4 Documentation

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4 Documentation

4.1 OVERVIEW

4.1.1 Introduction

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

- The importance of public safety;
- Justification of expenditure of public funds;
- Future reference by engineers (when improvements, changes, or rehabilitations are made to the highway facilities);
- Information leading to the development of defense in matters of litigation; and
- Public information.

Frequently it is necessary to refer to plans, specifications and analysis long after the actual construction has been completed. Most often this occurs when a developer wants to build near one of CDOT's drainage structures. Also, documentation permits evaluation of the performance of structures after flood events to determine if the structures performed as anticipated, or to establish the cause of unexpected behavior. In the event of a failure, it is essential that contributing factors be identified to avoid recurring damage.

4.1.2 Purpose

This chapter presents the minimum documentation required to be in hydraulic design files and on the construction plans. The focus of this documentation is on the findings obtained when using the other chapters of this manual. Designers should be familiar with all hydrologic and hydraulic design procedures mentioned in this chapter. The chapter also identifies procedures for organizing the documentation of hydraulic designs and reviews. The documentation must provide a complete history of the design process.

The goal of good documentation is to describe the design procedures that were used and to show how the final design and decisions were determined. Often there is the misconception that avoiding documentation will prevent or limit litigation losses by not providing a plaintiff with incriminating evidence. This is seldom the case, and documentation should be viewed as the record of reasonable and prudent design analysis based on the best available practices and technology. Good documentation provides the following:

- Protection of the Agency and design engineer by proving that reasonable and prudent actions were taken. It is unlikely such proof would increase a potential court award, and it may decrease an award by disproving any claims of negligence by a plaintiff.
- Identification of existing conditions and their implications on the drainage design at the time the design was completed, which could be important if legal action occurs at a later date;

- Documentation that rational, accepted procedures and industry-standard analyses were used at the time of the design, commensurate with perceived site importance and flood hazard (this would further disprove any negligence claims);
- Establishment of a continuous history of drainage design at the site which will facilitate future modification or reconstruction;
- A collection of filed data enabling a quick evaluation of any future site problems that might occur; and
- Aid in plan development by clearly stating the reasons and rationale for specific design decisions.

4.1.3 Scheduling

During the preconstruction phase of plan development, there are three key milestones leading to the advertisement date. These are the:

- Design Scoping Review (DSR) meeting;
- Field Inspection Review (FIR); and
- Final Office Review (FOR).

These milestones are explained in the *CDOT Project Development Manual* and *Roadway Design Guide*.

DSR Meeting

DSR is held to familiarize the various disciplines with objectives of the project determined by the planning process and to establish specific criteria and direction that will be used for preliminary design. The amount of information available to the Hydraulic Engineer prior to the DSR depends greatly on the nature of the project. In cases where Hydraulic Engineer has experience in the system and is familiar with the site, he will present the anticipated scope of required drainage work and the amount and character of field survey needed for hydraulic design work. If the site information is not available to the Hydraulics engineer, experiences from similar cases from surrounding project sites may be used.

FIR Meeting

Prior to the FIR meeting, all preliminary information must be provided to the Project Manager except for structures, such as bridges, needing detailed structural design. Preliminary hydraulic design for such structures must be completed before submitting a design request to the bridge designer. Preliminary hydraulic information (Hydraulic Information Sheet, if available) should be provided to Staff Bridge and the structural designer prior to preparation of the structure selection report. Additionally, if the project is required to provide permanent water quality, alternatives should be provided, and a preferred alternative recommended in the preliminary permanent water quality report presented at the FIR meeting.

Consultants or in-house designers must provide a preliminary hydraulics report when FIR plans are submitted. Reports must follow the Hydraulic Design Report Outline found in Appendix A of this chapter. FIR-level hydraulic reports must include at minimum a discussion of how each item in the outline will be addressed in the FOR submittal.

FOR Meeting

The revised hydraulic design (incorporating FIR comments) should be submitted to the Project Manager as soon as possible after the FIR. This allows the Project Manager adequate time to include the information in the plans and specifications, compute quantities, and produce the FOR-level cost estimate.

The Final Hydraulic Information Sheet should be provided to Staff Bridge or the structural consultant for inclusion in the FOR plan set. If a project is required to provide permanent water quality, documentation of the recommended alternative must be provided, including documentation required by the Colorado Department of Public Health and the Environment.

Consultants or in-house designers must submit the final hydraulics report with the FOR plans and specifications, or sooner if there are potential changes created during final design. All changes to the analyses, drainage patterns, or structural designs in the FIR-level report must be clearly presented in the FOR submittal.

4.1.4 Responsibility

The hydraulic engineer of record is responsible for determining what hydrologic analyses, hydraulic design, and related information is to be documented during the plan-development process. The CDOT Hydraulic Engineer makes the determination that the documentation is complete for the entire design-development process.

The CDOT Hydraulic Engineer may choose to accept the hydraulic design by signing CDOT Form 1048. The record plan sets will be signed and stamped by the hydraulic engineer of record.

The reviewing CDOT Hydraulics Engineer may choose to indicate concurrence with consultant designs on CDOT Form 1048. The engineer of record must be a registered professional engineer in the State of Colorado, and must sign and seal the plans and specifications, and any corresponding record plan and specifications sets for CDOT's Central Files and region files. Electronic copies of the record plans and specifications should be stored using CDOT ProjectWise data management system.

4.2 PROCEDURE

4.2.1 Practices

The following practices are required for documenting hydrologic and hydraulic designs, and analyses for CDOT projects:

- Hydrologic and hydraulic data, preliminary calculations and analyses, and all related information used in developing conclusions and recommendations related to drainage requirements, including alternatives for structure size and location, must be compiled in a documentation file;
- All design assumptions and pertinent criteria including the related decisions must be documented. The documentation must show that design decisions have been based on sound engineering principles rather than personal opinions;

- The level of detail of documentation for each design or analysis must be commensurate with the risks and importance of the facility;
- Uncertainties should be stated in terms which are not definite (e.g., the culvert may cause backwater, rather than the culvert will cause backwater);
- All related references must be included in the documentation file, including published data and reports, memos and letters, and interviews. Include dates and signed documents where appropriate;
- Data and design information must be documented from the conceptual stage of project development through service life to provide future designers with all relevant information;
- Documentation must be organized chronologically in a manner as concise and complete as practicable so that future designers can retrieve and use the information more effectively; and
- Documentation must be organized to lead the reader logically from the problem background, definition, data collection, findings, preliminary and final design, construction and implementation.

4.2.2 Storage of Design Documentation

The Region Hydraulics Unit will store and maintain documentation files including paper files, computer storage media, microfilm, or microfiche using CDOT ProjectWise data management system. These will be used during construction, for defense in litigation, and to aid future replacement, modification, or extension. To minimize storage requirements, include only documentation that is not retained elsewhere. Original plans, project correspondence, construction modifications, geology drill logs, and inspection reports are types of documentation that do not need to be duplicated in the Region Hydraulic Unit files.

Hydrologic and hydraulic documentation must be retained in the Region Hydraulic Unit at least until the drainage facility is totally replaced, or modified as a result of a new drainage study.

4.3 DOCUMENTATION PROCEDURES

4.3.1 Introduction

The intent of these documentation requirements is not to limit inclusion to only listed items, but rather to establish a minimum requirement consistent with hydraulic design procedures outlined in this manual. Additional documentation may be warranted. For example, if a drainage facility is sized by other than normal procedures, or if the size of the facility is governed by factors other than hydrologic or hydraulic factors, a narrative detailing the basis of the design must be included in the project documentation. Additionally, the designer must include in the project file items not listed below, but which are useful in understanding the analysis, design, findings, and final recommendations. These may include photographs, public meeting minutes, newspaper clippings, and records of interviews with local residents, adjacent property owners or maintenance forces. Appendix B provides an example project checklist for hydraulic design that can be used when assembling the hydraulic site file.

4.3.2 Hydrology

The hydraulic engineer should refer to Chapter 7 - Hydrology when performing the hydrologic analysis for a project. The following items used as a basis for the design or analysis should be included in the project file:

- The size of the contributing watershed area and identification of the source of the information used (such as a topographic map name);
- Topography of the contributing watershed area including survey control information, georeferenced aerial photos, DEMs, DTMs/TINs, rasters, and LiDAR datasets;
- Geology, land use, soil type, soil classification, and additional basin characterstics as appropriate;
- Design frequency and justification of its selection;
- The hydrologic discharge, methods used to calculate discharge, and discussion of the rationale for the selected design discharge;
- Hydrograph estimating method and findings;
- Flood frequency curves, including the design flood, 100-year flood, and 500-year flood for bridges;
- Discharge hydrograph curves for the design flood, 100-year flood, 500-year flood, and other significant historical floods; and
- The expected level of development in the upstream watershed over the anticipated life of the facility (include sources of information and the basis of estimation for development projections). Anticipated upstream development may provide justification for obtaining project funding from other sources.

4.3.3 Hydraulic Data for Bridges

The hydraulic design for bridges should be based on Chapter 10 - Bridges. The following items used as a basis for the design should be included in the project file:

- A complete hydraulic study report;
- A summary of all pertinent correspondence, field-inspection notes, agreements, and minutes of meetings, especially those with public involvement;
- Landowner concerns (e.g. cattle passes, equipment access, water rights, irrigation, etc.);
- Environmental concerns, including recommended depths and velocities for high and low design flows for fish passage;
- Potential flood hazards to adjacent properties;
- Relevant information on existing structures in the vicinity, utilities, and right of way;
- Observed highwater, dates, and discharges (if available);
- Evidence of ice or debris problems;
- Topography of the site including survey control information, georeferenced aerial photos, DEMs, DTMs/TINs, rasters, LiDAR datasets and bathymetric surveys;
- A drainage-area map, if used;
- Design flows;
- Stream profile and cross sections;

- Cross sections used in determination of design highwater;
- Roughness coefficient (Manning's *n* value) assignments;
- Flowline elevation of the design centerline at the intersection of the channel and the roadway;
- Roadway geometry (plan and profile);
- Velocity measurements or estimates, and locations (include both the through-bridge and channel velocity) for the design, 100-, and 500-year floods (where reqiured), and any historical floods;
- A summary of the hydraulic calculations for the waterway opening, documenting the optimum;
- Highwater surface elevations corresponding to the design, 100-year, and 500-year floods;
- Information on the method used for design highwater determination;
- Structure type, size, and location layout;
- Performance curve that includes calculated backwater, velocity and scour for the design, 100-year and 500-year floods;
- Magnitude and frequency of overtopping floods;
- Geotechnical considerations in foundation selection and design;
- Copies of all computer analyses (input data files as well as output files);
- Economic analysis of design and alternatives when required;
- Risk analysis assessment if design is based on non-conventional design-frequency floods;
- Floodway consistency determination, or support for and approval of floodway; and
- Recommended type, number, and spacing of bridge deck drains. A brief narrative for the recommended bridge deck drainage, and a table summarizing the recommendation should be included.

The **construction plans**, including:

- Completed Bridge Hydraulic Information Sheet for new bridges; and
- Hydraulic information on the general layout for bridge widening and special designs.

4.3.4 Hydraulic Data for Culverts

The hydraulic design of culverts should be based on Chapter 9 - Culverts. The following items used as a basis for the design should be included in the project file:

For cross culverts, the construction plans should contain the following for culverts 30 inches and larger, or if the conventional design frequency peak flow is 20 cfs or larger:

$D.A.$ =	______	square miles or acres (drainage area of contributing basin)
Q_{design} =	______	cfs (design discharge associated with the frequency indicated by the subscript)
DHW =	______	ft (design headwater elevation which prevents the design discharge from inundating the roadway)
AHW =	______	ft (allowable headwater elevation)

MHW =	______	ft (maximum headwater that can be tolerated due to "non-hydraulic" features, i.e. private buildings, roadway profile, flowline of ditches that would pass water into an adjacent basin)
Q_{100} =	______	cfs (100-year recurrence frequency discharge)
HW =	______	ft (headwater elevation corresponding to the 100-year recurrence frequency discharge)

In the above definitions for *DHW, AHW, MHW,* and *HW*, all elevations pertain to the culvert inlet.

For irrigation culverts, only water-right flow, stage (*DHW*), and freeboard are required.

For culvert designs, the following items must be included in the project file:

- A summary of all pertinent correspondence, field inspection notes, agreements, and minutes of meetings, especially with public involvement;
- Landowner concerns (e.g. cattle passes, equipment access, water rights, irrigation, etc.);
- Environmental concerns, including recommended depths and velocities for high and low design flows for fish passage;
- Potential flood hazards to adjacent properties;
- Evidence of ice or debris problems;
- Topography of the site including survey control information, georeferenced aerial photos, DEMs, DTMs/TINs, rasters, and LiDAR datasets;
- A drainage-area map, if used;
- Design flows;
- Stream profile, cross sections and cross sections used in determination of design highwater;
- Roughness coefficient (Manning's *n* value) assignments;
- Flowline elevation of the design centerline at the intersection of channel and roadway;
- Roadway geometry (plan and profile);
- Information on the method used for design highwater determination;
- Allowable headwater elevation and basis for its selection;
- Observed highwater elevations, dates, and discharges;
- Magnitude and fequency of overtopping floods;
- Stage-discharge curves for the undisturbed, existing and proposed conditions;
- Depth and velocity measurements (or estimates) and locations for the design, 100-year, and other check floods if necessary;
- Performance curves showing the calculated backwater elevations, outlet velocities, and scour for the design, 100-year, 500-year, and historical floods;
- Inlet and outlet scour computation for culverts 48" and larger;
- Structure type, size and location layout;
- Type of culvert entrance and outlet conditions;
- Culvert outlet appurtenances, and energy dissipation calculations and designs;

- Copies of all computer analyses (input data files as well as output files), and standard culvert computation sheets given in the Culvert Chapter of this manual;
- Floodway consistency determination or support for and approval of floodway revisions;
- Type of culvert pipe construction material.

The following are examples of hydraulic data that must be shown on the project plan sheets.

Culverts smaller than 42 inches in diameter:

Drainage Basin: Big Gulch Basin
Station 26+512.9
Required: 36-inch culvert pipe with end sections at inlet and outlet.

$D.A.$ = 955 acres
Q_{design} = 47 cfs
DHW = 8208.5 ft
AHW = 8210.5 ft
Q_{100} = 62.5 cfs
HW_{100} = overtopping

Notes:

1. If the water surface elevation corresponding to the 100-year recurrence frequency flood (HW_{100}) exceeds the AHW (8210.5 ft in this case), then denote HW_{100} by "overtopping" instead of providing a specific elevation.
2. If the existing culverts need to be extended, the project plans must include the following text after "Required:" Extend the existing culvert __ft left (inlet) and/or __ ft right (outlet) with end sections. The extended culvert must be of the same material as the existing culvert.

Concrete Box Culverts (CBC) and culvert pipes larger than 42 inches in diameter:

Drainage Basin: Big Gulch Sub Basin No. 1
Station 26 + 959.0
Required: 60-inch culvert pipe with full headwalls, wingwalls, and aprons at inlet and outlet.

$D.A.$ = 3080 acres
Q_{design} = 110 cfs
DHW = 8193.4 ft
AHW = 8197.0 ft
Q_{100} = 155 cfs
HW_{100} = 8195.4 ft

Notes:

1. If the water surface elevation corresponding to the 100-year flood (HW_{100}) exceeds the AHW (8197.0 ft in this case), then denote HW_{100} by "overtopping" instead of providing a specific elevation.
2. If the existing culverts need to be extended, the project plans must include the following text after "Required:" Extend the existing culvert __ft left (inlet) and/or __ ft right (outlet) with end sections. The extended culvert must be of the same material as the existing culvert.

4.3.5 Open Channels

The hydraulic design of channels should be based on Chapter 8 - Channels. If not documented elsewhere, the following items used as a basis for the design should be included in the project file:

Open channel designs:

- A summary of all pertinent correspondence, field inspection notes, agreements, and minutes of meetings, especially with public involvement;
- Landowner concerns (e.g. cattle passes, equipment access, water rights, irrigation, etc.);
- Environmental concerns, including recommended depths and velocities for high and low design flows for fish passage;
- Potential flood hazards to adjacent properties;
- Relevant information on existing structures in the vicinity, utilities, and right of way;
- Observed highwater, dates, and discharges (if applicable);
- Topography of the channel including survey control information, georeferenced aerial photos, DEMs, DTMs/TINs, rasters, LiDAR datasets and bathymetric surveys;
- A drainage-area map, if used;
- Design flows;
- Stream profile and cross sections;
- Cross sections and their locations used in determination of the design water surface;
- Information on method used for design water surface determinations;
- Roughness coefficient (Manning's *n* value) assignments;
- Roadway geometry (plan and profile);
- Magnitude and fequency of overtopping floods;
- Water surface profiles through the reach for the design, 100-year, and any historical floods;
- Stage-discharge curves for the design, 100-year, and any historical floods;
- Channel velocity estimates and locations for the design, 100-year, 500-year, and any historical floods;
- A summary of hydraulic calculations for the waterway opening, documenting the optimum;
- Design or analysis of materials proposed for the channel bed and banks;
- Energy dissipation calculations and designs;
- Copies of applicable computer analyses;
- Floodway consistency determination or support for and approval of floodway revision;
- Freeboard; and
- Risk assessment.

Roadways with longitudinal encroachments into the floodplain - include the water surface profiles corresponding to the 100-year and the design flood.

4.3.6 Storm Drains

The project plans for storm drains must contain the following information on the **plan** view of the trunkline:

a) Length, size and type of pipe material;
b) Inlet labels, invert and rim elevations; and
c) Flow direction.

The project plans for storm drains must contain the following information on the **profile** view of the trunkline:

a) Stationing;
b) Design flow and frequency for each reach of pipe;
c) Design-flow hydraulic grade line for each reach of pipe;
d) Length, size and slope for each reach of pipe;
e) Invert inlet and outlet elevations for each reach of pipe, including inlet labels, invert and rim elevations; and
f) Exact locations (station and offset distance).

The project hydraulic design file for storm drains must contain the following:

- Computations for drainage areas, inlets, and pipes, including hydraulic grade lines;
- Copies of all computation sheets;
- A topographic map of the complete drainage area, and grading plans;
- Design frequency;
- If required, justification for use of a frequency other than the conventional frequency (2-, 5-, or 10-year) recommended by this manual;
- Information concerning outfalls, existing storm drains, and other design considerations;and
- A schematic layout indicating the overall storm-drain system.

A separate storm-drain system is required for the construction phase of the project. The documentation for the construction phase shall follow the above guidelines.

4.3.7 Pump Stations

The hydraulic design of channels should be based on Chapter 13 - Storm Drains. The following items used as a basis for the design should be included in the project file:

- Inflow design hydrograph for drainage area to pump;
- Flood-frequency curve for attenuated peak discharge;
- Maximum allowable-headwater elevations and related probable damage;
- Sump dimensions;
- Stage-storage curve;
- Stage-pump discharge relation, and starting sequence and elevations;
- Available storage amounts;
- Mass curve-routing results;

- Pump sizes and operations;
- Discharge line and fittings sizing;
- Total dynamic-head curves;
- Selected pump-performance curves;
- Calculations and design report; and
- Line storage and pit storage capacities.

4.3.8 Detention and Water Quality Ponds

The project plans for detention ponds must include the following:

- Drainage area;
- Design storage volume and stage;
- Design discharge, frequency for inflow and outflow; and
- Grading plan for the project area including the pond.

The project file for designs of water quality ponds must contain the following additional information:

- Hydrological analyses;
- Storage-discharge calculations;
- Stage versus storage volume graph; and
- Stage versus outflow graph, including the 2-year, 100-year, and the design water-surface elevations.

4.3.9 Design Computations

Hydrologic and hydraulic design computations are an important part of the project file. The design computations should be maintained during and after construction, and for permanent reference. They provide a permanent record of design-analysis methods, materials used, and structure dimensions. The design computations should be in sufficient detail so that others can understand the original design.

Arrange the hydrologic and hydraulic design computations so that they can be easily followed by others. The title sheet of the computations should include the project number, project name, county name, station of structure, initials of those who prepared the computations, and the date of preparation. Each sheet of the design computations should be thoroughly checked and initialed by the designer and a design checker.

When unconventional methods or formulas are used in the hydrologic or hydraulic design, list the sources of the methods or formulas. When different considerations have been used for economic purposes, include all quantities and calculations substantiating these considerations. When computations are made by a computer, identify the program used (including software version), and the computer input and output values with an explanation of terms, assumptions, and computations used. Provide a sketch with an explanation of all abbreviations and symbols used in the input and output sheets of the program. When using a spreadsheet application, there should be supporting documentation describing the spreadsheet in the file, or referenced in the file.

APPENDIX A - HYDRAULIC DESIGN REPORT OUTLINE

1. Table of Contents

2. Introduction

- Project location shown on an area map; and
- Site location: stationing, state highway number, stream name, geographic reference (county, nearest town), legal description, (section, township, range).

3. Hydrology

Drainage basin map showing basin boundaries, areas, structure locations, direction of flow, north arrow, scale, name, date, and source of map, etc.

Basin description including: area, length, width, shape, elevation range, topography, factors influencing runoff (e.g. soil type, vegetal cover, detention structures and natural storage, development).

Channel description including: cross-section geometries, classification of stream form, bed material composition, channel bed and bank stability, sediment transport, conveyance factors, debris and ice problems, 100-year floodplain limits, and ordinary high-water elevations.

Precipitation data including: intensity, duration, frequency, principal cause of runoff, peak season, annual and seasonal distribution.

Flood history including: recorded floods, technical and media reports, visual observations, records of interviews with property owners and maintenance personnel.

Design flood frequency: Use the conventional flood frequency recommended by this manual. Use a different frequency only if supported by risk analysis.

Prediction of design discharge including: methods of analysis, parameters, criteria for design discharge selection, recurrence interval curve for 2-, 25-, 50-, and 100-year (500-year for bridges) discharges.

4. Existing Structure

Description: type of structure, size, structure ID number, year built, color photos showing the structure and its vicinity (upstream, downstream, and roadway).

Capacity and adequacy problems: information pertaining to flood marks, scour holes, head cutting, bed and bank degradation and aggradation, debris accumulation, ice jams, wetlands, cattle and wildlife crossings, and other maintenance and operation-related issues.

5. Design Discussion

- Discuss circumstances influencing the design, and concerns by CDOT Region personnel, local municipality representatives, and landowners.

- Document the need for channel or other improvements, debris control, present and future land use, and roadway grade.
- Document the allowable highwater elevation, its location, and the basis for its selection (including right-of-way and environmental limitations).
- Evaluate potential damage to surrounding property and roadway for both the design and 100-year flood (500-year for bridges).
- Indicate measures proposed to mitigate impacts and to restore and preserve the natural and beneficial values negatively affected by the construction. Discuss practical alternatives and justification for longitudinal and other significant encroachments.
- Determine requirements for compliance with Section 402 National Pollutant Discharge Elimination System (NPDES) and Section 404 of the Clean Water Act.
- List structure alternatives and discuss reasons for the type and size selection. Include cost comparisons in the discussion.

6. Recommended Design

Document the size, location, and skew of structures. For bridges, give the net and excavated width of encroachment at the flowline (thalweg) elevation. Also for bridges, list minimum low-girder elevation, design water-surface elevation with the required freeboard, estimated scour profile, training dikes, guide banks, spur dikes and detour culvert requirements. For irrigation structures, document water rights, freeboard, and trash rack if required. For irrigation structures that include inverted siphons, provide documentation for spillway, trash rack, and safety warning signs.

Document the required channel improvements and bank protection necessary for the safe operation of the structure.

7. Appendix

Include computer runs, with input files and tabulated trial runs, which fulfill the reporting requirements for the design described above.

Include the Bridge Hydraulic Information Sheet.

For storm drains, show inlet calculations, hydraulic grade line calculations, spreadsheet column definitions, etc.

APPENDIX B – EXAMPLE PROJECT CHECKLIST FOR HYDRAULIC DESIGN

Check Appropriate Items

Project Engineer: ________________

Project Number: _________________ Project Sub Account Code (SA): _________________

Location (include city and county) ____

A. REFERENCE DATA

Electronic Maps:

☐ USGS Digital Contour Maps

Name: Scale: Date:

☐ LIDAR or Survey data

☐ CDOT ☐ Other

☐ Local Zoning Maps

☐ Flood Hazard Delineation

☐ Floodplain Delineation (NFIP)

☐ Local Land Use

☐ Soils Maps

☐ Geologic Maps

☐ Aerial Photos

Scale: Date:

Studies by External Agencies:

☐ USACE Floodplain Information Report

☐ NRCS Watershed Studies

☐ Local Watershed Management

☐ USGS Gauges and Studies

☐ Interim Floodplain Studies

☐ Water Resource Data

☐ Regional Planning Data

☐ U.S Forest Service

☐ Utility Company Plans

☐ District Drainage Records

☐ Flood Records (highwater, newspaper)

Studies by CDOT Internal Sources:

☐ Hydraulics Section Records

☐ Region Drainage Records

☐ Bridge/Roadway Design

Reports:

☐ Data Reports

☐ Hydraulic Design Report

☐ Construction Inspection Reports

B. HYDROLOGY DATA

Technical Resources:

☐ CDOT Drainage Design Manual

☐ Internal and FHWA Directives

☐ FHWA Hydraulic Engineering Publications

☐ USACE Hydraulic Engineering Publications

☐ Technical Library

Discharge Calculations:

☐ Discharge Calculations

☐ Rational Formula

☐ HEC-HMS

☐ NRCS

☐ WMS

☐ Regional Analysis

☐ Regression Equations

☐ Area-Discharge Curves

☐ USGS Gaging Data

☐ Log-Pearson Type III Gage Rating

High Water Elevations:

☐ CDOT Survey

- ☐ External Sources
- ☐ Internal Sources
- ☐ Personal Reconnaissance

Flood History:

- ☐ External Sources
- ☐ Personal Reconnaissance
- ☐ Maintenance Records
- ☐ Photographs

Software:

- ☐ USGS NSS
- ☐ USGS Peak FQ
- ☐ USGS NWISWeb
- ☐ USGS StreamStats
- ☐ NRCS
- ☐ WinTR-55
- ☐ WinTR-20
- ☐ HEC-HMS
- ☐ WMS

C. HYDRAULIC DESIGN

Calibration of Highwater (HW) Data:

- ☐ Discharge and Frequency of High Water elevations
- ☐ Influences Responsible for High Water elevations
- ☐ Analyze Hydraulic Performance of Existing Facility for Minimum Flow Through 100-yr Flow
- ☐ Analyze Hydraulic Performance of Proposed Facility for Minimum Flow Through 100-yr Flow

Drainage Appurtenances:

- ☐ Bridges
- ☐ Culverts
- ☐ Storm Drains
- ☐ Storage
- ☐ Dissipators
- ☐ Bank Protection
- ☐ Channel Stabilization
- ☐ Erosion and Sediment Control
- ☐ Wetlands
- ☐ Fish and Wildlife Protection

Technical Aids:

- ☐ CDOT Drainage Design Manual
- ☐ FHWA publications
- ☐ AASHTO publications
- ☐ CDOT Procedural Directives
- ☐ Technical Library

Software:

- ☐ HY-8 (FHWA Culvert Analysis)
- ☐ HEC-RAS (Water Surface Profile)
- ☐ HEC-HMS (Watershed Modeling)
- ☐ SMS (Surface Water Modeling System)
- ☐ FHWA Hydraulic Toolbox
- ☐ SAMwin (Hydraulic Design Package for Channels)
- ☐ SRH 2D (Sedimentation and River Hydraulics)
- ☐ FHWA BRI-STARS Bridge Streamtube Alluvial River Simulation Model