MEMORANDUM FOR RECORD 1 November 2006

SUBJECT: Chesapeake Bay Sediment Model Review Meeting

The subject review committee meet on 18 October 2006 (for the sixth time) at the EPA's Chesapeake Bay Program Office in Annapolis Maryland. Presentations were made by Drs. Cerco and Kim on recent developments and status of the sediment transport as well os some other model components. Emphasis was on the sediment transport model. The ROMS bed model was tested with the Harris and Wieberg (1997) total transport formulation for the sand component and a cohesive formulation of Dr. Larry Sanford UM. The goals set for the sediment transport model (Cerco) were to simulate the turbidity maximum, shoals as distinguished from channel areas, and realistic sediment management options.

Some simple cases were used to test the bed model outside the 50,000 cell grid. Continuous erosion with uniform and non-eroding sand component conditions were run. The ROMS bed model was also included into the 50,000 cell Chesapeake Bay grid.

There was discussion of the model behavior as presented and a general consensus of the following steps/concerns:

1. Submersed aquatic vegetation are a concern as they damp waves, protect shorelines, and attenuate resuspension. Feedback between SAV and wave/currents might be added.

2. A bug was uncovered in the bed model and this bug must be fixed with help from ROMS modelers.

3. The cohesive fraction of the model need to be operated in an accumulation mode.

4. A method needs to be developed to skip-up the bed model.

5. Test concentration settling velocity for cohesive fraction.

6. Initial calibration of the water quality portion of the model can proceed.

7. Sediment model still needs parameter values. A conference call will be arranged for local sediment experts and the review committee members to suggest values.

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Memorandum for the Record
October 25, 2006
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Larry Sanford thoughts on the CBP/ROMS bed model, October 25, 2006

The main premise of my thinking is that we DO need to account for cohesive sediment strengthening with age/depth into the bed, as well as armoring by a coarser fraction. These are fundamentally different processes which have the same effect (limiting erosion) but for different reasons and in different environments. Much of the Bay bottom is far too muddy for armoring to have a significant limiting effect, and yet all of the data Jerome and I have collected in this environment says that erosion is nevertheless highly limited. This limitation is responsible for the phenomena that Jerome has addressed with his suggestions. However, I think that there are more general ways of accomplishing what Jerome has suggested. We can use our observations to parameterize these more general algorithms, which will apply specifically to the cohesive sediment classes.

Chris, Courtney and I are sporadically working on incorporating some general formulations into the ROMS bed model. However, there may be simpler ways of approximately capturing the essence of consolidation-induced erosion limitation, that can be implemented with just a few lines of code in the CBP model. These are based on the following general principles about the dynamic behavior of cohesive sediment beds:

1. It is very important to account for the gradient in critical stress within each bed layer. This allows using thicker, more numerically efficient bed layers while still capturing the essence of erosion limitation, including erosion only during periods of accelerating stress. I proposed a formula for calculating erosion in the presence of critical stress gradients in both Sanford and Maa (2001) and a more recent ms that is in review. Now I am working on an even simpler way of implementing this idea numerically. Accounting for gradients in critical stress can have a large effect on predicted erosion behavior, especially for thick bed layers and long time steps.

2. It is also important to account for the time variability of the interface critical stress (but not necessarily the time variability of deeper layer critical stresses). This includes both increases in critical stress during net erosion and decreases in critical stress during net deposition. During net erosion, the interface critical stress increases because erosion is digging into the gradient mentioned above. During net deposition, the interface critical stress decreases because the newly deposited sediment particles are much more erodible. I am working on simple approximations that can be implemented rapidly in CBP/ROMS to get at the essence of this behavior. Interestingly, allowing for a decreasing interface critical stress during deposition replicates behaviors associated with using a critical stress for deposition, while actually using a continuous deposition formulation.

3. Accounting for consolidation in some fashion is also important. The exponential approach to equilibrium idea I have been pursuing is one way to do this, but consolidation effects can also be approximated by burying sediment in deeper layers with higher critical stresses. This results in

the rate of net deposition determining the rate of consolidation, which may be OK for our purposes.

In addition to the above, here are some specific thoughts about the CBP/ROMS model:

4. The finest particle class should be allowed to deposit, but not to resuspend. The idea is that when it deposits it is immediately added to the intermediate cohesive particle class through aggregation in the sediment bed. Then all cohesive sediments follow the same erosion behavior, as distinguished from the non-cohesive behavior of the largest sediment class. The finest sediments are added to the system only as new inputs, including riverine sources, shoreline sources, and in situ production. Consequently, they also have the highest organic carbon fraction.

5. Sand transport should be modeled in the water quality model using only total transport formulae, not worrying about explicitly modeling suspended sand profiles. Then sand deposition or erosion in a particular model cell are calculated only from convergence or divergence in total transport. This gets away from having to deal with the extremely rapid sand settling speeds.

6. Here are my suggestions for particle class characteristics:
a. fine - approx. 5.8 um/sec=0.5 m/d settling speed (5 um particle with bulk density of 1500), added to intermediate class upon deposition
b. intermediate - approx 300 um/s=26 m/d settling speed, taucrit(min) for a newly deposited particle = 0.05 Pa. The profile of critical stress below the interface layer for the intermediate (cohesive) class will be determined from our erosion tests.
c. large – approx. 1.16 cm/s=1000 m/d settling speed, but don't worry about modeling suspended profiles per se, taucrit=0.2 Pa.