CHAPTER 4

DOCUMENTATION

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4.1 OVERVIEW

4.1.1 Introduction

An important part of the design or analysis of any hydraulic facility is the documentation. Appropriate documentation of the design of any hydraulic facility is essential because of:

- the importance of public safety;
- justification of expenditure of public funds;
- future reference by designers (when improvements, changes or rehabilitations are made to the highway facilities);
- information leading to the development of defense in matters of litigation; and
- public information.

Frequently, it is necessary to refer to plans, specifications and analysis long after the actual construction has been completed. Documentation permits evaluation of the performance of structures after flood events to determine if the structures performed as anticipated or to establish the cause of unexpected behavior, if such is the case. In the event of a failure, it is essential that contributing factors be identified so that recurring damage can be avoided.

4.1.2 Definition

The definition of hydrologic and hydraulic documentation as used in this Chapter is the compilation and preservation of the design and related details and all pertinent information on which the design and decisions were based. This shall include drainage area and other maps, field survey information, source references, photographs, engineering calculations and analyses, measured and other data and flood history including narratives from newspapers and individuals (e.g., highway maintenance personnel and local residents who witnessed or had knowledge of an unusual event.

4.1.3 Purpose

This Chapter presents the documentation that shall be included in the design files and on the construction plans. Although the Department's documentation requirements for existing and proposed drainage facilities are similar, the data retained for existing facilities are often slightly different than that for proposed facilities, and these differences are discussed. This Chapter focuses on the documentation of the findings obtained in using the other chapters of this *Manual*, and thus designers shall be familiar with all the hydrologic and hydraulic design procedures associated with this *Manual*. This Chapter identifies the Department's system for organizing the documentation of hydraulic designs and reviews to provide as complete a history of the design process as practical.

The major purpose of providing good documentation is to define the design procedure that was used and to show how the final design and decisions were determined. Often, there is expressed the myth that avoiding documentation will prevent or limit litigation losses because it supposedly precludes providing the plaintiff with incriminating evidence. This is seldom if ever the case and documentation should be viewed as the record of reasonable and prudent design

analysis based on the best available technology. Thus, good documentation can provide the following:

- protection for the Department by proving that reasonable and prudent actions were, in fact, taken (such proof should certainly not increase the potential court award and may decrease it by disproving any claims of negligence by the plaintiff);

- identifying the situation at the time of design, which might be very important if legal action occurs in the future;

- documenting that rationally accepted procedures and analysis were used at the time of the design that were commensurate with the perceived site importance and flood hazard (this should further disprove any negligence claims);

- providing a continuous site history to facilitate future reconstruction;

- providing the file data necessary to quickly evaluate any future site problems that might occur during the facility's service life; and

- expediting plan development by clearly providing the reasons and rationale for specific design decisions.

4.1.4 Project and Post Construction Documentation

Project documentation is required for each phase of the project. The normal project phase are: Concept/Pre-design, Design, and Construction. Following is a list of recommended documentation for each phase of the project:

4.1.4.1 Concept/Pre-design

Concept/Pre-design documentation shall include the following if available or within the budgetary restraints of the project:

- aerial photographs;
- contour mapping;
- watershed map or plan including:
  - flow directions,
  - watershed boundaries,
  - watershed areas, and
  - natural storage areas;

- surveyed data reduced to include:
  - existing hydraulic facilities,
  - existing controls,
  - profiles — roadway, channel, driveways,
  - cross sections — roadway, channels, faces of structures;

- flood insurance studies and maps by FEMA;
- NRCS soil maps;
- field trip report(s) that may include:

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- video recordings,
- audio recordings,
- photographs, and
- written analysis of findings with sketches; and

- reports from other agencies (local, State or Federal), UDOT personnel, newspapers and abutting property owners.

4.1.4.2 Design

Design documentation shall include all the information used to justify the design, including:

- reports from other agencies,
- hydrologic report,
- hydraulic report, and
- approvals.

4.1.4.3 Construction

Construction documentation shall include:

- plans;
- revisions;
- as-built plans and subsurface borings; and
- photographs.

4.1.4.4 Post Construction and Maintenance

Periodical inspections are conducted to assess the condition of the roadway infrastructure. UDOT Bridge Division inspects bridges and culverts in the state roadway system and keeps the records of their conditions in a computer database and also in files. Documentation shall include:

- record of operation during flooding events, complaints and resolutions;
- plans or descriptions of any repairs or modifications effected by maintenance forces or any other project; and
- periodic reports or reviews.
- Culvert inspection condition and reports.

4.1.5 <u>Scheduling</u>

8. Documentation shall not be considered as occurring at specific times during the design or as the final step in the process, which could be long after the final design is completed. Documentation should rather be an ongoing process and part of each step in the hydrologic and hydraulic analysis and design process. This will increase the accuracy of the documentation, provide data for future steps in the plan development process and provide consistency in the design even when different designers are involved at different times of the plan development process.

4.1.6 Responsibility

The Department's designer shall be responsible for determining what hydrologic analyses, hydraulic design and related information shall be documented during the plan development process. This designer shall make a determination that complete documentation has been achieved during the plan development process that will include the final design.

4.2 PROCEDURE

4.2.1 Introduction

A complete hydrologic and hydraulic design and analysis documentation file for each storm drain system, waterway encroachment or crossing shall be maintained by the region or/and central hydraulics section. Where practicable, this file shall include such items as:

- identification and location of the facility;
- photographs (ground and aerial);
- engineering cost estimates and actual construction costs;
- hydrologic investigations;
- drainage area maps, vicinity maps and topographic maps;
- contour maps;
- interviews (local residents, adjacent property owners and maintenance forces);
- newspaper clippings;
- design notes and correspondence relating to design decisions;
- history of performance of existing structure(s); and
- assumptions.

The documentation file shall contain design/analysis data and information that influenced the facility design and that may not appear in other project documentation.

4.2.2 Practices

Following are the Department's practices related to documentation of hydrologic and hydraulic designs and analyses:

1. Hydrologic and hydraulic data, preliminary calculations and analyses and all related information used in developing conclusions and recommendations related to drainage requirements, including estimates of structure size and location, shall be compiled in a documentation file.

2. The designer shall document all design assumptions and selected criteria including the related decisions.

3. The amount of detail of documentation for each design or analysis shall be commensurate with the risk and the importance of the facility.

4. Documentation shall be organized to be as concise and complete as practicable so that knowledgeable designers can understand years hence what was done by predecessors.

5. Circumvent incriminating statements wherever possible by stating uncertainties in less than specific terms (e.g., the culvert may back water rather than the culvert will back water).

6. Provide all related references in the documentation file to include such items as published data and reports, memos and letters and interviews. Include dates and signatures where appropriate.

7. Documentation shall include data and information from the conceptual stage of project development through service life to provide successors with all information.

8. Documentation shall be organized to logically lead the reader from past history through the problem background, into the findings and through the performance.

9. Include completed forms described in section 4.3 and the following forms for each documentation file: Bridge Information Sheet, Culvert Information Sheet, and Bridge Rip-Rap Information Sheet (See appendix A).

10. Discard Concept Report when the project has been completed.

4.2.2.1 Hydraulics Report

1. The Hydraulics Report shall be a summary of the hydrologic and hydraulic design.

2. The following outline may be used for the hydraulics report. A more complete outline is given in chapter 5.

    a. System Overview
    b. Hydrology
    c. Storm Drain System
    d. Bridges
    e. Culverts
    f. Ponds
    g. Open Channels
    h. Pump Stations
    i. Copies of Permits and Agreements
    j. Completed computation sheets

3. The initial hydraulics report shall be submitted to the region hydraulics engineer in accordance with design activity 58D

4. The final hydraulics report shall be submitted prior to PS&E incorporating any changes requested by the region hydraulics engineer.

4.2.3 <u>Storage</u>

To the extent possible, all data in the documentation file shall be maintained in electronic format. The hydraulics report shall be submitted in both electronic (Compact Disc) and paper formats.

The designer shall maintain the documentation files until completion of construction. After construction, the documentation file shall be stored in the region or central hydraulic section where it will be readily available to UDOT for defense of litigation and future replacement or extension. Only that documentation need be retained that is not retained elsewhere. Original complete plan sets, construction correspondence files, construction modifications and inspection reports are the types of documentation that usually do not need to be duplicated in the hydraulics section.

Hydrologic/hydraulic documentation shall be retained in the project plans or other permanent location at least until the drainage facility is totally replaced or modified as a result of a new drainage study.

4.3 DOCUMENTATION PROCEDURES

4.3.1 Introduction

The following items shall be included in the documentation file. The intent is not to limit the data to only those items listed, but rather establish a minimum requirement consistent with the hydraulic design procedures as outlined in this *Manual*. If circumstances are such that the drainage facility is sized by other than normal procedures or if the size of the facility is governed by factors other than hydrologic or hydraulic factors, a narrative summary detailing the design basis shall appear in the documentation file. Additionally, the designer shall include in the documentation file items not listed below but which are useful in understanding the analysis, design, findings and final recommendations.

4.3.2 Hydrology

The following items used in the design or analysis shall be included in the documentation file:

- contributing watershed area size and identification of source (map name, etc.);
- design frequency and decision for selection;
- hydrologic discharge and hydrograph-estimating method and findings;
- flood frequency curves to include design, 100-yr flood, discharge hydrograph and any historical floods; and
- expected level of development in upstream watershed over the anticipated life of the facility (include sources of and basis for these development projections).

4.3.3 Bridges

The following items shall be included in the documentation file:

- design and 100-yr highwater for undisturbed, existing and proposed conditions;
- stage-discharge curve for undisturbed, existing and proposed conditions;
- cross section(s) used in the design high-water determination;

- roughness coefficient ("n" value) assignments;
- information on the method used for design high-water determination;
- observed highwater, dates and discharges (if available);
- velocity measurements or estimates and locations (include both the through-bridge and channel velocity) for design and 100-yr floods;
- performance curve to include calculated backwater, velocity and scour for design, 100-yr flood and 500-yr flood for scour evaluation;
- magnitude and frequency of overtopping flood;
- copies of all computer analyses;
- complete hydraulic study report;
- economic analysis of design and alternatives;
- risk assessment;
- bridge scour evaluation results;
- roadway geometry (plan and profile); and
- potential flood hazards to adjacent properties.

4.3.4 Culverts

The following items shall be included in the documentation file:

- Hydraulic data sheet from chapter 9 of this Manual;
- culvert performance curves (if developed);
- allowable headwater elevation and basis for its selection;
- cross section(s) used in the design high-water determinations;
- roughness coefficient assignments ("n" values);
- observed highwater, dates and discharges;
- stage discharge curve for undisturbed, existing and proposed conditions to include the depth and velocity measurements or estimates and locations for the design, 100-yr and check floods;
- performance curves showing the calculated backwater elevations, outlet velocities and scour for the design, and any historical floods;
- type of culvert entrance condition;

- culvert outlet appurtenances and energy dissipation calculations and designs;
- copies of all computer analyses and standard computation sheets given in the Culvert Chapter of this *Manual*;
- roadway geometry (plan and profile); and
- potential flood hazard to adjacent properties.

4.3.5 Open Channels

The following items shall be included in the documentation file:

- stage-discharge curves for the design, 100-yr and any historical water surface elevation(s);
- cross section(s) used in the design water surface determinations and their locations;
- roughness coefficient assignments (“n” values);
- information on the method used for design water surface determinations;
- observed highwater, dates and discharges;
- channel velocity measurements or estimates and locations;
- water surface profiles through the reach for the design, and any historical floods;
- design or analysis of materials proposed for the channel bed and banks;
- energy dissipation calculations and designs; and
- copies of all computer analyses.
-

4.3.6 Storm Drains

The following items shall be included in the documentation file:

- computations for drainage areas, inlets and storm drains, including hydraulic grade lines;
- copies of the standard computation sheets given in the Storm Drainage Systems Chapter of this *Manual*;
- complete drainage area map;
- design frequency;
- information concerning outfalls, existing storm drains and other design considerations; and
- a schematic indicating storm drain system layout.

4.3.7 Pump Stations

The following items shall be included in the documentation file:

- inflow design hydrograph from drainage area to pump,
- inflow mass curve,
- maximum allowable headwater elevations and related probable damage,
- sump dimensions,
- stage-storage curve,
- stage-pump discharge relation and sequence,
- mass curve routing results,
- pump sizes and operations,
- discharge line and fittings sizing,
- total dynamic head curves,
- selected pump performance curves, and
- design report.

4.3.8 Computer Files

The following items shall be included in the documentation file and be clearly labeled:

- input data listing, and
- output results of selected alternatives.

4.4 REFERENCES

(1) AASHTO, *Highway Drainage Guidelines*, Task Force on Hydrology and Hydraulics, 2003.

HYDRAULIC DATA SHEET

Project Number:		Project Name:	
Project Location:		Structure Number:	
Prepared By:		Date:	

Hydraulic Information For Q_d, Q_{100}, and Q_{500}:

General Information:

1.	Drainage Area		Mi^2
2.	Flowline Elevation at Approach Section		ft
3.	Flowline Elevation at Bridge Section		ft

Design Information (Q_d):

1.	Design Frequency		yr
2.	Design Discharge		ft^3/sec
3.	Unconstricted WSEL at Approach Section		ft
4.	Constricted WSEL at Approach Section		ft
5.	Velocity Through Bridge Section		ft/sec

100-Year Flood Event (Q_{100}):

1.	100-Year Discharge		ft^3/sec
2.	Unconstricted WSEL at Approach Section		ft
3.	Constricted WSEL at Approach Section		ft
4.	Velocity Through Bridge Section		ft/sec
5.	Depth of Contraction Scour		ft
6.	Total Scour Depth at Left Abutment		ft
7.	Total Scour Depth at Right Abutment		ft
8.	Total Scour Depth at Piers		ft

500-Year Flood or Brigde Overtopping Event (Q_{500} or Q_{over}):

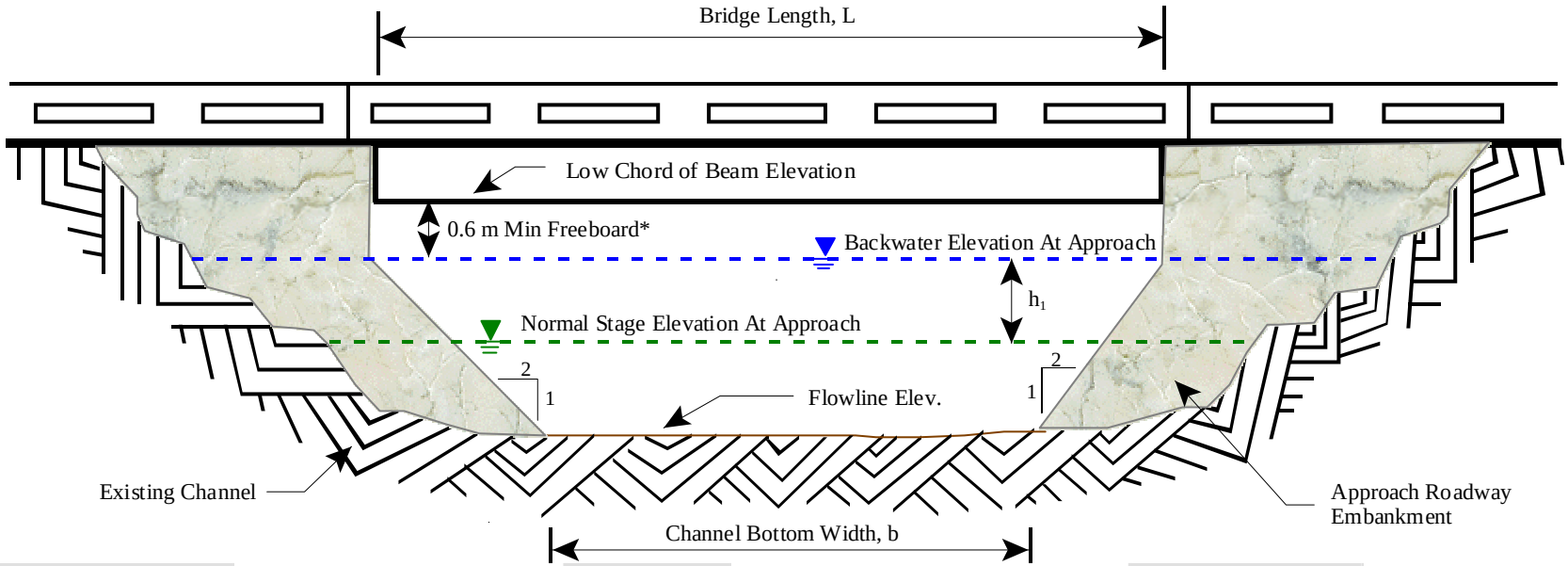
1.	500-Year Discharge		ft^3/sec
2.	Unconstricted WSEL at Approach Section		ft
3.	Constricted WSEL at Approach Section		ft
4.	Velocity Through Bridge Section		ft/sec
5.	Depth of Contraction Scour		ft
6.	Total Scour Depth at Left Abutment		ft
7.	Total Scour Depth at Right Abutment		ft
8.	Total Scour Depth at Piers		ft

Project No. _____ Project Name: _____

1.	Drainage area	_____	sq mi
2.	Inlet flowline elevation	_____	ft
3.	Outlet flowline elevation	_____	ft
4.	Design frequency	_____	yr
5.	Design frequency ($Q_{d)}$	_____	cfs
6.	Inlet water surface elevation for Q_d	_____	ft
7.	Outlet water surface elevation for Q_d	_____	ft
8.	Outlet velocity for Q_d	_____	ft/s
9.	100-year discharge (Q_{100})	_____	cfs
10.	Inlet water surface elevation for Q_{100}	_____	ft
11.	Outlet water surface elevation for Q_{100}	_____	ft
12.	Overtopping discharge (Q_{over})	_____	cfs
13.	Frequency of Q_{over} (500-year max	_____	yr
14.	Overtopping elevation	_____	ft

SPILL THROUGH ABUTMENTS - BRIDGE INFORMATION SHEET

Project Number: Project Name: Project Location:



Structure Number: _____ Prepared By: _____ Date: _____

CHANNEL X-SECTION @ BRIDGE INLET
(normal to channel-looking downstream)

A.	Design Frequency:	_____	yr	I.	Normal Stage Elev. (Unconstricted WSEL at	_____	ft
B.	Design Flow (Q_d):	_____	ft^3/sec	J.	Backwater Elev. (Constricted WSEL at approach):	_____	ft
C.	Bridge Length, L:	_____	ft	K.	WSEL at Bridge Outlet:	_____	ft
D.	Channel Bottom Width, b:	_____	ft	L.	Calculated Backwater Caused by Bridge, h1 (J-I):	_____	ft
E.	Flowline Elev.at Bridge	_____	ft	M.	Freeboard at Approach, (F-J):	_____	ft
F.	Low Chord Elevation:	_____	ft	N.	Freeboard at Bridge Outlet, (F-K):	_____	ft
G.	Pier Width:	_____	ft	O.	Velocity Through Bridge:	_____	ft/sec
H.	Skew Angle:	_____					

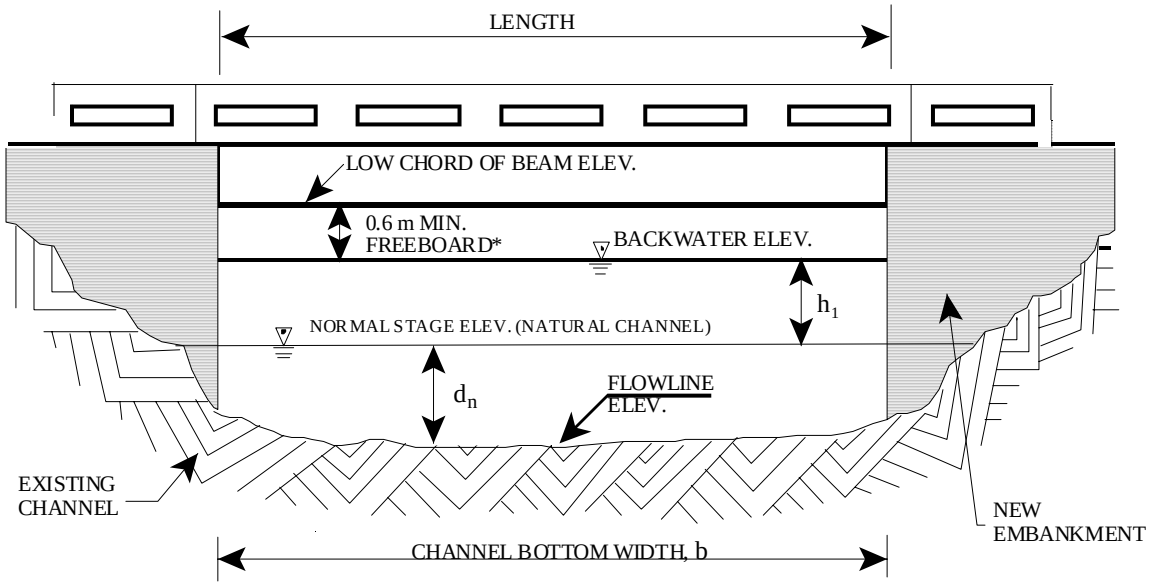
*Where not practical, consult the Region Environmental/Hydraulic Engineer for final decision.

VERTICAL ABUTMENTS - BRIDGE INFORMATION SHEET

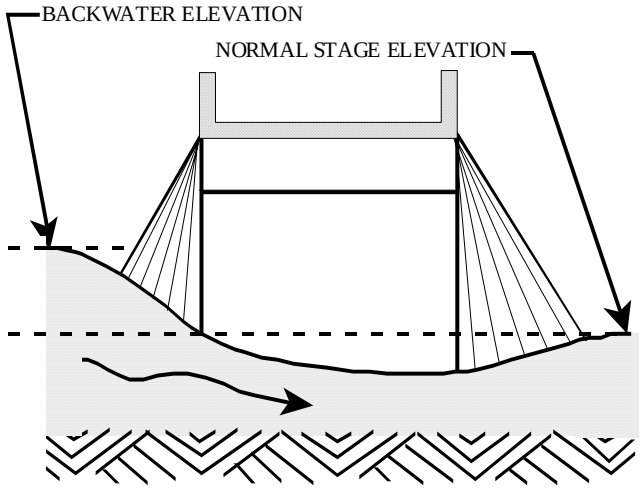
Project Number: _____ Project: _____ Design Freq: _____

Name of Stream: _____ Design Flow Q_n: _____ X-ing Station: _____
(@ center of channel bottom)

CROSS-SECTIONAL VIEW - VERTICAL ABUTMENTS



PROFILE OF STREAM CROSSING



A. Length: _____

B. Skew Angle: _____ deg. C. Pier Width: _____

D. Low Chord Elev: _____

E. Flowline Elev. At Bridge Inlet: _____

F. Normal Stage Elevation: _____

G. Backwater Elevation: _____

H. Probable Backwater, h_1(G-F): _____

I. Depth of Water in Natural Channel for Q_d, d_n(F-E): _____

J. Vertical Clearance (D-E): _____

K. Freeboard (D-G): _____

L. Velocity Through Bridge: _____

M. Channel Bottom Width, b: _____

*Where not practical, consult the Region Environmental/Hydraulic Engineer for final decision.

4.5 BRIDGE RIPRAP CALCULATIONS SHEET

Project Number:	_____	Project Name:	_____
Project Location:	_____	Structure Number:	_____
Prepared By:	_____	Date:	_____

Variables, Constants, & Related Assumptions For Estimating RIPRAP Size:
Calculations For Estimating RIPRAP Size:

$$F_r = \frac{V}{\sqrt{gy}}$$ ⟶ F_r = _____ Froude Number through bridge section

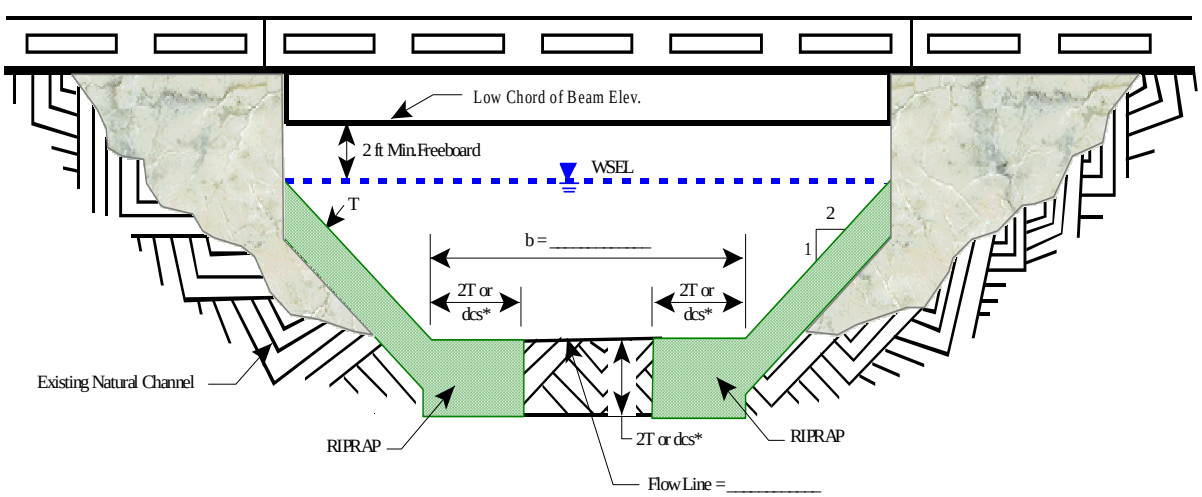
Page 112 HEC #18 ⟶ K = _____ Velocity coefficient

If $F_r < 0.80$

$$D_{50} = \frac{K}{S_s - 1}\left(\frac{V^2}{gy}\right) y$$ ⟶ D_{50} = _____ m **MEDIAN RIPRAP STONE DIAMETER** (Equation 81, Page 112 HEC #18)

If $F_r > 0.80$

$$D_{50} = \frac{K}{S_s - 1}\left(\frac{V^2}{gy}\right)^{0.14} y$$ ⟶ D_{50} = _____ m **MEDIAN RIPRAP STONE DIAMETER** (Equation 81, Page 112 HEC #18)

$T = 1.5D_{50}$ ⟶ T = _____ m RIPRAP THICKNESS

RIPRAP PLACEMENT AT BRIDGE SECTIONS FOR VERTICAL AND SPILLTHROUGH ABUTMENTS