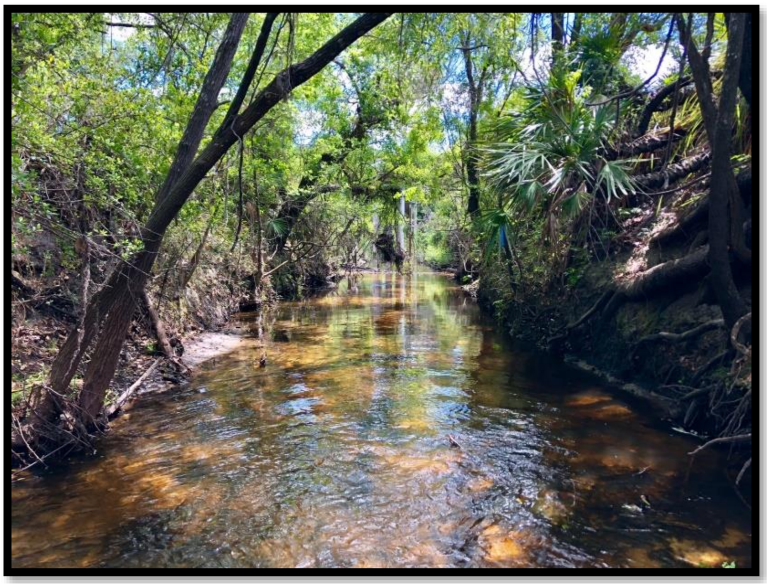
HORSE CREEK STEWARDSHIP PROGRAM
HARDEE AND DESOTO COUNTIES, FLORIDA

2023 ANNUAL REPORT

Prepared for:

Mosaic



April 2025

Prepared by:

FLATWOODS Consulting Group
A Verdantas Company

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

Michael C. Grzywacz
Ecologist

Shannon M. Gonzalez
AVP, Department Leader

EXECUTIVE SUMMARY

Introduction

The Upper Horse Creek Basin has been mined since the late 1980s. Various other active land uses, including several types of agriculture, occur in the Horse Creek Basin. In September 2001, Mosaic Fertilizer, LLC (Mosaic) commenced permitted discharges into Horse Creek from two permitted outfalls. In 2003, as a result of proposed mining activities by Mosaic in eastern Manatee and western Hardee Counties, Florida, and a series of legal challenges to the permits required for such mining, 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. A principal component of the agreement was the creation of the Horse Creek Stewardship Program (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 three basic components:

1. Water quality and biological monitoring;
2. Trend analysis; and,
3. Corrective action if mine related impacts or adverse trends are detected.

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.

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 2023, approximately 5,496 additional acres were mined in the Horse Creek Basin (206 acres, 2023) upstream of the northernmost monitoring site (HCSW- 1), and an additional 3,450 acres were mined in the Brushy Creek Basin (343 acres, 2023) upstream of two sampling sites: BCSW-1 and HCSW-2. Reclamation between 2003 and 2023 included 3,858 acres (0 acres, 2023) reclaimed to final contour in the Horse Creek Basin and 944 acres in the Brushy Creek Basin (51 acres, 2023), as well as 3,841 (0 acres, 2023) and 314 acres (0 acres, 2023) reconnected in the Horse Creek and Brushy Creek basins, respectively.

Monitoring Program Components

Four surface water locations on Horse Creek are monitored for physical, chemical, and biological parameters. One site on Brushy Creek is monitored for physical and chemical parameters only. Two of the Horse Creek sites are also long-term US Geological Survey (USGS) gauging (flow and stage) stations. Water quality sampling is conducted monthly from all sampling sites when representative flow conditions are present. Biological assessments are performed one to three times a year based on creek stage levels. The HCSP also incorporates stream flow, outfall effluent flow, and precipitation in the analysis of the conditions in Horse Creek.

Beginning with this report, data analysis and discussion excludes results from monitoring location HCSW-2. This change was approved previously by the HCSP Technical Advisory Group (TAG) and is documented in Appendix A, with additional information detailing the decision for the change outlined in Appendix C of the 2022 Annual Report. Sampling results from HCSW-2 in 2023 are summarized in Appendix G, and all data collected from HCSW-2 throughout the program can be found in the Microsoft Access database file that accompanies this report. References herein to "all HCSP sites" or similar will refer to HCSW-1, HCSW-3, and HCSW-4.

Water Quantity Results

Hardee and Desoto Counties were experiencing drought conditions from February 2023 through late September 2023, and again briefly in November 2023. Annual rainfall of 47.6 inches (1,209 mm) in 2023 was below the long-term (1978-2023)[1] average annual rainfall of 58.9 inches (1,496 mm). A ranking of annual average rainfall for the Period of Record (POR) National Oceanic and Atmospheric Administration (NOAA) station in the Horse Creek watershed places 2023 as the 54th highest year of 76 years, and 16th highest year over the HCSP POR (2003-2023).

There was no National Pollutant Discharge Elimination System (NPDES) discharge to Horse Creek in 2023. NPDES discharge from the Horse Creek outfalls usually does not occur until sufficient water storage accumulates in the mine circulation system. The 2023 annual average streamflow at both HCSW-1 (2.5 billion gallons) and HCSW-4 (18.7 billion gallons) were below their respective long-term annual averages[2] (ranked 41st and 39th of 46 years, respectively).

There is no evidence that mining and reclamation activities in the basin caused any statistically significant decrease in total streamflow over the USGS POR (1978 to 2023), according to the double mass curve analysis in this report. 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

Water quality parameters in 2023 were typically within the desirable range relative to trigger levels and Class III surface water quality standards at HCSW-1, the site with the highest percent of upstream mined lands and the site which receives the most concentrated outfall effluent. Alkalinity was the only parameter above the trigger level at HCSW-1 during 2023, none of which occurred during times of NPDES discharge.

[1]Historical rainfall information source NOAA station Myakka 336 from 1978 - present. Years with >10% missing data points removed from analysis.
[2] USGS POR Long term (1978 – 2023) annual average streamflow 7.7 and 41.3 billion gallons, HCSW-1 and HCSW-4 respectively

Ion concentrations (dissolved calcium, sulfate, and Total Dissolved Solids [TDS]) at HCSW-3 and HCSW-4 were above the trigger levels during low flow periods without an upstream NPDES discharge. An impact assessment was conducted in 2018 and found that the elevated dissolved ions were isolated to sites HCSW-3 and HCSW-4 as well as tributaries to Horse Creek in the vicinity of the two sites. These tributaries that contributed to elevated dissolved solids were all receiving runoff from land being utilized for agriculture.

There was one instance of apparent color levels falling just below the trigger level at HCSW-3 and HCSW-4 during a low flow period and without an upstream NPDES discharge. During drier periods, 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.

Over the HCSP POR, trends were detected in 16 of the 21 water quality parameters at HCSW-1 and 17 of the 21 parameters at HCSW-4. At HCSW-1, ten of the water quality parameters showed statistically significant trends in the direction of their respective trigger levels, while six of the parameters had statistically significant trends in the opposite direction of their respective trigger levels.

The largest trends detected by the program have been with specific conductance, TDS, and sulfate. Although the slopes for these trends increased from 2022, overall, these trends have been decreasing in magnitude as more data is collected. As discussed in the 2017 HCSP Annual Report, 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. Further information of the trend for specific conductivity (with reference to TDS and other ions) is provided in Appendix I of the 2017 and 2018 HCSP Annual Reports.

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 number 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. Their habitat and their presence point to the quality of a waterbody and whether it can sustain a diverse assemblage of aquatic life. The HCSP utilizes two Florida Department of Environmental Protection (FDEP) rapid biological assessment methods, Habitat Assessment (HA) and Stream Condition Index (SCI), to measure the health of a stream.

The HA method is used to score aquatic habitats[3] and allows for comparisons between sites. If a site has a high HA score, it suggests that the site should have a diverse and robust community of

[3] HA scores range from 11-160, with scores of 11 - 40 considered “Poor”, 41 - 80 “Marginal”, 81 - 120 “Sub-optimal”, and 121 – 160 “Optimal”.

macroinvertebrates assuming good water quality and adequate and consistent water flow. The SCI scores[4] the community diversity of the macroinvertebrates found on the habitats identified during the HA. Unlike a water quality sample, which offers a snapshot of stream conditions, the SCI can be used to interpret stream conditions over longer periods of time based on the abundance of certain groups of macroinvertebrates.

Benthic macroinvertebrate sampling was conducted at HCSW-1, HCSW-3, and HCSW-4 during sampling events in 2023. The Brushy Creek location is not included in the macroinvertebrate sampling component of the HCSP. The site closest to the two Mosaic NPDES outfalls (HCSW-1), had the highest HA scores for two of the three sampling events (121/160, Optimal, March and 119/160, Sub-optimal, December) and the highest SCI score for two of the three sampling events (39/100, Healthy[5], July and 67/100, Exceptional, December). The lowest SCI score came from HCSW-3 (20/100, Impaired, July) followed by HCSW-4 (28/100, Impaired, December). Typically, fall and summer SCI scores are lower. High flow conditions often cause bank scouring, especially in areas where the riparian buffer quality is poor. Bank scouring leads to erosion and habitat smothering. Summer is also associated with rapidly fluctuating water levels which inhibit aquatic macrophyte establishment and lower available light to productive habitats, therefore lowering substrate diversity and availability. The taxonomic laboratory also noted that the dominance of an exotic snail, *Mieniplotia scabra*, was a significant factor contributing to the lower scores at HCSW-3 and HCSW-4 in July. The first established populations of this non-native snail were reported in South Florida in 2018, theorized to be an aquarium trade introduction. More recent reports show their range expanding further north, including into the Peace River Basin (Benson, A.J., 2024).

Fish Results

As detailed below and in the report, the fish sampling data analyses revealed there is a decline in native species, both in abundance and richness, while invasive/exotic species are currently stable. It also found no significant trends in diversity scores, and both lower and higher diversity scores when invasive/exotic species were removed. The lack of diversity trends and opposite findings in diversity scores when removing invasive/exotic species implies a complex system that may be affected by many factors with no evidence that mining and reclamation activities in the basin are the cause. These may include sampling bias (inability to capture certain species due to physical limitations or sample methods), habitat degradation from human activities (agriculture or other land use changes), native species competing for resources with invasive/exotic species, or increasing trends of certain water quality parameters.

Unrelated to mining and reclamation activities, the number and abundance of exotic/invasive fish will likely continue to rise as new introductions to Florida waterways occur via the aquarium and aquaculture industries. With all site data combined, the year 2023 ranked 7th in fish diversity while 2019 saw the highest diversity over the HCSP POR (2003-2023). HCSW-4 has been the most diverse site over the HCSP POR.

[4] SCI scores range from 0-100, with scores of ≤34 considered impaired, average scores ≥40 considered healthy, and scores ≥65 considered exceptional.

[5] Average score ≥40

Conclusions

This report covers the 21st year of the HCSP, where some general conclusions can be drawn. Expected relationships between rainfall, runoff, and streamflow were observed in the 2003 to 2023 water quantity data. Trigger level exceedances within the HCSP and the detected monotonic trends are not related to mining operations. The benthic macroinvertebrate and fish communities found over the HCSP POR were typical of those found in Southwest Florida streams. Regulated mining and reclamation activities in the basin have not caused or contributed to reduced water quantity, deterioration of water quality, or reduction in quantity or diversity of benthic macroinvertebrates or fish populations.

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APPENDICES

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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 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 HCSP, which is funded and managed by Mosaic.

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 (Figure 1-1). It also provides mechanisms for corrective action with regard to detrimental changes or trends caused by Mosaic's activities, if any are identified. 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 overall stream health and quality, 2) investigating adverse conditions or significant trends identified through monitoring, and 3) implementing corrective action if any adverse changes to Horse Creek caused by Mosaic's mining activities are identified. 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 United States Geological Survey (USGS) facilities) of stream stage and discharge (flow) at two locations on the main stem of Horse Creek
- Daily recording of rainfall via Mosaic, Southwest Florida Water Management District (SWFWMD), and National Oceanic and Atmospheric Administration (NOAA) rain gauges in the upper Horse Creek basin
- Continuous recording of water temperature, dissolved oxygen (DO), conductivity, turbidity, and pH at HCSW-1, the Horse Creek site nearest to Mosaic's active mining operations
- Continuous recording of water temperature, DO, conductivity, turbidity, pH, and stream stage in Brushy Creek, immediately south of State Road 64
- Monthly water quality monitoring of 22 parameters at four sites on the main stem of Horse Creek and one site along Brushy Creek

- Sampling of fish, benthic macroinvertebrates, and field water quality parameters (temperature, DO, conductivity, turbidity, and pH) three times annually at four sites on the main stem of Horse Creek[6].

HCSP monitoring began in April 2003. At the time the HCSP was initiated, approximately 12,000 acres of land in the Upper Horse Creek Basin had been previously mined. From 2003 to 2023, 5,496 acres were mined (by Mosaic or legacy CF Industries operations) in the Horse Creek Basin upstream of the northernmost monitoring location (HCSW-1), including 206 acres in 2023. An additional 3,450 acres were mined in the Brushy Creek basin upstream of BCSW-1 and HCSW-2, including 343 acres in 2023.

This report, which is the twenty-first in a series of Annual Reports, presents the results of monitoring conducted from April 2003 through December 2023. All data presented in tables and figures were collected as part of the HCSP unless otherwise noted. 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. Each annual report is reviewed by the PRMRWSA and stakeholders from five counties that comprise the TAG. Comments, questions, and edit suggestions are solicited from the TAG for each report and are documented in Appendix C.

[6] Biological data (fish and benthic macroinvertebrates) are collected three times annually (three temporally independent samples) when/if stream conditions are appropriate. 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.

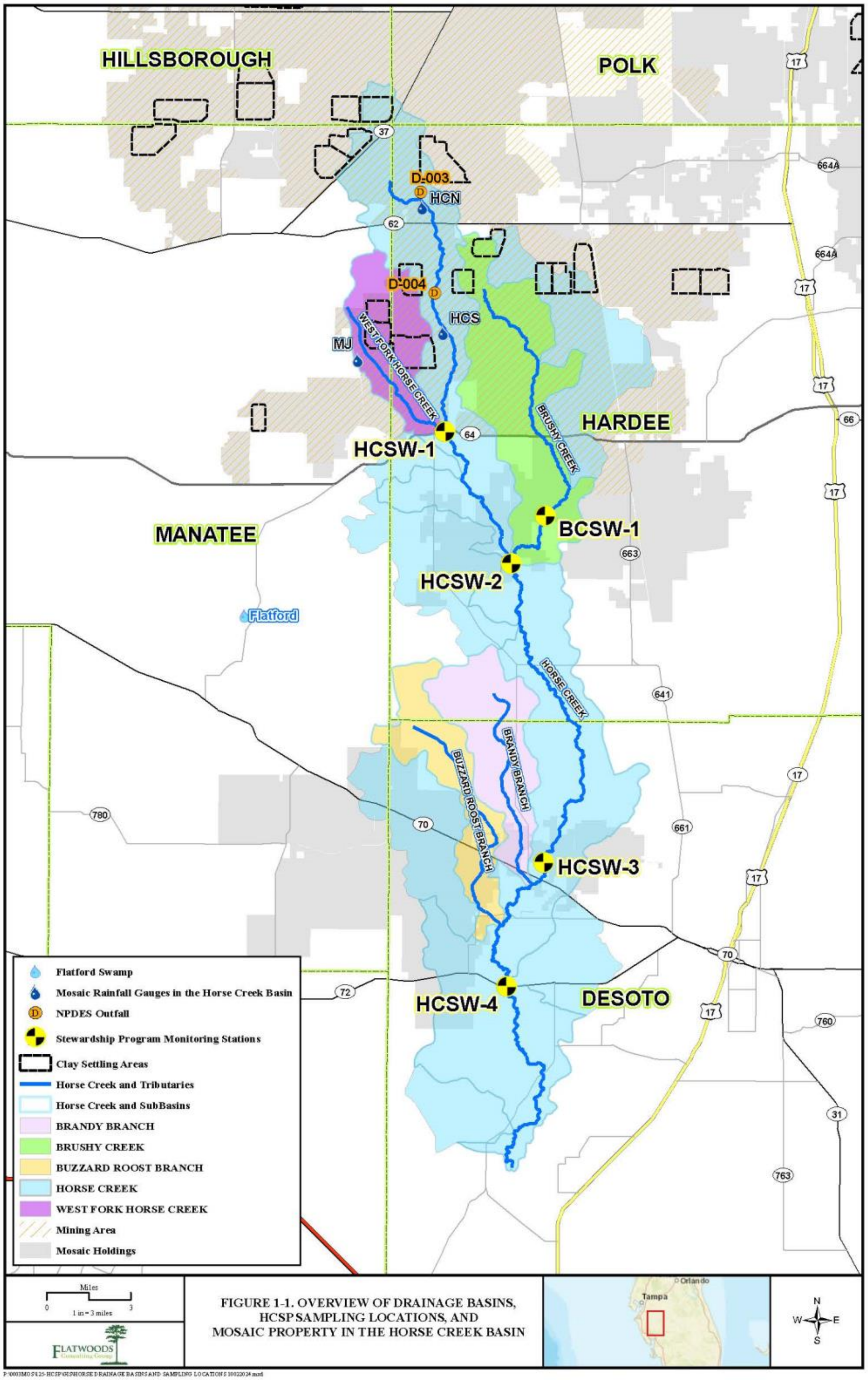


Figure 1-1 Overview of Drainage Basins, HSCP Sampling Locations, and Mosaic Property in the Horse Creek Basin

2.0 DESCRIPTION OF THE HORSE CREEK BASIN

Classified under USGS Hydrologic Unit Code (HUC) 0310010108, the Horse Creek Basin encompasses an area of 242.59 square miles, spanning five counties in South-Central Florida: Hillsborough, Polk, Manatee, Hardee, and DeSoto, with the majority of the watershed located in western Hardee and DeSoto Counties (U.S. Geological Survey, 2024, Figures 1-1 and 2-1). The 43-mile-long creek 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).

There are four major sub-basins within the Horse Creek Basin: West Fork Horse Creek, Brushy Creek, Brandy Branch, and Buzzard Roost. Two of the major tributaries, West Fork Horse Creek and Brushy Creek, are located within the northern portion of the Horse Creek Basin in the Polk Uplands. They are generally straight, at least partially channelized, and have relatively rapid flows (Lewelling, 1997). The other two major tributaries, occupying the central to southern Horse Creek Basin, are Buzzard Roost Branch and Brandy Branch. These lower reaches are located in the DeSoto Plains and Gulf Coast Lowlands area and are generally meandering, slower streams. Horse Creek ultimately discharges into the Peace River near Fort Ogden.

Elevation in the basin ranges from 135 feet near the headwaters to 30 feet 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 dominant soil groups in the Horse Creek basin are 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 average annual rainfall in the Peace River Basin, which includes Horse Creek, is 56.6 inches[7], with more than half of that falling during localized thundershowers in the wet season (June to September). November is typically the driest month of the year, averaging 2.05 inches over the historical period from 1944 to 2023. December and January are also characteristically dry, each averaging 2.2 and 2.4 inches, respectively. Dry conditions coincide with high evaporation rates, resulting in reduced stream flow, stage, and ground-water levels (Hammett, 1990). The wettest months of the year are typically June, July, and August, averaging 9.0, 9.3, and 9.5 inches, respectively.

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. 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).

All mining in the Horse Creek basin has occurred in the upper basin area north of State Road 64. The SWFWMD land use coverage maps for 2020 indicate that the Horse Creek basin is comprised of roughly 32.3% natural areas, 47.8% agriculture/land clearing, 15.6% mining, and 3.5% residential. Mining in the Brushy Creek basin has also occurred in the upper region of that basin. Land use in 2017 in the Brushy

[7] 1944 to present, NOAA site 336.

Creek basin was primarily 39.8% natural areas, 40.8% agriculture/land clearing, 18.1% mining, and <1% residential.

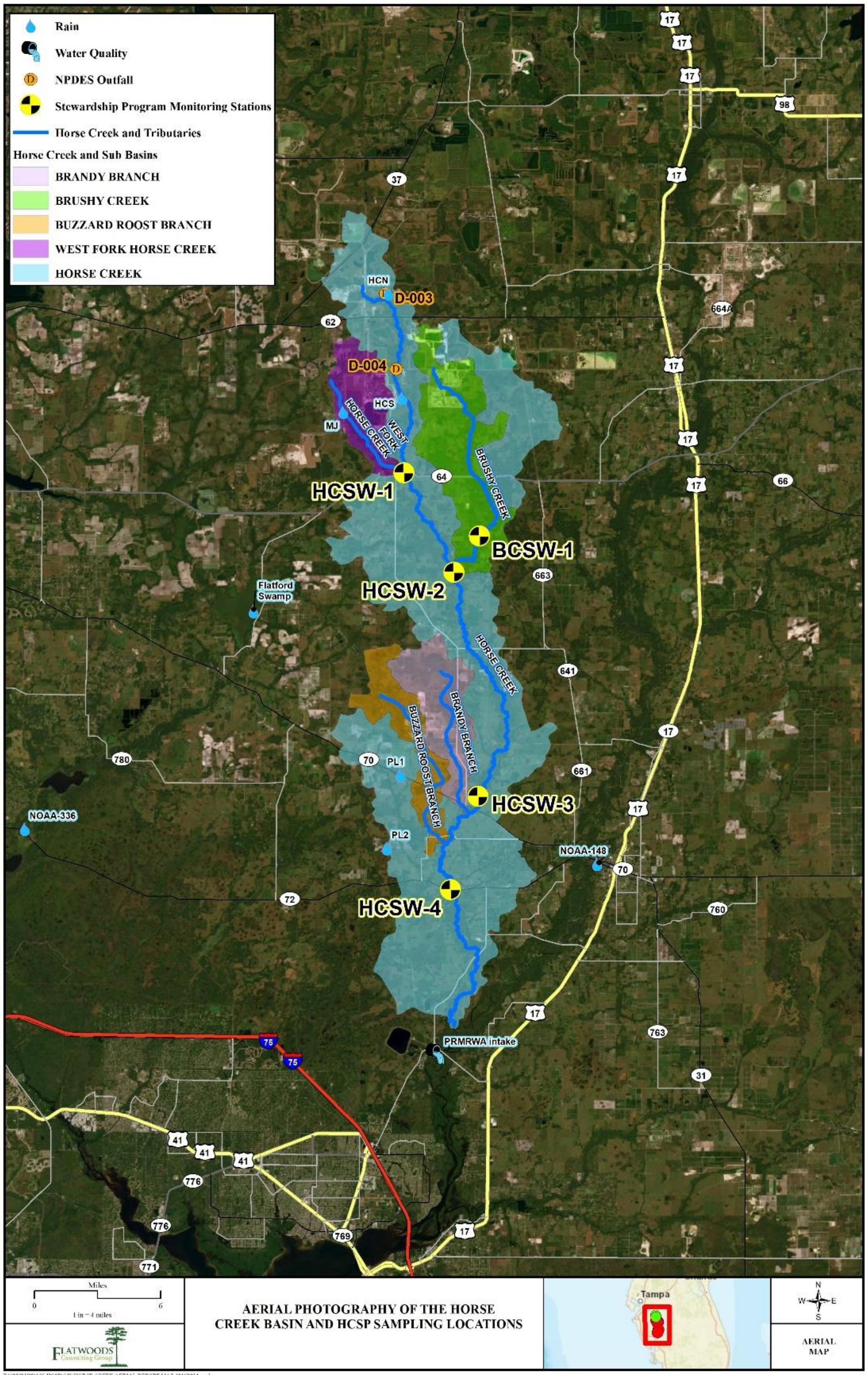


Figure 2-1 HCSP Sampling Locations and Outfalls Relative to the Horse Creek Sub-Basins

3.0 SUMMARY OF MINING AND RECLAMATION ACTIVITIES

3.1 Mining

Mining activities in the Horse Creek basin have occurred on four mines (and their associated tracts and extensions): Wingate (operated by Mosaic, previously Nu-Gulf Industries, Inc.), Fort Green (operated by Mosaic, previously International Minerals and Chemicals [IMC]), South Pasture (operated by Mosaic, previously CF Industries) and the Four Corners Mine. A summary of all mining and reclamation activities from 2003 to 2023 is provided below in Figure 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. (Environmental Science and Engineering, 1982) and a Development of Regional Impact statement prepared by Ardaman and Associates and colleagues (Ardaman and Associates, Inc., Armac Engineers, Inc., Joshua C. Dickinson, Environmental Science and Engineering, Inc., P.E. Lamoreaux and Associates, Inc., and Zellars-Williams, Inc., 1979). There are five Clay Settling Area (CSA) footprints entirely within Horse Creek and Brushy Creek Basins (Table 3-1, Figure 3-2).

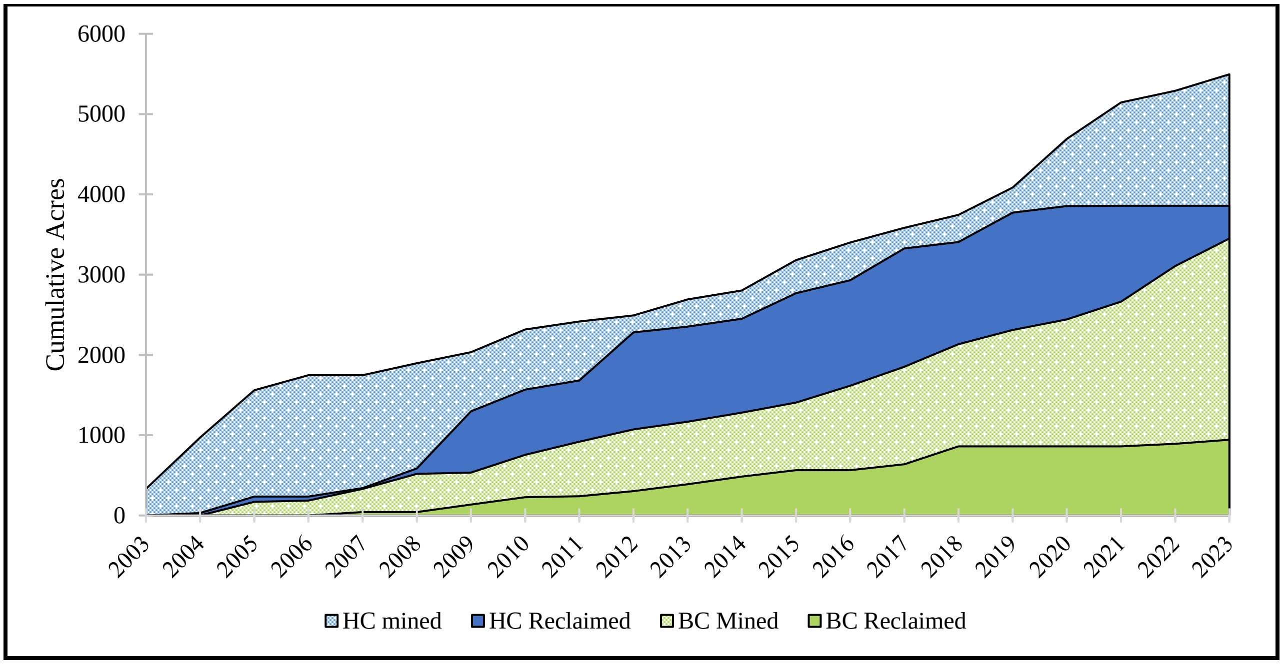


Figure 3-1 Cumulative Acres Mined and Reclaimed to Final Contour by Mosaic in the Horse Creek and Brushy Creek Basins

[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 3-1 Specifications of Clay Settling Areas Located Entirely Within the Horse Creek and Brushy Creek Basins

CSA	Service Year	Area	Crest	Pool	Discharge Point(s)
		Acres	NGVD, Feet		
W-5	1999	363	150	145	Four Corners Mine or Horse Creek through WG-D004
FGH-4	2001	415	164	159	Four Corners Mine or Horse Creek through WIN-004
FM-1	2009	275	164	159	Wingate Creek Mine or Horse Creek through WIN-004
FM-2	2013	378	164	159	Wingate Creek Mine or Horse Creek through WIN-004
O1-B	2023	897	140	135	Wingate Creek Mine or Horse Creek through WIN-004

Mosaic currently maintains two continuous water quality recorders, one in Horse Creek at SR 64 (HCSW-1) and one in Brushy Creek at SR 64. These instruments act as an early warning system in case of failure at the mines upstream of these locations. The instruments collect water temperature, DO, conductivity, turbidity, and pH measurements every 15 minutes. As of February 2019, notifications are sent out to both Mosaic and the PRMRWSA after 12 consecutive turbidity measurements of >150 NTU, as described in Appendix A, Change 14. Previous configurations of the turbidity alarm system are also listed in Appendix A. All alarms are investigated, and there have been no actionable turbidity incidents in Horse Creek since the Mosaic outfalls initiated discharges in September of 2001.

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 is summarized in Figures 3-1 and 3-2.

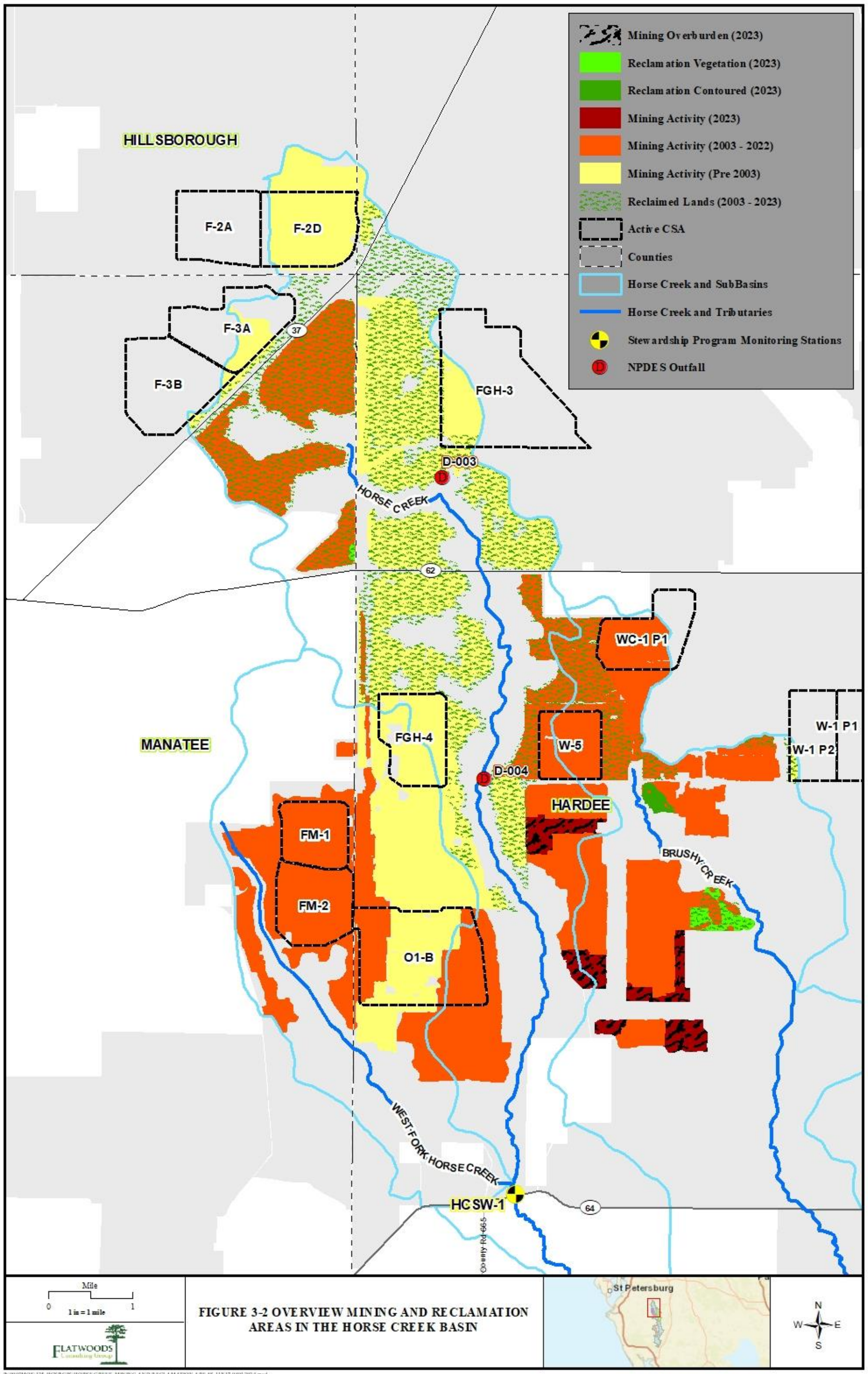


Figure 3-2 Overview Mining and Reclamation Areas in the Horse Creek Basin

4.0 METHODS

The HCSP compares water quantity (rainfall, streamflow, and National Pollutant Discharge Elimination System [NPDES] effluent flow) to water quality and biological parameters that are collected from four locations along Horse Creek and one location along Brushy Creek[9] (Figure 2-1, Table 4-1). Water quality and biological results are compared between sites and analyzed for trends over time. The data presented in this report comes from Mosaic and publicly available sources. Raw data and metadata are provided in the Microsoft Access database file accompanying this report. Method and procedural changes are documented in Appendix A, and a summary of major events throughout the HCSP is also provided in Appendix F.

Although sampling and data collection will still be collected at HCSW-2, beginning with this report, data analysis and discussion will exclude results from this site. This change is documented in Appendix A, with additional information detailing the decision for the change outlined in Appendix C of the 2022 Annual Report. Sampling results from HCSW-2 in 2023 and over the HCSP Period of Record (POR) are summarized in Appendix G, and all data collected from HCSW-2 throughout the program can be found in the Microsoft Access database file that accompanies this report. References herein to "all HCSP sites" or similar will refer to HCSW-1, HCSW-3, and HCSW-4.

[9] Monthly water quality, stream stage, and stream flow only at Brushy Creek site BCSW-1.

Table 4-1 HCSP Sampling Sites and Hydrologic Data Stations

Site/Station Name	Data Source	Location	Additional Parameters	Period of Record
HCSW-1	Mosaic	Horse Cr. ~30m US[2] of SR 64	Continuous & monthly water quality, triannual biology	4/2003-Present
HCSW-2[1]	Mosaic	Horse Cr. ~900m US of CR 663A	Monthly flow/stage, monthly water quality, & triannual biology	4/2003-Present
HCSW-3	Mosaic	Horse Cr. ~1000m US of SR 70	Monthly flow/stage, monthly water quality, & triannual biology	4/2003-Present
HCSW-4	Mosaic	Horse Cr. ~50m US of SR 72	Monthly water quality & triannual biology	4/2003-Present
BCSW-1	Mosaic	Brushy Cr. US of Post Plant Rd	Monthly flow/stage & monthly water quality	9/2009-Present
Brushy Creek	Mosaic	Brushy Cr. ~45 DS[3] of SR 64	Continuous water quality & stage	9/2009-Present[4]
Horse Creek near Myakka Head	USGS	Horse Creek & SR64	Real-time flow & water elevation	10/1977-Present
Horse Creek near Arcadia	USGS	Horse Creek & SR72	Real-time flow & water elevation	5/1950-Present
NOAA 336	NOAA	27.241700 -82.316100	Rainfall	9/1943-Present
Horse Creek North	Mosaic	27.6113300 -82.035489	Rainfall	1/2003-Present
Horse Creek South	Mosaic	27.539326 -82.024803	Rainfall	1/2003-Present
Manson Jenkins	Mosaic	27.454118, -81.952415	Rainfall	1/2003-Present
Pine Level 1	Mosaic	27.279290 -82.025980	Rainfall	7/2011-Present
Pine Level 2	Mosaic	27.228700 -82.036460	Rainfall	7/2011-Present
Flatford Swamp	SWFWMD	27.392000 -82.139700	Rainfall	3/1999-Present

[1] Data collection only at this site beginning in 2023, results are not included in data analysis or discussion
[2] US = upstream
[3] DS = downstream
[4] Stage monitoring beginning in 2022

Figure 4-1 Representative Photos of Horse Creek Sampling Locations, March 8, 2023

Figure 4-2 Representative Photos of Horse Creek Sampling Locations, July 6, 2023

Figure 4-3 Representative Photos of Horse Creek Sampling Locations, December 6, 2023

Water Quantity

NPDES Effluent Discharge

Mosaic has two permitted NPDES effluent discharges to Horse Creek, FTG-003 (NPDES Permit No. FL0027600) and WIN-004 (NPDES Permit No. FL0032522). FTG-003, referred to as "D-003" in the Fort Green Mine Complex NPDES permit, is a 20-foot concrete Montana flume. WIN-004, referred to as "D-004" in the Wingate NPDES permit, is a compound rectangular and trapezoidal Cipolleti steel weir with end contractions. The weir has the following dimensions: base width of 16.8 feet, top of Cipolletti weir width of 17.6 feet, height of 1.4 feet, and rectangular weir section width of 18.4 feet. Flow measurements from both outfalls are recorded in real time by pressure transducers, and values are reported to the FDEP per NPDES permit requirements.

Streamflow and Stage in Horse Creek

Two USGS gauging stations are located on the mainstem of Horse Creek. Station USGS02297155 is located on the State Road 64 bridge over Horse Creek and station USGS02297310 is located on the State Road 72 bridge over Horse Creek. Both stations collect streamflow and stage every 15 minutes. These stations are monitored and calibrated by the USGS, and the data produced is available to download via the USGS National Water Information System Web Interface.

The State Road 64 and State Road 72 sites are also the locations of the HCSP sampling sites HCSW-1 and HCSW-4, respectively. Mosaic has also installed additional staff gauges in Horse Creek at HCSW-2 and HCSW-3 and in Brushy Creek at site BCSW-1. These staff gauges are monitored by Mosaic staff monthly during routine water quality sampling.

Rainfall

Mosaic maintains five real time rain gauges in the Horse Creek Basin. Three are located in the Upper Horse Creek Basin[10], and two are located in the Lower Basin near HCSW-3 and HCSW-4[11] (Figure 2-1). The HCSP has historically used the Flatford Swamp SWFWMD rain gauge as a backup rainfall source when the Mosaic gauges are not operational. The HCSP also utilizes a NOAA rainfall gauge which has records going back to 1899. This gauge is located to the west of Horse Creek in Myakka River State Park. Previous reports averaged this NOAA Myakka gauge with another NOAA gauge in Arcadia, but the Arcadia gauge was decommissioned in April of 2021. Previous reports used a combination of these rain gauges for analyses, and while rainfall data is presented for each gauge, current reports only utilize the NOAA Myakka gauge. The NOAA data set is also used in analyses and discussions that involve pre-mining/pre-HCSP conditions. This is discussed further in Section 5.0.

Water Quality

Beginning in April of 2003, Mosaic collects monthly water quality samples from the four established sites in Horse Creek where streamflow conditions are representative (Table 4-1). In September 2009, a fifth site located in Brushy Creek was added for comparison purposes. All sampling associated with the HCSP follows the FDEP sample protocols (Standard Operating Procedure [SOP] 001/01). Samples are sent to the Mosaic Laboratory in Mulberry, Florida.

The Mosaic lab is a National Environmental Laboratory Accreditation Program (NELAP) certified lab (Certification No. E84578) and currently performs all HCSP analysis except radium in surface water which is typically outsourced to the NELAP certified Florida Radio Chemistry Services lab (Certification No. E83033), in Orlando, Florida. The HCSP has a Quality Assurance/Quality Control (QA/QC) manual that documents the procedures and protocols used in data collection and analysis by Mosaic, Mosaic contractors, and external data providers. Water quality analytes collected during monthly HCSP sampling are listed below in Table 4-2.

[10] Manson Jenkins, Horse Creek North, and Horse Creek South
[11] Pine Level 1 and 2

Table 4-2 Water Quality Parameters and Analytical Methods

Group	Parameter	Trigger value	Analytical Method	Historical MDL	Preservative[1]	Hold Time
Anions	Total Alkalinity as $CaCO_3$	> 100 mg/L	SM 2320 B-2011	0.24- 20 mg/L		14 days
	Chloride	> 250 mg/L	EPA 300.0	0.005- 30 mg/L		28 days
	Fluoride	> 1.5 mg/L and 4.0 mg/L*	EPA 300.0	0.003- 5.0 mg/L		28 days
	Sulfate	> 250 mg/L	EPA 300.0	0.0007- 100 mg/L		28 days
Cations	Dissolved Calcium	> 100 mg/L	EPA 200.7	0.008- 0.8 mg/L	0.45µm pore filter, HNO_3	28 days
	Dissolved Iron	> 1.0 mg/L	EPA 200.7	0.003- 0.1 mg/L	0.45µm pore filter, HNO_3	28 days
Nutrients	Chlorophyll-a, Corrected	> 15 mg/m^3	EPA 445	0.1- 2.0 µg/L		48 hours
	Nitrogen, Ammonia	> 0.3 mg/L	EPA 350.1	0.0008- 0.05 mg/L	H_2SO_4	28 days
	Nitrogen, Nitrate-Nitrite (NO_x)		EPA 353.2	0.0001- 1.0 mg/L	H_2SO_4	28 days
	Nitrogen, Total	> 3.0 mg/L	TKN + NO_x			
	Nitrogen, Total Kjeldahl (TKN)		EPA 351.2	0.008- 0.24 mg/L	H_2SO_4	28 days
	Orthophosphate	> 2.5 mg/L	EPA 365.1	0.002- 0.75 mg/L	0.45µm pore filter	48 hours
Physical	Color, Apparent	< 25 PCU	SM 2120 B-2011	2- 5 PCU		48 hours
	Dissolved Oxygen Saturation	< 38%	DEP FT 1500	0.5 mg/L	in-situ	in-situ
	pH	< 6.0, > 8.5 s.u.	DEP FT 1100	1 s.u.	in-situ	in-situ
	Specific Conductance	> 1,275 µS	DEP FT 1200	10 µS	in-situ	in-situ
	Total Dissolved Solids	> 500 mg/L	SM 2540 C-2015	5- 25 mg/L		7 days
	Turbidity	> 29 NTU	DEP FT 1600	0.1 NTU		15 minutes
Radiological	Radium, Combined	> 5.0 pCi/L	Ra-266 + Ra-228	1 pCi/L		
	Radium-226		EPA 903.1	0.2 pCi/L	HNO_3	6 months
	Radium-228		Ra-05	0.7 pCi/L	HNO_3	6 months

[1] All samples preserved and placed in wet ice within 15 minutes of collection. Samples that were preserved in acid were acidified to >0 and <2 pH standard units

* 1.5 mg/L at HCSW-4 and 4.0 mg/L at all sites upstream of HCSW-4

Biology

Macroinvertebrates

Macroinvertebrate samples are collected from the four Horse Creek water quality sites up to three times per year during representative flow conditions. Sampling previously occurred within three sample windows: March – April, July – September, and October – December, with no two sample events less than 90 days apart. To allow the program more opportunities to sample, the SCI sample window was changed to three temporally independent (at least 90 days apart) samples within a year. Macroinvertebrate sampling follows the Stream Condition Index (SCI) protocol outlined in FDEP SOP

SCI-1000. At the time of sampling, the stream itself is assessed using the aquatic habitat characterization or Habitat Assessment method (HA, FDEP SOP FT-3000), Rapid Periphyton Survey (RPS, FDEP SOP FS- 7230), Linear Vegetation Survey (LVS, FS-7320), and Physical/Chemical Characterization (FDEP SOP FT-3001).

Once habitats are identified, a sampling strategy is applied based on the protocols outlined in FDEP SOP SCI-1000 (Table 4-3). "Major" or primary habitats (rocks, roots, submerged macrophytes, leaf packs, and snags) as well as "minor" or secondary habitats (sand, muck, and silt) are sampled for macroinvertebrates using a 600µm mesh D-frame dipnet, a brush, and/or hands, depending on substrate. Primary habitats are considered "major" when there is two square meters or greater of that habitat type within the 100-meter stream segment sample site. If a primary habitat occurs at less than two square meters, the habitat is sampled as a minor habitat. Macroinvertebrates and substrate are packaged in 3-liter sample jars and field-preserved with 10% buffered formalin. Samples are shipped to an FDEP certified contract taxonomy lab in sealed labeled bottles and accompanied with a chain of custody form.

Table 4-3 FDEP SCI-1000 Macroinvertebrate Sampling Sweep Convention

Major Habitats	Sweeps[12] in each Major Habitat	Sweeps in Minor Habitat	Total Sweeps
0	0	20	20
1	10	10	20
2	7	6	20
3	5	5	20
4	4	4	20
5	3	5	20

Macroinvertebrate samples are sorted, organisms are identified and categorized, and an SCI score is calculated by the contract lab following the protocols outlined in FDEP SOP LT-7000 & SCI 1000. An SCI score consists of ten metrics, eight of which decrease in response to human disturbance, with two metrics (% very tolerant and % dominant) increasing in response to human disturbance. SCI scores can then be categorized to characterize stream health as follows: Category 1 – Exceptional (scores ≥65); Category 2 – Healthy (average scores ≥40); and Category 3 – Impaired (scores ≤34). Broken down further, the FDEP considers a stream segment as healthy or "passing" this assessment if it has an average score of at least two temporally independent SCIs (within a year and at least 90 days apart) that is ≥40, with neither of the two most recent SCI scores being <35. This is one criterion considered by FDEP towards a stream segment achieving the qualitative (or narrative) component of the Narrative/Numeric Nutrient Criteria (NNC) (i.e., no faunal imbalances). A more detailed description of the SCI calculation method can be found in DEP SOP SCI-1000.5.

[12] A sweep is equal to 0.125 m^2 of substrate. Smaller areas of habitat can be combined to total one sweep.

The HCSP report also uses the raw macroinvertebrate data to calculate the Shannon-Wiener Diversity Index on macroinvertebrate genera collected from the SCI. The index is calculated on taxa collapsed to genus using the following equation:

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

S = number of taxa in community and p_i = proportion of total abundance represented by i^{th} taxa. It should be noted that Shannon's H' can also be calculated using the natural log and the values of H' will be different but the values relative to each other will be the same provided only one calculation method is used.

Table 4-4 Equations for Calculating SCI Metrics for Peninsular Florida (Individual Metric Scores Range from Zero to Ten)

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 in 2004) differ.

Fish

The HCSP utilizes two fish collection methods: seining and electrofishing. Fish collection usually starts with seining before electrofishing because electrofishing can be disruptive to the fish (and macroinvertebrate) populations. Five seine net sweeps are collected within the flagged 100-meter stream segments targeting various micro-habitats (pools, tree stumps, leaf packs, macrophyte beds, etc.). The HCSP program uses a custom 4-foot x 8-foot seine to allow maneuverability in tight spaces and around submerged substrate. Captured fish are placed in a bucket of aerated creek water until they are identified (typically upon the completion of electrofishing).

Electrofishing employs a Smith-Root Apex electrofishing backpack, and each 100-meter stream segment receives 500 seconds of active shock time. The waveform, voltage, and frequency chosen at each site and for each event is dependent on the site's conductivity and the target species.

The fish that are caught are identified in the field according to American Fisheries Society-accepted taxonomic nomenclature (American Fisheries Society, 2013) and released back into the stream, except when the animal is invasive (per the conditions of the Florida Fish and Wildlife Conservation Commission [FWC] Scientific Collector's Permit). The permit is limited to preserving 12 specimens per species per year. Fish that need further taxonomic examination are photographed and preserved in 10% buffered formalin, and the sample and photos are sent to the Division of Ichthyology at the Florida Museum of Natural History (FLMNH) for identification.

Field data sheets are reconciled with confirmation ID from the FLMNH. Taxa richness and abundance are determined by site and for each sampling event, and data are compared among sites and across sampling events. Species accumulation curves are 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 is also determined for fish species using the same calculation method discussed previously. Morisita's Community Similarity Index is also determined for fish species and is calculated using the Ecological Methodology Software Version 7.4. The raw data in the accompanying HCSP database includes the catch method for each fish recorded.

5.0 WATER QUANTITY RESULTS

NPDES Discharge

The Fort Green Mine (FTG-003) and Wingate (WIN-004) effluent discharges are typically rainfall dependent, as opposed to being driven by the mining process. Table 5-1 below shows the correlation between the combined NPDES discharge, streamflow and stage at State Road 64 (HCSW-1) and State Road 72 (HCSW-4), and each rain gauge used in the HCSP. The strength of the correlation for the NOAA rain gauge is almost identical to the combined Mosaic rain gauges (Horse Creek South, Horse Creek North, Manson Jenkins, Pine Level 1, and Pine Level 2). Correlations were performed using Spearman's rank correlation coefficient (Rho, or R_s). The procedure outputs R_S values between +1 and -1, with values closer to either indicating stronger positive or negative relationships, respectively. Spearman's rank correlations were performed in Microsoft Excel using functions from the XLSTAT (version 2024.3.0) software add-in (XLSTAT, Lumivero, 2024).

There was no NPDES effluent discharge to Horse Creek from either of the outfalls in 2023. Typically, the majority of effluent discharge will come from WIN-004 when discharging does occur. Combined NPDES effluent discharge since outfall inception (2001) is displayed in Figure 5-1.

Table 5-1 Spearman's Rank Correlations (R_s) of Daily Average Streamflow in Horse Creek and NPDES Effluent with HCSP Water Quantity Gauges, 2003 – 2023 ($p < 0.0001$)

	Daily Average Flow			Total Daily Rainfall			Daily Average Water Level		
	Combined NPDES	USGS Flow SR64	USGS Flow SR72	NOAA	Avg. of Mosaic	SWFWMD Flatford Swamp	All Rain Gauges	USGS SR64 Staff Gauge	USGS SR72 Staff Gauge
Combined NPDES	1	0.62	0.40	0.16	0.17	0.16	0.19	0.61	0.55
USGS Flow SR64	0.62	1	0.80	0.27	0.30	0.27	0.32	0.95	0.88
USGS Flow SR72	0.40	0.80	1	0.21	0.23	0.21	0.25	0.78	0.98
NOAA	0.16	0.27	0.21	1	0.56	0.55	0.73	0.26	0.23
Avg. of Mosaic	0.17	0.30	0.23	0.56	1	0.67	0.90	0.28	0.25
SWFWMD Flatford Swamp	0.16	0.27	0.21	0.55	0.67	1	0.77	0.27	0.24
All Rain Gauges	0.19	0.32	0.25	0.73	0.90	0.77	1	0.31	0.28
USGS SR64 Staff Gauge	0.61	0.95	0.78	0.26	0.28	0.27	0.31	1	0.86
USGS SR72 Staff Gauge	0.55	0.88	0.98	0.23	0.25	0.24	0.28	0.86	1

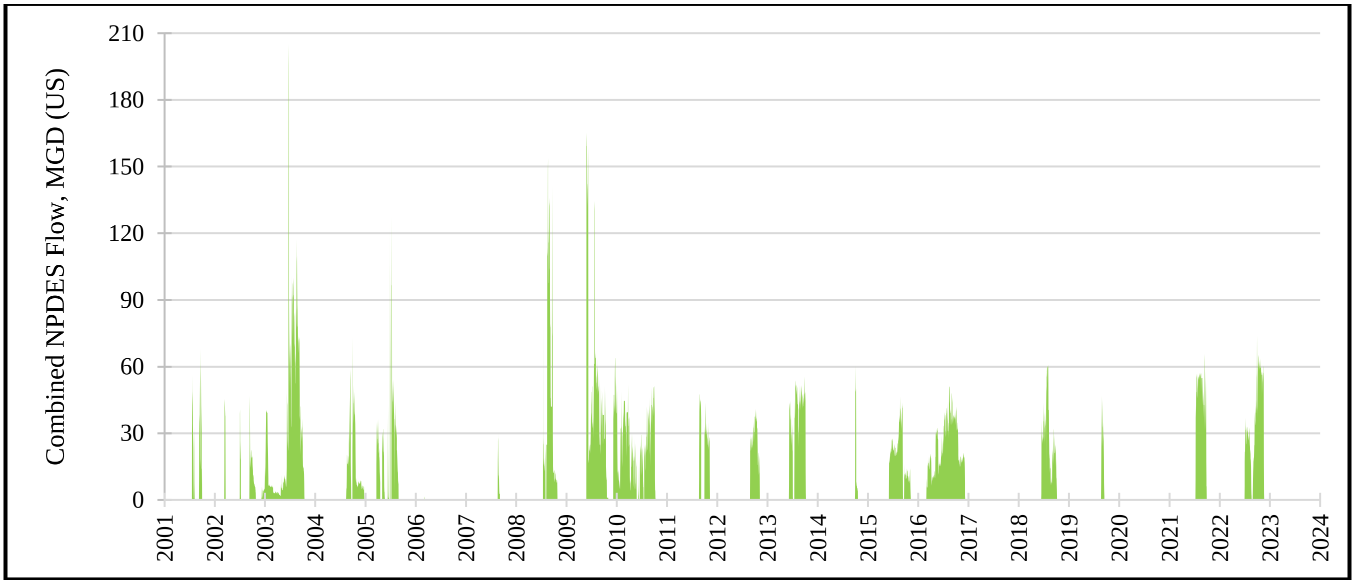


Figure 5-1 Daily Combined Effluent Flow (FTG-003 + WIN-004) to Horse Creek, POR

Rainfall-Runoff Relationship

Table 5-1 above shows the correlation between the flow in Horse Creek (State Road 64 and State Road 72) and the NPDES outfalls to the various flow, level, and rain gauges used in the HCSP (Figure 2-1). All gauge correlations were found to be statistically significant (Spearman's Rank Correlation, $p < 0.0001$). Previous reports have used multiple rain gauges and time spans to describe water quantity conditions in Horse Creek. Because the NOAA Myakka gauge has the longest uninterrupted record and the correlation to streamflow at HCSW-1 (State Road 64) was comparable to the average of all the Mosaic rain gauges, this report will utilize only the NOAA Myakka gauge. When discussing streamflow, this report will refer to the time span of 1978 – 2023, which corresponds to when both USGS gauging stations (State Road 64 and State Road 72) went online; and occasionally the time span of 2003 – 2023, which corresponds to the period that the HCSP has been active.

When compared to the HCSP POR (2003 – 2023), annual rainfall in 2023 was below average and ranked the 13th wettest year out of 21 years (Table 5-2). When compared to the 1978 – 2023 USGS POR, annual rainfall and annual average streamflow in 2023 were below average (Figure 5-2). According to the Palmer Drought Index, Hardee and Desoto Counties were experiencing drought conditions from February 2023 through late September 2023, and again briefly in November 2023 (Figure 5-3).

Although these results suggest that streamflow and rainfall in Horse Creek covary are more than would be expected by chance alone, not all the variation in streamflow can be explained by rainfall. Because the correlations aren't perfect (i.e. +1), this implies that other factors (such as antecedent conditions) also have an influence on the variation of streamflow. Figure 5-4 shows the relationship between average daily streamflow and total daily rainfall in 2023.

Figure 5-5 illustrates the relationship between cumulative annual streamflow (discharge) at HCSW-1 and annual NOAA rainfall from 1978 to 2023[13]. Changes in the relationship between rainfall and stream discharge can be seen as inflection points in the overall trend line slope. Over the HCSP POR at HCSW-1, there were three notable inflection points. Between 2000 and 2005 (slope 0.18), 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 POR, meaning there was more stream discharge per unit of rainfall. Between 2005 and 2008 (slope 0.04), which included several very dry years, cumulative discharge had almost no increase, despite changes in cumulative rainfall – likely due to recharging wetlands and groundwater. Thus, as expected during a very dry period, the relationship changed, and less water entered the stream per unit of rainfall than happened during wetter periods. From 2021 to 2022 (slope 0.20), there was a brief point where cumulative discharge increased relative to rainfall, likely due to the above average rainfall brought on by Hurricane Ian. With 2023 data, we can now see the relationship recede towards the average post-mining trend line and resume previous patterns.

The discharge-rainfall double mass curve also illustrates a pre-outfall (blue dashed line, slope 0.12) and post outfall (orange dashed line, slope 0.15) trendline, with both slopes on either side of the USGS POR trendline (grey dotted line, slope 0.13). This indicates that little has changed in regard to the rainfall draining uninterrupted to Horse Creek. 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 USGS POR (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 5-2 Annual Total Rainfall in Inches at Gauges in and near the Horse Creek Watershed, POR

Gauge	NOAA Myakka 336 Annual Average Rainfall, in.	Mosaic Gauges Annual Average Rainfall, in.
2023	47.6	38.9
HCSP POR Average (2003-2023)	58.4 (ranked 16th/21 years)	44.1 (ranked 13th/21 years)
USGS POR Average (1978 – 2023)	58.9 (ranked 34th/46 years)	
NOAA POR Average (1944 -2023[14])	56.6 (ranked 54th/76 years)	

[13] The NOAA gauge was significantly correlated to streamflow at HCSW-1, the combined NPDES effluent flow to Horse Creek, and Mosaic rain gauges. NOAA rainfall records also began before mining occurred in the Horse Creek Basin.
[14] NOAA Annual Average rainfall range 1944 to present, 36.5 – 82.3 inches. Analysis excludes years with missing data.

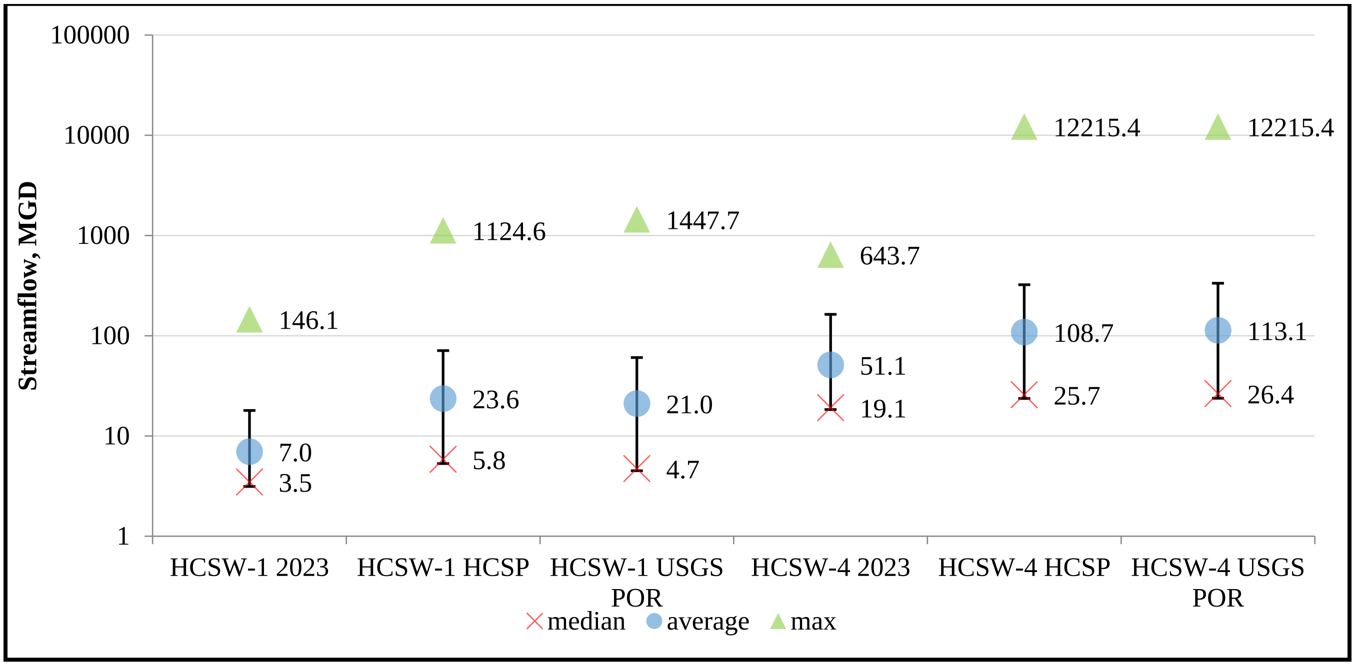


Figure 5-2 **Median, Average, Maximum, 10th Percentile (lower bar), and 90th Percentile (upper bar) Streamflow at HCSW-1 and HCSW-4, 2023 vs. HCSP Period (2003-2023) vs. USGS POR (1978 – 2023)**

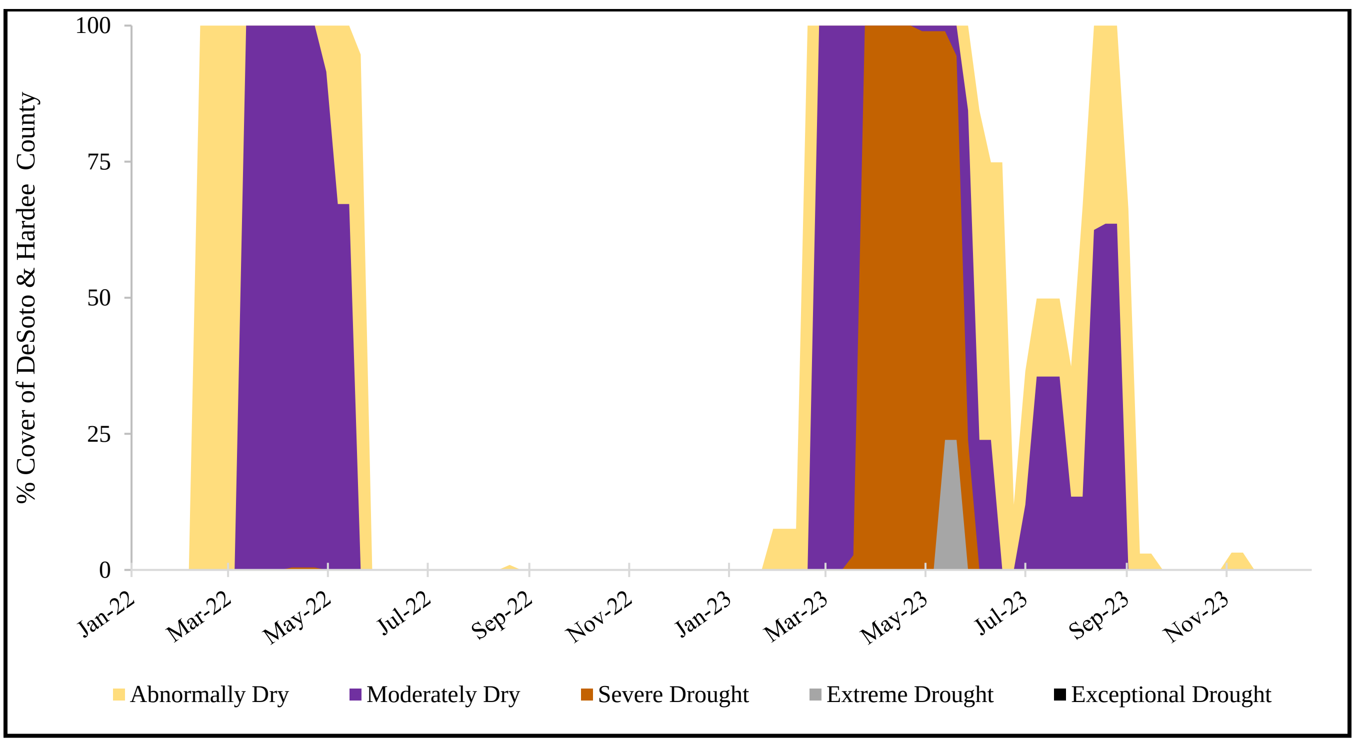


Figure 5-3 **Drought Intensity Coverage in Hardee and Desoto Counties (Palmer Drought Severity Index, NOAA)**

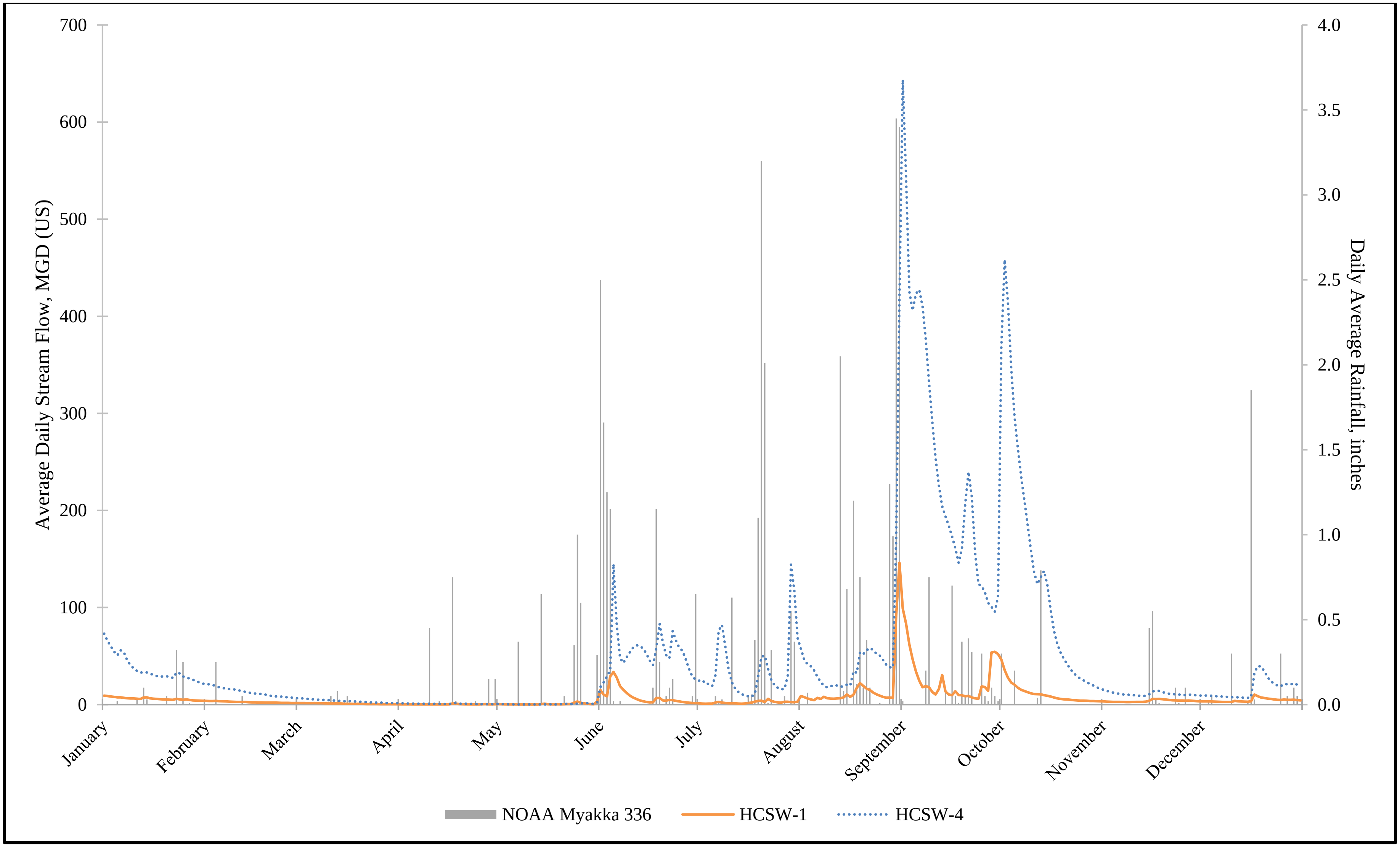


Figure 5-4 Average Daily Rainfall and Streamflow in 2023

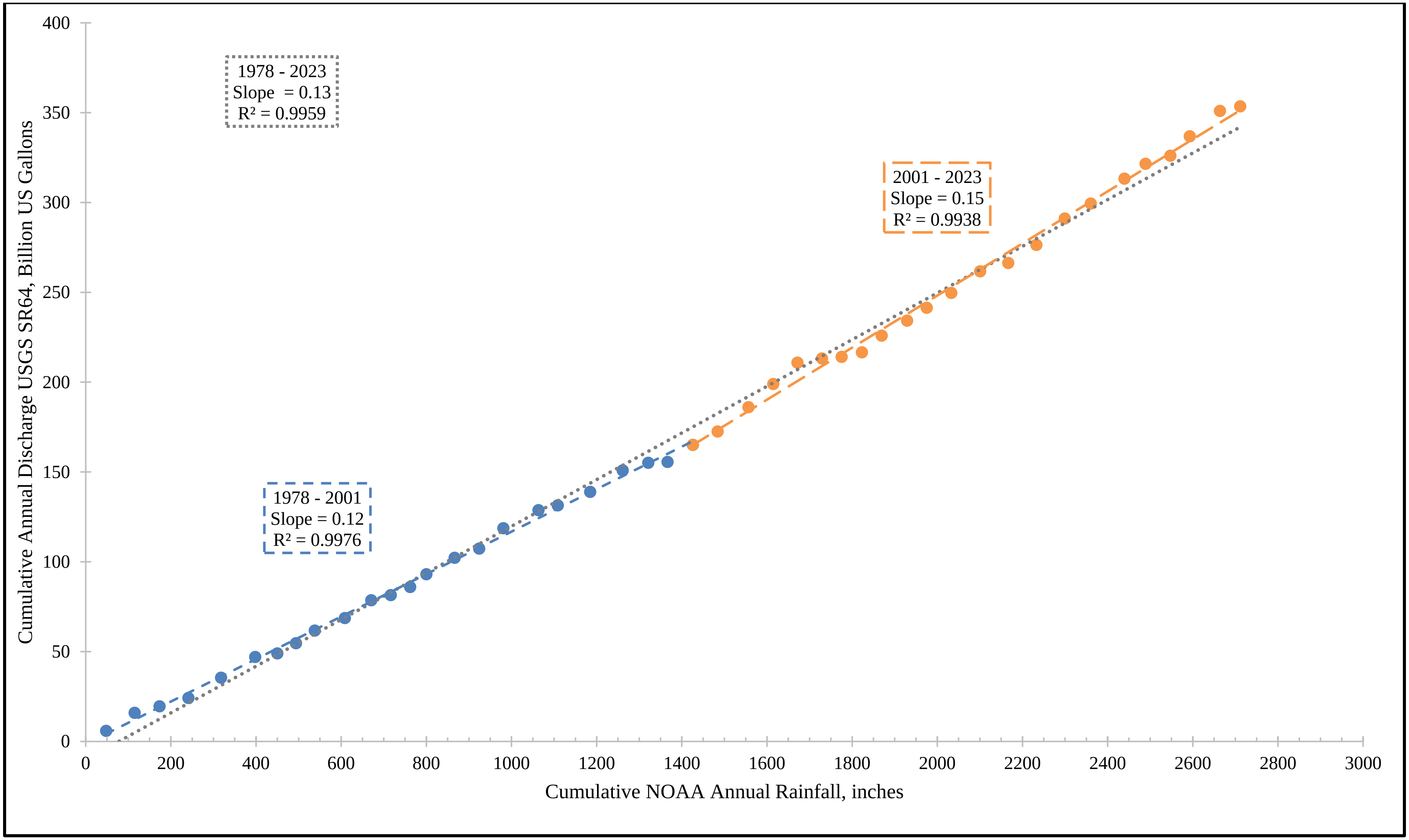


Figure 5-5 Double Mass Curve of Cumulative Daily Stream Discharge (USGS Gauge at SR64) and Rainfall (NOAA Myakka 336 Rain Gauge), 1978 – 2023

Summary of Water Quantity Results

Based on the long-term NOAA rain gauge in the Horse Creek Basin, annual rainfall in 2023 was below average over the USGS POR (ranked 34th in the last 46 years[15]). Streamflow at HCSW-1 in 2023 was ranked the 41st highest annual average flow in 46 years (2.5 billion gallons[16]). Streamflow at HCSW-4 in 2023 was ranked the 39th highest in 46 years (18.7 billion gallons[17]). There was no NPDES discharge in 2023, which was the 3rd year to have no NPDES in the 23 years since the outfalls have been online[18].

There is no evidence that mining and reclamation activities in the basin caused any statistically significant decrease in total streamflow over the USGS POR (1978 to 2023), according to the double mass curve analysis. In a previous study (Robbins & 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

Data Analysis

Monthly and continuous water quality data for the HCSP POR are presented in the figures below. Graphical representations of HCSP data include undetected values, represented by the respective Minimum Detection Levels (MDLs) for each parameter, except for Total Nitrogen (TN) and total radium. TN and total radium are composite parameters without MDLs. The values of these parameters for which one or both components were undetected are indicated. A 2018 Atkins study commissioned by the PRMRWSA compared the HCSP water quality data set to the state of Florida's Horse Creek water quality records and concluded that the HCSP data was consistent with other publicly available data sources.

Differences in the distribution of each water quality parameter between sites from 2003 to 2023 were evaluated using the Kruskal-Wallis test and a modified Peto-Peto procedure for data with non-detects (Table 6-1). The Kruskal-Wallis test uses ranks of the data to compare the distributions of groups for significant differences, with results often interpreted as differences in medians. With non-detected (or left-censored) data, the modified Peto-Peto procedure uses survival analysis techniques to include censored observations and compare the cumulative distribution functions (CDFs) between groups. While differences between the CDFs of groups can also be interpreted as differences in medians, this procedure is a bit more robust and can indicate other differences in distribution characteristics as well. Each of the

[15] Years with missing data excluded from analysis.
[16] 1978 – 2023 HCSW-1 annual average discharge = 7.7 billion gallons.
[17] 1978 – 2023 HCSW-4 annual average discharge = 41.3 billion gallons.
[18] 2001 – 2023 NPDES annual average discharge = 3.0 billion gallons

procedures above will state whether or not there are differences between groups. A subsequent pairwise comparison to determine specifically which groups are different was performed using a Wilcoxon test with Benjamini-Hochberg adjustment. The above analyses were performed in R (version 4.4.1) using functions from the base program (R Core Team, 2023), the EnvStats: An R Package for Environmental Statistics package (Millard, 2013), and the Non-detects And Data Analysis (NADA) 2: Data Analysis for Censored Environmental Data package (Julian & Helsel, 2024).

Individual water quality parameters were also examined for correlations with average daily streamflow, average daily NPDES discharge, and total daily rainfall. Because these three water quantity variables are correlated to each other (Table 5-1), a statistically significant correlation between NPDES discharge and water quality does not provide enough evidence alone to prove a causal relationship between water quality and mining, since the correlation could simply be more related to streamflow rather than the NPDES discharge. Water quality correlations were examined using a Kendall's rank correlation (Tau, or $T_{k)}$ procedure in R (version 4.4.1) using functions from the Kendall: Kendall Rank Correlation and Mann-Kendall Trend Test package (McLeod, 2022), EnvStats: An R Package for Environmental Statistics (Millard, 2013) and NADA: Nondetects and Data Analysis for Environmental Data (Lopaka, 2020) packages. Like Spearman's correlation, Kendall's correlation output values (T_k) range from +1 to -1, with values closer to either indicating stronger positive or negative relationships, respectively. This report uses Kendall's correlation as a more robust alternative to Spearman's correlation for water quality data analysis because it is more insensitive to errors (i.e., outliers) and there are modified procedures that better handle non-detect data, a common occurrence in these types of datasets. Similar to Fahrenheit and Celsius, Spearman's and Kendall's correlation coefficients can't be compared directly, but they convey the same information regarding the strength and direction of relationships. The results of this correlation analysis are presented in Table 6-2. Correlations are discussed in their respective water quality parameter section, if that section is present.

The HCSP utilizes a Seasonal Kendall trend test to detect monotonic trends in water quality parameters. The Seasonal Kendall test determines water quality trends after correcting for seasonality by only comparing data between similar seasons over time (Schertz, Alexander, & Ohe, 1991). More specifically, the Seasonal Kendall test compares the ranks of values within each season and combines the results to evaluate if there is an overall trend (Hirsch, Slack, and Smith, 1982). 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, Alexander, & Ohe, 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). Appendix B contains a literature review of the Seasonal Kendall test, and all statistical tests used in the HCSP reports.

Trend detection is often limited by several factors including the number of years of data (minimum five years), the frequency of collection, changing MDLs, and the availability of flow data. Now with 21 years of data, the power of the test to detect trends of small magnitude in this study is not limited ([Harcum, Loftis, and Ward, 1992], [Hirsch, Slack, and Smith, 1982]). Previous reports using the original method required data for parameters with variable MDLs (specifically fluoride, nitrate-nitrite, and ammonia) to be truncated to the highest detection limit, therefore affecting data quality by potentially introducing bias. Trends for these parameters were then evaluated using supplemental data collected by SWFWMD and removing HCSP data during periods where MDLs were excessively high. It was also stated that SWFWMD reduced sampling frequency in 2011, which may have led to inaccurate seasonal trend tests. There are now modifications to the Seasonal Kendall that handle non-detected values more accurately, including the allowance of parameters with variable MDLs. A sensitivity analysis was done with those three parameters using the updated Seasonal Kendall to observe if inclusion of the SWFWMD data and/or data with high MDLs had an effect on the analysis outcome. Results of the sensitivity analysis found that inclusion of the SWFWMD data masked a negative trend of fluoride at HCSW-1 and a positive trend of ammonia at HCSW-4. In the remainder of comparisons, inclusion of the SWFWMD data and removal of data with high MDLs had very similar results, suggesting these data points did not have a substantial impact on the overall trend or absence of a trend. Based on the analysis above, data analysis will no longer be supplemented with SWFWMD data, and HCSP data that was previously excluded for ammonia and nitrate-nitrite will be included. Fluoride data from the HCSP with excessively high MDLs will remain excluded.

Because HCSW-1 and HCSW-4 were the only sites with USGS flow data that is necessary for interpreting trends in flow-dependent parameters, they were the only sites 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 corrective action by Mosaic is necessary.

The Seasonal Kendall results for all parameters are presented in Table 6-3 followed by an in-depth discussion of trends presented for each individual parameter where a significant monotonic trend was detected. 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 (Table 6-3).

Parameters that were significantly correlated with USGS streamflow (Table 6-2) were corrected for the effect of annual variation in log streamflow using a Locally Estimated Scatterplot Smoothing (LOESS smooth, F=2/3) before the Seasonal Kendall was performed. LOESS (local polynomial regression) in the Seasonal Kendall 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, Alexander, & Smith, 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 sites or times with different instantaneous flow.

If the variability of a water quality parameter could be completely explained by streamflow, then during smoothing, all the data points would fall along a single best-fit line, and all 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. LOESS smoothing was done using log of streamflow within R version 4.4.1 using base program functions (R Core Team, 2023), with a smoothing factor (span) of 2/3, symmetric family, and degree of 1 for polynomials. Seasonal Kendall analyses were performed using functions from the EnvStats: An R Package for Environmental Statistics (Millard, 2013) and NADA2: Data Analysis for Censored Environmental Data (Julian & Helsel, 2024) packages.

The following discussion of water quality trends will cover only parameters where trends have been detected at HCSW-1. Additionally, nitrogen species are discussed as it relates to the State of Florida Numeric/Narrative Nutrient Criteria (NNC). Through the previous HCSP assessments, the TAG has been made aware of the inputs to Horse Creek from land use activities downstream of the Mosaic outfalls, including agriculture-related elevated and increasing trends of conductivity and dissolved constituents (Total Dissolved Solids [TDS], sulfate, and calcium). Appendix E includes a summary of impact assessment findings based on past trend assessments.

Table 6-1 Summary of Results from Kruskal-Wallis[1] between HCSP Sites, 2003 - 2023

Parameter	χ^2	p-value	Parameter	χ^2	p-value
Alkalinity	180.2	<0.001	Nitrogen, Total	72.4	<0.001
Calcium, Dissolved	82.2	<0.001	Orthophosphate	31.7	<0.001
Chloride	118.9	<0.001	Oxygen, Dissolved (% Sat)[2]	65.5	<0.001
Chlorophyll-*a*	42.3	<0.001	pH	67.6	<0.001
Color, Apparent	3.68	0.16	^{226}Radium	1.60	0.66
Dissolved Solids, Total	81.0	<0.001	^{228}Radium	0.28	0.96
Fluoride	123.2	<0.001	Radium, Combined	3.66	0.45
Iron, Dissolved	0.87	0.83	Specific Conductivity	50.0	<0.001
Nitrogen, Ammonia	28.87	<0.001	Sulfate	100.7	<0.001
Nitrogen, Nitrate-Nitrite	201.2	<0.001	Turbidity	0.07	0.96
Nitrogen, Total Kjeldahl	6.90	0.08			

[1] Kruskal-Wallis or a modified Peto-Peto procedure for data with non-detects.

[2] Percent DO calculated from DO saturation (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 2023.

Table 6-2 Kendall's Rank Correlations (T_k) Between Water Quality and Water Quantity at HCSW-1 and HCSW-4, as Represented by Average Daily Streamflow, Average Daily NPDES Discharge, and Total Daily Rainfall (NOAA Myakka 336) from 2003 to 2023, ($p < 0.05$)

Group	Parameter	HCSW-1			HCSW-4		
		Rainfall	NPDES	Streamflow	Rainfall	NPDES	Streamflow
Anions	Alkalinity (mg/L)	-0.15		-0.12	-0.20	-0.34	-0.51
	Chloride (mg/L)	-0.11	-0.31	-0.53	-0.11	-0.32	-0.57
	Fluoride (mg/L)		0.24	0.15	-0.12	-0.24	-0.42
	Sulfate (mg/L)		0.16			-0.30	-0.48
Cations	Calcium, Dissolved (mg/L)	-0.10	0.12			-0.46	-0.57
	Iron, Dissolved (mg/L)	0.13	0.14	0.42	0.12	0.27	0.51
Nutrients	Ammonia, Total (mg/L)						
	Chlorophyll-*a* (mg/m^3)	0.13	0.16	0.22		0.07	
	Nitrate-Nitrite (mg/L)		0.07	0.11		-0.23	-0.28
	Nitrogen, Total (mg/L)	0.11	0.17	0.31		0.11	0.20
	Total Kjeldahl Nitrogen (mg/L)	0.09	0.13	0.32	0.11	0.23	0.42
	Orthophosphate (mg/L)		0.11			0.08	
Physical	Color, Apparent (pcu)	0.20	0.20	0.45	0.16	0.38	0.56
	Dissolved Solids, Total (mg/L)		0.20			-0.42	-0.46
	Oxygen Dissolved (%Sat)[1]	-0.22	-0.40	-0.55	-0.23	-0.41	-0.56
	pH (su)	-0.15	-0.18	-0.24	-0.15	-0.22	-0.31
	Specific Conductance (µS)	-0.10	0.12		-0.12	-0.43	-0.54
	Turbidity (NTU)	0.16	0.25	0.41	0.11	0.18	0.34
Radiological	Radium 226 (pCi/L)		-0.09	-0.16		-0.13	-0.18
	Radium 228 (pCi/L)						
	Radium, Combined (pCi/L)		-0.08	-0.15		-0.10	-0.16

Highlighted values indicate the strongest correlations at each of the two sites.
Result field is blank where no significant ($p \geq 0.05$) correlation was detected.
Streamflow = respective USGS gauging site.
Rainfall = NOAA Myakka 336.

[1] Percent DO calculated from DO saturation (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 2023.

Table 6-3 Summary of Seasonal Kendall Trend Tests with LOESS (F=2/3) for HCSW-1 and HCSW-4, 2003 - 2023

Parameter	HCSW-1				HCSW-4			
	tau	p-value	slope	2023 Median[1]	tau	p-value	slope	2023 Median[1]
Alkalinity	0.41	<0.001	2.36	69	0.22	<0.001	0.70	48
Calcium, Dissolved[2]	0.41	<0.001	1.04	26.7	0.16	<0.001	0.65	49.2
Chloride	-0.96	<0.001	-0.36	15	-0.96	<0.001	-0.60	23.2
Chlorophyll-a[3]	0.81	<0.001	0.04	0.73	-0.28	<0.001	-0.07	1.09
Color, Apparent	0.16	<0.001	2.08	125	0.18	<0.001	2.55	135
Dissolved Solids, Total[2]	0.42	<0.001	7.67	238	0.21	<0.001	5.92	378
Fluoride	-0.24	<0.001	-0.006	0.48	-0.96	<0.001	-0.006	0.37
Iron, Dissolved	0.92	<0.001	0.008	0.23	0.45	<0.001	0.01	0.21
Nitrogen, Ammonia[2,3]	0.008	0.85	-	0.031	0.15	<0.001	0.002	0.049
Nitrogen, Nitrate-nitrite	-0.12	<0.05	-0.0002	0.068	-0.62	<0.001	-0.009	0.29
Nitrogen, Total Kjeldahl	0.93	<0.001	0.009	0.96	0.74	<0.001	0.02	1.02
Nitrogen, Total	0.08	0.10	-	1.04	-0.05	0.33	-	1.41
Orthophosphate[2,3]	0.04	0.33	-	0.356	0.02	0.74	-	0.42
Oxygen[4], Dissolved (% Sat)	0.06	0.32	-	90.4	-0.06	0.35	-	82.6
pH	0.41	<0.001	0.04	7.40	0.16	<0.001	0.02	7.12
Radium, 226	-0.31	<0.001	-0.004	0.7	-0.19	<0.001	-0.004	0.6
Radium, 228[2,3]	-0.03	0.19	-	0.68[5]	-0.05	0.06	-	0.69[5]
Radium, Combined	-0.90	<0.05	-0.008	1.5	-0.10	<0.05	-0.001	1.5
Specific Conductance[2]	0.36	<0.001	9.28	319	0.17	<0.001	6.34	471
Sulfate[2]	0.31	<0.001	2.69	58.3	-0.96	<0.001	-3.48	139
Turbidity	0.14	<0.05	0.04	3.2	0.19	<0.001	0.06	3.2

[1] Median values estimated using Kaplan-Meier (KM) procedure for data with non-detects.
[2] Data was not correlated with streamflow at HCSW-1; LOESS was not used.
[3] Data was not correlated with streamflow at HCSW-4; LOESS was not used.
[4] Percent DO calculated from DO saturation (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 2023.
[5] Approximately 87% of data is censored, KM median cannot be calculated, and KM mean is provided. Result may be biased based on high level of censoring.

6.1 Physio-Chemical Parameters

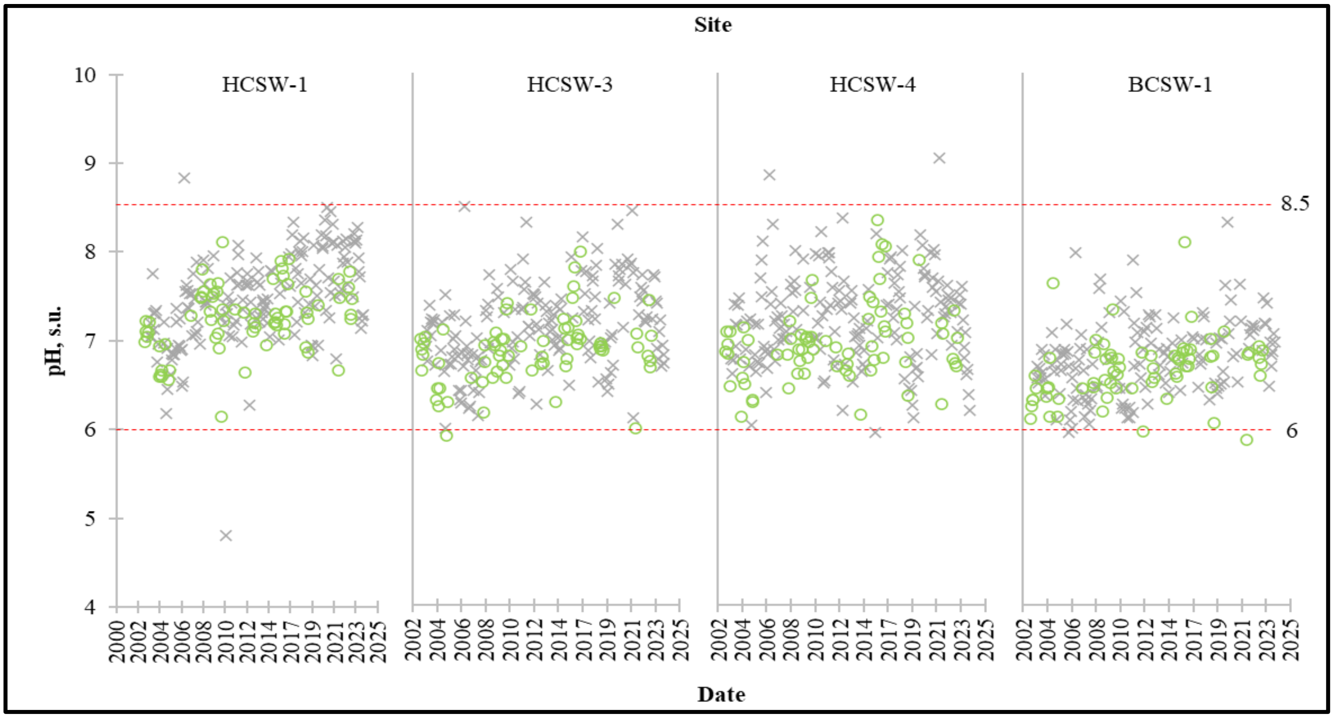
6.1.1 pH

Monthly pH sample values were within the range of established trigger levels (between 6 and 8.5 SU) during all 2023 sampling events (Figure 6-1). pH exceedances have been a rare occurrence over the HCSP POR (Appendix D). The continuous recorder located at HCSW-1 (the site closest to the NPDES outfalls) collects measurements every 15 minutes (~35,000 measurements per year). From January to early March of 2023, and briefly again in mid-May, water levels at HCSW-1 were very low and the meter appeared to be out of the water. Those data values were not representative and are therefore not reported. In the remainder 2023, there was one instance of the meter recording pH values outside of the established trigger levels in mid-May when water levels just began to rise (Figure 6-2). Low flow at HCSW-1 tends to show increases in pH values which may be partly attributed to the exposed limestone substrate in the stream banks that is unique to that site. There was no NPDES discharge to Horse Creek in all of 2023, and therefore, no discharge was occurring during the above trigger level exceedance. pH values at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these same locations (Ali & Gonzalez 2020; Price 2018).

pH levels were different among sites from 2003 to 2023 (Kruskal-Wallis, $p < 0.001$, Table 6-1), with HCSW-1 being significantly different from HCSW-3 and HCSW-4 (Wilcoxon pairwise comparison, $p < 0.05$). Median values for pH are highest at HCSW-1, followed by HCSW-4 and HCSW-3.

At both HCSW-1 and HCSW-4, pH was negatively correlated with rainfall, NPDES discharge, and streamflow (Kendall's rank correlations, $p < 0.05$, Table 6-2), with streamflow having the strongest correlation with pH at both sites. Since the NPDES discharge itself is positively correlated with rainfall and streamflow (Table 5-1), the pH/NPDES and pH/streamflow correlations are most likely due to peak rainfall during the year which typically coincides with NPDES discharge.

There was a slightly increasing monotonic trend between 2003 and 2023 for pH at HCSW- 1 and HCSW-4 (Seasonal Kendall with LOESS, slope = 0.04 SU per year and 0.02 SU per year flow-adjusted concentrations, respectively, Table 6-3). It is likely that these pH trends are being driven by land use changes. As natural areas characterized by pine flatwoods and wetlands with acidic drainage are developed, water quality is more influenced by alkaline runoff and ground water and less influenced by acidic vegetation.



Red dotted line denotes trigger level(s).

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

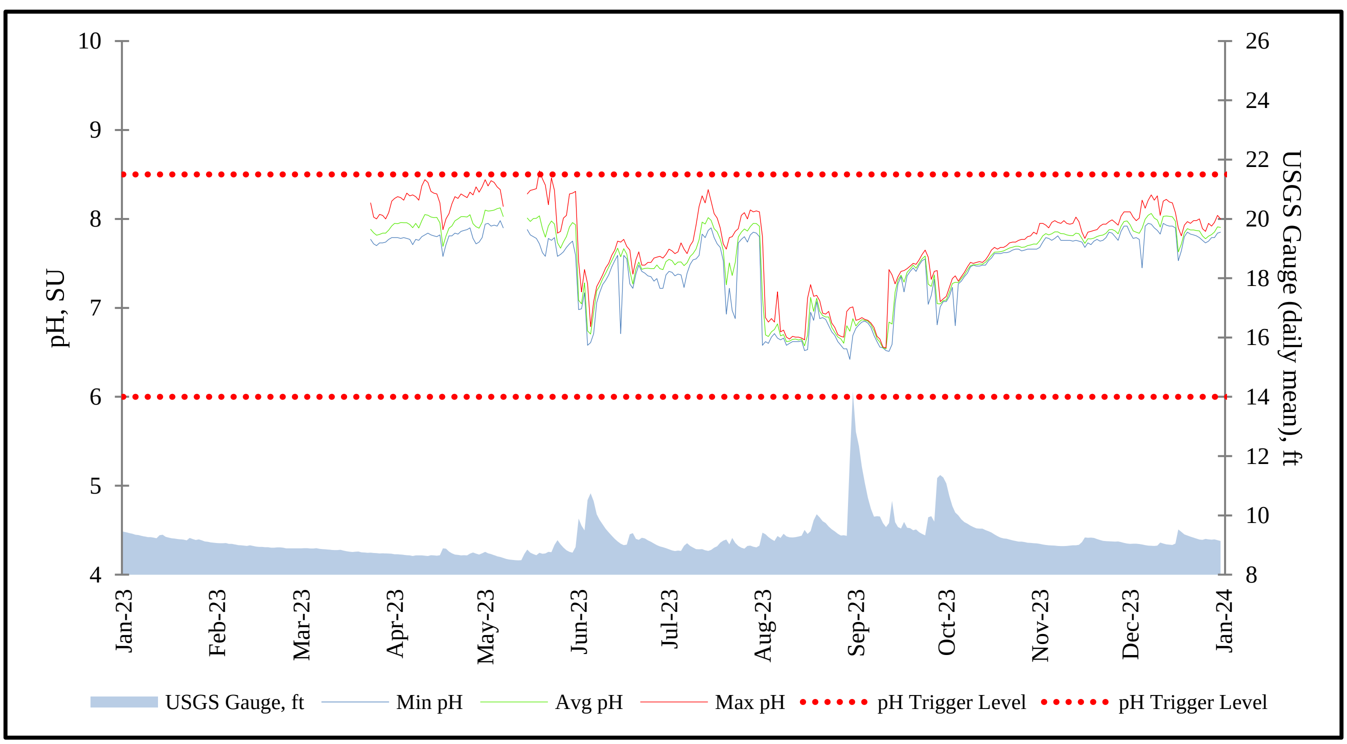


Figure 6-2 Relationship Between Daily Mean pH and Daily Mean Streamflow at HCSW-1, 2023

6.1.2 Turbidity

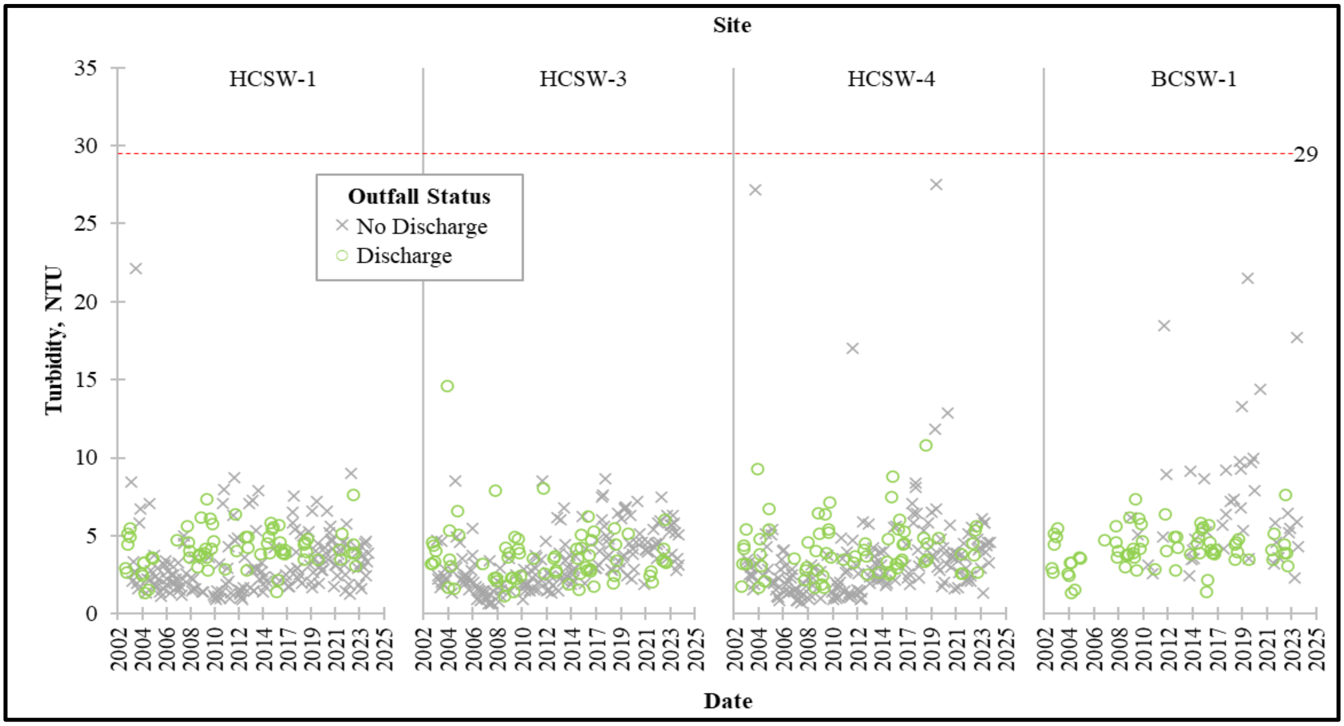
Turbidity levels during all monthly sampling events in 2023 were below the 29 NTU trigger level and have been over the entire HCSP POR (Figure 6-3). From January to early March of 2023, and briefly again in mid-May, water levels at HCSW-1 were very low and the continuous recorder appeared to be out of the water. Those data values were not representative and are therefore not reported. On June 15, 2023, there was a brief instance where continuous recorder turbidity measurements triggered an alert for a potential CSA dam breach (twelve consecutive readings (3 hours) of > 150 NTUs). The alert was investigated and found to be a false alarm as likely either debris from upstream or organisms (crayfish) became lodged within the deployment structure. There have been no actionable turbidity alerts since the program came online.

In the remainder of 2023, there were a few isolated instances of higher turbidity measurements that most likely coincided with higher rainfall events or material becoming lodged in the deployment structure (Figure 6-4). There was no NPDES discharge to Horse Creek in all of 2023, and therefore, no discharge was occurring during the trigger level exceedances above. 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 (Ali & Gonzalez 2020; Price 2018).

There was no difference in turbidity levels among sites from 2003 to 2023 (Kruskal-Wallis, p-value > 0.05, Table 6-1); with all sites being similar to each other (Wilcoxon pairwise comparison, $p > 0.05$). Median turbidity values were almost identical at all sites.

At both HCSW-1 and HCSW-4, turbidity was positively correlated with rainfall, NPDES discharge, and streamflow (Kendall's rank correlations, $p < 0.05$, Table 6-2), with streamflow having the strongest correlation with turbidity at both sites. Because streamflow and NPDES discharge and are positively correlated with rainfall (with lag times), turbidity is typically highest during or following periods of high rainfall and high streamflow.

There was a slightly increasing monotonic trend between 2003 and 2023 for turbidity at HCSW-1 and HCSW-4 (Seasonal Kendall with LOESS, slope = 0.04 NTU per year and 0.06 NTU per year, flow-adjusted concentrations, respectively, Table 6-3). With a larger trend at HCSW-4 compared to HCSW-1 and higher turbidity following rainfall, this suggests these trends may be attributed to other factors such land use changes and increased stormwater inputs. This slope is small and is not of ecological concern at this time but will continue to be monitored in the future.



Red dotted line denotes trigger level.

Figure 6-3 Turbidity Values Obtained During Monthly HCSP Water Quality Sampling Events, HCSP POR

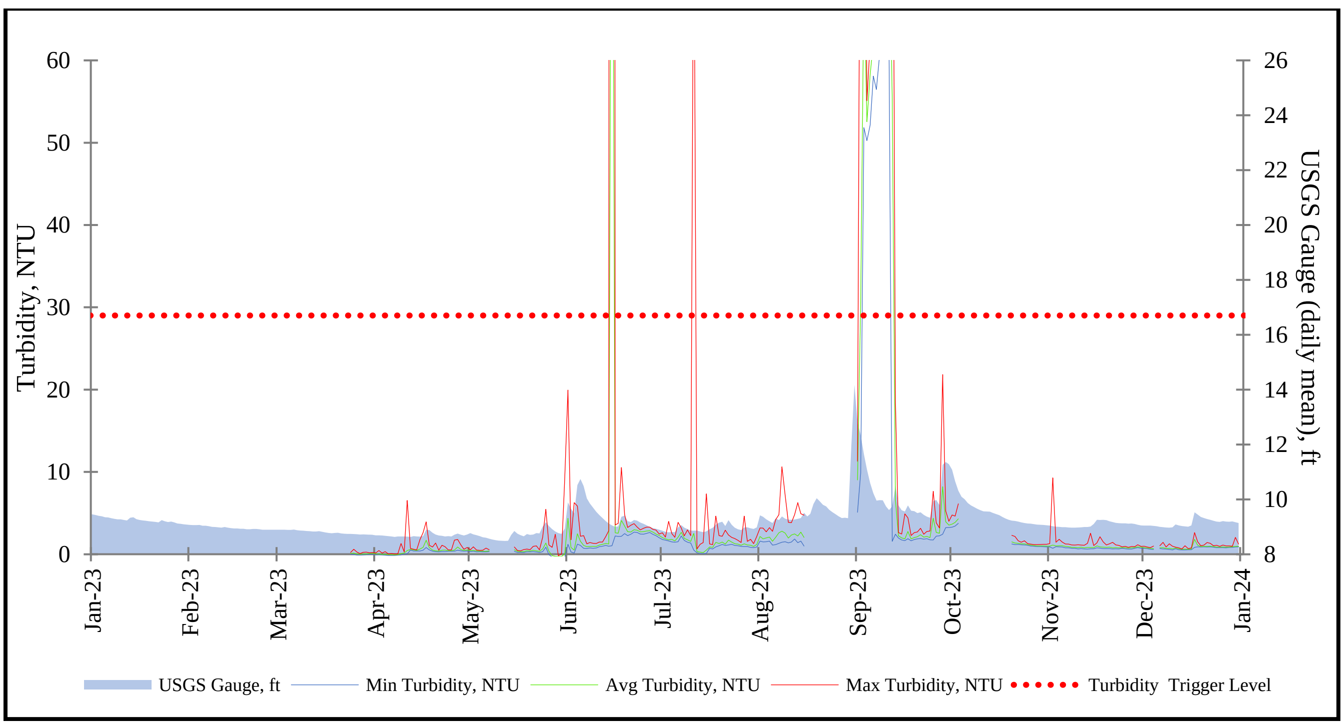


Figure 6-4 Relationship Between Daily Mean Turbidity and Daily Mean Streamflow at HCSW-1, 2023

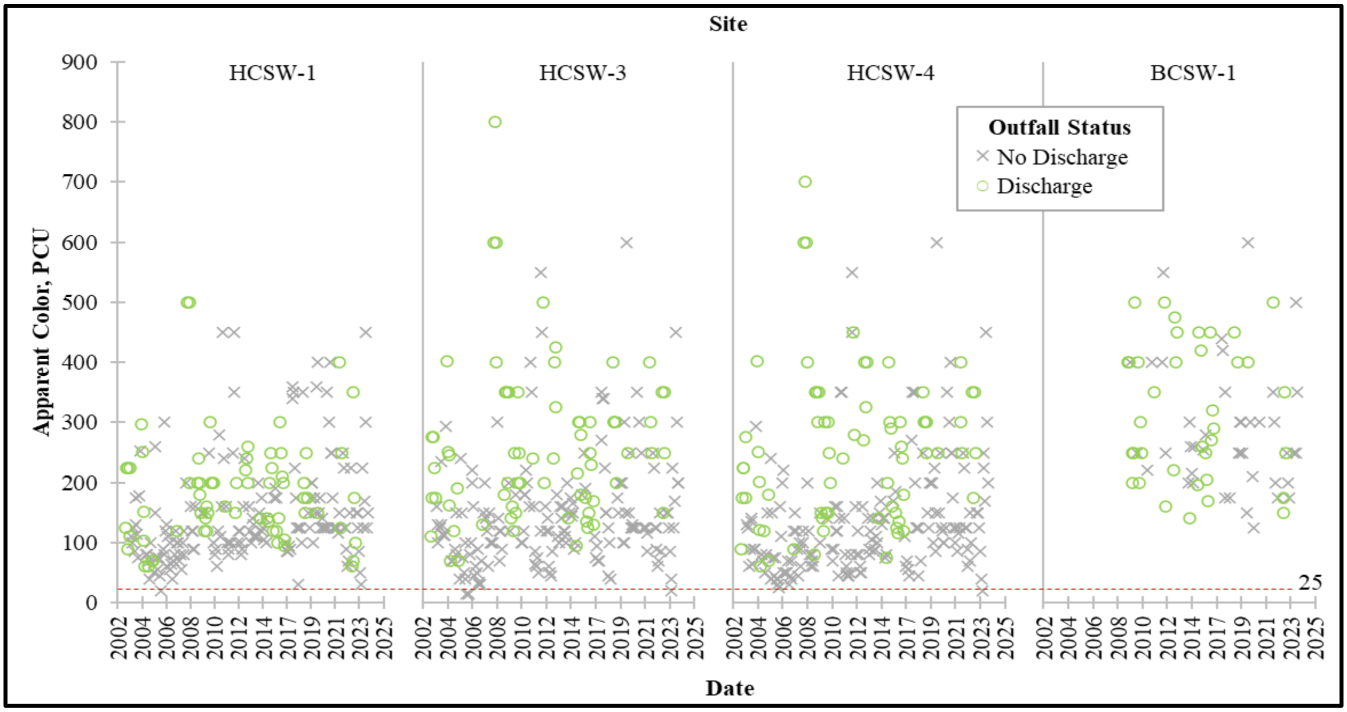
6.1.3 Apparent Color

In 2023, there were two instances of apparent color falling below the trigger level of 25 Platinum-Cobalt Units (PCU) during monthly sampling, one at HCSW-3 (20 PCU, May) and one at HCSW-4 (20 PCU, May) (Figure 6-5, Figure 6-23, Table 6-4, Appendix D). There was no NPDES discharge to Horse Creek in all of 2023, and therefore, no discharge was occurring when color values fell below the trigger level. The color levels at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these same locations (Ali & Gonzalez 2020; Price 2018).

There was no difference in color levels among sites from 2003 to 2023 (Kruskal-Wallis, $p > 0.05$, Table 6-1), with all sites being similar to each other (Wilcoxon pairwise comparison, $p > 0.05$). Median color values were highest at HCSW-3, followed by HCSW-4 and HCSW-1.

At both HCSW-1 and HCSW-4, apparent color was positively correlated with rainfall, NPDES discharge, and streamflow (Kendall's rank correlations, $p < 0.05$, Table 6-2), with streamflow having the strongest correlation with color at both sites. 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 sites of higher color values in the wet summer months, and lower color values in the dry, winter months, suggests 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). 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. This agricultural influence is also noted below with respect to several other parameters.

There was an increasing monotonic trend between 2003 and 2023 for apparent color at HCSW-1 and HCSW-4 (Seasonal Kendall with LOESS, slope = 2.08 PCU per year and 2.55 PCU per year, flow adjusted concentrations, respectively, Table 6-3). The observed trends at HCSW-1 and HCSW-4 are in the opposite direction of the trigger level, so they are not of concern as it relates to the HCSP. The program will continue to monitor these trends over time.



Red dotted line denotes trigger level.

Figure 6-5 Apparent Color Values Obtained During Monthly HCSP Water Quality Sampling Events, HCSP POR

6.2 Nutrients

6.2.1 Total Nitrogen

Total nitrogen[19] (TN, Equation 1) concentrations during all monthly sampling events in 2023 were below the trigger value of 3.0 mg/L at all sites (Figure 6-6). The major component of TN in nearly all samples was total organic nitrogen (16% – 93%, TON, Equation 2), and most of the total inorganic nitrogen[20] (6% – 84%, TIN, Equation 3) occurred at sites HCSW-3 and HCSW-4 (Figure 6-8 and 6-9) likely corresponding with the increased nutrient inputs from agriculture in the lower basin. TN concentrations were different among sites from 2003 to 2023 (Kruskal-Wallis, $p < 0.001$, Table 6-1), with HCSW-1 being significantly different from both HCSW-3 and HCSW-4 (Wilcoxon pairwise comparison, $p < 0.05$). Median values for TN are highest at HCSW-4, followed by HCSW-3 and HCSW-1. TN was positively correlated with rainfall, NPDES discharge, and streamflow at HCSW-1 and NDPES discharge and streamflow at HCSW-4

[19]TN is calculated as the arithmetic sum of Total Kjeldahl Nitrogen 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 TN 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 TN.

[20] On average TN in 2023 consisted of 15.34% TIN in the upper basin (HCSW-1 and HCSW-2) and 34.96% in the lower basin (HCSW-3 and HCSW-4)

(Kendall's rank correlations, $p < 0.05$, Table 6-2), with streamflow having the strongest correlation with TN at both sites. As streamflow and NPDES discharge are positively correlated with rainfall (with lag times), TN values are highest during or following periods of high rainfall and streamflow. The annual geometric mean for TN in 2023 was 1.16 mg/L, below the NNC threshold of 1.54 mg/L stated in Chapter 62-302.531(2)(c) of the Florida Administrative Code (F.A.C.). A brief discussion of HCSW-1 as it pertains to the NNC is summarized in Section 6.4.

Total Kjeldahl Nitrogen (TKN) concentrations over the HCSP POR are displayed in Figure 6-7. Although the overall comparison of TKN values among sites between 2003 and 2023 indicated there were no significant differences (Kruskal-Wallis, $p > 0.05$, Table 6-1), the subsequent pairwise comparison did find a significant different between HCSW-1 and HCSW-3 (Wilcoxon pairwise comparison, $p < 0.05$). In other words, the overall analysis showed that TKN values were similar across sites, but further analysis of each pair revealed that there was a specific pair (HCSW-1 and HCSW-3) that were significantly different. Median[21] values for TKN are highest at HCSW-3, followed by HCSW-4 and HCSW-1. TKN was significantly positively correlated with rainfall, NPDES discharge, and streamflow at both HCSW-1 and HCSW-4, with streamflow having the strongest correlation with TKN at both sites (Kendall's rank correlations, $p < 0.05$, Table 6-2). A slightly increasing monotonic trend was detected for TKN at both HCSW-1 and HCSW-4 (Seasonal Kendall with LOESS, slope = 0.009 mg/L per year and 0.02 mg/L per year, flow adjusted concentrations, respectively, Table 6-3).

Nitrate-nitrite concentrations over the HCSP POR are displayed in Figure 6-8. Nitrate-nitrite values were different among sites between 2003 and 2023 (Kruskal-Wallis, $p < 0.001$, Table 6-1), with all sites being significantly different from each other (Wilcoxon pairwise comparison, $p < 0.05$). Median[21] values for nitrate-nitrite are highest at HCSW-4, followed by HCSW-3 and HCSW-1. Nitrate-nitrite was positively correlated NPDES discharge and streamflow HCSW-1 and negatively correlated with NPDES discharge and streamflow at HCSW-4, with the strongest correlations being with streamflow at both sites (Kendall's rank correlations, $p < 0.05$, Table 6-2). There was a slightly decreasing monotonic trend for nitrate-nitrite at both HCSW-1 and HCSW-4 (Seasonal Kendall with LOESS, slope = -0.0002 mg/L per year and -0.009 mg/L per year, flow adjusted concentrations, respectively, Table 6-3).

In 2023, there was one instance of total ammonia exceeding the 0.3 mg/L trigger level during monthly sampling at HCSW-3 in December. However, this exceedance was qualified by the lab as an estimated value due to suspected matrix interference and failure to meet the established quality control criteria for either precision or accuracy and is

[21] Median values estimated using Kaplan-Meier (KM) procedure for data with non-detects.

therefore not presented. All other samples in 2023 had concentrations below the trigger level (Figure 6-9). Total ammonia values were different among sites from 2003 to 2023 (Kruskal-Wallis, $p < 0.001$, Table 6-1), with HCSW-1 being significantly different from HCSW-3 and HCSW-4 (Wilcoxon pairwise comparison, $p < 0.05$). Median[22] values for total ammonia are highest at HCSW-4, followed by HCSW-3 and HCSW-1. Total ammonia was not correlated with any water quantity parameters (rainfall, NPDES discharge, and streamflow) at HCSW-1 or HCSW-4 (Kendall's rank correlations, Table 6-2). There was a small increasing monotonic trend between 2003 and 2023 at HCSW-4 (Seasonal Kendall, slope = 0.002 mg/L per year, Table 6-3).

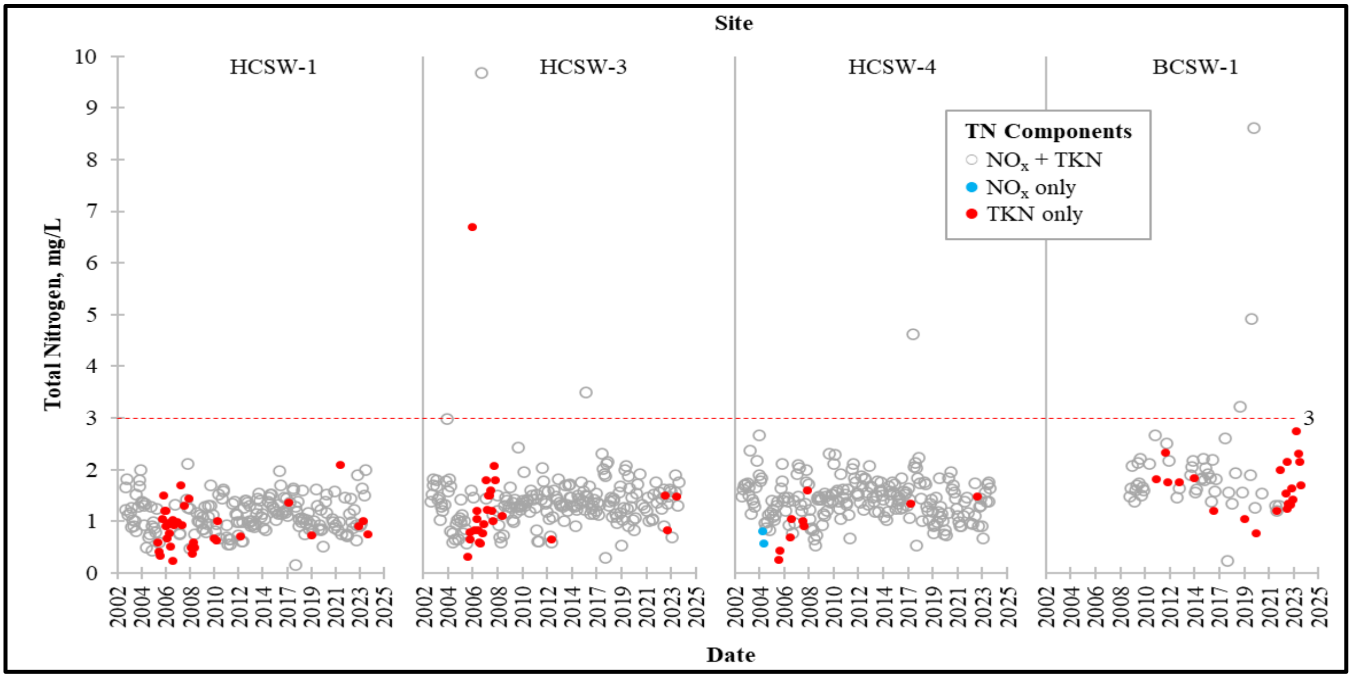
The 2019 HCSP Total Ammonia Impact Assessment found that no significant total ammonia concentration differences were detected between sampling sites over the HCSP POR. If the NPDES discharge was a source of total ammonia in Horse Creek, HCSW-1 concentrations would typically be more elevated than the other HCSP sites, and most of the exceedances would also occur there. Instead, total ammonia 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.

Equation 1 TN = TON + TIN

Equation 2 TON = Total Kjeldahl Nitrogen (TKN) – Total Ammonia (NH_3)

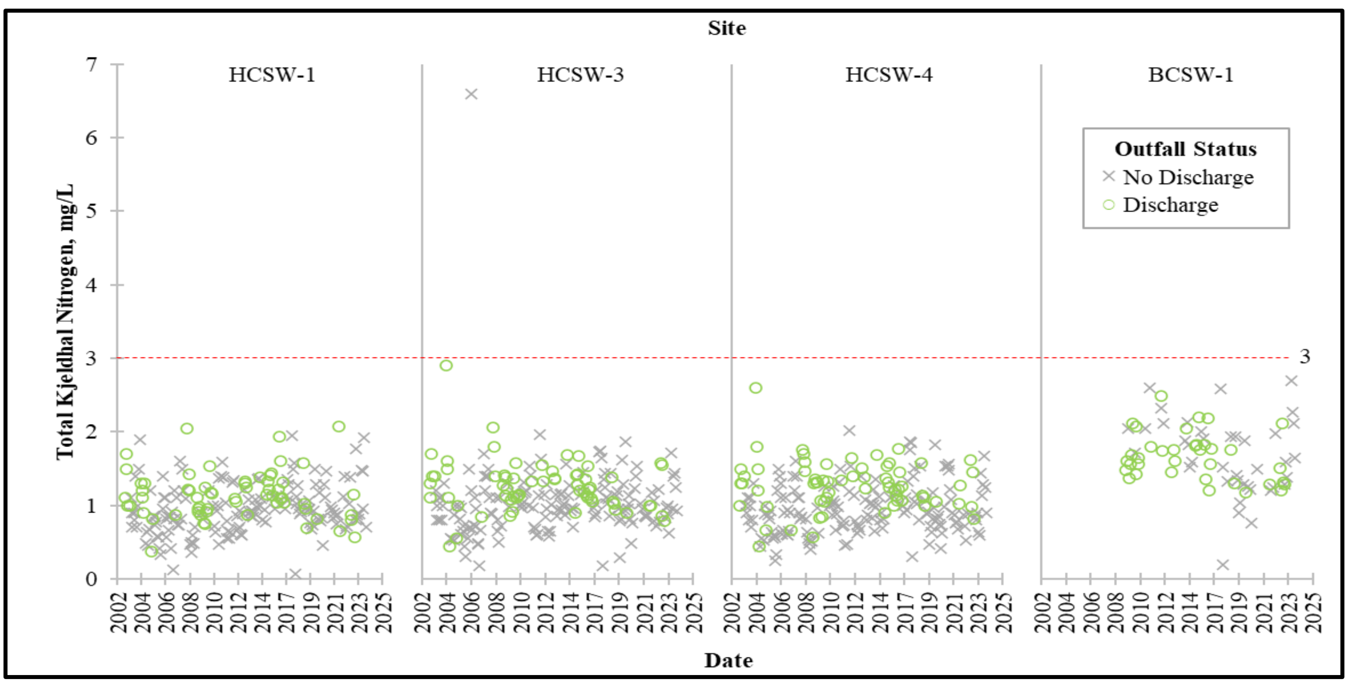
Equation 3 TIN = Nitrate & Nitrite (NO_x) + NH_3

[22] Median values estimated using Kaplan-Meier (KM) procedure for data with non-detects.



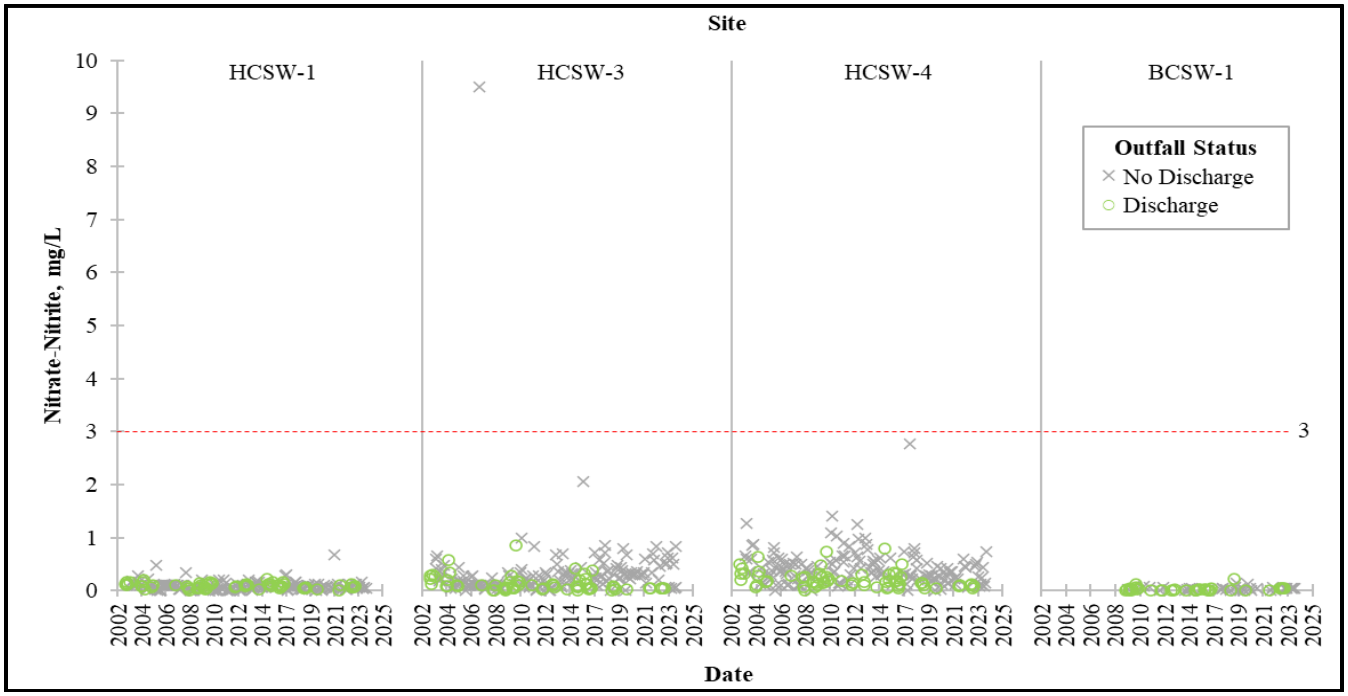
Red dotted line denotes trigger level.

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



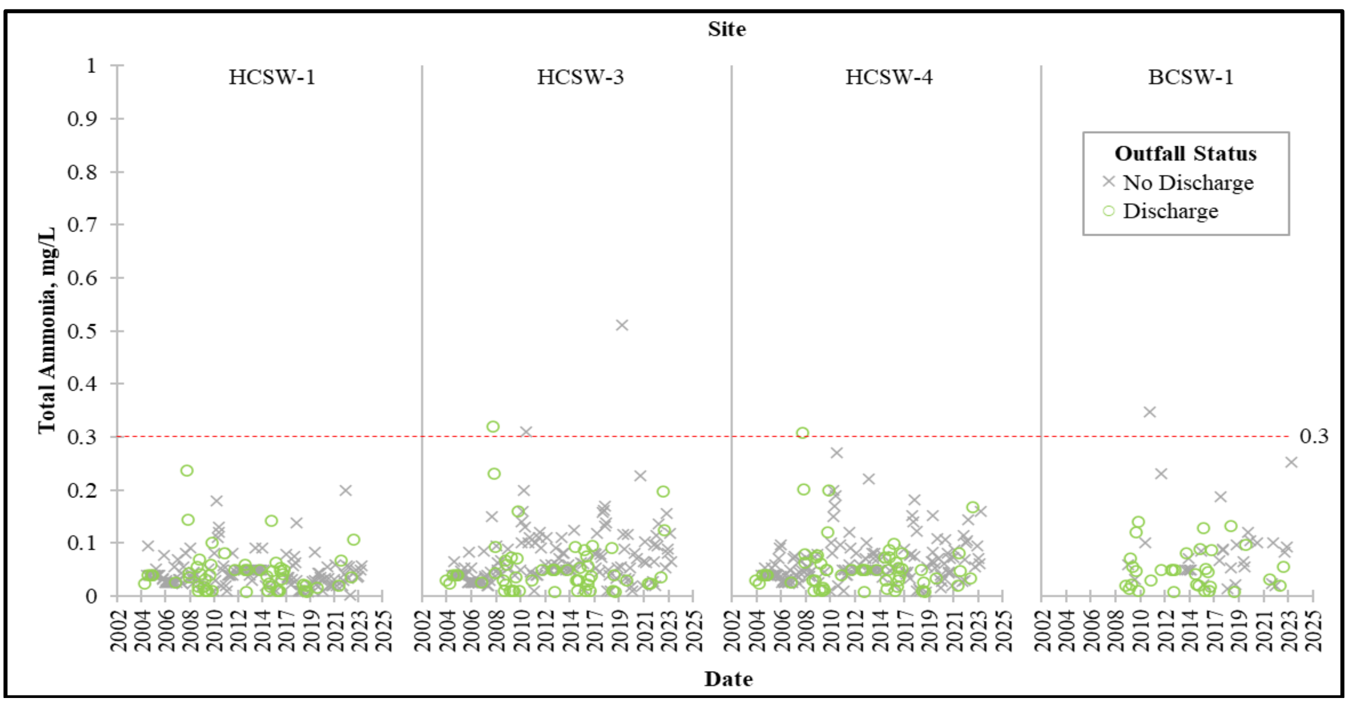
Red dotted line denotes trigger level.

Figure 6-7 TKN Concentrations Obtained During Monthly HCSP Quality Sampling, HCSP POR



Red dotted line denotes trigger level.

Figure 6-8 Nitrate-Nitrite as Nitrogen Concentrations Obtained During Monthly HCSP Water Quality Sampling, HCSP POR



Red dotted line denotes trigger level.

Figure 6-9 Total Ammonia Nitrogen Concentrations Obtained During Monthly HCSP Water Quality Sampling, HCSP POR

6.2.2 Corrected Chlorophyll-a

Corrected Chlorophyll-a (chlorophyll-a) values were below the trigger level of 15 µ/L during all sampling events at all sites in 2023 (Figure 6-10). Chlorophyll-a concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Ali & Gonzalez 2020; Price 2018).

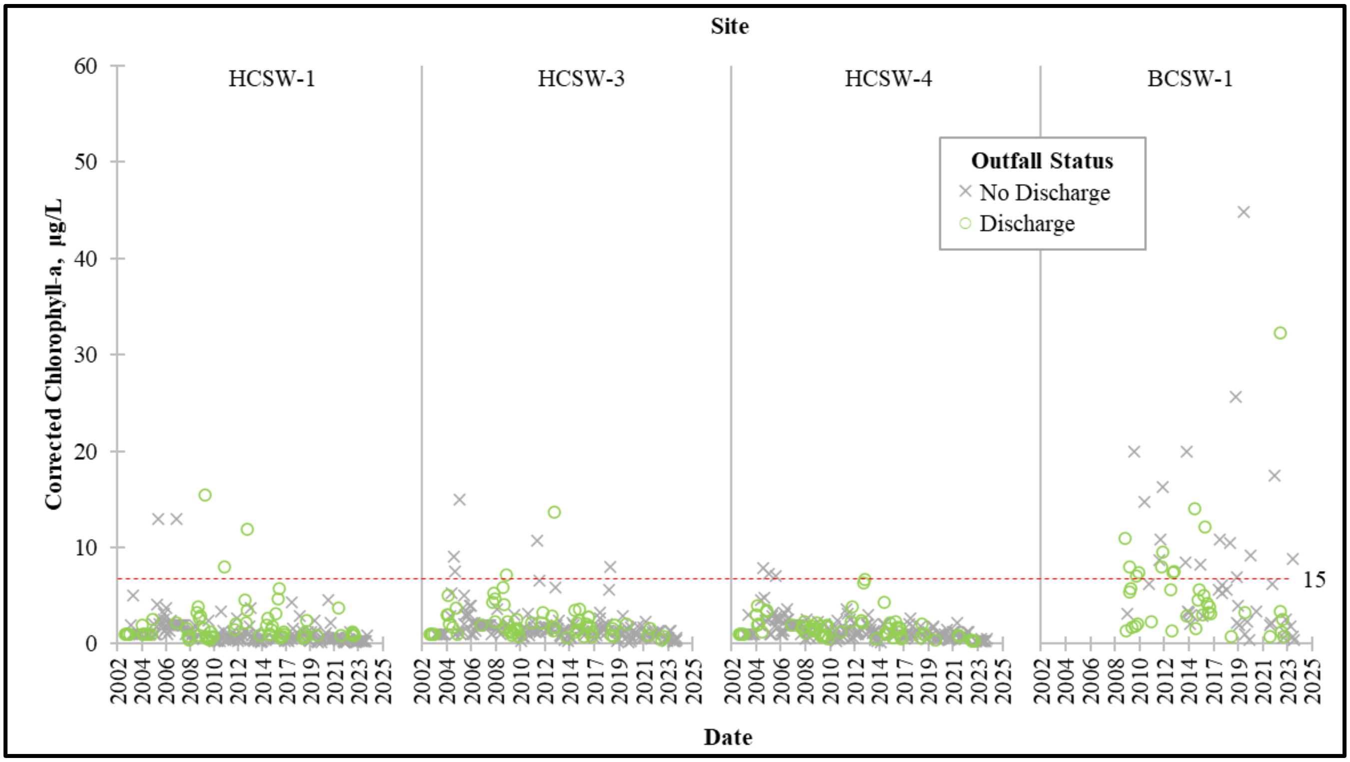
Chlorophyll-a concentrations were different among sites from 2003 to 2023 (Kruskal-Wallis, $p < 0.001$, Table 6-1), with all sites being significantly different from each other (Wilcoxon pairwise comparison, $p < 0.05$). Median[23] chlorophyll-a values were highest at HCSW-3, followed by HCSW-4 and HCSW-1.

Chlorophyll-a was positively correlated with rainfall, NPDES discharge, and streamflow at HCSW-1, with streamflow having the strongest correlation (Kendall's rank correlation, Table 6-2). At HCSW-4, chlorophyll-a was positively correlated with NPDES discharge (Kendall's rank correlations, Table 6-2). Because streamflow and NPDES discharge and are positively correlated with rainfall (with lag times), chlorophyll-a values can be elevated during or following periods of high rainfall and high streamflow when nutrients are washed into the stream.

There was an increasing monotonic trend between 2003 and 2023 for chlorophyll-a at HCSW-1 (Seasonal Kendall with LOESS, slope = 0.04 µ/L per year, flow-adjusted concentrations, Table 6-3) and a decreasing monotonic trend at HCSW-4 (Seasonal Kendall, slope = -0.07 µ/L per year, Table 6-3). Because the findings discussed in Section 5.0 of this report provide evidence that mining activities have not changed the overall relationship between annual rainfall and annual stream discharge at HCSW-1, this also supports that elevated chlorophyll-a levels following rain events are not related to mining.

The annual geometric mean for chlorophyll-a in 2023 was 0.30 µ/L, below the NNC threshold of 20 µ/L stated in Chapter 62-303.531(4) of the F.A.C. HCSW-1 shows no evidence of persistent algal blooms based on current chlorophyll-a levels and passing RPS and LVS results. A brief discussion of HCSW-1 as it pertains to the NNC is summarized in Section 6.4.

[23] Median values estimated using Kaplan-Meier (KM) procedure for data with non-detects.



Red dotted line denotes trigger level.

Figure 6-10 Corrected Chlorophyll-a Concentrations Obtained During Monthly HCSP Water Quality Sampling Events, HCSP POR

6.3 Dissolved Minerals and Radionuclides

6.3.1 Specific Conductivity

There were no instances of specific conductivity levels exceeding the 1,275 µS trigger level at any sites during all 2023 sampling events (Figure 6-11). From January to early March of 2023, and briefly again in mid-May, water levels at HCSW-1 were very low and the continuous recorder appeared to be out of the water. Those data values were not representative and are therefore not reported. There were two periods where the continuous recorder failed the specific conductivity continuing calibration verification (CCV), once from mid-August to mid-September, and once in November. There were no exceedances above the trigger level at these times, however, all values between these dates are qualified as estimates. In the remainder of 2023, there were no instances of the meter recording specific conductivity values above the trigger level (Figure 6-12). The specific conductivity at both HCSW-1 and HCSW-4 measured by the HCSP has been consistent with other water quality data sources (Ali & Gonzalez 2020; Price 2018).

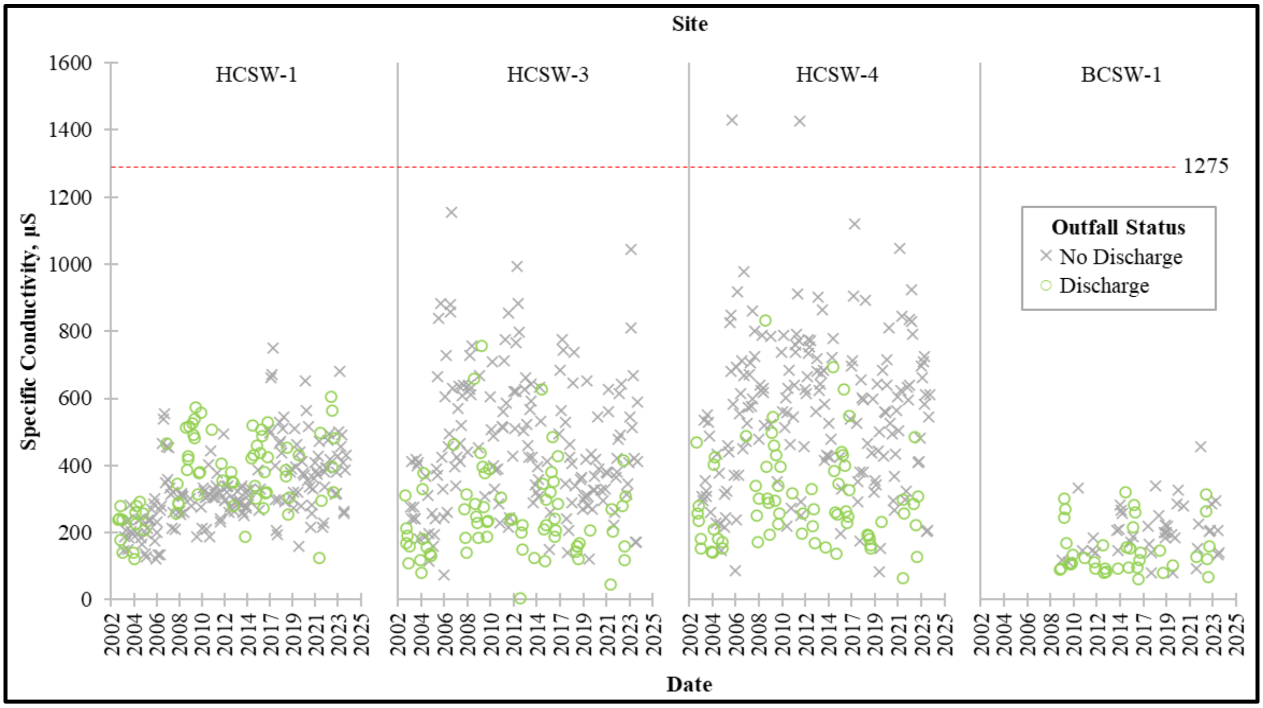
Specific conductivity values were different among sites between 2003 and 2023 (Kruskal-Wallis, $p < 0.001$, Table 6-1), with all sites being significantly different from each other (Wilcoxon pairwise comparison, $p < 0.05$). Median values for specific conductivity are highest at HCSW-4, followed by HCSW-3 and HCSW-1.

At HCSW-1, specific conductivity was negatively correlated with rainfall and positively correlated with NPDES discharge, with NPDES discharge having the strongest correlation (Kendall's rank correlations, Table 6-2). At HCSW-4, specific conductivity was negatively correlated with rainfall, NPDES discharge, and streamflow, with streamflow having the strongest correlation (Kendall's rank correlations, Table 6-2).

There was an increasing monotonic trend between 2003 and 2023 for specific conductivity at HCSW-1 (Seasonal Kendall-tau, slope = 9.28 µS per year) and HCSW-4 (Seasonal Kendall-tau with LOESS, slope = 6.34 µS per year, flow-adjusted concentrations, Table 6-3).

According to the Fort Green and Wingate NPDES discharge monitoring reports, the effluent specific conductivity over the HCSP POR ranged from 244 – 836 µS at FTG-003 and 360 – 657 µS at WIN-004. FTG-003 discharged for the first time since September 2009 in October 2022, immediately following Hurricane Ian. In 2023, when there was no NPDES discharge to Horse Creek, specific conductivity values from monthly sampling at HCSW-1 ranged from 256 – 680 µS and the highest non-qualified value from the continuous recorder was 709 µS on May 28th, 2023.

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 had increased concentrations under low flow conditions at all sites, were not related to the outfall, and elevated specific conductivity values at HCSW-3 and HCSW-4 were linked to tributaries in the lower basin that are impacted by agriculture.



Red dotted line denotes trigger level.

Figure 6-11 Specific Conductivity Measurements Obtained During Monthly HCSP Water Quality Sampling, HCSP POR

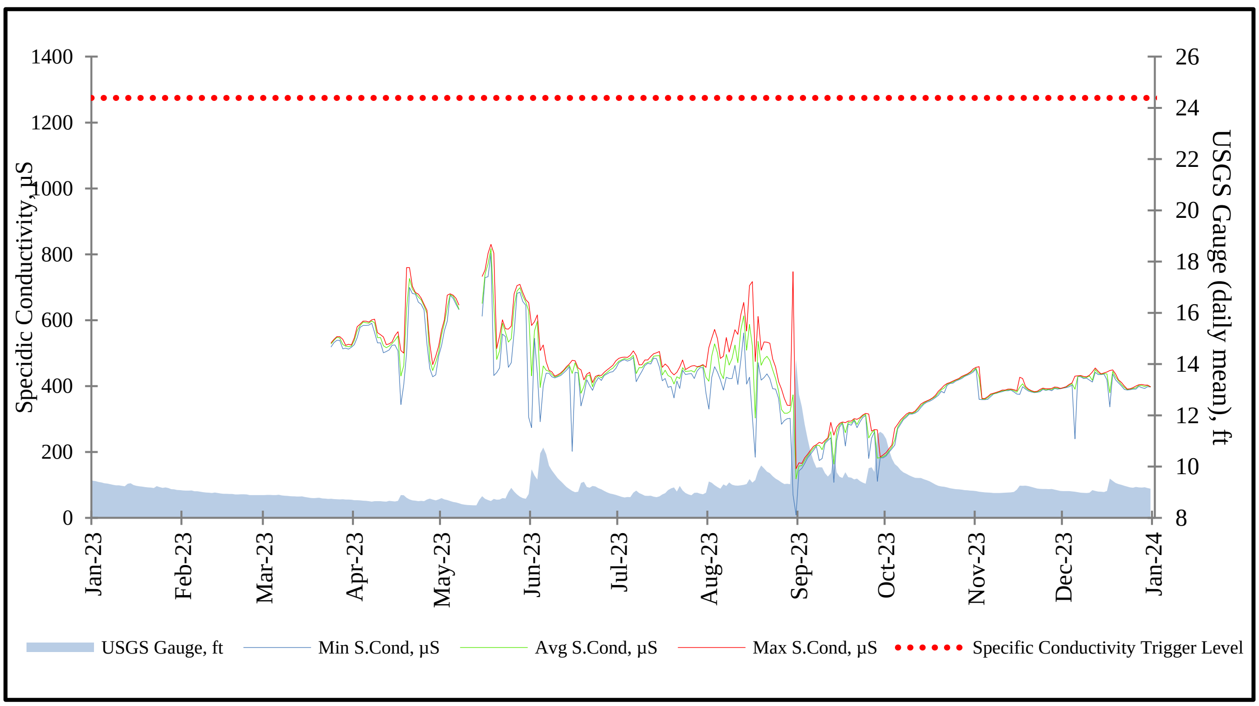


Figure 6-12 Relationship Between Daily Specific Conductivity and Daily Mean Streamflow at HCSW-1, 2023

6.3.2 Dissolved Calcium

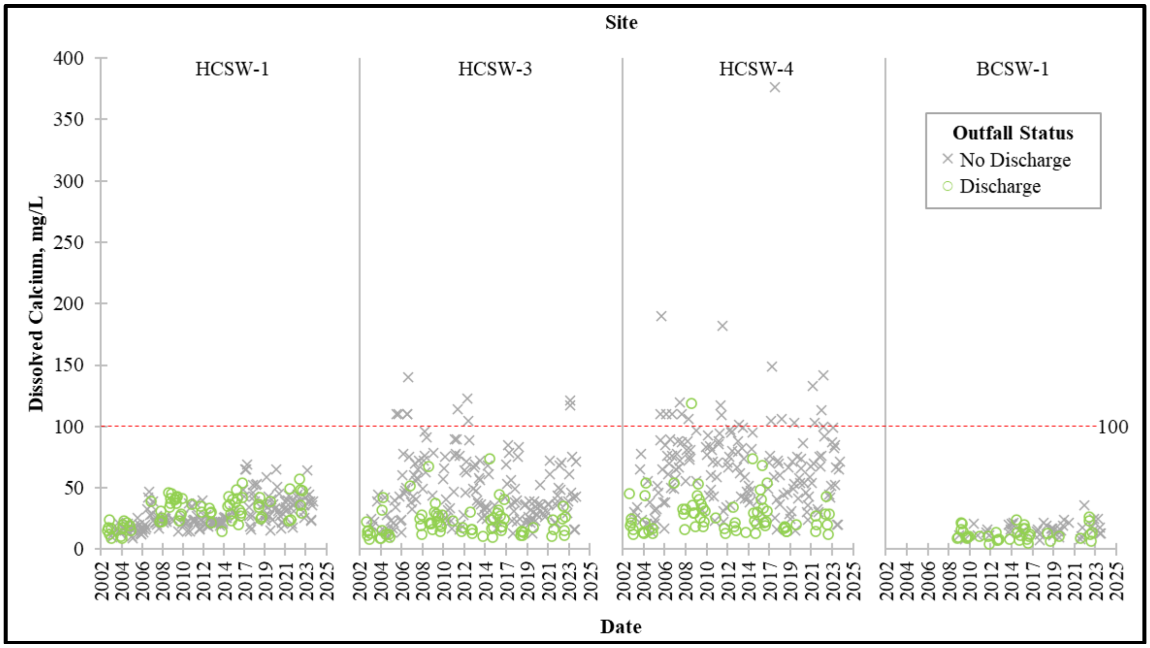
There were two dissolved calcium exceedances over the 100 mg/L trigger level in 2023, both at HCSW- 3 (Figure 6-13, Figure 6-23, Table 6-4, Appendix D). These exceedances occurred on April 11 and May 4, 2023. There was no NPDES discharge to Horse Creek in all of 2023, and therefore, no discharge was occurring during the above trigger level exceedances.

Calcium concentrations were different among sites from 2003 to 2023 (Kruskal-Wallis $p < 0.001$, Table 6-1), with all sites and all sites being significantly different from each other (Wilcoxon pairwise comparison, $p < 0.001$). Median values for calcium are highest at HCSW-4, followed by HCSW-3 and HCSW-1.

At HCSW-1, calcium was negatively correlated with rainfall and positively correlated with NPDES discharge, with NPDES discharge having the strongest correlation (Kendall's rank correlations, Table 6-2). At HCSW-4, calcium was negatively correlated with NPDES discharge and streamflow, with streamflow having the strongest correlation (Kendall's rank correlations, Table 6-2).

There was an increasing monotonic trend from 2003 to 2023 at HCSW- 1 (Seasonal Kendall, slope = 1.04 mg/L per year, Table 6-3) and HCSW-4 (Seasonal Kendall-tau with LOESS, slope = 0.65 mg/L per year, flow-adjusted concentrations, Table 6-3).

The relationship between historical dissolved calcium values, streamflow, 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, and elevated concentrations at HCSW-3 and HCSW-4 were linked to tributaries in the lower basin that are impacted by agriculture. To date, there have been no calcium exceedances at HCSW-1, the site closest to the outfalls (Figure 6-13).



Red dotted line denotes trigger level.

Figure 6-13 Dissolved Calcium Concentrations Obtained During Monthly HCSP Water Quality Sampling Events, HCSP POR

6.3.3 Dissolved Iron

Dissolved iron concentrations at all sites were below the 1 mg/L trigger level at all sites during all monthly sampling events in 2023 (Figure 6-14). A 2018 Atkins report commissioned by the PRMRWSA compared the HCSP dissolved iron dataset to the PRMRWSA data and found that they were similar. Other public sources of dissolved iron data in Horse Creek are very limited.

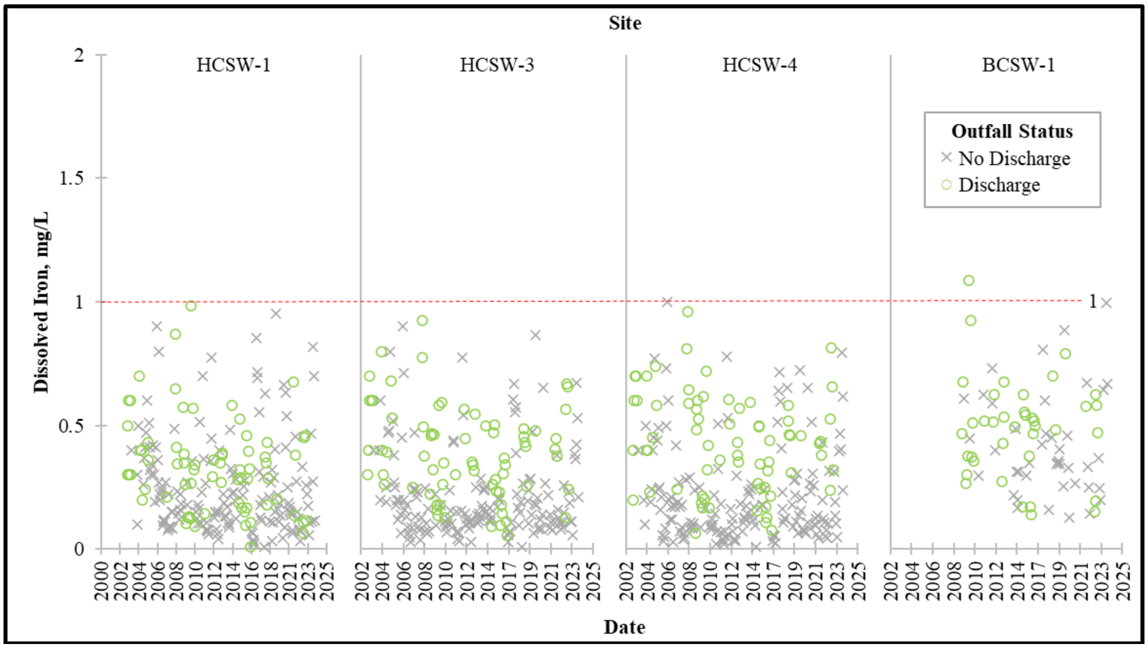
There were no differences in dissolved iron concentrations among sites between 2003 and 2023 (Kruskal-Wallis $p > 0.05$, Table 6-1), with all sites being similar to each other (Wilcoxon pairwise comparison, $p > 0.05$). Median[24] values for iron are highest at HCSW-1, followed by HCSW-4 and HCSW-3.

Dissolved iron was positively correlated with rainfall, NDPES discharge, and streamflow at both HCSW-1 and HCSW-4, with streamflow having the strongest correlation at both sites (Kendall's rank correlations, Table 6-2). Streamflow is positively correlated with rainfall (with lag times), and iron is generally highest during or following periods of high rainfall.

[24] Median values estimated using Kaplan-Meier (KM) procedure for data with non-detects.

There was a very slight increasing monotonic trend for dissolved iron at both HCSW-1 and HCSW-4 (Seasonal Kendall with LOESS, slope = 0.008 mg/L per year and 0.01 mg/L per year, respectively, flow-adjusted concentrations, Table 6-3).

Dissolved iron is a component of TDS. The 2018 TDS, Calcium, and Sulfate HCSP Impact Assessment showed that these analytes had increased concentrations under low flow conditions at all sites, were not related to the outfall, and elevated levels at HCSW-3 and HCSW-4 were linked to tributaries in the lower basin that are impacted by agriculture.



Red dotted line denotes trigger level.

Figure 6-14 Dissolved Iron Concentrations Obtained During Monthly HCSP Water Quality Sampling, HCSP POR

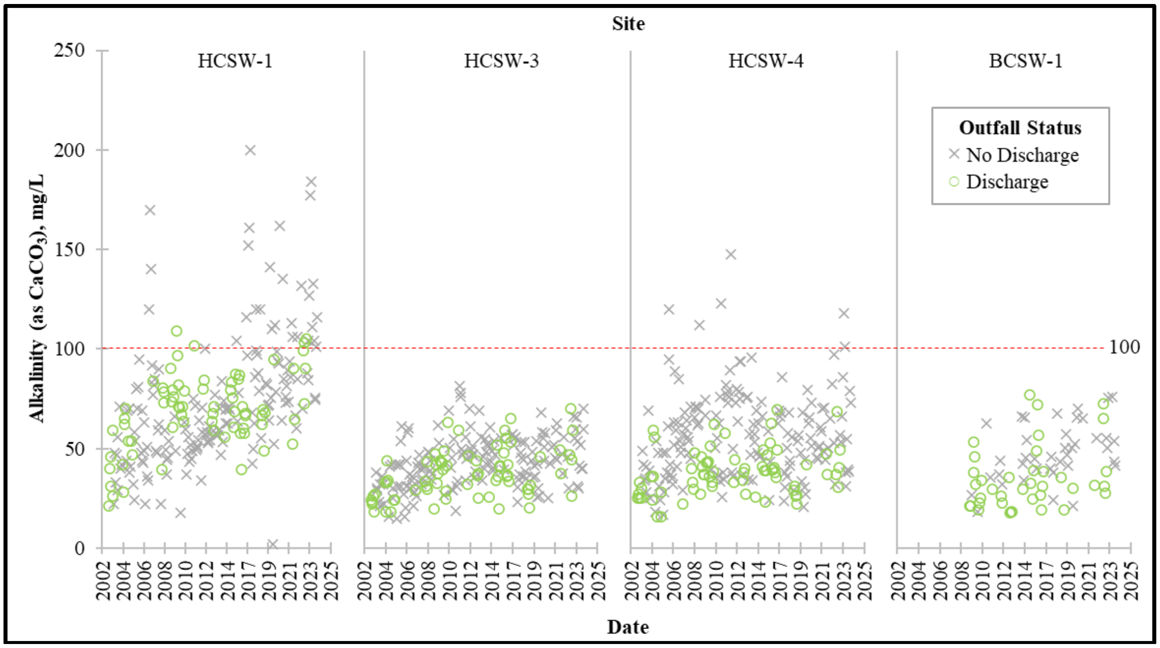
6.3.4 <u>Total Alkalinity</u>

During the monthly sampling in 2023, there were nine total alkalinity exceedances above the 100 mg/L trigger level. Seven occurred at HCSW-1 on February 7, March 7, April 11, May 4, June 13, July 11, and August 8, 2023, and two occurred at HCSW-4 on April 11 and May 4, 2023 (Figure 6-15, Figure 6-23, Table 6-4, Appendix D). There was no NPDES discharge to Horse Creek in all of 2023, and therefore, no discharge was occurring during the above trigger level exceedances. Like pH, low flow conditions at HCSW-1 tend to show elevated levels of total alkalinity which may be partly attributed to the exposed limestone substrate in the stream banks that is unique to that site. The total alkalinity concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Ali & Gonzalez, 2020; Price, 2018).

Total alkalinity values were different among sites from 2003 to 2023 (Kruskal-Wallis $p < 0.001$, Table 6-1), with all sites being significantly different from each other (Wilcoxon pairwise comparison, $p < 0.05$). Median values for alkalinity are highest at HCSW-1, followed by HCSW-4 and HCSW-3.

At HCSW-1, alkalinity was negatively correlated with rainfall and streamflow, with rainfall having the strongest correlation (Kendall's rank correlations, Table 6-2). At HCSW-4, alkalinity was negatively correlated with rainfall, NPDES discharge, with streamflow having the strongest correlation (Kendall's rank correlations, Table 6-2). This 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.

There was an increasing monotonic trend for alkalinity from 2003 to 2023 at both HCSW-1 and HCSW-4 (Seasonal Kendall with LOESS, slope = 2.36 mg/L per year and 0.70 mg/L per year, flow-adjusted concentrations, respectively, Table 6-3). 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 Water Quality Impact Assessment).



Red dotted line denotes trigger level.

Figure 6-15 Total Alkalinity Concentrations Obtained During Monthly HCSP Water Quality Sampling, HCSP POR

6.3.5 Chloride

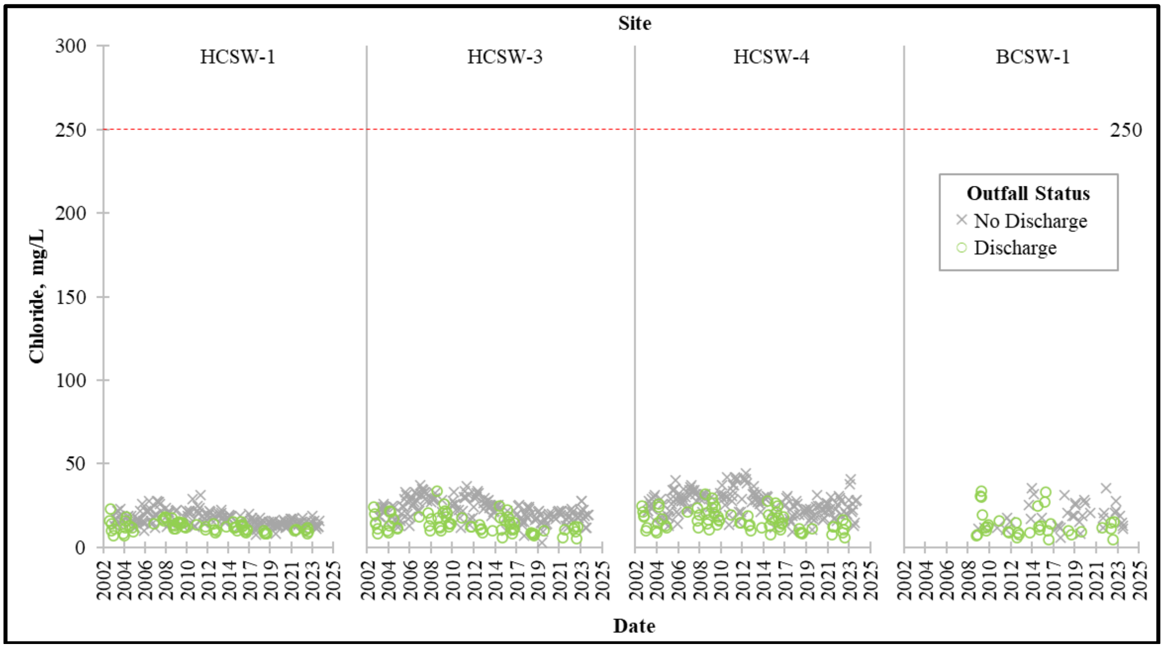
Chloride concentrations were below the 250 mg/L trigger level at all sites during monthly sampling in 2023 and have been throughout the HCSP POR (Figure 6-16). The chloride concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at those locations (Ali & Gonzalez 2020; Price 2018).

Chloride concentrations were different among sites between 2003 to 2023 (Kruskal-Wallis $p < 0.001$, Table 6-1), with all sites being significantly different from each other (Wilcoxon pairwise comparison, $p < 0.05$). Median[25] chloride values are highest at HCSW-4, followed by HCSW-3 and HCSW-1.

Chloride was negatively correlated rainfall, NPDES discharge, and streamflow at both HCSW-1 and HCSW-4, with streamflow having the strongest correlation at both sites (Kendall's rank correlations, Table 6-2). Because streamflow and NPDES discharge are positively correlated with rainfall (with lag times), chloride concentrations tend to be lower during or following periods of high rainfall.

[25] Median values estimated using Kaplan-Meier (KM) procedure for data with non-detects.

There was a decreasing monotonic trend for chloride from 2003 to 2023 at both HCSW-1 and HCSW-4 (Seasonal Kendall with LOESS, slope = -0.36 mg/L per year and -0.6 mg/L per year, respectively, flow-adjusted concentrations, Table 6-3). These trends are opposite that of the HCSP trigger level and are therefore not of concern.



Red dotted line denotes trigger level.

Figure 6-16 Chloride Concentrations Obtained During Monthly HCSP Water Quality Sampling, HCSP POR

6.3.6 Fluoride

During monthly sampling in 2023, fluoride concentrations were below the 4.0 mg/L trigger level established for HCSW-1 and HCSW-3, and the 1.5 mg/L trigger level established for HCSW-4 (Figure 6-17). The fluoride concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at those locations (Ali & Gonzalez 2020; Price, 2018).

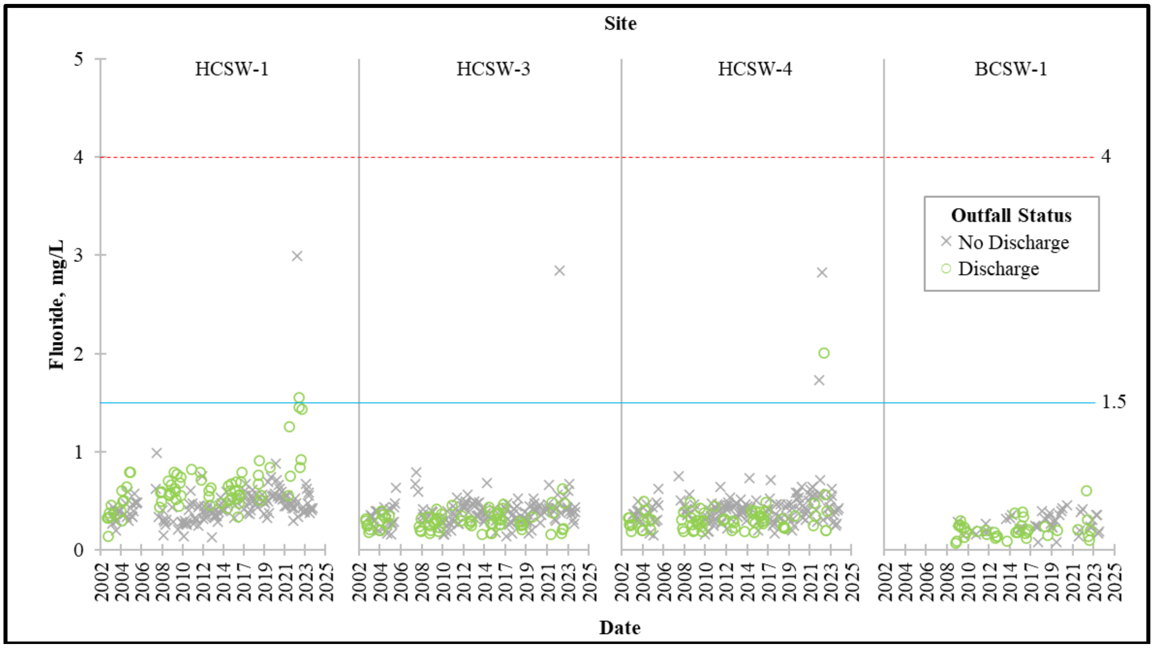
Fluoride concentrations were different among sites between 2003 and 2023 (Kruskal-Wallis $p < 0.001$, Table 6-1), with all sites being significantly different from each other (Wilcoxon pairwise comparison, $p < 0.05$). Median[26] values for Fluoride are highest at HCSW-1, followed by HSCW-4 and HCSW-3.

At HCSW-1, fluoride was positively correlated with NPDES discharge and streamflow, with NDPES discharge having the strongest correlation (Kendall's rank correlations, Table 6-2). At HCSW-4, fluoride was negatively correlated with rainfall, NPDES discharge, and

[26] Median values estimated using Kaplan-Meier (KM) procedure for data with non-detects.

streamflow, with streamflow having the strongest correlation (Kendall's rank correlations, Table 6-2). The positive relationship with NPDES discharge at HCSW-1 and the negative relationship with rainfall, NPDES discharge, and streamflow at HCSW-4 suggests that the NPDES discharge is contributing fluoride to Horse Creek, and it is being diluted as it moves further downstream.

There was a small decreasing monotonic trend detected for fluoride at both HCSW- 1 and HCSW-4 (Seasonal Kendall with LOESS, -0.006 mg/L per year at each site, flow adjusted concentrations, $p < 0.001$, Table 6-3). These trends are opposite that of the HCSP trigger level and are therefore not of concern.



Dotted red line denotes trigger level for HCSW-1 and HCSW-3. Solid blue line denotes trigger level for HCSW-4.

Figure 6-17 Fluoride Concentrations Obtained During Monthly HCSP Water Quality Sampling, HCSP POR

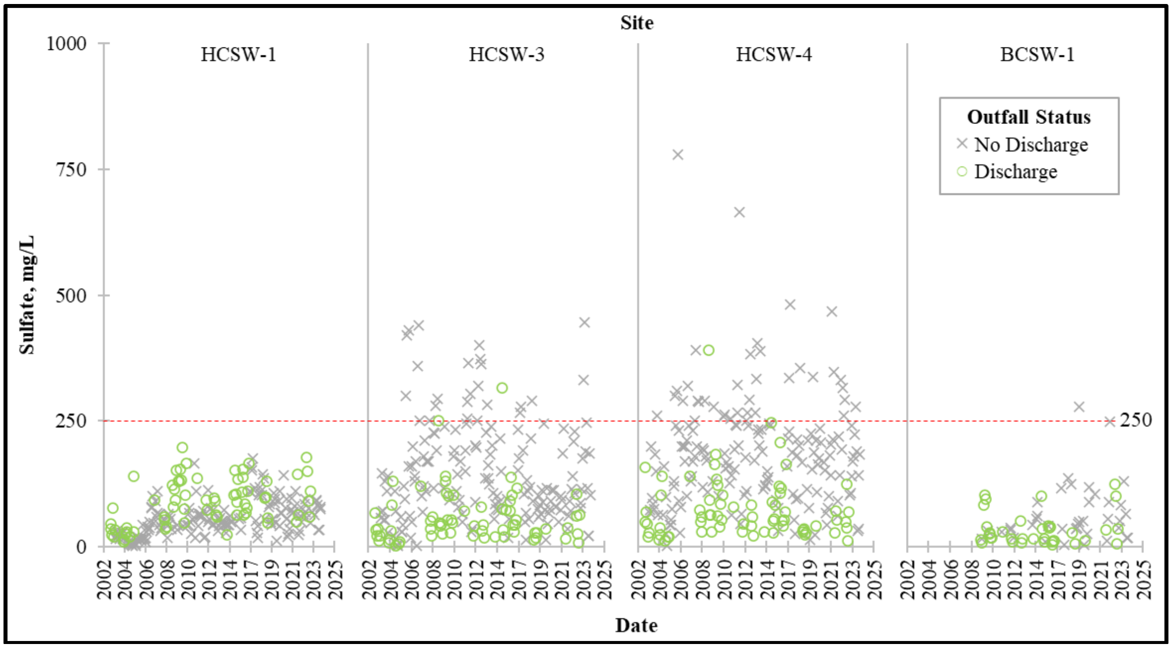
6.3.7 Sulfate

There were three sulfate exceedances above the 250 mg/L trigger level during monthly sampling in 2023 (Figure 6-18, Figure 6-23, Table 6-4, Appendix D). Two occurred at HCSW-3 on April 11 and May 4, 2023, and one at HCSW-4 on July 11, 2023. There was no NPDES discharge to Horse Creek in all of 2023, and therefore, no discharge was occurring during the above trigger level exceedances. There have been no sulfate trigger level exceedances at HCSW-1 over the HCSP POR (Figure 6-18). The sulfate concentrations at HCSW-1 and HCSW-4 measured by the HCSP are consistent with other water quality data sources at these locations (Ali & Gonzalez, 2020; Price, 2018).

Sulfate concentrations were different among sites between 2003 and 2023 (Kruskal-Wallis $p < 0.001$, Table 6-1), with all sites being significantly different from each other (Wilcoxon pairwise comparison, $p < 0.001$). Median values for sulfate are highest at HCSW-4, followed by HCSW-3 and HCSW-1.

At HCSW-1, sulfate was positively correlated with NPDES discharge (Kendall's rank correlations, Table 6-2). At HCSW-4, sulfate was negatively correlated with NDPES discharge and streamflow, with streamflow having the strongest correlation (Kendall's rank correlations, Table 6-2). 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 (Ali & Gonzalez, HCSP TDS, Sulfate and Calcium Impact Assessment, 2018).

There was an increasing monotonic trend from 2003 to 2023 at HCSW-1 (Seasonal Kendall, slope = 2.69 mg/L per year, Table 6-3) and a decreasing monotonic trend at HCSW-4 (Seasonal Kendall with LOESS, slope = -3.48 mg/L per year, flow-adjusted concentrations, Table 6-3). 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 (Ali & Gonzalez, HCSP TDS, Sulfate and Calcium Impact Assessment, 2018).



Red dotted line denotes trigger level.

Figure 6-18 Sulfate Concentrations Obtained During Monthly HCSP Water Quality Sampling, HCSP POR

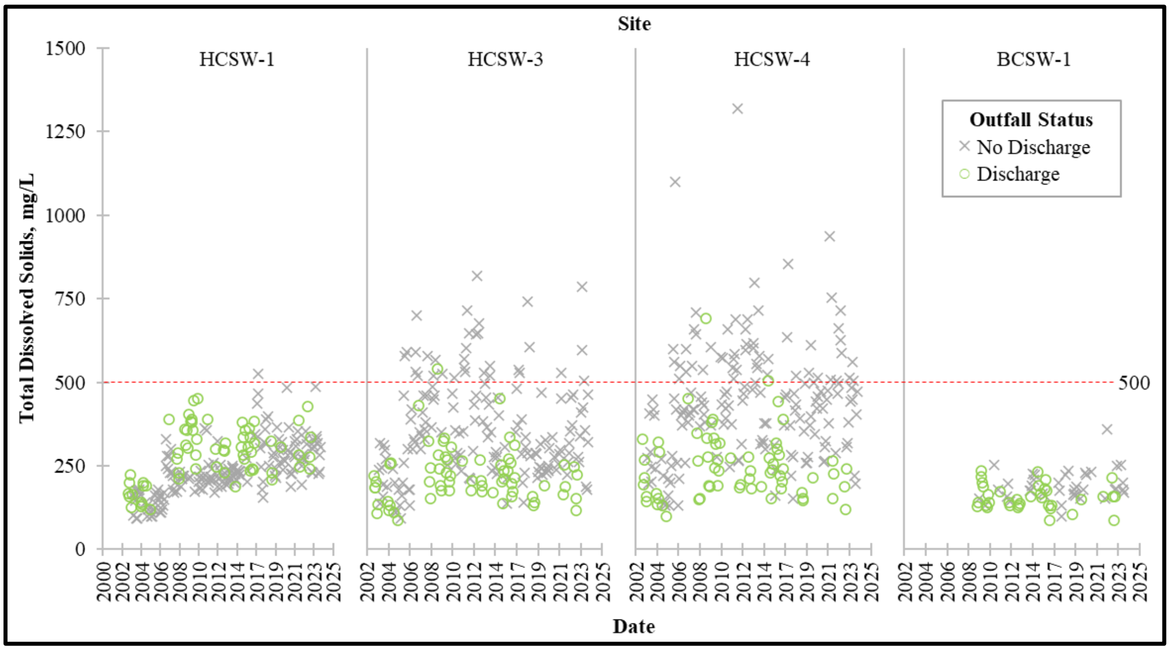
6.3.8 <u>Total Dissolved Solids</u>

There were six Total Dissolved Solids (TDS) exceedances above the 500 mg/L trigger level in 2023, three at HCSW-3 on April 11, May 4, and July 11, 2023, and three at HCSW-4 on March 7, July 11, and August 8, 2023 (Figure 6-19, Figure 6-23, Table 6-4, Appendix D). There was no NPDES discharge to Horse Creek in all of 2023, and therefore, no discharge was occurring during the above trigger level exceedances.

TDS concentrations were different among sites between 2003 and 2023 (Kruskal-Wallis $p < 0.001$, Table 6-1), with all sites being significantly different from each other (Wilcoxon pairwise comparison, $p < 0.001$). Median values for TDS are highest at HCSW-4, followed by HCSW-3 and HCSW-1.

At HCSW-1, TDS concentrations were positively correlated with NPDES discharge (Kendall's rank correlations, Table 6-2). At HCSW-4, TDS concentrations were negatively correlated with NPDES discharge and streamflow, with streamflow having the strongest correlation (Kendall's rank correlations, Table 6-2). TDS concentrations at the downstream sites are affected by agricultural irrigation return flows and groundwater seepage in the same manner as discussed above for specific conductivity, calcium, and sulfate (Ali & Gonzalez, HCSP TDS, Sulfate and Calcium Impact Assessment, 2018).

There was an increasing monotonic trend from 2003 to 2023 at both HCSW-1 (Seasonal Kendall, slope = 7.67 mg/L per year) and HCSW-4 (Seasonal Kendall with LOESS, slope = 5.92 mg/L per year, flow-adjusted concentrations, Table 6-3). The trend for TDS and other ions may be 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 (Ali & Gonzalez, HCSP TDS, Sulfate and Calcium Impact Assessment, 2018). There has been only one exceedance of TDS at HCSW-1 during the HCSP POR: 524 mg/L on April 11, 2017, 100 days after the last NPDES discharge (Appendix D).



Red dotted line denotes trigger level.

Figure 6-19 Total Dissolved Solids Concentrations Obtained During Monthly HCSP Water Quality Sampling, HCSP POR

6.3.9 <u>Combined Radium</u>

Combined radium[27] concentrations, were below the trigger level of 5.0 pCi/L at all sites during all monthly sampling in 2023 (Figure 6-20). The major component of combined radium in samples has been radium-226, with the majority of radium-228 being non-detect.

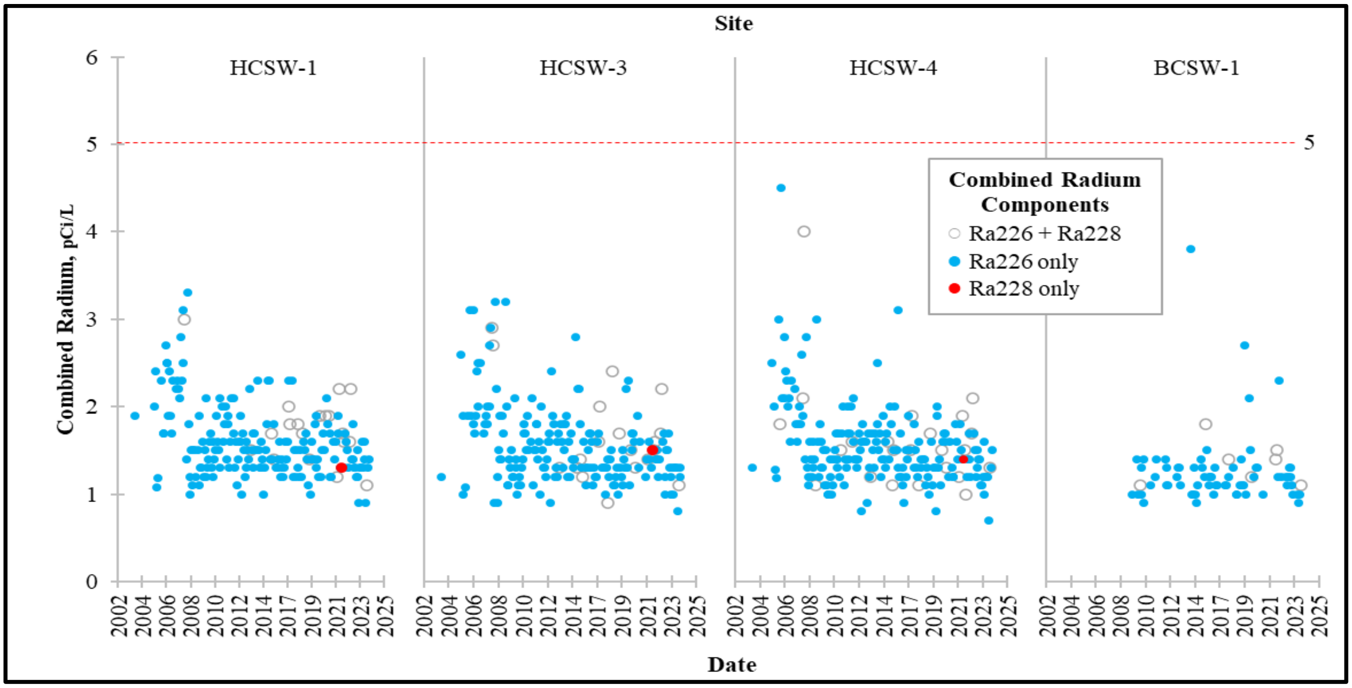
[27] The HCSP methodology specifies that "Radium 226 + 228" be analyzed as part of the monthly sampling. This data has been reported as both individual constituents and as a total. Starting in December 2003 and continuing through the present, the data has been analyzed and reported as Radium 226 and 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." 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 combined radium.

There was no difference in combined radium concentrations among sites from 2003 to 2023 (Kruskal-Wallis, $p > 0.05$, Table 6-1), with all sites being similar to each other (Wilcoxon pairwise comparison, $p > 0.05$). Median values of combined radium were very similar at all sites, with HCSW-1 and HCSW-4 tied for the highest, followed by HCSW-3. Combined radium was negatively correlated with NPDES discharge and streamflow at both HCSW-1 and HCSW-4, with streamflow having the strongest correlation with combined radium at both sites (Kendall's rank correlations, $p < 0.05$, Table 6-2). This indicates that combined radium concentrations are higher when NPDES discharge and streamflow are lower. There was a slight decreasing monotonic trend for combined radium between 2003 and 2023 at both HCSW-1 and HCSW-4 (Seasonal Kendall with LOESS, slope = -0.008 pCi/L per year and -0.001 pCi/L per year, flow adjusted concentrations, respectively, Table 6-3). These trends are opposite that of the HCSP trigger level and are therefore not of concern.

Radium-226 concentrations over the HCSP POR are displayed in Figure 6-21. There was no difference in radium-226 concentrations among sites between 2003 and 2023 (Kruskal-Wallis, $p > 0.05$, Table 6-1), with all sites being similar to each other (Wilcoxon pairwise comparison, $p > 0.05$). Median values for radium-226 were very similar at all sites, with the highest at HCSW-1, followed by a tie at HCSW-3 and HCSW-4. At both HCSW-1 and HCSW-4, radium-226 was negatively correlated with NPDES discharge and streamflow, with streamflow having the strongest correlation at both sites (Kendall's rank correlations, Table 6-2). There was a slight decreasing monotonic trend for radium-226 from 2003 to 2023 at both HCSW-1 and HCSW-4 (Seasonal Kendall with LOESS, slope = -0.004 pCi/L per year and -0.004 pCi/L per year, flow-adjusted concentrations, respectively, Table 6-3). These trends are opposite that of the HCSP trigger level and are therefore not of concern.

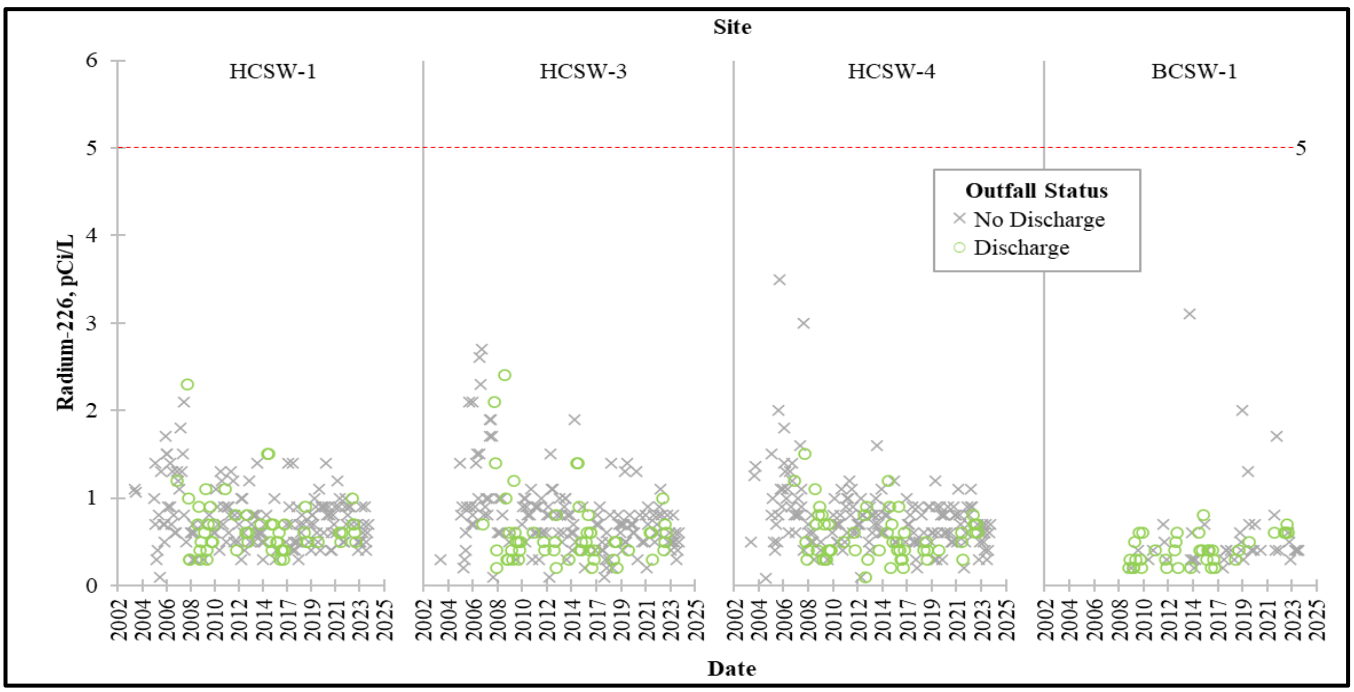
Radium-228 concentrations over the HCSP POR are displayed in Figure 6-21. There was no difference in radium-228 concentrations among sites between 2003 and 2023 (Kruskal-Wallis $p > 0.05$, Table 6-1), with all sites being similar to each other (Wilcoxon pairwise comparison, $p > 0.05$). Median values for radium-228 were similar, with the highest at HCSW-4, followed by HCSW-1 and HCSW-3. Radium-228 was not correlated with any of the water quantity variables (rainfall, NPDES discharge, or streamflow). There was no monotonic trend detected for radium-228 at HCSW-1 or HCSW-4 between 2003 and 2023 (Seasonal Kendall, $p > 0.05$, Table 6-3).

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 F).



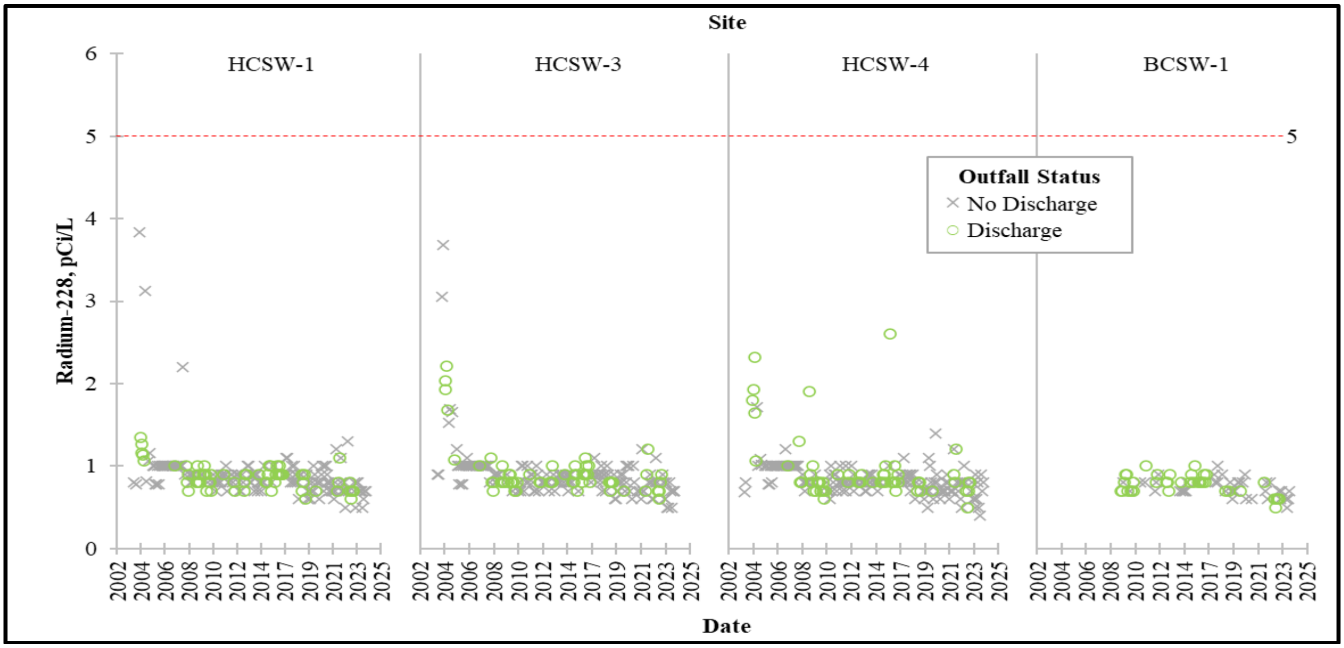
Red dotted line denotes trigger level.

Figure 6-20 Combined Radium Concentrations Obtained During Monthly HCSP Water Quality Sampling, HCSP POR



Red dotted line denotes trigger level.

Figure 6-21 Radium-226 Concentrations Obtained During Monthly HCSP Water Quality Sampling, HCSP POR



Red dotted line denotes trigger level.

Figure 6-22 Radium-228 Concentrations Obtained During Monthly HCSP Water Quality Sampling, HCSP POR

6.4 Summary of Water Quality Results

HCSW-1 is the site with the highest percent of upstream mined lands and the site that receives the most concentrated mining effluent. In 2023, alkalinity was the only parameter with exceedances above the trigger level at HCSW-1 (Figure 6-15, Table 6-4, Appendix D). There was no NPDES discharge in all of 2023, and therefore none of these trigger level exceedances occurred during times of NPDES discharge (Table 6-4, Appendix D).

Ion concentrations were above the trigger levels during low flow periods at HCSW-3 (dissolved calcium, sulfate, and TDS) and HCSW-4 (sulfate and TDS) in 2023 (Figure 6-13, 6-18, 6-19). Based on previous impact assessments, none of the observed exceedances pose a significant adverse ecological impact to Horse Creek that would be attributable to mining. The 2018 Impact Assessment concluded that exceedances predated outfalls and "exceedances also often occurred when there was no discharge, long after there had been a discharge, or during low streamflow conditions" (Appendix E). There were two instances of color values falling below the trigger level, one at HCSW-3 and one at HCSW-4 (Figure 6-5, Table 6-4, Appendix D), during a period of low streamflow and drought conditions (Figure 5-3).

Over the HCSP POR, trends were detected in 16 of the 21 water quality parameters at HCSW-1 and 17 of the 21 parameters at HCSW-4. At HCSW-1, ten of the water quality parameters showed statistically significant trends in the direction of their respective trigger levels, while six of the parameters had statistically significant trends in the opposite direction of their respective trigger levels. The potential trends for pH and specific conductivity (with reference to TDS and other ions) were discussed in the 2017 impact assessment (Appendix E). That study compared water quality trends in Horse Creek and Charlie Creek (a tributary of the Peace River which is used as a reference stream). Both creeks had similar increasing specific conductivity and pH trends over the same period, and 90% of the Horse Creek values fell within the Charlie Creek prediction intervals, despite Charlie Creek not being impacted by mining operations. The assessment concluded that the trends were due to regional land use changes and climatic conditions.

At HCSW-1, parameters with detected trends continue to meet all applicable Class I (potable water) and Class III surface water standards. Significant differences between sites were evident for several parameters. When sites were compared, HCSW-1 had the least similarities with the two other sites. Some nutrients (nitrate-nitrite, total ammonia, TKN, TN) and dissolved ions (specific conductivity, TDS, calcium, chloride, and sulfate) have higher concentrations downstream in Horse Creek (HCSW-3 and HCSW-4), potentially 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 site differences in Horse Creek are examined in the Horse Creek Stewardship Program Historical Report (Durbin and Raymond 2006).

In addition to their respective trigger levels, nutrients (TN and chlorophyll-a) were evaluated against the numeric (or quantitative) component of the NNC at HCSW-1, the site with the highest percentage of upstream mined lands. The annual geometric mean of TN was below the nutrient threshold in 2023, and that threshold has not been exceeded in the prior three years[28]. The annual geometric mean of chlorophyll-a was also below the nutrient threshold in 2023. As of 2023, HCSW-1 is considered to achieve the NNC under F.A.C. 62-302.351(2)(c) because it shows no imbalance of flora and fauna (chlorophyll-a, RPS, and LVS) and has a healthy macroinvertebrate community (SCI, Section 7.0), with an average SCI score ≥40, with neither of the two most recent scores <35[29].

Water quality parameters in 2023 were compared with water quantity variables: average daily streamflow, average daily NPDES discharge, and total daily rainfall at HCSW-1 and HCSW-4 (Table 6-2). At HCSW-1, alkalinity, chloride, DO, pH, radium-226, and combined radium were higher when streamflow was low. Some parameters, such as alkalinity and pH, may increase during these times due to the unique limestone substrate of this site. In addition, the majority of water in the stream during low quantity periods may be from groundwater (seepage or agricultural runoff) which has a higher concentration of dissolved ions than surface water. When streamflow

[28] Annual geometric means for TN: 1.16 mg/L (2023), 0.96 mg/L (2022), and 1.06 mg/L (2021).

[29] Average SCI score at HCSW-1 is 61, calculated from 2007 – 2023. Scores prior to 2007 used a different SCI method. Two most recent SCI scores at HCSW-1 were 67 (December) and 39 (July).

at HCSW-1 was high, concentrations of fluoride, iron, chlorophyll-a, nitrate-nitrite, TKN, TN, color, and turbidity were often elevated. When water quantity is high because of rainfall or streamflow, an increased amount of sediment and organic debris is washed into the stream, as well as runoff from agriculture, leading to increases in fluoride, iron, nutrients, turbidity, and color.

At HCSW-1, fluoride, sulfate, calcium, orthophosphate, TDS, and specific conductivity, were the only parameters that showed a stronger correlation to the NPDES discharge than rainfall or streamflow. There have been no exceedances of fluoride, sulfate, calcium, orthophosphate, or specific conductivity at HCSW-1 and just one exceedance of TDS over the HCSP POR. The single TDS exceedance at HCSW-1 occurred on April 11, 2017, during a period of low flow and no NPDES discharge, and there had been no NPDES discharge to Horse Creek in 124 days.

Table 6-4 Instances of Verified Trigger Level Exceedances Observed in 2023 HCSP Monthly Monitoring

Site	Date	Analyte	Result	Trigger Level	Last NPDES Discharge, days
HCSW-1	02/07/23	Alkalinity	104 mg/L	>100 mg/L	80
HCSW-1	03/07/23	Alkalinity	127 mg/L	>100 mg/L	108
HCSW-4	03/07/23	Dissolved Solids, Total	514 mg/L	>500 mg/L	108
HCSW-1	04/11/23	Alkalinity	177 mg/L	>100 mg/L	143
HCSW-3	04/11/23	Dissolved Solids, Total	595 mg/L	>500 mg/L	143
HCSW-3	04/11/23	Sulfate	332 mg/L	>250 mg/L	143
HCSW-3	04/11/23	Calcium, Dissolved	117 mg/L	>100 mg/L	143
HCSW-4	04/11/23	Alkalinity	118 mg/L	>100 mg/L	143
HCSW-1	05/04/23	Alkalinity	184 mg/L	>100 mg/L	166
HCSW-3	05/04/23	Color, Apparent	20 PCU	<25 PCU	166
HCSW-3	05/04/23	Dissolved Solids, Total	786 mg/L	>500 mg/L	166
HCSW-3	05/04/23	Sulfate	445 mg/L	>250 mg/L	166
HCSW-3	05/04/23	Calcium, Dissolved	121 mg/L	>100 mg/L	166
HCSW-4	05/04/23	Alkalinity	101 mg/L	>100 mg/L	166
HCSW-4	05/04/23	Color, Apparent	20 PCU	<25 PCU	166
HCSW-1	06/13/23	Alkalinity	111 mg/L	>100 mg/L	206
HCSW-1	07/11/23	Alkalinity	133 mg/L	>100 mg/L	234
HCSW-3	07/11/23	Dissolved Solids, Total	505 mg/L	>500 mg/L	234
HCSW-4	07/11/23	Dissolved Solids, Total	560 mg/L	>500 mg/L	234
HCSW-4	07/11/23	Sulfate	279 mg/L	>250 mg/L	234
HCSW-1	08/08/23	Alkalinity	104 mg/L	>100 mg/L	262
HCSW-4	08/08/23	Dissolved Solids, Total	506 mg/L	>500 mg/L	262

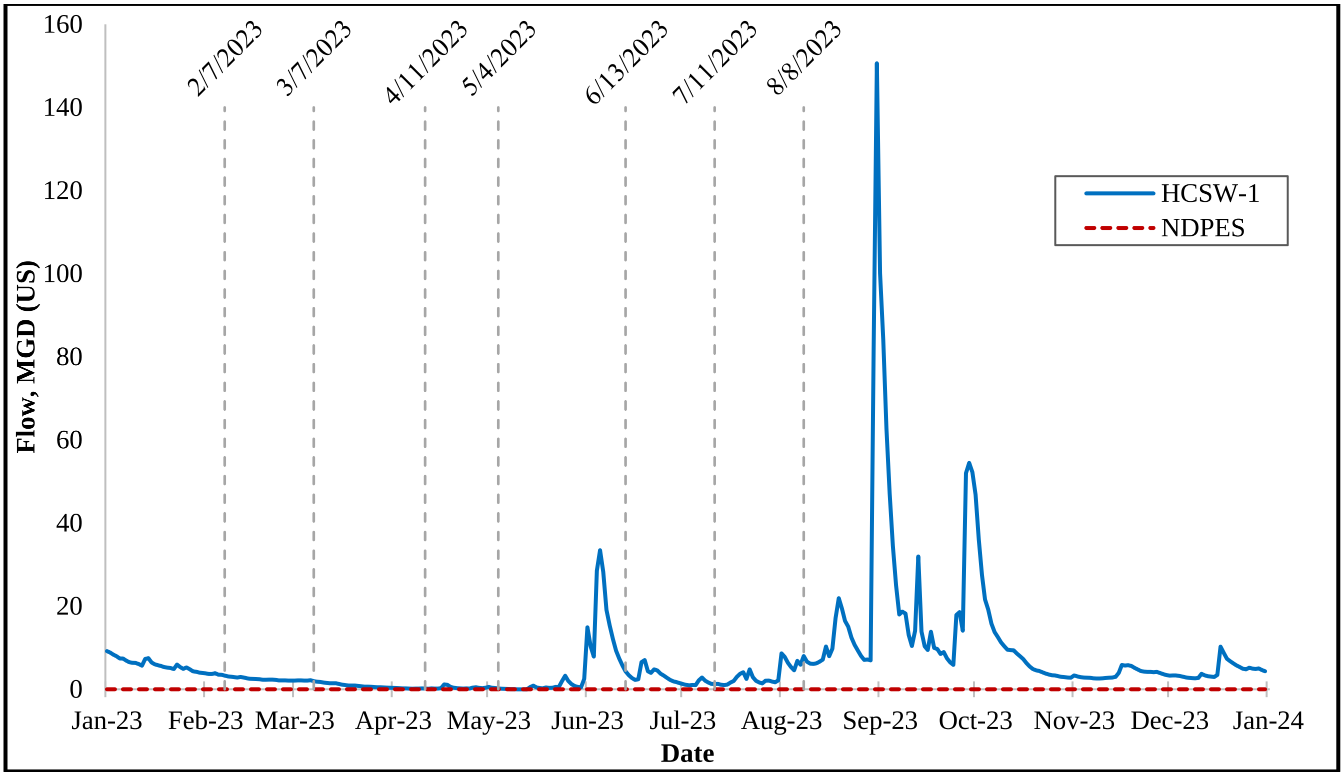


Figure 6-23 Water Quality Trigger Level Events vs Streamflow and Combined NPDES Discharge at HCSW-1, 2023

7.0 MACROINVERTEBRATE RESULTS

7.1 Benthic Macroinvertebrates

Benthic macroinvertebrate sampling was conducted at HCSW-1, HCSW-3, and HCSW-4 during all three sampling events in 2023. The Brushy Creek location is not included in the macroinvertebrate sampling component of the HCSP.

7.2 Stream Habitat Assessment

The habitat assessment parameters evaluated through this DEP procedure are related to the nature of the system being examined and its surroundings (e.g., stream substrate diversity and availability, water velocity, habitat smothering, artificial channelization, bank stability, riparian buffer width and riparian vegetation quality) and not directly associated with mining impacts. Water velocity and habitat smothering are parameters most likely to correlate with high flow conditions. The HA is a qualifier for water quality and biodiversity outcomes. A stream's HA score typically has a positive correlation with the biological response (e.g., SCI and Shannon-Wiener), except when there is some other inhibiting factor (e.g., poor water quality or environmental perturbation). If a stream scores low on an HA, the expectation is the site will have a low biological response score regardless of water quality.

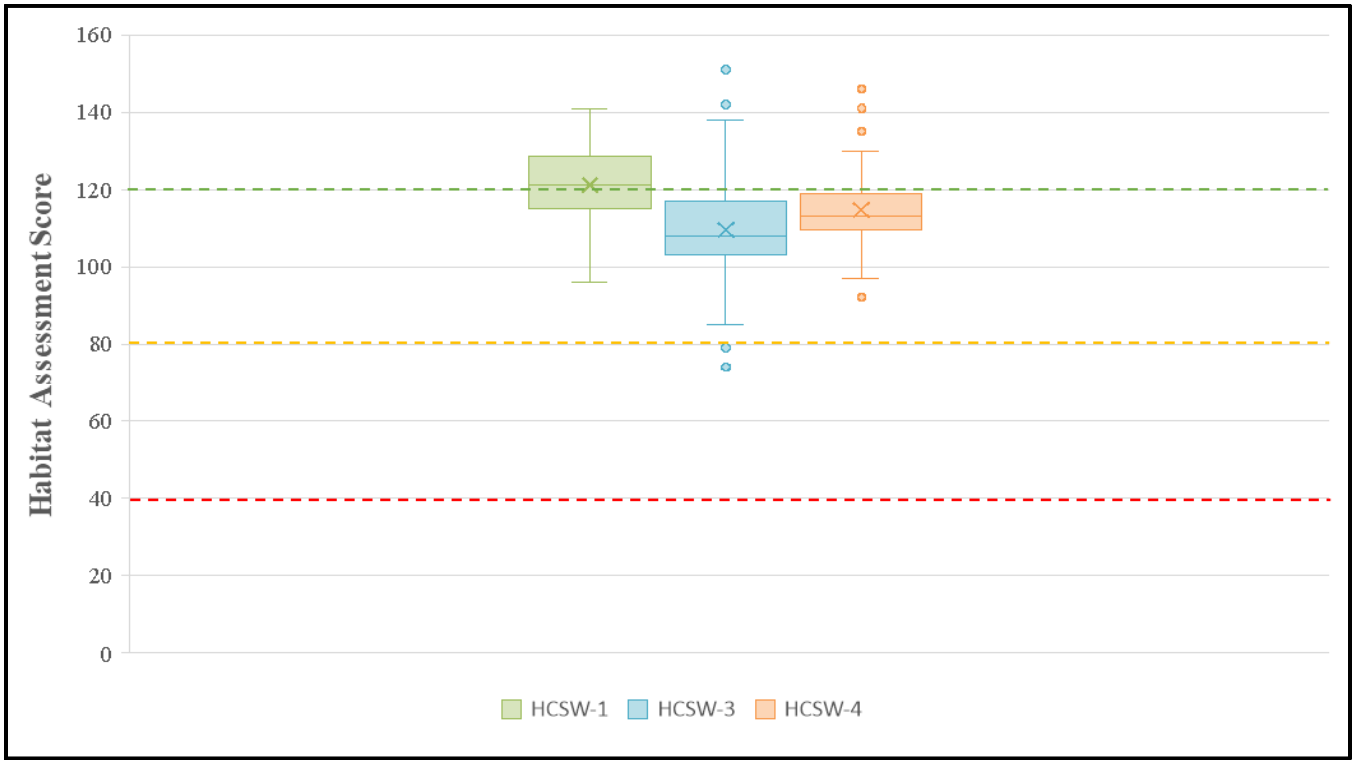
Habitat assessments rate productive habitats by the degree of smothering (none, slight, moderate, or severe). Sites further upstream in a basin (e.g., HCSW-1) tend to be less affected by habitat smothering because the drainage area is smaller, and streamflow and sediment load contributions are lesser compared to downstream conditions. Productive habitats (aquatic vegetation, leaf packs, rock, roots, and snags) further downstream in a drainage basin (e.g., HCSW-3 and HCSW- 4) are more susceptible to sediment smothering due to a larger drainage area, increased flow, higher sediment loads, and lower water velocities.

Once completed, HA scores are assigned to one of four categories (Optimal: 160 to 121 points, Sub-optimal: 120 to 81 points, Marginal: 80 to 41 points, and Poor: 40 to 11 points). The HA scores for Horse Creek ranged between 104 and 124 during all sampling events in 2023 (Table 7-1, Figure 7-1). Most scores fell into the category of "Sub-optimal" except for HCSW- 1 and HCSW-4 in March 2023, which scored in the "Optimal" category. The main factors that led to higher scores at HCSW-1 and HCSW-4 earlier in the year included having more substrate diversity and availability (relative to the stream segment size). Comparatively, factors that led to the slightly lower score observed at HCSW-3 earlier in the year included the lack of quality habitat and bank erosion, likely due to habitat smothering and cattle activity. Throughout the remainder of the year, scores were similar between sites.

Table 7-1 Habitat Scores Obtained During HCSP Biological Sampling Events in 2023

Habitat Characteristic[1]		HCSW-1			HCSW-3			HCSW-4		
		Mar. 8, 2023	Jul. 6, 2023	Dec. 6, 2023	Mar. 8, 2023	Jul. 6, 2023	Dec. 6, 2023	Mar. 8, 2023	Jul. 6, 2023	Dec. 6, 2023
Substrate Diversity (20)		13	8	14	5	9	4	10	9	10
Substrate Availability (20)		9	8	8	5	2	1	5	5	2
Water Velocity (20)		16	20	15	14	20	14	18	20	14
Habitat Smothering (20)		18	13	15	17	14	12	15	12	11
Artificial Channelization (20)		20	20	20	20	20	20	20	20	20
Bank Stability (10 each bank)	Right Bank	4	5	5	8	8	8	9	8	5
	Left Bank	5	6	6	9	7	7	9	6	8
Riparian Buffer Zone Width (10 each bank)	Right Bank	10	10	10	10	10	10	10	10	10
	Left Bank	10	10	10	10	10	10	10	10	10
Riparian Zone Vegetation Quality (10 each bank)	Right Bank	8	7	8	9	9	9	9	7	7
	Left Bank	8	7	8	9	8	9	9	7	7
Total Score[2]		121	114	119	116	117	104	124	114	108
Categorical Score		Optimal	Sub-optimal	Sub-optimal	Sub-optimal	Sub-optimal	Sub-optimal	Optimal	Sub-optimal	Sub-optimal

[1] Max scores for each metric in parentheses.
[2] The maximum possible score under this protocol is 160 (160-121 Optimal, 120-81 Suboptimal, 80-41 Marginal, 40-11 Poor)



Green dashed line, lower end of optimal score range (121)
Yellow dashed line, lower end of sub-optimal score range (81)
Red dotted line, lower end of marginal score range (41)

Figure 7-1 Total Habitat Scores Obtained During HCSP Biological Sampling Events at All Locations from 2003 to 2023

7.3 Stream Condition Index

A list of benthic macroinvertebrate taxa collected from 2003 to 2023 can be found in the attached database file[30]. Table 7-2 provides the SCI metrics along with their resulting SCI values and the total SCI scores calculated as a vial replicate average for the benthic macroinvertebrates collected at all sampled sites in 2023. It also includes the number of individuals extracted from the composited sample for identification (i.e., all 20 dipnet sweeps), which were analyzed by the WSP Global Inc. taxonomy laboratory.

In 2023, SCI scores were higher during the spring and winter sampling events compared to the summer event, with the highest scores occurring in the spring. Typically, fall and summer SCI scores are lower. High flow conditions often cause bank scouring, especially in areas where the

[30] Beginning with the 2010 annual report, the HCSP SCI data was reevaluated with strict interpretation of DEP 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 addition, some SCI results with more than the target number of individuals were randomly resampled to provide an unbiased result.

riparian buffer quality is poor. Bank scouring leads to erosion and habitat smothering. Summer is also associated with rapidly fluctuating water levels which inhibit aquatic macrophyte establishment and lower available light to productive habitats, therefore lowering substrate diversity and availability.

In March, all sampled sites were considered healthy or "passing" (averages of all SCI scores to that point were ≥40, with neither of the two most recent scores <35). After the July sampling event, HCSW-1 was still considered healthy, while HCSW-3 and HCSW-4 received impaired scores for this event (≤34). By December, HCSW-1 was still considered healthy and scores improved above the impaired threshold at HCSW-3 and HCSW-4. However, with one of their two most recent scores still below 35, these segments are considered impaired until they receive a subsequent score above that threshold.

Scores ranged from 20 (Impaired, HCSW-3, July) to 69 (Exceptional, HCSW-3, March) in 2023, mostly similar to other years (Table 7-2 and Figure 7-2). HCSW-3 having both the lowest and highest scores in 2023 highlights the seasonal variability of this system. The taxonomic laboratory also noted that the dominance of an exotic snail, *Mieniplotia scabra*, was a significant factor contributing to the lower scores at HCSW-3 and HCSW-4 in July. The first established populations of this non-native snail were reported in South Florida in 2018, theorized to be an aquarium trade introduction. More recent reports show their range expanding further north, including into the Peace River Basin (Benson, A.J., 2024).

The 2012 method[31] SCI scores (2007 – 2023) were evaluated for differences using the Kruskal- Wallis test with Benjamini-Hochberg adjustment. There was no difference in SCI scores among sites (Kruskal-Wallis, $p > 0.05$), with all sites being similar to each other (Wilcoxon pairwise comparison, $p > 0.05$).

SCI scores between 2007 and 2023 were examined for monotonic trends using an annual and seasonally adjusted Kendall trend analysis at each site. The sole detected trend in SCI scores was a seasonally adjusted value of -0.8 SCI units per year (Tau = -0.28, $p < 0.05$) at HCSW-3. When SCI scores from all sites were combined, there were no significant monotonic trends detected over time both in the annual and seasonally adjusted Kendall ($p > 0.05$).

Macroinvertebrate taxa richness from 2007 to 2023 was also examined for monotonic trends using an annual and seasonal Kendall trend analysis for each site. There was a significant increasing monotonic trend detected at HCSW-1 in both the annual and seasonal Kendall (0.51 units per year, Tau = 0.31, $p < 0.05$ and 0.53 units per year, Tau = 0.25, $p < 0.05$, respectively). When combining taxa richness from all sites, there were no monotonic trends detected in either the annual or seasonal Kendall ($p > 0.05$).

[31] The SCI method was revised in 2007 with final adoption in 2012. Scores prior to 2007 are not comparable to modern SCI scores due to the revised laboratory sorting techniques (Appendix F).

Table 7-2 SCI Metrics Calculated for Benthic Macroinvertebrates Collected at Each HCSP Location in 2023

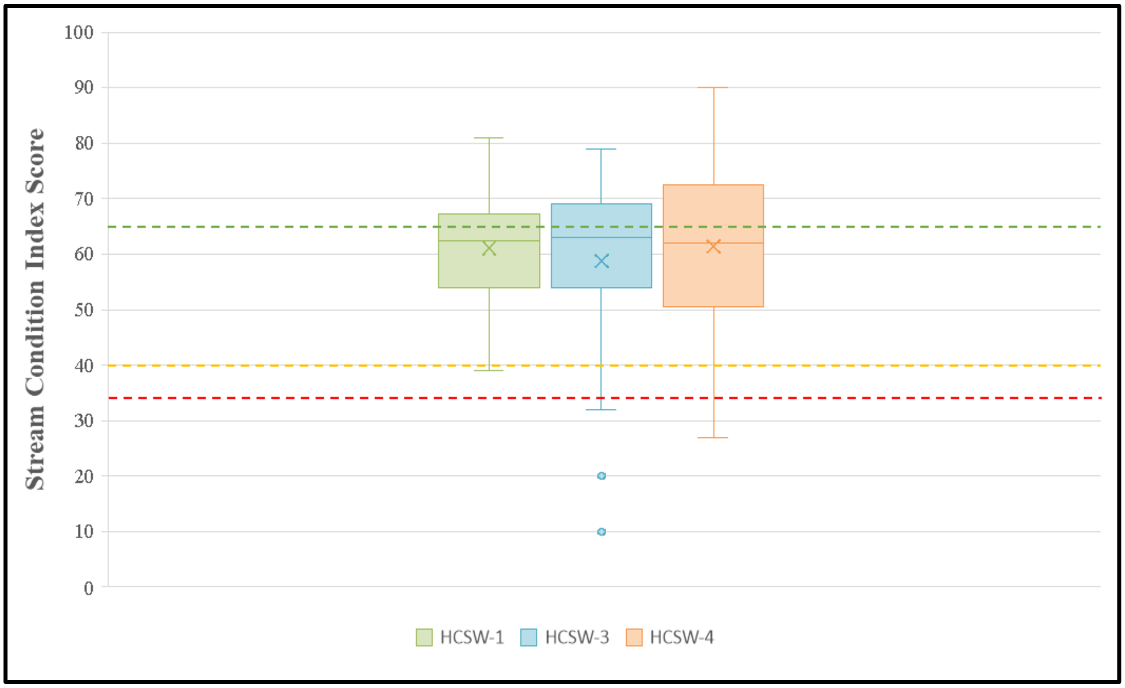
SCI Metric	HCSW-1			HCSW-3			HCSW-4		
	Mar. 8, 2023	Jul. 6, 2023	Dec. 6, 2023	Mar. 8, 2023	Jul. 6, 2023	Dec. 6, 2023	Mar. 8, 2023	Jul. 6, 2023	Dec. 6, 2023
Total Taxa	9.58	5.83	17.50	8.75	0.83	8.75	4.58	6.25	10.42
Ephemeropteran Taxa	6.00	8.00	16.00	20.00	8.00	12.00	14.00	12.00	16.00
Trichopteran Taxa	11.43	8.57	12.86	5.71	1.43	2.86	5.71	7.14	11.43
Percent Filterer Taxa	3.58	6.42	3.20	8.63	2.44	1.39	3.13	0.70	3.17
Clinger Taxa	12.86	10.00	17.14	12.86	1.43	10.00	12.86	7.14	18.57
Long-lived Taxa	13.33	10.00	6.67	10.00	13.33	3.33	3.33	0.00	10.00
Percent Dominant Taxon	17.11	6.05	17.50	16.71	1.34	11.90	2.69	0.57	8.56
Percent Tanytarsini	9.94	4.56	7.69	18.31	0.00	4.01	10.52	1.43	5.58
Sensitive Taxa	5.71	1.43	8.57	5.71	0.00	2.86	7.14	5.71	11.43
Percent Very Tolerant Taxa	10.43	9.41	12.69	17.37	8.08	8.17	20.00	9.75	15.32
Total SCI Score[1]	**56**	**39**	**67**	**69**	**20**	**36**	**47**	**28**	**61**
Healthy/Impaired	**Healthy**	**Healthy[2]**	**Exceptional**	**Exceptional**	**Impaired**	**Impaired[3]**	**Healthy**	**Impaired**	**Impaired[4]**
Total Number of Individuals	292	317	297	289	311	298	316	318	313

[1] SCI Score Categories: Category 1 – Exceptional (scores ≥65); Category 2 – Healthy (average scores ≥40); and Category 3 – Impaired (scores ≤34). To be considered healthy, a site's average SCI score must be ≥40, with neither of the two most recent scores <35.

[2] Average SCI score up to July 2023 event is 61, two most recent scores >35; site is considered healthy.

[3] Average SCI score up to December 2023 event is 59, one of the two most recent scores is <35; site is considered impaired.

[4] Average SCI score up to December 2023 is 61, one of the two most recent scores is <35; site is considered impaired.



Green dashed line = "Exceptional" (>65)
Yellow dashed line = "Healthy" (average score ≥40)
Red dashed line = "Impaired" (≤34)

Figure 7-2 SCI Scores for Samples Collected at All HCSP Sites from 2007 to 2023

7.3.1 SCI Metrics

Healthy stream systems generally support a higher number of taxa than disturbed streams, as reflected in the SCI metric for Total Taxa. At least 16 taxa must be identified in a sample to achieve a Total Taxa score above zero (Table 7-2, above). Except for one replicate at HCSW-3 in July, at least 16 taxa were collected in all other replicates across all sampled sites in 2023 (Figure 7-3, Table 7-2).

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 each replicate across all sampled sites in 2023.

Trichopterans, or caddisflies, are associated with more pristine waters, better habitats, a system with adequate flow, and DO; therefore, higher counts for the Trichopterans Taxa metric are associated with better ecological conditions. At least one caddisfly taxon must be collected for this SCI metric to be above zero. Except for one replicate at HCSW-3 in July, Trichopterans were collected in all other replicates across all sampled sites in 2023.

Of the functional feeding group measures, the relative abundance of filterers or suspension feeders (percentage of filterer individuals) has the highest correlation and most consistent relationship with human disturbance because they extract nutrients by straining food particles from the water column. If the water flow or quality of naturally occurring detritus 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. Each replicate across all sampled sites exhibited greater than one percent collector- filterers in 2023.

Clingers are taxa morphologically adapted to hold onto substrates in streams with adequate water velocity and are expected to decline as humans alter a stream's hydrograph (e.g., channelization, and land use changes) especially during flash flood events caused by high stormwater inputs from impervious surfaces. To score above zero for this SCI metric, at least one clinger taxon must be present in a sample. Except for one replicate at HCSW-3 in July, clinger taxa were present in all other replicates across all sampled sites in 2023.

Long-lived taxa 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 dry out 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. One replicate at HCSW-4 in March, both replicates at HCSW-4 in July, and one replicate at HCSW-3 in December did not have any long-lived taxa present in 2023. Long-lived taxa were present in the remaining replicates across all sampled sites in 2023.

Substantial shifts in proportions of major groups of organisms compared to reference conditions may indicate degradation. When pollution tolerant organisms displace other taxa, reducing taxa evenness, the percent dominant taxon metric decreases. The SCI score is zero if the Percent Dominant Taxa metric reaches or surpasses 64%. In 2023, the range across all sampled sites was 17.12% (HCSW-1, March) – 65.58% (HCSW-3, July), with only the one replicate at HCSW-3 surpassing 64%.

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 this metric score. If there are no Tanytarsini individuals in a sample, this SCI metric score is zero. In 2023, both replicates at HCSW-3 in July and one replicate at HCSW-4 in July did not have Tanytarsini individuals, while all remaining replicates across all sites did. The range of Percent Tanytarsini across all sampled sites was 0% (HCSW-3, HCSW-4, July) – 26.85% (HCSW-3, March).

Sensitive taxa refer to macroinvertebrates that are sensitive to human disturbance; therefore, more sensitive taxa would be present in undeveloped "natural" areas as opposed to watersheds with more man-made alterations. At least one sensitive taxon must be collected to raise the Number of Sensitive Taxa metric score above zero. In 2023, sensitive taxa were absent from one replicate at HCSW-1 in July, and both replicates at HCSW-3 in July. Sensitive taxa were collected in all remaining replicates across all sampled sites.

A number of taxa have been classified as "very tolerant" and are commonly present in areas with marked human disturbance (although they can be found in undisturbed sites as well). Therefore, more disturbed and/or developed areas are expected to have a higher percentage of tolerant taxa in comparison to areas that have not experienced human disturbance. Except for one replicate at HCSW-4 in March, all other replicates across all sampled sites contained very tolerant taxa in 2023. The range of Percent Very Tolerant Taxa for all replicates across all sampled sites was 0% (HCSW-4, March) – 22.73% (HCSW-3, July).

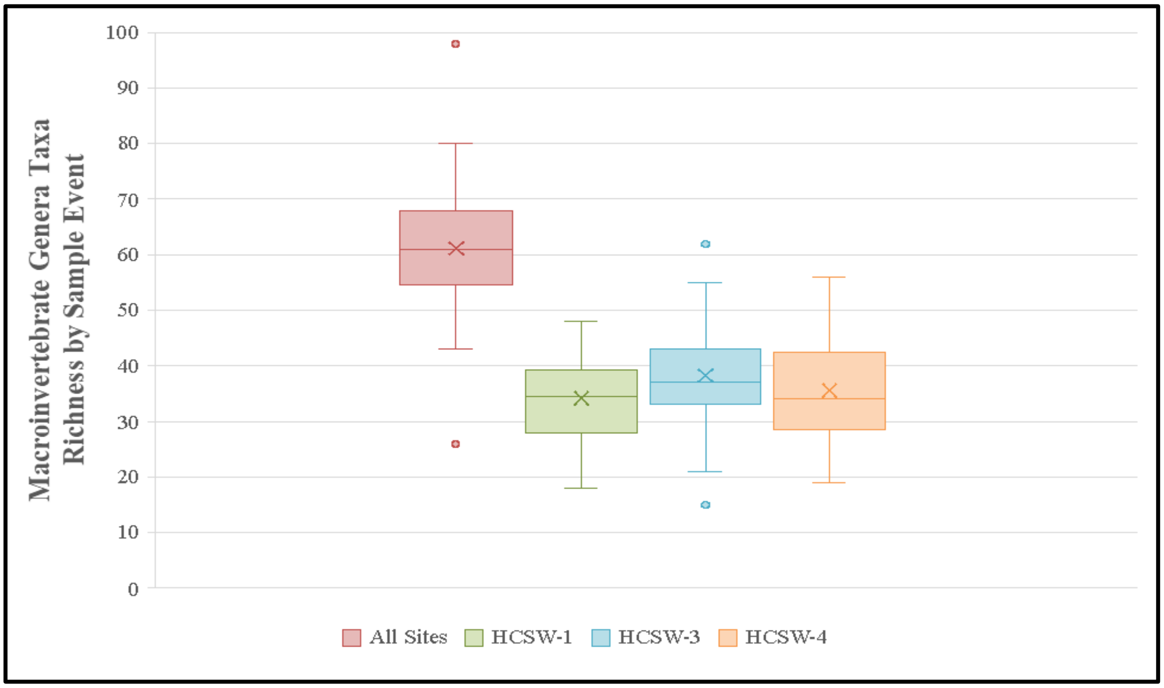


Figure 7-3 Macroinvertebrate Taxa Richness, 2007 - 2023

7.4 Shannon-Wiener Diversity Index

Although not a component of the SCI protocol, the Shannon-Wiener Diversity Index is calculated for generic diversity and evenness for each benthic macroinvertebrate sampling event at each location. This index 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 & Reynolds, 1988). The Shannon-Wiener Index assumes that all taxa are represented in a sample and that the sample was obtained randomly.

Equation 4 Shannon-Wiener Index (H')

$$\text{H}' = \sum_{i=1}^{S} p_i \log_2 p_i$$

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

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'. As diversity increases in a given sample, the value of H' increases. Therefore, a community with a higher Shannon-Wiener score (H') would indicate higher diversity.

For the Horse Creek macroinvertebrate data, genera diversity[32], rather than species diversity, was used to account for the high variability of species present from year to year. In 2023, the Shannon-Wiener Diversity Index scores for benthic macroinvertebrates calculated by sample event and site ranged from 2.16 H' (HCSW- 3, July) to 4.33 H' (HCSW-1, March). From 2007 to 2023, diversity scores between sites calculated by sample event were significantly different (Kruskal-Wallis, $p < 0.05$, Figure 7-4), with HCSW-1 scores being significantly different from HCSW-3 (Wilcoxon pairwise comparison, $p < 0.05$). Diversity scores calculated by sample event and site were examined for monotonic trends using an annual and seasonally adjusted Kendall trend analysis at each site and with all sites combined. A significant increasing monotonic trend was detected at HCSW-1 of 0.05 H' per year (Tau = 0.28, $p < 0.05$) and a significant decreasing monotonic trend was detected at HCSW-4 of -0.03 H' per year (Tau = -0.24, $p < 0.05$) in the seasonally adjusted Kendall. A significant increasing monotonic trend was detected at HCSW-1 of 0.04 H' per year (Tau = 0.22, $p < 0.05$) and a significant decreasing monotonic trend was detected at HCSW-4 of -0.04 H' per year (Tau = -0.21, $p < 0.05$) in the annual Kendall. When combining all sites, there were no monotonic trends detected for diversity scores in either the annual or seasonal Kendall ($p > 0.05$).

In 2023, the Shannon-Wiener Diversity Index scores for benthic macroinvertebrates calculated by year and site (annual scores) ranged from 3.01 H' (HCSW-4) to 4.03 H' (HCSW-1). There was no difference in annual diversity scores among sites from 2007 to 2023 (Kruskal-Wallis, $p > 0.05$), with all sites being similar to each other (Wilcoxon pairwise comparison, $p > 0.05$). Annual diversity scores were examined for monotonic trends using an annual Kendall trend analysis at

[32] 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.

each site and with all sites combined. A significant increasing monotonic trend was detected at HCSW-1 of 0.06 H' per year (Tau = 0.41, $p < 0.05$) and a significant decreasing monotonic trend was detected at HCSW-4 of -0.05 H' per year (Tau = -0.41, $p < 0.05$) in the annual Kendall. When combining all sites, there were no monotonic trends detected for annual diversity scores in the annual Kendall ($p > 0.05$).

Annual Shannon-Wiener diversity scores in 2023 were above average at HCSW-1, and below average at HCSW-3, HCSW-4, and when all sites were combined. When all sites were combined, the annual Shannon-Weiner score for 2023 ranked 16th out of 17 years (3.75 H', 2007 – 2023). When results from all events between 2007 and 2023 were combined by site, Shannon-Wiener diversity scores were >4 at all sites, with HCSW-3 having a score >5 (Figure 7-6).

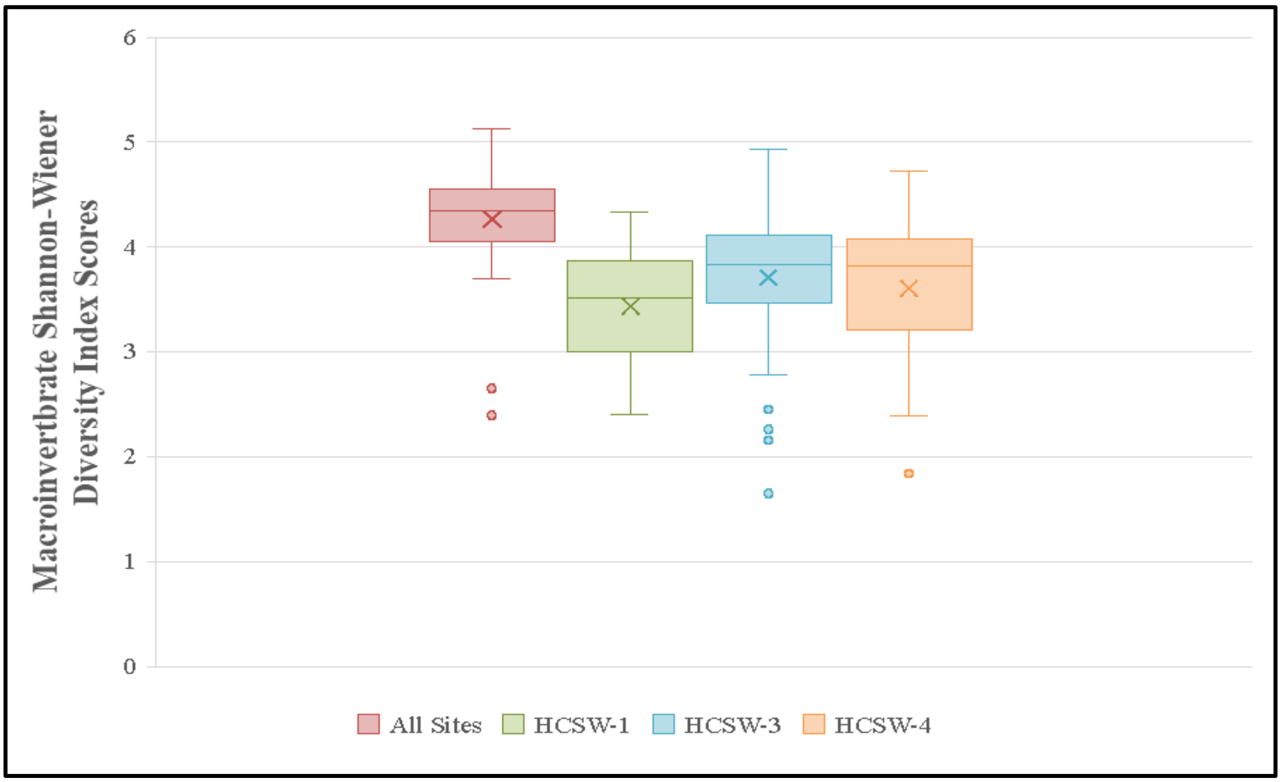


Figure 7-4 Macroinvertebrate Shannon-Wiener Diversity Index Scores by Sample Event and Site, 2007 to 2023

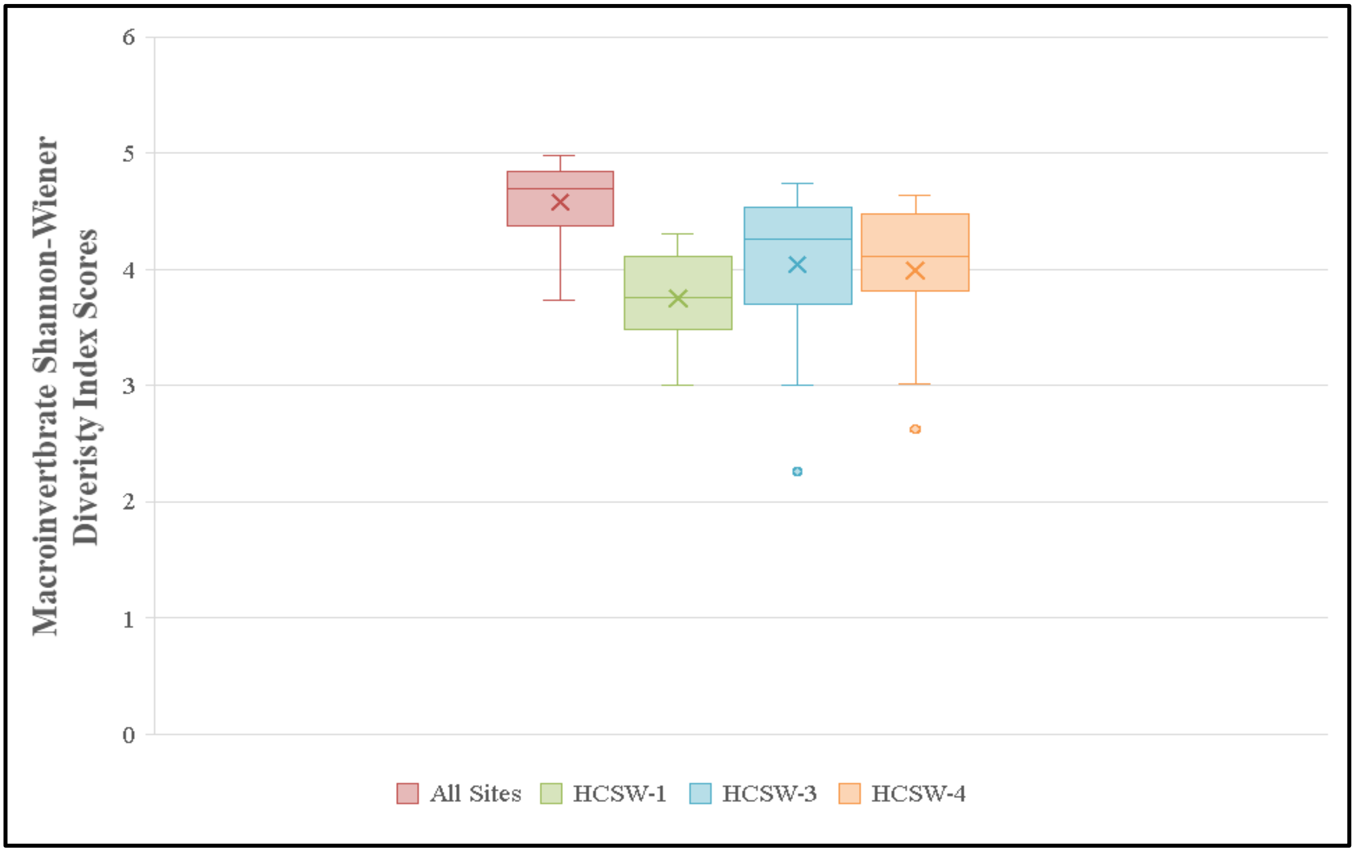


Figure 7-5 Annual Macroinvertebrate Shannon-Wiener Diversity Index Scores, 2007 – 2023

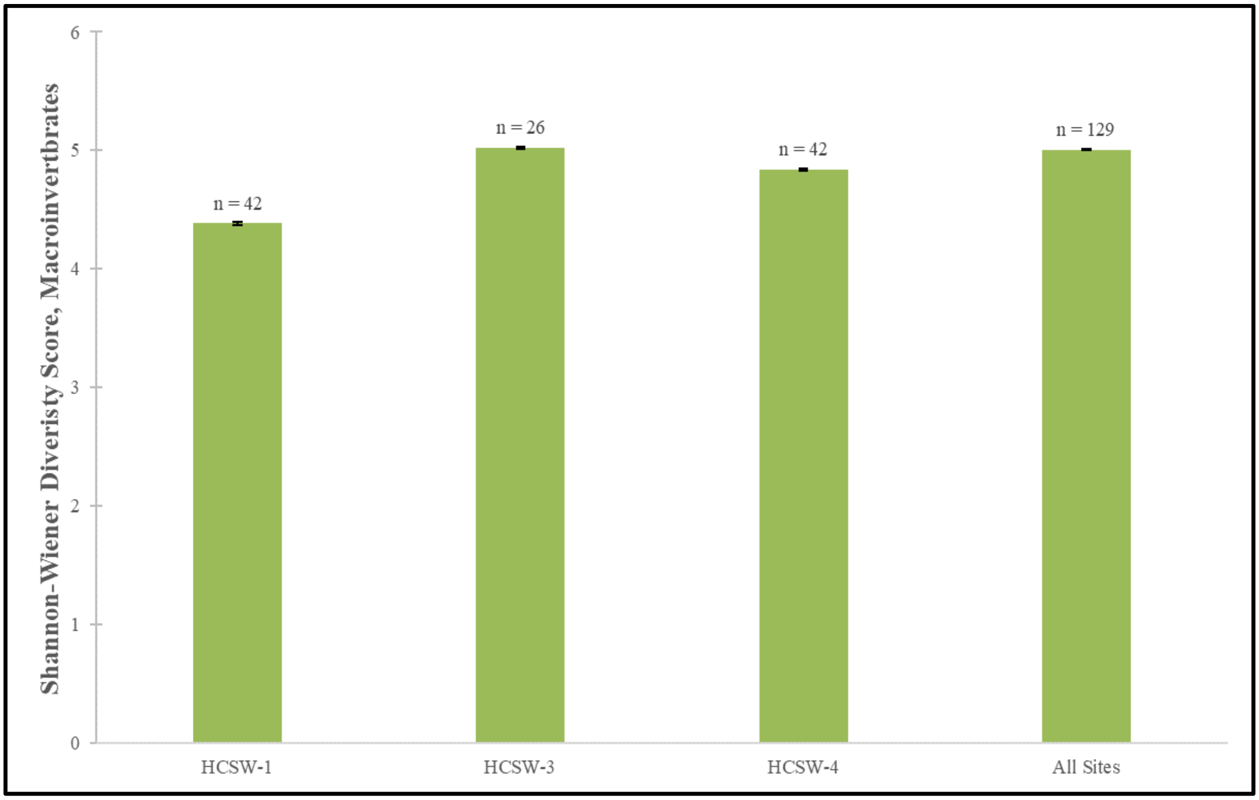


Figure 7-6 Shannon-Wiener Diversity Indices for Benthic Macroinvertebrate Genera per Site, 2007 – 2023[33]

7.5 Summary of Benthic Macroinvertebrate Results

Most sampling events resulted in categorical habitat assessment scores of "Sub-optimal", with HCSW-1 and HCSW-4 scoring in the "Optimal" category during the March sampling event. Factors that led to higher habitat assessment scores at HCSW-1 and HCSW-4 earlier in the year included having more substrate diversity and availability (relative to the stream segment size). Comparatively, factors that led to the slightly lower score observed at HCSW-3 earlier in the year included the lack of quality habitat and bank erosion, likely due to habitat smothering and cattle activity on the stream bank. Throughout the remainder of the year, scores were similar between sites.

HCSW-1 was the only sampled site to remain healthy or "passing" under the SCI protocol throughout 2023. HCSW-3 and HCSW-4 received impaired scores during the July sampling event but scored above the impaired threshold during the following sample event. Because one of their two most recent scores still below 35, these segments are considered impaired until they receive a subsequent score above that threshold. While unrelated to mining activities, the

[33] Error bars = 95% confidence intervals, n = sample size

dominance of an exotic snail, *Mieniplotia scabra*, was a significant factor contributing to the impaired scores at HCSW-3 and HCSW-4 in July.

HCSW-1 is the site closest to the NPDES outfalls and the only site that has consistently scored in the "healthy" to "exceptional" SCI range[34]. HCSW-4 is the furthest site from the NPDES outfalls and is tied with HCSW-1 for having the highest SCI average[35] over the 2007 - 2023 period. The differing categorical strengths at both sites can be attributed to the respective stream orders in which both sites are situated. HCSW-1 is located in the sheltered third 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 fourth order reach with an open-light canopy, fed by a number of first, second, and third 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 quality, HCSW-4 remains a highly productive site because it is connected to numerous sources of habitat and forage.

8.0 FISH RESULTS

In 2023, fish sampling was conducted at HCSW-1, HCSW-3, and HCSW-4 during all three sample events. The Brushy Creek location is not included in the fish sampling component of the HCSP.

During 2023, 21 species of fish were collected from the sampled Horse Creek sites (Table 8-1). No new fish species were observed in 2023 that were not previously observed at one of the sites, nor were any new species observed when considered at a site level. A total of 43 species of fish[36] have been observed from these three sites from 2003 to 2023, with a range of 12 to 32 species seen each year.

Of the native species collected from 2003 to 2023, most are common regionally, and none were unexpected for this portion of Florida. Live bearers (*Poeciliidae*), carps and minnows (*Cyprinidae*), sunfish (*Centrarchidae*), and Old-World silversides (*Atherininidae*) were the most commonly collected fish families during this time period. Eleven of the 43 species collected from 2003 to 2023 are not native to Florida: the African jewelfish (*Hemichromis letourneuxi*), Asian swamp eel (*Monopterus javanensis*), blue tilapia (*Oreochromis aureus*), brown hoplo (*Hoplosternum littorale*), leopard pleco (*Pterygoplichthys gibbiceps*), Nile tilapia[37] (*Oreochromis niloticus*), oriental weatherfish (*Misgurnus anguillicaudatus*), Orinoco sailfin catfish (*Pterygoplichthys multiradiatus*), sailfin catfish (*Pterygoplichthys pardalis*), vermiculated sailfin catfish[38] (*Pterygoplichthys disjunctivus*), and walking catfish (*Clarias batrachus*).

[34] Based on 2007-present scores i.e., scores calculated with the current 2012 SCI methodology.
[35] Average SCI scores (2007 - 2023) for sites HCSW-1, HCSW-3, and HCSW-4 were 61, 59, and 61, respectively.
[36] 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.
[37] Previously identified in 2014 Annual Report as *Oreochromis aureus* (blue tilapia). Confirmation identification as *O. niloticus* by FLMNH.
[38] Previously identified in 2004 Annual Report as *Hypostomus plecostomus* (suckermouth catfish). Confirmation identification as *P. disjunctivus* by FLMNH.

Table 8-1 Fish Collected from Horse Creek in 2023

Scientific Name	Common Name	HCSW-1			HCSW-3			HCSW-4			Total
		9-Mar	27-Jul	7-Dec	9-Mar	27-Jul	7-Dec	9-Mar	27-Jul	7-Dec	
Clarias batrachus	Walking Catfish						2		1		3
Etheostoma fusiforme	Swamp darter							1			1
Fundulus seminolis	Seminole Killifish				3		3			2	8
Gambusia holbrooki	Eastern Mosquitofish	49	7	36	217	55	166	64	44	33	671
Hemichromis letourneuxi	African Jewelfish						1	1			2
Heterandria formosa	Least Killifish	3			3	2		2	1		11
Hoplosternum littorale	Brown Hoplo							2			2
Ictalurus punctatus	Channel catfish							3	1		4
Labidesthes vanhyningi	Golden Silverside	7	4	11	20	2	40		4	48	136
Lepisosteus platyrhincus	Florida gar					2					2
Lepomis gulosus	Warmouth							1			1
Lepomis macrochirus	Bluegill	11	4	3	9	7	13	10	2	25	84
Lepomis microlophus	Redear sunfish	1			4		1	2			8
Lepomis punctatus	Spotted sunfish									1	1
Micropterus salmoides	Largemouth bass				5	1				1	7
Monopterus javanensis	Asian Swamp Eel		1	2			3	4	3	1	14
Notropis chalybaeus	Ironcolor Shiner	76			2		1				79
Notropis petersoni	Coastal Shiner	1		1	10	1	8	10	2	1	34
Poecilia latipinna	Sailfin Molly				63	50	12	11	1		137
Pterygoplichthys disjunctivus	*Vermiculated sailfin catfish*				2						2
Trinectes maculatus	Hogchoker				8	1		1		7	17
Total Taxa		7	4	5	12	9	11	13	9	9	21
Number of Individuals		148	16	53	346	121	250	112	59	119	1224
% Invasive		0%	6%	3.77%	0.58%	0%	2.40%	6.25%	6.78%	0.84%	1.88%

Invasive species are highlighted in red.

8.1 Fish Taxa Richness and Abundance

Most individuals collected in 2023 consisted of eastern mosquitofish (*Gambusia holbrooki*), ironcolor shiners (*Notropis chalybaeus*), sailfin mollies (*Poecilia latipinna*), or golden silversides[39] (*Labidesthes vanhyningi*) across all sample sites. This can generally be attributed to conditions that are conducive to seining for small species. Exotic/invasive fish were captured at all sampled sites in 2023. A slightly lower number of taxa were collected at HCSW-1 (eight taxa) compared to HCSW-3 and HCSW-4 (16 and 18 taxa, respectively) in 2023 (Table 8-1, Figure 8-1).

Fish taxa richness over the HCSP POR was examined for monotonic trends using an annual and seasonal Kendall trend analysis for each site. There was a significant decreasing monotonic trend detected in both the annual and seasonal Kendall at HCSW-1 (-0.11 units per year, Tau = -0.21, $p < 0.05$ and -0.1 units per year, Tau = -0.19, $p < 0.05$, respectively) and when all sites were combined by sampling event (-0.18 units per year, Tau = -0.26, $p < 0.05$ and -0.22 units per year, Tau = -0.27, $p < 0.05$, respectively). This negative trend may be attributed to the increasing number of exotic/invasive taxa found in Horse Creek (Figure 8-2). To investigate this further, taxa abundance and richness of native and exotic species were examined for trends separately. There were no trends detected for taxa richness or abundance of exotic species in both the annual and seasonal Kendall at any site or when all sites were combined ($p > 0.05$). This suggests that while present, exotic species populations appear to be stable. A significantly decreasing monotonic trend of native fish taxa abundance was observed at HCSW-3 (Annual and Seasonal Kendall, slope = -12 units per year, Tau = -0.21, $p < 0.05$ and slope = -15 units per year, Tau = -0.23, $p < 0.05$, respectively) and when all sites were combined (Annual and Seasonal Kendall, slope = -21.3 units per year, Tau = -0.22, $p < 0.05$ and slope = -27.7 units per year, Tau = -0.26, $p < 0.05$, respectively). There was also a significant decreasing monotonic trend of native fish taxa richness at HCSW-1 (Annual and Seasonal Kendall, slope = -0.14 units per year, Tau = -0.35, $p < 0.05$ and slope = -0.14 units per year, Tau = -0.31, $p < 0.05$), HCSW-4 (Seasonal Kendall, slope = -0.2 units per year, Tau = -0.21, $p < 0.05$), and when all sites were combined (Annual and Seasonal Kendall, slope = -0.29 units per year, Tau = -0.35, $p < 0.05$, and slope = -0.3 units per year, Tau = -0.35, $p < 0.05$, respectively). These trends and how they relate to diversity are discussed further in Section 8.4.

[39] 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.

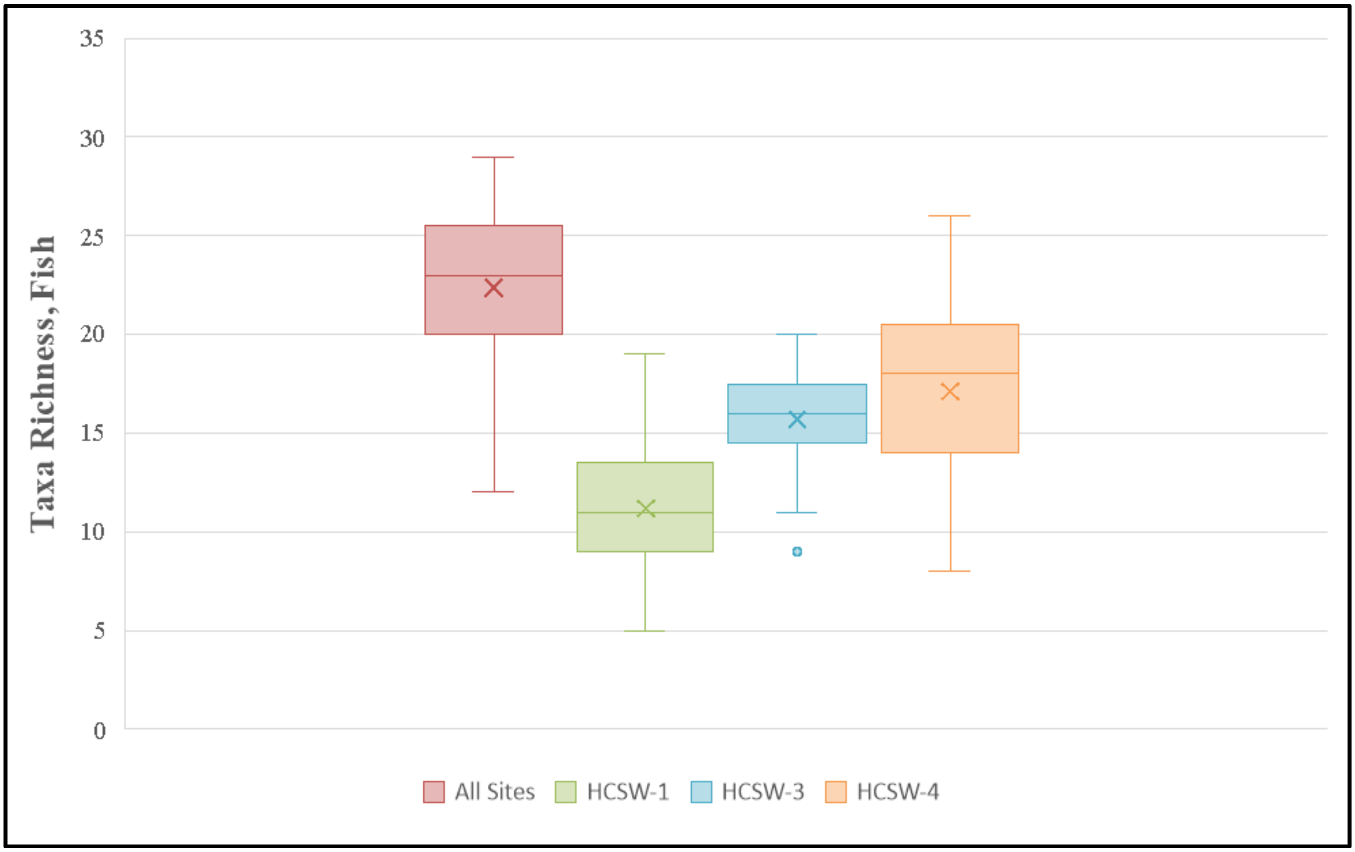


Figure 8-1 Fish Taxa Richness, HCSP POR

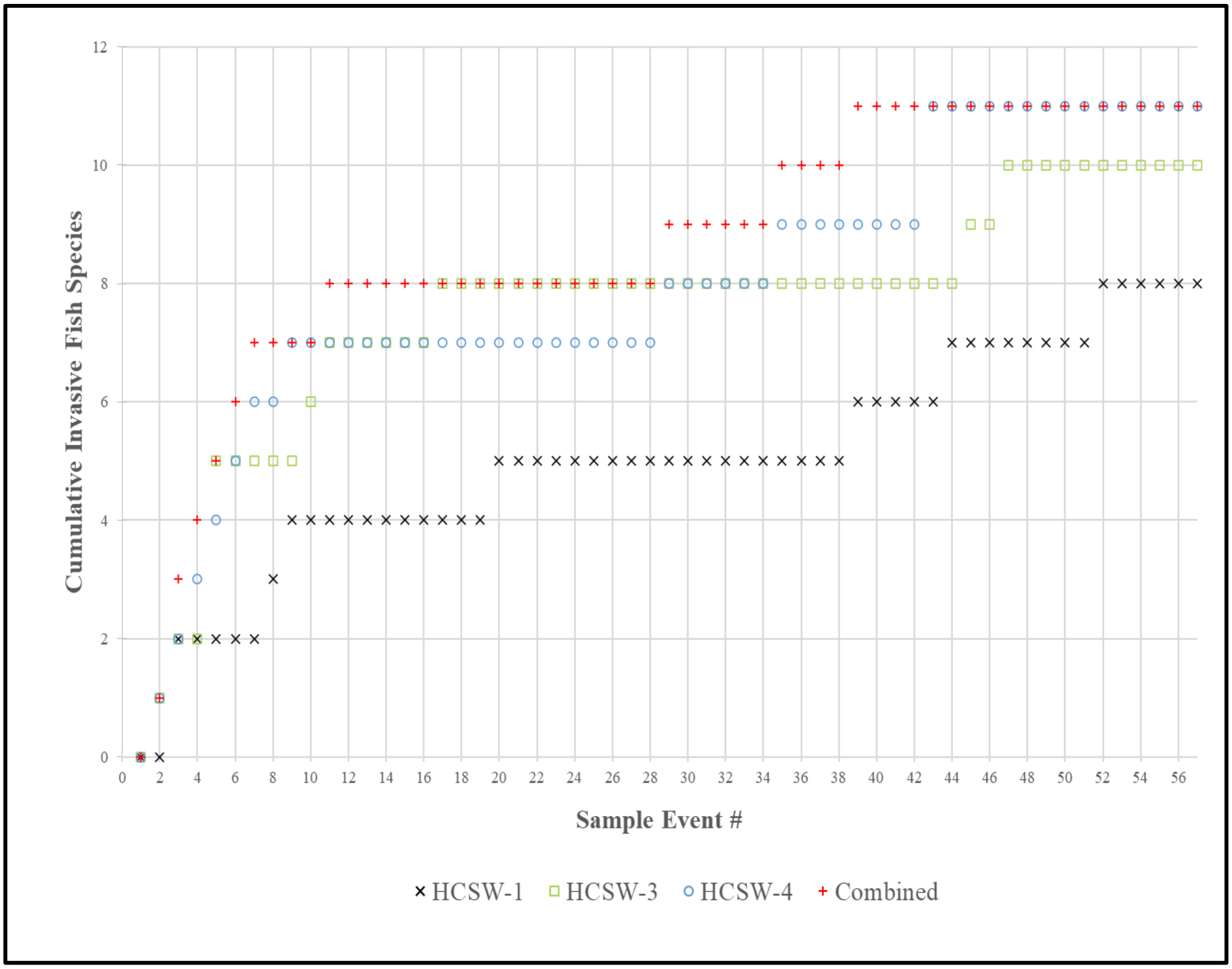


Figure 8-2 Invasive Fish Species Accumulation Curve, HCSP POR

8.2 Shannon-Wiener Diversity Index

The Shannon-Wiener Diversity Index is calculated for fish species diversity and evenness for each sampling event at each location. In 2023, the Shannon-Wiener Diversity Index scores for fish species calculated by sample event and site ranged from 1.37 H' (HCSW-1, December) to 2.28 H' (HCSW-4, March), similar to the HCSP POR (Figure 8-3). HCSW-4 was the most diverse site in 2023 and has been the most diverse site over the HCSP POR. Over the HCSP POR, there was no significant difference between diversity scores among sites calculated by sample event and site (Kruskal-Wallis, $p > 0.05$), with all sites being similar to each other (Wilcoxon pairwise comparison, $p > 0.05$). Fish species diversity scores calculated by sample event and site were examined for monotonic trends using an annual and seasonally adjusted Kendall trend analysis at each site and with all sites combined (Figure 8-6). No trends were detected in any of the analyses ($p > 0.05$). When HCSP POR sample events were combined by site, diversity is highest at HCSW-1 followed by HCSW-4 and HCSW-3 (Figure 8-4).

In 2023, the Shannon-Wiener Diversity Index scores for fish species diversity calculated by year and site (annual scores) ranged from 1.95 H’ (HCSW-3) to 2.48 H’ (HCSW-4). Over the HCSP POR, annual diversity scores between sites were significantly different (Kruskal-Wallis, $p < 0.05$, Figure 8-5), with HCSW-3 being significantly different from HCSW-4 (Wilcoxon pairwise comparison, $p < 0.05$). Annual fish species diversity scores were examined for monotonic trends using an annual Kendall trend analysis at each site and with all sites combined (Figure 8-7). No trends were detected in any of the analyses ($p > 0.05$).

When Shannon-Wiener Diversity Index scores for native species only were calculated by event and site, scores were slightly lower at HCSW-1 and when all sites were combined, and slightly higher at HCSW-3 and HCSW-4. This suggests that invasive species are negatively impacting native species in the lower basin. When Shannon-Wiener Diversity Index scores for native species only were calculated by year and site (annual scores), scores were slightly lower at all sites and when all sites were combined. This suggests invasive species are actually contributing to diversity, which is not abnormal since the diversity index will increase with an increase in taxa, whether or not the species is native. These opposite findings imply a complex system that may be affected by many factors. If diversity scores remained very similar, despite the increase in taxa richness from invasive species, it would suggest that invasive species are more abundant, skewing the evenness. To further investigate this, the diversity scores above for native fish species only were examined for monotonic trends using an annual and seasonal Kendall trend analysis at each site and with all sites combined. There were no trends detected for all native species, only diversity scores at all sites and when all sites were combined ($p > 0.05$). These findings, along with those from taxa richness and abundance, are further discussed in Section 8.4.

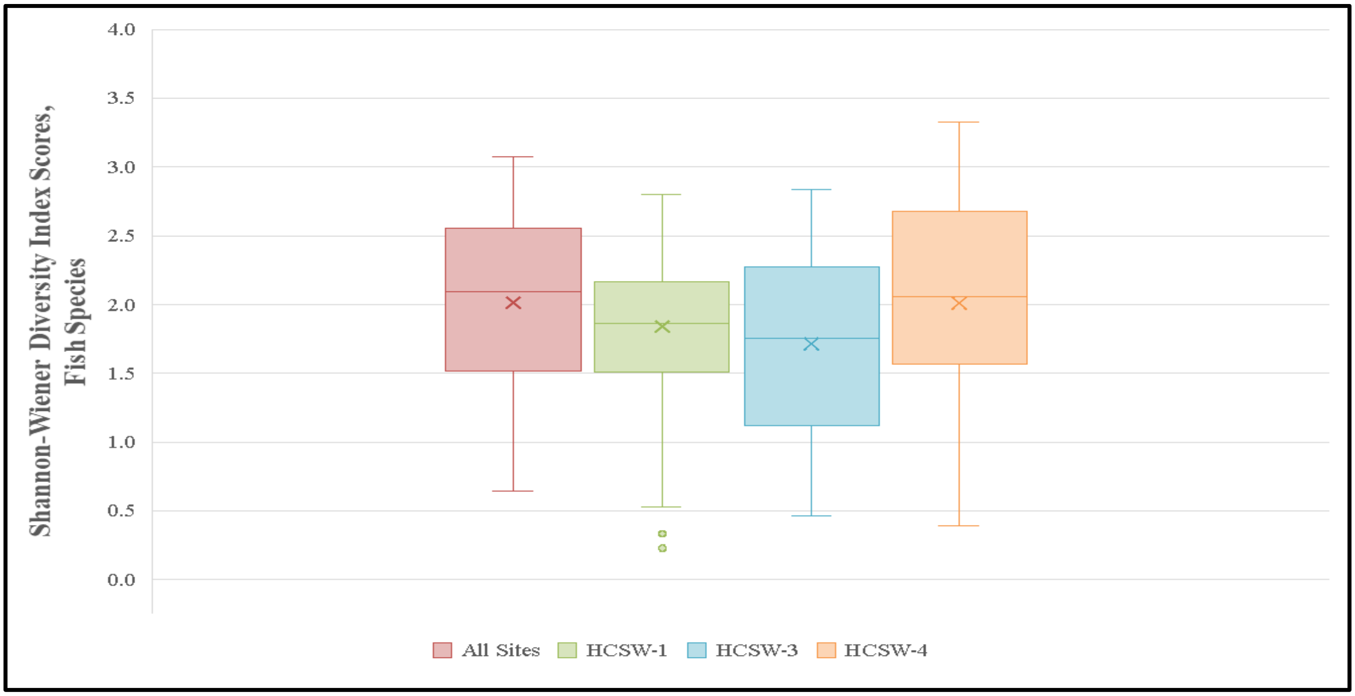


Figure 8-3 Shannon-Wiener Diversity Indices for Fish by Sample Event, HCSP POR

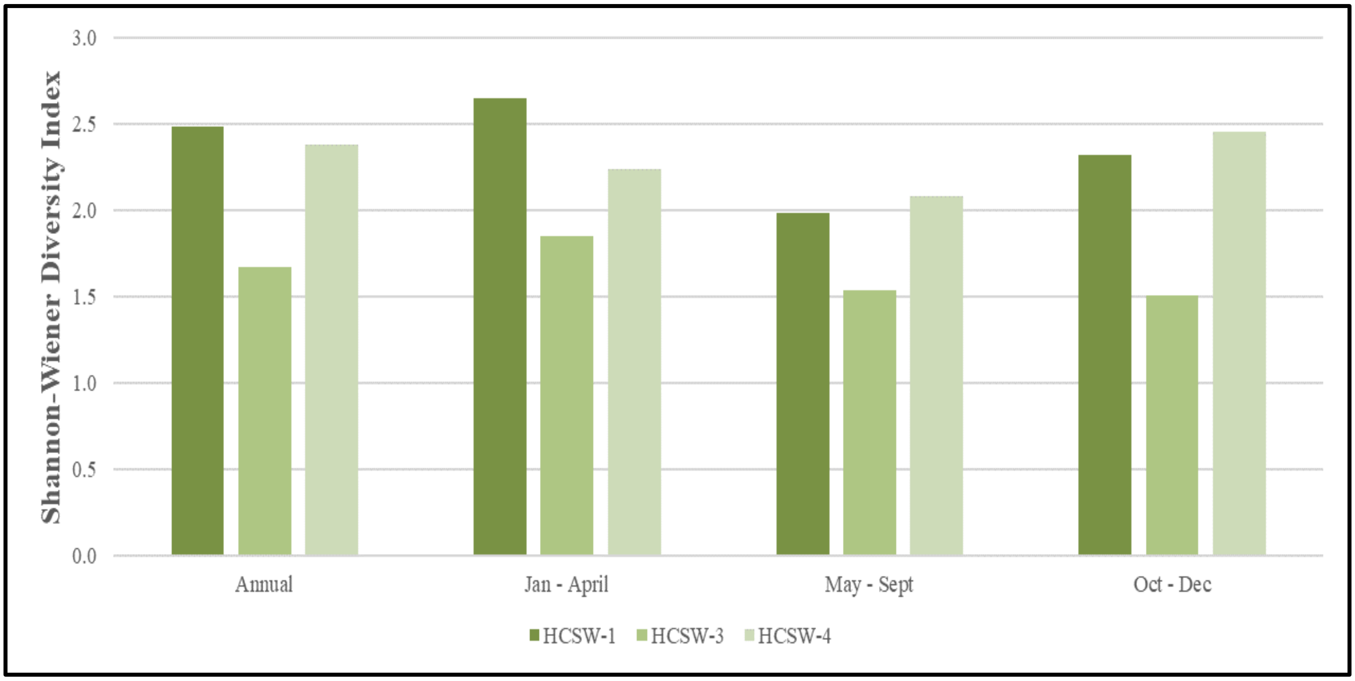


Figure 8-4 Shannon-Wiener Diversity Indices for Fish Samples Summarized Over All Sampling Dates, by Season, HCSP POR

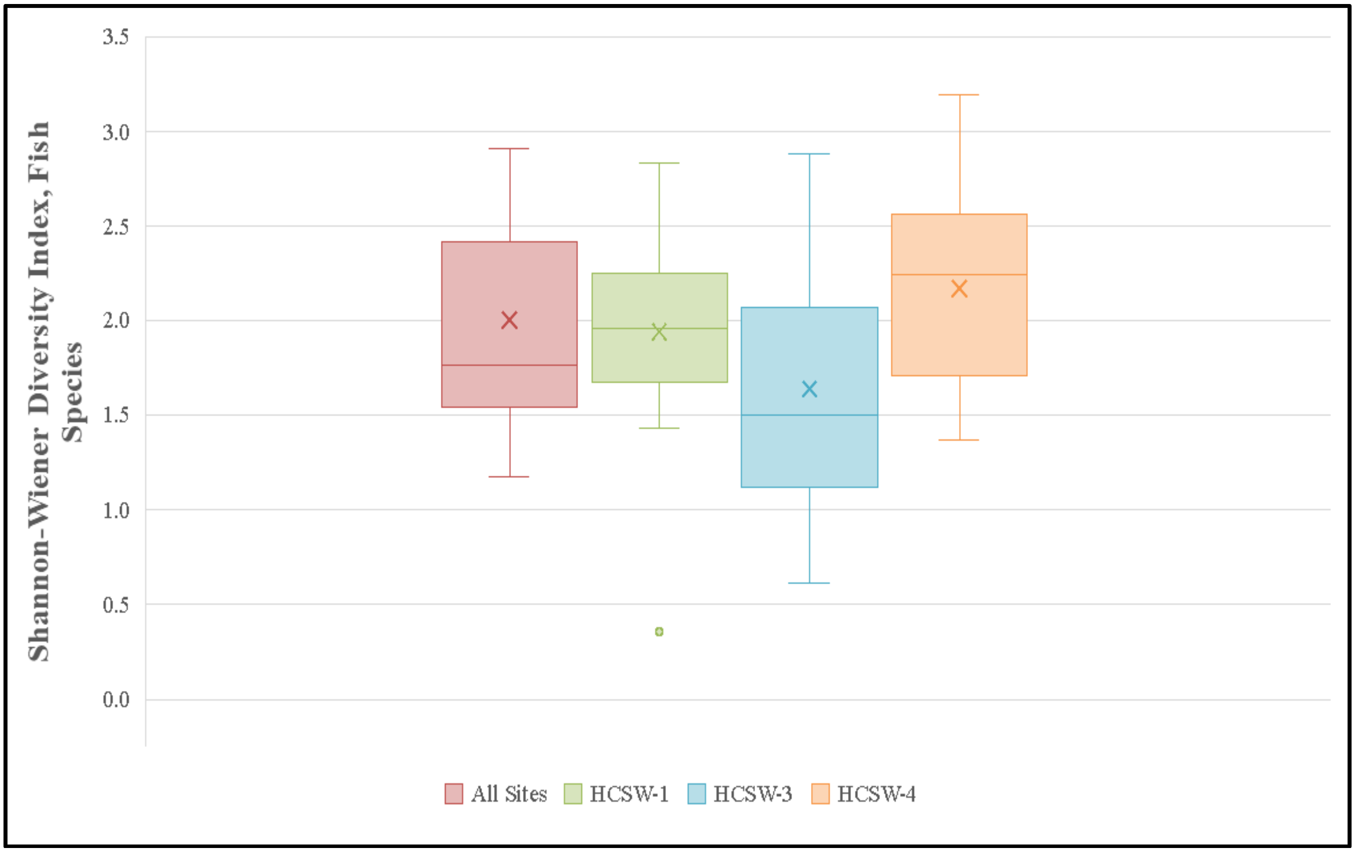


Figure 8-5 Annual Fish Shannon-Wiener Diversity Indices, HCSP POR

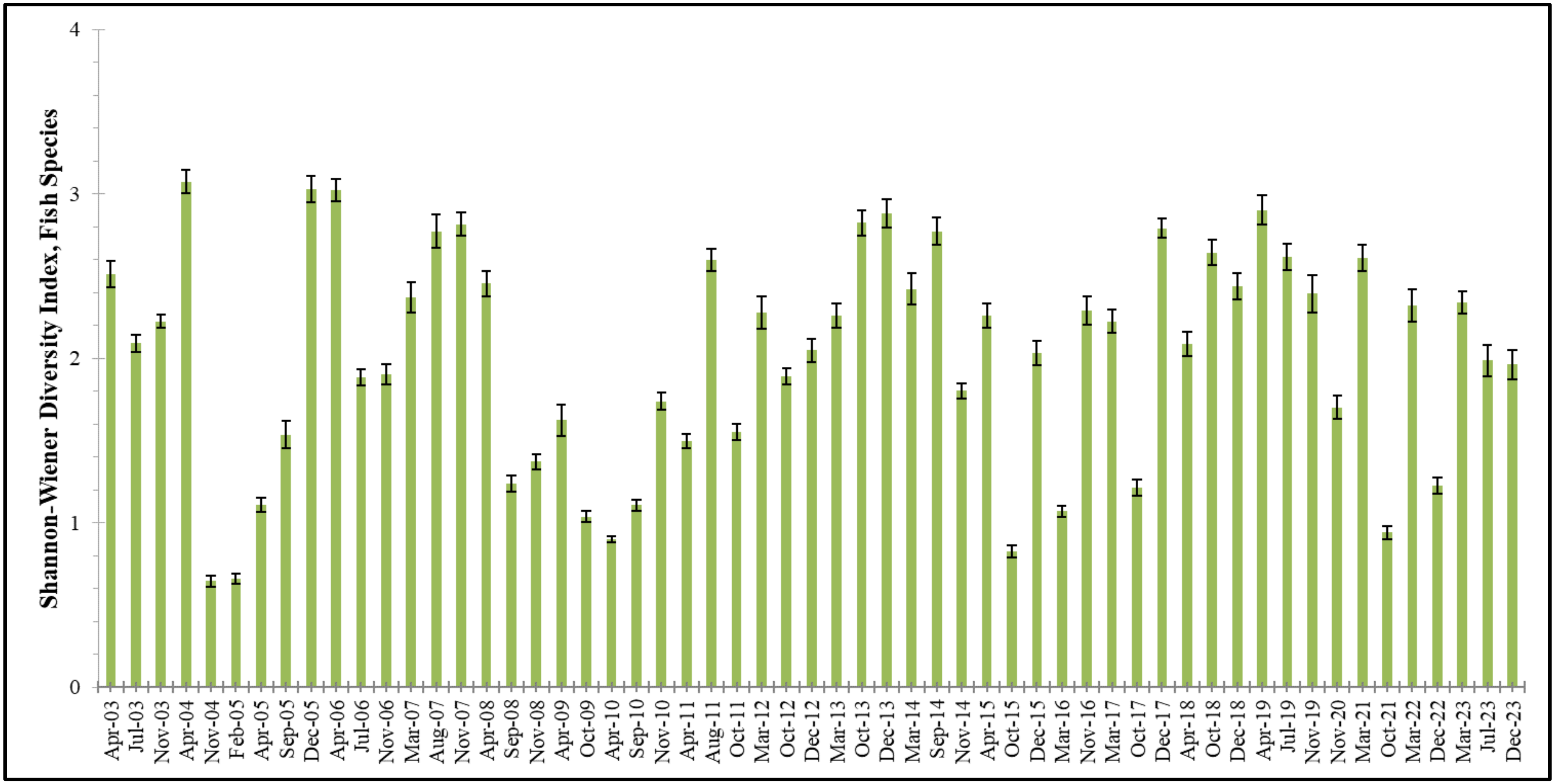


Figure 8-6 Shannon-Wiener Diversity Index Scores for Fish Samples from Horse Creek Summarized Over All Sites Combined, HCSP POR[40]

[40] Error bars = 95% confidence intervals.

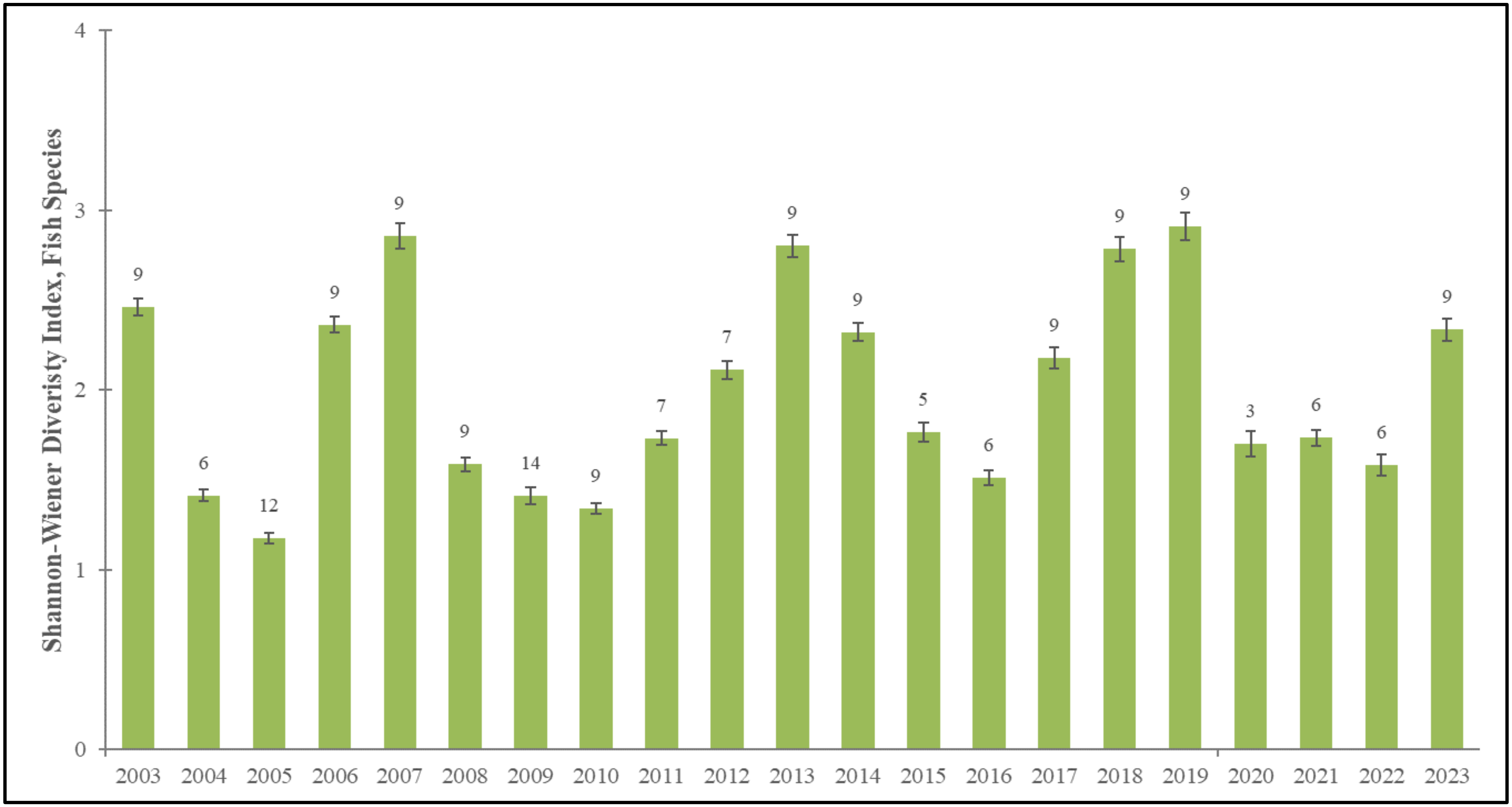


Figure 8-7 Shannon-Wiener Diversity Index Scores for Fish Samples from Horse Creek Summarized Over All Sites Combined, HCSP POR[41]

[41] Error bars = 95% confidence intervals. Labels above bars indicate sample size.

8.3 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:

Equation 5 Morisita's Index of Similarity (C_D)

$$C_D = \frac{2\sum_{i=1}^{S} x_i y_i}{(D_x + D_y)XY}$$

Where: C_D = Morisita's index of similarity between sample x and y
x_i = Number of times species i appears in sample X
y_i = Number of times species i appears in sample Y
D_x and D_y = Simpson's Diversity Index for samples 1 and 2
S = Number of unique species

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

Table 8-2 includes Morisita's Index values combined by year and site. When all sampling events for a given site are combined, fish communities were largely similar (84% - 97%, Table 8-2), with HCSW-1 being the least similar to other sites because it has a higher percentage of non-Poecilid fish captures compared to the other sites. When all sampling events for a given year are combined, fish communities were variable (45% - 100%, Table 8-2). When comparing all years of the HCSP, 2023 was most similar to 2006 (97%) and the least similar to 2019 (67%).

Table 8-2 Morisita's Similarity Index Matrix Comparing Fish Collected between Sites and Years

Site	HCSW-1	HCSW-3	HCSW-4
HCSW-1	1	0.84	0.94
HCSW-3		1	0.97
HCSW-4			1

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
2003	1	0.94	0.92	1.00	0.88	0.96	0.95	0.93	0.96	0.98	0.88	0.99	0.97	0.95	0.95	0.89	0.60	0.93	0.95	0.96	0.95
2004		1	1.00	0.96	0.71	1	1.00	1	0.99	0.96	0.73	0.94	0.98	1.00	0.88	0.78	0.48	0.96	0.99	0.99	0.91
2005			1	0.95	0.67	0.99	0.99	1.00	0.99	0.95	0.70	0.92	0.97	0.99	0.85	0.75	0.45	0.96	0.98	0.98	0.91
2006				1	0.84	0.97	0.96	0.95	0.98	0.98	0.85	1	0.98	0.96	0.94	0.88	0.59	0.96	0.97	0.97	0.97
2007					1	0.74	0.74	0.69	0.75	0.83	0.97	0.87	0.79	0.73	0.92	0.90	0.75	0.73	0.75	0.77	0.81
2008						1	0.99	1	1.00	0.97	0.75	0.95	1	1	0.90	0.80	0.50	0.96	0.99	0.99	0.93
2009							1	1	0.99	0.97	0.77	0.96	0.98	1	0.91	0.80	0.50	1	0.99	1.00	0.92
2010								1	0.99	0.95	0.71	0.93	1	1	0.86	0.76	0.46	0.96	0.98	0.98	0.91
2011									1	0.97	0.75	0.96	0.98	0.99	0.90	0.80	0.51	0.97	0.99	0.99	0.93
2012										1	0.87	0.98	0.99	0.97	0.94	0.87	0.57	0.95	0.97	0.97	0.96
2013											1	0.89	0.82	0.76	0.92	0.90	0.69	0.74	0.76	0.79	0.83
2014												1	0.97	0.95	0.97	0.90	0.62	0.94	0.96	0.97	0.95
2015													1	1	0.92	0.84	0.54	0.96	0.98	0.98	0.96
2016														1	0.89	0.79	0.48	0.96	0.99	0.99	0.93
2017															1	0.92	0.64	0.87	0.91	0.93	0.89
2018																1	0.74	0.82	0.84	0.84	0.91
2019																	1	0.63	0.56	0.55	0.67
2020																		1	0.98	0.97	0.96
2021																			1	1.00	0.95
2022																				1	0.94
2023																					1

8.4 Summary of Fish Results

Forty-three species of fish were collected from 2003 to 2023, with most captured individuals belonging to one of five families (Table 8-3). System-wide, very few additional species are expected to be collected during future monitoring events, as there has only been the addition of three species over the last decade, and the species accumulation curves based on the samples collected through 2023 appear to have approached a threshold (Figure 8-9). Most of the recent additions of species have come after review by the FLMNH. Some native species may be present in Horse Creek but were not collected during the HCSP from 2003 to 2023. These include the American eel (*Anguilla rostrata*) and black crappie (*Pomoxis nigromaculatus*).

Samples collected from 2003 to 2023 for the HCSP included eleven exotic/invasive 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. Thirty-six species of exotic/invasive fish not native to the United States have established populations in the fresh waters of Florida (Robbins, Page, Williams, Randall, & Sheehy, 2018). Unrelated to mining and reclamation activities, the number and abundance of exotic/invasive fish will likely continue to rise as new introductions occur via the aquarium and aquaculture industries, despite laws restricting such introductions (Chapter 68-5.003, F.A.C).

In 2023, 21 species of fish were collected from the sampled Horse Creek sites. Over the HCSP POR, fish richness is lower at HCWS-1, while diversity tends to be lower at HCSW-3. When all sites were combined, the year 2023 ranked 7th in fish diversity while 2019 ranked the highest (Figure 8-7).

The negative trends found in taxa richness were further investigated by looking at trends separately for native and invasive/exotic species in taxa abundance, taxa richness, and diversity scores. Overall, these analyses revealed there is a decline in native species, both in abundance and richness, while invasive/exotic species are currently stable. The opposite findings in diversity scores when grouping by site and year (annual scores) and by site and event implies a complex system that may be affected by many factors, even with no significant trends found for diversity scores. There may be several possible causes for this, such as sampling bias (inability to capture certain species due to physical limitations or sample methods), habitat degradation from human activities (agriculture or other land use changes), native species competing for resources with invasive/exotic species, or increasing trends of certain water quality parameters.

Table 8-3 HCSP Fish Captures by Family in Horse Creek, 2003 – 2023

Family	Family Type	HCSW-1	HCSW-3	HCSW-4	All Sites
Poeciliidae	Livebearers	50.29%	86.88%	69.21%	77.54%
Cyprinidae	Carps, minnows	31.58%	4.06%	12.77%	9.60%
Centrarchidae	Sunfishes	7.37%	2.22%	5.75%	3.87%
Atherinidae	Neotropical silversides	5.55%	2.06%	3.76%	2.95%
Cyprinodontidae	Rivulines, killifishes and live bearers	0.92%	2.00%	3.64%	2.43%
Cichlidae	Chichlids and tilapias	0.78%	1.33%	1.85%	1.44%
Achiridae	American soles	0.00%	0.73%	1.46%	0.90%
Percidae	Perches and darters	0.66%	0.06%	0.39%	0.23%
Clariidae	Air-breathing catfish	0.70%	0.06%	0.32%	0.21%
Ictaluridae	North American freshwater catfish	0.34%	0.11%	0.26%	0.18%
Cobititae	Loaches	0.58%	0.06%	0.16%	0.15%
Loricariidae	Suckermouth armored catfish	0.06%	0.17%	0.07%	0.12%
Synbranchidae	Swamp-eel	0.14%	0.10%	0.10%	0.10%
Elassomatidae	Pupfish	0.34%	0.03%	0.12%	0.09%
Lepisosteidae	Gars	0.52%	0.00%	0.10%	0.08%
Catostomidae	Suckers	0.06%	0.08%	0.02%	0.06%
Callichtyidae	Callichthyid armored catfishes	0.10%	0.05%	0.04%	0.05%
Aphredoderidae	Pirate perch	0.00%	0.00%	0.01%	0.00%
Amiidae	Bowfins	0.00%	0.00%	0.00%	0.00%
Native		97.68%	98.24%	97.39%	97.91%
Exotics		2.32%	1.76%	2.61%	2.09%
n, HCSP POR		4,991	29,250	16,466	50,707

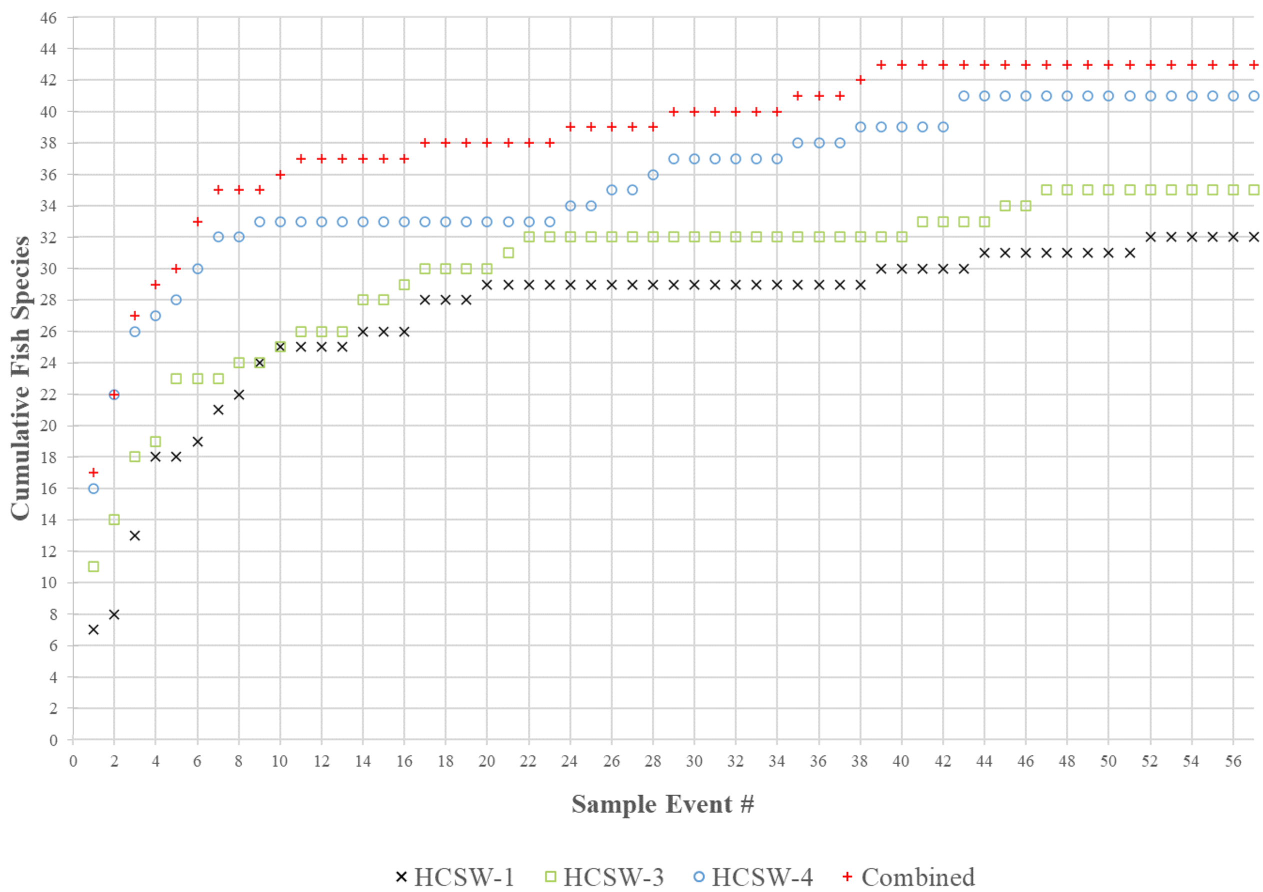


Figure 8-8 Species Accumulation Curve for Each HCSP Site and at All Sites Combined from 2003 to 2023

9.0 CONCLUSION

Over the past 21 years of the HCSP, the program has documented fluctuations in biological diversity and water quality. Most fluctuations were due to the antecedent precipitation and streamflow, and some are due to invasive species. The program has also demonstrated that the comparison of pre-mining and current rainfall/runoff relationship has not changed due to mining activities.

The surface water monitoring site closest to the outfall, HCSW-1, has experienced the least trigger level exceedances[42] and has had consistently high biodiversity scores relative to the other sites. The most common exceedance associated with HCSW-1 has been total alkalinity, which increases during low flow conditions and may also be a result of limestone outcroppings in the creek bed and banks. Total alkalinity is not positively correlated to NPDES discharge at HCSW-1; therefore, these exceedances are presumed to be unrelated to mining. If the releases from outfalls were affecting water quality in Horse Creek, HCSW-1 would be expected to experience the most trigger level exceedances, and the biodiversity scores would be diminished. This has not been the case, as evidenced by the monitoring results.

Further downstream in the basin, the program has documented non-point source pollution in the form of nutrients and dissolved ions associated with agriculture occurring near various tributaries to Horse Creek. Invasive fish and invasive plants have also impacted the riparian buffer, stream banks, habitat, forage, and the species distribution at the sample sites. These phenomena are not unique to this region and are mainly results of the aquarium trade introductions and land use changes. Mosaic will continue to monitor the health of Horse Creek and make recommendations to stakeholders in the region.

[42] 40, 84, 133 exceedances at HCSW-1, HCSW-3, and HCSW-4 respectively, HCSP POR.

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Appendix A

Cumulative Chronological List of Procedural Changes to the HCSP

Change 1: Summer Biological sampling from July – August to July – September.
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 October – November to October – December.
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 six 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 exceed 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 exceed 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 Southwest Florida Water Management District (SWFWMD), Florida Department of Environmental Protection (FDEP) and United States Geological Survey (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 CSAs providing real time monitoring to Peace River Manasota Regional Water Supply Authority (PRMRWSA).
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 at Hwy 64.
Year Implemented: 2009
Comments: In lieu of deleted three parameters, Mosaic Fertilizer, LLC (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 three-hour rolling average exceeds 150 NTU and send alerts to Mosaic and PRMRWSA when the six-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 PRMRWSA and Mosaic after 12 consecutive >150 NTU measurements.
Year Implemented: 2019
Comments: Previous protocol alerted Mosaic and PRMRWSA after a three-hour and six-hour >150 NTU rolling average, respectively. This system produced only false alarms.
Final Acceptance: February 13, 2019

Change 15: Dropped 0.3 mg/L dissolved iron trigger level at HCSW-4. HCSW-4 will be compared to the same 1 mg/L trigger level with which sites HCSW-1, HCSW-2 and HCSW-3 have been assessed.
Year Implemented: 2019
Comments: Analysis of Variance (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 Consulting Group Inc. (Flatwoods) examined every invertebrate entry in the database to determine if 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 on 11/20 during the 2019 TAG meeting. One TAG member, representing Charlotte County, objected to the change. The terrestrial and semi-aquatic macroinvertebrate information will continue to reside in the database; however, these organisms will be excluded from data analysis. Flatwoods cautions against their use because identification of non-aquatic organism is outside the scope of the work of the taxonomic lab and the Stream Condition Index (SCI) Standard Operating Procedure (SOP).
Final Acceptance: November 5, 2020- Updated July 27, 2021

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 0.64 (corrected)		
Year	**SW**	**Rank**
2017	4.99	1
2018	4.90	2
2014	4.88	3
2015	4.87	4
2010	4.81	5
2007	4.80	6
2013	4.77	7
2011	4.76	8
2004	4.72	9
2012	4.65	10
2009	4.64	11
2003	4.57	12
2008	4.54	13
2005	4.51	14
2006	4.42	15
2019	4.37	16
2016	4.35	17

Change 17: SCI sample windows will change from March - April, July – September, and October – December to three temporally independent samples within a year.
Year Implemented: 2021
Comments: The SCI sample window has been changed from 245 days to 365 days to allow the program to collect two to three temporally independent samples at least 90 days apart in accordance with Chapter 62-302.531(5), F.A.C. which states: "To qualify as temporally independent samples, each SCI shall be conducted at least three months apart. SCIs collected at the same location less than three months apart shall be considered one sample, with the mean value used to represent the sampling period."
Final Acceptance: November 19, 2021

Change 18: Diversity scores will be expressed with and without invasive species.
Year Implemented: 2021
Comments: Earlier reports calculated fish diversity using all fish. Future reports will show score with and without invasive taxa.
Final Acceptance: November 19, 2021

Change 19: ANOVA discontinued; new reports will use Kruskal – Wallis.
Year Implemented: 2021
Comments: The parametric ANOVA test was used to compare the means of a given water quality analyte at each site. Future reports will switch to the non-parametric Kruskal – Wallis test, which shows whether the values at one site are more often higher than another. This test also has more power than a traditional ANOVA.
Final Acceptance: November 19, 2021

Change 20: Rainfall -runoff relationship will be evaluated by season.
Year Implemented: 2021
Comments: Future reports will explore seasonality when looking at rainfall – runoff relationship in Horse Creek. Specifically, there will be a breakdown of the double mass curve by season as well as by year.
Final Acceptance: November 19, 2021

Change 21: Add appendix of changes to QA/QC manual, and review annually.
Year Implemented: 2021
Comments: The first draft of the QA/QC manual was presented to the TAG on November 1, 2021. The TAG decided that that manual will need to be reviewed annually with revision summaries captured in an Appendix to the manual going forward.
Final Acceptance: November 19, 2021

Change 22: Sampling will continue unchanged at HCSW-2. Historic and future site data will be moved into an appendix. Future reporting will only include a discussion and analysis of HCSW-1, HCSW-3, and HCSW-4.

Year Implemented: This change is in reporting only and therefore will go into effect beginning with the 2023 Annual Report.

Comments: After 20 years of data collection efforts, HCSW-2 has consistently demonstrated characteristics distinct from all other sites. Water quality, quantity, and biological data have shown conditions that are more indicative of a wetland system rather than a perennial flowing stream. Data (including failing bioassessment scores, trigger level exceedances, etc.) are qualified or disregarded. Following a tour of HCSW-2, alternative sites, and a follow-up discussion, members of the TAG came to an agreement on the decision above.

Final Acceptance: May 2nd, 2024

Appendix B

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 annual reports prior to 2007, 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 Fertilizer, LLC (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 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 trend test determines water quality trends after correcting for seasonality by only comparing values between similar seasons over time (Schertz et al. 1991). More specifically, the Seasonal Kendall test compares the ranks of values within each season and combines the results to evaluate if there is an overall trend (Hirsch, Slack, and Smith, 1982). 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

B-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 five-year datasets when the trend magnitude is between 0.05 and 0.20 units/year.

Table B-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 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.

When the Seasonal Kendall test was first applied to data in the 2008 HCSP Annual Report, trend detection was limited by several factors. With only five years of data, the power of the test to detect trends of small magnitude was limited (Table B-1, Harcum et al. 1992, Hirsch et al. 1982). In addition, the monthly data collected as part of the HCSP exhibited serial autocorrelation, meaning that adjacent monthly observations were not independent. Because the dependence in data for some parameters extended to observations made two months apart, collapsing the data into quarterly values was recommended (Harcum et al. 1992). This reduced the power of the test by an additional margin (Table B-1). Finally, data for parameters whose method detection limits have changed several times over the HCSP (fluoride, nitrate+nitrite) had to be truncated to the highest detection limit, thereby reducing the available data for the test. As a result, trends were harder to detect, and only the direction of the trend, not the magnitude of the trend, were valid

(Schertz et al. 1991). Now that the data set has expanded past five years, the Seasonal Kendall test is the most appropriate to detect monotonic trends in HCSP water quality data.

In annual reports prior to 2007, 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 C
Technical Advisory Group Meeting Summary

Horse Creek Stewardship Program 2023 Annual Report Comments and Questions

This document is in response to questions or comments following the release of the draft 2023 Annual Report for the Horse Creek Stewardship Program (HCSP) Project. For clarity, this document was separated into sections based on the Technical Advisory Group (TAG) member(s) that submitted the set of questions. Questions and comments included in this letter are shown first in bold followed by our responses in regular type.

The comment below was submitted by Kris Ramon, Project Manager III, Water Resources and Planning, Peace River Manasota Regional Water Supply Authority (PRMRWSA).

1. **"…I feel Appendix G should be expanded. I don't believe that referring to a Microsoft Access database is the best way to reference the HCSW-2 data for the year. I appreciate the summary of data from HCSW-2 in paragraphs three and four however I'd also like to see the data presented in tabular and graph form in Appendix G in similar fashion to that presented in the report. For example, provide the Water Quality results in similar fashion to Figures 6-1, 6-3, 6-5, etc. Provide the Macroinvertebrate results in similar fashion to Tables 7-1 and 7-2 and Figures 7-2 etc. Lastly, provide the Fish results in similar fashion to Table 8-1 and Figure 8-1, etc."**

   This topic was brought up at the TAG meeting for discussion. Flatwoods and Mosaic explained that including the same detailed information for HCSW-2 as for the other three sites would necessitate an in-depth analysis, thereby defeating the purpose of its removal from the main report. However, it was agreed that some additional information could still be presented. Appendix G has been expanded to include a brief summary of sampling performed for the current year (in this case, 2023), and a tabular comparison of summary statistics between all HCSP sites over the program Period of Record (POR) for trigger level exceedances, water quality parameter values, Habitat Assessment (HA) scores, and Stream Condition Index (SCI) scores.

The comment below was submitted by Amber Mitchell, Ecologist, EarthBalance.

1. **"Pg. 21 & Table 4-1: It's a little confusing that pg. 21 says the data from HCSW-2 won't be analyzed, but it's still included in Table 4-1 and the period of record is listed as 4/2003-present. It may help if you reword the last paragraph on Pg. 21 to make it more obvious that data is still being collected at that station. Maybe something along the lines of, 'Although hydrologic data is still being collected at HCSW-2, beginning with this report, data analysis and discussion will exclude results from this station. This change is documented in Appendix A…'"**

   The sentence was updated for clarity: "Although sampling and data collection will still be collected at HCSW-2, beginning with this report, data analysis and discussion will exclude results from this site. This change is documented in Appendix A…"

Sincerely,

Michael C. Grzywacz
Ecologist

Shannon M. Gonzalez
AVP, Department Leader

Horse Creek Stewardship Program 2023 Technical Advisory Group Meeting
In-Person and Via Microsoft Teams Meeting
March 3, 2025, 1:30 PM – 4:00 PM

ATTENDANTS

- James Guida (Peace River Manasota Regional Water Supply Authority)
- Kris Ramon (PRMRWSA)
- Shalina Odegard (PRMRWSA)
- Lindsey Sherwood (PRMRWSA)
- Brandon Moody (Charlotte County)
- Scott Browning (Manatee County)
- Heather Bryen (Sarasota County)
- Dalton Bodre (Sarasota County)
- Calvin Serviss (Earth Balance)
- Bethany Niec (Mosaic)
- Ryan Tickles (Mosaic)
- Shannon Gonzalez (Flatwoods)
- Michael Grzywacz (Flatwoods)

MEETING SUMMARY

The meeting began at 1:30 P.M. James Guida provided a brief introduction to the Horse Creek Stewardship Program (HCSP) to members of the Technical Advisory Group (TAG). Michael Grzywacz began the presentation of the 2023 HCSP annual report following the introduction. A brief questions and comments period immediately followed the presentation of the 2023 Annual Report. Of note, it was discussed which additional information could be incorporated into the new HCSW-2 appendix (Appendix G). These changes are detailed on page one of this appendix.

Appendix D

Summary of Trigger Exceedances from 2003 to 2023

Table D-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	Days Since Last NPDES Discharge
HCSW-4	5/25/2006	Alkalinity, mg/L	120	100	0.0	77
HCSW-1	4/25/2007	Alkalinity, mg/L	120	100	0.0	412
HCSW-1	5/16/2007	Alkalinity, mg/L	170	100	0.0	433
HCSW-1	6/20/2007	Alkalinity, mg/L	140	100	0.0	468
HCSW-4	5/4/2009	Alkalinity, mg/L	112	100	0.0	190
HCSW-1	1/5/2010	Alkalinity, mg/L	109	100	22.3	0
HCSW-4	6/8/2011	Alkalinity, mg/L	123	100	0.0	241
HCSW-1	10/24/2011	Alkalinity, mg/L	102	100	27.4	0
HCSW-4	5/2/2012	Alkalinity, mg/L	148	100	0.0	176
HCSW-1	11/6/2012	Alkalinity, mg/L	100	100	0.0	1
HCSW-1	12/3/2015	Alkalinity, mg/L	104	100	0.0	25
HCSW-1	12/13/2016	Alkalinity, mg/L	116	100	0.0	5
HCSW-1	2/15/2017	Alkalinity, mg/L	152	100	0.0	69
HCSW-1	3/7/2017	Alkalinity, mg/L	161	100	0.0	89
HCSW-1	4/11/2017	Alkalinity, mg/L	200	100	0.0	124
HCSW-1	12/6/2017	Alkalinity, mg/L	120	100	0.0	363
HCSW-1	4/18/2018	Alkalinity, mg/L	120	100	0.0	496
HCSW-1	4/11/2019	Alkalinity, mg/L	141	100	0.0	187
HCSW-1	6/13/2019	Alkalinity, mg/L	110	100	0.0	250
HCSW-1	10/7/2019	Alkalinity, mg/L	112	100	0.0	22
HCSW-1	4/13/2020	Alkalinity, mg/L	162	100	0.0	211
HCSW-1	5/12/2020	Alkalinity, mg/L	120	100	0.0	240
HCSW-1	7/14/2020	Alkalinity, mg/L	135	100	0.0	303
HCSW-1	5/11/2021	Alkalinity, mg/L	113	100	0.0	604
HCSW-1	6/16/2021	Alkalinity, mg/L	106	100	0.0	640
HCSW-1	1/11/2022	Alkalinity, mg/L	106	100	0.0	105
HCSW-1	2/8/2022	Alkalinity, mg/L	116	100	0.0	133
HCSW-1	3/8/2022	Alkalinity, mg/L	112	100	0.0	161
HCSW-1	4/21/2022	Alkalinity, mg/L	136	100	0.0	205
HCSW-1	5/19/2022	Alkalinity, mg/L	132	100	0.0	233
HCSW-1	8/16/2022	Alkalinity, mg/L	103	100	17.9	0
HCSW-1	11/16/2022	Alkalinity, mg/L	105	100	60.3	0
HCSW-1	02/07/23	Alkalinity, mg/L	104	100	0.0	80
HCSW-1	03/07/23	Alkalinity, mg/L	127	100	0.0	108
HCSW-1	04/11/23	Alkalinity, mg/L	177	100	0.0	143
HCSW-4	04/11/23	Alkalinity, mg/L	118	100	0.0	143
HCSW-1	05/04/23	Alkalinity, mg/L	184	100	0.0	166
HCSW-4	05/04/23	Alkalinity, mg/L	101	100	0.0	166
HCSW-1	06/13/23	Alkalinity, mg/L	111	100	0.0	206
HCSW-1	07/11/23	Alkalinity, mg/L	133	100	0.0	234
HCSW-1	08/08/23	Alkalinity, mg/L	104	100	0.0	262
HCSW-3	4/27/2006	Calcium, Dissolved, mg/L	110	100	0.0	49
HCSW-4	5/25/2006	Calcium, Dissolved, mg/L	110	100	0.0	77
HCSW-3	6/29/2006	Calcium, Dissolved, mg/L	110	100	0.0	112

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD	Days Since Last NPDES Discharge
HCSW-4	6/29/2006	Calcium, Dissolved, mg/L	190	100	0.0	112
HCSW-4	12/13/2006	Calcium, Dissolved, mg/L	110	100	0.0	279
HCSW-3	4/25/2007	Calcium, Dissolved, mg/L	110	100	0.0	412
HCSW-3	5/16/2007	Calcium, Dissolved, mg/L	110	100	0.0	433
HCSW-3	6/20/2007	Calcium, Dissolved, mg/L	140	100	0.0	468
HCSW-4	6/20/2007	Calcium, Dissolved, mg/L	110	100	0.0	468
HCSW-4	3/27/2008	Calcium, Dissolved, mg/L	120	100	0.0	204
HCSW-4	5/29/2008	Calcium, Dissolved, mg/L	110	100	0.0	267
HCSW-4	2/2/2009	Calcium, Dissolved, mg/L	106	100	0.0	99
HCSW-4	6/3/2009	Calcium, Dissolved, mg/L	119	100	141.8	0
HCSW-3	4/2/2012	Calcium, Dissolved, mg/L	114	100	0.0	146
HCSW-4	4/2/2012	Calcium, Dissolved, mg/L	117	100	0.0	146
HCSW-4	5/2/2012	Calcium, Dissolved, mg/L	109	100	0.0	176
HCSW-4	6/5/2012	Calcium, Dissolved, mg/L	182	100	0.0	210
HCSW-3	4/2/2013	Calcium, Dissolved, mg/L	123	100	0.0	148
HCSW-3	5/1/2013	Calcium, Dissolved, mg/L	105	100	0.0	177
HCSW-4	2/3/2014	Calcium, Dissolved, mg/L	101	100	0.0	120
HCSW-4	3/7/2017	Calcium, Dissolved, mg/L	105	100	0.0	89
HCSW-4	4/11/2017	Calcium, Dissolved, mg/L	149	100	0.0	124
HCSW-4	3/21/2018	Calcium, Dissolved, mg/L	106	100	0.0	468
HCSW-4	6/13/2019	Calcium, Dissolved, mg/L	103	100	0.0	250
HCSW-4	4/14/2021	Calcium, Dissolved, mg/L	133	100	0.0	577
HCSW-4	6/16/2021	Calcium, Dissolved, mg/L	103	100	0.0	640
HCSW-4	2/8/2022	Calcium, Dissolved, mg/L	113	100	0.0	133
HCSW-4	4/21/2022	Calcium, Dissolved, mg/L	142	100	0.0	205
HCSW-3	04/11/23	Calcium, Dissolved, mg/L	117	100	0.0	143
HCSW-3	05/04/23	Calcium, Dissolved, mg/L	121	100	0.0	166
HCSW-2	4/14/2004	Chlorophyll-a, µg/L	16	15	0.0	183
HCSW-2	5/26/2004	Chlorophyll-a, µg/L	21	15	0.0	225
HCSW-2	8/30/2004	Chlorophyll-a, µg/L	35	15	17.4	0
HCSW-3	8/30/2004	Chlorophyll-a, µg/L	38	15	17.4	0
HCSW-2	5/27/2005	Chlorophyll-a, µg/L	17	15	0.0	5
HCSW-2	11/17/2005	Chlorophyll-a, µg/L	17	15	0.0	81
HCSW-2	2/23/2006	Chlorophyll-a, µg/L	23	15	0.0	179
HCSW-2	3/28/2006	Chlorophyll-a, µg/L	30	15	0.0	19
HCSW-2	5/25/2006	Chlorophyll-a, µg/L	32	15	0.0	77
HCSW-2	6/29/2006	Chlorophyll-a, µg/L	45	15	0.0	112
HCSW-2	8/21/2006	Chlorophyll-a, µg/L	20	15	0.0	165
HCSW-2	5/16/2007	Chlorophyll-a, µg/L	25	15	0.0	433
HCSW-2	6/20/2007	Chlorophyll-a, µg/L	110	15	0.0	468
HCSW-2	7/18/2007	Chlorophyll-a, µg/L	17	15	0.0	496
HCSW-2	7/31/2008	Chlorophyll-a, µg/L	23	15	22.8	0
HCSW-2	1/5/2009	Chlorophyll-a, µg/L	25	15	0.0	71
HCSW-2	4/1/2009	Chlorophyll-a, µg/L	22	15	0.0	157
HCSW-1	2/2/2010	Chlorophyll-a, µg/L	15	15	33.3	0
HCSW-2	5/3/2011	Chlorophyll-a, µg/L	18	15	0.0	205

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD	Days Since Last NPDES Discharge
HCSW-2	2/2/2012	Chlorophyll-a, µg/L	75	15	0.0	86
HCSW-2	4/2/2012	Chlorophyll-a, µg/L	36	15	0.0	146
HCSW-2	5/2/2012	Chlorophyll-a, µg/L	34	15	0.0	176
HCSW-2	12/5/2012	Chlorophyll-a, µg/L	18	15	0.0	30
HCSW-2	5/1/2013	Chlorophyll-a, µg/L	53	15	0.0	177
HCSW-2	11/4/2013	Chlorophyll-a, µg/L	17	15	0.0	29
HCSW-2	4/8/2015	Chlorophyll-a, µg/L	29	15	0.0	171
HCSW-2	5/11/2015	Chlorophyll-a, µg/L	27	15	0.0	204
HCSW-2	10/12/2017	Chlorophyll-a, µg/L	16	15	0.0	308
HCSW-2	6/13/2019	Chlorophyll-a, µg/L	17	15	0.0	250
HCSW-2	3/8/2022	Chlorophyll-a, µg/L	15.2	15	0.0	161
HCSW-1	4/27/2006	Color, PCU	20	25	0.0	49
HCSW-3	4/27/2006	Color, PCU	15	25	0.0	49
HCSW-3	6/29/2006	Color, PCU	15	25	0.0	112
HCSW-3	05/04/23	Color, PCU	20	25	0.0	166
HCSW-4	05/04/23	Color, PCU	20	25	0.0	166
HCSW-2	7/2/2013	Dissolved Oxygen Saturation, %	24.8	38	34.3	0
HCSW-2	8/1/2013	Dissolved Oxygen Saturation, %	25.9	38	47.2	0
HCSW-3	8/1/2013	Dissolved Oxygen Saturation, %	38.4	39.9	47.2	0
HCSW-2	9/4/2013	Dissolved Oxygen Saturation, %	31.1	38	50.2	0
HCSW-2	10/1/2013	Dissolved Oxygen Saturation, %	36.7	38	49.1	0
HCSW-2	2/3/2014	Dissolved Oxygen Saturation, %	30.8	38	0.0	120
HCSW-2	8/6/2014	Dissolved Oxygen Saturation, %	18.1	38	0.0	304
HCSW-2	9/3/2014	Dissolved Oxygen Saturation, %	25.8	38	0.0	332
HCSW-2	10/6/2014	Dissolved Oxygen Saturation, %	20.2	38	49.9	0
HCSW-2	11/4/2014	Dissolved Oxygen Saturation, %	30.4	38	0.0	16
HCSW-2	12/2/2014	Dissolved Oxygen Saturation, %	35.3	38	0.0	44
HCSW-2	3/5/2015	Dissolved Oxygen Saturation, %	26.0	38	0.0	137
HCSW-2	7/6/2015	Dissolved Oxygen Saturation, %	11.3	38	23.6	0
HCSW-2	8/6/2015	Dissolved Oxygen Saturation, %	11.7	38	21.4	0
HCSW-3	8/6/2015	Dissolved Oxygen Saturation, %	39.1	39.2	21.4	0
HCSW-2	9/22/2015	Dissolved Oxygen Saturation, %	20.4	38	16.2	0
HCSW-2	10/5/2015	Dissolved Oxygen Saturation, %	18.9	38	10.8	0
HCSW-2	11/3/2015	Dissolved Oxygen Saturation, %	20.5	38	14.1	0
HCSW-2	2/23/2016	Dissolved Oxygen Saturation, %	37.0	38	0.0	107
HCSW-2	3/7/2016	Dissolved Oxygen Saturation, %	34.8	38	5.3	0
HCSW-2	4/6/2016	Dissolved Oxygen Saturation, %	34.2	38	11.2	0
HCSW-2	5/5/2016	Dissolved Oxygen Saturation, %	23.6	38	19.6	0
HCSW-2	6/7/2016	Dissolved Oxygen Saturation, %	20.6	38	16.1	0
HCSW-2	7/7/2016	Dissolved Oxygen Saturation, %	13.6	38	30.5	0
HCSW-2	8/4/2016	Dissolved Oxygen Saturation, %	26.8	38	30.8	0
HCSW-2	9/8/2016	Dissolved Oxygen Saturation, %	20.8	38	34.1	0
HCSW-2	10/18/2016	Dissolved Oxygen Saturation, %	19.1	38	22.6	0
HCSW-2	11/7/2016	Dissolved Oxygen Saturation, %	25.0	38	19.0	0
HCSW-2	12/13/2016	Dissolved Oxygen Saturation, %	24.8	38	0.0	5
HCSW-2	6/19/2017	Dissolved Oxygen Saturation, %	13.0	38	0.0	193

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD	Days Since Last NPDES Discharge
HCSW-2	7/17/2017	Dissolved Oxygen Saturation, %	6.7	38	0.0	221
HCSW-2	8/14/2017	Dissolved Oxygen Saturation, %	20.9	38	0.0	249
HCSW-2	9/25/2017	Dissolved Oxygen Saturation, %	8.7	38	0.0	291
HCSW-2	10/12/2017	Dissolved Oxygen Saturation, %	26.4	38	0.0	308
HCSW-2	11/15/2017	Dissolved Oxygen Saturation, %	38.4	38.6	0.0	342
HCSW-2	5/24/2018	Dissolved Oxygen Saturation, %	10.8	38	0.0	532
HCSW-3	5/24/2018	Dissolved Oxygen Saturation, %	32.7	38	0.0	532
HCSW-2	6/20/2018	Dissolved Oxygen Saturation, %	13.1	38	27.1	0
HCSW-3	6/20/2018	Dissolved Oxygen Saturation, %	31.5	38	27.1	0
HCSW-2	7/11/2018	Dissolved Oxygen Saturation, %	27.0	38	36.2	0
HCSW-2	10/2/2018	Dissolved Oxygen Saturation, %	39.5	39.8	9.4	0
HCSW-2	11/8/2018	Dissolved Oxygen Saturation, %	39.1	40.6	0.0	33
HCSW-2	1/10/2019	Dissolved Oxygen Saturation, %	39.1	40.6	0.0	96
HCSW-2	2/13/2019	Dissolved Oxygen Saturation, %	39.0	40.9	0.0	130
HCSW-2	3/6/2019	Dissolved Oxygen Saturation, %	42.3	42.4	0.0	151
HCSW-2	5/13/2019	Dissolved Oxygen Saturation, %	18.2	38	0.0	219
HCSW-2	7/9/2019	Dissolved Oxygen Saturation, %	24.3	38	0.0	276
HCSW-2	8/14/2019	Dissolved Oxygen Saturation, %	17.1	38	0.0	312
HCSW-2	9/9/2019	Dissolved Oxygen Saturation, %	3.4	38	26.3	0
HCSW-2	10/7/2019	Dissolved Oxygen Saturation, %	21.8	38	0.0	22
HCSW-2	11/11/2019	Dissolved Oxygen Saturation, %	24.2	38	0.0	57
HCSW-2	1/14/2020	Dissolved Oxygen Saturation, %	33.7	38	0.0	121
HCSW-2	6/9/2020	Dissolved Oxygen Saturation, %	7	38	0.0	268
HCSW-2	9/9/2020	Dissolved Oxygen Saturation, %	19.9	38	0.0	360
HCSW-2	10/12/2020	Dissolved Oxygen Saturation, %	10.8	38	0.0	393
HCSW-2	9/14/2021	Dissolved Oxygen Saturation, %	25	38	62.4	0
HCSW-2	10/12/2021	Dissolved Oxygen Saturation, %	36	38	0.0	14
HCSW-2	7/25/2022	Dissolved Oxygen Saturation, %	11.8	38	31.64	0
HCSW-2	8/16/2022	Dissolved Oxygen Saturation, %	22.6	38	17.88	0
HCSW-2	9/13/2022	Dissolved Oxygen Saturation, %	16.3	38	39.32	0
HCSW-2	10/11/2022	Dissolved Oxygen Saturation, %	13.4	38	63.96	0
HCSW-3	10/11/2022	Dissolved Oxygen Saturation, %	20.1	38	63.96	0
HCSW-4	10/11/2022	Dissolved Oxygen Saturation, %	26.6	38	63.96	0
HCSW-2	11/16/2022	Dissolved Oxygen Saturation, %	19.7	38	60.26	0
HCSW-2	12/7/2022	Dissolved Oxygen Saturation, %	27.7	38	0.0	18
HCSW-2	06/13/23	Dissolved Oxygen Saturation, %	28.8	38	0.0	206
HCSW-2	08/08/23	Dissolved Oxygen Saturation, %	36.4	38	0.0	262
HCSW-4	1/23/2007	Fluoride, mg/L	2.5	1.5	0.0	320
HCSW-4	2/14/2007	Fluoride, mg/L	2.5	1.5	0.0	342
HCSW-4	3/14/2007	Fluoride, mg/L	5.0	1.5	0.0	370
HCSW-4	1/11/2022	Fluoride, mg/L	1.73	1.5	0.0	105
HCSW-4	5/19/2022	Fluoride, mg/L	2.83	1.5	0.0	233
HCSW-4	7/25/2022	Fluoride, mg/L	2.01	1.5	31.64	0
HCSW-2	7/27/2006	Iron, Dissolved, mg/L	1.20	1	0.0	140
HCSW-2	6/3/2009	Iron, Dissolved, mg/L	1.03	1	141.8	0
HCSW-2	7/11/2018	Nitrogen, Ammonia, mg/L	0.77 G	0.3	36.2	0

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD	Days Since Last NPDES Discharge
HCSW-3	7/11/2018	Nitrogen, Ammonia, mg/L	0.38 G	0.3	36.2	0
HCSW-4	7/11/2018	Nitrogen, Ammonia, mg/L	0.54 G	0.3	36.2	0
HCSW-3	5/13/2019	Nitrogen, Ammonia, mg/L	0.51	0.3	0.0	219
HCSW-2	10/7/2019	Nitrogen, Ammonia, mg/L	0.32	0.3	0.0	22
HCSW-3	7/27/2005	pH, SU	5.90	6	40.3	0
HCSW-2	7/27/2006	pH, SU	5.95	6	0.0	140
HCSW-2	10/19/2006	pH, SU	5.99	6	0.0	224
HCSW-1	1/23/2007	pH, SU	8.83	8.5	0.0	320
HCSW-4	1/23/2007	pH, SU	8.85	8.5	0.0	320
HCSW-1	1/4/2011	pH, SU	4.80	6	0.0	86
HCSW-2	10/10/2012	pH, SU	5.96	6	40.1	0
HCSW-4	12/3/2015	pH, SU	5.95	6	0.0	25
HCSW-4	5/11/2021	pH, SU	9.04	8.5	0.0	604
HCSW-2	7/13/2021	pH, SU	5.86	6	42.7	0
HCSW-2	7/27/2004	Radium, Combined, pCi/l	5.1	5	0.0	287
HCSW-4	6/5/2012	Specific Conductance, µS	1425	1275	0.0	210
HCSW-4	6/29/2004	Sulfate, mg/L	261	250	0.0	259
HCSW-3	3/28/2006	Sulfate, mg/L	300	250	0.0	19
HCSW-4	3/28/2006	Sulfate, mg/L	300	250	0.0	19
HCSW-3	4/27/2006	Sulfate, mg/L	420	250	0.0	49
HCSW-4	5/25/2006	Sulfate, mg/L	310	250	0.0	77
HCSW-3	6/29/2006	Sulfate, mg/L	430	250	0.0	112
HCSW-4	6/29/2006	Sulfate, mg/L	780	250	0.0	112
HCSW-4	12/13/2006	Sulfate, mg/L	290	250	0.0	279
HCSW-3	5/16/2007	Sulfate, mg/L	360	250	0.0	433
HCSW-3	6/20/2007	Sulfate, mg/L	440	250	0.0	468
HCSW-4	6/20/2007	Sulfate, mg/L	320	250	0.0	468
HCSW-4	3/27/2008	Sulfate, mg/L	390	250	0.0	204
HCSW-4	5/29/2008	Sulfate, mg/L	290	250	0.0	267
HCSW-3	6/26/2008	Sulfate, mg/L	251	250	0.0	295
HCSW-4	6/26/2008	Sulfate, mg/L	287	250	0.0	295
HCSW-3	2/2/2009	Sulfate, mg/L	280	250	0.0	99
HCSW-4	2/2/2009	Sulfate, mg/L	290	250	0.0	99
HCSW-3	4/1/2009	Sulfate, mg/L	293	250	0.0	157
HCSW-3	6/3/2009	Sulfate, mg/L	251	250	141.8	0
HCSW-4	6/3/2009	Sulfate, mg/L	391	250	141.8	0
HCSW-4	12/2/2009	Sulfate, mg/L	279	250	0.0	32
HCSW-4	11/3/2010	Sulfate, mg/L	258	250	0.0	24
HCSW-4	1/4/2011	Sulfate, mg/L	262	250	0.0	86
HCSW-4	7/5/2011	Sulfate, mg/L	253	250	0.0	268
HCSW-3	2/2/2012	Sulfate, mg/L	254	250	0.0	86
HCSW-3	3/5/2012	Sulfate, mg/L	287	250	0.0	118
HCSW-4	3/5/2012	Sulfate, mg/L	267	250	0.0	118
HCSW-3	4/2/2012	Sulfate, mg/L	365	250	0.0	146
HCSW-4	4/2/2012	Sulfate, mg/L	321	250	0.0	146
HCSW-3	6/5/2012	Sulfate, mg/L	304	250	0.0	210

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD	Days Since Last NPDES Discharge
HCSW-4	6/5/2012	Sulfate, mg/L	665	250	0.0	210
HCSW-4	2/7/2013	Sulfate, mg/L	251	250	0.0	94
HCSW-3	3/6/2013	Sulfate, mg/L	319	250	0.0	121
HCSW-4	3/6/2013	Sulfate, mg/L	267	250	0.0	121
HCSW-3	4/2/2013	Sulfate, mg/L	400	250	0.0	148
HCSW-3	5/1/2013	Sulfate, mg/L	373	250	0.0	177
HCSW-4	5/1/2013	Sulfate, mg/L	292	250	0.0	177
HCSW-3	6/4/2013	Sulfate, mg/L	363	250	0.0	211
HCSW-4	6/4/2013	Sulfate, mg/L	383	250	0.0	211
HCSW-4	12/3/2013	Sulfate, mg/L	267	250	0.0	58
HCSW-3	1/2/2014	Sulfate, mg/L	282	250	0.0	88
HCSW-4	1/2/2014	Sulfate, mg/L	333	250	0.0	88
HCSW-4	2/3/2014	Sulfate, mg/L	404	250	0.0	120
HCSW-4	6/3/2014	Sulfate, mg/L	389	250	0.0	240
HCSW-3	6/3/2015	Sulfate, mg/L	316	250	13.1	0
HCSW-3	3/7/2017	Sulfate, mg/L	266	250	0.0	89
HCSW-4	3/7/2017	Sulfate, mg/L	335	250	0.0	89
HCSW-3	4/11/2017	Sulfate, mg/L	278	250	0.0	124
HCSW-4	4/11/2017	Sulfate, mg/L	482	250	0.0	124
HCSW-4	3/21/2018	Sulfate, mg/L	355	250	0.0	468
HCSW-3	4/18/2018	Sulfate, mg/L	290	250	0.0	496
HCSW-4	6/13/2019	Sulfate, mg/L	338	250	0.0	250
HCSW-4	5/12/2020	Sulfate, mg/L	293	250	0.0	240
HCSW-4	4/14/2021	Sulfate, mg/L	468	250	0.0	577
HCSW-4	6/16/2021	Sulfate, mg/L	347	250	0.0	640
HCSW-4	2/8/2022	Sulfate, mg/L	332	250	0.0	133
HCSW-4	4/21/2022	Sulfate, mg/L	315	250	0.0	205
HCSW-4	5/19/2022	Sulfate, mg/L	261	250	0.0	233
HCSW-4	6/14/2022	Sulfate, mg/L	291	250	0.0	259
HCSW-3	04/11/23	Sulfate, mg/L	332	250	0.0	143
HCSW-3	05/04/23	Sulfate, mg/L	445	250	0.0	166
HCSW-4	07/11/23	Sulfate, mg/L	279	250	0.0	234
HCSW-2	7/31/2008	Total Ammonia, mg/L	0.41	0.3	22.8	0
HCSW-3	7/31/2008	Total Ammonia, mg/L	0.32	0.3	22.8	0
HCSW-4	7/31/2008	Total Ammonia, mg/L	0.31	0.3	22.8	0
HCSW-3	5/3/2011	Total Ammonia, mg/L	0.31	0.3	0.0	205
HCSW-4	3/28/2006	Total Dissolved Solids, mg/L	600	500	0.0	19
HCSW-3	4/27/2006	Total Dissolved Solids, mg/L	580	500	0.0	49
HCSW-4	5/25/2006	Total Dissolved Solids, mg/L	560	500	0.0	77
HCSW-3	6/29/2006	Total Dissolved Solids, mg/L	590	500	0.0	112
HCSW-4	6/29/2006	Total Dissolved Solids, mg/L	1100	500	0.0	112
HCSW-4	11/9/2006	Total Dissolved Solids, mg/L	510	500	0.0	245
HCSW-4	12/13/2006	Total Dissolved Solids, mg/L	550	500	0.0	279
HCSW-3	4/25/2007	Total Dissolved Solids, mg/L	590	500	0.0	412
HCSW-3	5/16/2007	Total Dissolved Solids, mg/L	530	500	0.0	433
HCSW-3	6/20/2007	Total Dissolved Solids, mg/L	700	500	0.0	468

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD	Days Since Last NPDES Discharge
HCSW-4	6/20/2007	Total Dissolved Solids, mg/L	600	500	0.0	468
HCSW-3	7/18/2007	Total Dissolved Solids, mg/L	520	500	0.0	496
HCSW-4	7/18/2007	Total Dissolved Solids, mg/L	530	500	0.0	496
HCSW-4	1/30/2008	Total Dissolved Solids, mg/L	550	500	0.0	147
HCSW-4	3/27/2008	Total Dissolved Solids, mg/L	660	500	0.0	204
HCSW-4	5/29/2008	Total Dissolved Solids, mg/L	710	500	0.0	267
HCSW-3	6/26/2008	Total Dissolved Solids, mg/L	580	500	0.0	295
HCSW-4	6/26/2008	Total Dissolved Solids, mg/L	644	500	0.0	295
HCSW-3	2/2/2009	Total Dissolved Solids, mg/L	520	500	0.0	99
HCSW-4	2/2/2009	Total Dissolved Solids, mg/L	536	500	0.0	99
HCSW-3	4/1/2009	Total Dissolved Solids, mg/L	568	500	0.0	157
HCSW-3	6/3/2009	Total Dissolved Solids, mg/L	540	500	141.8	0
HCSW-4	6/3/2009	Total Dissolved Solids, mg/L	692	500	141.8	0
HCSW-3	12/2/2009	Total Dissolved Solids, mg/L	524	500	0.0	32
HCSW-4	12/2/2009	Total Dissolved Solids, mg/L	604	500	0.0	32
HCSW-4	11/3/2010	Total Dissolved Solids, mg/L	577	500	0.0	24
HCSW-3	1/4/2011	Total Dissolved Solids, mg/L	513	500	0.0	86
HCSW-4	1/4/2011	Total Dissolved Solids, mg/L	574	500	0.0	86
HCSW-4	7/5/2011	Total Dissolved Solids, mg/L	660	500	0.0	268
HCSW-3	12/21/2011	Total Dissolved Solids, mg/L	543	500	0.0	43
HCSW-4	12/21/2011	Total Dissolved Solids, mg/L	543	500	0.0	43
HCSW-3	1/12/2012	Total Dissolved Solids, mg/L	571	500	0.0	65
HCSW-4	1/12/2012	Total Dissolved Solids, mg/L	569	500	0.0	65
HCSW-3	2/2/2012	Total Dissolved Solids, mg/L	532	500	0.0	86
HCSW-4	2/2/2012	Total Dissolved Solids, mg/L	512	500	0.0	86
HCSW-3	3/5/2012	Total Dissolved Solids, mg/L	603	500	0.0	118
HCSW-4	3/5/2012	Total Dissolved Solids, mg/L	585	500	0.0	118
HCSW-3	4/2/2012	Total Dissolved Solids, mg/L	714	500	0.0	146
HCSW-4	4/2/2012	Total Dissolved Solids, mg/L	688	500	0.0	146
HCSW-4	5/2/2012	Total Dissolved Solids, mg/L	536	500	0.0	176
HCSW-3	6/5/2012	Total Dissolved Solids, mg/L	646	500	0.0	210
HCSW-4	6/5/2012	Total Dissolved Solids, mg/L	1320	500	0.0	210
HCSW-3	3/6/2013	Total Dissolved Solids, mg/L	643	500	0.0	121
HCSW-4	3/6/2013	Total Dissolved Solids, mg/L	660	500	0.0	121
HCSW-3	4/2/2013	Total Dissolved Solids, mg/L	818	500	0.0	148
HCSW-4	4/2/2013	Total Dissolved Solids, mg/L	595	500	0.0	148
HCSW-3	5/1/2013	Total Dissolved Solids, mg/L	648	500	0.0	177
HCSW-4	5/1/2013	Total Dissolved Solids, mg/L	614	500	0.0	177
HCSW-3	6/4/2013	Total Dissolved Solids, mg/L	675	500	0.0	211
HCSW-4	6/4/2013	Total Dissolved Solids, mg/L	687	500	0.0	211
HCSW-3	12/3/2013	Total Dissolved Solids, mg/L	528	500	0.0	58
HCSW-4	12/3/2013	Total Dissolved Solids, mg/L	617	500	0.0	58
HCSW-4	1/2/2014	Total Dissolved Solids, mg/L	601	500	0.0	88
HCSW-4	2/3/2014	Total Dissolved Solids, mg/L	799	500	0.0	120
HCSW-4	4/1/2014	Total Dissolved Solids, mg/L	555	500	0.0	177
HCSW-4	5/1/2014	Total Dissolved Solids, mg/L	544	500	0.0	207

Station ID	Date	Analyte	Concentration	Trigger Level	Combined NPDES Flow, MGD	Days Since Last NPDES Discharge
HCSW-3	6/3/2014	Total Dissolved Solids, mg/L	548	500	0.0	240
HCSW-4	6/3/2014	Total Dissolved Solids, mg/L	715	500	0.0	240
HCSW-3	7/1/2014	Total Dissolved Solids, mg/L	518	500	0.0	268
HCSW-4	7/1/2014	Total Dissolved Solids, mg/L	580	500	0.0	268
HCSW-4	4/8/2015	Total Dissolved Solids, mg/L	521	500	0.0	171
HCSW-4	5/11/2015	Total Dissolved Solids, mg/L	571	500	0.0	204
HCSW-4	6/3/2015	Total Dissolved Solids, mg/L	504	500	13.1	0
HCSW-3	3/7/2017	Total Dissolved Solids, mg/L	536	500	0.0	89
HCSW-4	3/7/2017	Total Dissolved Solids, mg/L	635	500	0.0	89
HCSW-1	4/11/2017	Total Dissolved Solids, mg/L	524	500	0.0	124
HCSW-3	4/11/2017	Total Dissolved Solids, mg/L	527	500	0.0	124
HCSW-4	4/11/2017	Total Dissolved Solids, mg/L	853	500	0.0	124
HCSW-3	1/17/2018	Total Dissolved Solids, mg/L	742	500	0.0	405
HCSW-4	1/17/2018	Total Dissolved Solids, mg/L	520	500	0.0	405
HCSW-4	3/21/2018	Total Dissolved Solids, mg/L	697 G	500	0.0	468
HCSW-3	4/18/2018	Total Dissolved Solids, mg/L	604	500	0.0	496
HCSW-4	4/11/2019	Total Dissolved Solids, mg/L	528	500	0.0	187
HCSW-4	6/13/2019	Total Dissolved Solids, mg/L	612	500	0.0	250
HCSW-4	2/10/2020	Total Dissolved Solids, mg/L	513	500	0.0	148
HCSW-4	5/12/2020	Total Dissolved Solids, mg/L	600	500	0.0	240
HCSW-4	4/14/2021	Total Dissolved Solids, mg/L	938	500	0.0	577
HCSW-3	5/11/2021	Total Dissolved Solids, mg/L	528	500	0.0	604
HCSW-4	2/8/2022	Total Dissolved Solids, mg/L	663	500	0.0	133
HCSW-4	4/21/2022	Total Dissolved Solids, mg/L	715	500	0.0	205
HCSW-4	5/19/2022	Total Dissolved Solids, mg/L	627	500	0.0	233
HCSW-4	6/14/2022	Total Dissolved Solids, mg/L	587	500	0.0	259
HCSW-4	03/07/23	Total Dissolved Solids, mg/L	514	500	0.0	108
HCSW-3	04/11/23	Total Dissolved Solids, mg/L	595	500	0.0	143
HCSW-3	05/04/23	Total Dissolved Solids, mg/L	786	500	0.0	166
HCSW-3	07/11/23	Total Dissolved Solids, mg/L	505	500	0.0	234
HCSW-4	07/11/23	Total Dissolved Solids, mg/L	560	500	0.0	234
HCSW-4	08/08/23	Total Dissolved Solids, mg/L	506	500	0.0	262
HCSW-3	9/27/2006	Total Nitrogen, mg/L	6.7	3	0.0	202
HCSW-3	6/20/2007	Total Nitrogen, mg/L	9.7	3	0.0	468
HCSW-2	1/30/2008	Total Nitrogen, mg/L	4.8	3	0.0	147
HCSW-3	2/23/2016	Total Nitrogen, mg/L	3.5	3	0.0	107
HCSW-4	6/19/2017	Total Nitrogen, mg/L	4.6	3	0.0	193

Note: Dissolved oxygen (% Saturation) data began in 2013. The HCSP DO sat trigger level is < 38%. The DO trigger level values listed in red text of Table D1 are FDEP time-of-day trigger levels.

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

Table D-2 Trigger Level Exceedance Summary Statistics by Site and Parameter

Site ID	Number of Exceedances, HCSP POR	Number of Exceedances Occurring during NPDES Discharge	Most Common Parameter
HCSW-1	41	5	Alkalinity (39)
HCSW-2	100	37	Dissolved Oxygen (62)
HCSW-3	84	11	TDS (33)
HCSW-4	133	8	TDS (50)
All sites	358	51	TDS (88)

Appendix E

Summary of Impact Assessments from 2003 to 2023

Table E-1 Historical HCSP Impact Assessment Summaries

Station	Date	Parameter	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.
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).

Station	Date	Parameter	Action Taken	Conclusions
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).
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.
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

Station	Date	Parameter	Action Taken	Conclusions
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.
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	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+nitrite 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.
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.

Station	Date	Parameter	Action Taken	Conclusions
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.
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-1 and HCSW-4	3/28/2017	Specific Conductivity	Impact Assessment performed looking at Horse Creek data upstream of outfall and Charlie Creek, a tributary of Peace River with no mining in its watershed. Trend analysis utilized included Seasonal Kendall and change point analysis.	HCSW-1 SC values were within 95% of prediction intervals of Charlie Creek. West Fork HC, Charlie, and HC upstream of outfalls all show positive trends. Increased conductivity at both Horse and Charlie Creek are largely due to regional changes in land use and climatic conditions.

Station	Date	Parameter	Action Taken	Conclusions
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 occurred when there was no discharge, long after there has been a discharge, or during low stream flow conditions.
All	9/30/2020 Published in 2019 Report Appendix I	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 F

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

F.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.

[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 – Discontinued 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 gauge 494 discontinued. Began using National Oceanic and Atmospheric Administration (NOAA) gauges.

January 2013 – Supplemented SWFWMD Flatfort Swamp rain gauge in addition 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 crossed both DeSoto and Hardee County as a Category 1 storm.

January 2018 – Flatwoods took over analysis and reporting of the HCSP including Impact Assessment sampling.

September 2022 – Hurricane Ian crossed over DeSoto and Hardee County beginning as a Category 2 storm then becoming a Category 1 storm.

F.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 sorted and analyzed by Wood PLC (now WSP Gloabal, Inc.), Newberry, Florida.

F.3 MAJOR MDL CHANGES

See Attached MS Access Database "MDLs" Table.

Appendix G

Summary of Data Collected from Sampling Location HCSW-2

Background

After years of data collection efforts, HCSW-2 has consistently demonstrated characteristics distinct from all other sites. Differences include sampling suitability timeframes, streamflow, physical properties of water chemistry, and biology; where HCSW-2 appears more similar to what would be expected from a wetland than the rest of Horse Creek. Throughout the Horse Creek Stewardship Program (HCSP), the Technical Advisory Group (TAG) has often contemplated moving or omitting HCSW-2 but has not taken action. In 2023, Flatwoods and Mosaic proposed that the TAG make a move toward a decision on the continuation of sampling at HCSW-2.

After deliberation by the TAG, it was proposed to continue all monitoring (both biological and monthly water quality) at HCSW-2 but only include the discussion and analysis of HCSW-1, HCSW-3, and HCSW-4 in future reporting and move the HCSW-2 data to an appendix. A consensus on the proposed plan was reached on May 2nd, 2024; all present TAG members agreed to the change, and there were no objections.

Below is a summary of all sampling conducted at HCSW-2 in 2023 and a brief narrative of the results. Summary statistics comparing HCSW-2 data to other HCSP sites over the Period of Record (POR, 2003-2023) are also provided for reference. In addition to the monthly reports submitted to the Peace River Manasota Regional Water Supply Authority (PRMWRSA), all data collected from HCSW-2 can be viewed and downloaded in tabular format from the Microsoft Access database file that accompanies this report.

HCSW-2: 2023 Sampling Summary

In 2023, Mosaic conducted routine monthly water quality sampling at HCSW-2 for 11 out of 12 months. There were two instances of dissolved oxygen below the trigger level during monthly sampling on June 13th and August 8th, 2023. There was one instance of total ammonia above the trigger level on August 8th, 2023, but the value was qualified due to a total ammonia detect in the sample blank. There was no NPDES discharge in all of 2023, therefore none of these instances occurred during times of NPDES discharge.

Biological sampling was unable to be performed in 2023 due to HCSW-2 not meeting the requirements outlined in the Florida Department of Environmental Protection (FDEP) Standard Operating Procedure (SOP) SCI-1000.

HCSW-2: POR Summary

Table 1 below provides summary statistics on trigger level exceedances by site and parameter over the HCSP POR, Table 2 compares the median values of all water quality parameters between the Horse Creek sites over the HCSP POR, and Table 3 displays the range of Habitat Assessment (HA) and Stream Condition Index (SCI) scores between sites over the HCSP POR.

Table 1 Trigger Level Exceedance Summary Statistics by Site and Parameter, HCSP POR

Site	No. of Exceedances, HCSP POR	No. of Exceedances Occurring During NPDES Discharge	Most Common Parameter	No. of Parameters Exceeded Over POR
HCSW-1	40	5	Alkalinity (35)	5
HCSW-2	100	36	Dissolved Oxygen (61)	8
HCSW-3	84	11	TDS (33)	9
HCSW-4	133	8	TDS (54)	11
All sites	357	60	TDS (88)	15

Table 2 Median Values of Water Quality Parameters Between HCSP Sites, HCSP POR

Parameter	HCSW-1	HCSW-2	HCSW-3	HCSW-4
	2023 Median[1]	2023 Median[1]	2023 Median[1]	2023 Median[1]
Alkalinity	69	41.2	41.2	48
Calcium, Dissolved	26.7	17.9	33.9	49.2
Chloride	15	16.9	19.4	23.2
Chlorophyll-a	0.73	3.65	1.36	1.09
Color, Apparent	125	190	150	135
Dissolved Solids, Total	238	206	285	378
Fluoride	0.48	0.32	0.35	0.37
Iron, Dissolved	0.23	0.2	0.2	0.21
Nitrogen, Ammonia	0.031	0.043	0.046	0.049
Nitrogen, Nitrate-nitrite	0.068	0.022	0.16	0.29
Nitrogen, Total Kjeldahl	0.96	1.25	1.09	1.02
Nitrogen, Total	1.04	1.31	1.34	1.41
Orthophosphate	0.356	0.297	0.352	0.42
Oxygen, Dissolved (% Sat)	90.4	34.5	78.4	82.6
pH	7.4	6.76	7.01	7.12
Radium, 226	0.7	0.5	0.6	0.6
Radium, 228[2]	0.685	0.877	0.631	0.695
Radium, Combined	1.5	1.3	1.4	1.5
Specific Conductance	319	244	373	471
Sulfate	58.3	33.7	94.1	139
Turbidity	3.2	2.66	3.15	3.2

[1] Median values estimated using Kaplan-Meier (KM) procedure for data with non-detects.
[2] >80% of data set is censored, KM median cannot be calculated, and KM mean is provided. Result may be biased based on high level of censoring.

Table 3 Summary Statistics of Habitat Assessment and Stream Condition Index Scores Between HCSP Sites, HCSP POR

	Habitat Assessment Scores[1]			Stream Condition Index Scores[2]		
	Min.	Median	Max.	Min.	Median	Max.
HCSW-1	96	121	141	39	63	81
HCSW-2	84	107	139	11	26	57
HCSW-3	74	108	151	10	63	79
HCSW-4	92	113	147	27	62	90

[1] The maximum possible score under this protocol is 160 (160-121 Optimal, 120-81 Suboptimal, 80-41 Marginal, 40-11 Poor)

[2] SCI Score Categories: Category 1 – Exceptional (scores ≥65); Category 2 – Healthy (average scores ≥40); and Category 3 – Impaired (scores ≤34). To be considered healthy, a site's average SCI score must be ≥40, with neither of the two most recent scores <35.