CECW-EH-D Engineer Regulation 1110-2-1405	Department of the Army U.S. Army Corps of Engineers Washington, DC 20314-1000	ER 1110-2-1405 30 September 1982
	Engineering and Design HYDRAULIC DESIGN FOR LOCAL FLOOD PROTECTION PROJECTS	
	Distribution Restriction Statement Approved for public release; distribution is unlimited.	

DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, D. C. 20314

DAEN-CWE-HD

Regulation
No. 1110-2-1405

30 September 1982

Engineering and Design
HYDRAULIC DESIGN FOR LOCAL FLOOD PROTECTION PROJECTS

1. Purpose. This regulation prescribes the design procedure and rationale for the hydraulic design of a local flood protection channel project. Design guidance is contained in the reference listed in paragraph 3 and recognized engineering texts.

2. Application. This regulation applies to all field operating activities having civil works design responsibilities.

3. Reference. EM 1110-2-1601

4. Design Rationale. The hydraulic design of a local flood protection project must result in a safe, efficient, realiable, and cost effective project with appropriate consideration of environmental and social aspects. A satisfactory design must cover portions and/or extensions of the following elements to the degree appropriate to the design stage (see paragraph 5 and 6a).

a. Safety - potential hazards to humans and property, creation of a false sense of security, consequences of flows exceeding the improved channel capacity.

b. Efficiency - channel cross section, plan, and bottom profile configuration to optimize conveyance and operation and maintenance.

c. Reliability - ability to achieve project purposes throughout project economic life; proper functioning of facilities such as pumps, gates, trash fenders, etc.

d. Cost effectiveness - initial, operational, maintenance, and replacement costs optimized on an annual cost basis.

e. Environmental and social aspects - fish and wildlife, beautification, recreational opportunities, handicap access, and mitigation of adverse impacts.

5. Project Design Process.

a. The initial step in the hydraulic design process is to develop a hydraulic design study plan in support of the design study. This plan will indicate the hydraulic design studies to be performed as the design progresses through its various stages. Careful consideration of the type and complexity of the hydraulics design studies required at various stages is necessary. An uncomplicated small project may require only basic hydraulic design studies while a complex project may require progression to more sophisticated hydraulic design studies as the design proceeds. The hydraulic design study plan will identify the inputs of data and results of studies from others (see Appendix A) required to properly conduct the hydraulic design studies. Coordination with other disciplines to assure the timely availability, format, and adequacy of the hydraulic design technical information inputs to and outputs from the hydraulic design studies is essential. Decisions as to portions, if any, of the hydraulic design studies requiring physical or mathematical modeling by others will be noted in the plan. The plan will indicate by schedule or other means, the timing of hydraulic design studies, input from others, and interfacing of outputs with the design study progress.

b. Following assembly of the initial inputs of data/studies required, the initial hydraulic design studies will be undertaken in support of the design study. Alternative designs are to be studied and presented in sufficient detail to provide a valid basis for plan comparison and to substantiate the recommended design commensurate with the design study progress.

c. Hydraulic design studies will continue in like manner, as required, until project construction is completed.

d. A continuous review and modification of the hydraulic design study plan in response to adjustments in the design study is essential to the hydraulic design process.

6. Hydraulic Design Presentation. The hydraulic design presentation in reports must cover the following:

a. General. Basically the hydraulic design presentation portion of all reports forwarded either for approval or information should contain sufficient detail to allow an independent assessment as to the soundness of the report conclusions and recommendations. The accuracy of hydraulic design studies (computations, physical and mathematical modelling, etc.,) is dependent on the accuracy of input data and the degree to which the computational procedure is representative of the hydraulic phenomena under consideration. As an example, water surface profiles determined for a constant cross-section, uniform sloped, concrete channel would be expected to have more accurate profiles than those determined for a complex, natural, braided stream. The degree of accuracy may often be demonstrated by sensitivity analysis procedures. The complexity/ sophistication of data input and hydraulic design studies is governed by the requirements of the design stage and is to be worked out in the project design process as indicated in paragraph 5 above. Report presentations will be sufficiently descriptive (writeups, sensitivity analysis, tables, equations, coefficients, model reports, example computations, etc.,) to satisfy the basic requirement given at the beginning of this paragraph.

b. Pre-Post Project Conditions. For channel improvements having an improved channel capacity less than the standard project flood (SPF), the consequences of flows exceeding the channel capacity (to and including the SPF) will be discussed and shown on plan and profile sheets. With-and-without project conditions are to be shown on the same sheet for comparative purposes. For reports containing plan comparisons, provided the same coverage for alternative plans when greater than channel capacity conditions influence the comparison.

c. Protective Measures. The presentation must indicate the greatest discharge for which damage prevention is claimed. All elements of the channel must perform satisfactorily (no damage exceeding ordinary maintenance) up to this discharge or it must be shown that an appropriate allowance has been made for deterioration. As a minimum, the presentation must show that all channel elements will perform satisfactorily for flows up to and including the annual flood frequency which has a 50 percent probability of being exceeded during the project economic life. For economic lives of 50 and 100 years, the annual flood frequency percent chance of exceedance is about 1.4 and 0.7 respectively.

d. Hydraulic Losses. Hydraulic loss factors (used in the determination of damage reduction and protective measures) must be as accurately determined as practical. Due to the inherent inaccuracy of determining these loss factors, a range of values is indicated. The presentation will indicate the procedure used to determine the loss factors, the sensitivity of stage and velocity to the loss factors, and the allowance, as required, for change during the life of the project.

e. Water Surface Profile Stability. The presentation must indicate the stability of the water surface profile throughout the project life (particularly for soft bottom channels) and describe the procedure used in this determination. Channels having low flow meanders or braids have the least stable profiles and require envelope profiles for both banks to account for bed configuration and bed form changes. Presentation of design measures to provide increased profile stability, such as channel cross section geometry, grade control structures, protective measures, and levees and flood walls are subject to the provisions of subparagraph c above. A sedimentation study is a necessary part of the profile stability presentation. Elements of such studies would include bed load, bed material, bed forms, shoaling and scouring tendencies, bank erosion, etc. Sufficient field data and analysis to define the severity of sediment aspects and substantiate design measures are required. Water surface profile stability is an important element of channel freeboard considerations.

f. Approach and Exit Channels. The presentation must include the approach and exit channels as defined in Appendix B. Plan and profile sheets are to show these channels which will be considered as part of the project. These sheets are to extend upstream and downstream to where the with-and-without project conditions (subparagraph b above) are essentially the same. Main channel mouths and the lower ends of inflowing tributaries and other entrances and upper ends of distributary channels are to be presented similarly. Where appropriate, the range of tailwater for exit channels (main and distributary) will be presented.

g. Operation and Maintenance. The presentation must include an operation and maintenance section that covers hydraulic design aspects. This section will discuss those hydraulic design aspects related to operation and maintenance as required by provisions of Federal Code 208.10, Title 33, as approved by the Secretary of the Army. It will form the basis for more detailed information to be included in the Operation and Maintenance Manual furnished local interests as provided for in the Federal Code. Additionally, if not presented in detail elsewhere, such matters will be covered as:

(1) Detailed operation and maintenance costs.

(2) Surveillance requirements and permanent features in support thereof such as bench marks and staff gages.

(3) Real estate needs in support of the Federal Code requirements such as access, dredging, disposal areas, preclusion of obstructions in flow-way, maintenance of protective measures, pondage, etc.

h. Freeboard. The freeboard design presentation must cover the following:

(1) The rationale for the use or non-use of freeboard for channels without levees or floodwalls.

(2) The rationale for magnitude of the nominal freeboard allowance for levees and floodwalls as related to the protected area (urban, agriculture, commercial, high hazard, etc.).

(3) Water surface profile stability as discussed in subparagraph e above.

(4) Conservatism of loss factors as discussed in subparagraph d above.

(5) Additional allowance for upstream of bridges and other contractions, trash, and costly structures such as pump stations.

(6) For mainline and tieback levees and flood walls, in addition to the above, measures to assure the least hazardous (damaging) initial overtopping location, superiority to prevent chain reaction failure of leveed cells or to assure initial overtopping of levee on least hazardous (damaging) side.

(7) Other design elements if not covered above.

i. Care of Water During Construction. The care of water during construction must be covered for all projects. For projects that could have hazardous conditions exceeding pre-project conditions during construction, the care of water during construction will be a Corps responsibility. Provisions for the care of water during construction will be designed by the Corps (reviewed and approved by the Corps if the design is accomplished by AE contract). When no hazardous condition related to care of water during construction is foreseen, the construction contract will require the contractor to provide a plan to be approved by the contracting officer. A construction flood warning plan will be covered for all projects if a need is indicated. For projects extending over several construction seasons, the care of water during construction plans must include contingency measures to assure the efficacy of constructed portions and to obviate project incurred damages (upstream of, downstream of, or within the constructed project reach). Permanent measures are to be used if a portion of the project is materially delayed or deleted.

j. Side Drainage. The presentation must include all side drainage provisions such as: tributaries, sewers, and overland flow. Include discharge capacity, rationale for its determination, protective measures, and/or any special provisions.

FOR THE COMMANDER:

JAMES W. RAY
Colonel, Corps of Engineers
Chief of Staff

2 Appendixes
APP A - Typical Factors Affecting Hydraulic Design
APP B - Typical Local Flood Protection Channel Project Features

APPENDIX A

TYPICAL FACTORS AFFECTING HYDRAULIC DESIGN

1. Hydrologic.

a. Climate-Weather (precipitation, wind, and temperature)

b. Discharge (Hydrographs, frequency, stage, and duration - annual and seasonal)

c. Trash-Ice

d. Sediment (Suspended and bed)

e. Morphology (Aggradation, degredation, meandering, etc.,)

f. Tides

2. Hydraulic.

a. Velocity

b. Slope

c. Energy losses (roughness, transitions, obstructions, etc.,)

d. Configuration (channel)

e. Water surface profile - Stage

f. Waves (wind, standing, and vessel)

g. Stability (channel)

3. Physical.

a. Geology

b. Topography - Hydrography

c. Vegetation

d. Sediment (sizes, physical characteristics, areal distribution, sources, and yields)

4. Environmental.

a. Esthetics

b. Culture

c. Ecology

d. Archeology

5. Social.

a. Recreation

b. Access - Egress

c. Safety - Welfare

d. Displacement

APPENDIX B

TYPICAL LOCAL FLOOD PROTECTION CHANNEL PROJECT FEATURES

1. Approach Channel	- That portion of the flow-way upstream of the constructed project that encompasses an altered regime.
2. Exit Channel	- That portion of the flow-way downstream of the constructed project that encompasses an altered regime.
3. Channel	- That portion of the project carrying flow. Descriptive adjectives are used to denote specific types such as: natural, constructed, riprapped, concrete, trapezoidal, leveed, overbank, low flow, bypass, etc.
4. Grade Control Structures	- Sills, weirs, drop structures, etc. that traverse the channel to stabilize the invert slope and/or control the velocity.
5. Bed and Bank Protective Measures	- Riprap, gabions, groins, concrete, concrete blocks, vegetation, etc., used to protect the channel bed and/or banks from erosion.
6. Channel Stabilization	- Pile dikes, groins, etc., as well as grade control structures and bed and bank protective measures.
7. Levees & Floodwalls	- Structures confining flow to a defined flow-way to prevent flooding.
8. Side Drainage	- Such structures as culverts, outfalls, chutes, and channels with appropriate energy dissipators used to control the entry of adjacent drainage.
9. Special Features	- Pump stations, ponding areas, junctions, bridge abutments and piers, diversion dams, transitions, recreational and social provisions, etc.