HCSP 2015 and 2016 Annual Reports

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Project Methods
Horse Creek Stewardship Program Overview

> Created to ensure that Mosaic’s mining activities do not adversely affect Horse Creek, Peace River, or Charlotte Harbor

> The 3 components of the plan are:
  - Monitoring and reporting on stream quality
  - Investigating adverse conditions or significant trends
  - Implementing corrective action for adverse changes to Horse Creek caused by Mosaic’s mining activities
Horse Creek North of SR64

- Upper Horse Creek basin including Mosaic outfalls
- HCSW-1 is at SR64 bridge
- HCSW-2 is north of Goose Pond Road
Horse Creek South of CR665

- Lower Horse Creek basin and the PRMRWSA Facility
- HCSW-3 is north of SR70
- HCSW-4 is at SR72 bridge
Water Quantity

> Stream Level
  – Monthly staff gauge readings at four Horse Creek stations

> Discharge
  – USGS daily streamflow at HCSW-1 and HCSW-4
  – Continuous Mosaic NPDES discharge

> Rainfall
  – NOAA daily rainfall at Myakka River State Park and Arcadia
  – SWFWMD Flatford Swamp daily rainfall
  – Mosaic daily rainfall at three upper Horse Creek Basin gauges
    • Horse Creek North
    • Horse Creek South
    • Manson Jenkins
Water Quality

> Monthly sampling by Mosaic at four stations
  – Stream Conditions
  – Field Measurements
    • Water temperature, pH, dissolved oxygen, specific conductivity, turbidity
  – Lab Analysis
    • 16 parameters including nutrients, minerals, and mining reagents
> Continuous sampling by Mosaic at HCSW-1
  – pH, dissolved oxygen, specific conductivity, temperature, turbidity
> Additional sampling coincident with biological sampling
  – Field parameters of temperature, pH, dissolved oxygen, specific conductivity, turbidity
Biological Sampling

> Benthic Macroinvertebrates:
  - Stream Habitat Assessment
  - Florida Stream Condition Index (SCI)
    - 20 dip-net sweeps in 100m stream segment
    - FDEP methodology (SCI-1000)
  - Shannon-Weiner Diversity Index

> Fish:
  - Sampled with 4ft x 8ft seine and electrofishing
  - Shannon-Weiner Diversity Index
  - Morisita’s Community Similarity Index
  - Species Accumulation Curve
<table>
<thead>
<tr>
<th>Pollutant Category</th>
<th>Parameter</th>
<th>Trigger Level</th>
<th>Reporting Units</th>
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<tr>
<td>Physiochemical Indicators</td>
<td>pH</td>
<td>&gt;8.5 or &lt;6.0</td>
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<td></td>
<td>Dissolved Oxygen</td>
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<td></td>
<td>Turbidity</td>
<td>&gt;29</td>
<td>NTU</td>
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<td></td>
<td>Color</td>
<td>&lt;25</td>
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<td>Nutrients</td>
<td>Total Nitrogen</td>
<td>&gt;3.0</td>
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<tr>
<td></td>
<td>Total Ammonia</td>
<td>&gt;0.3</td>
<td>mg/L</td>
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<td></td>
<td>Orthophosphate</td>
<td>&gt;2.5</td>
<td>mg/L</td>
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<td></td>
<td>Chlorophyll-a</td>
<td>&gt;15</td>
<td>mg/m³</td>
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<td>Dissolved Minerals</td>
<td>Specific Conductivity</td>
<td>&gt;1,275</td>
<td>µmhos/cm</td>
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<tr>
<td></td>
<td>Total Alkalinity</td>
<td>&gt;100</td>
<td>mg/L</td>
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<td></td>
<td>Dissolved Calcium</td>
<td>&gt;100</td>
<td>mg/L</td>
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<td></td>
<td>Dissolved Iron</td>
<td>&gt;1.0 or &gt;0.3 (HCSW-4)</td>
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<tr>
<td></td>
<td>Chloride</td>
<td>&gt;250</td>
<td>mg/L</td>
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<td></td>
<td>Fluoride</td>
<td>&gt;4.0 or &gt;1.5 (HCSW-4)</td>
<td>mg/L</td>
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<tr>
<td></td>
<td>Sulfate</td>
<td>&gt;250</td>
<td>mg/L</td>
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<tr>
<td></td>
<td>TDS</td>
<td>&gt;500</td>
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<tr>
<td>Mining Reagents</td>
<td>Radium 226+228</td>
<td>&gt;5.0</td>
<td>pCi/L</td>
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</table>
Impact Assessments

> Monthly water quality data are submitted to the PRMRWSA for review
  – Measurements are compared to “trigger values” that are based on state water quality standards or historical ranges
  – If a parameter is above the trigger value, an impact assessment is completed by Mosaic
    • The impact assessment is accepted as sufficient evidence that the exceedance was not caused by mining
    • Or Mosaic provides additional data or completes other corrective actions
  – Impact Assessments have been requested for several parameters
Annual Reports

> Annual reports are submitted to the PRMRWSA and the TAG for review
  – The TAG includes staff from several counties
  – Mosaic presents the results for water quantity, water quality, and biological data collected by the Program
  – The PRMRWSA and the TAG compile questions and comments that are incorporated into the final report draft
  – If any adverse long-term trends are identified in the report, Mosaic will conduct an impact assessment
Mining and Reclamation Methods
2015 Mining

> Mining
- Acres mined in 2015 – Red
- Acres mined in 2003-2014 – Green
- Areas mined prior to 2003 – Tan

> Reclamation
- Areas reclaimed prior to 2015 – Gray hatching
- Areas reclaimed (contouring) in 2015 Orange hatching
- Areas reclaimed (vegetation) in 2015 – Yellow hatching
2016 Mining

> Mining
- Acres mined in 2016 – Red
- Acres mined in 2003-2015 – Green
- Areas mined prior to 2003 – Tan

> Reclamation
- Areas reclaimed prior to 2016 – Gray hatching
- Areas reclaimed (contouring) in 2016 Orange hatching
- Areas reclaimed (vegetation) in 2016 – Yellow hatching
## Mining and Reclamation History

<table>
<thead>
<tr>
<th>Year</th>
<th>Acres Mined</th>
<th>Acres Reclaimed to Final Contour</th>
<th>Acres Reconnected</th>
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<td>Brushy Creek</td>
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<td>2004</td>
<td>638</td>
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<td>2005</td>
<td>590</td>
<td>169</td>
<td>205</td>
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<td>2006</td>
<td>187</td>
<td>17</td>
<td>0</td>
</tr>
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<td>2007</td>
<td>0</td>
<td>146</td>
<td>106</td>
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<td>2008</td>
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<td>2009</td>
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<td>2010</td>
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<td>220</td>
<td>270</td>
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<td>2011</td>
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<td>96</td>
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<td>2014</td>
<td>112</td>
<td>113</td>
<td>98</td>
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<tr>
<td>2015</td>
<td>378</td>
<td>126</td>
<td>318</td>
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<tr>
<td>2016</td>
<td>219</td>
<td>209</td>
<td>162</td>
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</table>
Summary of Sampling Conditions
April 2015 Conditions

HCSW-1

HCSW-2

HCSW-3

HCSW-4
October 2015 Conditions
December 2015 Conditions

HCSW-1

HCSW-2

HCSW-3

HCSW-4
March 2016 Conditions

HCSW-1

HCSW-2

HCSW-3

HCSW-4
November 2016 Conditions
Results and Conclusions: Biology
Biological Sampling Summary

> Benthic macroinvertebrates were sampled at all four locations during three events in 2015
  – Spring event on April 3, 2015, delayed Summer event on October 27, 2015, and Winter event on December 15, 2015

> Benthic macroinvertebrates were sampled at all four locations during two events in 2016
  – High water levels and flows prohibited a summer sampling event
  – Spring event on March 17, 2016 and Winter event on November 16, 2016.

> Fish sampling was conducted at all stations during three events in 2015
  – During the October 27, 2015 event the backpack electrofisher malfunctioned and samples were only collected via seine hauls

> Fish sampling was conducted at all stations during two events in 2016
Benthic Macroinvertebrate Conclusions - 2015

> Habitat Assessment
  – Optimal to sub-optimal
  – Main differences in scores for substrate diversity and availability

> Stream Condition Index
  – Healthy at all stations but HCSW-2 in October 2015 (Impaired)
    • Exceptional rating at HCSW-3 (April and October) and HCSW-4 (April and December)

> Biological Diversity
  – Diversity higher at HCSW-4 and HCSW-3
  – Diversity comparison only from 2007-2015 (updated 2-vial SCI method) and at stations HCSW-1, HCSW-3, and HCSW-4
  – Diversity not different among years
    • Spring and fall diversity at HCSW-3 increased
Benthic Macroinvertebrate Conclusions - 2016

> Habitat Assessment
- Optimal to sub-optimal
- Main differences in scores for substrate diversity and availability

> Stream Condition Index
- Healthy at all stations but HCSW-2 in November 2016 (Impaired)
  • Exceptional rating at HCSW-1 (April) and HCSW-4 (both events)

> Biological Diversity
- No increase/decrease in diversity over time at all stations combined
- Diversity not different among years from 2007 to 2016
- HCSW-4 and HCSW-3 had a higher diversity
Habitat Assessment Scores

2004 Hurricanes

Optimal
Sub-optimal
Marginal
Poor

Total Habitat Score

Date

2004 Hurricanes

HCSW-1
HCSW-2
HCSW-3
HCSW-4
Fish Results – 2015

> 25 fish species collected, 43 total
  – New species to Horse Creek collected at HCSW-4 (Pugnose minnow – *Opsopoeodus emiliae*)
  – Most fish caught were Poeciliidae

> Shannon-Weiner Diversity Index
  – Fish diversity was significantly lower at HCSW-2 than the other stations
  – Fish diversity by year was higher in 2013 and lower in 2010
    • No increasing or decreasing trends in diversity by year
    • No increasing or decreasing trends for all stations in median or seasonal diversity (using only HCSW-1, HCSW-3 and HCSW-4)

> Morisita’s Community Similarity Index
  – Communities similar between stations and years (ranging from 83 to 100% similar)
Fish Results – 2016

- 23 fish species collected, 44 total
  - New non-native species in Horse Creek collected at HCSW-1 (Asian swamp eel – *Monopterus javanensis*)
  - Two new species observed at HCSW-2 (Hogchoker – *Trinectes maculatus* and Blue Tilapia – *Oreochromis aureus*)
  - Most fish caught were Poeciliidae

- Shannon-Weiner Diversity Index
  - Fish diversity was significantly lower at HCSW-2 and higher at HCSW-4 than the other stations
  - Fish diversity by year was higher in 2013 and lower in 2010
    - No increasing or decreasing trends in diversity from 2003-2016
    - Small decreasing trend in fish diversity during spring sampling events (using HCSW-1, HCSW-3, and HCSW-4 data)

- Morisita’s Community Similarity Index
  - Communities similar between stations and years (ranging from 83 to 100% similar)
Fish Species Richness

Species Richness

HCSW-1
HCSW-2
HCSW-3
HCSW-4
Fish Species Diversity – Stations by Year

![Shannon-Wiener Diversity Index](image)

- **HCSW-1**
- **HCSW-2**
- **HCSW-3**
- **HCSW-4**
Fish Species Diversity - Years

The Shannon-Wiener Diversity Index values for each year from 2003 to 2016 are shown. The index varies from year to year, with some years having a higher number of species (N) than others. The years 2004, 2005, and 2007 had the highest numbers of species (N=12), while 2009 had the lowest (N=5). The diversity index ranges from 0 to 3.5, with higher values indicating greater diversity.
Fish Species Diversity - Stations

![Graph showing Shannon-Wiener Diversity Index for different stations.](image)
Species Accumulation Curve
Horse Creek Fish

> Fish capture data through 2014 from the HCSP included in UF Publication

> All 4 HCSP locations on many individual fish species distribution maps

> Largest continuous collection of fish for any waterbody in Florida

> (Other Universities jealous of UF of the HCSP fish collection.)
Results and Conclusions: Water Quantity
Rainfall – Mosaic Gauges Only

<table>
<thead>
<tr>
<th>Gauge</th>
<th>Horse Creek North</th>
<th>Horse Creek South</th>
<th>Manson Jenkins</th>
<th>Average of Mosaic Gauges</th>
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<td>53.4</td>
<td>59.75</td>
<td>30.10*</td>
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<td>53.82</td>
<td>60.74</td>
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<td>2005</td>
<td>54.52*</td>
<td>64.53</td>
<td>31.34*</td>
<td>66.04</td>
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<td>2006</td>
<td>31.82*</td>
<td>34.17</td>
<td>41.26</td>
<td>37.35</td>
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<td>40.49</td>
<td>36.8</td>
<td>37.48</td>
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<td>2009</td>
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<td>2011</td>
<td>24.54*</td>
<td>31.73*</td>
<td>39.85</td>
<td>37.11</td>
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<td>19.99*</td>
<td>36.06*</td>
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<td>2014</td>
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<td>2015</td>
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<td>35.64*</td>
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<td>2016</td>
<td>46.76*</td>
<td>50.72</td>
<td>48.09</td>
<td>51.43</td>
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</table>

*Gauge inoperable during parts of the year
Horse Creek Streamflow 2003-2016
Percentile Streamflow 2003-2016

HCSW-1: 10th, 50th, and 90th Percentile Streamflow

HCSW-4: 10th, 50th, and 90th Percentile Streamflow
Mosaic Rainfall and USGS Streamflow 2003-2016
Mosaic Rainfall and USGS Streamflow 2015-2016

Average Daily Rainfall (Mosaic gauges)

Average Daily Stream Flow for HCSW-1

Daily Precipitation (inches)

Average Daily Stream Flow (cfs)

Double mass curve uses Horse Creek at SR64 Streamflow and average of two NOAA gauges (Myakka River State Park and Arcadia)
NPDES Discharge 2003-2016

Average Daily Flow (cfs)

NPDES Discharge (Outfalls 003 and 004)

Average Daily Rainfall (Mosaic gauges)

NPDES Daily Discharge (Outfalls 003 and 004)
NPDES Discharge 2015-2016

Graphs showing average daily flow (cfs) and average daily discharge (cfs) for HCSW-1 and NPDES Discharge (Outfalls 003 and 004). Additionally, graphs showing average daily rainfall (inches) and daily precipitation (inches) for NPDES Daily Discharge (Outfalls 003 and 004).
Water Quantity Conclusions-2015 and 2016

> Annual average daily streamflow at HCSW-1 and HCSW-4 was above the long term averages
> NOAA annual average rainfall above long term average (63-64 inches compared to 53 inches)
> Peak stream flow followed rainfall events
> Base streamflow at HCSW-1 reflected outfall discharge periods
> Outfall discharge quantity influenced by wetter conditions over two years
> Double mass curve analysis shows no evidence of a decrease in streamflow with respect to rainfall over time
Water Quantity Conclusions-2015

> Flows were generally low from January to early-June before increasing slightly
  – Period of slightly higher flows during the dry season (late-January to late-February)
  – Flows moderate in August before a sharp increase at the end of August through September
  – Stable moderate flows in October before decreasing through end of the year

> NPDES discharge from WIN-004 for 152 days accounted for 19% of streamflow on average
  – Discharge occurred from June through November 2015
Water Quantity Conclusions-2016

> Flows generally low from March to early-June before rapidly increasing and remaining high for the reminder of the wet season
  - Final large increase in streamflow occurred in early-October following rain events then decreased through the end of the year
> NPDES discharge from WIN-004 for 283 days accounted for 73% of streamflow on average
  - Discharge occurred from March through early December 2016
Results and Conclusions: Water Quality
2015 and 2016 Summary: Differences Between Stations

> Downstream versus upstream stations
  – Higher downstream: nutrients (nitrate-nitrite) and ions (SC, calcium, chloride, and sulfate)

> HCSW-2: Horse Creek Prairie
  – Lower pH, DO, orthophosphate, and fluoride
  – Higher chlorophyll-a, color, and TKN

> Higher at HCSW-1 and HCSW-4
  – Dissolved oxygen and alkalinity

> Brushy Creek
  – Slightly higher turbidity, color, nitrogen (TN and TKN,), ammonia, chlorophyll-a, iron, and chloride than HCSW-1 and HCSW-2 but generally within Horse Creek range
  – NOx, SC, calcium, alkalinity, fluoride, sulfate, TDS, and radium slightly lower in Brushy Creek than Horse Creek (also orthophosphate in 2016 only)
2015 Summary: Trigger Level Exceedances

- pH (6.0 – 8.5)
  - HCSW-1 (December)

- Dissolved oxygen (<38%)
  - HCSW-2 (March, July-November)
  - HCSW-3 (August)

- Chlorophyll-a (>15 mg/m$^3$)
  - HCSW-2 (April, May)

- Dissolved Iron (>0.3 mg/L)
  - HCSW-4 (August-October)

- Alkalinity (>100 mg/L)
  - HCSW-1 (December)

- Sulfate (>250 mg/L)
  - HCSW-3 (June)

- TDS (>500 mg/L)
  - HCSW-4 (April-June)
2016 Summary: Trigger Level Exceedances

- Dissolved oxygen (<38%)
  - HCSW-2 (February-December)

- Total Nitrogen (3.0 mg/L)
  - HCSW-3 (February)

- Dissolved Iron (>0.3 mg/L)
  - HCSW-4 (July-September)

- Alkalinity (>100 mg/L)
  - HCSW-1 (December)
2015 Summary: Correlations with Water Quantity at HCSW-1

> Negative Correlation
  - Streamflow
    • Orthophosphate
  - Streamflow and NPDES Discharge
    • Radium
  - Streamflow and Rainfall
    • pH
  - Rainfall, Streamflow, and NPDES Discharge
    • DO (concentration and %sat) and chloride

> Positive Correlation
  - NPDES
    • Chlorophyll-a, SC, calcium, alkalinity, sulfate, TDS
  - Streamflow and NPDES
    • Fluoride
  - Rainfall, Streamflow and NPDES discharge
    • Turbidity, color, TN, TKN, nitrate-nitrite iron
2016 Summary: Correlations with Water Quantity at HCSW-1

> Negative Correlation
  – Rainfall
    • SC, calcium, alkalinity
  – Streamflow and NPDES Discharge
    • radium
  – Streamflow and Rainfall
    • pH
  – Rainfall, Streamflow, and NPDES Discharge
    • DO (concentration and %sat) and chloride

> Positive Correlation
  – NPDES Discharge
    • Chlorophyll-a, SC, calcium, alkalinity, sulfate, TDS
  – Rainfall, Streamflow, and NPDES Discharge
    • Turbidity, color, TN, TKN, iron
Seasonal Kendall Tau

> Non-parametric test for monotonic trends
> Identifies water quality trends after correcting for seasonality by only comparing median values between similar seasons over time
> Changes in detection limits in HCSP
  – Fluoride, nitrate-nitrite, ammonia
  – Used SWFWMD as an alternative to HCSP data
  – Went to annual trends only when SWFWMD data collection changed to bi-monthly
> Corrected for streamflow if relationship existed
> Produces a trend slope estimate
<table>
<thead>
<tr>
<th>Parameter</th>
<th>HCSW-1 Slope</th>
<th>HCSW-4 Slope</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>0.04 SU/yr</td>
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<td>Slope very small in magnitude. Isolated step change. Not of concern. See further discussion in Appendix I.</td>
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<tr>
<td>DO (% Saturation)</td>
<td>1.29%/yr</td>
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<td>Not an adverse trend</td>
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<td>Color</td>
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<td>6.32 PCU/yr</td>
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<td>Nitrogen, Ammonia</td>
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<td>Not an adverse trend</td>
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<td>Specific Conductance</td>
<td>10.2 (\mu\text{mhos/cm/yr})</td>
<td>7.47 (\mu\text{mhos/cm/yr})</td>
<td>See further discussion in Appendix I</td>
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<td>Calcium</td>
<td>0.86 mg/L/yr</td>
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<td>Related to Conductance Trend Discussion (See Appendix I)</td>
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<td>Iron</td>
<td>-0.01 mg/L/yr</td>
<td>-0.01 mg/L/yr</td>
<td>Not an adverse trend</td>
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<tr>
<td>Alkalinity</td>
<td>2.42 mg/L/yr</td>
<td>1.18 mg/L/yr</td>
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<td>Fluoride</td>
<td>0.01 mg/L/yr</td>
<td>0.01 mg/L/yr</td>
<td>Related to Conductance Trend Discussion (See Appendix I)</td>
</tr>
<tr>
<td>Sulfate</td>
<td>2.92 mg/L/yr</td>
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<td>Related to Conductance Trend Discussion (See Appendix I)</td>
</tr>
<tr>
<td>TDS</td>
<td>8.31 mg/L/yr</td>
<td>9.26 mg/L/yr</td>
<td>Related to Conductance Trend Discussion (See Appendix I)</td>
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## 2016 Summary: Seasonal Trends over Time 2003-2016

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HCSW-1 Slope</th>
<th>HCSW-4 Slope</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>0.05 SU/yr</td>
<td></td>
<td>Slope very small in magnitude. Isolated step change. Not of concern. See further discussion in Appendix I.</td>
</tr>
<tr>
<td>DO (mg/L)</td>
<td>0.06 mg/yr</td>
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<td>Not an adverse trend</td>
</tr>
<tr>
<td>DO (% Saturation)</td>
<td>0.74%/yr</td>
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<td>Not an adverse trend</td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td>4.31 PCU/yr</td>
<td>Not an adverse trend</td>
</tr>
<tr>
<td>Nitrogen, Ammonia</td>
<td>-0.001 mg/L/yr</td>
<td></td>
<td>Not an adverse trend</td>
</tr>
<tr>
<td>Specific Conductance</td>
<td>10.4 µmhos/cm/yr</td>
<td>7.94 µmhos/cm/yr</td>
<td>See further discussion in Appendix I</td>
</tr>
<tr>
<td>Calcium</td>
<td>1.05 mg/L/yr</td>
<td></td>
<td>Related to Conductance Trend Discussion (See Appendix I)</td>
</tr>
<tr>
<td>Iron</td>
<td>-0.01 mg/L/yr</td>
<td>-0.01 mg/L/yr</td>
<td>Not an adverse trend</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>2.39 mg/L/yr</td>
<td>1.08 mg/L/yr</td>
<td>Related to Conductance Trend Discussion (See Appendix I)</td>
</tr>
<tr>
<td>Fluoride</td>
<td>0.01 mg/L/yr</td>
<td>0.01 mg/L/yr</td>
<td>Related to Conductance Trend Discussion (See Appendix I)</td>
</tr>
<tr>
<td>Sulfate</td>
<td>3.67 mg/L/yr</td>
<td></td>
<td>Related to Conductance Trend Discussion (See Appendix I)</td>
</tr>
<tr>
<td>TDS</td>
<td>8.56 mg/L/yr</td>
<td>6.02 mg/L/yr</td>
<td>Related to Conductance Trend Discussion (See Appendix I)</td>
</tr>
</tbody>
</table>
2015 and 2016 Impact Assessments

> Determined whether statistically significant trends were adverse
> Focused on pH and specific conductivity (mentioned other ions in 2016 report)
> Compared HCSP data to SWFWMD data over longer time period
> Compared to Charlie Creek
> Compared to upstream stations and mining activity history
> Evaluated stream biological health
Upstream Horse Creek Sampling Locations
Impact Assessment: pH
Monthly HCSP and SWFWMD pH

- **pH (SU)**
- **Average Monthly Flow at SR64 USGS Gauge**
- **Avg Monthly NPDES Discharge**

Legend:
- HCSP
- SWFWMD
- NPDES
- Avg Monthly Flow at SR64 USGS Gauge
- Avg Monthly NPDES Discharge
## Monthly HCSP and SWFWMD pH

<table>
<thead>
<tr>
<th>LOESS Smooth Parameter</th>
<th>Stat</th>
<th>SWFWMD – Horse Creek Near Myakka Head</th>
<th>HCSP – HCSW-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>p-value</td>
<td>0.41</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>slope</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Logged Flow</td>
<td>p-value</td>
<td>0.27</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>slope</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LOESS Smooth Parameter</th>
<th>Stat</th>
<th>SWFWMD – Horse Creek Near Myakka Head</th>
<th>HCSP – HCSW-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>p-value</td>
<td>0.50</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>slope</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Logged Flow</td>
<td>p-value</td>
<td>0.28</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>slope</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Change-point Analysis of HCSP pH Data (2003-2016)

Plot of pH

Table of Significant Changes for pH

Confidence Level for Candidate Changes = 95%, Confidence Level for Inclusion in Table = 95%, Confidence Interval = 95%, Bootstraps = 1000, Without Replacement, MSE Estimates

<table>
<thead>
<tr>
<th>Year.Month</th>
<th>Confidence Interval</th>
<th>Conf. Level</th>
<th>From</th>
<th>To</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007.1</td>
<td>(2006.11, 2007.10)</td>
<td>100%</td>
<td>6.8153</td>
<td>7.4064</td>
<td>1</td>
</tr>
</tbody>
</table>
### Charlie Creek pH

![Graph showing pH data over time with statistical analysis](image)

<table>
<thead>
<tr>
<th>LOWESS Smooth Parameter</th>
<th>Statistics</th>
<th>SWFWMD and FDEP Data</th>
<th>USGS, SWFWMD, and FDEP Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>p-value</td>
<td>0.002</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>slope</td>
<td>-0.02</td>
<td>N/A</td>
</tr>
<tr>
<td>USGS Log Flow</td>
<td>p-value</td>
<td>0.002</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>slope</td>
<td>-0.01</td>
<td>N/A</td>
</tr>
</tbody>
</table>
HCSP and Charlie Creek pH Data-Periods With and Without NPDES Discharge
Long-term pH and Discharge

![Graph showing pH and discharge over time]

- **USGS Streamflow at SR64**
- **pH-NPDES Discharge**
- **pH-No NPDES Discharge**
Upstream Horse Creek pH

<table>
<thead>
<tr>
<th>pH</th>
<th>HC at SR37</th>
<th>HC Inlet</th>
<th>MJ SW-1</th>
<th>MJ SW-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>p-value</td>
<td>0.11</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>0.01</td>
</tr>
<tr>
<td>Slope</td>
<td>N/A</td>
<td>0.07</td>
<td>0.07</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Upstream Horse Creek pH

- HC Inlet
- HCSW-1 (no NPDES)
- HCSW-1 (with NPDES)

Date
- Aug-1987
- Jan-1993
- Jul-1998
- Jan-2004
- Jul-2009
- Dec-2014

pH (SU)
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

MJ SW-5
- HCSW-1 (no NPDES)
- HCSW-1 (with NPDES)
pH Summary

> Trend observed in seasonal analysis of 2003-2015 and 2003-2016 HCSP data but not annual analysis

> Increasing trend only in annual 1992-2015 and 1992-2016 SWFWMD data

> Change-point analysis of the HCSP data show a decline in 2004, increase in 2007, and stable from 2007-2016
  – Change-points correspond to a wet year with several hurricanes (2004) and a very dry time period (2006-2008)

> HCSW-1 pH values are almost all within the 95% prediction intervals of pH at Charlie Creek (unmined) and upstream stations, including during times of NPDES discharge

> No evidence of a consistent, continuing increase in pH at HCSW-1 over time
Impact Assessment: Specific Conductivity
Monthly HCSP and SWFWMD Conductivity
## Monthly HCSP and SWFWMD Conductivity

<table>
<thead>
<tr>
<th>LOESS Smooth Parameter</th>
<th>Stat</th>
<th>SWFWMD – Horse Creek Near Myakka Head</th>
<th>HCSP – HCSW-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>p-value</td>
<td>&lt;0.0001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>slope</td>
<td>12.4</td>
<td>12.4</td>
</tr>
<tr>
<td>Logged Flow</td>
<td>p-value</td>
<td>&lt;0.0001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>slope</td>
<td>11.2</td>
<td>11.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LOESS Smooth Parameter</th>
<th>Stat</th>
<th>SWFWMD – Horse Creek Near Myakka Head</th>
<th>HCSP – HCSW-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>p-value</td>
<td>&lt;0.0001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>slope</td>
<td>12.4</td>
<td>12.4</td>
</tr>
<tr>
<td>Logged Flow</td>
<td>p-value</td>
<td>&lt;0.0001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>slope</td>
<td>12.1</td>
<td>12.9</td>
</tr>
</tbody>
</table>
Change-point Analysis of HCSP SC Data (2003-2016)

Table of Significant Changes for SC

Confidence Level for Candidate Changes = 95%, Confidence Level for Inclusion in Table = 95%, Confidence Interval = 95%, Bootstraps = 1000, Without Replacement, MSE Estimates

<table>
<thead>
<tr>
<th>Year.Month</th>
<th>Confidence Interval</th>
<th>Conf. Level</th>
<th>From</th>
<th>To</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007.4</td>
<td>(2007.4, 2007.9)</td>
<td>100%</td>
<td>211.34</td>
<td>391.64</td>
<td>1</td>
</tr>
<tr>
<td>2010.11</td>
<td>(2007.5, 2011.5)</td>
<td>99%</td>
<td>391.64</td>
<td>312.45</td>
<td>4</td>
</tr>
<tr>
<td>2015.6</td>
<td>(2014.10, 2016.2)</td>
<td>99%</td>
<td>312.45</td>
<td>402.42</td>
<td>3</td>
</tr>
</tbody>
</table>
Change-point Analysis of SWFWMD SC Data (1998-2016)

Table of Significant Changes for SC

Confidence Level for Candidate Changes = 95%, Confidence Level for Inclusion in Table = 95%, Confidence Interval = 95%, Bootstraps = 1000, Without Replacement, MSE Estimates

<table>
<thead>
<tr>
<th>Year.Month</th>
<th>Confidence Interval</th>
<th>Conf. Level</th>
<th>From</th>
<th>To</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999.11</td>
<td>(1999.7, 2001.2)</td>
<td>100%</td>
<td>140.82</td>
<td>213.64</td>
<td>2</td>
</tr>
<tr>
<td>2007.4</td>
<td>(2007.2, 2007.10)</td>
<td>100%</td>
<td>213.64</td>
<td>367.57</td>
<td>1</td>
</tr>
</tbody>
</table>
## Charlie Creek Conductivity

**SWFWMD and FDEP Data**

<table>
<thead>
<tr>
<th>LOWESS Smooth Parameter</th>
<th>Statistics</th>
<th>SWFWMD and FDEP Data</th>
<th>USGS, SWFWMD, and FDEP Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Seasonal 1999-2016</td>
<td>Seasonal 2003-2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annual 2003-2016</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>p-value</td>
<td>0.90</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.50</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>slope</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>USGS Log Flow</td>
<td>p-value</td>
<td>0.46</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.27</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td></td>
<td>slope</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Seasonal 1999-2016**

- p-value: 0.90
- Slope: N/A

**Seasonal 2003-2016**

- p-value: 0.68
- Slope: N/A

**Annual 1992-2016**

- p-value: 0.50
- Slope: N/A

**Annual 1998-2016**

- p-value: 0.67
- Slope: N/A

**Annual 2003-2016**

- p-value: 1.00
- Slope: N/A
HCSP and Charlie Creek SC Data-Periods With and Without NPDES Discharge
Upstream Horse Creek Conductivity

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>p-value</td>
<td>0.44</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>0.001</td>
<td>0.05</td>
<td>0.003</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>N/A</td>
<td>4.29</td>
<td>4.71</td>
<td>3.93</td>
<td>3.28</td>
<td>8.8</td>
<td>16.1</td>
<td></td>
</tr>
</tbody>
</table>
Upstream Horse Creek Conductivity
Conductivity Trend Summary

> Statistically significant increasing trend detected even when period of record was expanded
  > Analysis of other stations shows influence of climatic and upstream conditions
> HCSW-1 SC values are almost all within the 95% prediction intervals of SC at Charlie Creek (unmined) and upstream stations, including during times of NPDES discharge
> SC at upstream Horse Creek and West Fork Horse Creek (no NPDES outfalls present) had been increasing over the same time period
> While some isolated conductivity values at HCSW-1 may be related to increased groundwater influence from NPDES discharges, majority of increasing trend can be explained upstream conditions and regional factors unrelated to NPDES discharge
Biological Health With Respect to Conductivity

- HCSW-1 and HCSW-4 populations are healthy with no evidence of declines over time
- Fish species each have salinity/SC tolerance which vary by life stage of the species
- Other factors like temperature and suitable habitat may affect taxa richness and abundance in Horse Creek
- The average SCI score at both HCSW-1 and HCSW-4 is well above 40 and the two most recent scores are above 35
- HCSW-1 also passes other biological metrics (RPS and LVS), indicating no biological impairment
Fish Diversity

SCI Scores

Shannon-Wiener Diversity Index

SCI 2004 Calculations
One Vial

SCI 2012 Calculations
Two Vials

SCI Score
Biological Health and Conductivity

![Graphs showing relationships between fish taxa richness, specific conductivity, and SCI 2012 score.]

- Fish Taxa Richness vs. Specific Conductivity (µmhos/cm)
- 3-Month Average Specific Conductivity (µmhos/cm)
- SCI 2012 Score

HCSW-1, HCSW-4 markers on graphs.
Water Quality Graphs
2003-2016
Total Nitrogen

![Graph showing Total Nitrogen levels over time for different locations and trigger levels.](graph.png)
TKN

Total Kjeldahl Nitrogen (mg/l)

- HCSW-1
- HCSW-2
- HCSW-3
- HCSW-4
- BCSW-1
- MDL
Nitrate-Nitrite Nitrogen (mg/l)

HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
MDL
Orthophosphate

- HCSW-1
- HCSW-2
- HCSW-3
- HCSW-4
- BCSW-1
- Trigger Level
- MDL
110 mg/L recorded at HCSW-2 in June 2007.
Specific Conductivity

The graph shows the specific conductivity (umhos/cm) over time for various locations labeled HCSW-1 through HCSW-4 and BCSW-1. The x-axis represents time spanning from April 2003 to October 2016. The y-axis represents specific conductivity values ranging from 0 to 1500 umhos/cm. The graph includes a trigger level and a method detection limit (MDL) indicated by horizontal lines. The data points for each location are marked with different symbols and colors for easy identification.
Calcium

HCSW-1  HCSW-2  HCSW-3  HCSW-4  BCSW-1  Trigger Level  MDL

Dissolved Calcium (mg/l)


Cardno
Iron

Dissolved Iron (mg/l)

- HCSW-1
- HCSW-3
- BCSW-1
- HCSW-4

Trigger Level, HCSW-1 to -3
MDL

Cardno
Total Dissolved Solids

![Graph showing total dissolved solids concentrations over time for different locations. The x-axis represents time from April 03 to October 16, and the y-axis represents total dissolved solids in mg/l. The graph includes data points for HCSW-1, HCSW-2, HCSW-3, HCSW-4, BCSW-1, trigger level, and MDL.](image-url)
Radium

Total Radium (pCi/L)

- HCSW-1
- HCSW-2
- HCSW-3
- HCSW-4
- BCSW-1
- Trigger Level
Thank you

For more information

Sheri Huelster - Cardno
*Project Scientist*

[sheri.huelster@cardno.com](mailto:sheri.huelster@cardno.com)

Kristan Robbins – Brown and Caldwell
*Senior Professional – Environmental Science*

[krobbins@brwncald.com](mailto:krobbins@brwncald.com)
Events Timeline

> April 2003 – HCSP Began
> August-September 2004 – Three Hurricanes (Charley, Frances, Jeanne) move up HC Basin
> August 2005 – Invert sorting method change (100-120 inverts in vial)
> June 2006 – Last clays from Ft. Green plant sent to CSAs FGH3 and FGH4
> November 2006 – FDEP invert sorting method change (2 vials, 140-160 inverts)
> 2006-2008 – Time of lower than average streamflow and rainfall in HC Basin
> October 2008 – Clays mined via dredge from Wingate Mine begin discharging through FTG-004
> March 2009 – Added CSA FM-1 to monitoring program
> September 2009 – discontinue monitoring FL-PRO, fatty acids, and total amines at all HC Locations. Added location in Brushy Creek w/out trigger levels and Impact Assessments
> December 2010 – Coldest December for Tampa Bay area in recorded history
> October 2011 – SWFWMD reduced sampling frequency at HCSW-1 and HCSW-4 to every other month
> November 2011 – SWFWMD rain gauge discontinued
> January 2013 – supplemented SWFWMD Flatford Swamp rain gauge in addition to NOAA and Mosaic gauges in annual report tables and graphics
> July 2014 – new FDEP SOP for the SCI (SCI 1000) calculations along with bioregions went into effect with the approval of the new QA rule.
Lab Changes Timeline

> April 2003 – November 2004: Various labs

> Parameters except Radiologicals:
  - December 2004 – May 2008: STL/Test America
  - June 2008 - Mosaic’s Laboratory
  - July 2008 – July 2010: Benchmark Analytical (still analyzing color and chlorophyll-a)
  - August 2010 – July 2011: Phoslab
  - August 2011 – Present: Mosaic’s Laboratory

> Radiologicals:
  - April 2006 – July 2008: KNL Labs (Radiologicals only)
  - August 2008 – Present: Florida Radiochemistry (Radiologicals only)
Major MDL Changes

> January 2006 – July 2008: nitrate-nitrite highly variable

> April 2003- December 2011: ammonia (around 0.3 mg/L through Oct 2007, variable through July 2008, stable through July 2011, then variable)

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

> April 2003 - December 2011: dissolved iron started at 0.1 mg/L, reduced to 0.022 mg/L in March 2006, then stable at 0.01 mg/L from August 2010

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

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

> March 2006 – February 2008: sulfate numerous changes; stable since March 2008