

## CHAPTER 2–LITERATURE COMPILATION

### BACKGROUND INFORMATION

An examination of trenchless technology was the starting point for the review of information pertaining to culvert pipe liners. Trenchless technology can be defined as the use of construction methods to install and repair underground infrastructure without digging a trench or open cutting.<sup>(3)</sup> Although considered a relatively new term, some trenchless technology methods have been practiced since the early 1900s.<sup>(2)</sup> Rapid development and expansion of trenchless technology has been observed over the past couple of decades due to the desire to cost-effectively install or rehabilitate underground infrastructure with minimal social and environmental impacts.

From this background review, it was determined how culvert lining relates to trenchless technology. Figure 1 presents a classification of trenchless technology showing the relationship of lining methods to trenchless technology. Specific methods pertaining to the installation of new infrastructure, under the categories of horizontal earth boring, pipe jacking and utility tunneling (i.e., auger boring, horizontal directional drilling, etc.) have been excluded. Culvert-lining methods were classified as a specialized trenchless rehabilitation method for existing infrastructure.<sup>(3)</sup> Five (5) different methods of culvert lining are currently used in practice and have been presented in the shaded boxes in Figure 1. As specified in the scope of work, culvert-lining methods were the focus of this report. Consequently, the five (5) culvert-lining methods presented in Figure 1 were researched and addressed in detail. Several lining methods had subsequent methods; these methods are presented in the shaded boxes in Figure 2.

Typically, trenchless technology methods have offered a more cost-efficient solution than open-cutting techniques, but successful installations required more rigorous planning, site investigations, and installation methods. Due to the technical nature of trenchless technology rehabilitation methods, previous trenchless technology rehabilitation installations were frequently addressed on a project-by-project basis. To aid the FHWA in gathering guidelines and specifications regarding culvert liners, the following literature sources were gathered and thoroughly reviewed.

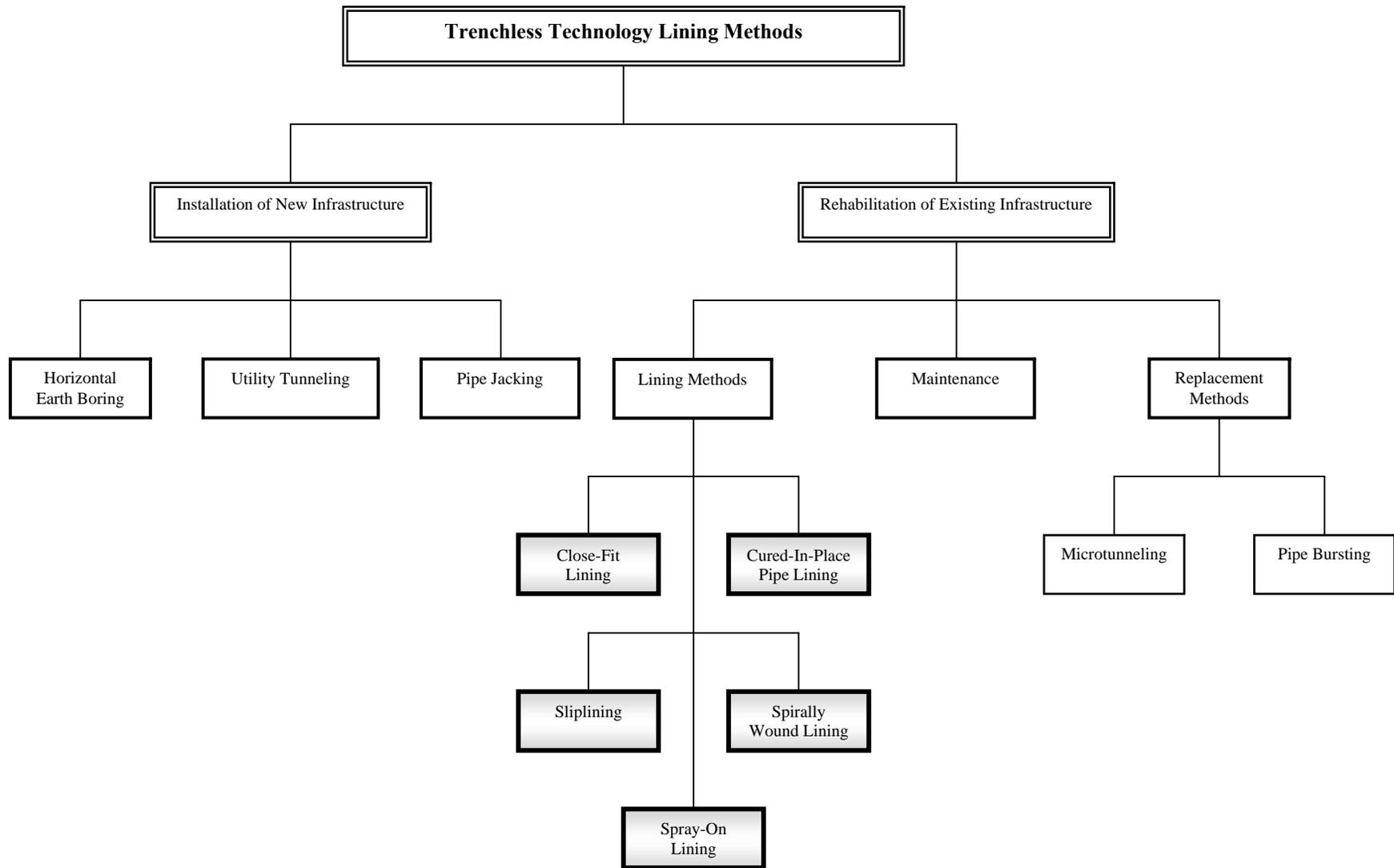


Figure 1. Flow Chart. Classification of Trenchless Technology Methods.<sup>(2)</sup>

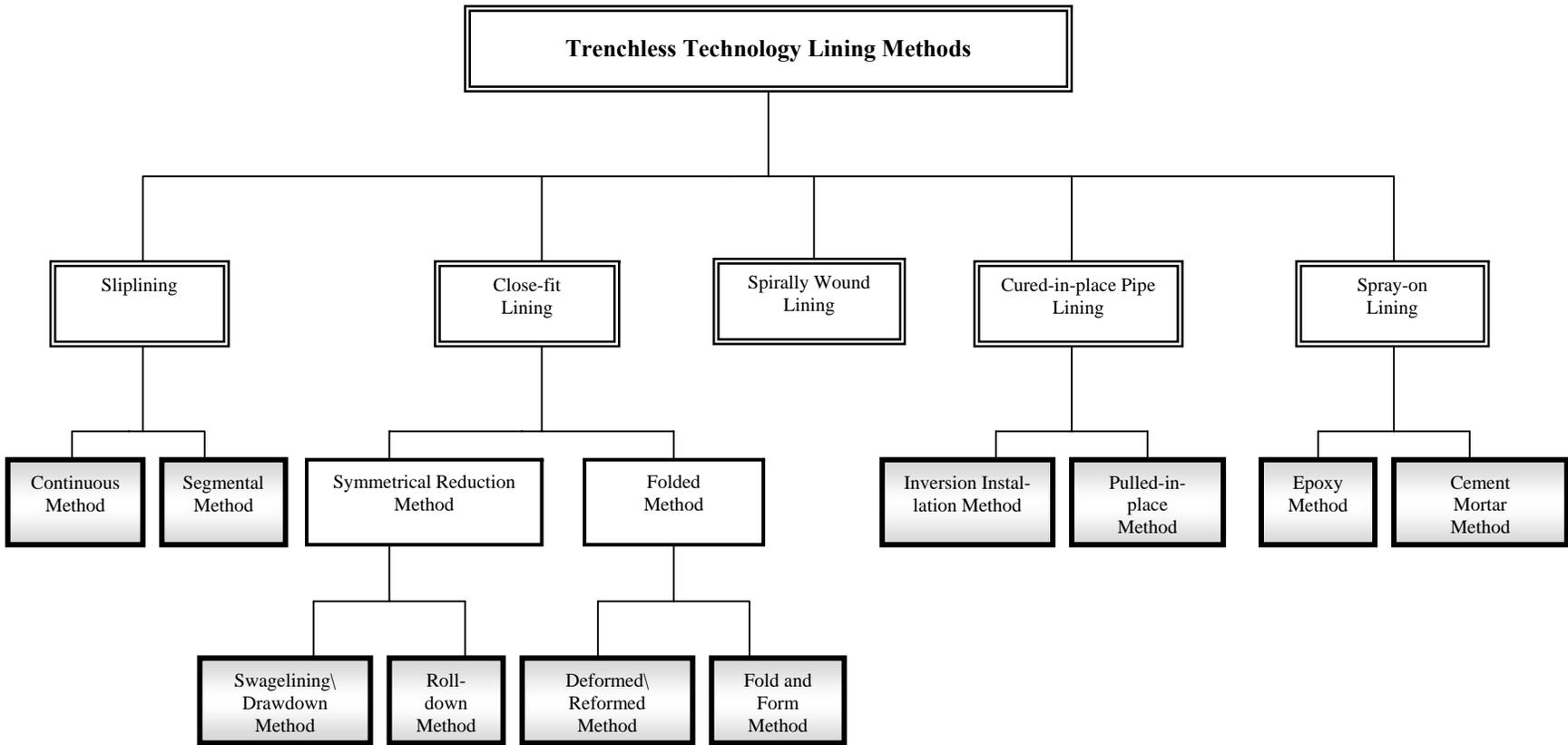


Figure 2. Flow Chart. Classification of Trenchless Technology Lining Methods.

## LITERATURE SOURCES

Several methods and databases were used to locate relevant literature for review. First, the standards published by the American Society for Testing and Materials (ASTM) were reviewed. Keyword Internet searches were then performed upon several databases including the FHWA, the U.S. DOT, Transportation Research Board (TRB), American Association of State Highway and Transportation Officials (AASHTO), National Technical Information Service (NTIS), American National Standards Institute (ANSI), National Association of Sewer Service Companies (NASSCO), CSU Library, and separate databases of several State DOTs. Utilizing Internet search engines, keyword searches of the World Wide Web (www) were also performed yielding information from manufacturers and case studies of culvert liner installations. Finally, appropriate personnel of the FHWA and Bureau of Land Management (BLM) were asked to provide any additional resources for inclusion in the literature review. Once sources were acquired and reviewed, the literature references from each source were cross-referenced for additional sources. Subsequent sections present the pertinent literature assembled for review, describing the state-of-the-practice in culvert lining. For presentational purposes, literature sources have been categorized into the five (5) following categories:

1. ASTM Standards
2. Government Agencies
3. Other Agencies, Organizations, Contractors, and Manufacturers
4. FHWA and BLM Personnel
5. Case Studies

### ASTM Standards

Review of ASTM Standards pertaining to culvert lining produced five (5) literature sources from which specific standards and guidelines were thoroughly reviewed. In conjunction with the specific standards obtained for lining methods, general information on trenchless technology was also acquired from the ASTM Standards review. A complete list of the five (5) ASTM sources used for review can be found in Appendix A.

### Government Agencies

Several government publications offered valuable information on culvert lining. Acquired publications were discovered through searches of government databases and the Internet. Upon review, these publications offered information regarding trenchless technology, descriptions of current lining methods, and three specific State DOT guidelines for culvert lining. In total, six (6)

sources were acquired, reviewed, and categorized under government agency sources. These sources are listed in Appendix A.

### **Other Agencies, Organizations, Contractors, and Manufacturers**

Most of the references classified under other agencies, organizations, contractors and manufacturers were discovered through keyword Internet searches and in references of previously acquired material. Due to the numerous agencies, organizations, and manufacturers involved with culvert lining, sixteen (16) literature sources were acquired and reviewed. These sources included manuals, evaluations, standards, guidelines, and installation requirements for various culvert-lining methods. Sources that were acquired and reviewed for inclusion in this report are listed in Appendix A.

### **FHWA and BLM Personnel**

To ensure that all relevant literature sources had been obtained, a complete list of acquired literature sources was sent to appropriate personnel in the FHWA and BLM for review. FHWA provided the listing of appropriate personnel. FHWA personnel were contacted via e-mail and provided the literature source list for review. Appendix A contains sources and agencies used as resources and their contributions.

### **Case Studies**

During the search and collection of the fore-mentioned literature sources, approximately twenty (20) case studies involving culvert-lining rehabilitation were obtained. Although these case studies did not provide design information, many of them did include project costs and cost analysis. Cost information was extracted from the case studies when applicable.

### **INFORMATIONAL SURVEY**

In order to more effectively gather general information and costs associated with each lining method and generate a list of manufacturers and contractors by state, an informational survey was generated for distribution. Before developing a survey, sample surveys from government agencies and other organizations were reviewed for content and format. These sample surveys provided insight into the type of format that would likely yield the most information while keep-

ing the time to fill out the survey to a minimum. To accomplish this, a survey format was developed and converted to portable document format (PDF) via Adobe Acrobat 5.0.

Interactive buttons and text boxes were used to create a survey form that could be completed quickly and easily on a computer using Adobe Acrobat Reader. In order to receive up-to-date information pertaining to the cost and installation of different lining methods, as well as to generate a listing of culvert lining manufacturers and contractors by state, the form was sent via e-mail to a current list of State DOTs, manufacturers, and private consultants. A copy of the disseminated survey form is located in Appendix B.

## **SUMMARY**

Information describing the state-of-the-practice in culvert lining was obtained from various sources, utilizing different searching techniques. Culvert lining was determined to be a specialized category of trenchless technology. For presentational purposes, the reviewed collection of literature sources was categorized into four categories. Individual sources were then categorized within these four categories and listed in bibliography format. Information was collected describing lining methods, their effective uses, advantages, limitations, general installation guidelines, and associated standards. Information collected on liner costs, manufacturers, and contractors was inadequate and incomplete. Thus, an informational survey was developed in an effort to obtain up-to-date cost information and to generate a complete listing of manufacturers and contractors by state. Information regarding the informational survey is presented in Chapter 4.