2020 ANNUAL POULTRY REPORT

COVERING JANUARY 1, 2019 – DECEMBER 31, 2019

Developed by Accomack County

Planning & Zoning Staff

Reviewed and Approved by the Accomack County Planning Commission on February 12, 2020

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EXECUTIVE SUMMARY 2020 (covering 2019)

The 2020 Executive Summary is intended to provide new or updated information to the 2019 Poultry Report.

Poultry Numbers:

As of February 1, 2020:

- Since July 1, 2014, 245 poultry broiler houses have been authorized by zoning permits.
- Staff estimates that of the 245 poultry houses authorized by zoning permit since July 1, 2014, **226** have been constructed, or are expected to be producing broiler chickens in the near future, which is up by **8** houses at this same time last year.
- One poultry zoning permit application for eight houses near Hallwood was filed on March 28, 2019 but is waiting on supplemental information, documentation and approvals from state agencies as part of the zoning application. Staff was aware of this application and referenced it as part of the 2019 Annual Poultry Report.
- As stated in the 2019 Annual Poultry Report, staff has estimated the poultry operations producing broiler chickens prior to July 1, 2014 at 254 poultry broiler houses; however, we believe that a number of these houses are no longer operational. As of the writing of this report, we do not have an accurate number of houses that are no longer operational.
- The total number of poultry houses prior to July 1, 2014 and permitted since July 1, 2014 total 499; of that, the total constructed are 480 poultry houses.

Table 1 - Poultry Numbers at a Glance

Approval Timeframe	# of Poultry Farms (based on Tax Map Parcel)	# of Poultry Houses Permitted *	# of poultry Houses Constructed, as of 12/31/2019	%age Constructed of Total Permitted
Before July 1, 2014	51	254	254	100%
After July 1, 2014	32	245	226	92.25%
GRAND TOTAL	**83**	**499**	**480**	**96.125%**

* Houses constructed before July 1, 2014 are presumed to be permitted.

Groundwater:

Since the 2018 Annual Poultry Report was written, 56 poultry operations on the Eastern Shore of Virginia (all located in Accomack County) entered into a consent order with the Virginia Department of Environmental Quality (DEQ). As of the 2019 Annual Poultry Report, DEQ determined that 54 needed to submit a groundwater withdrawal permit, as water withdrawal for the poultry operations is in excess of 300,000 gallons of water demand in a month, and those 54 poultry operations submitted the required application by the deadline of October 1, 2018.

DEQ reviewed the applications and completed the technical evaluations on all 54 facilities and prepared draft permits based upon this review. However, only 49 of the 54 poultry facilities agreed to proceed with the public notice advertisement of their draft permit on May 24, 2019. Additionally, four of the 49 poultry facilities failed to install the proper meters and did not comply with the Consent Special Orders (CSO) reporting requirements. Therefore, only 45 poultry facility draft permits were recommended for action before the State Water Control Board at their meeting on December 13, 2019.

At the December 13, 2019, the State Water Control Board approved **44** Groundwater Withdrawal Permit for Poultry Facilities: each permit contained three parts:

Part I – Operating Conditions which establish withdrawal limits and reporting requirements and identifies specific wells authorized by the permit; establishes requirements related to the Water Conservation and Management Plan (WCMP). 41 of the approved permits also have to incorporate a Mitigation Plan which is required for any facility for which the technical evaluation documents an area of impact that extends beyond the property boundaries.

Part II - Special Conditions which are facility specific conditions based upon the technical review; these may include the collection of geophysical logs, determination and reset of pump intakes; flow through meter installation and verification; camera surveys to identify undocumented well construction, water quality monitoring and alternative source investigations. ***18 of the 44 permitted facilities need to conduct the alternative source investigations.***

Part III – General Conditions – these are standardized and applicable to all the permits and outline the process and requirements to comply, to cease or confine activity, to mitigate, and to provide information, including the metering and equipment standards, monitoring and record maintenance, and new well construction. This also includes the process and requirements for minor and major modifications, as well as for permit reopening and permit renewals.

At this same meeting, the State Water Control Board had separated out **one** of the poultry facilities from the original 45 permit applications and addressed it separately due to an active Notice of Violation with DEQ for this facility. *This facility was approved with the all of the conditions required for the other approved permits, including an* ***alternative source investigation***. Therefore, a total of **45**

Groundwater Water Withdrawal Permits have been issued by the State Water Control Board, as of 12/13/2019.

The Groundwater Withdrawal Permits, including the ones that need to conduct an Alternative Aquifer Source Investigation, are shown on the map on the next page.

DEQ Water Withdrawal Permits as of 12/31/2019

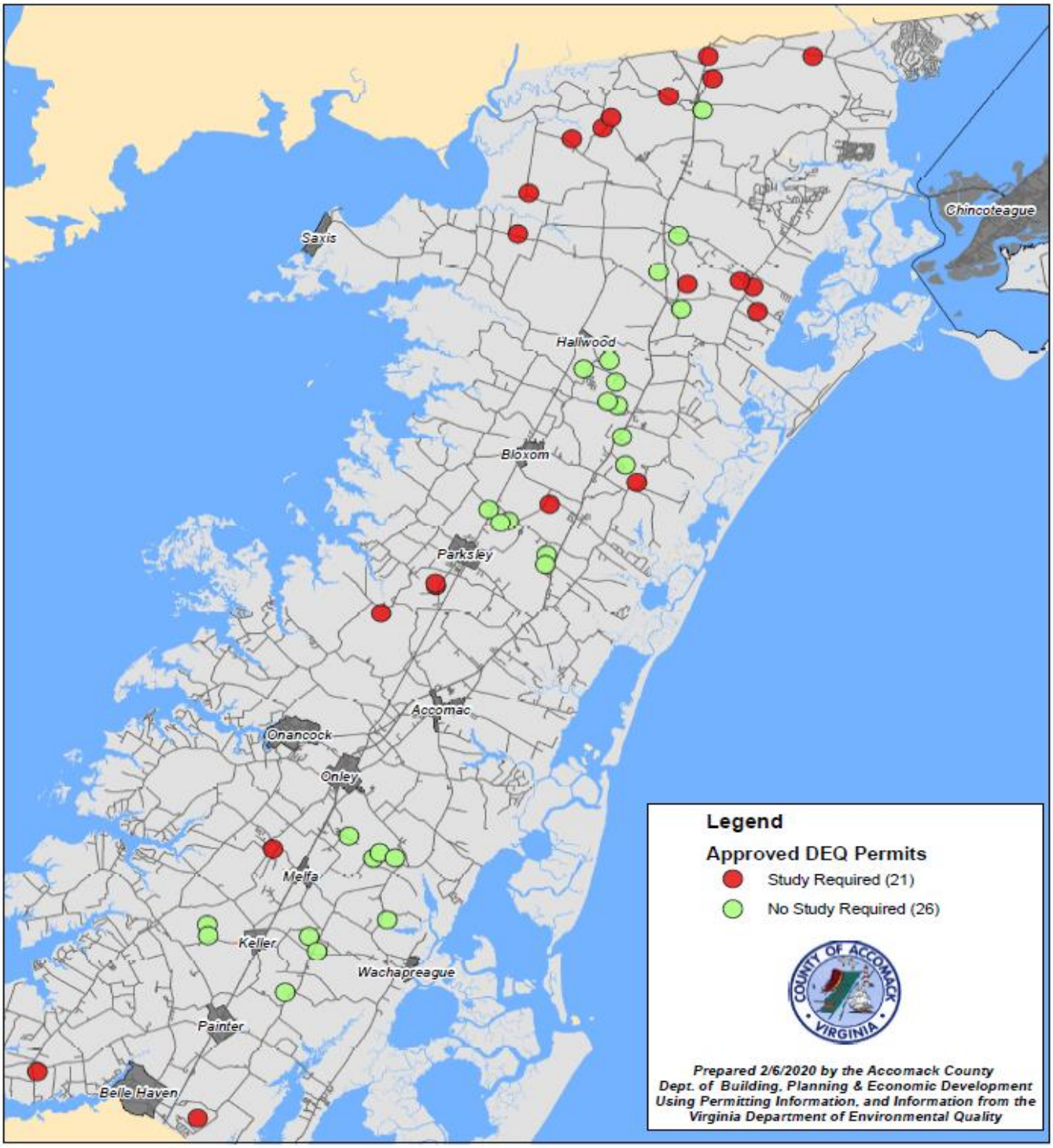

Table 2 - Groundwater Withdrawal Permits at a Glance

DEQ STATUS Groundwater Withdrawal Permits	# of Farms	DEQ Groundwater Permits - # of Farms conducting Alternative Aquifer Source Investigations
Approved on 12/13/2019	45	19
Applied for permit but did not agree to advertise for May 2019 hearing	5	0
Applied, advertised but failed to install meters – SWCB has not acted on these yet	4	0
DEQ has determined that NO PERMIT is required	2	0
GRAND TOTAL	56	19

As part of their initial outreach and evaluation criteria, DEQ determined that many of the poultry facilities in Accomack County did not meet the requirements to seek a Groundwater Withdrawal Permit, especially the older poultry houses and the smaller farms with only one or two poultry houses; as stated above, two facilities that initially entered into a Consent Order with DEQ were deemed to not meet the requirements and did not need to move forward with a Groundwater Withdrawal Permit application. In addition, there are some poultry facilities which had not been in operation yet (still under construction) and were not part of the DEQ Consent Order in 2018 that are now working with DEQ and submitting water withdrawal applications. ***Staff is working with DEQ to confirm this information and update our reporting information so that the Groundwater Withdrawal Statistics by # of Farms equates to our total Poultry Numbers by Farm in the section above.***

As part of the review of the groundwater withdrawal applications, DEQ has estimated the combined withdrawal of 390.2 million gallons annually, or combined average of 1.07 million gallons per day. Approval of these groundwater withdrawal permits are within the applicable statutes and regulations for the Eastern Shore Groundwater Management Area. This means that the permitted water withdrawal amounts for the poultry facility operations along with previously approved water withdrawal permits through the Eastern Shore for other operations (farming operations, municipal systems) are within the acceptable usage parameters established for the Eastern Shore Groundwater Management Area.

The 390.2 million gallons annually permitted by DEQ for the poultry facilities, which equates to 1.07 million gallons per day, **is significantly lower than water usage projections that were contained in the 2018 Annual Poultry Report.** At that time, initially, DEQ was estimating 3.1 million gallons per day. After discussions with DEQ and the Poultry Industry, staff had developed a low to a high range estimated usage of 1.215 million to 2.6 million gallons per day which we included in the 2018 Annual Poultry Report.

Other Groundwater Items:

- During the 2019 General Assembly, Senator Lynwood Lewis introduced SB1599 to make it easier for all large groundwater users to utilize the surficial aquifer which passed and was signed into law as the 2019 Acts of Assembly Chapter 755. This law requires the State Water Control Board to develop regulations to amend the existing groundwater withdrawal regulations to provide incentives and other modifications to promote the use of the surficial aquifer on the Eastern Shore. The proposed regulation has been advertised and the public comment period ended on 1/6/2020.

Buffers:

In 2019, staff issued 10 Notices of Violation relative to the landscape buffers for the poultry operations. The items that were cited, **in order of significance**, were:

1. Failure to install the landscape buffer
2. Destruction of existing buffers which had been accepted as part of the landscape plan and were supposed to be preserved
3. Failure to replace dead plant material
4. Mowing down of the plant material
5. Failure to follow the approved landscape plans.

In several instances the buffers running along the sides of the poultry operation properties were mowed. Buffers along the sides of poultry operations were permitted to be much smaller at installation from roadside buffers, which were sized much larger. It is apparent that the side buffers did not get as much attention and care as roadside buffers. As a result, weeds grew up in the buffers. The operators of the poultry farms mowed these areas, as they did with others parts of their land to keep them maintained. In some instances, the mowed buffers survived the mowing, however, growth was stifled. In other instances the mowed buffers needed replanting.

Some of the violations concerned the fact that the species planted within the buffer did not match what had been approved. If suitable and equitable plant species were installed, both in terms of initial planting size and height and anticipated growth rate, then landscape plan amendments and zoning permit amendments were considered and approved.

In some of the violation cases, there are areas where the naturalized vegetation that grew in following the mowing of portions of the buffer has proven to provide the same intention as the landscape buffer and we may wish to consider this for future review of the poultry ordinance. Several poultry operations utilized a cover crop (such as corn) during the summer season in addition to the landscape

buffer, especially along the roadside, which allowed for the visual buffering to occur at a much faster rate, especially during the period when visibility due to increased road traffic was more pronounced.

In most of the approved zoning permits with a landscape plan, the landscape buffers planted to screen poultry operations from the street or roads, or strategically planted to screen neighboring houses are in compliance with approved plans and are performing as expected.

Staff will be conducting annual inspections of the buffer for all poultry operations to ensure that the maintenance and survivability of the landscape material is upheld in accordance with the County's ordinance.

Stormwater:

Confined Poultry Operations are required to construct and maintain stormwater facilities. County staff perform inspections throughout the construction period until the stormwater management is complete and operational.

Each poultry farm's stormwater management system has been designed to make sure that the peak flow rate leaving the developed site will be less than or equal to the peak flow rate in the pre-developed condition.

Many poultry operators have completed construction of the site work, including the stormwater management facilities. County staff will begin monitoring each site for proper operation and maintenance of these facilities. As required by the Virginia Stormwater Regulations, a formal site inspection will be conducted at least once every five **(5)** years.

In 2019, there was one **(1)** poultry farm that exhibited technical problems related to stormwater management. This site relies on infiltration as the primary best management practice (BMP) and the owner is working with the contractor and the engineer to identify the problem, re-design the BMP, and construct the recommended improvements.

Since the 2019 Annual Poultry Report, there have been four **(4)** Notices to Comply and two **(2)** Notices of Violation issued to poultry construction sites.

Economic Impact:

The most obvious economic impact from the poultry industry in Accomack County are the benefits derived from the Perdue and Tyson processing plants. As of October 2019, employment at the two **(2)** plants is in excess of **3040** employees. The local economy also benefits from the poultry industry with employment and payroll in the following areas: poultry growers and farm workers, truck drivers, grain elevators, and grain farmers.

Virginia Institute of Marine Sciences (VIMS) Report:

In the 2019 Annual Poultry Report, we included a report conducted by the Eastern Shore Laboratory of VIMS called "Water quality in Southern Accomack County Watershed which summarized the results of water samplings taken stating **"**The spatial variability in the data for all parameters and the lack of correlation of any high values to poultry sites does not suggest storm water runoff impacts from poultry operations. Further sampling at these locations will monitor any changes in these water quality parameters as the poultry operations mature, and will help to assess the adequacy of siting regulations to ensure they are protective of the marine resources downstream of these operations."

The Eastern Shore Laboratory of VIMS has provided an updated report called "Water Quality in Accomack County Freshwater Streams" dated January 22, 2020 and included as Exhibit A to this report. Said report is a continuation of the monitoring and analysis from the prior year. Sampling was done following two inch rainfall events covering 83 streams at road crossing in southern and northern Accomack County and their analysis states **"No overall effect of poultry operations or other coverage variables on stream nutrient levels could be detected."**

The report indicated that watersheds without poultry operations had nutrient levels comparable to watersheds where poultry operations exists, both at the high and low ends of the nutrient concentration ranges. The report noted that there are some sites that exceed the Observable Effects Concentrations (OEC) values for phosphorus and nitrogen and should be examined further, including an inspection of storm water control from the poultry sites near Taylor's Creek near Pungoteague, Mill Branch of Guildford Creek and Katy Young Branch of Bagwell Creek.

Recently, press coverage of a different VIMS report was brought to our attention. A VIMS report titled "From Genes to Nitrogen Removal: Determining the Impacts of Poultry Industry Wastewater on Tidal Creek Denitrification" which was published in the January 2020 Environmental Science & Technology Journal. The following link is to the local press coverage: https://www.dailypress.com/news/dp-nw-vims-poultry-pollution-20200128-7a23xyeofnhztpsephagdez6zq-story.html). We have not had the opportunity to review the full report, but wanted to bring it to the attention of readers of this report, in the interest of transparency.

Conclusion:

96.25% of the poultry houses permitted since July 1, 2014 have been constructed. As of the writing of this report, there is no reason to believe that a significant surge in poultry house construction will occur in the foreseeable future. In fact, the trend is for older housing to become non-operational.

Staff will try to get a better handle on the number of older poultry houses that have become non-operational during 2020.

During 2019, the issuance of water withdrawal permits by DEQ brought closure to one of the remaining controversial matters related to the surge in poultry house construction.

As noted earlier in this report, staff worked through a number of issues to achieve buffer compliance. As of the writing of this report, though most of the buffers are in compliance, the majority of the enforcement cases are not completely closed. The buffer enforcement efforts over 2019 were cumbersome and extremely time consuming for a variety of reasons and evaluation to improve efficiency and compliance is needed during 2020.

This report includes the 2020 VIMS water quality report which covers data collected in 2019; it concludes that there were no apparent effects of the poultry industry on ESVA freshwater stream nutrient concentrations. VIMS will continue to conduct sampling and analysis to determine if these results are consistent over time.

As a follow up to that report, staff will visit and/or examine data for poultry operations mentioned that are upstream of the sampling stations mentioned in the executive summary portion of the report**.**

EXHIBIT A

"Water Quality in Accomack County Freshwater Streams"

Begins on the next page

Water quality in Accomack County Freshwater Streams

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22 January 2020

Executive Summary

Expansion of poultry house operations and use of litter as a soil amendment in Accomack County Virginia has raised concerns for water quality impacts both seaside and bayside of the Eastern Shore of Virginia (ESVA). This ongoing investigation is examining freshwater stream water quality in Accomack Virginia to identify water quality impairments from poultry operation storm water runoff. Sampling in 2019 followed two inch rainfall events covering 83 streams at road crossings in southern and northern Accomack County. Estimates of land cover in the drainages for these streams were used to determine correlations between stream water nutrient levels and the presence and distance of poultry operations, agricultural fields, residential housing, forest, and swamps. No overall effect of poultry operations or other coverage variables on stream nutrient levels could be detected.

Individual streamsheds for stations that exceeded the range of potential observable effects levels (OELs), estimated for Virginia streams, were examined more closely for potential loading sources. For total nitrogen, 27.7% of all stations exceeded the lower OEL limit (2.6 mg/L), with 6 of the 23 stations having poultry operation upstream of the sampling point. The upper OEL limit (3.66 mg/L) was exceeded in samples from 13.3% of all stations, with poultry operation in 3 of those 11 streamsheds. For total phosphorous, 12 stations (14.5% of the total) exceeded the lower OEL threshold (0.25 mg/L) with 2 of the twelve stations having poultry operations upstream. The upper OEL limit (0.284 mg/L) was exceeded at 9 stations, 2 of which had poultry operations in the drainage area.

Stream water quality will be assessed again in 2020, targeting both storm events and dry periods, and analysis will target greater resolution in nitrogen species (ammonia, nitrite + nitrate, total nitrogen) and phosphorous (dissolved orthophosphate, total phosphorous) in the water samples.

Background

Expansion of poultry house operations and use of litter as a soil amendment in Accomack County VA has raised concerns for water quality impacts both seaside and bayside of the Eastern Shore of Virginia (ESVA) where harvesting marine resources and aquaculture operations may be affected. Between 2014 and 2018, 218 houses were built. The expansion has slowed, with only 11 of the 218 being permitted in 2018, and an additional 8 houses were permitted in 2019, bringing the total number of permitted sites to 87, with 480 houses. Of those permitted and constructed, the poultry industry records at the end of 2018 showed 68 growers with 370 houses that were actively growing birds. Data on how many of the sites and houses were active in 2019 is not yet available.

The aerosols, dust, and litter from the poultry houses are potential sources of nitrogen, phosphorous, and fecal contamination to watersheds and receiving waters. Siting regulations, storm water controls, and management of litter storage, handling, and application are designed to limit these impacts, yet no analysis has been implemented to verify the efficacy of these protective measures. This investigation extends and expands a VIMS ESL initial effort to sample watersheds and determine nitrogen and phosphorous concentrations in freshwater streams in Accomack County. Data collected in 2018 were included in the Accomack County Annual Poultry Report for that year.

Methodology

Stream crossings at roadside right of ways were targeted for sampling. The location of 83 samples taken in 2019 covering southern and northern Accomack County are shown in Figure 1. The Onancock-Onley-Tasley-Allentown-Daugherty region was not sampled. At each location, latitude and longitude coordinates were recorded with a handheld Garmin GPS with ~12 ft accuracy (less under tree cover). Some coordinates were corrected based on mapping locations in GIS software to better reflect the road-stream crossing sample point. A YSI multiparameter water quality meter was used to record temperature, salinity, dissolved oxygen and pH of stream flow prior to sampling. This meter was maintained and calibrated by trained ESL staff. The data for stations and water quality meter readings are included as Appendix Table A1.

Sub-surface water samples were taken with clean 125 ml polypropylene bottles by a gloved technician, rinsed three times with site water prior to filling, and immediately placed on ice for transport to the ESL. Samples were frozen at -20 degrees C, and transferred frozen to analytical services at VIMS Gloucester Point for analysis of total nitrogen and total phosphorous. The method for analysis is included as Appendix Table A2. Lower detection limits were 0.0285 mg/L for TN and 0.0095 mg/L for TP.

Rainfall records were obtained from archived records for Melfa Airport: https://weatherspark.com/h/td/147126/Historical-Weather-at-Melfa-Accomack-Airport-Virginia-United-States-Today. A 1.91 inch rainfall was recorded in the 12 hours prior to sampling in southern Accomack County on 20 April 2019. A 2.05 inch rainfall was recorded for the 17 hours prior to sampling in northern Accomack County on 24 July 2019. Sample water was

visually assessed for turbidity and ranked as “clear” (low turbidity), “brown” (clear but organic stained), or turbid (cloudy, obvious particulate load).

Data were compiled in MS Excel spreadsheets. Statistical analysis utilized SAS Institute JMP software. Graphical plots were produced with Kaleida Graph software. GIS plotting of data was accomplished with ERSI software.

Sampling locations plotted in ESRI GIS on a base map were overlaid with NHD Stream flow lines for seaside and bayside ESVA. Topographic maps and VBMP 2017 aerial imagery were also applied to define watersheds for sample locations. Locations of permitted poultry operations, for which DEQ site visits have been made to confirm activity, were obtained from VA DEQ. Distance and bearing between sampling points and the nearest poultry operation, whether in the same watershed or not, were determined with ESRI software as a proxy for any airborne dust or nutrients transported from ventilation of the poultry houses.

Characteristics of watersheds draining to sampling points was estimated by visual inspection of topographic maps and the VBMP 2017 aerial imagery as base maps for a drainage area approximately 1 km upstream of the sampling points. Percent coverage of human residences, agricultural fields, forest, and swamp was recorded. Human residences were assumed to represent septic tank drain field inputs as well as lawn and garden fertilizer amendments, and animal/bird waste. Agricultural field area was assumed to represent fertilizer, manure, and other soil amendments as well as sediment runoff. Forest and swamp coverage were assumed to be non-source areas for nutrients, and swamp coverage was likely underrepresented due to a significant forest area that is periodically flooded by runoff in Accomack County. Forest area was often restricted to linear strips in stream gulleys, in which case, runoff from surrounding fields and housing may have had more influence than forest cover. Each sampling station was scored Y or N for presence or absence, respectively, of poultry operations anywhere upstream, regardless of distance. Data for station streamshed characteristics and nutrient analysis results are included as Appendix Table A3. Nutrient data were Log transformed prior to analysis, and Geometric means were calculated to determine central tendencies.

An Observed Effects Concentration (OEC) for Total Nitrogen (TN) in Virginia mountain and piedmont streams was proposed for between 2.60 and 3.66 mg/L and for Total Phosphorous (TP), an OEC threshold was proposed at 0.25-0.284 mg/L (Zipper et al., 2012). Although not necessarily applicable to the nature of ESVA freshwater streams and swamps, these values were used as “red flag” benchmarks in assessing nutrient levels in the stream samples which might bear closer examination.

Results and Discussion

Limited data on groundwater nitrate levels under the ESVA show relatively high values (>10 mg/L; Ator and Denver, 2015). Groundwater contributions to steam flow are variable and largely unknown but considered a major portion of the freshwater discharge to surface waters for the ESVA, whereas rivers dominate nutrient loadings in many other areas. Nitrogen as nitrate in groundwater contributes about 70% of streamflow nitrogen on the Delmarva as a whole, whereas

phosphorous is mainly associated with storm water runoff (Ator and Denver, 2012). A dry season sampling event would isolate groundwater flow from storm water runoff, and this approach, taken in 2018, will be expanded in 2020 to the stations sampled in this 2019 analysis. All of the samples taken in 2019 immediately followed ~2" rainfall events, and so would capture storm water runoff combined with groundwater flow. Ascribing source to nutrients in flowing streams is not an exact process, but identifying streamsheds with high nutrient levels can provide a basis for screening potential sources and directing resources for remedial action.

Watersheds without poultry operations had nutrient levels comparable to watersheds where poultry operations exist, both at the high and low ends of the nutrient concentration ranges. Overall, there was no significant difference between nutrient samples from stations with poultry operations in the watershed and those without (Table 1). The spatial distribution of TN and TP concentrations in stream water samples is presented in Figures 3-6. Samples from Northern Accomack County had an overall higher geomean TN value than Southern Accomack County streams (2.06 mg/L vs 1.65mg/L; Figures 3 and 4), but a lower geomean TP value (0.0959 mg/L vs 0.161mg/L; Figures 5 and 6). Sample locations greater than 2 km from any poultry operation had geomean values of 1.816 mg/L TN and 0.0872 mg/L TP, compared to geomeans for stations closer than 2 km to poultry operations at 1.586 mg/L TN and 0.0752 mg/L TP. More non-poultry watersheds exceeded the proposed criteria for Observable Effects Concentrations (OEC) for TN and TP in Virginia Streams (Zipper et al., 2012; Tables 2 and 3) than watersheds containing poultry operations. However, some sites exceeding the OEC values (Tables 2 and 3) are worth a closer examination. The spatial distribution of the sites above the OEC lower thresholds of 2.6 mg/L TN and 0.25 mg/L TP are shown in Figures 7 and 8.

Station 30 had the highest recorded nitrogen and phosphorous concentrations. The water sample had a high sediment load as well, which may have contributed to the levels found, especially for phosphorous, which is often particle associated (Figure x). Samples taken at this location in 2018 during both dry and wet sampling events had clear water and much lower concentrations of nutrients. This sample point picks up the north branch of Taylor's Creek near Pungoteague, and one of three stream branches in the watershed drain from the vicinity of 2 adjacent 12 house poultry operations. These high levels suggest an inspection of storm water control from the site may be warranted to determine if the sediment and nutrient loads found are from the poultry site or from local agricultural fields.

Station 59 (Mill Branch of Guilford Creek) had the next highest total nitrogen concentration. Three poultry operations are in this watershed, but a line of residences (Hopeton) between the poultry houses and the stream may have more of a direct impact. The next highest nitrogen value for a streamshed where a poultry operation exists is station 53 on Katy Young Branch of Bagwell Creek. This poultry operation appears to be in a position to drain to either station 53 or station 56, but it is closer to the stream affecting station 56 which also has an additional poultry operation in that watershed. Station 53 is also on the northern border of the town of Parksley. Station 56 as the more probable recipient of poultry operation runoff was not on the list of stations exceeding the OECs.

Stations 60, 61, 50, and 40 with poultry operations in the watersheds had nitrogen values between the lower and upper estimates for OECs. Station 60 has two multi-house operations in

its Gargothy Creek watershed. Station 61 is downstream of Station 59, and picks up another poultry operation in that stream segment. It also drains part of the Guilford community as does Station 62 with a lower nitrogen content but higher phosphorous concentration. Station 50 is on Lee Mont Branch of Hunting Creek, with a single poultry operation upstream and some drainage from the Lee Mont community. Station 40 was taken from a Gaskin Road ditch next to an older poultry operation. This station (40) also had a TP concentration exceeding the estimated OEC.

Besides Station 30 with the highest recorded phosphorous concentration mentioned above, the next highest TP sample where poultry operations may be a factor was a sample from Station 40, taken in a Gaskins Road ditch next to an older poultry house operation, followed by Station 41, downstream of Station 40 and also receiving drainage from residences along Gaskins Road and Savageville Road.

Correlation (bivariate) analysis of landuse/landcover variables (x) upstream of sample locations and nutrient values (y) were non-significant ($P > 0.05$) showing no discernable potential connections except for a positive relationship between increasing forest cover and total nitrogen concentrations and a negative relationship between increasing agricultural field coverage and total nitrogen concentrations (Figures 9 and 10; Appendix Table A4). An apparent increase in total nitrogen values with increasing residential coverage was not significant, and an apparent decrease in total nitrogen values with increasing swamp coverage was also not significant. Linear distance between sampling locations and poultry operations did not show any positive or negative effects on nutrient values (Figure 10). The compass direction between poultry operations and sample locations, which would indicate any prevailing wind effects, was also not significant (Figure 10). With the exceptions noted above, no apparent effects of the poultry industry on ESVA freshwater stream nutrient concentrations was apparent. Continued sampling and analysis would identify any localized problems and would continue to test these results.

Future directions

The stations sampled in 2019 will be resampled twice in 2020, once after a dry period that would accentuate groundwater sources, and one after a rain event to capture storm water runoff influences. Some of the stations sampled in 2019 after 2" rainfalls may not hold water after a dry period. The distance measure used in this analysis will be modified in the future to encompass the distance to nearest stream channel and distance downstream to the sampling point in an attempt to capture this dynamic more accurately. A study is underway by The Delmarva Poultry Industry, Inc, Maryland Department of the Environment, and the Keith Campbell Foundation for the Environment to directly measure ammonia production and attenuation from poultry operations. When those data are available they will permit the development of impact zones for determining inputs to streamsheds. Wetland and agricultural field databases will used to improve the accuracy of landcover estimates. Historical data on ESVA stream water quality from VA DEQ is being compiled in an effort to provide a temporal trend component to the analysis, which will be dependent on the spatial and temporal coverage of the available data. As multi-year data are collected and the sophistication of the analysis is built, greater resolution and stronger conclusions can be made.

References

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Giordano, JCP, MJ Brush, and IC Anderson. 2011. Quantifying annual nitrogen loads to Virginia's coastal lagoons: sources and water quality response. *Estuaries and Coasts* 34:297-309.

Zipper, CE, K Stephenson, L Shabman, G Yagow, and J Walker. 2012. *Technical and policy considerations and options in assessing nutrient stresses on freshwater streams in Virginia. Report of the Academic Advisory Committee for the Virginia Department of Environmental Quality*. Virginia Water Resources Research Center, Virginia Tech, Blacksburg, VA.

Table 1. Geomeans of total nitrogen and total phosphorous (mg/L) in freshwater streams of Accomack County with and without poultry houses in the watershed.

Sampling year	No Poultry TN	Poultry TN	No Poultry TP	Poultry TP
2018	1.489	1.149	0.043	0.035
2019	1.815	1.932	0.190	0.110
2018 + 2019	1.668	1.584	0.081	0.071
all data:	TN		TP	
poultry and no poultry	1.648		0.078	

Table 2. Data for stations exceeding the 2.6 mg/L lowest Observable Effects Level (OEC) for TN (Zipper et al., 2012). This represents 27.7% of all stations. The number of stations in the category with poultry operations in the watershed was 6 of 23 or 26.0%. Eleven samples exceed the upper limit of an OEC at 3.66 mg/L (yellow shading), 3 of which have poultry operations in the watershed.

date	Station	Distance	Bearing	Poultry	Humans	Forest	Field	Swamp	TN mg/L	TP mg/L
20 Apr 19	40	141	60	Y	0	50	50	0	2.608	0.6309
20 Apr 19	8			N	40	10	50	0	2.714	0.2417
24-Jul-19	81			N	0	30	30	40	2.787	0.0868
24-Jul-19	65			N	5	5	90	0	2.918	0.1729
20 Apr 19	21	300	45	N	0	50	50	0	2.929	0.2691
20 Apr 19	32	1030	45	N	0	30	70	0	3.016	0.501
24-Jul-19	79	1035	330	N	0	70	0	30	3.055	0.2472
20 Apr 19	5	1719	225	N	20	70	10	0	3.331	0.4483
24-Jul-19	50	969	120	Y	0	40	60	0	3.439	0.0941
24-Jul-19	60	458	45	Y	0	20	80	0	3.472	0.058
24-Jul-19	61	457	145	Y	20	30	50	0	3.484	0.1703
20 Apr 19	6	2000	225	N	0	50	0	50	3.526	0.0912
24-Jul-19	82	1628	315	N	20	10	50	20	4.109	0.0795
24-Jul-19	74	668	45	N	0	50	50	10	4.259	0.0546
24-Jul-19	49	1628	315	N	0	50	50	0	4.292	0.0946
24-Jul-19	52	1872	240	N	0	55	50	0	4.564	0.0318
24-Jul-19	58			N	0	50	50	0	4.76	0.0392
24-Jul-19	53	903	90	Y	50	40	10	0	5.35	0.0895
24-Jul-19	55			N	0	20	80	0	5.3790	0.2835
24-Jul-19	75	1216	240	N	0	50	0	50	6.296	0.1259
20 Apr 19	35			N	0	90	0	10	6.65	0.4104
24-Jul-19	59	500	225	Y	20	30	50	0	7.1970	0.0788
20 Apr 19	30	1552	135	Y	0	40	50	10	8.974	1.8169

Table 3. Data for stations exceeding the lower 0.25 mg/l lower Observable Effects Concentrations (OEC) for TP (Zipper et al., 2012). This represents 14.5% of all stations. Two of the 12 stations have poultry operations in the watershed or 16.7%. Seven of these 12 stations are the same as stations showing TN exceedances (Table 2). Nine of these stations exceed an upper limit for an OEC for phosphorous at 0.284 mg/L (yellow shading), 3 of which have poultry operations in the watersheds.

date	Station	Distance	Bearing	Poultry	Humans	Forest	Field	Swamp	TN mg/L	TP mg/L
20 Apr 19	1	1820	45	N	20	50	30	0	1.5532	0.2656
20 Apr 19	21	300	45	N	0	50	50	0	2.929	0.2691
24-Jul-19	55			N	0	20	80	0	5.3790	0.2835
24-Jul-19	63	752	135	N	0	30	10	60	2.067	0.3493
20 Apr 19	35			N	0	90	0	10	6.65	0.4104
20 Apr 19	5	1719	225	N	20	70	10	0	3.331	0.4483
20 Apr 19	41	383	120	Y	20	40	40	0	2.539	0.4585
20 Apr 19	32	1030	45	N	0	30	70	0	3.016	0.501
24-Jul-19	80			N	5	40	60	0	1.933	0.582
20 Apr 19	40	141	60	Y	0	50	50	0	2.608	0.6309
20 Apr 19	18			N	5	15	80	0	1.426	0.6834
20 Apr 19	30	1552	135	Y	0	40	50	10	8.974	1.8169

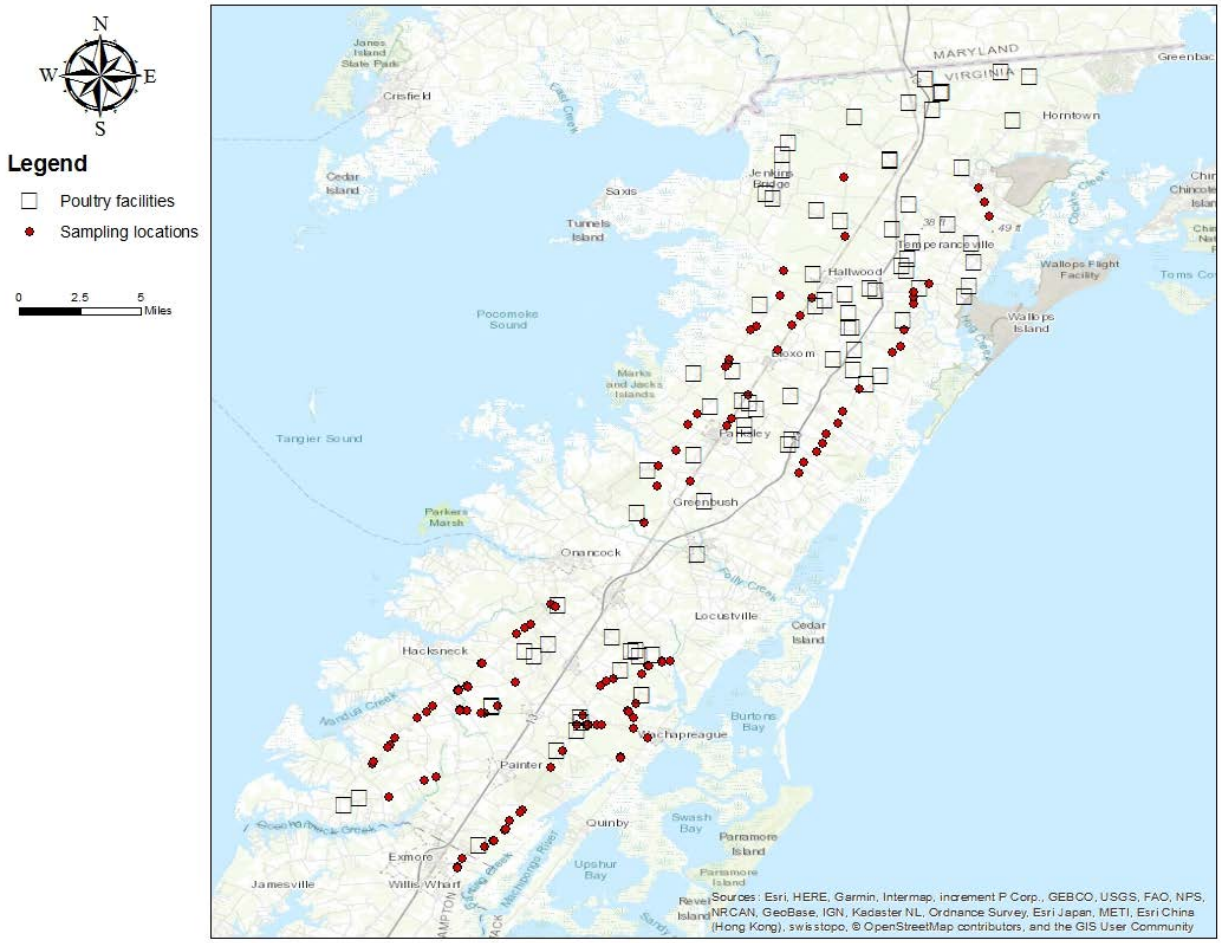

Figure 1. Sampling locations (red dots) in southern and northern Accomack County sampled in April and July of 2019. Known poultry operations are indicated by the square symbols.

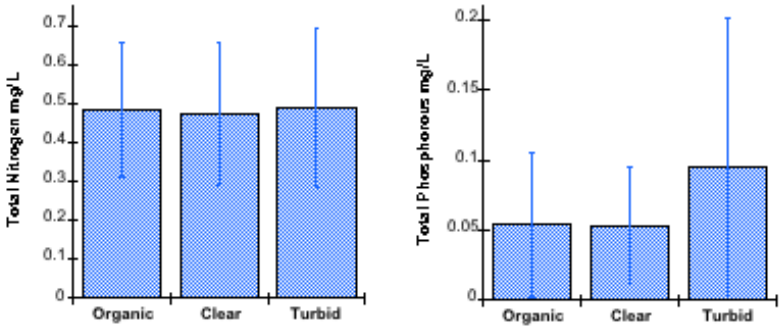

Figure 2. Effect of turbidity on nitrogen (left) and phosphorous (right) in stream water samples. Organic = "black water" organic stained clear water, Clear = low turbidity, Turbid = high turbidity samples.

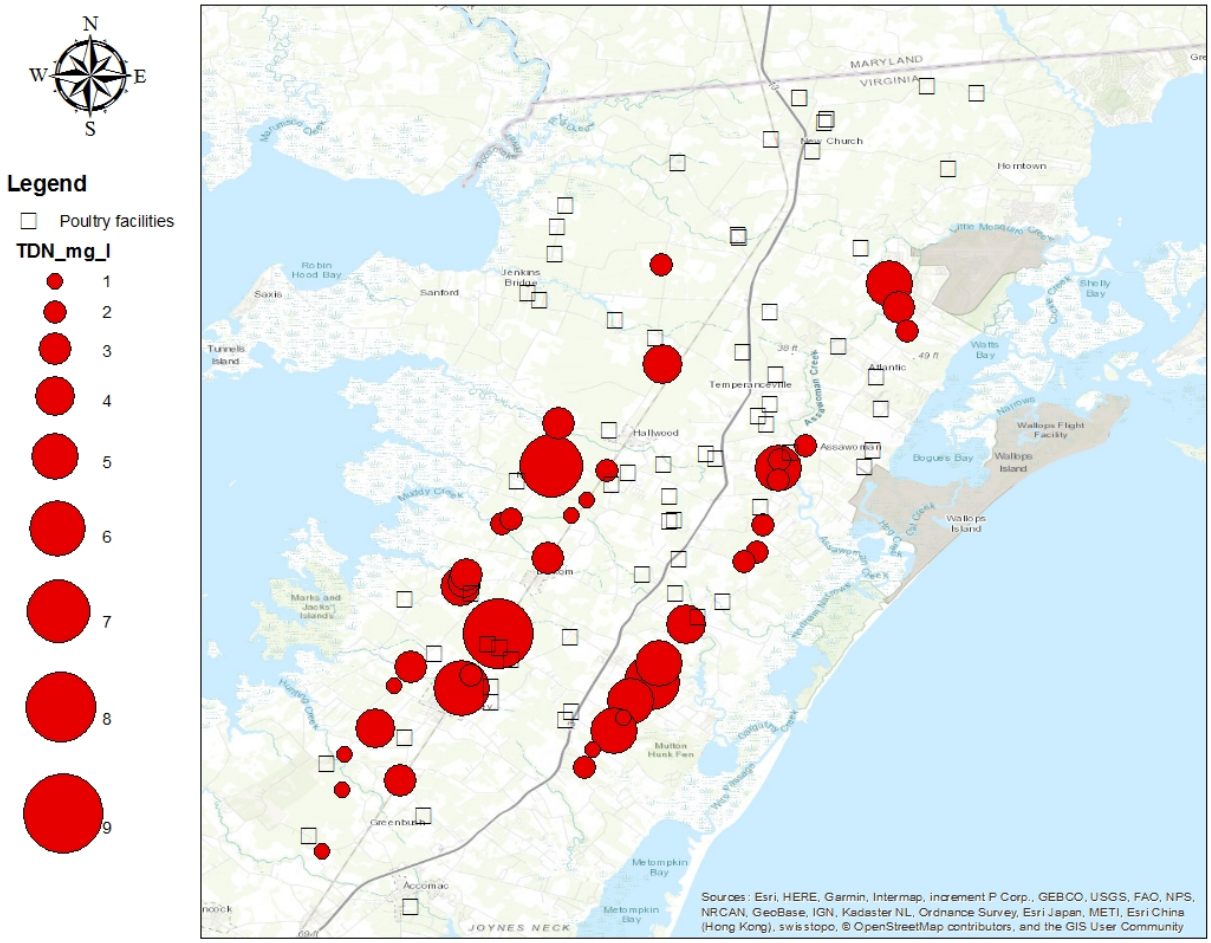

Figure 3. Total Nitrogen concentrations in water samples taken at streams crossing roads in northern Accomack County 24 July 2019.

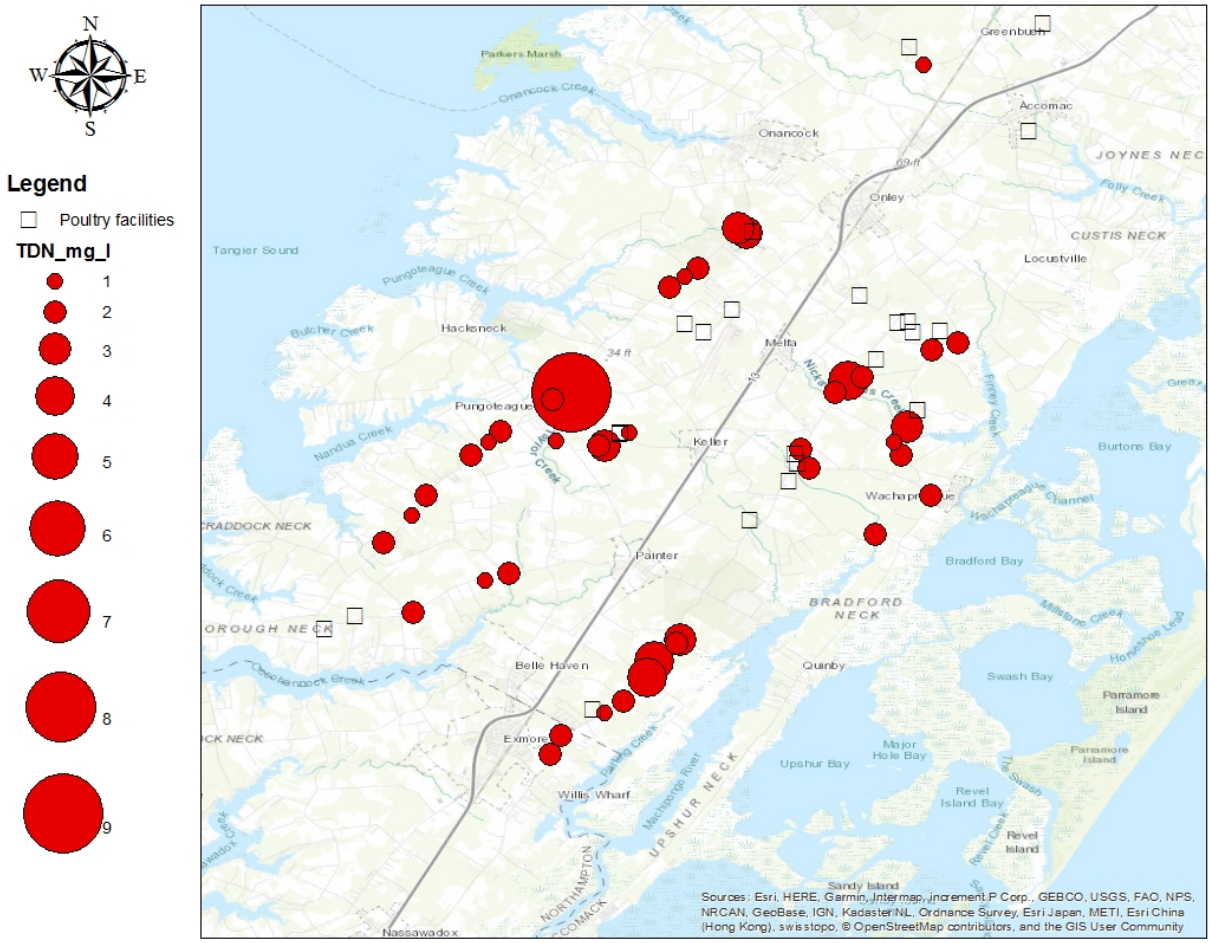

Figure 4. Total Nitrogen concentrations in water samples taken at streams crossing roads in southern Accomack County 20 April 2019.

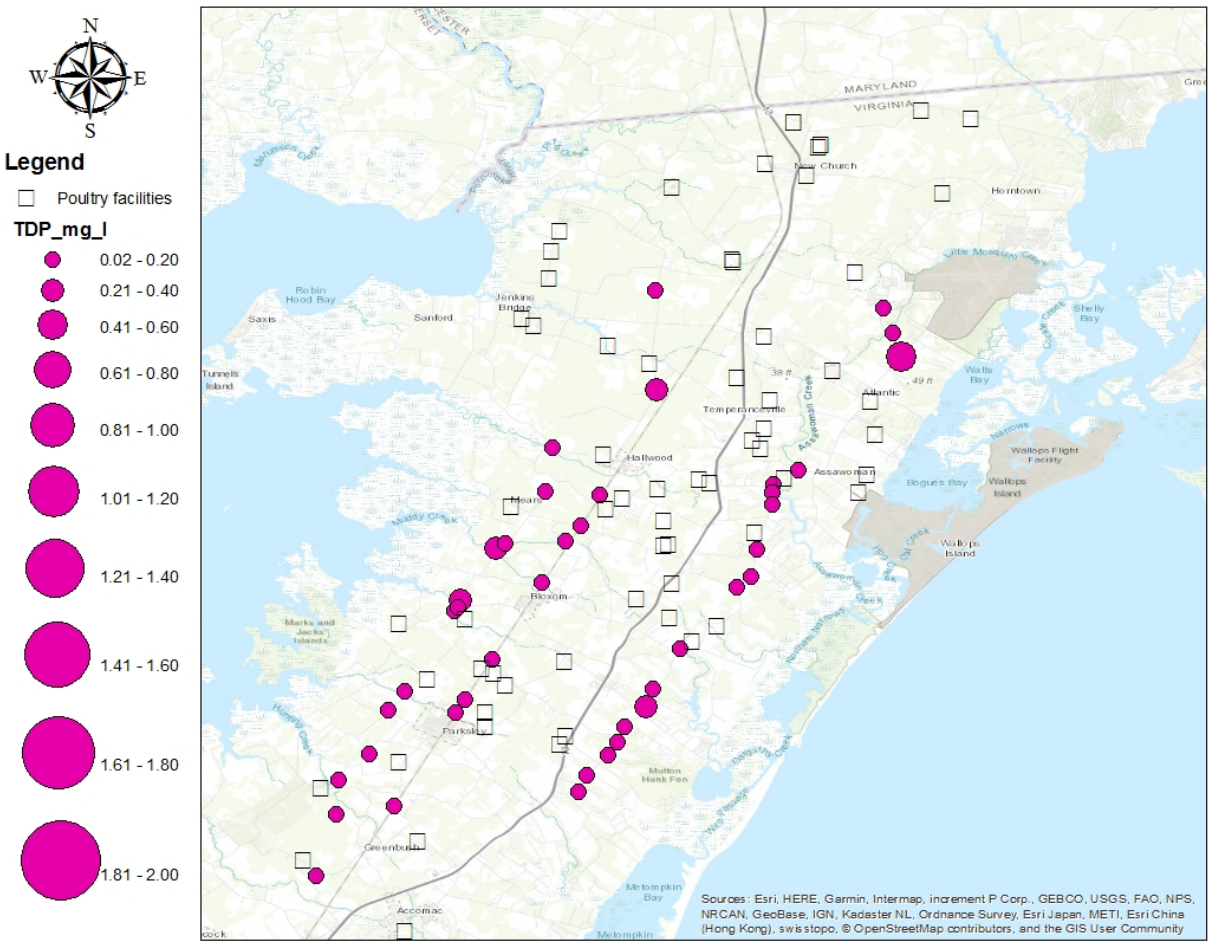

Figure 5. Total phosphorous concentrations in water samples taken at streams crossing roads in northern Accomack County 24 July 2019.

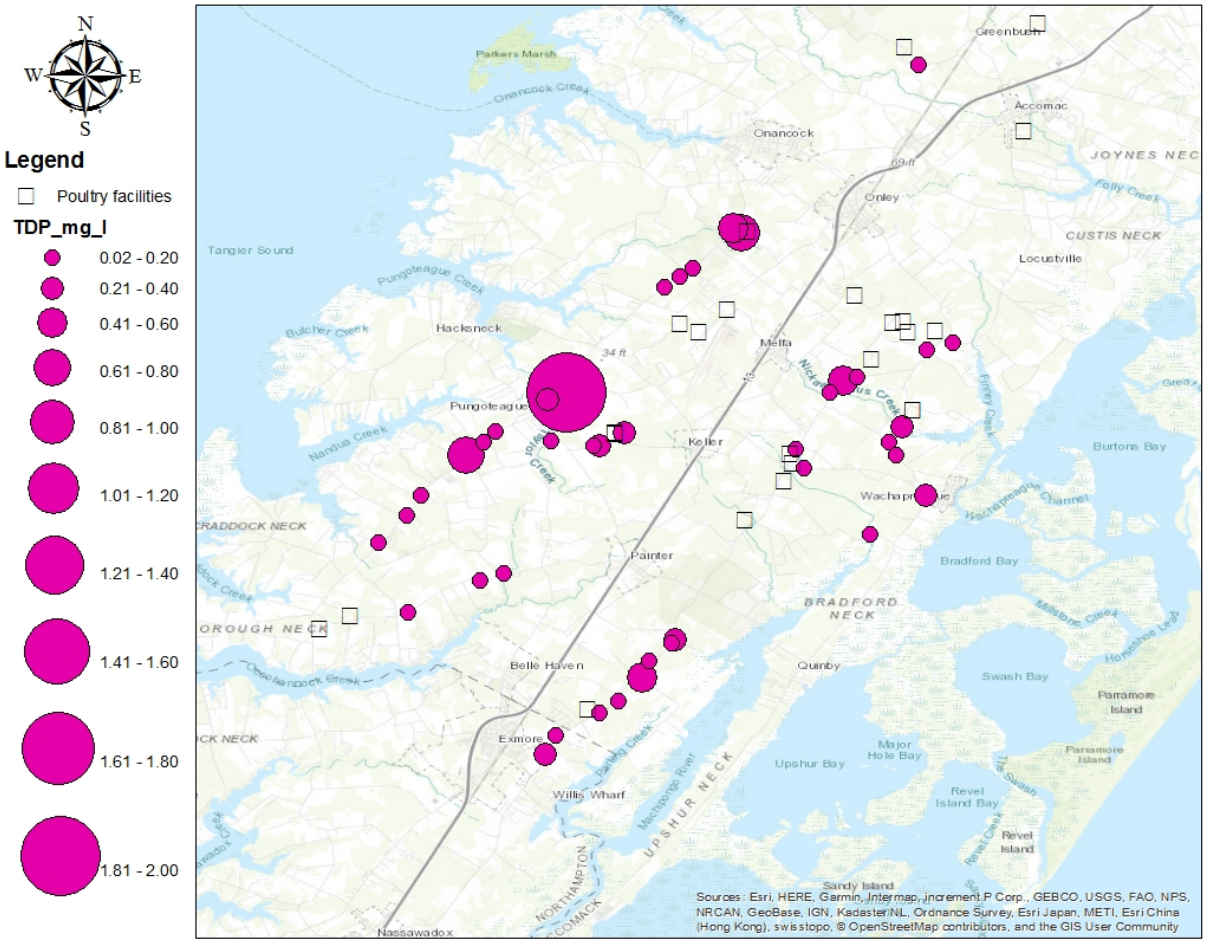

Figure 6. Total phosphorous concentrations in water samples taken at streams crossing roads in southern Accomack County 20 April 2019.

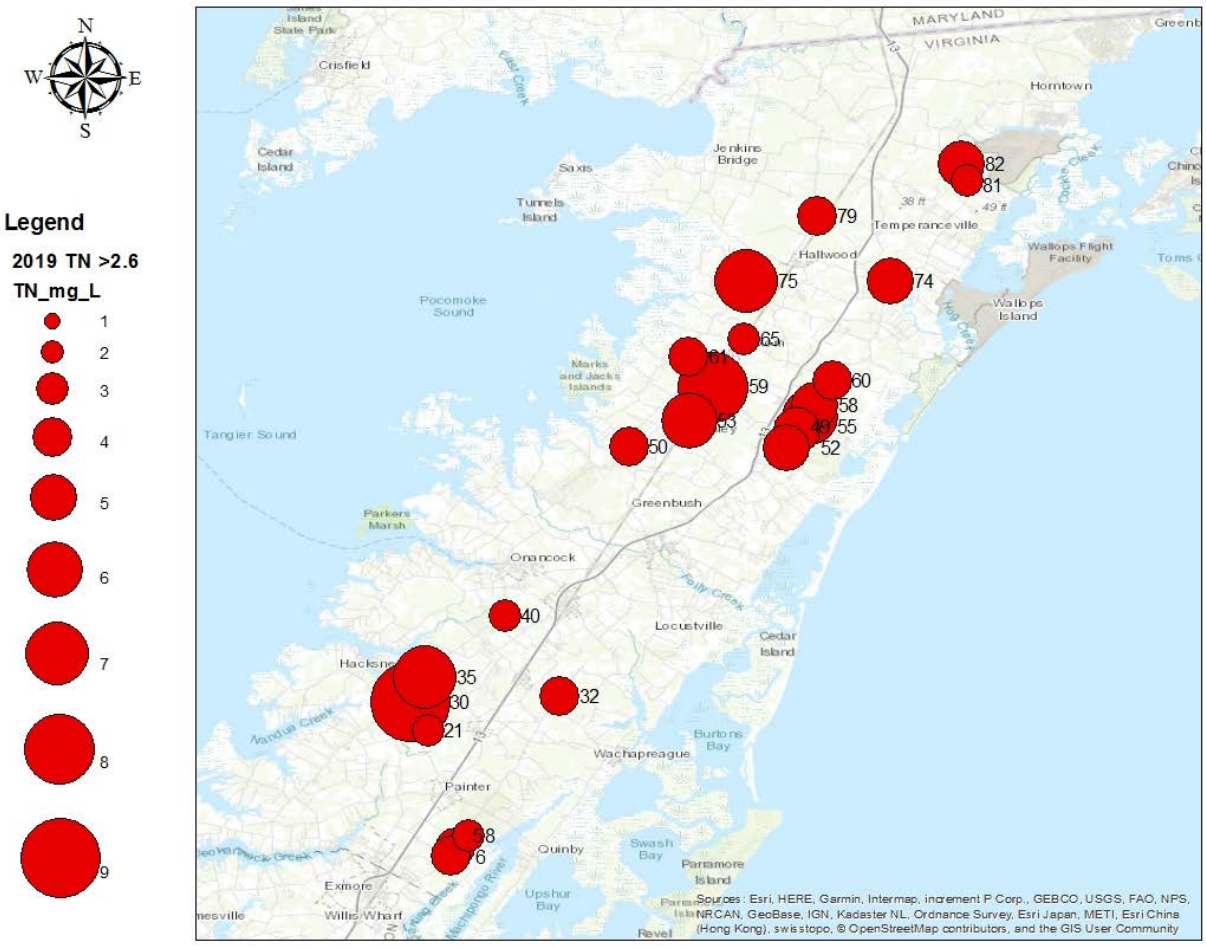

Figure 7. Stations with TN concentrations exceeding the OEC lower limit threshold of 2.60 mg/L.

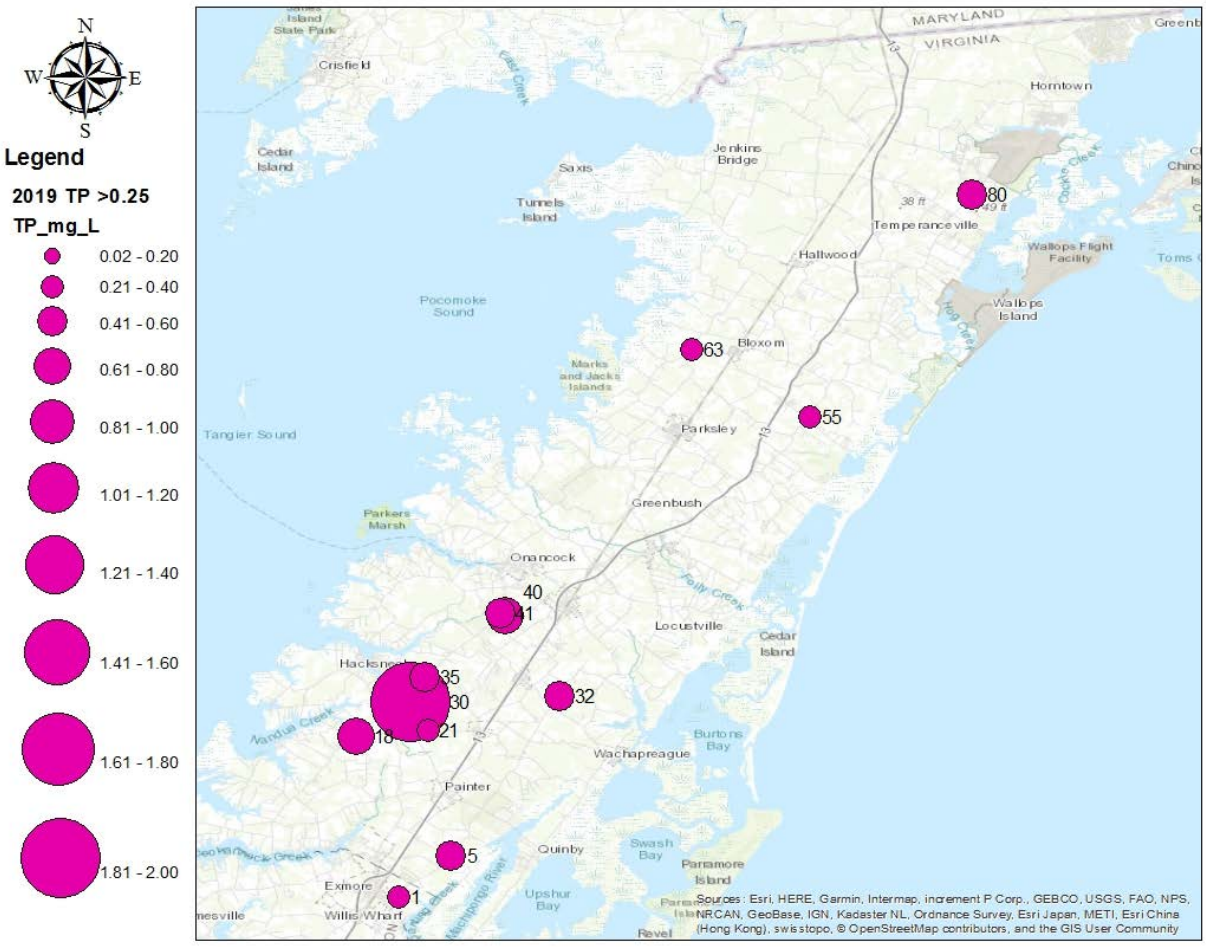

Figure 8. Stations with TP concentrations exceeding the OEC lower limit threshold of 0.25 mg/L.

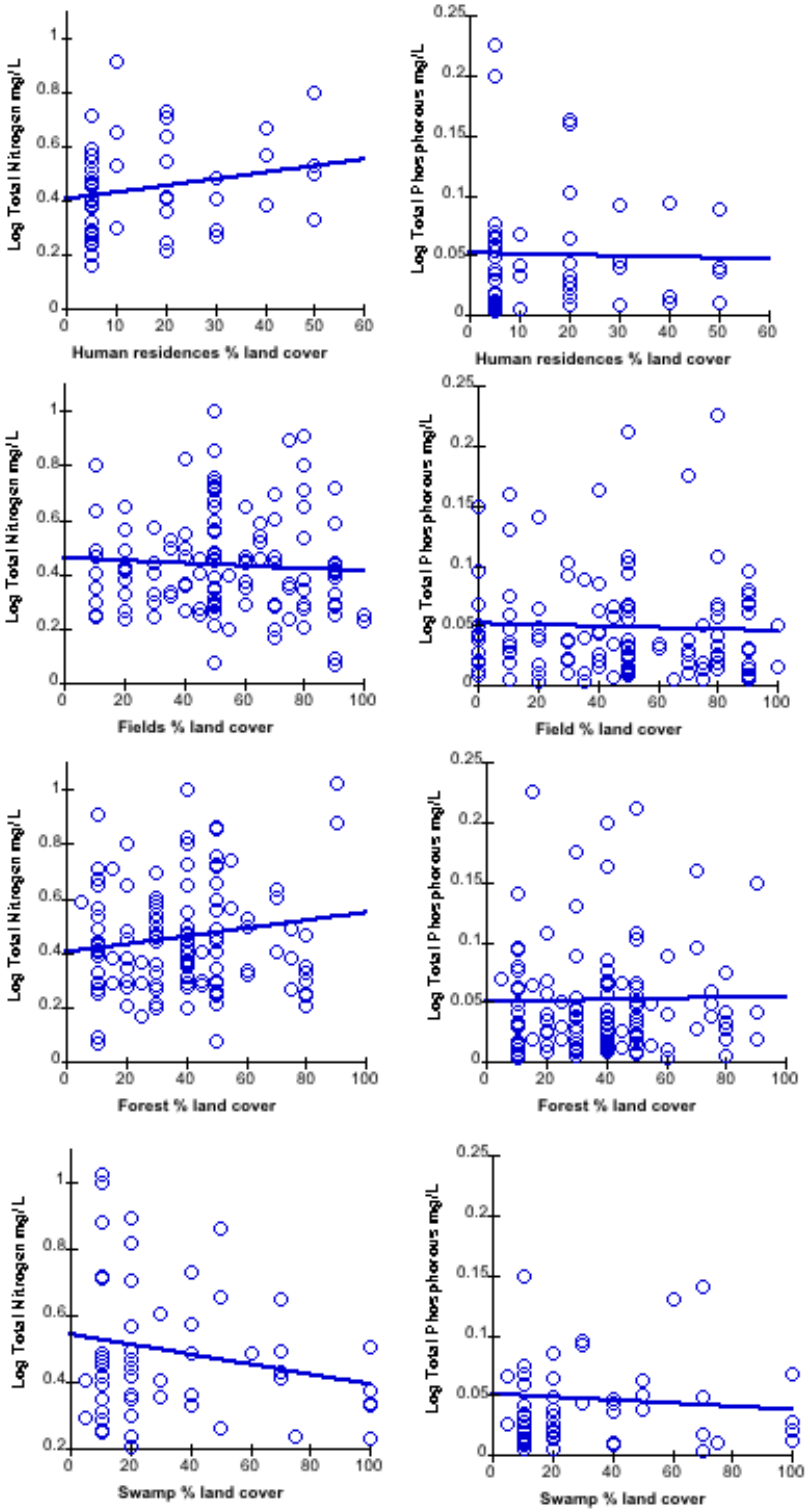

Figure 9. Total Nitrogen (left column) and total phosphorous (right column) in relation to % land cover characteristics for sample location drainages. The statistical analysis of these plots is presented in Appendix Table A4.

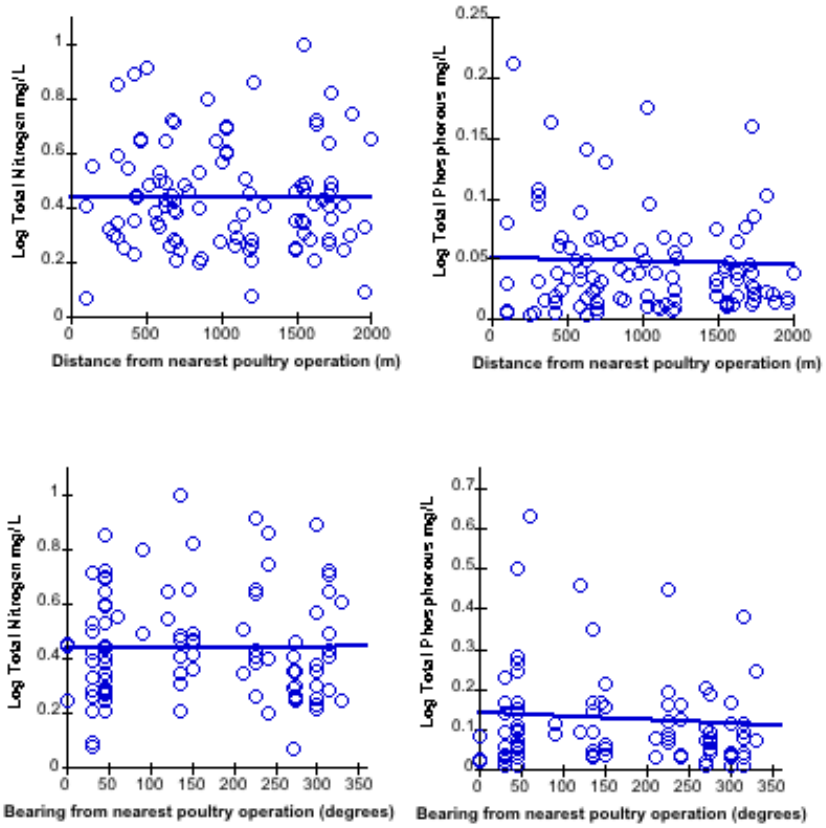

Figure 10. Total nitrogen and total phosphorous in stream water samples in relation to distance and compass bearing from the nearest poultry operation regardless of poultry operation watershed location to capture air transport of nutrients to watersheds. Statistical analysis of these plots is presented in Appendix Table A4.

Appendix

Table A1. Sample station data for Accomack stream water samples 2019 collected by hand held GPS and handheld YSI multiparameter water quality meter.

Sample #	date	time	Station	Lat	Long	Temp deg C	DO mg/L	Salinity	pH
61	4/20/19	9:43	15	37.6057	75.6960	18.00	3.34	0.15	8.57
62	4/20/19	9:50	13	37.5943	75.7125	19.70	7.95	0.85	7.62
63	4/20/19	10:03	8	37.5631	75.7703	17.60	7.42	0.05	8.07
64	4/20/19	10:07	7	37.5618	75.7716	17.20	4.40	0.05	7.05
65	4/20/19	10:10	6	37.5566	75.7780	17.10	4.97	0.05	6.81
66	4/20/19	10:14	5	37.5517	75.7801	17.80	6.52	0.07	6.85
67	4/20/19	10:19	4	37.5448	75.7874	17.50	7.38	0.04	7.08
68	4/20/19	10:25	3	37.5414	75.7928	17.60	7.78	0.06	7.04
69	4/20/19	10:30	2	37.5345	75.8057	17.70	5.65	0.06	6.95
70	4/20/19	10:36	1	37.5291	75.8089	17.40	5.82	0.07	6.89
71	4/20/19	10:53	9	37.5711	75.8497	18.00	5.24	0.04	7.04
72	4/20/19	10:59	10	37.5806	75.8282	19.20	6.24	0.09	6.97
73	4/20/19	11:03	11	37.5825	75.8212	18.20	6.57	0.07	6.84
74	4/20/19	11:12	12	37.5918	75.8583	17.40	6.34	0.06	7.03
75	4/20/19	11:16	14	37.6000	75.8500	18.00	4.83	0.06	6.96
76	4/20/19	11:20	16	37.6057	75.8457	18.20	6.43	0.04	6.57
77	4/20/19	11:24	18	37.6177	75.8326	18.60	6.57	0.15	6.47
78	4/20/19	11:30	24	37.6216	75.8271	19.40	6.77	0.06	6.90
79	4/20/19	11:35	27	37.6249	75.8236	18.80	3.77	0.06	6.81
80	4/20/19	11:43	21	37.6204	75.7927	16.70	4.06	0.06	6.34
81	4/20/19	11:50	22	37.6206	75.7945	18.50	6.09	0.06	6.54
82	4/20/19	11:53	25	37.6221	75.8073	19.90	7.04	0.08	6.73
83	4/20/19	11:58	29	37.6341	75.8082	18.90	6.33	0.06	6.91
84	4/20/19	12:03	30	37.6363	75.8025	18.10	5.73	0.08	6.78
85	4/20/19	12:10	35	37.6498	75.7944	19.10	6.10	0.15	6.95
86	4/20/19	12:18	26	37.6255	75.7958	19.50	6.15	0.05	7.51
87	4/20/19	12:26	37	37.6676	75.7735	18.20	6.57	0.04	7.06
88	4/20/19	12:30	38	37.6707	75.7688	18.30	4.32	0.03	5.66
89	4/20/19	12:33	39	37.6732	75.7652	17.90	6.24	0.04	6.21
90	4/20/19	12:40	41	37.6849	75.7532	19.70	5.39	0.04	6.29
91	4/20/19	12:44	40	37.6837	75.7506	21.50	5.02	0.04	6.55
92	4/20/19	12:57	36	37.6509	75.6879	19.70	6.14	0.07	6.83
93	4/20/19	13:02	34	37.6488	75.6957	19.30	6.83	0.10	6.79
94	4/20/19	13:09	33	37.6409	75.7165	19.90	7.36	0.18	6.80
95	4/20/19	13:13	32	37.6398	75.7206	19.40	5.71	0.13	6.85
96	4/20/19	13:17	31	37.6365	75.7243	18.90	6.18	0.08	6.89
97	4/20/19	13:22	20	37.6194	75.7345	19.90	6.94	0.06	6.77
98	4/20/19	13:27	17	37.6137	75.7321	19.20	4.40	0.06	6.51
99	4/20/19	13:34	19	37.6178	75.7048	20.07	4.33	0.04	5.81
100	4/20/19	13:38	23	37.6216	75.7070	19.10	5.10	0.05	6.22
101	4/20/19	13:54	28	37.6263	75.7030	19.80	6.17	0.08	6.52
102	24-Jul-19	8:08	55	37.7922	75.5832	24.20	4.03	0.05	7.50
103	24-Jul-19	8:15	58	37.7987	75.5804	19.50	9.93	0.13	7.48
104	24-Jul-19	8:27	60	37.8125	75.5711	19.60	9.58	0.12	7.35
105	24-Jul-19	8:37	64	37.8342	75.5512	23.20	5.66	0.14	7.03
106	24-Jul-19	8:44	66	37.8376	75.5464	20.40	5.28	0.11	7.27
107	24-Jul-19	8:50	67	37.8470	75.5444	20.30	7.17	0.11	7.11

108	24-Jul-19	8:57	72	37.8627	75.5390	20.00	6.68	0.11	6.91
109	24-Jul-19	9:02	74	37.8668	75.5388	18.80	6.52	0.11	6.81
110	24-Jul-19	9:07	76	37.8696	75.5388	22.00	5.65	0.10	6.44
111	24-Jul-19	9:13	77	37.8747	75.5297	21.70	5.44	0.11	6.64
112	24-Jul-19	9:26	80	37.9144	75.4943	22.90	1.86	0.12	6.92
113	24-Jul-19	9:31	81	37.9225	75.4970	20.80	5.46	0.10	7.09
114	24-Jul-19	9:39	82	37.9310	75.5003	19.70	7.52	0.09	7.11
115	24-Jul-19	9:57	83	37.9375	75.5797	21.60	5.42	0.08	6.60
116	24-Jul-19	10:09	79	37.9028	75.5793	26.80	6.03	0.51	7.64
117	24-Jul-19	10:18	73	37.8660	75.5989	21.00	6.77	0.11	7.89
118	24-Jul-19	10:28	71	37.8555	75.6059	22.30	3.55	0.13	6.71
119	24-Jul-19	10:29	70	37.8502	75.6109	22.00	6.35	0.09	6.79
120	24-Jul-19	10:37	65	37.8354	75.6193	21.90	4.66	0.11	6.08
121	24-Jul-19	10:51	78	37.8825	75.6155	22.00	6.09	0.15	7.26
122	24-Jul-19	11:01	75	37.8674	75.6180	21.70	2.80	0.10	6.54
123	24-Jul-19	11:07	69	37.8490	75.6320	22.00	6.71	0.09	6.77
124	24-Jul-19	11:13	68	37.8474	75.6355	23.10	3.67	0.85	6.31
125	24-Jul-19	11:22	63	37.8296	75.6478	23.40	2.73	1.06	7.09
126	24-Jul-19	11:26	62	37.8272	75.6486	22.40	6.91	0.17	7.49
127	24-Jul-19	11:30	61	37.8257	75.6499	23.90	6.64	0.12	6.91
128	24-Jul-19	11:41	57	37.7978	75.6670	21.20	6.19	0.10	7.18
129	24-Jul-19	11:46	54	37.7910	75.6726	23.30	5.12	0.07	7.04
130	24-Jul-19	12:05	50	37.7761	75.6826	22.00	6.12	0.15	7.11
131	24-Jul-19	12:10	47	37.7671	75.6901	26.10	3.05	0.13	6.72
132	24-Jul-19	12:16	44	37.7479	75.6775	24.00	4.14	0.09	7.19
134	24-Jul-19	12:31	43	37.7339	75.6868	26.20	4.32	0.10	7.19
135	24-Jul-19	12:42	42	37.7479	75.6773	21.30	5.24	0.11	7.06
136	24-Jul-19	12:51	45	37.7579	75.6708	21.70	6.30	0.11	6.61
137	24-Jul-19	13:10	53	37.7903	75.6493	20.60	6.71	0.15	7.12
138	24-Jul-19	13:18	56	37.7947	75.6462	22.30	6.71	0.09	7.03
139	24-Jul-19	13:27	59	37.8091	75.6366	20.80	6.24	0.13	6.72
140	24-Jul-19	14:04	52	37.7856	75.5904	22.00	7.50	0.16	7.48
141	24-Jul-19	14:11	51	37.7799	75.5928	21.60	5.13	0.07	6.78
142	24-Jul-19	14:17	49	37.7754	75.5964	24.90	5.62	0.12	7.24
143	24-Jul-19	14:24	48	37.7687	75.6036	23.40	5.57	0.10	7.37
144	24-Jul-19	14:29	46	37.7626	75.6067	22.80	5.29	0.18	7.32

Table A2. Determination of Total Dissolved Nitrogen and Total Dissolved Phosphorous by Skalar Auto Analyzer, ASC METHOD: 3005

Document Control Number: 00076

SCOPE AND APPLICATION:

1.1 This method describes the digestion procedure for total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP) in fresh and estuarine surface waters by the alkaline persulfate oxidation technique. The dissolved fraction are aliquots of sample which have passed through a filter to remove particulates. The method is suitable for the determination of total nitrogen (TN) and total phosphorus (TP) with necessary precautions to ensure that particulates are fully digested. The applicable range for TDN and TN is 0.09-0.90 mg/L. The applicable range TDP and TP is 0.01-0.40 mg/L.

SUMMARY OF METHOD:

2.1 The persulfate oxidation technique for nitrogen in water is performed under heated alkaline conditions, where all organic and inorganic forms of nitrogen are oxidized to nitrate. As the reaction proceeds, NaOH is consumed and the pH drops to < 2.2, which allows the oxidation of all phosphorus compounds to orthophosphate.

2.2 An aliquot of digested sample is analyzed for nitrate and orthophosphate using automated colorimetric methods (Method 3001 and Method 3003, respectively) to produce total nitrogen and total phosphorus concentrations.

Table A3. Watershed characteristic data derived from GIS plots and from analysis of water samples for total nitrogen (TN) and total phosphorous (TP). Only sampling points within 2 km of poultry operations were included in the distance analysis.

Station	Distance to nearest Poultry Houses	Bearing to nearest Poultry Houses	Poultry upstream in watershed	% Humans	% Forest	% Field	% Swamp	TN Units: mg/L MDL: 0.0285	TP Units: mg/L MDL: 0.0095
1	1820	45	N	20	50	30	0	1.5532	0.2656
2	1192	0	N	5	50	45	0	1.8680	0.0847
3	347	300	Y	0	0	100	0	0.7976	0.0381
4	845	240	N	5	40	55	0	1.5154	0.1628
5	1719	225	N	20	70	10	0	3.3310	0.4483
6	2000	225	N	0	50	0	50	3.5260	0.0912
7			N	20	40	0	40	1.2958	0.1062
8			N	40	10	50	0	2.7140	0.2417
9	1537	270	N	0	30	40	30	1.2790	0.1062
10			N	5	15	80	0	0.9608	0.1598
11			N	0	40	60	0	1.7792	0.1943
12			N	0	30	70	0	1.9470	0.0706
13			N	0	0	0	100	1.1852	0.0672
14			N	0	40	60	0	0.9585	0.0773
15			N	30	0	30	30	1.5564	0.2354
16			N	5	40	60	0	1.3748	0.1942
17	415	300	Y	0	0	75	20	1.2500	0.0447
18			N	5	15	80	0	1.4260	0.6834
19			N	0	0	0	100	1.1606	0.0481
20	100	270	Y	0	10	90	0	1.5858	0.0721
21	300	45	N	0	50	50	0	2.9290	0.2691
22	436	45	N	0	10	90	0	1.7718	0.1502
23	1200	30	N	0	50	50	0	0.9416	0.0600
24			N	5	25	70	0	0.9572	0.0692
25	1488	275	N	0	80	10	10	0.7756	0.1898
26	300	45	Y	0	10	90	0	0.9664	0.2482
27			N	0	20	80	0	1.2124	0.1401
28	587	30	N	50	60	35	0	2.1500	0.2293
29	1737	150	N	0	40	40	20	1.3278	0.2169
30	1552	135	Y	0	40	50	10	8.9740	1.8169
31			N	5	30	65	0	1.9060	0.1314
32	1030	45	N	0	30	70	0	3.0160	0.5010
33	691	45	N	0	20	80	0	1.4306	0.1685
34	688	30	N	0	0	90	10	1.4732	0.1687
35			N	0	90	0	10	6.6500	0.4104
36	626	315	Y	0	10	20	70	1.6892	0.1181
37	1282	135	Y	5	45	45	5	1.5478	0.1655
38	1625	135	N	0	80	0	20	0.6146	0.0460
39	1622	150	N	20	40	20	20	1.6210	0.1600
40	141	60	Y	0	50	50	0	2.6080	0.6309
41	383	120	Y	20	40	40	0	2.5390	0.4585
42								1.2144	0.0404
43	719	330	N	0	10	90	0	0.7813	0.0744
44			N	0	45	50	5	0.9796	0.0607
45	1538	135	N	30	20	50	0	2.0390	0.0958

46			N	40	10	50	0	1.4484	0.0370
47	651	225	N	0	50	50	0	0.8257	0.1634
48	1597	315	N	5	45	50	0	0.9285	0.0309
49	1628	315	N	0	50	50	0	4.2920	0.0946
50	969	120	Y	0	40	60	0	3.4390	0.0941
51	1852	275	N	0	50	30	20	0.9968	0.0520
52	1872	240	N	0	55	50	0	4.5640	0.0318
53	903	90	Y	50	40	10	0	5.3500	0.0895
54	1711	45	Y	30	30	40	0	0.8525	0.1085
55			N	0	20	80	0	5.3790	0.2835
56	782	150	Y	0	50	50	0	1.9060	0.1575
57	847	45	N	10	10	80	0	2.4360	0.1000
58			N	0	50	50	0	4.7600	0.0392
59	500	225	Y	20	30	50	0	7.1970	0.0788
60	458	45	Y	0	20	80	0	3.4720	0.0580
61	457	145	Y	20	30	50	0	3.4840	0.1703
62	516	135	N	5	75	10	10	2.0690	0.1476
63	752	135	N	0	30	10	60	2.0670	0.3493
64	1673	225	N	0	10	90	0	1.7240	0.1952
65			N	5	5	90	0	2.9180	0.1729
66	1717	0	N	0	40	50	10	1.8180	0.029
67	670	0	Y	0	20	60	10	1.8190	0.0846
68			N	0	30	70		1.7755	0.2265
69			N	0	80	20	0	1.1526	0.1024
70	1713	45	N	0	30	70	0	0.9203	0.0946
71	989	45	N	5	40	45	0	0.9010	0.1426
72	1094	30	N	0	30	30	40	1.1558	0.0234
73	577	210	Y	0	40	60	0	1.2410	0.0789
74	668	45	N	0	50	50	10	4.2590	0.0546
75	1216	240	N	0	50	0	50	6.2960	0.1259
76	427	45	Y	0	50	30	20	1.7970	0.0950
77	553	225	Y	5	75	20	0	1.4310	0.1206
78	1562	90	Y	0	50	10	40	2.0910	0.1148
79	1035	330	N	0	70	0	30	3.0550	0.2472
80			N	5	40	60	0	1.9330	0.5820
81			N	0	30	30	40	2.7870	0.0868
82	1628	315	N	20	10	50	20	4.1090	0.0795
83			N	0	25	75	0	1.3438	0.1219

Table A4. Statistical analysis of correlation plots shown in Figures x & y.

Bivariate Fit of Log TN mg/L By Distance

RSquare	2.564e-6
RSquare Adj	-0.01
Root Mean Square Error	0.1966
Mean of Response	0.440617
Observations (or Sum Wgts)	102

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.0000099	0.00001	0.0003
Error	100	3.8651689	0.038652	**Prob > F**
C. Total	101	3.8651788		0.9873

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.4400296	0.041535	10.59	<.0001*
Distance	5.7891e-7	3.615e-5	0.02	0.9873

Bivariate Fit of Log TP mg/L By Distance

RSquare	0.000688
RSquare Adj	-0.0093
Root Mean Square Error	0.057022
Mean of Response	0.047935
Observations (or Sum Wgts)	102

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00022398	0.000224	0.0689
Error	100	0.32515557	0.003252	**Prob > F**
C. Total	101	0.32537956		0.7935

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0507278	0.012047	4.21	<.0001*
Distance	-2.752e-6	1.049e-5	-0.26	0.7935

Bivariate Fit of Log TN mg/L By Bearing

RSquare	0.000119
RSquare Adj	-0.00988
Root Mean Square Error	0.196589
Mean of Response	0.440617
Observations (or Sum Wgts)	102

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.0004613	0.000461	0.0119
Error	100	3.8647176	0.038647	**Prob > F**
C. Total	101	3.8651788		0.9132

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.4376634	0.033315	13.14	<.0001*
Bearing	1.9319e-5	0.000177	0.11	0.9132

Bivariate Fit of Log TP mg/L By Bearing

RSquare	0.002774
RSquare Adj	-0.0072
Root Mean Square Error	0.056963
Mean of Response	0.047935

Observations (or Sum Wgts)	102

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00090260	0.000903	0.2782
Error	100	0.32447696	0.003245	**Prob > F**
C. Total	101	0.32537956		0.5991

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0520665	0.009653	5.39	<.0001*
Bearing	-0.000027	5.124e-5	-0.53	0.5991

Bivariate Fit of Log TN mg/L By Humans

RSquare	0.003903
RSquare Adj	-0.00326
Root Mean Square Error	0.208853
Mean of Response	0.451475
Observations (or Sum Wgts)	141

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.0237592	0.023759	0.5447
Error	139	6.0631475	0.043620	**Prob > F**
C. Total	140	6.0869067		0.4617

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.4450621	0.019618	22.69	<.0001*
Humans	0.0011233	0.001522	0.74	0.4617

Bivariate Fit of Log TP mg/L By Humans

RSquare	1.071e-5
RSquare Adj	-0.00718
Root Mean Square Error	0.054915
Mean of Response	0.049224
Observations (or Sum Wgts)	141

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00000449	4.491e-6	0.0015
Error	139	0.41918309	0.003016	**Prob > F**
C. Total	140	0.41918758		0.9693

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0491358	0.005158	9.53	<.0001*
Humans	1.5445e-5	0.0004	0.04	0.9693

Bivariate Fit of Log TN mg/L By Forest

RSquare	0.03096
RSquare Adj	0.023989
Root Mean Square Error	0.205997
Mean of Response	0.451475
Observations (or Sum Wgts)	141

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.1884511	0.188451	4.4409
Error	139	5.8984556	0.042435	**Prob > F**
C. Total	140	6.0869067		0.0369*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.3983041	0.03062	13.01	<.0001*
Forest	0.0015506	0.000736	2.11	0.0369*

Bivariate Fit of Log TP mg/L By Forest

RSquare	0.007548
RSquare Adj	0.000408
Root Mean Square Error	0.054708
Mean of Response	0.049224
Observations (or Sum Wgts)	141

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00316409	0.003164	1.0572
Error	139	0.41602349	0.002993	**Prob > F**
C. Total	140	0.41918758		0.3056

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0423343	0.008132	5.21	<.0001*
Forest	0.0002009	0.000195	1.03	0.3056

Bivariate Fit of Log TN mg/L By Field

RSquare	0.032295
RSquare Adj	0.025333
Root Mean Square Error	0.205855
Mean of Response	0.451475
Observations (or Sum Wgts)	141

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.1965759	0.196576	4.6388
Error	139	5.8903308	0.042376	**Prob > F**
C. Total	140	6.0869067		0.0330*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.5149196	0.03418	15.06	<.0001*
Field	-0.001323	0.000614	-2.15	0.0330*

Bivariate Fit of Log TP mg/L By Field

RSquare	0.00066
RSquare Adj	-0.00653
Root Mean Square Error	0.054898
Mean of Response	0.049224
Observations (or Sum Wgts)	141

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00027684	0.000277	0.0919
Error	139	0.41891075	0.003014	**Prob > F**
C. Total	140	0.41918758		0.7623

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0516049	0.009115	5.66	<.0001*
Field	-4.966e-5	0.000164	-0.30	0.7623

Bivariate Fit of Log TN mg/L By Swamp

RSquare	0.000271
RSquare Adj	-0.00697

Root Mean Square Error	0.209989
Mean of Response	0.451533
Observations (or Sum Wgts)	140

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.0016506	0.001651	0.0374
Error	138	6.0851895	0.044096	**Prob > F**
C. Total	139	6.0868401		0.8469

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.4496787	0.020171	22.29	<.0001*
Swamp	0.0001431	0.000739	0.19	0.8469

Bivariate Fit of Log TP mg/L By Swamp

RSquare	0.002761
RSquare Adj	-0.00446
Root Mean Square Error	0.054935
Mean of Response	0.048942
Observations (or Sum Wgts)	140

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00115322	0.001153	0.3821
Error	138	0.41646745	0.003018	**Prob > F**
C. Total	139	0.41762068		0.5375

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0504926	0.005277	9.57	<.0001*
Swamp	-0.00012	0.000193	-0.62	0.5375