4. Documentation

4.1. Overview

4.1.1 Introduction

Documentation is an essential part of the design, analysis, and history of any drainage structure because:

- Public safety is important.
- Expenditure of public funds needs justification.
- Designers refer to existing plans, specifications, and analyses when improvements, changes, rehabilitations, or new designs are made to drainage facilities.
- It provides information for the development of defense in matters of litigation.
- It is public information.

Documentation provides the information to evaluate a structure's performance after floods to determine whether the structure performed as anticipated or to establish the cause of unexpected behavior. In the event of damage or failure, it is essential that proper documentation exists so you as the hydraulic designer can identify contributing factors to avoid recurring damage.

This chapter:

- Identifies the Department's system for organizing the documentation of drainage structures.
- Presents minimum documentation requirements for different drainage structures.

4.1.2 Definition

Hydrologic and hydraulic documentation is defined as the compilation and preservation of all information relating to the design, construction, and maintenance of a drainage structure.

4.1.3 Purpose

The major purpose of providing good documentation is to define the design procedures used and to show how the final decisions were made and design determined. Documentation is especially important when litigation is involved.

The idea that avoiding documentation will prevent or limit litigation losses as it supposedly precludes providing the plaintiff with incriminating evidence is a persistent myth. In fact, lack of documentation commonly has the opposite effect.

Good documentation:

- Provides the agency protection by proving that reasonable and prudent actions were taken.
- Identifies the situation at the time of design, which may be important if legal action occurs.
- Shows that rationally accepted procedures and analyses that are commensurate with the perceived site importance and flood hazard were used at the time of design.
- Provides a continuous site history to facilitate future projects.
- Provides the file data necessary to quickly evaluate any future site problems.
- Expedites plan development by clearly providing the rationale for specific design decisions.

4.1.4 Scope of Documentation

Documentation is an ongoing process. It begins in the planning phase; continues through hydrologic analyses and hydraulic design, construction, and maintenance; and stops at the end of the drainage structure's life cycle.

Planning, design, construction, and maintenance/operation are the four phases of documentation to be considered.

Planning documentation can include:

- Aerial photographs
- Contour mapping
- Watershed map or plan

- Survey data reduced to include:
  - Existing hydraulic facilities
  - Basis for horizontal and vertical survey controls
  - Profiles: roadway, channel, driveways; and cross sections: roadway, channels, faces of structures
- Flood insurance studies and maps by FEMA
- Natural Resource Conservation Service soil maps
- Field trip report(s) including video or audio recordings, photographs, and sketches
- Reports from other agencies (local, state, or federal), Department personnel, newspapers, and abutting property owners
- Known flood information

Design documentation can include:

- Reports from other agencies
- Hydrologic reports
- Hydraulic reports
- Subsurface borings
- Plans, specifications, and estimate
- Permit stipulations that relate to hydrology or hydraulics

Additional design documentation details are included in Subsection 4.4, Design Documentation Requirements.

Construction documentation pertaining to drainage issues can include:

- Revisions, such as change orders, directives, and adjustments
- As-built plans
- Pile driving logs
- Photographs

These records may be available from the regional Contracts or Archives Section.

Maintenance or operation documentation can include:

- Record of operation, including flooding, icing, and debris
- Inspection and maintenance reports
- Plans or descriptions of any repairs or modifications made by maintenance forces
- Complaints and resolutions

4.1.5 Responsibility

The Department's statewide or regional hydraulics engineer is responsible for determining the appropriate documentation for specific hydraulic facilities. Every drainage study and facility will have a documentation file. Appendix A provides a Documentation Checklist for reference.

4.2. General Documentation Practices

1. Compile hydrologic and hydraulic data, preliminary calculations, and analyses as appropriate and all related information used in developing conclusions and recommendations related to drainage requirements, including estimates of structure size and location, in the structure's file.
2. Document all design assumptions and selected criteria, including the related decisions.
3. Match the amount of documentation for each design or analysis with the risk and importance of the drainage structure.
4. Organize the documentation concisely and completely so knowledgeable designers can understand what was done.
5. Identify the level of uncertainty affecting a hydraulic design.
6. Include all related data or references to reports, memos, interviews, letters, and published data in the structure's file. Include appropriate dates and signatures.
7. Organize the documentation to logically lead the reader from past history through the problem background, into the findings and through the performance of the drainage structure or facility.

8. For computer computations, including modeling, include hard copies of the input and summary output in the documentation file. If you choose to save full output in electronic format, you should select media type according to its long-term viability. Permanent records should not be solely in electronic format.

9. For all bridges and all culverts 48 inches in diameter or greater, prepare a Hydrologic and Hydraulic Report. The Hydrologic and Hydraulic Summary may be used as the report for culverts.

4.3. File Storage

The regional or statewide hydraulic engineer is responsible for maintaining complete hydrologic and hydraulic documentation files in the Hydraulic Section for use during construction, defense of litigation, and future replacement or rehabilitation. Only documentation not retained elsewhere needs to be included in the files.

In addition to hard copies of documentation, hydrologic and hydraulic files may be digitally archived. If digitally archived, files should be converted to a "generic" format such as PDF (Adobe Acrobat) files, which can be easily accessed. Keep in mind that computer technology changes rapidly, so what is available today may not be around five years from now.

Bridge files are maintained in the statewide Bridge Section and are filed by bridge number. Most other hydrologic and hydraulic files are maintained in the regional Hydraulics Section and are typically filed by route or location.

Follow the policies given in the *Alaska Highway Preconstruction Manual* Section 450.20 Maintenance of Project Development and Design Files. Retain hydrologic and hydraulic documentation until the drainage structure is replaced or modified as a result of a new drainage study. You should also keep information that would be useful for future designs, such as maintenance issues, icing/glaciering, etc., to provide continuous site history.

4.4. Design Documentation Requirements

These listed items establish minimum requirements consistent with hydrologic analysis and hydraulic design procedures. If the drainage structure is sized by other than normal procedures or if the size of the structure is governed by factors other than hydrologic or hydraulic, include a summary detailing the design basis in the structure's file. Additionally, include items that are not listed below but are useful in understanding the analysis, design, findings, and final recommendations.

If the design is consultant-prepared, provide copies of all design documentation to the responsible DOT&PF hydraulics engineer for inclusion in the Hydraulic Section files.

4.4.1 Hydrology

Include:

- Contributing watershed area size and identification of source (map name, etc.)
- Design flood frequency and decision for selection
- Hydrologic discharge and hydrograph estimating method and findings
- Flood frequency curves, including design, 100-year flood, discharge hydrograph, and any historical floods
- Expected level of development in upstream watershed over the anticipated life of the facility (include sources of and basis for these development projections)

4.4.2 Bridge Design

Include:

- Design and 100-year high water for existing, and proposed conditions
- Stage-discharge curve for undisturbed, existing, and proposed conditions
- Ordinary high-water line for rivers, and high tide line if tidal
- Cross-section(s) used in the design high-water determination
- Roughness coefficient ("n" value) assignments
- Information on the method used for design high-water determination
- Reported high water, dates, and discharges

- Velocity measurements or estimates and locations (include both the through-bridge and channel velocity) for design and 100-year floods
- Performance curve to include calculated backwater, velocity, and scour for design, 100-year flood, and 500-year or overtopping flood for scour evaluation
- Magnitude and frequency of overtopping flood
- Copies of input and summary output computer analyses
- Economic analysis of design and alternatives
- Bridge scour evaluation results
- Bridge deck drainage analysis
- Roadway geometry (plan and profile)
- Potential flood hazards to adjacent properties
- Consistency with FEMA requirements, or if not, why not

4.4.3 Culvert Design

Include:

- Allowable headwater elevation and basis for its selection, if developed
- Cross-section(s) used in the design high-water determinations
- Ordinary high-water line for streams, and high tide line if tidal
- Roughness coefficient assignments ("n" values)
- Reported high water, dates, and discharges
- Stage discharge curve for existing, and proposed conditions to include the depth and velocity measurements or estimates and locations for the design flood and check flood
- Performance curves showing the calculated backwater elevations, outlet velocities, and scour for the design, 100-year and any historical floods
- Fish passage discharge and computations, if required
- Type of culvert entrance condition
- Culvert outlet appurtenances and energy dissipation calculations and designs
- Copies of input and summary output computer analyses and/or standard computation sheets given in the culvert chapter of this manual
- Roadway geometry (plan and profile)
- Potential flood hazard to adjacent properties
- Notable hydraulic and/or gradient controls near the culvert, e.g., bedrock, beaver dam, waterfalls, etc.
- Slope of the existing pipe, proposed pipe, and channel
- Headwall and wingwall designs, if applicable

Note: Some types of minor culvert installations such as, driveways, local seeps, etc., utilize culverts larger than necessary for the potential discharge. In these cases, it is often unnecessary to perform in-depth design calculations. Provide any documentation that would be useful in understanding the design of these installations.

4.4.4 Open Channel Design

Include:

- Stage discharge curves for the design, 100-year and any historical water surface elevation(s)
- Ordinary high-water line for rivers, and high tide line if tidal
- Cross-section(s) used in the design water surface determinations and their locations
- Roughness coefficient assignments ("n" values)
- Information on the method used for design water surface determinations
- Reported high water, dates, and discharges
- Channel velocity measurements or estimates and locations
- Water surface profiles through the reach for the design, 100-year and any historical floods
- Slope of channel

- Substrate and bank material characterizations or descriptions; for gravel bed streams, estimate a D50 particle size
- Design or analysis of materials proposed for the channel bed and banks
- Energy dissipation calculations and designs
- Copies of input and summary output computer analyses

4.4.5 Storm Drain Design

Include:

- Computations for drainage areas, inlets, and storm drains, including hydraulic grade lines
- Check storm evaluation
- Computer analyses printouts and/or copies of standard computation sheets including assumptions for manhole configuration, junction losses, etc.
- Complete drainage area map
- Design frequency
- Information concerning outfalls, existing storm drains, and other design considerations
- A schematic indicating storm drain system layout
- A record of operations
- A record of additions to the system

4.4.6 Pump Station Design

Include:

- Inflow design hydrograph from drainage area to pump
- Inflow mass curve
- Maximum allowable headwater elevations and related probable damage
- Stage-pump discharge relation and sequence
- Sump dimensions
- Stage-storage curves
- Mass curve routing results
- Pump sizes and operations
- Discharge line and fittings sizing
- Total dynamic head curves
- Selected pump performance curves

4.5. Reporting Requirements

For design of all bridges over water and all culverts 48 inches in diameter or greater, an engineer-stamped Hydrologic and Hydraulic Report is required. The Hydrologic and Hydraulic Summary Table may be used as the report for culverts.

For projects that include maintenance and rehabilitation of existing drainage facilities, perform the level of hydrologic and hydraulic study commensurate with the significance of the risk or environmental impact.

The statewide hydraulics engineer is responsible for the hydrologic and hydraulic design aspects of all bridge projects. Regional hydraulics engineers are responsible for all single and multiple culvert projects of spans less than 20 feet, measured parallel to centerline of roadway, and other drainage projects requiring a report.

All Hydrologic and Hydraulic Reports shall be stamped by a qualified hydraulics engineer.

If the report is prepared by a consultant, the responsible DOT&PF hydraulics engineer will review and provide comments prior to the report's finalization. In addition, the responsible DOT&PF hydraulics engineer should review all changes or addenda related to hydraulic designs prior to the start of construction.

Submit preliminary Hydrologic and Hydraulic Reports to the design project manager before final design. Submit final Hydrologic and Hydraulic Reports to the design project manager and the responsible DOT&PF hydraulics engineer during Final PS&E for inclusion as a permanent part of the project records.

4.5.1 Environmental Review Document Summary

In accordance with 23 CFR 650.111(e), submit a location hydraulic study summary for inclusion in environmental review documents prepared pursuant

to 23 CFR part 771. Include the following in the summary:

- Discussion of the following items, commensurate with the significance of the risk or environmental impact, for all alternatives containing encroachments and for those actions that would support incompatible base flood-plain development:
    1. The risks associated with the implementation of the action
    2. The impacts on natural and beneficial floodplain values
    3. The support of probable incompatible floodplain development
    4. The measures to minimize floodplain impacts associated with the action
    5. The measures to restore and preserve the natural and beneficial floodplain values affected by the action
- Evaluation and discussion of the practicability of alternatives to any significant encroachments or to any support of incompatible flood-plain development

4.5.2 Hydrologic and Hydraulic Report

Include in the Hydrologic and Hydraulic Report the following information, commensurate with the significance of the environmental impact, risk or importance of the crossing:

1. Location map and site plan
2. Description of the project and any alternates
3. Hydraulic history of the site, which should include, but is not limited to, the following:
    - Tidal: Tidal influence
        - Mean Lower Low Water Elevation (MLLW)
        - Mean High Water Elevation (MHW)
        - Mean Higher High Water Elevation (MHHW)
        - Extreme High Water Elevation (EHW)
        - High Tide Line (HTL)
    - Nontidal: Freshwater streams
        - Flood of record elevation
        - High water marks
        - Ordinary High Water (OHW) Line or Meander Line (ML) with elevations at specific points, such as centerline of roadway
    - Navigation:
        - Navigability determination, if any
        - Present
        - Future or potential
    - Confluence:
        - Upstream – include distance and potential changes
        - Downstream – include distance and potential backwater
    - Mining activity:
        - Present
        - Future or potential
    - Debris problems:
        - Trees and underbrush
        - Bedload
        - Mud flow
        - Debris flow
        - Lake dumps
    - Icing problems: include description and location
        - Frazil
        - Aufeis (Glaciering)
        - Ice debris
        - Glacier-dammed lakes (type of breakout)
        - Type of breakup
    - Geomorphology:

- Description, such as straight, meander, braided, alluvial fan
- Channel geometry including bed width, slope, etc.
- Aggradation
- Degradation
- Potential for lateral movement

- Bedload: Bed material size
- Limiting geometric factors
  - Road sag elevation
  - Backwater constraints
  - Private property
  - Access requirements

4. Environmental: Environmental activities, such as fish passage considerations, that relate to the hydraulics of the stream or installation
5. Hydrology: A discussion of the hydrology of the site should include, but is not limited to, the following:
   - Drainage Basin Characteristics:
     - Drainage area
     - Storage area
     - Stream slope
     - Mean basin elevation
   - Frequency: Perform a flood frequency analysis for all bridges, longitudinal encroachments or culverts 48 inches in diameter and larger (or equivalent for other shapes) as follows:
     1. Design flood frequency as required by Table 1120-1 of the *Alaska Highway Preconstruction Manual*
     2. Q100: 1 percent exceedance probability. If capacity of structure is less than Q100, identify the discharge and the exceedance probability and address the probable damage, environmental impact and economic costs that will result if the Q100 occurs.
     3. Q500: 0.2 percent probability, or capacity of structure if less than Q500, for all bridges.
     4. Other high water events as required
   - Fish passage: For culvert crossings, evaluate design discharge for fish passage.
   - Flood of Record.
6. Local input: Local knowledge of past floods at the site
7. Hydraulic Analysis:
   - Backwater: A backwater analysis of the existing structure (or natural channel) versus the proposed structure(s) during a high water event that has an exceedance probability equal to 1 percent (Q100)
   - Overtopping flood: Estimate exceedance probability and provide water surface elevation and location (where determined)

     The overtopping elevation is defined as follows:
     - Bridges: superstructure low chord or low road grade elevation
     - Culverts: low road grade elevation
     - Other: top of riprap or top of structure elevation
   - Scour: For bridges, the calculated contraction, pier, and abutment scour associated with the proposed structure(s) and any countermeasures required for the following exceedance probabilities:
     - Q100: 1 percent probability
     - Q500: 0.2 percent probability, or the capacity of the structure if less than Q500
     - At lesser recurrence interval floods as required, or as engineering judgment dictates.

     If you incorporate appropriate abutment scour protection into the design, abutment scour calculations are not required.

8. Hydraulic Design: A discussion of the hydraulic features of the design and why they are needed
    - Alternate designs and their features
    - A discussion of the limitations of the alternates and why they were rejected
    - The size of riprap required, the method of placement and depth of key or length of toe.
9. Floodplain encroachments: Address the following items for all federally-funded construction projects that encroach on the 100-year floodplain as required by 23 CFR 650, Subpart A:
    a. Include a discussion of the following items, commensurate with the significance of the risk or environmental impact, for all alternatives containing encroachments and for those actions that would support incompatible base floodplain development:
        1. The risks associated with the implementation of the action
        2. The impacts on natural and beneficial floodplain values
        3. The support of probable incompatible floodplain development
        4. The measures to minimize floodplain impacts associated with the action
        5. The measures to restore and preserve the natural and beneficial floodplain values affected by the action
    b. Include an evaluation and discussion of the practicability of alternatives to any significant encroachments or to any support of incompatible floodplain development.
    c. Consult local, state, and federal water resource and floodplain management agencies to determine if the proposed highway action is consistent with the existing watershed and floodplain management programs, and to obtain current information on development and proposed actions in the affected watersheds.
10. Flood hazard area: If the proposed project falls within a designated flood hazard area, the following is required:
    a. Additional requirements: A discussion on the additional requirements imposed on the design because of the local floodplain regulations
    b. Compliance: The proposed methods of complying with the regulations
    c. Certification: Statement of certification as required by local ordinance
11. Conclusion: A summary of the hydraulic features and how they will accomplish the desired protection.
12. Hydrologic and Hydraulic Summary Table.
13. Illustrations: Include clarifying drawings, tables, charts, graphs, or pictures where appropriate.
14. Documentation: Include supporting or pertinent documentation in appendices.
15. Certification: A registered professional engineer will stamp all hydrologic and hydraulic reports.

4.5.3 Summary Hydraulic Report

A Summary Hydraulic Report may be used for projects that have minor hydraulic impacts or risks such as smaller bridges, maintenance or rehabilitation of existing drainage facilities, projects with culverts only, or minor encroachments. A Summary Hydraulic Report may consist of the following:

1. Introduction
2. Hydraulic History
3. Hydrology
4. Hydraulic Design, including riprap
5. Floodplain encroachment
6. Conclusion
7. Hydrologic and Hydraulic Summary Table, if applicable.

Discussion on these topics is included in section 4.5.2, Hydrologic and Hydraulic Report.

4.5.4 Hydrologic and Hydraulic Summary Table

Include a Hydrologic and Hydraulic Summary Table in the plans as follows:

1. For bridges – on the site plan sheet
2. For floodplain encroachments – on the applicable plan and profile (P&P) sheet. If the encroachment spans more than one P&P sheet, place the summary on the sheet where the encroachment begins.
3. For culverts – in a summary table or on the P&P sheet as follows:
    a. All culverts 48 inches in diameter or greater
    b. Any multiple culvert installation that has a total high water flow of 500 cubic feet per second (cfs) or greater for an exceedance probability of 2 percent (Q50)
    c. All culverts smaller than 48 inches in diameter for which a hydraulic analysis has been performed

Include in the Hydrologic and Hydraulic Summary Table the following information:

- Drainage area: in square miles
- Exceedance probabilities: in percentages for the exceedance probabilities used to size the installation as required in Table 1120-1, Design Flood Frequency, of the *Alaska Highway Preconstruction Manual*
- Discharges: in cubic feet per second (cfs) for the exceedance probabilities required in Table 1120-1, Design Flood Frequency, of the *Alaska Highway Preconstruction Manual*
- Water surface elevations: in feet for the exceedance probabilities required in Table 1120-1, Design Flood Frequency, of the *Alaska Highway Preconstruction Manual*
- Anticipated additional backwater: in feet for a high water event having an exceedance probability of 1 percent (Q100)
- Overtopping flood: for highway crossings, the discharge in cfs and water surface elevation in feet for the overtopping flood and its exceedance probability
- Datum elevation: Datum and, if appropriate, equation for Mean Sea Level (MSL) to Mean Lower Low Water (MLLW)
- Scour: The calculated contraction (general) scour depth and local scour depth

An example Summary Table for a bridge is included as Figure 4-1.

4.6. References

American Association of State Highway and Transportation Officials, current edition. *Highway Drainage Guidelines.*

PRELIMINARY HYDROLOGIC & HYDRAULIC SUMMARY			
Flood Frequency (year)	50	100	500
Exceedance Probability (%)	2	1	0.2
Discharge (cfs)	1860	2130	2690
Water Surface Elevation (ft)	1105.5	1105.9	1106.7
Anticipated Additional Backwater (ft)		0	
Contraction Scour (ft)		0.3	0.4
Abutment Scour (ft)		na	na

nc = not calculated na = not applicable

Drainage Area for this crossing: 49.5 square miles

Hydraulic Capacity: 4800 cfs at Low Superstructure elevation of 1110.11 ft which has an exceedance probability less than 0.2 percent.

Total Scour equals contraction scour + local scour

Figure 4-1
Example Summary Table for a Bridge

4. Appendix A: Project Documentation Checklist

Engineer _____ Project _____

City/Borough _____ Description _____

Check appropriate items:

REFERENCE DATA

Maps:

- ☐ USGS Quad Scale Date
- ☐ USGS 1:250 000
- ☐ Local zoning maps
- ☐ Flood hazard delineation (Quad.)
- ☐ Flood plain delineation (HUD)
- ☐ Local land use
- ☐ Soils maps
- ☐ Geologic maps
- ☐ Other maps:
- ☐ Aerial photos Scale Date

Studies By External Agencies:

- ☐ USACE Flood Plain Information Report
- ☐ NRCS watershed studies
- ☐ Local watershed management
- ☐ USGS gages and studies
- ☐ Interim Flood Plain Studies
- ☐ Water resource data
- ☐ Regional planning data
- ☐ Forestry Service
- ☐ Utility company plans

Studies By Internal Sources:

- ☐ Quarterly reports
- ☐ Hydraulics Section records
- ☐ Regional Office drainage records
- ☐ Flood records (High water, newspaper)

HYDROLOGY

Discharge Calculations:

- ☐ Drainage areas
- ☐ Rational formula
- ☐ HEC-1
- ☐ TR 55
- ☐ Gaging data: regional analysis
- ☐ Regression equations
- ☐ Area-discharge curves
- ☐ Log-Pearson Type III Gage Rating

High Water Elevations:

- ☐ DOT&PF survey
- ☐ External sources
- ☐ Personal reconnaissance

Flood History:

- ☐ External sources (newspapers, interviews, etc.)
- ☐ Personal reconnaissance
- ☐ Maintenance records
- ☐ Photographs
- ☐ Construction records

Water Quality:

- ☐ DOT&PF survey
- ☐ External sources
- ☐ Personal reconnaissance

HYDRAULIC DESIGN

Calibration of High Water Data:

- ☐ Discharge and frequency of high water elevation
- ☐ Influences responsible for high water elevation
- ☐ Analyze hydraulic performance of existing facility for min. flow through 100-year flood
- ☐ Analyze hydraulic performance of proposed facility for min. flow through 100-year flood
- ☐ Check flood(s)

Design Appurtenances:

- ☐ Dissipators
- ☐ Riprap
- ☐ Erosion and sediment control
- ☐ Fish and wildlife protection

Technical Aids:

- ☐ DOT&PF *Alaska Highway Drainage Manual*
- ☐ DOT&PF & FHWA directives
- ☐ DOT&PF *Alaska Preconstruction Manual*
- ☐ Technical library

Computer Programs:

- ☐ Culvert Inlets
- ☐ Direct Step Water Surface Profile
- ☐ Standard Step Water Surface Profile
- ☐ USACE HEC-2 Water Surface Profile
- ☐ USACE HEC-RAS Water Surface Profile
- ☐ FHWA Bridge Backwater
- ☐ Log-Pearson Type III Analysis
- ☐ HY8, CDS, HYDRAIN
- ☐ FESWMS-2DH, RMA2
- ☐ Other

HYDROLOGIC-HYDRAULIC REPORTS

Data Reports:

- ☐ DOT&PF data
- ☐ Other agency data
- ☐ Stream gaging records
- ☐ Environmental reports

DOT&PF:

- ☐ Surface Water Environmental Study
- ☐ Surface Water Environmental Study: Revisions
- ☐ Reconnaissance Report
- ☐ Reconnaissance Report: Revisions
- ☐ Location Report
- ☐ Location Report: Revisions
- ☐ Drainage Survey Inspection Report
- ☐ Drainage Survey Inspection Report Revisions
- ☐ Hydraulic Design Report
- ☐ Hydraulic Design Report: Revisions
- ☐ Construction Report
- ☐ Construction Report: Revisions
- ☐ Hydraulic Operation Report
- ☐ Hydraulic Operation Report: Revisions
- ☐ Bridge Inspection Reports/Soundings

Regulatory Documentation:

- ☐ Fish passage and habitat
- ☐ Regulatory floodway
- ☐ Zoning
- ☐ Other