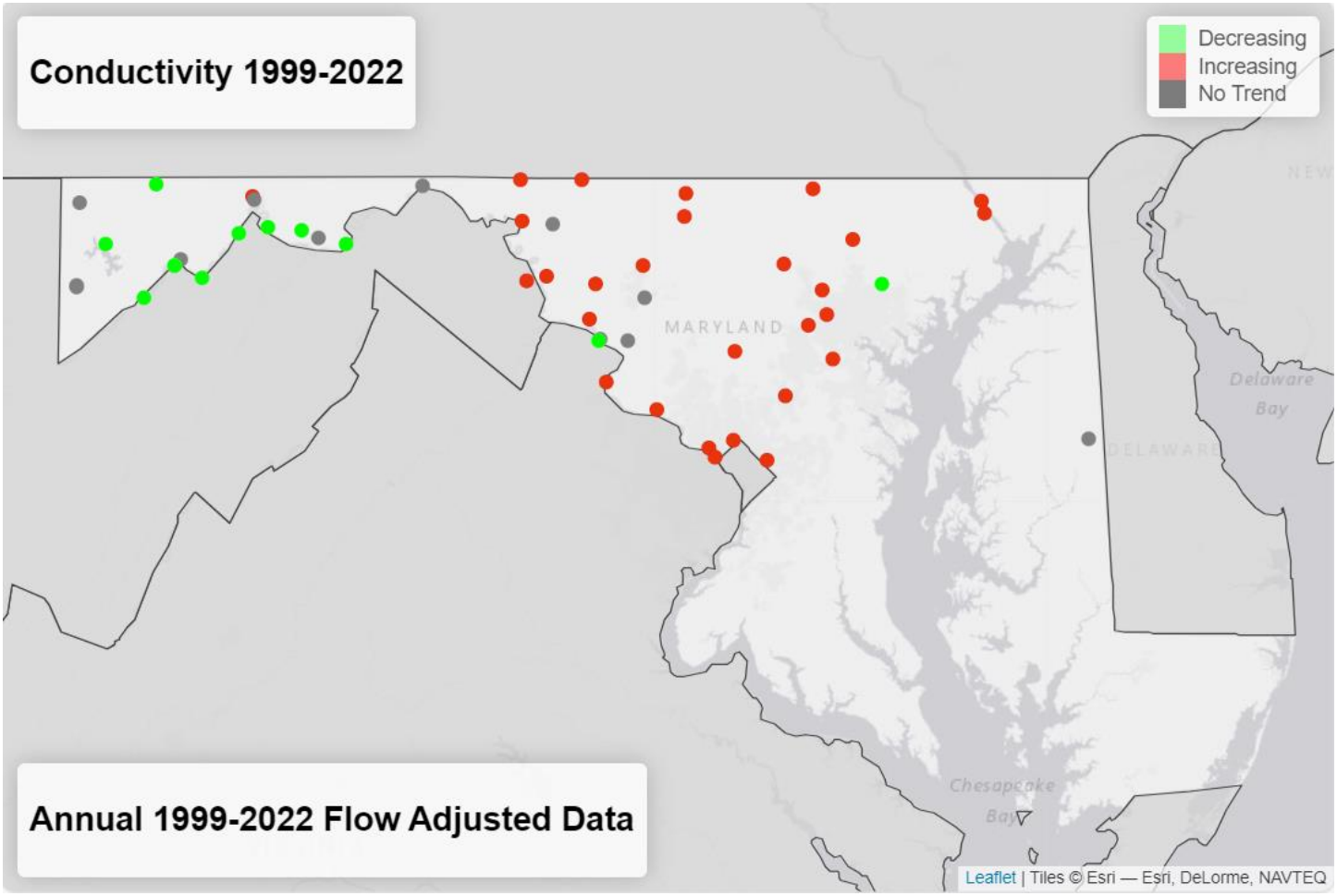

Figure 8. Trends in flow-adjusted conductivity concentrations 1999–2022

- 23% of stations (12 of 52) have decreased conductivity levels compared to 1999
- 54% of stations (28 of 52) have increased conductivity levels compared to 1999
- 23% of stations (12 of 52) do not have conductivity levels that are significantly different from 1999

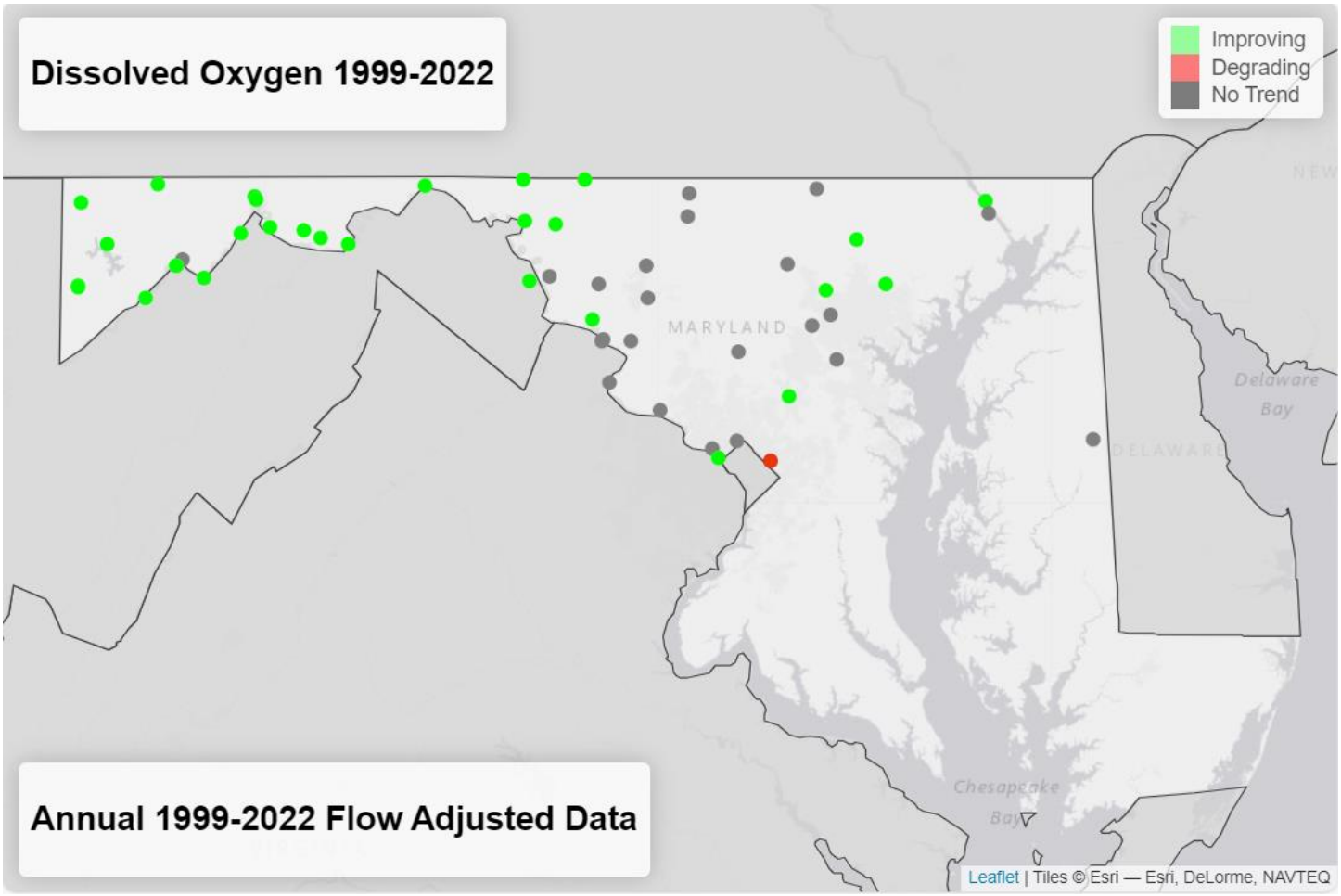

Figure 9. Trends in flow-adjusted dissolved oxygen concentrations 1999–2022

- 56% of stations (29 of 52) have improved dissolved oxygen levels compared to 1999
- 2% of stations (1 of 52) have degraded dissolved oxygen levels compared to 1999
- 42% of stations (22 of 52) do not have dissolved oxygen levels that are significantly different from 1999

Table 1. Trends in nutrients and total suspended solids at long-term non-tidal stations for the period 1999-2022. Highlighted values change by more than 50%, bolded values change by more than 20%, red indicates degrading (increasing) trends, green indicates improving (decreasing) trends, and empty cells indicate a not significant trend. Trends are significant at p <= 0.05.

Order	System	Station	Total Nitrogen		Total Phosphorus		Total Suspended Solids		Dissolved Inorganic Nitrogen		Orthophosphate	
			Flow-Adjusted	Observed	Flow-Adjusted	Observed	Flow-Adjusted	Observed	Flow-Adjusted	Observed	Flow-Adjusted	Observed
1	Western Maryland	LYO0004	imp.		imp >20%	imp >20%			imp >20%		imp >20%	
2	Western Maryland	YOU1139										
3	Western Maryland	YOU0925	imp.					deg > 50%				
4	Western Maryland	CCR0001	imp >20%	imp >20%					imp >20%	imp >20%		
5	Western Maryland	CAS0479			deg > 50%	deg > 20%					deg > 50%	
6	West. Upp. Potomac	NBP0689	imp >20%	imp >20%		deg > 50%	deg > 50%	deg > 50%	imp >20%	imp >20%		
7	West. Upp. Potomac	NBP0534	imp >20%	imp >20%			deg > 50%	deg > 50%	imp >20%	imp >20%		
8	West. Upp. Potomac	SAV0000				deg > 20%	deg > 50%	deg > 50%		deg		
9	West. Upp. Potomac	GEO0009	imp >20%	imp >50%	imp >50%	imp >50%			imp >20%	imp >50%		
10	West. Upp. Potomac	NBP0461	imp >20%	imp >20%	imp >50%	imp >50%					imp >50%	imp >50%
11	West. Upp. Potomac	NBP0326	imp >20%	imp >20%	imp >50%	imp >50%					imp >50%	imp >50%
12	West. Upp. Potomac	BDK0000	imp >20%									
13	West. Upp. Potomac	WIL0013										
14	West. Upp. Potomac	NBP0103	imp >20%	imp >20%	imp >50%	imp >50%			imp >20%	imp >20%	imp >50%	imp >50%
15	West. Upp. Potomac	NBP0023	imp >20%	imp >20%	imp >50%	imp >50%			imp.	imp.	imp >50%	imp >50%
16	West. Upp. Potomac	TOW0030					deg > 50%		deg > 50%			
17	West. Upp. Potomac	POT2766	imp >20%	imp >20%	imp >20%	imp >20%			imp >20%		imp >50%	imp >50%
18	West. Upp. Potomac	POT2386	imp.		imp >20%	imp >20%				deg > 20%	imp >20%	imp >20%
19	East. Upp. Potomac	CON0180			imp >20%	imp >50%	imp >20%	imp >20%			imp >50%	imp >50%
20	East. Upp. Potomac	CON0005			imp >50%	imp >50%	imp >20%	imp >20%			imp >50%	imp >50%
21	East. Upp. Potomac	POT1830	imp >20%	imp >20%	imp >20%	imp >20%					imp >50%	imp >50%
22	East. Upp. Potomac	ANT0366			imp >20%	imp >20%	imp >50%	imp >50%	deg	deg	imp >20%	imp >20%
23	East. Upp. Potomac	ANT0203	imp.	imp.	imp >50%	imp >50%	imp >20%	imp >20%			imp >50%	imp >50%
24	East. Upp. Potomac	ANT0044			imp >50%	imp >50%					imp >50%	imp >50%
25	East. Upp. Potomac	CAC0148	imp.		imp >20%	imp >20%					imp >50%	imp >50%
26	East. Upp. Potomac	CAC0031					imp >20%					
27	East. Upp. Potomac	POT1596	imp >20%	imp >20%		imp >20%					imp >50%	imp >50%

Order	System	Station	Total Nitrogen		Total Phosphorus		Total Suspended Solids		Dissolved Inorganic Nitrogen		Orthophosphate	
			Flow-Adjusted	Observed	Flow-Adjusted	Observed	Flow-Adjusted	Observed	Flow-Adjusted	Observed	Flow-Adjusted	Observed
28	East. Upp. Potomac	POT1595		imp >20%	imp >20%	imp >20%					imp >50%	imp >50%
29	Monocacy	MON0528	imp >20%	imp >20%			imp >20%	imp >20%				
30	Monocacy	BPC0035	imp.	imp.	imp >20%	imp >20%			imp.		imp >20%	imp >50%
31	Monocacy	MON0269	imp.	imp.	imp >20%	imp >20%	imp >20%				imp >50%	imp >50%
32	Monocacy	MON0155	imp >20%	imp >20%	imp >50%	imp >50%	imp >20%		imp >20%	imp >20%	imp >50%	imp >50%
33	Monocacy	MON0020	imp >20%	imp >20%	imp >50%	imp >50%			imp >20%	imp >20%	imp >50%	imp >50%
34	Middle Potomac	POT1471			imp >20%	imp >20%					imp >50%	imp >50%
35	Middle Potomac	SEN0008	imp >20%	imp >20%	imp >50%	imp >50%	imp >20%		imp >20%	imp >20%	imp >50%	imp >50%
36	Middle Potomac	CJB0005			imp >20%	imp >20%					imp >20%	
37	Middle Potomac	RCM0111	imp.	imp.								
38	Middle Potomac	POT1184	imp >20%	imp >20%	imp >20%	imp >20%			imp >20%		imp >50%	imp >50%
39	Middle Potomac	ANA0082	imp >20%	imp.				deg > 50%				
40	Gunpowder	GUN0476	deg	deg					deg	deg		
41	Gunpowder	GUN0258			imp >20%	imp >20%			deg			
42	Gunpowder	GUN0125		imp.	imp >50%	imp >50%	imp >50%	imp >50%				
43	Susquehanna	DER0015				imp >20%						
44	Susquehanna	CB1.0		imp.	imp.	imp.						
45	Patapsco	NPA0165	imp.	imp.		imp >20%				imp.		
46	Patapsco	PAT0285	imp.	imp.	imp >50%	imp >50%	imp >50%	imp >50%	imp.			
47	Patapsco	PAT0176	imp.	imp.	imp >20%		imp >20%	imp >20%	imp.			
48	Patapsco	JON0184	imp.	imp.	imp >20%	imp >20%		imp >20%				
49	Patapsco	GWN0115	imp.	imp >20%		imp >20%		imp >50%	imp.	imp >20%		
50	Patuxent	PXT0972	deg	deg			deg > 50%		deg	deg > 20%		
51	Patuxent	PXT0809		imp.								
52	Choptank	ET5.0							deg			

Table 2. Mean start, end, and difference in mean parameter value for period 1999-2022. Highlighted values change by more than 50%, bolded values change by more than 20%, red indicates degrading (increasing) flow-adjusted trends, green indicates improving (decreasing) flow-adjusted trends, and black text indicates a not significant flow-adjusted trend (see Table 1).

Order	Station	Total Nitrogen (mg/L)			Total Phosphorus (mg/L)			Total Suspended Solids (mg/L)			Dissolved Inorganic Nitrogen (mg/L)			Orthophosphate (mg/L)		
		1999/2000 Mean Value	2021/2022 Mean Value	Change	1999/2000 Mean Value	2021/2022 Mean Value	Change	1999/2000 Mean Value	2021/2022 Mean Value	Change	1999/2000 Mean Value	2021/2022 Mean Value	Change	1999/2000 Mean Value	2021/2022 Mean Value	Change
1	LYO0004	1.55	1.33	-0.22	**0.073**	**0.048**	**-0.025**	8.54	7.73	-0.81	**1.01**	**0.80**	**-0.21**	**0.020**	**0.013**	**-0.007**
2	YOU1139	1.14	1.09	-0.05	0.041	0.043	0.001	5.10	7.11	2.01	0.79	0.86	0.07	0.005	0.006	0.001
3	YOU0925	0.76	0.67	-0.09	0.018	0.020	0.002	2.26	3.84	1.57	0.48	0.46	-0.02	0.002	0.003	0.000
4	CCR0001	**0.58**	**0.40**	**-0.18**	0.013	0.014	0.000	1.66	2.63	0.96	**0.20**	**0.11**	**-0.09**	0.003	0.003	0.000
5	CAS0479	0.84	0.81	-0.03	**0.028**	**0.044**	**0.017**	2.55	4.55	2.00	0.54	0.60	0.05	**0.004**	**0.015**	**0.011**
6	NBP0689	**1.19**	**0.66**	**-0.53**	0.009	0.013	0.003	**1.34**	**4.04**	**2.70**	**0.98**	**0.54**	**-0.43**	0.002	0.002	-0.001
7	NBP0534	**1.06**	**0.74**	**-0.32**	0.009	0.011	0.002	**1.16**	**2.85**	**1.70**	**0.86**	**0.62**	**-0.24**	0.002	0.002	0.000
8	SAV0000	0.84	0.77	-0.07	0.011	0.013	0.002	**0.59**	**2.75**	**2.16**	0.62	0.67	0.05	0.003	0.003	0.001
9	GEO0009	**1.27**	**0.67**	**-0.60**	**0.033**	**0.012**	**-0.021**	6.31	6.12	-0.20	**0.94**	**0.51**	**-0.43**	0.004	0.002	-0.002
10	NBP0461	**1.10**	**0.76**	**-0.34**	**0.046**	**0.013**	**-0.034**	4.72	2.87	-1.85	0.73	0.66	-0.08	**0.006**	**0.003**	**-0.004**
11	NBP0326	**1.10**	**0.75**	**-0.35**	**0.045**	**0.016**	**-0.029**	5.18	2.88	-2.30	0.66	0.62	-0.04	**0.007**	**0.003**	**-0.004**
12	BDK0000	**0.69**	**0.51**	**-0.18**	0.017	0.015	-0.002	6.38	4.64	-1.74	0.47	0.44	-0.04	0.004	0.004	0.000
13	WIL0013	0.84	0.73	-0.11	0.015	0.016	0.001	2.16	2.55	0.40	0.54	0.57	0.03	0.004	0.004	0.000
14	NBP0103	**1.28**	**0.80**	**-0.47**	**0.060**	**0.022**	**-0.038**	3.28	3.21	-0.08	**0.85**	**0.68**	**-0.17**	**0.017**	**0.006**	**-0.010**
15	NBP0023	**1.16**	**0.80**	**-0.36**	**0.061**	**0.021**	**-0.040**	4.17	3.68	-0.49	0.75	0.63	-0.12	**0.012**	**0.006**	**-0.007**
16	TOW0030	0.56	0.58	0.02	0.015	0.013	-0.002	**1.24**	**2.33**	**1.09**	**0.20**	**0.36**	**0.16**	0.003	0.003	0.000
17	POT2766	**0.94**	**0.62**	**-0.32**	**0.035**	**0.022**	**-0.012**	2.95	3.53	0.57	**0.62**	**0.41**	**-0.21**	**0.009**	**0.003**	**-0.005**
18	POT2386	0.90	0.76	-0.14	**0.031**	**0.023**	**-0.008**	6.56	4.85	-1.70	0.48	0.56	0.07	**0.015**	**0.009**	**-0.006**
19	CON0180	3.96	3.82	-0.14	**0.095**	**0.051**	**-0.044**	**9.10**	**6.02**	**-3.08**	3.42	3.50	0.08	**0.056**	**0.025**	**-0.031**
20	CON0005	3.88	3.68	-0.20	**0.081**	**0.037**	**-0.044**	**11.00**	**5.80**	**-5.20**	3.37	3.38	0.01	**0.045**	**0.020**	**-0.025**
21	POT1830	**1.59**	**1.23**	**-0.36**	**0.041**	**0.022**	**-0.019**	4.73	4.14	-0.60	1.12	1.06	-0.06	**0.022**	**0.007**	**-0.015**
22	ANT0366	4.00	4.30	0.31	**0.144**	**0.072**	**-0.072**	**13.90**	**6.48**	**-7.42**	3.42	4.06	0.63	**0.082**	**0.045**	**-0.037**
23	ANT0203	4.78	4.27	-0.52	**0.236**	**0.075**	**-0.161**	**14.86**	**7.68**	**-7.18**	4.17	3.87	-0.30	**0.152**	**0.044**	**-0.108**
24	ANT0044	4.42	4.35	-0.07	**0.160**	**0.059**	**-0.100**	8.96	7.28	-1.67	3.92	3.90	-0.02	**0.094**	**0.031**	**-0.063**
25	CAC0148	1.53	1.35	-0.18	**0.078**	**0.045**	**-0.033**	4.28	3.87	-0.41	1.03	0.85	-0.18	**0.050**	**0.022**	**-0.027**

Order	Station	Total Nitrogen (mg/L)			Total Phosphorus (mg/L)			Total Suspended Solids (mg/L)			Dissolved Inorganic Nitrogen (mg/L)			Orthophosphate (mg/L)		
		1999/2000 Mean Value	2021/2022 Mean Value	Change	1999/2000 Mean Value	2021/2022 Mean Value	Change	1999/2000 Mean Value	2021/2022 Mean Value	Change	1999/2000 Mean Value	2021/2022 Mean Value	Change	1999/2000 Mean Value	2021/2022 Mean Value	Change
26	CAC0031	1.96	1.97	0.01	0.086	0.084	-0.002	6.15	4.20	-1.95	1.41	1.60	0.19	0.054	0.051	-0.004
27	POT1596	1.47	1.17	-0.30	0.067	0.051	-0.016	6.01	6.55	0.54	0.83	0.87	0.04	0.039	0.016	-0.023
28	POT1595	1.78	1.60	-0.18	0.052	0.034	-0.017	7.85	6.92	-0.93	1.29	1.17	-0.11	0.026	0.012	-0.013
29	MON0528	1.94	1.29	-0.65	0.099	0.098	0.000	6.69	4.59	-2.10	0.96	0.71	-0.25	0.063	0.051	-0.013
30	BPC0035	3.69	3.17	-0.52	0.045	0.028	-0.017	6.28	6.43	0.15	3.16	2.79	-0.36	0.027	0.014	-0.013
31	MON0269	2.75	2.22	-0.53	0.095	0.063	-0.032	7.64	4.65	-2.99	2.14	1.94	-0.19	0.053	0.025	-0.028
32	MON0155	3.41	2.07	-1.34	0.180	0.058	-0.121	10.42	6.10	-4.33	2.68	1.73	-0.95	0.127	0.022	-0.105
33	MON0020	3.40	2.37	-1.03	0.153	0.061	-0.092	10.32	7.63	-2.69	2.77	1.97	-0.81	0.096	0.033	-0.063
34	POT1471	2.03	1.94	-0.09	0.074	0.052	-0.023	8.53	7.57	-0.96	1.49	1.59	0.10	0.042	0.019	-0.024
35	SEN0008	2.91	2.01	-0.90	0.124	0.039	-0.085	5.61	4.23	-1.38	2.41	1.60	-0.80	0.085	0.013	-0.072
36	CJB0005	1.37	1.26	-0.11	0.027	0.018	-0.008	3.06	1.98	-1.08	0.91	0.94	0.03	0.014	0.010	-0.004
37	RCM0111	1.59	1.38	-0.22	0.052	0.056	0.005	7.15	6.37	-0.78	0.94	0.90	-0.04	0.012	0.012	0.000
38	POT1184	1.74	1.32	-0.42	0.070	0.037	-0.034	9.59	8.23	-1.36	1.14	0.88	-0.25	0.035	0.009	-0.026
39	ANA0082	1.50	1.19	-0.31	0.045	0.047	0.002	5.67	7.78	2.11	0.86	0.73	-0.13	0.009	0.008	-0.001
40	GUN0476	3.24	3.51	0.27	0.032	0.030	-0.002	5.70	4.41	-1.29	2.84	3.10	0.25	0.011	0.007	-0.004
41	GUN0258	2.43	2.62	0.18	0.020	0.015	-0.005	5.27	5.04	-0.23	2.08	2.33	0.25	0.006	0.005	-0.001
42	GUN0125	1.45	1.41	-0.04	0.041	0.019	-0.022	12.19	2.94	-9.25	0.99	1.15	0.15	0.006	0.005	-0.001
43	DER0015	3.43	3.59	0.16	0.044	0.033	-0.011	4.52	4.56	0.03	2.95	3.19	0.25	0.015	0.013	-0.003
44	CB1.0	1.53	1.43	-0.11	0.041	0.037	-0.005	8.06	9.21	1.15	1.13	1.12	-0.01	0.007	0.008	0.002
45	NPA0165	4.22	3.84	-0.37	0.019	0.015	-0.004	3.82	3.41	-0.41	3.82	3.52	-0.30	0.005	0.005	0.000
46	PAT0285	2.59	2.10	-0.49	0.047	0.016	-0.031	5.89	2.32	-3.57	2.15	1.92	-0.23	0.011	0.009	-0.002
47	PAT0176	2.23	1.91	-0.33	0.045	0.032	-0.013	5.81	3.22	-2.60	1.76	1.50	-0.25	0.012	0.009	-0.003
48	JON0184	1.92	1.80	-0.13	0.021	0.016	-0.005	4.02	3.00	-1.03	1.62	1.53	-0.09	0.007	0.010	0.003
49	GWN0115	1.80	1.47	-0.33	0.028	0.024	-0.004	4.11	2.43	-1.68	1.37	1.10	-0.27	0.007	0.009	0.002
50	PXT0972	2.86	3.04	0.19	0.024	0.022	-0.002	5.79	9.20	3.41	2.55	2.78	0.23	0.007	0.007	0.001
51	PXT0809	1.61	1.57	-0.04	0.028	0.028	0.000	5.85	6.27	0.42	1.19	1.19	0.00	0.004	0.004	0.000
52	ET5.0	1.86	1.85	-0.01	0.067	0.074	0.007	3.20	3.60	0.40	1.33	1.55	0.22	0.024	0.030	0.006

Table 3. Trends in chlorophyll, water temperature, conductivity and dissolved oxygen at long-term non-tidal stations for the period 1999-2022. Grey cells indicate stations not sampled for that parameter. Highlighted values change by more than 50%, bolded values change by more than 20%, red indicates degrading or increasing trends, green indicates improving or decreasing trends, and empty cells indicate a not significant trend except in the case of dissolved oxygen, where an increasing trend is improving and colored green, and a decreasing trend is degrading and colored red. Trends are significant at p <= 0.05.

Order	System	Station	Chlorophyll-α		Water Temperature		Conductivity		Dissolved Oxygen	
			Flow-Adjusted	Observed	Flow-Adjusted	Observed	Flow-Adjusted	Observed	Flow-Adjusted	Observed
1	Western Maryland	LYO0004							imp.	imp.
2	Western Maryland	YOU1139							imp.	imp.
3	Western Maryland	YOU0925			deg				imp.	imp.
4	Western Maryland	CCR0001					**imp >20%**	**imp >20%**	imp.	imp.
5	Western Maryland	CAS0479			deg		imp.		imp.	imp.
6	West. Upp. Potomac	NBP0689			deg		**imp >20%**	**imp >20%**	imp.	imp.
7	West. Upp. Potomac	NBP0534			deg	deg	imp.	imp.	imp.	imp.
8	West. Upp. Potomac	SAV0000			deg	deg	imp.	imp.	imp.	imp.
9	West. Upp. Potomac	GEO0009			deg	deg				
10	West. Upp. Potomac	NBP0461					**imp >20%**	**imp >20%**	imp.	imp.
11	West. Upp. Potomac	NBP0326			deg		**imp >20%**	**imp >20%**	imp.	**imp > 20%**
12	West. Upp. Potomac	BDK0000			**deg > 20%**	**deg > 20%**	deg		imp.	imp.
13	West. Upp. Potomac	WIL0013			deg	deg			imp.	imp.
14	West. Upp. Potomac	NBP0103					**imp >20%**	**imp >20%**	imp.	imp.
15	West. Upp. Potomac	NBP0023			deg		**imp >20%**	**imp >20%**	imp.	imp.
16	West. Upp. Potomac	TOW0030			deg	deg			imp.	imp.
17	West. Upp. Potomac	POT2766			deg		imp.	**imp >20%**	imp.	imp.
18	West. Upp. Potomac	POT2386	**imp >20%**	**imp >20%**				imp.	imp.	imp.
19	East. Upp. Potomac	CON0180	**imp >20%**	**imp >20%**	deg	deg	deg	deg	imp.	**imp > 20%**
20	East. Upp. Potomac	CON0005	**imp >20%**	**imp >20%**	deg	deg	deg	deg	imp.	imp.
21	East. Upp. Potomac	POT1830	**imp >20%**				deg		imp.	imp.
22	East. Upp. Potomac	ANT0366	**imp >20%**	**imp >20%**	deg	deg	deg	deg	imp.	imp.
23	East. Upp. Potomac	ANT0203	**imp >20%**	**imp >20%**	deg	deg			imp.	imp.
24	East. Upp. Potomac	ANT0044			deg	deg	deg			

Order	System	Station	Chlorophyll-α		Water Temperature		Conductivity		Dissolved Oxygen	
			Flow-Adjusted	Observed	Flow-Adjusted	Observed	Flow-Adjusted	Observed	Flow-Adjusted	Observed
25	East. Upp. Potomac	CAC0148			deg	deg	deg	deg		imp.
26	East. Upp. Potomac	CAC0031			deg		deg	deg	imp.	
27	East. Upp. Potomac	POT1596					imp.	imp.		
28	East. Upp. Potomac	POT1595			deg	deg				
29	Monocacy	MON0528		imp >20%	deg	deg	deg	deg		
30	Monocacy	BPC0035			deg	deg	deg			
31	Monocacy	MON0269			deg	deg	deg			
32	Monocacy	MON0155	imp >20%	imp >20%						
33	Monocacy	MON0020	imp >20%		deg	deg				
34	Middle Potomac	POT1471					deg			
35	Middle Potomac	SEN0008			deg	deg	deg > 50%	deg > 20%		
36	Middle Potomac	CJB0005			deg	deg	deg > 50%	deg > 50%		
37	Middle Potomac	RCM0111	deg > 50%	deg > 50%	deg	deg	deg > 50%	deg > 20%		
38	Middle Potomac	POT1184			deg		deg		imp.	imp.
39	Middle Potomac	ANA0082	deg > 50%	deg > 50%	deg		deg > 50%	deg > 20%	deg.	deg.
40	Gunpowder	GUN0476			deg	deg	deg	deg > 20%		
41	Gunpowder	GUN0258	deg > 20%		deg	deg	deg	deg	imp.	imp.
42	Gunpowder	GUN0125	imp >20%	imp >20%	deg	deg	imp >20%	imp >20%	imp.	imp > 20%
43	Susquehanna	DER0015	imp >20%	imp.	deg	deg	deg	deg		
44	Susquehanna	CB1.0					deg		imp.	imp.
45	Patapsco	NPA0165			deg	deg	deg > 20%	deg		
46	Patapsco	PAT0285			deg	deg	deg > 20%	deg		
47	Patapsco	PAT0176	imp >20%	imp >20%	deg	deg	deg > 20%	deg > 20%		
48	Patapsco	JON0184		deg > 20%	deg	deg	deg > 20%	deg	imp.	
49	Patapsco	GWN0115	imp >20%		deg	deg	deg > 50%	deg > 50%		
50	Patuxent	PXT0972	deg > 20%		deg	deg	deg	deg		
51	Patuxent	PXT0809			deg	deg	deg > 20%	deg > 20%	imp.	
52	Choptank	ET5.0	deg > 50%					imp.		

Table 4. Mean start, end, and difference in mean parameter value for period 1999-2022. Grey cells indicate stations not sampled for that parameter. Highlighted values change by more than 50%, bolded values change by more than 20%, red indicates degrading or increasing flow-adjusted trends, green indicates improving or decreasing flow-adjusted trends, and black text indicates a not significant flow-adjusted trend (see Table 3) except in the case of dissolved oxygen, where an increasing trend is improving and colored green, and a decreasing trend is degrading and colored red.

Order	Station	Chlorophyll-α (µg/L)			Water Temperature (°C)			Conductivity (µS/cm)			Dissolved Oxygen (mg/L)		
		1999/ 2000 Mean Value	2021/ 2022 Mean Value	Change	1999/ 2000 Mean Value	2021/ 2022 Mean Value	Change	1999/ 2000 Mean Value	2021/ 2022 Mean Value	Change	1999/ 2000 Mean Value	2021/ 2022 Mean Value	Change
1	LYO0004				10.0	11.0	0.9	175	193	18	9.1	9.6	0.5
2	YOU1139				10.2	10.9	0.7	126	112	-13	9.3	10.0	0.7
3	YOU0925				9.9	11.0	1.1	101	95	-6	10.2	11.0	0.8
4	CCR0001				8.6	9.6	1.0	**122**	**77**	**-45**	9.8	10.6	0.8
5	CAS0479				8.9	10.3	1.4	188	156	-33	10.0	11.3	1.3
6	NBP0689				10.4	12.0	1.5	**476**	**335**	**-141**	10.1	10.7	0.7
7	NBP0534				9.7	11.1	1.3	387	313	-74	10.4	11.0	0.6
8	SAV0000				9.1	10.8	1.7	129	106	-23	10.7	11.3	0.6
9	GEO0009				10.7	12.3	1.6	822	901	79	10.6	10.9	0.3
10	NBP0461				11.4	11.7	0.3	**477**	**318**	**-159**	9.7	11.3	1.7
11	NBP0326				11.8	13.0	1.2	**440**	**314**	**-126**	9.3	11.2	1.8
12	BDK0000				**9.2**	**11.5**	**2.3**	939	1050	111	10.5	10.9	0.4
13	WIL0013				10.1	11.9	1.8	281	283	2	10.2	11.3	1.1
14	NBP0103				12.2	13.1	0.9	**417**	**319**	**-98**	9.5	11.0	1.5
15	NBP0023				12.4	13.4	1.0	**406**	**310**	**-96**	9.4	10.8	1.4
16	TOW0030				12.0	14.1	2.1	188	169	-19	10.2	11.2	1.0
17	POT2766				13.4	14.7	1.3	298	239	-59	9.7	10.7	1.1
18	POT2386	**1.21**	**0.78**	**-0.42**	13.9	14.3	0.4	300	287	-12	9.8	10.3	0.6
19	CON0180	**1.91**	**1.03**	**-0.87**	12.3	14.6	2.3	385	428	43	9.5	11.4	1.9
20	CON0005	**1.68**	**1.11**	**-0.57**	13.1	15.3	2.1	387	440	53	9.9	11.5	1.6
21	POT1830	**1.63**	**1.09**	**-0.53**	14.5	15.3	0.8	311	327	16	9.7	10.3	0.6
22	ANT0366	**3.73**	**2.03**	**-1.69**	11.5	13.0	1.5	375	408	34	9.9	11.4	1.5
23	ANT0203	**1.99**	**1.12**	**-0.88**	12.8	13.9	1.1	505	539	34	9.4	10.2	0.8
24	ANT0044	1.86	1.84	-0.01	12.8	13.9	1.2	519	546	28	10.1	10.3	0.2
25	CAC0148	2.92	2.34	-0.58	12.1	13.1	1.0	218	247	30	10.6	10.7	0.1

Order	Station	Chlorophyll-α (µg/L)			Water Temperature (°C)			Conductivity (µS/cm)			Dissolved Oxygen (mg/L)		
		1999/ 2000 Mean Value	2021/ 2022 Mean Value	Change	1999/ 2000 Mean Value	2021/ 2022 Mean Value	Change	1999/ 2000 Mean Value	2021/ 2022 Mean Value	Change	1999/ 2000 Mean Value	2021/ 2022 Mean Value	Change
26	CAC0031	2.08	2.25	0.17	12.2	13.0	0.9	243	283	40	10.0	10.3	0.4
27	POT1596	1.71	2.04	0.33	14.0	14.5	0.5	283	263	-20	9.7	9.6	-0.1
28	POT1595	1.83	1.77	-0.06	13.7	14.7	0.9	320	311	-8	9.7	9.8	0.1
29	MON0528	2.18	1.69	-0.50	12.6	13.7	1.1	281	319	38	9.0	9.4	0.4
30	BPC0035	1.59	1.47	-0.12	11.9	13.0	1.2	240	253	13	9.9	10.1	0.1
31	MON0269	1.91	1.79	-0.13	13.0	14.1	1.1	270	301	31	9.4	9.8	0.4
32	MON0155	2.86	1.97	-0.90	13.0	13.8	0.8	298	293	-4	9.2	9.5	0.3
33	MON0020	2.29	1.76	-0.53	13.4	14.4	1.0	317	340	23	9.5	9.9	0.4
34	POT1471	1.83	1.70	-0.13	15.6	15.2	-0.4	310	335	26	9.5	9.7	0.2
35	SEN0008	2.24	2.38	0.14	13.0	15.2	2.1	252	421	170	10.6	10.9	0.3
36	CJB0005	1.89	2.11	0.21	13.1	14.0	0.9	382	631	249	10.8	10.8	0.0
37	RCM0111	3.38	5.60	2.22	13.4	14.8	1.4	333	518	185	9.1	9.7	0.5
38	POT1184	2.20	2.42	0.21	15.5	16.1	0.6	279	312	33	9.6	10.1	0.6
39	ANA0082	2.52	4.97	2.45	15.1	16.4	1.2	303	472	169	10.5	9.7	-0.8
40	GUN0476	1.48	1.23	-0.25	11.5	12.5	1.0	163	195	31	10.9	11.0	0.1
41	GUN0258	1.99	2.73	0.74	11.5	12.1	0.6	171	201	30	10.7	11.4	0.7
42	GUN0125	4.25	2.74	-1.52	13.6	15.5	1.9	424	306	-117	9.1	10.8	1.7
43	DER0015	1.52	1.11	-0.41	12.1	13.0	0.9	169	193	24	10.4	10.7	0.2
44	CB1.0	4.26	4.24	-0.02	15.2	15.6	0.3	239	252	13	9.7	10.4	0.8
45	NPA0165	1.43	1.33	-0.10	11.0	12.5	1.5	223	274	51	10.5	10.6	0.0
46	PAT0285	1.41	1.06	-0.36	12.3	13.5	1.3	230	283	53	10.1	10.2	0.1
47	PAT0176	2.02	1.28	-0.74	12.5	13.5	1.0	265	328	63	10.0	10.2	0.2
48	JON0184	1.59	1.53	-0.06	11.6	13.2	1.6	398	495	98	10.7	11.1	0.4
49	GWN0115	1.45	1.00	-0.45	11.6	13.2	1.6	323	557	234	10.4	10.5	0.1
50	PXT0972	1.11	1.35	0.24	11.5	12.5	1.0	137	158	21	10.3	10.3	0.0
51	PXT0809	4.22	5.39	1.17	13.6	14.4	0.8	148	206	58	9.3	9.6	0.3
52	ET5.0	0.76	1.22	0.46	14.0	14.2	0.2	147	140	-7	8.8	8.9	0.2

Works Cited

Murphy, R. R., E. Perry, J. Harcum, and J. Keisman. 2019. A Generalized Additive Model approach to evaluating water quality: Chesapeake Bay case study. Environmental Modeling & Software 118:1-13.