Horse Creek Stewardship Program
2018 Annual Report Summary
Overview

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

The three 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
2018 Annual Report Summary

- Project Methods
- Mining and Reclamation
- Summary of Sampling Conditions
- Results and Conclusions: Biology
- Results and Conclusions: Water Quantity
- Results and Conclusions: Water Quality
- Summary of 2018 TDS, Sulfate, and Calcium Impact Assessment
Methods

[Image of a fish lying on a measuring ruler]
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, and turbidity
• Lab Analysis of 16 parameters including nutrients, minerals, and mining reagents

Continuous (15-min intervals) sampling by Mosaic at HCSW-1
• pH, dissolved oxygen, specific conductivity, temperature, and turbidity

Additional sampling coincident with biological sampling
• Field parameters of temperature, pH, dissolved oxygen, specific conductivity, and turbidity
# Trigger Levels

<table>
<thead>
<tr>
<th>Pollutant Category</th>
<th>Analytical Parameters</th>
<th>Reporting Units</th>
<th>Trigger Level</th>
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Table 4-4
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-Wiener Diversity Index

**Fish:**
- Sampled with 4’ x 8’ seine and electrofishing
- Species richness
- Shannon-Wiener Diversity Index
- Morisita’s Community Similarity Index
- Species Accumulation Curve
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
- 2018 Impact Assessment
  - Part 1: Historical analysis of TDS, calcium, and sulfate
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

- Annual reports have been produced from 2003 to present.

- A historical report focusing on pre-2003 conditions was also prepared.
Mining and Reclamation Activities
Mining and Reclamation Activities

Adapted from Table 3-1

Acres


Horse Creek  Brushy Creek  Reclamation HC  Reclamation BC
Summary of Sampling Conditions
Sample Sites

Biological Sampling Summary

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<thead>
<tr>
<th>Month</th>
<th>Horse Creek Water Quality Sampling Events</th>
<th>Horse Creek Biology Sampling Events</th>
<th>Brushy Creek Water Quality Sampling Events</th>
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<td>January</td>
<td>Sampled January 17 (No flow at HCSW-2)</td>
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<td>February</td>
<td>Sampled February 7</td>
<td></td>
<td>Sampled</td>
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<td>March</td>
<td>Sampled March 21 (No flow at HCSW-2)</td>
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<td>Low flow</td>
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<td>April</td>
<td>Sampled April 18 (No flow at HCSW-2)</td>
<td>Sampled April 30 HCSW-1, 3, &amp; 4</td>
<td>Dry</td>
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<td>May</td>
<td>Sampled May 24</td>
<td></td>
<td>Sampled</td>
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<tr>
<td>June</td>
<td>Sampled June 20</td>
<td></td>
<td>Sampled</td>
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<td>July</td>
<td>Sampled July 11</td>
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<td>August</td>
<td>Sampled August 2</td>
<td></td>
<td></td>
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<tr>
<td>September</td>
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<tr>
<td>October</td>
<td>Sampled October 2</td>
<td>Sampled October 30 &amp; 31*</td>
<td>Sampled October 2</td>
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<tr>
<td>November</td>
<td>Sampled November 8</td>
<td></td>
<td>No flow-not sampled</td>
</tr>
<tr>
<td>December</td>
<td>Sampled December 12</td>
<td>Sampled December 17 &amp; 18</td>
<td>No flow-not sampled</td>
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*electrofishing conducted on December 4 due to equipment malfunction

Table 4-1
Habitat Assessment Scores
Artificial Channelization- 1940s vs. present
Macroinvertebrate Taxa Richness

Figure 7-3
Macroinvertebrate Shannon-Wiener Diversity

Figure 7-4
Macroinvertebrate Shannon-Wiener Diversity

Figure 7-4

Shannon-Wiener Diversity


Values: 7, 11, 4, 16, 9, 11, 11, 5, 12, 8, 7, 11, 12, 12, 8, 10, 11
Macroinvertebrate Diversity

Figure 7-6

Macroinvertebrate SW Diversity by Station

- HCSW-1: N=31
- HCSW-2: N=24
- HCSW-3: N=32
- HCSW-4: N=35
Macroinvertebrate Results - 2018

- Habitat Assessment
  - “Sub-optimal” at all sites except HCSW-3 in April which scored a “marginal”
  - Marginal score was primarily due to the lack of suitable productive habitat, water velocity, bank erosion, and riparian buffer quality

- Stream Condition Index
  - Scores at HCSW-1, HCSW-3, and HCSW-4 were in the “healthy” category (>35)
  - The April sample at HCSW-1 attained an “exceptional” score (>68)
  - Scores at HCSW-2 were “impaired” (<34)
    - Low score likely due to the site lacking streamflow and conditions conducive to keeping oxygen in the water to support macroinvertebrate populations

- Biological Diversity
  - Spring 2018 taxa richness was the highest recorded so far at HCSW-1, HCSW-3, & HCSW-4
  - Spring 2018 Shannon-Wiener diversity was the highest on record so far at HCSW-1 & HCSW-3
Macroinvertebrate Results POR

- **Stream Condition Index**
  - HCSW-1 is the only station with a detected trend in SCI scores for the period 2007-2018 (+2.33/year, Annual Kendall tau = 0.55, p<0.05)

- **Shannon-Wiener Diversity**
  - Overall diversity in 2018 across all four stations was the 2nd highest since 2003.
Fish
Fish Species Richness

Figure 7-7
Shannon-Wiener Diversity

Figure 7-8
Fish Species Diversity – Stations by Year
Figure 7-10

Shannon-Wiener Diversity Index
Fish Species Diversity – Years

Figure 7-12

[Bar chart showing Shannon-Wiener Diversity Index for different years from 2003 to 2018, with sample sizes (N) indicated for each year.]
Fish Species Diversity – Stations

Figure 7-11

Shannon-Wiener Diversity Index

- HCSW-1: N=43
- HCSW-2: N=33
- HCSW-3: N=43
- HCSW-4: N=46
## Fish Species– Morisita Diversity Index

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<tr>
<th></th>
<th>HCSW-1</th>
<th>HCSW-2</th>
<th>HCSW-3</th>
<th>HCSW-4</th>
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<td>0.97</td>
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<td>2015</td>
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<td>2017</td>
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<td>2018</td>
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Table 7-4
Species Accumulation Curve

Figure 7-13
2018 Fish Results & Conclusions

- Number of species caught: 21 (historical annual range 18-32)
- Cumulative total 2003-2018: 44
- No new fish species observed in 2018
  - When considered at the station level, two new invasive species observed
    - Vermiculated sailfin catfish (*Pterygoplichthys disjunctivus*) at HCSW-1 during all three sampling events
    - Asian swamp eel (*Monopterus javanensis*) at HCSW-3 during October event
  - 1.8% invasive fish (31% biomass) in 2018 catch
- Most commonly collected groups: livebearers, shiners, sunfishes, and silversides
Fish Results & Conclusions

• Number of species at each station in 2018
  – HCSW-1: 10 native, 4 invasive
  – HCSW-2: 6 native, 1 invasive
  – HCSW-3: 11 native, 3 invasive
  – HCSW-4: 12 native, 5 invasive

• Shannon-Wiener Diversity Index
  – Diversity by sampling event and station in 2018 ranged from 0.17 (HCSW-2, October) to 2.62 (HCSW-3, October)
  – Overall 2018 ranked 9th highest year based on diversity (lowest 2010, highest 2013)
  – Over the period of record, fish richness and diversity was lowest at HCSW-2 and highest at HCSW-1 (diversity) and HCSW-4 (richness)
Fish Results & Conclusions

• Morisita’s Index of Similarity
  – When all sampling events for a given station are combined, fish communities were very similar (88% - 99%), with HCSW-1 being the least similar
  – When all sampling events for a given year are combined, fish communities were very similar (87% - 100%)
    • 2005, 2009, and 2016 least similar to 2018
    • 2007 and 2017 most similar to 2018

• Trends
  – No increasing or decreasing trends when all stations were combined and analyzed annually or seasonally adjusted
  – No increasing or decreasing trends for individual stations by annual median diversity; spring, summer, or winter diversity
Water Quantity Results
Rainfall, 2018 Monthly

Figure 5-1

Total Monthly Rainfall, inches

January February March April May June July August September October November December

Horse Creek North  Horse Creek South  Manson Jenkins  Mosaic Average  SWFWMD Flatford
Rainfall - Mosaic Gauges

Figure 5-2

Cumulative Rainfall, inches

Total Monthly Rainfall, inches


Cumulative Rainfall, inches

0 100 200 300 400 500 600 700 800

Total Monthly Rainfall

0 2 4 6 8

Blue: Total Monthly Rainfall
Red: Cumulative Rainfall
Stream Stage, 2018

Figure 5-3

Stage Height NAVD 88, feet

Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec

HCSW-1 Water Elevation  HCSW-4 Water Elevation  HCSW-1  HCSW-2  HCSW-3  HCSW-4
Stream Stage Duration in 2018

Figure 5-4
Streamflow, 2018

Figure 5-5

Average Daily Stream Flow, cfs

Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec

HCSW-1  HCSW-4
Median Streamflow

Figure 5-6

[Graph showing streamflow data for HCSW-1 P50 and HCSW-4 P50 for the years 2002 to 2019. The x-axis represents the years, and the y-axis represents streamflow in cfs.]
Rainfall and Streamflow, 2018 Daily Average
Rainfall and Streamflow – Monthly Average

Figure 5-8
Rainfall and Streamflow – Double Mass Curve, 1978-2018

**1978-2018**
- Slope: 0.21
- $R^2 = 0.9978$

**2000-2005**
- Slope: 0.29
- $R^2 = 0.9929$

**2005-2008**
- Slope: 0.06
- $R^2 = 0.9809$

**2008-2018**
- Slope: 0.25
- $R^2 = 0.9962$
Rainfall and Streamflow – Double Mass Curve, 1978-2018

Pre-outfall
1978-2000
slope 0.20
$R^2 = 0.9975$

Post-outfall
2001-2018
slope 0.22
$R^2 = 0.9913$

1978-2018
slope 0.21
$R^2 = 0.9978$
Streamflow and NPDES Discharge, 2018

Figure 5-11

Average Daily Flow, cfs

WIN-004 Flow MGD
HCSW-1
Combined NPDES Discharge to Horse Creek, POR

D-003+004 MGD
## Combined NPDES Discharge to Horse Creek, POR

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<th>Rank</th>
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Water Quality Results
### Water Quality Results - ANOVA

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<td>Specific Conductance</td>
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<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Turbidity</td>
<td>0.77</td>
<td>0.510</td>
</tr>
<tr>
<td>Radiological</td>
<td>Radium, Combined</td>
<td>6.03</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
### Correlations with Water Quantity at HCSW-1 and HCSW-4

<table>
<thead>
<tr>
<th>Group</th>
<th>Parameter</th>
<th>HCSW-1</th>
<th>HCSW-4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rainfall</td>
<td>NPDES</td>
</tr>
<tr>
<td>Anions</td>
<td>Alkalinity</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Chloride</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Fluoride††</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Sulfate</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Cations</td>
<td>Calcium, Dissolved</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Iron, Dissolved</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Nutrients</td>
<td>Ammonia, Total††</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Chlorophyll-a</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Nitrate-Nitrite††</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Nitrogen, Total</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Nitrogen, Total Kjeldahl</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Orthophosphate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>Color, Apparent</td>
<td>+</td>
<td>+</td>
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<tr>
<td></td>
<td>Dissolved Solids, Total</td>
<td>+</td>
<td>+</td>
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<td></td>
<td>Oxygen Dissolved†</td>
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<td>-</td>
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<td></td>
<td>Oxygen, Dissolved</td>
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<td>-</td>
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<td>pH</td>
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<td></td>
<td>Specific Conductance</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Turbidity</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Radium, Total</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Spearman rank correlation. Statistically significant at $p<0.05$
Seasonal Kendall Tau

- Non-parametric test for monotonic trends
- Determines water quality trends after correcting for seasonality by only comparing values between similar seasons over time
- Corrected for streamflow if relationship existed
- Used SWFWMD as an alternative to HCSP data - F⁻, NOₓ, & NH₃
- Went to annual trends only when SWFWMD data collection changed to bi-monthly
- Produces a trend slope estimate
- Trend detection limited by
  - <5 years of data
  - Changes in method detection limits for parameters/proportion of non-detects
### Seasonal Trends over Time 2003-2018

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HCSW-1 Slope</th>
<th>HCSW-4 Slope</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkalinity</td>
<td>2.32 mg/L/yr</td>
<td>0.54 mg/L/yr</td>
<td>Discussed in Historical Assessment</td>
</tr>
<tr>
<td>Calcium</td>
<td>1.1 mg/L/yr</td>
<td></td>
<td>Discussed in Historical Assessment</td>
</tr>
<tr>
<td>Chlorophyll-a</td>
<td>-0.03 mg/M³/yr</td>
<td>-0.05 mg/M³/yr</td>
<td>Not an adverse trend</td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td>2.82 PCU/yr</td>
<td>Not an adverse trend</td>
</tr>
<tr>
<td>DO (mg/L)</td>
<td>0.04 mg/L/yr</td>
<td></td>
<td>Not an adverse trend</td>
</tr>
<tr>
<td>Fluoride</td>
<td>0.01 mg/L/yr</td>
<td></td>
<td>Slope very small in magnitude.</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>Nitrogen, Total Kjeldahl</td>
<td></td>
<td>0.02 mg/L/yr</td>
<td>Slope very small in magnitude; not at upstream station.</td>
</tr>
<tr>
<td>pH</td>
<td>0.04 SU/yr</td>
<td>0.02 SU/yr</td>
<td>Slope very small in magnitude. Isolated step change.</td>
</tr>
<tr>
<td>Specific Conductance</td>
<td>12.1 μS/yr</td>
<td>5.7 μS/yr</td>
<td>Discussed in Historical Assessment</td>
</tr>
<tr>
<td>Sulfate</td>
<td>4.24 mg/L/yr</td>
<td></td>
<td>Discussed in Historical Assessment</td>
</tr>
<tr>
<td>TDS</td>
<td>9.04 mg/L/yr</td>
<td></td>
<td>Discussed in Historical Assessment</td>
</tr>
<tr>
<td>Turbidity</td>
<td></td>
<td>0.09 NTU/yr</td>
<td>Slope very small in magnitude; not at upstream station.</td>
</tr>
</tbody>
</table>

Table 6-5
Proposed Changes to Kendall-Tau Trend Test Procedure

• Previous reports used season median of log-flow and respective parameter to calculate flow-adjusted values, i.e., the flow value and water quality value were collected on separate days within a season.

• We propose flow adjusting water quality values with the real-time log-flow values then calculating seasonal medians of those flow-adjusted values before running trend test. We can begin this in the 2019 report.
### Proposed changes to Kendall-tau trend test procedure

<table>
<thead>
<tr>
<th>Analyte</th>
<th>HCSW-1 Slope</th>
<th>HCSW-4 Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current</td>
<td>Proposed</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>2.32</td>
<td>1.97</td>
</tr>
<tr>
<td>Calcium, Dissolved</td>
<td>1.10</td>
<td>0.82</td>
</tr>
<tr>
<td>Chlorophyll-a</td>
<td>-0.03</td>
<td>-0.05</td>
</tr>
<tr>
<td>Color, Total</td>
<td>2.82</td>
<td>2.52</td>
</tr>
<tr>
<td>Dissolved Solids, Total</td>
<td>9.04</td>
<td>9.38</td>
</tr>
<tr>
<td>Fluoride*</td>
<td>0.010</td>
<td>0.008</td>
</tr>
<tr>
<td>Iron, Dissolved</td>
<td>-0.01</td>
<td>-0.01</td>
</tr>
<tr>
<td>Nitrogen, Ammonia*</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Nitrogen, Total Kjeldahl</td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td>Oxygen, Dissolved (mg/L)</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Oxygen, Dissolved (%Sat)</td>
<td></td>
<td>0.87</td>
</tr>
<tr>
<td>pH</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Radium, Total</td>
<td></td>
<td>-0.02</td>
</tr>
<tr>
<td>Specific Conductance</td>
<td>12.1</td>
<td>12.1</td>
</tr>
<tr>
<td>Sulfate</td>
<td>4.24</td>
<td>3.79</td>
</tr>
<tr>
<td>Turbidity</td>
<td></td>
<td>0.09</td>
</tr>
</tbody>
</table>

*Annual Kendall test
Proposed Changes to Kendall-Tau Trend Test Procedure

• “Parameters whose MDLs have changed over the course of the program were omitted from the analysis because of limited comparable data between sampling events and stations (i.e., fluoride, nitrate-nitrite, ammonia).”

• “Data for parameters whose method detection limits have changed several times over the HCSP (fluoride, nitrate-nitrite, ammonia) would have to be truncated to the highest detection limit, thereby reducing the available data for the test. As a result, trends were evaluated using alternative data collected by SWFWMD for these parameters; SWFWMD reduced sampling frequency in 2011, so seasonal trend tests may not be as accurate for those parameters.”
  – We propose omitting this language and utilizing both the Mosaic and State of Florida datasets
Proposed Changes to Kendall-Tau Trend Test Procedure
Proposed Changes to Kendall-Tau Trend Test Procedure
Proposed Changes to Kendall-Tau Trend Test Procedure

Nitrate-Nitrite, mg/L

April-03 April-06 April-09 April-12 April-15 April-18

Min of NOx Max of NOx2 Max of NOxMDL
## Trigger Level Exceedances

<table>
<thead>
<tr>
<th>Station ID</th>
<th>Month</th>
<th>Analyte</th>
<th>Concentration</th>
<th>Trigger Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCSW-1</td>
<td>April</td>
<td>Alkalinity (mg/L)</td>
<td>120</td>
<td>100</td>
</tr>
<tr>
<td>HCSW-4</td>
<td>March</td>
<td>Calcium, Dissolved (mg/L)</td>
<td>106</td>
<td>100</td>
</tr>
<tr>
<td>HCSW-2</td>
<td>May</td>
<td>Dissolved Oxygen (%Saturation)</td>
<td>10.8</td>
<td>37.5</td>
</tr>
<tr>
<td>HCSW-2</td>
<td>June</td>
<td>Dissolved Oxygen (%Saturation)</td>
<td>13.1</td>
<td>42.7</td>
</tr>
<tr>
<td>HCSW-2</td>
<td>July</td>
<td>Dissolved Oxygen (%Saturation)</td>
<td>27</td>
<td>38.5</td>
</tr>
<tr>
<td>HCSW-2</td>
<td>October</td>
<td>Dissolved Oxygen (%Saturation)</td>
<td>39.5</td>
<td>39.8</td>
</tr>
<tr>
<td>HCSW-2</td>
<td>November</td>
<td>Dissolved Oxygen (%Saturation)</td>
<td>39.1</td>
<td>40.6</td>
</tr>
<tr>
<td>HCSW-3</td>
<td>May</td>
<td>Dissolved Oxygen (%Saturation)</td>
<td>32.7</td>
<td>35.9</td>
</tr>
<tr>
<td>HCSW-3</td>
<td>June</td>
<td>Dissolved Oxygen (%Saturation)</td>
<td>31.5</td>
<td>36.4</td>
</tr>
<tr>
<td>HCSW-4</td>
<td>May</td>
<td>Dissolved Iron (mg/L)</td>
<td>0.651</td>
<td>0.3</td>
</tr>
<tr>
<td>HCSW-4</td>
<td>June</td>
<td>Dissolved Iron (mg/L)</td>
<td>0.581</td>
<td>0.3</td>
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<tr>
<td>HCSW-4</td>
<td>July</td>
<td>Dissolved Iron (mg/L)</td>
<td>0.518</td>
<td>0.3</td>
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<tr>
<td>HCSW-4</td>
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<td>Dissolved Iron (mg/L)</td>
<td>0.461</td>
<td>0.3</td>
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<tr>
<td>HCSW-4</td>
<td>September</td>
<td>Dissolved Iron (mg/L)</td>
<td>0.460</td>
<td>0.3</td>
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<tr>
<td>HCSW-4</td>
<td>October</td>
<td>Dissolved Iron (mg/L)</td>
<td>0.309</td>
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<tr>
<td>HCSW-3</td>
<td>January</td>
<td>Dissolved Solids, Total (mg/L)</td>
<td>742</td>
<td>500</td>
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<tr>
<td>HCSW-3</td>
<td>April</td>
<td>Dissolved Solids, Total (mg/L)</td>
<td>604</td>
<td>500</td>
</tr>
<tr>
<td>HCSW-4</td>
<td>January</td>
<td>Dissolved Solids, Total (mg/L)</td>
<td>520</td>
<td>500</td>
</tr>
<tr>
<td>HCSW-4</td>
<td>March</td>
<td>Dissolved Solids, Total (mg/L)</td>
<td>697 F</td>
<td>500</td>
</tr>
<tr>
<td>HCSW-2</td>
<td>July</td>
<td>Nitrogen, Ammonia (mg/L)</td>
<td>0.77 F</td>
<td>0.3</td>
</tr>
<tr>
<td>HCSW-3</td>
<td>July</td>
<td>Nitrogen, Ammonia (mg/L)</td>
<td>0.38 F</td>
<td>0.3</td>
</tr>
<tr>
<td>HCSW-4</td>
<td>July</td>
<td>Nitrogen, Ammonia (mg/L)</td>
<td>0.54 F</td>
<td>0.3</td>
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<tr>
<td>HCSW-3</td>
<td>April</td>
<td>Sulfate (mg/L)</td>
<td>290</td>
<td>250</td>
</tr>
<tr>
<td>HCSW-4</td>
<td>March</td>
<td>Sulfate (mg/L)</td>
<td>355</td>
<td>250</td>
</tr>
</tbody>
</table>

F - qualifier indicates that the analyte was detected in both the sample and the field blank
2018 pH

Figure 6-1

[Graph showing pH levels for different sites over the year, with data points for Mosaic and Flatwoods collectors.]
Unattended pH and Streamflow at HCSW-1

Figure 6-2

Streamflow, cfs

pH, standard units

HCSW-1 Streamflow  •••••• daily max pH  ••••• daily min pH
POR pH

Figure C-1

Outfall Status

- Flow
- No flow

pH, standard units

0.04 su/year 0.02 su/year
2018 Dissolved Oxygen Saturation

Figure 6-3
Unattended DO Saturation and Streamflow at HCSW-1

Figure 6-4

Dissolved Oxygen, % Saturation

Streamflow, cfs

HCSW-1 Streamflow  daily min %DO  daily max %DO
POR DO Saturation

Figure C-3

Outfall Status

- Flow
- No flow
2018 Turbidity

Figure 6-5
Unattended Turbidity and Streamflow at HCSW-1

Figure 6-6

Streamflow, cfs
Turbidity, NTU

HCSW-1 Streamflow  Mean Turbidity
POR Turbidity

Figure C-4

0.09 NTU/year
2018 Apparent Color

Figure 6-7
POR Apparent Color

2.82 PCU/year
2018 Total Nitrogen

Figure 6-8

[Graph showing total nitrogen levels across different sites and dates, with markers indicating NOx & TKN detected and NOx not detected.]
POR Total Nitrogen

Figure C-6

Outfall Status

- Flow
- No flow

Site
- HCSW-1
- HCSW-2
- HCSW-3
- HCSW-4
- BCSW-1

Total Nitrogen, mg/L

Date

2018 Total Kjeldahl Nitrogen

Figure 6-9
POR Total Kjeldahl Nitrogen

Figure C-7

Outfall Status
- Flow
- No flow

0.02 mg/L/year
2018 Nitrate-Nitrite

Figure 6-10
POR Nitrate-Nitrite

Figure C-8

Site

HCSW-1  HCSW-2  HCSW-3  HCSW-4  BCSW-1

Outfall Status

○ Flow
× No flow

NITRATES-NITRITE, mg/L

Date


2018 Total Ammonia

Figure 6-11
POR Total Ammonia

Figure C-9

Outfall Status

<0.001 mg/L/year
2018 Orthophosphate

Figure 6-12
POR Orthophosphate

Figure C-10

Outfall Status

- ○ Flow
- × No flow

Sites:
- HCSW-1
- HCSW-2
- HCSW-3
- HCSW-4
- BCSW-1

Orthophosphate, mg/L

Date


2018 Chlorophyll-a, corrected
POR Chlorophyll-a, corrected

Figure C-11

Outfall Status
- Flow
- No flow

0.03 mg/L/year

0.05 mg/L/year
2018 Specific Conductivity

![Graph showing specific conductivity data for different sites and collectors over time.](Figure 6-14)
Unattended Specific Conductivity and Streamflow at HCSW-1

Figure 6-15

Streamflow, cfs
Specific Conductivity, µS

HCSW-1 Streamflow
daily min S. Cnd.
daily max S. Cnd.

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
POR Specific Conductivity

Figure C-12

Outfall Status

Site

HCSW-1

HCSW-2

HCSW-3

HCSW-4

BCSW-1

Specific Conductance, µS

0

200

400

600

800

1000

1200

1400

Year

Date

HCSW-1

HCSW-2

HCSW-3

HCSW-4

BCSW-1

Flow

No Flow

12.1 µS/year

5.69 µS/year
2018 Dissolved Calcium

Figure 6-16
POR Dissolved Calcium

Figure C-13

1.1 mg/L/year
2018 Dissolved Iron
POR Dissolved Iron

Figure C-14

Outfall Status

- Flow
- No flow

HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1

Dissolved iron, mg/L

Date


0.01 mg/L/year


0.01 mg/L/year
2018 Alkalinity

Figure 6-18

[Graph showing Alkalinity levels across different sites (HCSW-1, HCSW-2, HCSW-3, HCSW-4, BCSW-1) with specific dates (Jan, Apr, Jul, Oct) and measurements in mg/L. The graph includes symbols for "flow" (○) and "no flow" (×).]
POR Alkalinity

Figure C-15

2.32 mg/L/year

0.54 mg/L/year
2018 Chloride
POR Chloride

Figure C-16

Chloride, mg/L

Date

Site

HCSW-1

HCSW-2

HCSW-3

HCSW-4

BCSW-1
2018 Fluoride
POR Fluoride

0.01 mg/L/year
2018 Sulfate
POR Sulfate

Figure C-18

4.24 mg/L/year
2018 Total Dissolved Solids

Figure 6-22

[Diagram showing total dissolved solids for sites HCSW-1, HCSW-2, HCSW-3, HCSW-4, and BCSW-1 over different months with data points indicating flow and no flow.]
POR Total Dissolved Solids

Figure C-19

9.04 mg/L/year
2018 Combined Radium

Figure 6-23
POR Combined Radium
Water Quality Conclusion - 2018

- 24 water quality exceedances in 2018
  - 1 at HCSW-1 (Alkalinity)
  - 6 at HCSW-2 (DO (5) and NH₃ (1))
  - 6 at HCSW-3 (DO (2), TDS (2), SO₄ (1), and NH₃ (1))
  - 11 at HCSW-4 (Fe (6), SO₄ (1), NH₃ (1), TDS (2), and Ca (1))

- Site closest to outfalls has the least number exceedances.
- HCSW-2 unlike other sites due to upstream impoundment and prairie. Longer residence time, periods of reduced or no water velocity, thick anaerobic organic benthic layer
- NH₃ exceedances were F-qualified, Field blank > trigger value, and HCSW-1< trigger value
- HCSW-4 Fe similar to other sites but site has a lower trigger level
- HCSW-1 alkalinity exceedance occurred 495 days after the last discharge
- SO₄, TDS, and Ca exceedances occurred only at sites in lower basin
- SO₄, TDS, Ca, and specific conductance trend was detected 2003-2018 - discussed in impact assessment
Water Quality Conclusion at HCSW-1

- 326 exceedances, 13 parameters, all sites, POR
  - 18, 73, 72, and 163 exceedances at HCSW-1, HCSW-2, HCSW-3, and HCSW-4, respectively
- HCSW-1: 13 Alkalinity, 1 Chlorophyll-a, 1 Color, 2 pH, and 1 TDS
  - 3 of 18 occurred concurrently with NPDES discharge

<table>
<thead>
<tr>
<th>Date</th>
<th>Analyte</th>
<th>Concentration</th>
<th>Trigger Level</th>
<th>NPDES, cfs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/5/2010</td>
<td>Alkalinity (mg/L)</td>
<td>109</td>
<td>100</td>
<td>34.5</td>
</tr>
<tr>
<td>2/2/2010</td>
<td>Chlorophyll-a (mg/m³)</td>
<td>15.4</td>
<td>15</td>
<td>51.6</td>
</tr>
<tr>
<td>10/24/2011</td>
<td>Alkalinity (mg/L)</td>
<td>102</td>
<td>100</td>
<td>42.3</td>
</tr>
</tbody>
</table>
2018 Impact Assessment
2018 Impact Assessment:

- Part 1: Historical analysis of TDS, calcium, and sulfate
  - The objective was to determine if Mosaic activities in the Upper Horse Creek Basin were contributing to the TDS, dissolved calcium, and sulfate exceedances documented in the HCSP

- Part 2: Ambient water quality assessment measuring TDS, calcium, and sulfate in neighboring streams not affected by mining against variable flow conditions
  - Hypothesis: elevated values occur under low-flow conditions
Data Sources

• Existing historical groundwater data collected through Mosaic’s Hydrogeologic Investigation and Monitoring Plan of Study (HIMPOS)

• Wastewater data from Mosaic’s National Pollutant Discharge Elimination System (NPDES) Discharge Monitoring Report (DMR) data

• Flow data collected by United States Geological Survey (USGS) gauging stations

• Surface water data from the HCSP and the State of Florida’s Impaired Waters Rule (IWR) database - Run 54

• Upper and Lower Horse Creek basins were characterized and scored using the Landscape Development Intensity Index (LDI) and SWFWMD land use shapefiles (1990, 1999, & 2011)
  – LDI calculated across entire watershed instead of typical 100m buffer of upstream reach
Dominant ions

• Average molar concentrations of each ion in the upper and lower Horse Creek basins:
  – CaCO$_3$, Na$^+$ and Ca$^{2+}$ most abundant ions in upper basin
  – CaCO$_3$, SO$_4^{2-}$ and Ca$^{2+}$ most abundant ions in lower basin

• Average ionic concentrations are elevated in the lower basin relative to the upper basin, with the exception of Na$^+$

• Suggests that there are different processes and/or contributions driving water chemistry in the two basins
**Time and Location of Exceedances**

- Wingate and Fort Green Mines and their respective outfalls are upstream of all four monitoring stations
- Wingate D-004 outfall is ~4.2 miles downstream of Fort Green D-003 outfall
- HCSW-1 closest to and ~5.5 downstream of Wingate D-004
  - HCSW-1 is the closest representation to the full impact of the outfalls
- Pre-mining exceedances first occurred in 1997 and 1999 all in the Lower Basin
- Exceedances in the Lower Basin have become more frequent since the mid-2000s
- First and only exceedance (TDS, SO₄, or Ca) in the Upper Basin was April 11, 2017 (TDS only)
  - Prior to that exceedance, most recent NPDES discharge through the outfalls occurred 124 days earlier
  - Stream flow consisted of no effluent, no surface runoff, and 100% groundwater seepage

<table>
<thead>
<tr>
<th>HCSW-1</th>
<th>HCSW-2</th>
<th>HCSW-3</th>
<th>HCSW-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of combined (TDS, calcium and sulfate) exceedances, period of record</td>
<td>1</td>
<td>0</td>
<td>60</td>
</tr>
</tbody>
</table>
Total Dissolved Solids, POR

Upper Horse Creek

- HCSP
- IWR
- Trigger value

Lower Horse Creek

- HCSP
- IWR
- Trigger value

$n = 333$

$n = 645$
Calcium, POR

Upper Horse Creek Lower Horse Creek

Calcium, mg·L⁻¹

n = 503

HCSP IWR Trigger value


Calcium, mg·L⁻¹

Calcium – Upper and Lower Basins
Sulfate – Upper and Lower Basins
Estimating TDS from Specific Conductivity

- Wingate and Fort Green NPDES wastewater permits do not require TDS, but do require specific conductivity, which can be used to estimate TDS

- A notable exception to effluent making up a fraction of creek flow occurred on June 3, 2009
  - TDS exceedances that day only occurred at HCSW-3 and HCSW-4
  - TDS value at HCSW-1 was below the trigger level

- No calcium or sulfate exceedances in the Upper Basin
Estimating TDS from Specific Conductivity

\[ y = 0.5834x + 43.317 \]
\[ R^2 = 0.8984 \]
Observations

- TDS, sulfate and calcium concentrations in Horse Creek tended to be lower when there was a discharge through either outfall than when there was no discharge.

- Discharges are driven by stormwater – not process demand.

- All TDS, calcium, and sulfate exceedances (except June 3, 2009 and June 3, 2015) occurred when the outfalls were:
  - Inactive
  - Often long inactive (9-503 days)
  - Horse Creek was under very low flow conditions.
Flow vs. TDS

The diagram shows the relationship between TDS (Total Dissolved Solids) and Horse Creek Flow (cfs) under different discharge conditions.

- **No discharge**
  - TDS (mg/L): 157.0
  - Flow range: 0 to 4000 cfs

- **Discharge**
  - TDS (mg/L): 27.0
  - Flow range: 0 to 4000 cfs

The graphs illustrate the decrease in TDS levels with increasing flow, indicating a potential correlation between the two variables.
Flow vs. Calcium
Flow vs. Sulfate
Historical Analysis

- Approximately 40 tributaries drain into Horse Creek between just north of HCSW-1 and HCSW-4
- Six are named system with designated WBIDs
- Four have some historical TDS, sulfate, and calcium data
- Cypress Branch and Brushy Creek
  - Drain into Upper Basin
  - No excursions above trigger levels
- Brandy Branch and Buzzard Roost Branch
  - Drain into Lower Basin
  - Excursions above trigger levels since the start of their period of records
  - Neither watershed has been mined or has a permitted wastewater discharge
TDS – Major Tributaries
Calcium – Major Tributaries
Sulfate – Major Tributaries
TDS – Major Tributaries
Calcium – Major Tributaries
Sulfate – Major Tributaries
Groundwater

- Mosaic maintains a number of monitoring wells as part of their Hydrogeological Investigation and Monitoring Plan of Study (HIMPOS)

- Located in Wingate Mine and drilled to depths from 18’ to 356’

- Bulk of TDS data was below trigger level

- Bulk of TDS data above trigger level occurred in the deepest well at 356’

- All but one calcium value in wells <356’ were below trigger level

- All sulfate values regardless of depth were below trigger level
TDS – HIMPOS Wells
Calcium – HIMPOS Wells
Sulfate – HIMPOS Wells
Historical Analysis Conclusions

- 231 of 232 TDS, sulfate, and dissolved calcium exceedances have occurred in the Lower Basin

- Trigger value exceedances occurred before Mosaic outfalls were online
  - Exceedances do occur more regularly in recent times

- All days but two, exceedances have occurred when the outfalls were not discharging – and had not been for weeks

- Exceedances also occur when Horse Creek is under low-flow conditions – suggesting non-point source input

- Neither the surficial groundwater data nor the outfall water quality data demonstrate excessively high levels for either of the three parameters
Historical Analysis Conclusions

- HCSW-3 and HCSW-4 have records of regular exceedances
- Values for all three parameters in the Lower Basin began to fluctuate more in the 1990’s, when natural lands were being converted to intensive human uses
- Agricultural practices are linked to increased TDS and dissolved ions in adjacent freshwater systems
  - Elevated ions evident at Brandy Branch and Buzzard Roost Branch
- Lower Basin is more influenced by agriculture than the Upper Basin
## Land Use Change

<table>
<thead>
<tr>
<th>WBID</th>
<th>Whole-Basin Landscape Development Index</th>
<th>2011 Land Use Break Down</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1990</td>
<td>1999</td>
<td>2011</td>
<td>Natural</td>
<td>Silviculture</td>
<td>Land Clearing/Agriculture</td>
<td>Low Intensity Development</td>
<td>High Intensity Development</td>
</tr>
<tr>
<td>Upper Horse Creek</td>
<td>2.14</td>
<td>3.66</td>
<td>4.11</td>
<td>30%</td>
<td>&lt;1%</td>
<td>39%</td>
<td>1%</td>
<td>30%</td>
</tr>
<tr>
<td>Lower Horse Creek</td>
<td>2.42</td>
<td>2.47</td>
<td>2.66</td>
<td>35%</td>
<td>1%</td>
<td>30%</td>
<td>5%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Brushy Creek</td>
<td>2.04</td>
<td>2.06</td>
<td>2.81</td>
<td>41%</td>
<td>0%</td>
<td>48%</td>
<td>1%</td>
<td>10%</td>
</tr>
</tbody>
</table>
**Ambient Water Quality Assessment**

- Two tributaries of the Peace River within conceptual phosphate limit without mining:
  - Charlie Creek
  - Limestone Creek

- Characterized the aquatic habitat condition using applicable approved DEP methods:
  - FT3001 Physical/Chemical Characterization
  - FT3100 Stream and River Habitat Assessment
  - Landscape Development Index
  - Human Disturbance Gradient

- Sampling conducted consists of 15 TDS, calcium, and sulfate samples at each site no less than one week apart

- Field measurements taken at each sampling event include DO, specific conductivity, pH, depth, temperature, turbidity, water velocity, and secchi depth

- Currently in progress, 14/15 samples collected
Questions & Comments
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