

## **ENV Report 19 - *Physical Forces Near Commercial Tows* by Stephen T. Maynard**

### **ABSTRACT**

The Upper Mississippi River-Illinois Waterway System (UMR-IWWS) Navigation Study evaluates the justification of additional lockage capacity at sites on the UMR-IWWS while maintaining the social and environmental qualities of the river system. The system navigation study is implemented by the Initial Project Management Plan (IPMP) outlined in "Upper Mississippi River-Illinois Waterway System Navigation Study," (U.S. Army Corps of Engineers (USACE) 1994). The IPMP outlines Engineering, Economic, Environmental and Public Involvement Plans.

Physical forces in the region near and beneath commercial tows occur because of the propeller jet and the displacement of water by the hull of the vessel. Physical forces are quantified in terms of the changes in pressure, velocity, and shear stress and are used to determine substrate scour, sediment resuspension, and effects on aquatic organisms.

This study of forces near and beneath commercial tows is conducted in a physical model. The reason for this is that field measurements beneath a vessel are difficult to obtain because some of the primary tows of interest are operating in shallow water with as little as a 0.6-m clearance beneath the tow. In addition, propeller jet bottom velocities can exceed 4 m/sec. Operation of velocity meters or other measuring devices in such an environment is quite difficult. The difficulty of obtaining field data means that verification data for the physical model is lacking. The approach used herein is to use a large physical model to minimize scale effects. Propeller jets, a main emphasis of this study, are operated at speeds where the thrust coefficients are dependent of Reynold's number, suggesting similarity with the prototype.

The results presented herein for the physical forces near commercial tows focus on the design tow using the UMR-IWWS. The design tow is a three-wide by five-long barge tow, loaded to about 2.74 m in diameter. These data are from experiments in a 1:25 -scale model channel, barges, and towboat that has operating propellers, rudders, and open-wheel or Kort nozzle propellers. The following parameters were measured in the model:

- a. Channel bottom pressure under moving tow.
- b. Near-bed velocity and bed shear stress changes under the barges of a moving tow.
- c. Near-bed velocity and bed shear stress changes in the stern region from the propeller jet for a stationary tow and from the combined effects of the propeller jet and the wake flow for a moving tow.

Analytical/empirical methods were developed to describe near-bed velocity and shear stress as a function of tow parameters.