CHAPTER 8 CONCLUSION AND RECOMMENDATIONS

8.1 OVERVIEW

Research presented herein explored the accuracy of HEC-RAS to calculate flow depths and total energy loss through a meander bend with and without bendway weirs. HEC-RAS is a 1-D hydraulic model that is commonly used during 2-D and 3-D analysis. Since HEC-RAS is often used in 2-D and 3-D analysis, research was needed to determine the accuracy of HEC-RAS during such analysis. In this study, analysis of HEC-RAS was limited to a gradually-varied, steady-flow situation. Exploration of HEC-RAS extended through the base-line analysis and the bendway-weir analysis. Conclusions for the base-line analysis are the following:

1. Modified Test reduced the assumed Manning's *n* of 0.015 for concrete in HEC-RAS to 0.013;
2. At 8 cfs, the Modified Test exhibited 0.25% difference in cross-sectional average flow depth from the physical model in the Type I bend;
3. At 8 cfs, the Modified Test exhibited 0.64% difference in cross-sectional average flow depth from the physical model in the Type III bend; and
4. The Modified Test was the foundation model for trial analysis in the bendway-weir testing program.

Conclusions for the bendway-weir analysis are the following:

1. Trial 16 was selected to be the best possible HEC-RAS model;
2. Trial 16 simultaneously adjusted Manning's *n*, and contraction and expansion coefficients at all necessary cross sections to achieve results;
3. At 8 cfs, Trial 16 results displayed a 3% difference in cross-sectional average flow depth from the physical model in the Type I bend and at 16 cfs, Trial 16 results displayed a 1% difference in cross-sectional average flow depth from the physical model in the Type III bend;
4. Trial 16 results displayed a 60% difference in total energy loss from the physical model in the Type I bend and a difference of 7% in the Type III bend; and
5. Based on total energy results, additional research is needed to note the effect of spiral currents and secondary currents on the total energy loss.

As stated as part of the bendway-weir analysis conclusions, additional research was completed to observe the effect of spiral currents and secondary currents on the total energy loss through a meander bend. Spiral currents and secondary currents are collectively referred to as minor loss due to a meander bend. Using the data from the base-line analysis, research was completed to determine the effect of minor loss due to meander bends. Conclusions of this research are the following:

1. At 16 cfs, average minor loss due to a meander bend was 57% of total energy loss in Type I bend;
2. At 16 cfs, average minor loss due to a meander bend was 24% of total energy loss in Type III bend; and

3. Minor loss due to a meander bend is significant and, therefore, methodology is needed to aid calculating more accurate total energy loss through a meander bend.

Conclusions from methodology development are as follows:

1. Twenty-three dimensionless π terms were developed based on significant external, material, and channel properties;
2. Twenty-three dimensionless π terms were regressed against $\bar{h}_{BEND}/\bar{h}_{Sf}$;
3. π_5, shown in Equation 7.1, was selected as the most significant pi term;
4. Predictor equation shown in Equation 7.2 was used to calculate cross-sectional average minor loss due to a meander bend;
5. Equation 7.3 was used to calculate cross-sectional average minor loss due to a meander bend;
6. Equation 7.5 was used to calculate average total energy loss through a meander bend;
7. Methodology was developed to incorporate the π_5 method into HEC-RAS output, which is stated in Chapter 7, Section 7.1.3; and
8. Example problem was used to incorporate the π_5 method into natural river systems shown in Chapter 7, Section 7.3.

8.2 RECOMMENDATIONS FOR FURTHER RESEARCH

Research completed in this study started the process to accurately calculate total energy loss along meander bends. Further research needs to be completed to determine

the limitations to the π_5 methodology and to extend this methodology to the bendway-weir analysis.

During the study, the bendway-weir analysis had limited options. Limitations such as only adjusting Manning's *n*, and contraction and expansion coefficients prohibited investigation of various trials stated in this analysis. The trial list is shown in Table 5.1. By increasing the scope of the analysis, additional HEC-RAS features can be investigated to conclude if HEC-RAS accurately predicts flow depths and total energy loss through meander bends with bendway weirs. Suggested HEC-RAS features for future analysis are the following:

1. bridge options including skewing options for angled bendway weirs;
2. blocked obstructions;
3. ineffective flow lines (Eom, 2004); and
4. weir options.

Creative exploration is needed to use these options in order to define a bendway weir in HEC-RAS. Exploring and exhausting the additional options can conclusively determine whether HEC-RAS is able to accurately calculate flow depths and total energy loss through meander bends with bendway weirs.

CHAPTER 9 REFERENCES

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