An Ecological Study of Gunston Cove

2015

FINAL REPORT

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by

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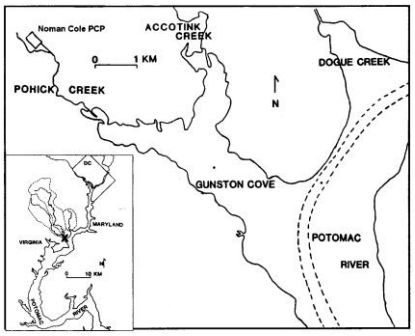
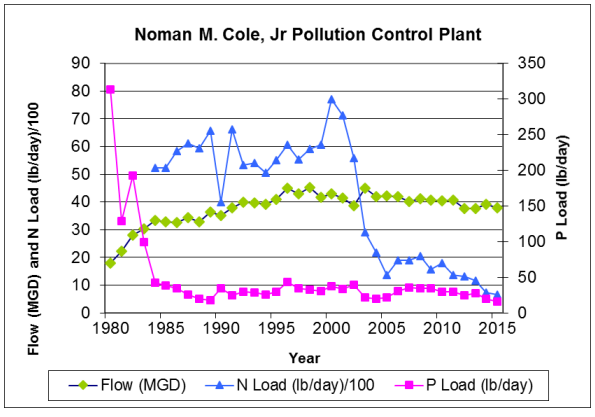
Executive Summary



Gunston Cove is an embayment of the tidal freshwater Potomac River located in Fairfax County, Virginia about 12 miles (20 km) downstream of the I-95/I-495 Woodrow Wilson Bridge. The Cove receives treated wastewater from the Noman M. Cole, Jr. Pollution Control Plant (NCPCP) and inflow from Pohick and Accotink Creeks which drain much of central and southern Fairfax County. The Cove is bordered on the north by Fort Belvoir and on the south by the Mason Neck. Due to its tidal nature and shallowness, the Cove does not seasonally stratify vertically, and its water mixes gradually with the adjacent tidal Potomac River mainstem. Thermal stratification can make nutrient management more difficult, since it can lead to seasonal oxygen-diminished bottom waters that may result in fish mortality. Since 1984 George Mason University personnel, with funding and assistance from the Wastewater Management Program of Fairfax County, have been monitoring water quality and biological communities in the Gunston Cove area including stations in the Cove itself and the adjacent Potomac River mainstem. This document presents study findings from 2015 in the context of the entire data record.

The Chesapeake Bay, of which the tidal Potomac River is a major subestuary, is the largest and most productive coastal system in the United States. The use of the bay as a fisheries and recreational resource has been threatened by overenrichment with nutrients which can cause nuisance algal blooms, hypoxia in stratified areas, and a decline of fisheries. As a major discharger of treated wastewater into the tidal Potomac River, particularly Gunston Cove, Fairfax County has been proactive in decreasing nutrient loading since the late 1970's.



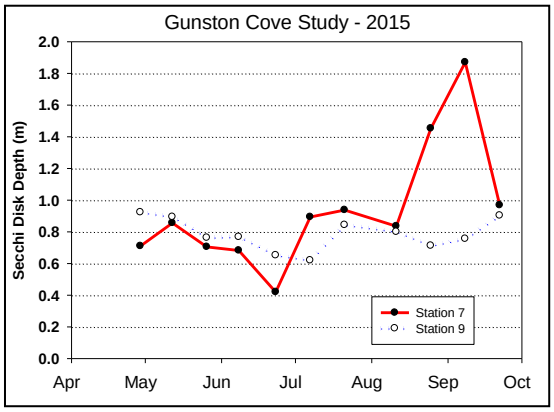
As shown in the figure to the left, phosphorus loadings were dramatically reduced in the early 1980's. In the last several years, nitrogen, and solids loadings as well as effluent chlorine concentrations have also been greatly reduced or eliminated. These reductions have been achieved even as flow through the plant has slowly increased.

The ongoing ecological study reported here provides documentation of major improvements in water quality and biological resources which can be attributed to those efforts. Water quality improvements have been substantial in spite of the increasing population and volume of wastewater produced. The 30 plus year record of data from

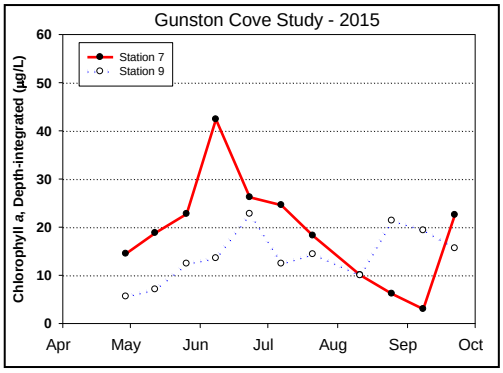
Gunston Cove and the nearby Potomac River has revealed many important long-term trends that validate the effectiveness of County initiatives to improve treatment and will aid in the continued management and improvement of the watershed and point source inputs.

The year 2015 was characterized by above normal temperatures for the entire study period. Monthly precipitation was over three times the normal amount in June and continued above normal into July which caused flow increases in both Accotink Creek and the River mainstem.

Mean water temperature was well above normal in May and peaked in July at the time of the highest air temperatures of the year. Specific conductance was generally in the 200-400 µS/cm (micro-Siemens per centimeter) range and similar at both sites. At both sites values declined in June, probably due to runoff events. Indicators of photosynthetic intensity (dissolved oxygen-percent saturation and field pH) indicated strong photosynthesis in the Cove through the summer, especially in July and early August. In the River, values were generally moderate with little seasonal trend indicating lower photosynthetic activity in the River than in the Cove. Light penetration dropped markedly in June in the aftermath of the local flow and flushing events. But as the summer went on Secchi Disk depth in the Cove rose markedly reaching a record depth of 1.9 meters. Low light attenuation and low turbidity also indicated clear water in late August and early September. The increased presence of submersed aquatic vegetation is contributing to consistently high levels of dissolved oxygen in the Cove and enhanced water clarity.



Ammonia nitrogen was low (<0.08 mg/L or milligrams per liter) on most dates with highest values in late June in both Cove and River. Un-ionized ammonia nitrogen levels continue to remain very low and pose no threat to aquatic life in contrast to the early years of the study. Nitrate was found at moderate levels at both sites in the spring and decreased steadily in the early summer. In both regions nitrate dropped below 0.2 mg/L by the end of August. Total phosphorus was similar at both sites and showed little seasonal pattern. Soluble reactive phosphorus values were generally much lower being mostly below 0.01 mg/L in almost all samples. Nitrogen to phosphorus ratio (by weight) was often similar at the two sites, but in late summer was typically lower in the River. Values indicated phosphorus limitation of primary producers (phytoplankton and submersed aquatic vegetation) and did not approach ratios associated with the onset of nitrogen limitation (7.2). Biochemical oxygen demand showed a summer maximum at both sites, but the Cove station was typically higher. Total suspended solids and volatile suspended solids were similar at both sites and showed little seasonal pattern.

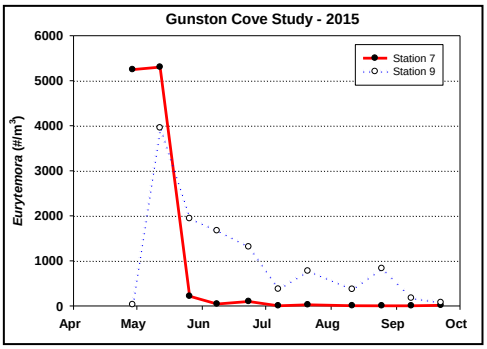


Algal populations as measured by chlorophyll *a* (a biomolecule critical in photosynthesis) were higher in Gunston Cove during the spring, peaking at about 43 ug/L (micrograms per liter) in early June. From thereon chlorophyll *a* values steadily declined through early September to less than 5 ug/L. In late September chlorophyll increased somewhat in the Cove. In the Potomac River values increased slowly through the end of June, but remained below Cove values until late August. Maximum chlorophyll *a* in the River was about 25 ug/L. Total phytoplankton cell density and biovolume in the Cove increased steadily through late May exhibiting a marked decline in June. Biovolume continued to decline in late June whereas cell density started to increase again. In the River both cell density and biovolume showed muted seasonal patterns relative to the Cove stations, but generally increased through the study period as had chlorophyll.

Phytoplankton (i.e., flora of freely suspended, often minute organisms that drift with water) cell density was dominated by cyanobacteria on all dates and at both sites due to their small size. The filamentous diatom *Melosira* and Pennate 2 were the most important diatoms on most dates at both sites. *Cryptomonas*, *Chroomonas* and *Dictyosperium* were the most important other algae in both study areas.

Diatoms (a beneficial type of photosynthesising algae) dominated phytoplankton biovolume in the Cove and River for most of the year. *Oscillatoria* had the highest biovolume for cyanobacteria on all dates. The filamentous diatom *Melosira* and discoid centrics were the most important diatoms on most dates at both sites. *Cryptomonas* was consistently among the dominant other algae in both study areas.

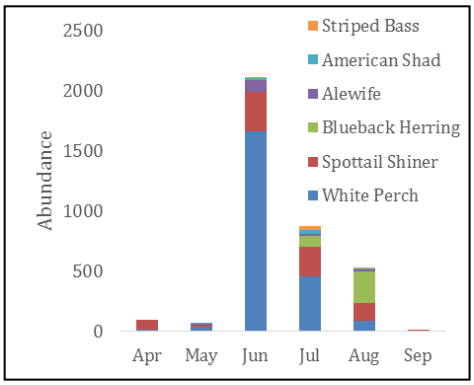
Rotifers (microscopic aquatic animals) were the most numerous zooplankton (heterotrophic plankton) in the study area with abundances similar at the two study sites with peak densities of 1000-1500 per liter. *Brachionus* and *Keratella* were the dominants at both sites. Rotifer populations in the Cove declined in June following runoff events. Maxima later occurred in both late July and late September. In the River, rotifer maxima occurred in late May and early September. The small cladoceran (aquatic crustaceans also known as water fleas) *Bosmina* was found in moderate densities in early May at both sites. The larger abundant cladoceran *Diaphanosoma* had spring maxima at both sites, but levels were greatly reduced compared to most previous years. *Daphnia* had a short-lived peak in early May in the Cove.



Populations of the other herbaceous cladocera, *Ceriodaphnia*, and *Moina*, were quite low. *Leptodora*, the predaceous cladoceran, was found at moderate densities in late May in the Cove. Nauplii (immature copepods) did not display a strong seasonal pattern at either site. Densities were 50-150/L on most dates. *Eurytemora*, a calanoid copepod, reached a peak of nearly 5000/m^3 in the River at both

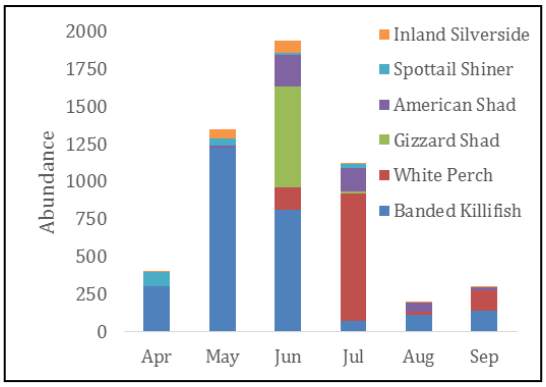
sites in spring. Cyclopoid copepods were much reduced in 2015 compared to 2014. Overall, this data indicates that the zooplankton assemblage in Gunston Cove is dynamic and shows a diversity of organisms that are important to ecosystem recovery.

In 2015 ichthyoplankton (i.e., eggs and larvae of fish) was dominated by clupeids, most of which were *Dorosoma* sp. (Gizzard Shad), but with a relatively high density of river herring (Alewife and Blueback Herring) also present. *Morone sp.* (White Perch or Striped Bass) larvae were found in relatively low densities. A non-clupeid species, Inland Silverside, was found in relatively high densities in the ichthyoplankton samples in 2015. The highest density of fish larvae occurred in mid-May, which is slightly earlier than usual (typically the peak is late May). This peak was driven by a high density of clupeid larvae. Most clupeids are spawn from March – May and remain in tidal tributaries such as Gunston Cove until they are juvenile. They then usually remain several months as juveniles as well, and use Gunston Cove as a nursery.



In trawls (right), the majority of the adult and juvenile fish collected were represented by four taxa. White Perch (*Morone americana*) dominated with 58% of the catch, followed by Spottail Shiner (*Notropis hudsonius*), Blueback Herring (*Alosa aestivalis*), and Alewife (*Alosa pseudoharengus*). Other numerically abundant species included American Shad, Striped Bass, Banded Killifish and Blue Catfish. Other catfishes than Blue Catfish were found in very low numbers in the trawls; 3 Brown Bullhead and 2 Channel Catfish. There is a visible trend of increasing numbers of Blue Catfish and decreasing numbers of other catfishes, which may be a sign that Blue Catfish is outcompeting similar species. Blue Catfish catches were spread over the year in 2015, but were all caught in the Potomac River mainstem. White Perch was by far the most abundant species and was found in all months at all stations, with peak abundance in June.

In seines (below), the most abundant species was Banded Killifish (*Fundulus diaphanus*), followed by White Perch. Banded Killifish was far more abundant in seines than in trawls, which emphasizes the preference of Banded Killifish for the shallow littoral zone (the area sampled with a seine, while trawls sample the open water). The abundance peak of Banded Killifish was in May, while White Perch was found in highest abundance in July. Other species with high abundances were Gizzard Shad, American Shad, Spottail Shiner, Inland Silverside, Golden Shiner, Tessellated Darter, and Quillback.



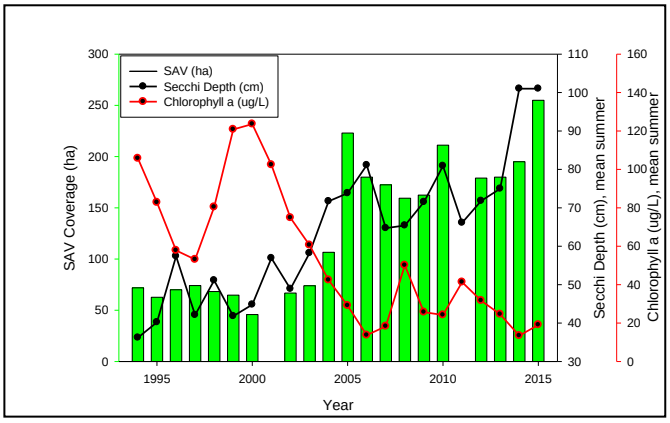
In summary, fyke nets provide an important contribution to the total catch because the composition of the catch is different than the trawl and seine collections. While Banded

Killifish was by far the most dominant (as in seine collections), sunfishes represented a much higher relative contribution to the catch, represented in order of abundance by Pumpkinseed, Bluegill, Redear Sunfish, and Redbreast Sunfish. In addition, Banded Killifish abundances in fyke nets were highest in July, while the peak in seine collections is in May. This represents a spatial shift of Banded Killifish into the submersed aquatic vegetation (SAV) beds once these beds are established.

Oligochaetes (i.e., aquatic worms) were the most abundant benthic taxon at both sites. In the River amphipods (i.e., crustacea, shrimp-like in form) were also very abundant and gastropods (i.e., aquatic snails) were common. In the Cove, gastropods were the second most abundant taxon and chironomids (i.e., aquatic insects or midges) were much reduced compared with previous years. The introduced bivalve *Corbicula* constituted the majority of bivalves, but several specimens of native Unionid river mussels (organisms that are particularly sensitive to ammonia nitrogen) were also found. The benthos of the study area is exhibiting some positive changes over the early years of the study. Submersed aquatic vegetation coverage in 2015 was increased over 2013 and 2014 and was near record levels.

In the anadromous creek survey (of fish migrating from salt water to spawn in fresh water), Alewife was the dominant species in both larval and adult collections in both Pohick and Accotink Creeks. In the hoop net sets, an unprecedented high number of adults were captured in recent years for both Alewife and Blueback Herring; 1007 and 965 respectively. We also caught an unusually large number of Hickory Shad in 2015. In a notable sign of recovery Pohick Creek, which was totally void of spawning fish in the early years of the study, now harbors more spawners than Accotink Creek.

Data from 2015 generally reinforced the major trends which were reported in previous years. First, phytoplankton algae populations (which can cause nuisance algal blooms, hypoxia in stratified areas, and a decline of fisheries) in Gunston Cove have shown a clear pattern of declined since 1989. Accompanying this decline have been more normal levels of pH and dissolved oxygen, and increased water clarity which are critical for a life-sustaining aquatic habitat. Data available for 2013 from Virginia Institute of Marine Science for SAV (submersed aquatic vegetation) assessment and the coverage by plants remained at the elevated levels observed since 2005. The increased water clarity in the Cove has brought the rebound of SAV which provides increased habitat value for fish and fish food organisms. The SAV also filters nutrients and sediments and itself will inhibit the overgrowth of phytoplankton algae. This trend is undoubtedly the result of phosphorus removal practices at Noman M. Cole Pollution Control Plant which were initiated in the late 1970's (see first figure in Executive Summary). This lag period of 10-15 years between phosphorus control and



phytoplankton decline has been observed in many freshwater systems resulting at least partially from sediment loading to the water column which can continue for a number of years. Gunston Cove is now an internationally recognized case study for ecosystem recovery due to the actions that were taken and the subsequent monitoring to validate the response.

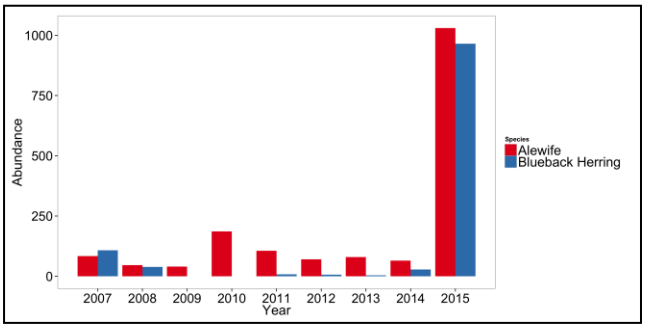
A second significant change in water quality documented by the study has been the removal of chlorine and ammonia from the Noman M. Cole, Jr. Pollution Control Plant effluent. A decline of over an order of magnitude in ammonia nitrogen has been observed in the Cove as compared to earlier years. The declines in ammonia and the elimination of chlorine from the effluent (to values well below those that may result is toxicity problems) have allowed fish to recolonize tidal Pohick Creek which now often has more spawning activity than tidal Accotink Creek. Monitoring of creek fish allowed us to observe recovery of this habitat which is very important for spawning species such as Shad. The decreased ammonia, suspended solids, and phosphorus loading from the plant have contributed to overall Chesapeake Bay cleanup.

Another trend of significance which is indicative of the Cove recovery is changes in the relative abundance of fish species. While it is still the dominant species in trawls, White Perch has gradually been displaced in seines by Banded Killifish. This trend continued in 2015 with Banded Killifish being over twice as abundant in seines as White Perch. Blue Catfish have entered the area recently, and brown bullhead has decreased greatly in the Cove.

Clearly, recent increases in SAV provide refuge and additional spawning habitat for Banded Killifish and Sunfish. Analysis shows that White Perch dominance was mainly indicative of the community present when there was no SAV; increased abundances of Bay Anchovy indicative for the period with some SAV; and Banded Killifish and Largemouth Bass indicative of the period when SAV beds were expansive. While the seine does not sample these SAV areas directly, the enhanced growth of SAV provides a large bank of Banded Killifish that spread out into the adjacent unvegetated shoreline areas and are sampled in the seines. The fyke nets that do sample the SAV areas directly documented a dominance of Sunfish and Banded Killifish in the SAV beds. In addition to SAV expansion, the invasive Blue Catfish may also have both direct (predation) and indirect (competition) effects, especially on species that occupy the same niche such as Brown Bullhead and Channel Catfish. Overall, these results indicate that the fish assemblage in Gunston Cove is dynamic and supports a diversity of commercial and recreational fishing activities.

Juvenile anadromous species continue to be an important component of the fish assemblage in Gunston Cove. We have seen declines in “river herring” (a multispecies group than includes both Alewife and Blueback Herring) since the mid-1990s, which is in concordance with other surveys around the Potomac and Chesapeake watersheds. In January 2012, a moratorium on river herring was put in effect to alleviate fishing pressure in an effort to help stocks rebound. We reported last year that the larval abundances of the *Alosa* genus was high in 2014, possibly resulting in higher adult abundances in 2015. We indeed saw higher numbers of juvenile Blueback Herring and Alewife in trawls in 2015.

The most direct indication we have of the status of river herring spawning populations is the anadromous study in Pohick and Accotink Creeks (which included Dogue Creek and Quantico Creek up to 2008). We witnessed a one to two orders of magnitude increase in catches from Accotink and Pohick Creeks of Alewife and Blueback Herring (the two species that are considered river herring) in 2015 (figure to the right). This is three years since the moratorium has been in place in Virginia and neighboring states, which means this is likely the first cohort protected by this moratorium for one full life cycle. Through meetings with the Technical Expert Working group for river herring (http://www.greateratlantic.fisheries.noaa.gov/protected/riverherring/tewg/index.html) it has become clear that not all tributaries of the Chesapeake Bay, in Virginia and elsewhere, have seen increased abundances in 2015; some surveyors even reported declines. Since the decline in river herring was related both to overfishing and habitat degradation, it could be the case that habitat in those areas has not recovered sufficiently to support a larger spawning population now that fishing pressure is released. This while the habitat in the Gunston Cove may be of suitable quality to support a larger spawning population now that reduced fishing pressure allows for more adults to return to their natal streams. Continued monitoring in years after this large spawning population was observed, will determine if this spawning season results in a successful year class, and if this is the first year of continued high river herring abundances.



In short, due to the strong management efforts of the County and the robust monitoring program, Gunston Cove has proven an extremely valuable case study in eutrophication recovery for the bay region and even internationally. The onset of larger areas of SAV coverage in Gunston Cove will have further effects on the biological resources and water quality of this part of the tidal Potomac River. It is important to continue the data record that has been established to allow assessment of how the continuing increases in volume and improved efforts at wastewater treatment interact with the ecosystem as SAV increases and plankton and fish communities change in response. Furthermore, changes in the fish communities from the standpoint of habitat alteration by SAV, introductions of exotics like snakeheads, and possible effects such as those from contaminants of emerging concern (e.g. hormones and other pharmaceuticals) need to be followed.

Global climate change is becoming a major concern worldwide. Since 2000 a slight, but consistent increase in summer water temperature has been observed in the Cove which may reflect the higher summer air temperatures documented globally. Other potential effects of directional climate change remain very subtle and not clearly differentiated given seasonal and cyclic variability.

We recommend that:

1. Long term monitoring should continue. The revised schedule initiated in 2004 which focuses sampling in April through September should capture the major

trends affecting water quality and the biota. The Gunston Cove study is a model for long term monitoring which is necessary to document the effectiveness of management actions. This process is sometimes called adaptive management and is recognized as the most successful approach to ecosystem management.

2. The fyke nets have proven to be a successful addition to our sampling routine. Even though a small, non-quantitative sample is collected due to the passive nature of this gear, it provides us with useful information on the community within the submersed aquatic vegetation beds. Efficient use of time allows us to include these collections in a regular sampling day with little extra time or cost. We recommend continuing with this gear as part of the sampling routine in future years.
3. Anadromous fish sampling is an important part of this monitoring program and has gained interest now that the stock of river herring has collapsed, and a moratorium on these taxa has been established in 2012. We recommend continued monitoring, and we plan to use the collections before and during the moratorium to help determine the effect of the moratorium. Our collections will also form the basis of a population model that can provide information on the status of the stock.
4. GMU's Potomac Environmental Research and Education Center instituted a continuous water quality monitoring site at Pohick Bay marina in May 2011. This program was suspended in 2014 due to ramp construction near the monitor, but we will consider reinstituting the program in 2017 should the County consider it valuable.
5. As River restoration continues, the benthic community including native mussels is showing signs of rejuvenation. We recommend that more use be made of the benthos in tracking recovery of the River. To that end we recommend that the Benthic Index of Biotic Integrity (B-IBI) be adapted to for conditions in the tidal freshwater Potomac River. Furthermore, we recommend an assessment of the status of native river mussel populations.
6. Recent work has raised awareness that some pollutants may be causing sublethal stress on fish populations which are manifest in higher incidences of disease and abnormalities. We recommend that that a pilot study be done to establish a baseline of the incidence of these impacts in specific Gunston Cove taxa and explore the feasibility of routine assessment of fish abnormalities as part of the monitoring program.

List of Abbreviations

BOD	Biochemical oxygen demand
cfs	cubic feet per second
DO	Dissolved oxygen
ha	hectare
l	liter
LOWESS	locally weighted sum of squares trend line
m	meter
mg	milligram
MGD	Million gallons per day
NS	not statistically significant
NTU	Nephelometric turbidity units
SAV	Submersed aquatic vegetation
SRP	Soluble reactive phosphorus
TP	Total phosphorus
TSS	Total suspended solids
um	micrometer
VSS	Volatile suspended solids
#	number