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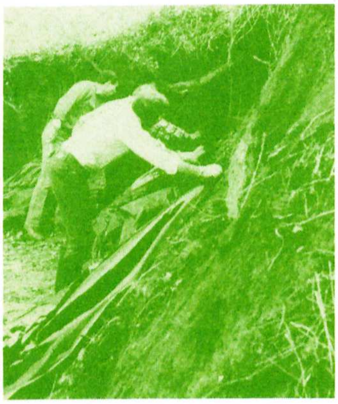

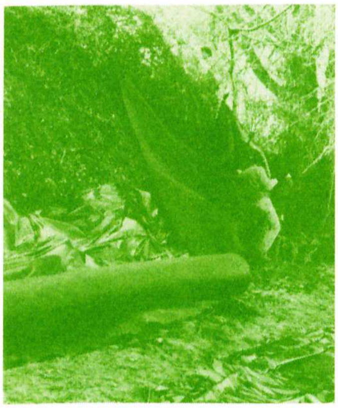

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GUIDELINES FOR THE ORGANIZATION OF ARCHEOLOGICAL SITE STABILIZATION PROJECTS: A MODELED APPROACH

by

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June 1988

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This set of guidelines is designed to identify means for evaluating archeological site preservation technical options and to set up a procedure for selecting the proper options to be employed in specific situations.

In the absence of any prior guidelines, these guidelines are based on interviews with Federal archeologists with direct personal experience in specific site preservation situations. The guidelines so developed were tested at a prehistoric mound site on Huffine Island, Tenn., and those efforts are presented as a case study in site preservation.

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PREFACE

This study was conducted under Work Unit 32357 of the Environmental Impact Research Program (EIRP). The EIRP is sponsored by the Office, Chief of Engineers (OCE), US Army, and is assigned to the US Army Engineer Waterways Experiment Station (WES) under the purview of the Environmental Laboratory (EL). Technical Monitors were Dr. John Bushman and Mr. David P. Buelow of OCE and Mr. Dave Mathis of the US Army Engineer Water Resources Support Center. Dr. Roger T. Saucier, EL, was the EIRP Program Manager.

The study was performed at the Center for Archaeological Research (Center), University of Mississippi, University, Miss., under Contract No. DACW39-86-K-0015. Dr. Robert M. Thorne served as principal investigator. The report was prepared by Dr. Thorne and was edited by Ms. Lee T. Byrne of the WES Information Products Division, Information Technology Laboratory. Editorial supervision of the archeological content was provided by Dr. James J. Hester, EL, WES.

Technical Advisors in State-level positions were Ms. Hester Davis, Arkansas Archeological Survey; Ms. Margaret Brown, Cahokia Mounds State Historic Site; and Mr. Dennis Labatt and the late Mr. Mitchell Hillman, Poverty Point State Commemorative Area, La. The National Park Service Advisors included Messrs. Francis A. Calabrese and Mark Lynott from the Midwest Archeological Center at Lincoln, Nebr., and Mr. Bennie C. Keel, Consulting Archeologist, Department of the Interior, Washington, DC. The Tennessee Valley Authority Technical Advisor was Mr. J. Bennett Graham. Corps of Engineers archeologists formed the largest group of single agency representatives interviewed and included Ms. Jan Biella, Albuquerque District; Ms. Rebecca Otto, Omaha District; Mr. Terry Norris, St. Louis District; Mr. Larry Banks, Southwest Division; and Dr. Hester, WES.

The study was conducted under the direct supervision of Dr. F. Douglas Shields, Water Resources Engineering Group, and Dr. Michael R. Palermo, Research Projects Group; and under the general supervision of Dr. Raymond L. Montgomery, Chief, Environmental Engineering Division, and Dr. John Harrison, Chief, EL.

COL Dwayne G. Lee, CE, was Commander and Director of WES. Dr. Robert W. Whalin was Technical Director.

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CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
inches	2.54	centimetres
miles (US statute)	1.609347	kilometres
square feet	0.09290304	square metres
square yards	0.8361274	square metres

GUIDELINES FOR THE ORGANIZATION OF ARCHEOLOGICAL SITE STABILIZATION PROJECTS: A MODELED APPROACH

PART I: INTRODUCTION

Archeological Site Preservation in Context

1. Maintenance of archeological sites on Federal land is both a legal and moral responsibility that each land-managing agency must accept to preserve these nonrenewable resources. The purpose of these guidelines is to provide the inexperienced resource manager with guidance in solving practical problems onsite to maintain the integrity of specific significant cultural properties.

2. Archeological sites are susceptible to a natural aging process that cannot be completely avoided. While the process acts in response to the environment within which the site is situated, the rate of change and subsequent data loss are difficult to predict. Erosional forces, looting, and acts of vandalism that destroy sites can be reduced with some success. These are the types of destructive forces that are usually addressed in formal attempts to protect archeological properties. The forces that produce erosional loss are better understood and, therefore, site loss models can be constructed. Looting, particularly at sites that produce artifacts suitable for sale on the collector's market, is foreseeable in that it is possible to predict that site or data loss will occur. However, even under ideal circumstances, forecasting when and by whom a site will be vandalized or looted is less certain. While site protection problems may appear to be understated here, there is little doubt about the reality of those problems and the national need for better organized efforts to solve them.

3. The following definitions are used to clarify the related activities of site protection, stabilization, and preservation.

a. Protection means the actual installation of a structural or nonstructural material on an archeological site or the completion of some activity designed to prevent or to mitigate the adverse effects of natural or cultural processes.

b. Stabilization means the effective mitigation of those adverse effects as a result of applying an appropriate and effective protective technology.

c. Preservation means the condition of equilibrium achieved as a result of applying an appropriate technology that serves to arrest or retard deterioration.

d. Preservation technology refers broadly to any equipment, methods, and techniques that can be applied to the discovery; analysis; interpretation; restoration; conservation; protection; and management of prehistoric and historic sites, structures, and landscapes. (Williamson, Jefferson, and Warren-Findley 1986).

4. Protection and stabilization are attainable goals, but preservation in its absolute sense cannot be achieved since no effective means of stopping or reversing the aging process has been identified. The aging process can be retarded, however, and it is from this perspective that the definition of preservation given above is presented.

Legislative and Regulatory Basis for Preservation

5. Preservation of our national heritage has a relatively long history of individual and community involvement and support. Congress has provided public support in the form of laws designed to protect the various expressions of the Nation's cultural heritage. Pertinent legislation, regulations, and Executive Orders are presented by Speser (1986), by the US Congress Office of Technology Assessment (Williamson, Jefferson, and Warren-Findley 1986), and in an appendix to US Army Corps of Engineers Regulation (ER) No. 1130-2-438.

6. Efforts to preserve sites have been quite limited to date. Over two decades ago, the National Park Service (NPS) led in cultural resource preservation attempts. The NPS efforts focused on the stabilization of standing masonry and adobe-walled ruins, and in 1962 the Ruins Stabilization Handbook was prepared. The more ambitious Reservoir Inundation Study was initiated in the 1970's to investigate the effects of site inundation (Lenihan 1981a and b). More recently, the Tennessee Valley Authority (TVA) instituted a research and demonstration program of experimental archeological site stabilization (Thorne 1985). Currently, the US Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., has an active program addressing the problems of site

preservation (Thorne, Fay, and Hester 1987). Presumably, such preservation efforts will increase in the future.

Preservation Requirements of the Corps of Engineers

7. Stewardship of historic properties is an important element of Corps of Engineers (CE) Civil Works project management, and agency responsibility for these properties is clearly set forth in both statute and regulation. ER 1130-2-438 will provide the Corps with a set of uniform standards for the management of cultural resources. New construction and operating projects are considered in the regulation, and in both instances, site protection and preservation are specifically included as alternatives within historic property management procedures. The development of a Feature Design Memorandum (FDM) for new construction or a Historic Properties Management Plan (HPMP) for operational projects provides an orderly decision-making procedure that includes site stabilization alternatives. The guidelines developed herein are to be used with the FDM and the HPMP to provide a series of standardized evaluation and decision-making stages for use in the site stabilization process.

8. The decisions that must be made if a property is to be stabilized should come as early in the planning process as possible. While the decision-making process included here can be applied to archeological sites during any stage of project design, construction, or operation, it is more specifically intended for application during the design (continued planning and engineering) stage of project development. This equates with the Archeological Survey Stage. Decisions regarding stabilization technologies to be applied should be included in the developing mitigation program and referenced in the appropriate Memorandum of Agreement required at the end of the Project Planning and Evaluation (PP&E) stage (ER 1105-2-50, paragraph 3-6(b)). The most appropriate time for making these determinations is during the project planning process. If the planning process is already completed, the practical application of a directed decision-making process can be used to address current needs on operational projects, where the physical impacts to sites have not been previously addressed.

9. The jurisdiction for resource protection is clarified in ER 1130-2-438, which specifically addresses funding authority for historic property

management on operational projects and new construction. In both instances, requests for funds follow procedures already in place. When ER 1130-2-438 is implemented and district management plans are completed, archeological site stabilization will become less of a reactive element of resource management and will follow a more carefully planned schedule.

10. Until District HPMP's become fully established for operational projects, most archeological site stabilization efforts will continue to be reactive. Operational project resources requiring protective attention have probably been already adversely impacted by the time their deteriorating condition is noticed. Reactive site administration will be reduced in some cases since the history of a particular property and its National Register eligibility will be known. In other instances, site significance must be ascertained as the first step in the installation of a stabilization technology. Until most Corps-managed lands have been inventoried for historic properties, the value of a specific site will likely be judged only on the basis of its immediate interpretive worth, and not on the potential of the site's contents to contribute to a broader regional interpretive scheme. As a consequence, an underlying assumption for the development of these guidelines is that single component sites are potentially as important as multicomponent sites for purposes of protection.

Problems of Archeological Site Preservation

11. Archeological site preservation is a complex procedure requiring consultation with and the cooperation of a number of specialists. Protection of a significant historic property requires an understanding of the forces acting on the property and the expertise necessary to understand these forces, which may lie outside the specialized training of the resource manager. Archeologists, who are generally not trained in hydrology, soil mechanics, or erosion control, must depend on scientists knowledgeable in those fields for advice. Likewise, specialists in other disciplines are rarely schooled in the nature and intricacies of archeological site composition, structure, and interpretation. Resource managers must counsel these advisors concerning site contents and the difficulties in protecting sites from deterioration. These advisors must understand that all archeological features are not tangible in the same sense as stone tools or ceramics. Pit and post mold outlines, buried

soils, and depositional profiles are important interpretive elements of archeological sites that must be given equal consideration in the stabilization design.

12. Written accounts concerning recent attempts to stabilize archeological properties indicate little effort to chronicle the events that make up the preservation process. To some extent, the lack of an accurate accounting of stabilization planning activities may be a direct consequence of the source of preservation funds. Projects undertaken with Operations and Maintenance (O&M) money are less likely to be documented than those efforts associated with new construction. Documented in-house projects appear to have been conceived and completed within a broader framework of project management. While the intent and, frequently, the end products of stabilization activity are of immeasurable benefit, the lack of a written report is a disservice to those planning similar activities. Stabilization projects designed to preserve historic properties in place, however small, should be incorporated into the scientific record in an accessible fashion.

13. The stabilization or protection of a historic property should not be viewed as the end product of a preservation effort, but rather, as a step between careful planning and long-term site monitoring. Poststabilization inspection is particularly important at the present time, since the process of archeological site stabilization has a very brief history and there is as yet little evidence of how archeological site components react to various technologies used in the stabilization effort. For example, no one has chronicled the extent of compaction or fracturing that will occur when a midden deposit or mound fill is covered with riprap, nor have the effects of covering agents such as gunite been studied. The effects of site burial on artifacts has not been extensively studied, although preliminary research in this area has been initiated by the California Department of Transportation (Garfinkel and Lister 1983). The variety of microenvironments in which sites occur is so broad and the resources are influenced by such a range of forces that monitoring of stabilization efforts is necessary. Periodic inspection of the stabilized site will reveal the success or failure of preservation efforts; any deleterious effects may be noted and subsequently corrected. Notes on site monitoring should be paired with the initial stabilization effort notes so that a complete record is available.

14. While many archeological sites share common elements, no single stabilization technique is suitable for use on all sites. Preservation efforts must be designed on a site-by-site basis, and the technique to be employed should be selected from a list of carefully considered alternatives. It is the purpose of this document to provide a set of preservation/ stabilization alternatives within an ordered stabilization decision-making framework.

15. Archeologists recognize that totally effective archeological site preservation is not possible. The best efforts can be used to relieve extraordinary stresses of natural and cultural origin. As a consequence, the rate of deterioration of materials and the alteration of their depositional environments may be retarded. An effort must be made to ensure that everyone involved with a particular stabilization situation understands that the best effort can do nothing more than maintain the status quo.

Technical Advisor Participation in Guideline Development

16. Since archeological site stabilization projects have not been routinely reported in the past, technical advisors from various Federal and State agencies were interviewed regarding their knowledge of site loss, site stabilization efforts, and the success or failure of those efforts. To ensure that all interviews produced comparable data in the same topic areas, 15 categories of questions were developed. Each of the 11 technical advisors interviewed was asked to respond to each set. Questions were verbally presented, and both questions and responses were tape-recorded. Each interview session was structured by this standardized format, but response time was limited only by the quantity of information presented by each respondent. The questions asked were the following:

- a. How do you view archeological preservation as it relates to your agency? To the Federal archeology program?
- b. How familiar are you with the body of literature that deals with site stabilization?
- c. To whom would you turn for professional advice--both inside and outside the archeological community?
- d. How does one decide if a specific site should be stabilized rather than excavated or simply left for "nature to take its course"?

e. If more than one site of an equal kind is a potential candidate for stabilization, what criteria should be used in selecting a site over other choices?

f. What funding alternatives can be considered in site stabilization efforts?

g. Who is or should be in a position to decide which site to stabilize or when?

h. How much personal experience have you had in site stabilization? Why did you become involved in site stabilization?

i. Who financed the stabilization effort(s)? Were funds provided in response to a Federally mandated program? Were they provided from some portion of a particular budget such as O&M?

j. Please describe the decision-making process leading to site stabilization. Who was involved? Were these people also involved in deciding that stabilization was an appropriate means of treating the site?

k. Once the stabilization of a site was decided on, what procedures were involved in selecting the technique to be used to stabilize the site? How many alternatives were proposed before a final decision was reached? Was cost a determining factor?

l. How much attention was given to potential impact of the stabilization technique on the resource? What was the basis for those considerations? Were similar site stabilization projects looked at beforehand?

m. What prestabilization testing was completed? How much for poststabilization control?

n. What standards for monitoring were established before the stabilization procedure was begun?

o. Who is responsible for monitoring? Who pays for it? Who should be responsible? The Federal agency? The State Historic Preservation Officer (SHPO)?

Interview Results

17. Everyone interviewed believed that site preservation was a part of their particular agency's cultural resource management program as well as part of the broader Federal archeological responsibility. Most thought that site preservation was a viable alternative to the excavation of sites, although only two had been involved in stabilization efforts. While none really felt that site avoidance equated with preservation, each indicated knowledge of this approach.

Familiarity with the
stabilization literature

18. Of the 11 advisors, only 4 had knowledge of the literary base for site stabilization that has been developed in the last two decades. Of these four, two have been directly involved with site stabilization; one is presently involved with a review of the literature, and one has established a program of site stabilization for his agency.

Identification
of technical advisors

19. When asked, these four advisors were the only ones who could identify potential stabilization consultants within the archeological community. All suggested that they would draw on their own experiences combined with their current knowledge of the literary base. The TVA archeologist and CE representatives suggested that they could call on specialists within their own agencies for nonarcheological advice. The advisors without a land-managing agency affiliation indicated that they would likely have to seek such expertise from the private sector. All felt that they could rely on one or more of the Federal agencies for some degree of engineering advice.

Evaluation of
preservation options

20. All those interviewed thought that the basic selection of sites for actual stabilization efforts should be determined by the National Register eligibility of each site. None of the advisors particularly liked the "let nature take its course" alternative unless natural processes could be encouraged, e.g. fertilization of grass plots to stimulate growth. If each advisor had to choose between the stabilization or excavation of a site, all agreed that each case would have to be determined individually after consideration of the nature of the site and its potential for loss.

Selection of a site for protection

21. If a choice had to be made between sites of equal value, with only one chosen for stabilization, most of the advisors felt that the best choice for protection would be the site with the greatest chance of long-term survival. A suggestion was offered that some degree of prediction of future archeological data needs might be helpful in making a choice.

Funding of site stabilization

22. The question concerning a potential funding source for site stabilization produced a virtually uniform answer--monies should be provided from an appropriate source within each land-managing unit. The specific agency budgetary area of fiscal support would be dependent on the degree of agency responsibility for the adverse effects to which the site was being subjected. Most felt that the mitigation of impacts to specific resources on operational projects on CE-managed land should be funded from that project's O&M budget. Construction-related impacts would be funded from project development funds. Funding for each of the advisor's experiences was reported to have been agency specific. Fiscal support had come largely from O&M funds, and that support had been provided in response to the Federally mandated archeological resource management program. The program established by the TVA is an exception in that O&M monies were not and are not being used, although the agency's experimental stabilization program is in response to the Federal management mandate. Protection of archeological resources from looting is the responsibility of each land manager. Authority is provided under several statutes and Executive Orders, although currently, funding for surveillance activities is minimal.

Site stabilization decisions

23. Without exception, all of the advisors felt that the project's archeologist should be the authority recommending which sites to stabilize and when. Any decision made to protect a site would be subject to the applicable regulations of the land-managing agency responsible for the site. All advisors recognized that approval at higher levels within each agency's management structure would be necessary.

Personal experience in stabilization projects

24. Four of the advisors had personal hands-on experience with site stabilization, and two more had been supervisors in stabilization projects for their particular agencies.

Steps in the decision-making process

25. In all cases of reported practical experience in stabilization, traditional site location survey and testing served as the initial step in determining the needs for protection. The next minimal test leading toward the eventual protection effort was application of criteria for admission to the National Register. If the site was not eligible, the regulatory process

excluded the site from any further consideration as a candidate for stabilization. Project or agency archeologists and their immediate supervisors were responsible for making the recommendation to protect a site, with the supervisors concurring with the archeologist's recommendation. In contrast, the experimental approach being taken by the TVA is not structured necessarily toward protection of Register quality sites, but rather it is designed to test the appropriateness of specific protection technologies. Some of the sites included in that program are of Register quality while others are not. In all cases, the decision-making process was initiated by the agency archeologist and the contractor responsible for carrying out the experimental program.

Selection of an appropriate stabilization technology

26. Technology selection in the TVA program is largely the contractor's responsibility, but the agency archeologist is asked for comments and approval of all proposed approaches. The approach taken by the NPS and CE archeologists was somewhat different in that both agencies rely on direct engineering advice about appropriate techniques. Recommendations from the engineers, with some exceptions, were skewed toward the selection of traditionally accepted erosion control techniques. Unless the archeologist made a counter suggestion, the engineers considered only one or two alternative approaches. Project cost was always evaluated, but the precise impact of cost on the technology selection process was difficult to determine. It is reasonable to assume that cost estimates were integral elements of the selection process since projection of project costs is required prior to obtaining agency approval for the work to be done.

Concern for the impacts of stabilization on the resource

27. In every case, the advisors expressed concern about the impact that any protective technology would have on the contents of a site. They stated they had no real basis for judging what negative impacts might occur, nor could they predict with certainty that there would be any. The judgments of those with experience were based largely on engineering advice combined with the archeologist's knowledge of site content and context. These judgments appear to have been largely intuitive.

28. The four interviewees with stabilization experience were the same ones who were familiar with the literature on stabilization. Only one had

visited a similar project before embarking on a project of his own. All four indicated that they had consulted with colleagues during the planning-design phase of their own projects. None thought this to have been particularly helpful, however, since the number of informed people from whom they could seek advice was limited.

Prestabilization site testing

29. In every case, prestabilization archeological content testing was carried out, but not for poststabilization control. In one case, site excavation was required prior to the installation of the protective material, but again, not for purposes of establishing a control system.

Monitoring standards

30. In no case was a set of written standards devised for monitoring the site after the protection effort was completed. Visual monitoring for determining stabilization success or failure was the primary goal in all cases. Each of the four experienced advisors felt that site inspection should occur at least annually and in some cases more frequently. Frequency of inspection was directly related to the site's location, the technology applied, and specifics of individual environments (e.g. inundation cycles or periods of high water). One advisor suggested that nonarcheologists could be trained to monitor stabilized resources and report the results of those inspections to the appropriate resource manager.

Monitoring responsibility

31. All the advisors felt that fiscal support for site monitoring was the responsibility of the primary support or land-managing agency. Inspection from other sources was not considered appropriate since the experienced advisors were already employed by the land-managing agencies responsible for the resources in their charge.

Conclusions from the Interviews

32. At the completion of the interviews, two broad experience patterns were clearly present: (a) very few archeologists have experience in site protection and stabilization, and (b) those with experience use the methodology of professionals from areas other than archeology or cultural resource management to make site protection/stabilization decisions. As evidenced by

data collected as a part of another WES project (Thorne, Fay, and Hester 1987), neither of these patterns was particularly surprising.

33. While site protection and stabilization continue to be alternatives for mitigating adverse effects on archeological resources, past efforts have not followed a clearly identifiable decision-making process. Stabilization efforts must follow an organized planning and application process so that written accounts can serve as a dependable underpinning for future efforts. Organized planning and rigorous selection and application of stabilization technology will help to ensure that the best choices are made in the site protection process.

34. While all of the technical advisors felt that site stabilization was a part of their agency's charge, only four had any knowledge of the existing literature that deals with the stabilization of archeological properties. This same group had hands-on experience with site protection and felt that their best guidance for future projects would be their own experience aided by their familiarity with pertinent reports. Those advisors who were not associated with a land-managing agency felt that they would have to seek advice from the private sector, but no specific resource persons were identified.

35. Protection under the law is limited to sites eligible for the National Register; therefore, National Register eligibility was selected as the basic criterion for determining which individual properties should be protected. When more than one property had to be considered, most thought that those properties with the longest potential life span should be selected. Selection of an appropriate preservation technology was thought to be site specific, and funding for each effort should be provided from some portion of the land-managing agency's budget.

36. All of the advisors felt that some written standard for site stabilization would be useful as long as the standards were not rigid in their application. Monitoring of every effort should be included as the final step in establishing and maintaining preservation standards.

37. The overall conclusion was that an explicit set of written guidelines for the selection of preservation options should be developed. The formulation of this set of guidelines is the subject of Part II to follow.

PART II: PLANNING AND DECISION-MAKING PROCESSES

Archeological Site Stabilization--an Organizational Base

38. Considerable thought has been given to the broad range of technologies currently available for archeological site stabilization (Lenihan 1981a and b; Thorne 1985, Thorne, Fay, and Hester 1987; Williamson, Jefferson, and Warren-Findley 1986). Most of the technologies currently recognized as potential mechanisms for site stabilization are based on well-established and -tested erosion control measures. Archeological site stabilization efforts have emphasized the use of these accepted technologies since erosion of various kinds is the most common form of site impact (Figure 1). While such technologies are frequently appropriate, alternatives can be identified and tested. Less traditional technologies have been installed at some sites and are currently being evaluated (Thorne 1985; Fay 1987). While evaluation of these alternative technologies is in progress, a determination of the appropriateness of those experiments is some years away.

Deficiencies in Prior Preservation Efforts

39. Deficiencies in descriptions of previous stabilization efforts include project organization, applied technology assessment, and publication. In most of the available reports, an accurate description of the effort undertaken is presented and forms the core of the report. Most reports include site or resource descriptions and a discussion of the factors impacting the resource. Very few explain why a particular technology was chosen over others, what range of alternative technologies were considered before a selection was made, or what areas of outside expertise were called on in support of the effort. Stabilization goals are not always clearly stated, and it is often hard to determine if the effort has been or will be successful.

40. Site preservation applications must be monitored, and the degree of success or failure of the effort should be evaluated. Monitoring can take a variety of forms and can be accomplished by a variety of individuals. It is not absolutely necessary that the individual who monitors the effort be trained in historic property management, but it is important that the

Figure 1. Riprap streambank protection being installed at Poverty Point, Louisiana

individual be instructed in what to observe. A monitoring schedule should be devised on a particular case basis that is appropriate for the conditions.

41. The purpose of monitoring a stabilization effort is twofold: (a) evaluation of the applied technology to ensure that the cultural resource is being protected and (b) provision of a data base from which other attempts may benefit. Some means should then be found for the dissemination of the results of the assessment. That report must include notations about the strengths and weaknesses of the applied technology and, if failure was noted, an accurate accounting of why the failure occurred. A description of the immediate environment in the site preservation work area is also desirable so that others working in a similar setting can assess the adequacy of the technology.

42. Another deficiency, the most important omission characteristic of recent stabilization attempts, centers around documentation. Frequently, site stabilization has either not been formally described or is recorded in a format that is difficult to access. Since site stabilization as a form of resource management is a developing concern, adequate reporting of stabilization/preservation attempts is critical. Publication or accessible recording of all monitoring efforts is essential if the advantages,

disadvantages, successes, and failures of preservation efforts are to be incorporated into the design of new projects. The indication of why a specific technology was successful in a specific setting and what advantages accrued to the resource is important, but it is equally important that failures and disadvantages be documented. Such information can come about only as a result of the monitoring process. Throughout the publication procedure, care should be taken to ensure that the goals of the stabilization effort are clearly presented and that the results of the follow-up monitoring are included.

Stages in Planning of Stabilization Efforts

43. Efforts to stabilize archeological properties should be carefully planned, following a series of uniform stages within the total preservation process. Procedural uniformity for the general treatment of historic properties is set forth in ER-1105-2-50, but at the time that document was prepared, archeological site stabilization was not specifically considered. As a consequence, within ER 1105-2-50, site stabilization and preservation have not been given the same consideration as were other mitigation options. Even within the overall guidance framework, the degree of attention given to preservation and stabilization varies from District to District within the Corps. Site avoidance during project construction has been widely used as a principal means to protect historic properties, but this approach neither guarantees future stability nor preservation. Some archeologists have successfully presented a case for stabilization as an adjunct to site avoidance, but the application of this approach is not uniform, even when similar circumstances are present.

44. The procedural base for managing cultural resources (ER 1105-2-50) will be further strengthened when ER 1130-2-438 is implemented. Under that Regulation, as each operational project HPMP is developed, site preservation can be considered as one alternative for the management of significant properties. Until each District gains some experience in both HPMP development and the use of site stabilization as a management technique, each operational project HPMP will stand alone as a unique individual management plan. These guidelines encourage planners to initiate stabilization projects by providing a common procedural and project development format.

Planning requirements

45. Precursors of site stabilization obviously include site discovery, cultural content evaluation, and the recognition that the site is being or may be subjected to a detrimental impact. If the site is determined to be of National Register quality, Public Law 99-662 (Section 943) authorizes the preservation, restoration, and maintenance of the property (once it has been placed on the National Register). If the site is already under stress, the effects of the adverse impacts will normally be obvious, and mitigation plans, including preservation options, may be structured accordingly.

Use of specialists

46. Predicting possible negative impacts from new construction or identifying potential negative impacts from changes in the operation of existing projects may be more difficult. Archeologists may not have the requisite training or expertise to make these predictions, and the services of specialists trained in areas such as erosion control may be required. Not only can these specialists help in determining the relationship between a construction effort and a secondary impact to a historic property, they can determine the effects on historic resources for projects that have been in operation for a long period.

Integration with the planning process

47. New construction projects are subject to survey and subsequent planning, but without an operational HPMP for existing properties, resource assessments for those properties may not yet have been completed. Sites on operational projects may be unknown until they are adversely impacted. A variety of specialists may be consulted to determine the rate of future impact if alterations in operational water levels are proposed or when development of certain parcels is planned. A project HPMP should include mechanisms for identifying secondary impacts to significant properties and include site stabilization as an option within management alternatives.

The Decision-Making Model

48. As noted earlier, previous site stabilization efforts have not been rigorously structured according to any formalized organizational format. This is unfortunate since historic property stabilization is an increasingly important aspect of cultural resource management. At the same time, prior

projects have included some of the steps in the decision-making process suggested herein. Figure 2 is a compilation of activities that have been reported by the various archeologists who served as technical advisors. The stages are considered to be adequate for the development and implementation of a site protection project. The visual portrayal of the organization of a stabilization effort should aid engineers and other involved professionals in understanding how a preservation project may be structured.

49. Figure 2 and the attendant discussion focuses on historic property stabilization to the exclusion of other mitigation procedures. The procedures suggested here, ideally at least, should work in all cases where site protection is the preferred alternative. At the same time, the reality of differing funding sources and the immediacy of a particular case may require some restructuring of the proposed format.

50. On new construction projects, site location and cultural content identification and evaluation are parts of the normal project planning process and logically lead to an evaluation of National Register significance. As this sequence of events develops, the likelihood of site loss can be predicted and plans developed to ameliorate that loss, following previously established planning stage policy. Funding for these efforts is normally available from general project planning funds. Mitigation measures, whether excavation, stabilization, or a combination, are commonly funded from general construction monies.

51. A different set of initial actions may occur on those Corps-owned projects that were put into operation before a historic properties assessment was completed. Obviously, resource location, identification, and evaluation are required prior to a stabilization effort.

52. The next step according to Public Law 99-662 is placement of the property on the National Register. In the past, a determination of eligibility was all that was required. Since nomination to the Register may be somewhat time-consuming, a delay in the process must be anticipated and plans structured accordingly. While these steps may occur on operational projects as a consequence of a systematic program of resource assessment, they may also occur in almost a serendipitous manner. For example, initial site location may be made by project employees or reported to project employees by members of the general public. The following material identification and evaluation may be made without reference to a preservation plan, and the likelihood of

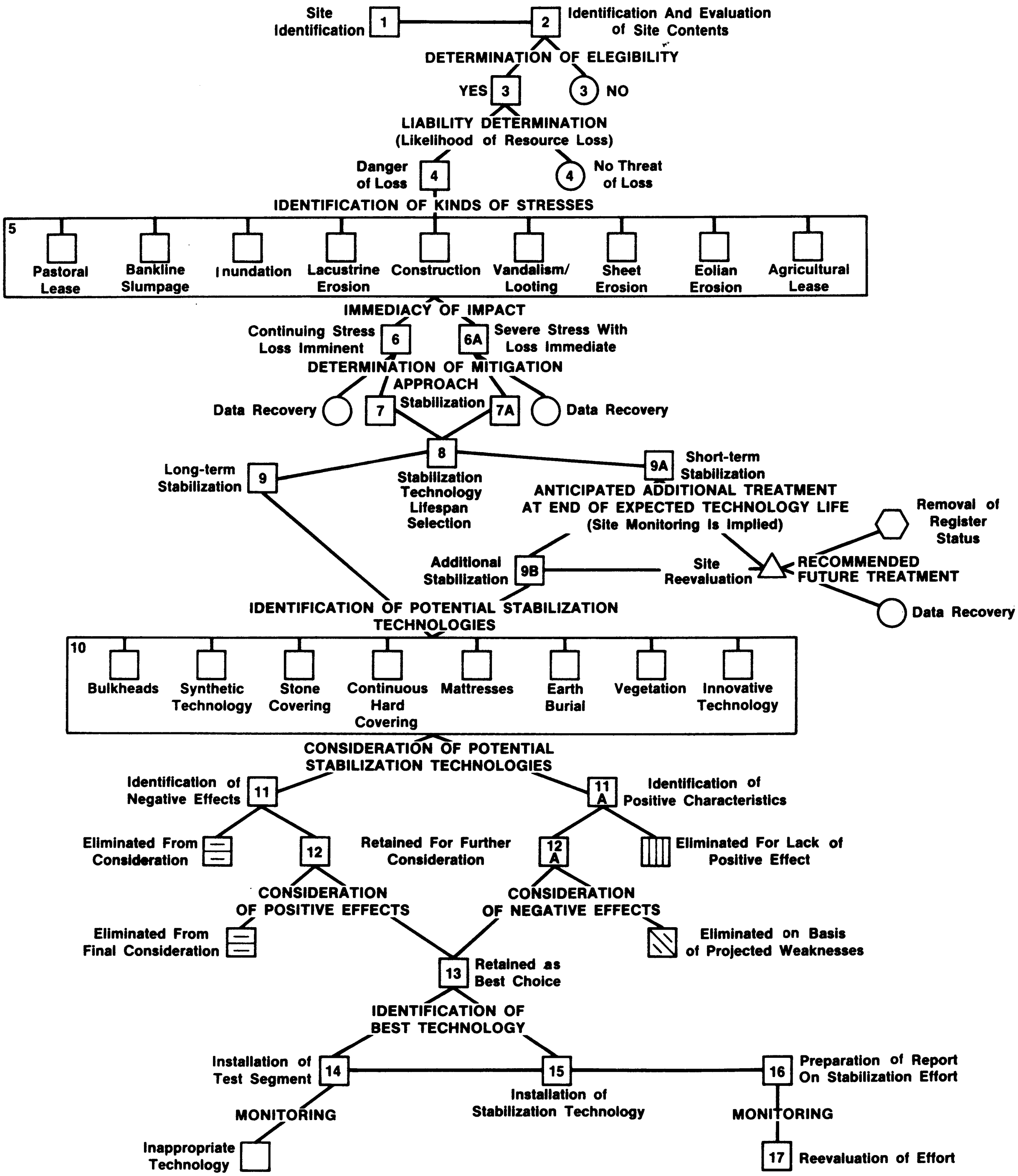

Figure 2. Schematic of proposed steps in archeological site stabilization projects

resource loss may also be anticipated at this point. Finally, considerations for mitigation options including preservation will begin. Funding for completion of the mitigation measures on operating projects must normally be found within the existing O&M budget.

53. Once a route leading to site protection is selected and the stabilization process is set into motion, the previously suggested free-flowing exchange of information among the specialists involved in the process not only is desirable but must be an integral part of the process. The combined expertise of specialists involved in the project should provide the most successful plan for dealing with archeological site loss. As a result, funding requirements can be more realistically determined, and the adequacy of the preservationist approach can be better assured.

54. The proposed steps in archeological site stabilization projects (Figure 2) are clarified in the following paragraphs. This progression is generalized from information gleaned from a number of sources, and specific cases of site protection may not require all of the steps included here. By the same token, the steps as presented can provide optional sets of activities that may not be readily apparent. Some explanation may also be necessary to ensure that the decision-making pathway within Figure 2 is clearly understood.

Site Identification, Probability of Loss, and Stress

Identification (Steps 1 and 2)

55. Steps 1 and 2 (Figure 3) pertain to site identification and the identification and evaluation of site contents, respectively (see paragraphs 21, 27, and 50-53).

Determination of eligibility (Step 3)

56. Some caution must be raised regarding the process of National Register determination, particularly in light of Section 943 of Public Law 99-662. Care must be exercised to ensure that historic properties are considered not only initially, but later as well. Sites with demonstrated contents that do not meet current Register criteria may be reevaluated in the future, when their data may be recognized as important. Analytical techniques available to archeologists are appearing in greater numbers almost daily, and the degree of sophistication of these techniques is continually expanding interpretive horizons for archeologists and resource managers. This expansion

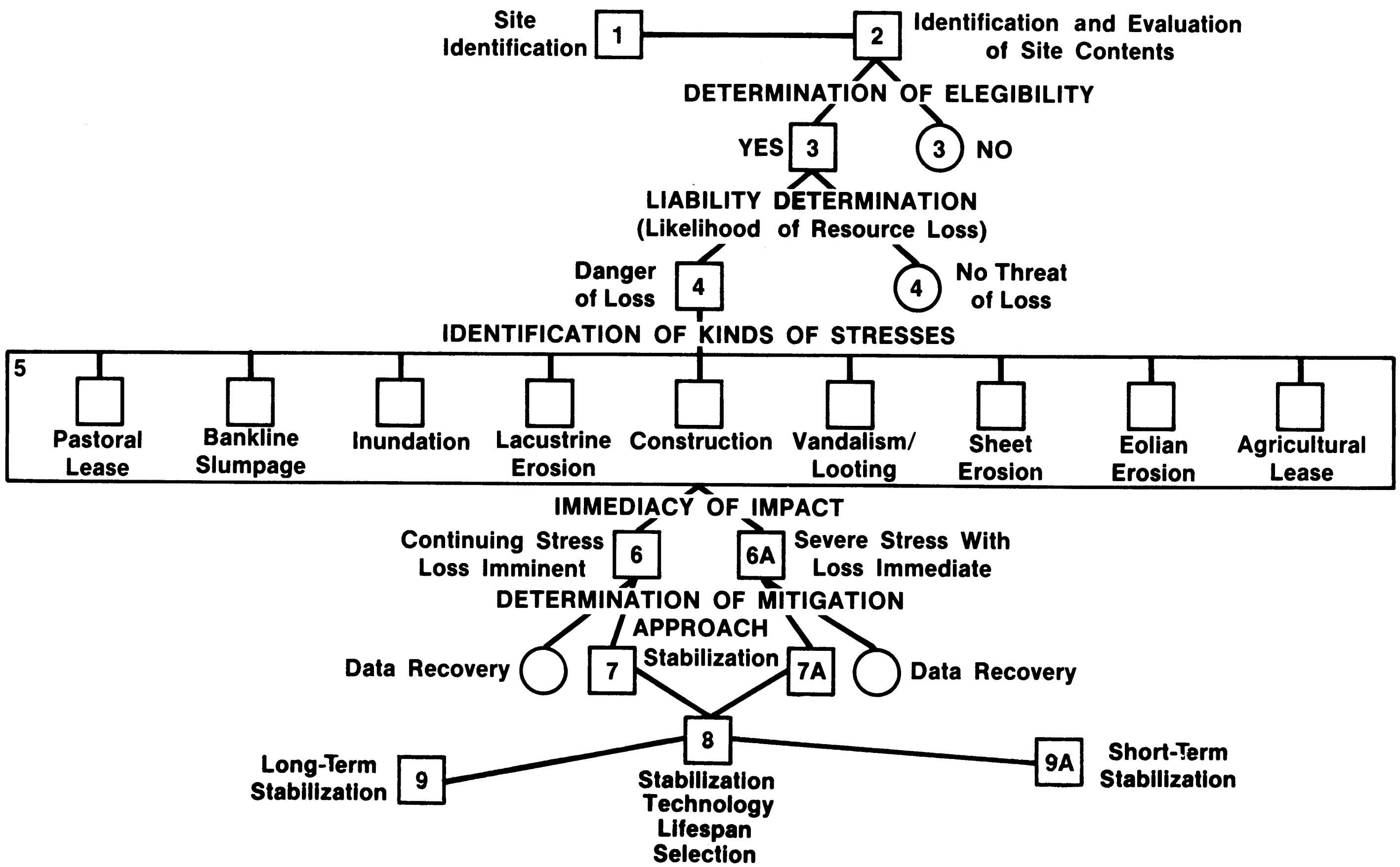

Figure 3. Schematic presentation of proposed steps in archeological site stabilization projects Steps 1-9

of professional knowledge of prehistoric and early historic events, in turn, precipitates the generation of new or different research questions. Sites that have no apparent value vis-a-vis contemporary research issues may be of vital significance in the resolution of future research questions. In preservation strategy and practice, the opportunity to reassess the value of a site and its contents must be retained.

Liability determination (Step 4)

57. One observation that is usually made during site location and assessment procedures is whether or not a property has any liability for future loss. Sites that are likely to remain undisturbed will be identified as well as those that may be damaged or destroyed (Step 4, Figure 3). Frequently, some effort will be made to ensure the continued safety of a property by allowing it to be overgrown with native vegetation, but this does not constitute preservation in the sense being considered here. Jeopardized properties that can have that stress actively relieved are of concern. If a significant property is being considered for active maintenance, as many of the factors impacting the property as possible must be identified, and applicable technology should ultimately protect against as many of them as possible.

Identification of stresses (Step 5)

58. Step 5 (Figure 3) identifies nine factors as examples of the most commonly noted stresses on archeological sites. Research completed by Thorne, Fay, and Hester (1987) provides a lengthy listing of stresses that have been identified by various historic property managers.

Immediacy of impact (Step 6)

59. Once the impacting stresses have been recognized, their identification often will lead to a definition of the immediacy of the threats to the resource. Figure 3 shows Step 6 as being divided. The division makes a distinction between continuing stresses such as looting or erosion (Step 6) and those immediate and frequently more severe stresses that will result from the direct impact of some construction effort (Step 6A).

Determination of
mitigation approach (Step 7)

60. Determination of the immediacy of the threat then leads to that portion of the process involving the selection of the most appropriate means of mitigating potential loss (Step 7, Figure 4). Data recovery, in its various forms, is a viable and frequently necessary alternative for protecting

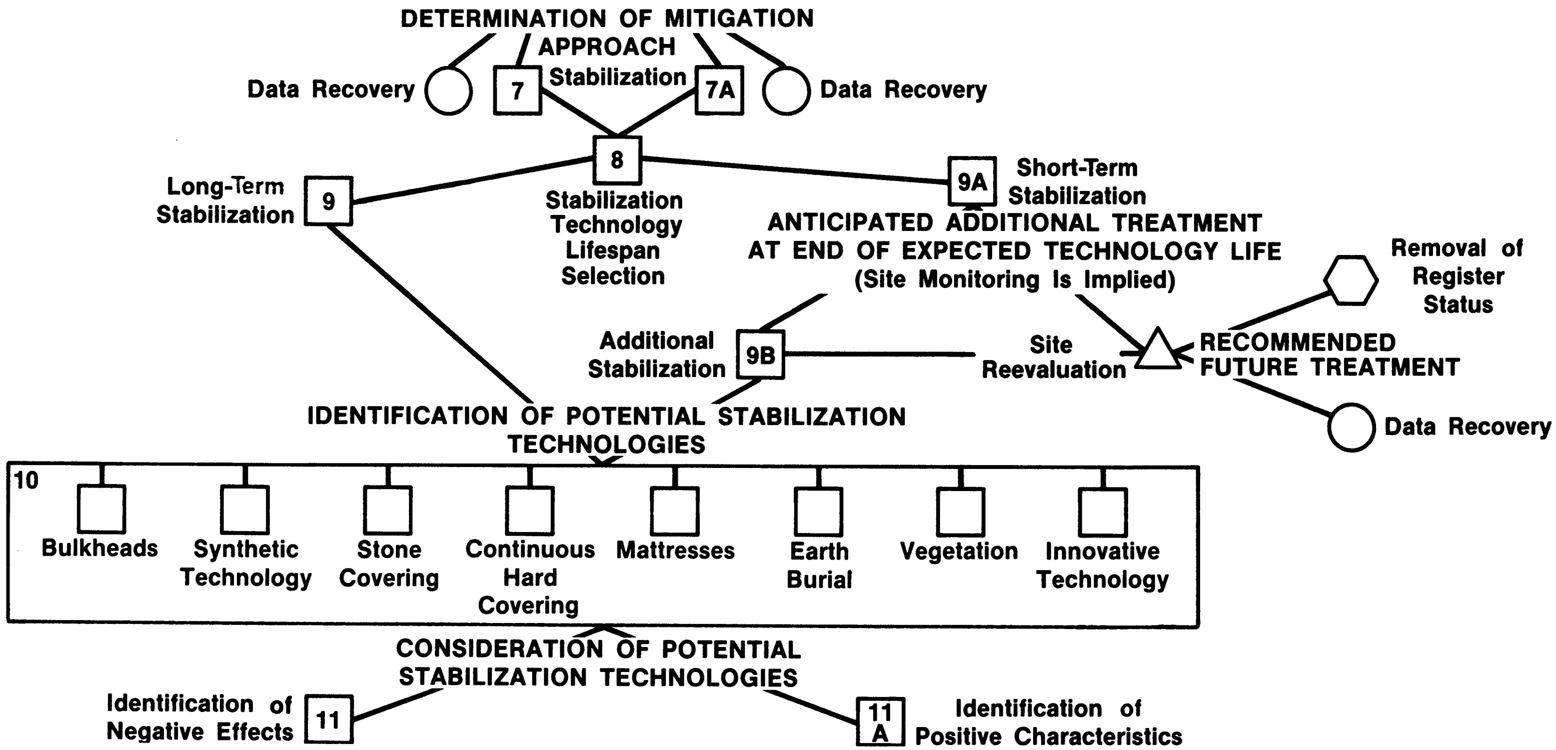

Figure 4. Schematic presentation of proposed steps in archeological site stabilization projects
Steps 7-11

the data that may be lost from some sites. At other sites, stabilization and subsequent maintenance may prove to be the best choices for maximum use of the resource.

Long-term versus short-term stabilization approaches (Steps 8 and 9)

61. Examination of the existing literature suggests that most of the attempts to stabilize sites in the past have been viewed as having an indefinite life. This apparent attitude toward preservation may be found in chronicled instances of earth burial (Thorne 1985) or in cases of sites being covered with impermeable materials. Riprap is frequently chosen because it is relatively indestructible.

Life span selection (Step 8)

62. Within certain limits, stabilization technology life expectancy is predictable and requires careful consideration as a part of the planning process. In traditional erosion zone projects, long-term stabilization with minimal maintenance is generally the desired goal. The same is usually the case with archeological site stabilization projects; however, short-term stabilization might be a viable and desirable alternative. The planner should be aware that technology life can be treated as a variable, and more than one useful life span option is available for consideration (Step 8, Figure 4).

63. Short-term stabilization might be more desirable in some cases, and to some extent, the resource manager must anticipate future needs or actions that might occur at or near the site to be protected. Since technologies are being continually developed or improved, these methods or products must be reviewed for possible use on archeological properties. Many of the available technologies are not new but have been used for other purposes for years. Their use in an archeological context, however, may represent a new application. For example, nonwoven filter cloth is now being used experimentally as a means of stabilizing a cutbank on a mound in the Tennessee River Valley (see Part 3).

Long-term versus short-term treatment (Steps 9 and 9A)

64. If long-term stabilization is selected (Step 9, Figure 4), the next step is identification of the potential means for stabilizing the property. If, however, a short-term stabilization approach is chosen (Step 9A,

Figure 4), then additional treatment must be anticipated after the useful life of the first effort is reached. Therefore, site monitoring must be more frequent than is necessary for technologies with a longer life span, especially as the end of the short-term treatment nears. Finally, the stabilization effort must be reevaluated before the technology begins to fail, and a decision must be made to perform additional stabilization work or recover the data from the site; or, in an unlikely circumstance, the site must be declared to no longer be of significance. This latter option will occur only if the applied technology has completely failed or if sufficient data have been retrieved from similar resources and show that the preserved site is redundant, containing data that will probably not contribute to local or regional interpretations.

65. Installation of additional stabilization is the alternative more likely to be chosen and results from the process that led to temporary, short-term stabilization in the first place. If a short-term alternative for resource maintenance is selected, Step 10, the identification of more permanent appropriate technologies, must ultimately follow. Since the original effort had been planned, the move to a more permanent form of stabilization should be begun well before the end of the expected life span of the original technology. When sufficient funding is not initially available for long-term stabilization, short-term protection at a lower cost may be the best option. By using a less expensive first approach, adequate fiscal support may be obtained for permanent treatment at a later date.

Identification of potential stabilization technologies (Step 10)

66. The planning process as presented to this point is derived from long-established procedures for the treatment of historic properties. (Additional procedural support will be available when ER 1130-2-438 becomes effective.) The identification of appropriate stabilization technologies (Step 10, Figure 4) is not as well defined, however, since resource stabilization/preservation is essentially still in its infancy as a mitigation approach. Therefore, no single approach can be demonstrated to be better than any other. Many archeological site stabilization efforts rely on established erosion control techniques since they have been shown to be effective. Unfortunately, there is no background documentation of the effects of placing erosion control structures on archeological property. At this step in the

process, the cultural resource manager must again seek advice from hydrologists, geologists, or engineers who are knowledgeable about erosion control techniques. In most cases, these will be the same specialists who have helped to identify those stresses that are destroying the resource. These advisors can suggest appropriate choices that may be available. Consultation with these same individuals (specialists) is advantageous since they will already be familiar with the problem. In addition, archeologists can refer to a variety of works to improve their understanding of the various stabilization technologies that are available (Keown et al. 1977; Keown and Dardeau 1980; Thorne 1985; Thorne, Fay, and Hester 1987; Henderson and Shields 1984).

67. The best approach to the identification of potentially appropriate technologies will be for the resource manager to establish a minimal set of criteria that any proposed technologies must meet. Since site stabilization efforts must meet the specific needs of each resource, no minimal set of criteria will be proposed herein, but criteria that should be considered for each site include weight tolerance or limitations, chemical or pH compatibility, permissibility of physical contact between the resource and the stabilizing mechanism, and preference for natural or synthetic materials or use of both. Cost benefit ratios are always an important consideration, but fiscal constraints should not be a prime consideration at this point in the planning process.

68. While consideration of traditional stabilization technologies is expected and appropriate, neither the design specialists nor the archeologist should be hesitant about considering innovative options. In addition, they should not hesitate to request advice and assistance from the various companies that produce stabilization materials. Most of these manufacturers are interested in new applications for their products since increased sales potential and improved public relations are corporate goals. Individual company representatives are also likely to have a personal interest in resource preservation and will, as a consequence, readily participate in preservation efforts as specific product advisors.

69. While stabilization designers may take comfort in the knowledge that certain technologies are appropriate in certain erosional environments, the stress that these technologies may put on an archeological property has yet to be defined or clearly understood. The technologies most frequently borrowed from erosion control and applied to archeological stabilization

efforts include: riprap, riprap combined with a natural (gravel) or synthetic (filter fabric) filter, gunite (both reinforced and unreinforced), site burial with a culturally sterile and contrasting matrix (sand, clay, or topsoil), and vegetation planting (with both indigenous and introduced species). Other site-protecting mechanisms that have been put in place, but that are not directly applied to the cultural bearing matrix, include the use of signs, camouflage with cut brush, stream channel realignment and stabilization, park development, access exclusion using some barrier such as fencing, or a combination of one or more of the above.

70. The potential stabilization technologies included in Step 10 (Figure 4) are intended as examples since they have been reported to be the most frequently employed approaches to the problem. Unfortunately, no single solution to the threat of site loss is best. While many of the noted instances of site stress (Step 5) are similar, case specific attributes may vary widely from region to region and from site to site within regions.

71. Even though true site preservation cannot be achieved, the process of site content aging may be retarded by effective preservation efforts. Every effort must be made to ensure that the technology applied to the site does not retard some elements of the aging process while hastening others. Under ideal conditions, a broad range of background physical and chemical data should be collected from the site and evaluated before stabilization technology selection is initiated. These data include such items as cultural deposit pH and chemical constituents, soil compaction data, organic matter content, and a mechanical analysis of the soil making up the cultural deposit. Samples should be taken from a number of loci within the site since no single data point is representative of the entire site. Many sites worthy of stabilization are made up of differing depositional environmental/site situations that must be considered before a final technology can be selected. For example, habitation areas near streams, lakeshores, and coastlines may contain shell middens, flaking stations, and domicilary areas. The pH between these various depositional units is expected to vary. Similarly, the artifactual, floral, and faunal composition of these units are expected to differ widely, and these differences must be considered in the technology selection.

72. After identification of the site characteristics to be considered, the selection of an appropriate preservation technology can be made easier by developing charts similar to those shown in Appendix A. The charts serve as

examples of how the various strengths and weaknesses of a specific technology can be portrayed. The development of comparison charts such as these must be a team effort. The archeologist is not likely to know about the various engineering aspects to be considered, just as an engineer should not be expected to have a working knowledge of the intricacies of archeological site composition. Should a technology be included that was developed and tested for some other use, relevant data may have to be acquired from the manufacturer before a comparative table can be developed.

Critical consideration of the stabilization alternatives

73. Negative effects (Step 11). The development and inspection of the comparative charts from Step 10 leads to Steps 11 and 11A in Figure 5. At this stage in the selection process, the full range of technologies that might satisfy the stabilization needs should be considered from a dual perspective. The negative effects of each of those technologies should be carefully considered, and technologies likely to adversely impact the cultural deposit should be eliminated from further consideration. Presumably, not all of the proposed technologies will be eliminated, and these will be retained for further consideration in Step 12. It may be best to develop some means of ranking the technologies being considered and to identify an appropriate minimal threshold of rejection.

74. Positive effects (Step 11A). Similarly, the positive characteristics of each of the technologies should be considered and a minimal effective threshold established (Step 11A, Figure 5). Those technologies which fall below that threshold would be eliminated on the basis of their lack of positive effects, while those above that threshold would be retained for future consideration (Step 12A).

75. The consideration process should then be reversed, and the favorable elements of those retained from Step 12 should be considered while the unfavorable elements of the Step 12A candidates should be inspected. Minimal functional thresholds should again be applied in the consideration process, but at this juncture only advantageous attributes are really being considered. The procedures in Steps 11 and 12 should have eliminated those approaches that would negatively impact a site while the procedures in Steps 11A and 12A would have eliminated the weaker of the positive technologies. It is at this

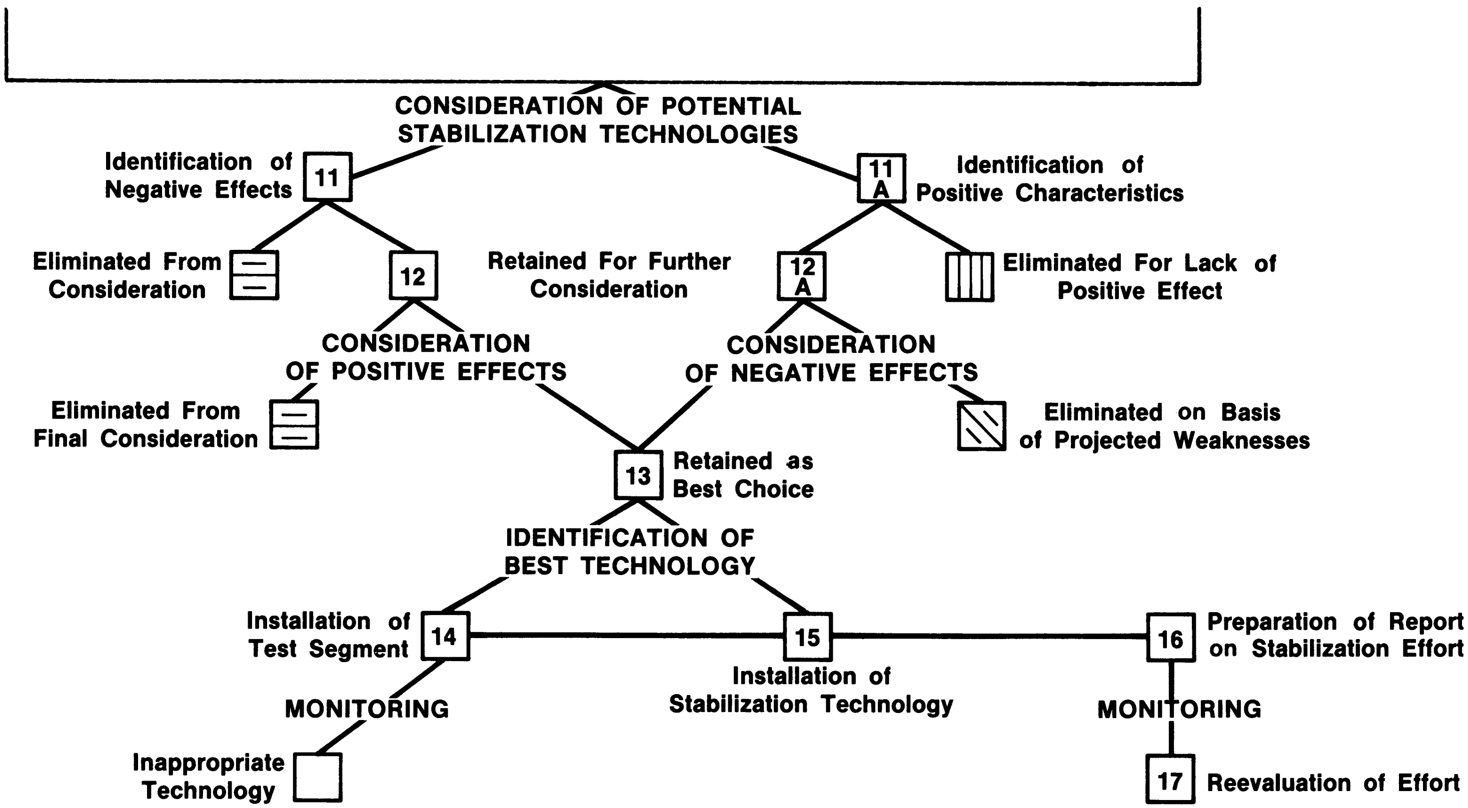

Figure 5. Schematic presentation of proposed steps in archeological site stabilization projects
Steps 11-17

juncture that potential weaknesses of all of the considered technologies must be estimated and further eliminations made.

76. These projections are particularly critical at this point in site preservation history since the development of an adequate site stabilization process is still in its infancy. Several cases of previous site stabilization efforts can be chronicled, but sufficient time has not passed to allow a true evaluation of any of them (Thorne 1981, Thorne 1985, Fay 1987, Lynott 1984). Monitoring of these efforts is currently underway, but publication of the results may be some time in coming. In essence, site stabilization efforts, as they are currently being applied, are experimental in nature and must not be attempted without careful consideration of the final results.

Technology selection, installation, and evaluation (Step 13)

77. Step 13 (Figure 5) should present the archeologist with the best choice of protecting the historic property. If the threat of site loss is not too severe and if the best choice has not been tested in an archeological context as a stabilization medium, the decision may be made to install a test segment on the site (Step 14, Figure 5). Short-term and frequent monitoring must be carried out to determine if the approach is adequate. If, on the basis of this trial period, the technology that has been put into place proves ineffective, then a second choice must be made, or the first choice must be altered to eliminate its negative effects. If the test segment proves effective, the balance of the site can be protected using the same technology.

78. If a long-term stabilization approach has been selected but requires testing, it may become necessary to loop back to Steps 9A, 9B, and 10 to select a short-term protective device to protect the balance of the site during the test period. The long-term test technology and the short-term expedient should be installed at the same time. Since short-term stabilization technology has not been shown to be a fully viable approach as yet, the evaluation of this effort should be completed as carefully as that of the test section. If the short-term expedient fails, it must be replaced or repaired.

79. If, on the other hand, the selected technology has been tested for its archeological and engineering adequacy, Step 14 can be bypassed, and the selected technology can be put into place. This portion of the decision-making process is depicted in Figure 5. Preparation of the report that carefully describes the selection process and the installation of the selected

technology does not represent the final step of the procedure. Rather, these activities are only the beginning stages of the preservation process that are to be followed by monitoring and reevaluation.

Monitoring

80. Monitoring is the routine reevaluation of the effectiveness of the preservation option that has been applied. It consists of routine visits to the site to record the nature and extent of any posttreatment changes. The range of such changes extends from nonchange to total failure. Typically, when changes occur, they are often of a partial or geographically restricted nature and are due to continued illegal excavations, stream channel flanking, seepage, slumping, etc. The monitoring process provides the means to identify such partial failures at an early date and thus permits early planning of the remedy.

81. The act of stabilizing an historic property does not end when it can be shown that the applied technology is successful. Rather, as stated previously, the monitoring process must continue and in some instances, maintenance efforts may be required at a future date. This eventuality must be considered as a part of any HPMP or FDM as well as during the development of any stabilization scheme. Project operations and maintenance budgets must then be structured to include preserved site care and, when necessary, specific line items may have to be added to the fiscal request.

Publication of Results

82. Given the current state of archeological site stabilization, it is incumbent on anyone who initiates a preservation program to make those efforts available to other archeologists who share common problems. Initial descriptive reports should be followed up with assessment reports that are based on monitoring and technology evaluation.

Cost Evaluation

83. As an intentional omission, stabilization project costs and cost-benefit ratios have been given minimal mention here. Since historic

properties are nonrenewable resources, their value is incalculable, and the development of a cost-benefit ratio could be considered inappropriate. The resource manager must exercise his best judgment in selecting a technology to stabilize a specific site, and under that circumstance, common sense would dictate that a most-for-the-money approach be taken. Consideration of the energy levels associated with impacts can lead to selection of lower cost options where feasible.

PART III: A CASE STUDY: HUFFINE ISLAND MOUND STABILIZATION--AN APPLICATION OF THE DECISION-MAKING MODEL

84. During the time the interviews for this study were being completed, the TVA staff archeologist was notified of a suspected mound group on an island in the Tennessee River (Figure 6). The information suggested that one of the mounds in the group had been badly eroded and was being lost. The island is located within a TVA reservoir adjacent to a shipping channel. Access to the area is only by boat.

85. This writer was the principal investigator for the TVA's experimental program of site stabilization in the Tennessee River Valley (Thorne 1985, Fay 1987). Therefore, the investigators became directly involved in a decision-making process that would ultimately lead to the protection and stabilization of the site at Huffine Island. Protection of the island site presented an opportunity to test the applicability of the various steps in the decision-making model.

Application of the Step-by-Step Decision-Making Process

86. In this case, site identification (Step 1) did not occur as the result of a specific resource identification project carried out by professional archeologists. Rather, TVA's attention to the continuing resource loss was initiated by one of the staff members of the Tennessee Wildlife Resources Authority.

87. The location was inspected by the TVA staff archeologist, who confirmed the existence of an archeological site and the fact that a mound in the complex was indeed being eroded. A program of survey and testing of the island was undertaken (Step 2), and the site was deemed to be eligible for admission to the National Register (Step 3). Had the site not been of Register quality, only the paperwork necessary to enter the site into the State's site files and the TVA's inventory would have been completed. The site would not have been given further consideration for preservation.

88. The site was visited during the early stages of the annual drawdown cycle of the lake, and the probability of continuing loss was verified (Step 4). The variety of stresses operating to obliterate the site were

identified at that time (Step 5). These included lateral current erosion, collapse of the cutbank, and wave-stimulated erosion.

89. Careful inspection of the site indicated that looting was not a problem. The island is part of a migratory waterfowl refuge and hence is a restricted-access area. The majority of the arable land is being used to grow winter feed for ducks and geese. The shoreline where the damaged mound is located is subjected to both wind- and boat-generated wave erosion. Four of the mounds in the group had been disked and planted in rye grass. Stresses that required mitigation included agricultural impact, erosion from waves, and annual fluctuations in water level. The water level in the lake is drawn down in early winter in anticipation of heavier spring rains. During the higher water level in summer, an attempt is made to control mosquitoes by alternately raising and lowering the water level in the lake. While the extent of controlled fluctuation is only 1 ft*, a cycle of shoreline wetting and drying is established.

Figure 6. Profile of mound on Huffine Island after removal of vines (after Thorne 1987)

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 4.

90. Since the mound group had not been previously described and no documentation was available regarding the size of the mound being eroded away, only a rough estimate of the rate of loss could be made. The highest apparent point of the mound was assumed to be near the center of the original structure, and measurements were made on a north-south and an east-west axis. Measurement to the north was to the edge of the cutbank while eastern, western, and southern measurements were to the toe of the mound slope. These three distances were averaged to produce a working basal radius of 85 ft, which would have produced a basal area of approximately 22,698 ft^2. The portion of the basal area that remains is approximately 13,049 ft^2 or 57 percent of the mound. It is then possible to suggest that approximately 43 percent of the mound has been lost since Watts Bar Lake was filled in 1942. This represents a rate of slightly more than 1 percent/year. Visual inspection of the site combined with the identification of the adverse effects acting on the site clearly indicated that unless some action was taken, the resource would eventually be lost (Step 6). There was no indication of severe stress that would lead to the immediate loss of the mound or of the data that it contained; therefore, the decision-making course appropriately avoided Steps 6A-7A.

91. Since site impacts from wave erosion, cyclical inundation, and agricultural activity would lead to the eventual loss of the mound, it was necessary to decide whether a mitigation approach using data recovery would be preferable to one that would lead through protection to stabilization. While data recovery would have been a reasonable approach, several considerations suggested that this would not have been the best treatment for the site at that time (fall 1986). The late winter-early spring rainy season was only 3 months away, and there would have been little time to initiate and complete a massive data recovery program. In addition, the prehistory of that portion of the Tennessee River Valley has not been intensively studied, and no regional research design has been prepared, suggesting that excavation of the mound would have provided isolated chronological and spatial data. Further, the mound requiring treatment was relatively well preserved over its remaining area, as are the other mounds in the complex. Finally, the TVA was already involved in a site protection and stabilization program, and this particular site could be treated as a part of that ongoing program. As a result of all

of these factors, stabilization of the resource was determined to be the best choice for treatment of the site (Step 7).

92. While both short- and long-term stabilization options (Step 8) were available, several considerations led to the choice of short-term protection. Regardless of the life span of the selected technology, all stabilization considerations were governed by the fact that the area to be protected was accessible only by boat and the nearest paved launching ramp was about 4 river miles away. Personnel and equipment would have to be brought in by boat, and if any heavy machinery would be involved, barge-mounted equipment would be necessary. Personnel safety must always be considered, and working from the water would add risk that could be avoided. Riprap or some other stone covering was considered to be prohibitively expensive and was not viewed as a good choice for placement against the nearly vertical cutbank along the mound's face. Maintenance of a long-term protective technology would be costly because of the island environment and its relative inaccessibility. One viable long-term option that was considered would be to place material dredged from the shipping channel during the course of its normal maintenance along the base of the mound to create a breakwater and buffer zone between the lake and the mound face. However dredging was not scheduled for that segment of the river at that time.

93. Short-term stabilization (Step 9A) was chosen as the best approach, even though it was apparent that additional protective efforts (Step 9B) would likely be necessary in the future. Additional steps to stabilize the site would become apparent as a result of semiannual monitoring of the stabilization effort, although such action should be predictable, as well.

94. As the evaluation was being conducted, between long- and short-term protection approaches, most of the traditionally employed streambank and shoreline stabilization technologies were considered and eliminated from the potential stabilization technologies to be employed (Step 10). Use of a geosynthetic material was considered to be the best option available. These materials are generally used as an underliner for more traditional stabilization materials such as riprap or continuous paving, where the purpose of the geosynthetic material is to replace a stone filter bed.

95. Steps 11-11A and 12-12A were completed with the identification of the anticipated positive and negative attributes of two kinds of synthetic filter materials. The two kinds of materials under consideration were woven

filter cloth and nonwoven filter fabric. Once the attributes of each were identified, consideration was given to the weight (thickness and strength) of the material that would be the most serviceable. The attributes of both filter cloth and nonwoven fabric are briefly presented in Table 1.

Table 1

Comparison of Positive and Negative Factors of Woven Filter Cloth and Nonwoven Filter Fabric

Positive	Negative
Woven Filter Cloth	
Light weight/yd^2 High tear strength Installed with steel pins Roll size easily transported by boat Easily cut to size for installation Relatively inexpensive to purchase and install	Woven fabric--porous enough for silt passage Steel pins would be intrusive into the mound fill Subject to vandalism by theft Thin material would not cushion wave forces
Nonwoven Filter Fabric	
Light weight/yd^2 High tear strength Installed with steel pins Pores would allow water passage but trap silts Roll size easily transported by boat Easily cut to size for installation Thickness of material would provide some cushioning of wave forces Relatively inexpensive to purchase and install	Small pores in material may trap silt that will increase material weight Steel pins would be intrusive into the mound fill Subject to vandalism by theft

96. A nonwoven filter fabric was determined to be the best choice (Step 13). After considering the various weights available from a variety of sources, Amoco 4557 was selected. The material was put into place during December of 1986 (Step 15), and the report of that installation has been completed (Step 16) (Fay 1987) (Figure 7).

97. The cutbank that had developed along the side of the mound proved to be well suited for the application of the filter fabric. The bank was not

Figure 7. Filter fabric covering on Huffine Island Mound, Watts Bar Lake, Tennessee

quite vertical and was not scarred by erosional channels. The few undulations that were present did not produce a surface so irregular as to interfere with fitting the fabric to the contours. Very little vegetation was growing directly on the cutbank, although vines of several species (principally honeysuckle) were growing over the top and hanging against the face of the bank. These were not rooted, and removal was accomplished by cutting the runners along the top of the bank. Once the vegetation was removed, a span of 120 ft of cutbank was exposed for protection.

98. The 14.5-ft-wide fabric was cut into appropriate lengths and draped from the top of the mound like a curtain. The first piece was installed on the downstream end of the bank and pinned into place using 18-in. steel pins with a 1-1/2-in. washer affixed to the top to keep the pins from pulling through the fabric. Additional pieces of material were added with a 6- to 8-in. overlap at the joints. Once all of the pieces were in place, additional pins were added to ensure that the fabric conformed to the undulations of the cutbank.

99. Preparation of the bank and installation of the fabric took 1 workday for a crew of five to complete. Total cost of the project, including travel, labor, and materials, was less than $2,000. The filter fabric has an

estimated life of 5 years, placing the daily cost for stabilizing the site at a little less than $1/day (Thorne 1987). A summary of the decision-making steps actually chosen during the Huffine Island site stabilization project is illustrated in Figure 8.

Evaluation of Stabilization Effectiveness

100. The site was revisited 3 months after placement of the material and again after 6 months. At the time of the first inspection, the lake was still at its winter level, and the material had not been subjected to flooding. No damage to the material was noted. Hand pressure on the fabric dislodged soil particles, suggesting that dry slumping under the fabric might be a problem. No tools were available to remove the pins holding the joints in the fabric together, and visual inspection of the mound fill was not possible at that time.

101. Between the first and second visits, the decision was made to add an extra length of fabric along the top edge of the cutbank. This material would be placed to fit over the edge and provide protection to the crest of the erosional face.

102. At the 6-month visit, the vine cover hanging over the face of the mound was becoming reestablished over the center portion of the profile and in places was hanging 6 ft down from the top. Rather than disturb that mantle of growth, one area on each end at the top of the erosional cutbank was provided additional coverage. The eastern top end of the bank was covered with a 28-ft span to protect an overhang being lost from dry slump. Some dressing was necessary before the fabric could be pinned into place. In addition, a 14-ft area on the western end was covered. The only preparation necessary in this area was the removal of vines along the top of the bank. Five 18-in. pins were inserted between these two sections of fabric to serve as a control for measuring any future loss from the top of the bank.

103. One of the seams was opened midway up the face of the cutbank, and the mound fill was inspected for excessive dryness. The fill material appeared moist and well consolidated, and dislodged particles appeared to be material loosened at the time of initial fabric installation.

104. Additional monitoring of the test area is scheduled to be completed at 3-month intervals with needed repairs being made at those times.

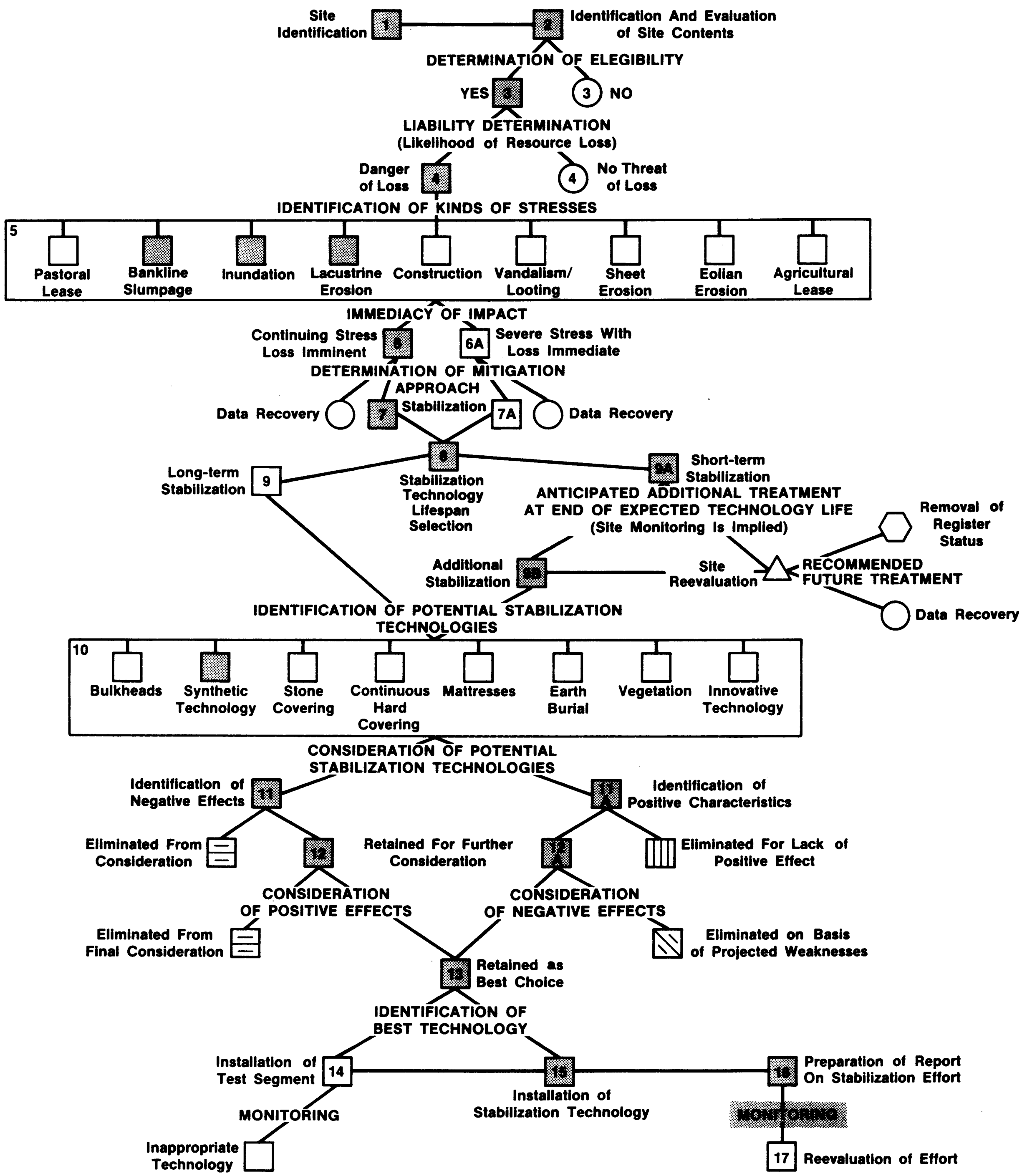

Figure 8. Decision-making steps chosen during site stabilization at Huffine Island are illustrated by means of dark shading

Should it become apparent that the fabric is failing prematurely or that erosion is continuing underneath the fabric, an alternative stabilization technique will be sought.

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APPENDIX A
ADVANTAGES AND DISADVANTAGES OF SPECIFIC PRESERVATION TECHNIQUES

Table A1

Pavements (Revetments)

Continuous Poured (Placed) Concrete or Asphalt	Articulated Concrete	Sprayed Concrete (Shotcrete or Gunite)
	Advantages	
Effective shoreline protection	Effective shoreline protection	Effective shoreline protection
Provides horizontal (overhead) protection	Moderately low maintenance	Moderately low maintenance
Difficult for vandals to remove	Difficult for vandals to remove	Moderately difficult for vandals to remove
Materials locally available	No direct contact with artifact-bearing materials required	No direct contact with artifact-bearing materials required
No direct contact with artifact-bearing materials required		Materials available locally
Low maintenance		Heavy equipment traffic may be reduced
Construction skills available locally		Less shaping of slope required
	Disadvantages	
Heavy equipment required on site	Heavy equipment required on site	Not as strong or durable as conventional concrete

(Continued)

Table A1 (Concluded)

Continuous Poured (Placed) Concrete or Asphalt	Articulated Concrete	Sprayed Concrete (Shotcrete or Gunite)
Slope may require shaping prior to installation	Slope may require shaping prior to installation	Equipment may not be available locally
Vulnerable to erosion at toe and margins	Vulnerable to erosion at toe and margins	Some operator skill required may not be available locally
Useful only on gentle slopes	Useful only on gentle slopes	Vulnerable to erosion at toe and margins
Pavement may attract vehicles and visitors to site	Pavement may attract vehicles and visitors to site	Pavement may attract vehicles and visitors to site
	Effectiveness of protection and need for maintenance depends on nature of articulation and joints	
	Materials not usually locally available	

Table A2

Prefabricated Blankets, Fabrics

Advantages	Disadvantages
Can be molded into irregular shapes and to irregular surface/subsurface contours	Some material types are costly
Yields: semi-elastic and plastic	Some material types are susceptible to disintegration upon long exposure to the sun
Can be used on horizontal, sloping, and vertical surface	Can be torn, ripped, and vandalized
Can be used with aggregates and other filler or additive material	Will deform and not protect underlying artifacts and materials to vehicular traffic
Add strength to sites and fill material	
Can abet (prefertilized) grass and plant growth	
Resistant to wave, rain, and surface water flow erosion	
Increase slope stability	
Can be permeable or nonpermeable	

Table A3

Bulkheads

Piles	Interlocking Sheets	Timber	Masonry
	Advantages		
Encourage stream and shoreline stability	Encourage stream and shoreline stability	Encourages stream and shoreline stability	Encourages stream and shoreline stability
Provide shoreline protection	Provide shoreline stability	Provides shoreline protection	Provides shoreline protection
May not directly contact artifact-bearing matrix	Require less periodic maintenance	May not directly contact artifact-bearing matrix	May not contact artifact-bearing materials
May be made from locally available materials	May not directly contact artifact-bearing zone	May be made from locally available materials	Locally available materials
			Low maintenance
	Disadvantages		
Provide no horizontal surface protection	Provide no horizontal surface protection	Provides no horizontal surface protection	No horizontal surface protection
Require heavy machinery for installation	Require heavy machinery or barge for installation	May require machinery to handle heavy materials	Heavy equipment required for construction
Machine impact to cultural deposit likely	Installation machinery impact to site possible	Machine impact to cultural deposit possible	Vulnerable to erosion and undercutting at toe

(Continued)

Table A3 (Concluded)

Piles	Interlocking Sheets	Timber	Masonry
Lifespan dependent on treatment of wood and local environmental factors	May be undercut by wave action	Lifespan dependent on treatment of wood and local environmental factors	Does not protect site against vandalism
	May require periodic maintenance		
May be undercut by wave action	May require backfilling between bulkhead and bankline to prevent slumpage	Wood preservative could be absorbed by cultural remains	
May require yearly maintenance		Does not protect site against vandalism	
May require backfilling between bulkhead and bankline to prevent slumpage	Not made of locally available materials		
Wood preservative could be absorbed by cultural remains	Do not protect site against vandalism		
Do not protect site against vandalism			

Table A4

Pervious Blankets (Riprap, etc.)

Machine-Dumped Stone	Hand-Placed Stone	Manufactured Shapes (Gabions, Tetrapods)	Brush Mattresses	Tire Mattresses
		Advantages		
Effective shoreline protection	Effective shoreline protection	Effective shoreline protection even in high-energy environment	Effective temporary protection for shorelines and riverbanks	Moderately effective shoreline protection
Low maintenance	Low maintenance	Shapes are too heavy to be moved by vandals	Materials usually available locally	Materials usually locally available
Suitable stone widely available	Suitable stone widely available	Require no direct contact with artifact-bearing material	Cleaning operations may provide materials needed	May assist establishment of vegetation on shorelines
Less vulnerable to erosion at margins and toe than impervious protection methods	Lower volumes and thickness required		May assist establishment of vegetation on shorelines	
Requires no direct contact with artifact-bearing material	Less heavy equipment required on site			
	Attractive appearance			
	Requires no direct contact with artifact-bearing material			

(Continued)

Table A4 (Concluded)

Machine-Dumped Stone	Hand-Placed Stone	Manufactured Shapes (Gabions, Tetrapods)	Brush Mattresses	Tire Mattresses
		Disadvantages		
Requires heavy equipment on or near site Large volumes and thicknesses required Can be removed by vandals with some effort Haul distance significant to cost Potential artifact damage during dumping	Labor intensive Can be removed by vandals with some effort More vulnerable to erosion at margins and toe	Not usually available locally Subject to damage during haulage and placement Requires filter blanket and coarse stone base Heavy equipment required onsite Potential artifact damage during placement	Labor intensive High maintenance Tiedowns may require contact with artifact-bearing material Fire hazard Can be removed by vandals	Labor intensive Tiedowns may require contact with artifact-bearing materials Two or more layers needed for protection Unsightly appearance Can be removed by vandals