TETRA TECH

MEMO

To:	Gary Shenk, EPA; Peter Claggett, USGS
Cc:	Tom Schueler, CSN
From:	Mark Sievers, Tetra Tech Inc.
Date:	March 31, 2014
Subject:	Land Use Loading Literature Review Task Summary and Results

The memo is separated into the following sections (click for hyperlink):

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1.0 Project Background and Purpose

In October 2012 the Chesapeake Bay Program (CBP) Water Quality Goal Implementation Team (WQGIT) held a two-day retreat to identify critical priorities for the midpoint assessment for the Chesapeake Bay Total Maximum Daily Load (TMDL). One of the high-priority issues the WQGIT identified was improving the resolution of urban land uses in the Chesapeake Bay Watershed Model (CBWM) to produce more accurate loading rates for the urban sector. To that end, the Land Use and Urban Storm Water Workgroups of the Chesapeake Bay Advisory Committee agreed that a first task should be to conduct a literature review and synthesis to summarize the current science on runoff generation and unit nutrient and sediment loading rates for different subcategories of urban land use. The CBP tasked Tetra Tech, through a technical direction, to perform the literature search and preliminary analysis. This technical memo summarizes and documents the findings of the literature review and subsequent analysis.

Generally, the task involved analysis of the scientific literature and TMDL model reports to determine unique unit loading rate(s) (lbs/ac/yr) and runoff concentrations (mg/L) for distinct urban land uses and distinguishing as much as possible the rates for impervious cover (e.g., streets, highways, rooftops, parking lots, residential) and pervious cover (e.g., golf courses). If, during the review, individual land use loading rates or concentrations were found in articles and reports they were entered into a spreadsheet for further analysis.

This memo briefly describes the current methodology for urban land use simulation in the Phase 5.32 CBWM, as well as the literature search and review, data entry, and quality assurance procedures followed for this task. Analyses of findings are included through box plots, histograms, and a statistical analysis.

2.0 Literature Search for Potentially Relevant Studies

Tetra Tech reviewed available literature in an effort to establish appropriate loading estimates for the CBWM. Tetra Tech reviewed many sources of information, including existing CBP documents, CBWM documentation, national databases, reports associated with calibrated and validated models used to support nutrient TMDLs across the country, as well as scientific literature.

Keywords such as the following were included in search terms:

- Nutrient/sediment loads/EMCs/concentration.

- Impervious cover; impervious disconnect.
- Land uses: golf course, rooftop, parking lot, rural roads, urban roads, residential (low, high).
- Stormwater runoff, slope, or quality/runoff characteristics.
- Best management practice (BMP) implementation field monitoring inflows.
- Average daily traffic; extreme events (e.g., large rainfalls); seasonal variations in urban loads.
- Stormwater flow path (e.g., swale vs concrete ditch) and water quality.
- Ground water effects from stormwater runoff water quality.

Multiple variations of the above search terms were entered until the results returned no longer revealed unique and seemingly relevant studies. If during the keyword search an article was found that fit the criteria described above, staff logged document information into a *Master Sources Spreadsheet*.

The Master Sources Spreadsheet contains three tabs: *Reference List*, *Wish List*, and *Overall List*. The *Reference List* tab was used to compile basic information regarding all the articles identified as potentially useful during the keyword searches. The information included the keyword searched, the document URL, citation for the reference, document title, and filename for the downloaded article (if available). A column was added to assign the article, with a unique identifier, to a reviewer and a column was added for review notes. The *Wish List* tab was used to store information about potentially useful studies and articles identified during the review process. For example, if the reviewer noticed additional articles in the references section that appeared to be relevant, the reviewer added them to the wish list to be located and downloaded for review. The *Overall List* tab contains a compilation of all the articles, including reviewed articles and those on the wish list. Additional studies included on the *Wish List* tab were checked against studies on the *Overall List* and if not already being included in the review, they were acquired and evaluated as well. This tab also served to keep track of documents which were not found.

In addition to the general online search, Tetra Tech reviewed studies compiled and provided by Peter Claggett (USGS) and Tom Schueler (Center for Watershed Protection). Tetra Tech also searched the websites for the Center for Watershed Protection (http://www.cwp.org/online-watershed-library-owl), Water Environment Research Foundation (http://www.werf.org/i/a/ka/Stormwater.aspx), and Transportation Research Board (http://www.trb.org/Main/Home.aspx)[1]. Articles from these sites that met the criteria were downloaded and the link, search word, and citations were logged in the same manner as the general Internet search results.

Lastly, data were obtained from the National Stormwater Quality Database (NSQD)[2]. The database is the product of an EPA-funded project by the University of Alabama and the Center for Watershed

[1] Data and links on the CBP's Data Hub (http://www.chesapeakebay.net/data) were also reviewed; however, no loading rate data were found.
[2] Version 3 (Dated February 3, 2008). Tetra Tech contacted Robert Pitt and learned that an updated version has not been released (http://rpitt.eng.ua.edu/Research/ms4/mainms4.shtml).

Protection. NSQD contains stormwater quality data and site information for 8,602 events for more than 100 cities and counties throughout the United States.

3.0 Literature Review and Data Entry for Relevant Loading Rate and Concentration Data

As noted above, in the *Master Sources Spreadsheet*, each study was assigned to a reviewer with a unique document identifier associating the document with the reviewer. Each reviewer then analyzed the assigned article to determine if it did in fact include unique loading rates (lbs/ac/yr), concentration data, and runoff coefficients for different categories of urban land uses. Relevant studies were found to be those where runoff and nutrient/sediment concentrations were monitored for the unique land use, cover type, or source and then reported. For studies having no relevant loading data, the reviewer entered a comment in the *Master Sources Spreadsheet* that the document was not useful or relevant. For reports and articles deemed to contain relevant loading rate data, the reviewer provided a synopsis of the study.

Throughout the literature review, effort was made to obtain information from primary sources, which are the original sources of data. If an article summarized data from another study/article/report, the original document was put on the *Wish List* so that the data would be obtained from the original sources. The main reason behind this was to obtain data details from the original source that are not usually available from sources that only summarize data.

Tetra Tech created a *Data Collection Spreadsheet* to compile unique loading rate and concentration data from the reviewed studies. Only concentrations and loadings before BMP treatment were entered. The data spreadsheet has two tabs:

- *Study Details*: Provides descriptive information to characterize multiple aspects of each study, including a brief description of each study, standard citation information, a list of urban land uses addressed, and a series of columns to denote whether the study addressed such factors as ground water, atmospheric deposition, and dry or stormwater monitoring.
- *Loads_EMCs*: Urban land use-specific loading and concentration data. Each entry consisted of a report ID, state, land use, parameter, values, unit, and comments.

While Tetra Tech attempted to include information related to special considerations such as whether studies accounted for seasonal effects, impacts from ground water, watershed impacts, or extreme events, there was generally no discussion of such factors. Most of the data are related to edge-of-pavement measurements rather than stream measurements. In addition, while Tetra Tech tried to focus on recent data from Chesapeake Bay watershed states, because of limited data, Tetra Tech included studies from across the contiguous country and a few from southern Canada. For instance, many of the highway data from literature was from Texas and California.

4.0 Search, Review, and Data Entry of TMDL Model Reports

Besides the literature search, Tetra Tech also conducted an extensive search for model reports related to nutrient and sediment TMDLs for water bodies in the Chesapeake Bay watershed and nearby states. Tetra Tech relied primarily on individual state websites to identify and download potentially relevant TMDL reports, but also used the Assessment TMDL Tracking and Implementation System (ATTAINS). Most of the TMDLs reviewed did not present existing loads by land use. Many were for more rural areas where there was no benefit from disaggregating urban lands into specific land uses. In addition, many TMDL reports only used a generic urban land use. Generally, TMDLs addressed total nutrients rather than species (e.g., ammonia). When relevant data were available, it was entered into a *TMDL Master Spreadsheet*. TMDL report information (e.g, report ID, title, file name, year, state) were recorded in the *TMDL Information* tab. Existing loading rates by land use were entered into the *TMDL Value* tab, along with area, parameter, units, water body, and notes. The actual TMDLs were not entered, only the existing loads, which were mainly for the impaired water body, but occasionally reference water body loading rates were present, and thus entered. Occasionally, The TMDL report did not report loading rates (e.g., lb/ac/yr) but instead reported loads (e.g., lb/yr) and land use area (e.g., acres). Both pieces of information were entered into the *TMDL Value* tab and then used to calculate the loading rate. Following is a brief synopsis of the state TMDLs searched and findings.

- *Delaware:* In a search for relevant TMDL reports in Delaware, listed at http://www.dnrec.state.de.us/water2000/Sections/Watershed/TMDL/tmdlinfo.htm#co, Tetra Tech did not find any sediment TMDL reports. There were some details related to land use-based loadings, primarily accumulation rates from model calibration runs. These are not actual watershed loading rates for comparison to information obtained from other TMDL reports; however, land use accumulation rates from a few reports are included as examples.
- *Maryland:* Maryland TMDL reports are listed at http://www.mde.state.md.us/programs/Water/TMDL/CurrentStatus/Pages/Programs/WaterPrograms/TMDL/Sumittals/index.aspx. None of the Maryland nutrient TMDL reports reviewed contained loadings per urban land use. Although sediment TMDLs do separate urban loadings into pervious and impervious, the loading rates were taken from the CBWM, so they were not included in this data compilation. Tetra Tech reviewed nutrient, biochemical oxygen demand, and sediment TMDL reports alphabetically until "L." Tetra Tech did not find any useful information, so we assumed that the remaining TMDL reports would contain similar information that was not useful to the analysis.
- *New York:* Tetra Tech reviewed all available approved nutrient and sediment TMDL reports (http://www.dec.ny.gov/chemical/23835.html), including small lakes phosphorus TMDL reports. Seven are listed on the website; only two have disaggregated urban loadings.
- *Pennsylvania:* Tetra Tech limited its review to approved nutrient TMDL reports only. Many of Pennsylvania's TMDL reports include both nutrients and sediment/siltation as pollutants of concern with significant overlap between nutrient TMDLs and sediment/siltation TMDL reports. Half of the 49 nutrient TMDL reports were relevant and reviewed. After reviewing the nutrient TMDL reports for relevance, Tetra Tech reviewed 23 out of 50 of the sediment TMDLs and 29

out of 86 of the siltation TMDL reports. A large proportion of the sediment TMDLs were for acid mine drainage, not urban sources, so these were not relevant.

- *Virginia:* Virginia TMDL reports are available through a searchable database at http://www.deq.state.va.us/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLDevelopment/ApprovedTMDLReports.aspx. Tetra Tech relied on an EPA list of approved nutrient TMDL reports to initially identify relevant reports. Most of Virginia's approved TMDL reports are not related to nutrient or sediment impairments. The spreadsheet indicated there were 271 nutrient impaired water bodies with TMDL reports in Virginia. Of these, 66 were associated with the Chesapeake Bay TMDL and many were not available from either the Virginia Department of Environmental Quality website or the ATTAINS database. Other reports did not list land use-specific loadings or did so by using GWLF standard loading rates.
- *West Virginia:* West Virginia TMDL reports are listed by state hydrologic group at http://www.dep.wv.gov/WWE/watershed/TMDL/Pages/default.aspx. There are a handful of nutrient and sediment TMDL reports (for lakes, pre-2000) that present loads and acres by urban land use. The West Virginia Department of Environmental Protection's sediment TMDLs from 2004–2008 were developed using GWLF and LSPC. Baseline loads are presented by land use for each modeled subwatershed (including an urban/residential/roads category); however, no associated acres are presented in the TMDL report. The exceptions were the Potomac Direct Drain TMDL reports, for which acres are presented. Should this be "Since 2009 sediment TMDLs have been developed iron as a surrogate because iron proved adequate for meeting sediment targets; therefore, sediment information is not presented.
- *Kentucky:* Kentucky TMDL reports are listed at http://water.ky.gov/waterquality/Pages/ApprovedTMDLs.aspx. Tetra Tech reviewed nutrient and sediment TMDL reports (including TMDL reports for organic enrichment. There were no TMDL reports that included land use loading rates.
- *North Carolina:* Tetra Tech searched for nutrient and sediment TMDL reports that were available online from the North Carolina Department of Environment and Natural Resources (http://portal.ncdenr.org/web/wq/ps/mtu/tmdl/tmdls). There were eight sediment TMDL reports (for turbidity) and 11 nutrient TMDL reports (TN, TP, dissolved oxygen). Some of the turbidity TMDL reports did not use total suspended solids (TSS) or sediment as the pollutant, so Tetra Tech did not review them. Tetra Tech did review all TMDL reports.
- *Ohio:* Available TMDL reports were obtained from ATTAINS at http://iaspub.epa.gov/tmdl_waters10/attains_impaired_waters.tmdls?p_state=OH. Most of the TMDL reports cover multiple impairment listings. Many TMDL reports used load duration curves, with sediment TMDL reports tending to be linked to habitat impairment with allocations expressed as Qualitative Habitat Evaluation Index (QHEI) scores rather than TSS loads. Tetra Tech found 11 TMDL reports relevant for review, five of which had land use loadings.
- *Tennessee:* Tetra Tech identified a number of nutrient and siltation TMDL reports for review (http://iaspub.epa.gov/waters10/attains_state.control?p_state=TN#tmdl_by_pollutant). Tetra Tech's initial review of several nutrient TMDL reports revealed that they all referred to identical land use loading rates from Homer et al. (1994), which was included in the *Protocol for Developing Nutrient TMDLs* (USEPA 1999) as initial guidance for TMDL report developers. Because it was not clear that these rates were actually used in the TMDL reports and because of

the redundant nature of the text across the different reports, Tetra Tech did not review additional nutrient TMDL reports from Tennessee. Similarly, Tetra Tech reviewed several siltation TMDL reports developed across several years. The siltation TMDL reports include identical language and methodology valuations, and revealed that none contain land use loading rates.

5.0 Quality Assurance/Quality Control

Data quality is an important aspect of any data analysis project. Tetra Tech employed several quality techniques. First, as previously stated, Tetra Tech tried to use primary data. This decreases the chances of error when it was summarized by a secondary source. As part of the literature review, Tetra Tech looked for indications of data quality; however, the majority of documents did not have statements regarding data quality. Some literature identified that the data were collected under an established quality plan (such as a quality assurance project plan), while others simply stated that data were analyzed in a laboratory using EPA or other standard methods or that quality control samples (e.g., blanks) were collected. The bulk of the concentration data was obtained from NSQD. Before being included in the database, data went through a quality check that was based on the "reasonableness of data, extreme values, relationships among parameters, sampling methods, and a review of the analytical methods" (Maestre and Pitt 2005).

Once data entry was complete, Tetra Tech reviewed the list of documents from which we obtained data. This review was to ensure that the same data were not entered from two different literature sources by the same author using the same water quality study. One such case was found where the same data were used by an author in a journal article and conference proceedings. One set of data was removed so the data analysis was not skewed. Similarly, to prevent data skewing, Tetra Tech did not use data from literature obtained from NSQD.

Using Excel's random number function, Tetra Tech randomly identified 10 percent of the data that were entered into the data collection spreadsheets. (Data from NSQD were not included in the data quality check effort because they were obtained in an Excel spreadsheet file that was assumed to have undergone quality checks before the data was entered into the database.) To help assess data entry quality, additional records were selected from documents that were not represented in the original 10 percent random samples. In addition, any record that had required calculations (e.g., the average of six individually listed concentrations) was flagged for a data quality check. A staff member who was not part of the original data entry process performed the data quality check.

Of the 571 TMDL entries (land use-parameter pairs), 74 entries were selected for data entry checks. These checks included the random 10 percent of entries in addition to entries from documents not selected as part of the random 10 percent, and all entries where Tetra Tech performed calculations. Only one record was found in error. This record was an instance where Tetra Tech averaged six annual loads. The average was corrected in the entry.

There were 1,504 entries from the literature. Of these, 177 entries were selected for data entry check. As with the values from the TMDL reports, these checks included the random 10 percent of entries in addition to entries from documents not selected as part of the random 10 percent and all entries where Tetra Tech performed calculations. There were nine entries that failed the data entry check. One instance was a calculated average of 13 entries. The other eight entries had the incorrect parameter listed because of copy-down error in Excel. These were corrected along with all entries from the document with the copy-down error. In addition, the data were reviewed as a whole to ensure that no additional copy-down errors were present. None were found.

6.0 Data Standardization/Processing

Because data were collected from numerous studies, authors, and sources, Tetra Tech needed to standardize the data to proceed with data analysis. Standardization required converting loading and concentrations to lb/ac/yr and mg/L, respectively. Parameter names were also converted to a common name (e.g., NH_3, ammonia, and total ammoniacal nitrogen were standardized to ammonia), and land uses were converted to standardized names. Several TMDL reports only reported annual loads and land use areas, and in some cases only presented daily or monthly loads. Tetra Tech used these to calculate the standardized annual unit area loading rates. Attachment A includes a list of the original parameter names and how they were standardized.

Similarly, Tetra Tech needed to standardize land use names to simplify data analyses in a meaningful way. During data entry Tetra Tech recorded the land use as it was referred to in the literature. Additional information (e.g., highway average daily traffic and mixed land use percentages) were also recorded as part of the land use. At the completion of data entry, there were more than 250 land use names. Land uses were first standardized in general, single land use categories (e.g., residential and commercial). Next the land uses were categorized in more specific categories (e.g., low-density residential, high-use roads, mixed residential, and commercial) for additional data analysis. Not all of the original land uses from literature could be classified in the general or specific standardizations. For example, mixed land uses were not categorized into general categories, but they were categorized during the specific standardization. Attachment B provides a list of original land uses and their general and specific standardization categories.

The data analysis focused on only TN, TP, and TSS. Therefore, once the units, parameter, and land uses were standardized, Tetra Tech reviewed the nitrogen species data to determine cases where TN was not provided in the literature, but could be calculated using the nutrient species information. Several occurrences were found in both the literature-entered information and the TMDL report information.

NSQD (Version 3 [Dated February 3, 2008]) Excel file was downloaded from http://rpitt.eng.ua.edu/Research/ms4/mainms4.shtml on January 14, 2014. Before the data could be added to the literature data, it was processed. First, columns that contained data that were not relevant to this effort (e.g., rain zone, latitude) were deleted. The database contains samples taken at the end of a

BMP treatment train. These were removed, as this effort was looking at raw concentrations unreduced by BMPs. For each record, land use is listed in the database; however, some were labeled as "unknown." Unknown land uses were deleted because they will not aid in determining the water quality from specific land uses. Tetra Tech also looked at the type of conveyance. If the type was swale, the data were not used. As with the literature and TMDL values, TN was calculated when possible. Lastly, the land uses were standardized. If a record was more than 90 percent of a single land use, it was attributed to that land use. Otherwise, the land use was considered a mix.

Tetra Tech further processed the data before beginning the data analyses. First, any concentration data from the literature review was combined with the loading rates obtained from NSQD. Because of the vast majority of edge-of-pavement samples in the literature data and NSQD, the limited water quality data taken from in streams (four sites) were excluded from the analysis. In addition, the vast majority of data represented mean concentrations; therefore, the few records that represented the geometric mean, maximum, or median values (approximately 100 entries) were also excluded from the analysis.

For the loading analysis, because the TMDL values represent in-stream watershed loadings, Tetra Tech removed the literature loading rates for edge-of-pavement sampling. Model inputs such as LSPC/HSPF accumulation rates and QUAL2E buildup rates were also excluded from the analysis because they do not represent watershed loadings and thus are not directly comparable. Several of the TMDL reports indicated that the loading rates for certain land uses were 0. These were excluded from the analysis so that they did not skew results. One TMDL reported monthly loading rates. These were converted to a yearly loading rate, which was used in the analysis. Tetra Tech also separated loading rates from calibrated models and models that used standard values.

7.0 Analysis and Results

7.1 Analysis – Box Plots

Tetra Tech created box plots showing the literature and TMDL values for each parameter (TN, TP, TSS). The plots, presented in Attachment C, are separated into concentration and then loading rate plots that show the minimum/maximum values, 10th/90th percentile, and the median. Each plot is accompanied by a table of the plotted data along with the number of samples and average. The plots were developed using the actual values and then the Y-axis was converted to log scale to better see the range of data. Several land uses only had limited data—sometimes only one or two data points—which were plotted for comparison purposes, with some of the results appearing to contradict other results. An example is the results for mixed land use for residential and highway. There is a single data point representing the median for mixed land use for residential and highway that is significantly higher than the medians for either residential or highway, but the point is within the 90th percentile for each. For reference, Attachment B presents tables on how the land uses from NSQD, TMDL reports, and literature were aggregated.

7.1.1 Concentration Data Analysis Summary (NSQD and literature)

The median TN concentrations for most of the major land use categories are very close to the current model's concentration of 2 mg/L for developed land. Parking lots and open space have slightly lower median concentrations, while transportation and impervious areas have slightly higher median concentrations. Although there appears to be a median slightly higher than the overall median, turf, golf courses, and high-use roads do not have enough data points to make a definite determination. Similarly, on the basis of limited data, driveways and roofs appear to have a slightly lower median than the overall median.

For TP, the model uses a concentration of 0.27 mg/L for developed land. The median concentrations for most of the major land use categories identified from NSQD and the literature review are close to the model's concentration, with the exception of turf and residential lawns, which are an order of magnitude higher on the basis of limited data. Parking lots and open space have lower medians than the overall median. There is limited data on roofs, which appear to have a lower median than other land uses.

The median TSS concentration from NSQD and the literature review is 64.4 mg/L. Of the land uses with sufficient data (more than two data points), most median land use concentrations were within 15 mg/L of the overall median value. Some exceptions were open space which had a lower median value, but similar 90th percentile value, and turf, which had a higher median value, but limited data. Similarly, limited data from recreation and golf courses showed a higher median than the overall median, while roofs showed a lower median. TSS concentrations from the model were not available as a single value.

Mixed land uses that included residential, institutional, or commercial land use track closely to the model concentrations for both TN and TP. Mixed land use that includes residential/highway or commercial/industrial has somewhat higher median concentrations. Mixed land uses that included highways or roads were variable and did not show a distinct pattern of higher or lower concentrations than the modeled TN and TP values.

7.1.2 Seasonal Variation Analysis Summary (NSQD and literature)

Overall, the nutrient and sediment concentrations are fairly stable across the seasons. Summer concentrations are consistently slightly higher than the other seasons for all three parameters, but the majority of summer values are captured within the four season (overall) concentration between the 10th/90th percentiles.

7.1.3 Loading Rate Data Analysis Summary (TMDL reports and literature)

There were some limitations to the TMDL loading data set. Many of the land uses did not have any or only had one data point for some or all of the three parameters—TN, TP, TSS. For one set of plots, the loading rates from TMDL reports were separated on the basis of model calibration. Some TMDLs were developed using calibrated models. For other TMDLs, the models used literature or observed concentrations. Calibrated loading rates tended to be greater than the non-calibrated model loading rates

based on literature. The reasoning behind this was not investigated. Generally, residential, commercial, industrial, and institutional were higher than the overall medians, while the generic low- and high-developed land uses were less than the median. This might be due to the generic low- and high-developed land uses being from non-calibrated model TMDLs, which had loading rates that were less than the ones using calibrated models. Given the disparity between the calibrated and non-calibrated models and the small number of data sets (some land uses only had one or two data points), it is difficult to reach a definite conclusion using the loadings rates.

7.2 Analysis – Histograms

Histrograms were developed to investigate the loading rate and concentration distributions. Plots were developed to look at different land uses (Attachment D). Each plot is accompanied with a table that shows the count of data entries that fall into the loading rate and concentration range. The plots were developed using the actual values and then the Y-axis was converted to log scale to better see the range of data. Because of the spread of data, unequal data ranges were used. The plots illustrate that none of the data is normally distributed and is greatly skewed to the lower loading rates and concentrations.

7.3 Analysis – Impervious Regression

Many of the NSQD records and several literature sources reported percent impervious, so Tetra Tech compared these to TN, TP, and TSS concentrations. Figure 1, Figure 2, and Figure 3 show the paired concentration versus drainage area percent impervious when data is available. Not enough paired data is available for in-stream concentration or loading comparisons. These regressions grouped all land uses together, so they did not consider different land uses. The regressions only looked at edge-of-pavement concentrations, along with a limited number of concentrations after runoff exited swales, and do not represent watershed values. The regressions were developed using the actual concentrations and then the Y-axis was converted to log scale to better see the range of data. No relationship was found.

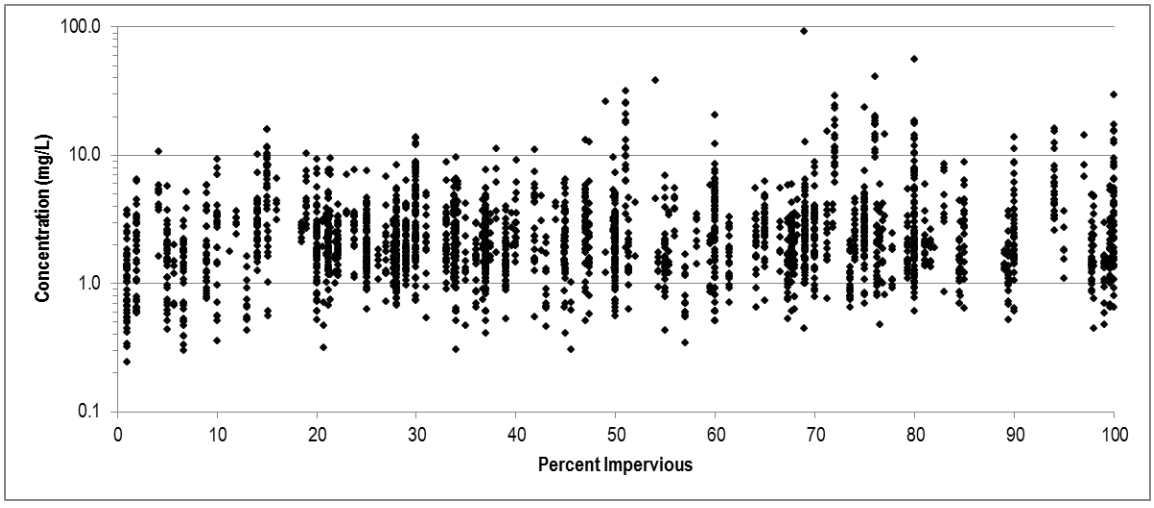

Figure 1. TN concentrations from literature versus percent imperviousness.

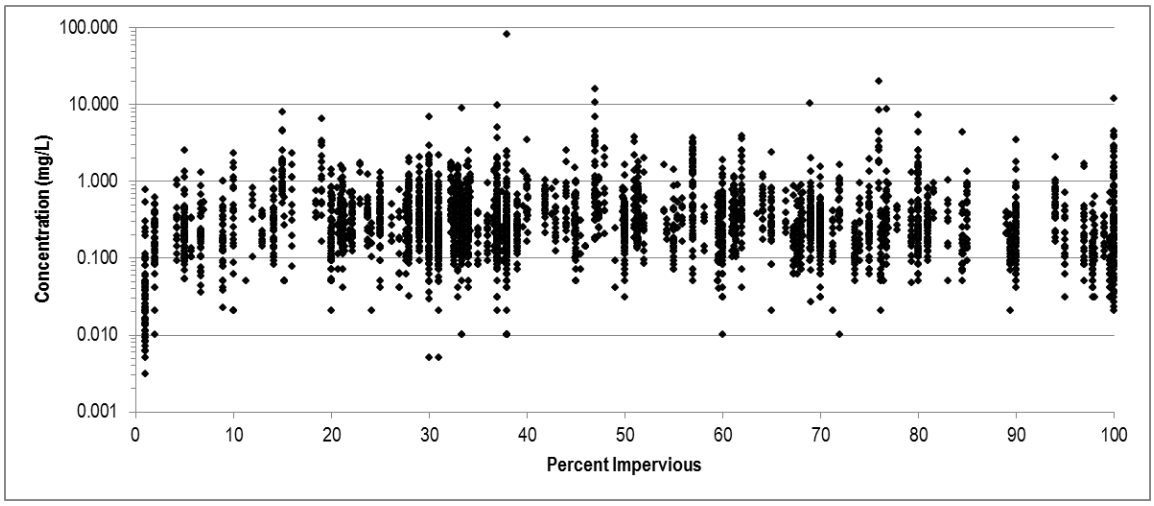

Figure 2. TP concentrations from literature versus percent imperviousness.

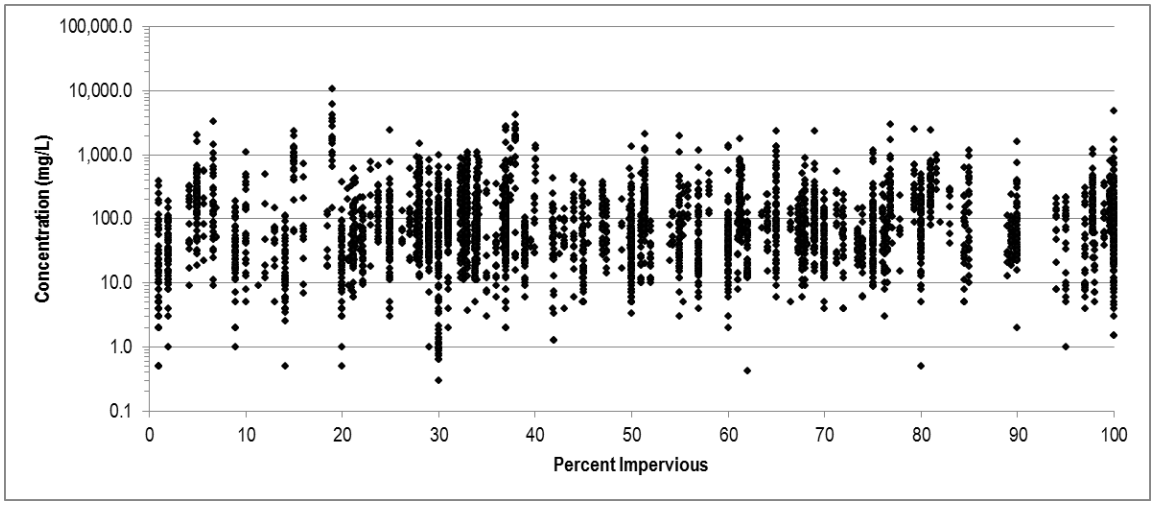

Figure 3. TSS concentrations from literature versus percent imperviousness.

7.4 Analysis – Wilcoxon Rank-Sum Test

Tetra Tech used the Wilcoxon rank-sum test was used to determine if specific land use concentrations or loadings are significantly different from the overall population. Helsel and Hirsch (2002) describe the test in *Statistical Methods in Water Resources*.

Available data were first evaluated for validity of the normality assumption by plotting histograms to see if the data are symmetrical about the mean, and by calculating the mean, standard deviation and skew. Data showed significant right skew, which can be seen in the example figures below (Figure 4 through Figure 6). In addition, the calculated skew was also greater than the rule of thumb value of $2 \times \sqrt{6/n}$, where *n* is the count of the data set, which indicated significant skew. Hence, a nonparametric approach (distribution-free approach) was necessary to evaluate the data sets. Generally, nonparametric tests

replace assumptions about normality with less stringent assumptions, such as symmetry and continuity of distributions.

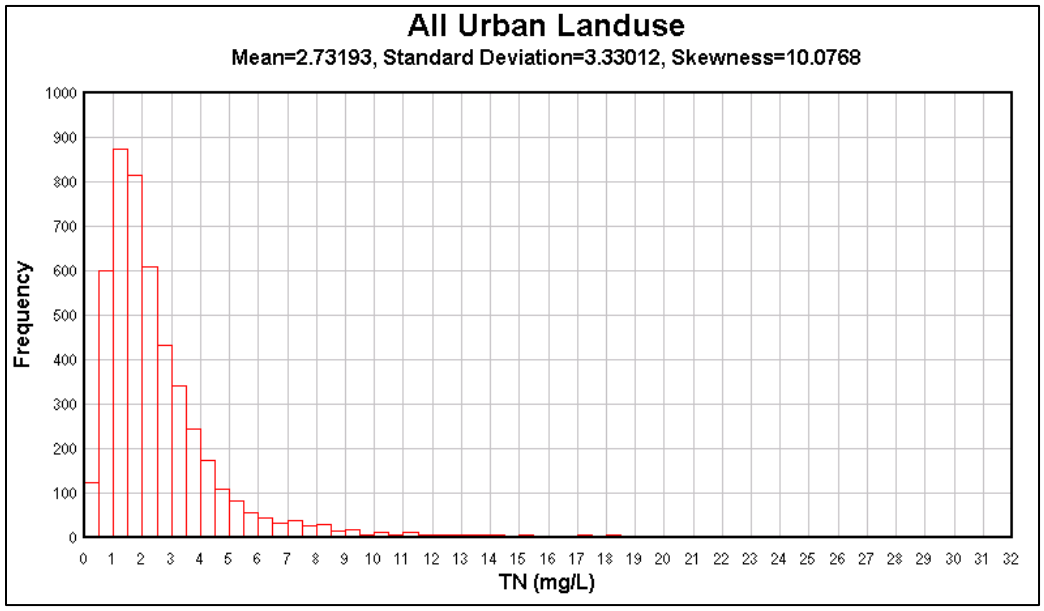

Figure 4. Histogram showing the frequency distribution of TN concentrations.

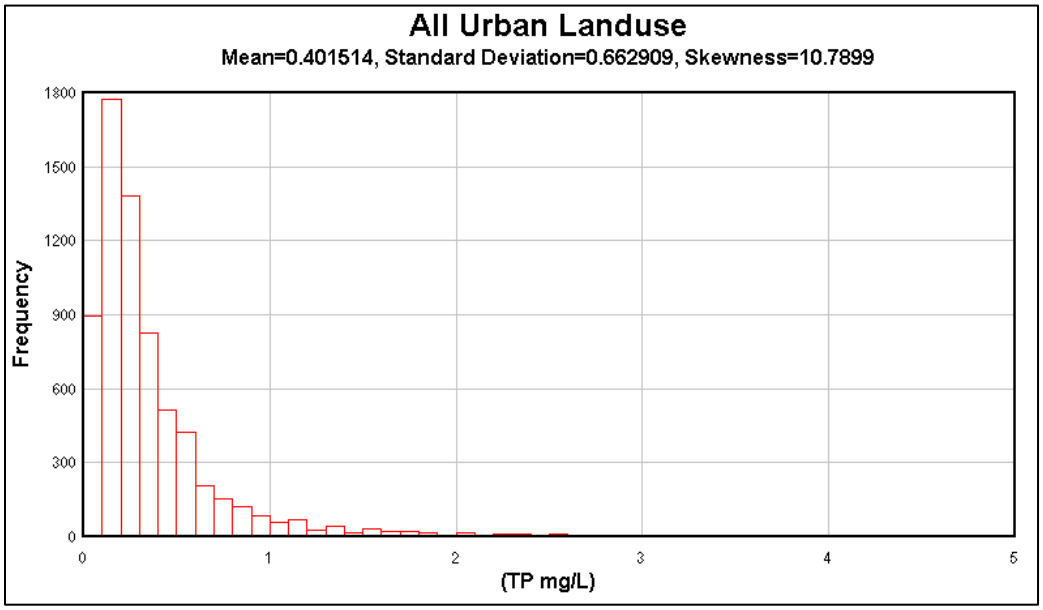

Figure 5. Histogram showing the frequency distribution of TP concentrations.

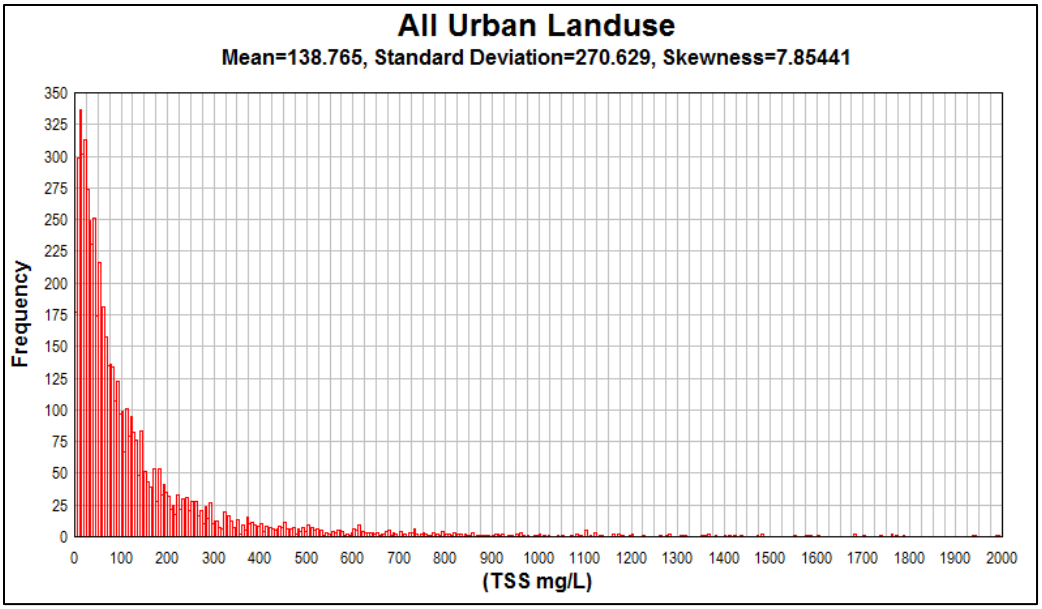

Figure 6. Histogram showing the frequency distribution of TSS concentrations.

7.4.1 Hypothesis Testing

The Wilcoxon rank-sum test is a nonparametric alternative to the two-sample t-test, which is based solely on the order in which the observations from the two samples fall. The test is a procedure for comparing independent samples of sizes m and n from two populations. The nonparametric procedure requires calculation of the ranks of all N (= n + m) observations after the two samples are combined and the observations are ordered from smallest to largest.

The TN, TP, and TSS concentration and loading rates from an overall urban land use category population were compared to samples from various detailed urban land use categories. The rank-sum test was used to determine if one of the constituents, TN, TP, or TSS (concentrations or loading rates), significantly differs (α = 0.05) between the overall urban land use category population and any of the detailed urban land use categories.

Null hypothesis for this test:

- H_0: mean concentration/loading rate (individual) = mean concentration/loading rate (overall).

Alternative hypothesis for this test:

- H_a: mean concentration/loading rate (individual) ≠ mean concentration/loading rate (overall).

7.4.2 Wilcoxon Rank-Sum Statistic

Let W be the sum of the ranks of the observations in the first sample. Let us take the first sample as the smaller sample size referred to as n and the large sample size designated as m. If the two populations

have the same continuous distribution and the observations in both samples take different values (i.e., there are no ties when the observations are ranked), the exact distribution of *W* has mean:

$$\mu_w = n \cdot (N + 1)/2 \quad \text{where } N = (n + m)$$

And a standard deviation is given as:

$$\sigma_w = \sqrt{n \cdot m \cdot (N + 1)/12}$$

Consideration was also given to tied records. Each set of tied records were given ranks equal to the average of their individual ranks. A correction for ties was incorporated based on a formula Conover (1980) proposed, which specified a correction to σ_w (Helsel and Hirsch 2002). When ties were present the formula for σ_{wt} was used:

$$\sigma_{wt} = \sqrt{\frac{n \cdot m}{N \cdot (N-1)} \sum_{k=1}^{N} R_k^2 - \frac{n \cdot m (N+1)^2}{4(N-1)}}$$

The Wilcoxon rank sum test rejects the null hypothesis that the two populations have identical distributions when the observed rank sum *W* is far from its mean.

The rank sum statistic *W* becomes approximately normal as the two sample sizes increase. (Typically the sample size is greater than 10.) The normal approximation affords a way to automate and program the test to be run on several data sets (67 data sets for this project). That is, we can use the z-statistic with the normal distribution approximation:

$z = (W - \mu_w)/ \sigma_w$ when no ties were present.

or

$z = (W - \mu_w)/ \sigma_{wt}$ when ties are present.

For a fixed level α test (0.05 for this analysis), for a two-tailed test result reject H_0 (i.e., the two distributions are different) if:

$|z| > z_{\text{two-tailed}}$ when H_a: $\mu_1 \neq \mu_2$

Next the p-value was also calculated using the test statistic and evaluated agains the significance level value. When the p-value was found to be less than the level of significance α we rejected the null hypothesis considering the result to be statistically significant, with the two distributions being different.

Table 1 and Table 2 present a summary of the Wilcoxon rank-sum test results (including the p-value), sample size, and mean and median of each data set along with if it was greater than (+) or less than (-)

the overall data set. These tables only represent the concentration data. Attachment E presents both the concentration and loading rate results along with the associated p-value, sample size, and additional notes. Individual land uses were compared to the overall total data set. This was done to prevent skewing from taking out data. For instance, open space were compared to the overall data set, not the overall data set minus the open space data. The results show that there are several land uses that are significantly different from the overall data pool. Open space was the only land use where TN, TP, and TSS concentrations all showed significant differences. There were several cases where TP and TSS showed differences, but TN did not. When looking at the data, it is important to note the sample size. Some land use data sets had little data (e.g., 9), while others had a large data set (e.g., more than 1,000), and this represented a larger portion of the overall data set.

Table 1. Wilcoxon Rank-Sum Test Results for Individual Land Use Concentrations versus Overall Concentrations

Land Use/Season	Sig. Diff. from Overall?	Count	Median (mg/L)	+ or - Overall Median?	Mean (mg/L)	+ or - Overall Mean?	p-value
TN							
Overall	**n/a**	**4,778**	**1.98**	**n/a**	**2.73**	**n/a**	**n/a**
Commercial	No	696	1.98	0	2.68	-	0.2573
Industrial	No	500	2.00	+	2.70	-	0.8510
Institutional	No	55	1.89	-	2.12	-	0.2085
Open Space	Yes	116	1.23	-	1.62	-	0.0000
Parking Lot	Yes	14	1.60	-	1.45	-	0.0211
Residential	No	1,529	2.00	+	2.76	+	0.9025
Transportation	Yes	230	3.11	+	4.28	+	0.0000
Roads-Low Use	No	17	2.17	+	2.30	-	0.8734
Roads-Medium Use	Yes	30	2.46	+	2.91	+	0.0444
Commercial/Industrial/High-Intensity Developed	No	1,240	2.02	+	2.71	-	0.1009
Institutional/Open Space	Yes	171	1.36	-	1.78	-	0.0000
Roads/Transportation	Yes	230	3.11	+	4.28	+	0.0000
Impervious	Yes	245	2.89	+	4.09	+	0.0000
Spring	No	1,249	2.03	+	2.79	+	0.1667
Summer	Yes	1,093	2.27	+	3.11	+	0.0000
Fall	No	1,246	1.93	-	2.68	-	0.2595
Winter	Yes	1,079	1.66	-	2.36	-	0.0000
TP							
Overall	**n/a**	**6,823**	**0.25**	**n/a**	**0.41**	**n/a**	**n/a**
Commercial	Yes	978	0.19	-	0.30	-	0.0000
Industrial	No	578	0.23	-	0.39	-	0.1346
Institutional	Yes	56	0.19	-	0.23	-	0.0026
Open Space	Yes	144	0.08	-	0.21	-	0.0000
Parking Lot	No	12	0.17	-	0.23	-	0.1132
Residential	Yes	2,316	0.26	+	0.40	-	0.0450
Transportation	No	641	0.24	-	0.62	+	0.1997
Roads-Low Use	Yes	15	0.36	+	0.44	+	0.0438

Land Use/Season	Sig. Diff. from Overall?	Count	Median (mg/L)	+ or - Overall Median?	Mean (mg/L)	+ or - Overall Mean?	p-value
Roads-Medium Use	No	20	0.21	-	0.25	-	0.3298
Commercial/Industrial/High-Intensity Developed	Yes	1,605	0.21	-	0.35	-	0.0000
Institutional/Open Space	Yes	200	0.12	-	0.21	-	0.0000
Recreation/Golf Course	No	9	0.16	-	0.49	+	0.2391
Roads/Transportation	No	641	0.24	-	0.62	+	0.1997
Impervious	No	660	0.24	-	0.61	+	0.4823
Pervious	No	11	1.03	+	1.00	+	0.3533
Spring	No	1,742	0.24	-	0.39	-	0.0787
Summer	Yes	1,622	0.29	+	0.53	+	0.0000
Fall	No	1,849	0.25	0	0.41	-	0.8831
Winter	Yes	1,475	0.22	-	0.33	-	0.0000
TSS							
Overall	**n/a**	**6,324**	**64.42**	**n/a**	**140.44**	**n/a**	**n/a**
Commercial	Yes	887	50.40	-	112.97	-	0.0001
Industrial	Yes	581	73.00	+	167.84	+	0.0054
Institutional	No	57	64.26	-	84.90	-	0.2481
Open Space	Yes	139	22.00	-	99.39	-	0.0000
Parking Lot	No	11	49.50	-	103.82	-	0.6558
Residential	Yes	2,186	60.00	-	123.48	-	0.0012
Transportation	No	460	66.68	+	126.22	-	0.8405
Residential-Low Density	Yes	11	156.00	+	214.23	+	0.0016
Roads-High Use	Yes	11	129.00	+	154.89	+	0.0238
Roads-Medium Use	Yes	48	119.00	+	163.86	+	0.0002
Roads-Low Use	Yes	25	126.00	+	253.20	+	0.0003
Commercial/Industrial/High-Intensity Developed	No	1,519	61.00	-	135.86	-	0.6132
Institutional/Open Space	No	196	32.50	-	95.18	-	0.0000
Roads/Transportation	No	460	66.68	+	126.22	-	0.8405
Impervious	No	471	65.00	+	122.32	-	0.6024
Spring	Yes	1,621	69.97	+	148.88	+	0.0022
Summer	Yes	1,534	76.00	+	174.20	+	0.0052
Fall	Yes	1,677	56.00	-	123.40	-	0.0005
Winter	Yes	1,318	53.50	-	109.71	-	0.0000

Note: **Blue bold** text indicates overall land use values that land use data is compared against. Red text indicates a significant difference was found using the Wilcoxon rank-sum test.

Table 2. Wilcoxon Rank-Sum Test Results for Individual Land Use Concentrations versus Transportation and Residential Concentrations

Land Use	Sig. Diff. from Transportation?	Count	Median (mg/L)	+ or - Transportation Median?	Mean (mg/L)	+ or - Transportation Mean?	p-value
TN							
Transportation	**n/a**	**4,778**	**1.98**	**n/a**	**2.73**	**n/a**	**n/a**
Roads-Low Use	Yes	17	2.17	+	2.30	-	0.0107
Roads-Medium Use	No	30	2.46	+	2.91	+	0.1109
TP							
Transportation	**n/a**	**6,823**	**0.25**	**n/a**	**0.41**	**n/a**	**n/a**
Roads-Low Use	No	15	0.36	+	0.44	+	0.0705
Roads-Medium Use	No	20	0.21	-	0.25	-	0.2325
TSS							
Transportation	**n/a**	**6,324**	**64.42**	**n/a**	**140.44**	**n/a**	**n/a**
Roads-High Use	Yes	11	129.00	+	154.89	+	0.0192
Roads-Medium Use	Yes	48	119.00	+	163.86	+	0.0002
Roads-Low Use	Yes	25	126.00	+	253.20	+	0.0003
Land Use	**Sig. Diff. from Residential?**	**Count**	**Median (mg/L)**	**+ or - Residential Median?**	**Mean (mg/L)**	**+ or - Residential Mean?**	**P-value**
TSS							
Residential	**n/a**	**6,324**	**64.42**	**n/a**	**140.44**	**n/a**	**n/a**
Residential-Low Density	Yes	11	156.00	+	214.23	+	0.0005

Note: **Blue bold** text indicates aggregated land use values that the other land use data is compared against. Red text indicates a significant difference was found using the Wilcoxon rank-sum test.

8.0 Summary/Conclusion/Recommendations

8.1 Summary

Tetra Tech identified 69 documents (e.g., articles and reports) that contained useful data out of 272 that we reviewed. This resulted in more than 1,400 entries for various land uses and parameters, with most of the data coming from the edge-of-pavement rather than in-stream concentrations that considered watershed-wide effects such as stream bank erosion. There were 64 TMDL reports from which more than 1,300 entries were obtained. On the basis of the histograms, neither data set was a normal distribution.

8.2 Objective Conclusions

As part of the technical direction, Tetra Tech was asked to answer three questions as part of a technical memorandum. These questions are listed and discussed below.

8.2.1 Do land use concentration/loading rates differ from overall concentration/loading rates?

The primary objective of this analysis was to determine if there was a unique source areas or cover types that depart in a meaningful way from the average nutrient loading for generic pervious or impervious land. On the basis of visually inspecting the box plots and the Wilcoxon rank-sum test results, there were some land uses (e.g., open space, turf, urban pervious, low-density developed) that departed from

the overall distribution for all parameters. There were several other land use categories that exhibited a difference for two of the parameters. The box plots show that there is very little seasonal variability; however, the Wilcoxon rank-sum test showed TN and TP to be different from the overall data in summer and winter, while TSS is different from the overall data for all seasons.

8.2.2 If so, can the land use be accurately mapped and incorporated into the CBWM?

After determining that several land uses are significantly different from the overall distribution, the next question would be if the pollutant dynamics of the source or cover type can be accurately mapped and simulated in the context of existing or future versions of the CBWM.

One of the most available land use geospatial data sets is the National Land Cover Database (NLCD). Several states in the Chesapeake Bay watershed use this data set, and it is the basis for the land use used in the CBWM. It breaks developed lands into high, medium, and low intensity and open space. It has an associated geospatial file that contains percent imperviousness for urban areas. Besides NLCD, there are other sources of land use data in the watershed. A few are listed below.

- *DC*: Includes residential (high, medium, low-medium, and low density); commercial; industrial; institutional; public (federal, local); roads; transportation/communication/utilities; mixed; and parks/open space.
- *Delaware*: Includes residential (single family, multifamily, mobile home parks); commercial; industrial; transportation (parking lots, airports, railroads, highways); recreational; institutional/government; utilities; mixed; and transitional.
- *Maryland*: Separate land uses to residential (high, medium, and low density); commercial; industrial; institutional; transportation; and open land, in addition to large lot subdivision in agricultural and forest settings.

There are other sources of land use information, such as local counties and organizations (e.g., Delaware Valley Regional Planning Commission). Information on roads and highways can be found from several sources including the National Highway Planning Network, NavTeq, and state transportation departments. Each source has its advantages and disadvantages regarding the types of roads included and the information available (e.g., number of lanes, width information).

8.2.3 If so, would the land use respond in a unique manner to the application of a new or existing urban BMP?

Verifying progress towards meeting the bay TMDL is an important function of the CBWM. If different urban land uses are simulated in the future, an important consideration is whether the efficiency of BMPs and other restoration practices on these disaggregated land uses would be different from the efficiencies for the overall urban land use category. The CBWM has set urban BMP and restoration practice efficiencies for the aggregated urban land use category in the current model. While, efficiency data was not specifically reviewed as part of this study's literature review, Tetra Tech does not foresee the need to determine different efficiencies for each BMP or restoration practice based on potential disaggregated land use categories.

Pollutant removal efficiency representation, as set in the CBWM, reflects the long-term load reduction of pollutants discharged from the receiving stream relative to the load delivered from the upstream watershed of catchment. Where locally robust monitoring results are available, the efficiencies can be

determined on the basis of local climate, land use, and BMP design conditions. More often the amount and quality of local monitoring information is lacking and the efficiencies of individual practices is determined from published literature sources that represent efficiencies across a range of geography factors (e.g., topography and land use) and design standards. Therefore, the current BMP and restoration practices in the CBWM represent an aggregate of land uses and conditions, making the efficiencies applicable to the range of potential disaggregated land uses.

8.3 Conclusion

8.3.1 Data Limitations and Precautions with Interpretation

As previously stated, the majority of NSQD and literature concentration data was edge-of-pavement or outfall-specific data. Outfall monitoring is typically only done during storm events; therefore, it will not characterize dry-weather runoff (e.g., landscape watering, car washing, and illicit discharges). In addition, this type of data will not consider factors such as fertilizer leaching, stream erosion, sewer overflows, septic tanks, and ground water.

Several of the land use categories had limited data, making definite recommendations tricky, because the available data might represent extremes within that land use. This is especially the case with specific land use categories (e.g., low-use residential) and less common categories (e.g., turf, parking lots, and golf courses). Even a common land use such as recreational had limited data. Some of the land uses with limited data (e.g., golf course) were hypothesized at the beginning of the study as potentially having concentrations that were significantly different than a general overall urban land use concentration. More data is needed to reach a conclusion.

Atmospheric deposition plays a role in concentrations and loadings from urban surfaces, being that it is an important source of nitrogen on impervious surfaces; however, its influence on the results is unknown. From this study, highly impervious areas (e.g., roads) had higher TN and TSS concentrations than areas seen as having more pervious areas (e.g., open space), which might be expected. Also, the medians for many land use categories are similar, which could be a result of atmospheric deposition on areas of similar impervious-pervious ratios.

Tetra Tech reviewed the TMDL reports to determine if the models used in development were calibrated or used literature or default values. Calibrated loading rates tended to be greater than the non-calibrated model loading rates based on literature. Given the disparity between the calibrated/non-calibrated models and the small number of data sets (some land uses only had a one or two data points), it is difficult to reach a definite conclusion using only the loadings rates; therefore, only concentrations were used in making the preliminary recommendations below.

8.3.2 Preliminary Recommendations

Table 3 presents preliminary recommendations using this study's findings and using edge-of-pavement concentration data from NSQD and the literature search. The table identifies if specific land use category (or season) concentration shows a significant difference from the overall concentration for TN,

TP, and TSS on the basis of the box plots in Attachment C or the Wilcoxon rank-sum test results in Attachment E. Responses regarding box plots were determined using visual inspection and are subjunctive. Table 6, along with Table 1 and Table 2, can form the basis of decisions made by the CBP or workgroup committees. The concentrations in Table 1 can be used as starting points in CBWM calibration.

Not enough sources separated pervious from impervious land uses. From the statistical analysis, impervious data only showed a significant difference in TN concentration for the overall concentration. Not enough data was available to make a definitive conclusion for pervious surfaces. Despite this, it is still recommended to separate pervious and impervious areas, as practical and possible.

Table 3. Preliminary Recommendations Using Concentration Data from NSQD and Literature Search

Land Use/Season	Box Plots			Wilcoxon			Recommendation/Comment
	TN	TP	TSS	TN	TP	TSS	
Aggregated							
Commercial	N	N	N	N	Y	Y	Separate loading category.
Industrial	N	N	N	N	N	Y	No change.
Institutional	N	N	N	N	Y	N	No change.
Open Space	Y	Y	Y	Y	Y	Y	Separate loading category.
Recreational	A-I	A-N	A-Y	A	A	A	More data is needed; however, it appears it could be different from overall.
Residential	N	N	N	N	Y	Y	Separate loading category.
Transitional	0	A-N	A-Y	0	A	A	Not enough data was available to make a decision.
Transportation	Y	N	N	Y	N	N	Separate loading category.
Residential							
Residential, High Density	0	A-I	A-I	0	A	A	Aggregated residential only showed significant difference for TP and TSS. Separated, low- and medium-density residential show potential for being different from overall; however, more data is needed. Low-density residential showed a significant difference from the general residential median. There was not enough data to make comparisons for TN and TSS or high and medium density.
Residential, Low Density	A-I	A-I	A-Y	A	A	Y	
Residential, Medium Density	A-I	A-I	A-Y	A	A	A	
Residential, Driveway	A-I	A-I	A-Y	A	A	A	More data is needed; however, it appears it could be different from overall.
Residential, Lawn	A-Y	A-Y	A-Y	A	A	A	More data is needed; however, it appears it is different from overall.
Residential, Roof	A-I	A-Y	A-I	A	A	A	More data is needed; however, it appears it could be different from overall.
Roads							
Roads, High Use	A-Y	A-I	Y	A	A	Y	Classification is based on average daily traffic, of which there is limited data. There appears to be a difference from the overall for high- and medium-use roads. All road subcategory TSS concentrations were significantly different than the general transportation concentration.
Roads, Low Use	N	N	Y	N	Y	Y	
Roads, Medium Use	Y	N	Y	Y	N	Y	
Pervious/Impervious							
Impervious	Y	N	N	Y	N	N	Keep separate from pervious.
Parking Lot	A-I	Y	I	Y	N	N	More data is needed; however, it appears it could be different from overall.
Roof	A-I	A-Y	A-Y	A	A	A	More data is needed; however, it appears it could be different from overall.
Pervious	N	Y	A-Y	A	N	A	Keep separate from impervious.
All Turf	A-Y	A-Y	A-Y	A	A	A	More data is needed; however, it appears it is different from overall.
Golf Course	A-I	A-N	A-Y	A	A	A	More data is needed.
CBP Combinations							

Land Use/Season	Box Plots			Wilcoxon			Recommendation/Comment
	TN	TP	TSS	TN	TP	TSS	
Comm./Ind./High-Intensity Dev.	N	N	N	N	Y	N	Results do not show need for this specific combination.
Institutional/Open Space	Y	Y	Y	Y	Y	N	Data from Open Space appears to dominate this result. Reinforces need for separate Open Space category.
Recreation/Golf Course	A-I	A-Y	A-Y	A	N	A	More data is needed; however, it appears it could be different from overall.
Seasons							
Spring	N	N	N	N	N	Y	No change.
Summer	N	Y	N	Y	Y	Y	Potential adjustment of seasonal concentration.
Fall	N	N	Y	N	N	Y	No change.
Winter	Y	N	Y	Y	Y	Y	Potential adjustment of seasonal concentration.

Notes:
Y = Yes; N = No; I = Indeterminate; A = Additional data needed (under 10 data points available); 0 = no data.
This table was created using edge-of-pavement concentration data from NSQD and the literature search. Responses regarding box plots were determined using visual inspection and are subjunctive.

8.4 Potential Future Efforts

While Tetra Tech conducted an in-depth literature search, there still might be literature available for review that was not found. In addition, there were several articles and books that we did not obtain for the literature review. However, unless the literature is for land use categories not represented in NSQD (which only contain generalize residential, industrial, institutional, transportation, commercial, open, and mixed), any new data would have limited impact due to the large amount of data from NSQD for general and mixed land uses. Because of time and resources, Tetra Tech focused the TMDL report search and review to the watershed and surrounding states. The TMDL report search could be expanded to other states.

Additional analysis could be conducted on the existing data. Examples of additional analyses include:

- Looking at different nitrogen and phosphorus species for analysis. For example, ammonia, nitrate, TKN, orthophosphate, and dissolved phosphorus all have significant literature data to perform statistics on.
- Performing statistical analyses on land uses that had fewer than 10 data points.
- Performing statistical analyses on mixed land use combinations for statistical analysis.

Because some land uses are underrepresented with limited data, land use-specific monitoring could be beneficial, although it is difficult to identify a watershed that drains only one urban land use. Although there was some watershed-wide loading rate data, the majority of concentration data obtained was edge-of-pavement, and additional monitoring could be tailored to look at the water quality of streams affected by single land uses.

9.0 References

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Attachment A: Parameter Standardization

Table 4. Water Quality Parameter Standardization for Data from Literature

Original Parameter	Standardized Parameter
Ammonia	Ammonia
Ammonia-Nitrogen	Ammonia
Dis. Nitrogen	Diss. N
Dis. Ortho Phosphorus	Soluble Phosphate
Dis. P	Diss. Phos
Dis. Phosphorus	Diss. Phos
Dis. TKN	soluble Kjeldahl nitrogen
Diss. Phos	Diss. Phos
dissolved inorganic nitrogen	Dis. Inorg. N
Dissolved N	Diss. N
Dissolved P	Diss. Phos
Dissolved Phosphorous	Diss. Phos
dissolved reactive phosphorus	Soluble Phosphate
DP	Diss. Phos
Inorganic N	Inorg. N
N02+3	NO2+NO3
NH3	Ammonia
NH3 as N	Ammonia
NH3-N	Ammonia
NH4	Ammonia
Nitrate	Nitrate
Nitrate + Nitrite	NO2+NO3
Nitrate plus Nitrite	NO2+NO3
Nitrate-Nitrite Nitrogen	NO2+NO3
Nitrite	Nitrite
NO2+NO3	NO2+NO3
NO3	Nitrate
NO3-N	Nitrate
NO3-NO2 as N	NO2+NO3
NOX	NO2+NO3
Nox-N	NO2+NO3
OP	Orthophosphate
Org N	Organic N
Org. N.	Organic N
Organic N	Organic N
Organic P	Organic P
ORN	Organic N
ORP	Organic P
Ortho Phosphate	Orthophosphate
Ortho-P	Orthophosphate
Orthophosphate	Orthophosphate
Ortho-Phosphate	Orthophosphate
Ortho-Phosphorus	Orthophosphate
Oxidized nitrogen	NO2+NO3
P04-P	Orthophosphate
particle bound phosphorus	Particulate Phosphorus
Particulate Phos	Particulate Phosphorus
Particulate Phosphorous	Particulate Phosphorus
Particulate Phosphorus	Particulate Phosphorus
Phosphate	Orthophosphate
Phosphorus	TP
PO4	Orthophosphate
PP	Particulate Phosphorus
Sediment	TSS
SKN	soluble Kjeldahl nitrogen
soluble Kjeldahl nitrogen	soluble Kjeldahl nitrogen
soluble organic phos	Soluble Org. P
soluble phos	Diss. Phos
Soluble Phosphate	Soluble Phosphate
soluble reactive phosphorus	Soluble Phosphate
SRP	Soluble Phosphate
TKN	TKN
TKN as N	TKN
TN	TN
total ammonical nitrogen	Ammonia
Total N	TN
Total P	TP
Total Phosphorus	TP
total soluble phosphorus	Diss. Phos
TP	TP
TSS	TSS

Attachment B: Land Use Standardization

Table 5. Land Use Standardization for Data from NSQD and Literature Review

Original Land Use from Literature	General Standardization	Specific Standardization(s)
Bridge Deck	Transportation	Roads/Transportation; Impervious
Commercial	Commercial	Commercial/Industrial/High-Intensity Developed
Commercial/Institutional	na[a]	MIX-Com/Inst
Commercial-Parking Lot	Parking lot	Parking lot; Impervious
Commercial-Roof	na	Roof; Impervious
Gas station	Commercial	Commercial/Industrial/High-Intensity Developed; Impervious
Golf course	Golf course	Golf course; Recreation/Golf Course; Pervious
Highway	Transportation	Roads/Transportation; Impervious
Highway - Residential (8.8K ADT)[b]	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Highway (>300K ADT)	Transportation	Roads-High Use; Roads/Transportation; Impervious
Highway (>50K ADT)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (111K ADT)	Transportation	Roads-High Use; Roads/Transportation; Impervious
Highway (114K ADT)	Transportation	Roads-High Use; Roads/Transportation; Impervious
Highway (120K ADT)	Transportation	Roads-High Use; Roads/Transportation; Impervious
Highway (21.5K ADT)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (25K ADT)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (30K ADT)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (35K ADT)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (41K ADT)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (43K ADT)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (47K ADT)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (5.5K ADT)	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Highway (51K ADT)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (AADT <30K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (AADT >200K)	Transportation	Roads-High Use; Roads/Transportation; Impervious
Highway (AADT 100-200K)	Transportation	Roads-High Use; Roads/Transportation; Impervious
Highway (AADT 30-60K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (AADT 60-100K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 116K)	Transportation	Roads-High Use; Roads/Transportation; Impervious
Highway (ADT 149K)	Transportation	Roads-High Use; Roads/Transportation; Impervious
Highway (ADT 17K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 200K)	Transportation	Roads-High Use; Roads/Transportation; Impervious
Highway (ADT 20K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 24K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 26K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 28K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 42K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 43K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 47K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 47K-with swale)	Transportation	Roads-Medium Use; Roads/Transportation
Highway (ADT 53K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 58K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 65K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 70K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 8.6K)	Transportation	Roads-Low Use; Roads/Transportation; Impervious

Original Land Use from Literature	General Standardization	Specific Standardization(s)
Highway (ADT 80K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 85K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 88K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (ADT 9K)	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Highway (Snowmelt) (ADT 116K)	Transportation	Roads-High Use; Roads/Transportation; Impervious
Highway (Snowmelt) (ADT 17K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (Snowmelt) (ADT 24K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (Snowmelt) (ADT 26K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (Snowmelt) (ADT 42K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (Snowmelt) (ADT 53K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (Snowmelt) (ADT 65K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (Snowmelt) (ADT 8.6K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (Snowmelt) (ADT 80K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (Snowmelt) (ADT 85K)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious
Highway (Snowmelt)-Rural (ADT 2.5K)	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Highway (Snowmelt)-Rural (ADT 2K)	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Highway (Snowmelt)-Rural (ADT 7.3K)	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Highway (Snowmelt)-Rural (ADT 7.7K)	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Highway-Rural (ADT 2.5K)	Transportation	Roads-Low Use; Roads/Transportation
Highway-Rural (ADT 2K)	Transportation	Roads-Low Use; Roads/Transportation
Highway-Rural (ADT 7.3K)	Transportation	Roads-Low Use; Roads/Transportation
Highway-Rural (ADT 7.7K)	Transportation	Roads-Low Use; Roads/Transportation
Industrial	Industrial	Commercial/Industrial/High-Intensity Developed
Industrial (Heavy >56% imp)	Industrial	Commercial/Industrial/High-Intensity Developed
Industrial/Commercial (64%/26%) (Light<44%imp)	na	MIX-Com/Ind; Commercial/Industrial/High-Intensity Developed
Industrial-Parking Lot	Parking lot	Parking lot; Impervious
Industrial-Roof	Industrial	Roof; Commercial/Industrial/High-Intensity Developed; Impervious
Institutional	Institutional	Institutional/Open space/Very Low-Density Residential
Manufacturing	Industrial	Commercial/Industrial/High-Intensity Developed
MIX_Residential/Industrial/Open (55/35/10)[c]	na	MIX-Res/Mult
MIX-Commercial/Highway(61.6/37.6)	na	MIX-Com/Hwy
MIX-Commercial/Highway(61/39)	na	MIX-Com/Hwy
MIX-Commercial/Industrial (50/50)	na	MIX-Com/Inst
MIX-Commercial/Industrial(49/44)	na	MIX-Com/Ind; Commercial/Industrial/High-Intensity Developed
MIX-Commercial/Multiple (23.1/76.8)	na	MIX-Com/Mult
MIX-Commercial/Multiple (31.8/68.1)	na	MIX-Com/Mult
MIX-Commercial/Multiple (40/52)	na	MIX-Com/Mult
MIX-Commercial/Multiple (55/45)	na	MIX-Com/Mult
MIX-Commercial/Multiple (56/44)	na	MIX-Com/Mult
MIX-Commercial/Multiple (61.1/38.9)	na	MIX-Com/Mult
MIX-Commercial/Multiple (65.3/34.7)	na	MIX-Com/Mult
MIX-Commercial/Multiple (76/24)	na	MIX-Com/Mult
MIX-Commercial/Multiple (87/13)	na	MIX-Com/Mult
MIX-Commercial/Open(63/29)	na	MIX-Com/Open
MIX-Commercial/Open(72.5/19.2)	na	MIX-Com/Open
MIX-Commercial/Open/Residential (39/36/20)	na	MIX-Mult
MIX-Commercial/Residential(50.4/43.8)	na	MIX-Com/Res
MIX-Commercial/Residential(57/43)	na	MIX-Com/Res

Original Land Use from Literature	General Standardization	Specific Standardization(s)
MIX-Commercial/Residential(58/42)	na	MIX-Com/Res
MIX-Commercial/Residential(62.7/37.1)	na	MIX-Com/Res
MIX-Commercial/Residential(63/37)	na	MIX-Com/Res
MIX-Commercial/Residential(67.1/32.9)	na	MIX-Com/Res
MIX-Commercial/Residential(68.8/31.2)	na	MIX-Com/Res
MIX-Commercial/Residential(70/30)	na	MIX-Com/Res
MIX-Commercial/Residential(74.8/25.2)	na	MIX-Com/Res
MIX-Commercial/Residential(74/26)	na	MIX-Com/Res
MIX-Commercial/Residential(85/15)	na	MIX-Com/Res
MIX-Commercial/Residential(87/13)	na	MIX-Com/Res
MIX-Commercial/Unknown	na	MIX-Com/Mult
MIX-Highway/Industrial (57/29)	na	MIX-Ind/Hwy
MIX-Highway/Multiple (65.9/34.1)	na	MIX-Hwy/Mult
MIX-Industrial	na	MIX-Ind/Unk
MIX-Industrial/Commercial(60/40)	na	MIX-Com/Ind; Commercial/Industrial/High-Intensity Developed
MIX-Industrial/Commercial(74/19)	na	MIX-Com/Ind; Commercial/Industrial/High-Intensity Developed
MIX-Industrial/Commercial(79.5/17.8)	na	MIX-Com/Ind; Commercial/Industrial/High-Intensity Developed
MIX-Industrial/Highway(67.5/10.8)	na	MIX-Ind/Hwy
MIX-Industrial/Multiple (40/60)	na	MIX-Ind/Mult
MIX-Industrial/Multiple (45.6/54.4)	na	MIX-Ind/Mult
MIX-Industrial/Multiple (57.9/42.1)	na	MIX-Ind/Mult
MIX-Industrial/Multiple (60.9/38.8)	na	MIX-Ind/Mult
MIX-Industrial/Open (82/18)	na	MIX-Ind/Open
MIX-Industrial/Open (86/11)	na	MIX-Ind/Open
MIX-Industrial/Open(54.7/35.9)	na	MIX-Ind/Open
MIX-Industrial/Open(56/44)	na	MIX-Ind/Open
MIX-Industrial/Open(65/29)	na	MIX-Ind/Open
MIX-Industrial/Open(76.5/23.5)	na	MIX-Ind/Open
MIX-Industrial/Residential(52/45)	na	MIX-Ind/Res
MIX-Industrial/Residential(60.1/40)	na	MIX-Ind/Res
MIX-Industrial/Residential(70/30)	na	MIX-Ind/Res
MIX-Industrial/Residential(71.4/14.5)	na	MIX-Ind/Res
Mix-Industrial/unknown	na	MIX-Ind/Unk
MIX-Institutional/Residential (52/48)	na	MIX-Inst/Res
MIX-Open/Commercial(58/36)	na	MIX-Com/Open
MIX-Open/Highway(67/33)	na	MIX-Open/Hwy
MIX-Open/Industrial(75/22)	na	MIX-Ind/Open
MIX-Open/Multiple (39/61)	na	MIX-Open/Mult
MIX-Open/Multiple (43/57)	na	MIX-Open/Mult
MIX-Open/Multiple (50/50)	na	MIX-Open/Mult
Mix-Residential	na	MIX-Res
MIX-Residential/Commercial (50/50)	na	MIX-Com/Res
MIX-Residential/Commercial(44.84/15.39)	na	MIX-Com/Res
MIX-Residential/Commercial(50.4/49.6)	na	MIX-Com/Res
MIX-Residential/Commercial(50.7/45.9)	na	MIX-Com/Res
MIX-Residential/Commercial(50/38)	na	MIX-Com/Res
MIX-Residential/Commercial(57/43)	na	MIX-Com/Res
MIX-Residential/Commercial(58.55/41.45)	na	MIX-Com/Res
MIX-Residential/Commercial(60/30)	na	MIX-Com/Res

Original Land Use from Literature	General Standardization	Specific Standardization(s)
MIX-Residential/Commercial(60/40)	na	MIX-Com/Res
MIX-Residential/Commercial(61/36)	na	MIX-Com/Res
MIX-Residential/Commercial(64/35)	na	MIX-Com/Res
MIX-Residential/Commercial(66/34)	na	MIX-Com/Res
MIX-Residential/Commercial(70/30)	na	MIX-Com/Res
MIX-Residential/Commercial(72/28)	na	MIX-Com/Res
MIX-Residential/Commercial(78/16)	na	MIX-Com/Res
MIX-Residential/Commercial(81.7/18.3)	na	MIX-Com/Res
MIX-Residential/Commercial(83/10)	na	MIX-Com/Res
MIX-Residential/Commercial(84/16)	na	MIX-Com/Res
MIX-Residential/Commercial(85.5/10.2)	na	MIX-Com/Res
MIX-Residential/Commercial(87.2/12.8)	na	MIX-Com/Res
MIX-Residential/Commercial(87/11.5)	na	MIX-Com/Res
MIX-Residential/Commercial/Open (35/35/30)	na	MIX-Mult
MIX-Residential/Highway(52/48)	na	MIX-Res/Hwy
MIX-Residential/Industrial(67/18)	na	MIX-Ind/Res
MIX-Residential/Industrial(78/15)	na	MIX-Ind/Res
MIX-Residential/Institutional(78/22)	na	MIX-Inst/Res
MIX-Residential/Institutional(88/12)	na	MIX-Inst/Res
MIX-Residential/Multiple (46/54)	na	MIX-Res/Mult
MIX-Residential/Multiple (47/54)	na	MIX-Res/Mult
MIX-Residential/Multiple (48.1/50.1)	na	MIX-Res/Mult
MIX-Residential/Multiple (48/52)	na	MIX-Res/Mult
MIX-Residential/Multiple (50/50)	na	MIX-Res/Mult
MIX-Residential/Multiple (51.9/48.1)	na	MIX-Res/Mult
MIX-Residential/Multiple (54/46)	na	MIX-Res/Mult
MIX-Residential/Multiple (55/45)	na	MIX-Res/Mult
MIX-Residential/Multiple (56.8/43)	na	MIX-Res/Mult
MIX-Residential/Multiple (56.8/43.2)	na	MIX-Res/Mult
MIX-Residential/Multiple (56/44)	na	MIX-Res/Mult
MIX-Residential/Multiple (57.2/41.8)	na	MIX-Res/Mult
MIX-Residential/Multiple (57/43)	na	MIX-Res/Mult
MIX-Residential/Multiple (60/40)	na	MIX-Res/Mult
MIX-Residential/Multiple (60/40.1)	na	MIX-Res/Mult
MIX-Residential/Multiple (85/15)	na	MIX-Res/Mult
MIX-Residential/Multiple (88.09/11.91)	na	MIX-Res/Mult
MIX-Residential/Multiple (88/12)	na	MIX-Res/Mult
MIX-Residential/Multiple (88/9.2)	na	MIX-Res/Mult
MIX-Residential/Multiple (89.3/10.8)	na	MIX-Res/Mult
MIX-Residential/Open (55/22)	na	MIX-Res/Open
MIX-Residential/Open(13/74)	na	MIX-Res/Open
MIX-Residential/Open(13/87)	na	MIX-Res/Open
MIX-Residential/Open(20/80)	na	MIX-Res/Open
MIX-Residential/Open(21.4/74.2)	na	MIX-Res/Open
MIX-Residential/Open(33/66)	na	MIX-Res/Open
MIX-Residential/Open(65/30)	na	MIX-Res/Open
MIX-Residential/Open(70/23)	na	MIX-Res/Open
MIX-Residential/Open(72/13)	na	MIX-Res/Open
MIX-Residential/Open(79.4/11.3)	na	MIX-Res/Open

Original Land Use from Literature	General Standardization	Specific Standardization(s)
MIX-Residential/Open(79/10)	na	MIX-Res/Open
MIX-Residential/Open(80/15)	na	MIX-Res/Open
MIX-Residential/Open(81.8/18.2)	na	MIX-Res/Open
MIX-Residential/Open(82.5/17.5)	na	MIX-Res/Open
MIX-Residential/Open(82/18)	na	MIX-Res/Open
MIX-Residential/Open(84.2/15.8)	na	MIX-Res/Open
MIX-Residential/Open(84/12)	na	MIX-Res/Open
MIX-Residential/Open(84/16)	na	MIX-Res/Open
MIX-Residential/Open(85/10)	na	MIX-Res/Open
MIX-Residential/Open(89/11)	na	MIX-Res/Open
MIX-Residential/Unknown (58/unknown)	na	MIX-Res
MIX-Residiential/Unknown	na	MIX-Res
Office	Commercial	Commercial/Industrial/High-Intensity Developed
Open Space	Open Space	Institutional/Open space/Very Low-Density Residential
Parking lot	Parking lot	Parking lot; Impervious
Parking lot	Parking lot	Parking lot; Impervious
Parking Lot - Commercial	Parking lot	Parking lot; Commercial/Industrial/High-Intensity Developed; Impervious
Parking lot - Institutional	Parking lot	Parking lot; Impervious
Parking Lots (Commercial) - 90% asphalt	Parking lot	Parking lot; Impervious
Parking Lots (Commercial) - 100% asphalt	Parking lot	Parking lot; Impervious
Parking Lots (Commercial) - 100% impervious	Parking lot	Parking lot; Impervious
Parking Lots (Commercial) - 90% asphalt	Parking lot	Parking lot; Impervious
Parking Lots (Open Space/Park) - 88% asphalt	Parking lot	Parking lot; Impervious
Parking Lots (Open Space/Park) - 99% asphalt	Parking lot	Parking lot; Impervious
Parking Lots (Residential) - 40% asphalt	na	Residential-Driveway; Impervious
Parking Lots (Residential) - 79% asphalt	na	Residential-Driveway; Impervious
Recreational	Recreational	Recreation/Golf Course
Residential	Residential	na
Residential - High Density	Residential	Residential, High Density; Commercial/Industrial/High-Intensity Developed
Residential - Low Density	Residential	Residential, Low Density
Residential - Medium Density	Residential	Residential, Medium Density; Commercial/Industrial/High-Intensity Developed
Residential - Multi Family	Residential	Residential, High Density; Commercial/Industrial/High-Intensity Developed
Residential - Single Family	Residential	Residential, Low Density
Residential (Multi)	Residential	Residential, High Density; Commercial/Industrial/High-Intensity Developed
Residential (Single/Multi)	Residential	Residential, Medium Density; Commercial/Industrial/High-Intensity Developed
Residential, Single Family	Residential	Residential, Low Density
Residential-Driveway	na	Residential-Driveway; Impervious
Residential-Lawn	Turf	Residential-Lawn; Residential-Lawn; Pervious
Residential-Medium Density	Residential	Residential, Medium Density; Commercial/Industrial/High-Intensity Developed
Residential-Medium Density/Industrial (Heavy >56% imp)	na	MIX-Ind/Res
Residential-Roof	na	Residential-Roof; Impervious
Residential-Townhouse	Residential	Residential, Medium Density; Commercial/Industrial/High-Intensity Developed

Original Land Use from Literature	General Standardization	Specific Standardization(s)
Road - Commercial/residential	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Road - Local	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Road - Residential (325 ADT)	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Road - Residential (665 ADT)	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Roads - Highway	Transportation	Roads/Transportation; Impervious
Roads - Rural (6K ADT)	Transportation	Roads-Low Use; Roads/Transportation
Roof	na	Roof; Impervious
Rooftop, Nonresidential	na	Roof; Impervious
Rural highway (<30ADT)	Transportation	Roads-Low Use; Roads/Transportation
Single Family Residential	Residential	Residential, Low Density
Street	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Street - Residential	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Street-Arterial	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Street-Arterial Commercial	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Street-Arterial Industrial	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Street-Collector	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Street-Collector Industrial	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Street-Collector Residential	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Street-Commercial (ADT=10.6K)	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Street-Commercial (ADT=5.1K)	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Street-Feeder	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Street-Feeder Residential	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Street-Residential (ADT=3.1K)	Transportation	Roads-Low Use; Roads/Transportation; Impervious
Transitional	Transitional	na
Transportation	Transportation	Roads/Transportation
Turf	Turf	Pervious
Undeveloped	Open Space	Institutional/Open space/Very Low-Density Residential
Urban highway (>30 ADT)	Transportation	Roads-Medium Use; Roads/Transportation; Impervious

Notes:

[a] na = original land use not included as part this standardization.

[b] Numbers associated with highways or roads are the average daily traffic (ADT). Numbers followed by "K" are in the thousands.

[c] Numbers in parentheses for mixed land use areas represent the respective percentage for each land use. For example, MIX-Commercial/Highway (61.6/37.6) represents 61.3 percent commercial and 37.6 percent highway.

Table 6. Land Use Standardization for Data from TMDL Reports and Literature Review

Original Land Use from TMDL Reports	General Standardization	Specific Standardization
Com/Ind	MIX-Com/Ind	MIX-Com/Ind
Commercial	Commercial	Commercial
Commercial/Heavy Industrial	MIX-Com/Ind	MIX-Com/Ind
commercial/industrial	MIX-Com/Ind	MIX-Com/Ind
Commercial/Industrial/Transport	MIX-Com/Ind	MIX-Com/Ind
Commercial/Industrial/Transportation	MIX-Com/Ind	MIX-Com/Ind
Developed Open Space	Open Space	Open Space
Developed, High	Developed	Developed-High Intensity
Developed, Low	Developed	Developed-Low Intensity
Developed, Medium	Developed	Developed-Medium Intensity
High Density Residential	Residential	Residential-High Density
High Intensity Commercial/Industrial/Transportation	MIX-Com/Ind	MIX-Com/Ind
High Intensity Commercial/Industrial/Transportation_Impervious	Urban-Impervious	Urban-Impervious
High Intensity Commercial/Industrial/Transportation_Pervious	Urban-Pervious	Urban-Pervious
High Intensity Developed	Developed	Developed-High Intensity
High Intensity Development	Developed	Developed-High Intensity
High Intensity Residential	Residential	Residential-High Density
High Intensity Residential/Urban	Residential	Residential-High Density
High Intensity Residential_Impervious	Urban-Impervious	Impervious-HDR
High Intensity Residential_Pervious	Urban-Pervious	Pervious-HDR
Impervious Commercial	Urban-Impervious	Impervious-Comm
Impervious Developed	Urban-Impervious	Urban-Impervious
Impervious residential	Urban-Impervious	Impervious-Res
Industrial	Industrial	Industrial
Institutional	Institutional	Institutional
Low Density Residential	Residential	Residential-Low Density
Low Intensity Developed	Developed	Developed-Low Intensity
Low Intensity Development	Developed	Developed-Low Intensity
Low Intensity Residential	Residential	Residential-Low Density
Low Intensity Residential_Impervious	Urban-Impervious	Impervious-LDR
Low Intensity Residential_Pervious	Urban-Pervious	Pervious-LDR
medium intensity residential	Residential	Residential-Medium Density
medium/high residential	Residential	Residential-Medium Density
Office/Light Industrial	Commercial	Commercial
Open urban grass	Urban-Pervious	Urban-Pervious
Park	Recreational	na[a]
Paved Roads	Roads	Roads
Pervious Commercial	Urban-Pervious	Pervious-Com
Pervious Developed	Urban-Pervious	Urban-Pervious
Pervious residential	Urban-Pervious	Pervious-Res
Recreational	Recreational	na
recreational grasses	Urban-Pervious	Urban-Pervious
Residential	Residential	na
Residential	Residential	na
Residential (new)	Residential	Residential-Medium Density
Residential +2.0 ac/dwell, sewered	Residential	Residential-Low Density
Residential +2.0 ac/dwell, unsewered	Residential	Residential-Low Density
Residential <0.25 ac/dwell, sewered	Residential	Residential-High Density

Original Land Use from TMDL Reports	General Standardization	Specific Standardization
Residential 0.25-0.5 ac/dwell, sewered	Residential	Residential-Medium Density
Residential 0.5-1.0 ac/dwell, sewered	Residential	Residential-Medium Density
Residential 0.5-1.0 ac/dwell, unsewered	Residential	Residential-Medium Density
Residential 1.0-1.5 ac/dwell, sewered	Residential	Residential-Medium Density
Residential 1.0-1.5 ac/dwell, unsewered	Residential	Residential-Medium Density
Residential 1.5-2.0 ac/dwell, sewered	Residential	Residential-Low Density
Residential 1.5-2.0 ac/dwell, unsewered	Residential	Residential-Low Density
Residential/Urban/Road	Residential	na
Roads	Roads	Roads
Transitional	Transitional	Transitional
Transportation/Communication	Commercial	Commercial
Turf grass	Urban-Pervious	Urban-Pervious
Urban Commercial	Commercial	Commercial
Urban Grasses	Urban-Pervious	Urban-Pervious
urban green space	Urban-Pervious	Urban-Pervious
Urban Impervious	Urban-Impervious	Urban-Impervious
Urban Pervious	Urban-Pervious	Urban-Pervious
Urban Residential	Residential	na
Urban/Recreational Grasses	Urban-Pervious	Urban-Pervious
Utilities	MIX-Com/Ind	MIX-Com/Ind

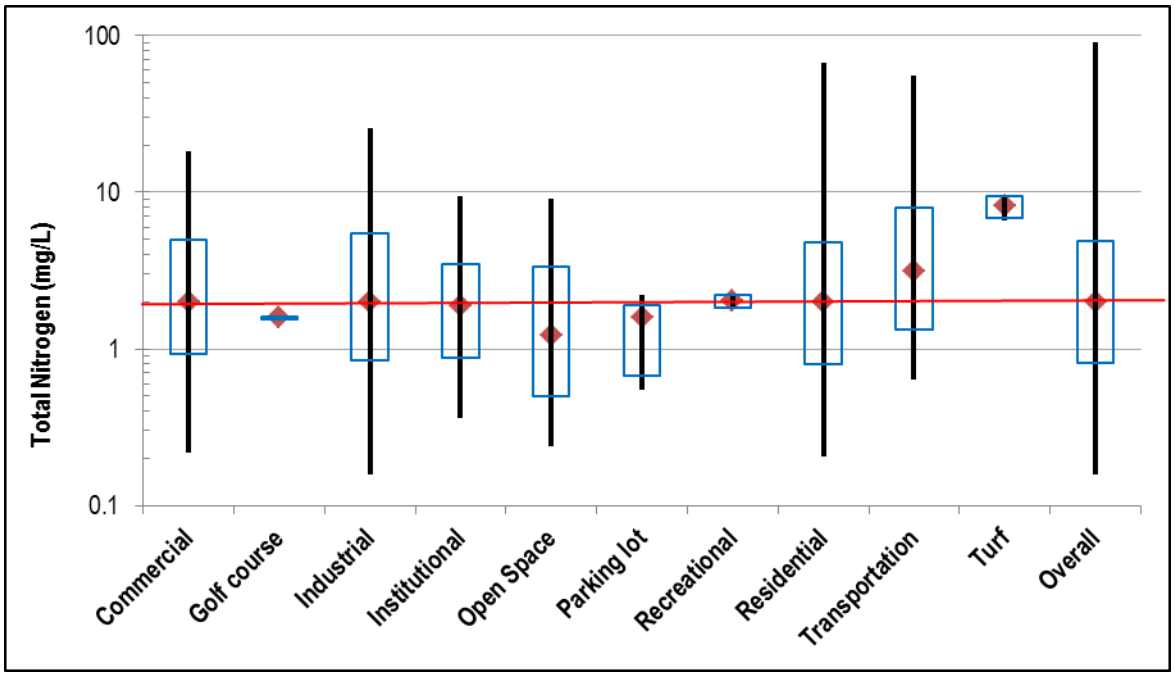
Note:
[a] na = original land use not included as part this standardization.

Attachment C: Box Plots

Attachment C.1: Concentration Statistics/Box Plots from NSQD and Literatures Reviews

Table 7. TN Concentration Statistics from NSQD and Literature Review for General Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Commercial	696	0.22	2.68	18.20	0.94	1.98	5.01
Golf course	2	1.54	1.58	1.62	1.55	1.58	1.61
Industrial	500	0.16	2.70	25.90	0.84	2.00	5.43
Institutional	55	0.36	2.12	9.37	0.88	1.89	3.46
Open Space	116	0.24	1.62	9.14	0.50	1.23	3.34
Parking lot	14	0.55	1.45	2.19	0.67	1.60	1.90
Recreational	2	1.80	2.03	2.26	1.85	2.03	2.21
Residential	1,529	0.20	2.76	67.49	0.79	2.00	4.78
Transportation	230	0.64	4.28	55.38	1.32	3.11	7.93
Turf	2	6.60	8.15	9.70	6.91	8.15	9.39
Overall	4,778	0.16	2.73	90.10	0.81	1.98	4.84

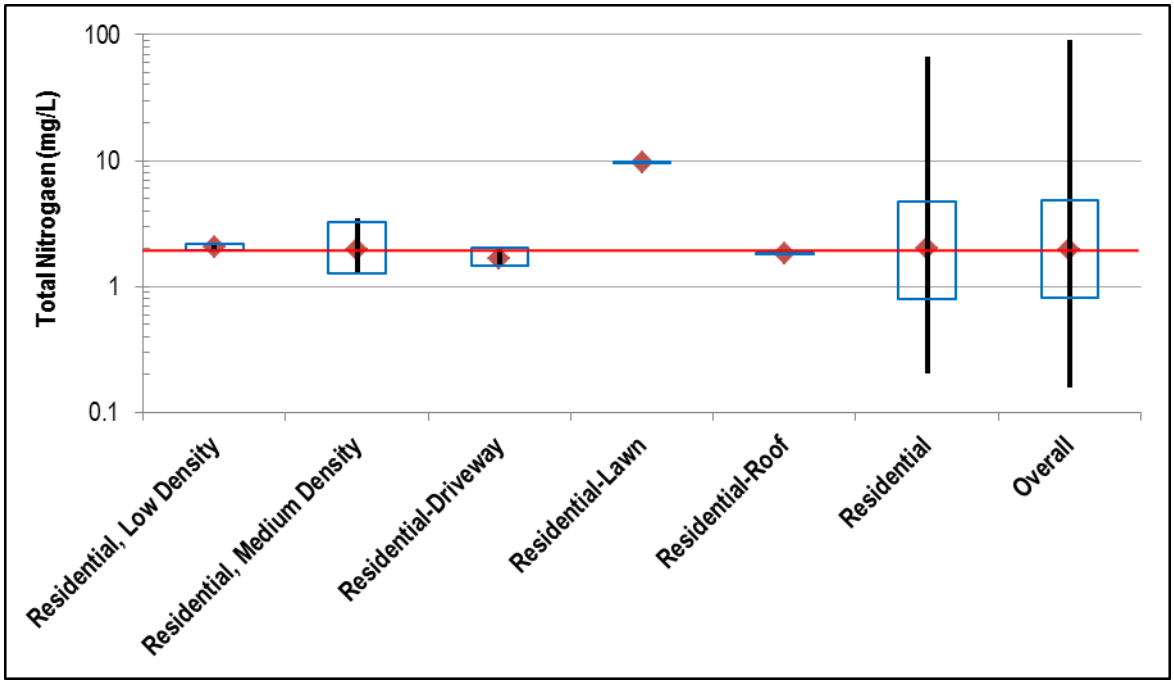


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 7. TN concentration statistics from NSQD and literature review for general land uses.

Table 8. TN Concentration Statistics from NSQD and Literature Review for Residential Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Residential, Low Density	2	1.89	2.06	2.23	1.92	2.06	2.19
Residential, Medium Density	4	1.23	2.17	3.50	1.28	1.99	3.22
Residential-Driveway	3	1.43	1.73	2.10	1.48	1.66	2.01
Residential-Lawn	1	9.70	9.70	9.70	9.70	9.70	9.70
Residential-Roof	1	1.84	1.84	1.84	1.84	1.84	1.84
Residential	1,529	0.20	2.76	67.49	0.79	2.00	4.78
Overall	4,778	0.16	2.73	90.10	0.81	1.98	4.84

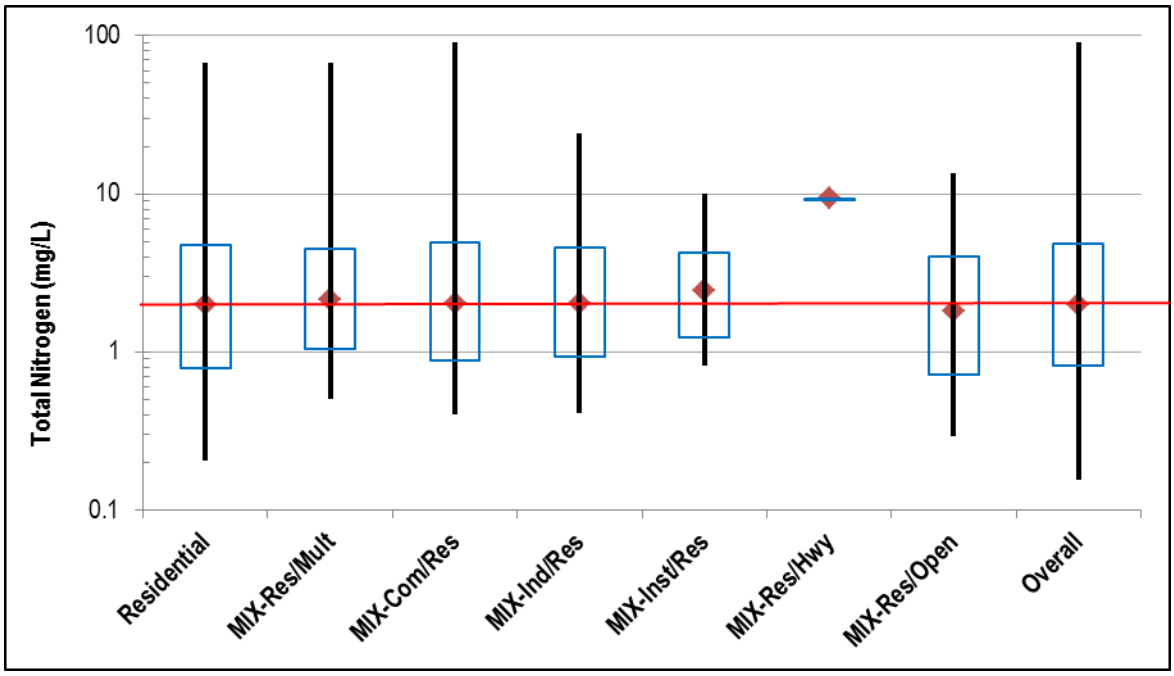


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 8. TN concentration statistics from NSQD and literature review for residential land uses.

Table 9. TN Concentration Statistics from NSQD and Literature Review for Mixed Residential Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Residential	1,529	0.20	2.76	67.49	0.79	2.00	4.78
MIX-Res/Mult	248	0.50	2.86	68.03	1.04	2.14	4.48
MIX-Com/Res	352	0.40	3.08	90.10	0.89	2.03	4.90
MIX-Ind/Res	47	0.41	3.11	24.15	0.93	2.01	4.58
MIX-Inst/Res	101	0.82	2.73	10.00	1.23	2.44	4.26
MIX-Res/Hwy	1	9.36	9.36	9.36	9.36	9.36	9.36
MIX-Res/Open	295	0.29	2.16	13.50	0.71	1.80	4.01
Overall	4,778	0.16	2.73	90.10	0.81	1.98	4.84

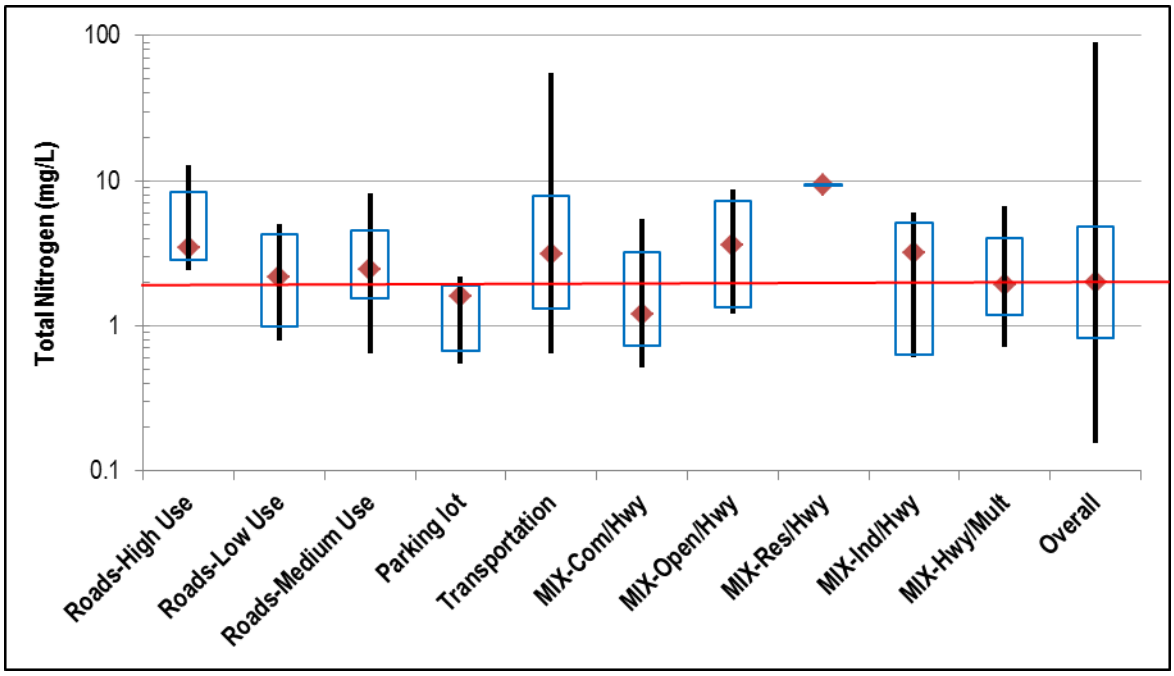


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 9. TN concentration statistics from NSQD and literature review for mixed residential land uses.

Table 10. TN Concentration Statistics from NSQD and Literature Review for Transportation Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Roads-High Use	7	2.39	4.94	12.67	2.83	3.48	8.34
Roads-Low Use	17	0.79	2.30	5.00	0.99	2.17	4.29
Roads-Medium Use	30	0.64	2.91	8.24	1.55	2.46	4.51
Parking lot	14	0.55	1.45	2.19	0.67	1.60	1.90
Transportation	230	0.64	4.28	55.38	1.32	3.11	7.93
MIX-Com/Hwy	22	0.51	1.66	5.44	0.72	1.20	3.22
MIX-Open/Hwy	7	1.21	4.04	8.64	1.34	3.56	7.20
MIX-Res/Hwy	1	9.36	9.36	9.36	9.36	9.36	9.36
MIX-Ind/Hwy	5	0.60	2.82	6.08	0.63	3.15	5.09
MIX-Hwy/Mult	11	0.71	2.31	6.72	1.18	1.91	3.98
Overall	4,778	0.16	2.73	90.10	0.81	1.98	4.84

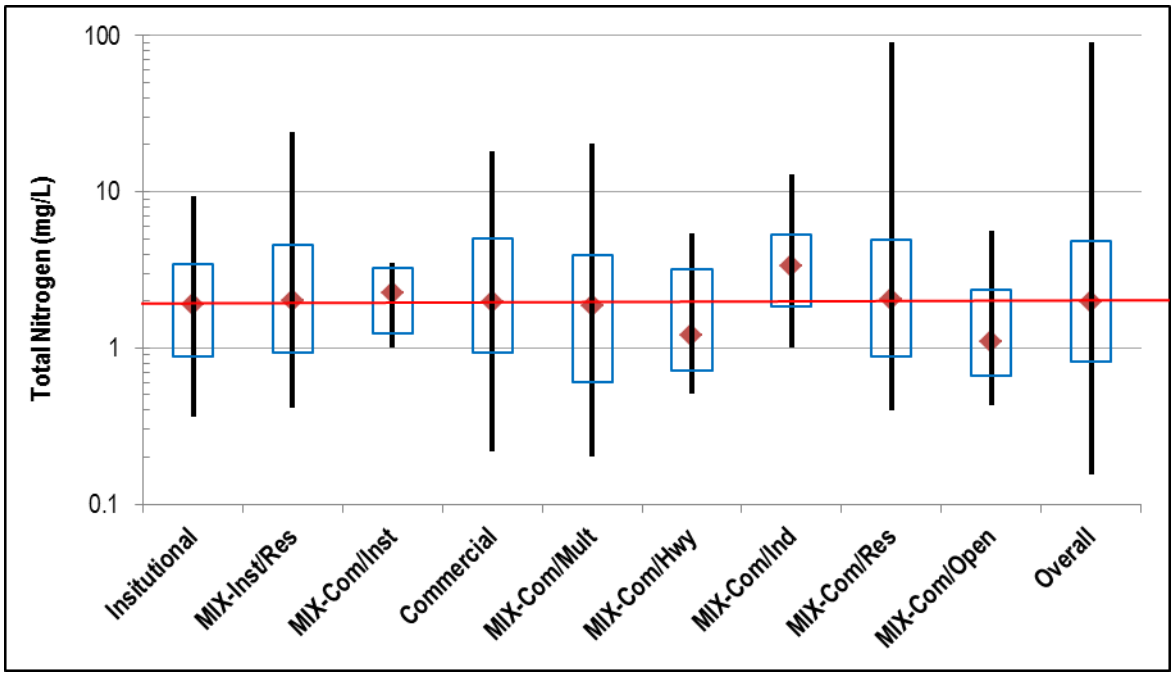


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 10. TN concentration statistics from NSQD and literature review for transportation land uses.

Table 11. TN Concentration Statistics from NSQD and Literature Review for Mixed Institutional and Commercial Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Institutional	55	0.36	2.12	9.37	0.88	1.89	3.46
MIX-Inst/Res	47	0.41	3.11	24.15	0.93	2.01	4.58
MIX-Com/Inst	2	1.00	2.25	3.50	1.25	2.25	3.25
Commercial	696	0.22	2.68	18.20	0.94	1.98	5.01
MIX-Com/Mult	113	0.20	2.40	20.20	0.60	1.87	3.90
MIX-Com/Hwy	22	0.51	1.66	5.44	0.72	1.20	3.22
MIX-Com/Ind	39	1.01	3.63	12.84	1.86	3.32	5.33
MIX-Com/Res	352	0.40	3.08	90.10	0.89	2.03	4.90
MIX-Com/Open	48	0.43	1.41	5.61	0.66	1.10	2.35
Overall	4,778	0.16	2.73	90.10	0.81	1.98	4.84

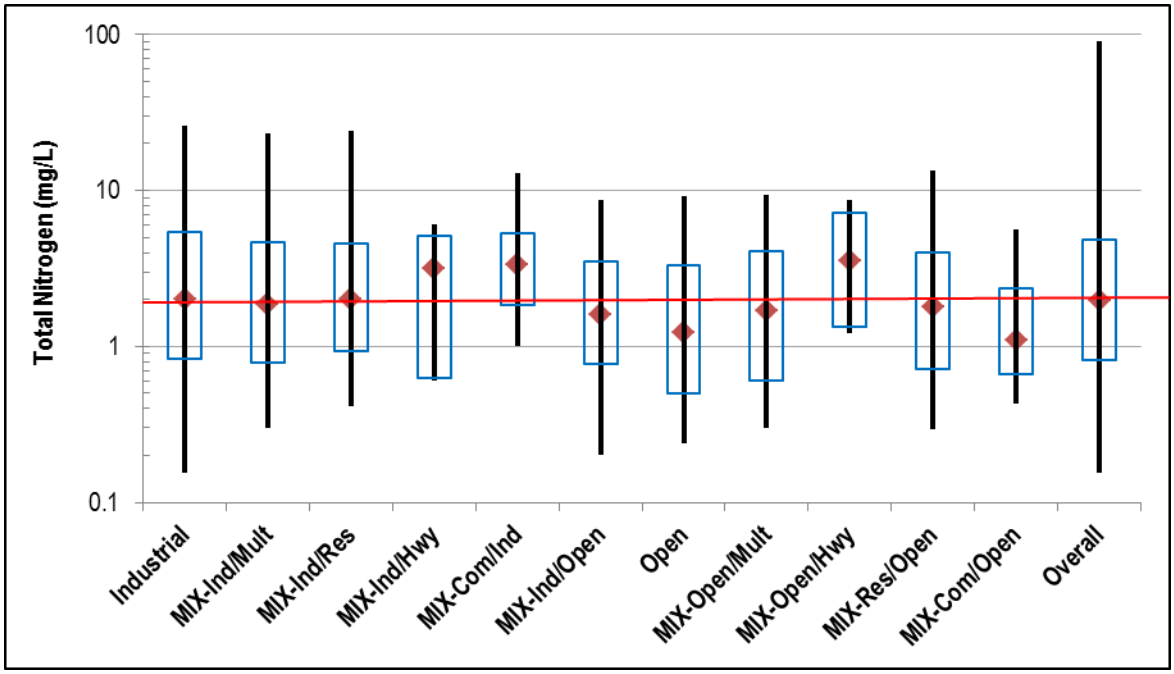


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 11. TN concentration statistics from NSQD and literature review for mixed institutional and commercial land uses.

Table 12. TN Concentration Statistics from NSQD and Literature Review for Mixed Industrial and Open Space Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Industrial	500	0.16	2.70	25.90	0.84	2.00	5.43
MIX-Ind/Mult	46	0.30	2.77	23.30	0.79	1.85	4.70
MIX-Ind/Res	47	0.41	3.11	24.15	0.93	2.01	4.58
MIX-Ind/Hwy	5	0.60	2.82	6.08	0.63	3.15	5.09
MIX-Com/Ind	39	1.01	3.63	12.84	1.86	3.32	5.33
MIX-Ind/Open	66	0.20	2.06	8.70	0.77	1.61	3.50
Open	116	0.24	1.62	9.14	0.50	1.23	3.34
MIX-Open/Mult	71	0.30	2.13	9.40	0.60	1.69	4.10
MIX-Open/Hwy	7	1.21	4.04	8.64	1.34	3.56	7.20
MIX-Res/Open	295	0.29	2.16	13.50	0.71	1.80	4.01
MIX-Com/Open	48	0.43	1.41	5.61	0.66	1.10	2.35
Overall	4,778	0.16	2.73	90.10	0.81	1.98	4.84

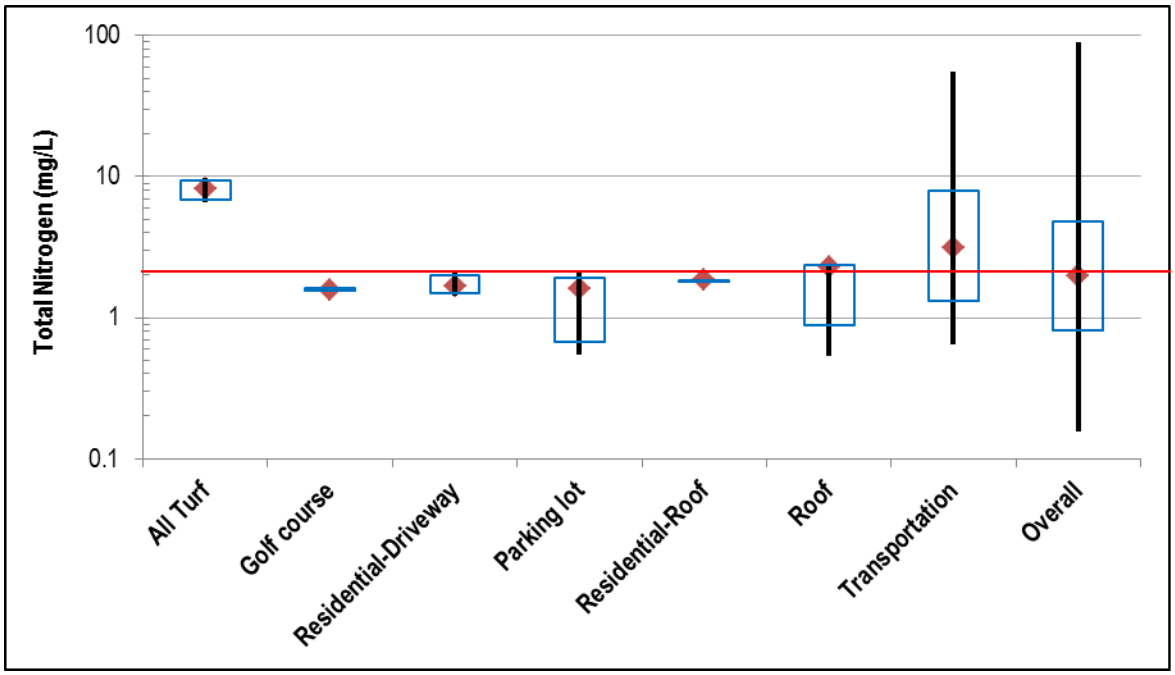


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 12. TN concentration statistics from NSQD and literature review for mixed industrial and open space land uses.

Table 13. TN Concentration Statistics from NSQD and Literature Review for Pervious and Impervious Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
All Turf	2	6.60	8.15	9.70	6.91	8.15	9.39
Golf course	2	1.54	1.58	1.62	1.55	1.58	1.61
Residential-Driveway	3	1.43	1.73	2.10	1.48	1.66	2.01
Parking lot	14	0.55	1.45	2.19	0.67	1.60	1.90
Residential-Roof	1	1.84	1.84	1.84	1.84	1.84	1.84
Roof	3	0.54	1.74	2.40	0.89	2.27	2.37
Transportation	230	0.64	4.28	55.38	1.32	3.11	7.93
Overall	4,778	0.16	2.73	90.10	0.81	1.98	4.84

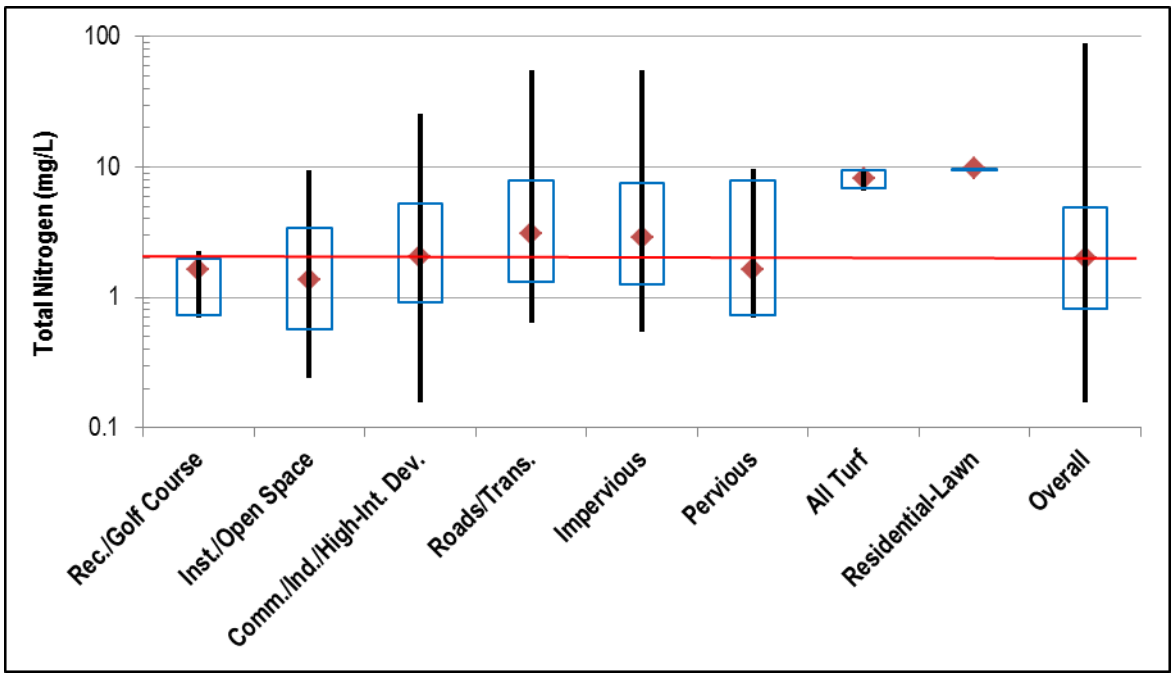


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 13. TN concentration statistics from NSQD and literature review for pervious and impervious land uses.

Table 14. TN Concentration Statistics from NSQD and Literature Review for LUWG Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Rec./Golf Course	7	0.70	1.47	2.26	0.72	1.62	1.98
Inst./Open Space	171	0.24	1.78	9.37	0.57	1.36	3.39
Comm./Ind./High-Int. Dev.	1,240	0.16	2.71	25.90	0.91	2.02	5.25
Roads/Trans.	230	0.64	4.28	55.38	1.32	3.11	7.93
Impervious	245	0.54	4.09	55.38	1.25	2.89	7.55
Pervious	7	0.70	3.22	9.70	0.72	1.62	7.84
All Turf	2	6.60	8.15	9.70	6.91	8.15	9.39
Residential-Lawn	1	9.70	9.70	9.70	9.70	9.70	9.70
Overall	4,778	0.16	2.73	90.10	0.81	1.98	4.84

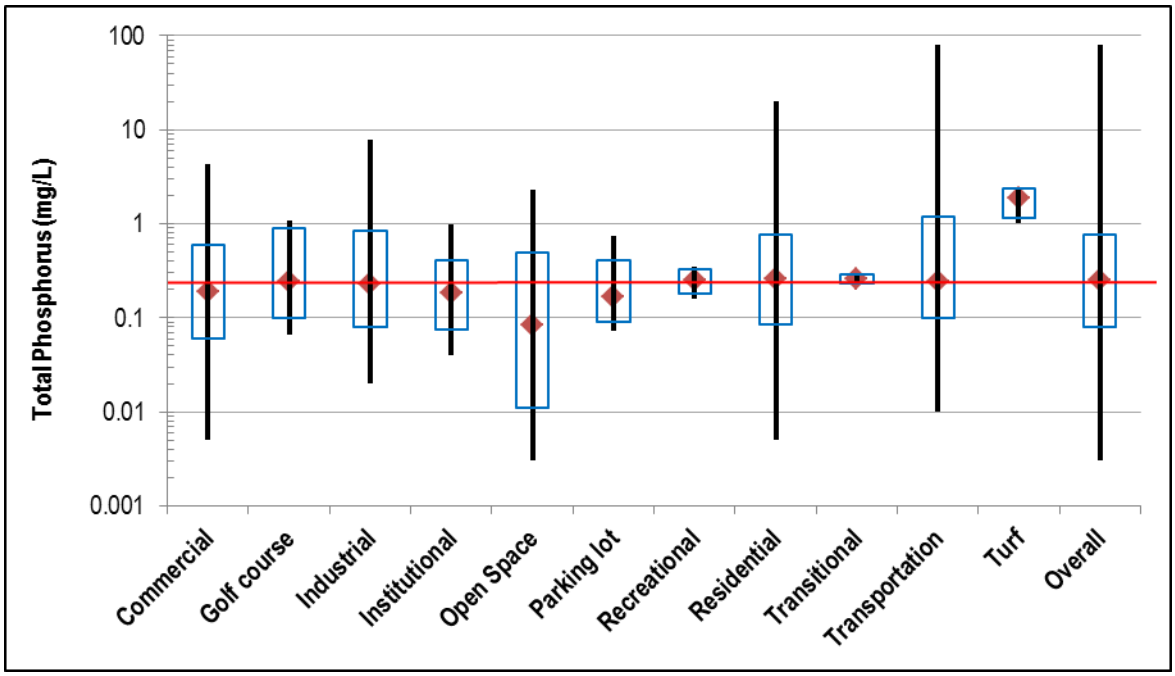


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 14. TN concentration statistics from NSQD and literature review for LUWG land uses.

Table 15. TP Concentration Statistics from NSQD and Literature Review for General Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Commercial	978	0.01	0.30	4.27	0.06	0.19	0.60
Golf course	3	0.07	0.46	1.07	0.10	0.24	0.90
Industrial	578	0.02	0.39	7.90	0.08	0.23	0.83
Institutional	56	0.04	0.23	0.98	0.08	0.19	0.41
Open Space	144	0.00	0.21	2.29	0.01	0.08	0.50
Parking lot	12	0.07	0.23	0.75	0.09	0.17	0.41
Recreational	2	0.16	0.26	0.35	0.18	0.26	0.33
Residential	2,316	0.01	0.40	19.90	0.09	0.26	0.76
Transitional	2	0.22	0.26	0.30	0.23	0.26	0.29
Transportation	641	0.01	0.62	80.20	0.10	0.24	1.19
Turf	4	1.03	1.78	2.34	1.15	1.88	2.34
Overall	6,823	0.00	0.41	80.20	0.08	0.25	0.77

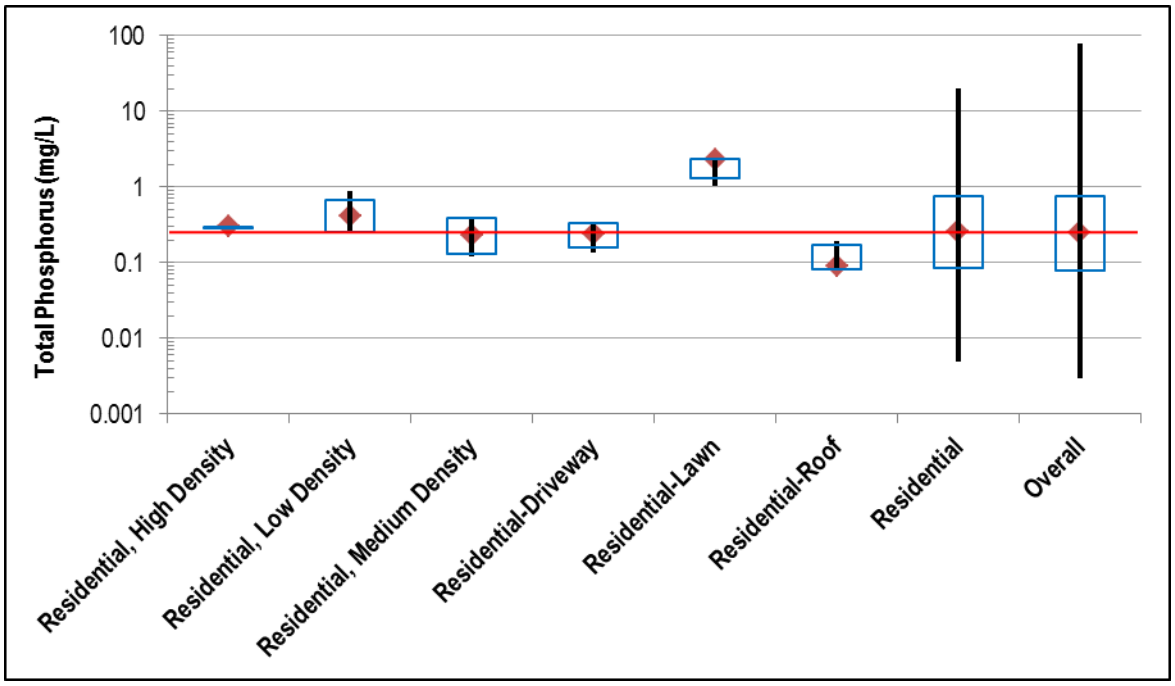


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 15. TP concentration statistics from NSQD and literature review for general land uses.

Table 16. TP Concentration Statistics from NSQD and Literature Review for Residential Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Residential, High Density	1	0.30	0.30	0.30	0.30	0.30	0.30
Residential, Low Density	9	0.25	0.46	0.87	0.26	0.41	0.68
Residential, Medium Density	6	0.12	0.25	0.41	0.13	0.23	0.40
Residential-Driveway	3	0.14	0.24	0.35	0.16	0.24	0.33
Residential-Lawn	3	1.03	1.90	2.34	1.29	2.33	2.34
Residential-Roof	3	0.08	0.12	0.19	0.08	0.09	0.17
Residential	2,316	0.01	0.40	19.90	0.09	0.26	0.76
Overall	6,823	0.00	0.41	80.20	0.08	0.25	0.77

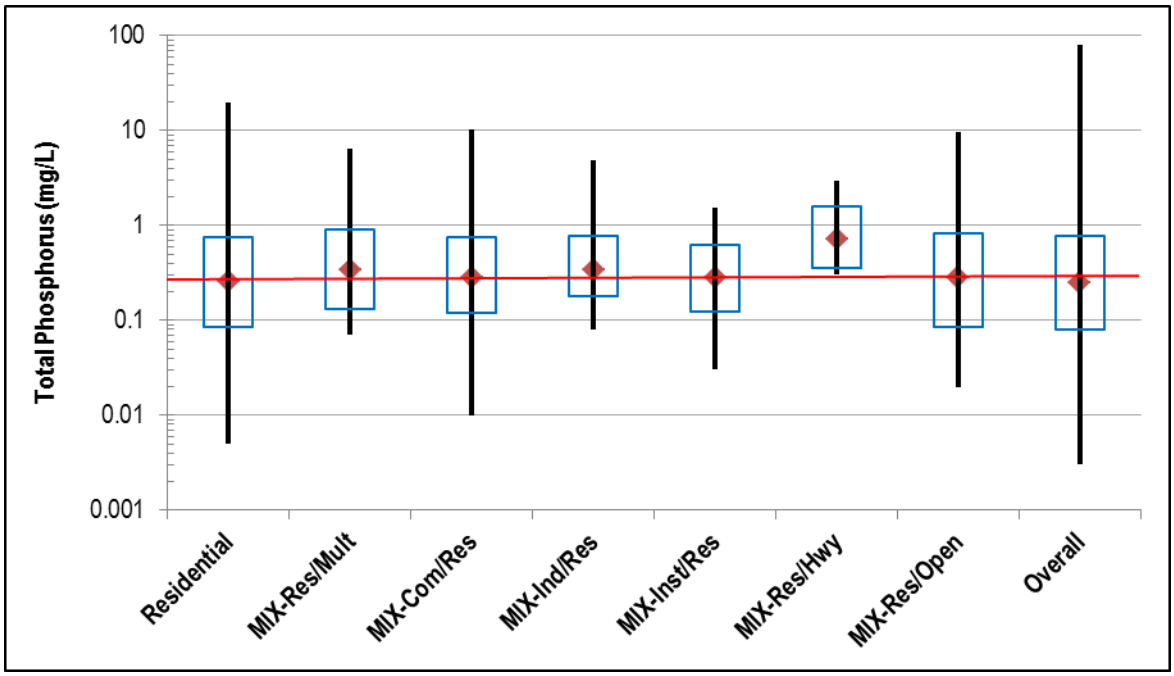


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 16. TP concentration statistics from NSQD and literature review for residential land uses.

Table 17. TP Concentration Statistics from NSQD and Literature Review for Mixed Residential Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Residential	2,316	0.01	0.40	19.90	0.09	0.26	0.76
MIX-Res/Mult	312	0.07	0.49	6.42	0.13	0.34	0.90
MIX-Com/Res	478	0.01	0.41	10.20	0.12	0.28	0.75
MIX-Ind/Res	43	0.08	0.58	4.88	0.18	0.34	0.79
MIX-Inst/Res	106	0.03	0.34	1.55	0.13	0.28	0.63
MIX-Res/Hwy	8	0.30	0.92	2.95	0.35	0.71	1.59
MIX-Res/Open	346	0.02	0.42	9.67	0.08	0.29	0.82
Overall	6,823	0.00	0.41	80.20	0.08	0.25	0.77

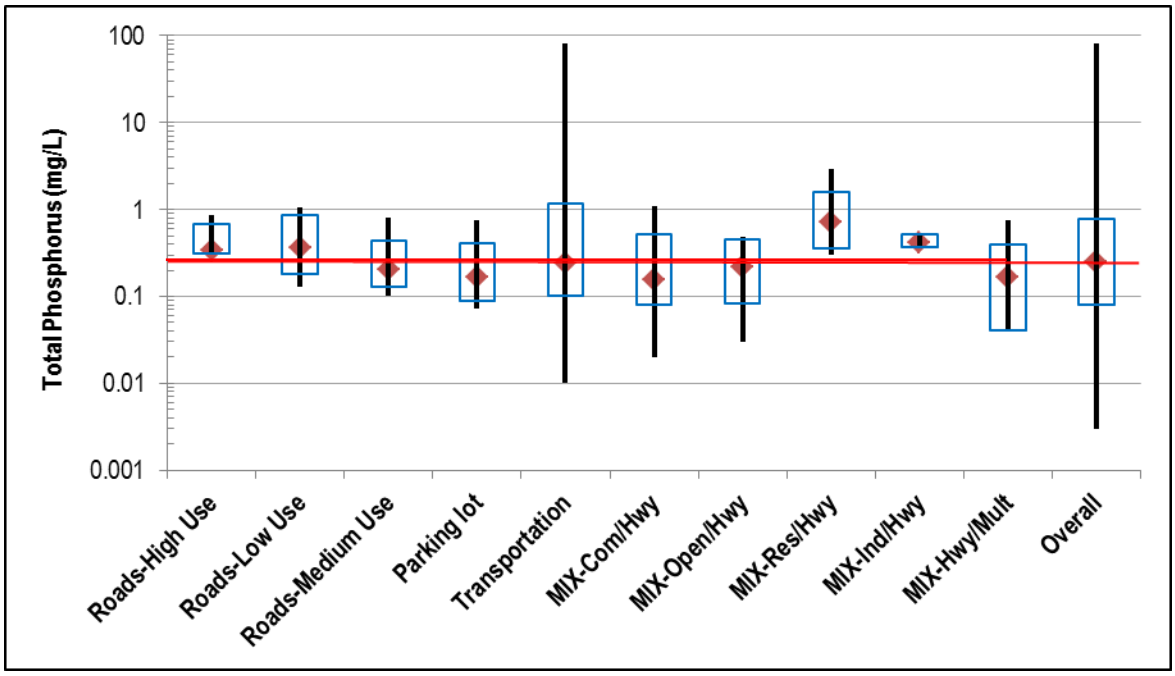


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 17. TP concentration statistics from NSQD and literature review for mixed residential land uses.

Table 18. TP Concentration Statistics from NSQD and Literature Review for Transportation Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Roads-High Use	7	0.31	0.47	0.86	0.32	0.34	0.68
Roads-Low Use	15	0.13	0.44	1.05	0.18	0.36	0.85
Roads-Medium Use	20	0.10	0.25	0.80	0.13	0.21	0.44
Parking lot	12	0.07	0.23	0.75	0.09	0.17	0.41
Transportation	641	0.01	0.62	80.20	0.10	0.24	1.19
MIX-Com/Hwy	28	0.02	0.25	1.08	0.08	0.16	0.51
MIX-Open/Hwy	7	0.03	0.25	0.48	0.08	0.22	0.46
MIX-Res/Hwy	8	0.30	0.92	2.95	0.35	0.71	1.59
MIX-Ind/Hwy	3	0.35	0.43	0.54	0.36	0.41	0.51
MIX-Hwy/Mult	11	0.04	0.23	0.75	0.04	0.17	0.39
Overall	6,823	0.00	0.41	80.20	0.08	0.25	0.77

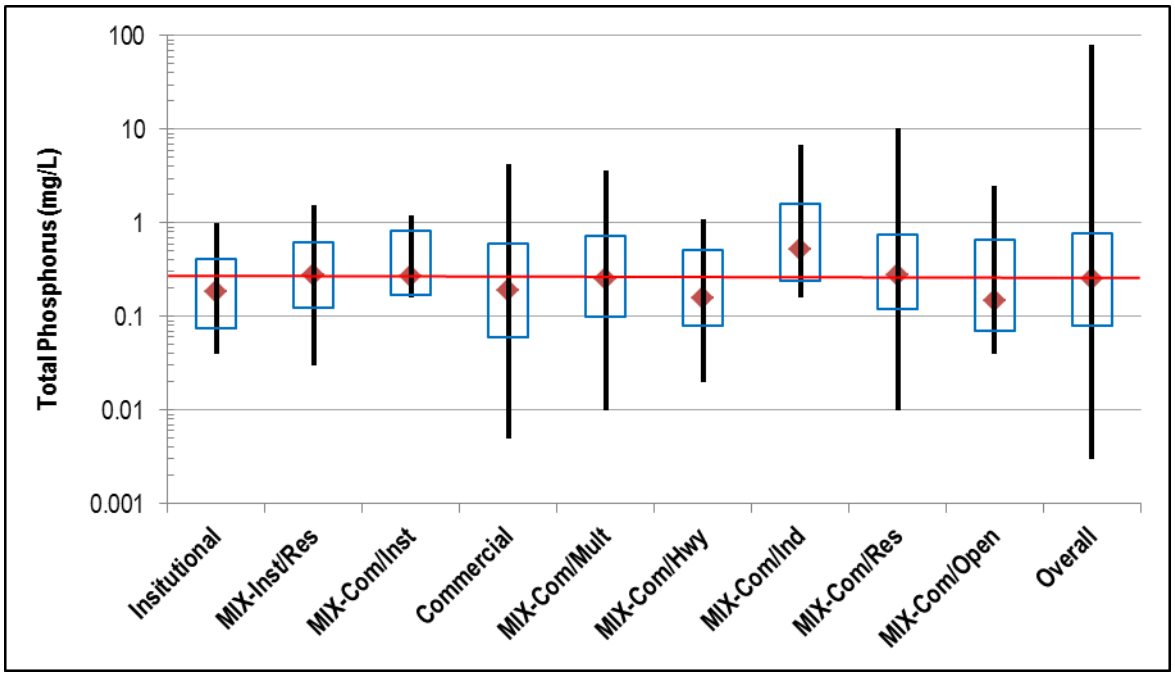


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 18. TP concentration statistics from NSQD and literature review for transportation land uses.

Table 19. TP Concentration Statistics from NSQD and Literature Review for Mixed Institutional and Commercial Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Institutional	56	0.04	0.23	0.98	0.08	0.19	0.41
MIX-Inst/Res	106	0.03	0.34	1.55	0.13	0.28	0.63
MIX-Com/Inst	6	0.16	0.42	1.20	0.17	0.27	0.83
Commercial	978	0.01	0.30	4.27	0.06	0.19	0.60
MIX-Com/Mult	153	0.01	0.36	3.67	0.10	0.25	0.72
MIX-Com/Hwy	28	0.02	0.25	1.08	0.08	0.16	0.51
MIX-Com/Ind	40	0.16	0.86	6.72	0.24	0.52	1.59
MIX-Com/Res	478	0.01	0.41	10.20	0.12	0.28	0.75
MIX-Com/Open	61	0.04	0.30	2.50	0.07	0.15	0.65
Overall	6,823	0.00	0.41	80.20	0.08	0.25	0.77

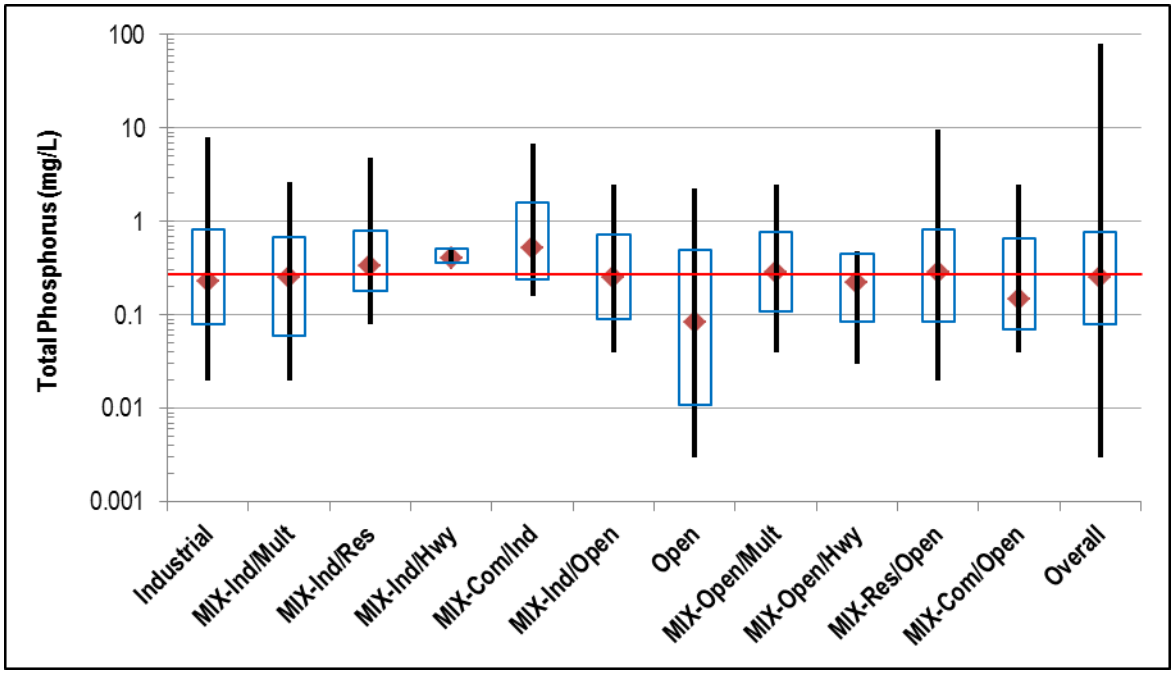


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 19. TP concentration statistics from NSQD and literature review for mixed institutional and commercial land uses.

Table 20. TP Concentration Statistics from NSQD and Literature Review for Mixed Industrial and Open Space Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Industrial	578	0.02	0.39	7.90	0.08	0.23	0.83
MIX-Ind/Mult	42	0.02	0.37	2.64	0.06	0.25	0.69
MIX-Ind/Res	43	0.08	0.58	4.88	0.18	0.34	0.79
MIX-Ind/Hwy	3	0.35	0.43	0.54	0.36	0.41	0.51
MIX-Com/Ind	40	0.16	0.86	6.72	0.24	0.52	1.59
MIX-Ind/Open	83	0.04	0.37	2.50	0.09	0.25	0.74
Open	144	0.00	0.21	2.29	0.01	0.08	0.50
MIX-Open/Mult	74	0.04	0.40	2.50	0.11	0.29	0.78
MIX-Open/Hwy	7	0.03	0.25	0.48	0.08	0.22	0.46
MIX-Res/Open	346	0.02	0.42	9.67	0.08	0.29	0.82
MIX-Com/Open	61	0.04	0.30	2.50	0.07	0.15	0.65
Overall	6,823	0.00	0.41	80.20	0.08	0.25	0.77

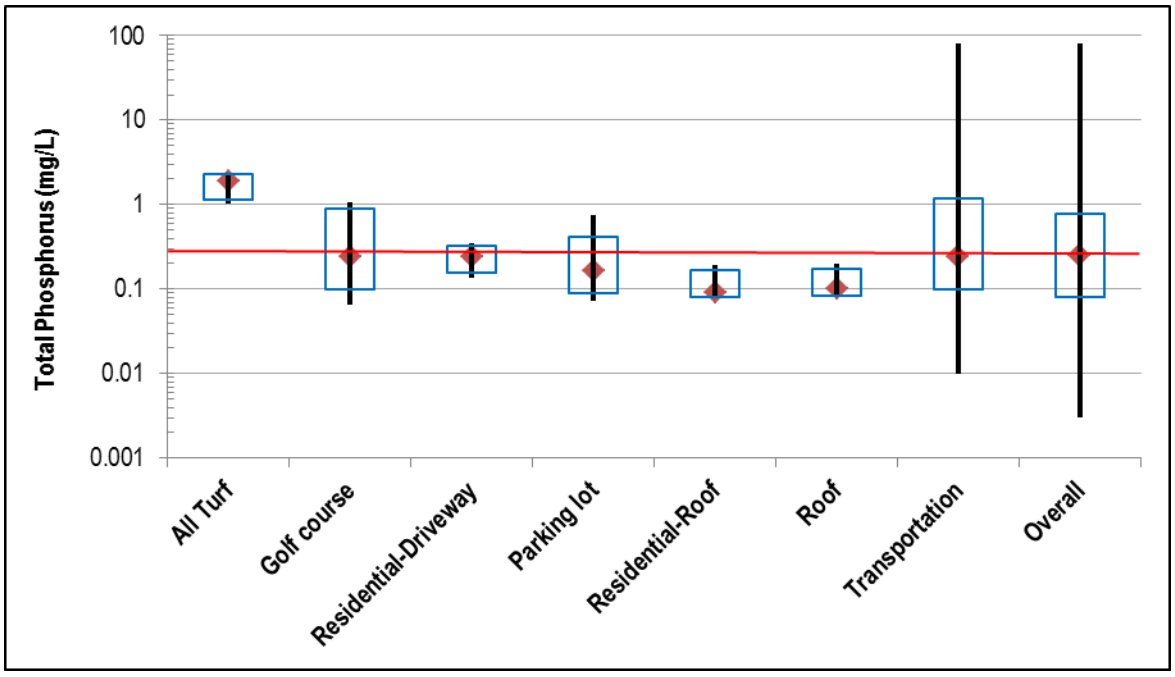


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 20. TP concentration statistics from NSQD and literature review for mixed industrial and open space land uses.

Table 21. TP Concentration Statistics from NSQD and Literature Review for Pervious and Impervious Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
All Turf	4	1.03	1.78	2.34	1.15	1.88	2.34
Golf course	3	0.07	0.46	1.07	0.10	0.24	0.90
Residential-Driveway	3	0.14	0.24	0.35	0.16	0.24	0.33
Parking lot	12	0.07	0.23	0.75	0.09	0.17	0.41
Residential-Roof	3	0.08	0.12	0.19	0.08	0.09	0.17
Roof	4	0.08	0.12	0.20	0.08	0.10	0.17
Transportation	641	0.01	0.62	80.20	0.10	0.24	1.19
Overall	6,823	0.00	0.41	80.20	0.08	0.25	0.77

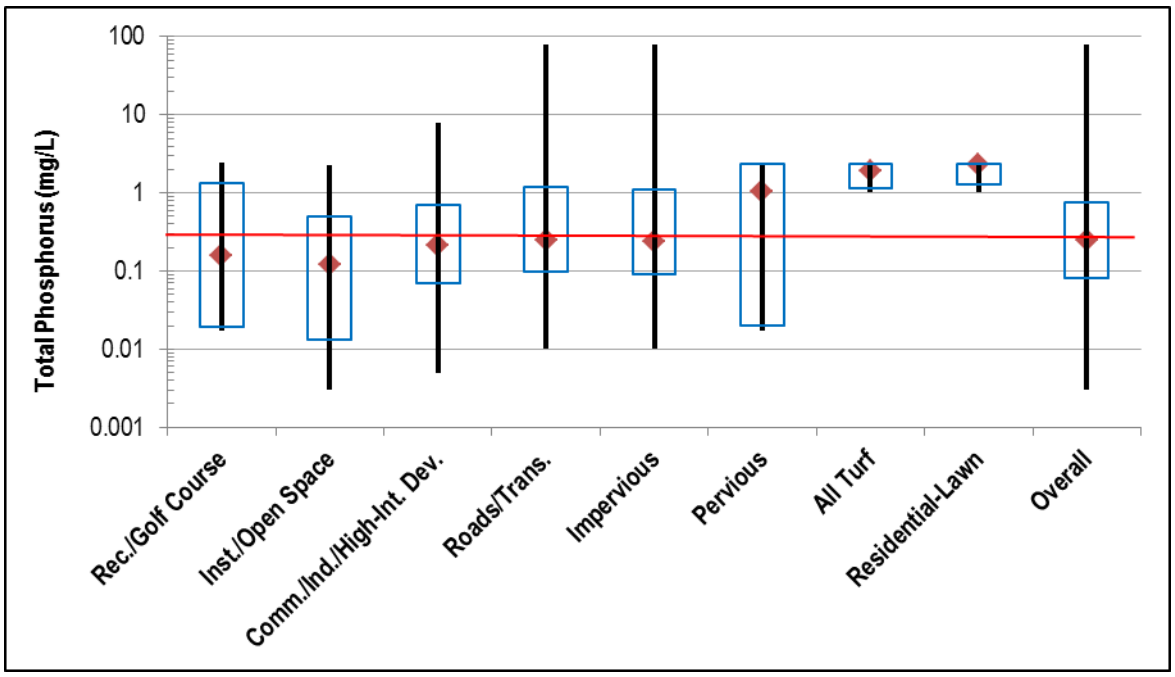


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 21. TP concentration statistics from NSQD and literature review for pervious and impervious land uses.

Table 22. TP Concentration Statistics from NSQD and Literature Review for LUWG Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Rec./Golf Course	9	0.02	0.49	2.44	0.02	0.16	1.34
Inst./Open Space	200	0.00	0.21	2.29	0.01	0.12	0.50
Comm./Ind./High-Int. Dev.	1,605	0.01	0.35	7.90	0.07	0.21	0.69
Roads/Trans.	641	0.01	0.62	80.20	0.10	0.24	1.19
Impervious	660	0.01	0.61	80.20	0.09	0.24	1.12
Pervious	11	0.02	1.00	2.44	0.02	1.03	2.34
All Turf	4	1.03	1.78	2.34	1.15	1.88	2.34
Residential-Lawn	3	1.03	1.90	2.34	1.29	2.33	2.34
Overall	6,823	0.00	0.41	80.20	0.08	0.25	0.77

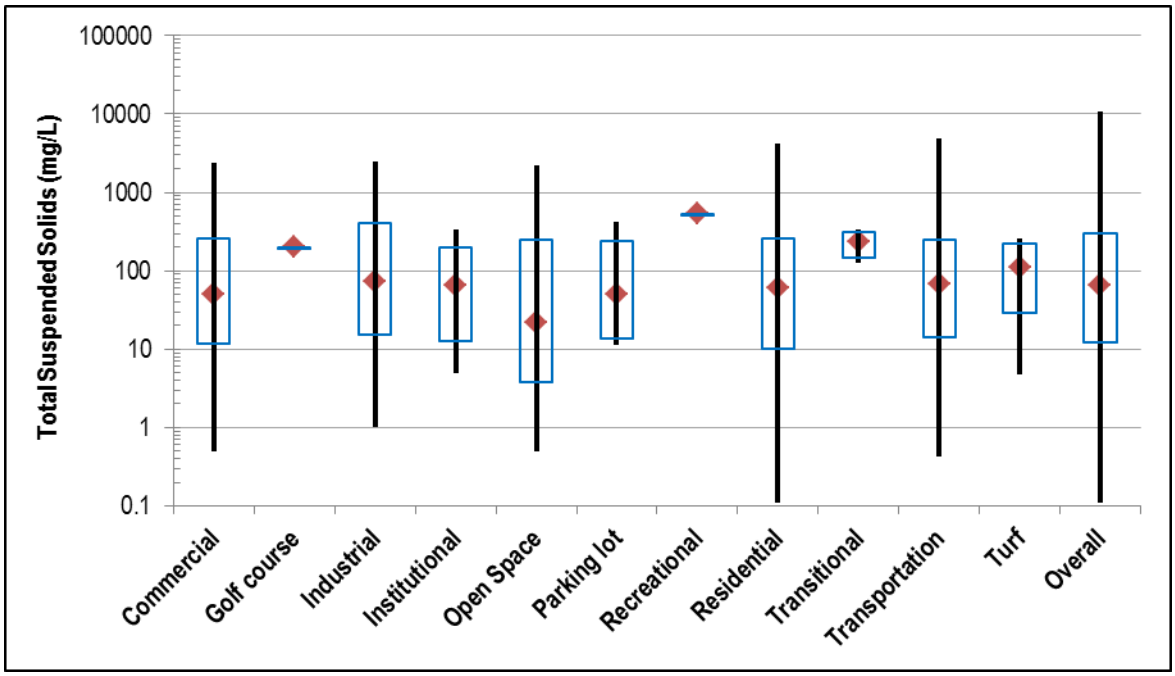


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). Current concentration in the model is represented as red horizontal line.

Figure 22. TP concentration statistics from NSQD and literature review for LUWG land uses.

Table 23. TSS Concentration Statistics from NSQD and Literature Review for General Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Commercial	887	0.50	112.97	2,385	11.82	50.40	254.40
Golf course	1	202.00	202.00	202	202.00	202.00	202.00
Industrial	581	1.00	167.84	2,490	15.00	73.00	402.00
Institutional	57	5.00	84.90	340	12.60	64.26	199.27
Open Space	139	0.50	99.39	2,180	3.80	22.00	248.40
Parking lot	11	11.24	103.82	425	13.45	49.50	241.00
Recreational	1	530.00	530.00	530	530.00	530.00	530.00
Residential	2,186	0.11	123.48	4,168	10.00	60.00	262.50
Transitional	2	128.00	231.50	335	148.70	231.50	314.30
Transportation	460	0.42	126.22	4800	13.99	66.68	244.60
Turf	4	4.77	120.94	262	28.84	108.50	223.00
Overall	6,324	0.11	140.44	10,700	12.00	64.42	300.00

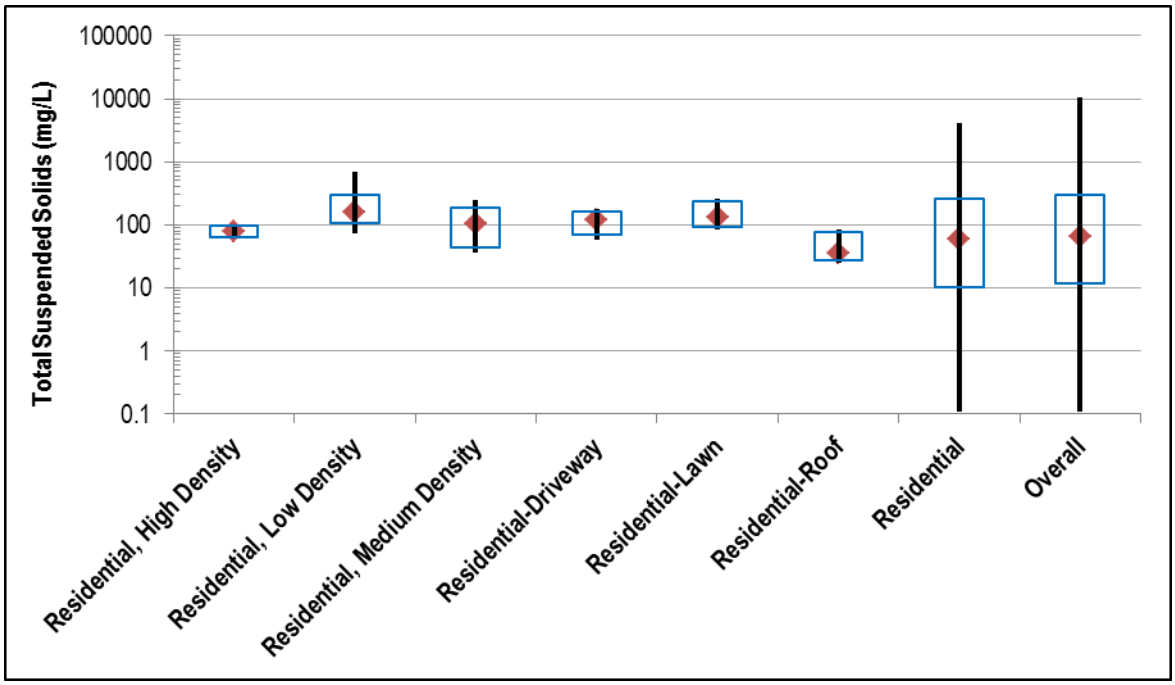


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 23. TSS concentration statistics from NSQD and literature review for general land uses.

Table 24. TSS Concentration Statistics from NSQD and Literature Review for Residential Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Residential, High Density	3	61.00	80.13	102	64.28	77.40	97.08
Residential, Low Density	11	73.00	214.23	680	105.00	156.00	305.00
Residential, Medium Density	7	37.00	117.01	252	44.20	105.00	184.84
Residential-Driveway	2	57.00	117.50	178	69.10	117.50	165.90
Residential-Lawn	3	85.00	159.67	262	94.40	132.00	236.00
Residential-Roof	3	25.00	48.67	85	27.20	36.00	75.20
Residential	2,186	0.11	123.48	4,168	10.00	60.00	262.50
Overall	6,324	0.11	140.44	10,700	12.00	64.42	300.00

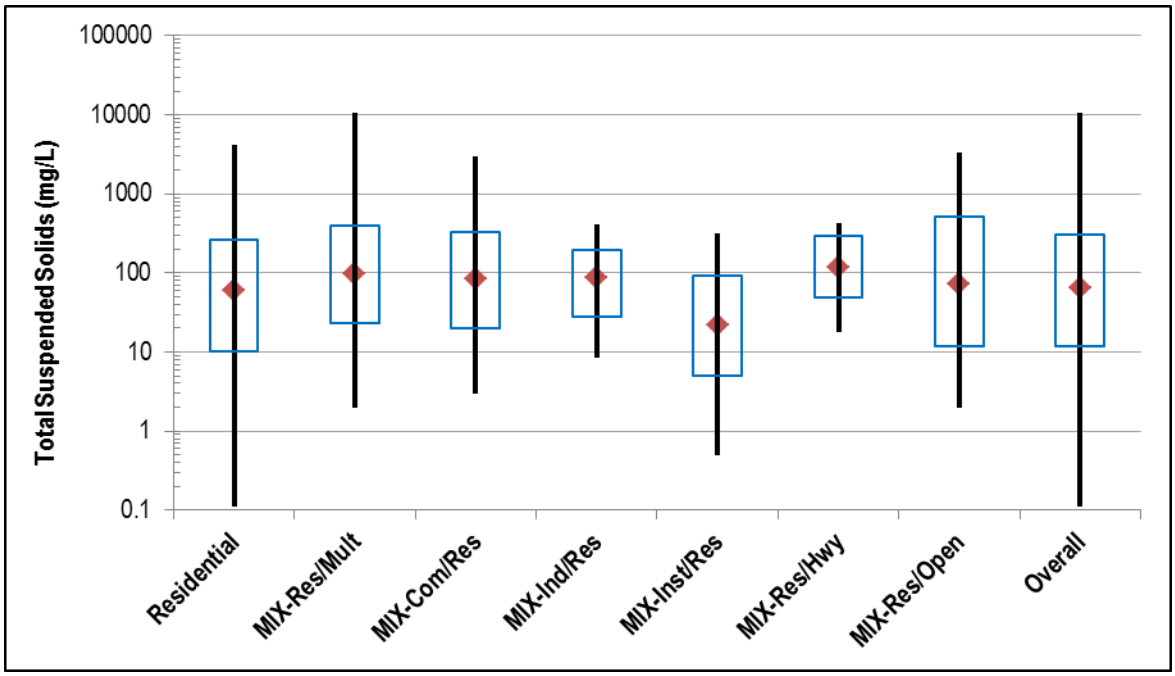


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 24. TSS concentration statistics from NSQD and literature review for residential land uses.

Table 25. TSS Concentration Statistics from NSQD and Literature Review for Mixed Residential Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Residential	2,186	0.11	123.48	4,168	10.00	60.00	262.50
MIX-Res/Mult	333	2.00	258.02	10,700	23.20	96.00	399.60
MIX-Com/Res	476	3.00	154.23	2,996	20.00	82.69	325.00
MIX-Ind/Res	64	8.50	105.04	410	28.20	86.50	191.90
MIX-Inst/Res	109	0.50	42.59	314	5.00	22.00	93.60
MIX-Res/Hwy	9	17.70	173.01	427	49.46	118.00	297.40
MIX-Res/Open	319	2.00	182.45	3,375	12.00	73.00	509.39
Overall	6,324	0.11	140.44	10,700	12.00	64.42	300.00

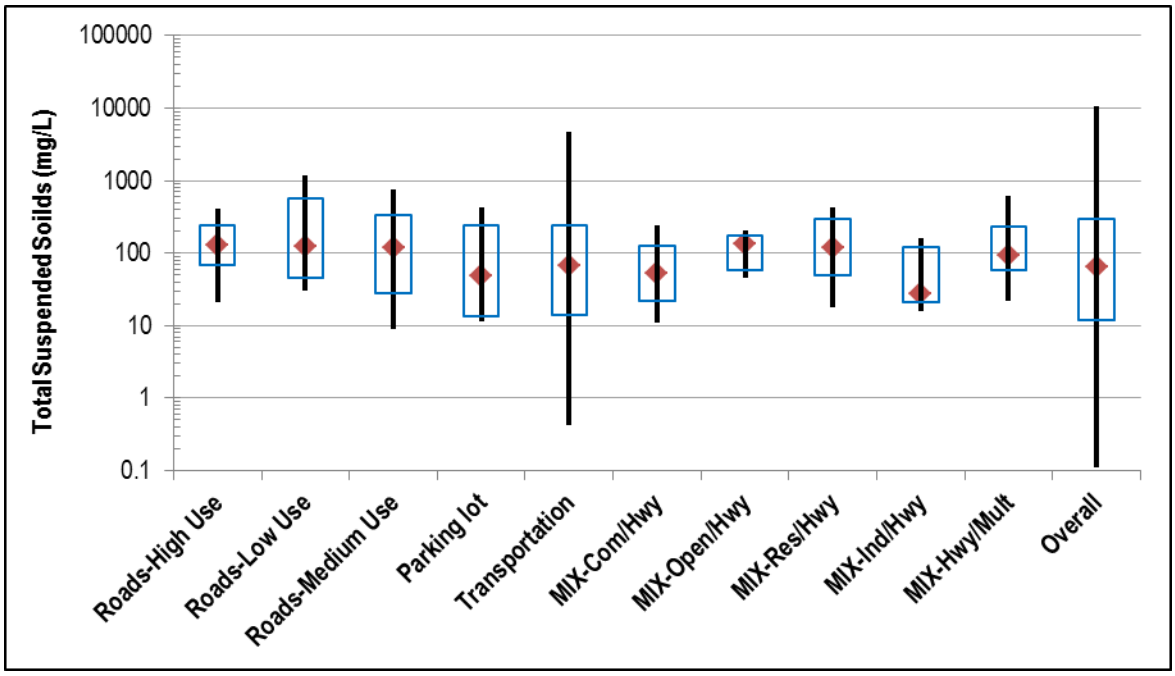


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 25. TSS concentration statistics from NSQD and literature review for mixed residential land uses.

Table 26. TSS Concentration Statistics from NSQD and Literature Review for Transportation Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Roads-High Use	11	21.00	154.89	406	67.70	129.00	240.00
Roads-Low Use	25	30.00	253.20	1,202	45.40	126.00	564.12
Roads-Medium Use	48	9.00	163.86	752	28.40	119.00	341.80
Parking lot	11	11.24	103.82	425	13.45	49.50	241.00
Transportation	460	0.42	126.22	4,800	13.99	66.68	244.60
MIX-Com/Hwy	27	11.00	70.44	239	22.20	52.00	123.80
MIX-Open/Hwy	7	45.00	118.71	209	58.80	134.00	176.00
MIX-Res/Hwy	9	17.70	173.01	427	49.46	118.00	297.40
MIX-Ind/Hwy	5	16.00	58.00	158	20.80	28.00	118.80
MIX-Hwy/Mult	12	22.00	144.17	614	57.50	93.00	228.40
Overall	6,324	0.11	140.44	10,700	12.00	64.42	300.00

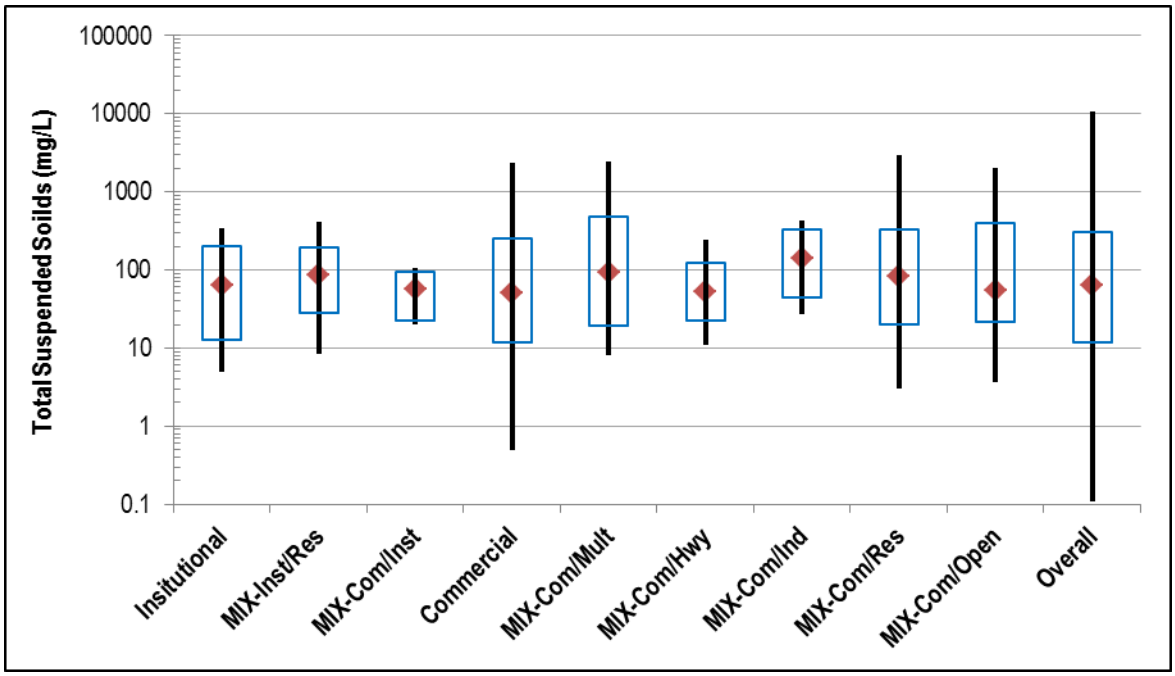


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 26. TSS concentration statistics from NSQD and literature review for transportation land uses.

Table 27. TSS Concentration Statistics from NSQD and Literature Review for Mixed Institutional and Commercial Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Insitutional	57	5.00	84.90	340	12.60	64.26	199.27
MIX-Inst/Res	64	8.50	105.04	410	28.20	86.50	191.90
MIX-Com/Inst	7	20.00	55.29	104	22.40	57.00	95.60
Commercial	887	0.50	112.97	2,385	11.82	50.40	254.40
MIX-Com/Mult	159	8.00	194.59	2,418	19.41	93.00	475.40
MIX-Com/Hwy	27	11.00	70.44	239	22.20	52.00	123.80
MIX-Com/Ind	39	27.00	169.65	426	43.60	143.00	332.00
MIX-Com/Res	476	3.00	154.23	2,996	20.00	82.69	325.00
MIX-Com/Open	54	3.70	174.79	2,060	21.30	54.00	393.10
Overall	6,324	0.11	140.44	10,700	12.00	64.42	300.00

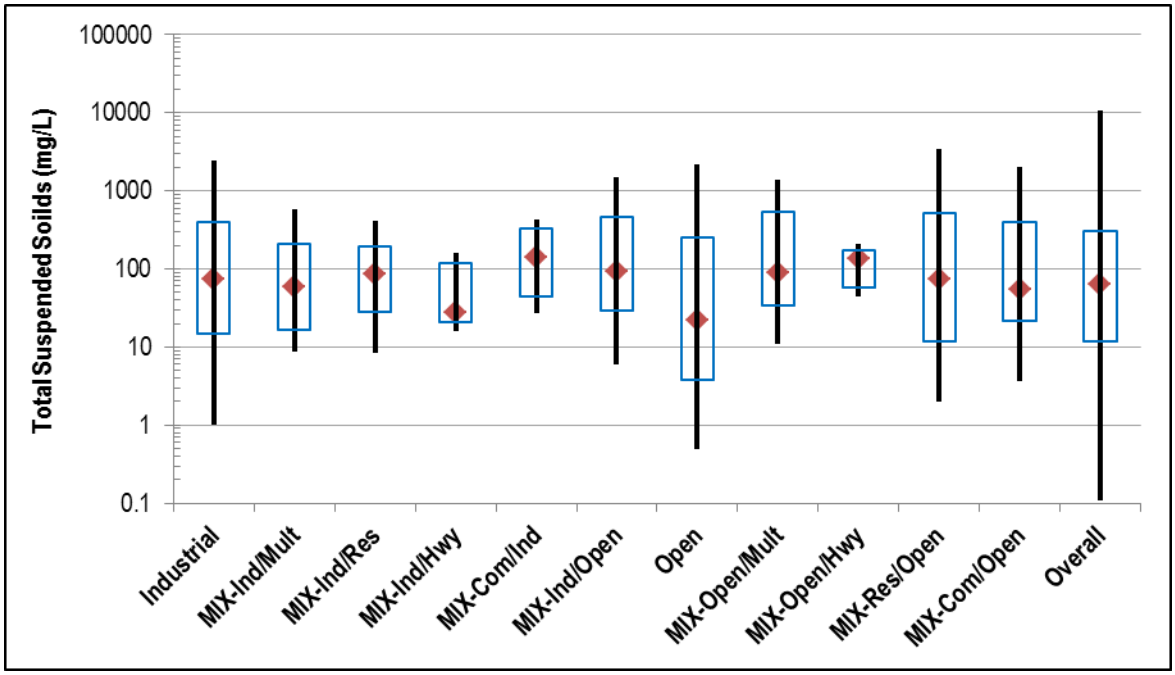


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 27. TSS concentration statistics from NSQD and literature review for mixed institutional and commercial land uses.

Table 28. TSS Concentration Statistics from NSQD and Literature Review for Mixed Industrial and Open Space Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Industrial	581	1.00	167.84	2,490	15.00	73.00	402.00
MIX-Ind/Mult	49	8.70	94.78	576	16.60	58.00	208.80
MIX-Ind/Res	64	8.50	105.04	410	28.20	86.50	191.90
MIX-Ind/Hwy	5	16.00	58.00	158	20.80	28.00	118.80
MIX-Com/Ind	39	27.00	169.65	426	43.60	143.00	332.00
MIX-Ind/Open	85	6.00	191.59	1,472	29.00	94.00	464.00
Open	139	0.50	99.39	2,180	3.80	22.00	248.40
MIX-Open/Mult	74	11.00	206.58	1400	34.60	89.00	531.40
MIX-Open/Hwy	7	45.00	118.71	209	58.80	134.00	176.00
MIX-Res/Open	319	2.00	182.45	3,375	12.00	73.00	509.39
MIX-Com/Open	54	3.70	174.79	2,060	21.30	54.00	393.10
Overall	6,324	0.11	140.44	10,700	12.00	64.42	300.00

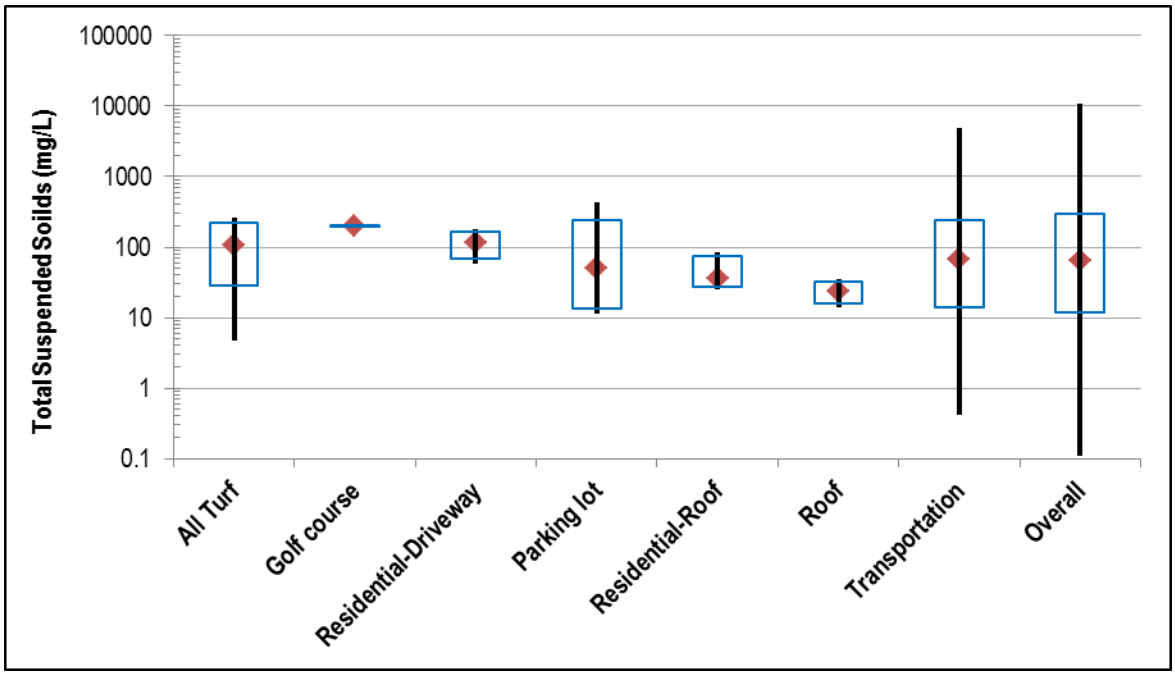


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 28. TSS concentration statistics from NSQD and literature review for mixed industrial and open space land uses.

Table 29. TSS Concentration Statistics from NSQD and Literature Review for Pervious and impervious Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
All Turf	4	4.77	120.94	262	28.84	108.50	223.00
Golf course	1	202.00	202.00	202	202.00	202.00	202.00
Residential-Driveway	2	57.00	117.50	178	69.10	117.50	165.90
Parking lot	11	11.24	103.82	425	13.45	49.50	241.00
Residential-Roof	3	25.00	48.67	85	27.20	36.00	75.20
Roof	3	14.00	24.33	35	16.00	24.00	32.80
Transportation	460	0.42	126.22	4,800	13.99	66.68	244.60
Overall	6,324	0.11	140.44	10,700	12.00	64.42	300.00

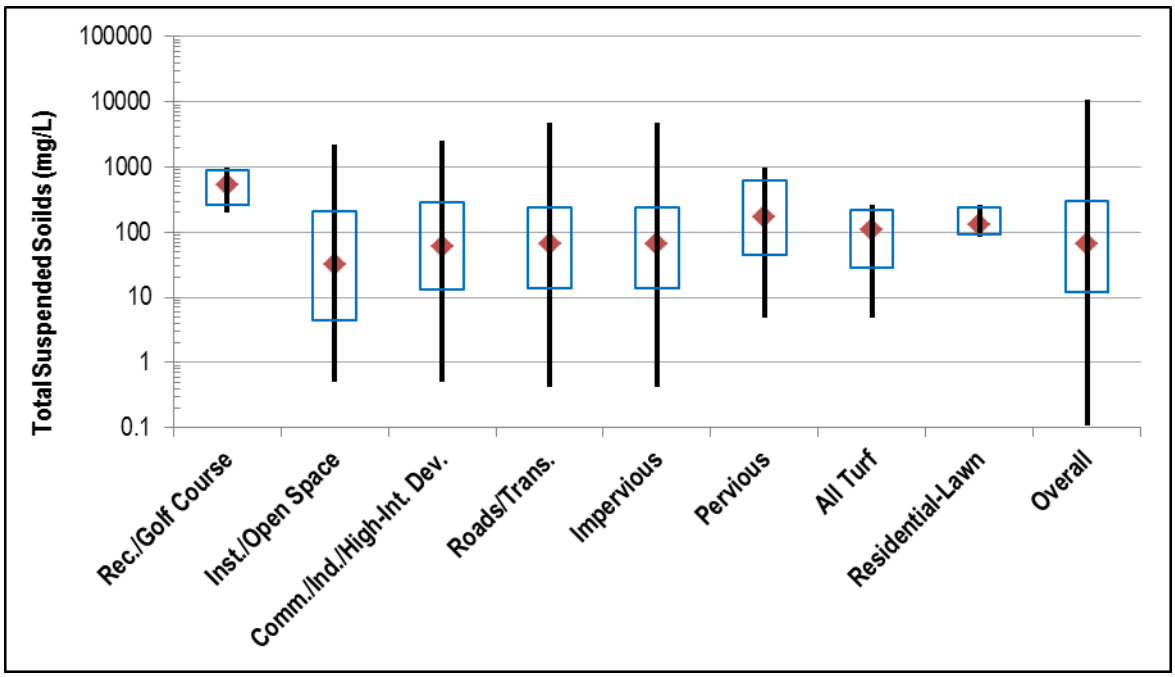


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 29. TSS concentration statistics from NSQD and literature review for pervious and impervious land uses.

Table 30. TSS Concentration Statistics from NSQD and Literature Review for LUWG Land Uses

Land Use	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Rec./Golf Course	3	202.00	575.00	993.00	267.60	530.00	900.40
Inst./Open Space	196	0.50	95.18	2180.00	4.50	32.50	211.08
Comm./Ind./High-Int. Dev.	1,519	0.50	135.86	2490.00	13.00	61.00	292.40
Roads/Trans.	460	0.42	126.22	4800.00	13.99	66.68	244.60
Impervious	471	0.42	122.32	4800.00	13.95	65.00	240.37
Pervious	6	4.77	279.80	993.00	44.89	167.00	627.50
All Turf	4	4.77	120.94	262.00	28.84	108.50	223.00
Residential-Lawn	3	85.00	159.67	262.00	94.40	132.00	236.00
Overall	6,324	0.11	140.44	10700.00	12.00	64.42	300.00



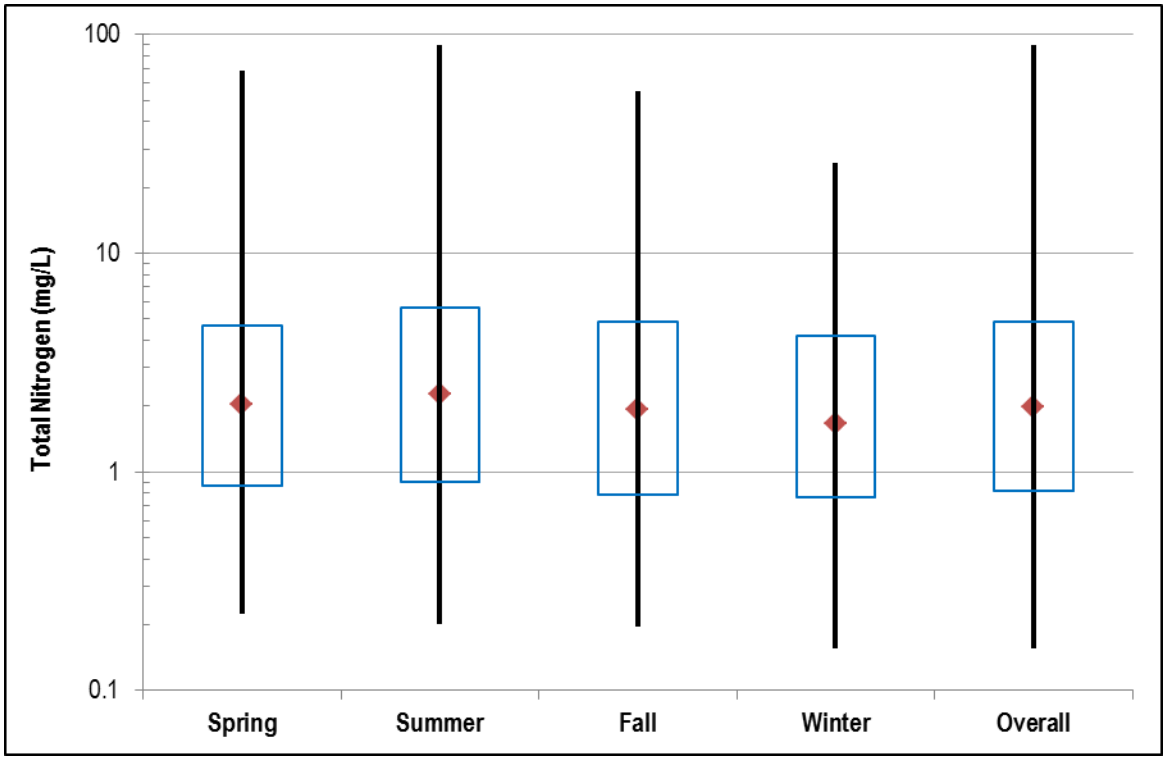
Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 30. TSS concentration statistics from NSQD and literature review for LUWG land uses.

Attachment C.2: Seasonal Concentration Statistics/Box Plots from NSQD and Literatures Reviews

Table 31. TN Seasonal Concentration Statistics from NSQD and Literature Review

Season	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Spring	1,249	0.22	2.79	68.03	0.86	2.03	4.70
Summer	1,093	0.20	3.11	90.10	0.90	2.27	5.60
Fall	1,246	0.20	2.68	55.38	0.79	1.93	4.84
Winter	1,079	0.16	2.36	25.90	0.77	1.66	4.22
Overall	4,778	0.16	2.73	90.10	0.81	1.98	4.84

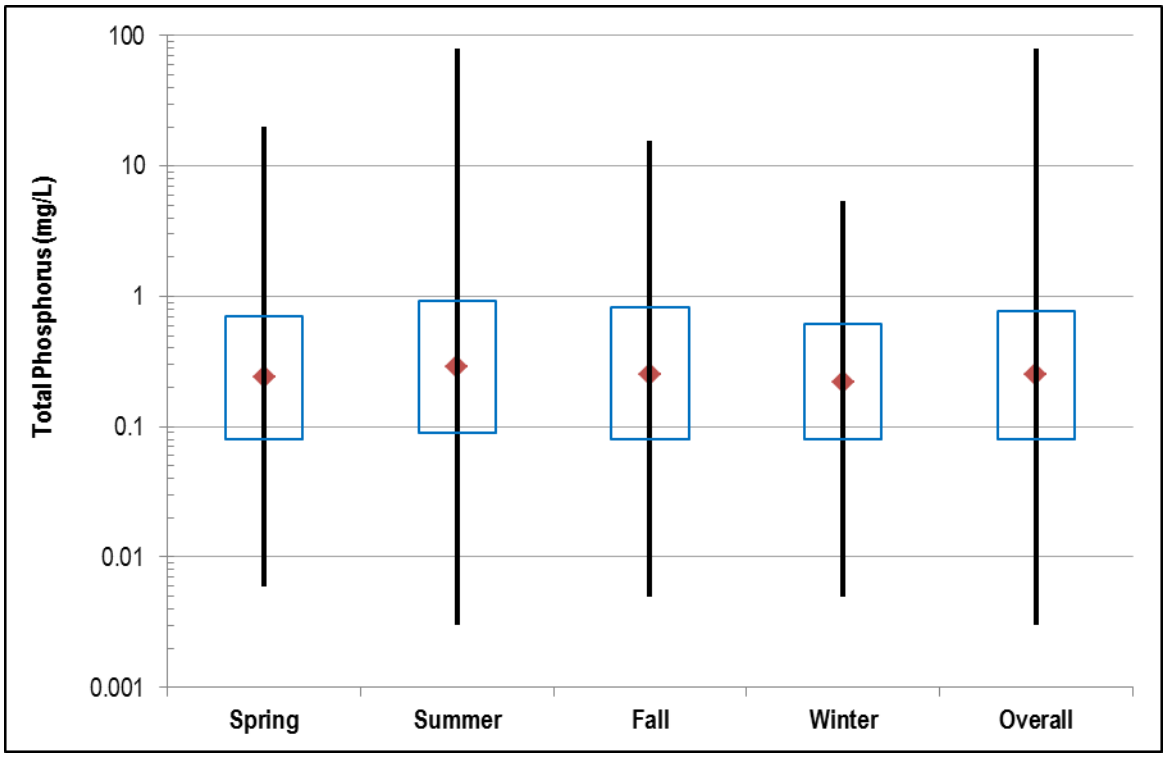


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 31. TN seasonal concentration statistics from NSQD and literature review.

Table 32. TP Seasonal Concentration Statistics from NSQD and Literature Review

Season	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Spring	1,742	0.01	0.39	19.90	0.08	0.24	0.71
Summer	1,622	0.00	0.53	80.20	0.09	0.29	0.92
Fall	1,849	0.01	0.41	15.60	0.08	0.25	0.83
Winter	1,475	0.01	0.33	5.33	0.08	0.22	0.62
Overall	6,823	0.00	0.41	80.20	0.08	0.25	0.77

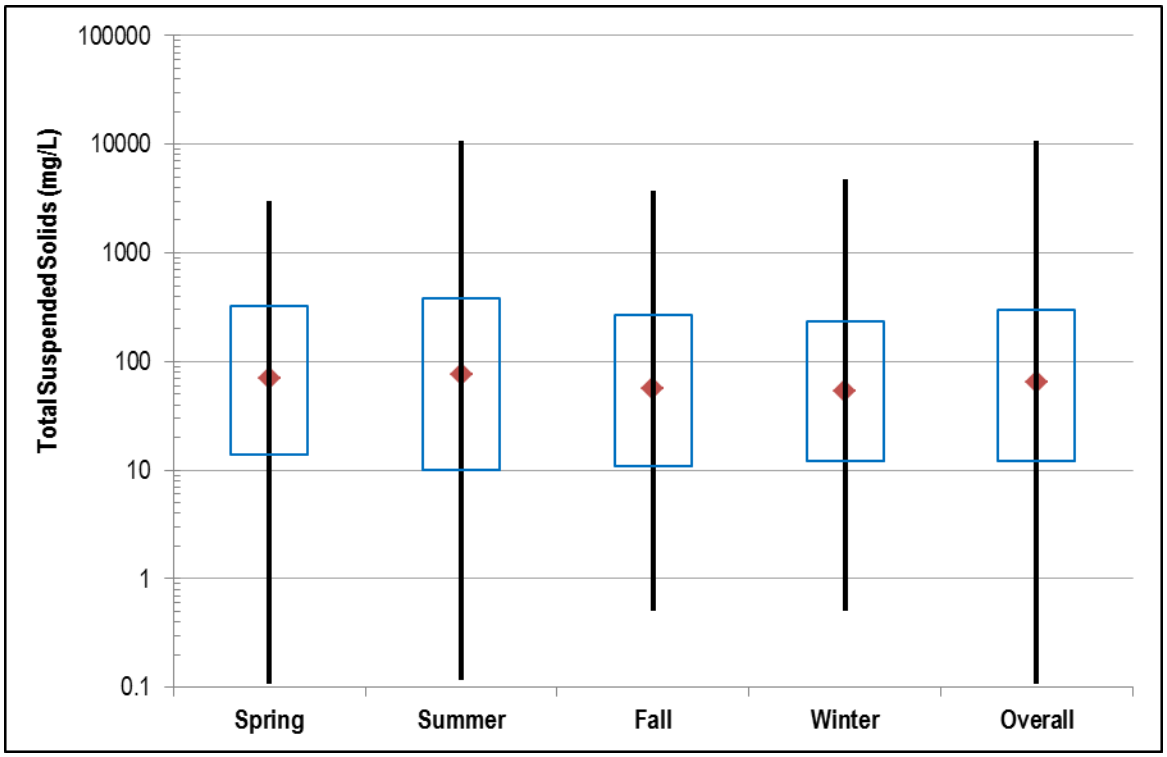


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 32. TP seasonal concentration statistics from NSQD and literature review.

Table 33. TSS Seasonal Concentration Statistics from NSQD and Literature Review

Season	Count	Concentration (mg/L)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Spring	1,621	0.11	148.88	2,996	14.00	69.97	326.00
Summer	1,534	0.12	174.20	10,700	10.00	76.00	383.40
Fall	1,677	0.50	123.40	3,700	11.00	56.00	265.40
Winter	1,318	0.50	109.71	4,800	12.00	53.50	236.60
Overall	6,324	0.11	140.44	10,700	12.00	64.42	300.00



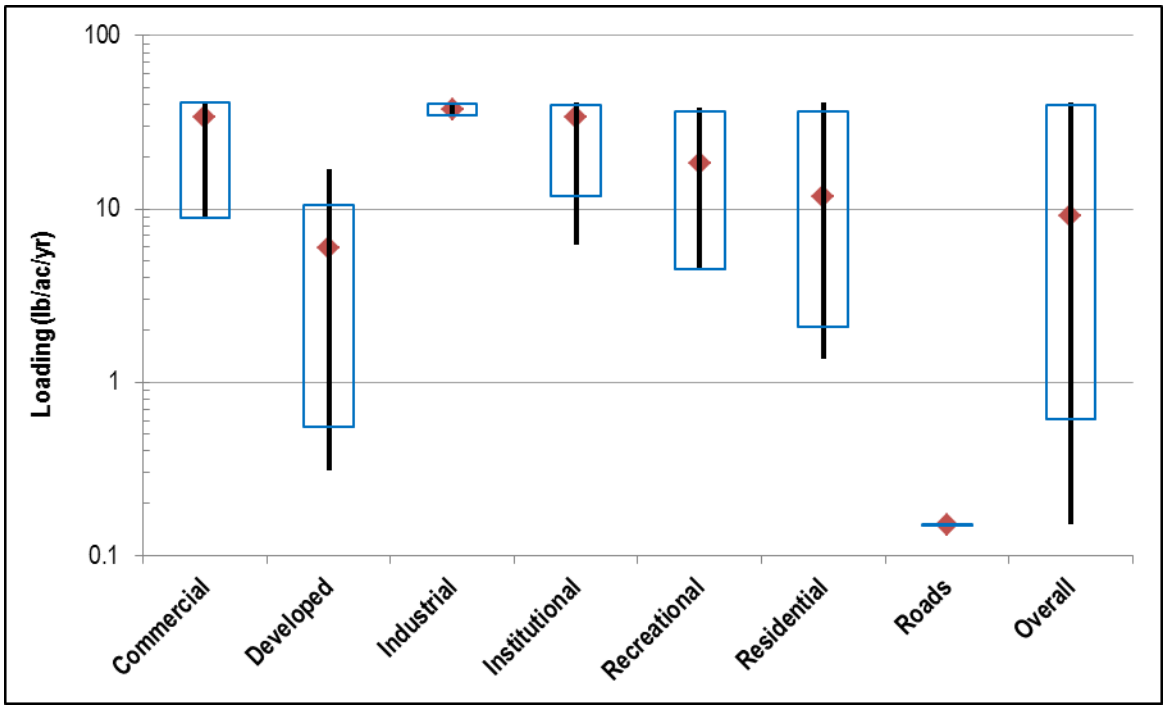
Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 33. TSS seasonal concentration statistics from NSQD and literature review.

Attachment C.3: Loading Rate Statistics/Box Plots from TMDL Report and Literatures Reviews

Table 34. TN Loading Rate Statistics from TMDL Report and Literature Reviews for General Land Uses

Land Use	Count	Loadings (lb/ac/yr)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Commercial	7	8.91	26.32	40.87	8.92	34.12	40.87
Developed	21	0.31	5.43	17.02	0.55	5.99	10.56
Industrial	2	34.12	37.49	40.87	34.79	37.49	40.19
Institutional	3	6.25	27.08	40.87	11.82	34.12	39.52
Recreational	4	4.46	19.77	38.18	4.46	18.21	36.31
Residential	17	1.36	15.66	41.42	2.09	11.72	36.82
Roads	1	0.15	0.15	0.15	0.15	0.15	0.15
Overall	65	0.15	14.17	41.42	0.62	9.06	39.79

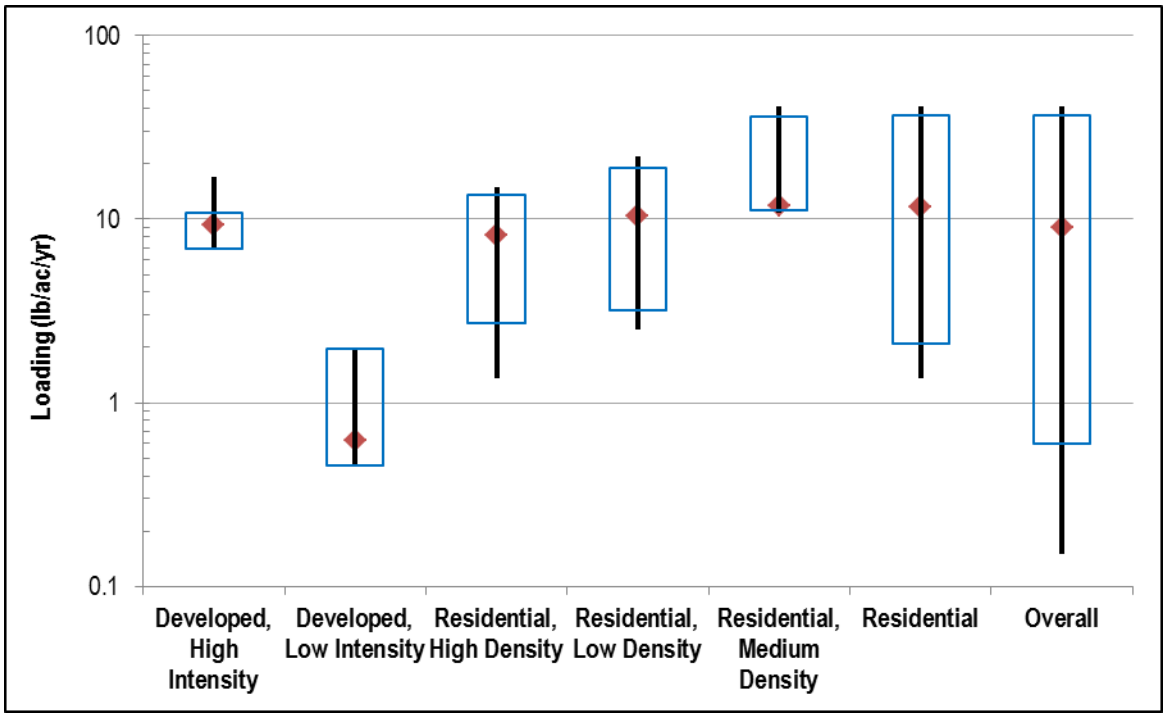


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 34. TN loading rate statistics from TMDL report and literature reviews for general land uses.

Table 35. TN Loading Rate Statistics from TMDL Report and Literature Reviews for Developed and Residential Land Use Categories

Land Use	Count	Loadings (lb/ac/yr)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Developed, High Intensity	11	9.59	9.59	17.02	6.95	9.25	10.79
Developed, Low Intensity	10	0.85	0.85	1.96	0.45	0.62	1.96
Residential, High Density	2	1.36	8.20	15.03	2.73	8.20	13.66
Residential, Low Density	6	2.49	10.88	22.09	3.18	10.39	19.07
Residential, Medium Density	5	10.89	20.92	41.42	11.22	11.86	36.34
Residential	17	1.36	15.66	41.42	2.09	11.72	36.82
Overall	57	0.15	13.37	41.42	0.60	9.06	36.82



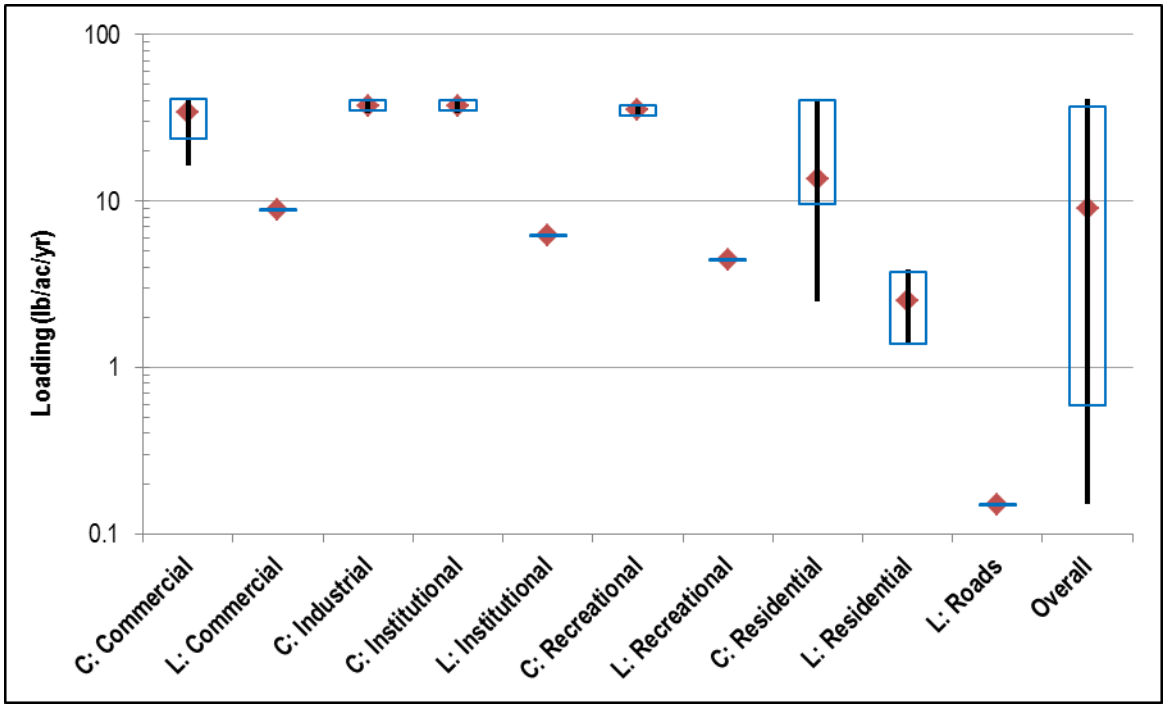
Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 35. TN loading rate statistics from TMDL report and literature reviews for developed and residential land use categories.

Table 36. TN Loading Rate Statistics from TMDL Report and Literature Reviews for General Land Use Categories in Calibrated/Non-Calibrated Models

Land Use	Count	Loadings (lb/ac/yr)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
C: Commercial	5	16.47	33.29	40.87	23.53	34.12	40.87
L: Commercial	2	8.91	8.92	8.92	8.91	8.92	8.92
C: Industrial	2	34.12	37.49	40.87	34.79	37.49	40.19
C: Institutional	2	34.12	37.49	40.87	34.79	37.49	40.19
L: Institutional	1	6.25	6.25	6.25	6.25	6.25	6.25
C: Recreational	2	31.96	35.07	38.18	32.58	35.07	37.55
L: Recreational	2	4.46	4.46	4.46	4.46	4.46	4.46
C: Residential	12	2.49	20.00	41.42	9.52	13.45	40.19
L: Residential	4	1.36	2.57	3.86	1.40	2.53	3.77
L: Roads	1	0.15	0.15	0.15	0.15	0.15	0.15
Overall	57	0.15	13.37	41.42	0.60	9.06	36.82

Note: "C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.



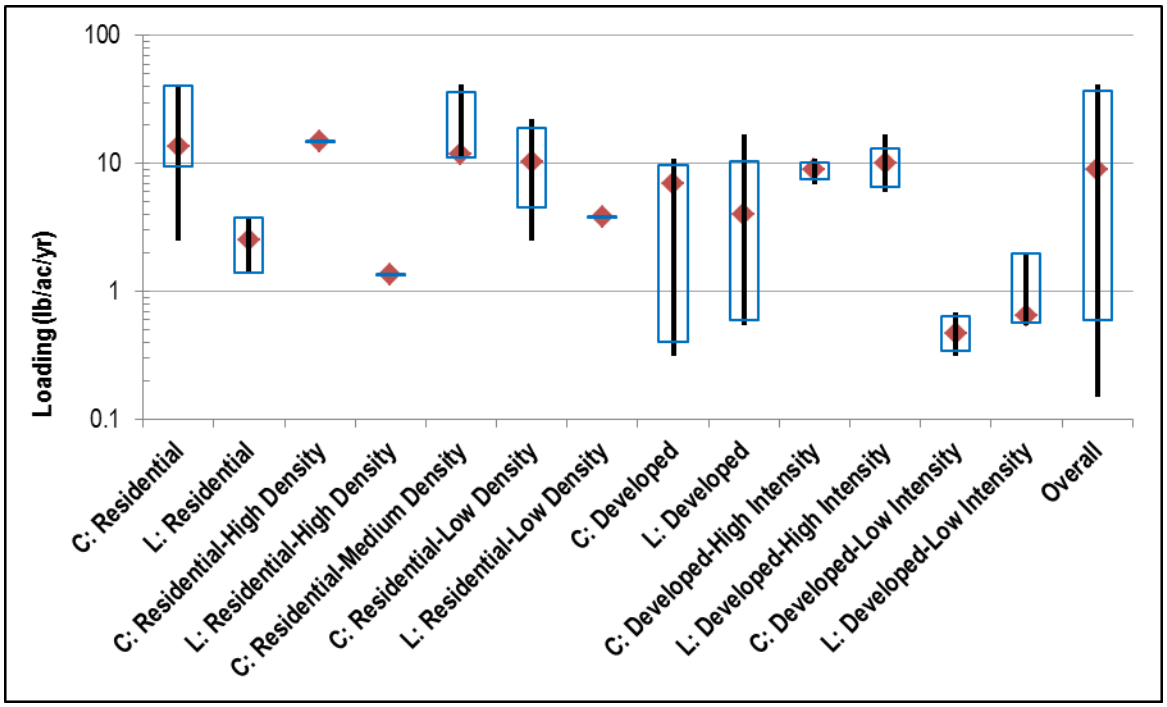
Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). "C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.

Figure 36. TN loading rate statistics from TMDL report and literature reviews for general land use categories in calibrated/non-calibrated models.

Table 37. TN Loading Rate Statistics from TMDL Report and Literature Reviews for Developed and Residential Land Use Categories in Calibrated/Non-Calibrated Models

Land Use	Count	Loadings (lb/ac/yr)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
C: Residential	12	2.49	20.00	41.42	9.52	13.45	40.19
L: Residential	4	1.36	2.57	3.86	1.40	2.53	3.77
C: Residential-High Density	1	15.03	15.03	15.03	15.03	15.03	15.03
L: Residential-High Density	1	1.36	1.36	1.36	1.36	1.36	1.36
C: Residential-Medium Density	5	10.89	20.92	41.42	11.22	11.86	36.34
C: Residential-Low Density	4	2.49	11.34	22.09	4.55	10.39	18.88
L: Residential-Low Density	1	3.86	3.86	3.86	3.86	3.86	3.86
C: Developed	7	0.31	5.31	10.79	0.41	6.95	9.75
L: Developed	14	0.55	5.49	17.02	0.59	3.98	10.40
C: Developed-High Intensity	4	6.95	8.93	10.79	7.54	8.99	10.27
L: Developed-High Intensity	7	5.99	9.97	17.02	6.60	9.97	13.14
C: Developed-Low Intensity	3	0.31	0.49	0.68	0.34	0.47	0.64
L: Developed-Low Intensity	7	0.55	1.00	1.96	0.57	0.64	1.96
Overall	57	0.15	13.37	41.42	0.60	9.06	36.82

Note: "C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.

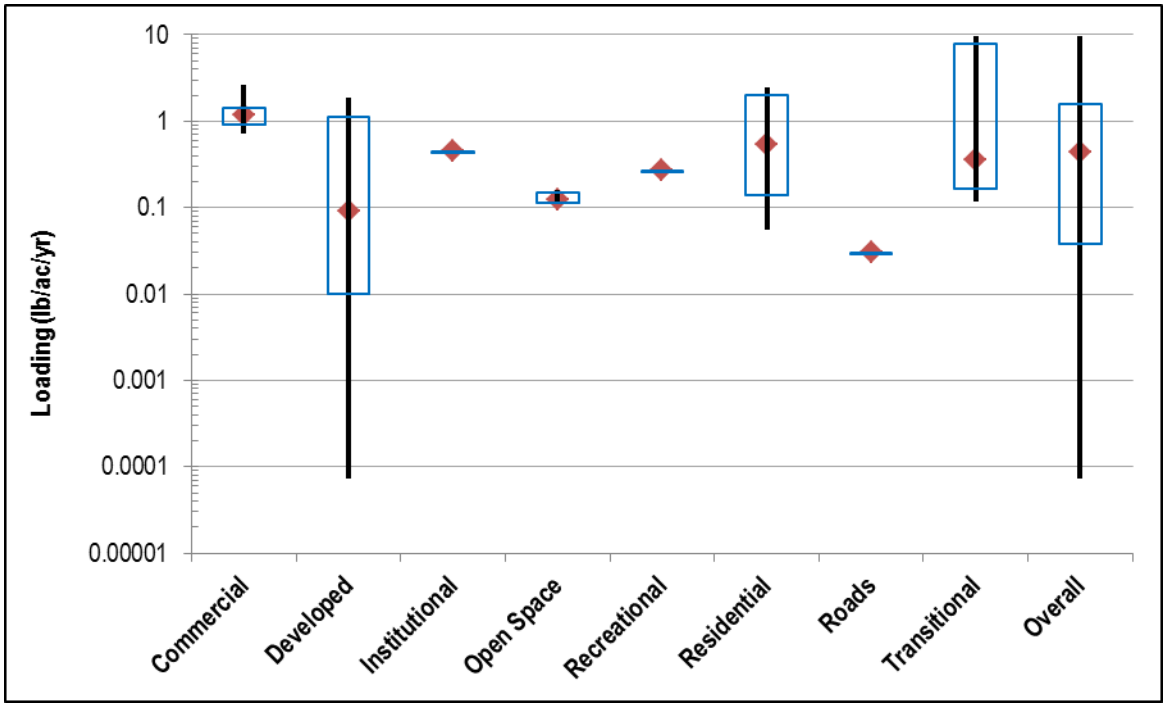


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). "C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.

Figure 37. TN loading rate statistics from TMDL report and literature reviews for developed and residential land use categories in calibrated/non-calibrated models.

Table 38. TP Loading Rate Statistics from TMDL Report and Literature Reviews for General Land Uses

Land Use	Count	Loadings (lb/ac/yr)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Commercial	21	0.71	1.21	2.63	0.90	1.18	1.43
Developed	82	0.00	0.34	1.89	0.01	0.09	1.11
Institutional	1	0.45	0.45	0.45	0.45	0.45	0.45
Open Space	6	0.11	0.13	0.16	0.11	0.12	0.15
Recreational	2	0.27	0.27	0.27	0.27	0.27	0.27
Residential	51	0.06	0.90	2.47	0.14	0.54	2.00
Roads	1	0.03	0.03	0.03	0.03	0.03	0.03
Transitional	3	0.12	3.40	9.74	0.17	0.35	7.86
Overall	199	0.00	0.68	9.74	0.04	0.44	1.57

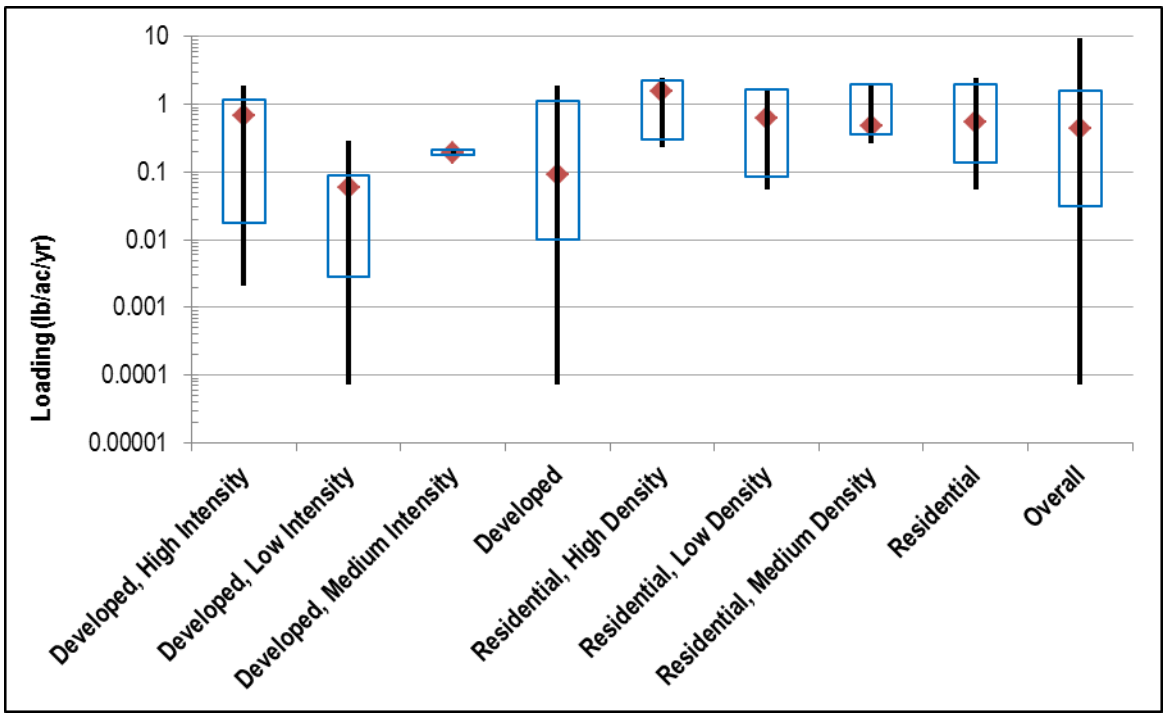


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 38. TP loading rate statistics from TMDL report and literature reviews for general land uses.

Table 39. TP Loading Rate Statistics from TMDL Report and Literature Reviews for Developed and Residential Land Use Categories

Land Use	Count	Loadings (lb/ac/yr)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Developed, High Intensity	35	0.00	0.68	1.89	0.02	0.69	1.18
Developed, Low Intensity	41	0.00	0.06	0.29	0.00	0.06	0.09
Developed, Medium Intensity	6	0.18	0.19	0.22	0.18	0.19	0.21
Developed	82	0.00	0.34	1.89	0.01	0.09	1.11
Residential, High Density	10	0.23	1.48	2.47	0.30	1.55	2.28
Residential, Low Density	16	0.06	0.82	1.74	0.08	0.62	1.64
Residential, Medium Density	16	0.26	0.91	2.03	0.37	0.47	1.97
Residential	51	0.06	0.90	2.47	0.14	0.54	2.00
Overall	188	0.00	0.69	9.74	0.03	0.45	1.57



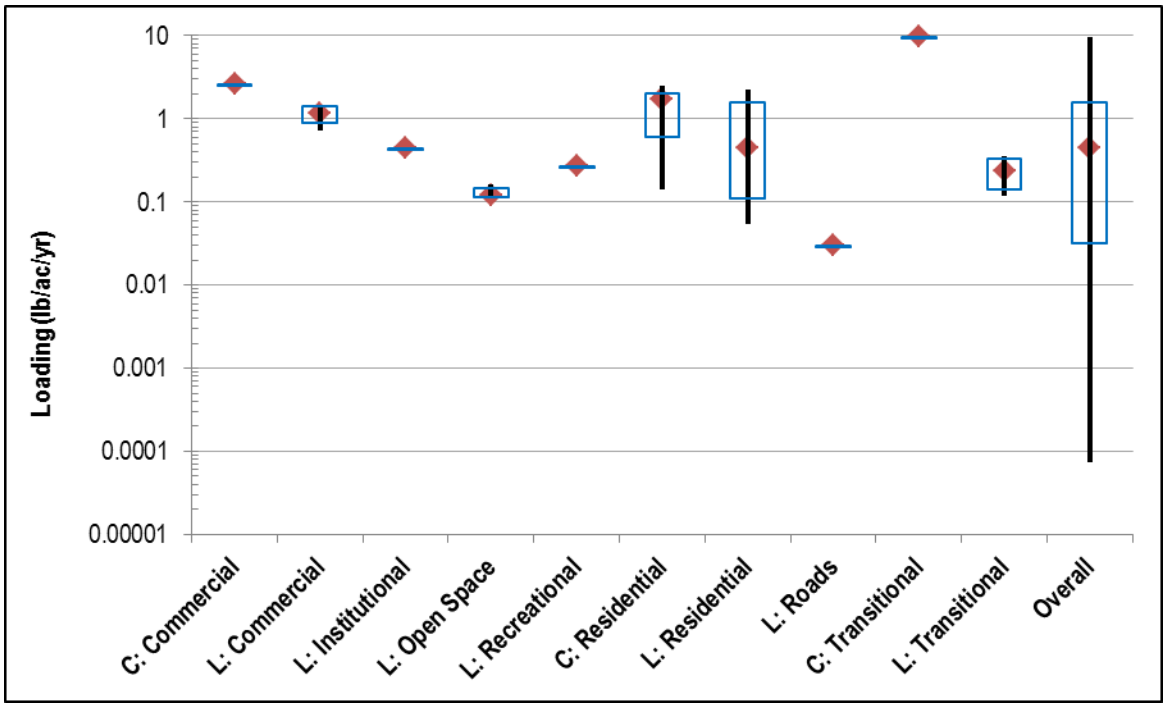
Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 39. TP loading rate statistics from TMDL report and literature reviews for developed and residential land use categories.

Table 40. TP Loading Rate Statistics from TMDL Report and Literature Reviews for General Lands Use Categories in Calibrated/Non-Calibrated Models

Land Use	Count	Loadings (lb/ac/yr)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
C: Commercial	1	2.63	2.63	2.63	2.63	2.63	2.63
L: Commercial	20	0.71	1.14	1.43	0.89	1.16	1.41
L: Institutional	1	0.45	0.45	0.45	0.45	0.45	0.45
L: Open Space	6	0.11	0.13	0.16	0.11	0.12	0.15
L: Recreational	2	0.27	0.27	0.27	0.27	0.27	0.27
C: Residential	15	0.14	1.39	2.47	0.61	1.71	2.02
L: Residential	35	0.06	0.67	2.26	0.11	0.45	1.57
L: Roads	1	0.03	0.03	0.03	0.03	0.03	0.03
C: Transitional	1	9.74	9.74	9.74	9.74	9.74	9.74
L: Transitional	2	0.12	0.24	0.35	0.14	0.24	0.33
Overall	188	0.00	0.69	9.74	0.03	0.45	1.57

Note: "C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.



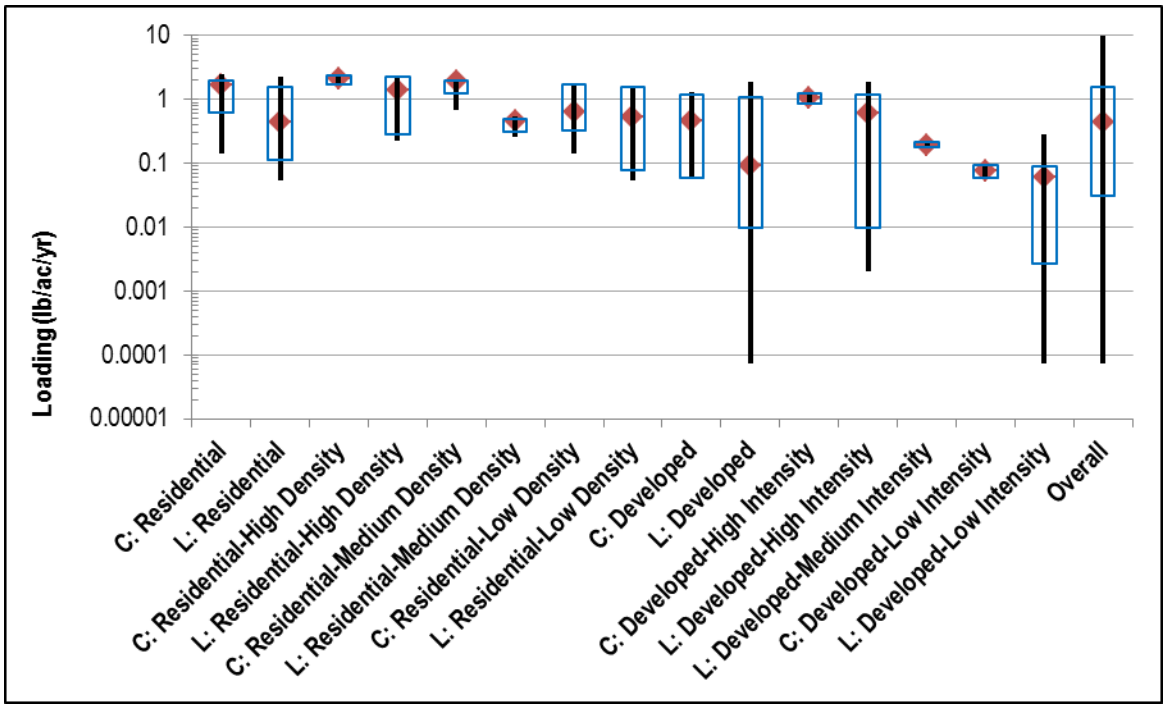
Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). "C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.

Figure 40. TP loading rate statistics from TMDL report and literature reviews for general land use categories in calibrated/non-calibrated models.

Table 41. TP Loading Rate Statistics from TMDL Report and Literature Reviews for Developed and Residential Land Use Categories in Calibrated/Non-Calibrated Models

Land Use	Count	Loadings (lb/ac/yr)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
C: Residential	15	0.14	1.39	2.47	0.61	1.71	2.02
L: Residential	35	0.06	0.67	2.26	0.11	0.45	1.57
C: Residential-High Density	2	1.68	2.07	2.47	1.76	2.07	2.39
L: Residential-High Density	8	0.23	1.33	2.26	0.28	1.43	2.26
C: Residential-Medium Density	6	0.68	1.72	2.03	1.24	1.90	2.02
L: Residential-Medium Density	10	0.26	0.43	0.54	0.32	0.45	0.49
C: Residential-Low Density	5	0.14	0.96	1.74	0.32	0.63	1.73
L: Residential-Low Density	10	0.06	0.68	1.57	0.08	0.53	1.57
C: Developed	8	0.06	0.57	1.31	0.06	0.45	1.21
L: Developed	74	0.00	0.31	1.89	0.01	0.09	1.09
C: Developed-High Intensity	4	0.81	1.07	1.31	0.87	1.08	1.27
L: Developed-High Intensity	31	0.00	0.63	1.89	0.01	0.62	1.17
L: Developed-Medium Intensity	6	0.18	0.19	0.22	0.18	0.19	0.21
C: Developed-Low Intensity	4	0.06	0.08	0.10	0.06	0.08	0.10
L: Developed-Low Intensity	37	0.00	0.06	0.29	0.00	0.06	0.09

Note: "C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.

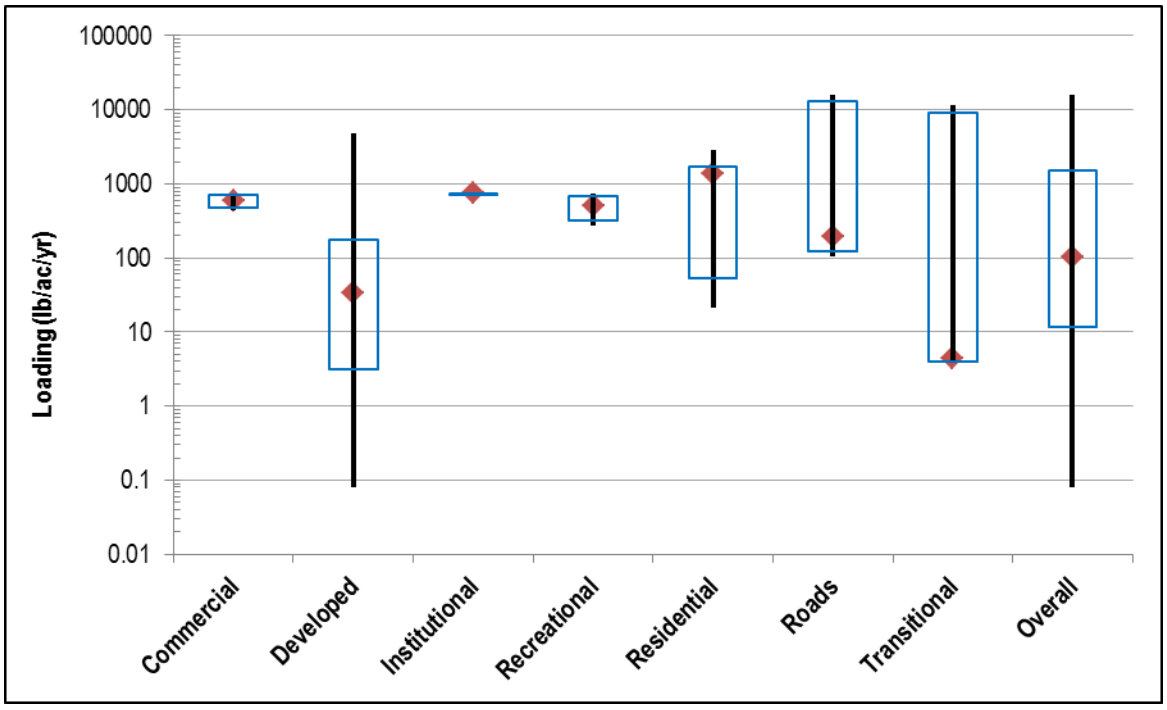


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). "C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.

Figure 41. TP loading rate statistics from TMDL report and literature reviews for developed and residential land use categories in calibrated/non-calibrated models.

Table 42. TSS Loading Rate Statistics from TMDL Report and Literature Reviews for General Land Uses

Land Use	Count	Loadings (lb/ac/yr)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Commercial	2	446	593	741	475	593	711
Developed	87	0	145	4,860	3	34	177
Institutional	1	741	741	741	741	741	741
Recreational	2	268	504	741	315	504	693
Residential	69	21	1,150	2,835	53	1,372	1,721
Roads	3	105	5,489	16,170	122	192	12,975
Transitional	3	4	3,844	11,523	4	4	9,219
Overall	191	0	723	16,170	12	104	1,514

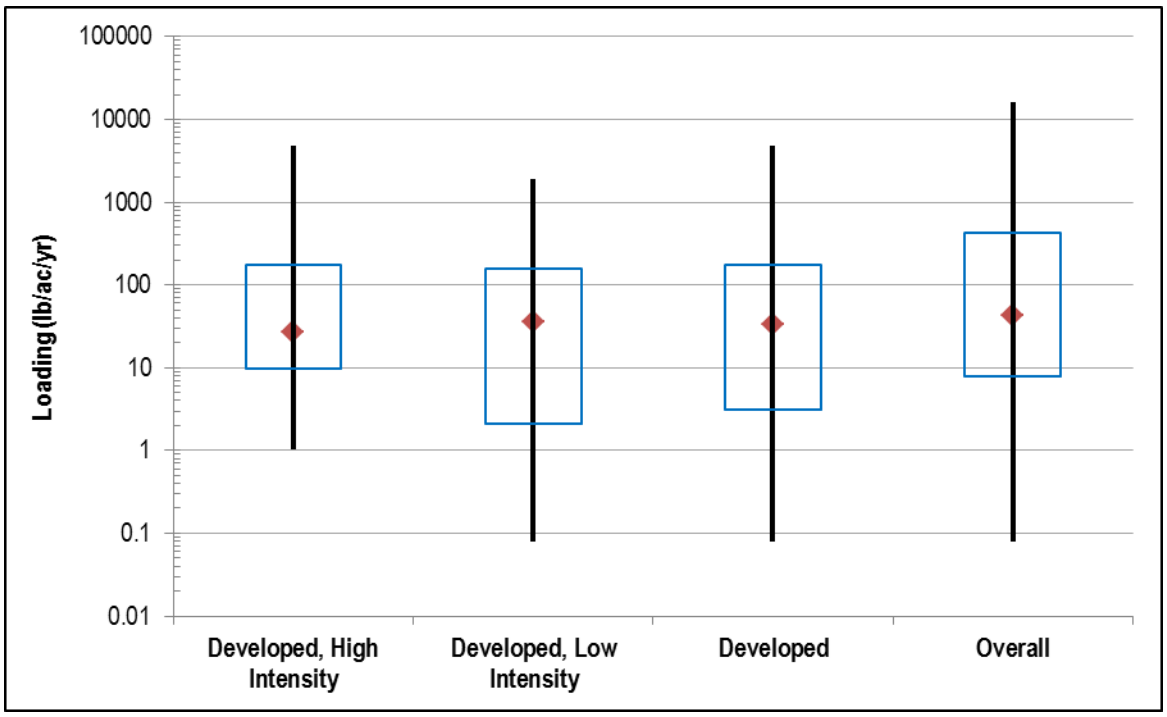


Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 42. TSS loading rate statistics from TMDL report and literature reviews for general land uses.

Table 43. TSS Loading Rate Statistics from TMDL Report and Literature Reviews for Developed Land Use Categories

Land Use	Count	Loadings (lb/ac/yr)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
Developed, High Intensity	37	1	205	4,860	10	26	177
Developed, Low Intensity	50	0	101	1,894	2	36	155
Developed	87	0	145	4,860	3	34	177
Overall	136	0	445	16,170	8	43	424



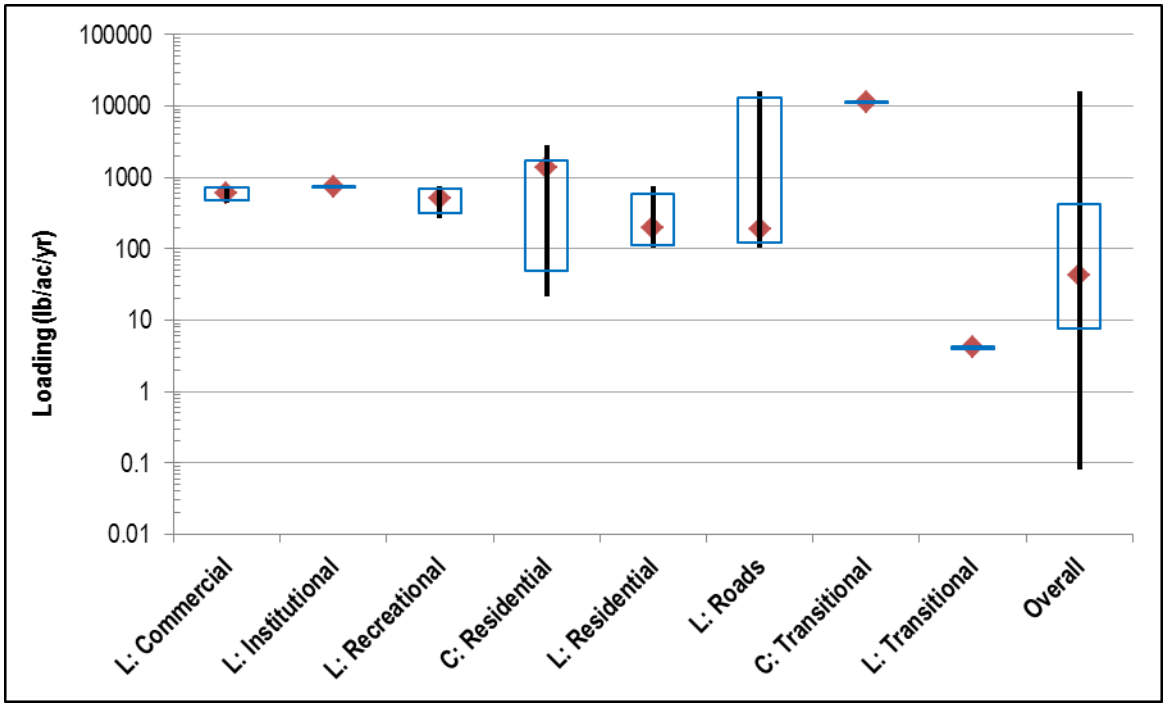
Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar).

Figure 43. TSS loading rate statistics from TMDL report and literature reviews for developed land use categories.

Table 44. TSS Loading Rate Statistics from TMDL Report and Literature Reviews for General Land Use Categories in Calibrated/Non-Calibrated Models

Land Use	Count	Loadings (lb/ac/yr)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
L: Commercial	2	446	593	741	475	593	711
L: Institutional	1	741	741	741	741	741	741
L: Recreational	2	268	504	741	315	504	693
C: Residential	64	21	1,194	2,835	49	1,376	1,704
L: Residential	4	105	309	741	111	196	599
L: Roads	3	105	5,489	16,170	122	192	12,975
C: Transitional	1	11,523	11,523	11,523	11,523	11,523	11,523
L: Transitional	2	4	4	4	4	4	4
Overall	136	0	445	16,170	8	43	424

Note: "C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.



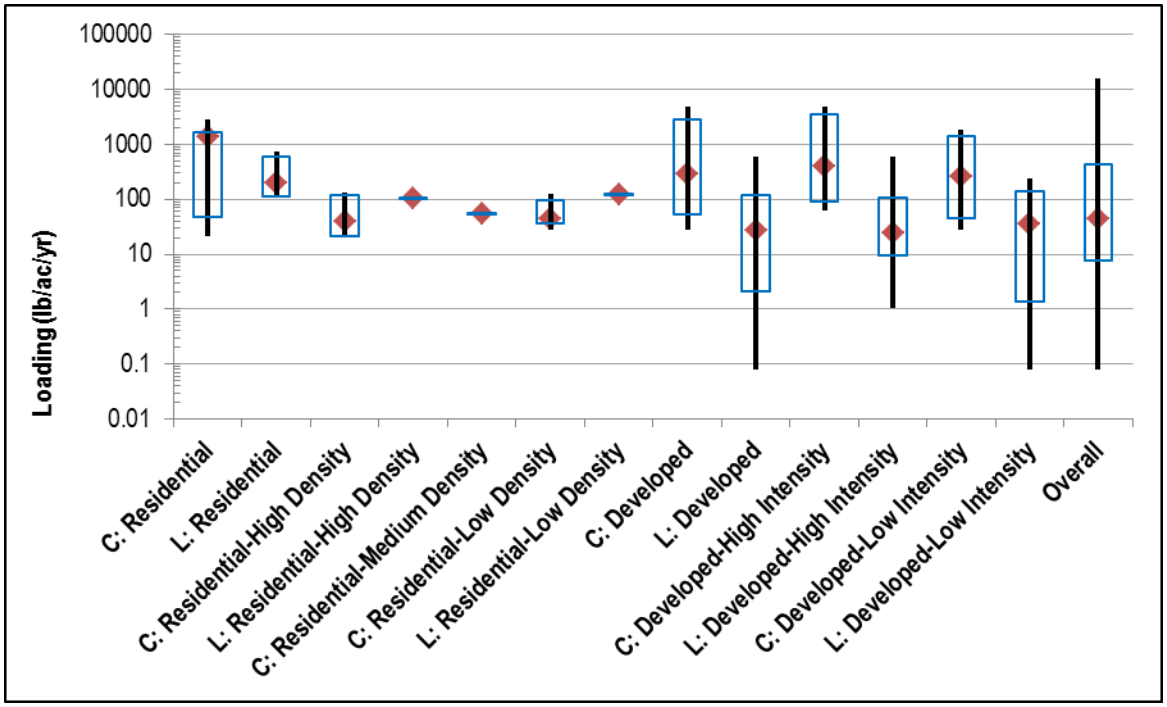
Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). "C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.

Figure 44. TSS loading rate statistics from TMDL report and literature reviews for general land use categories in calibrated/non-calibrated models.

Table 45. TSS Loading Rate Statistics from TMDL Report and Literature Reviews for Developed and Residential Land Use Categories in Calibrated/Non-Calibrated Models

Land Use	Count	Loadings (lb/ac/yr)					
		Minimum	Average	Maximum	10th percentile	Median	90th percentile
C: Residential	64	21	1,194	2,835	49	1,376	1,704
L: Residential	4	105	309	741	111	196	599
C: Residential-High Density	6	21	60	136	22	39	121
L: Residential-High Density	1	105	105	105	105	105	105
C: Residential-Medium Density	1	55	55	55	55	55	55
C: Residential-Low Density	6	28	60	124	36	45	99
L: Residential-Low Density	1	124	124	124	124	124	124
C: Developed	8	27	1,019	4,860	52	294	2,784
L: Developed	79	0	57	594	2	27	118
C: Developed-High Intensity	4	63	1,430	4,860	93	398	3,592
L: Developed-High Intensity	33	1	57	594	9	24	106
C: Developed-Low Intensity	4	27	608	1,894	44	254	1,453
L: Developed-Low Intensity	46	0	57	246	1	36	144
Overall	136	0	445	16,170	8	43	424

Note: "C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.



Note: Figure shows median (red dot), 10th/90th percentile range (blue box), and minimum/maximum (black bar). "C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.

Figure 45. TSS loading rate statistics from TMDL report and literature reviews for developed and residential land use categories in calibrated/non-calibrated models.

Attachment D: Histograms

Attachment D.1: Concentration Statistics/Histograms from NSQD and Literatures Reviews

Table 46. Frequency of TN Counts per Concentration Range from NSQD and Literatures Reviews by Land Use

Range (mg/L)	Overall	Commercial	Industrial	Institutional	Open Space	Parking lot	Residential	Transportation
0–1	723	77	72	7	49	3	238	13
1–2	1,689	273	175	25	38	10	525	51
2–5	1,907	275	195	21	25	1	628	115
5–10	346	56	46	2	4	0	98	36
10–15	66	10	8	0	0	0	22	7
15–25	35	5	3	0	0	0	12	6
25–40	7	0	1	0	0	0	4	1
40–60	2	0	0	0	0	0	1	1
60–80	2	0	0	0	0	0	1	0
80–100	1	0	0	0	0	0	0	0
Total	4,778	696	500	55	116	14	1,529	230

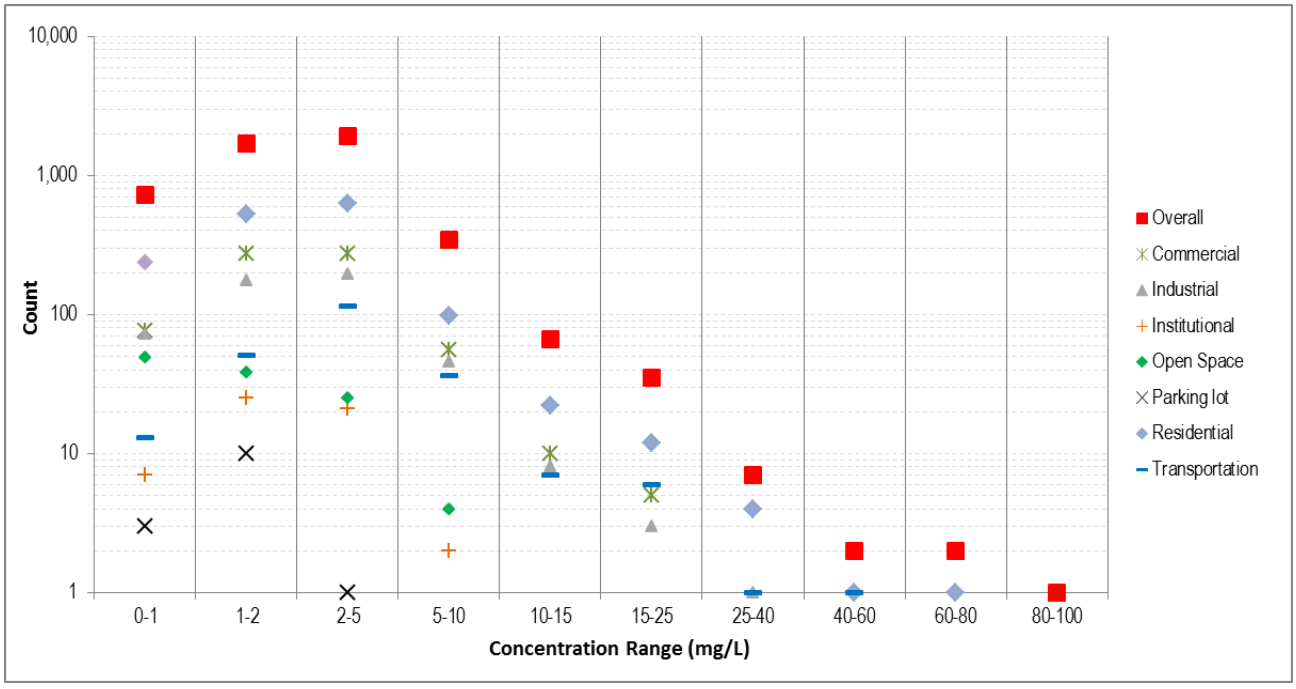


Figure 46. Frequency of TN counts per concentration range from NSQD and literatures reviews by land use.

Table 47. Frequency of TN Counts per Concentration Range from NSQD and Literatures Reviews by Season

Range (mg/L)	Overall	Spring	Summer	Fall	Winter
0–1	723	164	134	213	201
1–2	1,689	438	323	430	452
2–5	1,907	538	497	483	346
5–10	346	83	103	90	60
10–15	66	16	23	15	11
15–25	35	6	11	10	8
25–40	7	1	1	4	1
40–60	2	1	0	1	0
60–80	2	2	0	0	0
80–100	1	0	1	0	0
Total	4,778	1,249	1,093	1,246	1,079

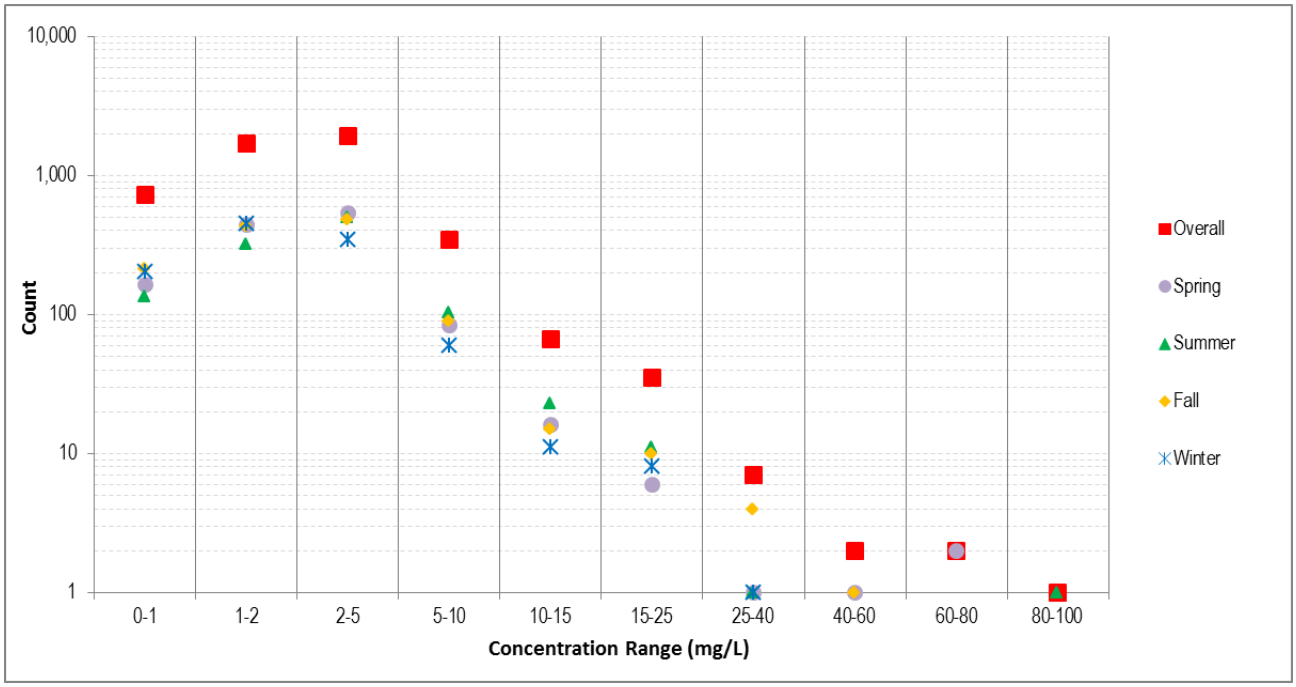


Figure 47. Frequency of TN counts per concentration range from NSQD and literatures reviews by season.

Table 48. Frequency of TP Counts per Concentration Range from NSQD and Literatures Reviews by Land Use

Range (mg/L)	Overall	Commercial	Industrial	Institutional	Open Space	Parking lot	Residential	Transportation
0–0.5	5,386	825	464	51	124	11	1,815	504
0.5–1	991	119	76	5	14	1	353	66
1–2	311	23	29	0	5	0	113	34
2–5	116	11	7	0	1	0	29	34
5–10	13	0	2	0	0	0	5	1
10–15	3	0	0	0	0	0	0	1
15–25	2	0	0	0	0	0	1	0
25–45	0	0	0	0	0	0	0	0
45–80	0	0	0	0	0	0	0	0
80–100	1	0	0	0	0	0	0	1
Total	6,823	978	578	56	144	12	2,316	641

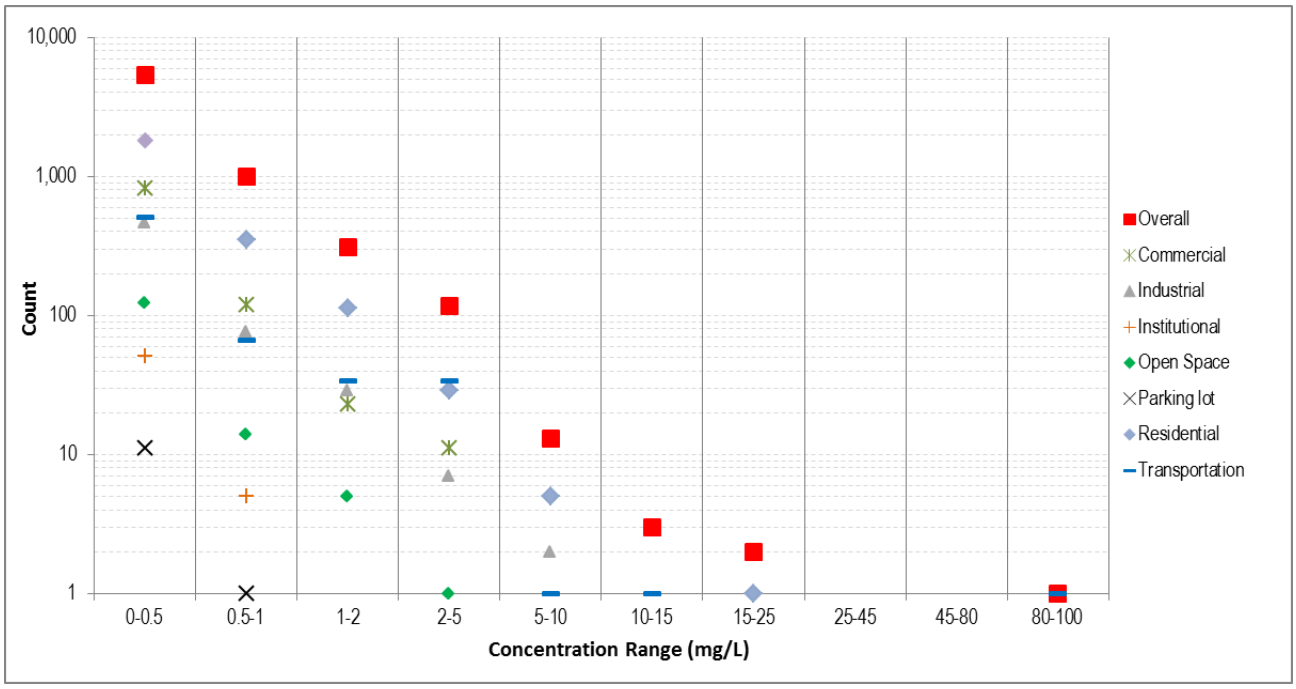


Figure 48. Frequency of TP counts per concentration range from NSQD and literatures reviews by land use.

Table 49. Frequency of TP Counts per Concentration Range from NSQD and Literatures Reviews by Season

Range (mg/L)	Overall	Spring	Summer	Fall	Winter
0–0.5	5,386	1,405	1,185	1,462	1,226
0.5–1	991	245	289	248	191
1–2	311	63	102	97	43
2–5	116	24	36	39	14
5–10	13	4	7	1	1
10–15	3	0	2	1	0
15–25	2	1	0	1	0
25–45	0	0	0	0	0
45–80	0	0	0	0	0
80–100	1	0	1	0	0
Total	6,823	1,742	1,622	1,849	1,475

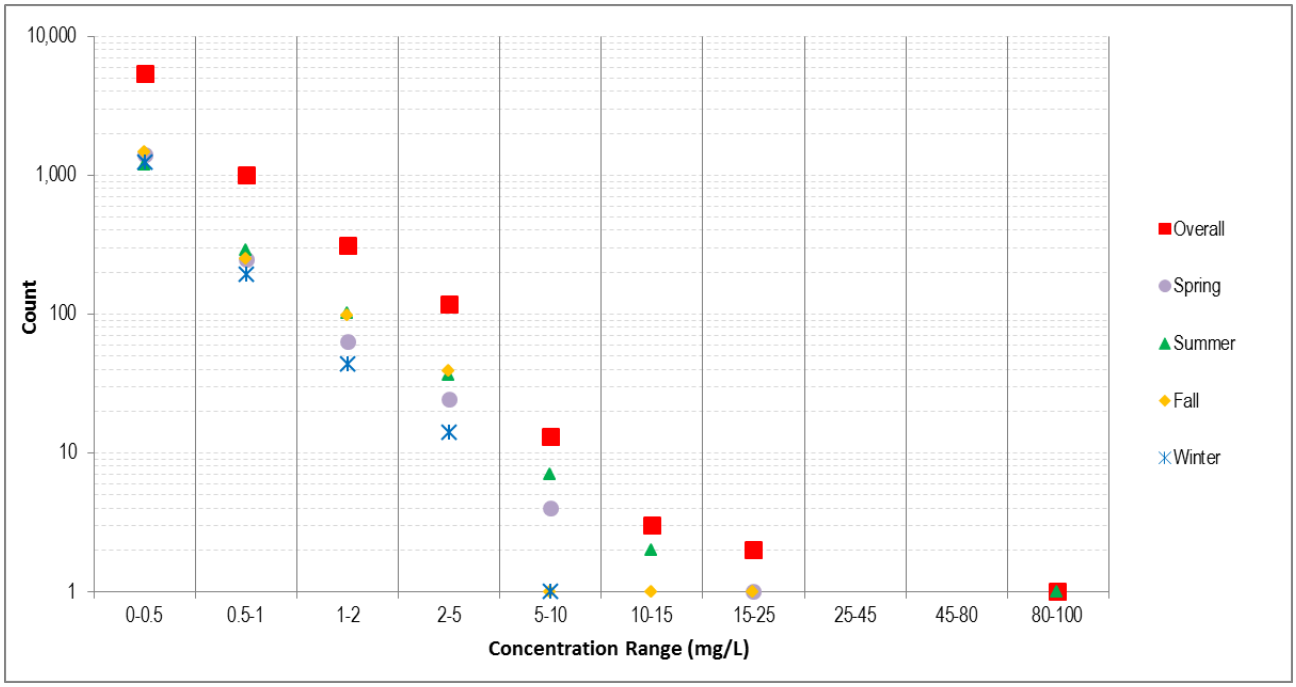


Figure 49. Frequency of TP counts per concentration range from NSQD and literatures reviews by season.

Table 50. Frequency of TSS Counts per Concentration Range from NSQD and Literatures Reviews by Land Use

Range (mg/L)	Overall	Commercial	Industrial	Institutional	Open Space	Parking lot	Residential	Transportation
0–25	1,428	237	104	18	73	4	543	112
25–50	1,179	197	118	8	13	2	397	85
50–100	1,450	175	127	11	20	1	551	82
100–250	1,442	186	135	19	19	3	460	135
250–500	509	62	50	1	10	1	152	31
500–1,000	225	20	32	0	2	0	58	10
1,000–2,500	77	10	15	0	2	0	20	4
2,500–5,000	12	0	0	0	0	0	5	1
5,000–10,000	1	0	0	0	0	0	0	0
10,000–15,000	1	0	0	0	0	0	0	0
Total	6,324	887	581	57	139	11	2,186	460

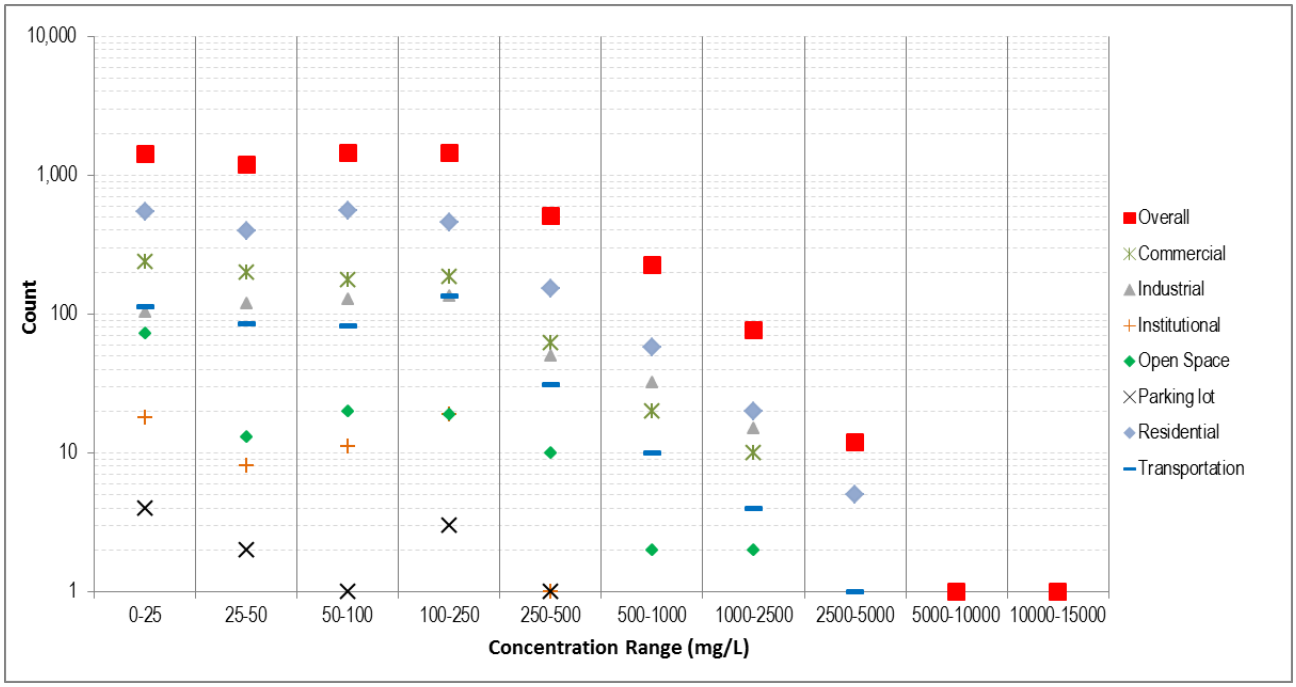


Figure 50. Frequency of TSS counts per concentration range from NSQD and literatures reviews by land use.

Table 51. Frequency of TSS Counts per Concentration Range from NSQD and Literatures Reviews by Season

Range (mg/L)	Overall	Spring	Summer	Fall	Winter
0–25	1,428	295	362	432	325
25–50	1,179	299	232	334	291
50–100	1,450	424	303	367	328
100–250	1,442	369	379	360	253
250–500	509	140	152	116	81
500–1,000	225	64	79	47	29
1,000–2,500	77	28	19	18	10
2,500–5,000	12	2	6	3	1
5,000–10,000	1	0	1	0	0
10,000–15,000	1	0	1	0	0
Total	6,324	1,621	1,534	1,677	1,318

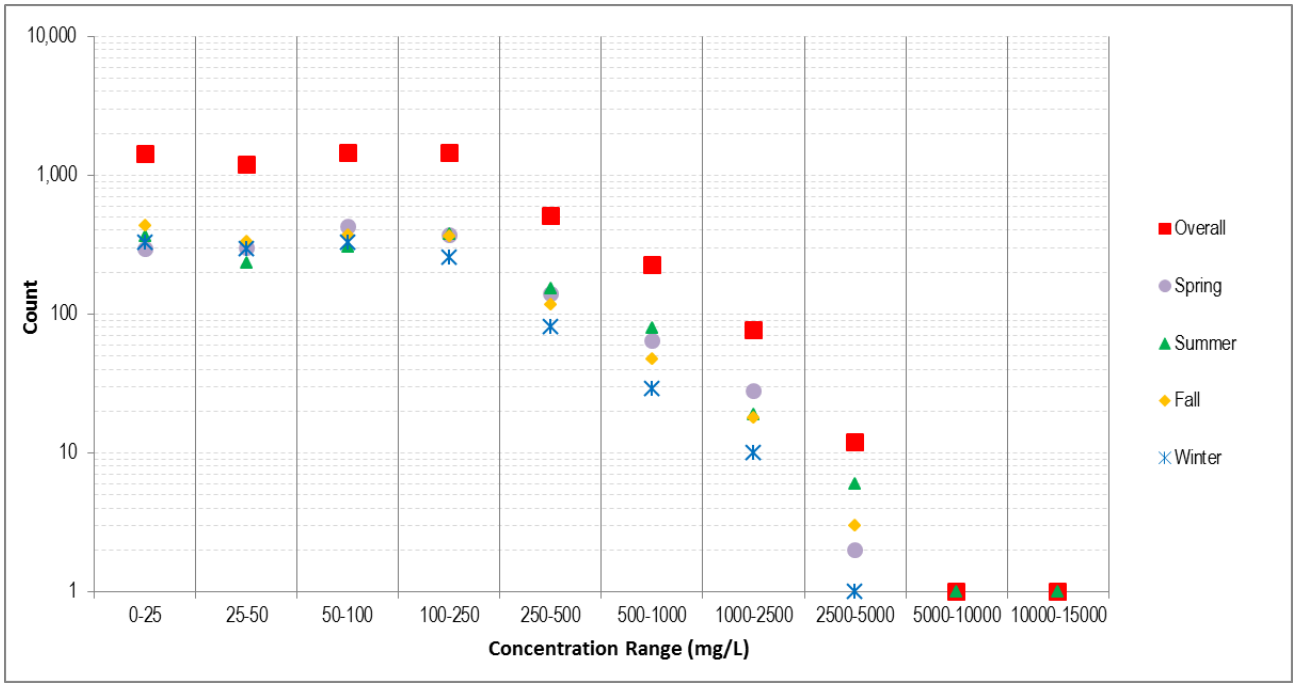


Figure 51. Frequency of TSS counts per concentration range from NSQD and literatures reviews by season.

Table 52. Frequency of TSS Counts per Concentration Range from NSQD and Literatures Reviews by Land Use

Range (mg/L)	Overall	Residential	Residential-Low Density	Transportation	Roads-High Use	Roads-Medium Use	Roads-Low Use
0–25	1,428	543	0	112	1	3	0
25–50	1,179	397	0	85	0	4	4
50–100	1,450	551	1	82	1	9	4
100–250	1,442	460	8	135	8	25	9
250–500	509	152	1	31	1	5	5
500–1,000	225	58	1	10	0	2	1
1,000–2,500	77	20	0	4	0	0	2
2,500–5,000	12	5	0	1	0	0	0
5,000–10,000	1	0	0	0	0	0	0
10,000–15,000	1	0	0	0	0	0	0
Total	6,324	2,186	11	460	11	48	25

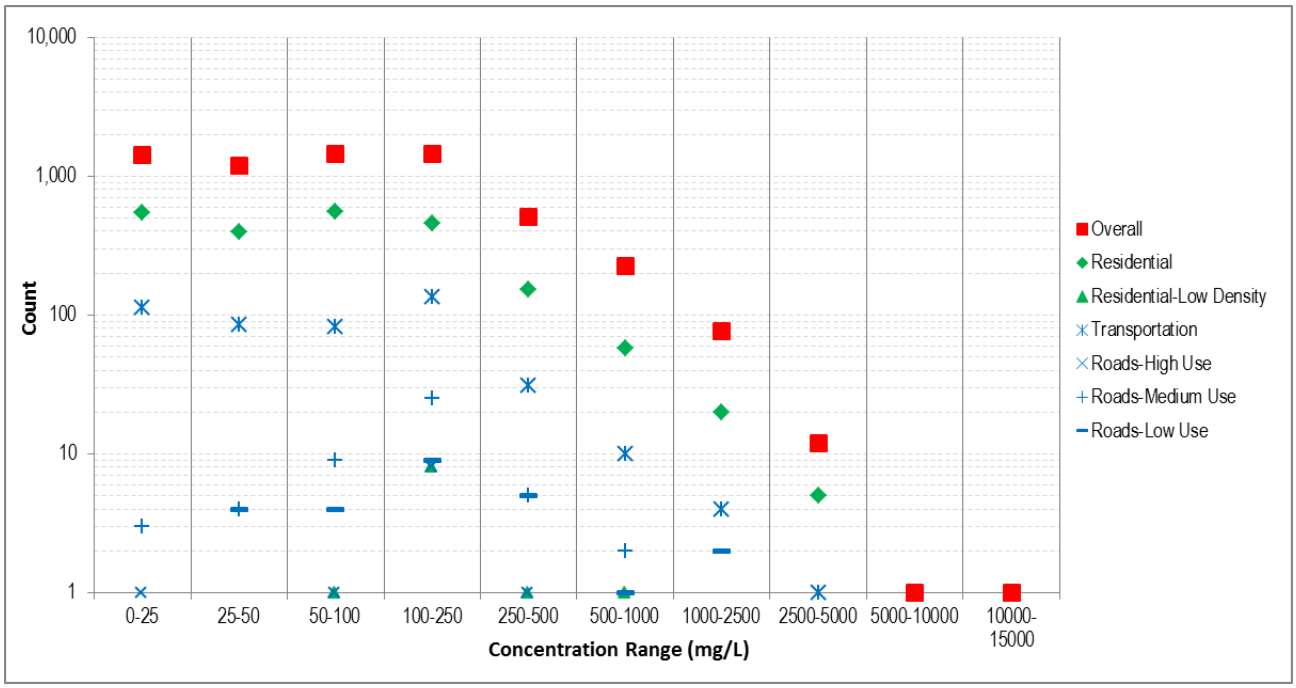


Figure 52. Frequency of TSS counts per concentration range from NSQD and literatures reviews by land use.

Attachment D.2: Loading Rate Statistics/Histograms from TMDL Reports and Literatures Reviews

Table 53. Frequency of TN Counts per Loading Rate Range from TMDL Reports and Literatures Reviews by Land Use

Range (lb/ac/yr)	Overall	Residential	Developed-Low intensity	Developed-High intensity
0–0.5	4	0	2	0
0.5–1	7	0	6	0
1–2	4	2	2	0
2–5	9	3	0	0
5–7.5	5	0	0	3
7.5–10	7	1	0	4
10–15	7	4	0	3
15–20	4	2	0	1
20–30	3	2	0	0
30–45	15	3	0	0
Total	65	17	10	11

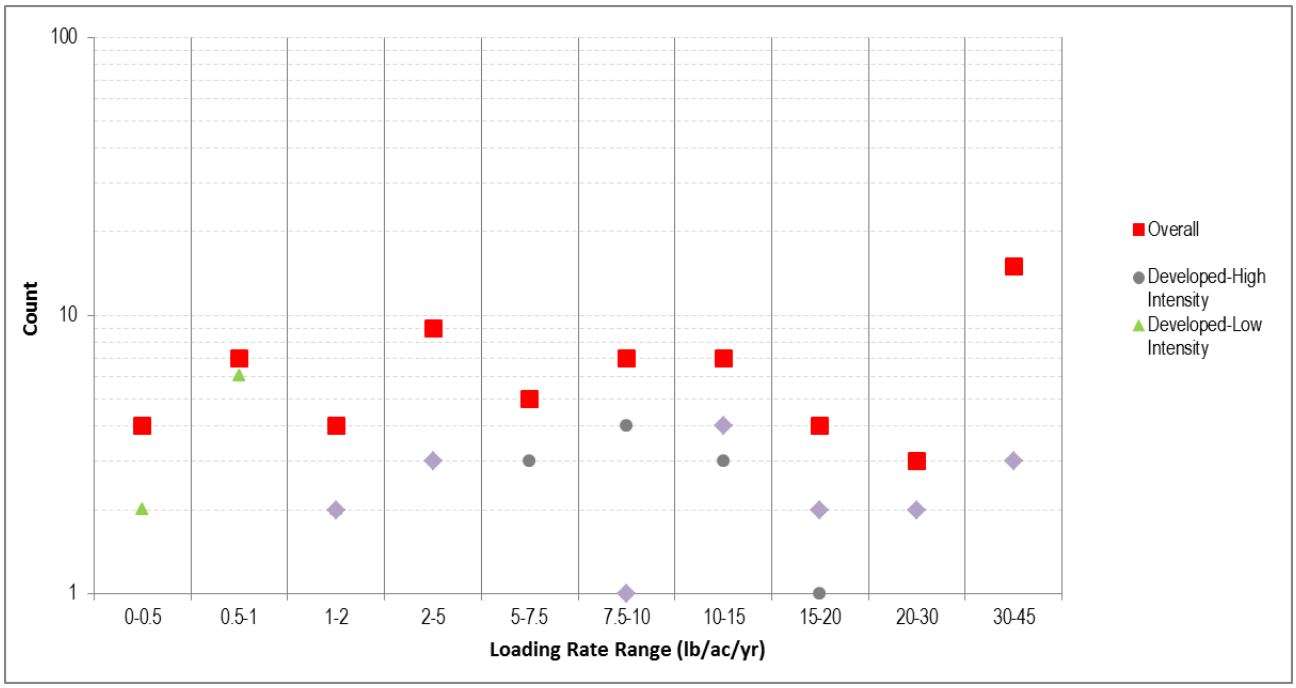


Figure 53. Frequency of TN counts per loading rate range from TMDL reports and literatures reviews by land use.

Table 54. Frequency of TP Counts per Loading Rate Range from TMDL Reports and Literatures Reviews by Land Use

Range (lb/ac/yr)	Overall	Developed-High Intensity	Developed-Low Intensity	Urban-Pervious	Commer-cial	Residen-tial	Residential-High Density	Residential-Medium Density	Residential-Low Density
0–0.1	57	7	38	4	0	4	0	0	3
0.1–0.25	25	0	2	3	0	7	1	0	2
0.25–0.5	28	8	1	2	0	13	1	9	1
0.5–1	31	5	0	8	4	9	1	2	4
1–1.5	36	14	0	0	16	2	2	0	0
1.5–2	11	1	0	0	0	10	1	3	6
2–2.5	8	0	0	0	0	6	4	2	0
2.5–5	2	0	0	0	1	0	0	0	0
5–7.5	0	0	0	0	0	0	0	0	0
7.5–10	1	0	0	0	0	0	0	0	0
Total	199	35	41	17	21	51	10	16	16

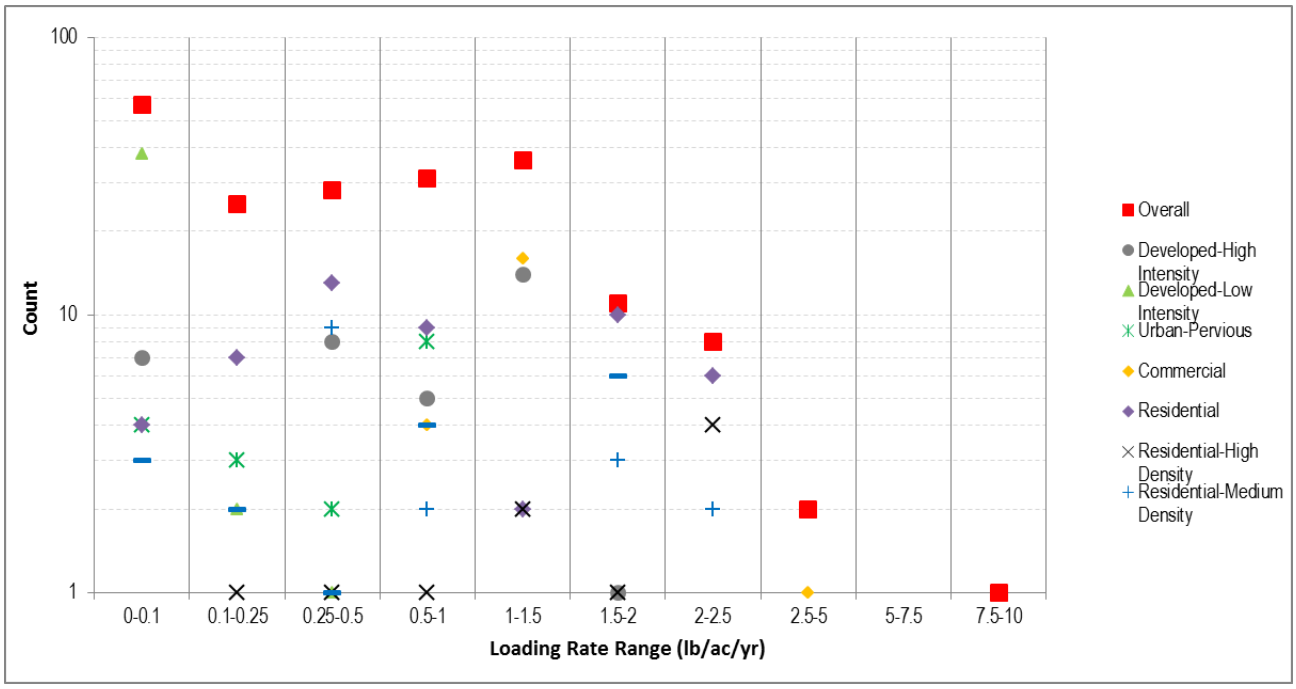


Figure 54. Frequency of TP counts per loading rate range from TMDL reports and literatures reviews by land use.

Table 55. Frequency of TSS Counts per Loading Rate Range from TMDL Reports and Literatures Reviews by Land Use

Range (lb/ac/yr)	Overall	Residential	Developed-Low Intensity	Developed-High Intensity	Urban-Pervious
0–25	45	3	18	18	4
25–50	29	4	13	5	7
50–100	19	3	8	6	2
100–250	23	5	9	5	0
250–500	10	1	1	0	0
500–1,000	7	2	0	2	0
1,000–2,500	51	50	1	0	0
2,500–5,000	5	1	0	1	0
5,000–10,000	0	0	0	0	0
10,000–20,000	2	0	0	0	0
Total	191	69	50	37	13

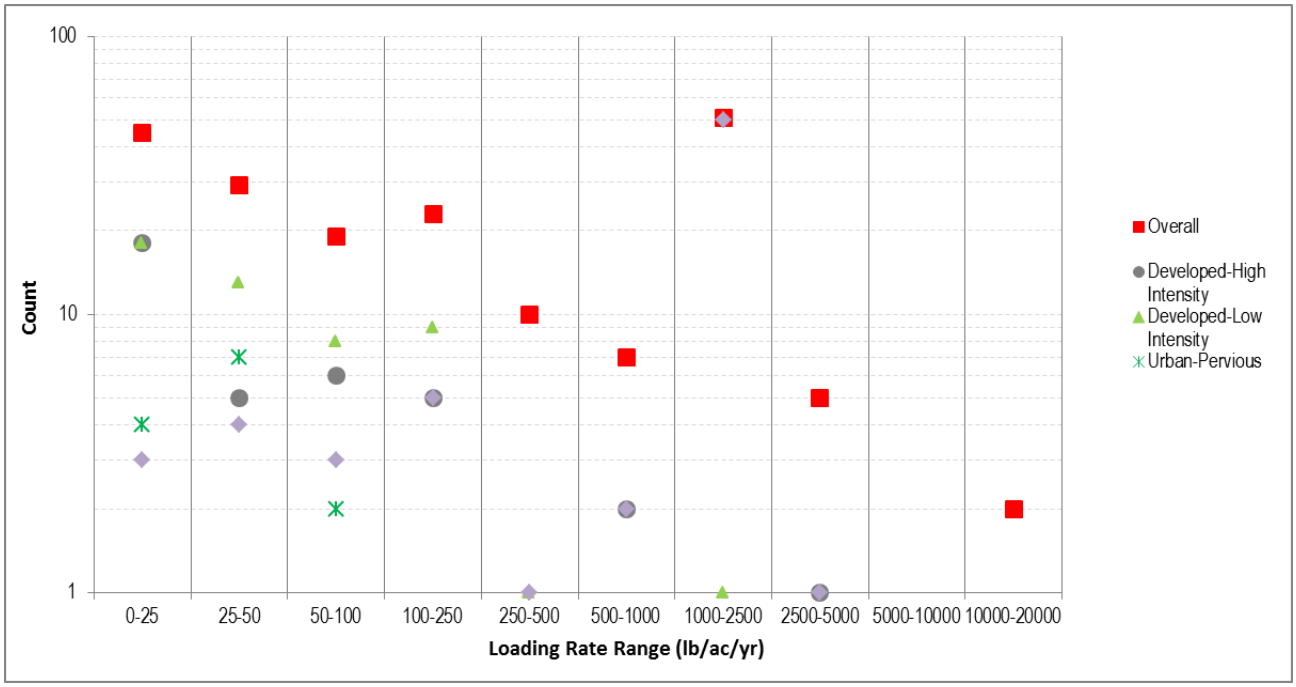


Figure 55. Frequency of TSS counts per loading rate range from TMDL reports and literatures reviews by land use.

Attachment E: Results of Wilcoxon Rank-Sum Test

Table 56. Wilcoxon Rank-Sum Test Results for Individual Land Use Concentrations versus Overall Concentrations

Land Use	P-value (observations)	Decision Rationale	Remarks
TN (concentration data) – Overall number of samples: 4,778			
Commercial	0.2573 (696)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TN concentrations in the Commercial and Overall categories are any different from each other.
Industrial	0.851 (500)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TN concentrations in the Industrial and Overall categories are any different from each other.
Institutional	0.2085 (55)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TN concentrations in the Institutional and Overall categories are any different from each other.
Open Space	0.0000 (116)	**Statistically significant**	Reject Ho at alpha = 0.05. The TN concentrations from Open Space category are significantly different than those in Overall category at a p-value of 0.000.
Parking lot	0.0211 (14)	**Statistically significant**	Reject Ho at alpha = 0.05. The TN concentrations from Parking lot category are significantly different than those in Overall category at a p-value of 0.021.
Residential	0.9025 (1,529)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TN concentrations in the Residential and Overall categories are any different from each other.
Transportation	0.0000 (230)	**Statistically significant**	Reject Ho at alpha = 0.05. The TN concentrations from Transportation category are significantly different than those in Overall category at a p-value of 0.000.
Roads-Low Use	0.8734 (17)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TN concentrations in the Roads-Low Use and Overall categories are any different from each other.
Roads-Medium Use	0.0444 (30)	**Statistically significant**	Reject Ho at alpha = 0.05. The TN concentrations from Roads-Medium Use category are significantly different than those in Overall category at a p-value of 0.044.
Commercial/Industrial/ High-Intensity Developed & Overall	0.1009 (1,240)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TN (mg/L) in the Commercial/Industrial/High-Intensity Developed and Overall categories are any different from each other.
Impervious & Overall	0.0000 (245)	**Statistically significant**	Reject Ho at alpha = 0.05. The TN (mg/L) from Impervious category are significantly different than those in Overall category at a p-value of 0.000.
Institutional/Open space/Very Low-Density Residential & Overall	0.0000 (171)	**Statistically significant**	Reject Ho at alpha = 0.05. The TN (mg/L) from Institutional/Open space/Very Low-Density Residential category are significantly different than those in Overall category at a p-value of 0.000.
Roads/Transportation & Overall	0.0000 (230)	**Statistically significant**	Reject Ho at alpha = 0.05. The TN (mg/L) from Roads/Transportation category are significantly different than those in Overall category at a p-value of 0.000.
TP (concentration data) – Overall number of samples: 6,823			
Commercial	0.0000 (978)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP concentrations from Commercial category are significantly different than those in Overall category at a p-value of 0.000.
Industrial	0.1346 (578)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP concentrations in the Industrial and Overall categories are any different from each other.
Institutional	0.0026 (56)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP concentrations from Institutional category are significantly different than those in Overall category at a p-value of 0.003.
Open Space	0.0000 (144)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP concentrations from Open Space category are significantly different than those in Overall category at a p-value of 0.000.
Parking lot	0.1132 (12)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP concentrations in the Parking lot and Overall categories are any different from each other.

Land Use	P-value (observations)	Decision Rationale	Remarks
Residential	0.045 (2,316)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP concentrations from Residential category are significantly different than those in Overall category at a p-value of 0.045.
Transportation	0.1997 (641)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP concentrations in the Transportation and Overall categories are any different from each other.
Roads-Low Use	0.0438 (15)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP concentrations from Roads-Low Use category are significantly different than those in Overall category at a p-value of 0.044.
Roads-Medium Use	0.3298 (20)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP concentrations in the Roads-Medium Use and Overall categories are any different from each other.
Commercial/Industrial/ High-Intensity Developed	0.0000 (1,605)	**Statistically significant**	Statistically Significant. Reject Ho at alpha = 0.05. The TP (mg/L) from Commercial/Industrial/High-Intensity Developed category are significantly different than those in Overall category at a p-value of 0.000.
Impervious	0.4823 (660)	Not statistically significant	Not Statistically Significant. We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP (mg/L) in the Impervious and Overall categories are any different from each other.
Institutional/Open space/Very Low-Density Residential	0.0000 (200)	**Statistically significant**	Statistically Significant. Reject Ho at alpha = 0.05. The TP (mg/L) from Institutional/Open space/Very Low-Density Residential category are significantly different than those in Overall category at a p-value of 0.000.
Pervious	0.3533 (11)	Not statistically significant	Not Statistically Significant. We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP (mg/L) in the Pervious and Overall categories are any different from each other.
Recreation/Golf Course	0.2391 (9)	Not statistically significant	Not Statistically Significant. We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP (mg/L) in the Recreation/Golf Course and Overall categories are any different from each other.
Roads/Transportation	0.1997 (641)	Not statistically significant	Not Statistically Significant. We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP (mg/L) in the Roads/Transportation and Overall categories are any different from each other.
TSS (concentration data) – Overall number of samples: 6,324			
Commercial	0.0001 (887)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS concentrations from Commercial category are significantly different than those in Overall category at a p-value of 0.000.
Industrial	0.0054 (581)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS concentrations from Industrial category are significantly different than those in Overall category at a p-value of 0.005.
Institutional	0.2481 (57)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TSS concentrations in the Institutional and Overall categories are any different from each other.
Open Space	0.0000 (139)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS concentrations from Open Space category are significantly different than those in Overall category at a p-value of 0.000.
Parking lot	0.6558 (11)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TSS concentrations in the Parking lot and Overall categories are any different from each other.
Residential	0.0012 (2,186)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS concentrations from Residential category are significantly different than those in Overall category at a p-value of 0.001.
Transportation	0.8405 (460)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TSS concentrations in the Transportation and Overall categories are any different from each other.
Residential-Low Density	0.0016 (11)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS concentrations from Residential-Low Density category are significantly different than those in Overall category at a p-value of 0.002.
Roads-High Use	0.0238 (11)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS concentrations from Roads-High Use category are significantly different than those in Overall category at a p-value of 0.024.
Roads-Medium Use	0.0002 (48)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS concentrations from Roads-Medium Use category are significantly different than those in Overall category at a p-value of 0.000.

Land Use	P-value (observations)	Decision Rationale	Remarks
Roads-Low Use	0.0003 (25)	Statistically significant	Reject Ho at alpha = 0.05. The TSS concentrations from Roads-Low Use category are significantly different than those in Overall category at a p-value of 0.000.
Commercial/Industrial/ High-Intensity Developed	0.6132 (1,519)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TSS (mg/L) in the Commercial/Industrial/High-Intensity Developed and Overall categories are any different from each other.
Impervious	0.6024 (471)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TSS (mg/L) in the Impervious and Overall categories are any different from each other.
Institutional/Open space/Very Low-Density Residential	0.0000 (196)	Statistically significant	Reject Ho at alpha = 0.05. The TSS (mg/L) from Institutional/Open space/Very Low-Density Residential category are significantly different than those in Overall category at a p-value of 0.000.
Roads/Transportation	0.8405 (460)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TSS (mg/L) in the Roads/Transportation and Overall categories are any different from each other.

Notes:
Null Hypothesis: Ho - No difference in the means μ1-μ2 =0.
Alternative Hypothesis: Ha - There is a difference in the means μ1-μ2 ≠0.
Wilcoxon Rank Sum Test. Two-Sided Test Results (alpha =0.05, z =1.96).

Table 57. Wilcoxon Rank-Sum Test Results for Individual Land Use Concentrations versus Transportation Concentrations

Land Use	P-value (observations)	Decision Rationale	Remarks
TN (concentration data) – Overall number of samples: 230			
Roads-Low Use	0.0107 (17)	Statistically significant	Reject Ho at alpha = 0.05. The TN concentrations from Roads-Low Use category are significantly different than those in Transportation category at a p-value of 0.011.
Roads-Medium Use	0.1109 (30)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TN concentrations in the Roads-Medium Use and Transportation categories are any different from each other.
TP (concentration data) – Overall number of samples: 641			
Roads-Low Use	0.0705 (15)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP concentrations in the Roads-Low Use and Transportation categories are any different from each other.
Roads-Medium Use	0.2325 (20)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP concentrations in the Roads-Medium Use and Transportation categories are any different from each other.
TSS (concentration data) – Overall number of samples: 460			
Roads-High Use	0.0192 (11)	Statistically significant	Reject Ho at alpha = 0.05. The TSS concentrations from Roads-High Use category are significantly different than those in Transportation category at a p-value of 0.019.
Roads-Medium Use	0.0002 (48)	Statistically significant	Reject Ho at alpha = 0.05. The TSS concentrations from Roads-Medium Use category are significantly different than those in Transportation category at a p-value of 0.000.
Roads-Low Use	0.0003 (25)	Statistically significant	Reject Ho at alpha = 0.05. The TSS concentrations from Roads-Low Use category are significantly different than those in Transportation category at a p-value of 0.000.

Notes:
Null Hypothesis: Ho - No difference in the means μ1-μ2 =0.
Alternative Hypothesis: Ha - There is a difference in the means μ1-μ2 ≠0.
Wilcoxon Rank Sum Test. Two-Sided Test Results (alpha =0.05, z =1.96).

Table 58. Wilcoxon Rank-Sum Test Results for Individual Land Use Concentrations versus Residential Concentrations

Land Use	P-value (observations)	Decision Rationale	Remarks
TSS (concentration data) – Overall number of samples: 2,186			
Residential-Low Density	0.0005 (11)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS concentrations from Residential-Low Density category are significantly different than those in Residential category at a p-value of 0.001.

Notes:
Null Hypothesis: Ho - No difference in the means μ1-μ2 =0.
Alternative Hypothesis: Ha - There is a difference in the means μ1-μ2 ≠0.
Wilcoxon Rank Sum Test. Two-Sided Test Results (alpha =0.05, z =1.96).

Table 59. Wilcoxon Rank-Sum Test Results for Seasonal Concentrations versus Overall Concentrations

Season	P-value (observations)	Decision Rationale	Remarks
TN (concentration data) – Overall number of samples: 4,778			
Spring	0.1667 (1,249)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TN concentrations in the Spring and Overall categories are any different from each other.
Summer	0.0000 (1,093)	**Statistically significant**	Reject Ho at alpha = 0.05. The TN concentrations from Summer category are significantly different than those in Overall category at a p-value of 0.000.
Fall	0.2595 (1,246)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TN concentrations in the Fall and Overall categories are any different from each other.
Winter	0.0000 (1,079)	**Statistically significant**	Reject Ho at alpha = 0.05. The TN concentrations from Winter category are significantly different than those in Overall category at a p-value of 0.000.
TP (concentration data) – Overall number of samples: 6,823			
Spring	0.0787 (1,742)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP concentrations in the Spring and Overall categories are any different from each other.
Summer	0.0000 (1,622)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP concentrations from Summer category are significantly different than those in Overall category at a p-value of 0.000.
Fall	0.8831 (1,849)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP concentrations in the Fall and Overall categories are any different from each other.
Winter	0.0000 (1,475)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP concentrations from Winter category are significantly different than those in Overall category at a p-value of 0.000.
TSS (concentration data) – Overall number of samples: 6,324			
Spring	0.0022 (1,621)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS concentrations from Spring category are significantly different than those in Overall category at a p-value of 0.002.
Summer	0.0052 (1,534)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS concentrations from Summer category are significantly different than those in Overall category at a p-value of 0.005.
Fall	0.0005 (1,677)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS concentrations from Fall category are significantly different than those in Overall category at a p-value of 0.001.
Winter	0.0000 (1,318)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS concentrations from Winter category are significantly different than those in Overall category at a p-value of 0.000.

Notes:
Null Hypothesis: Ho - No difference in the means μ1-μ2 =0.
Alternative Hypothesis: Ha - There is a difference in the means μ1-μ2 ≠0.
Wilcoxon Rank Sum Test. Two-Sided Test Results (alpha =0.05, z =1.96).

Table 60. Wilcoxon Rank-Sum Test Results for Individual Land Use Loading Rates versus Overall Loading Rates

Land Use	P-value (observations)	Decision Rationale	Remarks
TN (loading rate data) – Overall number of samples: 65			
Residential	0.3083 (17)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TN loading rates in the Residential and Overall categories are any different from each other.
C: Residential	0.0430 (12)	**Statistically significant**	Reject Ho at alpha = 0.05. The TN loading rates from C: Residential category are significantly different than those in Overall category at a p-value of 0.043.
Developed-Low Intensity	0.0001 (10)	**Statistically significant**	Reject Ho at alpha = 0.05. The TN loading rates from Developed-Low Intensity category are significantly different than those in Overall category at a p-value of 0.000.
Developed-High Intensity	0.8362 (11)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TN loading rates in the Developed-High Intensity and Overall categories are any different from each other.
TP (loading rate data) – Overall number of samples: 199			
Commercial	0.0000 (21)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP loading rates from Commercial category are significantly different than those in Overall category at a p-value of 0.000.
L: Commercial	0.0000 (20)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP loading rates from L: Commercial category are significantly different than those in Overall category at a p-value of 0.000.
Residential	0.0041 (51)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP loading rates from Residential category are significantly different than those in Overall category at a p-value of 0.004.
C: Residential	0.0001 (15)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP loading rates from C: Residential category are significantly different than those in Overall category at a p-value of 0.000.
L: Residential	0.3297 (35)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP loading rates in the L: Residential and Overall categories are any different from each other.
Developed-Low Intensity	0.0000 (41)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP loading rates from Developed-Low Intensity category are significantly different than those in Overall category at a p-value of 0.000.
L: Developed, Low Intensity	0.0000 (37)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP loading rates from L: Developed, Low Intensity category are significantly different than those in Overall category at a p-value of 0.000.
Developed-High Intensity	0.3899 (35)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP loading rates in the Developed-High Intensity and Overall categories are any different from each other.
L: Developed, High Intensity	0.7408 (31)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP loading rates in the L: Developed, High Intensity and Overall categories are any different from each other.
Residential-High Density	0.0013 (10)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP loading rates from Residential-High Density category are significantly different than those in Overall category at a p-value of 0.001.
Residential-Medium Density	0.1746 (16)	**Statistically significant**	Reject Ho at alpha = 0.05. The TP loading rates from Residential-Medium Density category are significantly different than those in Overall category at a p-value of 0.042.
L: Residential, Medium Density	0.8977 (10)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP loading rates in the L: Residential, Medium Density and Overall categories are any different from each other.
Residential-Low Density	0.0415 (16)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP loading rates in the Residential-Low Density and Overall categories are any different from each other.
L: Residential, Low Density	0.6917 (10)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP loading rates in the L: Residential, Low Density and Overall categories are any different from each other.
Urban-Pervious	0.3121 (17)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP loading rates in the Urban-Pervious and Overall categories are any different from each other.
L: Urban-Pervious	0.5408 (11)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP (lb/ac/yr) in the L: Urban-Pervious and Overall categories are any different from each other.

Land Use	P-value (observations)	Decision Rationale	Remarks
TSS (loading rate data) – Overall number of samples: 191			
Residential	0.0000 (69)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS loading rates from Residential category are significantly different than those in Overall category at a p-value of 0.000.
C: Residential	0.0000 (64)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS loading rates from C: Residential category are significantly different than those in Overall category at a p-value of 0.000.
Developed-Low Intensity	0.0001 (50)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS loading rates from Developed-Low Intensity category are significantly different than those in Overall category at a p-value of 0.000.
L: Developed, Low Intensity	0.0000 (46)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS loading rates from L: Developed, Low Intensity category are significantly different than those in Overall category at a p-value of 0.000.
Developed-High Intensity	0.0002 (37)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS loading rates from Developed-High Intensity category are significantly different than those in Overall category at a p-value of 0.000.
L: Developed, High Intensity	0.0000 (33)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS loading rates from L: Developed, High Intensity category are significantly different than those in Overall category at a p-value of 0.000.
Urban-Pervious	0.0056 (13)	**Statistically significant**	Reject Ho at alpha = 0.05. The TSS loading rates from Urban-Pervious category are significantly different than those in Overall category at a p-value of 0.006.

Notes:
"C" represents data from calibrated models. "L" represents data from non-calibrated models that used literature or observed values.
Null Hypothesis: Ho - No difference in the means μ1-μ2 =0.
Alternative Hypothesis: Ha - There is a difference in the means μ1-μ2 ≠0.
Wilcoxon Rank Sum Test. Two-Sided Test Results (alpha =0.05, z =1.96).

Table 61. Wilcoxon Rank-Sum Test Results for Individual Land Use Loading Rates versus Residential Loading Rates

Land Use	P-value (observations)	Decision Rationale	Remarks
TP (loading rate data) – Overall number of samples:51			
Residential-High Density	0.0642 (10)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP loading rates in the Residential-High Density and Residential categories are any different from each other.
Residential-Medium Density	0.6697 (16)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP loading rates in the Residential-Medium Density and Residential categories are any different from each other.
Residential-Low Density	0.6274 (16)	Not statistically significant	We cannot reject Ho. It cannot be concluded at alpha = 0.05 that the mean of TP loading rates in the Residential-Low Density and Residential categories are any different from each other.

Notes:
Null Hypothesis: Ho - No difference in the means μ1-μ2 =0.
Alternative Hypothesis: Ha - There is a difference in the means μ1-μ2 ≠0.
Wilcoxon Rank Sum Test. Two-Sided Test Results (alpha =0.05, z =1.96).