CHAPTER 6–CONCLUSION

Trenchless-technology techniques for culvert rehabilitation have experienced increasing use in the United States. Due to higher traffic density, social and environmental impacts, and high construction costs associated with open-cutting techniques, State DOTs, consultants and Federal agencies, such as the FHWA, have turned toward trenchless technology as a cost-effective solution to culvert rehabilitation. In the past, culvert-lining techniques were developed on a project-by-project basis due to lack of standards and specifications. CSU was contracted to develop written procedures and standards on trenchless technologies for culvert pipe liners for the FLH-FHWA. Accomplishment of this goal was achieved by dividing the study into three (3) tasks. First, a thorough literature review was performed and a survey of Federal agency personnel conducted. Secondly, a Multi-Criteria Decision Analysis tool in Microsoft® Excel was constructed. Lastly, a final report was compiled that included the results of the literature review, the survey, and a complete description of the creation and instruction for use of the MCDA.

In order to meet the objectives of Task 1 of this study, a thorough review of the literature on trenchless technology was conducted. Various sources were obtained utilizing several searching techniques. Information gathered from these sources regarding liner costs, manufacturers, and contractors was incomplete. An informational survey was developed and distributed in order to obtain information that was more complete. From the background review, a relationship between culvert lining and trenchless technology was conjectured. Five (5) methods applicable to culvert rehabilitation were reviewed and described according to a finite list of characteristics. The five (5) methods reviewed were: sliplining, close-fit lining, spirally wound lining, cured-in-place pipe lining, and spray-on lining.

To meet the goals of Task 2, the data and information compiled in the literature review and survey were used to construct a framework for the decision-analysis tool. Information was incomplete and inadequate for several methods; these methods were eliminated from the decision framework. Resulting was a final list of methods, which were:

- Sliplining segmental
- Sliplining continuous
- Close-fit lining deformed/reformed
- Close-fit lining fold and form
- Spirally wound lining
- Cured-in-place pipe lining inversion
- Cured-in-place pipe lining pulled-in place

- Spray-on lining cement-mortar
- Spray-on lining epoxy

A list of criteria was determined that the decision maker indicates preference for in the decision-analysis tool. These criteria were:

- Design life
- Capacity reduction
- Abrasion and corrosion resistance
- Installation time
- Flow bypass requirements
- Digging requirements
- Cost
- Safety
- Environmental concerns

Each alternative was given a performance score in the context of each criterion, based on information assembled in the literature review and survey. Three (3) MCDA alternative ranking methods were included in this project. The Weighted Average Method and the Discrete Compromise Programming Method are value-based methods and the PROMETHEE method is an outranking method. Users can select a method of their choice or they can compare the results of all three (3) methods. It is recommended that the Weighted Average Method be the first choice for alternative ranking in this project.

Four (4) culvert characteristics were imperative to the operation of the MCDA; these characteristics were:

- Culvert length
- Diameter of culvert
- Existence of changes in diameter and/or discontinuities along the culvert
- Necessity of restoration of structural integrity

In the Excel MCDA, alternative rating scores and relative importance criteria are entered into alternative weighting equations resulting in a list ranking the alternatives.

In the Excel workbook, one (1) additional criterion could be added as well as five (5) subcriteria per criterion. An example of subcriteria would be to further divide cost into categories such as cost of installation, cost of liner, etc. If information was available, one (1) alternative could be

added to the MCDA. Information exists to extend the diameter limitation from 122 centimeters (48 inches) to 164 centimeters (60 inches).