Community Playbook for Healthy Waterways

Chapter 6.1 Addendum

This Addendum furthers Chapter 6.1 of the Playbook. Specifically, water quality and quantity monitoring data from 2006-2021 at 72 sites in Sarasota County are analyzed and used to illustrate potential metrics for better understanding and managing dissolved inorganic nitrogen (DIN) in surface waters. DIN is bioavailable and is food to fuel Harmful Algae Blooms.

The Sarasota County region lies within two National Estuary Programs – Sarasota Bay and Coastal Heartland (Charlotte Harbor). Nitrogen loads to these estuary systems have traditionally been estimated using a Pollutant Loading Model which has been a useful tool. This Addendum is intended to augment these ongoing efforts by utilizing the water quality and quantity data collected over the past ±15 years and available on the Water Atlas. With respect to water quality in streams, several forms of nitrogen that in sum constitute total nitrogen (TN) are typically analyzed. Total nitrogen consists of nitrate (NO_3) the most common bioavailable form; organic nitrogen which is generally less available to biota; and nitrate (NO_2) and Ammonium (NH_4, typically present at relatively low levels except in highly polluted situations (*Report on the Environment,* United States Environmental Protection Agency, undated).

Inorganic dissolved nitrogen (DIN) as referred to in this Addendum is the sum of ammonium (NH_4), nitrite (NO_2), and nitrate (NO_3) nitrogen. DIN in elevated concentrations can be indicative of anthropogenic sources such as wastewater byproducts, synthetic fertilizers, and possibly areas where natural landscapes with organic matter have been removed and replaced with compacted fill material (sands, silts, and clays). DIN is bioavailable providing food for plant and algae growth.

This Addendum indicates that water quality and quantity data can provide useful management metrics for management of relative DIN concentrations and loads, increasing the potential for improved DIN source identification as well as targeted investments for DIN reduction.

The water quality data reviewed is reported as a concentration in units of milligrams per liter (mg/L). The data was collected by Sarasota County Government (SCG) and Manatee County Government (MCG) and found to be a relatively complete data sets, requiring some quality assurance and control (QA/QC) review. Since the water quantity data collected by Sarasota County under the Automated Rainfall Monitoring System (ARMS) program is limited to stream stage without the application of rating curves to provide discharges, historical and ongoing stage/discharge stations operated by the United States Geological Survey (USGS) in the Sarasota County region were utilized as the proof-of-concept source for quantifying nitrogen loads in this Addendum.

In addition to the results of this effort, potential metrics for the management of DIN concentrations and loads are presented. Recommendations are also provided.

WATER QUALITY – NITROGEN CONCENTRATION DATA

Background:

Monthly water quality samples have been collected in various streams at approximately 75 locations by SCG and MCG. These samples are analyzed by a certified laboratory which typically report Total Nitrogen (TN), Total Kjeldahl Nitrogen (TKN), Ammonia/Ammonium (NH_3/NH_4), and Nitrite plus Nitrate (NOx). Organic nitrogen is defined as TKN less NH_3/NH_4. The data is then uploaded to the Water Atlas.

Evaluation:

Water quality data for each sampling location were downloaded from the Water Atlas. The evaluation process included sorting the nitrogen related concentrations, removal of duplicate values, notation of the location and period of record, and determination of basic statistics for each parameter at each sampling location. The percentage of the total nitrogen that is in the form of DIN was determined for each site. Time series plots of the various forms of nitrogen (ammonium, nitrite + nitrate, and organic nitrogen) were determined for each sampling location site as illustrated in **Figure 1** for Whitaker Bayou (WH-2).

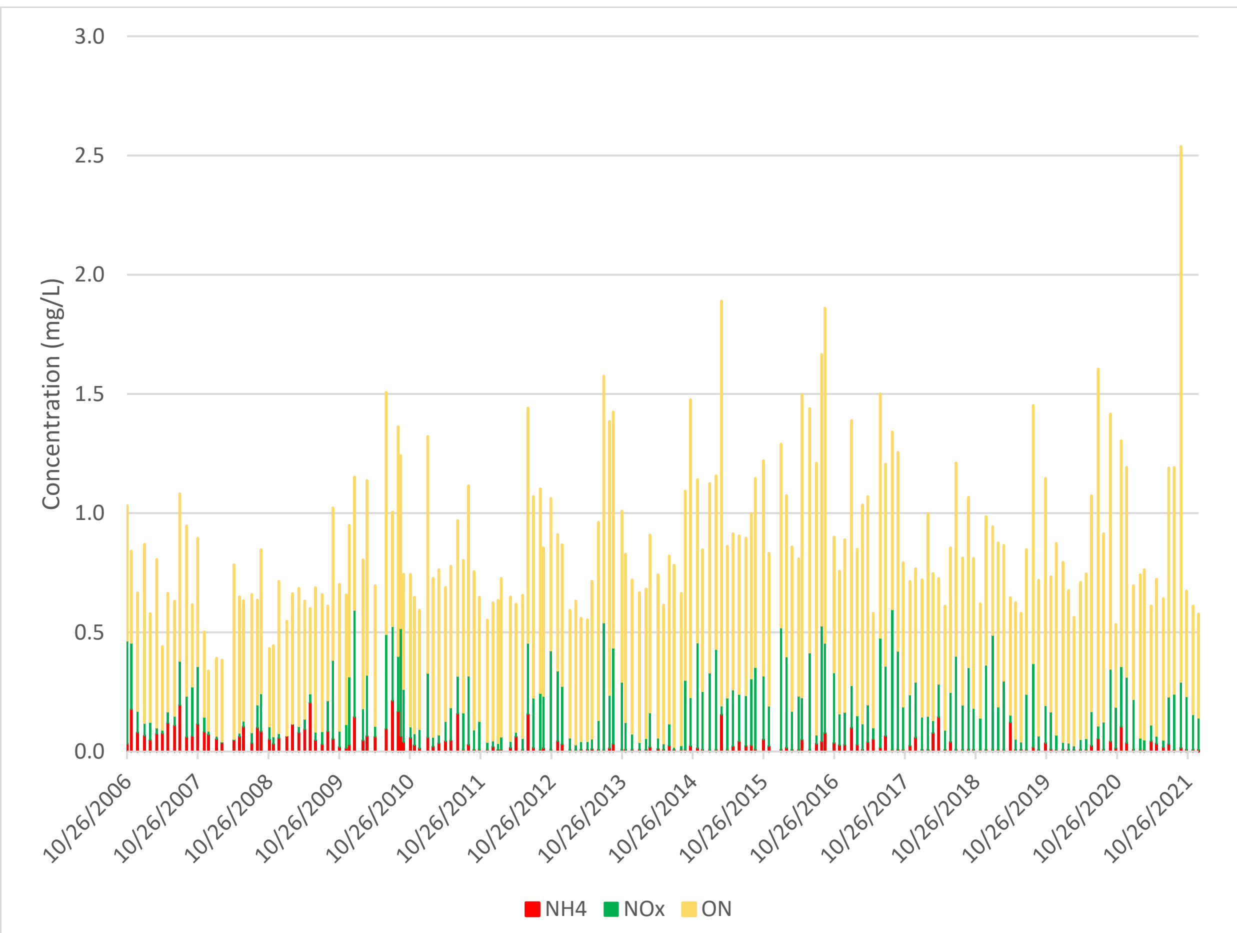

Figure 1- Whitaker Bayou (WH-2) : Nitrogen Time Series

Exhibit 1 provides a summary of the nitrogen concentration related evaluations, arranged in ascending order of the average percentage of DIN to TN. In addition, **Exhibit 1** includes the average total nitrogen concentration, period of record, and number of samples.

The effort suggests an apparent correlation between watershed areas with anthropogenic alterations and increasing percentages DIN. Conversely, watershed areas with limited anthropogenic alterations or certain management strategies generally exhibit low DIN percentages below 10%. Examples of watershed areas with seemingly beneficial management strategies include areas of Catfish Creek, Elligraw Bayou, and Cow Pen Slough. Coincidentally, these watershed areas all contain the in-line impoundment of surface water which may create increased residence times and associated opportunities for the uptake of DIN by aquatic and microbial organisms.

Using the DIN percentages summarized in **Exhibit 1** as a management metric, **Table 1** illustrates a potential prioritization framework. For this illustration, DIN percentages were aggregated into one of eight groups or management grades. As the highest management grade reflects the lowest DIN percentage, it establishes an aspirational management goal for areas with higher DIN. In other words, the higher the management grade, the better. As this is illustrative, the number of management grades or categories could be modified if and as preferred.

Table 1 – Potential Prioritization for Management of DIN Reduction

Management Grade	DIN (%)	No. of Sites
A+	Less than 10	6
A-	10 – 15	9
B+	15 – 20	12
B-	20 – 25	11
C+	25 – 30	14
C-	30 – 40	10
D	40 – 50	5
F	Greater than 50	1

Exhibit 2 presents a visual application of the potential management prioritization framework in **Table 1**.

Table 2 provides a preliminary review and estimate of potential DIN sources for a limited number of the monitoring locations identified in **Exhibit 1** and **Exhibit 2.** A more thorough investigation and "boots on the ground" approach is expected to lead to additional and more direct identification of elevated DIN sources. Confirmed sources of DIN that are also sources of elevated levels of total nitrogen or in close proximity to a waterway/estuary could be further prioritized.

Table 2 – Preliminary Review and Estimate of Potential DIN Sources

Sampling Site	Notes	DIN (%)	Potential DIN Source(s)
Catfish Creek (CAT-2)	Management Grade B+ but BAN is double Station CAT located less than 1/2 mile upstream	18	Venetian MHP Package Plant and nitrate infiltration adjacent to Catfish Creek
Phillippi Creek (C498-Lin)	Management Grade C-	35	Legacy Atlantic Wastewater Treatment Facility and infiltration pond adjacent to Main A
Woodmere Creek (WoodS-Head)	Management Grade C-	35	Japanese Gardens MHP Package Plant and nitrate infiltration to drainage ditch
Phillippi Creek (RBW-R)	Management Grade C-	39	Camelot Lakes MHP Package Plant and nitrate infiltration adjacent to drainage ditch
Alligator Creek (Briar-Mid)	Management Grade D	41	Legacy nitrogen from Venice Gardens lakes, non-AWT reclaimed water storage and application to the east, and onsite sewer treatment and disposal systems to the west
Phillippi Creek (BBB-Fruit)	Management Grade D	42	Legacy Meadow Woods Wastewater Treatment Facility and non-AWT reclaimed water application area and legacy Bobby Jones Golf Course
Phillippi Creek (RBW-W)	Management Grade D	42	Legacy Meadow Woods Wastewater Treatment Facility and non-AWT reclaimed water application area and legacy Bobby Jones Golf Course
Alligator Creek (Briar-Tail)	Management Grade D	42	Legacy nitrogen from Venice Gardens lakes, non-AWT reclaimed water storage and application to the east, and onsite sewer treatment and disposal systems to the west
Phillippi Creek (C341-17th)	Management Grade F	66	Legacy sports facilities upstream

Recommendations:

1. As illustrated herein, the relative DIN percentage should be a used as a meaningful metric to prioritize strategic reduction investigations, management actions, and investments. Proximity to waterways should also be considered for prioritization.
2. Discontinued monitoring locations identified in **Exhibit 1** should be reinstated if BAN percentages for their period of record exceeded 15%.
3. The following sampling locations should be added to address significant watershed area gaps:
   - South Creek at U.S.41
   - Fox Creek at I-75
   - Fox Creek upstream of confluence with Shakett Creek
   - Forked Creek at S.R. 776
   - Wares Creek
   - Palma Sola Creek
   - Unnamed drainage ditches at El Conquistador Parkway
4. Partnerships and coordination opportunities to augment SCG and MCG monitoring with other municipalities, estuary programs, and entities such as the Suncoast Waterkeepers should be leveraged.

WATER QUANTITY – HYDROLOGICAL DATA

Background:

SCG has also been collecting water quantity data in the form of rainfall and stream stages under their Automated Rainfall Monitoring System (ARMS) since the mid-2000's. There are approximately 50 ARMS monitoring sites many of which are situated at or near the SCG water quality sampling locations. In addition, the United States Geological Survey (USGS) operates several stream stage monitoring stations within the Sarasota County region.

To determine pollutant loads, the water quality monitoring stream stage data must be converted to stream flow/volume. To do this, discrete stages and flows are field measured over a representative range to establish a stage vs. flow relationship referred to as a rating curve. The rating curve is then applied to the continuous stage data to establish continuous flow volumes over the entire period of record. The continuous flows can then be converted to corresponding daily, monthly, and annual runoff volumes typically in units of acre-feet. The product of the runoff volume and the nutrient concentration yields the nutrient load typically in units of pounds of nitrogen.

Evaluation:

Since discharge information is not available for the ARMS stream stage data, the USGS water quantity monitoring stations in the Sarasota County region which do contain both stream stages and discharges were reviewed. The USGS monitoring stations are also subject to a standard QA/QC protocol and approval process as noted in published data. Specifically, the data for Whitaker Bayou (USGS station 02299861) was downloaded and utilized to demonstrate proof-of-concept for computing both total nitrogen and DIN loads. After computing the daily, monthly, and annual acre-feet of runoff volumes, unit inches of runoff were also computed by dividing the volume in acre-feet by the contributing watershed area. The contributing watershed area utilized for this effort was based upon that determined from the SCG's detailed hydrodynamic model program.

As the location of USGS steam station 02299861 corresponds to SCG water quality monitoring station WH-2, monthly runoff volumes were multiplied by monthly nitrogen concentrations to obtain monthly nitrogen loads. These monthly loads were then added to obtain annual loads. For water quality monitoring site WH-1, located at U.S.41, the unit runoff volume for WH-1 was multiplied by the WH-2 contributing area. The resulting runoff volumes were then multiplied by the nutrient concentrations for WH-1 to estimate annual nitrogen loads at WH-1 for the common period of record (water quality monitoring at WH-1 was discontinued between 2008 and 2012). The WH-1 and WH-2 monitoring locations are identified on **Exhibit 2**.

Table 3 summarizes the resulting annual loads for the period of record at WH-1 (Whitaker Bayou at U.S.41) and upstream WH-2 (Whitaker Bayou at USGS Station 02299861).

Table 3 – Annual Nitrogen Loads for WH-1 and WH-2

Year	Rainfall (inches)	Runoff (inches)	TN (pounds)		BAN (pounds)	
			WH-1	WH-2	WH-1	WH-2
2007	30.21	7.90	5,374	4,760	2,856	1,427
2008	34.32	9.74	*	5,046	*	994
2009	32.67	6.44	*	3,979	*	1,171
2010	44.43	12.32	*	10,652	*	3,502
2011	40.64	10.11	*	6,690	*	1,403
2012	45.79	14.80	16,696	13,460	4,628	3,922
2013	52.67	27.70	34,935	28,626	9,061	7,661
2014	51.05	10.00	10,350	7,522	3,293	1,497
2015	39.65	7.70	8,416	6,370	647	1,819
2016	49.11	21.25	28,990	24,320	6,915	6,642
2017	65.00	22.55	22,473	21,638	2,715	8,243
2018	48.71	16.24	14,946	11,836	2,801	3,635
2019	50.09	13.40	10,851	10,879	6,554	2,820
2020	57.42	19.57	24,968	17,221	12,810	3,656
2021	46.71	12.54	13,159	11,306	3,796	1,885
Mean	**45.90**	**14.15**	**17,378**	**12,287**	**5,098**	**3,352**

* Nutrient concentrations not available for calculation as sampling appears to have been temporarily discontinued.

In summary, annual total nitrogen (TN) and dissolved inorganic nitrogen (DIN) loads for Whitaker Bayou (WH-2) between 2007 and 2021 averaged 12,287 pounds and 3,352 pounds, respectively. The corresponding annual TN and DIN loads for Whitaker Bayou (WH-1) between 2007 and 2021 are estimated to have averaged 17,378 pounds and 5,098 pounds, respectively.

As noted in **Table 3**, actual annual TN and DIN loads can vary significantly from year to year. **Figure 2** compares annual rainfall and runoff volumes and indicates a moderate positive correlation and R-squared of 0.6. This is considered reasonable due to seasonal variations in antecedent moisture conditions (landscape and soil wetness prior to rainfall) as the same amount of rainfall in the dry season would typically generate less runoff than in the wet season. However, as indicated in **Figure 3,** annual loads are strongly correlated with the annual runoff for W-2 with an R-squared of 0.92. This is expected as nutrient loads being the product the runoff and concentration and suggests that runoff volumes may be a good surrogate for nitrogen loads.

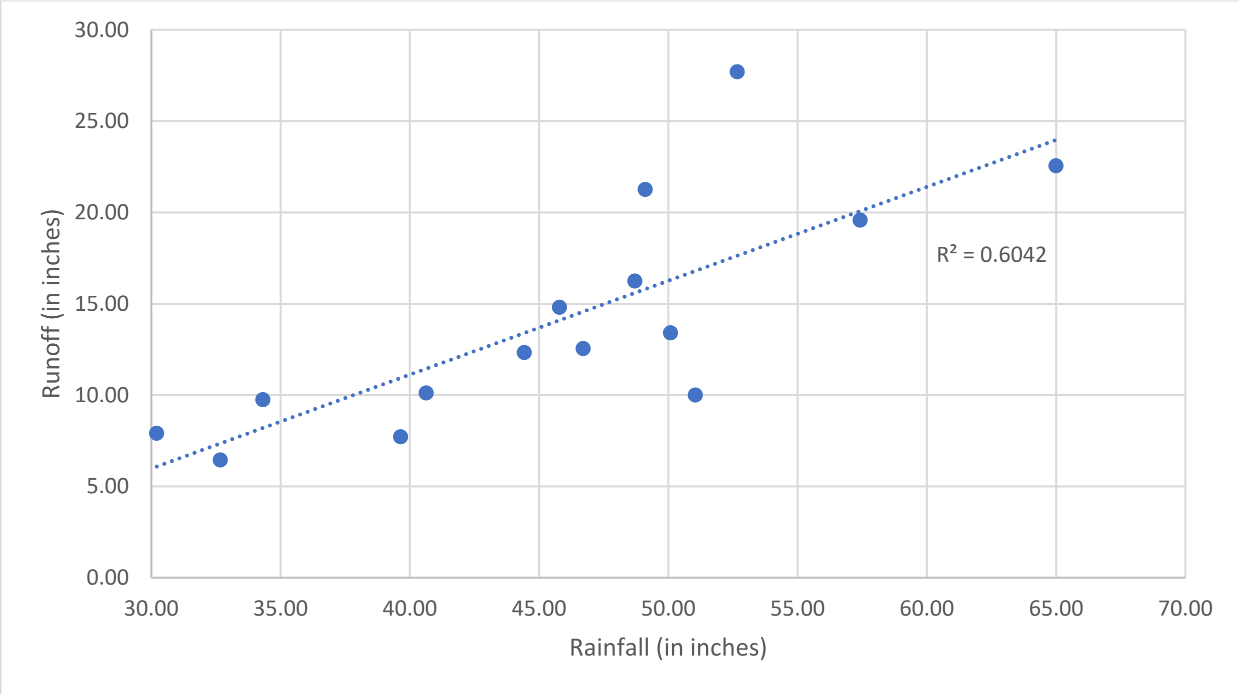

Figure 2 – Whitaker Bayou: Annual Rainfall vs. Annual Runoff

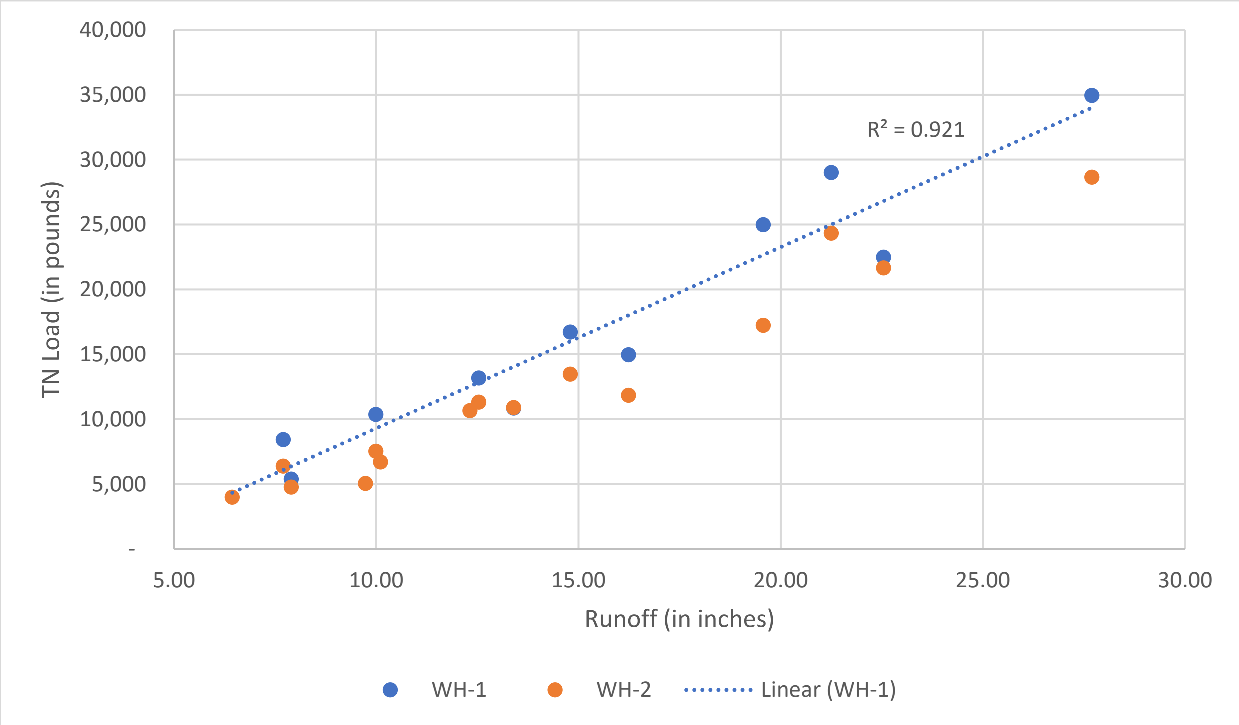

Figure 3 – Whitaker Bayou: Annual Runoff vs. Annual Loads

Figures 4 and 5 graphically present the annual and monthly variations in TN and DIN loads for WH-2 between 2007 and 2022 and illustrates that most of the annual loads typically occur during the wet season (June through September).

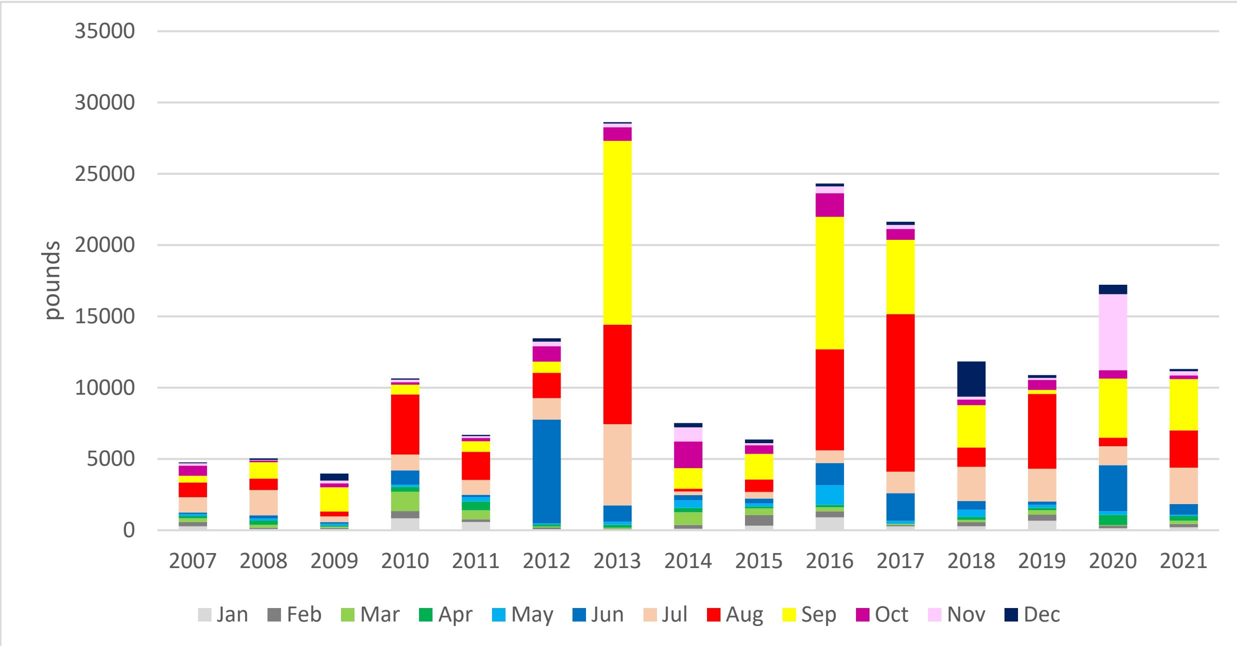

Figure 4 – Annual and Monthly TN Loads for WH-2

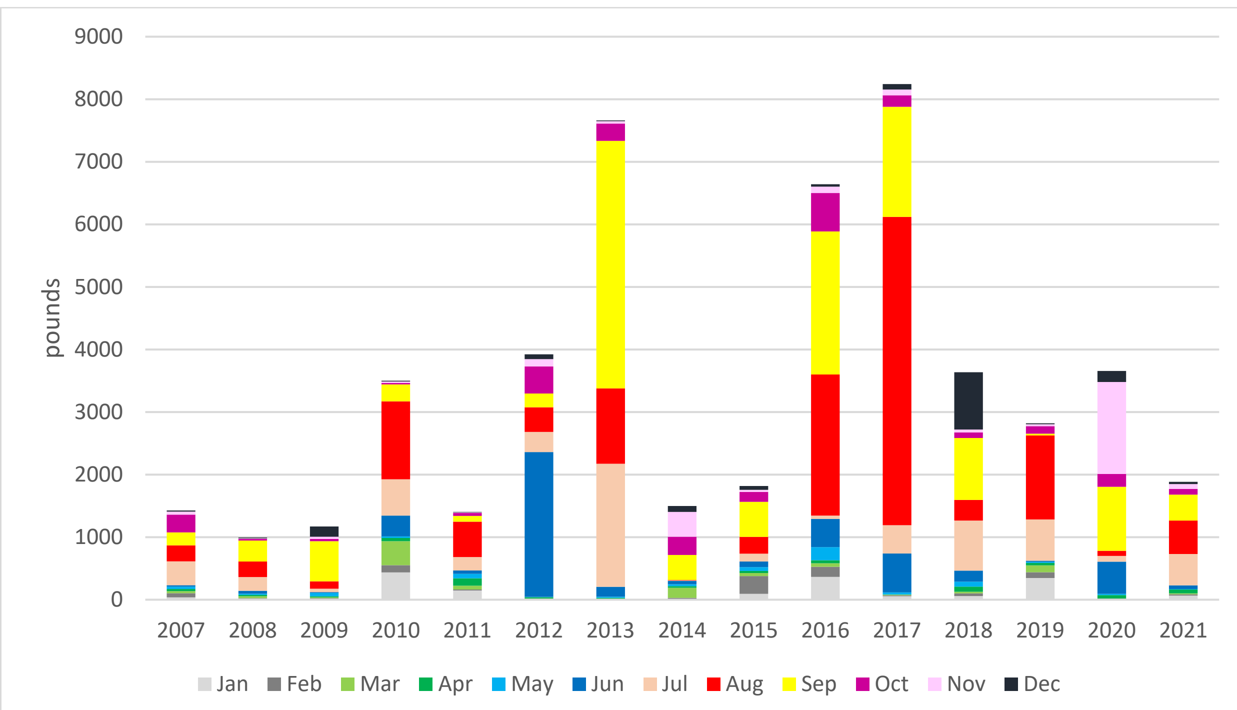

Figure 5 – Annual and Monthly DIN Loads for WH-2

The unit annual TN and DIN loads defined as pound per acre may also be a useful metric for relative DIN management prioritization and investment. Although not part of the scope of this Addendum, unit TN and DIN loads were provisionally estimated for WH-1 and several other sites throughout the Sarasota region. Provisionally, these unit TN and DIN loads are contrasted in **Table 4** below:

Table 4 – Average Annual Unit Nitrogen Loads

Site	Location	TN Unit Load (lb/ac)	BAN Unit Load (lb/ac)
DPS	Deer Prairie Creek at Dam*	3.89	0.19
MY-B	Myakka River@ S.R. 72*	4.80	0.34
CAT	Catfish Creek @ Central Sarasota Parkway**	3.52	0.40
CPS-1	Cow Pen Slough @ Kings Gate Weir**	4.20	0.40
MY-A	Myakka River @ Myakka Road*	4.98	0.42
HWC	Howard Creek @ Myakka Valley Trail*	5.57	0.54
CAT-2	Catfish Creek @ U.S. 41	3.45	0.69
WH-2	Whitaker Bayou @ 38th Street	3.63	0.99
WH-1	Whitaker Bayou @ U.S. 41	3.74	1.01
RBW-H	Phillippi Creek @ Bahia Vista Road	4.62	1.03
PH-41	Phillippi Creek @ U.S. 41	4.26	1.04

As indicated by the provisional evaluation in **Table 4**, there does not appear to be a clear correlation between watershed with anthropogenic alterations and unit TN loads. However, watersheds with anthropogenic changes such as Whitaker Bayou and Phillippi Creek appear to have significantly higher unit DIN loads than more natural or managed watershed areas (noted in **Table 4** with a single or double asterisk, respectively).

Recommendations:

Unit DIN loads for watershed areas should be developed as metric for the relative comparison and management of DIN.

Measured nitrogen loads should be used as the basis for planning purposes as well as pollutant loading model calibration/verification.

Engage the USGS or qualified hydrologist to develop rating curves and manage the ARMS data base.