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GORDON

REBUTTAL TO MAYNORD'S ESTES PARK PAPER

MVS COMPARISON OF MICROMODEL FLOW VISUALIZATION AND ACOUSTIC DOPPLER CURRENT PROFILER (ADCP) TO GPS FLOAT SURVEY, VICKSBURG FRONT

The flow visualization used in the Vicksburg Front Micromodel study employed time exposure photography. The camera settings were setup to capture streaks of hundreds of floating particles seeded on the surface of the water in the Micromodel. The end result showed the general trend of water flow in the model at the surface. Figures 1 and 2 illustrate flow visualization used in the Vicksburg Front Micromodel study. The process does not represent the same physical phenomena as the GPS float survey conducted of the prototype for the following reasons:

Figure 1, Flow Visualization, Vicksburg Front Micromodel, High Flow

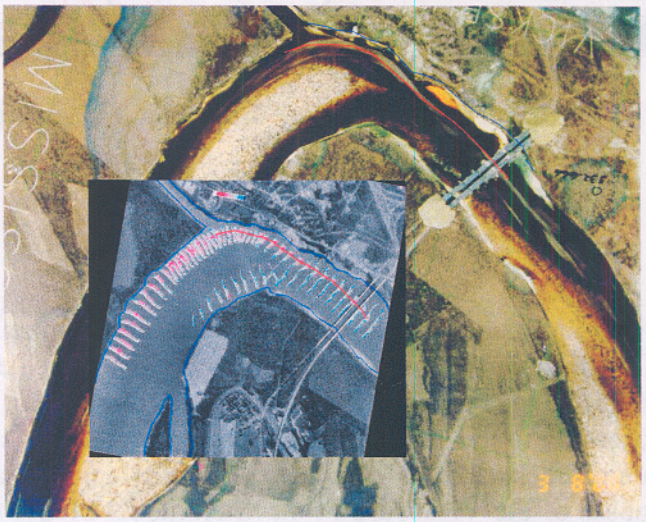

Figure 2 Flow Visualization, Vicksburg Front Micromodel, Low Flow Pathline Comparison with ADCP

Figure 3 is a map showing the GPS float survey. The seeding of floats in the GPS float survey of the prototype conducted by contractor for ERDS in Vicksburg Front did not represent individual floating particles captured throughout the reach under study. Instead, a comparatively small amount of floaters were introduced at the upper end of the study reach and at few other selected locations downstream and then the single paths tracked along the river.

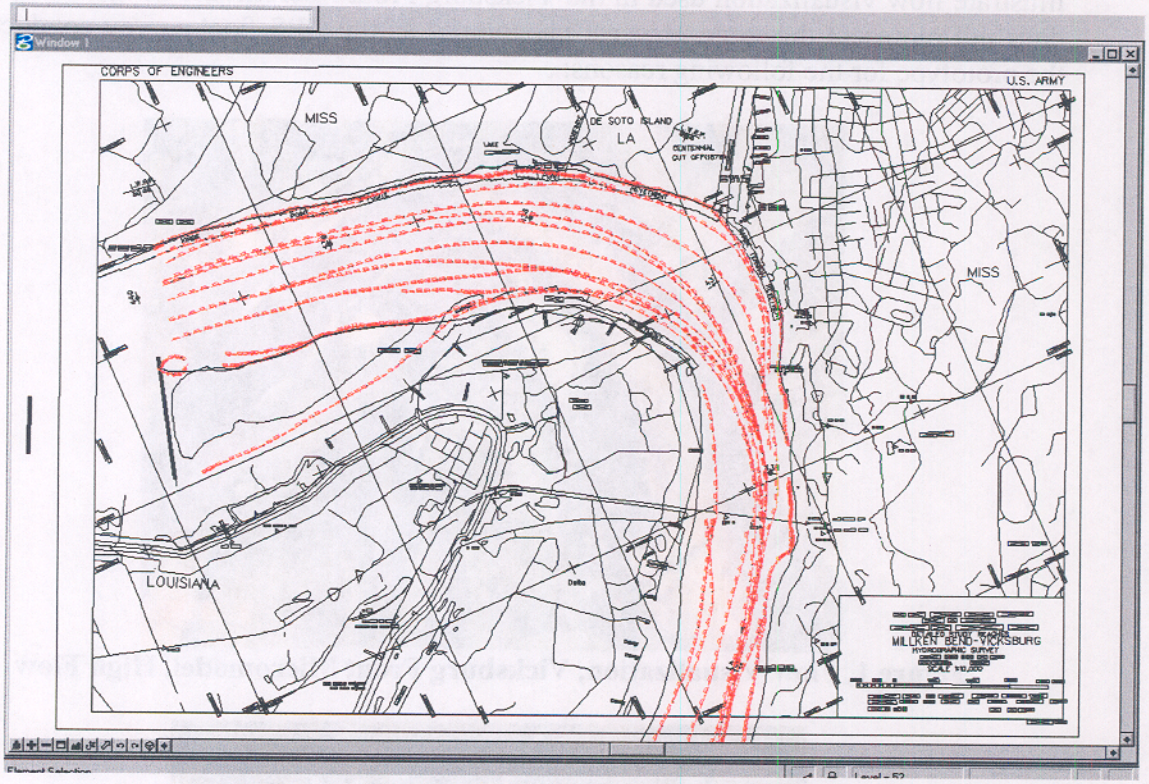

Figure 3. GPS Float Survey at Vicksburg Front

2. The confetti introduced in the Micromodel represented an instantaneous snapshot of hundreds of floaters throughout the study reach viewed in the photo frame, whereas the floaters introduced in the prototype represented a relatively small amount of floaters (under 20 according to the survey) placed in the water not as a snapshot but as individual float pathlines or tracks established over a relatively long data collection period of 5 days. For the purposes of the Vicksburg Front Micromodel Study, the seeding resolution was actually reduced somewhat in order to better define critical flow. In this manner, the main concentration of flow was visualized along the thalweg and matched up exceptionally well with the ADCP data (Figure 2). In both the Micromodel and the

ADCP, the direction of the main current was directed off the rock protrusion near Mile 436.5 L and directed toward the right descending side of the navigation spans of the bridges.

3. In the time exposure methodology used in the Micromodel, because of the high resolution of floaters, streaks were parallel and did not cross path lines. In this manner, relative flow distribution was captured, as observed in Vicksburg Front Micromodel study. In the GPS float survey of the prototype, because of the poor resolution established by the low seeding, pathlines were not parallel and crossed at numerous areas of the survey, including Mile 439.2 near the left descending bank, two areas near Mile 437.8 near the right descending bank in the side channel, one area at Mile 437 near the right descending side of the channel, an area in the left descending side of the main channel at Mile 437.4, an area off the right descending bank at Mile 436.6, and multiple pathlines crossing in the main channel near Mile 435.4. In addition, many floats that were placed in their respective starting positions in close proximity with each other deviated in their directional pathlines enormously.

As an example, two floats near the middle of the channel near Mile 439.3 were at the same relative point, yet the float pathlines that developed were not parallel and veered off from each other by as much as 500 feet. Another example was observed at the upper end of the reach in the main channel near Mile 439.8. Two floats in this location were placed within 80 feet of each other approximately 900 feet off the left descending bank, yet veered off from each other by as much as 720 feet near Mile 437. These two examples illustrate a great discrepancy in the direction of flow and would also influence the true recording of flow magnitude.

The above shortcoming of a non-continuous seeded float survey with low resolution is further verified in a particular flow visualization technique performed by WES in the St. Louis Harbor study in the early 1990s. Figures 4 and 5 are photographs illustrating a particular flow visualization method whereby reflective floating tracers were tracked using photographic time exposure. The flow and stage conditions observed in the two photos were exactly the same in the model, the only difference being that two different tests were done with floaters dropped in slightly different positions. In both tests, non-continuous, low resolution seeding was introduced in the most upstream part of the model and then tracked. This was the same method of seeding used in the prototype float survey at Vicksburg Front.

Figures 4 and 5. Flow visualization at WES, St. Louis Harbor Study, 19.2 Feet Stage

What is interesting to note is the fact that not only did the pathlines of flow cross in several locations, but the relative direction of flow was different in each photo, even though the flow conditions were exactly the same in the model. These tests verify that a float survey conducted in this manner is highly suspect in capturing true flow distribution and thus subject to erroneous interpretation of flow.

Comparison of Acoustic Doppler Current Profile (ADCP) vs. Float Survey.

ADCP is a standard field data collection method of water flow used by USACE, USGS, and others. Hydroacoustic transducers are mounted on a vessel and generate pulses of sound at a known frequency. As the sound travels through the water, it is reflected in all directions by particulate matter (e.g., sediment, biological matter, bubbles). Some portion of the reflected energy travels back along the transducer axis toward the transducer where processing electronics measure the change in frequency. The Doppler shift is applied and thus the transducers reflect the velocity of the water along the axis of the acoustic beam. When tied to a compass and GPS, the three-dimensional direction of velocity is recorded. A vessel mounted with ADCP can thus collect near real-time velocity profile data at any given location of the river.

The particular vessel and ADCP system used to collect data through the Vicksburg Reach was the MV Boyer. The MV Boyer has a proven track record for collecting accurate velocity data with the ADCP. Calibration of velocity with the Price Current Meter using

the ADCP system of this vessel has been within 2% to 5 %, well within the accepted values and standards established by the USGS.

A total of 56 transects were collected in the Vicksburg Front reach in October of 1999 during a stage of XX on the Vicksburg gage. Figure 6 is a plan view map showing magnitude and horizontal direction of the ADCP data collected along the transects at a depth of 5 feet. From this data, the main path line or concentration of flow along the thalweg can be clearly visualized and is shown in figure 7.

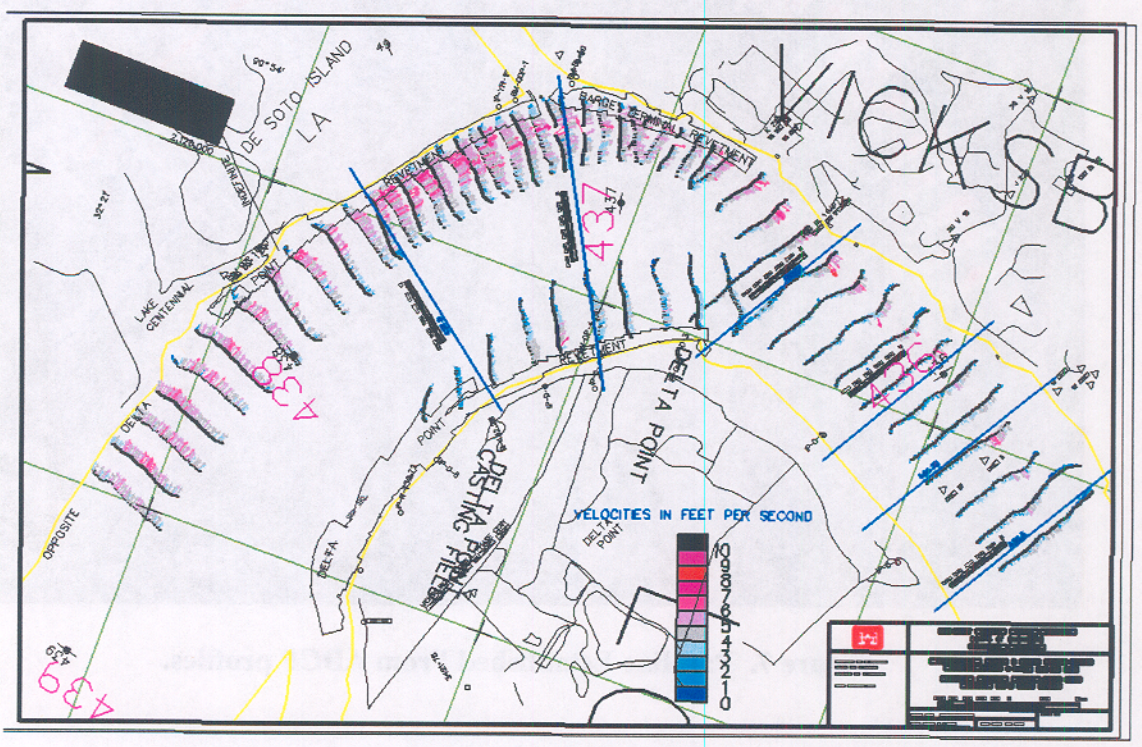

Figure 6. Plan View ADCP Velocity Profiles at 5 Feet Depth

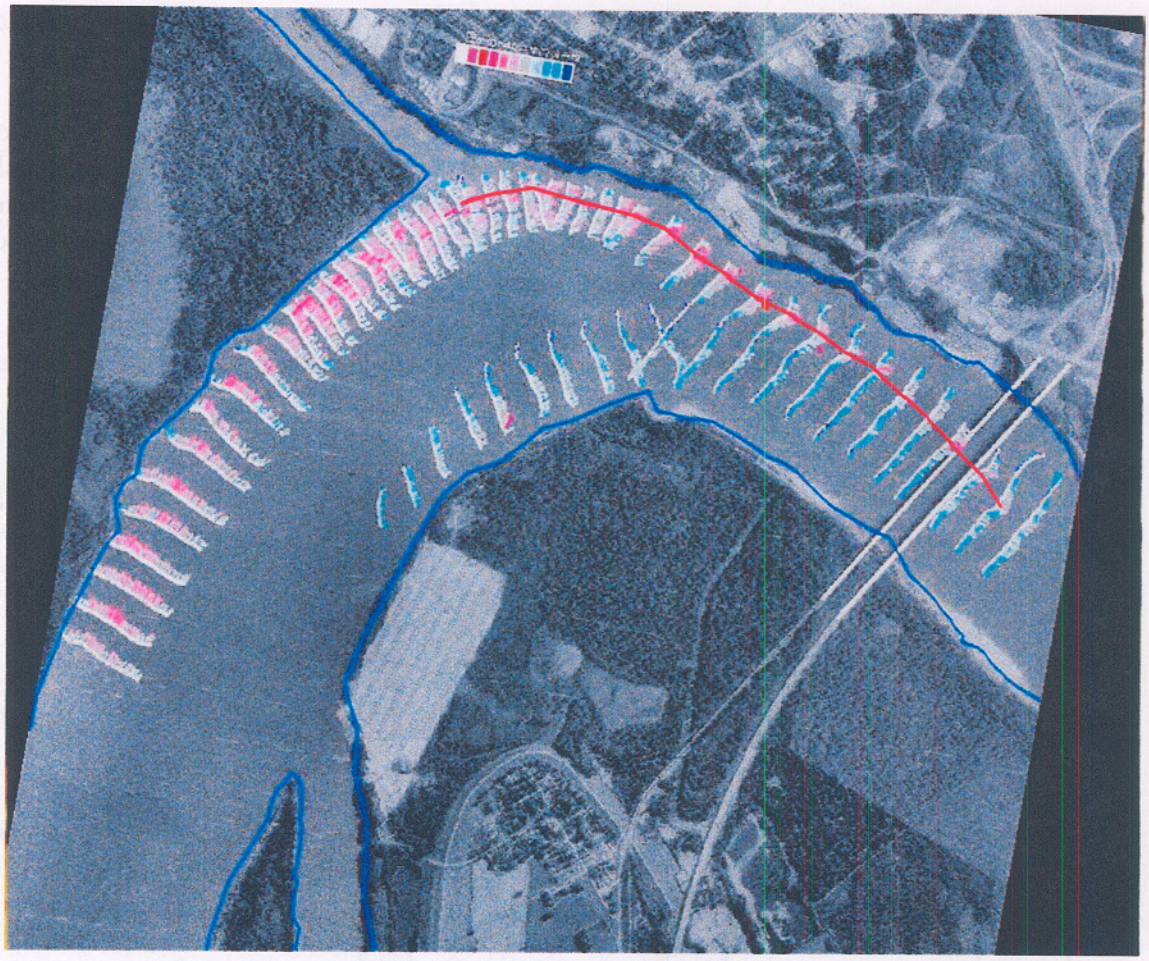

Figure 7. Pathline Established From ADCP profiles.

Figure 8 shows the plan view vector map of the ADCP prototype data superimposed on the GPS prototype float survey. Although each survey was taken at a different stage and flow condition, general comparisons and inferences can still be made about the characteristics of flow measured by the two methods of data collection. Results indicated some major differences that reinforce the observation that the float survey is highly suspect:

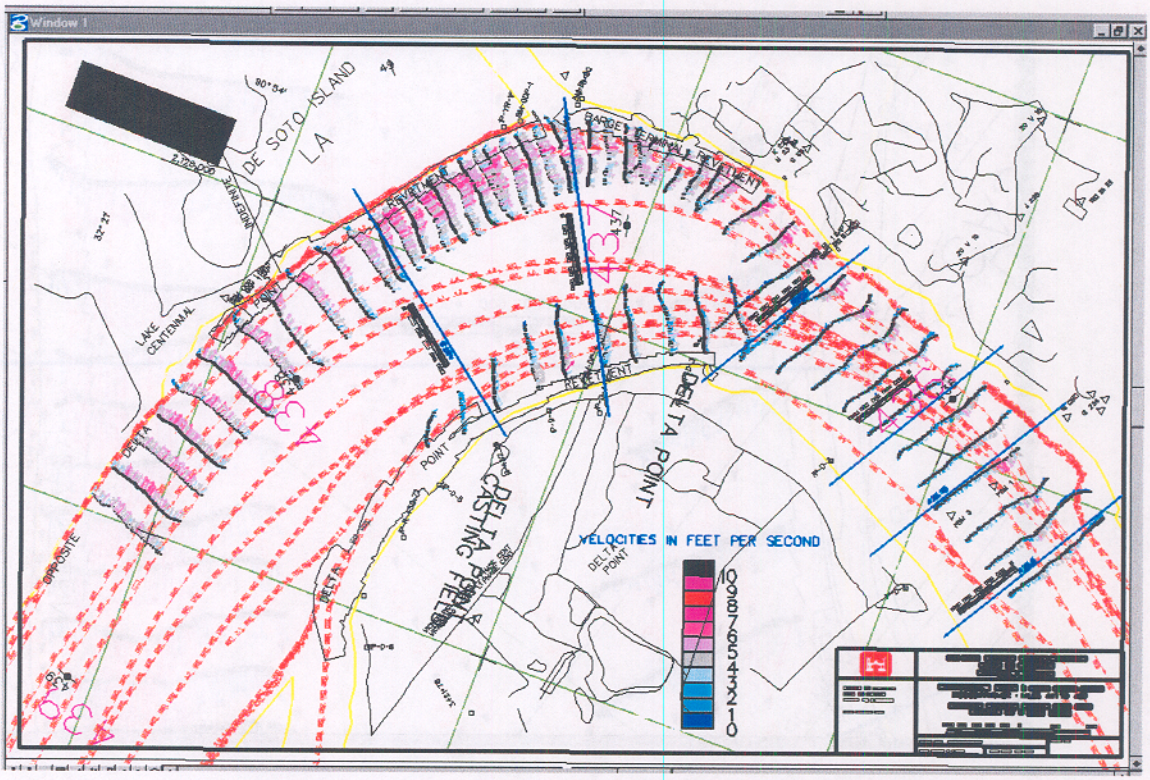

Figure 7. ADCP vs. GPS Float Survey

1. Except for a few floats hugging the left descending bank, no floats existed within the majority of the main navigation channel, between Mile 437.5 Mile 436.5 (Figures 8, 9, and 10). This was a very critical area for the Vicksburg Front Study and was accurately and clearly defined with the ADCP data but not with the float survey. The one critical float that was used in Maynard's paper showing a difference in direction of flow along the main channel between the float survey and the Micromodel was actually outside the main navigation channel in this critical reach (the float path line was over the shallow bar at delta point. The path line of this float was not parallel with the path line of the thalweg established by the ADCP transects. This fact, combined with the discussion generated previously that this particular float deviated substantially in path line direction from another float placed in almost nearly the same position, make the float survey highly suspect.

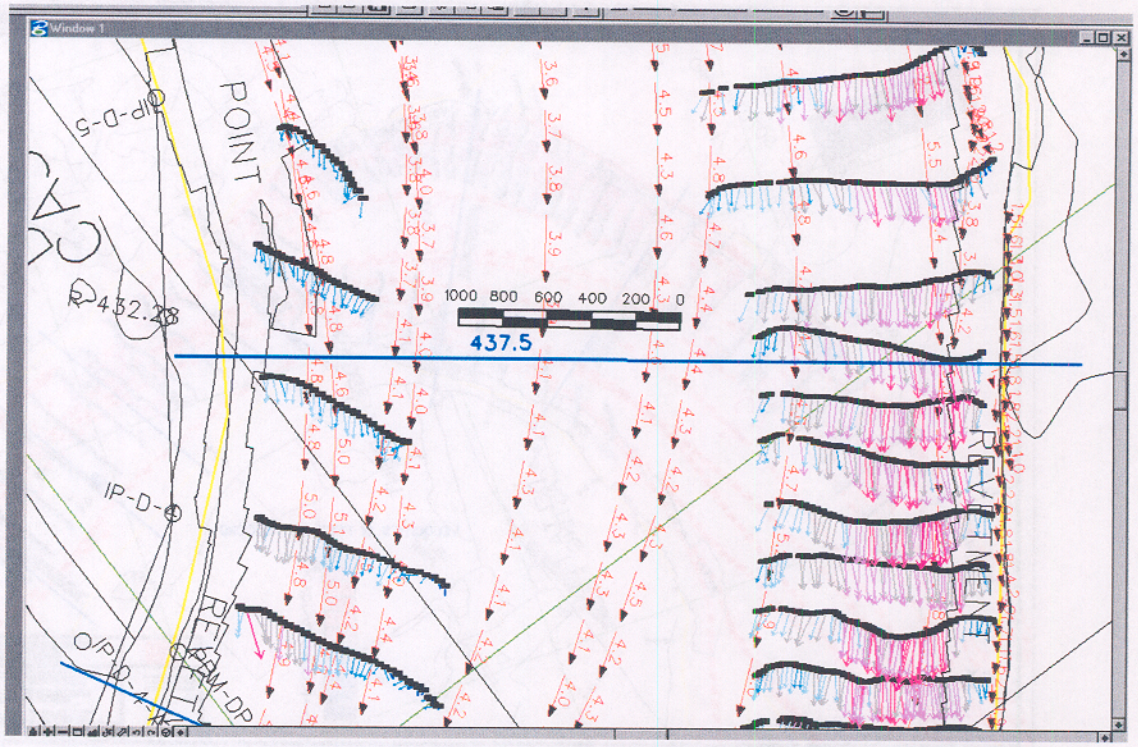

Figure 8. ADCP vs. GPS Float Survey in Critical Reach near Mile 437.5

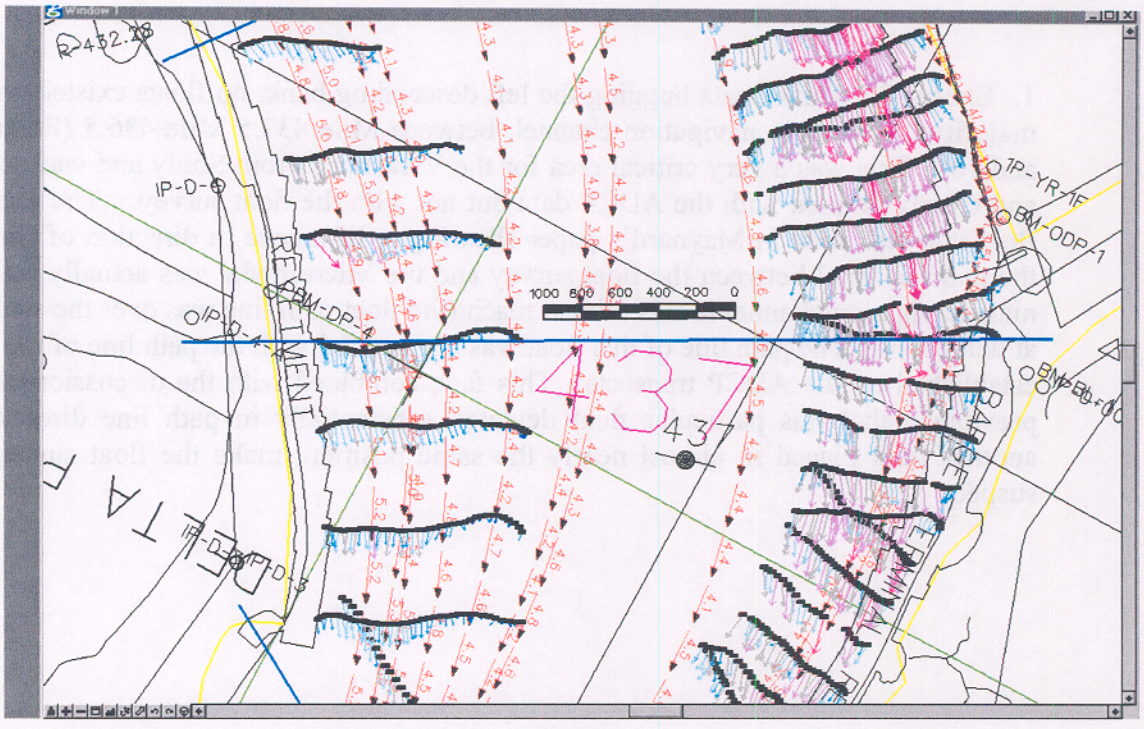

Figure 9. ADCP vs. GPS Float Survey in Critical Reach near Mile 437

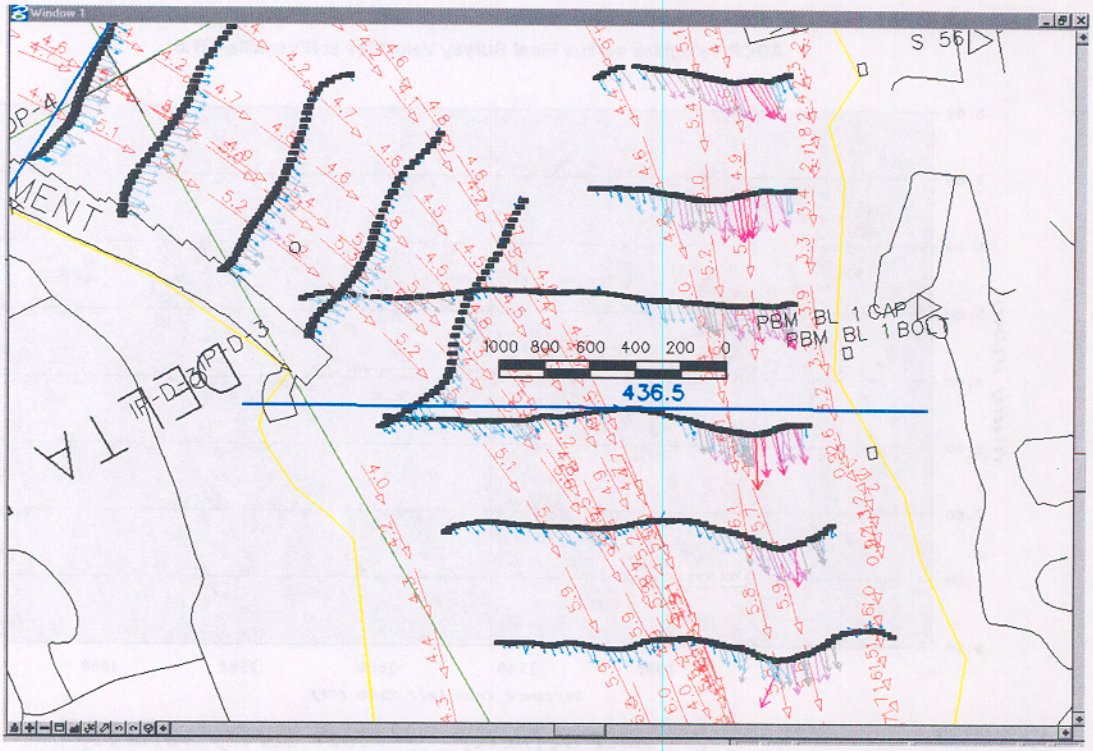

Figure 10. ADCP vs. GPS Float Survey in Critical Reach Near Mile 436.5

2. The relative magnitude of velocity values of the float survey is suspect. Figures 11 through 13 are comparative profiles of the ADCP at 5 feet depth collected at low flow compared to the float survey collected near the surface at high flow. Results indicate that the highest magnitude of velocities recorded from the float surveys in the critical reach between Mile 437.5 and Mile 436 were actually lower than ADCP values collected at low flow. Velocity magnitude collected on any river or stream along the thalweg will always be comparatively higher as flow, stage, and energy increases. Thus, the float survey values in this critical reach are highly suspect.

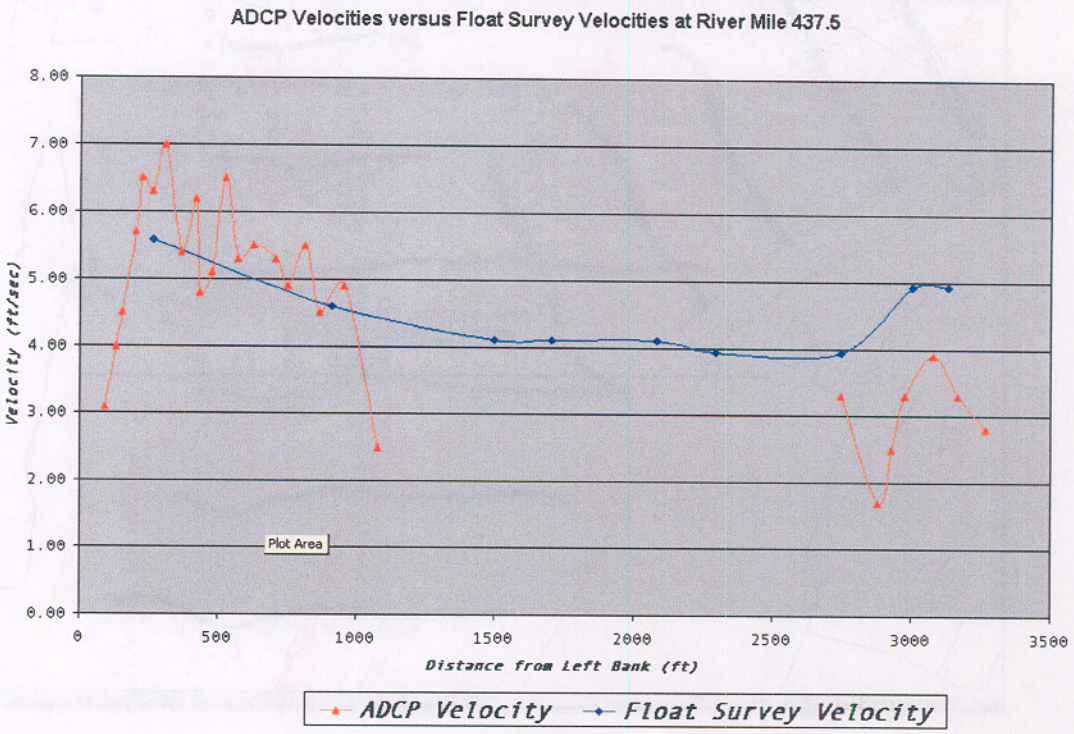

Figure 11. Velocity Comparisons, ADCP vs. Float Survey

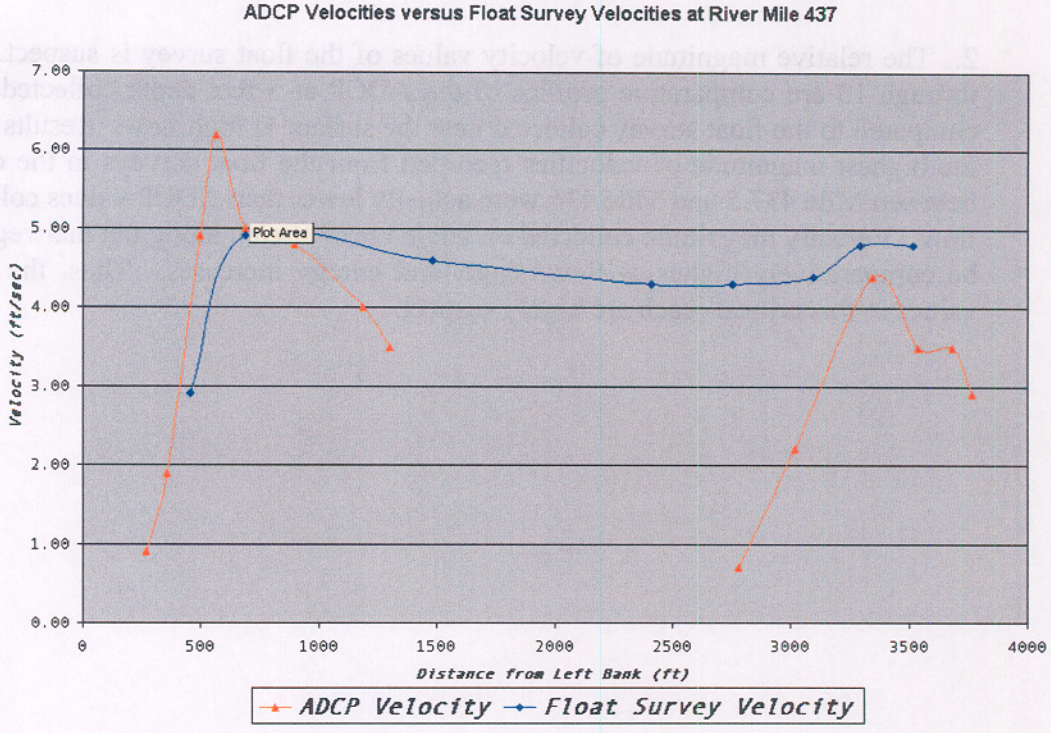

Figure 12. Velocity Comparisons, ADCP vs. Float Survey

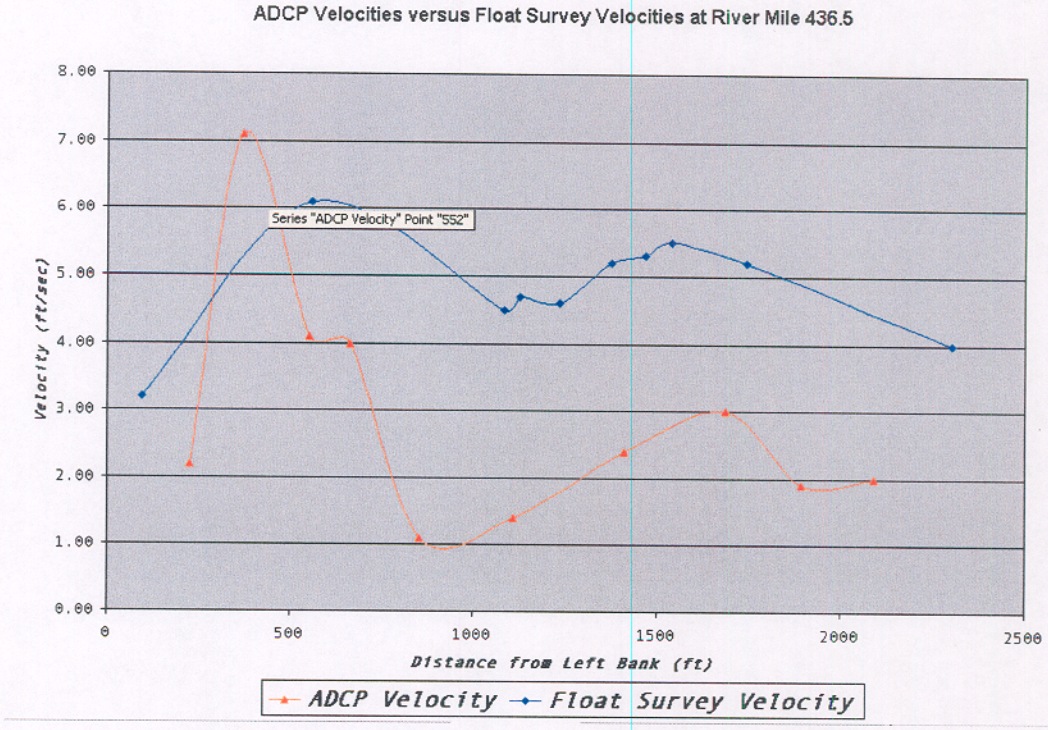

Figure 13. Velocity Comparisons, ADCP vs. Float Survey

In summary, the above comparisons between the Micromodel, the float survey of the prototype, the float survey conducted at WES, and the ADCP exemplify that there were major flaws in using the float survey technique conducted at Vicksburg Front for defining both the direction and magnitude of flow. The non-continuous seeding and the low resolution of floaters used in this survey limit the ability to collect any trustworthy velocity data.