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2018 Masonville Cove – Patapsco River Shallow Water Monitoring Data Report

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Shallow Water Monitoring Data Report

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Executive summary

Masonville Cove, a small inlet of the upper tidal Patapsco River, figures in local Baltimore lore as a natural respite from the rigors of early 20th century city life. However, as the Patapsco River was heavily impacted by pollution from centuries of being a center of commerce and population, so too was Masonville Cove. In 2007, the Maryland Port Administration received a permit to build a dredged material containment facility at the Masonville Marine Terminal, adjacent to Masonville Cove. As part of the mitigation agreement for this project, the Maryland Department of Natural Resources (DNR) deployed a continuous water quality monitor in the summer of 2009, ahead of the construction of the dredged material containment facility. Since 2009, DNR has continued to deploy a monitor during most of the year, although it has been removed in the winter in some years due to icing conditions. In continuation of this project, a water quality monitor was deployed off the Masonville Cove pier during 2018.

Water quality conditions in Masonville Cove during 2018, as in the rest of the Chesapeake Bay watershed, were influenced by meteorological events. 2018 was the wettest year on record in Central Maryland as almost 72-inches of precipitation fell on the region. Not only did this lead to massive discharge events affecting salinity and turbidity, but the numerous storm events continuously flushed algae from Masonville Cove. Chlorophyll readings improved to the lowest levels since monitoring began in Masonville Cove. These lower algal concentrations may be related to the improved dissolved oxygen conditions observed in 2018. Turbidity readings improved slightly from the prior year, which were the worst observed water clarity conditions since 2009, but current conditions were still slightly below average in terms of turbidity threshold failure rates.

All 2018 continuous monitoring data, as well as data from previous years, are available on the DNR "Eyes on the Bay" website (eyesonthebay.dnr.maryland.gov/contmon/ContMon.cfm). Data from grab samples are available through the Chesapeake Bay Program's Data Hub (https://www.chesapeakebay.net/what/data). The most recent seven days of water quality data can also be viewed on the "Eyes on the Bay" Masonville Cove webpage (eyesonthebay.dnr.maryland.gov/contmon/masonville.cfm). Data collected in 2018 at the time of each instrument replacement (pigments, suspended solids, Secchi disk depth and ambient water quality data) are also available for download via the following link: eyesonthebay.dnr.maryland.gov/contmon/GetConMonDataHub_StationTable.cfm?station=XIE4742&DataHubID=1930&startdate=1-1-2018&enddate=12-31-2018.

Introduction

In 2007, the Maryland Port Administration (MPA) submitted plans to the United States Army Corps of Engineers (USACE) to construct a Dredged Material Containment Facility (DMCF) in the vicinity of the Masonville Marine Terminal (Figure 1). The terminal, located on the upper Patapsco River in Baltimore, is a major port for the automotive industry. The design for the DMCF uses sand and clay dikes to contain material dredged from the navigation channels in Baltimore Harbor. The same year, an environmental impact study submitted to USACE suggested mitigation for the project. Mitigation was deemed necessary as the DMCF was to fill 130 acres of tidal open water, cover 10 acres of upland habitat and disturb 1 acre of vegetated wetland and 0.38 acres of submerged aquatic vegetation (SAV).

In 2018, as continuation of the mitigation plan implemented in 2009, the Resource Assessment Service of the Maryland Department of Natural Resources (DNR) monitored water quality in Masonville Cove adjacent to the DMCF site. DNR deployed a continuous water quality monitor that collected data every 15 minutes on a suite of water quality parameters, including dissolved oxygen, salinity, temperature, turbidity, pH and chlorophyll. Data from this monitor were telemetered to the DNR website "Eyes on the Bay" (eyesonthebay.net) and displayed in near real-time. DNR personnel visited the station every two to four weeks to replace the meters and to collect water samples for analyses of total suspended solids, chlorophyll *a* and pheophytin concentrations. The continuous monitoring site at Masonville Cove was one of three continuous monitoring stations located in the upper Patapsco in 2018. The other two sites were deployed adjacent to the National Aquarium in the Baltimore Harbor.

Description of continuous monitoring

In 2018, a data collection device known as a sonde was attached to a piling on the Masonville Cove pier (39.2447°, -76.5972°) with its instrumentation deployed 1 meter below the water surface (see Figure 1 for station location). This location is approximately one-tenth of a mile west of the deployment location used before 2013 (Figure 1). The location change was made so that DNR field personnel would be able to access the site during winter months, which allows the monitor to be deployed year-round. Prior to 2013, the site was only accessible by boat so the monitor needed to be removed during the winter months when icing at the boat ramp precluded access. The data sonde deployed in Masonville Cove was a YSI™ 6600 V2 (Yellow Springs Instruments, Yellow Springs, Ohio), which housed several water quality sensors (Figure 2). The water quality indicator data collected by each sensor are explained in greater detail in the following section. The sonde collected a reading from each sensor simultaneously every 15 minutes for the duration of its deployment. These readings were stored in the sonde's data memory and sent, by attached cellular telemetry equipment, to DNR headquarters in Annapolis. There, the data were posted on DNR's "Eyes on the Bay" website (eyesonthebay.net) for easy public access. This website enables the public to access near real-time water quality data for numerous locations throughout Maryland. The data are called "near real-time" because there is a lag of approximately 30-minutes to one hour between the time that the sonde collects the data and the time that the data are posted on the website. A page specific to Masonville Cove on the "Eyes on the Bay" website also displays charts and data from the most recent seven days. This page can be found at: eyesonthebay.dnr.maryland.gov/contmon/masonville.cfm.

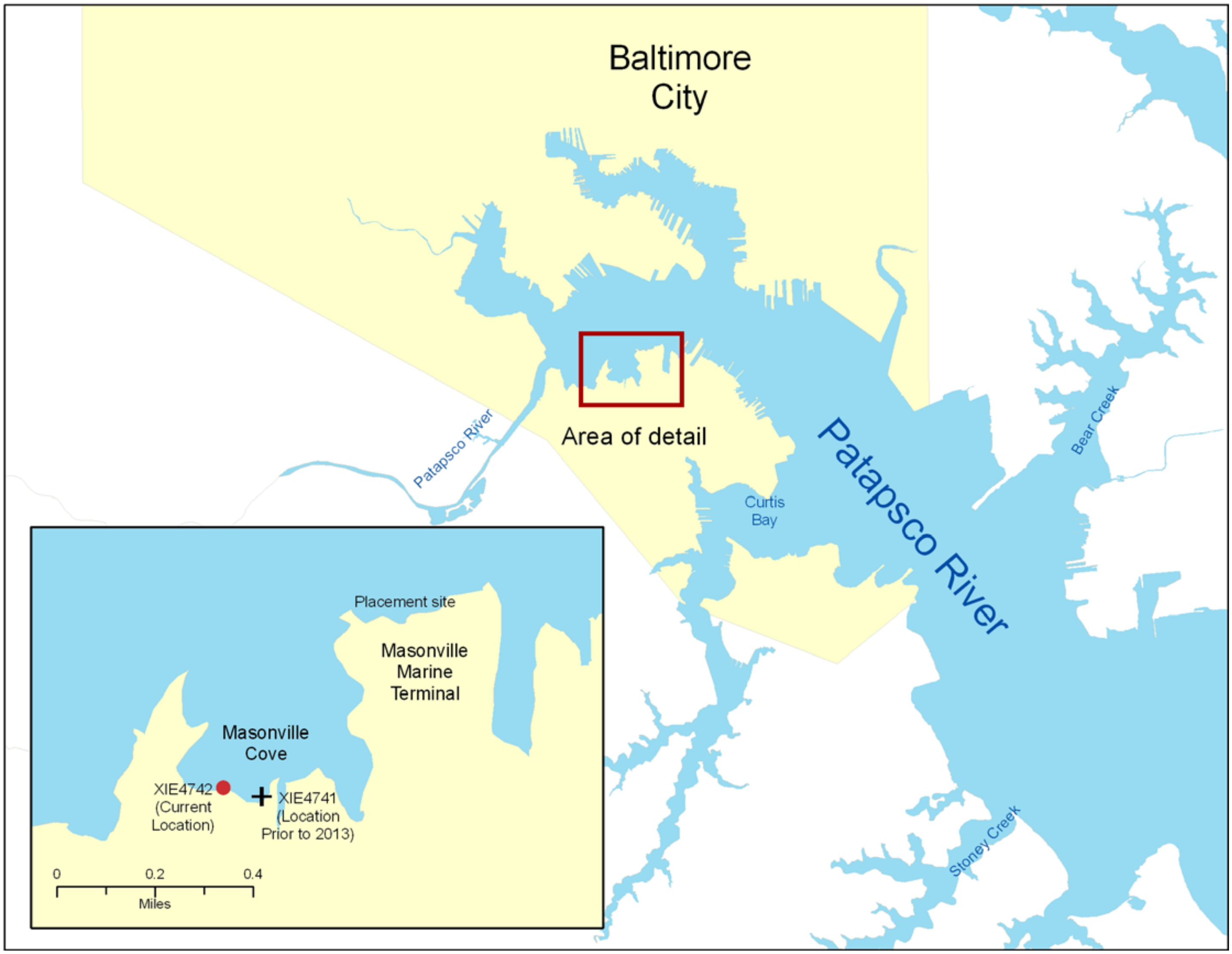

Figure 1. Map of the Patapsco River and Masonville Cove. The inset shows the 2018 continuous monitor location within the cove, the location of the monitor prior to 2013 and the approximate site for dredged material placement.

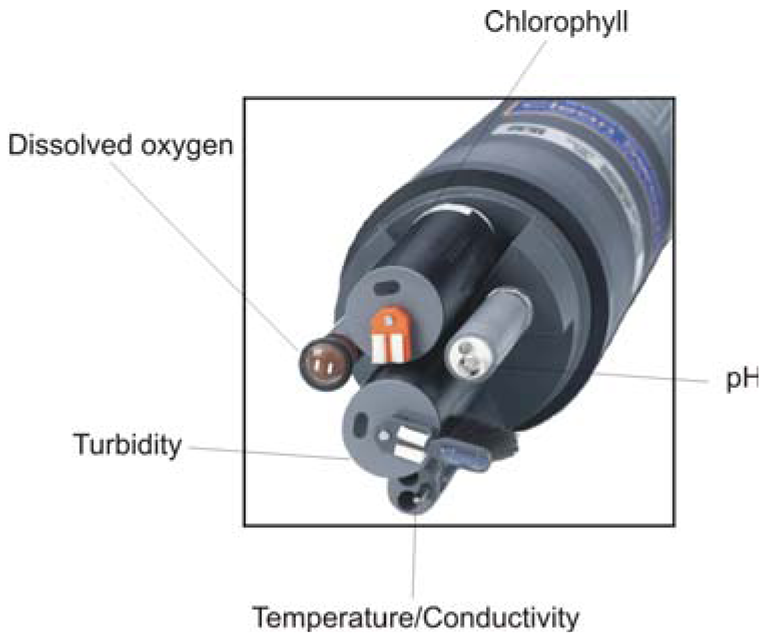

Figure 2. YSI 6600 continuous monitoring sonde showing individual sensors. Image courtesy of YSI, Inc.

Continuous monitoring parameters

The continuous monitor at Masonville Cove, like all continuous monitors in the DNR Shallow Water Monitoring Program, collect data on six water quality parameters:

1. Dissolved oxygen (DO): Fish and other aquatic life require DO to survive. Maryland state water quality criteria require a minimum DO concentration of 5 milligrams per liter (mg/L) (COMAR 1995). This threshold is necessary for the survival of many fish and shellfish species, including blue crabs (*Callinectes sapidus*) and striped bass (*Morone saxitilis*).
2. Salinity: Salinity, or salt concentration, is calculated automatically by the continuous monitoring sonde from conductivity and temperature readings. Salinity in the Patapsco River comes from the Chesapeake Bay. Therefore, areas closer to the Bay have higher salinities, except perhaps during large freshwater releases from the Conowingo Dam on the Susquehanna River. During periods of low precipitation and river flow, salinity increases as salty water intrudes further up the river. During wetter periods, salinity decreases. Salinity also cycles in relation to tides, increasing during flood tides and decreasing during ebb tides. Salinity levels are important to aquatic organisms, as some organisms are adapted to live only in brackish or salt water, while others require fresh water.
3. Water temperature: Water temperature is another variable affecting suitability of waterways for aquatic organisms. Many aquatic organisms can tolerate gradual temperature changes associated with changing seasons, but sudden changes can cause stress. Higher water temperatures cause more dissolved oxygen to come out of solution and enter the air, decreasing the amount available to fish and other aquatic organisms.
4. pH: The acidity of water is indicated by pH. A neutral pH is 7; lower values indicate more acidity, while higher numbers indicate more alkaline conditions. pH is affected by salinity (higher salinities tend to buffer pH in the 7-8 range) and algal blooms (large algal blooms can raise the pH over 8 in low salinity waters).

5. Turbidity: Turbidity is a measure of water clarity. Events that stir up sediment or cause runoff, such as storms, will increase turbidity. Dense algal blooms will also cause higher turbidities. Relatively clear water (low turbidity) is required for growth and survival of submerged aquatic vegetation (SAV).
6. Chlorophyll: Chlorophyll concentration is a surrogate measure of the amount of algae in the water. Chlorophyll is the main photopigment responsible for photosynthesis, the process by which sunlight is converted into food energy. Chlorophyll concentrations are calculated from fluorescence values collected by the sensors. One downside to this method is that certain species of phytoplankton, such as cyanobacteria or blue-green algae, fluoresce outside the detection range of the chlorophyll fluorescence sensor.

Calibration of continuous monitors and collection of laboratory water samples

Pigments and suspended solids data were obtained by DNR staff during deployment and replacement of continuous monitoring data sondes. Discrete whole water samples were collected to measure chlorophyll *a*, pheophytin and total suspended solids. Data sondes were removed and replaced with freshly calibrated instruments on a biweekly basis between April and October and once a month between November and March. At the time of each instrument replacement, Secchi disk depth was recorded for use in water clarity determination and water column profiles were taken. During profiles, an instrument was lowered into the water and collected readings for depth, water temperature, pH, dissolved oxygen and salinity.

Masonville Cove continuous monitor deployment

In 2018, a continuous monitor at Masonville Cove was deployed most of the year. A monitor was not deployed between January 12th and January 24th because surface ice precluded deployment. Data sondes collected 30,567 data records and 19 calibration samples were collected and analyzed in 2018. Malfunctions to water quality monitoring sondes precluded data collection between January 1st and January 12th, April 15th and April 25th, and October 10th and October 23rd. Additional gaps seen in the data are where questionable data were removed for quality assurance purposes. Automated telemetry generally operated when deployed, but there were times when telemetry did not work properly, which led to gaps in near real-time web presentation of the data. Telemetry issues did not, however, impede the sonde from collecting data.

On January 19th, Maryland Environmental Service (MES) contacted DNR to inform them that telemetry equipment deployed at Masonville was vandalized the night of January 18th-19th, sometime between 7pm and 8pm. The door of the weatherproof housing was ripped off and the battery within was removed. The housing and enclosed datalogger, as well as the solar panel and PVC mount, were removed from the pier and thrown onto the ice covering the cove. Staff from Living Classroom were able to retrieve the equipment off the ice and return to DNR. MES notified MDTA Police and an incident report (#181R000111) was filed.

Telemetry equipment was reinstalled at Masonville Cove on April 12th. However, telemetry equipment owned and operated by DNR at another continuous monitoring station in Maryland was infected by malware on April 20th, which necessitated the deactivation of all telemetry equipment to prevent further problems. After DNR worked with equipment manufacturers and their cellular provider to resolve this issue and take proper safeguards to minimize the risk of future malware attacks, telemetry at Masonville Cove was reactivated on June 28th.

2018 Precipitation and Discharge Events

Precipitation increases runoff into waterways, which can lead to a higher input of nutrients that fuel algal blooms, decrease water clarity and suppress SAV growth. Although beyond the scope of sampling for this report, precipitation has also been tied to increased loads of contaminants from urban and industrial centers in and around Baltimore (Leffler and Greer 2001).

After two consecutive years with below average precipitation, 2018 was the wettest year on record in central Maryland. Annual precipitation for 2018 at Baltimore Washington International (BWI) Thurgood Marshall Airport was almost 72 inches, which surpassed the previous record of 62.66 inches in 2003, and was 30 inches greater than the 30-year average (Figure 3). Not only did total precipitation surpass monthly averages in 8 of the 12 months, but monthly rainfall records were set in July and November, and three other months (May, September, and December) ranked in the top ten on record for those particular months. July was by far the wettest month in 2018 as three daily rainfall records were set between July 17th and July 24th, and over 14 inches of rain fell on the region over those eight days. September was the second wettest month of the year, fueled partially by the remnants of Hurricane Florence, which impacted the region mid-month, and led to a daily rainfall record (2.22 inches) on September 18th. Precipitation during these two extremely wet months was associated with numerous sanitary sewer overflows throughout the Patapsco River watershed, which spilled over 90 million gallons of untreated, diluted wastewater throughout Baltimore City and County in July, and another 60 million gallons in September.

Daily mean discharge at the USGS gaging station in the Gwynns Falls reflected the pattern of precipitation seen in 2018 (Figure 4). Gage data show numerous spikes throughout 2018, which are indicative of the precipitation events that affected the region during the year. Flows were generally above the daily historic median during most of the year, except for January and March, which were dryer than average (Figure 3), as well as April, in which an average amount of precipitation fell. The largest flows of the year occurred during heavy rains in July and September. July flows were almost 80-times greater than the daily historic median, while September flows were 65-times greater. One other flow of note that occurred in mid-December was more than 30-times greater than the daily historic median and coincided with another daily rainfall record set on December 15th (2.24 inches).

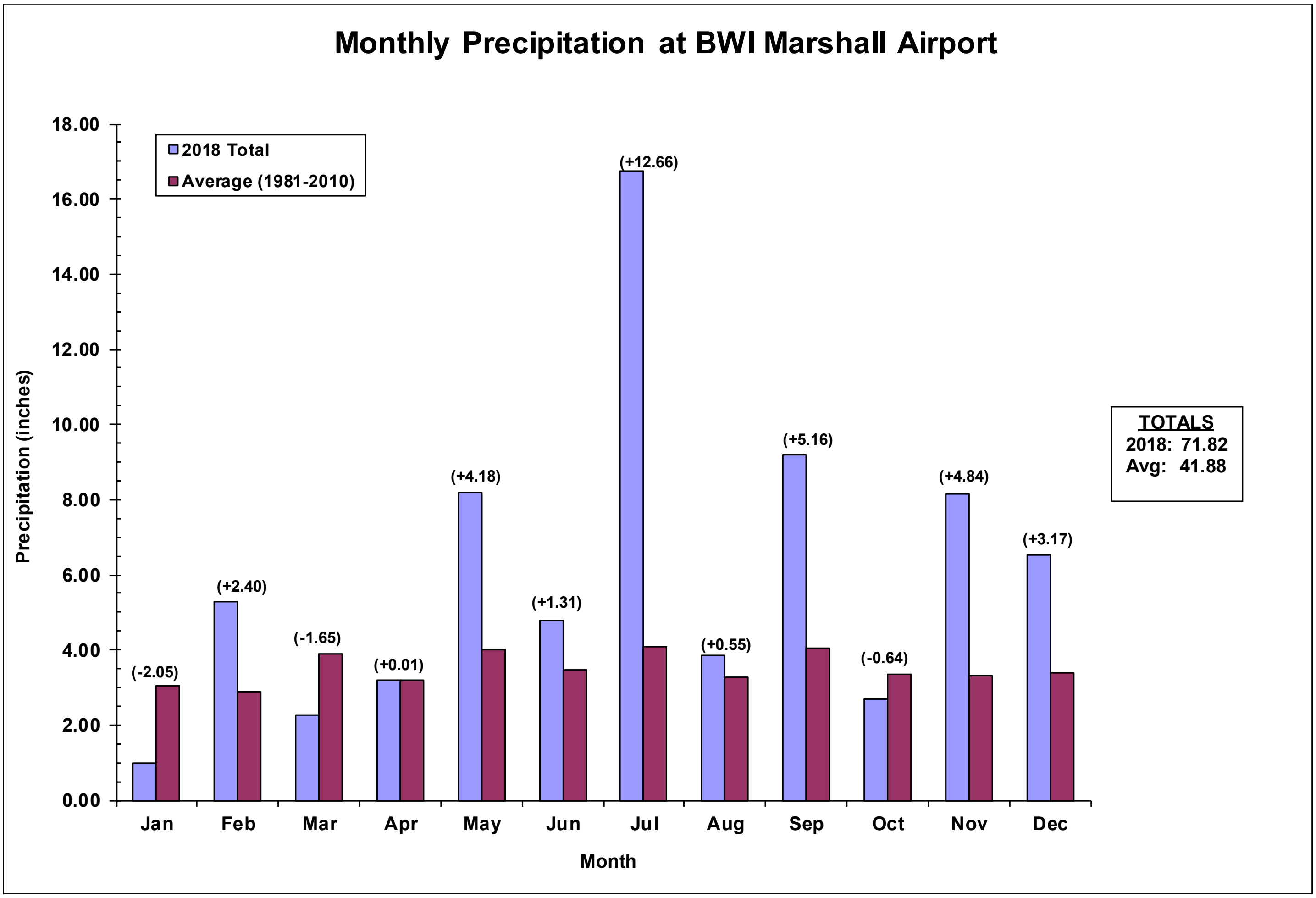

Figure 3. Total 2018 monthly precipitation at BWI Thurgood Marshall Airport compared to 30-year averages. Data source: National Weather Service (weather.gov/media/lwx/climate/bwiprecip.pdf).

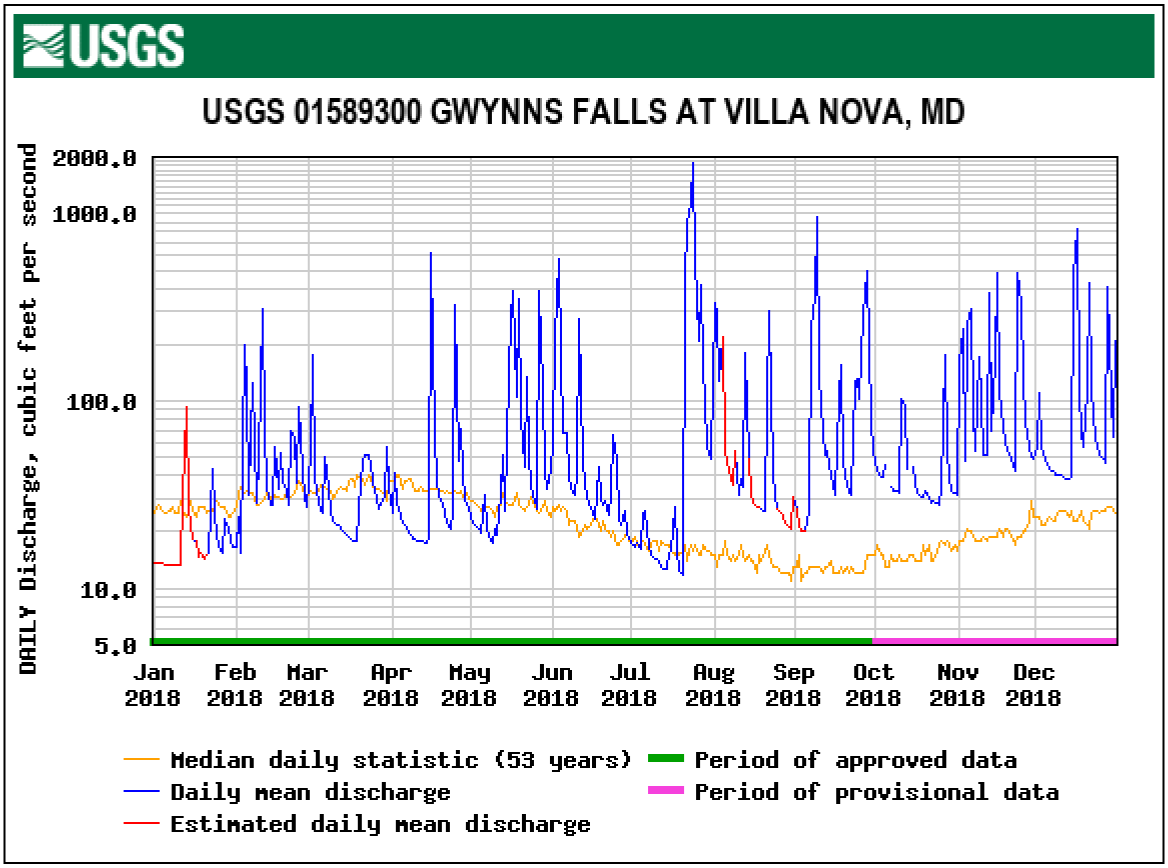

Figure 4. 2018 daily discharge in cubic feet per second measured at a USGS gaging station northwest of Masonville Cove. Graph courtesy of the United States Geological Survey (waterdata.usgs.gov/nwis/dv/?site_no=01589300).

2018 Continuous Monitoring Data

Water Temperature

Water temperature at Masonville Cove rose predictably during the first six months of 2018 as air temperatures increased (Figure 5). Temperatures approached 30°C (86° F) in early July and generally remained at or near those levels into September. Heavy rains in early September led to an almost 10°C (15° F) drop that precipitated a decline in water temperature, as air temperatures dropped, through much of the rest of the year. Variability in the plots in Figure 5 was most likely a result of diel variation in temperature (warming temperatures during the day and cooling temperatures during the night).

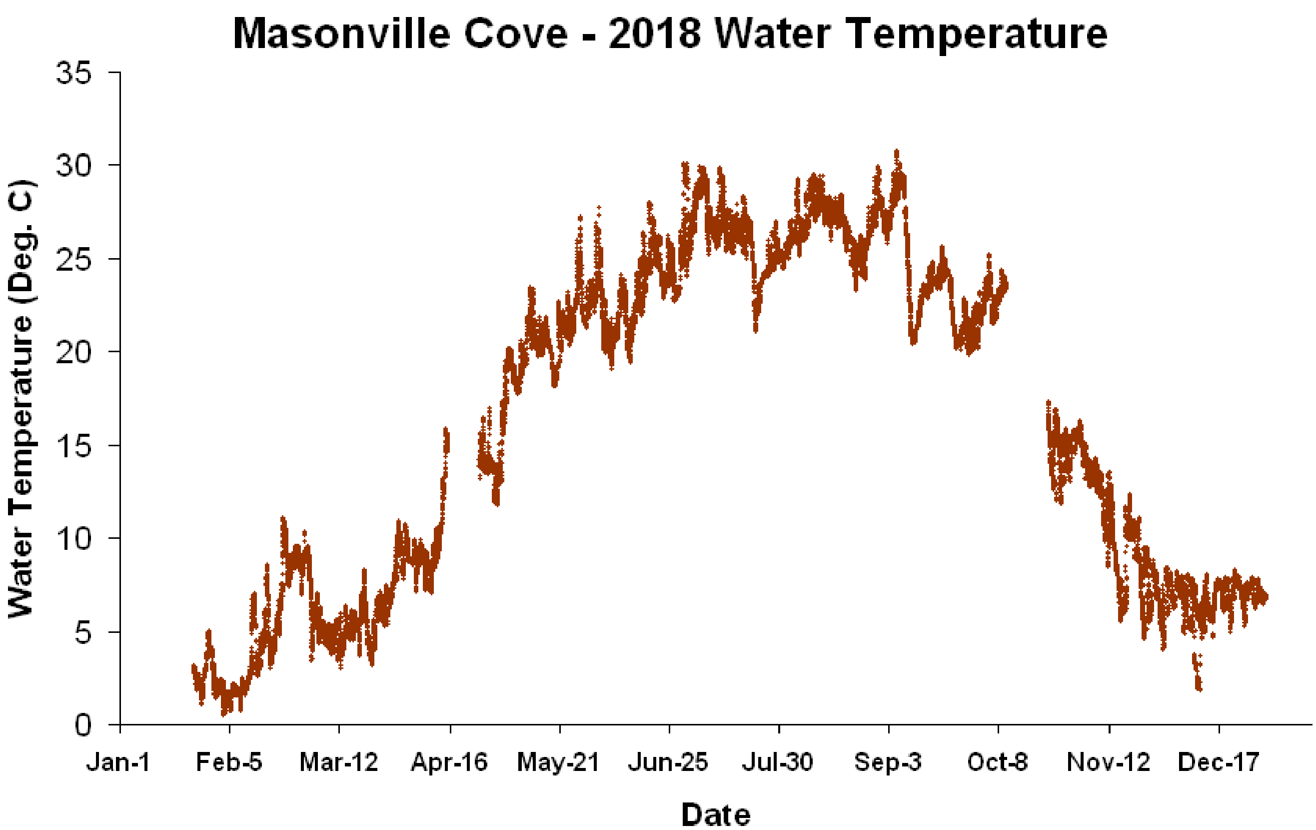

Figure 5. Water temperature at Masonville Cove Continuous Monitor during 2018.

Salinity

Salinity tends to vary with precipitation and streamflow. The general annual trend in salinity that has been observed at Masonville Cove since monitoring began in 2009 is higher values in late winter and early spring, a drop in readings during the wetter summer months, and a rise in values again in the late fall and early winter. The historically wet year in 2018, however, led to a deviation in this trend. Salinity values were generally higher in January, but dropped through a wet February (Figure 3) and early March. Salinity concentration rose again during a dry March (Figure 3) to its highest concentration of the year (15.48 parts per thousand – ppt) and leveled off during April. Heavy rains impacted the region in May, which led to salinity declining from 8.5 ppt at the beginning of month to less than 1 ppt at the end. Record precipitation through the rest of 2018 (Figure 3) coincided with salinity values generally remaining suppressed below 6 ppt for the remainder of the year.

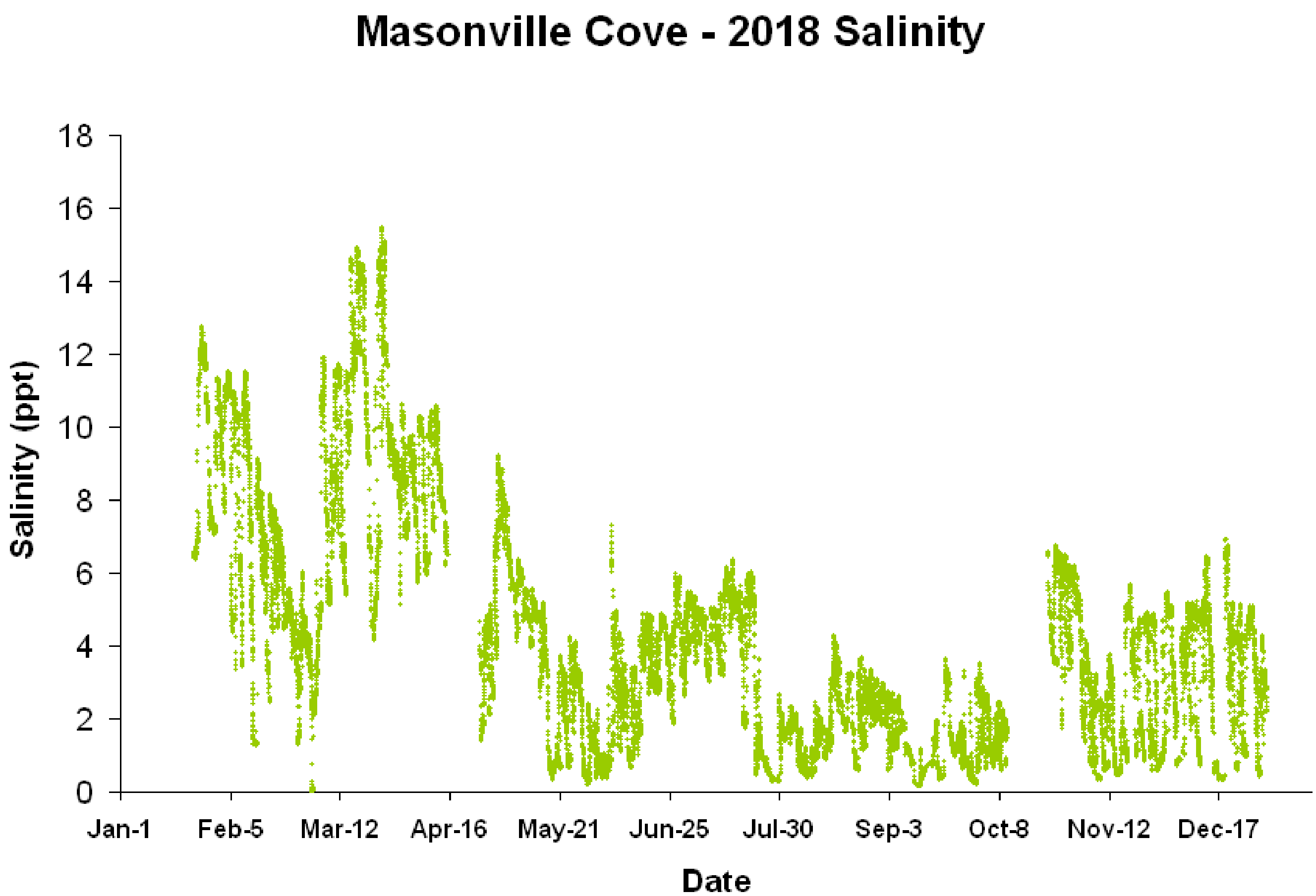

Figure 6. Salinity levels at Masonville Cove Continuous Monitor during 2018.

Dissolved Oxygen

Dissolved oxygen (DO) values remained high through most of the spring and early summer in 2018 (Figure 7). In mid-May DO concentration peaked to its highest levels (20.4 mg/L; 231% saturation) in 2018, which coincided with the presence of an algal bloom (Figure 8) within Masonville Cove. Oxygen concentrations can become super-saturated (greater than 100% saturation) and peak during the day during such conditions when algal cells are photosynthesizing and producing large amounts of oxygen. However, DO can drop to very low levels at night when photosynthesis ceases and oxygen is consumed through cellular respiration.

Furthermore, decreases in chlorophyll levels can signal the death and decomposition of algal blooms and are often accompanied by a drop in DO levels. The decomposition process can consume significant amounts of oxygen in the water and can lead to conditions harmful to aquatic organisms. For example, as algal bloom conditions in Masonville Cove subsided between May 14th and May 20th, DO concentrations dropped to 2.8 mg/L (31% saturation). For most of the summer, oxygen levels did tend to follow the pattern of chlorophyll concentrations (Figure 8) and the large swings seen in DO levels between late May and late July (Figure 7) may be indicative of algal bloom conditions in Masonville Cove during this time period. For example, as chlorophyll levels dropped in early June, DO concentration dropped from 15.4 mg.L (184% saturation) to 4 mg/L (47% saturation). Oxygen concentrations stabilized in late July when heavy rains impacted the region and flushed much of the algae from Masonville Cove (see below). The lowest DO reading of the year 0.7 mg/L; 9% saturation) occurred on August 16th and coincided with a small spike in chlorophyll concentrations (Figure 8).

Oxygen readings gradually increased in the fall and early winter as water temperature cooled (Figure 5). This pattern is expected since cooler waters can hold more dissolved oxygen than warmer waters.

As part of the 1987 Chesapeake Bay Agreement, the signatories agreed “to provide for the restoration and protection of living resources, their habitats and ecological relationships.” Further, the Chesapeake Executive Council (CEC) committed to “develop and adopt guidelines for the protection of water quality and habitat conditions necessary to support the living resources found in the Chesapeake Bay system, and to use these guidelines in the implementation of water quality and habitat protection programs.” Because prolonged periods of low DO concentrations can stress and be detrimental to the survival of juvenile fish and other aquatic animals (U.S. Environmental Protection Agency, 2003),.a document was produced by the Chesapeake Bay Program outlining dissolved oxygen thresholds for various living resources (Jordan et al. 1992). The State of Maryland adopted these dissolved oxygen thresholds as standards in 1995 (COMAR 1995). For shallow water habitats, the DO criteria are a 30-day average of 5 mg/L and an instantaneous minimum of 3.2 mg/L. Table 1 shows the percentage of time the Masonville Cove DO data fell below these criteria values between April and September, which is generally the time of year that DO values are the lowest due to warmer waters. In 2018, DO failure rates decreased for the second consecutive year (Table 1) and were among the lowest failure rates since monitoring began at Masonville Cover in 2009. Concentrations were below 5 mg/L 14.7% of the time, the second lowest rate since monitoring began, and below 3.2 mg/L for 4% of all readings, the lowest annual rate recorded. Both the 3.2 mg/L and 5 mg/L failure rates were much lower than the average failure rate over the prior 9-years of monitoring (11.9% for 3.2 mg/L; 25.5% for 5 mg/L). These improved oxygen conditions in Masonville Cove may be related to the lower algal concentrations recorded in 2018 (Table 2).

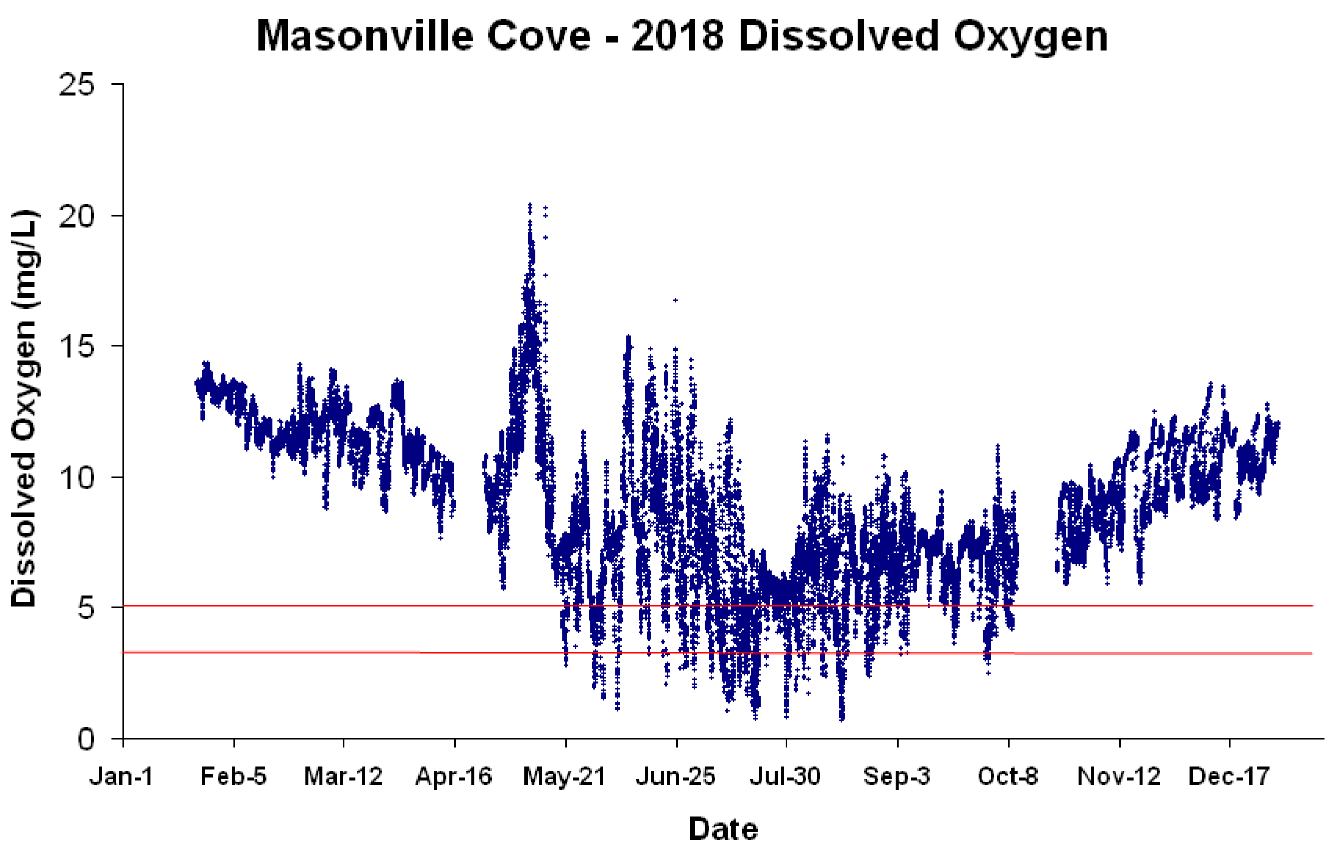

Figure 7. Dissolved oxygen levels at Masonville Cove Continuous Monitor during 2018. (*Red lines indicate 5 mg/L and 3.2 mg/L criteria.)*

Table 1. Dissolved oxygen criteria failure at Masonville Cove Continuous Monitor during June through November, 2009, March through October, 2010 and April through September, 2011 to 2018.

Continuous Monitor	2009	2010	2011	2012	2013	2014	2015	2016	2017	**2018**
Dissolved Oxygen less than 5 mg/L	28.3%	20.0%	14.3%	30.6%	26.0%	24.9%	26.4%	33.0%	26.2%	**14.7%**
Dissolved Oxygen less than 3.2 mg/L	9.9%	8.6%	8.2%	14.2%	11.7%	8.8%	13.5%	19.0%	13.4%	**4.3%**

Chlorophyll

Chlorophyll concentrations tend to vary with and are an indicator of, algal (phytoplankton) levels. Readings above 15 micrograms per liter (µg/L) represent algal blooms that can negatively affect living resources. Chlorophyll concentrations greater than 50 µg/L represent significant algal blooms and concentrations above 100 µg/L represent severe blooms. At Masonville Cove, chlorophyll readings indicate numerous algal blooms occurred in 2018, but only a couple were in the significant to severe range (Figure 8).

In late January and early February, chlorophyll concentrations hovered around 50 µg/L, before dropping below 10 µg/L as numerous precipitation events impacted the region (Figure 3), flushing algae from Masonville Cove. Chlorophyll levels approached 50 µg/L again in March, before dropping below 15 µg/L through most of April. In late April, concentrations began to rise and readings indicated a significant to severe algal bloom occurred during the middle of May. The highest chlorophyll reading of the year (350 µg/L) occurred on May 14th during this bloom. Water samples collected by DNR biologists on May 10th showed the presence of two potentially harmful algal species, *Prorocentrum minimum* (6,160 cells/mL) and *Karlodinium veneficum* (1,232 cells/mL). Satellite images from May 9th also showed algal bloom conditions extending from the mainstem Chesapeake Bay into the Patapsco River (Figure 9). Chlorophyll readings then quickly dropped to below 5 µg/L on May 20th as more than 5-inches of rain fell on the region over five days between May 15th and May 19th.

Chlorophyll readings then indicated a significant bloom in early June and a significant to severe bloom in late June. Heavy rains in mid-June and July flushed algae from Masonville Cove and the extremely wet second half of 2018 (Figure 3) led to chlorophyll concentrations that generally remained below 15 µg/L for the remainder of the year.

As stated previously, chlorophyll readings greater than 15 µg/L and 50 µg/L indicate blooms with potential ecosystem effects and significant blooms, respectively. Table 2 lists the percentage of data readings that exceed these thresholds for Masonville Cove during the portion of the 2018 deployment that coincided with SAV growing season (March – October). Algal blooms during this period may impede the ability of SAV to grow and reproduce. In 2018, chlorophyll levels exceeded the 15 µg/L threshold during 23.3% of readings, the lowest since monitoring began, and exceeded the 50 µg/L threshold during 1.5% of readings, the second lowest annual rate (Table 2). Both rates were also much lower than the average rate over the prior nine years of monitoring (45.4% for 15 µg/L; 6.6% for 50 µg/L). These low chlorophyll concentrations during much of 2018 may be the result of the numerous storms during the historically wet year continuously flushing algae from Masonville Cove and the Patapsco River.

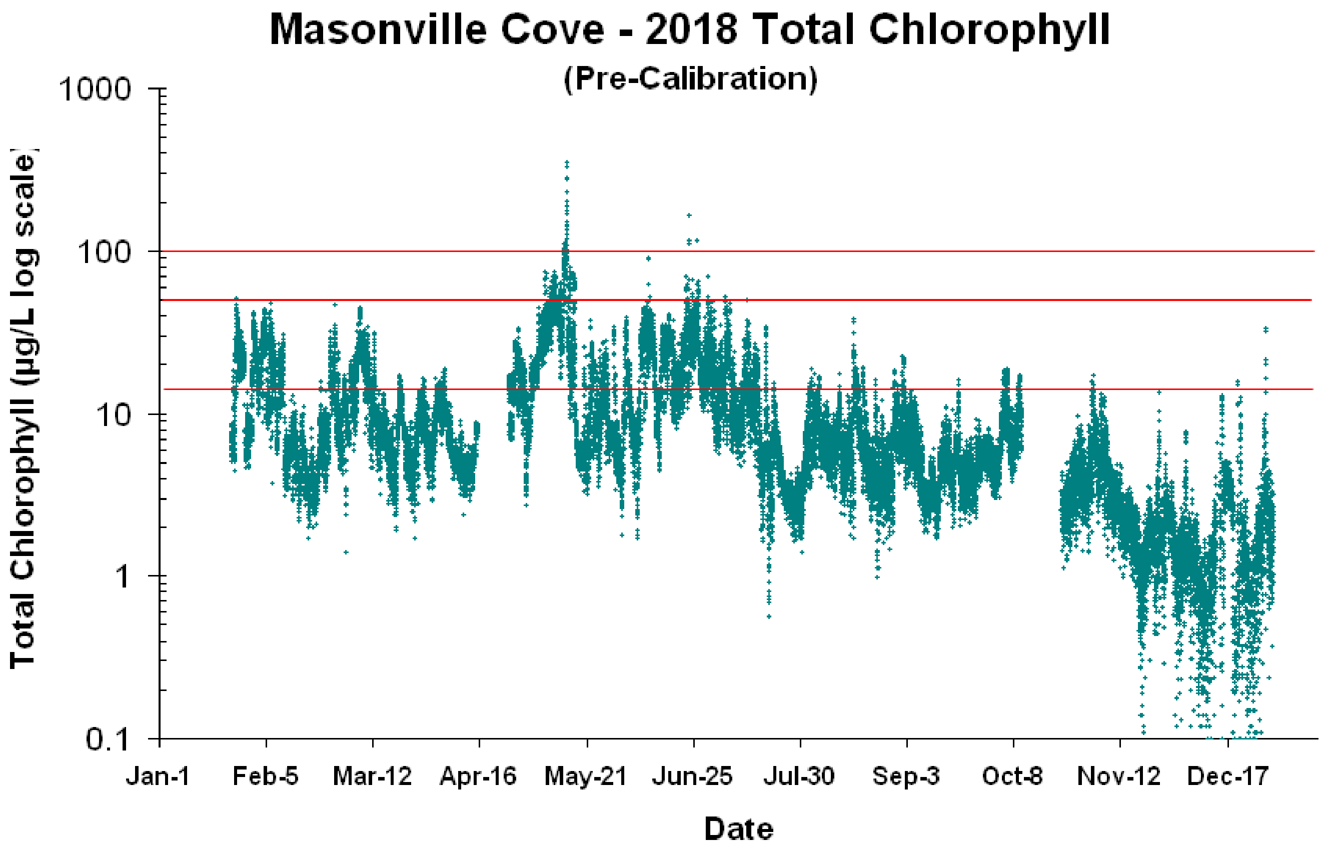

Figure 8. Total chlorophyll levels at Masonville Cove Continuous Monitor during 2018. *(Red lines indicate thresholds above which levels may have harmful effects on aquatic ecosystems—15 mg/L—are considered significant blooms—50 mg/L—or are considered severe blooms—100 mg/L.)*

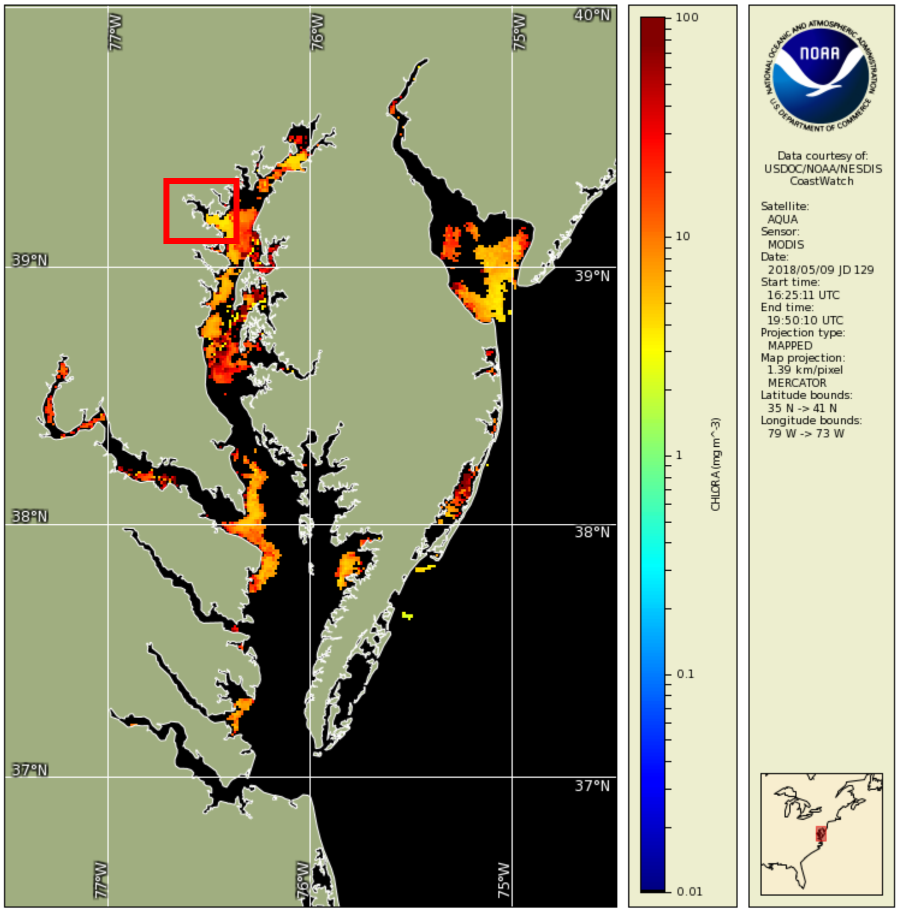

Figure 9. Satellite map from May 9, 2018 of chlorophyll *a* concentrations within the Chesapeake Bay and associated tributaries. Map courtesy of NOAA CoastWatch, East Coast Node (coastwatch.chesapeakebay.noaa.gov/).

Table 2. Chlorophyll threshold failure at Masonville Cove Continuous Monitor during June through November, 2009 and March through October, 2010 to 2018.

Continuous Monitor	2009	2010	2011	2012	2013	2014	2015	2016	2017	**2018**
Readings greater than 15 µg/L	37.4%	59.0%	38.8%	55.6%	52.1%	36.2%	43.1%	40.1%	46.4%	**23.3%**
Readings greater than 50 µg/L	3.3%	6.6%	0.9%	14.5%	10.5%	5.2%	8.9%	4.0%	5.5%	**1.5%**

pH

pH readings tend to fluctuate between 7 and 9 in most Chesapeake Bay tidal waters, with spikes above 9 indicating potential algal blooms. High pH in the absence of high chlorophyll also can indicate that a blue-green algal bloom may have occurred (the chlorophyll sensors on the continuous monitors deployed at Masonville Cove are not designed to detect the wavelengths emitted by cyanobacteria). At Masonville Cove, 395 pH values exceeded a value of 9 in 2018 (Figure 10). All of these values occurred during the significant to severe algal bloom in early to mid-May (Figure 8). The highest pH value of the year (9.52) was recorded on May 14th. Values then approached 9 during algal blooms in early and late June, before declining toward neutral values in the second half of the year as chlorophyll concentrations also declined.

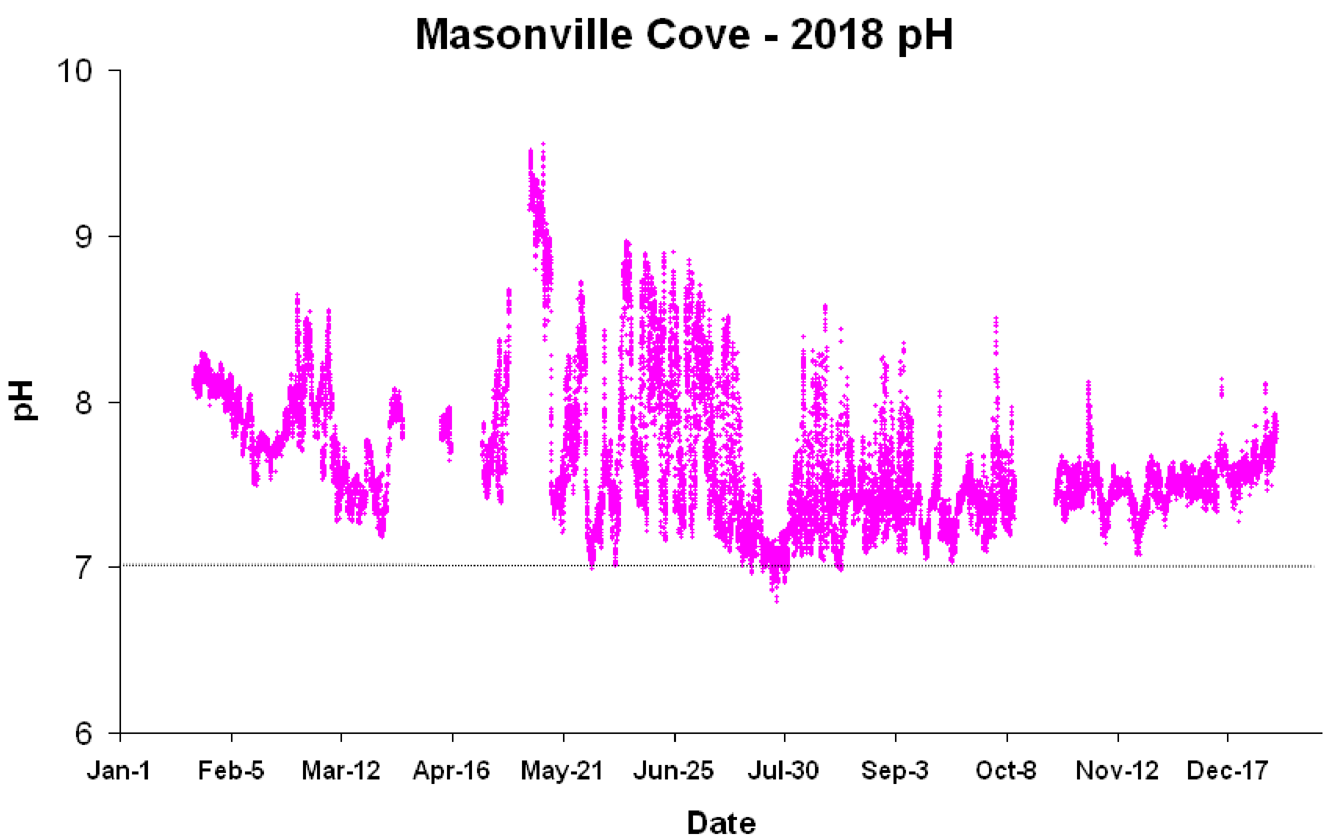

Figure 10. pH levels at Masonville Cove Continuous Monitor during 2018. *(Line indicates neutral pH.)*

Turbidity

Turbidity is quantified by measuring how much light is reflected from suspended particles in the water and is used to determine water clarity. Lower turbidity values indicate less reflection and, therefore, clearer water, while values above 7 Nephelometric Turbidity Units (NTU) are generally thought to be detrimental to SAV growth based on the effects of elevated turbidity in other systems (M. Trice, MD DNR, personal communication). During the historically wet year of 2018, turbidity levels spiked extremely high to more than 100 NTU three times (Figure 11), and all of these occurred during and in the aftermath of heavy precipitation and discharge events. Readings also spiked other times during the year, generally following precipitation events, but the majority (53%) of turbidity values throughout the year were at or below 7 NTU (median value: 6.7 NTU).

Turbidity values generally remained below 10 NTU for the first four months of the year, with three peaks at or greater than 50 NTU following precipitation events. Readings spiked to 50 NTU on February 5th, 80 NTU on February 12th, and 130 NTU on March 3rd. In May, more than 5-inches of rain fell on the region over five days between May 15th and May 19th and flooding rains again impacted central Maryland on May 27th. These storms led to numerous discharge events in May (Figure 4), and the heavy rains overwhelmed sanitary lines and caused over 20-million gallons of untreated, diluted wastewater to be spilled into the watershed during sanitary sewer overflows reported by the Baltimore City and Baltimore County Departments of Public Works. As a results of these events, a turbidity spike to over 300 NTU, the largest reading of the year, was measured in Masonville Cove on May 28th.

Following record setting rains (4.79-inches) and numerous sanitary sewer overflows in the watershed on July 21st, turbidity readings peaked to 171 NTU on July 22nd. The remnants of Hurricane Florence also impacted the region on September 17th-18th and dropped 2.5-inches of rain on central Maryland and led to a turbidity spike of 82 NTU on September 18th. Lastly, there were several discharge events (Figure 4) and turbidity peaks between 40 and 50 NTU during the historically wet November and December (Figure 3).

Turbidity measurements above 7 NTU, as stated previously, are considered a threshold for detrimental effects on SAV. Although a slight majority (53%) of turbidity values in Masonville Cove were at or below 7 NTU in 2018, almost 54% of turbidity values during the SAV growing season (March through October) were above this threshold (Table 3). This rate was slightly above the average of the prior nine years (50.9%). Thus, water clarity conditions in Masonville Cove in 2018, during the seasons most important to SAV growth, were considered poor.

Details of the sanitary sewer overflows described in this section can be found through the Maryland Reported Sewer Overflow Database:
mde.state.md.us/programs/water/Compliance/Pages/ReportedSewerOverflow.aspx#.

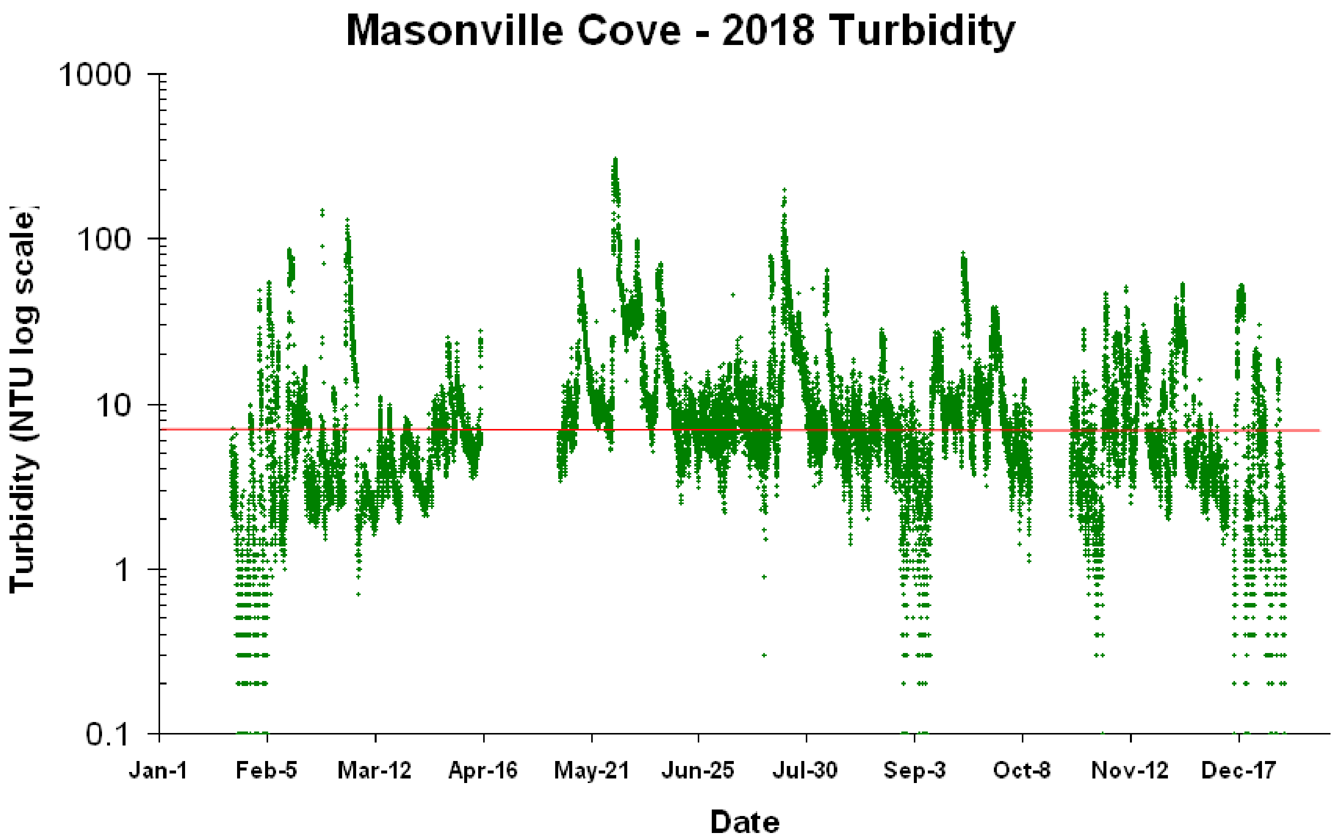

Figure 11. Turbidity levels at Masonville Cove Continuous Monitor during 2018. *(Red line indicates threshold above which levels are considered detrimental to bay grass growth.)*

Table 3. Turbidity threshold failure at Masonville Cove Continuous Monitor during June through December, 2009 and March through October, 2010 to 2018.

Continuous Monitor	2009	2010	2011	2012	2013	2014	2015	2016	2017	**2018**
Readings greater than 7 NTU	54.6%	60.1%	51.6%	35.0%	53.9%	52.9%	53.8%	34.9%	60.9%	**53.8%**

Submerged Aquatic Vegetation (SAV) in the Patapsco River

SAV, or underwater grasses, are an important component of estuarine ecosystems. SAV provides habitat for juvenile fish and shellfish, supplies food for waterfowl, filters and oxygenates the water and helps stabilize bottom sediments. Since 1984, SAV within the Chesapeake Bay and associated tributaries has been assessed annually (with the exception of 1988) by the Virginia Institute of Marine Science (VIMS). Figure 12 shows total area and density of SAV within the Patapsco beginning in 1994 (the first year SAV was found in the river) through 2018.

Total area of SAV within the Patapsco River remains well below the restoration goal of 389 acres. 2005 was the single best year with 72% of the restoration goal achieved, including SAV beds within Masonville Cove. Both 2004 and 2005 were generally very good years for SAV throughout the Chesapeake Bay region and the increases in coverage have been attributed to an accompanying population explosion and range expansion of dark false mussels (*Mytilopsis leucophaeata*). These filter feeders may have increased water clarity and allowed SAV coverage to significantly expand (L. Karrh, MD DNR, personal communication). In 2006, mussel populations declined, SAV beds disappeared in Masonville Cove and total area of SAV within the Patapsco decreased 83%. In 2010, there was no SAV in the entire Patapsco River. In 2018, total area within the Patapsco doubled from the previous year. Approximately 31 acres of SAV were observed in the Patapsco River, most in tributaries near the river's mouth. This area is approximately 8% of the river's restoration goal. However, SAV continues to be absent within Masonville Cove.

This increase in SAV coverage in the Patapsco River follows the recent trends seen throughout the Chesapeake Bay watershed. Many tributaries have seem record expansions of SAV beds over the past few years and bay-wide, SAV coverage exceeded 90,000 acres in 2018. Poor water clarity and lack of viable seed banks may explain the lack of SAV coverage within Masonville Cove.

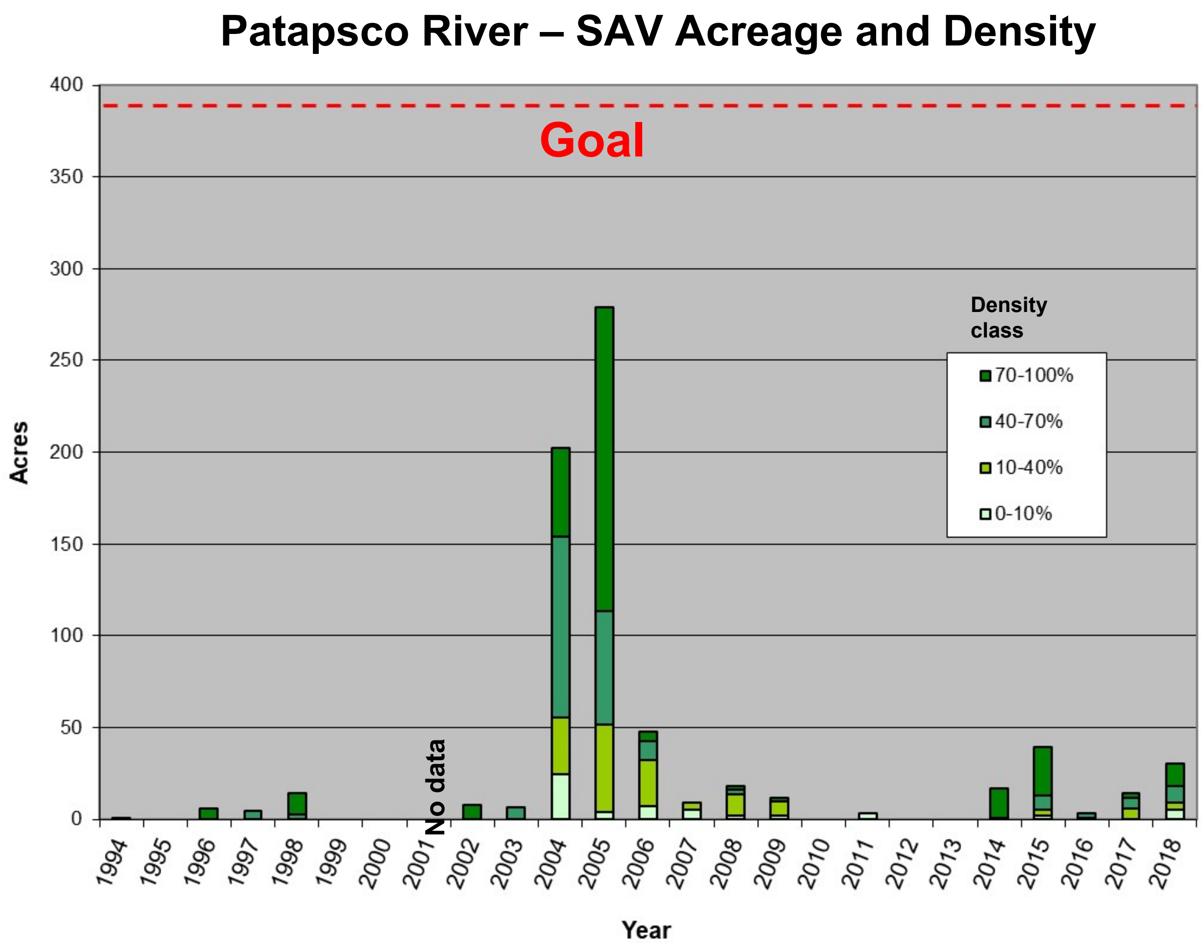

Figure 12. Total area and density of SAV in the Patapsco River between 1994 and 2018. (*Restoration goal is 389 acres)*

Pigments, Suspended Solids and Secchi Depths

Bi-weekly grab samples of water were taken at the Masonville Cove station when the YSI meters were exchanged during continuous monitoring service visits. Samples collected during November through March were collected monthly instead of bi-weekly (Table 4). Secchi depth, a measure of water clarity, was also recorded at the Masonville Cove station each time a grab sample was collected.

For the grab samples, the water was processed in the field using vacuum filtration and the resulting particulate samples were delivered to the laboratory for analysis. Samples collected during continuous monitoring service visits were analyzed for pigments and suspended solids. All analyses were performed by the University of Maryland's Chesapeake Biological Laboratory (CBL) Nutrient Analytical Services Laboratory (NASL). For details on methods, procedures, analysis and detection limits, refer to the Quality Assurance Project Plan (QAPP) for the Shallow Water Monitoring Program. This document can be found at: http://eyesonthebay.dnr.maryland.gov/eyesonthebay/documents/SWM_QAPP_2018_2019_Draft_v6.pdf. Results of the laboratory analyses are presented graphically in Appendix A (Figures A-1 through A-3). Secchi depth measurements are presented in Figure A-4. The suspended sediments, pigments and Secchi depth data are also presented in Table A-1 of Appendix A.

Pigments

As previously noted, chlorophyll concentrations in excess of 50 µg/l may be indicative of a significant algal bloom. At Masonville Cove in 2018, chlorophyll concentrations exceeded the 50 mg/l threshold on one sample date (May 10) with a measured value of 61.6 µg/l (Figure A-1). Chlorophyll values were below the 50 µg/l threshold for all other sample dates. The lowest chlorophyll concentrations were observed during the months of January, February, April, September, November, and December. During these months, chlorophyll concentrations were consistently less than 10 µg/l. Pheophytin values around 7 µg/l were frequently observed at Masonville Cove during the months of May through July 2018 (Figure A-2). For all other months, pheophytin values remained below 5 µg/l.

Suspended Solids

Concentrations of suspended solids at Masonville Cove were below 15 mg/l throughout 2018 with just two exceptions (Figure A-3). On February 8, just one day after 0.4 inches of rain fell in the region, the concentration of suspended solids was 23.3 mg/l. Later in the year, a peak value of 104.9 mg/l suspended solids was observed on May 29, 2018. Historically, May 2018 was the third-wettest May on record, and over 6 inches of rainfall occurred in the two weeks prior to the May 29 sample date. This large input of rainwater and runoff likely contributed to the high suspended solids concentration in late May.

Secchi Depths

Secchi depths show an inverse relationship to suspended solids concentrations. During most of 2018, Secchi depths measured between 0.4 m and 1.1 m. (Figure A-4). Secchi depths less than 0.4 m were observed on February 8 and May 29 when higher concentrations of suspended solids were present. The greatest Secchi depth measurement (1.6 m) occurred on December 13 and coincided with the lowest suspended solids concentration (3.8 mg/l) in 2018.

Table 4. Deployment and calibration record for Masonville Cove continuous monitor in 2018.

Scheduled calibration date	Samples collected	Comment
January 12, 2018	No	Old sonde removed; ice cover prevented Secchi reading and deployment of replacement sonde
January 24, 2018	Yes	New sonde deployed
February 8, 2018	Yes	PVC tube for housing sonde during deployment replaced
March 8, 2018	Yes	
April 12, 2018	Yes	Telemetry equipment reinstalled
April 25, 2018	Yes	
May 10, 2018	Yes	Algal samples collected
May 29, 2018	Yes	
June 14, 2018	Yes	
June 28, 2018	Yes	Telemetry reactivated
July 12, 2018	Yes	
July 31, 2018	Yes	
August 16, 2018	Yes	
August 29, 2018	Yes	Telemetry malfunctioned
September 13, 2018	Yes	Telemetry data reestablished
September 25, 2018	Yes	
October 10, 2018	Yes	
October 23, 2018	Yes	
November 15, 2018	Yes	Telemetry malfunctioned
December 13, 2018	Yes	Telemetry data reestablished

Ambient Water Quality

Ambient water quality data (salinity, dissolved oxygen, water temperature, and pH) were collected concurrently with the grab samples. The data values are presented graphically in Figures A-5 to A-8 in Appendix A. These water quality parameters are measured as a profile, with readings recorded at 0.5m depth intervals at the station. In the graphs, the individual readings within a profile are represented by separate data points. The solid line on each graph intersects the mean value for the parameter on each sampling date. All data values for dissolved oxygen, pH, salinity and water temperature are provided in Table A-2 of Appendix A.

Salinity

Salinity concentrations at Masonville Cove were closely correlated to precipitation patterns in 2018. Early in the year (January through early April), salinity concentrations ranged from around 4.5 ppt to 8.5 ppt (Figure A-5). Salinity values declined through April, and with the onset of heavy rain in May, dropped dramatically to less than 1 ppt by the end of the month. As above-average precipitation continued through the remainder of the year, salinity at Masonville Cove fluctuated between 0 ppt and 6.5 ppt.

Dissolved oxygen

Dissolved oxygen concentrations at Masonville Cove generally ranged between 5 mg/l and 14 mg/l throughout 2018 (Figure A-6). Concentrations were lower during the summer months, with values less than 5 mg/l often measured in the bottom waters during May through August. Summer dissolved oxygen values also showed the most pronounced differences between surface water and bottom water measurements. Summer surface water oxygen values were often higher than bottom water values by as much as 4 mg/l or more. Unusually high values of dissolved oxygen (13.6-15.4 mg/l) on May 10 correspond to high chlorophyll concentrations (> 60 µg/l) also observed on this date and may be the result of increased photosynthetic activity during an algal bloom. As further evidence of bloom conditions, a peak pH value of 9.27 also occurred on May 10, 2018.

Water Temperature and pH

Water temperature varied seasonally at Masonville Cove, beginning with a measurement around 3.0 °C on January 24 and gradually rising to a peak of 27.7 °C on July 12 (Figure A-7). Water temperature remained elevated well into the month of October before falling rapidly to a mean value of 6.95 °C on December 13. Other than the peak pH value of 9.27 on May 10, pH values at Masonville Cove generally fluctuated between 7 and 8 throughout 2018 (Figure A-8).

<u>Conclusion</u>

Shallow water monitoring was conducted in Masonville Cove in the upper Patapsco River during 2018. Continuous monitoring data provide a critical function for assessing the health of Maryland's tidal waters in areas historically lacking water quality information. Shallow water data provide information about the effects of nutrient pollution and weather events on Masonville Cove and the Patapsco River as a whole. In 2018, a historically wet year in Central Maryland led to overall improved algal and dissolved oxygen conditions. This improvement may have been related to the numerous storms that impacted the region throughout the year, continuously flushing algae from Masonville Cove and thus preventing algal death and decomposition, which can lead to hypoxic and anoxic conditions. Samples collected during a severe algal bloom in May did indicate the presence of two potentially harmful algal species, *Prorocentrum minimum* and *Karlodinium veneficum*. Finally, the numerous precipitation and discharge events in 2018 led to water clarity conditions that were slightly below average and no submerged aquatic vegetation was found in Masonville Cove. Thus, although conditions in Masonville Cove appear to have improved in terms of algal and dissolved oxygen concentrations, it is unclear whether this trend will continue. Additional monitoring is needed to determine the long-term effects of the large amounts of sediment and nutrients that were washed into the Patapsco River during the extremely wet year.

Shallow water monitoring information is not only used for characterizing the health of shallow water habitats, but it is also useful for: 1) assessing Chesapeake Bay water quality criteria for dissolved oxygen, water clarity and chlorophyll in shallow water habitats; 2) determining attainment or nonattainment of shallow water habitats for their designated uses; 3) assessing SAV habitats and identifying potential SAV restoration sites; 4) providing information to better understand ecosystem processes and the impact of extreme events (e.g. hurricanes, high flows, sanitary sewer overflows) in shallow water and open water environments; 5) providing data for calibrating the Bay Eutrophication and Watershed Model; and 6) assessing mitigation efforts in relation to the dredged material containment facility at the Masonville Marine Terminal.

References

COMAR (Code of Maryland Regulations). 1995. Code of Maryland Regulations: 26.08.02.03 – Water Quality Criteria Specific to Designated Uses. Maryland Department of the Environment. Baltimore, Maryland.

Jordan, S., C. Stegner, M. Olson, R. Batiuk and K. Mountford. 1992. Chesapeake Bay dissolved oxygen goal for restoration of living resources habitats. Chesapeake Bay Program, Reevaluation Report #7c. CBP/TRS88/93. Annapolis, Maryland.

Leffler, M. and J. Greer. 2001. Taking on toxics in Baltimore Harbor. Maryland Marine Notes 19(2). mdsg.umd.edu/MarineNotes/Mar-Apr01/

Appendix A

Results of laboratory and ambient water quality analyses for:
Masonville Cove Pier (Station XIE4742)

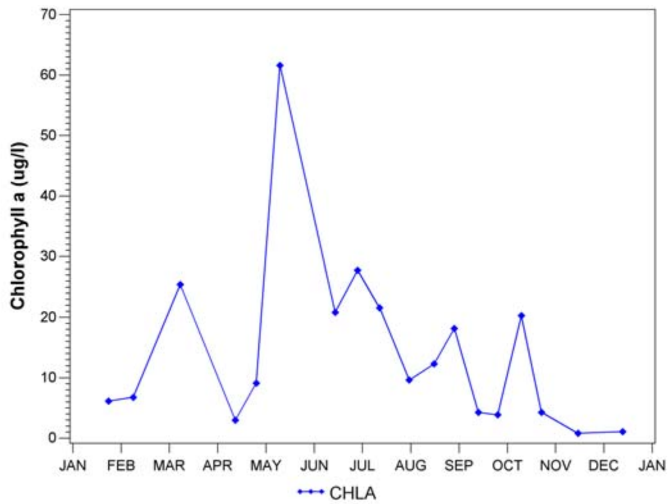

Figure A-1. Chlorophyll *a* concentrations at Masonville Cove in 2018.

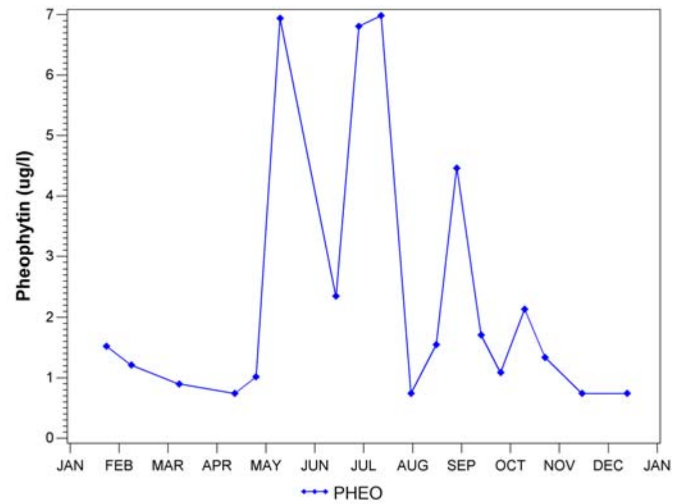

Figure A-2. Pheophytin concentrations at Masonville Cove in 2018.

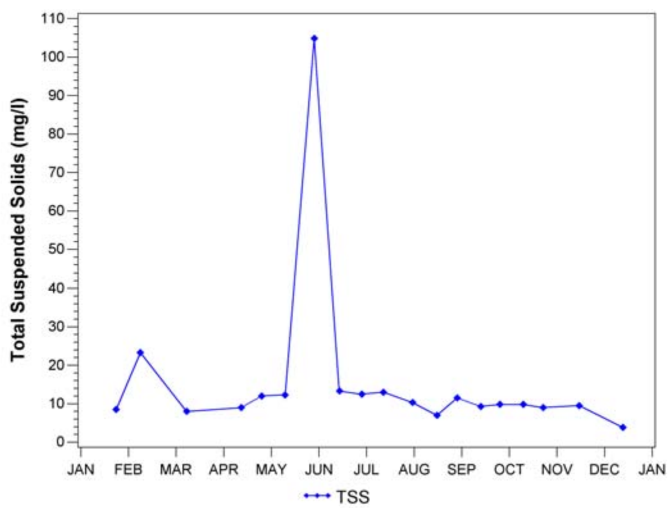

Figure A-3. Total suspended solids concentrations at Masonville Cove in 2018.

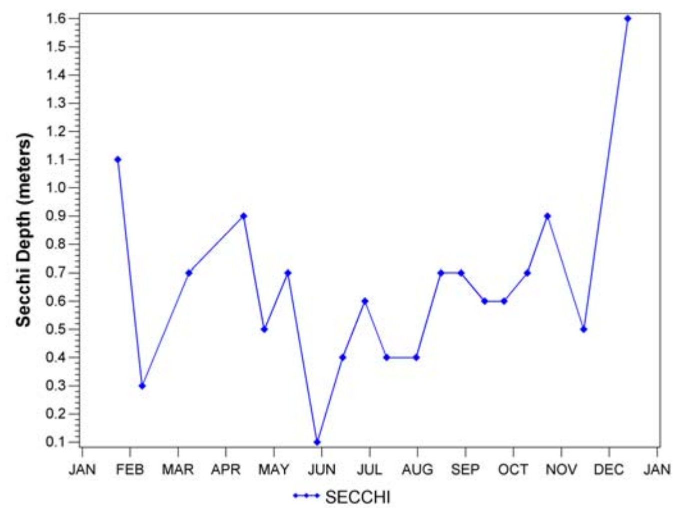

Figure A-4. Secchi depth at Masonville Cove in 2018.

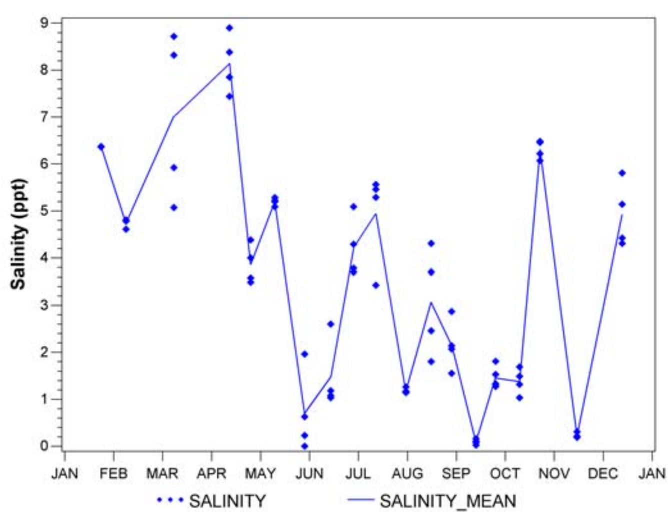

Figure A-5. Salinity concentrations at Masonville Cove in 2018.

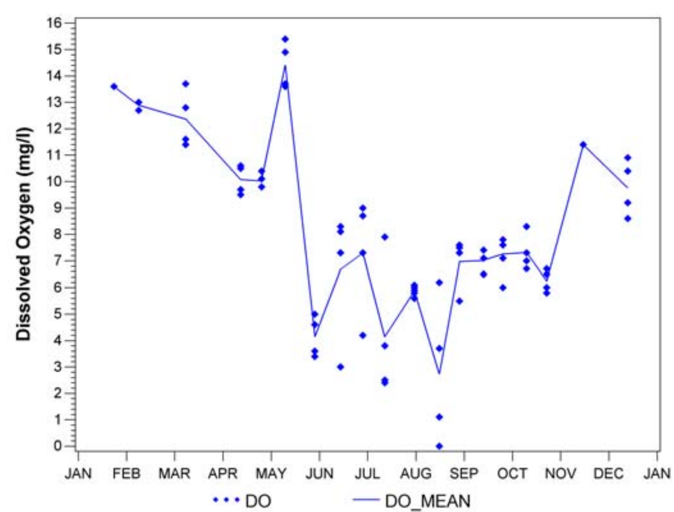

Figure A-6. Dissolved oxygen concentrations at Masonville Cove in 2018.

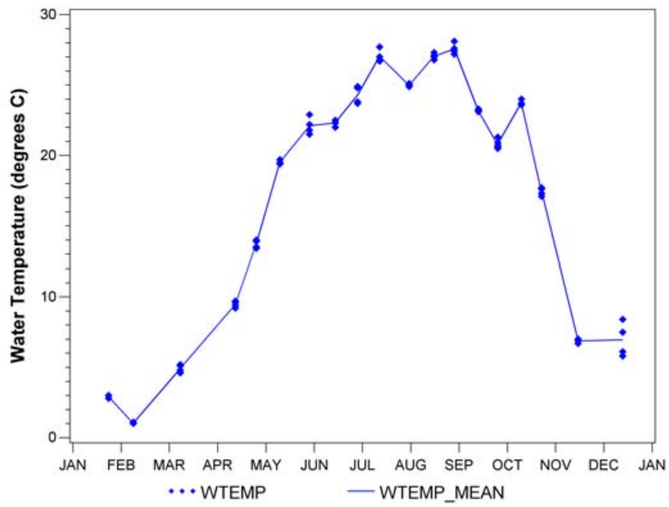

Figure A-7. Water temperature at Masonville Cove in 2018.

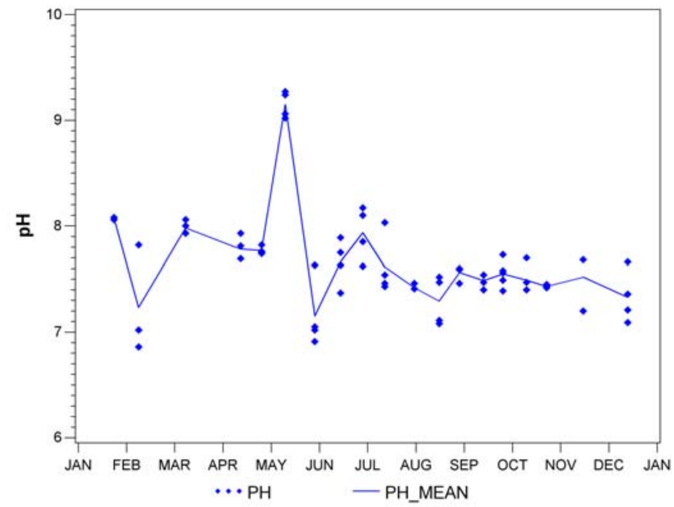

Figure A-8. Values of pH at Masonville Cove in 2018.

Graphs with multiple y-values on a single point on the x-axis represent values measured at different depths in the water column. In such cases, lines intersect the mean value.

Table A-1. Discrete Continuous Monitoring Data for Chlorophyll-a, Pheophytin, Total Suspended Solids and Secchi Disk Depth for Masonville Cove (XIE4742) in 2018.

Date	Sample Depth (m)	Chlorophyll-a (ug/L)	Pheophytin (ug/L)	Total Suspended Solids (mg/L)	Secchi Depth (m)
01/24/18	1	6.141	1.522	8.5	1.1
02/08/18	1	6.764	1.210	23.3	0.3
03/08/18	1	25.418	0.897	8.0	0.7
04/12/18	1	2.990	<0.740	9.0	0.9
04/25/18	1	9.078	1.015	12.0	0.5
05/10/18	1	61.588	6.942	12.3	0.7
05/29/18	1	Invalid data [1]	Invalid data [1]	104.9	0.1
06/14/18	1	20.826	2.350	13.3	0.4
06/28/18	1	27.768	6.809	12.5	0.6
07/12/18	1	21.574	6.985	13.0	0.4
07/31/18	1	9.612	<0.740	10.3	0.4
08/16/18	1	12.282	1.549	7.0	0.7
08/29/18	1	18.156	4.459	11.5	0.7
09/13/18	1	4.272	1.709	9.3	0.6
09/25/18	1	3.845 [2]	1.089 [2]	9.8	0.6
10/10/18	1	20.292	2.136	9.8	0.7
10/23/18	1	4.272	1.335	9.0	0.9
11/15/18	1	0.801	<0.740	9.5	0.5
12/13/18	1	1.068	<0.740	3.8	1.6

1) Sample results rejected due to quality control criteria
2) High optical density (750 nm); actual value recorded

Table A-2. Ambient Water Quality Data for Dissolved Oxygen (D.O.), pH, Salinity and Water Temperature for Masonville Cove (XIE4742) in 2018 (continued on next page).

Date	Sample Depth (m)	D. O. (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
01/24/18	1.0	13.6	8.08	6.37	2.8
01/24/18	1.9	13.6	8.06	6.36	3.0
02/08/18	0.5	13.0	7.02	4.81	1.0
02/08/18	1.0	12.7	7.82	4.61	1.0
02/08/18	1.4	13.0	6.86	4.78	1.1
03/08/18	0.5	12.8	8.06	5.07	4.6
03/08/18	1.0	13.7	8.00	5.92	4.8
03/08/18	1.5	11.6	7.93	8.32	5.1
03/08/18	2.2	11.4	7.93	8.72	5.2
04/12/18	0.5	10.5	7.81	7.44	9.4
04/12/18	1.0	10.6	7.93	7.85	9.2
04/12/18	1.5	9.7	7.69	8.38	9.7
04/12/18	2.0	9.5	7.69	8.90	9.6
04/25/18	0.5	10.1	7.82	3.49	14.0
04/25/18	1.0	10.4	7.74	3.58	13.9
04/25/18	1.5	9.8	7.76	4.00	13.5
04/25/18	1.9	9.8	7.75	4.38	13.4
05/10/18	0.5	15.4	9.27	5.09	19.7
05/10/18	1.0	14.9	9.24	5.22	19.4
05/10/18	1.5	13.7	9.06	5.20	19.5
05/10/18	1.9	13.6	9.02	5.28	19.5
05/29/18	0.5	5.0	7.05	0.00	21.8
05/29/18	1.0	4.6	7.63	0.23	21.5
05/29/18	1.5	3.4	7.02	0.63	22.2
05/29/18	2.2	3.6	6.91	1.96	22.9
06/14/18	0.5	8.1	7.75	1.03	22.5
06/14/18	1.0	8.3	7.89	1.08	22.5
06/14/18	2.0	7.3	7.63	1.18	22.3
06/14/18	2.7	3.0	7.37	2.60	22.0
06/28/18	0.5	8.7	8.10	3.70	24.9
06/28/18	1.0	9.0	8.17	3.78	24.8
06/28/18	1.5	7.3	7.85	4.29	23.8
06/28/18	2.2	4.2	7.62	5.09	23.7
07/12/18	0.5	7.9	8.03	3.43	27.7
07/12/18	1.0	3.8	7.54	5.29	26.7
07/12/18	1.5	2.4	7.43	5.46	26.8
07/12/18	2.0	2.5	7.46	5.56	27.0

Table A-2 (continued). Ambient Water Quality Data for Dissolved Oxygen (D.O.), pH, Salinity and Water Temperature for Masonville Cove (XIE4742) in 2018.

Date	Sample Depth (m)	D. O. (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
07/31/18	0.5	6.0	7.41	1.17	25.1
07/31/18	1.0	6.1	7.46	1.26	25.0
07/31/18	1.5	5.9	7.41	1.15	25.0
07/31/18	2.0	5.8	7.41	1.14	24.9
07/31/18	2.3	5.6	7.41	1.14	24.9
08/16/18	0.5	6.2	7.47	1.80	27.3
08/16/18	1.0	3.7	7.52	2.46	27.1
08/16/18	1.5	1.1	7.11	3.70	27.0
08/16/18	2.2	0.0	7.08	4.31	26.8
08/29/18	0.5	7.6	7.60	1.55	28.1
08/29/18	1.0	7.5	7.59	2.07	27.4
08/29/18	1.5	7.3	7.60	2.14	27.6
08/29/18	2.2	5.5	7.46	2.87	27.2
09/13/18	0.5	7.1	7.54	0.02	23.3
09/13/18	1.0	7.4	7.40	0.10	23.2
09/13/18	1.5	7.1	7.54	0.08	23.1
09/13/18	2.1	6.5	7.47	0.16	23.1
09/25/18	0.5	7.8	7.58	1.27	20.6
09/25/18	1.0	7.8	7.73	1.32	20.5
09/25/18	1.5	7.6	7.56	1.33	20.7
09/25/18	2.0	7.1	7.49	1.53	20.9
09/25/18	2.4	6.0	7.39	1.81	21.3
10/10/18	0.5	8.3	7.70	1.03	24.0
10/10/18	1.0	7.3	7.47	1.32	23.7
10/10/18	1.5	7.0	7.40	1.49	23.7
10/10/18	2.1	6.7	7.40	1.69	23.6
10/23/18	0.5	6.5	7.45	6.07	17.3
10/23/18	1.0	6.7	7.42	6.22	17.1
10/23/18	1.5	5.8	7.43	6.48	17.6
10/23/18	1.8	6.0	7.43	6.46	17.7
11/15/18	0.5	11.4	7.68	0.19	7.0
11/15/18	1.0	11.4	7.20	0.21	6.7
11/15/18	1.6	11.4	7.68	0.31	6.9
12/13/18	0.5	10.4	7.36	4.31	6.1
12/13/18	1.0	10.9	7.66	4.42	5.8
12/13/18	1.5	9.2	7.21	5.14	7.5
12/13/18	2.0	8.6	7.09	5.81	8.4