PRE-RESTORATION ANALYSIS OF DISCHARGE, SEDIMENT TRANSPORT RATES, WATER QUALITY, AND LAND-USE IMPACTS IN THE FOWL RIVER WATERSHED, MOBILE COUNTY, ALABAMA

By

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Project Description and Methodology

The assessment of dynamic sediment transport rates and water quality in the Fowl River estuary is part of a multi-faceted approach to characterize current health of marshes in there and to predict the fate of marshes in the future. The purpose of this investigation is to assess general hydrogeologic and water-quality conditions and to estimate sediment loads for the Fowl River Watershed to determine if adequate sediment is available to sustain these estuarine marshes.

Field parameters were measured, and water samples were collected at three sites for selected discharge events and tide levels from March to September 2018 (Figure 1). Field parameters included: pH, temperature, turbidity, dissolved oxygen, conductivity, and salinity. Monitored stations were established at regular intervals from 25 to 75 ft apart at right angles to shore. Field parameters and water samples were collected at vertical intervals from about one ft above the bottom, one to two ft from the surface, and at mid-levels for deeper stations.

This investigation was combined with elements of a 2014-15 Geological Survey of Alabama assessment of water quality and sediment transport rates in the upstream, freshwater, fluvial parts of the Fowl River Watershed in 2014 and 2015 comprehensively evaluate sediment transport conditions in the Fowl River Watershed.

Figure 1. Monitoring sites in the Fowl River

Results and Findings

Land use/cover

Dominant land cover in the Fowl River Watershed is woody and herbaceous wetlands and evergreen and mixed forests in the upstream, freshwater, fluvial part of the Watershed and woody and herbaceous wetlands, saltwater marsh, and evergreen and mixed forest in the estuarine part of the Watershed. These land cover categories account for more than 50% of the Watershed area.

Stream flow

Stream flows in Fowl River and its tributaries are relatively unimpacted by man and are primarily influenced by relatively low topographic relief, extensive wetlands, vegetation (anastomosing conditions), and tidal effects. Relatively small gradients for Fowl River streams are reflected in flow velocities, that average 0.7 ft/s. Minimum discharge measured at the U.S. Geological Survey (USGS) stream gaging site 02471078, Fowl River at Half Mile Road near Laurendine, Alabama, during the 2014-15 study was 18 cfs (September 28, 2014) and the maximum was 2,040 cfs, measured during an overbank flood on April 13, 2015. Average daily discharge was 33.5 cfs. Minimum discharge during the 2018 assessment was 11.4 cfs (November 12, 2018) and maximum was 421cfs (August 17, 2018). Average daily discharge was 42.0 cfs.

Field parameters

All field parameters were highly variable, depending on discharge and temperature. Values of pH were significantly higher during low flow when salinity levels were increased. Average temperature at site FR1 (lower estuary) was 16.8°C in March 2018 and 29.7°C in August 2018. Average conductivity at site FR2 (mid-estuary) was 90 mS/cm during a high flow event in July 2018 and 4781 mS/cm during a low flow event in August 2018. Average salinity at site FR1 in August 2018 for the near surface stations was 3.9 parts/thousand (ppt) and 8.7 ppt for near bottoms stations, indicating the presence of a salt water wedge and stratification caused by tidal influx of brackish water from Mobile Bay moving upstream through the estuary (Figure 2).

Turbidity

Average measured turbidity and discharge for the 2014-15 assessment, illustrates that generally watersheds with the highest average discharge have the lowest average turbidity. This suggests that the monitored Fowl River sites have limited sources of turbidity so that elevated discharge events provide dilution, resulting in relatively low turbidity. Average turbidity for Fowl River at Half Mile Road (upstream, freshwater, fluvial part of the watershed) during the 2014-15 assessment was 34 NTU.

Average turbidity for the 2018 assessment was 15 NTU for site FR3 (upper estuary), 14 NTU for site FR2 (mid-estuary), and 21 NTU at site FR1 (lower estuary). Turbidity at sites FR2 and FR1 is significantly impacted by tides and stratification of salt and fresh water that causes higher turbidities to remain near the bottom. Average turbidity for near-surface stations was 13 and 17 NTU, respectively, while the near bottom stations were 15 and 25 NTU, respectively. The impact was greater during periods of lower discharge, where average turbidity for site FR1 on August 2, 2018, for near surface stations was 7 NTU, while the near bottom stations were 22 NTU (Figure 2). Stratification of turbidity in estuarine environments has been addressed in

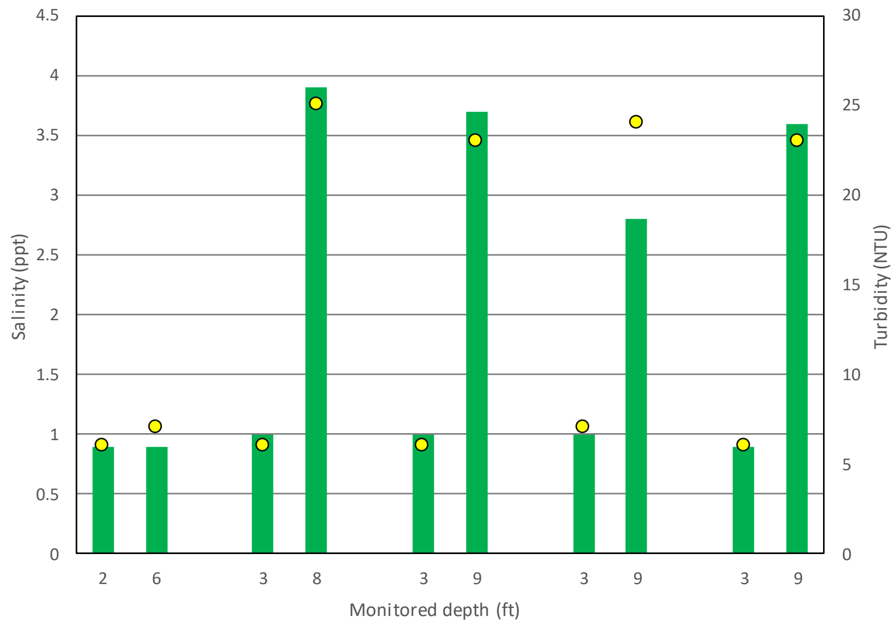

Figure 2.—Example of stratification impacting turbidity and salinity at site FR2 in the Fowl River Estuary.

numerous studies that demonstrated suppression of turbulence and vertical distribution of sediment by stratification. These studies also demonstrated that salt water intrusion in an estuary creates a trapping mechanism that reduces turbulent mixing and keeps suspended sediment near the bottom. This is an important concept that explains, at least in part, that adequate quantities of sediment are unavailable for marsh accretion in the Fowl River estuary.

Sediment transport and loading

Sediment loads in streams are composed of relatively small particles suspended in the water column (suspended sediment) and larger particles that move on or periodically near the streambed (bed sediment). A pre-monitoring assessment of sediment characteristics in the upstream, fluvial part of the watershed in 2014 indicated that relatively little bed sediment was present in the streams at selected Fowl River monitoring sites. Therefore, total sediment loads for the 2014-15 assessment were assumed to be primarily suspended. Water depth and tidal impacts prevented any attempt to quantify bed sediment transport in the estuarine part of the watershed during the 2018 assessment. Therefore, most sediment transported in the estuary was also assumed to be suspended.

Annual suspended sediment loads were estimated for Fowl River monitored sites using the computer regression model Regr_Cntr.xls (*Regression with Centering*) (Richards, 1999). The program is an Excel adaptation of the USGS seven-parameter regression model for load estimation in perennial streams. The regression with centering program requires total suspended solids (TSS) concentrations and average daily stream discharge to estimate annual loads.

Results of the 2014-15 assessment show that Fowl River at Half Mile Road had an estimated suspended sediment load of 795 t/yr. For comparison, the largest suspended sediment load in the Dog River watershed was Eslava Creek (site 10) with 10,803 t/yr. Sediment loads at monitored sites FR3, FR2, and FR1 (upstream to downstream) for the 2018 assessment were

361, 392, and 3,120 t/yr, respectively. Note that the load estimated for the Fowl River at Half Mile Road site in the 2014-15 assessment (795 t/yr) was 55% greater than the load for site FR3 (Fowl River Road), even though site FR3 is downstream and has a 61% larger drainage area. This is due to a flood event in mid-July 2014 that lasted several days and yielded a maximum average daily flow of 1,420 cfs, which was 80% higher than the maximum average daily flow at the Half Mile Road site for the 2018 assessment (289 cfs). This supports the conclusion by Cook (2015), that the vast majority of sediment transport occurs in the Fowl River Watershed during a few large discharge events.

Normalizing suspended loads to unit watershed area permits comparison of monitored watersheds and negates the influence of drainage area size and discharge on sediment loads. The Fowl River at Half Mile Road site had an estimated normalized sediment load of 52 t/mi^2/yr, determined during the 2014-15 assessment. Normalized sediment loads estimated for the 2018 assessment for estuary sites FR3, FR2, and FR1 were 9.4, 7.9, 52 t/mi^2/yr, respectively. For comparison, the largest normalized suspended sediment loads in the Dog River watershed was Spencer Branch (site 2), with an estimated normalized load of 4,332 t/mi^2/yr.

Without human impact, erosion rates in the watershed, called the geologic erosion rates, would be 64 t/mi^2/yr. Normalized sediment loads for the Fowl River at Half Mile Road site estimated during the 2014-15 assessment and all three estuary sites in the 2018 assessment were below the geologic erosion rate. This is another indication that the watershed is most likely sediment-starved, and adequate sediment for marsh accretion is not available.

Percentages of organic and inorganic material in suspended sediment provides information about the origin, composition, and depositional history of a water body. The percentage weight lost on ignition gives a crude measure of the organic content of sediment. Lost-on-ignition results document decreasing organic material from upstream to downstream in suspended sediments in the Fowl River estuary. On average, 41% of suspended sediment was lost on ignition in samples collected at site FR3 (upper estuary), 34% was lost from samples collected at site FR2 (mid estuary), and 12% was lost from samples collected at site FR1 (lower estuary). This indicates that an increasing volume of organic material settles out of the water column as water flows from the freshwater, fluvial part of Fowl River watershed to Mobile Bay, resulting in bottom sediment in the mid- and lower-estuary dominated by organic-rich clay.

The composition of bottom sediment provides information about sediment transport, depositional patterns, and the availability of sediment for marsh accretion and sustainability. Therefore, bottom sediment samples were collected at 25 locations between monitoring sites FR2 and FR1 and at site FR3. Based on general lithologic field descriptions, an upstream to downstream depositional trend is observed, characterized by decreasing grain sizes and increasing volumes of clay and organic material.

Conclusions

Conclusions derived from evaluation of data in the 2014-15 and 2018 Fowl River sediment transport assessments are that the Fowl River Watershed is relatively rural and is dominated by forests, wetlands, and marsh that limit erosion and transport of sediment downstream to the estuary. Estimated sediment loads, significantly below the geologic erosion rate, confirm that the watershed is sediment-starved. Evaluation of bottom sediment samples also confirms that coarse-grained sediment is limited, with deposition in isolated areas of the upper- and mid-estuary. Therefore, adequate sediment to sustain marshes in the estuary is unavailable. Additionally, stratification caused by tidal movement of brackish water upstream along the bottom of the estuary has effectively trapped much of the suspended sediment on and near the bottom, preventing overbank deposition of sediment and limiting material for marsh accretion.

Literature Cited

Richards, R. P., 1999. Estimation of pollutant loads in rivers and streams: a guidance document for NPS programs: Heidelberg College.