

3.0 SCIENCE & TECHNOLOGY PROGRAM IMPLEMENTATION

All activities developed under the S&T Program would be coordinated and approved through the Program Manager. The S&T Program would provide analytical tools (e.g., hydrodynamic and ecological models) and frequently assess the effectiveness of those tools through close communication with the PET. This section of the appendix provides the proposed organizational structure, including the S&T Office, and a discussion of the major functions of that Office. For each major function, a brief description is provided why that function is important, a short assessment of lessons learned where a similar function has been used in other ecosystem restoration efforts, and finally, the LCA approach to implementation of each function based on those lessons learned.

3.1 Organization

The main structural elements of the S&T Program and its relationship to Program Management Team are shown in **figure A-3.1**. It consists of four major components: The S&T Office, a Science Coordination Team, a Science Board, and ad hoc Peer Review Committees. The program would be flexible and would reach out to scientists within Louisiana, nationally and internationally, and would provide for direct communication with Program Management Team and the PET.

3.1.1 Science & Technology Office

The S&T Office is the focal point for activities of the S&T Program. It provides a physical location and primary point of contact for all agencies and individuals with interests in science and technology. It must communicate regularly and efficiently with LCA Program Management Team and the PET while maintaining a separate identity and independence from the day-to-day activities of implementation. The S&T Office consists of the Director and appropriate staffing to meet required mission task and goals. Funds would be allocated to the Science Program by the Program Manager to support plan implementation by the PET and to address programmatic-level science needs. For example, funds could be used to: (1) develop necessary scientific data and information to implement features found in the near-term course of action; and (2) fund coastal restoration science and technology proposals to address uncertainties related to enhancing system-wide understanding, engineering concepts, and operational methods (see Section 2.0).

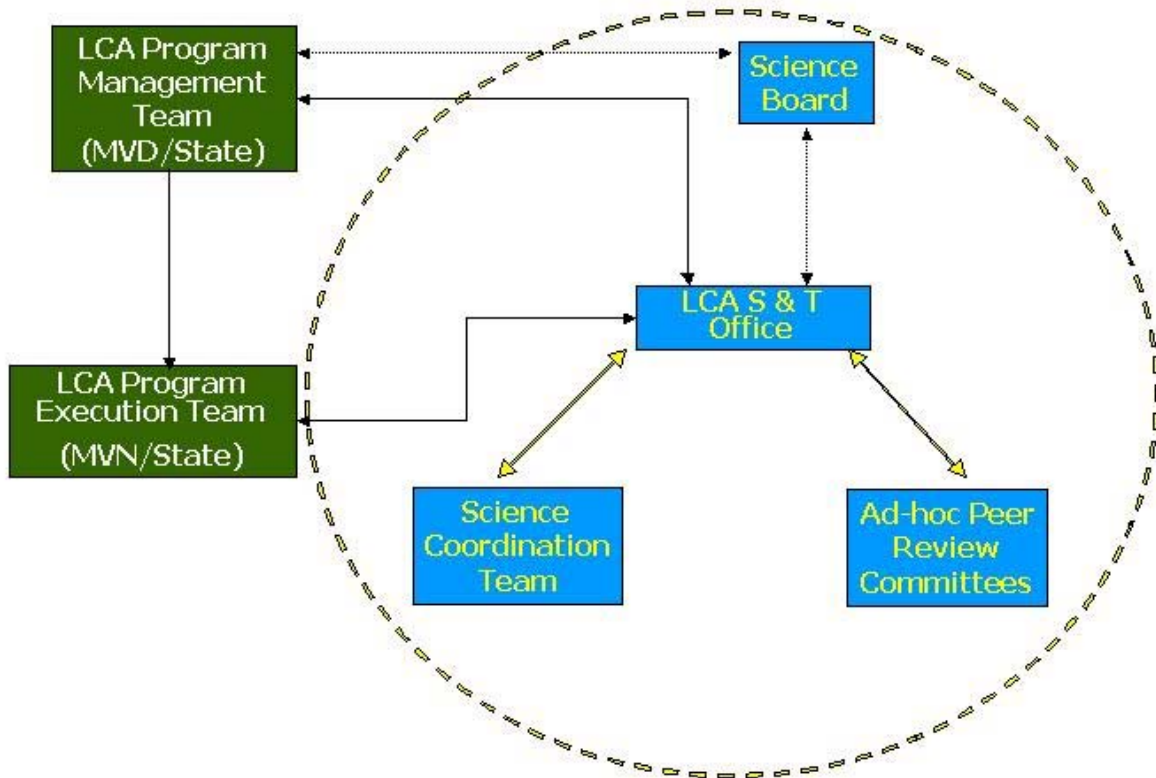


Figure A-3.1. S&T Program and Management. This figure presents the structure and lines of communication between the S&T Program, LCA Program Management Team, and the PET.

3.1.1.1 The Director

The Director oversees the S&T Program and is responsible for the operation of the S&T Program and the conduct of all functions of the S&T Program. The Director is a member of the Program Management Team. Program budget requests are prepared by the Director in coordination with the PET request and submitted to the Program Manager. A copy of the S&T budget request would also be provided to the PET for consistency in submission of the program budget request to the Program Manager. The Director is a federal employee under the S&T Office and should meet the qualifications set by the Program Manager. More specifically, the Director should have:

- Experience in managing complex scientific programs and a variety of scientific disciplines;
- Undertaken substantial scientific research work in any field related to LCA;
- Experience managing environmental issues or advising high-level managers in methods for promoting science-based decision making; and

- A record of publication in the peer reviewed scientific literature.

The Director is appointed by and reports directly to the Program Manager. He/she is spokesperson for the S&T Program at all levels within the LCA structure and has responsibility for the conduct of the S&T Office and all functions of the S&T Program. The office of the Director should be a centrally located area of activity in Louisiana. The State offers the Louisiana State University & Agricultural and Mechanical College campus in Baton Rouge as the site of this office. This type of major research university would be an appropriate location to best coordinate and execute the S&T Program.

The S&T Office consists of the Director and appropriate staffing to meet required mission task and goals. Depending upon the specific contracting mechanisms used to support S&T Program activities, it is possible that some science and technology contracting personnel, but not all, may be located within the S&T Office.

3.1.1.2 The role of the science & technology office

It is expected that the Director would consult regularly with the PET and utilize a number of different mechanisms and processes to achieve program goals. Where activities are delegated or contracted out, the Director remains responsible for the quality and integrity of the processes and products.

In general, the S&T Office coordinates, administers, and reports on science activities conducted as part of the LCA planning and implementation effort. It does not perform or manage the science studies. It is envisioned that specific responsibilities of the Director and the S&T Office would include:

- Develop an Annual S&T Plan and Report, to include updates/revisions to conceptual models that includes any necessary revisions of conceptual models regarding system function based on new science findings (from all credible sources),
- Ensure communication with the Science Coordination Team, the Science Board, Program Management Team, PET, and other groups and organizations with interests in the S&T Program,
- Identify opportunities and recommend to the Program Manager competitive funding mechanisms for some science and technology activities,
- Develop and implement Peer Review processes and mechanisms for the S&T Program,
- Establish a knowledge center or clearing house for science and technology-related reports, documents, and publications,
- Lead in the conception and selection of demonstration projects and baseline studies that reduce scientific and engineering risk and uncertainties (see section on Scientific Uncertainties),
- Facilitate communication between S&T Program product developers and product users (e.g., PET),
- Provide a framework for decision-making, in which issues will be clearly and technically defined,

- Work with scientists and managers to develop research projects that resolve scientific uncertainties that inhibit restoration planning, predictive modeling, and program implementation,
- Provide input to the PET during the scoping phase of studies and preparation of engineering, design, and decision documents,
- Provide scientific data, analysis, and interpretation critical to the design, construction and operation of restoration projects as appropriate for the evaluation of ecological success of projects, and for the modification of existing or future projects when “success” is found to be limited,
- Recommend and execute, as appropriate, focused data collection and investigations to provide:
 - Studies to assess initial baseline and monitoring to document ecological conditions,
 - Demonstration project studies and continuing AEAM,
 - Develop data management and dissemination protocols to support system-level restoration planning and execution,
 - Assess the immediate and long-term effectiveness of restoration actions in meeting program goals in concert with the PET,
 - Provide information and synthesis in a timely manner and useful formats,
 - Provide input to external review groups, and
 - Provide input for AEAM activities.

3.1.2 Science Board (SB)

The Science Board (SB) will be a small group that meets periodically and is knowledgeable of the ongoing activities of the program. The SB would consist of the appropriate number of members depending on scope of particular review: several National Academy of Science-level academics (convened on a contract basis), in addition to a representative of the USACE (Federal lead agency), a representative of the State of Louisiana (Non-Federal lead), and a representative of appropriate additional Federal agencies.

Each member of the SB would have appropriate scientific credentials in an appropriate field of science or engineering and have experience in the science and technology issues surrounding coastal restoration.

The role of the SB is to periodically review the S&T Program, as well as the overall LCA program, as it relates to use of science and technology, and to prepare reports providing recommendations and advice to the Program Manager and Director of the S&T Office. The purpose of these reviews and reports is to provide an independent assessment of the program. The Director of the S&T Office will keep regular communication with the SB between formal review sessions. Additionally, the SB would:

- Review the LCA program to identify gaps in scientific information and AEAM tools and strategies,
- Recommend tools, processes, and methodologies from a review of current research to improve ongoing LCA restoration efforts,

- Work closely with the Director to review recommended changes that are needed in the applied science strategies of the restoration program,
- Possibly recommend establishing new science initiatives, innovative restoration tools, and other challenging research and development issues, and
- Report to Program Manager and the Director of the S&T Office regarding the effectiveness of the S&T Program to meet the science and information needs of the restoration program.
- Provide recommendations to better incorporate the output of the S&T program into the overall LCA Program.
- Provide reviews of how effectively the PMT is incorporating the output of the S&T Program and the recommendations of the SB into the overall LCA Program, and make recommendations to improve use of S&T program results.

3.1.3 Science Coordination Team (SCT)

The SCT would provide the S&T Program with a mechanism for coordinating LCA Plan science initiatives with ongoing and planned science activities being undertaken in state and federal agencies, under CWPPRA or other restoration efforts, and within the broader scientific community. The SCT members would assist with information transfer, planning periodic science symposia, and would advise the Director of new scientific developments and technological advances occurring within other agencies. The SCT would be an inclusive body with members representing federal, state and local governmental agencies with scientific interests, non-governmental organization (NGOs), academic institutions, and private interests. The Director would chair the SCT.

3.1.4 Ad hoc Peer Review Committees

All scientific investigations and project studies would be subject to a peer review by an independent panel of experts. The peer review may include a review of the economic and environmental assumptions and projections, project evaluation data, economic analyses, environmental analyses, engineering analyses, formulation of alternative plans, methods for integrating risk and uncertainty, and models used in evaluation of proposed projects.

3.2 LCA S&T Office Functions

One of the primary functions of the S&T Office would be to continuously identify areas of scientific and engineering uncertainties as discussed in Section 4.0 below, and design and execute studies to reduce those uncertainties. The S&T Office must also maintain regular and frequent communication with those planning, designing and constructing projects (PET) in order to ensure continuity between the needs and objectives of the two groups. A seamless integration of monitoring, modeling, and research activities and personnel is critical to the success of the S&T Plan and will remain a high priority of the S&T Office. Several related functions are discussed below.

3.2.1 Develop Analytical Tools: Hydrodynamic and Ecological Modeling and Assessment

3.2.1.1 What are models and why they are important?

Models are mathematical or conceptual approximations of systems that embody essential processes, functions, and structure of real systems. Conceptual and numerical models are pillars of AEAM for a number of reasons. Models can be used as a template on which knowledge about system processes and functions can be systematically organized, integrated, and updated through the feedback loop provided by AEAM. Used in this way, models become the dynamic archive for knowledge about system response to variability in driving variables, changes in input or outputs, or management actions. This dynamic archive should include all elements of the natural setting, the hydrologic cycle, and its ecological analogues and key processes must be considered over the range of time and spatial scales in which they naturally occur.

Three broad categories of models are commonly used to describe ecosystems: conceptual, physical and mathematical. Conceptual models are a visual or narrative summary that describes the important components of an ecosystem and the interactions among them. They can be used to organize information and develop a framework that qualitatively describes system function and process. Physical models may be used as a means of investigating the qualitative effects of large and small diversions of river water and sediment into the adjacent wetlands. Physical models are also useful in conveying to the public and special interest groups a visual representation of complex processes that will be influenced by management alternatives. Mathematical models use a numerical description of complex processes and interactions. Mathematical models can be used as a surrogate for a system so that management actions can be tested and improved in a virtual context. This testing can include mathematically rigorous uncertainty and error analysis to identify model sensitivity to key variables. This knowledge may be used to refine or reorient monitoring and research activities and to develop risk-based decision-making procedures. Use of models as system surrogates helps avoid ineffective (and expensive) management actions and attendant negative impacts on high value natural resources. They may be used to forecast benefits and impacts of alternative actions as part of cost/benefits analysis and thereby help identify optimal restoration actions. Modeling results may also be used to develop mitigation plans to compensate for unavoidable impacts. They may also be used to develop and explore innovative solutions and approaches to restoration not possible with direct experimentation because of time, funding, or risk. Most important, simulation of long-term system dynamics using models can be used to evaluate the sustainability of management alternatives. This last use of models is particularly important when systems are restored to conditions for which historical reference conditions are unavailable. In this last case, mathematical models provide the only means for evaluating the sustainability of management actions.

Mathematical models useful for LCA restoration can be broadly separated into three categories by scale of application and discipline: natural resource/ecosystem models, engineering models, and socio-economic models. Natural resource and ecosystem models attempt to understand, quantify, and integrate patterns of biotic responses to trends of climatic variability, geological framework and evolution, watershed and groundwater hydrology, physio-chemical properties of soils, hydraulics and hydrodynamics of rivers, estuaries, and the coast,

sediment transport and deposition, salinity, and water quality. Engineering models for LCA restoration focus on those portions of the ecosystem that constrain or would be directly altered by the siting, sizing, construction and operation of diversions designed to prevent wetland loss. Engineering models address water and sediment yield, local subsidence, geologic faulting, depth of water in the receiving area, proximity of the river to the receiving area, exposure of the receiving area to storm surges and waves, infrastructure affected by the diversion, and similar factors. Socioeconomic models link human and economic value to biological and physical processes so that management actions can consider risks to communities and market-based resources and infrastructure. Socioeconomic models would integrate social sciences with physical and ecological sciences to forecast responses of human populations and activities to restoration action. It is important that all three types of models utilize the same modules to simulate processes that are common across two or more modeling categories. Ultimately, all three types of models must be used as an integrated tool to develop and support a biophysical environment that sustains both human and natural communities.

Annual (or more frequent) internal meetings would facilitate communications among modeling teams and publication in the peer review literature would be encouraged. Provisions in the program structure are made for modeling team members to coordinate with modeling teams supporting other large ecosystem restorations and for communication between monitoring and modeling functions.

3.2.1.2 The LCA approach

In addition to the broad approaches listed above, the LCA approach would include the following more specific elements. First, the modeling approach used in LCA would respect the diverse conventions and traditions employed by the different disciplines that typically engage in restoration modeling. That is, modeling approaches would be used that integrate the tools of the different disciplines in a way that maintains the fidelity of the guiding principles of each discipline, particularly the way that the different disciplines incorporate scale in their tools. By so doing, modeling tools developed by the LCA S&T Program would be able to adequately simulate the many different wetland processes that occur over a wide range of scales. Models would be developed by the S&T Program in consultation with the PET to ensure that the models have appropriate input requirements, functional capabilities and output needed by the PET and meet agencies' requirements for assessment of NEPA compliance and Fish and Wildlife Coordination Act. The PET would provide feedback to the S&T Program for refinement and extension of models for continued use to the LCA Program. This process of model development, application, and refinement would be an integral part of the entire S&T Program, and would continue as each model evolves.

3.2.2 Data Acquisition, Scientific Investigations, and Monitoring

Models described above can help guide restoration and management decisions. However, models are only useful if they are driven by high quality data and accurate assumptions about ecological relationships. Monitoring provides the data that models use, and scientific investigation analyzes the accuracy of the assumptions and functions used in the models. Given the high level of scientific uncertainty involved in restoration activities of the magnitude planned

for LCA, both components are critical to accurate modeling. In addition, only through effective data acquisition, monitoring, and focused applied research can the “success” of restoration or need for modification of management actions be elucidated. LCA implementation would affect the entire coast of Louisiana; therefore it is essential that data acquisition and monitoring be conducted on the project-specific, basin and system-wide scales. Monitoring and research designs should be nested to support long-term, large-scale status and trends and short-term question-specific monitoring at the project level. The data would characterize baseline conditions (physical, chemical, biological, socio-economic, etc.) necessary to evaluate changes in trajectories of critical processes and conditions over time. These baseline data are essential to monitor changes as they are affected by LCA projects. Data would be utilized to assess LCA performance measure targets, assess system responses, and improve conceptual and mathematical models and working hypotheses.

3.2.2.1 Lessons learned from data acquisition and monitoring systems in restoration

The United States General Accounting Office (GAO) in 2003 conducted assessments of comprehensive ecosystem restoration programs that included specific recommendations regarding monitoring (GAO-03-345 and GAO-03-999T). In these programs the GAO found that a comprehensive monitoring plan was lacking, prohibiting the ability to comprehensively assess restoration progress. Further, they found significant data gaps and the lack of consistent, reliable information and measurement indicators. Without a comprehensive monitoring plan based on key indicators, the GAO suggests that the ability to understand how an ecosystem responds to restoration actions would be severely limited and that decision-making using an AEAM framework would be greatly hindered.

The CWPPRA Federal/State Task Force for Louisiana initiated a wetlands monitoring program in 1990 to evaluate the effectiveness of individual CWPPRA projects, concentrating on physical and biological variables specific to project goals and objectives. While project-specific monitoring was effective at assessing small-scale projects, it was not comprehensive enough to evaluate cumulative effects on a larger basin or coast-wide scale. The CWPPRA monitoring program has evolved to a more programmatic approach by implementing in 2003 the Coast-wide Reference Monitoring System (CRMS – *Wetlands*), which is a robust system-wide monitoring design to facilitate the evaluation of physical, biological, and landscape variables across larger temporal and spatial scales. CRMS-*Wetlands* focuses on key system indicators that would provide data necessary to conduct comprehensive wetland assessments, refine conceptual models, and support an AEAM program.

3.2.2.2 The LCA approach

Results of data acquisition and monitoring would be used to evaluate the effectiveness of individual projects, to assess LCA’s progress towards meeting program objectives, and to identify opportunities for improving LCA implementation. LCA conceptual models of ecosystem functions have produced working hypotheses of how the system would respond to management actions over space and time. The working hypotheses are based on the current understanding of the causal factors that have led to the deterioration of our coastal landscape. The conceptual models provide the rationale for identifying performance measures, and a

framework for selecting variables to be measured to document status and trends of ecosystem properties.

A proposed system-wide assessment and monitoring plan (SWAMP) would be developed that incorporates existing monitoring efforts (to the extent possible) within a system-wide experimental design. The SWAMP would integrate monitoring of biological, chemical, physical and climatological variables in four modules: wetlands, barrier islands, inshore waters and rivers, and near coastal waters. The variables monitored would include those necessary to assess performance measures and to document the long-term restoration of LCA ecosystems. The first of these modules, wetlands, was designed under the CWPPRA monitoring program (CRMS – *Wetlands*, Steyer et al., 2003). It describes linkages to project-specific and system-wide objectives, reference site issues, statistical design, monitoring variables, sampling design, and implementation criteria. This framework is currently being used as a template for inland waters and rivers and would also be used for the other modules.

In addition, baseline, project specific, and broad-scope research projects would be undertaken to discover and analyze those ecological and biological processes that would likely be affected by LCA project activities. Research projects may address issues relating to community dominance, populations of rare or listed species, component food web, etc. in order to ascertain likely effects of river diversions, sediment additions, nutrient regime changes, etc. on the component biota. These results would be used to refine model assumptions and functions, and the data and ensuing model outputs would help guide management actions.

3.2.3 Data Management, Computing and Information Framework

3.2.3.1 Why is information technology important?

The LCA restoration process would include data collection, development of modeling and assessment tools based on those processes, development of decision support tools for evaluating project alternatives, and publishing data, analyses, and plans for end-users in and out of government. An enormous amount of data would come in different formats from different organizations and must be organized and integrated into forms that are widely accessible and useable. It is critical that scientists, engineers, and managers from a variety of disciplines and organizations be able to operate in a collaborative environment. A well-conceived computing and information framework is key to this success and should be constructed by appropriate scientists and resource managers in conjunction with information technology (IT) personnel.

3.2.3.2 The LCA approach

The computing and information framework needs of such ecosystem management projects have given birth to an entirely new field of science (informatics). Informatics is becoming the enabling technological structure upon which hydrologic, geotechnical, and biological developments are being based. Informatics technology areas (ITAs) are presented below:

- *Integrated Frameworks.* Integrated frameworks provide a common technology structure to deliver information and technology. Establishing commonalities in the technical

architecture of LCA science and technology tools and systems would improve usability and interoperability as well as reduce the total cost of the product. Frameworks should exist for multi-dimensional models, geospatially-driven decision support tools, and for web-delivered products.

- *Data, Data Fusion, Aggregation, Management, and Mining.* This ITA focuses on a common set of methodologies that locate, collect, manipulate, describe, and use data in support of LCA business processes. The effective use of data requires establishing a formal database structure, data models, and the consolidation of disparate information sources for the purpose of discovering useful information and ultimately for driving higher-level informatics tools.
- *Modeling and Assessment.* The ability to develop and apply modeling and assessment (M&A) tools is critical to the success of LCA. Models and assessment tools would be used to simulate various physical, chemical, and biological processes, in multiple time and space scales, on numerous computing platforms. It is important to understand from the beginning how computational S&T would be conducted and on what computational infrastructure (networks, computers, mass storage devices, etc.). Much time and funding can be saved through improved coordination of model development activities within and across application areas.
- *GIS/CADD.* The pervasiveness of spatial data throughout the S&T community motivates the need to collectively address GIS/CADD. Standards (e.g., data models) emplaced within the GIS/CADD area allow S&T tools to share and reuse GIS/CADD data and the supporting functionality to visualize, manipulate, analyze, and display geospatial information. The ability to expand modeling and decision support into 2- and 3-dimensional space/time, as provided by geospatial technologies, will tremendously enhance the products available to LCA. Common data standards must be agreed upon, and used to achieve technical and financial rewards.
- *Decision Support.* Decision support is viewed as the set of capabilities that synthesize and present information that directly aids the decision process. These capabilities complement the GIS/CADD and M&A ITAs by infusing their results into the decision process. In many cases, decision makers cannot directly use GIS/CADD and M&A-derived information. In such cases, screening tools, low-fidelity models, data converters, analytical methods, and visualization techniques translate the information to feed a collaborative decision process. The technology required to provide decision support to decision makers should be minimized to decrease the training burden on the user base. Ideally, decision-support capabilities would be distributed via the Internet Web, thereby requiring no more than a simple Web browser to access the decision-support capabilities.
- *Data Centers.* Data in LCA would exist in three general forms: (1) geospatial, (2) scientific, and (3) multi-media. The underlying technology used to store, manage, and share this information is critical to the success of LCA and thus, an early goal for the LCA S&T Program would be the establishment of one or multiple LCA Data Centers.

The Data Centers' function is to be repositories of geospatial, scientific, and multimedia information housed to aid LCA. It may be most practical to have multiple Data Centers, perhaps responsible for different data types, as long as a central authority makes sure that all of the Centers interoperate efficiently.

All of the models, tools, and Websites should be provided in a secure environment that allows access to appropriate parties but is consistent with computer security requirements of the stakeholders. Security would be important in every computing and information framework activity, and as a result, would require detailed implementation plans. These plans would require discussion and agreement between the cost-sharing partners and appropriate stakeholders.

Given the number of organizations and disciplines involved in LCA, it would be useful to have a computing and information framework group to ensure that the products developed provide the necessary functionality to accomplish the purposes of LCA. The group should meet periodically to exchange information and discuss necessary adjustments that could occur, given the rapid pace of technology change in this field.

3.2.4 Decision Support

3.2.4.1 Why decision support is important?

Decision support describes the framework and process used to integrate analysis with decision-making, and represents the primary purpose of the S&T Program. The Program seeks to help decision makers to make the best possible decisions about the design and implementation of LCA Plan projects in the face of uncertainty, and to reduce uncertainty over time in order to improve future project planning and decision-making. The challenge for the S&T Program is to develop a decision support framework that incorporates scientific approaches directly into the LCA Plan planning and implementation process. By definition, science is the process of continuing inquiry. Decisions to pursue some actions must be made, but there is a need to continually apply science as a process in order to minimize the likelihood of future errors. Indeed, we act in part in order to learn, and this learning helps to improve our models of the system so that future actions are better able to define and achieve desired goals. Learning while doing is what it means to take a science-based approach to the LCA Plan.

In recognition of pervasive uncertainties, the S&T Program incorporates AEAM as its central organizing theme and operational process. AEAM is more than a description of how we would learn about the natural ecosystem and its links to ecological and socioeconomic outcomes; it can also help guide how projects in the LCA Plan would be formulated, selected and implemented in a sequence over time. Presumably, what we learn from successive rounds of project planning and implementation could cause us to rethink the operation of already implemented projects and the design of future projects, as well as to adjust the S&T Program and supporting analytical models to better inform future decision-making. This has been proven in CWPPRA, Everglades restoration and other programs.

3.2.4.2 Systems-scale synthesis model for decision support

LCA projects are expected to work synergistically to serve program goals and meet program constraints. This means that the ideal LCA Plan would be a system of projects built incrementally and then operated in consideration of other projects in place and being planned at the same time. The decision support framework should organize the suite of LCA analytical efforts in a way that supports this systems nature of LCA. This can best be accomplished through the development of a “systems synthesis model” that provides the means to systematically consolidate and connect ecosystem modeling with evaluations of ecological and socioeconomic outcomes of interest to decision makers. Such a systems synthesis model would be used to rapidly simulate the multiple outcomes of various combinations of projects/alternatives while identifying the logic and assumptions underlying these predictions and their role in decision-making.

The purpose of the systems synthesis model is to help decision makers to expedite the evaluation of tradeoffs to support decision-making on incremental investments. A well-constructed systems synthesis model will aid in the identification of uncertainties. In the LCA Plan, where decision-making is expected to be an open process, the desired contribution of the systems synthesis model to decision support requires that the assumptions, computational techniques, logic and uncertainties underlying model results are transparent to all. The USACE Institute for Water Resources has promoted this approach as part of its “shared vision planning” model. That model or some other “computer aided decision support system” would be adapted for decision support in the LCA context. The usefulness of augmenting the system synthesis model with “multi criteria decision analysis” techniques could help decision makers and stakeholders to explore tradeoffs, reveal priorities, and highlight areas of agreement and disagreement in order to facilitate deliberation and decision-making.

An important role of the systems synthesis model is to help identify and prioritize key uncertainties in order to inform the design of demonstration projects and experiments that can help reduce uncertainties over time. The ultimate use of the knowledge gained is to improve the predictive accuracy of the model for use in future rounds of decision-making. This means that the systems synthesis model must have a clear process and capability to use what is learned in order to make model improvements over time so that subsequent rounds of decision-makers are better informed. For example, while the systems synthesis model must be empirical, best professional judgment or literature values could be employed where there are significant uncertainties in data or in relationships among variables in the model. The representation of such judgments in a “Bayesian” (prior knowledge and accumulated experience) framework could allow the model to be solved, the propagation of uncertainty into the model prediction to be represented, and critical uncertainties to be identified as a way to target the AEAM studies for model improvement for the next round of decision support. The Bayesian approach as well as other methods for conducting sensitivity analysis on parameters and data characterized by high levels of uncertainty would be investigated.

3.2.4.3 Environmental and socioeconomic evaluations

Formulating and evaluating incremental actions for the LCA Plan, and then informing the decision on the best mix of such actions in any planning round, is the challenge that can be addressed by a system-level evaluation process. At the heart of system-wide evaluations are spatially-robust predictions of hydrodynamics, landscape evolution, and water quality. Predictions of these basic “ecosystem effects” in turn inform predictions of multiple ecological and socioeconomic outcomes of concern to decision makers.

Metrics for these multiple ecological and socioeconomic outcomes, linked to predictions of ecosystem effects, are necessary if the modeling efforts are going to inform the deliberations of decision makers. Ecological outcomes, represented in non-monetary metrics, most closely reflect the specific outcomes of concern to decision makers and can be linked to predicted ecosystem effects with an acceptable level of certainty. For example, the LCA Plan may have a primary interest in securing certain species numbers and composition at a certain location. To the extent that predictive uncertainties can be adequately represented, predictions of species populations would be pursued. If, however, critical uncertainties in predictions of the state of the species cannot be identified and represented for decision makers, then the evaluations might alternatively rely on predictions of habitat suitability for the species that could be made with greater level of certainty.

In the case of socioeconomic outcomes, some may be represented quantitatively with monetary metrics while others are qualitative. The LCA Plan could affect a wide variety of traditional “national economic development” (NED) outcomes such as navigation and flood control, as well as NED effects relating to industry and commercial and recreational fisheries. In addition, some RED outcomes could be affected by the LCA Plan, including alterations in the way people live, work, recreate, relate to one another, and cope as members of society. In addition, cultural impacts, such as changes to the individual and societal norms, values, and beliefs, are not incorporated into a NED analysis.

Socioeconomic assessment would also pursue the evaluation of regional economic development (RED) effects representing local and regional economic outcomes. To capture some of the socioeconomic outcomes, the socioeconomic evaluation would estimate the aggregate net NED effects of restoration actions associated with quantifiable socioeconomic outcomes, including implementation costs. RED assessments would focus on estimation of both monetary effects (e.g., income) as well as non-monetary effects (community structure). Finally, various methods and non-monetary metrics, such as the Social Impact Assessment (SIA), would be developed to assess the aforementioned qualitative social and cultural effects.

3.2.5 Peer Review

3.2.5.1 Why peer review is important?

The more complex restoration activities become, the more uncertainty is associated with their outcomes due to limitations in understanding, data availability or analytical procedures. Peer review of science and technology products, and program operations, can improve the

technical quality and scope of the products and procedures as well as adding credibility to the conclusions and recommendations presented (NRC, 2002). In the case of coastal Louisiana, incorporating peer review as a routine part of S&T Program operations is essential for a number of reasons:

- The complexity of the ecosystem problems and the multiple possible solutions means that the solutions are not always obvious. Peer review can assist in verifying that approaches are broad in scope and that a considered process has been used to identify restoration actions.
- Peer review can provide assurance that the studies informing restoration decisions are reflecting the continual evolution of procedures in science and technology, and that methodologies are both current and appropriate.
- An independent verification of the quality of S&T Program products provides ongoing credibility to the restoration program as a whole, and provides valuable resource information for periodic reviews at the program level.
- Peer review is a widely recognized mechanism for quality assurance in technical studies and its use within the LCA program throughout the planning and implementation process would contribute to a wider understanding of how the technical opportunities and challenges implicit in such an ambitious program are being handled.

3.2.5.2 Lessons learned on using peer review in ecosystem restoration

There have been several recent evaluations of the use of peer review in science and environmental planning (e.g., Kostoff, 1997; NRC, 1998). Most recently and most directly relevant to LCA planning are the National Research Council report on 'Review Procedures for Water Resources Project Planning' (NRC, 2002) and the draft report of the Chief of Engineers Environmental Advisory Board (EAB) on Independent Scientific Review, both of which examined existing procedures and experiences in ecosystem restoration programs. Some key points from the documents are summarized here.

The EAB assessment of the peer review processes notes that a guiding process for peer review that is accepted by all participants is essential. This process needs to ensure that the subject matter of the review should be clearly identified and should provide for sufficient time, funding, and background information for the process to succeed. The process should also have iterative feedback loops that permit communication between the reviewers and the originators of the items under review. While disagreement may remain between reviewers and authors of the reviewed items, the process must be accepted as a fair approach to revealing legitimate differences in professional opinion. Considering the importance of objectivity and timeliness, the EAB also suggests an external body to convene a review panel. The review panel should be from an independent or neutral organization and should be formed by interviewing the prospective panelists to determine their interest, availability, and qualifications to gauge the objectivity.

In its report, the NRC noted that the role of review panels is not to present a final judgment on whether a project should be implemented (NRC (2002)). NRC suggests that an independent body oversee reviews, and that reviewers should be neither selected by nor

employed by the PET. Importantly, supporting this observation the report also recommends that the decision regarding the degree of a reviewer's independence should be open to review by all interested parties.

Both NRC and EAB note that peer review can be most effective in complex issues when incorporated early in the process, and that accountability is best assured by requiring written responses to the reviewer's observations and comments. For the above reasons, the S&T Office would manage certain aspects of the review of LCA execution.

A National Technical Review Committee (NTRC) was convened during development of the LCA Study to provide in-progress scientific and technical reviews of work products and recommendations. The 10-member NTRC comprised of nationally recognized experts in diverse fields proved very valuable in improving the LCA Study products. It is expected that this successful model of an ad-hoc peer review will be improved by incorporating the recommendations of the NRC and the EAB, and that ad-hoc peer review will continue to provide helpful insights to improve program and project efficiency.

3.2.5.3 The LCA approach to peer review

It would be the responsibility of the Science and Technology Director, working with the Science Board, to develop clear procedures for peer review for products of the S&T Program and the Project Execution Teams that may be adopted by the LCA Program Manager as a Policy to guide peer review throughout the LCA effort. It is expected that these procedures would provide for different approaches to peer review being used for different types of products (NRC 2002). Note that risk and magnitude criteria can be helpful in determining the level of peer review appropriate for different products and efforts (Figure 4-2, page 45 in NRC, 2002). It is also expected that the LCA peer review policy would consist of three levels, which follow:

- Review of specific work products or reports. This part of the Policy would detail procedures for review of different types of products and identify procedures for review initiation, review process, reviewer selection, review feedback and tracking, and transmittal of review findings to decision makers. The process would be designed to be responsive to program needs and objectives. The process would likely incorporate a combination of ad hoc review boards (e.g., by program function), reviews by selected individuals, and specially constituted review panels. Individuals with on-the-ground experience may serve as useful resources to reviewers, as appropriate, while maintaining independence of the review process.
- Review at the Program level. It is anticipated that the LCA Program Manager would initiate periodic reviews of the S&T Program, as well as other major Program elements. For instance, the NRC may be asked to review aspects of the S&T Program once the Program has developed sufficiently for a record of activities and products to be established. The Policy would identify principles to be followed during these periodic reviews and provide guidance to management regarding the frequency and direction of such reviews.

- Peer review on all future scopes of work that the S&T Program has developed will also be included. The LCA Program Manager would coincide with the peer reviews and address major Program elements. The future scopes of work would help identify any future, potential problems not foreseen within the LCA PET.