MEMORANDUN FOR RECORD 18 March 2006

SUBJECT: Chesapeake Bay Sediment Transport Model Review

The third meeting between the sediment transport principal investigators and review team members was held 24 and 25 January at the USEPA Chesapeake Bay Program offices in Annapolis, MD. A sub-group brainstorming web conference also took place on 8 March. Review team member Drs. Earl Hayter, USEPA, Chris Sherwood, USGS, and Allen Teeter, Computational Hydraulics and Transport, participated in both meetings. During the main review meeting, the status of the overall water quality model, sediment field investigation results, and the sediment model were described and discussed. Dr. Cerco gave a good overview of the components of the complete water quality model program.

Field surveys that monitored water column conditions and characterized the erodibility of bed material at certain points were described. Particularly interesting field results related to bed erodibility. The availability of erodible bed sediment material was found to be limited (due to vertical differences in erodibility). The bed was less erodible in shallow water. Depositional areas were more erodible. The eroded-mass limit was about 0.2 kg/m^2 (thickness ≈ 0.2 kg $m^{-2}/\sim 200$ kg $m^{-3} = 1$ mm) off Maryland Point in 18-ft water depth, and the critical shear stress was about 0.05 Pa. A similar critical stress was observed off Douglas Point in 14-ft water depth while in Gunston Cove at 18-ft water depth a higher critical stress of 0.13 Pa was observed. Erosion rates for a given shear stresses were also similar for Maryland and Douglas Points but lower for Gunston Cove by one or two orders of magnitude.

Dr. Sanford reported that salinity effects on suspended material characteristics were not observed. Dr. Halka et al. have almost completed work that will describe time-averaged bank loads for use in the model. Model production simulations will have spatially varying loads into certain near-shore cells. Typically, these bank materials have 35 percent sand and 65 percent silt and clay. The light model is almost complete and will be state-of-the-art.

Dr. Kim described a preliminary two-grain-class sediment model with sand and cohesive sediment classes at the January meeting. The model structure was adopted from SEDZLJ. Deposited material are aged daily for six days in the bed. However, that model bed structure and erosion functions were not compatible with the field information. A brainstorming session was suggested at the main meeting to explore alternate model bed structures that might incorporate the empirical information developed by this study. Shear and concentration effects on flocculation and settling velocity are currently in the sediment model.

The main point of discussion for the brainstorming session was Dr. Kim's review of four model bed structures including those from SEDZLJ, DELFT-3D, ROMS, and one developed by Dr. Sanford (SBM). The consensus was that the bookkeeping functionality of the ROMS bed model could be used along with the bed exchange functions of SBM to formulate a new bed model that could better incorporate field results. There was much discussion of whether or not the coding for the new bed model should be a portable, stand-alone, and callable module as opposed to coding imbedded into the remainder of the sediment model. The issue is the speed of development. Dr. Sherwood emphasized that ROMS is moving toward the former and some opportunities for synergism between ROMS development and this work may occur in the next month or two.

Comments and Recommendations (Teeter)

A greater number of grain classes, perhaps four, should be considered for the model. Class interval spacing should be geometric or by constant phi intervals.

The effects of salt flocculation on estuarine sedimentation are controversial. However, salinity effects have been observed on both settling rates and on erodibility of cohesive sediments (as well as the adsorption of colloidal material). Field investigators should be encouraged to document their finding relative to salinity effects. Down the road, model-to-field suspended sediment comparisons should be examined with salinity effects in mind.

Sediment beds with greater than about 10-20 percent clay content can be considered cohesive. The sediment fraction less than 16 micron is most cohesive. Except in certain near-shore and main-stem entrance areas, most of the bay bed area will be cohesive. Should bed shear stress exceed the critical value for cohesive sediment but not for the coarse fraction, winnowing of the cohesive fraction will occur as was discussed at our meeting. The converse condition – critical value of coarse fraction exceeded but not exceeded for the cohesive fraction – results in neither fraction being eroded if the bed is cohesive. Other grain-class couplings occur during flocculation and deposition. Cohesive couplings between different grain classes contribute to the poorly sorted (large standard deviations) grain distributions commonly observed in cohesive sediment environments.

Erodibility of newly deposited cohesive sediment varies with both standing time and solids content (or other density parameter). Since standing time and solids content are related, either parameter is useful to characterize erodibility. Critical or threshold shear stresses and erosion rate parameters vary much more widely than discussed at our meeting. Spatial distribution of erodibility is related to the distribution of erosive forces as well as other factors. The bed model will be critical to correctly defining erodibility and to initializing the sediment bed.

The SBM includes bioturbation as the sole process operating to vertically redistribute bed material. Bioturbation is generally a relatively slow process acting over many days, weeks and months. Initially after deposition, hindered settling, then self-weight consolidation, can alter bed density much more rapidly. Site-specific depositional conditions determine which of these processes dominate vertical transport and density profile of bed material. If suspended concentrations and depositional fluxes are very low, material will deposit at about the same density as the existing bed. However, if suspended concentrations are several hundred mg/l or more (and thus depositional fluxes relatively high) the initial density of deposits might be as low as 50 kg/m^2. The point is that in some situations consolidation processes are far more important to vertical sediment distribution than bioturbation.

Bed layers stratified with respect to erodibility should be considered as an alternative to uniform layers since important changes in erodibility apparently occur over small vertical distances (~1 mm). This might greatly reduce the number of bed layers required to adequately describe the vertical variation of erodibility.

Other factors affect bed erodibility such as organic content, pore fluid ion concentration and type, temperature, etc. No model has ever attempted to model all conditions and it should not be attempted here. The optimum model is one that will reproduce observed suspended sediment and bed grain conditions by including the most important factors. Once a model is up and running, analysis of results will help determine the final model structure.

Additional Comments and Recommendations (Hayter)

Since the sediment transport model is within the water quality model, the presence of organic matter in the bed needs to accounted for during predicted resuspension events. That is, what ever the fraction organic carbon is in a particular bed layer, that mass of organic matter needs to be resuspended along with the resuspended inorganic clays, silts, and sands. I concur with Dr. Teeter's recommendation that the sediment model should be capable of simulating the transport of multiple size classes on noncohesive sediment.