CHAPTER 3

HYDROLOGIC STUDY STRATEGY

3-1. General. This chapter describes a general strategy for performing the hydrologic analysis associated with planning and design investigations of interior areas. Study strategy is defined as the study procedures, assumptions, and related activities commensurate with the study process described in Chapter 2. Hydrologic study procedures are presented within this framework for feasibility and design (GDM and FDM) investigations.

3-2. Minimum Facility Concepts.

a. The hydrologic study strategy is formulated on the premise that interior facilities (that will be a component of the recommended plan) will be planned and evaluated separately (incrementally) from the line-of-protection project. The major project feature (levee/floodwall) is conceptually divided from the planned interior facilities by initially evaluating a "minimum" interior facility considered integral to the line-of-protection. If a levee/floodwall is in existence, the "minimum" interior facility is that presently in place, and no special efforts are required to establish the separation. If a levee is being proposed (planned), the "minimum" facility must be formulated and the evaluation of the line-of-protection benefits performed with the facility in place. The residual interior flooding problem is the target of the interior facility planning efforts, and benefits attributable to the increased interior facilities will be the reduction in the residual damage. See Section 6-4 for a more complete discussion of the conceptual separation and determination of damage reduction benefits attributable to the levee, floodwall and additional interior facilities.

b. The "minimum" facilities are intended to be the starting point from which additional interior facilities planning will commence. The suggested criteria for determining the "minimum" facility presented is intended to yield facilities that can be quickly and easily determined. The facilities will, except in rare cases, be found inadequate upon further interior facility planning; thus increased facilities will be formulated, evaluated, and included as a component of the recommended line-of-protection plan that is an incrementally justified component of the overall flood control project. It is expected that the interior facilities included in the final plan will provide interior area flood relief for residual flooding.

c. The minimum facility should provide interior flood relief such that during low exterior stages (gravity conditions) the local storm drainage system functions essentially as it did without a levee in place for floods up to that of the storm sewer design. If a local storm drainage system is in existence, then the minimum facility should pass the local system design event with essentially no increase in interior flooding. If no local system presently exists, but future plans include a storm drainage system, it is reasonable to proceed as if it exists and its design capacity is consistent with local design practices.

d. Minimum interior facilities will most often consist of natural detention storage and gravity outlets sized to meet the local drainage system. However, they may include other features, such as, collector drains, excavated detention storage, and pumping plants if they are more cost effective.

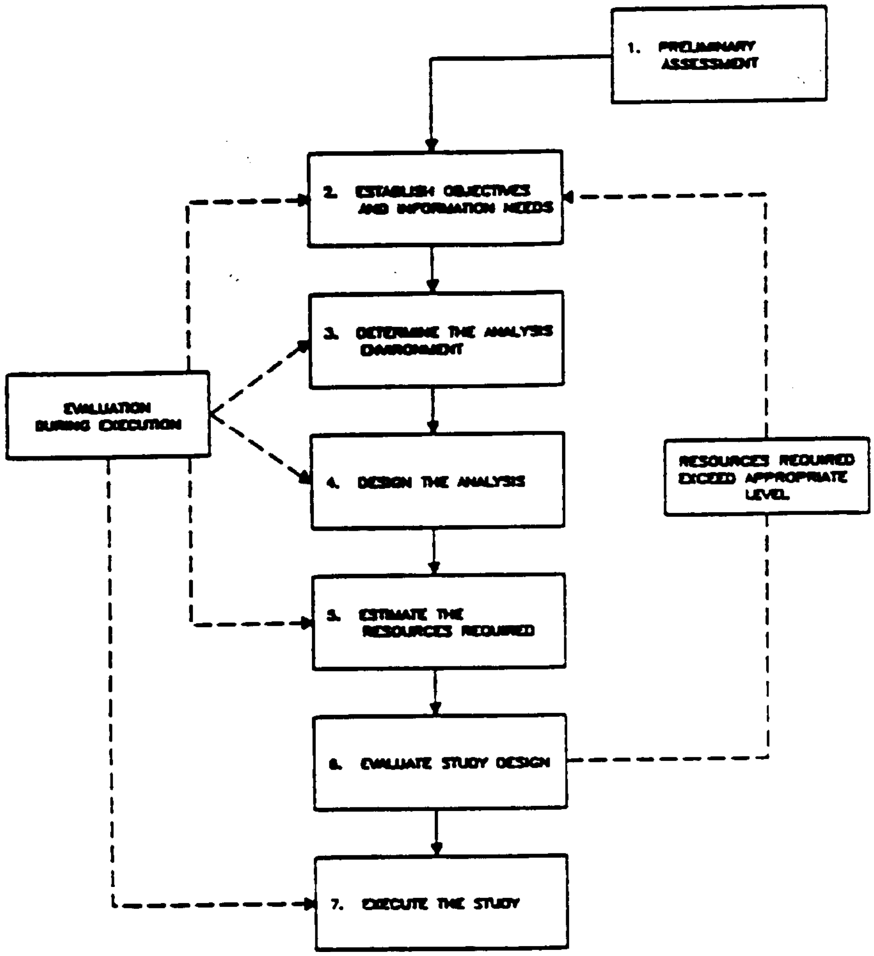
e. Special case situations may arise in which the "minimum" interior facility concept is simply not applicable. Examples may include coastal areas where a significant portion of the interior water comes from wave splash over the line-of-protection; alternatives for interior flooding that substantially reduce the volume of water arriving at the line-of-protection, such as diversions or line-of-protection re-alignment; and line-of-protection projects in which the interior facility is a significant element in the overall project or where the interior measures are integral to the project in such a manner that separation is impractical. In the above and other similar situations that may arise during an interior study, the analyst is encouraged to adhere to the concept of separable evaluation and justification as much as practically possible to ensure careful analysis of interior solutions. Where completely impractical, the reason should be documented and the analysis proceed in a logical, systematic manner considering the line-of-protection works and interior facilities as a unit.

3-3. Overview of Hydrologic Study Strategy.

a. Hydrologic analyses of interior areas must address the coincident nature of flooding at the line-of-protection for existing and future "with" and "without" conditions.

b. Development of the hydrologic engineering study strategy is an important first step in producing quality technical results needed. Figure 3.1 is a schematic of steps that can assist in formulating the hydrologic study. Table 3.1 summarizes hydrologic study detail for planning and design studies.

c. Study resources include manpower, schedules, and funding allocations for the various participants in the study. Resource allocation should be a coordinated effort among the study manager and representatives of the various elements. Under some circumstances, adjustments in scope of the hydrologic aspects of the study to meet resource allocations may be accomplished by reducing the number of alternatives investigated or by modifying the of analysis procedures. Appropriate detail and scope must be maintained, however, to meet required guidelines, regulations, and study procedures. Compromises between the study coordinator and the participant in resource allocations requirements may be required to meet these objectives.



1. Perform steps 2 through 6 in an abbreviated manner to formulate the relationship between overall interdisciplinary study objectives, strategy and the study resources required to meet these objectives.

2. Assist in formulating overall study objectives and strategy. Identify decisions required to carry out the strategy and meet the objectives. Establish information required to support these decisions. Be specific as to what, where, when, quantity and quality.

3. Assess the physical (meteorological, topographic, infrastructure, etc.) conditions influencing the study design. Determine the data that is available and its quality.

4. Develop an analysis strategy and select procedures that will provide the information required to meet the overall study objectives in a manner that effectively utilizes resources. Establish requirements for data to be acquired, sources and quality.

5. Develop a detailed work plan to carry out the analysis designed in step 4. Be specific as to who, what, where, when, how, quantity and quality. Document the analysis design, working plan and resource requirements. Tabulate resources needed to carry out each task and provide each information requirement.

6. Evaluate the analysis design, resources required, the study/design objectives, and make adjustments as considered appropriate. If the resources required (established in step 5) exceed what is considered appropriate then return to step 2 and reestablish overall study objectives; do not change the analysis without adjusting the objectives.

7. During execution periodically evaluate the objectives, analysis, and resources; make adjustments as considered appropriate.

FIGURE 3.1 Hydrologic Study Design

Table 3.1
Hydrologic Analysis Process*
Level of Detail Guidelines

Type of Study	Comments
I. Feasibility	
A. Preliminary	A. Rough hydrology, simplified procedures, judgements, and information from previous studies.
B. Formulation Process	B. Final existing and future without condition hydrology. Continuously enhanced detail for each iteration of analysis of alternatives.
C. Evaluation/Plan Selection	C. Final hydrology for plan selection, justification, and impact assessments; i.e., discharge frequency functions, performance criteria, definition of operation and maintenance procedures, and legal and institutional requirements.
II. Reformulation (when required)	Use feasibility hydrology unless conditions change. If conditions change, proceed as described above for feasibility studies.
III. General Design Memorandum (GDM)	Final design level (cost effective analysis) for pumping stations, interior channels, gravity outlets, ponding areas and other measures based on the component sizes, configuration, and performance criteria established in Part II. Provide detailed O&M, legal, and institutional requirements.
IV. Feature Design Memorandum (FDM)	Refinements to GDM design for major plan features, such as pump stations. Refine operation of plan, etc.
V. Operations Manual	Describe in detailed operations manual hardware (streamgages, raingages, etc., necessary to operate the selected plan).

*Process is ideally conceived to proceed from I to V as shown.

3-4. Strategies for Planning Studies.

a. Hydrologic Study Strategies. Hydrologic study strategies presented for planning studies are procedures and actions directly applicable to the Corps planning process.

b. Existing Without Condition System Layout. Existing without conditions system layouts are based on criteria and requirements defined in paragraph 2-3c. Specific criteria and considerations in laying out the study area are:

(1) The system is assumed to be in place and operating as planned, if the line-of-protection (levee, floodwall, seawall) is presently in place or authorized for construction.

(2) If the line-of-protection is not presently in place, its feasibility and specification will be determined based on appropriate formulation and evaluation procedures. The feasibility study will include plans of alignment of the line-of-protection which minimize the contributing runoff area to the interior. This requires special attention to tie back levees, diversions, and use of pressure conduits (Reference 4).

(3) If, as in the above paragraph 3-4b(2), the line-of-protection is not in place, a minimum facility (described in paragraph 3-1) will be formulated and considered as part of the line-of-protection system.

c. Existing Without Condition Assessments. Hydrologic analyses of existing without conditions will be performed to develop the basis for which the interior facilities will be planned. The analyses provide flood hazard information (frequency, magnitude, elevations, velocities) which are integrated into assessments of other study elements (i.e., flood damage, cost, social and environmental). Hydrologic analyses include development of data for estimating elevation-frequency functions (discharge or storage based) at desire locations throughout the system. The general hydrologic strategy for analyzing existing without conditions is:

(1) Assess available information.

(2) Perform field reconnaissance of the area: conduct interviews, survey data needs, gather historic event information, determine physical and operational characteristics of existing components.

(3) Assess analytical criteria for performing the study; i.e., layout for line-of-protection and existing condition components; determine subbasin and damage reach delineation and existing land use patterns.

(4) Analyze exterior stage conditions at existing or potential outlets of interior facilities.

(5) Develop rainfall-runoff analysis parameters for the interior areas as appropriate. Parameters include data for rainfall, loss rates, runoff transforms (unit hydrograph, or kinematic wave), and routing criteria. See EM 1110-2-1408 (Reference 3), EM 1110-2-1405 (Reference 2), and HEC Training Document No.15 (Reference 12).

(6) Formulate and evaluate the minimum interior facility described in paragraph 3-1b.

(7) Generate hydrographs for the interior system by rainfall-runoff analyses, combine flows, and perform channel and storage routings as required throughout the system. The coincident flood routings (interior and exterior stage considerations) through the line-of-protection at existing gravity or pressure outlet and pumping station location may be performed separately or in conjunction with the other system analysis. Seepage contributions should be included if pertinent.

(8) Develop elevation (discharge or storage based) frequency functions or event parameters (historic record analysis) at selected damage reaches and other locations.

d. Future Condition Assessments. Future without analyses repeat the hydrologic strategy and procedures defined under existing without conditions for the most likely future conditions as defined in paragraph 2-3c(2). This includes both land use and conveyance system changes. Other future alternative land use conditions may be assessed if desired or necessary. Future land use development patterns and other actions may affect hydrologic loss rates, runoff transforms and possibly natural storage and conveyance areas. These effects, including assumptions of encroachment, sediment, and maintenance requirements to maintain the functional integrity of the proposed project, must be determined and documented. Analyses of future with and without project conditions are normally developed and presented at decade intervals throughout the life of the proposed project (Reference 8).

e. Formulation and Evaluation. Hydrologic analyses of flood loss reduction actions and measures are performed for several combinations of measures (plans), operation plans, and performance targets following the broad approach outlined in Chapter 2. The initial evaluation should assess the potential for improved operation of the existing system. If improved operation procedures are found to be attractive for the present system they should be detailed and incorporated as part of the existing system. The typical sequence of the feasibility analysis is to evaluate increased gravity outlet capacity initially, ponding second, pumping stations third, interceptor systems fourth, and then other measures. A description of these measures is presented in detail in Chapter 5.

f. Other Study Considerations. There are several important subproblems that must be resolved by the hydrologic engineer in the formulation and evaluation of proposed interior systems. Among these are such items as exterior elevations for gravity outlet gate closure and pump on and off elevations. If they can be determined by independent analysis involving only of hydrologic factors and the results do not significantly affect plans that are formulated and evaluated, then the hydrologic engineer should solve them. If they interact in important ways with the measures being formulated, these technical subproblems should be incorporated into the planning process that considers costs, benefits, and impacts of measures. It is often useful to examine the sensitivity of the performance of the planned interior facilities to variations in such factors.

(1) The basic concept as discussed briefly in paragraph 2-3f is that the recommended plan will emerge from the planning process considering the full range of concerns and planning objectives. Costs and benefits will dominate, but other social, environmental, and functional performance issues are important.

(2) The performance of the interior facilities over the full range of anticipated interior events, including those that exceed the design level, are particularly important. What happens when design is exceeded? Do excess waters rise slowly or rapidly? What is the warning time for evacuation? Can interior area occupants get into and out of the area as needed? What are the provisions for emergency services (police, fire protection, medical service) and other life support requirements (food, water, shelter, and power)? Will the formulated facilities continue to function as planned under conditions that may prevail during the occurrence of a full range of possible interior storm events up to the magnitude of the Standard Project Storm. The hydrologic engineer should participate in the decision process in these and similar items for which his technical expertise is particularly helpful.

3-5. Strategies for Design Studies.

a. The General Design Memorandum (GDM) and Feature Design Memorandum (FDM) studies detail the selected plan specified at the conclusion of the planning process. The type of components, configuration of the system, and performance standards are specified as part of the plan. The design study objective is to provide refinement detail sufficient to meet construction and subsequent operation and maintenance criteria. Another major objective is to perform cost effective assessments of the refinements and components while maintaining the integrity of the recommended plan. Hydrologic design analyses should interface with other design elements to achieve those objectives. This should include hydraulic design elements of the recommended plan such as the size, invert elevations, and development of rating curves for gravity outlets, pumping station sump dimensions, and water surface profiles and flow velocities associated with proposed runoff conveyance system (Reference 2).

b. Selected hydrologic design considerations are described below. The items vary with each study.

(1) Pump station requirements include: Pump start and stop elevations; selection of desired pump floor elevation and determination of the need for

flood proofing above the floor elevation; the extent of automation of the pump station operations to be commensurate with the extent of advance warning time.

(2) River data and criteria commensurate with gravity outlet capabilities including selection of final gravity outlet gate closure elevations and the need for a manual or automated system of opening gravity outlets when interior pond stages exceed river stages.

(3) Detention storage requirements include: storage allocation for sediment, final interior stage frequency curves, duration and depth data to determine potential hazards associated with ponding, and the real estate requirements (permanent right-of-way and/or flowage easements).

(4) Other hydrologic evaluations include: final assessment of impacts from interior runoff events which produce interior stages exceeding selected pond right-of-way, pump station floor elevations, and other existing development elevations, including the impacts from the standard project storm; and the determination of cofferdam levels for the construction of the interior flood control features (may include the development of seasonal stage frequency curves for anticipated construction schedules). Seepage can be a major consideration where external river stages remain high for prolonged periods.

(5) The actions required to operate and maintain the proposed system must be described in detail. These include flood warning-emergency preparedness components and actions. The operations and maintenance requirements should be described by flood stage or elevation.