



Assessment of Estuarine Water Quality at Fort Pulaski National Monument

2023 Data Summary



Looking north toward Cockspur Island Lighthouse from the South Channel of the Savannah River.
NPS / SECN

Assessment of estuarine water quality at Fort Pulaski National Monument: 2023 data summary

Science Report NPS/SR—2025/241

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Please cite this publication as:

Starkey, E. N. 2025. Assessment of estuarine water quality at Fort Pulaski National Monument: 2023 data summary. Science Report NPS/SR—2025/241. National Park Service, Fort Collins, Colorado.
<https://doi.org/10.36967/2308470>

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Contents

	Page
Figures.....	iv
Tables.....	iv
Abstract.....	v
Summary and Key Findings.....	vi
Introduction.....	1
Overview	1
Monitoring Objectives.....	1
Study Area	3
Fort Pulaski National Monument	3
Methods.....	5
Water-Quality Data Collection.....	9
Water-Quality Assessment Criteria	9
Results.....	11
Parameter-Based Water Condition Assessments.....	11
Literature Cited	21

Figures

	Page
Figure 1. Southeast Coast Network fixed-station monitoring sites and estuarine and marine water resources in the vicinity of Fort Pulaski National Monument in Georgia.	4
Figure 2. Map showing the location of parkwide assessment sites (site numbers from Table 1) sampled in July 2023 at Fort Pulaski National Monument.	8
Figure 3. Water clarity ratings for sites sampled at Fort Pulaski National Monument July 10–13, 2023.....	12
Figure 4. Chlorophyll <i>a</i> concentrations for sites sampled at Fort Pulaski National Monument July 10–13, 2023..	13
Figure 5. Dissolved inorganic nitrogen concentrations for sites sampled at Fort Pulaski National Monument July 10–13, 2023.....	14
Figure 6. Dissolved inorganic phosphorus concentrations for sites sampled at Fort Pulaski National Monument July 10–13, 2023.....	15
Figure 7. Dissolved oxygen concentrations for sites sampled at Fort Pulaski National Monument July 10–13, 2023.	16
Figure 8. Water-quality index rating for sites sampled at Fort Pulaski National Monument July 10–13, 2023.	17

Tables

	Page
Table 1. Site name (which includes site number 01, 02, ...etc.), waterbody name and location, depth, coordinates, and chemical and physical attributes of sampling sites at Fort Pulaski National Monument, July 10–13, 2023.	6
Table 2. Water-quality monitoring condition criteria for water-quality parameters collected by the Southeast Coast Network based on thresholds set by EPA (2012) [µg/L—micrograms per liter; mg/L—milligrams per liter].	10
Table 3. Condition criteria used for water-quality assessment summaries at individual sampling sites and parks.	10
Table 4. Water-quality parameter values and assessment conditions for sampling sites in the vicinity of Fort Pulaski National Monument July 10–13, 2023.....	18

Abstract

In July 2023 the Southeast Coast Network assessed water-quality at Fort Pulaski National Monument as part of the National Park Service Vital Signs Monitoring Program. Monitoring was conducted following methods developed by the Environmental Protection Agency (EPA) as part of the National Coastal Assessment Program (EPA 2014). Laboratory analysis measured chlorophyll *a* and total and dissolved concentrations of nitrogen and phosphorous. Field measurements included water temperature, pH, dissolved oxygen, and salinity. Water clarity, which requires a Secchi depth measurement, was calculated when possible. All measured parameters were rated as good, fair, or poor based on thresholds set by the EPA (2012).

The purpose of this document is to report the most recently collected data from the monument as part of an ongoing long-term water-quality monitoring program. This report was designed to provide water-quality monitoring data to managers as a concise summary in the context of applicable federal standards developed by the EPA. Previous synoptic assessments of water-quality conditions at Fort Pulaski National Monument were conducted in August 2007, July 2014, and July 2018 as part of NPS Inventory and Monitoring efforts.

Based on the EPA summary water-quality index rating, overall water-quality conditions at Fort Pulaski National Monument during 2023 sampling were fair. The summary water-quality index rating for overall water-quality conditions is consistent with findings from 2014–2018.

Summary and Key Findings

In July 2023 the Southeast Coast Network assessed water-quality at Fort Pulaski National Monument as part of the National Park Service Vital Signs Monitoring Program. Monitoring was conducted following methods developed by the Environmental Protection Agency (EPA) as part of the National Coastal Assessment Program (EPA 2014). Laboratory analysis measured chlorophyll *a* and total and dissolved concentrations of nitrogen and phosphorous. Field measurements included water temperature, pH, dissolved oxygen, and salinity. Water clarity, which requires a Secchi depth measurement, was calculated when possible. All measured parameters were rated as good, fair, or poor based on thresholds set by the EPA (2012).

- Water clarity was rated good at twenty-eight sites (93.3%), fair at one site (3.3%) and poor at one site (3.3%).
- Chlorophyll *a* concentrations were rated good at nine sites (30%) and fair at twenty-one sites (70%).
- Dissolved inorganic nitrogen (DIN) concentrations were good at eleven sites (37%) and fair at nineteen sites (63%).
- Dissolved inorganic phosphorus (DIP) concentration were fair at all thirty sites (100%).
- Dissolved oxygen concentrations (bottom) were rated good at eight sites (27%) and fair at twenty-two sites (73%).
- A water-quality condition summary index was calculated for each site sampled at Fort Pulaski National Monument based on the categorical assessments of chlorophyll *a*, DIN and DIP concentrations, dissolved oxygen, and water clarity. This summary index indicated fair water-quality conditions at all thirty sites (100%).
- See [supplemental materials](#) to compare the distribution of good, fair, and poor ratings for each parameter across the period of record.
- Based on the EPA summary water-quality index rating, overall water-quality conditions at Fort Pulaski National Monument during 2023 sampling were fair.
- The EPA summary water-quality index rating is consistent with findings from 2014–2018.

Introduction

Overview

Due to the importance of water resources to park management from ecological, regulatory, and visitor experience perspectives, estuarine water and sediment quality in and around parks were selected to be monitored by the National Park Service (NPS) Inventory and Monitoring Division's Southeast Coast Network (SECN; DeVivo et al. 2008). Since 2005, the network has employed a multiscale approach to assess estuarine resources in seven park units located in North Carolina, Georgia, and Florida. Data collected as part of this effort are intended help resource managers: (1) better understand ecological processes and impacts caused by development, (2) make informed management decisions, and (3) form/maintain strategic partnerships to monitor and improve water quality conditions in and around park units. In addition, given the diverse and dynamic nature of estuaries, this monitoring is intended to capture the spatial and temporal variability of these systems.

Monitoring at permanent fixed stations using continuous data loggers and discrete samples allows for evaluation of temporal patterns in core water quality parameters (dissolved oxygen, pH, salinity, temperature, and turbidity), nutrients (nitrogen and phosphorus) and chlorophyll *a*. While fixed-station monitoring provides fine resolution data to determine diel, monthly, and seasonal fluctuations in water quality, it lacks spatial extent. To fill this gap, spatial variability of water and sediment quality is determined with park-wide assessments every five years. These assessments include discrete sampling of nutrients, water quality parameters, and evaluation of sediment contaminants following methods developed by the Environmental Protection Agency-National Coastal Assessment Program. This monitoring approach leads to an understanding of the spatiotemporal status and variability of estuarine water quality and yields information useful to park management.

The SECN's monitoring approach is extensively documented in the Protocol for Monitoring Estuarine Water and Sediment Quality in Selected Southeast Coast Network Parks: Protocol Narrative (Gregory et al. 2013 and Starkey et al. 2023) and associated Standard Operating Procedures (SOPs). Version 1.0 of the protocol (Gregory et al. 2013) was implemented between 2007 and 2018. Version 2.0 of the protocol (Starkey et al. 2023) was implemented 2019 to present and was updated to align with new technology and techniques documented in revised Standard Operating Procedures. Monitoring objectives remain consistent across both versions of the protocol.

Monitoring Objectives

The Southeast Coast Network identified an overall goal of monitoring the status and trends in water and sediment quality in estuaries surrounding SECN parks. To achieve this goal, data are collected and analyzed to meet four specific monitoring objectives. These objectives remain consistent across both versions of the protocol (Gregory et al. 2013; Starkey et al. 2023) and are listed below.

1. Determine diel and seasonal water-quality patterns for five core parameters (dissolved oxygen, salinity, temperature, pH, and turbidity) at selected coastal areas near SECN parks using fixed-station continuous data loggers.

2. Determine monthly and seasonal patterns in nutrients (nitrogen and phosphorus) and chlorophyll *a* at selected coastal areas near SECN parks by collecting discrete water samples.
3. Determine status and spatial variability of water and nutrient conditions in estuarine waters every five years near SECN parks.
4. Determine status and spatial variability of benthic sediment quality (organic contaminants, carbon, and metal levels) every 10 years in estuarine waters near SECN parks.

This report summarizes water-quality monitoring data collected during a parkwide assessment to address objective 3 at Fort Pulaski National Monument. Data were gathered from July 10–July 13, 2023. The purpose of this document is to report the most recently collected data from the monument as part of an ongoing long-term water-quality monitoring program. This report was designed to provide water-quality monitoring data to managers as a concise summary in the context of applicable federal standards developed by the Environmental Protection Agency (EPA). Previous synoptic assessments of water-quality conditions at Fort Pulaski National Monument were conducted in August 2007, July 2014, and July 2018 as part of I&M monitoring efforts (Gregory et al. 2010; Wright 2015; Starkey et al. 2019).

Study Area

Fort Pulaski National Monument

Fort Pulaski National Monument (FOPU) is in Chatham County, Georgia along the Savannah River, at the confluence of the river and the Atlantic Ocean (Figure 1). The monument consists of two islands that were primarily saltmarsh until human intervention. Cockspur Island probably supported some coastal hammock forest or woodland, based on the composition of existing vegetation. Cockspur Island was selected for fortification as early as the 18th century. In the early 19th century, as part of the development of the site for defense, the island was modified by the installation of drainage canals and a dike system. The site was later affected by the deposition of dredge spoil material from the Savannah River, which continued until recent times. During the civil war period, vegetation was removed and kept in early successional stages to enhance visibility.

Since the abandonment of the fort in the late 1800s, a large portion of central Cockspur Island has reverted to maritime forest. Currently the upland portions of Cockspur Island (approximately 260 acres or 105.2 hectares) support a mosaic of maritime forest, maritime shrub communities, maintained grasslands, and successional spoil-deposit areas. The island also includes more than 340 acres (137.6 hectares) of tidal shrubland and tidal herbaceous marsh.

McQueen's Island makes up the largest portion of land holdings for the national monument (about 4,900 acres [1,983 hectares]), and the majority of the island consists of salt marsh. A railroad was constructed along the northern edge of the island in 1887 to connect the city of Savannah with Tybee Island. The railroad was operated until 1933. US Highway 80 was constructed in 1923. The highway crosses the central portion of the island and then continues east along the old railroad grade. In 1994 Chatham County converted the abandoned railroad right-of-way to a multipurpose hiking trail. Both the highway and the converted rails-to-trails areas support habitat for numerous ruderal herbaceous coastal plain species (DeVivo et al. 2008).

Water resources at Fort Pulaski National Monument have been affected by land/waterway use in the surrounding watersheds. Examples of water-quality effects applicable to the park include nonpoint source pollution from urban and agricultural areas, elevated metal concentrations in dredged sediments of the Savannah River shipping channel, effects of multiple Superfund sites and landfills, and water pollution from malfunctioning septic systems (McFarlin and Alber 2005).

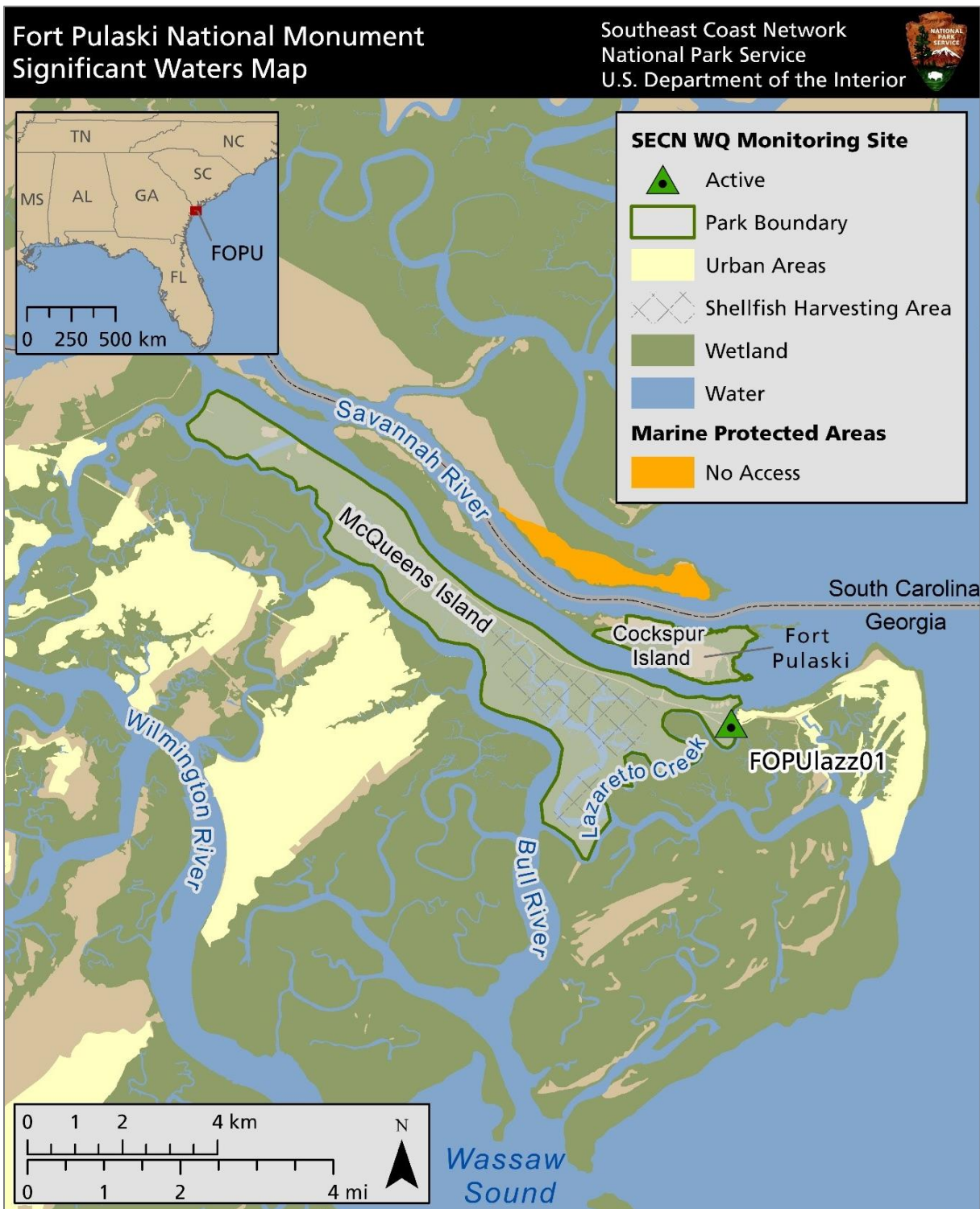


Figure 1. Southeast Coast Network fixed-station monitoring sites and estuarine and marine water resources in the vicinity of Fort Pulaski National Monument in Georgia. Indicated are areas of wetlands (FWS 2024), urbanized area (USCB 2023), and areas designated as having special uses or restrictions (NOAA 2023). NPS / SECN

Methods

The water-quality assessment was conducted in estuarine waters in the vicinity of Fort Pulaski National Monument, following the methods developed by the Environmental Protection Agency (EPA) National Coastal Assessment Program. Descriptions of the water-quality parameters and the assessment criteria are from the EPA National Coastal Assessment IV Report (EPA 2012). Methods used for these assessments were adapted and integrated into protocols tailored specifically to parks in the Southeast Coast Network (Starkey et al. 2023). Site selection and sampling methodology are briefly outlined in the following sections.

In 2023, thirty sites in estuarine waters near the monument were randomly selected for monitoring following methods developed by the EPA (Table 1, Figure 2; Stevens 1997; Stevens and Olsen 1999; Stevens and Olsen 2004). This method of randomly selecting spatially balanced sites provides managers with a statistically valid estimate of the overall conditions of the assessed resource within or around the park.

Table 1. Site name (which includes site number 01, 02, ...etc.), waterbody name and location, depth, coordinates, and chemical and physical attributes of sampling sites at Fort Pulaski National Monument, July 10–13, 2023. The table references site names used to present data in this report (Figure 2). All coordinates are in NAD83 Datum, in UTM zone 17. Salinity, pH, and water temperature measured at a depth of 0.5 meters unless water depth was too shallow in which case it was measured at 0.1 meters (0.3 feet). [SAV—sub-aquatic vegetation; m—meters; °C—degrees Celsius; PSU—practical salinity units].

Site Name	Water Body	UTMX	UTMY	SAV	Debris	Site Depth (m)	Water Temp (°C)	pH	Salinity (PSU)
FOPU01_2023	Savannah River	508476	3544790	No	No	4.1	29.07	7.64	15.79
FOPU02_2023	South Channel	499910	3549388	No	No	1.8	28.14	7.29	9.26
FOPU03_2023	South Channel	506902	3544573	No	No	2.4	29.24	7.48	14.70
FOPU04_2023	Lazaretto Creek	510146	3542255	No	No	2.0	29.41	7.63	17.63
FOPU05_2023	St. Augustine Creek	502512	3545571	No	No	5.9	29.46	7.23	16.93
FOPU06_2023	South Channel	512283	3543231	No	No	2.4	29.22	7.67	17.67
FOPU07_2023	Bull River	506903	3540097	No	No	2.3	30.16	7.56	27.81
FOPU08_2023	South Channel	501552	3548583	No	No	2.3	28.31	7.36	10.82
FOPU09_2023	Savannah River	507678	3544342	No	No	3.0	29.03	7.54	14.30
FOPU10_2023	South Channel	505408	3545321	No	No	0.5	29.01	7.43	14.12
FOPU11_2023	South Channel	502011	3548348	No	No	1.7	28.22	7.40	11.84
FOPU12_2023	Bull River	504995	3543716	No	No	2.6	30.04	7.51	25.40
FOPU13_2023	South Channel	508174	3513308	No	No	3.2	29.92	7.69	17.28
FOPU14_2023	Oyster Creek	507525	3542125	No	No	2.4	30.28	7.60	27.40
FOPU15_2023	Tybee Creek	509806	3539981	No	No	6.8	30.32	7.78	29.07
FOPU16_2023	South Channel	512009	3542874	No	No	3.1	29.28	7.63	17.25
FOPU17_2023	Unnamed Tidal Creek	504352	3545486	No	No	2.7	29.71	7.24	16.74
FOPU18_2023	Lazaretto Creek	508242	3540594	No	No	2.7	30.45	7.58	27.07
FOPU19_2023	Savannah River	510172	3544632	No	No	1.3	29.91	7.74	16.83
FOPU20_2023	Lazaretto Creek	510659	3541528	No	No	6.2	30.01	7.55	22.00
FOPU21_2023	South Channel	504231	3546465	No	No	7.4	28.92	7.39	13.83

Table 1 (continued). Site name (which includes site number 01, 02, ...etc.), waterbody name and location, depth, coordinates, and chemical and physical attributes of sampling sites at Fort Pulaski National Monument, July 10–13, 2023. The table references site names used to present data in this report (Figure 2). All coordinates are in NAD83 Datum, in UTM zone 17. Salinity, pH, and water temperature measured at a depth of 0.5 meters unless water depth was too shallow in which case it was measured at 0.1 meters. [SAV—sub-aquatic vegetation; m—meters; °C—degrees Celsius; PSU—practical salinity units].

Site Name	Water Body	UTMX	UTMY	SAV	Debris	Site Depth (m)	Water Temp (°C)	pH	Salinity (PSU)
FOPU22_2023	Lazaretto Creek	508311	3539762	No	No	4.1	30.17	7.78	29.30
FOPU23_2023	South Channel	500957	3549047	No	No	2.3	28.54	7.37	10.31
FOPU24_2023	Bull River	506838	3541746	No	No	8.0	29.99	7.67	28.50
FOPU25_2023	South Channel	503874	3546675	No	No	4.6	28.87	7.39	13.73
FOPU26_2023	Savannah River	504270	3548380	No	No	5.7	28.33	7.53	14.47
FOPU27_2023	Unnamed Tidal Creek	506133	3540756	No	No	3.6	30.34	7.76	29.20
FOPU28_2023	South Channel	502255	3547813	No	No	3.4	28.19	7.36	11.84
FOPU29_2023	Bull River	507343	3541027	No	No	2.0	30.16	7.49	25.84
FOPU30_2023	South Channel	507678	3543435	No	No	2.8	29.43	7.55	15.59

Fort Pulaski National Monument
2023 Parkwide Assessment Sampling Sites

Southeast Coast Network
National Park Service
U.S. Department of the Interior



Figure 2. Map showing the location of parkwide assessment sites (site numbers from Table 1) sampled in July 2023 at Fort Pulaski National Monument. NPS / SECN

Water-Quality Data Collection

The water-quality assessment conducted during this sampling period incorporated hydrographic profiles at 0.5–1.0 meter (1.6–3.3 feet [ft]) intervals at each site, to measure temperature, pH, dissolved oxygen, and salinity. Chlorophyll *a* and total dissolved nutrient samples were collected from 0.5 meters (1.6 ft) below the surface. Chlorophyll *a* samples were processed using known volumes of water samples that were filtered onto glass-fiber filters then refrigerated and submitted for laboratory analysis.

Water clarity was estimated at each site using a Secchi disk to determine light extinction depths, which were converted to light attenuation coefficients (*k*) using the equation: $k = c / \text{Secchi depth (in meters)}$ where “*c*” is a constant that corresponds to the water body’s naturally occurring clarity conditions (i.e., *c* = 1.0 for naturally turbid conditions, *c* = 1.4 for normal turbidity conditions, or *c* = 1.7 for waters supporting submerged aquatic vegetation (SAV) restoration [Smith et al. 2006; EPA 2016]). Fort Pulaski National Monument uses a constant (*c*) of 1.0 because the area is “naturally turbid” (EPA 2016). This method of estimating water-clarity condition is generally used when information on light transmission in the water column is missing. The Southeast Coast Network is reporting derived values to maintain data consistency across network parks. Water clarity was not assessed at sites with excessive current or depths too shallow to ascertain an accurate Secchi measurement. When sites were too shallow to access by boat, or when they were in heavily trafficked channels where safety was a concern, alternate sites were used.

Water-Quality Assessment Criteria

The categorical assessments (e.g., good, fair, poor) use measurements of chlorophyll *a*, nutrient concentrations, bottom dissolved oxygen, and water clarity (Table 2) and are intended to characterize acutely degraded water-quality conditions at a site. The assessments do not consistently identify sites that experience occasional or infrequent hypoxia, nutrient enrichment, or decreased water clarity. Therefore, a rating of poor for the water-quality index means the site likely exhibited consistently poor conditions before or after the assessment period. If a site is designated fair or good, the site did not experience poor conditions on the date of sampling; however, the site could be characterized by poor conditions for short time periods.

Site assessments were also made using an index that combines the ratings for each parameter into a site-specific water-quality index rating. This index allows for general comparisons between sites in a park (Table 3) and can be used to summarize overall conditions in the waters around a park. This rating also allows general comparisons between parks and at the same park over time based on the percentage of sites that fall within the good, fair, or poor categories.

Table 2. Water-quality monitoring condition criteria for water-quality parameters collected by the Southeast Coast Network based on thresholds set by EPA (2012) [$\mu\text{g/L}$ —micrograms per liter; mg/L —milligrams per liter].

Rating	Water Clarity (k) ^A	Chlorophyll a ($\mu\text{g/L}$)	Dissolved Inorganic Nitrogen (DIN) (mg/L)	Dissolved Inorganic Phosphorus (DIP) (mg/L)	Dissolved Oxygen (mg/L)
Good	< 2.30	< 5	< 0.1	< 0.01	>5
Fair	2.30–2.99	5–20	0.1–0.5	0.01–0.05	2–5
Poor	> 2.99	> 20	> 0.5	> 0.05	<2

^A Light attenuation coefficients (k) were used to assess water-clarity conditions using criteria categories in Smith et al. (2006) which are comparable to the EPA (2012) criteria for the assessed water bodies.

Table 3. Condition criteria used for water-quality assessment summaries at individual sampling sites and parks.

Rating	Site Water-Quality Index Rating ^A	Park Water-Quality Index Rating ^A
Good	A maximum of one indicator is rated fair, and no indicators are rated poor.	Less than 10% of sites are in poor condition, and more than 50% of sites are in good condition.
Fair	One indicator is rated poor, or two or more indicators are rated fair.	10% to 20% of sites are in poor condition, or 50% or less of sites are in good condition.
Poor	Two or more of the five indicators are rated poor.	More than 20% of sites are in poor condition.
Missing	Two components of the indicator are missing, and the available indicators do not suggest a fair or poor rating.	NA

^A Park and site water-quality index ratings are adapted from ratings established by the EPA (2012).

Results

Parameter-Based Water Condition Assessments

Figures 3–7 illustrate the spatial distribution of sampling sites and the corresponding ratings for water clarity, chlorophyll *a*, dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), and bottom-reading dissolved oxygen (DO) based on each parameter’s corresponding condition category. Inset graphs on Figures 3–7 show the proportion of sites in the assessed area that were placed in each rating category. The map and graph in Figure 8 summarize Fort Pulaski National Monument’s water-quality conditions during the assessment. Site-specific water-quality data for each parameter are also presented in Table 4. For comparison with past assessments, maps and condition rating summary graphs for sample years 2007–2023 can be found in the supplementary materials.

- Water clarity was rated good at twenty-eight sites (93.3%), fair at one site (3.3%) and poor at one site (3.3%).
- Chlorophyll *a* concentrations were rated good at nine sites (30%) and fair at twenty-one sites (70%).
- Dissolved inorganic nitrogen concentrations were good at eleven sites (37%) and fair at nineteen sites (63%).
- Dissolved inorganic phosphorus concentrations were fair at all thirty sites (100%).
- Dissolved oxygen concentration (bottom) was rated good at eight sites (27%) and fair at twenty-two sites (73%).
- Overall, condition ratings for each parameter have been relatively consistent since monitoring began in 2007. However, one notable improvement was for chlorophyll *a* concentrations, which had 3% of sites rated as good in 2014, 0% rated as good in 2018 and 30% rated as good in 2023. The distribution of sites rated as good in 2023 was clustered in the South Channel of the Savannah River near the intra-coastal waterway (Elba Island Cut). The distribution of good, fair, and poor ratings for each parameter across the period of record can be seen using the maps provided in the [supplemental materials](#).
- A water-quality condition summary index was calculated for each site sampled at Fort Pulaski National Monument based on the categorical assessments of chlorophyll *a*, DIN and DIP concentrations, dissolved oxygen, and water clarity. This summary index indicated fair water-quality conditions at all thirty sites (100%). In 2014 and 2018 all thirty sites (100%) were also rated as fair, which indicates relatively stable water-quality conditions at Fort Pulaski National Monument.
- See [supplemental materials](#) to compare the proportion of good, fair, and poor ratings for each parameter across the period of record.
- Based on the summary water-quality index rating, overall water-quality conditions at Fort Pulaski National Monument during 2023 sampling were fair.
- The summary water-quality index rating is consistent with findings from 2014–2018.



Figure 3. Water clarity ratings for sites sampled at Fort Pulaski National Monument July 10–13, 2023. Inset graph shows the percent of sites in each condition category [Green—good; yellow—fair; red—poor].
NPS / SECN

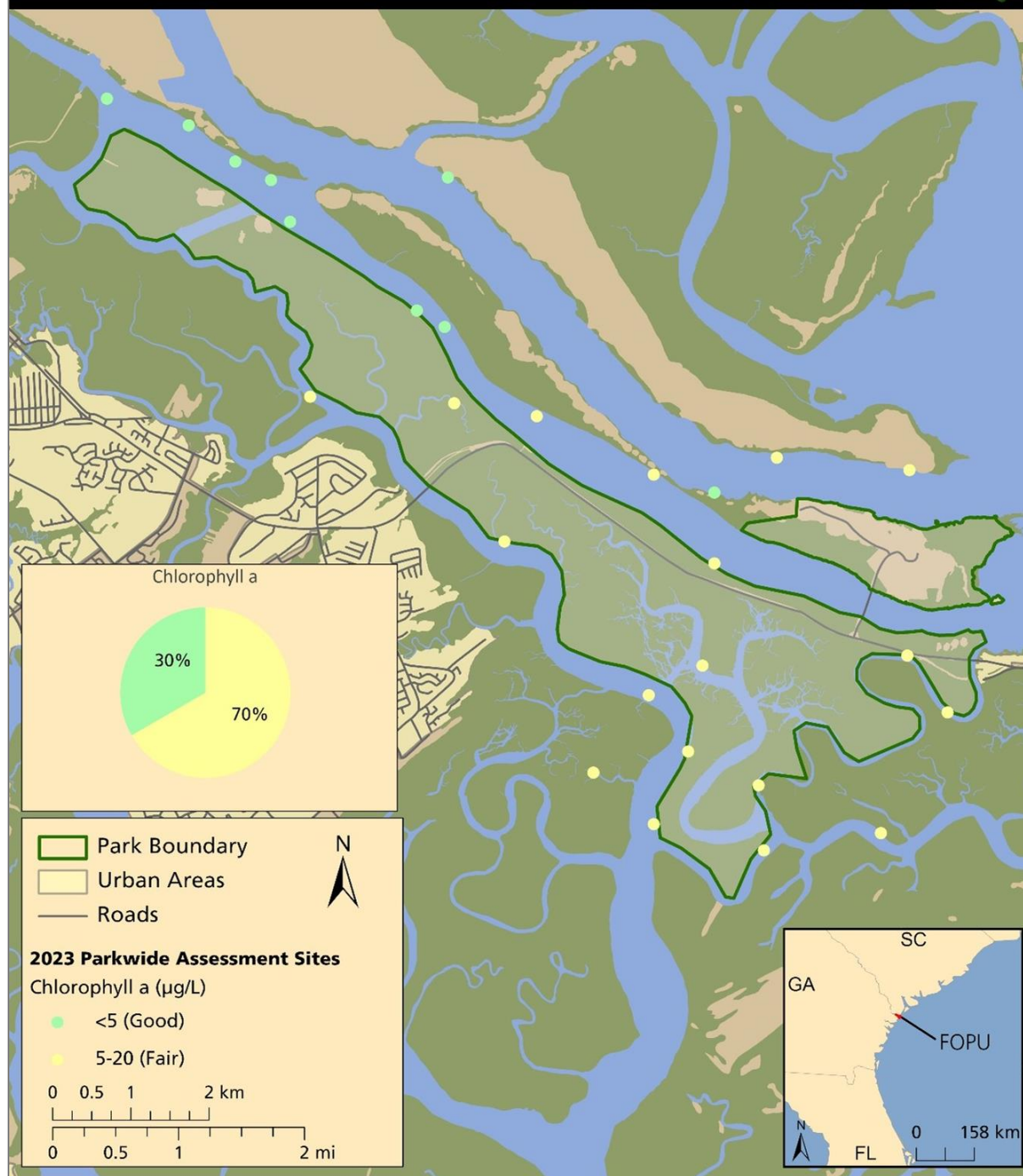


Figure 4. Chlorophyll a concentrations for sites sampled at Fort Pulaski National Monument July 10–13, 2023. Inset graph shows the percent of sites in each condition category [Green—good; yellow—fair].
NPS / SECN

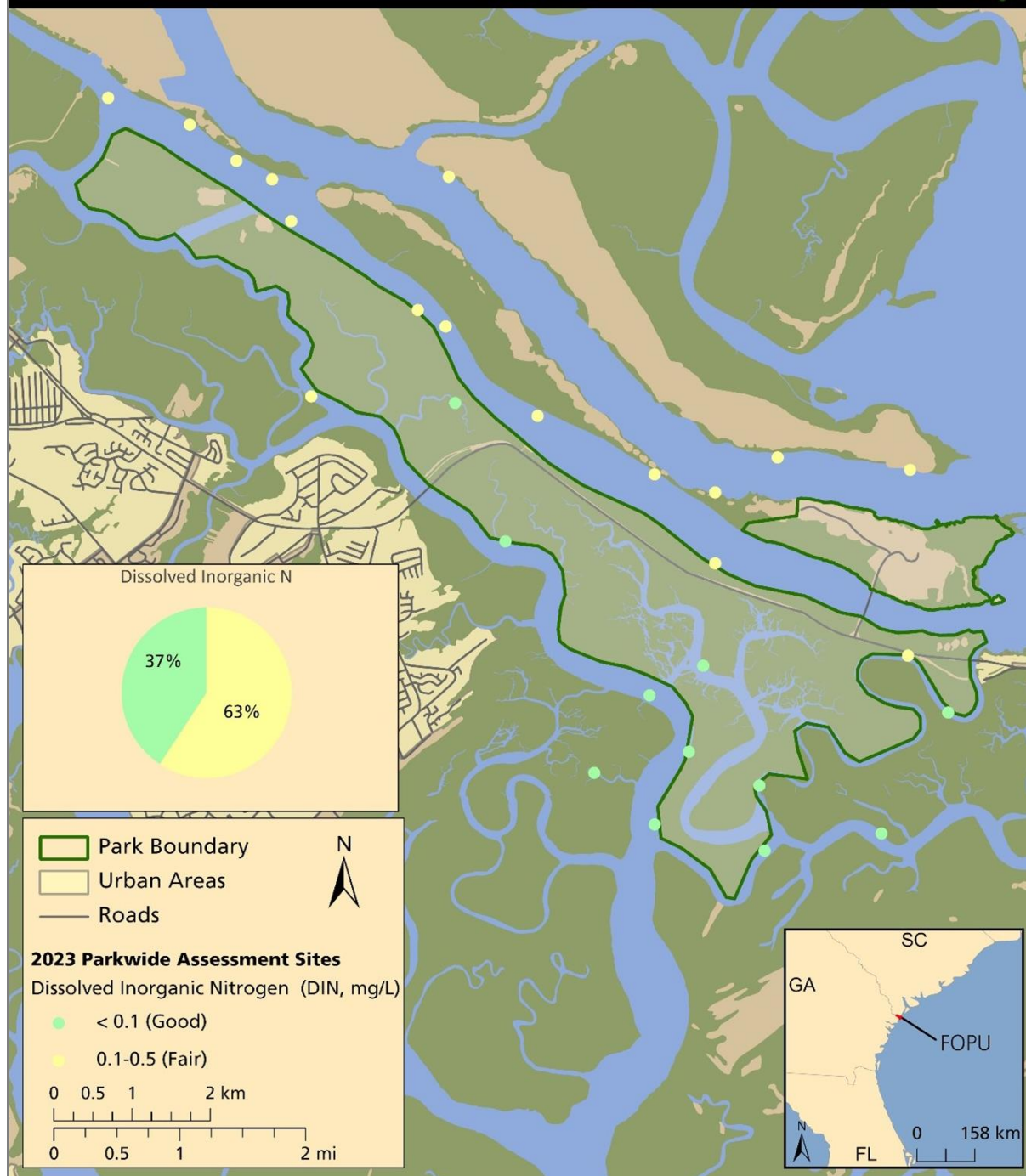


Figure 5. Dissolved inorganic nitrogen concentrations for sites sampled at Fort Pulaski National Monument July 10–13, 2023. Inset graph shows the percent of sites in each condition category [Green—good; yellow—fair]. NPS / SECN



Figure 6. Dissolved inorganic phosphorus concentrations for sites sampled at Fort Pulaski National Monument July 10–13, 2023. Inset graph shows the percent of sites in each condition category [Yellow—fair]. NPS / SECN



Figure 7. Dissolved oxygen concentrations for sites sampled at Fort Pulaski National Monument July 10–13, 2023. Inset graph shows the proportion of sites in each condition category [Green—good; yellow—fair]. NPS / SECN



Figure 8. Water-quality index rating for sites sampled at Fort Pulaski National Monument July 10–13, 2023. Inset graph shows the proportion of sites in each condition category [Yellow—fair]. NPS / SECN

Table 4. Water-quality parameter values and assessment conditions for sampling sites in the vicinity of Fort Pulaski National Monument July 10–13, 2023. Water clarity was assessed using light attenuation values (k) using a constant (1.0) for estuarine waters that are “naturally turbid” (Smith et al. 2006) and assessment categories that correspond to EPA (2012). Condition of other assessed parameters based on EPA (2012) [Green ^D—good; yellow ^E—fair; red ^F—poor; *result was less than or equal to the Method Detection Limit [MDL reported]; k— light attenuation coefficient; µg/L—micrograms per liter; N—Nitrogen; mg/L—milligrams per liter; P— Phosphorous; — data not collected]. Dissolved oxygen concentrations are taken near the bottom (deepest reading).

Site	Water Clarity (k) ^A	Chlorophyll a (µg/L) ^B	Dissolved Oxygen (DO, mg/L) ^B	Dissolved Inorganic Nitrogen (DIN, mg/L) ^B	Dissolved Inorganic Phosphorus (DIP, mg/L) ^B	Total Dissolved Nitrogen (mg/L) ^{B,C}	Total Dissolved Phosphorus (mg/L) ^{B,C}	Site WQ Index Rating
FOPU01_2023	0.8 ^D	5.16 ^E	5.1 ^D	0.2070 ^E	0.0320 ^E	0.45	0.0432	Fair ^E
FOPU02_2023	1.7 ^D	2.77 ^D	4.4 ^E	0.3010 ^E	0.0432 ^E	0.57	0.0520	Fair ^E
FOPU03_2023	1.1 ^D	6.39 ^E	4.6 ^E	0.2040 ^E	0.0346 ^E	0.45	0.0440	Fair ^E
FOPU04_2023	0.6 ^D	11.24 ^E	5.3 ^D	0.1530 ^E	0.0311 ^E	0.40	0.0443	Fair ^E
FOPU05_2023	1.1 ^D	7.28 ^E	3.9 ^E	0.1078 ^E	0.0316 ^E	0.43	0.0481	Fair ^E
FOPU06_2023	2.0 ^D	10.88 ^E	4.8 ^E	0.1720 ^E	0.0317 ^E	0.42	0.0420	Fair ^E
FOPU07_2023	2.5 ^E	6.85 ^E	4.2 ^E	0.0345 ^D	0.0246 ^E	0.29	0.0404	Fair ^E
FOPU08_2023	1.1 ^D	3.16 ^D	4.2 ^E	0.2910 ^E	0.0434 ^E	0.55	0.0518	Fair ^E
FOPU09_2023	0.9 ^D	4.11 ^D	4.6 ^E	0.2290 ^E	0.0389 ^E	0.46	0.0500	Fair ^E
FOPU10_2023	3.3 ^F	5.10 ^E	4.6 ^E	0.2210 ^E	0.0371 ^E	0.48	0.0457	Fair ^E
FOPU11_2023	1.3 ^D	2.94 ^D	4.2 ^E	0.2760 ^E	0.0423 ^E	0.52	0.0512	Fair ^E
FOPU12_2023	1.4 ^D	9.69 ^E	4.2 ^E	0.0497 ^D	0.0267 ^E	0.33	0.0489	Fair ^E
FOPU13_2023	2.0 ^D	12.59 ^E	5.5 ^D	0.1540 ^E	0.0293 ^E	0.39	0.0380	Fair ^E

^A Light attenuation coefficients (k) were used to assess water-clarity conditions using criteria categories in Smith et al. (2006) which are comparable to the EPA (2012) criteria for the assessed water bodies.

^B Where µg/L = micrograms per liter; N = Nitrogen; mg/L = milligrams per liter; P = Phosphorous.

^C There are no EPA condition criteria for TDN and TDP.

^D Conditions are assessed as good using parameters from the EPA (2012) (also with a green background).

^E Conditions are assessed as fair using parameters from the EPA (2012) (also with a yellow background).

^F Conditions are assessed as poor using parameters from the EPA (2012) (also with a red background).

Table 4 (continued). Water-quality parameter values and assessment conditions for sampling sites in the vicinity of Fort Pulaski National Monument July 10–13, 2023. Water clarity was assessed using light attenuation values (k) using a constant (1.0) for estuarine waters that are “naturally turbid” (Smith et al. 2006) and assessment categories that correspond to EPA (2012). Condition of other assessed parameters based on EPA (2012) [Green ^D—good; yellow ^E—fair; red ^F—poor; *result was less than or equal to the Method Detection Limit [MDL reported]; k— light attenuation coefficient; µg/L—micrograms per liter; N—Nitrogen; mg/L—milligrams per liter; P— Phosphorous; — data not collected]. Dissolved oxygen concentrations are taken near the bottom (deepest reading).

Site	Water Clarity (k) ^A	Chlorophyll a (µg/L) ^B	Dissolved Oxygen (DO, mg/L) ^B	Dissolved Inorganic Nitrogen (DIN, mg/L) ^B	Dissolved Inorganic Phosphorus (DIP, mg/L) ^B	Total Dissolved Nitrogen (mg/L) ^{B,C}	Total Dissolved Phosphorus (mg/L) ^{B,C}	Site WQ Index Rating
FOPU14_2023	0.6 ^D	14.22 ^E	4.6 ^E	0.0431 ^D	0.0248 ^E	0.34	0.0470	Fair ^E
FOPU15_2023	1.4 ^D	10.57 ^E	5.4 ^D	0.0224 ^D	0.0218 ^E	0.30	0.0446	Fair ^E
FOPU16_2023	1.7 ^D	8.91 ^E	4.6 ^E	0.1820 ^E	0.0312 ^E	0.42	0.0412	Fair ^E
FOPU17_2023	1.4 ^D	11.13 ^E	3.4 ^E	0.0997 ^D	0.0334 ^E	0.45	0.0505	Fair ^E
FOPU18_2023	0.7 ^D	10.87 ^E	4.6 ^E	0.0382 ^D	0.0263 ^E	0.29	0.0434	Fair ^E
FOPU19_2023	1.7 ^D	6.40 ^E	5.3 ^D	0.2020 ^E	0.0327 ^E	0.44	0.0424	Fair ^E
FOPU20_2023	1.4 ^D	8.97 ^E	4.4 ^E	0.0823 ^D	0.0239 ^E	0.31	0.0357	Fair ^E
FOPU21_2023	1.7 ^D	4.15 ^D	4.3 ^E	0.2300 ^E	0.0382 ^E	0.51	0.0477	Fair ^E
FOPU22_2023	1.3 ^D	9.88 ^E	5.6 ^D	0.0271 ^D	0.0253 ^E	0.30	0.0470	Fair ^E
FOPU23_2023	1.3 ^D	3.39 ^D	4.2 ^E	0.2980 ^E	0.0423 ^E	0.55	0.0531	Fair ^E
FOPU24_2023	1.7 ^D	9.66 ^E	5.2 ^D	0.0273 ^D	0.0256 ^E	0.28	0.0408	Fair ^E
FOPU25_2023	1.7 ^D	4.05 ^D	4.3 ^E	0.2350 ^E	0.0382 ^E	0.49	0.0477	Fair ^E
FOPU26_2023	1.1 ^D	3.04 ^D	4.3 ^E	0.2390 ^E	0.0371 ^E	0.50	0.0471	Fair ^E

^A Light attenuation coefficients (k) were used to assess water-clarity conditions using criteria categories in Smith et al. (2006) which are comparable to the EPA (2012) criteria for the assessed water bodies.

^B Where µg/L = micrograms per liter, N = Nitrogen; mg/L = milligrams per liter; P = Phosphorous.

^C There are no EPA condition criteria for TDN and TDP.

^D Conditions are assessed as good using parameters from the EPA (2012) (also with a green background).

^E Conditions are assessed as fair using parameters from the EPA (2012) (also with a yellow background).

^F Conditions are assessed as poor using parameters from the EPA (2012) (also with a red background).

Table 4 (continued). Water-quality parameter values and assessment conditions for sampling sites in the vicinity of Fort Pulaski National Monument July 10–13, 2023. Water clarity was assessed using light attenuation values (k) using a constant (1.0) for estuarine waters that are “naturally turbid” (Smith et al. 2006) and assessment categories that correspond to EPA (2012). Condition of other assessed parameters based on EPA (2012) [Green ^D—good; yellow ^E—fair; red ^F—poor; *result was less than or equal to the Method Detection Limit [MDL reported]; k— light attenuation coefficient; µg/L—micrograms per liter; N—Nitrogen; mg/L—milligrams per liter; P— Phosphorous; — data not collected]. Dissolved oxygen concentrations are taken near the bottom (deepest reading).

Site	Water Clarity (k) ^A	Chlorophyll a (µg/L) ^B	Dissolved Oxygen (DO, mg/L) ^B	Dissolved Inorganic Nitrogen (DIN, mg/L) ^B	Dissolved Inorganic Phosphorus (DIP, mg/L) ^B	Total Dissolved Nitrogen (mg/L) ^{B,C}	Total Dissolved Phosphorus (mg/L) ^{B,C}	Site WQ Index Rating
FOPU27_2023	1.4 ^D	10.70 ^E	5.4 ^D	0.0255 ^D	0.0237 ^E	0.26	0.0391	Fair ^E
FOPU28_2023	1.1 ^D	3.72 ^D	4.4 ^E	0.2650 ^E	0.0421 ^E	0.57	0.0595	Fair ^E
FOPU29_2023	1.4 ^D	6.31 ^E	4.0 ^E	0.0420 ^D	0.0267 ^E	0.36	0.0500	Fair ^E
FOPU30_2023	1.7 ^D	8.88 ^E	4.8 ^E	0.1980 ^E	0.0329 ^E	0.41	0.0410	Fair ^E

^A Light attenuation coefficients (k) were used to assess water-clarity conditions using criteria categories in Smith et al. (2006) which are comparable to the EPA (2012) criteria for the assessed water bodies.

^B Where µg/L = micrograms per liter, N = Nitrogen; mg/L = milligrams per liter; P = Phosphorous.

^C There are no EPA condition criteria for TDN and TDP.

^D Conditions are assessed as good using parameters from the EPA (2012) (also with a green background).

^E Conditions are assessed as fair using parameters from the EPA (2012) (also with a yellow background).

^F Conditions are assessed as poor using parameters from the EPA (2012) (also with a red background).

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National Park Service
U.S. Department of the Interior



Science Report NPS/SR—2025/241
<https://doi.org/10.36967/2308470>

Natural Resource Stewardship and Science

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