2023 Caspian Lake Water Quality Monitoring Results: Lay Monitoring Program and LaRosa Partnership Program

Mark Mitchell, Lake Monitoring and Community Outreach Coordinator
VT Department of Environmental Conservation, UVM Lake Champlain Sea Grant

VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION
WATERSHED MANAGEMENT DIVISION
LAKES & PONDS PROGRAM

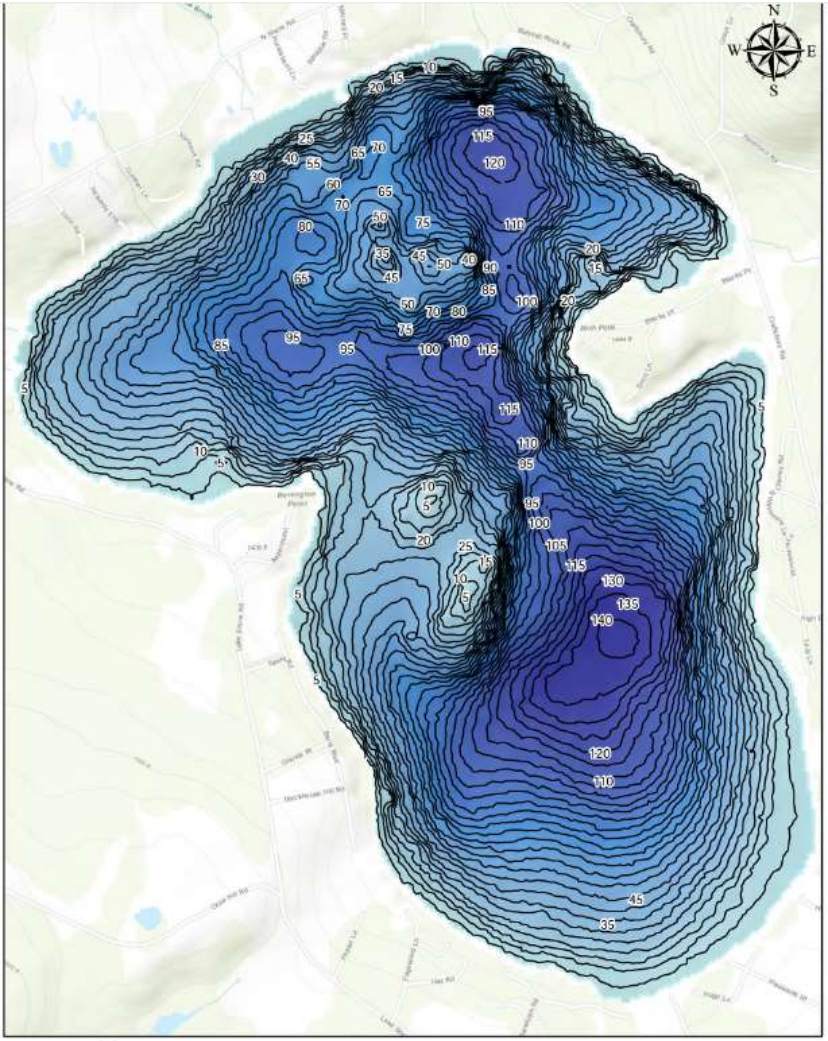
VERMONT LAY MONITORING PROGRAM •1979•

Sea Grant
Lake Champlain

Lay Monitoring Program (LMP) 2023 Lake Sampling Overview

- Biweekly from June through August (total of 6 samples for summer mean):
  - *Basic Sampling:* Measure Secchi disk transparency depth (clarity)
  - *Supplemental Sampling:* Collect hose, epilimnetic and hypolimnetic water samples that are lab tested for total phosphorus (nutrient) concentration and chlorophyll-a (algae) concentration
  - Pilot caffeine sampling (wastewater)
  - Complete a lake sampling webform (and report cyanobacteria conditions)

https://dec.vermont.gov/watershed/lakes-ponds/monitor/lay-monitoring



Legend

Depth (ft.)

High : 0

Low : 142

Depth Contour (5 ft.)

0 0.1 0.2 0.4 Miles

Source data collected: 7/24/2018

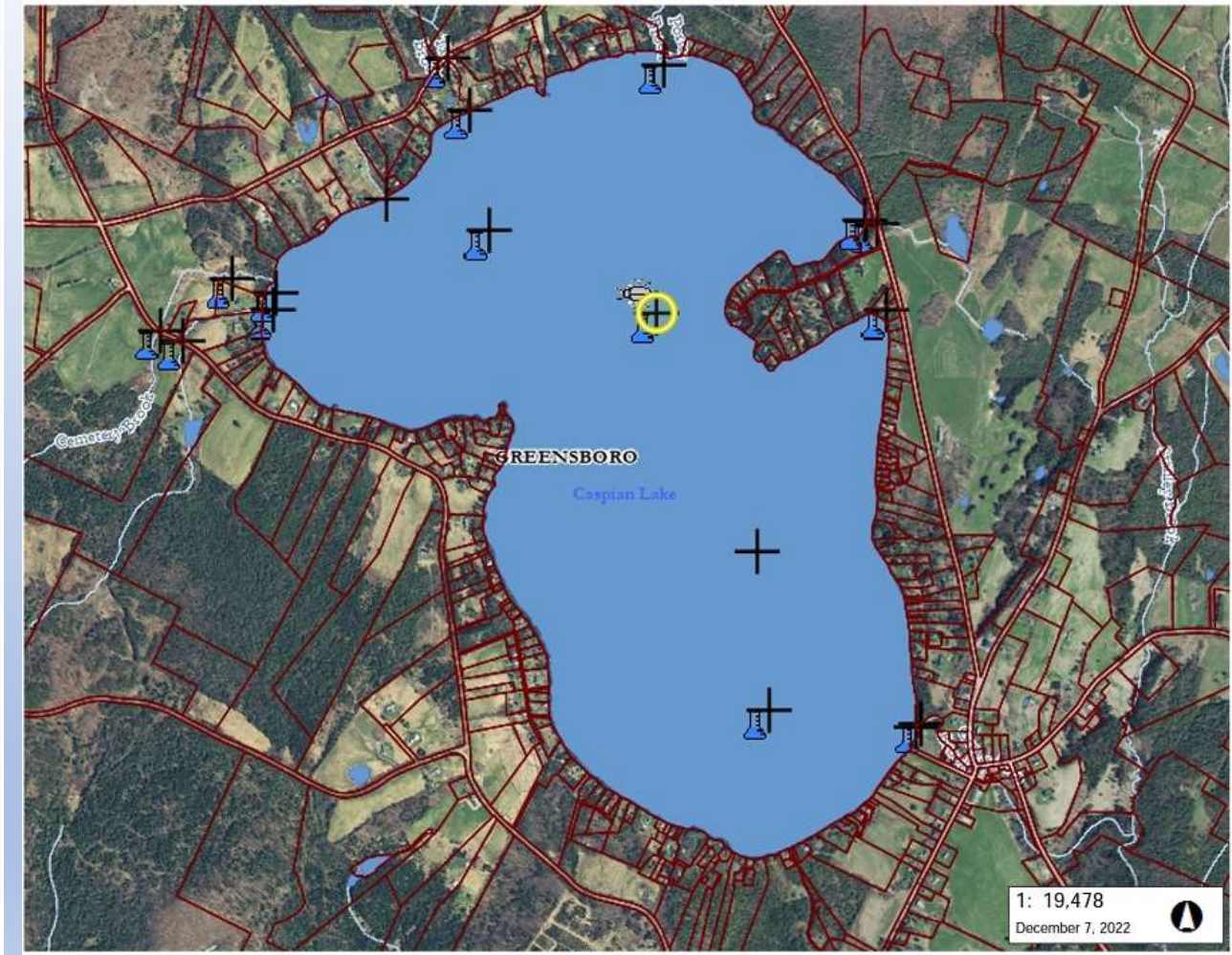
VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION
WATERSHED MANAGEMENT DIVISION
LAKES & PONDS PROGRAM

VERMONT

Caspian Lake Monitoring Station #1 (Center)

Vermont Agency of Natural Resources

vermont.gov



990.0 0 495.00 990.0 Meters

WGS_1984_Web_Mercator_Auxiliary_Sphere 1" = 1623 Ft. 1cm = 195 Meters

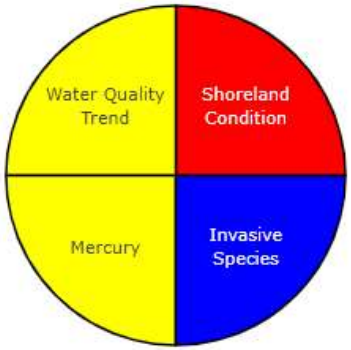
THIS MAP IS NOT TO BE USED FOR NAVIGATION

Vermont Lake Score Card

Caspian Lake

https://dec.vermont.gov/watershed/lakes-ponds/data-maps/scorecard

Scores | Water Quality Data | Lake Information



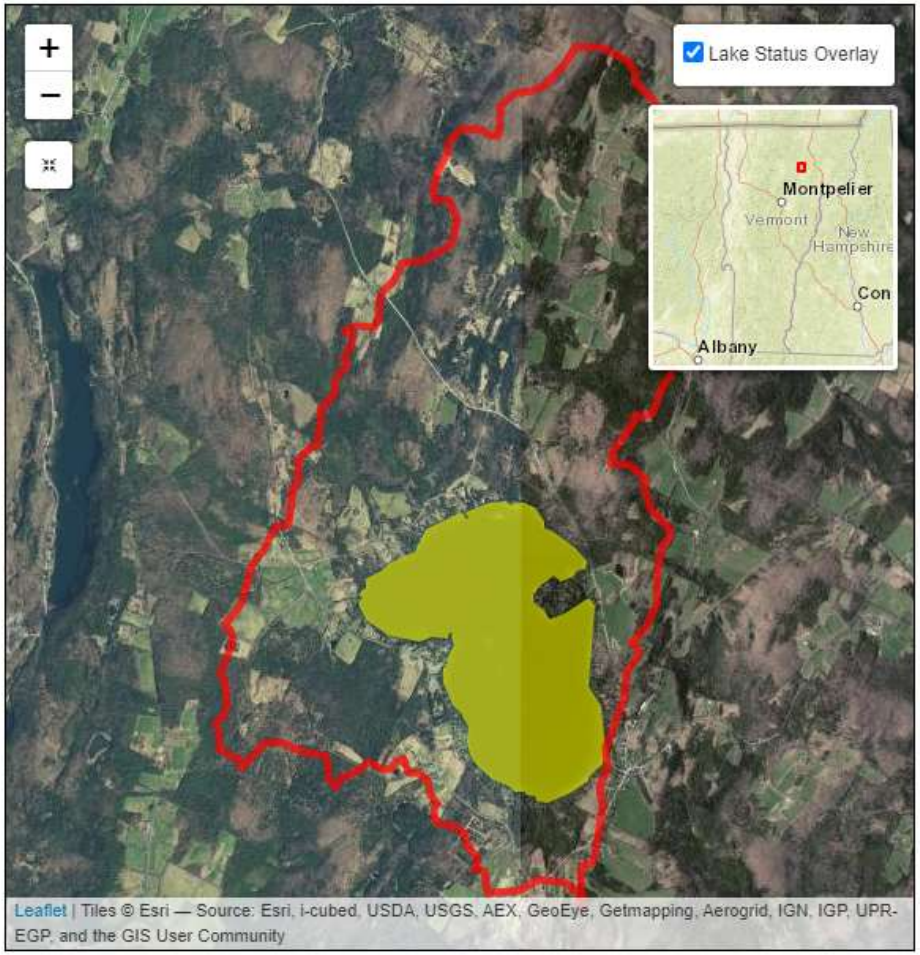
Watershed:	Highly Disturbed
WQ Standards:	Stressed

Details

Stressed – Flow alteration

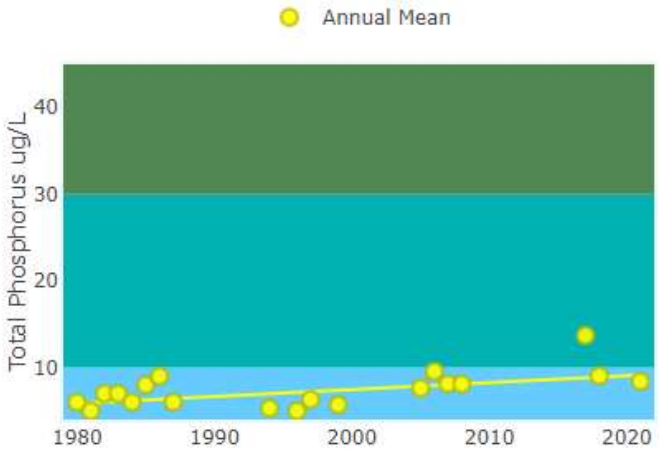
Color Scoring System
- Good Conditions
- Fair Conditions
- Poor Conditions
- Insufficient Data

Learn How Lakes Are Scored



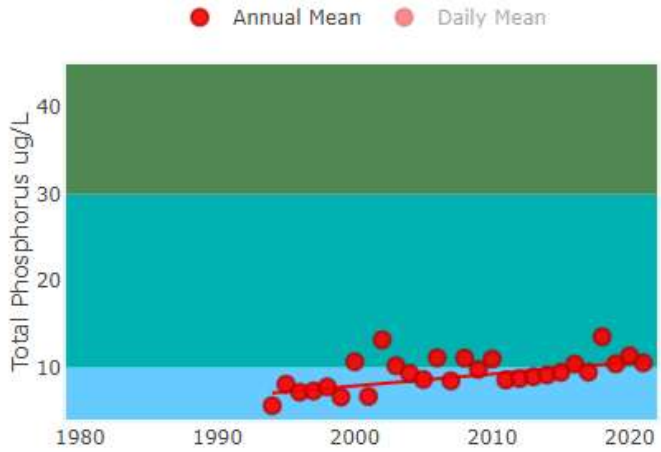
Spring Phosphorus

Trend: Significantly Increasing (p-value=0.0115)



Summer Phosphorus

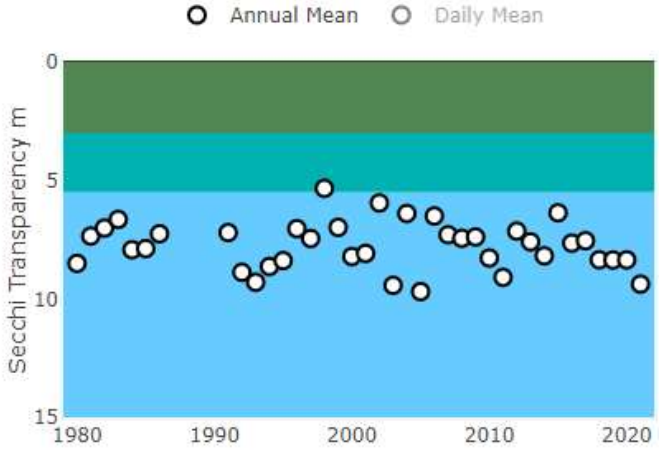
Trend: Highly Significantly Increasing (p-value=0.001)



CASPIAN LAKE SCORE CARD WATER QUALITY TRENDS

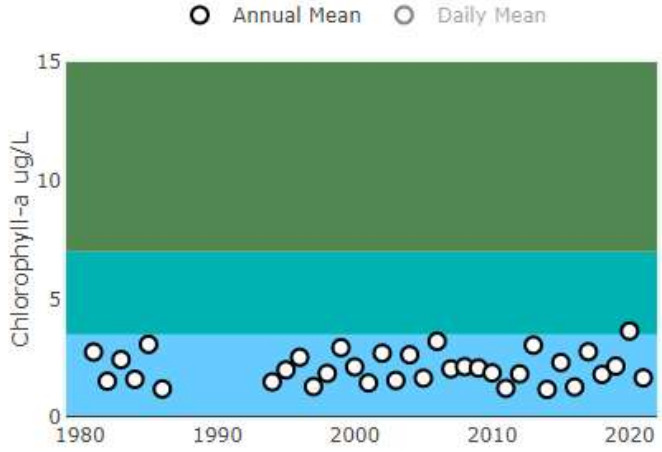
Summer Secchi

Trend: Stable (p-value=0.2967)



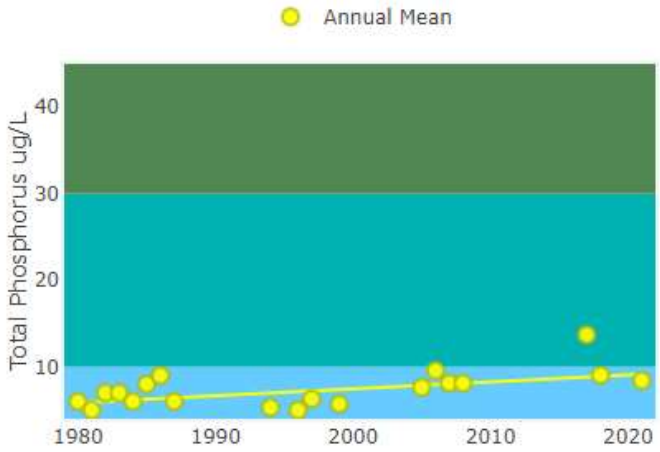
Summer Chlorophyll-a

Trend: Stable (p-value=0.7782)



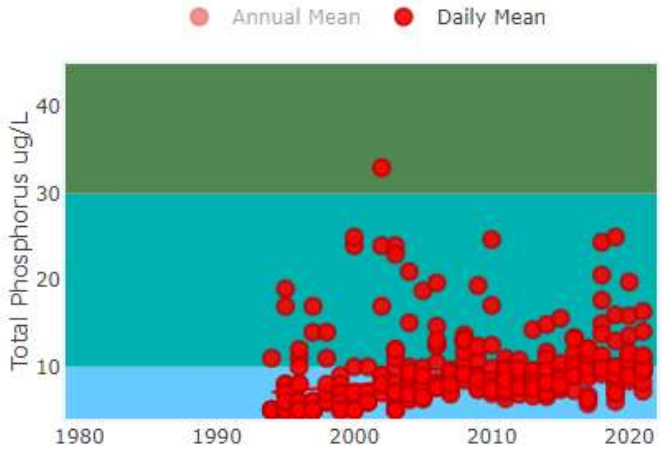
Spring Phosphorus

Trend: Significantly Increasing (p-value=0.0115)



Summer Phosphorus

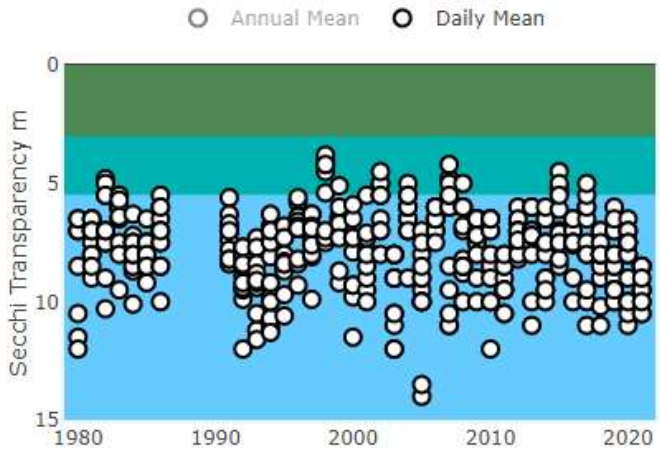
Trend: Highly Significantly Increasing (p-value=0.001)



CASPIAN LAKE SCORE CARD WATER QUALITY TRENDS

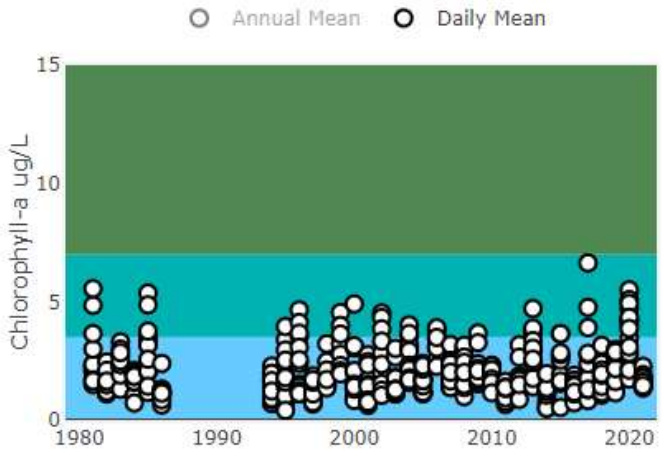
Summer Secchi

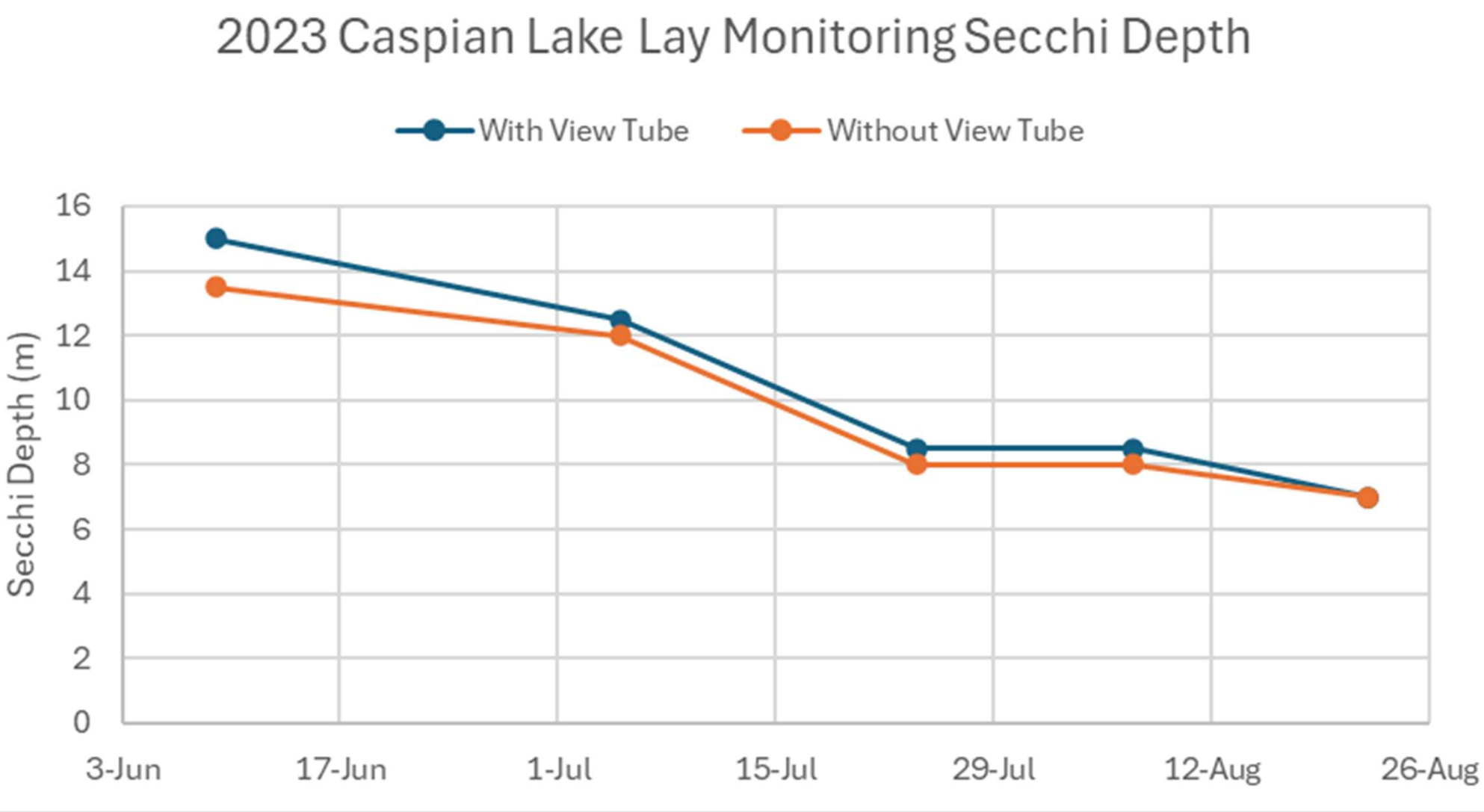
Trend: Stable (p-value=0.2967)

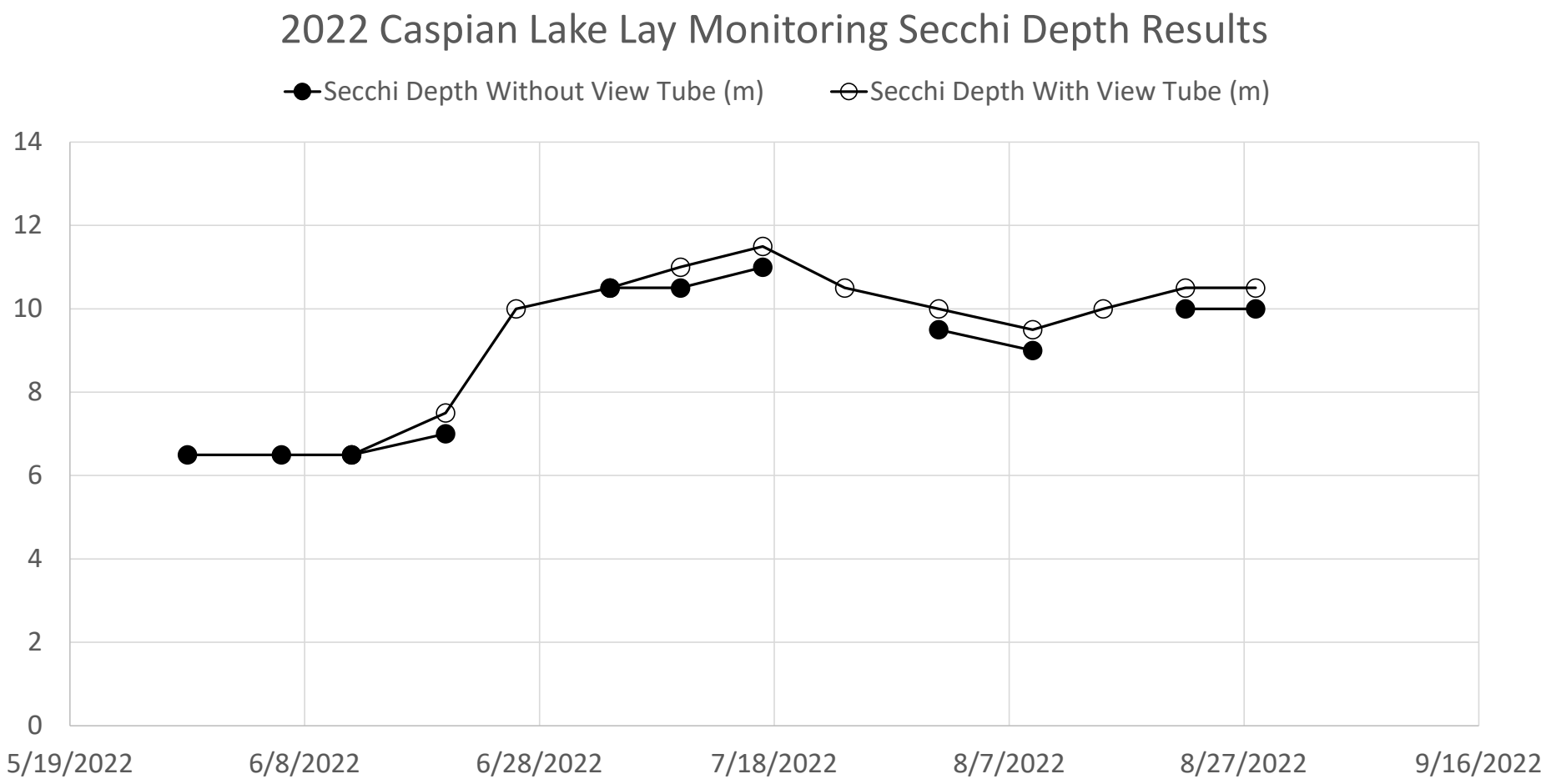


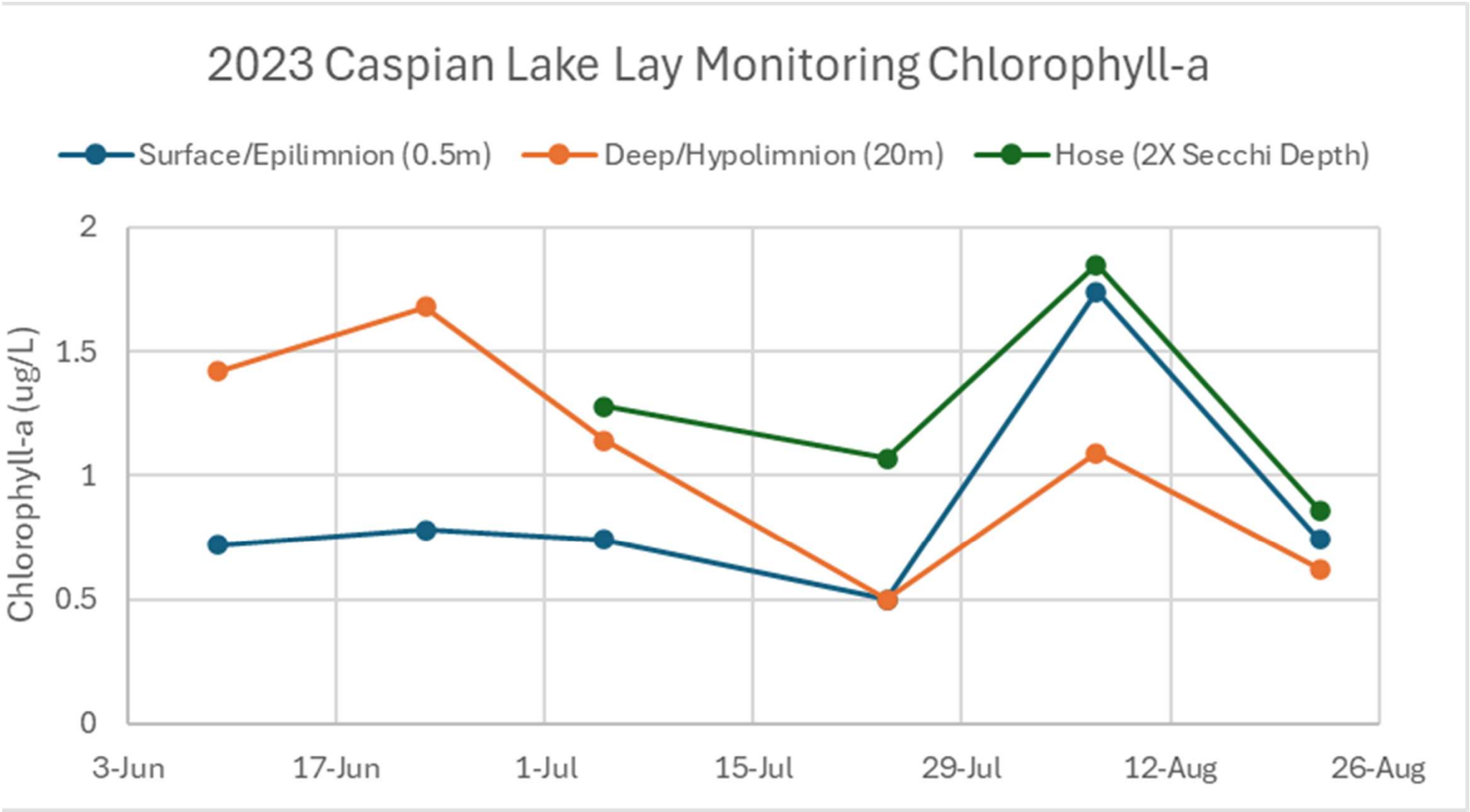
Summer Chlorophyll-a

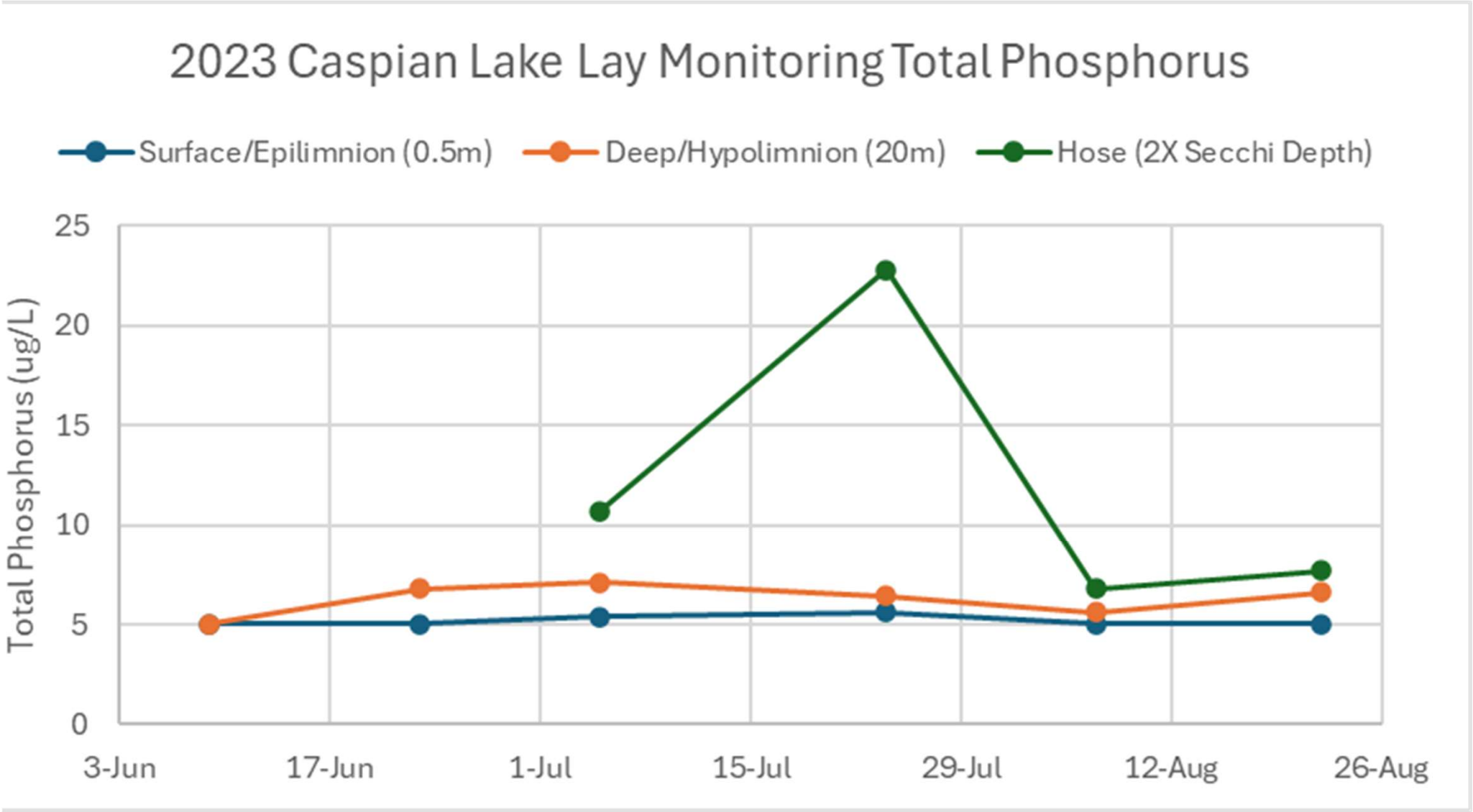
Trend: Stable (p-value=0.7782)

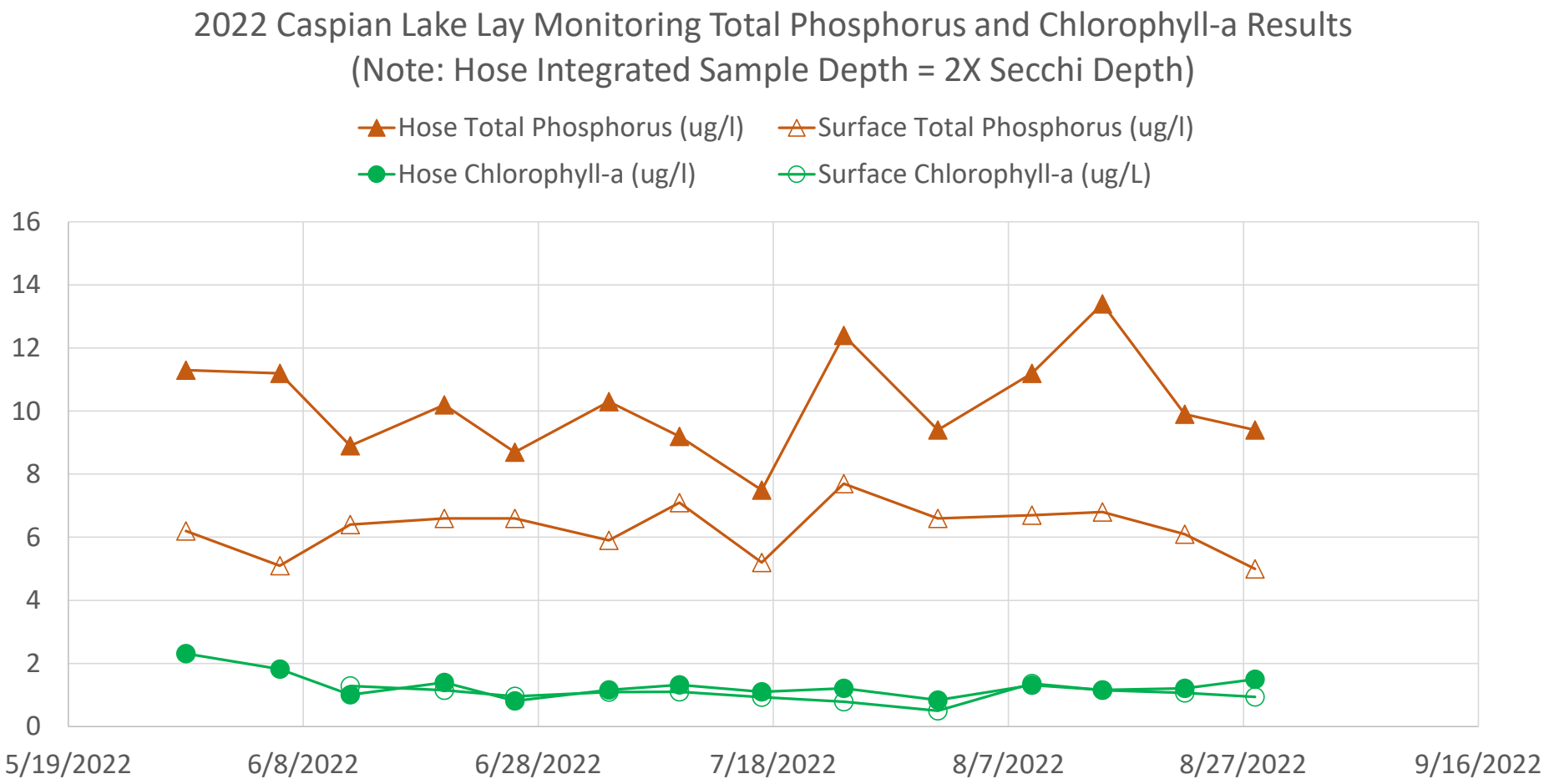



2023 Caspian Lake Lay Monitoring Secchi Depth
With View Tube
Without View Tube
Secchi Depth (m)
16
14
12
10
8
6
4
2
0
3-Jun
17-Jun
1-Jul
15-Jul
29-Jul
12-Aug
26-Aug

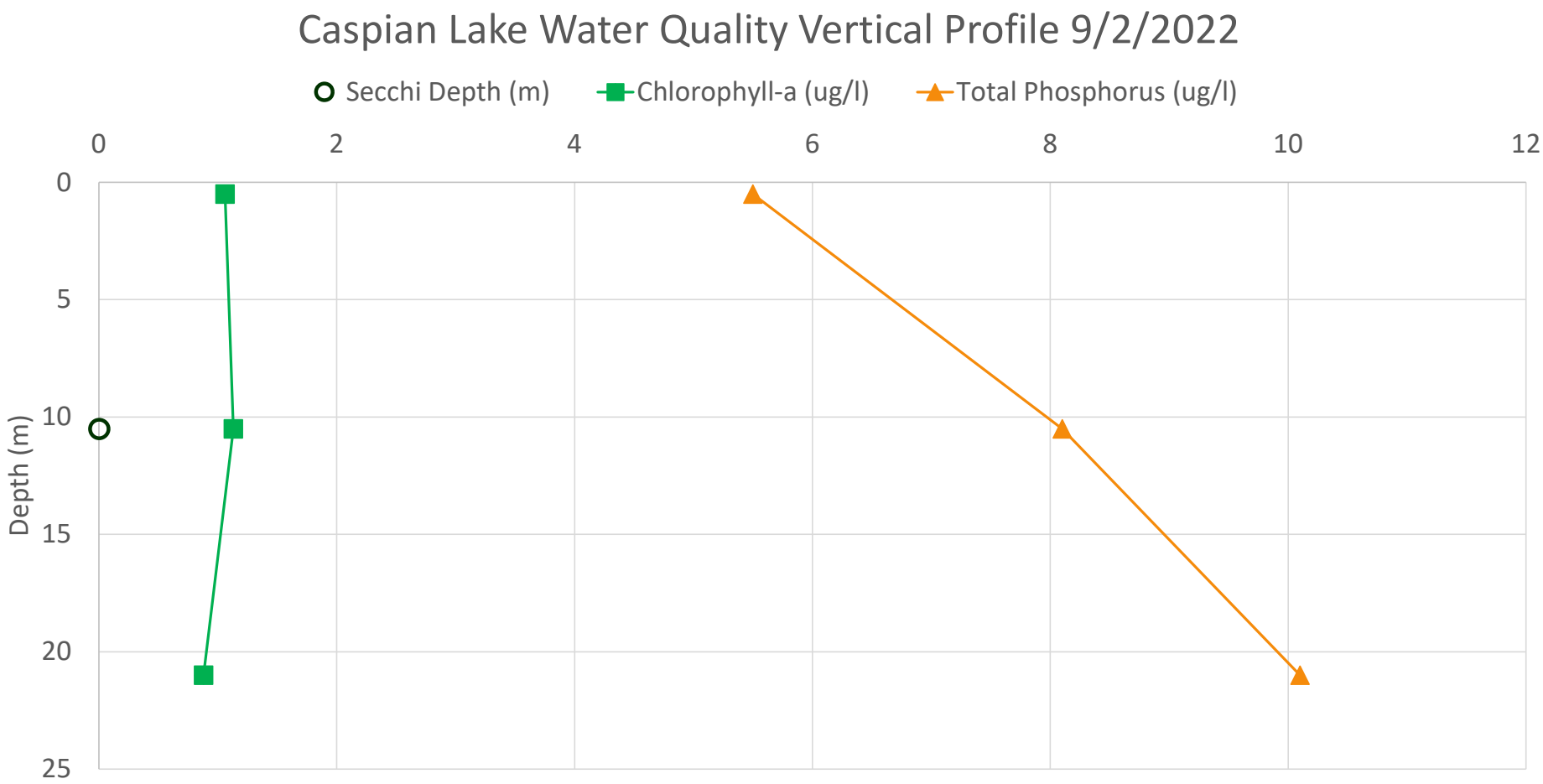

2022 Caspian Lake Lay Monitoring Secchi Depth Results
Secchi Depth Without View Tube (m)
Secchi Depth With View Tube (m)
14
12
10
8
6
4
2
0
5/19/2022
6/8/2022
6/28/2022
7/18/2022
8/7/2022
8/27/2022
9/16/2022

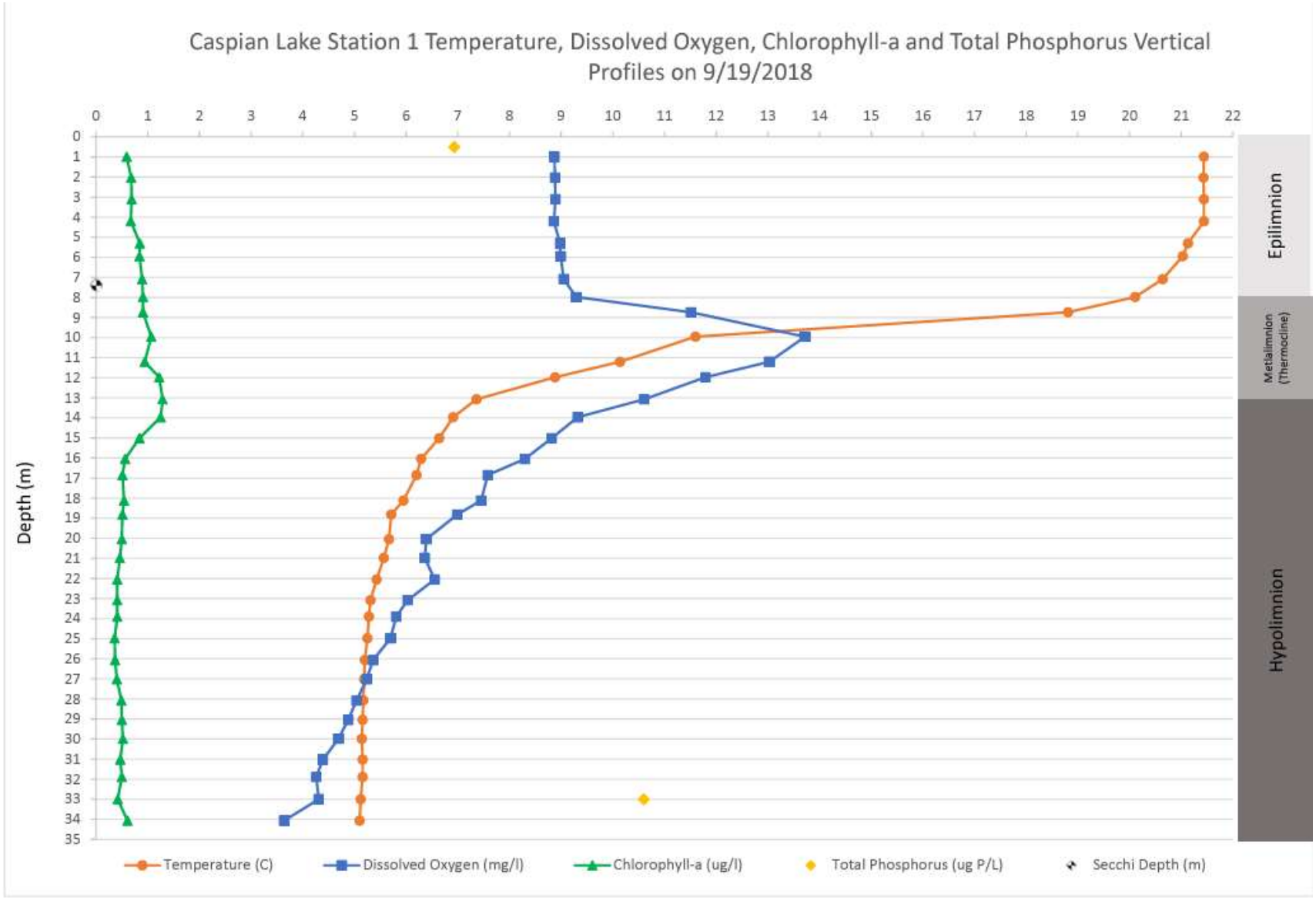

2023 Caspian Lake Lay Monitoring Chlorophyll-a
Surface/Epilimnion (0.5m)
Deep/Hypolimnion (20m)
Hose (2X Secchi Depth)
Chlorophyll-a (ug/L)
2
1.5
1
0.5
0
3-Jun
17-Jun
1-Jul
15-Jul
29-Jul
12-Aug
26-Aug

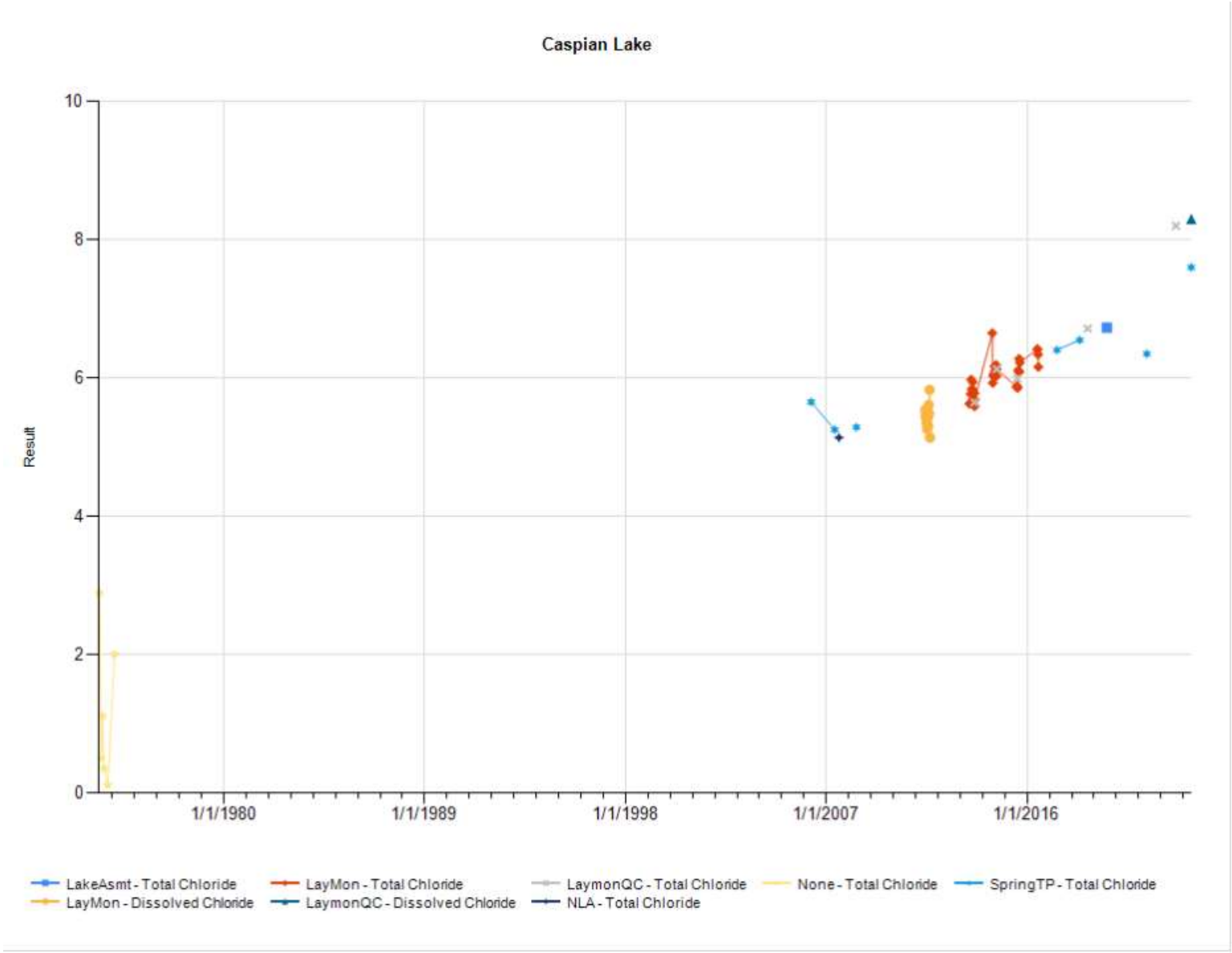

2023 Caspian Lake Lay Monitoring Total Phosphorus
Surface/Epilimnion (0.5m)
Deep/Hypolimnion (20m)
Hose (2X Secchi Depth)
Total Phosphorus (ug/L)
25
20
15
10
5
0
3-Jun
17-Jun
1-Jul
15-Jul
29-Jul
12-Aug
26-Aug


2022 Caspian Lake Lay Monitoring Total Phosphorus and Chlorophyll-a Results
(Note: Hose Integrated Sample Depth = 2X Secchi Depth)
Hose Total Phosphorus (ug/l)
Surface Total Phosphorus (ug/l)
Hose Chlorophyll-a (ug/l)
Surface Chlorophyll-a (ug/L)
16
14
12
10
8
6
4
2
0
5/19/2022
6/8/2022
6/28/2022
7/18/2022
8/7/2022
8/27/2022
9/16/2022

DATE	HOSE SAMPLE DEPTH (M)	HOSE TOTAL PHOSPHORUS (UG/L)	SURFACE TOTAL PHOSPHORUS (UG/L)	HOSE CHLOROPHYLL-A (UG/L)	SURFACE CHLOROPHYLL-A (UG/L)	SECCHI DEPTH WITHOUT VIEW TUBE (M)	SECCHI DEPTH WITH VIEW TUBE (M)
5/29/2022	13	11.3	6.2	2.31		6.5	
6/6/2022	13	11.2	5.1	1.82		6.5	
6/12/2022	13	8.9	6.4	1.01	1.29	6.5	6.5
6/20/2022	15	10.2	6.6	1.4	1.15	7	7.5
6/26/2022	20	8.7	6.6	0.81	0.96		10
7/4/2022	21	10.3	5.9	1.16	1.09	10.5	10.5
7/10/2022	21	9.2	7.1	1.32	1.1	10.5	11
7/17/2022	20	7.5	5.2	1.1	0.93	11	11.5
7/24/2022	21	12.4	7.7	1.21	0.79		10.5
8/1/2022	20	9.4	6.6	0.84	0.5	9.5	10
8/9/2022	19	11.2	6.7	1.31	1.36	9	9.5
8/15/2022	20	13.4	6.8	1.16	1.15		10
8/22/2022	20	9.9	6.1	1.21	1.07	10	10.5
8/28/2022	21	9.4	5	1.5	0.94	10	10.5
Mean	**18.4**	**10.2**	**6.3**	**1.30**	**1.03**	**8.8**	**9.8**
A1 Critieria	**Euphotic Zone**	**12**	**12**	**2.6**	**2.6**	**5.0**	**5.0**


Caspian Lake Water Quality Vertical Profile 9/2/2022
Secchi Depth (m)
Chlorophyll-a (ug/l)
Total Phosphorus (ug/l)
0
2
4
6
8
10
12
Depth (m)
0
5
10
15
20
25


Caspian Lake Station 1 Temperature, Dissolved Oxygen, Chlorophyll-a and Total Phosphorus Vertical Profiles on 9/19/2018
Depth (m)
Epilimnion
Metalimnion (Thermocline)
Hypolimnion
Temperature (C)
Dissolved Oxygen (mg/l)
Chlorophyll-a (ug/l)
Total Phosphorus (ug P/L)
Secchi Depth (m)


Caspian Lake
Result
10
8
6
4
2
0
1/1/1980
1/1/1989
1/1/1998
1/1/2007
1/1/2016
LakeAsmt - Total Chloride
LayMon - Total Chloride
LaymonQC - Total Chloride
None - Total Chloride
SpringTP - Total Chloride
LayMon - Dissolved Chloride
LaymonQC - Dissolved Chloride
NLA - Total Chloride

LaRosa Partnership Program (LPP) Tributary Sampling Overview

- Tributaries first sampled by LMP 2019-2020
- Since 2021, sampled by LPP ~biweekly from April/May to September + storm events
- 763C.buryRd (Trib 10)
  - Highest TP recorded in past years
- C.bury-Blacks PT (Trib 6)
  - Occasionally high TP events in past years
- Porter-S Bridge
  - Greatest volume of tributary flow into Caspian Lake
- Tate-NShoreRd
  - 2nd greatest volume of tributary flow into Caspian Lake
- Cem-LShoreRd
  - Occasionally high TP events in past years

LPP Sample Parameters Overview: Total Phosphorus & Chloride

Total Phosphorus

- Sources
  - Developed land runoff, roads, driveways
  - Fertilizers – lawns and agriculture
- Impacts
  - Feeds plants, algae and cyanobacteria
  - Aesthetics, Recreation, Aquatic Life Uses
- Vermont Water Quality Standards Nutrient Criteria for Aquatic Biota Use (+ Biological Criteria)
  - Not to be exceeded at low median monthly flow (baseflow) during June through October
  - 12 ug/L for small high gradient streams (SHG)
  - 15 ug/L for medium high gradient streams (MHG)
  - 27 ug/L for warm-water medium gradient streams and rivers (WWMG)

Total Chloride

- Sources
  - Road salt
  - Wastewater, water softeners
- Impacts
  - Affects chemical processes of biological organisms
  - Aquatic Life Use
- Vermont Water Quality Standards Chloride Criteria for Aquatic Biota Use
  - 860 mg/L maximum (acute)
  - 230 mg/L average (chronic)
  - Studies show chloride can impact organisms at lower concentrations

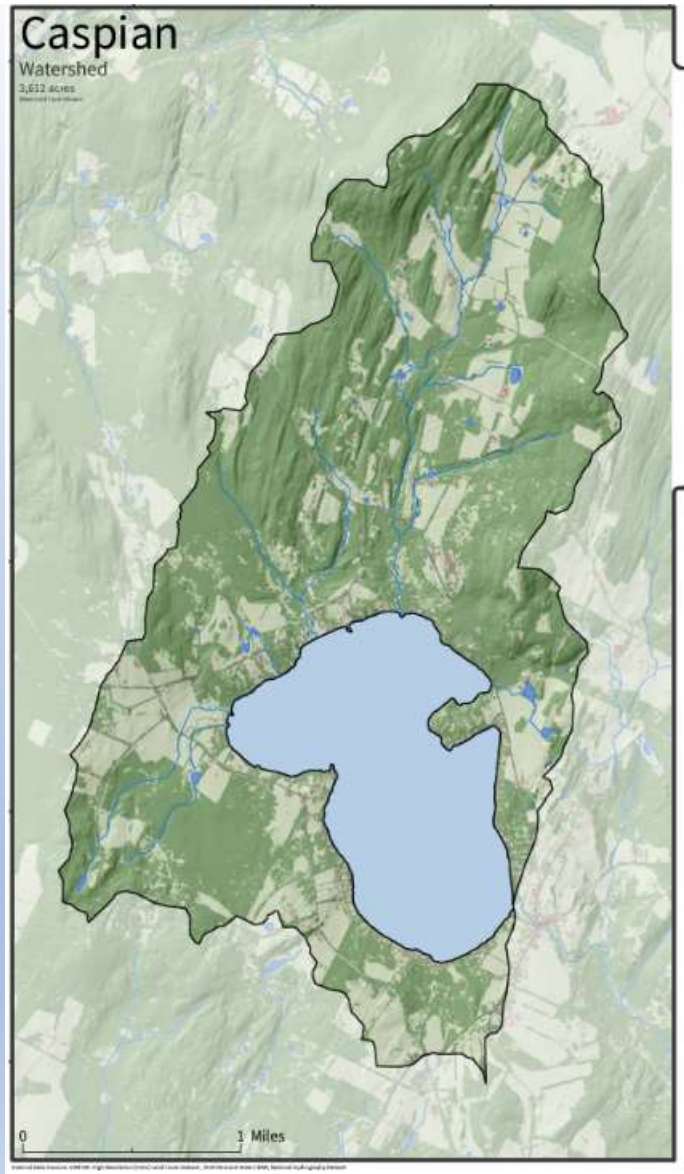
Chemical Parameters – Nitrogen

Total Nitrogen

- Impacts
  - Can fuel specific types of cyanobacteria blooms
  - Too much nitrogen, as nitrate, in drinking water can be harmful to young infants or young livestock.
- Sources
  - Fertilizers – lawn and ag
  - Sewage
- Vermont Water Quality Standards
  - Not to exceed 5.0 mg/l as NO3-N at flows exceeding low median monthly flows, in Class B(1) and B(2) waters.
  - Not to exceed 2.0 mg/l as NO3-N at flows exceeding low median monthly flows, in Class A(1) and A(2) waters at or below 2,500 feet altitude, National Geodetic Vertical Datum.

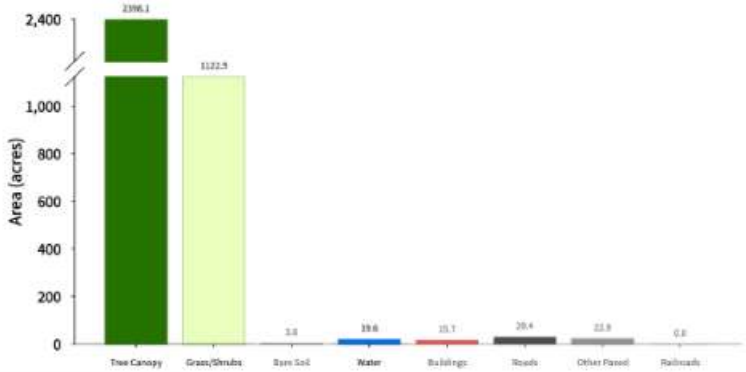
Parameters Monitored in 2022

- Porter Brook
  - TP, TN, Chloride
- Tate Brook
  - TP
- Cemetery Brook 2
  - TP
- Trib 6
  - TP, TN, Chloride
- Trib 10
  - TP, TN



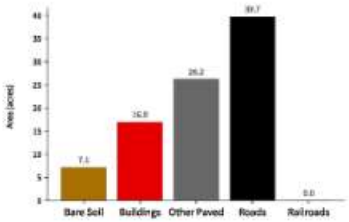
High-Resolution Land Cover Summary

Base Land Cover (Top-Down*)

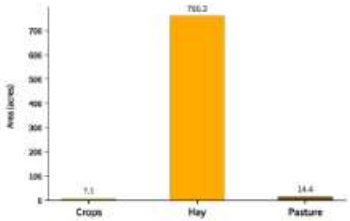


Supplemental Land Cover

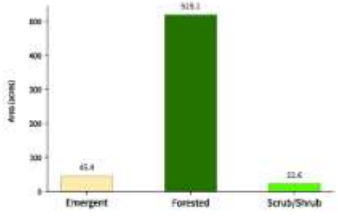
Impervious Surfaces (89.89 acres - 2.5 % of total)
(Bottom-Up**)



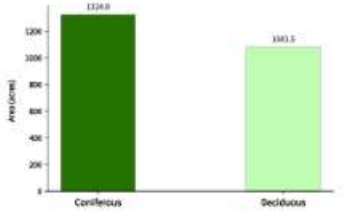
Agriculture (781.85 acres - 21.6 % of total)



Wetlands (587.03 acres - 16.3 % of total)

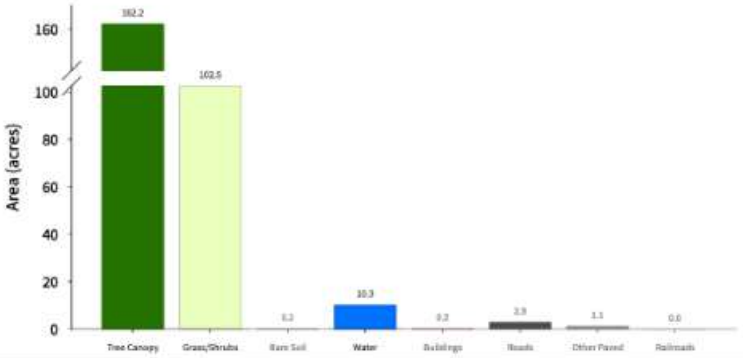


Tree Canopy (2,406.28 acres - 66.6 % of total)



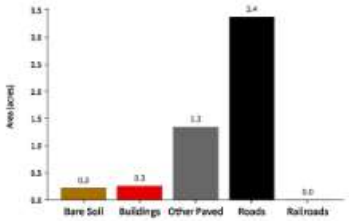
High-Resolution Land Cover Summary

Base Land Cover (Top-Down*)

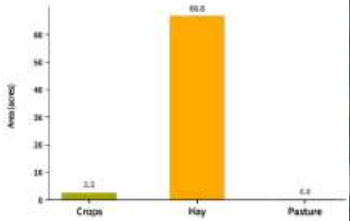


Supplemental Land Cover

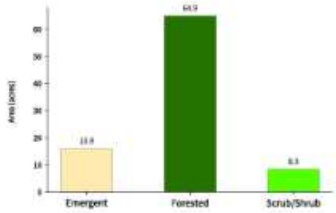
Impervious Surfaces (5.19 acres - 1.9 % of total)
(Bottom-Up**)



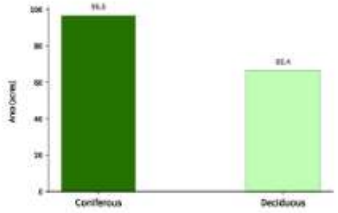
Agriculture (69.13 acres - 24.7 % of total)

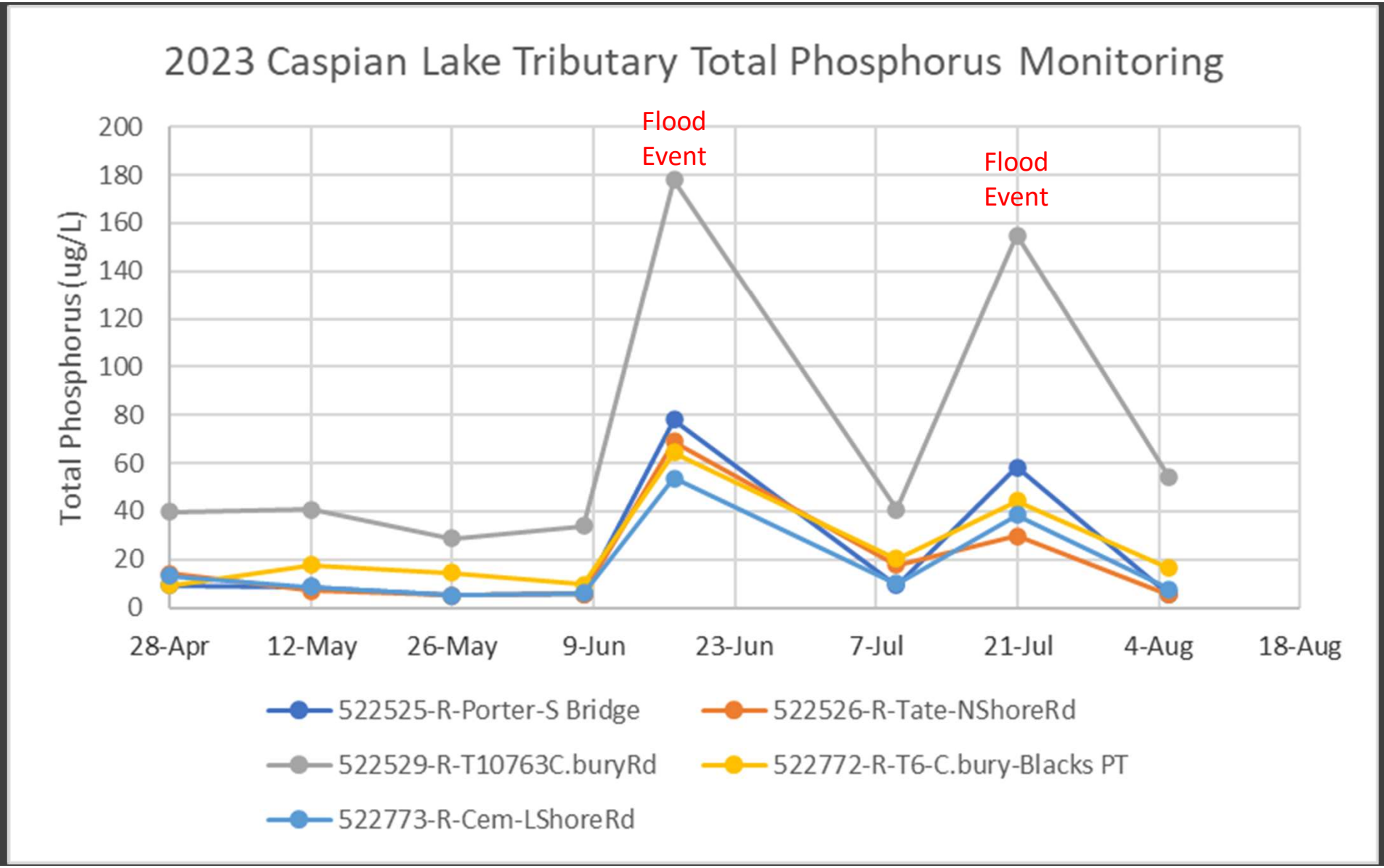


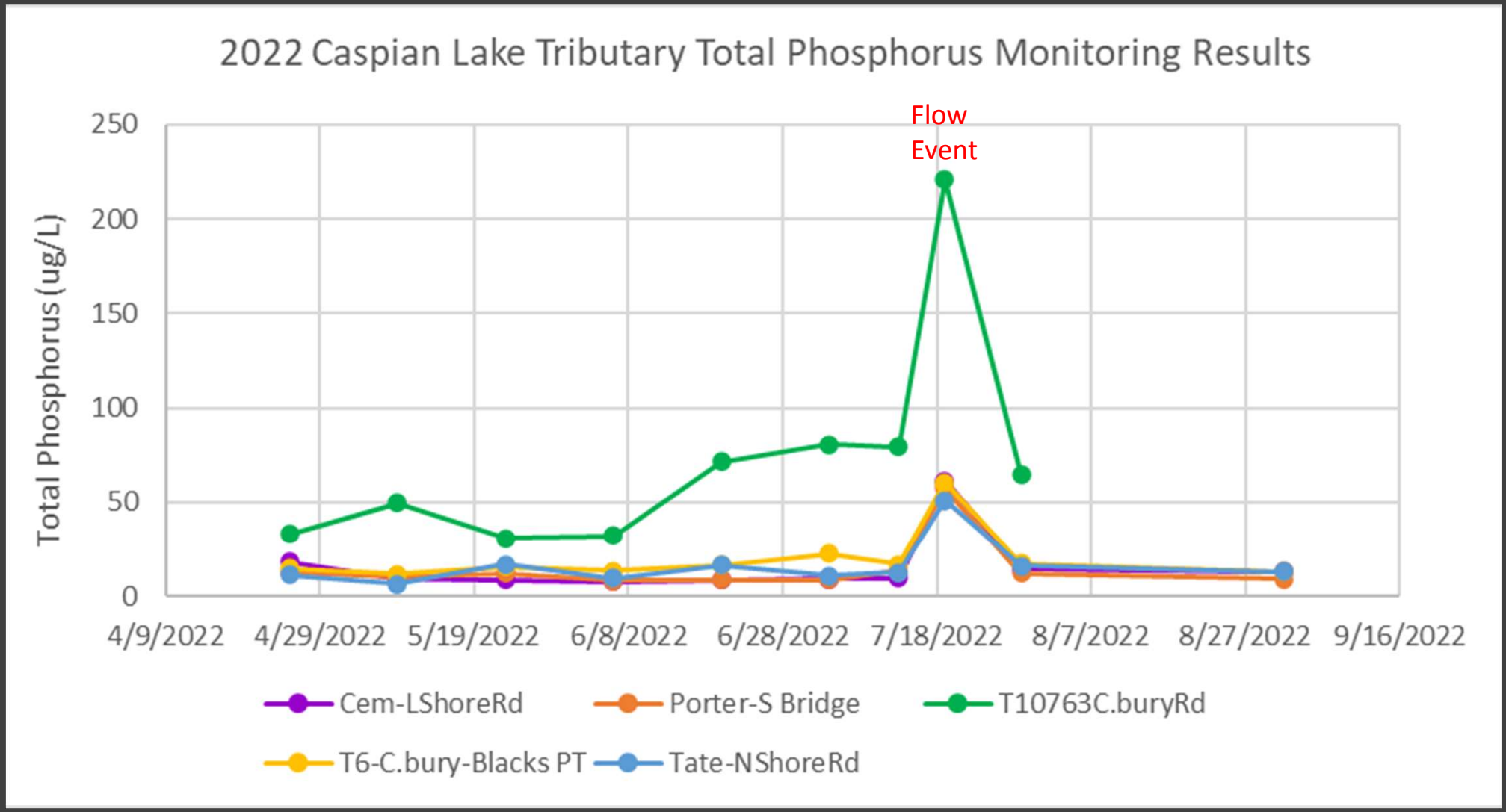
Wetlands (89.08 acres - 31.8 % of total)

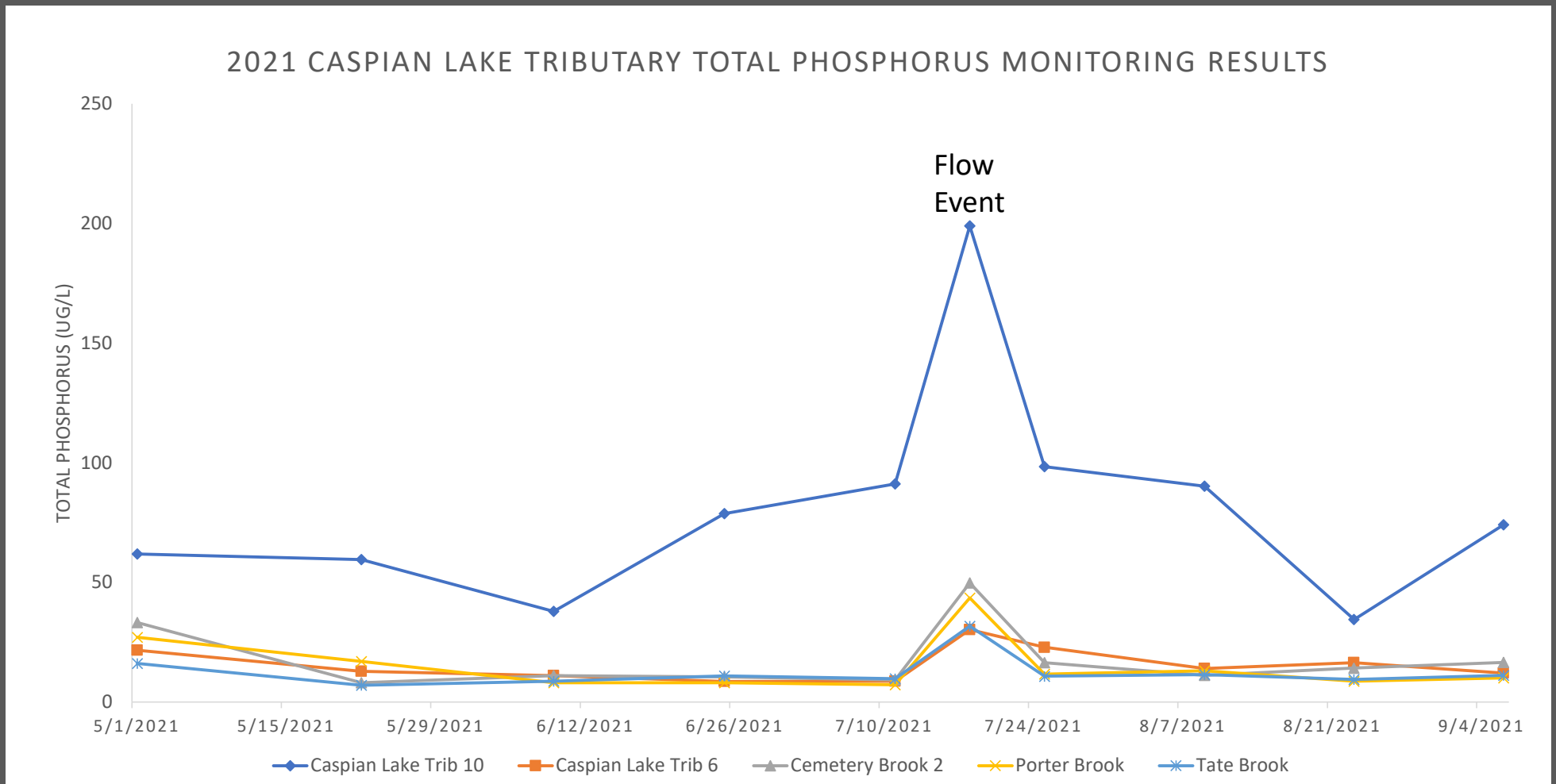


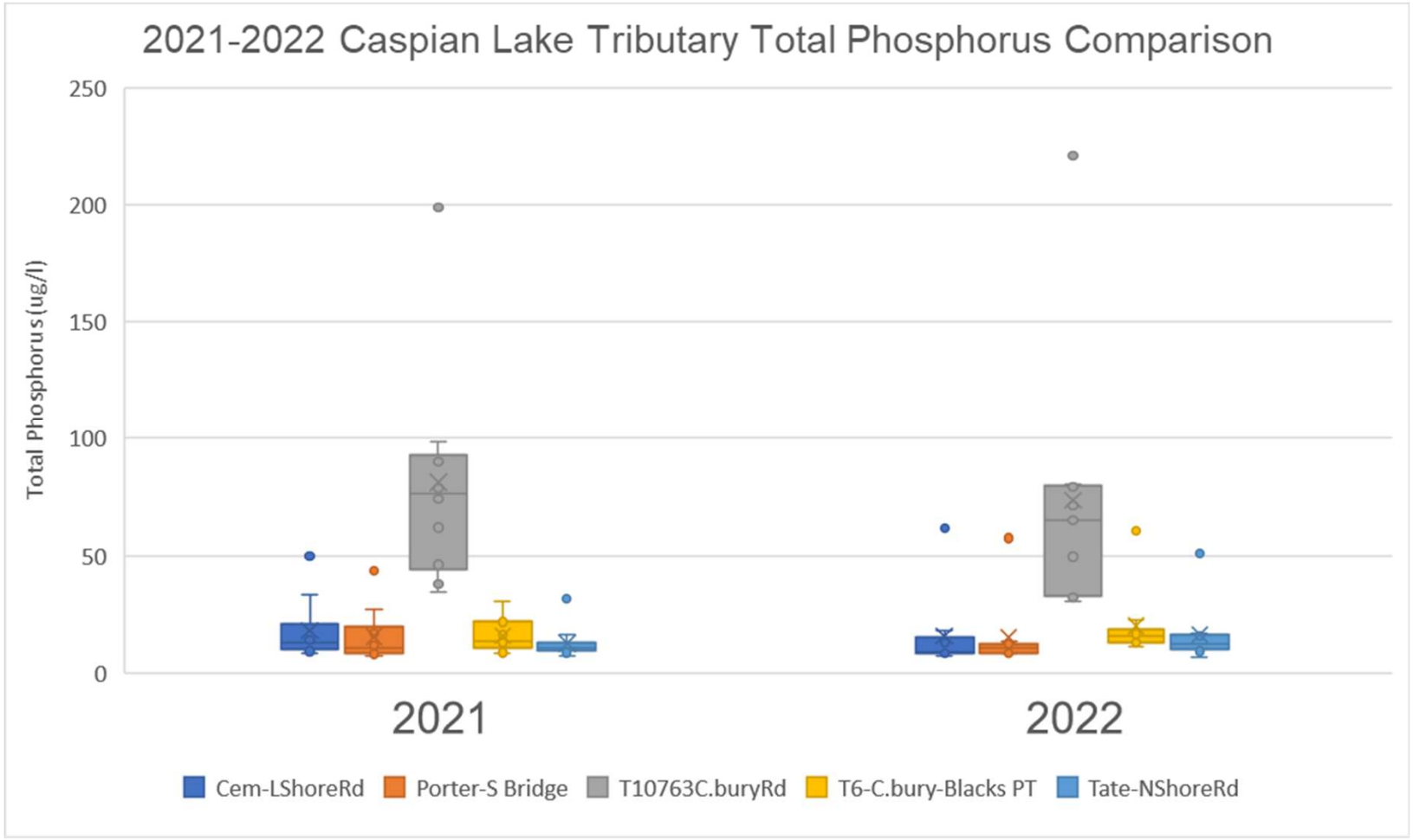
Tree Canopy (162.99 acres - 58.2 % of total)

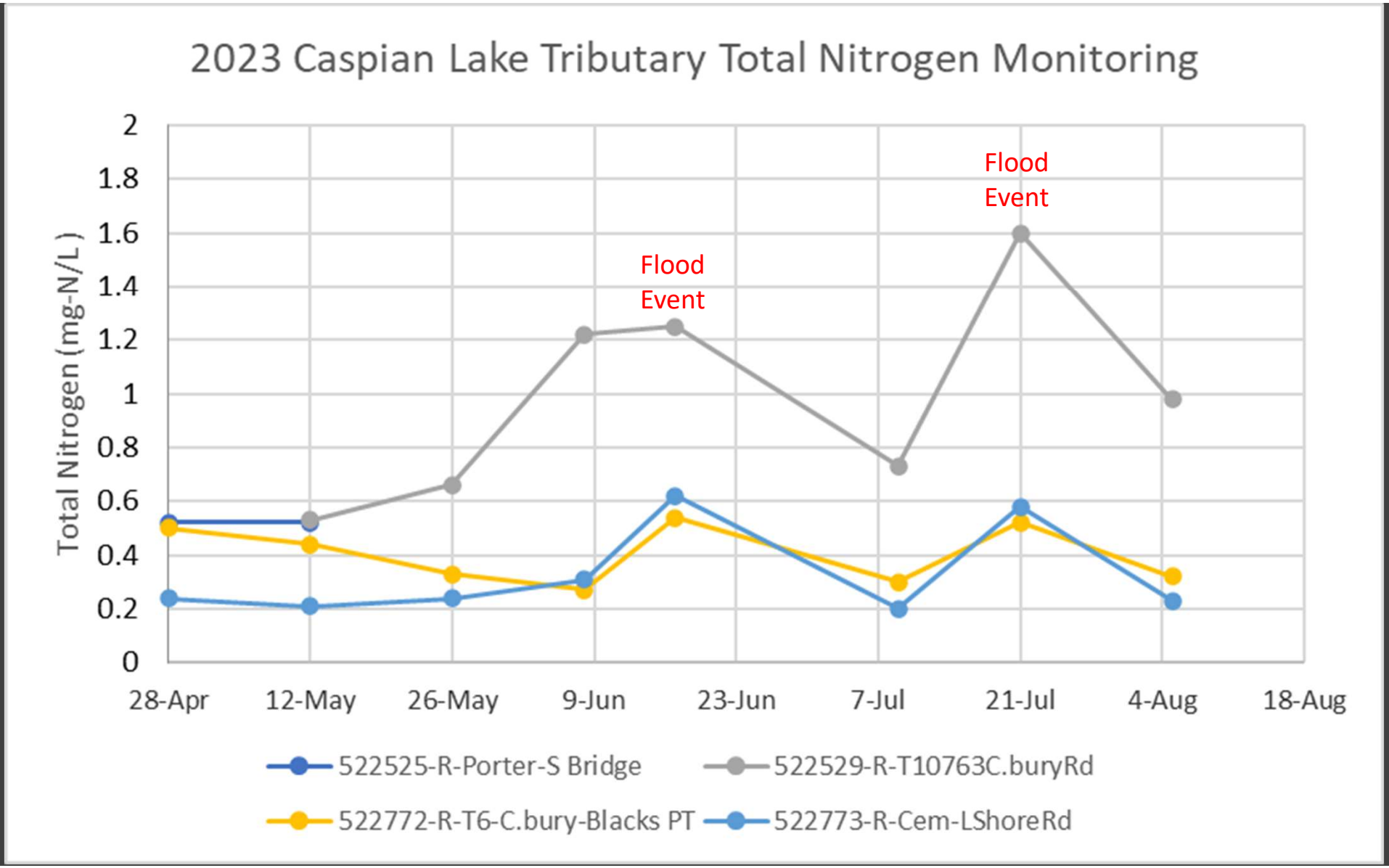


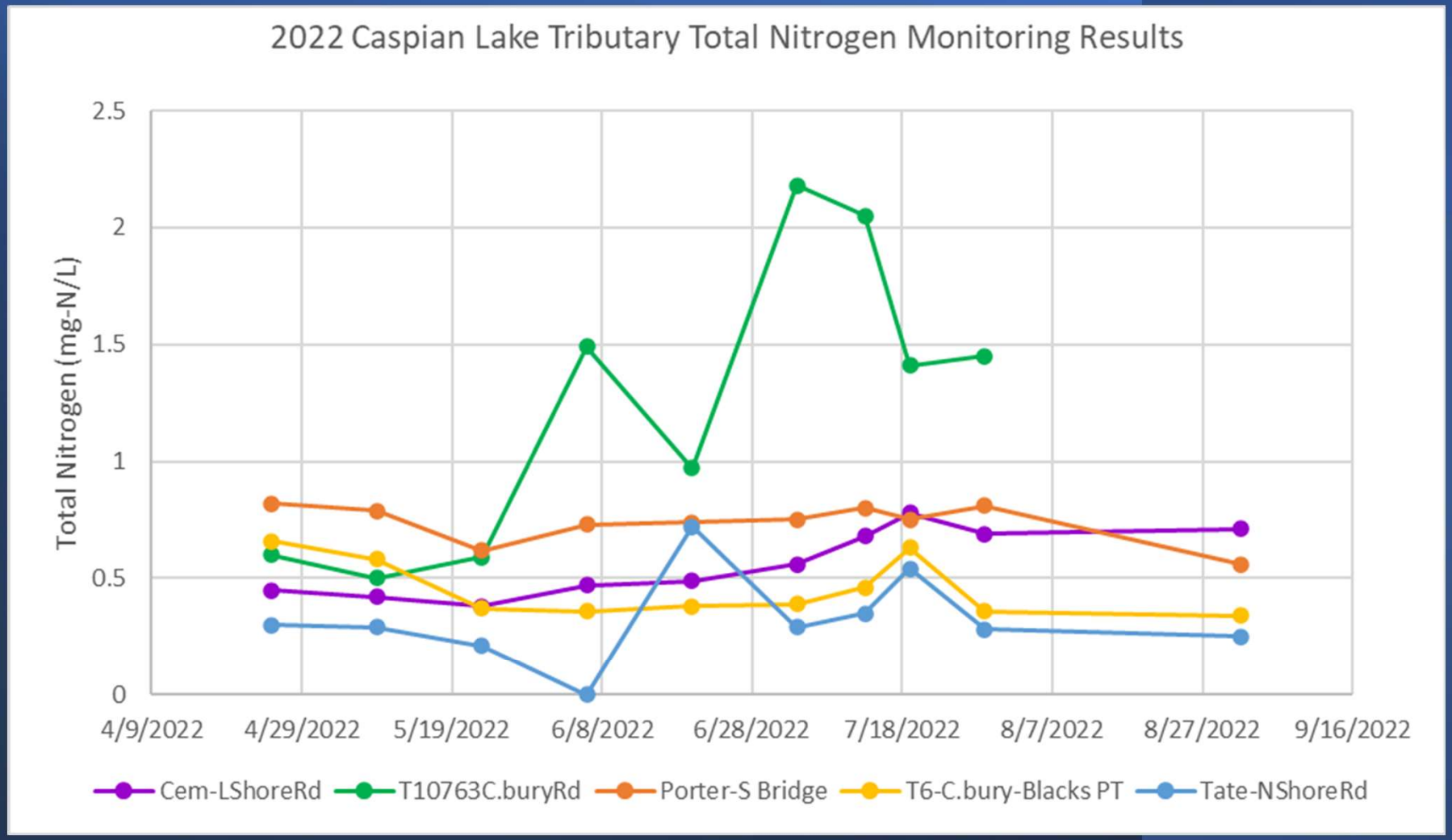

2023 Caspian Lake Tributary Total Phosphorus Monitoring
Flood Event
Flood Event
Total Phosphorus (ug/L)
200
180
160
140
120
100
80
60
40
20
0
28-Apr
12-May
26-May
9-Jun
23-Jun
7-Jul
21-Jul
4-Aug
18-Aug
522525-R-Porter-S Bridge
522526-R-Tate-NShoreRd
522529-R-T10763C.buryRd
522772-R-T6-C.bury-Blacks PT
522773-R-Cem-LShoreRd

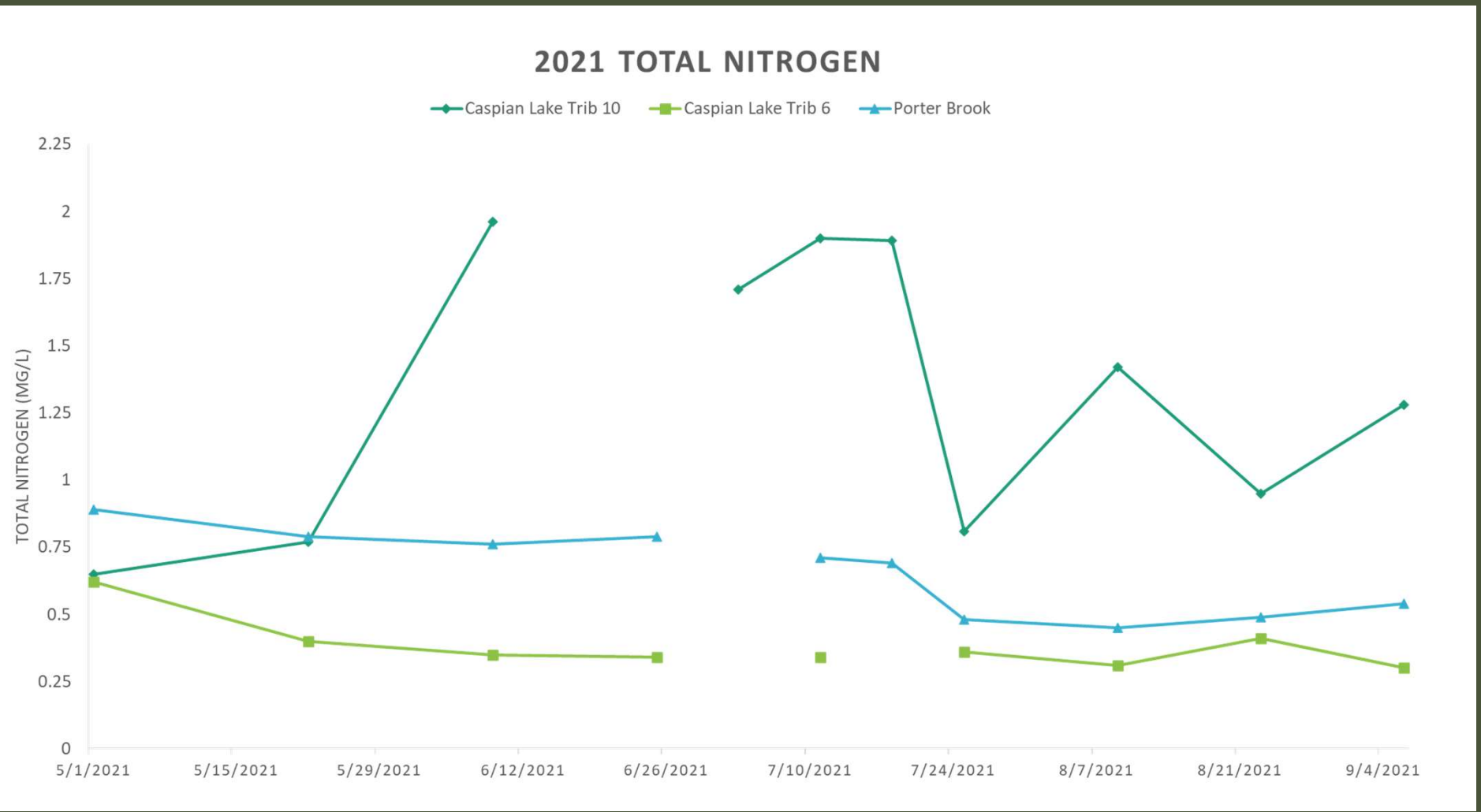

2022 Caspian Lake Tributary Total Phosphorus Monitoring Results
Flow Event
Total Phosphorus (ug/L)
250
200
150
100
50
0
4/9/2022
4/29/2022
5/19/2022
6/8/2022
6/28/2022
7/18/2022
8/7/2022
8/27/2022
9/16/2022
Cem-LShoreRd
Porter-S Bridge
T10763C.buryRd
T6-C.bury-Blacks PT
Tate-NShoreRd

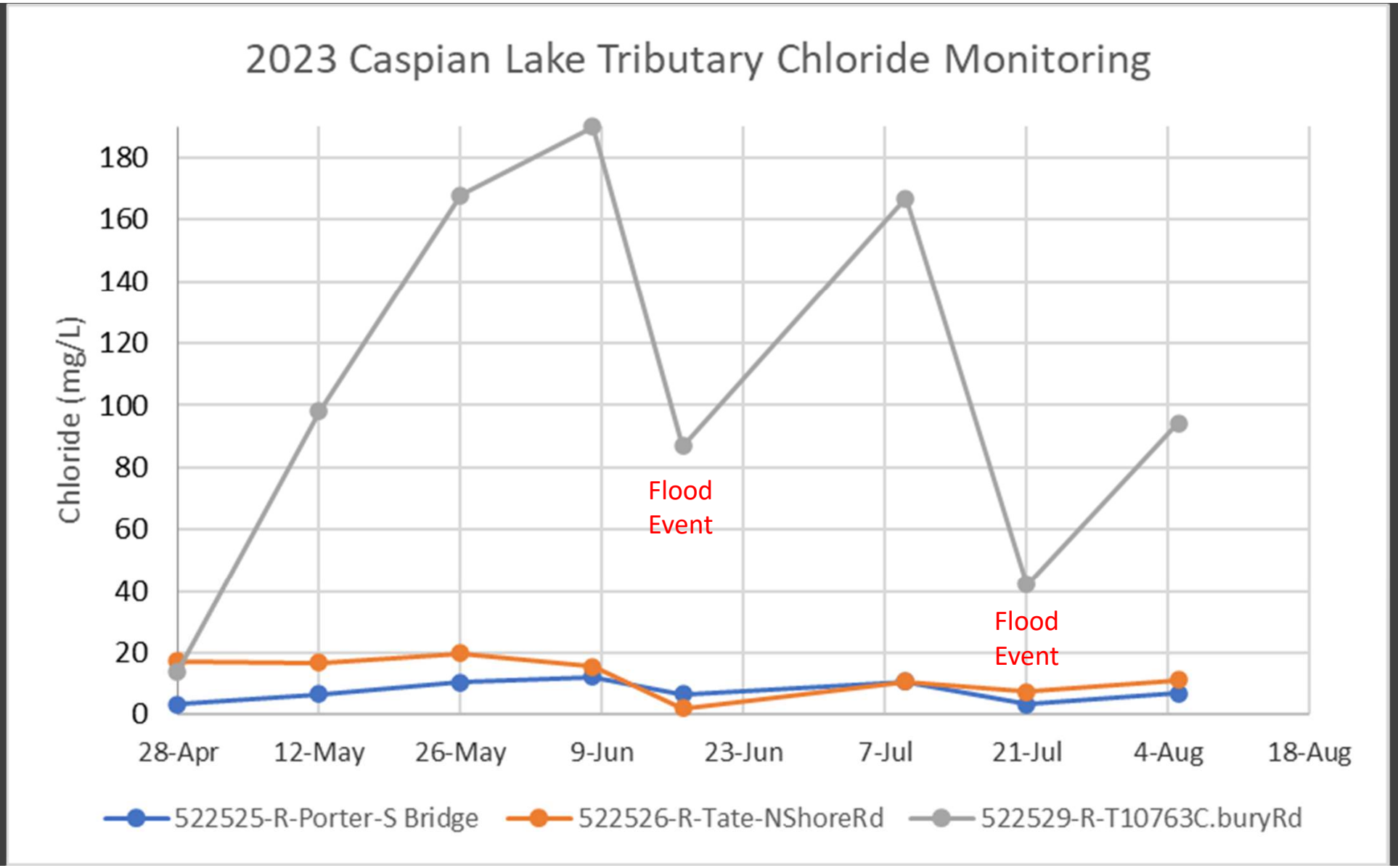

2021 CASPIAN LAKE TRIBUTARY TOTAL PHOSPHORUS MONITORING RESULTS
TOTAL PHOSPHORUS (UG/L)
250
200
150
100
50
0
Flow Event
5/1/2021
5/15/2021
5/29/2021
6/12/2021
6/26/2021
7/10/2021
7/24/2021
8/7/2021
8/21/2021
9/4/2021
Caspian Lake Trib 10
Caspian Lake Trib 6
Cemetery Brook 2
Porter Brook
Tate Brook

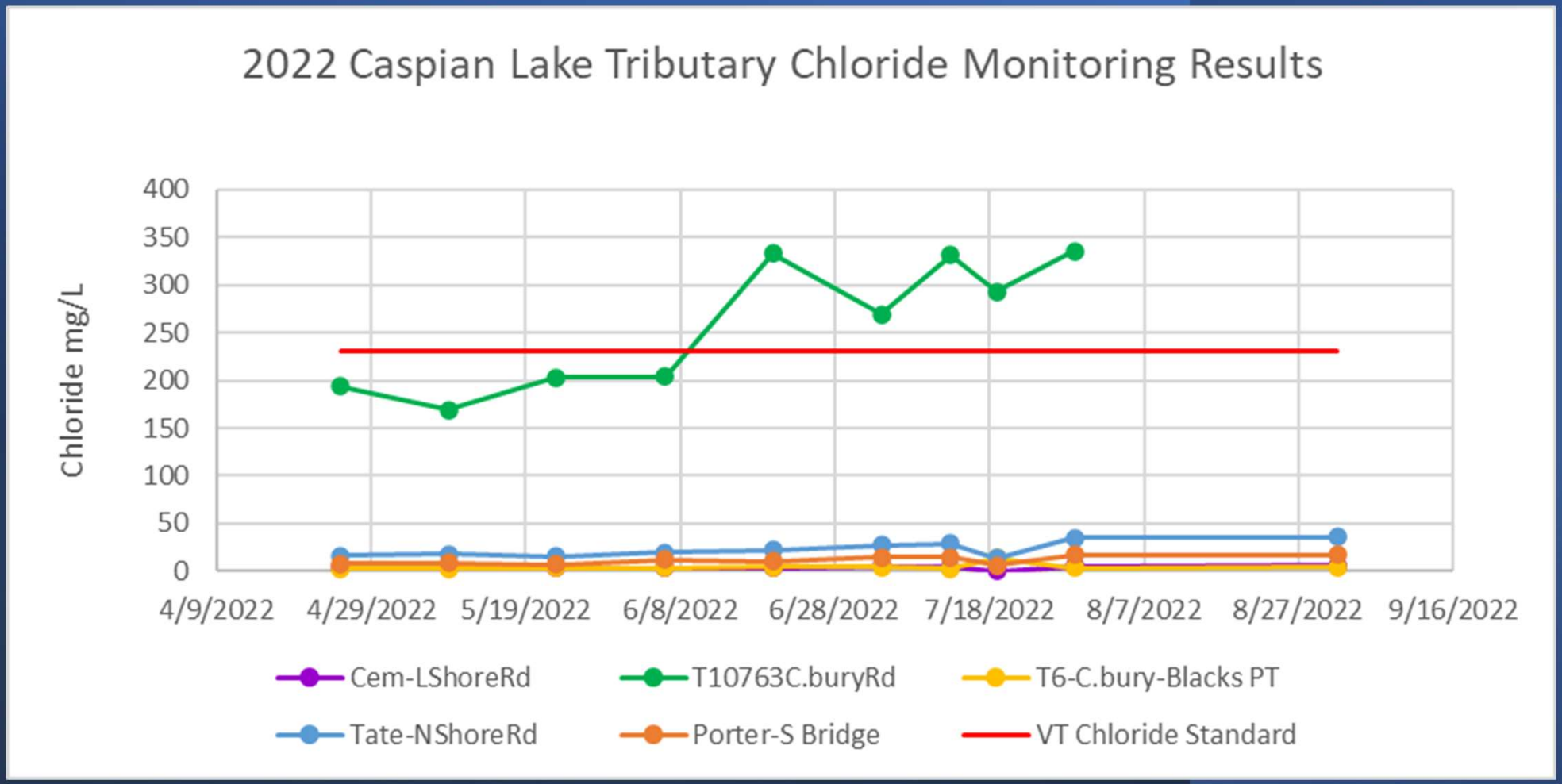

2021-2022 Caspian Lake Tributary Total Phosphorus Comparison
Total Phosphorus (ug/l)
250
200
150
100
50
0
2021
2022
Cem-LShoreRd
Porter-S Bridge
T10763C.buryRd
T6-C.bury-Blacks PT
Tate-NShoreRd

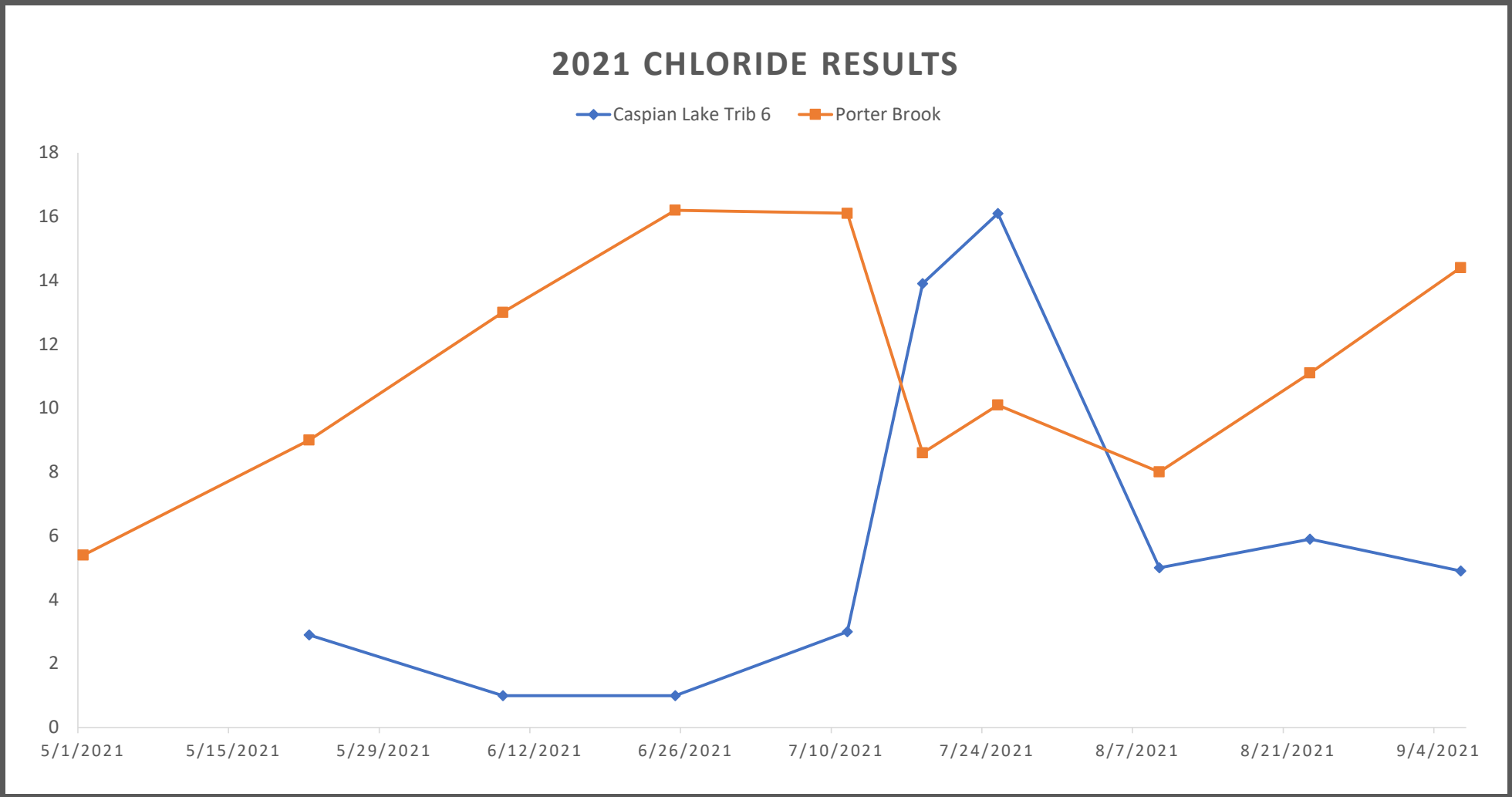

2023 Caspian Lake Tributary Total Nitrogen Monitoring
Total Nitrogen (mg-N/L)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Flood Event
Flood Event
28-Apr
12-May
26-May
9-Jun
23-Jun
7-Jul
21-Jul
4-Aug
18-Aug
522525-R-Porter-S Bridge
522529-R-T10763C.buryRd
522772-R-T6-C.bury-Blacks PT
522773-R-Cem-LShoreRd


2022 Caspian Lake Tributary Total Nitrogen Monitoring Results
Total Nitrogen (mg-N/L)
2.5
2
1.5
1
0.5
0
4/9/2022
4/29/2022
5/19/2022
6/8/2022
6/28/2022
7/18/2022
8/7/2022
8/27/2022
9/16/2022
Cem-LShoreRd
T10763C.buryRd
Porter-S Bridge
T6-C.bury-Blacks PT
Tate-NShoreRd


2021 TOTAL NITROGEN
Caspian Lake Trib 10
Caspian Lake Trib 6
Porter Brook
TOTAL NITROGEN (MG/L)
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
5/1/2021
5/15/2021
5/29/2021
6/12/2021
6/26/2021
7/10/2021
7/24/2021
8/7/2021
8/21/2021
9/4/2021

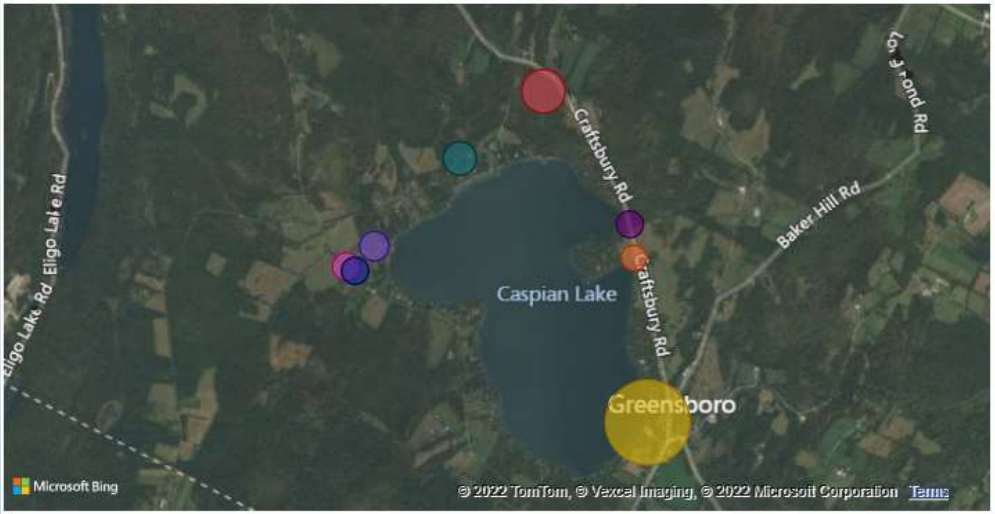

2023 Caspian Lake Tributary Chloride Monitoring
Chloride (mg/L)
180
160
140
120
100
80
60
40
20
0
28-Apr
12-May
26-May
9-Jun
23-Jun
7-Jul
21-Jul
4-Aug
18-Aug
Flood Event
Flood Event
522525-R-Porter-S Bridge
522526-R-Tate-NShoreRd
522529-R-T10763C.buryRd


2022 Caspian Lake Tributary Chloride Monitoring Results
Chloride mg/L
400
350
300
250
200
150
100
50
0
4/9/2022
4/29/2022
5/19/2022
6/8/2022
6/28/2022
7/18/2022
8/7/2022
8/27/2022
9/16/2022
Cem-LShoreRd
T10763C.buryRd
T6-C.bury-Blacks PT
Tate-NShoreRd
Porter-S Bridge
VT Chloride Standard


2021 CHLORIDE RESULTS
Caspian Lake Trib 6
Porter Brook
18
16
14
12
10
8
6
4
2
0
5/1/2021
5/15/2021
5/29/2021
6/12/2021
6/26/2021
7/10/2021
7/24/2021
8/7/2021
8/21/2021
9/4/2021

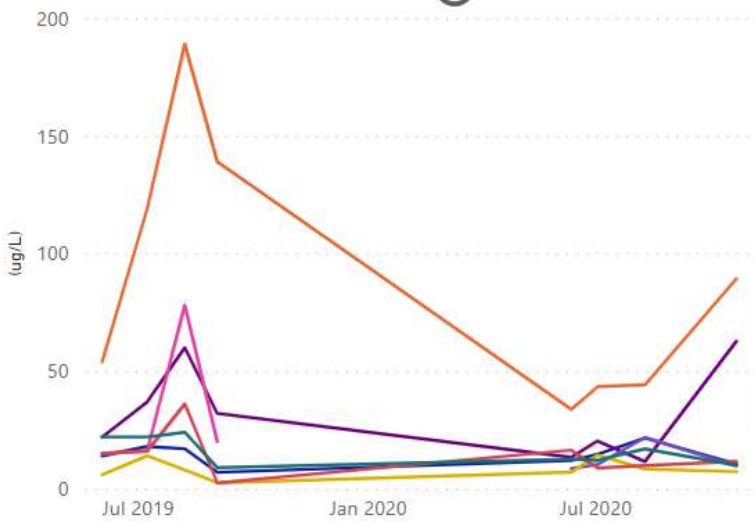
Water Quality Monitoring Results for Lake Caspian and Major Tributaries – 2019 & 2020

Monitoring Locations Sized by Watershed Area



Location Name	Watershed (acres)	% Forest	% Ag	% Developed	% Water/Wetland	% Shrub
Caspian Lake Trib 1	163	81.01	8.61	3.83	6.15	0.41
Caspian Lake Trib 10	30	14.29	62.40	18.05	0.00	5.26
Caspian Lake Trib 6	151	68.38	16.61	10.73	3.53	0.73
Cemetery Brook	176	55.05	37.50	7.45	0.00	0.00
Cemetery Brook 2	339	41.09	40.17	8.19	0.79	9.76
Outlet - Greensboro Brook	4392	54.54	13.07	7.06	22.86	2.48
Porter Brook	1358	75.93	14.96	5.03	1.13	2.95
Tate Brook	622	75.13	2.72	3.72	15.30	3.15

Phosphorus Monitoring Results by Station



Data Filters

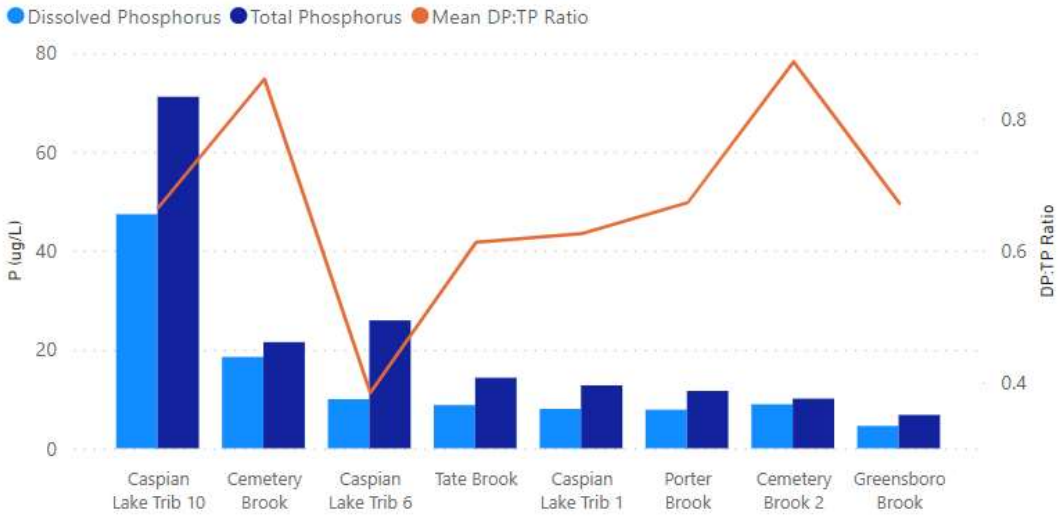
Analyte

- [ ] Dissolved Phosphorus
- [x] Total Phosphorus

Location Name

- [ ] Select all
- [ ] Caspian Lake
- [x] Caspian Lake Trib 1
- [x] Caspian Lake Trib 10
- [x] Caspian Lake Trib 6
- [x] Cemetery Brook
- [x] Cemetery Brook 2
- [x] Outlet - Greensboro Brook
- [x] Porter Brook
- [x] Tate Brook

Mean Dissolved P, Total P, and DP:TP Ratio



2023 Monitoring Summary & 2024 Next Steps

https://lamotte.com/horizontal-water-sampler-1087

- Lay Monitoring Program (LMP)
  - 2023 Summary: Very high Secchi depths decreased by ~5 m after July 10th floods but recovered in early August back to clarity seen in early June. Chlorophyll-a was very low and then increased slightly in August similarly with all three sampling methods (eplimnetic, hypolimnetic, and depth-integrated hose). Total phosphorus was very low with all three sampling methods except for the hose after July 10th floods and in late August, possibly due to sediment trapped in the metalimnion. All summer means qualify for A1 reclassification. All caffeine results except one (hose) were below the lab reporting limit (0.5 ug/L).
  - 2024 Next Steps: LMP volunteer continues collecting biweekly hose, epilimnetic (0.5 m) and hypolimnetic (20 m) samples, while adding metalimnetic (10 m) sampling. Caffeine testing will also continue at a lower lab reporting limit (≤0.1 ug/L). LMP staff collects vertical profile data during annual visit.
- LaRosa Partnership Program (LPP)
  - 2023 Summary: Site 763C.buryRd (Trib 10) has very high TP, TN, and chloride
  - 2024 Next Steps: LPP volunteers continue collecting biweekly samples through August at all sites with a focus on 763C.buryRd (Trib 10)