HORSE CREEK STEWARDSHIP PROGRAM
HARDEE AND DESOTO COUNTIES, FLORIDA

2019 ANNUAL REPORT

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Prepared by:

FLATWOODS
Consulting Group

8306 Laurel Fair Circle•Suite 120
Tampa, FL 33610•813-600-5747

Eesa G. Ali
Senior Water Resource Analyst

Shannon M. Gonzalez
Senior Ecologist/Principal

EXECUTIVE SUMMARY

Introduction

The Upper Horse Creek Basin has been mined since the late 1980s[1]. Before the Horse Creek Stewardship Program (HCSP) was implemented, some 12,000 acres had been mined. The Horse Creek Basin also is the home of substantial agricultural and other active land uses. In 2003, after a series of legal challenges to required mining permits, Mosaic Fertilizer, LLC (Mosaic) and the Peace River Manasota Regional Water Supply Authority (PRMRWSA) executed a settlement agreement to ensure that mining would not have negative impacts on Horse Creek, a major tributary of the Peace River, as a result of proposed mining activities by Mosaic in eastern Manatee and western Hardee Counties, Florida. A principal component of the agreement was the creation of the HCSP.

The overall goals of the HCSP are to ensure that Mosaic's mining activities do not interfere with the ability of the PRMRWSA to withdraw water from the Peace River for potable use or adversely affect Horse Creek, the Peace River, or Charlotte Harbor. The program, which is funded and managed by Mosaic, has two purposes:

1. In order to detect any adverse stream water quality conditions or significant trends that may occur as a result of mining, the HCSP provides a protocol for the collection of information on the physical, chemical, and biological characteristics of Horse Creek during Mosaic's mining activities in the watershed, and
2. If detrimental stream water quality changes or trends caused by Mosaic's activities are found, the HCSP provides mechanisms for corrective action.

The program is limited to the investigation of the potential impacts of Mosaic's mining activities on the Horse Creek Basin and is not intended to investigate the potential impacts of other land uses or mining activities by other entities.

This program offers additional protection to Horse Creek; this protection is not usually present in the vast majority of regulatory scenarios.

This program has three basic components:

1. Monitoring and reporting on stream water quality;
2. Investigating adverse water quality conditions or significant trends that are identified through monitoring; and,
3. Implementing corrective action for any adverse water quality changes to Horse Creek caused by Mosaic's mining activities.

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[1] Based on historical aerial photos, mining began within the upper horse creek basin in 1986 (north or SR 37), 1989 (south of SR 37), and 1998 (south of SR 62.

The HCSP is unique in that it does not rely solely upon the exceedance of a standard or threshold to bring about further investigation and corrective action, where appropriate. The presence of a significant temporal trend alone will be sufficient to initiate such steps. Monitoring for the HCSP began in April 2003, and this report presents the results of the entire 17 years of monitoring.

Mining and Reclamation

At the time the HCSP was initiated, some 12,000 acres of land in the Upper Horse Creek Basin had already been mined. From 2003 to 2018, about 3,745 additional acres were mined in the Horse Creek Basin upstream of the northernmost monitoring location, and an additional 2,134 acres were mined in the Brushy Creek basin upstream of two sampling stations: BCSW-1 and HCSW-2. In 2019, 341 additional acres were mined in the Horse Creek Basin upstream of the northernmost monitoring location, and an additional 176 acres were mined in the Brushy Creek basin upstream of BCSW-1 and HCSW-2. Reclamation in 2019 included 366 acres reclaimed to final contour in the Horse Creek basin and 0 acres in the Brushy Creek basin, as well as 120 and 76 acres reconnected in the Horse Creek and Brushy Creek basins, respectively.

Monitoring Program Components

Four locations on Horse Creek are monitored for physical, chemical, and biological parameters; two of these sites are also long-term US Geological Survey (USGS) gauging stations.

- **Water quantity data** were collected continuously from the USGS gauging stations at two HCSP sampling stations, HCSW-1 and HCSW-4.
- **Rainfall data** were collected daily from three Mosaic rain gauges located in the Horse Creek Basin.
- **Water quality data** were collected during monthly sampling events at HCSP stations 1 to 4, continuously from one Horse Creek location (HCSW-1), and at all four stations during biological sampling events.
- **Biological (fish and benthic macroinvertebrates) sampling events** are scheduled to occur three times each year.

Water Quantity Results

As detailed below and in the report, the data show that there is no evidence that mining and reclamation activities in the basin caused any statistically significant decrease in total streamflow over the period of record – from 1978 to 2019.

The annual average daily streamflow at Horse Creek in 2019 at HCSW-1 (35 cfs) was slightly above the average for the period of record (31.6 cfs). The 2019 annual average at HCSW-4 (145 cfs) was below the long-term annual average (185.4 cfs)[2]. Historical USGS flow records go back to mid-1977 at HCSW-1 and 1951 at HCSW-4. A ranking of annual average flows between 1978

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[2] Long-term annual average of daily streamflow calculated for 1978 to 2018 for HCSW-1 and 1951 to 2018 for HCSW-4 using USGS gauging stations.

and 2019 places 2019 as 18th highest at HCSW-1 and 23rd at HCSW-4; or 10th highest at both sites over the HCSP period of record (2003-2019).

Annual rainfall of 49 inches in 2019 was below the long-term average annual rainfall of 54 inches (1908-2019)[3]. A ranking of annual average rainfall for the period of record (1908-2019) National Oceanic and Atmospheric Administration (NOAA) stations in the Horse Creek watershed places 2019 as the 77th highest year, and 14th highest since 2003.

National Pollutant Discharge Elimination System (NPDES) discharge occurred for 24 days uninterrupted in 2019, between August 23rd and September 15th. NPDES discharge from the Horse Creek outfalls usually does not occur until sufficient water storage accumulates in the circulation system, resulting in a lag. The 2019 NPDES discharge was the 15th largest over the 19 years the outfalls have been online[4].

There is no evidence that mining and reclamation activities in the basin caused any statistically significant decrease in total streamflow over the period of record (1978 to 2019), according to the double mass curve analysis. In a previous study (Robbins and Durbin 2011) that compared streamflow during dry years in reference and potentially impacted streams before and during phosphate mining, there was no evidence that phosphate mining practices caused lower monthly flows in the potentially impacted streams (including Horse Creek) than what would be expected given the conditions in a reference stream (Charlie Creek).

Water Quality Results

As detailed below and in the report, water quality data continue to show that there is no evidence that mining and reclamation activities in the basin are causing or contributing to adverse water quality changes in Horse Creek.

Water quality parameters in 2019 were almost always within the desirable range relative to trigger levels and water quality standards at the station with the highest percent of upstream mined lands and receiving the most concentrated effluent (HCSW-1). Alkalinity was the only parameter above the trigger level at HCSW-1 during 2019, but the exceedance did not occur during an NPDES discharge.

Monthly sampling found one total ammonia and nine Dissolved Oxygen (DO) percent saturation exceedances at HCSW-2 between January and November. HCSW-2 has historically had trigger level exceedances related to chlorophyll-a, nutrients (including ammonia) and dissolved oxygen. These three parameters point to the same phenomenon which is eutrophication. Previous annual reports have indicated that HCSW-2 receives coarse organic material (nutrient source) from an upstream prairie. This added nutrient content is compounded by less flushing and an increased residence time due to the impoundment upstream caused by a farm road crossing with above grade

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[3] Historical rainfall information came from the following stations and years: 1908 to 1943 NOAA station 148, 1944 to 2018 average of NOAA station 148 and 336.

[4] **POR NPDES average 3.2 billion gallons (BG), median 2.2 BG, minimum 0 BG, maximum 9.3 BG, 2019 0.65 BG**

culverts. HCSW-2 is the only HCSP site with a mucky bottom. It is also the site with the least number of samples historically due to regular low and no-flow conditions.

There was one trigger level exceedance at HCSW-3: total ammonia. An impact assessment was conducted to examine the historical record of ammonia in Horse Creek. That report found that the ammonia exceedances were episodic, predated the outfalls to Horse Creek, and were unrelated to the NPDES discharge. These exceedances may be due to agricultural operations along Horse Creek and its tributaries and successive periods of drying and rewetting of the Horse Creek floodplain.

There were four exceedances at HCSW-4: calcium (1), TDS (2), and sulfate (1). An impact assessment was conducted in 2018 and found that the elevated dissolved ions (TDS, calcium, and sulfate) were isolated to sites HCSW-3 and HCSW-4 as well as tributaries to Horse Creek in the vicinity of the two sites (Appendix I). These tributaries that contributed to elevated dissolved solids were all draining land being utilized for agriculture.

Twelve water quality parameters showed statistically significant increasing or decreasing monotonic trends in 2019 at HCSW-1 or HCSW-4. Several of the trends detected during the statistical analysis either have an estimated slope that 1) was not in the direction of an adverse trend (dissolved oxygen saturation, color, and dissolved iron) or 2) was very small compared to the observed differences between primary and duplicate field samples (pH, turbidity, Total Kjeldahl Nitrogen (TKN), and fluoride).

Specific conductivity, TDS, calcium, and sulfate had reported monotonic trends with higher estimated rates of change. The potential trend for specific conductivity (with reference to TDS and other ions) was discussed in Appendix I of the 2017 Annual Report. That 2017 discussion indicated that the phenomenon of increasing specific conductivity was occurring regionally in streams with or without mining, before the HCSP program, at sites upstream of the HCSP sites, and, despite trends, the sites were meeting primary drinking and Class III water quality standards.

Benthic Macroinvertebrate Results

As detailed below and in the report, the data show that mining and reclamation activities in the basin are not having an adverse impact on the diversity or numbers of benthic macroinvertebrates. Benthic macroinvertebrates are small aquatic animals and aquatic larval stages of insects that are large enough to see with the naked eye, have no backbone, and are found in and around water bodies during some period of their lives. They live among stones, logs, sediments, and aquatic plants on the bottom of streams, rivers, and lakes.

Habitat assessment scores ranged from 79 (marginal) to 137 (optimal) at all stations in 2019, which is typical of previous scores for the HCSP. There continues to be low amounts of available quality habitat at sites HCSW-1, HCSW-3, and HCSW-4 due to bank erosion and resulting sand smothering. Stream Condition Index (SCI) scores at the three stations were at or above 35 (considered "Healthy") for all sampling events except for HCSW-4 in November. Station HCSW-2 had one SCI sampling event with a score below 35 (considered "Impaired"), similar to past scores because of unique, natural upstream conditions (Horse Creek Prairie).

Benthic invertebrate taxa diversity and SCI metrics in Horse Creek exhibited both seasonal and year-to-year variation. In 2019, taxa diversity was the lowest to date. Despite this, overall diversity scores remain high. Generally, taxa diversity indices and SCI metrics show few monotonic trends over time and are very similar between sampling events and stations. However, HCSW-2 has lower SCI scores than other stations (long term average of 31 compared to 60-65) because of natural conditions. Natural habitat conditions at HCSW-2 include lower dissolved oxygen and lower pH than other Horse Creek stations; these conditions are related to the station experiencing regular low or no-flow conditions, increased residence time, the upstream impoundment, and the presence of Horse Creek Prairie, the large marsh located upstream of the biological sampling station.

Fish Results

As detailed below and in the report, the fish sampling data illustrate that there is no evidence that mining and reclamation activities in the basin are causing any decrease in fish taxa richness abundance or diversity. No monotonic trend (positive or negative) was detected over time across the entire HCSP reach (i.e. when combining all stations). With all station data combined, 2019 saw the highest fish diversity (tied with 2003 and 2013) over the HCSP period of record. Additionally, the site closest to the outfall (HCSW-1) shows the highest fish diversity of the four stations for the period of record.

Conclusions

This report covers the seventeenth year of an ongoing monitoring program, where some general conclusions can be drawn. Expected relationships between rainfall, runoff, and streamflow were observed in the 2003 to 2019 water quantity data. Program trigger levels were exceeded for seven parameters in 2019 and nine parameters had statistically significant trends from 2003 to 2018, but the exceedances and trends are not related to mining operations. The benthic macroinvertebrate and fish communities found over the HCSP period of record were typical of those found in a Southwest Florida stream. Regulated mining and reclamation activities in the basin have not caused or contributed to reduced water quantity, deterioration of water quality, or reduction quantity or diversity of benthic macroinvertebrates or fish populations.

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1.0 INTRODUCTION

As a result of proposed mining operations by Mosaic Fertilizer, LLC (Mosaic) in eastern Manatee and western Hardee Counties, Florida, and a series of legal challenges to the permits required for such mining, Mosaic and Peace River Manasota Regional Water Supply Authority (PRMRWSA) executed a settlement agreement structured to ensure that mining would not have negative impacts on Horse Creek, a major tributary of the Peace River. A principal component of that agreement was the creation of the Horse Creek Stewardship Program (HCSP), which is funded and managed by Mosaic. The program document, as referenced in the settlement agreement, is provided as Appendix A.

There are two purposes for the HCSP. First, it provides a protocol for the collection of information on the physical, chemical, and biological characteristics of Horse Creek during Mosaic's mining activities in the watershed (Figure 1-1). This information would then allow the ability to detect any adverse conditions or significant trends that may occur as a result of mining. Second, it provides mechanisms for corrective action with regard to detrimental changes or trends caused by Mosaic's activities, if any are found. The program is limited to the investigation of the potential impact of Mosaic mining activities on the Horse Creek Basin and is not intended to investigate the potential impacts of other land uses or mining activities by other entities.

The overall goals of the program are to ensure that Mosaic's mining activities do not interfere with the ability of the PRMRWSA to withdraw water from the Peace River for potable use nor adversely affect Horse Creek, the Peace River, or Charlotte Harbor. There are three basic components to the HCSP: 1) monitoring and reporting on stream quality, 2) investigating adverse conditions or significant trends identified through monitoring, and 3) Implementing corrective action for any adverse changes to Horse Creek caused by Mosaic's mining activities. An important aspect of this program is that it does not rely solely upon the exceedance of a standard or threshold to bring about further investigation and, where appropriate, corrective action. The presence of a significant temporal trend alone is sufficient to initiate such steps. This protection mechanism is not present in the vast majority of regulatory scenarios.

The HCSP provides for the following data collection:

- Continuous recording (via US Geological Survey (USGS) facilities) of stage and discharge at two locations on the main stem of Horse Creek
- Daily recording of rainfall via Mosaic and USGS rain gauges in the upper Horse Creek basin
- Continuous recording of temperature, Dissolved Oxygen (DO), conductivity, turbidity, and pH at HCSW-1, the Horse Creek station nearest to Mosaic's active mining operations

- Monthly water quality monitoring of 21 parameters at four stations on the main stem of Horse Creek[5]
- Sampling of fish, benthic macroinvertebrates, and field water quality parameters (temperature, dissolved oxygen, conductivity, turbidity and pH) three times annually at four stations on the main stem of Horse Creek[6].

HCSP monitoring began in April 2003. At the time the HCSP was initiated, some 12,000 acres of land in the Upper Horse Creek Basin had been previously mined. From 2003 to 2019, about 4,086 acres were mined (by Mosaic or legacy CF Industries operations) in the Horse Creek Basin upstream of the northernmost monitoring location, and an additional 2,310 acres were mined in the Brushy Creek basin upstream of BCSW-1 and HCSW-2.

This report, which is the seventeenth in a series of Annual Reports, presents the results of monitoring conducted from April 2003 through December 2019. All data presented in tables and figures was collected as part of the HCSP unless otherwise noted. Additional sources of data since 2000 have also been included in the box plots to provide a short historical perspective (Appendix C). A separate HCSP historical report (Durbin and Raymond 2006) contains a review and summary of all available historical water quality and biological information for Horse Creek.

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[5] In 2009, the list of parameters was reduced by three (total amines, total fatty acids, and FL-PRO were removed), and an additional station on Brushy Creek (tributary of Horse Creek) was added.

[6] Biological data (fish and benthic macroinvertebrates) are collected three times annually (March to April, July to September, and October to December). Specific months when biological sampling occurs may change from year to year to avoid very low or very high flows, which would impede representative sampling.

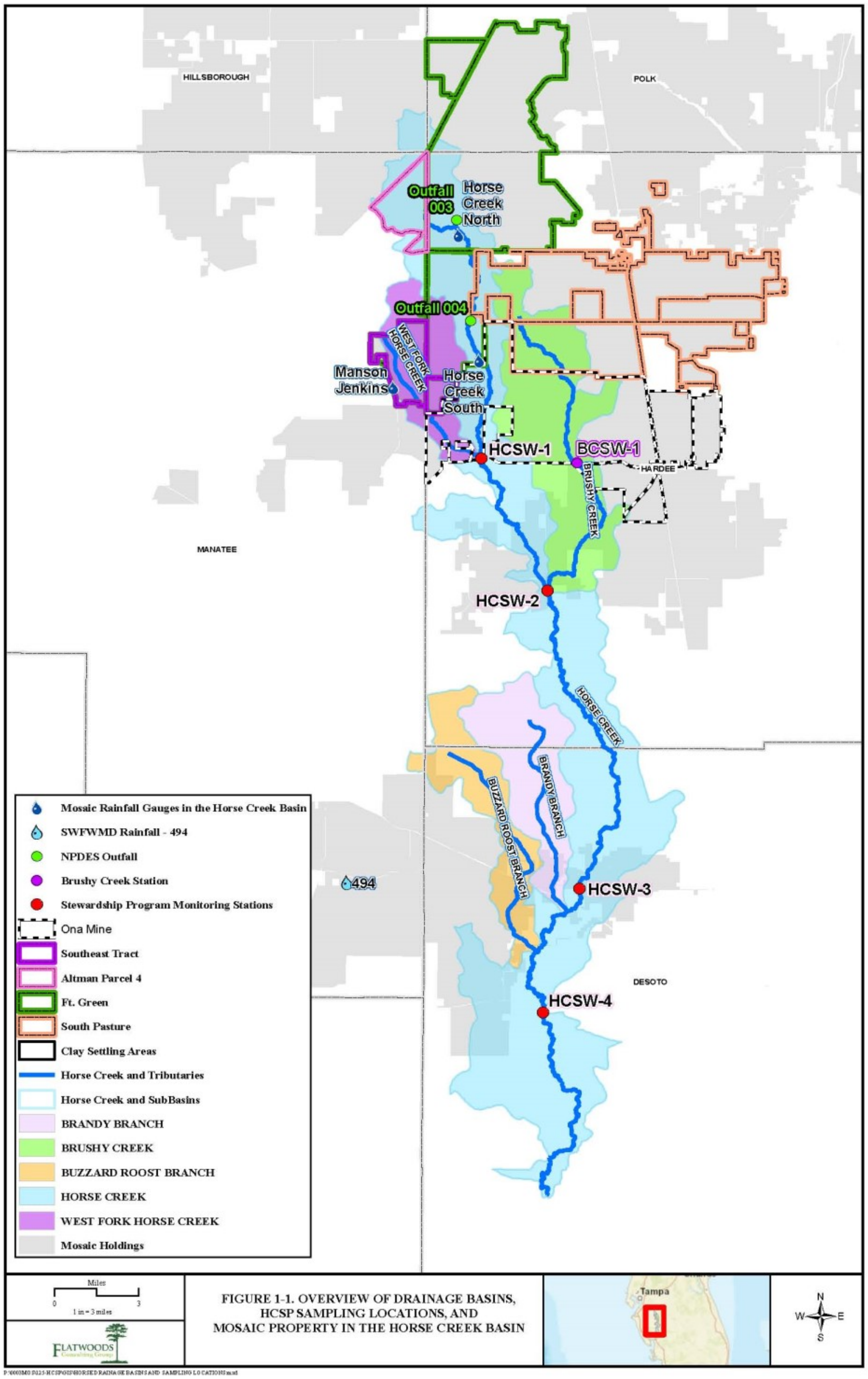

Figure 1-1 Overview of Drainage Basins, HSCP Sampling Locations, and Mosaic Property in the Horse Creek Basin

2.0 DESCRIPTION OF THE HORSE CREEK BASIN

The Horse Creek basin is located in five counties of South-Central Florida: Hillsborough, Polk, Manatee, Hardee, and DeSoto, with the majority of the watershed spanning portions of western Hardee and DeSoto Counties (Figures 1-1 and 2-1). Horse Creek is a major tributary of the Peace River that drains into the southwestern portion of the Peace River Basin and supplies approximately 15 percent of the surface water runoff to the Peace River (Lewelling 1997).

The basin occupies some 241 square miles, and the length of the channel is approximately 43 miles. Horse Creek has an elongated basin with a north-to-south drainage that is influenced by the general topography of the area. Six sub-basins and five tributaries make up the Horse Creek Basin. West Fork Horse Creek and Brushy Creek, two northern tributaries in the Polk Uplands, are generally straight, at least partially channelized, and have relatively rapid flows (Lewelling 1997). The remaining tributaries, occupying the central to southern Horse Creek Basin, include Buzzard Roost Branch and Brandy Branch. These lower reaches are located in the DeSoto Plains/Gulf Coast Lowlands area and are generally meandering, slower streams. Horse Creek ultimately discharges into the Peace River near Fort Ogden (Southwest Florida Water Management District (SWFWMD) 2000).

The topography of the Horse Creek basin generally follows the north-to-south drainage flows of the creek. Elevation in the basin ranges from 135 feet in the north to 30 feet in the south near the confluence of Horse Creek and the Peace River. The basin is located in the mid-peninsular physiographic zone of Florida, in three subdivisions: Polk Uplands, DeSoto Plains, and Gulf Coast Lowlands. The Polk Uplands underlie the northern portion of the Horse Creek Basin, where the elevation generally exceeds 100 feet National Geodetic Vertical Datum (NGVD). In this location, the channel of Horse Creek is generally steep and slightly incised, with swiftly moving water. The central Horse Creek basin is located in the DeSoto Plain. Average elevations in this area range from 30 to 100 feet NGVD. Where Horse Creek enters the Peace River, the Gulf Coast Lowlands range in elevation from about 30 to 40 feet NGVD. The Horse Creek channel in the DeSoto Plain and Gulf Coast Lowlands is slower and more sinuous than the northern channel (SWFWMD 2000, Lewelling 1997).

The northern Horse Creek Basin is located in the Polk Uplands, with Pomona-Floridana-Popash soils characterized by nearly level, poorly drained, and very poorly drained sandy soils. Some soils in this association have dark colored subsoil at a depth of less than 30 inches over loamy material, and some are sandy to a depth of 20 to 40 inches and are loamy below. The extreme northern basin of Horse Creek contains isolated areas of the Arents-Hydraquents-Neilhurst soils group, parts of which have been strip-mined for phosphate (Robbins et al. 1984).

The central and southern Horse Creek Basin is located in the DeSoto Plain, which is a very flat, submarine plain probably formed under Pleistocene Wicomico seas, 70 to 100 feet above present sea level (Cowherd et al. 1989). The Smyrna-Myakka-Ona and Smyrna-Myakka-Immokalee soil associations characterize this portion of the Horse Creek Basin with flat, poorly drained soils that are sandy throughout (Lewelling 1997). The soil group Bradenton-Felda-Chobee is also located immediately adjacent to the main channel of Horse Creek, from below State Road 64 to just above the mouth of the creek. These soils are characterized by nearly level, poorly drained, and very poorly drained soils that are sandy to a depth of 20 to 40 inches and underlain by loamy material or that are loamy throughout and subject to frequent flooding.

The dominant soil groups in the Horse Creek basin are generally poorly drained, reducing the infiltration of rainwater to the water table in the surficial aquifer, thereby limiting the amount of water available to support baseflow (SWFWMD 2000).

The climate of Horse Creek Basin is subtropical and humid with an average temperature of about 72º F. Summer temperatures average 80º F, and winter temperatures average 60ºF (Hammett, 1990). The average daily temperatures in Hardee County, in the northern Horse Creek Basin, range from 52º F to 91º F (Robbins et al. 1984). The average daily temperatures in DeSoto County, in the southern Horse Creek Basin, range from 49º F to 92º F. Average relative humidity in Horse Creek Basin ranges from 57 percent in the mid-afternoon to 87 percent at dawn. The prevailing wind is from the east-northeast, with the highest average wind speed, 7.8 mph, occurring in March (Cowherd et al. 1989).

The average annual rainfall in the Peace River Basin, which includes Horse Creek, is 54 inches, with more than half of that falling during localized thundershowers in the wet season (June to September)[7]. Rain during fall, winter, and spring is usually the result of large, broad frontal systems instead of local storms. November is typically the driest month of the year, averaging 1.75 inches over the historical period from 1908 to 2019. The months of December and January are also characteristically dry, averaging 1.87 and 2.22 inches, respectively. Dry conditions coincide with high evaporation rates and generally result in the lowest stream flows, lake stages, and ground-water levels of the year (Hammett, 1990). The wettest months of the year are typically August and June, averaging 8.60 and 8.51 inches, respectively.

Horse Creek flows through a generally rural area. Major land use activities in the basin are primarily agricultural, with extractive mining activities occurring in the northern part of the basin. Agricultural activities include cattle grazing, row crop farming, citrus grove production, sod farming, and conversion of native lands to pasture for both cattle grazing and hay production.

Small rural agricultural communities are located in and near the Horse Creek drainage basin including Fort Green, Ona, and Myakka Head in the northern portion of the basin; Limestone, Lily, and Edgeville in the approximate center of the basin; and Arcadia, Fort Ogden, and Nocatee near the southern end of the basin (Post et al. 1999). Generally, the northern Horse Creek basin is covered more by natural vegetation, while the southern basin is covered mostly by pasture and row crops (SWFWMD 2000).

Total acreages in each land cover type and proportions of the various land uses differ between regions of the basin. The percent mining cover has increased between 1988 and 2017, according to Southwest Florida Water Management District (SWFWMD) land use maps for those years. Mining is the primary land use above State Road 64, but the percentage of land devoted to mining decreases rapidly downstream.

Water quality sampling in Brushy Creek was added to the HCSP in 2009. Land use in 2011 in the Brushy Creek basin is primarily agricultural/land clearing (48.42%), mining (10.5%), and natural (40.5%). Overall, the Brushy Creek basin has a similar percentage of rangeland (15%), upland forest (13%), and wetland (29%) land use as the Horse Creek Basin.

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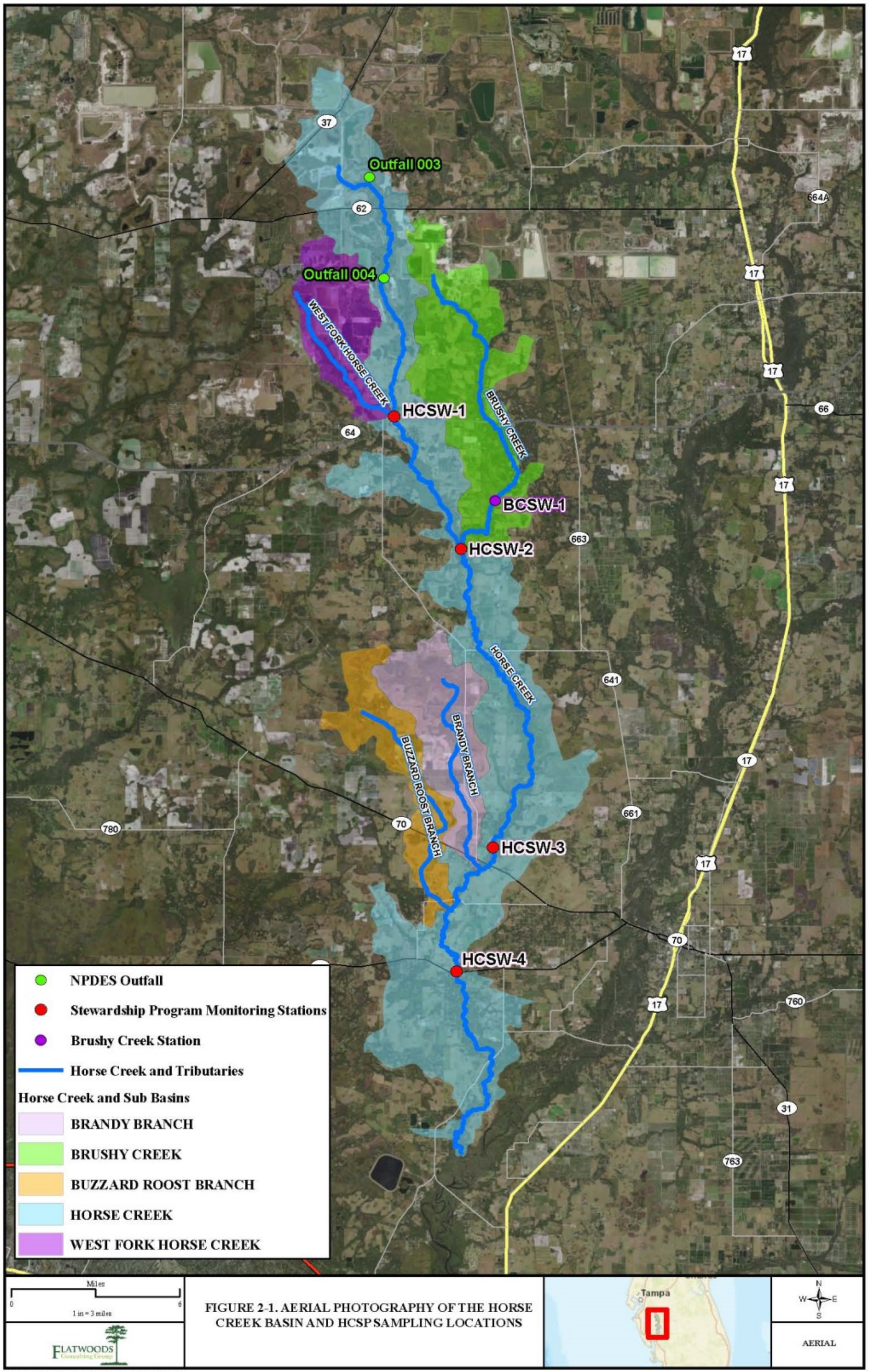
[7] Historical rainfall information came from the following stations and years: 1908-1943 NOAA station 148, 1944 to 2019 average of NOAA station 148 and 336.



P:\0003MOS\125-HCSP\GIS\HORSE CREEK AERIAL REPORT MAP.mxd

Figure 2-1 Aerial Photograph of the Horse Creek Basin Relative to the HCSP Sampling Locations

3.0 SUMMARY OF MINING AND RECLAMATION ACTIVITIES

3.1 Mining

Mining activities in the Horse Creek basin have occurred on two mines: Fort Green Mine (operated by Mosaic, previously International Minerals and Chemicals (IMC)) and South Pasture Mine (operated by Mosaic, previously CF Industries) including the South Pasture Extension, and the Four Corners Mine which includes both the Altman Tract and Ona. A summary of all mining and reclamation activities from 2003 to 2019 is provided below in Table 3-1[8]. Information on pre-mining conditions in the Horse Creek Basin may be found in an Environmental Impact Statement prepared by Environmental Science and Engineering, Inc. (1982) and a Development of Regional Impact statement prepared by Ardaman and Associates and colleagues (1979). There are four Clay Settling Areas (CSAs) in the Horse Creek Basin at the Fort Green Mine (Figure 3-1, Table 3-2).

Table 3-1 Total acres Minded, Reclaimed to Final Contour, and Reconnected by Mosaic in the Horse Creek and Brushy Creek Basins

Year	Acres Mined		Acres Reclaimed to Final Contour		Acres Reconnected	
	Horse Creek	Brushy Creek	Horse Creek	Brushy Creek	Horse Creek	Brushy Creek
2003	332	0	0	0	1462	0
2004	638	0	30	0	0	0
2005	590	169	205	0	38	0
2006	187	17	0	0	205	0
2007	0	146	106	42	0	0
2008	150	187	245	0	66	0
2009	137	16	711	95	315	0
2010	283	220	270	91	0	0
2011	100	164	114	12	0	0
2012	76	153	600	63	0	0
2013	198	96	71	85	0	0
2014	112	113	98	96	0	0
2015	378	126	318	81	793	183
2016	219	209	162	0	138	0
2017	183	236	396	73	125	0
2018	162	282	80	223	94	42
2019	341	176	366	0	120	76
Total	**4086**	**2310**	**3772**	**861**	**3356**	**76**

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[8] Beginning in 2015, annual reports contained revised information when legacy CF Industries holdings became part of Mosaic (table updated with acres mined at South Pasture in Horse Creek and Brushy Creek basins, from 2004 to 2015). Total acres mined, reclaimed, and reconnected in each basin may be different in earlier reports.

Table 3-2 Specifications of Clay Settling Areas Located in the Horse Creek Basin

CSA	Service Year	Area	Crest	Pool	Discharge Point(s)
		Acres	NGVD, Feet		
FGH-3	1999	933	151	146	Fort Green Plant, Four Corners, or Payne Creek through FTG-002
FGH-4	2001	415	164	159	Fort Green Plant or Horse Creek through WIN-004
FM-1	2009	350	164	159	Wingate Creek Mine or Horse Creek through WIN-004
FM-2	2013	426	164	159	Wingate Creek Mine or Horse Creek through WIN-004

Mosaic currently maintains a YSI EXO3 Sonde at the Horse Creek and SR 64 (HCSW-1) bridge as a warning system in case of a failure at the mine upstream. This instrument collects temperature, specific conductivity, pH, dissolved oxygen, and turbidity measurements every 15 minutes continuously. As of February 13, 2019, notifications are sent out to both Mosaic and the TAG after twelve consecutive turbidity reading of >150 NTU, as described in Appendix B, change number 14. Previous configurations of the turbidity alarm system are also listed in Appendix B.

3.2 Reclamation

Reclamation of Mosaic's mined lands is an ongoing process in the Horse Creek Basin. The reclamation process consists of a combination of backfilling, moving overburden to the required final contours, phased re-planting of both upland and wetland communities, and periodic compliance monitoring of hydrology and replanting success. In general, reclamation typically takes three years to meet applicable criteria for herbaceous wetlands and 15 years to meet applicable criteria for forested wetlands. The number of acres reclaimed to the final contour and the acres reconnected to Horse Creek are summarized in Table 3-1 and Figure 3-1.

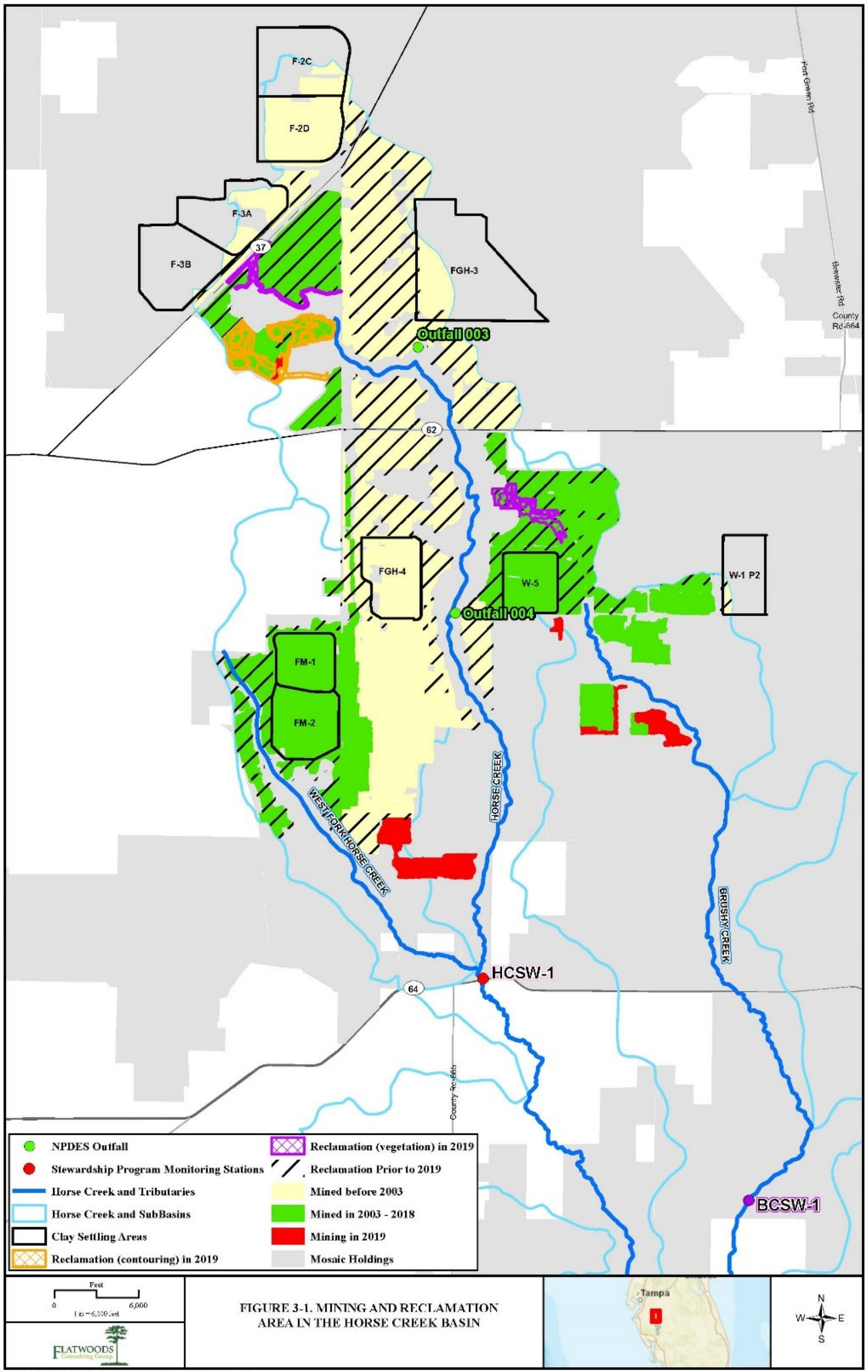

Figure 3-1 Mining and Reclamation Areas in the Horse Creek Basin

4.0 METHODS

4.1 Station Locations and Sampling Schedule

Four Horse Creek locations are monitored for physical, chemical, and biological parameters (Figures 1-1, 4-1):

- HCSW-1 - Horse Creek at State Road 64 (USGS Station 02297155)
- HCSW-2 - Horse Creek at County Road 663A (Goose Pond Road)
- HCSW-3 - Horse Creek at State Road 70 (also known as Horse Creek at Wuthrich Road)
- HCSW-4 - Horse Creek at State Road 72 (USGS Station 02297310)

As indicated above, HCSW-1 and HCSW-4 are also long-term USGS gauging stations, with essentially continuous stage and discharge records since 1977 and 1950, respectively. Monthly water quality sampling and semiannual biological sampling began in April 2003 (Table 4-1). Water quality and biological sampling events are subject to flow conditions in the creek, accessibility, and water and biological hazards.

In September 2009, based on recommendations of the PRMRWSA and the Technical Advisory Group (TAG), Mosaic began sampling water quality at an additional station on Brushy Creek (BCSW-1 at Post Plant Road). Brushy Creek is a tributary to Horse Creek and flows into Horse Creek between the HCSW-1 and HCSW-2 sampling stations. This additional station was added for comparison purposes and will not be evaluated against the HCSP trigger levels and exceedances because Mosaic does not have a NPDES discharge on Brushy Creek. The Brushy Creek location is also not included in the macroinvertebrate or fish sampling components of the program.

Figure 4-1 Representative Photos of Horse Creek Sampling Stations[9]

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[9] Photos Taken November 13, 2019

Table 4-1 Schedule of Water Quality and Biological Sampling Events of the HCSP in 2019

Month	Horse Creek Water Quality Sampling Events	Horse Creek Biology Sampling Events	Brushy Creek Water Quality Sampling Events
January	Sampled January 10		Sampled
February	Sampled February 13		Sampled
March	Sampled March 6		Sampled
April	Sampled April 11	Sampled April 9, HCSW-1, 3, & 4	No flow
May	Sampled May 13		No flow
June	Sampled June 13		No flow
July	Sampled July 9	Sampled July 3, HCSW-1, 3, & 4	Sampled
August	Sampled August 14		Sampled
September	Sampled September 9		Sampled
October	Sampled October 7		No flow
November	Sampled November 11	Sampled November 13, all sites	Sampled
December	Sampled December		No flow

4.2 Water Quantity

Approved discharge data were obtained from the USGS (http://waterdata.usgs.gov/fl/nwis/nwis) for HCSW-1 and HCSW-4. Staff gauges were installed, and stream cross sections were surveyed by Mosaic at HCSW-2 and HCSW-3; stage data were obtained at those stations during monthly water quality sampling. Discharge data were obtained for Mosaic's NPDES-permitted discharges into Horse Creek (FTG-003 and WIN-004 outfalls) for 2003 to 2019 (Figure 1-1).

Daily rainfall data were obtained from Mosaic's rain gauges in the Horse Creek Basin (Figure 1-1). The general relationship between rainfall and streamflow was graphically evaluated. All rainfall gauges with an extended period of record are located in the upper portion of the Horse Creek basin. The Pine Level 1 and Pine Level 2 rain gauges that are in the lower Horse Creek basin were installed in August 2011 and are included in the correlation analysis comparing streamflow to rainfall gauge. A separate report (Durbin and Raymond, 2006) addresses long-term rainfall patterns in the area.

4.3 Water Quality

A continuous monitoring unit is installed at HCSW-1 to record pH, specific conductivity, dissolved oxygen, and turbidity. Beginning in April 2003, data was recorded at least hourly, and daily mean, maximum, and minimum was downloaded at least monthly. This data provides for the characterization of natural background fluctuations and allows for the detection of instantaneous conditions or general water quality changes not observed during the collection of monthly grab samples.

Water quality samples were obtained monthly, when representative flow was present, by Mosaic at each of the four monitoring stations beginning in April 2003. The four Horse Creek and one Brushy Creek locations were sampled the same day, working from downstream to upstream. All activities affecting sample collection, sample handling, and field measurement activities were thoroughly documented. Field sample collection logs were completed at each station that include the following information: stream elevations, flow, stream dimensions, a qualitative description of the water appearance, weather conditions, water quality meter readings, sample preservation, and field notes. Individual sample containers were labeled with identification codes, date and time of sampling, sample preservation, and the desired analysis. Sample transmittal chain-of-custody records were filled out during sampling listing locations, times, and required analysis.

Field measurements were taken of temperature, pH, dissolved oxygen saturation[10], specific conductivity, and turbidity using meters that were operated and maintained according to manufacturer's instructions. Instruments were calibrated in the field prior to making measurements using the appropriate standards and acceptance limits (Table 4-2). All calibration activities were documented, and records checked for completeness and accuracy. Field measurements by Flatwoods in association with the three biological sampling events employed an YSI ProDSS multi-parameter data sonde with the same measuring methods and acceptance limits listed in Table 4-2. Flatwoods also employed a Hach 2100Q unit for turbidity measurement.

Table 4-2 HCSP Water Quality Sampling Field Methods and Acceptance Limits Associated with Monthly Sampling by Mosaic Staff

Analyte	Meter Used	Method	Minimum Detection Limit	Acceptance Limit
pH	Hach HOD	150.1	1 S.U.	+/- 0.2 standards units of the calibration standard
Temperature	Hach	170.1	N/A	1 degree Centigrade
Specific Conductivity	Hach	120.1	10 uS/cm	+/- 5% of the calibration standard
Dissolved Oxygen	Hach HOD	360.1	0.5 mg/L	+/- 0.2 mg/L of the correct Dissolved Oxygen - Temperature value
Turbidity	Hach 2100P	180.1	0.1 NTU	+/- 8% of the calibration standard

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[10] In May 2013, Mosaic began collecting dissolved oxygen saturation (DO Sat) data in addition to mg/L because of the changes to the dissolved oxygen standard. The continuous recorder at HCSW-1 began recording DO Sat in January 2011. For all prior dates, reported DO Sat was calculated using DO (mg/L), temperature, and salinity. HCSP no longer records DO concentration as of 2018. See Section 4.3.1 for an explanation of the change in DO standards.

Surface water samples were collected in a manner that represented the physical and chemical characteristics of Horse Creek without contamination or bias in the sampling process. Water samples for chemical analysis were collected from mid-channel and the top 1 foot of the water column but below the actual surface. Samples were usually obtained by wading into the stream and collecting samples upstream from the sampler. When flooded conditions precluded wading, samples were collected with a secondary container from the bridge at mid-channel. Samples were collected using unpreserved secondary sample containers, which were used to fill the pre-preserved sample containers. pH levels were checked and adjusted where applicable containers were stored on ice prior to transport to laboratories for analysis. The monthly surface water samples were analyzed using the methods listed in Table 4-3. Laboratory analyses were performed by experienced personnel according to National Environmental Laboratory Accreditation Conference (NELAC) protocols.

Results were tabulated to allow for comparisons among stations and sampling events, through time, and to the “trigger values” established for the HCSP (Table 4-4). In addition, results were compared with applicable Florida surface water quality standards (which in many cases are the same as the trigger values).

The state of Florida adopted a Numeric Nutrient Criteria (NNC) in October 2014. The HCSP nutrient trigger levels and the NNC requires the evaluation of nutrient concentrations over different time scales. Monthly samples are compared to the trigger level and identify acute changes in nutrient concentrations that warrant investigation, while the NNC threshold is based on annual geometric mean concentrations and evaluate longer term trends. The NNC thresholds are used in conjunction with biological metrics to determine compliance. A site must first pass the floral components (Rapid Periphyton Survey, Linear Vegetation Survey, and annual geometric mean for chlorophyll-a), then either be within the nutrient thresholds or Stream Condition Index (SCI) requirements in order to be in compliance according to 62-302.531(2)(c), F.A.C. Therefore, incorporating the NNC thresholds as standalone trigger levels for the HCSP would be inappropriate and would not accurately reflect the NNC.

Table 4-3 Water Quality Parameters and Laboratory Methods

Parameter	Method	Hold Time	Preservation	Minimum Detection Limit Range	Container
Color	110.2	48 hours	Unpreserved	2-5 PCU	Clear HDPE bottle
Total Kjeldahl Nitrogen	351.2	28 days	Sulfuric Acid, pH < 2	0.008-0.24 mg/L	Clear HDPE bottle
Nitrate-Nitrite Nitrogen	353.2	28 days	Sulfuric Acid, pH < 2	0.0001-1.0 mg/L	Clear HDPE bottle
Total Ammonia Nitrogen	350.1	28 days	Sulfuric Acid, pH < 2	0.0008-0.05 mg/L	Clear HDPE bottle
Orthophosphate	365.1	48 hours	Unpreserved	0.002-0.75 mg/L	Clear HDPE bottle
Chlorophyll-*a*	SM 10200H	48 hours	Unpreserved	0.1-2.0 µg/l	Opaque plastic bottle
Specific Conductivity	120.1	28 days	Unpreserved	10 µS	Clear HDPE bottle
Total Alkalinity	310.1	14 days	Unpreserved	0.24-3.0 mg/L CaCO3	Clear HDPE bottle
Dissolved Calcium*	200.7	28 days	Unpreserved	0.008-0.8 mg/L	Clear HDPE bottle
Dissolved Iron*	200.7	28 days	Unpreserved	0.003-0.1 mg/L	Clear HDPE bottle
Chloride	300	28 days	Unpreserved	0.005-30 mg/L	Clear HDPE bottle
Fluoride	300	28 days	Unpreserved	0.003-5.0 mg/L	Clear HDPE bottle
Total Radium (Radium 226+228)	903	6 months	Nitric Acid, pH < 2	1 pCi/l	Clear HDPE bottle
Sulfate	300	28 days	Unpreserved	0.0007-100 mg/L	Clear HDPE bottle
Total Dissolved Solids	160.1	7 days	Unpreserved	5-25 mg/L	Clear HDPE bottle

- All water samples were preserved at 4°C while awaiting analysis.
- Orthophosphate samples were initially filtered in the laboratory rather than the field. While Mosaic is cognizant of the Florida Department of Environmental Protection (FDEP) Standard Operating Procedure (SOP) for field sampling, the decision was made to have samples lab filtered (less risk of contamination and the guarantee of lab filtering within hours of lab delivery). Starting in January 2005, samples were field-filtered with a 0.45-micron filter.
- The analytical method for iron and calcium was changed during the 2003–2005 monitoring period.
- Total radium is the arithmetic sum of Radium 226 and Radium 228. Total nitrogen is reported as the arithmetic sum of nitrate-nitrite nitrogen and total Kjeldahl nitrogen. As requested by the PRMRWSA, if either of each pair is undetected, the Minimum Detection Level (MDL) of the undetected constituent will be used as part of the total. This use of MDL for undetected constituents is contrary to both laboratory and FDEP SOPs.
- Petroleum Range Organics, Fatty Amido-amines, and Total Fatty Acid analysis were discontinued in September 2009.

Table 4-4 Parameters, General Monitoring Protocols, and Corrective Action Trigger Values

Pollutant Category	Analytical Parameters	Analytical Method	Reporting Units	Monitoring Frequency	Trigger Level	Basis for Initiating Corrective Action Process
General Physio-chemical Indicators	pH	Calibrated Meter	Std. Units	Monthly	<6.0->8.5	Exceedance of or statistically significant trend line predicting concentrations in excess of trigger level.
	Dissolved Oxygen Saturation(9)	Calibrated Meter	%	Monthly	<38% daily average	
	Turbidity	Calibrated Meter	NTU(1)	Monthly	>29	
	Color	EPA 110-2	PCU	Monthly	<25	
Nutrients	Total Nitrogen	EPA 351 + 353	mg/L(2)	Monthly	>3.0	
	Total Ammonia	EPA 350.1	mg/L	Monthly	>0.3	
	Ortho Phosphate	EPA 365	mg/L	Monthly	>2.5	
	Chlorophyll-*a*	EPA 445	mg/m^3 (µg/L)	Monthly	>15	
Dissolved Minerals	Specific Conductance	Calibrated Meter	µs/cm(3)	Monthly	>1,275	
	Total Alkalinity	EPA 310.1	mg/L	Monthly	>100	
	Calcium	EPA 200.7	mg/L	Monthly	>100	
	Iron	EPA 200.7	mg/L	Monthly	>0.3 (6); >1.0(7)	
	Chloride	EPA 325	mg/L	Monthly	>250	
	Fluoride	EPA 300	mg/L	Monthly	>1.5(6); >4(7)	
	Radium 226+228	EPA 903	pCi/L(4)	Monthly	>5	
	Sulfate	EPA 375	mg/L	Monthly	>250	
	Total Dissolved Solids	EPA 160	mg/L	Monthly	>500	
Biological Indices: Macro-invertebrates	Total Taxa	Stream Condition Index (SCI) sampling protocol, taxonomic analysis, calculation of indices according to SOP-002/01 LT 7200 SCI Determination	Units vary based upon metric or index	Semi-annual	HCSP- NA FDEP- more than 1 sample < 34 in a year	Statistically significant declining trend with respect to SCI values, as well as presence, abundance, or distribution of native species
	Ephemeropteran Taxa					
	Tricopteran Taxa					
	Percent Collector-Filterer Taxa					
	Long-lived Taxa					
	Clinger Taxa					
	Percent Dominant Taxon					
	Percent Tanytarsini					
	Sensitive Taxa					
	Percent Very Tolerant Taxa					
	Shannon-Wiener Diversity(a)					

Pollutant Category	Analytical Parameters	Analytical Method	Reporting Units	Monitoring Frequency	Trigger Level	Basis for Initiating Corrective Action Process
Biological Indices: Fish	Taxa Richness		Units vary based upon metric or index	Semi-annual	N/A	Statistically significant declining trend with respect to presence, abundance, or distribution of native species
	Abundance					
	Shannon-Wiener Diversity[(a)]					
	Morisita Similarity Index[(a)]					
	Species Accumulation Curves[(b)]					

Notes:

(1) Nephelometric turbidity units.
(2) Milligrams per liter.
(3) Microsiemens per centimeter.
(4) PicoCuries per liter.
(5) If reagents are not detected after two years, sampling frequency will be reduced to quarterly - if subsequent data indicate the presence of reagents, monthly sampling will be resumed. Parameter sampling removed from program in September 2009 as agreed by TAG.
(6) At Station HCSW-4 only, recognizing that existing levels during low-flow conditions exceed the trigger level.
(7) At Stations HCSW-1, HCSW-2, and HCSW-3.
(8) Some metrics have been revised from original HCSP plan document due to revision of FDEP SCI Protocol.
(9) Revised from Dissolved Oxygen trigger of <5.0 mg/L based on changes to FDEP water quality standards,

References:

(a) Brower, J. E., Zar, J. H., von Ende, C. N. Field and Laboratory Methods for General Ecology. 3rd Edition. Wm. C. Brown Co., Dubuque, IA. pp. 237; 1990
(b) Gotelli, N.J., and G.R. Graves. 1996. Null Models in Ecology. Smithsonian Institution Press, Washington, DC.

4.4 Benthic Macroinvertebrates

Benthic macroinvertebrate sampling was conducted at stations HCSW-1, HCSW-3, and HCSW-4 during the April, July, and November 2019 sampling events. HCSW-2 was only sampled in November of 2019. The water velocity at HCSW-2 during the April and July sampling events was below the minimum acceptable velocity of 0.05 $m \cdot sec^{-1}$ (DEP-SOP-003/11, SCI 1100.2.2.1). The Brushy Creek location is not included in the macroinvertebrate sampling component of the HCSP.

At each Horse Creek station, a Stream Habitat Assessment (DEP Form FD 9000-4 & 9000-5), Physical/Chemical Characterization (DEP Form FD 9000-3), Rapid Periphyton Survey (DEP Form FD 9000-25), and Linear Stream Vegetation Survey (DEP Form FD 9000-32) were performed. The habitat assessment is comprised of a variety of physical criteria that are independently evaluated on a numerical scale, and the component values are summed to provide a quantitative rating for a stream segment that is presumed to be proportional to the quality of the stream for native macroinvertebrates. The Physical/Chemical form records a variety of other information and also provides for the delineation of various microhabitats in the stream into categories to allow for sampling of such microhabitats in general proportion to their abundance.

Macroinvertebrate sampling was performed in Horse Creek according to the SCI protocol developed by the Florida Department of Environmental Protection (FDEP) (DEP-SOP-003/11, SCI 1000) by personnel with training and experience in the SCI protocol and who have successfully passed FDEP audits for the protocol. The SCI is a standardized macroinvertebrate sampling methodology that accounts for the various microhabitats available (e.g. leaf packs, snags, aquatic vegetation, roots/undercut banks) within a 100-meter segment of stream. Utilizing this methodology, 20 half-meter D-frame dip net sweeps are performed within a 100-meter segment of the stream.

The number and quality of benthic macroinvertebrate microhabitats present during the sampling event determines the number of sweeps performed within each microhabitat type. Consistent with FDEP protocols, each benthic macroinvertebrate sample was processed and taxonomically analyzed. Data from each invertebrate sample were used to calculate the various SCI metrics and resulting overall SCI values as per the methodology for the Florida Peninsula (Table 4-5).

The SCI methodology has been updated several times and the HCSP has kept up with these changes. The SCI scores reported in Section 5.3 of the 2019 Annual Report from 2003-2006 were calculated using the 2004 method. SCI scores from 2007 to present were calculated using the 2012 method. Scores from the 2004 SCI (2003 to 2006[11]) and the 2007 or 2012 SCI (2007 onward) may not be directly comparable, given the differences in how they were collected.

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[11] The November 2006 sample was collected under the SCI 2007 protocol and rescored under the SCI 2012 calculations. However, statistical analyses do not include that sample because the other two 2006 samples were collected under the old protocol and are not comparable.

SCI macroinvertebrate samples[12] were also used to calculate the Shannon-Wiener Diversity Index, over various time spans and locations. H’ = $\frac{N log_2 N - \sum(n_i log_2 n_i)}{N}$, where N = total number of species in a sample and n_i = number of an individual species.

Table 4-5 Equations for Calculating Peninsular Florida SCI Metrics

SCI Metric	2004/2007* Peninsula Score	2012 Peninsula Score
Total Taxa	10*(X-16)/25	10*(X-15)/24
Ephemeropteran Taxa	10*X/5	10*X/5
Trichopteran Taxa	10*X/7	10*X/7
Percent Collector-Filterer Taxa	10*(X-1)/39	10*(X-0.7)/43
Long-lived Taxa	10*X/4	10*X/3
Clinger Taxa	10*X/8	10*X/7
Percent Dominant Taxa	10-(10*[(X-10)/44])	10-(10*[(X-14)/50])
Percent Tanytarsini	10*[ln(X+1)/3.3]	10*[ln(X+1)/3.4]
Sensitive Taxa	10*X/9	10*X/7
Percent Very Tolerant Taxa	10-(10*[ln(X+1)/4.1])	10-(10*[(ln(X+1)-0.7)/4.0])

Note: In each equation, “X” equals the number representing the count or percentage listed in the corresponding row of the left column. For calculated values greater than ten, the score is set to ten; for values calculated less than zero, the score is set to zero.

** 2004 and 2007 used the same metric calculations; only the number of individual invertebrates (100-120 for 2004 and 140-160 for 2007) and vial replicates (no replicate before 2007) differ.*

4.5 Fish

Fish sampling was conducted at all stations during the November 2019 sampling events and at all stations but HCSW-2 during the April 2019 and July 2019 sampling events. The Brushy Creek location is not included in the fish sampling component of the HCSP.

Fish were collected with a 4-foot by 8-foot seine (3 mm mesh size) and by electrofishing with a Smith-Root, Inc. backpack unit (Model Apex Electrofisher). Electrofishing was timed (500 seconds), and the number of seine hauls (five) was recorded to standardize the sampling efforts among stations and between events.

Larger fish (generally those larger than about 10 cm) were identified, weighed, measured, and released in the field, while smaller fish (<10 cm) were preserved in the field for analysis in the laboratory. All fish collected were identified in the field or laboratory according to American Fisheries Society-accepted taxonomic nomenclature (American Fisheries Society 2013). Total length (mm) and weight (g) were recorded for each individual, with the following exception: for samples with very large numbers of fish of the same species (a common occurrence with species like eastern mosquitofish [*Gambusia holbrooki*], least killifish [*Heterandria formosa*], and sailfin

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[12] Previous HCSP annual reports used all identified macroinvertebrates in Shannon-Wiener analysis. Beginning in 2019, the analysis removed all terrestrial and semiaquatic macroinvertebrates from the analysis but maintains their occurrence in the database.

molly [*Poecilia latipinna*]), a randomly selected subset of individuals (approximately 10) were measured for length and weight, while the remaining individuals were counted and then weighed en masse.

Taxa richness and abundance were determined by station and for each sampling event, and data were compared among stations and across sampling events. Species accumulation curves were plotted to estimate the efficacy of the sampling at producing a complete list of the species present in the sampled portions of the stream. The Shannon-Wiener Diversity Index and Morisita's Community Similarity Index were calculated using the Ecological Methodology Software Version 7.0 (www.exetersoftware.com).

5.0 WATER QUANTITY RESULTS AND DISCUSSION

5.1 Rainfall

Mosaic Rain Gauges

Figure 5-1 includes 2019 total monthly rainfall data from the three Mosaic rain gauges located in the Horse Creek watershed (see Figure 1-1 for locations) as well as the nearby SWFWMD Flatford Swamp gauge. Total and median monthly rainfall in 2019 was different at each gauge, but the heaviest rainfall was observed between July and August at all locations (Figure 5-1). 2019 was ranked as the 16th wettest year (35.3 inches, POR average 44.6 inches) since 2003 when calculated using the average of the Mosaic gauges, and 10th wettest (47 inches, POR 47.8 inches) according to the Flatford gauge (Table 5-1, Figure 5-2).

NOAA Rain Gauges

A ranking of annual rainfall of the nearest NOAA (National Oceanic and Atmospheric Administration) gauges places 2019 as the 77th wettest year since records began 122 years ago in 1908 and 14th wettest year since 2003. The historic annual rainfall average for the closest long-term NOAA stations[13] between 1908 and 2018 is 53.9 inches; the annual average for 2019 was 49.3 inches.

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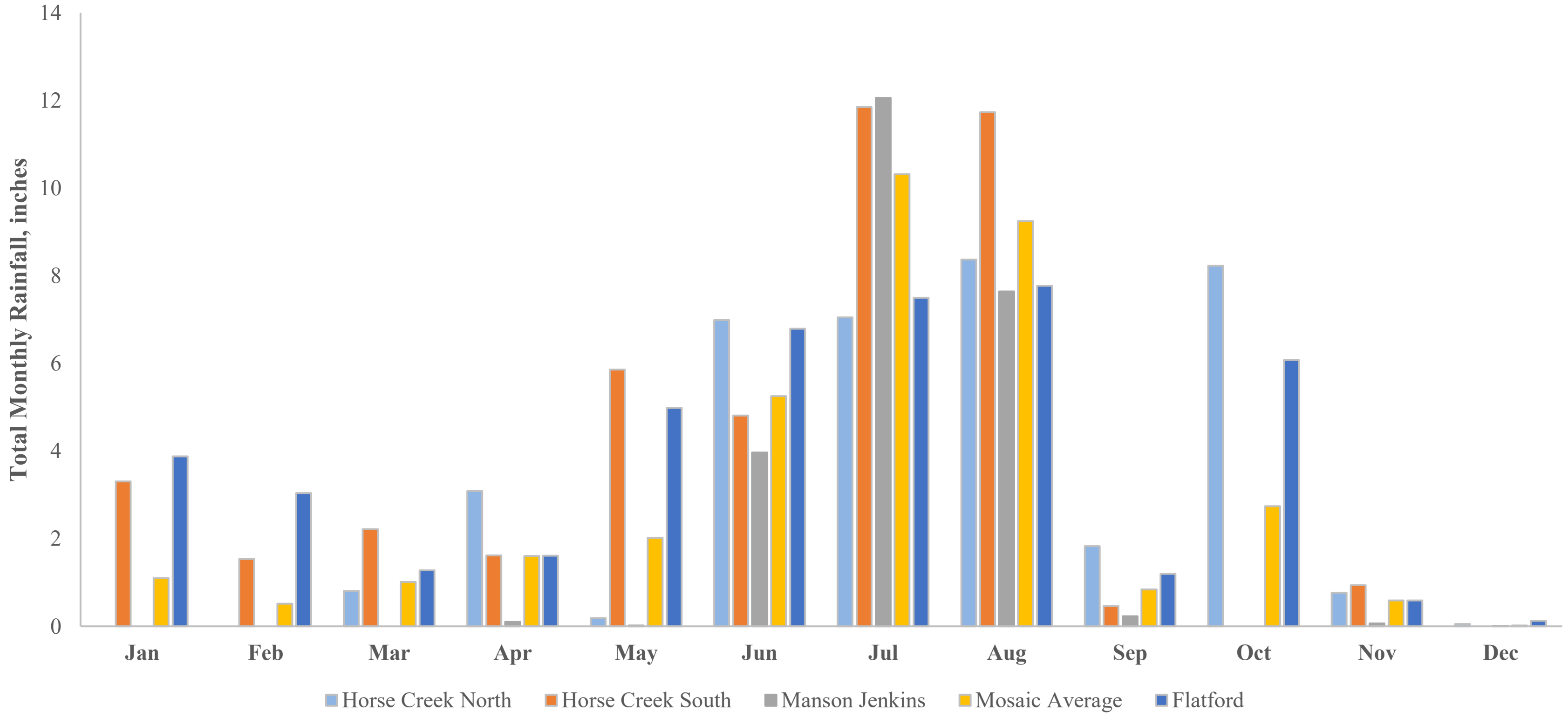
[13] Historical rainfall information came from the following stations and years: 1908 to 1943 NOAA station 148, 1944 to 2019 average of NOAA station 148 and 336.

Table 5-1 Annual Total Rainfall in Inches at Gauges in the Horse Creek Watershed

Gauge	Horse Creek North	Horse Creek South	Manson Jenkins	Average of Mosaic Gauges	SWFWMD Flatford	Pine Level 1	Pine Level 2
2003	53.4	59.75	30.10*	57.10	49.85*	NA	NA
2004	53.82	60.74	62.15	58.90	59.85	NA	NA
2005	54.52*	64.53	31.34*	66.04	42.40	NA	NA
2006	31.82*	34.17	41.26	37.35	31.11	NA	NA
2007	33.9	31.97	32.49	32.79	38.45	NA	NA
2008	40.49	36.8	37.48	38.26	44.94	NA	NA
2009	36.63	43.7	46.87	42.40	44.23	NA	NA
2010	32.53	37.47	41.84	37.28	41.11	NA	NA
2011	24.54*	31.73*	39.85	37.11	40.25	12.94*	16.01*
2012	19.99*	36.06*	37.96*	44.49	51.99	35.56*	41.13
2013	38.54*	54.69	34.33*	48.63	47.39	46.13*	49.14
2014	47.93	39.22*	40.37*	49.06	52.69	49.75*	47.51
2015	37.20*	35.64*	45.38*	44.13	59.89	26.25*	51.44
2016	46.76*	50.72	48.09	51.43	53.99	*	46.66
2017	47.12*	49.16	43.87	47.03	38.06*	56.49*	60.95*
2018	38.91	63.25*	49.06	51.29	69.6	*	37.96*
2019	37.38	44.34	24.1	35.27	44.86*	33.41	43.14

* - Gauge was non-functional during portion of year.



SWFWMD Flatford gauge was down between December 3- 31. All Mosaic Gauges were operational for the entire year.

Figure 5-1 Total Monthly Rainfall in The Horse Creek Watershed in 2019

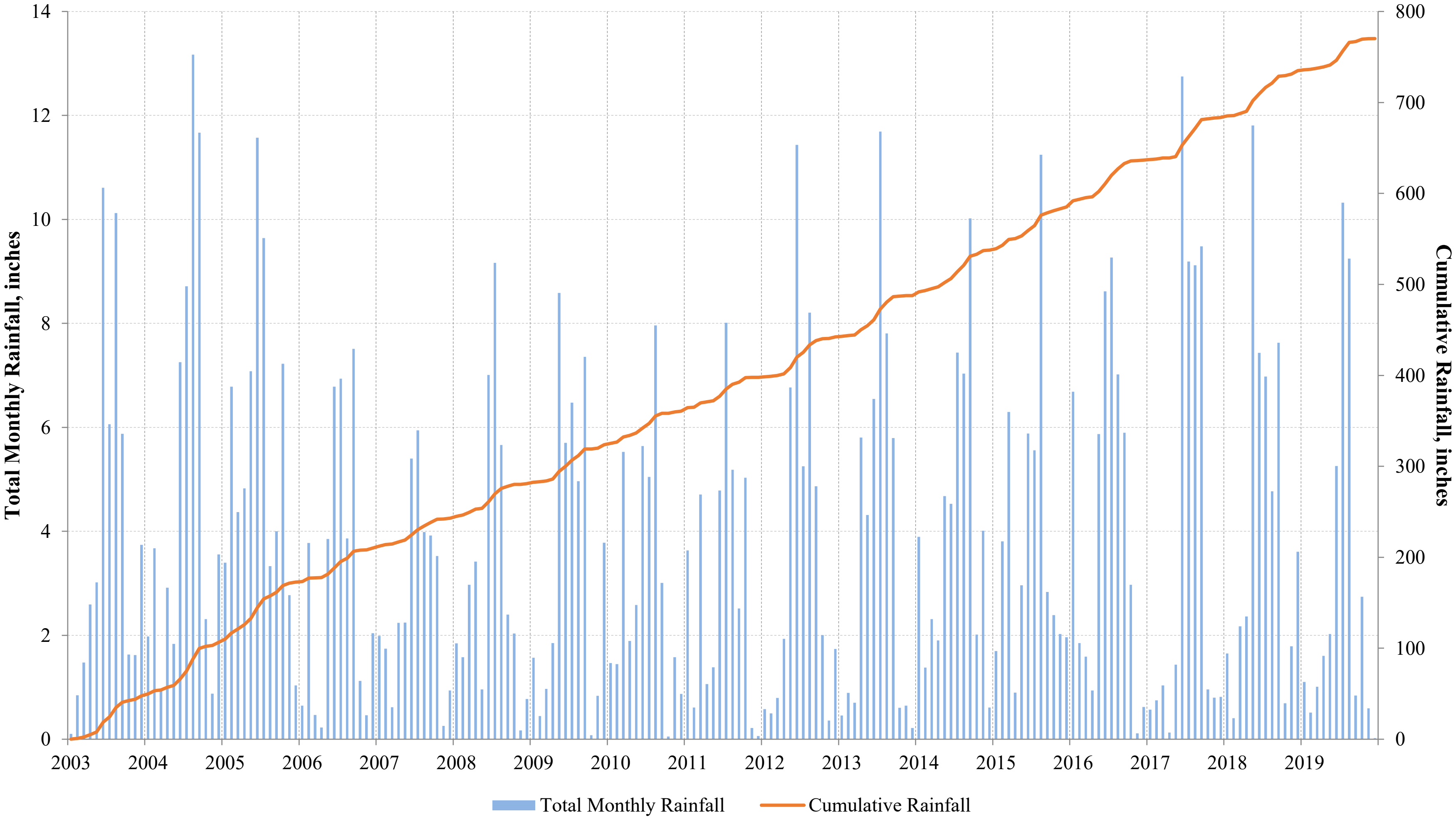


Figure 5-2 Total Monthly Rainfall from the Average of Three Mosaic Gauges[14]

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[14] When all three Mosaic gauges were out of service, the average of two Pine Level rain gauges was used; otherwise, the average of the operational Mosaic rain gauges was reported.

5.2 Stream Stage

Figure 5-3 illustrates the relationship between the staff gauge readings made during each Mosaic monthly water-quality sampling event. It also provides the average daily stage as recorded at the USGS gauging stations at HCSW-1 and HCSW-4. Patterns of daily stage levels were clearly temporally correlated among the four stations (Figure 5-3). Stage height (feet NAVD) collected monthly by Mosaic at four sites and continuously by the USGS at two sites was examined using Spearman's rank correlations (Zar 1999) because the gauge heights were not distributed normally (Shapiro-Wilk test for normality, $p < 0.001$) at all gauges except HCSW-2. Gauge heights showed a strong and significant correlation between all Mosaic stations and USGS stations (Table 5-2). Such close correspondence is expected for a fairly small watershed in a low gradient setting like peninsular Florida.

Mean daily stage levels in 2019 were fairly low during the dry season, with little change in stage height through May 2019. Water elevations increased in late-July through September at both HCSW-1 and HCSW-4 (Figure 5-3). Stage duration curves for 2019 were developed for HCSW-1 and HCSW-4 (Figure 5-4) to indicate the percentage of time stream stage was above particular elevations. Stage at HCSW-1 varied by 4.1 feet between the curve's P10 (70.3 feet NAVD) and P90 (66.2 feet NAVD) in 2019, indicating that the stream stayed within its banks most of the time (P10 and P90 are commonly used to bracket the 'typical' fluctuation of a water body, thus omitting the highest and lowest 10 percent of the flows). Stream stage at HCSW-4 was more variable than at HCSW-1 between the P10 (21.1 feet NAVD) and P90 (11.4 feet NAVD) (9.7-foot difference).

Table 5-2 Spearman's Rank Correlations (R_s) of Monthly Gauge Height (NAVD), 2003-2019 ($P < 0.0001$)

	HCSW-4 (USGS)	HCSW-1 (Mosaic)	HCSW-2 (Mosaic)	HCSW-3 (Mosaic)	HCSW-4 (Mosaic)
HCSW-1 (USGS)	0.90	0.99	0.82	0.81	0.90
HCSW-4 (USGS)	1	0.90	0.84	0.86	0.99
HCSW-1 (Mosaic)		1	0.81	0.77	0.88
HCSW-2 (Mosaic)			1	0.88	0.84
HCSW-3 (Mosaic)				1	0.86

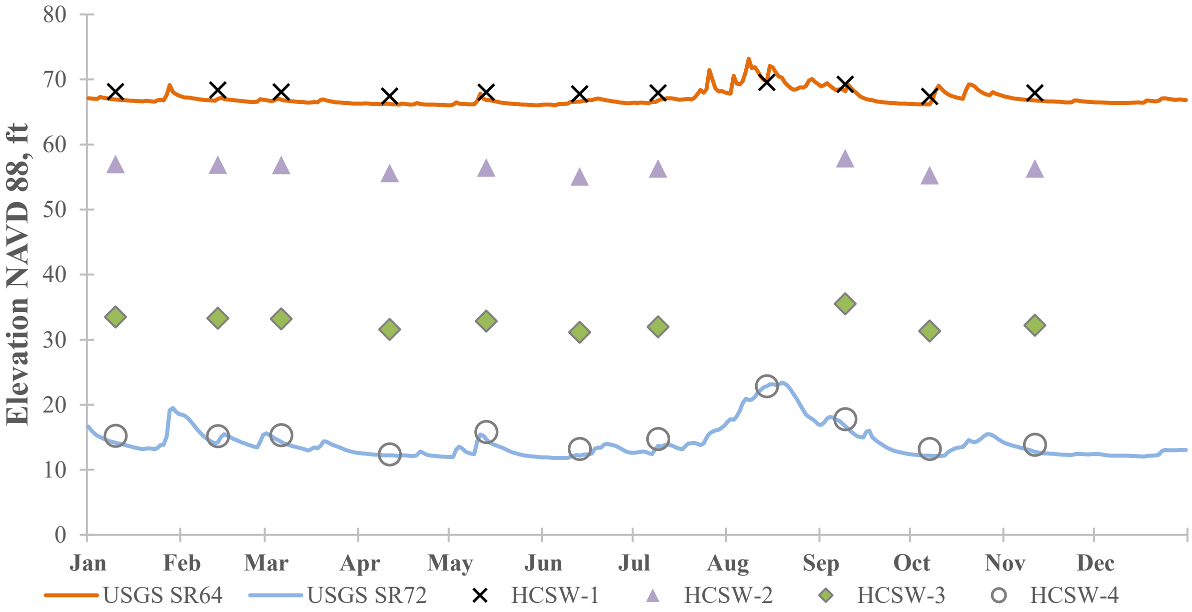

Figure 5-3 Stream Stage at HCSP Monitoring Stations in 2019[15]

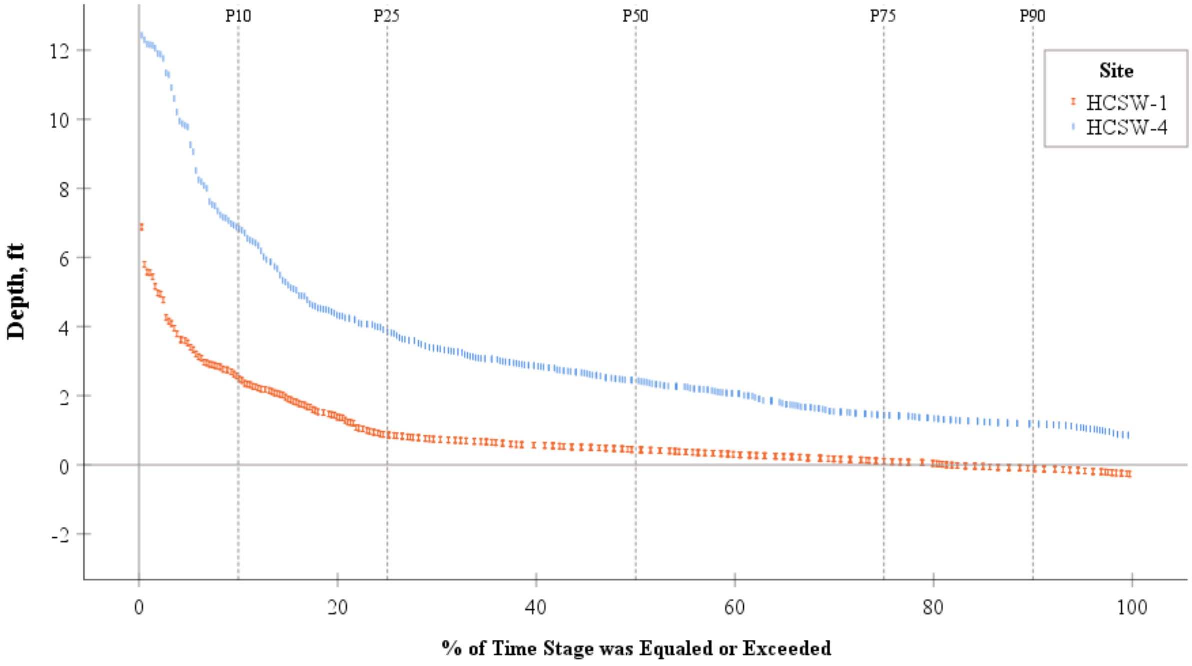

Figure 5-4 Stage Duration Curves for HCSW-1 and HCSW-4 in 2019 Showing Percent of Year Water Levels were at or above a Given Stage[16]

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[15] Individual data points are from Mosaic's monthly monitoring and continuous lines are average daily stage from USGS (Stations 02297155 and 02297310)
[16] Stage relativized by respective minimum gauge heights: HCSW-1 (66.3 ft.) and HCSW-4 (10.96 ft. NAVD, 88).

5.3 Streamflow

The average daily streamflow for 2019, obtained from the USGS continuous recorder data for HCSW-1 and HCSW-4, is presented in Figure 5-5. In 2019, flows were generally low for most of the year, with elevated flows occurring in February, August, September, and late October through early November. Average daily stream flows exhibited a similar pattern at both HCSW-1 and HCSW-4, with higher flows at HCSW-4 ending later than HCSW-1 for the summer wet season (Figure 5-5).

At HCSW-1, annual average streamflow in 2019 was ranked 20th since records began 42 years ago in 1978 and 11th since the HCSP began in 2003[17]. At HCSW-4, annual average streamflow in 2019 was ranked 43rd since records began in 1951, 25th since 1978, and 10th since the HCSP began in 2003 (Figure 5-6)[18].

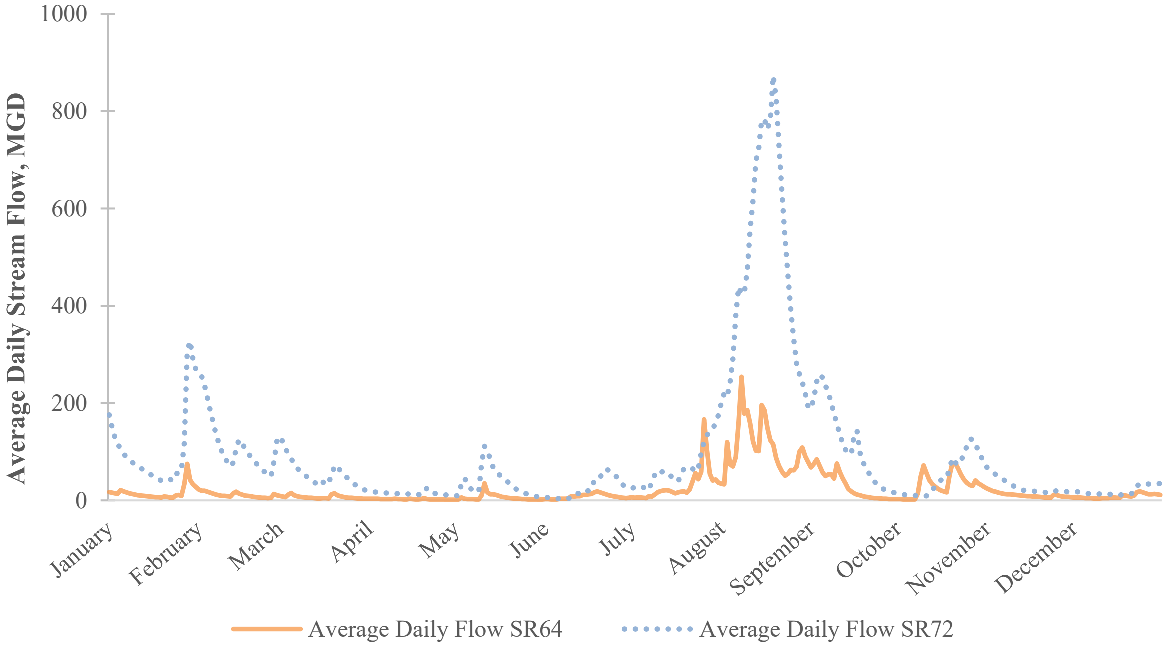

Figure 5-5 Average Daily Streamflow at HCSW-1 and HCSW-4 in 2019

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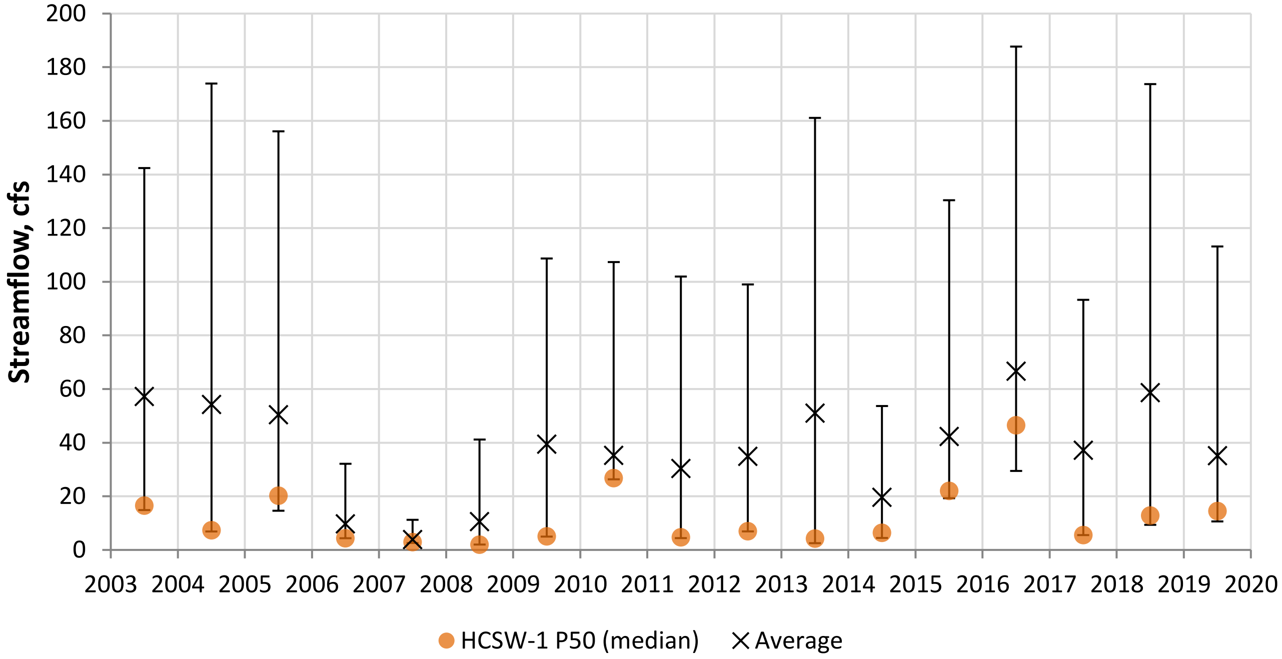
[17] 2019 annual average streamflow at HCSW-1 was 35.2 cfs, POR annual average 31.6 cfs, and HCSP period annual average 35.6 cfs

[18] 2019 annual average streamflow at HCSW-4 was 144.9 cfs, POR annual average 185.4 cfs, and HCSP period annual average 173.3 cfs.



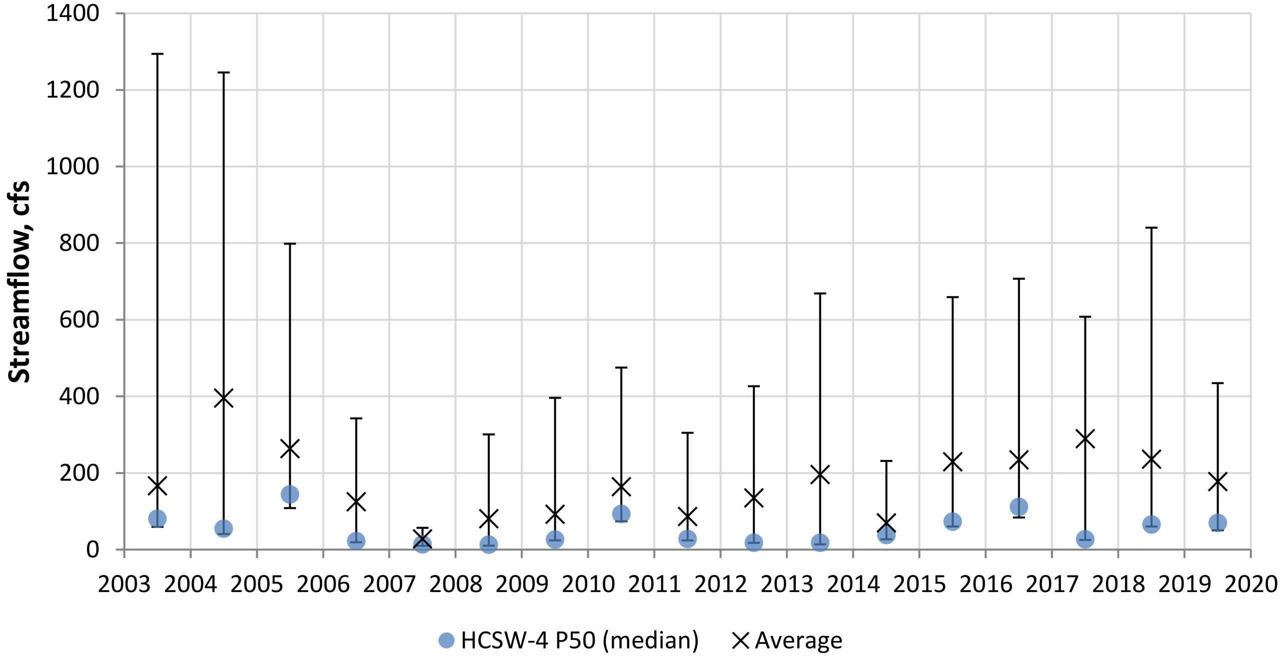


Figure 5-6 Median, 10th Percentile (Lower Bar), 90th Percentile (Upper Bar), and Average Streamflow at HCSW-1 and HCSW-4

5.4 Rainfall-Runoff Relationship

Stream discharge at HCSW-1 and the average daily rainfall for 2019 (average of daily rainfall at three Mosaic rain gauges upstream of Highway 64) are compared in Figure 5-7. To examine the strength of correlation between daily stream discharge and rainfall, Spearman's rank correlation procedure was used (Zar 1999). Average monthly streamflow at HCSW-1 was compared to total monthly rainfall at the SWFWMD Flatford Swamp gauge, the three Mosaic rain gauges, and the average total monthly rainfall of the Mosaic gauges for the years 2003 to 2019 (Table 5-3).

The correlation between stream discharge at HCSW-1 and rainfall was statistically significant for each rainfall gauge (Table 5-4). Although these results suggest that stream discharge and rainfall in Horse Creek covary more than would be expected by chance alone, not all of the variation in streamflow can be explained by rainfall ($0.50 \leq r \leq 0.58$). The lag between rainfall and runoff, as well as other antecedent condition factors, has strongly affected this relationship in the full dataset; however, there was very little lag between 2019 rainfall events and streamflow response in late-July to early October (Figure 5-7). At the beginning of the wet season (May 14th in 2019), the lag effect between rainfall and streamflow was more apparent as the surrounding wetlands or small creeks had yet to fill or resume flow. However, later in the wet season when the wetlands and small creeks were full, the lag was much shorter, as can be seen in Figure 5-7.

Figure 5-9 illustrates the relationship between cumulative annual discharge at HCSW-1 and annual NOAA rainfall from 1978 to 2019[19]. Changes in the relationship between rainfall and stream discharge can be seen as inflection points in the overall trend line slope. Over the HCSW-1 period of record, there were three potential inflection points. In 2000 (purple solid line on Figure 5-9, slope = 0.29), cumulative discharge began to increase slightly relative to rainfall for a few years when rainfall was above average relative to the slope of the overall period of record, meaning there was more stream discharge per unit of rainfall. Between 2005 and 2008 (green dashed line on Figure 5-9, slope 0.06), which included several very dry years, cumulative discharge had almost no increase, despite changes in cumulative rainfall. Thus, as expected during a very dry period, the relationship changed, and less water entered the stream per unit rainfall than happened during wetter periods. After 2008 (blue dotted line on Figure 5-9, slope 0.25), the slope was again similar to the wet period of 2000 to 2005, and greater than the overall period of record slope (0.21), because rainfall began to return to average conditions and cumulative discharge began to resume previous patterns relative to cumulative rainfall.

Figure 5-9 also illustrates a pre-outfall (pink dotted line, slope 0.2) and post outfall (red dashed line, slope 0.23) trendline, with both slopes on either side of the POR trendline slope of 0.21. This indicates that little has changed in regard to the rainfall draining uninterrupted to the Horse Creek.

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[19] To look at the relationship between stream discharge and rainfall over the stream gauge period of record, HCSW-1 discharge was converted from cubic feet per second (cfs) to cumulative discharge in billions of gallons/ days. Cumulative historical rainfall was calculated from NOAA gauges 148 and 336, which have a longer period of record than the SWFWMD or Mosaic gauges. Potential inflection points are limited to changes in slope that lasted at least three (3) years.

If mining was having a significant effect on the amount of water that reached Horse Creek at HCSW-1 compared to rainfall, then one would expect to see one or more large inflection points that correspond to the beginning of mining in the basin or the mining of large tracts lasting for many years. However, for the majority of the period of record (which included pre-mining data), the relationship is remarkably constant over time, with only a few minor inflection points that correspond to unusually wet and dry periods in the 2000s. These findings suggest that mining activities have not changed the overall relationship between annual rainfall and annual stream discharge at HCSW-1, based on the data available.

Table 5-3 Spearman's Rank Correlations (R_s) of Monthly Average Streamflow and Total Monthly Rainfall, 2003- 2019

Rain Gauge	r_s HCSW-1 Streamflow	p-value	N	r_s HCSW-4 Streamflow	p- value	N
Horse Creek North	0.51	<0.0001	184*	0.47	<0.0001	175*
Horse Creek South	0.54	<0.0001	196*	0.52	<0.0001	187*
Manson Jenkins	0.50	<0.0001	189*	0.52	<0.0001	180*
Average Mosaic Rainfall**	0.58	<0.0001	201*	0.56	<0.0001	192*
SWFWMD Flatford Swamp	0.53	<0.0001	204*	0.51	<0.0001	195*
Pine Level 1†	0.60	<0.0001	68*	0.61	<0.0001	68*
Pine Level 2†	0.63	<0.0001	97*	0.64	<0.0001	97*

*Months missing >10 days were removed from analysis.
** Average of Horse Creek North, Horse Creek South, and Manson Jenkins rain gauges.
†Pine level gauges came online on August 2011

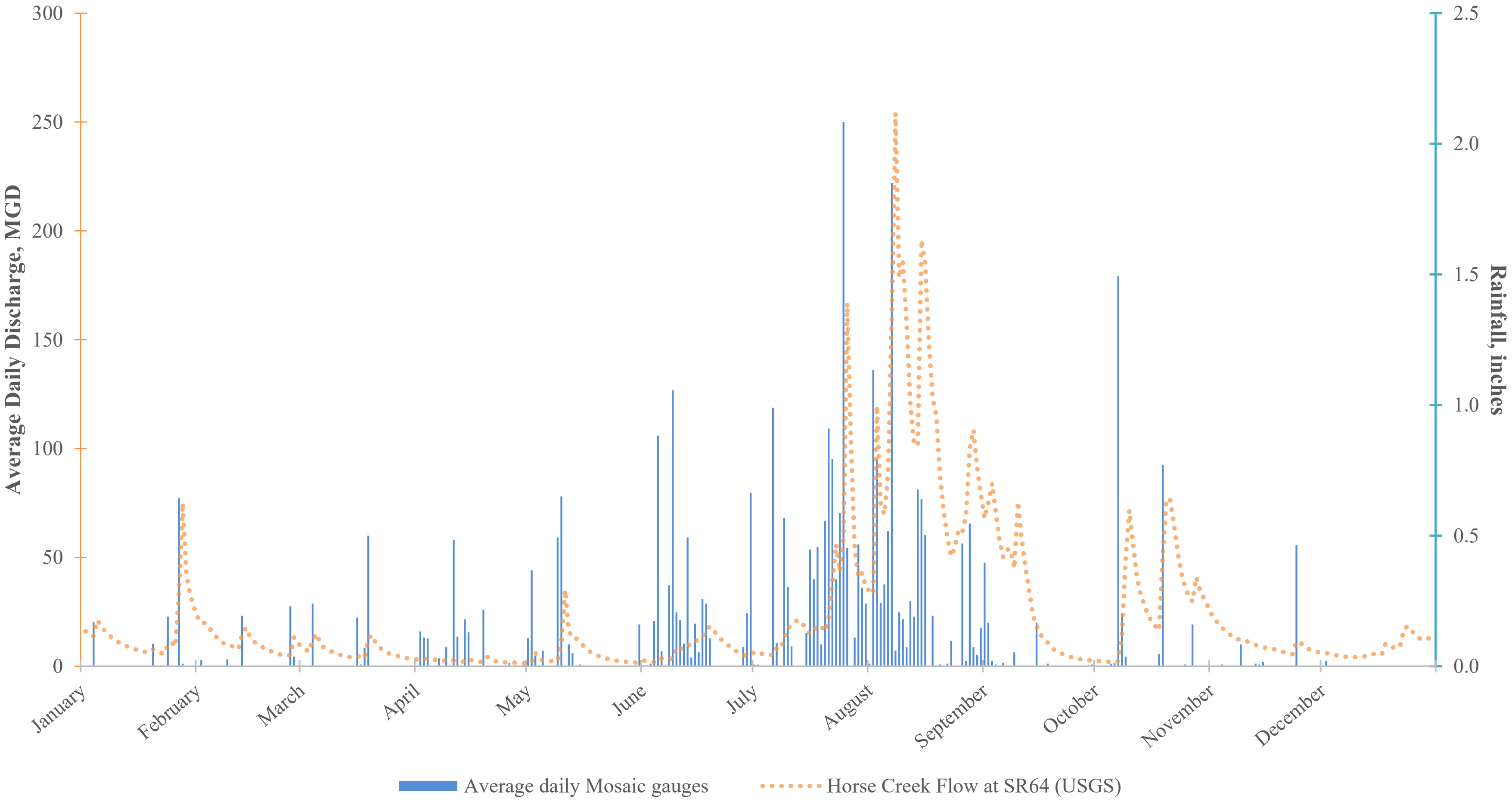

Figure 5-7 Average Daily Streamflow at HCSW-1 and Average Daily Rainfall[20], 2019

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[20] Average daily rainfall calculated from average of Horse Creek North, Horse Creek South, and Manson Jenkins gauges

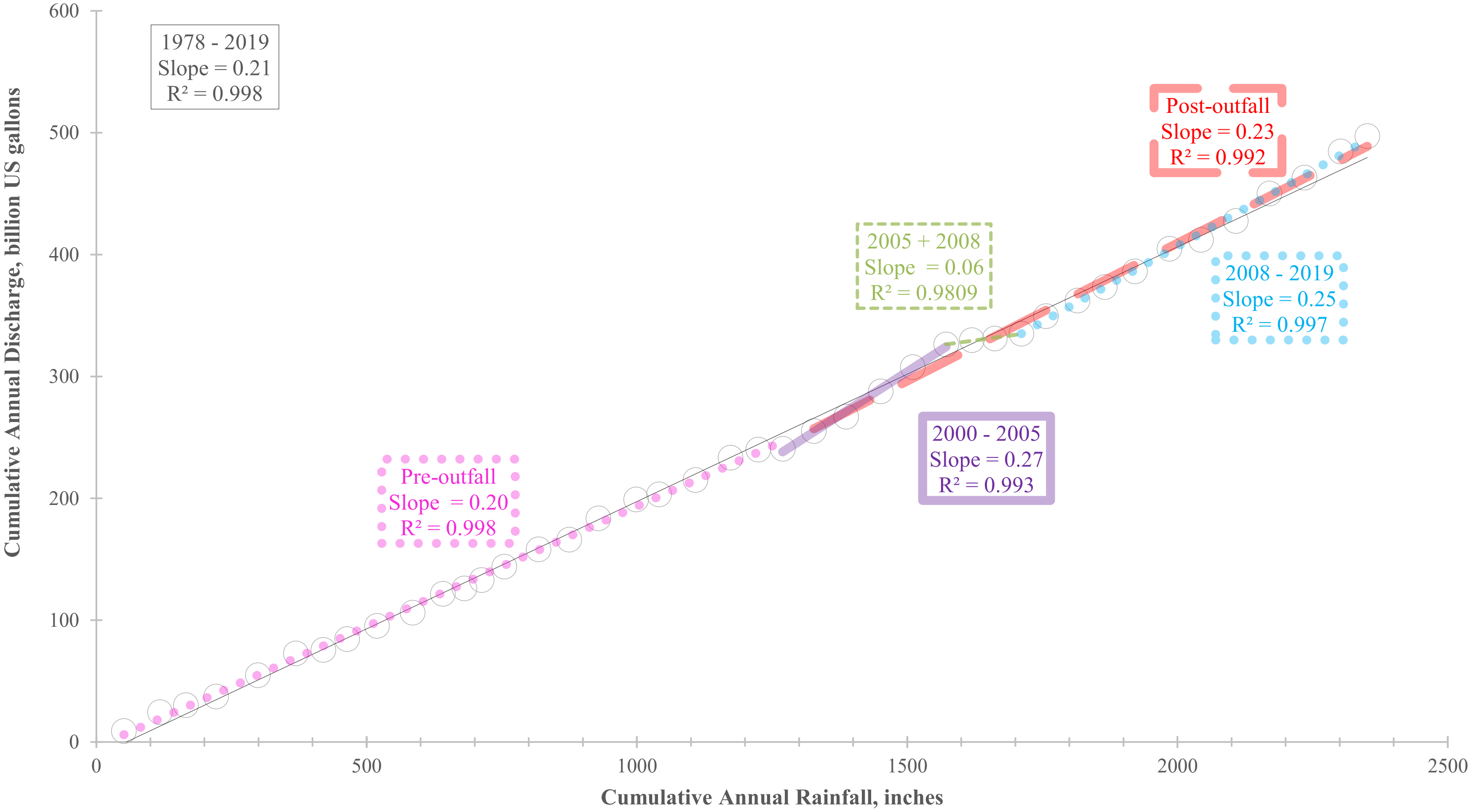

Figure 5-8 Double Mass Curve of Cumulative Daily Discharge[21] and Rainfall [22]

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[21] Horse Creek at SR64 USGS flow

[22] Average of NOAA Rain Gauges 148 And 36

5.5 NPDES Discharges

Industrial wastewater is discharged to Horse Creek through two outfalls (FTG-003 on the Fort Green NPDES Permit FL0027600 and WIN-004 on the Wingate NPDES Permit FL0032522, see Figure 1-1). Both outfalls are 20-foot wide concrete flumes with continuous flow measurement. A mine wastewater system consists of clay settling areas, mined but not yet reclaimed land, and unmined but disturbed lands. The runoff from all these lands is contained within the industrial wastewater system boundaries. The "loop" of wastewater from the phosphate beneficiation plant to the clay settling areas with the subsequent return of clarified water to the plant for reuse is the backbone of the system. The system has a finite storage capacity and excess wastewater (as a result of rainfall into the system) is discharged from permitted outfalls.

In 2019, there was no NPDES discharge from outfall FTG-003 and there has not been one since July 26, 2009. Win-004 discharged 649 million gallons between August 23 and September 15, 2019 (Table 5-5, Figure 5-10 & 5-11) or the fifteenth largest discharge since discharges began in 2001. During that same period, Horse Creek at HCSW-1 discharged 1.5 billion gallons. Prior to the August 23, 2019 NPDES discharge, the last WIN-004 discharge ended on October 6, 2018. Mosaic has no other discharges to Horse Creek (including from the legacy CF Industries property), and no other known industrial wastewater discharges to Horse Creek or any of its tributaries by any other firm are known.

A spearman rank correlation was run to examine if the NPDES discharge and streamflow in Horse Creek were related. Comparing HCSW-1 stream discharge and NPDES discharge from 2003 to 2019 using a Spearman's rank correlation procedure (Zar 1999) indicates they covary strongly ($r_s = 0.71$, $p < 0.0001$, Table 5-6). Thus, an increase in one parameter will correspond to an increase in the other. Just as streamflow at HCSW-1 was correlated with rainfall (Table 5-4), so too is streamflow correlated with NPDES discharge (Table 5-6), with lag times and antecedent conditions affecting this relationship.

There is a lag in the start of NPDES discharge relative to rainfall (similar to the lag between rainfall and streamflow), because the NPDES system must fill to the discharge elevation, which can occur further into the wet season. NPDES discharge can also continue after the wet season rains have stopped until water is once again below the discharge elevation in the circulation system.

Table 5-4 Total Monthly Mosaic NPDES[23] Discharge to Horse Creek, 2019

Month	Discharge to Horse Creek (MG)*
January	0
February	0
March	0
April	0
May	0
June	0
July	0
August	274
September	375
October	0
November	0
December	0
Annual Total	**649**

*All values represent WIN-004. There were no discharges through FTG-003 in 2019

Table 5-5 Spearman's Rank Correlations (R_s) of Monthly Average NPDES Discharge with USGS Daily Streamflow, Gauge Height, and Total Monthly Rainfall, 2003- 2019

Gauge	r_s (with NPDES Outfall)	p value	N* (Sample Size)
HCSW-1 (USGS Streamflow)	0.71	< 0.0001	204
HCSW-1 (USGS Gauge Height)	0.65	< 0.0001	204
Horse Creek North (Rain)	0.36	< 0.0001	184
Horse Creek South (Rain)	0.33	< 0.0001	196
Manson Jenkins (Rain)	0.28	< 0.001	189
Average Mosaic Rainfall	0.34	< 0.0001	201
SWFWMD Flatford Swamp (Rain)	0.29	< 0.0001	204

*Months missing>10 days of data were removed from analysis

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[23] 2003-2019 NPDES flow average 3.2 billion gallons (BG), median 2.2 BG, minimum 0 BG, maximum 9.3 BG

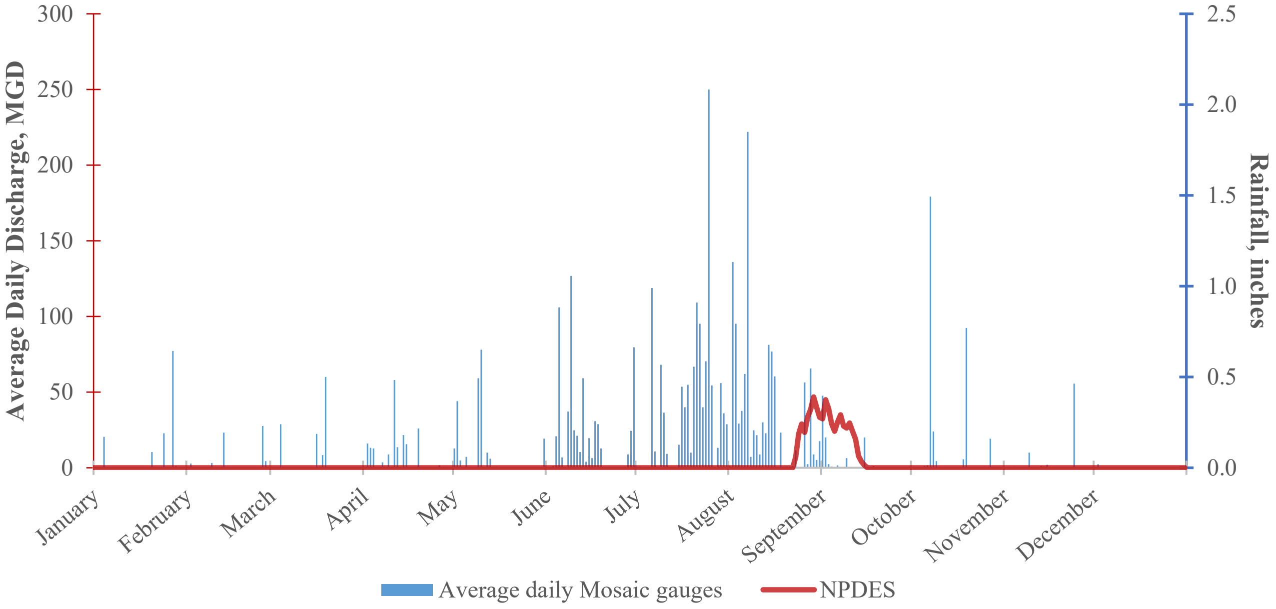

Figure 5-9 Combined Mosaic NPDES Discharge[24] and Average Daily Rainfall in The Horse Creek Watershed, 2019

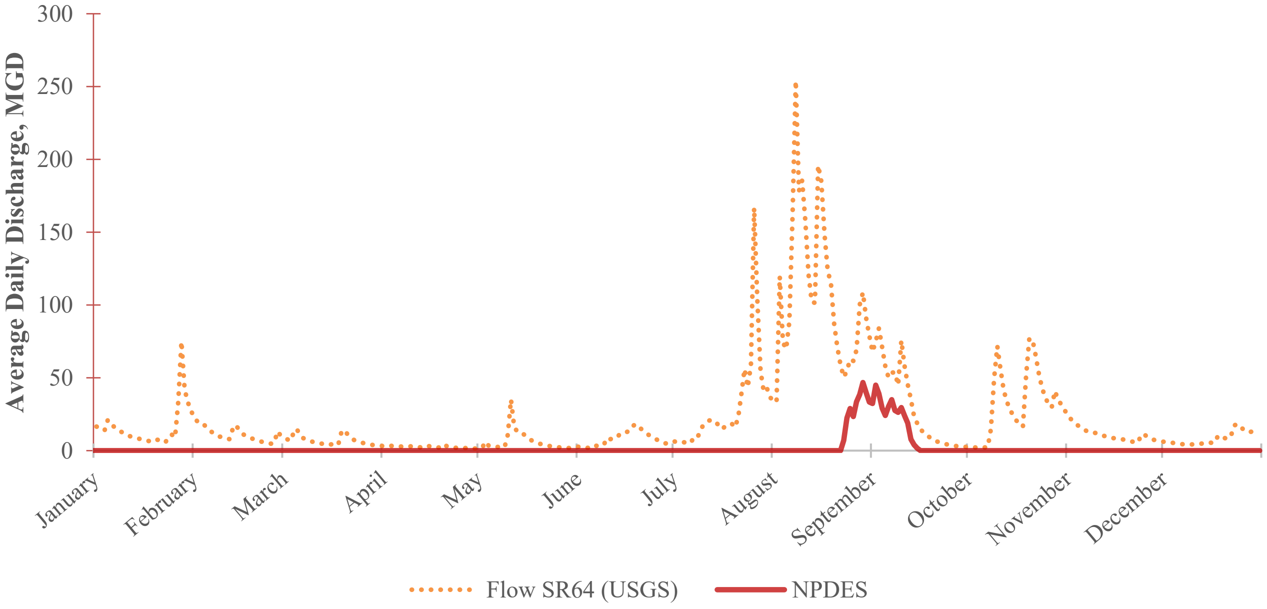

Figure 5-10 Daily Streamflow at HCSW-1 and Combined Mosaic NPDES Discharge[18], 2019

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[24] NPDES Represents Only Wingate D-004. Fort Green D-003 Did Not Discharge In 2019.

5.6 Summary of Water Quantity Results

Based on the two long-term NOAA rain gauges in the Horse Creek Basin, 2019 was the 77th wettest year since records began in 1908[25] and the 14th wettest year during the period of the HCSP (2019 49.3 inches, POR 53.9 inches). Horse Creek flow[26] at HCSW-1 in 2019 was ranked the 12th highest annual average flow (2019, 35.2 cfs) compared to all other years during the period of the HCSP (35.6 cfs); flow at HCSW-4 (235 cfs, HCSP POR 173.3 cfs) was ranked 4th. In 2019, the NPDES outfalls discharged the 15th largest output since discharges began in 2001 (649 million gallons) or a daily average of 27 MGD over the 24 days of discharge. NPDES discharges began 101 days after the summer rains began and contributed between 9-65% of the flow measured at HCSW-1.

There is no evidence that mining and reclamation activities in the basin caused any statistically significant decrease in total streamflow over the period of record (1978 to 2019), according to the double mass curve analysis. In a previous study (Robbins and Durbin 2011) that compared streamflow during dry years in reference and potentially impacted streams before and during phosphate mining, there was no evidence that phosphate mining practices caused lower monthly flows in the potentially impacted streams (including Horse Creek) than what would be expected given the conditions in a reference stream (Charlie Creek).

6.0 WATER QUALITY RESULTS AND DISCUSSION

The results of field measurements and laboratory analyses of water samples obtained monthly during 2019 at each HCSP monitoring station are presented in this section (see Appendix C for water quality figures from 2003 through present). Continuous recorder data for pH, dissolved oxygen, turbidity, and specific conductivity are also presented, along with the field measurements obtained during benthic macroinvertebrate and fish sampling on 9 April, 3 July, and 13 November 2019. Water quality raw data are included in the attached database. Brushy Creek at Post Plant Road (BCSW-1) has been added to water quality figures for comparison purposes. There is no NPDES discharge to Brushy Creek. Changes made to the HCSP protocol, including the addition of BCSW-1 as a sampling site and the dropping of mining reagents from the sampling analyte list, are documented in Appendix B.

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[25] Historical rainfall information came from the following stations and years: 1908 to 1943 NOAA station 148, 1944 to 2019 average of NOAA station 148 and 336. POR annual average 53.9 inches.

[26] Long-term annual average of daily streamflow calculated for 1978 to 2019 for HCSW-1 and 1951 to 2019 for HCSW-4 using USGS gauging stations.

6.1 Data Analysis

Monthly and continuous water quality data for 2019 are presented on scatter plots. HCSP samples for the duration of the HCSP are presented in Appendix C. Graphical representations of HCSP data include undetected values, represented by the respective Minimum Detection Levels (MDLs) for each parameter, except for total nitrogen and total radium. Total nitrogen and total radium are composite parameters without MDLs. Values of these parameters for which one or both components were undetected are marked.

Based on a literature review on tests for water quality data trend detection (Appendix D), the best monotonic trend detection method for use in the HCSP is the Seasonal Kendall. Because the USGS recommends a minimum of five years of data collection before applying the Seasonal Kendall test (Schertz et al. 1991), the 2008 Annual Report was the first report to include this analysis. The Seasonal Kendall was developed by and is now the method of choice for the USGS (Hirsch et al. 1982, Helsel et al. 2006).

The Seasonal Kendall test determines water quality trends after correcting for seasonality by only comparing values between similar seasons over time (Schertz et al. 1991). The Seasonal Kendall test selects one value for each season (average, median, or subsample) and makes all pair-wise comparisons between time-ordered seasonal values (Harcum et al. 1992). A test statistic (Tau) is computed by comparing the number of times a later value is larger than an earlier value in the data set, and vice-versa (Schertz et al. 1991). Results for the Seasonal Kendall include the magnitude of the statistic Tau, its significance (p), its slope (Sen slope estimator), and the direction of significant monotonic trends. The trend (Sen) slope is the median slope of all pair-wise comparisons. The direction of this slope (positive or negative) is more resistant to the effects of observations below minimum detection limits and missing data than the magnitude of the slope. The slope is a measure of the monotonic trend; the actual temporal variation may include step trends or trend reversals. If alternate seasons exhibit trends in opposite directions, the Seasonal Kendall test will not detect an overall trend (Lettenmaier 1988).

Trend detection is often limited by several factors including the number of years of data (atleast >5 years), the frequency of collection, changing minimum detection limits (MDLs), and the availability of flow data. With seventeen years of data, the power of the test to detect trends of small magnitude in this study is not limited (Harcum et al. 1992, Hirsch et al. 1982). Data for parameters whose method detection limits have changed several times over the HCSP (fluoride, nitrate-nitrite, ammonia) would have to be truncated to the highest detection limit, thereby reducing the available data for the test. As a result, trends were evaluated by combining HCSP and SWFWMD data for these parameters. Because HCSW-1 and HCSW-4 were the only stations with USGS flow data that is necessary for interpreting trends in flow-dependent parameters, they were the only stations used in this trend analysis. Any changes over time detected using the Seasonal Kendall test should be further examined to determine if the perceived change is caused by a data bias, if its magnitude is ecologically significant, and if the cause of the trend is related to Mosaic mining activities. If warranted, an impact analysis can be performed on statistically significant trends to determine if trends are caused by Mosaic mining activities and if a corrective action by Mosaic is necessary.

A summary of the Seasonal Kendall Tau results for all parameters is presented in Table 6-1 with an in-depth discussion of trends presented for each individual parameter. The year was split into three seasons, corresponding to wet/dry periods. Season one encompassed the first part of peninsular Florida's dry season, January through April. Season two spanned May to September (the wet season along with May, which in this region tends to be fairly rainy), and season three represented the second dry season during the calendar year, October through December. The Sen slope estimate for a parameter was only reported if the trend was statistically significant (significant p values [less than 0.05] are in **bold** in Table 6-2).

Parameters that were significantly correlated with USGS streamflow were corrected for the effect of annual variation in log streamflow using a Locally Estimated Scatterplot Smoothing (LOESS) (smooth, F=0.5) before the Seasonal Kendall-tau was performed. LOESS (local polynomial regression) in the seasonal Kendall-tau describes the relationship between the concentrations of a water quality parameter and streamflow using a weighted regression. The residuals of the smoothing have the effect of streamflow subtracted and are called flow-adjusted concentrations (Hirsch et al. 1991). Flow-adjusted concentrations are necessary when the variable in question has an inherent relationship with streamflow, which can confound any comparisons made of water quality between stations or times with different instantaneous flow. If the variability of a water quality parameter could be completely explained by streamflow, then during smoothing, all of the data points would fall along a single best-fit line, and all of the residuals (distance between the points and the line) would be zero. For real data, the differences between the data points and the best-fit line show the part of the variability in water quality that is not caused by changes in streamflow, i.e. the flow-adjusted concentrations. Kendall-tau analyses were performed in R (version 3.1.1) using the R function EnvStats: KendallTrendTest (Millard 2013). LOESS smoothing was done using log of streamflow within the R function stats: loess (R Core Team 2014), with a smoothing factor (span) of 0.5, symmetric family, and degree of 1 for polynomials.

Differences in water quality between stations from 2003 to 2019 for each water quality parameter were evaluated using Analysis of Variance (ANOVA) and Duncan's post hoc test (Table 6-2). This analysis will help to identify potential differences among stations that can be examined in more detail as the HCSP continues. A summary of the ANOVA results for all parameters is presented in Table 6-2 with detailed discussion presented under each parameter heading below.

Water quality parameters were compared with water quantity variables recorded during the same month from 2003 to 2019, including average daily streamflow for the month, average daily NPDES discharge for the month, and total monthly rainfall. Because these three water quantity variables are correlated to each other (Table 5-6), a statistically significant correlation between NPDES discharge and water quality does not prove a causal relationship between water quality and mining discharge. The results of this correlation analysis are presented in Table 6-3. Each of these correlations is discussed further in each water quality parameter section.

Table 6-1 Summary of Seasonal Kendall-tau with LOESS (F=0.5) for HCSW-1 and HCSW-4 from 2003 to 2019

Parameter	HCSW-1				HCSW-4			
	tau	p-value	slope	2019 Median	tau	p-value	slope	2019 Median
Alkalinity	0.46	<0.001	2.0	77	0.42	<0.001	1.1	44
Calcium, Dissolved	0.52	<0.001	1.2	31	0.34	<0.01	0.7	46
Chloride	-0.20	>0.05	N/A	13	-0.12	>0.05	N/A	19
Chlorophyll-a[2]	-0.05	>0.05	N/A	0.7	-0.08	>0.05	N/A	0.8
Color, Apparent	0.16	>0.05	N/A	175	0.27	<0.01	2.6	200
Dissolved Solids, Total	0.48	<0.001	8.5	296	0.299	<0.01	5.5	371
Fluoride*	0.33	<0.01	0.01	0.49	0.38	<0.001	0.00	0.32
Iron, Dissolved	-0.42	<0.001	-0.01	0.21	-0.38	<0.001	-0.01	0.25
Nitrogen, Ammonia*	-0.07	>0.05	N/A	0.31	0.32	<0.001	0.001	0.05
Nitrogen, Nitrate-nitrite*	-0.10	>0.05	N/A	0.05	-0.19	>0.05	N/A	0.25
Nitrogen, Total	0.11	>0.05	N/A	0.89	0.01	>0.05	N/A	1.12
Nitrogen, Total Kjeldahl	0.10	>0.05	N/A	0.81	0.04	>0.05	N/A	0.84
Orthophosphate[2]	0.01	>0.05	N/A	0.36	-0.01	>0.05	N/A	0.35
Oxygen[1,] Dissolved (%Sat)	0.48	<0.001	0.8	88	0.13	>0.05	N/A	76
pH	0.50	<0.001	0.04	7.40	0.28	<0.01	0.02	6.76
Radium, Total	-0.16	>0.05	N/A	1.4	-0.207	>0.05	N/A	1.4
Specific Conductance	0.49	<0.001	11.0	358	0.36	<0.001	7.9	392
Sulfate	0.46	<0.001	3.9	56	0.39	<0.001	3.9	153
Turbidity	0.11	>0.05	N/A	3	0.38	<0.001	0.08	5

*SWFWMD data used to supplement HCSP data.

[1] Percent DO calculated from DO saturation (mg/L) and temperature. Temperature data was not available for samples prior to June 2006.

[2] Data was not correlated with streamflow for either station; LOESS was not used.

Table 6-2 Summary of Results from ANOVA for Differences Between Stations, 2003-2019

Group	Parameter	F	p-value
Anions	Alkalinity	76.3	<0.001
	Chloride	39.5	<0.001
	Fluoride	74.5	<0.001
	Sulfate	74.7	<0.001
Cations	Calcium, Dissolved	77.2	<0.001
	Iron, Dissolved	0.03	0.811
Nutrients	Chlorophyll-*a*	44.1	<0.001
	Nitrogen, Ammonia	34.9	0.007
	Nitrogen, Nitrate-Nitrite	76.7	<0.001
	Nitrogen, Total	19.8	<0.001
	Nitrogen, Total Kjeldahl	21.2	<0.001
	Orthophosphate	10.4	<0.001
Physical	Color, Apparent	8.8	<0.001
	Dissolved Solids, Total	66.4	<0.001
	Oxygen, Dissolved (%Sat)	240	<0.001
	pH	59.2	<0.001
	Specific Conductance	59.8	<0.001
	Turbidity	0.5	0.704
Radiological	Radium, Combined	6.6	<0.001

[1] DO saturation (%) calculated from DO concentration (mg/L) and temperature. Temperature data was not available for samples prior to June 2006. Analysis period for DO % saturation is from June 2006 to December 2019.

Table 6-3 Spearman's Rank Correlation Between Water Quality and Water Quantity Parameters at HCSW-1 and HCSW-4, 2003 – 2019

Group	Parameter	HCSW-1			HCSW-4		
		Rainfall	NPDES	Streamflow	Rainfall	NPDES	Streamflow
Anions	Alkalinity (mg/L)	-0.29			-0.50	-0.45	-0.83
	Chloride (mg/L)	-0.32	-0.58	-0.76	-0.30	-0.57	-0.84
	Fluoride (mg/L) ††		0.44	0.24	-0.19	-0.44	-0.78
	Sulfate (mg/L)		0.33		-0.23	-0.54	-0.75
Cations	Calcium, Dissolved (mg/L)	-0.23	0.23		-0.24	-0.59	-0.84
	Iron, Dissolved (mg/L)	0.56	0.28	0.59	0.39	0.49	0.76
Nutrients	Ammonia, Total (mg/L) ††	0.13		0.16			0.13
	Chlorophyll-*a* (mg/m^3)		0.26	0.26	0.18		
	Nitrate-Nitrite (mg/L) ††	0.17		0.13		-0.23	-0.19
	Nitrogen, Total (mg/L)	0.41	0.26	0.49	0.19	0.14	0.30
	Nitrogen, Total Kjeldahl (mg/L)	0.42	0.29	0.52	0.26	0.39	0.56
	Orthophosphate (mg/L)						
Physical	Color, Apparent (pcu)	0.41	0.34	0.65	0.29	0.52	0.83
	Dissolved Solids, Total (mg/L)		0.33	0.21	-0.23	-0.53	-0.76
	Oxygen Dissolved (%Sat)†	-0.42	-0.34	-0.43	-0.45	-0.48	-0.76
	pH (S.U.)	-0.35	-0.17	-0.34	-0.28	-0.25	-0.51
	Specific Conductance (µS)	-0.21	0.23		-0.30	-0.54	-0.82
	Turbidity (NTU)	0.30	0.39	0.64	0.23	0.31	0.57
Radiological	Radium, Total (pCi/L)		-0.23	-0.23		-0.27	-0.31

Values displayed are statistically significant at $p < 0.05$
†Percent DO calculated from DO saturation (mg/L) and temperature. Temperature data was not available for samples prior to June 2006.
††SWFWMD data used to supplement HCSP data.

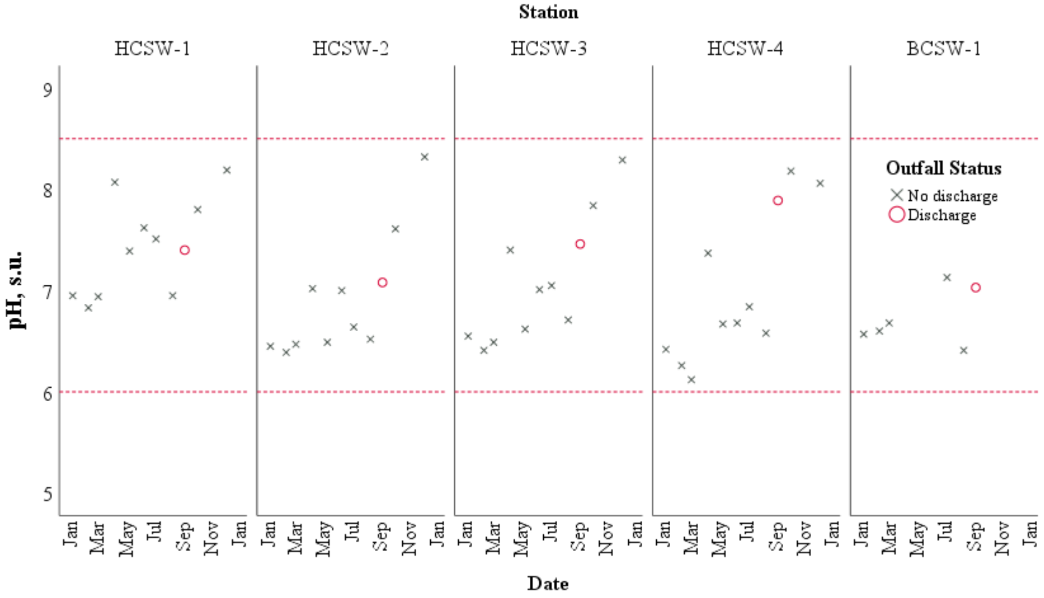
6.2 Physio-Chemical Parameters

6.2.1 pH

Measurements of pH, dissolved oxygen, turbidity, and specific conductivity were obtained in the field during each monthly water-quality sampling event. Values of pH were within the range of established trigger levels during all of 2019 sampling events at all stations (Figure 6-1); This has been the case for most of the period of record monthly HCSP pH data (Appendix C, Figure C-1). The continuous recorder at HCSW-1 recorded several excursions above the 8.5 S.U. pH trigger level in January, April, and May during periods of low creek flow and no NPDES discharge (Figure 6-2). It is likely that the pH sensor was out of the water when these exceedances occurred. This is further corroborated with the specific conductivity probe registering between 0-10 µS during the same periods which is indicative of the probes being suspended in the air.

Levels of pH were different among stations from 2003 to 2019 (ANOVA $p < 0.001$, Table 6-2); with HCSW-2 having the lowest pH and HCSW-1 the highest (Duncan's multiple range-test, $p < 0.05$). HCSW-2 lies just downstream of the Horse Creek Prairie, a blackwater swamp system that has the potential to add substantial organic acids from plant decomposition and decrease the pH (Reid and Wood 1976). Brushy Creek also contributes to HCSW-2, and similarly has a relatively low pH compared to HCSW-1 (Figure 6-1). At HCSW-1 and HCSW-4, pH was significantly negatively correlated with rainfall, NPDES discharge, and streamflow, at respective gauging stations (Spearman's rank correlation, Table 6-3). At HCSW-1, pH was positively correlated with rainfall and streamflow, and to a lesser extent, the NPDES discharge. Since the NPDES discharge itself is positively correlated with rainfall and stream flow (Table 5-5), the pH/NPDES and pH/streamflow correlations are most likely due to peak rainfall during the year which coincides with NPDES discharge.

There was a slightly increasing monotonic trend between 2003 and 2019 for pH at HCSW-1 and HCSW-4 (Seasonal Kendall-tau with LOESS, slope = 0.04 S.U./year and 0.02 S.U./year flow-adjusted concentrations, Table 6-3). The slopes for these potential trends are small compared to limits in laboratory prediction or the observed differences between primary and duplicate field samples. The evaluation of changes in pH over time for this report would be very similar to what was discussed in previous reports (2018 Annual Report – Appendix I); therefore, pH was not included in this year's impact assessment. Based on previous reports, the pH increase at HCSW-1 over the course of the HCSP program is not ecologically significant and is therefore, not of concern at this time.



The red dotted line represents analyte trigger level. pH 6 minimum, pH 8.5 maximum.

Figure 6-1 Values of pH Obtained During Monthly HCSP Water Quality Sampling Events, 2019

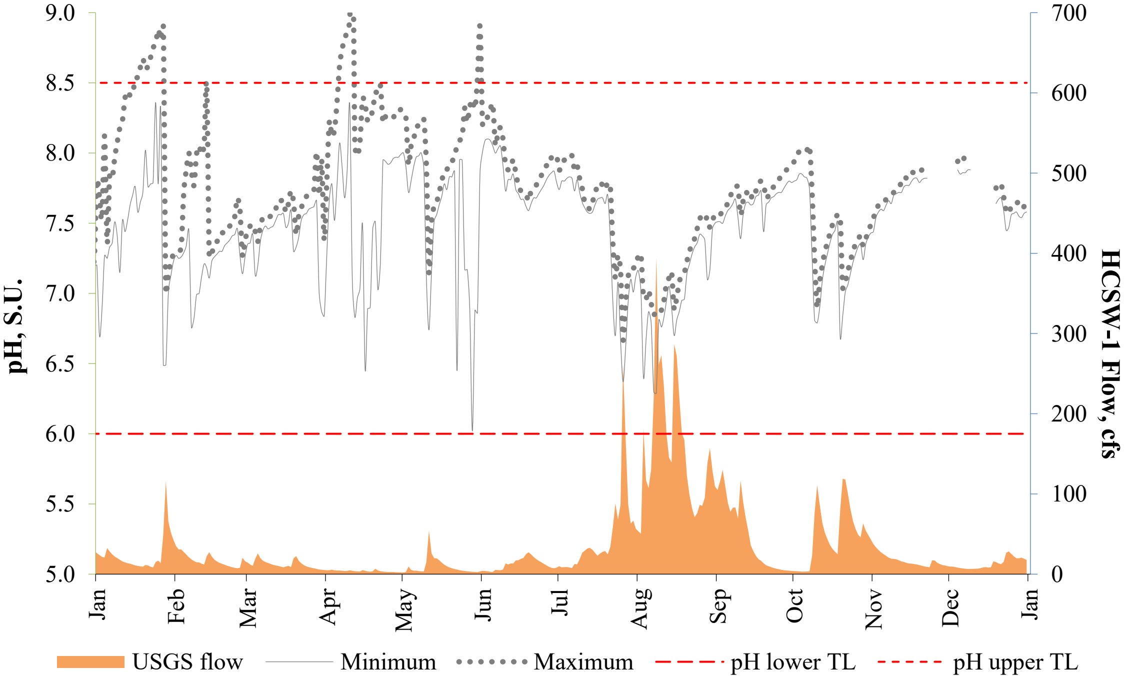


Figure 6-2 Relationship Between Daily Mean pH[27] (HCSW-1 Continuous Recorder) and Daily Mean Streamflow, 2019

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[27] Minimum pH detection limit = 0.1 S.U.

6.2.2 Dissolved Oxygen

There were nine DO saturation exceedances detected during monthly sampling – all at HCSW-2 (Figure 6-3, Table 6-4). The upstream continuous recorder at HCSW-1 (the site closest to the NPDES outfalls) recorded no exceedances for all of 2019 (Figure 6-4). For parts of the year the creek is disconnected due to the impoundment caused by the roadway/culvert immediately upstream of HCSW-2. This impoundment, coupled with the organic inputs from the upstream prairie, has created a situation where HCSW-2 experiences frequent low or no flow conditions, consistently slower water velocities (when compared to other HCSP monitoring stations), increased residence time, deposition of coarse organic matter, and the formation of an anaerobic mucky streambed – all conditions that drive DO concentrations down.

DO saturation was different among stations from 2006 to 2019 (ANOVA, Table 6-2), with lowest values occurring at HCSW-2 and the highest at HCSW-1 (Duncan's multiple range test, $p < 0.05$). Dissolved oxygen saturation was negatively correlated with all water quantity variables at both HCSW-1 and HCSW-4 (rainfall, streamflow, and NPDES discharge, Spearman's rank correlations, Table 6-3), but the strongest correlation was with streamflow. Because streamflow and NPDES discharge are positively correlated with rainfall (with lag times), dissolved oxygen is lowest during or following periods of high rainfall. During the wet season, higher temperatures in the stream drive down the oxygen saturation, and the decomposition of woody debris washed into the stream during high rains can increase oxygen demand.

DO saturation at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these same locations (Appendix C, Figure C-23). An increasing monotonic DO saturation trend of 0.8% per year was detected at HCSW-1 between 2006-2019[28] (Seasonal Kendall-tau with LOESS, $p < 0.001$, Table 6-1).

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[28] Temperature data was not collected until 2006. Temperature and conductivity are required to calculate DO saturation. Monthly DO saturation values were calculated from 2006-2012 and DO sat was collected in-situ starting in 2013.

The red dotted line represents analyte trigger level. Red X denotes values that were >38% but failed the time-of-day criteria for DO saturation.

Figure 6-3 Dissolved Oxygen Percent Saturation Obtained During Monthly HCSP Water Quality Sampling Events, 2019

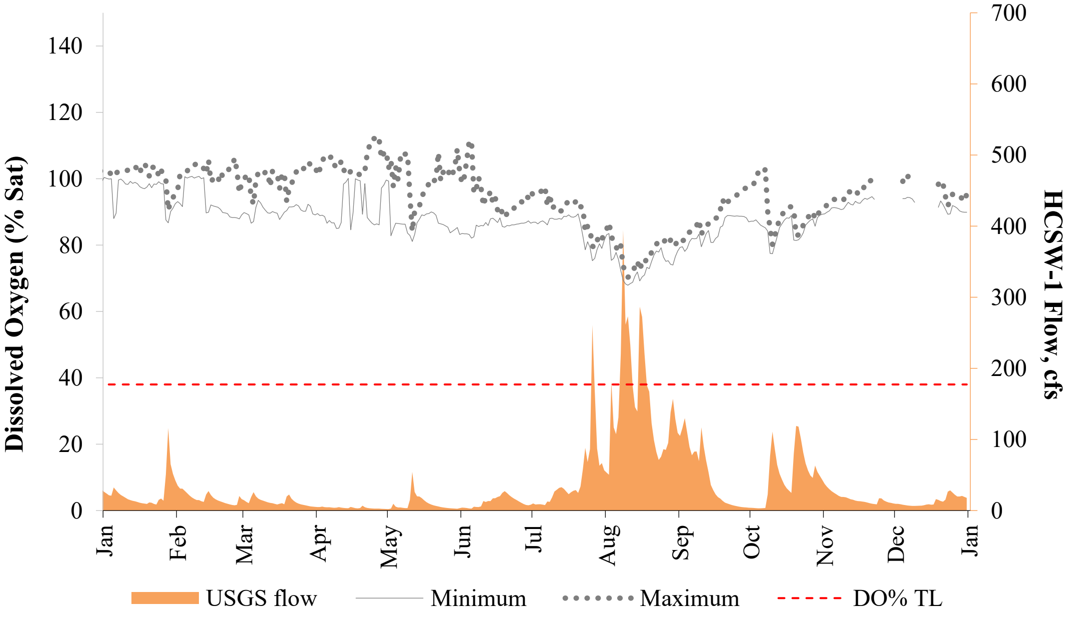

Figure 6-4 Relationship Between Daily Mean DO Percent Saturation[29] (HCSW-1 Continuous Recorder) and Daily Mean Streamflow, 2019

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[29] Minimum DO detection limit = 1%.

6.2.3 Turbidity

Turbidity levels at all stations in 2019 were below the trigger level and Class III Surface Water Quality Standard of 29 nephelometric turbidity units (NTUs). Monthly turbidity levels have been below this trigger level for the entire HCSP period of record (Appendix C, Figure C-4). Turbidity measured at HCSW-1 by the continuous recorder was similar to monthly measurements with the exception of a few isolated higher measurements that most likely coincide with higher rainfall events or material becoming lodged in the deployment structure (Figure 6-6). Some of the higher continuous recorder turbidity measurements did cause an alert for potential CSA dam breach (twelve consecutive readings (3 hours) of > 150 NTUs). All of the alerts were investigated and found to be false alarms as either water levels were too low for the sensor, debris from upstream became lodged within the deployment structure, or organisms (crayfish) became lodged in the deployment structure. There have been no actionable turbidity alerts since the program came online.

Turbidity levels were not different among stations from 2003 to 2019 (ANOVA, Table 6-2). Turbidity was positively correlated with all water quantity parameters at HCSW-1 and HCSW-4 (streamflow, rainfall, and NPDES discharge, Spearman's rank correlation, Table 6-3), but the strongest correlation was with streamflow. Because NPDES discharge and streamflow are positively correlated with rainfall (with lag times), turbidity is typically highest during or following periods of high rainfall and high streamflow (Figure 6-6). Turbidity measurements at Brushy Creek were similar to Horse Creek stations during most events (Figure 6-5).

The turbidity levels at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these same locations (Appendix C, Figure C-24) and between 2003 and 2019 there was no trend detected at HCSW-1 and a monotonic trend of 0.08 NTU/year at HCSW-4 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1). This slope is small and does not appear to be related to NPDES discharge as there was no trend at HCSW-1; it is not of ecological concern at this point but will continue to be monitored in the future.

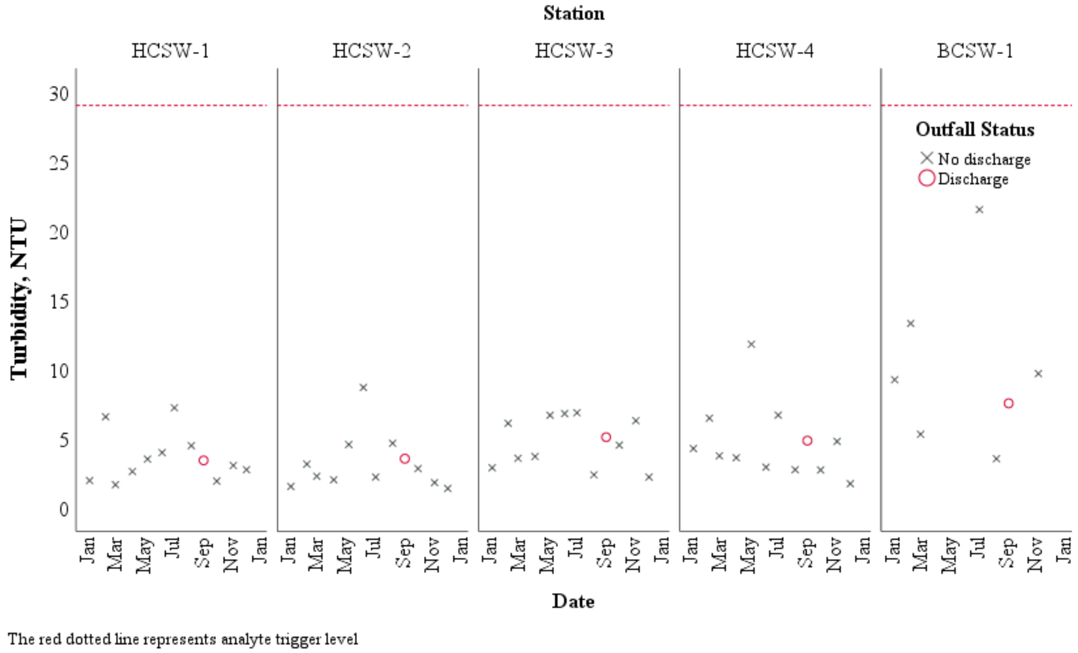

Figure 6-5 Turbidity Levels Obtained During Monthly HCSP Water Quality Sampling Events, 2019

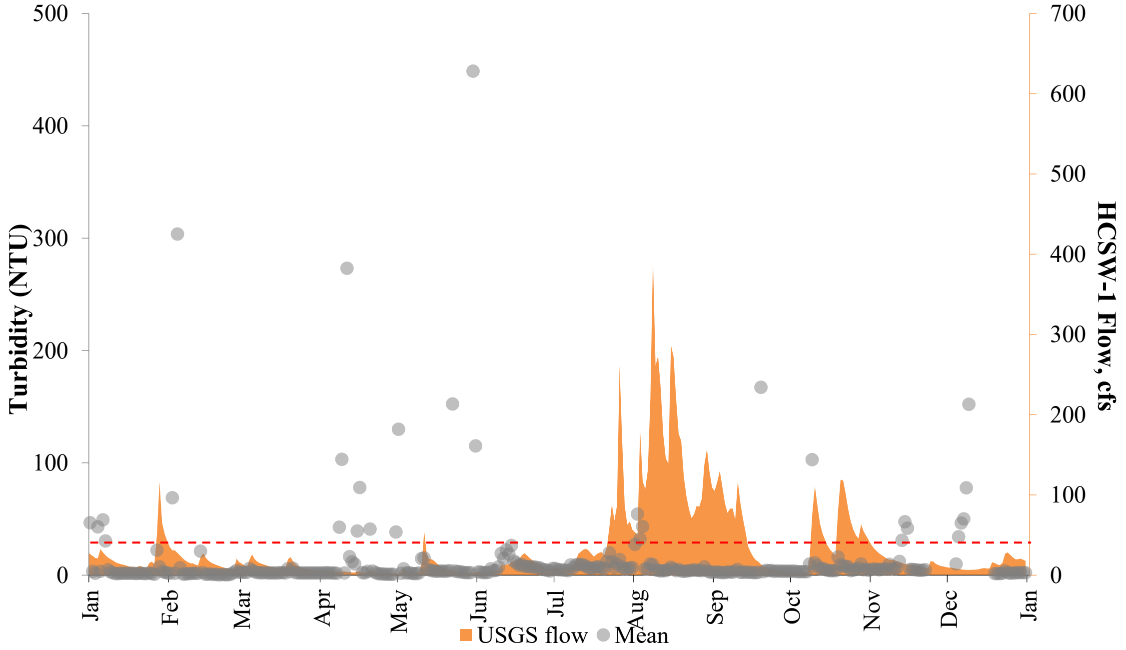

Figure 6-6 Relationship Between Daily Mean Turbidity[30] (HCSW-1 Continuous Recorder) and Daily Mean Streamflow, 2019

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[30] Minimum detection limit = 0.1 NTU

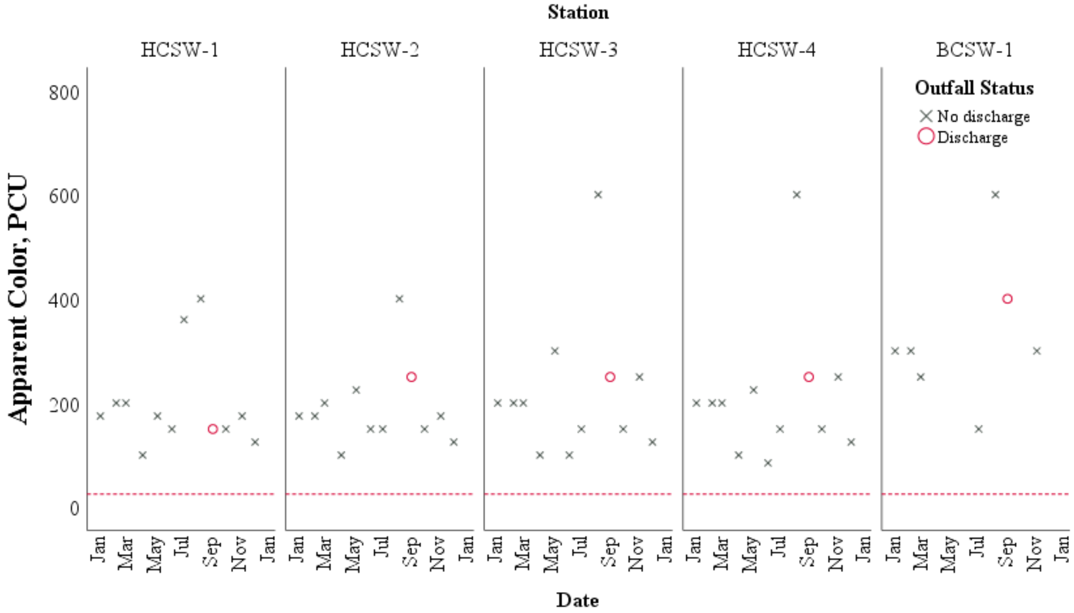
6.2.4 Apparent Color

All color values in 2019 were above the trigger level of 25 Platinum-Cobalt Units (PCU) (indicating desirable conditions) during all events at all stations (Figure 6-7). The color levels at HCSW-1 measured by the HCSP are consistent with other water quality data sources at this same location (Appendix C, Figure C-25).

Color levels were different among stations from 2003 to 2019 (ANOVA, Table 6-2), with HCSW-2 having the highest color and HCSW-1 having the lowest (Duncan's multiple range test, $p < 0.05$). HCSW-2 receives input from Horse Creek Prairie which contributes higher color levels to this station. Brushy Creek generally has higher color than the Horse Creek stations and also flows into Horse Creek above HCSW-2 (Figure 6-7). Color was positively correlated with all water quantity variables at HCSW-1 and HCSW-4 (rainfall, streamflow, and NPDES discharge, Spearman's rank correlations, Table 6-3) but the strongest correlation was with streamflow. As streamflow and NPDES discharge are positively correlated with rainfall (with lag times), color values are highest during or following periods of high rainfall and streamflow.

The similar pattern among the stations, with higher color in the wet, summer months, and lower levels in the dry, winter months, suggest that color is affected by the differential inputs of surface water and groundwater seepage. During the wet season when surface flows from wetland areas are highest, the transport of tannins to Horse Creek adds more color to the water (Reid and Wood 1976). This was very evident during and after Hurricane Charley in 2004 (Appendix C, Figure C-5). As the dry season begins, groundwater seepage provides a proportionally higher contribution of clearer water to Horse Creek, thereby decreasing the color of the water. It is likely that agricultural irrigation return flows also have some impact on color in the stream by introducing clearer groundwater during the drier parts of the year or during dry years like 2006 and 2007. This agricultural influence is also noted below with respect to several other parameters.

No trend was detected at HCSW-1 over the HCSP period of record (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1). However, an increasing monotonic trend was detected at HCSW-4 over the same period (slope = 2.6 PCU per year flow-adjusted concentration, Table 6-1). The trigger level for color in the HCSP is expressed as a minimum, so the observed upward trend at HCSW-4 is not of concern as it relates to a defined HCSP trigger level; over time, the program will continue to monitor this trend.



The red dotted line represents the analyte trigger value

Figure 6-7 Color Levels Obtained During Monthly HCSP Water Quality Sampling, 2019

6.3 Nutrients

6.3.1 Total Nitrogen

Total nitrogen[31] (TN) concentrations were between 0.04 and 2.08 mg/L during all sampling events at all Horse Creek stations in 2019, consistently below the trigger value of 3.0 mg/L at all stations (Figure 6-8). The major component of total nitrogen in nearly all samples was organic nitrogen. The total nitrogen concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Appendix C, Figure C-26) and exhibited no monotonic trend since 2003 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1). Total nitrogen concentrations were different among stations from 2003 to 2019 (ANOVA, Table 6-2; Appendix C, Figure C-6), with the lowest concentrations at HCSW-1 and the highest at HCSW-4 (Duncan's multiple range test, $p < 0.05$). Total nitrogen was positively correlated with all water quantity variables at HCSW-1 and HCSW-4 (rainfall, streamflow, and NPDES discharge), but the strongest correlation was with streamflow (Spearman's rank correlations, Table 6-3). As streamflow and NPDES discharge are positively correlated with rainfall (with lag times), total nitrogen values are highest during or following periods of high rainfall and streamflow. Total nitrogen concentrations at Brushy Creek in 2019 were slightly higher than most concentrations at the Horse Creek stations (Figure 6-8).

In addition to the trigger level for TN, HCSW-1, the station with the highest percent of upstream mined lands, was evaluated against the state numeric nutrient standards. Under those standards, in order to avoid being listed as impaired for nutrients, a stream must pass a combination of biological and/or numerical criteria. According to 62-302 and 62-303 F.A.C., biological and nutrient data collected during the HCSP at HCSW-1 indicate no nutrient impairment (Appendix I, 2017 Annual Report). As of December 2019, HCSW-1 meets the nutrient criteria set in 62-302.351(2)(c), because it shows no imbalance of flora and fauna (chlorophyll, RPS, and LVS) and has healthy benthic macroinvertebrate conditions (SCI). HCSW-1 shows no evidence of persistent algal blooms, has an annual geometric mean concentration of chlorophyll that is < 3.2 µg/L, and annual geomean of TN that is < 1.65 mg/L, and has 16 passing Rapid Periphyton Surveys (RPS) and Linear Vegetation Surveys (LVS) from 2012 to 2019. The HCSW-1 average of SCI scores is > 40, with neither of the two most recent scores < 35.

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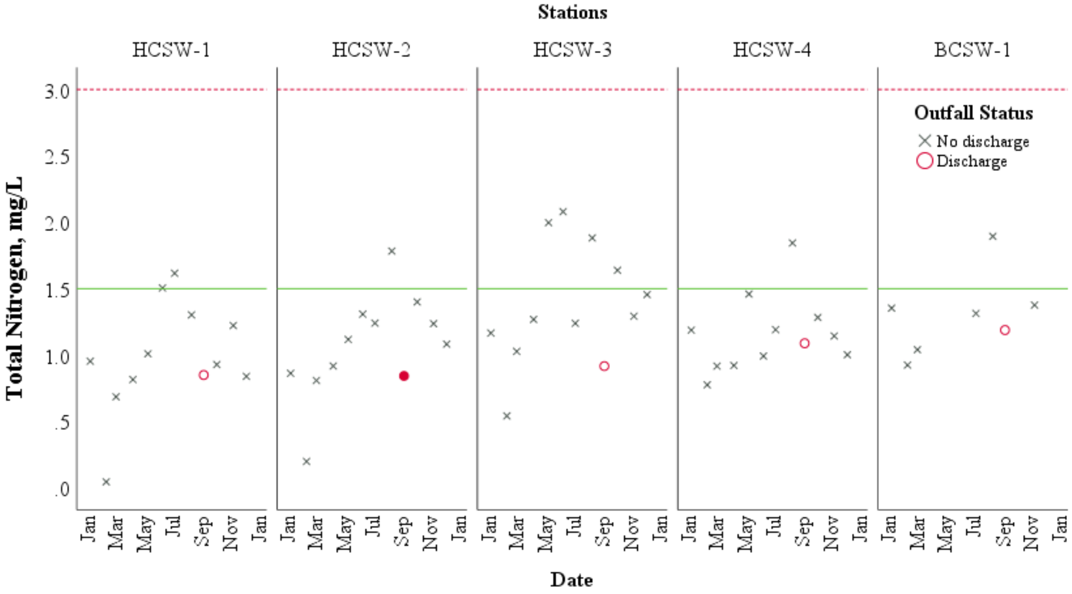
[31] Total nitrogen is calculated as the arithmetic sum of TKN and nitrate-nitrite. As requested by the PRMRWSA, if either TKN or nitrate-nitrite is undetected, the MDL of the undetected constituent will be used as part of the total nitrogen calculation. Note that this use of MDL for undetected constituents is inconsistent with typical laboratory and DEP SOPs and may result in artificially high estimates of total nitrogen.



The red dotted line represents analyte trigger level. Green line indicates TN NNC for west central Florida streams. Solid red circle represents "J9" sample (i.e. Nitrate+Nitrite was not detected)

Figure 6-8 Total Nitrogen Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2019

6.3.2 Total Kjeldahl Nitrogen

The HCSP does not have an independent trigger value for Total Kjeldahl Nitrogen (TKN), but TKN is used to calculate TN which does have a trigger level of 3 mg/L. TN consisted mostly of TKN (61% - 100%) in 2019 Horse Creek samples, and 92%- 100% in Brushy Creek. The source for most of the TKN measured in 2019 (Figure 6-9) at both Horse Creek and Brushy Creek was organic nitrogen (57%- 99.9%).

The TKN concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources for these locations (Appendix C, Figure C-27). No monotonic trend for TKN was detected over the HCSP period of record at either site (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1).

Concentrations of TKN were different among stations from 2003 to 2019 (ANOVA, Table 6-2), with HCSW-2 having a higher concentration than the other three stations and HCSW-1 having the lowest (Duncan's multiple range test, $p < 0.05$). Brushy Creek, which contributes to HCSW-2, typically has higher TKN concentrations than the Horse Creek stations (Appendix C, Figure C-27). TKN was positively correlated with rainfall, streamflow, and NPDES discharge at HCSW-1 and HCSW-4 (Spearman's rank correlations, Table 6-3). Streamflow and NPDES discharge are positively correlated with rainfall (with lag times), and TKN values are highest during or following periods of high rainfall.

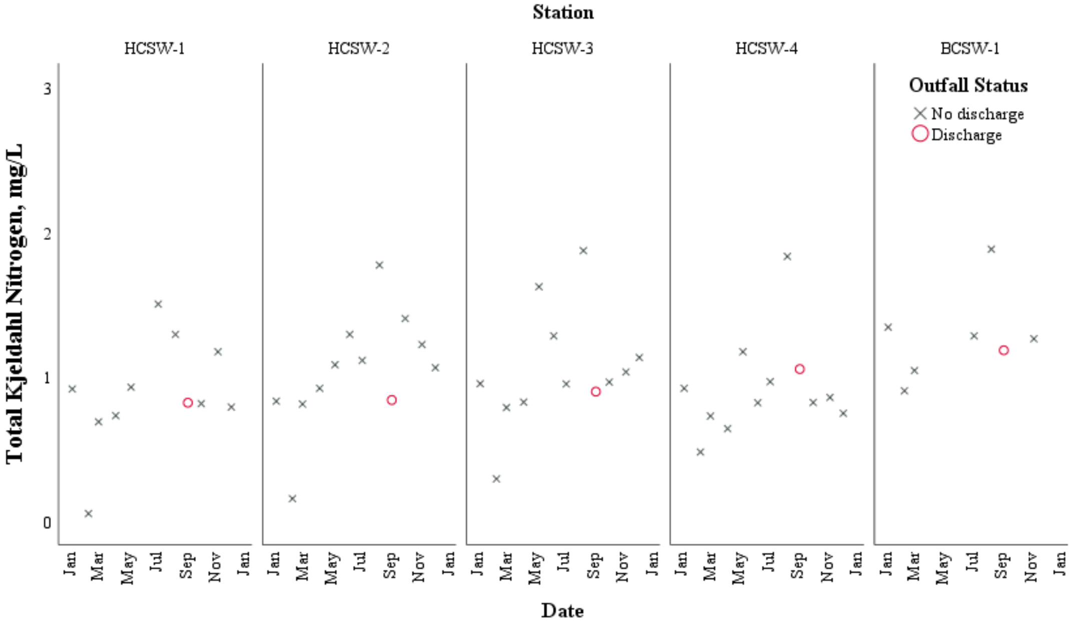


Figure 6-9 TKN Concentrations Obtained During Monthly HCSP Quality Sampling, 2019

6.3.3 Nitrate-Nitrite Nitrogen

The HCSP does not have an independent trigger value for Nitrate-Nitrite (NOx), but NOx is used to calculate TN which does have a trigger level of 3 mg/L (Figure 6-10). Concentrations of NOx were different among stations from 2003 to 2019 (ANOVA, Table 6-2; Appendix C, Figure C-8), with HCSW-2 having the lowest mean concentration followed by HCSW-1, HCSW-3, then HCSW-4 (Duncan's multiple range test, $p < 0.05$). NOx concentrations at the two upstream locations (HCSW-1 and HCSW-2) made up less than 12 percent of TN, while concentrations at the downstream locations (HCSW-3 and HCSW-4) accounted for up to 46 percent (average of 23 percent) of TN in 2019.

NOx concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources (Appendix C, Figure C-28). Based on trend analysis performed by combining[32] HCSP data with SWFWMD from 2003 to 2019, no monotonic trends were detected for nitrate-nitrite at either HCSW-1 or HCSW-4 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1).

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[32] Between 1/06- 5/08, HCSP NOx MDLs were censored at high concentrations (low accuracy, MDLs 0.1- 1.0 mg/L, NOx). Previous reports ran trend analysis on SWFWMD datasets only. NOx trend analysis in this report was handled by supplementing the HCSP data with SWFWMD data from 2003- 2019 period and the removal of the low accuracy NOx data with MDLs ≥0.05 mg/L. Typical NOx MDLs for HCSP data are ≤0.05 mg/L.

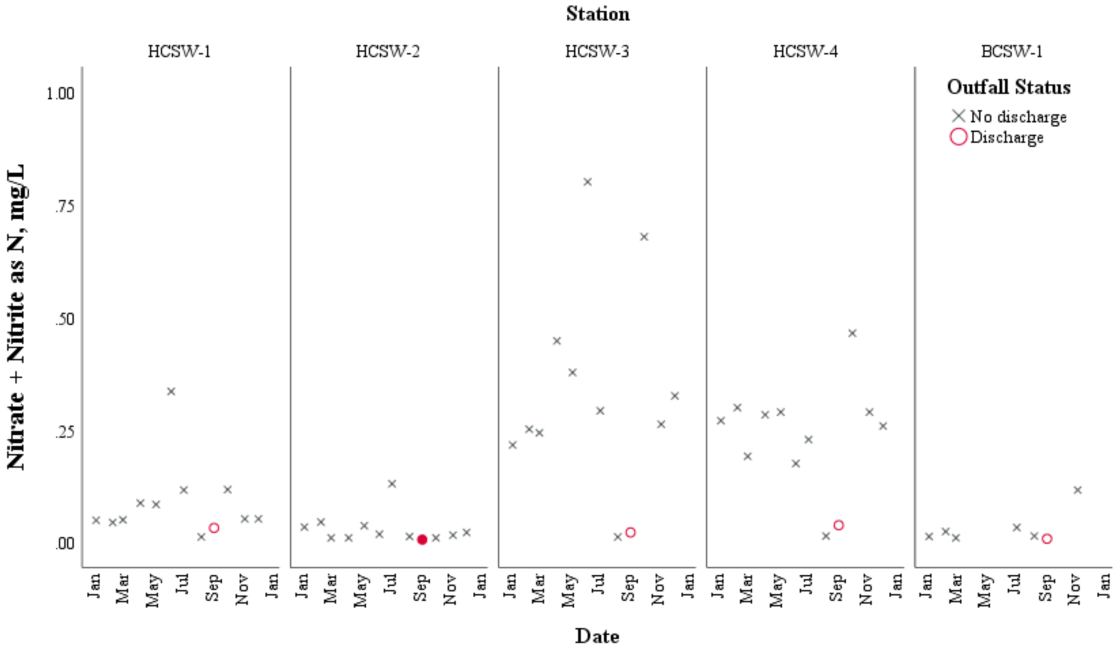

Figure 6-10 Nitrate-Nitrite as Nitrogen Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2019

6.3.4 Total Ammonia as Nitrogen

Total ammonia as nitrogen levels were within a similar range during almost all sampling events at all stations in 2019 (Figure 6-11). The exceedances that occurred at station HCSW-2, and HCSW-3 occurred during times when there was no NPDES discharge (Table 6-4,). This phenomenon might be attributable to samples being collected following successive periods of drying and rewetting (Cabrera, 1993). Over the HCSP period of record, concentrations of ammonia were different among stations (ANOVA, Table 6-2), with HCSW-1 having the lowest mean concentration followed by HCSW-3, HCSW-4, then HCSW-2 (Duncan's multiple range test, $p < 0.05$).

The ammonia concentrations at HCSW-1 measured by the HCSP have been below the 0.3 mg/L trigger level over the entire HCSP period of record (Appendix C, Figure C-9). Outside of the HCSP, there was one ammonia exceedance at HCSW-1 since the outfall came online and two pre-outfall exceedances (Appendix I, Table 1). Based on trend analysis performed by combining[33] HCSP data with SWFWMD from 2003 to 2019, no monotonic trend was detected for ammonia at HCSW-1 (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1). A slight trend of 0.0012 mg/L/year was detected at HCSW-4 (Seasonal Kendall-tau with LOESS, $p < 0.001$, Table 6-1).

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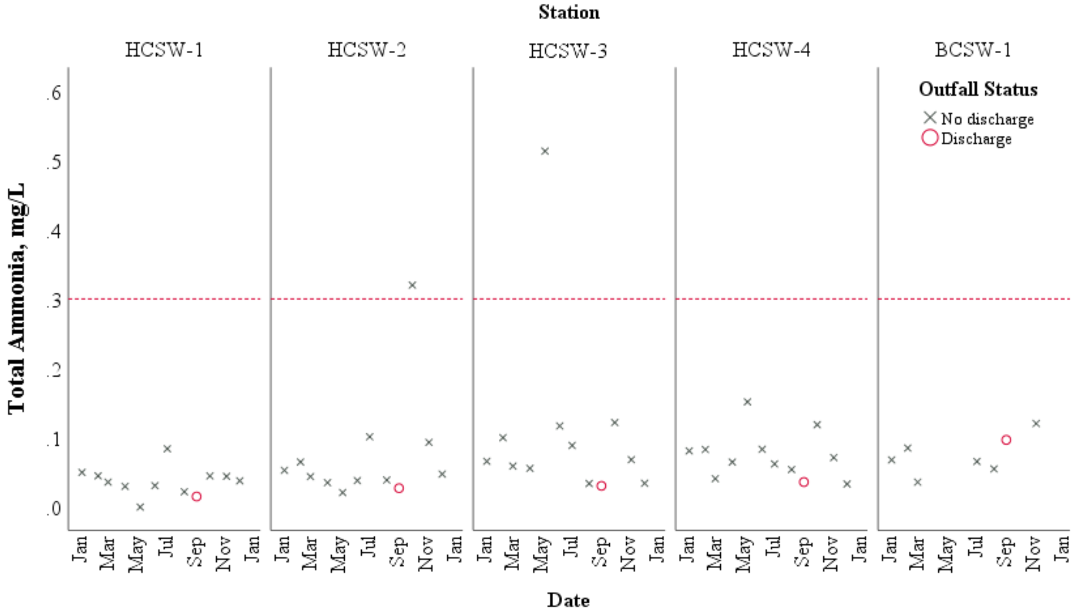
[33] Between 7/12- 2/15, HCSP ammonia MDLs were censored at high concentrations (lower accuracy, MDLs >0.04 mg/L, NOx). Previous reports ran trend analysis on SWFWMD datasets only. Ammonia trend analysis in this report was handled by supplementing the HCSP data with SWFWMD data from 2003-2019 period and the removal of the censored ammonia data with MDLs >0.04 mg/L..



The red dotted line represents analyte trigger level

Figure 6-11 Total Ammonia (as Nitrogen) Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2019

6.3.5 Orthophosphate

Orthophosphate concentrations were well below the trigger level of 2.5 mg/L in 2019 at all stations and events (Figure 6-12). Brushy Creek orthophosphate concentrations were similar to Horse Creek during sampling events in 2019. The orthophosphate concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Appendix C, Figure C-30). No monotonic trends were detected at HCSW-1 or HCSW-4 over the HCSP period of record (Seasonal Kendall-tau, $p > 0.05$, Table 6-1).

Orthophosphate concentrations were different among stations from 2003 to 2019 (ANOVA, Table 6-2; Appendix C, Figure C-10), with concentrations lowest at HCSW-2, followed by HCSW-3, HCSW-1, then HCSW-4 (Duncan's multiple range test, $p < 0.05$). There was no correlation detected between orthophosphate and any water quantity parameters at HCSW-1 or HCSW-4 over the HCSP period of record (Spearman's rank correlation, Table 6-3).

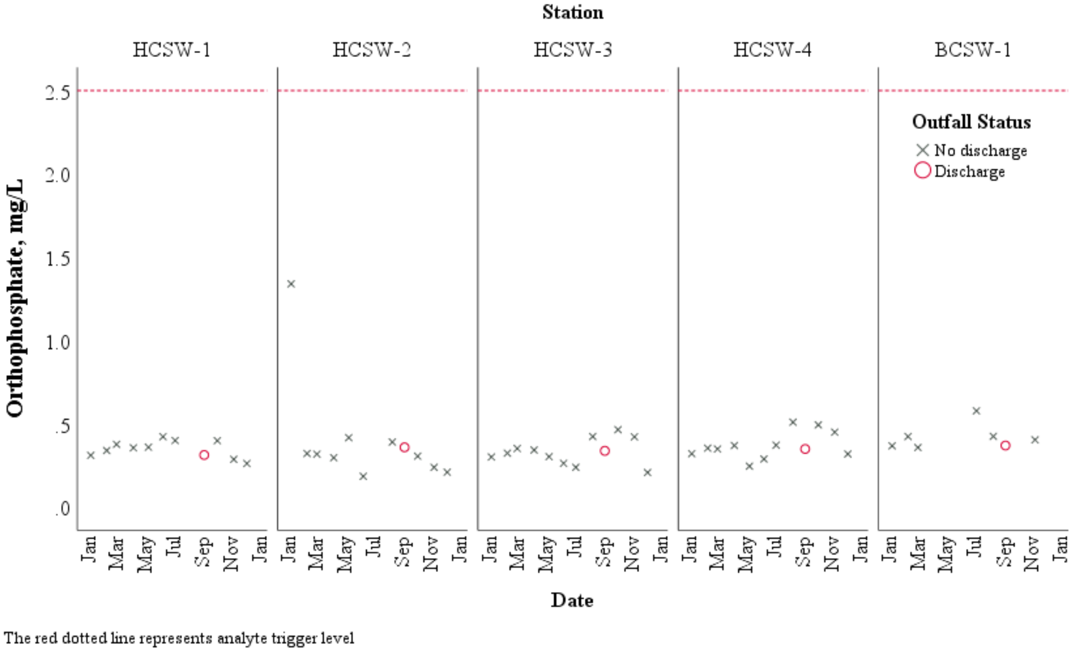


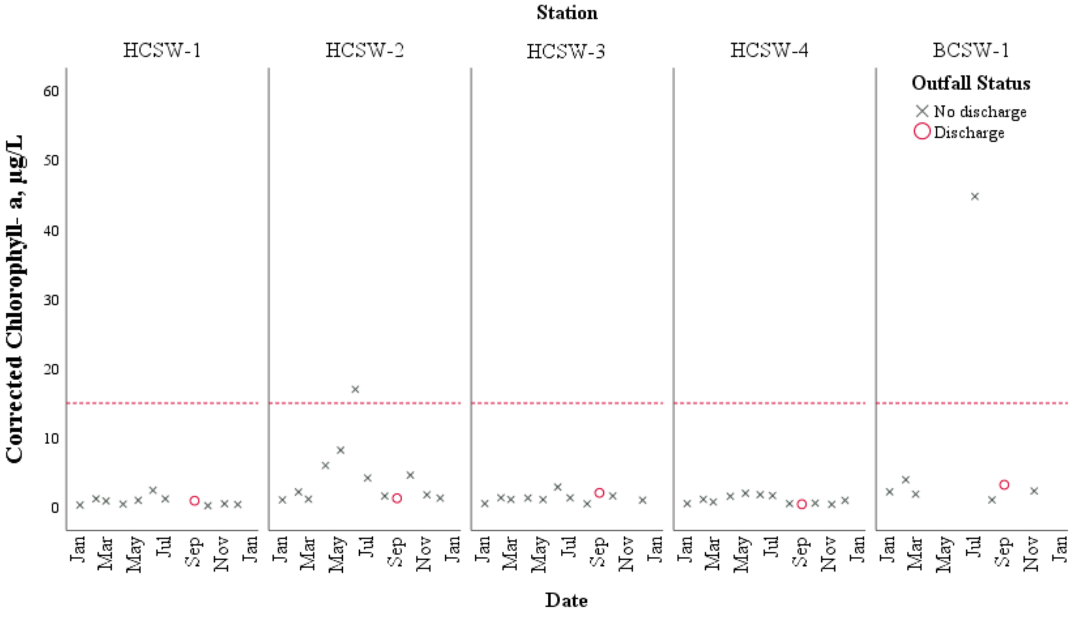
Figure 6-12 Orthophosphate Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2019

6.3.6 Corrected Chlorophyll-*a*

Corrected Chlorophyll-a (referred in this report as chlorophyll-a) values were below the trigger level of 15 mg/m^3 during all sampling events at all four Horse Creek stations in 2019, except for HCSW-2 in June (Figure 6-13, Table 6-4). Chlorophyll-a concentrations at Brushy Creek were higher than concentrations at all Horse Creek stations with one value (44.8 mg/m^3, July) exceeding the trigger values established for Horse Creek (Figure 6-13). Both BCSW-1 and HCSW-2 are prone to intermittent flow conditions which lead to increased residence time and increase the potential for algae blooms. The chlorophyll-a concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Appendix C, Figure C-31).

Chlorophyll-a concentrations were different between stations from 2003 to 2019 (ANOVA, Table 6-2; Appendix C, Figure C-11), with concentrations at HCSW-1 being the lowest followed by HCSW-4, HCSW-3, then HCSW-2 (Duncan's multiple range test, $p < 0.05$). Chlorophyll-a was weakly positively correlated with NPDES discharge and streamflow at HCSW-1, and weakly positively correlated with rainfall at HCSW-4 (Spearman's rank correlation, Table 6-3). No trends were detected at either HCSW-1 or HCSW-4 over the HCSP period of record (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1).

According to the 2013 FDEP NNC implementation document, streams sites with annual geometric means 3.2 - 20 mg/m^3 require further study to determine "whether chlorophyll-a conditions reflect imbalance in flora or not". The 2019 annual geometric mean corrected chlorophyll-a concentration was 0.66 mg/m^3, 2.8 mg/m^3, 1.0 mg/m^3, 0.9 mg/m^3 at HCSW-1, HCSW-2, HCSW-3, and HCSW-4, respectively. The 2019 geometric mean for chlorophyll-a at Brushy Creek was 3.47 mg/m^3. The elevated chlorophyll-a values at both HCSW-2 and BCSW-1 (Appendix C, Figure C-11) are to be expected since flow at both sites is intermittent and therefore increases water residence time.



The red dotted line represents analyte trigger level

Figure 6-13 Corrected Chlorophyll-a Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2019

6.4 Dissolved Minerals, Mining Reagents, and Radionuclides

6.4.1 Specific Conductivity

During all sampling events and at all stations, specific conductivity levels were well below the trigger level of 1275 µS in 2019 (Figure 6-14). Levels of specific conductivity in 2019 followed the same general pattern at all stations, with lower values during higher rainfall months and higher values during low rainfall months (Figure 6-15). The specific conductivity at both HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources (Appendix C, Figure C-32). Specific conductivity values at Brushy Creek were lower than Horse Creek stations throughout 2019.

Specific conductivity was different between stations over the HCSP period of record (ANOVA, Table 6-2; Appendix C, Figure C-12), with the lowest overall measurements at HCSW-2, followed by HCSW-1, HCSW-3, and then HCSW-4 (Duncan's multiple range test, $p < 0.05$). At HCSW-1, specific conductivity was positively correlated with NPDES discharge and negatively correlated with rainfall (Table 6-3). At HCSW-4, specific conductivity was negatively correlated with rainfall, streamflow, and NPDES discharge (Spearman's rank correlations, Table 6-3). Specific conductivity exhibited an increasing trend since 2003 at HCSW-1 and HCSW-4 (Seasonal Kendall-tau with LOESS, Sen slope = 11 µS and 7.9 µS per year flow-adjusted concentrations, respectively, Table 6-1). The monotonic trends as well as a change point analyses for HCSW-1 were discussed in the 2017 Impact Assessment.

The 2017 HCSP Impact Assessment's change-point analysis of the dissolved ion data for HCSW-1 showed concentration increases around drought periods. The 2018 TDS, calcium, and sulfate (components of specific conductivity) HCSP Impact Assessment showed that these analytes showed increased concentrations under low flow conditions, were not related to the outfall, and were linked to tributaries in the lower basin that are impacted by agriculture. To date, all specific conductivity exceedances have occurred at HCSW-4 only (Appendix C, Figure C-12).

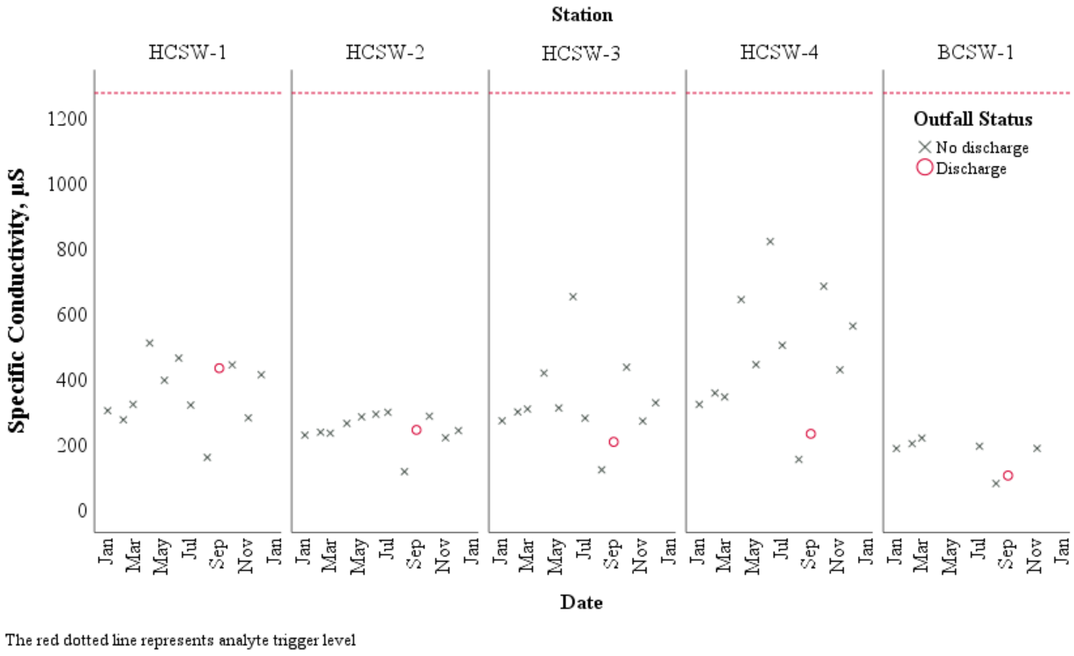


Figure 6-14 Specific Conductivity Measurements Obtained During Monthly HCSP Water Quality Sampling Events, 2019

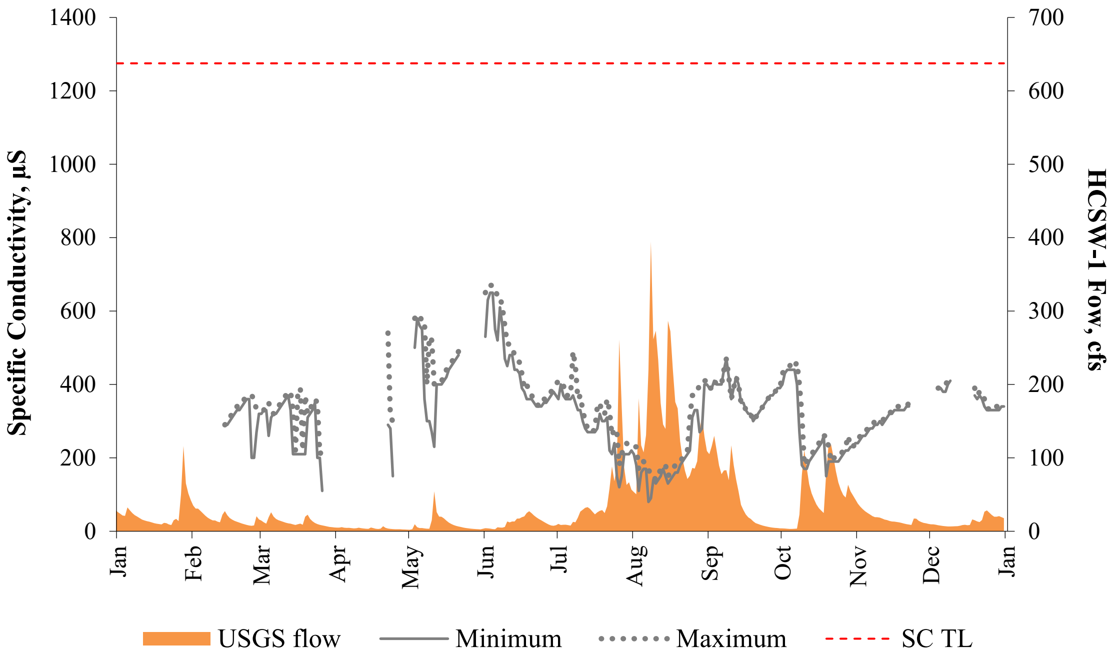


Figure 6-15 **Relationship Between Daily Mean Specific Conductivity (HCSW-1 Continuous Recorder[34]) and Daily Mean Streamflow, 2019**

6.4.2 Dissolved Calcium

Dissolved calcium concentrations were lower than the trigger value of 100 mg/L at all Horse Creek stations during all events in 2019 except for the June sampling event at HCSW-4 (Figure 6-16, Table 6-4). Brushy Creek had lower calcium concentrations than the Horse Creek stations.

Concentrations of calcium were different between stations from 2003 to 2019 (ANOVA, Table 6-2; Appendix C, Figure C-13), with the lowest overall concentrations at HCSW-2, followed by HCSW-1, HCSW-3, and then HCSW-4 (Duncan's multiple range test, $p < 0.05$). Calcium was positively correlated with NPDES discharge and negatively correlated with rainfall at HCSW-1 (Table 6-3), but negatively correlated with rainfall, streamflow, and NPDES discharge at HCSW-4.

Dissolved calcium exhibited an increasing monotonic trend from 2003 to 2019 at both HCSW-1 (Seasonal Kendall-tau with LOESS, Sen slope = 1.2 mg/L per year flow-adjusted concentrations, Table 6-1) and HCSW-4 (Seasonal Kendall-tau with LOESS, Sen slope = 0.7 mg/L per year flow-adjusted concentrations). The relationship between historical

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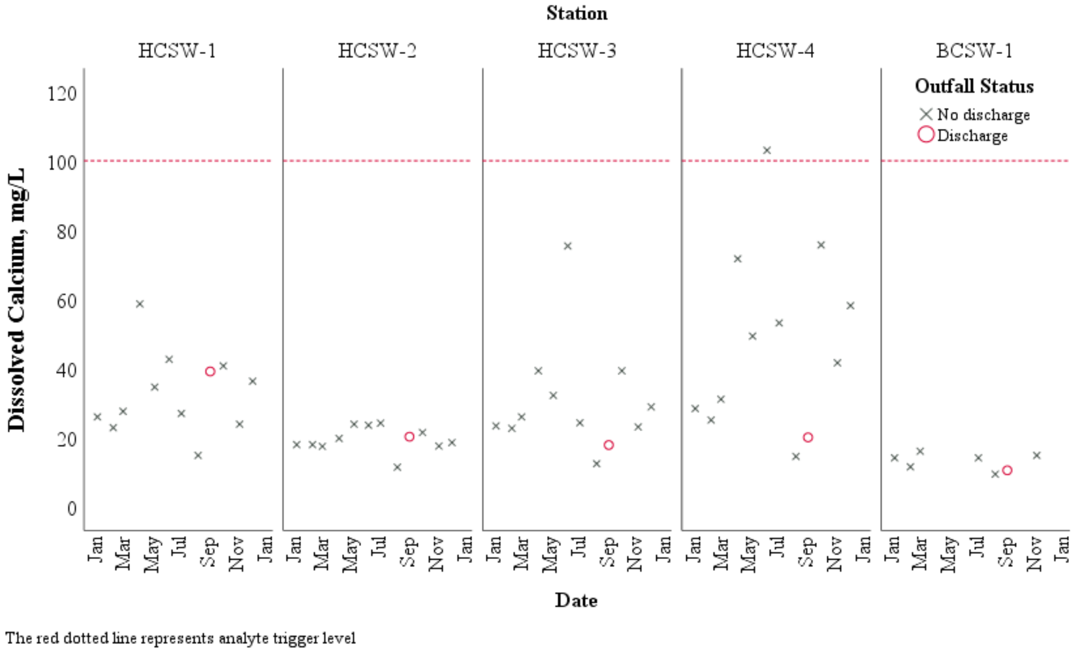
[34] Minimum detection limit = 10 µS

dissolved calcium values, stream flow, baseflow, NPDES discharge, and land use were discussed in detail in the 2018 HCSP TDS, Sulfate, and Calcium Impact Assessment. The Impact Assessment showed that calcium concentrations increased under low flow conditions, were not related to the outfall, and were linked to tributaries in the lower basin that are impacted by agriculture. To date, there have been no calcium exceedances at HCSW-1 and HCSW-2, the two sites closest to the outfalls (Appendix C, Figure C-13).



The red dotted line represents analyte trigger level

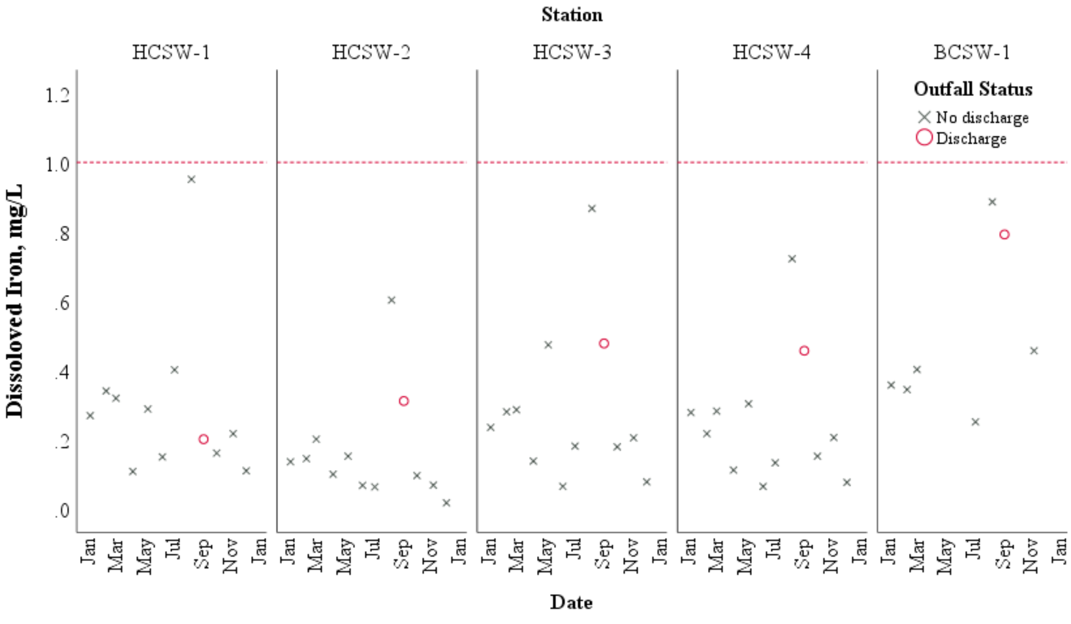
Figure 6-16 Dissolved Calcium Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2019

6.4.3 Dissolved Iron

Dissolved iron concentrations at all stations were below the 1 mg/L trigger level during all sampling events in 2019. The iron concentrations at HCSW-1 and HCSW-4 measured by the HCSP were not compared to data collected by other sources because the historical data is limited for this water quality parameter. Over the HCSP period of record, HCSW-4 was compared to a 0.3 mg/L trigger level and the other three stations were compared to a 1.0 mg/L iron trigger level. In December 2019, during the 2018 HCSP Annual Report TAG meeting, the PRMRWA and TAG agreed to compare all stations instead to the 1.0 mg/L trigger level(Appendix B, change #15).

Dissolved iron concentrations were not different among stations over the HCSP period of record (ANOVA, Table 6-2; Appendix C, Figure C-14). Iron was positively correlated with all water quantity variables at HCSW-1 and HCSW-4 (rainfall, streamflow, and NPDES discharge, Spearman's rank correlations, Table 6-3); streamflow and NPDES discharge are positively correlated with rainfall (with lag times), and iron is generally highest during or following periods of high rainfall. Brushy Creek had slightly higher iron concentrations than most Horse Creek stations in 2019.

Over the HCSP period of record, there were decreasing monotonic trends for dissolved iron since at both HCSW-1 and HCSW-4 (Seasonal Kendall-tau with LOESS, slope = -0.01 mg/L per year flow-adjusted concentration at both sites, Table 6-1). Because the direction of this potential trend is opposite that of the HCSP trigger level, it is not of concern.



The red dotted line represents analyte trigger level

Figure 6-17 Dissolved Iron Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2019.

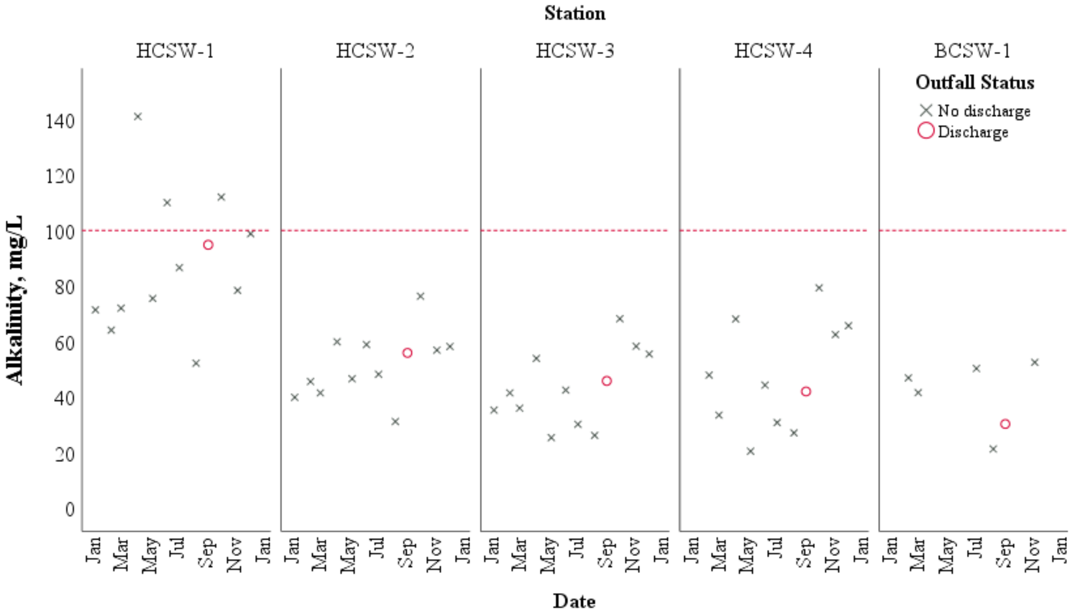
6.4.4 Total Alkalinity

There were three Total Alkalinity exceedances in 2019 all occurring at HCSW-1 when there was no NPDES discharge (Figure 6-18, Table 6-4). The alkalinity concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Appendix C, Figure C-34).

Total alkalinity was different among stations from 2003 to 2019 (ANOVA, Table 6-2), with values highest at HCSW-1, followed by HCSW-4, HCSW-2, then HCSW-3 (Duncan's multiple range test, $p < 0.05$, Figure 6-20). Alkalinity was negatively correlated with rainfall, streamflow, and NPDES discharge at HCSW-4 (Spearman's rank correlation,

Table 6-3), which is consistent with the concept that higher flows from rainfall would reflect the lower alkalinity of rainwater, compared with dry season inputs of groundwater. This condition suggests that groundwater seepage and agriculture irrigation runoff may also contribute to higher levels of alkalinity at HCSW-4. Alkalinity at HCSW-1 was negatively correlated with rainfall and not correlated with streamflow or NPDES discharge (Table 6-3). Higher levels of alkalinity at HCSW-1 may be partly attributed to the exposed limestone substrate in the stream banks that is unique to that station and other upstream factors that were discussed as part of the 2017 HCSP Specific Conductivity Impact Assessment.

There was an increasing monotonic trend present from 2003 to 2019 at both HCSW-1 and HCSW-4 (Seasonal Kendall-tau with LOESS, slope = 2.0 mg/L and 1.1 mg/L per year flow-adjusted concentration, respectively, Table 6-1). The estimated slope for HCSW-1 and HCSW-4 is small compared to the differences between primary and field duplicate samples (≤16 mg/L). The trend for alkalinity, like specific conductivity, may have been influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities, but the current concentrations are stable and not biologically harmful (2017 HCSP Impact Assessment).



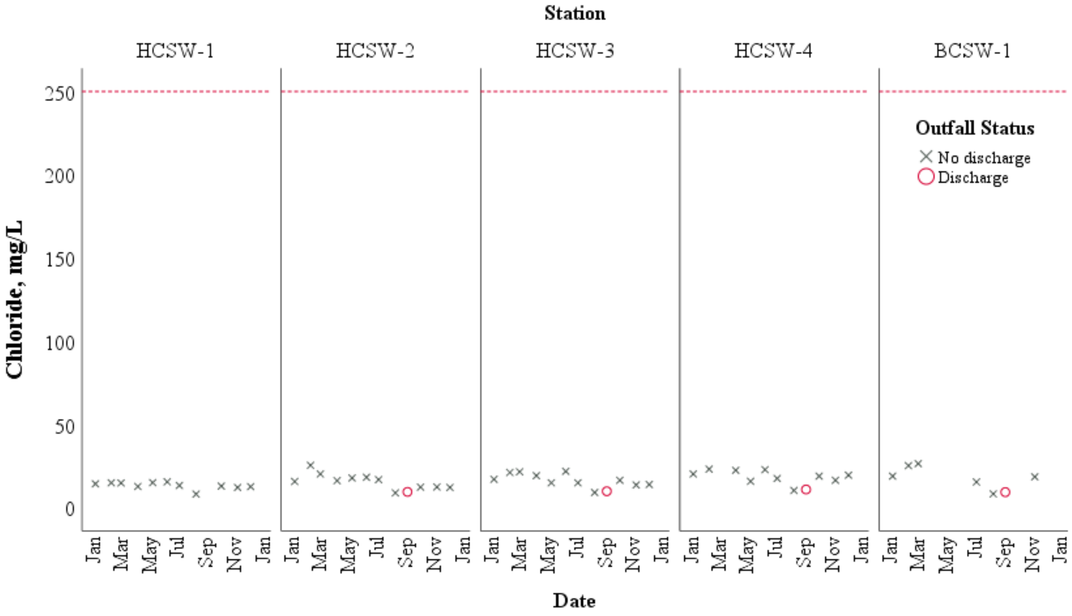
The red dotted line represents analyte trigger level

Figure 6-18 Total Alkalinity Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2019

6.4.5 Chloride

Chloride concentrations were below the trigger level at all sites for all of 2019 (Figure 6-19) and have been throughout the HCSP period of record (Appendix C, Figure C-16). Chloride concentrations were different among stations during all sampling events from 2003 to 2019 (ANOVA, Table 6-2), with a pattern of increasing concentrations from upstream to downstream (Duncan's multiple range test, $p < 0.05$), suggesting the possible influence from groundwater seepage and agriculture irrigation runoff.

Chloride was negatively correlated with all water quantity parameters at HCSW-1 and HCSW-4 (rainfall, streamflow, and NPDES discharge, Spearman's rank correlations, Table 6-3). Because streamflow and NPDES discharge are positively correlated with rainfall (with lag times), chloride concentrations tends to be lower during or following periods of high rainfall. Brushy Creek had similar concentrations to the Horse Creek stations. No monotonic trends were detected at either HCSW-1 or HCSW-4 over the HCSP period of record (Seasonal Kendall-tau with LOESS, $p > 0.05$, Table 6-1).



The red dotted line represents analyte trigger level

Figure 6-19 Chloride Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2019

6.4.6 Fluoride

Fluoride concentrations were well below the trigger level of 4.0 mg/L established for HCSW-1, HCSW-2, and HCSW-3, as well as the 1.5 mg/L trigger level for HCSW-4 in 2019 (Figure 6-20) and over the entire HCSP period of record (Appendix C, Figure C-17). Brushy Creek tends to have lower fluoride concentrations than the Horse Creek stations. The fluoride concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at those locations (Appendix C, Figure C-36).

Fluoride concentrations were different among stations over the HCSP period of record (ANOVA, Table 6-2), with the highest concentrations at HCSW-1, followed by HCSW-4, HCSW-3, then HCSW-2 (Duncan's multiple range test, $p < 0.05$). Fluoride was positively correlated with NPDES discharge and streamflow at HCSW-1 (Spearman's rank correlations, Table 6-3) and negatively correlated with streamflow, NPDES discharge, and rainfall at HCSW-4. The positive relationship with NPDES and streamflow at HCSW-1 and the negative relationship with streamflow, NPDES, and rainfall at HCSW-4 suggests that the NPDES discharge is contributing more fluoride to the Horse Creek than other sources, and it is being diluted as it moves further downstream.

Based on trend analysis performed by combining[35] HCSP data with SWFWMD from 2003 to 2019, a very small monotonic trend was detected for fluoride at both HCSW-1 and HCSW-4 (0.01 and < 0.01 mg/L/year, respectively Seasonal Kendall-tau with LOESS, $p < 0.05$, Table 6-1). The magnitude of the detected trends is less than the method Practical Quantitation Limit (PQL) and the trends themselves might be an artifact of most of the dataset consisting of values very near detection limits.

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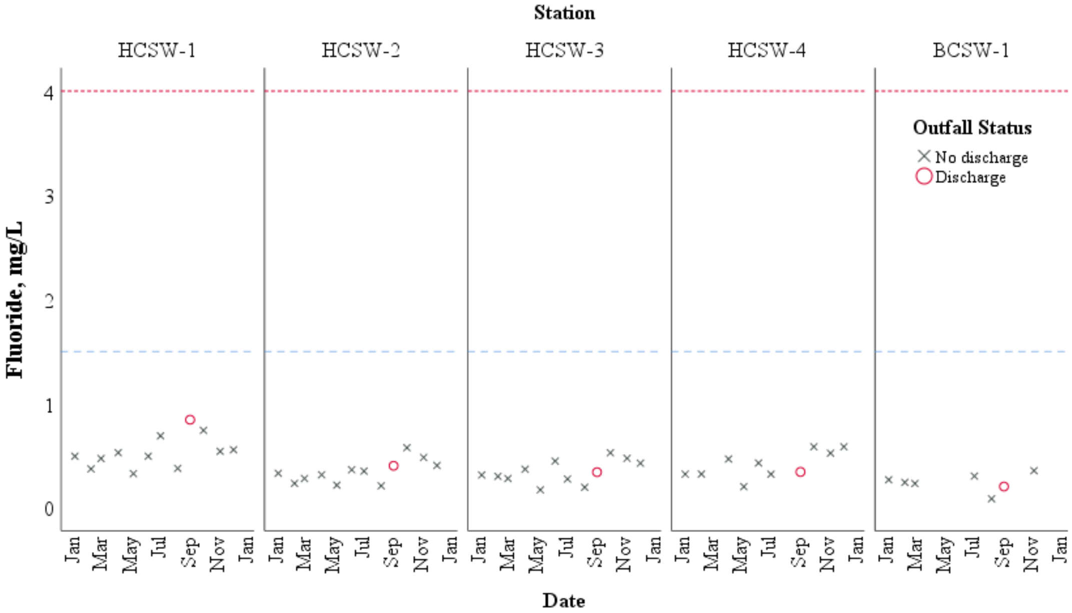
[35] Between 5/06- 3/08, HCSP fluoride MDLs were censored at high concentrations (low accuracy, MDLs 0.5- 5.0 mg/L, NOx). Previous reports ran trend analysis on SWFWMD datasets only. Fluoride trend analysis in this report was handled by supplementing the HCSP data with SWFWMD data from 2003-2019 period and the removal of the low accuracy fluoride data with MDLs ≥0.5 mg/L. Typical fluoride MDLs for HCSP data are ≤0.1 mg/L.



Dotted lines represents the analyte trigger values. Blue line represents trigger level specific to HCSW-4.

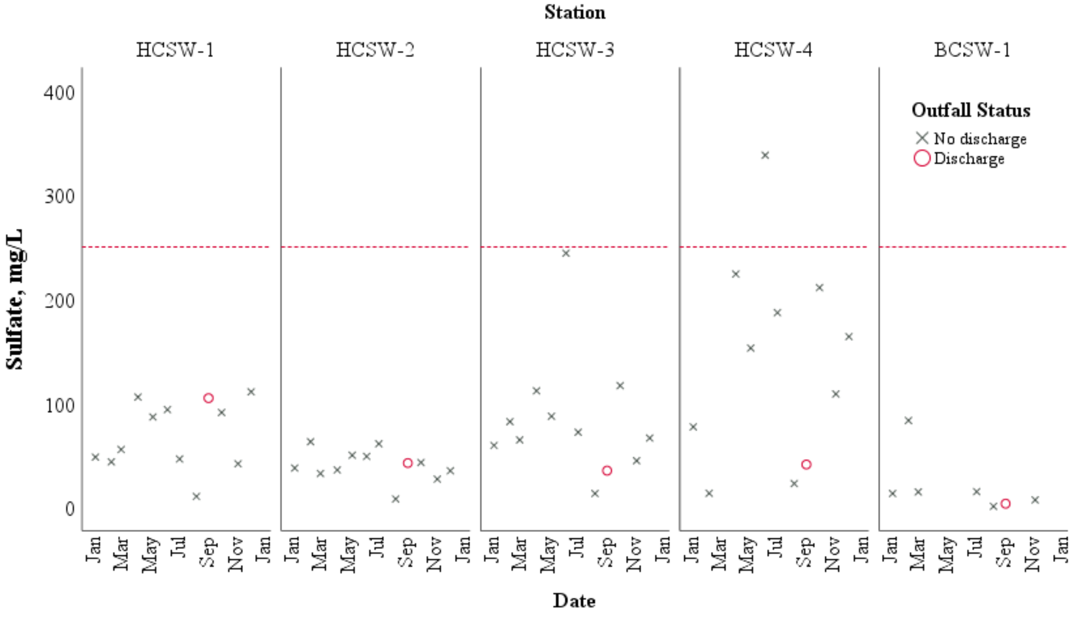
Figure 6-20 Fluoride Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2019

6.4.7 Sulfate

The single recorded sulfate exceedance in 2019 occurred at HCSW-4 in June, 338 days after the last NPDES discharge (Table 6-4, Figure 6-21). Brushy Creek sulfate concentrations tended to be lower than at Horse Creek stations during all events in 2019 and throughout the HCSP period of record (Appendix C, Figure C-18). The sulfate concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Appendix C, Figure C-37).

Sulfate concentrations were different among stations over the HCSP period of record (ANOVA, Table 6-2), with lowest levels at HCSW-2, followed by HCSW-1, HCSW-3, then HCSW-4 (Duncan's multiple range test, $p < 0.05$). As with specific conductivity, TDS, and calcium, sulfate concentrations were found to be higher during periods of low stream flow, and within proximity to agricultural runoff (2018 Annual Report, Appendix I). At HCSW-1, sulfate was positively correlated with NPDES discharge (Table 6-3) but negatively correlated with rainfall, streamflow, and NPDES discharge at HCSW-4 (Spearman's rank correlation, Table 6-3). There have been no sulfate trigger exceedances at HCSW-1 or HCSW-2 over the period of record (Appendix C, Figure C-18).

There was an increasing monotonic trend present from 2003 to 2019 at both HCSW-1 and HCSW-4 (Seasonal Kendall-tau with LOESS, slope = 3.9 mg/L per year flow-adjusted concentration at both sites, Table 6-1). The trend for sulfate, like conductivity, is being influenced by regional factors unrelated to mining activities including, drought-period baseflow contributions, and land being converted to irrigated agricultural fields; but the current concentrations are stable and not biologically harmful (2018 Annual Report, Appendix I).



The red dotted line represents analyte trigger level

Figure 6-21 Sulfate Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2019

6.4.8 Total Dissolved Solids

There were two Total Dissolved Solids (TDS) exceedances of the trigger level in April and June 2019, both occurring at HCSW-4 (Table 6-4 & Figure 6-24). Brushy Creek concentrations were typically lower than at the Horse Creek stations. The TDS concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at those locations (Appendix C, Figure C-38).

As with sulfate concentrations, TDS concentrations over the course of the 2003 to 2019 HCSP period of record were lowest at HCSW-2, followed by HCSW-1, HCSW-3, and then HCSW-4 (ANOVA, Duncan's multiple range test, $p < 0.05$, Table 6-2). TDS concentrations were negatively correlated with rainfall, streamflow, and NPDES discharge at HCSW-4 (Spearman's rank correlation, Table 6-3), but positively correlated with streamflow and NPDES discharge at HCSW-1 (Table 6-3). Both sulfate and TDS at downstream stations are affected by agricultural irrigation return flows and groundwater seepage downstream in the same manner as discussed above for conductivity, calcium, and sulfate (2018 Annual Report, Appendix I).

There was an increasing monotonic trend present from 2003 to 2019 at both HCSW-1 (Seasonal Kendall-tau with LOESS, slope = 8.5 mg/L per year flow-adjusted concentration) and HCSW-4 (slope = 5.5 mg/L per year flow-adjusted concentration, Table 6-1). The trend for TDS and other ions may have been influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities, but the current concentrations are stable and not biologically harmful (2018 Annual Report, Appendix I). There has been only one exceedance of TDS at HCSW-1 during the period of record: 524 mg/L on April 11, 2017- 100 days after the last discharge.

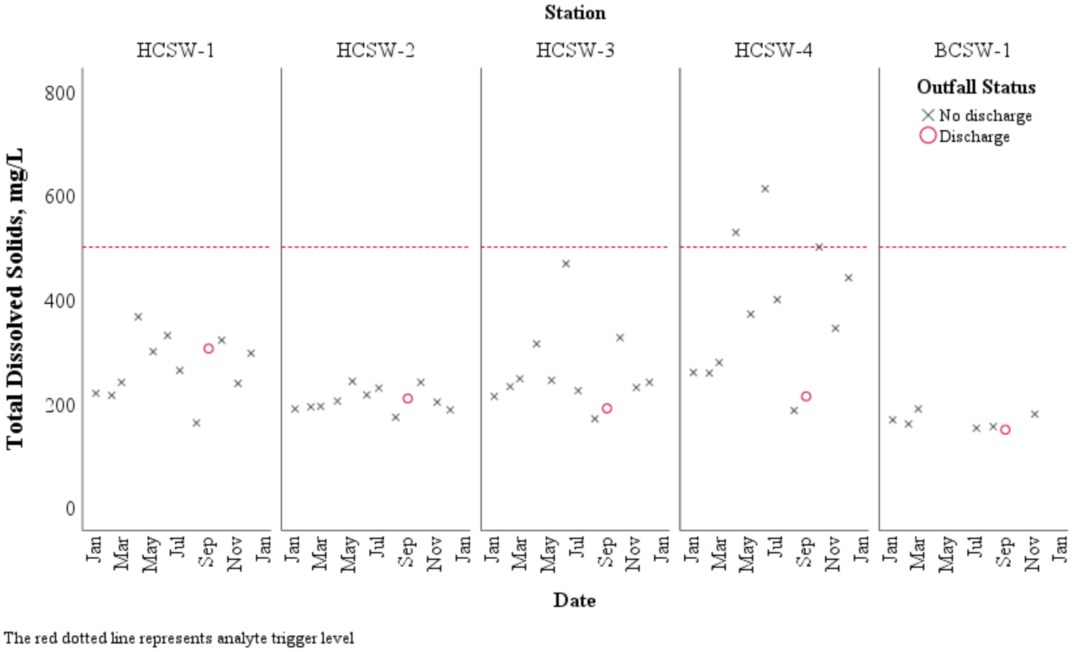


Figure 6-22 Total Dissolved Solids Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2019

6.4.9 Total Radium

Phosphate ore is a source of radioactivity as naturally occurring uranium-238 disintegrates into isotopes of radium and radon, which emit alpha particles in water. A water quality study of unmined and reclaimed basins in phosphate-mining areas found that radium concentrations of surface waters were slightly higher in unmined areas than in reclaimed basins, probably because of undisturbed phosphate deposits near the surface of unmined lands (Lewelling and Wylie 1993). Clay-settling areas may trap radioactive chemicals associated with clay slurry but release only small amounts of radioactive chemicals into surface waters (Lewelling and Wylie 1993).

In Horse Creek during 2019, total radium[36] levels were below the trigger level of 5 pCi/L (Figure 6-25) at all stations during all sampling events. Brushy Creek concentrations were similar to Horse Creek stations. There were no monotonic trends observed since 2003 for total radium at HCSW-1 or HCSW-4[37] (Seasonal Kendall-tau, $p > 0.05$, Table 6-1). Total radium levels from 2003 to 2019 were different among stations (ANOVA, Table 6-2) with lowest levels at HCSW-2, followed by HCSW-4, HCSW-1, then HCSW-3 (Duncan's multiple range test, $p < 0.05$). Total radium was negatively correlated with NPDES discharge and streamflow at HCSW-1 and HCSW- 4 (Spearman's rank correlations, Table 6-3), indicating that radium was higher when NPDES discharge and streamflow were low. Some of the correlation analyses with radium and water quantity may be affected by an apparent step decrease that occurred in 2008, coincident with a change in analytical laboratories (Appendix K).

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[36] The HCSP methodology specifies that "Radium 226 + 228" be analyzed as part of the monthly sampling. This data has been reported as both individual constituents and as a total (Appendix E). Starting in December 2003 and continuing through the present, the data has been analyzed and reported as Radium 226 and Radium 228 separately and an arithmetic sum of the two numbers ("Radium 226 + 228"). As requested by the PRMRWSA, if either Radium 226 or Radium 228 is undetected, the MDL of the undetected constituent will be used as part of the "Radium 226 + 228." This use of MDL for undetected constituents as part of a calculated constituent is contrary to both laboratory and DEP SOPs.

[37] POR record Total Radium data contains mostly censored values (i.e. less than values or values reported at the MDL). Additionally, the HCSP protocol inherently overestimates Total Radium by summing the 226Ra and 228Ra values at their respective MDLs.

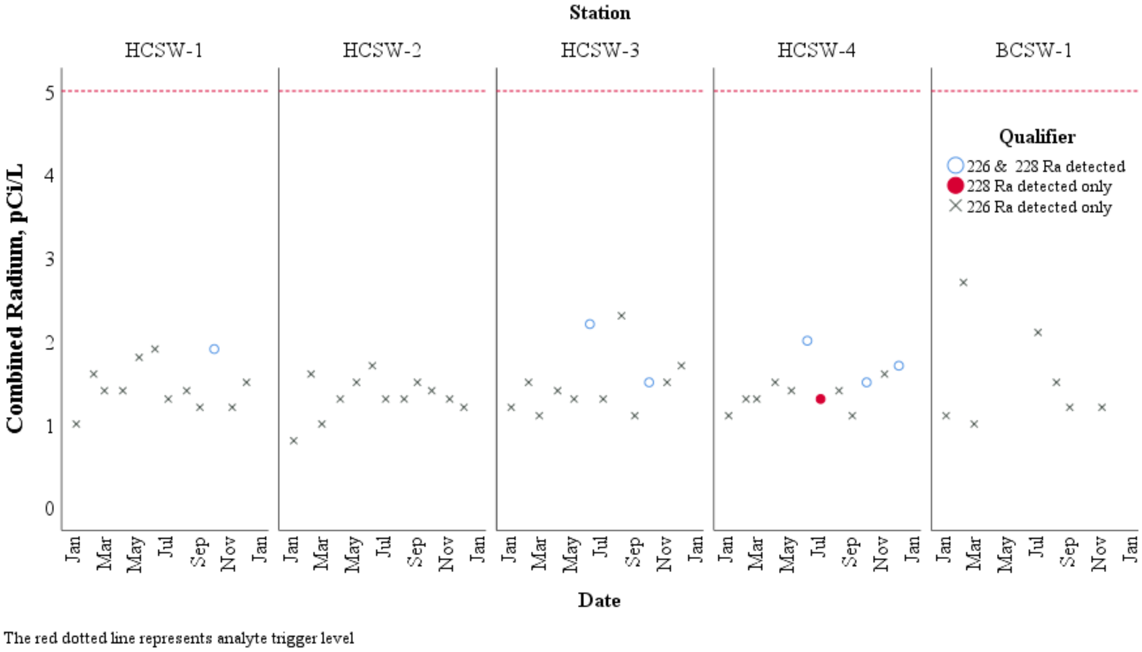

Figure 6-23 Combined Radium (^{226}Ra + ^{228}Ra) Obtained During Monthly HCSP Water Quality Sampling, 2019

6.5 Summary of Water Quality Results

Water quality parameters in 2019 were almost always within the desirable range relative to trigger levels and surface water quality standards at the station with the highest percent of upstream mined lands and receiving the most concentrated mining effluent (HCSW-1, Table 6-4). Alkalinity was the only parameter above the trigger level at HCSW-1 during 2019, but the exceedances did not occur during times of NPDES discharge (Table 6-4). The dissolved oxygen trigger level was exceeded during most of the monthly sampling events at HCSW-2 (January to November 2019) but at no other stations. Based upon historical conditions in Horse Creek (Durbin and Raymond 2006), the reported values for dissolved oxygen at HCSW-2 are the result of natural conditions (proximity to hypoxic segment of stream – Horse Creek Prairie) and are not related to mining activities.

Total Ammonia was above the trigger value at sites HCSW-2 and HCSW-3 in October and May 2019 and an impact assessment was completed to look at historical ammonia values in Horse Creek (Appendix I). The report found that ammonia exceedances predated the outfalls, occurred mostly in the Lower Horse Creek basin, and did not appear to be as a result of NPDES discharge but rather agricultural operations along the shoreline of Horse Creek and its tributaries.

Ion concentrations (dissolved calcium, sulfate, and TDS) were above the trigger levels during low flow periods in April and June at HCSW-4. Based on impact assessments already completed, none of the observed exceedances pose a significant adverse ecological impact to Horse Creek that would be attributable to mining (2018 HCSP Annual Report, Appendix I).

Nine water quality parameters showed statistically significant increasing trends over the HCSP period of record at HCSW-1 (7) or HCSW-4 (8). Several of the trends detected during the statistical analysis either have an estimated slope that 1) was not in the direction of an adverse trend (dissolved oxygen saturation, color), or 2) was very small compared to the observed differences between primary and duplicate field samples (pH, turbidity, TKN, and fluoride) (Table 6-5). As the period of record increases, trends slopes are decreasing (Specific conductivity, TDS, sulfate, calcium). The potential trends for pH and specific conductivity (with reference to TDS and other ions) were discussed in Appendix I of the 2017 HCSP Annual Report.

Parameters with detected trends at HCSW-1 meet all applicable state drinking water and Class III surface water standards. Significant differences between stations were evident for several parameters. When stations were compared, HCSW-2 was the most dissimilar from the other three stations, especially in pH, dissolved oxygen, color, chlorophyll-*a*, and some dissolved ions (dissolved calcium, fluoride, sulfate, and TDS). Some nutrients (nitrate-nitrite, total ammonia, TKN, and TN) and dissolved ions (specific conductivity, calcium, chloride, and sulfate) had higher concentrations downstream in Horse Creek, probably because of increased groundwater seepage and the predominance of agricultural irrigation runoff in the lower Horse Creek basin during dry periods. Differences in topography, geology, and land use that could account for these station differences in Horse Creek are examined in the Horse Creek Stewardship Program Historical Report (Durbin and Raymond 2006).

Water quality parameters were compared with water quantity variables recorded during the same month: average daily streamflow for the month, average daily NPDES discharge for the month, and total monthly rainfall (Table 6-3). In general, pH, dissolved oxygen, and most dissolved ions are higher when the overall quantity of water in the Horse Creek system is low. (In this report, chlorophyll-a, specific conductivity, calcium, alkalinity, sulfate, and TDS showed the opposite pattern with NPDES discharge at HCSW-1). Conversely, turbidity, color, iron, and nitrogen concentrations are high when the water quantity is also high. When water quantity in Horse Creek is low, the stream is often pooled or slow-moving, leading to algal blooms that may increase pH and chlorophyll-a, particularly at HCSW-2. In addition, the majority of water in the stream during low quantity periods may be from groundwater (seepage or agricultural runoff); groundwater has a higher concentration of dissolved ions than surface water. When water quantity is high because of rainfall or streamflow, an increased amount of sediment and organic debris is washed into the stream, leading to increases in turbidity, color, iron, and nitrogen.

Table 6-4 Instances of Trigger Level Exceedance Observed in 2019 HCSP Monthly Monitoring

Site	Date	Analyte	Result	Trigger Level	Last NPDES Discharge, days	Average Daily Discharge, MG
HCSW-1	11-Apr	Alkalinity, mg/L	141	100	187	0.75
HCSW-1	13-Jun		110	100	250	0.75
HCSW-1	7-Oct		112	100	22	1.59
HCSW-4	13-Jun	Calcium, Dissolved, mg/L	103	100	250	0.75
HCSW-2	13-Jun	Corrected Chlorophyll a, mg/m^3	17	15	250	0.75
HCSW-2	10-Jan	Dissolved Oxygen Saturation, %	39.1	40.6*	96	0.75
HCSW-2	13-Feb		39	40.9*	130	0.75
HCSW-2	6-Mar		42.3	42.4*	151	0.75
HCSW-2	13-May		18.2	39.8*	219	0.75
HCSW-2	9-Jul		24.3	39.6*	276	0.75
HCSW-2	14-Aug		17.1	40.4*	312	0.75
HCSW-2	9-Sep		3.4	39.8*	0	26.28
HCSW-2	7-Oct		21.8	40.2*	22	1.59
HCSW-2	11-Nov		24.2	40.4*	57	1.59
HCSW-4	11-Apr	Total Dissolved Solids, mg/L	528	500	187	0.75
HCSW-4	13-Jun		612	500	250	0.75
HCSW-2	7-Oct	Nitrogen, Ammonia, mg/L	0.32	0.3	22	1.59
HCSW-3	13-May		0.51	0.3	219	0.75
HCSW-4	13-Jun	Sulfate, mg/L	338	250	250	0.75

*HCSP Dissolved Oxygen Saturation Trigger level is 38%. Values in trigger level column indicate FDEP time-of day criteria.

Table 6-5 Summary of Trends Over Time (2003 to 2019) from Seasonal Kendall-tau Analysis

Parameter	HCSW-1 Slope	HCSW-4 Slope	Discussion
Alkalinity	2 mg/L/yr	1.1 mg/L/yr	Not an adverse trend
Calcium	1.2 mg/L/yr	0.7 mg/L/yr	Discussed in 2018 Historical Assessment
Color		2.6 PCU/yr	Not an adverse trend
DO saturation	0.8%/yr		Not an adverse trend*
pH	0.04 S.U./yr	0.02 S.U./yr	Slope very small in magnitude. Isolated step change.
Specific Conductance	11 µS/yr	7.9 µS/yr	Discussed in 2017 Historical Assessment
Sulfate	3.9 mg/L/yr	3.9 mg/L/yr	Discussed in 2018 Historical Assessment
TDS	8.5 mg/L/yr	5.5 mg/L/yr	Discussed in 2018 Historical Assessment
Turbidity		0.08 NTU/yr	Slope very small in magnitude; not at HCSW-1.

*In some cases increased DO is a symptom of adverse conditions caused by eutrophcation and algal blooms and in other cases it can indicate improved flow conditions. In this case , Horse Creek shows no evidence of eutrophication based on both its nutrient concentrtaions and floral metrics.

7.0 BIOLOGICAL RESULTS AND DISCUSSION

7.1 Benthic Macroinvertebrates

Benthic macroinvertebrate sampling was conducted at all stations during the April, July, and November 2019 sampling events except for HCSW-2 during the April and July 2019 sampling events. The Brushy Creek location is not included in the macroinvertebrate sampling component of the HCSP.

As discussed in Section 4.4, the calculation methodology for the SCI was initially revised by FDEP in June 2004, and sampling conducted from 2003 to 2006 uses that methodology. In 2007, the FDEP SCI protocol[38] was again revised, this time to include provisions for the taxonomic analysis of two aliquots for every SCI sample collected to account for variation in sample sorting (DEP-SOP-002/01 LT 7200). Under the new protocol, the SCI score for each sample is the arithmetic average of the SCI scores of the two aliquots. In addition to the change in aliquots in 2007, the new protocol also gives a slightly different ecological interpretation of SCI scores (Table 4-5). The SCI protocol was revised again in 2012 (DEP-SOP-003/11 SCI 1000), making changes to the SCI calculation but not the sampling methodology. This report has scores in the tables and graphics updated to the 2012 methodology. Scores from the 2004 SCI formulae (collected from 2003 to 2006) and the 2012 SCI formulae (collected from 2007 to the present with two vials) may not be directly comparable, given the differences in how they were collected (noted in Figures 7-2 to 7-5). Any statistical analysis conducted on the invertebrate sampling in this report omits the samples collected under the 2004 SCI (collected from 2003 to 2006).

7.2 Stream Habitat Assessment

The majority of the habitat assessment parameters evaluated through the FDEP procedure are not directly related to mining, but are generally related to the nature of the system being examined and its surroundings (e.g., substrate diversity and availability, artificial channelization, bank stability, buffer width, and vegetation quality). Parameters that might be hypothesized to have some linkage to mining are water velocity and habitat smothering, primarily as a result of NPDES discharges to a stream. The Stream Habitat Assessment (HA) is best looked at as qualifier to water quality and biodiversity outcomes: if a stream scores high on the HA, the expectation is the biological response (e.g. SCI & Shannon-Wiener) will also score higher, unless there is some other effect inhibiting life (e.g. water quality, environmental perturbation). If a stream scores low on a HA, the expectation is the site will have a low biological response score regardless of water quality.

For the habitat assessment metric on smothering, the productive habitats are evaluated and the degree to which they are smothered is recorded (none, slight, moderate, or severe). HCSW-1 is higher up in the basin and receives less sediment load that could smother the various habitats (roots, snags, and rock) from upstream sources. The more downstream locations have a larger

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[38] Appendix J includes SCI 2004, 2007, and 2012 scores for comparison.

basin area that contributes both sediment and flowing water. HCSW-3 and HCSW-4 have higher smothering that occurs in the productive habitats (roots, snags, and aquatic vegetation) usually after high flows when sediment settles out after flow decreases.

The habitat quality of Horse Creek ranged between 79 and 137 during all sampling events in 2019 (Table 7-1, Figure 7-1). All sampling events resulted in categorical scores of "sub-optimal" except at HCSW-1 and HCSW-3 in April. HCSW-1 scored in the "optimal" category while HCSW-3 scored in the "marginal" category. The higher scores at HCSW-1 were due to having more substrate diversity and availability. The lower scores at HCSW-3 were due to rescoring of riparian buffer quality (based on best professional judgement), low available quality habitat, and bank erosion, likely because of higher flows and cattle activity. Some of the minor variation among the sampling events for a given station primarily reflects differences in habitat quality and quantity caused by changes in stream stage, which affects the availability and ratios of in-stream habitats, and also the inherent variability in the habitat scoring protocol itself. The fall sampling event is usually immediately following summer high flows where the banks are scoured (lower habitat stability), and there may not be any vegetation in the water to sample as a productive habitat (lower substrate diversity and availability). For those reasons, the overall habitat assessment score tends to be lower in the summer or fall.

Table 7-1 Habitat Scores Obtained During HCSP Biological Sampling Events in 2019

Habitat Characteristic		HCSW-1			HCSW-2			HCSW-3			HCSW-4		
		4-Apr-19	3-Jul-19	13-Nov-19	4-Apr-19	3-Jul-19	13-Nov-19	4-Apr-19	3-Jul-19	13-Nov-19	4-Apr-19	3-Jul-19	13-Nov-19
Substrate Diversity (20)		14	9	10	Not sampled	Not sampled	7	5	5	2	2	8	2
Substrate Availability (20)		20	8	4			1	3	3	1	1	2	1
Water Velocity (20)		14	20	20			8	14	19	16	15	18	20
Habitat Smothering (20)		19	17	13			12	11	16	11	11	16	11
Artificial Channelization (20)		20	20	20			20	20	20	20	15	19	20
Bank Stability (10 each bank)	Right Bank	7	5	3			10	8	9	9	9	9	9
	Left Bank	7	6	4			9	7	6	8	7	9	9
Riparian Buffer Zone Width (10 each bank)	Right Bank	9	10	10			10	3	5	10	10	10	10
	Left Bank	9	10	10			10	3	1	10	6	10	10
Riparian Zone Vegetation Quality (10 each bank)	Right Bank	9	7	9			8	2	5	5	8	9	8
	Left Bank	9	8	9			9	3	2	5	8	9	8
Total Score*		**137**	**120**	**112**			**104**	**79**	**91**	**97**	**92**	**119**	**108**

† Max scores for each metric in parentheses.

* - The maximum possible score under this protocol is 160 (121-160 Optimal, 81-120 Suboptimal, 41-80 Marginal, <40 Poor).

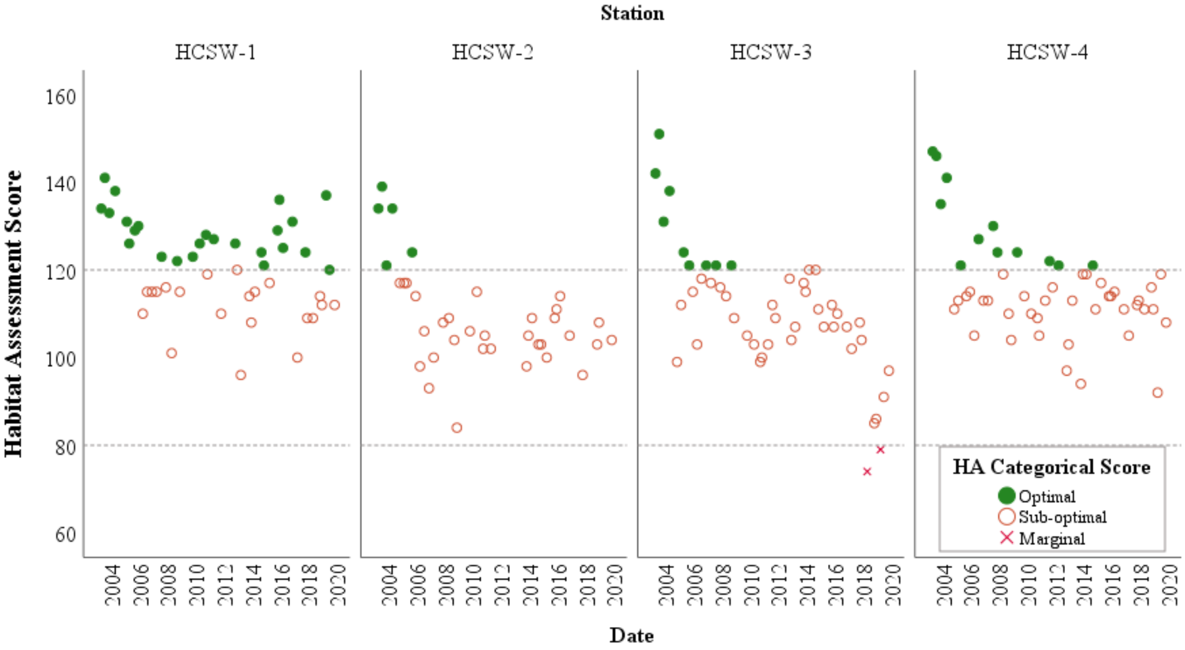

Figure 7-1 **Aquatic Habitat Assessment Scores Obtained during HCSP Biological Sampling Events at all Locations from 2003 to 2019**

7.3 Stream Condition Index

A list of the benthic macroinvertebrate taxa collected from 2003 to 2019 is on the attached database file[39]. Table 7-2 provides the SCI metrics, resulting SCI values, and total SCI scores calculated as a vial average for the benthic macroinvertebrates collected at the four stations during each sampling event in 2019. The numbers of individuals included in Table 7-2 represent the number extracted from the whole sample for identification (i.e., all 20 dipnet sweeps), which were analyzed by the taxonomist (only a portion of each sample is sorted and processed, per the Standard Operating Procedure (SOP)). The SCI scores in 2019 were at or above 35 (considered "Healthy") for all stations and events except HCSW-2 and HCSW-4 in November. The biological sampling location at HCSW-2 frequently has lower flow and lower dissolved oxygen conditions than the other stations. The sampling location at HCSW-4 is more prone to substrate smothering compared to the other stations especially in the fall following higher flows.

Final SCI scores for the samples ranged from 19 (HCSW-2 in November) to 71 (HCSW-1 in November) in 2019, similar to other years (Table 7-2 and Figure 7-2). An annual Kendall trend test was run on each station and found a positive 1.15 units/year monotonic trend at HCSW-1 (Kendall-tau = 0.44, $p < 0.05$). A Seasonal Kendall trend analysis was then performed for each

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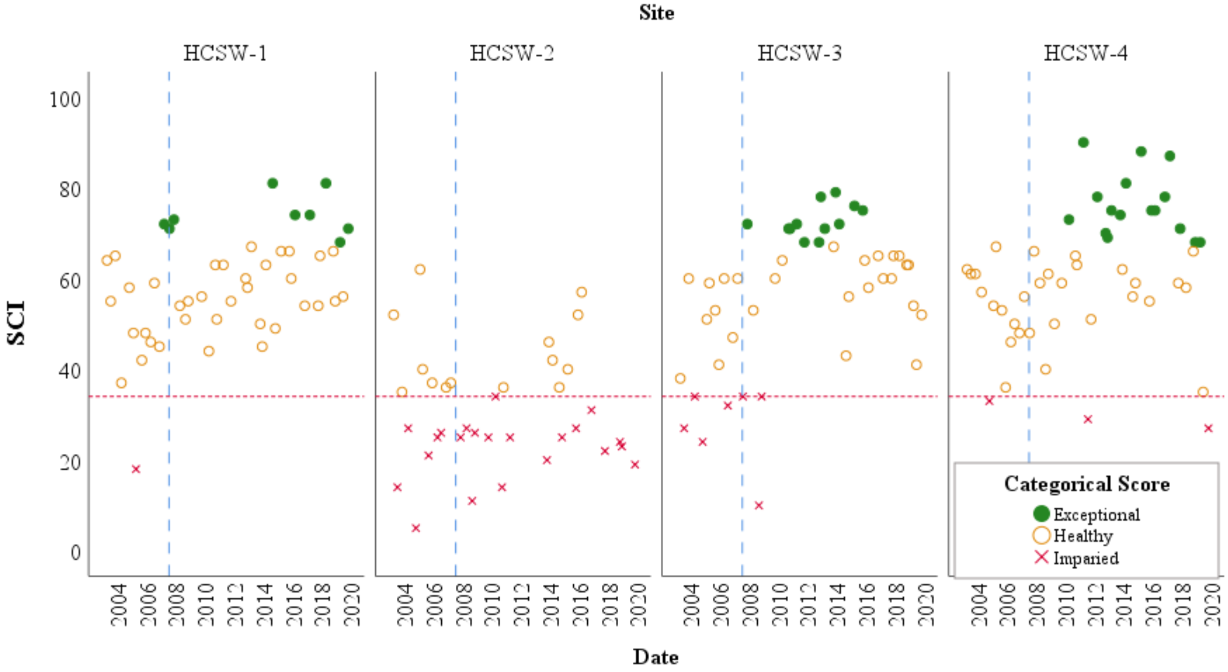
[39] Beginning with the 2010 annual report (Appendix J), the HCSP SCI data was reevaluated with strict interpretation of FDEP SOP guidance, including the upper and lower limits of the SOP target number of individuals, the SOP target of a minimum velocity of 0.05 m/sec 28 days prior to sampling, the SOP target of waiting at least 90 days after abatement of a stream dessication event (i.e. no refugia for organisms), and the SOP target of less than a 0.5 m water level increase in the previous 28 days. As a result of this evaluation, some SCI scores have been removed from the analysis (Appendix J). In addition, some SCI results with more than the target number of individuals were randomly resampled to provide an unbiased result.

station and found no significant monotonic trends at any of the stations. When considered over time from 2007 to 2019 (period when the 2012 SCI formulae can be used), the overall SCI scores were variable at each station; when all stations were combined, the SCI scores showed no significant monotonic trends over time. Because of low streamflow and dissolved oxygen concentrations related to the upstream prairie system, the SCI scores were lower at HCSW-2 than other stations (ANOVA: $F = 39$, $p < 0.001$; Duncan's multiple range test: $p < 0.05$, long term average of 30.2 compared to 60-64).

Table 7-2 SCI Metrics Calculated for Benthic Macroinvertebrates Collected at Four Locations in Horse Creek during 2019

SCI Metric	HCSW-1						HCSW-2					
	9-Apr-19		3-Jul-19		13-Nov-19		9-Apr-19		3-Jul-19		13-Nov-19	
	Raw Score	SCI Value	Raw Score	SCI Value	Raw Score	SCI Value	Raw Score	SCI Value	Raw Score	SCI Value	Raw Score	SCI Value
Total Taxa	27.00	5.00	22.00	2.92	28.50	5.63	No Sample - flow conditions not met for SCI		No Sample - flow conditions not met for SCI		25.50	4.38
Ephemeropteran Taxa	4.50	9.00	3.00	6.00	5.00	10.00					2.50	5.00
Trichopteran Taxa	3.50	5.00	5.00	7.14	4.00	5.71					0.00	0.00
Percent Filterer Taxa	11.66	2.55	19.14	4.29	10.88	2.37					2.59	0.44
Long-lived Taxa	7.00	10.00	4.50	6.43	7.50	10.71					0.50	0.71
Clinger Taxa	1.50	5.00	1.00	3.33	3.00	10.00					0.50	1.67
Percent Dominant Taxon	31.59	6.48	19.48	8.90	20.03	8.79					51.59	2.48
Percent Tanytarsini	5.05	5.28	1.29	2.32	1.33	2.37					0.32	0.73
Sensitive Taxa	3.00	4.29	2.00	2.86	4.50	6.43					0.50	0.71
Percent Very Tolerant Taxa	2.54	8.77	6.82	6.61	17.37	4.49					74.33	0.95
Total SCI Score	**68**		**56**		**71**						**19**	
Healthy/Impaired	**Exceptional**		**Healthy**		**Exceptional**						**Impaired**	
Total Number of Individuals	308		319		299						308	
Total Taxa	19.00	1.67	26.50	4.79	32.00	7.08	24.00	3.75	18.00	1.25	14.00	0.21
Ephemeropteran Taxa	3.00	6.00	2.50	5.00	2.50	5.00	5.00	9.00	3.00	6.00	2.00	4.00
Trichopteran Taxa	2.50	3.57	4.50	6.43	2.00	2.86	2.50	3.57	3.50	5.00	1.00	1.43
Percent Filterer Taxa	17.30	3.86	6.18	1.27	4.66	0.92	20.35	4.57	1.75	0.24	1.82	0.26
Long-lived Taxa	5.00	7.14	2.50	3.57	4.50	6.43	6.50	9.29	4.00	5.71	3.50	5.00
Clinger Taxa	1.50	5.00	1.00	3.33	2.50	8.33	1.00	3.33	1.00	3.33	1.50	5.00
Percent Dominant Taxon	36.50	5.50	29.57	6.89	32.12	6.38	19.65	8.87	51.00	2.60	66.89	0.00
Percent Tanytarsini	2.21	3.03	0.00	0.00	0.00	0.00	12.82	7.65	0.00	0.00	0.00	0.00
Sensitive Taxa	2.00	2.86	1.00	1.43	4.00	5.71	4.00	5.71	2.50	3.57	2.50	3.57
Percent Very Tolerant Taxa	1.28	9.53	19.15	4.24	17.71	4.44	12.17	5.45	21.56	3.99	15.56	4.85
Total SCI Score	**54**		**41**		**52**		**68**		**35**		**27**	
Healthy/Impaired	**Healthy**		**Healthy**		**Healthy**		**Exceptional**		**Healthy**		**Impaired**	
Total Number of Individuals	308		315		299		316		305		302	



Blue dashed vertical line indicates change in SCI calculation method. Red dotted horizontal line represents impaired score ceiling.

Figure 7-2 SCI Scores for Samples Collected at all HCSP Locations from 2003 to 2019

7.3.1 SCI Metrics

A healthy stream system will generally support a higher number of taxa than a disturbed stream. This is reflected in the Total Taxa SCI metric. In order to achieve an SCI score above zero for this metric, at least 16 taxa must be identified in a sample. Over 16 taxa were collected in at least one of the two replicates at all sampling locations except for exactly 16 taxa in HCSW-4 in November (Figure 7-3).

Ephemeropterans, or mayflies, are typically associated with more pristine waters and better habitat conditions; therefore, a higher count for the Ephemeropterans Taxa metric results in a higher SCI score. At least one mayfly taxon must be present to score this SCI metric above zero. Ephemeropterans were collected in at least one of the two replicates at all sampling locations.

Trichopterans, or caddisflies, are also associated with more pristine waters and better habitats; therefore, higher counts for the Trichopterans Taxa metric are also associated with better ecological conditions. At least one caddisfly taxon must be collected in order for this SCI metric to be above zero. Trichopterans were collected in at least one of the two replicates at all locations except at HCSW-2 in November 2019.

Disruption of food webs has long been associated with human influence, especially organic pollution. Of the functional feeding group measures, the relative abundance of filterers or suspension feeders (percentage of filterer individuals) had the highest correlation and most consistent relationship with human disturbance. Filter feeders extract nutrients by straining food particles from the water column. If the water flow or quality of the organic matter in the water is compromised, a reduction in filter feeders will occur. To score above zero for this Percent Filterers metric, more than one percent of the sample must be comprised of collector-filterers. All sampling locations exhibited greater than one percent collector-filterers in each replicate sampled.

Clingers are those taxa morphologically adapted to hold onto substrates during routine flow conditions and would be expected to decline as humans alter a stream's hydrograph (e.g., channelization), especially during abrasive events caused by high stormwater inputs from impervious surfaces. This Clinger Taxa metric increases as the number of clinger taxa increases within a sample. To score above zero for this SCI metric, at least one clinger taxon must be present in a sample. Clinger taxa were present in at least one of the two replicates at all locations in 2019.

Long-lived taxa are those that require more than one year to complete their life cycles; thus, they would not be expected in great numbers in intermittent streams or tributaries that go dry before the life cycle can be completed. Long-lived taxa richness would be expected to decrease if a disturbance event occurred at a site within a year of sampling. To score above zero for this SCI metric, at least one long-lived taxon must be present in a sample. Long-lived taxa were collected in at least one of the two replicates at all locations in 2019.

Substantial shifts in proportions of major groups of organisms, compared to reference conditions, may indicate degradation. Percent dominant taxon increases in conditions where a few pollution tolerant organisms are very abundant, to the exclusion of other taxa. The SCI score is zero if the Percent Dominant Taxa metric reaches or surpasses 64%. The range for all four sites was 16.22% (HCSW-1, November) – 68.21% (HCSW-4, November).

Species in the Chironomid assemblage Tanytarsini (midges) are commonly associated with less disturbed sites. Therefore, as the percentage of Tanytarsini increases for a sampling site there is a corresponding increase in the Percent Tanytarsini metric score. If there are no Tanytarsini individuals in a sample, this SCI metric score is zero. Tanytarsini individuals were not found in either sample replicates at HCSW-3 and HCSW-4 in July and November. The range of Percent Tanytarsini for all four sites was 0% (HCSW-3 and HCSW-4, July and HCSW-2, HCSW-3, and HCSW-4, November) –15.89% (HCSW-4, April).

Sensitive taxa are those that have been identified as sensitive to human disturbance; therefore, more sensitive taxa would be present in undeveloped "natural" areas as opposed to developed watersheds. At least one sensitive taxon must be collected to raise this Number of Sensitive Taxa metric score above zero. Sensitive taxa were collected in at least one of the two replicates at all locations in 2019.

A number of taxa have been classified as "very tolerant", meaning they are commonly present in areas with marked human disturbance (although they may also be found in undisturbed sites as well). Therefore, more disturbed and/or developed areas would be expected to have a higher percentage of tolerant taxa in comparison to areas that have not experienced human disturbance. This Percent Very Tolerant Taxa metric is similar to the percent contribution of Dominant Taxa metric in that, as the fraction of a sample comprised by these taxa increases, the calculated metric decreases. All replicates at all sites contained very tolerant taxa. The range of Percent Very Tolerant Taxa for all four sites across replicates was 0.63% (HCSW-3, April) – 78.06% (HCSW-2, November).

An annual Kendall trend analysis of taxa richness was run for each respective station and found a positive 0.88 units/year monotonic trend at HCSW-3 (Kendall-tau = 0.45, $p < 0.05$). A seasonal Kendall trend analysis was then performed for each station and found a positive 0.75 units/year monotonic trend at HCSW-3 (Kendall-tau = 0.36, $p < 0.05$).

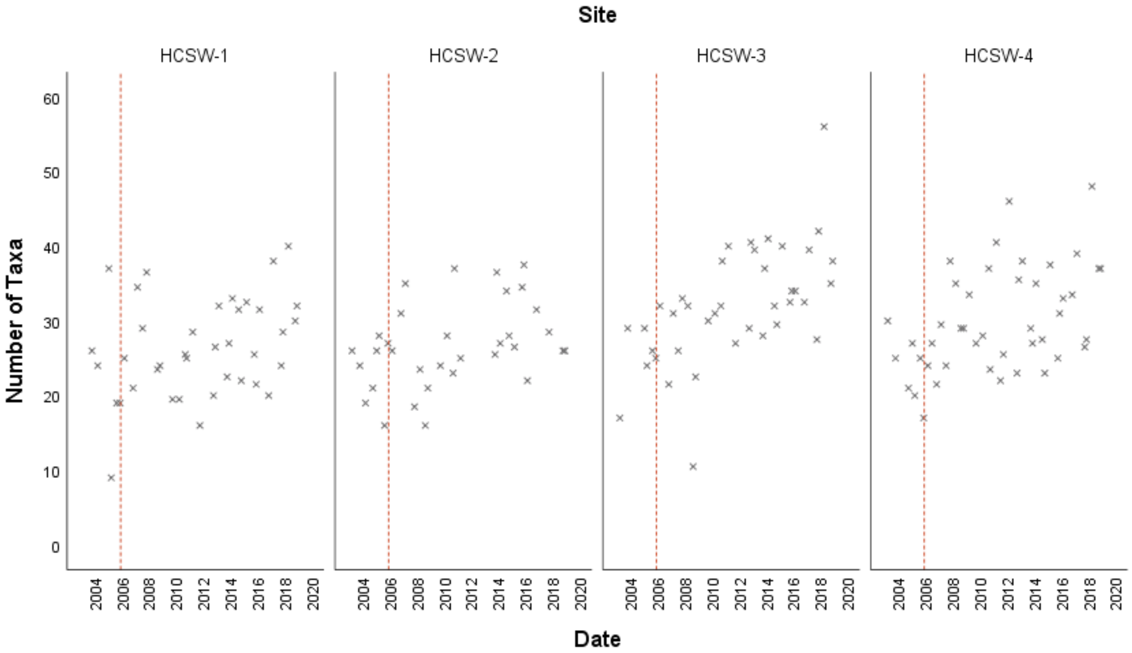


Figure 7-3 Number of Invertebrate Taxa Collected at all Locations for the HCSP from 2003 to 2019

7.3.2 Shannon-Wiener Diversity Index

Although not a component of the SCI protocol, the Shannon-Wiener Diversity Index is calculated for generic diversity for each benthic macroinvertebrate sampling event at each location. This index, one of the most popular measures of diversity, is based on information theory and is a measure of the degree of uncertainty in predicting what taxa would be drawn at random from a collection of taxa and individuals (Ludwig and Reynolds 1988). The Shannon-Wiener Index assumes that all taxa are represented in a sample and that the sample was obtained randomly:

$$H' = \sum_{i=1}^{S} (p_i)(log_2\, p_i)$$

where, H' = Information content of sample (bits/individual), index of taxa diversity,
S = Number of taxa, and
p_i = Proportion of total sample belonging to i^{th} taxa.

The Shannon-Wiener Index, H', increases with the number of taxa in the community and theoretically can reach very large values (Krebs 1998). In practice, however, H' does not generally exceed 5.0 for biological communities. The index is affected both by the number of taxa and their relative abundance; a greater number of taxa and a more even distribution of individuals across taxa both increase diversity as measured by H'. For example, consider two hypothetical communities, each with 100 individuals of 10 taxa captured. Community A is dominated by one taxon (91 of 100 individuals), while only one individual was captured for each of the other nine taxa. Community B, however, is even, with 10 individuals captured for each of the ten taxa. While taxa richness is the same for both communities, the Shannon-Wiener Diversity Index shows that Community B is much more diverse than Community A (H’ = 3.3 and 0.7, respectively), because Community A is dominated by only one taxon.

For the Horse Creek data, generic diversity[40], rather than species diversity, was used to account for the high variability of species present from year to year. In Horse Creek in 2019, the Shannon-Wiener Diversity Index for macroinvertebrates by sample date and station ranged from 1.84 (November, HCSW-4) to 3.96 (November, HCSW-1, Figure 7-4). An annual Kendall trend analysis of macroinvertebrate diversity was run for each respective station and found no significant monotonic trends at any of the stations. A Seasonal Kendall trend analysis was then performed for each station and again found no

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[40] After a conversation with Dr. John Epler (entomologist) about updates to the accuracy of the species identification of a few Tanytarsini spp., an overall review of the data was performed. Some of the taxonomic classifications of older data (prior to 2006) had changed, so the database had multiple names for the class, family, or genus of some individuals. Taxonomic names were updated and consolidated where appropriate, which changed the number of individual genera counted for each sampling event. The richness and diversity stats were rerun for each sampling event, along with the combined diversity measures for the year and sampling location. All graphs and tables represent the updated generic diversity scores after data review and consolidation.

significant monotonic trends at any of the stations. When all stations and dates within years were combined, diversity was significantly different among years from 2007 to 2019 and had no significant monotonic trend (ANOVA: F = 1.7, $p < 0.05$, Figure 7-5). Although 2019 had the lowest diversity of any year to date, the overall Shannon-Weiner scores remain high. When results from all events from 2007 to 2019 were combined by station, there was a significant difference between stations (ANOVA: F = 7.1, $p < 0.001$, Figure 7-6), where HCSW-3 and HCSW-4 had higher diversity than HCSW-1 and HCSW-2 (Duncan's multiple range test, $p < 0.05$).

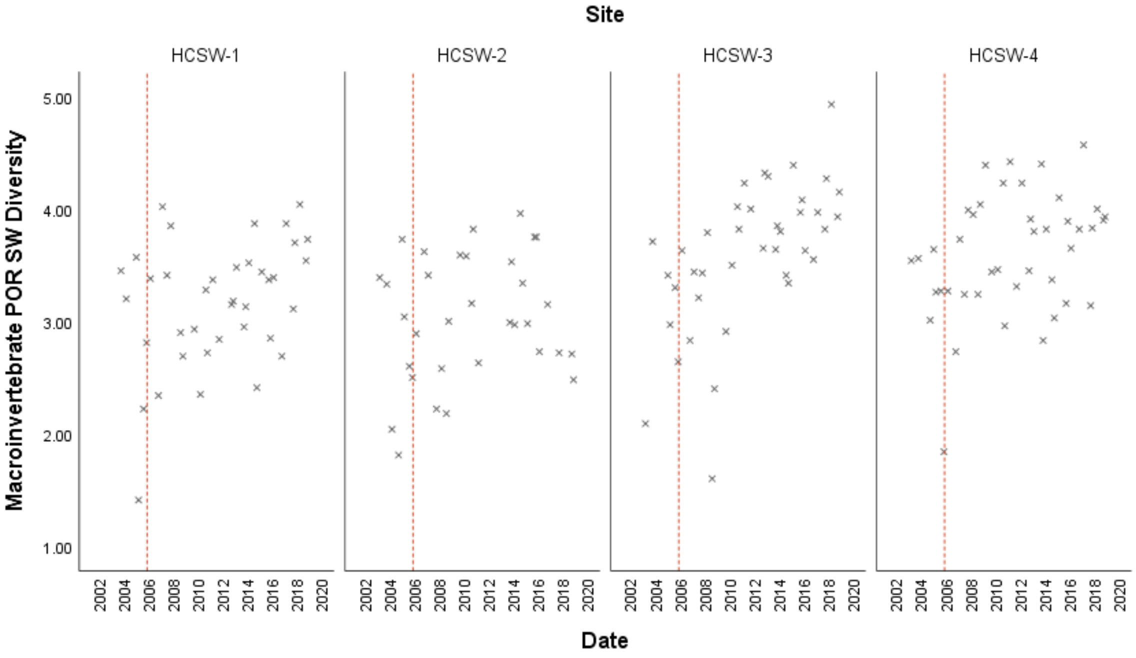
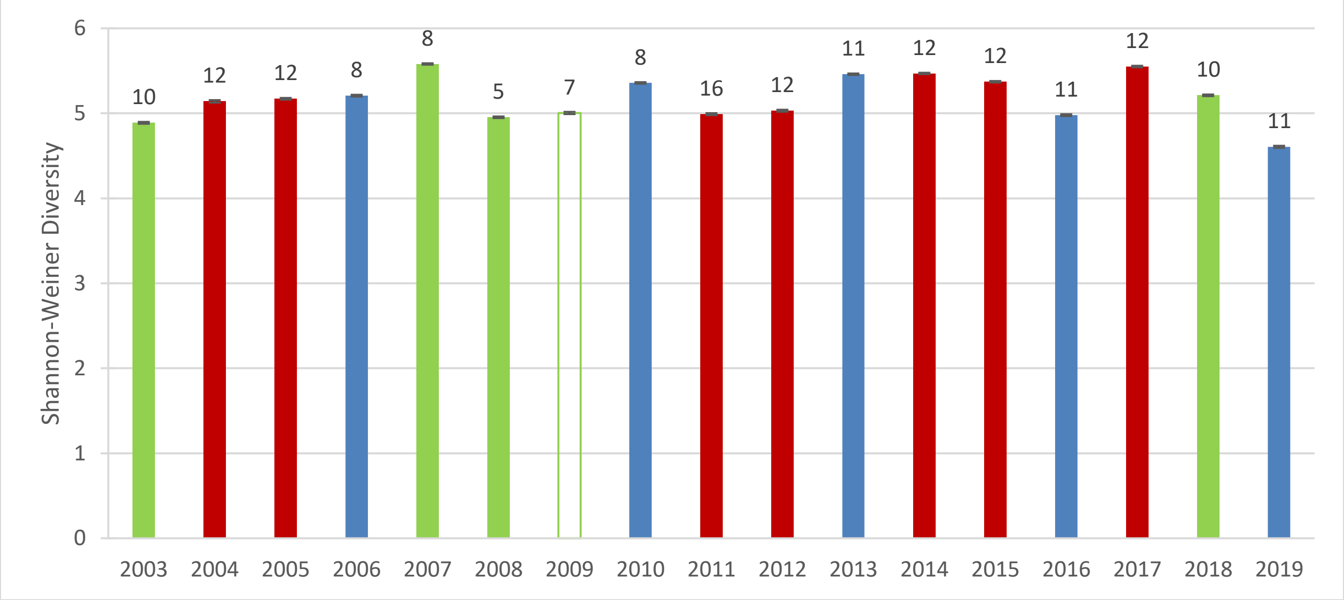


Figure 7-4 **Shannon-Wiener Diversity Indices for Benthic Macroinvertebrate Genera from all HCSP Locations from 2003 to 2019**



Red bars indicate three or more samples at HCSW-2, blue indicate two samples, green indicates one sample, and clear indicates no samples

Figure 7-5 **Shannon-Wiener Diversity Indices for Benthic Macroinvertebrate Genera per Year from Horse Creek for Combined Sample Dates and Stations.**

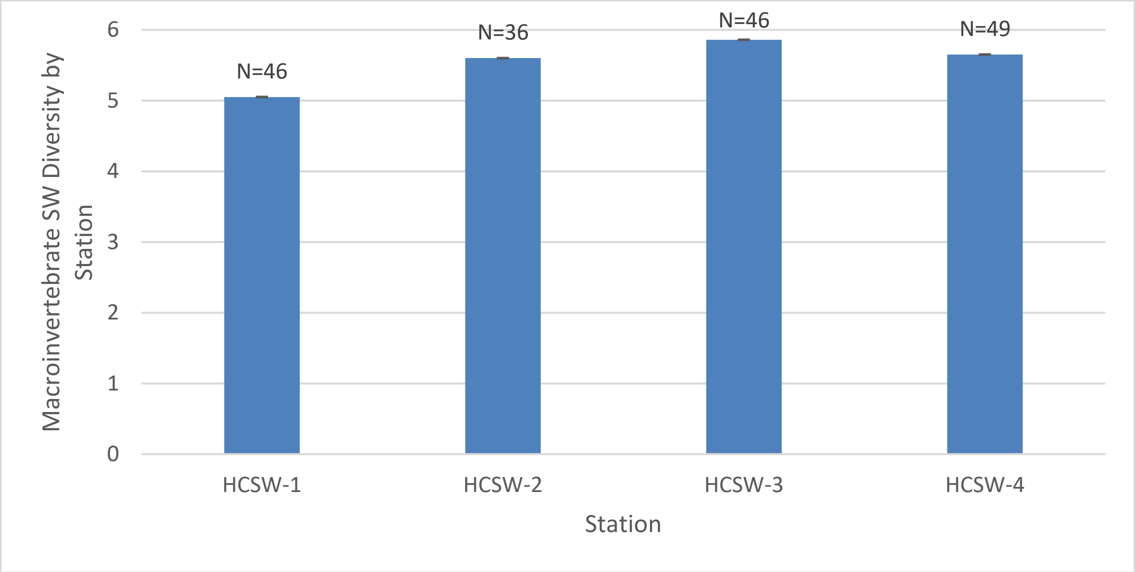


Figure7-6 Shannon-Wiener Diversity Indices for Benthic Macroinvertebrate Genera per Station at Horse Creek for Combined Sample Dates

7.3.3 Summary of Benthic Macroinvertebrate Results

All sampling events resulted in categorical habitat assessment scores of "sub-optimal" except at HCSW-1 and HCSW-3 in April. HCSW-1 scored in the "optimal" category while HCSW-3 scored in the "marginal" category. The higher scores at HCSW-1 were due to having more substrate diversity and availability. The lower scores at HCSW-3 were due to riparian buffer quality[41], low available quality habitat and bank erosion likely because of higher flows and cattle activity. Despite the lower habitat assessment score, HCSW-3 SCI scores were consistently in the healthy range through 2019.

In 2019, all stations and events received categorical SCI scores of "Healthy" (≥35) or "Exceptional" (≥68) except for HCSW-2 and HCSW-4 in November, which received scores of "Impaired" (≤34). HCSW-1, the site closest to the NPDES outfalls, is the only site that has consistently scored in the "healthy" to "exceptional" SCI range[42]. HCSW-4, the site furthest from the NPDES outfalls, has the highest SCI average over the 2007 - 2019 period. The differing strengths at both sites can be attributed to the respective stream orders in which both stations are situated. HCSW-1 is located in the sheltered 3rd order reach of Horse Creek with a robust buffer, moderate canopy, and perennial flow, with water quality that meets its designated use. HCSW-4 is located in a 4th order reach with an open-light canopy, fed by a number of 1st, 2nd, and 3rd order stream confluences, and upstream of the Peace River confluence. It has a drainage area of 218 square miles: an order of magnitude larger than Horse Creek at HCSW-1. Despite its highly variable flow and water

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[41] Prior to 2018

[42] Based on 2007-present scores i.e. scores calculated with the current 2012 SCI methodology.

quality, HCSW-4 remains a highly productive site because it is connected to numerous sources of habitat and forage.

HCSW-2 was not sampled in April or July due to the site not meeting the required velocity of >0.05m·sec^{-1}. Despite the frequent episodes of low or no flow conditions at HCSW-2, the site consistently scored in the optimal - sub-optimal (>81) habitat assessment range over the entire HCSP period of record. Considering the site has adequate habitat, a robust riparian buffer, and good water chemistry (relative to HCSP parameters), despite being situated directly downstream from a large prairie system, what appears to be lacking is continuous streamflow and conditions conducive to keeping oxygen in the water and supporting a diverse population of macroinvertebrates.

7.4 Fish

Fish sampling was conducted at all stations except HCSW-2 during the April and July 2019 sampling events and at all stations during the November 2019 sampling event. The Brushy Creek location is not included in the fish sampling component of the HCSP.

During 2019, 19 species of fish were collected from the four Horse Creek sampling stations; they are listed in Table 7-3. In Horse Creek overall, there were no new fish species observed in 2019 that were not previously observed at one of the stations. When species observations are considered at the station level, one new invasive fish species was found at HCSW-2 (Asian swamp eel – *Monopterus javanensis*) during the November 2019 event, and one new invasive fish species was found at HCSW-3 during the April and July 2019 events (Orinoco sailfin catfish – *Pterygoplichthys multiradiatus*). A total of 44 species of fish[43] have been observed in Horse Creek from 2003 to 2019, with a range of 18 to 32 species seen each year.

Of the native species collected from 2003 to 2019, most are common regionally, and none were unexpected for this portion of Florida. Live bearers (Poeciliidae), carps and minnows (Cyprinidae), sunfish (Centrarchidae), killifish (Cyprinodontidae), and Old World silversides (Atherininidae) were the most commonly collected fish families during this time period. Eleven of the 44 species collected from 2003 to 2019 are not native to Florida: the African jewelfish (*Hemichromis letourneuxi*), Asian swamp eel, blue tilapia (*Oreochromis aureus*), brown hoplo (*Hoplosternum littorale*), leopard pleco (*Pterygoplichthys gibbiceps*), Nile tilapia[44] (*Oreochromis niloticus*), oriental weatherfish (*Misgurnus anguillicaudatus*), Orinoco sailfin catfish, sailfin catfish (*Pterygoplichthys pardalis*), vermiculated sailfin catfish[45] (*Pterygoplichthys disjunctivus*), and walking catfish (*Clarias batrachus*).

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[43] HCSP fish samples have been periodically sent to the fish collection of Florida Museum of Natural History (FLMNH). Fish species identifications from the museum collection were used to update the HCSP database and all diversity and richness calculations.

[44] Previously identified in 2014 Annual Report as *Oreochromis aureus* (blue tilapia). Confirmation identification as *O. niloticus* by FLMNH.

[45] Previously identified in 2004 Annual Report as *Hypostomus plecostomus* (suckermouth catfish). Confirmation identification as *P. disjunctivus* by FLMNH.

7.4.1 Taxa Richness and Abundance

Most of the individuals collected at each sampling station consisted of eastern mosquitofish (*Gambusia holbrooki*), golden silverside[46] (*Labidesthes vanhyningi*), or coastal shiners (*Notropis petersoni*). This can generally be attributed to conditions that are conducive to seining for small species. Invasive fish were captured at all sites during all sample events except for the July 2019 sample at HCSW-1. During all three sampling events, a slightly lower number of taxa were collected at HCSW-2 (3 to 5) compared to the other stations (7 to 13) (Table 7-3, Figure 7-7). Taxa richness showed no monotonic trend over time at stations HCSW-1, HCSW-3, and HCSW-4 (Kendall-tau of annual median, $p > 0.05$). A trend of -0.07 units/ year was detected at HCSW-2 for the 2003-2018 period (Kendall-tau of annual median, $p < 0.01$).

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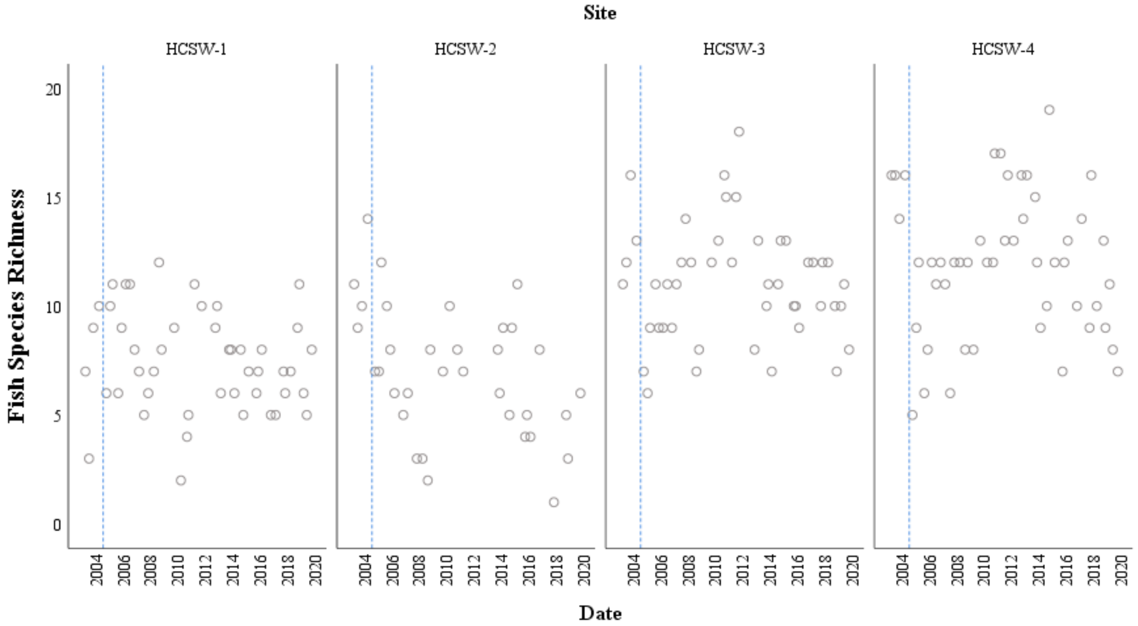
[46] This species was previously considered brook silversides (*Labidesthes sicculus*), but was confirmed by the FLMNH to actually be the golden silverside. Any previous reference to brook silverside should be considered a golden silverside.

Table 7-3 Fish Collected from Horse Creek during Sampling Events in 2019

Scientific Name	Common Name	HCSW-1			HCSW-2			HCSW-3			HCSW-4		
		4-Apr	3-Jul	13-Nov	4-Apr	3-Jul	13-Nov	4-Apr	3-Jul	13-Nov	4-Apr	3-Jul	13-Nov
Clarias batrachus	Walking catfish*	3			No flow	No flow		2					
Fundulus seminolis	Seminole killfish						1				1	11	
Gambusia holbrooki	Eastern mosquitofish	22		2			22	5	18	22	10		5
Heterandria formosa	Least killfish						2	3					
Ictalurus punctatus	Channel catfish									1			
Labidesthes vanhyningi	Golden silverside	4		11				6	12	13	2	11	11
Lepisosteus platyrhincus	Florida gar		2										1
Lepomis macrochirus	Bluegill	11	4	5			2	4	10	1	5	7	3
Lepomis marginatus	Dollar sunfish		3										
Lepomis microlophus	Redear sunfish			1				1	2				
Lucania goodei	Bluefin killfish										2	1	
Micropterus salmoides	Largemouth bass		1	1					1		1	2	
Monopterus javanensis	Asian swamp eel*			4			5	1	1	2	2	2	4
Notropis chalybaeus	Ironcolor shiner										4		
Notropis petersoni	Coastal shiner	9	2	7				16	1	16	10	3	8
Poecilia latipinna	Sailfin molly						3		2	3			
Pterygoplichthys disjunctivus	Vermiculated sailfin catfish*	1		1					4		1		
Pterygoplichthys multiradiatus	Orinoco sailfin catfish*							1	1				
Trinectes maculatus	Hogchoker							14	13	2	9	4	1
Total Taxa		**6**	**5**	**8**			**6**	**10**	**11**	**8**	**11**	**8**	**7**
Number of Individuals		**50**	**12**	**32**			**35**	**53**	**65**	**60**	**47**	**41**	**33**
% Invasive		**8**	**0**	**16**			**14**	**8**	**9**	**3**	**6**	**5**	**12**

*Invasive species



Dotted blue line indicates passage of hurricanes in 2004

Figure 7-7 Species Richness for Fish at all HCSP Locations from 2003 to 2019[47].

7.4.2 Shannon-Wiener Diversity Index

Fish diversity by sampling event and station in 2019 ranged from 0.33 (HCSW-2, April) to 2.99 (HCSW-4, April), similar to the ranges during events from 2003 to 2018 (Figure 7-8). When fish samples were combined across all sampling events within 2019, HCSW-1 and HCSW-3 had the highest species diversity, both with a score of 2.67 (Figure 7-9). HCSW-4 has been the most diverse site for twelve of the seventeen years of the HCSP; however, HCSW-3 has been the most diverse site for the last two years (2018 and 2019). HCSW-2 has been the least diverse site every year of the HCSP except 2005.

Over all combined years, fish diversity varied between all stations, and mean diversity was lowest at station HCSW-2 (ANOVA, F = 24.124, $p < 0.001$; Duncan's multiple range test, $p < 0.05$). Station HCSW-1 showed the highest fish diversity of the four stations over the period of record (Figure 7-11).

Fish diversity showed no monotonic trend over the 2003-2019 period at stations HCSW-1, HCSW-3, and HCSW-4 when grouping the station data by year (Annual Kendall-tau, $p > 0.05$). Likewise, stations HCSW-1, HCSW-3, and HCSW-4 showed no monotonic trend over this period when grouping the station data by sample date, both in the seasonally adjusted and non-adjusted analyses (Seasonal Kendall-tau and Kendall-tau, $p > 0.05$). At

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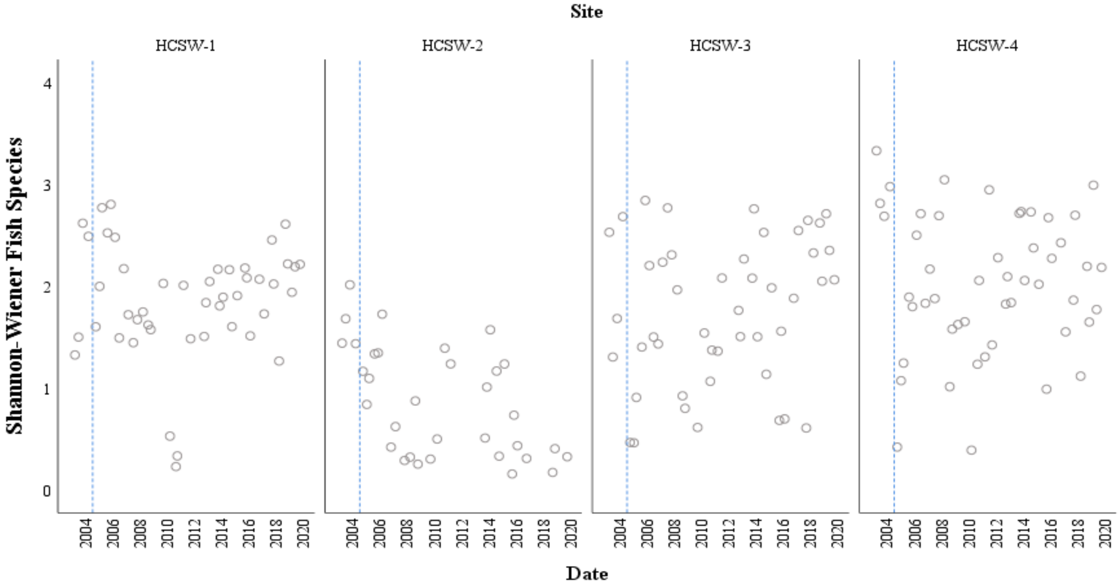
[47] Because of a malfunction with the backpack electrofishing unit, fish were only collected using the seine method during the 27 October 2015 sampling event. Data may not be comparable to other sampling events.

HCSW-2, a monotonic trend of -0.07 units/year was detected over the 2003-2019 period when grouping the station data by year (Annual Kendall-tau, $p < 0.05$). Likewise, a monotonic trend was detected over this period when grouping the station data by sample date, both in the seasonally adjusted analysis (-0.05 units/year) and non-adjusted analysis (-0.07 units/year)(Seasonal Kendall-tau and Kendall-tau, $p < 0.05$).

Fish diversity trend analysis throughout Horse Creek was compared across sites (i.e. combining all stations) by sampling event and by year to detect changes in the entire HCSP reach. No trend was detected when grouping the combined station data by sampling event both in the seasonally adjusted analysis and non-adjusted analysis (Seasonal Kendall-tau and Kendall-tau, $p > 0.05$). Likewise, no trend was detected when grouping the combined station data by year (Annual Kendall-tau, $p > 0.05$). Analyses performed excluding the data from HCSW-2 similarly yielded no trend in fish diversity over time (Seasonal Kendall-tau, Kendall-tau, Annual Kendall-tau, $p > 0.05$).

Diversity was not significantly different between dates when stations were combined (ANOVA, F= 1.33, $p > 0.005$, Figure 7-10). When data was combined by year (Figure 7-12), fish diversity was lowest in 2009 and highest in 2003, 2013, and 2019. Diversity between years, however, was not significantly different (ANOVA F = 1.64, $p > 0.05$).



Dotted blue line indicates passage of hurricanes in 2004

Figure 7-8 Shannon-Wiener Diversity Indices for Fish Samples from all HCSP Locations from 2003 to 2019[48]

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[48] Because of a malfunction with the backpack electrofishing unit, fish were only collected using the seine method during the 27 October 2015 sampling event. Data may not be comparable to other sampling events.

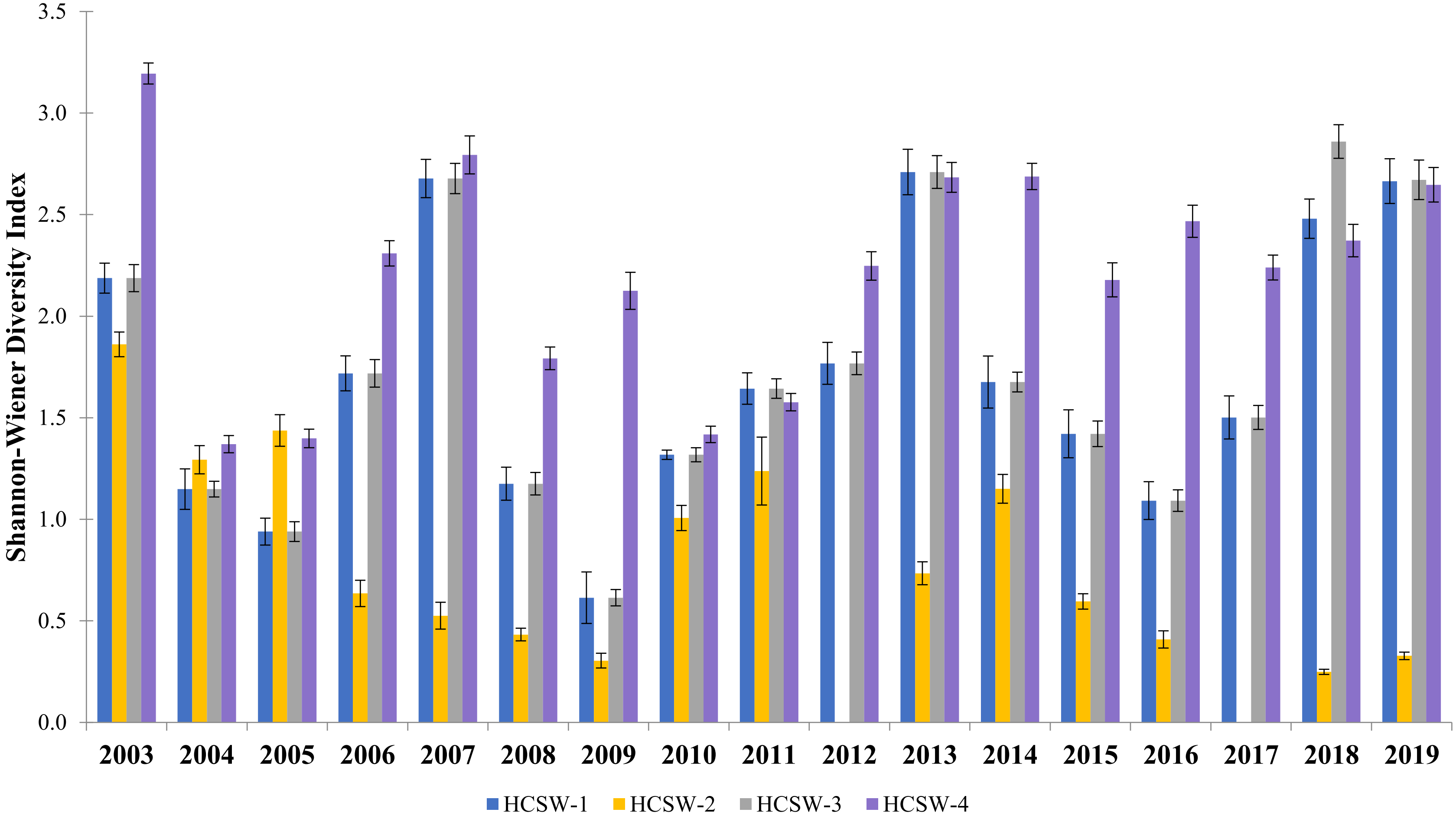

Figure 7-9 **Shannon-Wiener Diversity Index and 95% Confidence Limits for Fish Samples from Four Stations in Horse Creek, Summarized over Sampling Events within Each Year**[49]

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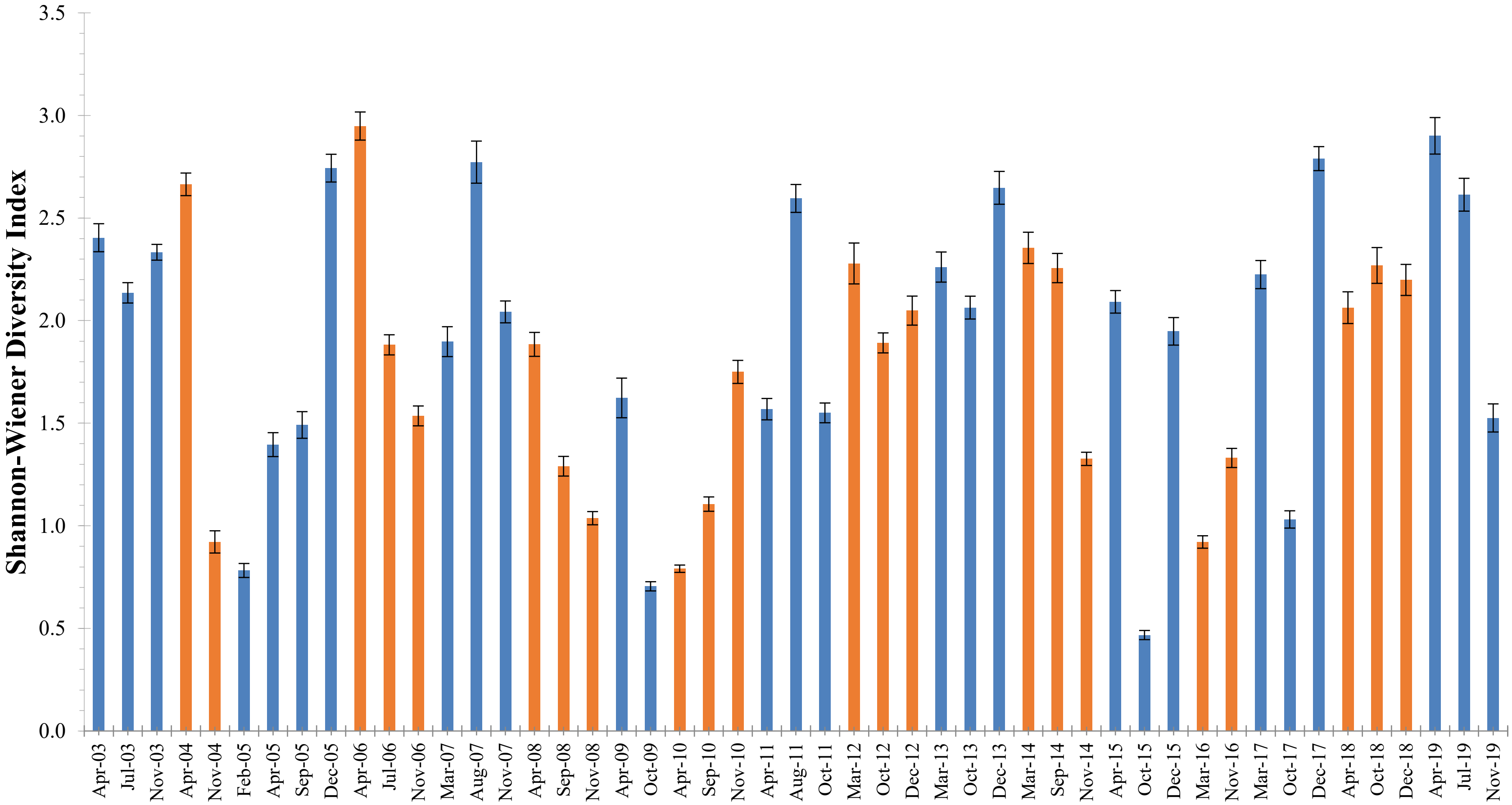
[49] Because of a malfunction with the backpack electrofishing unit, fish were only collected using the seine method during the 27 October 2015 sampling event. Data may not be comparable to other sampling events. Missing HCSW-2 values = 0- 1 species caught and SW score = 0.



Alternating colors used to delineate years

Figure 7-10 Shannon-Wiener Diversity Indices and 95% Confidence Limits for Fish Samples from Horse Creek Summarized Over all Stations per Sampling Event[50]

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[50] Because of a malfunction with the backpack electrofishing unit, fish were only collected using the seine method during the 27 October 2015 sampling event. Data may not be comparable to other sampling events.

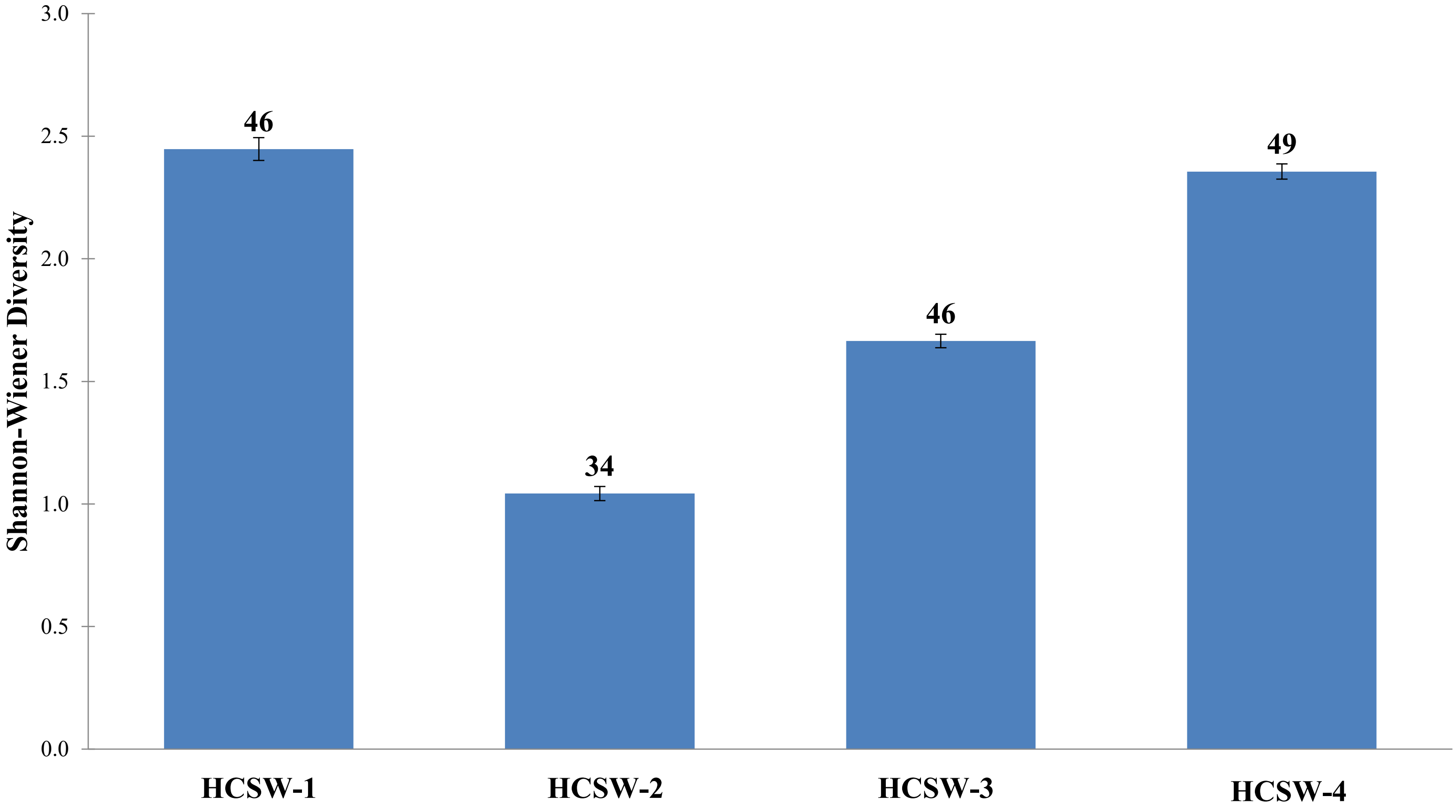

Figure 7-11 **Shannon-Wiener Diversity Indices and 95% Confidence Limits for Fish Samples from Four Stations in Horse Creek Summarized over all Sampling Dates**[51]**.**

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[51] Because of a malfunction with the backpack electrofishing unit, fish were only collected using the seine method during the 27 October 2015 sampling event. Data may not be comparable to other sampling events.

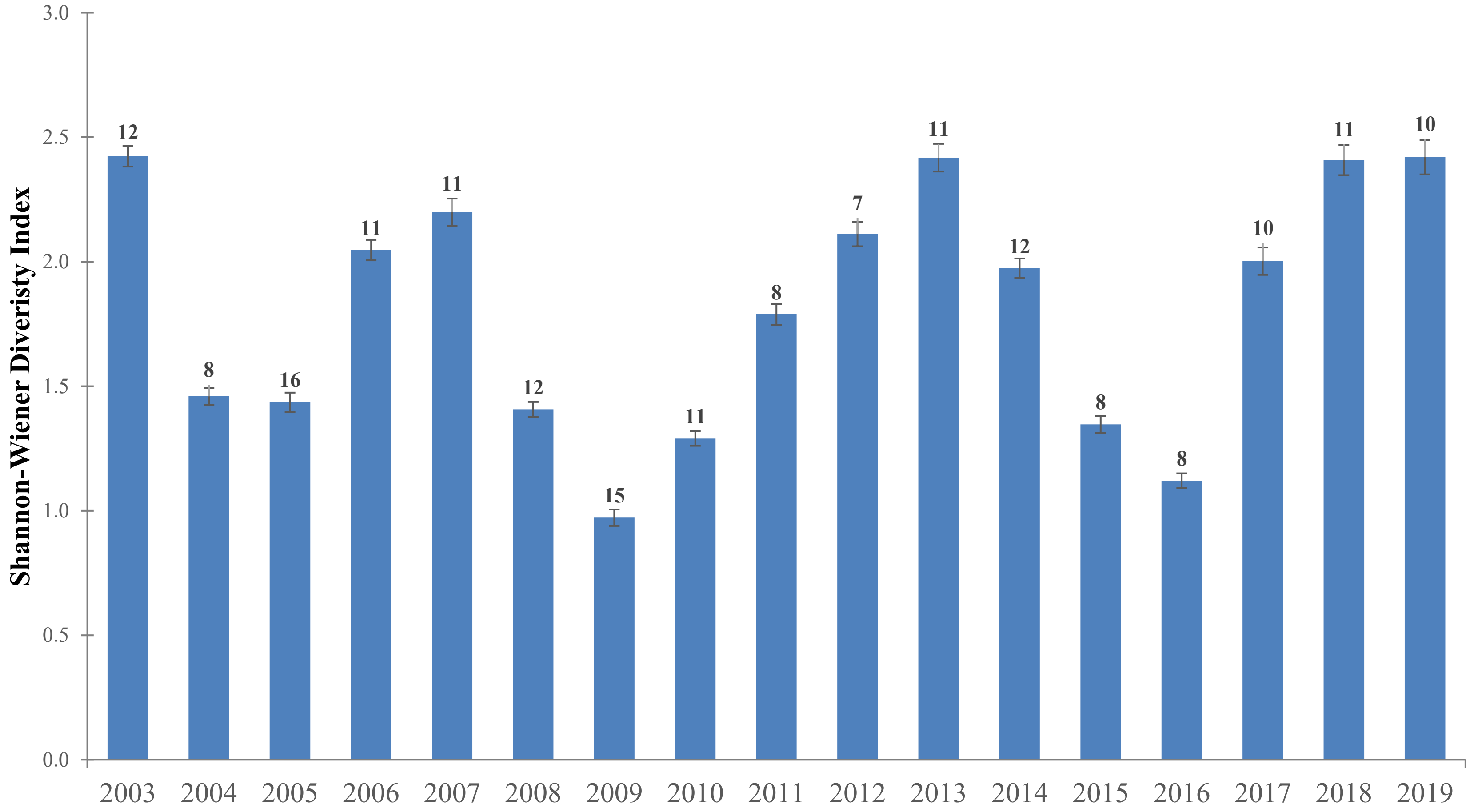

Figure 7-12 Shannon-Wiener Diversity Indices and 95% Confidence Limits for Fish Samples from Sixteen Years at Horse Creek Summarized over all Stations Combined[52]

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[52] Because of a malfunction with the backpack electrofishing unit, fish were only collected using the seine method during the 27 October 2015 sampling event. Data may not be comparable to other sampling events.

7.4.3 Morisita's Index of Similarity

Morisita's Index of Similarity measures the similarity of two communities by comparing the relative abundance of each species within and between communities. Of the similarity measures available, this index is preferred because it is nearly independent of sample size (Krebs 1998). Morisita's Index of Similarity is calculated as:

$$C_{\lambda} = \frac{2\sum X_{ij} X_{ik}}{(\lambda_1 + \lambda_2) N_j N_k}$$

Where C_{λ} = Morisita's index of similarity between sample *j* and *k*
X_{ij}, X_{ik} = Number of individuals of species *i* in sample *j* and sample *k*
$N_j = \Sigma X_{ij}$ = Total number of individuals in sample *j*
$N_k = \Sigma X_{ik}$ = Total number of individuals in sample *k*

Morisita's Index varies from 0 (no similarity – no species in common) to about 1 (complete similarity – all species in common) (Krebs 1998).

Table 7-4 includes Morisita's Index values combined by year or station. When all sampling events for a given station are combined, fish communities were largely similar (79% - 98%, Table 7-4), with HCSW-1 being the least similar to other stations because it has a higher percentage of non-Poecilid fish captures compared to the other stations. When all sampling events for a given year are combined, fish communities were very similar (83% - 100%, Table 7-4). Compared to 2019, 2007 was the most similar (94%) and 2009 the least similar (83%) (Table 7-4).

Table 7-4 Morisita's Similarity Index Matrix Comparing Sapling Dates Within Stations or Within Years for 2003 to 2019 Samples

	HCSW-2	HCSW-3	HCSW-4
HCSW-1	0.79	0.84	0.94
HCSW-2		0.98	0.93
HCSW-3			0.97

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
2003	0.96	0.96	0.99	0.99	0.96	0.92	0.94	0.98	0.98	0.97	0.99	0.95	0.93	0.96	0.95	0.92
2004		0.98	0.99	0.95	1	0.99	1	0.99	0.95	0.90	0.99	0.99	0.99	0.92	0.90	0.86
2005			0.98	0.94	0.97	0.94	0.97	0.99	0.94	0.88	0.98	0.96	0.96	0.89	0.88	0.84
2006				0.99	0.99	0.96	0.98	0.99	0.98	0.95	1	0.98	0.97	0.95	0.94	0.91
2007					0.96	0.93	0.94	0.97	0.99	0.98	0.99	0.95	0.93	0.98	0.96	0.94
2008						0.99	1	0.99	0.95	0.90	0.99	1	1	0.93	0.90	0.86
2009							1	0.96	0.93	0.87	0.97	0.99	1	0.91	0.88	0.83
2010								0.98	0.95	0.89	0.98	1	1	0.91	0.89	0.84
2011									0.96	0.92	0.99	0.98	0.97	0.93	0.92	0.88
2012										0.98	0.98	0.96	0.94	0.97	0.95	0.91
2013											0.95	0.91	0.88	0.97	0.96	0.92
2014												0.98	0.97	0.95	0.94	0.90
2015													1	0.92	0.90	0.86
2016														0.91	0.88	0.84
2017															0.96	0.91
2018																0.93

7.4.4 Summary of Fish Results

Forty-four species of fish were collected from 2003 to 2019, with most captured individuals belonging to one of five families (Table 7-5). System wide, very few additional species are expected to be collected during future monitoring events, as there has only been the addition of five species over the last 10 years (a total of 39 species were collected in 2006, 40 species in 2008, 41 species at the end of 2012, and 44 species at the end of 2016), and the species accumulation curves based on the samples collected through 2017 appear to have approached a threshold (Figure 7-13). Most of the recent species additions have come after review by the Florida Museum of Natural History. Some native species may be present in Horse Creek but were not collected during the HCSP from 2003 to 2019. These include the American eel (*Anguilla rostrata*) and black crappie (*Pomoxis nigromaculatus*).

Samples collected from 2003 to 2019 for the HCSP included 11 exotic species: African jewelfish, Asian swamp eel, blue tilapia, brown hoplo, leopard pleco, Nile tilapia, oriental weatherfish, Orinoco sailfin catfish, sailfin catfish, vermiculated sailfin catfish, and walking catfish. Over 30 species of exotic fish have established reproducing populations in Florida (http://floridafisheries.com), and more will likely continue to be introduced in spite of laws restricting such introductions. Consequently, additional exotic species are expected to be collected in Horse Creek during future monitoring events as new introductions occur and as such species expand their ranges in Florida.

Table 7-6 presents a summary of the number of individual fish captured for several major fish groups at each station per year, including exotic fish species. At each station, the number of individuals per fish groups varies considerably over time and is heavily influenced by sampling conditions. The inherent variability of the data, as well as small differences in sampling effort between years and stations, makes it difficult to look for trends in fish group abundance over time, but a visual examination shows no general trends of increase or decrease in the exotic group or the native fish groups.

In 2019, 19 species of fish were collected from the four Horse Creek sampling stations. Abnormally cold winters in 2009 to 2010 and 2010 to 2011 may have led to decreased fish diversity at some stations in 2010 and 2011, with evidence of recovery and recruitment in 2012 and 2013. Over the period of record, fish richness and diversity were lowest at HCSW-2, the only station with a detected trend, and the only station with a water supply problem. When all stations were combined, the year 2009 saw the lowest fish diversity while 2003, 2013, and 2019 saw the highest diversity (Figure 7-12). There were no increasing or decreasing trends when all stations were combined and analyzed by sampling event (seasonally and non-seasonally adjusted) and by year. No consistent patterns over time were evident in the abundance of fish from exotic and native fish groups (Table 7-6).

Table 7-5 Percentage of Individual Fish Captures per Year for Most Abundant Fish Families/Groups in Horse Creek from 2003 to 2019 as Part of the HCSP

Fish Family	Common Name	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Total
Poeciliidae	Live bearers	51%	97%	87%	70%	84%
Cyprinidae	Carps & minnows	31%	0%	4%	13%	7%
Centrarchidae	Sunfish	7%	1%	2%	6%	3%
Cyprinodontidae	Killifish	1%	1%	2%	4%	2%
Atherininidae	Old world silversides	5%	0%	2%	3%	2%
Exotics		2%	1%	2%	3%	2%

Table 7-6 Number of Individual Fish Captured per year for Major Native and Exotic Fish Groups in Horse Creek from 2003 to 2019 as Part of the HCSP[30]

HCSW-1																	
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Native Poecilids	181	78	75	341	25	275	47	328	308	213	42	61	57	47	13	125	34
Native Sunfish	46	26	31	20	23	24	14	7	14	9	23	12	4	2	4	38	30
Native Catfish	5	9	3	4	3	2	0	1	2	1	2	1	2	0	0	0	0
Native Other	25	69	57	140	87	268	33	4	164	155	148	168	58	18	85	220	45
Exotics	2	1	5	0	0	1	7	0	1	6	19	7	2	1	8	24	9
Total Fish	259	183	171	505	138	570	101	340	489	384	234	249	123	68	110	383	118
Sampling Events	3	2	4	3	3	3	1	3	2	2	3	3	3	2	3	3	3
HCSW-2																	
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Native Poecilids	363	1735	3093	568	908	1335	2519	1695	394	0	981	1514	2702	1062	233	491	317
Native Sunfish	41	15	9	13	2	1	1	1	1	0	12	8	5	0	0	6	2
Native Catfish	1	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Native Other	21	61	43	1	6	12	4	50	13	0	15	38	34	6	0	6	1
Exotics	4	2	22	1	4	40	3	2	0	0	48	17	4	3	0	3	5
Total Fish	430	1815	3167	583	920	1388	2527	1748	408	0	1056	1577	2747	1071	233	503	325
Sampling Events	3	2	4	2	2	3	1	2	1	0	2	3	3	2	1	2	1
HCSW-3																	
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Native Poecilids	669	1606	4125	727	489	3122	1677	2874	1364	2092	383	738	2117	1011	755	325	89
Native Sunfish	49	24	35	31	44	19	5	78	78	28	35	28	20	7	13	77	19
Native Catfish	1	0	0	0	4	1	0	1	1	2	7	0	0	0	1	0	1
Native Other	180	114	23	145	202	106	11	215	143	299	211	101	162	30	152	288	133
Exotics	1	14	37	12	17	23	53	7	3	80	67	52	38	34	11	23	12
Total Fish	900	1758	4220	915	756	3271	1746	3175	1589	2501	703	919	2337	1082	932	690	254
Sampling Events	3	2	4	3	3	3	1	3	2	2	3	3	3	2	3	3	3
HCSW-4																	
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Native Poecilids	172	713	705	280	62	794	409	2423	2112	998	772	276	248	113	100	323	15
Native Sunfish	52	27	5	67	54	62	66	38	97	74	84	41	21	15	43	57	18
Native Catfish	6	2	2	0	0	1	0	0	1	1	17	1	1	5	5	3	0
Native Other	77	52	12	53	174	173	311	205	188	425	465	146	198	55	313	287	145
Exotics	15	6	31	20	4	12	5	19	3	20	129	64	17	14	24	14	9
Total Fish	322	800	755	420	294	1042	791	2685	2401	1518	1467	528	485	202	485	670	187
Sampling Events	3	2	4	3	3	3	2	3	3	3	3	3	3	2	3	3	3

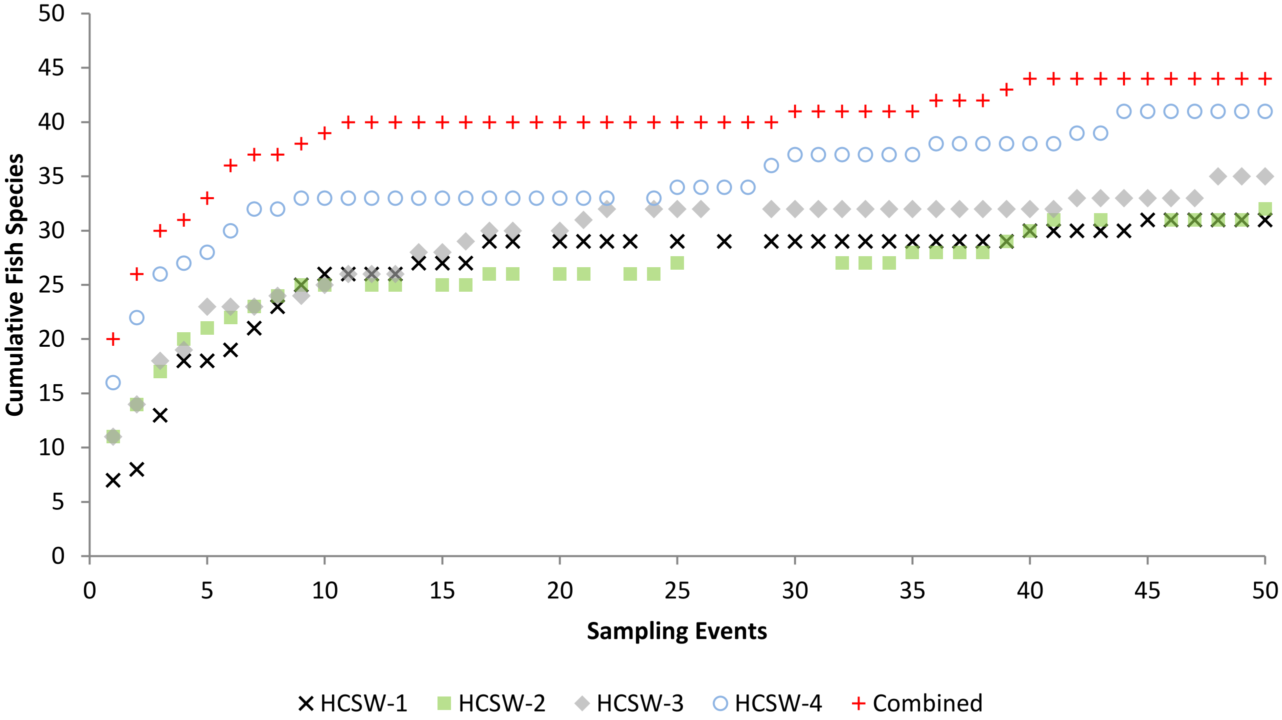

Figure 7-13 Species Accumulation Curve for each HCSP station and at All Stations Combined from 2003 to 2019

8.0 CONCLUSIONS

8.1 Water Quantity Results

Annual average flow at HCSW-1 and HCSW-4 in 2019 was the 12th highest and 4th highest, respectively, since the HCSP started in 2003. Most of the high flow occurred August through September. Total annual rainfall for 2019 in the Horse Creek Basin was the 16th wettest according to the Mosaic rain gauge network and the 14th wettest according to the two nearest NOAA gauges since 2003. The NPDES discharge that did occur was the 15th largest that had occurred in the 18 years the outfalls have been online. NPDES discharges in 2019 began 101 days after the summer rains began and contributed between 9-65% of the flow measured at HCSW-1.

There is no evidence that mining and reclamation activities in the basin caused any statistically significant decrease in total streamflow over the period of record (1978 to 2019), according to the double mass curve analysis. In a previous study (Robbins and Durbin 2011) that compared streamflow during dry years in reference and potentially impacted streams before and during phosphate mining, there was no evidence that phosphate mining practices caused lower monthly flows in the potentially impacted streams (including Horse Creek) than what would be expected given the conditions in a reference stream (Charlie Creek).

8.2 Water Quality Results

Across all parameters monitored during the HCSP monthly sampling program, HCSW-1, the sampling station closest to the NPDES outfalls, had three trigger level exceedances of alkalinity during periods of low creek flow. At the time of the alkalinity trigger level exceedances, outfalls were not discharging and had not discharged in days (22-250 days). This suggests this exceedance is related to baseflow inputs to Horse Creek. All other parameters were well below the respective HCSP established trigger levels at HCSW-1. The trends that were detected at HCSW-1 were studied in the 2017 and 2018 HCSP Impact Assessments which both point to land use changes and non-point sources throughout the Horse Creek Basin.

Nine of the HCSW-2 monthly samples exceeded the time-of-day criteria for dissolved oxygen saturation. HCSW-2 is unlike the other three sites primarily due to the road crossing immediately upstream of the site that impounds the system except during periods of high flow. The impoundment coupled with the organic inputs from the upstream wet prairie has created a system with frequent low or no flow conditions, increased residence time, accretion of coarse organic material, a thick anaerobic benthos, and a higher oxygen demand. The impacts of these conditions are evident in the aquatic habitat assessment, the diversity of macroinvertebrate and fish communities, and the episodic spikes in chlorophyll-a values in HCSW-2.

The two stations furthest from the outfalls, HCSW-3 and HCSW-4, have historically had more trigger level exceedances than HCSW-1. In 2019, there were trigger level exceedances in dissolved calcium (HCSW-4), TDS (HCSW-4), ammonia (HCSW-3), and sulfate (HCSW-4). Both sites are affected by runoff from agriculture directly to Horse Creek and via tributaries that cross agricultural land.

The 2019 HCSP Impact Assessment analyzed all available surface water and groundwater data for total ammonia (TAN) in Horse Creek and its major tributaries. TAN values have approached and exceeded the HCSP trigger levels throughout Horse Creek before the HCSP period of record. Exceedances of TAN often occurred when there was no discharge or long after there has been a discharge through either outfall.

Over the period of record, no significant TAN concentration differences were detected between HCSP sampling stations. If the NPDES discharge was a source of TAN in Horse Creek, HCSW-1 concentrations would typically be more elevated that the other HCSP stations, and most of the exceedances would also occur there. Instead, TAN trigger level exceedances are episodic and mostly occur at sites further downstream than HCSW-1. It is more likely that other land uses as well as periods of desiccation of stream sediments in Horse Creek and its tributaries are driving ammonia fluxing in Horse Creek.

8.3 Benthic Macroinvertebrate Results

Overall diversity in 2019 across all four stations was the lowest of any year to date; however, the overall Shannon-Weiner diversity index scores remain high. The highest SCI score attained in 2019 occurred at HCSW-1, the station closest to the NPDES outfalls. It is the only station to have a detected trend (+1.15 units/year) in SCI scores when analyzed annually. No stations had any detected trends when analyzed seasonally. HCSW-1 also has the highest average habitat assessment score of all for stations over the HCSP period of record. It is the only station with consistently “healthy” or better SCI scores since 2007. It does have a lower period of record Shannon- Wiener diversity score than the other three sites which has to do with the station being located in a lower order reach of Horse Creek relative to the other three stations.

8.4 Fish Results

Over the period of record, fish richness and diversity were lowest at HCSW-2, the only station with a detected trend, and the only station with a water supply problem. When all stations were combined, the year 2009 saw the lowest fish diversity and 2003, 2013, and 2019 saw the highest diversity. There were no increasing or decreasing trends when all stations were combined and analyzed by sampling event (seasonally and non-seasonally adjusted) and by year. No consistent patterns over time were evident in the abundance of fish from exotic and native fish groups. When years were combined, HCSW-1, the station closest to the NPDES outfalls, showed the highest diversity of the four stations.

9.0 RECOMMENDATIONS

9.1 Previous Recommendations

9.1.1 General Recommendations

- The TAG stakeholders should proactively engage state agencies regarding Horse Creek.
- Make HCSP data available on the state of Florida WIN. Flatwoods is currently working with the state to get this type of access.

9.1.2 Annual Report Recommendations

The TAG did not have any annual report recommendations in 2018.

9.2 Current Recommendations

9.2.1 General Recommendations

- Sarasota County suggested that the TAG meetings be recorded.
- Manatee County suggested that the HCSP continue to monitor HCSW-2 going forward.
- Charlotte County suggested that the Shannon Wiener Diversity Index be calculated with terrestrial and semiaquatic macroinvertebrates. The PRMRWSA believes calculating only aquatic macroinvertebrates would be better going forward.

9.2.2 Annual Report Recommendations

- TAG members will be given a deadline of November 17, 2020, to provide comments and questions on the annual report. The PRMRWSA will compile this information and provide to Flatwoods in a single document.

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Appendix A

Horse Creek Stewardship Program

INTENT

The purpose of this program is two-fold. First, it provides a protocol for the collection of information on physical, chemical and biological characteristics of Horse Creek during IMC Phosphates' (IMC) mining activities in the watershed in order to detect any adverse conditions or significant trends that may occur as a result of mining. Second, it provides mechanisms for corrective action with regard to detrimental changes or trends caused by IMC's' activities, if any are found.

The overall goals of the program are to ensure that IMC Phosphates' mining activities do not interfere with the ability of the Peace River/Manasota Regional Water Supply Authority (PRMRWSA) to withdraw water from the Peace River for potable use nor adversely affect Horse Creek, the Peace River or Charlotte Harbor.

There are three basic components to this stewardship program:

- Monitoring and Reporting on Stream Quality,
- Investigating Adverse Conditions or Significant Trends Identified Through Monitoring, and
- Implementing Corrective Action for Adverse Stream Quality Changes Attributable to IMC Activities

An important aspect of this program is that it will not rely solely upon the exceedance of a standard or threshold to bring about further investigation and, where appropriate, corrective action. The presence of a significant temporal trend alone will be sufficient to initiate such steps. This protection mechanism is not present in most regulatory scenarios.

The mission of the PRMRWSA is to provide a reliable and safe drinking water supply to the citizens of the four counties comprising the PRMRWSA, Charlotte, DeSoto, Manatee, and Sarasota Counties. The Peace River Facility is a critical component of the PRMRWSA's water supply system. The Peace River Facility located in DeSoto County utilizes the Peace River as its supply source.

It is critical for the PRMRWSA to protect the Peace River from impacts that would be detrimental to the operation of the Peace River Facility. As a tributary to the Peace River, the PRMRWSA's goal for the Horse Creek Stewardship Program is to provide assurance that the quantity and quality of Horse Creek flow as it contributes to the Peace River does not adversely impact the operation of the Peace River Facility.

PROGRAM IMPLEMENTATION AND OVERSIGHT

IMC will implement and fund the Horse Creek Stewardship Program with oversight by the PRMRWSA. The PRMRWSA will create and coordinate a Technical Advisory Group (TAG) to consist of a representative from each of its members to review and provide input on the program throughout the duration of the monitoring. IMC will create a project-specific Quality Assurance and Quality Control (QA/QC) plan for the program detailing all sampling, laboratory procedures, benthic and fish monitoring protocols and data analysis. The QA/QC plan will be consistent with the analogous protocols established in the HydroBiological Monitoring Program (HBMP) for the Lower Peace River/Upper Charlotte Harbor.

HISTORICAL, BACKGROUND AND CONTEMPORANEOUS DATA

IMC will compile available data collected by others on water quality, quantity and aquatic biology of Horse Creek. This is expected to include, but is not limited to, information collected by the U.S. Geological Survey (USGS), the Florida Department of Environmental Protection (FDEP), the Southwest Florida Water Management District (SWFWMD), the Charlotte Harbor Environmental Center (CHEC). Horse Creek data contained in the U.S. Environmental Protection Agency's (EPA) STORET database will also be obtained. Historic data will be reviewed to provide background information on Horse Creek, and data from ongoing collection efforts will be obtained to supplement that collected by IMC.

MONITORING PERIOD

Water quantity, water quality, macroinvertebrates and fish will be monitored as outlined below during the time that IMC Phosphates is conducting mining and reclamation in the Horse Creek watershed. Monitoring will begin no later than April 2003. In the event of temporary interruptions in mining activities (up to one year), this monitoring will continue during the period of inactivity. Monitoring will cease when mining and reclamation operations are completed in the Horse Creek watershed.

SURFACE WATER MONITORING STATIONS

Four locations on Horse Creek will be monitored for physical, chemical and biological parameters:

- HCSW-1 - Horse Creek at State Road 64 (USGS Station 02297155)
- HCSW-2 - Horse Creek at County Road 663A (Goose Pond Road)
- HCSW-3 - Horse Creek at State Road 70
- HCSW-4 - Horse Creek at State Road 72 (USGS Station 02297310)

As indicated above by their station ID numbers, HCSW-1 and HCSW-4 are also long-term USGS gauging stations, with essentially continuous stage and discharge records since 1977 and 1950, respectively.

WATER QUANTITY MONITORING AND ANALYSIS

Discharge data will be obtained from the USGS for stations HCSW-1 and HCSW-4 for compilation with other data collected through this monitoring program. If not already present, staff gauges will be installed in the stream at HCSW-2 and HCSW-3 and surveyed to National Geodetic Vertical Datum (NGVD). If not already available, stream cross sections will be surveyed at those locations, extending to the approximate limits of the 25-year floodplain. Staff gauge readings will be recorded at the time of any sampling efforts at those stations. Data on rainfall will be obtained using IMC's rain gauge array (including any additional gauges installed in the Horse Creek basin in the future).

Data analysis will focus upon, but not necessarily be limited to, the ongoing relationship between rainfall and streamflow in the Horse Creek watershed. This relationship can be established from data collected early in the monitoring program and used to track the potential effects of mining on streamflow. Analytical approaches are outlined under Water Quality below and such methods will be more fully described in the QA/QC plan to be developed as part of this stewardship program.

SURFACE WATER QUALITY MONITORING AND ANALYSIS

Water quality data will be obtained monthly at each station where flow is present. Field measurements will be made of temperature, pH, specific conductance, turbidity and dissolved oxygen. Grab samples will be collected and analyzed for:

Nitrate + Nitrite
Total Kjeldahl Nitrogen
Total Nitrogen
Total Ammonia Nitrogen
Ortho Phosphate
Chlorophyll a
Calcium
Color
Total Alkalinity
Chloride
Fluoride
Radium 226 + 228
Sulfate
Iron
Mining Reagents (petroleum-based organics, fatty acids, fatty amido amines).

At Station HCSW-1, a continuous monitoring unit will be installed to record temperature, pH, conductivity, dissolved oxygen and turbidity. Because this station is located at a bridge crossing for a highway, the unit will be located some distance (within 100 m) upstream or downstream from the bridge to minimize the likelihood of vandalism. The unit will be permanently installed, and its location surveyed. Data will be recorded frequently (at least hourly) and will be downloaded at least monthly. This data will provide for the characterization of natural background fluctuations and may allow for the detection of general water quality changes not observed during the collection of monthly grab samples.

Table 1 presents the analytical schedules and procedures. All sampling will be conducted according to the FDEP's Standard Operating Procedures (SOP) for field sampling. Laboratory analyses will be performed by experienced personnel according to National Environmental Laboratory Accreditation Council

(NELAC) protocols, including quality assurance/quality control considerations. Invertebrate sampling will be conducted by personnel with training and experience in the FDEP's SOP for such sampling.

Results will be tabulated to allow for comparisons among stations and sampling events and through time. Results will be compared with available historic data for Horse Creek and its tributaries, and with applicable Florida surface water quality standards. Typical parametric and non-parametric statistics will be used to describe the results. Regression analysis is expected to be employed to examine the relationship between each parameter and time. Both linear and non-linear regression will be considered, depending upon the patterns observed in the data. Since at least some of the parameters can be expected to vary seasonally, use of methods such as the Seasonal Kendall's Tau Test is anticipated. Other potential methods include Locally Weighted Scatterplot Smooth (LOWESS). In addition to trend analyses, annual reports will contain general statistics such as mean, median, standard deviation and coefficient of variance for each numerical parameter. Such general statistics will be calculated on both an annual and seasonal basis. Because the data will be maintained in a standard software format (i.e., MS Excel or MS Access), there will be virtually no logistical limitations on the types of analyses that can be conducted. The only limitations will result from the nature of the data itself (i.e., data quantity, distributions, etc.).

For each parameter, data analysis will focus upon, but not necessarily be limited to, (1) the relationship between measured values and the "trigger values" as presented in Table 1 and (2) temporal patterns in the data which may indicate a statistically significantly trend toward the trigger value. Statistical significance will be based upon $\alpha=0.05$, unless data patterns/trends or other related information indicate that use of another significance level is more appropriate. Since the purpose of this monitoring is to detect trends toward the trigger values, should they be present, trend analyses and other statistical tests will generally focus only upon changes toward the trigger values. This will increase the statistical power for detecting such changes.

At least initially, the term over which trends are analyzed will be dependent upon the data collected to date. As the period of record increases, data analysis can move from a comparison of months, to seasons, to years. As noted above, seasonal patterns will always be considered during data analysis and attention will be given to differentiation between natural seasonal/climatic variation and anthropogenic effects (including mining), where possible. Where historic data exist for a given parameter or station, such data can be evaluated relative to that collected through this effort, although sampling frequency and consistency may not be enough to conduct standard trend analysis methods. Analytical methods will be more fully described in the QA/QC plan to be developed as part of this stewardship program.

AQUATIC MACROINVERTEBRATE SAMPLING AND ANALYSIS

Macroinvertebrate sampling will be performed three times annually and, in general, will be conducted concurrently with a monthly water quality sampling event. The first event would occur in March or April, the second event in July or August, and the third event in October or November. Specific months when sampling occurs may change from year to year to avoid very low or very high flows, which would impede representative sampling.

In accordance with the FDEP Standard Operating Procedures (DEP-SOP-001/01 FS 7000 General Biological Community Sampling), invertebrate sampling will not be conducted ". . . during flood stage or recently dry conditions." This is interpreted here to mean that a given sampling station will not be sampled for macroinvertebrates if (a) water is above the top of the stream bank, or is too deep or fast-moving to sample safely, or (b) if the stream has been dry during the preceding 30 days. In the event either of these situations occurs, the station will be revisited approximately one month later to determine whether sampling is appropriate at that time. If the stream is still in flood or has again been dry during the preceding 30 days, invertebrate sampling will be postponed until the next season's sampling event. Note that the above situations are expected to be quite rare at the Horse Creek stations, and sampling efforts will generally be planned to avoid such conditions.

Sampling will be conducted at the same four stations on Horse Creek used for flow and water quality monitoring. The aquatic habitats at each station will be characterized, streamside vegetation surveyed, and photo stations established. Qualitative macroinvertebrate sampling will be performed according to the Stream Condition Index (SCI) protocol developed by FDEP (DEP-SOP-002/01 LT 7200) or subsequently FDEP-approved sampling methodology. Consistent with FDEP protocols, each invertebrate sample will be processed and taxonomically analyzed. Data from the samples will be used to determine the ecological index values presented in Table 1. Additional indices may also be calculated to further evaluate the invertebrate community. As noted in Table 1, the focus of the analysis will be to screen for statistically significant declining trends with respect to presence, abundance, and distribution of native species, as well as SCI values. Results may also be compared with available historic macroinvertebrate data for Horse Creek and its tributaries, or with data from other concurrent collecting efforts in the region, if appropriate. Analysis of invertebrate community characteristics will include consideration of flow conditions, habitat conditions and selected water quality constituents.

Analytical approaches are outlined under Water Quality Monitoring and Analysis section above and such methods will be more fully described in the QA/QC plan to be developed as part of this Horse Creek Stewardship Program.

FISH SAMPLING AND ANALYSIS

Fish sampling will be conducted three times annually, concurrent with aquatic macroinvertebrate sampling at the same four stations on Horse Creek. Based upon stream morphology, flow conditions and in-stream structure (logs, sand bars, riffles, pools, etc.); several methods of sampling may be used, including seining, dip netting, and electrofishing. Sample collection will be timed to standardize the sampling efforts among stations and between events.

All fish collected will be identified in the field according to the taxonomic nomenclature in Common and Scientific Names of Fishes from the United States and Canada (American Fisheries Society 1991, or subsequent editions). Voucher specimens will be taken of uncommonly encountered species and of individuals that cannot be readily identified in the field; with such specimens being preserved and logged in a reference collection maintained for this monitoring program. All fish will be enumerated and recorded. Total length and weight will be determined and recorded for individuals, however, for seine hauls with very large numbers of fish of the same species (a common occurrence with species like *Gambusia holbrooki*, *Heterandria formosa* and *Poecilia latipinna*), individuals of the same species may be counted and weighed en masse, with only a randomly selected subset (approximately 10 to 20 individuals of each such species) being individually measured for length and weight. Any external anomalies observed on specimens will be recorded.

Taxa richness and abundance and mean catch per unit effort will be determined for each station and each event, and data can be compared among stations and across sampling events. The ecological indices presented in Table 1 will be calculated, and additional indices may also be calculated to evaluate the fish community, including similarity indices, species accumulation/rarefaction curves, diversity indices and evenness indices. As noted in Table 1, the focus of the analysis will be to screen for statistically significant declining trends with respect to presence, abundance, and distribution of native species. Results may also be compared with available historic fisheries data for Horse Creek and its tributaries, and with data from other concurrent regional collecting efforts, if applicable. Analysis of fish community characteristics will include consideration of flow conditions, habitat conditions and selected water quality constituents.

Analytical approaches are outlined under Water Quality above and such methods will be more fully described in the QA/QC plan to be developed as part of this stewardship program.

REPORTING

All data collected through this monitoring program will be compiled annually (January - December records) and a report will be generated summarizing the results. This report will include narrative, tabular and graphical presentation of the discharge records, surface water quality data, macroinvertebrate and fish sampling results. Results of statistical analyses will also be provided. Discussion will be included comparing across the sampling stations, as well as among seasons and sampling years. Emphasis will be placed upon identifying spatial and/or temporal trends in water quality and/or biological conditions. Where available, data collected from the same stations prior to the initiation of this program will be reviewed and incorporated to allow for longer-term evaluation of Horse Creek. In addition, data available from sampling/monitoring efforts by agencies or other public entities will be reviewed and incorporated, where pertinent. Each report will also provide general information on the location and extent of IMC mining activities in the Horse Creek watershed, as they relate to this monitoring effort. Reports will be submitted to the PRMRWSA, as well as to the DEP Bureau of Mine Reclamation (BMR) and SWFWMD.

In addition to the reporting outlined above, raw data compiled through sampling will be provided to the PRMRWSA monthly. This data will be submitted within six (6) weeks of each sampling event (pending the completion of laboratory/taxonomic analyses).

MONITORING PROGRAM EVALUATION

To ensure this program is providing useful information throughout its tenure, it will be evaluated regularly. Each annual report will include a section devoted to a summary of the immediate and long-term utility of each information type being collected. Recommendations will also be provided in the report regarding possible revisions, additions or deletions to the monitoring program to ensure that it is appropriately focused. Based upon such recommendations, IMC Phosphates will coordinate with the PRMRWSA and TAG on a regular basis regarding amendments to the monitoring program. Coordination on this issue may be initiated at any time by either party and will occur at least once every five years, whether either party individually requests it.

PROTOCOL FOR ADDRESSING POTENTIAL PROBLEMS IDENTIFIED THROUGH MONITORING

An important element of the monitoring program will be the ongoing analyses of data to detect exceedances of specific trigger values (see Table 1) as well as statistically significant temporal trends toward, but not necessarily in excess of, those values. The analyses will evaluate the data collected through this Horse Creek Stewardship Program, as well as that reported by other entities where appropriate.

IMPACT ASSESSMENT/CHARACTERIZATION

In the event the annual data evaluation identifies trigger value exceedances or statistically significant trends in Horse Creek, IMC will conduct an impact assessment to identify the cause of the adverse trend. The impact assessment may include more intensive monitoring of water quality in terms of frequency of sampling, laboratory analyses conducted, or locations monitored. In all cases, however, the impact assessment will include supplemental quantitative and qualitative data evaluations and consultation with PRMRWSA scientists, as well as perhaps other investigations within the basin (e.g., examination of land use changes, discharge monitoring records reviews of others, water use permit reports of others, etc.).

If the "impact assessment" demonstrates to the satisfaction of IMC and PRMRWSA scientists that IMC's activities in the Horse Creek watershed did not cause the exceedance or trend, IMC would support the PRMRWSA's efforts to implement actions to reverse or abate the conditions. IMC's support will focus upon scientific solutions where IMC can assist in the abatement of others' problems.

If the impact assessment indicates or suggests that IMC is the cause of the exceedances or trend, then IMC shall take immediate corrective actions. The intensity of such actions would be based upon the potential for ecological harm to the ecology of Horse Creek or the integrity of the potable water supply to the PRMRWSA.

CORRECTIVE ACTION ALTERNATIVES EVALUATION AND IMPLEMENTATION

The first step in the corrective action process shall be to prepare quantitative projections of the short-term and long-term impacts of the trigger value exceedance or adverse trends. Quantitative models and other analytical tools will provide IMC and PRMRWSA scientists with the analyses necessary to determine: (1) whether the impacts will persist or subside over the long term; (2) the cause(s) of the adverse trend(s) in terms of specific IMC activities that are contributing to the trend(s); and (3) alternative steps that IMC could effectuate to reverse the adverse trend, if needed.

If impact modeling confirms that adverse trends in water quality or a trigger value exceedance is caused by IMC activities in the Horse Creek watershed, IMC shall meet with PRMRWSA within 30 days of detection of the adverse trend or trigger exceedance to evaluate alternative solutions developed by IMC. IMC shall begin implementation of its proposed alternative solution selected by the PRMRWSA within 30 days and report to PRMRWSA as implementation milestones are reached. Throughout the modeling, alternatives assessment, and preferred alternative implementation steps of the corrective action process, more intensive impact assessment monitoring will continue to track the continuation, or the abatement, of the trigger value exceedance or adverse trend. Only when the impact assessment monitoring demonstrated conclusively that the condition has been reversed, with respect to the parameter(s) of concern, would IMC reduce its efforts back to the general monitoring and reporting program.

Alternative solutions may include conventional strategies such as the implementation of additional best management practices, raw material substitutions, hydraulic augmentation of wetlands, etc. IMC shall consider “out of the box” solutions (such as discharges of water to result in lower downstream concentrations of a parameter of concern, where the pollutant does not originate from IMC’s activities) and emerging principles and technologies for water quantity management, water quality treatment and watershed protection, as well as other innovative solutions recommended by PRMRWSA.

Table A-1 Parameters, General Monitoring Protocols and Corrective Action Trigger Values for the Horse Creek Stewardship Plan

Pollutant Category	Analytical Parameters	Analytical Method	Reporting Units	Monitoring Frequency	Trigger Level	Basis for Initiating Corrective Action Process
General Physio-chemical Indicators	pH	Calibrated Meter	Std. Units	Monthly	<6.0->8.5	Excursions beyond range or statistically significant trend line predicting excursions from trigger level minimum or maximum.
	Dissolved Oxygen	Calibrated Meter	mg/L⁽¹⁾	Monthly	<5.0	Excursions below trigger level or statistically significant trend line predicting concentrations below trigger level.
	Turbidity	Calibrated Meter	NTU⁽²⁾	Monthly	>29	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Color	SM 2120B	PCU	Monthly	<25	Excursions below trigger level or statistically significant trend line predicting concentrations below trigger level.
Nutrients	Total Nitrogen	EPA 351.2 + 353.2	mg/L	Monthly	>3.0	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total Ammonia	EPA 350.1 + FDEP SOP 10_03_83	mg/L	Monthly	>0.3	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Ortho Phosphate	EPA 365.1	mg/L	Monthly	>2.5	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Chlorophyll *a*	EPA 445	mg/L	Monthly	>15	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.

Pollutant Category	**Analytical Parameters**	**Analytical Method**	**Reporting Units**	**Monitoring Frequency**	**Trigger Level**	**Basis for Initiating Corrective Action Process**
Dissolved Minerals	Specific Conductance	Calibrated Meter	µs/cm(3)	Monthly	>1,275	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total Alkalinity	SM 2320 B	mg/L	Monthly	>100	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Calcium	EPA 200.7	mg/L	Monthly	>100	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Iron	EPA 200.7	mg/L	Monthly	>0.3 (6); >1.0(7)	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Chloride	EPA 300.0	mg/L	Monthly	>250	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Fluoride	EPA 300.0	mg/L	Monthly	>1.5(6); >4(7)	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Radium 226+228	EPA 903.1 + Ra-05	pCi/L(4)	Quarterly	>5	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Sulfate	EPA 300.0	Mg/L	Monthly	>250	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total Dissolved Solids	SM 2540 C	Mg/L	Monthly	>500	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
Mining Reagents	Petroleum Range Organics	EPA 8015 (FL-PRO)	mg/L	Monthly(5)	>5.0	Exceedance of or statistically significant trend line predicting concentrations in excess of, trigger level.
	Total fatty acids, including Oleic, Linoleic, and Linolenic acid.	EPA/600/4-91/002	mg/L	Monthly(5)	>NOEL	Statistically significant trend line predicting concentrations in excess of the No Observed Effects Level (NOEL to be determined through standard toxicity testing with IMC reagents early in monitoring program, NOEL to be expressed as a concentration–e.g., mg/L)
	Fatty amido-amines	EPA/600/4-91-002	mg/L	Monthly(5)	>NOEL	Statistically significant upward trend line predicting concentrations in excess of No Observed Effects Level (NOEL to be determined through standard toxicity testing with IMC reagents early in monitoring program, NOEL to be expressed as a concentration – e.g., mg/L)

Pollutant Category	Analytical Parameters	Analytical Method	Reporting Units	Monitoring Frequency	Trigger Level	Basis for Initiating Corrective Action Process
Biological Indices: Macroinvertebrates	Total Number of Taxa	Stream Condition Index (SCI) sampling protocol, taxonomic analysis, calculation of indices according to SOP-002/01 LT 7200 Stream Condition Index (SCI) Determination	Units vary based upon metric or index	3 times per year	N/A	Statistically significant declining trend with respect to SCI values, as well as presence, abundance or distribution of native species
	Abundance					
	Percent Diptera					
	Number of Chironomid Taxa					
	Shannon Weaver Diversity(a)					
	Florida Index					
	EPT Index					
	Percent Contribution of Dominant Taxon					
	Percent Suspension Feeders/Filterers					
Biological Indices: Fish	Total Number of Taxa	Various appropriate standard sampling methods, taxonomic analysis, calculation of indices using published formulas	Units vary based upon metric or index	3 times per year	N/A	Statistically significant declining trend with respect to presence, abundance or distribution of native species
	Abundance					
	Shannon-Weaver Diversity(a)					
	Species Turnover (Morisita Similarity Index(a)					
	Rarefaction/Species Accumulation Curves(b)					

Notes:

(1) Milligrams per liter
(2) Nephelometric turbidity units
(3) Microsiemens per centimeter.
(4) PicoCuries per liter.
(5) If reagents are not detected after two years, sampling frequency will be reduced to quarterly - if subsequent data indicate the presence of reagents, monthly sampling will be resumed.
(6) At Station HC SW-4 only, recognizing that existing levels during low-flow conditions exceed the trigger level.
(7) At Stations HC SW-1, HC SW-2, and HC SW-3

References:

(a) Brower, J. E., Zar, J. H., von Ende, C. N. Field and Laboratory Methods for General Ecology. 3rd Edition. Wm. C. Brown Co., Dubuque, IA. pp. 237; 1990

(b) Gotelli, N.J., and G.R. Graves. 1996. Null Models in Ecology. Smithsonian Institution Press, Washington, DC.

Appendix B

Cumulative Chronological List of Procedural Changes to the HCSP

Change 1: Summer Biological sampling from July – Aug to July – Sep.
Year Implemented: 2004
Comments: Allows flexibility with sampling during high flows.
Provisional Acceptance: 2004
Final Acceptance: April 4, 2007

Change 2: Fall Biological sampling from Oct – Nov to Oct – Dec.
Year Implemented: 2004
Comments: Allows flexibility with sampling during high flows.
Provisional Acceptance: 2004
Final Acceptance: April 4, 2007

Change 3: Biological sampling should be separated by at least 6 weeks in time.
Year Implemented: 2004
Comments: Ensures that sample results capture seasonal variation.
Provisional Acceptance: 2004
Final Acceptance: April 4, 2007

Change 4: Accept that historical background levels of dissolved iron at HCSW-4 exceeds the trigger level of 0.3 mg/l.
Year Implemented: 2004
Comments: Station HCSW-4 trigger levels reflect the more stringent Class I levels. Historically Station HCSW-4 background levels for dissolved iron are similar to the rest of the basin but also higher than 0.3.
Provisional Acceptance: 2004
Final Acceptance: April 4, 2007

Change 5: Accept that historical background levels of dissolved oxygen and chlorophyll at HCSW-2 exceeds the trigger level.
Year Implemented: 2004
Comments: Station HCSW-2 is directly downstream of Horse Creek Prairie which routinely delivers slow moving water low in dissolved oxygen and high in chlorophyll to station HCSW-2
Provisional Acceptance: 2004
Final Acceptance: April 4, 2007

Change 6: Continue to compile, compare, present and discuss ongoing Horse Creek Data from WMD, FDEP and USGS with Horse Creek Stewardship Program (HCSP) data.
Year implemented: 2005
Comments: Enhances program
Provisional Acceptance: July 2006
Final Acceptance: April 4, 2007

Change 7: Biological Sampling stage level criteria from > 10 ft at HCSW-1 & > 5 ft at HCSW-4 to > 10 ft at HCSW-1 & > 4 ft at HCSW-4
Year implemented: 2007
Comments: Biological samples will be collected when stage levels are below these stated levels to ensure safety and quality samples.
Provisional Acceptance: July 2006
Final Acceptance: April 4, 2007

Change 8: The data range used in the historical water quality comparison should be static historical data beginning somewhere around 1990-1993.
Year Implemented: Beginning with the 2007 Annual Report.
Comments: Historical water quality comparison should be static instead of a moving window allowing consistent and continuous comparison with historical data.
Provisional Acceptance: June 2008
Final Acceptance: November 4, 2009

Change 9: Add clay settling area (CSA) FM-1 to existing monitoring program.
Year Implemented: Prior to 2009 wet season.
Comments: Recently constructed SCA FM-1 will be added to existing CSA's providing real time monitoring to Peace River Manasota River Water Authority (PRMRWA).
Provisional Acceptance: March 2009
Final Acceptance: November 4, 2009

Change 10: Deletion of three water quality parameters: FL-PRO, Fatty Acids, and Total Amines.
Year Implemented: 2009
Comments: These parameters have rarely been above the detection limit and chemical processing plants are not found in the Horse Creek watershed.
Provisional Acceptance: March 2009
Final Acceptance: November 4, 2009

Change 11: Addition of new water quality sample location for Brushy Creek @ Hwy 64.
Year Implemented: 2009
Comments: In lieu of deleted three parameters Mosaic will collect samples and provide data monthly from this location minus trigger levels and impact assessments.
Provisional Acceptance: March 2009
Final Acceptance: November 4, 2009

Change 12: Modifications to CSA monitoring methodology.
Year Implemented: 2014
Comments: Mosaic presented a monitoring proposal utilizing rolling averages of continuously measured turbidity values at HCSW-1, with a set point of 150 NTU. This set point was based on a review of historic data at the station and was selected to be sensitive enough to detect any potential turbidity excursions that might result from an upstream CSA dam breach, but not so sensitive as to result in a number of false positives. The telemetric equipment would send text messages and email alerts to Mosaic when the 3-hour rolling average exceeds 150 NTU and send alerts to Mosaic and PRMRWSA when the 6-hour rolling average exceeds 150 NTU. Three-hour alerts would trigger Mosaic investigation of the source of high turbidity, and necessary follow-up with PRMRWSA staff in the event that the cause of the alarm was associated with a dam breach or other significant upset condition at Mosaic's operations. Three tests were conducted, and following the final test, PRMRWSA staff authorized the removal of the old liquid level monitoring equipment located in the field on Mosaic property and the equipment located at the PRMRWSA's facility.
Provisional Acceptance: February 2014
Final Acceptance: July 14, 2014

Change 13: Change of the dissolved oxygen trigger level from concentration (mg/L) to percent saturation.
Year Implemented: 2014 Annual Report, November 2015 Monthly Report
Comments: In 2013, FDEP changed the Class III state water quality standard from concentration in mg/L to percent saturation. For the Florida peninsula region, the new daily average standard is 38% for continuous recorder data and time of day translation saturation for grab samples. A memo describing these changes was provided to the Technical Advisory Group (TAG) on November 18, 2015.
Provisional Acceptance: November 9, 2015
Final Acceptance: January 21, 2016

Change 14: Changed turbidity alert protocol to alert TAG and Mosaic after 12 consecutives >150 NTU measurements.
Year Implemented: 2019
Comments: Previous protocol alerted Mosaic and TAG after a 3-hour and 6-hour >150 NTU rolling average, respectively. This system produced only false alarms.
Final Acceptance: February 13, 2019

Change 15: Dropped 0.3mg/L dissolved iron trigger level at HCSW-4. HCSW-4 will be compared to the same 1 mg/L trigger level sites, HCSW-1, HCSW-2 and HCSW-3 have been assessed with.
Year Implemented: 2019
Comments: ANOVA showed that there was no difference in iron concentrations at the four sample sites. The TAG that met on December 2019 decided to drop the more stringent standard at site HCSW-4. The change will take effect in 2019 annual report.
Final Acceptance: December 12, 2019

Change 16: Macroinvertebrate Shannon-Wiener analysis will exclude terrestrial and semi-aquatic macroinvertebrates.
Year Implemented: 2020
Comments: Flatwoods examined every invertebrate entry in the database to determine is there were non-aquatic organisms included in the dataset. Those organisms were flagged in the database and excluded in the 2019 annual report Shannon- Wiener analysis (see table below). Flatwoods presented the findings and updated method to the TAG in 11/20 during the 2019 TAG meeting. One person, Ruta Vardys, Charlotte county, objected to the change. The terrestrial and semi-aquatic macroinvertebrate information will continue to reside in the database. Flatwoods cautions against its use because identification of non-aquatic organism is outside the scope of the work of the taxonomic lab and the SCI SOP.

Final Acceptance: November 5, 2020

Classic- Range 0.67

Year	SW	Rank
2017	4.99	1
2018	4.92	2
2014	4.88	3
2015	4.87	4
2010	4.82	5
2007	4.79	6
2013	4.77	7
2011	4.74	8
2004	4.74	9
2009	4.66	10
2012	4.64	11
2019	4.61	12
2008	4.56	13
2003	4.51	14
2006	4.44	15
2005	4.42	16
2016	4.32	17

Aquatic Bugs Only- Range 0.97

Year	SW	Rank
2007	5.58	1
2017	5.55	2
2014	5.47	3
2013	5.46	4
2015	5.37	5
2010	5.36	6
2018	5.21	7
2006	5.21	8
2005	5.17	9
2004	5.14	10
2012	5.03	11
2009	5.00	12
2011	4.99	13
2016	4.98	14
2008	4.95	15
2003	4.89	16
2019	4.61	17

Appendix C

Additional Water Quality Graphs

Analyte trigger level represented by red dotted line. 6=minimum, 8.5=maximum

Figure C-1 Values of pH Obtained During Monthly HCSP Water Quality Sampling, 2003-2019

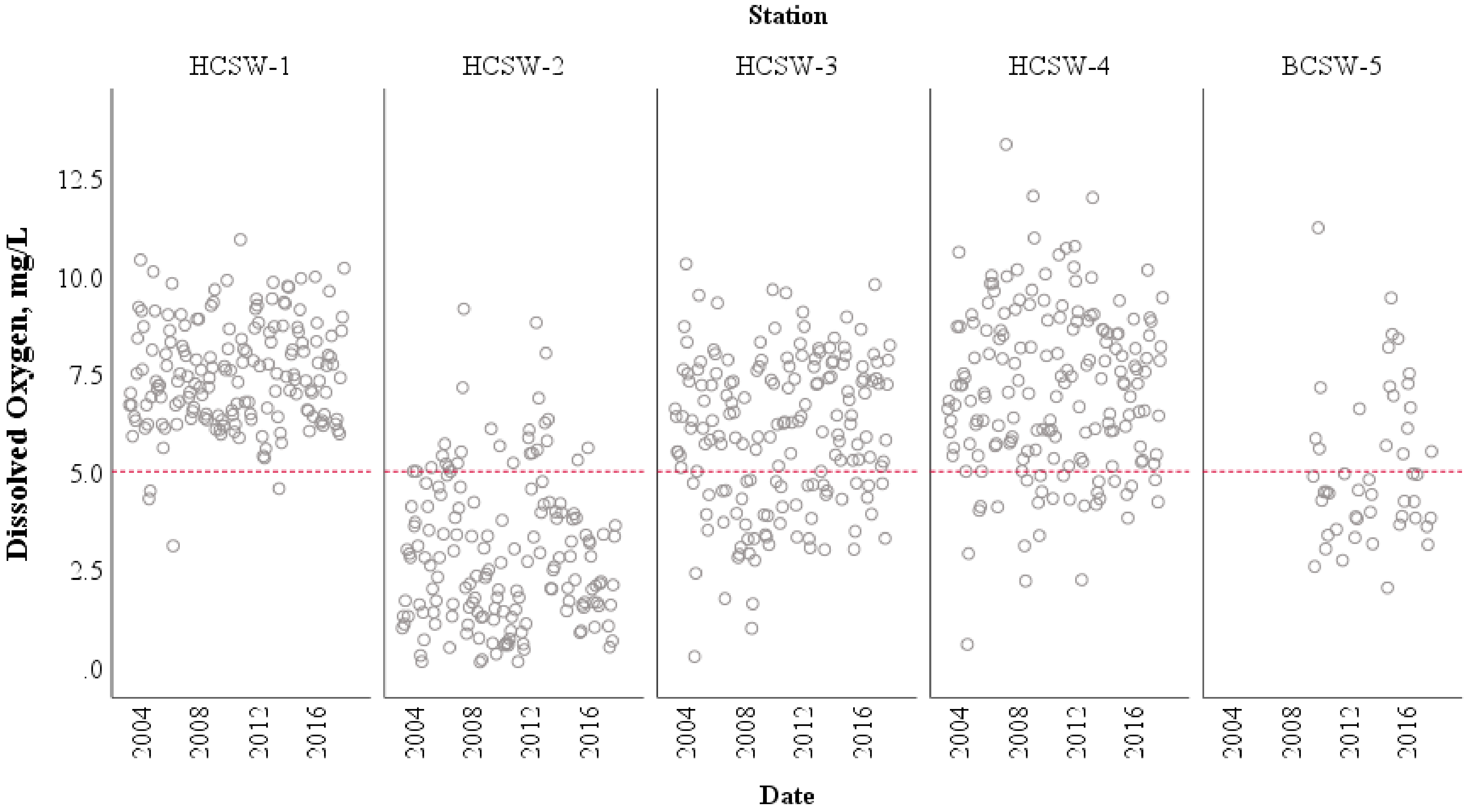
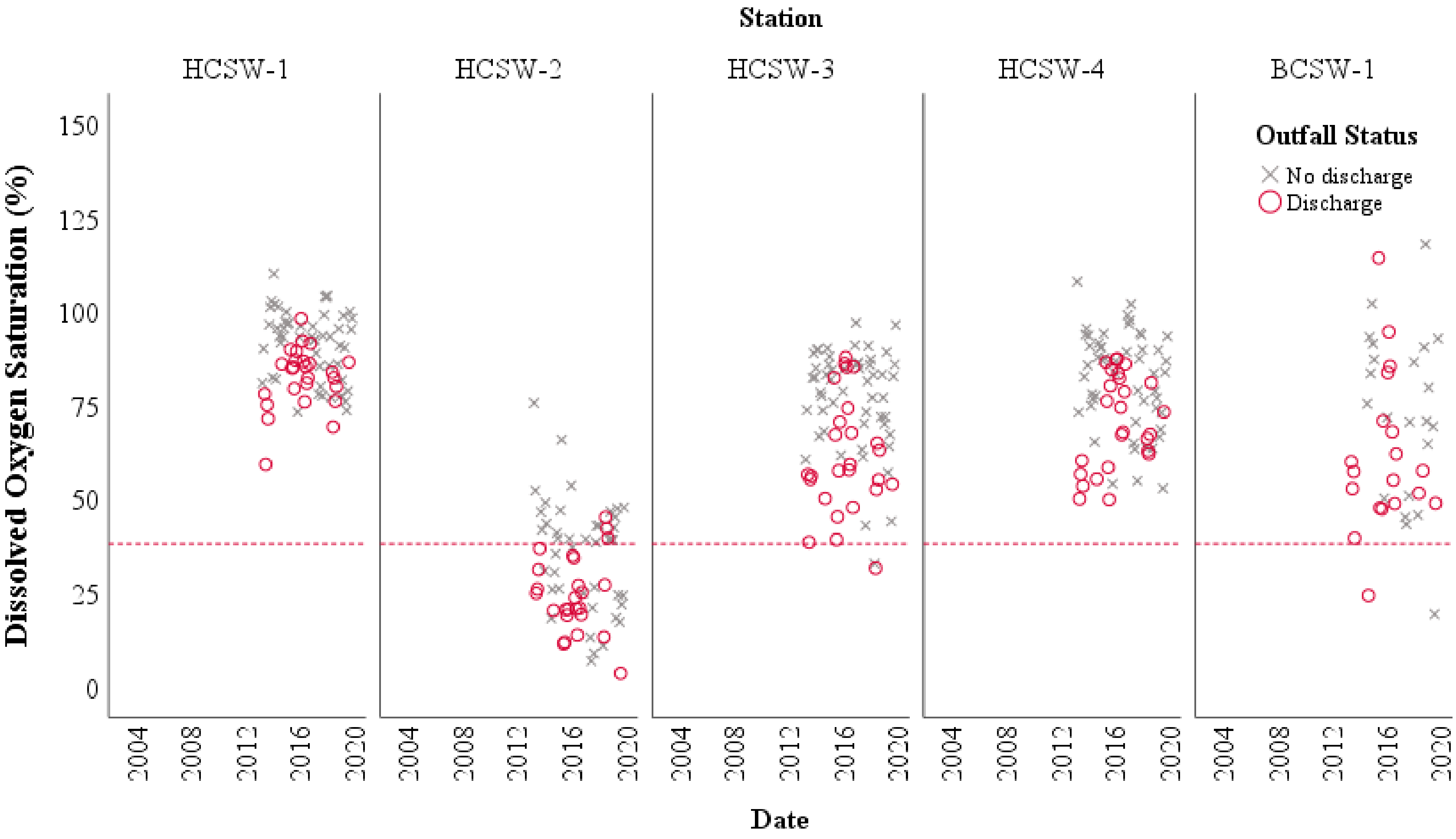


Figure C-2 Dissolved Oxygen Concentrations Obtained During Monthly HCSP Water Quality Sampling Events, 2003-2018. This analyte was discontinued in 2018.



Analyte trigger level represented by red dotted line

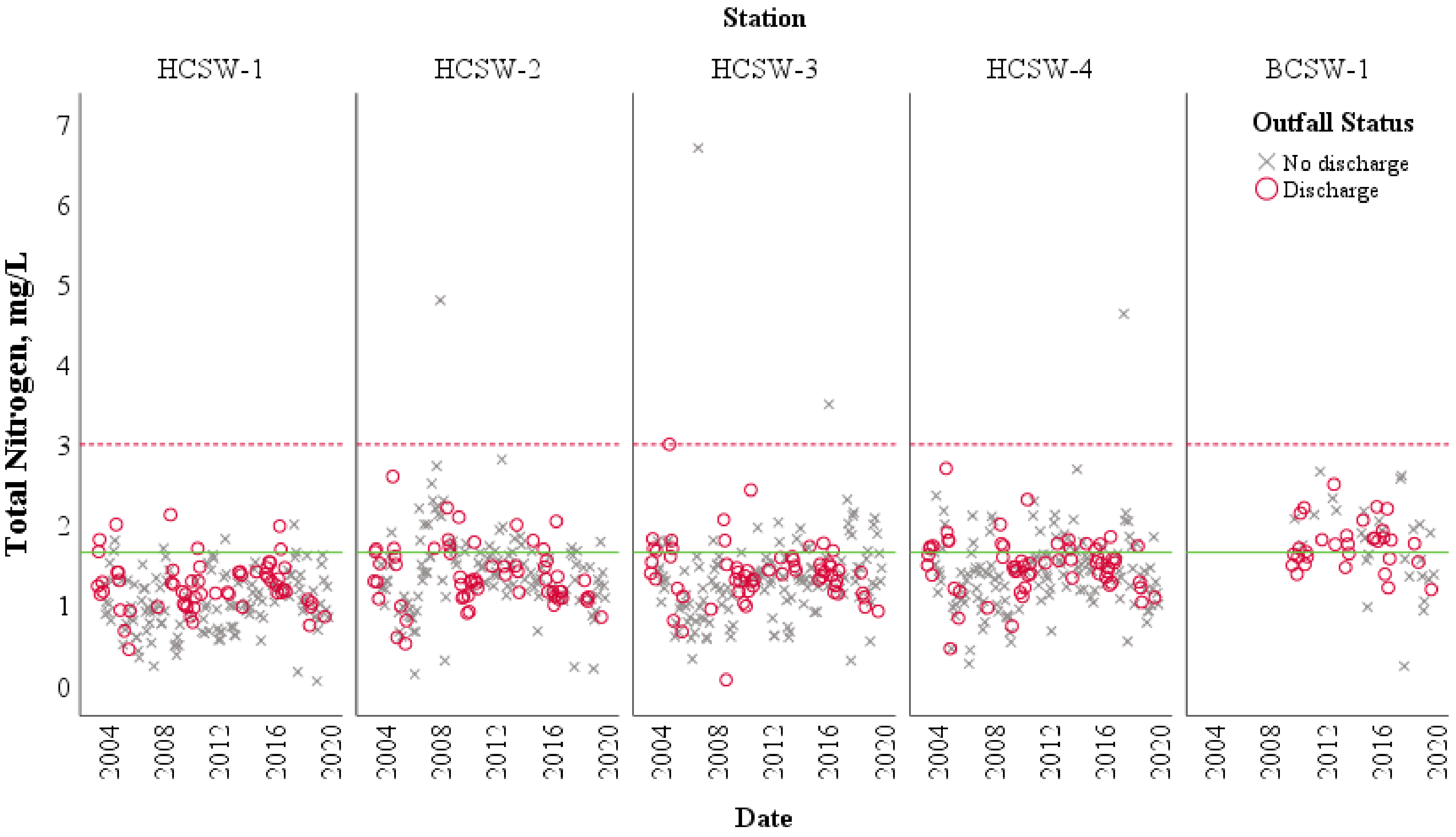
Figure C-3 Dissolved Oxygen Percent Saturation Obtained During Monthly HCSP Water Quality Sampling Events, 2003-2019

Analyte trigger level represented by red dotted line

Figure C-4 Turbidity Levels Obtained During Monthly HCSP Water Quality Sampling Events, 2003-2019

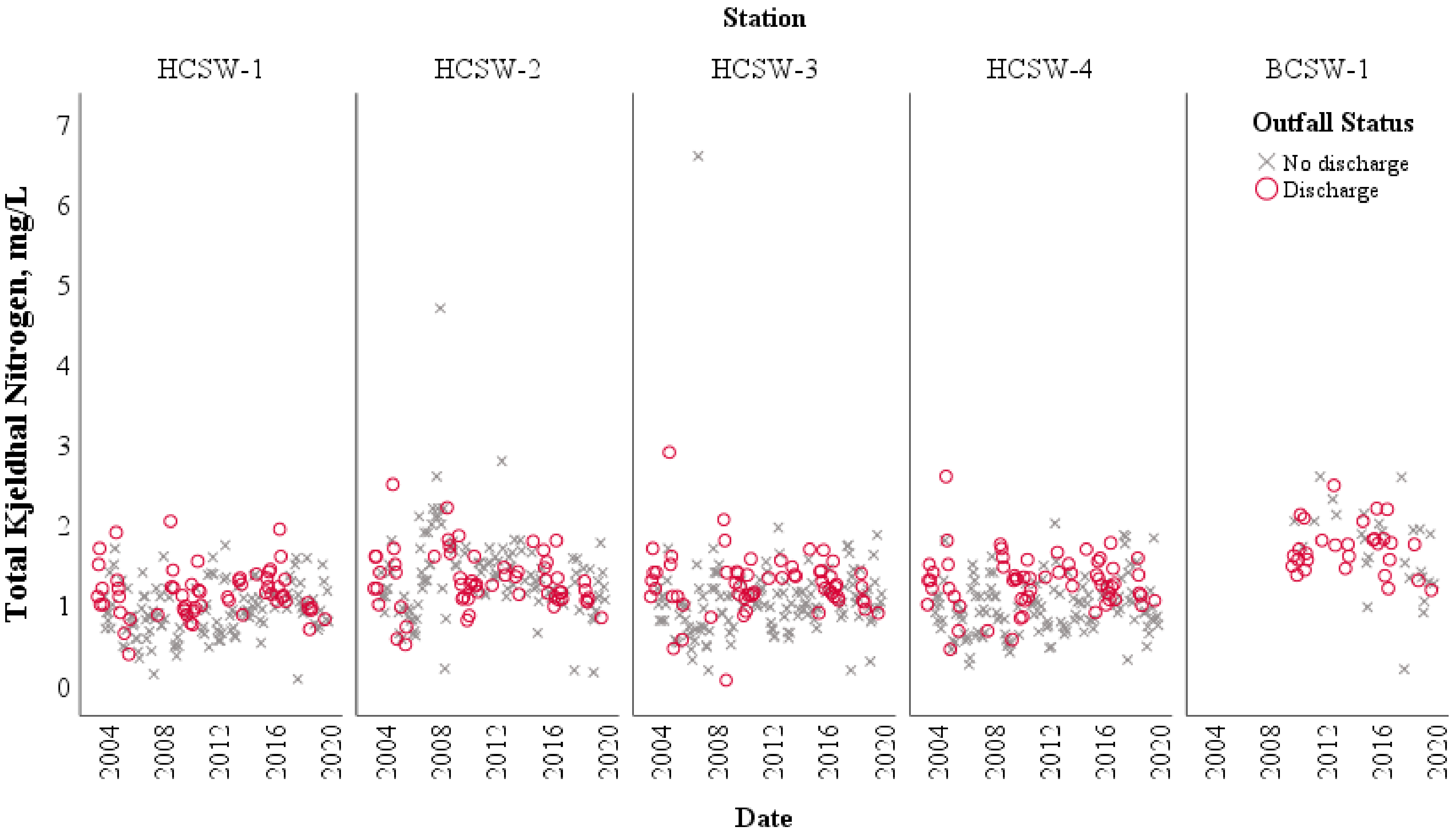
Analyte trigger level represented by red dotted line

Figure C-5 Color Levels Obtained During Monthly HCSP Water Quality Sampling, 2003-2019



Analyte trigger level represented by red dotted line. Green line indicates NNC for west central Florida.

Figure C-6 Total Nitrogen Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019



Analyte trigger level represented by red dotted line

Figure C-7 **Total Kjeldahl Nitrogen Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019**

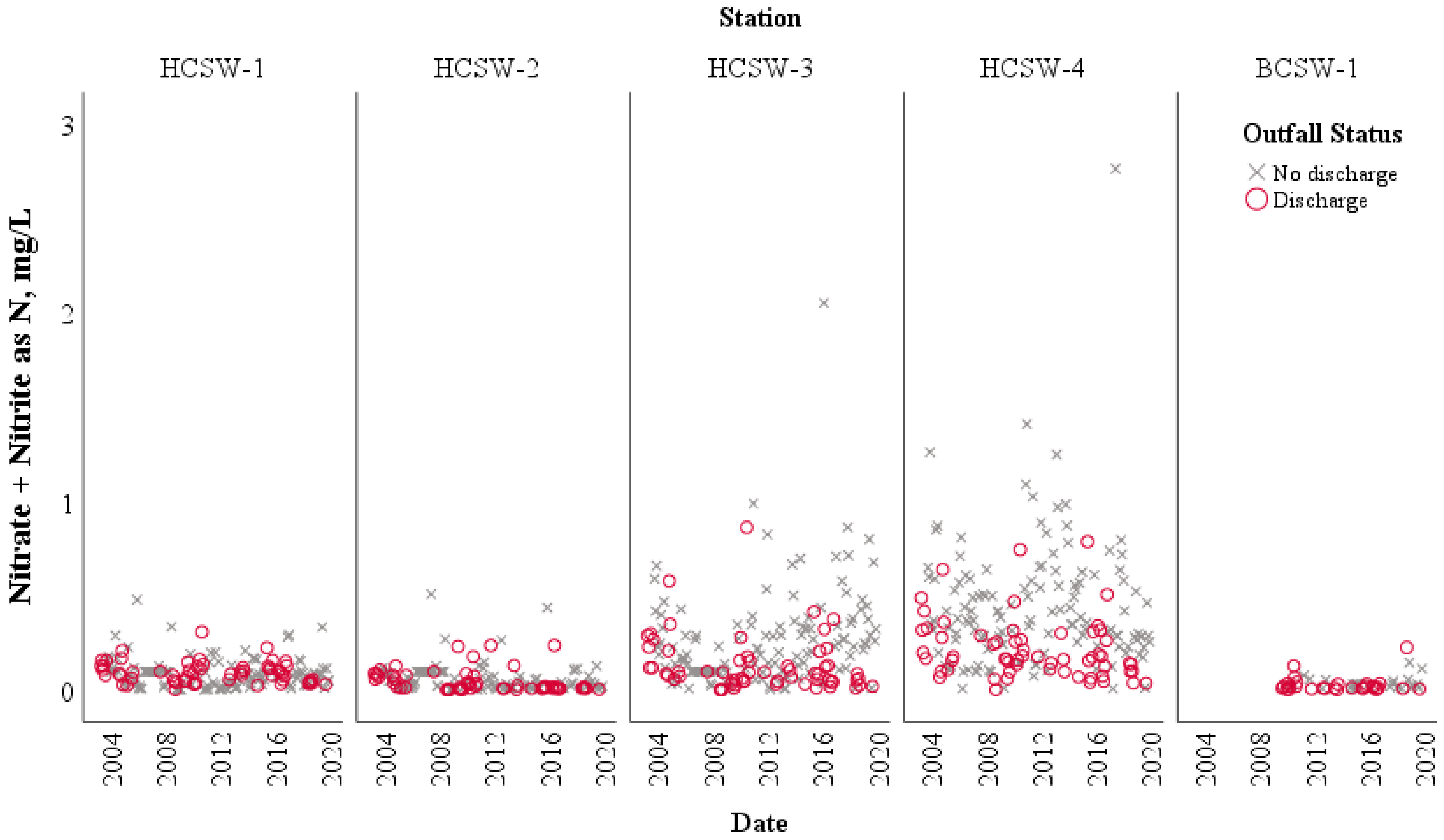
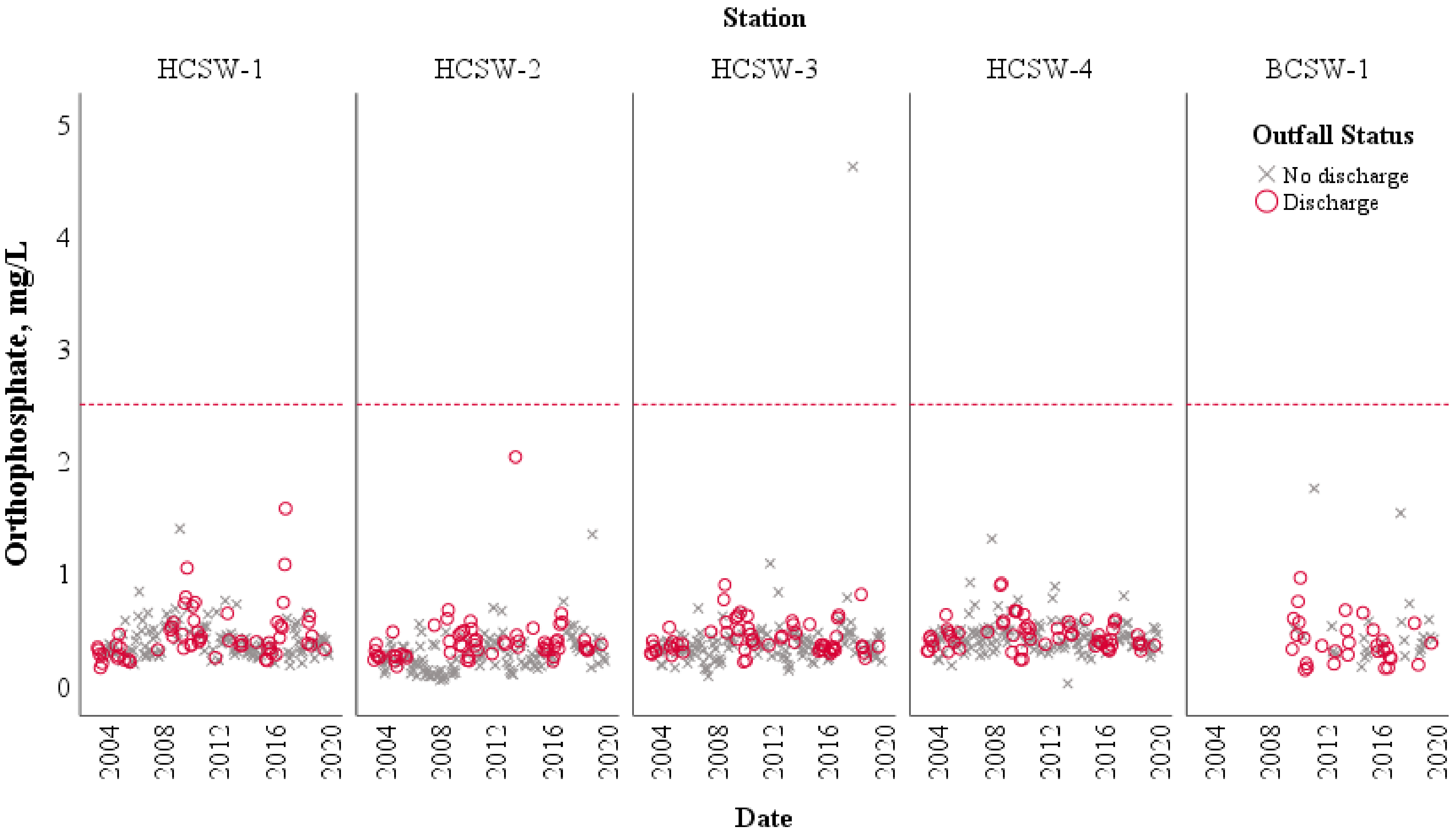


Figure C-8 **Nitrate-Nitrite as Nitrogen Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019**

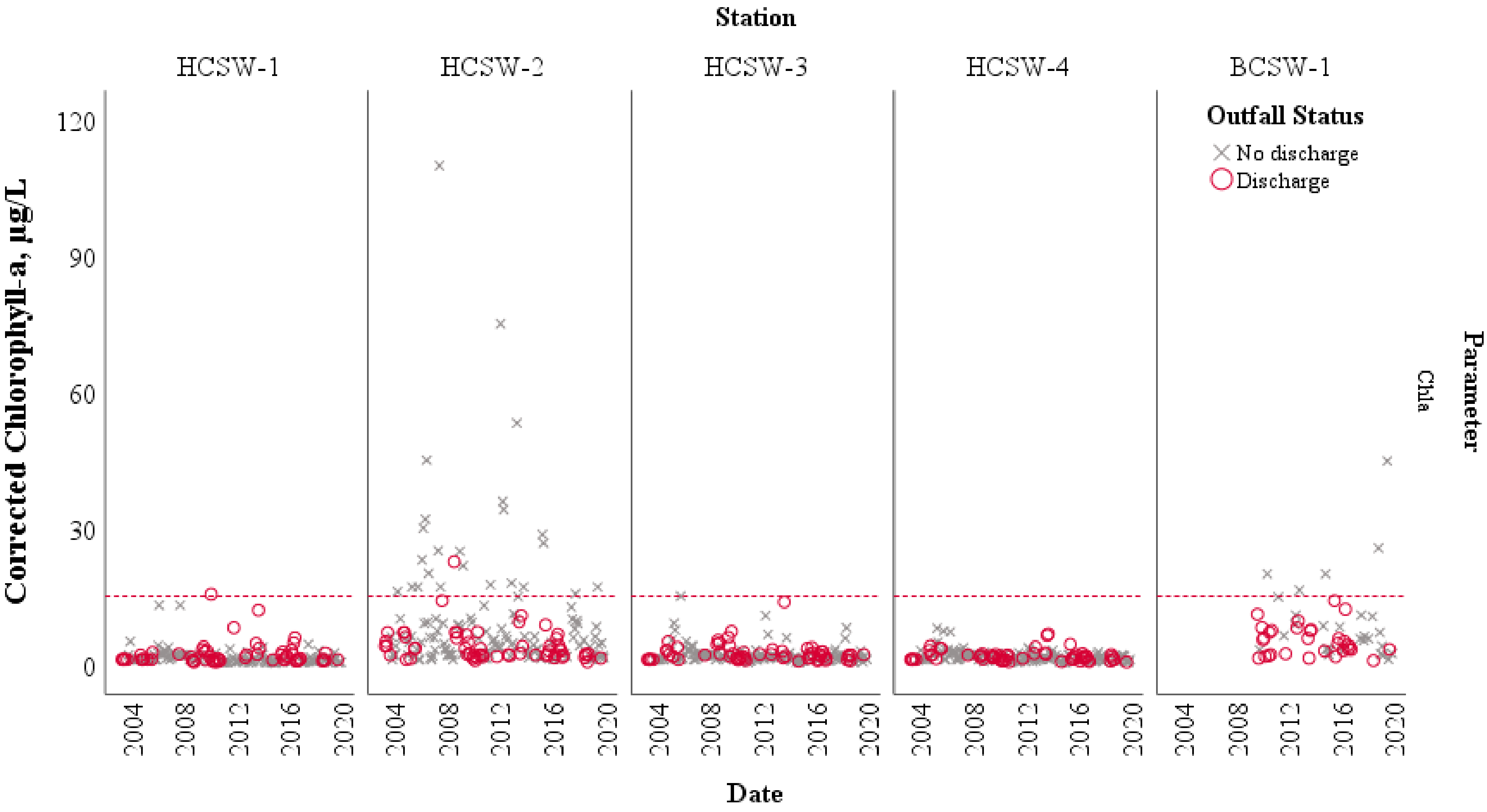
Analyte trigger level represented by red dotted line

Figure C-9 **Total Ammonia as Nitrogen Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019**



Analyte trigger level represented by red dotted line

Figure C-10 Orthophosphate Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019



Analyte trigger value represented by red dotted line

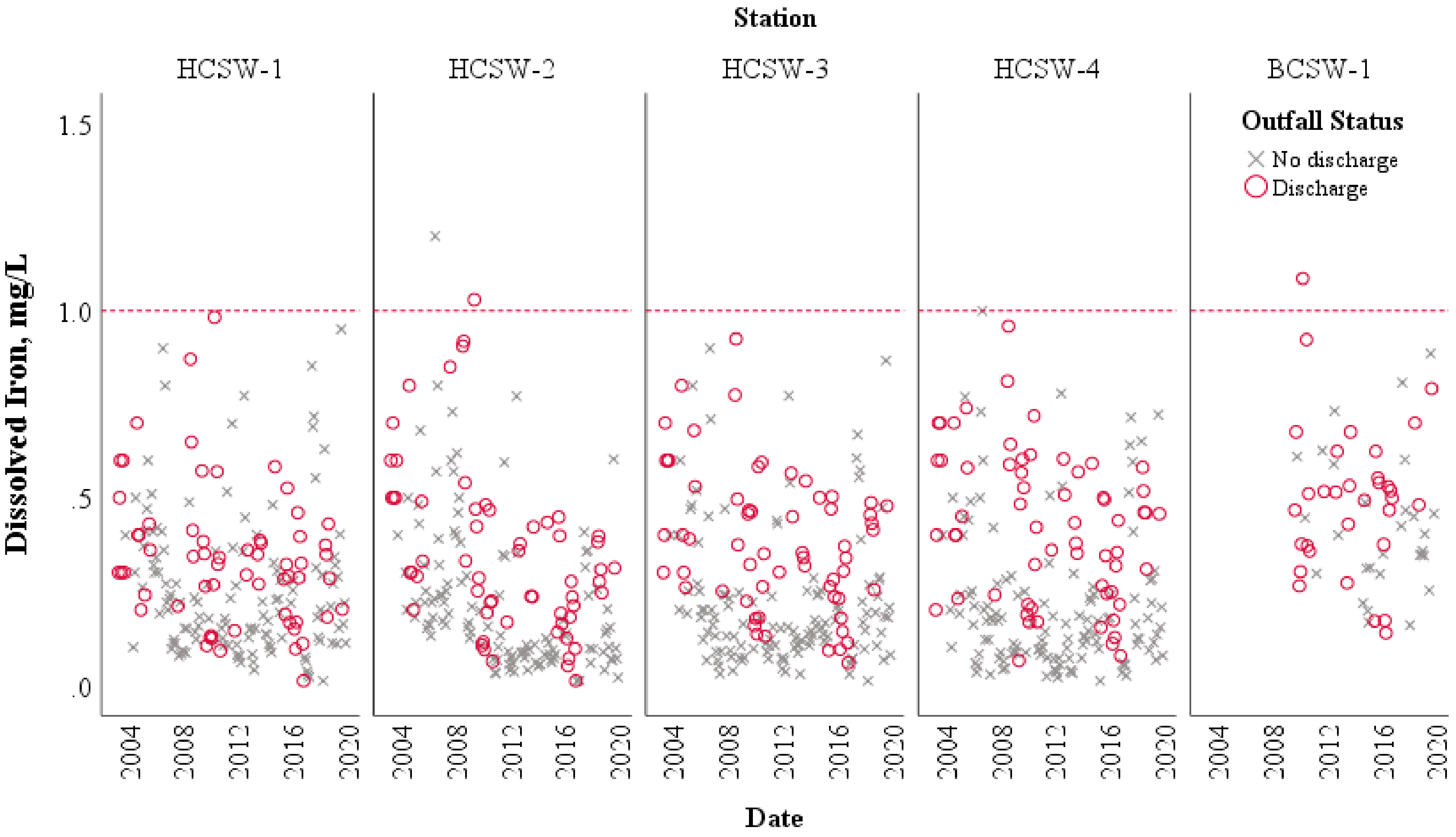
Figure C-11 Chlorophyll-a Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019

Analyte trigger level represented by red dotted line

Figure C-12 Specific Conductivity Obtained During Monthly HCSP Water Quality Sampling Events, 2003-2019

Analyte trigger value represented by red dotted line

Figure C-13 Dissolved Calcium Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019

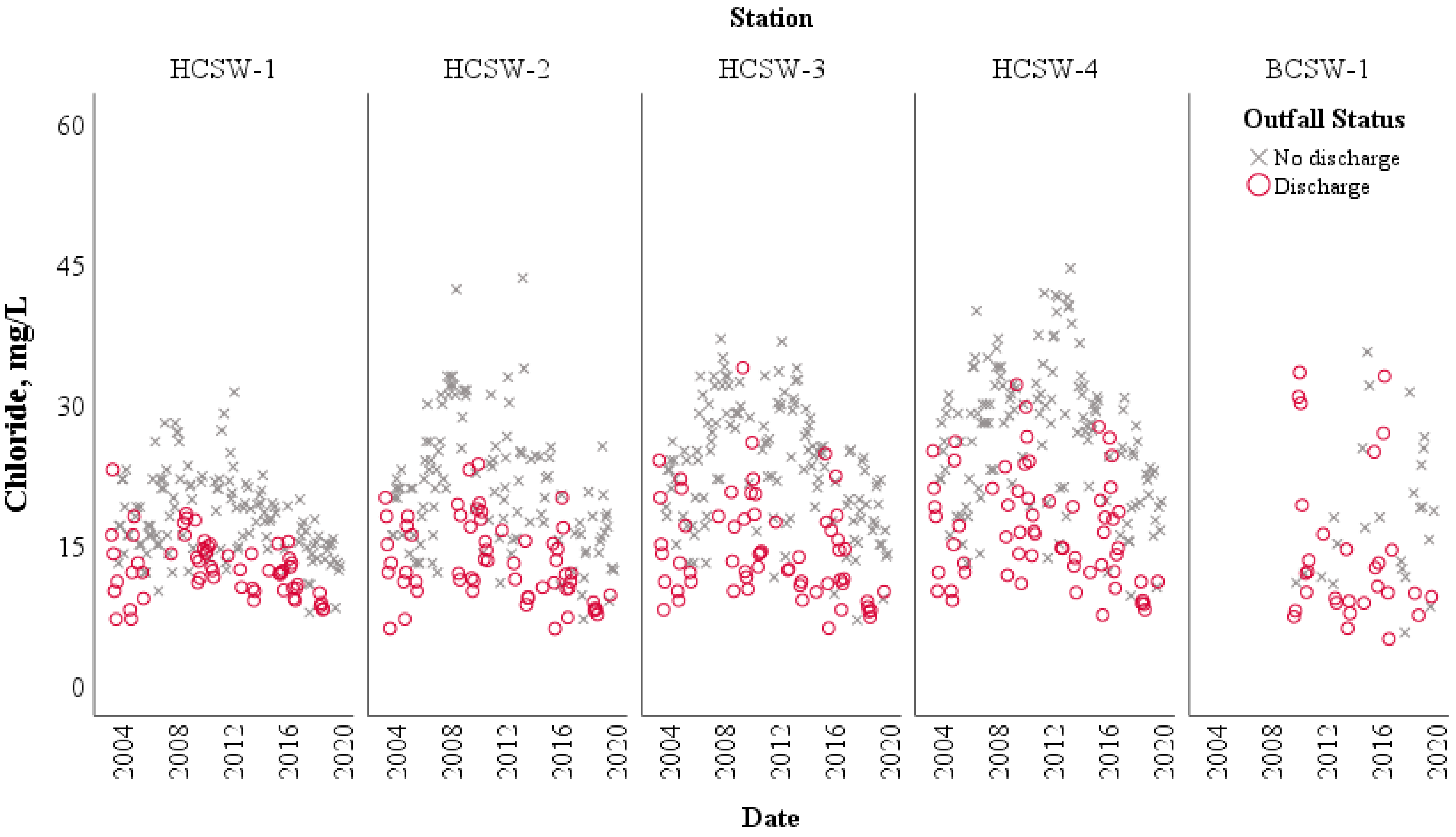


Analyte trigger level represented by red dotted line

Figure C-14 Dissolved Iron Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019

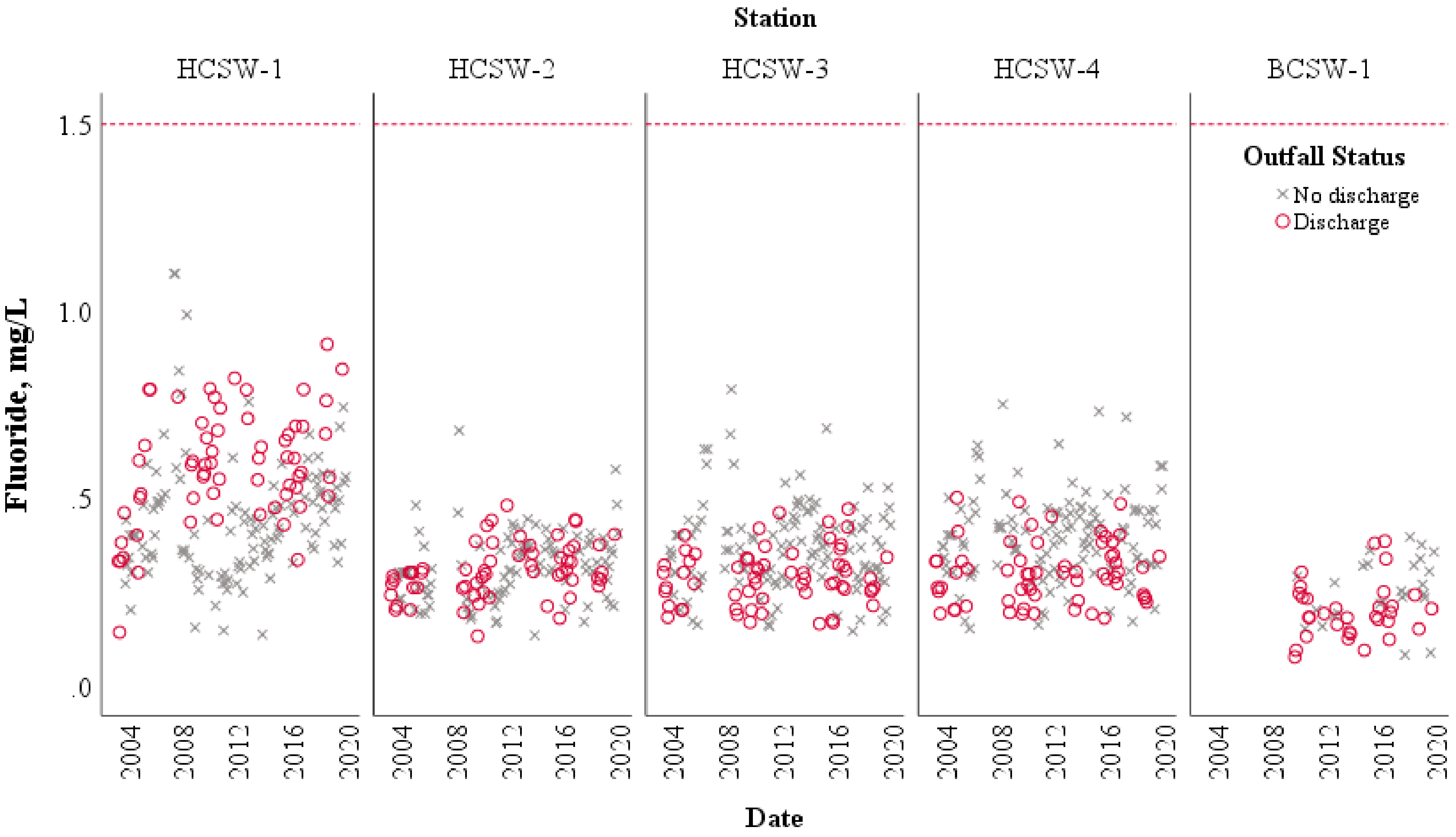
Analyte trigger value represented by red dotted line

Figure C-15 Total Alkalinity Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019



Chloride trigger value = 250mg/L

Figure C-16 Chloride Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019



Red dotted line represents fluoride trigger level for HCSW-4. Trigger level for HCSW-1, HCSW-2, and HCSW-3 = 4mg/L

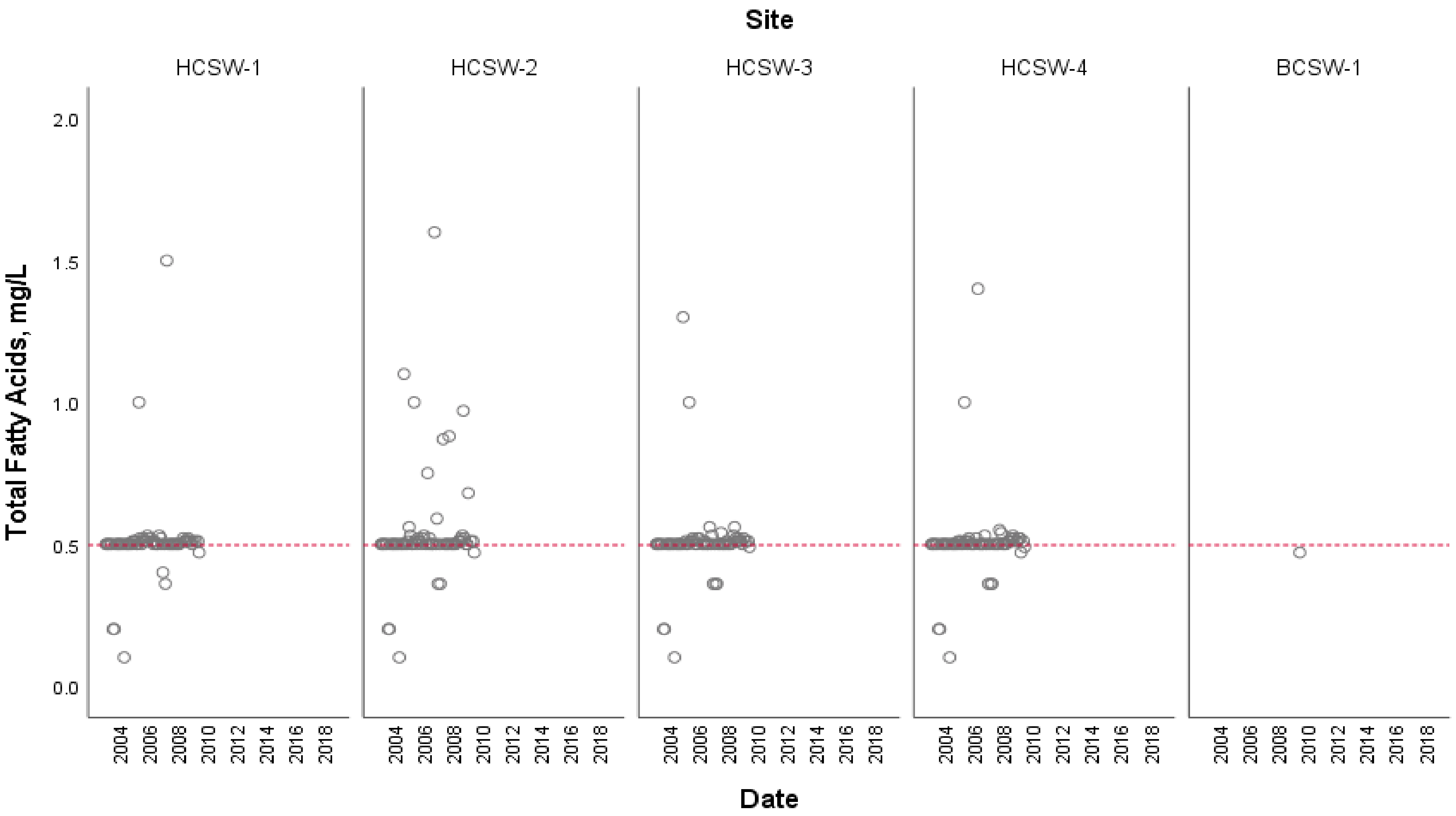
Figure C-17 Fluoride Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019

Analyte trigger level represented by red dotted line

Figure C-18 Sulfate Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019

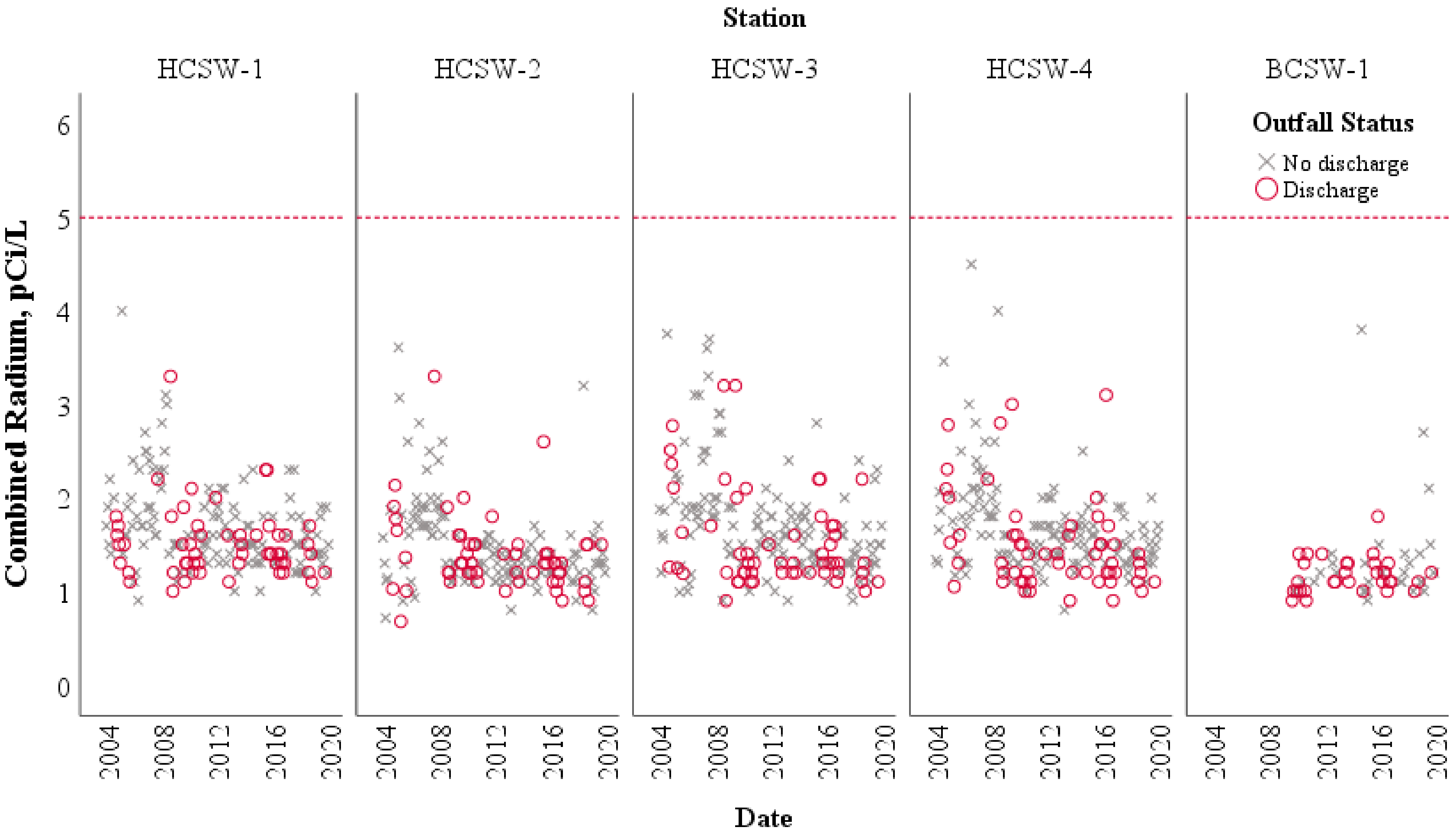
Analyte trigger level represented by red dotted line

Figure C-19 Total Dissolved Solids Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2019



Analyte trigger level represented by red dotted line

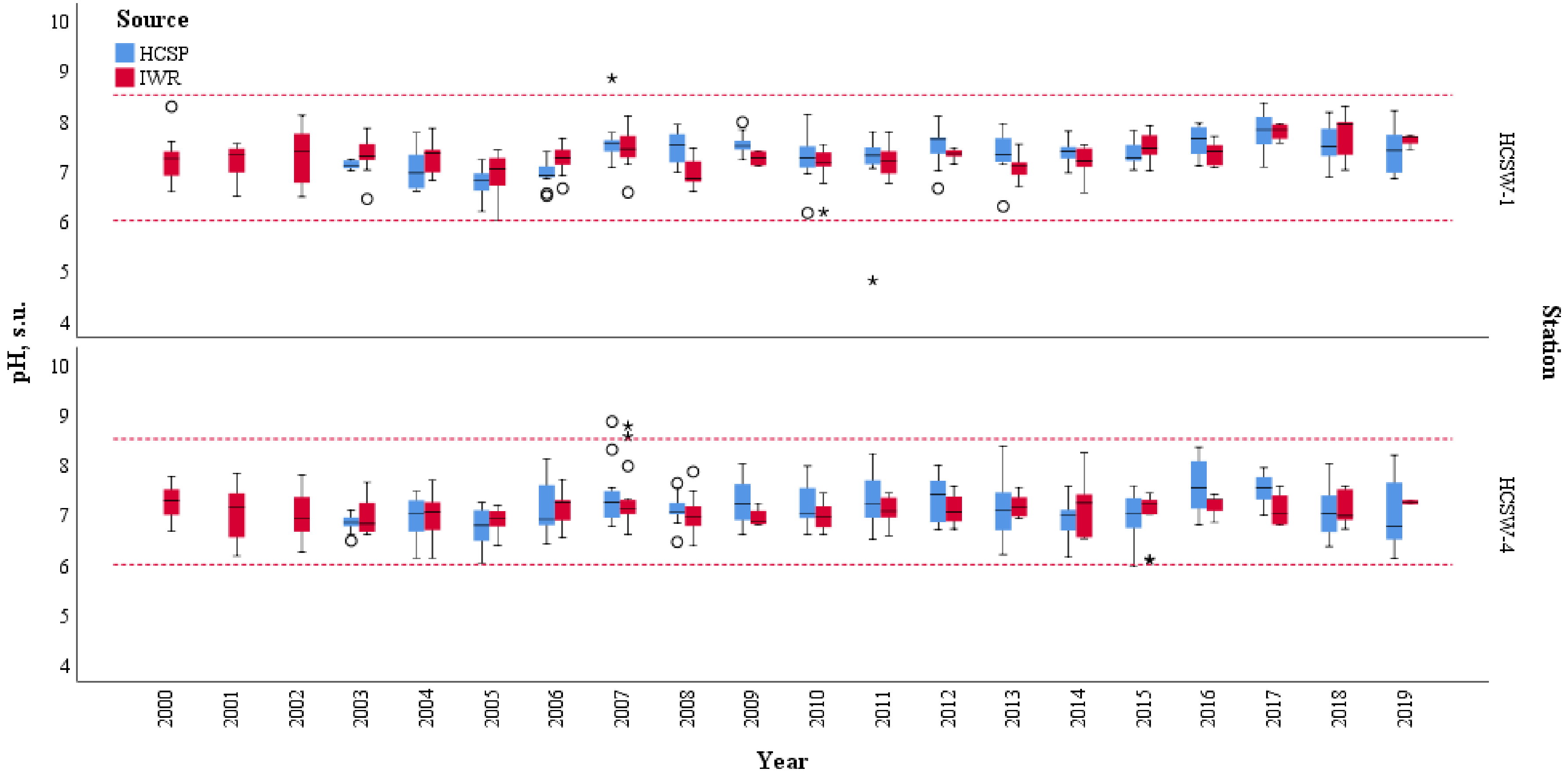
Figure C-20 **Total Fatty Acids (Above MDL Only) Concentrations Obtained During Monthly HCSP Water Quality Sampling, 2003-2009. This Analyte Was Dropped in 2009.**



Analyte trigger level represented by red dotted line

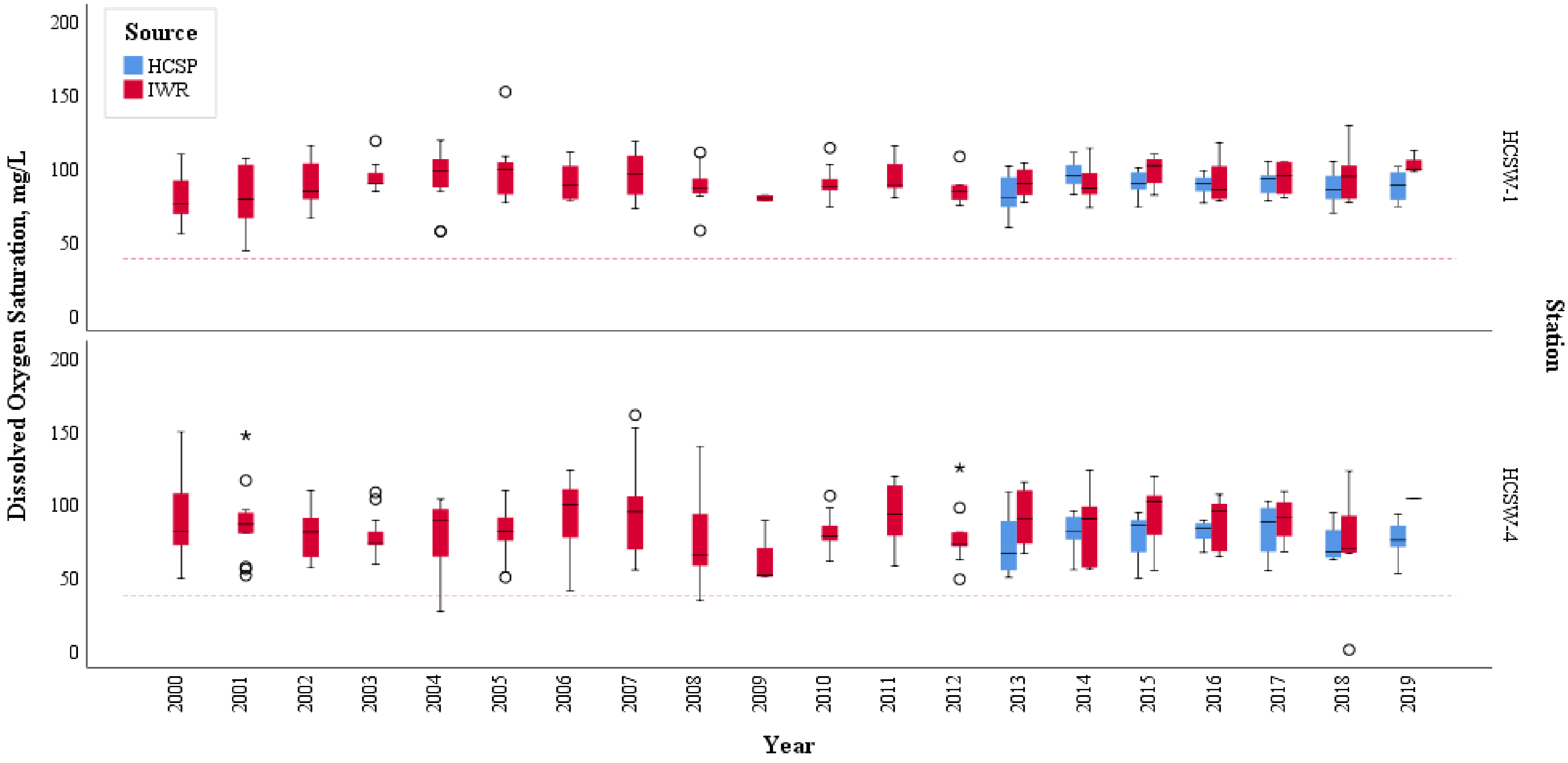
Figure C-21 Total Radium (^{226}Ra + ^{226}Ra) Obtained During Monthly HCSP Water Quality Sampling, 2003-2019

C.2 WATER QUALITY BOXPLOTS: PUBLIC SOURCES AND HCSP FROM 2000 to 2019



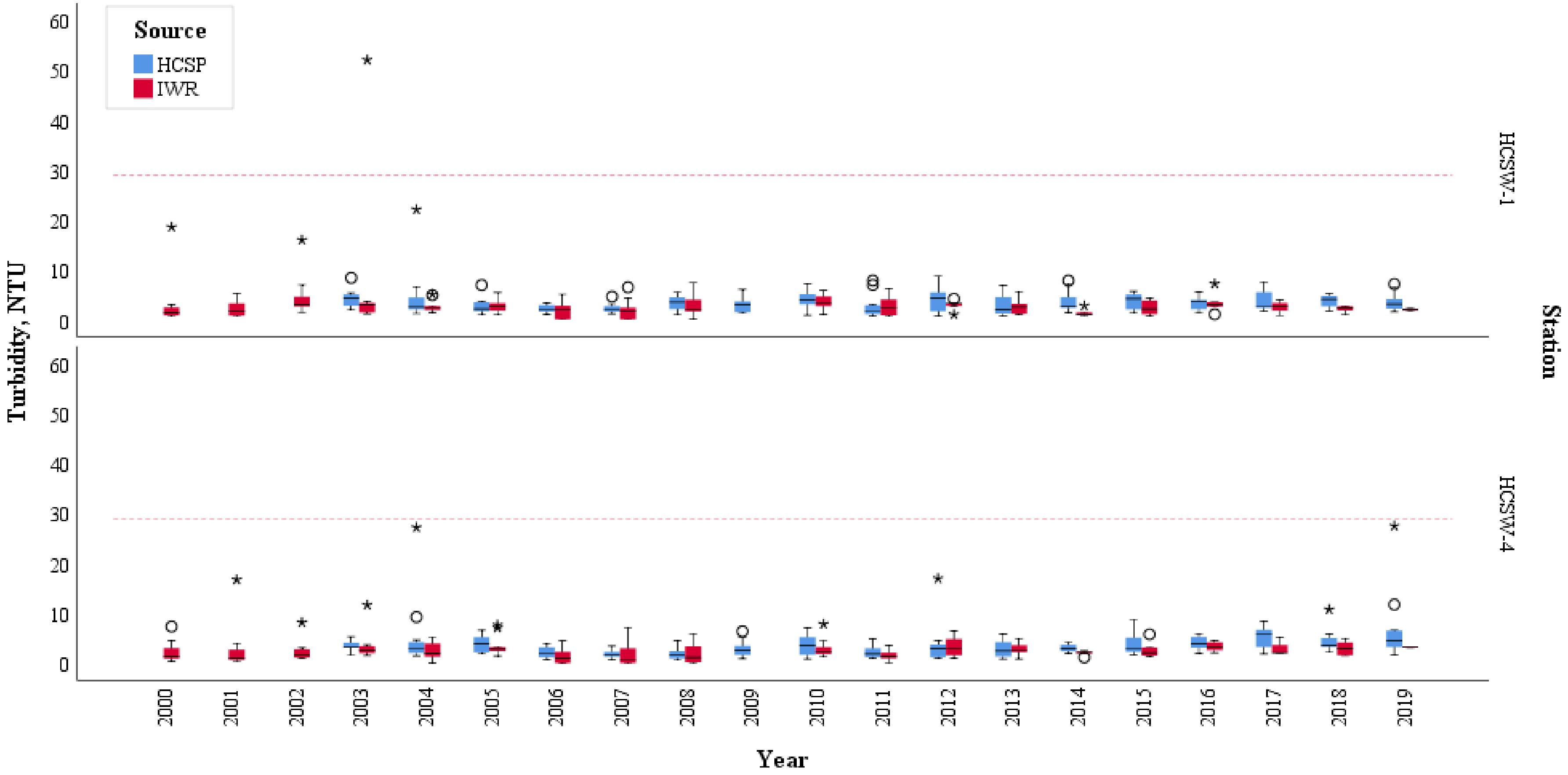
Analyte trigger level represented by red dotted line

Figure C-22 HCSW-1 and HCSW-4 Values of pH Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019



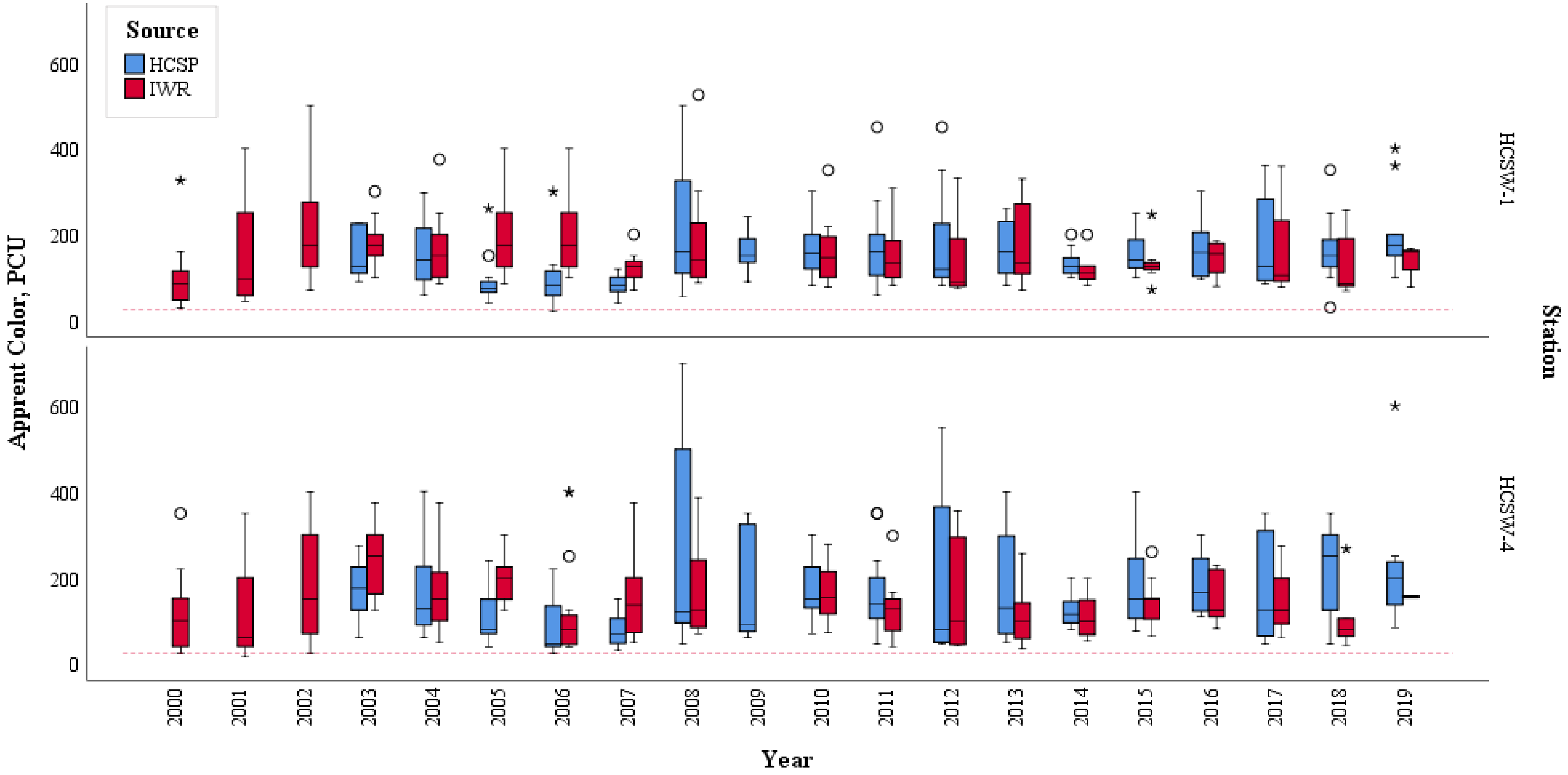
Analyte trigger level represented by red dotted line

Figure C-23 HCSW-1 and HCSW-4 DO Saturation Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019



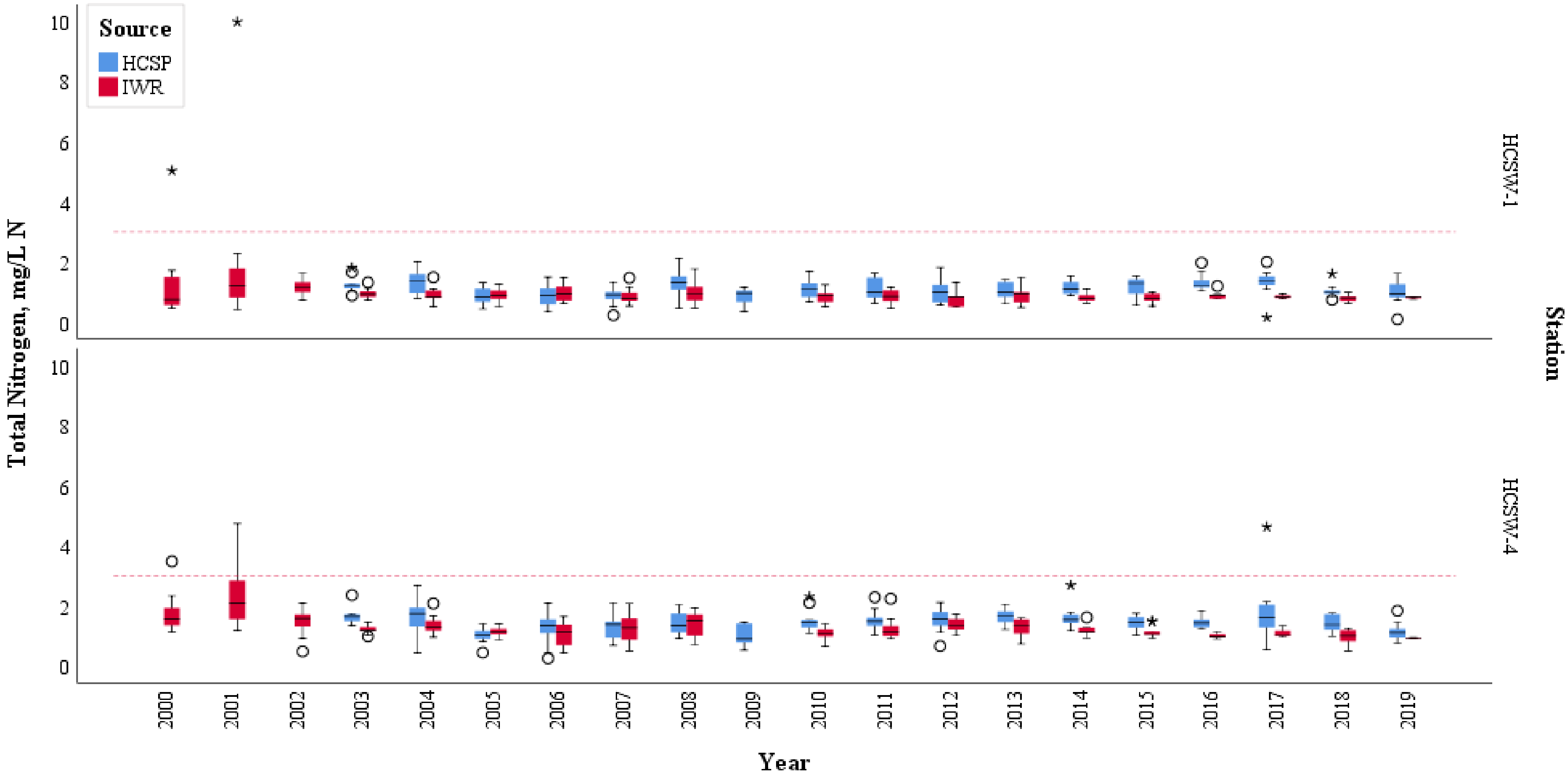
Analyte trigger level represented by red dotted line

Figure C-24 HCSW-1 and HCSW-4 Values of Turbidity Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019



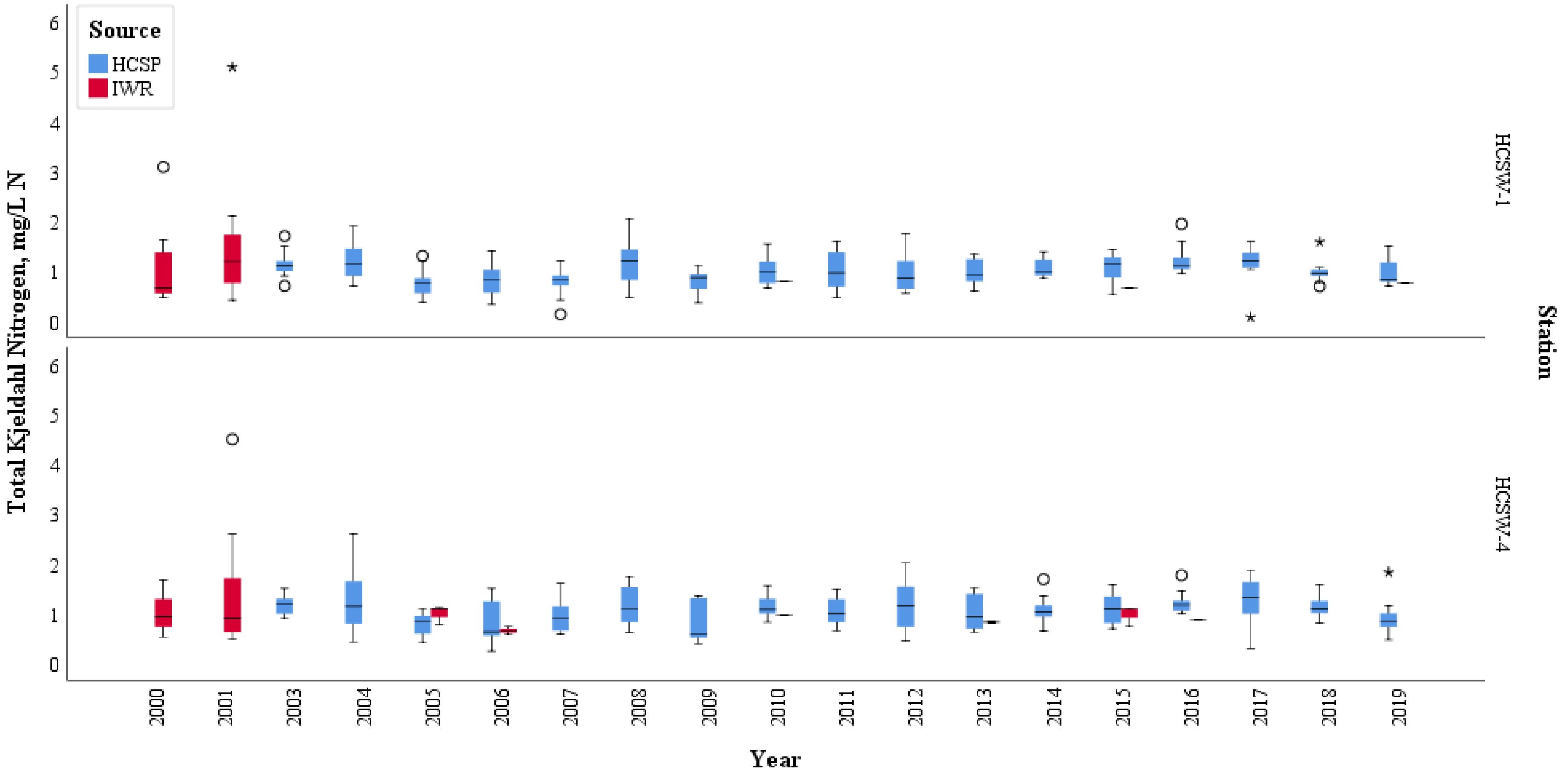
Analyte trigger level represented by red dotted line

Figure C-25 HCSW-1 and HCSW-4 Values of Apparent Color Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019



Analyte trigger level represented by red dotted line

Figure C-26 HCSW-1 and HCSW-4 Total Nitrogen Concentrations Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019



Analyte trigger level represented by red dotted line

Figure C-27 HCSW-1 and HCSW-4 TKN Concentrations Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019

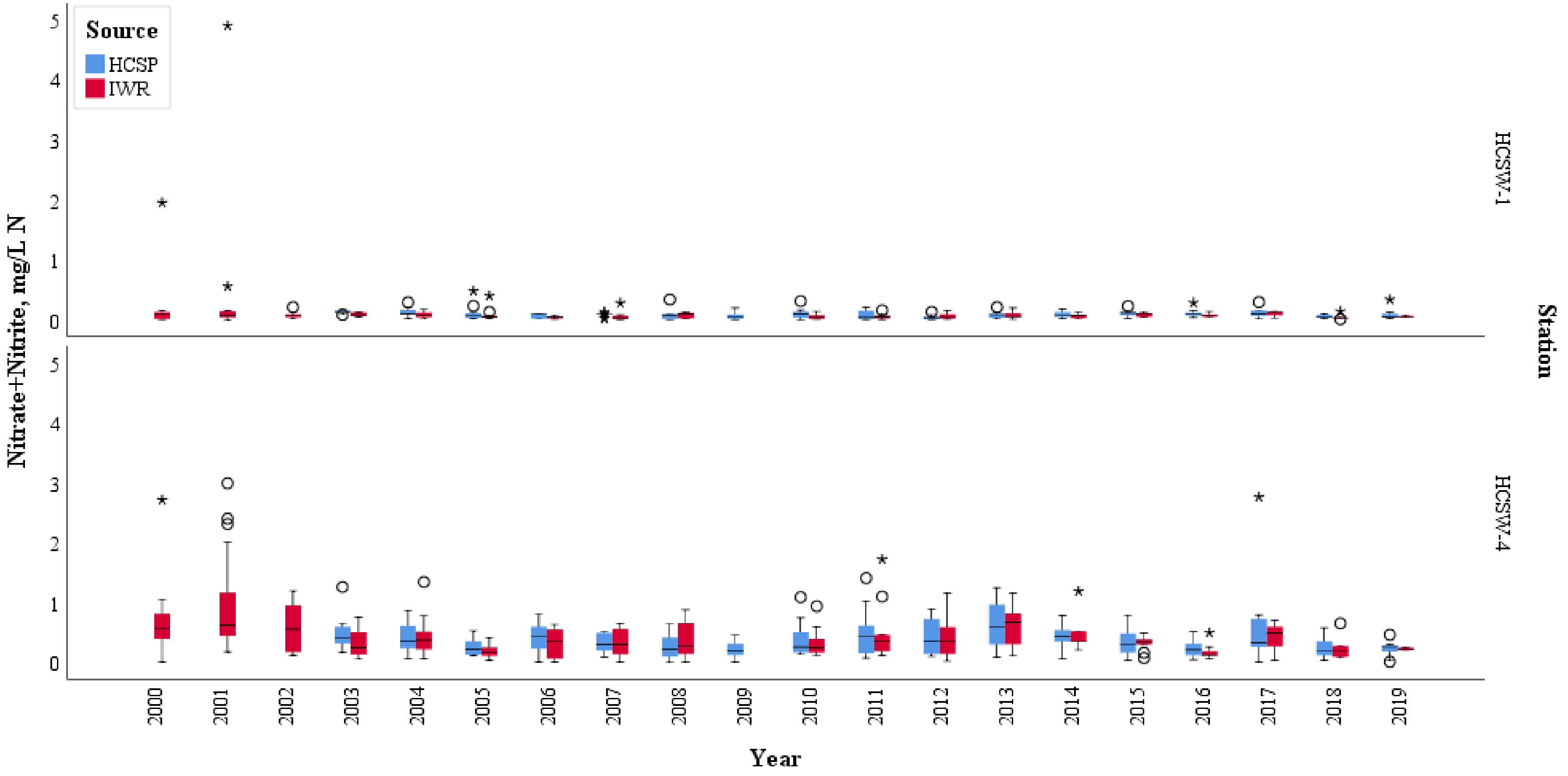
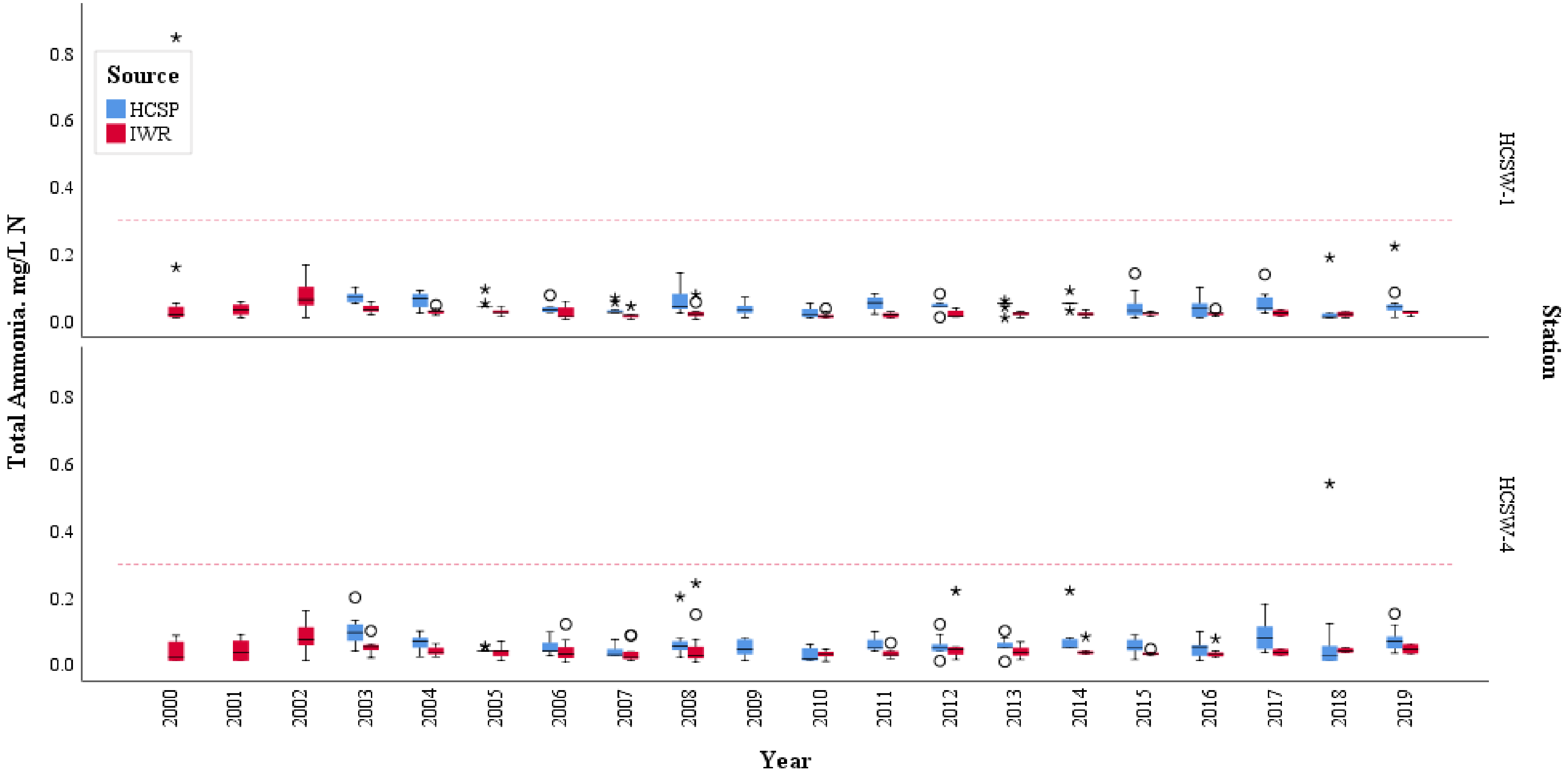
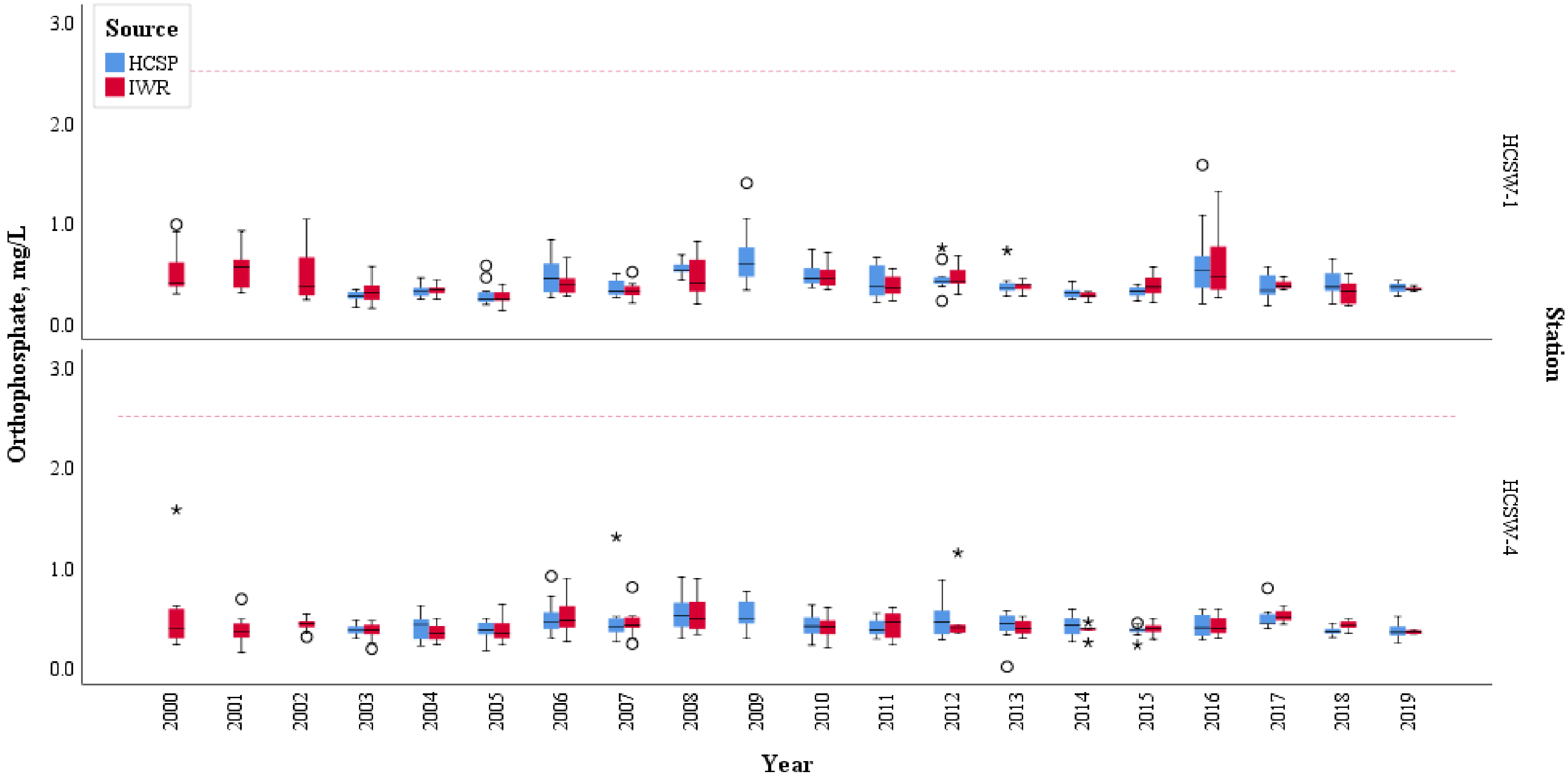


Figure C-28 HCSW-1 and HCSW-4 Nitrate-Nitrite Concentrations Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019



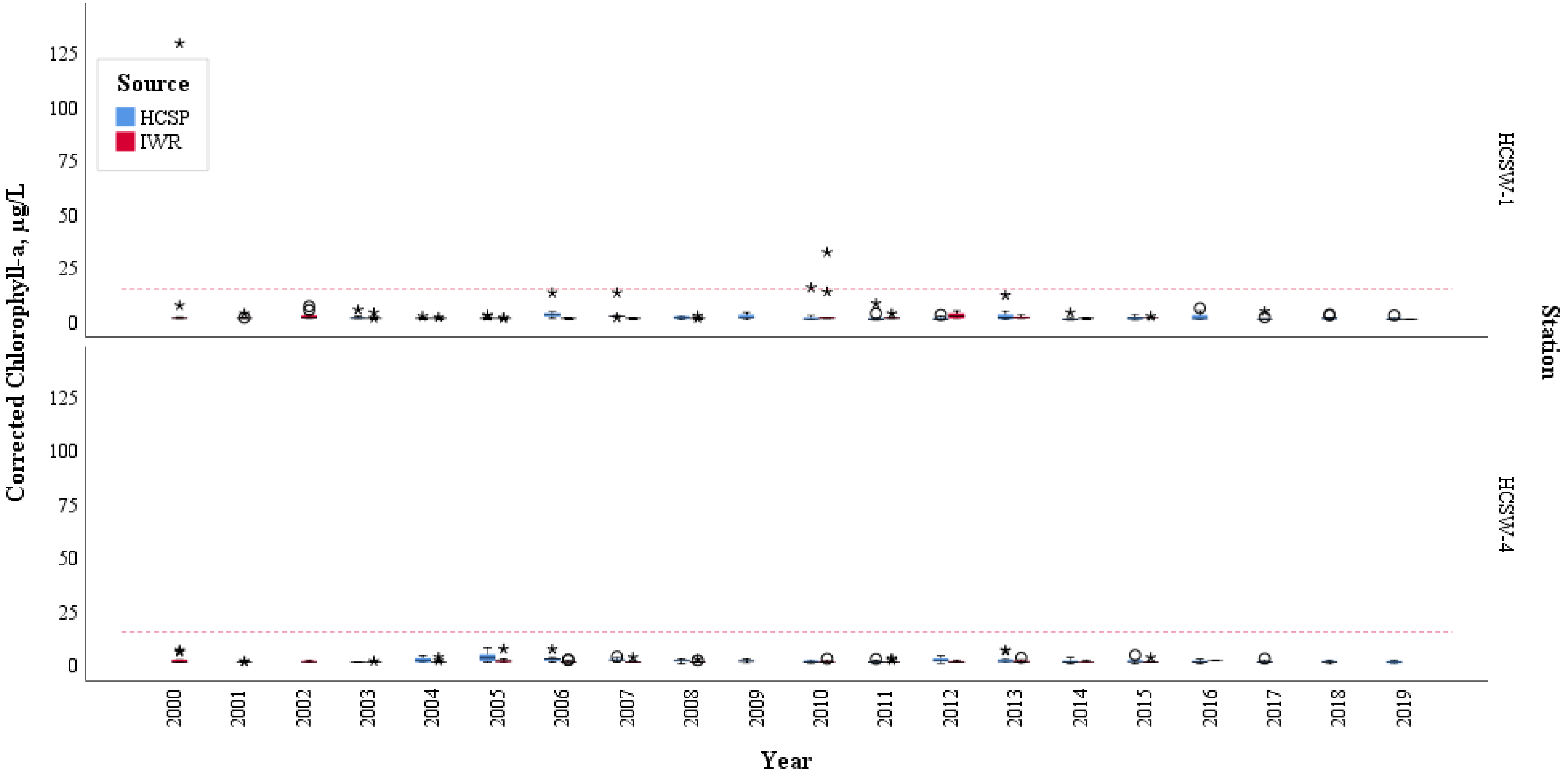
Analyte trigger level represented by red dotted line

Figure C-29 HCSW-1 and HCSW-4 Ammonia Concentrations Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019



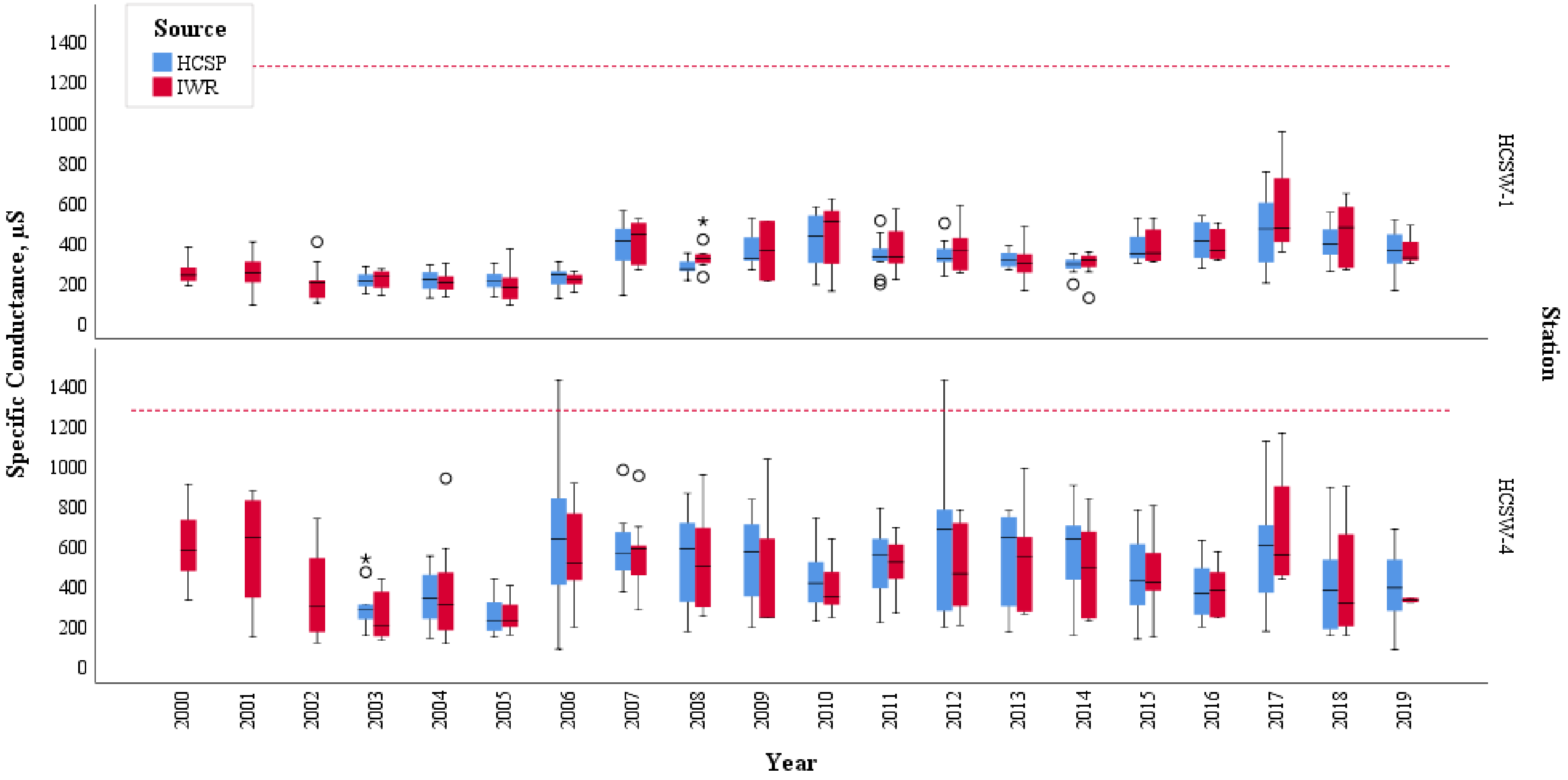
Analyte trigger level represented by red dotted line

Figure C-30 **HCSW-1 and HCSW-4 Orthophosphate Concentrations Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019**



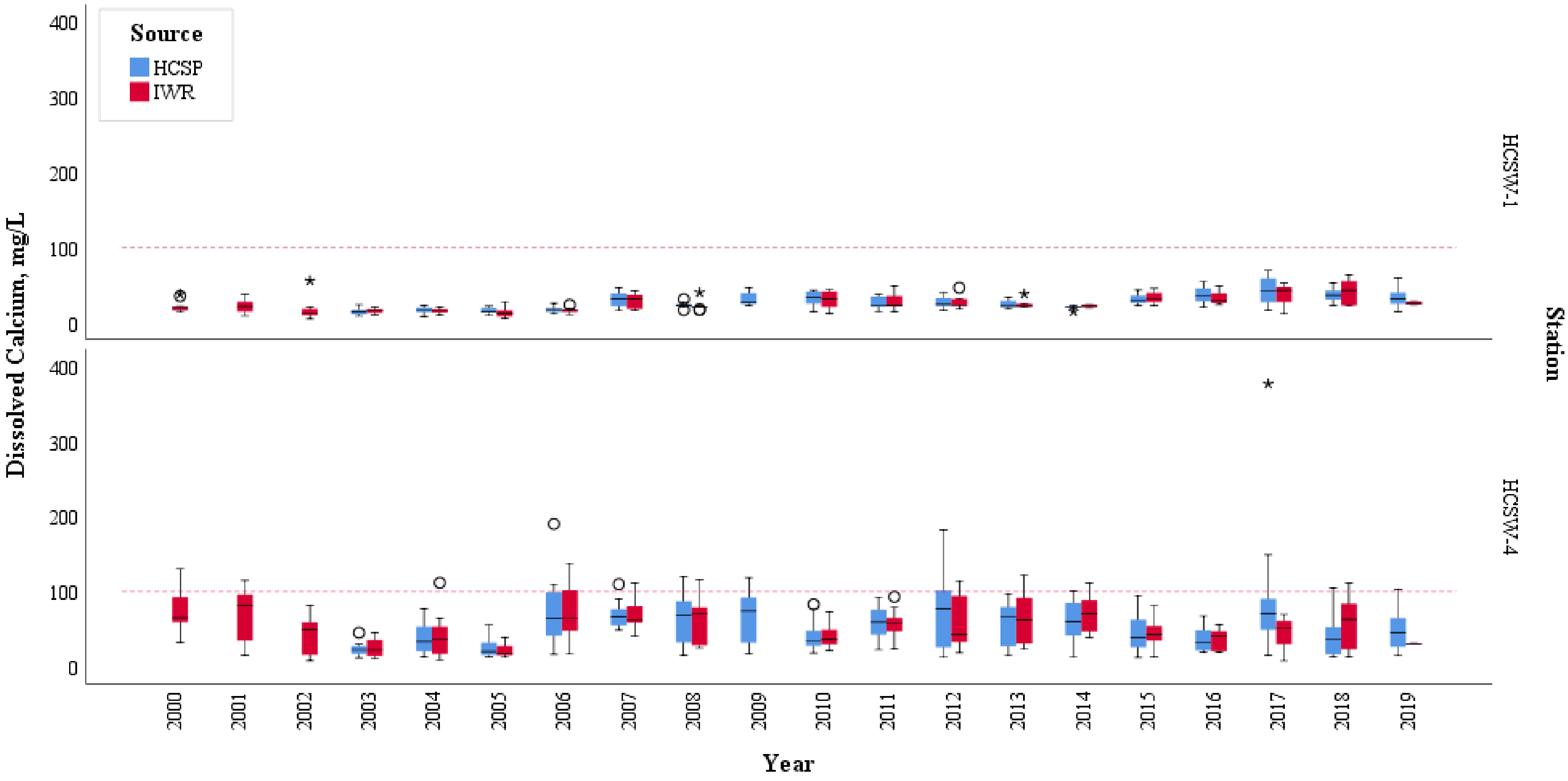
Analyte trigger level represented by red dotted line

Figure C-31 **HCSW-1 and HCSW-4 Corrected Chlorophyll-a Concentrations Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019**



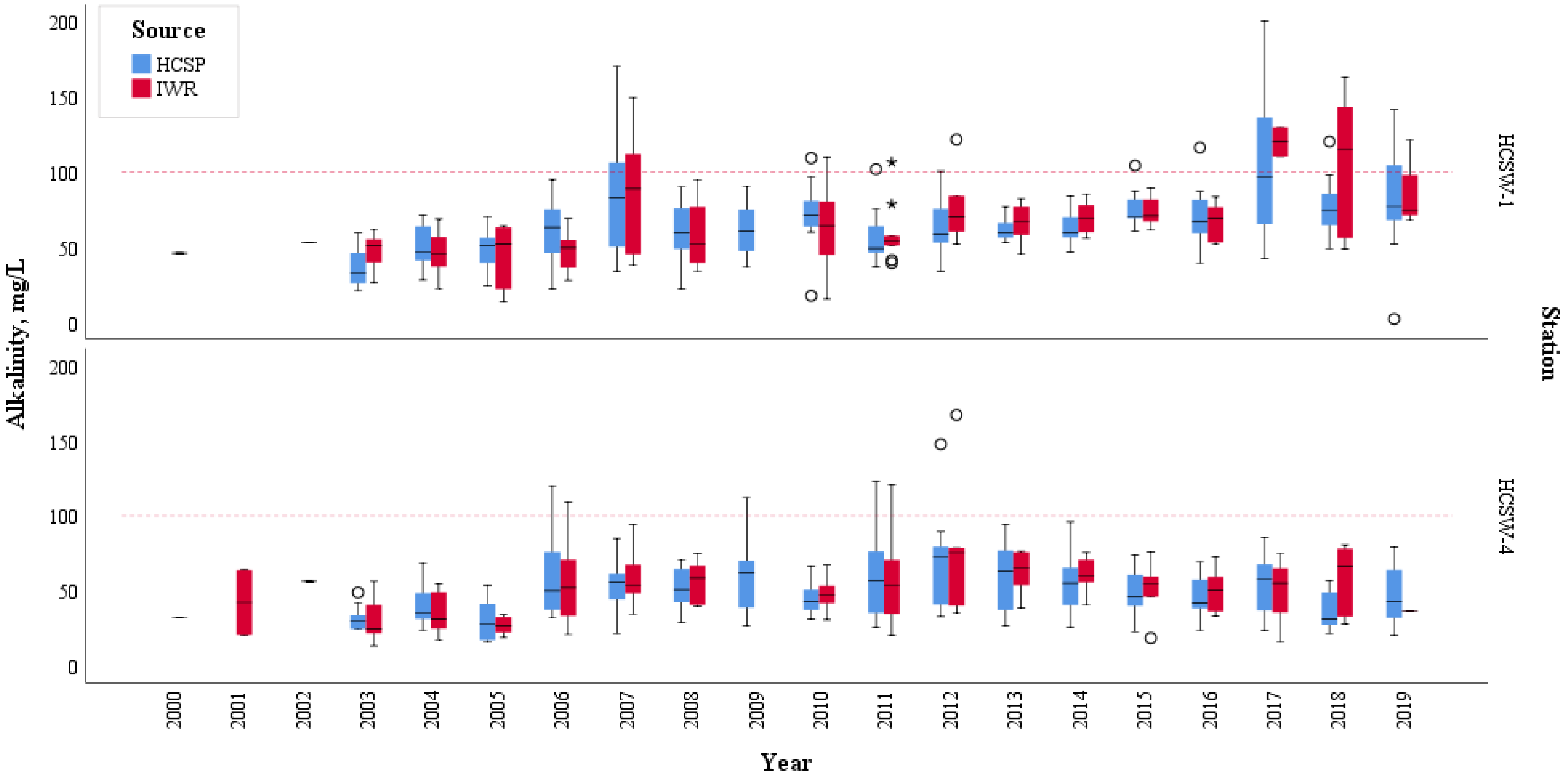
Analyte trigger level represented by red dotted line

Figure C-32 HCSW-1 and HCSW-4 Values of Specific Conductivity Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019



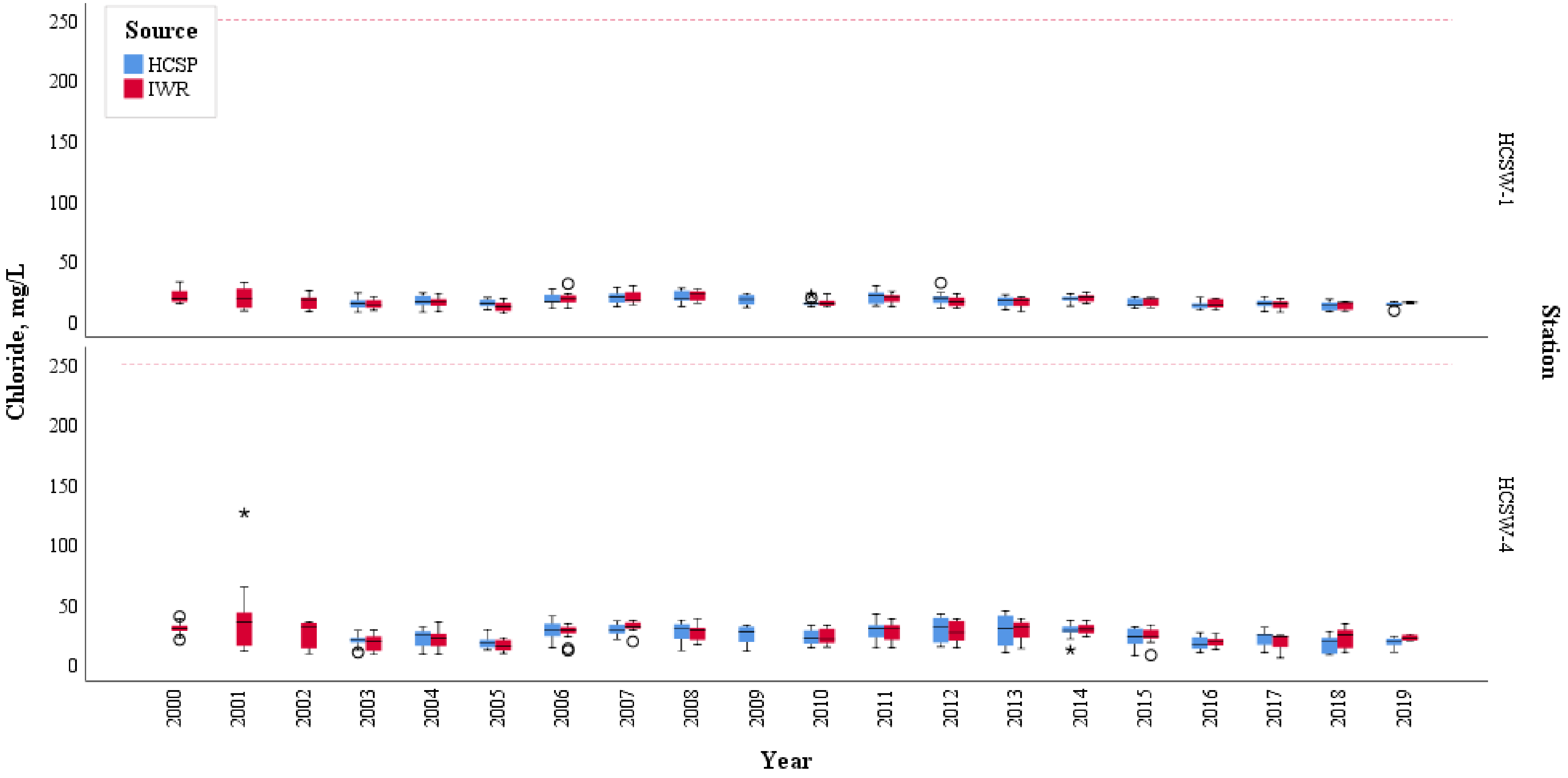
Analyte trigger level represented by red dotted line

Figure C-33 HCSW-1 and HCSW-4 Calcium Concentrations Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019



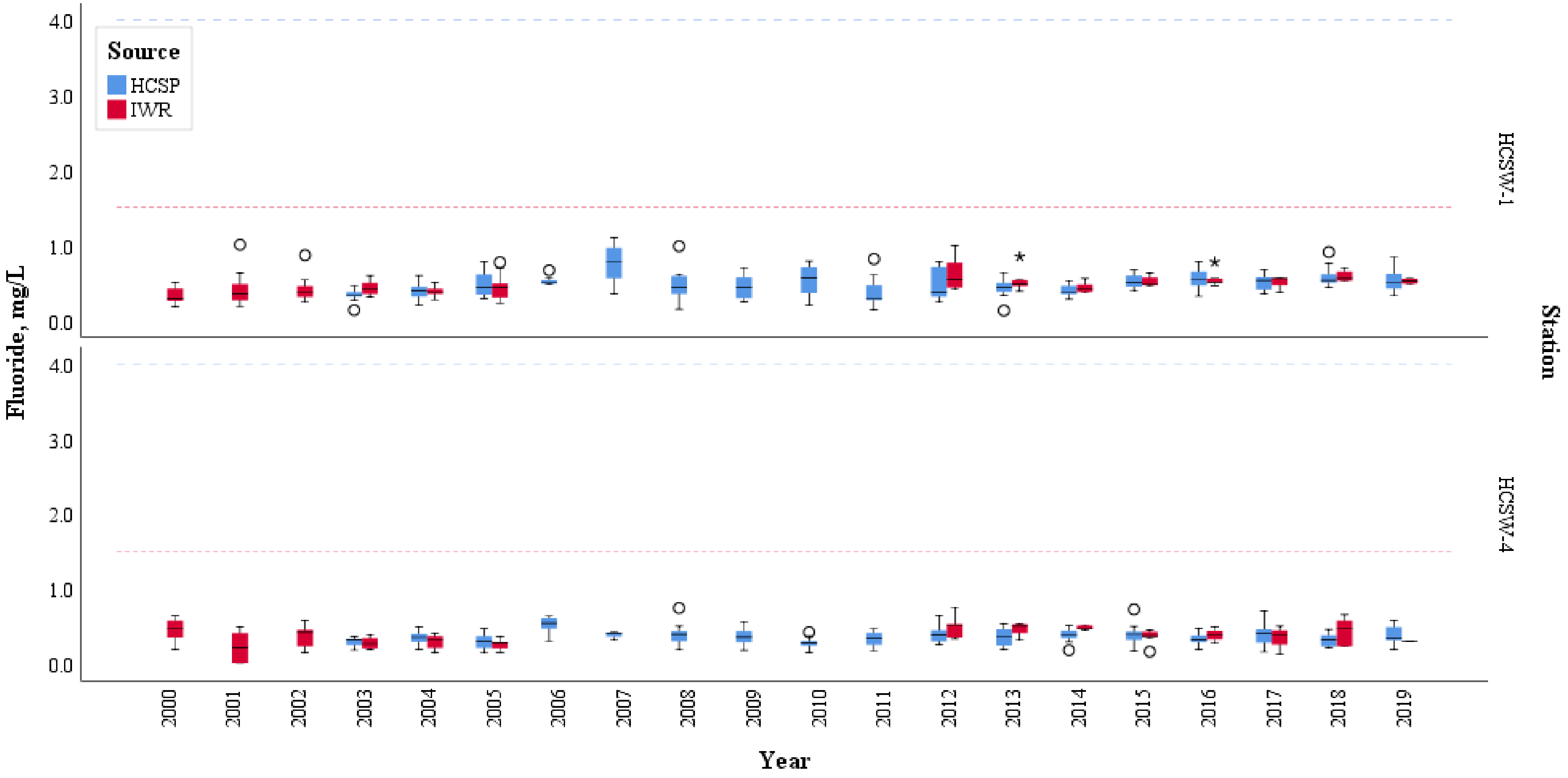
Analyte trigger level represented by red dotted line

Figure C-34 HCSW-1 and HCSW-4 Alkalinity Concentrations Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019



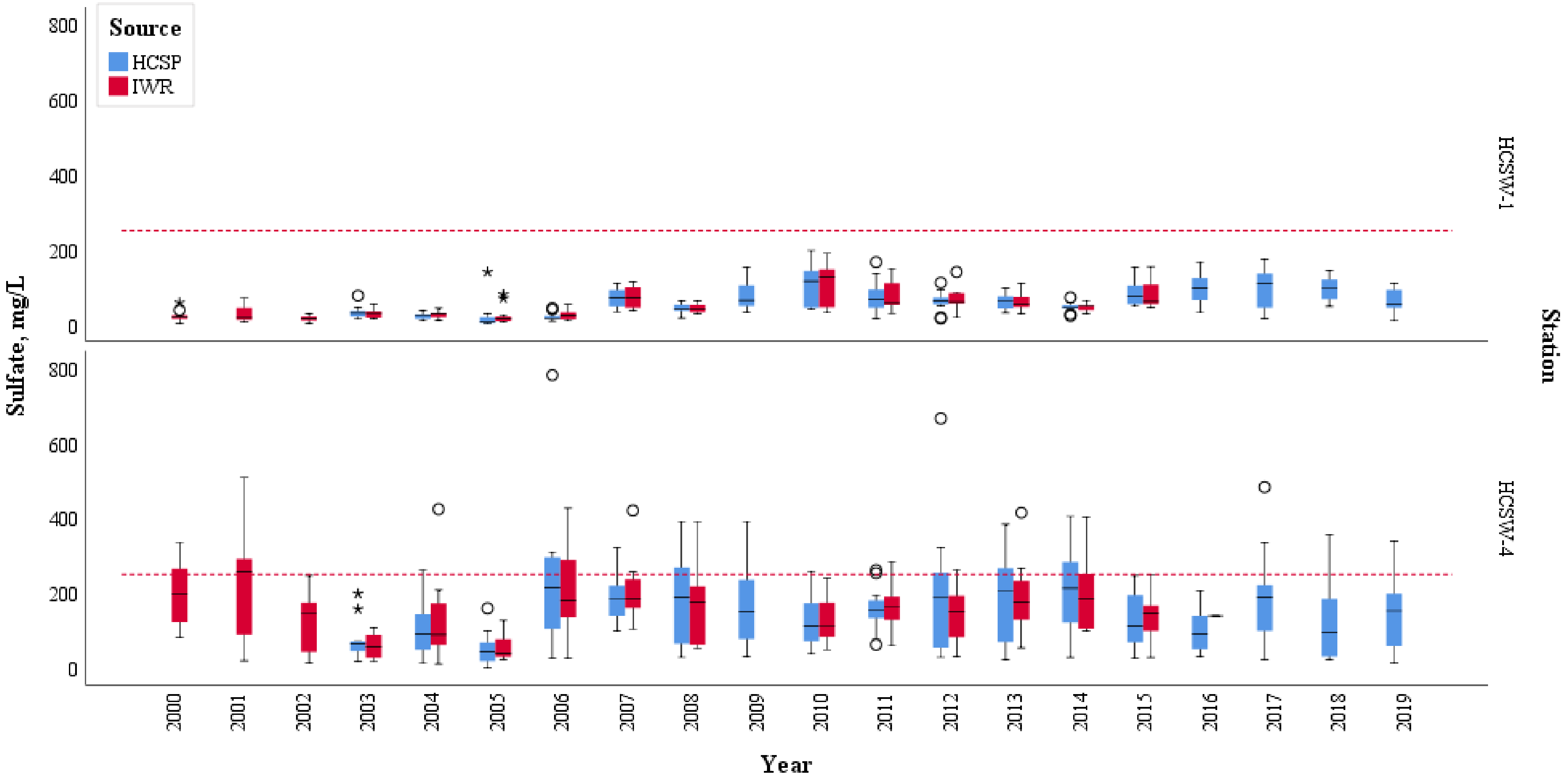
Analyte trigger level represented by red dotted line

Figure C-35 **HCSW-1 and HCSW-4 Chloride Concentrations Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019**



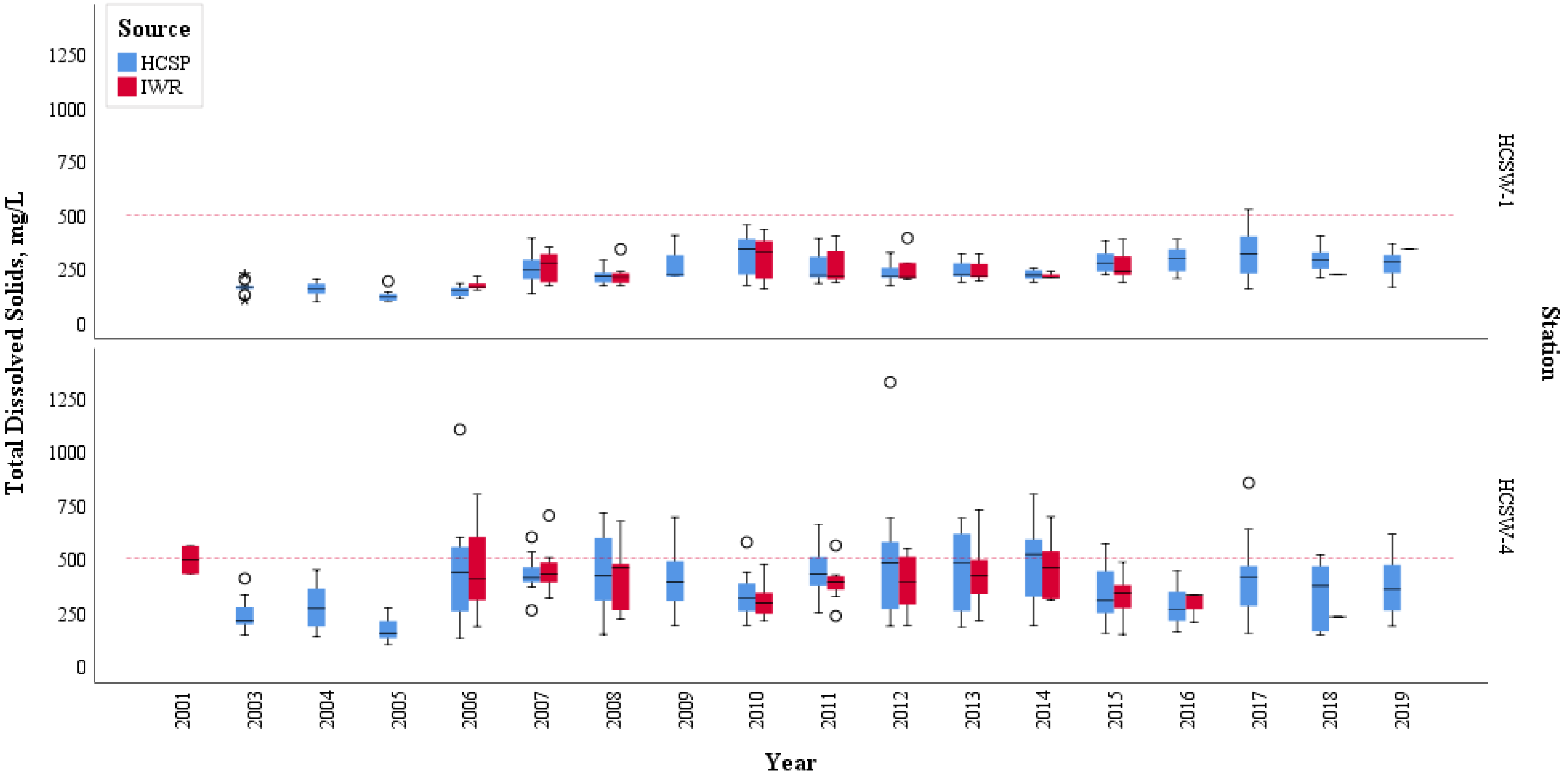
Analyte trigger level for HCSW-4 represented by red dotted line. Analyte trigger level for HSCW-1, HCSW-2, and HSCW-3 represented by dashed blue line.

Figure C-36 HCSW-1 and HCSW-4 Fluoride Concentrations Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019



Analyte trigger level represented by red dotted line

Figure C-37 HCSW-1 and HCSW-4 Sulfate Concentrations Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019



Analyte trigger level represented by red dotted line

Figure C-38 HCSW-1 and HCSW-4 TDS Concentrations Obtained from Various Data Sources (FDEP IWR Database Run 58 and HCSP), 2000 to 2019

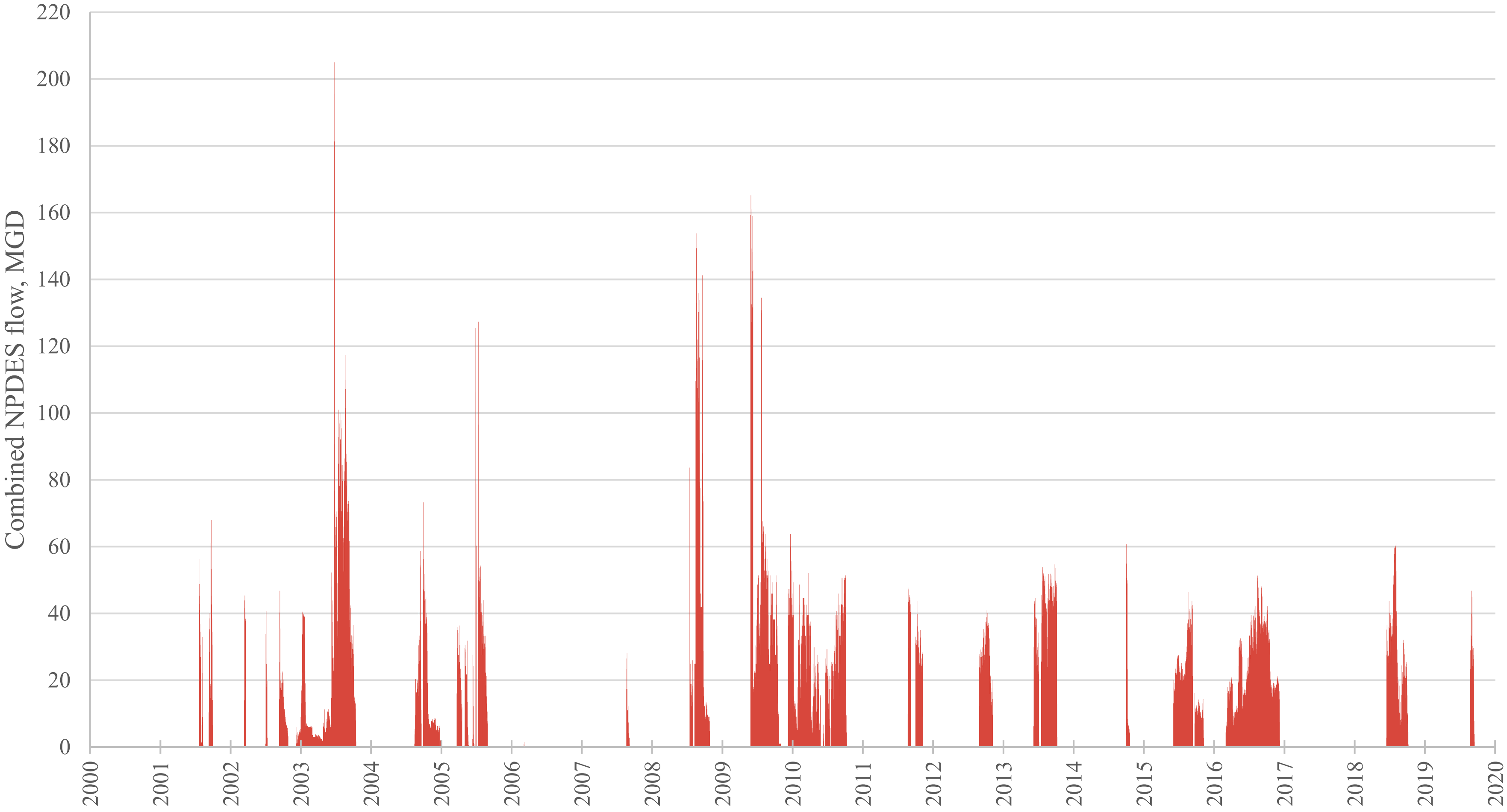


Figure C-39 Combined NPDES flow (FTG-003 & WIN-004) to Horse Creek, Period of Record

Table C-1 POR NPDES Summary Statistics

Row Labels	D-003 + D-004 Million Gallons	Rank
2001	1239	14
2002	1338	13
2003	9253	1
2004	2222	10
2005	3411	7
2006	4	18
2007	210	17
2008	4613	5
2009	8767	2
2010	6712	4
2011	1766	12
2012	1947	11
2013	4597	6
2014	456	16
2015	3224	8
2016	7047	3
2017	0	19
2018	3201	9
2019	649	15
Total	60656	
Min	0	
Max	9253	
Median	2222	
Average	3192	

Appendix D

Literature Review of Statistical Trend Analysis Methods

The following is a literature review of water quality data trend detection tests, intended to identify the best monotonic trend detection method for use in the Horse Creek Stewardship Program (HCSP). Based on information gleaned from a variety of sources, including the USGS (United States Geological Survey), the Seasonal Kendall test was determined to be the best method for use in the HCSP. Because the method needs a minimum of five years of data collection, the 2008 HCSP Annual Report will be the first report to include this analysis. In this (2007) and previous annual reports (2003–2006), a variation of this test, the annual median Mann-Kendall, was used on the combined data from several data sources (HCSP, Southwest Florida Water Management District (SWFWMD), USGS) for the period 1990 through 2007 to detect possible changes over time. Any changes over time detected using either method may result from a variety of causes, including changes in analytical methods, climatic variation, or anthropogenic causes; an impact assessment may be conducted to determine if the trend is caused by Mosaic mining activities. The following review describes both trend methods that have been or will be used in the HCSP.

Water quality monitoring data exhibits several characteristics that make trend analysis with traditional parametric statistics methods difficult. Water quality datasets often violate the assumptions of parametric statistics, such as the need for independent observations, normal distributions, and constant variance (Berryman et al. 1988, Lettenmaier 1988). In addition, water quality data may be seasonally cyclical or flow-dependent, and datasets may contain missing, censored, or truncated data. Although many methods have been proposed for trend detection, nonparametric methods are the most recommended for detecting trends in water quality data (Berryman et al. 1988, Lettenmaier 1988, Hirsch et al. 1982).

Trend detection methods include graphical methods, time series analysis, parametric statistical tests, and nonparametric statistical tests (Berryman et al. 1988). Graphical methods of trend analysis involve visual interpretation of the data, with no explicit test for trends. This method is often used for exploratory data analysis before other trend detection methods are applied. In time series analysis, a time series is broken down into components (base level, trend, cycle, etc.) using equations. These equations can be combined into a predictive model that can be used to estimate future water quality. Although trends can be modeled using time series analysis, the method does not determine the trend significance, or the chance that the trend is not random. Statistical tests may be used on the results of the time series analysis to detect trends, but it is considered more appropriate and efficient to use other statistical methods directly. In addition, time series analysis is not appropriate for datasets with irregularly spaced observations or truncated data (observations below method detection limit) (Berryman et al. 1988).

Statistical tests detect trends by applying a rule that the magnitude of the trend is large compared to the variance. Statistical tests may be parametric (based on a normal distribution) or nonparametric. Parametric methods assume that the data is normally distributed, independent, and of constant variance. Although parametric methods are robust against data that violates these assumptions, the power of the test to detect trends is reduced. When these assumptions are violated, as with most water quality data, nonparametric methods are preferred. Because nonparametric methods are based on ranks of observations rather than magnitudes, they can be used on datasets with non-normal distributions or truncated data (Berryman et al. 1988, Lettenmaier 1988, Hirsch et al. 1982). Nonparametric methods can also be adapted for data that is not independent with corrections for seasonality or serial autocorrelation (Berryman et al. 1988, Hirsch et al. 1982, Harcum et al. 1992).

Nonparametric tests may be used to detect monotonic trends, step trends, or multi-step trends (Berryman et al. 1988). Monotonic trends are gradual and unidirectional, but step trends may occur suddenly, be restricted to a limited time period, and may reverse direction over time. Nonparametric methods used to detect step trends include the Mann-Whitney (single step), Kolmogorov-Smirov (single step), and Kruskal-Wallis (multi-step) tests. For each of these tests, the mean ranks before and after a designated time-step are compared, similar to parametric t-tests or ANOVA.

In the absence of *a priori* knowledge of a time-specific potential impact that could affect water quality, monotonic trends are typically the most common trends examined. Nonparametric methods that detect monotonic trends include the Mann-Kendall, Spearman, Cox-Stuart, and Friedman's tests. The Spearman and Kendall are considered the most powerful; these methods detect trends by a significant correlation between the parameter values and time (Berryman et al. 1988). Several of these methods have been adapted for use with seasonally cyclic data; the most commonly used seasonally adjusted method for water quality trend analysis is the Seasonal Kendall method (Lettenmaier 1988, Hirsch et al. 1982, Harcum et al. 1992, Helsel et al. 2006).

The Seasonal Kendall method is a frequently recommended method for detecting trends in water quality data (Lettenmaier 1988, Hirsch et al. 1982, Harcum et al. 1992, Helsel et al. 2006). The Seasonal Kendall was developed by and is now the method of choice for the United States Geological Survey (USGS) (Hirsch et al. 1982, Helsel et al. 2006). Other agencies that have used the Seasonal Kendall include the United States Environmental Protection Agency (EPA), South Florida Water Management District (SFWMD), Departments of Environmental Protection in Virginia and Oregon, Charlotte Harbor National Estuary Program (CHNEP), National Institute of Water and Atmospheric Research (NIWA), and many universities.

The Seasonal Kendall test determines water quality trends after correcting for seasonality by only comparing values between similar seasons over time (Schertz et al. 1991). The Seasonal Kendall test selects one value for each season (average, median, or subsample) and makes all pair-wise comparisons between time-ordered seasonal values (Harcum et al. 1992). A test statistic (Tau) is computed by comparing the number of times a later value is larger than an earlier value in the data set, and vice-versa (Schertz et al. 1991). Results for the Seasonal Kendall include the magnitude of the statistic Tau, its significance (p), its slope (Sen slope estimator), and the direction of significant trends. The trend (Sen) slope is the median slope of all pairwise comparisons. The direction of this slope (positive or negative) is more resistant to the effects of observations below minimum detection limits and missing data than the magnitude of the slope. The slope is a measure of the monotonic trend; the actual temporal variation may include step trends or trend reversals. If alternate seasons exhibit trends in opposite directions, the Seasonal Kendall test will not detect an overall trend (Lettenmaier 1988).

The power of the Seasonal Kendall test to detect trends in water quality data depends on sample size, season size, significance level, and the magnitude of trend to be detected (Harcum et al. 1992, Hirsch et al. 1982). Collapsing monthly data into quarters or years will reduce the power of the test to detect trends. If monthly data exhibits serial autocorrelation (dependence between adjacent months), however, collapsing is necessary to preserve an accurate significance level (p). Serial autocorrelation may make the actual p value much higher than expected (i.e. $p = 0.15$ instead of $p = 0.05$), leading to a very liberal interpretation of the significance level of potential trends. The loss of power caused by collapsing the data into quarters ceases to matter as sample size increases or the desired trend magnitude increases (Table 1, Harcum et al. 1992). The power difference between monthly and quarterly data disappears in 10-year datasets when the desired trend magnitude is 0.02 units/year, and in 5-year datasets when the trend magnitude is between 0.05 and 0.20 units/year.

Table D-1 Power Comparison for Monthly and Quarterly (Median) Data for Five and Ten Years of Data (Adapted from Figures in Harcum et al. 1992)

Years of Data	Trend Slope (Units/Yr)	Power (Monthly Data)	Power (Quarterly Data)
5	0.002	0.05	0.05
5	0.005	0.09	0.06
5	0.02	0.6	0.31
5	0.05	0.97	0.83
5	0.2	1	1
5	0.5	1	1
10	0.002	0.12	0.1
10	0.005	0.45	0.32
10	0.02	0.98	0.95
10	0.05	0.99	0.99
10	0.2	1	1
10	0.5	1	1

The USGS recommends at least five years of data with less than five percent truncated observations for the Seasonal Kendall test. Trends detected in datasets with more than five percent of the observations below the method detection limit will have an accurate direction, but the slope magnitude will be a poor estimate (Schertz et al. 1991).

Based on this literature review on tests for water quality data trend detection, the best monotonic trend detection method for use in the Horse Creek Stewardship Program (HCSP) is the Seasonal Kendall. Because the USGS recommends a minimum of five years of data collection before applying the Seasonal Kendall test (Schertz et al. 1991), the 2008 Annual Report will be the first report to include this analysis.

When the Seasonal Kendall test is applied to data in the 2008 HCSP Annual Report, trend detection will be limited by several factors. With only five years of data, the power of the test to detect trends of small magnitude will be limited (Table 1, Harcum et al. 1992, Hirsch et al. 1982). In addition, the monthly data collected as part of the HCSP exhibits serial autocorrelation, meaning that adjacent monthly observations are not independent. Because the dependence in data for some parameters extends to observations made two months apart, collapsing the data into quarterly values is recommended (Harcum et al. 1992). This will reduce the power of the test by an additional margin (Table 1). Finally, data for parameters whose method detection limits have changed several times over the HCSP (fluoride, nitrate+nitrite) will have to be truncated to the highest detection limit, thereby reducing the available data for the test. As a result, trends will be harder to detect, and only the direction of the trend, not the magnitude of the trend, will be valid (Schertz et al. 1991). Despite these limitations, the Seasonal Kendall test is still the most appropriate to detect monotonic trends in HCSP water quality data, once five years of measurements have been collected.

In this (2007) and previous annual reports (2003–2006), the dataset collected by the HCSP was not of sufficient length for the Seasonal Kendall analysis. Instead, those reports included a variation of this test, the Mann-Kendall, where the data from several data sources (HCSP, SWFWMD, USGS) were collapsed into annual median values to detect possible changes over time for years 1990 to the present. Although collapsing the data into annual medians results in a loss of power to detect changes, it is a valid method for water quality trend detection (Harcum et al. 1992). The combined data set used in the HCSP reports includes data collected from 1990 to 2007 by the Florida Department of Environmental Protection (FDEP), USGS, SWFWMD, and HCSP with various analytical methods, sampling frequencies, and method detection limits that may bias the results. The annual median Mann-Kendall was chosen over the Seasonal Kendall as a more conservative approach. All trend analysis methods are heavily influenced by the observations at the beginning and end of a dataset, so the effects of the recent drought years should also be considered when examining potential changes.

Because of all the potential sources of bias in the combined dataset (changes in methods, different agency sources, different sampling frequencies, climatic variation, etc.), a statistically significant Mann-Kendall test may be caused by factors other than anthropogenic sources. Any changes over time detected using either the annual median Mann-Kendall or Seasonal Kendall test should be further examined to determine if the perceived change is caused by a data bias, if its magnitude is ecologically significant, and if the cause of the trend is related to Mosaic mining activities. If warranted, an impact analysis can be performed on statistically significant trends to determine if trends are caused by Mosaic mining activities and if a corrective action by Mosaic is necessary.

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Appendix E

TAG Meeting Summary

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-2	6/19/2017	Dissolved Oxygen Saturation, %	13.0	37.5	0
HCSW-2	7/17/2017	Dissolved Oxygen Saturation, %	6.7	39.8	0
HCSW-2	8/14/2017	Dissolved Oxygen Saturation, %	20.9	40.9	0
HCSW-2	9/25/2017	Dissolved Oxygen Saturation, %	8.7	39.8	0
HCSW-2	10/12/2017	Dissolved Oxygen Saturation, %	26.4	38.6	0
HCSW-2	11/15/2017	Dissolved Oxygen Saturation, %	38.4	38.6	0
HCSW-2	5/24/2018	Dissolved Oxygen Saturation, %	10.8	37.5	0
HCSW-3	5/24/2018	Dissolved Oxygen Saturation, %	32.7	35.9	0
HCSW-2	6/20/2018	Dissolved Oxygen Saturation, %	13.1	42.7	27
HCSW-3	6/20/2018	Dissolved Oxygen Saturation, %	31.5	36.4	27
HCSW-2	7/11/2018	Dissolved Oxygen Saturation, %	27.0	38.5	36
HCSW-2	10/2/2018	Dissolved Oxygen Saturation, %	39.5	39.8	9
HCSW-2	11/8/2018	Dissolved Oxygen Saturation, %	39.1	40.6	0
HCSW-2	1/10/2019	Dissolved Oxygen Saturation, %	39.1	40.6	0
HCSW-2	2/13/2019	Dissolved Oxygen Saturation, %	39.0	40.9	0
HCSW-2	3/6/2019	Dissolved Oxygen Saturation, %	42.3	42.4	0
HCSW-2	5/13/2019	Dissolved Oxygen Saturation, %	18.2	39.8	0
HCSW-2	7/9/2019	Dissolved Oxygen Saturation, %	24.3	39.6	0
HCSW-2	8/14/2019	Dissolved Oxygen Saturation, %	17.1	40.4	0
HCSW-2	9/9/2019	Dissolved Oxygen Saturation, %	3.4	39.8	26
HCSW-2	10/7/2019	Dissolved Oxygen Saturation, %	21.8	40.2	0
HCSW-2	11/11/2019	Dissolved Oxygen Saturation, %	24.2	40.4	0
HCSW-4	1/23/2007	Fluoride, mg/L	2.5	1.5	0
HCSW-4	2/14/2007	Fluoride, mg/L	2.5	1.5	0
HCSW-4	3/14/2007	Fluoride, mg/L	5.0	1.5	0
HCSW-2	7/11/2018	Nitrogen, Ammonia, mg/L	0.77 G	0.3	36
HCSW-3	7/11/2018	Nitrogen, Ammonia, mg/L	0.38 G	0.3	36
HCSW-4	7/11/2018	Nitrogen, Ammonia, mg/L	0.54 G	0.3	36
HCSW-3	5/13/2019	Nitrogen, Ammonia, mg/L	0.51	0.3	0
HCSW-2	10/7/2019	Nitrogen, Ammonia, mg/L	0.32	0.3	0
HCSW-3	7/27/2005	pH, SU	5.90	6	40
HCSW-2	7/27/2006	pH, SU	5.95	6	0
HCSW-2	10/19/2006	pH, SU	5.99	6	0
HCSW-1	1/23/2007	pH, SU	8.83	8.5	0
HCSW-4	1/23/2007	pH, SU	8.85	8.5	0
HCSW-1	1/4/2011	pH, SU	4.80	6	0

Horse Creek Stewardship Program 2019 Technical Advisory Group Meeting
Via Microsoft Teams Meeting
November 3, 2020 1:30 PM – 4:00 PM
Minutes - Recorded by Michael Grzywacz

ATTENDANTS

- Ruta Vardys (Charlotte County Utilities)
- Mandy Hines (Desoto County)
- Jeff Clark (Earth Balance)
- Eesa Ali (Flatwoods)
- Michael Grzywacz (Flatwoods)
- Shannon Gonzalez (Flatwoods)
- Alissa Powers (Manatee County Parks and Natural Resources Dept.)
- Rob Brown (Manatee County Environmental)
- Bethany Niec (Mosaic)
- Ryan Tickles (Mosaic)
- Daniel Roberts (PRMRWSA)
- Sam Stone (PRMRWSA)
- Terri Holcomb (PRMRWSA)
- Ashlee Edwards (Sarasota County Public Works Dept.)
- John Ryan (Sarasota County Water Resources)

INTRODUCTION

The meeting began at 1:30 P.M. Sam Stone gave a brief introduction of the Horse Creek Stewardship Program (HCSP). Eesa Ali began the presentation of the 2019 HCSP annual report after these questions.

MINING

Daniel Roberts asked about the difference between final contour and reconnection. Eesa Ali and Ryan Tickles answered that final contour referred to earth moving following mining and reconnection referred to reconnecting an existing stream or wetland system.

Ruta Vardys asked if site visits would be available post pandemic. Ryan Tickles said that they would resume when the pandemic was over.

WATER QUALITY

Ruta Vardys asked why water quality was “bad” at HCSW-2 if wetlands promote water quality treatment. Eesa Ali answered that while wetlands take up nutrients, they do put out low oxygen water.

Ruta Vardys asked if the limestone bottom at HCSW-1 treated water more than organics or sand. Eesa Ali answered that it may facilitate ion exchange but whether it treated water for a particular analyte was unknown.

Ruta Vardys asked about the ammonia limit for surface waters. Eesa Ali described the HCSP trigger value of 0.3 mg/L DEP limit is a temperature, conductivity, and pH dependent calculation. He also talked about ammonia vs ammonium toxicity as it related to fish.

STREAM CONDITION INDEX SCORES

Sam Stone asked if we should consider moving up the sampling area for HCSW-3 due to the reduced buffer and habitat. Eesa responded by saying that the habitat assessment scores qualify the Stream Condition Index (SCI) scores, but it would not hurt to move the site upstream.

Sam Stone asked if HCSW-2 gave us any useful data. Eesa Ali answered that a new site would need to be upstream of the prairie system. Shannon stated that such a site upstream of the prairie would be very close to HCSW-1.

SHANNON-WIENER DIVERSITY INDEX SCORES

Sam Stone asked why the macroinvertebrate Shannon-Wiener scores for HCSW-1 and HCSW-2 were lower than HCSW-3 and HCSW-4. Eesa Ali responded that the values are dependent on both stream order and connectivity. HCSW-4 is supplied and connected with many tributaries that drain a larger area that HCSW-1. HCSW-4 also confluences with the Peace River. The habitat, forage, and water velocities are vastly different at HCSW-1 and HCSW-4. Eesa Ali also described the River Continuum Concept but at the time forgot the name of the concept.

Mandy Hines asked if HCSW-2 showed degradation in previous years or just recently. In addition, she asked about the low macroinvertebrate diversity in 2019 and what that means for mining impacts. Eesa Ali explained that the water quality metrics used to characterize the HCSP sites were designed for streams, and HCSW-2 acts like a wetland due to the upstream prairie and the intermittent flow caused by the upstream culverts.

Ruta Vardys asked about the significance of invasive fish species moving north. Eesa Ali described the advance of invasive species from downstream connected sites to upstream sheltered sites.

STREAMFLOW AND DISCHARGE

Daniel Roberts asked how long it took for water to travel from D-004 (Wingate) to HCSW-1 (Horse Creek at SR64). This question will need to be answered at a later date.

Sam Stone asked if Mosaic has or will discharge in 2020. Ryan Tickles said that there had been no discharges in 2020.

ANNUAL REPORT SUMMARY PRESENTATION

The Technical Advisory Group (TAG) agreed to send questions and responses to Sam Stone by November 17, 2020. Sam agreed to compile the questions and send to Flatwoods. The presentation and meeting ending shortly after 4 P.M.

Appendix F

Summary of Trigger Exceedances from 2013 to 2019

Table F-1 List of Exceedances for Monitored Parameters from 2003 to Present for Current Trigger levels

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-4	5/25/2006	Alkalinity, mg/L	120	100	0
HCSW-1	4/25/2007	Alkalinity, mg/L	120	100	0
HCSW-1	5/16/2007	Alkalinity, mg/L	170	100	0
HCSW-1	6/20/2007	Alkalinity, mg/L	140	100	0
HCSW-4	5/4/2009	Alkalinity, mg/L	112	100	0
HCSW-1	1/5/2010	Alkalinity, mg/L	109	100	22
HCSW-4	6/8/2011	Alkalinity, mg/L	1223	100	0
HCSW-1	10/24/2011	Alkalinity, mg/L	102	100	27
HCSW-4	5/2/2012	Alkalinity, mg/L	148	100	0
HCSW-1	11/6/2012	Alkalinity, mg/L	100	100	0
HCSW-1	12/3/2015	Alkalinity, mg/L	104	100	0
HCSW-1	12/13/2016	Alkalinity, mg/L	116	100	0
HCSW-1	2/15/2017	Alkalinity, mg/L	152	100	0
HCSW-1	3/7/2017	Alkalinity, mg/L	161	100	0
HCSW-1	4/11/2017	Alkalinity, mg/L	200	100	0
HCSW-1	12/6/2017	Alkalinity, mg/L	120	100	0
HCSW-1	4/18/2018	Alkalinity, mg/L	120	100	0
HCSW-1	4/11/2019	Alkalinity, mg/L	141	100	0
HCSW-1	6/13/2019	Alkalinity, mg/L	110	100	0
HCSW-1	10/7/2019	Alkalinity, mg/L	112	100	0
HCSW-2	4/14/2004	Chlorophyll a, µg/L	16	15	0
HCSW-2	5/26/2004	Chlorophyll a, µg/L	21	15	0
HCSW-2	8/30/2004	Chlorophyll a, µg/L	35	15	17
HCSW-3	8/30/2004	Chlorophyll a, µg/L	38	15	17
HCSW-2	5/27/2005	Chlorophyll a, µg/L	17	15	0
HCSW-2	11/17/2005	Chlorophyll a, µg/L	17	15	0
HCSW-2	2/23/2006	Chlorophyll a, µg/L	23	15	0
HCSW-2	3/28/2006	Chlorophyll a, µg/L	30	15	0
HCSW-2	5/25/2006	Chlorophyll a, µg/L	32	15	0
HCSW-2	6/29/2006	Chlorophyll a, µg/L	45	15	0
HCSW-2	8/21/2006	Chlorophyll a, µg/L	20	15	0
HCSW-2	5/16/2007	Chlorophyll a, µg/L	25	15	0
HCSW-2	6/20/2007	Chlorophyll a, µg/L	110	15	0
HCSW-2	7/18/2007	Chlorophyll a, µg/L	17	15	0
HCSW-2	7/31/2008	Chlorophyll a, µg/L	23	15	23

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-2	1/5/2009	Chlorophyll a, µg/L	25	15	0
HCSW-2	4/1/2009	Chlorophyll a, µg/L	22	15	0
HCSW-1	2/2/2010	Chlorophyll a, µg/L	15	15	33
HCSW-2	5/3/2011	Chlorophyll a, µg/L	18	15	0
HCSW-2	2/2/2012	Chlorophyll a, µg/L	75	15	0
HCSW-2	4/2/2012	Chlorophyll a, µg/L	36	15	0
HCSW-2	5/2/2012	Chlorophyll a, µg/L	34	15	0
HCSW-2	12/5/2012	Chlorophyll a, µg/L	18	15	0
HCSW-2	5/1/2013	Chlorophyll a, µg/L	53	15	0
HCSW-2	11/4/2013	Chlorophyll a, µg/L	17	15	0
HCSW-2	4/8/2015	Chlorophyll a, µg/L	29	15	0
HCSW-2	5/11/2015	Chlorophyll a, µg/L	27	15	0
HCSW-2	10/12/2017	Chlorophyll a, µg/L	16	15	0
HCSW-2	6/13/2019	Chlorophyll a, µg/L	17	15	0
HCSW-1	4/27/2006	Color, PCU	20	25	0
HCSW-3	4/27/2006	Color, PCU	15	25	0
HCSW-3	6/29/2006	Color, PCU	15	25	0
HCSW-3	4/27/2006	Calcium, Dissolved, mg/L	110	100	0
HCSW-4	5/25/2006	Calcium, Dissolved, mg/L	110	100	0
HCSW-3	6/29/2006	Calcium, Dissolved, mg/L	110	100	0
HCSW-4	6/29/2006	Calcium, Dissolved, mg/L	190	100	0
HCSW-4	12/13/2006	Calcium, Dissolved, mg/L	110	100	0
HCSW-3	4/25/2007	Calcium, Dissolved, mg/L	110	100	0
HCSW-3	5/16/2007	Calcium, Dissolved, mg/L	110	100	0
HCSW-3	6/20/2007	Calcium, Dissolved, mg/L	140	100	0
HCSW-4	6/20/2007	Calcium, Dissolved, mg/L	110	100	0
HCSW-4	3/27/2008	Calcium, Dissolved, mg/L	120	100	0
HCSW-4	5/29/2008	Calcium, Dissolved, mg/L	110	100	0
HCSW-4	2/2/2009	Calcium, Dissolved, mg/L	106	100	0
HCSW-4	6/3/2009	Calcium, Dissolved, mg/L	119	100	142
HCSW-3	4/2/2012	Calcium, Dissolved, mg/L	114	100	0
HCSW-4	4/2/2012	Calcium, Dissolved, mg/L	117	100	0
HCSW-4	5/2/2012	Calcium, Dissolved, mg/L	109	100	0
HCSW-4	6/5/2012	Calcium, Dissolved, mg/L	182	100	0
HCSW-3	4/2/2013	Calcium, Dissolved, mg/L	123	100	0
HCSW-3	5/1/2013	Calcium, Dissolved, mg/L	105	100	0

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-4	2/3/2014	Calcium, Dissolved, mg/L	101	100	0
HCSW-4	3/7/2017	Calcium, Dissolved, mg/L	105	100	0
HCSW-4	4/11/2017	Calcium, Dissolved, mg/L	149	100	0
HCSW-4	3/21/2018	Calcium, Dissolved, mg/L	106	100	0
HCSW-4	6/13/2019	Calcium, Dissolved, mg/L	103	100	0
HCSW-2	7/27/2006	Iron, Dissolved, mg/L	1.20	1	0
HCSW-2	6/3/2009	Iron, Dissolved, mg/L	1.03	1	142
HCSW-2	7/2/2013	Dissolved Oxygen Saturation, %	24.8	41.7	34
HCSW-2	8/1/2013	Dissolved Oxygen Saturation, %	25.9	41.1	47
HCSW-3	8/1/2013	Dissolved Oxygen Saturation, %	38.4	39.9	47
HCSW-2	9/4/2013	Dissolved Oxygen Saturation, %	31.1	40.7	50
HCSW-2	10/1/2013	Dissolved Oxygen Saturation, %	36.7	36.9	49
HCSW-2	2/3/2014	Dissolved Oxygen Saturation, %	30.8	42.4	0
HCSW-2	8/6/2014	Dissolved Oxygen Saturation, %	18.1	41.8	0
HCSW-2	9/3/2014	Dissolved Oxygen Saturation, %	25.8	38.8	0
HCSW-2	10/6/2014	Dissolved Oxygen Saturation, %	20.2	38.6	50
HCSW-2	11/4/2014	Dissolved Oxygen Saturation, %	30.4	39.8	0
HCSW-2	12/2/2014	Dissolved Oxygen Saturation, %	35.3	40.1	0
HCSW-2	3/5/2015	Dissolved Oxygen Saturation, %	26.0	38.3	0
HCSW-2	7/6/2015	Dissolved Oxygen Saturation, %	11.3	40.4	24
HCSW-2	8/6/2015	Dissolved Oxygen Saturation, %	11.7	40.9	21
HCSW-3	8/6/2015	Dissolved Oxygen Saturation, %	39.1	39.2	21
HCSW-2	9/22/2015	Dissolved Oxygen Saturation, %	20.4	38.8	16
HCSW-2	10/5/2015	Dissolved Oxygen Saturation, %	18.9	40.9	11
HCSW-2	11/3/2015	Dissolved Oxygen Saturation, %	20.5	38.6	14
HCSW-2	2/23/2016	Dissolved Oxygen Saturation, %	37.0	43	0
HCSW-2	3/7/2016	Dissolved Oxygen Saturation, %	34.8	39.7	5
HCSW-2	4/6/2016	Dissolved Oxygen Saturation, %	34.2	42.5	11
HCSW-2	5/5/2016	Dissolved Oxygen Saturation, %	23.6	43	20
HCSW-2	6/7/2016	Dissolved Oxygen Saturation, %	20.6	42	16
HCSW-2	7/7/2016	Dissolved Oxygen Saturation, %	13.6	42	30
HCSW-2	8/4/2016	Dissolved Oxygen Saturation, %	26.8	40.9	31
HCSW-2	9/8/2016	Dissolved Oxygen Saturation, %	20.8	39.2	34
HCSW-2	10/18/2016	Dissolved Oxygen Saturation, %	19.1	39.2	23
HCSW-2	11/7/2016	Dissolved Oxygen Saturation, %	25.0	42	19
HCSW-2	12/13/2016	Dissolved Oxygen Saturation, %	24.8	41.3	0

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-2	10/10/2012	pH, SU	5.96	6	40
HCSW-4	12/3/2015	pH, SU	5.95	6	0
HCSW-2	7/27/2004	Radium, Combined, pCi/l	5.1	5	0
HCSW-4	6/5/2012	Specific Conductance, µS	1425	1275	0
HCSW-4	6/29/2004	Sulfate, mg/l	261	250	0
HCSW-3	3/28/2006	Sulfate, mg/L	300	250	0
HCSW-4	3/28/2006	Sulfate, mg/L	300	250	0
HCSW-3	4/27/2006	Sulfate, mg/L	420	250	0
HCSW-4	5/25/2006	Sulfate, mg/L	310	250	0
HCSW-3	6/29/2006	Sulfate, mg/L	430	250	0
HCSW-4	6/29/2006	Sulfate, mg/L	780	250	0
HCSW-4	12/13/2006	Sulfate, mg/L	290	250	0
HCSW-3	5/16/2007	Sulfate, mg/L	360	250	0
HCSW-3	6/20/2007	Sulfate, mg/L	440	250	0
HCSW-4	6/20/2007	Sulfate, mg/L	320	250	0
HCSW-4	3/27/2008	Sulfate, mg/L	390	250	0
HCSW-4	5/29/2008	Sulfate, mg/L	290	250	0
HCSW-3	6/26/2008	Sulfate, mg/L	251	250	0
HCSW-4	6/26/2008	Sulfate, mg/L	287	250	0
HCSW-3	2/2/2009	Sulfate, mg/L	280	250	0
HCSW-4	2/2/2009	Sulfate, mg/L	290	250	0
HCSW-3	4/1/2009	Sulfate, mg/L	293	250	0
HCSW-3	6/3/2009	Sulfate, mg/L	251	250	142
HCSW-4	6/3/2009	Sulfate, mg/L	391	250	142
HCSW-4	12/2/2009	Sulfate, mg/L	279	250	0
HCSW-4	11/3/2010	Sulfate, mg/L	258	250	0
HCSW-4	1/4/2011	Sulfate, mg/L	262	250	0
HCSW-4	7/5/2011	Sulfate, mg/L	253	250	0
HCSW-3	2/2/2012	Sulfate, mg/L	254	250	0
HCSW-3	3/5/2012	Sulfate, mg/L	287	250	0
HCSW-4	3/5/2012	Sulfate, mg/L	267	250	0
HCSW-3	4/2/2012	Sulfate, mg/L	365	250	0
HCSW-4	4/2/2012	Sulfate, mg/L	321	250	0
HCSW-3	6/5/2012	Sulfate, mg/L	304	250	0
HCSW-4	6/5/2012	Sulfate, mg/L	665	250	0

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-4	2/7/2013	Sulfate, mg/L	251	250	0
HCSW-3	3/6/2013	Sulfate, mg/L	319	250	0
HCSW-4	3/6/2013	Sulfate, mg/L	267	250	0
HCSW-3	4/2/2013	Sulfate, mg/L	400	250	0
HCSW-3	5/1/2013	Sulfate, mg/L	373	250	0
HCSW-4	5/1/2013	Sulfate, mg/L	292	250	0
HCSW-3	6/4/2013	Sulfate, mg/L	363	250	0
HCSW-4	6/4/2013	Sulfate, mg/L	383	250	0
HCSW-4	12/3/2013	Sulfate, mg/L	267	250	0
HCSW-3	1/2/2014	Sulfate, mg/L	282	250	0
HCSW-4	1/2/2014	Sulfate, mg/L	333	250	0
HCSW-4	2/3/2014	Sulfate, mg/L	404	250	0
HCSW-4	6/3/2014	Sulfate, mg/L	389	250	0
HCSW-3	6/3/2015	Sulfate, mg/L	316	250	13
HCSW-3	3/7/2017	Sulfate, mg/L	266	250	0
HCSW-4	3/7/2017	Sulfate, mg/L	335	250	0
HCSW-3	4/11/2017	Sulfate, mg/L	278	250	0
HCSW-4	4/11/2017	Sulfate, mg/L	482	250	0
HCSW-4	3/21/2018	Sulfate, mg/L	355	250	0
HCSW-3	4/18/2018	Sulfate, mg/L	290	250	0
HCSW-4	6/13/2019	Sulfate, mg/l	338	250	0
HCSW-4	3/28/2006	TDS, mg/L	600	500	0
HCSW-3	4/27/2006	TDS, mg/L	580	500	0
HCSW-4	5/25/2006	TDS, mg/L	560	500	0
HCSW-3	6/29/2006	TDS, mg/L	590	500	0
HCSW-4	6/29/2006	TDS, mg/L	1100	500	0
HCSW-4	11/9/2006	TDS, mg/L	510	500	0
HCSW-4	12/13/2006	TDS, mg/L	550	500	0
HCSW-3	4/25/2007	TDS, mg/L	590	500	0
HCSW-3	5/16/2007	TDS, mg/L	530	500	0
HCSW-3	6/20/2007	TDS, mg/L	700	500	0
HCSW-4	6/20/2007	TDS, mg/L	600	500	0
HCSW-3	7/18/2007	TDS, mg/L	520	500	0
HCSW-4	7/18/2007	TDS, mg/L	530	500	0
HCSW-4	1/30/2008	TDS, mg/L	550	500	0
HCSW-4	3/27/2008	TDS, mg/L	660	500	0
HCSW-4	5/29/2008	TDS, mg/L	710	500	0

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-3	6/26/2008	TDS, mg/L	580	500	0
HCSW-4	6/26/2008	TDS, mg/L	644	500	0
HCSW-3	2/2/2009	TDS, mg/L	520	500	0
HCSW-4	2/2/2009	TDS, mg/L	536	500	0
HCSW-3	4/1/2009	TDS, mg/L	568	500	0
HCSW-3	6/3/2009	TDS, mg/L	540	500	142
HCSW-4	6/3/2009	TDS, mg/L	692	500	142
HCSW-3	12/2/2009	TDS, mg/L	524	500	0
HCSW-4	12/2/2009	TDS, mg/L	604	500	0
HCSW-4	11/3/2010	TDS, mg/L	577	500	0
HCSW-3	1/4/2011	TDS, mg/L	513	500	0
HCSW-4	1/4/2011	TDS, mg/L	574	500	0
HCSW-4	7/5/2011	TDS, mg/L	660	500	0
HCSW-3	12/21/2011	TDS, mg/L	543	500	0
HCSW-4	12/21/2011	TDS, mg/L	543	500	0
HCSW-3	1/12/2012	TDS, mg/L	571	500	0
HCSW-4	1/12/2012	TDS, mg/L	569	500	0
HCSW-3	2/2/2012	TDS, mg/L	532	500	0
HCSW-4	2/2/2012	TDS, mg/L	512	500	0
HCSW-3	3/5/2012	TDS, mg/L	603	500	0
HCSW-4	3/5/2012	TDS, mg/L	585	500	0
HCSW-3	4/2/2012	TDS, mg/L	714	500	0
HCSW-4	4/2/2012	TDS, mg/L	688	500	0
HCSW-4	5/2/2012	TDS, mg/L	536	500	0
HCSW-3	6/5/2012	TDS, mg/L	646	500	0
HCSW-4	6/5/2012	TDS, mg/L	1320	500	0
HCSW-3	3/6/2013	TDS, mg/L	643	500	0
HCSW-4	3/6/2013	TDS, mg/L	660	500	0
HCSW-3	4/2/2013	TDS, mg/L	818	500	0
HCSW-4	4/2/2013	TDS, mg/L	595	500	0
HCSW-3	5/1/2013	TDS, mg/L	648	500	0
HCSW-4	5/1/2013	TDS, mg/L	614	500	0
HCSW-3	6/4/2013	TDS, mg/L	675	500	0
HCSW-4	6/4/2013	TDS, mg/L	687	500	0
HCSW-3	12/3/2013	TDS, mg/L	528	500	0
HCSW-4	12/3/2013	TDS, mg/L	617	500	0
HCSW-4	1/2/2014	TDS, mg/L	601	500	0
HCSW-4	2/3/2014	TDS, mg/L	799	500	0

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-4	4/1/2014	TDS, mg/L	555	500	0
HCSW-4	5/1/2014	TDS, mg/L	544	500	0
HCSW-3	6/3/2014	TDS, mg/L	548	500	0
HCSW-4	6/3/2014	TDS, mg/L	715	500	0
HCSW-3	7/1/2014	TDS, mg/L	518	500	0
HCSW-4	7/1/2014	TDS, mg/L	580	500	0
HCSW-4	4/8/2015	TDS, mg/L	521	500	0
HCSW-4	5/11/2015	TDS, mg/L	571	500	0
HCSW-4	6/3/2015	TDS, mg/L	504	500	13
HCSW-3	3/7/2017	TDS, mg/L	536	500	0
HCSW-4	3/7/2017	TDS, mg/L	635	500	0
HCSW-1	4/11/2017	TDS, mg/L	524	500	0
HCSW-3	4/11/2017	TDS, mg/L	527	500	0
HCSW-4	4/11/2017	TDS, mg/L	853	500	0
HCSW-3	1/17/2018	TDS, mg/L	742	500	0
HCSW-4	1/17/2018	TDS, mg/L	520	500	0
HCSW-4	3/21/2018	TDS, mg/L	697 G	500	0
HCSW-3	4/18/2018	TDS, mg/L	604	500	0
HCSW-4	4/11/2019	TDS, mg/L	528	500	0
HCSW-4	6/13/2019	TDS, mg/L	612	500	0
HCSW-2	7/31/2008	Total Ammonia, mg/L	0.41	0.3	23
HCSW-3	7/31/2008	Total Ammonia, mg/L	0.32	0.3	23
HCSW-4	7/31/2008	Total Ammonia, mg/L	0.31	0.3	23
HCSW-3	5/3/2011	Total Ammonia, mg/L	0.31	0.3	0
HCSW-3	9/27/2006	Total Nitrogen, mg/L	6.7	3	0
HCSW-3	6/20/2007	Total Nitrogen, mg/L	9.7	3	0
HCSW-2	1/30/2008	Total Nitrogen, mg/L	4.8	3	0
HCSW-3	2/23/2016	Total Nitrogen, mg/L	3.5	3	0
HCSW-4	6/19/2017	Total Nitrogen, mg/L	4.6	3	0

Note: Dissolved oxygen (% Saturation) data began in 2013. The HCSP DO sat trigger level is < 38%. The trigger level values listed in Table F2 are FDEP time-of-day trigger levels.

G- Indicates that the analyte was detected in the sample as well as the field blank.

Table F-2 List of exceedances for parameters no longer monitored or trigger levels no longer used for HCSP evaluation

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-1	8/30/2004	Dissolved Oxygen, mg/L	4.3	5	17
HCSW-1	9/29/2004	Dissolved Oxygen, mg/L	4.5	5	56
HCSW-1	4/27/2006	Dissolved Oxygen, mg/L	3.1	5	0
HCSW-1	8/1/2013	Dissolved Oxygen, mg/L	4.56	5	47
HCSW-2	4/30/2003	Dissolved Oxygen, mg/L	1	5	5
HCSW-2	5/27/2003	Dissolved Oxygen, mg/L	1.3	5	9
HCSW-2	6/19/2003	Dissolved Oxygen, mg/L	1.1	5	23
HCSW-2	7/14/2003	Dissolved Oxygen, mg/L	1.7	5	85
HCSW-2	8/28/2003	Dissolved Oxygen, mg/L	3	5	80
HCSW-2	9/25/2003	Dissolved Oxygen, mg/L	1.3	5	29
HCSW-2	10/29/2003	Dissolved Oxygen, mg/L	2.9	5	0
HCSW-2	11/20/2003	Dissolved Oxygen, mg/L	2.8	5	0
HCSW-2	12/16/2003	Dissolved Oxygen, mg/L	4.1	5	0
HCSW-2	1/29/2004	Dissolved Oxygen, mg/L	5	5	0
HCSW-2	2/24/2004	Dissolved Oxygen, mg/L	3.6	5	0
HCSW-2	3/16/2004	Dissolved Oxygen, mg/L	3.7	5	0
HCSW-2	5/26/2004	Dissolved Oxygen, mg/L	3.1	5	0
HCSW-2	6/29/2004	Dissolved Oxygen, mg/L	1.6	5	0
HCSW-2	7/27/2004	Dissolved Oxygen, mg/L	0.3	5	0
HCSW-2	8/30/2004	Dissolved Oxygen, mg/L	0.14	5	17
HCSW-2	9/29/2004	Dissolved Oxygen, mg/L	1.4	5	56
HCSW-2	10/27/2004	Dissolved Oxygen, mg/L	0.7	5	8
HCSW-2	11/18/2004	Dissolved Oxygen, mg/L	2.8	5	7
HCSW-2	12/15/2004	Dissolved Oxygen, mg/L	4.7	5	5
HCSW-2	1/26/2005	Dissolved Oxygen, mg/L	4.1	5	0
HCSW-2	2/24/2005	Dissolved Oxygen, mg/L	3.5	5	0
HCSW-2	3/30/2005	Dissolved Oxygen, mg/L	2.6	5	25
HCSW-2	5/27/2005	Dissolved Oxygen, mg/L	2	5	0
HCSW-2	6/22/2005	Dissolved Oxygen, mg/L	1.4	5	0
HCSW-2	7/27/2005	Dissolved Oxygen, mg/L	1.1	5	40
HCSW-2	8/23/2005	Dissolved Oxygen, mg/L	1.7	5	15
HCSW-2	9/29/2005	Dissolved Oxygen, mg/L	2.3	5	0
HCSW-2	10/27/2005	Dissolved Oxygen, mg/L	4.6	5	0
HCSW-2	11/17/2005	Dissolved Oxygen, mg/L	2.8	5	0
HCSW-2	12/20/2005	Dissolved Oxygen, mg/L	4.4	5	0
HCSW-2	2/23/2006	Dissolved Oxygen, mg/L	3.4	5	0

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-2	5/25/2006	Dissolved Oxygen, mg/L	4.9	5	0
HCSW-2	7/27/2006	Dissolved Oxygen, mg/L	0.5	5	0
HCSW-2	9/27/2006	Dissolved Oxygen, mg/L	1.3	5	0
HCSW-2	10/19/2006	Dissolved Oxygen, mg/L	1.6	5	0
HCSW-2	11/9/2006	Dissolved Oxygen, mg/L	2.9	5	0
HCSW-2	12/13/2006	Dissolved Oxygen, mg/L	3.8	5	0
HCSW-2	1/23/2007	Dissolved Oxygen, mg/L	3.38	5	0
HCSW-2	3/14/2007	Dissolved Oxygen, mg/L	4.06	5	0
HCSW-2	4/25/2007	Dissolved Oxygen, mg/L	4.6	5	0
HCSW-2	8/27/2007	Dissolved Oxygen, mg/L	2.03	5	9
HCSW-2	9/26/2007	Dissolved Oxygen, mg/L	0.86	5	0
HCSW-2	10/29/2007	Dissolved Oxygen, mg/L	1.08	5	0
HCSW-2	11/29/2007	Dissolved Oxygen, mg/L	1.53	5	0
HCSW-2	12/17/2007	Dissolved Oxygen, mg/L	2.13	5	0
HCSW-2	1/30/2008	Dissolved Oxygen, mg/L	3.34	5	0
HCSW-2	2/26/2008	Dissolved Oxygen, mg/L	1.65	5	0
HCSW-2	3/27/2008	Dissolved Oxygen, mg/L	4.21	5	0
HCSW-2	4/23/2008	Dissolved Oxygen, mg/L	1.77	5	0
HCSW-2	5/29/2008	Dissolved Oxygen, mg/L	2.33	5	0
HCSW-2	6/26/2008	Dissolved Oxygen, mg/L	1.41	5	0
HCSW-2	7/31/2008	Dissolved Oxygen, mg/L	0.74	5	23
HCSW-2	8/26/2008	Dissolved Oxygen, mg/L	0.13	5	97
HCSW-2	9/30/2008	Dissolved Oxygen, mg/L	1.27	5	12
HCSW-2	10/16/2008	Dissolved Oxygen, mg/L	0.19	5	9
HCSW-2	11/12/2008	Dissolved Oxygen, mg/L	1.29	5	0
HCSW-2	12/4/2008	Dissolved Oxygen, mg/L	3.04	5	0
HCSW-2	1/5/2009	Dissolved Oxygen, mg/L	2.29	5	0
HCSW-2	2/2/2009	Dissolved Oxygen, mg/L	2.38	5	0
HCSW-2	3/4/2009	Dissolved Oxygen, mg/L	3.35	5	0
HCSW-2	4/1/2009	Dissolved Oxygen, mg/L	2.49	5	0
HCSW-2	7/8/2009	Dissolved Oxygen, mg/L	0.61	5	35
HCSW-2	8/5/2009	Dissolved Oxygen, mg/L	1.21	5	56
HCSW-2	9/2/2009	Dissolved Oxygen, mg/L	1.5	5	25
HCSW-2	10/7/2009	Dissolved Oxygen, mg/L	0.34	5	35
HCSW-2	11/3/2009	Dissolved Oxygen, mg/L	1.78	5	0
HCSW-2	12/2/2009	Dissolved Oxygen, mg/L	1.98	5	0
HCSW-2	2/2/2010	Dissolved Oxygen, mg/L	2.67	5	33
HCSW-2	3/3/2010	Dissolved Oxygen, mg/L	3.75	5	36

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-2	4/6/2010	Dissolved Oxygen, mg/L	1.42	5	11
HCSW-2	5/5/2010	Dissolved Oxygen, mg/L	0.56	5	7
HCSW-2	6/2/2010	Dissolved Oxygen, mg/L	0.6	5	0
HCSW-2	7/12/2010	Dissolved Oxygen, mg/L	0.62	5	6
HCSW-2	8/3/2010	Dissolved Oxygen, mg/L	0.56	5	25
HCSW-2	9/8/2010	Dissolved Oxygen, mg/L	0.72	5	34
HCSW-2	10/6/2010	Dissolved Oxygen, mg/L	0.93	5	9
HCSW-2	11/3/2010	Dissolved Oxygen, mg/L	1.28	5	0
HCSW-2	1/4/2011	Dissolved Oxygen, mg/L	3.02	5	0
HCSW-2	2/3/2011	Dissolved Oxygen, mg/L	1.47	5	0
HCSW-2	3/2/2001	Dissolved Oxygen, mg/L	1.95	5	0
HCSW-2	4/5/2011	Dissolved Oxygen, mg/L	0.14	5	0
HCSW-2	5/3/2011	Dissolved Oxygen, mg/L	1.78	5	0
HCSW-2	7/5/2011	Dissolved Oxygen, mg/L	0.89	5	0
HCSW-2	8/16/2011	Dissolved Oxygen, mg/L	0.59	5	0
HCSW-2	9/7/2011	Dissolved Oxygen, mg/L	0.45	5	0
HCSW-2	10/24/2011	Dissolved Oxygen, mg/L	1.11	5	27
HCSW-2	11/29/2011	Dissolved Oxygen, mg/L	2.7	5	0
HCSW-2	3/5/2012	Dissolved Oxygen, mg/L	4.55	5	0
HCSW-2	5/2/2012	Dissolved Oxygen, mg/L	3.32	5	0
HCSW-2	10/10/2012	Dissolved Oxygen, mg/L	2.92	5	40
HCSW-2	11/6/2012	Dissolved Oxygen, mg/L	3.95	5	0
HCSW-2	12/5/2012	Dissolved Oxygen, mg/L	4.74	5	0
HCSW-2	1/9/2013	Dissolved Oxygen, mg/L	4.15	5	0
HCSW-2	6/4/2013	Dissolved Oxygen, mg/L	4.21	5	0
HCSW-2	7/2/2013	Dissolved Oxygen, mg/L	2.01	5	34
HCSW-2	8/1/2013	Dissolved Oxygen, mg/L	2	5	47
HCSW-2	9/4/2013	Dissolved Oxygen, mg/L	2.48	5	50
HCSW-2	10/1/2013	Dissolved Oxygen, mg/L	2.56	5	49
HCSW-2	11/4/2013	Dissolved Oxygen, mg/L	3.97	5	0
HCSW-2	12/3/2013	Dissolved Oxygen, mg/L	3.8	5	0
HCSW-3	7/27/2004	Dissolved Oxygen, mg/L	4.7	5	0
HCSW-3	8/30/2004	Dissolved Oxygen, mg/L	0.27	5	17
HCSW-3	9/29/2004	Dissolved Oxygen, mg/L	2.4	5	56
HCSW-3	6/22/2005	Dissolved Oxygen, mg/L	3.9	5	0
HCSW-3	7/27/2005	Dissolved Oxygen, mg/L	3.5	5	40
HCSW-3	8/23/2005	Dissolved Oxygen, mg/L	4.4	5	15
HCSW-3	7/27/2006	Dissolved Oxygen, mg/L	4.5	5	0

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-3	8/21/2006	Dissolved Oxygen, mg/L	3.7	5	0
HCSW-3	9/27/2006	Dissolved Oxygen, mg/L	1.8	5	0
HCSW-3	10/19/2006	Dissolved Oxygen, mg/L	4.5	5	0
HCSW-3	7/18/2007	Dissolved Oxygen, mg/L	3.93	5	0
HCSW-3	8/27/2007	Dissolved Oxygen, mg/L	2.8	5	9
HCSW-3	9/26/2007	Dissolved Oxygen, mg/L	2.88	5	0
HCSW-3	10/29/2007	Dissolved Oxygen, mg/L	3.06	5	0
HCSW-3	11/29/2007	Dissolved Oxygen, mg/L	4.3	5	0
HCSW-3	2/26/2008	Dissolved Oxygen, mg/L	3.64	5	0
HCSW-3	3/27/2008	Dissolved Oxygen, mg/L	4.75	5	0
HCSW-3	4/23/2008	Dissolved Oxygen, mg/L	3.27	5	0
HCSW-3	5/29/2008	Dissolved Oxygen, mg/L	2.9	5	0
HCSW-3	6/26/2008	Dissolved Oxygen, mg/L	4.78	5	0
HCSW-3	7/31/2008	Dissolved Oxygen, mg/L	0.99	5	23
HCSW-3	8/26/2008	Dissolved Oxygen, mg/L	1.62	5	97
HCSW-3	9/30/2008	Dissolved Oxygen, mg/L	3.28	5	12
HCSW-3	10/16/2008	Dissolved Oxygen, mg/L	2.73	5	9
HCSW-3	6/3/2009	Dissolved Oxygen, mg/L	3.89	5	142
HCSW-3	7/8/2009	Dissolved Oxygen, mg/L	3.38	5	35
HCSW-3	8/5/2009	Dissolved Oxygen, mg/L	3.33	5	56
HCSW-3	9/2/2009	Dissolved Oxygen, mg/L	3.87	5	25
HCSW-3	10/7/2009	Dissolved Oxygen, mg/L	3.13	5	35
HCSW-3	4/6/2010	Dissolved Oxygen, mg/L	4.74	5	11
HCSW-3	7/12/2010	Dissolved Oxygen, mg/L	3.67	5	6
HCSW-3	8/3/2010	Dissolved Oxygen, mg/L	4.61	5	25
HCSW-3	9/8/2010	Dissolved Oxygen, mg/L	4.09	5	34
HCSW-3	8/16/2011	Dissolved Oxygen, mg/L	4.14	5	0
HCSW-3	9/7/2011	Dissolved Oxygen, mg/L	3.32	5	0
HCSW-3	6/5/2012	Dissolved Oxygen, mg/L	4.64	5	0
HCSW-3	7/5/2012	Dissolved Oxygen, mg/L	3.28	5	0
HCSW-3	8/2/2012	Dissolved Oxygen, mg/L	3.05	5	0
HCSW-3	9/5/2012	Dissolved Oxygen, mg/L	3.8	5	24
HCSW-3	10/10/2012	Dissolved Oxygen, mg/L	4.66	5	40
HCSW-3	7/2/2013	Dissolved Oxygen, mg/L	4.65	5	34
HCSW-3	8/1/2013	Dissolved Oxygen, mg/L	3	5	47
HCSW-3	9/4/2013	Dissolved Oxygen, mg/L	4.4	5	50
HCSW-3	10/1/2013	Dissolved Oxygen, mg/L	4.5	5	49
HCSW-4	8/30/2004	Dissolved Oxygen, mg/L	0.58	5	17

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD
HCSW-4	9/29/2004	Dissolved Oxygen, mg/L	2.9	5	56
HCSW-4	6/22/2005	Dissolved Oxygen, mg/L	4	5	0
HCSW-4	7/27/2005	Dissolved Oxygen, mg/L	4.1	5	40
HCSW-4	9/24/2006	Dissolved Oxygen, mg/L	4.1	5	0
HCSW-4	7/31/2008	Dissolved Oxygen, mg/L	3.1	5	23
HCSW-4	8/26/2008	Dissolved Oxygen, mg/L	2.2	5	97
HCSW-4	9/30/2008	Dissolved Oxygen, mg/L	4.77	5	12
HCSW-4	7/8/2009	Dissolved Oxygen, mg/L	4.2	5	35
HCSW-4	8/5/2009	Dissolved Oxygen, mg/L	3.36	5	56
HCSW-4	9/2/2009	Dissolved Oxygen, mg/L	4.89	5	25
HCSW-4	10/7/2009	Dissolved Oxygen, mg/L	4.48	5	35
HCSW-4	7/12/2010	Dissolved Oxygen, mg/L	4.31	5	6
HCSW-4	4/5/2011	Dissolved Oxygen, mg/L	4.89	5	0
HCSW-4	9/7/2011	Dissolved Oxygen, mg/L	4.29	5	0
HCSW-4	7/5/2012	Dissolved Oxygen, mg/L	2.23	5	0
HCSW-4	9/5/2012	Dissolved Oxygen, mg/L	4.12	5	24
HCSW-4	7/2/2013	Dissolved Oxygen, mg/L	4.16	5	34
HCSW-4	8/1/2013	Dissolved Oxygen, mg/L	4.46	5	47
HCSW-4	9/4/2013	Dissolved Oxygen, mg/L	4.74	5	50
HCSW-4	10/1/2013	Dissolved Oxygen, mg/L	4.3	5	49
HCSW-1	6/20/2007	Total Fatty Acids, mg/L	1.5	0.5	0
HCSW-2	11/18/2004	Total Fatty Acids, mg/L	1.1	0.5	7
HCSW-2	3/30/2005	Total Fatty Acids, mg/L	0.56	0.5	25
HCSW-2	4/27/2005	Total Fatty Acids, mg/L	0.53	0.5	0
HCSW-2	12/13/2006	Total Fatty Acids, mg/L	1.6	0.5	0
HCSW-2	6/20/2007	Total Fatty Acids, mg/L	1.6	0.5	0
HCSW-2	7/18/2007	Total Fatty Acids, mg/L	0.87	0.5	0
HCSW-2	12/17/2007	Total Fatty Acids, mg/L	0.88	0.5	0
HCSW-2	12/4/2008	Total Fatty Acids, mg/L	0.97	0.5	

Note: Dissolved oxygen (mg/L) is listed for comparison purposes because it was the trigger level from 2003-2013. Total fatty acid monitoring stopped in September 2009 when the new Brushy Creek (BCSW-1) monitoring location was added.

Appendix G

Summary of Impact Assessments from 2003 to 2019

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-4	7/14/2003	Dissolved Iron	A special sampling program was carried out in August 2003 where samples were collected from three locations on Horse Creek and two tributaries, but flow conditions were very high. In October 2003, eleven stations were sampled while flow was closer to normal.	Readings appear normal for the basin, the lower trigger level at this location caused the exceedance due to differences in water class. The trigger value may be set too low at this location.
HCSW-2	8/28/2003	Dissolved Oxygen	A sampling program was attempted in August 2003 in the northern portion of the stream, but flow conditions were very high. Instead, six locations including tributaries were sampled at the end of October 2003.	Low DO levels persisted at HCSW-2 due to generally low streamflow levels and a greater amount of organics than the other stations. The low levels are not due to mining upstream.
HCSW-2	4/14/2004	Chlorophyll a	A special sampling program was carried out in May 2004 where samples were taken from four upstream locations in Horse Creek (due to dry conditions of tributaries).	Elevated chlorophyll a concentrations were caused by low streamflow and the physical nature of the stream channel and not mining activities.
HCSW-4	6/29/2004	Sulfate	A special sampling program was carried out where samples were taken from nearby tributaries as well as the Horse Creek Stewardship Program (HCSP) stations during July 2004.	Nearby tributary basins have high amounts of agricultural activity (requiring irrigation) and streamflow was very low at this time which led to the elevated sulfate concentration in June 2004.

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-2	7/27/2004	Total Radium	None	Blank sample results had high values, making other values suspect. No impact assessment required for July 2004, but future results should be monitored.
HCSW-1	8/30/2004	Dissolved Oxygen	None	Impact assessment deferred until the streamflow in Horse Creek are near normal for the time period the exceedance occurred (multiple hurricanes passing through region dramatically increased streamflow).
HCSW-2	8/30/2004	Dissolved Oxygen	None	Impact assessment deferred until the streamflow in Horse Creek are near normal for the time period the exceedance occurred (multiple hurricanes passing through region dramatically increased streamflow).
HCSW-3	8/30/2004	Dissolved Oxygen	None	Impact assessment deferred until the streamflow in Horse Creek are near normal for the time period the exceedance occurred (multiple hurricanes passing through region dramatically increased streamflow).

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-4	8/30/2004	Dissolved Oxygen	None	Impact assessment deferred until the streamflow in Horse Creek are near normal for the time period the exceedance occurred (multiple hurricanes passing through region dramatically increased streamflow).
HCSW-2	8/30/2004	Chlorophyll a	None	Impact assessment deferred until the streamflow in Horse Creek are near normal for the time period the exceedance occurred (multiple hurricanes passing through region dramatically increased streamflow).
HCSW-3	8/30/2004	Chlorophyll a	None	Impact assessment deferred until the streamflow in Horse Creek are near normal for the time period the exceedance occurred (multiple hurricanes passing through region dramatically increased streamflow).
HCSW-2	11/18/2004	Total Fatty Acids	A special sampling program was carried out in January 2005, where three Horse Creek locations and a tributary (Brushy Creek) were sampled.	Nearby Horse Creek Prairie is likely to contribute to the elevated levels since all other stations had undetected values for fatty acids. Low streamflow and high organics in this region, not mining, were likely contributing factors.

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-2	4/27/2005	Total Fatty Acids	A special sampling program was carried out in June 2005, where three Horse Creek locations and a tributary were sampled.	The exceedance is most likely caused by the surrounding habitat conditions and not impacted by mining.
HCSW-2	7/27/2006	Iron	None	Nearby Horse Creek Prairie is likely to contribute to the elevated levels since all other stations had lower iron concentrations.
HCSW-1	1/23/2007	pH	Compared measurement to Southwest Florida Water Management District (SWFWMD) measurements for the months of January and February.	Not an actual exceedance but equipment malfunction
HCSW-4	1/23/2007	pH	Compared measurement to SWFWMD measurements for the months of January and February.	Not an actual exceedance but equipment malfunction
HCSW-1	4/25/2007	Alkalinity	Statistical analysis of HCSP alkalinity and SWFWMD measurements. When alkalinity compared to streamflow, there was a weak negative correlation between the two (high alkalinity during low flow).	No evidence that high alkalinity was caused by mining but was rather a seasonal pattern caused by lower water levels and flow. Once those recovered during the wet season, the alkalinity values decreased.

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-1	6/20/2007	Total Fatty Acids	Used conclusions from the FIPR on the rate of biodegradation and soil leaching of organic compounds in a controlled environment.	It was unlikely that fatty acids from mining process water are responsible for the elevated levels seen. Instead it represents the variation in naturally occurring fatty acids in Horse Creek.
HCSW-2	6/20/2007	Total Fatty Acids	Used conclusions from the FIPR on the rate of biodegradation and soil leaching of organic compounds in a controlled environment.	It was unlikely that fatty acids from mining process water are responsible for the elevated levels seen. Instead it represents the variation in naturally occurring fatty acids in Horse Creek.
HCSW-2-FD	6/20/2007	Total Nitrogen	Compared to nitrate+nitrate and TKN values from April 2003 through August at HCSP.	Elevated measurements most likely due to lab analyst or instrument error. The total nitrogen levels recorded are not corroborated by measurements taken before or after the exceedance.
HCSW-3	6/20/2007	Total Nitrogen	Compared to nitrate+nitrate and TKN values from April 2003 through August at HCSP.	Elevated measurements most likely due to lab analyst or instrument error. The total nitrogen levels recorded are not corroborated by measurements taken before or after the exceedance.
HCSW-2	7/31/2008	Ammonia	None	Elevated concentrations are either due to laboratory method change or a seasonal fluctuation in the nitrogen cycle.

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-3	7/31/2008	Ammonia	None	Elevated concentrations are either due to laboratory method change or a seasonal fluctuation in the nitrogen cycle.
HCSW-4	7/31/2008	Ammonia	None	Elevated concentrations are either due to laboratory method change or a seasonal fluctuation in the nitrogen cycle.
HCSW-4	5/4/2009	Alkalinity	Statistical analysis of HCSP alkalinity and SWFWMD measurements. When alkalinity compared to rainfall, there was a strong negative correlation between the two (high alkalinity during low flow).	No evidence that high alkalinity was caused by mining but was rather a seasonal pattern caused by lower water levels, flow, and rainfall. Once those recovered during the wet season, the alkalinity values decreased.
HCSW-1	2/2/2010	Chlorophyll a	None	No connection with mining. May have been a sampling error since color, pH, and DO do not indicate a significant algal bloom causing an elevated chlorophyll a reading.
HCSW-1	1/4/2011	pH	Compared to SWFWMD measurements from December 2010 through March 2011.	Not an actual exceedance but equipment malfunction.
HCSW-3	5/3/2011	Ammonia	None	No connection with mining. Lab analyzing the data was getting back results that were ten-times higher than other labs. Split sampling conducted in October 2011, verified that it was lab error.

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-1	11/6/2012	Alkalinity	None	Although National Pollutant Discharge Elimination System (NPDES) discharge occurred prior to the November 2012 alkalinity exceedance, HCSW-1 alkalinity does not show a consistent pattern of exceeding the trigger level during periods of NPDES discharge.
HCSW-4	6/19/2017	Total Nitrogen	Looked at nitrate-nitrite and TKN results as well as rainfall and streamflow prior to sampling event (no SWFWMD data available for May or July 2017).	In June 2017 there was a heavy rainfall event immediately preceding the sampling event, which increased runoff and streamflow in Horse Creek. This rainfall event, which followed an extended period of dry conditions most likely caused the much higher than normal TN concentrations at all stations, and the trigger exceedance at HCSW-4.
HCSW-1, HCSW-3, and HCSW-4	5/30/2019	TDS, Sulfate, Calcium	I. Historical analysis of TDS, calcium, and sulfate. II. Water quality field study measuring the same three parameters in neighboring streams not affected by mining vs flow. In progress. Due in fall 2019.	Historical analysis indicates TDS, sulfate, and calcium values have approached and exceeded HCSP trigger levels before levels were established and before Mosaic's outfalls were online. These exceedances also often occur when there is no discharge, long after there has been a discharge, or low stream flow conditions.

Station	Date	Exceedance	Action Taken	Conclusions
HCSW-1, HCSW-2, HCSW-3, HCSW-4, and BCSW-1	9/30/2020	Total Ammonia	I Historical NH_3 analysis II field recon of potential sources from HCSW-2 – HCSW-4	No association with NPDES discharge. Appears to be flushing from periodic desiccation and inundation of stream sediments. Inconclusive regarding non-point sources due to lack of source specific NH_3 samples

Appendix H

Summary of Trends from the 2008 to 2019 HCSP Annual Reports

Table H-1 Summary of Trends Detected at HCSW-1

Year	Parameter	Trend	Comment
2008	Alkalinity	increasing trend with slope of 4.58	Alkalinity was higher in the dry season and lower during times of National Pollutant Discharge Elimination System (NPDES) discharge. The trend was not shown to be linked to mining discharge. The trend is more likely linked to climate factors not completely accounted for in the Locally Estimated Scatterplot Smoothing (LOESS) smoothing with streamflow.
	Specific Conductance	increasing trend with slope of 15.31	Specific conductivity was higher in the dry season and lower (or equal) during times of NDPES discharge. The trend was not shown to be linked to mining discharge. The trend is more likely linked to climate factors not completely accounted for in the LOESS smoothing with streamflow.
2009	Alkalinity	increasing trend with slope of 4.71	As with specific conductivity, it is likely that this trend is strongly influenced by the dry conditions in 2006 to 2007, given that most of the highest alkalinity measurements are associated with periods without NPDES discharge. The estimated slopes for both stations are small compared to the historic Horse Creek Stewardship Program (HCSP) Minimum Detection Level (MDL) (≤ 1 mg/L) and/or the differences between primary and field duplicate samples (≤ 17 mg/L).
	Dissolved Calcium	increasing trend with slope of 1.56	As with specific conductivity, it is likely that this trend is strongly influenced by the dry conditions in 2006 to 2007, given that most of the highest calcium measurements are associated with periods without NPDES discharge. The estimated slope of the trend for HCSW-1 is small compared to historic HCSP differences between primary and field duplicate samples (≤ 8.0 mg/L).
	Chloride	slight increasing trend with slope of 0.50	As with the other dissolved ion parameters, the trend for HCSW-1 is small compared to the historic HCSP MDL (≤ 4.06 mg/L) and differences between primary and field duplicate samples (≤ 5.0 mg/L). The observed changes in chloride over time are probably related to the differences in rainfall over the course of the HCSP.
	Orthophosphate	slight increasing trend with slope of 0.03	The slope is very small compared to historic HCSP values for laboratory Minimum Detection Limits (≤ 0.075 mg/L) or differences between primary and field duplicate samples (≤ 0.034 mg/L). Therefore, the trends at both stations are not of concern at this time and could be related to extreme differences in rainfall and streamflow within the sampling period.

Year	Parameter	Trend	Comment
	Specific Conductance	increasing trend with slope of 16.73	It is likely that this trend is strongly influenced by the dry conditions and subsequent higher than average specific conductivity in 2006 to 2007, given that specific conductivity is greatly influenced by rainfall and most of the highest specific conductivity measurements are associated with dryer years. The estimated slope of the trend for HCSW-1 is not of concern currently because of the substantial variability in rainfall over the course of the HCSP.
	Total Dissolved Solids	increasing trend with slope of 9.46	As with the other dissolved ion parameters, the trend for HCSW-1 is small compared to differences between primary and field duplicate samples (≤ 44 mg/L). The observed changes in TDS over time are probably related to the differences in rainfall over the course of the HCSP.
2010	pH	slight increasing trend with slope of 0.06	2010 Impact Assessment concluded that estimated slope was too small to be ecologically significant.
	Fluoride	slight increasing trend with slope of 0.01	
	Ammonia	slight decreasing trend with slope of -0.002	2010 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Orthophosphate	slight increasing trend with slope of 0.27	2010 Impact Assessment found that the evident trend was caused by a data bias and extending the period of record before 2003 caused the trend to no longer be valid. Concentrations in 2008-2010 were similar to those before 2003.
	Specific Conductance	increasing trend with slope of 16.68	2010 Impact Assessment found step-change in specific conductivity and dissolved ions likely caused by increased groundwater contributions from 2006-2008 drought and subsequent influence from Wingate dredge mining outfall discharge. Concentrations after 2008 remain relatively steady, with no evidence of biological impact.
	Alkalinity	increasing trend with slope of 4.19	
	Dissolved Calcium	increasing trend with slope of 1.60	
	TDS	increasing trend with slope of 10.66	
2011	pH	slight increasing trend with slope of 0.05	2011 Impact Assessment concluded that estimated slope was too small to be ecologically significant.
	Fluoride	slight increasing trend with slope of 0.01	
	Ammonia	slight decreasing trend with slope of -0.002	2011 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Dissolved Iron	slight decreasing trend with slope of -0.02	
	Orthophosphate	slight increasing trend with slope of 0.02	2011 Impact Assessment found that the evident trend was caused by a data bias and extending the period of record before 2003 caused the trend to no longer be valid. Concentrations in 2008-2011 were similar to those before 2003.
	Specific Conductance	increasing trend with slope of 14.57	2011 Impact Assessment found step-change in specific conductivity and dissolved ions likely caused by increased groundwater contributions from 2006-2008 drought and subsequent influence from Wingate dredge mining outfall discharge. Concentrations after 2008 remain relatively steady, with no evidence of biological impact.
	Alkalinity	increasing trend with slope of 3.91	
	Dissolved Calcium	increasing trend with slope of 1.37	

Year	Parameter	Trend	Comment
	Sulfate	Increasing trend with slope of 2.82	
	Total Dissolved Solids	increasing trend with slope of 9.65	
2012	pH	slight increasing trend with slope of 0.05	2012 Impact Assessment concluded that estimated slope was too small to be ecologically significant.
	Color	slight increasing trend with slope of 5.25	
	Ammonia	slight decreasing trend with slope of -0.0003	2012 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Dissolved Iron	slight decreasing trend with slope of -0.02	
	Orthophosphate	slight increasing trend with slope of 0.02	2012 Impact Assessment found that the evident trend was caused by a data bias and extending the period of record before 2003 caused the trend to no longer be valid. Concentrations in 2008-2012 were similar to those before 2003.
	Specific Conductance	increasing trend with slope of 10.6	2012 Impact Assessment found step-change in specific conductivity and dissolved ions likely caused by increased groundwater contributions from 2006-2008 drought and subsequent influence from Wingate dredge mining outfall discharge. Concentrations after 2008 remain relatively steady, with no evidence of biological impact.
	Alkalinity	increasing trend with slope of 2.96	
	Dissolved Calcium	increasing trend with slope of 1.05	
	Sulfate	Increasing trend with slope of 2.27	
	Total Dissolved Solids	increasing trend with slope of 6.64	
2013	pH	slight increasing trend with slope of 0.05	Although the HCSP HCSW-1 pH data does show a step-change increase in 2007 during the drought period (which probably causes the statistically significant Seasonal Kendall Tau trend), there is no evidence that NPDES discharge is raising pH at HCSW-1. It is more likely that the step-change increase in pH may partially originate at stations upstream of HCSW-1 with no NPDES influence.
	Fluoride	slight increasing trend with slope of 0.02	2013 Impact Assessment concluded that estimated slope was too small to be ecologically significant.
	Ammonia	slight decreasing trend with slope of -0.002	2013 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Dissolved Iron	slight decreasing trend with slope of -0.01	
	Specific Conductance	increasing trend with slope of 11.2	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
	Alkalinity	increasing trend with slope of 2.50	
	Dissolved Calcium	increasing trend with slope of 0.99	
	Sulfate	Increasing trend with slope of 4.19	
	Total Dissolved Solids	increasing trend with slope of 10.3	

Year	Parameter	Trend	Comment
2014	pH	slight increasing trend with slope of 0.04	Although the HCSP HCSW-1 pH data does show a step-change increase in 2007 during the drought period (which probably causes the statistically significant Seasonal Kendall Tau trend), there is no evidence that NPDES discharge is raising pH at HCSW-1. It is more likely that the step-change increase in pH may partially originate at stations upstream of HCSW-1 with no NPDES influence.
	Fluoride	slight increasing trend with slope of 0.01	2014 Impact Assessment concluded that estimated slope was too small to be ecologically significant.
	DO Saturation	slight increasing trend with slope of 1.43	2014 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Ammonia	slight decreasing trend with slope of -0.001	
	Dissolved Iron	slight decreasing trend with slope of -0.01	
	Specific Conductance	increasing trend with slope of 9.46	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
	Alkalinity	increasing trend with slope of 2.28	
	Dissolved Calcium	increasing trend with slope of 0.71	
	Sulfate	Increasing trend with slope of 2.85	
	Total Dissolved Solids	increasing trend with slope of 7.07	
2015	pH	increasing trend with slope of 0.04	Although the HCSP HCSW-1 pH data does show a step-change increase in 2007 during the drought period (which probably causes the statistically significant Seasonal Kendall Tau trend), there is no evidence that NPDES discharge is raising pH at HCSW-1. It is more likely that the step-change increase in pH may partially originate at stations upstream of HCSW-1 with no NPDES influence.
	Dissolved Oxygen-%Sat	increasing trend with slope of 1.29	2015 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Ammonia	slight decreasing trend with slope of -0.001	
	Dissolved Iron	slight decreasing trend with slope of -0.01	
	Specific Conductance	increasing trend with slope of 10.2	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively
	Alkalinity	increasing trend with slope of 2.42	
	Dissolved Calcium	increasing trend with slope of 0.86	

Year	Parameter	Trend	Comment
	Fluoride	slight increasing trend with slope of 0.01	constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
	Sulfate	Increasing trend with slope of 2.92	
	Total Dissolved Solids	increasing trend with slope of 8.31	
2016	pH	increasing trend with slope of 0.05	Although the HCSP HCSW-1 pH data does show a step-change increase in 2007 during the drought period (which probably causes the statistically significant Seasonal Kendall Tau trend), there is no evidence that NPDES discharge is raising pH at HCSW-1. It is more likely that the step-change increase in pH may partially originate at stations upstream of HCSW-1 with no NPDES influence.
	Dissolved Oxygen-mg/L	increasing trend with slope of 0.06	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
	Dissolved Oxygen-%Sat	increasing trend with slope of 0.74	
	Ammonia	slight decreasing trend with slope of -0.001	
	Dissolved Iron	slight decreasing trend with slope of -0.02	
	Specific Conductance	increasing trend with slope of 10.4	
	Alkalinity	increasing trend with slope of 2.39	
	Dissolved Calcium	increasing trend with slope of 1.05	
	Fluoride	slight increasing trend with slope of 0.01	
	Sulfate	Increasing trend with slope of 3.67	
	Total Dissolved Solids	increasing trend with slope of 8.56	
2018	pH	Slight increasing trend with slope of 0.04 SU/yr	Slope very small in magnitude. Isolated step change. Not of concern.
	Alkalinity	Increasing trend with slope of 2.32 mg/L/yr	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
	Chlorophyll-a	Slight decreasing trend with slope of -0.03	
	DO (mg/L)	Slight increasing trend with slope of 0.04 mg/L/yr	
	Fluoride	Slight increasing trend with slope of 0.01 mg/L/yr	
	Iron	Slight decreasing trend with slope of -0.01 mg/L/yr	

Year	Parameter	Trend	Comment
	Specific Conductance	Increasing trend with slope of 12.1 µS/yr	
	Sulfate	Increasing trend with slope of 12.1 µS/yr	2018 Impact Assessment historical analysis indicated TDS, sulfate, and calcium values have approached and exceeded HCSP trigger levels before levels were established and before Mosaic's outfalls were online. These exceedances also often occur when there is no discharge, long after there has been a discharge, or low stream flow conditions.
	Calcium	Increasing trend with slope of 1.1 mg/L/yr	
	TDS	Increasing trend with slope of 4.24 mg/L/yr	
2019	Alkalinity	2 mg/L/yr	Not an adverse trend
	Calcium	1.2 mg/L/yr	Discussed in 2018 Historical Assessment
	DO saturation	0.8%/yr	Not an adverse trend
	pH	0.04 SU/yr	Slope very small in magnitude. Isolated step change.
	Specific Conductance	11 µS/yr	Discussed in 2017 Historical Assessment
	Sulfate	3.9 mg/L/yr	Discussed in 2018 Historical Assessment

Table H-2 Summary of Trends Detected at HCSW-4

Year	Parameter	Trend	Comment
2008	Dissolved Oxygen	slight decreasing trend with slope of -0.40	May be influenced by climate or other land use in southern basin.
	Orthophosphate	slight increasing trend with slope of 0.02 (data not correlated with streamflow)	Magnitude of trend not ecologically significant. May be influenced by climate or other land use in southern basin.
2009	Alkalinity	increasing trend with slope of 1.90	As with specific conductivity, it is likely that this trend is strongly influenced by the dry conditions in 2006 to 2007, given that most of the highest alkalinity measurements are associated with periods without NPDES discharge. The estimated slopes for both stations are small compared to the historic HCSP MDL (≤ 1 mg/L) and/or the differences between primary and field duplicate samples (≤ 17 mg/L).
	Dissolved Oxygen	slight decreasing trend with slope of -0.42	It appears the declining trend stems from the difference between DO concentrations in 2006-2007 (dry years) compared to 2008-2009. When comparing DO overall annual and seasonal medians, DO concentrations in 2008-2009 are consistent with those in 2003-2005. Given this information and the fact that HCSW-1 does not show a significant trend, it is unlikely that mining activities are contributing to a perceived trend in dissolved oxygen concentrations at HCSW-4.
	Orthophosphate	slight increasing trend with slope of 0.02 (data not correlated with streamflow)	The slope is very small compared to historic HCSP values for laboratory Minimum Detection Limits (≤ 0.075 mg/L) or differences between primary and field duplicate samples (≤ 0.034 mg/L). Therefore, the trends at both stations are not of concern at this time and could be related to extreme differences in rainfall and streamflow within the sampling period.

Year	Parameter	Trend	Comment
2010	Color	increasing trend with slope of 12.07	2010 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Orthophosphate	slight increasing trend with slope of 0.02	2010 Impact Assessment found that the evident trend was caused by a data bias and extending the period of record before 2003 caused the trend to no longer be valid. Concentrations in 2008-2010 were similar to those before 2003.
	Alkalinity	Increasing trend with slope of 1.62	2010 Impact Assessment found step-change in specific conductivity and dissolved ions likely caused by increased groundwater contributions from 2006-2008 drought and subsequent influence from Wingate dredge mining outfall discharge. Concentrations after 2008 remain relatively steady, with no evidence of biological impact.
2011	Color	increasing trend with slope of 11.47	2011 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Dissolved Iron	slight decreasing trend with slope of -0.01	
	Alkalinity	increasing trend with slope of 1.31	2011 Impact Assessment found step-change in specific conductivity and dissolved ions likely caused by increased groundwater contributions from 2006-2008 drought and subsequent influence from Wingate dredge mining outfall discharge. Concentrations after 2008 remain relatively steady, with no evidence of biological impact.
2012	Color	increasing trend with slope of 10.6	2012 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Dissolved Iron	slight decreasing trend with slope of -0.01	
	Alkalinity	increasing trend with slope of 1.66	2012 Impact Assessment found step-change in specific conductivity and dissolved ions likely caused by increased groundwater contributions from 2006-2008 drought and subsequent influence from Wingate dredge mining outfall discharge. Concentrations after 2008 remain relatively steady, with no evidence of biological impact.
2013	Color	increasing trend with slope of 7.29	2013 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Dissolved Iron	slight decreasing trend with slope of -0.01	
	Alkalinity	increasing trend with slope of 1.37	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
	Chloride	slight increasing trend with slope of 0.36	
	Fluoride	Slight increasing trend with slope of 0.01	

Year	Parameter	Trend	Comment
2014	Color	increasing trend with slope of 6.61	2014 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Dissolved Iron	slight decreasing trend with slope of -0.01	
	Specific Conductance	increasing trend with slope of 9.01	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
	Alkalinity	increasing trend with slope of 1.40	
	Chloride	slight increasing trend with slope of 0.33	
	Fluoride	slight increasing trend with slope of 0.01	
	Sulfate	increasing trend with slope of 3.21	
	TDS	increasing trend with slope of 12.2	
2015	Color	increasing trend with slope of 6.32	2015 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Dissolved Iron	slight decreasing trend with slope of -0.01	
	Specific Conductivity	increasing trend with slope of 7.47	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
	Alkalinity	increasing trend with slope of 1.18	
	Fluoride	Slight increasing trend with slope of 0.01	
	Total Dissolved Solids	increasing trend with slope of 9.26	
2016	Color	increasing trend with slope of 4.31	2016 Impact Assessment concluded that estimated slope was in the opposite direction of adverse change.
	Dissolved Iron	slight decreasing trend with slope of -0.01	
	Specific Conductivity	increasing trend with slope of 7.94	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively
	Alkalinity	increasing trend with slope of 1.08	
	Fluoride	Slight increasing trend with slope of 0.01	

Year	Parameter	Trend	Comment
	Total Dissolved Solids	increasing trend with slope of 6.02	constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
2018	pH	Slight increasing trend with slope of 0.02 mg/L/yr	Slope very small in magnitude. Isolated step change. Not of concern.
	Alkalinity	Increasing trend with slope of 0.54 mg/L/yr	The specific conductivity increases in recent years were influenced by regional factors unrelated to mining activities, drought-period baseflow contributions, upstream conditions, and increased influence of groundwater in current mining activities. Any small portion of the change in specific conductivity that may have been affected by changes in NPDES water quality is likely to stay relatively constant at HCSW-1 in the near future given planned mining practices and the stable range of concentrations shown since Wingate mine began discharging to Horse Creek in 2008.
	Chlorophyll-a	Slight decreasing trend with slope of -0.05	
	Color	Increasing trend with slope of 2.82 PCU/yr	
	Iron	Slight decreasing trend with slope of -0.01 mg/L/yr	
	Nitrogen, Total Kjeldahl	Slight increasing trend with slope of 0.02 mg/L/yr	
	Radium, Combined	Slight decreasing trend with slope of -0.02 pCi/L/yr	
	Specific Conductance	Increasing trend with slope of 5.7 µS/yr	
	Turbidity	Slight increasing trend with slope of 0.09 NTU/yr	
2019	Alkalinity	1.1 mg/L/yr	Not an adverse trend
	Calcium	0.7 mg/L/yr	Discussed in 2018 Historical Assessment
	Color	2.6 PCU/yr	Not an adverse trend
	pH	0.02 SU/yr	Slope very small in magnitude. Isolated step change.
	Specific Conductance	7.9 µS/yr	Discussed in 2017 Historical Assessment
	Sulfate	3.9 mg/L/yr	Discussed in 2018 Historical Assessment
	TDS	5.5 mg/L/yr	Discussed in 2018 Historical Assessment
	Turbidity	0.08 NTU/yr	Slope very small in magnitude; not at upstream station.

Appendix I

2019 Total Ammonia Water Quality Impact Assessment

HORSE CREEK STEWARDSHIP PROGRAM
HARDEE AND DESOTO COUNTIES, FLORIDA
TOTAL AMMONIA HISTORICAL ANALYSIS

Prepared for:

Mosaic

Mr. Ryan Tickles
Mosaic Fertilizer, LLC
13830 Circa Crossing Drive
Lithia, Florida 33547

September 30, 2020

Prepared by:

FLATWOODS
Consulting Group

8306 Laurel Fair Circle•Suite 120
Tampa, FL 33610•813-600-5747

Eesa G. Ali
Senior Water Resource Analyst

Shannon M. Gonzalez
Senior Ecologist/Principal

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1.0 SUMMARY

The objective of this report is to determine if Mosaic Fertilizer, LLC's (Mosaic's) activities in the Upper Horse Creek Basin are contributing to the ammonia exceedances documented within the Horse Creek Stewardship Program (HCSP).

Mosaic has two outfalls that intermittently discharge to Horse Creek. The Wingate D-004 outfall is approximately 4.2 miles downstream of the Fort Green D-003 outfall. The HCSP established four sample sites along Horse Creek: HCSW-1, HCSW-2, HCSW-3, and HCSW-4. HCSW-1 is closest to and approximately 5.5 miles downstream of the Wingate Mine outfall and HCSW-2, HCSW-3, and HCSW-4 are 12, 25.8, and 32.2 miles further downstream, respectively.

Episodic total ammonia trigger level exceedances have occurred throughout the entire Horse Creek basin and its tributaries, regardless of whether the potential for mining inputs existed or not. The 2019 HCSP Annual Report Spearman Rank Correlation analysis detected a significant positive correlation between rainfall and total ammonia and to a lesser extent National Pollutant Discharge Elimination System (NPDES) discharge (which itself is correlated to streamflow). There was no total ammonia concentration difference detected between Waterbody IDs (WBIDs), basins, HCSP sites, or between samples collected during NPDES discharge, no discharge, and pre-outfall (Analysis of Variance (ANOVA), p>0.05).

Site	**HCSW-1 N= 500**	**HCSW-2 N= 184**	**HCSW-3 N= 235**	**HCSW-4 N= 659**
Number of total ammonia trigger level exceedances, period of record*	3	3	5	6
Date of first recorded trigger level exceedance**	7/19/1976	7/31/2008	7/31/2008	8/11/1975
Basin	**Upper Basin, n = 740**		**Lower Basin, n = 940**	
Number of total ammonia trigger level exceedances, period of record*	9		12	
Date of first recorded trigger level exceedance**	7/19/1976		8/11/1975	

*Period of record: HCSW-1 5/72- 12/19, HCSW-2 5/03-12/19, HCSW-3 5/72-12/19, HCSW-4 10/71-3/20. Period of record for Upper Horse Creek basin period record ammonia data: 5/72-9/19. Lower Horse Creek Basin ammonia data: 10/71-9/19
**Date of first recorded Mosaic discharge- 9/30/2001

Other than phosphate mining, the dominant land use in the Upper Horse Creek Basin, according to the most recent Landscape Development Index (LDI) maps (2017), is agriculture (34.8% by area). Agriculture dominates the lower Horse Creek Basin at 60.2% (Appendix A). Three tributaries of Horse Creek: Brushy Creek, West Fork Horse Creek, and Buzzard Roost Branch, have documented historical elevated total ammonia values. No phosphate mining has occurred in the Buzzard Roost watershed.

2.0 INTRODUCTION

This Impact Assessment was conducted in response to exceedances of trigger levels for total ammonia during HCSP monthly monitoring activities. As part of the HCSP plan, Mosaic must initiate impact assessments to determine if Mosaic's activities are a contributing factor to exceedances or deleterious water quality trends in Horse Creek.

The Upper Basin (WBID 1787B) and part of the Lower Basin (WBID 1787A1) of Horse Creek is classified as a Class III (Fish Consumption; Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife) surface water. Approximately 1.6 miles downstream of HCSW-4, Horse Creek becomes a Class I surface water (WBID 1787A2) to the confluence with the Peace River. The Peace River, from the confluence with Horse Creek to the southern line of section 15, Township 39 South, Range 23 East is proposed as a Class I-treated (potable water supply with treatment) surface water, pending Environmental Protection Agency (EPA) approval, *62-302.400.17.b.14, F.A.C*. Because of the downstream Class I designation and the settlement with the Peace River Manasota River Water Authority (PRMRWA), the HCSP adopted trigger levels are based on secondary potable water quality standards and water treatment needs. Pursuant to Ch. *62-302.530, F.A.C.,* Ammonia has a single criterion for Class I and Class III waters based on the following:

The 30-day average Total Ammonia as Nitrogen (TAN) value shall not exceed the average of the values calculated from the following equation, with no single value exceeding 2.5 times the value from the equation:

$$30 - \text{day Average} = 0.8876 \times \left(\frac{0.0278}{1 + 10^{7.688-pH}} + \frac{1.1994}{1 + 10^{pH-7.688}}\right) \times \left(2.126 \times 10^{0.028\times(20-MAX(T,7))}\right)$$

Where T and pH are defined as the paired temperature (°C) and pH associated with the TAN sample. For purposes of total ammonia nitrogen criterion calculations, pH is subject to the range of 6.5 to 9.0. The pH shall be set at 6.5 if measured pH is < 6.5 and set at 9.0 if the measured pH is > 9.0. pursuant to Ch. *62-302.530, F.A.C.*

This report focuses on existing historical flow data collected by United States Geological Survey (USGS) gauging stations and surface water quality data from the HCSP and the State of Florida's Impaired Waters Rule (IWR) database- Run 59. A copy of the past and current run of the IWR dataset can be downloaded here: http://publicfiles.dep.state.fl.us/dear/IWR/

HCSP sites (Appendix A) were lumped into WBIDs. HCSW-1 and HCSW-2 data were associated with IWR data corresponding to the Upper Horse Creek Basin (WBID 1787B), while HCSW-3 and HCSW-4 were associated with IWR data corresponding to the Lower Horse Creek Basin (WBID 1787A1). HCSW-2 is located downstream of the Horse Creek/Brushy Creek confluence, on the border between the Lower Horse Creek Basin and the Upper Horse Creek Basin. The data presented below demonstrates more similarity between HCSW-2 and the HCSW-1/Brushy Creek sites than the sites in Lower Horse Creek Basin.

3.0 TOTAL AMMONIA

Total ammonia is a form of inorganic nitrogen that consists of unionized ammonia (NH_3) and ionized ammonia or ammonium (NH_4^+). Most fish excrete NH_3 into water as waste. NH_3 is toxic to fish because it can enter the bloodstream via the gills where it can be converted to NH_4^+, which is even more toxic to fish (USEPA, 1999). Different fish taxa have various strategies to manage ammonia toxicity; and fish susceptibility to ammonia toxicity is variable depending on life stage and other stressors (e.g. intense swimming, feeding behavior, etc.). Generally, NH_4^+ values at or below 0.02 mg/L are considered safe for fish (USEPA, 1999). However, NH_4^+ in water cannot pass through the gill epithelia in fish (Hillaby and Randall, 1979), so it is useful to convert total ammonia values to NH_3 with respect to fish toxicity.

Ammonia occurs naturally in the environment and its occurrence in soil, sediment, and water is primarily due to nitrogen fixation by bacteria and plants (Figure 3-1). Environmental conditions and microbial activity will increase ammonia through mineralization or decrease ammonia through oxidation. Periods of desiccation and inundation of sediments will mediate mineralization activity (Cabrera 1993, Merbt, et al., 2016). Elevated inorganic nitrogen concentrations in aquatic systems can cause stress in fish, invertebrates, macrophytes, and algal communities to varying degrees. Most of the eutrophication problems plaguing freshwater systems are due to changes in land use and the expanded overuse of inorganic fertilizers.

Total ammonia concentrations in surface waters can be affected by industrial and domestic effluents, precipitation, stream flow, agricultural runoff, and stormwater from urban areas (Constable, et al., 2003). Ammonia has been used for decades as an additive in potable water supply in the form of chloramine which is a less volatile disinfectant than hypochlorite or elemental chlorine and prevents the formation of carcinogenic organochlorines. With respect to phosphate mining, historically ammonia has been used in flotation to separate phosphate from ore and as an ingredient in the production of ammonium phosphate fertilizer. None of these processes requiring ammonia occur in the Horse Creek watershed.

The proportion of total ammonia that is unionized is affected by pH, salinity, and temperature (Figure 3-2, A, B, & C). Unionized ammonia and therefore fish toxicity, increases with increasing pH and temperature (Thurston, et al. 1981). Unionized ammonia decreases with increased salinity; however, hardness may also reduce ammonia toxicity (Wicks, et al. 2002, Soderberg & Meade 1993). Total ammonia values used in this review are expressed as total ammonia as nitrogen or TAN.

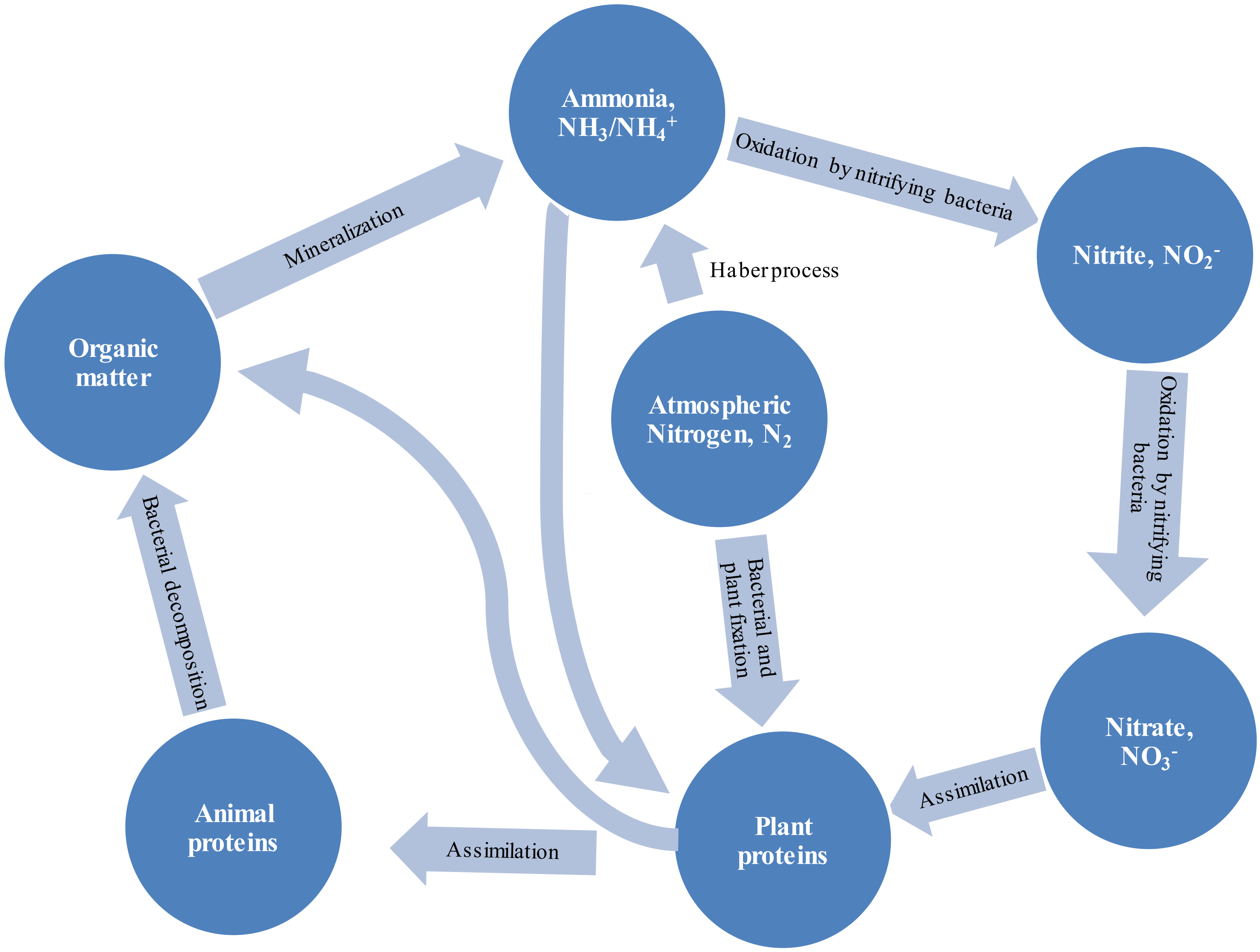
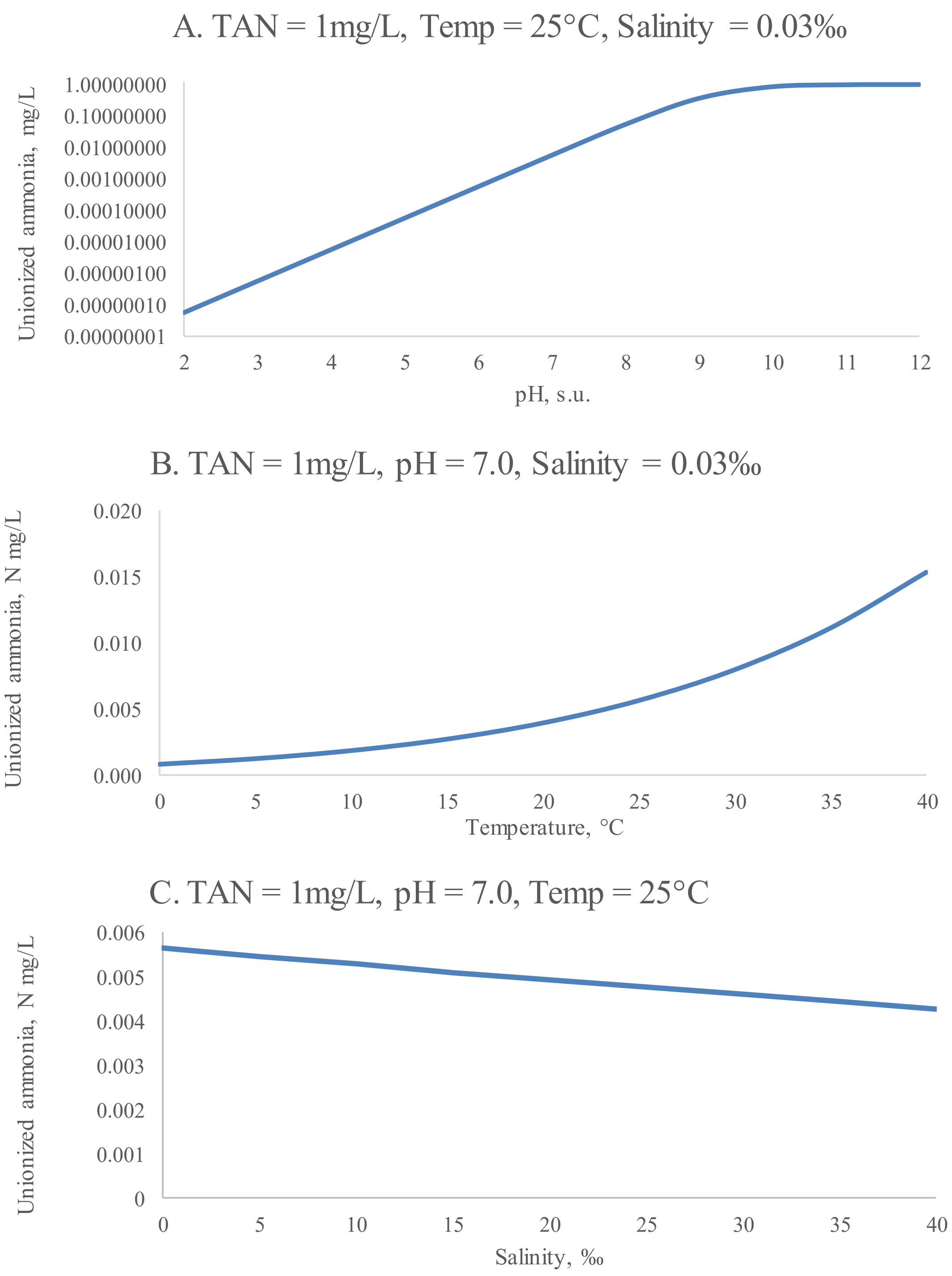


Figure 3-1 Simplified Nitrogen Cycle


A. TAN = 1mg/L, Temp = 25°C, Salinity = 0.03‰

B. TAN = 1mg/L, pH = 7.0, Salinity = 0.03‰

C. TAN = 1mg/L, pH = 7.0, Temp = 25°C

Figure 3-2 The Relationship Between Total Ammonia, Unionized Ammonia, pH (A), Temperature (B) and Salinity (C)

4.0 HISTORICAL OVERVIEW OF TOTAL AMMONIA TRIGGER LEVEL EXCEEDANCES IN HORSE CREEK

State of Florida records show ammonia water quality data collection in the Horse Creek Basin began in 1971 in the Lower Basin (WBID 1787A, Horse Creek above Peace River) and in 1972 in the Upper Horse Creek Basin (WBID 1787B, Horse Creek above Brushy Creek). The IWR and Mosaic total ammonia data period of record are shown in the table below. The Wingate and Fort Green NPDES wastewater permits do not require reporting of TAN. Additionally, there is no available public or Mosaic groundwater TAN data; as a result, this report used only surface water data collected by the state and by Mosaic through the HCSP.

Table 4-1 Period of Record Data for Horse Creek Sample Stations and Basins

Sample Site	IWR	n	Mosaic	n	Total
Lower Basin (WBIDs 1787A1 and 1787A2)	10/1971 – 3/2019	491	5/2003-12/2019	449	940
Horse Creek at SR72 (HCSW-4)	10/1971 – 3/2019	438	5/2003-12/2019	221	659
Horse Creek at SR70 (HCSW-3)	5/1972 – 8/1992	7	5/2003-12/2019	228	235
Upper Basin (WBID 1787B)	5/1972 – 4/2019	237	5/2003-12/2019	503	740
Horse Creek at Goose Pond Road, (HCSW-2)	5/2015 & 4/2019	2	5/2003-12/2019	182	184
Horse Creek at SR64 (HCSW-1)	5/1972 – 4/2019	233	6/2003-12/2019	267	500

Values reported by the Southwest Florida Water Management District (SWFWMD) and USGS prior to the year 2000 were disconnected from quality assurance/quality control metadata in the IWR database which resulted in unknown method detection limits, practical quantitation limits and, occasionally, analytical methods. Using data with unknown precision and multiple available analytical methods is unavoidable in a historical analysis. Values prior to 2000 (22% of all data used) should therefore be viewed as estimates.

The Wingate and Fort Green Mines and their respective outfalls occur in and upstream of the Upper Horse Creek Basin. The Wingate D-004 outfall is approximately 4.2 miles downstream of the Fort Green D-003 outfall. No discharge has occurred from D-003 since 2009 and except for an active CSA, the site is being reclaimed. The HCSP established four sample sites along Horse Creek: HCSW-1, HCSW-2, HCSW-3, and HCSW-4. HCSW-1 is closest to, and approximately 5.5 miles downstream of, the Wingate Mine outfall and HCSW-2, HCSW-3, and HCSW-4 are 12, 25.8, and 32.2 miles further downstream, respectively (Appendix A).

Water passing through HCSW-1 in the Upper Basin comes from a 42 square mile drainage area (02297155 USGS NWIS). The HCSW-4 drainage area in the Lower Horse Creek is 218 square miles (02297310 USGS NWIS). This means that HCSW-1 would represent the closest representation to the full impact of Fort Green and Wingate NPDES outfalls both in proximity and concentration.

The first recorded discharge through the Fort Green Mine Outfall D-003 occurred on July 19, of 2001 and the first recorded discharge through the Wingate Mine Outfall D-004 occurred on September 10, 2002. The first recorded total ammonia values above the HCSP trigger level thresholds occurred before mining began in the Horse Creek basin, and it occurred in the Lower Basin in 1975 (Figure 4-1). Table 4-2 summarizes all occurrences of total ammonia values above the trigger level and compares those values to the State of Florida Class I & III criteria for total ammonia in surface waters.

Of the 21 documented TAN trigger level exceedances in Horse Creek, 12 occurred during periods of no NPDES discharge, and most of those 12 occurred before the outfalls were online (Figure 4-1). Some 15 out of 21 trigger level exceedances occurred at sites downstream of HCSW-1, the HCSP site closest to the outfalls. The single exceedance that occurred in 2019, occurred at HCSW-3 during a period of no NPDES discharge. The three trigger level exceedances that occurred in July of 2018 were at sites downstream of HCSW-1 and were G-qualified because TAN was detected in the field blank at a concentration higher that the TAN trigger value and the majority of the Horse Creek historical sample values. Mosaic has since taken steps to investigate cross-contamination in the collection of samples when G-qualifiers occur.

There was no NPDES discharge to Horse Creek during 2017 yet there were two documented TAN trigger level exceedances in the lower basin. In July 2008 three trigger level exceedances occurred at the HCSP sites downstream of HCSW-1. The July 2008 samples were not accompanied with the typical quality controls like a field blank and duplicate sample. TAN trigger level exceedances in Horse Creek occur mostly in the rainy season between May and September, with one occurring in December. Finally, of the 21 trigger level exceedances, only three exceeded the Class I and III TAN standard, and they all occurred before the outfalls were online.

Since the outfalls came online in September 2001 to December 2019, there have been 2,071 days of discharge. There were 403 samples (150 unique dates) collected on days when there was a discharge, and six of those samples (three unique dates, not including the V or G-qualified samples) exceeded the HCSP TAN trigger value. One of those six exceedances occurred at HCSW-1 (Figure 4-3). That exceedance coincided with a 20.13 Million Gallons per Day (MGD) NPDES discharge and high flow conditions at HCSW-1 on July 6, 2010.

An ANOVA was conducted on period of record (IWR, Mosaic, and HCSP) TAN concentrations between sites, WBIDs (Figure 4-2), basins, and between samples collected during and outside periods of discharge. No significant differences were detected between any of those respective groupings (ANOVA, $p>0.05$). The 2019 HCSP Annual Report utilized SWFWMD data and HCSP data only and the ANOVA detected a difference between sites with a $p = 0.007$, with HCSW-1 having the lowest mean concentration. The 2019 HCSP Annual Report found that TAN concentrations were positively correlated to rainfall and stream flow at HCSW-1 and positively correlated to streamflow only at HCSW-4. No monotonic TAN trends were detected at HCSW-1 or HCSW-4.

Table 4-2 Total Ammonia Exceedances in Horse Creek, Period of Record

Data Source	Site	Basin	Date	Qualifier	TAN, mg/L	Temperature, °C	pH, s.u.	30-day TAN criteria, mg/L	Single-sample TAN criteria, mg/L	NH_4^+, mg/L	Horse Creek flow, cfs	NPDES flow, cfs
IWR	HCSW-4	LHC	08/11/75		0.34	30	6.8	1.05	2.64	0.002	135	NA
IWR	HC @ CR665	LHC	07/19/76		0.36	29	5.7	1.19	2.98	0.000	NA	
IWR	HCSW-1	UHC			0.34	27	7.2	1.1	2.74	0.004	NA	
IWR	HCSW-4	LHC	06/13/77		10	34	7.7	0.46	1.16	0.501	0.23	
IWR	HCSW-4	LHC	08/27/96		3.2	27	7.4	0.96	2.41	0.052	66	
IWR	HCSW-1	UHC	06/07/00		0.85	26.4	8.27	0.34	0.85	0.088	0	
HCSP	HCSW-2	UHC	07/31/08		0.41	26.5	6.46	1.4	3.5	0.001	NA	35
HCSP	HCSW-3	LHC			0.32	29.2	6.52	1.17	2.93	0.001	NA	
HCSP	HCSW-4	LHC			0.31	29.1	6.83	1.11	2.77	0.002	134	
MOS	Ona SW2M	UHC	08/04/09		0.32	NA	NA	NA	NA	NA	NA	85
MOS	Ona SW6W	UHC			0.37	NA	NA	NA	NA	NA	NA	
MOS	Ona SW2M	UHC	06/01/10	V	0.66	NA	NA	NA	NA	NA	23	0
MOS[†]	HCSW-1	UHC	07/06/10		0.35	28	6.25	1.27	3.18	0.000	120	20
HCSP	HCSW-3	LHC	05/03/11		0.31	26.6	7.34	1.03	2.57	0.004	NA	0
MOS	HCSW-4	LHC	12/03/13		1	19.3	7.44	1.53	3.83	0.010	3.7	0
IWR	HC @ 120th St	LHC	06/13/17		0.31	27.7	5.76	1.3	3.24	0.000	NA	0
MOS	HCSW-3	LHC	09/27/17		0.6	29.2	6.91	1.08	2.69	0.004	NA	0
HCSP	HCSW-2	UHC	07/11/18	G	0.77	28.2	7	1.11	2.78	0.005	NA	56
HCSP	HCSW-3	LHC		G	0.38	28.3	6.89	1.15	2.87	0.002	NA	
HCSP	HCSW-4	LHC		G	0.54	28.9	6.74	1.15	2.87	0.002	667	
HCSP	HCSW-3	LHC	05/13/19		0.51	27	6.62	1.33	3.33	0.001	NA	0

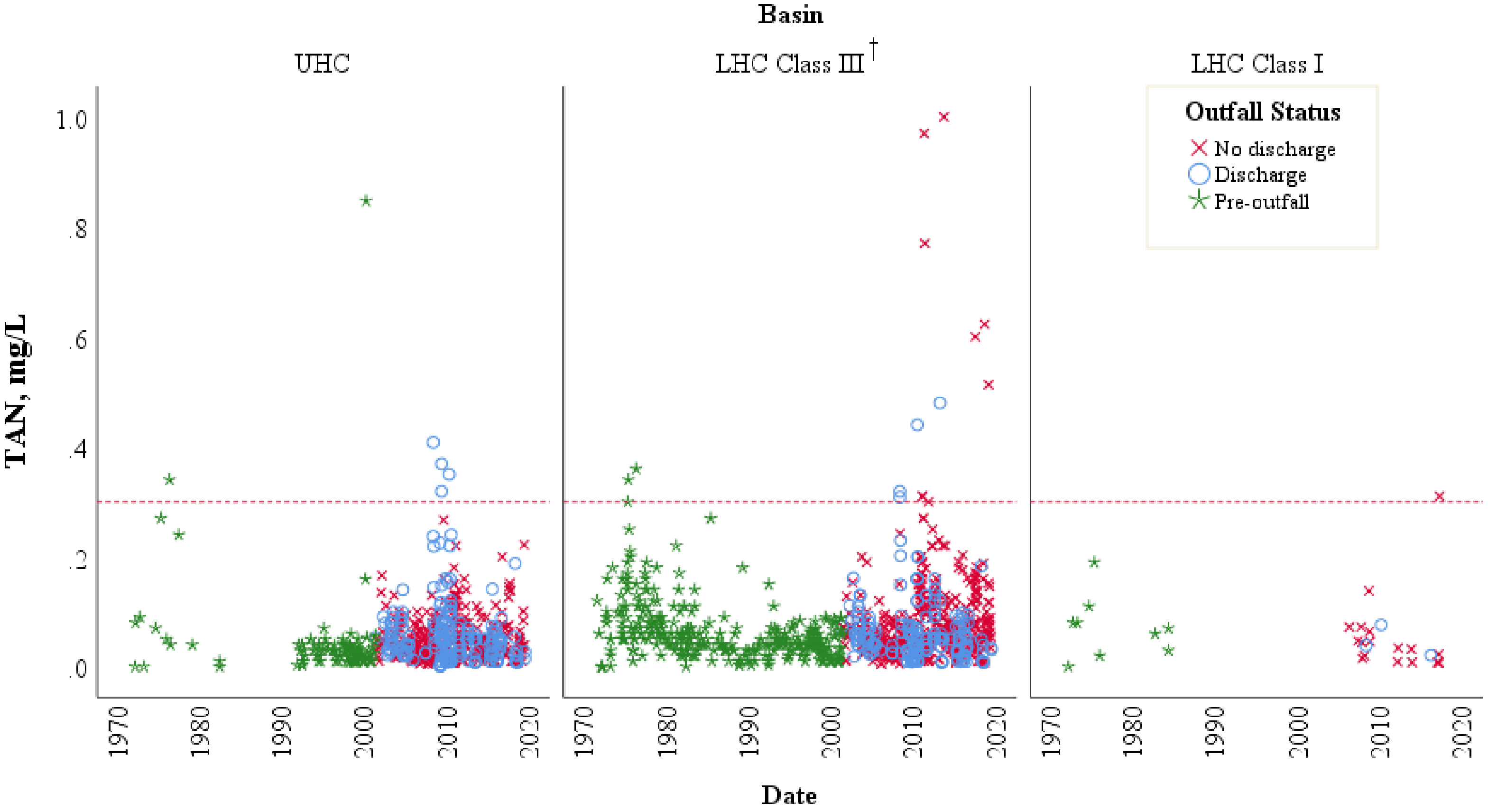
Values above red dotted line occurred before outfalls were online.

Highlighted cells indicate values exceed Class I-III criteria for either the 30-day average or single-day total ammonia as N criteria. Unionized ammonia values >0.02 mg/L are also highlighted.

[†] Other Mosaic sample- unrelated to HCSP.

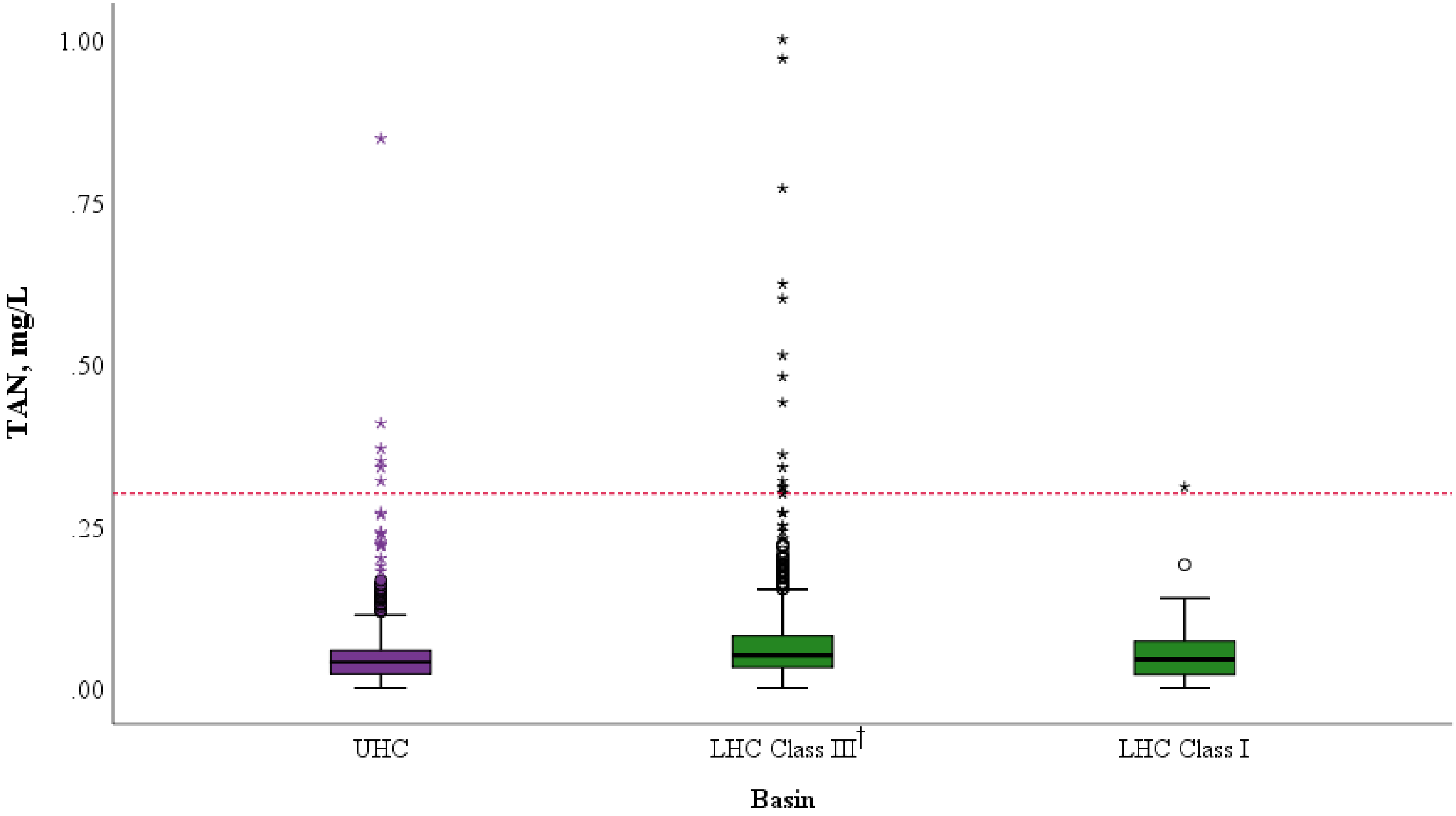
V- Indicates analyte detected in both the sample and method blank.

G- Indicates analyte detected in both the sample and field blank.



†Not shown in graphic above due to scaling are two outliers in the Lower Horse Creek Class-III reach- 10 mg/L (June 1977), and 3.2 mg/L (August 1996).
Red dotted line denotes HCSP TAN trigger value.

Figure 4-1 Total Ammonia Values for the Upper and Lower Horse Creek Basins, Period of Record



The red dotted line denotes the TAN trigger level.
Circles indicate 1.5x the interquartile (IQ) range, asterisks indicate values >3x the IQ range, and the line across the box indicates the median.
Purple and green boxes indicate mined and unmined areas respectively.
†Not shown in graphic above due to scaling are two outliers in the Lower Horse Creek Class III- 10 mg/L (June 1977), and 3.2 mg/L (August 1996).

Figure 4-2 **Boxplot of TAN Data Split Between the Upper, Lower Class III and Lower Class I Horse Creek Basins**[1]

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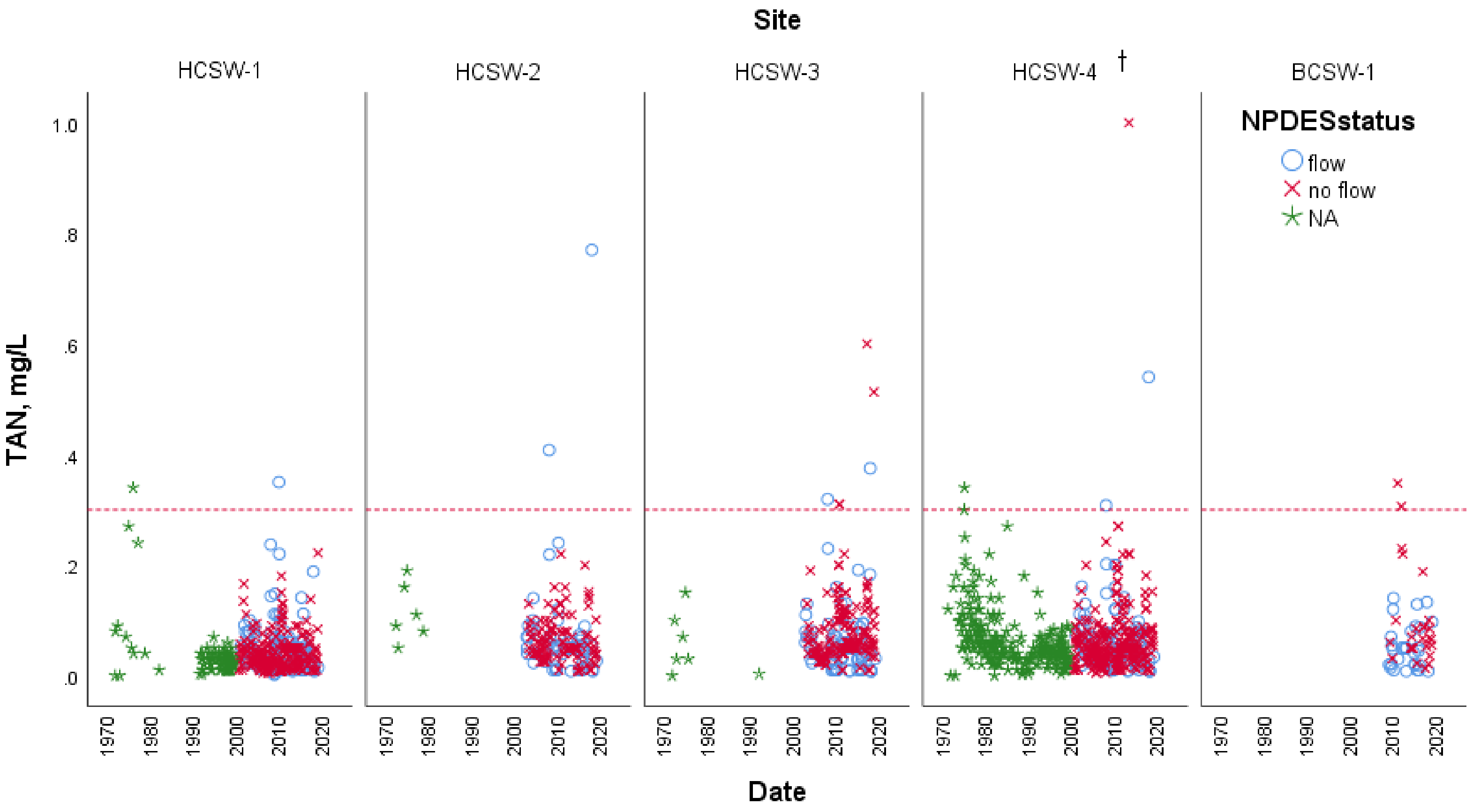
[1] Period of record (1972- 2019, n= 740, Upper Basin; 1971- 2019, n= 920, Lower Class III; and 1972-2018, n= 20, Lower Class I).

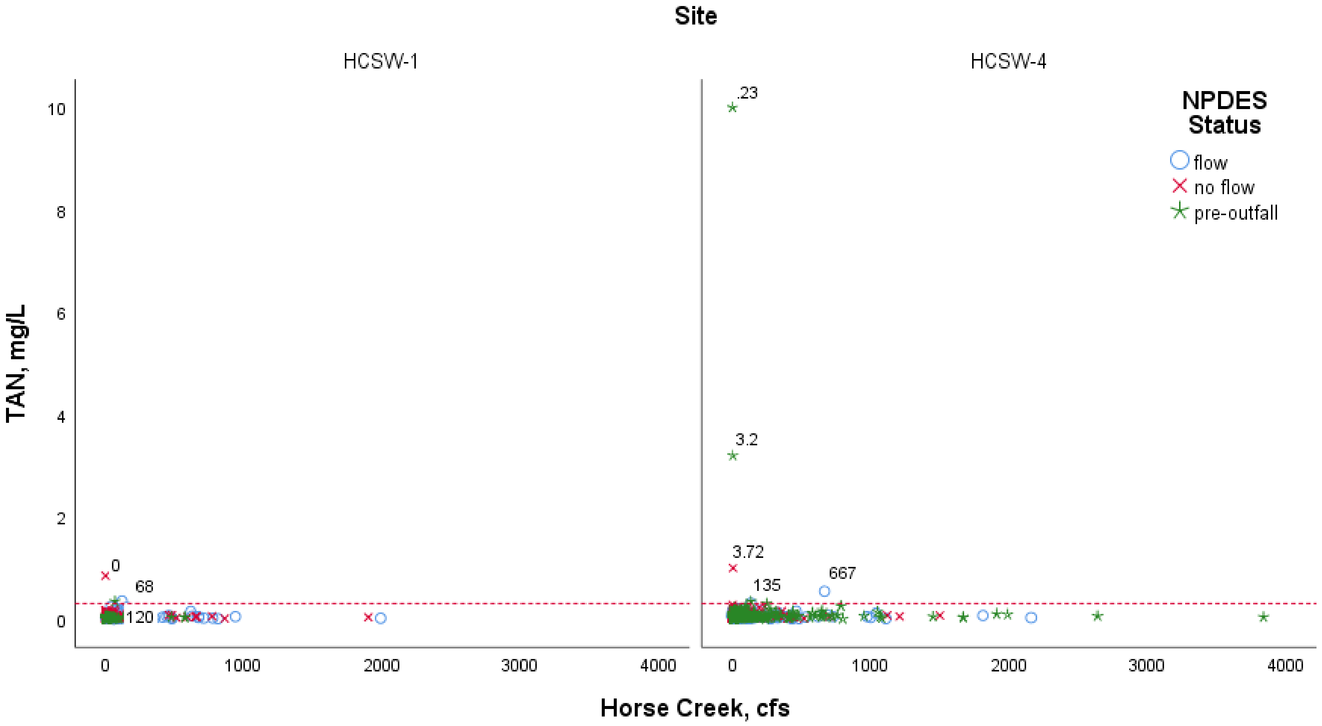


†Not shown in graphic above due to scaling are two outliers at HCSW-4 - 10 mg/L (June 1977), and 3.2 mg/L (August 1996).
Red dotted line denotes the HCSP TAN trigger value.

Figure 4-3 Combined IWR and HCSP Period of Record TAN Values Collected at the HCSP Monitoring Sites

5.0 CREEK FLOW

TAN was found to be positively correlated to stream flow at both HCSW-1 (Figure 6-1, Spearman rank correlation of IWR and Mosaic data, ρ = 0.1, α<0.05, n= 477) and HCSW-4 (Spearman rank correlation of IWR and Mosaic data, ρ = 0.1, α<0.05, n= 656) but not correlated to NPDES flow. Previous HCSP Annual Reports utilized a limited data set consisting of only the SWFWMD subset of the IWR data in its spearman analysis and found the same positive correlations at HCSW-1 and HCSW-4 with creek flow but also a correlation with HCSW-1 TAN and NPDES discharge (Spearman, ρ = 0.4 (flow) & ρ = 0.26 (NPDES); α<0.003, n = 127).



Red dotted line denotes TAN trigger value

Figure 5-1 TAN[2] vs Stream Flow

6.0 MAJOR TRIBUTARIES TO HORSE CREEK

Between the confluence of West Fork Horse Creek (upstream of HCSW-1 at State Road 64) and HCSW-4 at State Road 72, there are approximately 40 tributaries that drain into Horse Creek. Most of these waterbodies are unnamed 1st order streams. Six of the forty tributaries are named systems, with designated WBIDs. Of those six WBIDs, four have historical TAN data in the IWR database (Figure 7-1 and 7-2).

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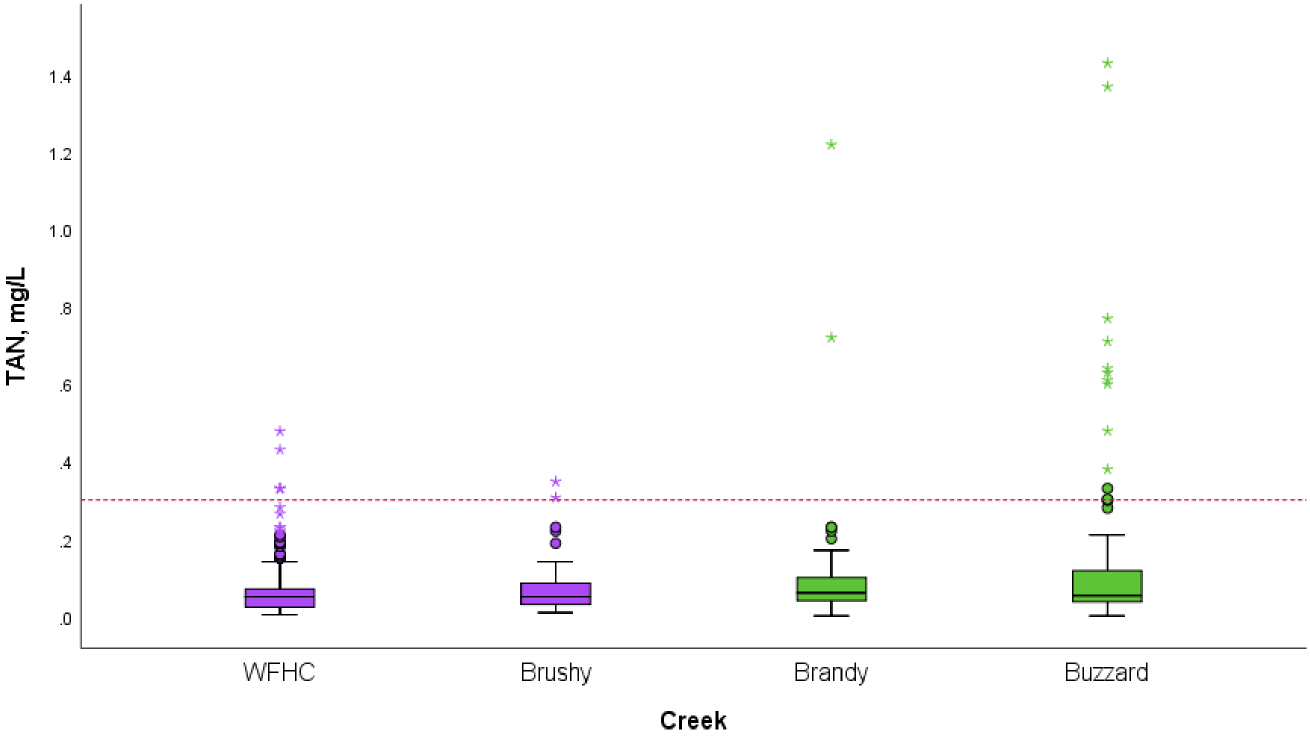
[2] TAN exceedances are labeled with stream flow values. HCSW-1 and HCSW-4 flow values are from USGS stations 02297155 and 02297310, respectively. Mean and median flow in during the data period was 33 and 7 cfs at HCSW-1 and 171 and 40 cfs in the Lower Basin.

Cypress Branch and Brushy Creek Drain into the Upper Horse Creek Basin, between HCSW-1 and HCSW-2. Brandy Branch and Buzzard Roost Branch both drain into the Lower Horse Creek Basin between HCSW-3 and HCSW-4. All four of those creeks show excursions above the trigger values set for TAN in Horse Creek (Figure 7-2). Both Brandy Branch and Buzzard Roost Branch cross sod fields along Lily County Line Road. Neither watershed have been mined for phosphates or have permitted wastewater discharges.



The red dotted line denotes the TAN trigger level.
Circles indicate 1.5x the interquartile (IQ) range, asterisks indicate values >3x the IQ range, and the line across the box indicates the median.
Purple and green boxes indicate mined and unmined areas respectively.

Figure 6-1 Boxplot of TAN Data from the Tributaries of Horse Creek, Period of Record[3]

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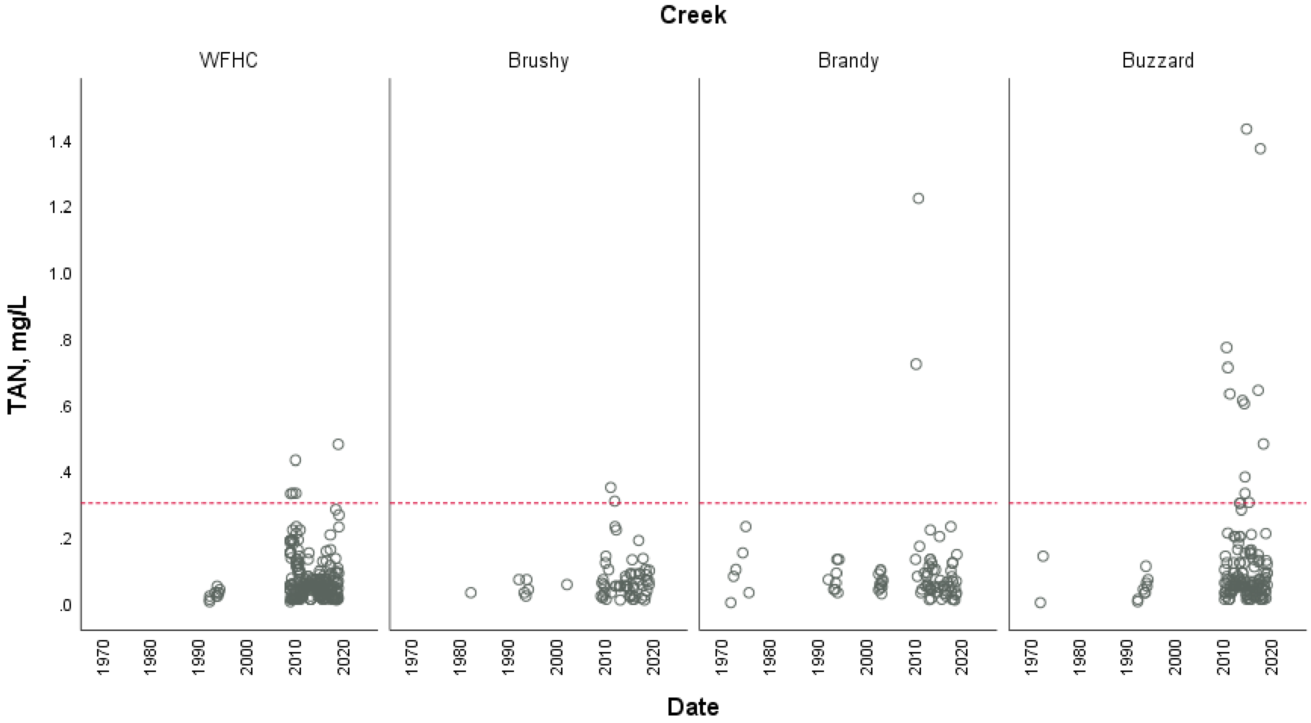
[3] (2009-2019, n=288, West Fork Horse Creek; 2009- 2019, n=66, Brushy Creek; 2010-2019, n=79, Brandy Branch; 2012-2019, 163, Buzzard Roost Branch).



Red dotted line denotes HCSP TAN trigger value.

Figure 6-2 Combined IWR and HCSP TAN Values Collected from the Tributaries of Horse Creek, Period of Record

6.1 Horse Creek and Horse Creek Tributary Reconnaissance

On December 3, 2019, Flatwoods staff hiked down the mainstem of Horse Creek from Goose Pond Road to SR 72 during low flow conditions. The team was unable to traverse the entire creek stretch due to fencing crossing the creek. Efforts were made to target key anthropogenic points of interest along Horse Creek that were apparent from aerials. TAN samples, photos, and meter readings were taken at confluences and near human activity (Appendix A, Appendix B).

The reconnaissance team found several tributaries of Horse Creek discharging water with extremely high specific conductivity compared to Horse Creek (Table 7-1). None of the collected samples had elevated TAN levels but considering the season, the low flow from the tributaries, and the low activity in the adjacent agriculture area it was an anticipated outcome. The reconnaissance team identified intense human activity linked to the use of inorganic nitrogen fertilizers very close to, and in some cases within, Horse Creek. Human activity included cattle in the stream, orchard pivots pointed at Horse Creek, and row crops within the flood plain of Horse Creek.

Table 6-1 Field Reconnaissance Results, December 3, 2019

Site	Time	TAN, mg/L	Q	NH_4^+, mg/L	Depth, m	Velocity, m/s	Temp, ºC	DO %	Specific Conductance, µS	pH, s.u.	Turbidity, NTU
Buzzard Roost Br. @ Pine Level St.	8:50	0.1	I	0.00123	0.36	0.3	15.7	92	1452	7.64	0.54
Unnamed Trib. @ 108th Ave.	9:25	0.04	I	0.00019	0.27	0.1	13.9	89.4	503	7.28	1.16
Brandy Br. @ SR70	9:50	0.03	I	0.00036	0.152	0.3	14.2	101.3	1612	7.68	0.77
Pasture Trib. 1	12:20	0.05	I	0.00038	0.177	0.2	16.7	101.5	1200	7.39	1.22
Horse Cr. Up from Pasture Trib. 1	12:30	NA	NA	NA	x	0.3	17.7	93.9	267	7.38	1.55
Agricultural Trib. 1	12:50	0.07	I	0.00004	0.114	0.2	17.1	104.4	1195	6.27	0.29
Horse Cr. Up from Agricultural Trib. 1	12:40	NA	NA	NA	x	0.2	17.7	96.1	372	7.50	1.86
Horse Cr. @ Goose Pond Rd.	15:40	0.05	I	0.00017	0.65	0.1	17.9	37.3	236	7.01	1.04
HCSW-4	15:40	NA	NA	NA	x	0.3	18.5	108.5	556	7.65	2.04

* Red text indicates analyte exceedance.

7.0 CONCLUSION

There have been 2,079 days of NPDES discharge between 2001 and 2019. There were 403 samples that coincided with the NPDES discharge. Six of the 403 samples exceeded the 0.3 mg/L HCSP TAN trigger levels, and three of those exceedances occurred at or upstream of HCSW-1. Five TAN trigger level exceedances predated the outfalls and seven exceedances occurred during periods of no NPDES discharge.

Over the period of record, no significant TAN concentration differences were detected between HCSP sampling stations. If the NPDES discharge was a source of TAN in Horse Creek, HCSW-1 concentrations would typically be more elevated that the other HCSP stations, and most of the exceedances would also occur there. Instead, TAN trigger level exceedances are episodic and mostly occur at sites below HCSW-1. It is more likely that other land uses as well as periods of desiccation of stream sediments in Horse Creek and its tributaries are driving ammonia fluxing in Horse Creek. Therefore, it is our opinion that the TAN trigger level exceedances are unrelated to phosphate mining activities in the Horse Creek Basin.

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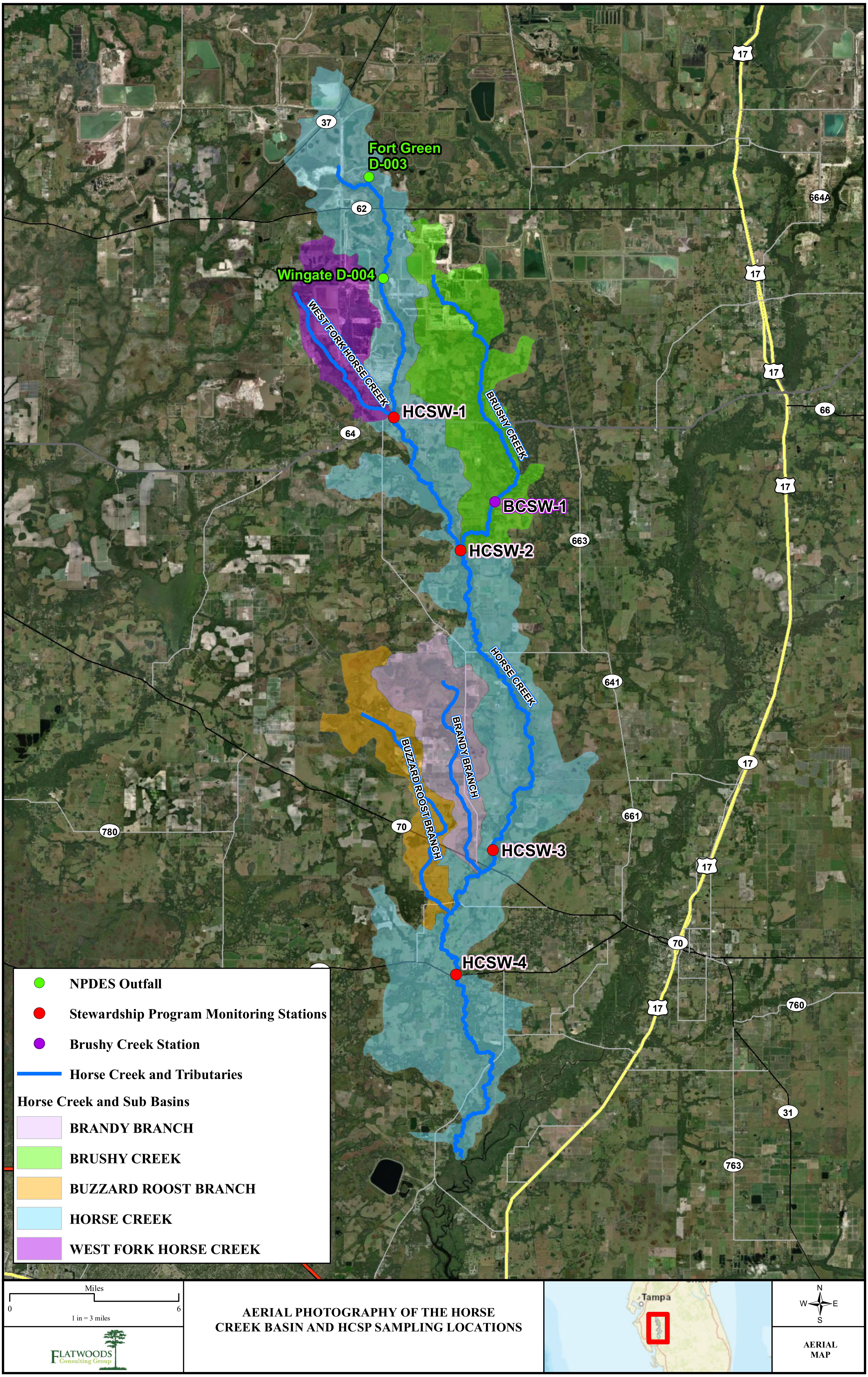

AERIAL PHOTOGRAPHY OF THE HORSE CREEK BASIN AND HCSP SAMPLING LOCATIONS

FLATWOODS Consulting Group

AERIAL MAP

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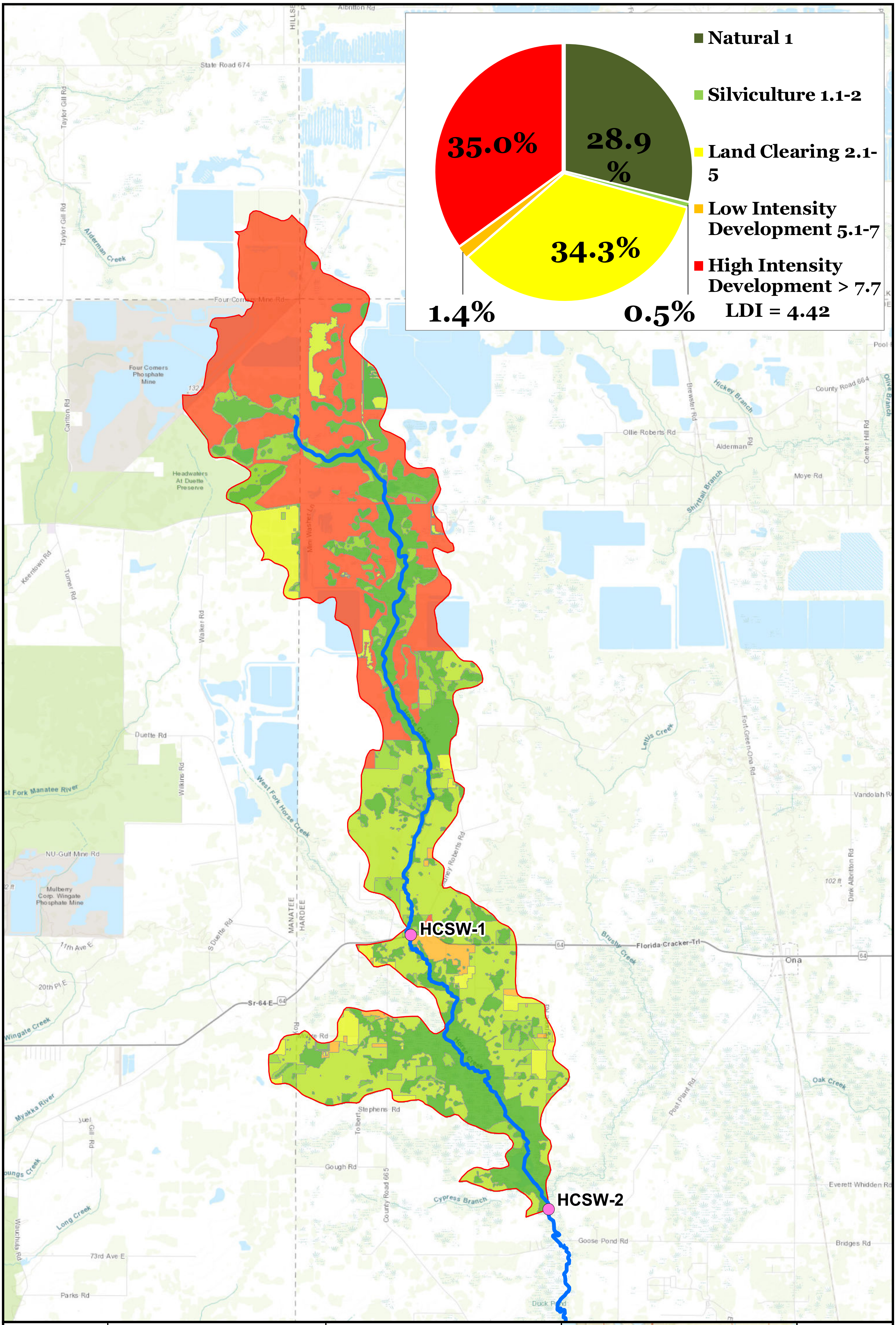

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1 in = 1.5 miles

HORSE CREEK STEWARDSHIP PROGRAM
MOSAIC FERTILIZER, LLC

DESOTO COUNTY, FLORIDA

FLATWOODS Consulting Group

● Stewardship Program Monitoring Stations

▭ Upper Horse Creek WBID

LDI Value
🟩 1
🟩 1.1 - 2.0
🟩 2.1 - 3.0
🟩 3.1 - 4.0
🟨 4.1 - 5.0
🟨 5.1 - 6.0
🟧 6.1 - 7.0
🟧 7.1 - 8.0
🟥 8.1 - 9.0
🟥 9.1 - 10.0

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2017 LANDSCAPE DEVELOPMENT INTENSITY INDEX MAP

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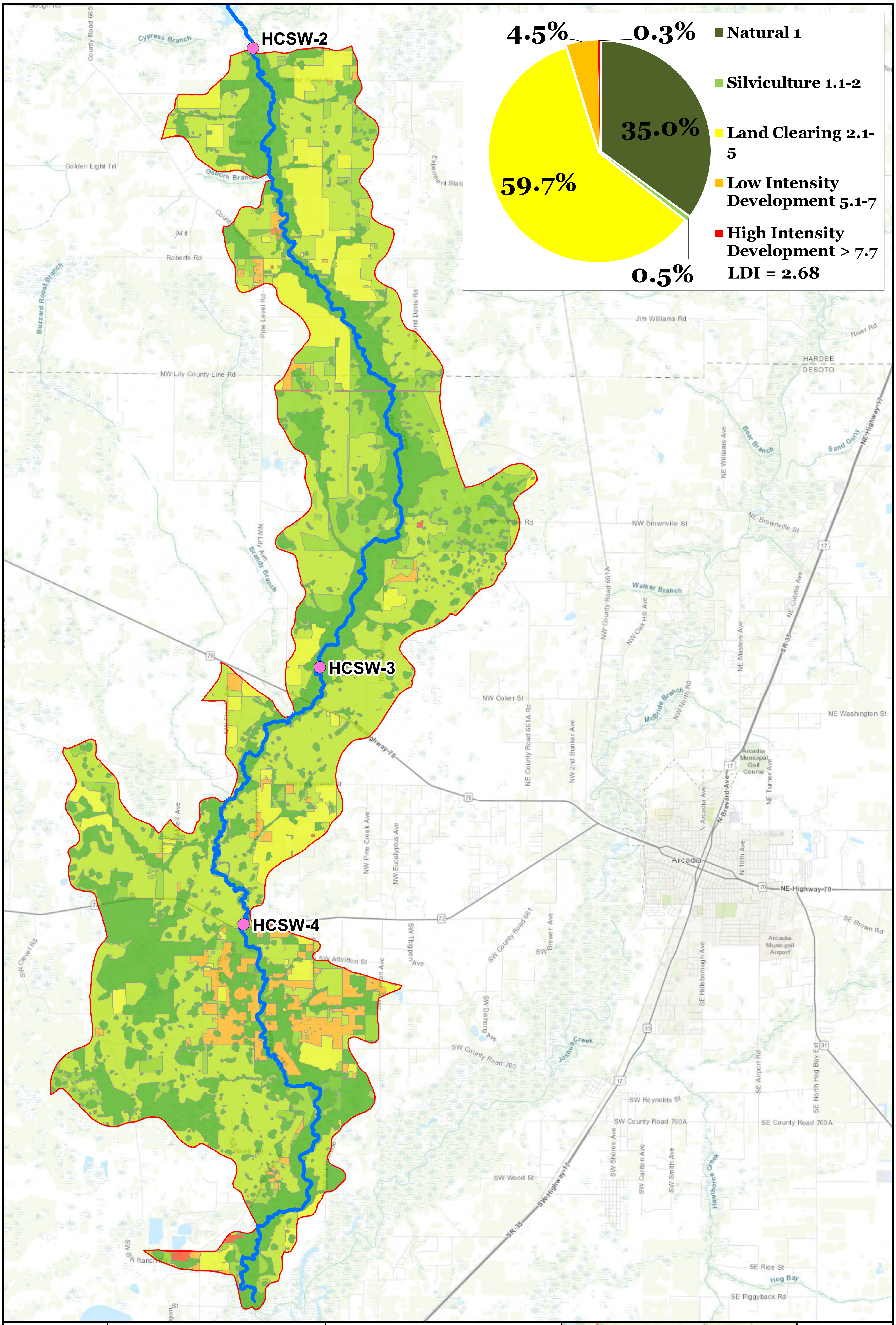

Miles

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1 in = 1.5 miles

FLATWOODS
Consulting Group

HORSE CREEK
STEWARDSHIP PROGRAM
MOSAIC FERTILIZER, LLC

HARDEE AND MANATEE
COUNTIES, FLORIDA

● **Stewardship Program Monitoring Stations**

▭ **Lower Horse Creek**

LDI Value

🟩 **1**	🟨 **5.1 - 6.0**
🟩 **1.1 - 2.0**	🟧 **6.1 - 7.0**
🟩 **2.1 - 3.0**	🟧 **7.1 - 8.0**
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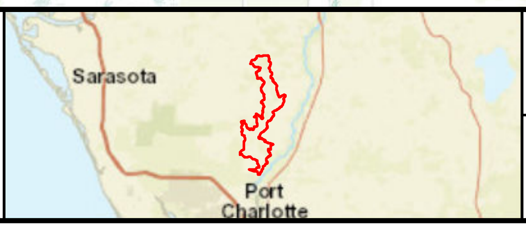

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2017 LANDSCAPE DEVELOPMENT INTENSITY INDEX MAP

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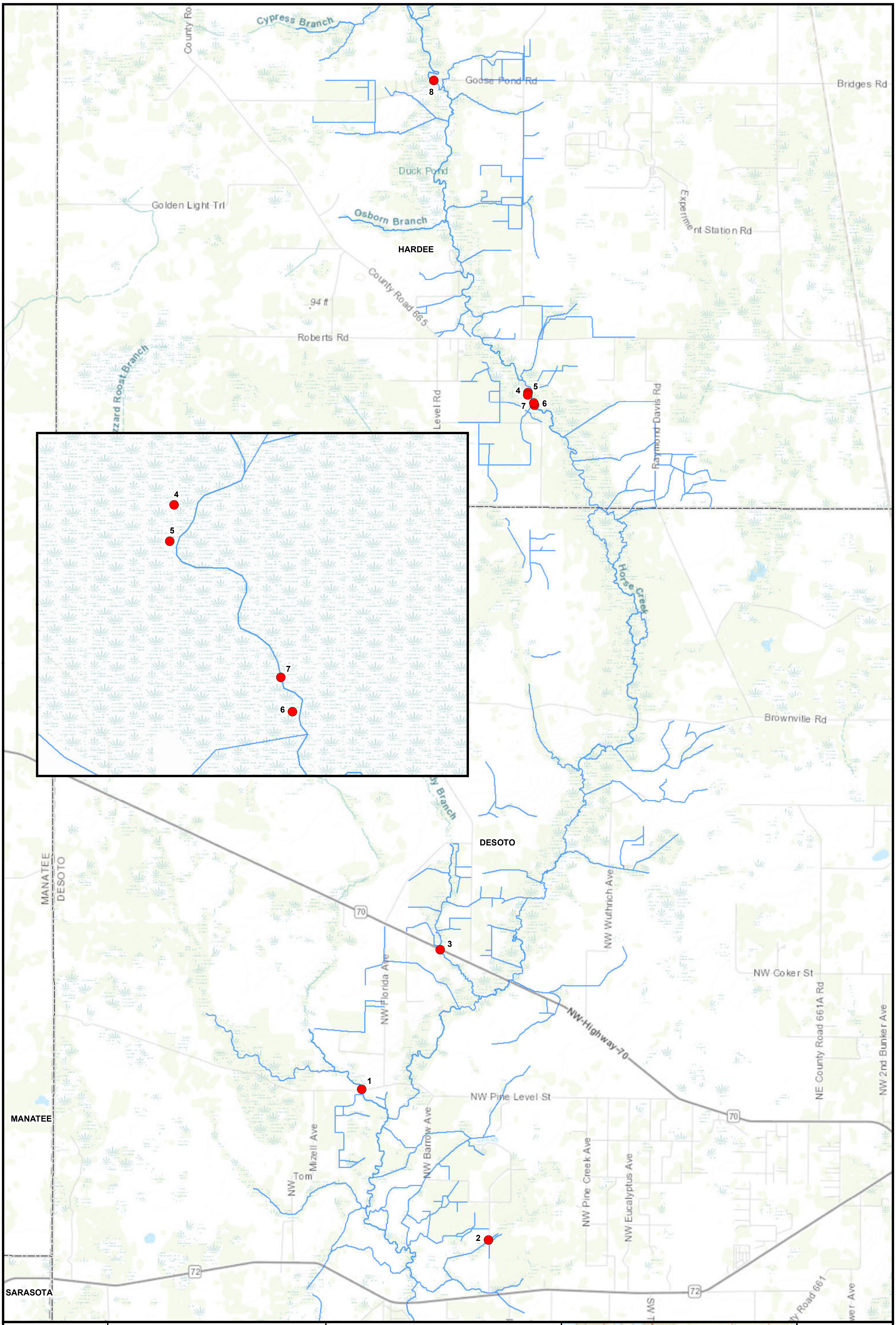

Miles

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FLATWOODS Consulting Group

HORSE CREEK
STEWARDSHIP PROGRAM
MOSAIC FERTILIZER, LLC

DESOTO AND HARDEE
COUNTIES, FLORIDA

● **Photo Station**

— **Horse Creek And Tributaries from NHD**

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PHOTO
STATION
MAP

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Photo Station 1 Buzzard Roost Branch at Pine Level Street, view upstream

Photo Station 2 Unnamed Tributary at 108th Avenue, view downstream

Photo Station 3 Brandy Branch at SR 70, view upstream

Photo Station 3 Brandy Branch at SR 70, view downstream

Photo Station 4 Pasture Tributary 1, view upstream

Photo Station 4 Drainage area of Pasture Tributary 1, view upstream

Photo Station 4 Drainage area of Pasture Tributary 1, view upstream

Photo Station 5 Pasture Tributary 1 and Horse Creek confluence, view downstream

Photo Station 6 Agricultural Tributary 1, view upstream

Photo Station 6 Drainage area of Agricultural Tributary 1, view upstream

Photo Station 7 Confluence of Agricultural Tributary 1 and Horse Creek, view upstream

Photo Station 8 Horse Creek at Goose Pond Road, view upstream

Appendix J

Comments on HCSP SCI Data

Comments on HCSP SCI Data Massachusetts

Beginning with the 2010 annual report, the Horse Creek Stewardship Program (HCSP) Stream Condition Index (SCI) data was reevaluated with strict interpretation of Florida Department of Environmental Protection (FDEP) Standard Operating Procedure (SOP) guidance, including the upper and lower limits of the SOP target number of individuals, the SOP target of a minimum velocity of 0.05 m/sec 28 days prior to sampling, the SOP target of waiting at least 90 days after abatement of a stream desiccation event (i.e. no refugia for organisms), and the SOP target of less than a 0.5 m water level increase in the previous 28 days. As a result of this evaluation, some SCI scores have been removed from the analysis (in red italics). In addition, some SCI results with more than the target number of individuals were randomly resampled to provide an unbiased result.

Date	HCSW-1					HCSW-2					HCSW-3					HCSW-4				
	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments
4/25/2003	*134*	*64*	NA	NA	Stream presumed dry earlier in month with no refugia for organisms; sample taken less than 90 days from when dry conditions abated	134	52	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	142	38	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	147	62	NA	NA	
7/29/2003	*141*	*55*	NA	NA	Greater than 0.5m water level increase over previous 28 days	*139*	*14*	NA	NA	Greater than 0.5m water level increase over previous 28 days	*151*	*27*	NA	NA	Less than SOP target number of individuals; Greater than 0.5m water level increase over previous 28 days	*146*	*61*	NA	NA	Less than SOP target number of individuals; Greater than 0.5m water level increase over previous 28 days
11/20/2003	133	65	NA	NA		121	35	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	131	60	NA	NA		135	61	NA	NA	
4/22/2004	138	37	NA	NA		134	27	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	138	*34*	NA	NA	Less than SOP target number of individuals	141	*57*	NA	NA	Less than SOP target number of individuals
11/3/2004	NA	*58*	NA	NA	Less than SOP target number of individuals	117	5	NA	NA		99	*24*	NA	NA	Less than SOP target number of individuals	111	33	NA	NA	
2/15/2005	131	48	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	117	62	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	112	51	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	113	54	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP

Date	HCSW-1					HCSW-2					HCSW-3					HCSW-4				
	HA Score	**2004 SCI Score**	**2007 SCI Score**	**2012 SCI Score**	**Comments**	**HA Score**	**2004 SCI Score**	**2007 SCI Score**	**2012 SCI Score**	**Comments**	**HA Score**	**2004 SCI Score**	**2007 SCI Score**	**2012 SCI Score**	**Comments**	**HA Score**	**2004 SCI Score**	**2007 SCI Score**	**2012 SCI Score**	**Comments**
4/20/2005	126	18	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	117	40	NA	NA		124	59	NA	NA		121	67	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP
9/15/2005[1]	129	42	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	124	21	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	121	53	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	114	53	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP
12/15/2005	130	48	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	114	37	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	115	41	NA	NA		115	36	NA	NA	
4/6/2006	110	46	NA	NA	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	98	25	NA	NA		103	60	NA	NA		105	46	NA	NA	
7/27/2006	*115*	*59*	NA	NA	Stream presumed dry at end of May with no refugia for organisms; sample taken less than 90 days from when dry conditions abated	106	26	NA	NA	Stream presumed dry in May with no refugia for organisms; sample taken less than 90 days from when dry conditions abated; Less than SOP target number of individuals	118	32	NA	NA	Stream presumed dry in May with no refugia for organisms; sample taken less than 90 days from when dry conditions abated	127	50	NA	NA	
11/28/2006[2]	115		40	45		93		34	36		121		43	47		113		42	48	
3/28/2007	115		65	72	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	100		32	37	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	117		55	60	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	113		50	56	

Date	HCSW-1					HCSW-2					HCSW-3					HCSW-4				
	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments
8/9/2007	123		65	71		-		-	-	Does not meet SOP minimum velocity requirements - no sample	121		29	34	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	130		41	48	
11/27/2007	116		65	73		108		22	25		116		65	72	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	124		61	66	
4/24/2008	*101*		47	54	Did not meet SOP minimum velocity requirements	109		23	27		114		48	53		104		52	59	
9/12/2008	122		45	51	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	104		9	11		121		7	10		119		33	40	
11/19/2008	115		48	55	Randomly subsampled because original sort had more than the recommended number of individuals from FDEP SOP	84		25	26		109		29	34		108		56	61	
4/22/2009	--		-	-	Does not meet SOP minimum velocity requirements - no sample	-		-	-	Does not meet SOP minimum velocity requirements - no sample	-		-	-	Does not meet SOP minimum velocity requirements - no sample	105		45	50	
10/22/2009	124		49	56		123		22	25		106		54	60		114		52	59	
4/20/2010	126		37	44		115		29	34		103		59	64		110		68	73	
9/28/2010	128		55	63		102		11	14		99		65	71		109		58	65	
11/4/2010 (or 11/11/10)	119		45	51		105		32	36		100		64	71		105		55	63	
4/18/2011	127		56	63		102		20	25		103		67	72		113		83	90	
8/9/2011	--		-		Severe thunderstorm with rising water levels – no sample	-		-	-	Suspected water level increase >0.5m and habitats less than 28 days inundated – no sample	112		-	-	Normal stream channel not accessible (flooded) according to SOP – no sample	122		26	29	

Date	HCSW-1					HCSW-2					HCSW-3					HCSW-4				
	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments
10/26/2011	110		49	55		-		-	-	Normal stream channel not accessible (flooded) according to SOP - no sample	109		61	68		116		45	51	
3/30/2012	--		-	-	Low water levels - no samples collected	-		-	-	Dry - no samples collected	-		-	-	Does not meet SOP minimum velocity requirements - no sample	121		73	78	
10/26/2012	126		54	60		-		-	-	Normal stream channel not accessible (flooded) according to SOP – no sample	118		61	68		97		64	70	
12/12/2012	120		51	58		-		-	-	Does not meet SOP minimum velocity requirements - no sample	104		72	78		103		62	69	
3/20/2013	96		61	67		-		-	-	Does not meet SOP minimum velocity requirements - no sample	107		65	71		113		69	75	
10/28/2013	114		44	50		98		15	20		117		61	67		94		68	74	
12/16/2013	108		40	45		105		43	46		115		72	79		119		55	62	
3/18/2014	115		57	63		109		37	42		120		66	72		119		74	81	
9/3/2014	124		74	81		103		33	36		120		38	43		121		50	56	
11/10/2014	121		43	49		103		21	25		111		49	56		111		52	59	
4/3/2015	117		59	66		100		36	40		107		70	76		117		83	88	
10/27/2015	129		62	66		109		23	27		112		68	75		114		48	55	
12/15/2015	136		54	60		111		49	52		107		58	64		114		68	75	
3/17/2016	125		68	74		114		52	57		110		51	58		115		69	75	
11/16/2016	131		49	54		105		27	31		107		59	65		111		72	78	
3/23/2017	100		67	74		-		-	-	Does not meet SOP minimum velocity requirements - no sample	102		54	60		105		82	87	
10/19/2017	124		47	54		96		19	22		108		53	60		112		52	59	
12/4/2017	109		59	65		-		-	-	Does not meet SOP minimum velocity requirements - no sample	104		58	65		113		65	71	
4/30/18	109			81						Does not meet SOP minimum velocity requirements - no sample	74			65		111			58	
10/30/18						103			24		85			63		116			66	
10/31/18	114			66	Sample events less than 90 days apart, average SCI score = 60.5					Sample events less than 90 days apart, average SCI score = 23.5					Sample events less than 90 days apart, average SCI score = 63.5					Sample events less than 90 days apart, average SCI score = 67
12/17/18						108			23		86			63		111			68	
12/18/18	112			55																
4/9/19	137			68							79			54		92			68	

Date	HCSW-1					HCSW-2					HCSW-3					HCSW-4				
	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments	HA Score	2004 SCI Score	2007 SCI Score	2012 SCI Score	Comments
7/3/19	120			56						Does not meet SOP minimum velocity requirements - no sample	91			41		119			35	
11/13/19	112			71		104			19		97			52	Less than desirable habitat and extensive sand smothering	108			27	Less than desirable habitat and extensive sand smothering

[1] Sorting method change in FDEP SOP

[2] Sorting and calculation method change in FDEP SOP; two vial average

Appendix K

Summary of Major Events, Lab Changes, and Potentially Erroneous Data Recorded during the HCSP

K.1 EVENTS TIMELINE

April 2003 – Horse Creek Stewardship Program (HCSP) began.

August 2004 – Hurricane Charley moves up the Horse Creek Basin. A few days later, there were odor complaints in the Peace River. As a response, monthly water sampling was increased to weekly sampling to aid in determining problems with water quality data, primarily dissolved oxygen in the Peace River watershed (including estuary and lower tributaries)[1]. In Horse Creek near Myakka Head (HCSW-1) water levels did not drop to hypoxic levels; however, at Horse Creek near Arcadia (HCSW-4) a drop was observed (it did see the fastest recovery to pre-hurricane conditions of sites tested)[7].

September 2004 – Hurricane Frances moves up the Horse Creek Basin.

September 2004 – Hurricane Jeanne moves up the Horse Creek Basin. The combined effects of the three hurricanes appear to be related to hypoxic conditions recorded in the Peace River watershed with areas within 20 km of the eyewall experiencing hypoxic condtions[7]. Dissolved oxygen (DO) took approximately two to three months to recover to pre-hurricane levels at most locations.

August 2005 – Invertebrate sorting methodology change in Florida Department of Environmental Protection (FDEP) Stream Condition Index (SCI) Standard Operating Procedure (SOP). Target number of individuals between 100 and 120 per sample (SCI-2004).

October 2005 – U.S. Geological Survey (USGS) rain gauge discontinued at HCSW-1. Began using Southwest Florida Water Management District (SWFWMD) rain gauge 494 for annual reports.

June 2006 – The last clays from Fort Green beneficiation plant were sent to clay settling areas (CSAs) FGH3 and FGH4 which discharge to Horse Creek via FTG-003 and FTG-004.

November 2006 – Invertebrate sorting methodology change in FDEP SCI SOP. Two vials with a target number of individuals of 140-160 per sample are required. The average SCI score of the two vials is used for reporting purposes (SCI-2007).

2006 – 2008 – Time period with lower than average streamflow and rainfall for the Horse Creek Basin.

July 2006 - September 2008 – Very little National Pollutant Discharge Elimination System (NPDES) discharge (stormwater and baseflow only) from FTG-003 and FTG-004 due to extremely dry conditions.

October 2008 – Clays mined via dredge from the Wingate Mine began to be transported to facilities and FM1 in the Horse Creek basin for processing and storage. NPDES discharge was comprised mostly of groundwater from the Wingate mining process.

March 2009 – Added CSA FM-1 to existing monitoring program.

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[1] Tomasko, D.A., C. Anastasiou, and C. Kovach. 2006. Dissolved oxygen dynamics in Charlotte Harbor and its contributing watershed, in response to Hurricanes Charley, Frances, and Jeanne – impacts and recovery. Estuaries and Coasts 29 (6A): 932-938.

September 2009 – discontinue monitoring Florida Petroleum Residual Organics (FL-PRO), fatty acids, and total amines at all four Horse Creek locations. Sampling began in Brushy Creek (BCSW-1) minus trigger levels and impact assessments.

Winter 2009/2010 – Florida experienced one of the coldest winters on record (December-February the 10th coldest period in Tampa since records started in 1890). In Hillsborough County, overnight lows in early January were at or below freezing for 12 consecutive nights. Cold temperatures led to large fish kill in the area as a result.

December 2010 – Coldest December for the Tampa Bay area in recorded history (the daily average [53.2°C] was 10°C lower for the month than normal). Several areas throughout west-central and southwest Florida also set record lows.

October 2011 – SWFWMD reduced sampling frequency at HCSW-1 and HCSW-4 to every other month from monthly sampling.

November 2011 – SWFWMD rain gaugue 494 discontinued. Began using NOAA gauges.

January 2013 – Supplemented SWFWMD Flatfort Swamp rain gauge in additoin to NOAA gauges and Mosaic gauges in annual report tables and graphics.

July 2014 – New FDEP SOP for the SCI (SCI 1000) calculations along with newly estabished bioregions (Panhandle West, Big Bend, Northeast, and Peninsula) went into effect with the approval of the new QA rule. This new methodology is referred to as the SCI-2012 method in the report.

September 2017- Hurricane Irma crosses both DeSoto and Hardee County as a Category 1 storm.

January 2018 – Flatwoods took over sampling and reporting of the HCSP.

K.2 LAB CHANGES TIMELINE

April 2003 – November 2004: Various labs

December 2004 – May 2008: STL/Test America (all but Radiologicals)

April 2006 – July 2008: KNL Labs (Radiologicals only)

July 2008 – July 2010: Benchmark Analytical (all parameters except Radiologicals)

July 2008 – November 2014: Benchmark Analytical (color and chlorophyll-a only)

August 2008 – Present: Florida Radiochemistry (Radiologicals only)

August 2010 – Present: Mosaic's Laboratory

December 2014 – Present: Mosaic's Laboratory started analyzing color and chlorophyll-a

January 2018 – Macroinvertebrate samples analyzed by Wood.

K.3 MAJOR MDL CHANGES

January 2006 – July 2008: Nitrate-Nitrite highly variable

April 2003 – December 2011: Ammonia (around 0.03 mg/L through October 2007, variable through July 2008, stable through July 2011, then variable)

December 2007: Orthophosphate abnormally high value (0.75 mg/L)

April 2003 – December 2011: Dissolved iron started at 0.1 mg/L, reduced in March 2006 to 0.022 mg/L, stable from August 2010 at around 0.01 mg/L

March 2006 – February 2008: Chloride numerous changes ranging from 0.022-30 mg/L; stable since March 2008

March 2006 – February 2008: Fluoride numerous changes ranging from 0.017-5 mg/L; relatively stable since March 2008

March 2006 – February 2008: Sulfate numerous changes; stable since March 2008

K.4 POSSIBLE OUTLIER DATA IDENTIFIED BUT REMAINING IN ANALYSIS

The data listed in the table below was identified in Decision Memo #1 as outlier data but remains in Appendix C graphs and data analysis.

Parameter	Date	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Units	Explanation
TKN	9/27/2006			6.6		mg/L	Outlier based on adjacent sampling events and SWFWMD data from the same month. Likely lab error. Was not removed from analysis.
TN	9/27/2006			6.7		mg/L	Outlier based on TKN sample being higher than adjacent sampling events and SWFWMD data from the same month. Likely lab error. Was not removed from analysis.
TKN	1/30/2008		4.7			mg/L	Outlier based on adjacent sampling events and SWFWMD data from the same month. Likely lab error. Was not removed from analysis.

Parameter	Date	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Units	Explanation
TN	1/30/2008		4.8			mg/L	TKN was an outlier based on adjacent sampling events and SWFWMD data from the same month. Likely lab error. Was not removed from analysis.

K.5 ERRONEOUS AND OUTLIER DATA REMOVED FROM ANALYSIS

The data listed in the table below was identified in Decision Memo #1 as erroneous or outlier data that should be removed from all graphs and analysis.

Parameter	Date	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Units	Explanation
pH	1/23/2007	8.8	8	8.5	8.9	SU	Compared HCSW-1 and HCSW-4 to SWFWMD measurements for January and February 2007; not an actual exceedance but equipment malfunction. All measurements were elevated. Removed from analysis.
	1/4/2011	4.8				SU	When compared measurement to SWFWMD collected that month and to previous months was found to be much lower than other values; not exceedance but equipment malfunction. Removed from analysis.

Parameter	Date	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Units	Explanation
Ammonia	7/31/2008	0.24	0.41	0.32	0.31	mg/L	Elevated concentrations are either due to laboratory method change or a seasonal fluctuation in the nitrogen cycle. Removed from analysis
	8/3/2010	0.06	0.1	0.07	0.05	mg/L	Lab analyzing the data was getting back results that were ten-times higher than other labs. Split sampling conducted in October 2011, verified that it was lab error. All results during time period of higher results (August 2010 to July 2011) removed from analysis.
	9/8/2010	0.1	0.12	0.16	0.12	mg/L	
	10/6/2010	0.01	0.24	0.01	0.2	mg/L	
	11/3/2010	0.01	0.01	0.05	0.01	mg/L	
	12/7/2010	0.08	0.11	0.1	0.1	mg/L	
	1/4/2011	0.03	0.08	0.14	0.08	mg/L	
	2/3/2011	0.18	0.13	0.16	0.2	mg/L	
	3/2/2011	0.11	0.13	0.2	0.15	mg/L	
	4/5/2011	0.13	0.13	0.13	0.17	mg/L	
	5/3/2011	0.12	0.22	0.31	0.19	mg/L	
	6/8/2011				0.27	mg/L	
	7/5/2011	0.02	0.02	0.1	0.02	mg/L	
Nitrate-Nitrite	6/20/2007			9.5		mg/L	Order of magnitude higher than adjacent sampling events and SWFWMD data from the same month. Likely lab error. Removed from data analysis as an outlier.
TN	6/20/2007			9.7		mg/L	Elevated measurements most likely due to lab analyst or instrument error in the nitrate-nitrite result. The total nitrogen levels recorded are not corroborated by measurements taken before or after the exceedance. Removed from data analysis as an outlier.

Parameter	Date	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Units	Explanation
Fluoride	7/27/2006	2.6				mg/L	Value did not agree with the field duplicate and was an order of magnitude higher than previous values. It also occurred during the MDL elevated period. Removed from analysis.
	5/25/2006		0.5			mg/L	All values between May 2006 and Feb 2008 are suspect because the MDL was raised above the previously measured maximum; the lab diluted all samples subject to the U.S. Environmental Protection Agency's (EPA) 300.0 method because the chloride and sulfate concentrations during the drought period were very high. During this period, all fluoride measurements with a U code are removed from the analysis, and all those with I codes (almost all the non-U samples) should be considered estimates only.
	6/29/2006		0.5			mg/L	
	7/27/2006		0.5			mg/L	
	8/21/2006		0.5	0.5	0.5	mg/L	
	9/27/2006		0.5	0.5	0.5	mg/L	
	10/19/2006	1	0.5	1	1	mg/L	
	11/9/2006	1	0.5	2.5	2.5	mg/L	
	12/13/2006	0.5	0.5	1	2.5	mg/L	
	1/23/2007	1	1	2	2.5	mg/L	
	2/14/2007	1	0.5	2.5	2.5	mg/L	
	3/14/2007	1	1	2.5	5	mg/L	
	4/25/2007	1	0.5	0.5	1	mg/L	
	5/16/2007		0.5	1	0.5	mg/L	
	6/20/2007		0.5	2.5	1	mg/L	
	7/18/2007		0.5	1	1	mg/L	
	8/27/2007		0.5	0.5	0.5	mg/L	
	9/26/2007		0.5	0.5	0.5	mg/L	
	11/29/2007		0.26			mg/L	
	12/17/2007		0.25			mg/L	
	1/30/2008		0.25			mg/L	
	2/26/2008		0.25			mg/L	

Parameter	Date	HCSW-1	HCSW-2	HCSW-3	HCSW-4	Units	Explanation
Total Radium	7/27/2004	4.76	5.12	4.16	3.26	pCi/L	Blank sample results had high values (2.52 pCi/L) for Radium 228. The high blank measurement makes all other Radium 228 values suspect and most likely high by the same amount found in the blank. Removed from analysis.