OFFICE OF BRIDGE DEVELOPMENT
MANUAL ON HYDROLOGIC AND HYDRAULIC DESIGN
CHAPTER 3

APPENDIX A
CHECKLIST FOR PREPARATION OF H&H REPORTS

SEPTEMBER 2007

CHECKLISTS FOR PREPARATION OF H&H REPORTS

The Office of Bridge Development has developed the following checklists of those items that should normally be considered in the development of H&H Reports submitted for review and approval. Report preparers are encouraged to review these checklists, and to address those items that are pertinent to the report that they are preparing for the SHA review.

TABLE OF CONTENTS

A standard table of contents is recommended for all H&H reports. If necessary, it can be modified to accommodate special features of a report. The format for a typical table of contents is listed below:

Table of Contents of items contained in the report
List of Appendices
List of Figures
List of Tables
Executive Summary

HYDROLOGY REPORT

The Maryland State Highway Administration and the Maryland Department of the Environment have jointly adopted a methodology for the analysis of flood peaks and hydrographs in Maryland. The methodology was developed for the State by a Hydrology Panel comprised of State, Federal, Consultant and University personnel with special expertise in the field of hydrology. The report of this panel is entitled "Application of Hydrologic Methods in Maryland." The report is being continuously updated as new information is evaluated and included in the methodology.

Application of the methodology developed by the panel requires the use of a computer program entitled "GISHydro 2000." This computer program is also being continuously revised to incorporate improved methods of hydrologic analysis.

Additional guidance on hydrologic analysis in included in Chapter 8, Hydrology.

Hydrology reports submitted to the SHA should describe the necessary input information to run the program, and all pertinent output information provided by the program. Engineers preparing

hydrology reports are expected to be familiar with the Panel Report and the GIS Hydro Program. Most of the guidance for technical hydrologic analysis is provided by these references. However, hydrologic analysis remains as much an art as a science, and the various judgments and decisions used to develop the hydrologic estimates need to be explained in the hydrology reports submitted for review.

In some cases, the project may fall within the boundaries of a Federal Emergency Management Agency (FEMA) flood study, and the FEMA discharges will need to be used in the hydraulic analysis to satisfy Federal requirements. (The GIS Hydro methodology is still necessary to satisfy State requirements.)FEMA is responsible for managing the National Flood Insurance Program. The agency has conducted flood studies throughout Maryland for purposes of limiting development on flood plains. Property owners within communities that are in compliance with the FEMA regulations are eligible for flood insurance. FEMA establishes limits on flood plain development for new studies, and maintains control over the development on flood plains where studies have been completed.

If a highway project affects a FEMA flood study, the SHA is required to prepare studies to show that (1) the project is consistent with the regulations of FEMA and (2) the project is consistent with the State regulations discussed in Section 8.3 of Chapter 8. FEMA is concerned with flood flows based on existing conditions in the watershed, and therefore has different standards than the State which estimates flood flows based on ultimate development in the watershed. It has been the experience of the SHA that, in general, the State requirements are more restrictive than the FEMA requirements, but this may not always the case.

Procedures for addressing the requirements of FEMA are set forth in Chapter 4 of this manual. Typically, the FEMA flood discharges are used to evaluate the effect of the highway project on the flood elevations established by FEMA. If the hydrology evaluations indicate that the FEMA flood estimates have significant errors, however, additional work may be required to revise the FEMA flood plain boundaries and water surface elevations.

The following check list should be consulted when preparing the format and content of the hydrology report.

If pertinent information is not included as a part of the GIS Hydro input/output, then it should be added to the hydrology report. However, there is no need to duplicate information already included in the text as input/output from the GIS Hydro 2000 program.

1. Introduction

- 1.1 Objectives
- 1.2 Project Description
- 1.3 Stream Classification (including restrictions

on in-stream construction)
1.4 Roadway Classification and Design Flood
1.5 Wetlands
1.6 Previous Studies
1.7 GISHydro 2000 Program

2. Watershed Description

2.1 Location and Size
2.2 Runoff Curve Number
2.2.1 Existing Development Conditions*
2.2.2 Pre-Urban Development Conditions*
2.2.3 Ultimate Development Conditions*
*include storm drain network where appropriate
2.3 Soils
2.4 Physiographic Features
2.5 Hydraulic Structures (including publicly owned SWM)
2.6 Wetlands
2.7 Other Significant Features

3. Hydrologic Analysis

3.1 Fixed Region Regression Equations
3.1.1 Existing Development Conditions
3.1.2 Other Hydrologic Methods
3.2 TR-20 Method
3.2.1 Drainage Area
3.2.2 Runoff Curve Number.
3.2.3 Time of Concentration
3.2.4 Rainfall Duration and Distribution (See Section 3.4 below)
3.2.5 TR-20 Reach Routing
3.2.6 TR-20 Model/Watershed subdivisions
3.2.7 Description of unit hydrograph
3.3 FEMA Studies
3.3.1 FEMA Flood Discharges
3.3.2 Verification/Evaluation of FEMA Discharges
3.4 Rainfall data

NOAA Atlas 14 should be used for rainfall data. Please note that the NOAA site coordinates are in decimals, not in minutes and seconds. If you use GIS-Hydro's MD state plane coordinates and convert them to northing and easting coordinates you are going to get a number in degrees, minutes and seconds. However, you need to convert minutes and seconds to decimals in order to obtain the new rainfall data from NOAA Atlas 14. (Example:76 25′38′′ = 76.4272.) Please include your site coordinates in the discussion of rainfall in the text portion of your reports.

4. Evaluation of Results.

4.1 Pre-Urban Development Conditions

4.2 Ultimate Development Conditions

4.3 Table and Chart of Flood Frequency-Discharge Values

4.4 Qualitative and quantitative evaluation

4.5 Comparison with results of other studies

4.6 Flood frequency plots for existing conditions depicting a) TR-20 analysis b) Regression Equation analysis and c) Selected Flood Frequency Plot developed as per the guidelines in "Application of Hydrologic Methods in Maryland". Include plot of bankfull flow discharge.

4.7 Flood frequency plot for Condition of Ultimate Development.

5. Recommendations

5.1 Basis for Acceptance of Estimated Flood Discharges

5.2 Permits/Approvals

6. References and Correspondence

7. Appendices

7.1 GISHydro 2000 Input/Output Tables and Diskettes

7.2 Diskette containing the text of the Hydrology Report

7.3 Culvert analysis (for flood routings)

1. Methodology (FHWA Charts, HY-8, etc.)
2. Structure data
3. Estimation of tailwater depth
4. Inlet/outlet control computations
5. Entrance and exit conditions
6. Manning's "n" values (including computations)
7. Rating curves (computations and plots)
   a. Elevation vs. cross-sectional area
   b. Elevation vs. discharge
   c. Elevation vs. storage volume

8.0 MAPS/EXHIBITS

Maps should show north direction, scale, legend, title and SHA contract number, and be placed at an appropriate section in the report. For example, vicinity and location maps should be included in the Introduction. Many of the features below can be accessed and printed from GISHydro 2000.

8.1 Vicinity and location maps
8.2 Drainage area map
8.3 Existing land use map
8.4 Zoning map
8.5 Soils map
8.6 Time(s) of concentration path map
8.7 Topographic maps
8.8 TR-20 schematics (pre- and post-construction conditions with existing and ultimate development summary data)
8.9 Cross-sectional plots obtained from field measurements.)
8.10 Floodplain maps (FEMA, etc.)
8.11 Pre- and Post-construction conditions maps (roadway and/or structures)
8.12 Wetlands map
8.13 Forest cover map
8.14 Dated color photographs of structures (including upstream and downstream faces), stream channels, overland flow areas, unusual conditions, etc
These maps and exhibits may be separate or combined as long as the required information is clearly distinguishable.

9.0 HYDROLOGIC DATA ON H&H PLAN SHEET

9.1 Hydrologic Data
I. Source list title of report
II Drainage Area
III Methods of Analysis - identify all methods of analysis including any flood routing procedures
IV Provide computed flood discharges, based on existing and ultimate development methodologies
V Historic Floods - include all significant historic floods which have occurred in the watershed.
VII Complete Section 7 if the waterway is subject to tidal influence. If tidal flows govern for the design discharge, make sure that this condition is clearly identified in this section.
VIII Comments make a note of any special or unusual features affecting the hydrology of the watershed or of the methodology used in the flood estimates

9.2 Hydraulic Data
II Hydraulic Data - Identify the design flood, 100-year flood and other floods (Q-500, overtopping flood) of significance in the design
III Bridge Scour Data - Identify design flood for scour and check flood for scour.

CHAPTER 14 STREAM MORPHOLOGY AND CHANNEL CROSSING REPORT

A preliminary stream morphology report is to be prepared for each project involving a structure over a waterway. If the preliminary study indicates a need for further study, a detailed stream morphology study may be prepared. Key issues involved in the morphology evaluation include:

- The effect of the stream on the structure,
- The effect of the structure on the stream,
- The impacts and benefits of the project on the stream and its flood plain.

Guidance on the preparation of these reports is presented in Chapter 14. An outline of factors to consider and methods of analyses is presented below.

ELEMENTS OF STREAM MORPHOLOGY STUDIES

1. Existing Crossing
2. Long-Term Changes in Channel Bed Elevation
3. Channel Lateral Movement
4. Sediment Dynamics
5. Debris
6. Structure and Bend Scour
7. Environmental Considerations
8. Historic and Contemporary Modifications to Channels and Valleys

Preliminary Morphology Study

BACKGROUND DATA COLLECTION

Existing Land-Use and Existing and Ultimate Hydrology
Bankfull Flow and Channel Geometry Estimates
Physiographic Region and Geology of Site
Historic and Contemporary Modifications to Channels and

Valleys
Valley and Channel Planform Characteristics

VISUAL ASSESSMENT

Summary of Field Procedures
- *Equipment and Mapping*
- *Photographic Documentation*
- *Organization of the Visual Assessment*

Key Features and Observations
- *Existing Crossing*
- *Channel Classification at the Crossing*
- *Base Level Points*
- *Low-Flow High-Gradient Features*
- *Stream Banks*
- *Pools*
- *Bars, Riffles, and Surface Particle-Size Characteristics*
- *Debris*
- *Channel Confluences and Tributaries*
- *Other Structures and Flow Obstructions*
- *Terraces, the Active Floodplain, and Other Valley Bottom Features*
- *Channel-Valley Orientation and Channel Planform*

RAPID CHANNEL MEASUREMENTS

Pebble Count
Bulk Bar Sample
Soil and Bed Load Materials for Scour Studies
Potential for Long-Term Degradation
- *Cumulative Degradation Method*
- *Pool Base Level Method*

ANALYSIS AND DEVELOPMENT OF RECOMMENDATIONS

Development of the Scope of the Detailed Study Scope (where Recommended)

Detailed Morphology Study

PRELIMINARY STUDY REVIEW AND SITE RE-EXAMINATION
Development of the Detailed Study Scope
- *Extent of the Channel Profile Survey*
- *Sediment Assessment Reach*
- *Lateral Channel Movement*

Preliminary Assessment of Structure Alternatives

Provide information on the types of structures that fit the Alternative

1. Describe combinations of structure types and stream channel alignments that best fit the crossing location. Provide justification for selection of preferred structure/stream channel alternative.

Hydrologic and Hydraulic Data Sheet

Part IV of the Hydrologic Data Section provides for a summary of stream morphology, using the Rosgen Classification System. All items should be filled in. Also, Part VII, Comments provides space for additional comments if there are significant stream morphology issues to be addressed in the design of the structure.

HYDRAULIC REPORT

In some cases, a report combining the hydrology report and /or the geotechnical report with the hydraulic report under one cover. For such reports, there will still be a need to summarize the hydrologic and geomorphological information in the hydraulic report. However, the summary sections can be abbreviated through the use of page references to the other reports.

I. INTRODUCTION

A. Objective

B. Description of project

C. Functional classification of roadway and design criteria, including maximum allowable headwater

D. DNR/MDE stream classifications (including restrictions on in-stream construction

E. Historic data and evaluation of reliability (high water marks, etc.)

F. Other hydraulic control structures (both upstream and downstream) and their effect on long term channel response.

G. FEMA-established water-surface elevations

H. Frequency and magnitude of the incipient overtopping flood and the magnitude of the 500-year flood

I. Previous studies (including discussion of results)

J. Reference datum (NGVD, etc.) for elevations

L. Hydrology (source, date, methodology used; magnitude and frequency of peak flood discharges including the incipient overtopping flood for condition of ultimate development; status of approval by MDE);use of hydrographs to develop flood routing studies.)

M. Methodologies/Scope of work (Type and extent of work to be accomplished; methodologies (HEC-RAS, etc,) used to carry out the study. Methodologies and concept must be approved by the SHA prior to commencement of the study)

O. Calibration of the computer models with known (reliable) high water marks.

P. Brief summary of Stream Geomorphology Report, including preferred (preliminary)Structure/Stream Channel alternative

II. ANALYSIS

A. Overview of Stream Reach

- Describe the stream reaches upstream and downstream of the crossing site and include photographs depicting representative sections. Include information regarding the length of the upstream and downstream reaches and the reasons for selecting the stream reach limits.
- Describe the flood plains with regard to width, vegetative cover (grass, shrubs, evergreen, deciduous or mixed forest) roughness (n) values, presence or lack of an active flood plain, location of the channel within the channel, and existing development.
- Describe the stream channel as to width, type of channel, existing features such as riffles, pools, point bars, utility crossings, existing and potential erosion, meander patterns, existing channel capacity and orientation with the bridge at the crossing site.
- Tie in the above descriptions and photographs of representative channel and flood plain characteristics to cross-section locations. Summarize information regarding the cross-sections including the number upstream and downstream and the average spacing between upstream and downstream cross-sections.

B. Modeling Methodology*

- Software used must be up-to-date. Report the model version/description and date for all software used.
- HEC-RAS is the standard SHA method for developing water surface profiles.
- Other software may be used for some applications with prior SHA approval:

    - HEC-2 for analysis of some FEMA models
    - FHWA FESWMS-2DH for complex sites such as wide flood plains where a 1-D model would be inadequate
    - FHWA HY-8 Culvert Program for analysis of complex culverts (Use HEC-RAS to establish tailwater elevations at the crossing and to extend the water surface profile above the crossing site)
    - Physical (lab) models for special locations where existing methodologies are inadequate, i.e. hydraulic lab studies of Woodrow Wilson complex piers to improve estimates of scour depths.

C. Methodology for starting water-surface elevations can be based on one of the following approaches:

1. Use known water-surface elevations when information is reliable. Develop a rating curve from the data.
2. Use a downstream control point to develop a rating curve.
3. Normal Depth Computations. Perform a boundary condition sensitivity analysis by first estimating the slope for normal depth computations. The water-surface elevations generated should then be analyzed in the model as known WSEL's. Increase these depths by one foot and rerun the analysis. Compare tailwater elevations at the structure to be modeled to ensure profile convergence. Extend the model downstream if tailwater elevations do not remain constant.

4. Complex situations, such as a crossing just upstream of a confluence, may require consideration of varying starting water-surface elevations:

a. Lower downstream elevations to compute velocities for estimating scour potential

b. Higher downstream elevations to compute flood elevations

D. Discussion of the reach of stream to be studied
   1. length,
   2. number of cross-sections and how developed (survey vs. photogrammetry, etc.)

E. Manning's "n" values

1. Describe channel and overbanks for all reaches (supported by dated color photographs)
2. Selection of reasonable values depends in part on the knowledge and experience of Engineer; Make estimates based on summertime conditions
3. Guidelines:
   - Ven Te Chow, 1959, Open Channel Hydraulics. McGraw Hill Book Company, NY NY
   - Roughness Characteristics of natural Channels, USGS Water Supply Paper 1849
   - Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains, FHWA-TS-84-204, April, 1984 Tables of Manning's "n" values included in HEC-RAS which can be used for comparative purposes.
   - Maryland Stream Survey Reports for bankfull flows.
4. The Engineer is encouraged to consider the use of the procedures in the FHWA manual referenced above (Cowan's method for channels and a variation of Cowan's method for flood plains)to estimate "n" values. However, there is a potential for the Engineer to overestimate roughness values unless care is taken in its application.

F. Structure Details

All structures modeled should be provided with the following details (including dimensions):

1. Location
2. Type of structure, listed in order of preference

   a. Pipe culvert
   b. Steel pipe arch culvert
   c. Concrete box culvert/rigid frame
   d. Bridges and bottomless arch structures
   e. Other

3. Waterway opening
   a. Shape (include piers and abutments)
   b. Cross-sectional area
   c. Dimensions

d. Low chord profile
e. Location of guide banks (if present)

4. Length (between upstream and downstream faces)
5. Upstream and downstream invert elevations
6. Size, shape, and nose conditions of piers and foundations
7. Culvert entrance and outlet conditions (beveled headwall, wingwalls, riprap aprons and basins, etc.)
8. Silt condition within the structure (for culverts)
9. Road and watershed divide profile(s) including low point(s) of road and watershed overflow)
10. Parapets (how are they modeled?)
    a. Type (grooved, open rail, solid wall, etc.)
    b. Height and extent
11. Median barriers, existing and proposed
12. Skew angle
13. Any other conditions

G. Hydraulic Modeling Selections and Coefficients
1. Bridge and culvert entrance and exit loss coefficients
2. Pier coefficients
3. Weir coefficients and overtopping flow computations
4. Adjustments for pressure flow
5. Justify selection of Modeling Option:
   Low Flow Condition: Momentum (include drag Cd), Energy and Yarnell (include pier K,
   High Flow Condition: Energy or Pressure/weir flow
6. Method of analysis for multiple openings (conveyance, bridge, culvert)

H. Approach Roads
1. Typical roadway cross-sections
2. Road and structure profiles
3. limits of fill and cut slopes in flood plain

I. Channels:
Summarize information on selected channel alternative recommended in Geomorphology Report and status of approval

III FINDINGS AND CONCLUSIONS

Prepare a brief discussion summarizing the results of the hydraulic studies including:

A. Pre-construction Conditions (ultimate runoff)

B. Post-construction conditions (ultimate runoff)

Please note that some studies may not require results from all four conditions listed above. Please check with SHA as to the required information.

In the summary report discussion, address the following as appropriate:

A. Validity and accuracy of starting water-Surface elevations

B. Detailed description and justification of various special modeling techniques, such as bridge modeling, split flow analyses, flow around islands, consideration of ineffective flow areas, roadway overflows and any iterative procedures used.

C. Qualitative and quantitative evaluation of results

D. Effect of project on floodwater levels (especially in regard to flood plains in the National Flood Plain Insurance Program administered by FEMA)

E. Effects on properties, particularly sensitive land use areas such as 4-f properties.

F. Loss/gain of flood storage volume and its effect on downstream discharges.

G. Right-of-way considerations, if additional ROW is required.

H. Listing of all permits required for the project including time restrictions, if any.

I. Froude numbers for the 100-year flood (pre and post construction)

J. Shear Stress values for the 2-year and 10-year floods (pre and post construction)

K. Discussion of protection of culvert inlets and outlets (See information regarding the scour report)

IV. REFERENCES

All references used to prepare the study should be identified with source, title, and date of publication for the following:

A. Methodology

B. Computer program(s)

C. Charts

D. Tables

E. Graphs

F. FEMA study

G. Gage data

H. Topographic maps

I. High water marks

J. Previous studies

K. Text books

L. Technical publications

M. Correspondence

N. Other

V. DOCUMENTATION

Project records need to contain the following information when it is applicable to the project. If this information is not presented in the body of the Hydraulic Report, it should be included in appendices to the Hydraulic Report.

A. Input data to the hydraulic model

1. Discharges with corresponding locations on stream
2. Manning's "n" values (including photographs)
3. Contraction and expansion loss coefficients
4. Known water-surface elevations (if any)
5. Starting water-surface elevations
6. Calibration with known water-surface elevations
7. Cross-sections (indicate if they are from survey or from a previous study. If surveyed, indicate survey documentation.
8. Computations for development of structure models

B. Hydraulic parameters comparison tables (pre- and post-construction conditions) Use a comparison table format to present data.

1. Water-surface and energy grade elevations
2. Stream channel velocity
3. Shear stress at channel bottom (2-year and 10-year floods when required)
4. Floodplain top width (including effective flow top width wherever used)
5. Stream channel Froude Numbers for 100-year flood.

C. FHWA culvert analyses (FHWA Program HY-8)

1. Estimation of tailwater depth

a. Cross-sections used
b. Roughness parameters (including computations)

2. Inlet/outlet control computations
3. Entrance conditions: Consider the use beveled edges on all culverts to minimize entrance losses.
4. Hand computations (if any)
5. Input and detailed output data from HY-8

D. Cross-sectional plots

Cross-sections used in the hydraulic model should be plotted, preferably at a scale of 1" = 20'. For some projects, this scale may not be practical and a scale in the range of 1" =50' may be needed). Depict the following on the cross-sections:

1. Water surface elevations (pre- and post-construction) for the 2-year, 10-year, 100-year,500-year overtopping and design floods
2. Manning's "n" values and ineffective areas
3. Channel stations & survey base line (should have GR station as 1,000 for all cross-sections)
4. Low flow channel
5. Low chord and roadway profiles (at bridges)
6. Channel modifications and relocations
7. Cross-sections at culverts and bridge structures may need to be plotted at a scale of 1" = 10' so that low flow channel for fish passage can be clearly shown. Reduced plots of cross-sections should also be submitted on 17"x 11" sheets.

E. Floodplain delineation on topographic maps

1. Pre- construction conditions
2. Post- construction conditions

These maps should identify all the cross-sections used in the hydraulic models. The following information should be clearly shown on these maps:

1. 100-year flood plain limits based on ultimate development conditions in the flood plain (100-year and 500-year floodplain limits also need to be plotted for FEMA studies)
2. Base line (should have GR station as 1,000 for all cross-sections)A possible exception may apply to GEO-RAS application
3. Segmental "n" values on cross-sections
4. Ineffective flow areas
5. Existing and Proposed Structures
6. Identification of Roadways and waterways

7. Identification of improved properties in the 100-year floodplain

    a. Elevation where water enters first
    b. Elevation where water enters first floor

    If the proposed construction increases the 100-year floodplain elevations, the improved properties in the additional flooding area also should be shown with the above elevations.

F. Water-surface profiles

The stream thalweg and the water-surface profiles for various storm events (including for overtopping and design floods) should be plotted, for both pre- and post- construction conditions. This profile plot should also show the following information:

1. Structures (maximum low chord and minimum roadway sag elevations)
2. For FEMA studies, FEMA-established base flood and floodway elevations upstream of the proposed structure)
3. Tributary confluences
4. Dams (crest elevation and top and bottom widths)
5. Structure bottom profile (if buried)
6. Cross-sections' location
7. Identification of roadways, and dams, etc. by names
8. Reference point for the channel distance

G. Cost comparison

Preliminary costs of each proposed alternative structure should be estimated based on the following costs (Costs should be submitted to SHA as a separate submittal):

1. Structural (including headwalls and wingwalls)
2. Environmental (including wetlands, baffles, etc.)
3. Channel and bank protection (including riprap, stream restoration and enhancement, etc.)
4. Scour protection (See Scour Report)
5. Channel modifications and/or relocations
6. Embankment, etc.

H. Detailed computer input and output listings

Comment should be provided, rather liberally, to explain various aspects of the input models, such as the following:

1. Bridge cross-sections

2. Modifications to pre-construction cross-sections sections due to the proposed construction
3. Changes in discharge values due to tributary confluences
4. Embankment encroachments onto the flood plain
5. Inclusion of additional hydraulic losses
6. Cross-sections field-surveyed or derived partially from the topographic maps
7. Location (over a dam crest, inside a culvert, etc.)
8. References (for example, starting water-surface elevations, if taken from a previous study)

The detailed output listings should be provided for selected floods, typically the 2,10, and 100-year floods along with the design year and incipient overtopping floods. All the listings should be clearly identified and should contain the flow distribution at all cross-sections.

I Insert a Compact Disk (CD) in the project Hydraulic Report. The following information is to be included on the CD as appropriate:

1. The entire text of the Hydraulic report, the Geotechnical Report and their respective appendices,
2. Input and output data and tables for all water surface profile runs
3. Information and model studies pertaining to studies developed to meet FEMA requirements
4. Correspondence with other agencies directly related to the development or review and approval of the hydraulic report.
5. Information pertaining to the preparation and approval of necessary permits or of measures taken to comply with environmental requirements

VIII HYDROLOGY AND HYDRAULIC DATA (H&H) SHEET

Complete the H&H Sheet to summarize the results of the hydraulic study and analysis:

I. Hydraulic data of waterway area, energy slope, water surface elevations and discharges, velocities and depths for the channel and overbank areas, overtopping flows, etc.
II Roadway and Structure Data
III Survey Book Documentation
IV Flood Plain Management Data
V Comments of interest regarding the hydraulic aspects of the design.

SCOUR EVALUATION REPORT

A scour evaluation report is to be prepared for every project of the Office of Bridge Development involving a structure over a stream. Separate reports should be submitted for bridges and bottomless arch culverts. Scour reports for culverts be included in the hydraulic report.

The following guidance applies to the preparation of scour reports:

Culverts

The format for the scour evaluation is typically limited to addressing a few basic concerns for pipe, pipe arch and box culverts, and can be included in the hydraulic report. The information of interest for these structures is the design of the endwalls (wingwalls, cutoff walls with a minimum depth of 3 feet, etc.) and the scour protection at the inlet and outlet ends of the culvert. The riprap protection typically consists of a pad on the order of 25 feet or more with a D50 sized to resist the scouring force of the converging flow at the inlet and the concentrated flow at the outlet. For high outlet velocities or for degrading downstream channels, additional energy dissipation and stream stability measures may be required. Guidelines on culvert outlet designs, such as riprap basins, are presented in Chapter 13 Culverts. The extent of analysis of outlet protection should be commensurate with the degree of risk of failure of the structure and the potential for degradation of the downstream channel. Additional stability studies may be needed for locations where overtopping flows have the potential to damage the embankment fill and threaten the destruction of the entire pipe installation. Countermeasures for such locations include selection of the type of structure to resist damage and riprap slope protection in the vicinity of the pipe.

Inlets for metal pipe and pipe arch structures need to be anchored to prevent uplift of the inlet section during periods of pressure flow.

The summary section for culvert scour evaluations should address the following, as appropriate:

- Culvert analysis including outlet velocities for the design flood and the overtopping flood
- Design of culvert entrances and outlets (types of endwalls and cutoff walls)
- Transition sections at culvert inlets and outlets; need for riprap protection
- Computation of D50 size to resist scour for the design flow
- Special riprap designs required for outlet protection and stream stabilization measures

- Designs for uplift protection of metal pipe inlets
- Risk assessment of potential for embankment and culvert failure for overtopping flows

Culverts supported on footings, such as steel arch or concrete "bottomless culverts" are to be treated as bridges for purposes of scour evaluation, as discussed in the Bridge Section below:

Bridges

Scour Evaluation Reports for bridges and bottomless culverts are to be prepared in accordance with the detailed guidance in Chapter 11, Evaluating Scour at Bridges.

- Preparation of the scour report is accomplished through an interdisciplinary effort of hydraulic, geotechnical and structural engineers.
- The ABSCOUR Program is used to estimate contraction, abutment and pier scour. The ABSCOUR output report is to be included in the scour report. The guidance in the ABSCOUR Users Manual (Appendix A of Chapter 11) is to be followed in obtaining input data and in evaluating the scour results.
- The engineers conducting a scour evaluation need to be familiar with the information in Chapter 11, and in particular with the guidance in Appendix A of Chapter 11, the User's Manual for the ABSCOUR Program.
- For bottomless culverts, the guidance in Chapter 11, Appendix C is to be used in addition to the other guidance in Chapter 11 to develop the scour evaluation procedure.

- If rock is present, special procedures are to be used to evaluate the resistance to scour of the rock as explained in the ABSCOUR Users Manual, Appendix A of Chapter 11. This should include an evaluation of the rock by SHA personnel in the Office of Materials and Technology
- Since there are many factors involved in the scour evaluation that cannot be precisely defined, engineering judgment is necessary in arriving at a reasonable estimate of scour depths. These judgments need to be documented in the scour report.
- Engineers should not accept the scour estimate provided by the ABSCOUR Program, until the various factors affecting scour have been evaluated and determined to be reasonable. The ABSCOUR Program can be used to conduct sensitivity analyses of these various factors.
- Consideration is to be given to the findings of the stream morphology report in regard to the potential for channel degradation, lateral channel movement, accumulation of debris and sediment transport.

Format for Scour Reports

The format for the Scour Evaluation Report should be consistent with the format below, excerpted from the report section of Chapter 11, "Evaluating Scour at Bridges". Consult Chapter 11 for guidance on what is to be included in each of these sections.

11.6 Bridge Scour Evaluation Studies and Reports

11.6.1 General

11.6.2 Introduction and Background

11.6.3 Scope of Study

11.6.4 Summary and Recommendations

11.6.5 Hydrology Study

11.6.6 Site Investigation

11.6.7 Stream Classification, Morphology and Stability Study

11.6.8 Subsurface Study of Underlying Soils and Rock

11.6.9 Type, Size and Location of the Bridge (TS&L)

11.6.10 Approach Roadways

11.6.11 Hydraulic Study

11.6.12 Scour Evaluation; Development of the Bridge Scour Cross-section.

11.6.13 Significance of the Scour Evaluation

11.6.14 Structural and Geotechnical Design Considerations

11.6.15 Scour Countermeasures

11.6.16 Appendices

11.6.17 Documentation

REFERENCES

For further references to items on the check list, please consult the individual chapters in the manual addressing the item of interest.