OFFICE OF STRUCTURES
MANUAL ON HYDROLOGIC AND HYDRAULIC DESIGN

CHAPTER 3 Appendix A

CHECKLISTS FOR PREPARATION OF H&H REPORTS

April 28, 2016

(Some minor editing will be performed at a later date)

Table of Contents

3A.1 Introduction

The Office of Structures has developed the following checklists to serve as an all-inclusive list of those items to be considered in the development of H&H Reports submitted for review and approval. The term H&H Report is used as a convenient title for various studies and reports submitted during the project development phase including those pertaining to hydrology, hydraulics, stream morphology, and scour evaluation. The checklists present the methodologies, format and documentation to be used in the preparation of the reports.

The engineer is to use the check lists to assure that the appropriate topics for each project have been included and addressed. Please be aware of the sequence and time schedules for preparing reports as set forth in Chapter 3 Policies and Procedures, and in Chapter 5 Project Development.

In some cases, when approved by the Office of Structures, it may be appropriate to prepare a report combining the hydrology report, the geotechnical report and the hydraulic report under one cover. For such reports, a summary of the hydrologic and geomorphologic information will need to be included in the hydraulic report. However, the summary sections can be abbreviated through the use of page references to the other reports. Please also note that there may be a duplication of the same item in different checklists, depending on the particular concern to be addressed. Such duplication in the various reports can be minimized by referencing the initial study in other subsequent checklists.

3A.2 Standard Table of Contents

A standard table of contents is required 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:

Executive Summary
List of Report Chapters and Sub-Chapters
List of Figures
List of Tables
List of Appendices

3A.3 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 latest report of this panel is entitled "Application of Hydrologic Methods in Maryland". The report is available at http://www.gishydro.eng.umd.edu. It is updated periodically as new information or procedures are evaluated and approved. Application of the methodology developed by the panel normally requires the use of the latest approved version of GISHydro. This computer program is also periodically revised to incorporate improved methods of hydrologic analysis. Additional guidance on hydrologic analysis in included in Chapter 8, Hydrology.

The Office of Structures Policy for hydrologic design is summarized below:

Structures and their approach roadways shall, as a minimum, be designed for the passage of the design year flood (based on ultimate development in the watershed) in accordance with the information in Table 1. Designs for a higher recurrence interval flood may be used where justified to reduce the flood hazard to traffic or to adjacent properties. A design exception will be necessary in order to design for a flood with a lower recurrence interval than those listed in Table 1:

Table 1 Recurrence Interval for Design Flood

Highway Classification * (See Highway Location Manual)	**Recurrence Interval for Design Flood (years)**
Interstate, other Freeways and Expressways, and Rural, Urban and Other Principal Arterials	100
Intermediate and Minor Arterials	50
Major and Minor Collectors	25
Local Streets	10

* Interstate, Freeway, Expressway and Arterial ramps and frontage roads should be assigned a design flood recurrence interval consistent with the crossroad being serviced by the ramps and frontage roads; however, the hydraulic design of ramp structures must not interfere with or compromise the designs of the structures carrying the higher class traffic lanes.

Hydrology reports involving computer programs 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 latest version of GISHydro. 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 GISHydro 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. Procedures for addressing the requirements of FEMA are set forth in Chapter 5 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 and hydraulic 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 Office of Structures has developed the following checklist to serve as an all-inclusive list of those items to be considered in the development of Hydrologic Reports submitted for review and approval. If pertinent information is not included as a part of the GISHydro 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 latest GISHydro program.

Cover Page
- Title of report
- Person or Agency preparing the report
- Structure/Bridge Number
- FMIS Number
- Study location including County
- Date

Executive Summary

1 Introduction
- 1.1 Objectives
- 1.2 Project Description
- 1.3 Stream Classification (including restrictions on in-stream construction)
- 1.4 Roadway Classification, AADT and Design Flood
- 1.5 Hydrologic software used in the study
- 1.6 Flooding History
- 1.7 Previous Studies
- 1.8 FEMA Studies
  - 1.8.1 FEMA Flood Discharges
  - 1.8.2 Evaluation of FEMA Discharges
- 1.9 Stream Morphology
- 1.10 Wetlands

2 Watershed Description
- 2.1 Location (County, Physiographic Province), size, and shape;
- 2.2 Runoff Curve Number
  - 2.2.1 Existing Development Conditions
  - 2.2.2 Ultimate Development Conditions
- 2.3 Soils- Hydrologic Conditions
- 2.4 Hydraulic Structures (including publicly owned SWM facilities, dams or flow diversion structures)
- 2.5 Other Significant Features affecting hydrology i.e. Karst (limestone) regions

3 Hydrologic Analysis (using latest version of GISHydro)
- 3.1 Statistical analyses (Tasker, gage analysis); any other methods used
- 3.2 WinTR-20 (TR-20)
  - 3.2.1 Drainage Areas/Subareas
  - 3.2.2 Time of Concentration
  - 3.2.3 Rainfall Duration and Distribution (NOAA Atlas 14)
  - 3.2.4 Reach Routing
  - 3.2.5 Storage Routing
  - 3.2.6 Selection of dimensionless unit hydrograph
  - 3.2.7 Calibration of Results

3.3 Low Flow Hydrologic Studies for Use in Evaluating Passage of Fish and Aquatic Organisms (AOP).

4 Evaluation of Results: Findings and Recommendations
- 4.1 Existing Development Conditions
- 4.2 Ultimate Development Conditions
- 4.3 Comparison with results of other studies (FEMA, etc.,)
- 4.4 Discussion of Major Flood Events in the past.
- 4.5 Basis for Acceptance of Estimated Flood Discharges
- 4.6 Permits/Approvals

5 References and Correspondence

6 Appendices
- 6.1 Appendix A - GISHydro Outputs
  - 6.1.1 Existing Development Conditions
    - 6.1.1.1 Basin Statistics
    - 6.1.1.2 Basin composition (RCN values)
    - 6.1.1.3 Regression equations and Tasker Analysis
  - 6.1.2 Ultimate Development condition
    - 6.1.2.1 Basin statistics
    - 6.1.2.2 Basin composition (RCN's)
- 6.2 Appendix B – Single area and subdivided watershed TC computations and TC path map
- 6.3 Appendix C – Flood routing (if required)
  - 6.3.1 Reach routing with all supporting data and studies
  - 6.3.2 Reservoir routing
- 6.4 Appendix D – Single Area Watershed
  - 6.4.1 Existing Development Conditions
  - 6.4.2 Ultimate Development Conditions
  - 6.4.3 TR-20 Model Printouts
- 6.5 Appendix E – Subdivided Watershed
  - 6.5.1 Existing Development Conditions
  - 6.5.2 Ultimate Development Conditions
  - 6.5.3 TR-20 Model Printouts
- 6.6 Appendix F – Hydrology Panel Discussions and Recommendations
  - 6.6.1 Flood Frequency Curves
  - 6.6.2 Dimensionless Hydrograph used
- 6.7 Appendix G – CD containing the text of the Hydrology Report (MS Word *.docx files and PDF along with all maps, photos, exhibits, figures and tables.

7 Maps, Photos, and 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 the latest GISHydro version.

- 7.1 Vicinity Map - Use 1:2000 scale
- 7.2 Location Map - Use 1 inch = 6 miles
- 7.3 Photo – Looking at upstream face of bridge
- 7.4 Photo- Looking at downstream face of bridge
- 7.5 Photo – Stream channel approaching upstream face of bridge

7.6 Photo – Stream channel downstream of bridge
7.7 Photo – Roadway profile looking left of bridge
7.8 Photo – Roadway profile looking right of bridge
7.9 Wetland Map
7.10 FEMA Flood Insurance Rate Map
7.11 Drainage Area Map (Subdivided or Single)
7.12 Existing Conditions Land Use Map
7.13 Ultimate Conditions Land Use Map
7.14 Most Recent Zoning Map
7.15 Soils Distribution Map
7.16 TC Flow path Map
7.17 Tables as necessary to summarize, explain and illustrate the information in the Hydrology Report

3A.4 Stream Morphology 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 preliminary and detailed stream morphology reports is presented in the following sections of this chapter. (Please note that the information in Chapter 14 of the H&H Manual entitled 'Stream Morphology" no longer reflects current SHA guidance on developing stream morphology studies. Chapter 14 has been retained for its extensive background information and its general discussion of the scope of stream morphology studies).

3A.4.1 Elements of Stream Morphology Studies

- Existing Crossing
- Long-Term Changes in Channel Bed Elevation
- Channel Lateral Movement
- Sediment Supply and Mobility
- Debris
- Structure and Bend Scour
- Environmental Considerations (fish and AOP passage, wetlands, forests, etc.,
- Historic and Contemporary Modifications to Channels and Valleys.
- Chesapeake Bay critical areas
- Integration of stream morphology findings into recommendations for structure type and size.

3A.4.2 Types of Studies

A preliminary morphology study will often serve to answer the most significant issues regarding the effects of highway construction on a stream and the likely consequences of the stream on the highway structure and to answer the question if a detailed study is required. If the detailed study is needed, determine its scope.

However, in some cases, a more detailed study may be necessary to evaluate complex site conditions or to obtain information for channel design. A detailed study is only conducted when approved by the Office of Structures.

If a detailed study is not conducted, an enhanced preliminary morphology study will normally be required to obtain additional information as described in subsection 3A.4.2.1.

Guidance on the preparation of stream morphology reports for studies on minor projects on state and county secondary road systems is presented in Chapter 11, Appendix G

The Office of Structures is not involved in channel restoration projects; accordingly, studies for this type of work are not addressed in this chapter.

3A.4.2.1 Outline of a Preliminary Morphology Study

1. Background Data Collection
   - Existing Development Conditions 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

2. 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
     - Low-Flow High-Gradient Features
     - Stream Banks
     - Pools
     - Bars, Riffles, Head cuts, Debris Potential
     - Surface Particle-Size Characteristics
   - Barriers to Passage of Fish and other Aquatic Organisms (AOP)
     - Channel Confluences and Tributaries
     - Other Structures and Flow Obstructions
     - Terraces, the Active Floodplain, and Other Valley Bottom Features
     - Channel-Valley Orientation and Channel Planform

- Sediment Assessment
    - Pebble Count
    - Bulk Bar Sample
    - Soil and Bed Load Materials for Scour Studies
- Analysis and Development of Recommendations
    - Summary and Conclusions
    - Need for a Detailed Study
    - Purpose and Scope of the Proposed Detailed Study

3. Where no detailed study is planned, the preliminary study report becomes a Preliminary Enhanced Stream Morphology Report and it should include the following information:
    - the anticipated scour type at the structure (live bed or clear water);,
    - sediment supply and mobility,
    - lateral channel movement,
    - long-term bed degradation,
    - anticipated changes, if any, in shear stresses in the channel caused by the project,
    - bankfull geometry,
    - aquatic organisms passage measures.

3A.4.2.2 Outline of a Detailed Morphology Study

A detailed morphology study is prepared when recommended in the Preliminary Study and approved by the Office of Structures. Detailed studies are normally conducted to either evaluate complex site conditions and/or to obtain information for channel design.

1 Review of the preliminary study and re-examination of the site to obtain additional information and to define the scope of the detailed study including:

- Extent of the Channel Profile Survey
- Sediment Assessment Reach
- Lateral Channel Movement
- Soil and Bed Load Materials for Scour Studies
- Selection of Locations for Data Collection

2 Data Collection

- Valley Longitudinal Profile
- Channel Profile Survey
- Channel Cross Sections
- Bed Sediments
- Barriers to Passage of Fish and other Aquatic Organisms (AOP)
- Bankfull Flow Indicators and Channel Characteristics
- Subsurface Sampling: Site Borings, Geoprobe® Samples, and Trenches (MDE permit may be required for obtaining channel samples)
- Bank Geometry, Bank Materials, and Stratification
- Lateral Channel Movement and Planform Changes
- Long-term bed degradation

3 Analysis

Analysis of Long-Term Changes in the Stream Bed Elevation (Note that items marked with an asterisk "*" below would be included in the study only when directed by the SHA).

- Channel Degradation
- Channel Aggradation
- Riffle-Crest Reference Line for Long-Term Channel Changes*
- Estimation of the Degraded Stream Profile and Long-Term Channel Degradation*
- Estimation of the Minimum Degraded Riffle-Crest Slope, S_{dgr}
- Slope Change at Confluences*
- Crossings on Tributaries
- Estimation of Pool Geometry (width, length and depth)

- Lateral Channel Movement and Planform Changes

  Delineation of the potential channel lateral movement zone (CLMZ) upstream, through and downstream of the structure; identification of substructure elements located within the boundaries of the CLMZ.

- Stream Cross Section Characteristics and Flow Analyses
  - Bankfull Flow Estimate
  - Critical Channel Boundary Shear Stress
  - Top-of-Bank Flow Estimate
  - Identification of blockages to passage of fish and other aquatic organisms passage (AOP)
  - Rosgen Channel Classification
- Characteristics of Bed Material and Load
  - Bed Load Gradation
  - Largest Particles on the Bar
  - Analysis of Riffle Pebble Count Data
  - Assessment of Bed Load Mobility
- Stability of Riffles
- Preliminary Assessment of Structure Alternatives
- Provide information on the combinations of structure types and stream channel alignments that best fit the crossing location. Provide justification for selection of preferred alternative locations.

4 Recommendations

- Type size and location of structure based on long term bed degradation (LTBD), channel lateral migration zone (CLMZ), and AOP needs
- Stable channel geometry in reach where bridge is located
- Channel work, if any
- Clear water vs. live bed scour conditions at structure

Wildlife, Fish and Aquatic Organisms (AOP) Passage

Passage of wildlife, fish and other aquatic organisms (amphibians, snails, etc.) is an important factor in the design of waterway structures, particularly culverts, and should be carefully considered at the time of selection of the structure type. In some cases, it may be necessary to use

a bridge or a bottomless arch culvert in lieu of a concrete box or structural plate culvert to provide for adequate passage (See Chapter 13 Culverts).

Provisions for passage of wildlife, fish and other aquatic organisms (AOP) should be discussed in the hydraulic report and the geomorphology report, where appropriate.

The Federal Highway Administration has completed a guideline entitled "Fish Passage in Large Culverts with Low Flows". An interim product entitled a "Low Flow Calculator" will be incorporated in a new version of HY-8 planned for publication in 2015. The Office of Structures plans to adopt the procedures described in the research report and the updated HY-8 manual for evaluating fish passage. A user's manual for this guideline is being developed by the FHWA to facilitate the implementation of methodologies for evaluating and designing for fish passage in large culverts.

3A.5 Hydraulics Report

The scope and content of the hydraulic report will be influenced by whether the structure under consideration is located in a flood plain subject to the requirements of the National Flood Insurance Program (FEMA flood plain). If this is the case, the hydraulic report should address the appropriate items listed in Table 1 of Chapter 5, Project Development.

1. EXECUTIVE SUMMARY

   The Executive Summary should be a brief, one or two page description of the hydraulic study, presenting the key hydraulic information and confirming that the structure design meets the requirements of the Office of Structures.

2. INTRODUCTION

   A. Objective

   B. Description of project

   C. Functional classification of roadway and design criteria, including maximum allowable headwater; AADT, consideration of evacuation routes and safety considerations for school bus routes

   D. DNR stream classification including restrictions on in-stream construction

   E. Historic data and evaluation of reliability (high water marks, OOS file data and inspection reports, District knowledge of structure performance and flooding areas during previous floods, etc.)

   F. Other hydraulic control structures (both upstream and downstream) and the effect on flood plain elevations.

   G. Availability of FEMA studies. Include a copy of the FIRM exhibit.

   H. Other factors which may affect hydraulic design conditions (Tidal surge, Sea level rise due to climate change, downstream normal depth, etc.)

   I. Frequency and magnitude of the incipient overtopping flood and, in most cases, the magnitude of the 500-year flood. Under certain circumstances, the Office of Structures may agree that this flood can be omitted.

J. Previous studies (including discussion of results)

K. Reference datum (NAVD, NGVD, etc.) for elevations

L. Hydrology (source, date, methodology used; magnitude and frequency of peak flood discharges; status of approval by MDE); use of hydrographs to develop flood routing studies.) Ultimate development discharges needed to analyze pre-construction and post-construction designs.

3. PROJECT DESCRIPTION AND MODELING METHODOLOGY

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. Explain how the cross-section locations were determined (survey vs. photogrammetry, etc.,) and describe any controlling hydraulic features in the reach.
- 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.
- Describe any potential barriers to the passage of fish and other aquatic organisms (AOP)
- Photographs of the structure and flood plain reach under study. Identify each photo with the date photo was taken and information to describe the photo and the location from which it was taken.

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.
- The latest HEC-RAS version for developing water surface profiles.
- Other software may be used for some applications with prior SHA approval:
  - SRH-2D, TUFLOW, HEC-RAS-2D (5.0) etc. for complex sites such as wide flood plains where a 1-D model would be inadequate. (Use of 2-D models are not normally used in studies by the Office of Structures)
  - 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; for example, previous hydraulic lab studies of Woodrow Wilson complex piers to improve estimates of scour depths.

- TIDEROUT2 for certain hydraulic studies involving tidal bridges

C. Methodology for starting water-surface elevations can be based on one or more 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 (water surface elevations). 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 or near a controlled flood control reservoir, may require consideration of varying starting water-surface elevations:

a. Lower downstream elevations to compute velocities for estimating worst-case scour conditions.

b. Higher downstream elevations for estimating flood elevations

D. Manning's "n" values (See also Chapter 9, Channels)

1. Describe channel and overbanks for all stream reaches (supported by dated color photographs with location included on the photograph)

2. Selection of reasonable “n” values depends in part on the knowledge and experience of the Engineer; Consider use of higher n values (summertime conditions) for evaluating flood elevations and lower n values (winter conditions) for evaluating worst case flow velocities for a scour analysis.

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, last modified September 1, 2005
- 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.

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. The HEC-RAS run needs to be calibrated to provide for consistent channel discharges upstream, through and downstream of the structure.

E. Structure Details - All structures modeled should be provided with the following details (including dimensions):

1. Location
2. Description of the type of structure, providing appropriate dimensions and explanations:
   a. Pipe and pipe arch culvert; culverts with other shapes
   b. Concrete box culvert/rigid frame
   c. Bridge and bottomless arch structures
   d. Other
3. Waterway opening
   a. Shape (include piers and abutments)
   b. Cross-sectional area
   c. Dimensions
   d. Low chord profile
   e. Any upstream or downstream hydraulic controls affecting flow patterns at bridge (existing bridge abutments, etc.)
   f. contraction and expansion patterns at bridge
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 and debris condition within the structure; describe significant blockages
9. Road and weir profile(s) including low point(s) of road and weir (if not on the roadway)
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

F. 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 Conditions: Momentum, Energy and Yarnell

   High Flow Condition: Energy or Pressure/weir flow

6. Method of analysis for multiple openings (conveyance, bridge, culvert, if applicable)

G. Approach Roads

1. Typical roadway cross-sections including side slopes

2. Road and structure profiles; include location and elevation of sump

3. Limits of fill and cut slopes in flood plain

H. Channels:

Summarize information, where applicable, on selected channel alternative recommended in Geomorphology Report and status of approval

I. Surface preparation for 2-D Models, where applicable; discuss requirements for use of model; use of 2-D models must be approved by the Office of Structures.

4. ANALYSIS

1. Summarize the results of the following studies:

- Pre-construction Conditions using ultimate runoff discharges.
- Post-construction conditions using ultimate runoff discharges

2. Describe the approach used to verify the validity and accuracy of the input information and the reliability of the HEC-RAS (or other model) results including:

A. Starting water-Surface elevations

B. Special modeling techniques, such as bridge modeling, split flow analyses, etc.

C. Flow distributions upstream, at the bridge and approach roads, and downstream of the structure

D. Manning "n" values, energy slopes Froude Numbers and flow velocities in the study reach and at the structure; defaults to critical depths; location and extent of cross-sections, etc.

E. Channel Stability, Sediment Mobility, and Shear Stress values for the pre-construction and post- construction conditions for the 2-year and 10-year flood discharges.

F. Calibration of the computer models with known (reliable) high water marks if feasible.

5. FINDINGS AND CONCLUSIONS

Prepare a brief written discussion in the report summarizing the results of the hydraulic studies. Include a statement that the proposed structure and approach roads meet the following design criteria: The highway/structure design meets the criteria for the design flood as set forth in Table 1 of this appendix

1 Where appropriate, summarize the effect of the project on floodwater levels

A. In regard to flood plains in the National Flood Insurance Program administered by FEMA)

B. Effect on developed properties and particularly sensitive areas such as NEPA 4-(f) lands

2. Effect of project on passage of fish and aquatic organisms (AOP) and wildlife

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

4. Right-of-way considerations, if additional ROW is required.
5. List all permits required for the project including time restrictions, if any.
6. Brief statement on effect of the proposed project on channel stability.

6. 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. Cross-section surveys
K. Previous studies
L. Text books
M. Technical publications
M. Correspondence
N. Other

7. DOCUMENTATION

As appropriate, the following information should be included in the Hydraulic Report, the Hydraulic Data Sheet or in an appendix to the Hydraulic Report.

A. Input data to the hydraulic model
    1. Discharges with corresponding locations on stream reaches; Note changes in discharge values due to tributary confluences
    2. Manning's "n" values (including photographs)
    3. Contraction and expansion loss coefficients; inclusion of additional hydraulic losses (bends, large constrictions, etc.
    4. Known water-surface elevations (if any)
    5. Starting water-surface elevations (note if taken from a previous study)
    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. Output data sheets and reports for the HEC-RAS model (or other computer programs), including standard Tables 1 and 2. Include shear stress values, and stream reach and length. The detailed output listings should be clearly identified and should contain the flow distribution at all cross-sections.

C. Hydraulic parameters tables, comparing pre-and post-construction conditions for selected storm frequencies (Q-2; Q-10; Q design; incipient overtopping discharge, Q-100, etc.). Use a comparison table format to present the following data.

1. Water-surface elevations
2. Energy grade elevations
3. Stream channel velocity
4. Shear stress values in channel for 2-year and 10-year flood discharges
5. Stream channel Froude Numbers, based on flow condition, for 100-year flood.

D. 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

E. 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). Consider plotting 8.5x11” and including the larger scale as a PDF on the CD submitted with the Hydraulic Report.

1. Water surface elevations (pre- and post- construction) for the 2-year, 10- year, 100-year, and 500- year overtopping and design floods
2. Manning's "n" values and ineffective areas
3. Channel stations & survey base line
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 8.5”x 11” or 17"x 11" sheets.
8. Modifications to pre-construction cross-sections sections due to the proposed construction
9. Note if cross-sections field-surveyed or derived partially from the topographic maps

F. Floodplain delineation on topographic maps for pre-construction and post construction conditions. (use 1" = 100' unless use of a different scale is approved by the Office of Structures). These maps should identify all the cross-sections used in the hydraulic models. The following information should be clearly shown on these maps:

1. 2-year, 10-year and100-year discharge flood plain limits based on ultimate development discharges in the flood plain. (Other flood frequency discharges may be plotted if needed.)
2. Base line
3. Ineffective flow areas
4. Existing and Proposed Structures
5. Identification of Roadways and waterways
6. Identification of improved properties in the 100-year floodplain, including elevation where water enters first floor.

In some cases, an exhibit depicting FEMA mapping and FEMA study limits may need to be included with the flood plain delineation maps.

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. As a general rule, increases in floodwater elevations at improved properties are not allowed

G. Water-surface profiles

The stream thalweg, energy gradients and the water-surface profiles for various storm events (including 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 (Refer to Table 1, Chapter 5)
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

H. Cost comparisons when requested by the Office of Structures

Preliminary cost estimates of each proposed location alternative structure should include the following project elements. (Costs should be presented to SHA in a separate submittal):

1. Structure and roadway approaches
2. Environmental features provided (including wetlands, baffles, etc.)
3. Channel and bank protection (including riprap, stream enhancement, etc.)

4. Scour protection
5. Channel modifications and/or relocations

I. Detailed computer input and output listings. (Comment should be provided, in some detail, to explain various aspects of the input models, such as the following):

The detailed output listings should be provided for selected floods, typically the 2, 10, 100 and 500-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.

J. Insert a Compact Disk (CD/DVD) in the project Hydraulic Report. The following are to be included on the CD/DVD as appropriate:

1 A copy of the complete Hydraulic Report in Microsoft Word format, a copy of the letter of approval for the Hydrologic Report and the Geotechnical Report with appendices. Include correspondence with other agencies directly related to the development or review and approval of the hydraulic report.

2 A PDF file of the entire report which is to be archived.

3 A digital copy of the model

4 Information pertaining to the preparation and approval of necessary permits or of measures taken to comply with environmental requirements

5 Information and model studies pertaining to studies developed to meet FEMA requirements, if applicable.

6 Flood plain maps and CADD files.

3A.6 Hydrology and Hydraulics (H&H) Data Sheet

Complete the H&H Data Sheet to summarize the results of the various H&H studies and analyses. Fill in all information. If the requested information is not applicable, note this in the appropriate space.

Note that there are two different H&H Data Sheets: one for various types of culverts, and one for bridges and bottomless arch structures. A reduced-size version of the two H&H plan sheets is included below for identification purposes.

1. Hydrologic Data on H&H Plan Sheet

The requested information is the same for both the culvert and bridge data sheets

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.

VI Stream Morphology – See Section A 3.4 Stream Morphology and Channel Crossing Report of this Appendix. 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.

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. Describe in Section VIII how the combination of the tidal storm surge and the upland riverine flood is analyzed.

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

2a. Hydraulic Data on H&H Plan Sheet (Culverts).

Fill in all information. If the requested information is not applicable, note this in the appropriate space. Refer to the notes provided for guidance on the details of the desired information.

I Sources of information and Methods of Analysis

II Hydraulic data of waterway area, energy slope, water surface elevations and discharges, velocities and depths for the channel and overbank areas, overtopping flows, etc.

III Refer to note on Scour Data

IV Roadway and Structure Data, including references to discussions on Fish and AOP passage

V Design Criteria

VI Flood Plain Management Data

VII Comments of interest regarding the hydraulic aspects of the design.

2b. Hydraulic Data on H&H Plan Sheet (Bridges and Bottomless Arch Culverts)

Fill in all information. If the requested information is not applicable, note this in the appropriate space. Refer to the notes provided for guidance on the details of the desired information.

I. Sources of information and Methods of Analysis.

II Hydraulic data of waterway area, energy slope, water surface elevations and discharges, velocities and depths for the channel and overbank areas, overtopping flows, etc.

III Bridge Scour Data: Fill in all requested information; (Use N/A if information is not applicable); Use VII Comments as needed – for example, to list information when there are more than two piers. Refer to notes on Scour Data for guidance on what is needed.

IV Roadway and Structure Data, including references to discussions on Fish and AOP passage.

V Design Criteria.

VI Flood Plain Management Data.

VII Comments of interest regarding the hydraulic aspects of the design.

3. Title Block and General Plan Sheet I.D. Blocks. Fill in the following information:

- H/H Title Block
- Structure Inventory Number
- Survey Book information related to H/H studies
- Specify Datum used (NGVD, 1929; NAVD, 1988; etc.)

4. Reduced-scale version of H&H Data Sheets

The following reduced-scale versions provide an overview of the information to be provided on the H&H Data sheets.

HYDROLOGIC DATA

I. SOURCE: _____
PREPARED BY: ☐ SHA ☐ CONSULTANT: _____ DATE: _____
FILE LOCATION: _____

II. DRAINAGE AREA: ACRES _____ SQUARE MILES _____

III. METHOD(S) OF ANALYSIS:

_____ USGS GAGE DATA ANALYSIS
- GAGING STATION NO. _____
- LOCATION _____
- DRAINAGE AREA _____
- YEARS OF CONTINUOUS RECORD _____

_____ FIXED REGION REGRESSION EQUATIONS
REFERENCE _____
_____ NRCS WinTR-20 METHOD - VERSION USED (DATE) _____
- RCN (EXISTING-HOMOGENEOUS WATERSHED) _____
- RCN (ULTIMATE HOMOGENEOUS WATERSHED) _____
- T_c (HOMOGENEOUS WATERSHED)[1] _____

_____ FEMA BASE FLOOD (100-YEAR) DISCHARGE _____ (CFS) METHOD USED BY FEMA _____
_____ OTHER (DESCRIBE) _____

HAS FLOOD ROUTING BEEN USED IN DETERMINING FLOOD DISCHARGES? YES ☐ NO ☐
METHOD SELECTED _____

IV. COMPUTED FLOOD DISCHARGES

RETURN PERIOD (YEARS)	FLOOD DISCHARGE (CFS) BASED ON EXISTING WATERSHED DEVELOPMENT	FLOOD DISCHARGE (CFS) BASED ON ULTIMATE WATERSHED DEVELOPMENT
2		
10		
25		
50		
100		
500		

V. HISTORIC FLOODS

YEAR	MAGNITUDE (CFS)	HIGH WATER ELEVATION	WHERE MEASURED	SOURCE OF DATA

VI. STREAM MORPHOLOGY

STREAM TYPE _____ VALLEY TYPE _____
STREAM BED MATERIAL: _____ D16 _____ D50 _____ D84 _____
ESTIMATED LONG TERM BED DEGRADATION: YES ☐ NO ☐ AMOUNT: _____
ESTIMATED LATERAL CHANNEL MOVEMENT: YES ☐ NO ☐ AMOUNT: _____
SOURCE: _____
BANK FULL CHARACTERISTICS:
OBTAINED FROM: REGIONAL CURVE ☐ OTHER ☐ DESCRIBE: _____
Q _____ AREA _____ WIDTH _____ DEPTH _____
SLOPE _____ MANNINGS "n" VALUE _____ SINUOSITY _____

VII. TIDAL FLOWS

100-YEAR STORM TIDE ELEVATION (FT) _____ MAXIMUM DISCHARGE (CFS) _____
500-YEAR STORM TIDE ELEVATION (FT) _____ MAXIMUM DISCHARGE (CFS) _____
SOURCE OF INFORMATION _____

DESIGN DISCHARGE _____ (CFS) RETURN PERIOD _____ YEARS TIDAL PERIOD (HRS) _____
HOW DETERMINED? (EXPLAIN) _____
WATER SURFACE ELEVATION FOR DESIGN CONDITION (FT)
OF TIDAL FLOW GOVERNS HYDRAULIC DESIGN) _____

VII. COMMENTS: _____

HYDRAULIC DATA

I. SOURCE: _____
PREPARED BY: ☐ SHA ☐ CONSULTANT: _____ DATE: _____
FILE LOCATION: _____ ITEM 71 RATING[1] _____
METHOD(S) OF ANALYSIS: HEC-RAS ☐ OTHER: _____

II. HYDRAULIC DATA

FLOW CONDITIONS[2]	CHANNEL CROSS-SECTION	STRUCTURE WATERWAY AREA	ENERGY SLOPE	WATER SURFACE ELEVATION	CHANNEL Q (cfs)	CHANNEL W (ft)	CHANNEL V (fps)	CHANNEL D (ft)	LEFT OVERBANK LOOKING DOWNSTREAM Q (cfs)	LEFT OVERBANK LOOKING DOWNSTREAM W (ft)	LEFT OVERBANK LOOKING DOWNSTREAM V (fps)	LEFT OVERBANK LOOKING DOWNSTREAM D (ft)	RIGHT OVERBANK LOOKING DOWNSTREAM Q (cfs)	RIGHT OVERBANK LOOKING DOWNSTREAM W (ft)	RIGHT OVERBANK LOOKING DOWNSTREAM V (fps)	RIGHT OVERBANK LOOKING DOWNSTREAM D (ft)	DISCHARGE OVER ROAD
Q_{DESIGN} FOR ROADWAY CLASSIFICATION DESCRIBE _____	APPROACH[3] (SPECIFY LOCATION BELOW)	N/A															N/A
	UPSTREAM AT STRUCTURE																
	DOWNSTREAM AT STRUCTURE																N/A
Q_{100} DESCRIBE _____	APPROACH[3] (SPECIFY LOCATION BELOW)	N/A															N/A
	UPSTREAM AT STRUCTURE																
	DOWNSTREAM AT STRUCTURE																N/A
$Q_{INCIPIENT\ OVERTOPPING}$ DESCRIBE _____	APPROACH[3] (SPECIFY LOCATION BELOW)	N/A															N/A
	UPSTREAM AT STRUCTURE (i.e., BR-UP)																
	DOWNSTREAM AT STRUCTURE																N/A
Q_{500} OR $Q_{CHECK\ FLOOD}$ DESCRIBE _____	APPROACH[3] (SPECIFY LOCATION BELOW)	N/A															N/A
	UPSTREAM AT STRUCTURE																
	DOWNSTREAM AT STRUCTURE																N/A

III. BRIDGE SCOUR DATA

A. SCOUR EVALUATION STUDY TITLE: _____
PREPARED BY: ☐ SHA ☐ CONSULTANT: _____ DATE: _____
FILE LOCATION: _____ ITEM 113 RATING[1] _____
METHOD(S) OF ANALYSIS: ABSCOUR ☐ OTHER: _____

B. SCOUR ESTIMATES:

	DESIGN CONDITIONS (OCCURRENCE SPECIAL CONDITIONS SUCH AS OVERTOPPING, ICE, TAILWATER, INFLUENCE OF CONSTRUCTION, ETC.)	FLOOD DISCHARGE RETURN PERIOD (YEARS)	FLOOD DISCHARGE MAGNITUDE (CFS)	LONG TERM DEGRADATION / AGGRADATION (FT)[4]	CONSTRUCTION[5] SCOUR DEPTH (LOOKING DOWNSTREAM) (FT): LT OVERBANK	CONSTRUCTION[5] SCOUR DEPTH (LOOKING DOWNSTREAM) (FT): MAIN CHANNEL	CONSTRUCTION[5] SCOUR DEPTH (LOOKING DOWNSTREAM) (FT): RT OVERBANK	CHANNEL BED LOAD GEOGRAD	TYPE OF SCOUR (LIVE BED/CLEAR WATER)
DESIGN FLOOD FOR SCOUR									
CHECK FLOOD FOR SCOUR									
OTHER									

TOTAL SCOUR ESTIMATED TOTAL SCOUR AT SUBSTRUCTURE/ CHANNEL ELEMENTS INCLUDES LONG TERM DEGRADATION/AGGRADATION PLUS CONTRACTION SCOUR, PLUS LOCAL SCOUR

LOCATION OF CHANNEL OR SUBSTRUCTURE ELEMENT	ESTIMATED PILE TIP ELEVATION	ELEVATION OF BOTTOM OF STREAM CHANNEL BED OR SCOUR HOLE (FT): DESIGN FLOOD	ELEVATION OF BOTTOM OF STREAM CHANNEL BED OR SCOUR HOLE (FT): CHECK FLOOD	SCOUR COUNTER MEASURES ☐ EXISTING ☐ NEW
CHANNEL TABLE(S)				
ABUTMENT1				
ABUTMENT2				
PIER NO.				
PIER NO.				

IV. ROADWAY AND STRUCTURE DATA

ITEM	EXISTING STRUCTURE	PROPOSED STRUCTURE
DATE BUILT		
OVERTOPPING ELEVATION		
OVERTOPPING LOCATION		
INCIPIENT OVERTOPPING FLOW CONDITION $Q_{OVERTOPPING}$ / Q_{FLOOD}[7]		
FREEBOARD[8]		
TOTAL STRUCTURE WATERWAY AREA[9]		
STREAM CHANNEL INVERT AT U/S FACE		
STRUCTURE DESCRIPTION[10]		

NOTES:

BLANK SPACES INDICATE THAT DATA IS NOT AVAILABLE OR IS NOT APPLICABLE

1. ITEM 71 RATING AND ITEM 113 RATING REFER TO THE OOS SHA DATABASE, FORM 7
2. RECORD FLOW CONDITIONS USED IN ANALYSIS: DISCHARGE (Q), TAILWATER CONDITION AND HOW SELECTED, ETC.
3. APPROACH SECTION SHOULD BE SELECTED AS PER GUIDANCE IN ABSCOUR USERS MANUAL
4. DESIGN FLOOD FOR SCOUR IS Q_{100} OR $Q_{INCIPIENT}$
5. ENTER CONTRACTION SCOUR DEPTHS ONLY (APPROXIMATE LINE 121 IN ABSCOUR OUTPUT) - NOT ABUTMENT SCOUR
6. IF SCOUR RESISTENT BEDROCK CONTROLS SCOUR, ENTER BEDROCK ELEVATION AND NOTE THIS CONDITION UNDER COMMENTS
7. RECORD INCIPIENT OVERTOPPING DISCHARGE (Q) AND RECURRENCE INTERVAL
8. RECORD CLEARANCE BETWEEN WATER SURFACE ELEVATION AND LOW CHORD FOR DESIGN DISCHARGE FOR ROADWAY CLASSIFICATION
9. RECORD TOTAL FLOW AREA UNDER STRUCTURE (DOWNSTREAM END)
10. ENTER TYPE, SPAN LENGTH AND MAXIMUM VERTICAL UNDER-CLEARANCE

V. DESIGN CRITERIA

ROADWAY CLASSIFICATION: _____ DESIGN STORM: _____
THE STRUCTURE IS DESIGNED TO ACCOMODATE THE _____ YEAR EVENT.
ESTIMATED DEPTH OF FLOW OVER ROAD IF OVERTOPPED BY THE DESIGN STORM: _____
— HAS A DESIGN EXCEPTION FOR THE DESIGN STORM BEEN GRANTED?
YES ☐ DATE: _____ NO ☐
OTHER KNOWN FLOODING LOCATIONS ON THIS ROADWAY: _____

VI. FLOOD PLAIN MANAGEMENT DATA

DATE OF FLOOD INSURANCE STUDY _____ COMMUNITY PANEL NO. _____

PROJECT LOCATION (CHECK BELOW):

_____ BEYOND FEMA PROGRAM LIMITS (NOT IN "A" HAZARD ZONE)
_____ FEMA HAZARD ZONE "A"; NO BASE FLOOD ELEVATIONS ESTABLISHED
_____ FEMA HAZARD ZONE "A"; BASE FLOOD ELEVATIONS ESTABLISHED

REGULATORY FLOODWAY _____ YES _____ NO
MAXIMUM CHANGE IN WATER SURFACE ELEVATION UPSTREAM OF BRIDGE DUE TO HIGHWAY PROJECT (MAX. BACKWATER) _____ FT.

LOCATION OF MAX. BACKWATER FROM UPSTREAM FACE OF BRIDGE _____ FT.

DESCRIBE TYPE OF STUDY DONE TO DETERMINE CONSISTENCY WITH NFIP STANDARDS _____
DATE COMMUNITY ACKNOWLEDGEMENT FORM ISSUED: _____

IS THE PROJECT CONSISTENT WITH THE CODE OF FEDERAL REGULATIONS, PART 650 A, LOCATION AND HYDRAULIC DESIGN OF ENCROACHMENTS ON FLOOD PLAINS (23 CFR 650 A). YES ☐ NO ☐

IS THE PROJECT CONSISTENT WITH THE ANNOTATED CODE OF MARYLAND (COMAR 26.17.04)? YES ☐ NO ☐

VII. COMMENTS: _____

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
OFFICE OF STRUCTURES

HYDROLOGIC AND HYDRAULIC DATA

SCALE AS SHOWN DATE CONTRACT
DESIGNED BY
DRAWN BY
CHECKED BY
SHEET NO. OF

OTHER CONTRACTS FOR THIS STRUCTURE _____ _____

SHEET FORMAT, ISSUED: 8-25-80, REVISED: 9-16-93, REVISED: 9-14-11

STRUCTURE INVENTORY NO.

SURVEY BOOK NO.

DATUM:

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PRINT DATE: Tuesday, December 11, 2012 AT 09:23 AM

INDEXED

HYDROLOGIC DATA

I. SOURCE: _____

PREPARED BY: ☐ SHA ☐ CONSULTANT: _____ DATE: _____

FILE LOCATION: _____

II. DRAINAGE AREA: ACRES _____ SQUARE MILES _____

III. METHOD(S) OF ANALYSIS:

_____ USGS GAGE DATA ANALYSIS
- GAGING STATION NO. _____
- LOCATION _____
- DRAINAGE AREA _____
- YEARS OF CONTINUOUS RECORD _____

_____ FIXED REGION REGRESSION EQUATIONS
REFERENCE _____

_____ NRCS WinTR-20 METHOD - VERSION USED (DATE) _____
- RCN (EXISTING-HOMOGENEOUS WATERSHED) _____
- RCN (ULTIMATE HOMOGENEOUS WATERSHED) _____
- T_C (HOMOGENEOUS WATERSHED)[1] _____

_____ FEMA BASE FLOOD (100-YEAR) DISCHARGE _____ (CFS) METHOD USED BY FEMA _____

_____ OTHER (DESCRIBE) _____

HAS FLOOD ROUTING BEEN USED IN DETERMINING FLOOD DISCHARGES? YES ☐ NO ☐

METHOD SELECTED _____

IV. COMPUTED FLOOD DISCHARGES

RETURN PERIOD (YEARS)	FLOOD DISCHARGE (CFS)	
	BASED ON EXISTING WATERSHED DEVELOPMENT	BASED ON ULTIMATE WATERSHED DEVELOPMENT
2		
10		
25		
50		
100		
500		

V. HISTORIC FLOODS

YEAR	MAGNITUDE (CFS)	HIGH WATER ELEVATION	WHERE MEASURED	SOURCE OF DATA

VI. STREAM MORPHOLOGY

STREAM TYPE _____ VALLEY TYPE _____

STREAM BED MATERIAL: _____ D16 _____ D50 _____ D84 _____

ESTIMATED LONG TERM BED DEGRADATION: YES ☐ NO ☐ AMOUNT: _____

ESTIMATED LATERAL CHANNEL MOVEMENT: YES ☐ NO ☐ AMOUNT: _____

SOURCE: _____

BANK FULL CHARACTERISTICS:
OBTAINED FROM: REGIONAL CURVE ☐ OTHER ☐ DESCRIBE: _____

Q _____ AREA _____ WIDTH _____ DEPTH _____

SLOPE _____ MANNINGS 'N' VALUE _____ SINUOSITY _____

VII. TIDAL FLOWS

100-YEAR STORM TIDE ELEVATION (FT) _____ MAXIMUM DISCHARGE (CFS) _____

500-YEAR STORM TIDE ELEVATION (FT) _____ MAXIMUM DISCHARGE (CFS) _____

SOURCE OF INFORMATION _____

DESIGN DISCHARGE _____ (CFS) RETURN PERIOD _____ YEARS TIDAL PERIOD (HRS) _____

HOW DETERMINED? (EXPLAIN) _____

WATER SURFACE ELEVATION FOR DESIGN CONDITION (FT)
(IF TIDAL FLOW GOVERNS HYDRAULIC DESIGN) _____

VII. COMMENTS: _____

HYDRAULIC DATA

I. SOURCE: _____

PREPARED BY: ☐ SHA ☐ CONSULTANT: _____ DATE: _____

FILE LOCATION: _____ ITEM 71 RATING[1] _____

METHOD(S) OF ANALYSIS: HEC-RAS ☐ HY-8 ☐ OTHER: _____

II. HYDRAULIC DATA FOR CULVERT

FLOW CONDITIONS[2]	CHANNEL CROSS-SECTION	DEPTH OF FLOW	ENERGY SLOPE FOR CULVERT BARREL	WATER SURFACE ELEVATION	CHANNEL Q (cfs)	CHANNEL W (ft)	CHANNEL V (fps)	CHANNEL D (ft)	LEFT OVERBANK LOOKING DOWNSTREAM Q (cfs)	LEFT OVERBANK LOOKING DOWNSTREAM W (ft)	LEFT OVERBANK LOOKING DOWNSTREAM V (fps)	LEFT OVERBANK LOOKING DOWNSTREAM D (ft)	RIGHT OVERBANK LOOKING DOWNSTREAM Q (cfs)	RIGHT OVERBANK LOOKING DOWNSTREAM W (ft)	RIGHT OVERBANK LOOKING DOWNSTREAM V (fps)	RIGHT OVERBANK LOOKING DOWNSTREAM D (ft)	DISCHARGE OVER ROAD
$Q_{DESIGN\ FOR\ ROADWAY\ CLASSIFICATION}$ DESCRIBE _____	CULVERT INLET																
	CULVERT OUTLET							BACK OF BARREL									N/A
Q_{100} DESCRIBE _____	CULVERT INLET																
	CULVERT OUTLET							BACK OF BARREL									N/A
$Q_{INCIPIENT\ OVERTOPPING}$ DESCRIBE _____	CULVERT INLET																
	CULVERT OUTLET							BACK OF BARREL									N/A

III. SCOUR DATA: SCOUR ANALYSIS IS NOT NEEDED FOR CULVERT. IF CULVERT IS BOTTOMLESS, USE THE OSS BRIDGE AND BOTTOMLESS STRUCTURE H&H SHEET.

IV. ROADWAY AND STRUCTURE DATA

ITEM	EXISTING STRUCTURE	PROPOSED STRUCTURE
DATE BUILT		
OVERTOPPING ELEVATION		
OVERTOPPING LOCATION		
INLET OR OUTLET CONTROL		
INCIPIENT OVERTOPPING FLOW CONDITION (OVERTOPPING Q ≤ 100 YR FLOOD)[3]		
FREEBOARD[4]		
TOTAL STRUCTURE WATERWAY AREA		
STRUCTURE DESCRIPTION[5]		
INLET TREATMENT[6]		
OUTLET TREATMENT[6]		
MANNINGS 'N' VALUE[7]		
FISH PASSAGE CONCERNS, ISSUES OR TREATMENT? (Y OR N)[8]		

NOTES:

BLANK SPACES INDICATE THAT DATA IS NOT AVAILABLE OR IS NOT APPLICABLE

1. ITEM 71 RATING REFER TO THE OOS SIBA DATABASE, FORM 7
2. RECORD FLOW CONDITIONS USED IN ANALYSIS (DISCHARGE (Q), TAILWATER CONDITION AND HOW SELECTED, ETC.). FOR DEPRESSED CULVERTS, UNDER COMMENTS, INDICATE THE ASSUMPTIONS MADE AS TO WHETHER SEDIMENT WILL REMAIN
3. RECORD INCIPIENT OVERTOPPING DISCHARGE (Q) AND RECURRENCE INTERVAL
4. RECORD CLEARANCE BETWEEN WATER SURFACE ELEVATION AND LOW CHORD FOR DESIGN DISCHARGE FOR ROADWAY CLASSIFICATION
5. ENTER LENGTH, SIZE, TYPE, AND NUMBER OF CELLS; DESCRIBE ANY SPECIAL FEATURES UNDER COMMENTS
6. DESCRIBE TYPE OF INLET/OUTLET AND EROSION PROTECTION
7. COMPOSITE 'N' VALUE OF STRUCTURE
8. DESCRIBE FISH PASSAGE CONCERNS, ISSUES, OR TREATMENT UNDER COMMENTS SECTION

VI. FLOOD PLAIN MANAGEMENT DATA – FROM NEW H&H SHEET

DATE OF FLOOD INSURANCE STUDY _____ COMMUNITY PANEL NO. _____

PROJECT LOCATION (CHECK BELOW):

_____ BEYOND FEMA PROGRAM LIMITS (NOT IN 'A' HAZARD ZONE)

_____ FEMA HAZARD ZONE 'A'; NO BASE FLOOD ELEVATIONS ESTABLISHED

_____ FEMA HAZARD ZONE 'A'; BASE FLOOD ELEVATIONS ESTABLISHED

REGULATORY FLOODWAY _____ YES _____ NO

MAXIMUM CHANGE IN WATER SURFACE ELEVATION UPSTREAM OF BRIDGE DUE TO HIGHWAY PROJECT (MAX. BACKWATER) _____ FT.

LOCATION OF MAX. BACKWATER FROM UPSTREAM FACE OF BRIDGE _____ FT.

DESCRIBE TYPE OF STUDY DONE TO DETERMINE CONSISTENCY WITH NFIP STANDARDS _____

DATE COMMUNITY ACKNOWLEDGEMENT FORM ISSUED: _____

DATE OF CLOMR: _____

IS THE PROJECT CONSISTENT WITH THE CODE OF FEDERAL REGULATIONS, PART 650 A, LOCATION AND HYDRAULIC DESIGN OF ENCROACHMENTS ON FLOOD PLAINS (23 CFR 650 A). YES ☐ NO ☐

IS THE PROJECT CONSISTENT WITH THE ANNOTATED CODE OF MARYLAND (COMAR 26.17.04)? YES ☐ NO ☐

VII. COMMENTS: _____

REVISIONS

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
OFFICE OF STRUCTURES

HYDROLOGIC AND HYDRAULIC DATA

SCALE: AS SHOWN DATE: CONTRACT:

DESIGNED BY

DRAWN BY

CHECKED BY

SHEET NO. OF

INDEXED

OTHER CONTRACTS FOR THIS STRUCTURE _____ _____

SHEET FORMAT, ISSUED: 8-25-80, REVISED: 9-16-99, REVISED: 9-14-11

STRUCTURE INVENTORY NO.

SURVEY BOOK NO.

DATUM:

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PRINT DATE: Tuesday, December 11, 2012 AT 09:09 AM

3A.7 Scour Assessment and Scour Evaluation Reports

A scour assessment or scour evaluation report conducted in accordance with the provisions of Chapter 11 of the Office of Structures H&H Manual is to be prepared for every project of the Office of Structures involving a structure over a stream.

- For certain projects, such as a deck replacement that does not affect the substructure of a bridge, a full scour evaluation study may not be necessary if the structure has already been rated as a low risk under Item 113 of the FHWA Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges; and the Office of Structures Guide for Completing Structure Inventory and Appraisal Input Forms. For such cases, a scour assessment conducted in accordance with Chapter 11, Appendix F may serve to document that there is low risk of a safety hazard to the traveling public or of damage to the structure.
- For new bridges, or for existing bridges undergoing extensive rehabilitation affecting the substructure, a scour evaluation will be required in accordance with Federal and State design standards as described in Chapter 11. The following guidance applies to the preparation of scour reports:

3A.7.1 Scour Reports for Culverts:

The format for the scour evaluation or assessment is typically limited to addressing a few basic concerns for pipe, pipe arch and box culverts, and can be included in the hydraulic report. This normally includes design of the endwalls (wingwalls, cutoff walls, 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 culvert 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
- 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 arch culverts" are to be treated as bridges for purposes of scour evaluation, as discussed in the Bridge Section below:

3A.7.2 Scour Report for 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.

- Chapter 11 incorporates the guidance of the Federal Highway Administration as set forth in the FHWA manual HEC-18.
- Preparation of the scour report is to be accomplished through an interdisciplinary effort of hydraulic, geotechnical and structural engineers; team members should be listed in the report.
- The guidelines in Chapter 11, Section 1.4 Policy, Tables 1 and 2 are to be followed in designing bridge foundations for scour.
- The latest version of the ABSCOUR Program is to be 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 User's Manual (Appendix A of Chapter 11) is to be followed in obtaining input data and in evaluating the scour results.
- Evaluate new structures or structures being rehabilitated for the 100-year, 500-year and incipient overtopping floods, based on ultimate development in the watershed. Evaluate an existing bridge for the above three floods based on existing development in the watershed. (See Chapters 8 and 11).
- 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, Parts I and II 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.
- If rock is present, special procedures are to be used to evaluate the resistance to scour of the rock as explained in the ABSCOUR User's Manual, Appendix A of Chapter 11. This should include an evaluation of the rock by SHA personnel in the Office of Materials and Technology or others specialists familiar with rock mechanics and the Erodibility Index Method
- Since many factors involved in the scour evaluation 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.
- Full consideration in the design of the structure foundations is to be given to the findings of the stream morphology report regarding the potential for long-term 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.

Bridge Scour Evaluation Studies and Reports:

1 General

2 Introduction and Background

3 Scope of Study

4 Summary and Recommendations

5 Hydrology Study

6 Site Investigation

7 Stream Classification, Morphology and Stability Study

8 Subsurface Study of Underlying Soils and Rock

9 Type, Size and Location of the Bridge (TS&L), including foundation details such as proposed or existing elevations of footings, pile caps and pile tip elevations

10 Approach Roadways

11 Hydraulic Study

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

13 Significance of the Scour Evaluation

14 Structural and Geotechnical Design Considerations

15 Scour Countermeasures

16 Appendices

17 Documentation

3A.8 References

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