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MONITORING SUSPENDED SEDIMENT PLUMES TO EVALUATE THE EFFECTS OF AGITATION DREDGING IN SAVANNAH HARBOR

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ABSTRACT
Resource agency concerns over the dredging practices in the Savannah Harbor prompted the USACE Savannah District (CESAS) to commission a comprehensive study to evaluate environmental effects. CESAS is currently citing findings and recommendations in the final report in their permitting effort for existing and future maintenance dredging activities that involve agitation dredging and open water disposal. The comprehensive Scope of Work (SOW) developed was a collaborative effort between CESAS, reviewing agencies, and Applied Technology and Management (ATM) technical staff. The data collection study design required three distinct simultaneous efforts: water chemistry sampling, *in situ* water quality profiling, and monitoring the dredged material discharge plume. This last effort utilized acoustic doppler technology. SEDIVIEW, an acoustic doppler post-processing software package, was employed to quantify total suspended solids (TSS) concentrations from the acoustic backscatter signal. Total recoverable chemistry (TRC) samples were collected both upgradient and downgradient of the dredged material discharge to quantify the concentrations of selected constituents released to the water column as a result of the dredging activity. *In situ* profiles were also performed upgradient and downgradient to measure changes to water quality (especially, dissolved oxygen) resulting from the dredging activity. All data were analyzed and presented in the final report. Effects to aquatic resources resulting from changes to suspended sediment concentrations, water chemistry, and water quality were also evaluated. The fate of the suspended material was also modeled using SSFATE, a program developed for the USACE by Applied Science Associates, Inc..

INTRODUCTION
This paper describes the first application of new technology and monitoring techniques to measure sediment plumes resulting from agitation dredging. Historically, tracking suspended sediment plumes resulting from dredging operations has been difficult due to the dynamic nature of suspended sediment transport. By using a new acoustic tracking technique, ATM was able to accurately follow and study a dredge plume from source to dissipation. The method utilizes existing current measurement instrumentation to estimate suspended sediment concentrations in dredged material discharge plumes. The method permits collection of large volumes of high-resolution, real-time data over a large spatial and temporal scale with reasonable resources.

While this study focused on dredging in Savannah Harbor, the method described can be applied to estimate suspended sediment concentrations resulting from other activities of concern to water resource managers including runoff from disturbed uplands, fluvial erosion, and offshore sediment disposal. Additionally, the method could be applied to coastal process studies including sediment circulation and deposition patterns.

BACKGROUND
The Savannah Harbor portion of the Lower Savannah River is a high sedimentation environment that presents challenges for maintaining navigable depths for ships calling on this fast-growing port. In the Harbor, berth operators have depended upon agitation dredging (dragging a structure such as a steel I-beam

along the bottom) to maintain berths since at least 1932. In addition to agitation dredging, hydraulic cutterhead dredging with direct pipeline discharge to the adjacent Federal navigation channel is also currently permitted in parts of the Harbor. Both methods utilize the tidal and river currents to flush the suspended sediments down the river.

Several natural resource management agencies have expressed concerns over the potential environmental effects of this practice since the late 1980's. Four previous studies (Richardson 1984, Hussey, Gay, and Bell, Inc. 1975, EMC, 1993, and Skidaway Institute of Oceanography 1993) found the impacts to be temporary and minimal. However, resource management agencies found these studies to be incomplete and inadequate to properly assess the risk of harm to aquatic life.

PURPOSE

The potential adverse impacts from these dredging practices (including increased concentrations of suspended sediments, the release of sequestered contaminants to the water column, and reduction of dissolved oxygen) concerned natural resource managers. Previous studies had failed to completely address their questions. To address any remaining deficiencies, the US Army Corps of Engineers, Savannah District (CESAS) commissioned ATM to conduct an additional field study that would provide the data necessary to evaluate the environmental effects of the dredging. Study findings and recommendations addressed these resource agency concerns. The three main goals of the study were to:

1) Catalog aquatic resources in the river at risk from the effects of the dredging and conduct a literature review of published effects levels on these resources;

2) Conduct field studies to determine the level of temperature, DO, salinity, turbidity, and selected chemical parameters associated with the plume including relative effects in comparison to the background sediment levels; and

3) Determine the potential for effects on the identified aquatic resources from the data collected.

METHODS

Six data collection events were performed for the study. Each effort monitored a six-hour agitation or direct pipeline discharge dredging operation. Three vessels tracked the plume location during the operation and collected simultaneous acoustic, water quality and water chemistry data.

A vessel-mounted RD Instruments (RDI) 1200 kHz Acoustic Doppler Current Profiler (ADCP) tracked the location of the dredge plume in the water column along predefined cross-sectional transects of the river (Figure 1).

Transects were established from shore to shore at 1000-foot intervals downriver of dredging operations. Acoustic backscatter data was viewed in the RDI operating software TRANSECT to instantaneously determine the location of the dredge plume. The ADCP operator would then advise the two vessels collecting water chemistry and water quality data of the location and geometry of the dredge plume. Water chemistry and water quality data were then collected within the tracked dredge plume and the locations logged with dGPS equipment.

After field data collection, the acoustic backscatter data was post-processed using SEDIVIEW to quantify the suspended sediment concentrations in the plume. ATM was the first to apply the SEDIVIEW post-processing program and methods in the United States. SEDIVIEW is the product of Dredging Research Limited (DRL) of the United Kingdom.

SEDIVIEW produces a continuous two-dimensional picture of the suspended sediment concentrations in the water column. An example presentation of the SEDIVIEW output is presented in Figure 2. Each color contour of the concentrations is an interpretation of an ADCP transect. The SEDIVIEW calibration method utilizes laboratory-analyzed total suspended solids (TSS) grab samples taken in the plume and the water quality profile data to determine the accuracy of the suspended sediment estimate. Parameters to adjust for a successful calibration include acoustic signal interpretation constants and spreading corrections.

While monitoring for suspended sediments with the ADCP, ATM simultaneously collected total recoverable chemistry samples and performed water quality profiles. The ADCP data, water chemistry samples and water quality profiles were all collected along the same transects. Sediment samples were analyzed for metals, dioxins and furans, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, organic carbon, total petroleum hydrocarbons, tri-*n*-butyltin, and pesticides. Additionally, ATM compared the results of the water samples, dissolved oxygen measurements, sediment quality data, and concentrations of suspended sediments to applicable criteria to evaluate the potential environmental effects.

The data were coupled with ATM's three-dimensional hydrodynamic model of the lower Savannah River Estuary and imported to a Corps of Engineers' model (SSFATE) to predict the concentration and fate of suspended sediments for any berth location in the Harbor. This model can also be adapted to track a conservative contaminant released to the water column from the dredged material. The model therefore ultizes the data collected in the six events monitored to predict suspended sediment concentrations and contaminant dilution for other sites requesting permits to maintain their berths by either agitation dredging or direct pipeline discharge.

CONCLUSIONS
Utilizing this methodology, ATM was able to quantify suspended sediment concentrations and water quality effects from the dredging events. As found in previous studies, water quality changes were nearfield and brief in duration. Other specific results are presented in the follow paragraphs.

- Contaminants detected downstream of the dredging activity were determined to be below acute toxicity levels while in the water column. The highest concentrations of contaminants found in the water column were determined to occur for very brief durations.

- Water quality profiles taken downriver sometimes indicate that agitation dredge operations create a nearfield and brief DO depression. Low, near bottom DO depressions downstream of agitation dredge operations were equal to or less than DO concentrations in background profiles.

- The lowest dissolved oxygen concentration measured for the fall and spring monitoring events were from the near bottom profile data. Occurrence of the lowest dissolved oxygen concentrations were not consistently in the suspended sediment plume and in some cases were found in background transects performed during the monitoring event. Turbidity profile data indicate elevated levels of suspended material in the same water column location as the depressed DO concentration suggesting the presence of a fluidized layer occurring in the Harbor.

- The effects on water quality should only be discussed qualitatively for one event, location, and transect, however, because there are other confounding factors from other inputs (besides the dredging activity) and changes to the river system (river geometry and hydrodynamics) that are causing a concentration change between the background transect and the monitored transects irrespective of the dredging activity effect.

- Effects from the presence of agitation dredged suspended material appear to be within the background variance presently occurring in Savannah Harbor for the seasons and conditions monitored. The conclusion, therefore, is that dissolved oxygen depression or increase, while observed in some cases, is not a significant effect of agitation dredging generally. Berth sediments should be evaluated individually for oxygen demand potential, especially during sensitive periods (like hot summer days) and in sensitive areas.

- During agitation dredging events, TSS concentrations of up to 800 mg/L were observed 100 feet downriver of the event, but the larger particles settle out of the water column rapidly and the fine particle concentrations dilute quickly. In the worst-case scenario observed in the 2000-2001 study, the highest TSS levels observed 2000 feet downriver were approximately 150 mg/L. Visual clarity can also be reduced significantly for a small portion of the river cross-section within 100 feet of the dredged material source as was evidenced by the turbidity data collected.

The results of this study were cited in the agitation dredge permitting process and addressed natural resource managers' concerns about suspended sediment and other water quality effects from agitation dredging. Presentation of all data collected, analysis and discussion of effects on aquatic resources are presented in the July 2001 Final Report titled, “Savannah Harbor Ecosystem Restoration: Agitation Dredge Evaluation Study”. The final report includes complete discussions of water chemistry, sediment chemistry, suspended material, geometry of the dredge plume and water quality.

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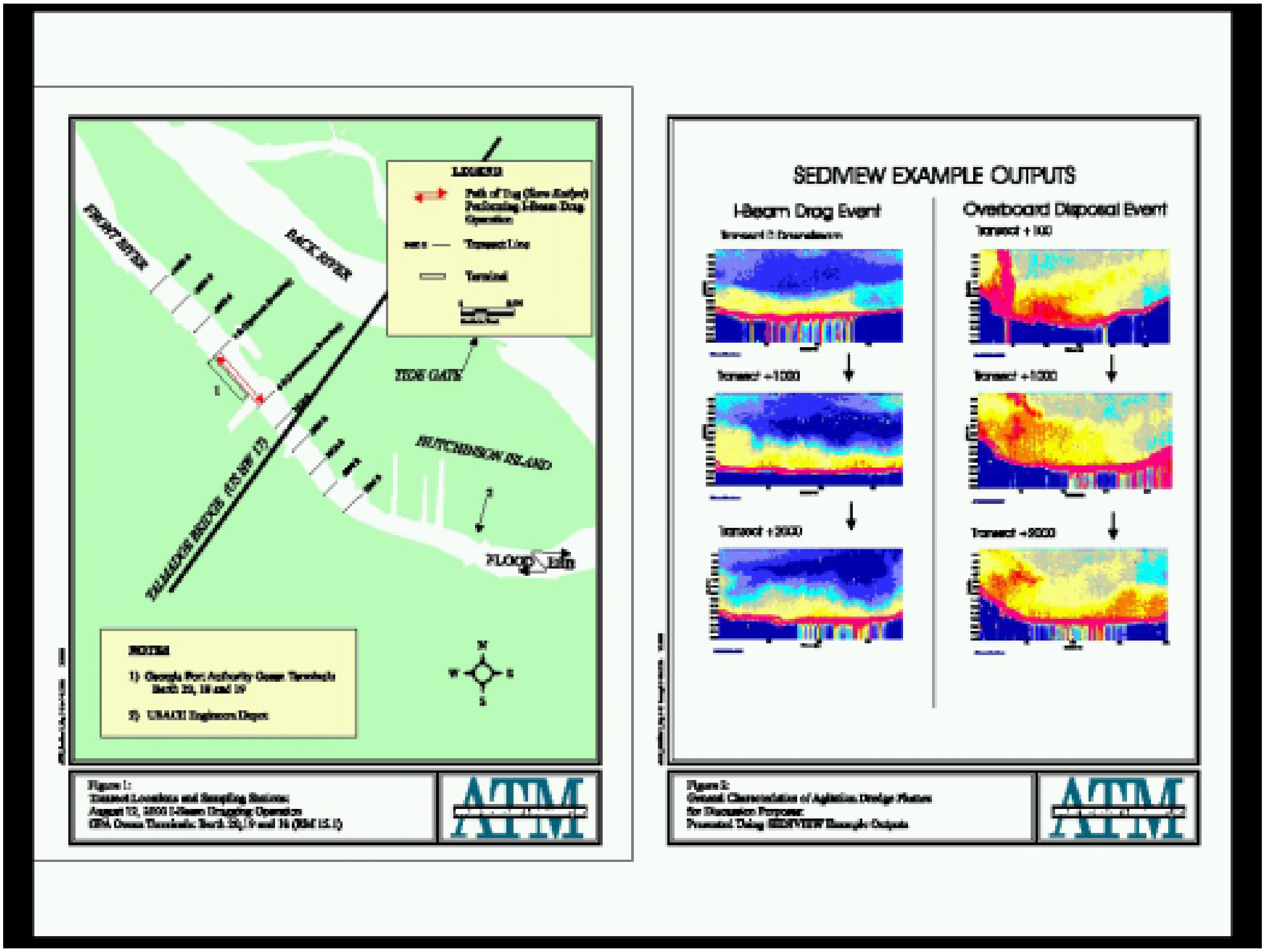

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