PURPOSE AND OBJECTIVES

Tampa Bay Water retained PBS&J to conduct a preliminary analysis of water quality impacts due to potential discharges from gypsum stack closures at two phosphate mining facilities, South Pierce and Green Bay. The South Pierce facility discharges into the South Prong of the Alafia River, whereas the Green Bay facility discharges into the North Prong. Fluoride has been identified as a parameter of concern. The purpose of the analysis was to determine if the anticipated discharges would impact water quality conditions in the river such that fluoride concentrations would exceed the Class I standard of 1.5 mg/L.

DATA SOURCES AND METHODS

The tool used for this analysis was a spreadsheet computer model that was developed specifically for this project to simulate conditions along the river corridor. The model provides mass-balance calculations based on both river flows and fluoride concentrations. Simulated conditions were those expected during average monthly dry weather flows in the Alafia River, which occur in the local area in the spring time, between January and April. The dry weather analysis provided conservative estimates of potential impacts.

Data used to calculate average monthly dry weather flows in the Alafia River were available from the four USGS gauging stations shown in Figure 1. However, adequate application of the computer model required estimating contributing watershed flows at relatively short segments along the river. This was accomplished by developing a drainage area versus flow relationship. Figure 2 shows the median flow and drainage area corresponding to each USGS station, the regression line, and the corresponding coefficient of determination. As expected, a strong linear relationship exists between the variables. The median flow versus drainage area relationship was used to estimate the flow from each of the drainage areas shown in Figure 1, as well as the incremental flow within each river segment. River segments are the portions of the river associated with each drainage area. The extent of the drainage areas was determined using the
subbasin delineation as depicted in the Alafia River Watershed hydrologic/hydraulic (H&H) model developed by Hillsborough County as part of the County’s Watershed Management Program (Alafia River Watershed Management Plan, 2002).

The spreadsheet computer model conducts fluoride mass-balance calculations at each of the river segments using the estimated median flow and the corresponding concentrations from historical water quality data. The model was validated by comparing the model-predicted fluoride concentration at each river segment with the historical data. The location of the water quality stations is shown in Figure 3.

The validated model represents the “without gypsum stack discharge” conditions. It should be noted that the characteristics of the available data, such as multiple data sources and irregular sampling periods, made possible only a preliminary model validation. However, it is considered that the validated model is adequate to address the project purposes. A more detailed validation approach would require data availability for the same time period and collected under the same conditions throughout the river corridor.

Issues associated with the water quality data include the following:

- The analysis indicated that data collected before 1990 do not accurately represent current water quality conditions in the Alafia River due to best management practices and discharge modifications made by permitted facilities in the watershed. Therefore, all data collected prior to 1990 was not considered for this project.

- Data for the period after 1990 include FDEP approved emergency order discharge conditions, which do not represent typical ambient water quality conditions in the Alafia River. The emergency discharges resulted in significantly increased concentrations of fluoride and other parameters in the Alafia River. These data were not considered in model development and validation for this analysis. Known major non-routine discharges in post-1990 Alafia River fluoride data include:
  - Mulberry spill (55 million gallons) - 12/97 and 1998
  - North Prong emergency order discharges (multiple facilities) - 9/04-2/05

- The FDEP data collected in 2004 and 2005 as part of the Total Maximum Daily Load / Impaired Waters Rule program was an intensive data collection effort over a relatively short time period. It was determined that data collected as part of this program would biased the results. Therefore, the data was not consider in the analysis.

- The Coronet groundwater discharges to intermittent ditches, 2003 – 2004 (e.g., 750 ppm fluoride reported in 2003) was considered in the analysis and it is reflected by the measured data.
RESULTS

Various modeling scenarios and sub-scenarios were simulated for this analysis. They are listed in Table 1. The attached appendix includes tabular summaries for Scenarios 1, 2, and 3 and sub-scenarios 1 a-f, 2 a-f, and 3 a-f. Results of the simulations indicate that the increase in fluoride concentration due to the gypsum stack discharges in the area immediately downstream of the North and South Prongs would be about 0.02 mg/L for each facility if the fluoride concentration in the discharge is 2.5 mg/L. That represents a total increased concentration of 0.04 mg/L when the South Pierce and Green Bay facilities are discharging. The increase would be less than 0.01 mg/L for both facilities if the fluoride concentration in the discharge is reduced to 1.7 mg/L through improved treatment and/or dilution. Based on the expected increases and the historical fluoride concentrations, it is anticipated that the Class I fluoride concentration standard would likely be met downstream of the confluence of the North Prong and South Prong, as well as in the portion of the South Prong upstream from the confluence and downstream from USGS Station 02301300.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Data Set Characteristics</th>
<th>Sub-Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fluoride data for the period 1990 to current, except for the periods affected by emergency discharges ((1))</td>
<td>Base Model Run Discharge Sub-Scenarios a through f</td>
</tr>
<tr>
<td>2</td>
<td>Fluoride data for the period 1990 to current, except for the periods affected by emergency discharges ((1)) and the data collected through the FDEP Impaired Waters Rule Program ((2))</td>
<td>Base Model Run Discharge Sub-Scenarios a through f</td>
</tr>
<tr>
<td>3</td>
<td>Fluoride data for the period 2005 and 2006 ((3)), except for the periods affected by emergency discharges ((1)) and the data collected through the FDEP Impaired Waters Rule Program ((2))</td>
<td>Base Model Run Discharge Sub-Scenarios a through f</td>
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Notes:
2. The FDEP sampling for the Impaired Waters Rule program is a relatively intensive data collection program over a short time period, which would bias the results.
3. Data at some critical stations, such as that just downstream of the North Prong/South Prong junction, exist only for 2005 and 2006.
4. The base model run represents no gypsum stack discharges.
   - Discharge Scenario a simulates a discharge from the Green Bay facility of 2.5 mgd at 2.5 mg/L.
   - Discharge Scenario b simulates a discharge from the South Pierce facility of 2.5 mgd at 2.5 mg/L.
   - Discharge Scenario c simulates a discharge from both facilities of 2.5 mgd each at 2.5 mg/L.
   - Discharge Scenario d simulates a discharge from the Green Bay facility of 2.5 mgd at 1.7 mg/L.
   - Discharge Scenario e simulates a discharge from the South Pierce facility of 2.5 mgd at 1.7 mg/L.
   - Discharge Scenario f simulates a discharge from both facilities of 2.5 mgd each at 1.7 mg/L.
5. Flow rates (2.5 mgd) and fluoride concentration data (2.5 and 1.7 mg/l) used in the simulations were provided by representatives from the FDEP Bureau of Mine Reclamation and Mosaic.
DISCUSSION

The spreadsheet model utilized in this analysis is capable of simulating changes in fluoride concentrations along the Alafia River. It also proved to be a useful tool for evaluating the potential water quality impacts associated with anticipated gypsum stack closures at the Green Bay and South Pierce facilities. These facilities are located in the upper reaches of the North and South Prongs, respectively. The simulations represent average dry weather flow conditions (January – April data) when the influence of industrial discharges on water quality would be expected to be greatest because the opportunities for dilution are lowest because of low river flows. Although a full model validation was not conducted due to the limitations of the available water quality data, the model was sensitive enough to simulate downstream changes in fluoride concentrations in response to modeled discharges from the two gypsum stack closures. It should be noted that the data used for model validation embody the influences of existing point and non-point discharges from the entire watershed, including permitted discharges from phosphate mining and processing facilities.

The model can also be used to establish proposed Class I boundaries that accommodate the expected increases in fluoride concentrations associated with these future industrial discharges. The results of this analysis indicate that, based on measured fluoride concentrations in the river segment just downstream from the North and South Prongs confluence, the Class I fluoride concentration standard of 1.5 mg/l could be met under average low flow conditions with simultaneous discharges from both gypsum stack closures (each at flow rates of 2.5 mgd and concentrations of 2.5 mg/l fluoride). In addition, the model results indicate that the Class I fluoride concentrations could be met further upstream in the South Prong under these simulated low river flow conditions.

CONCLUSION

Based on the findings described above, and based on the analysis of the available water quality data, it can be concluded that the Class I boundary established at the confluence of the North and South Prongs could reasonably accommodate simultaneous gypsum stack closure in each Prong without resulting in a violation of the Class I standard for fluoride under low flow conditions, while affording significant water quality protection in the Alafia River.