

**APPENDIX C  
CONTENT OF ENGINEERING APPENDIX  
TO FEASIBILITY REPORT**

**C-1. General**

The engineering appendix to the feasibility report shall include applicable items in the following paragraphs and any additional information required for the specific project concerned. Comparative studies, field investigations, design, and screening level cost estimates shall be in sufficient detail to substantiate the recommended plan and the baseline estimate. The level of design shall be consistent with engineering plan presented in the Management Plan. Prior to generating any geospatial data, a check of the National Geospatial Data Clearinghouse shall be made to determine if data required by the project already exists. Geospatial data created in-house or by contract needs to be documented using the Federal Geospatial Metadata Standards and post on the Internet as outlined in EM 1110-1-2909.

**C-2. Hydrology and Hydraulics**

C-2.1. Present the basis and results of hydrologic and hydraulic studies required for determining the functional design requirements of all water resource projects. Explain the methods used, why the methods were selected, and the basic assumptions on which these studies are based. Provide basic data as appropriate and discuss the limitations of the collected data. Present results and conclusions and explain how they apply to design and real estate requirements. In the event only a minimum design documentation report (DDR) is to be prepared, the hydrologic and hydraulic information in the engineering appendix to the feasibility report shall be sufficiently detailed to support the development of project real estate requirements and preparation of P&S. As appropriate for the specific type of project under development and to the extent necessary to support plan formulation and the project cost estimate, hydrologic studies shall include:

C-2.1.1. Consequences of flows exceeding discharge capacity of the project.

C-2.1.2. Project-induced changes obligating mitigation.

C-2.1.3. Discharge-frequency relationships.

C-2.1.4. 0.2% chance of exceedance flood or SPF (0.5 probable maximum flood).

C-2.1.5. Stage-discharge relationships.

C-2.1.6. Flow duration.

C-2.1.7. Flood inundation boundaries and flood stage hydrographs.

C-2.1.8. Reservoir yields.

C-2.1.9. Risk and uncertainty analysis for sizing of the project under study.

C-2.1.10. Water quality conditions.

C-2.1.11. Groundwater conditions.

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C-2.1.12. Preliminary project regulation plan.

C-2.1.13. Preliminary Real Estate taking line elevations.

C-2.1.14. Criteria for facility/utility relocations.

C-2.1.15. Criteria for identification of flowage easements required for project function.

C-2.1.16. Criteria in support of project OMRR&R requirements.

C-2.1.17. Environmental engineering considerations incorporated into the design and regulation plan.

C-2.2. In a separately identified section, present information about residual flooding; i.e., flooding from any source which will occur as a result of project capacity exceedance. This information shall identify, as a minimum, the following:

C-2.2.1. Warning time of impending inundation.

C-2.2.2. Rate of rise, duration, depth, and velocity of inundation.

C-2.2.3. Delineation on the best available mapping base the extent of inundation for the 1% and 0.2% chance of exceedance floods for the project being designed. When appropriate include analyses of historic floods.

C-2.2.4. Access and egress problems created by flooding.

C-2.2.5. Potential for loss of life as a result of C-2.2.1 through C-2.2.3.

C-2.2.6. Identification of any potential loss of public services.

C-2.2.7. Potential physical damages.

C-2.3. In a separately identified section, present information about flooding which will be induced by the project, if any; i.e., flooding caused by project construction or operation as determined by comparing without-project to with-project conditions. This information shall identify, as a minimum, the following:

C-2.3.1. Information categories required by C-2.2 above.

C-2.3.2. Anticipated frequency of induced flooding.

C-2.4. Based on the design flood, also provide inundation risks during project life for an array of chance of exceedance floods up to the 0.2% chance flood.

C-2.5. Hydraulic studies shall include the following:

C-2.5.1. Hydraulic roughness determinations.

C-2.5.2. Water surface profiles.

- C-2.5.3. Stage-discharge relationships.
- C-2.5.4. Head loss.
- C-2.5.5. Flow and velocity.
- C-2.5.6. Structural sizing needed to meet design capacities including riprap or other slope protection.
- C-2.5.7. Water control facilities.
- C-2.5.8. Energy dissipating facility features.
- C-2.5.9. Erosion control requirements.
- C-2.5.10. Existing and post-project sedimentation.
- C-2.5.11. Water control and order of work during construction.
- C-2.5.12. Criteria for facility/utility relocations.
- C-2.5.13. Other special facilities needed to meet project operation, water quality and environmental requirements.
- C-2.5.14. Instrumentation and monitoring.

#### C-2.6. *Coastal studies.*

C-2.6.1. ER 1110-2-1407 prescribes the design procedures and rationale for the hydraulic design of coastal shore protection projects. In most cases, the design of these projects shall be carried out to the extent that they are adequate to serve as the basis for P&S with minimal associated post-authorization studies.

C-2.6.2. Coastal navigation projects at the entrance to the mouth of any river or at any inlet must be assessed with respect to their effects on the adjacent shores. Particular reference shall be made to erosion and/or accretion for a distance of not less than 10 miles on either side of the entrance. Most of the studies, pertaining to coastal processes, are required by ER 1110-2-1407 and shall be used to assess the adjacent shore characteristics before and after the entrance modifications.

C-2.7. *Navigation projects.* ER 1110-2-1404 prescribes the design procedures and rationale for the hydraulic design of navigation projects.

### **C-3. Surveying, Mapping, and Other Geospatial Data Requirements**

C-3.1. Develop sufficient surveying, mapping, and other geospatial data information to support preparation of the feasibility report and the Real Estate Appendix thereto. The initial work shall include a check of the National Geospatial Data Clearinghouse to determine if any data required for the project is already available. A brief outline of additional surveying and mapping required for design, plans and specifications, construction, and operations shall also be developed. In the event only a minimum design documentation report (DDR) is to be prepared, the surveying and mapping information in the engineering appendix to the feasibility report shall be sufficiently detailed to support the development of project real estate requirements and preparation of P&S.

C-3.2. When new mapping or other geospatial data are required obtaining the products in a timely manner is often a problem. New mapping is generally derived from aerial photography, which in snowbelt and forested areas of the country can only be accomplished during two short time periods in the year. Advanced planning is required to insure that funding is available to obtain the services when required; otherwise a delay in obtaining the data of a year or more could occur.

#### **C-4. Geotechnical**

C-4.1. Develop, describe, and present sufficient geotechnical information to verify the project plan, site selection, foundation design, selection of all structures, and cost estimates. In the event only a minimum design documentation report (DDR) is to be prepared, the geotechnical information in the engineering appendix to the feasibility report shall be sufficiently detailed to support the development of project real estate requirements and preparation of P&S. This information shall include studies, methods, reasons for selection, and conclusions and recommendations as follows:

C-4.1.1. Regional and site geology.

C-4.1.2. Completed exploration, which shall include the number, size, and type of exploratory borings; the number of pressure tests and pumping tests; and the number, size, and type of exploratory excavations and the type of equipment used. Describe results of exploration and tests.

C-4.1.3. Selection of preliminary design parameters.

C-4.1.4. Geophysical investigations.

C-4.1.5. Groundwater studies, which shall include present conditions, anticipated changes, and the effects of those changes.

C-4.1.6. Recommended instrumentation.

C-4.1.7. Earthquake studies which shall include regional and site earthquake history, fault studies, recommended preliminary design seismic motions or coefficients. Initial selection of defensive design measures shall be presented.

C-4.1.8. Preliminary foundation design and slope stability analysis.

C-4.1.9. Excavatability analysis with possible blasting constraints and controls.

C-4.1.10. Anticipated construction techniques, limitations, and problems.

C-4.1.11. Potential borrow sites and disposal sites.

C-4.1.12. Potential sources of concrete materials and results of materials investigations.

C-4.1.13. Describe potential sources and indicate suitability of concrete materials and plant, earth and rock borrow material, and stone slope protection.

C-4.2. For projects where soils strongly influence the design and selection of structures and project features perform sufficient physical property testing and discuss selected design values. Conduct probabilistic analyses when appropriate. Where leakage or seepage through, under, or around water retention structures is indicated, adequate pumping or pressure tests shall be conducted and their results presented. Preliminary performance thresholds (seepage quantities, uplift, internal phreatic levels, and movement) shall be described. For coastal projects where structural changes could have regional impacts, geomorphologic studies shall be performed to identify the cause and effect of long-term historic changes and the processes, past and present, which caused those changes. Drawings shall include, but not be limited to, a plan of exploration, bedrock and groundwater contour maps, geologic sections (with interpretations), exploration records (logs of borings, exploratory excavation maps, etc.), and plans and sections of foundation design (founding elevations, excavation limits, reinforcement, and treatment).

C-4.3. A summary of any additional exploration, testing, and analysis required for preparation of the DDR and P&S shall be provided.

C-4.4. A summary of the laboratory-testing program completed and a description of the evaluations made in the selection of the design parameters shall be included in the appendix.

## **C-5. Environmental Engineering**

The following environmental engineering factors shall be incorporated into each aspect of the project.

C-5.1. Use of environmentally renewable materials.

C-5.2. Design of positive environmental attributes into the project.

C-5.3. Inclusion of environmentally beneficial operations and management for the project.

C-5.4. Beneficial uses of spoil or other project refuse during construction and operation.

C-5.5. Energy savings features of the design.

C-5.6. Maintenance of the ecological continuity in the project with the surrounding area and within the region.

C-5.7. Consideration of indirect environmental costs and benefits.

C-5.8. Integration of environmental sensitivity into all aspects of the project.

C-5.9. The perusal of the Environmental Review Guide for Operations (ERGO) with respect to environmental problems that have become evident at similar existing projects and, through foresight during this design stage, have been mitigated/addressed in the project design.

C-5.10. Incorporation of environmental compliance measures into the project design.

## **C-6. Civil Design**

C-6.1. *Site selection and project development.* Discuss the selection of the project site and evaluation of alternative layouts, alignments, components, aesthetics, relocation of facilities, etc., and describe components and features, including the improvements required on lands to enable the proper disposal of dredged or excavated material. In the event only a minimum design documentation report (DDR) is to be prepared, the site selection information in the engineering appendix to the feasibility report shall be sufficiently detailed to support the development of project real estate requirements and preparation of P&S.

C-6.2. *Real Estate.* Develop and describe the engineering requirements relating to the determination of what lands, easements, right-of-ways, and borrow and disposal sites are necessary for the construction, operation, and maintenance of the project. Prepare preliminary design drawings depicting such engineering requirements for use by Engineering and Real Estate in jointly determining the project land requirements.

C-6.3. *Relocations.* Describe the facility/utility relocations required as a result of the project. Discuss the methods proposed for accomplishing the relocations and the land requirements related thereto.

## **C-7. Structural Requirements.**

The following structural data shall be presented in the engineering appendix. In the event only a minimum design documentation report (DDR) is to be prepared, the structural information in the engineering appendix to the feasibility report shall be sufficiently detailed to support the development of project real estate requirements and preparation of P&S.

C-7.1. Identify all functional design requirements and technical design criteria for the structural elements of the project. Include references, loads, load combinations, load factors, safety factors, and assumed or calculated uplift pressures.

C-7.2. Identify appropriate survey, hydrologic, hydraulic, and geotechnical data used as the basis for structural design. Also identify key design data obtained through coordination with other disciplines (e.g., machinery loads).

C-7.3. Provide the structural basis for site selection studies. Include descriptions of any structural measures to maintain or enhance environmental quality.

C-7.4. Provide the technical basis for selection of type and configuration of main and major appurtenant structures for all of the alternatives studied.

C-7.5. Describe evaluation and selection of substructure alternatives based on economy and performance.

C-7.6. Describe site restrictions, probable construction techniques and sequence, and plans for dewatering and care of water. Indicate how these considerations affected evaluation of the alternatives.

C-7.7. Provide results of stability analyses to show application of stability criteria, methods of analysis, and assumptions for each type of structural monolith. The analysis summary for all monoliths should be sufficient to reduce cost contingencies to an acceptable level.

C-7.8. Provide results of initial stress analysis to show application of strength criteria, methods of analysis, assumptions, and key dimensions of components of each major structural system. The analysis summary for all structural elements should be sufficient to reduce cost contingencies to an acceptable level.

C-7.9. Provide results of initial seismic analysis to show application of seismic criteria, methods of analysis, assumptions, and key dimensions of components of each major structural system required to meet seismic requirements. The seismic analysis summary for structural systems should be sufficient to determine if seismic loading controls the design of the structures and should be sufficient to reduce cost contingencies to an acceptable level.

C-7.10. Summarize results of initial thermal stress analyses of massive concrete monoliths.

C-7.11. Describe results of any other analyses, laboratory tests, or field tests, which were necessary to evaluate unprecedented site conditions, operating environment, materials, or load level.

C-7.12. Identify plans for further studies, tests, and analyses after the feasibility phase. This shall include identification of any significant unresolved design issues, an evaluation of how these issues affect current cost contingencies, and how they may impact design costs and schedule.

#### **C-8. Electrical and Mechanical Requirements.**

Identify all functional design requirements and technical design criteria for the electrical and mechanical systems and equipment of the project. Provide the technical basis for selection of type and configuration of electrical and mechanical equipment. A letter from the Federal Power Agency indicating marketability of any hydroelectric power to be produced by the project shall be included in the feasibility report. This section of the appendix shall include appropriate technical information supporting the estimates of hydropower production for the proposed plan. In the event only a minimum design documentation report (DDR) is to be prepared, the electrical and mechanical information in the engineering appendix to the feasibility report shall be sufficiently detailed to support the development of project real estate requirements and preparation of P&S.

#### **C-9. Hazardous and Toxic Materials.**

When, based on previous land usage, the potential for the presence of hazardous and toxic materials exists, perform and report upon sufficient investigations and testing to identify the nature and extent of such materials. Include the estimated cost for remediation design and/or treatment and/or removal/disposal of these materials in the baseline cost estimate. In the event only a minimum design documentation report (DDR) is to be prepared, the hazardous and toxic waste information in the engineering appendix to the feasibility report shall be sufficiently detailed to support the development of project real estate requirements and preparation of P&S.

#### **C-10. Construction Procedures and Water Control Plan**

Briefly describe the construction procedure and water control plan for each construction stage of the proposed plan. Sufficient hydraulic and hydrologic data, hydrographic and topographic information, structural information, geologic and soils information, and environmental information shall be included to support the general features of the water control plan. The plan should also discuss erosion and sedimentation control.

#### **C-11. Initial Reservoir Filling and Surveillance Plan**

For projects involving dams and reservoirs, briefly describe the initial reservoir-filling plan. Include information on the preferred filling rate, the available options to control it, the consequences of sole purpose operation to control the rate, water quality requirements for the initial filling, and the most probable types of problems that might develop during initial filling. Describe the proposed hydrologic data collection and transmission system and the plans for reading and evaluating instrument data and making visual inspections of the dam and downstream areas, both related to increments of pool level. Also describe the organization that will be responsible for decisions and implementation of emergency plans in the event of need. Outline guidelines on conditions requiring notification of personnel in that organization and implementation of emergency plans.

#### **C-12. Flood Emergency Plans for Areas Downstream of Corps Dams**

Flood emergency plans will be developed for areas downstream of a Corps dam that would be affected by sudden failure of the dam. Plans shall include development of a flood warning system, inundation maps, notification procedures, etc. The organizations that will be responsible for decisions and implementation shall be described. The plans shall be closely coordinated with the appropriate Federal, State and local agencies. Reference ER 1130-2-530.

#### **C-13. Environmental Objective and Requirements.**

Develop sufficient environmental information to support preparation of the feasibility report and the Real Estate Appendix thereto. A brief outline of additional environmental objectives and requirements for design, plans and specifications, construction, and operations shall also be developed. In the event only a minimum design documentation report (DDR) is to be prepared, the environmental information in the engineering appendix to the feasibility report shall be sufficiently detailed to support the development of project real estate requirements and preparation of P&S.

#### **C-14. Reservoir Clearing**

Include a brief description of clearing limits, acreage and costs involved, and a discussion of proposed methods of disposal of cleared material.

#### **C-15. Operation and Maintenance**

Describe the plan proposed for operation, maintenance, repair, replacement, and rehabilitation of all features (Federal and non-Federal) of the project, including detailed estimates of the Federal and non-Federal costs and a chart of the proposed Federal and non-Federal organizations.



C-15.1. For projects to be maintained and operated according to regulations prescribed by 33 CFR Part 208, Paragraph 208.10, describes the necessary operation and maintenance requirements to be included in the O&M manual furnished to local interests.

C-15.2. For projects involving channel and/or debris basin clean out, include the anticipated frequency and equipment requirements.

C-15.3. For complex projects, such as multiple-purpose projects with power production, an analysis will be included covering the staffing recommended for each project function, such as power, navigation, flood control, reservoir operation, etc. Such analysis will include a comprehensive description of the operational requirements the marketing agency foresees for the power facilities, the number of transmission lines terminated in the project switchyard and such other data and operating criteria as may affect project staffing. The proposed location and size of facilities (space) for the use of administrative, supervisory and maintenance personnel will be included and justified in the staffing analysis. Provision of separate structures for administrative, supervisory and maintenance or other purposes for the primary functions of the project will be based on sound economic justifications.

C-15.4. For navigation channels, the estimated effect of required overdepth on the frequency and cost of maintenance dredging will be discussed.

#### **C-16. Access Roads**

Describe the proposed permanent access roads and those for use during construction of the project. Describe suitability of temporary access roads for permanent use upon completion of construction. The authority to utilize, improve, reconstruct, and maintain existing public roads for access to the project during construction contained in Section 207(a), P.L. 86-645 as amended by Section 208 of P.L. 87-874, shall be considered when this is more economical than provision of a new access road. If studies indicate that use and improvement of an existing public road for access meet the requirements of the cited legislation, the basic cost comparisons and criteria, including views of local interests exercising jurisdiction over the road, shall be included in the engineering appendix or in a DDR. The cost estimate shall show separately the cost of improving the public road, the cost of constructing the remaining portion of road and the total cost. These data are necessary for a determination pursuant to the above-cited law.

#### **C-17. Corrosion Mitigation**

When the water analysis and soil determinations indicate that corrosion mitigation may not be required, the survey data, conclusions and recommendations can be presented as a section of the appendix. If it appears that extensive corrosion mitigation will be required, a DDR shall be submitted to present complete information covering the results of surveys and tests to determine the corrosion characteristics of the water and soil at the site, the conclusions reached, and the proposed solution. The water analysis shall be complete, including resistivity, and "pH" at the site.

#### **C-18. Project Security**

The designer is directed to use the security engineering manuals, Army TM 5-853-1, -2, -3, and -4, dated May 1994, produced by the Protective Design Mandatory Center of Expertise at the Omaha District as a guide in developing physical security plans. Questions on these manuals or on physical security of civil works projects may be directed to Protective Design Center, Omaha District.

### **C-19. Cost Estimates**

The development of an accurate baseline cost estimate that represents the scope and schedule established in the feasibility report is essential. The baseline cost estimate documentation submitted must be in the MCACES format and include the summary sheets for direct costs, indirect costs, and owner costs to the subfeature level for all features and a total project cost summary that addresses escalation through project completion. It must contain a narrative that discusses cost relationships and assumptions made based on the level of design, quantity issues and unknowns. The narrative shall also identify the risks or uncertainties used in the development of contingencies. One floppy disk, containing the complete estimate and associated database, will be provided for review by CECW-AR.

### **C-20. Schedule for Design and Construction**

In coordination with the Construction Division, provide the estimated time required for construction of the project and its principal components. Provide a schedule to show the sequence of proposed land acquisition, design and construction operations, and the funds required by fiscal year.

### **C-21. Special Studies**

Identify engineering requirements, budget requirements, and schedule for special studies, such as hydraulic model studies, project site specific seismic studies, and concrete thermal studies, required during PED. Provide a discussion of features required to ensure that the project is in compliance with various environmental regulations and/or mitigation commitments.

### **C-22. Plates, Figures, and Drawings**

Plates, figures and illustrations that use color in originals to differentiate project features must also include colored copies in documents forwarded for review. Otherwise, project features shall be identified by the use of varied shading, bars, crosshatch, etc., in order to differentiate specific items in monochromatic copies. When photographs are used to illustrate project features, they shall be clear and provide interpretive value.

### **C-23. Data Management.**

During the feasibility study, an engineering data management system for the project shall be established to insure that all information developed for the project is cataloged and stored for use during the future phases of the project.

### **C-24. Use of Metric System Measurements.**

To be consistent with public law and executive orders, it is important that the use and integration of the metric system be included in Civil Works plan formulation and design process, construction work, and project operations to the maximum extent practicable. In considering the use of metric measurements the non-Federal sponsor's needs and concerns must be taken into account. The Engineering Appendix to the Feasibility Study shall document the discussions and decision concerning the use of metric measurements.