

EXHIBIT 11-E CHECKLIST FOR DRAINAGE STUDIES AND REPORTS**CHECKLIST FOR DRAINAGE STUDIES AND REPORTS**

This is a checklist of items to be considered for inclusion in hydraulic studies and reports. For definition of terms see section entitled “*Definitions*” of this chapter.

1. PRELIMINARY

a. Review of basic guidelines

1. A floodplain cannot be altered in any way until it has been shown that such alteration will pass the base flood without significant damage to either the flood plain or surrounding property. This requirement is often referred to as “conveyance of the base flood.” (Conveyance may be through structures, over the roadway, through escapements, through overflow channels, or any combination of the above.)
2. Approval for actions within a flood plain cannot be given until various options of alignments, grade, and waterway area have been appraised.
3. No bridge abutments or embankment shall encroach on a regulatory floodway.

b. Collect appropriate and readily available published data such as:

1. USGS quadrangle maps
2. NFIP maps – Flood plain maps may be obtained from the National Flood Insurance Program (NFIP), or the Local Caltrans District office
3. Aerial photos - Check with Caltrans
4. Runoff records - USGS water supply papers
5. Rainfall records- Various sources
6. Prior hydrology reports including photos and plans

c. Coordinate with other agencies

1. Determine whether permits are required.
2. Determine how the area is zoned.
3. Investigate possibility of cooperative projects.
4. Determine whether there exist or proposed water resource projects that will influence the design, and summarize details (Watershed area, storage capacity, etc., when pertinent).
5. Determine whether there is ongoing or proposed clearing, construction, land leveling, land development, aggregate mining, etc., that would affect flow in or the stability at the stream.

d. Floodplain Encroachments

1. Executive order 11988 establishes the federal policy on floodplain management. This policy has been implemented by 23 CFR, Part 650A (23 CFR 650A).
2. CFR 650A requires all encroachments and all actions, which affect an area, subject to flooding by flood or tide having a one-percent chance of being exceeded in any given year, to comply with a floodplain management policy. Repairs made to existing facilities with emergency funds (see *Local Programs Manual* which discusses Emergency Relief) during or immediately following a disaster are exempt from this policy.

e. The hydrology and hydraulics report shall:

1. Only be as comprehensive as the conditions warrant. Calculations with short comments are sufficient for a culvert in a well-defined drainage environment. A complete comprehensive document is required for a major stream crossing in an ecological setting.
2. Generally be structured along these guidelines with:
 - a. Background data and estimates of future flood.
 - b. Calculations to determine velocities, water surface elevations, backwater and scour depth (the lead agency should provide a disk with the data used to run HEC-2 or WSPRO. If a program other than these is used, that program should be provided on a disc along with the data used).
 - c. Illustrative photos.
 - d. Comments on selection of design flood, conveyance of 100-year flood, channel change, effect on stream stability, and provisions for fish passage.

f. Suggested desirable hydraulic features

1. The following features should be considered in the design of a bridge or culvert:
 - a. Use of warped wingwalls
 - b. No open vents
 - c. No piers in main channel
 - d. Use of energy dissipaters
 - e. Extending pier walls to edge of deck
 - f. No piers in navigable channel

2. FIELD RECONNAISSANCE -- Should be made by the engineer making the hydrologic and hydraulic analysis

a. Channel stability

1. Estimate the erodability of streambed material.
2. Document bends, meanders, and any eroded areas.
3. Is the existing protection providing adequate erosion control, and if so, is it fragile?
4. Are there signs of aggradations or degradation? Other scour considerations?
5. Are there any upstream or downstream mining operations?

b. Potential problems

1. Consideration of the value of the property that would be damaged by the base flood or overtopping flood.
2. Size and amount of drift.
3. Ice, snow.
4. Banks that would erode if flow is accelerated or redirected.
5. Check adequacy of abutment protection.

c. Environmental considerations

1. Avoid support of incompatible floodplain development.
2. Minimize the impact of highway actions that adversely affect the base floodplain.
3. Restore and preserve the natural and beneficial floodplain values (fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aqua culture, forestry, natural moderation of floods, water quality maintenance, groundwater discharge, etc.).
4. Be consistent with the standards/criteria of the National Flood Insurance Program of the Federal Emergency Management Agency (FEMA).

d. Alternative sites

1. Locate suitable alternative sites.
2. What are the advantages and disadvantages of the alternative sites?

e. Existing structures (including relief or overflow structures)

1. Locate existing nearby upstream or downstream structures with respect to proposed crossing or encroachment.
2. For each existing nearby structure note the type, number of spans, span lengths, vertical clearance, bent design or pier orientation.
3. For each nearby existing culvert estimate the size and number of cells.

f. Hydraulic data

1. Locate high water marks (give date and elevation).
2. Document both the flood history and source of information.
3. Document the damage to existing structures including abrasion, corrosion, wingwall failure, culvert entrance failure, pier settlement, or excessive aggradations or degradation.
4. Note the use of bank protection, drop structures, or any other sign of corrective work at existing structures.

g. Factors affecting water stage

1. Determine whether flood flow can escape to, or enter from, other watersheds during floods.
2. Determine whether any of the flow can bypass the site.
3. Determine whether backwater or tides affect the flow.
4. Determine what will control an overtopping flood.

3. ECONOMIC ANALYSIS

- a. Make an economic analysis of all the reasonable alternatives based on construction cost, aesthetic cost, ecological cost, flood damage cost, loss of traffic service, etc.
- b. Reject from further considerations those options that are not economically suitable alternatives.

4. FIELD SURVEY

- a. Obtain topographic data for the suitable site alternatives. Extend limits to include overflows where practicable.
- b. Locate, sketch, and record significant features such as buildings, levees, walls, fences, ditches, trees, boulders, etc., and where significant, record elevations.
- c. Record water surface elevation, the elevation of the path of greatest depth as in a stream channel (thalweg elevation), and estimate velocity of flow.
- d. Set tidal gages where tidal influence is possible and record data hourly throughout the survey.
- e. Obtain channel cross-sections 500 and 1000 feet upstream and downstream where necessary.
- f. Obtain data on boat traffic.
- g. Take ample photographs at each site to illustrate the hydraulic and ecological features.
- h. Take physical measurements of the existing structure and/or any other bridge or culvert with similar characteristics either upstream or downstream.
- i. Where possible determine the foundation type (spread footings, piles) and foundation depth of all nearby structures

5. SITE MAP CONSTRUCTION

- a. Purpose: For use in estimating flood flow distribution; to locate cross section of stream; to show location of proposed encroachment and structures, alignment of piers, skew of crossing, stream controls, existing encroachments, existing highway structures, etc.
 1. A specially prepared site map showing one foot and two feet contours, vegetation, and manmade improvements is normally required. In some cases cross-sections normal to flood flow are acceptable in lieu of the map. A minimum of 3 cross sections is required including one upstream, one at the crossing, and one downstream.
 2. The site map should include the limits of the overtopping flood when practical.
 3. Where there are two or more suitable alignments, a site map must be prepared for each.

6. HYDROLOGIC ANALYSIS

- a. Hydrologic considerations
 1. Determine drainage area above the proposed encroachment. Subdivide where runoff characteristics are or will be significantly different.
 2. List available flood records at the encroachment and/or at nearby hydraulically similar
 3. Calculate the flow at the proposed encroachment for the base flood and the design flood, if different. Include any other flow within the floodplain that affects the design of the project. The flood calculations should be made by using at least two widely used methods. Nearby stream gage data may be used, if the data is adequate to furnish the above.
 4. Plot the flood frequency curve.
 5. Plot the stage discharge curve.
- b. Establish the existing flow conditions
 1. Determine the distribution of flow and velocities for several discharges or stages in the natural channel for existing conditions. USCE, USGS, FEMA, etc., studies may be used as a general case.
 2. Establish the maximum permissible upstream water surface for base flood.
- c. Hydraulic design for bridges
 1. Compute the water surface profile for various trial bridge lengths and discharges at each of the alternative sites. If alternate alignments are proposed, compute the water surface profile for various trial bridge lengths and discharges at each of the alternative sites.

(The Lead Agency should provide a disc with the data used to run the HEC-2 or WSPRO water surface profile computer programs. If a program other than HEC-2 or WSPRO is used that program should be provided on a disc along with the data used.)

(For the base flood, backwater caused by the encroachment together with that caused by all other man-made obstructions is limited to one foot above the water surface of the base flood.) Design must be in accordance with 23 CFR 650 Subpart A. The local agency must comply with FEMA's regulatory floodplain rules or they may lose their federal flood insurance.
 2. Select alignment, grade, bridge type and size waterway openings, etc., on the basis of overall economic calculations and freeboard requirements (see section 10, *Design Standards*).

3. Check “conveyance” of base flood.
 4. Calculate scour depth at piers. (Recommended reference HEC-18 *Evaluating Scour at Bridges*, FHWA)
 5. Design pertinent features such as riprap for bank protection, cross channel stabilizers for streambed control, energy dissipaters to reduce downstream velocities, spur dikes to equalize flow, etc. (Recommended references are HEC - 18 *Evaluating Scour at Bridges* and HEC - 20 *Stream Stability at Highway Structures*).
- d. Hydraulic design for culverts (Recommended reference; Caltrans *Highway Design Manual*)
1. Determine allowable headwater elevation.
 2. Compute and plot performance curves for trial culvert sizes at alternate alignments.
 3. Evaluate erosion, abrasion, and corrosion potentials.
 4. Select alignment, grade, and culvert design on the basis of overall economic calculations related to the design standards appropriate to the project.
- e. Hydraulic design for longitudinal encroachments
1. Determine the effect of the proposed encroachment on water surface profile using various roadway design, alternatives, and the base flood.
 2. Evaluate the effects on scour and deposition in the channel.
 3. Select roadway design on the basis of overall economic calculations.
 4. Design pertinent features such as bank protection, etc. (Recommended reference HEC-11 *Design of Riprap Revetment, FHWA and/or Bank and Shore Protection*, Caltrans)

7. CONTRACT PLANS

The following data shall be shown on the contract plans, and may be shown in tabular form. List the frequency, magnitude and pertinent water surface elevations for:

- a. Minimum Design Flood
- c. Base Flood
- d. Overtopping Flood
- e. Flood of Record, if available

The data used for design must be designated and if different from the above, the data must be shown on the plans.

HYDRAULIC REFERENCES

- *Guidelines for Hydraulic Considerations in Highway Planning and Location, Volume I, Highway Drainage Guidelines, AASHTO, 1999.*
- *Guidelines for Hydrology, Volume II, Highway Drainage Guidelines, AASHTO, 1999.*
- *Highway Hydrology, HDS No.2, FHWA-SA-96-067, 1996.*
- Flood-frequency analysis, such as those of U. S. Geological Survey or other water-resources agencies, for the region in which the structure is located.
- *Highways in the River Environment Hydraulic and Environmental Design Considerations, U.S. Department of Transportation, FHWA, 1983*
- *Stream Stability at Highway Structures, HEC-20, FHWA-0IP-90-014, 1991*
- Bradley, J. N., 1979, *Hydraulics of Bridge Waterways, Hydraulic Design Series No. 1, Federal Highway Administration, U.S. Government Printing Office, Washington, DC, 1978, 111 p.*
- *Evaluating Scour at Bridges, Second Edition, HEC-18, FHWA-IP-90-017, 1993.*
- *Highway Research Board, 1979, Scour at Bridge Waterways, National Cooperative Highway Research Program Synthesis 5, Highway Research Board, National Academy of Sciences, 2101 Constitution Avenue, Washington, DC 20418.*
- *Hydraulic Design of Highway Culverts, September 1985, Hydraulic Design Series No.--, Report No. FHWA-1P-85-15.*
- *Circular Memorandum, G. M. Williams, July 21, 1966 Plans for Pipe Culvert Inlet and Outlet Structures, Federal Highway Administration.*
- *Guidelines for Hydraulic Design of Culverts, Volume IV, Highway Drainage Guidelines, AASHTO, 1999.*
- Searcy, J. K., *Design of Roadside Drainage Channels, 1985, Federal Highway Administration, Hydraulic Design Series No. 4, U.S. Government Printing Office, Washington, DC.*
- *Bridge Deck Drainage Systems, HEC-21, FHWA-SA-92-010, 1993*
- *Standard Environmental Reference (SER), Chapter 17 "Flood Plains"*
- *Design of Encroachments on Flood Plains Using Risk Analysis, HEC 17, FHWA-EPD-86-112, 1981*
- For information regarding flood plain delineation studies, write to: Department of Housing and Urban Development, Federal Insurance Administration, Assistant Administrator for Flood Insurance, 451 7th Street, SW, Washington, DC 20410
- *Design of Rip rap Revetment, HEC-11, FHWA-1P-89-016, 1989.*
- *CALTRANS Highway Design Manual*
- *AASHTO Model Drainage Manual*

Instructions: To be used as guide for Hydraulic Studies and Reports