OFFICE OF STRUCTURES

MANUAL FOR HYDROLOGIC AND HYDRAULIC DESIGN

CHAPTER 6

DOCUMENTATION

June 2020

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

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CHAPTER 6 DOCUMENTATION

6.1 OVERVIEW

6.1.1 Introduction

This chapter provides details regarding the MDOT SHA Office of Structure's procedures for documentation of analyses, which are completed as part of the design of hydraulic structures. Sections herein provide information regarding the types of documents used and created, details on the required documentation of studies and analyses completed for Office of Structures projects, and specifics on the management and retention of the various project information, including data, analyses, and all related documentation.

Documentation is an important component of the design process associated with any new or modified hydraulic structure. Appropriate documentation of all structure and site analyses is necessary to:

- Obtain the required permits and agency approvals;
- Emphasize the importance of public safety;
- Justify expenditures of public funds;
- Provide essential information for future changes or rehabilitations to a structure;
- Develop information needed for matters of litigation;
- Respond to requests of the public for information;
- Evaluate future changes in the site conditions.

It is sometimes necessary to refer to plans, specifications, and analyses after construction has been completed. Documentation can be used in post-flood event evaluations to determine if the structure performed as anticipated or to establish the cause of unexpected behavior. In the event of a failure, it is essential that contributing factors be identified so that recurring damage can be avoided, and design criteria improved to avoid similar problems in the future.

6.1.2 Terminology

The term SHHD Team Leader is used to refer to the MDOT SHA Structure Hydrology and Hydraulics Division (SHHD) personnel who leads the team to which a specific project is assigned.

The term hydrologic and hydraulic documentation is used in this chapter to refer to the compilation and preservation of design and analysis details as well as all pertinent information on which design decisions were based. This may include:

- Field survey information and measurements
- Photographs
- Correspondence, telephone logs, and minutes of meetings
- Flood history (including narratives from news media, state personnel, or local residents)
- Hydrologic analysis

- Hydraulic analysis
- Stream morphology studies
- Geotechnical investigations
- Scour evaluations
- Design plans and specifications

Documentation does not only occur at specific times during the design, or as a final step in the design process. Rather, it should be an ongoing work task that is an integral part of each step in the structure type, size, and location (TS&L) determination, and the design process. Proper record keeping throughout the project development process greatly facilitates the task of compilation and summarization of essential information. This approach will improve the accuracy of the documentation, provide a sound basis for future steps in the project development process, and provide for consistency in the design even when different designers are involved during different phases of project development.

6.1.3 Purpose

Proper documentation serves to define the design and analysis procedures used, and to record the basis of the design alternative selection, as well as the development of design details. Documentation provides a record of reasonable and prudent decisions based on an appropriate degree of data collection and analysis. Thus, documentation should provide the following:

- Identification and delineation of existing conditions at the time of design. This could prove to be very important if legal action occurs in the future.
- A record of the procedures and analyses used in the design which were commensurate with the perceived site conditions and flood hazard. This should serve to provide further support to the State's position for any claims of negligence that may be filed in the future.
- A continuous history of changes which have occurred at the structure. Such information may be of great value in facilitating decisions about future reconstruction.
- The information necessary to evaluate future site problems that might occur during the structure's service life.
- A record of the analyses procedures and results for inclusion in submissions made to other offices and agencies, facilitating the task of others in the review and approval process.
- The facilitation of efficient and orderly plan development as a result of recording the reasons and rationale for specific design decisions.

6.1.4 General Procedures

The following general procedures are to be used in documenting all analyses and studies for the Office of Structures:

- The engineer shall follow the guidance provided in Section 6.3 when preparing documentation of analyses and studies.
- The engineer should document all design assumptions and indicate how this information was used in the decision-making process.

- Documentation should be concise, sequentially organized, and complete as practicable so that designers who may review the documentation in the future will be able to understand the basis for the original design.
- References should be given to studies or reports by others that have been used in the decision-making process.
- Degree of precision and the probability of occurrence for the design criteria used in the analysis should be documented. If the chosen method of analysis is for a "worst case condition" that may have a low probability of occurrence, this assumption should be specified. Reports should not imply that calculated values are correct to one or two decimal points if the assumptions made or data used do not support this degree of precision.
- Project documentation should include a record of the dates of milestones achieved along with the names of the persons involved in each step of the decision-making process. Complete minutes of important meetings should be prepared and distributed to meeting participants for comments and/or concurrence.
- A summary of the hydrologic, stream morphology, hydraulic, and scour data for each project site is to be included in the final structure design plans. This is accomplished in the form of the H&H Data Sheet, as described in Section 6.3.8.
- Data and analyses documentation records should be maintained and archived as detailed in Section 6.4. Minimum data archive procedures are established; however, it may be prudent to retain additional information or analysis data on a project-specific basis. This need, and any project-specific data retention requirements, shall be determined by the SHHD Team Leader.

6.2 TYPES OF RECORDS

There are many records to be considered and/or utilized in the hydraulic design of structures. Additional information regarding data sources is provided in Chapter 5, Data Sources and Field Surveys. These records can be considered in three different categories as follows.

6.2.1 Structure Hydrology and Hydraulics Division Records

There are records under the direct control of the SHHD. These records are developed during the design analysis process. The reporting format and minimum requirements for these records are detailed in Section 6.3. These records include:

- Hydrologic Analysis Reports and Approval Letters
- Hydraulic Analysis Reports (including reports for MDE submissions and reports for FEMA CLOMR/LOMR applications) and Approval Letters
- Preliminary and Detailed Stream Morphology Reports
- Bridge Scour Evaluation and Assessment Reports
- Computer Input/Output Files (including hydrologic and hydraulic models, GIS data, and survey and mapping data with all pertinent dates)
- Hydrologic and Hydraulic Data Sheet in the Plans, Specifications, and Estimate (PS&E) Package

- Other analyses files, field trip reports, site visit photos, meeting minutes, or design and analysis related information

6.2.2 Other MDOT SHA Office Records

There are records under the direct control of an MDOT SHA office other than the Structure Hydrology and Hydraulics Division. These records may be used in the design analysis process and should be referenced in the appropriate documentation accordingly. These records include:

- Highway Location Reference for Roadway Functional Classification and Average Annual Daily Traffic (AADT) Count
- Structure Location Map (MDOT Roads and Highways tool)
- MDOT SHA GIS Data
- Structure Inventory and Appraisal (SIA) Database
- Structure Asset Management (SAM) Database
- Environmental/Location Studies and Reports
- Survey Records
- Avoidance, Minimization, and Mitigation Plans and Reports
- Type, Size, and Location (TS&L) Plans
- Permit Applications
- Foundation Reports
- Plans, Specifications, and Estimate (PS&E) Packages
- As-built Plans (should include pile tip elevations for structures on piles)
- Bridge Inspection Reports and Photos
- District Office Records on Bridge Performance and Flooding History

6.2.3 Records of Other Agencies

There are records prepared by agencies other than MDOT SHA (federal, state, and local) that are used in plan development as a basis for decisions about the hydraulic design. These records should be referenced in the appropriate documentation accordingly. These records may include:

- USGS Topographic Maps
- USGS Hydrologic, Hydraulics, and Sediment Transport Study Reports
- USFWS Reports on Bankfull Discharge and Channel Characteristics
- USFWS Wetlands Mapping Resources
- FEMA and/or MDE Floodplain Maps and Studies (mdfloodmaps.com)
- Computer Program Files (e.g., HEC-RAS models) for flood studies prepared by or for FEMA, Corps of Engineers, or other governmental agencies
- Maryland Department of the Environment (MDE) Stream Classification
- MD Department of Natural Resources (DNR) Scenic and Wild River Classification
- Information and recommendations provided by the MDE

- MD DNR data concerning Aquatic Organism Passage (AOP) and/or wildlife passage.
- Other organization's records concerning regional and/or watershed-based studies concerning AOP or fish passage in Maryland watersheds

An inclusive list and description of potential data types and sources useful for SHHD studies is provided in Chapter 5, Data Sources and Field Surveys.

6.3 DOCUMENTATION OF ANALYSES AND STUDIES

Engineers completing analyses and studies for MDOT SHA projects are responsible for documenting all work in accordance with MDOT SHA OOS procedures. If an Engineer is of the opinion that a procedure, methodology, or form of documentation other than those approved by the Office of Structures should be used for a particular analysis or study, advanced approval by the SHHD Team Leader shall be obtained prior to commencement of work.

The SHHD Team Leader is responsible for reviewing and approving H&H studies conducted for MDOT SHA projects, including:

- Hydrologic Studies
- Stream Morphology Studies
- Hydraulic Studies
- Bridge Scour Evaluation and Assessment Studies
- Forensic/Post-Flood Studies (may be required after a catastrophic flood which resulted in either a structural failure, or damage to adjacent properties, or both)

The SHHD Team Leader is also responsible for preparation and review of the Hydrologic and Hydraulic Data Sheet to ensure that it is accurate and complete. Complex or unusual features of the design should be outlined in the comments sections of this sheet. Appropriate references should be listed for any special studies or reports that were used as a basis for the design of the structure. The Hydrologic and Hydraulic Data Sheet is an important document for record keeping and long-term archive of data since it is included in the permanent record plan set for each structure.

The format and content of reports shall be in accordance with the outlines provided in this Section, except in the case where project-specific criteria require otherwise. In this case, direction and instructions from the SHHD Team Leader shall take precedence. In all cases, the engineer shall work in close cooperation with the SHHD Team Leader to minimize communication errors that would result in non-productive work. Reports shall be self-contained to the extent practicable. Where necessary, reference may be made to outside sources of information used by the Engineer in preparing data or exhibits for the reports.

SHHD has developed standard report outlines which are presented in Table 6-3 through Table 6-8. Report outlines are provided for the documentation of the various studies which are part of the project development phase, including reports pertaining to hydrology, hydraulics, stream morphology, and scour evaluation. These outlines can be considered as typical checklists of items to be included in MDOT SHA reports. Items included in the outlines which are not applicable to a particular project can be omitted from the documentation. Engineers should use these outlines to assure that the appropriate topics for each project have been included and addressed. Note that

there is some intentional duplication of key information in the different report types (e.g., roadway classification). Duplication of information and data can be minimized by referencing the initial study. For example, a summary of hydrologic information can be provided in the hydraulic analysis report with a reference to the hydrologic analysis report.

In some cases, per SHHD Team Leader direction, a combined hydrology, stream morphology, hydraulics and scour evaluation report may be prepared. This may occur for in-kind replacement projects or rehabilitation and deck replacement projects. In these cases, the report sections for hydrology, stream morphology, and hydraulics should be expanded to include the data specified in the individual study reports, as noted in Table 6-3, Table 6-4, and Table 6-6, respectively.

The typical project development sequence for completing studies and the associated documentation reports is provided in Chapter 4, Project Development. The minimum submittal requirements associated with each completed analysis or study phase are provided in Section 6.4.3. The SHHD Team Leader may request that the Engineer provide one or more preliminary or technical submissions for review prior to development of the draft report to assure that the analysis is proceeding in a manner acceptable to the MDOT SHA.

6.3.1 Standard Report Requirements

Regardless of the study topic, all SHHD documentation reports must include certain standard features. These include the following:

- Cover Page (Title, Structure Number, FMIS Number, Location/County, Date, Prepared by)
- Executive Summary
- Table of Contents (List of Report Chapters and Sub-Chapters)
- List of Figures
- List of Tables
- List of Appendices
- References
- Appendices (with information clearly organized and identified using dividers)

6.3.2 Standard Mapping Requirements

Standard SHHD reports require a vicinity map and location map. These maps must include a north arrow and scale bar, provide clear and legible labeling, and be presented at a scale which facilitates the map intent. The vicinity map, which should show a larger surrounding area than the location map, is intended to allow a reader or reviewer to find and navigate to the subject project site. The location map is intended to provide an overview of the study site and surrounding area. Depending on the study site specifics, it may be necessary to provide an additional project area map at a more detailed scale to highlight significant site features (e.g., a nearby confluence or adjacent hydraulic structures). Figures 6-1 and 6-2 provide examples of typical project maps.

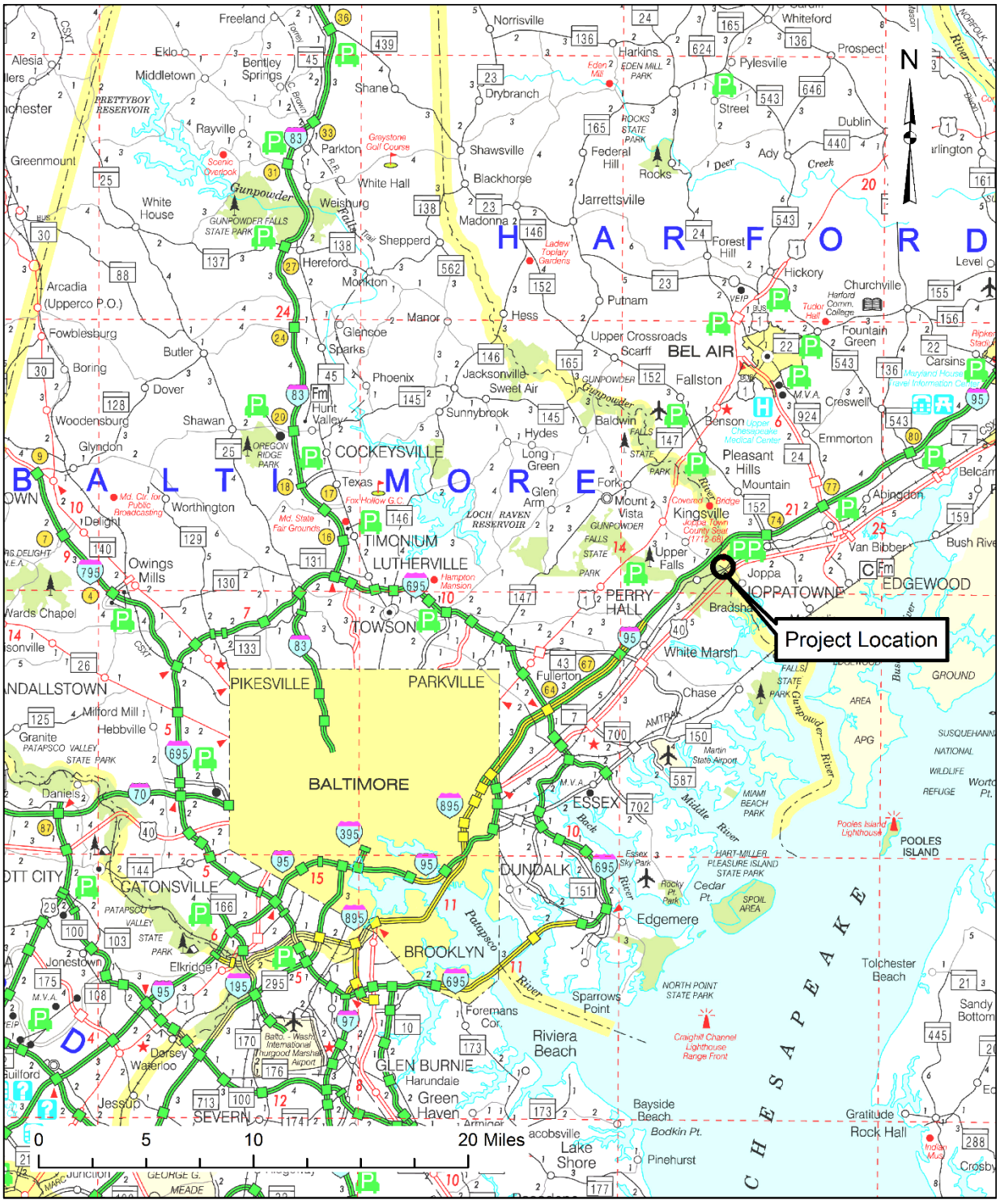


Figure 6-1. Example of a Project Vicinity Map

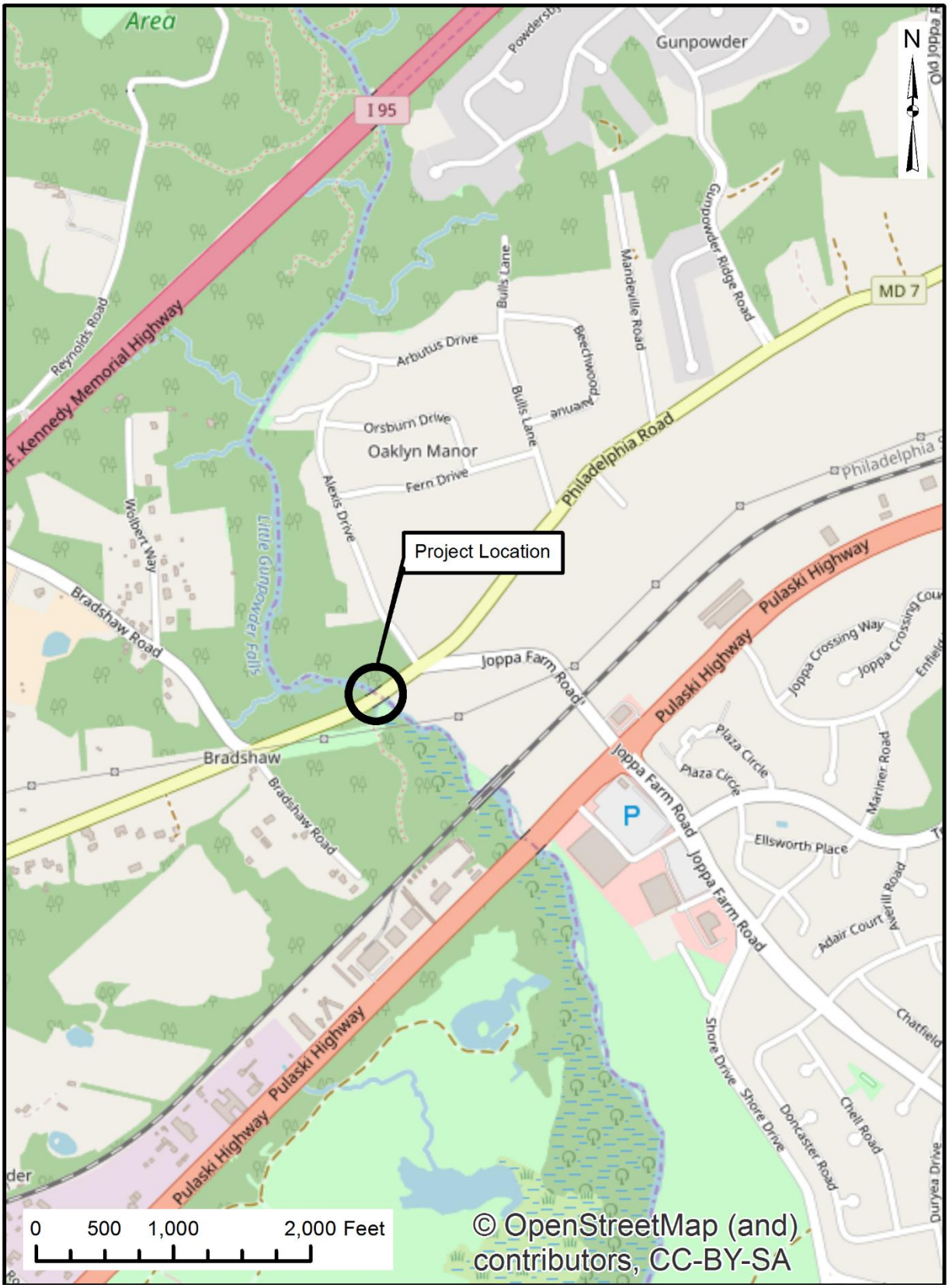


Figure 6-2. Example of a Project Location Map

Other standard maps required in the documentation of completed studies and analyses include drainage area maps, soil maps, land use maps, zoning maps, photo location maps, floodplain maps, and other study specific maps. All maps of these listed maps should include the following minimum information:

- North arrow
- Scale
- Legend
- Title or figure caption with route number and stream name
- Title or figure caption with MDOT SHA FMIS number and structure number

In addition to these basic minimum requirements, there are SHHD symbolic (CAD/GIS) standards for the 100-year floodplain map, which is required as an appendix to the hydraulics analysis report. These standards are presented in Table 6-2 (GIS/ArcGIS) and Table 6-1 (CAD/MicroStation). Figure 6-3 provides an example of a standard 100-year floodplain map.

Table 6-1 SHHD Floodplain Mapping Standards, ArcGIS

Category					
[Contour]	**Layer Name**	**Color**	**Geometry Type**	**Weight**	**Example**
Minor Existing	EX_Minor	(130,130,130)	Dash	1.00	
Major Existing	EX_Major	(130,130,130)	Dash	1.13	
Major Existing Label	EX_Major Label	(130,130,130)	Text - Aerial		Major Existing Label
Minor Proposed	PROP_Minor	(0,0,0)	Continuous	1.00	
Major Proposed	PROP_Major	(0,0,0)	Continuous	1.13	
Major Proposed Label	PROP_Major_Label	(0,0,0)	Text - Aerial		Major Proposed Label
[Roadway]					
Existing Roadway	EX_Edge_of_Road	(130,130,130)	Continuous	1.13	
Existing Trails	EX_Trail	(0,0,0)	Dash	1	
Railroad	Railroad	(0,0,0)	Continuous	1	
Proposed Roadway	PROP_Roadway	(255,0,0)	Continuous	1.13	
Roadway Labels	Roadway_Labels	(0,0,0)	Text - Aerial		Roadway Labels
[Structure]					
Existing Structure	EX_Structure	(0,0,0)	Dash	1	
Proposed Structure	PROP_Structure	(179,0,212)	Continuous	1.13	
Building	Building	(156,156,156)	Polygon	1.13	
Tree/ Shrub	Tree Line	(0,153,0)	Polygon	1.13	
Stream, Tributary, etc.	Stream	(0,92,230)	Polygon	1.13	FLOW
[Completed Surveys]					
Cross Sections					
HEC_RAS XS	HEC_XS	(179,0,212)	Dash	2.25	106
Interpolated_XS	INTERP_XS	(0,153,0)	Dash	2.25	106
Survey_XS	SURV_XS	(230,0,0)	Continuous	2.25	106
Traverse Line	SURV_Traverse Line	(230,0,0)	Continuous	2	0+00 0+50 1+00 1+50 2+00 2+50
Data Collection Bndy	DC_Boundary	(169,0,230)	Continuous	1.13	
Existing Water Surface Elevation Floodplain Boundary	EX_Flood	(0,0,255)	Dash	2.63	
Proposed Water Surface Elevation Floodplain Background	PROP_Flood	(0,153,0)	Continuous	2.63	
Building	SURV_Building	(230,0,0)	Polygon	1.13	FF ELEV. & BF ELEV.
Floodplain Background Shade	Flood_Fill	(245,245,190)	Polygon		
Existing Ineffective Flow Area	EX_Ineffective	(0,255,0)	Polygon	2	
Proposed Ineffective Flow Area	PROP_Ineffective	(0,135,0)	Polygon	2	

Table 6-2 SHHD Floodplain Mapping Standards, MicroStation

CATEGORY	LEVEL	COLOR	STYLE	WEIGHT	EXAMPLE
+ [Contours]					
Minor Existing	Minor	236	3	0	
Major Existing	Major	236	3	2	
Major Existing Label	(font = font000, weight 15, heigh 15)				Major Existing Label
Minor Proposed	Pro_Minor	0	0	0	
Major Proposed	Pro_Major	0	0	2	
Major Proposed Label	(font = font000, weight 15, heigh 15)				Major Proposed Label
+ [Roadway, Routes, Driveway, Etc..]					
Existing Roadway	Road_Edge	0	0	3	
Existing Trails	Trail	0	1	1	
Proposed Roadway	Pro_Roadway	3	0	2	
Roadway Labels	(font = font000, weight 15, heigh 15)				Roadway Labels
+ [Structures, Guard Rails, etc..]					
Existing Structure	EX_Struct	0	2	2	
Proposed Structure	Pro_Struct	5	0	4	
+ [Houses, Sheds, etc.]					
Buildings	BLDG	0	0	3	
+ [Border, etc.]					
Plan Sheet Border	Border	0	0	4	
Title Block & Legend	Title Block	0	0	2	
Title Block & Legend Text	(font = font000, weight 31, heigh 31)				Title Block & Legend Text
North Arrow	North Arrow	0	0	2	
Scale Bar	Scale_Bar	0	0	3	200' 100' 0' 100' 200' SCALE: 1"=100'
+ [Rail Road, Train Tracks, CSX, etc..]					
Tracks	Rail	0	RailRoad	2	
Structure	Rail_Struct	0	0	2	
+ [Trees, Bushes, Shrubs, etc..]					
Tree Line	Tree_Line	2	Woods Line	2	
Bushes & Shrubs	Bushes	2	0	2	
+ [Streams, Tributary, etc..]					
Streams & Tributary	Stream	2	6	2	
Flow Direction	Stream	2	0	2	FLOW
Stream Name Label	(font = font000, weight 15, heigh 15)				Little Bennett Creek
+ [Completed Surveys]					
Cross Sections	GRAD_BRKL (font = eng_modified, weight 15, heigh 15)	3	0	6	106
Traverse Line	BLIN_STAN (font = eng_modified, weight 15, heigh 15)	3	0	2	0+00 0+50 1+00 1+50 2+00
Data Collection Boundary	DC_Boundary	5	3	3	
Buildings	Surv_BLDG (font = eng_modified, weight 15, heigh 15)	2	0	3	FF ELEV. & BF ELEV.
Roadway Cenerline Profile	Surv_Profile (font = eng_modified, weight 15, heigh 15)	2	4	3	Profile 1
+ [Added Features]					
Existing Water Surface Elevation Floodplain Boundary	EX_Flood	1	3	8	
Proposed Water Surface Elevation Floodplain Boundary	Pro_Flood	16	0	8	
Floodplain Background Shade	Flood_Fill	128	0	0	
Existing Ineffective Flow Area	Ex_Ineffective	3	0	6	
Proposed Ineffective Flow Area	Pro_Ineffective	152	0	6	
HEC-RAS Cross Sections	HEC_XS	5	2	6	106
Interpolated Cross Sections	Interp_XS	0	2	6	106

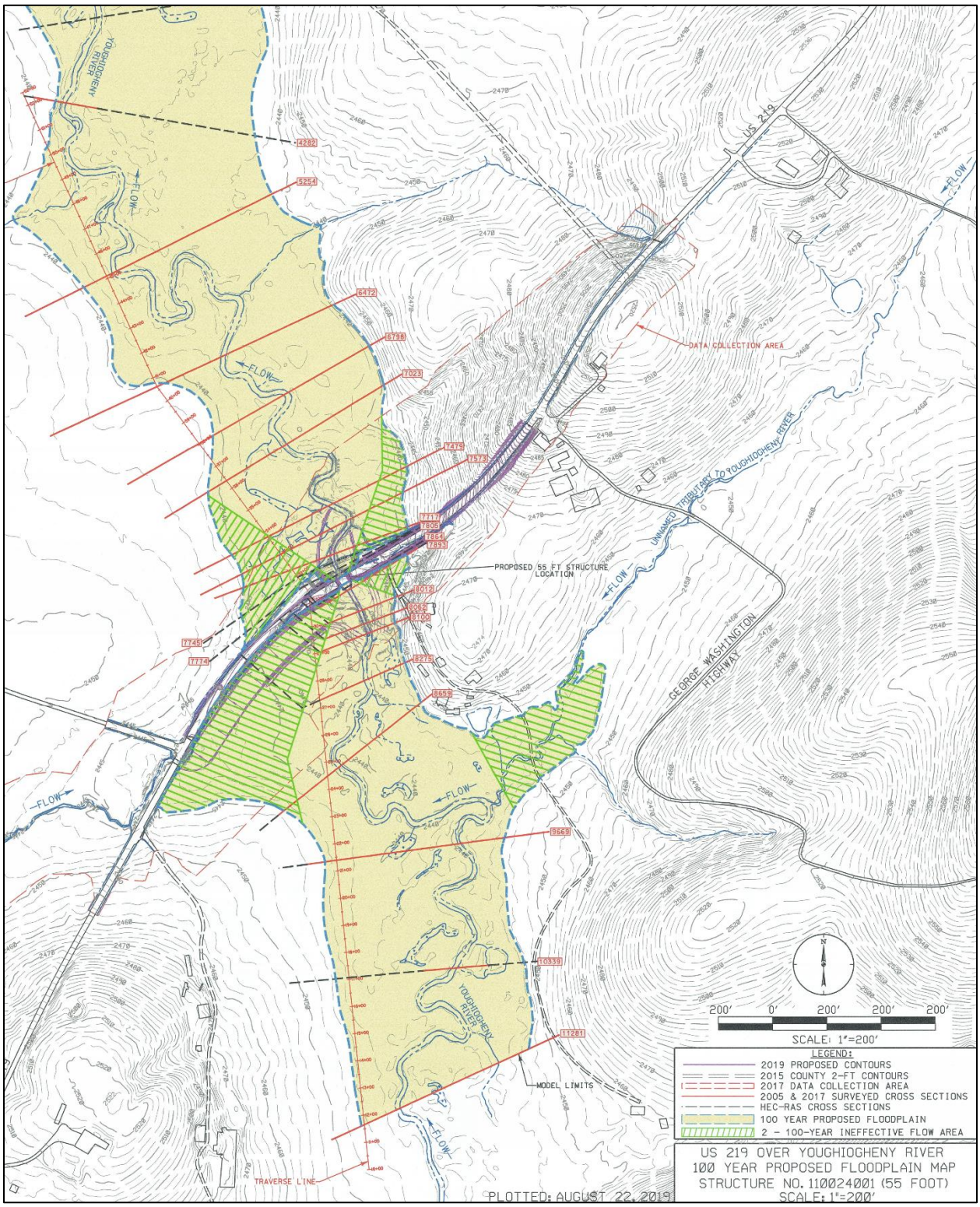


Figure 6-3. Example of a 100-year Floodplain Map

6.3.3 Hydrologic Analysis Reports

Hydrologic analysis reports are to be prepared in accordance with the procedures and methodologies presented in this manual. The MDOT SHA and the MDE have jointly adopted a methodology for the analysis of flood peak discharges and hydrographs in Maryland. The methodology was developed by the Maryland Hydrology Panel, which is a panel of hydrology experts comprised of state, federal, consultant, and university personnel with special expertise in the field of hydrology. The Panel's report, which outlines the jointly adopted methodology, is titled "Application of Hydrologic Methods in Maryland". The report is updated periodically as new information or procedures are evaluated and approved. Application of the methodology developed by the Panel requires the use of the latest approved version of GISHydro. This computer program is also periodically revised to incorporate improved methods of hydrologic analysis.

The report outline provided in Table 6-3 is a typical checklist of items to be included in SHHD Hydrologic Analysis Reports. This standard report outline should be altered when necessary, with sub-headings added or removed as appropriate to address project specific characteristics and any additional analysis documentation required.

Table 6-3 Hydrologic Analysis Report Outline

- Cover Page
- Executive Summary
- 1 Introduction and Background
  - 1.1 Objectives
  - 1.2 Project Description (including Vicinity/Location Maps and Site Photos)
  - 1.3 Stream Classification and In-stream Construction Restrictions
  - 1.4 Roadway Functional Classification, AADT, and Design Flood
  - 1.5 Methods and Software Used in the Study
  - 1.6 Flooding History
  - 1.7 Previous Studies
  - 1.8 FEMA Studies (including FEMA discharges)
  - 1.9 USGS Stream Gage
  - 1.10 Stream Morphology, Bankfull Stream Parameters, Rosgen Classification
  - 1.11 Wetlands
  - 1.12 Reference Datum
- 2 Watershed Description
  - 2.1 Location (County, Physiographic Region)
  - 2.2 Land Use Characteristics
    - 2.2.1 Existing Development Condition
    - 2.2.2 Ultimate Development Condition / Zoning Data
  - 2.3 Soil Hydrologic Characteristics
  - 2.4 Hydraulic Structures (storage reservoirs or flow diversion structures)
  - 2.5 Other Significant Hydrologic Features (i.e., Karst/limestone regions)
- 3 Methodology and Analyses
  - 3.1 Statistical Analyses (Fixed Region Regression Equations / USGS PeakFQ)
  - 3.2 WinTR-20 or TR-20 Analysis
    - 3.2.1 Drainage Area and Subareas
    - 3.2.2 Time of Concentration (Tc)
    - 3.2.3 Runoff Curve Number (Existing and Ultimate Development Conditions)
    - 3.2.4 Precipitation (Duration and Distribution)
    - 3.2.5 Reach Routing
    - 3.2.6 Storage Routing
    - 3.2.7 Tidal Prism Analysis
    - 3.2.8 Dimensionless Unit Hydrograph
    - 3.2.9 Model Calibration
  - 3.3 Low Flow Hydrology for Evaluating Aquatic Organism Passage
- 4 Evaluation of Results
  - 4.1 Existing Development Conditions
  - 4.2 Ultimate Development Conditions
  - 4.3 Comparison with Other Study Results (i.e., FEMA) and Past Flood Events
  - 4.4 Required Permits/Approvals
- 5 Conclusion and Recommendations
- 6 References

	Appendices
A	H&H Data Sheet, Summary Table for Hydrology (see Table 6-9 for template)
B	GISHydro2000 or GISHydroNXT Output
	Existing Development Conditions, including Basin Statistics, Basin Composition (RCN values), Fixed Region Regression Equation Estimates, and Tasker Analysis
	Ultimate Development Condition, including Basin Statistics, Basin Composition (RCN values)
C	Flood Frequency Curves
D	Tc Computations and Tc Flow Path Map
E	Routing
	Reach routing tables with all supporting data and studies
	Reservoir routing tables with all supporting data and studies
F	Win TR-20 or TR-20 Input and Output Files, Single Area Watershed
	Existing Development Conditions
	Ultimate Development Conditions
G	Win TR-20 or TR-20 Input and Output Files, Subdivided Watershed
	Existing Development Conditions
	Ultimate Development Conditions
H	Land Use and Soil Data
	Zoning Data
	NRCS Soil Report
I	Maps, Photos, and Exhibits (if not included in report body)
	Photos (including upstream and downstream face of bridge, stream channel upstream and downstream of structure, roadway profiles looking left and right of structure)
	Wetland Map
	FEMA Flood Insurance Rate Map
	Drainage Area Map (Single and Subdivided)
	Existing Conditions Land Use Map
	Ultimate Development Conditions Land Use Map
	Most Recent Zoning Map
	Soils Distribution Map
	Existing Conditions RCN Map
	Ultimate Development Conditions RCN Map
J	Hydrology Panel Recommendations/Correspondence
K	Computation files for AOP Low Flow Hydrology
L	Digital Files: report (MS Word and PDF versions), maps, photos, exhibits, figures and tables, TR-20/WinTR-20 input and output file, relevant GIS data files.

6.3.4 Stream Morphology Reports

Stream morphology reports are to be prepared in accordance with the procedures and methodologies presented in this manual. The goal of MDOT SHA stream morphology studies is to provide recommendations for the structure design based on river mechanics and morphological conditions.

Stream morphology studies are generally completed for OOS projects involving a structure over a waterway and may consist of 1) an assessment and, if required, 2) a detailed study. The assessment should describe key morphological issues including the stability or instability of the channel, the effects of the stream on the structure, the effects of the structure on the stream, the potential impacts and/or benefits of the proposed project on the stream and floodplain, and the collection of data required for the scour evaluation. If the assessment indicates a need for further analysis, the SHHD may authorize a detailed stream morphology study to evaluate complex site conditions or to obtain information for channel stability design. The detailed study scope should be developed based on the assessment findings and recommendations. If channel work is proposed, a detailed stream morphology study is typically required.

The report documenting the stream morphology assessment should include the following information:

- Description of existing crossing and any issues related to stream stability and existing scour (including specific field measured values tied to a structure control point, where possible)
- Description of historic and contemporary modifications to channels and valleys
- Identification and discussion regarding any environmental considerations (AOP, wetlands, forests, etc.)
- Discussion of any tidal effects or influence
- Discussion of sediment dynamics and potential debris impacts
- Description and photos of the base level control reach, project reach, and supply reach
- Description and photos of the assessment reach, including base flow water surface slope; threshold depth, width, and discharge; boundary shear stress; and critical shear stress
- Description of the riffle assessment, including length, slope, and bed material classification (pebble count D50)
- Anticipated scour type at the structure (live bed or clear water)
- Potential lateral channel movement, including estimates of lateral migration rates and how lateral erosion potential may impact the type, size, and/or location of the new or replacement structure
- Potential long-term bed degradation and associated impact on scour and/or AOP
- Potential bend scour depth
- Bedload particle size distribution (for scour evaluation)
- Anticipated relative channel shear stress change as a result of project and recommendations for further studies to mitigate shear stress changes, if necessary
- Recommendations for AOP measures
- Factors/conditions placing MDOT infrastructure or public safety at risk

- Discussion related to any factors which may impact hydraulics analysis (i.e., cross section locations)
- Recommendations for type, size, and location of new or replacement structure
- Recommendations for design considerations (such as optimal skew angle or channel stabilization)
- Recommendations for additional required data or study including the scope or recommendation for a detailed study

The report outlines provided in Table 6-4 and Table 6-5 are a typical checklist of items to be included in SHHD Stream Morphology Assessment Reports and Detailed Stream Morphology Study Reports, respectively. These standard report outlines should be altered when necessary, with sub-headings added or removed as appropriate to address project specific characteristics and any additional analysis documentation required.

Table 6-4 Stream Morphology Assessment Report Outline

	Cover Page
	Executive Summary
1	Introduction and Background
	1.1 Study Objectives
	1.2 Regional Bankfull Flow and Channel Geometry Estimates
	1.3 Physiographic Region and Geology of Site
	1.4 Historic and Contemporary Modifications to Channels and Valleys
	1.5 Stream and Valley Classification
2	Visual Assessment
	2.1 Summary of Field Procedures
	2.2 Key Features and Observations
	2.2.1 Base Level Control Reach
	2.2.2 Project Reach
	2.2.3 Supply Reach
	2.2.4 Sediment Transport Assessment Reach
	2.3 Barriers to Passage of Fish and other Aquatic Organisms
	2.4 Scour Analysis Recommendations
3	Conclusion and Recommendations
	3.1 Sediment Transport Assessment Summary
	3.2 Structure Size, Type, and Location Recommendations
	3.3 Parameters and Recommendations for Scour Study
	3.4 Purpose and Scope of any Additional Recommended Study
	3.5 Channel Work Recommendations
4	References
	Appendices
A	H&H Data Sheet, Summary Table for Stream Morphology (see Table 6-10 for template)
B	Maps, Photos, and Exhibits (if not included in report body)
	Vicinity and Location Map
	Photos and Photo Location Map
C	Pebble Count or Bedload Collection Results
D	Digital Files: report (MS Word and PDF versions), maps, photos, exhibits, figures and tables, relevant GIS and/or CAD data files.

Table 6-5 Detailed Stream Morphology Study Report Outline

	Cover Page
	Executive Summary
1	Introduction and Review of Assessment Study
	1.1 Objectives and Assessment Recommendations
	1.2 Extent of the Channel Profile Survey
	1.3 Description of Project Reach
	1.4 Sediment Assessment Reach
	1.5 Lateral Channel Movement
	1.6 Soil and Bed Load Materials for Scour Studies
	1.7 Selection of Locations for Data Collection
2	Data Collection and Subsurface Investigation
	2.1 Valley Longitudinal Profile
	2.2 Channel Profile Survey
	2.3 Channel Cross Sections
	2.4 Bed Sediments
	2.5 Barriers to Passage of Fish and other Aquatic Organisms (AOP)
	2.6 Bankfull Flow Indicators and Channel Characteristics
	2.7 Subsurface Sampling (Note MDE permit may be required)
	2.8 Bank Geometry, Bank Materials, and Stratification
	2.9 Lateral Channel Movement and Planform Changes
	2.10 Long-Term Bed Degradation
3	Analysis
	3.1 Long-Term Changes in the Stream Bed Elevation
	3.2 Lateral Channel Movement and Planform Changes
	3.3 Stream Cross Section Characteristics and Flow Analyses
	3.4 Characteristics of Bed Material and Load
	3.5 Stability of Riffles
	3.6 Preliminary Assessment of Structure Alternatives
	3.7 Preliminary Assessment of Channel Alterations or Relocations
4	Conclusion and Recommendations
	4.1 Recommendations for Additional Field Work or Data Collection
	4.2 Recommendations for Structure Size, Type, and Location
	4.3 Remedial Efforts for Channel/Structure Stabilization
	4.4 Required Channel Work
	4.5 Scour Study Recommendations
5	References
	Appendices
A	Maps, Photos, and Exhibits (if not included in report body)
	Vicinity and Location Map
	Photos and Photo Location Map
B	Digital Files: report (MS Word and PDF versions), maps, photos, exhibits, figures and tables, relevant GIS and/or CAD data files.

6.3.5 Hydraulic Analysis Reports

Hydraulic analysis reports are to be prepared in accordance with the procedures and methodologies presented in this manual. The report documenting the hydraulic analysis of a proposed structure must provide the minimum information required to show that the proposed design meets all regulatory requirements. The analysis methodology, review/approval process, and documentation content will be impacted by whether the subject structure is located within a Federal Emergency Management Agency (FEMA) regulated floodplain or is located within an area designated by MDE as tidal. See Chapter 3 Procedures, Design Guidelines, and Permits and Chapter 4 Project Development for detail on the process and procedures for the various cases.

For projects located within a FEMA regulated floodplain, the MDOT SHA SHHD and the MDE Water and Science Administration (Waterway Construction Division) have developed a process to integrate SHHD and FEMA hydraulic modeling efforts. The goal is to improve the analysis efficiency and subsequent project approval, while also providing MDE, FEMA, and the community with the best available data regarding the regulated floodplain. More information on the integrated modeling process is provided in *Recommendations for Hydraulic Analyses in FEMA Special Flood Hazard Areas in Maryland* (Maryland Hydraulics Panel, 2018). Note that the Maryland Hydraulics Panel plans to provide updates to this report in the future, based on implementation of the process for SHHD projects.

If a project is located within a FEMA floodplain, the hydraulic analysis shall follow the guidance presented in *Recommendations for Hydraulic Analyses in FEMA Special Flood Hazard Areas in Maryland* (2018). Projects in a FEMA AE Zone (detailed study area) shall follow the integrated MDE/FEMA modeling approach. The modeling approach for projects located within a FEMA Zone A (approximate study area), or any other FEMA Zone type (e.g., V/VE Coastal) shall be determined on a case by case basis. These projects should be discussed with the SHHD Team Leader to decide on the scope of the study.

The report outline provided in Table 6-6 is a typical checklist of items to be included in the SHHD Hydraulics Report. This standard report outline should be altered when necessary, with sub-headings added or removed as appropriate to address project specific characteristics and any additional analysis documentation required.

Table 6-6 Hydraulic Analysis Report Outline

	Cover Page	
	Executive Summary	
1	Introduction and Background	
	1.1	Objectives
	1.2	Project Description (including Vicinity/Location Maps and Site Photos)
	1.3	Roadway Functional Classification, AADT, and Design Flood
	1.4	Stream Classification and In-stream Construction Restrictions
	1.5	Flooding History
	1.6	Other Hydraulic Control Structures (including any impact to flooding)
	1.7	Previous Studies
	1.8	FEMA Studies (Hydrology and Hydraulics)
	1.9	USGS Stream Gage
	1.10	Stream Morphology, Bankfull Stream Parameters, Rosgen Classification
	1.11	Wetlands
	1.12	Other Hydraulic Factors (i.e., tidal influence, downstream backwater)
	1.13	Reference Datum (Coordinate System)
2	Hydrologic Analysis	
	2.1	Watershed Characteristics Summary
	2.2	Methodology and Analysis
	2.3	Results and Approved Peak Flood Discharges
3	Methodology and Analyses	
	3.1	Methodology and Software
	3.2	Modeling
		3.2.1 Reach and Floodplain Characteristics
		3.2.2 Data Sources (including FEMA model, if applicable)
		3.2.3 Cross Section Data and Locations (Geometry)
		3.2.4 Boundary Conditions
		3.2.5 Manning's Roughness Coefficients
		3.2.6 Contraction/Expansion Coefficients
		3.2.7 Existing and Proposed Structures
		3.2.8 Structure Modeling
		3.2.9 Ineffective Flow Areas
		3.2.10 Other Analysis Details (i.e., multiple openings, split flow, or low flow/high flow model)
		3.2.11 Channel Improvement and/or Stability Design
		3.2.12 AOP Design Considerations
		3.2.13 Model Calibration (as applicable)
4	Results and Discussion	
	4.1	Flood Elevations (Water Surface and Energy)
	4.2	Velocity and Shear Stress (if Proposed Channel Work)
	4.3	Comparison Tables
	4.4	Required Permits/Approvals
5	Conclusion and Recommendations	
6	References	

	Appendices
A	H&H Data Sheet, Summary Table for Hydraulics (see Table 6-11 or 6-12 for template)
B	MDE Hydrologic Analysis Approval Letter
C	HEC-RAS Standard Tables
	Existing Conditions
	Proposed Conditions
D	Existing/Proposed Floodplain Map(s)
E	Cross Section Plots (at consistent scale)
	Existing Conditions
	Proposed Conditions
F	Water Surface Profiles
	Existing Conditions
	Proposed Conditions
G	Maps, Photos, and Exhibits (if not included in report body)
	Photos (including upstream and downstream face of bridge, stream channel upstream and downstream of bridge, roadway profiles looking left and right of bridge, representative photos to support selected Manning's n values)
	Wetland Map
	FEMA Flood Insurance Rate Map
	Drainage Area Map (Single and/or Subdivided)
H	Digital Files: report (MS Word and PDF versions), maps, photos, exhibits, figures and tables, analysis software (i.e., HEC-RAS or HY-8) existing and proposed conditions file, relevant GIS data files.

Revisions to the FEMA Flood Insurance Rate Map (FIRM) may be required due to changes resulting from MDOT SHA's proposed replacement design. Revisions may also be required due to improvements in the accuracy of analysis, related to the integrated MDE/FEMA modeling approach. FEMA's review and comments on the proposed project or the proposed model corrections/improvements are obtained through submittal of a conditional letter of map revision (CLOMR) or letter of map revision (LOMR), respectively. More information on when FEMA approvals are required, and how they are obtained, is provided in *Recommendations for Hydraulic Analyses in FEMA Special Flood Hazard Areas in Maryland* (Maryland Hydraulics Panel, 2018).

The report outline provided in Table 6-7 is a typical list of those items to be considered in development of the report to be submitted with the required CLOMR or LOMR application. Some sections may not be applicable based on the project specifics. The report should accompany FEMA's MT-2 CLOMR/LOMR application forms and provide the recommended "narrative on project and submittal". Much of the terminology in Table 6-7 comes from the FEMA MT-2 instruction document, which is available on the FEMA website. This FEMA guidance document should be referred to when developing the report and completing the required MT-2 forms.

Table 6-7 FEMA LOMR/CLOMR Report (Narrative) Outline

	Cover Page
	Executive Summary
1	Introduction and Background
	1.1 Objectives
	1.2 Summary of FEMA Coordination (pre-submission meetings/communication)
	1.3 Project Description (including Vicinity/Location Maps and Site Photos)
	1.4 Endangered Species Act (ESA) Compliance (for CLOMR only)
	1.5 Community Coordination
	1.6 Previous Studies
	1.6.1 Previous FEMA Floodplain Analysis (include effective FIRM)
	1.6.2 FEMA Hydrology and Flood Discharges
	1.7 Horizontal and Vertical Reference Datum
2	Hydraulics Analysis
	2.1 Methodology
	2.2 Duplicate Effective Model
	2.3 Corrected Effective Model
	2.3.1 Model Cross Section Data
	2.3.2 Boundary Condition
	2.3.3 Loss Coefficients
	2.3.4 Structure Modeling and Details
	2.3.5 Other Revisions
	2.4 Existing or Pre-Project Conditions Model
	2.4.1 Structure Modeling and Details
	2.4.2 Floodplain Revisions
	2.4.3 Other Revisions
	2.5 Revised or Post-Project Conditions Model
	2.5.1 Structure Modeling and Details
	2.5.2 Floodplain Revisions
	2.5.3 Floodway Revisions (if applicable)
3	Results and Discussion
	3.1 Duplicate Effective Model
	3.2 Corrected Effective Model
	3.3 Existing or Pre-Project Conditions Model
	3.4 Revised or Post-Project Conditions Model
4	Conclusion
5	References
	Appendices
A	Endangered Species Act (ESA) Compliance (for CLOMR only)
B	Digital Copy of Model Input and Output Files
C	Results of cHECk-RAS and Responses to Comments
D	Annotated FIRM
E	Certified Topographic Work Map (to include data as noted on the MT form instructions)
F	Proposed Design (if applicable)
G	As-Builts/Survey (if applicable)
H	MT-2 Forms
I	Property Owner's Notification Letters (sent once the letter template is approved by FEMA)
J	Meeting Minutes / Communication Records
K	Digital Files: GIS and/or CAD data (cross-sections, stream line, floodplain delineation, contours)

6.3.6 Bridge Deck Drainage Design Memos

Bridge deck drainage analysis is conducted to confirm that the bridge and its highway approaches are designed to provide safe and efficient conveyance of surface runoff. The analysis must determine if the bridge meets OOS design criteria, or if the construction of scuppers (deck drainage structures) are required. Analysis may also be required to verify the adequacy of existing scuppers, and to design and add new scuppers if necessary.

Documentation of the analysis is to be prepared in accordance with the procedures and methodologies presented in Chapter 12 of this manual and must provide the minimum information required to show that the proposed bridge deck drainage and scupper design, if necessary, meet OOS design criteria. Typically, the analysis will require the use of MPADD, which is a software program developed by the MDOT SHA. Analysis documentation is typically done in the form of a memo, which is to be submitted to and signed by the OOS Deputy Director. The body of the memo should include a purpose statement, a brief project summary, a summary of analysis results, and the resulting recommendations. The following should be included with the memo in the project archive, and as an attachment to the memo if requested by the OOS Deputy Director:

- Printout from MPADD listing all inputs and outputs.
- Final structure and roadway design plans including sheets with bridge layout, road profile, lane widths, drainage structures, drainage inlets, drainage ditches, and other relevant detail.

6.3.7 Bridge Scour Evaluation and Assessment Reports

Scour evaluation and assessment reports are to be prepared in accordance with the procedures and methodologies presented in this manual. 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. For projects that do not affect the substructure of a bridge (e.g., deck resurfacing) a full scour evaluation study may not be required by MDOT SHA. If the structure has been rated as a low risk under Item 113 of the Federal Highway Administration's (FHWA) *Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges* and the Office of Structure's *Guide for Completing Structure Inventory and Appraisal Input Forms*, a scour assessment conducted in accordance with Chapter 11 may be completed to document that there is low risk of a safety hazard to the traveling public or of damage to the structure.

Chapter 11 of this manual incorporates the guidance of the FHWA as set forth in HEC-18. Preparation of the scour report is to be accomplished through an interdisciplinary effort of hydraulics, geotechnical and structural engineers; team members should be listed in the report. The report outline provided in Table 6-8 is a typical checklist of items to be included in SHHD Scour Reports. This standard report outline should be altered when necessary, with sub-headings added or removed as appropriate to address project specific characteristics and any additional analysis documentation required.

A full scour evaluation or assessment study is not required for paved bottom structures such as pipe, pipe arch, and box culverts. Rather, the study for a paved bottom structure is generally limited to addressing a few basic concerns. The documentation of this study can generally be included in

the hydraulics analysis report. The summary section for a paved bottom structure scour evaluation should address the following, as necessary based on project specifics:

- Culvert analysis including estimation of 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, and the need for riprap protection.
- Special riprap designs required for outlet protection and/or stream stabilization measures.
- Designs for uplift protection of metal pipe inlets.
- Risk assessment of potential for embankment and culvert failure for overtopping flows.
- Long-term bed degradation (LTBD) and lateral channel migration assessments.

Bottomless culverts supported on footings, such as steel arch or concrete arch culverts, are to be treated as bridges for purposes of scour evaluation as described in Chapter 11. In this case the scour report should follow the outline provided in Table 6-8.

Table 6-8 Scour Evaluation Report Outline

	Cover Page
	Executive Summary
1	Introduction and Background
	1.1 Objectives
	1.2 Project Description (including Vicinity/Location Maps and Site Photos)
	1.3 Existing Bridge Scour Rating and Site Investigations
	1.4 Subsurface and Geologic Investigations
	1.5 Proposed Structure and Approach Roadways
2	Hydrologic Analysis
3	Stream Morphology, Classification, and Stability Study
4	Hydraulic Analysis
5	Scour Analysis
	5.1 Analysis Input Data
	5.2 Scour Analyses and Estimates
6	Summary and Recommendations
7	References
	Appendices
A	H&H Data Sheet, Summary Table for Bridge Scour (see Table 6-13 for template)
B	ABSCOUR Input and Output Files
C	Summary of ABSCOUR Model Results
D	Geotechnical Investigation Results
E	Correspondence and Record of Other Expert Opinions
F	Maps, Photos, and Exhibits (if not included in report body)
G	Digital Files: report (MS Word and PDF versions), maps, photos, exhibits, figures and tables, analysis software (ABSCOUR or TideRout2) file, relevant GIS data files.

6.3.8 Hydrology and Hydraulics (H&H) Data Sheets

The Hydrology and Hydraulics (H&H) Data Sheet has been developed to provide a summary record of the results of the various SHHD studies, including hydrology, stream morphology, hydraulics and scour, on the final design plans. The required data is compiled from individual summary tables (Table 6-9 through Table 6-13), which shall be included as Appendix A in the Hydrology, Stream Morphology, Hydraulics, and Scour Reports. The complete H&H Data Sheet for each project is included in the final proposed design plans of the PS&E package. Note that there are two different hydraulics summary tables; one for bridges and other bottomless structures (Table 6-11), and one for the various types of culverts (Table 6-12). Examples of complete H&H Data Sheets to be shown on the design plans are included as Figure 6-4 and Figure 6-5 for bridges and culverts, respectively.

Sections 6.3.8.1 through 6.3.8.5 provide general guidance to be considered in completing the data summary tables. Note that for all tables, if the information is not applicable or available, "NA" should be noted in the appropriate space.

6.3.8.1 Hydrologic Data

Summary information from the final approved hydrologic analysis report is provided on this form (Table 6-9). Instructions for each section are as follows:

I. Provide information regarding the hydrology report, or other data source if applicable. The prepared by field should be used to indicate who prepared the study (e.g., SHHD or a consultant).
II. Provide the drainage area in acres and square miles.
III. Check the cell next to the methods of analysis used and provide summary information for each. WinTr-20 summary data should be provided for the single basin model. Project specific information, such as watershed subdivisions and any flood routing procedures used, should be included in Section VII, Comments.
IV. Complete only if the waterway is subject to tidal influence. Clearly note if tidal flows govern for the design discharge. Describe in Section VII, Comments how the combination of the tidal storm surge and the upland riverine flood is analyzed.
V. Include information for any significant historic floods which have occurred in the watershed.
VI. Provide computed flood discharges, based on existing and ultimate land use development conditions.
VII. Note if any special or unusual features affect the hydrology of the watershed or the methodology used in the flood estimation. Includes information regarding any low flow hydrology computations for AOP.

Table 6-9 H&H Data Sheet, Summary Table for Hydrology

STRUCTURE LOCATION _____ STRUCTURE # _____

I. REPORT TITLE _____

PREPARED BY _____ DATE _____

MDE APPROVAL DATE _____

II. DRAINAGE AREA _____ (ACRES) _____ (SQUARE MILES)

III. METHOD(S) OF ANALYSIS

_____ USGS GAGE DATA ANALYSIS

GAGE STATION NO _____ LOCATION (LAT/LONG) _____

DRAINAGE AREA _____ (SQ MILES) YEARS OF CONTINOUS RECORD _____

_____ FIXED REGION REGRESSION EQUATIONS, REGION/DATE: _____

_____ NRCS WinTR-20, VERSION/DATE _____

WATERSHED CHARACTERISTICS (SINGLE BASIN):

EXISTING RCN _____ ULTIMATE RCN _____ TIME OF CONCENTRATION _____

_____ FEMA BASE FLOOD (100-YR) DISCHARGE _____ STUDY DATE _____

_____ OTHER (DESCRIBE) _____

IV. TIDAL FLOWS, DATA SOURCE _____

100-YR STORM TIDE ELEVATION _____ (FT) MAXIMUM DISCHARGE _____ (FT^3/S)

500-YR STORM TIDE ELEVATION _____ (FT) MAXIMUM DISCHARGE _____ (FT^3/S)

DESIGN DISCHARGE _____ (FT^3/S) RETURN PERIOD _____ (YRS) TIDAL PERIOD _____ (HRS)

HOW DETERMINED _____

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

V. HISTORIC FLOODS

_____

_____

VI. PEAK FLOWS

RETURN PERIOD (YEARS)	EXISTING DEVELOPMENT (FT^3/S)	ULTIMATE DEVELOPMENT (FT^3/S)
2		
10		
25		
50		
100		
500		

VII. COMMENTS

_____

_____

_____

_____

6.3.8.2 Stream Morphology Data

Summary information from the final approved stream morphology report(s) is provided on this form (Table 6-10). Instructions for each section are as follows:

I. Provide information regarding the stream morphology assessment report, or other data source if applicable. The "prepared by" field should be used to indicate who prepared the study (e.g., SHHD or a consultant).
II. Provide stream morphology characterization data as determined in the stream morphology assessment study. The bankfull characteristics data will typically be derived using the equations determined by the U.S. Fish and Wildlife Service in the Maryland Stream Survey, Bankfull Discharge and Channel Characteristics of Streams studies, as per the appropriate physiographic region.
III. Provide information regarding the detailed stream morphology report, or N/A if a detailed study was not required. The prepared by field should be used to indicate who prepared the study (e.g., SHHD or a consultant).
IV. Provide stream morphology characterization data as determined in the detailed stream morphology study.
V. In the comment field, note if any special or unusual stream morphology features at the site. Also note any details regarding significant stream work proposed or any proposed channel protection measures.

Table 6-10 H&H Data Sheet, Summary Table for Stream Morphology

STRUCTURE LOCATION _____ STRUCTURE # _____

I. STREAM MORPHOLOGY ASSESSMENT

REPORT TITLE _____

PREPARED BY _____ DATE _____

II. STREAM TYPE _____ VALLEY TYPE _____

BED LOAD MATERIAL _____ D16 _____ D50 _____ D84 _____

POTENTIAL LONG-TERM BED DEGRADATION/AGGRADATION
(BASED ON RAPID CHANNEL MEASUREMENTS) _____ (FT)

POTENTIAL BEND SCOUR _____ (FT)

POTENTIAL LATERAL CHANNEL MOVEMENT _____ (FT)

STREAM BED LOCATION (JUST DOWNSTREAM) _____ (PERCHED, GRAVEL, BEDROCK)

STRUCTURE LOCAION (VALLEY ALIGNMENT) _____

BANKFULL CHARACTERISTICS, OBTAINED FROM:
(LIST REGION/YEAR, USFWS STREAM SURVEY STUDY) _____

Q _____ (FT^3/S) AREA _____ (FT^2) WIDTH _____ (FT) DEPTH _____ (FT)

DEBRIS POTENTIAL _____

III. DETAILED STREAM MORPHOLOGY

REPORT TITLE _____

PREPARED BY _____ DATE _____

IV. VALLEY SLOPE _____ (FT/FT)

POTENTIAL LONG-TERM BED DEGRADATION/AGGRADATION
(BASED ON VALLEY/STREAM PROFILE) _____ (FT)

ASSESSMENT RIFFLE DATA:

HYDRAULIC RADIUS _____ (FT) AVERAGE SLOPE _____ (FT/FT) MANNING'S N _____

BED MATERIAL: D16 _____ D50 _____ D84 _____ D95 _____

CRITICAL SHEAR STRESS _____ (LB/FT^2) CRITICAL DEPTH _____ (FT)

TOP OF BANK/BANKFULL: Q _____ (FT^3/S) DEPTH _____ (FT) SHEAR STRESS _____ (LB/FT^2)

V. COMMENTS

_____

_____

_____

6.3.8.3 Hydraulic Data (Bridges and Bottomless Arch Culverts)

This form is applicable for bridges and bottomless culverts. Summary information from the final approved hydraulics analysis report is provided on this form (Table 6-11). Instructions for each section are as follows:

I. Provide information regarding the hydraulics report, or other data source if applicable. The prepared by field should be used to indicate who prepared the study (e.g., SHHD or a consultant).
II. Complete with the proposed conditions hydraulic analysis results data including energy grade line elevation (E.G. Upstream), water surface elevation (W.S. Upstream), structure open area, discharge through the structure (Q Structure), discharge over the roadway (Q Weir), maximum velocity through the structure, and the top width of flow (channel and floodplain) at the cross section upstream of the structure.
III. Provide data related to the existing and proposed roadway and structure.
IV. Provide design criteria data for the crossing. Include information regarding whether the proposed structure meets the roadway classification design flood, or if not, what flood discharge the structure is designed to accommodate.
V. Include data regarding FEMA floodplain status and requirements.
VI. Note if any special or unusual features affect the hydraulic aspects of the design.

6.3.8.4 Hydraulics Data (Culverts)

This form is applicable for culverts. Summary information from the final approved hydraulics analysis report is provided on this form (Table 6-12). Instructions for each section are as follows:

I. Provide information regarding the hydraulics report, or other data source if applicable. The prepared by field should be used to indicate who prepared the study (e.g., SHHD or a consultant).
II. Complete with the proposed conditions hydraulic analysis results data including energy grade line elevation (E.G. Upstream), water surface elevation (W.S. Upstream), total flow area of the culvert group, discharge through the structure (Q Culvert Group), discharge over the roadway (Q Weir), maximum velocity at the outlet of the structure, and the top width of flow (channel and floodplain) at the cross section upstream of the structure.
III. Provide data related to the existing and proposed roadway and structure.
IV. Provide design criteria data for the crossing. Include information regarding whether the proposed structure meets the roadway classification design flood, or if not, what flood discharge the structure is designed to accommodate.
V. Include data regarding FEMA floodplain status and requirements.
VI. Note if any special or unusual features affect the hydraulic aspects of the design. Include information regarding any existing AOP issues or proposed AOP design considerations.

Table 6-11 H&H Data Sheet, Summary Table for Hydraulics (Bridge)

STRUCTURE LOCATION _____ STRUCTURE # _____

I. REPORT TITLE _____

PREPARED BY _____ DATE _____

MDE APPROVAL DATE _____

II. HYDRAULICS DATA (PROPOSED CONDITIONS – UPSTREAM OF STRUCTURE)

ELEVATION PRESSURE FLOW BEGINS: _____ (FT)

ELEVATION WEIR FLOW BEGINS: _____ (FT)

BASE FLOW WATER SURFACE ELEVATION (APPROXIMATE): _____ (FT)

FLOOD (YEAR)	E.G. UPSTREAM (FT)	W.S. UPSTREAM (FT)	STRUCTURE OPEN AREA (FT^2)	Q STRUCTURE (FT^3/S)	Q WEIR (FT^3/S)	MAX VELOCITY STRUCTURE (FT/S)	TOP WIDTH AT UPSTREAM XS (FT)
2							
10							
25							
50							
100							
500							
INCIPIENT OVERTOPPING							

III. ROADWAY AND STRUCTURE HYDRAULIC CONDITION

ITEM	EXISTING STRUCTURE	PROPOSED STRUCTURE
DATE BUILT		
EDGE OF TRAFFIC LANE, LOWEST ELEVATION		
OVERTOPPING ELEVATION		
OVERTOPPING LOCATION		
INCIPIENT OVERTOPPING FLOW		
TOTAL STRUCTURE OPENING AREA		
MIN CHANNEL EL. (UPSTREAM)		
STRUCTURE TYPE AND TOTAL CLEAR SPAN LENGTH		

IV. DESIGN CRITERIA

ROADWAY CLASSIFICATION _____ DESIGN FLOOD _____ (YEAR)

DISCHARGE CROSSING CAN ACCOMMODATE _____ (FT^3/S)

ESTIMATED MAX FLOW DEPTH OVER TRAVEL LANES IF OVERTOPPED BY DESIGN FLOOD _____

IF DESIGN FLOOD CRITERIA NOT MET, DESIGN EXCEPTION APPROVAL DATE _____

OTHER KNOWN FLOODING LOCATIONS ON THIS ROADWAY _____

_____

_____

NAVIGABLE CHANNEL (Y/N) _____ MAX VERTICAL CLEARANCE _____ (FT) OFFICIAL COAST GUARD (Y/N) _____

V. FEMA FLOODPLAIN DATA

FLOOD INSURANCE STUDY DATE _____ COMMUNITY PANEL NO. _____

PROJECT LOCATION (ZONE A, ZONE AE, OUTSIDE FEMA LIMITS) _____

REGULATORY FLOODWAY YES _____ NO _____

MAXIMUM WATER SURFACE ELEVATION CHANGE UPSTREAM OF STRUCTURE _____ (FT)

MAXIMUM WATER SURFACE ELEVATION CHANGE DOWNSTREAM OF STRUCTURE _____ (FT)

CLOMR/LOMR REQUIRED (Y/N) _____ FEMA APPROVAL DATE _____

DATE HYDRAULIC MODEL SUBMITTED TO MDE NFIP COORDINATOR _____

VI. COMMENTS

_____

_____

_____

Table 6-12 H&H Data Sheet, Summary Table for Hydraulics (Culvert)

STRUCTURE LOCATION _____ STRUCTURE # _____

I. REPORT TITLE _____

PREPARED BY _____ DATE _____

MDE APPROVAL DATE _____

II. HYDRAULICS DATA (PROPOSED CONDITIONS)

ELEVATION PRESSURE FLOW BEGINS: _____ (FT)

ELEVATION WEIR FLOW BEGINS: _____ (FT)

BASE FLOW WATER SURFACE ELEVATION (APPROXIMATE): _____ (FT)

FLOOD (YEAR)	E.G. UPSTREAM (FT)	W.S. UPSTREAM (FT)	TOTAL FLOW AREA (FT^2)	Q CULVERT GROUP (FT^3/S)	Q WEIR (FT^3/S)	CULVERT VELOCITY DOWNSTREAM (FT/S)	TOP WIDTH AT UPSTREAM XS (FT)
2							
10							
25							
50							
100							
500							
INCIPIENT OVERTOPPING							

III. ROADWAY AND STRUCTURE HYDRAULIC CONDITION

ITEM	EXISTING STRUCTURE	PROPOSED STRUCTURE
DATE BUILT		
OVERTOPPING ELEVATION (FT)		
OVERTOPPING LOCATION		
INLET OR OUTLET CONTROL		
INCIPIENT OVERTOPPING FLOW (DISCHARGE AND RECURRENCE)		
TOTAL STRUCTURE OPENING AREA (FT^2)		
STRUCTURE LENGTH, SIZE, TYPE, AND NUMBER OF CELLS		
INLET TREATMENT		
OUTLET TREATMENT		
STRUCTURE COMPOSITE MANNING'S N		
AQUATIC ORGANISM PASSAGE CONCERNS, ISSUES, TREATMENT		

IV. DESIGN CRITERIA

ROADWAY CLASSIFICATION _____ DESIGN FLOOD _____ (YEAR)

DISCHARGE CROSSING CAN ACCOMMODATE _____ (FT^3/S)

ESTIMATED MAX FLOW DEPTH OVER TRAVEL LANES IF OVERTOPPED BY DESIGN FLOOD _____

IF DESIGN FLOOD CRITERIA NOT MET, DESIGN EXCEPTION APPROVAL DATE _____

OTHER KNOW FLOODING LOCATIONS ON THIS ROADWAY

_____

_____

NAVIGABLE CHANNEL (Y/N) _____ MAX VERTICAL CLEARANCE _____ (FT) OFFICIAL COAST GUARD (Y/N) _____

V. FEMA FLOODPLAIN DATA

FLOOD INSURANCE STUDY DATE _____ COMMUNITY PANEL NO. _____

PROJECT LOCATION (ZONE A, ZONE AE, OUTSIDE FEMA LIMITS) _____

REGULATORY FLOODWAY YES _____ NO _____

MAXIMUM WATER SURFACE ELEVATION CHANGE UPSTREAM OF STRUCTURE _____ (FT)

MAXIMUM WATER SURFACE ELEVATION CHANGE DOWNSTREAM OF STRUCTURE _____ (FT)

CLOMR/LOMR REQUIRED (Y/N) _____ FEMA APPROVAL DATE _____

DATE HYDRAULIC MODEL SUBMITTED TO MDE NFIP COORDINATOR _____

VI. COMMENTS

_____

_____

_____

6.3.8.5 Bridge Scour Data

Summary information from the final approved scour report is provided on this form (Table 6-13). Instructions for each section are as follows:

I. Provide information regarding the scour report, or other data source if applicable. The prepared by field should be used to indicate who prepared the study (e.g., SHHD or a consultant).
II. Provide scour depth estimates for the design and check floods. Provide the estimated total scour elevations used for foundation design.
III. Note if any special or unusual scour issues at the site.

Table 6-13 H&H Data Sheet, Summary Table for Bridge Scour

STRUCTURE LOCATION _____ STRUCTURE # _____

I. REPORT TITLE _____

PREPARED BY _____ DATE _____

MDOT SHA APPROVAL DATE _____

METHOD OF ANALYSIS _____

II. SCOUR ESTIMATES

	DESIGN CONDITIONS (SUCH AS OVERTOPPING, LOW TAILWATER, INFLUENCE OF CONFLUENCE, ETC.)	FLOOD DISCHARGE		LONG TERM DEGRADATION/ AGGRADATION (FT)	CONTRACTION ☐ OR BEND SCOUR ☐ DEPTH (FT) (CHECK WHICH ONE USED)		
		RETURN PERIOD (YRS)	MAGNITUDE (FT^3/S)		LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK
DESIGN FLOOD FOR SCOUR							
CHECK FLOOD FOR SCOUR							
OTHER							

	CHANNEL BED LOAD (DESCRIBE)	SCOUR TYPE (LIVE BED/CLEAR WATER)	TOTAL SCOUR DEPTH (FT)				
			ABUTMENT A	PIER(S) NO:			ABUTMENT B
DESIGN FLOOD FOR SCOUR							
CHECK FLOOD FOR SCOUR							
OTHER							

ESTIMATED TOTAL SCOUR (LONG TERM DEGRADATION/AGGRADATION, CONTRACTION SCOUR, AND LOCAL SCOUR)

ELEMENT	ESTIMATED PILE TIP ELEVATION	SCOUR ELEVATION (FT)		SCOUR COUNTER MEASURES
		DESIGN FLOOD	CHECK FLOOD	
CHANNEL THALWEG				
ABUTMENT A				
ABUTMENT B				
PIER NO:				
PIER NO:				
PIER NO.				

III. COMMENTS

_____

_____

_____

HYDROLOGIC DATA

I. REPORT TITLE _____
PREPARED BY _____ DATE _____
MDE APPROVAL DATE _____

II. DRAINAGE AREA _____ (ACRES) _____ (SQUARE MILES)

III. METHOD(S) OF ANALYSIS:

_____ USGS GAGE DATA ANALYSIS
GAGE STATION NO. _____ LOCATION (LAT/LONG) _____
DRAINAGE AREA _____ (SQ. MILES) YEARS OF CONTINOUS RECORD _____
_____ FIXED REGION REGRESSION EQUATIONS, REGION/DATE _____
_____ NRCS WinTR-20, VERSION/DATE _____
WATERSHED CHARACTERISTICS (SINGLE BASIN):
EXISTING RCN _____ ULTIMATE RCN _____ TIME OF CONCENTRATION _____
_____ FEMA BASE FLOOD (100-YR DISCHARGE) _____ STUDY DATE _____
_____ OTHER (DESCRIBE) _____

IV. TIDAL FLOWS, DATA SOURCE _____

100-YR STORM TIDE ELEVATION _____ (FT) MAXIMUM DISCHARGE _____ (FT³/S)
500-YR STORM TIDE ELEVATION _____ (FT) MAXIMUM DISCHARGE _____ (FT³/S)
DESIGN DISCHARGE _____ (FT³/S) RETURN PERIOD _____ (YRS) TIDAL PERIOD _____ (HRS)
HOW DETERMINED _____
WATER-SURFACE ELEVATION FOR DESIGN CONDITION
(IF TIDAL FLOW GOVERNS HYDRAULIC DESIGN) _____ (FT)

V. HISTORIC FLOODS

VI. PEAK FLOWS

RETURN PERIOD (YEARS)	EXISTING DEVELOPMENT (FT³/S)	ULTIMATE DEVELOPMENT (FT³/S)
2		
10		
25		
50		
100		
500		

VII. COMMENTS

STREAM MORPHOLOGY

I. STREAM MORPHOLOGY ASSESSMENT
REPORT TITLE _____
PREPARED BY _____ DATE _____

II. ASSESSMENT DATA
STREAM TYPE _____ VALLEY TYPE _____
BED LOAD MATERIAL _____ D16 _____ D50 _____ D84 _____
POTENTIAL LONG-TERM BED DEGRADATION/AGGRADATION
(BASED ON RAPID CHANNEL MEASUREMENTS) _____ (FT)
POTENTIAL BEND SCOUR _____ (FT)
POTENTIAL LATERAL CHANNEL MOVEMENT _____ (FT)
STREAM BED LOCATION (JUST DOWNSTREAM) _____ (PERCHED, GRAVEL, BEDROCK)
STRUCTURE LOCATION (VALLEY ALIGNMENT) _____
BANKFULL CHARACTERISTICS, OBTAINED FROM:
(LIST REGION/YEAR, USFWS STREAM SURVEY STUDY) _____
Q _____ (FT³/S) AREA _____ (FT²) WIDTH _____ (FT) DEPTH _____ (FT)
DEBRIS POTENTIAL _____

III. DETAILED STREAM MORPHOLOGY
REPORT TITLE _____
PREPARED BY _____ DATE _____

IV. DETAILED STUDY DATA
VALLEY SLOPE _____ (FT/FT)
POTENTIAL LONG-TERM BED DEGRADATION/AGGRADATION
(BASED ON RAPID CHANNEL MEASUREMENTS) _____ (FT)
ASSESSMENT RIFFLE DATA:
HYDRAULIC RADIUS _____ (FT) AVERAGE SLOPE _____ (FT/FT) MANNING'S N _____
BED MATERIAL: D16 _____ D50 _____ D84 _____ D95 _____
CRITICAL SHEAR STRESS _____ (LB/FT²) CRITICAL DEPTH _____ (FT)
TOP OF BANK/BANKFULL: Q _____ (FT³/S) DEPTH _____ (FT) SHEAR STRESS _____ (LB/FT²)

V. COMMENTS

HYDRAULICS DATA

I. REPORT TITLE _____
PREPARED BY _____ DATE _____
MDE APPROVAL DATE _____

II. HYDRAULIC DATA (PROPOSED CONDITIONS–UPSTREAM OF STRUCTURE)
ELEVATION PRESSURE FLOW BEGINS: _____ (FT)
ELEVATION WEIR FLOW BEGINS: _____ (FT)
BASE FLOW WATER SURFACE ELEVATION (APPROXIMATE): _____ (FT)

FLOOD (YEAR)	E.G. UPSTREAM (FT)	W.S. UPSTREAM (FT)	STRUCTURE OPEN. AREA (FT²)	Q STRUCTURE (FT³/S)	Q WEIR (FT³/S)	MAX. VELOCITY STRUCTURE (FT/S)	TOP WIDTH AT UPSTREAM XS (FT)
2							
10							
25							
50							
100							
500							
INCIPIENT OVERTOPPING							

III. ROADWAY AND STRUCTURE HYDRAULIC CONDITION

ITEM	EXISTING STRUCTURE	PROPOSED STRUCTURE
DATE BUILT		
EDGE OF TRAFFIC LANE, LOWEST ELEVATION		
OVERTOPPING ELEVATION		
OVERTOPPING LOCATION		
INCIPIENT OVERTOPPING FLOW		
TOTAL STRUCTURE OPENING AREA		
MIN. CHANNEL EL. (UPSTREAM)		
STRUCTURE TYPE AND TOTAL CLEAR SPAN LENGTH		

IV. DESIGN CRITERIA
ROADWAY CLASSIFICATION _____ DESIGN FLOOD _____ (YEAR)
DISCHARGE CROSSING CAN ACCOMODATE _____ (FT³/S)
ESTIMATED MAX FLOW DEPTH OVER TRAVEL LANES IF OVERTOPPED BY DESIGN FLOOD _____
IF DESIGN FLOOD CRITERIA NOT MET, DESIGN EXCEPTION APPROVAL DATE _____
OTHER KNOWN FLOODING LOCATIONS ON THIS ROADWAY _____
NAVIGABLE CHANNEL (Y/N) _____ MAX VERTICAL CLEARANCE _____ (FT) OFFICIAL COAST GUARD (Y/N) _____

V. FEMA FLOODPLAIN DATA
FLOOD INSURANCE STUDY DATE _____ COMMUNITY PANEL NO. _____
PROJECT LOCATION (ZONE A, ZONE AE, OUTSIDE FEMA LIMITS) _____
REGULATORY FLOODWAY: YES _____ NO _____
MAXIMUM WATER SURFACE ELVATION CHANGE UPSTREAM OF STRUCTURE _____ (FT)
MAXIMUM WATER SURFACE ELVATION CHANGE DOWNSTREAM OF STRUCTURE _____ (FT)
CLOMR/LOMR REQUIRED (Y/N) _____ FEMA APPROVAL DATE _____
DATE HYDRAULIC MODEL SUBMITTED TO MDE NFIP COORDINATOR _____

VI. COMMENTS

BRIDGE SCOUR

I. REPORT TITLE _____
PREPARED BY _____ DATE _____
MDOT APPROVAL DATE _____
METHOD OF ANALYSIS _____

II. SCOUR ESTIMATES

	DESIGN CONDITIONS (SUCH AS OVERTOPPING, LOW TAILWATER INFLUENCE OF CONFLUENCE, ETC.)	FLOOD DISCHARGE		LONG TERM DEGRADATION/ AGGRADATION (FT)	CONTRACTION□ OR BEND SCOUR□ DEPTH (FT) (CHECK WHICH ONE USED)		
		RETURN PERIOD (YRS)	MAGNITUDE (FT³/S)		LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK
DESIGN FLOOD FOR SCOUR							
CHECK FLOOD FOR SCOUR							
OTHER							

	CHANNEL BED LOAD (DESCRIBE)	SCOUR TYPE (LIVE BED/CLEAR WATER)	TOTAL SCOUR DEPTH (FT)				
			ABUTMENT A	PIER(S) NO.:			ABUTMENT B
DESIGN FLOOD FOR SCOUR							
CHECK FLOOD FOR SCOUR							
OTHER							

ESTIMATED TOTAL SCOUR (LONG TERM DEGRADATION/AGGRADATION, CONTRACTION SCOUR, AND LOCAL SCOUR)

ELEMENT	ESTIMATED PILE TIP ELEVATION	SCOUR ELEVATION (FT)		SCOUR COUNTER MEASURES
		DESIGN FLOOD	CHECK FLOOD	
CHANNEL THALWEG				
ABUTMENT A				
ABUTMENT B				
PIER NO:				
PIER NO:				
PIER NO:				

III. COMMENTS

PLACE CONSULTANT LOGO HERE

REVISIONS

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF STRUCTURES
<PROJECT NAME>
<PROJECT DESCRIPTION>
<PROJECT DESCRIPTION>

BRIDGE ONLY – HYDROLOGIC AND HYDRAULIC DATA

SCALE _____ DATE _____ CONTRACT NO. <CONTRACT NO.>

DESIGNED BY _____
DRAWN BY _____
CHECKED BY _____

DRAWING NO. _____ OF #

SHEET NO. _____ OF #

BY: $USERNAME$

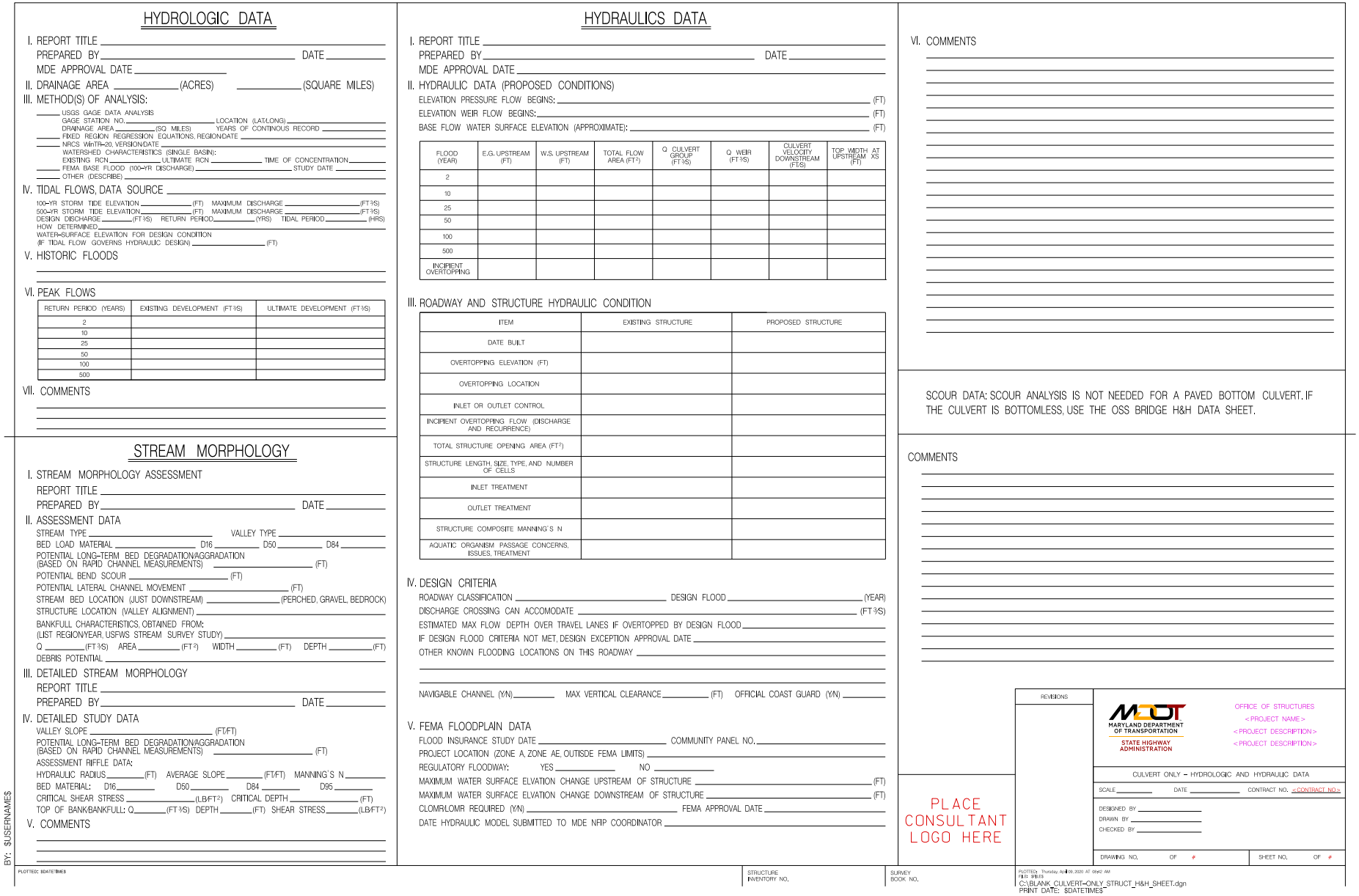
PLOTTED: $DATETIME$

STRUCTURE INVENTORY NO.

SURVEY BOOK NO.

PLOTTED: Thursday, Apr 09, 2020 AT 08:41 AM
FILE: $FILE$
C:\BLANK_BRIDGE&BOTTOMLESS_STRUCT_H&H_SHEET.dgn
PRINT DATE: $DATETIME$

Figure 6-4. H&H Data Sheet for Bridge Projects



HYDROLOGIC DATA

I. REPORT TITLE _____
PREPARED BY _____ DATE _____
MDE APPROVAL DATE _____

II. DRAINAGE AREA _____ (ACRES) _____ (SQUARE MILES)

III. METHOD(S) OF ANALYSIS:

_____ USGS GAGE DATA ANALYSIS
GAGE STATION NO. _____ LOCATION (LAT/LONG) _____
DRAINAGE AREA _____ (SQ. MILES) YEARS OF CONTINOUS RECORD _____
_____ FIXED REGION REGRESSION EQUATIONS, REGION/DATE _____
_____ NRCS WinTR-20, VERSION/DATE _____
WATERSHED CHARACTERISTICS (SINGLE BASIN):
EXISTING RCN _____ ULTIMATE RCN _____ TIME OF CONCENTRATION _____
_____ FEMA BASE FLOOD (100-YR DISCHARGE) _____ STUDY DATE _____
_____ OTHER (DESCRIBE) _____

IV. TIDAL FLOWS, DATA SOURCE _____

100-YR STORM TIDE ELEVATION _____ (FT) MAXIMUM DISCHARGE _____ (FT^3/S)
500-YR STORM TIDE ELEVATION _____ (FT) MAXIMUM DISCHARGE _____ (FT^3/S)
DESIGN DISCHARGE _____ (FT^3/S) RETURN PERIOD _____ (YRS) TIDAL PERIOD _____ (HRS)
HOW DETERMINED _____
WATER-SURFACE ELEVATION FOR DESIGN CONDITION
(IF TIDAL FLOW GOVERNS HYDRAULIC DESIGN) _____ (FT)

V. HISTORIC FLOODS

VI. PEAK FLOWS

RETURN PERIOD (YEARS)	EXISTING DEVELOPMENT (FT^3/S)	ULTIMATE DEVELOPMENT (FT^3/S)
2		
10		
25		
50		
100		
500		

VII. COMMENTS

STREAM MORPHOLOGY

I. STREAM MORPHOLOGY ASSESSMENT
REPORT TITLE _____
PREPARED BY _____ DATE _____

II. ASSESSMENT DATA
STREAM TYPE _____ VALLEY TYPE _____
BED LOAD MATERIAL _____ D16 _____ D50 _____ D84 _____
POTENTIAL LONG-TERM BED DEGRADATION/AGGRADATION
(BASED ON RAPID CHANNEL MEASUREMENTS) _____ (FT)
POTENTIAL BEND SCOUR _____ (FT)
POTENTIAL LATERAL CHANNEL MOVEMENT _____ (FT)
STREAM BED LOCATION (JUST DOWNSTREAM) _____ (PERCHED, GRAVEL, BEDROCK)
STRUCTURE LOCATION (VALLEY ALIGNMENT) _____
BANKFULL CHARACTERISTICS, OBTAINED FROM:
(LIST REGION/YEAR, USFWS STREAM SURVEY STUDY) _____
Q _____ (FT^3/S) AREA _____ (FT^2) WIDTH _____ (FT) DEPTH _____ (FT)
DEBRIS POTENTIAL _____

III. DETAILED STREAM MORPHOLOGY
REPORT TITLE _____
PREPARED BY _____ DATE _____

IV. DETAILED STUDY DATA
VALLEY SLOPE _____ (FT/FT)
POTENTIAL LONG-TERM BED DEGRADATION/AGGRADATION
(BASED ON RAPID CHANNEL MEASUREMENTS) _____ (FT)
ASSESSMENT RIFFLE DATA:
HYDRAULIC RADIUS _____ (FT) AVERAGE SLOPE _____ (FT/FT) MANNING'S N _____
BED MATERIAL: D16 _____ D50 _____ D84 _____ D95 _____
CRITICAL SHEAR STRESS _____ (LB/FT^2) CRITICAL DEPTH _____ (FT)
TOP OF BANK/BANKFULL: Q _____ (FT^3/S) DEPTH _____ (FT) SHEAR STRESS _____ (LB/FT^2)

V. COMMENTS

HYDRAULICS DATA

I. REPORT TITLE _____
PREPARED BY _____ DATE _____
MDE APPROVAL DATE _____

II. HYDRAULIC DATA (PROPOSED CONDITIONS)
ELEVATION PRESSURE FLOW BEGINS: _____ (FT)
ELEVATION WEIR FLOW BEGINS: _____ (FT)
BASE FLOW WATER SURFACE ELEVATION (APPROXIMATE): _____ (FT)

FLOOD (YEAR)	E.G. UPSTREAM (FT)	W.S. UPSTREAM (FT)	TOTAL FLOW AREA (FT^2)	Q CULVERT GROUP (FT^3/S)	Q WEIR (FT^3/S)	CULVERT VELOCITY DOWNSTREAM (FT/S)	TOP WIDTH AT UPSTREAM XS (FT)
2							
10							
25							
50							
100							
500							
INCIPIENT OVERTOPPING							

III. ROADWAY AND STRUCTURE HYDRAULIC CONDITION

ITEM	EXISTING STRUCTURE	PROPOSED STRUCTURE
DATE BUILT		
OVERTOPPING ELEVATION (FT)		
OVERTOPPING LOCATION		
INLET OR OUTLET CONTROL		
INCIPIENT OVERTOPPING FLOW (DISCHARGE AND RECURRENCE)		
TOTAL STRUCTURE OPENING AREA (FT^2)		
STRUCTURE LENGTH, SIZE, TYPE, AND NUMBER OF CELLS		
INLET TREATMENT		
OUTLET TREATMENT		
STRUCTURE COMPOSITE MANNING'S N		
AQUATIC ORGANISM PASSAGE CONCERNS, ISSUES, TREATMENT		

IV. DESIGN CRITERIA
ROADWAY CLASSIFICATION _____ DESIGN FLOOD _____ (YEAR)
DISCHARGE CROSSING CAN ACCOMODATE _____ (FT^3/S)
ESTIMATED MAX FLOW DEPTH OVER TRAVEL LANES IF OVERTOPPED BY DESIGN FLOOD _____
IF DESIGN FLOOD CRITERIA NOT MET, DESIGN EXCEPTION APPROVAL DATE _____
OTHER KNOWN FLOODING LOCATIONS ON THIS ROADWAY _____
_____
_____
NAVIGABLE CHANNEL (Y/N) _____ MAX VERTICAL CLEARANCE _____ (FT) OFFICIAL COAST GUARD (Y/N) _____

V. FEMA FLOODPLAIN DATA
FLOOD INSURANCE STUDY DATE _____ COMMUNITY PANEL NO. _____
PROJECT LOCATION (ZONE A, ZONE AE, OUTISDE FEMA LIMITS) _____
REGULATORY FLOODWAY: YES _____ NO _____
MAXIMUM WATER SURFACE ELVATION CHANGE UPSTREAM OF STRUCTURE _____ (FT)
MAXIMUM WATER SURFACE ELVATION CHANGE DOWNSTREAM OF STRUCTURE _____ (FT)
CLOMR/LOMR REQUIRED (Y/N) _____ FEMA APPROVAL DATE _____
DATE HYDRAULIC MODEL SUBMITTED TO MDE NFIP COORDINATOR _____

VI. COMMENTS

SCOUR DATA: SCOUR ANALYSIS IS NOT NEEDED FOR A PAVED BOTTOM CULVERT. IF THE CULVERT IS BOTTOMLESS, USE THE OSS BRIDGE H&H DATA SHEET.

COMMENTS

PLACE CONSULTANT LOGO HERE

REVISIONS

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

OFFICE OF STRUCTURES
<PROJECT NAME>
<PROJECT DESCRIPTION>
<PROJECT DESCRIPTION>

CULVERT ONLY – HYDROLOGIC AND HYDRAULIC DATA

SCALE _____ DATE _____ CONTRACT NO. <CONTRACT NO.>

DESIGNED BY _____
DRAWN BY _____
CHECKED BY _____

DRAWING NO. _____ OF #
SHEET NO. _____ OF #

BY: $USERNAME$
PLOTTED: $DATETIME$
STRUCTURE INVENTORY NO.
SURVEY BOOK NO.
PLOTTED: Thursday, Apr 09, 2020 AT 09:42 AM
FILE: $FILE$
C:\BLANK_CULVERT-ONLY_STRUCT_H&H_SHEET.dgn
PRINT DATE: $DATETIME$

Figure 6-5. H&H Data Sheet for Culvert Projects

6.4 DATA RETENTION REQUIREMENTS

This section provides guidance regarding the permanent documentation of analyses and study information related to the hydraulic design of structures. As a practical matter, there is a limit to the amount of information that can be kept; project files must be periodically reviewed and purged as necessary to make space for new files. Procedures have been established, with emphasis placed on recording and archiving the essential design and analysis information. The process of maintaining electronic files serves to facilitate storage and subsequent retrieval of project records.

The storage of both electronic and hard copy project data is required for the following:

- Active Projects: this includes projects in all stages of design and construction. Some permit approvals may have been obtained (e.g., hydrologic analysis review approval), but the project is not yet constructed.
- Shelved Projects: this includes projects in any stage of design that have been put on hold for an indefinite period of time.
- Completed Projects: this includes projects that have been permitted and constructed.

6.4.1 Responsibility

The SHHD Team Leader assigned to a project or area of work is responsible for assuring compliance with the data retention requirements as described in this Section. This includes overseeing the compilation and management of all documentation and supporting data. The SHHD Team Leader is responsible for ensuring the appropriate archival storage of these materials after a project is completed. Engineers who conduct analysis or studies for MDOT SHA projects are responsible for ensuring that data is stored and organized according to the direction of the SHHD Team Leader and the applicable standard MDOT SHA practices.

For any analysis or study completed by consultant engineers outside of MDOT SHA, the consultant engineer is responsible for temporary file storage and data management, and for delivery of all required data to MDOT SHA for long-term data archiving. Consultant engineers shall coordinate with the SHHD Team Leader in order to provide all required digital files and data prior to the completion of an assigned task.

6.4.2 Data Management for Active Projects

All electronic data, models, analysis documentation, or other information associated with active projects shall be stored in a project specific folder using the ProjectWise software system. Project folders shall be named using the structure 7-digit inventory number. Figure 6-6 provides an example of a typical project folder structure. The specific folder structure for each project shall be established and/or approved by the SHHD Team Leader. Regardless of folder structure specifics, the overall setup shall be established in a logical manner so that users not familiar with the project will be able to easily navigate the project folder and find the necessary data.

For ease and efficiency of work, electronic data and work files may also be stored temporarily on an engineer's local computer system. The limitation of this file storage method includes the lack

of data backup in case of hardware failure and the restricted data access for other project engineers. Therefore, engineers shall ensure that all electronic data is stored using the ProjectWise software system on the MDOT SHA network system in a timely manner, as directed by the SHHD Team Leader.

The file storage and data management method detailed here applies for work completed on-site at MDOT SHA by either state employed or consultant engineers. Electronic data files associated with work completed by consultants outside of MDOT SHA shall be submitted based on coordination and the request of the SHHD Team Leader.

For all MDOT SHA projects, it is essential that the data files included with any permitting agency submittals shall be stored in the project folder in the ProjectWise system (i.e., hydrology or hydraulic analysis reports submitted to MDE or CLOMR/LOMR applications submitted to FEMA). This is required for work completed in-house at MDOT SHA and for work completed by consultant engineers. At a minimum, the electronic files shall include the analysis report (MS Word and pdf versions), all appendices as detailed in Section 6.3, and any final model input/output files.

Project folders should be reviewed periodically and purged of unnecessary or outdated information. Working files, outdated models, or draft report files should be deleted in order to reduce file storage requirements as well as possible errors due to accidental use of superseded data. Essential information should remain as a part of the permanent project file to be archived upon project completion in accordance with Section 6.4.4 of this manual.

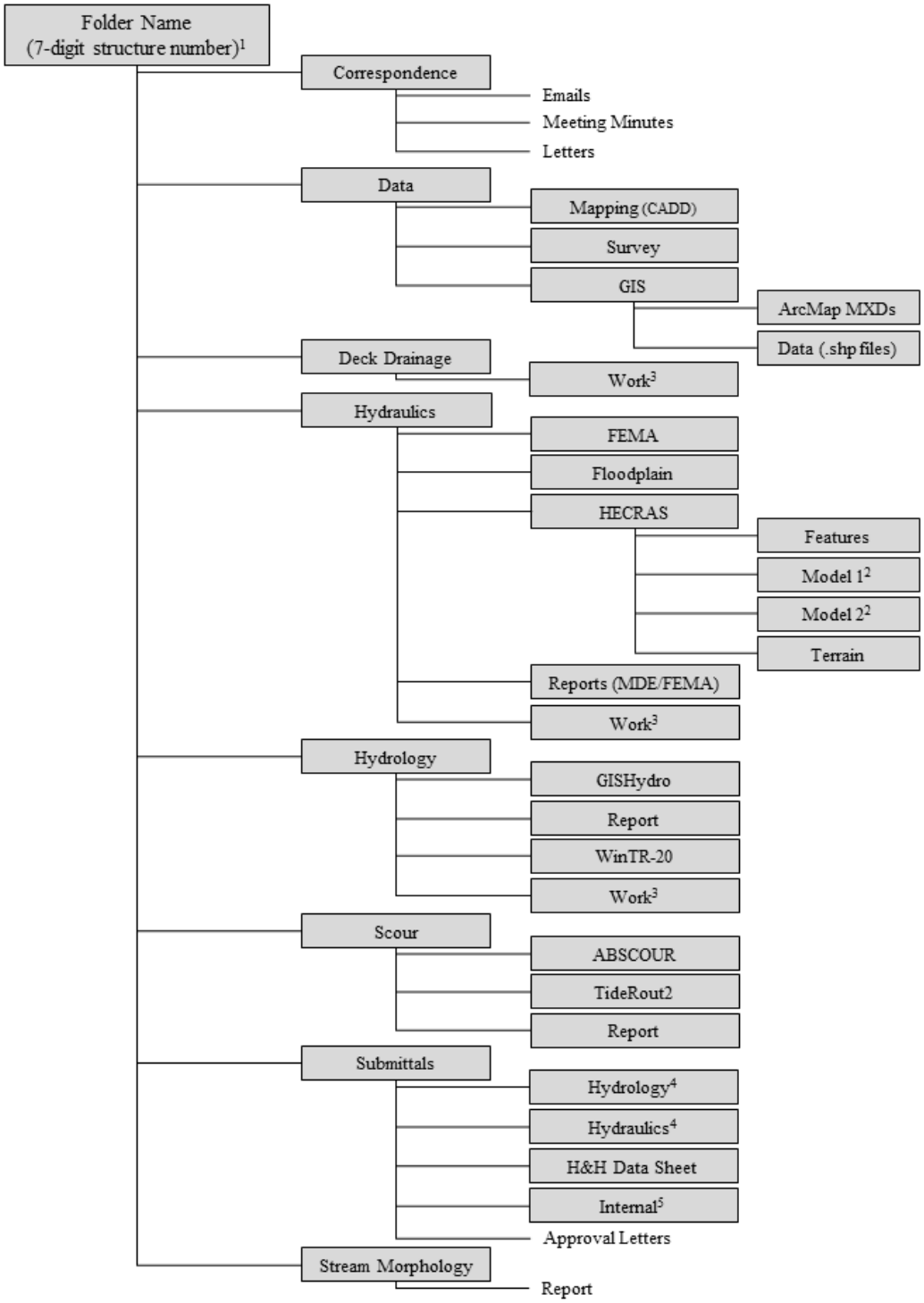


Figure 6-6. Typical Active Project Folder Structure

Notes: Standard date format is year, month, day (i.e., September 4, 2019 is 190904)
[1]Include project description (route and stream name) in "folder description" field.
[2]Subfolder for each model iteration, named with *xxdate*, where xx represents stream initials (e.g., cc200304).
[3]Include individual user folder with user initials: Work_*ui*, where ui represents user initials.
[4]Subfolder for each submission, named with topic, agency, and date (i.e., Hydrology_MDE_*date*).
[5] Include substandard design requests/approvals (waivers), scour recommendations, deck drainage recommendations.

6.4.3 Data Submittals for Completed Projects

For studies and analyses completed by consultant engineers, where electronic files are not stored on the MDOT SHA network system, all essential analysis data should be submitted to the SHHD Team Leader at the completion of a task. In addition to the final completed study submittals, draft analyses and reports shall be submitted to the SHHD Team Leader for review. Draft versions of the report should be submitted in electronic format (MS Word and pdf documents unless otherwise requested by the SHHD Team Leader).

After incorporation of all MDOT SHA review comments, the final submittal should include 2 printed copies of the full report including appendices and all digital files as specified in Table 6-14 (see SHHD Team Leader for digital file preferred transfer method). The printed report and digital files are used for MDE and, if applicable, FEMA review submittals, and for MDOT SHA archives. The minimum required electronic files are listed in Table 6-14 for each study type. Engineers shall coordinate with the SHHD Team Leader to confirm any additional project specific data or files to be submitted.

Table 6-14 Data Submittal Requirements

Hydrology	Stream Morphology	Hydraulics	Scour
Report/Appendices (MS Word and PDF)	Report/Appendices (MS Word and PDF)	Report/Appendices (MS Word and PDF)	Report/Appendices (MS Word and PDF)
GISHydro Data files	GIS Shapefiles and/or CAD files	HEC-RAS or HY-8 model files	ABSCOUR Input and Output files
WinTR-20 Input and Output files	Site Photos	GIS Shapefiles	Geotechnical Investigation files
GIS Shapefiles		Floodplain Map (CAD/GIS and PDF)	
Computation files (i.e., Tc or RCN)			

6.4.4 Archive Procedures

All electronic data, models, analysis documentation, or other information associated with a project should be organized, compiled and stored once it is determined that a project is complete or if a project is shelved (put on hold) for any reason. The project folders created for each agency submittal, as detailed in Section 6.4.2, should form the basis for the project archive. Other significant project data, such as approval letters or memo, minutes from design critical meetings, final models used for analysis or design but not submitted for agency review, or other computational data files, should be compiled and added to the submittal folder to create the electronic project archive file. The compiled project archive file should be reviewed and vetted by the SHHD Team Leader.

The electronic data archives are stored on a secure server. This secure server location is determined by the MDOT SHA Information System Manager and communicated to the SHHD Team Leaders. The SHHD Team Leader should coordinate the archive of the compiled project data file.

6.5 STREAM CONSTRUCTION AS-BUILT SURVEY

The documentation of construction (as-built survey) is typically required for projects that include channel stabilization and/or restoration (mitigation) and the data is critical for projects that require a LOMR submittal to FEMA with associated modeling of post-construction conditions. These projects typically require Stream Construction As-built Certification, which may include: (1) consultation and inspection during construction resulting in redline changes to the plans; (2) field surveys during and at the completion of stream construction; (3) population of the Stream As-built Checklist included within the construction plans during and at completion of stream construction; and (4) submission of the Final Stream Construction As-built Certification Package to MDOT SHA.

Special provisions to the standard MDOT SHA specifications may be required for the Stream Construction As-built Certification, a Stream Restoration/Stabilization Specialist, and/or a Designated Specialist. The Stream Restoration/Stabilization Specialist is an individual provided by the contractor, as required per the invitation to bid (IFB), who should be experienced in all aspects of stream stabilization and restoration including construction. The Designated Specialist is an individual provided by MDOT SHA who does not direct the contractor but coordinates with the SHHD Team Leader and is typically familiar with the design or is part of the design team. For large and/or complex projects involving in-stream construction, both the Stream Restoration/Stabilization Specialist and Designated Specialist may be requested to be on-site during construction.

The IFB and contract documents typically require an As-built Inspector who is responsible for submission of the Final Stream Construction As-built Certification Package. Typically, the As-built Inspector is required to be licensed in the State of Maryland as a Professional Engineer or Professional Land Surveyor and should be an individual that is experienced in stream stabilization/restoration and construction.

The Final Stream Construction As-built Certification Package certifies that the stream construction has been completed as specified per the contract documents (plans and specifications). This includes specific design elements which are identified in the Stream Construction As-built Checklist, such as in-stream structures, survey logs, delivery tickets for materials, photographs, and documentation of any field changes and/or design decisions. The SHHD Team Leader shall ensure that the Stream Construction As-built Checklist is included in the final design plans and that the as-built certification forms are enclosed in the IFB and final contract documents.

The Stream Construction As-built Checklist, which should include field survey requirements both during and at the completion of constructions, should at a minimum include:

1. Type of structure
2. Start and completion dates
3. Horizontal location of critical points including beginning and ending
4. Vertical elevation of critical points to correspond with the horizontal location
5. Size of rock/riprap required including the appropriate depth and stone size
6. Length and width of structures

7. Critical information (i.e. location, elevation and size) regarding individual facets for structures such as footer rock for toe-protection or in-stream structures.
8. Top and bottom width; reference points, adequate elevations and size of rock of the channel at control structures such as armored riffles.
9. Horizontal and vertical locations of key points for wood or other in-stream and bank stabilization structures
10. Allowable tolerances for the different features
11. Inspectors name printed and signature block

The Final Stream Construction As-built Certification Package should include the following in addition to the items detailed above for the Stream Construction As-built Checklist:

1. Adequate survey points using ground and/or aerial based LiDAR, photogrammetry, or Total Station survey and grade breaks to develop proposed contours at SHHD requested contour intervals. Projects that may be involved in research, monitoring programs, or with specific permit requirements may require 0.5-ft contours instead of the typical 1.0-ft contours. This may require additional survey points. The topographic survey must be sufficiently detailed to update cross section data for use in a post-project condition hydraulic model when submitting a LOMR to FEMA.
2. Field survey providing the horizontal and vertical locations of material changes, bank or bed protection, and control or habitat structures.
3. Surveyed cross sections, which should at a minimum be provided at beginning and ending points of stream facets including riffles and pools.
4. Thalweg and water surface profiles, which should be at a minimum include points taken at major grade breaks. This is subjective depending upon the site conditions. Steeper gradient streams may require grade breaks greater than 1.0-ft while flatter systems maybe 0.2-ft. The objective is to obtain information that represents the constructed channel profile.
5. Cross section and profile monuments should be installed and shown on the stream as-built plans.
6. Monuments (concrete or rebar) should be installed at photo documentation location points. These monuments should also be surveyed, photographed, and shown on the stream as-built plans.
7. Critical information regarding in-stream and stream stabilization structures shall be displayed on the as-built plan with annotation of structure limits and elevations provided in the cross sections and profile plots in accordance with the design plans.

Detailed information on the number and type of as-built submissions; procedures to be followed if design parameters are not met; measurement and method of payment and other site-specific requests will typically be included within the IFB and contract documents. In general, all as-built plans shall adhere to the CADD standards established by MDOT SHA. The scale of plan sheets, profiles, and cross sections should be the same as the design plans.

REFERENCES

FEMA (2018). Federal Emergency Management Agency. Instructions for Completing the Application Forms for Conditional Letters of Map Revision and Letters of Map Revision. https://www.fema.gov/media-library/assets/documents/1343

Maryland Hydraulics Panel (2018). Report of the Maryland Hydraulics Panel: Recommendations for Hydraulic Analyses in FEMA Special Flood Hazard Areas in Maryland. http://www.gishydro.eng.umd.edu/hydraulics_panel.htm.

Maryland Hydrology Panel (2016). Applications of Hydrologic Methods in Maryland, Fourth Edition. http://www.gishydro.eng.umd.edu/panel.htm.